Peer Review Follow-On Comments on the April 2013 Draft of

An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska

U.S. Environmental Protection Agency

Region 10

Seattle, WA

INTRODUCTION

In May 2012, the U.S. Environmental Protection Agency (EPA) publicly released the first external review draft of *An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska* for review and public comment. External peer review of the May 2012 draft assessment was coordinated by Versar, an independent contractor. Versar assembled 12 independent experts to serve as peer reviewers. The selected reviewers were:

- Mr. David Atkins, Watershed Environmental, LLC (expertise in mining and hydrology)
- Mr. Steve Buckley, WHPacific (expertise in mining and seismology)
- Dr. Courtney Carothers (expertise in indigenous Alaskan cultures)
- Dr. Dennis Dauble, Washington State University (expertise in fisheries biology and wildlife ecology)
- Dr. Gordon Reeves, USDA Pacific Northwest Research Station (expertise in fisheries biology and aquatic biology)
- Dr. Charles Slaughter, University of Idaho (expertise in hydrology)
- Dr. John Stednick, Colorado State University (expertise in hydrology and biogeochemistry)
- Dr. Roy Stein, Ohio State University (expertise in fisheries and aquatic biology)
- Dr. William Stubblefield, Oregon State University (expertise in aquatic biology and ecotoxicology)
- Dr. Dirk van Zyl, University of British Columbia (expertise in mining and biogeochemistry)
- Dr. Phyllis Weber Scannell (expertise in aquatic ecology and ecotoxicology)
- Dr. Paul Whitney (expertise in wildlife ecology and ecotoxicology)

After review of the May 2012 draft was complete, Versar compiled detailed comments from each of the 12 reviewers and provided a Final Peer Review Meeting Summary Report (hereafter, the peer review report) to EPA in September 2012. This report is available at http://www.epa.gov/ncea/pdfs/bristolbay/Final-Peer-Review-Report-Bristol-Bay.pdf. EPA reviewed these detailed comments and, based on both review comments and comments submitted by the public, developed an improved and expanded draft assessment.

This second external review draft assessment was released to the public in April 2013. EPA asked the 12 independent experts who peer reviewed the May 2012 draft to evaluate how well the April 2013 draft of the assessment reflected that we fully understood and sufficiently responded to the comments they provided on the previous draft. This evaluation was limited to the comments and suggestions each reviewer provided in the peer review report submitted to EPA by Versar. EPA suggested that each peer reviewer conduct this evaluation using the April 2013 draft of the assessment, the specific comments and suggestions provided by the peer reviewer on the May 2012 draft of the assessment (as reflected in the peer review report), and the draft response to comments document EPA provided to each reviewer. The draft response to comments document detailed how EPA responded to specific comments and suggestions provided in the peer review report.

Each peer reviewer was asked to provide a letter report evaluating how well the April 2013 draft of the assessment addressed both the key recommendations provided in the peer review report's Executive Summary and the specific comments provided by that individual reviewer in the peer review report.

This document includes the Scope of Work that each reviewer received from EPA and presents the follow-on review materials submitted to EPA by each of the 12 reviewers, organized in alphabetical order. EPA also is releasing a separate document that includes all peer review comments on both the May 2012 and April 2013 drafts of the assessment and EPA's responses to these comments. This Response to Peer Review Comments document is available at http://cfpub.epa.gov/ncea/bristolbay/recordisplay.cfm?deid=242810, under the Downloads section.

Revised Draft Bristol Bay Assessment

Peer Review Follow-On

Scope of Work

Introduction

The U.S. EPA is developing an assessment of the potential impacts of large-scale surface mining on fish resources of the Bristol Bay watershed, Alaska. A draft assessment was released for public comment in May 2012 and was also peer reviewed by twelve expert scientists and engineers. This external peer review was coordinated by a contractor, Versar, Inc. Versar compiled detailed comments from each of the twelve reviewers and provided a peer review report to the Agency in September 2012. The EPA has reviewed these detailed comments and has developed an improved and expanded draft assessment. This revised draft assessment was released for public comment on April 26, 2013.

EPA is asking the twelve experts who peer reviewed the May 2012 draft to evaluate how well the revised draft assessment incorporates and responds to the comments they provided on the previous draft. This evaluation is limited to the individual comments and suggestions each reviewer provided in the September 2012 final peer review report. The purpose of this scope of work is to outline the specific tasks requested by the EPA, the timelines for all deliverables, and associated terms and conditions.

Level of Effort Estimate: [redacted]

Task 1: Conflict of Interest

The Contractor shall complete the conflict of interest form (Attachment A). This form will be considered confidential and used by EPA staff to identify any potential conflicts of interests that have arisen since completion of the last peer review report. The conflict of interest form shall be provided to the EPA Project Officer within 10 calendar days of initiation of this contract.

Task 2: Confirm Receipt of Review Materials

On or about May 20, 2013, the EPA Project Officer will provide the Contractor materials to be used for the evaluation outlined in this contract. Materials to be provided include the following:

1. *Final Peer Review Report, External Peer Review of the EPA's Draft Document, An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska,* dated September 17, 2012. This document is 193 pages.
2. The draft response to comments document detailing how EPA responded to comments provided by the external peer reviewers. It is anticipated that this draft report will be roughly 300 pages.

3. The April 2013 version of the draft Bristol Bay Assessment. This draft report is approximately 600 pages.
4. Revised Appendix I (Conventional Water Quality Mitigation Practices for Mine Design, Construction, Operation and Closure) and new Appendix J (Compensatory Mitigation and Large-Scale Hardrock Mining in the Bristol Bay Watershed). Combined, the appendices are approximately 50 pages. Other appendices are not considered part of the evaluation being conducted under this contract.

Materials will be provided as electronic files via email and in paper copy form via overnight delivery. All documents will be provided in MS Word (Word 2007; Office 97) format.

The contractor shall confirm receipt of review materials within 72 hours of receipt.

Task 3: Evaluation of review materials

The Contractor (reviewer) shall conduct an evaluation of how well the revised draft assessment incorporates and responds to comments provided by the Contractor on the previous draft. The Contractor should note that some comments were considered outside of the scope of the assessment and are addressed in the EPA's response to comments document only. The EPA suggests that the contractor conduct this evaluation using the following approach:

1. Using the final peer review report (Document 1 above), review comments and suggestions made on the May 2012 draft. The Contractor should specifically review key recommendations in the Executive Summary of the peer review report and the comments and suggestions provided *by the Contractor* in Section III (i.e., the Contractor does not need to address comments made by other peer reviewers).
2. Review the EPA's response to comments document (Document 2 above) that details how EPA responded to specific comments and suggestions provided in the peer review report. The EPA's response to comments document is structured the same as the peer review report.
3. Review the revised draft Bristol Bay Assessment (Documents 3 and 4 above) to assess how EPA's responses to comments and suggestions were implemented in the revised draft.

The Contractor shall provide a letter report evaluating how well the revised draft Bristol Bay Assessment addresses both the key recommendations provided in the Executive Summary of the peer review report and the specific comments provided by the Contractor in the peer review report.

The Contractor shall deliver their evaluation to the EPA Project Officer within 30 calendar days of EPA providing all review documents. Evaluations shall be delivered electronically via email.

Review of Contractor Deliverables

Deliverable 1: The Contractor shall provide a completed and signed conflict of interest statement to the EPA Project Officer within 10 days of the initiation of this contract.

Deliverable 2: The Contractor shall confirm receipt of EPA-provided review materials within 72 hours of receipt.

Deliverable 3: The Contractor shall provide a summary evaluation of EPA's response to the September 2012 peer review report in letter form within 30 days of receipt of EPA-provided materials.

Use of Deliverables By the EPA

The EPA plans to publicly release a comprehensive response to comments document upon release of the final Bristol Bay Assessment. The EPA also plans to release the letter evaluation provided by the Contractor as part of this contract upon release of the final Bristol Bay Assessment. Release of the final Bristol Bay Assessment is anticipated in 2013.

Confidentiality and Non-Disclosure

Materials provided by the EPA to the Contractor are to be considered confidential until released by the EPA. Materials in paper form may not be copied, shared, or otherwise distributed. Electronic files may not be forwarded or distributed. The EPA realizes that the peer review report (Document 1) was made publicly available in November 2012 and the revised draft assessment (Documents 3 and 4) were made available for public comment in April 2013. The EPA prefers that the Contractor direct others interested in these two documents to the EPA's Bristol Bay website (www.epa.gov/BristolBay) to obtain copies. EPA's draft response to comments document (Document 2) will be released to the public when finalized and at the time that the final assessment is completed. The Contractor shall take responsible steps to insure the confidentiality of materials provided by the EPA for this evaluation.

The Contractor shall not discuss their evaluation of the revised draft assessment with members of the press or public, or in meetings, workshops, or conferences. This restriction shall remain in effect until publication of the final EPA assessment, or the end of calendar year 2013, whichever comes first.

The Contractor is free to consult with colleagues on technical issues raised in the report provided that such consultation is limited to discussions of the revised draft assessment (Documents 3 and 4).

Expenses

No travel is associated with the work outlined in this contract. It is not expected that the Contractor shall incur any expenses associated with completion of the work outlined in this scope of work.

EPA Contacts

EPA Project Officer: Ms. Jenny Thomas, U.S. Environmental Protection Agency, Office of Water, 1200 Pennsylvania Avenue, NW., Washington, DC 20460. 202-564-4524, thomas.jenny@epa.gov.

Mr. David Atkins, Watershed Environmental, LLC

Peer Review Follow-On Comments on the April 2013 Draft of

An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska

From: David Atkins [[redacted]
Sent: Tuesday, July 16, 2013 5:06 PM
To: Thomas, Jenny
Subject: review comments...

Dear Jenny,

Please find my review comments attached (underlined in text). Thanks for understanding my need to delay delivery and let me know if you have any questions.

Best regards,
David

SUMMARY OF KEY RECOMMENDATIONS FROM PEER REVIEWERS

This section summarizes the significant general recommendations put forth by the peer reviewers regarding EPA's draft assessment. In developing these recommendations, peer reviewers provided input on three major areas of the assessment: (1) scope, (2) technical content and (3) editorial suggestions. Reviewers also identified research needs for EPA to consider. Please note that this summary of peer review comments did not reflect a consensus or group perspective, but was compiled from a discussion of individual peer reviewer recommendations. Additional details, including references cited, can be found in the reviewers' individual comments in Section III.

Scope of the Document:

- Articulate the purpose of the document more clearly via a primer on the Ecological Risk Assessment process. If the purpose of the assessment is to inform EPA as the decision maker, then the level of detail should correspond to this purpose. The authors should justify and explain what level of detail is required.

  RESPONSE: Additional information on both the purpose of the assessment and ecological risk assessment (ERA) in general has been added to Chapters 1 and 2, as well as the Executive Summary. Section 1.2 includes information about the use of the assessment. The assessment has been reorganized into two major sections (problem formulation, risk analysis and characterization) to clarify where different chapters fall in the typical ERA process.

  Response: This response is adequate.

- Include a statement upfront about the role of risk managers and other audiences, such as project managers/engineers, regulators, mine owners/operators. Knowing their role ensures inclusion of information necessary for any risk assessment by (1) describing the need for a risk assessment, (2) listing those decisions influenced, and (3) characterizing what risk managers require from the risk assessment.

  RESPONSE: Section 1.2 of the revised assessment discusses the use of the assessment.

  Response: This response is adequate.

- Explain why the scope for human and wildlife impacts was limited to fish-mediated effects, as well as why fish-mediated effects on humans were limited to Alaska Native cultures. Reviewing effects beyond fish-mediated ones (e.g., potential for complete loss of the subsistence way of life) would improve the assessment.

  RESPONSE: The scope of the assessment has been clarified throughout the document, particularly in Chapters 1 and 2. Throughout the assessment we acknowledge that direct effects of large-scale mining on wildlife and Alaska Native

cultures may be significant, but that these direct effects are outside the scope of the current assessment.

Response: This response is adequate.

- Be more consistent throughout the document in terms of the level of detail provided for the different scenarios and stressors. For example, the document has devoted 36 pages to the discussion of catastrophic Tailings Storage Facility (TSF) failure, while sections on the pipeline, water treatment, and road/culvert failures are brief. Indeed, the long discussion on the TSF failure belies a certainty and understanding of dam failure dynamics that is inaccurate.

  RESPONSE: The final document includes more failure scenarios (e.g., diesel pipeline failure, wastewater treatment plant failure, and refined seepage scenarios) in Chapter 8. It also explains why these specific failure scenarios were chosen, and discusses these scenarios in greater detail than the previous draft (i.e., to more closely match the level of detail originally provided only for the TSF failure scenario). Also see detailed responses to comments on Peer Review Question 5.

  Response: This response is adequate.

Technical Content:

Mine Scenario

- Consider the document to be a screening-level assessment of all potential stressors. Focusing on failure mode overemphasizes catastrophic events (e.g., TSF failing), rather than considering all potential stressors, such as holding mine owners strictly accountable for their day-to-day activities with regard to best practices.

  RESPONSE: Additional information on the purpose and scope of the assessment has been added to Chapters 1 and 2. A screening of all potential stressors, including individual chemicals, is presented in Section 6.4.2. Also see detailed responses to Peer Review Question 2 on the use of "best practices" and responses to Peer Review Question 5 on failure scenarios.

  Response: This response is adequate.

- Reexamine the document's use of historical data and case studies to describe and estimate the risk of failure for certain mine facilities (including the TSF, pipeline, water treatment, etc.), as these examples from extant mines may not be an appropriate analog for a new mine in the Bristol Bay watershed.

  RESPONSE: The TSF failure range was, and still is, based on design goals, not the historical data. The historical TSF failure data are provided as background. The pipeline failure rates are based on the most relevant historical data from the petroleum industry. They are directly relevant to the diesel pipeline, and experiences at the Alumbrera mine (described in the previous draft) and the

Antamina and Bingham Canyon mines (added to this draft) suggest that they also are relevant to the product concentrate pipeline. Water treatment failure rates were not quantified. However, recent reviews cited in the revised draft indicate that water collection and treatment failures have been reported at nearly all analogous mines in the U.S. The estimation of culvert failure frequencies has been revised and is now based on only recent literature (2002 and later). We believe that these estimates are appropriate.

Response: This response is adequate.

- Expand the discussion on the use of "best" management practices, as the document states that the mine scenario employs "good," but not necessarily "best" practice. For a mine developed in the Bristol Bay watershed, only "best" practice likely would be appropriate and anything less may not be permitted. Even so, without a track record of "best" practice (e.g., new technologies), we cannot assume that technology, by itself without appropriate operational management controls, can always mitigate risk.

  RESPONSE: The term "best management practices" is a term generally applied to specific measures for managing non-point source runoff from storm water (40 CFR Part 130.2(m)). Measures for minimizing and controlling sources of pollution in other situations often are referred to as best practices, state of the practice, good practice, conventional, or simply mitigation measures. We assume that these types of measures would be applied throughout a mine as it is constructed, operated, closed, and post-closure, and have used the term "conventional modern" throughout the assessment to refer to these measures. To remove any ambiguity related to the subjectiveness of terms "good" or "best", we have removed them in the revision and have provided definitions for relevant terms used in Box 4-1.

  Response: This response is adequate.

- Adopt a broader range of mine scenarios (not only minimum and maximum) so as to bound potential impacts, especially at smaller mine sizes (e.g., 50^{th} percentile). Underground mine development, with its different impacts, also should be considered and included in the assessment.

  RESPONSE: A third mine size scenario (250 million tons) has been added to the assessment, to represent the worldwide median sized porphyry copper mine (based on Singer et al. 2008).

  Response: This response is adequate.

- Based on the hypothetical mine scenario, perpetual management of the geotechnical integrity of the waste rock and tailings storage facilities, as well as perpetual water treatment and monitoring, will most likely be necessary (i.e., a "walk away" closure scenario after mining ends may not be possible). Therefore, emphasize how monitoring and management of the geotechnical integrity of waste rocks and tailing storage facilities should continue "In Perpetuity" (i.e., for at least tens of thousands of years). Discuss what conditions would need to be met to allow "walk away" closure in the Bristol Bay environment gaining insight into these observations from mines where perpetual treatment and monitoring are ongoing (e.g., the Equity Silver Mine in British Columbia).

RESPONSE: The conditions for closure and the potential need for perpetual site management are discussed in general terms in the revised assessment. The primary condition assumed to be required is water chemistry that meets all criteria and permit conditions and that is stable or improving. However, even though there are some facilities with "perpetual treatment" conditions in place, there is obviously no information about how these facilities perform over very long periods of time.

Response: This response is adequate.

- Identify, in technical detail, how exploratory effects (e.g., drill holes, blasting, overflight, etc.) were managed. This includes roads, airstrips, helipads, camps, fuel dumps, and ATV trails that have already been developed or imposed on the watershed, and what "mitigation" already has been undertaken on those sites. Assess the consequences/impacts of these activities in the Cumulative Risks section.

  RESPONSE: The effects of exploratory activities are outside of the scope of this assessment.

  Response: This response is adequate.

Risks to Salmonid Fish

- Place potential mining impacts in the context of the entire Bristol Bay watershed by emphasizing the relative magnitude of impacts. For example, of the total salmon habitat, assess the proportion lost due to mining. Further, reflect on the non-linear nature of the relationship between habitat and salmon production; 5% of the habitat could be critical and thus responsible for 20% or more of salmon recruitment. Intrinsic potential, which measures the ability of particular habitats to support fishes, would lend credibility to this analysis.

  RESPONSE: We are unable to build a complete Intrinsic Potential (IP) model, as this would require validation and more elaborate construction of metrics appropriate to this region. Our preliminary characterization provides the building blocks for assessing the distribution of key habitat-forming and constraining features across these watersheds. We now include a characterization of the major drivers of habitat potential across the watershed and place the mine-site specific effects in this context (Chapters 3, 7, and 10).

  Response: This response is adequate.

- Include a section on the impact of Global Climate Change with explicit reference to a monitoring program that will allow scientists, if the mine is built, to distinguish between effects of climate change and mining effects on the physical and biological components of this ecosystem.

RESPONSE: Climate change projections and potential impacts are now included in Chapter 3, and as important external factors in the risk analyses presented in Chapters 7, 9, 10, and 14. Development of a monitoring program to distinguish between mining and climate change effects is outside of the scope of the assessment.

Response: This response is adequate.

- Explicitly recognize that the transportation corridor and all associated ancillary development, including future resource developments made possible by the initial mining project, will necessarily and inevitably have impacts (hydrologic, noise, dust, emissions, etc.). These impacts will vary in duration, intensity, severity, relative importance, spatial dispersion, and inevitably expand geographically through time with further "development." These impacts should be incorporated into the Cumulative Risks section.

  RESPONSE: The cumulative risk section (Chapter 13) has been expanded to include the multiple transportation corridors, ancillary mining development and secondary development associated with multiple mines in a qualitative discussion. The issues addressed in the assessment of the transportation corridor (Chapter 10) have also been expanded to include chemical spills, dust, invasive species, and road treatment salts.

  Response: This response is adequate.

- Incorporate current research findings into stream crossing and culvert-design practices (e.g., arch culverts, bridges, etc.).

  RESPONSE: We describe current culvert design practices in a box titled "Culvert Mitigation" in Chapter 10.

  Response: This response is adequate.

- Recognize in the assessment that risk and impact are not equivalent. Risk may be low, but the potential impact could be huge (e.g., in the case of a TSF failure).

  RESPONSE: Risk has been defined in many ways, even by risk assessors. The commenter seems to define risk as probability. To avoid that potential source of confusion, we use the term "probability" for that concept. Similarly, the commenter seems to use "impact" where we use "effect" or "magnitude of effect". We use "risk" to refer to both concepts combined—that is, an event or effect and its probability).

  Response: This response is adequate.

- Recognize and justify chronic behavioral endpoints, such as those potentially affecting survival and long-term success of fish populations.

  RESPONSE: The chronic behavioral effects of copper on salmonids, the primary endpoint of concern, were described in Chapter 5 and are now described in Chapter 8. Although those effects occur at lower levels of copper than conventional

survival, growth and reproduction endpoints for salmonids, they are less sensitive than the conventional endpoints for aquatic invertebrates.
Response: This response is adequate.

Wildlife

- Recognize that the draft assessment did not account for all levels of ecology, such as the individual (e.g., a bald eagle nest), population, community, ecosystem, and landscape levels. Fold other levels of organization into the stressors assessment where appropriate or justify a more limited approach.

  RESPONSE: As is appropriate for an ecological risk assessment (as opposed to an environmental impact assessment), this assessment focuses on a specific, limited set of endpoints as defined in Chapter 5. We have added text in Chapters 2 and 5 to explain both why these endpoints were selected, and that responses other than those considered in the assessment, at multiple levels of ecological organization, are likely but are outside the scope of the assessment.

Response: This response is adequate.

- Discuss in the document fishes other than salmonids The assessment focuses on risks to sockeye salmon in the Bristol Bay watershed (and also considers anadromous salmonids, rainbow trout, and Dolly Varden), but does not account for potential impacts to other members of the resident fish community. Further, primary and secondary production, including nutrient flux was not addressed. Expanding the assessment to consider other levels of organization, including direct as well as indirect effects on wildlife and other fish, would provide additional context in the assessment of mine-related impacts.

  RESPONSE: See response to comment above; we also incorporated additional information from Appendices A, B, and C into the Chapter 5 text, to provide additional detail on the area's biota. We chose our endpoints for reasons described in Chapters 2 and 5. Other endpoints, including indirect effects on fish and wildlife, are now discussed more explicitly, but are generally considered outside the scope of the assessment.

Response: This response is adequate.

Human Cultures

- Use case histories to provide insight and anticipate mining impacts on Alaska Natives (e.g., those exemplifying the Exxon Valdez oil spill impacts, cumulative effects of oil and gas development in the North Slope region, and social impacts related to mining development in Alaska).

  RESPONSE: Examples from applicable case studies, including the Exxon Valdez oil spill, are cited in Chapter 12 of the revised assessment.

  Response: This response is adequate.

- As noted above (Scope of the Document), clarify why the scope was limited to fish-mediated effects. The potential direct and indirect impacts for human cultures extend far beyond fish-mediated impacts (e.g., potential complete loss of the subsistence way of life). The rationale for this narrow focus should be fully explained. In addition, a clear explanation should be given for why fish-mediated human impacts focused only on Alaska Native cultures.

  RESPONSE: The assessment focuses on a specific, limited set of endpoints as defined in Chapter 5. We have added text to explain both why these endpoints were selected, and that responses other than those considered in the assessment are likely but are outside the scope of the assessment. The assessment was expanded (Chapters 5 and 12) to acknowledge that there are a wide range of potential direct and indirect impacts to indigenous culture, but they are outside of the scope of this assessment. The discussion of potential effects to indigenous cultures was expanded to explain that a loss of subsistence resources would extend beyond a loss of food resources to social, cultural, and spiritual disruption. The text has been expanded to acknowledge the strong cultural ties of many non-Alaska Natives to the region, and potential effects on all residents from loss of a subsistence way of life. However, the focus of the assessment remains on effects on indigenous cultures resulting from effects on salmon.

  Response: This response is adequate.

Water Balance/Hydrology

- Better characterize water resources and assess the potential effect of mine development on these resources by (1) generating a diagram similar to the conceptual models beginning on page 3-7 to illustrate the potential effects of mine construction and operation on surface- and ground-water hydrology; (2) developing a quantitative water balance and identifying water gains and losses; (3) identifying seasonality of hydrologic processes, including frozen soils and their associated values (e.g., mm/yr) for each component of the water balance; (4) incorporating these processes into a landscape characterization; (5) evaluating how global climate change will influence these hydrologic processes and rates; and 6) using this characterization to demonstrate the expected hydrologic modification associated with the mine scenarios and infrastructure development.

  RESPONSE: The original Figure 4-9 (new Figure 6-5) has been revised to more clearly show water management in the assessment's mine scenarios. In addition, three schematics illustrating water flows under each of the mine size scenarios (Figures 6-8 through 6-10) have been added to Chapter 6, as have quantitative water balances for each mine size scenarios. A qualitative discussion of climate change is included in Chapters 3 (Section 3.8) and 14 (Box 14-2).

  Response: This response is adequate.

- Demonstrate the interconnectedness of groundwater, surface water, hyporheic zone, and its importance to fish habitat. Address how interconnectedness changes over time

– seasonally, and with varying weather (e.g., wet vs. dry summers or years, and over the long term as climate changes).

RESPONSE: We lack the data to demonstrate this interconnectedness in a spatially and temporally uniform manner, but do include examples of known points of high connectivity (Chapter 7) and qualitatively discuss the potential role of climate change (Chapter 3).

Response: This response is adequate.

- Provide information on all rivers, including ephemeral and intermittent streams, and first-order to main-stem streams that could be potentially influenced by the proposed mine, its ancillary facilities, and the transportation corridor.

  RESPONSE: Due to lack of consistent coverage, we rely on the NHD hydrography layer in this analysis, and can only address ephemeral and intermittent streams qualitatively (Chapter 7).

  Response: This response is adequate.

- Emphasize the importance of a thorough characterization of the leaching potential of acid-generating and non-acid generating waste rock and tailings, given the low buffering capacity and mineral content in the streams and wetlands that could receive runoff and treated water from the proposed mine. Recognize that collection and treatment of runoff and leachate generated will be critical to maintain baseline water chemistry in these streams and wetlands.

  RESPONSE: We agree that these are important issues, and the discussion of leachate from waste rocks and tailings has been expanded in the revised assessment (Chapter 8).

  Response: This response is adequate.

Geochemistry/Metals

- Reference the most current geochemistry data on potentially acid-generating, non-acid generating, and metal leaching so as to describe any potential effects of seepage and changes to surface- and ground-water quality via non-catastrophic failure.

  RESPONSE: We used the geochemistry data in PLP's Environmental Baseline Document, as summarized by the USGS in Appendix H. The effects of seepage on water quality are analyzed in Chapter 8 of the revised assessment.

Response: This response is adequate.

- Explain how contaminants/metals were selected (and others ignored) by EPA as causes for concern. Information should be included on additional metals and their toxicity so as to assess impacts of potential leachates. The Pebble Limited Partnership baseline document presented additional metals that might be useful to include in the assessment.

  RESPONSE: The revised assessment describes the selection of contaminants and other stressors of concern in Section 6.4.2. Additional metals, process chemicals and dissolved

solids are now included.

Response: This response is adequate.

Mitigation Measures

- Incorporate the critical mitigation information from Appendix I into the main report's mine scenarios. Include standard mitigation measures that could provide insight into how well they might work in this context. If this information is not included in the main report, then justify its absence.

  RESPONSE: Mitigation measures incorporated into design and operation to minimize potential impacts were included in the assessment, as were some reclamation measures for closure; these measures are made clearer in the revised assessment. These mitigation measures were a sub-set of those presented in Appendix I. The assessment assumes that measures chosen for the scenarios would be effective. Mitigation to compensate for effects on aquatic resources that cannot be avoided or minimized by mine design and operation would be addressed through a regulatory process that is beyond the scope of this assessment. Nevertheless, in response to public and peer comments we have included a discussion of compensatory mitigation in Appendix J of the revised assessment.

  Response: This response is adequate.

- Emphasize mitigation measures (e.g., minimization, compensation, reclamation) in the main report, as they ultimately influence the range of mining impacts and consider time frames of mitigation or reclamation measures (e.g., immediate response, long-term reclamation).

  RESPONSE: See response to previous comment. Mitigation measures are discussed at greater length in the revised assessment report (e.g., Chapter 4 and Appendix J).

  Response: This response is adequate.

Uncertainties and Limitations

- Clarify the uncertainty vs. certainty in Chapter 8 by (1) defining levels of uncertainty and (2) assessing the certainty of some mine impacts. Discuss data limitations in the context of uncertainty.

  RESPONSE: The individual analysis chapters and the revised Integrated Risk Characterization (Chapter 14) discuss certainties and data limitations to a greater extent, as suggested.

  Response: This response is adequate.

- Articulate early in the document how much uncertainty is acceptable. The assessment provides little insight with respect to the decisions the document is intended to support.

RESPONSE: Acceptable levels of uncertainty can be defined prior to an assessment if a decision and a decision maker are identified and if data will be collected by a specified design to implement a specified model, as described in the EPA's Data Quality Objectives process, However, because this assessment is based on available data and is intended as a background scientific document rather than a decision document, it is not possible to specify the amount of uncertainty that is acceptable. Rather, the available data determine the uncertainty and if the assessment is subsequently used to inform a decision, the decision maker must determine whether the level of uncertainty is acceptable.

Response: This response is adequate.

Editorial Suggestions:

- The title of the document leads one to believe that the assessment addresses the entire Bristol Bay watershed; rather, the report deals with two major rivers and their watersheds, the Nushagak and Kvichak. Thus, the title should be changed to reflect the emphasis on these two rivers and their watersheds. A possible title may be "An Examination (or identification) of the Potential Impacts of Mining and Mining Associated Activities on Salmon Ecosystems in the Nushagak River and Kvichak River watersheds, Bristol Bay."

  RESPONSE: The assessment addresses multiple scales: the Bristol Bay watershed, the Nushagak and Kvichak River watersheds, the watersheds of the three streams draining the Pebble deposit, and the watersheds crossed by the transportation corridor. These multiple scales, and how they are used throughout the assessment, are described more clearly in the revision (Chapter 2).

  Response: This response is adequate.

- Revise the Executive Summary to more precisely reflect the findings in the document.

  RESPONSE: The Executive Summary has been rewritten to reflect the revised assessment findings.

  Response: This response is adequate.

- The appendices contain detailed and useful information that should be summarized and included in the main document (e.g., Appendix E: Economics, Appendix G: Road and Pipelines, and Appendix I: Mitigation). Additionally, consider expanding the preface to include information on the use of the appendices. If the information is not included in the main report, then justify its absence.

  RESPONSE: More information from the appendices was brought forward into appropriate chapters of the revised report. The purpose of the appendices—to provide the detailed background characterization necessary for the ecological risk assessment—has also been clarified in Chapter 2. The document no longer

contains a preface because that material has been incorporated into Chapters 1 and 2.

Response: This response is adequate.

- Discuss in more detail the instructive and well-thought-out conceptual models (pages 3-7 to 3-11) illustrating the impacts of mining on Bristol Bay ecosystem processes. Also, consider expanding the conceptual models to include wildlife, fish-wildlife interactions, vegetation/terrestrial habitat, and hydrologic processes. Allow them to guide the text because they appear detailed and complete.

  RESPONSE: Additional information on the use of conceptual models throughout the assessment has been incorporated into Chapter 2. The more comprehensive conceptual models presented in Chapter 6 (Chapter 3 in the first draft) have been broken into their relevant component parts throughout the risk analysis and characterization chapters, to better frame the specific pathways addressed in each chapter. Additional conceptual models considering impacts on wildlife, Alaska Native populations, and cumulative effects of multiple mines have been added to Chapters 12 and 13.

  Response: This response is adequate.

- Incorporate the information contained in the conceptual models into a formal framework, such as a Bayesian or other decision-analysis models.

  RESPONSE: This is an excellent suggestion for future efforts, but is beyond the scope of the current assessment.

  Creating a Bayesian Belief Network would require that the Agency convene experts to subjectively estimate the probabilities of each transition in the conceptual models. In contrast, this assessment is intended to elucidate the risks from potential mining based on available data and analyses of those data.

  A Decision Analysis would require that alternative outcomes be specified, the utility of each outcome for a decision maker be defined and the probabilities of each outcome be estimated for each possible decision so that the expected utilities of each outcome can be calculated. Because this assessment is not a decision document, these requirements are not feasible or appropriate.

  Response: This response is adequate.

- Generate a standard operating protocol for significant figures and use it throughout the document.

  RESPONSE: The authors have carefully addressed this issue. Numbers from the literature or from the PLP EBD retain the number of significant figures in the original. Numbers derived for this assessment have the appropriate number of significant figures given the precision of the input data and uncertainties due to modeling and extrapolation.

  Response: This response is adequate.

- Remove all references to Mount St. Helens as a surrogate for a TSF failure. Using a non-human-caused release of material into the ecosystem as an analogue for a mine failure is not comparable in terms of likelihood or risk for a human-caused release. It would be more appropriate to extrapolate from the impacts of known mine failures.

  RESPONSE: We are puzzled by this comment. The Mount Saint Helens data were used strictly to address the rate of benthic habitat recovery from a massive deposition of fine mineral particles. The hydrological processes that determine the recovery of substrate texture and the requirements of fish or aquatic invertebrates are not known to depend on whether mineral particles were from a natural event or an anthropogenic event. We have reviewed the literature on known mine failures. They studied tailings spills in terms of toxicity but not in terms of physical habitat effects, which is why we used Mount Saint Helens data. Nevertheless, we have removed references to Mount St. Helens in the revised assessment to eliminate concern.

  Response: This response is adequate.

- Ensure that the draft assessment remains part of the public record, allowing the document history to remain intact.

  RESPONSE: All drafts of the watershed assessment will remain part of the public record.
  Response: This response is adequate.

Research Needs:

- What are the acute and chronic impacts of mixtures of contaminants, including metals, acid mine drainage, etc., on the fauna and flora of the Nushagak River and Kvichak River watersheds? What species are most sensitive and might surrogate species exist for those for which we do not have data? Review the European literature and regulatory requirements for additional data.

  RESPONSE: The acute and chronic impacts of contaminant mixtures, including metals and acid mine drainage (i.e., metals in low pH-waters) were addressed using concentration additivity models in the leachate chemistry tables in Chapters 5 and 6 (now Chapters 8 and 11). Additional toxicity data were obtained by searches of the EU and OECD database eChem, the EPA's ECOTOX and the Environment Canada site. More metals are now included. In general, metals are most toxic to aquatic arthropods rather than fish, as discussed for copper.

  Response: This response is adequate.

- Can an inventory of nutrients, total organic carbon, and dissolved organic carbon inputs to aquatic environments be developed that demonstrates their relative magnitude and spatial variation from headwaters to Bristol Bay? What is the relative importance of marine-derived nutrients relative to other nutrients from watershed and terrestrial sources? What is the current atmospheric input of nutrients?

RESPONSE: These data would be very useful in the risk assessment, but are not currently available for the Bristol Bay region. We agree this is a research need.

Response: This response is adequate.

- What are the locations of subsistence areas and can these areas be characterized and differentiated by collecting local environmental and ecological knowledge (e.g., fish overwintering areas, climate change, ecological shifts, etc.)?

  RESPONSE: The revised assessment incorporated current data on subsistence use areas available from ADF&G. EPA acknowledges that these data are incomplete and would encourage additional collection of subsistence data and Traditional Ecological Knowledge.

  Response: This response is adequate.

- What impact might mining have on other important wildlife species in the basin (e.g., freshwater seals in Iliamna Lake)?

  RESPONSE: The scope of the assessment is focused on potential risks to salmon from large-scale mining and salmon-mediated effects to indigenous culture and wildlife. Direct effects on wildlife from large-scale mining are likely to be important and Appendix C (now a stand-alone US Fish and Wildlife report) provides useful information for a future evaluation of direct effects on wildlife from large-scale mining. We agree that this is an important area for future research.

  Response: This response is adequate.

- What is the comprehensive hydrologic regime of the specific project mining area, and the broader watershed system as characterized by baseline monitoring, spatial distribution, and quantitative flow of surface- and ground-waters?

  RESPONSE: Comprehensive spatial estimates of mean annual flow are now presented in Chapter 3. Quantification of spatial and temporal patterns of groundwater flows is an acknowledged highly desirable product, but it not feasible within the scope of this assessment. Results of an independent groundwater-surface water modeling effort are described in Chapter 7.

  Response: This response is adequate.

- What is the cumulative impact of commercial fisheries on the Bristol Bay watershed, especially in an ecosystem context as related to marine-derived nutrient and energy flow? Acknowledge that commercial fishing has had an impact on the amount of marine-derived nutrients returned to the watersheds.

  RESPONSE: The impact of commercial fisheries on the watershed is not within the scope of this assessment. Information on commercial fisheries management has been added in Box 5-2. However, the purpose of this assessment is not to assess the relative effects of potential mining and commercial fishing—it is to evaluate

potential effects on endpoints if a mine were to be developed, given existing conditions and activities in the region.

Response: This response is adequate.

Dr. David Atkins

WRITTEN PEER REVIEW COMMENTS

1. GENERAL IMPRESSIONS

The Bristol Bay Watershed Assessment (the Assessment) presents a comprehensive overview of current conditions in the watershed and establishes the uniqueness and global importance of the area to global salmon ecology (e.g., the report states that nearly 50% of the global sockeye salmon population comes from Bristol Bay and nearly 50% of the salmon in Bristol Bay come from the Nushagak and Kvichak Rivers, which encompass nearly half of the watershed area). The report also describes in detail the importance of the fishery to Native Alaska cultures, the importance and uniqueness of subsistence activities, and the scale of the commercial fishery. Furthermore, the report also outlines the reliance of the local economy on the salmon fishery.

RESPONSE: No change suggested or required.

<u>Response: None.</u>

There is no question that a mine, especially of the type and magnitude analyzed in the Assessment, could have significant impacts and that if these impacts are not or cannot be properly managed and/or mitigated, the consequences could be profound. The Assessment presents a mining scenario based on preliminary documents prepared for the Pebble Project, which sets out a conventional approach for development of a very large mine that includes open-pit and block-cave underground mining methods and conventional waste rock and tailings management. Development of the mine as proposed would eliminate streams and wetlands in the project area permanently. The importance of this impact is not put in context of the watershed as a whole, so it is not possible to determine the magnitude of the risk to salmon. The Assessment also did not consider whether there are any methods that could effectively minimize, mitigate or compensate for these impacts.

RESPONSE: A characterization of the landscape factors influencing salmon habitat potential is now included to provide context for the stream habitat impacts described in the document (Chapter 3). The assessment describes the magnitude of risks to salmon habitat. Due to lack of knowledge of limiting factors, ascribing comprehensive risks to salmon populations is not feasible in this assessment. Mitigation to compensate for effects on aquatic resources that cannot be avoided or minimized by mine design and operation would be addressed through a regulatory process that is beyond the scope of this assessment. Nevertheless, in response to public and peer review comments we have included a discussion of compensatory mitigation in Appendix J of the revised assessment.

<u>Response: This response is adequate.</u>

The Assessment also focuses on the risk of failure of the tailings storage facility, a low probability, but high impact scenario. The Assessment further describes the potential for long-term acid and metals production from waste rock and the necessity for water treatment. Under the mining scenario as described, perpetual management of the geotechnical integrity of the waste rock and tailings storage facilities and perpetual water treatment could be necessary. In addition, failure is always a possibility, albeit a possibility that is difficult to quantify with any degree of certainty as explained in the Assessment. The Assessment also does not consider alternative engineering strategies (so called 'best practice' approaches) that could lessen the risk of failure and possibly the necessity for perpetual management and water treatment. As such, the report could be considered a screening level assessment that presents the likelihood of occurrence and corresponding consequences of failures under the presented development scenario, but does not describe the magnitude of risk to salmon.

RESPONSE: With regard to the terminology of "best", "good", or other terms for the practices used, what was intended to be conveyed in the assessment is that we assumed modern mining technology and operations. Measures for minimizing and controlling sources of pollution, outside of stormwater requirements, may be referred to as best practices, state of the practice, good practice, conventional, or simply mitigation measures. We have added a text box in the revision (Chapter 4) to discuss terms. Mitigation measures considered feasible, appropriate, and 'permittable' (as per Ghaffari et al. 2011) were considered in the assessment, and these are measures common to other copper porphyry mines. Evaluation of alternative strategies (e.g., other options presented in Appendix I) is outside the scope of this assessment, but such evaluation should be part of the permitting process for a specific mining plan. The assessment describes the magnitude of risks to salmon habitat. Due to lack of knowledge of limiting factors, production, and demographics, ascribing comprehensive risks to salmon populations is not feasible for this assessment.

Response: I concur with this response. It does highlight information on alternative strategies that may come from a specific mining plan as it is assessed in the permitting process.

Question 1. ***The EPA's assessment focused on identifying the impacts of potential future large-scale mining to the fish habitat and populations in these watersheds. The assessment brought together information to characterize the ecological, geological, and cultural resources of the Nushagak and Kvichak watersheds. Did this characterization provide appropriate background information for the assessment? Was this characterization accurate? Were any significant literature, reports, or data missed that would be useful to complete this characterization, and if so what are they?***

Based on my general understanding of the watersheds, I consider the general background information presented in the Assessment accurate and sufficiently complete for the endpoints of this watershed assessment in the following areas:

- General view of Pacific salmon populations
- General view of resident (non-anadromous) fish
- Wildlife populations
- Native cultures

RESPONSE: No change suggested or required.

Response: None required.

The Assessment also describes the current economics of the watershed, including commercial and sport fishing and subsistence activities.

RESPONSE: No change suggested or required.

Response: None required.

Additionally, the report highlights several general aspects of the area that make the fishery unique in both its abundance and diversity:

- The unique hydrology of the area (strong groundwater and surface water interaction) that contributes to stable flows and temperatures favorable for salmon reproduction.
- The importance of anadromous fish in transferring marine-derived nutrients to upland areas and thus providing nutrients to areas that would naturally be nutrient poor.
- The lack of roads and infrastructure that make the area unique as one of the few intact ecosystems remaining in the world, and possibly unique for this type of fishery.

RESPONSE: No change suggested or required.

Response: None required.

It would be helpful in the background section to better describe the uniqueness of the Bristol Bay watershed ecosystem in the Pacific Northwest. This could include a description of other similar ecosystems in the region that have undergone development and documentation of any changes in fish populations associated with this development. The Assessment does mention the Fraser River as an analogue, but the scale of development in this watershed, and even the success of the salmon fishery, seems to be a point of contention, with some saying mining and fish coexist, and other saying the impacts are severe.

RESPONSE: The unique conservation value of Bristol Bay fisheries is now discussed in Chapter 5.

Response: The uniqueness of the watershed is adequately described in Chapter 5. Organizing this information in terms of endpoints also better frames the context of the assessment.

It would also be helpful to better explain fish resources in the proposed project area in comparison to other areas within the watershed. I understand some of the necessary data may not be available for the project area. It would be helpful to know, however, if the habitat in the project area is typical, exceptional, or inferior to that in other areas of the watershed.

RESPONSE: We now include figures showing reported salmon species distributions and salmon diversity by HUC-12 watershed, across the Nushagak and Kvichak River watersheds (Figure 5-3; Figures 5-4 through 5-8). It is informative to note that salmonid diversity is relatively high in the project area. Information on population sizes and vital rates are limited for the region, but are reported where known. In addition, we include summary statistics and figures of stream and valley characteristics across the assessment area (Section 3.4), and compare stream attributes in the project area to those of the larger watersheds (Section 7.2.1). These results generally illustrate that the project area contains streams of a size and gradient well within the range of suitability for salmon, as amply demonstrated by the distribution of spawning and rearing salmon within the project area streams (Figures 5-4 through 5-8).

Response: The information presented in these sections adequately addresses the concern.

Regarding geological resources, the report describes the Pebble deposit and five other mineral deposits in the Nushagak and Kvichak watersheds. It would be helpful to know if there are other mineral resources or oil and gas resources in the Bristol Bay watershed as a whole that could also be exploited. It would also be helpful to describe the portion of the watershed that is off-limits to development due to park and protected area status vs. those lands that are open to mineral development.

RESPONSE: The scope of the assessment was to evaluate the potential impacts from large-scale mining on salmon resources; thus, consideration of prospective oil or gas development in the area was outside the scope. The mineral resources identified in the assessment are those in the Bristol Bay watershed that have had some level of identification or exploration at this time. Mine claims within the Nushagak and Kvichak River watersheds are shown in Figure 13-1 and discussed in greater detail throughout Chapter 13. The assessment assumes that mining would occur on lands open to mineral development.

Protected areas within the Bristol Bay watershed and the Nushagak and Kvichak River watersheds are shown in Figures 2-3 and 2-4. We have clarified in the text that the Nushagak and Kvichak River watersheds represent the least-protected area of the Bristol Bay watershed. Other state documents exist that map out areas in the Bristol Bay watershed off-limits to development.

Response: The information presented in these sections and figures adequately addresses this concern.

Question 2. ***A formal mine plan or application is not available for the porphyry copper deposits in the Bristol Bay watershed. EPA developed a hypothetical mine scenario for its risk assessment, based largely on a plan published by Northern Dynasty Minerals. Given the type and location of copper deposits in the watershed, was this hypothetical mine scenario realistic and sufficient for the assessment? Has EPA appropriately bounded the magnitude of potential mine activities with the minimum and maximum mine sizes used in the***

scenario? Are there significant literature, reports, or data not referenced that would be useful to refine the mine scenario, and if so what are they?

The hypothetical mining scenario presented in the Assessment is based on a “Preliminary Assessment Technical Report” of the Pebble deposit prepared for Northern Dynasty Minerals by Wardrop (referred to as Ghaffari et al. 2011), in conformance with Canadian National Instrument 43-101 (NI 43-101) which is used to set standards for public disclosure of scientific and technical information about mineral projects of companies on bourses supervised by the Canadian Securities Administrators. By most accounts, the Pebble deposit is a world-class deposit and the Wardrop report counts nearly 11 billion tonnes of total resource. It is unlikely that all the ore currently identified would be mined, so 11 billion tonnes would be an upper bound for this particular deposit. It is also certain that exploiting the Pebble deposit would have to be at a scale large enough to justify the capital investment to build an infrastructure in such a remote area. Although the Assessment is ostensibly about any mining development in the Bristol Bay watershed, the use of the Wardrop scenario for Pebble effectively makes the report an assessment of mining the Pebble deposit.

RESPONSE: The purpose of the assessment is to estimate potential impacts of large-scale surface porphyry copper mining on salmon ecosystems in the Bristol Bay watershed. The preliminary plan for mining the Pebble deposit was used as the basis for the assessment because that deposit is the most likely to advance in the near term. Also, the Agency believes that mining of other porphyry copper deposits in the watershed would proceed with a similar approach, since the scenarios used are similar to what has been done at other porphyry copper deposits. Therefore, it is appropriate to use Northern Dynasty Mineral’s 2011 plan for the Pebble deposit (Ghaffari et al. 2011) as the basis for the scenarios; however, a final mining plan may differ from what is presented in Ghaffari et al. (2011). Chapter 13 of the revised assessment also considers the potential cumulative effects of additional smaller copper porphyry mines in the watershed. No change suggested or required.

Response: The response adequately addresses the concern.

The question then becomes what size mine is feasible from a technical and economic point of view. The Pebble deposit mine plan, as presented in the Wardrop report, outlines three scenarios:

- An “investment decision case” for a 25-year mine life that would mine 2 billion tonnes of ore;
- A “reference case” for a 45-year mine life that would mine 3.8 billion tonnes of ore; and
- A “resource case” for a 78-year mine life that would mine 6.5 billion tonnes of ore, or 55% of the total measured, indicated and inferred resource.

The Assessment chose minimum and maximum mine sizes of 2 billion and 6.5 billion tonnes of ore, respectively. Thus, the resource estimate used for the Assessment is the same as that for the two end members presented by Wardrop. This would make the mine one of the largest in the world, exceeding the size of the 10th percentile of global porphyry copper deposits by an order of magnitude (see Appendix H of the Assessment). Mines that ultimately become this size usually expand by increments, as exploration discovers new ore zones and expansion permits are granted.

RESPONSE: Yes, the scenarios represent large-scale mines. The purpose of the assessment is to estimate potential impacts of large-scale surface porphyry copper mining on salmon ecosystems in the Bristol Bay watershed, so large mine sizes are appropriate. It is quite likely that large mines would be created in increments, but this would not influence our assessment, as we have evaluated impacts based on volumes of material released in the event of failures or accidents and on material processed as proposed in Ghaffari et al. (2011) as reasonable for a deposit of this size, regardless of the time period for mine operation. However, we have included a third, smaller mine in our revision to represent the median-sized porphyry copper mine on a worldwide basis (250 million tons).

Response: This discussion and inclusion of the 250 million ton scenario is adequate.

The Wardrop report further delineates Pebble West as a low-grade deposit near the surface that would most efficiently be mined using open-pit methods, with Pebble East as a deeper, higher-grade deposit that would most efficiently be mined using underground methods (specifically block-caving). Mine facilities, as outlined in the Wardrop report, would include:

- Open-pit mining utilizing conventional drill, blast and truck-haul methods for near-surface deposits.
- Underground, block-cave methods for deeper deposits.
- A process plant with throughput of 200,000 tonnes/day that utilizes conventional crush-grid-float technology with secondary gold recovery.
- Other mine-site facilities, including:
    - Tailings storage.
    - Waste rock storage (the estimated waste/ore strip ratio is 2:1).
    - A natural-gas fired power plant.
    - Shop, office, and camp buildings.
    - Pipelines to ship ore concentrate slurry to the port facility; return water from the tailings slurry after separation at the port facility; and fuel.

RESPONSE: No change suggested or required.

Response: None.

This mining and ore processing approach is conventional, and the Assessment includes these elements. A mine developer may present alternative plans that could vary or alter how the mine is developed, but the fundamental components would most likely remain the same.

RESPONSE: The EPA agrees with this comment. No change suggested or required.

Response: None.

Because the Assessment is presented as a general assessment of mining risks and impacts in Bristol Bay and not a specific analysis of the Pebble Project, reliance on the scenario presented in Wardrop makes the assessment overly specific. Further, Chapter 7 provides more specific information on "Cumulative and Watershed-Scale Effects of Multiple Mines," which presents analysis of potential impacts from mining five additional deposits in various stages of development (presumably from early exploration to pre-feasibility). The information presented in Chapter 7 seems more like another mining scenario than a cumulative impacts assessment. Therefore, I would suggest a broader range of potential mining scenarios be organized as follows, with the detail of assessment necessarily becoming more speculative with each subsequent scenario in the list (due to the lack of geologic and engineering information on the other deposits):

- Development of one, average-sized porphyry copper deposit (50th percentile or 250 million tonnes of ore as described in Appendix H) in the location of the Pebble deposit.
- Development of a mega-mine in the location of the Pebble deposit (of the range between 2 and 6.5 billion tons of ore) that may develop after multiple expansion and permitting cycles.
- Development of a mining district consisting of an average-sized Pebble mine and other potential mines (i.e., those presented in Chapter 7).
- Maximum development of all identified potential resources to their most likely ultimate extent.

Considering this broader range of scenarios would help the reader to better understand the range of potential risks and impacts.

RESPONSE: The Pebble deposit is located in the watershed of interest, the deposit is similar to other copper porphyry deposits in the world, and components of the scenarios are common and anticipated for any such deposit of this type; thus, we feel that use of the Pebble deposit characteristics and location is appropriate. The revised assessment includes an additional mine size scenario (Pebble 0.25), representing the worldwide median size porphyry copper mine (Singer et al. 2008). The revised assessment expands the cumulative impacts discussion (Chapter 13) further by including transportation corridors and secondary impacts.

<u>Response: This discussion adequately addresses the concern.</u>

Question 3. ***EPA assumed two potential modes for mining operations: a no-failure mode of operation and a mode involving one or more types of failures. Is the no-failure mode of operation adequately described? Are engineering and mitigation practices sufficiently detailed, reasonable, and consistent? Are significant literature, reports, or data not referenced that would be useful to refine these scenarios, and if so what are they?***

The no-failure scenario attempts to quantify the impacts from developing the footprint of the project alone. In reality, various failures and accidents inevitably occur, and they may have a range of impacts from inconsequential to large. So this scenario is presented to describe the minimum impact that could be expected from project development assuming everything works as planned.

RESPONSE: This comment is a correct interpretation of our "no-failure" scenario. Because this distinction was not clear to many other readers, the revision no longer uses the term "no failure". The no-failure scenario from the draft assessment has been changed to a chapter on the effects of the footprint of a mining operation, without regard for operational problems (Chapter 7).

Response: I concur with the modification to describing 'footprint' impacts.

The mine will, by necessity, remove those streams and wetlands that are beneath the pit, waste rock, tailings and processing plant development areas. There should be some flexibility in siting facilities other than the pit or underground workings. For the 'no-failure' scenario, the Assessment presents lengths of stream and areas of wetlands that would be lost due to physical displacement of the aquatic resources from mine development and reduction in flows from mine water management. The assessment presents the following resources that would be lost and that have been shown to be spawning or rearing habitat for coho, Chinook, and sockeye salmon, or have resident populations of rainbow trout and Dolly Varden:

	25-year scenario	78-year scenario
Eliminated or blocked streams (km)	87.5	141.4
Reduced flow (>20%; km)	2	10
Eliminated wetlands (km^2)	10.2	17.3

Given the range of uncertainty with the proposed mine plan, presenting stream lengths and wetland areas to the tenth place implies unrealistic accuracy. Significant figures should be checked and consistent throughout the document, and ranges should be presented if known (e.g., results for the pits could be presented with more accuracy since we know where they will be, whereas other facilities that could be located in different areas should be presented with an appropriate range of uncertainty).

RESPONSE: The authors have carefully addressed this issue. Numbers from the literature or from the PLP EBD retain the number of significant figures in the original. Numbers derived for this assessment have the appropriate number of significant figures given the precision of the input data and uncertainties due to modeling and extrapolation.

Response: The discussion and modification adequately address the concern.

The impacts as presented appear substantial, mainly because of the very large nature of the project. However, it would be helpful to describe the significance of this loss, specifically with regard to the following questions:

- What impact would the loss to streams and wetlands have on the fishery within the Nushagak and Kvichak basins?

RESPONSE: Impacts of habitat loss and alteration are very difficult to quantify given the lack of information on limiting factors, production and capacity estimates. We were unable to comprehensively evaluate impacts at the population level, except for the most severe cases where total losses of runs could be reasonably assumed.

Response: This remains a significant gap in the assessment that will require further data collection and interpretation.

- Is this loss significant in comparison to the fishery as a whole?

RESPONSE: Losses of streams and wetlands under the mine footprint could not be related to the fishery due to reasons listed above. For the TSF failure scenario that completely eliminates or blocks access to suitable habitat in the North Fork Koktuli River, we estimate that the entire Koktuli portion of the run (~28% of Nushagak escapement) could be lost. Higher proportional losses would occur if significant downstream effects occurred due to transport of toxic tailings fines beyond the Koktuli as modeled under the Pebble 2.0 TSF failure.

Response: Same as above.

- Are there local communities that could be affected by this specific loss?

RESPONSE: Wildlife and resident fish communities would be affected by reductions in spawning salmon. Local communities would also be affected by the reduction, which is now discussed in Chapters 12 and 13 (e.g., Chapter 13 now contains tables which refer to specific subsistence resources used by individual communities).

Response: This discussion is adequate.

- Is fragmentation of the resource from this loss a significant impact (i.e., are there stocks that are unique to the project area)?

RESPONSE: Stock structure and genetic diversity are not well known at the project scale, but based on evidence from other parts of Bristol Bay watersheds, local adaptation is highly likely. Discussion of fragmentation effects is now included in Chapters 7 and 10.

Response: This discussion is adequate.

There is no discussion of engineering and mitigation practices in this section. The responsible regulatory authority would require the project proponent to present a mitigation plan to compensate for these impacts before permitting. Measures would include minimization of impact through facility siting, reclamation if possible, and compensation if reclamation were not feasible. A thorough analysis of possible mitigation approaches and the likelihood of their success are necessary to fully evaluate impacts from the ‘no-failure’ scenario.

RESPONSE: Mitigation measures for design and operation are more clearly called out in the revised assessment. While measures chosen here may differ from what is

required during the regulatory process, the assessment is not a mining plan and not an evaluation of a mining plan. The assessment assumes that measures chosen for the scenarios would be as effective as possible and examines only accidental failures rather than a failure to choose a proper mitigation measure. Mitigation to compensate for effects on aquatic resources that cannot be avoided or minimized by mine design and operation would be addressed through a regulatory process that is beyond the scope of this assessment. Nevertheless, in response to public and peer comments we have included a discussion of compensatory mitigation in Appendix J of the revised assessment.

Response: This response highlights the fact that the assessment is not an evaluation of a mining plan, but rather more general. As such, the new material is acceptable and the revisions are appropriate for the intention of the document.

Question 4. ***Are the potential risks to salmonid fish due to habitat loss and modification and changes in hydrology and water quality appropriately characterized and described for the no-failure mode of operation? Does the assessment appropriately describe the scale and extent of risks to salmonid fish due to operation of a transportation corridor under the no-failure mode of operation?***

For the no-failure mode of mine operation, the risks to salmonid fish due to habitat loss and modification in the vicinity of the project are described in terms of loss of lengths of stream or areas of wetlands. Project proponents state that the mine will only impact a very small fraction of the watershed (under a no-failure scenario). It is important to establish whether the modeled impact (e.g., the loss of 87.5 km of streams) is significant, both in terms of the absolute impact, as well as the effect on ecosystem fragmentation.

RESPONSE: Footprint effects on habitat loss are now characterized in relation to the distribution of habitat conditions throughout the larger watersheds. Fragmentation effects are not anticipated at the mine site, apart from blockage of headwater streams as described, but are anticipated in the case of the transportation corridor (Chapter 10) and TSF failure (Chapter 9).

Response: This response is adequate.

In addition, project proponents often state they will preserve and even improve the fishery. As mentioned in the answer to the previous question, it would be helpful to know what kinds of mitigation efforts could be employed – minimization, reclamation and compensation – and have some assessment of the potential effectiveness.

RESPONSE: Mitigation measures, including wastewater treatment and closure and post-closure monitoring and maintenance, were included in discussion of the mine scenarios in the draft assessment, and this discussion has been expanded in the revised assessment. The mitigation measures proposed within the mine scenarios are those that could reasonably be expected to be proposed for a real mine (they are a subset of options presented in Appendix I), all of which were presented as appropriate for the Pebble deposit in Ghaffari et al. (2011). Reclamation is not mitigation, but the revised

assessment includes also some suggested measures to be used in closure/post-closure to reclaim the disturbed areas. Mitigation to compensate for effects on aquatic resources that cannot be avoided or minimized by mine design and operation would be addressed through a regulatory process that is beyond the scope of this assessment. Nevertheless, in response to public and peer comments we have included a discussion of compensatory mitigation in Appendix J of the revised assessment.

Response: This response is appropriate and highlights the strengths of the regulatory process that would assess compensation for effects that cannot be avoided or minimized. The expanded discussion of mitigation is appropriate for the context of the assessment. It does not address whether mitigation could improve the fishery.

The Assessment determines that construction of the transportation corridor could alter the habitat, chemistry, and the migration path across the corridor for the over 30 streams that the corridor will cross or come near. The report further states that the corridor could affect 270 km of streams below the corridor and 240 km of streams above, but that there is no way to assess the magnitude. Therefore, the impacts of the corridor on fish populations are unknown, and this impact is not described in a way that can allow a reviewer to draw any conclusion.

RESPONSE: The revised assessment states that "the exact magnitudes of changes in fish productivity, abundance and diversity cannot be estimated at this time," but summarizes the species, abundances, and distributions that would potentially be affected. Also, the assessment concludes that, assuming typical maintenance practices after mine operations, approximately 15 of 32 culverted streams with restricted upstream habitat would be entirely or in part blocked at any time. "As a result, salmonid passage—and ultimately production—would be reduced in these streams, and they would likely not be able to support long-term populations of resident species such as rainbow trout or Dolly Varden."

Response: This response is appropriate. I am not an expert in culvert design and maintenance, so have no basis to evaluate the appropriateness of the estimate of the number of culverts that could be blocked at any time after mine operations cease.

Further, the references for road design and construction practices seem to be more representative of forest and rangeland roads than the type of road that would likely be constructed for this type of project. It would be helpful to cite experience from other transportation corridors constructed for mining and oil and gas projects and developed recently in Alaska.

RESPONSE: Because the proposed mining would take place in an undeveloped area, the literature is necessarily from areas outside of Bristol Bay. Further, we found no data concerning the performance of culverts for mining or oil and gas projects in the region. However, to the extent possible we used examples from representative environments. The failure frequencies cited in the assessment are not restricted to forest roads. One of the papers used for general information (Furniss et al. 1991) focuses on forest and rangeland roads, but it is a seminal publication on the potential effects of roads, particularly as they relate to salmon. The general conclusions of that

paper should be applicable to the transportation corridor considered in the assessment. Information on current design standards is now included within throughout Chapter 10, and relies on recent literature.

Response: The revised section is appropriate for the scope of the assessment. Other designs may be implemented that could result in more favorable performance, but the specific designs would have to be reviewed in detail and appropriate existing analogs would have to be selected for performance evaluation.

Question 5. ***Do the failures outlined in the assessment reasonably represent potential system failures that could occur at a mine of the type and size outlined in the mine scenario? Is there a significant type of failure that is not described? Are the probabilities and risks of failures estimated appropriately? Is appropriate information from existing mines used to identify and estimate types and specific failure risks? If not, which existing mines might be relevant for estimating potential mining activities in the Bristol Bay watershed?***

The Assessment focuses on some low probability, high impact failures (e.g., TSF failure), and presents summaries of failures at existing mines. The majority of the focus is on catastrophic failures, such as TSF, pipeline, water collection and treatment, and road and culvert. Anecdotal information regarding mine failures is numerous, but often not well documented, so it is difficult to get information on the details of failures of other projects. It is also difficult to extrapolate the probability of failure from one site to the next, and the report stresses the wide range of uncertainty, depending on design and environment. Without a more detailed understanding of the mine plan and associated engineering, as well as additional detailed analysis, it is difficult to determine if the failure probability estimates presented in the Assessment are reasonable.

RESPONSE: The authors concur with the commenter that it can be "difficult to get information on the details of failures of other projects". The statistics for historic tailings dam failures are derived from the largest available database and include many tens of thousands of dam-years. The pipeline failure data cover millions of kilometer-years of pipeline experience. The data on failures of water collection and treatment systems and of culverts are less extensive. We also recognize that even with detailed engineering and design information, the prediction of failure probabilities is extremely difficult. Finally, since all of these low-probability failures are statistical phenomena, the actual experience at any one site could be vastly different than another similar site, even when the failure probabilities have the same distribution.

Response: This response is adequate.

The focus on catastrophic failures also takes attention away from what is probably a more likely scenario. Every project is subject to accidents and smaller, non-catastrophic failures that have varying degrees of consequence. Sometimes these failures are easily identified and fixed and other times they can go un-noticed for periods of time.

RESPONSE: Because the number of potential failures is extremely large, it is necessary to choose a representative set of failure scenarios. The revised assessment includes more failure scenarios (e.g., diesel pipeline failure, quantitative wastewater treatment plant failure, truck accidents and spills, and refined leachate seepage scenarios) and explains why these particular failure scenarios were chosen.

Response: This response is adequate.

It would be helpful to describe some smaller-scale failures that have occurred at mine sites. A partial list includes: accidents and spills along the transportation corridor or within the mine site; unanticipated seepage of contaminated water that may be difficult to detect, collect and treat; movement of water along preferential flow pathways that are difficult to characterize; temporary failure of water collection and treatment systems; mistakes in engineering analysis that underestimate the volume of water that must be collected and treated or overestimate the volume of water available for use; and designing based on incomplete data and understanding of climate conditions.

RESPONSE: There is a wide variety of failures that could occur, including those provided by the commenter. Because the number of potential failures is extremely large, it is necessary to choose a representative set of failure scenarios. The revised assessment includes more failure scenarios (e.g., diesel pipeline failure, quantitative wastewater treatment plant failure, truck accidents and spills, and refined seepage scenarios) and explains why these particular failure scenarios were chosen.

Response: This response is adequate.

Question 6. ***Does the assessment appropriately characterize risks to salmonid fish due to a potential failure of water and leachate collection and treatment from the mine site? If not, what suggestions do you have for improving this part of the assessment? Are significant literature, reports, or data not referenced that would be useful to characterize these risks, and if so what are they?***

Water treatment failures of varying scale occur at virtually every site that treats water, and mine sites are no exception. The risk of failure of water treatment described in the assessment is useful as background, but as the report states, the risk is highly uncertain. A non-catastrophic water treatment system failure is fairly likely to occur at some point during the mine life, and, hence, requires a detailed assessment. The treatment in the Assessment is cursory (less than one page). This type of failure is much more likely than a TSF failure (which receives more than 20 pages of analysis), and therefore requires a much more thorough treatment given the probability of occurrence and likelihood of impact to salmon species.

RESPONSE: The wastewater treatment failure scenario has been expanded and is now detailed and quantified in Chapter 8 of the revised assessment. Additionally, the non-catastrophic failures of seepage collection from the TSF and waste rock piles also have been included as scenarios with new and refined analyses.

Response: This response is adequate.

The background water chemistry indicates mineral concentrations are very low. Therefore, water treatment will be challenging if background conditions are to be met. Treatment will be especially challenging given the sensitivity of the species of concern to concentrations of copper, for instance, as well as the sensitivity to temperature that may be difficult to match in a water treatment system.

RESPONSE: A mine would not necessarily have to match the low background concentrations, but would at minimum be held to the water quality standards that protect the existing and designated uses of the waterbodies where a discharge might occur. In the Bristol Bay area, all waterbodies are protected for all uses and permit limitations would be derived to be protective of the most stringent applicable Alaska Water Quality Standards (WQS). In addition, we believe that compliance with the more recent Federal Water Quality Criterion for copper would be necessary to protect aquatic life.

Response: This response is adequate.

During mine operation, a lapse in treatment would likely be identified and addressed quickly. This type of treatment failure is ephemeral and would likely have a short-term impact on the fishery, depending on the time of year of occurrence. It is likely that any impacts to the fishery could recover in subsequent years after the problem is fixed. The site will require water treatment long after closure, possibly in perpetuity. This period is more problematic, as a water treatment failure could go unnoticed for some time or the resources may not be available to correct it quickly, depending on how long after closure the failure occurs and the stewardship of the treatment system.

RESPONSE: A failure during operation would be corrected quickly only if it did not require extensive repairs or the manufacture and import of replacement equipment. The EPA agrees that water collection and treatment failures after mine closure would be less likely to be corrected in a timely manner. In addition, events after closure, such as filling of the pit, would affect water quantities and qualities in ways that would affect treatment success. A discussion of this issue has been added to Chapter 8 of the revised assessment. A discussion of financial assurance has been added in Box 4-3.

Response: This response is adequate.

Question 7. ***Does the assessment appropriately characterize risks to salmonid fish due to culvert failures along the transportation corridor? If not, what suggestions do you have for improving this part of the assessment? Are significant literature, reports, or data not referenced that would be useful to characterize these risks, and if so what are they?***

The description of culvert failure is necessarily general because there are currently no designs. The general data on culvert failures presented for the types of culverts described in the references cited (principally for forest and range land) indicate a high probability of failure (30-66% failure rate). It is probable, however, that the transportation corridor for the project would be constructed to a higher standard than most of the roads included in these papers. It would be helpful to know if similar data are available for highly engineered roads of the type likely to be built for the project.

RESPONSE: The assessment assumes modern mining technology and operations. We did not find information explicitly from highly engineered roads, but to the extent possible we used recent literature from representative environments. The failure frequencies cited in the revised assessment are from modern roads and are not restricted to forest or rangeland roads. Information on current design standards is now included in text boxes throughout Chapter 10

Response: This response is adequate.

Question 8. ***Does the assessment appropriately characterize risks to salmonid fish due to pipeline failures? If not, what suggestions do you have for improving this part of the assessment? Are significant literature, reports, or data not referenced that would be useful to characterize these risks, and if so what are they?***

The discussion of pipeline failures is based on published failure rates, principally for oil and gas pipelines. This analysis results in a pipeline failure rate of one per 1,000 km per annum. This is a pretty generic number that does not consider actual pipeline design. Rather it indicates that pipelines designed using standard practices do fail with a fairly high frequency. The Assessment does not apply this failure rate to the gas and diesel pipelines because "they are not particularly associated with mining." Without the mine, there would be no pipeline. So given that this rate of failure is quantifiable based on good data and that the pipeline would be built to serve the project, this risk should be considered.

RESPONSE: The assessment assumes that pipeline design follows standard ASME practices. A diesel pipeline failure and resultant spill into two creeks has been added in Chapter 11 in the revised assessment. A gas leak is considered but is not analyzed because of the lack of significant causal linkage to fish production.

Response: This response is adequate.

A concentrate pipeline spill would have differing impacts depending on when and where the spill occurred, with deposition in Lake Iliamna likely being the worst outcome. As noted in the report, it is likely that a pipeline spill would be detected rapidly and that the volume of the spill would be limited and amenable to remediation. A better description of how concentrate pipeline failures have occurred would be helpful to better understand the risk for this project (e.g., the July 2012 Antamina concentrate pipeline failure, although this pipeline would operate under a much different pressure regime due to extreme altitude change).

RESPONSE: Consolidated, statistically representative data on concentrate pipeline failures are not readily available, although anecdotal evidence from some case studies can be found. The pipeline failure statistics reviewed for the assessment come primarily from oil and gas pipelines, but also include some water and hazardous liquid pipelines. The performance of mining concentrate pipelines is not expected to be better than the performance of oil pipelines, because concentrate pipelines would be expected to be more susceptible to internal corrosion and abrasion. The 2012 Antamina concentrate pipeline failure in Peru was reportedly caused by the rupture of a pipe elbow in a valve station. The regulatory, geographic, and operating conditions of the Antamina pipeline may differ greatly from those of the concentrate pipeline in the assessment scenarios. A discussion of causes and probabilities of pipeline failures is included in Section 11.1 of the revised assessment. The revised assessment also includes discussions of concentrate spills at the Bingham Canyon, Utah, and Alumbrera, Argentina, copper mines (Section 11.3.4.2).

Response: This response is adequate.

Question 9. ***Does the assessment appropriately characterize risks to salmonid fish due to a potential tailings dam failure? If not, what suggestions do you have for improving this part of the assessment? Are significant literature, reports, or data not referenced that would be useful to characterize these risks, and if so what are they?***

The Assessment generically describes tailings dam failures and the potential impact in detail. It also uses some site-specific information on tailings supernatant and humidity cell leachate. There is no question that a tailings dam failure would be catastrophic for the fishery and the project, and although low probability, is the single largest risk to the fishery. A tailings dam failure could harm a very large area of the watershed for a very long period of time and could require a massive and expensive remediation effort.

RESPONSE: Agreed. No change suggested or required.

The tailings deposition and storage methods outlined in the Wardrop NI 43-101 report and presented in the Assessment are conventional for the industry and comply with Alaska State regulations. Because of the dire consequences of a failure in this highly sensitive and unique environment, it would be necessary to employ state of the art methods for tailings management and go ‘beyond compliance’ when designing and constructing this facility. This may include employing methods that are novel, incur significant additional cost for construction, and lead to a more stable and lower maintenance facility in the long term, such as dry stack or paste rock tailings (blending waste rock in with tailings in the impoundment to provide extra geotechnical stability). These methods, however, are not common practice and in some instances are still under development.

RESPONSE: The assessment addresses state of practice methods to identify potential risks that could result from such practices. The EPA agrees that there is a possibility that a mining proponent could design and propose practices that go beyond the state of practice in order to reduce potential risks.

Response: This response is adequate.

Question 10. ***Does the assessment appropriately characterize risks to wildlife and human cultures due to risks to fish? If not, what suggestions do you have for improving this part of the assessment? Are significant literature, reports, or data not referenced that would be useful to characterize these risks, and if so what are they?***

The assessment does a good job analyzing the importance of fish resources to other wildlife and to Alaska Native communities. The lack of site-specific information in the report results in only very general conclusions that there 'would be some effect.' Of course, wildlife in the project area and any traditional use of these lands would be affected by project construction under the no-failure scenario. However, due to the lack of information, it is unclear if this is an area rich in other wildlife or if there are traditional native land users that rely on the area. Although the conclusion of this section is necessarily general, it would be helpful to have more detailed characterization of wildlife and native use in the project area.

RESPONSE: More information about subsistence harvest use in the area of the mine scenarios and other areas of the watershed that may be affected by mining activities has been added to the report. Because the scope of the assessment includes potential effects to Alaska Native communities related to salmonids, this has been the focus of the evaluation of potential effects on indigenous cultures. However, EPA recognizes that there are potential effects due to loss of subsistence harvest areas for other species, as well as potential effects on non-Alaska Natives who practice a subsistence way of life. This is clarified in the revised assessment (particularly in Chapters 12 and 13).

As the commenter notes, there is limited information about the use of specific mining claim areas by wildlife. The Pebble Limited Partnership Environmental Baseline Data Report includes data on the presence/absence of wildlife species around the Pebble claim, but we are not aware of any data on abundance of wildlife, so a more detailed characterization of a specific mine claim area may not be possible. There is some information about subsistence use of the mining claim areas which has been published by Alaska Department of Fish and Game. General areas of wildlife harvests have been added as a figure to the revised assessment.

Response: This response is adequate.

Under the failure scenario, a tailings dam failure, in particular, would be catastrophic for wildlife and Alaska Native communities that use the area.

RESPONSE: A new Figure 5-2 illustrates that subsistence use of fish is extensive in areas downstream of the TSF in the Mulchatna and Nushagak Rivers, and this fact is now referenced. Effects of a TSF failure on wildlife are now discussed in Section 12.1.

Response: This response is adequate.

Question 11. ***Does the assessment appropriately describe the potential for cumulative risks from multiple mines? If not, what suggestions do you have for improving this part of the assessment?***

According to the Assessment, cumulative risks result from the potential development of at least five additional prospects: Humble, Big Chunk, Groundhog, Sill, and 38 Zone. Exploiting these prospects would amount to development of a mining district (see discussion for Question 2 in regards to appropriateness of the mining scenario).

RESPONSE: No change suggested or required.

The Assessment quantifies the loss of stream lengths and wetland areas that potentially support salmon and resident fish from the development of these projects under a 'no-failure' scenario. The assessment is highly speculative given that mine development plans are not available for these prospects.

RESPONSE: Cumulative impacts assessments evaluate past, present and reasonably foreseeable future actions that are temporally and spatially linked to the project under consideration. The potential mines in the revised assessment are reasonably foreseeable based on State of Alaska planning documents and industry exploration activities. We have expanded the discussion of cumulative impacts in Chapter 13.

Response: This response is adequate.

As with the Pebble scenario, it would be helpful to put this loss of resource in perspective in terms of the fish resources as a whole. It would also be helpful to describe any mitigation measures that are feasible to offset the impact of loss of streams and wetlands. Furthermore, it would be helpful to better understand the role these developments could have in further fragmenting salmon populations.

RESPONSE: Due to lack of comprehensive estimates of limiting factors across the impacted watersheds, population level effects could not be quantitatively estimated except for the most severe cases where total losses of runs could be reasonably assumed. Our ability to estimate population level effects was limited to situations that were assumed to completely eliminate habitat productivity and capacity in an entire watershed for which estimates of escapement could be inferred. For this assessment, these conditions are only met in the TSF failure scenario that completely eliminates and blocks access to suitable habitat in the North Fork Koktuli River. In that case, we estimate that the entire Koktuli portion of the run (~28% of Nushagak escapement) could be lost. Higher proportional losses would occur if significant downstream effects occurred due to transport of toxic tailings fines beyond the Koktuli as modeled under the full TSF failure.

Compensatory mitigation is governed by a regulatory process outside the scope of this assessment but will be an important part of any permitting process. Nevertheless, in response to public and peer comments we have included a discussion of compensatory mitigation in Appendix J of the revised assessment.

We have expanded the cumulative effects discussion (Chapter 13) to give a broader description of streams, wetlands and fish at risk and have incorporated a discussion of the possible effects on biological complexity and fragmenting salmon populations.

<u>Response: This response is adequate and points out the additional analyses that would be required during the permitting process.</u>

The following potential subsidiary impacts from development of a mining district of this scale should also be described in more detail or at least mentioned:

- The extensive road network required to support mines in the area and the attendant development associated with this network.
- The camps associated with the project, in migration of workers to the project areas, and the demand for resources to be imported from outside the area.
- Invasive species that may follow this scale of development.

RESPONSE: The discussion about the cumulative effects of roads (including invasive species), secondary development, and mining camps has been expanded in Chapter 13.

<u>Response: This response is adequate.</u>

Question 12*. Are there reasonable mitigation measures that would reduce or minimize the mining risks and impacts beyond those already described in the assessment? What are those measures and how should they be integrated into the assessment? Realizing that there are practical issues associated with implementation, what is the likelihood of success of those measures?*

The Assessment describes what is considered to be conventional 'good' mining practice, but does not adequately describe and assess mitigation measures that could be required by the permitting and regulatory process. A thorough analysis of possible mitigation measures as employed for other mining projects and the likelihood that they could be successful in this environment would be necessary.

RESPONSE: With regard to the terminology of "best", "good", or other terms for the practices used, what was intended to be conveyed in the assessment is that we assumed modern mining technology and operations. The terms are qualitative when generally interpreted, or have a regulatory meaning. The term "best management practices" is a term generally applied to specific measures for managing non-point source runoff from stormwater (40 CFR Part 130.2(m)). Measures for minimizing and controlling sources of pollution in other situations are referred to as best practices, state of the practice, good practice, conventional, or simply mitigation measures. We have added a text box in the revision Chapter 4 to discuss terms. Mitigation measures considered

feasible, appropriate, and 'permittable' (as per Ghaffari et al. 2011), were considered in the assessment, and these are measures common to other copper porphyry mines. Evaluation of alternative strategies (e.g., other options presented in Appendix I for the mitigation of the same issue) should be part of the permitting process for a specific mining plan. The State of Alaska does have statutory and/or regulatory requirements for an approved Plan of Operations (11 AAC 86.800), a Reclamation Plan (Alaska Statute (AS) 27.19.30) and appropriate Financial Assurance (AS 27.19.040) and the revised Chapter 4 notes these requirements.

Response: This response is adequate.

It is highly likely that for mines located in the Bristol Bay watershed, conventional engineering practices would not be sufficient. Therefore, it is important to consider mitigation on numerous fronts when determining the viability of the project. A section on innovative and state-of-the-art approaches for both mitigation and construction of mine facilities would be helpful to better understand if risks can be minimized or eliminated given sufficient funds.

RESPONSE: The EPA agrees generally that conventional engineering practices may not be sufficient, but it may not be appropriate to test innovative approaches in a watershed such as the Bristol Bay watershed. The EPA is not aware of innovative mitigation measures that have sufficient history to be applicable to this location.

Response: This area requires more research and would benefit from a survey of current industry practice.

Under the no-failure scenario, the footprint of the mine (open pit, block-cave subsidence zone, waste rock and tailings areas) will by necessity destroy habitat. There may be ways to create equivalent habitat to compensate for lost habitat in areas within the watershed that are currently not productive for fish. This form of mitigation may work for resident fish, but it is unclear if it would work for anadromous fish that return to very specific locations to spawn.

RESPONSE: Mitigation to compensate for effects on aquatic resources that cannot be avoided or minimized by mine design and operation would be addressed through a regulatory process that is beyond the scope of this assessment. Nevertheless, in response to public and peer comments we have included a discussion of compensatory mitigation in Appendix J of the revised assessment. Appendix J includes a discussion of the challenges of creating equivalent habitat for anadromous and resident fish and why this would be particularly challenging in the context of the Bristol Bay watershed.

Response: This response is adequate.

It is also becoming common practice to offset impacts from project development with preservation of equivalent habitat areas that are also at risk from development (http://bbop.forest-trends.org/). It is unclear if this is a feasible consideration for this project as this could involve allowing one development (e.g., Pebble), while potentially taking away the development rights of others (presumably for proper compensation).

Dr. David Atkins

RESPONSE: See response to above comment. The potential efficacy of using habitat preservation as a form of compensatory mitigation for impacts in the Bristol Bay watershed is discussed in Appendix J.

Response: This response is adequate.

Question 13. ***Does the assessment identify and evaluate the uncertainties associated with the identified risks?***

The Assessment states: the 'range of failures is wide, and the probability of occurrence of any of them cannot be estimated from available data.' Uncertainty is addressed throughout the report, typically with a qualitative discussion. There is a high degree of uncertainty with respect to how the mine would be developed, operated and closed, as well as how any impacts would be mitigated. This large uncertainty makes assessing risk difficult.

RESPONSE: No change suggested or required.

Response: None.

Question 14. ***Are there any other comments concerning the assessment, which have not yet been addressed by the charge questions, which panel members would like to provide?***

Long-term risks from development of an open pit have not been characterized. It is difficult to predict the chemistry of the lake that will form in the open pit, but there is some potential that water quality will be poor, which may be exacerbated by pit backfilling with waste rock. The pit lake could impact waterfowl and may have some impact on groundwater if there is outflow when the lake reaches an equilibrium level.

RESPONSE: The potential pit was not assessed because it is not anticipated that salmon or other fish (the primary assessment endpoint) would reach it. Therefore, it is out of scope. However, a pit lake as a potential source of water to streams is briefly considered in the revised Chapter 8. The scenarios no longer include the placement of acid generating waste rock in the pit at closure

Response: This response is adequate.

3. SPECIFIC OBSERVATIONS

[NOTE: in the page notations below, S = Section, P = Paragraph, L = line]

1. Global: All significant figures should be reviewed to make sure they are reflective of the level of uncertainty (i.e., using an estimate of 141.4 km of streams eliminated when this value is probably realistically +/- 50%).

RESPONSE: All significant figures in calculations and measurements made by EPA have been reviewed and changed to reflect the uncertainty of the analysis. For example km of stream is reported to the km. Significant figures from cited documents are as reported in the document.

<u>Response: This response is adequate.</u>

2. Global: Many references cited in the text are not included in the reference list.

   RESPONSE: References have been updated.

   <u>Response: This response is adequate.</u>

3. Global: The executive summary, main report, and appendices, in many instances, present different information with sometimes different implications. These three levels of detail of information should be more cohesive.

   RESPONSE: We have re-written the executive summary and main report to make them more consistent with each other and the appendices.

   <u>Response: This response is adequate.</u>

4. Page ES-24 (P2): Suggest changing 'Cumulative Risks' to 'Cumulative Effects of Multiple Mine Development.'

   RESPONSE: The title of the chapter (now Chapter 13 was changed.

   <u>Response: This response is adequate.</u>

5. Page 3-2 (P1): The justification for excluding ancillary development from the assessment should be better explained. In some instances, opening up an area for natural resource development has had as much or more impact on the environment and ecosystems as the development itself (for example, oil and gas development in some areas of the Amazon Basin)

   RESPONSE: Discussion of ancillary mining infrastructure (in addition to the pit, TSFs, waste rock piles, roads and pipelines) has been added to Box 6-1, and discussion of induced development (development which follows initial development in an unimproved setting) has been added to Chapter 13.

   <u>Response: This response is adequate.</u>

6. Page 3-7 to 3-11: The conceptual models are quite helpful, but are not referenced or utilized sufficiently when discussing impacts. It would be helpful to more fully incorporate them into the assessment.

   RESPONSE: Sub-components of the conceptual models have been included at the outset of the risk analysis chapters, to better frame the pathways evaluated in each chapter.

<u>Response: This response is adequate.</u>

7. Page 4-1 (P1, L9): Why does the assessment describe current ‘good’ and not ‘best’ practice? The rationale for this decision needs to be described. In addition, it is likely that anything other than ‘best’ practice would not be permitted in this context.

   RESPONSE: With regard to the terminology of “best”, “good”, or other terms for the practices used, what was intended to be conveyed in the assessment is that we assumed modern mining technology and operations. The terms are qualitative when generally interpreted, or have a regulatory meaning. The term “best management practices” is a term generally applied to specific measures for managing non-point source runoff from storm water (40 CFR Part 130.2(m)). Measures for minimizing and controlling sources of pollution in other situations are referred to as best practices, state of the practice, good practice, conventional, or simply mitigation measures. We have added a text box in the revision Chapter 4 to discuss terms. Mitigation measures considered feasible, appropriate, and ‘permittable’ (as per Ghaffari et al. 2011) were considered in the assessment, and these are measures common to other copper porphyry mines.

   <u>Response: This response is adequate.</u>

8. Page 4-11 (P3, L10): The liner lifetime is quite low, and given the importance of this assumption, would warrant more than a personal communication that does not appear in the references (North pers. comm.).

   RESPONSE: The discussion of liners has been expanded and moved to Chapter 4 (Section 4.2.3.4) in the revision. The personal communication reference has been removed.

   <u>Response: This response is adequate.</u>

9. Page 4-21 (P1, L4): Is the assumption about the TSF locations from the authors or from the Wardrop 43-101 report?

   RESPONSE: The location of the TSFs is a combination of alternative sites described in Ghaffari et al. 2011 (the Wardrop report), in the NDM 2006 Water Rights Application (see reference list for Chapter 6), and our knowledge of site characteristics suitable for tailings impoundments.

   <u>Response: This response is adequate.</u>

10. Page 4-26 (S4.3.7-Water Management): It would help to provide appropriate ranges for numbers (e.g., the precipitation at the mine and TDF is 803 and 804 mm/yr, respectively, which implies an unrealistic degree of certainty). It would also be helpful to include a diagram. I am uncertain why ‘cooling tower’ water losses would be included in the mine water balance since power generation would likely be at a remote location and other impacts from power generation are not considered in this

assessment.

RESPONSE: In general, we have presented our best estimates for the parameter values discussed in the assessment and have used these estimates in our analyses and calculations. A full uncertainty analysis is beyond the scope of this assessment, so we have provided ranges only for critical parameters such as the mine size. We followed the Ghaffari et al. (2011) mine plan in placing power generation on the site, which is the reason for the natural gas pipeline. Therefore, water use for cooling is appropriate.

Net precipitation at the mine site has been recalculated. The monthly mean flows for each gage were summed across the year, producing an area-weighted average of 860 mm/yr. Ghaffari et al. (2011) describe the construction of a combined-cycle natural gas-fired gas turbine power plant at the mine site and estimate the cooling tower evaporative and drift losses from the plant. The cooling tower losses were included because they would constitute a substantial consumptive water use.

Response: This response is adequate.

11. Page 4-31 (P3, L6): How was the filling time of 100 to 300 years for the pit estimated? What constitutes full (e.g., within x% of the pre-mining water table)?

    RESPONSE: The filling time was calculated from the estimated inflow rate to the empty pit. Most of the groundwater infiltration would come from the uppermost 100 m and the direct precipitation rate would be constant, so the filling rate would not decrease significantly until the water level was close to the surface compared to the pit depths. We recognize that as the water level approached the surface, the cone of depression would shrink and the filling rate would decrease. We have not attempted to refine our analysis to account for this decrease in rate and the available data do not merit such a refinement.

    The filling time was simply calculated by dividing the pit volume by the inflow rate. In practice, when the pit was full the pit level would be maintained below the overflow level by pumping if treatment were required or be allowed to establish a natural outlet at its low point if treatment was not necessary.

    Response: This response is adequate.

12. Page 4-52: The PMP is based on the Miller (1963) reference (not included in the reference list). How was it estimated?

    RESPONSE: The PMP was based on Technical Paper No. 47 (http://www.nws.noaa.gov/oh/hdsc/PMP_documents/TP47.pdf). This PMP was used as the precipitation input to a Type-1 (for Alaska) HEC-HMS simulation to calculate a runoff hydrograph. 291 cms was determined to be the peak discharge from this 24-hour design storm.

    Response: This response is adequate.

13. Page 5-22: Should refer to ‘recapture efficiency’ rather than ‘recovery rate’. How were the values of 16% and 63% derived?

    RESPONSE: The words “recovery rate” were meant to be descriptive and not as a defined technical term. There is no standard term in widespread usage for the parameter reported (i.e. the percentage of excess water available for reintroduction into the streams versus the total amount captured by the mine processes). In the revised assessment, we have changed the wording to “reintroduced” (Table 6-3, Section 6.1.2.5). The reintroduction percentages were calculated as part of the water balance. The water balance totaled all the sources of water captured per year and then subtracted all of the annual consumptive water losses. The remaining annual volume of water is excess water that the mine does not need for operations and which is available for reintroduction to the streams. The ratio of the annual reintroduced volume to the annual captured volume yields the reintroduction percentage.

    Response: This response is adequate.

14. Page 5-23: The mean annual unit runoff values are not reproducible from the values given for drainage area and measured mean annual flow.

    RESPONSE: These values have been corrected.

    Response: This response is adequate.

15. Page 5-32 to 5-39: Tables showing flow changes for different mine sizes and figures for minimum mine size are difficult to interpret. A different presentation method and/or narrative description would help.

    RESPONSE: Tables, figures, and text for this section have been revised.

    Response: This response is adequate.

16. Page 5-45 (S5.2.3): The preceding section (Section 5.2.2) focuses on ‘Effects of Downstream Flow Changes’ and Section 5.2.3 focuses on wastewater treatment. It is not clear why this is the sole focus of Section 5.2.3. In addition, only a short paragraph is included in this section. Certainly there are other possible risks beyond water treatment, and even this discussion is too cursory given the importance of the issue.

    RESPONSE: Discussion of water treatment has been expanded in Chapter 8 (a new chapter in the revised assessment).

    Response: This response is adequate.

17. Page 5-45 (S5.2.4): This section states a number of assumptions that could result in under or over estimating impacts on stream flow from the mine footprint. This section leaves the impression there is a lot of uncertainty, both with assumptions behind the estimation and with how successful any attempts at mitigation may be. Therefore, we

are left with very large error bars on estimates that should be reflected in the numbers presented for loss of length of streams and areas of wetlands.

RESPONSE: We have improved the rigor of the analyses regarding the impact of mining on streamflow. We have attempted to be very explicit about our assumptions and approaches, and we believe the analyses are appropriate and defensible.

Response: This response is adequate.

18. Page 5-46 (P3): This paragraph discusses the possibility that estimates of stream length blocked by mine construction may be overestimated if engineered diversion channels are successful. This is an important form of mitigation that needs to be evaluated further. It would be helpful to evaluate mitigation efforts in similar types of systems to determine if reconstructing streams is feasible and could be successful.

    RESPONSE: Appendix J includes a discussion of the efficacy of constructed spawning channels. There is little evidence in the scientific literature to suggest that such channels are effective at creating suitable spawning habitat. Furthermore, there is nothing in the scientific literature that suggests salmon streams could be successfully reconstructed in landscapes where significant alternations in area soils, hydrology and groundwater flow paths have occurred, such as would be the case with the mine scenarios described in the assessment.

    Response: This response is adequate.

19. Page 5-59 (Bullet 4): Whole effluent toxicity (WET) testing and downstream biotic community monitoring would likely be part of any discharge permit. This requirement would not preclude developing a better understanding of protective discharge chemistry and temperature requirements before permitting, especially given the quality of the receiving water.

    RESPONSE: Appropriate WET testing and downstream biotic monitoring would be desirable if a mine were permitted. Additional studies of site specific chemistry and temperature tolerances may also be desirable. No change required.

20. Page 5-60 (S5.4.2): The statement that mine traffic will not be a large enough volume to affect runoff needs support. Do we know the road will only be used for mine traffic? Can we estimate the volume of mine traffic for a mine of this size and then look at runoff from an analog system?

    RESPONSE: This statement has been deleted from the assessment. However, we found no analogous data that would allow us to quantify runoff.

    Response: This response is adequate.

21. Page 5-60 (S5.4.4.1): How was the number of stream crossings determined (e.g., what criteria were used to define a stream vs. a channel)?

RESPONSE: All USGS designated streams were included. No artificial channels were identified and all natural channels are streams.

Response: This response is adequate.

22. Page 5-65 to 5-68 (S5.4.8.2): Text states that 240 km of stream upstream of the transportation corridor has a gradient greater than 10% and, therefore, is likely to support fish. Should this be less than 10% (as stated in the header to Table 5-22 and Table 6-9)? If so, how was the <10% value chosen?

    RESPONSE: The comment is correct, though in the revised assessment we use <12% as the criterion and cite a relevant source.

    Response: This response is adequate.

23. Page 5-74 (S5.5): Salmon-mediated effects on wildlife seem under-analyzed in the report, particularly when compared to the information presented in Appendix C.

    RESPONSE: The discussion of potential salmon-mediated effects on wildlife has been expanded (Chapter 12).

    Response: This response is adequate.

24. Page 5-75 (S5.6): As above, salmon-mediated effects on Alaska Native Cultures seems under-analyzed in the report, particularly when compared to the information presented in Appendix D.

    RESPONSE: The discussion of potential salmon-mediated effects on Alaska Native cultures has been expanded (Chapter 12).

    Response: This response is adequate.

25. Page 6-3 (S6.1.2.1): I don't find the Mt. St. Helens analogy useful.

    RESPONSE: It has been removed.

    Response: This response is adequate.

26. Page 6-9 (P1, L1): Why would 'present' resident and anadromous fish not suffer habitat loss in the event of a TSF failure? Are they upstream of the area inundated?

    RESPONSE: Yes, these populations are upstream of the TSF-affected area. However, they may be impacted by barriers to seasonal movement or fragmented by loss of connectivity. This has been clarified in the text.

    Response: This response is adequate.

27. Page 6-28 (S6.1.5): The 'Weighing Lines of Evidence' section is not well developed and not particularly useful. It also does not inform the risk characterization and

uncertainty discussion.

RESPONSE: The EPA believes that it is important to weigh all relevant lines of evidence. An explicit weighing allows readers and reviewers to see what was weighed and how it was weighted. Such transparency is desirable in general. Therefore, the weighing of evidence has been expanded and the method is better explained.

Response: This response is adequate.

28. Page 6-30 (P1, L2): The statement that risks of failure of the gas and diesel pipelines are not considered because they are not particularly associated with mining makes no sense. Without the mine, there would be no need for the pipeline. And if the types of failures and risks are well known, then this is one of the areas that could actually be assessed with some degree of certainty.

RESPONSE: Diesel pipeline failure has been added. A gas pipeline is still not assessed because it is judged to not pose a potentially significant risk to fish (see Chapter 11).

Response: This response is adequate.

29. Page 6-36 (S6.3, P2): Designating closure as ‘premature closure,’ ‘planned closure,’ and ‘perpetuity’ with water treatment ceasing immediately, continuing until permits are exhausted or water is nontoxic, or until institutions fail does not seem reasonable. Any of these closure scenarios would be planned, and would involve regulatory compliance reviews, bonding, etc. Walking away without continuing to collect and treat water would be an unlikely scenario. The issue of treatment in perpetuity is a larger issue that needs to be treated in detail.

RESPONSE: The premature closure scenario is intended to address the possibility that the closure plan is not followed. It highlights the need for adequate bonding and for plans that include closure by the bond-holding agency.

Response: This response is adequate.

30. Page 6-37 (P4, L4): The report states that (acid generating) waste rock could be left in place in the event of premature closure. This scenario should be addressed in the mine closure plan and during the closure bonding process.

RESPONSE: The premature closure scenario is intended to address the possibility that the closure plan is not followed. It highlights the need for adequate bonding and for plans that include closure by the bond-holding agency.

Response: This response is adequate.

31. Page 8-1 to 8-2: Given that this chapter discusses overall risk to salmon, it would be helpful to put the estimates of km lost in terms of the total stream or watershed available habitat. We need some context and metric for assessing significance.

RESPONSE: In Table 2-1, we have explicitly expressed the relative areas of each spatial scale as % of the scale above it (e.g., the % of the entire Bristol Bay watershed made up of the Nushagak and Kvichak River watersheds, the % of the Nushagak and Kvichak River watersheds made up of the mine scenario watersheds, etc.).

Response: This response is adequate.

32. Page 8-2 (S8.1.2): The focus on a few types of catastrophic failures does not reflect the current typical mining scenario. Based on experience at other mines, it is more likely that smaller-impact failures and accidents would occur during the mine life. It would be helpful to use some current case studies to illustrate this point.

    RESPONSE: The number of possible types, magnitudes and combinations of failures and accidents is virtually infinite. Therefore, we used a bounding strategy. The potential effects are bounded by those of routine operations and a realistic severe failure or accident. We also cite case studies from recent reviews of mining failures and individual failure cases to indicate some of the possibilities.

    Response: This response is adequate.

33. Page 8-3 (T8-1): Why would most concentrate pipeline failures occur between stream and wetland crossings?

    RESPONSE: Most of the transportation corridor is not on or adjacent to a stream or wetland. Therefore, most failures would occur in those areas between stream and wetland crossings.

    Response: This response is adequate.

Mr. Steve Buckley, WHPacific

Peer Review Follow-On Comments on the April 2013 Draft of

An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska

From: Buckley, Steve [mailto:SBuckley@whpacific.com]
Sent: Thursday, July 11, 2013 6:25 PM
To: Thomas, Jenny
Subject: RE: Bristol Bay Peer Review - Confidentiality Reminder

Thank you Jenny
Please find attached my follow-on review.
My comments are in red.
Let me know if you have any questions or need any more information.
Thanks
Steve Buckley

DRAFT
EPA Response to Peer Review Report
External Peer Review of EPA's Draft Document
An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska

11 June 2013

U.S. Environmental Protection Agency

Seattle, WA

EPA DRAFT RESPONSE TO PEER REVIEW COMMENTS

An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska

OVERVIEW

In May 2012, the U.S. Environmental Protection Agency (EPA) released the draft assessment entitled *An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska* (hereafter, the assessment). Because this document is considered a highly influential scientific assessment, it has strict requirements for peer review as laid out in the *EPA's Peer Review Handbook* (3rd Edition). These requirements included peer review by external expert reviewers and documentation of how peer review comments are incorporated into the revised work product.

From May to August 2012, this draft assessment was evaluated by twelve external expert reviewers; comments from these reviewers were incorporated into a final peer report, which was submitted to the EPA in September 2012. This document details the EPA's draft responses to the peer review comments received on the May 2012 draft of the report, as provided in the final peer review report. Please note that this is a draft document, and that it should not be distributed beyond the EPA and the peer reviewers. It is considered deliberative material and intended for internal use only, as the assessment continues to undergo revision. Once the assessment has been finalized, a final draft of this document will be completed and released to the public.

STRUCTURE OF THE DRAFT RESPONSE TO COMMENTS DOCUMENT

This draft response to comments document follows the structure of the final peer review report for the assessment. It is organized into two main sections:

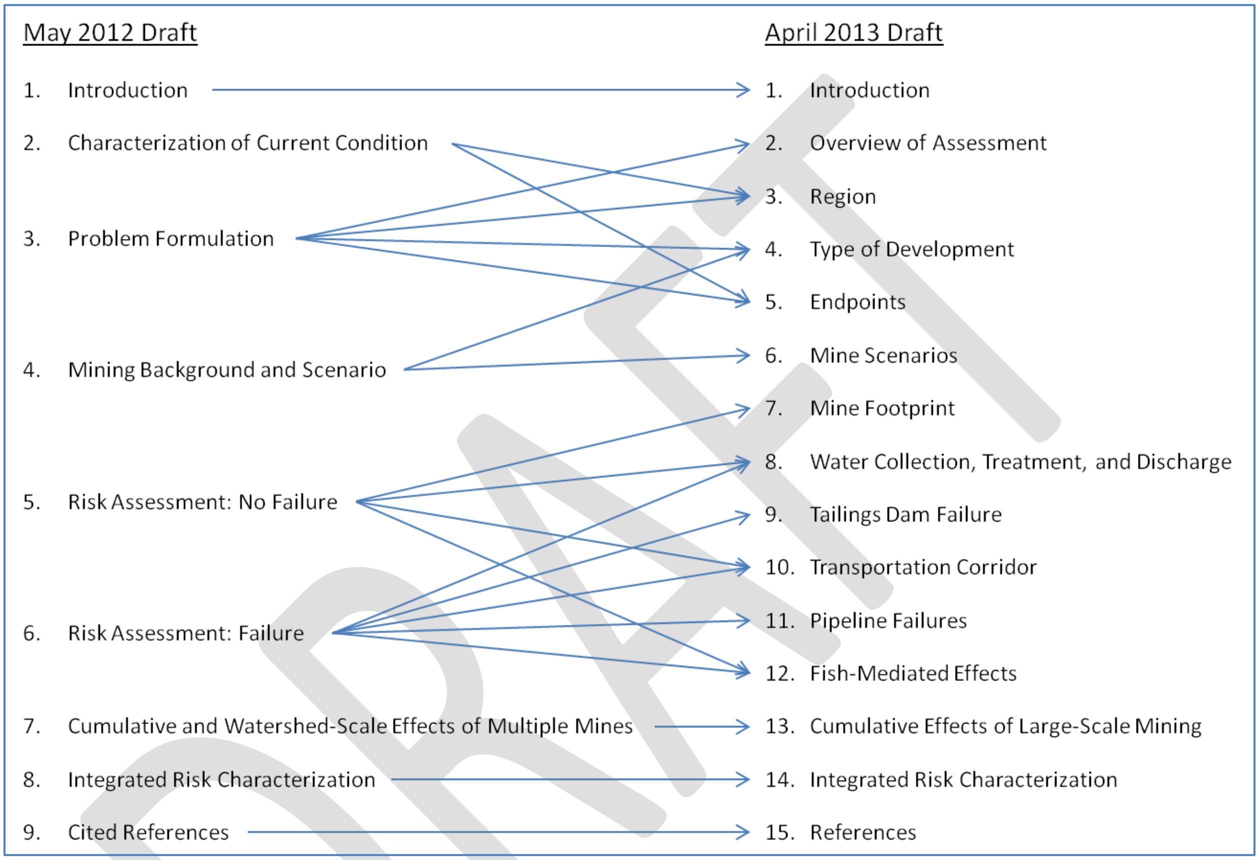
(1) **Summary of Key Recommendations from Peer Reviewers**. This section details general big-picture issues raised by the peer reviewers in the August 2012 peer review meeting.

(2) **Written Peer Review Comments**. This section details each reviewer's individual comments on the assessment, organized according to general impressions, responses to charge questions, and specific observations.

Within each section, the original text from the final peer review report is included here, followed by EPA responses to the comments contained in that text (in bold italics). The EPA considered all comments provided in the final peer review report, although not all comments resulted in changes to the draft assessment. The EPA responses provided in this document explain either how the assessment was revised to address the comment, or why the assessment was not changed in response to the comment.

ORGANIZATION OF THE APRIL 2013 DRAFT ASSESSMENT

In response to several comments, the revised April 2013 draft of the assessment has been reorganized to highlight its foundation as an ecological risk assessment, improve overall clarity, and reduce redundancy. A cross-walk between chapters of the May 2012 and April 2013 drafts is provided below to help illustrate where material from the May 2012 can be found in the revised assessment.



SUMMARY OF KEY RECOMMENDATIONS FROM PEER REVIEWERS

This section summarizes the significant general recommendations put forth by the peer reviewers regarding EPA's draft assessment. In developing these recommendations, peer reviewers provided input on three major areas of the assessment: (1) scope, (2) technical content and (3) editorial suggestions. Reviewers also identified research needs for EPA to consider. Please note that this summary of peer review comments did not reflect a consensus or group perspective, but was compiled from a discussion of individual peer reviewer recommendations. Additional details, including references cited, can be found in the reviewers' individual comments in Section III.

Scope of the Document:

- Articulate the purpose of the document more clearly via a primer on the Ecological Risk Assessment process. If the purpose of the assessment is to inform EPA as the decision maker, then the level of detail should correspond to this purpose. The authors should justify and explain what level of detail is required.

  RESPONSE: Additional information on both the purpose of the assessment and ecological risk assessment (ERA) in general has been added to Chapters 1 and 2, as well as the Executive Summary. Section 1.2 includes information about the use of the assessment. The assessment has been reorganized into two major sections (problem formulation, risk analysis and characterization) to clarify where different chapters fall in the typical ERA process.

  The reorganization of the report clarifies the purpose of the assessment and includes information on the intended audience. It also explains the ERA process much better than the initial draft. The overall organization of the assessment has been improved by identifying the assessment endpoints first, before outlining the potential risks. In addition, the elimination of the No Failure/Failure sections in the draft report helps avoid confusion on what type of system failures are being assessed.

- Include a statement upfront about the role of risk managers and other audiences, such as project managers/engineers, regulators, mine owners/operators. Knowing their role ensures inclusion of information necessary for any risk assessment by (1) describing the need for a risk assessment, (2) listing those decisions influenced, and (3) characterizing what risk managers require from the risk assessment.

  RESPONSE: Section 1.2 of the revised assessment discusses the use of the assessment.

  Section 1.2 discusses the use of the assessment in greater detail than the initial draft. This information is also treated more thoroughly in the Executive Summary.

- Explain why the scope for human and wildlife impacts was limited to fish-mediated effects, as well as why fish-mediated effects on humans were limited to Alaska Native cultures.

Reviewing effects beyond fish-mediated ones (e.g., potential for complete loss of the subsistence way of life) would improve the assessment.

RESPONSE: The scope of the assessment has been clarified throughout the document, particularly in Chapters 1 and 2. Throughout the assessment we acknowledge that direct effects of large-scale mining on wildlife and Alaska Native cultures may be significant, but that these direct effects are outside the scope of the current assessment.

The scope of the assessment is outlined in the Executive Summary and explains which potential impacts are considered and which are not and why.

- Be more consistent throughout the document in terms of the level of detail provided for the different scenarios and stressors. For example, the document has devoted 36 pages to the discussion of catastrophic Tailings Storage Facility (TSF) failure, while sections on the pipeline, water treatment, and road/culvert failures are brief. Indeed, the long discussion on the TSF failure belies a certainty and understanding of dam failure dynamics that is inaccurate.

RESPONSE: The final document includes more failure scenarios (e.g., diesel pipeline failure, wastewater treatment plant failure, and refined seepage scenarios) in Chapter 8. It also explains why these specific failure scenarios were chosen, and discusses these scenarios in greater detail than the previous draft (i.e., to more closely match the level of detail originally provided only for the TSF failure scenario). Also see detailed responses to comments on Peer Review Question 5.

The inclusion of additional system failure scenarios does indeed more closely match the level of detail of the TSF failure scenario. However, the level of detail does still seem to imply a certainty and understanding of the impacts of a tailings dam failure which are simply beyond the scope of the assessment.

Technical Content:

Mine Scenario

- Consider the document to be a screening-level assessment of all potential stressors. Focusing on failure mode overemphasizes catastrophic events (e.g., TSF failing), rather than considering all potential stressors, such as holding mine owners strictly accountable for their day-to-day activities with regard to best practices.

RESPONSE: Additional information on the purpose and scope of the assessment has been added to Chapters 1 and 2. A screening of all potential stressors, including individual chemicals, is presented in Section 6.4.2. Also see detailed responses to Peer Review Question 2 on the use of "best practices" and responses to Peer Review Question 5 on failure scenarios.

There still seems to be room for improvement on the organization of the assessment in trying to identify the potential stressors from catastrophic events versus normal operations. Chapters 7-11 are better organized and help to outline these various system failure scenarios.

- Reexamine the document's use of historical data and case studies to describe and estimate the risk of failure for certain mine facilities (including the TSF, pipeline, water treatment, etc.), as these examples from extant mines may not be an appropriate analog for a new mine in the Bristol Bay watershed.

  RESPONSE: The TSF failure range was, and still is, based on design goals, not the historical data. The historical TSF failure data are provided as background. The pipeline failure rates are based on the most relevant historical data from the petroleum industry. They are directly relevant to the diesel pipeline, and experiences at the Alumbrera mine (described in the previous draft) and the Antamina and Bingham Canyon mines (added to this draft) suggest that they also are relevant to the product concentrate pipeline. Water treatment failure rates were not quantified. However, recent reviews cited in the revised draft indicate that water collection and treatment failures have been reported at nearly all analogous mines in the U.S. The estimation of culvert failure frequencies has been revised and is now based on only recent literature (2002 and later). We believe that these estimates are appropriate.

  Culvert failure frequency based primarily on large woody debris loading in forest streams is probably not appropriate information to accurately estimate failure frequency along the transportation corridor. Ice and floods would probably have more impacts on stream crossings. There is not much discussion of other crossing methods other than bridges which might reduce the impacts of stream crossings on fish in Box 10.2 Culvert Mitigation.

- Expand the discussion on the use of "best" management practices, as the document states that the mine scenario employs "good," but not necessarily "best" practice. For a mine developed in the Bristol Bay watershed, only "best" practice likely would be appropriate and anything less may not be permitted. Even so, without a track record of "best" practice (e.g., new technologies), we cannot assume that technology, by itself without appropriate operational management controls, can always mitigate risk.

  RESPONSE: The term "best management practices" is a term generally applied to specific measures for managing non-point source runoff from storm water (40 CFR Part 130.2(m)). Measures for minimizing and controlling sources of pollution in other situations often are referred to as best practices, state of the practice, good practice, conventional, or simply mitigation measures. We assume that these types of measures would be applied throughout a mine as it is constructed, operated, closed, and post-closure, and have used the term "conventional modern" throughout the assessment to refer to these measures. To remove any ambiguity related to the subjectiveness of terms "good" or "best", we have removed them in the revision and have provided definitions for relevant terms used in Box 4-1.

  These changes help reduce confusion about "good" and "best" management practices.

- Adopt a broader range of mine scenarios (not only minimum and maximum) so as to bound potential impacts, especially at smaller mine sizes (e.g., 50th percentile). Underground mine development, with its different impacts, also should be considered and included in the assessment.

RESPONSE: A third mine size scenario (250 million tons) has been added to the assessment, to represent the worldwide median sized porphyry copper mine (based on Singer et al. 2008).
The addition of the .25 hypothetical mine scenario helps bracket the potential impacts described in the assessment and there is a short discussion about the potential impacts from large-scale underground mine development.

- Based on the hypothetical mine scenario, perpetual management of the geotechnical integrity of the waste rock and tailings storage facilities, as well as perpetual water treatment and monitoring, will most likely be necessary (i.e., a "walk away" closure scenario after mining ends may not be possible). Therefore, emphasize how monitoring and management of the geotechnical integrity of waste rocks and tailing storage facilities should continue "In Perpetuity" (i.e., for at least tens of thousands of years). Discuss what conditions would need to be met to allow "walk away" closure in the Bristol Bay environment gaining insight into these observations from mines where perpetual treatment and monitoring are ongoing (e.g., the Equity Silver Mine in British Columbia).

  RESPONSE: The conditions for closure and the potential need for perpetual site management are discussed in general terms in the revised assessment. The primary condition assumed to be required is water chemistry that meets all criteria and permit conditions and that is stable or improving. However, even though there are some facilities with "perpetual treatment" conditions in place, there is obviously no information about how these facilities perform over very long periods of time.

  The revised assessment clarifies the potential conditions at closure and some of the water treatment scenarios which could take place.

- Identify, in technical detail, how exploratory effects (e.g., drill holes, blasting, overflight, etc.) were managed. This includes roads, airstrips, helipads, camps, fuel dumps, and ATV trails that have already been developed or imposed on the watershed, and what "mitigation" already has been undertaken on those sites. Assess the consequences/impacts of these activities in the Cumulative Risks section.

  RESPONSE: The effects of exploratory activities are outside of the scope of this assessment.

Risks to Salmonid Fish

- Place potential mining impacts in the context of the entire Bristol Bay watershed by emphasizing the relative magnitude of impacts. For example, of the total salmon habitat, assess the proportion lost due to mining. Further, reflect on the non-linear nature of the relationship between habitat and salmon production; 5% of the habitat could be critical and thus responsible for 20% or more of salmon recruitment. Intrinsic potential, which measures the ability of particular habitats to support fishes, would lend credibility to this analysis.

  RESPONSE: We are unable to build a complete Intrinsic Potential (IP) model, as this would require validation and more elaborate construction of metrics appropriate to this region. Our preliminary characterization provides the building blocks for assessing the distribution of key habitat-forming and constraining features across these watersheds. We

now include a characterization of the major drivers of habitat potential across the watershed and place the mine-site specific effects in this context (Chapters 3, 7, and 10).

The revised assessment does a better job of providing some context to the potential impacts of the various mine scenarios in Chapter 7.

- Include a section on the impact of Global Climate Change with explicit reference to a monitoring program that will allow scientists, if the mine is built, to distinguish between effects of climate change and mining effects on the physical and biological components of this ecosystem.

  RESPONSE: Climate change projections and potential impacts are now included in Chapter 3, and as important external factors in the risk analyses presented in Chapters 7, 9, 10, and 14. Development of a monitoring program to distinguish between mining and climate change effects is outside of the scope of the assessment.

  The revised draft includes several new sections dealing with the potential role of climate change.

- Explicitly recognize that the transportation corridor and all associated ancillary development, including future resource developments made possible by the initial mining project, will necessarily and inevitably have impacts (hydrologic, noise, dust, emissions, etc.). These impacts will vary in duration, intensity, severity, relative importance, spatial dispersion, and inevitably expand geographically through time with further "development." These impacts should be incorporated into the Cumulative Risks section.

  RESPONSE: The cumulative risk section (Chapter 13) has been expanded to include the multiple transportation corridors, ancillary mining development and secondary development associated with multiple mines in a qualitative discussion. The issues addressed in the assessment of the transportation corridor (Chapter 10) have also been expanded to include chemical spills, dust, invasive species, and road treatment salts.
  The reorganization of these chapters provides additional information on potential impacts from the transportation corridor, and reads more clearly than the initial assessment.

- Incorporate current research findings into stream crossing and culvert-design practices (e.g., arch culverts, bridges, etc.).

  RESPONSE: We describe current culvert design practices in a box titled "Culvert Mitigation" in Chapter 10.

  There is not much discussion of other crossing methods other than bridges which might reduce the impacts of stream crossings on fish in Box 10.2 Culvert Mitigation.

- Recognize in the assessment that risk and impact are not equivalent. Risk may be low, but the potential impact could be huge (e.g., in the case of a TSF failure).

  RESPONSE: Risk has been defined in many ways, even by risk assessors. The commenter seems to define risk as probability. To avoid that potential source of confusion, we use the term "probability" for that concept. Similarly, the commenter seems to use "impact"

where we use "effect" or "magnitude of effect". We use "risk" to refer to both concepts combined—that is, an event or effect and its probability).

This seems to be a reasonable way to deal with the confusion of terms.

- Recognize and justify chronic behavioral endpoints, such as those potentially affecting survival and long-term success of fish populations.

  RESPONSE: The chronic behavioral effects of copper on salmonids, the primary endpoint of concern, were described in Chapter 5 and are now described in Chapter 8. Although those effects occur at lower levels of copper than conventional survival, growth and reproduction endpoints for salmonids, they are less sensitive than the conventional endpoints for aquatic invertebrates.

  The new format treats these issues more clearly.

Wildlife

- Recognize that the draft assessment did not account for all levels of ecology, such as the individual (e.g., a bald eagle nest), population, community, ecosystem, and landscape levels. Fold other levels of organization into the stressors assessment where appropriate or justify a more limited approach.

  RESPONSE: As is appropriate for an ecological risk assessment (as opposed to an environmental impact assessment), this assessment focuses on a specific, limited set of endpoints as defined in Chapter 5. We have added text in Chapters 2 and 5 to explain both why these endpoints were selected, and that responses other than those considered in the assessment, at multiple levels of ecological organization, are likely but are outside the scope of the assessment.

  The revision explains the ERA process much better and outlines the decision to use the given assessment endpoints as well as the limitations of the scope of the assessment.

- Discuss in the document fishes other than salmonids The assessment focuses on risks to sockeye salmon in the Bristol Bay watershed (and also considers anadromous salmonids, rainbow trout, and Dolly Varden), but does not account for potential impacts to other members of the resident fish community. Further, primary and secondary production, including nutrient flux was not addressed. Expanding the assessment to consider other levels of organization, including direct as well as indirect effects on wildlife and other fish, would provide additional context in the assessment of mine-related impacts.

  RESPONSE: See response to comment above; we also incorporated additional information from Appendices A, B, and C into the Chapter 5 text, to provide additional detail on the area's biota. We chose our endpoints for reasons described in Chapters 2 and 5. Other endpoints, including indirect effects on fish and wildlife, are now discussed more explicitly, but are generally considered outside the scope of the assessment.

  These changes improve the organization of the document and bring information from some of the Appendices forward into the document.

<ins>Human Cultures</ins>

- Use case histories to provide insight and anticipate mining impacts on Alaska Natives (e.g., those exemplifying the Exxon Valdez oil spill impacts, cumulative effects of oil and gas development in the North Slope region, and social impacts related to mining development in Alaska).

  RESPONSE: Examples from applicable case studies, including the Exxon Valdez oil spill, are cited in Chapter 12 of the revised assessment.

- As noted above (Scope of the Document), clarify why the scope was limited to fish-mediated effects. The potential direct and indirect impacts for human cultures extend far beyond fish-mediated impacts (e.g., potential complete loss of the subsistence way of life). The rationale for this narrow focus should be fully explained. In addition, a clear explanation should be given for why fish-mediated human impacts focused only on Alaska Native cultures.

  RESPONSE: The assessment focuses on a specific, limited set of endpoints as defined in Chapter 5. We have added text to explain both why these endpoints were selected, and that responses other than those considered in the assessment are likely but are outside the scope of the assessment. The assessment was expanded (Chapters 5 and 12) to acknowledge that there are a wide range of potential direct and indirect impacts to indigenous culture, but they are outside of the scope of this assessment. The discussion of potential effects to indigenous cultures was expanded to explain that a loss of subsistence resources would extend beyond a loss of food resources to social, cultural, and spiritual disruption. The text has been expanded to acknowledge the strong cultural ties of many non-Alaska Natives to the region, and potential effects on all residents from loss of a subsistence way of life. However, the focus of the assessment remains on effects on indigenous cultures resulting from effects on salmon.

<ins>Water Balance/Hydrology</ins>

- Better characterize water resources and assess the potential effect of mine development on these resources by (1) generating a diagram similar to the conceptual models beginning on page 3-7 to illustrate the potential effects of mine construction and operation on surface- and ground-water hydrology; (2) developing a quantitative water balance and identifying water gains and losses; (3) identifying seasonality of hydrologic processes, including frozen soils and their associated values (e.g., mm/yr) for each component of the water balance; (4) incorporating these processes into a landscape characterization; (5) evaluating how global climate change will influence these hydrologic processes and rates; and 6) using this characterization to demonstrate the expected hydrologic modification associated with the mine scenarios and infrastructure development.

  RESPONSE: The original Figure 4-9 (new Figure 6-5) has been revised to more clearly show water management in the assessment's mine scenarios. In addition, three schematics illustrating water flows under each of the mine size scenarios (Figures 6-8 through 6-10) have been added to Chapter 6, as have quantitative water balances for each mine size

scenarios. A qualitative discussion of climate change is included in Chapters 3 (Section 3.8) and 14 (Box 14-2).

It seems that some additional explanation of the water balance results would be appropriate. Perhaps an additional diagram which is somewhere between the simplified cartoon in Figure 6.5 and the detailed Tables such as 6.8 would help the reader visualize the results of the water balance model.

- Demonstrate the interconnectedness of groundwater, surface water, hyporheic zone, and its importance to fish habitat. Address how interconnectedness changes over time – seasonally, and with varying weather (e.g., wet vs. dry summers or years, and over the long term as climate changes).

  RESPONSE: We lack the data to demonstrate this interconnectedness in a spatially and temporally uniform manner, but do include examples of known points of high connectivity (Chapter 7) and qualitatively discuss the potential role of climate change (Chapter 3).

  Figure 7.14 helps provide some additional information on surface and groundwater interconnectivity and fish habitat. Given the numerous locations where the document mentions these features as being critical to the understanding of the watersheds it seems that a more detailed treatment of these factors is warranted.

- Provide information on all rivers, including ephemeral and intermittent streams, and first-order to main-stem streams that could be potentially influenced by the proposed mine, its ancillary facilities, and the transportation corridor.

  RESPONSE: Due to lack of consistent coverage, we rely on the NHD hydrography layer in this analysis, and can only address ephemeral and intermittent streams qualitatively (Chapter 7).

  Use of the NHD layer seems appropriate at this level of assessment. Hopefully more detailed information on stream character and location will be developed in the future.

- Emphasize the importance of a thorough characterization of the leaching potential of acid-generating and non-acid generating waste rock and tailings, given the low buffering capacity and mineral content in the streams and wetlands that could receive runoff and treated water from the proposed mine. Recognize that collection and treatment of runoff and leachate generated will be critical to maintain baseline water chemistry in these streams and wetlands.

  RESPONSE: We agree that these are important issues, and the discussion of leachate from waste rocks and tailings has been expanded in the revised assessment (Chapter 8).

  Chapter 8 is better organized, however it seems that some additional diagrams would help the reader visualize the information contained in the Tables 8.1 to 8.3 i.e. where and what does this information potentially impact.

<u>Geochemistry/Metals</u>

- Reference the most current geochemistry data on potentially acid-generating, non-acid generating, and metal leaching so as to describe any potential effects of seepage and changes to surface- and ground-water quality via non-catastrophic failure.

RESPONSE: We used the geochemistry data in PLP's Environmental Baseline Document, as summarized by the USGS in Appendix H. The effects of seepage on water quality are analyzed in Chapter 8 of the revised assessment.

- Explain how contaminants/metals were selected (and others ignored) by EPA as causes for concern. Information should be included on additional metals and their toxicity so as to assess impacts of potential leachates. The Pebble Limited Partnership baseline document presented additional metals that might be useful to include in the assessment.

  RESPONSE: The revised assessment describes the selection of contaminants and other stressors of concern in Section 6.4.2. Additional metals, process chemicals and dissolved solids are now included.

<u>Mitigation Measures</u>

- Incorporate the critical mitigation information from Appendix I into the main report's mine scenarios. Include standard mitigation measures that could provide insight into how well they might work in this context. If this information is not included in the main report, then justify its absence.

  RESPONSE: Mitigation measures incorporated into design and operation to minimize potential impacts were included in the assessment, as were some reclamation measures for closure; these measures are made clearer in the revised assessment. These mitigation measures were a sub-set of those presented in Appendix I. The assessment assumes that measures chosen for the scenarios would be effective. Mitigation to compensate for effects on aquatic resources that cannot be avoided or minimized by mine design and operation would be addressed through a regulatory process that is beyond the scope of this assessment. Nevertheless, in response to public and peer comments we have included a discussion of compensatory mitigation in Appendix J of the revised assessment.

  The addition of the information in Appendix J helps to explain where and when mitigation might enter into the regulatory process.

- Emphasize mitigation measures (e.g., minimization, compensation, reclamation) in the main report, as they ultimately influence the range of mining impacts and consider time frames of mitigation or reclamation measures (e.g., immediate response, long-term reclamation).

  RESPONSE: See response to previous comment. Mitigation measures are discussed at greater length in the revised assessment report (e.g., Chapter 4 and Appendix J).

  The addition of the information in Appendix J helps to explain where and when mitigation might enter into the regulatory process.

<u>Uncertainties and Limitations</u>

- Clarify the uncertainty vs. certainty in Chapter 8 by (1) defining levels of uncertainty and (2) assessing the certainty of some mine impacts. Discuss data limitations in the context of uncertainty.

RESPONSE: The individual analysis chapters and the revised Integrated Risk Characterization (Chapter 14) discuss certainties and data limitations to a greater extent, as suggested.

This is a much better way to outline the uncertainty and data limitations.

- Articulate early in the document how much uncertainty is acceptable. The assessment provides little insight with respect to the decisions the document is intended to support.

  RESPONSE: Acceptable levels of uncertainty can be defined prior to an assessment if a decision and a decision maker are identified and if data will be collected by a specified design to implement a specified model, as described in the EPA's Data Quality Objectives process, However, because this assessment is based on available data and is intended as a background scientific document rather than a decision document, it is not possible to specify the amount of uncertainty that is acceptable. Rather, the available data determine the uncertainty and if the assessment is subsequently used to inform a decision, the decision maker must determine whether the level of uncertainty is acceptable.

  The revised draft does a better job in the Executive Summary identifying the use of the assessment and the uncertainties and limitations of the assessment.

<u>**Editorial Suggestions:**</u>

- The title of the document leads one to believe that the assessment addresses the entire Bristol Bay watershed; rather, the report deals with two major rivers and their watersheds, the Nushagak and Kvichak. Thus, the title should be changed to reflect the emphasis on these two rivers and their watersheds. A possible title may be "An Examination (or identification) of the Potential Impacts of Mining and Mining Associated Activities on Salmon Ecosystems in the Nushagak River and Kvichak River watersheds, Bristol Bay."

  RESPONSE: The assessment addresses multiple scales: the Bristol Bay watershed, the Nushagak and Kvichak River watersheds, the watersheds of the three streams draining the Pebble deposit, and the watersheds crossed by the transportation corridor. These multiple scales, and how they are used throughout the assessment, are described more clearly in the revision (Chapter 2).

- Revise the Executive Summary to more precisely reflect the findings in the document.

  RESPONSE: The Executive Summary has been rewritten to reflect the revised assessment findings.

- The appendices contain detailed and useful information that should be summarized and included in the main document (e.g., Appendix E: Economics, Appendix G: Road and Pipelines, and Appendix I: Mitigation). Additionally, consider expanding the preface to include information on the use of the appendices. If the information is not included in the main report, then justify its absence.

  RESPONSE: More information from the appendices was brought forward into appropriate chapters of the revised report. The purpose of the appendices—to provide the detailed background characterization necessary for the ecological risk assessment—has

also been clarified in Chapter 2. The document no longer contains a preface because that material has been incorporated into Chapters 1 and 2.

- Discuss in more detail the instructive and well-thought-out conceptual models (pages 3-7 to 3-11) illustrating the impacts of mining on Bristol Bay ecosystem processes. Also, consider expanding the conceptual models to include wildlife, fish-wildlife interactions, vegetation/terrestrial habitat, and hydrologic processes. Allow them to guide the text because they appear detailed and complete.

  RESPONSE: Additional information on the use of conceptual models throughout the assessment has been incorporated into Chapter 2. The more comprehensive conceptual models presented in Chapter 6 (Chapter 3 in the first draft) have been broken into their relevant component parts throughout the risk analysis and characterization chapters, to better frame the specific pathways addressed in each chapter. Additional conceptual models considering impacts on wildlife, Alaska Native populations, and cumulative effects of multiple mines have been added to Chapters 12 and 13.

- Incorporate the information contained in the conceptual models into a formal framework, such as a Bayesian or other decision-analysis models.

  RESPONSE: This is an excellent suggestion for future efforts, but is beyond the scope of the current assessment.

  Creating a Bayesian Belief Network would require that the Agency convene experts to subjectively estimate the probabilities of each transition in the conceptual models. In contrast, this assessment is intended to elucidate the risks from potential mining based on available data and analyses of those data.

  A Decision Analysis would require that alternative outcomes be specified, the utility of each outcome for a decision maker be defined and the probabilities of each outcome be estimated for each possible decision so that the expected utilities of each outcome can be calculated. Because this assessment is not a decision document, these requirements are not feasible or appropriate.

- Generate a standard operating protocol for significant figures and use it throughout the document.

  RESPONSE: The authors have carefully addressed this issue. Numbers from the literature or from the PLP EBD retain the number of significant figures in the original. Numbers derived for this assessment have the appropriate number of significant figures given the precision of the input data and uncertainties due to modeling and extrapolation.

- Remove all references to Mount St. Helens as a surrogate for a TSF failure. Using a non-human-caused release of material into the ecosystem as an analogue for a mine failure is not comparable in terms of likelihood or risk for a human-caused release. It would be more appropriate to extrapolate from the impacts of known mine failures.

  RESPONSE: We are puzzled by this comment. The Mount Saint Helens data were used strictly to address the rate of benthic habitat recovery from a massive deposition of fine mineral particles. The hydrological processes that determine the recovery of substrate

texture and the requirements of fish or aquatic invertebrates are not known to depend on whether mineral particles were from a natural event or an anthropogenic event. We have reviewed the literature on known mine failures. They studied tailings spills in terms of toxicity but not in terms of physical habitat effects, which is why we used Mount Saint Helens data. Nevertheless, we have removed references to Mount St. Helens in the revised assessment to eliminate concern.

- Ensure that the draft assessment remains part of the public record, allowing the document history to remain intact.

  RESPONSE: All drafts of the watershed assessment will remain part of the public record.

Research Needs:

- What are the acute and chronic impacts of mixtures of contaminants, including metals, acid mine drainage, etc., on the fauna and flora of the Nushagak River and Kvichak River watersheds? What species are most sensitive and might surrogate species exist for those for which we do not have data? Review the European literature and regulatory requirements for additional data.

  RESPONSE: The acute and chronic impacts of contaminant mixtures, including metals and acid mine drainage (i.e., metals in low pH-waters) were addressed using concentration additivity models in the leachate chemistry tables in Chapters 5 and 6 (now Chapters 8 and 11). Additional toxicity data were obtained by searches of the EU and OECD database eChem, the EPA's ECOTOX and the Environment Canada site. More metals are now included. In general, metals are most toxic to aquatic arthropods rather than fish, as discussed for copper.

- Can an inventory of nutrients, total organic carbon, and dissolved organic carbon inputs to aquatic environments be developed that demonstrates their relative magnitude and spatial variation from headwaters to Bristol Bay? What is the relative importance of marine-derived nutrients relative to other nutrients from watershed and terrestrial sources? What is the current atmospheric input of nutrients?

  RESPONSE: These data would be very useful in the risk assessment, but are not currently available for the Bristol Bay region. We agree this is a research need.

- What are the locations of subsistence areas and can these areas be characterized and differentiated by collecting local environmental and ecological knowledge (e.g., fish overwintering areas, climate change, ecological shifts, etc.)?

  RESPONSE: The revised assessment incorporated current data on subsistence use areas available from ADF&G. EPA acknowledges that these data are incomplete and would encourage additional collection of subsistence data and Traditional Ecological Knowledge.

- What impact might mining have on other important wildlife species in the basin (e.g., freshwater seals in Iliamna Lake)?

  RESPONSE: The scope of the assessment is focused on potential risks to salmon from large-scale mining and salmon-mediated effects to indigenous culture and wildlife. Direct

effects on wildlife from large-scale mining are likely to be important and Appendix C (now a stand-alone US Fish and Wildlife report) provides useful information for a future evaluation of direct effects on wildlife from large-scale mining. We agree that this is an important area for future research.

- What is the comprehensive hydrologic regime of the specific project mining area, and the broader watershed system as characterized by baseline monitoring, spatial distribution, and quantitative flow of surface- and ground-waters?

  RESPONSE: Comprehensive spatial estimates of mean annual flow are now presented in Chapter 3. Quantification of spatial and temporal patterns of groundwater flows is an acknowledged highly desirable product, but it not feasible within the scope of this assessment. Results of an independent groundwater-surface water modeling effort are described in Chapter 7.

- What is the cumulative impact of commercial fisheries on the Bristol Bay watershed, especially in an ecosystem context as related to marine-derived nutrient and energy flow? Acknowledge that commercial fishing has had an impact on the amount of marine-derived nutrients returned to the watersheds.

  RESPONSE: The impact of commercial fisheries on the watershed is not within the scope of this assessment. Information on commercial fisheries management has been added in Box 5-2. However, the purpose of this assessment is not to assess the relative effects of potential mining and commercial fishing—it is to evaluate potential effects on endpoints if a mine were to be developed, given existing conditions and activities in the region.

WRITTEN PEER REVIEW COMMENTS

1. GENERAL IMPRESSIONS

David A. Atkins, M.S.

The Bristol Bay Watershed Assessment (the Assessment) presents a comprehensive overview of current conditions in the watershed and establishes the uniqueness and global importance of the area to global salmon ecology (e.g., the report states that nearly 50% of the global sockeye salmon population comes from Bristol Bay and nearly 50% of the salmon in Bristol Bay come from the Nushagak and Kvichak Rivers, which encompass nearly half of the watershed area). The report also describes in detail the importance of the fishery to Native Alaska cultures, the importance and uniqueness of subsistence activities, and the scale of the commercial fishery. Furthermore, the report also outlines the reliance of the local economy on the salmon fishery.

RESPONSE: No change suggested or required.

There is no question that a mine, especially of the type and magnitude analyzed in the Assessment, could have significant impacts and that if these impacts are not or cannot be properly managed and/or mitigated, the consequences could be profound. The Assessment presents a mining scenario based on preliminary documents prepared for the Pebble Project, which sets out a conventional approach for development of a very large mine that includes open-pit and block-cave underground mining methods and conventional waste rock and tailings management. Development of the mine as proposed would eliminate streams and wetlands in the project area permanently. The importance of this impact is not put in context of the watershed as a whole, so it is not possible to determine the magnitude of the risk to salmon. The Assessment also did not consider whether there are any methods that could effectively minimize, mitigate or compensate for these impacts.

RESPONSE: A characterization of the landscape factors influencing salmon habitat potential is now included to provide context for the stream habitat impacts described in the document (Chapter 3). The assessment describes the magnitude of risks to salmon habitat. Due to lack of knowledge of limiting factors, ascribing comprehensive risks to salmon populations is not feasible in this assessment. Mitigation to compensate for effects on aquatic resources that cannot be avoided or minimized by mine design and operation would be addressed through a regulatory process that is beyond the scope of this assessment. Nevertheless, in response to public and peer review comments we have included a discussion of compensatory mitigation in Appendix J of the revised assessment.

The Assessment also focuses on the risk of failure of the tailings storage facility, a low probability, but high impact scenario. The Assessment further describes the potential for long-term acid and metals production from waste rock and the necessity for water treatment. Under the mining scenario as described, perpetual management of the geotechnical integrity of the waste rock and tailings storage facilities and perpetual water treatment could be necessary. In addition, failure is always a possibility, albeit a possibility that is difficult to quantify with any degree of certainty as explained in the Assessment. The Assessment also does not consider alternative engineering strategies (so called 'best practice' approaches) that could lessen the risk of failure and possibly the necessity for perpetual management and water treatment. As such, the report could be considered a screening level assessment that presents the likelihood of occurrence and corresponding consequences of failures under the presented development scenario, but does not describe the magnitude of risk to salmon.

RESPONSE: With regard to the terminology of "best", "good", or other terms for the practices used, what was intended to be conveyed in the assessment is that we assumed modern mining technology and operations. Measures for minimizing and controlling sources of pollution, outside of stormwater requirements, may be referred to as best practices, state of the practice, good practice, conventional, or simply mitigation measures. We have added a text box in the revision (Chapter 4) to discuss terms. Mitigation measures considered feasible, appropriate, and 'permittable' (as per Ghaffari et al. 2011) were considered in the assessment, and these are measures common to other copper porphyry mines. Evaluation of alternative strategies (e.g., other options presented in Appendix I) is outside the scope of this assessment, but such evaluation should be part of the permitting process for a specific mining plan. The assessment describes the magnitude of risks to salmon habitat. Due to lack of knowledge of limiting factors, production, and demographics, ascribing comprehensive risks to salmon populations is not feasible for this assessment.

Steve Buckley, M.S., CPG

The assessment attempts to evaluate the potential impacts of mining development in the Nushagak and Kvichak watersheds. The main deficiency in the assessment is that it uses only two hypothetical mine scenarios to bracket the potential impacts of mining activities on the ecological resources in the watershed. Both of these mine scenarios are larger than the 90th percentile of all porphyry copper deposits in the world. In order to properly assess the potential effects of mining activities, in the absence of any specific mining proposal, a minimum mine scenario on the order of the 50th percentile of worldwide porphyry copper deposits would be more appropriate. Three or four mine scenarios would allow for a broad range of analysis, and the reader would be able to put the potential impacts of mining development in wider perspective.

RESPONSE: A third mine size scenario (Pebble 0.25, 250 million tons) is included in the revised assessment, to represent the worldwide median size porphyry copper mine (Singer et al. 2008).

This is a major improvement in the assessment.

A large part of the assessment provides information related to catastrophic potential system failures such as tailings dam failures and pipeline ruptures. There is inadequate information on, and analysis of, potential mitigation measures at the early stages of mine development, which would attempt to reduce the impacts of mining activities on fish and water quality. The bulk of the document is dedicated to evaluating the impacts of tailings dam failure on aquatic resources and yet in Chapter 4, the assessment provides a probability of tailings dam failure at 1 in every 2,000 mine years.

RESPONSE: Mitigation measures were included in the draft assessment and are more clearly identified in the revision. Analysis of alternative mitigation measures would be part of a permitting process and is outside the scope of this assessment. A discussion of compensatory mitigation in the Bristol Bay watershed has been added as Appendix J in the revised assessment.

While failures of a TSF might be rare, they do happen, their effects may be very damaging, and they could be devastating to local communities; thus, the assessment evaluates what risks might be evident should such an event occur. The revised assessment also expands the evaluation of risks for some lesser magnitude, but higher probability, events.

The reorganization of the assessment improves the discussion about when and where mitigation measures might enter the regulatory process and the addition of several additional system failures brings more balance to the TSF failure analysis. The level of detail of the TSF analysis still might present the reader with the sense that the impacts from this type of system failure can be modeled or predicted beyond actuality.

The assessment identifies the interconnectivity of groundwater, surface water, and fish habitat as being a major component of the quality of the fishery in the watershed yet puts relatively little effort into the analysis of the detailed relationships between groundwater, surface water, water quality, and fish habitat, even though this is likely the most important factor in assessing the potential impacts of mining activities on the fisheries in the watershed.

RESPONSE: We lack the data to demonstrate this interconnectedness in a spatially and temporally uniform manner, but do include examples of known points of high connectivity and modeled locations of high groundwater-surface water interaction (Chapter 7).

The addition of Figure 7.14 improves the understanding of some of these relationships. More effort could be put into bringing this information forward given its importance to understanding the watershed and fish habitat.

Additional mine scenarios and a more detailed investigation of the geomorphology, surface, and groundwater hydrology and their relation to fish habitat would provide the reader with a more accurate and more useful scope of analysis.

RESPONSE: We now describe the broad geomorphic context for stream habitat in the Nushagak and Kvichak River watersheds by characterizing gradient and watershed terrain (Chapter 3). The revised scenarios include an additional mine size (representative of the worldwide median size).The revision includes more failure scenarios (e.g., diesel pipeline failure, quantitative water treatment failure, and refined seepage scenarios) and explains why these particular failure scenarios were chosen.

The addition of the stream characterization in Chapter 3 and the analysis of the 0.25 mine scenario are major improvements.

Courtney Carothers, Ph.D.

Synopsis: EPA's draft document examines the potential impacts of large-scale mining development on the quality, quantity, and genetic diversity of salmonid fish species in the Nushagak River and Kvichak River watersheds of Bristol Bay, Alaska. To the extent that both wildlife and Alaska Native communities in the region depend upon salmonids, fish-mediated impacts to these other "endpoints of interest" are also explored. A hypothetical mining scenario, informed by current exploration, planning, and study in the Pebble deposit area, is described using minimum and maximum estimates for mine production and includes the construction of a transportation corridor to Cook Inlet. Even in the absence of any failures or accidents, construction and operation of such a mine would have significant impacts to salmonids in stream systems proximate to the mine footprint with some related impacts to wildlife and human communities. At least one or more accidents or failures are expected to occur over the long lifetime of the mine. Immediate and long-term severe impacts to salmonids are expected to occur with any significant failure, with relatedly pronounced impacts to wildlife and Alaska Native communities in the region. Multiple mines in the region would amplify these impacts.

RESPONSE: No change suggested or required.

General impressions: Overall, the main report is well-written and presents information in multiple ways, including: narrative, conceptual models, images, figures, and tables. The report synthesizes a large amount of information, much of which is described in detail in the report's appendices. The report highlights the unique characteristics of this watershed: incredibly productive and sustainable salmon fisheries, relatively little large-scale modification of the natural environment, and active subsistence-based indigenous cultures still occupying their homelands and many still using their Native language. Making central these features of the watershed, the tone of the report suggests that some negative impacts to salmonids, wildlife, and Alaska Native cultures are necessarily expected to accompany any large-scale mining development and operation in this region.

RESPONSE: No change suggested or required.

The document should provide a clear articulation of the scope of human impacts considered in this assessment. The main report considers only *fish-mediated* impacts to *Alaska Native cultures*. The restriction of scope to only fish-mediated impacts should be further clarified. A host of social, cultural, and economic impacts would accompany large-scale mining development in this region. These direct and indirect human impacts, both positive and negative, were the focus of many public comments on the EPA draft document, yet they fall outside of the scope of consideration in this report. If the narrowed scope of fish-mediated impacts is justified, these other impacts should be clearly identified as outside of the scope of this report. At times in the report (e.g., p. 5-77), these other impacts are superficially mentioned. Unless a full treatment of these impacts is included (including a presentation of a large literature explores these impacts internationally, e.g., Ballard and Banks 2003), this cursory discussion should be removed. If maintained, the narrow scope should be reiterated throughout the report to remind the reader that these larger human impacts are not considered.

RESPONSE: The scope of the assessment has been more clearly articulated in Chapter 2, which also now contains an overview conceptual model diagram demonstrating which potential sources, stressors, and responses associated with large-scale mining were considered outside of scope. The fact that direct impacts to Alaska Native cultures are not within the

scope of the assessment does not imply that they will not occur or that they are unimportant, and this has been clarified in Chapters 2 and 12.

The report should articulate more clearly why Alaska Native cultures are the only human groups included in the assessment of fish-mediated human impacts. The report notes: "because…Alaska Native cultures are intimately connected and dependent upon fish, …the culture and human welfare of indigenous peoples, as affected by changes in the fisheries are additional endpoints of the assessment" (ES-1-2). This suggests that the limitation of fish-mediated human considerations to Alaska Native cultures is not due to government-to-government relationship between tribes and the federal government, nor the special status afforded by environmental justice concerns, but rather because of their close connections to, and dependence on fish. Arguably, other human groups also have connections to fish and depend upon on salmon in this region in various ways, but are excluded from analysis of potential impact in this report. This comment is not meant to detract from the importance of the focus on Alaska Native cultures and the primarily indigenous communities in this region for assessing fish-related impacts. Rather, the comment is made to suggest the inclusion of a clear justification for this focus, or the broadening of scope to include other human groups who are also connected to, and dependent upon, salmon in this region (e.g., substantial information on the economic dimensions of salmon resources in this region is summarized in Appendix E, but little is presented in the main report). Additionally, the assessment of fish-mediated effects to Alaska Native cultures is primarily focused on subsistence fisheries. More discussion of the role of commercial engagements in salmon fisheries (e.g., commercial harvesting, processing, recreational fishing businesses and employment) in the watershed communities in this region would be helpful.

RESPONSE: EPA focused on the Alaska Native communities in response to the original request we received from nine federally recognized tribal governments. The text (Chapter 12) has been expanded to acknowledge the strong cultural ties of many non-Alaska Natives to the region, and potential effects on all residents from loss of a subsistence way of life. However, the focus of the assessment remains on effects on indigenous cultures. The importance of the commercial fishery to the regional culture has been added to the text.

<u>Dennis D. Dauble, Ph.D.</u>

Overall, the main report and each of the accompanying appendices were well written. I was unable to identify major inaccuracies or bias in the material as presented. There were shortcomings in the main report, however. For example, some topics would benefit by being expanded (Sections 5.6 and 8.7), while others have more detail than appeared necessary (Section 6.1). The assessment effectively addressed three appropriate time periods: (1) operation, (2) post-closure, and (3) perpetuity. Potential effects are bounded by a minimum and maximum mine size, which is also appropriate. Inclusion of inference by analogy strengthened the conclusions reached in the assessment and helped validate results obtained from model predictions.

RESPONSE: Previous Section 5.6 (wildlife and culture) has now been expanded and treated as a stand-alone chapter (Chapter 12). The summary of risks from the mine scenarios

(previous Section 8.7, now Chapter 14) has been expanded to include fish-mediated risks to wildlife and culture, and more numerical results are included.

Most figures and tables were useful. The conceptual models and accompanying illustrations of potential habitat effects (Figs 3-2A and C) are important because they provide a view of complicated pathways and relationships among potential activities and environmental attributes. However, these relationships are not revisited in any detail later in the document. I recommend discussing the conceptual models in more detail in the main report (Section 3.6) and summary section in Chapter 8.

RESPONSE: Additional information on the use of conceptual models throughout the assessment has been incorporated into Chapter 2. The more comprehensive conceptual models presented in Chapter 6 (previously in Chapter 3) have been broken into their relevant component parts throughout the risk analysis and characterization chapters, to better frame the specific pathways addressed in each chapter.

The Integrated Risk Assessment (Chapter 8) did a creditable job of summarizing habitat losses and risks from mine operations. What is missing, however, are quantitative descriptions of habitat lost relative to total habitat available in the larger watershed and individual systems. Habitat loss should be further discussed in terms of salmonid life stage and productivity (i.e., not all stream miles are equal).

RESPONSE: Unfortunately, no salmon habitat characterization is available for the region. The State of Alaska has not even identified all anadromous streams in the region. Productivity data are not available, even for the streams studied by the PLP. However, the revised Chapter 14 contains tables summarizing habitat loss in stream lengths and wetland areas.

If anything, the conclusions could be strengthened. The summary of uncertainties and limitations (Section 8.5) dwells on things that “could not be quantified” due to lack of information, model limitations, or insufficient resources. Thus, this reader was left somewhat in limbo as to the potential magnitude of effects from mining activities. (Note that this “neutral voice” is carried throughout the Executive Summary). Many people might interpret such statements of uncertainty as no proven effect. My point is that probable environmental consequences of mining activities are much greater than this report alludes to, given that consequences <u>are</u> <u>likely,</u> even if their magnitude is “uncertain.”

RESPONSE: We use a neutral voice throughout the document to convey the neutral scientific perspective of this scientific assessment. We tried to convey the qualitative likelihood of occurrence when quantitative probabilities were not obtainable. This section has been edited in Chapter 14 of the revised version to make the relationship between uncertainty and probability of occurrence clearer.

Section 8.7 is perhaps the most important section of the report. It should be comprehensive, i.e., cover all resources and be more quantitative. Missing from the summary were impacts on wildlife, human culture, resident fish, and other ecological resources. Essential details from Appendices A, C, E, F, and I, for example, could be synthesized and moved into the main report.

RESPONSE: The summary of risks from the mine scenarios (Chapter 14 in the revised version) has been expanded to include fish-mediated risks to wildlife and culture and more numerical results.

Gordon H. Reeves, Ph.D.

The purpose of the report is unclear, which makes it difficult to assess. The report focused on the potential impact of a hypothetical mine on salmon and salmon habitat in two watersheds in Bristol Bay, AK. However, it is not clear whether the analysis was intended to be a case study of the potential impacts of a hypothetical mine under the various scenarios presented or whether the intent was to develop a framework for assessing mining scenarios. These are two very different objectives, which makes it critical that the purpose be clearly stated in the beginning of the document so that reviewers and others understand the purpose of the document. There certainly was much confusion among members of the review panel and the people who commented on the report because of this.

RESPONSE: We have clarified the purpose of the assessment in Chapters 1 and 2.

I think that the credibility of the report could be improved substantially if the analyses were formalized and more clearly articulated and defined. The authors could consider using a decision support process, such as a Bayesian approach (see Marcot, B.G., J.D. Steventon, G.D. Sutherland, and R.K. McCann. 2006. Guidelines for developing and updating Bayesian belief networks applied to ecological modeling and conservation. Canadian Journal of Forest Research 36: 3063-3074). This would provide more transparency to any analysis and allow others to better understand how results and conclusions were derived. Also, it would identify critical relations that should be considered and provide insight about the consequences of not considering them. This will undoubtedly take additional time and effort, but I believe it would be well worthwhile. Examples of where such analysis has been done are in: (1) Armstrup et al. 2008. A Bayesian Network Modeling Approach to Forecasting the 21st Century Worldwide Status of Polar Bears. Pages 213-268. *In* E.T. DeWeaver et al., editors. Artic Sea Ice Decline: Observations, Projections, Mechanisms, and Implications. Geophysical Monograph 180. American Geophysical Union, Washington, D.C.; and (2) Lee, D.C. et al. 1997. Broadscale Assessment of Aquatic Species and Habitats. Vol. III, Chapter 4. U.S. Forest Service, General Technical Report PNW-GTR-405. Portland, Oregon.

RESPONSE: Creating a Bayesian Belief Network would require that the Agency convene experts to subjectively estimate the probabilities of each transition in the conceptual models. In contrast, this assessment is intended to elucidate the risks from potential mining based on available data and analyses of those data.

I thought one of the strongest aspects of the report were the conceptual diagrams of relations between the various aspects of the development and operation of a mine and the components of the ecosystem that influence salmon and their habitat (Chapter 3). These diagrams show the components of the ecosystem, the relation among them, and how mine impacts could potentially influence given parts of the ecosystem directly or indirectly as a result of cascading effects. They are a good first step in developing a decision support framework, as suggested in the previous paragraph. There was, however, little discussion about them in the text and it was not clear if or how they were used or considered in the analyses. The authors should, at the very least, clearly identify which parts of the networks were considered and why these particular avenues were pursued and others were not. This would provide additional insights into potential limitations of the analyses and results.

RESPONSE: The more comprehensive conceptual models presented in Chapter 6 (previously in Chapter 3) have been broken into their relevant component parts throughout the risk analysis and characterization chapters, to better frame the specific pathways addressed in each chapter.

If this was a case study, the report appeared to have considered available literature and reports on all aspects of the mine, its operation and the parameters that could be affected by it. I am not familiar with this literature so it is not possible for me to comment on the adequacy of the literature and reports considered. Assumptions about the location and operation of the mine seemed reasonable and the authors clearly articulated limitations of available data and other information concerning the mine's location and operation. I found the consideration of the mine during the various phases of development and operation and the discussion about potential development of other mines in the area particularly insightful. Inclusion of experiences from other mining operations was also helpful in understanding the conclusions about potential impacts of the mine and its operation over time. Additionally, the consideration of the potential development of other mines in the area was particularly insightful and provided a good picture, albeit not in depth, of potential cumulative effects on aquatic resources in the Bristol Bay area.

RESPONSE: No changes suggested or required.

Parts of the report on the ecology of fish and aquatic ecosystems, road, and culverts – topics that I am familiar with – were covered very well and the conclusions about potential impacts of the mine and its operation generally seemed justified. The authors presented available data and information on fish distribution and abundance relative to the presumed location of the various components of the mine operation. Their analyses were appropriate but rather cursory, which is not unexpected given the restrictions of time and available data. However, there are some additional considerations and analyses that could be done, which I think would improve the report. I identify these in answers to specific charge questions. Limitations of the results were readily acknowledged. However, as mentioned above, there are additional limitations that resulted from only considering selected potential avenues of impacts. These should be discussed in the revision.

RESPONSE: The discussion of scope (Chapter 2), endpoints (Chapter 5), and uncertainties (throughout the risk analysis and characterization chapters) has been expanded in the revised assessment.

The authors do a good job of summarizing the scientific literature on salmon ecosystems, roads, and culverts. Most of this is from studies in areas outside of Bristol Bay. Interpretations of the findings were accurate. However, there was no discussion about potential limitations on the application of the studies to the area being considered. For example, Furniss et al. (1991) deals with roads in forest and rangeland settings. These are very different environments than Bristol Bay, which suggests that road impacts will likely differ. Much attention is given to "headwater streams" and their ecological importance (p. 5-19 – 5-21). Headwater streams for the area of consideration need to be defined so that appropriateness of the application of the literature can be better judged.

RESPONSE: Headwater streams in the study area are now more fully described (Chapter 7). Because the potential mining described in the assessment would take place in an undeveloped area, much of the literature is necessarily from areas outside of Bristol Bay. However, to the extent possible we used examples from representative environments. With respect to Furniss et al. (1991), though it focuses on forest and rangeland roads, it is a seminal publication on the potential effects of roads, particularly as they relate to salmon. The general conclusions of that paper should be applicable to the transportation corridor described in the assessment.

A major component that is missing from the report is consideration of the potential impacts of climate change. Climate change is identified as a factor in the conceptual model of potential habitat and water quality effects associated with mine accidents and catastrophic failures (Fig. 3-2D). However, I believe that it is a key factor that will have influence in all aspects of the assessment, not just failures and natural disturbance events (Fig. 3-2C). It needs to be considered in other aspects, such as water quality and availability. Climate change should also be included in any analysis because it will be critical to build it into any monitoring program that is developed in order to be able to differentiate its impact on salmon and their habitat from potential impacts of the mine.

RESPONSE: Climate change projections and potential impacts are now included in Chapter 3 (Section 3.8). It is mentioned as an important external factor in the risk analyses presented in Chapters 7, 9, and 10, and the issue is summarized in Box 14-2.

<u>Charles Wesley Slaughter, Ph.D.</u>

The Assessment (Volume 1 – Main Report) provides a fairly comprehensive review of fisheries-driven issues, from the perspective of salmonids. Appendices (Volumes 2 and 3) are very informative. The high significance of the Bristol Bay watershed, specifically of the Nushagak and Kvichak river systems, for commercial fisheries on the global scale and for sport and subsistence fisheries at the regional and local scales, was appropriately described.

RESPONSE: No changes suggested or required.

The potential risks and impacts are fairly and succinctly stated. Given the extremely long-term nature of the projected Pebble project, and the irreversible changes which would be imposed to the region, the risks seem, if anything, understated. I attribute this to the decision to focus this Assessment on salmon and anadromous fisheries, with less attention on "salmon-mediated" impacts – i.e., effects on indigenous culture, on wildlife other than salmon, etc.

RESPONSE: No changes suggested or required.

Chapter 2 (Characterization of Current Condition) provides only a superficial overview of the landscape of the Bristol Bay watersheds; a reader would preferably have access to Wahrhaftig (1965) or Selkregg (1976), as only two (relatively dated) suggestions, to gain a more comprehensive understanding of the region.

RESPONSE: Additional information on the physical environment of the region (e.g., geology, vegetation, etc.), along with an expanded treatment of the regional landscape, has been incorporated into Chapter 3 (e.g., Figures 3-4 through 3-7). Chapter 3 also includes the suggested citations.

The "Water Management" section (4.3.7) seems cursory, highly generalized, and optimistic. Statements such as "uncontrolled runoff would be eliminated"; "water from these upstream reaches would be diverted around and downstream of the mine where practicable"; and "Precipitation…would be collected and stored…" do not indicate actual (proposed) practices or techniques, nor inspire confidence that actual runoff events during "normal" conditions, let alone during hydrologic extremes (such as a rain-on-snow event with underlying soils still frozen), would be planned for or actually managed adequately.

RESPONSE: Water management measures are more clearly described and discussed in Section 6.1.2.5 of the revised draft, and in sub-sections for the mine components in the scenarios. The assessment no longer contains a no failure scenario, so complete water collection is not longer assumed. Rather, standard and common practices are incorporated.

Perhaps I missed it, but I found no acknowledgment of the potential presence of or consequences of perennially frozen soils – permafrost – in the Bristol Bay watershed, or more specifically in the Pebble ore deposit locale or the proposed transportation corridor. Selkregg (1976), Fig. 136, shows soils of the Pebble locale as INT/2g, INT/1g – HYP, or SOU/2g-HYP – that is, well-drained gravelly soils (INT) or well-drained acidic soils (SOU) with interspersed peaty, poorly-drained shallow discontinuous permafrost. There is abundant literature on the influence of permafrost on engineered structures, roads, hydrology, etc. Even if the bulk of the terrain involved in the proposed Pebble mine, road and infrastructure project is founded on well-drained gravelly soils, any interspersed permafrost-underlain terrain can prove problematic in terms of landscape stability, potential erosion, and consequent structural, engineering, hydrologic and water quality issues. See Specific Observations for a few suggested references in**.**

RESPONSE: We have expanded our characterization of the soils and permafrost distribution in the Bristol Bay watershed in Chapter 3 of the revised assessment. As part of this expansion, we summarize the nature and distribution of permafrost by physiographic region.

While there is extensive discussion of a proposed transportation corridor, there was no mention of construction of a major airfield. A project of this magnitude would undoubtedly require development of a facility in close proximity to the mine(s) capable of handling C130 and commercial jet passenger and cargo traffic, at least to the 737 class, if not 747. I don't know what the footprint for such an airfield would be, but it would be substantial, and with requisite roads, fuel handling, etc., would be a major project in itself. This would seem to be a logical component of a comprehensive assessment of the potential Pebble project.

RESPONSE: The scope of the assessment has been clarified in Chapter 2, and construction and operation of a new airport is considered outside the scope of the assessment. We would expect that a full evaluation of any future mining permit applications and subsequent National Environmental Policy Act Environmental Impact Statements would consider these effects if a new airport is proposed.

As noted in the Executive Summary, the Assessment does NOT address several major components of the (hypothetical) Pebble project, including electrical generation and transmission, a deep-water port, or "secondary development" and associated infrastructure which would follow an initial mining project. A truly comprehensive analysis should incorporate full analysis of these aspects. This Assessment is thus inadequate in terms of considering potential broader consequences for the Bristol Bay watershed system.

RESPONSE: The scope of the assessment has been clarified in Chapter 2, and we have stated throughout the text that areas outside of scope may also be important factors.

John D. Stednick, Ph.D.

The purpose of the document is not clearly stated in either the Executive Summary or the Introduction. Need to specifically identify the document as an environmental risk assessment. There is a misconception that it is a CWA Section 404(c) review, rather than an environmental risk assessment. The document should have the utility to inform future users of the risk to the watershed resources from mining activities in the watershed. The assessment can be used by others for decision making purposes, and includes current and appropriate methodologies for all identified stressors, such that study results can be duplicated. And all stressors are evaluated to a similar level of detail.

RESPONSE: Additional information on both the purpose of the assessment and ecological risk assessment (ERA) in general has been added to Chapters 1 and 2, as well as the Executive Summary. Section 1.2 includes information about the use of the assessment. The assessment has been reorganized into two major sections (problem formulation, risk analysis and characterization) to clarify where different chapters fall in the typical ERA process.

The document characterizes the potential environmental effects of an open pit mine over a copper porphyry complex in southwest Alaska using a hypothetical mine design based on similar ore deposits and mine complexes elsewhere. Proposed mine activity has been identified by the Pebble Limited Partnership though Northern Minerals Dynasty and should be cited to improve applicability of the risk assessment. Furthermore, a wider range of mining scenarios should be developed and analyzed for environmental risk assessment. Environmental consequences were estimated by the environmental risk assessment model approach for both 'no-failure' and 'failure' scenarios. The Executive Summary concluded that the effects of mine development resulted in significant salmon habitat losses. Potential effects on other aquatic species were not identified. The assessment evaluated environmental risks under the development and closure scenarios using large catastrophic events and did not include smaller, yet more frequent excursions or system failures. Nor did the assessment look at the full range of mine development scenarios, specifically what are the risks associated with a smaller underground operation?

RESPONSE: The assessment used the Pebble deposit and its characteristics, as described by Northern Dynasty Minerals in the Ghaffari et al. (2011) report. That report is cited extensively in both the original review draft and the revision. A median-sized mine (based on worldwide mine sizes) has been added to the scenarios in the revised assessment. Because the number of potential failures is extremely large, it is necessary to choose a representative set of failure scenarios. The final document includes more failure scenarios (e.g., diesel pipeline failure,

quantitative water treatment failure, and refined seepage scenarios) and explains why the particular failure scenarios were chosen. Underground mining is a potential for any mining site that has high-quality ore located at depth, but sources of potential impact considered in scope for the assessment would be common for either a surface or an underground mine (e.g., water withdrawal, tailings dam failure, water treatment failure, seepage, etc).

The conclusions of the Executive Summary are strongly worded (e.g., pages ES 13 to 24), yet the uncertainties presented later in the report make the strong conclusions tenuous. An expanded discussion of uncertainties and limitations may temper those 'conclusions.'

RESPONSE: Each risk analysis chapter of the revised assessment now includes an uncertainty section. The Executive Summary has been rewritten to reflect the revised assessment text.

Site characterization/description of current conditions is too brief. More information is needed for a full site characterization. Any reader unfamiliar with the setting would not fully understand the physical, biological, or ecological inventories and linkages in the study area. The risk assessment of failure and no failure are covered in Chapters 5 and 6 with varying levels of detail and substantiation of conclusions. Statements like "salmon is important in the human diet, thus a salmon loss affects human health" seem like a weak argument, especially when additional information in the appendix suggests a larger effect.

RESPONSE: Additional information on the region's physical environment has been added to Chapter 3 (e.g., Figures 3-4 through 3-7), and additional information on the region's biological communities from Appendices A through C has been incorporated into the main text. The purpose of the appendices—to provide the detailed background characterization necessary for the ecological risk assessment—has also been clarified in Chapter 2.

The Pebble Limited Partnership has a large environmental baseline database (EBD), but does not appear to be cited or used. Justification for the inclusion or exclusion of these data should be made. Reference is often made to various data, but these data were not presented.

RESPONSE: The EBD was used and cited more than 70 times in the May 2012 review draft and even more in the revised assessment. Data from the PLP EBD concerning hydrology, water quality, and biology of the streams on the site and along the transportation corridor have been extensively incorporated into the assessment in the analyses in Chapters7 through 11. However, to the extent possible, the assessment relies on peer-reviewed literature.

Review and revise the water balance section, which would include: 1) generating a diagram or conceptual figure similar to page 3-7 to illustrate the potential effects of mine construction and operation on surface and groundwater hydrology; 2) developing a quantitative water balance for surface and groundwater resources; 3) incorporating seasonality (especially assessing the role of frozen soil); 4) identifying hydrologic processes and their associated values (e.g., mm/yr) for each component of the water balance in time and space, and then incorporating into a landscape characterization; 5) demonstrating the interconnectedness of groundwater, surface water, and the importance to fish habitat and stream productivity; 6) evaluating the influence of global climate change on these hydrologic processes and rates; and 7) using this characterization demonstrate the expected hydrologic modification associated with the mine scenarios and infrastructure development and closure scenarios.

RESPONSE:
1) We included schematics to illustrate potential effects of mine construction and operation of surface hydrology, including effects via groundwater changes (e.g., Figure 6-5, Figures 6-8 through 6-10).
2) Our water balance focuses on surface water hydrology (including interactions with groundwater). A comprehensive groundwater hydrology water balance is beyond the scope of the assessment.
3) The core of our analyses is an annual water balance, but we have maintained the simple approach to seasonality used in the first draft of the assessment.
4) We have adopted a basic approach to representing the dominant hydrologic processes at the mine site; a comprehensive representation of all hydrologic processes is beyond the scope of this assessment.
5) Throughout the assessment, we have identified and quantified the interconnectedness of surface water, groundwater, and their importance to fish habitat and stream productivity.
6) A section on potential climate change effects has been added to Chapter 3.
7) We have used our updated water balance and hydrologic modeling approaches to estimate expected responses of mine scenarios, infrastructure development and closure scenarios.

One common theme that emerged from the public comment session during the peer review meeting in Anchorage, AK was the questioning of the document timing, from draft release to the public comment period to the unannounced completion of a final document. These concerns should be addressed in the new document.

RESPONSE: This type of contextual information is not directly relevant to the ecological risk assessment, but clarification of the timing and use of the assessment has been included in Chapter 1.

Roy A. Stein, Ph.D.

Accuracy of Presentation. Overall, I was pleased with the accuracy of the presentation. Typically, peer-reviewed citations to the scientific literature were cited as supportive documentation for most all of the factual information (though the well-developed appendices, e.g., Appendix E: Economics; Appendix I: Mitigation, could be used to far better advantage, see below). Unfortunately, in the main report, many data are missing, especially with regard to salmonid populations, their diversity (both across species wand within species across populations), their relative population sizes, their distribution across the watershed, their vital rates (i.e., recruitment, growth, and survival across life stages), and to what extent the Pebble Mine and its associated activities will reduce these populations (for there is no question they will indeed be reduced through both the mine footprint and all allied operations in the drainage), both through impacts on individual populations and the overall production of salmonids (and other fishes) in the Bristol Bay watershed.

RESPONSE: We now include figures showing reported salmon species distributions and salmon diversity by HUC-12 watersheds across the Nushagak and Kvichak River watersheds (Figures 5-3 through 5-8). Information on population sizes and vital rates are limited for the region, but are reported where known. Due to lack of comprehensive estimates of limiting factors across the impacted watersheds, population-level effects could not be quantitatively estimated except for the most severe cases, where total losses of runs could be reasonably assumed.

Whereas I am relatively confident about accuracy of the fisheries information included, I cannot comment in detail regarding the accuracy of the mining information or impacts on the Native Alaskan cultures (though the impact of the mine on this culture was confined to fish-mediated effects). That a Native Alaskan culture 4,000 years old is in jeopardy bothers me greatly; might this complete subsistence way of life in the Bristol Bay watershed be eliminated with the exploitation of the copper via open-pit mining? In turn, what impacts might there be on subsistence users, other than Native Alaskans? Even though these sections seemed reasonably well presented (with caveats above) and appropriately supported with citations, they do lie beyond my expertise.

RESPONSE: No changes suggested or required.

My concerns about the document revolve around issues that were not considered, i.e., Global Climate Change, "In Perpetuity" issues, groundwater-surface water exchange issues (owing to missing information), impacts of Routine Mine Operations in a more realistic setting, the seemingly undue influence on a failure of the Tailings Storage Facility, and other somewhat more minor issues (see comments below). With any revision, the authors should include this information by eliminating redundancy (see below), thereby not increasing document length.

RESPONSE: We have thoroughly revised our approach to quantifying hydrologic responses to the mine scenarios. We explicitly include groundwater-mitigated effects on surface waters. Climate change projections and potential impacts are now included in Chapter 3 (Section 3.8), and are considered as important external factors in the risk analyses as summarized in Box 14-2. See responses to the commenter's specific comments and to Dr. Stednick's hydrologic comments below.

<u>Clarity of Presentation</u>. Generally speaking, I believe that the writing was intelligent, reasonably insightful, and, more specifically, on task. One significant criticism with regard to the presentation revolves around the organization of the document. As detailed below, the organizational scheme lent itself to redundancy, from the Introduction through the various chapters to the Integrated Risks Characterization chapter. Owing to this redundancy, the report is likely too long by about 20% and any revision and shortening should serve to improve its impact on readers.

RESPONSE: The assessment has been reorganized to eliminate redundancy and help clarify the structure of the document.

The conceptual block and arrow diagrams (pages 3-7 to 3-11) were quite instructive. They nicely demonstrate the interactions that occur within this mining scenario. The main report would be much improved if text were to review this set of interactions. Clearly, a tremendous amount of time, effort, and thought went into generating these diagrams and it is indeed a true shortcoming of the main report that essentially no text was spent stepping through these diagrams.

RESPONSE: Additional information on the use of conceptual models in the assessment has been incorporated into Chapter 2. The more comprehensive conceptual models presented in Chapter 6 (previously in Chapter 3) have been broken into their relevant component parts throughout the risk analysis and characterization chapters, to better frame the specific pathways addressed in each chapter. Additional conceptual models considering impacts on wildlife, Alaska Native populations, and cumulative effects of multiple mines have been added to Chapters 12 and 13.

Soundness of Conclusions. The conclusions were well supported, where there were published data to support them. Many statements that could be interpreted as conclusions were often more qualitative than desirable in a review document such as this one, owing to the lack of information (percent of salmonids lost owing to routine mine operations, impacts of mining and the transportation corridor on wetlands, extent of groundwater-surface water disruptions, just to name a few). Consequently, the soundness of the conclusions are somewhat compromised by a lack of information.

RESPONSE: No changes suggested or required.

In addition, what would aid readers is a succinct statement of the purpose (risk assessment?, impact on water quality and then through to fishes and beyond?, etc.) and scope (relatively narrow impact of the mine on salmonids and ripple effects out from there) of the document early in the initial chapter. In so doing, both reviewers and readers will be informed as to the direction of the document and thus better informed as they move through the document.

RESPONSE: Additional information on both the purpose of the assessment and ecological risk assessment (ERA) in general has been added to Chapters 1 and 2, as well as the Executive Summary.

Finally, a portion of the public testimony complained about the process, specifically about the time allowed for document review, the data reviewed, the validity of the hypothetical mine, etc. Though I found most all comments to be somewhat disingenuous, I still would offer the following advice: Provide a section upfront that deals with process issues surrounding the review, i.e., explaining the constraints under which EPA was operating; without a section like this, complaints, such as those described above (coming from just one segment of the public), will go unanswered.

RESPONSE: Chapters 1 and 2 now clarify the purpose of the assessment and document how public participation was incorporated into the process (e.g., Box 1-1).

William A. Stubblefield, Ph.D.

The document, "An Assessment Of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska," is a well-written, comprehensive document that employs a risk assessment-type approach to an *a priori* evaluation of potential environmental effects on the ecosystem and potential receptor species (e.g., salmon) that may be affected by a potential copper mine located in the Bristol Bay area of Alaska. This document is somewhat unique, in that no actual mine has been proposed at the location and few site- or project-specific data are available. Therefore, no specific information about development plans and potential operational and closure activities associated with the mine are available. Rather, the authors have attempted to develop a hypothetical mine and attempted to assess possible environmental effects associated with mine development, operation, and closure. Although interesting, the potential reality of the assessment is somewhat questionable. It is also unclear why EPA undertook this evaluation, given that a more realistic assessment could probably have been conducted once an actual mine was proposed and greater detail about operational parameters available. The approach taken in the document attempted to be comprehensive and evaluated a variety of scenarios that may affect aquatic resources in the Bristol Bay region. Given the importance of salmon populations in the area, both from a financial and societal perspective, it is important that a comprehensive evaluation of potential environmental effects associated with mine development and operations be conducted. The authors have attempted to conduct such a comprehensive evaluation and have attempted to quantify (to the extent possible) the probability of adverse effects occurring. Implementation of this approach is proper, and with the correct data, can provide a comprehensive evaluation of potential environmental effects. Unfortunately, because of the hypothetical nature of the approach employed, the uncertainty associated with the assessment, and therefore the utility of the assessment, is questionable.

RESPONSE: The EPA respectfully disagrees that the hypothetical nature of the approach compromises the utility of the assessment. All mining plans are hypothetical. They change in response to the results of assessments, regulatory requirements, public input, and unforeseen conditions and events. They cease to be hypothetical only after the mine is closed. At every step in the process, assessments of the current plan are useful even though plans will change. This assessment is based largely on a preliminary plan, published by Northern Dynasty Minerals (Ghaffari et al. 2011). Although layout of mining components in a future mine plan may differ somewhat from the preliminary plan or the EPA scenarios, the main components of mining would remain the same for open-pit mining (and underground mining would face the same waste issues).

A variety of uncertainties and data needs were identified as a result of this effort and this alone may provide sufficient value to justify the document and approach. For example, the authors note that there is not an abundance of chronic toxicity data considered in deriving the EPA's ambient water quality criteria for copper and that there is an uncertainty associated with whether the biotic ligand model (BLM) adequately protects species of concern in Bristol Bay. It would seem appropriate for EPA (perhaps in concert with industry) to develop the data to improve our understanding of copper toxicity and to ensure that regulatory standards are, in fact, appropriate for their intended use. A substantial body of data evaluating copper chronic toxicity has been developed by the copper industry as a result of regulatory requirements driven by the European REACH regulations. It may be beneficial for EPA to examine these data, thus resulting in a reduction in any uncertainty associated with the evaluation of environmentally acceptable metals concentrations. It should also be noted that similar datasets and biotic ligand models exist for number of other metals that may be of concern at the Bristol Bay site.

RESPONSE: The EPA has examined the EU's 2008 Voluntary Risk Assessment of Copper (the relevant REACH document). Although they do derive a chronic species sensitivity

distribution, it is because of the way they include and aggregate data, rather than the generation of new data. In particular, they have no data for sensitive aquatic insects, so the EU does not resolve that problem. The BLM was used for copper because copper is the contaminant of greatest concern and because the copper BLM has been approved by the EPA Office of Water. Other metals with BLMs, such as zinc and nickel, occur at much lower levels in leachates.

One suggestion that would improve the document is that EPA should include a basic description of the risk assessment process and the relationship between the risk assessor and the risk manager, i.e., the decision maker. They must include a discussion of why the assessment is being conducted, the decisions that will be informed, and what information they need from the risk assessor.

RESPONSE: Additional contextual information for the assessment has been included in Chapter 1, and additional information on ecological risk assessment has been incorporated into Chapters 1 and 2. The assessment has also been restructured into problem formulation and risk analysis and characterization sections, to make the assessment's structure as an ecological risk assessment clearer.

Taken from the USEPA's Guidelines for Ecological Risk Assessment (EPA630/R-95/002F; April 1998). Note 2nd sentence re: the role of the risk manager.

> *"2.1. THE ROLES OF RISK MANAGERS, RISK ASSESSORS, AND INTERESTED PARTIES IN PLANNING*
>
> *During the planning dialogue, risk managers and risk assessors each bring important perspective to the table.* ***Risk managers, charged with protecting human health and the environment, help ensure that risk assessments provide information relevant to their decisions by describing why the risk assessment is needed, what decisions it will influence, and what they want to receive from the risk assessor.*** *It is also helpful for managers to consider and communicate problems they have encountered in the past when trying to use risk assessments for decision making.*

In turn, risk assessors ensure that scientific information is effectively used to address ecological and management concerns. Risk assessors describe what they can provide to the risk manager, where problems are likely to occur, and where uncertainty may be problematic. In addition, risk assessors may provide insights to risk managers about alternative management options likely to achieve stated goals because the options are ecologically grounded."

RESPONSE: Section 1.2 in the revised assessment discusses uses of the assessment.

Dirk van Zyl, Ph.D., P.E.

Planning and designing a large mine, and especially one in a sensitive environmental setting such as Bristol Bay, involves many iterations before a design evolves that is provided for further public considerations. The EPA elected to use a design, developed for Northern Dynasty Minerals Ltd. in a preliminary assessment prepared following the guidance of National Instrument (NI) 43-101, as the basis for extensive evaluations in their risk assessment. The resulting risk assessment can be at best characterized as preliminary, screening level, or conceptual. There are both technical and process issues that must be addressed before this risk assessment can be considered complete or of sufficient credibility to be the basis for a better understanding of the impacts of mining in the Bristol Bay watershed.

RESPONSE: The EPA respectfully disagrees that the hypothetical nature of the approach compromises the utility of the assessment. All mining plans are hypothetical. They change in response to the results of assessments, regulatory requirements, public input, and unforeseen conditions and events. They cease to be hypothetical only after the mine is closed. At every step in the process, assessments of the current plan are useful even though plans will change. This assessment is based largely on a preliminary plan, published by Northern Dynasty Minerals (Ghaffari et al. 2011). Although layout of mining components in a future mine plan may differ somewhat from the preliminary plan or the EPA scenarios, the main components of mining would remain the same for open-pit mining (and underground mining would have the same waste issues).

With respect to the proposed transportation corridor, we note in the assessment that "Although this route (the one proposed in the EPA scenario) is not necessarily the only option for corridor placement, the assessment of potential environmental risks would not be expected to change substantially with minor shifts in road alignment. Along any feasible route, the proposed transportation corridor would cross many streams, rivers, wetlands, and extensive areas with shallow groundwater, including numerous mapped (and likely more unmapped) tributary streams to Iliamna Lake (Figures 10-1 and 10-2)."

There are a number of items that require specific attention prior to finalizing the report. While my comments below provide further details, from a global perspective the following aspects must be addressed:

- A better sense about the range of impacts from a mining project that use not only different technologies but also different lay-out options in its development than that assumed in the EPA Assessment;
- More attention to the use of appropriate order of magnitude numbers reflective of the quality of data, e.g. less accuracy is obtained when 1:62,500 scale vs. 1:12,500 scale maps are used;
- Correction of errors associated with misquoting and incorrect use of information in the literature; and
- A critical review and rewrite of the Executive Summary to reflect the tone, terminology, information sources and results of the main body of the report. One example of an error and one of inconsistent terminology are:
    - Page ES-10: "Thus, the mine draws on plans published by the Pebble Limited Partnership (PLP)", this is incorrect as the plans that were used were prepared for Northern Dynasty Minerals Ltd.
    - Page ES-10: "…our scenario reflects the general characteristics of mineral deposits in the watershed, contemporary mining technologies and best practices…" The main body of the report emphasizes on a number of occasions (such as Page 4-1, 4-17) that "Our mine scenario represents current good, but not necessarily best, mining practices".

My comments contained above and below are based on a single review of the report, i.e. contractual time constraints were such that I could not afford a second review of the report. It is therefore possible that there are other errors remaining in the report that I did not observe in my review. It is therefore recommended that after making these corrections and edits that EPA subject the report again to a rigorous independent review.

RESPONSE: The scenarios evaluated are meant to represent those expected to be present as typical for mining porphyry copper deposits of this type. Although layout of mining components at a site may differ somewhat from what we present in the scenarios, the main components of mining would remain the same for open-pit mining (and underground mining would have the same waste issues). Therefore, no change is required for technologies presented in the original assessment, and we have noted in the assessment that there could be different layouts than what we have presented.

Errors and inconsistencies in sections of the document are noted and have been corrected in the revised assessment. With regard to the terminology of "best", "good", or other terms for the practices used, what was intended to be conveyed is that we have assumed modern mining technology and operations. The terms are qualitative when generally interpreted, or have a regulatory meaning (for example, "best management practices" applies to the setting of stormwater control, but not specific to mining sites), and thus we have eliminated their use in the revised assessment. The assessment is being re-reviewed by the external expert reviewers.

Phyllis K. Weber Scannell, Ph.D.

My comments on EPA's draft document, *An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska,* follow a three-day peer review meeting in Anchorage, AK. On the first day of the meeting, the Peer Review Team heard testimony on the importance of the resources in the potentially affected area and on possible effects of mineral development on the fish and wildlife resources and on local residents. The issues of mineral development are complex, particularly with respect to protecting the environment and the interests of local residents. I understand and appreciate the complexity of these issues; however, the charge of the Peer Review Team is to review EPA's draft document, *An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska*, and offer suggestions to strengthen the report. My comments, included below, are focused on the accuracy and thoroughness of the draft document.

The document "An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska" and the accompanying appendices provide an in-depth and thoroughly documented description of the environment and resources of the areas under consideration for mineral development, although not in the entire Bristol Bay region. Appendices A and B are particularly thorough in describing the salmon and non-salmon fishes in the region; the discussion of species specific fish sensitivities to certain toxicants adds important information for future consideration of project development.

RESPONSE: No change suggested or required.

The assumptions for developing and operating large porphyry copper mine may not be aligned with features of a future mining project. Too much emphasis was placed on effects of catastrophic failures, such as failure of a tailings dam or pipeline, and too little emphasis on the need to identify and control seepage water, run-off from PAG (potentially acid generating) and NAG (not acid generating) waste rock areas, and water treatment.

RESPONSE: Because the number of potential failures is extremely large, it is necessary to choose a representative set of failure scenarios. The revised assessment includes more failure scenarios (e.g., diesel pipeline failure, quantitative water treatment failure, and refined seepage scenarios) and explains why the particular failure scenarios were chosen.

The document discussed effects of dewatering on suppressing stream flows and groundwater inputs but did not consider effects of the discharge of treated wastewater. The section on hydrology illustrates the need for more complete hydrologic information before any project development. The need for bypassing all clean water sources around a development site should be addressed.

RESPONSE: The revised assessment more clearly presents that clean water would be diverted around the site, retained in settling ponds, and released following settling and/or treatment, if required. Discharge of treated wastewater is analyzed and discussed in greater depth in the new Chapter 8, Water Collection, Treatment, and Discharge. The assessment is based on the best hydrologic information available for the site; however, additional hydrologic information may be available and/or acquired for any future mine plan in this watershed. We agree that detailed hydrologic information is critically important for responsible project development. We have updated our hydrologic analyses to represent the probable influence of mine scenarios on surface water/groundwater interaction.

As stated in my response to charge questions, I believe that the two most important questions for mineral development in this region are: can a mine be designed and operated for future closure? and, if not, is it acceptable to develop a large porphyry copper mine in a region of high value salmon habitat that will essentially require perpetual treatment? These two questions must be addressed when considering protection of the fish, wildlife, and human resources of the region.

RESPONSE: We agree that these are important questions to be addressed but they are risk management, not risk assessment, questions. The purpose of the assessment is to evaluate risks to the salmon fishery from large-scale mining. Risk management decisions will be made during the permitting process. No changes to the assessment were made in response to this comment.

Paul Whitney, Ph.D.

Response (with a wildlife perspective) – The main document is fish centric and it should be, given the importance of salmon in the Bristol Bay ecosystem. Wildlife (aquatic, wetland and upland species) and terrestrial resources related to potential mine and haul road impacts are glossed over. The summary write ups for several species of wildlife (Appendix C) are very good regarding natural history and some potential impacts. Information in Appendix C tends to focus on the proposed mine site and less on the proposed haul road and game management units in the Kenai Mountains.

RESPONSE: Direct effects on wildlife and terrestrial resources are outside the scope of the assessment, as clarified in Chapter 2. Effects on wildlife are now treated in Chapter 12.

USFWS RESPONSE: We acknowledge the comment regarding quality of Appendix C. Information in Appendix C is intended to focus on the entire Nushagak and Kvichak River watersheds to the extent that data exist. To the extent that a potential mining-related road is within the Nushagak and Kvichak River watersheds, information about selected wildlife species is included in Appendix C. Information about selected wildlife species on the Cook Inlet side of the Chigmit Mountains is not included in the wildlife report. The Kenai Mountains are not in the Nushagak and Kvichak River watersheds.

A variety of authors have obviously contributed to the documents and it appears that the direction given to them or their interpretation of goal statements varies. For example, if one of the goals of the assessment is to evaluate the risk to wildlife due to risk to fish (Executive Summary, page 1, last para) it's not clear why so much verbiage in Appendix C (wildlife) is devoted to species such as caribou that are not closely associated with fish. Information in Appendix C could be used to assess direct impacts if the scope of the assessment is expanded. For example, if the goal is to assess the impact of potential mining on the ecosystem (see Executive Summary page 1, para 1), the information on caribou in Appendix C is more relevant. The apparent diversity of goal statements cited in the main assessment gives mixed messages regarding the clarity of the presentation (see more detailed discussion below).

RESPONSE: As the commenter notes, the scope of the assessment is focused on potential risks to salmon from large-scale mining and salmon-mediated effects to indigenous culture and wildlife. EPA agrees with the commenter that direct effects on wildlife are likely to be important and that Appendix C (now a stand-alone USFWS document) provides useful information for an evaluation of direct effects on wildlife from large-scale mining. We would expect that a full evaluation of any future mining permit applications and subsequent National Environmental Policy Act Environmental Impact Statements would consider these direct effects. The revised assessment acknowledges the potential for direct effects on wildlife as well as risks due to fish, but states that these effects are outside the scope of the assessment.

USFWS RESPONSE: The scope of Appendix C is broader than that of EPA's assessment because it is a USFWS document prepared to serve various purposes, including statewide or regional land use planning, completion of environmental documentation for permitting of development projects, and activities related to Landscape Conservation Cooperatives in Alaska. The former Appendix C is now a separate USFWS report which is cited by the assessment but is no longer an appendix of the assessment. However, information in the USFWS report document has been used by EPA to provide a more complete assessment of overall watershed resources at risk due to potential mining, and to strengthen the assessment of risks to wildlife from fish-mediated effects of the mine in the revised assessment.

The charge question related to wildlife asks for an evaluation of the risk to wildlife due to the risk to fish. If the risk to fish cannot be quantified because there is little or no demographic information, then any evaluation of risk to wildlife can't be quantified and must be qualitative. Merely stating that a qualitative increased risk for fish will also result in a qualitative increased risk for wildlife is not adequate. I am not satisfied with such an obvious and general conclusion. I do not understand why the scope of the main document is limited to an indirect evaluation of fish-caused risk to wildlife. The following responses to charge questions leans more toward an ecosystem evaluation that includes, not only risk of fish to wildlife, but also risk of direct wildlife and vegetation loss to fish and other direct risks to wildlife, such as noise and human presence.

RESPONSE: EPA acknowledges that there are numerous potential direct risks to wildlife from large-scale mining. However, this evaluation is outside of the scope of the assessment. The revised assessment provides a clearer explanation of the reasons for its defined scope.

2. RESPONSES TO CHARGE QUESTIONS

Question 1. ***The EPA's assessment focused on identifying the impacts of potential future large-scale mining to the fish habitat and populations in these watersheds. The assessment brought together information to characterize the ecological, geological, and cultural resources of the Nushagak and Kvichak watersheds. Did this characterization provide appropriate background information for the assessment? Was this characterization accurate? Were any significant literature, reports, or data missed that would be useful to complete this characterization, and if so what are they?***

David A. Atkins, M.S.

Based on my general understanding of the watersheds, I consider the general background information presented in the Assessment accurate and sufficiently complete for the endpoints of this watershed assessment in the following areas:

- General view of Pacific salmon populations
- General view of resident (non-anadromous) fish
- Wildlife populations
- Native cultures

RESPONSE: No change suggested or required.

The Assessment also describes the current economics of the watershed, including commercial and sport fishing and subsistence activities.

RESPONSE: No change suggested or required.

Additionally, the report highlights several general aspects of the area that make the fishery unique in both its abundance and diversity:

- The unique hydrology of the area (strong groundwater and surface water interaction) that contributes to stable flows and temperatures favorable for salmon reproduction.
- The importance of anadromous fish in transferring marine-derived nutrients to upland areas and thus providing nutrients to areas that would naturally be nutrient poor.
- The lack of roads and infrastructure that make the area unique as one of the few intact ecosystems remaining in the world, and possibly unique for this type of fishery.

RESPONSE: No change suggested or required.

It would be helpful in the background section to better describe the uniqueness of the Bristol Bay watershed ecosystem in the Pacific Northwest. This could include a description of other similar ecosystems in the region that have undergone development and documentation of any changes in fish populations associated with this development. The Assessment does mention the Fraser River as an analogue, but the scale of development in this watershed, and even the success of the salmon fishery, seems to be a point of contention, with some saying mining and fish coexist, and other saying the impacts are severe.

RESPONSE: The unique conservation value of Bristol Bay fisheries is now discussed in Chapter 5.

It would also be helpful to better explain fish resources in the proposed project area in comparison to other areas within the watershed. I understand some of the necessary data may not be available for the project area. It would be helpful to know, however, if the habitat in the project area is typical, exceptional, or inferior to that in other areas of the watershed.

RESPONSE: We now include figures showing reported salmon species distributions and salmon diversity by HUC-12 watershed, across the Nushagak and Kvichak River watersheds (Figure 5-3; Figures 5-4 through 5-8). It is informative to note that salmonid diversity is relatively high in the project area. Information on population sizes and vital rates are limited for the region, but are reported where known. In addition, we include summary statistics and figures of stream and valley characteristics across the assessment area (Section 3.4), and compare stream attributes in the project area to those of the larger watersheds (Section 7.2.1). These results generally illustrate that the project area contains streams of a size and gradient well within the range of suitability for salmon, as amply demonstrated by the distribution of spawning and rearing salmon within the project area streams (Figures 5-4 through 5-8).

Regarding geological resources, the report describes the Pebble deposit and five other mineral deposits in the Nushagak and Kvichak watersheds. It would be helpful to know if there are other mineral resources or oil and gas resources in the Bristol Bay watershed as a whole that could also be exploited. It would also be helpful to describe the portion of the watershed that is off-limits to development due to park and protected area status vs. those lands that are open to mineral development.

RESPONSE: The scope of the assessment was to evaluate the potential impacts from large-scale mining on salmon resources; thus, consideration of prospective oil or gas development in the area was outside the scope. The mineral resources identified in the assessment are those in the Bristol Bay watershed that have had some level of identification or exploration at this time. Mine claims within the Nushagak and Kvichak River watersheds are shown in Figure 13-1 and discussed in greater detail throughout Chapter 13. The assessment assumes that mining would occur on lands open to mineral development.

Protected areas within the Bristol Bay watershed and the Nushagak and Kvichak River watersheds are shown in Figures 2-3 and 2-4. We have clarified in the text that the Nushagak and Kvichak River watersheds represent the least-protected area of the Bristol Bay watershed. Other state documents exist that map out areas in the Bristol Bay watershed off-limits to development.

Steve Buckley, M.S., CPG

The background information presented in the characterization of the ecologic, hydrologic, and geologic resources is overly broad in scope. Specifically, the descriptions of the relationship between landforms, streams, and surface water and the interaction with groundwater are mentioned as very important to fish in the watersheds, yet there is insufficient detail to assess these interactions and consequently, the characterization of these resources is weak. There is more detailed information available in the Environmental Baseline Document (EBD) regarding the relation between landforms, streams, groundwater, and fish habitat in the watershed.

RESPONSE: Descriptions of the region's physical environment have been expanded in Chapter 3. We provide additional detail on the broad-scale habitat characteristics of the watersheds, but providing the detail necessary to assess groundwater interactions comprehensively is beyond the scope of this document, and data are not available to do so.

The revision improves the treatment of this issue but given how critical this information is to understanding the watershed, fish habitat and the potential impacts from mining, a more comprehensive analysis will be required at some point.

Courtney Carothers, Ph.D.

The background information presented on the ecological and geological resources of the Nushagak and Kvichak watersheds appears to be appropriate and accurate. The report notes that there is a lack of quantitative data on salmonid populations in this region, a lack of a full identification and characterization of salmon presence, spawning, and rearing areas, and a lack of detailed understanding of how local stream and river system features (e.g., temperature, habitat structure, predator-prey relationships, limiting factors) affect salmonid production in the region. Further, climate change is noted to be affecting local conditions. These unknowns are important to stress throughout the report.

RESPONSE: Each risk analysis chapter of the revised assessment now includes an uncertainty section. Climate change is now incorporated more explicitly as an important external factor that could interact with mining impacts (Box 14-2).

The cultural characterization presented in Appendix D presents detailed information on historical and contemporary Yup'ik and Dena'ina communities of this region, stressing the centrality of salmon and subsistence in these cultures. This assessment benefits from the time-depth of relationships developed by Boraas and Knott. Overall, this section of the report is based on standard ethnographic methods, although the research design and analysis could be explained in more detail (and described in a separate methods section). The "voices of the people" sections are helpful to present directly the perspectives given by local people. These quotes reveal the complexity of subsistence and contemporary village concerns in this region. At times, the cultural assessment can minimize this complexity.

RESPONSE: Additional detail was added to the methodology section of Appendix D.

As detailed in the specific comments below, potential risks and impacts to subsistence are underestimated and at times framed in the report as primarily ones of physical health and economic factors. As described in Appendix D, harvesting, processing, sharing, and consuming wild foods are central to social, cultural, spiritual, psychological, and emotional well-being in Yup'ik and Dena'ina cultures. The subsistence lifestyle is considered central to the health of the people and communities of this region. This is particularly important to note for indigenous communities who continue to cope with the legacies of colonialism. This point is made in Appendix D (but at times could also be strengthened there, as suggested below), and is articulated in some of the quoted interview material.

RESPONSE: The assessment text regarding the importance of the subsistence way of life has been expanded to recognize the centrality of subsistence to the social, cultural, and spiritual well-being of the indigenous cultures.

Recent data on subsistence harvests, use areas, and local context collected for the PLP Environmental Baseline Document (as well as evaluation and discussion of such data, e.g., Langdon et al. 2006) and by the Alaska Department of Fish and Game (e.g., Fall et al. 2012) would be a useful addition to the cultural characterization. Other studies of local traditional ecological knowledge (e.g., Kenner 2005) may help to supplement the assessment of the abundance and distribution of fish species in this region, or to supply information on other less-studied freshwater fishes. Recent research on the contemporary salmon-based livelihoods of the region (e.g., Holen 2011, 2009a, and 2009b; Hebert 2008; Donkersloot 2005) would also be helpful to include. An inclusion of case studies of salmon-based cultures that have suffered depletions of their resource base would add to the presentation of likely fish-mediated impacts to culture (e.g., Colombi and Brooks 2012).

RESPONSE: The suggested references were consulted during the revision of the report and the discussion of subsistence has been expanded. In addition, case studies have been cited where applicable in the discussion of potential effects to indigenous cultures in Chapter 12.

Appendix E also characterized the economic baseline of the region. Why is this dimension not asked about here?

RESPONSE: The focus of the assessment is potential effects on salmon from large-scale mining. There are two secondary endpoints: salmon-mediated effects on wildlife and Alaska Native culture. The economics related to potential salmon-mediated effects are not evaluated because they are outside the scope of the ecological risk assessment. Appendix E presents information regarding the economic value of salmon is presented as background for the descriptive material in Chapter 5, and could be used as a basis for future analyses. However, this assessment does not include an economic endpoint.

Dennis D. Dauble, Ph.D.

As noted in the approach, characterization of and risk to ecological resources emphasized salmon and other important sport and commercial fish species. Consequently, the description of non-salmonid species generally lacked estimates of population size, except for sport and subsistence catch statistics. There was a long list of other resident fish in Appendix A, but their role in the Bristol Bay watershed (including the Nushagak River and Kvichak River watersheds) is not described in any detail there or in the main report. Available data on known or perceived ecological interactions among salmonid and resident fish should be included in the assessment.

RESPONSE: The assessment endpoints—salmonid fishes and their effects on wildlife and Alaska Native cultures—have been clarified in Chapters 2 and 5; other fish species are thus outside the scope of the assessment. However, we recognize in the text that other fishes (as well as other biota) are important components of the ecosystem, and have included a table of all documented fish species in the region in Chapter 5 to better reflect the fish fauna in the region.

Another limitation to the salmon-centric assessment is that risk assessment endpoints, described in Chapter 3 of the main report, do not address other aquatic ecological resources. Consequently, while there was acknowledgment of ecological dependencies among salmon, other fishes, and land mammals, very little information was provided on primary and secondary production processes of aquatic communities. For example, the relative importance of marine-derived nutrients (MDN) in the form of salmon eggs and carcasses is discussed, but there is only brief mention of aquatic insects in the diet salmonid species. What nutrient levels occur in these stream systems with and without MDN?

RESPONSE: We recognize that nutrient status, and more important prey availability, is a critical component of habitat capacity for fish in these systems, and may be strongly driven by salmon derived nutrients. We concur that more information is needed regarding potential limiting factors for salmon productivity and capacity, and that food availability may be one such factor. The role of aquatic invertebrates in the diet of salmonids receives more attention in the revised draft, and is an essential part of the risk assessment for water treatment and discharge, given the relatively high sensitivities of aquatic invertebrate taxa to metals. However, because water chemistry data may not provide a complete picture of trophic status, particularly where direct consumption of salmon flesh, eggs, and fry is of such high importance as it is in many of the area streams, we determined that nutrient status of area streams is outside the scope of this assessment.

A description of major groups of aquatic invertebrates in terms of biomass and seasonal abundance should be included in the main report. Further, aquatic and terrestrial food webs and linkages need more embellishment. One approach might be to add narrative text with the conceptual model discussion, including descriptions of community structure, function, and biomass.

RESPONSE: Additional detail on food webs is beyond the scope of this assessment (as detailed in Chapters 2 and 5). Further, available data are inadequate to assess risks at that level of specificity. For example, there are no acute copper toxicity data for any aquatic insects and only one old chronic value for a caddisfly.

More detail on river and lake limnology would be helpful. For example, the hydrology of the watershed is mainly limited to a brief discussion of salmonid habitats. The geology of the basin emphasizes geology of mining areas and mineral processes. A more landscape-based description is warranted given the importance of geology to surface water processes and groundwater movement. The report would benefit from having a summary table listing lake size/volume and river length/discharge for watersheds potentially affected (and not affected) by mining activities.

RESPONSE: We now include maps of geology and estimated mean annual flow for the study region (Chapter 3).

Also missing were specific habitat requirements for rearing of juvenile salmon. A brief description of where pink and chum salmon spawn and rear in the Bristol Bay watershed relative to other salmon species should be included in the main report. There was nothing in Appendix A on where coho, pink, and chum salmon reside within the Bristol Bay watershed.

RESPONSE: Identified spawning and rearing habitats for the five Pacific salmon species are reflected in Figures 5-3 through 5-8, and additional text on salmon life histories has been included in Chapter 5.

Each appendix has a wealth of supporting information and could serve as a stand-alone document. However, having to work back-and-forth between the main report and appendices to interpret critical aspects of the assessment presents a challenge. Don't assume the average reader will read (and interpret) these appendices. To help remedy, the authors of the main report should strive to directly cite relevant information (and/or a specific appendix) that supports their conclusions.

RESPONSE: Additional information from Appendices A and B has been pulled into Chapter 5 of the main assessment. In addition, the purpose of the appendices has been clarified in Chapter 2.

Gordon H. Reeves, Ph.D.

The assessment, which included the report and appendices, was comprehensive and thorough regarding the ecological resources of the Nushagak and Kvichak watersheds. The best available data on fish numbers and distribution (Alaska Dept. of Fish and Game's aerial escapement counts, records from the Anadromous Waters Catalog and Alaska Freshwater Fish Inventory, and the Environmental Baseline Document of the Pebble Limited Partnership (2011)) were used for the assessment. These data formed the foundation for much of the assessment on potential impacts to anadromous salmonids and their freshwater habitat in these watersheds and their characterization appeared to be accurate. The authors also appeared to have thoroughly identified and considered all of the appropriate literature.

RESPONSE: No change suggested or required.

Charles Wesley Slaughter, Ph.D.

If only Volume 1 (the Main Report) is considered, the characterization of some aspects of the Nushagak and Kvichak watersheds would have to be termed cursory. Chapter 2, Volume 1 (Characterization of Current Condition) provides only a superficial overview of the landscape of the Bristol Bay watersheds; a reader would preferably have access to Wahrhaftig (1965) or Selkregg (1976), as only two (relatively dated) suggestions, to gain a more comprehensive understanding of the region. Similarly, Volume 1 provides a relatively superficial discussion of non-fish wildlife concerns, or human/cultural concerns

RESPONSE: Additional information on the region's physical environment from Selkregg (1974) has been included in Chapter 3. We have also clarified that our discussion of biological communities focuses on the assessment endpoints, as defined in Chapters 2 and 5.

By contrast, the information provided in Appendices A-H appears to be comprehensive and complete for each subject field. (Appendix I appears to be a general "template" summary, not tailored to the Bristol Bay watershed environment).

RESPONSE: The purpose of the appendices vs. the main assessment document has been clarified in Chapter 2. Appendix I is not meant to be specific to any given region, but discusses options that are possible and notes that their applicability is dependent on site-specific constraints. What would be chosen for the Bristol Bay watershed environment, given a mining plan and permit application, also would be dependent on regulatory decisions.

As noted in the Executive Summary, the Assessment does NOT address several major components of the (hypothetical) Pebble project, including electrical generation and transmission, a deep-water port, or "secondary development" and associated infrastructure, which would follow an initial mining project. A truly comprehensive analysis should incorporate a full analysis of these aspects.

RESPONSE: The scope of this assessment was tailored to its purpose, as clarified in the first two chapters. We would expect that a full evaluation of any future mining permit applications and subsequent National Environmental Policy Act Environmental Impact Statements would consider these components.

John D. Stednick, Ph.D.

The site characterization needs to be expanded. The report needs to better characterize the physical setting. There are a variety of data sources that can be used to better describe the physical setting. It would be useful to see geology, geomorphology, soils, vegetation, digital elevation maps, hypsometric curves of the watersheds in question, streamflow data, and precipitation data—especially storm events and water quality data for surface and groundwater over time and space. Various geographical information system maps would be useful here.

RESPONSE: Maps displaying information about the physical setting have been added in Chapter 3.

The salmon populations and habitat linkage needs to be better documented since many of the mine impacts are resulted from hydrologic modification. Figures 3-2A to 3-2E represent good thinking and an understanding of the linkages and potential effects of mining on these resources. The linkages to indigenous peoples is illustrated in Figure 3-2E, but little text is presented, referring the reader to the Appendix. The other conceptual models are not adequately addressed in the text. These flow charts provide an opportunity to present processes and linkages as related to potential effects of mine development activity and need to be developed within the text. Indeed, they seem to stand alone with little discussion of potential effects. Additionally, not all charts have adequate materials in the appendix for coverage, thus the variability in resource coverage is inconsistent and infers either a writing bias or data (lack of) bias.

RESPONSE: Conceptual models are now linked with relevant text, and are included in each of the risk analysis and characterization chapters.

The assessment concludes that a hydrologic modification will have detrimental salmon habitat consequences. The groundwater contributions to streamflows are important, both hydrologically and ecologically. Additional streamflow and groundwater data are needed to represent this linkage. Similarly, additional water quality data over time and space are needed and should include water hardness for metal standards. Depth to groundwater as related to streamflow, age dating of waters, and streamflow modeling would all be useful to illustrate the groundwater upwelling and hyporheic exchanges.

RESPONSE: We have incorporated a figure illustrating modeled and observed groundwater upwelling zones (Chapter 7).

Site disturbance will be significant, yet there is no discussion of soil erosion. Soil erosion and subsequent suspended sediment transport would have the potential to have significant effects on water quality, channel delivery efficiency, salmon, salmon habitat, and metal transport. There is a generic discussion of road construction related to erosion, but road standards, road location, road usage, road maintenance (salting, grading, or watering), and length of roads would help in the risk assessment.

RESPONSE: Soil erosion on the mine site is not assessed because the scenario prescribes that runoff will be directed to retention basins. Salts used to reduce dust and improve winter traction on roads are discussed in Section 10.3.3 (Chemical Contaminants in Stormwater Runoff). Road usage and length are also factored into the risk assessment (e.g., in the assessment of chemical spills (Section 10.3.3) and potential impacts from dust (Section 10.3.5)). Potential mitigation measures for stormwater runoff, erosion, and sedimentation are discussed in Box 10-3.

Are any endangered or threatened species present, either state or federally listed?

RESPONSE: Text has been added to Chapter 5 stating that there are no state or federal endangered or threatened species in the region.

Roy A. Stein, Ph.D.

Overall Characterization. The characterization of the resources of the Nushagak and Kvichak watersheds was appropriate and accurate in the ecological arena save for the issues discussed below. Geological and cultural resources seemed adequately characterized, but they are not within my expertise. Finally, given the emphasis on these two watersheds (not the entire Bristol Bay watershed), might there be some consideration of a more circumscribed document title?

RESPONSE: The assessment deals with multiple spatial scales (now clarified in Chapter 2). The Bristol Bay watershed is the largest spatial scale considered in the assessment, and it is the only one that encompasses all of the issues discussed in the document.

Broad Scale Comments:

Global Climate Change I. Risks to salmonids seem far greater than what is reviewed throughout this portion of the document. Missing, in my view, is any consideration of Global Climate Change, especially in light of the expected life of the mine (25-78 years), applied directly to the Bristol Bay Watershed (save for a brief mention on page 5-28, 2nd full paragraph). Given our current understanding, general changes likely include more intense precipitation events and increased temperature (and then of course, all that follows from these two changes and as models become more sophisticated, more specific geographically localized impacts could be assessed). With more intense storms come a greater likelihood of a failure of Tailings Storage Facilities (i.e., commensurate with more frequent and more intense flooding), more acidity from Pre-Tertiary waste rock (which will enter quite vulnerable, poorly buffered streams), and greater sediment influx into streams (and increasing fines in the gravel by as little as 5%, quite a small proportion, "…causes unacceptable effects on salmonid reproduction" (page 8-6; also see Chapter 7), which could occur during "routine operations", especially in light of the fact that sediment influx into streams is a cumulative process). Increased stream temperatures, depending on the absolute increase over a period of 78 years (and beyond, see "in perpetuity" comments below), could lead to reductions in salmon spawning success, as extant populations are specifically adapted to the current temperature regime. As is apparent, both increasing intensity of storms and increasing temperature will likely compromise salmon spawning success, and growth and survival of their offspring in the freshwater environment of Nushagak and Kvichak rivers.

RESPONSE: Climate change projections and potential impacts are now included and discussed in Chapter 3 and are included as important external factors in the risk analyses presented in Chapters 7, 9, 10 and 14.

What this would entail, at the very least, is a discussion of a monitoring system to quantify the impacts of Global Climate Change whose impacts on the ecosystem can then be differentiated from mine impacts. My concern is that if the mine is built, all negative impacts of the mine on salmonids, etc., could be attributed to Global Climate Change rather than the true culprit which would be the mining activities.

RESPONSE: Climate change projections and potential impacts are now included in Chapter 3, and Box 14-2 includes a discussion of the need for future monitoring to differentiate climate change effects from large-scale mining effects.

Global Climate Change II. Indeed, climate change is affecting Alaskan salmon as demonstrated (in a paper that just appeared online July 11, 2012) by a loss of a late-migrating population of pink salmon in a small stream near Juneau, in favor of an early-migrating one. Genetic evidence supports this explanation for Kovach et al. (2012) had 17 generations of data (since 1979) showing the reduction of the September spawners in favor of the late-August ones in response to increasing stream temperatures. As Kovach et al. (2012) write in their concluding paragraph:

> "We no longer observe the clear phenotypic distinction between early- and late-migrating individuals that was once present in the system. Apparently, the very-late-migrating phenotype has been greatly reduced or potentially lost. Although microevolution may have allowed this population to successfully track environmental change, it may have come at the cost of a decrease of within-population biocomplexity – the loss of the late run. This is not a surprising result; by definition, directional selection will decrease genetic variation. However, it does highlight the importance of maintaining sufficient genetic and phenotypic

variation within populations in order for them to have the ability to respond to environmental change."

The ramifications of this work are obvious. As pointed out in the report (pages ES-8, 2-22, 5-28 as just a few examples), the exceptional quality of the Bristol Bay salmon stocks depend on the pristine quality of a set of quite diverse aquatic habitats, which has led to the development of genetically diverse stocks of salmon within species, each uniquely adapted to particular habitats. Reducing this variability by mining on top of the rivers that produce >50% of the wild sockeye salmon in Bristol Bay serves to reduce the flexibility with which these stocks respond to any environmental change (most notably Global Climate Change), and most notably during the time course of the Pebble Mine.

RESPONSE: Climate change projections and potential impacts are now discussed in Chapter 3 and include these points.

Groundwater Exchange. One of the key aspects of this system is the importance of groundwater exchange with surface streams and this groundwater contributes mightily to salmonid egg incubation success and survival (page 2-21). Simultaneous with this is the fact that the water demands of the proposed mine will require more than just surface waters available to it, but rather the mine will have to exploit groundwater resources to support its operations. This is yet another risk to salmonid success for reduction in the availability of groundwater will lead to increased temperatures in summer (see pages 3-7, 5-28, 5-29) and less inviting overwinter habitats (pages 5-20, 5-29), further exacerbating both mining and climate change effects.

RESPONSE: We have updated our hydrologic analyses to represent the probable influence of mine scenarios on surface water/groundwater interaction. Climate change projections and potential impacts are now discussed in Chapter 3.

Exploration Effects. During the public testimony segment, several Alaskan Natives argued that impacts owing to exploration have already occurred. A series of points were made: 1) exploration equipment was left behind, despoiling the landscape, 2) noise from helicopters frightened moose making them less vulnerable to exploitation, and 3) habitat change has already begun just due to exploration activities.

RESPONSE: EPA acknowledges this testimony, but potential or actual impacts of exploration activities are outside the scope of the assessment as defined in Chapter 2.

"In Perpetuity." Following up on the idea of increased risk (see previous points) to salmon, I struggled with the idea of this mine being monitored and maintained "in perpetuity" (e.g., pages ES-2, 4-32, 4-34). First, this relates directly to the Global Climate Change issues, in that these changes likely will continue to build through time, further exacerbating negative impacts on salmon. Even without climate change, salmon are in peril from mining operations in the Nushagak and Kvichak rivers; with climate change, the cards are stacked against them.

RESPONSE: The post-closure phase of mining begins when reclamation is completed and monitoring and maintenance commences using the controls put into place during closure; exactly how long the site would require monitoring and maintenance is unknown, and thus may be 'in perpetuity'. There are no existing examples from which to evaluate success of treatment in perpetuity. No mine in Alaska has maintained a tailings pond into post-closure,

although one small mine did maintain a pond during a many year hiatus from operations. Under AS 72.90.040, financial assurance is required to be sufficient to cover expenses for as long as treatment need is predicted, even into perpetuity (e.g., Red Dog Mine). Maintaining a water cover over the tailings is a part of the reclamation and closure plan for the Red Dog Mine. The comment is noted and understood. No changes suggested or required.

Second, what regulatory or institutional mechanisms currently available place the responsibility of these efforts on the corporation "in perpetuity"? Because mining companies come and go, might there be mechanisms that come into play if this particular company goes bankrupt? Might there be some sort of bonding process that protects the environment from the mine's remains into the long-term future? If not, should new legislation be pursued? Acknowledgement of this important issue should be front and center in the document, in my view.

RESPONSE: There are many requirements that have to be met including compliance with the CWA § 404(b)(1) Guidelines and adequate financial assurance under AS 72.90.040. The former would lead to the least environmentally damaging, preferred alternative and the latter to having adequate financial resources to cover the cost of perpetual treatment. These issues would be addressed in a permit process. Our purpose in the assessment is to evaluate the potential effects of the primary features of a mine, assuming conventional modern mitigation measures. Additional information on the regulations and financial assurance issues associated with mining has been added in Chapter 4 (Boxes 4-2 and 4-3). The comment is noted and understood.

Third, I began the review process with idea that the mine would be built, would capture its resources, and then would end by restoring the site. The scenario that includes monitoring and maintenance 1,000 years into the future continues to bother me. One solution that comes to mind is that Federal or state government would be charged with these monitoring and long-term maintenance activities, paid for by a hefty tax on the minerals removed from this site.

RESPONSE: Currently, the solution is the requirement and provision of adequate financial assurance (under AS 72.90.040, when speaking specifically about Alaska) by the company. The comment is noted and understood. No change suggested or required.

Finally, I am not encouraged by any of the text surrounding this issue, the two most relevant quotes (pages 4-31 and 5-45, respectively) being:

> "There are no examples of such successful, long-term collection and treatment systems for mines, because these time periods (100's to 1000's of year) exceed the lifespan of most past large-scale mining activities, as well as most human institutions."
>
> "We know of no precedent for the long-term management of water quality and quantity on this scale at an inactive mine."

RESPONSE: The post-closure phase of mining begins when reclamation is completed and monitoring and maintenance commences using the controls put into place during closure; exactly how long the site would require monitoring and maintenance is unknown, and thus may be 'in perpetuity'. There are no existing examples from which to evaluate success of

treatment in perpetuity. No mine in Alaska has maintained a tailings pond into post-closure although one small mine did maintain a pond during a many year hiatus from operations. Under AS 72.90.040, financial assurance is required to be sufficient to cover expense for as long as treatment need is predicted, even into perpetuity (e.g., Red Dog Mine). Maintaining a water cover over the tailings is a part of the reclamation and closure plan for the Red Dog Mine. The comment is noted and understood. No changes suggested or required.

And, finally, a quote from Chapter 8 on page 8-13:

> "The promises of today's mine developers may not be carried through by future generations of operators whose sole obligation is to the shareholders of their time (Blight 2010)."

RESPONSE: The comment is noted and understood. No changes suggested or required.

William A. Stubblefield, Ph.D.

The EPA's assessment document presents a seemingly comprehensive compilation of the data associated with the ecological, geological, economic, and cultural resources of the Bristol Bay area. The characterization as presented seems to provide appropriate background information for the assessment considering the hypothetical nature of the evaluation. Without having specific knowledge of the area in question, it is not possible to provide an assessment as to whether the characterization was accurate. I'm unaware of significant literature, reports, or data that were specific to the site and would be useful for consideration. The assessment should be expanded to include greater detail regarding the environmental aspects of the site.

RESPONSE: Additional information on the physical environment of the region and assessment endpoints has been incorporated into Chapters 3 and 5.

Dirk van Zyl, Ph.D., P.E.

The geological information was taken from documents prepared to conform to and in compliance with the standards set by National Instrument 43-101 (NI 43-101) (Ghaffari et al., 2011). This regulatory instrument emphasizes resource information for projects. While I cannot comment on the accuracy of the regional geological information, the document should reflect accurate geological information of the Pebble District as known at the time when the report was prepared.

RESPONSE: The assessment uses geological information available for the Pebble site area. Geological information from Selkregg (1974) has been incorporated into Chapter 3.

My review did not include the Environmental Baseline Document (EBD) of the PLP. However, in scanning that document, it seems that more site-specific information on site hydrogeology may be available than was described in the EPA Assessment. While the latter refers to the EBD extensively in terms of fish populations, etc., it does not refer to it for much of the site physical characterization. EPA should address this in edits to the Draft Assessment.

RESPONSE: Additional site-specific hydrogeology information has been incorporated in Chapters 3and 7 and in the calculation of water quality values in Chapter 8. EBD data were used along with USGS data for hydrologic analysis in both drafts of the assessment, but the sources of data were not discussed as extensively in the previous draft.

Phyllis K. Weber Scannell, Ph.D.

The Environmental Assessment presents a well-documented discussion of the fish and wildlife resources of the Nushagak River and Kvichak River Watersheds, with more limited discussions of the remainder of the Bristol Bay Watershed. The document discusses interactions among species, including nutrient flows and the importance of groundwater systems; however, information on contributions of marine-derived nutrients and existing pressures on the environment are not as complete, or lacking. The information is general in nature. Should mine development go forward, it will be necessary to obtain ecological information specific to the potentially affected areas. The information should include timing of fish spawning, egg hatch, in-migration and out-migration, and similar specific life-history information for important wildlife species.

RESPONSE: We have clarified the use of information at different scales (Bristol Bay watershed and Nushagak and Kvichak River watersheds in the problem formulation chapters, smaller spatial scales in the risk analysis and characterization chapters). General information on assessment endpoints is included in Chapter 5, with more detailed information included in the appendices.

Paul Whitney, Ph.D.

Fish Population Estimates. There are several places in the text where impacts of the loss and degradation of habitat on fish populations was not quantified because of the lack of demographic data for salmonids (e.g., page ES-26, third bullet). These statements are only partially accurate. It is true that population models such as life tables or Leslie matrices require population age class data to estimate population numbers. However, even if demographic data are available, these population models do not relate population estimates to habitat quality. Incomplete data and relating fish population estimates to habitat quality are not an uncommon problem in ecology and there are many approaches for dealing with this issue. Approaches such as Ecosystem Diagnosis and Treatment (McElhany et al. 2010), Expert Panels (Marcot et al. 2012), Bayesian nets (Lee and Reiman 1997), Discussion with experts (Appendix G), or Weighing Lines of Evidence (Section 6.1.5) are just some of the methods for relating habitat quality to fish abundance. Models and expert opinions, of course, bring their own uncertainties but it seems better to have quantitative estimates (and discussion of the estimates) of all the potential fish losses due to habitat loss than no estimate at all.

RESPONSE: Approaches such as EDT, mentioned above, were considered, but rejected due to lack of stream-reach specific information needed to provide the sort of quantitative estimates desired. Expert panels and Bayesian Belief Networks are recognized as potentially providing useful guidance for identifying key uncertainties and directing future research and

monitoring efforts. However, this was deemed outside the scope of this assessment, and we instead focus on the risks associated with the types of habitat change that would be expected under the mining scenarios outlined. We restrict quantitative estimates of population level effects to the most severe cases where total losses of runs could be reasonably assumed.

Even though the Executive Summary indicates that the impacts of loss and degradation of habitat on fish populations could not be quantified, the text does provide some estimates. For example, the assessment (page 6-11, first full para) estimates "that the combined effects of direct losses of habitat in the North Fork Koktuli, down stream in the mainstem Koktuli and beyond, and impacts on macroinvertebrate prey for salmon could adversely affect 30 to 50% of Chinook salmon returning to spawn in the Nushagak River watershed." This type of statement, and the basis for the statement followed by a discussion of uncertainty, is a good example of the estimates that would better describe possible impacts of the example mine on salmonids. Another example estimate appears on page 6-39 for four species of salmon.

RESPONSE: We restrict quantitative estimates of population level effects to the most severe cases where total losses of runs could be reasonably assumed, such as the example given above. The text of the revised assessment has been clarified for consistency regarding feasibility of estimates.

Question 2. ***A formal mine plan or application is not available for the porphyry copper deposits in the Bristol Bay watershed. EPA developed a hypothetical mine scenario for its risk assessment, based largely on a plan published by Northern Dynasty Minerals. Given the type and location of copper deposits in the watershed, was this hypothetical mine scenario realistic and sufficient for the assessment? Has EPA appropriately bounded the magnitude of potential mine activities with the minimum and maximum mine sizes used in the scenario? Are there significant literature, reports, or data not referenced that would be useful to refine the mine scenario, and if so what are they?***

David A. Atkins, M.S.

The hypothetical mining scenario presented in the Assessment is based on a "Preliminary Assessment Technical Report" of the Pebble deposit prepared for Northern Dynasty Minerals by Wardrop (referred to as Ghaffari et al. 2011), in conformance with Canadian National Instrument 43-101 (NI 43-101) which is used to set standards for public disclosure of scientific and technical information about mineral projects of companies on bourses supervised by the Canadian Securities Administrators. By most accounts, the Pebble deposit is a world-class deposit and the Wardrop report counts nearly 11 billion tonnes of total resource. It is unlikely that all the ore currently identified would be mined, so 11 billion tonnes would be an upper bound for this particular deposit. It is also certain that exploiting the Pebble deposit would have to be at a scale large enough to justify the capital investment to build an infrastructure in such a remote area. Although the Assessment is ostensibly about any mining development in the Bristol Bay watershed, the use of the Wardrop scenario for Pebble effectively makes the report an assessment of mining the Pebble deposit.

RESPONSE: The purpose of the assessment is to estimate potential impacts of large-scale surface porphyry copper mining on salmon ecosystems in the Bristol Bay watershed. The preliminary plan for mining the Pebble deposit was used as the basis for the assessment because that deposit is the most likely to advance in the near term. Also, the Agency believes that mining of other porphyry copper deposits in the watershed would proceed with a similar approach, since the scenarios used are similar to what has been done at other porphyry copper deposits. Therefore, it is appropriate to use Northern Dynasty Mineral's 2011 plan for the Pebble deposit (Ghaffari et al. 2011) as the basis for the scenarios; however, a final mining plan may differ from what is presented in Ghaffari et al. (2011). Chapter 13 of the revised assessment also considers the potential cumulative effects of additional smaller copper porphyry mines in the watershed. No change suggested or required.

The question then becomes what size mine is feasible from a technical and economic point of view. The Pebble deposit mine plan, as presented in the Wardrop report, outlines three scenarios:

- An "investment decision case" for a 25-year mine life that would mine 2 billion tonnes of ore;
- A "reference case" for a 45-year mine life that would mine 3.8 billion tonnes of ore; and
- A "resource case" for a 78-year mine life that would mine 6.5 billion tonnes of ore, or 55% of the total measured, indicated and inferred resource.

The Assessment chose minimum and maximum mine sizes of 2 billion and 6.5 billion tonnes of ore, respectively. Thus, the resource estimate used for the Assessment is the same as that for the two end members presented by Wardrop. This would make the mine one of the largest in the world, exceeding the size of the 10th percentile of global porphyry copper deposits by an order of magnitude (see Appendix H of the Assessment). Mines that ultimately become this size usually expand by increments, as exploration discovers new ore zones and expansion permits are granted.

RESPONSE: Yes, the scenarios represent large-scale mines. The purpose of the assessment is to estimate potential impacts of large-scale surface porphyry copper mining on salmon ecosystems in the Bristol Bay watershed, so large mine sizes are appropriate. It is quite likely that large mines would be created in increments, but this would not influence our assessment, as we have evaluated impacts based on volumes of material released in the event of failures or accidents and on material processed as proposed in Ghaffari et al. (2011) as reasonable for a deposit of this size, regardless of the time period for mine operation. However, we have included a third, smaller mine in our revision to represent the median-sized porphyry copper mine on a worldwide basis (250 million tons).

The Wardrop report further delineates Pebble West as a low-grade deposit near the surface that would most efficiently be mined using open-pit methods, with Pebble East as a deeper, higher-grade deposit that would most efficiently be mined using underground methods (specifically block-caving). Mine facilities, as outlined in the Wardrop report, would include:

- Open-pit mining utilizing conventional drill, blast and truck-haul methods for near-surface deposits.
- Underground, block-cave methods for deeper deposits.

- A process plant with throughput of 200,000 tonnes/day that utilizes conventional crush-grid-float technology with secondary gold recovery.
- Other mine-site facilities, including:
  - Tailings storage.
  - Waste rock storage (the estimated waste/ore strip ratio is 2:1).
  - A natural-gas fired power plant.
  - Shop, office, and camp buildings.
  - Pipelines to ship ore concentrate slurry to the port facility; return water from the tailings slurry after separation at the port facility; and fuel.

RESPONSE: No change suggested or required.

This mining and ore processing approach is conventional, and the Assessment includes these elements. A mine developer may present alternative plans that could vary or alter how the mine is developed, but the fundamental components would most likely remain the same.

RESPONSE: The EPA agrees with this comment. No change suggested or required.

Because the Assessment is presented as a general assessment of mining risks and impacts in Bristol Bay and not a specific analysis of the Pebble Project, reliance on the scenario presented in Wardrop makes the assessment overly specific. Further, Chapter 7 provides more specific information on “Cumulative and Watershed-Scale Effects of Multiple Mines,” which presents analysis of potential impacts from mining five additional deposits in various stages of development (presumably from early exploration to pre-feasibility). The information presented in Chapter 7 seems more like another mining scenario than a cumulative impacts assessment. Therefore, I would suggest a broader range of potential mining scenarios be organized as follows, with the detail of assessment necessarily becoming more speculative with each subsequent scenario in the list (due to the lack of geologic and engineering information on the other deposits):

- Development of one, average-sized porphyry copper deposit (50^{th} percentile or 250 million tonnes of ore as described in Appendix H) in the location of the Pebble deposit.
- Development of a mega-mine in the location of the Pebble deposit (of the range between 2 and 6.5 billion tons of ore) that may develop after multiple expansion and permitting cycles.
- Development of a mining district consisting of an average-sized Pebble mine and other potential mines (i.e., those presented in Chapter 7).
- Maximum development of all identified potential resources to their most likely ultimate extent.

Considering this broader range of scenarios would help the reader to better understand the range of potential risks and impacts.

RESPONSE: The Pebble deposit is located in the watershed of interest, the deposit is similar to other copper porphyry deposits in the world, and components of the scenarios are common and anticipated for any such deposit of this type; thus, we feel that use of the Pebble deposit characteristics and location is appropriate. The revised assessment includes an additional mine size scenario (Pebble 0.25), representing the worldwide median size porphyry copper

mine (Singer et al. 2008). The revised assessment expands the cumulative impacts discussion (Chapter 13) further by including transportation corridors and secondary impacts.

Steve Buckley, M.S., CPG

Additional mine scenarios are necessary to appropriately bound the magnitude of potential mine activities. The maximum mine size in the mine scenario seems appropriate given the existing public information on the Pebble deposit. The minimum mine size of 2 billion tons exceeds the 90th percentile of global porphyry copper deposits. Using a minimum mine scenario in the range of 250 million tons or in the 50th percentile range of global porphyry copper deposits would be more appropriate to bound the lower end of the magnitude of potential mine activities. It would also be useful to include some variation in mining methods. This could include incremental development of a smaller open pit in the lower grade zones of a deposit, along with a portion of the higher grade deposit being mined by underground block caving methods to further assess the minimum potential impact of the mine scenario.

RESPONSE: The revised assessment includes a mine size scenario (Pebble 0.25) representing the worldwide median-sized porphyry copper mine as presented in Singer et al (2008). The revision does not evaluate risks from hazards for underground mining, but a brief discussion of underground mining is included in Chapter 4. The failures assessed would apply whether the mining technique were underground or surface.

The revised assessment is a major improvement with the addition of mine scenario 0.25 and the brief discussion of underground mining.

Courtney Carothers, Ph.D.

The hypothetical mine scenario was closely based on a probable mine prospect under development. As such, it appears to be realistic and sufficient, if challenging to conceptualize as fully hypothetical given this association.

RESPONSE: No change suggested or required.

The report notes that the Pebble deposit may exceed 11 billion metric tons (4-17). The rationale for choosing 6.5 billion metric tons as a maximum size is based "most likely mine to be developed (4-19)." The rationale for not choosing a higher potential maximum could be explained.

RESPONSE: Both the 2 and the 6.5 billion ton scenarios were presented in Ghaffari et al. (2011) as economically viable, technically feasible, and permittable. The purpose of the assessment was to estimate potential impacts of large-scale surface porphyry copper mining on salmon ecosystems in the Bristol Bay watershed; the 6.5 billion ton mine is a large mine. Because this size mine is on the lower bound of a maximum size, it is a conservative assumption for the risk assessment. Thus, for the purposes of the assessment, it is not necessary to hypothesize an even larger mine.

Dennis D. Dauble, Ph.D.

The hypothetical mine scenario initially appeared realistic and useful in terms of potential project scope. However, it was apparent during the public hearing, and upon further discussion between members of the panel, that assumptions on mine size should be revisited based on deposit characteristics and extraction potential. Also, assumed practices and operations should be verified against current best-practice and State of Alaska permitting guidelines.

RESPONSE: The revised assessment includes a smaller sized mine that is based on the median-sized porphyry copper mine on a worldwide basis. The State of Alaska does not have permitting guidelines that address the size of a mining operation. Land use activities were previously subject to stipulations meant to minimize surface damage or disturbance under 11 Alaska Administrative Code (AAC) 96.140, but this regulation was repealed in December 2002. The State does have statutory and/or regulatory requirements for an approved Plan of Operations (11 AAC 86.800), a Reclamation Plan (Alaska Statute (AS) 27.19.30) and appropriate Financial Assurance (AS 27.19.040).

Referenced literature provides appropriate context, however, I cannot help believe that information on environmental impacts from past mining activities conducted in the Rocky Mountain metal belt would be relevant to this assessment in some cases. It is also possible that recent published information from Holden Mine in northern Washington State would help establish context for effects of leachates and model results that predict downstream transport of tailing material in a wilderness setting, for example.

RESPONSE: Environmental impacts from historic mining are the basis for understanding that risks from hazards of mining need evaluation. Modeling of tailings transport was based on the expected characteristics of tailings for the Pebble deposit. There is an expanse of literature on Superfund sites and interactions of metals associated with sediments and their leaching. We included a number of selected sites in our background information, but to include all possible sites would get further away from the scope of the assessment, which was to evaluate potential effects within the Bristol Bay watershed.

Gordon H. Reeves, Ph.D.

No comments on this question.

Charles Wesley Slaughter, Ph.D.

Given the available information base for the ore deposits of the Bristol Bay watershed, and the publicity which has attended the Pebble planned development over the past several years, the Assessment's hypothetical mine scenario seems fairly realistic. Further, it is appropriate that the Assessment consider the probable impacts of other future mineral development projects once an initial entry (presumably Pebble-Northern Dynasty Minerals) has been accomplished. Such subsequent development – "cumulative effects over a long time period" – could (and should) receive **more** emphasis than is accorded in the Assessment.

RESPONSE: The assessment of cumulative effects of multiple mines is given more emphasis in the new Chapter 13.

John D. Stednick, Ph.D.

The document does not adequately bound the range of mine scenarios. The minimum mine development scenario is not adequately addressed. A frequent criticism during the public comment session was that mine plans presented in the assessment are not representative of current standards. A *compilation* of existing world porphyry mine complexes as well as other types of mines specific to Alaska would better inform the reader of mining processes and potential risks. The physical setting in Southwest Alaska is not the same as the Bingham Mine in Salt Lake City. Currently, the document refers to a particular mine in a particular risk assessment (stressor), e.g., the Fraser River for salmon, Aitika for chemistry, and Altiplano for pipeline failures.

RESPONSE: The revision includes a smaller mine size that represents the worldwide median size for a porphyry copper mine (Singer et al. 2008), to help with the issue of the range of scenarios. EPA disagrees that the mine scenarios evaluated are not representative of current standards. This view apparently stems from use of the term "good" rather than "best" practices in the draft assessment. The reason for using that term is that the term "best management practices" is a term generally applied to specific measures for managing non-point source runoff from stormwater (40 CFR Part 130.2(m)). Measures for minimizing and controlling sources of pollution in other situations are often referred to as best practices, state of the practice, good practice, conventional practice, or simply mitigation measures. We assume that these types of measures would be applied throughout a mine as it is constructed, operated, closed, and maintained post-closure, regardless of the qualifier that one wishes to place with it. A text box was added to the revised Chapter 4 that discusses terms to help clarify our intention for descriptors used. The Fraser River example was considered because it had been used as an analogue by others, but was dismissed as not representative of Bristol Bay. Other mines that are noted in the assessment are illustrative of specific issues only and not used for risk evaluation in the Bristol Bay watershed. While physical settings are not the same, the components and the impacts are similar and thus included to help a reader understand where and how these things occur.

The Bureau of Land Management has identified certain lands that will be excluded from development. This reference needs to be followed up.

RESPONSE: The purpose of the assessment was to estimate potential impacts of large-scale surface porphyry copper mining on salmon ecosystems in the Bristol Bay watershed. This presupposes that our mine scenarios are located in areas that are not excluded from development. The majority of land in the two watersheds is state land that is available for mine development, and Figures 2-3 and 2-4 now indicate protected areas within the Bristol Bay watershed.

Roy A. Stein, Ph.D.

Hypothetical Mine Scenario. Though mining does not lie within my area of expertise, I thought that this scenario helped me understand the potential impact of a mine of this magnitude in a wilderness, pristine watershed. I find it difficult to comment as to whether this scenario is realistic and sufficient, though I did use this scenario to guide my comments below. From the text, it is apparent that this is a realistic scenario, based on documents filed by the company with the Canadian government. This makes this scenario the most realistic one could expect.

a. **Minimum and Maximum Mine Size.** For me, as an ecologist, this bounding helped me to understand the potential impacts of the Pebble Mine, though I did not understand what the probability of either mine size happening in the near term. Understanding these probabilities would be helpful to the readers.
b. **Mine-Size Continuum**. Is it more likely that the initial Pebble Mine will be maximum or minimum in size? Wouldn't it be far better to review a continuum of mine sizes from the smallest that is economically feasible to one that is intermediate in size and then to one (or two) that would take to the largest realistic mine size? With this continuum, the reader begins to understand the overall impact of various mine sizes on the Bristol Bay ecosystem. Some reflection on these mines sizes and their impacts would have helped me interpret the Environmental Risk Assessment with some additional insight.

RESPONSE: The State of Alaska does not have permitting guidelines that address the size of a mining operation. Many identified deposits never become developed mines for various reasons, and it is unknown how many deposits exist and are economically viable for exploration of mining feasibility. Once it is decided to develop a site, there are a number of things that must occur before a mine begins operation. Thus, it is not possible to predict the probability of either mine size happening in a specific period, at least with any certainty. All we can say is that there are deposits that have the potential to be mined in the future.

It is more likely that an initial mine would begin at a smaller scale and become larger and perhaps be permitted in stages of increasing size. However, there are different approaches in how plans are presented and these depend on multiple factors, including economics and projected costs/gains in prices of the metal being mined. For example, if it were not economically viable to mine only a small part of a known large deposit, a larger mine would be proposed and planned for. The revised assessment includes a size scenario that represents the worldwide median-sized mine to provide more of a continuum of sizes.

One Watershed. Given the productivity of salmon from these two river systems (50% of the sockeye salmon in Bristol Bay are produced from these rivers), might there be some thought given to limiting the mining operations to a single watershed, either the Nushagak or the Kvichak (page ES-2)? In so doing, in a single stroke, the impact of this mine on salmon is reduced by 50% or more. Could the Pebble Mine be confined to one watershed, such as where the majority now falls – in the Nushagak River (both the north and south forks of the Koktull River) watershed? Even so, this suggestion becomes especially pertinent to Chinook salmon spawning in the Nushagak River, for this run is "near the world's largest" (page ES-5), but yet the Nushagak watershed is small relative to other watersheds (such as the Kuskokwim and the Yukon) where Chinook salmon are abundant. As a result, any impacts to the watershed by a mine of this size are magnified, another concern when considering this location. Without mining expertise, I cannot judge whether it would be possible to mine in only one of the watersheds, rather than both. Even so, some consideration should be given to this suggestion.

RESPONSE: Restricting impacts to one watershed would change the risks, and could be a part of future mine plans. We chose to represent a suite of realistic mine scenarios based upon preliminary mining plans and the location of the ore deposit which lies in both watersheds.

William A. Stubblefield, Ph.D.

No comments on this question.

Dirk van Zyl, Ph.D., P.E.

The hypothetical mine scenario adopted by the EPA relied almost exclusively on the document prepared for Northern Dynasty Minerals (NDM), one of the partners of the Pebble Limited Partnership. Developing a mine plan for a specific ore body is a large task and is undertaken by a large team of engineers and scientists. In the process of developing a mine plan many options are considered for each facility and its components, including mining methods, process design options, waste rock management options, tailings management options, shipment of product, etc. The hypothetical mine scenario was prepared by an independent consulting company for one of the partners and this plan does not necessarily represent the design and management options that will be selected for developing this ore body. Because of ore grades and the deposit style, it is most likely that an open pit mine will be developed as assumed in the report for the western lower grade ore body and that underground mining will be used for the eastern higher grade ore body. The size of the ore body and the strip ratio for an open pit mine are completely dependent on metal prices and production costs at the time of mine development. Metal prices and production costs will also be a major factor in deciding whether to first develop an underground mine instead of an open pit mine. While some of the components of the final mine may contain elements of the conceptual mine, it is impossible to know whether the hypothetical mine scenario is realistic, as will be further discussed in the comments below.

RESPONSE: It is acknowledged in the assessment that the mine scenarios might not look exactly like a mine presented in a mining plan. The assessment is not a mining plan and is not an evaluation of a mining plan; it simply uses current information for the Pebble deposit because it is a large ore deposit which has had extensive exploration with potential for development in the near future. An additional scenario has been included in the revision to match the worldwide median mine size and show a better continuum of scenarios possible. We consider our scenarios to be realistic, as they were presented as possible layouts for the Pebble deposit and stated in Ghaffari et al. (2011) as being "economically viable, technically feasible, and permittable".

To address the issue of sufficiency it is necessary to understand the range of potential outcomes related to the various options. For the most part, the EPA study used the information from the NDM document for evaluating impacts to salmonids. Using different options, both technological as well as site selection, for some or many of the facilities could result in impacts that are different from those described in the report. I would therefore suggest that using only the present hypothetical mine scenarios is insufficient. There could be a range of impacts, such as the surface areas of facilities, which in some cases could be smaller than what was chosen and in other cases larger. However, this does not mean that the hypothetical mine represents “average conditions.” I therefore consider the mine scenario not sufficient for the assessment.

RESPONSE: It is acknowledged in the assessment that the components in the mine scenarios might not be exactly what would be proposed in a mining permit application for this location or for other locations within the Bristol Bay watershed. The purpose of the assessment was to evaluate potential impacts of large-scale surface porphyry copper mining in the Bristol Bay watershed, so the assessment was not meant to represent “average conditions”. However, an additional mine size scenario has been included in the revision to match the worldwide median porphyry copper mine size and show a better continuum of scenarios possible.

The minimum and maximum mine sizes selected by EPA are 2 billion tonnes mined over 25 years and 6.5 billion tonnes mined over 78 years; in both cases, the daily ore processing rate is 200,000 tonnes. As indicated above, the final economic mine size at the time of development will be determined by metal prices and production costs. Note that production costs, as used here, include all the considerations related to regulatory, environmental and social aspects of the mine and its environs. Mining companies typically make investment decisions for periods of 20 to 30 years. It is seldom, if ever, that a new investment will be made based on a 78 year mine life; however, the upside potential will be taken into account when an investment for a shorter mine life is made. It is also unlikely that environmental regulatory agencies will consider issuing a permit, including closure plans, etc. for a 78-year project. Furthermore, even if the mine ultimately continues for 78 years, it is certain that the operating and environmental control technologies and societal expectations will change in that period and therefore the elements used by EPA for the maximum size hypothetical mine will certainly not be valid for such a long mine life. It is therefore my conclusion that assuming the development of a 2 billion tonne ore body is realistic, but that assuming development of a 6.8 billion tonne ore body, using static technology assumptions, is not.

RESPONSE: While it is true that an actual mine likely would be permitted in increments, the assessment never stated that the 78-yr scenario would not be done this way. In fact, the assessment does not discuss how such scenarios would be permitted at all, and to do so is outside the scope of the assessment. The purpose of the assessment is to estimate potential impacts of large-scale surface mining of copper porphyry on salmon ecosystems in the Bristol Bay watershed, and that necessarily assumes that the mine scenarios are permitted. It is true that some technologies would have advanced over time from ‘day one’ of mine scenario development, and we acknowledge this in our assessment. It is impossible to predict, however, how impacts from use of future technologies would differ from those in use today, or how they would change conditions existing at the time they began being used. We can only present and predict potential impacts based on use of the most appropriate technologies available at the current time. No change suggested or required.

The EPA assessment report includes a range of the literature and reports in evaluating the selected mine scenario. However, I have a number of specific comments about various aspects of the report as well as the references.

Good practice vs. best practice. On p. 4-1 of the report, the EPA states: "Described mining practices and our mine scenarios reflect the current practice for porphyry copper mining around the world, and represent current good, but not necessarily best, mining practices". EPA does not clarify this decision, nor does the report clarify the distinction between "good" and "best" practices. It can only be concluded that "best" will be better than "good". On the basis of this, it is inconceivable to me that the Bristol Bay communities, the Alaska regulatory authorities as well as Federal Regulatory Authorities will not demand that the company follow "best mining practices", however that is defined at the time. It is also inconceivable to me that the company will not follow "best mining practices" in the design and development of such a mine. During the engagement processes, the stakeholders will have to agree what represents "best" practice in the design of the mining project. It is important to note that most of the failure statistics used as a basis for the evaluations in the report are derived from data gathered over the last 50 years or so (e.g. refer to p. 4-45 of report). It may be argued that this information is mostly for mines following "good" practices and, in many cases, for projects that had a lower standard of care. To my knowledge, there are no statistics available that compare failure rates of facilities designed and operated under "good" practice to those designed and operated under "best" practices, whatever definitions are used for "good" and "best".

RESPONSE: The term "best management practices" is a term generally applied to specific measures for managing non-point source runoff from stormwater (40 CFR Part 130.2(m)). Measures for minimizing and controlling sources of pollution in other situations often are referred to as best practices, state of the practice, good practice, conventional, or simply mitigation measures. We assume that these types of measures would be applied throughout a mine as it is constructed, operated, closed, and post-closure, regardless of the qualifier that one wishes to place with it. To remove any ambiguity and subjectiveness of terms "good" or "best", we have removed them in the revision and have added Box 4-1, which includes definitions for several terms used.

The EPA also is not aware of any statistics available that compare dams designed (and/or operated) under different standards; however, the probabilities for dam failure used in the assessment were not derived solely from the historical record. Historical failures were discussed as supporting background information and present a defensible upper bound on the failure probabilities. The failure probabilities used in the assessment are based on Alaska's dam classification and required safety factors applied to the method of Silva et al. (2008). The data presented by Silva et al. (2008) consider only the annual probability of failure from slope instability, but the methodology is equally applicable to other failure modes. The discussion of failure probabilities in the revision (Chapter 9) is expanded to clarify this issue.

Mine scenarios. The executive summary indicates (p. ES-11): "The mine scenario includes minimum and maximum mine sizes, based on the amount of ore processed (2 billion metric tons vs. 6.5 billion metric tons), and approximately corresponding mine life spans of 25 to 78 years, respectively". This seems to indicate that the mine life cycle in the first case consists of 25 years of operational life followed by closure and, similarly for the second case, 78 years of operational life followed by closure. However, a careful review of the water management section (section 4.3.7) indicates that this is not the case. The EPA water balance calculations are simplified to a set of deterministic values in Table 4-5 for four water management stages during the overall mine life cycle: start-up, operations minimum mine (25 years), operations maximum mine (78 years), and post-closure. For post-closure, only the 78-year mine life numbers are used. It therefore seems that EPA is not considering that the 25-year mine will close, but that its life will automatically be extended to 78 years. Does this mean that the EPA really does not evaluate the minimum mine size completely, i.e. the 25-year mine life followed by closure? It is important that this be clarified as it would be inconsistent not to evaluate closure of the 25-year mine. It is possible that additional evaluations, or at least additional explanations, will be required to clarify this.

RESPONSE: The reviewer is correct. Our water balance calculations only explicitly present the closure of the Pebble 6.5 scenario. The water balance for the Pebble 0.25 and the Pebble 2.0 scenarios would be similar, but in those scenarios there would be no water captured in TSF 2 or TSF 3 and the amounts captured in the pit would be proportionally smaller, as they are in the operating scenarios. While the pit is filling in each of the three scenarios, the total amount of water captured is slightly less than the amount captured during operations, and about 35% to 45% of the water captured is available for reintroduction to the streams. Once the pit is full, the amount captured at the mine pit area drops substantially and 100% of the captured water is reintroduced. Post closure flows for the three mine scenarios are presented in Table 6-8.

Tailings management technologies. Ongoing technology development has resulted in a broader range of tailings management options than only slurry tailings disposal. Filtered dry stack tailings can be considered as a realistic option, even for mines with higher production rates. Flotation of remaining sulfides in the tailings before deposition is also a realistic option for mines; it has been done successfully at the Thompson Creek Mine in Idaho for the last 18 plus years. While these technologies are mentioned, they are not selected for reasons such as technology not being appropriate for the climatic conditions and concerns with disposal of pyrite waste. Both of these are not insurmountable technical issues and adopting such management options will reduce failure probabilities and potential impacts following a failure. The failure mode of a filtered dry stack facility not containing sulfides will be completely different from a slurry impoundment and the potential environmental impacts of these other tailings management options will definitely be far smaller than those for the selected mine scenario using slurry tailings disposal.

RESPONSE: Selective flotation to lower the pyrite content has been added to the discussion of processing in Chapter 4 and referenced in Chapter 6 as being done in the assessment scenarios. How tailings are managed within the impoundment can affect water chemistry and a dry stack with sulfides removed may produce the best water quality results after reclamation if the fate of the sulfide tailings is never considered. According to Ghaffari et al. (2011), 14% of the tailings produced would be pyritic (with the selective flotation method used), which equates to an average of 28,000 tons/day in a 200,000 tons/day mining operation, or over 255 million tons during a 25-year estimated lifetime for that scenario. These tailings need to be managed in such a manner that oxidation does not lead to acidic drainage and the most effective way is to deposit them subaqueously. Additionally, a "rule of thumb" for design of dry stack tailings is to allot 25 acres for every thousand dry tons of tailings per day over the life of a 20-year operation (SME Mining Engineering Handbook 1973). Assuming our scenario of 200,000 tons per day processed and that 99% of this material was waste tailings, this would amount to 4900 acres (25 *200,000 *.99/1000) or 19.8 km^2 over 20 years. This exceeds the internal surface area taken up by the TSF for tailings deposited over 25 years for the same mass of material processed per day by 5.6 km^2; thus, even if there were not a risk of

the PAG tailings acidic leaching potential, dry stack tailings disposal at this site would create additional surface area loss versus the scenario's traditional dam.

Waste rock management. The waste rock management plan on p. 4-13 calls for the potentially acid generating (PAG) waste rock to be separated from the rest of the waste rock and states that the "PAG waste rock might be placed in the open pit at closure to minimize oxidation of sulfide minerals and generation of acid drainage". However, on p. 4-33 it is stated that: "PAG waste rock will be processed through the flotation mill prior to mine closure, with tailings placed into the TSF (tailings storage facility) or the mine pit." These two alternatives represent completely different management, economic and environmental conditions and are not consistent. Milling the PAG waste rock represents a higher cost than placing the PAG rock in the pit and placing the PAG waste rock tailings in the TSF will increase the size of the TSF. Placing the PAG tailings in the pit will set up a completely different management scenario than placing the PAG waste rock in the pit. The EPA should clarify which option or range of options they select for evaluation and use that consistently in the assessment.

RESPONSE: These statements have been made consistent. The revised assessment scenarios include processing the PAG waste rock over the course of operations to minimize the length of time a PAG waste rock pile would be on the surface, and thus minimize its potential for oxidation and subsequent release of acidic leachate. There is no longer mention of PAG rock being disposed in the pit at closure (Section 6.3.3).

Water balance and management – waste rock. Mine site water balance and management is a very complex issue as recognized by the EPA on p. 4-27: "…water balance development is challenging and requires a number of assumptions". Because of these uncertainties, complex probabilistic dynamic models are employed at mines where the site details are better defined than that of the EPA hypothetical mine scenario. The information in Box 4-2 indicates that the "captured flows include water captured at the mine site and the TSFs (Table 4-5). The total amount of water captured at the mine site includes net precipitation (precipitation minus evapotranspiration [footnote: during operations most of these areas will not be covered with vegetation and the correct terminology here is "evaporation"]) over the areas of the mine pit, the waste rock piles, and the cone of depression (without double-counting any areas of overlap)". On p. 4-23 it is stated that: "Monitoring and recovery wells and seepage cut-off walls would be placed downstream of the piles to manage seepage, with seepage directed either into the mine pit or collection ponds". Figure 4-9 shows this schematically where leachate from the waste rock enters the groundwater that then flows to the mine pit or to the monitoring and collection well. However, if net precipitation only includes the components above (precipitation minus evapotranspiration), effectively excluding infiltration, and if this net precipitation is captured from that waste rock pile (as stated in Box 4-2), then there should not be any water available to infiltrate into the waste rock pile, i.e. there should not be any leachate. All references to seepage from the waste rock piles are incorrect following the EPA's assumptions of total capture of net precipitation. In addition, the approach that is used in the water balance is inconsistent with observed field performance and descriptions in the literature, as is it difficult to imagine a case where there is zero infiltration into a porous waste rock pile (e.g. Nichol et al., 2005 and Fretz et al., 2011). The EPA must clarify the whole water balance model and the evaluations. For the assessment to have any credibility, the water balance and management evaluations should reflect realistic conditions.

RESPONSE: The term "evapotranspiration" has been corrected to 'evaporation' in the revised assessment when discussing the operational phase. Total precipitation equals the sum of evaporation, transpiration (where applicable), runoff, and infiltration. Net precipitation included in the water balance includes all water falling onto the site components minus water leaving only via evaporation (i.e. it includes both runoff and infiltration). Leachate/seepage water originates from precipitation which has infiltrated the waste rock piles or tailings onto which it fell. Therefore, the discussion of seepage is not incorrect, and there is no indication that the scenarios represent "zero infiltration", as we discuss (as noted in the comment made) how seepage and leachate is managed. However, the water balance section has been revised for clarity (new Section 6.2.2). As the commenter notes, the assessment discusses seepage collection systems. However, the assessment does not assume total capture. Our water balance assumes that 50% of the leachate that is lost from the TSFs and from the portion of the waste rock piles outside the drawdown zone of the pit escapes into the groundwater and eventually into the streams.

Dam failure – tailings storage facilities. During operations, "water falling within the perimeter of a TSF would be captured directly in the TSF, but runoff from catchment areas up-gradient of the TSF would be diverted downstream" (p. 4-27). At closure, water would be removed from the TSF providing more storage, but also maintaining a small pool to "keep the core of the tailings hydrated and isolated from oxidation" (p. 4-32). This seems to assume that the diversion systems will be kept in place and most likely will be upgraded to divert up-gradient surface water around the tailings impoundment. It is likely that the design criterion for the upgraded diversion system during the post-closure period will be the probable maximum flood (PMF) as is done at a number of mines. Dam failure analyses were done assuming that the flood leaving the TSF includes the PMF inflow from the up-gradient catchment, excess water on top of the tailings and 20% of the tailings volume (Box 4-8). While one can argue that a failure including all these materials may be a plausible, although a very low likelihood event during operations, it seems less probable that such a failure will take place for the mine closure period when an upgraded diversion system is in place. Also, during the closure phase, the tailings will consolidate and be less mobile. Note that the densification behavior of oil sand tailings referred to on p. 4-32 (i.e. the Wells, 2011 reference) does not apply to copper tailings. The presence of clay minerals and bitumen in the mature fine tailings portion of the oil sand tailings is the source of the different behavior (Znidarčić et al., 2011).

RESPONSE: It is assumed that post closure scenarios will have drainage facilities in place that could safely pass storm events. However, the decision was made to assume a failure that was consistent for both the operational and post operation scenarios. The PMF would overtop the main dam of the TSF and drain into the North Fork Koktuli as a representative failure, assuming that drainage facilities were either not yet operational or had failed. It is important to note that the PMF peak flow generated only 291 cms, which is small when compared to the peak flow release at the failing dam (149,263 cms and 11,637 cms for the large and small failures, respectively). 20% was selected to represent the volume released from the TSF because it fell within a reasonable range when compared to release volumes of historic failures. The 20% volume included both solids and pore water.

Reclamation slope of waste rock. On p. 4-32 it is stated that: "We assume that NAG waste rock would be sloped to a stable angle (less than 15%) (Blight and Fourie, 2003)". I contacted Profs.

Geoff Blight and Andy Fourie about this statement and received the following response from Prof. Blight: "The only reference to 15 degrees (not 15 %) slopes is the following, talking about the outer tailings, not waste rock covered, slopes of decommissioned TSFs: "it must be remembered that the outer slopes will need to be rehabilitated, and that for vegetation to be stable, and surface erosion minimal, the maximum outer slope should not exceed 15 degrees." This error in reference must be corrected; it is recommended that more typical closure slopes of about 30% (or 3H:1V, about 18 degrees) for waste rock should be used in the evaluations.

RESPONSE: The text has been changed to correctly read 15 degrees in Chapter 4 and Appendix I.

Phyllis K. Weber Scannell, Ph.D.

The Environmental Assessment discusses a hypothetical mine (given that mine plans have not been developed). Page 4-5 of the document states that "rocks associated with porphyry copper deposits tend to straddle the boundary between net acidic and net alkaline . . ." The Pebble Project Environmental Baseline Report (SRK 2011, Chapter 11) summarizes testing on the samples from the pre-Tertiary porphyry mineralized rock in Pebble East Zone (PEZ) and Pebble West Zone (PWZ). The metals leaching/acid rock drainage study showed acidic conditions occurring immediately in core with low NP, but the average delay to onset of acidic conditions was estimated to be about 20 years. Copper was leached in the highest concentrations, but Co, Cd, Ni, and Zn also leached from samples from PEZ. Wacke (sedimentary rock) samples from PEZ and PWZ leached As, Sb, and Mo, in addition to Cu. (SRK, page 58). The available information on acid generation and metals leaching appears to be preliminary. Development and permitting of a viable mine plan will require extensive sampling and data analysis of ore samples, plans for classifying waste rock (as PAG and NAG), and, possibly, plans for collecting and treating runoff and seepage waters.

RESPONSE: EPA agrees that developing and permitting a viable mine would require extensive information. The assessment is not a mining plan. The scenario presents a suggested treatment option for mining influenced water and settling ponds for water that is simply stormwater runoff. No change required.

The Environmental Assessment seems a bit premature in making an assessment of the potential for acid rock drainage (ARD) or metals leaching (ML). Data on metals other than Cu are insufficient and possible toxicities to fish are not addressed. Further, the description of the potential mine may not reflect a likely mine scenario. It is difficult to calculate potential risks to the environment without a specific mine plan. The section of the Environmental Assessment should be revised as more data on ARD and ML become available.

RESPONSE: The assessment uses the geochemistry data that are available from the Pebble Limited Partnership. Copper was emphasized in the review draft because the EPA believed, and still believes, that it is the contaminant of greatest concern. Toxicities to fish of the other metals were not discussed because they had been screened out. However, the revised assessment explains the screening process and the selection of copper in more detail in a new section on the identification of stressors of concern (Section 6.4.2) and more metals have been added to the screening assessment. The toxicities of all metals reported in the leachate are now

addressed either as individual elements or, in the case of major ions, as contributors to total dissolved solids. The mine scenario is based on the most recent preliminary plan released by Northern Dynasty Minerals (Ghaffari et al. 2011).

Paul Whitney, Ph.D.

Reclamation Plan. I am not familiar with the Northern Dynasty Minerals mine plan. I wonder if their mine plan includes a Reclamation Plan. If not, why not? If their mine plan includes a Reclamation Plan, why isn't it presented as part of the Bristol Bay Assessment? The feasibility of reclaiming the waste rock and tailings areas and possibility the pit (page 4-23, last para, last sentence) seems important for evaluating the acceptability of the example mine. I am not aware of any mine regulating agency that does not require a Reclamation Plan as part of a mine application. I wonder if a Reclamation Plan that involved placing waste rock and tailings back in the pit and reducing surface infiltration would greatly reduce the need for water treatment.

RESPONSE: The assessment is not a mine plan. The NDM document relied upon for information in the assessment (Ghaffari et al. 2011) is a preliminary mine plan and does include conceptual reclamation measures which we have used in our scenarios. The State of Alaska requires a Reclamation Plan of all mining facilities unless they are very small (AS 27.19.010). EPA's revised scenarios utilize blending throughout the mine life to eliminate the need for long-term storage of PAG waste rock. Reclamation activities for the scenarios are discussed more clearly in the revision and are activities that are considered feasible and common at other similar existing mining sites. The scenarios in the assessment assume that reclamation is properly completed, but concentrates the discussion on impacts that are expected even with such activities.

Best Mining Practices. The assessment refers to the example mine plan as having both the "best" mining practices (e.g., page ES-10, five lines from the bottom) and "not necessarily best" mining practices (e.g., page 4-17, four lines from the top). Both of these statements can't be accurate.

RESPONSE: With regard to the terminology of "best", "good", or other terms for the practices used, what was intended to be conveyed is that we have assumed modern mining technology and practices. The terms are qualitative when generally interpreted, or have a regulatory meaning (best management practices), and thus we have eliminated their use in the revised assessment to avoid confusion.

Noise Levels. The mine plan should provide information on the location, frequency, and size of blasting, sound level isopleths around the mine, and efforts to minimize sound levels as the mine develops. I wonder if a majority of the sound levels will attenuate as mining activities move deeper into the ground or if will there be a hundred years of blasting at the surface level. The interviews with the villagers indicate that blasting and helicopter noise is a concern (Appendix D, Cultural Characterization, page 94). A characterization of current noise levels in relation to the area and timing of current and past wildlife use would help to determine if the whole or parts of the watersheds are less than pristine.

RESPONSE: Noise from large-scale mines is outside of the scope of this assessment because it is not known to affect salmonid populations. EPA agrees that a full evaluation of any future

mining permit applications and subsequent National Environmental Policy Act Environmental Impact Statements would consider these direct effects on wildlife.

Water treatment during the winter. I wonder if it will be possible to treat water during the winter. Will such treatment have to occur in a warm building? If so, what are the temperature consequences of releasing warm treated water into streams?

RESPONSE: Although water quality standards for temperature are directed toward summer maximum temperatures, we emphasize the importance of the year-round thermal regime to which salmon are adapted. Abnormally warm temperatures could accelerate egg maturation and reduce survival of incubating salmon. We state that a protective approach would discharge water that met baseline thermal regime conditions throughout the year, and describe the risks associated with failure to meet this regime.

Yes, it is possible to treat water during the winter, and treatment facilities would be contained in structures to prevent freezing of the treatment plant. While the Alaska water quality standards (18 AAC 70) do contain maximums for water temperature, even the most stringent of these (13°C) may be too high for winter-time discharge. Very likely, following a permit application, ADF&G would determine an appropriate temperature for winter discharge and the facility would have to meet this value, especially for discharges to anadromous streams. Temperature can be easily lowered during the winter by exposure to ambient air.

Cone of Depression. I have worked on pit mines where hydrogeologists model the lateral extent of the cone of depression and have mapped the lateral extent as an area around the pit. The lateral extent of the cone of depression, illustrated in Figure 4-9, appears to be underestimated and has no effect on streams or wetlands. The figure has no scale. Is the lateral extent of the cone of depression in Figure 4-9 based on modeling (see Box 4-2, para 3, last sentence)? If so, how many NWI wetlands and meters of stream are in the area used for the model? If there are wetlands or streams in the modeled area, how far down stream will the cone of depression influence stream flow and wetland hydrology?
The information in Box 4-2 doesn't clearly (at least to me) deal with the proportions of run-on and run-off water. If the diverted run-on water is supposed to mitigate the cone of depression. will it be available for down stream resources? Why won't diverted water seep back into the near-by pit versus mitigating the cone of depression? The answer to these questions is on page 5-72, but merely indicating there will be a reduction is not very informative.

RESPONSE: The cone of depression is now projected to dewater streams and wetlands with which it intersects. These losses are incorporated into the water balance calculations used to estimate changes in downstream streamflow presented in Chapter 7. The lateral extent of the cone of depression was estimated using the Dupuit-Forcheimer discharge formula for steady-state radial flow into a fully penetrating well in a phreatic aquifer with a diameter equal to the average mine pit diameter. The radius of influence was determined by balancing the net precipitation falling within the cone of depression with the calculated flow into the mine pit. Section 6.2.2.1 and Box 6-2 in the revised draft (Section 4.3.7 and Box 4-2 in the original draft assessment) contain additional details on the methodology.
Our estimate of the mine pit inflow agrees closely with the estimate provided in Ghaffari et al. (2011). The estimated cone of depression would extend about 1.2 km beyond the pit rim. The water within the cone of depression that would flow to the mine pit is included in the water

balance. The revised assessment presents estimates of the changes in streamflow at individual downstream gages.

Figure 4-9 (now Figure 6-5) is merely a schematic of the flows and is not to be interpreted as an exact representation of the expected flow regime. The figure is not to scale and is not based on modeling.

All of the precipitation falling within the cone of depression is considered to flow into the mine pit. These losses are incorporated into the water balance calculations used to estimate changes in downstream streamflow presented in Chapter 7. Streams within the cone of depression would dry up. The assessment assumes that water from streams upstream of the cone of depression would be diverted through pipes or channels to locations on streams downstream of the cone of depression. The diverted water would not seep or flow into the mine pit.

Run-on and run-off water terminology. I am used to referring to up gradient or adjacent water that runs onto the pit or tailings facilities as run-on water and to water from the mine or storage facilities as run-off water. The assessment doesn't always distinguish these two types of water. For example, on page 4-13, line 6 refers to precipitation run-off water as up gradient water. On page 4-26, the first bullet refers to run-off water as water running off mine facilities. The terminology overlap makes it difficult (at least for me) to understand how the run-on and run-off water will be captured and diverted around the mine facilities or used for other purposes. In addition to calculations, diagrams of the diversions would be helpful. Will there be parallel diversion ditches around the facilities, one for run-on and one for run-off water? Will one or both of these ditches be lined? How will the water in these ditches be influenced by the cone of depression? These questions are alluded to in the discussion on page 4-27(second para), but are not explicitly addressed. I am sure engineers can and have answered these questions for other mines with water balance analyses. It would be interesting to see an explicit summary of the water balance for the various facilities. Such analyses would be good for the example mine plan during operation and once the mine is no longer a net consumer of water (page 5-44, para 2). Without the water balance analyses, potential impacts are not easily understood or quantifiable.

RESPONSE: A single diversion ditch intercepts up-gradient surface water and routes it around the areas disturbed by mining, preventing it from mixing with waters that have encountered site materials. The revised assessment includes a more detailed water balance (Chapter 6).

Some ideas for how to manage and separate run-on and run-off water might help determine which streams might dry up and what type of mitigation measures (i.e., lining ditches) could minimize the impact. In addition, if run-on water can be maintained in a diversion ditch, what is the opportunity for developing a reclamation plan for the ditches? Such plans might be able to minimize and partially compensate for lost reaches of headwater streams.

RESPONSE: The revised assessment does include some possible reclamation activities for closure, although others could be proposed for an actual mining plan. Water would continue to be diverted around areas where the water could encounter contaminants. Mitigation to compensate for lost streams would be addressed through a regulatory process that is beyond the scope of this assessment. Nevertheless, in response to public and peer comments we have included a discussion of compensatory mitigation in Appendix J of the revised assessment.

Protective approach. A "protective approach" is mentioned on page 5-30 (para 3, last sentence). This has something to do with water management and would be good to explain.

RESPONSE: This has been clarified in Chapter 7.

Question 3. ***EPA assumed two potential modes for mining operations: a no-failure mode of operation and a mode involving one or more types of failures. Is the no-failure mode of operation adequately described? Are engineering and mitigation practices sufficiently detailed, reasonable, and consistent? Are significant literature, reports, or data not referenced that would be useful to refine these scenarios, and if so what are they?***

David A. Atkins, M.S.

The no-failure scenario attempts to quantify the impacts from developing the footprint of the project alone. In reality, various failures and accidents inevitably occur, and they may have a range of impacts from inconsequential to large. So this scenario is presented to describe the minimum impact that could be expected from project development assuming everything works as planned.

RESPONSE: This comment is a correct interpretation of our "no-failure" scenario. Because this distinction was not clear to many other readers, the revision no longer uses the term "no failure". The no-failure scenario from the draft assessment has been changed to a chapter on the effects of the footprint of a mining operation, without regard for operational problems (Chapter 7).

The mine will, by necessity, remove those streams and wetlands that are beneath the pit, waste rock, tailings and processing plant development areas. There should be some flexibility in siting facilities other than the pit or underground workings. For the 'no-failure' scenario, the Assessment presents lengths of stream and areas of wetlands that would be lost due to physical displacement of the aquatic resources from mine development and reduction in flows from mine water management. The assessment presents the following resources that would be lost and that have been shown to be spawning or rearing habitat for coho, Chinook, and sockeye salmon, or have resident populations of rainbow trout and Dolly Varden:

	25-year scenario	78-year scenario
Eliminated or blocked streams (km)	87.5	141.4
Reduced flow (>20%; km)	2	10
Eliminated wetlands (km^2)	10.2	17.3

Given the range of uncertainty with the proposed mine plan, presenting stream lengths and wetland areas to the tenth place implies unrealistic accuracy. Significant figures should be checked and consistent throughout the document, and ranges should be presented if known (e.g., results for the pits could be presented with more accuracy since we know where they will be, whereas other facilities that could be located in different areas should be presented with an appropriate range of uncertainty).

RESPONSE: The authors have carefully addressed this issue. Numbers from the literature or from the PLP EBD retain the number of significant figures in the original. Numbers derived for this assessment have the appropriate number of significant figures given the precision of the input data and uncertainties due to modeling and extrapolation.

The impacts as presented appear substantial, mainly because of the very large nature of the project. However, it would be helpful to describe the significance of this loss, specifically with regard to the following questions:

- What impact would the loss to streams and wetlands have on the fishery within the Nushagak and Kvichak basins?

RESPONSE: Impacts of habitat loss and alteration are very difficult to quantify given the lack of information on limiting factors, production and capacity estimates. We were unable to comprehensively evaluate impacts at the population level, except for the most severe cases where total losses of runs could be reasonably assumed.

- Is this loss significant in comparison to the fishery as a whole?

RESPONSE: Losses of streams and wetlands under the mine footprint could not be related to the fishery due to reasons listed above. For the TSF failure scenario that completely eliminates or blocks access to suitable habitat in the North Fork Koktuli River, we estimate that the entire Koktuli portion of the run (~28% of Nushagak escapement) could be lost. Higher proportional losses would occur if significant downstream effects occurred due to transport of toxic tailings fines beyond the Koktuli as modeled under the Pebble 2.0 TSF failure.

- Are there local communities that could be affected by this specific loss?

RESPONSE: Wildlife and resident fish communities would be affected by reductions in spawning salmon. Local communities would also be affected by the reduction, which is now discussed in Chapters 12 and 13 (e.g., Chapter 13 now contains tables which refer to specific subsistence resources used by individual communities).

- Is fragmentation of the resource from this loss a significant impact (i.e., are there stocks that are unique to the project area)?

RESPONSE: Stock structure and genetic diversity are not well known at the project scale, but based on evidence from other parts of Bristol Bay watersheds, local adaptation is highly likely. Discussion of fragmentation effects is now included in Chapters 7 and 10.

There is no discussion of engineering and mitigation practices in this section. The responsible regulatory authority would require the project proponent to present a mitigation plan to compensate for these impacts before permitting. Measures would include minimization of impact through facility siting, reclamation if possible, and compensation if reclamation were not feasible. A thorough analysis of possible mitigation approaches and the likelihood of their success are necessary to fully evaluate impacts from the 'no-failure' scenario.

RESPONSE: Mitigation measures for design and operation are more clearly called out in the revised assessment. While measures chosen here may differ from what is required during the regulatory process, the assessment is not a mining plan and not an evaluation of a mining plan. The assessment assumes that measures chosen for the scenarios would be as effective as possible and examines only accidental failures rather than a failure to choose a proper mitigation measure. Mitigation to compensate for effects on aquatic resources that cannot be

avoided or minimized by mine design and operation would be addressed through a regulatory process that is beyond the scope of this assessment. Nevertheless, in response to public and peer comments we have included a discussion of compensatory mitigation in Appendix J of the revised assessment.

Steve Buckley, M.S., CPG

The engineering and mitigation designs associated with the no-failure mode of operation are inadequate. There is no detailed discussion of engineering practices. There is insufficient discussion of any potential mitigation measures and there is a lack of any detailed research into applicable engineering and mitigation methods. Appendix I provides some engineering and mitigation practices along with water quality mitigation and monitoring during closure; however, these are not discussed or accounted for in the main assessment document.

RESPONSE: Mitigation measures, including wastewater treatment and closure and post-closure monitoring and maintenance, were included as part of the mine scenarios in the draft assessment, and this discussion has been expanded in the revised assessment. The mitigation measures proposed within the mine scenarios are those that could reasonably be expected to be proposed for a real mine (they are a subset of options presented in Appendix I), all of which were presented as appropriate for the Pebble deposit in Ghaffari et al. (2011). Mitigation to compensate for effects on aquatic resources that cannot be avoided or minimized by mine design and operation would be addressed through a regulatory process that is beyond the scope of this assessment. Nevertheless, in response to public and peer comments we have included a discussion of compensatory mitigation in Appendix J of the revised assessment.

The reorganization and additional discussions presented in Appendix J clarify when and where mitigation would become part of the regulatory process. The chapter organization is much better than the first draft with respect to Failure/No Failure modes.

Courtney Carothers, Ph.D.

The no-failure mode of operation appears to be described adequately. The engineering and mitigation practices appear to be sufficiently detailed, reasonable, and consistent, although I have no particular expertise with which to evaluate this part of the assessment.

RESPONSE: No change suggested or required.

It would be helpful to have a clear statement about how well the local (geotechnical, hydrologic, and environmental) conditions in this region have been studied and characterized. How much is understood about the seasonal variation in these conditions and how those variations would affect these scenarios? How well are statistics from mines and TSFs constructed in very different environments likely to apply here?

RESPONSE: TSF failure probabilities are based on Alaska's dam classification and required safety factors applied to the method of Silva et al. (2008). The discussion of failure probabilities is expanded to clarify this issue. Therefore, the failure is not a consequence of

any specific site conditions or seasonal phenomena. However, the discussion of local and regional conditions has been expanded in the revised assessment. It is recognized that some issues such as hydrology are very complex and additional information will be useful in future analysis of any mine plans.

Dennis D. Dauble, Ph.D.

The description of the no-failure mode for mine operation appears adequate in terms of potential mitigation measures that might be employed. I have limited knowledge of current engineering practices and subsequent risks to the environment from best practices of modern mines, including those operating under optimal conditions. However, it would be helpful to include a short discussion on which mitigation measures would be most applicable to mining activities in the Bristol Bay watershed.

RESPONSE: Standard design mitigation measures considered feasible, appropriate, and 'permittable' (as per Ghaffari et al. 2011) were considered and are discussed in Chapter 6 and Appendix I of the revised assessment; these are standard measures common to other copper porphyry mines. Evaluation of measures that would be proposed for an actual mine would occur through the regulatory process. Whether these same measures would be appropriate for all locations within the Bristol Bay watershed would depend on the given site's specific characteristics.

Gordon H. Reeves, Ph.D.

No comments on this question.

Charles Wesley Slaughter, Ph.D.

Based on the actual history of other major resource extraction projects in Alaska and throughout the world, a "no failure" assumption seems unrealistic. Rather, the assumption should be that there will be failures, of varying modes and magnitudes, over the life of the project. This reality is recognized in several sections of text.

RESPONSE: Our intention for the "no-failure" scenario was to identify and evaluate the unavoidable environmental effects if all systems and mitigation measures operated perfectly, and to separate those effects from a scenario where systems periodically failed. The "no failure" chapter has been eliminated. The revised assessment differentiates between potential effects from the footprint of a mine (Chapter 7), water treatment (Chapter 8), TSF failures (Chapter 9), the transportation corridor (Chapter 10), and pipeline failures (Chapter 11).

In some sections in the Assessment, presumed "mitigation practices" are either cursory, optimistic, or so general as to be un-supported. Examples include Section 4.3.7's cursory, generalized statements about handling water: "Uncontrolled runoff would be eliminated…The mine operator would capture and collect surface runoff and either direct it to a storage location…or reuse or release it after testing and any necessary treatment"; "…water from these upstream reaches would be diverted around and downstream of the mine where practicable"; "precipitation would be collected and stored…"; and "Assuming no water collection and treatment failures, this excess captured water would be treated to meet existing water quality standards and discharged to nearby streams, partially mitigating flow lost from eliminated or blocked upstream reaches." Other examples from Chapter 6: "…assuming no water collection and treatment failures" and "excess captured water would be treated…and discharged to nearby streams..."

RESPONSE: Water management (mitigation) measures are more clearly described and discussed in the revised Section 6.1.2.5, and in sub-sections for the mine components in the scenarios. However, the intent of the assessment is not to specify technologies, beyond those already identified by the existing preliminary mining plans. Rather, the assessment focuses on the environmental outcomes of conventional modern mining practices and effluents.

John D. Stednick, Ph.D.

The no-failure mode is not adequately described. Assessment of the effects of the mine is based on large risk failures of low probability and did not include low risk failures of higher probability. The report concludes (and emphasizes) that the mine footprint will disrupt/disturb contributing watershed and wetland areas and result in hydrologic modification. The hydrologic modification affects salmonid habitats, particularly in low flow conditions. Regulatory oversight will include the State of Alaska, and certainly mitigation measures would be required. The task is to address the adequacy of these mitigation measures.

RESPONSE: Our intention for the "no-failure" scenario was to identify and evaluate the unavoidable environmental effects if all systems and mitigation measures operated perfectly, and to separate those effects from a scenario where systems periodically failed. The revised assessment no longer uses the term "no-failure", and does address effects from scenarios having higher probability and lesser magnitude (e.g., failure to collect or treat leachate water) in addition to those with lower probability and higher magnitude (e.g., TSF failure). Mitigation to compensate for effects on aquatic resources that cannot be avoided or minimized by mine design and operation would be addressed through a regulatory process that is beyond the scope of this assessment. Nevertheless, in response to public and peer comments we have included a discussion of compensatory mitigation in Appendix J of the revised assessment.

Pollutant/toxicity assessment focused on copper. Other metals can be presented to show the range of metal concentrations for chronic and acute toxicity. Suitability of treatment processes for all wastewaters can be included to address potential effects on receiving waters.

RESPONSE: Although copper is emphasized due to its dominance of the toxicity of leachates, other metals were and are presented (Chapter 8).

The discussion of roads is mostly related to fish blockage and some soil erosion. Information on current design standards was not included and tended to relay on dated references from logging roads

RESPONSE: The discussion of roads covers risks related to filling and alteration of wetlands, stream crossings, fine sediments, dust deposition, runoff contaminants, and invasive species. Information on current design standards is now included within text boxes throughout Chapter 10, and relies on recent literature. The failure frequencies cited in the assessment are from modern roads and not restricted to forest roads. One of the papers used for general information (Furniss et al. 1991) focuses on forest and rangeland roads, but it is a seminal publication on the potential effects of roads, particularly as they relate to salmon.

There were no engineering or mitigation practices described in this section or in the document.

RESPONSE: Mitigation measures, including wastewater treatment and closure and post-closure monitoring and maintenance, were included in discussion of the mine scenarios in the draft assessment as part of the design. This discussion has been expanded in the revised assessment.

Roy A. Stein, Ph.D.

No Failure Operations and Their Impact. What about the failure of continued monitoring, of continual inspection, of continual, rigorous oversight? This is more insidious than a catastrophic failure of some sort, but perhaps just as dangerous (in fact, one research geochemist testified during public testimony that of 150 hard-rock mines, none operated without leakage of leachate). How can we be sure that mine operators will be held strictly accountable for their actions with regard to best mining practices (a point emphasized by those who testified in favor of the Pebble Mine that indeed best management practices would be used), meeting all the various and sundry regulations, and communicating all of these activities back to the regulatory organization? Will there be a force of will on the part of EPA or other regulatory body to be sure that all activities of the operator are appropriate and within regulatory limits? The down-side of poor monitoring and lack of rigorous oversight is the loss of salmonid populations. These losses are, in my view, less important than compromising human health and life. Yet, at the Upper Big Branch Mine in West Virginia, dust standards have been exceeded for years, leading to a dust explosion that killed 29 miners on April 5, 2010. In turn, even surviving miners were not immune to these dust impacts, for they suffer from "black lung", a condition that literally shortens their life by decades. In turn, much of the monitoring of these conditions has historically been the responsibility of the owner corporation, rather than an independent regulatory body, much like "the fox guarding the chickens". Here at the Pebble Mine site, where only fish (but, of course, Native Alaskan subsistence users, plus other human users as well) are at stake, would one expect rigorous oversight by appropriate regulatory bodies? Skepticism leads to cynicism when contemplating the Upper Big Branch Mine case history in the context of the Pebble Mine proposal.

RESPONSE: Our intention for the "no-failure" scenario was to identify and evaluate the unavoidable environmental effects if all systems and mitigation measures operated perfectly, and to separate those effects from a scenario where systems periodically failed. The "no failure" chapter has been eliminated. The revised assessment differentiates between potential effects from the footprint of a mine (Chapter 7) water treatment (Chapter 8), TSF failures (Chapter 9), the transportation corridor (Chapter 10), and pipeline failures (Chapter 11).

Holding the mining company accountable is done through the regulatory process and is outside scope of this assessment.

Engineering Practices and Mitigation. I did not think that mitigation was well described in text, but Appendix I is quite well developed and was instructive to me as I moved through the documents. I would suggest including the ideas in Appendix I in the mitigation section of the main report. Other comments on mitigation issues can be found below associated with Question 12.

RESPONSE: Mitigation measures for design and operation are included in the assessment (Chapter 6), and are those that reasonably could be expected to be proposed for a real copper porphyry mine (they are a subset of options presented in Appendix I). Many, if not all, of these measures were presented as appropriate for the Pebble deposit in Ghaffari et al. (2011). Mitigation to compensate for effects on aquatic resources that cannot be avoided or minimized by mine design and operation would be addressed through a regulatory process that is beyond the scope of this assessment. Nevertheless, in response to public and peer comments we have included a discussion of compensatory mitigation in Appendix J of the revised assessment. Mitigation measures have been explained more clearly throughout the revised assessment.

William A. Stubblefield, Ph.D.

It is interesting and appropriate that the EPA has included both modes of operation in conducting this assessment. This approach provides some degree of "bounding" for the assessment; however, the degree of accuracy (i.e., predictability) for either scenario cannot be known at this time. The document appropriately acknowledges that there are a variety of potential mitigating factors (e.g., acts of God, accidents, market changes) that may render the assumptions used in this assessment incorrect.

RESPONSE: Our intention for the "no-failure" scenario was to identify and evaluate the unavoidable environmental effects if all systems and mitigation measures operated perfectly, and to separate those effects from a scenario where systems periodically failed. There were a number of comments on this approach so the revised assessment no longer uses the term "no-failure" and addresses effects from the foot print (i.e., the no failure scenario), failure scenarios having higher probability and lesser magnitude (e.g., failure to collect or treat leachate water), and failure scenarios having lower probability and higher magnitude (e.g., TSF failure).

No change suggested or required.

Dirk van Zyl, Ph.D., P.E.

The no-failure mode of operation failures is based on surface disturbances and potential blockages caused by the various facilities. For example, for the mine pit, TSF and waste rock facility, the surface areas of these facilities are used as a basis for calculating the streams and wetlands affected by the mining activities. While the failure mode is adequately described, engineering and mitigation practices are not adequately described by EPA.

RESPONSE: Mitigation measures associated with the mine components (e.g., waste rock pile, TSF, etc.) were discussed in the sections presenting those components. They were not repeated in the section on failures. These measures are included again in the revised assessment (Chapters 4 and 6), but are described in greater detail. However, the emphasis of the assessment is on the consequences of failures rather than on the details of how inadequate mitigation may cause the failures.

The EPA Assessment states on p. 8-1 "Routine operations are defined as mine operations conducted according to conventional practices, including common mitigation measures, and that meet applicable criteria and standards". The adverse effects listed are: direct impacts as a result of removal of streams in footprint of mine pit and waste storage areas; reduced streamflow resulting from water retention; removal of wetlands in the footprint of the mine; indirect impacts of stream and wetland removal; diminished habitat quality in streams below road crossings; and inhibition of salmonid movement from culverts that may block or diminish use of full stream length.

RESPONSE: No change suggested or required.

Any mine in Bristol Bay will have to undergo a rigorous and lengthy regulatory review and permitting process. I do not know of a process that will exclude consideration of the impact of all mine facilities on the streams and wetlands in the region. Therefore, I would suggest that the full implications of "mine operations conducted according to conventional practices, including common mitigation measures, and that meet applicable criteria and standard" should have been addressed in the report. The EPA (2003) document on Generic Ecological Assessment Endpoints for Ecological Risk Assessment specifically details the applicability of Section 404 of the CWA in addressing community and ecosystem-level endpoints. "The CWA provides authority for the Corps to require permit application to avoid and minimize wetlands impacts and requires EPA to develop, in coordination with the Corps, the criteria used for Section 404 decisions. When damages to wetlands are unavoidable, the Corps can require permitees to provide compensatory mitigation". It is unclear why this was not included in the evaluations.

RESPONSE: This is not a permitting document. The purpose of the assessment is to evaluate the effects of the operation of a mine on salmon ecosystems in the Bristol Bay watershed, while following conventional practices, including common mitigation measures. Once those effects are described, then it is appropriate to determine 1) if unacceptable environmental effects are likely to occur and 2) whether those effects can be offset (made acceptable from a regulatory standpoint) with compensatory mitigation. In other words, compensatory mitigation is a next step and not within the scope of this assessment. Nevertheless, we have included a discussion of compensatory mitigation in Appendix J in the revised assessment.

Similarly, one would expect that the regulatory reviews will require that the impacts resulting from loss of streams, streamflow and road crossings will be addressed through engineering designs, proposed mitigation measures, as well as regulatory and community engagement best mining practices (see discussion above on "good" vs. "best" practices).

RESPONSE: Our scenarios included mitigation measures through engineering design and operations to reflect standard industry practices. The purpose of the assessment was to evaluate risks in the presence of these measures. The commenter is correct that alternatives

for such measures would be evaluated during the permitting (regulatory) process. No change suggested or required.

On p. 4-33, it is stated that "Environmental impacts associated with premature closure may be more significant than those associated with planned closure, as mine facilities may not be at the end condition anticipated in the closure plan and there may be uncertainty about future reopening of the mine". Further text describes potential negative impacts from such a premature closure. One of the outcomes of the regulatory review and permitting will be the establishment of financial assurance that will provide State and Federal Regulatory Agencies with the financial resources to accommodate a closure. These obligations are typically reviewed on a 3 or 5-year interval to also make sure that they are adequate to cover premature closures. If the mining company is still managing the site, then they will have responsibilities under all Federal and State Regulations and the dire picture painted by the EPA Assessment should not come to pass.

RESPONSE: The revision includes language that addresses financial assurance (Box 4-3).

Because of this major oversight of the realities when permitting and operating a mine it is essential that the scenarios be reviewed by evaluating the effects that regulatory requirements and resulting mitigation methods would have on the no-failure conditions before completely reworking the no-failure mode of operations and their impacts. Other significant reports and data that should be reviewed include typical permitting documents and resulting requirements for similar mines in the US and Canada to obtain a range of potential outcomes. The results from such an evaluation will also contribute significantly to the discussions in Alaska when the Pebble Mine and other mines in Bristol Bay are brought forward to permitting.

RESPONSE: Our intention for the "no-failure" scenario was to identify and evaluate the unavoidable environmental effects if all systems and mitigation measures operated perfectly, and to separate those effects from a scenario where systems periodically failed. The revised assessment no longer uses the term "no-failure", but simply presents effects from scenarios having higher probability and lesser magnitude (e.g., failure to collect or treat leachate water) as well as those having lower probability and higher magnitude (e.g., TSF failure).

Phyllis K. Weber Scannell, Ph.D.

Chapter 4 provides a detailed description of a hypothetical mine design for a porphyry copper deposit in the Bristol Bay watershed. Some of the assumptions appear to be somewhat inconsistent with mines in Alaska. In particular, the descriptions of effects on stream flows from dewatering and water use do not account for recycling process water, bypassing clean water around the project, or treating and discharging collected water.

RESPONSE: The issues mentioned were discussed in Sections 4.2.3 (tailings storage) and 4.3.7 (water management) in the original draft document. They are now addressed in Chapter 6 of the revised document, which describes the mine scenarios, and in Chapter 4, which provides generic background on porphyry copper deposits and mining. Streamflow effects presented in Chapter 7 now reflect a complete water balance, including water capture and re-use, bypass, and discharge from the wastewater treatment facility, as suggested by the commenter.

Section 4.3.8, Post-closure Site Management, raises critically important issues – can a mine in this area be designed for closure? Is it acceptable to develop and operate a mine that will require essentially perpetual treatment? It is my belief that these are the essential questions that should be addressed during any mine permitting process.

RESPONSE: EPA agrees that these are important questions to be addressed, but they are risk management, not risk assessment, questions. The purpose of the assessment is to evaluate risks to the salmon fishery from large-scale mining. Risk management decisions will be made during the permitting process. Thus, no changes to the assessment were made in response to this comment.

Section 4.3.8.1 raises concerns about long term water quality and quantity from the mine pit. These concerns need to be addressed during a mine permitting process. Pit water quality depends on how the pit is developed, what reclamation will occur, if reclamation will be concurrent with mining, and what kinds of water treatment will be used. Tailings storage facility (TSF) water quality depends on how the mine tailings are managed; it may be possible to use dry stack tailings with sulfide removal rather than submerged tailings.

RESPONSE: EPA agrees that water quality can be influenced by design and reclamation, but when the latter entails creating a pit lake there is little flexibility for reclamation concurrent with mining. How tailings are managed within the impoundment can affect water chemistry, and a dry stack with sulfides removed may produce the best water quality results after reclamation if the fate of the sulfide tailings is never considered. According to Ghaffari et al. (2011), 14% of the tailings produced will be pyritic, which equates to an average of 28,000 tpd in a 200,000 tpd mining operation (over 255 million tons during a 25 year mine life). These tailings need to be managed in such a manner that oxidation does not lead to acidic drainage, so the most effective way is to deposit them subaqueously. Some suggested common mitigation measures for management of the pit at and post closure are included in the revised assessment (Chapter 6).

Paul Whitney, Ph.D.

Mitigation Plan. Most mine permit applications I have worked on include both mitigation to minimize environmental impact and mitigation to compensate for environmental impact. The assessment outlines a variety of mitigation measures to minimize impact, but no compensatory mitigation. This is a concern, for I wonder if compensatory mitigation for the example mine is even possible in the watersheds.

RESPONSE: The purpose of the assessment is to evaluate the effects of the footprint and operation of a mine that follows conventional practices, including common mitigation measures. Once those effects are described, then it is appropriate to determine 1) if unacceptable environmental effects are likely to occur and 2) whether those effects can be offset (made acceptable) with compensatory mitigation. Determining compensatory mitigation is a next step and outside the scope of this assessment; however, we have included a discussion of compensatory mitigation in Appendix J in the revised assessment.

The watersheds are characterized with descriptors such as "pristine" (e.g., page 6-29, last para, second line), "nearly pristine" (e.g., pages 2-25 and 7-2) and "exceptional quality" (page 2-20). It is also stated that the return of the salmon "fuel" (i.e., provide energy to) the terrestrial food web. If in fact the watersheds are pristine or nearly pristine, the habitat is high quality and there is little, if any, opportunity for compensatory mitigation (i.e., improving low quality habitat) in the terrestrial and fresh water environments. For example, if 55 miles of streams and streamside wetlands are lost to the mine footprint (page ES 15, first bullet), is it possible to find miles of very degraded stream to plan for and implement compensatory mitigation? If one assumes a mitigation ratio of 3:1 for enhancement, one might have to find 165 miles of degraded stream for compensation. I suspect (but don't know) that there are very few (if any) miles of degraded stream where compensatory mitigation could occur in the Bristol Bay watershed(s). If this is the case, it might not be possible to demonstrate no net loss for waters of the US, and this is something EPA should be interested in.

RESPONSE: The comment is correct in stating that the exceptional quality of the Bristol Bay environment leaves little opportunity for compensatory mitigation. Determining compensatory mitigation is outside the scope of this assessment; however, we have included a discussion of compensatory mitigation in Appendix J in the revised assessment.

I agree that the ecological resources can be ranked as having high quality because the human footprint on the habitat is small (i.e., few roads and villages), but from an energetics (i.e., fuel) and food web perspective, the pristine characterization may not be accurate. The commercial catch of approximately 27.5 million fish each year (up to 70% of the total number of sockeye produced) is a lot of calories that are not flowing through the ecological foodwebs of the watersheds. Granted, some of the commercial catch (if not caught) might not enter the watersheds, but some and perhaps a lot would, especially in good run years. While the harvest level might be sustainable, the loss of energy to commercial fishing causes pause to characterize the watersheds as pristine or nearly pristine. The potential impact of fisheries on energy flow has been addressed by Pauly et al. (2000) and Libralato et al. (2008). I wonder if it is technically possible that a reduction in the commercial fishery is a compensatory mitigation measure.

RESPONSE: Compensatory mitigation requirements address the need for project proponents to replace aquatic resources and ecosystem functions that their project has impacted. Reduced fishing harvests would not replace lost spawning and rearing habitat. Further, it would remove the burden of compensation from the party that caused the damage. Determining compensatory mitigation is outside the scope of this assessment; however, we have included a discussion of compensatory mitigation in Appendix J in the revised assessment.

<u>Effluent treatment.</u> Water quality information in the assessment for benchmarks, background, and leachate is extensive. A thorough review of the water quality and toxicity information is beyond the scope of work of this review. After several reads of this information, it appears that the work is good for copper. For example, work on salmonid olfaction and copper conducted by McCarthy et al. (2007) is potentially important and is cited. The inhibiting effects of copper on olfactory receptor neurons cited by McCarthy et al. (2007) at or above 2 µg/L are lower than the Alaska hardness-based standards and the biotic ligand model (BLM) standard in Table 5-14, but are above the biotic ligand model standard in Tables 5-15 and 5-16. I assume this is due to differences in binding of copper by dissolved organics but I am not sure. Whether one decides to use the 2 µg/L benchmark, or the even lower BLM benchmarks that are in some cases below

background values in Table 5-19, I think the key question is whether proposed leachate processing can cost-effectively achieve benchmarks that hover around background concentrations. The answer is beyond my level of expertise.

RESPONSE: BLM-derived copper criteria are derived for the different leachates. The values depend on the co-occurring ions, which differ considerably among leachates and, in the case of ambient waters, on dissolved organic matter. The low copper benchmarks would be achievable with treatment by reverse osmosis, which has been used at other mines. Whether it is economically feasible to achieve benchmarks close to background concentrations is outside the scope of the assessment. No change suggested or required.

I do not agree with the assessment's critical question – whether or not effects are observed at these low levels (page 5-57, Exposure-Response Data from Analogous Sites, second sentence). If effects are observed at background concentrations, it seems unreasonable to ask for an even lower benchmark than background concentrations. The uncertainties assessment at the bottom of page 5-57 also seems unreasonable. The possibility that background concentrations are not protective in particular cases seems highly unlikely for one of the most productive salmon communities in the world.

RESPONSE: The passages cited by the reviewer refer to the possibility of effects at copper concentrations below criteria, not below background. Similarly, the studies mentioned found effects below criteria levels but above background concentrations.

I can think of many questions that are more critical than looking for effects on salmonids at background or near background concentrations of copper. For example, it might be more important to ask what concentrations of copper will result in a significant impact on the salmonid populations and to ask what impact a mixing zone would have on salmonid populations. Last but not least, what are the potential impacts of all toxics on the many other non-salmonid species?

RESPONSE: See response to previous comment regarding background concentrations versus water quality criteria. Because water quality is so high at the site, the threshold for copper toxicity is low based on the biotic ligand model. Effects on salmonid populations from exceeding toxic thresholds cannot be estimated because the available monitoring data do not characterize salmonid demographics or productivity in the streams draining the site. However, the analysis has been expanded to include estimates of kilometers of stream habitat that would be exposed to copper levels sufficient to cause aversion, sensory deprivation, decreased reproduction, or kills. Mixing zones are not allowed by the State of Alaska for water quality compliance in anadromous streams, and the available stream data are not sufficient for mixing zone modeling. However, a discussion of mixing zones, including the amount of mixing that would be required to reach nontoxic levels, has been added. Non-salmonid fish are not included as endpoint species. However, because copper and most other metals are most toxic to arthropods, the assessment implicitly addresses non-salmonid fish (which depend on arthropods in the food web) as well.

Question 4. ***Are the potential risks to salmonid fish due to habitat loss and modification and changes in hydrology and water quality appropriately characterized and described for the no-failure mode of operation? Does the assessment appropriately describe the scale and extent of risks to salmonid fish due to operation of a transportation corridor under the no-failure mode of operation?***

David A. Atkins, M.S.

For the no-failure mode of mine operation, the risks to salmonid fish due to habitat loss and modification in the vicinity of the project are described in terms of loss of lengths of stream or areas of wetlands. Project proponents state that the mine will only impact a very small fraction of the watershed (under a no-failure scenario). It is important to establish whether the modeled impact (e.g., the loss of 87.5 km of streams) is significant, both in terms of the absolute impact, as well as the effect on ecosystem fragmentation.

RESPONSE: Footprint effects on habitat loss are now characterized in relation to the distribution of habitat conditions throughout the larger watersheds. Fragmentation effects are not anticipated at the mine site, apart from blockage of headwater streams as described, but are anticipated in the case of the transportation corridor (Chapter 10) and TSF failure (Chapter 9).

In addition, project proponents often state they will preserve and even improve the fishery. As mentioned in the answer to the previous question, it would be helpful to know what kinds of mitigation efforts could be employed – minimization, reclamation and compensation – and have some assessment of the potential effectiveness.

RESPONSE: Mitigation measures, including wastewater treatment and closure and post-closure monitoring and maintenance, were included in discussion of the mine scenarios in the draft assessment, and this discussion has been expanded in the revised assessment. The mitigation measures proposed within the mine scenarios are those that could reasonably be expected to be proposed for a real mine (they are a subset of options presented in Appendix I), all of which were presented as appropriate for the Pebble deposit in Ghaffari et al. (2011). Reclamation is not mitigation, but the revised assessment includes also some suggested measures to be used in closure/post-closure to reclaim the disturbed areas. Mitigation to compensate for effects on aquatic resources that cannot be avoided or minimized by mine design and operation would be addressed through a regulatory process that is beyond the scope of this assessment. Nevertheless, in response to public and peer comments we have included a discussion of compensatory mitigation in Appendix J of the revised assessment.

The Assessment determines that construction of the transportation corridor could alter the habitat, chemistry, and the migration path across the corridor for the over 30 streams that the corridor will cross or come near. The report further states that the corridor could affect 270 km of streams below the corridor and 240 km of streams above, but that there is no way to assess the magnitude. Therefore, the impacts of the corridor on fish populations are unknown, and this impact is not described in a way that can allow a reviewer to draw any conclusion.

RESPONSE: The revised assessment states that "the exact magnitudes of changes in fish productivity, abundance and diversity cannot be estimated at this time," but summarizes the species, abundances, and distributions that would potentially be affected. Also, the assessment concludes that, assuming typical maintenance practices after mine operations, approximately 15 of 32 culverted streams with restricted upstream habitat would be entirely or in part blocked at any time. "As a result, salmonid passage—and ultimately production—would be reduced in these streams, and they would likely not be able to support long-term populations of resident species such as rainbow trout or Dolly Varden."

Further, the references for road design and construction practices seem to be more representative of forest and rangeland roads than the type of road that would likely be constructed for this type of project. It would be helpful to cite experience from other transportation corridors constructed for mining and oil and gas projects and developed recently in Alaska.

RESPONSE: Because the proposed mining would take place in an undeveloped area, the literature is necessarily from areas outside of Bristol Bay. Further, we found no data concerning the performance of culverts for mining or oil and gas projects in the region. However, to the extent possible we used examples from representative environments. The failure frequencies cited in the assessment are not restricted to forest roads. One of the papers used for general information (Furniss et al. 1991) focuses on forest and rangeland roads, but it is a seminal publication on the potential effects of roads, particularly as they relate to salmon. The general conclusions of that paper should be applicable to the transportation corridor considered in the assessment. Information on current design standards is now included within throughout Chapter 10, and relies on recent literature.

Steve Buckley, M.S., CPG

Risks to fish due to habitat loss and modification and changes in hydrology and water quality are overly simplified given the broad parameters used to model these potential risks. More specific details on the water balance would help define potential risks to fish from dewatering and habitat loss. For example, there is no attempt to identify groundwater flow paths or the specific response of various landforms to seasonal changes in precipitation and runoff, yet 34 pages are dedicated to an attempt to quantify these impacts. More detailed information is needed to accurately quantify the changes in anticipated runoff and infiltration in the proposed area to determine potential impacts to hydrology and water quality.

RESPONSE: A revised and much more detailed water balance and streamflow analysis is now incorporated in the assessment (Chapters 6 and 7). The revised draft also includes estimates of the specific changes in flow at individual gages. The commenter is correct that the assessment does not specifically address the potential changes in landforms or, for that matter, to vegetation in the land areas such as the drawdown zone which would be among the areas most affected by the mine development. We consider that any such changes would have only a secondary impact on salmon relative to the impacts that the assessment does address.

The additional information presented in Chapter 3 on stream characterization along with the information in Figure 7.14 on groundwater and fish habitat are major improvements to the document.

Additional ecological information on the contributing watershed area for each fish bearing stream crossing would help identify the potential impacts to fish due to the construction and operation of a transportation corridor.

RESPONSE: Additional information on watershed attributes (discharge, channel gradient, floodplain potential) of streams crossed by the transportation corridor, and their importance to salmonids, is now included in the analysis presented in Chapter 10.

This information is a critical addition to the revised assessment.

Courtney Carothers, Ph.D.

Six key direct and indirect mechanisms are identified to pose potential risk to salmonid fish species: eliminated or blocked streams (87.5-141.4 km), reduced stream flow, removal of wetlands (10.2-17.3 km), indirect effects of stream and wetlands removal (downstream effects likely diminishing fish production), diminished habitat quality downstream of road crossings, and blocked movement of salmonids at road crossings. These mechanisms are described clearly. The report appears to appropriately describe the scale and extent of risks under a no-failure mode of operation, although I have no particular expertise with which to evaluate this assessment.

RESPONSE: No change suggested or required.

Dennis D. Dauble, Ph.D.

The assessment describes the number of stream miles impacted under each mode of operation, including miles blocked and eliminated. Less specific were descriptions of impacts due to sedimentation and leachates. What is lacking is quantitative estimates of spawning and rearing habitat that would be lost relative to the total habitat available. Having this information would help provide perspective of overall risk to individual watersheds and the Bristol Bay watershed as a whole. Risks to salmonid fish due to changes in water quality (i.e., toxic materials) need to consider differences in sensitivity and behavioral response according to salmonid life stage.

RESPONSE: Stream habitat losses are now characterized in relation to the distribution of habitat conditions throughout the larger watersheds (Chapters 3 and 7). The assessment of risks from aqueous toxicity distinguishes overt toxic effects on early life stages from behavioral effects on adults.

Surface water characteristics of site watersheds within the area of probable impact are detailed in Table 5-17, but not so for other streams and lakes in the broader watershed. More information should be presented where available. It is not clear whether potentially affected streams and lakes might be nutrient limited (seems that they might be given their dependence on MDN). For example, include N or P concentrations and some discussion about primary and secondary productivity.

RESPONSE: We recognize that nutrient status, and more importantly prey availability, is a critical component of habitat capacity for fish in these systems, and may be strongly driven by

salmon derived nutrients. We concur that more information is needed regarding potential limiting factors for salmon productivity and capacity, and that food availability may be one such factor. However, because water chemistry data may not provide a complete picture of trophic status, particularly where direct consumption of salmon flesh, eggs, and fry is of such high importance, and because nutrient status is a water quality or habitat parameter not directly influenced by mining operations as outlined in our conceptual models (e.g., Figure 7-1), we determined that nutrient status of area streams is outside the scope of this assessment.

I found risks to salmonid fish due to operation of the transportation corridor well-described with respect to spatial distribution of fish and their habitats.

RESPONSE: No changes suggested or required.

Gordon H. Reeves, Ph.D.

The potential risks to the freshwater habitat of anadromous salmonids are appropriately characterized and described for the no-failure mode of operation. The report considered the primary potential impacts of mine development and operation that could impact habitat and quantified the impacts where possible. The analyses seemed sound and logical, given the acknowledged limitations about the actual mine location and operation.

RESPONSE: No change suggested or required.

One possible factor that could influence the results was the use of the USGS 1:63,360 maps for developing the stream network. These maps generally underrepresent the amount of small streams, which can be ecologically important contributors to the overall productivity of the freshwater habitat of anadromous salmonids. This is acknowledged in the limitations (p. 5-46). Thus, the potential loss and modification of habitat that the report describes could be considered minimal at this time. It would be prudent to confirm the accuracy of the stream layer developed from the 1:63,360 maps in any future analysis.

RESPONSE: The EPA agrees with this comment. No change to the assessment suggested or required.

The potential impact of the mine development and operation on the productive capacity of the various river systems could be developed more fully to gain better insights into potential impacts of the mine. The authors considered the amount of habitat that could potentially be impacted by mine development and operation by estimating the stream length that would be impacted and by considering the percent of spawners of the various species (from ADF&G surveys) observed in potentially impacted areas. However, the productive capacity of given stream reaches for a given fish species can vary widely. Any additional analysis could consider using Intrinsic Potential (IP) (Burnett et al. 2007. Ecological Applications 17:66–80), which considers local geomorphic features to estimate the potential of a given stream reach to provide high quality habitat for a given species. The concept, developed for use in the Pacific Northwest (PNW), has been applied successfully for Chinook salmon in the upper Copper River (A. Bidlack, EcoTrust, Cordova, AK, unpublished). The IP model for Chinook salmon from the PNW that was used in the Copper River was modified after discussion with local biologists. Similar modification may be needed for the PNW IP model for coho salmon to be used in Bristol Bay.

RESPONSE: We now include a characterization of stream channel gradient, watershed terrain (% flatland), and mean annual flow for all streams in the two watersheds. We are unable to build a complete IP model, as this would require validation and more elaborate construction of metrics appropriate to this region, but our preliminary characterization provides the building blocks for assessing the distribution of key habitat-forming and constraining features across these watersheds.

Another factor that I believe merits further consideration is the potential impact of altered thermal regimes of discharge water from treatment facilities (p. 5-28). Warmer water could have potential ecological impacts, particular during the time when eggs are in the gravel. Eggs could develop more quickly and fry could emerge earlier as a result of even minor changes in water temperatures (see: McCullough, D.A. 1999. A review and synthesis of effects of alternations to water temperature regime on freshwater life stages of salmonids, with special reference to Chinook salmon. US Environmental Protection Agency, Seattle, EPA 910-R-99-010. 279 p.; and McCullough, D.A., J.M. Bartholow, H.I. Jager, and 11 co-authors. 2009. Research in thermal biology: burning questions for coldwater stream fishes. Reviews in Fisheries Science 17: 90-113.). These changes could be significant ecologically.

RESPONSE: This is now addressed in Chapter 8.

The report noted in several places that the potential impact on groundwater flows was not understood at this time but that disruptions of flow paths could have critical impacts on aquatic resources. One impact that was not mentioned is the loss of over-wintering habitat. K.M. Burnett (U.S.D.A. Forest Service, PNW Research Station, Corvallis, OR., draft report) found that the major overwintering areas for coho salmon in the Nome River, AK were at points of groundwater inputs. The groundwater influx created areas that were less likely to freeze during winter.

RESPONSE: Overwintering effects from thermal changes are now described in Chapter 7.

Charles Wesley Slaughter, Ph.D.

Yes, the risks to salmonids are well characterized with regard to the hypothetical mine operation itself. However, I suggest that the concept of "no failure," if taken as applying to the entire operation from inception through operation, is not realistic.

RESPONSE: The "no failure" scenario was not meant to represent a realistic scenario. Rather, it was meant to illuminate the effects that would occur solely from a mine footprint, even in the absence of accidents or failure. The revised assessment no longer uses the term "no-failure", but simply presents effects from scenarios having higher probability and lesser magnitude (e.g., failure to collect or treat leachate water) and those having lower probability and higher magnitude (e.g., TSF failure).

The Assessment makes a fair start toward considering the risks to salmonids from the potential transportation corridor. However, the many issues regarding stream and wetlands directly or indirectly affected by roads and pipelines are not fully explored. The extent (length, area) of streams and wetlands affected, as outlined in the text, should be considered a very optimistic lower estimate. The specific issues mentioned, such as bridge or road maintenance, culvert blockage or failure, erosion from cuts, fills, and the roadway itself, are all significant. I simply suggest that the potential consequences of imposition of the (hypothetical) transportation corridor, and future expansions consequent to ancillary infrastructure development and further additional resource extraction projects, would be broader, more severe and of more consequence (and thus should receive more emphasis) than the Assessment indicates. I suggest more fully incorporating Frissell and Shaftel's Appendix G into the body of the Assessment.

RESPONSE: The revised assessment notes that the characterization of both stream length and wetland area affected likely represents a conservative estimate of the potential effects of the transportation corridor on hydrologic features of this area. The cumulative risk section (Chapter 13) has been expanded to include the transportation corridor, ancillary mining development and secondary development. Additional information from Appendix G is incorporated into the main text, and the appendix is referenced in a number of places.

John D. Stednick, Ph.D.

To address this question, a water balance needs to be developed for the study area watersheds. Develop a water balance that includes all the principal components and how they may vary in time and space. The site characterization needs significant improvement, particularly as related to hydrologic inventories and processes. Little to no data are presented on temperature, precipitation, evaporation, frozen soils, soil moisture storage, and groundwater storage and movements. The data that are presented often have unreasonable significant figures. The linkage between surface and groundwater needs to be better demonstrated. Hyporheic exchanges are recognized as being important, but the assessment does not demonstrate this linkage.

RESPONSE: A complete annual water balance with patterns of temporal variability has been developed and incorporated into the revised assessment. Detailed temporal variability is beyond the scope of the assessment. The significant figures of reported data and analysis results have been reduced to a reasonable number. Detailed data presentations on temperature, precipitation, evaporation, frozen soils, soil moisture storage, and groundwater storage and movements are generally not reported. We cite sources of information, and data are cited and reported as needed for assumptions of analyses conducted for the assessment. Additional information on surface water- groundwater interactions has been added.

Iliamna Lake hydrology needs to be characterized. What are the inflows, outflows, and turnover rates? What is the existing water quality in the lake? Aquatic life should be characterized as well. What is the risk of pollutants entering the lake from the road corridor or upstream mine development operations?

RESPONSE: The overall hydrology of the lake was not included because none of the scenarios would result in a change in the hydrology or water quality of the lake as a whole. Rather, any effects in the lake would be limited to the vicinity of outflows from the affected streams. Risks from contamination of tributaries to Iliamna Lake are discussed in Chapters 8, 10 and 11of the revised assessment.

Climate variability is recognized as a game changer. What are the potential future scenarios for temperature and precipitation changes in southwest Alaska, and how will these scenarios affect the water balance? How will climate change affect the availability of water for mine operations, including processing and potable uses?

RESPONSE: Climate change projections and potential impacts are now discussed in Chapter 3.

Similarly, a complete water quality characterization is lacking. What is the water quality in surface waters, groundwaters, in time, and in space? What is the definition of background water quality? Numerous exploratory activities have taken place in the watershed and have the potential to affect water resources. How were these separated or addressed? Given the geologic and geomorphologic settings for the study area, are we comfortable that the watershed ridges delineate the watershed area? Groundwater movements may ignore the physical watershed area boundary and follow groundwater gradients. Streamflow measurements from the gauged watersheds could be useful in answering this question. Similarly, the linkage of groundwater and hyporheic exchange needs to be better demonstrated. Do these exchanges occur in all stream segments and gradients? What effect does the groundwater have on stream temperatures? Are depth to groundwater readings available? Is a groundwater monitoring program in place?

RESPONSE: The water quality described as background by the PLP in their Environmental Baseline Document was accepted as such in the assessment. Water quality in the three streams that drain the site was presented in Table 5-17 (now Table 3-4). The assessment now includes information on estimated groundwater interaction strength across the project area streams (Figure 7-14).

The tables and hydrographs (pages 5-32 to 5-39) are unclear. What streamflow changes are associated with what salmon species and life stage? A boundary condition for adults is different than for fry.

RESPONSE: Maps of species distributions in relation to affected stream segments are now included in Chapter 7. The environmental flow analyses are not species or life stage specific, but assume an overall risk associated with proportional deviations from the baseline flow regime.

The proposed mine will use large quantities of water in ore processing and transport. How much is required and how will this affect water resources; both surface and groundwater?

RESPONSE: The water balance has been extensively revised (Chapters 6 and 7), and updated estimates are incorporated into the streamflow computations provided in Chapter 7. Effects on groundwater resources are explicitly incorporated in the analysis of the pit dewatering, associated cone of depression, leachate leakage from the TSF and the waste rock piles, and interbasin groundwater transfers.

The no-failure mode of operation is predicted to change the watershed contributing area and hence streamflow, and uses the boundary condition of a 20% change in streamflow as significant salmonid habitat loss. The assessment assumes a liner response between watershed area and streamflow contribution, and a linear response between habitat productivity and watershed area.

RESPONSE: A more comprehensive water balance is now used to estimate streamflows, which incorporates losses and additions due to pit dewatering, and wastewater treatment plant processing and distribution, such that the relationship of watershed area and streamflow is not linear. We do not assume a linear response between habitat productivity and watershed area.

Upland settings are probably more productive in terms of productivity and should be addressed as such.

RESPONSE: Relative productivity of aquatic habitats has not been extensively documented across the region.

Toxin assessment focused on copper, and other metals can be presented to show the range of metal concentrations for chronic and acute toxicity, i.e., arsenic, molybdenum, silver, barium, and lead. Given the very clean waters (low hardness and organic carbon), the chronic toxicity of various metals should be evaluated. Water quality varies in time and space in the study area, and a better characterization of water quality could be developed. Metal loads could be calculated with streamflow records. What is the proportioning of dissolved versus total metals? Are metals transported with sediments? Do organic carbon fluxes change in space or time?

RESPONSE: The influence of receiving water chemistry was incorporated to the extent that current science allows. The toxicity of copper was corrected for water chemistry using the biotic ligand model, and the toxicity of other metals was corrected for hardness, when models were available. In each case, water chemistry of the individual receiving stream was used for the correction, Also, instream concentrations are based on streamflows, including changes in streamflows due to mine operations. Both sediment and organic matter concentrations are quite low in all three streams at the Pebble site, so copper remains dissolved in the model and other metals in leachates are likely to remain dissolved as well.

Salmonid risk from travel corridor: The proposed road location has the potential to affect 270 km of stream between stream crossings and Lake Iliamna. The expected road erosion and sediment production has known effects on salmonid resources. The discussion of the travel corridor does not include the potential for road failures, landslides, blocked culverts, or ditch failure. The discussion does not talk about traffic volume or the potential of hazardous material transport on the travel corridor. Need to address road maintenance, fugitive road dust, and road chemicals either dust or ice control.

RESPONSE: The original draft assessment included discussion of the potential for road and slope failures, blocked culverts, and soil erosion from road cuts, borrow areas, road surfaces, shoulders, cut-and-fill surfaces, and drainage ditches. The revised assessment factors traffic estimates into assessments of chemical spills from transport truck accidents (Section 10.3.3) and impacts from dust (Section 10.3.5). Salts used for to reduce dust and improve winter traction are discussed in Section 10.3.3. Potential mitigation measures for stormwater runoff, erosion, and sedimentation are discussed in Box 10-3.

There is no discussion of water processing after delivery of the slurry to the sea port and return of waters back to the mine site.

RESPONSE: Section 6.1.2.5 of the revised assessment discusses that the water would be returned to the process water ponds. The scenarios indicate that slurry water would be returned to the site without treatment other than removal of solids.

Roy A. Stein, Ph.D.

No-Failure Mode of Operation. My comments regarding the no-failure mode of operations and their impact on salmon can be found under Question 3.

RESPONSE: See response to Question 3.

Road Use I: Page 5-60. Beyond calcium chloride, how can we be confident that the typical chemicals that derive from highway use will not occur on this mine road (as noted on page 5-60)? Is it because the low volume of traffic? If so, would not we expect accumulation through time…over the 78 years of the mine operation (see Appendix G for some detailed analysis: should some of this material be added to the main report?)? What about the impact of road dust on nearby aquatic systems (wetlands, streams, rivers, etc.)?

RESPONSE: The text relating to traffic and contaminated runoff has been modified in the revised assessment to read: "It is unlikely that the potential transportation corridor would have sufficient traffic to significantly contaminate runoff with metals or oil, but stormwater runoff from roads at the mine site itself might contain sufficient metal concentrations to affect stream water quality." Though traffic-associated contaminants may be expected to increase over time, they would probably not be as significant as stormwater runoff-associated metals from the mine site. As noted in the revised assessment, the main impact of dust from the transportation corridor on salmonids would likely be a reduction in riparian vegetation and subsequent increase in fine bed sediment. The main impact of dust at the mine site would be a direct increase in fine bed sediment due to mine construction and operation (the effects of increased sediment loading are discussed in Section 10.3.4).

Road Use II: Page 5-62 to 5-63 (plus Appendix G: again, as with other appendices, include more of this information in the main report). Will there be frost heave of the road bed such that specific structures will have to be installed to prevent this movement of the road bed? These roads will be treated with chemicals, such as calcium chloride, to keep the dust down and contribute to an ice-free condition, but no data are available for the impacts of these chemicals on nearby streams. How then do we deal with this issue (page 5-62 and 5-63)? The suggestion is that one needs to have roads built at least 8 meters from streams, but this cannot be the case in this situation, simply because of the large number of streams, rivers, and wetlands along the road corridor? More detail as to the impact of the transportation corridor should be added, including issues, such as truck accidents, fuel spills, other chemical spills, etc.

RESPONSE: The assessment does not address potential frost heave of the road bed, although this factor will need to be considered during design of a road. Additional information has been added to the revised assessment on the potential impact of calcium chloride on nearby vegetation, surface water, groundwater and aquatic species. According to the USDA Forest Service (1999), application of chloride salts should be avoided within 8 m of water bodies. We agree that the 8 m buffer zone for salts would be difficult to maintain, but it could be achieved

at some cost in dust suppression and winter road salting. It would not require keeping roads out of that zone.

Additional information from Appendix G is incorporated into the main text, and the appendix is referenced in a number of places. The revised assessment contains greater detail on the potential impact of the transportation corridor. For example, the assessment now factors traffic estimates into assessments of chemical spills from transport truck accidents (Section 10.3.3) and potential impacts from dust (Section 10.3.5). Fuel spills are covered in Chapter 11.

Road Use III: page 5-71 (plus Appendix G). The road will intersect multiple streams and rivers along the northern end of Iliamna Lake, where as many as one third of the sockeye salmon in this lake spawn. And this is where the causeway across Iliamna Lake will be built as well. From my perspective, it seems that impacts on spawning sockeye will be large in this area (without saying anything about causeway: will there be culverts or bridges to allow water and fish to communicate with the rest of the lake)? I would argue this is important, given salmon are attracted to certain odors and water-flows and these odors and water-flows are coming from inlets streams into Iliamna Lake. Preventing any sort of blockage of water flow or salmon migration would be the goal. Are there other issues that should be considered when building this causeway?

RESPONSE: The assessment makes no mention of a causeway across Iliamna Lake. We believe the commenter is referring to a proposed causeway over the upper end of Iliamna Bay, which is part of Cook Inlet. Culverts or bridges would be built to allow fish access between streams crossed by the proposed road and Iliamna Lake. The issue of culvert blockage is discussed in the assessment.

Road Use IV. Points made by public testimony reinforces the idea that as this area is opened to the public, the opportunity for new, invasive species to colonize this pristine ecosystem increases dramatically, likely to 100%. Simply put, invasive species will now be carried by humans via the road, inadvertently, into this previously inaccessible watershed.

RESPONSE: EPA assumes that the proposed road would be closed to the public during mining operations but potentially could become a public road after mining operations cease. Even when not open to the public, construction and operation of the proposed transportation corridor increase the probability that new terrestrial and aquatic species will be transported to and potentially establish themselves in the Bristol Bay region. If the road were opened to the public, the probability of colonization by invasive species may increase further, but rates of introduction by industrial and public vehicles cannot be distinguished given available information. Invasive species are addressed in Section 10.3.6 of the revised assessment.

William A. Stubblefield, Ph.D.

The document appears to adequately address potential questions associated with habitat loss due to hydrologic changes, especially considering the hypothetical nature of the mine and the lack of specific detailed information regarding an actual proposed facility and all of the associated operational details of the facility. The assessment of potential impacts and ecosystem protection parameters is predominately based upon the publication of Richter et al. (2011). Additional support and evaluation of these recommendations for fisheries populations in the Bristol Bay area should be closely evaluated.

RESPONSE: Prompted by this comment, we consulted with regional biologists and hydrologists to evaluate the suitability of the sustainability boundary approach for flows. We asked them if there was any reason that fish populations in these streams, or the specific hydrology of the area, made it exceptional with regard to this approach (e.g., was there any reason to think that the Richter approach was not applicable here). We received uniform support for applying this approach to Bristol Bay streams. We strengthen our emphasis that this is a precautionary approach, and that the detailed hydrologic and habitat modeling work that PLP contractors have begun will help provide a useful basis for more sophisticated flow-habitat modeling.

Dirk van Zyl, Ph.D., P.E.

Chapter 5 of the EPA Assessment is entitled: "Risk Assessment: No Failure". Chapter 5 presents an evaluation of habitat loss and modification resulting from the hypothetical mine. A summary of the "risks" associate with the "no failure" case is provided in Chapter 8. There is specific focus on evaluating the magnitudes of the losses and modifications to the environment.

RESPONSE: No change requested or required.

A risk assessment addresses three questions (Kaplan and Garrick, 1981):

- What can happen? (i.e., What can go wrong?)
- How likely is it that that will happen?
- If it does happen, what are the consequences?

There are a large number of risk assessment methods and it is common to express the magnitude of risk as a combination of likelihood of occurrence and consequences (IEC, 2009). This is the typical outcome for engineering assessments of systems. For example, in the case of a Failure Mode and Effects Analysis (FMEA), it would be typical to develop a risk matrix to combine likelihood of occurrence and consequences to express the level or magnitude of risk in qualitative terms (Robertson and Shaw, 2012).

The EPA Assessment describes the two components of risk but does not provide any information on the magnitude of the risk. For example, for the no-failure condition it describes the length of streams, areas of wetlands, etc. that will be impacted by developing the mine, i.e. the consequences. One may argue that the likelihood of occurrence of these consequences is unity (or certainty) if the mine is developed, as this is not specifically addressed by the report.

RESPONSE: The risk assessment does address engineering risks in the manner specified, including magnitudes of spills, leakage, etc., and the consequences for water and habitat quality. We now explicitly clarify that losses of stream length are unavoidable for a project of this magnitude (Chapter 7). The magnitude of the risk or the likelihood that the stream lengths will be lost if the mine is constructed is 100%.

One would next expect an expression of the magnitude of this risk based on some comparison of the consequences to a set of outcomes that could result in acceptable or unacceptable risks. The

EPA suggests this as an approach in its 1998 Guidelines for Ecological Risk Assessment (EPA, 1998): "In some cases, professional judgment or other qualitative evaluation techniques may be used to rank risks using categories, such as low, medium, and high, or yes and no". Quantitative approaches such as fuzzy logic has also been used to develop expressions of magnitude of risk as described by EPA (1998): "For example, Harris et al. (1994) evaluated risk reduction opportunities in Green Bay (Lake Michigan), Wisconsin, employing an expert panel to compare the relative risk of several stressors against their potential effects. Mathematical analysis based on fuzzy set theory was used to rank the risk from each stressor from a number of perspectives, including degree of immediate risk, duration of impacts, and prevention and remediation management. The results served to rank potential environmental risks from stressors based on best professional judgment".

RESPONSE: Although the 1998 ERA Guidelines describe professional judgments as an acceptable method for ranking risks in appropriate circumstances, it is not appropriate for this assessment. The purpose of this watershed assessment is not to rank risks. It is to estimate, as far as existing data and knowledge allow, the risks associated with proposed and potential mining activities in the Bristol Bay watershed. EPA decided during the problem formulation that this assessment would be based on published science. An assessment based on elicitation of expert judgment could be performed in the future, if desired.

It is unclear to the reader how significant a loss of 87.5 km of streams in the Nushagak River and Kvichak River watersheds is to the overall ecosystem. Are there any criteria that can be used to develop such an expression? Can a multi-stakeholder workshop (as is often done) be used to develop such criteria and expressions of risk magnitude? Without having such expressions of risk magnitude it is impossible for those without specific expertise in salmonids to evaluate whether this is a significant risk. Price et al. (2010) states that: "Between 1999 and 2008, 3,500 fish passage barrier culverts were replaced with fish-passable structures, reportedly opening nearly 5,955 km of fish habitat in Washington streams (Governor's Salmon Recovery Office 2008)". Comparing the loss of 85 km to this gain of 5,955 km seems to imply that 85 km loss may represent a relatively small risk, which may not be the case at all. However, the EPA Assessment does not provide any insight in the magnitude of risk except to provide a value for the consequences.

RESPONSE: The purpose of the assessment is not to assign significance to the risks, but to provide information for decision-makers on the consequences of mining.

The EPA did conduct a multi-stakeholder conference to determine the significant endpoints and exposure pathways for the assessment. However, the EPA decided during the problem formulation that this assessment would be based on published science. Therefore, a multi-stakeholder workshop would not be an appropriate mechanism to estimate risks or their significance.

Comparing the potential loss of salmon-supporting streams in the Nushagak and Kvichak River watersheds to restoration of streams in Washington for salmon recovery may not be very useful. The comment does illustrate that seemingly inconsequential or insignificant losses have frequently led to diminished or even lost salmon stocks. In the example cited, apparently 3,500 seemingly inconsequential actions had to be remedied at public expense because of their cumulative impacts.

Similar comments can be made with respect to the relative risks associated with the other losses of ecological functions for other failure modes.

RESPONSE: See response to previous comment.

It is recognized that it is important to maintain separation between the risk assessment and risk management functions. As expressed by the National Research Council Panel in their report on Science and Decisions (NRC, 2009): "The committee is mindful of concerns about political interference in the process, and the framework maintains the conceptual distinction between risk assessment and risk management articulated in the Red Book. It is imperative that risk assessments used to evaluate risk-management options not be inappropriately influenced by the preferences of risk managers".

RESPONSE: The EPA agrees with this comment and its implication that assessors should not judge significance. No changes suggested or required.

Providing an expression of risk magnitude should not interfere at all in the separation of risk assessment and risk management, but should provide the risk manager with one extra level of analysis and insight from the expert assessor of the problem at hand. Multi-stakeholder interaction will only serve to enhance the value of the risk ranking.

RESPONSE: See response to previous comment on this topic.

On p. 4-33, it is stated that after closure: "No PAG waste rock would remain on the surface". It is also stated in Chapter 4 that PAG and NAG waste will be segregated. On p. 5-48, it is stated that: "However, the primary concern during routine operation would be waste rock leachate. That leachate would become more voluminous as the waste rock piles and uses of waste rock for construction increased during operation. After mine closure, it would be a major source of routinely generated wastewater along with water pumped from the TSF and pit. Leachate composition from tests of the three waste rock types (Tertiary, East Pre-Tertiary, West Pre-Tertiary) is presented in Tables 5-14 through 5-16". There is no specific indication which of these waste rock types could be described as PAG or NAG and Chapter 5 seems to assume that these 3 samples are representative of the total amount of waste rock, about 4 billion tonnes for one mine scenario. If all the PAG material will be removed from the surface, as stated in the scenario in Chapter 4, and the NAG will not generate acid drainage, then it is difficult to understand why the waste rock piles and waste rock used for construction (supposedly all NAG at this stage) would be the major source of "routinely generated wastewater."
Note that it is further unclear why there would be water pumped from the tailings and the pit if the TSF were closed, as discussed above, and if it will take the mine pit 100 to 300 years to fill. Some clarification is in order.

RESPONSE: This issue has been clarified in the revised document. PAG and NAG waste rocks would be identified during the course of mining, but the available test results indicate that pre-Tertiary rock is PAG. The PAG waste rock would be segregated and none would remain at mine closure. However, some will be on the surface during operation. In addition, the NAG waste rock produces potentially toxic leachates that must be collected and treated. Water could be pumped from the TSFs and the pit for treatment before discharge. Treatment of pit water would occur once it is a source rather than a sink.

A further reference to the fate of waste rock after closure is found on p. 5-77 of the EPA Assessment: "Under the mine scenario, the mine pit, waste rock piles, and TSF would remain on the landscape in perpetuity and thus represents permanent habitat loss." It should be noted that the scenario states that PAG will not remain on the surface, whatever volume and area of land surface that represents.

RESPONSE: Section 6.3.3 of the revised assessment clarifies that no PAG waste would remain on the surface.

The descriptions of exposure and exposure-response resulting from the transportation corridor in Section 5-4 of the EPA Assessment focus on potential impacts and make use of references that are clearly not representative of the expected road construction. A number of these references date from 1975 and 1976 (p. 5-59) and are not necessarily representative of road design and construction practices in 2012. On p. 5-62, the following statement and reference is given: "Sediment loading from roads can severely affect streams below the right-of-way (Furniss et al., 1991 and references therein)". This reference is specifically focused on forest and rangeland roads, clearly not representative of a major transportation road between a mine and the port facilities from where its products are shipped. This publication contains many recommendations specifically for forest and rangeland roads and some of them are indicative that it is not applicable to the transportation corridor for a major mine access road: "Design cut slopes to be as steep as practical. Some sloughing and bank failure is usually an acceptable trade-off for the reduced initial excavation required" (p. 306); and "stream crossings can be considered dams that are designed to fail. The risk of failure is substantial for most crossings, so *how* they fail is of critical importance" (p. 310). The reference also refers to the application of oil as a dust abatement additive on p. 312, which is hardly acceptable practice. In my review, I did not find that any of the references used in the EPA Assessment refer specifically to mine roads such as those considered for the transportation corridor at the Pebble Mine scenario.

RESPONSE: The information cited from the two publications noted by the commenter is still true today. The first use of Darnell (1976) was incorrect, and has been changed to Furniss et al. (1991). Although Furniss et al. (1991) focuses on forest and rangeland roads, it is a seminal publication on the potential effects of roads, particularly as they relate to salmon. The general conclusions of that paper should be applicable to the transportation corridor described in the assessment. Furniss et al. (1991) lists a number of guidelines for road design and construction that will help minimize adverse effects on salmonid habitats. It does not specifically advocate the application of oil as a dust abatement additive. It merely states that whatever chemicals are used, they should be applied so as not to enter streams, and that subsequent transport of these substances into water courses should be evaluated.

The failure frequencies cited in the revised assessment are from modern roads and not restricted to forest roads. Because the proposed mining would take place in an undeveloped area, the literature used in the assessment is necessarily from areas outside of Bristol Bay. However, we used recent literature from representative environments to the extent possible. Lastly, information on current design standards that would be used along the proposed transportation corridor is now included within text boxes throughout Chapter 10.

It is further interesting that it is stated on p. 5-60 that there will be 20 bridges and 14 culverts along the road without referring to this as an assumption, and no reference is cited for this information. Will there be a change in impact if the decision is made to build 30 bridges and 4 culverts or 34 bridges and no culverts?

RESPONSE: The estimate of 20 bridges came from Ghaffari et al. (2011). In the revised assessment, crossings that would be bridged (now 18) are based on mean annual stream flows, as explained in the text. If a decision was made to build more bridges and fewer culverts, there would be a change in impact, but scenarios with 30 or more bridges are probably not realistic.

The discussion on the potential impacts of the transportation corridor on salmonids serves the purpose of highlighting some aspects that engineers and fish biologists must take into account when designing and maintaining the final transportation corridor for the Pebble Mine and other mines in the Bristol Bay area. However, this assessment does not appropriately describe the scale and extent of the risks to salmonid fish due to operation of a transportation corridor under the no-failure mode of operation.

RESPONSE: The "no failure" mode of operation was meant to illuminate the effects that would occur solely from a mine footprint, even in the absence of accidents or failure. This term has been eliminated in the revised assessment. The no-failure scenario from the draft assessment has been changed to a section on the effects of the footprint of a mining operation, without regard for operational problems (Chapter 7). The revised assessment places the streams along the transportation corridor into the context of the entire Nushagak and Kvichak River watersheds with respect to important watershed attributes such as discharge, channel gradient, and floodplain potential. Potential risks to fish habitats and populations associated with the proposed corridor are then evaluated in some detail.

Phyllis K. Weber Scannell, Ph.D.

The no-failure model makes a number of assumptions about how the mine will be developed – some may be accurate, some may be considerably different. It is important to take under consideration that Pebble is currently a prospect, not a mine. Should this project proceed to mine development, it will be incumbent on the mining company to develop a rigorous mine plan that includes detailed information on all aspects of a future project. This mine plan will be reviewed by state and federal staff with experience in large project development.

RESPONSE: The EPA agrees with this comment. No changes suggested or required.

The no-failure model discusses the amount of riverine habitat that will be lost to mining by the mine pit, tailing storage facility, and waste rock dumps. Anadromous fish habitat is protected under Alaska Statute 16.05.840-870. The statute requires review of a project potentially affecting fish habitat and, where necessary, avoidance, mitigation, or compensation. A project must provide free passage of fish; the project cannot be placed in such a way that fish are prohibited from moving into the upstream reaches. Estimates of habitat loss from the mine footprint are not possible without a more detailed plan of operations for the mine.

RESPONSE: The scenarios presented are meant to represent those expected as typical for mining of porphyry copper deposits of this type, and are based on preliminary mine plans from NDM (Ghaffari et al. 2011). Although layout of mining components at a site may differ somewhat from what we present in the scenarios, the main components of mining will remain

the same for open-pit mining. Given stream density in the area, direct losses of stream and wetland habitat of a similar magnitude would be inevitable with projects of the specified magnitudes.

There are many aspects of the development of a large mine project that need thorough review to ensure that habitats are protected. These include, but are not limited to: classification and storage of waste rock, lower grade ore, overburden, and high grade ore; development and maintenance of tailings storage facilities; development and concurrent reclamation of disturbed areas, including stripped areas and mine pits; collection and treatment of point and non-point source water; quantity and timing of discharges of treated water; monitoring of ground water, seepage water and surface water; and biomonitoring. The transportation corridor will require review and permitting of every stream crossing of fish-bearing waters. In addition, plans should be developed for truck wheel-washing to minimize transport of contaminated materials.

RESPONSE: The EPA agrees that these aspects would need to be subject to a thorough review during the development and approval of a detailed mining plan. No changes suggested or required.

Paul Whitney, Ph.D.

Material Resource Areas. Material resource areas, mentioned on page 4-34, for the road and pipelines should be discussed in more detail. Will aggregate be required? If so, where are the aggregate resources in relation to floodplains? I spent a summer surveying material resource areas for a proposed arctic and subarctic pipeline and access road. Suitable material resource areas are sizeable and are often important (e.g., aggregate) for wildlife (such as bears that hibernate or survive the winter in dens) and fishery resources. Sometimes dens can only be excavated in non-permafrost (i.e., aggregate) soils. It appears the project area is in a zone of discontinuous permafrost, but permafrost could be more continuous in the higher elevations along the road through the Kenai Mountains. An accurate assessment should determine the permafrost location(s), as well as the area and importance of material resources for fish and wildlife. In addition, Reclamation Plans for the material resource areas should be briefly discussed to ensure that areas mined for aggregate will not avulse and capture streams.

RESPONSE: EPA agrees with this commenter that the impacts of material resource areas to wildlife, fishery and other subsistence resources could be significant and must be addressed in an environmental impact statement and as part of the 404 permit review. Review of potential material resource areas was not included in the scope of this assessment.

Water for Dust Control. Dust control for the 86-mile proposed haul road will likely require a lot of water. Where will this water come from? Withdrawal from streams crossed by the haul road could have impingement and flow reduction consequences. Adequate screening could solve the impingement issue. Some back-of-the-envelope calculations could determine if water withdrawals for dust control could alter the projected hydrographs when salmonids are present in the streams.

RESPONSE: We expect water for dust control to be a small amount from any one source. Permits would be required from the State of Alaska that would address impingement issues. We do not expect this to be a major issue.

Question 5. ***Do the failures outlined in the assessment reasonably represent potential system failures that could occur at a mine of the type and size outlined in the mine scenario? Is there a significant type of failure that is not described? Are the probabilities and risks of failures estimated appropriately? Is appropriate information from existing mines used to identify and estimate types and specific failure risks? If not, which existing mines might be relevant for estimating potential mining activities in the Bristol Bay watershed?***

David A. Atkins, M.S.

The Assessment focuses on some low probability, high impact failures (e.g., TSF failure), and presents summaries of failures at existing mines. The majority of the focus is on catastrophic failures, such as TSF, pipeline, water collection and treatment, and road and culvert. Anecdotal information regarding mine failures is numerous, but often not well documented, so it is difficult to get information on the details of failures of other projects. It is also difficult to extrapolate the probability of failure from one site to the next, and the report stresses the wide range of uncertainty, depending on design and environment. Without a more detailed understanding of the mine plan and associated engineering, as well as additional detailed analysis, it is difficult to determine if the failure probability estimates presented in the Assessment are reasonable.

RESPONSE: The authors concur with the commenter that it can be "difficult to get information on the details of failures of other projects". The statistics for historic tailings dam failures are derived from the largest available database and include many tens of thousands of dam-years. The pipeline failure data cover millions of kilometer-years of pipeline experience. The data on failures of water collection and treatment systems and of culverts are less extensive. We also recognize that even with detailed engineering and design information, the prediction of failure probabilities is extremely difficult. Finally, since all of these low-probability failures are statistical phenomena, the actual experience at any one site could be vastly different than another similar site, even when the failure probabilities have the same distribution.

The focus on catastrophic failures also takes attention away from what is probably a more likely scenario. Every project is subject to accidents and smaller, non-catastrophic failures that have varying degrees of consequence. Sometimes these failures are easily identified and fixed and other times they can go un-noticed for periods of time.

RESPONSE: Because the number of potential failures is extremely large, it is necessary to choose a representative set of failure scenarios. The revised assessment includes more failure scenarios (e.g., diesel pipeline failure, quantitative wastewater treatment plant failure, truck

accidents and spills, and refined leachate seepage scenarios) and explains why these particular failure scenarios were chosen.

It would be helpful to describe some smaller-scale failures that have occurred at mine sites. A partial list includes: accidents and spills along the transportation corridor or within the mine site; unanticipated seepage of contaminated water that may be difficult to detect, collect and treat; movement of water along preferential flow pathways that are difficult to characterize; temporary failure of water collection and treatment systems; mistakes in engineering analysis that underestimate the volume of water that must be collected and treated or overestimate the volume of water available for use; and designing based on incomplete data and understanding of climate conditions.

RESPONSE: There is a wide variety of failures that could occur, including those provided by the commenter. Because the number of potential failures is extremely large, it is necessary to choose a representative set of failure scenarios. The revised assessment includes more failure scenarios (e.g., diesel pipeline failure, quantitative wastewater treatment plant failure, truck accidents and spills, and refined seepage scenarios) and explains why these particular failure scenarios were chosen.

Steve Buckley, M.S., CPG

The engineering failures reasonably represent potential system failures outlined in the mine scenario based on historic porphyry copper deposits of this type. It is less clear if the failures reasonably represent a mine scenario based on state of the art engineering and mitigation practices. Appendix I provides some information related to potential system failures and possible mitigation measures designed to minimize these risks but these are not treated in any detail in the assessment. It would be difficult to pull together the most modern engineering and mitigation practices from around the world but it could help bound the risks associated with modern mine development.

RESPONSE: Our purpose in the assessment is to evaluate the risks from hazards resulting from a mine operated with appropriate mitigation measures for design, operation, monitoring and maintenance, and closure. Accidents and failures happen regardless of mitigation measures; thus, effects of several failures are evaluated. Mitigation measures related to our mine scenarios are now clearly discussed in Chapter 6.

The revisions clarify when and where potential mitigation measures would be treated in the regulatory process.

The Red Dog mine in northwest Alaska might be relevant for estimating potential mining activities in the watershed. Although the characteristics of the deposit differ significantly, at roughly 150 million tons it is half the size of a reasonable minimum mine scenario and would be helpful to characterize some minimum mine development scenario.

RESPONSE: A third mine size scenario, representing the worldwide median size porphyry copper mine (Singer et al. 2008), is included in the revised assessment.

This improves the assessment.

Courtney Carothers, Ph.D.

The potential failures outlined in this assessment include: tailings dam failures, pipeline failures, water collection and treatment failures, and road and culvert failures. These failures appear to represent the key potential failures for this mining scenario, their risks appear to be estimated reasonably, and statistics from existing mines appear to be used appropriately, although I have no particular expertise with which to evaluate this assessment. As we discussed in our peer review panel, the focus here is on catastrophic failure. More detail should be provided on likely non-catastrophic failures, ones that would be more difficult to detect.

RESPONSE: Because the number of potential failures is extremely large, it is necessary to choose a representative set of failure scenarios. The revised assessment includes more failure scenarios (e.g., diesel pipeline failure, quantitative water treatment failure, and refined leachate seepage scenarios) and explains why these particular failure scenarios were chosen. We did include leachate seepage scenarios (Chapter 8), which would be more difficult to detect than catastrophic failures.

Dennis D. Dauble, Ph.D.

My experience in system failure of mines of the size and type outlined in the scenario is limited. However, what does seem to be missing is the long-term effects of leachates to receiving water bodies in any type of risk scenario, including both non-failure and failure modes. That is, assuming no catastrophic failure, how might tailings constituents interact with aquatic habitats seasonally, such as during periods of snowmelt and severe rainfall events?

RESPONSE: The original draft assessment contained a scenario in which tailings leachate was not fully contained and reached a stream (Section 6.3 in the May 2012 draft). The revised assessment includes estimates of leachate escaping from the TSFs and from the waste rock piles, bypassing the collection systems, and entering the streams (Chapter 8). The estimated loadings of copper and other elements from these leachate flows are included in stream concentration estimates. The assessment discusses the impacts of these concentrations on the aquatic habitat and biota. The commenter is correct that we did not include a scenario in which the dam does not fail, but snowmelt and severe rainfall would result in overtopping and release of untreated water. That is very plausible, but there are just too many possible failure scenarios to include more than a few of them.

Gordon H. Reeves, Ph.D.

No comments on this question

Charles Wesley Slaughter, Ph.D.

Potential failures seem reasonable, based on history of other mining operations. However, the consequences of hydrologic extremes during winter (frozen soil) conditions are not adequately addressed. The possibility of the mining operation and the transportation network encountering discontinuous permafrost is not mentioned, although at least some soils maps indicate permafrost presence.

RESPONSE: Warhaftig (1965) reports that permafrost is sporadic or absent in the Nushagak-Bristol Bay Lowland (Table 3-1). If permafrost were detected during project development or construction, the designs would need to address any potential impacts on the infrastructure and potential impacts of the infrastructure on the permafrost. Frozen soil could improve vehicular access to parts of the project site and minimize the disturbance from such access. The occurrence of an extreme hydrologic event, such as heavy rainfall on frozen soil or heavy rain on an existing snowpack, could produce unusually heavy runoff and higher than normal stream flows. We analyzed the impact of a tailings dam failure during the Probable Maximum Precipitation (PMP) event, thereby generating the Probable Maximum Flood (PMF). The increased flow due to precipitation was, in most of the scenarios, small compared to the flow released from the TSF. Any increases in the peak runoff due to frozen soil or melting snowpack would also be small relative to the TSF release, so the modeled scenario can be considered a reasonable bounding estimate.

Designs for the components of the mine infrastructure would need to consider the natural cold region conditions and incorporate appropriate design features and safety factors to achieve an acceptable level of performance. Ghaffari et al. (2011) says "The Pebble deposit is located under rolling, permafrost-free terrain in the Iliamna region of southwest Alaska..." and "The deposit is situated approximately 1,000 ft amsl, in an area characterized by tundra, gently rolling hills and the absence of permafrost." Ghaffari et al. (2011) describes the transportation corridor thusly: "The road route traverses terrain generally amenable to road development. ...There are no significant occurrences of permafrost or areas of extensive wetlands." Nevertheless, if sporadic areas of permafrost are discovered, the designs will need to address the interactions between the infrastructure and the permafrost.

The probability approach outlined for potential TSF dam failure is unpersuasive. It is difficult to relate to a number like "0.00050 failures per dam year," or to the implication on p. 4-47 that one can expect a tailings dam failure only once in 10,000 to one million "dam years." This could suggest to the casual reader that failure of the hypothesized TSF1 dam (for which one "dam year" is one year) should not be anticipated in either the time of human occupation of North America, or the span of human evolution.

RESPONSE: The commenter is correct. The proposed dams, if designed, built, and maintained to current engineering best practices, would be anticipated to have a low annual probability of failure. However, the failure probability would not be zero. The writers concur with the commenter that these low probability numbers may be difficult for the casual reader to grasp, so we now also present estimates of probability in terms of probability failure over different time periods. The discussion of this issue has been expanded to clarify that the failure rate is a design goal and is not based on empirical evidence.

Box 4-6 suggests that the Operating Basis Earthquake (OBE) for a 7.5-magnitude event at the Pebble locale has an estimated return period of 200 years. Such a return interval probability is difficult to interpret, given the lack of historical seismic records for the region; in any event, such a return period estimate is in no way predictive of future seismic activity, in year 2012 or year 2212. (The suggested 200-year return period should also be viewed in light of the 79-year suggested operating life of the hypothetical Pebble operation, probable longer-time operations at other mineral extraction sites which would be developed following implementation of Pebble and building from the infrastructure associated with Pebble, and also the projected very long persistence of the TSFs following cessation of active mining).

RESPONSE: Box 9-2 in the revised assessment (Box 4-6 in the May 2012 draft of the assessment) provided the OBE and return period determined by NDM in the Preliminary Assessment. A detailed engineering design and safety evaluation is outside the scope of this assessment. The discussion of seismicity (Section 3.6) addresses the uncertainty in interpreting and predicting earthquake magnitude and recurrence in the Pebble area.

Box 4-6 does note that "The return periods stated in Alaska dam safety guidance are inconsistent with the expected conditions for a large porphyry copper mine developed in the Bristol Bay watersheds, and represent a minimal margin of safety."

RESPONSE: The return periods used are consistent with the Alaska Dam Safety Guidance, however the operator could include additional margin of safety in the design for critical structures. The return period and seismic safety factors do not inform the failure analysis in this assessment, but would be important considerations during the review process for any future mine plan.

John D. Stednick, Ph.D.

The assessment reasonably addresses potential large system failures, but should include a variety of smaller and perhaps more frequent failures (see Question 4). A large tailings storage facility failure compared to a blocked road drainage culvert. The level of detail in the assessment of the potential system failures varies considerably and baits the question--why? Does this demonstrate lack of understanding of failure prediction, lack of failure prediction, or writing team expertise?

RESPONSE: The EPA does not believe that a blocked culvert requires or deserves the same level of analysis as a tailings dam failure and spill. The latter is a much more complex phenomenon with multiple consequences that require evidence and analysis such as the potential toxicity of the spilled tailings. In contrast, blockage of a culvert is a relatively straightforward phenomenon. Further, a TSF failure poses a much greater concern for stakeholders and local communities due to the large magnitude of potential effects.

Tailings storage facility: The liquefaction phenomenon, internal and external erosion, seepage, and overtopping are some of the main failure modes of tailings storage facilities. A large quantity of stored water is the primary factor contributing to most tailings storage failures. The risk of physical instability for a conventional tailings facility can be reduced by having good drainage and little (if any) ponded water. Some suggest that the tailing pond freeboard should be able to accommodate the 100-year, 72-hour storm/streamflow event. What are the State of Alaska standards? Discuss the probability of failure of a TSF from other than overtopping by a precipitation/streamflow event. The potential of seismic activity and its effect on tailings storage and other earthworks needs to be addressed.

RESPONSE: The historic failure probabilities for tailings dams presented in the assessment include all modes of failure, including slope instability, liquefaction, overtopping, erosion, and seismic activity. Historical failures were discussed as supporting background information and present a defensible upper bound on the failure probabilities. The failure probabilities used in the assessment are based on Alaska's dam classification and required safety factors applied to the method of Silva et al. (2008). The data presented by Silva et al. (2008) consider only the annual probability of failure from slope instability, but the methodology is equally applicable to other failure modes. The discussion of failure probabilities in the revision (Chapter 9) is expanded to clarify this issue.

Chemical transport spill: Mine development and ore processing will require significant loads of petroleum and chemical products. Although the exact processing formulations are not given, most copper porphyry mines use similar formulation in ore flotation and processing. How will chemicals be stored, transported, and recycled? What are the opportunities for accidents to occur?

RESPONSE: Storage of chemicals is addressed in the assessment. Petroleum transport is by pipeline and an assessment of the risk of spills has been added in Chapter 11 of the revised assessment. Process chemicals would be transported by truck. Discussion of truck transport and potential for accidents has been included in Chapter 10, including a quantitative analysis of the risk of wrecks and of wrecks that cause spills into streams or wetlands.

Roy A. Stein, Ph.D.

Failures Appropriate for Mines of this Size and Type. Given my background, I can't answer with any authority, though the comparisons seemed appropriate, though clearly no extant mines are as large as the one proposed herein. Some of the public testimony spoke directly to comparisons with existing mines in dry areas would be completely inappropriate because it is the hydrology of the Bristol Bay watershed that would make it so very vulnerable to mining impacts.

RESPONSE: No change suggested or required.

Failures Not Described? I speak to failures associated with routine operations previously in this review, as well as chemical spills along the transportation corridor. Also included herein should be impacts of the Cook Inlet Port and potential spills, accidents, etc., on the marine ecosystem.

RESPONSE: Because the number of potential failures is extremely large, it is necessary to choose a representative set of failure scenarios. The revised assessment includes more failure scenarios (e.g., diesel pipeline failure, quantitative water treatment failure, and refined seepage scenarios) and explains why these particular failure scenarios were chosen. Discussion of transport and potential for accidents has been included in Chapter 10, but risks are not evaluated. Potential impacts in Cook Inlet are important and should be considered in the regulatory process should a company submit a permit. However, because this is an assessment of the Bristol Bay watershed, evaluation of impacts from the port (and

transportation corridor outside the Nushagak and Kvichak River watersheds) is outside the scope of this assessment.

Probabilities and Risks of Failures. These seemed reasonably well documented, though again this falls outside of my expertise. Even though out of my realm, I still would have liked a more quantitative assessment of these risks, developed in a rigorous, defensible way. I am discouraged when I understand that history (in the eyes of the mining company) is not a good predictor of the future because technology has taken us so much farther along, reducing risks of whatever failure significantly. In my view, this is a specious argument and one that should be roundly put to bed by the authors of this report. History is indeed the absolute best predictor of the future and technological changes that have occurred since past mines must be absolutely and critically evaluated to determine if indeed risks do go down. This is a serious issue and one that should be addressed with some rigor by the authors.

RESPONSE: Historical failures were discussed as supporting background information. The failure probabilities used in the assessment are based on Alaska's dam classification and required safety factors applied to the method of Silva et al. (2008). The EPA has strengthened the discussion of failure probabilities (Chapter 9) to the extent that available evidence allows.

Existing Mines as Comparisons. Given my background, I can't answer with any authority, though the comparisons seemed appropriate, though clearly no extant mines are as large as the one proposed herein (nor does it incorporate all we have learned in the mining business since the last mine for which we have data). Even so, I again caution the authors that these existing, historical mines provide the best data we have to estimate risks of failure and that, under no circumstances, should one accept the indefensible argument that progress with mine safety (speaking broadly, not just human health) has progressed to the point that these risks, previously quantified in these older mines, are now small. As suggested above, we have no other quantitative values for risk, except for existing mines and we cannot simply erroneously lower the risk based on new, **untested** technologies.

RESPONSE: We agree that it is appropriate to include in our scenarios technologies that are in current use and not those that are untested, and thus have done so. No change suggested or required.

Proportional Losses of Salmon. Is it possible to estimate the proportion of the salmon runs compromised in the face of major failures in tailing storage facilities or other failures? In other words, I would recommend adding a chapter that uses best estimates of salmon produced within the Bristol Bay watershed and then assess the maximum impact of, let's say, a Tailing Storage Facility failure---with this failure, might we lose 10%, 40%, or 75% of our salmon productivity? In addition to this estimate, one might estimate the number of stocks or unique genetic units lost with a major failure? I know these numbers are difficult to get, but if one begins with escapement from these systems as well as insights from harvest, we may be able to bound these impacts. Only in this fashion can we put these data into context. This exercise also will serve to counter the argument by the mining company that they are only destroying some small percentage of salmon habitat and hence (assuming a linear relationship between habitat lost and salmon eliminated) only some very small percentage of salmon. Because losing 2% of critical headwaters habitat may translate to huge losses of salmon (say 20%), one simply cannot assume a linear relationship between habitat and salmon. Explicitly making this argument improves the rigor of the main report.

RESPONSE: The fact that salmon productivity cannot be assumed to be linearly related to habitat has been more explicitly elaborated in the revised assessment. Due to lack of comprehensive estimates of limiting factors across the impacted watersheds, population level effects could not be quantitatively estimated, except in the most severe cases where total losses of runs could be reasonably assumed. Our ability to estimate population level effects was limited to situations that were assumed to completely eliminate habitat productivity and capacity in an entire watershed for which estimates of escapement could be inferred. For this assessment, these conditions are only met in the TSF failure scenario that completely eliminates or blocks access to suitable habitat in the North Fork Koktuli River. In that case, we estimate that the entire Koktuli portion of the run (~28% of Nushagak escapement) could be lost. Higher proportional losses would occur if significant downstream effects occurred due to transport of toxic tailings fines beyond the Koktuli as modeled under the Pebble 2.0 TSF failure.

Correlations between Ocean and Terrestrial Conditions. From the literature (see Irwin and Fukuwaka. 2011. ICES *J. Mar. Sci*. 68: 1122 as just one example), we know what climatic conditions lead to poor rearing conditions in the ocean, thus compromising growth and ultimately survival of salmon. Given these ocean conditions, might we have correlative effects in the terrestrial environment, thus leading to a cumulative effect of ocean and terrestrial impacts? For example, if particular oceanic conditions underlie poor survival, might this correlate with an increased probability of flooding, leading to a higher probability of a Tailings Storage Facility failure, leading to a cumulative synergistic effect that could be multiplicative in its negative impact on salmon populations? Was there any attempt to correlate these impacts? Just how realistic is it to reflect on these sorts of multiplicative effects? Might these effects have a catastrophic effect on salmon populations?

RESPONSE: Pursuing this hypothesis would require a research effort that is beyond the scope of this assessment.

William A. Stubblefield, Ph.D.

The scope of failures described in the assessment seems to be sufficiently comprehensive and all likely failure-types are considered. The probabilities and risks for failure seem to be adequately estimated, given the state-of-the-science; however, these estimates are likely to be very sensitive to site-specific concerns and operational considerations. Once site-specific information is available, it is likely that much better estimates of failure potential at a site can be developed.

RESPONSE: We agree that more site-specific information could support more site-specific estimates. No change required.

Dirk van Zyl, Ph.D., P.E.

Failure modes outlined in the EPA Assessment do not reasonably represent the potential failures

that could occur at a mine of the type and size outlined in the mine scenario.
The EPA Assessment considers a series of large, or catastrophic, type failures. The failure modes considered in the mine scenario include four major items: tailings management facility; pipelines; water collection and treatment; and, road and culvert. These failure modes are included in the risk assessments for a mine of this type and size, either qualitatively as is typically done in FMEA, or quantitatively. However, the range of failure modes will also consider many other types of failures that can also occur during regular mine operations. These other types of failures may result in the full spectrum of risks (from insignificant to very high) depending on site and mine life-cycle conditions. Performing extensive analyses for the four major items implies that they could occur and that they are the only failure modes that will be significant.

RESPONSE: It is true that any of the failures analyzed could occur, as based on historic and current knowledge of mining; however, a focus on these failures does not imply that they are the only failures that will be significant. Because the number of potential failures is extremely large, it is necessary to choose a representative set of failure scenarios. The revised assessment includes more failure scenarios (e.g., diesel pipeline failure, quantitative water treatment failure, and refined seepage scenarios) and explains why these particular failure scenarios were chosen.

Responses to the other parts of the current question (Are the probabilities and risks of failures estimated appropriately? Is appropriate information from existing mines used to identify and estimate types and specific failure risks? If not, which existing mines might be relevant for estimating potential mining activities in the Bristol Bay watershed?) are further discussed in my responses to other questions below.

RESPONSE: No change suggested or required.

Phyllis K. Weber Scannell, Ph.D.

This section focuses on catastrophic failures; however, there are a number of non-catastrophic failures that can occur at a mine site. Non-catastrophic failures include leakage of contaminated water to ground or surface waters from PAG waste rock, the tailing storage facility, and exposed ore surfaces, and from emergency discharge of untreated water from the TSF and ore spills from trucking accidents. Such failures can be minimized or prevented with good site planning and monitoring. An additional “failure” has been experienced at a mine in Alaska when the water elevation of the tailing pond was sufficiently high to cause groundwater flow across a natural divide into an opposite drainage.

RESPONSE: Because the number of potential failures is extremely large, it is necessary to choose a representative set of failure scenarios. The review draft contained a scenario in which tailings leachate was not fully contained and reached a stream (Section 6.3 in the May 2012 draft). The revised assessment document includes more failure scenarios (e.g., diesel pipeline failure, truck accidents, quantitative water treatment failure, and refined seepage scenarios) in Chapters 8, 10 and 11 and explains why these particular failure scenarios were chosen.

Paul Whitney, Ph.D.

Sediment Transport. The failure analysis indicates a sediment transport study was beyond the scope of the assessment. Not only is such a study important for fish resources, it is important for all ecological resources, especially plant community succession along the stream and a delta into Bristol Bay.

RESPONSE: EPA agrees that a sediment transport study is important to fully characterize the watershed and potential impacts from large-scale mining. The scenarios indicate that runoff eroding sediment from the site would be directed to sediment retention basins. Sediment runoff from the road is considered in Chapter 10. The development and implementation of a model of sediment (i.e., tailings) transport after the initial tailings outflow would require a research and development effort that is beyond the scope of this assessment.

This might seem extreme, but the failure analysis indicates the Koktuli, Mulchatna, and Nushagak Rivers would stabilize into a new channel after a failure and not continue to work their way across the floodplain and eventually transport materials hundreds of miles down river. The Mount St. Helens eruption, given as an analogy in the assessment (page 6-3), certainly moved sediment into the Columbia River Channel, the Columbia River Estuary, and Pacific Ocean over a hundred miles away. Copper concentrations in the Columbia River estuary as a result of the eruption ranged from 1 to 43 µg/L (Lee 1996). The upper limit of the range is approximately 20 times greater than the no-effect benchmark listed in the assessment. The down stream consequences of changes in sediment transport and water/sediment chemistry for fish and wildlife are sometimes very large, not anticipated (see Peace Athabasca Delta response below), and costly to remediate. Solutions for the Peace Athabasca Delta involving check dam construction may not be directly applicable to a tailings dam failure analysis in the assessment but may have some value short of dredging. I'm not sure how it would work, but a mitigation effort (page 4-32, para 3, last sentence) using bulk tailings would apparently be placed down gradient to catch tailings in the event of a failure. Is this a safety check dam? It is possible that the assessment could be improved if this and other redundant efforts to minimize risk could be discussed in more detail and considered in the failure analysis.

RESPONSE: We have clarified this in Chapter 9 of the revised assessment. Our intent was to describe a channel becoming reestablished in the deposited tailings and slowly reworking the entire valley bottom, moving the fine material downstream. We agree that tailings would be carried downstream to Bristol Bay over the long term with adverse impact to waters. The mitigation addressed in the comment, where a levee was created downstream to capture the flow of tailings, was not our intent. We described a reclamation scenario where the tailings are dewatered and sloped to eliminate the chances of mass failure of the impoundment. Mitigating impoundment failure by creating a second dam downstream would greatly increase the mine footprint on salmon habitat.

I agree with the assessment's statement on page 6-11 (6 lines down) that impacts of a tailings dam failure to fish would extend down the mainstem Koktuli River and possibly further. If the Mount St. Helens analogy is a good one, the impacts could reach Bristol Bay. Even if the Mount St Helens analogy is not a good one, I suspect sediments would continue to move down river as the river(s) moved across their floodplains through time. I also agree with the assessment's statement that the time to reach dilution approaching background would be very long, as the sediments in tributary rivers to Bristol Bay will be continually reworked (page 6-25) and resuspended.

RESPONSE: EPA agrees with the commenter. No change suggested or required.

As a terrestrial ecologist, I have always been impressed by the impact of Bennett Dam on sediment transport in the Peace Athabasca Delta ecosystem over 600 miles away (Cordes 1975). The assessment does mention the potential impact of toxics on the likelihood of plant community succession on deposited tailings (page 6-10), but this causal pathway was not assessed. Given the increases in metal concentrations in the Columbia River Estuary cited by Lee (1996) for the Mount St. Helens eruption, an assessment of down stream sedimentation and changes in sediment chemistry should be addressed. The likelihood that far reaching impacts of a failure could influence plant succession and wildlife habitat quality is probably not anticipated but given the Mount St. Helens analogy and the lessons learned from Bennett Dam, the likelihood of such impacts deserve more attention.

RESPONSE: This comment recommends expanding the scope of the assessment to include direct effects on terrestrial plants and wildlife habitat. The scope was set during the planning and problem formulation processes to encompass the expressed concerns of the Alaska Native organizations that asked the Agency to address potential mining in the Bristol Bay watershed, as well as the needs of the Agency's decision makers. This scoping process is in keeping with the Guidelines for Ecological Risk Assessment (USEPA 1998). The commenter may be more familiar with Environmental Impact Statements, which are full disclosure documents and therefore are more broadly focused.

<u>Sediment Benchmarks.</u> Once again, as a terrestrial ecologist with ecological risk assessment experience, I know that sediment chemistry and determining toxic benchmarks for sediments is very complex and subject to varied opinions. I admire the MacDonald et al. (2000) effort to reach consensus on sediment benchmarks but I have three concerns. First, the consensus values listed in MacDonald et al. (2000) are geometric means of values from several sources. The mean consensus values likely do not equate to No Observed Effect Concentrations, which would probably be lower than the mean values. Second, the lack of observed effects was sometimes for a "majority" of sediment dwelling organisms, but not all (MacDonald et al. 2000, Table 1). Third, some of the sources used for the mean values included interstitial water, but apparently not all (Table 1). I will always remember Dr. John Stein (currently the acting director of NOAA's Northwest Fisheries Science Center in Seattle) standing up at a workshop for the Columbia River Channel Deepening Project. He had a small bottle of sediment and water in his hand and, while shaking it, he said something to this effect: It's the pore water we are interested in. Considering that a proposed mine, at some point, will be reviewed by NOAA, it seems appropriate to consult with NOAA regarding benchmarks for <u>all</u> the species of sediment/pore water-dwelling organisms likely to occur in the potentially effected watersheds addressed in the assessment.

RESPONSE: The EPA agrees that pore water concentrations are generally useful predictors of toxic effects of sediment, and sediment pore water toxicity is addressed in the assessment.

However, the MacDonald et al. (2000) benchmarks are also a useful line of evidence. NOAA has been consulted during the development of this assessment. No change required.

Question 6. ***Does the assessment appropriately characterize risks to salmonid fish due to a potential failure of water and leachate collection and treatment from the mine site? If not, what suggestions do you have for improving this part of the assessment? Are significant literature, reports, or data not referenced that would be useful to characterize these risks, and if so what are they?***

David A. Atkins, M.S.

Water treatment failures of varying scale occur at virtually every site that treats water, and mine sites are no exception. The risk of failure of water treatment described in the assessment is useful as background, but as the report states, the risk is highly uncertain. A non-catastrophic water treatment system failure is fairly likely to occur at some point during the mine life, and, hence, requires a detailed assessment. The treatment in the Assessment is cursory (less than one page). This type of failure is much more likely than a TSF failure (which receives more than 20 pages of analysis), and therefore requires a much more thorough treatment given the probability of occurrence and likelihood of impact to salmon species.

RESPONSE: The wastewater treatment failure scenario has been expanded and is now detailed and quantified in Chapter 8 of the revised assessment. Additionally, the non-catastrophic failures of seepage collection from the TSF and waste rock piles also have been included as scenarios with new and refined analyses.

The background water chemistry indicates mineral concentrations are very low. Therefore, water treatment will be challenging if background conditions are to be met. Treatment will be especially challenging given the sensitivity of the species of concern to concentrations of copper, for instance, as well as the sensitivity to temperature that may be difficult to match in a water treatment system.

RESPONSE: A mine would not necessarily have to match the low background concentrations, but would at minimum be held to the water quality standards that protect the existing and designated uses of the waterbodies where a discharge might occur. In the Bristol Bay area, all waterbodies are protected for all uses and permit limitations would be derived to be protective of the most stringent applicable Alaska Water Quality Standards (WQS). In addition, we believe that compliance with the more recent Federal Water Quality Criterion for copper would be necessary to protect aquatic life.

During mine operation, a lapse in treatment would likely be identified and addressed quickly. This type of treatment failure is ephemeral and would likely have a short-term impact on the fishery, depending on the time of year of occurrence. It is likely that any impacts to the fishery could recover in subsequent years after the problem is fixed. The site will require water treatment long after closure, possibly in perpetuity. This period is more problematic, as a water treatment failure could go unnoticed for some time or the resources may not be available to correct it quickly, depending on how long after closure the failure occurs and the stewardship of the treatment system.

RESPONSE: A failure during operation would be corrected quickly only if it did not require extensive repairs or the manufacture and import of replacement equipment. The EPA agrees that water collection and treatment failures after mine closure would be less likely to be corrected in a timely manner. In addition, events after closure, such as filling of the pit, would affect water quantities and qualities in ways that would affect treatment success. A discussion of this issue has been added to Chapter 8 of the revised assessment. A discussion of financial assurance has been added in Box 4-3.

Steve Buckley, M.S., CPG

Less than a page (4-39) is devoted to the failure of water and leachate collection and treatment. This seems inadequate given it would be one of the main systems that could impact fish at the potential mine site. In contrast, 20 pages are devoted to tailings dam failure (p.4-39 to 4-60).

RESPONSE: The wastewater treatment failure scenario has been expanded and is now detailed and quantified in Chapter 8 of the revised assessment.

This reorganization is helpful along with the additional information on wastewater treatment failure scenarios.

Courtney Carothers, Ph.D.

The report concludes that wastewater and leachate treatment and collection failures could expose local streams to mildly to highly toxic water harmful to invertebrates and fish species. Depending on the type of failures, these exposures could last from a period of hours to years. The report notes that in the case of Red Dog Mine, Alaska, the water treatment system was inadequately designed, but does not discuss why such a design was approved and allowed to be implemented, nor does it discuss the likelihood of replicating such a design flaw in future mining scenarios.

RESPONSE: The Red Dog Mine's treatment system was inadequately designed because the amount of water to be treated was underestimated. Mine site hydrology is often difficult to predict and treatment systems may fail despite the intent of mining companies and regulators.

Dennis D. Dauble, Ph.D.

More information on local hydrology, including seasonal runoff patterns (e.g., peak flows) and groundwater movement would be useful. I found no description of existing water quality characteristics of potential receiving waters, except what is included in Table 5-17 of the main report. Are these values (such as hardness, which moderates metal toxicity) consistent throughout the watersheds, including downstream lakes? Other questions include: What volumes of leachates might be collected and treated versus volumes not captured and subsequently released downstream? Is copper the only constituent of concern to aquatic animals? Are there processing chemicals that would also be toxic?

RESPONSE: Monthly flow patterns for area streams are now presented in Chapter 7. The three streams described in Table 7-17 are the three potential receiving waters for any site effluents. The water balance, including leachate volumes, is now described in the assessment (Chapter 6). Copper is the primary contaminant of concern. Others are described in the new Section 6.4.2.3 and discussed in Chapters 8 and 11.

The assessment should also consider and discuss relative risk to aquatic ecosystems from downstream transport of sediment-bound metals to Iliamna Lake, if deemed probable.

RESPONSE: Although metals in aqueous emissions would partition to sediment, and the sediment would mobilize during high flows and eventually reach the lake, this route is not judged to be significant. Toxicity is caused by dissolved metals, and concentrations from release of metals from transported sediment to lake water are likely to be minor.

<u>Gordon H. Reeves, Ph.D.</u>

The report focused primarily on the lethal effects of the contamination from leachate and water treatment and collection failures. However, could there be ecological consequences to fish and invertebrates that are not directly lethal but that could have ecological consequences over the long term? I suggest that this needs to be considered more fully in this assessment.

RESPONSE: The report addresses both acute lethal effects and chronic lethal and nonlethal toxic effects to both fish and the invertebrates on which they feed. It is highlighted in the text when estimated concentrations are sufficient to cause acute lethality. Such effects are important not only because they are severe but also because they could occur during episodic exposures.

Sockeye salmon are most abundant salmon in Bristol Bay and a primary species of focus in this analysis. The direct impacts of mine and mine-related activities have been considered but there appears to be a lack of consideration of the impact on zooplankton, the food source for sockeye. If this were a deliberate omission, then a statement about why it was omitted is required. The revision should include this if it was an oversight.

RESPONSE: Any effluents would be released to the streams draining the site. In those ecosystems, zooplankton are rare and the primary food organisms for fish are benthic invertebrates. However, the toxicological data used to assess effects on invertebrates are dominated by planktonic crustaceans. Therefore, if toxic concentrations of metals reach Iliamna or other lakes, the toxicity assessment would actually be more relevant to the plankton that occur there than to the insects in the receiving streams. Hence, the numerous references to effects on aquatic invertebrates are relevant to zooplankton and no new analyses are needed.

Charles Wesley Slaughter, Ph.D.

No. Text suggests that a monitoring well field downslope from the TSF (and presumably from all hypothetical TSFs) would detect seepage; such seepage would then be intercepted and either returned to the TSF or "treated and released to the stream channel." Either action presupposes adequacy of monitoring seepage and subsurface flow (both spatially and temporally); returning such water to the stream further presupposes fully adequate treatment to meet both regulatory and aquatic biota requirements for water quality and flow regime.

RESPONSE: The water treatment and leachate capture discussions have been expanded and are now detailed and quantified in Chapter 8 of the revised assessment.

Assumptions are very generalized and optimistic: "assuming no water collection and treatment failures" and "excess captured water would be treated…and discharged to nearby streams…" – this assumes both "no failures" over the life of the operation, and that such treated "excess captured water" could be successfully treated before release to fully meet both regulatory water quality criteria and the possibly more sensitive biological requirements of individual invertebrates and fish stocks (Appendices A & B).

RESPONSE: Water management (mitigation) measures are more clearly described and discussed in Section 6.1.2.5 of the revised assessment, and in sub-sections for the mine components in the scenarios. Our intention for the "no-failure" scenario was to identify and evaluate the unavoidable environmental effects if all systems and mitigation measures operated perfectly, and to separate those effects from a scenario where systems periodically failed. However, the "no failure" scenario is no longer included. The purpose of the assessment is to describe the potential adverse environmental effects that could exist even with appropriate and effective site mitigation measures. The assessment is not intended to duplicate or replace a regulatory process, which is where required permit discharge limits for water quality would be determined.

John D. Stednick, Ph.D.

The TSF is designed to hold the tailings under water to minimize the oxidation of pyritic materials and limit ARD or AMD production. The TSF will be underlain by hypalon to capture leakage waters. There is the possibility of failure to collect waters from the TSF—either surface runoff or leakage with or without storm (precipitation) events. There is also the possibility of failure of the treatment plant to treat the wastewater. Such treatment systems in Colorado usually have a bypass pond to temporarily hold waters for later pump back and treatment as a result of power failure, plant going off-line, storm events, or plant maintenance.

RESPONSE: The original draft assessment contained a scenario in which tailings leachate was not fully contained and reached a stream (Section 6.3 in the May 2012 draft); however, this has been refined with new data in the revision for seepage from the TSF and waste rock piles that escapes capture from the mitigation measures (Chapter 8). Additionally, the scenario presents a suggested treatment option for mining influenced water and settling ponds for stormwater runoff. A wastewater treatment plant failure scenario in the revised assessment assumes emergency storage capacity has been exceeded or the bypass system fails.

The waters in the study area have very low buffering capacity; metal toxicity would occur at low concentrations and dilution of metals would require time and space. The maximum index counts on page 6-39 are confusing and not well related to the risk characterization. Copper was used as an example metal, but other metals are also toxic and further characterization of the waste rock can be presented. Further analysis of a water and leachate collection failure can be made over time: the effects of dilution flows over the various months with low flows, or when adult salmon are present in the stream as opposed to juveniles – or, when juveniles are emerging. The toxicity quantification is difficult and appears more of an academic exercise here, rather than site specific.

RESPONSE: Undiluted leachate concentrations are used to calculate the hazard quotients (we assume that is what the reviewer means by "maximum index counts"), to screen the constituents for contaminants of concern, and because the State of Alaska does not allow mixing zones in anadromous streams. However, dilution was considered in the failure scenarios for waste rock leachates and tailings leachates. Copper was emphasized because it is by far the most toxic metal relative to concentrations in rock, tailings and concentrate leachates. Site specific water chemistry was used to estimate the toxicological benchmarks for copper and for metals with hardness-dependent toxicity. More detailed analyses of dilution are included in Chapter 8 of the revised assessment.

Leachate collection from the tailings area is only briefly described. What are the State of Alaska standards for collection and treatment? What are the potential effects of not collecting or treating the tailings leachate waters? Compare the detail and length of leachate discussion to the TSF failure discussion (see earlier comments).

RESPONSE: There are no specific AK State standards for collection and treatment of tailings leachate, but any discharge to waters of the United States requires a Clean Water Act Section 402 (CWA § 402) permit. In Alaska, the Department of Environmental Conservation issues these permits under the Alaska Pollutant Discharge Elimination System program. Such permits would contain effluent limitations that are protective of the State WQS. The original draft assessment contained a scenario in which tailings leachate was not fully contained and reached a stream (Section 6.3 of the May 2012 draft); however, this has been refined with new data in the revision (Chapter 8) for seepage from the TSF and waste rock piles that escapes capture from the mitigation measures.

Given the hydrologic connection between surface and groundwaters, what effect will interception of all waters on the TSF do to the surrounding wetlands and groundwater levels? Again the lack of a water balance does not let the reader determine if this water interception is significant or will have significant resource effects.

RESPONSE: The water balance presented in the revised assessment quantifies the amount of water captured at each TSF under each scenario. The assessment also presents the percentage change in streamflow at existing gages in the North Fork Koktuli, the South Fork Koktuli, and the Upper Talarik.

The water balance presented in the assessment looks at the overall amount of water dedicated to consumptive uses, which therefore would no longer be available to contribute to groundwater recharge or stream flow. Furthermore, the assessment attempts to quantify the

annual amount of and percentage increase or decrease in streamflow for individual stream reaches. These stream flow results are presented in Chapter 7 of the revised assessment.

Our analysis does not attempt to explicitly calculate groundwater levels or drawdown except within the cone of depression around the mine pit. Our analysis assumes that all precipitation that falls outside the actual mine footprint (i.e., the physically disturbed areas) would continue to contribute to groundwater recharge and stream flow, although the exact flow patterns would change due to collection of surface runoff and stream diversions. Areas within the footprint would most likely see some decrease in the groundwater levels due to the collection, management, and possible treatment of surface runoff, with some potential increases downstream of the points of water release from the wastewater treatment plant. Overall, the cumulative reduction in streamflow would be approximately equal to the amount of water retained on the site as tailings pore water.

Most, if not all of these failures are the result of human error. What safeguards will be in place? What are the best mining practices to minimize human error?

RESPONSE: The mitigation measures proposed within the mine scenarios are those that could reasonably be expected to be proposed for a real mine (they are a subset of options presented in Appendix I), all of which were presented as appropriate for the Pebble deposit in Ghaffari et al. (2011). We assume that these types of measures would be applied throughout a mine as it is constructed, operated, closed, and maintained through post-closure. Because the possibility for human error is inherent in any activity in which a human is involved, accidents and failures happen. Human error-caused accidents and failures are minimized when the humans involved follow careful and responsible management of the mining site. No change suggested or required.

Roy A. Stein, Ph.D.

Groundwater Connectivity and TSF Construction I. Extensive connectivity between surface water and groundwater means that any failure will allow contaminated waters to flow quickly to areas of importance for salmon. And, indeed how does one build a tailings pond (coarse textured glacial drift in the Pebble Mine area) with this much permeability? Why would one only line the tailings dam; shouldn't the entire Tailings Storage Facility be lined? Would not this be "Best Practice"?

RESPONSE: Our estimates of the expected leakage from the full TSFs range from about 2 to 6 m^3/min. If a mine at the Pebble deposit goes forward, the design of the TSFs should include a more thorough flow analysis that would calculate the expected rate of flow and associated flow paths from the TSFs. If the calculated leakage rates were unsatisfactory from an environmental, operational, or economic perspective, the designer could incorporate other design elements (e.g., a liner) to reduce the expected leakage rate. Full liners beneath TSFs are not always used; however, there is a growing requirement to use liners to minimize risks of groundwater contamination, with new mines in Australia being required to justify why one wouldn't be required (Commonwealth of Australia 2007). Liners are not required in the US. Whether something is "best" depends on the specifics of the site. The mitigation measures proposed within the mine scenarios are those that could reasonably be expected to be proposed

for a real mine (they are a subset of options presented in Appendix I), all of which were presented as appropriate for the Pebble deposit in Ghaffari et al. (2011). Evaluation of different mitigation measures to determine if lining the facility would be "best" for this site would be part of the regulatory process and thus is outside the scope of this assessment.

Groundwater Connectivity and TSF Construction II: A water-impermeable barrier will be installed only on the interior dam face and nowhere else. To prevent communication between these facilities and the groundwater, is it feasible to map groundwater inputs before the facility is filled, place barriers over these areas, and thereby reduce influx of groundwater into the facility and perhaps prevent movement of toxic water into the groundwater? I make this point with some hesitation, given the point made on page 5-29:

> "Projecting specific mining-associated changes to groundwater and surface water interactions in the mine area is not feasible at this time."

RESPONSE: See response to previous comment.

Failure of Leachate and Water Collections. See my comments under Question 12 below. In addition, I see this as a huge undertaking for which monitoring and response (mitigation) are clearly as important as the actual plan to capture these wastes.

RESPONSE: EPA agrees with this comment. No change suggested or required.

William A. Stubblefield, Ph.D.

The risk assessment attempts to consider the effects of metal discharges for water and leachate from the mine site. This assessment is based on metals concentrations measured in potentially "similar" mine waters from other sites; concentrations of metals are likely to differ based on source material and operational differences. The effects concentrations used in the evaluation are based on US EPA ambient water quality criteria (AWQC) for metals, and this approach is appropriate for "screening level" evaluations. It should be noted that exceedence of an AWQC does not portend the occurrence of adverse effects. Ambient water quality criteria are derived in such a way that they are intended to represent "safe concentrations." In other words, if environmental concentrations remain below the AWQC, it is assumed that unacceptable adverse effects will not occur; exceedence of an AWQC suggests that adverse effects may occur to some species, but that this must be evaluated more closely. Salmonid species are not the most sensitive organisms in the copper AWQC species sensitivity distribution (SSD); therefore, direct effects on salmon are even less likely at concentrations in the range of the AWQC.

RESPONSE: Effluents or ambient waters from mines at other sites were not used. The leachate concentrations used (except for the product concentrate leachate) are from available results of material leaching tests from the Pebble deposit. Otherwise, the Agency agrees with these comments. The assessment used criteria for screening, but then examines the toxicity data more closely, including field data to determine potential effects (e.g., aversion, sensory inhibition, mortality and reduced reproductive success of salmonid fish). The greater sensitivity of aquatic insects was described in the May 2012 draft of the assessment and is further highlighted in the revised assessment. The protectiveness of the copper criterion is considered in both the original and revised assessments.

It is interesting to note that the risk assessment document states that copper is one of the "best-supported criteria. However, it is always possible that it would not be protective in particular cases due to unstudied conditions or responses." Further, the document goes on to suggest that organisms such as mayflies etc. are important to the aquatic ecosystem but are not considered in the copper AWQC and therefore may not be sufficiently protective. It also suggests that because an acute-chronic ratio approach is employed to correct the final acute value to obtain a final chronic value, there may be increased uncertainty associated with the protectiveness of the chronic criterion. This appears to be an area where EPA might benefit by conducting research (either alone or in concert with industry) to reduce uncertainty in the criteria to an acceptable level. In addition, additional chronic toxicity data may be available from research conducted in response to the European REACH regulations and consideration of this research may reduce the level of uncertainty in the criteria. Bioavailability correction via the BLM approach is only considered for copper in the risk assessment; biotic ligand models have been developed for a number of metals (e.g., zinc, nickel) and these should be considered in the assessment as well. Finally, the assessment approach seems to use a sum TU-based approach for assessing "metals mixture" impacts. This is based on an assumption of additive interactions among the metals. Although this is probably the best assumption in going forward, limited data are available to support this approach.

RESPONSE: The EPA has examined the EU's 2008 Voluntary Risk Assessment of Copper (the relevant REACH document). Although the authors could derive a chronic species sensitivity distribution, that is because the way that they include and aggregate data differs from the EPA's method. They apparently did not generate new test data for the assessment. In particular, they have no data for sensitive aquatic insects, so the EU assessment does not resolve that problem. The BLM was used for copper because it is the contaminant of greatest concern and because the copper BLM has been approved by the EPA Office of Water. Other metals with BLMs, such as zinc and nickel, occur at lower levels in leachates relative to their toxicities, so BLM modeling was not justified.

Areas where additional research would be beneficial include:

- Mixtures: Information regarding the potential interactive effects of multiple metal exposures would be useful and would reduce assessment uncertainty.
- Species sensitivity concerns: there is extremely limited data (esp. chronic datat) on all of the salmon species of concern in Bristol Bay
- Additional data, especially chronic toxicity data and data for additional metals for which no water quality criteria exists, would be extremely helpful.

RESPONSE: The EPA agrees that these are good research topics. No change is suggested or required.

<u>Dirk van Zyl, Ph.D., P.E.</u>

The EPA Assessment does not identify or appropriately characterize the risks to salmonid fish due to a potential failure of water and leachate collection and treatment from the mine site. It only estimates the likelihoods of occurrence and the consequences. See discussion under

Question 4 above regarding suggestions for improving estimation and expression of the magnitude of risks to salmonid fish due to potential failure of water and leachate collection and treatment from the mine site.

RESPONSE: The EPA believes that the likelihood of an occurrence and its consequences constitute an appropriate and generally accepted definition of risk. We have estimated those to the extent that existing information allows. We have added to the discussion of leachate contamination, including estimation of the magnitude of leachate escaping the collection system and entering surface waters (Chapter 8).

Water collection and treatment failure likelihood. An estimate is presented for the amount of seepage that may flow from the TSF. Similar estimates are not presented for the waste rock piles. The effects of the effective exclusion of oxygen from the saturated or partially saturated tailings should be considered in developing an estimate of the water quality of the resulting seepage. It may be an important factor in reducing the oxidation of sulfide minerals remaining in the interior of the TSF. This same effect could also mitigate the release of poor water quality in the long-term following closure. The precipitation on the site may be sufficient to effectively retain a suction saturated profile in parts of the TSF.

RESPONSE: The revised assessment presents an estimate of the amount of seepage from the waste rock piles (Table 6-3). The water quality of the leachate from the TSF was modeled with the concentrations reported from the tailings humidity cell tests. The reported copper concentration of 0.00533 mg/l is lower than some of the reported groundwater concentrations, and is the same order of magnitude as the highest reported stream concentration of 0.0013 mg/l. The TSF at closure was modeled with free standing water at the surface and with downward flow with an estimated gradient between 0.07 and 0.12.

Water collection and treatment failure consequences. Water collection and treatment is being done at a number of mines in North America. Past experience at the Red Dog mine is quoted; however, there are many other examples that could have been examined. An important example is that of the Equity Silver Mine in British Columbia (Aziz and Meints, 2012): "Acid Rock Drainage (ARD) was discovered at the Equity Silver Mine in the interior of British Columbia in 1981. The latest water treatment plant was installed in 2003, 9 years after the mine closed in 1994, and is the fourth successive treatment plant for the site that has treated ARD for a period of over 30 years. Discharge water quality was maintained since 1991 except during two high flows associated with freshet conditions in 1997 and 2002. ARD collection and treatment system upgrades were installed after 2002 and these have performed well through three large freshet conditions in 2007, 2011 and 2012. The timeframe for treatment is perpetuity and financial assurance is in place for a total amount of $56.291 million through a long-term security bond (letter of credit) with the BC Provincial Regulatory Authority. The security bond is reviewed by stakeholders every 5 year". Collection and treatment at Equity Silver indicates that companies are committing to long-term water treatment of ARD and that regulatory frameworks are in place to protect water quality in downstream streams and rivers. It is recommended that EPA perform a more thorough review of other sites where water treatment occurs to better characterize this failure mode.

RESPONSE: We have been unable to obtain a copy of the cited report. The 2010 Sustainability Report, which is available, does not contain these specifics. This mine

apparently has begun perpetual water treatment. A comprehensive review of mine sites with water treatment systems is beyond the scope of this assessment.

Phyllis K. Weber Scannell, Ph.D.

This section of the report provides an in-depth discussion of possible sources and fates of contaminated water. Chapter 6.3 discusses possible adverse effects from early mine closure or prematurely shutting down a water treatment system. These issues highlight the need for a mine plan that includes concurrent reclamation, sufficient bonding to conduct reclamation in the event of an early shut down, and plans and specifications for collection and bypass of clean water and collection and diversion to a water treatment system of contaminated water.

RESPONSE: The EPA agrees with this comment. No change suggested or required.

The Risk Characterization (Section 6.3.3) discusses possible contaminant loads to downstream waters. As stated in this section, it "serves to indicate the large potential risk from improperly managed waste rock leachate." This statement highlights the need for an in-depth mine plan with sufficient monitoring and fail-safe provisions. An emergency discharge of untreated waters from a tailings storage facility could be made to a collection pond for later treatment or the tailings pond could be engineered to accommodate a higher flood event so the likelihood of overtopping is minimized.

RESPONSE: The waste rock leachate scenario referenced by the commenter has been eliminated and replaced with a more detailed and realistic scenario for waste rock leachate collection and treatment (Chapter 8).

Section 6.3.3 (Risk Characterization) states "Alternatively, water collection and treatment failure could be a result of an inadequately designed water treatment system which could result in the release of inadequately treated water as at the Red Dog Mine, Alaska (Ott and Scannell 1994, USEPA 1998, 2008). In that case, the failure could continue for years until a new or upgraded treatment system is designed and constructed." This statement is misleading and overly simplistic; the water treatment system at the Red Dog Mine was designed to treat the predicted flows. However, the stream bypass and collection systems were constructed in 1991 to intercept seepage waters. The additional water that was collected and treated dictated construction of a second water treatment system in 1992. Sand filters were added in 1993 to remove fine particulate Zn. The issue was not that the water treatment was inadequate, but that the pre-mining hydrologic data was insufficient and that state, federal, and mine officials lacked experience in mine construction on permafrost soils.

RESPONSE: The water treatment failure at Red Dog was, as the commenter describes, the result of an unintended failure to design a plant that was adequate for the mine and site. The passage has been expanded to clarify the nature of the failure.

Overall, the discussions of risks to salmonid fish due to a potential failure of water and leachate collection and treatment from the mine site highlight the need for more comprehensive information on groundwater, including delineating flow pathways, depth to surface, and water volumes. Additional information is needed on water collection, storage, and treatment at future mine facilities.

RESPONSE: Discussions of wastewater collection and treatment have been considerably expanded in Chapter 8.

Paul Whitney, Ph.D.

No comment on this question.

Question 7. ***Does the assessment appropriately characterize risks to salmonid fish due to culvert failures along the transportation corridor? If not, what suggestions do you have for improving this part of the assessment? Are significant literature, reports, or data not referenced that would be useful to characterize these risks, and if so what are they?***

David A. Atkins, M.S.

The description of culvert failure is necessarily general because there are currently no designs. The general data on culvert failures presented for the types of culverts described in the references cited (principally for forest and range land) indicate a high probability of failure (30-66% failure rate). It is probable, however, that the transportation corridor for the project would be constructed to a higher standard than most of the roads included in these papers. It would be helpful to know if similar data are available for highly engineered roads of the type likely to be built for the project.

RESPONSE: The assessment assumes modern mining technology and operations. We did not find information explicitly from highly engineered roads, but to the extent possible we used recent literature from representative environments. The failure frequencies cited in the revised assessment are from modern roads and are not restricted to forest or rangeland roads. Information on current design standards is now included in text boxes throughout Chapter 10.

Steve Buckley, M.S., CPG

The references provided in this section emphasize culvert failures in the Pacific Northwest and Tongass National Forest. The streams and culverts in these regions are heavily influenced by large woody debris loading. It would be more appropriate to classify the various potential stream crossings by watershed and the amount of large woody debris available to be recruited to the stream and influence culvert blockage.

RESPONSE: Many of the references in the assessment relate to the Pacific Northwest, because much work on culverts and potential impacts on salmon have been performed there. Flanders et al. (2000) has been deleted in the revised assessment. The failure frequencies cited

in the revised assessment are from the best available literature concerning modern roads, and are not restricted to forest roads.

The bulk of the information presented on culvert failure research relates to roads in forested watersheds and these may not be as applicable to the proposed transportation corridor. The additional information provided on the character of each potential stream crossing is more useful for the assessment of the potential impacts of the mine road to fish passage.

Courtney Carothers, Ph.D.

Culvert failures due to blockage and erosion are noted to be common and are likely to occur in this scenario. Culvert failures would prevent the movement of fish, which could eliminate a year class from blocked stream systems and fragment upstream and downstream populations, increasing likelihood of localized population depletions and extinctions. Monitoring and maintenance of culverts can be expected to decrease after mine operation, increasing the risks of these failures. The report appears to appropriately characterize risks to salmonid fish due to culvert failures along the transportation corridor, although I have no particular expertise with which to evaluate this assessment.

RESPONSE: No change suggested or required.

Dennis D. Dauble, Ph.D.

Mitigation practices, such as new culvert design, was well described, as was bridging of roadways and porous fills to mitigate risks due to culvert failure along the transportation corridor. This assessment also included appropriate risk characterization for both the no-failure and failure scenarios. There should be literature available from the Washington State Department of Transportation on fish passage relative to culvert placement and design. Otherwise, I have no suggestions for improvement.

RESPONSE: We have examined literature on fish passage relative to culverts from the Washington State Department of Transportation. Culvert failure frequencies from their 2012 paper, in which approximately 62%of culverts were identified as total or partial barriers, were not used in the assessment because we could not determine the age of examined roads.

Gordon H. Reeves, Ph.D.

The literature review of culverts and their potential impacts on fish and fish habitat is very thorough and the presentation of results is accurate. However, most of the cited material is from studies done in areas outside of Bristol Bay and the direct applicability of results is problematic. This should be done in the revision.

RESPONSE: Because the proposed mining would take place in an undeveloped area, much of the literature is necessarily from areas outside of Bristol Bay. However, to the extent possible

we used examples from representative environments, and applied the results to the proposed mine.

I think that there are potential mitigation measures that were not presented. The primary one, besides the use of bridges, as suggested in the report, is making all culverts be arch culverts. These culverts make use of the stream bottom, which reduces the potential for the culverts to become perched and impede upstream movement, and are less likely to change the gradient than other culvert types. All culverts could, as recommended in the report, be at least one bank width, which is larger than required by the state of Alaska. This would minimize the possibility of plugging with debris.

RESPONSE: A number of culvert types (e.g., arch culverts) may be used on the proposed transportation corridor; it is not in EPA's purview to suggest which ones should be used. However, culvert design approaches specified in the Memorandum of Agreement between the Alaska Department of Fish and Game and the Alaska Department of Transportation and Public Facilities (ADF&G and ADOT 2001) are described in Box 10-2 of the revised assessment.

The review of potential road impacts lacked two possible consequences. One is that roads could be corridors for the introduction of invasive species, plants and animals. The consequences of the successful establishment of non-native species could have critical ecological impacts on native species and the ecosystem. The second consequence is that a road will allow greater access to streams where access was previously limited. Fish populations could be more easily and intensively harvested in sport and subsistence fisheries, which adds additional stresses to the populations. Lee et al. (1997. Assessment of the condition of aquatic ecosystems in the Interior Columbia River basin. Chapter 4. Eastside Ecosystem Management Project. PNW-GTR-405. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.) found a direct relation between road access and the status of salmonid populations in the Columbia Basin.

RESPONSE: We agree with the commenter that roads could be corridors for the introduction of invasive species. The potential impacts of invasive species as a result of construction and operation of the proposed transportation corridor are discussed in Section 10.3.6 in the revised assessment. With respect to stream access, EPA assumes that the proposed road would be closed to the public during mining operations but potentially could become a public road after mining operations cease. If that were the case, there would be greater access to streams and fish populations. However, the potentially important impact to fish would likely occur from secondary (induced) development, or development resulting from the introduction of industry, roads and infrastructure associated with mining. This is briefly discussed in Section 13.3 in the revised assessment. Improved accessibility would increase hunting and fishing pressure, as well as competition with existing subsistence users.

Charles Wesley Slaughter, Ph.D.

No. The Assessment does not adequately address the road/stream crossing/culvert issue. Given the projected transportation corridor, Pebble locale to Cook Inlet, and the inevitability of a further network of "minor" roads in the mine and TSF locale, plus additional infrastructure linkages, road/culvert/stream crossings are a major concern for aquatic habitat and fisheries. Readers of the Assessment should be directed to Frissell and Shaftel's Appendix G for a more comprehensive discussion of this important topic.

RESPONSE: The revised assessment addresses the road/stream crossing/culvert issue in detail. Secondary development is now described qualitatively in Chapter 13 of the revised assessment. The reader is repeatedly directed to Appendix G for more details.

The specific consequences of a failure on salmonid habitat and biology are portrayed well.

RESPONSE: No changes suggested or required.

John D. Stednick, Ph.D.

No. It is unclear how the estimate that 50% of the culverts would fail was obtained, given that the literature shows a range of 30 to 60% (Section 4.4.4). What literature was used? Are road BMPs satisfactory in this environment? Have the Alaska BMPs been audited? Culvert repair taking a week to several repairs in a month seems high. If the road crosses a critical salmon rearing stream, conservative pipe sizing or bridgework could be considered. The direct loss or inaccessibility of upstream salmon habitat does not necessarily translate to salmon loss. Timing of culvert blocking event with salmon migration and duration of blockage should be considered. Need to include references to Alaska Department of Natural Resources and Alaska Department of Transportation.

RESPONSE: The literature showed a range of 30 to 66%, with an average of roughly 50%. The literature used was noted in Section 10.3.2.1. However, Flanders et al. 2000 was deleted in the revised assessment, bringing the average culvert failure frequency to 47%.

Best management practices (BMPs) or mitigation measures would be used to minimize potential impacts to salmon ecosystems from construction and operation of the proposed transportation corridor. These BMPs, and their likely effectiveness, are now discussed in text boxes throughout Chapter 10 (e.g., Box 10-2). Environmental characteristics along the transportation corridor would likely render the effectiveness of standard or even "state of the art" mitigation measures highly uncertain. Further discussion on this is contained in Box 10-5 of the revised Assessment.

We are not aware of any audits of Alaska BMPs.

The text relating to culvert repair considers that the proposed mining would occur in an often harsh, remote environment.

Design considerations (including sizing) for culverts are now discussed in Box 10-2. Culverts would be designed in accordance with guidance in Alaska Highway Drainage Manual (ADOT 1995) and the Memorandum of Agreement between the Alaska Department of Fish and Game and the Alaska Department of Transportation and Public Facilities (ADF&G and ADOT 2001). Both of these documents are cited within Box 10-2.

Blockage of a culvert by debris or downstream erosion would prevent the in-and-out migration of salmon and the movement of other fish among seasonal habitats. The direct loss or

inaccessibility of upstream salmon habitat does not necessarily translate to loss of a population of salmon, but production would ultimately be reduced. If blockage of a culvert by debris or downstream erosion occurred during in-migration of salmon and persisted for several days, it would result in the loss of spawning and rearing habitat. If it occurred during out-migration and persisted for several days, it could cause the loss of a year class of salmon from a stream.

What are the design considerations for the culverts? What precipitation/streamflow relationships will be used for sizing purposes? What are the usual casual mechanisms for culvert failure? How much woody material do these streams carry? Do culverts fail from debris plugging, road slumps, or overtopping by storm events? What road BMPs will be implemented?

RESPONSE: Design considerations (including sizing) for culverts are now discussed in Box 10-2. Culverts would be designed in accordance with guidance in Alaska Highway Drainage Manual (ADOT 1995) and the Memorandum of Agreement between the Alaska Department of Fish and Game and the Alaska Department of Transportation and Public Facilities (ADF&G and ADOT 2001).

As noted in Section 10.3.2, culverts are deemed to have failed if culverts (and thus fish passage) are blocked (e.g., by debris, ice, or beaver activity) or if stream flow exceeds culvert capacity, resulting in overtopping and potential road washout. The causal mechanisms for culvert failure are briefly discussed in Section 10.3.2.

We do not have an estimate of the amount of woody material carried by streams in the assessment area.

BMPs (e.g., stormwater runoff and fine sediment mitigation) that would be implemented are now discussed in text boxes throughout Chapter 10 of the revised assessment.

Roy A. Stein, Ph.D.

Sizing Culverts: Page 5-61. Here the suggestion is that "Culverts must be 0.9 times the ordinary high-water width…" and where the channel slope is less than 5%, the "the culvert is allowed to be 0.75 times" this same metric. Does this take into account global climate changes, which would mean higher flow rates than historically has been the case? Shouldn't culverts be sized larger than what historical flow rates would suggest, given that Climate Change will likely result in more intense storms and therefore greater stream flows than has historically been the case?

RESPONSE: The commenter makes a good point. We do not believe that the sizing suggestions noted by the commenter (found in the Memorandum of Agreement between the Alaska Department of Fish and Game and the Alaska Department of Transportation and Public Facilities (ADF&G and ADOT 2001) take into account global climate change. Climate change projections and potential impacts are now included in Chapter 3. We note in Chapter 10 of the revised assessment that climate-related changes, such as increased flood frequency and shorter return interval for major flood events, would likely undermine the structure of the proposed transportation corridor and stream crossings. The variability and magnitude of stream flows could also enhance other impacts described in the chapter. Interactions between climate change and mining risks are discussed in Box 14-2.

Culvert Failures: Page 6-42. Culvert failure rates of 30-66% suggest we are doing something wrong with establishing these culverts to maintain stream flow under a road. How might we reduce this rate of failure (larger culverts? placement issues? solutions of any sort?)? In fact, if indeed 50% of the culverts will be blocked (see bottom of page 6-43), are we not dealing with an unacceptable solution of running streams under roads? Might there be some replacement of these culverts with bridges; certainly, bridges are more expensive to build, but they simply do not have the failure (i.e., blockage) rate that culverts do. Might there be a trade-off here between initial investment costs (high for bridges) and salmon protection (fewer blockage events)? What would Best Management Practices tell us in this context?

RESPONSE: In the revised assessment, culvert failure frequencies are reported as 30 to 58%, with an average failure estimate of 47%. The likelihood of extended blockages would be low during mine operations because the roadway would be monitored daily to ensure that failures could be rapidly identified and repaired. However, the likelihood would increase after mine operations cease, if inspection and maintenance frequencies declined to those of typical roads.

Best management practices (BMPs) or mitigation measures would be used to minimize potential impacts to salmon ecosystems from construction and operation of the proposed transportation corridor. These BMPs, and their likely effectiveness, are now discussed in text boxes throughout Chapter 10.

Bridges would generally have less impact on salmon than culverts, but can result in the loss of long riparian side channels if they do not span the entire floodplain. The actual decision as to what type of structure (bridge versus culvert) would be constructed at each crossing would be made by industry engineers in consultation with state permitting staff.

William A. Stubblefield, Ph.D.

Potential effects on salmonid populations were evaluated due to culvert blockage and failures. Culvert blockages will prevent salmon passage leading to possible effects on reproductive success. Literature data for the incidence of culvert failures were used in assessing failure probability. This seems to be an appropriate approach given the hypothetical nature of the mine used in the assessment; however, this is not my area of expertise and I am not aware of additional data that should be considered.

RESPONSE: No change suggested or required.

Dirk van Zyl, Ph.D., P.E.

Road and culvert failure likelihood. The likelihood of road and culvert failures is discussed in Section 4.4.4 (p. 4-62). This section relies on the paper by Furniss et al. (1991) for a number of aspects. As was pointed out above, this paper is focused on forest and rangeland roads and is not applicable to the access road for the Pebble Mine. It is recommended that further evaluations be done of similar roads at mines constructed between mines and port facilities to update this section.

RESPONSE: Furniss et al. (1991) does focus on forest and rangeland roads, but it is a seminal publication on the potential effects of roads, particularly as they relate to salmon. The general conclusions of that paper should be applicable to the transportation corridor proposed in the assessment. The failure frequencies cited in the revised assessment are from modern roads and not restricted to forest roads. Because the proposed mining would take place in an undeveloped area, much of the literature used in the assessment is necessarily from areas outside of Bristol Bay. However, to the extent possible we used recent literature from representative environments. We found no literature concerning the operational success of culverts on roads between mines or connecting mines and ports.

Road and culvert failure consequences. The failure consequences discussed in Section 6.4 seem to be based on almost total regulatory failure during and after operations. The information also serves to highlight the aspects that should be considered when designing, operating and maintaining the access road during operations and subsequently during closure.

RESPONSE: In the revised assessment, consequences of failures and routine operations are covered in Chapter 10. The failure consequences are not based on almost total regulatory failure. Rather, they take into account the use of best management practices (BMPs) or mitigation measures that are discussed in text boxes throughout Chapter 10. Nonetheless, environmental characteristics along the transportation corridor would likely render the effectiveness of standard or even "state of the art" mitigation measures highly uncertain. Further discussion on this is contained in Box 10-5 of the revised assessment.

Phyllis K. Weber Scannell, Ph.D.

The risks to salmonid fish due to culvert failures would be minimized by implementation of permits by Alaska Department of Fish and Game (ADF&G), Habitat Division. Under A.S. 16.05.840-870, Alaska has some of the most protective laws for fish and fish habitat in the United States. Further, given the lack of specific information on road alignments, construction methods and stream crossings, it is not possible to calculate lengths of affected streams, quantify loss of fish habitats, or predict failures of culverts, side slopes, etc. The document would be strengthened if it included specific information on locations of spawning and rearing habitats and estimated the contribution of fish habitats in the Nushagak River and Kvichak River Watersheds to the Bristol Bay fishery.

RESPONSE: Best management practices (BMPs) or mitigation measures that would be used to minimize potential impacts to salmon ecosystems from construction and operation of the proposed transportation corridor are now discussed in text boxes throughout Chapter 10. Box 10-2 specifically refers to fish habitat regulations under Title 16.

As noted in the revised assessment, uncertainty exists in the characterization of streams and wetlands affected by the proposed transportation corridor. Based on the chosen road alignment scenario (which agrees with that proposed in Ghaffari et al. 2011) we feel that we are justified in estimating the potential footprint of the proposed corridor and its potential impact on fish habitats and populations. We note in the revised assessment that "Although this route (the one proposed in the EPA scenario) is not necessarily the only option for corridor placement, the assessment of potential environmental risks would not be expected to change

substantially with minor shifts in road alignment. Along any feasible route, the proposed transportation corridor would cross many streams, rivers, wetlands, and extensive areas with shallow groundwater, including numerous mapped (and likely more unmapped) tributary streams to Iliamna Lake (Figures 10-1 and 10-2).”

Specific information on locations of spawning and rearing habitats along the proposed transportation corridor is difficult to obtain; as noted in the revised assessment, the Alaska Anadromous Waters Catalog and Alaska Freshwater Fish Inventory do not necessarily characterize all potential fish-bearing streams because of limited sampling along the corridor. Nonetheless, the revised assessment summarizes the species, abundances, and distributions that would potentially be affected, and places the streams along the transportation corridor into the context of the entire Nushagak and Kvichak River watersheds with respect to important watershed attributes such as discharge, channel gradient, and floodplain potential. As far as placing potential mining impacts in the context of the entire Bristol Bay watershed, we are unable to build a complete IP model, as this would require validation and more elaborate construction of metrics appropriate to this region. However, our preliminary characterization provides the building blocks for assessing the distribution of key habitat-forming and constraining features across these watersheds.

Paul Whitney, Ph.D.

Criteria for bridge versus culvert installations along the proposed haul road. The dynamic process of beaver dams causing streams to move across the floodplain should also be a criterion for determining if and where culverts are installed for a potential road (pages 4-36 and 4-63). Even if salmonids are not present at a stream crossing, the mosaic of active and decayed beaver ponds in the floodplain can be important rearing areas for forage fish and benthic drift that are utilized by salmonids (Snodgrass and Meffe, 1997; Schlosser and Kallemeyn, 2000). If beaver dams (but not salmonids) are present above proposed stream crossings, bridges or causeways that allow the streams to move across the floodplain should be recommended versus a culvert.

RESPONSE: Our revised assessment is based on the assumption that crossings over streams with mean annual flows greater than 0.15m^3/s would be bridged. However, the actual decision as to what type of structure (bridge versus culvert) would be constructed at each crossing would be made by industry engineers in consultation with state permitting staff. We agree with the reviewer that beavers can have an important influence of channel location and morphology. However, beavers move frequently, so over the life of the road the locations of beaver dams would change and therefore seem unlikely to provide a good criterion for crossing designs.

Beaver are known to block culverts at the upstream ends. Beaver-proof culverts are an option, but all the designs I am aware of would certainly hinder, if not block, movement of forage fish and benthic drift. Causeways or bridges are the best way to encourage beaver activity (i.e., functions) and all the benefits that accrue.

RESPONSE: The actual decision as to what type of structure (bridge versus culvert) would be constructed at each crossing would be made by industry engineers in consultation with state permitting staff.

Toxic plume. Spills of transported chemicals are not quantified in the culvert failure section of the assessment. I have participated in a mine risk assessment and a landfill risk assessment where spills of cyanide and landfill leachate have been modeled. While I did not conduct the plume movement analyses, stream hydrologists readily calculated how far spilled materials would move down stream until the concentrations of chemicals in streams reached acceptable benchmarks. The longevity of a spill of chemicals for copper processing should be calculated. It appears that the Water Treatment failure assessment on page 6-39 conducted some sort of plume analysis to determine the potential for an impact on Iliamna Lake. Perhaps it is possible to use this analysis, or at least the model, to address the consequence of a spill of transported chemicals.

RESPONSE: We have modeled the transport of spills from pipeline failures and emissions from the wastewater treatment plant and leakage of leachates. In Section 10.3.3.1 of the revised assessment we estimate the number of reagent spills that would occur over the roughly 25-year life of Pebble 2.0 scenario. We did not conduct a plume analysis for a spill of transported chemicals, but given the toxicity of sodium ethyl xanthate (Section 6.4.2.3) we expect that a spill of this compound into a stream along the transportation corridor would cause a fish kill. Given the uncertainty concerning the nature and magnitude of a truck accident and spill, we decided that a quantitative analysis of transport and fate would not materially contribute to the value of the assessment.

Question 8. ***Does the assessment appropriately characterize risks to salmonid fish due to pipeline failures? If not, what suggestions do you have for improving this part of the assessment? Are significant literature, reports, or data not referenced that would be useful to characterize these risks, and if so what are they?***

David A. Atkins, M.S.

The discussion of pipeline failures is based on published failure rates, principally for oil and gas pipelines. This analysis results in a pipeline failure rate of one per 1,000 km per annum. This is a pretty generic number that does not consider actual pipeline design. Rather it indicates that pipelines designed using standard practices do fail with a fairly high frequency. The Assessment does not apply this failure rate to the gas and diesel pipelines because “they are not particularly associated with mining.” Without the mine, there would be no pipeline. So given that this rate of failure is quantifiable based on good data and that the pipeline would be built to serve the project, this risk should be considered.

RESPONSE: The assessment assumes that pipeline design follows standard ASME practices. A diesel pipeline failure and resultant spill into two creeks has been added in Chapter 11 in the revised assessment. A gas leak is considered but is not analyzed because of the lack of significant causal linkage to fish production.

A concentrate pipeline spill would have differing impacts depending on when and where the spill occurred, with deposition in Lake Iliamna likely being the worst outcome. As noted in the report, it is likely that a pipeline spill would be detected rapidly and that the volume of the spill would be limited and amenable to remediation. A better description of how concentrate pipeline failures have occurred would be helpful to better understand the risk for this project (e.g., the July 2012 Antamina concentrate pipeline failure, although this pipeline would operate under a much different pressure regime due to extreme altitude change).

RESPONSE: Consolidated, statistically representative data on concentrate pipeline failures are not readily available, although anecdotal evidence from some case studies can be found. The pipeline failure statistics reviewed for the assessment come primarily from oil and gas pipelines, but also include some water and hazardous liquid pipelines. The performance of mining concentrate pipelines is not expected to be better than the performance of oil pipelines, because concentrate pipelines would be expected to be more susceptible to internal corrosion and abrasion. The 2012 Antamina concentrate pipeline failure in Peru was reportedly caused by the rupture of a pipe elbow in a valve station. The regulatory, geographic, and operating conditions of the Antamina pipeline may differ greatly from those of the concentrate pipeline in the assessment scenarios. A discussion of causes and probabilities of pipeline failures is included in Section 11.1 of the revised assessment. The revised assessment also includes discussions of concentrate spills at the Bingham Canyon, Utah, and Alumbrera, Argentina, copper mines (Section 11.3.4.2).

Steve Buckley, M.S., CPG

The assessment does generally describe the potential risks to fish from hypothetical pipeline failures.

RESPONSE: No changes suggested or required.

Courtney Carothers, Ph.D.

A pipeline failure would be expected to release toxic leachate into stream systems in the transportation corridor, none of which would dilute the leachate enough to prevent severe toxic effects (both immediate and long-term). The report discusses three pipeline failures in the Bajo de la Alumbrera mine in Argentina. The largest pipeline failure lasted two hours (compared to only two minutes of exposure hypothesized in the current mine scenario). The report could more clearly describe this case and its likely effects. The report appears to appropriately characterize risks to salmonid fish due to pipeline failures, although I have no particular expertise with which to evaluate this assessment.

RESPONSE: The EPA agrees that it would be desirable to have more information on the effects of the largest Bajo de la Alumbrera spill, but we have included all information on that failure that is available.

Dennis D. Dauble, Ph.D.

The risks to salmonid fish due to release of pipeline concentrate/slurry and leachates (as return water) are well described. However, risks of a diesel fuel spill are not. More detail could be provided on reclaimed water. For example, what toxic constituents (and at what volumes) would be released to the environment if these pipelines failed?

RESPONSE: A diesel pipeline failure and resultant spill into two creeks has been added in Chapter 11 in the revised assessment. New data on concentrate leachate in the slurry have been added, and it is assumed to also describe the return water.

Gordon H. Reeves, Ph.D.

Assuming that characterizations of the pipeline failure are accurate, the potential impacts on fish and fish habitat are appropriate and reasonable. It was clear that the effects of a pipeline failure could be major, depending on the duration and timing of the spill, because of the concentration of metals in the slurry, the particular life-stage present, flow conditions, and the reduced potential to fully remove the material from a stream or wetland afterwards.

RESPONSE: No change suggested or required.

The one question that I had about this section was the potential impact on phytoplankton and zooplankton in Lake Iliamna, particularly at the local scale. I assume that any spill from pipeline failure would have potential impacts on the lake and on phytoplankton and zooplankton, the major food for juvenile sockeye salmon. The ecological consequences would depend on the extent and intensity of any spill and on how juvenile sockeye use areas near tributary streams. I would expect that a spill could be particularly detrimental if juvenile sockeye use the area near or adjacent to natal streams when they enter the lake. I think this should be considered in more detail in any additional analysis.

RESPONSE: The toxicity data for species sensitive to copper and most other potentially toxic metals are derived from planktonic crustaceans, so it is already addressing planktonic lake species more directly than stream benthic species. However, the more detailed analyses of aqueous releases in the revised assessment (Chapter 11) provide a better basis for addressing the risk of exposure in Iliamna Lake. Because the aqueous phase of the product concentrate slurry would enter the stream briefly and would be rapidly diluted in the lake, it is not judged to be a major risk to plankton relative to the potentially sustained direct effects on salmon eggs and larvae of the deposited solid phase or relative to stream invertebrates, which would have much less benefit of dilution.

Charles Wesley Slaughter, Ph.D.

No. Concerns with pipelines crossing streams, watercourses and wetlands are similar to those earlier expressed for the road corridor. On-site investigation may well reveal many more "watercourses," including intermittent and ephemeral streams, than the 70 crossings cited; possible pipeline failures thus may have much wider potential for impacting salmonids than is indicated in the Assessment.

RESPONSE: The document has been edited to indicate that 70 is a minimum value.

The "probability" argument on p. 6-32 is an understandable attempt at quantification, but is unpersuasive. Given the spill history of TAPS, pipelines in the Prudhoe Bay field, and recently in Montana (?), suggesting the probability (with what confidence limits?) that there would be only 1.5 stream-contaminating spills or two wetland-contaminating spills over 78 years of operation seems wildly optimistic (and what is half a spill?).

RESPONSE: If you think of the mine as a repeated experiment (i.e., many mines with concentrate pipelines of that length and duration), we would expect a mean frequency of 1.5 spills. A more straightforward explanation is that we expect 1 or 2 spills, given the scenario. These frequencies are based on a large data set, not just the TAPS experience (which is an atypical pipeline design and much larger than the diesel line) or the spill in the Yellowstone River (which is a single event). An explanation of the frequency has been added in Section 11.1 of the revised assessment.

Assuming that any spill (over the 78-year project span) would last only two minutes (p. 6-32, p. 6-34), with a consequent minimal volume of spilled material, also seems highly optimistic. Even highly-automated systems, with redundant sensors and automatic responses, are susceptible to error or failure, and the Bristol Bay watershed environment is not benign with regard to mechanical apparatus. The authors appear to recognize this with their discussion of the Alumbrera incident.

RESPONSE: The scenario has been modified to a 5-minute response. Also, more information has been added about the possibility of system failure or human error in response to this and similar comments. The uncertainty discussion in Chapter 11 indicates that the exposure scenario is predicated on the successful operation of a remote shutoff. There may be extreme weather or geological events that render the remote shutoff system inoperable. We did not evaluate those events, so the assessment may underestimate these risks.

The specific **consequences** of a failure on salmonid habitat and biology are portrayed well.

RESPONSE: No changes suggested or required.

John D. Stednick, Ph.D.

The pipeline corridor consists of four pipelines over a distance of 86 miles. No information was provided on pipeline structure or placement, other than mentioning of stream crossings. The pipeline failure of concentrate slurry was modeled using chemistry from the Aitik (Sweden) mine. Is this best approximation? That mine is about 80 years old and is processing ore from the edge of the pit, with much lower sulfur content than Pebble.

RESPONSE: More information on the pipeline structure and placement was provided in Section 6.1.3.2 of the revised assessment. We have replaced the USGS leachate data from the Aitik product with analyses from actual concentrate slurry provided by Rio Tinto to describe the aqueous phase of the slurry and the return water, which would be alkaline (Section 11.3.2.1). However, the Aitik data are used to estimate the risks from deposition of the product in a stream or wetland. The environmental leaching of the concentrate would resemble the USGS's leaching test of the concentrate, not the alkaline solution in the pipeline slurry. To the

best of our knowledge, no other aqueous leach test of a porphyry copper product concentrate is available.

Pipeline failures can be significant in any environment and spill or pipe break prevention requires significant monitoring. Will automatic shutoff controls be included? Are workers stationed 24 hours/day every day? Some of the past Alaska failures were in winter conditions, when things were not easily visible--under ice or snow cover. How will this be addressed?

RESPONSE: Our scenarios include remotely-operated valves tied to a supervisory control and data acquisition (SCADA) continuous monitoring system tied to a continuously staffed control room. The remotely-operated valves could be triggered either manually or through software, but we expect that except in the event of a clear rupture of the pipeline, the SCADA signals would trigger an alarm that would initiate manual intervention by the operator. Consistent with best management practices, we have assumed that the pipeline would be visually inspected along its full length at least daily, and that the inspection protocols would consider the difficulties of detecting a spill under snow or ice. Potential remedial actions for cleanup up of diesel, product concentrate and return water spills are discussed in Chapter 11.

The toxicity approach seems reasonable. What is the anticipated chemistry of the return waters? Diesel spill monitoring? The geometric mean of three values (which references) indicates that there is a 14% probability of failure in each pipeline in each year. This is not acceptable at any level.

RESPONSE: The return water is assumed to be the same as the aqueous phase of the slurry water. A diesel spill scenario has been added in Chapter 11. The pipeline failure rate reported in the assessment is similar to the rates calculated in studies by others and represents several large datasets. Some of the reported failures are due to corrosion, which tends to result in small releases; some of the failures are due to mechanical impacts, which tend to produce larger releases; some are due to other causes. The buried pipelines in our scenarios would be expected to have a lower incidence of rupture from third party activities, but may have a higher incidence of rupture due to landslides or earthquakes than the overall dataset. Corrosion or corrosion leaks could go undetected for longer periods of time compared to an aboveground pipeline.

Roy A. Stein, Ph.D.

Pipeline Failures I. What dictates 14 km between automatic shut-off valves; shouldn't this distance be shorter as the pipe becomes larger, i.e., related to the amount of liquid/slurry that would be spilled upon pipe failure? Shouldn't all of these pipelines be double-walled? What would Best Management Practices tell us in this context?

RESPONSE: The distance between valves appears to be consistent with current practices. The pipelines are described as double-walled in above-ground reaches. A double-walled pipeline along the entire length of a pipeline might be desired from a purely environmental protection standpoint; however, it may not be feasible or cost effective to do this. Therefore, we have proposed the most commonly used (and accepted method) of double-walled construction over any water bodies. There are a large number of factors that go into standard practices for

design, construction, and testing of pipelines. In the draft assessment, we included a selected number of these factors as examples of our design mitigation measures. In the revised assessment (Section 6.1.3.2), we have included a statement that the design would follow the standards of the American Society of Mechanical Engineers, to indicate that modern mitigation measures would be included.

Pipeline Failures II. Like all other failures, it seems to me that "Standard Operating Procedures (SOP)" for mitigation should be in place in anticipation of any future spill or contamination of the environment. I do not think that these procedures need to be in this report, but an acknowledgement of their presence and that mining companies will follow these SOPs in response to any spills that occur, be it pipeline, TSF, truck, leachate bed, etc.

RESPONSE: The EPA agrees that a mining company should have an SOP for remediating spills, but we have not been able to find such an SOP for remediating a product concentrate pipeline spill.

William A. Stubblefield, Ph.D.

Potential effects on salmonid populations were evaluated due to potential pipeline failures as part of the risk assessment. This evaluation focused on potential failures associated with the pipelines for the product concentrate slurry and return water. No consideration of the natural gas or diesel pipelines was presented, stating that such pipelines "are common and the risks are well-known." Although I would acknowledge the failures in natural gas and petroleum pipelines are common, I would not discount the potential effects to salmon populations associated with such spills.

RESPONSE: A diesel pipeline failure and resultant spill into two creeks has been added in Chapter 11. Natural gas is not a contaminant of concern because it would vaporize and, at worst, burn, which would not pose a significant risk to salmonid fish.

Evaluation of potential impacts due to a spill of product concentrate slurry or return water was based on extant data from an existing copper mine in Sweden; to the extent that this slurry and return water is representative of similar materials coming from the Pebble mine, this approach is appropriate. The assumptions used in the amount of material that might possibly be spilled seems appropriate and based on past experience and realistic assumptions; however, these assumptions need to be reconsidered if and when a real mine plan is prepared.

RESPONSE: The Aitik leachate is no longer used to estimate the aqueous phase of the slurry, in response to other comments. Because the slurry would be alkaline, appropriate analytical data were obtained from Rio Tinto (Section 11.3.2.1). However, the Aitik data are still used for the leaching of the concentrate in a stream or wetland where neutral water would be the leaching agent. No other relevant data are available.

Dirk van Zyl, Ph.D., P.E.

The EPA Assessment does not identify or appropriately characterize the risks to salmonid fish due to pipeline failures. It only estimates the likelihoods of occurrence and the consequences.

See discussion under Question 4 above regarding suggestions for improving estimation and expression of the magnitude of risks to salmonid fish due to pipeline failures.

RESPONSE: The EPA believes that the likelihood of an occurrence and its consequences constitute an appropriate and generally accepted definition of risk. We have estimated those to the extent that existing information allows.

Pipelines failure likelihood. The EPA Assessment focuses on the failure of the concentrate pipeline because "We do not assess failures of the natural gas or diesel pipelines here because such pipelines are common, their risks are well known and they are not particularly associated with mining". I find this statement puzzling because all pipeline failures should be of concern. It is further puzzling because the likelihood of pipeline failures for the concentrate pipeline is derived from the failure statistics for pipelines in the oil and gas industry (p. 4-60). Failure of the Baja de la Alumbrera concentrate pipeline in Argentina is suggested as an analog, indicating that such failures can occur; however, I disagree that "it suggests that concentrate pipeline failures are common at a modern copper mine." This last statement is not supported by any further analysis of concentrate pipeline failures at other modern copper mines. It is recommended that such analyses be performed or that the text be edited to indicate this shortcoming.

RESPONSE: The revised assessment contains an analysis of the risks of a diesel pipeline spill in Section 11.5. Natural gas is not a contaminant of concern because it would vaporize and, at worst, burn off, which would not pose a significant risk to salmonid fish (Chapter 11). The quoted statement is literally correct. Baja de la Alumbrera is a modern copper mine and pipeline failures are common there. This suggests that failures are common. Further, concentrate pipeline failures at the Antamina and Bingham Canyon mines are now discussed. However, the statement in the revised assessment has been weakened by changing "common" to "not uncommon." To support that statement, a review of pipeline failures at U.S. porphyry copper mines has been added (Section 11.1). However, the EPA has not found a sufficient record of product concentrate pipeline operations to develop a probability of failure that is specific to that pipeline type.

Pipelines failure consequences. Failure consequences are focused on the release of concentrate into water. As indicated in Appendix H of the report, the analog concentrate from the Aitik mine is dominated by chalcopyrite, a sulfide mineral which contains the copper. If the concentrate is submerged under water in relatively slow flowing streams then very little long-term release of the copper will occur, as the water does not contain sufficient oxygen to allow for sulfide oxidation. It is only when the concentrate is transported to locations above the water level that oxidation and release of metals will occur.

RESPONSE: Subaqueous oxidation of sulfides does occur in well oxygenated waters as this comment recognizes by stipulating "relatively slow moving streams". However, as the flow data in the spill scenario indicate, these are not slow moving streams. Subaqueous leachate column tests are conducted to assess the potential for subaqueous oxidation. Tests conducted by the Pebble partnership indicate the potential for subaqueous oxidation. Salmonids require high dissolved oxygen levels, so salmonid streams are necessarily well oxygenated. For example, the EBD states that mean dissolved oxygen levels for the North Fork Koktuli River was 10.2 ppm. This oxygen would oxidize the sulfides.

Phyllis K. Weber Scannell, Ph.D.

This section of the document focuses on effects of pipeline failures; however, without a viable mine plan, descriptions of pipelines and estimates of possible effects are speculative. The resource developer may opt to build a pipeline to transport fuel from the coast to the mine site or slurry concentrate to the port. Construction of any pipelines would require review and approval by state and federal agencies, such approvals would likely contain monitoring plans to ensure pipeline integrity. However, the risks of pipeline failures should not be minimized; the Fort Knox Mine near Fairbanks recently experienced a 45,000 gallon spill of cyanide solution after a bulldozer struck a supply line (Fairbanks Daily News Miner, August 24, 2012).

RESPONSE: The EPA agrees that the specific locations of pipelines and requirements for monitoring may differ from our scenario, which is based on preliminary mine plans (Ghaffari et al. 2011). However, we believe our scenario is plausible and allows an evaluation of potential impacts from pipeline failures. The Fort Knox spill has been added to the assessment as an example of spills due to human error in Section 11.1.

The risks of a pipeline failure to salmonid fish depend on the duration of the spill, the type of material spilled (return water or concentrate), the location of the spill (in the uplands or in a waterway), and the timing. The effects of a pipeline failure in a waterway when juvenile salmon are present would be far more severe than a pipeline failure in an upland area.

RESPONSE: EPA agrees with this comment. Discussion of spill location and life stage exposed has been expanded in Section 11.3, and the other issues have been carried over from the May 2012 draft.

Given that there currently is no information on road alignments or locations of future pipelines, it is not possible to estimate the number of stream crossings (70, page 6-30) or an exact length (269 km, page 6-30) of potentially affected waterways. The risks from pipeline failures outlined in the draft document should be revised when more specific information on the mine plan of operations becomes available.

RESPONSE: The road alignment and length in Northern Dynasty Mineral's preliminary mine plan (Ghaffari et al. 2011) were used in this assessment. The number of stream crossings was also detailed in that plan, and was checked by the EPA using USGS data. We would expect that risks would be re-evaluated as part of a future specific transportation corridor plan. No change required.

Paul Whitney, Ph.D.

Refer to comments/responses to Questions 2 and 7.

RESPONSE: See responses to those questions.

Question 9. ***Does the assessment appropriately characterize risks to salmonid fish due to a potential tailings dam failure? If not, what suggestions do you have for improving this part of the assessment? Are significant literature, reports, or data not referenced that would be useful to characterize these risks, and if so what are they?***

David A. Atkins, M.S.

The Assessment generically describes tailings dam failures and the potential impact in detail. It also uses some site-specific information on tailings supernatant and humidity cell leachate. There is no question that a tailings dam failure would be catastrophic for the fishery and the project, and although low probability, is the single largest risk to the fishery. A tailings dam failure could harm a very large area of the watershed for a very long period of time and could require a massive and expensive remediation effort.

RESPONSE: Agreed. No change suggested or required.

The tailings deposition and storage methods outlined in the Wardrop NI 43-101 report and presented in the Assessment are conventional for the industry and comply with Alaska State regulations. Because of the dire consequences of a failure in this highly sensitive and unique environment, it would be necessary to employ state of the art methods for tailings management and go 'beyond compliance' when designing and constructing this facility. This may include employing methods that are novel, incur significant additional cost for construction, and lead to a more stable and lower maintenance facility in the long term, such as dry stack or paste rock tailings (blending waste rock in with tailings in the impoundment to provide extra geotechnical stability). These methods, however, are not common practice and in some instances are still under development.

RESPONSE: The assessment addresses state of practice methods to identify potential risks that could result from such practices. The EPA agrees that there is a possibility that a mining proponent could design and propose practices that go beyond the state of practice in order to reduce potential risks.

Steve Buckley, M.S., CPG

The assessment does generally describe the potential risks to fish from tailings dam failures.

RESPONSE: No change suggested or required.

Courtney Carothers, Ph.D.

In the event of a tailings spill, invertebrates and fish would be exposed to toxic tailings and leachate. Actual tailings failure examples suggest the range of exposure would spread to an area more than 100 km. Copper would be especially toxic to invertebrates, fish eggs and larvae. Toxicity would last for decades. The report appears to appropriately characterize risks to salmonid fish due to a potential tailings dam failure, although I have no particular expertise with which to evaluate this assessment.

RESPONSE: No change suggested or required.

Dennis D. Dauble, Ph.D.

Tailings deposition is described in Chapter 4 of the main report, but I could not find anything that described potential risks to fishes, including effects to aquatic food webs and loss of fish spawning and rearing habitat.

RESPONSE: The TSF failure description and the assessment of risks were presented in separate chapters in the original draft assessment, but have now been moved into one location (Chapter 9) for clarity.

As noted in the text, the sediment transport model used could only simulate sediment transport and deposition ~30 km downstream of the mine site. Thus, potential effects to fish habitats were not well quantified for the mainstem Koktuli River (and beyond), in addition to the Mulchatna and Nushagak rivers. Is there a likelihood that any tailings material might reach Lake Illiamna? If not, say so in the document. It is equally useful to say where impacts will not occur (as it relates to sensitive habitat) as it is to describe where impacts are likely and reasonable.

RESPONSE: None of the 3 TSFs are in the watershed of Iliamna Lake. The hydrology of the site has been clarified and better maps added to clarify this issue. Risks to Iliamna Lake from water treatment failures, even if they occur in the Nushagak drainage, are now noted (e.g., transport of toxic leachate from the South Fork Koktuli to Upper Talarik Creek via groundwater exchange between theses basins; Chapter 8). However, sediment (i.e., tailings) would not follow that route.

The assessment deemed that it was "not possible" to determine how far the initial slurry deposition would extend, how far re-suspended sediments would travel, and how long erosion processes would continue. It seems that information from other mine closure sites could be used by assessment authors to infer effect by analogy. The statement alluding to potential sediment run out distance at the bottom of page 4-56 of the main report should be included in the summary of effects. This is an important point.

RESPONSE: The revised assessment now includes a clearer description of the magnitude and duration of effects. We apply the runout distance equations of Rico et al. (2008) to conclude that under Pebble 2.0 scenario dam failure conditions, runout distance exceeds 307 km (190 miles), reaching the marine waters of Bristol Bay (Section 9.3.2).

Gordon H. Reeves, Ph.D.

Assuming that characterizations of the dam failure are accurate, the potential impacts on fish and fish habitat are appropriate and reasonable. Impacts, like those of a pipeline failure, are likely to be widespread in the watershed and to be long lasting, resulting from inundation of areas by sediments and contaminants in the water. I think that potential impacts across the broader scale could be developed and highlighted more fully. Also, consideration of Intrinsic Potential (see response to Question 4) could provide additional insights into potential impacts of a tailings dam failure.

RESPONSE: While we were unable to conduct a full Intrinsic Potential modeling exercise, we have quantified the distribution of classes of gradient, mean annual flow, and % flatland for reaches of the site watersheds where TSFs would be placed. As highlighted in the report, streams – especially those downstream of the TSFs in the mainstem North Fork Koktuli and South Fork Koktuli – are low-gradient, floodplain prone channels that currently support spawning populations of several salmon species, rainbow trout, and Dolly Varden.

I think that potential consequences of climate change on hydrographs should have been considered in this section. More precipitation is projected to occur as rain in the winter rather than snow for many parts of AK. How would this potentially impact the tailings dam facilities? This seems to be a key piece of information that is needed to better understand the risk of dam failure and the potential for impacts on aquatic resources.

RESPONSE: Climate change projections and potential impacts are described in Chapter 3, and referenced here as a key uncertainty for in perpetuity management of the TSFs and other mine infrastructure. The probabilities for dam failure discussed in this assessment involve dams constructed in a variety of climates. Any potential increase in precipitation due to climate change is but one of the conditions for which the dams would need to be designed. A design developed to handle a higher level of precipitation would be expected to have a similar failure probability to one designed for an area of lower precipitation as long as the same design standards, e.g. the safety factor against overtopping, were used in both designs. Of course, if the design did not consider the possibility of increased precipitation as a design factor, and climate change did cause such an increase, then the probability of failure would be higher.

I thought that results to date of the impacts of the volcanic eruption at Mt. St. Helens, while not exactly the same as a mine operation, were not useful in considering long-term impacts and the response of aquatic ecosystems to such major disturbances. The impacts on streams are still more prevalent and extensive than what is described in the report. Most stream systems are transporting large amounts of fine sediment and areas of exposed gravels are rare.

RESPONSE: Extensive discussion of the Mount St. Helens analogy has been removed at the prompting of several reviewer comments including this one. We have retained key references from the region that are illustrative for considerations of likelihood of fine sediment transport and recovery (or lack thereof).

Charles Wesley Slaughter, Ph.D.

Yes. Physical consequences of TSF dam failure are fairly portrayed. I would only suggest that effects of initial sediment deposition and long-term remobilization and redeposition would extend beyond the spatial and temporal limits of the modeling used in the Assessment.

RESPONSE: Agreed. We now more clearly state that remobilization and deposition could be extensive; potentially reaching Bristol Bay.

Employing advanced eco-hydraulic modeling tools such as MIKE-11, MIKE-SHE (DHI, Copenhagen), and consultation with state-of-art practitioners (IAHR-International Association for Hydraulics Research, UI Center for Ecohydraulics Research, and others), along with improved high-resolution input data such as LIDAR survey of the complete Kvichak and Koktuli/Nushagak systems, would allow a more complete estimate of potential hydrologic and sedimentation (and consequently biotic) consequences of TSF dam failure for the entire river system, headwaters to Bristol Bay.

RESPONSE: We agree that LIDAR survey data would greatly improve the understanding of the project area topography. Alternative modeling platforms coupled with LIDAR have the potential to improve the estimates provided in this assessment, but these data collection and modeling efforts were not within the scope of this project.

John D. Stednick, Ph.D.

The tailings dam failure was modeled and the distance of sediment transport was estimated. The modeled tailings dam failure used an estimate of 20% mobilization from the tailings ponds. How was this value determined? The model was run to a stream length of 30 km (the rivers confluence), yet the report acknowledges that a sediment pulse could run for hundreds of kilometers. The moisture content of the tailings is estimated to be 45% by volume (page 4-50); the 20% volume of sediment may be underestimated. This initial risk to salmonid fish is clear, but the persistence of the sediment affect could be discussed.

RESPONSE: 20% was selected as a reasonable estimate, falling within the range of historic failure release volumes (e.g., Azam and Li 2010 state 1/5 (i.e., 20%) and Dalpatram 2011 states 20-40%). We agree that the total volume released during a failure would vary depending on water content, consolidation of tailings, and meteorological conditions in the valley during the time of the failure. We also agree that the sediment initially deposited on the valley floodplains and the sediment that remains downstream of the failed dam would become a continuous source of tailings, with the potential to re-suspend during each subsequent rainfall-runoff event that occurs before any sort of mitigation/clean-up efforts could be implemented to control this process. The 20% used was based on recent literature for the amount that is generally released from these types of dam failures. The tailings dam failure was intended to be a conservative analysis to shed light on whether a failure is a significant concern in the Nushagak River watershed.

The Mount St. Helens analogy is inappropriate for a variety of reasons and such comparisons should be removed from the assessment.

RESPONSE: Use of the Mount St. Helens analogy has been removed.

The probable maximum precipitation (PMP) value was extrapolated from Miller (1963) and the assessment commented how this value might be reduced upon further analysis. Conversely, additional data could increase this value. There was no discussion of the recurrence interval of this 24-hour storm.

RESPONSE: The assessment used the published PMP from Technical Paper No. 47 (the current guidance available from NOAA, at www.nws.noaa.gov/oh/hdsc/studies/pmp.html). Within TP 47 the 24- hour PMP values presented exceed those provided for the 100-year 24-hour event. While actual planning, design, and construction of a TSF dam will require additional study, for the purposes of this assessment we relied on readily available information and current published guidance for the determination of a design storm event with the magnitude that would likely be considered during design of the dam. The published PMP was applied to a Type-1 storm within HEC-HMS to determine a flood hydrograph that would result in the watershed located above the TSF as described for the purposes of this assessment. This hydrograph is expected to peak at 291 cms and was applied to the hydraulic model to cause an overtopping and subsequent failure of the TSF dam. The flood wave generated by the dam failure had a peak flow of 149,263 cms and 11,637 cms (large and small dam failures respectively). The hydrology discussed and applied related to the dam failure represents a precipitation and runoff event of the magnitude that the dam would be expected to accommodate, but in this assessment was used as a mode of failure.

No hydrologic data were provided. The streamflow gauging stations operated by the US Geological Survey near the study area suggest peak streamflow rates from snow melt and from rain events. The hydrograph shape and magnitude help determine if rain or snowmelt dominated. In the assessment, the peak flow estimate from the Natural Resources Conservation Service runoff method used a Type 1a storm distribution, the least intense precipitation distribution, but the literature would suggest that a Type 1 distribution would be more appropriate for Alaska. How does this storm event compare to the measured flood at Ekwok (page 4-50)? The curve number (CN) was not identified, nor the methods used to calculate that value. Similarly, the watershed slope, time to peak, hydraulic length, channel routing functions, and channel resistance methods or results were not presented. What precipitation data are available? The design of culverts, bridges, and storm water ponds all require good precipitation records and the confidence in that estimate is based on record length.

RESPONSE: We agree that the Type-1 storm is appropriate for Alaska. This has been corrected and updated. Additional hydrologic parameters were also included in the update to better describe the development of the HEC-HMS model. It is important to note that this hydrologic event was used to provide a mode of failure for the dam. The flood wave generated by the dam dwarfs the PMP hydrograph and the runoff from the storm event is not relevant.

The comparison is unclear for a 3,313 m^3/s flow in a 2,551 km^2 watershed area to the TSF flow of 1,862 m^3/s and an area of 1.4 km^2. What was the precipitation and recurrence interval for the Ekwok storm? The relation of groundwater flows to streamflow during storm events needs to be evaluated. The flood producing precipitation events in this area no doubt add to groundwater flows.

RESPONSE: This discussion was provided to help the reader understand the magnitude of the dam failure flood wave relative to an event that was experienced by a local community. We also wanted to draw attention to the fact that such a failure would occur in the upper end of the watershed where typical storm events do not generate floods of such magnitude. We

acknowledge that the two watersheds are not similar and the intent was not to draw comparisons of runoff potential from one watershed to another, just to help the reader gain context.

With a new estimate of precipitation depth of known recurrence interval, the design storm could result in a higher flood event with greater velocities and greater sediment transport ability, along with a greater sediment volume released from the TSF, resulting in a greater risk to salmonid fish and habitats.

RESPONSE: We agree. The tailings dam failure was intended to be a conservative analysis to shed light on whether a failure is a significant concern in the Nushagak River watershed. No change suggested or required.

Roy A. Stein, Ph.D.

TSF Failure and Remediation. The text on pages 6-1 to 6-2 states:

> "Remediation may occur following a tailings spill, but it is uncertain. A spill would flow into a roadless area and into streams and rivers that are too small to float a dredge, so the proper course of remediation is not obvious."

At this juncture in time, this statement points to the fact that we do not have the technology, or the appropriate operating procedures, in place to remediate a TSF spill. Does this essentially let the mine operator "off the hook"? Should we be promulgating mining activities in locations where we cannot remediate spills, given our current state of knowledge or ability to apply current techniques? What guidance would "Best Management Practices" provide for this situation?

RESPONSE: The intent of the statement is to point out the challenges of remediation of a large-scale tailings spill in a remote area. Large-scale tailings cleanup is challenging even in urban and more developed rural areas where there is road/rail access for equipment and transport of contaminated sediment. In the assessment watersheds, the only current access to downstream areas is provided by the rivers themselves, which are generally too small for large-scale dredging equipment.

William A. Stubblefield, Ph.D.

Potential effects on salmonid populations were evaluated due to tailings dam failures. Tailings dam failure would potentially result in the release of large volumes of mine tailings and associated contaminated waters, leading to possible acute and long-term effects on salmon populations. It is also important to note that direct effects on salmon may be very species dependent, due to life-cycle differences, and the time at which the dam failure occurs. Potential effects due to sediment inundation/impaction can adversely affect habitat, leading to decreased spawning. Evaluation of the potential for tailings dam failure effects considered acute and chronic risks due to aqueous exposures, chronic risks due to sediment exposures, and risks due to dietary exposures. All of these seem to be appropriate exposure pathways and all were adequately considered, although site-specific information will improve risk predictions.

RESPONSE: Agreed. No change suggested or required.

Dirk van Zyl, Ph.D., P.E.

The EPA Assessment does not identify or appropriately characterize the risks to salmonid fish due to a potential tailings dam failure. It only estimates the likelihoods of occurrence and the consequences. See discussion under Question 4 above regarding suggestions for improving estimation and expression of the magnitude of risks to salmonid fish due to potential tailings dam failure.

RESPONSE: The EPA believes that the likelihood of an occurrence and its consequences constitute an appropriate and generally accepted definition of risk. In this case we have estimated those for a tailings dam failure to the extent that existing information allows. Although fish abundance data are limited for this region, we did identify the potential magnitude of a tailings dam failure to the Chinook run of the Nushagak River.

TSF failure likelihood. The failure statistics given on p. 4-45 are based on tailings failure statistics over the last 50 years or so. Was there also a review of the operational histories, and therefore failures, of tailings impoundments designed and constructed in the last 10 to 15 years? It is recognized that one of the failures identified in Box 4-4 (Aurul S.A. Mine, Baie Mare, Romania) falls in this category. However, many of the failures included in the analyses are associated with older tailings facilities, especially those associated with large releases of tailings solids. A significant improvement in tailings management is the implementation of an Independent Tailings Dam Review Board (ITRB) for large mining projects (Morgenstern, 2010). An example of the activities of an ITRB is given in Minera Panamá (2012). Morgenstern (2010) provides a listing of tailings failures from 2001 and 2010 and comments that “in no case, to the knowledge of the Writer, was there systematic third party review” of the failed facilities as would be the case when an ITRB is active. I expect that a tailings review board will also be used for the Pebble Mine and the behavior of a tailings management facility designed and operated under these conditions will be more representative of the potential failure likelihoods expected for such a facility. It is expected that this likelihood will be much lower than those used in the evaluations of the scenario in the EPA Assessment.

RESPONSE: The probabilities for dam failure used in the assessment were not derived solely from the historical record. Historical failures were discussed as supporting background information and present a defensible upper bound on the failure probabilities. The failure probabilities used in the assessment are based on Alaska’s dam classification and required safety factors applied to the method of Silva et al. (2008) which compares dams designed, constructed, and/or operated under different standards. The discussion of failure probabilities in the revision (Chapter 9) is expanded to try to clarify this issue.

TSF failure consequences. It is difficult to estimate the volume of tailings that will be released when a tailings impoundment fails. The release of 20 percent of tailings from a slurry deposited TSF may be realistic when it contains a large pool and is subjected to a large flood, but it is unrealistically high for a TSF containing a small or no pool (such as in the case of a filtered dry stack). I would consider the assumption that a release of 20% of the tailings material for the

Pebble mine scenario is on the high side, even during operations. When the mine is closed and the tailings reclaimed I would consider the 20% release assumption as unrealistic, especially if the closure implementation included a diversion system designed for the PMF. It is further unrealistic to assume that the released tailings will remain in the downstream channels and flood plains following the failure. In the case of the Aznalcóllar Tailings Dam failure in Spain, all the released tailings downstream of the mine were removed. While such a removal action will impact parts of the watershed, it will help to recover the area faster than leaving all the tailings in place and will also reduce the longer-term impacts on downstream water quality. I therefore disagree with the assumption on p. 6-2 that "the assessment assumes that significant amounts of tailings would remain in the receiving watershed for some time and remediation may not occur at all." Box 6-1 provides "background on relevant analogous tailings spill sites" and three historic sites are used as analogs. These are not realistic analogs, as they all relate to historic mining under completely different scenarios. While the material historically released in these streams were from base metal mines, the circumstances of their release, especially in the case of the Clark Fork and the Coeur D'Alene Rivers, were very different. Long-term uncontrolled releases occurred in these river systems due to regulatory circumstances or historically acceptable practices that differ significantly from those in the 21st Century.

RESPONSE: We concur with the commenter that the estimation of the potential release volume is difficult and inexact. The release of 20% of impounded tailings used in our analysis is well below the reports of 30% to 66% in the historic record. Dry stacking was not proposed in the Ghaffari et al. (2011) report and has not been proposed in our scenarios. Ghaffari et al. (2011) proposed maintaining a pond on the top of the TSF to keep the pyritic tailings submerged, implying that the bulk of the tailings would remain saturated. We acknowledge that there are other tailing management strategies that could reduce the potential risk of failure.

The remediation of the 1998 Aznalcóllar Tailings Dam failure in Spain was completed within the 6 months between the April failure and the onset of heavy rains in October. The Aznalcóllar area, near Seville, has a much drier and warmer climate than the Bristol Bay area. It is also a heavily farmed area with flatter topography and far better access. The success at removing the tailings from the Aznalcóllar failure would be difficult to replicate in the Bristol Bay area, and significant amounts of tailings would remain in the receiving watershed for some time.

Box 6-1 in the original draft assessment (now Box 9-1) clearly states that the analogs presented "provide evidence concerning the nature of exposures to aquatic biota". They are not used to address the probability of a tailings dam failure or other aspects of the release of tailings.

Phyllis K. Weber Scannell, Ph.D.

The assessment considers two possible failures of the tailings dam: a partial-volume failure occurring during mine operations and a catastrophic failure occurring during or after mine operations. The partial-volume failure (as modeled in the assessment) would result in a greater than 1,000-fold increase in discharge and the catastrophic failure in a greater than 6,500-fold discharge.

RESPONSE: No change suggested or required.

The discussion of tailings dam failures describes possible changes in channel and floodplain morphology and briefly mentions that the tailings deposition would be a source of easily transportable, potentially toxic material.

RESPONSE: No change suggested or required.

The potential for increased metals loadings to river and lake systems is understated. Although there are no current predictions of tailings water quality, the water quality of tailings water from similar mines could be used to model increases in metals loading from dam failures.

RESPONSE: The original draft and the revised assessment use tailings leachate data from the PLP EBD (see Chapter 8). We believe that is more defensible than use of tailings leachates from other mines.

In addition to the partial-volume failure and the catastrophic failure, there are other possible sources of metals loadings from the tailings pond. Examples are emergency releases of untreated tailings water, seepage of tailings water into the groundwater, and flow from the tailings pond to groundwater in an adjacent drainage as the head (i.e. hydrostatic pressure) is increased as the tailings pond is filled. The last example was experienced at the Red Dog Mine when the increased elevation of the tailings pond caused water to flow underground into the Bonns Creek drainage instead of the Red Dog Creek drainage. Interception ditches were installed after the increases in metals loading to Bonns Creek were detected.

RESPONSE: Because the number of potential failures is extremely large, it is necessary to choose a representative set of failure scenarios. The original and revised drafts of the assessment include "seepage of tailings water into the groundwater, and flow from the tailings pond to groundwater in an adjacent drainage" but not emergency releases of tailings water.

<u>Paul Whitney, Ph.D.</u>

<u>Duration.</u> I agree with the assessment that it would take a "very long time" (page 6-25, first full para, last line) to reach concentrations that would not exceed threshold exposure levels. A "very long time" could mean hundreds of years to one person or geological time (i.e., millions of years) to another person. The assessment could be improved if some sidebars are put on the time likely required for no risk dilution or "more normal channel and floodplain." One suggestion would be to estimate the amount of time it would take the river/stream to move across the floodplain in the "relatively undisturbed" Bristol Bay watershed. I would also like to know whether reclamation or rip rap or rock weirs in areas with spilled tailings would reduce or extend the time to reach "more normal" conditions.

RESPONSE: We agree that geomorphic analyses of channel/floodplain recovery following a TSF failure would help improve the estimation of recovery time, but such an analysis would be a research and development effort beyond the scope of this assessment. Analogous examples of recovery following massive contributions of sediment to stream systems were explored (e.g., Mount St. Helens) but were not uniformly valued by reviewers, and were dropped from the assessment.

Question 10. ***Does the assessment appropriately characterize risks to wildlife and human cultures due to risks to fish? If not, what suggestions do you have for improving this part of the assessment? Are significant literature, reports, or data not referenced that would be useful to characterize these risks, and if so what are they?***

David A. Atkins, M.S

The assessment does a good job analyzing the importance of fish resources to other wildlife and to Alaska Native communities. The lack of site-specific information in the report results in only very general conclusions that there 'would be some effect.' Of course, wildlife in the project area and any traditional use of these lands would be affected by project construction under the no-failure scenario. However, due to the lack of information, it is unclear if this is an area rich in other wildlife or if there are traditional native land users that rely on the area. Although the conclusion of this section is necessarily general, it would be helpful to have more detailed characterization of wildlife and native use in the project area.

RESPONSE: More information about subsistence harvest use in the area of the mine scenarios and other areas of the watershed that may be affected by mining activities has been added to the report. Because the scope of the assessment includes potential effects to Alaska Native communities related to salmonids, this has been the focus of the evaluation of potential effects on indigenous cultures. However, EPA recognizes that there are potential effects due to loss of subsistence harvest areas for other species, as well as potential effects on non-Alaska Natives who practice a subsistence way of life. This is clarified in the revised assessment (particularly in Chapters 12 and 13).

As the commenter notes, there is limited information about the use of specific mining claim areas by wildlife. The Pebble Limited Partnership Environmental Baseline Data Report includes data on the presence/absence of wildlife species around the Pebble claim, but we are not aware of any data on abundance of wildlife, so a more detailed characterization of a specific mine claim area may not be possible. There is some information about subsistence use of the mining claim areas which has been published by Alaska Department of Fish and Game. General areas of wildlife harvests have been added as a figure to the revised assessment.

Under the failure scenario, a tailings dam failure, in particular, would be catastrophic for wildlife and Alaska Native communities that use the area.

RESPONSE: A new Figure 5-2 illustrates that subsistence use of fish is extensive in areas downstream of the TSF in the Mulchatna and Nushagak Rivers, and this fact is now referenced. Effects of a TSF failure on wildlife are now discussed in Section 12.1.

Steve Buckley, M.S., CPG

No comments on this section.

Courtney Carothers, Ph.D.

Wildlife: The sections discussing risk to wildlife resulting from effects on salmonids are fairly short. Those animals that directly feed on these fish are likely to be impacted, as well as those that depend on other resources enhanced by the marine-derived nutrients supplied by salmon carcasses. The report concludes that the primary aquatic contaminant is copper (5-75), but notes that the ore processing chemicals are unknown, as are their toxicities (5-59). These unknowns could be noted as potential contaminants.

RESPONSE: Section 8.2.2.5 now includes a discussion of ore processing chemicals and their toxicity.

Human cultures: Overall, the main report (and Appendix D) describes the central role that salmon play in both Yup'ik and Dena'ina culture, both traditionally and in contemporary communities. As noted above, the scope of the assessment focusing on these two cultural groups should be made more clearly. Appendix E, for example, focuses on other human groups local to this region, and those who migrate to the region for commercial fishing and recreation, who may also be affected by risk to fish in this region. The vulnerabilities listed in Appendix D (p. 4-5) could be listed in the main report more clearly as risks.

RESPONSE: The assessment text has been expanded to identify these vulnerabilities.

Literature on the effects of contaminated or declining resources on subsistence communities could be utilized to describe likely impacts in more detail. For example, the report notes: "the actual responses of Alaska Native cultures to any impacts of the mine scenario is uncertain" (ES-26). While the specific responses are uncertain, likely responses can be predicted (and many are articulated in Appendix D). There are data on the psychological, social, cultural, and economic disruptions caused by the Exxon Valdez oil spill (e.g., Braund and Kruse 2009; Palinkas et al. 1993), the cumulative effects of oil and gas development in the North Slope region (e.g., Braund and Associates 2009; NRC 2003), and social impacts related to mining development in Alaska (e.g., TetraTech 2009; Storey and Hamilton 2004). Drawing on some of this literature could help provide likely scenarios for impacts to Alaska Native subsistence-based communities from decreased quality, quantity, or diversity of salmonids. Current and recent responses to salmon shortages in the Yukon-Kuskowkim region may also be helpful to include.

RESPONSE: The references provided have been reviewed and information from case studies used where appropriate to provide data on responses of Alaska Native communities to disruptions in subsistence resources (see Chapter 12).

Clearly the impacts to subsistence are not just lost food sources, but loss of healthy subsistence lifeways, loss of practices, loss of cultural connections to the past, loss of connection to specific places, loss of teaching and learning, loss of sharing networks, loss of individual, community, and cultural identity, among others as detailed in Appendix D. This point could be made more forcefully. As noted above and detailed in the specific comments below, subsistence is framed at times in the report as primarily important for physical health and economic necessity. The cultural, social, psychological, and spiritual aspects of subsistence livelihoods should also be consistently highlighted.

RESPONSE: The assessment has been expanded to bring forward more information on the psychological, cultural, social, and spiritual connections between Alaska Native cultures and fish.

As discussed Appendix D, Alaska Native cultures in this region and other regions in the state are also dependent upon the cash economy, both for subsistence production and for other needs. The role of commercial salmon fishing or other wage engagements related to salmon in the study communities, while discussed in Appendix E, is not given much discussion in the main report. How dependent is the subsistence economy upon commercial and recreational fisheries and in this region?

RESPONSE: Additional information about the connections between the subsistence way of life and the commercial and recreational fisheries has been added to the text of the revised assessment.

There is a brief mention of non-fish related impacts to Alaska Native communities in the main report (5-77). Unless a full treatment of these impacts (positive and negative) is included, these paragraphs should be removed. While in general, I am supportive of an increased scope (i.e., it is incredibly difficult to isolate only salmon-mediated impacts to Alaska Native communities), these other economic, social, and cultural impacts are not presented fully in the analysis, nor was the ethnographic research designed to investigate these impacts, so passing mention of them here does not seem appropriate.

RESPONSE: The text of the assessment has been clarified to indicate the scope of the assessment does not include an evaluation of direct effects on indigenous culture or human welfare, because it is limited to aquatic pathways and impacts. However, the fact that there would be direct effects is acknowledged in Chapter 12, consistent with comments from peer reviewers and the public.

Dennis D. Dauble, Ph.D.

There is considerable detailed information in Appendices D and E relating to impacts of the project to the economy. This information includes how salmon affect all segments of the population, such as cultural resources of Native Peoples. However, not addressed in detail were long-term impacts to Native Peoples that might occur after losing a way of life that includes salmon. The description of potential impacts to their health and welfare should be expanded. There are numerous examples of how Columbia River tribes have been negatively impacted due to loss of fish resources (and fishing as a lifestyle) as a result of dam construction. These impacts go beyond simple economics.

RESPONSE: EPA recognizes that there is a great deal of information about cultural and health effects on indigenous populations from loss of fish resources. We have referenced some case studies in the assessment (with a primary focus on Alaska), and have expanded the discussion of potential effects from a loss of salmon resources in Chapter 12.

The report should include a discussion of effects specific to unique user groups. That is, some communities rely almost solely on sockeye; kings are more important to others. These impacts could be segregated by watershed, for example. Also, some groups have more option for subsistence gathering if sockeye and Chinook salmon resources are impacted. Potential impacts of a declining salmon population due to mining operations would be less for them than groups "on the edge" who currently rely mainly on salmon.

RESPONSE: The text of the revised assessment (Section 5.4.2.2) has been expanded to acknowledge the differences between communities with regard to use and reliance on salmon and other fish resources.

Disturbance of wildlife from noise and roadways should be included with respect to migration corridors and critical habitat. Highlight species most likely at risk from human disturbance, habitat loss/displacement (from the project footprint), and loss of salmon. For instance, do some piscivorous species have the ability to shift their diet to include another source of protein? If so, how would this shift affect the human culture with reference to a subsistence lifestyle?

RESPONSE: EPA recognizes that there are potential direct effects on wildlife from large-scale mining operations, including disturbances from noise and roadways; however direct effects on wildlife are outside of the scope of the assessment, as explained in Chapter 2. We would expect that a full evaluation of any future mining permit applications and subsequent National Environmental Policy Act Environmental Impact Statements would consider these direct effects on wildlife.

Gordon H. Reeves, Ph.D.

These topics are outside my area of expertise so I cannot comment on if the report adequately characterizes the risk to wildlife and human cultures. I am familiar with some of the literature on the importance of salmon to wildlife and the report represents the finding fairly and accurately. I cannot provide any additional literature, reports, or data.

RESPONSE: No change suggested or required.

Charles Wesley Slaughter, Ph.D.

No. The Assessment clearly qualified that its objective was to consider risks to salmonids, and only inferentially consider "salmon-mediated" effects.

RESPONSE: No change suggested or required.

Appendix C provides a comprehensive discussion of non-fish wildlife and the relation of those populations to salmon. However, the Assessment itself (Volume 1) provides only a brief summary in Chapter 2.2.3, which could allow a cursory reader to perhaps conclude that wildlife populations have little risk of impact from the hypothetical Pebble project. Is this the intent of the Assessment authors? A more in-depth reading of Appendix C allows inferring potential consequences to wildlife and birds of "salmon-mediated" impacts of mining development.

RESPONSE: We have clarified assessment endpoints and provided additional background information from Appendices A and B in Chapter 5. Direct effects on wildlife are outside the scope of the assessment (as stated in Chapter 2), but their potential importance is acknowledged in Chapter 12.

The assessment has been expanded to include more information from Appendix C of the draft report (now an independent U. S. Fish and Wildlife Report).

The scope of the assessment is focused on potential risks to salmon from large-scale mining and salmon-mediated effects to indigenous culture and wildlife. EPA recognizes the complexity of potential direct, secondary, and cumulative effects on wildlife. We would expect that a full evaluation of any future mining permit applications and subsequent National Environmental Policy Act Environmental Impact Statements would consider these complexities and utilize the information in U.S. Fish and Wildlife report (Appendix C of the draft report.)

USFWS RESPONSE: We acknowledge the comment about the comprehensive discussion of wildlife and the relation of selected species to salmon in Appendix C. Appendix C could be used as the basis of an assessment of potential impacts of mining on wildlife, but decisions related to assessment scope with regard to potential impacts of mining on wildlife is the responsibility of EPA.

Appendix D provides a comprehensive and useful discussion of the indigenous people of the Bristol Bay region and of their traditional ecological knowledge and cultures. Appendix D clearly lays out the vulnerabilities and risks (summarized on p. 4-5 and pp. 150-153) associated with the (hypothetical) major resource extraction projects. However, the Assessment (Volume 1) provides only cursory consideration of these human aspects of the potential project – on p. ES-23, and in Section 2.2.5. Presumably, this is because the EPA mandate is to conduct an ecological risk assessment, rather than assessment of consequences for human populations, whether indigenous, native, resident, non-native, non-resident, or the larger cash economy world as represented by the State of Alaska, Northern Dynasty Minerals, or Pebble Limited Partnership.

RESPONSE: The scope of the assessment related to Alaska Native cultures is limited to salmon-mediated effects—that is, potential effects on indigenous culture if there are negative effects on salmon. The assessment draws on the more comprehensive information in Appendix D to evaluate these risks. The text of the revised assessment has been expanded to include and discuss the vulnerabilities and risks to Alaska Native culture from potential large-scale mining.

John D. Stednick, Ph.D.

The effect on wildlife section largely focuses on the return of nutrients to the land in various shapes and forms and adds little to the risk discussion. Other than marine-derived nutrients, other stressors exist. What are the consequences of the mine operation on other wildlife habitats? Habitat fragmentation? Noise and light disruptions, etc.?

RESPONSE: The scope of the assessment is focused on potential risks to salmon from large-scale mining and salmon-mediated effects to indigenous culture and wildlife. The EPA recognizes the complexity of potential direct, secondary, and cumulative effects on wildlife and would expect that a full evaluation of any future mining permit applications and subsequent National Environmental Policy Act Environmental Impact Statements would consider these complexities. The final assessment acknowledges the potential for direct effects on wildlife (Chapter 12).

Mine development will require the use of explosives. What are the effects of the nitrate and ammonia in the air following each detonation? The National Trends Network data suggest that the area receives about 1 kg/ha/yr of nitrogen in precipitation. Thus, the increase in atmospheric inputs from the explosions may exceed the marine-derived nutrients. What are the consequences?

RESPONSE: See response to previous comment. Also, stressors evaluated were based on how they would significantly affect our primary endpoint of interest (the region's salmon resources) and their relevance to EPA's regulatory authority and decision-making context. Although atmospheric inputs from mining operations are a potential source of contamination to streams, they are not considered as significant as other stressors and are not regulated under the Clean Water Act. Finally, because of terrestrial nitrogen fixation, nitrogen is not believed to be the most important marine derived nutrient.

The potential loss or change in lifestyles of indigenous peoples is important, but this information seems relegated to Appendix D. Include more of this information in the main body of the text. Actually, there is a significant amount of information in the appendices that should be brought forward.
It is unclear why there is such variability in the detail or depth of assessment of each of the stressors. Why does the TSF failure section have 34 pages while the section on potential effects on native peoples only has a few pages with a reference to an appendix? The unevenness of the coverage needs to be addressed.

RESPONSE: The text of the revised assessment has been expanded to incorporate more of the background information from Appendix D and a more comprehensive evaluation of potential salmon-mediated risks to indigenous culture. The assessment's primary endpoint is the abundance and production of salmonid fish, so effects on those receptors are treated in more depth than the secondary endpoints, fish-mediated effects on wildlife and Alaska Native cultures.

Roy A. Stein, Ph.D.

Risks to Wildlife. The importance of salmon in bringing Marine Derived Nutrients (MDN) into these freshwater ecosystems and watersheds and their role in influencing wildlife and associated interactions between wildlife and human cultures was well described. Loss of these nutrients would severely compromise wildlife, and thereby human (through reductions of subsistence harvest), populations. The appendix dealing with wildlife was quite detailed and well done and it would serve the main report well for the authors to include critical information from this appendix.

RESPONSE: No change suggested or required.

USFWS RESPONSE: We acknowledge the comment regarding the quality of Appendix C. Comments related to the scope of the assessment are not specific to Appendix C and are the responsibility of EPA.

Risks to Native Alaskan Culture I. I thought that the assessment could be approved if the same approach used for the mine, i.e., a case history approach, was used for human cultures. Surely, there exist situations where salmon have declined or have been reduced by development/exploitation (the Fraser River, perhaps?) where subsistence by Native Alaskans was historically paramount. Once the salmon were reduced, what was the impact on the Native Alaskans subsistence culture? How did the Native Peoples respond? From whence did they get sustenance, cash, etc.? What sort of displacement occurred?

RESPONSE: The EPA recognizes that there is a great deal of information about cultural and health effects on indigenous populations from loss of fish resources. We have referenced some case studies in the assessment (with a primary focus on Alaska), and have expanded the discussion of potential effects from a loss of salmon resources.

Risks to Native Alaskan Culture II. The only risks reviewed here came via salmon-mediated impacts on the culture of Native Alaskans. Direct impacts of the mine through jobs (potentially positive), wildlife (likely negative), etc. all could be discussed briefly, serving to broaden the overall impact of the mine and its associated activities on Native Alaskans.

RESPONSE: The EPA acknowledges that the scope of the assessment is limited to salmon-mediated risks to indigenous culture and that there would be many other potential effects (positive and negative) from development of large-scale mining in the region. Direct impacts to Alaska Native culture have been acknowledged in the revised report, but are outside of the scope of the assessment.

Risks to Other Cultures. I was a little surprised that little text was spent on recreational anglers, commercial fishers, subsistence users (other than Native Alaskans), etc. Appendices provide some guidance here and this text need not be voluminous, but mentioning these impacts of the mine on these groups would improve the main report.

RESPONSE: The discussion in the revised assessment has been expanded to acknowledge potential effects on non-Alaska Native subsistence users. The EPA acknowledges that there are potential impacts on recreational anglers and commercial fishers. However, because the assessment focused on fish-related effects to Alaska Native culture, an evaluation of potential impacts to the recreational and commercial sectors is outside of the scope of this assessment.

William A. Stubblefield, Ph.D.

Potential effects to wildlife and human cultures are briefly addressed in the risk assessment. No "quantitative" assessment of potential effects is provided. For the most part, it appears that potential affects to both wildlife and human cultural endpoints are directly proportional to the injury suffered by salmon populations as a result of any spills or failures. Given the level of detail available at this point in time regarding mine operations and closure, that is probably about as far as any assessment could go. I'm not aware of any literature reports or data that would assist in further characterization of these potential injuries.

RESPONSE: No change suggested or required.

Dirk van Zyl, Ph.D., P.E.

The EPA Assessment does not identify or appropriately characterize the risks to wildlife and human cultures due to risks to fish. It only estimates the likelihoods of occurrence and the consequences. See discussion under Question 4 above regarding suggestions for improving estimation and expression of the magnitude of risks to wildlife and human cultures due to risks to fish.

RESPONSE: The EPA believes that the likelihood of an occurrence and its consequences constitute an appropriate and generally accepted definition of risk. We have estimated those to the extent that existing information allows.

Phyllis K. Weber Scannell, Ph.D.

The document focuses on effects to wildlife that would occur from failures – tailings dam failure, pipeline failure, etc. There are other sources of disturbance to wildlife that should be addressed in a future mine plan and agency review and permitting. Other mines in Alaska limit truck traffic on the haul road during caribou migrations, incinerate all kitchen waste, educate workers on bear safety, and prohibit inappropriate disposals of food containers or other wildlife attractants. Other factors that might need to be addressed to protect wildlife are limiting air traffic and noise during certain times of the year. Unless addressed, these issues are more likely to cause detrimental effects to wildlife than dam or pipeline failures.

RESPONSE: No change suggested or required. The EPA agrees with the reviewer that any future mine plan would require an evaluation of, and mitigation for, direct effects on wildlife.

Paul Whitney, Ph.D.

Problem Formulation for Wildlife. If one addresses the problem formulation for wildlife at face value, the answer is pretty straight forward. The assessment tells us that the consequences of loss and degradation of habitat on fish populations could not be quantified because of the lack of quantitative information concerning salmon, char, and trout populations (page ES-26, third bullet). Furthermore, we learn that indirect effects, such as risks to wildlife, cannot be quantified (page 5-75, para 1, last line). Stating that reduced salmon production would reduce the abundance and production of wildlife (page 5-75, para 1, last sentence) is accurate but not appropriate for a document that is intended to provide a scientific and technical foundation for future decision making (page ES-1, para 1, last sentence). It is certainly possible to provide a more complete scientific and technical response to a question regarding impact to wildlife. I respectfully suggest that the first step in developing a more complete scientific and technical response is to modify Question 10 by deleting the words "due to risks to fish" and to separate the risk analysis for wildlife from the risk analysis for human culture. A revised wildlife question should address both indirect and direct risks. A revised human culture question should address (among many other risks) both direct and indirect risks to fish and wildlife.

RESPONSE: As the reviewer notes, the scope of the assessment is focused on potential risks to salmon from large-scale mining and salmon-mediated effects to indigenous culture and wildlife. The EPA agrees with the reviewer that direct effects on wildlife are likely to be important. We would expect that a full evaluation of any future mining permit applications and subsequent National Environmental Policy Act Environmental Impact Statements would consider these direct effects. The revised assessment acknowledges the potential for direct effects on wildlife as well as risks due to fish.

<u>Mixed Messages.</u> The assessment and questions given to the review committee give mixed messages regarding the scope of work. A variety of statements and conclusions in the assessment are inter-related, as one would expect for a document that addresses ecosystem issues. While acknowledging the overlapping issues and responses, I offer the following discrete points that give me mixed messages regarding the scope of work and an appropriate characterization of risks to wildlife. Since these points are related, there is some repetition of information but each of the following items address a discrete issue.

1. The PREFACE (para 2) clearly states "Our goals in conducting this assessment are to complete an objective assessment of the potential impacts of large scale mining on aquatic resources in the Bristol Bay watershed." This statement is subject to wide interpretation by this reviewer and by the document itself. For example, aquatic resources include many species of wildlife and the Cederholm papers indicate that there are 137 species of wildlife that are associated or closely associated with fish. Wildlife species and their associations are aquatic resources but have been glossed over in the assessment. The lack of follow-through in implementing the above goal statement (i.e., not addressing aquatic wildlife and wildlife associated with fish) is problematic. One can readily understand that timing and budget constraints result in some statements indicating that data are just not available or that certain types of modeling, while possible, were not conducted. However, it is difficult to understand why potential impacts to wildlife are limited to indirect effects due to loss of fish if the assessment was truly conducted as an assessment of aquatic resources. The message is mixed because the goal is to assess aquatic resources, but many aquatic resources are not assessed.

   RESPONSE: The assessment has been revised and reorganized to better explain the goals and objectives of the assessment. As stated in previous responses to comments, the focus of the wildlife assessment is limited to salmon-mediated effects.

2. The assessment was supposedly conducted as an ecological risk assessment (Abstract, line 5). One of the first steps of an ecological risk assessment is to state well defined endpoints. Suter (1993, page 22) presents 5 criteria that any endpoint should satisfy. My notes are in brackets.

a. Societal relevance (Assessment appears to do a good job of identifying concerns of people living near the area of the proposed mine. Yet, many of the potential endpoints listed in site models (e.g., Figure 3-2E) are not addressed. The reason for not assessing endpoints in the site models (such as wildlife quality and quantity) should be provided. Better yet, clearly state both direct and indirect endpoints for wildlife.)
b. Biological relevance (The biological – especially ecological – relevance is incomplete. Wildlife and the functions they provide are relevant in that wildlife comprise many of the secondary and tertiary consumer species in the ecosystem. The upland and aquatic habitats utilized by wildlife are the indirect and direct sources of many nutrient and energy inputs to fish in the Bristol Bay ecosystem. The upland components of the Bristol Bay ecosystem should be assessed in more detail to provide a biologically relevant assessment. If not, the assessment should directly indicate why not).
c. Unambiguous operational definition (Overall a good job for a hypothetical mine. See response to Question 2 for suggestions).
d. Accessibility to prediction and measurement (The inability to estimate the impact on salmon numbers is problematic. Is the inability due to a lack of population data, the unwillingness to utilize peer-reviewed methods other than demographic population modeling, or some other reason? Furthermore, the potential reduction in marine-derived nutrients and the potential impact on wildlife can be assessed and predicted – see below).
e. Susceptibility to the hazardous agent (The assessment does a good job on the hazards for aquatic resources but not susceptibility to wildlife biotic (e.g., loss of habitat) and abiotic stressors (e.g., ice dams and scouring, as well as hydrographs and sedimentation influence on ecological succession). Furthermore, an adequate ecological risk assessment should address ALL ecological stressors (e.g., loss of habitat and disturbance) not just toxics).

Suter's five criteria should be addressed when selecting endpoints. All the endpoints selected and illustrated in figures should be assessed. The incomplete assessment of quantitative estimates of all the impacts on salmon, non-salmonid fish, wildlife, as well as community and ecosystem parameters should be remedied.

RESPONSE: The criteria above apply to the specific assessment endpoints considered in the assessment, as described in Chapter 5. Each of these endpoints meets the above criteria, and additional information describing endpoints within the ecological risk assessment process has been added to the beginning of Chapter 5.

3. A complete assessment of aquatic resources as stated in the PREFACE should address both direct and indirect risks to the many species of wildlife and wildlife habitat that are aquatic resources and closely associated to aquatic resources. The list of all the aquatic species and habitat is lengthy. A partial list of categories of wildlife and wildlife habitats that are aquatic resources includes grebes, ducks, shorebirds, beaver, muskrat, otter, mink, and riparian, emergent, and aquatic vegetation. The impact of mining on all of the aquatic resources is given scant coverage in the assessment, with the possible exception of impact to wetlands. The PREFACE provides wide ranging goals but the assessment has many gaps, and I wonder why.

RESPONSE: The latest draft of the assessment has been revised and reorganized to better explain the goals and objectives of the assessment. Those goals and objectives focus the assessment on salmonid fish and a limited qualitative discussion of the salmon-mediated effects on wildlife and Alaska Native cultures. The EPA acknowledges and agrees with the reviewer that there will be direct and indirect effects of mining on wildlife, but the detailed evaluation of those effects will be left to the NEPA and permitting processes should a mine be proposed.

4. The Executive Summary (para 1) indicates "…USEPA launched this assessment to determine the significance of Bristol Bay's ecological resources and evaluate the potential impacts of large-scale mining on these resources." The emphasis on salmonids does not fairly represent the entirety of ecological resources. To me, ecological resources should include ecological parameters such as plant community succession, species diversity, energy flow, and structure and function, in addition to the information on salmonids.

   RESPONSE: The scope of the assessment has been clarified in Chapter 2, and the specific endpoints considered in the assessment are described in Chapter 5. We recognize throughout the text that other ecosystem components are important and potentially will be affected by large-scale mining, but fall outside this assessment's scope. Ecological risk assessments focus on endpoints that are important to decision makers and stakeholders, are susceptible to the stressors, and meet other criteria; they do not attempt to cover all ecosystem components (Suter 1993, EPA 1998).

5. The Scope of the assessment (ES-,1 last para) indicates that "wildlife … as affected by changes in the fisheries are additional endpoints of the assessment." This informs the reader that only wildlife species that are affected by changes in the fisheries will be an endpoint. Yet many species of wildlife that are affected by changes in the fisheries are not addressed. In addition, such an endpoint glosses over the importance of assessing fish that are affected by changes in wildlife. For example, beaver modify aquatic habitat and terns prey on fish. The scope of the assessment seems to brush over many of the important fish and wildlife interactions discussed by Cederholm et al. (2000) and Cederholm et al. (2001) and to focus mainly on marine-derived nutrients. I am pleased with the discussion of the marine-derived nutrients but am not clear how the emphasis on this one interaction, which is not quantified in the assessment, furthers the understanding of potential mining impact on the Bristol Bay ecosystem.

   RESPONSE: The EPA agrees with the reviewer that there are many complex fish and wildlife interactions in the study area and the revised assessment acknowledges this fact. The assessment focused on loss of MDN to the system and on potential loss of fish as a food source for wildlife as important potential salmon-mediated effects on wildlife. We would expect that a full evaluation of any future mining permit applications and subsequent National Environmental Policy Act Environmental Impact Statements would include analysis of other potential causes of effects on wildlife.

6. Gende et al. (2004) use a variety of methods to quantify both the marine-derived nutrients and energy that transfer from salmon to terrestrial wildlife and habitats. For example, they determined that bears moved nearly 50% of the salmon-derived nutrients and energy

from streams by capturing salmon and dragging the carcasses from the stream. Gende has also worked with University of Alaska Associate Professor Mark Wipfli (Gende et al. 2002) on the relationship of salmon to terrestrial habitats. Alaskan and national experts are likely available to assist EPA in quantifying the movement of marine-derived nutrients to the terrestrial ecosystem.

RESPONSE: The references are appreciated. The EPA acknowledges that a more quantitative evaluation of salmon-derived nutrients to the terrestrial ecosystem may be possible. However, this type of evaluation would require further data collection and significant analysis, which is beyond the scope of this assessment. A detailed evaluation of the movement of marine-derived nutrients to the terrestrial ecosystem is not needed to assess the impacts of mining on salmonids, and is more detailed than is needed for a qualitative discussion of the salmon-mediated effects on wildlife and Alaska Native culture. We would expect that a full evaluation of any future mining permit applications and subsequent National Environmental Policy Act Environmental Impact Statements would address potential effects to salmon-derived nutrients.

7. As mentioned above, the assessment does a fine job of emphasizing the importance of marine-derived nutrients transported to the terrestrial environment but has relatively little information on the importance of terrestrial-derived allochthonous nutrients transported to the aquatic environment. Doucett et al. (2007) discuss methods for measuring terrestrial subsidies to aquatic food webs using stable isotopes of hydrogen. The potential loss of terrestrial subsidies due to mining might be as great as a potential reduction of marine-derived nutrients. It would be informative to discuss the relative importance of marine-derived, autochthonous, and allochthonous nutrients. Such information might influence "best mining practices" and reclamation that can partially compensate for lost allochthonous inputs.

   RESPONSE: See response to previous comment.

8. Figure 3-2E indicates wildlife quality, quantity or genetic diversity, as well as wildlife predation are important to Alaska Native Cultures. Tribal elders are said to have concern for "potential direct effects on other subsistent resources" (which includes wildlife and vegetation). In addition, Appendix D comments on concerns regarding wildlife (e.g., caribou) and vegetation (e.g., berry gathering) that are not directly linked to the fisheries. An assessment of the direct impact of potential mining and the ongoing exploration on wildlife and vegetation would address the concerns mentioned above. Once again, I wonder why the site model figures outline so much detail that is not addressed in the assessment text.

   RESPONSE: The conceptual models were drafted to gain an understanding of all potential sources, stressors, and effects from large-scale mining and have been revised to clarify the scope of the assessment. The EPA focused the assessment on potential risks to salmonids and subsequent salmon-mediated effects on indigenous culture and wildlife. There are many other potential risk pathways which are outside the scope of this assessment, including potential loss of plant and wildlife subsistence and other cultural resources (see Figure 2-1).

The conceptual models have been modified to more accurately reflect issues within the assessment's scope, and to more clearly identify those pathways considered outside of scope when they are included.

9. Comments in the main assessment Volume 1 (page 5-76, first lines) indicate that information on wildlife and potential direct impacts are being collected but are not included. Including measures of direct wildlife impact in addition to indirect impact as a result of changes in fisheries would greatly improve the assessment. There are many ways to estimate the impact of habitat loss on wildlife (Morrison et al. 1998). A better understanding of impacts on wildlife would presumably provide a better technical basis for designing a reclamation plan.

   RESPONSE: The scope of the assessment is focused on potential risks to salmon from large-scale mining and salmon-mediated effects to indigenous culture and wildlife. EPA agrees with the reviewer that direct effects on wildlife are important and that there are ways to estimate effects related to habitat loss. We would expect that a full evaluation of any future mining permit applications and subsequent National Environmental Policy Act Environmental Impact Statements would consider these direct effects. The revised assessment acknowledges the potential for direct effects on wildlife. The assessment does not include a reclamation plan and is not intended to support the development of a reclamation plan.

10. The assessment (page 5-77, last sentence) states: "Although this assessment is focused on salmon, the non-salmon-related impacts on native cultures from routine mine operation are likely to be more significant…" If this is in fact the case, what better reason could there be for increasing the scope to include wildlife, vegetation, community, and ecosystem structure and function (i.e., non-salmon)? Methods and mine-related examples for assessing such an increased scope are available from the Northwest Habitat Institute (nwhi.org) in Corvallis. Discussions with Tom O'Neil, Executive Director, indicate that available data from the Alaska GAP Analysis Project and the Alaska Natural Heritage Program could likely be used to make such assessments.

    RESPONSE: See response to previous comment. This type of evaluation would be valuable but would require further data collection and significant analysis, which is beyond the scope of this assessment.

11. The risk assessment's focus on "indirect effects on wildlife" (page 5-1, para 2) is consistent with some of the several goal statements that lean toward fish influence on wildlife. I have difficulty reconciling this emphasis because further on in the text (page 5-75, para 1, last line) it is stated that the "indirect effects cannot be quantified." If the indirect effects cannot be quantified, one should think it is even more important to get a handle on the direct effects, which can be assessed by any one of several wildlife methodologies (Morrison et al. 1998).

    RESPONSE: Wildlife is not a main focus of this assessment. We agree that a more detailed assessment of direct and indirect impacts of mining to wildlife will have to be done as part of the NEPA and permitting processes. This assessment is focused on salmon because of the world class, outstanding salmon fisheries in Bristol Bay.

Further, as a keystone species, salmon serve as an excellent indicator of overall impacts to the ecosystem.

12. The assessment indicates the exceptional quality of the fish populations and their importance to the region's wildlife is due to five key characteristics. The fourth characteristic is "the increased ecosystem productivity associated with anadromous salmon runs" (page 2-20, Section 2.3). Similar statements are made by Woolington (2009). How is this increase measured, and what is the baseline for the increase? I am sure the biologists that wrote about the increase are trying to convey the concept that the energy and marine-derived nutrients provided by salmonids is incorporated into the primary and secondary production in the terrestrial ecosystems in the Bristol Bay watersheds. I am not sure that such a statement considers the loss of energy and marine-derived nutrients as a result of commercial fishing. Is it possible that commercial harvest may decrease ecosystem productivity compared to productivity prior to pre-European (e.g., 200 hundred years ago) harvests? Perhaps it would be more accurate to delete the word "increase." On the surface, this might seem like a small edit but this edit is one of many edits needed to address, not only the existing conditions in the watersheds, but also the existing conditions relative to "pre-European conditions." My understanding of a Cumulative Impact Analysis is that it includes <u>past</u> assessments of ecosystem resources and functions as well as current and future conditions (see discussion of Cumulative Impacts in response to Question 11).

    RESPONSE: The purpose of the assessment is to evaluate potential effects of large-scale mining on the fishery, not the effects of commercial fishing. Therefore, the potential effects on wildlife associated with loss of marine-derived nutrients considers the present condition of the watershed and fishery as a baseline for an evaluation of potential future effects of large-scale mining.

13. Pauly et al. (2000) and Libralato et al. (2008) address the energy impacts of fisheries. I would be interested to know if the impact of fisheries on marine-derived nutrients and energy available to the wildlife and terrestrial ecosystems in the Bristol Bay watersheds could be compared to the potential impact of the example mine on marine-derived nutrients and energy available to the watersheds. Is the potential impact of the mine small in relation to the impact of commercial fishing or very large compared to commercial fishing? Such information would be informative for determining acceptability of risks. It is possible that such a comparison could stimulate discussion of the possibility of compensatory mitigation for losses due to mining.

    RESPONSE: Compensatory mitigation for losses of aquatic resources from mining is governed by a regulatory process outside the scope of this project. Nevertheless, in response to public and peer comments we have included a discussion of compensatory mitigation in Appendix J of the revised assessment.

14. The assessment could be greatly improved if more of the linkages and pathways illustrated in the various Conceptual Models were addressed and if impacts on ecological parameters, such as community succession (down gradient, in the lake and on tailings and waste rock) and aquatic and upland structure and function, were addressed. For example, Site Reclamation is illustrated and highlighted as orange boxes in three places on Figure

3-2C (I'm not sure what the orange highlighting signifies, for there is no legend on this figure). Information on possible wildlife limiting factors (e.g., calving and nesting habitat) and plant communities in the watershed could improve the quality of Site Reclamation. A Reclamation Plan needs to address the likelihood that reclamation can be implemented and if so what benefits it might accrue through time. This type of information would likely result in a better risk assessment.

RESPONSE: EPA agrees that more detailed information on wildlife limiting factors would need to be collected and evaluated as a part of a site reclamation plan. We would expect that a full evaluation of any future mining permit applications and subsequent National Environmental Policy Act Environmental Impact Statements would include this information as a basis for a site reclamation plan.

15. The discussion of wildlife species in Appendix C is very good but little of the insight provided in these descriptions of hunted or trapped species is reflected in the assessment of impact of potential mining practices on wildlife. I cannot help but wonder (i.e., mixed message) why Appendix C is so thick and so little of the good information in Appendix C is reflected in the assessment document. For example, the impact of noise and human presence related to mining and roads is addressed on page 54 (Appendix C). Such an impact on certain sensitive species could be equal to or greater than the loss of wildlife habitat in the mine footprint. Woolington (2009) indicates that the Red Dog Mine in Alaska has implemented certain measures that have reduced the impact of the haul road on wildlife. It would be good to know what these measures are and if such measures would be equally effective for a road relatively close to Anchorage.

RESPONSE: The purpose of the appendices vs. the main assessment document has been clarified in Chapter 1. The former Appendix C has now been published as a separate US Fish and Wildlife Service document because it serves purposes for the USFWS beyond the scope of the EPA's assessment.

USFWS RESPONSE: We acknowledge the comment about the quality of Appendix C. Comments related to the scope of the watershed assessment are not specific to Appendix C and are the responsibility of EPA.

Will the proposed haul road to the mine be closed to the public and hunting? If so, the impact of the road may not be high. I can remember Val Geist saying that wildlife behave the way one teaches them to behave. Examples are deer in the streets of Banff Park during the daytime and big horn sheep and elk foraging along the Trans Canada Highway in the Park. The big horn sheep often stop traffic as people stop to observe them. Outside the Park, where deer and elk are hunted, one is less likely to see deer and elk along the highway and deer take on a more nocturnal existence.

RESPONSE: For purposes of the assessment, EPA assumes that the road would be closed to the public during mining operations but potentially could become a public road after mining operations cease. About 80% of the transportation corridor is on private land owned by various Alaska Native Village Corporations, with which the Pebble Limited Partnership has existing commercial partnerships. Alaska Native Regional Corporations are charged with managing land and resources within their

control in the best interests of their shareholders. Chapter 13 includes a discussion on the potential impacts of increased access due to additional roads.

The scope of the assessment is focused on potential risks to salmon from large-scale mining and salmon-mediated effects to indigenous culture and wildlife. EPA has not evaluated direct effects from a transportation corridor on wildlife. We would expect that a full evaluation of any future mining permit applications and subsequent National Environmental Policy Act Environmental Impact Statements would consider the direct effects of the transportation corridor on wildlife.

16. As an arctic and sub arctic small-mammal wonk, I anticipate that any discussion of Alaskan ecosystems will include some discussion of the less charismatic fauna (small mammals and songbirds) and the functions they provide. Such discussion is given little attention in the assessment.

    RESPONSE: These issues are outside the scope of the assessment, as specified in Chapter 2. Appendix C (now an independent US Fish and Wildlife report) selected key wildlife species for characterization, based on their direct dependence on salmon or on their roles in distributing marine derived nutrients through the ecosystem. It was not possible to fully characterize every species. The EPA recognizes that there are multiple species that were not fully characterized and that have important functions in the terrestrial and aquatic ecosystem. We would expect that a full evaluation of any future mining permit applications and subsequent National Environmental Policy Act Environmental Impact Statements would consider all species present in these watersheds.

    USFWS RESPONSE: The USFWS selected key species to include in Appendix C and the selection method is described in the report. We certainly concur that small mammals are important from an ecosystem perspective, but they are less linked to fish or to public concerns than the selected species. Songbirds were included in the wildlife report under landbirds.

Question 11. ***Does the assessment appropriately describe the potential for cumulative risks from multiple mines? If not, what suggestions do you have for improving this part of the assessment?***

David A. Atkins, M.S

According to the Assessment, cumulative risks result from the potential development of at least five additional prospects: Humble, Big Chunk, Groundhog, Sill, and 38 Zone. Exploiting these prospects would amount to development of a mining district (see discussion for Question 2 in regards to appropriateness of the mining scenario).

RESPONSE: No change suggested or required.

The Assessment quantifies the loss of stream lengths and wetland areas that potentially support salmon and resident fish from the development of these projects under a 'no-failure' scenario. The assessment is highly speculative given that mine development plans are not available for these prospects.

RESPONSE: Cumulative impacts assessments evaluate past, present and reasonably foreseeable future actions that are temporally and spatially linked to the project under consideration. The potential mines in the revised assessment are reasonably foreseeable based on State of Alaska planning documents and industry exploration activities. We have expanded the discussion of cumulative impacts in Chapter 13.

As with the Pebble scenario, it would be helpful to put this loss of resource in perspective in terms of the fish resources as a whole. It would also be helpful to describe any mitigation measures that are feasible to offset the impact of loss of streams and wetlands. Furthermore, it would be helpful to better understand the role these developments could have in further fragmenting salmon populations.

RESPONSE: Due to lack of comprehensive estimates of limiting factors across the impacted watersheds, population level effects could not be quantitatively estimated except for the most severe cases where total losses of runs could be reasonably assumed. Our ability to estimate population level effects was limited to situations that were assumed to completely eliminate habitat productivity and capacity in an entire watershed for which estimates of escapement could be inferred. For this assessment, these conditions are only met in the TSF failure scenario that completely eliminates and blocks access to suitable habitat in the North Fork Koktuli River. In that case, we estimate that the entire Koktuli portion of the run (~28% of Nushagak escapement) could be lost. Higher proportional losses would occur if significant downstream effects occurred due to transport of toxic tailings fines beyond the Koktuli as modeled under the full TSF failure.

Compensatory mitigation is governed by a regulatory process outside the scope of this assessment but will be an important part of any permitting process. Nevertheless, in response to public and peer comments we have included a discussion of compensatory mitigation in Appendix J of the revised assessment.

We have expanded the cumulative effects discussion (Chapter 13) to give a broader description of streams, wetlands and fish at risk and have incorporated a discussion of the possible effects on biological complexity and fragmenting salmon populations.

The following potential subsidiary impacts from development of a mining district of this scale should also be described in more detail or at least mentioned:

- The extensive road network required to support mines in the area and the attendant development associated with this network.
- The camps associated with the project, in migration of workers to the project areas, and the demand for resources to be imported from outside the area.
- Invasive species that may follow this scale of development.

RESPONSE: The discussion about the cumulative effects of roads (including invasive species), secondary development, and mining camps has been expanded in Chapter 13.

Steve Buckley, M.S., CPG

The assessment does describe the potential for cumulative risks from the development of multiple mines in the area; however, the section is misleading in that it describes specific mine footprints and tailings disposal sites at these prospects where there is no information on the size or character of the potential future mine sites. The assessment does not describe the cumulative effects of mine development.

RESPONSE: We have modified the descriptions of potential future mines to make them less specific (e.g., recognizing that mining infrastructure could go anywhere in the subject claim blocks). We have expanded the discussion of potential cumulative effects to include the cumulative effects of multiple mines and development induced by the advent of large scale mining in the watershed (Chapter 13).

These revisions are a major improvement to the document.

Courtney Carothers, Ph.D.

In general, the report suggests that effects from multiple mines would increase the prevalence and cumulative impacts of the risks described for the one-mine scenario. Again, for the cultural assessment, the conclusion is made that effects on humans would be primarily "direct and indirect loss of food sources" (7-15). As the number of large-scale mines increases in this region, the entire subsistence way of life could come under threat. This would be a much larger impact than lost food sources.

RESPONSE: The text of the revised report (Chapter 12) has been expanded to clarify that a loss of the subsistence way of life goes well beyond the loss of food resources.

Dennis D. Dauble, Ph.D.

Individual risk is described in varying levels of detail with overall risk or effects considered to be largely additive. However, the relative magnitude of the effects of mining each ore deposit is difficult to discern. It is possible that one of the smaller ore sites could be developed within an acceptable risk scenario, but it is difficult to determine given that the assessment is largely built on potential impacts of the Pebble Mine. To put things in perspective (individually and cumulatively), there should be a discussion of habitat lost given each individual mine footprint, during normal operation (includes water treatment and withdrawal) and as a result of pollutant exposure. Also, Section 7.4.1 of the main report provides estimates of stream miles affected due to blockage and elimination, but provides nothing quantitative for other direct and indirect impacts of mine operation. The cumulative risk discussion in Chapter 7 could be expanded to link up with the conceptual model described in Chapter 3.

RESPONSE: We cannot reliably predict the habitat loss due to additional mines. We have tried to describe plausible examples of where additional mines could be developed on the basis

of active exploration on existing claim blocks. In the revised assessment (Chapter 13) we predicted aquatic resource impacts based on a typical mine footprint being constructed anywhere in the block and an average stream and wetlands density. We also expanded discussion of the impacts of ancillary mine infrastructure and induced development. This provides a conservative estimate of the cumulative effects of multiple mines and sheds light on whether cumulative effects are a significant concern. We have developed a specific conceptual model for cumulative impacts and used it to enhance the discussion.

Gordon H. Reeves, Ph.D.

I found this chapter well done, even though the analysis was less extensive than what was done for the Pebble Mine. It is clear that multiple populations would be put at varying degrees of risk simultaneously if mine development occurs as is portrayed in this report. This certainly could compromise the "portfolio effect" (Schindler et al. 2010 Nature 465|3 June 2010|doi:10.1038/nature09060), which has maintained the long-term productivity of sockeye salmon in Bristol Bay.

RESPONSE: We have added the portfolio effect to the discussion of the potential effect of multiple mines.

Charles Wesley Slaughter, Ph.D.

Yes – but a qualified "yes." The Assessment appropriately outlines the probability of additional resource extraction projects beyond Pebble itself, and recognizes that additional resource opportunities (beyond the claims depicted in Figure 4-6), currently unknown or unverified, could become viable or desirable to some interests in the future. Section 7.4 summarizes many of the risks. However, the brief coverage (16 pages) accorded the entire subject of "cumulative risks" is **not** consonant with the very long-term, spatially dispersed (and presumably linked by transportation and communication corridors) impacts and risks of multiple mines (and associated infrastructure) in many different sectors of the Bristol Bay watershed.

RESPONSE: We have added to the cumulative effects section (now Chapter 13) by discussing the effects of induced development, including transportation corridors, and the effects of increased overall access in the watersheds (Box 6-1 discusses cumulative effects in terms of a single mine). The cumulative effects assessment is not a definitive, quantitative evaluation. It is, instead, a plausible example of how a mining district could develop and a conservative estimate of the impacts to aquatic resources and fish. It is intended to shed light on whether cumulative effects are a significant concern.

John D. Stednick, Ph.D.

Cumulative risks can result from multiple risks (effects) from a single mine or individual risks from multiple mines. This chapter identified potential risks from proposed mine activities; without consideration of design standards or performance criteria, which is difficult without specific mine designs/plans. Environmental risks were weighted equally – a TSF failure as compared to a blocked culvert. The simple addition of stream length, as affected by various mine footprints, does not represent a cumulative risk.

RESPONSE: We have added to the cumulative effects section (now Chapter 13) by discussing the effects of induced development, including transportation corridors, and the effects of increased overall access in the watersheds (Box 6-1 discusses cumulative effects in terms of a single mine). The cumulative effects assessment is not a definitive, quantitative evaluation. It is, instead, a plausible example of how a mining district could develop and a conservative estimate of the impacts to aquatic resources and fish. It is intended to shed light on whether cumulative effects are a significant concern.

Roy A. Stein, Ph.D.

Cumulative Risks from Multiple Mines. Clearly, as amply demonstrated in the Environmental Risk Assessment, cumulative risks would be greater than those from just the Pebble Mine, even though these risks are difficult to quantify. Important points made in this section deal with the economies of scale that would benefit additional mines coming to the Bristol Bay watershed. After the first mine, new mines become more profitable simply because some of the infrastructure (roads, power, fuel pipelines, etc.) has already been provided, thus reducing cost outlays for the establishment of new mines. To me, this seems as quite an insidious process, for once the door is swung open for the first mine, then many more will follow owing to infrastructure considerations; with these additional mines come far greater cumulative environmental risks. Quantifying these risks would help the reader and the public understand what the ramifications of allowing one mine to begin operations might be. More text attempting to quantify these cumulative impacts would be useful and instructive.

RESPONSE: We have added to the cumulative effects section (now Chapter 13) by discussing the effects of induced development, including transportation corridors, and the effects of increased overall access in the watersheds (Box 6-1 discusses cumulative effects in terms of a single mine). The cumulative effects assessment is not a definitive, quantitative evaluation. It is, instead, a plausible example of how a mining district could develop and a conservative estimate of the impacts to aquatic resources and fish. It is intended to shed light on whether cumulative effects are a significant concern.

William A. Stubblefield, Ph.D.

The potential for cumulative risks associated with the development of multiple mines in the Bristol Bay watershed is not treated with a great degree of detail. Although each of the potential stressors (e.g., water withdrawal, habitat illumination, road and stream crossings) are acknowledged and addressed, little quantitative consideration is given to the potential effects associated with development of multiple mines. This, however, is probably appropriate given the hypothetical nature of the single mine scenario and the potential for greater impacts associated with the development of multiple lines. Short of concluding that "failures at one mine could be bad and failures at multiple mines could be worse," little else could be concluded. It is noted that the multiple mines scenario leads to multiple tailings impoundments, more roads and culverts, increased discharge potential of contaminated waters and increased habitat loss and reduction of water resources and all of these lead to potentially greater environmental injury as a result of failures.

RESPONSE: We have added to the cumulative effects section (now Chapter 13) by discussing the effects of induced development, including transportation corridors, and the effects of increased overall access in the watersheds (Box 6-1 discusses cumulative effects in terms of a single mine). The cumulative effects assessment is not a definitive, quantitative evaluation. It is, instead, a plausible example of how a mining district could develop and a conservative estimate of the impacts to aquatic resources and fish. It is intended to shed light on whether cumulative effects are a significant concern.

Dirk van Zyl, Ph.D., P.E.

The EPA Assessment does not appropriately describe the potential for cumulative risks from multiple mines. In fact, the assessment does not identify the risks, only the likelihood of occurrence and the consequences. See discussion under Question 4 above about estimating and expressing the magnitude of risks and what is required to appropriately describe the potential for cumulative risks from multiple mines.

RESPONSE: The EPA believes that the likelihood of an occurrence and its consequences constitute an appropriate and generally accepted definition of risk. We have estimated those to the extent that existing information allows.

The cumulative assessment is very conceptual at best, as there are no specific proposals from any of the other potential resource areas. Cumulative impacts can only be evaluated once further details about other potential mines and their plans are available. At this time, this section can at best be seen as speculation.

RESPONSE: The cumulative effects discussion is not meant to be a definitive, quantitative evaluation. We have presented a plausible example of how a mining district could develop and a simple estimate of the impacts to aquatic resources and fish. It is intended to shed light on whether cumulative effects are a significant concern.

It is impossible to improve this part of the assessment with the information on mine development currently available; it can only be done when further information is published by the various mining companies.

RESPONSE: Definitive quantitative risk assessments of future mines will need to wait for more information on those mines and on the resources they could potentially impact. This assessment is meant to identify potential issues of concern with development of large scale mining in the two watersheds. Based on the information available now, is the possibility of cumulative impacts from multiple mines and induced development a significant concern? We have utilized the existing information on the number of mining claims, the extent of recent exploration activities, local and state land use plans, and the ubiquitous nature of fish habitat in the watersheds to shed light on that question. Future environmental impact statements will provide more definitive analyses. We have tried to improve the cumulative analysis by

discussing the potential impacts from entire mine footprints, transportation corridors, induced development and increased access.

Phyllis K. Weber Scannell, Ph.D.

There are two issues that should be considered: cumulative effects from a single mine and cumulative effects from multiple mines. Cumulative effects from a single mine might include aquatic habitat degradation from non-point sources, including run-off from exposed mineralized rock, seepage from the tailings impoundment, contaminated dust, noise, and other forms of disturbance.

RESPONSE: We added a discussion on the cumulative effects from a single mine (Box 6-1), as well as discussion of multiple transportation corridors, induced development and increased access (Chapter 13).

Cumulative effects from multiple mines are difficult to predict because there are too many unknowns. It is frequently to the advantage of a mining company to take advantage of existing infrastructure, without building new camps, new mills, etc. It is also possible to use an old mine pit for tailings or waste rock disposal from a new site; however, none of these features can be determined until there is sufficient exploration to determine if mining is feasible, to characterize the deposit, and to develop a detailed mine plan. To date, there is not sufficient information to predict cumulative effects from multiple mines.

RESPONSE: We have expanded the discussion of cumulative impacts from multiple mines in Chapter 13. The analysis of cumulative effects is largely qualitative rather than predictive. It is a plausible example of future cumulative effects that can shed light on whether cumulative effects is an important topic for consideration as plans for mining in the Nushagak and Kvichak River watersheds move forward.

Paul Whitney, Ph.D.

Need to Address Past Impacts. EPA's guidance for reviewing cumulative impact analyses (EPA 1999 – most recent guidance on EPA's website) asks that past, present and reasonably foreseeable actions be considered. The assessment's coverage of cumulative risks from multiple mines certainly addresses "reasonably foreseeable" mines. Not addressed in the analysis is past impact(s) and how such impact(s) might be additive to current and foreseeable impacts. As commented above, commercial fisheries remove a lot of the salmon (up to 70% - over 10 million fish) annually from the drainages associated with the mine. The continual annual reduction, or loss of energy and nutrients that might otherwise return to the ecosystems, should be considered a past impact as part of the cumulative impact analysis.

RESPONSE: The purpose of the assessment is to evaluate potential effects of large-scale mining on the fishery, not the effects of commercial fishing. Therefore, the assessment considers the present condition of the watershed and fishery as a baseline for an evaluation of potential future effects of large-scale mining. We have expanded the discussion on past, present and reasonably foreseeable actions in Chapter 13. Since the fishery has sustained

itself for over 100 years despite commercial fish harvesting, it is unclear to what degree reduced escapement to the watersheds has had negative impacts. As Hilborn (2006) states, "Recent paleoecological analysis of returns to Bristol Bay show no indication of decreased production since commercial exploitation began." Furthermore, the fishery is tightly managed by the Alaska Department of Fish and Game, which reduces the harvest to increase escapement when necessary.

I have prepared/managed cumulative impact analyses of fish and wildlife for a relatively small (e.g., a 200-acre aggregate mine) and a relatively large 7,100-acre coal mine in Washington. A cumulative impact analysis of past, present, and future fish and wildlife losses for the coal mine expansion in a large watershed indicated cumulative impacts of the expansion were less than one percent of past mining, agriculture, urban and forest activities in the watershed. In addition, the cumulative loss could be fully mitigated by compensatory restoration. I would be interested to know what the estimated fish and wildlife loss is due to the example copper mine in comparison to the loss related to the commercial fishery. In addition, I would be interested to know if potential fish and wildlife losses due to mining could be fully mitigated. If the watershed is pristine or nearly pristine, the opportunity for compensatory mitigation may be low. If the past impact of the commercial fishery is large and the watersheds are not pristine, there may be opportunities. There is not much degraded habitat that could be improved by a mitigation plan. If such a cumulative impact analysis were conducted, it may stimulate conversation about reducing commercial fishing to compensate for impact losses due to mining.

RESPONSE: Mitigation to compensate for effects on aquatic resources that cannot be avoided or minimized by mine design and operation would be addressed through a regulatory process that is beyond the scope of this assessment. Nevertheless, in response to public and peer comments we have included a discussion of compensatory mitigation in Appendix J of the revised assessment. Appendix J includes a discussion of the challenges of creating equivalent habitat for anadromous and resident fish and why this would be particularly challenging in the context of the Bristol Bay watershed. Compensatory mitigation requirements address the need for project proponents to replace aquatic resources and ecosystem functions that their project has impacted. Reduced fishing harvests would not replace lost spawning and rearing habitat. Further, it would remove the burden of compensation from the party that caused the damage.

Question 12. ***Are there reasonable mitigation measures that would reduce or minimize the mining risks and impacts beyond those already described in the assessment? What are those measures and how should they be integrated into the assessment? Realizing that there are practical issues associated with implementation, what is the likelihood of success of those measures?***

David A. Atkins, M.S.

The Assessment describes what is considered to be conventional 'good' mining practice, but does not adequately describe and assess mitigation measures that could be required by the permitting and regulatory process. A thorough analysis of possible mitigation measures as employed for other mining projects and the likelihood that they could be successful in this environment would be necessary.

RESPONSE: With regard to the terminology of "best", "good", or other terms for the practices used, what was intended to be conveyed in the assessment is that we assumed modern mining technology and operations. The terms are qualitative when generally interpreted, or have a regulatory meaning. The term "best management practices" is a term generally applied to specific measures for managing non-point source runoff from stormwater (40 CFR Part 130.2(m)). Measures for minimizing and controlling sources of pollution in other situations are referred to as best practices, state of the practice, good practice, conventional, or simply mitigation measures. We have added a text box in the revision Chapter 4 to discuss terms. Mitigation measures considered feasible, appropriate, and 'permittable' (as per Ghaffari et al. 2011), were considered in the assessment, and these are measures common to other copper porphyry mines. Evaluation of alternative strategies (e.g., other options presented in Appendix I for the mitigation of the same issue) should be part of the permitting process for a specific mining plan. The State of Alaska does have statutory and/or regulatory requirements for an approved Plan of Operations (11 AAC 86.800), a Reclamation Plan (Alaska Statute (AS) 27.19.30) and appropriate Financial Assurance (AS 27.19.040) and the revised Chapter 4 notes these requirements.

It is highly likely that for mines located in the Bristol Bay watershed, conventional engineering practices would not be sufficient. Therefore, it is important to consider mitigation on numerous fronts when determining the viability of the project. A section on innovative and state-of-the-art approaches for both mitigation and construction of mine facilities would be helpful to better understand if risks can be minimized or eliminated given sufficient funds.

RESPONSE: The EPA agrees generally that conventional engineering practices may not be sufficient, but it may not be appropriate to test innovative approaches in a watershed such as the Bristol Bay watershed. The EPA is not aware of innovative mitigation measures that have sufficient history to be applicable to this location.

Under the no-failure scenario, the footprint of the mine (open pit, block-cave subsidence zone, waste rock and tailings areas) will by necessity destroy habitat. There may be ways to create equivalent habitat to compensate for lost habitat in areas within the watershed that are currently not productive for fish. This form of mitigation may work for resident fish, but it is unclear if it would work for anadromous fish that return to very specific locations to spawn.

RESPONSE: Mitigation to compensate for effects on aquatic resources that cannot be avoided or minimized by mine design and operation would be addressed through a regulatory process that is beyond the scope of this assessment. Nevertheless, in response to public and peer comments we have included a discussion of compensatory mitigation in Appendix J of the revised assessment. Appendix J includes a discussion of the challenges of creating equivalent habitat for anadromous and resident fish and why this would be particularly challenging in the context of the Bristol Bay watershed.

It is also becoming common practice to offset impacts from project development with preservation of equivalent habitat areas that are also at risk from development (http://bbop.forest-trends.org/). It is unclear if this is a feasible consideration for this project as this could involve allowing one development (e.g., Pebble), while potentially taking away the development rights of others (presumably for proper compensation).

RESPONSE: See response to above comment. The potential efficacy of using habitat preservation as a form of compensatory mitigation for impacts in the Bristol Bay watershed is discussed in Appendix J.

Steve Buckley, M.S., CPG

There are many reasonable mitigation measures that could reduce the risks and impacts beyond those described in the assessment. Some of these are contained in the Appendices and referenced therein but not discussed in detail or described in the assessment. It is beyond the time constraints provided in this review to develop an exhaustive research list of these potential mitigation measures; however, EPA could include measures designed to: reduce the mine footprint and limit the number of potentially affected watersheds; reduce, isolate, or eliminate the amount of potentially acid generating waste; provide secondary containment measures for all pipeline corridors; and use natural streambed arch culverts and bridges at fish bearing stream crossings.

RESPONSE: The mitigation measures proposed within the mine scenarios are a subset of options presented in Appendix I, all of which were presented as appropriate for the Pebble deposit in Ghaffari et al. (2011). Appendix I includes multiple options for each source of contamination, with some having specific applicability (e.g., site and material characteristics) and others being more broadly applicable. Some additional mitigation measures have been added to the scenarios in Chapter 6 of the revised assessment (e.g., processing PAG waste rock over the life of the mine and selective flotation to minimize pyrite in tailings). Mitigation to compensate for effects on aquatic resources that cannot be avoided or minimized by mine design and operation (e.g., by reducing the footprint or limiting the number of affected wetlands) would be addressed through a regulatory process that is beyond the scope of this assessment. Nevertheless, in response to public and peer comments we have included a discussion of compensatory mitigation in Appendix J of the revised assessment.

This seems to be a reasonable approach.

Courtney Carothers, Ph.D.

While I do not have knowledge of mitigation measures, a more thorough discussion of mitigation measures could be included. Even if mitigation measures are largely deemed to be ineffective in this case, they should be presented and evaluated as such.

RESPONSE: The EPA agrees with this comment and Appendix I is intended to provide that discussion. The mitigation measures proposed within the mine scenarios are those that could reasonably be expected to be proposed for a real mine (they are a subset of options presented in Appendix I), all of which were presented as appropriate for the Pebble deposit in Ghaffari et al. (2011). Evaluation of alternative strategies (e.g., other options presented in Appendix I for the mitigation of the same issue) should be done during a permitting process for a specific

mining plan. The assessment assumes that measures chosen for the scenarios would be as effective as possible.

Dennis D. Dauble, Ph.D.

Potential mitigation measures are well described in Appendix I. I have no suggestions for additional measures. Implementation of mitigation measures is entirely dependent on the regulatory framework for operations and the oversight and monitoring practices that would be mandated as a condition of the mining activity. Thus, some discussion of how/which mitigation practices would be most applicable in the Bristol Bay watershed (and limitations thereof), given constraints and characteristics of local hydrology and geology, is warranted.

RESPONSE: The mitigation measures proposed within the mine scenarios are those that could reasonably be expected to be proposed for a real mine, are a subset of options presented in Appendix I, and were presented as appropriate for the Pebble deposit in Ghaffari et al. (2011). Evaluation of alternative strategies (e.g., other options presented in Appendix I for the mitigation of the same issue) should be done during a permitting process for a specific mining plan. Permit applicant mitigation measures that reduce the risks identified in the assessment would be welcome during the application process.

Gordon H. Reeves, Ph.D.

I identified one potential mitigation for culverts – the use of open arch types that are at least one bankfull width in size. As described in my response to Question 7, this could reduce many of the potential impacts raised by the authors.

RESPONSE: Suggestion noted. In our scenarios (Chapter 6), we assumed state-of-the-art practices for design, construction, and operation of the road infrastructure, including design of bridges and culverts for fish passage.

Charles Wesley Slaughter, Ph.D.

If it is assumed that the PLP project, or some similar development, were to go forward, I cannot suggest mitigation measures beyond those discussed above. Since a major concern for salmonids – perhaps THE major concern – is with consequences of the transportation corridor, simply having the mine without the roads/pipelines would alleviate much potential risk. However, there is presumably no practical, economically feasible way to not have the transportation corridor; air transport of all materials to and from the site might technically be possible, but would not be economically feasible.

RESPONSE: We agree that it would be infeasible to have a mine in this location without also having road access. No change suggested or required.

John D. Stednick, Ph.D.

The purpose of this assessment is not to identify mitigation measures. This suggests that things can be fixed by mitigation. Risks were identified for a variety of situations, and the preventative measures would better address the mining impacts. Mitigation measures are also a mining cost that needs to be determined by the mining company and compliance with state and Federal regulatory authorities.

RESPONSE: Comment noted. We agree that mitigation measures required for an actual mine would be determined through the regulatory process. No change suggested or required.

Roy A. Stein, Ph.D.

Mitigation: Complete Tailings Storage Facility (TSF) Failure. In some ways, some of the failures reviewed herein are not really subject to mitigation. For example, if a Tailings Storage Facility (TSF) completely fails, options for mitigation become limited very quickly. With a complete failure, it is “game over”, with toxic sediments flowing into the Nushagak River all the way to Bristol Bay, thereby destroying the entirety of salmonid spawning habitat in this river by redirecting the channel and inundating the gravel/cobble steam bed with sediment (meters in depth). Mitigation under these circumstances is impossible, in my view. Given this scenario, I was surprised that the impacts were only assessed 30 km downstream of the TSF failure; is this realistic? I think not, given what we know of other mines.

RESPONSE: We acknowledge the limitations of the hydrologic modeling. We now emphasize more clearly the potential for the effects of TSF failure to extend to Bristol Bay. The potential for remediation (and associated risks) are discussed in Section 9.7.

The amount of text dedicated to a TSF failure is large (36 pages) as compared to other failures. I suggest this section be shortened to bring it more in line with other sections. Briefly summarizing impacts would focus the text and help the reader appreciate what it would mean to have a TSF failure without having to wade through so much text.
RESPONSE: We have revised this section of the assessment. However, given its importance to stakeholders, local communities, and decision makers, it was not significantly shortened. Other accidents and failures are now addressed in more detail.

Dry Stacking Mine Tailings: Appendix I, page 9. Given the horrific impact of a TSF dam failure, should mine operators consider a relatively new technique incorporating “paste tailings technology”? Here, tailings are thickened by water removal (down to 20% water) and filtering; tailings are then dry stacked onto a lined disposal site. These stacks “have a lower potential for structural failure and environmental impacts” (Martin et al. 2002). I would encourage the authors to argue for this substitute for the more traditional TSF for this solves at least two problems: 1) eliminates the possibility of a TSF failure (a huge gain!) and 2) reduces the amount of monitoring and maintenance of the waste tailings “In Perpetuity” (another major gain). Finally, what does “Best Management Practices” have to say about these two approaches to the storage of tailings waste?

RESPONSE: We agree that dry stack storage and paste storage are options for mine proponents to consider. Although the option of using paste tailings is one that might be explored, the type of tailings disposal that operators propose is generally based on two things: the type of mine and the quantity of tailings. A balance would need to be considered between the low risk/high impact of a tailings dam failure and the certainty of increased area of disposal and the increased cost of tailings handling for paste tailings. A "rule of thumb" for design of dry stack tailings is to allot 25 acres for every thousand dry tons of tailings per day over the life of a 20 year operation (SME Mining Engineering Handbook 1973). This would amount to 4,900 acres (25 *200000 *.99/1000). Since paste tailings are more voluminous than dry and the scenario contains a 25 year mine life rather than 20 years, the area of a paste tailings facility would exceed the calculated amount resulting in over a 1/3 increase in the area occupied by tailings than contemplated in the current mine scenario. With a paste tailings facility, the monitoring and maintenance of a large dam is removed but that is replaced by the monitoring and perhaps treatment of the leachate draining through the tailings pile (that contains 20% water) as well as the long-term maintenance of the cap that is placed over the tailings at the end of the mine life. The choice of a tailings disposal methodology may be affected by the need to avoid or minimize effects to wetlands or the technical feasibility of constructing the structural components of the project.

Mitigation: Partial TSF Failure. If a TSF partially fails or is discovered beginning to fail, then I believe mine operators have a chance to save the dam and thereby protect the river, but only if: 1) the appropriate Standard Operating Procedures (SOP) for an emergency response are in place, 2) the necessary equipment (my presumption here is that heavy, earth-moving equipment would be required), materials, and supplies are onsite near the facility, and 3) trained personnel (meaning that they have practiced these repair SOPs in the preparation for such an event) are available for immediate action. One might argue that these procedures are more proactive than mitigating and I would agree, reflecting the near impossibility of invoking any mitigation measures associated with TSF failure.

RESPONSE: Our scenarios presuppose that there are mitigation measures in place, but examines the effects of a failure of those measures. EPA agrees that SOPs are part of a mining operation and plan; however, inclusion of SOPs and details for emergency responses to a failing dam were outside the scope of this assessment. No change suggested or required.

Dredging: Post TSF Failure. In the text (pages 6-1 to 6-2), a reference is made to dredging materials out of the river post spill. I can't imagine this would mitigate any losses of spawning substrate for salmon. Indeed, because only 5% fines in gravel substrates compromise salmon reproductive success (and perhaps even selection of these areas for spawning in the first place), removal of meters of sediment with a dredge doesn't seem to be a solution. Whereas dredging might, in a best-case scenario, reduce the time to recovery of the substrate, I don't believe it will hasten recovery significantly. Dredging also serves to bring toxic sediments up into the water column perhaps compromising all organisms in the system. By not dredging, we allow the natural system to recover, which, in my view, would be preferable to any sort of "dredging mitigation". Some reflection by the authors on this issue would be valuable.

RESPONSE: Agreed. Adverse effects of dredging are discussed in Section 9.7.

Mitigation: Pipeline Failure. With automatic shut-off valves stationed along all four pipelines, we would expect to know precisely just how much effluent will be spilled during any single event. With this information in hand, mine operators can easily anticipate spill size, toxicant characteristics and thereby judge what equipment, materials, and supplies would be necessary for mitigating any spill. As with the TSF failure, mine operators should have in place: 1) the appropriate Standard Operating Procedures (SOP) for an emergency response, 2) the necessary equipment, materials, and supplies onsite near the pipeline (given the length of the road, these items should be cached at several locations along the road, such that response time is minimized), and 3) trained personnel (meaning that they have practiced these mitigation SOPs in the preparation for such an event) are available for immediate action. Shouldn't pipes be double-walled? Again, what would "Best Mining Practices" say in this context?

RESPONSE: The draft assessment included pipeline failure scenarios that quantified the magnitude of spill events. The draft included the most commonly used and accepted practice of using double walled pipes where above ground and water. There is, to the best of our knowledge, no standard SOP for a product concentrate slurry spill. As is discussed in the assessment, terrestrial spills would be excavated. Spills to streams might also be excavated, although the physical damage to habitat would be considerable and the efficacy of excavation would depend on how far stream flow had spread the material. An assessment of diesel spills has been added to the revised assessment in Chapter 11, and it refers to a NOAA and API report for standard remedial practices.

Mitigation: Failure of Water and Leachate Collection. This failure differs from TSF and pipeline failure, where failures are more akin to catastrophic, for here failure is somewhat more gradual in coming (my guess is). Proactive vigilance is the watch phrase here where continual, careful monitoring will indicate when failure begins. Because the "spill potential" is relatively small (certainly compared to a TSF failure), less urgency is required on the part of mine operators. However, as pointed out previously, just because the potential is small, over time the impacts could be great. Hence, the mitigation undertaken with water and leachate collections would require (one would hope) just the tweaking of the collection system in place to eliminate leakage through time. Again, personnel trained in how to respond to these gradual increases in water and leachate leaks are required to stay ahead of this issue, thus preventing any toxic materials from flowing downstream into the Nushagak and Kvichak rivers.

RESPONSE: The revised assessment acknowledges that the leachate capture system is not likely to capture all leachate during routine operations and shows that water quality standards would be exceeded in a considerable stream length as a result. Mitigation measures that ensure or maximize the detection of leachate in groundwater before it reaches surface waters would be vital.

William A. Stubblefield, Ph.D.

I'm sure there are number of technological/engineering measures that could be implemented to reduce the potential for environmental injury associated with development of mining in the Bristol Bay watershed. The development of this *a priori* risk assessment provides useful information in identifying were potential risks may exist and should provide mine development professionals with the degree of guidance about the types of risks and potential consequences of mine activity failures. Perhaps by recognizing the magnitude of adverse consequences associated with potential failures, steps can be taken to implement safety measures early in the planning process that would render mine development more acceptable. In addition, using the assessment to define areas of uncertainty my provide direction for future research that would be beneficial for the project. Again, because of the lack of detail associated with the hypothetical mine scenario, it is impossible to estimate the likelihood of success of any mine control activities.

RESPONSE: One purpose of this assessment is to inform future decisions concerning mine design and required mitigation. The purposes of the assessment are clarified in the revised introduction (Chapter 1).

Dirk van Zyl, Ph.D., P.E.

Yes, there are reasonable mitigation measures that would reduce or minimize the mining risks and impacts beyond those already described and incorporated by the EPA in the assessment. There are a host of measures that are not addressed in the assessment and lists of these are identified below under the headings of regulatory and engineering. This list is by no means exhaustive.

RESPONSE: See response under the commenter's headings of "Regulatory" and "Engineering" below.

While the EPA Assessment presents a series of potential mitigation measures in the main report, the majority were rejected. Appendix J [sic] to the report also includes a generic discussion of mitigation measures. The Main Report does not address the application or implications of these in any project specific details, e.g. compensatory mitigation for wetlands, streams and other aquatic resources.

RESPONSE: The EPA did not reject the majority of potential mitigation options mentioned in the report. The mitigation measures proposed within the mine scenarios are those that could reasonably be expected to be proposed for a real mine. They are a subset of options presented in Appendix I, were presented as appropriate for the Pebble deposit in Ghaffari et al. (2011), and are common with mining of porphyry copper deposits. Mine design for the scenarios is closely based on that presented in Ghaffari et al. (2011) and incorporates the mitigation measures included in that mine design. Mitigation to compensate for effects on aquatic resources that cannot be avoided or minimized by mine design and operation would be addressed through a regulatory process that is beyond the scope of this assessment. Nevertheless, in response to public and peer comments we have included a discussion of compensatory mitigation in Appendix J of the revised assessment.

Multi-stakeholder engagement processes, such as Failure Mode and Effects Analysis, can be used to further expand on these mitigation measures. It is recommended that EPA recognize these and potentially other measures that may be proposed in the public comments and make a serious effort in including the potential effects of these on failure likelihoods, consequences and risk magnitudes. It is an important aspect of improving on the range of potential outcomes.

RESPONSE: The EPA recognizes that other mitigation measures and mine designs have the potential to address impacts and risks identified in the assessment. Evaluating the risks of all potential mitigation measures and mine designs is not a goal of this assessment, which identifies potential risks of concern from plausible mine scenarios based on current practices and a recent plan (Ghaffari et al. 2011). A permit applicant's mitigation measures that further reduce the risks identified in the assessment are appropriate for the application process.

Regulatory. The EPA Assessment neglects the typical outcomes resulting from the permitting and regulatory processes for new mines, where permit stipulations may require specific actions resulting from discussions, public comments and regulatory frameworks. The following is a partial list of these:

- Section 404 of the CWA (See discussion under Question 3 above).
- Permitting stipulations and requirements for monitoring. Using permit stipulations for monitoring can reduce a large number of the consequences identified in the report. For example, the consequences associated with blocked culverts, etc. can be significantly reduced by permit monitoring requirements and subsequent enforcement.
- Financial assurance will be required for mine closure. Financial assurance can be a very beneficial tool during operations, premature closures, mine closure, as well as post-closure monitoring and maintenance. Experience gained during operations can help develop the closure and post-closure financial assurance requirements.

RESPONSE: The assessment is intended to identify impacts and risks of concern which may inform future NEPA and permitting processes. The revised assessment presents basic discussion of financial assurance and listings of requirements for permitting a mine in Chapter 4. The assessment is not a mining plan and is not meant to replace the regulatory process for development of mining plans for these prospects, but can inform that process about important risks that should be addressed.

Engineering. A number of engineering options are mentioned in the report but discounted in many cases. Many of these engineering mitigations are currently used in the industry. The following may repeat a number of those mentioned in the report:

- Redundancy, e.g. additional embankments may be considered downstream of the TSF to contain tailings and supernatant that may be transported as a result of TMF failure. While this may result in a larger local surface impact, it will protect downstream waters in the case of a failure resulting in tailings discharge.
- Further processing of tailings to remove the remaining sulfides.
- Tailings management options other than slurry deposition, such as production and management of filter cake.
- Waste rock management options to reduce releases during operations, e.g. addition of lime to the PAG rock.
- High standards implemented for road design, construction, monitoring and maintenance.
- Double containment of all pipes containing concentrate and other materials. This is already required under the International Cyanide Code for all pipelines containing cyanide solutions.

RESPONSE: The revised assessment presents background information on mining, including a sub-set of mitigation measures from Appendix I, in Chapter 4 and the scenario-specific

information in Chapter 6. The option of selective flotation to reduce the amount of sulfide in the bulk tailings, as well as processing of PAG waste rock over the course of operations, have been included in Chapter 6. In the draft assessment, selective flotation was discussed in the background information, but was missed in the scenarios. A double-walled pipeline along the entire length of a pipeline might be desired from a purely environmental protection standpoint; however, it may not be feasible or cost effective to do this given the length of the pipeline. Therefore, the assessment proposed the most commonly used (and accepted method) of double-walled construction over any water bodies. While the EPA opted not to include redundancy in tailings embankments in the scenarios, this option, as well as full pipeline double-wall construction, could be evaluated for appropriateness during the regulatory process for any future permit application.

The likelihood of success of these proposed and other potential mitigation measures can be evaluated by considering their impacts on the overall project. A range of alternative project technical alternatives and facility-siting locations will have to be developed instead of using only the hypothetical scenario.

RESPONSE: The purpose of the assessment is to describe the potential adverse environmental effects that could exist even with appropriate and effective site mitigation measures. Considering alternative options is part of a permit application process and outside the scope of this assessment. No change required.

Phyllis K. Weber Scannell, Ph.D.

There are many avoidance or mitigation measures that would be implemented to reduce or minimize mining risks. I have described some possible approaches when answering the previous questions. To summarize:

The two most important questions for reducing or minimizing mining risks are:
- Can a mine in this area be designed for closure?
- Is it acceptable to develop and operate a mine that will require essentially perpetual treatment?

RESPONSE: EPA agrees that these are key questions that must be addressed in the regulatory process. Our purpose in the assessment is to evaluate the risks resulting from a mine operated with modern conventional mitigation measures for design, operation, monitoring and maintenance, and closure. The regulatory process addresses significant and unacceptable risks. Chapter 4 of the revised assessment discusses regulatory and financial assurance requirements for mining in Alaska.

Specific Measures that can be taken to minimize risk include:

Limiting metals contamination and acid drainage:
- Design the mine pit to limit oxidation on pit walls. Where feasible, conduct concurrent reclamation.
- Develop plans for classification and storage of waste rock, lower grade ore, overburden, and high grade ore.

- Develop and maintain tailings storage facilities with fail-safe provisions. An emergency discharge of untreated waters from a tailings storage facility could be made to a collection pond for later treatment or the tailings pond could be engineered to accommodate a higher flood event so the likelihood of overtopping is minimized. Consider alternate methods for tailings disposal (dry stack following sulfide removal, etc.).
- Implement concurrent reclamation of disturbed areas, including stripped areas and mine pits.
- Collect and treat point and non-point source water.
- Design and implement plans for the quantity and timing of discharges of treated water; especially if the treated water is high in total dissolved solids. Monitor ground water, seepage water, and surface water.
- Design system for collection and bypass of clean water and collection and diversion of contaminated water to a water treatment system.
- Require stations for truck wheel washing.

RESPONSE: Many of the measures presented here were included in the scenarios and in Appendix I and are mitigation measures commonly included for mining of this type. Other bullets noted here are good suggestions for things to address during the regulatory process, should a permit application be submitted.

Protection of Fish Habitat:

- Review all in-stream activities in waters important to the spawning, rearing, or migration of anadromous and resident fish.
- Design and implement a biomonitoring program.
- Review every road crossing of fish bearing waters to ensure free passage of fish.

RESPONSE: Suggestions noted for consideration during any future regulatory permitting process.

Possible Measures to Limit Effects to Wildlife:

- At the planning stages, design aspects of the project to create or enhance wetland and aquatic habitats for fish, bird, and wildlife species.
- Limit truck traffic on the haul road during migrations.
- Incinerate all kitchen waste.
- Educate workers on bear (or other wildlife) safety.
- Limit air traffic and noise during critical times of the year.

RESPONSE: Suggestions noted for consideration during any future regulatory permitting process.

Paul Whitney, Ph.D.

Comments on Mitigation. The key word here is “reasonable.” What is reasonable to a person not involved in mining on a day to day basis will likely not be reasonable to a mining company executive or mining engineer. The likelihood that “reasonable” means different things to different people is exacerbated by the mixed messages regarding "best" mining practices (e.g., page ES-10, five lines from the bottom) versus "not necessarily best" mining practices (e.g., page 4-17, four lines from the top). As mentioned above, both of these statements can't be accurate. For purposes of this discussion, I am assuming that there are many more mining practices that could be proposed to address many of the uncertainties mentioned in the assessment. First of all, most of the mitigation measures mentioned in the assessment provide one line of protection and I suspect there are many types of redundant mitigation that could be implemented. Redundant protection such as: double-walled pipes in all sections that cross floodplains (above and below grade); poly liner/vegetated caps to soak up and capture run off water before it contacts waste rock; redundant clay, glacial till (waste360.com/mag/waste_landfills_glacial_till); poly liners; and secondary liquid collection systems.

RESPONSE: The EPA has revised the assessment to better explain the qualifying terms. What was intended is that we have assumed modern conventional mining technology and operations. The terms are qualitative when generally interpreted, or have a regulatory meaning ("best management practices"), and thus we have eliminated their use in the revised assessment. Measures for minimizing and controlling sources of pollution in other situations often are referred to as best practices, state of the practice, good practice, conventional, or simply mitigation measures. We assume that these types of measures would be applied throughout a mine as it is constructed, operated, closed, and post-closure, regardless of the qualifier that one wishes to place with it. To remove any ambiguity and subjectiveness of terms "good" or "best", we have removed them in the revision and have added Box 4-1, which includes definitions for several terms used. Double-walled pipelines were included in the scenarios for sections above or beneath water bodies. Redundant mitigation measures are appropriate for consideration during the permitting process.

I appreciate the assessment's discussion of the potential difficulties of using poly liners, but the discussion might benefit from a review of Koerner et al. (2005) that provides another perspective on the life of HDPE liners. The relationship of liner life to temperature is presented in their Table 2 and a summary in the text indicates that covered liners have a "half life of 446 years at 20 degrees Centigrade." This is a lot different from the 20 to 30 year estimate of service life cited in the assessment on page 4-11(last para). Appendix I does cite a 2011 version of the Koerner et al. (2005) paper and appears to misquote it (page 9, last para, last full sentence). The Koerner et al. (2005) paper estimates a "halflife of 446 years" not a "lifetime" of 446 years, as cited in Appendix I. Perhaps Koerner updated his 2005 estimate in the 2011 version.

RESPONSE: In the 2011 Koerner reference, there is conflicting text – the 446 years is listed as the "lifetime", and later also as "half-life"; "449" years is also stated as the half-life and one is referred to the Table in the report with the title of "Lifetime", where there is no such number. It appears the author is using the terms half-life and lifetime to mean the same thing. Later in the white paper, there is text that states "…its predicted lifetime (as measured by its half-life)…". The following text has been used in Appendix I and is consistent with the reference: "…Koerner et al. (2011) presents that a nonexposed HDPE liner could have a predicted lifetime ("as measured by its half-life") of 69 years at 40 °C to 446 years at 20 °C."

The discussion of liners has been moved to Chapter 4 in the revised assessment and includes 69 to 600 years as half-lives, based on Rowe 2005 and Koerner et al. 2011. The personal communication reference has been removed.

I assume a mining engineer (if asked) could design a series of smaller impoundments or innovative lined impoundments that could avoid a lot of the problems cited in the assessment. The trade-off might be increased loss of natural resources due to a larger footprint and increased construction cost, but the risk cited in the assessment and the risk of a catastrophic failure might be greatly lowered.

RESPONSE: An engineer could design a series of smaller impoundments that would likely decrease the risk of catastrophic failure, but would impact a larger footprint and increase construction costs. However, cumulative risk of failure would increase. More than one dam, even if they are smaller, means a higher risk of failures, even if they contain less volume, as well as more points where water management systems could fail, even if the dam itself does not.

I would be interested to know what THE BEST mining practices are. If the mitigation measures mentioned in Appendix I are, in fact, the best, it should be so stated and taken into consideration in the assessment. For example, page 4-21 of the assessment indicates the TSF would be unlined and not have an impermeable barrier between the tailings and groundwater. Appendix I, page 9 indicates TSFs can be lined if problems are expected. There is a lot of good information in the Koerner et al. (2005) paper and Appendix I. It seems the types of mitigation measures in Appendix I could be better captured in the main report.

RESPONSE: The terms "best", "good" or other are qualitative when generally interpreted, or have a regulatory meaning (best management practices when referring to storm water measures). Measures for minimizing and controlling sources of pollution in other situations often are referred to as best practices, state of the practice, good practice, conventional, or simply mitigation measures. The multiple measures presented in Appendix I are options that might be "best", depending on the site-specific conditions and any other constraints. More discussion on mitigation measures has been added to the scenarios in Chapter 6 of the revised assessment.

Compensatory mitigation and reclamation are briefly mentioned in the assessment. A more detailed discussion of the opportunities and feasibility of reclamation and compensatory mitigation might reduce the likelihood of potential impacts of the example mine plan (see response to Question 3).

RESPONSE: Mitigation to compensate for effects on aquatic resources that cannot be avoided or minimized by mine design and operation would be addressed through a regulatory process that is beyond the scope of this assessment. Nevertheless, in response to public and peer comments we have included a discussion of compensatory mitigation in Appendix J of the revised assessment.

Question 13. ***Does the assessment identify and evaluate the uncertainties associated with the identified risks?***

David A. Atkins, M.S

The Assessment states: the 'range of failures is wide, and the probability of occurrence of any of them cannot be estimated from available data.' Uncertainty is addressed throughout the report, typically with a qualitative discussion. There is a high degree of uncertainty with respect to how the mine would be developed, operated and closed, as well as how any impacts would be mitigated. This large uncertainty makes assessing risk difficult.

RESPONSE: No change suggested or required.

Steve Buckley, M.S., CPG

The assessment identifies some of the uncertainties associated with the identified risks but does not evaluate these in great detail.

RESPONSE: No change suggested or required.

Courtney Carothers, Ph.D.

The report includes specific sub-sections to discuss uncertainties for the risks associated with habitat modification (Section 5.2.4), pollutants (5.3.4), and water collection and treatment failure (6.3.4). Uncertainties related to abundance and distribution of fish in the watershed draining the mine site, road and stream crossings, salmon-mediated effects on wildlife, salmon-mediated effects on human welfare and Alaska Native cultures, tailings dam failure, pipeline failure, and road and culvert failures are not discussed in separate sections; however, several uncertainties related to these risks are noted throughout the report, and in summary sections (Sections 8.5 and 8.6).

RESPONSE: We have added separate uncertainty sections to each of the major topics in the risk assessment chapters.

The "sensitivity relative to overall results" of the key assumptions and uncertainties presented in Table 4.8 in Appendix E (pp. 193-195) would be a helpful model to employ in the main report. For non-experts in the technical dimensions of mine construction and operation, uncertainty rankings would be useful. For example, "We are 'highly uncertain' about the accuracy of these predictions given this unknown factor," or "We expect this uncertainty has a negligible effect on the model we employ to calculate this risk."

RESPONSE: The assessment has been restructured to consider certain impacts resulting from the mine footprint (Chapter 7) separately from less certain impacts resulting from potential failures (e.g., Chapters 8 and 9). For uncertainties considered in each chapter, we also have, when possible, indicated a general categorization of (1) the level of uncertainty, and (2) the sensitivity of our conclusions to this uncertainty.

Dennis D. Dauble, Ph.D.

The most likely scenarios and probabilities of failure are described based on assumptions of project size and magnitude. For the most part, estimated risks are conservative (i.e., effects are stated as "likely" if no further information is available). A weakness of Integrated Risk Characterization (Chapter 8 of the main report) is having a long list of identified uncertainties, which leads one to speculate, "so what do we know?" Not being familiar with the formal risk assessment process, it appears this "assessment" (which is loosely based on a risk assessment framework), falls short of providing something with any degree of certainty.

RESPONSE: The assessment does not state that effects are likely if no further information is available. The assessment, as far as the available information allows, identifies potential events and their effects, their probabilities of occurrence, and possible ranges. Uncertainties, inherent in any risk assessment or mine plan, are clearly identified in the assessment.

Gordon H. Reeves, Ph.D.

Uncertainties and limitations are explicitly identified and acknowledged for topics that I am familiar with (fish and aquatic ecology and fish habitat) throughout the report. These are summarized succinctly and clearly and the consequences to the findings are articulated.

RESPONSE: No change suggested or required.

Charles Wesley Slaughter, Ph.D.

Yes. The authors fairly attempt (pp. ES-24-26, and in each chapter) to note the various uncertainties and assumptions incorporated into the Assessment. Sections 8.5 and 8.6 briefly summarize those uncertainties. A question remains concerning the "uncertainties" associated with assigning probabilities to various failure scenarios; I remain unconvinced that those probabilities have real meaning or significance for decision-making (see response to Question 5, above).

RESPONSE: As explained in the assessment (particularly in Chapter 14), the probabilities have various sources and different interpretations, which we have tried to make clear. Some of them are more useful in decision making than others, but all are the best values that could be derived from available information. Most are based on empirical frequencies, but some are engineering goals or regulatory targets.

John D. Stednick, Ph.D.

The uncertainties are presented adequately.

RESPONSE: No change suggested or required.

Roy A. Stein, Ph.D.

Uncertainties. I think that the Environmental Risk Assessment did a nice job of identifying uncertainties surrounding this presentation, but a relatively poor job of quantifying them (at least partially due to a lack of information). As a consequence, I found this section more than disconcerting. Certainly, the authors have worked hard to present an accurate portrayal of the impact of a large-scale open pit mine in the watershed of Bristol Bay. Even so, upon review of the list of uncertainties with regard to this effort (pages 8-10 to 8-13), I conclude that we know little of what the impact of this mine will be in any quantitative sense. Clearly, from the Environmental Risk Assessment, we do know qualitatively what is likely to occur when a mine of this size and type will be put into operation in this environment.

RESPONSE: The goal of the assessment is to evaluate risks from large-scale mining to salmon populations and secondary effects of salmon losses. Where applicable information was available, we quantified our uncertainties to the extent possible. Where information was lacking, we provided a qualitative assessment. This approach also reveals missing information that will be needed for any future environmental assessment.

However, from the list of uncertainties, we are operating at the outside edge (and beyond in many cases) of the semi-predictive models used in anticipating the impacts of the mine footprint, the routine operations of the mine, and the impacts of failures of TSF, pipelines, and water/leachate collections on extant salmon populations. And our knowledge of the baseline populations of the seven species of salmonids is no better, for we do not know the size, diversity, distribution, or vital rates (i.e., recruitment, growth, and survival across life stage) of these fishes.

RESPONSE: The EPA agrees that we do not know everything we would like to know about fish populations in the project area, but we do know the approximate extent of various species, and we do know that spawning and rearing by salmon, Dolly Varden, and rainbow trout occur in the project area. We summarize the types of risks to fish from plausible mine scenarios.

Couple these two sets of uncertainty and the prognosis outlined in the report is suspect, at the very least, and somewhat anticipatory at best (I cannot bring myself to use the word "predictive"). I fully realize that these are the cards the authors were dealt (I do applaud the authors for making the best of an information-poor environment), but it seems to me that we are on tenuous ground when we attempt to predict the impact of the Pebble Mine on salmon, associated wildlife, and Native Alaskan cultures in the Bristol Bay Watershed.

RESPONSE: EPA agrees that the assessment is not a definitive quantified prediction of all impacts to salmon, wildlife, and Alaska Native cultures of large scale mining. However, the revised draft does develop more quantitative estimates of the implications of the mine scenarios than the first review draft. The point of a risk assessment is to make the best prognostication possible given the available information. The complexity of a large mine and of the receiving ecosystems, as well as the unpredictability of the natural processes and human errors that would challenge the integrity of a mine, make prediction tenuous even with the most detailed mine plan. However, the assessment evaluates the likely impacts of a set of plausible mine scenarios, thereby highlighting potential risks and impacts of concern. This will inform decisions going forward and any NEPA or permitting processes in the future.

William A. Stubblefield, Ph.D.

The risk assessment attempts to identify and evaluate the uncertainties associated with each of the recognized potential risks. The authors have, for the most part, successfully identified a number of uncertainties that may affect the accuracy and conclusions of the risk assessment. Clearly, this information should provide a basis for prospective mine planners and regulatory authorities to focus their efforts to minimize potential environmental risks. In some cases the uncertainties identified are probably best addressed through the development of additional data and this should guide future research efforts undertaken prior to mine development and operation.

RESPONSE: No change suggested or required.

Dirk van Zyl, Ph.D., P.E.

The EPA Assessment does not identify the risks, only the likelihood of occurrence and the consequences. See discussion under Question 4 above about risk. Uncertainties are identified and evaluated for the likelihoods of occurrence and in some cases for the consequences. However, because the magnitudes of the risks are not expressed, their uncertainties are also not explicitly expressed.

RESPONSE: The EPA believes that the likelihood of an occurrence and its consequences constitute an appropriate and generally accepted definition of risk. We have estimated those to the extent that existing information allows.

The report identifies uncertainties in a number of sections, including in Chapter 8. In many cases, these uncertainties are expressed in qualitative terms and are not quantified. The biggest uncertainty/variability in the evaluation of a hypothetical project is associated with the potential range of design features, waste management options and operational details that could be included. This was completely overlooked in the analysis by assuming a specific design for the hypothetical mine. The failure likelihoods and consequences on salmonid fish are very dependent on the assumptions for the hypothetical mine. These uncertainties are neither clearly identified nor included in the evaluations. This is a major shortcoming of the present analysis.

RESPONSE: The comment is correct in stating that the scenarios are a major source of uncertainty with respect to what might be implemented if an actual mine were developed. However, the scenarios are intended to represent a mine using modern conventional practices and are based on the preliminary mining plan put forward by Northern Dynasty Minerals as "permittable" (Ghaffari et al. 2011). Any future plans put forward would undoubtedly differ, and a permitted mine plan would differ from that put forward by the mining companies. The actual operation of a mine, in turn, inevitably differs from the approved plans. Rather than attempt to estimate the uncertainties in predicting all of those changes in plan, the EPA chose to put forward reasonable and typical scenarios, estimate some associated risks, and describe the uncertainties associated with the risk estimation. Identification of the risks associated with a typical mine can inform initial mine design and the NEPA and permitting processes. The revised draft makes this clear.

Phyllis K. Weber Scannell, Ph.D.

The important features of the Environmental Assessment are to describe the fish, wildlife, and human use of the subject area and to define possible risks from development of a large porphyry copper mine. There are many uncertainties associated with the identified risks and most were identified in the document. The document could be strengthened by putting a greater emphasis on sources of contamination (such as mine seepage, poorly designed collection systems, exposed pit walls, etc.) in relation to the permeability of the soils.

RESPONSE: The revised assessment includes more emphasis on sources of contamination (e.g., diesel pipeline failure, quantitative wastewater treatment plant failure, and a refined seepage scenario) and their potential hydrologic transport including through permeable soil and rock.

The 5th bullet on page 8-11 outlines important uncertainties for protecting fish species. These uncertainties include life-stage-specific sensitivities to temperature, habitat structure, prey availability, and sublethal toxicities. These factors must be considered should a mining project go forward.

RESPONSE: The EPA agrees with this comment. No change suggested or required.

The 6th bullet on this page discusses the preliminary nature of leaching test data. These tests must be sufficiently comprehensive to predict both short term and long term water quality from all sources, including PAG and NAG waste rock, pit walls, and pyritic tailings.

RESPONSE: The EPA used the available leaching test data and agrees with the comments about future tests.

Paul Whitney, Ph.D.

Uncertainty summary. The discussion of uncertainties in the assessment is, in most cases, appropriate. It seems that one could use these discussions as a scope for additional work needed prior to an assessment that would properly assess risk of the example mine. As the uncertainty discussion appears in the assessment, this reader wonders what to make of it. There is a lot of uncertainty in this world that we find acceptable; the ultimate goal seems to determine if the cumulative uncertainty is acceptable or not. Such an evaluation remains to be made and I'm not sure how it could be made based on the level of information presented in the assessment and the current state of the uncertainty discussions.

RESPONSE: The goal of the risk assessor is to describe the uncertainty, not determine whether it is acceptable. The acceptability of existing uncertainty is a judgment made by the risk manager, who must decide whether to make a decision or defer the decision until more information is available.

The summaries of uncertainty included in Sections 8.5 and 8.6 could be improved if some sort of realistic and useful conclusion(s) could be presented. The Section 8.6 summary seems to "pile on" uncertainties, rather than summarize the uncertainties in the assessment. While piling on is informative, it is not the sort of summary I was looking for. Conclusions in the Section 8.5 summary of conclusions remind us that the effects of mining on fish populations could not be quantified and, as a substitute, the effects on habitat were used as a surrogate. So we are left with an estimate of 87.5 to 141.4 km of streams that would be removed and this would cause an adverse effect. Based on this very general risk conclusion, we learn that "In summary, it is unlikely that there would be significant loss of salmon subsistent resources related to the mine footprint" (page 5-77, last paragraph). First, it's not clear how this conclusion was reached. Second, if such a conclusion was possible for subsistent resources based on the data available, why couldn't such a conclusion be reached for sport and commercial fisheries? Third, does it follow that no significant loss to salmon subsistence resources would result in no significant loss to wildlife that utilize this resource? If so, such an indirect analysis is not informative regarding an environmental assessment for the example mine. Alternatively, a direct assessment of the loss of habitat using habitat-based population models for both fish and wildlife would be much more informative.

RESPONSE: Uncertainties are now discussed in each chapter of the assessment so they can be more closely associated with a particular topic.

Additional information on the geographic scope of subsistence use in the area has been added to the assessment and the conclusions clarified accordingly. Although there is some (incomplete) information on subsistence use areas, similar data are lacking for the geographic scope of sport and commercial fishing in the watershed.

There is not sufficient data to quantify the loss of salmon as a subsistence resource under various scenarios or to quantify the fish-mediated effects to wildlife. Discussions of these topics have been expanded to illustrate the complexity of the interactions and provide further qualitative assessment. Direct effects on wildlife from habitat loss related to large-scale mining are outside of the scope of this assessment.

<u>Adaptive Management.</u> Holling (1978) in his Adaptive Environmental Assessment and Management book discusses political uncertainty and how adaptive management might be able to address the issue. Considering that the mine being proposed is a multi-century system, it's poignant to realize that Alaska was owned by Russia about 150 years ago and Oregon was being claimed by the Spanish about 200 years ago.

RESPONSE: The commenter is correct in pointing out the inapplicability of adaptive management to decisions like whether to permit large scale mine development in the Bristol Bay watershed. Not only is the time horizon inappropriate, but mine permitting decisions cannot be remade iteratively like the resource management decisions for which Hollings and Walters developed adaptive management (e.g., setting annual fishing limits). However, careful monitoring and revision of permit conditions, although not literally adaptive management, could have some of its benefits. Monitoring requirements and provisions for modifying permits are beyond the scope of this assessment.

Adaptive management is a tool designed to deal with uncertainties in risk evaluations (Ruhl and Fischmann 2010). If implemented properly, with testable hypotheses of risk, adaptive management may be something to consider for the example mine. My experience with adaptive management is that adequate funds are seldom allocated to learn by doing, to test hypotheses and to implement new management if hypotheses are not met. Formalizing financial instruments to ensure that funds are available is equally difficult to negotiate. Nonetheless, I agree with Ruhl and Fischmann that the theory of adaptive management is sound and may be the only way to deal with uncertainties such as climate change. Considering the number of uncertainties identified in the assessment, for the scope of work to clearly state hypotheses, to address the uncertainties, to fund studies to test the hypotheses, and to fund alternative management if hypotheses are not met is cumulatively daunting. For example, there are about 50 state variables in each of the Site Model Figures (3-2A, B, C and D). All totaled, that's about 200 (50 x 4 figures) state variables for salmon alone. Considering there are 100s more species, that's about 20,000 (200 x 100 species) state variables. Then there are fluxes/linkages between the state variables and that is another 20,000 fluxes/linkages that should be monitored. For adaptive management to work, clear goals and hypotheses to assess whether observed data meet the goals should be stated for approximately 40,000 variables and linkages. Then there is the task of defining the monitoring methods and statistics to determine whether or not goals for the variables and linkages are being met. I acknowledge that there are probably ways to trim down the monitoring effort, but one can start to imagine the enormity of implementing a monitoring plan for adaptive management. Then there is also what to do if goals are not realized. I am not aware of any alternative to adaptive management other than contingency planning which often lacks the "learn by doing" feature of adaptive management.

RESPONSE: See response to previous comment.

Important wordsmithing. So many of the uncertainty evaluations make statements about certain parameters that "could not be predicted" (page ES-20, para 4); "could not be quantified" (e.g., page 6-11, second full para); or are "unpredictable" (page 5-44, para, line 8). These are just a few of many examples. It would be more acceptable, at least to me, to state that estimates were not included in the assessment. This type of wording occurs in some parts of the assessment and might be more accurate.

RESPONSE: Changes have been made in Chapter 7 (formerly Chapter 5) and Chapter 9 (formerly Chapter 6).

Vague wording. The assessment includes a lot language that seems vague, at least to me. The list is long but includes: "highly pure water"; "other ecological responses"; "key wildlife"; "essential wildlife"; "overall ecosystem functioning"; "serious population-level consequences"; "different thermal characteristics"; "could be locally significant"; and "very long time." Lackey (2001) acknowledges the need for scientists to communicate with the public using normative science but expresses concerns that normative descriptors such as ecosystem health are subject to wide interpretation. He suggests that the most direct alternative to using normative science is to simply and clearly describe what is being discussed. The assessment would benefit if the normative type words used above (any many more) were quantified with estimates, a range or some type of measureable or testable parameter.

RESPONSE: The authors have tried to be precise with the language of the assessment and avoid normative terms. Changes to the text of the revised assessment have been made with this comment in mind.

Question 14. ***Are there any other comments concerning the assessment, which have not yet been addressed by the charge questions, which panel members would like to provide?***

David A. Atkins, M.S.

Long-term risks from development of an open pit have not been characterized. It is difficult to predict the chemistry of the lake that will form in the open pit, but there is some potential that water quality will be poor, which may be exacerbated by pit backfilling with waste rock. The pit lake could impact waterfowl and may have some impact on groundwater if there is outflow when the lake reaches an equilibrium level.

RESPONSE: The potential pit was not assessed because it is not anticipated that salmon or other fish (the primary assessment endpoint) would reach it. Therefore, it is out of scope. However, a pit lake as a potential source of water to streams is briefly considered in the revised Chapter 8. The scenarios no longer include the placement of acid generating waste rock in the pit at closure.

Steve Buckley, M.S., CPG

None.

Courtney Carothers, Ph.D.

None.

Dennis D. Dauble, Ph.D.

Based on public comments and discussions that took place by panel members in Anchorage August 7-9 of this year, this report confuses in both intent and approach. Is the intent of EPA's assessment to characterize potential impacts to the Bristol Bay watershed (title) or does it address a more defined portion of the Nushagak River and Kvichak River watersheds (objective statement)? Was the approach an "assessment" (a fairly broad term) or an "ecological risk assessment" (suggests a specific scientific framework was applied to the risk/effects analyses)? These shortcomings should be addressed in the final assessment document.

RESPONSE: We have revised the discussion of purpose, scope and endpoints in response to this and other similar comments (see Chapters 1 through 5 of the revised assessment). The assessment addresses multiple spatial scales, as detailed in Chapter 2. It is an ecological risk assessment, but that term is usually shortened to assessment to make the document more readable.

Gordon H. Reeves, Ph.D.

The major issue that was not considered in the assessment was the potential impact of climate change, particularly regarding the form and timing of precipitation. Admittedly, there is uncertainty about the magnitude of changes that will result from climate change, which makes it difficult to consider. However, the potential consequences of climate changes on such topics as tailing site facilities, water availability, and culvert failure seem appropriate. It will also be important to consider potential impacts of climate change so their signal can be distinguished from potential mine impacts during any monitoring that occurs.

RESPONSE: Climate change projections, including increases in precipitation, are addressed in Chapter 3 of the revised assessment. Projected precipitation increases are used as the basis for a qualitative discussion of the link among changes in precipitation, hydrology, and mining including site facilities, water availability, and culverts (Box 14-2). This box also discusses the importance of monitoring impacts of climate change to distinguish between potential impacts of climate change and potential impacts from the mine.

Charles Wesley Slaughter, Ph.D.

I would simply re-emphasize that a truly comprehensive assessment of the potential consequences of a large-scale mineral extraction project, be it the “hypothetical” Pebble-like project or a different endeavor, should fully consider both the immediate project-specific impacts, and the long-term watershed-wide consequences of “ancillary” developments – such as other mines, which might become economic once the primary project’s infrastructure is in place. There should be full recognition of the irreversible nature of such developments, and of the potential and limitations of possible reclamation or mitigation measures for the full suite of resources and ecosystem “services” involved, both short-term and long-term.

RESPONSE: Ecological risk assessments generally have more limited scopes than comprehensive environmental impact statements. This document is not meant to be a comprehensive evaluation of all impacts potentially stemming from a large-scale mine, and its scope has been more clearly defined in Chapter 2. We have added discussion to the cumulative assessment chapter (Chapter 13) to emphasize the long-term watershed-wide consequences of ancillary or induced development. We have added a discussion of compensatory mitigation in Appendix J.

John D. Stednick, Ph.D.

There are several references to streamflow measurements that would be especially helpful to better characterize the site. The US Geological Survey has some streamflow gauging stations and precipitation records that would complement the analysis. Annual precipitation values were derived apparently from a computer model used to analyze global climate change at University of Alaska Fairbanks. How do these data compare to field measurements? The prediction of a 10, 50, 100, or larger event using a short-term precipitation record, results in a larger error term on the predicted streamflow. How common is the occurrence of rain on snow (ROS) streamflow events?

RESPONSE: U.S. Geological Survey and PLP data are presented in Chapter 7 of the assessment. We believe the SNAP data used in the assessment to be the best available for summarizing precipitation inputs to large areas; these data have been updated from the May 2012 draft of the assessment. We used accepted, published data to estimate the size of the probable maximum flood. We do not make estimates of 10, 50, or 100 year events.

Dust production and transport: A variety of mining processes will generate dust. What are the wind patterns, chemical composition, and opportunity to land in surface waters or wetland areas? What potential is there for metal or toxin transport? Overburden removal will require explosives that leave nitrate, ammonia, and often sulfur in the air. What about this transport? Or rain out?

RESPONSE: Stressors evaluated in the assessment were based on how they would significantly affect our primary endpoint of interest (the region's salmon resources) and their relevance to EPA's regulatory authority and decision-making context. Although fugitive dusts from mining operations are a potential source of contamination to streams, and should be considered in a regulatory permitting process, they are not considered as significant as other stressors chosen for the assessment and are not regulated under the Clean Water Act. Discussions of transport dust and associated potential impacts are now included in Chapter 10.

The literature cited is often dated or lacking. The technical review panel has proposed numerous references that can be used to strengthen the document.

RESPONSE: We have reviewed all references suggested by the peer reviewers to the extent possible, and have incorporated information where applicable.

Roy A. Stein, Ph.D.

- **IN PERPETUITY**
  Sustainable Salmon vs. One-Time Mine. Some irony exists as one considers the trade-off between salmon and this mining operation (and make no mistake, we cannot have both mining and productive salmon stocks in the Bristol Bay watershed). We are trading sustainable salmon stocks that, with science-driven management, rigorous regulatory oversight, and limited exploitation, should provide salmon literally 1000s of years into the future against the development of a mine that will provide minerals in the relative short term (within 25 to 78 years). As a result of the mining operation, the government (and likely it will be the state or Federal government) will be saddled with a 1000 years (at a minimum, based on the assessment) of monitoring and maintenance of this closed-mine site.

  RESPONSE: No change suggested or required.

- **MINERAL NEEDS**
- **Strategic Needs.** I was surprised that no section of the Environmental Risk Assessment included any justification for why copper (does mining copper fulfill a strategic need for the

United States; most all sites I researched do not list copper as a strategic mineral for our country), gold, molybdenum, and some additional rare earth elements were needed within the context of our economy. Are other sources available? Are these specific elements in short supply? Are they required for the United States to compete in worldwide markets regarding cell phones, other electronic devices, or solar panels? For example, rhenium is used in the aviation industry and some web sites suggest it is critical to our defense industry. Some justification would have helped me understand this huge undertaking.

RESPONSE: The EPA agrees that the strategic need for these resources should be discussed in the broader NEPA environmental assessment process, but this topic is beyond the scope of this assessment.

- **ORGANIZATIONAL ISSUES**
  Page 5-59. I struggled throughout the document with organizational issues. As I read more and more text, I had the sense that I had read these facts or these perspectives previously. I mention this above but it is here on page 5-59 that the issue is nicely summarized. Note the text in the last paragraph of the page, where it discusses all of the important issues associated with roads and stream crossings. My suggestion would be that these sections (for every topic) be combined such that one section would exist for Roads, one for the Pipelines, etc. In so doing, the reader can capture all of the relevant information about a specific aspect of the mine in a single section of the report. I believe this would improve impact, readability, and shorten the report substantially (and also serve to reduce what seems to be a fair amount of redundancy).

RESPONSE: We have reorganized the document in response to this and similar comments to improve readability and clarity.

Pages 6-10 to 6-11. These pages reflect another example of redundancy. Text to this point discussed and reviewed just how long we might expect the fine sediments to persist in rivers and streams post tailings dam failure. Yet, here again, on pages 6-10 to 6-11, these numbers are reiterated. Combining these sections would help the reader and reduce redundancy.

RESPONSE: The TSF failure analysis was formerly split between two chapters and has now been combined into one (Chapter 9).

Section 6.3, Pages 6-36 to 6-42. Not to beat a dead horse, but in this section, nearly all of the citations to tables and figures are to those tables and figures that are found in sections of the report other than Section 6. This organizational scheme is what makes the report cumbersome to read and follow the logic and the argument.

RESPONSE: The assessment has been completely reorganized, as suggested by reviewers.

William A. Stubblefield, Ph.D.

None

Dirk van Zyl, Ph.D., P.E.

The EPA Assessment mentions twice that "interactions with regional stakeholders" and interactions with members of the Intergovernmental Technical Team were used to refine the analysis, etc. (p. ES-2 and p. 3-6). A robust stakeholder process includes careful documentation of the stakeholders identified during the project (which may include stakeholder mapping), records of meetings (attendee lists, meeting notes, etc.), resolution of differences, etc. The EPA Assessment does not contain any references to any such materials, which implies to me that the stakeholder process was informal and not robust.

RESPONSE: Details on stakeholder involvement in the assessment process have been added in Box 1-1.

Phyllis K. Weber Scannell, Ph.D.

At present, Pebble remains a prospect and there is no plan of operations for the mine. Should the project move forward to development of a mine, it will be necessary to develop an in-depth mining plan of operations. The mining plan should include the following:

- Transportation – of equipment and personnel and for shipping ore. Transportation of ore, including loading facilities, wheel washing, and other measures to prevent ore spillage and contamination.
- Siting of mine facilities, including tailings ponds, waste rock storage areas, concentrate storage area, bypass systems for clean water, and collection systems for contaminated water.
- Mill operations, including a description of the process for concentrating ore.
- Chemical and fuel storage and Spill Prevention and Contingency Plans.
- Personnel housing, including handling of domestic waste (sewage, garbage).
- Water treatment plant. Processes that will be used, anticipated concentrations of metals and TDS, anticipated discharge volumes, and predicted mass loadings.
- Monitoring plans for seepage from tailings ponds, waste rock storage areas, etc. Monitoring likely will include a series of wells and possibly, a pump-back system.
- Predictions for acid rock generation and measures that will be put in place during mining to minimize future seepage from the mine site.
- Plans for concurrent reclamation and future closure of the mine.
- Specifications for sufficient bonding to provide site stabilization and water treatment in the event of a premature or temporary shut-down and reclamation at closure.

RESPONSE: The commenter is correct that these are important points that should be considered in evaluation of a mining plan once submitted. No change suggested or required.

After the Mine Plan of Operations is developed, an environmental assessment plan should be developed that identifies potential effects to fish and wildlife and their habitats from specific components of the mine (as listed above). In addition, the assessment should include cumulative effects of nearby mines (if appropriate) on fish and wildlife habitats and water quality.

RESPONSE: The commenter is correct and we would expect these things to be considered during the regulatory permitting process. No change suggested or required.

Among the most important issues that must be addressed are transportation, potential for acid mine drainage and metals leachate, control of point and non-point pollution, and developing the mine for future closure.

RESPONSE: The commenter is correct and we would expect these things to be considered in more detail during the regulatory permitting process. No change suggested or required.

Paul Whitney, Ph.D.

Here are a number of other comments that do not fit neatly under the first 13 questions:

1. Unquantifiable wetland and riparian loss. There are many parameters that are supposedly unquantifiable. An example "unquantifiable" parameter is the area of riparian floodplain (page ES-14). Another example is the "unquantifiable area of riparian floodplain and wetland habitat that would be lost…" (page 8-2, first sentence). There are many methods to characterize or delineate riparian floodplain and wetland. For example, information in Table 5-23 and associated text on page 5-69 characterize wetland loss within 100 and 200 meters of the road. This is a rather crude method but it is at least an estimate. Perhaps it would be accurate to say that the area of riparian floodplain and wetland habitat lost was not characterized. Such a statement would be more internally consistent with statements that the natural system is "incompletely characterized" (page ES-25). Better yet, characterize the wetland and riparian habitat losses using one of the many existing methods. Section 8.2 is a good start. An explicit list of wetland and riparian loss estimates seems important for an EPA review. Once a list of potential wetland and riparian losses is tallied, the next question is whether or not it would be possible to compensate for such an impact. If it is not possible, it might not be possible to achieve no net loss of wetland resources.

   RESPONSE: The EPA agrees that greater quantification of wetland and riparian losses is essential for the NEPA and permitting processes that oversee compensatory mitigation and "no net loss". This assessment is based on existing information (including wetland inventories) and, as the commenter has pointed out, reveals the areas where existing information is lacking.

2. Combinations and Permutations of analyses. The review of the assessment is somewhat complicated by the relationship of certain analyses to following analyses and so on. Take, for example, the use of the Mount St. Helens eruption as a surrogate for a tailings dam failure. One could assume that such an analogy is inappropriate and recommend that it be deleted from the assessment. If this recommendation was followed for an initial baseline, all subsequent information on distance moved, toxicity, remediation, and duration of impact would no longer apply and would presumably be deleted. Alternatively, EPA might further develop the Mount St. Helens eruption analogy and demonstrate why it is a useful part of the assessment. If this is the case, the related following (i.e., secondary)

information presented on distance moved, toxicity, remediation, and duration would be retained. Then, it is appropriate for a reviewer to comment on the adequacy of the following secondary information. Then, it is a possibility that the secondary or following information is not accurate and the reviewer has to consider that it could be dropped or retained. Soon, a reviewer of the assessment document is wondering how to address an unwieldy and hard to follow combination of initial, secondary, and tertiary events. More likely than not, most reviewers do not consider all the combinations and recommendations. As a result, the reviewers' comments could fall short of adequately addressing the restructuring of the main assessment. In short, EPA should not assume that following the reviewers' comments will result in an assessment that addresses the next iteration of initial, secondary, and tertiary comments.

RESPONSE: The EPA believes that this comment raises an important point. We did delete the analogy to Mount Saint Helens ash, as recommended by other peer reviewers. However, as the comment indicates, that leaves the assessment with no analysis of recovery of salmonid streams from the deposition of large volumes of fine particulate material.

3. Address all levels of ecology. Ecological resources can be characterized at many levels of organization. Populations are often characterized by birth and death rates. Communities are often characterized by species diversity, succession, and associations of species. Ecosystems are often characterized by structure, function, nutrient cycling, and energy flow. From a wildlife perspective, the assessment does a fine job of discussing marine-derived nutrients but concludes that "…the fish mediated risk to wildlife – cannot be quantified given available data…" The assessment could be improved if information regarding community and ecosystem parameters were quantified (or at least addressed at the level that marine-derived nutrients were addressed). Woolington (2009) comments on the importance of certain seral stages for wildlife. I am confident that an interview with him, reclamation specialists, and others at ADF&G could provide a lot of information on community succession, plant diversity, and wildlife habitat relationships. This information, in addition to the insight provided in Appendix C, would provide a much better understanding of possible mine impacts and opportunities for compensatory mitigation. It is also possible that traditional knowledge of villagers might provide insight to understanding plant community and ecosystem parameters.

   RESPONSE: Ecological risk assessments are not intended to address all levels of biological organization. Rather, as described in the Guidelines for Ecological Risk Assessment (USEPA 1998), they focus on a limited number of assessment endpoints that are most likely to influence a decision because of their importance and susceptibility. The endpoints were selected in consultation with stakeholders and decision makers. Further, even if more consideration of the effects of marine-derived nutrients on terrestrial plant communities were included, the salmon-mediated effects of the mine on wildlife still could not be quantified. We have clarified the assessment scope, and recognize that numerous other important ecosystem components also could be affected.

4. Ecosystem evaluation. The Ecosystem Integrity Section (2.3.5) seems to miss the mark. It mentions the "nearly pristine conditions," with the caveat that approximately 70% of salmon returning to spawn are commercially harvested. This is then described as a managed and sustainable landscape. Maintaining a sustainable resource is not an accurate characterization of a nearly pristine ecosystem. First of all, sustainability means a lot of different things to different people. For example, forests in the Pacific Northwest are managed in a sustainable way but the ecosystem is hardly pristine. Hilborn (2005) discusses the multiple definitions of sustainability. Instead of deciding which definition he likes the best, he indicates that sustainability is like good art – it's hard to describe but we know it when we see it. Second, Hilborn (2005) states: "The record shows clearly that almost all forms of human activity – agriculture, forestry, urbanization, industrialization, and migration – reduce biodiversity of natural flora and fauna. This is almost certainly the case with fishing as well." Hilborn acknowledges the sustainability of the Bristol Bay fishery but I doubt if he would claim that there is no impact of the fishery on the ecosystem of Bristol Bay.

   RESPONSE: Additional information on commercial fisheries management has been added to Chapter 5 of the revised assessment. However, the purpose of this assessment is not to assess the relative effects of potential mining and commercial fishing—it is to evaluate potential effects on endpoints if a mine were to be developed, given existing conditions and activities in the region.

   Rather than emphasizing the nearly pristine conditions and sustainability of the fishery, I suggest that other measureable characterizations of the aquatic and terrestrial ecosystem be measured and quantified. For example, a description of plant communities and succession would provide the reader with a better understanding of how plant communities are naturally maintained, and subsequently, how possible mining activities might alter the successional processes. Failure to address and understand such relationships led to unexpected consequences for down stream plant communities, wildlife diversity, and village residents in the Peace Athabasca (Cordes 1975) Delta when the Bennett Dam was built hundreds of miles up stream on the Peace River. The drastic changes in the ecosystem function were related to changes in just a few inches of water in the delta at certain times of the year. The Bristol Bay assessment would be improved if the expected changes in the hydrographs and sediment transport were related to the successional processes that maintain early successional plant associations such as the alder-willow association, which is important for moose. The write up for moose (Appendix C, page 33) indicates that these early successional associations are maintained by bank scouring. It would be good to know the role of ice dams and anchor ice on current levels of scouring and how changes due to mining might alter these important sustainable functions. The assessment's emphasis on fish and fish mediated impacts runs the risk of missing possible impacts on the terrestrial environment and down stream sedimentation that would not only influence human culture but also the aquatic environment. The impact on terrestrial resources and wildlife is not inconsequential to aquatic resources, at least in my opinion. Throughout my evaluation, I cite references that discuss the importance of specific associations between fish and wildlife.

RESPONSE: A comprehensive assessment of potential impacts of large-scale mining would need to consider all levels of ecological organization. The scope of this assessment, however, is much narrower, as described throughout the problem formulation chapters (Chapters 1-6). We clarified the assessment scope, and recognize that numerous other important ecosystem components also could be affected.

5. Multi-directional fish and wildlife relationships. The assessment's emphasis on marine-derived nutrients and the reduction of this salmon-derived resource only looks at a one-way fish to wildlife interaction. Wildlife to fish functions, such as beaver dam building, are very important wildlife to fish interactions. Both salmonid fish, as well as forage fish, receive benefits from beaver functions such as tree felling, dam building, and food storage (Snodgrass and Meffe, 1997; Schlosser and Kallemeyn, 2000). This issue is briefly mentioned in Section 5.2.1.2 (para 1) and discussed on pages 5-19 and 5-22, but needs to be expanded to address the benefits for fish. The dynamic process of dam construction and dam decay is important, not only for moving streams across the flood plain, but also for creating a mosaic of plant associations and wildlife (e.g., moose) habitat in and near the floodplain. In addition, such activities create a mosaic of habitat for forage fish. An accurate characterization of the impact of a potential mine and road necessitates, not only an assessment of the loss of fish on wildlife, but also the loss of wildlife and their functions on fish. The influence of wildlife and terrestrial processes and functions on fish discussed in the Cederholm papers needs to be included in the problem formulation step. The dynamic process of beaver dams causing creeks to move across the floodplain should also be a criteria for determining if and where culverts , versus bridges or causeways) are installed for a potential road (pages 4-36 and 4-63).

RESPONSE: Additional text has been added discussing the functional role of beaver dams in Chapter 7. The discussion of wildlife in Chapter 5 has been expanded to acknowledge the complexity of fish/wildlife interactions in the watersheds. Please note that the assessment does not use beaver activity as a criterion for determining what type of structure (bridge vs. culvert) would be constructed at each crossing. The revised assessment assumes that crossings over streams with mean annual flows greater than 0.15m^3/s would be bridged. However, the actual decision as to what type of structure would be constructed at each crossing would be made by industry engineers in consultation with state permitting staff.

6. (i.e.Measuring fish wildlife interactions. Understanding and addressing the multi-directional interaction of fish and wildlife are facilitated by an approach developed by the Northwest Habitat Institute, introduced in Johnson and O'Neil (2000) and elaborated on the Northwest Habitat Institute web site (nwhi.org). The Interactive Biodiversity Information System (IBIS) database allows an assessment of fish and wildlife interactions and functional characterizations (i.e., ecosystem functions). The IBIS database is a logical extension of the Jack Ward Thomas Wildlife Habitat Relationships and the GAP analysis for the Pacific Northwest. Such an analysis could build on information in the Alaska GAP database and the Natural Heritage Program database in Alaska.

RESPONSE: A comprehensive assessment of potential impact of large-scale mining

would need to consider all levels of ecological organization and interaction. The scope of this assessment, however, is much narrower, as described throughout the problem formulation chapters (Chapters 1-6). We clarified the assessment scope, and recognize that numerous other important ecosystem components also could be affected.

7. Ecological risk assessment for toxic chemicals. The amount of information in the assessment pertaining to ecological toxics risk is impressively large. The amount of time and team expertise needed to adequately review this information is well beyond the scope of the proposed review. If a team was assembled to review this information, I would ask them to consider:

    a. The applicability of a probabilistic risk assessment to address some of the uncertainty associated with the deterministic information presented in the assessment;
    b. Stressors in addition to toxics (e.g., habitat loss, noise, human disturbance, light, and water warming in the winter); and
    c. The relationship of stressors to populations in addition to no observed effect levels.

    I have worked on large scale impact assessments where the stress of habitat loss far exceeds the potential stress of toxics. I would think EPA would want to know whether or not this is the case for the example mine in their assessment.

    RESPONSE: The revised assessment evaluates the potential impacts from habitat loss and toxic releases from plausible mine scenarios based on existing information about the watersheds. The review panel includes an expert on aquatic toxicology who did provide an excellent review of that material.

8. My only regret in this review is that I could not visit the proposed mine site and watersheds during the summer and the winter. I have flown over the Bristol Bay watersheds while working for other mines in Alaska, but I have never been on the ground in these watersheds. I am concerned that if I did visit the proposed sites my assessment points above might change and even change dramatically. It is hoped that all the EPA staff and biologists working on the assessment are able to visit the watersheds in the summer and winter.

    RESPONSE: No changes suggested or required.

3. SPECIFIC OBSERVATIONS

[NOTE: in the page notations below, S = Section, P = Paragraph, L = line]

David A. Atkins, M.S.

1. Global: All significant figures should be reviewed to make sure they are reflective of the level of uncertainty (i.e., using an estimate of 141.4 km of streams eliminated when this value is probably realistically +/- 50%).

RESPONSE: All significant figures in calculations and measurements made by EPA have been reviewed and changed to reflect the uncertainty of the analysis. For example km of stream is reported to the km. Significant figures from cited documents are as reported in the document.

2. Global: Many references cited in the text are not included in the reference list.

   RESPONSE: References have been updated.

3. Global: The executive summary, main report, and appendices, in many instances, present different information with sometimes different implications. These three levels of detail of information should be more cohesive.

   RESPONSE: We have re-written the executive summary and main report to make them more consistent with each other and the appendices.

4. Page ES-24 (P2): Suggest changing 'Cumulative Risks' to 'Cumulative Effects of Multiple Mine Development.'

   RESPONSE: The title of the chapter (now Chapter 13 was changed.

5. Page 3-2 (P1): The justification for excluding ancillary development from the assessment should be better explained. In some instances, opening up an area for natural resource development has had as much or more impact on the environment and ecosystems as the development itself (for example, oil and gas development in some areas of the Amazon Basin)

   RESPONSE: Discussion of ancillary mining infrastructure (in addition to the pit, TSFs, waste rock piles, roads and pipelines) has been added to Box 6-1, and discussion of induced development (development which follows initial development in an unimproved setting) has been added to Chapter 13.

6. Page 3-7 to 3-11: The conceptual models are quite helpful, but are not referenced or utilized sufficiently when discussing impacts. It would be helpful to more fully incorporate them into the assessment.

   RESPONSE: Sub-components of the conceptual models have been included at the outset of the risk analysis chapters, to better frame the pathways evaluated in each chapter.

7. Page 4-1 (P1, L9): Why does the assessment describe current 'good' and not 'best' practice? The rationale for this decision needs to be described. In addition, it is likely that anything other than 'best' practice would not be permitted in this context.

   RESPONSE: With regard to the terminology of "best", "good", or other terms for the practices used, what was intended to be conveyed in the assessment is that we assumed modern mining technology and operations. The terms are qualitative when generally interpreted, or have a regulatory meaning. The term "best management practices" is a term generally applied to specific measures for managing non-point source runoff from storm water (40 CFR Part 130.2(m)). Measures for minimizing and controlling sources of pollution in other situations are referred to as best practices, state of the practice, good

practice, conventional, or simply mitigation measures. We have added a text box in the revision Chapter 4 to discuss terms. Mitigation measures considered feasible, appropriate, and 'permittable' (as per Ghaffari et al. 2011) were considered in the assessment, and these are measures common to other copper porphyry mines.

8. Page 4-11 (P3, L10): The liner lifetime is quite low, and given the importance of this assumption, would warrant more than a personal communication that does not appear in the references (North pers. comm.).

   RESPONSE: The discussion of liners has been expanded and moved to Chapter 4 (Section 4.2.3.4) in the revision. The personal communication reference has been removed.

9. Page 4-21 (P1, L4): Is the assumption about the TSF locations from the authors or from the Wardrop 43-101 report?

   RESPONSE: The location of the TSFs is a combination of alternative sites described in Ghaffari et al. 2011 (the Wardrop report), in the NDM 2006 Water Rights Application (see reference list for Chapter 6), and our knowledge of site characteristics suitable for tailings impoundments.

10. Page 4-26 (S4.3.7-Water Managment): It would help to provide appropriate ranges for numbers (e.g., the precipitation at the mine and TDF is 803 and 804 mm/yr, respectively, which implies an unrealistic degree of certainty). It would also be helpful to include a diagram. I am uncertain why 'cooling tower' water losses would be included in the mine water balance since power generation would likely be at a remote location and other impacts from power generation are not considered in this assessment.

    RESPONSE: In general, we have presented our best estimates for the parameter values discussed in the assessment and have used these estimates in our analyses and calculations. A full uncertainty analysis is beyond the scope of this assessment, so we have provided ranges only for critical parameters such as the mine size. We followed the Ghaffari et al. (2011) mine plan in placing power generation on the site, which is the reason for the natural gas pipeline. Therefore, water use for cooling is appropriate.

    Net precipitation at the mine site has been recalculated. The monthly mean flows for each gage were summed across the year, producing an area-weighted average of 860 mm/yr. Ghaffari et al. (2011) describe the construction of a combined-cycle natural gas-fired gas turbine power plant at the mine site and estimate the cooling tower evaporative and drift losses from the plant. The cooling tower losses were included because they would constitute a substantial consumptive water use.

11. Page 4-31 (P3, L6): How was the filling time of 100 to 300 years for the pit estimated? What constitutes full (e.g., within x% of the pre-mining water table)?

    RESPONSE: The filling time was calculated from the estimated inflow rate to the empty pit. Most of the groundwater infiltration would come from the uppermost 100 m and the direct precipitation rate would be constant, so the filling rate would not decrease significantly until the water level was close to the surface compared to the pit depths. We recognize that as the water level approached the surface, the cone of depression would

shrink and the filling rate would decrease. We have not attempted to refine our analysis to account for this decrease in rate and the available data do not merit such a refinement.

The filling time was simply calculated by dividing the pit volume by the inflow rate. In practice, when the pit was full the pit level would be maintained below the overflow level by pumping if treatment were required or be allowed to establish a natural outlet at its low point if treatment was not necessary.

12. Page 4-52: The PMP is based on the Miller (1963) reference (not included in the reference list). How was it estimated?

    RESPONSE: The PMP was based on Technical Paper No. 47 (http://www.nws.noaa.gov/oh/hdsc/PMP_documents/TP47.pdf). This PMP was used as the precipitation input to a Type-1 (for Alaska) HEC-HMS simulation to calculate a runoff hydrograph. 291 cms was determined to be the peak discharge from this 24-hour design storm.

13. Page 5-22: Should refer to 'recapture efficiency' rather than 'recovery rate'. How were the values of 16% and 63% derived?

    RESPONSE: The words "recovery rate" were meant to be descriptive and not as a defined technical term. There is no standard term in widespread usage for the parameter reported (i.e. the percentage of excess water available for reintroduction into the streams versus the total amount captured by the mine processes). In the revised assessment, we have changed the wording to "reintroduced" (Table 6-3, Section 6.1.2.5). The reintroduction percentages were calculated as part of the water balance. The water balance totaled all the sources of water captured per year and then subtracted all of the annual consumptive water losses. The remaining annual volume of water is excess water that the mine does not need for operations and which is available for reintroduction to the streams. The ratio of the annual reintroduced volume to the annual captured volume yields the reintroduction percentage.

14. Page 5-23: The mean annual unit runoff values are not reproducible from the values given for drainage area and measured mean annual flow.

    RESPONSE: These values have been corrected.

15. Page 5-32 to 5-39: Tables showing flow changes for different mine sizes and figures for minimum mine size are difficult to interpret. A different presentation method and/or narrative description would help.

    RESPONSE: Tables, figures, and text for this section have been revised.

16. Page 5-45 (S5.2.3): The preceding section (Section 5.2.2) focuses on 'Effects of Downstream Flow Changes' and Section 5.2.3 focuses on wastewater treatment. It is not clear why this is the sole focus of Section 5.2.3. In addition, only a short paragraph is included in this section. Certainly there are other possible risks beyond water treatment, and even this discussion is too cursory given the importance of the issue.

RESPONSE: Discussion of water treatment has been expanded in Chapter 8 (a new chapter in the revised assessment).

17. Page 5-45 (S5.2.4): This section states a number of assumptions that could result in under or over estimating impacts on stream flow from the mine footprint. This section leaves the impression there is a lot of uncertainty, both with assumptions behind the estimation and with how successful any attempts at mitigation may be. Therefore, we are left with very large error bars on estimates that should be reflected in the numbers presented for loss of length of streams and areas of wetlands.

    RESPONSE: We have improved the rigor of the analyses regarding the impact of mining on streamflow. We have attempted to be very explicit about our assumptions and approaches, and we believe the analyses are appropriate and defensible.

18. Page 5-46 (P3): This paragraph discusses the possibility that estimates of stream length blocked by mine construction may be overestimated if engineered diversion channels are successful. This is an important form of mitigation that needs to be evaluated further. It would be helpful to evaluate mitigation efforts in similar types of systems to determine if reconstructing streams is feasible and could be successful.

    RESPONSE: Appendix J includes a discussion of the efficacy of constructed spawning channels. There is little evidence in the scientific literature to suggest that such channels are effective at creating suitable spawning habitat. Furthermore, there is nothing in the scientific literature that suggests salmon streams could be successfully reconstructed in landscapes where significant alternations in area soils, hydrology and groundwater flow paths have occurred, such as would be the case with the mine scenarios described in the assessment.

19. Page 5-59 (Bullet 4): Whole effluent toxicity (WET) testing and downstream biotic community monitoring would likely be part of any discharge permit. This requirement would not preclude developing a better understanding of protective discharge chemistry and temperature requirements before permitting, especially given the quality of the receiving water.

    RESPONSE: Appropriate WET testing and downstream biotic monitoring would be desirable if a mine were permitted. Additional studies of site specific chemistry and temperature tolerances may also be desirable. No change required.

20. Page 5-60 (S5.4.2): The statement that mine traffic will not be a large enough volume to affect runoff needs support. Do we know the road will only be used for mine traffic? Can we estimate the volume of mine traffic for a mine of this size and then look at runoff from an analog system?

    RESPONSE: This statement has been deleted from the assessment. However, we found no analogous data that would allow us to quantify runoff.

21. Page 5-60 (S5.4.4.1): How was the number of stream crossings determined (e.g., what criteria were used to define a stream vs. a channel)?

RESPONSE: All USGS designated streams were included. No artificial channels were identified and all natural channels are streams.

22. Page 5-65 to 5-68 (S5.4.8.2): Text states that 240 km of stream upstream of the transportation corridor has a gradient greater than 10% and, therefore, is likely to support fish. Should this be less than 10% (as stated in the header to Table 5-22 and Table 6-9)? If so, how was the <10% value chosen?

    RESPONSE: The comment is correct, though in the revised assessment we use <12% as the criterion and cite a relevant source.

23. Page 5-74 (S5.5): Salmon-mediated effects on wildlife seems under-analyzed in the report, particularly when compared to the information presented in Appendix C.

    RESPONSE: The discussion of potential salmon-mediated effects on wildlife has been expanded (Chapter 12).

24. Page 5-75 (S5.6): As above, salmon-mediated effects on Alaska Native Cultures seems under-analyzed in the report, particularly when compared to the information presented in Appendix D.

    RESPONSE: The discussion of potential salmon-mediated effects on Alaska Native cultures has been expanded (Chapter 12).

25. Page 6-3 (S6.1.2.1): I don't find the Mt. St. Helens analogy useful.

    RESPONSE: It has been removed.

26. Page 6-9 (P1, L1): Why would 'present' resident and anadromous fish not suffer habitat loss in the event of a TSF failure? Are they upstream of the area inundated?

    RESPONSE: Yes, these populations are upstream of the TSF-affected area. However, they may be impacted by barriers to seasonal movement or fragmented by loss of connectivity. This has been clarified in the text.

27. Page 6-28 (S6.1.5): The 'Weighing Lines of Evidence' section is not well developed and not particularly useful. It also does not inform the risk characterization and uncertainty discussion.

    RESPONSE: The EPA believes that it is important to weigh all relevant lines of evidence. An explicit weighing allows readers and reviewers to see what was weighed and how it was weighted. Such transparency is desirable in general. Therefore, the weighing of evidence has been expanded and the method is better explained.

28. Page 6-30 (P1, L2): The statement that risks of failure of the gas and diesel pipelines are not considered because they are not particularly associated with mining makes no sense. Without the mine, there would be no need for the pipeline. And if the types of failures and risks are well known, then this is one of the areas that could actually be assessed with some degree of certainty.

RESPONSE: Diesel pipeline failure has been added. A gas pipeline is still not assessed because it is judged to not pose a potentially significant risk to fish (see Chapter 11).

29. Page 6-36 (S6.3, P2): Designating closure as 'premature closure,' 'planned closure,' and 'perpetuity' with water treatment ceasing immediately, continuing until permits are exhausted or water is nontoxic, or until institutions fail does not seem reasonable. Any of these closure scenarios would be planned, and would involve regulatory compliance reviews, bonding, etc. Walking away without continuing to collect and treat water would be an unlikely scenario. The issue of treatment in perpetuity is a larger issue that needs to be treated in detail.

    RESPONSE: The premature closure scenario is intended to address the possibility that the closure plan is not followed. It highlights the need for adequate bonding and for plans that include closure by the bond-holding agency.

30. Page 6-37 (P4, L4): The report states that (acid generating) waste rock could be left in place in the event of premature closure. This scenario should be addressed in the mine closure plan and during the closure bonding process.

    RESPONSE: The premature closure scenario is intended to address the possibility that the closure plan is not followed. It highlights the need for adequate bonding and for plans that include closure by the bond-holding agency.

31. Page 8-1 to 8-2: Given that this chapter discusses overall risk to salmon, it would be helpful to put the estimates of km lost in terms of the total stream or watershed available habitat. We need some context and metric for assessing significance.

    RESPONSE: In Table 2-1, we have explicitly expressed the relative areas of each spatial scale as % of the scale above it (e.g., the % of the entire Bristol Bay watershed made up of the Nushagak and Kvichak River watersheds, the % of the Nushagak and Kvichak River watersheds made up of the mine scenario watersheds, etc.).

32. Page 8-2 (S8.1.2): The focus on a few types of catastrophic failures does not reflect the current typical mining scenario. Based on experience at other mines, it is more likely that smaller-impact failures and accidents would occur during the mine life. It would be helpful to use some current case studies to illustrate this point.

    RESPONSE: The number of possible types, magnitudes and combinations of failures and accidents is virtually infinite. Therefore, we used a bounding strategy. The potential effects are bounded by those of routine operations and a realistic severe failure or accident. We also cite case studies from recent reviews of mining failures and individual failure cases to indicate some of the possibilities.

33. Page 8-3 (T8-1): Why would most concentrate pipeline failures occur between stream and wetland crossings?

    RESPONSE: Most of the transportation corridor is not on or adjacent to a stream or wetland. Therefore, most failures would occur in those areas between stream and wetland crossings.

Steve Buckley, M.S., CPG

1. Page xii: ICF is referred to in the document page xvi, but not listed as acronym or abbreviation.

   RESPONSE: ICF is the name of one of the contracting companies that has worked on the assessment, and is only referred to as ICF in the introductory material (thus is not included as an acronym or abbreviation).

2. Page ES-2 (P2, L5-6): "altered by geologic processes by would not degrade…" is unclear

   RESPONSE: Metals do not degrade but their chemical form may be altered (via speciation, binding, formation of salts, etc.). This is explained in the revised Executive Summary.

3. Page ES-24 (P4, L2): "geologic defects" in unclear.

   RESPONSE: This was clarified in the revised assessment.

4. Page 1-1 (P3, L1): "17 existing mine claims…" should read "existing claim blocks"

   RESPONSE: Corrected.

5. Page 4-11 (P3, L10): "North pers. comm." There is no reference, date, or information on North.

   RESPONSE: The discussion of liners has been expanded and moved to Chapter 4 (Section 4.2.3.4) of the revised assessment, and includes additional material and references on liner lifetime. The personal communication reference has been removed.

6. Page 5-20 (P4, L3): The "northeastern United States" not comparable to western Alaska.

   RESPONSE: We agree that these two regions differ in many important ways, but the general patterns of headwater contributions of nutrients and other resources is shared between them, as reflected in the numerous citations of studies from Alaska that follow in this paragraph.

7. Page 7-1 (P1, L5): "claims blocks" should read "claim blocks."

   RESPONSE: Corrected.

8. Page 7-3 (P3, L4): As above

   RESPONSE: Corrected.

9. Page 7-6 (P2, L5): As above

   RESPONSE: Corrected.

10. Page 7-7 (P2, P4): As above

    RESPONSE: Corrected.

11. Page 8-1,2 (P2, P3): In the discussion of removal of stream kilometers and wetlands it would be helpful to express these numbers in a percentage of the overall watershed stream kilometers and wetlands to put perspective on these numbers.

    RESPONSE: In Table 2-1, we have explicitly expressed the relative areas of each spatial scale as % of the scale above it (e.g., the % of the entire Bristol Bay watershed made up of the Nushagak and Kvichak River watersheds, the % of the Nushagak and Kvichak River watersheds made up of the mine scenario watersheds, etc.).

Courtney Carothers, Ph.D.

1. Page ES-2 (P3): "wildlife and the Alaska Native cultures *of this region*."

   RESPONSE: The Executive Summary has been rewritten to incorporate this change.

2. Page ES-5 (P2): "Chief among these resources are world-class commercial, sport, *and subsistence* fisheries for Pacific salmon…"

   RESPONSE: Language added to the revised assessment.

3. Page ES-8 (last P): 1. Should Alutiiq (Sugpiaq) cultural group also be included? Alutiiq residents noted in Igiugig and Kokhanok (Appendix D, p 15). 2. Change 2nd sentence to: "In contrast, the salmon base upon which indigenous peoples in the Pacific Northwest depend is severely threatened."

   RESPONSE: 1. Although there are residents of other cultural groups in the watersheds, the predominant cultures are Yup'ik and Dena'ina, so we have focused on these groups but have added mentioned of the Aleut/Alutiiq. 2. This sentence has been edited.

4. Page ES-9 (P1): "Salmon are integral to the entire way of life in these cultures as subsistence food, *fishing and subsistence-based livelihoods*, and as the foundation for…"

   RESPONSE: Language added to the revised assessment.

5. Page ES-9 (P2): "52% of the subsistence harvest, *although for some communities this proportion is substantially higher*" (e.g., noted to be as high as 82% on pg 93 of Appendix D).

   RESPONSE: Language added to the revised assessment.

6. Page ES-10 (P1): Could also add replacement value for subsistence resources or for salmon, and the range of estimates for economic valuation of subsistence presented in Appendix E, noting of that economic valuations do not fully capture the value of these practices.

   RESPONSE: Language added to the revised assessment.

7. Page ES-14 (#1): Are these all the fish spp. at risk, or only the one deemed to be commercially, recreationally valuable? Subsistence spp also include others. Should make clear what the focus is.

   RESPONSE: This sentence refers to the sockeye being particularly at risk because they spawn and rear below the road. Commercial or recreational value is not considered.

8. Page ES-23 (P3): As noted above, other mines in Alaska (e.g., Red Dog) and oil and gas development studies on North Slope may be useful to include predictions about how subsistence practices will change with mining development and perceived impacts. Including citations with these statements would be helpful.

   RESPONSE: Chapter 12 has been expanded to include discussions of and references to studies of impacts to subsistence practices from resource extraction industries.

9. Page ES-23,24 (last P): "if salmon quality or quantity is adversely affected *(or perceived to be affected*)"

   RESPONSE: Language added to the revised assessment.

10. Page ES-26 (last bullet): There is much data on cultural disruptions caused by the Exxon Valdez oil spill, and cumulative effects of oil and gas development in North Slope region, current salmon shortages in Yukon-Kuskowkim. Clearly subsistence is not about lost food, but about lost lifeways, loss of practices, loss of teaching/learning, and loss of identity. This point could be made more forcefully. While the specific impacts may not be entirely predictable, there are likely outcomes that could be included based on experiences in other regions of the state and/or world.

    RESPONSE: The point suggested was made more forcefully in Chapter 12 of the revised assessment.

11. Page 1-2 (P2): "this assessment does not provide an economic *or social* cost/benefit analysis…"

    RESPONSE: Language added to the revised assessment.

12. Page 2-15 (P1): Other important subsistence fish spp not listed in Table 2-5, e.g., whitefish and winter freshwater fish are listed as integral subsistence species in Appendix D. Again make focus here clear.

    RESPONSE: Scope of the assessment and the specific assessment endpoints considered have been clarified in Chapters 2 and 5. Table 5-1 has been incorporated from Appendix B to give a more complete view of the fish species found in the watershed.

13. Page 2-18 (S2.2.4): The net economic valuation ranges presented in Table 73, Appendix E would be helpful to include here.

    RESPONSE: Because the assessment is not meant to be a cost-benefit analysis, we only briefly consider the economic value of the assessment endpoints. In addition, Table 73

deals with the economic value of moose, caribou, and brown bear, which are only considered in terms of fish-mediated effects.

14. Page 2-19 (last sentence): "because no alternative food sources are economic viable." This is a bit of a misrepresentation. The point is that people choose to live subsistence lifestyles. Even if food at the stores was cheap, many would choose not to substitute for subsistence hunting, fishing and gathering. This narrow economic framing misses the cultural and lifestyle component of subsistence, and frames it merely as food procurement. This is not the case throughout the document, but in this instance I would suggest changing this sentence to reflect the irreplaceability of the subsistence lifestyle (dependent on access to high-quality foods) rather than the economic viability of substituting alternative food sources.

    RESPONSE: The revised assessment expands the discussion of the cultural and lifestyle importance of subsistence (Chapters 5 and 12). The economic viability of alternative foods is mentioned in Chapter 12, but in the context of a variety of benefits of subsistence.

15. Page 2-20 (first sentence): Here and in Appendix D, the legal framework for federal and state definitions of subsistence should be clarified. Several times in Appendix D an indigenous subsistence priority is noted (e.g., pg 88: "No other state in the United States so broadly grants a subsistence priority to wild foods to indigenous peoples as does Alaska."). The authors should clarify what they mean by indigenous preference (i.e., as opposed to rural preference?) in state and federal subsistence management. They should include particular references and additional clarifying information.

    RESPONSE: Citations were included in Appendix D in response to this comment.

16. Page 3-2 (P1): "would be benign or have no effect on the environmental *or social systems*,"

    RESPONSE: Discussion of scope has been rewritten (Chapter 2).

17. Page 3-4 (P1): "…provide subsistence for Alaska Natives *and others*." Particularly because subsistence is defined as a rural right in Alaska, all subsistence users should be included as potentially affected groups.

    RESPONSE: References to non-Alaska Natives who practice a subsistence way of life have been included in the assessment. However, the focus remains on Alaska Natives.

18. Page 3-11 (Fig 3-2E): This conceptual model appears less developed than the others. It would interesting to work on expanding it out to include missing dimensions; e.g., add health and healing activity (in addition to nutrition), cultural continuity (alongside social relations and linked to language and traditional ways of teaching). With a decrease in economic opportunities comes an increase in reliance on transfer payments. Overall it is a nice illustration, but strikes me as less complete than the others.

    RESPONSE: The conceptual model has been revised and expanded in response to this comment.

19. Page 4-15 (Table 4-3): Estimation of 200,000 metric tons of ore processed per day is much higher rate than any of the other mining operations listed in Table 4-4. Is this due to the

low/moderate quality of the ore?

RESPONSE: Initially, EPA utilized the ore production rate that was available in Ghaffari et al. (2011), but we have added a smaller sized scenario to the revised assessment to be similar to the worldwide median-sized porphyry copper mine. Processing throughput is generally a function of the quality of ore and the cost of mining and processing the ore. Ghaffari et al. (2011) state: "The process is based on conventional grind-crush-float technology, using proven plant equipment of the largest sizes that have been industrially installed", which suggests that mining rates are limited also by the size of proven mineral processing equipment.

20. Page 4-21 (last P): 208 m high dam is "much higher than most existing tailings dams." What are average dam heights? Or how much higher than most existing tailings dams? Does this high height affect probability of failures?

    RESPONSE: Table 4-1 presents dam heights at other Alaska mines, all of which are significantly lower than 209 m. Higher dams mean larger impoundments, storing more tailings; thus, if failure occurs, more waste material can be released.

21. Page 4-23 (P2): "a well field spanning the valley floor." This is unclear. Could it be added to Fig 4-7? How often would groundwater be monitored?

    RESPONSE: The revision clarifies this sentence, adding that installation would be at the downstream base of all tailings dams to monitor groundwater flowing into the valley. It was not added to the revised figures primarily to keep the figure from becoming too "busy".

22. Page 5-48 (P1): "effluents would be required to meet criteria." How different is treated discharged water from unaffected water?

    RESPONSE: Estimates of wastewater composition have been added to the assessment (Table 8-9). Background surface water data are presented in Table 8-10.

23. Page 5-59 (2nd bullet): Is there any information available on ore processing chemicals, how much are used, and likely toxicities?

    RESPONSE: The toxicity of sodium ethyl xanthate, the primary processing contaminant of concern, is now considered (Section 8.2.2.5). However, its concentration in tailings and concentrate slurries cannot be estimated with any reasonable confidence due to the lack of publicly available information.

24. Page 5-76 (bullet list): The list of cultural factors that may be negatively impacted could include others: individual, community, and cultural identity; sense of place and place attachments; community sustainability; cultural unity/conflict avoidance.

    RESPONSE: The list of cultural factors that could be negatively impacted was expanded in the revised assessment.

25. Page 6-46 (bullet list): In addition to the two listed, another should be added noted that subsistence practices (harvesting, processing, sharing, consuming) are important for

psychological, social, emotional, and cultural health and well-being.

RESPONSE: This section was clarified to focus on nutritional benefits. The discussion of health benefits from subsistence practices was expanded elsewhere.

26. Page 6-47 (P1): "…the physical, *psychological, social, and cultural* benefits of engaging in a subsistence lifestyle…"

    RESPONSE: Revision made.

27. Page 6-47 (P1): References should be added (and were included earlier in the report) for the statement: "would likely employ a small fraction of Alaska Natives."

    RESPONSE: This section has been revised and references the experience of other Alaska Native communities.

28. COMMENTS SPECIFIC TO APPENDIX D

    a. Single-space for consistency with the rest of appendices

    RESPONSE: Appendix D has been single spaced.

    b. The title is a bit misleading. Only eight pages in the report discuss traditional ecological knowledge, and here not in much depth.

    RESPONSE: The TEK section was expanded.

    c. The research design, methods, and data analysis should be described in more detail. Clarify sampling procedure (both for communities and individuals). For example, it is unclear if younger generations, particularly active subsistence harvesters, were targeted as well as elders and culture bearers. Interview protocol should be included clearly as an Appendix.

    RESPONSE: The methodology section has been expanded. Villages were asked to identify Elders and culture bearers for interviews. Younger generations and/or subsistence harvesters were not targeted but could have been included by villages for interviews.

    d. This section may make a few overstatements (e.g., "only in Alaska are wild salmon abundant").

    RESPONSE: comment noted and taken into consideration during revisions.

    e. P12 **–** "those outside of the state." Change to "outside the region," as many urban Alaskans are not familiar with subsistence communities.

    RESPONSE: The text has been revised.

    f. P12 **–** "Since the questions dealt with a cultural standard, there were few alternative points of views." Should cultural agreement be a matter of investigation rather than assumed? This statement needs to be justified. Perhaps with the authors' 40+ years of experience working with these communities they have come to expect cultural agreement, especially among elders. If this is the case, that should be clarified. To what extent did group interviews (2-6 people interviewed together, except for one single interview) also contribute to cultural agreement? These details are important given that the results are given on an agree/disagree format.

RESPONSE: The text has been revised to clarify this point.

g. P17 – 2,738 is listed in Table 2 and 2,329 is listed here.

RESPONSE: The discrepancy has been corrected.

h. P19 – Here is perhaps another example of overstatement – 100% of the population has access to waters of the rivers and lakes. What is meant here? For subsistence, this access depends upon having transportation and gear or social relations. Do 100% of people have this in this region?

RESPONSE: The text has been revised and a table added to clarify that the topic is access to drinking water.

i. P20 – Reword "the archaeological work is largely due to five projects."

RESPONSE: The text has been revised to clarify.

j. P26 – "located along a salmon stream indicates salmon were *likely* a primary resource."

RESPONSE: Text has been revised.

k. P31-32 – Several of these quotes focus on social changes (e.g., elimination of dog teams, relationships to commercial fishing changing over time). People likely harvest less fish now because they do not support dog teams, yet now they need more money for fuel and equipment. These are important considerations for understanding contemporary mixed economy. These points are mentioned in this cultural characterization, but perhaps could be made a bit more clearly. At times, even the contemporary characterization reads a bit like "timeless" traditional cultural relationships to the land and resources, yet it is important to accurately characterize the subsistence-based communities in their full contemporary realities and complexities.

RESPONSE: The quotes in the section focus on history and culture.

l. P34 – "Large disruptions to the population *have not been documented to* occur until epidemic…"

RESPONSE: Text has been revised to clarify.

m. P34/5 – Both kashgee and qasgiq are used for men's house – it is also defined three times over these first few pages of this section.

RESPONSE: The text was revised.

n. P35 – "earlier bow and arrow wards" should either be explained or omitted.

RESPONSE: Reference omitted from the revised text.

o. P38, first full paragraph, last sentence – What is meant by "observe the practice?" This general statement is not adequately supported. Authors should provide specific instances or more discussion if this point is to be included. As written, it risks conveying a static view of TEK and practice and culture. Many indigenous communities in Alaska, e.g., Kodiak villages, while exploited by a colonial economic system, also strategically adapted to benefit from those systems in ways compatible with their village lifestyles (e.g., cannery and village co-dependencies that elder fishermen in this region remember fondly; Carothers 2010). It would be helpful to have more information on this context in this region (e.g., Hébert 2008; Donkersloot

2005).

RESPONSE: Text omitted from the revised draft.

p. P40 – More information would be useful on Alaska Native participation in commercial fishing in this historic period up through the present.

RESPONSE: Additional reference to Alaska Native participation in commercial fishing has been added to the assessment text.

q. P47-48 – Ellam yua and tnughit are defined twice.

RESPONSE: Comment noted. No change made.

r. P81-84, Table 9 – Second/third part of questions no explained. Since this is an agree/disagree table, remove other questions for which no information is presented. All questions would ideally be contained in an interview protocol attached as an appendix.

RESPONSE: This change has not been made. The authors chose to both identify the interview questions and the summary responses in this table. As identified in the introduction the semi-structured interview format was not a "survey" in which one would ask everyone the same set of questions (as required by structured interview protocol), but the protocol called for respondents to talk about the subject elicited by the question. This is a very standard interview technique in anthropology.

s. P87 – 'non-monetize' – but important to note that the modern subsistence economy now depends upon cash inputs (ATVs, boats, snow machines, gas, parts, repairs, guns, nets, etc.).

RESPONSE: The relationship between the modern subsistence way of life and the market economy has been acknowledged in the appendix and the assessment text.

t. P88 – First full sentence, last sentence poorly worded.

RESPONSE: This section has been slightly reworded for clarity.

u. P89-90 – The subsistence discussion is confusing.

RESPONSE: No suggestions for revisions were made.

v. P92-93, Tables – Update with recent data if possible.

RESPONSE: Tables 12 and 13 contain the most recent data available to the public.

w. P100 – If percentage of working age population not in labor force is a better measure, it should be included rather than official employment rates (or in addition to).

RESPONSE: These data were added to the appendix.

x. P110 – "Villagers in the study also eat store-bought foods, but do not prefer them" – make clear again that most residents interviewed were elders or identified culture bearers. A concern for many subsistence villages in other regions of Alaska is the displacement of younger generations from fish camp and other subsistence practices, and preferences for store foods, particularly candy and soda. If this region is unique in that regard, make that clear here.

RESPONSE: The text was revised to make it clear that the interviewees expressed preference for subsistence foods. The section on nutrition was also expanded.

y. Section C "Physical and Mental Well-being" – Subsistence for emotional/mental health should be added as a sub-section here. Given the high rates of social problems in Alaska Native villages (e.g., suicide, violence, addiction), many cultures talk about subsistence practices as being healing activities or producing emotion, spiritual and/or mental health. This important aspect isn't covered in the other sub-sections.

RESPONSE: The discussion of suicide was expanded and a discussion on behavioral and mental health was added to the "Social Relations" section. The text of the assessment was expanded to acknowledge the social and spiritual aspects of the subsistence way of life.

z. P113 – Makhoul et al. is listed as 2010 in references.

RESPONSE: This error was corrected.

aa. P114 – Change Local Wild Fish *and Local Practices*, and "ecologically, *socially, culturally, spiritually,* and possibly even evolutionarily." Point is that subsistence salmon are not just vehicles for protein and nutrition, but form the basis of incredibly important subsistence ways of life that are irreplaceable.

RESPONSE: The revision was made and the discussion of social and spiritual values of the subsistence way of life was expanded in the appendix and the assessment.

bb. P115 – Add 'cultural and social disruption' to the list of risks.

RESPONSE: This revision was made.

cc. P152, 2nd and last bullet points – These are risks of mining development, not of decreased quality/quantity of fish (defined as outside the scope of this assessment). The last bullet point would apply to fish-effects if reworded – some community members may decide it is not safe to eat fish, causing factions of those who express concern and those who do not. Others to possibly include: cultural loss as younger generations do not learn the practices of subsistence; stress on other areas and communities of the region where people may target subsistence resources; and health risks of eating contaminated fish.

RESPONSE: Comment noted. These topics were discussed in the assessment text (Chapter 12).

dd. P156 – Sing to sign.

RESPONSE: Correction made.

ee. Several grammatical errors throughout.

RESPONSE: Every effort was made to correct grammatical errors.

29. COMMENTS SPECIFIC TO APPENDIX E

a. P9 – Components of total value should include indigenous homeland for Alaska Native cultural groups.

RESPONSE: The value of indigenous homeland and the value of being able to bequest that homeland and cultural traditions onto future generations is included in the net economic value analysis presented in Section 5. Section 5.2 discusses and attempts to quantify the cultural value of engaging in a subsistence livelihood,

referred to as the "activity value". Additionally, Section 5.6 discusses the importance of the existence and bequest value of the resource, and the challenges encountered in estimating these values.

b. P12 – Clarify usage of Aleut (Alutiiq/Sugpiaq?).

RESPONSE: The Bristol Bay region includes Alutiiq and Sugpiaq Native Alaskans. This has been clarified in the text of Appendix E.

c. P22 and 26 – Change Boraas citations to Boraas and Knott.

RESPONSE: This change has been incorporated.

d. P32 – Much of recreational use is non-market and could be included in the list at end of 2nd paragraph.

RESPONSE: Because we do estimate the value of recreational fishing, sport hunting, and non-consumptive wildlife viewing, these are not identified as non-market values in this paragraph.

e. P96 – Citation for typical crew share of 10%?

RESPONSE: This estimate is based on the author's interviews with crew members. Appendix E has been revised to make this clear.

f. P122 – Reasons for differences in earnings between local residents and others is important. The mixed subsistence-cash economy and cultural ideas about commercial work in this region may offer an explanation. See: Koslow 1986, Langdon 1986, Carothers 2010.

RESPONSE: These references have been added to Appendix E and a brief discussion has been incorporated in the document.

g. P134 – Ugashik, Egegik, and South Naknek have over 30.

RESPONSE: Thank you for noting that these communities have over 30 permit holders per 100 residents. We have emphasized this in the text.

h. P136, last paragraph – This paragraph seems abrupt/misplaced. A more thorough discussion is needed here to include these points.

RESPONSE: This paragraph describes information in Table 39, which appears immediately below the paragraph. The earnings data in Table 39 is from the US Census as well as the Alaska Commercial Fisheries Entry Commission. As earnings data is limited and the reasons for variation in earnings are not apparent, an additional discussion was not incorporated.

i. P178, Section 4.3 – No discussion of role of regional and village Native corporations or the Community Development Quota program for federally-managed fisheries.

RESPONSE: Section 4.3 provides a broad overview of the economy of the Bristol Bay Region. Although specific entities and programs like the Native corporations and Community Development Quota program are not named, the relative importance of government at a state, regional, and local level is considered. There are many other entities that participate in the economy and government programs that support it. This model of the regional economy does not identify specific government entities or programs.

j. P191 – While the majority of formal sector jobs are taken by nonresidents, may want to note that local economy – subsistence – is all local and highly dependent on resources of the region.

RESPONSE: We appreciate this comment, and this section of Appendix E discusses the local and regional importance of subsistence in paragraph 3. Because this information is covered in detail in paragraph 3, additional information was not incorporated into the paragraph summarizing jobs captured by the market.

k. P193 – 2009 is mentioned as an unrepresentative year and given a sensitivity ranking of "high." More information should be included on the anomalous 2009 – in what direction should we expect to interpret data from this year compared to more average years, or those at other ends of the extremes?

RESPONSE: The yearly variation in the commercial fishing industry is described in detail in Chapter 3. The 2009 fishing data is given a sensitivity rating of high as the data presented in Chapter 4 estimating commercial fishing wages and jobs rely on inputs from the 2009 fishing season.

There is no reason to believe that 2009 is inherently an unrepresentative year for the fishery, but it is impossible to know if it is a representative year for the future performance of the fishery. In order for the wage and job estimates presented in Chapter 4 to be representative of future performance, the 2009 data used to represent the base year would need to also be representative of future performance of the commercial fishery.

To clarify that this is a potential bias as the future of the commercial fishery cannot be predicted, the text associated with this item has been rephrased.

l. P195 – Number of households engaged in subsistence – ADF&G data should provide estimates.

RESPONSE: The analysis relies on data from ADF&G; however, the item listed here identifying the potential bias of the number of households engaged in subsistence acknowledges that the data from ADF&G is purely an estimate. Should the data relied on from ADF&G be found to be inaccurate for some reason, this analysis that relies on those data would be biased accordingly.

m. P198 – ATV, snow machines, should be added to "boats and trucks"; work by Robert Wolfe and others (Wolfe et al. 2009) suggests that about one third of households in Alaska Native villages harvest the majority of subsistence foods (and share, especially with the least active households). How does this finding affect these estimates?

RESPONSE: We recognize that ATVs and snow machines are frequently used in the subsistence harvest. The original data source used to develop these expenditure estimates did not specify expenditures for these machines, and thus they are not identified in the quantified expenditures. In this analysis the total expenditure estimates drive the analysis, not the composition of what these expenditures purchased. Differences in the composition of expenditures would have a negligible bias, as identified in Section 4.8.

The finding from the Wolfe 2009 citation provided above would not affect these findings. This analysis relied on the assumption that all native households are participating in the subsistence harvest, and estimated expenditures based on that

assumption. If some native households are more active than others, the expenditures by less active native households will be lower than those estimated here, but this will be offset by higher expenditures by more active native households.

n. P202 – Explain why % of adults with 4+ years of college is used in this model? The model was not explained clearly enough for me to understand it.

RESPONSE: The percentage of adults with four or more years of college education is used in the model along with other relevant regional variables to predict adjusted gross income per capita for each community. This instrumental variable is included in the analysis because it is a variable that is relevant for predicting adjusted gross income per capita in each community. For additional information on the analysis used, please see Duffield (1997).

o. Some fisheries, e.g., crab fisheries, are not included in the economic analysis, yet depend in part of Bristol Bay ecosystems, as discussed in Appendix F.

RESPONSE: As noted in the assessment, there are other species present that support a commercial fishery, such as the crab fishery the commenter notes. Although Appendix E is predominately focused on the importance of the salmon fishery, some considerations for the commercial and subsistence value of these fisheries is included.

Section 4.3 of Appendix E provides an overview of the regional economy, which fish harvesting and processing. Table 53 estimates employment in the fish harvesting and processing sector. As identified in the footnote to Table 53, these employment estimates include fisheries in addition to the salmon fishery.

Appendix E also acknowledges and considers that subsistence harvests may include species other than salmon. In Section 2.2 of Appendix E the general distribution of subsistence harvest by Bristol Bay residents is presented. As identified in this section, Bristol Bay subsistence harvest includes salmon, non-salmon fish, birds and eggs, vegetation, marine mammals, marine invertebrates, and land mammals. Subsistence expenditures are estimated based on the number of native households and expenditure estimates from Goldsmith (1998). Goldsmith's expenditures consider subsistence expenditures more broadly, thus these other species are included in the economic analysis.

p. References – Peterson et al. 1992 and Brown and Burch 1992 not included in references.

RESPONSE: Change has been incorporated.

30. COMMENTS SPECIFIC TO APPENDIX G

a. Mitigation measures are largely concluded to be ineffective. Would be helpful to compare mitigation measures and their success/failure in other mining examples.

RESPONSE: Appendix G contains available information about mitigation measures generally related to roads and pipelines. Mitigation measures are not specific to mining operations.

31. COMMENTS SPECIFIC TO APPENDIX H

a. P7 – Exposure of groundwater and waterfowl to chemical contaminants are listed as main environmental concerns from tailings storage facilities. Impacts to human health from ingesting contaminated water or birds. Clarify in report that direct risks to human health are not accessed (only through reduction or elimination of subsistence harvests?).

RESPONSE: The assessment language has been clarified to acknowledge that there are potential direct risks to human health, but that the scope of the assessment is limited to potential effects to indigenous cultures related to salmon. An evaluation of human health effects from ingestion of contaminated non-salmon subsistence foods is not within the scope of the assessment. EPA expects that a full evaluation of any future mining permit applications and subsequent National Environmental Policy Act Environmental Impact Statements would consider these direct effects.

Dennis D. Dauble, Ph.D.

1. Appendix B, Page 30: Table 1. I suggest adding a column to indicate relative abundance, for example, if individual fish species listed are abundant, common or rare. Also, are there known differences in distribution and abundance for the Nushagak and Kvichak watersheds relative to those watersheds unlikely to be affected by mining activities?

   RESPONSE: This information, when known, has been added to Appendix B.

2. Appendix A, Page 42: The statement that diminished salmon runs present a "negative feedback loop" where spawner abundance declines, appears to conflict with the last paragraph on page 41.

   RESPONSE: The text describes bottom-up effects of MDN on stream ecosystems and points out that these linkages have not been empirically established. The negative feedback loop mentioned in the following paragraph could result from reductions in salmon-based resources that promote either bottom-up (i.e., a reduction in salmon-derived N and P) or direct (i.e., a reduction in salmon eggs and flesh that can be consumed by fish) benefits to juvenile fishes. Further, the fact that bottom-up effects of MDN have not been firmly established does not negate considerable circumstantial evidence for bottom-up nutritional deficits in Columbia Basin spawning streams. Edits have been made to help clarify.

3. Appendix F, Page 3: Is there significant sediment transport from the Bristol Bay watershed to the Nushegak and Togiak Bays/estuaries?

   RESPONSE: A new section was added to Appendix F that discusses the importance of estuary habitat to salmon populations.

4. Appendix F, Page 7: What is the juvenile salmon resident time in Bristol Bay? How quickly (and at what size/time of year) do they move from shallow nearshore to offshore habitats?

RESPONSE: A new section was added to Appendix F that discusses the importance of estuary habitat to salmon populations.

5. Page 8-15 (L2): Suggest deleting "likely." There will be impacts.

   RESPONSE: We believe this language is consistent with the uncertainties explained in the assessment. No change has been made.

Gordon H. Reeves, Ph.D.

1. Page 6-9 (P1): Why would resident fish not "suffer" immediate loss of habitat as a result of dam failure like anadromous fish would?

   RESPONSE: This statement refers to fish located upstream of TSF failure and affected downstream reaches. This has been clarified in the text.

2. Couldn't fish move to another stream if a culvert is blocked and prevents upstream movement? This may eliminate the fish from a particular stream for a year but it might not reduce the overall productivity.

   RESPONSE: This comment is based on the assumption that spawning and rearing habitat are not limiting. We believe that they area.

Charles Wesley Slaughter, Ph.D.

1. Global: Provision of full color versions of all figures would have been helpful to this review. The selected color versions supplied here were useful – we should have had them all.

   RESPONSE: Comment noted.

2. Page 2-4: Color codes are confusing – use of different colors for same "moisture state" in the five regions doesn't make sense (to me).

   RESPONSE: Figure 2-2 (Figure 3-1 in the revised assessment) depicts hydrologic landscapes across the Nushagak and Kvichak watersheds separated into their physiographic divisions as defined by Wahrhaftig (1965), combined with their climate class as defined by Feddema (2005). Each color group (e.g., yellow, green, red, etc) represents a separate physiographic division while color intensity (e.g., light green to dark green) represents the climate class within a given physiographic division. The use of different colors is intended to show the variety of climate classes within a given physiographic division, while also depicting similarities in climate class across different physiographic divisions (e.g., darkest red and darkest green show that two areas having different physiographic characteristics are alike in their climate class).

3. Page 3-4 (S3.4, L1): …when mine ***is*** active

   RESPONSE: Correct (now in Section 4.2.4).

4. Page 4-5 (last P): Refers to Fig. 3-1, but "existing road segments" listed are not shown on Fig. 3-1, nor are several cited locales: Williams Port, Pile Bay, King Salmon, and Naknek.

   RESPONSE: This reference has been deleted.

5. Page 4-11 (first P): "The vast majority of tailings dams are less than 30 m in height…" DOES THIS REFER TO TAILINGS DAMS AT ALL KNOWN MINING OPERATIONS, OR TAILINGS DAMS ENVISIONED OR PROBABLY TO BE USED IN BRISTOL BAY WATERSHED?

   RESPONSE: The sentence refers to all known mining operations. The text was changed from "The vast majority of tailings dams..." to "The majority of existing tailings dams..." (Chapter 4).

6. Page 4-11 (first P): "Although upstream construction is considered unsuitable for impoundments intended to be very high or to contain large volumes of water or solids….this method is still routinely employed." ARE THE TSFs SUGGESTED IN THIS ASSESSMENT CONSIDERED "UPSTREAM," "DOWNSTREAM," OR "CENTERLINE"? Para. 1, Section 4.3.5 (p. 4-21), states that "the most plausible sites" for TSFs are "the higher mountain," which suggests that these TSFs would be "upstream" facilities, therefore "considered unsuitable…"

   RESPONSE: The TSFs suggested in the scenarios would be constructed using the downstream method and then switched to a centerline method. It is true that in this location, the upstream construction would be unsuitable. The discussion of the upstream method was intended for background and has been moved to Chapter 4 in the revision, with the scenario-specific suggestions discussed in Chapter 6.

7. Page 4-23 (P2): Text suggests that a monitoring well field downslope from the TSF (and presumably from all hypothetical TSFs) would detect seepage; such seepage would then be intercepted and either returned to the TSF or "treated and released to the stream channel." Either action presupposes adequacy of monitoring seepage and subsurface flow (both spatially and temporally); returning such water to the stream further presupposes fully adequate treatment to meet both regulatory and aquatic biota requirements for water quality and flow regime.

   RESPONSE: Yes, the well fields would be downstream from all embankments for all TSFs and this has been clarified in the revision. It is assumed for the scenarios that mitigation measures are operated appropriately. Text has been clarified in the new Chapter 6 to indicate that water would be treated to meet permit requirements. Scenarios in the revised assessment evaluate effects from uncaptured seepage during routine operations from both the TSFs and waste rock piles.

8. P4-26 to 4-28 (S4.3.7): This "Water Management" section seems cursory, highly generalized, and optimistic. Statements such as "uncontrolled runoff would be eliminated"; "water from these upstream reaches would be diverted around and downstream of the mine where practicable"; and "Precipitation…would be collected and stored…." do not indicate actual (proposed) practices or techniques, nor inspire confidence that actual runoff events during "normal" conditions, let alone during hydrologic extremes (such as a rain-on-snow

event with underlying soils still frozen) would be planned for or actually managed adequately.

RESPONSE: Water management measures are more clearly described and discussed in the revision (Section 6.1.2.5), and in sub-sections for the mine components in the scenarios. Measures are standard and common to existing mine sites.

Collection and diversion structures would need to be designed and built to handle the anticipated flows over the life of the mine, including during extreme weather events. The details of these collection and conveyance systems are beyond the scope of this assessment and are more properly in the domain of the permitting process when a specific mine plan is proposed.

9. P4-29 (P1): Suggests that 20% more water than available would be required "during startup," and that difference would be satisfied "from water stored in the TSF"; if 20% more than is available would be needed, where would it come from to be available from the TSF?

   RESPONSE: The water balance has been revised in Chapter 6. The mine operation would capture more water than needed during all phases of operation. Water could be stored in the TSF as soon as the starter embankment is operational. Ghaffari et al. (2011) further explain: "Once the TSF starter embankment construction is complete, site water will be diverted into this facility to ensure adequate make-up water for process plant start-up. At this time, advanced open pit dewatering will commence. This water will either be treated and discharged or diverted to the TSF, depending on environmental requirements."

10. Page 4-29 (P3): Assumptions are very generalized and optimistic: "assuming no water collection and treatment failures" and "excess captured water would be treated…and discharged to nearby streams..." – this assumes both "no failures" over the life of the operation, and that such treated "excess captured water" could be successfully treated before release to fully meet both regulatory water quality criteria and the possibly more sensitive biological requirements of individual invertebrates and fish stocks (Appendices A & B).

    RESPONSE: Water management measures are more clearly described and discussed in the revision in Section 6.1.2.5, and in sub-sections for the mine components in the scenarios. Measures are standard and common to existing mine sites. The revised assessment considers water treatment failure quantitatively and includes refined scenarios with new data for seepage from TSFs and waste rock piles.

11. Section 4.3.8: This and the previous section mention (but in my view, do not adequately stress) the extremely long time frame for post-mining active management and oversight. Many hundreds of years of active management is a longer time than many industrial, corporate or governmental entities are capable of really embracing – witness the current US Congressional practice of "kicking the can down the road" – a human trait.

    RESPONSE: This issue is addressed in Section 4.2.4 of the revised assessment.

12. Page 4-32 (S4.3.8.2, P3): Suggests that pyritic tailings could be "shipped off site" – i.e., to where? Deep ocean dumping, or Yucca Mountain?

RESPONSE: For smaller amounts of tailings, the option of shipping them to an off-site location for disposal might be an option; however, this is less likely with large mines with high volumes of tailings, so has been removed in the revised assessment.

13. Page 4-34 to 4-37 (S4.3.9): This reviewer finds the short Transportation Corridor sub-chapter to be succinct, but inadequate and superficial in view of the long-term consequences of imposition of the transportation corridor as portrayed. These deficiencies are addressed, in part, in other sectors of the Assessment, most comprehensively in Appendix G.

    RESPONSE: The transportation corridor analysis has been substantially expanded, and is now found in its own chapter (Chapter 10).

14. Page 4-38 (Box 4-3, P2): Para. 2 states that the southwest extension of the Lake Clark Fault is currently understood to extend to perhaps 16 +/- km from the Pebble ore deposit; however, this is not reflected in Figure 4-11, which suggests that the Lake Clark Fault terminates perhaps 100 km northeast of the Pebble locale. Elsewhere in Box 4.3, there is acknowledgement that, while there is no evidence of recent tectonic activity in the immediate Pebble vicinity, there is relatively little site-specific data or long-term historical seismic record. I infer that any predictions concerning seismicity or earthquake occurrence of any magnitude would have very high uncertainty.

    RESPONSE: Figure 4-11 (now Figure 3-15) has been revised to more accurately illustrate the current understanding of the terminus of the Lake Clark Fault. Section 3.6 describes the uncertainties in predicting seismicity in the Pebble region.

15. Page 4-41 (Box 4-4): Note that in each of the four tailing dam failure examples, the failed structure was roughly an order of magnitude **smaller** (in height) than the hypothetical TSF-1 structure, yet those failures had major negative consequences.

    RESPONSE: Text was added to Section 9.1.1 in the revised assessment to indicate that the dams in these failure examples were significantly smaller than the dams proposed in our mine scenarios."

16. Page 4-45 to 4-47 (S4.4.2.2): The probability approach to tailing dam failure is unpersuasive as presented. It is difficult to relate to a number like "0.00050 failures per dam year," or to the implication (p. 4-47) that one can expect a tailings dam failure only once in 10,000 to one million "dam years." This could suggest to the casual reader that failure of the hypothesized TSF1 dam (for which one "dam year" is one year) should not be anticipated in either the time of human occupation of North America, or the span of human evolution.

    RESPONSE: The proposed dams, if designed, built, and maintained to current engineering best practices, would be anticipated to have a low annual probability of failure but the failure probability would not be zero. We concur with the commenter that these low probability numbers may be difficult for the casual reader to grasp, so we also present the estimates of probability in terms of probability failure over different time periods. For example, an annual probability of failure of 0.0005 equates to a 5% probability of failure over 100 years and a 39% probability of failure over 1000 years. Text was also added to clarify the basis for our failure rates.

17. Page 4-48 (Box 4-6): Box 4-6 suggests that the Operating Basis Earthquake (OBE) for a 7.5-magnitude event at the Pebble locale has an estimated return period of 200 years. Such a return interval probability is difficult interpret, given the lack of historical seismic record for the region; in any event, such a return period estimate is in no way predictive of future seismic activity, in year 2012 or year 2212.
Box 4-6 does note that "The return periods stated in Alaska dam safety guidance are inconsistent with the expected conditions for a large porphyry copper mine developed in the Bristol Bay watersheds, and represent a minimal margin of safety..

RESPONSE: The return periods used are consistent with the Alaska Dam Safety Guidance, but the operator could include an additional margin of safety in the design for critical structures. The return period and seismic safety factors do not inform the failure analysis in this assessment.

18. Page 4-50 to 4-60 (S4.4.2.4): The modeled hydrologic consequences of overtopping/flooding of the hypothetical TSF1 dam/reservoir seem reasonable, given the relatively limited hydrologic data set available for model input. Probable Maximum Precipitation and Probable Maximum Flood results should be approximately "correct" and within the same order of magnitude of potential storm and flood events. The potential consequences outlined (peak flow volume, sediment transport and deposition, length of stream corridor impacted) appear realistic for the scenario. I suggest that this topic and hypothetical result should be given more visibility and emphasis in the assessment.

RESPONSE: The dam failure was modeled as an overtopping event since the possibility could exist. However, the magnitude of the PMP run-off as compared to the resulting failure flood wave is very small. We agree that an actual dam design will consider additional information, but this assessment did not investigate the hydrology of the PMF in greater detail.

19. Page 4-62 to 4-63 (S4.4.4): While accurate, this section does not adequately address the road/stream crossing/culvert issue. Given the projected transportation corridor, Pebble locale to Cook Inlet, and the inevitability of a further network of "minor" roads in the mine and TSF locale, plus additional infrastructure linkages, road/culvert/stream crossings are a major concern for aquatic habitat and fisheries. This issue receives more attention in Sections 5.4 and 6.4, and is mentioned elsewhere in Volume 1 (e.g., Table 8.1, Box 8-1, para. 8.1.2.4.). Readers of the Assessment should be directed to Frissell and Shaftel's Appendix G for a more comprehensive discussion of this important topic.

RESPONSE: This issue is now analyzed in more detail in its own chapter (Chapter 10). The appendix is cited.

20. Chapter 5: Assumes scenario of "no failure" for entire project, over complete project life. Is this a realistic scenario, given experience with industrial developments in real-world settings subject to vagaries of equipment, landscape, geology, weather, local climate, and human judgment and decision making/execution?

RESPONSE: The "no failure" scenario has been eliminated in response to several comments, and is now considered in terms of mine footprint impacts in Chapter 7.

21. Page 5-1 (S5.1.1): Question: is "sampling extensively for summer fish distribution over several years" adequate for characterizing fish populations, given the wide fluctuations in salmon escapement and return note elsewhere in the Assessment (e.g., Table 5-1, para. 5.1.2)?

    RESPONSE: The answer to this question is of course dependent upon the objectives of the characterization. For the purposes of this section of the assessment, identifying species distributions within the study area, sampling was adequate for minimally characterizing the distribution of salmon, Dolly Varden, and rainbow trout within the project area, including known spawning areas.

22. Page 5-12 to 5-48 (S5.2): Estimates of habitat, wetland and stream blockage or loss seem reasonable, but, as noted in the text, are probably conservative or "at the low end."

    RESPONSE: Agreed. No change suggested or required.

    Estimates of probable streamflow diminution (p. 5-25) seem reasonable, but make no reference to seasonality.

    RESPONSE: We assume a constant seasonal demand, thus streamflow changes follow baseline seasonal patterns under this analysis. We clarify that water managers may alter holding and release of water to address environmental flow needs.

23. Page 5-29 to 5-30 (thermal regimes): This section makes no mention of aufeis or "nalyds," ice accumulations which can exert major control on spring and early summer habitat availability and thermal conditions. For examples, see Slaughter (1990), among many other references.

    RESPONSE: Citation and text have been added in Section 7.3.2.

24. Page 5-30 to 5-31: Concur that maintenance of natural flow regime is the desirable target; the "sustainability boundary" approach is a way to attempt managing within the "natural" bounds of variability. Note: Figure 5-9 is map of streams and wetlands lost, <u>not</u> predicted flow alteration hydrograph (see last sentence, p. 5-31).

    RESPONSE: Figure references have been updated.

25. Page 5-37 (Figure 5-10): UT100D – predicted flow is ALWAYS below lower 20% sustainability boundary. UT100C, UT100C1, UTC100B –predicted flows are always within the 20% +/- sustainability boundaries.

    RESPONSE: Figure has been revised, and data now presented in Table 8-1.

26. Page 5-38 (Figure 5-11): Predicted flow for two upper gages (SK100G, SK100F) is always below the 20% sustainability boundary. Predicted flow at other gages appears to be near or within the 10% and 20% lower sustainability boundary.

    RESPONSE: Figure has been revised, and data now presented in Table 8-2.

27. Page 5-39 (Figure 5-12): Predicted high flow for NK119A is far below the lower 20% sustainability boundary throughout the open water season. From onset of snowmelt, flow at

other gages is roughly at or within the lower 20% sustainability boundary.

RESPONSE: Figure has been revised, and data now presented in Table 8-3.

28. Page 5-41: Gage NK119A – is the estimated decrease of streamflow (minimum mine size) 63% (Table 5-13) or 73% (text)?

    RESPONSE: Values have been updated.

29. Page 5-41: In any case, text is clear: predicted flow reductions for North and South Forks Koktuli River are materially below the lower 20% sustainability boundary. Text suggests that while upper Talarik Creek would be essentially obliterated in this hypothetical scenario, lower gaging stations on Talarik Creek might have partial augmentation of reduced flows, from small tributary flows and groundwater; without supporting data, this suggestion seems unsupportable.

    RESPONSE: Revised text illustrates important trans-watershed groundwater contributions to lower Upper Talarik Creek.

30. Page 5-42 to 5-45: These pages fairly summarize the potential for substantive alterations to streamflow regime and surface water/groundwater relationships.

    RESPONSE: No change suggested or required.

31. Page 5-44 (P3): "Once the mine is no longer a net consumer of water, we assume that flow regulation through the water treatment facility could be designed to somewhat approximate natural hydrologic regimes, which could provide appropriate timing and duration of connectivity with off-channel habitats." I suggest that this is a highly optimistic assumption, and does not address water quality questions (which are raised elsewhere in the Assessment).

    RESPONSE: We emphasize that the ability to manage flows will be dependent upon sufficient infrastructure and flexibility in water management.

32. Page 5-45 (S5.2.3): This entire paragraph should receive greater emphasis.

    RESPONSE: This section (now Section 7.3.3) has been expanded.

33. Page 5-46 (P4): Ignores variable-source-area concepts, which are widely accepted in hydrologic and watershed analysis.

    RESPONSE: We respectfully disagree. The variable source area concept presents the idea about the expansion and contraction of saturated areas that are the immediate source of streamflow during storms. In does not invalidate the notion that the total drainage area contributes with long flowpaths to streams. These long flowpaths ultimately contribute to saturated zones that support perennial streamflows..

34. Page 5-46 (P5): Assumes requirement for more water than is available, but leaves hanging the question of where that more water might be sourced. Given that the site is a watershed headwaters, what might be tapped as additional water supply, and what might be the impacts

on that source(s)?

RESPONSE: The revised water balance indicates that the mine would have the capability to capture more water than it needs during all operational phases, including start-up, from within the mine footprint.

35. Page 5-59 to 5-63 (S5.4): See earlier cautions concerning stream crossings, culverts. Note that road cuts and culverts are particularly susceptible to development of aufeis ("icings"), often resulting from blockage or alteration of subsurface water movement during cold conditions, as witnessed by long-standing AKODT maintenance issues – Richardson, Steese, Dalton highways, for example.

    RESPONSE: The potential for culvert blockage by aufeis is discussed in Chapter 10 of the revised assessment.

36. Page 5-60 (S5.4.2, P1): The statement that "…it is unlikely that a mine access road would have sufficient traffic to significantly contaminate runoff with metals or oil" is unsupported; it might be instructive to look at traffic loads for the access road from the Steese Highway to the Ft. Knox mine, a much smaller operation than the proposed Pebble development.

    RESPONSE: This statement no longer occurs in the assessment.

37. Page 5-60 (S5.4.2, P2): First sentence is correct. Second sentence is unsupported and probably incorrect (see Appendix G). Yes, runoff from roads is location-specific; that **does not** mean that runoff from roads would be insignificant to salmonids, given the very large number of streams (perennial, intermittent, and ephemeral), and wetlands, which would be intersected by the total road system of the Pebble project. This also seems to be contradicted by Section 5.4.3.

    RESPONSE: This issue is now given more attention in Chapter 10.

38. Page 5-60 (S5.4.4.1): There are many more water or seep crossings than 34 – see USGS topog sheets, ACME Mapper, or Google Earth.

    RESPONSE: The number of crossings has been updated in the revised assessment.

39. Page 5-61 (S5.4.4.2 and 5.4.4.3): Development of aufeis ("icings") consequent to partial or full culvert blockage, or induced by soil mantle compaction (i.e., by roads or off-road vehicle traffic) can partially or wholly block stream channels. Such blockage, in association with ice on the streambed, may last long past snowmelt and persist well into early summer, possibly affecting fish movement.

    RESPONSE: The potential impact of aufeis on stream channels and potential existence past breakup is discussed in Chapter 10 of the revised assessment.

40. Page 5-62 (S5.4.5): While I don't have the specific citations at hand, there are published analyses of dust effects associated with the North Slope haul road and Prudhoe Bay road network. Obvious effects include accelerated snowmelt along the road corridor, and nutrient or pollutant contributions to road corridor environs.

RESPONSE: The revised assessment includes information from published literature on dust effects in the Arctic (Chapter 10).

41. Page 5-63 (S5.4.6.3): Should it read "…*impacting* 270.3 km of stream…"? (Incidentally, it is interesting that this coarse assessment finds it possible to state impact to within 100-meter resolution.)

    RESPONSE: The revised assessment notes that risks to salmonids from de-icing salts and dust suppressants could be locally significant, but we cannot state that the entire stream length between potential road crossings and Iliamna Lake would be affected.

42. Page 5-65 (S5.4.7.3 and 5.4.8.3): Viewing the transportation corridor landscape, via maps, Google Earth or ACME Mapper, gives me the impression that the estimate of 4.9 km^2 wetlands directly impacted is a very low number. It is easy to play with the numbers given on pp. 5-69 - 5-70, regardless of their accuracy; 66 km of road impacting wetlands, assuming a 10-meter roadway footprint, yields 0.66 km^2 of wetlands "under the road" (vs. 0.18 km^2 in the text). The 200-meter proximity to wetlands cited, over 66 km of road, yields some 13 km^2 of wetland impact (vs. 7.3 km^2 in the text). 80 km of road within 200 m of streams or wetlands yields 16 km^2 of road/wetland impact. Since these are all assumptions and estimates, it is not possible to conclude that any of these figures would be the "true" area impacted.

    RESPONSE: The 0.18 km^2 refers to the area of wetlands which would be filled by the roadbed "intersecting" wetlands (19.4 km length of roadbed x 9.1 m width of roadbed), and does not include roadbed adjacent to wetlands (note that this area is 0.11 km^2 in the revised assessment due to a slight change in methodology for measuring road length). The 4.9 km^2 (not 7.3 km^2) area of wetland within 200 m of the length of road (on both sides) within the study area is based on actual National Wetland Inventory (NWI) data (the calculation methodology is described in Box 10-1 of the revised assessment).

    Though NWI data were utilized in this analysis, the 200 m road buffer was derived from a literature estimate of the road-effect zone for secondary roads.

43. Page 5-74 (S5.4.10): Should this say ***impact*** rather than "risk"?

    RESPONSE: "Impact" could be used here, but we chose to use "risk" to note the probability rather than certainty that salmon would be affected by the corridor-associated activities/events listed

    Text implies that even this "no-failure" scenario will impact salmonids; however, it is apparently not possible to estimate specific changes or the magnitude of such changes.

    RESPONSE: The no-failure scenario has been eliminated in response to several comments; effects resulting from the mine footprint are now discussed in Chapter 7. The exact magnitudes of changes in fish productivity, abundance and diversity cannot be estimated at this time, but the species, abundances, and distributions that would potentially be affected are summarized in Chapter 10 of the revised Assessment.

44. Page 5-74 to 5-77 (S5.6): This section seems cursory and understated, particularly in view of the extensive discussion of Appendix D.

RESPONSE: The discussion of fish-mediated effects on Alaska Native culture has been expanded and is now in Chapter 12.

45. Section 6.1: Concur with general overview statements, and with conclusions regarding immediate consequences of TSF dam failure, which would likely be as severe as or more severe than stated in 6.1.2.1.
P. 6-6, first sentence – note that the failure scenario predicts over 70% fines < 0,1 mm, vs. the 6% "natural" fines concentrations.
P. 6-13, last para. – the assumption that overtopping would not occur in winter is not warranted, as the authors admit when citing the Nixon Fork Mine incident. In the Bristol Bay environment, a major rain-on-snow event in winter or spring is within the realm of possibility, and of course human error is, if not inevitable, always possible.

RESPONSE: We clarify that the scenario we chose to illustrate overtopping did not occur during low-flow conditions, but was in response to a flood. We acknowledge that failure at other times, and in response to other events, is possible (Section 9.3).

46. Page 6-15 (Box 6.2): Box text implies that human error, lack of timely oversight and correction was responsible – but never directly says "human error." The apparent assumption that there is no hydrologic activity after freeze-up (or perhaps, after an ice cover forms on the pool) was naïve and incorrect. At least in that case, it appears that both dam and spillway design (not adequately considering winter and ice conditions) and operation/inspection (human error) were responsible.

RESPONSE: The comment is probably correct. However, we have no evidence that the commenter's conclusion that both engineering error and operator error were responsible was correct.

47. Section 6.1.4.1: Appropriately recognizes the long time period for exposure, over extended stream lengths, through both initial deposition and multiple re-mobilization and redeposition events.

RESPONSE: Agreed. No change suggested or required.

48. Page 6-28 (S6.1.5 and Table 6-6): Seems jargon-laden and does not add to strength of the Assessment.

RESPONSE: Opinion has been divided concerning this explicit weighing of evidence. Given that the analysis of risks to fish from exposure to spilled tailings involves six separate lines of evidence, the EPA intended to show and discuss how the evidence was weighed.

49. Page 6-29 (S6.1.7): Concur that remediation "…would be particularly difficult and damaging…"

RESPONSE: No changes suggested or required.

50. Page 6-30 (S6.2): Even though "We do not assess failures of the natural gas or diesel pipelines…," those pipelines would be equally susceptible to failure as the slurry line.

Concerns with pipelines crossing streams, watercourses and wetlands are similar to those earlier expressed for the road corridor. Similarly, I suspect that careful inspection would reveal many more "watercourses," including intermittent and ephemeral streams, than the 70 crossings cited.

RESPONSE: A diesel spill has been added to the assessment, but it was judged that a gas leak would not pose a potential risk to fish (Chapter 11).

The "probability" argument on p. 6-32 is an understandable attempt at quantification, but is unpersuasive. Given the spill history of TAPS, pipelines in the Prudhoe Bay field, and recently in Montana (?), suggesting the probability (with what confidence limits?) that there "should be" only 1.5 stream-contaminating spills in78 years of operation seems wildly optimistic.

RESPONSE: These probabilities and frequencies are based on a large data set, not just the TAPS experience (which is an atypical pipeline design and much larger than the diesel line) or the spill in the Yellowstone River (which is a single event).

Assuming that any spill (over the 78-year project span) would last only two minutes (pp. 6-32, 6-34), with a consequent minimal volume of spilled material, also seems highly optimistic. Even highly-automated systems, with redundant sensors and automatic responses, are susceptible to error or failure, and the Bristol Bay watershed environment is not benign with regard to mechanical apparatus.

RESPONSE: The EPA agrees with this comment and has increased the response time to 5 minutes.

The authors appear to recognize this with their discussion of the Alumbrera incident.

RESPONSE: No change suggested or required.

51. Section 6.4: Potential road/culvert failures are recognized (again, not that ice issues are not discussed). Extended periods for repair/rebuilding might be anticipated – witness the repeated problems with the highway to Eagle, AK over the past several years – and that is a State of Alaska responsibility, not that of a private company.

RESPONSE: We agree with the commenter that extended periods for repair/rebuilding might be anticipated. Chapter 10 of the revised assessment notes that long-term fixes to a road that was damaged by erosional failure of a culvert may not be possible until conditions are suitable to replace a culvert or bridge crossing. Further, multiple failures, such as might occur during an extreme precipitation event, would likely require longer to repair.

Potential for multiple simultaneous or concurrent failures is appropriate. Non-Alaska examples would be the Pacific Northwest flood events of 1964 and 1996, both major precipitation events with widespread flooding and road failures, in a region with much more developed infrastructure and response capacity.

RESPONSE: We agree with the commenter with respect to the likelihood for multiple simultaneous or concurrent failures during extreme precipitation events. This is alluded to in the assessment.

52. Chapter 7: Recognition of probable additional mining activity, in the wake of a Pebble project, is appropriate. Assessment is necessarily limited to currently-known potential mining projects. The cumulative and irreversible consequences of multiple developments, with associated road, power, housing, communications infrastructure ("secondary development") should be more heavily emphasized, even though it is not possible to quantify all those consequences.

    RESPONSE: The cumulative impacts of multiple developments, road corridors, and secondary or induced development have been emphasized through additional discussion in Chapter 13.

53. Chapter 8: Section 8.1.2 – note many potential failure modes not analyzed; the lack of analysis in this Assessment should not be taken to mean that such failure could not or will not occur.

    RESPONSE: Because the number of potential failures is extremely large, it is necessary to choose a representative set of failure scenarios. The focus of the assessment was on potential effects to salmon. The revised assessment includes more failure scenarios (e.g., diesel pipeline failure, quantitative water treatment failure, and refined seepage scenarios) and explains why these particular failure scenarios were chosen. Section 14.1.2 in the revised assessment explains that the assessment only presents a few failure scenarios. The EPA agrees with the commenter that lack of analysis should not imply a failure could or will not occur.

54. Table 8-1 (Row 2): The reasoning behind the statement that "Most [product concentrate pipeline] failures would occur between stream or wetland crossing [sic] and might have little effect on fish" is hard to understand; stream crossings, whether via elevated utilidors or via sub-channel borings or utilidors, are locales of angular change, piping connections and joints, and subject to stresses of hydrologic extreme events – so why would such sites be less subject to potential pipeline failure?

    RESPONSE: Most of the corridor is not at or adjacent to a stream or wetland. Therefore, failures are most likely to occur between streams or wetlands rather than at streams or wetlands. The statement is not about probabilities per unit length.

55. Page 8-4 (Box 8-1): As noted elsewhere, the probability arguments for TSF dam failure are not persuasive, and seem designed to imply that a TSF dam failure would not occur within the next 10,000 years (or 3,000 to 300,000 years with three TSFs operational). This implication is difficult to square with information on actual past failures presented in Box 4-4 and Table 4-8.

    RESPONSE: The discussion of this issue has been expanded to clarify that the failure rate is a design goal and is not based on empirical evidence.

56. Chapter 8: The potential risks and impacts are fairly and succinctly stated. Given the extremely long-term nature of the projected Pebble project, and the irreversible changes which would be imposed to the region, the risks seem, if anything, understated. I attribute this to the decision to focus this Assessment on salmon and anadromous fisheries, with some attention on salmon-mediated impacts – i.e., effects on indigenous culture, on wildlife other

than salmon, etc.

RESPONSE: No change suggested or required.

John D. Stednick, Ph.D.

1. Page ES-9: Economics of Ecological Resources – section seems weak.

   RESPONSE: Economic data were included as background only. Economic effects of mining are not assessed.

2. Page ES-14: Overall risk to salmon and other fish. Never really separates fish species out in other discussions. Dolly varden more sensitive to metals?

   RESPONSE: The distributions of the salmonid species can be and are distinguished by species, but not by their sensitivities to metals. For copper and some other metals, data are available for rainbow trout that can be applied to other salmonids. Dolly Varden have not been used as a test species.

3. Page 2-3 (P3): Four climate classes. Why this classification system? Perhaps easier to identify by watershed maps?

   RESPONSE: Climate classes are used as defined from Feddema (2005) to give the average annual moisture index. The Feddema Index was used as it broadly characterizes a given landscape location on a spectrum of wetter to drier conditions due to the effects of precipitation and evapotranspiration. Climate classes are used independent of watershed boundaries, as this classification system allows one to compare regions that are either alike or dissimilar across watershed boundaries and highlight that, depending on scale, watersheds can be quite heterogeneous in their degree of water availability from headwaters to mouth. The revised assessment now has five classes ranging from semiarid to very wet as shown in Figure 3-1.

4. Page 2-5: Precipitation values – significant figures?

   RESPONSE: Precipitation values as shown in Figure 2-3 (Figure 3-2 in the revised assessment) are calculated from SNAP data. SNAP data report monthly values of precipitation to the nearest mm. During calculations, all precipitation values are rounded to the nearest whole mm.

5. Page 2-23: Monthly values of streamflow. Would be nice to see average or daily streamflows somewhere.

   RESPONSE: The purpose of this figure is to show the general pattern of annual streamflows in this region. More detailed information (e.g., daily flows) are readily available for the USGS gages, but those data are not necessary to illustrate general annual trends.

6. Pages 3-7 to 3-11: Would like to see more discussion of conceptual models. If a picture is worth a 1000 words……

RESPONSE: Conceptual models have been revised and new models developed, and these models now appear in each of the risk analysis chapters to clarify the pathways considered in each chapter.

7. Page 4-1 (P1): *…represent current good, but not necessarily best, mining practices*. Why not use the best methods or state of the art methods?

   RESPONSE: With regard to the terminology of "best", "good", or other terms for the practices used, what was intended to be conveyed in the assessment is that we assumed modern mining technology and operations. The terms are qualitative when generally interpreted, or have a regulatory meaning. The term "best management practices" is a term generally applied to specific measures for managing non-point source runoff from storm water (40 CFR Part 130.2(m)). Measures for minimizing and controlling sources of pollution in other situations are referred to as best practices, state of the practice, good practice, conventional, or simply mitigation measures. We have added a text box in the revised Chapter 4 to discuss terms.

8. Page 4-18: Shaded relief. Perhaps contour lines in another figure?

   RESPONSE: This figure is showing shaded relief of the landscape in Figure 4-6 and is consistently used across multiple figures as a common base map for figures in this assessment. It was decided to use shaded relief as opposed to contour lines to keep the figure(s) cleaner in appearance, while also showing general topographic features. The focus of this figure is on significant mineral deposits within the assessment watersheds and not topography, therefore we have decided to keep the background as currently shown.

9. Page 4-21 (P1): *…most plausible sites given geotechnical, hydrologic, and environmental considerations.* Can this be elaborated?

   RESPONSE: This sentence was intended to convey that these locations have similar geotechnical, hydrologic, and environmental conditions to the site of TSF 1. A more comprehensive overview of the geologic and geomorphic setting of the Nushagak and Kvichak River watersheds is now provided in Chapter 3.

10. Page 4-21 (P2): *The TSF would be unlined other than on the upstream dam face and there would be no impermeable barrier constructed between tailings and underlying groundwater.* Is this correct? I thought I read the whole TSF would be underlain by liner?

    RESPONSE: The assessment states that TSF embankments would have an engineered liner, but the impoundment is not lined in our scenarios. A full liner is possible, but with very large TSFs, stability with a liner may become an issue and benefits must be weighed against other potential adverse outcomes, as well as costs. This is something that could be considered in a regulatory permitting process. No change required.

11. Page 4-24: *Leachate Recovered*. This refers to only the leachate collected from the dam face?

    RESPONSE: No, this box refers to leachate from tailings and waste rock. The text "leachate recovered" in the formula included in the box refers to the leachate recovered in testing conducted by the PLP. No change required.

12. Page 4-26: Water management. This is confusing. Collect precipitation for processing, yet divert upstream waters around the mine and not use? Where are the leachate recovery wells, and are they just a safeguard?

    RESPONSE: Water management measures are now clearly described and discussed in the revision (Section 6.1.2.5), and in sub-sections for the mine components in the scenarios. Upstream water sources would be diverted around a mining site to minimize losses of that water source to the environment, as it could remain uncontaminated. The leachate monitoring wells are to monitor groundwater downstream from the TSFs and waste rock piles that would experience infiltration of their surfaces by precipitation falling on them. Those wells could be converted to recovery wells, or new recovery wells placed, if it were found that seepage from these structures had contaminated the groundwater. Measures are standard and common to existing mine sites.

13. Page 4-28: Significant figures on precipitation estimates? What is the ET and how is it calculated?

    RESPONSE: The water balance is now discussed in detail in Section 6.2.2 and the water inputs discussed in Section 6.2.2.1. In the revised assessment, we used the three known USGS gages draining the Pebble deposit site [NK100A (USGS 15302250) on the North Fork Koktuli, SK100B (USGS 15302200) on the South Fork Koktuli, and UT100B (USGS 15300250) on the Upper Talarik] to calculate monthly mean flows at each gage over their period of record. Monthly mean flows for each gage were summed across the year and then averaged across the three gauges weighted by their watershed area to produce an area-weighted average of net (Precipitation – ET) yearly runoff of 860 mm/year for the general deposit area. All data were presented to the nearest whole mm.

14. Page 4-31 (P3): *...the mine pit would take approximately 100 to 300 years to fill.* From groundwater inflow only? Why such a large range of the estimate?

    RESPONSE: The time for the pit to fill was based on groundwater infiltration and direct precipitation into the pit and was presented as an approximate range. The lower end of the range of estimates pertained to the Pebble 2.0 scenario and the higher end pertained to the Pebble 6.5 scenario. Current estimates are approximately 20 years, 80 years, and 300 years for the Pebble 0.25, Pebble 2.0, and Pebble 6.5 scenarios, respectively.

15. Page 4-50 (P3): This peak flow calculation and discussion is confusing and needs clarification.

    RESPONSE: Presentation of the peak flow calculations and hydrologic modeling of the TSF failure scenarios has been revised and clarified. This is now presented in Section 9.3.

16. Page 4-52: What is the recurrence interval of the 356 mm?

    ***RESPONSE: The recurrence interval is not reported in the reference cited. The PMP 24-hr is greater than the reported 100-yr 24-hr (see Technical Paper No.47).
    http://www.nws.noaa.gov/oh/hdsc/studies/pmp.html
    http://www.nws.noaa.gov/oh/hdsc/PMP_documents/TP47.pdf***

17. Page 4-60 (P4): Why a geometric mean using three values?

    RESPONSE: The three values were chosen because they represented subsets of the available data that better represented the conditions of the proposed pipelines (i.e., pipelines less than 20 cm in diameter, pipelines in northern climates, and pipelines run by small operators). Focusing on these three subsets reduced the range of the estimated probability of failure. The geometric mean was used because the comparison involved ratios with potentially significant differences in magnitude in the denominators. Using the geometric mean typically reduces the bias that a small dataset can introduce into an arithmetic mean. In this case, the difference between the two means (0.0010 vs. 0.0011) is immaterial and small with respect to the range of failure probabilities.

18. Page 5-10: Define *highest reported index spawner*.

    RESPONSE: Section 7.1.2 defines this as the highest count of salmon reported in the EBD for selected index reaches.

19. Page 5-20 (P1): …*salmon abundance related to pool size….and beaver ponds provide particularly large pools*. Are data available to characterize the stream type? Are beaver present?

    RESPONSE: We now provide a characterization of stream gradient, mean annual flow, and % flatland to characterize general stream and valley characteristics. Beaver are present in the area (Chapter 7).

20. Page 5-22 (P2): *Assuming that no natural flow or uncontrolled runoff would be generated from the mine footprint.* Is all precipitation is intercepted or does this refer to the subsurface streamflow generation mechanisms?

    RESPONSE: In our scenarios, we assume that all precipitation that falls within the mine footprint (except the fraction of the TSF and waste rock leachate that bypasses the groundwater interception and collection systems) is managed by the operator by collection and routing leading to either storage in a TSF or testing, potential treatment, and release to the environment. Any water consumed or stored on site would reduce the total streamflow below baseline conditions, although some stream reaches would receive increased stream flows due to discharges from the wastewater treatment plant. Groundwater and streamflows are inextricably interdependent throughout the site, so one could anticipate that areas with lower streamflows would also have lower groundwater levels.

21. Page 5-23: It appears that the mean annual unit runoff is calculated incorrectly.

    RESPONSE: This has been corrected.

22. Page 5-24: Table shows flow returned from footprint. Does not fit with page 5-22?

    RESPONSE: Water balance descriptions, tables, and figures have been extensively revised.

23. Page 5-29 (P2): Groundwater-surface water connectivity. Are data available to show this connection throughout the watersheds or does the groundwater only return to the hyporheic in the low gradient areas? Similarly, where are the temperature data that suggest the lake and groundwater connection or this reference by incorporation?

    RESPONSE: Figure 7-14 is now included to illustrate areas of modeled upwelling strength. We provide several examples of groundwater-moderated temperatures from the EBD data. But water temperature data are not generally summarized here and we refer the reader to the extensive data provided in the EBD.

24. Pages 5-32 to 5-39: The tables and hydrographs illustrating the potential flow changes are difficult to appreciate or interpret. Another means of presentation?

    RESPONSE: We now include figures (7-10 through 7-17) illustrating the locations, extent and magnitude of flow changes.

25. Page 5-41 (Table 5-13): The value of 0.15 km affected by the maximum mine size is questioned.

    RESPONSE: Stream lengths are now rounded to 1 km

26. Page 5-52 (Table 5-17): Can we see summary statistics on water quality, not just means? Plot of concentrations vs. streamflow?

    RESPONSE: Coefficients of variation have been added to the table (now Table 8-10). Plots of concentrations versus other variables are available in PLP's Environmental Baseline Document, Chapter 9.

27. Page 5-55: *These effluent specific values are higher than those for background surface water because of the higher content of mineral ions.* This sentence needs clarification.

    RESPONSE: The sentence has been rewritten to clarify that it refers to differences in the BLM-derived criteria.

28. Page 6-6 (Table 6-1): Last line. What is the +/- value after the mean?

    RESPONSE: + or – one standard deviation are reported for the basin-wide samples; this has been clarified in the table.

29. Page 6-13 (P3): *…an intense local storm.* Why use the Type 1a distribution for precipitation distribution?

    RESPONSE: This has been corrected to Type 1 per SCS guidance for Alaska.

Roy A. Stein, Ph.D.

1. Global (see Table 5-3 as example): Some thought should be given to significant figures for the numerical values given in the report, especially so for Chapter 5, where much uncertainty exists regarding stream lengths blocked (for example) by the mine footprint: "…34.9 km of

first- through third-order streams…" will be eliminated. Rounding in this context makes sense for we really do not know this impact to the nearest 0.1 km. I would encourage a thorough review of these values throughout the report.

RESPONSE: Significant figures for calculations and measurements by EPA have been changed to reflect uncertainty (for example, stream length is reported to the km). Significant figures from literature are not revised.

2. Page 2-17: Salmon populations are closely managed by Alaska Department of Fish and Game; how closely and what do we know of the populations that are managed regarding numbers, resilience, variability, etc.? A box summarizing the fishery management practiced by Alaska Department of Fish and Game would help put biological resources in perspective.

   RESPONSE: Box 5-2 has been added in Chapter 5, providing an overview of commercial fisheries management in Bristol Bay.

3. Page 2-17: The importance of salmonids to marine predators is likely not an issue, given the very large numbers of salmon stocked in the Pacific.

   RESPONSE: No changes suggested or required.

4. Page 2-20: Nushagak and Kvichak rivers contain >58,000 km of streams; 13% is anadromous fish habitat, but this is likely underestimated. How do we know this is an underestimate? What proportion of this >58,000 km has been surveyed?

   RESPONSE: ADF&G estimates that the current listing of Waters Important for the Spawning, Rearing and Migration of Anadromous Fishes represents "less than 50% of the streams, rivers and lakes actually used by anadromous species" (ADF&G AWC database, available at: www.adfg.alaska.gov/sf/SARR/AWC/)). This clarification has been added to the assessment in Box 7-1.

5. Page 2-25 (bottom of page): I wonder if a bit more couldn't be written about the idea of a salmon sanctuary, fleshing out the ideas of Rahr and Pinsky here.

   RESPONSE: The creation of salmon sanctuaries in the Bristol Bay region is a management decision, and thus outside the scope of this assessment; therefore, no change is necessary.

6. Page 3-2: With all the items in the first full paragraph eliminated from consideration (e.g., power generations, worker housing, Cook Inlet Port), might the analysis herein be considered minimal impact on the Bristol Bay watershed?

   RESPONSE: The scope of the assessment has been clarified throughout the document, particularly in Chapters 1 and 2. It is true that this assessment only considers a subset of potential impacts from large-scale mining.

7. Pages 3-7 to 3-11: These conceptual models might best be placed in the chapter to which they refer; in so doing, it is easier for the reader to follow along. In turn, these models did not seem to be discussed in text to the extent that they drove the impacts generated. Add more explanatory text.

RESPONSE: In the revised assessment, conceptual models are presented and discussed in the appropriate chapters.

8. Page 4-5 (bottom of page): Typically, when citing a figure in another chapter, i.e., one not near the current text, the format should be "see Figure 3-1" to keep the reader on track.

   RESPONSE: Comment noted. Figure references have been retained in parentheses.

9. Page 4-8: Is there some chance of "block caving" here? Some text clarifying this point here would be appropriate.

   RESPONSE: Additional information on block caving is provided in Chapter 4 (Section 4.2.3.1 and Box 4-4).Block-caving is a possibility for mining deposits that are deeper. Sources of hazards assessed for risks, however, would be similar, as block-caving and surface mining both create tailings, waste rock (block-caving does have a smaller amount of waste rock), and sources of contamination to the water.

10. Chapter 4: Could these data and insights be productively moved to Chapter 5, thus reducing redundancy? The organization would be 1) a description of the mine features relevant to the text, then 2) a discussion of salmon and the mining impacts on their habitat. Separating these into chapters seems artificial.

    RESPONSE: Revision of the assessment has included organization of material into additional chapters and the EPA believes this new organization is easier to follow.

11. Page 5-20 (P3): What does the phrase, "free-water area" mean? Ice free, perhaps?

    RESPONSE: Removed.

12. Pages 5-20 to 5-21: Paragraphs on these two pages reflect some of the redundancy that I saw throughout the report. In the 3rd full paragraph on page 5-20, text begins with "…groundwater inputs may be critical…" and in turn on page 5-21 in the first full paragraph, the topic sentence begins "…groundwater-influenced stream flow…likely benefit fish…" Both deal with the same topic. Hence, these two paragraphs could easily be combined, serving to shorten the text, reduce redundancy, and improve readability.

    RESPONSE: These paragraphs have been combined.

13. Page 5-22: Similarly, the text on page 5-22 includes citations (at the end of the same sentences) to both sections and tables and figures in Chapter 4. This suggests to me that the text is not only overlapping, it is redundant and better overall report organization would serve its presentation well.

    RESPONSE: Chapters have been reorganized, but some cross-chapter referencing remains necessary. In this case, it is important that the reader be able to refer back to the mine scenarios and operations chapter if desired, to better understand the complex water management system and budget that drives the analysis in Chapter 7.

14. Page 5-23 (Table 5-5): Some explanation in the table title would benefit the reader, as to where these gages are placed in the stream. The labeling is arcane at best UT100D; letters

suggest Upper Talarik Cr., but what is 100D. Now, I figured out from text that the first ones were high in the watershed and then they proceeded downstream (increasing drainage area gave me a hint as well). Use better descriptors (such as SK1 through SK5 from low to high stream order) or explain the ones that are being used.

RESPONSE: New figures illustrating gage locations are included. Gage names remain consistent with EBD usage for consistency.

15. Page 5-26 (Table 5-7): I cannot find any bold in this table that would reflect the pre-mining condition. Is that the same column as "Pre-Mining" as it is in Table 5-8 on page 5-34 (and the next few tables as well)?

    RESPONSE: Corrected.

16. Page 5-27: Cite Figure 5-8 in text any time the stream gages are mentioned. The reader then has the ability to easily refer back to stream gage locations.

    RESPONSE: Corrected.

17. Pages 5-32 to 5-39: How do these tables and figures differ? Might they be 10% reduction in flow, 11-20% reduction inflow and >20% reduction in flow, as suggested in text? If so, then these table and figure titles need to reflect this information and be better described in the legends of the figures. Finally, do we need both tables and figures?

    RESPONSE: Figures have been removed, with exception on one illustration to clarify process.

18. Page 5-31: The Richter et al. (2011) reference, which underpins this section is incomplete in the Literature Cited (Chapter 9), suggesting only March as the publication date. Update in any revision.

    RESPONSE: Citation has been updated.

19. Page 5-31: It should be made clear that the Richter et al. (2011) sets quite specific bounds for all rivers regarding ecosystem function and does not provide any specific insight into salmon production (made somewhat clear in the last sentence of the next to the last paragraph on page 5-43). I think an additional caveat stating this explicitly on page 5-31 would improve the text.

    RESPONSE: Additional clarification has been added.

20. Page 5-46: Stream flow losses due to the mine footprint are discussed first as underestimated, then as overestimated, and then a conclusion that they are underestimated (i.e., because the mine will need more water than is available from surface run-off). If this is the case, why go through the other scenarios…to seem even-handed? I am not sure all of this text is required.

    RESPONSE: Uncertainties and assumptions sections have been revised.

21. Page 5-46: Mine start-up will require more water than is available from the footprint of the mine itself. Hence, water will be captured from other streams than just those associated with

the mine, which will influence stream flow and groundwater supplies. Are there estimates of the amount beyond the surface water that will be required?

RESPONSE: An extensively-revised water balance description and accounting are now used. Indirect effects of groundwater loss to pumping are incorporated.

22. Pages 5-53 to 5-58: I am a little confused by this section. The implication throughout is that copper toxicity will be based on the response of aquatic invertebrates (which would then be protective of direct effects on salmon). However, near the end of this section, there is a discussion about zooplankton being most sensitive and a comment about the reliance of juvenile sockeye rearing in lakes on these zooplankton. Yet, there is no resolution of what criteria will be used for toxicity values…will it be aquatic invertebrates or the more sensitive zooplankton? Clarification is required here.

    RESPONSE: Zooplankton are aquatic invertebrates. The same criteria apply to both invertebrates in the benthos and those that drift in the lake.

23. Page 5-59: "Discharge permits for mine in the Bristol Bay watershed should include relevant whole-effluent toxicity testing and monitoring of biotic communities in receiving streams". Does this quote solve the problem mentioned in the previous comment? Is this a realistic expectation for mine operators before permits are issued?

    RESPONSE: The statement reflects the hopes of the assessment authors. They do not constitute an obligation upon the State of Alaska. This is clarified in the revised assessment.

24. Page 5-68 (Table 5-22): >10% rather than <10% in the table title.

    RESPONSE: The reference was correct in the draft. Table 10-8 now shows streams with gradients <12% likely to support salmon.

25. Chapter 6: Rivers is lower case when multiple rivers are listed.

    RESPONSE: Comment noted.

26. Page 6-1: Why assume that only 20% of the tailings stored would be mobilized with any dam failure? Is there a justification for this important assumption? Yes, see Appendix I, page 14 for citation to Dalpatram (2011); this should be cited in the main report in Chapter 6.

    RESPONSE: Citations of Dalpatram (2011) and Azam and Li (2010) have been added, drawn from Appendix I.

27. Page 6-4: Add map showing the impact of the failed TSF 1, i.e., distribution of sediments and impact downstream.

    RESPONSE: Because we are not predicting specific sediment depths in this revision, we have determined that this information was best presented by a description in the text and tables.

28. Page 6-42: The sentence in mid-paragraph (3rd complete paragraph on this page) "…multiple

failures such as might occur…" My guess is that an example should follow the phrase "such as."

RESPONSE: Culvert failures are described in the preceding paragraphs (in greater detail in the revised assessment), so an example is not needed here.

29. Page 7-2: The sentence at the end of the last full paragraph on the page makes little sense: "The overall consequences are diminished and extinct salmon populations."

    RESPONSE: This sentence has been clarified.

30. Page 8-6 (last sentence of 2nd complete para): "further" should be "farther"; sorry, I just couldn't help myself…

    RESPONSE: Text revised.

William A. Stubblefield, Ph.D.

None

Dirk van Zyl, Ph.D., P.E.

I have indicated a number of specifics in the text above and do not have any others to list.

Phyllis K. Weber Scannell, Ph.D.

1. Page 4-11: The document states "geomembranes are generally estimated by manufactures to last 20 to 30 years when covered by tailings (North pers. comm...)." Unless North is a P.E. with experience in geomembranes, the statement needs a stronger reference. For example, Erickson et al (2008)* discuss the quality issues with geomembranes related to manufacture, installation and application of a soil-based cover (such as bentonite).

   RESPONSE: The reference is appreciated, but others were chosen for use related to time of life for liners. The discussion of liners has been expanded and moved to Chapter 4 (Section 4.2.3.4) in the revision, and includes additional material and references on lifetime. The personal communication reference has been removed.

2. Page 4-23 (L1): This first sentence is confusing and implies that oxygen has low solubility because it is in the tailings pond. Suggested change: eliminate the first phrase "In a TSF".

   RESPONSE: The change has been made in the revised assessment.

3. Page 6-36 (P3): Last sentence states: [water] treatment would continue until institutional failures ultimately resulted in abandonment of the system, at which time untreated leachate discharges would occur. This statement is not supported by any documentation and is not clear what is being implied. Failure of governments? As stated in my response to questions,

any mine plan must include sufficient bonding and plans for reclamation, including necessary water treatment.

RESPONSE: Bonding and a perpetual trust could result in treatment for some period, but it possible that long-term funding will not last to the end of time.

4. Page 6-37 (P4): End of paragraph states "premature closure could leave waste rock piles in place." Again, there is a need for plans for mine closure, concurrent reclamation and sufficient bonding.

   RESPONSE: The premature closure scenario is intended to address the possibility that the closure plan is not followed. It highlights the need for adequate bonding and for plans that include closure by some agency.

5. App G, Page 5 (P1, last line): Document states: "…other short road segments connect Dillingham to Aleknagik and Naknek to King (Figure 1)."
   Shouldn't King be King Salmon?

   RESPONSE: Corrected.

6. App G, Page 5 (P3): Dolly Varden should be capitalized throughout the document. The list of fish species should contain scientific names or reference a table of common and scientific names.

   RESPONSE: Corrected.

   The document states "In the most comprehensive published field inventory, Woody and O'Neal (2010) reported." Because the authors have not reviewed other documents on field inventories, the phrase "most comprehensive" should be changed to "a comprehensive"

   RESPONSE: Corrected.

Paul Whitney, Ph.D.

A lot of page and paragraph comments are included the above responses to charge questions. I have no further comment.

Dr. Courtney Carothers

Peer Review Follow-On Comments on the April 2013 Draft of

An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska

From: Courtney Carothers [mailto:clcarothers@alaska.edu]
Sent: Thursday, July 18, 2013 1:21 AM
To: White, Jessica; Thomas, Jenny
Subject: Carothers' summary evaluation of EPA's response to 2012 peer review report

Dear Jessica and Jenny,

Please find attached my letter summarizing my evaluation of the EPA's response to 2012 peer review report.

I did not include the editorial corrections in my letter, but note them below.

Could you please confirm receipt of this email and document and please let me know if I need to provide anything else.

Best regards,

Courtney Carothers

Editorial corrections:

Page vi: Affects to Effects

Page ES-2, ES-25, (and others): Alaska native to Alaska Native (consistent usage throughout document)

Page ES-9: first full paragraph, first full sentence, rewrite to: "The subsistence way of life in many Alaska Native villages is augmented with participation in the cash economy."

Pages 1-6; 14-13; fisherman to fishermen

Page 5-2; 8watersheds

Page 5-2; "These resources generate significant benefit for…., and provide sustenance for Alaska Native populations *and other rural residents.*"

Page 12-9: second full paragraph, period missing at end of first sentence, incorrect comma.

Dr. Courtney Carothers

Summary Evaluation of the U.S. EPA's Response to September 2012 Peer Review Report

Date: July 17, 2013

Jessica White
Contracting Officer
USEPA Headquarters
Ariel Rios Building
1200 Pennsylvania Avenue, N.W.
Washington, DC 20460

Dear Ms. Jessica White:

As per the terms of my peer review contract and supplemental clarification of the scope of work, I provide here my summary evaluation of the U.S. EPA's response to: 1) the key recommendations in the Executive Summary of the Peer Review Report that pertain to my areas of expertise and 2) the individual comments and suggestions that I provided in the Peer Review Report. This summary is based upon my review of the following documents:

1. The April 2013 version of the draft Bristol Bay Assessment (referred to as "Revised Assessment" in this letter). This document is available at: http://www.epa.gov/ncea/pdfs/bristolbay/bristol_bay_assessment_erd2_2013_vol1.pdf

2. Revised Appendix I (Conventional Water Quality Mitigation Practices for Mine Design, Construction, Operation and Closure) and new Appendix J (Compensatory Mitigation and Large-Scale Hardrock Mining in the Bristol Bay Watershed). Other appendices are not considered part of the evaluation being conducted under this contract. Appendix I is available at: http://ofmpub.epa.gov/eims/eimscomm.getfile?p_download_id=513560. Appendix J is available at: http://ofmpub.epa.gov/eims/eimscomm.getfile?p_download_id=513561

3. *Final Peer Review Report, External Peer Review of the EPA's Draft Document, An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska,* dated September 17, 2012 (referred to as "Peer Review Report" in this letter). This document is available at: http://www.epa.gov/ncea/pdfs/bristolbay/Final-Peer-Review-Report-Bristol-Bay.pdf

4. *An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska, External Review Draft*, dated May 2012. EPA 910-R-12-004a.

5. The draft response to comments document detailing how the EPA responded to comments provided by the external peer reviewers in the Peer Review Report (referred to as "EPA Response" in this letter).

I. Comments on the U.S. EPA's Response to Key Recommendations in the Peer Review Report (relevant to my areas of expertise)

Scope of the Document
KEY RECOMMENDATION: "Explain why the scope for human and wildlife impacts was limited to

fish--- mediated effects, as well as why fish--- mediated effects on humans were limited to Alaska Native cultures. Reviewing effects beyond fish--- mediated ones (e.g., potential for complete loss of the subsistence way of life) would improve the assessment."

> *EPA RESPONSE: "The scope of the assessment has been clarified throughout the document, particularly in Chapters 1 and 2. Throughout the assessment we acknowledge that direct effects of large--- scale mining on wildlife and Alaska Native cultures may be significant, but that these direct effects are outside the scope of the current assessment."*

Overall, the scope of the assessment has been more clearly articulated. Figure 2.1 is helpful to convey the focus points of this assessment, as well as other important impacts and groups that fall outside of this scope. The Revised Assessment explains why the scope for human impacts was limited to fish-‐mediated effects; however, the EPA Response also notes the prevalence of direct human impacts discussed in public comment of the May 2012 draft watershed assessment. These public comments, in addition to peer review comments, prompted an expanded discussion of direct impacts of mining on people in the Revised Assessment, particularly in Chapter 12. Given the narrow focus of the majority of the assessment on fish-‐mediated human impacts, the important addition of a discussion of direct effects in Chapter 12 could be more clearly contained in a separate section to avoid confusion. The section should also be prefaced with the clarification that it is a partial review of direct effects that have been identified in previous case studies, rather than a review, summary, or study of all possible impacts.

The Revised Assessment also clarifies the focus on Alaska Native cultures in at least two places:

> *"Fish--- mediated effects on Alaska Natives were considered because sustainability of the region's fish populations is critical to the future of Alaska Natives in Bristol Bay, and because concern about the region's fishery resources prompted original requests from Alaska Natives that USEPA examine issues in the Bristol Bay watershed" (1--- 3)*
>
> *"Although Alaska Natives are not the only people that would potentially be affected by mining in the region, Endpoint 3 focuses on Alaska Native populations because of the centrality of salmon and other salmon--- dependent resources to their way of life and well--- being, and because this assessment was initiated in response to requests from federally recognized tribal governments to restrict large---scale mining the watersheds" (5--- 2)*

Both of these statements indicate that the assessment focuses primarily on Alaska Natives in the region for two reasons: 1) the centrality of salmon to the indigenous cultures of the region, and 2) the original request for the assessment came from Alaska Natives and federally-‐recognized tribal governments. It would helpful to also clarify if the EPA had special obligation to conduct this review given the government-‐to-‐government relationship of these tribes with the federal government. The addition of this second point (that Alaska Native cultures are considered an endpoint in this assessment in part because tribal governments asked for the assessment to be conducted) should also be added to the Executive Summary. As written, the Executive Summary's discussion of scope (ES-‐2) discusses wildlife and Alaska Native cultures together as endpoints given their dependence on salmon. As discussed in the first peer review process, this grouping is awkward and potentially offensive. Sections that link discussion of these two endpoints (e.g., Section 13.4.2) should be divided into separate sections.

<u>Technical Content: Human Cultures</u>

KEY RECOMMENDATION: "Use case histories to provide insight and anticipate mining impacts on

Alaska Natives (e.g., those exemplifying the Exxon Valdez oil spill impacts, cumulative effects of oil and gas development in the North Slope region, and social impacts related to mining development in Alaska)."

> *EPA RESPONSE: "Examples from applicable case studies, including the Exxon Valdez oil spill, are cited in Chapter 12 of the revised assessment."*

The inclusion of these case studies has strengthened the report. These case studies provide insights into both fish-mediated effects to cultures and communities, as well as direct effects from resource exploration and development.

KEY RECOMMENDATION: "As noted above (Scope of the Document), clarify why the scope was limited to fish--- mediated effects. The potential direct and indirect impacts for human cultures extend far beyond fish--- mediated impacts (e.g., potential complete loss of the subsistence way of life). The rationale for this narrow focus should be fully explained. In addition, a clear explanation should be given for why fish--- mediated human impacts focused only on Alaska Native cultures."

> *EPA RESPONSE: "The assessment focuses on a specific, limited set of endpoints as defined in Chapter 5. We have added text to explain both why these endpoints were selected, and that responses other than those considered in the assessment are likely but are outside the scope of the assessment. The assessment was expanded (Chapters 5 and 12) to acknowledge that there are a wide range of potential direct and indirect impacts to indigenous culture, but they are outside of the scope of this assessment. The discussion of potential effects to indigenous cultures was expanded to explain that a loss of subsistence resources would extend beyond a loss of food resources to social, cultural, and spiritual disruption. The text has been expanded to acknowledge the strong cultural ties of many non--- Alaska Natives to the region, and potential effects on all residents from loss of a subsistence way of life. However, the focus of the assessment remains on effects on indigenous cultures resulting from effects on salmon."*

See comments above under "Scope of the Document." The expanded discussion of subsistence and recent research in the region in Chapter 5 has greatly strengthened the assessment. The revisions of the language in the Revised Assessment to reflect the whole suite of physical, social, cultural, economic, and spiritual aspects of subsistence have also adequately addressed earlier concerns raised.

<u>Editorial Suggestions</u>

KEY RECOMMENDATION: "The appendices contain detailed and useful information that should be summarized and included in the main document (e.g., Appendix E: Economics, Appendix G: Road and Pipelines, and Appendix I: Mitigation). Additionally, consider expanding the preface to include information on the use of the appendices. If the information is not included in the main report, then justify its absence."

> *EPA RESPONSE: "More information from the appendices was brought forward into appropriate chapters of the revised report. The purpose of the appendices—to provide the detailed background characterization necessary for the ecological risk assessment—has also been clarified in Chapter 2. The document no longer contains a preface because that material has been incorporated into Chapters 1 and 2."*

More information from Appendix E (as well as Appendix D) has been included in the main body of the report, but as described below, more information from Appendix E is relevant to include, particularly Alaska Native engagements in commercial fishing and fish-based tourism in this region.

Research Needs

KEY RECOMMENDATION: "What are the locations of subsistence areas and can these areas be characterized and differentiated by collecting local environmental and ecological knowledge (e.g., fish overwintering areas, climate change, ecological shifts, etc.)?"

> EPA RESPONSE: "The revised assessment incorporated current data on subsistence use areas available from ADF&G. EPA acknowledges that these data are incomplete and would encourage additional collection of subsistence data and Traditional Ecological Knowledge."

The Revised Assessment includes more detailed information about subsistence harvests and use areas (e.g., Figure 5.12). The necessary caveats that these data are coarse and incomplete, and that additional studies of traditional ecological knowledge (especially in times of social and environmental change) are greatly needed, are important to highlight in the main text (e.g., coarseness and limitations of data explained in Box 5.1 should also be repeated in main text).

II. Individual Responses to Charge Questions

1. General Impressions: Comments here are addressed above in response to clarification of scope in Section I, Key Recommendations.

2. Question 1: Additional methodological detail was added to Appendix D, but the revised Appendix D was not included for review and was "not considered part of the evaluation being conducted under this contract" (Statement of Work, p 1), so could not be reviewed.

   I found evidence throughout the Revised Assessment that supports EPA's response that "the assessment text regarding the importance of the subsistence way of life has been expanded to recognize the centrality of subsistence to the social, cultural, and spiritual well-being of the indigenous cultures" (EPA Response, p 40).

   Suggested references on subsistence harvests, use areas and local context were included in the Revised Assessment. Section 5.4 of the Revised Assessment (updating section 5.6 of the original report) is substantially improved from the first draft assessment.

   I disagree with the EPA response that Appendix E on the economics of salmon in the region is not relevant to explore the salmon-mediated effects to Alaska Native cultures (EPA Response, p 39). Just as salmon are central to culture, they are central to the mixed (market and non-market) economies of the Alaska Native communities of the region. The dependence of the local communities and cultures on commercial fishing and tourism, as well as the links between these commercial engagements and subsistence fisheries are important aspects to consider in evaluation salmon-mediated effects to Alaska Native cultures. Some additional information from Appendix E has been added to the report. More of this information, particularly that information relevant to the Alaska Native communities in the region (e.g., community engagement in, and dependence on, commercial fisheries) would enhance the report. The fish-mediated potential impacts to commercial fishing would affect Alaska Native cultures; commercial fishing has long been a part of the communities and cultures in this region.

Additional references on subsistence and mixed economies would strengthen the revisions (e.g., p 5-36, last paragraph, no references provided; Krieg et al. 2007, Wolfe and Walker 1987, among others would be helpful references to add).

Krieg, T.M., J. A. Fall, M. B. Chythlook, R. LaVine, and D. Koster. 2007. Sharing, Bartering, and Cash Trade of Subsistence Resources in the Bristol Bay Area, Southwest Alaska. Alaska Department of Fish and Game, Division of Subsistence Technical Paper No 326, Juneau.

Wolfe, R.J. and R. J. Walker. 1987. Subsistence Economies in Alaska: Productivity, Geography, and Development Impacts. *Arctic Anthropology* 24(2): 56-81.

3. Questions 2-9; 12, 13: EPA responses are sufficient.

4. Question 10: While the EPA Response notes that additional discussion of the connections between subsistence and commercial fishing in this region has been added to the report, I did not find much evidence of these additions. One instance of this addition in the Revised Assessment includes a short paragraph (5-36) only briefly mentioning these connections. Chapter 5, Section 5.4, for example, could include a discussion of Alaska Native engagements in, and dependence on, commercial fishing and fish-related tourism businesses in the region. Similarly, Chapter 12, Section 12.2 could include a section that discusses how decreased commercial fishing and tourism opportunities would affect Alaska Native communities and cultures. Some of this information is contained in Appendix E and could be brought forward into the main body of the report.

   As noted above, the report makes clear the scope of the assessment of human impacts is limited to fish-mediated effects. However, the EPA Response notes that Chapters 5 and 12 have been expanded to acknowledge the range of direct and indirect impacts of mining to human cultures and communities. At times, there is some slippage between the defined scope and the partial inclusion of direct impacts. For example, the list of salmon-mediated effects on Alaska Natives (section 12.2, p 12-6) lists a direct effect of mining on social systems ("a shift from part-time to full-time wage employment in mining or mine-associated jobs would affect subsistence gathering capabilities by reducing the time available to harvest and process subsistence resources.") This is not a salmon-mediated effect, but a direct effect of mining. I agree that these direct effects are highly important to consider and deserve acknowledgement and discussion in the report. However, because the scope has been narrowly defined as salmon-mediated effects, the interspersing of some direct effects into sections that describe salmon-mediated effects calls into question this focus. As stated above, the discussion of direct effects could be contained within separate sections in Chapters 5 and 12. These sections should reiterate that a full treatment of these direct effects is outside of the scope of this assessment, and as such the abbreviated discussions are necessarily cursory and incomplete. Given the number of public comments that focused on direct effects, this clarification and acknowledgement is appropriate and may be less confusing if placed in separate sections within the report.

5. Question 11: Chapter 12 now clarifies that the cumulative effects of multiple mines on humans would not merely be a loss of food resources, but possibly the loss of subsistence way of life.

6. Specific observations: EPA responses are sufficient, with the following notes:

In response to specific observation #3, the Revised Assessment now includes the mention of "Aleut/Alutiiq people" inhabiting the Alaska Peninsula (Revised Assessment, p5-2). Should this be rewritten as "Aleut/Unangan and Alutiiq/Sugpiaq peoples," or is the cultural group being referred to only the Alutiit/Sugpiat? If the latter, "Alutiiq/Sugpiaq people" should be used to be consistent with current published usage. If the former is true, that both Aleut/Unangan and Alutiiq/Sugpiaq peoples inhabit this region, it should be rewritten as "Aleut/Unangan and Alutiiq/Sugpiaq peoples" for clarity. While many Alutiiq/Sugpiaq people refer to themselves as Aleut in the English language, the usage of Aleut/Alutiiq is confusing. The standard usage of Alutiiq/Sugpiaq is preferable.

Revisions were noted to Appendix D and E. Responses seem sufficient, but as these revised appendices were not provided for review, I cannot comment on these revisions.

III. Specific Observations of the Revised Assessment

Section 5.2.6 (p 5-27): The last paragraph of this section should add language about the holistic fishery systems in this region. In addition to the relatively pristine salmon ecosystems and populations, the region is occupied by indigenous human cultures who continue to occupy their homelands, speak their languages, and continue to depend upon these intact fisheries. These features of the Bristol Bay fishery systems also greatly add to the watershed's global conservation value.

Table 5.1 (p 5-3): Some subsistence use species described in Box 5.1 are not listed in Table 5.1 as harvested (H) species (e.g., least cisco, round whitefish; and broad whitefish, which does not appear in Table 5.1).

Section 12.2.3 and Box 12.1 (p 12-11): The text preceding Box 12-1 states that Bristol Bay residents have expressed mixed opinions about development and mining. Box 12-1 focuses only on concerns about potential effects of large-scale mining in the Bristol Bay watershed. These are effective at conveying some of the testimony received about concerns; however, missing are excerpts of testimony representative of those who expressed desires for jobs and development related to large-scale mining. The EPA authors could add in a couple of additional quotes reflecting the full spectrum of opinions expressed in the testimony received at public meetings. If the excerpts in Box 12.1 represent the bulk of testimony received, this point should be made in the box text. I

also attach several editorial corrections in an email correspondence.

I commend the EPA team for careful and thoughtful revisions of the sections I have reviewed closely. I appreciate the attention given to the peer review comments throughout this process of review and revision. Please let me know if I can answer any questions or be of further assistance.

Sincerely,

Courtney Carothers

Dr. Dennis Dauble, Washington State University

Peer Review Follow-On Comments on the April 2013 Draft of

An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska

From: [redacted]t]
Sent: Friday, July 12, 2013 6:29 PM
To: Thomas, Jenny
Subject: Bristol Bay Peer Review Follow On

Hi Jenny
The attached two Word (docx) documents complete my peer reviewer activity on the Revised Draft Bristol Bay Assessment Peer Review Follow-On (this one needs an acronymn!), specifically Task 2: Evaluate review materials. The attachments are 1. comments as inserted into the comment-response document format, and 2. additional comments not covered in the former approach.

Please let me know at your convenience if there is anything additional I need to do to complete the invoice. Thanks for involving me in this important process.
DDD

July 12, 2013

Dennis Dauble
[redacted]

Peer Reviewer Evaluation of Second External Review Draft (April 2013):

An Assessment of Potential Mining Impacts on

Salmon Ecosystems of Bristol Bay, Alaska

ADDITIONAL COMMENTS NOT COVERED BY THE COMMENT RESPONSE FORMAT

In terms of overall organization, the second draft is much improved. One issue is Section 6.4 (conceptual model) included with descriptions of the mine footprint and operations did not work for me. I do agree, however, that this section serves as a useful transition from Mine Scenarios (Chapter 6) to the first risk assessment chapter (Chapter 7). To resolve this arrangement, I suggest you either (1) Move Section 6.4 to the end of Chapter 5 and expand the Introduction/Overview to Chapter 7 to include a brief discussion that it is the first of several risk assessment chapters, or (2) make Section 6.4 a separate chapter (after the current Chapter 6 and before the current Chapter 7).

Although the title says "ecosystem", one weakness of the document continues to be the paucity of ecological information, i.e., the ecosystem does not begin and end with salmon Nutrient exchange focuses almost entirely on the role of salmon and marine-derived nutrients. Watershed and terrestrial inputs are rarely discussed, nor is bottom-up energy flow from algae/periphyton to aquatic invertebrates to fish. I revisit this point several times in my other comments.

Overall, the second external review draft was impressive in terms of detail, supporting graphics and tables, and depth of discussion. One challenge to having so many complex tables was that often little or no narrative text was provided, leaving the reader to figure out their meaning largely on their own. I strongly suggest adding one or two sentences for each table in the text prior to the "call out" that states key results or example data from that table.

One useful addition to the second draft was the summary of evidence tables. Although somewhat subjective (or qualitative), they helped provide nice summary of effects for each exposure scenario. I could provide numerous examples of other useful tables and figures but there were too many to count. Needless to say this document should serve as a model for completeness. The authors should be collectively proud of their accomplishment.

Dr. Dennis Dauble

The following specific technical and editorial comments are also offered to improve the Assessment document.

1. p. ES-4, line 4- On what basis would the site be monitored during the post-mining phase? Would a specific state or federal regulatory requirement be in effect?
2. p. ES-28, bullet 4- There should be an additional statement about uncertainty as it relates to effects on primary and secondary production, hence the salmonid food web.
3. p. 5-34, last line of page- The call out for Table 5-1 should come after "non-salmon fishes.:
4. p. 7-12, section 7.1.2- Please clarify if aerial index counts are estimates of individual fish or redds.
5. p. 8-29- Please state if avoidance is considered harmful (i.e., fish are excluded from preferred habitat) or good (i.e., they are able to detect and move to non-polluted areas).
6. p. 8-31, line 19- Based on what author's experience?
7. p. 8-43, Table 8 19- Is something missing here? No data is presented.
8. p. 8-48, Table 8 22 and p. 8-49, Table 8 23- What does the dash or hyphen (-) mean in these tables? No data or no effect?
9. p. 8-62, section 8.3.1.2- Heat transfer between atmosphere and stream bottom will likely over-ride and mitigate any increases in water temperature than might occur downstream of the confluence of the source.
10. p. 9-19, line 12- Thr reference to Tables 9-3 and 9-4 provides an opportunity to provide relevant examples of depth and velocity from each scenario.
11. p. 10-20, section 10.3.2- Please clarify the last sentences of the 1st paragraph.
12. p. 11-11, line 11- This sentence implies contaminated groundwater would expose aquatic organisms to toxic concentrations. Suggest add a caveat, such as "If toxic concentrations were present in groundwater, areas of upwelling might pose a risk to aquatic invertebrates and fish eggs/larvae unless sufficient dilution occurred."
13. p. 11-17, line 16- "non-trivial" is an odd choice of words. Suggest replace with significant or large or substantial.
14. p. 12-5, line 3- the dietary maximum for pigs and poultry can be used as a surrogate benchmark for what? All wildlife? Bears and ducks? Please state.
15. p. 12-8, line 14- It's not obvious there is reliance of subsistence users on water for transportation in the area of probable impacts due to water-withdrawal. Specific locations should be identified if possible.
16. p. 13-8, line 15- Note that additional mines might also "tier off" the infrastructure developed for the Pebble 0.25 scenario.
17. Chapters 8, 9 and 13 included insufficient discussion of risk to primary and secondary production. For example, there would be loss of production due to sediment deposition and scouring (tailings dam failure), due to floc formation from leachate (water collection, treatment and discharge), and would multiply across projects (cumulative effects). Further these alterations in the aquatic community would impact focal fish species through loss of food, and, ultimately, subsistence lifestyles.

June 12, 2013

Dennis Dauble
[redacted]

Peer Reviewer Evaluation of Second External Review Draft (April 2013):

An Assessment of Potential Mining Impacts on

Salmon Ecosystems of Bristol Bay, Alaska

This letter report was developed in response to Statement of Work (SOW), Revised Draft Bristol Bay Assessment Peer Review Follow-On, of June 2013. The general approach as specified by the SOW was to 1. Review key recommendations in the Executive Summary of the 17 September 2012 Final Peer Review Report, *External Peer Review of the EPA's Draft Document*, *An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska (Draft Assessment),* in addition to specific comments and suggestions provided on the *Draft Assessment* by myself (Contractor); 2. Review the EPA's response to the Peer Review Report, Draft of June 12, 2013; and, 3. Review the April 2013 revised *Draft Assessment*, revised Appendix I and new Appendix J to evaluate how well these documents incorporated and responded to comment provided by this Contractor.

On June 26, 2013, I received an e-mail from Jenny Thomas, EPA Contracting Officer, that suggested peer reviewer letter reports be organized in a manner to allow EPA to easily see how our evaluation comments correspond to their responses to the Peer Review Report. Consequently, I used EPA's draft response to comments document as a template for my evaluation. My evaluation comments follow EPA's bold italicized responses in blue font.

It should be noted that several of my first-round review comments were responded to by referring to changes made to appendices to the main report. However, without having these appendices to examine, it was impossible to assess whether my comments were adequately resolved in the revision process.

Additional comments of concern to this reviewer that did not neatly fit into the peer review response to comment document format are attached as a separate document. These comments are both editorial and technical in nature and should be considered prior to release of the final *Assessment* document.

KEY RECOMMENDATIONS FROM PEER REVIEWERS, EPA RESPONSE AND DENNIS D. DAUBLE'S CORRESPONDING EVALUATION OF REVISIONS MADE TO THE APRIL 2013 REVISED DRAFT BRISTOL BAY ASSESSMENT

Scope of the Document:

- COMMENT: Articulate the purpose of the document more clearly via a primer on the Ecological Risk Assessment process. If the purpose of the assessment is to inform EPA as the decision maker, then the level of detail should correspond to this purpose. The authors should justify and explain what level of detail is required.

  •RESPONSE: Additional information on both the purpose of the assessment and ecological risk assessment (ERA) in general has been added to Chapters 1 and 2, as well as the Executive Summary. Section 1.2 includes information about the use of the assessment. The assessment has been reorganized into two major sections (problem formulation, risk analysis and characterization) to clarify where different chapters fall in the typical ERA process.

  Dennis D. Dauble- The first page of the Executive Summary now provides an excellent lead-in to the document. The first four paragraphs clearly establish context and intent of the main Assessment document. Further detail is provided in the first section, Scope of the Assessment.

- COMMENT: Include a statement upfront about the role of risk managers and other audiences, such as project managers/engineers, regulators, mine owners/operators. Knowing their role ensures inclusion of information necessary for any risk assessment by (1) describing the need for a risk assessment, (2) listing those decisions influenced, and (3) characterizing what risk managers require from the risk assessment.

  RESPONSE: Section 1.2 of the revised assessment discusses the use of the assessment.

  Dennis D. Dauble- This comment was adequately described in Section 1.2 as well as paragraph 3-5 of the Executive Summary.

- COMMENT: Explain why the scope for human and wildlife impacts was limited to fish-mediated effects, as well as why fish-mediated effects on humans were limited to Alaska Native cultures. Reviewing effects beyond fish-mediated ones (e.g., potential for complete loss of the subsistence way of life) would improve the assessment.

  RESPONSE: The scope of the assessment has been clarified throughout the document, particularly in Chapters 1 and 2. Throughout the assessment we acknowledge that direct effects of large-scale mining on wildlife and Alaska Native cultures may be significant, but that these direct effects are outside the scope of the current assessment.

  Dennis D. Dauble-I am comfortable with revisions made to describe the scope of the assessment. As far as potential effects to Alaska Native cultures, it's my opinion that fish-mediated impacts should be the focus. Further, risk of large-scale mining activities to their subsistence lifestyle is covered as well as it can be at this point in time.

- COMMENT: Be more consistent throughout the document in terms of the level of detail provided for the different scenarios and stressors. For example, the document has devoted 36 pages to the discussion of catastrophic Tailings Storage Facility (TSF) failure, while sections on the pipeline, water treatment, and road/culvert failures are brief. Indeed, the long discussion on the TSF failure belies a certainty and understanding of dam failure dynamics that is inaccurate.

  RESPONSE: The final document includes more failure scenarios (e.g., diesel pipeline failure, wastewater treatment plant failure, and refined seepage scenarios) in Chapter 8. It also explains why these specific failure scenarios were chosen, and discusses these scenarios in greater detail than the previous draft (i.e., to more closely match the level of detail originally provided only for the TSF failure scenario). Also see detailed responses to comments on Peer Review Question 5.

  Dennis D. Dauble- The Revised Draft Assessment is now a more balanced document in terms of level of detail for individual failure scenarios. I believe the amount of text devoted to each failure scenario is appropriate for the level of perceived risk and for the amount of information available.

Technical Content:

Mine Scenario

- COMMENT: Consider the document to be a screening-level assessment of all potential stressors. Focusing on failure mode overemphasizes catastrophic events (e.g., TSF failing), rather than considering all potential stressors, such as holding mine owners strictly accountable for their day-to-day activities with regard to best practices.

  RESPONSE: Additional information on the purpose and scope of the assessment has been added to Chapters 1 and 2. A screening of all potential stressors, including individual chemicals, is presented in Section 6.4.2. Also see detailed RESPONSEs to Peer Review Question 2 on the use of "best practices" and RESPONSEs to Peer Review Question 5 on failure scenarios.

  Dennis D. Dauble- While it may appear the document focused on failure mode, these are the types of events of primary concern. Thus, they require more discussion in terms of both potential effects and uncertainty. One suggestion is to add a statement early in both the Executive Summary and Introduction that states something like " This document includes an assessment of potential failure scenarios, as well as effects that may occur during day-to-day operations of a large-scale mine."

- COMMENT: Reexamine the document's use of historical data and case studies to describe and estimate the risk of failure for certain mine facilities (including the TSF, pipeline, water treatment, etc.), as these examples from extant mines may not be an appropriate analog for a new mine in the Bristol Bay watershed.

  RESPONSE: The TSF failure range was, and still is, based on design goals, not the historical data. The historical TSF failure data are provided as background. The pipeline failure rates are based on the most relevant historical data from the petroleum industry.

They are directly relevant to the diesel pipeline, and experiences at the Alumbrera mine (described in the previous draft) and the Antamina and Bingham Canyon mines (added to this draft) suggest that they also are relevant to the product concentrate pipeline. Water treatment failure rates were not quantified. However, recent reviews cited in the revised draft indicate that water collection and treatment failures have been reported at nearly all analogous mines in the U.S. The estimation of culvert failure frequencies has been revised and is now based on only recent literature (2002 and later). We believe that these estimates are appropriate.

Dennis D. Dauble- I was impressed with how much new literature was added to the Revised Draft, particularly with the number of relevant examples from mining and other industry. I found the use of "box text" to highlight specific examples to be very informative.

- COMMENT: Expand the discussion on the use of "best" management practices, as the document states that the mine scenario employs "good," but not necessarily "best" practice. For a mine developed in the Bristol Bay watershed, only "best" practice likely would be appropriate and anything less may not be permitted. Even so, without a track record of "best" practice (e.g., new technologies), we cannot assume that technology, by itself without appropriate operational management controls, can always mitigate risk.

  RESPONSE: The term "best management practices" is a term generally applied to specific measures for managing non-point source runoff from storm water (40 CFR Part 130.2(m)). Measures for minimizing and controlling sources of pollution in other situations often are referred to as best practices, state of the practice, good practice, conventional, or simply mitigation measures. We assume that these types of measures would be applied throughout a mine as it is constructed, operated, closed, and post-closure, and have used the term "conventional modern" throughout the assessment to refer to these measures. To remove any ambiguity related to the subjectiveness of terms "good" or "best", we have removed them in the revision and have provided definitions for relevant terms used in Box 4-1.

  Dennis D. Dauble- Box 4.1 does an adequate job of resolving this comment. The topic is further covered in Appendices I and J.

- COMMENT: Adopt a broader range of mine scenarios (not only minimum and maximum) so as to bound potential impacts, especially at smaller mine sizes (e.g., 50^{th} percentile). Underground mine development, with its different impacts, also should be considered and included in the assessment.

  RESPONSE: A third mine size scenario (250 million tons) has been added to the assessment, to represent the worldwide median sized porphyry copper mine (based on Singer et al. 2008).

  Dennis D. Dauble- The third scenario is an excellent addition. More important, in my mind, was comparative data on other mines within the region, for example Table 4.1.

- COMMENT: Based on the hypothetical mine scenario, perpetual management of the geotechnical integrity of the waste rock and tailings storage facilities, as well as perpetual water treatment and monitoring, will most likely be necessary (i.e., a "walk away" closure scenario after mining ends may not be possible). Therefore, emphasize how monitoring and management of the geotechnical integrity of waste rocks and tailing storage facilities should continue "In Perpetuity" (i.e., for at least tens of thousands of years). Discuss what conditions would need to be met to allow "walk away" closure in the Bristol Bay environment gaining insight into these observations from mines where perpetual treatment and monitoring are ongoing (e.g., the Equity Silver Mine in British Columbia).

COMMENT: ***RESPONSE: The conditions for closure and the potential need for perpetual site management are discussed in general terms in the revised assessment. The primary condition assumed to be required is water chemistry that meets all criteria and permit conditions and that is stable or improving. However, even though there are some facilities with "perpetual treatment" conditions in place, there is obviously no information about how these facilities perform over very long periods of time.***

Dennis D. Dauble- Given my experience with assessments of long-term risk of contaminants from the Hanford Site in southeastern Washington State, I can understand the suggestion for 10,000 year or "in perpetuity" scenarios. However, I believe this risk scenario is difficult if not impossible to describe give the huge range of possibilities for mining development and potential impacts on the environment. I am comfortable with the general terms provided in the Assessment.

- COMMENT: Identify, in technical detail, how exploratory effects (e.g., drill holes, blasting, overflight, etc.) were managed. This includes roads, airstrips, helipads, camps, fuel dumps, and ATV trails that have already been developed or imposed on the watershed, and what "mitigation" already has been undertaken on those sites. Assess the consequences/impacts of these activities in the Cumulative Risks section.

  RESPONSE: The effects of exploratory activities are outside of the scope of this assessment.

  Dennis D. Dauble- I disagree, in part. Exploratory activities are one part of mining development where Stage 1= exploratory, Stage 2=construction, Stage 3=operation, and Stage 4-site closure. The Main document should at least provide a brief description of whether specific exploratory activities such as drill holes, blasting, roads, airstrips/helipads, camps and trails fit within or are "superseded" by the overall mine development footprint. I would argue this description would suffice and that exploratory activities need not be discussed in either a mitigation or cumulative risk chapter.

<u>Risks to Salmonid Fish</u>

- COMMENT: Place potential mining impacts in the context of the entire Bristol Bay watershed by emphasizing the relative magnitude of impacts. For example, of the total salmon habitat, assess the proportion lost due to mining. Further, reflect on the non-linear nature of the relationship between habitat and salmon production; 5% of the habitat could be critical and thus responsible for 20% or more of salmon recruitment. Intrinsic potential, which measures the ability of particular habitats to support fishes, would lend credibility to this analysis.

RESPONSE: We are unable to build a complete Intrinsic Potential (IP) model, as this would require validation and more elaborate construction of metrics appropriate to this region. Our preliminary characterization provides the building blocks for assessing the distribution of key habitat-forming and constraining features across these watersheds. We now include a characterization of the major drivers of habitat potential across the watershed and place the mine-site specific effects in this context (Chapters 3, 7, and 10).

Dennis D. Dauble-I noted several significant improvements in relating salmon habitat lost in terms of its rearing and/or spawning potential. Species distribution and habitat use maps have been "upgraded" throughout the document to reflect life history attributes in relation to mining development.

- COMMENT: Include a section on the impact of Global Climate Change with explicit reference to a monitoring program that will allow scientists, if the mine is built, to distinguish between effects of climate change and mining effects on the physical and biological components of this ecosystem.

  RESPONSE: Climate change projections and potential impacts are now included in Chapter 3, and as important external factors in the risk analyses presented in Chapters 7, 9, 10, and 14. Development of a monitoring program to distinguish between mining and climate change effects is outside of the scope of the assessment.

  Dennis D. Dauble- The topic of climate change was extensively and adequately covered throughout the revised Assessment, both in terms of additive risk and uncertainty. The authors are to be commended for their careful attention to this complicated topic.

- COMMENT: Explicitly recognize that the transportation corridor and all associated ancillary development, including future resource developments made possible by the initial mining project, will necessarily and inevitably have impacts (hydrologic, noise, dust, emissions, etc.). These impacts will vary in duration, intensity, severity, relative importance, spatial dispersion, and inevitably expand geographically through time with further "development." These impacts should be incorporated into the Cumulative Risks section.

  RESPONSE: The cumulative risk section (Chapter 13) has been expanded to include the multiple transportation corridors, ancillary mining development and secondary development associated with multiple mines in a qualitative discussion. The issues addressed in the assessment of the transportation corridor (Chapter 10) have also been expanded to include chemical spills, dust, invasive species, and road treatment salts.

  Dennis D. Dauble- I am comfortable with revisions made on this topic in both the transportation and cumulative risk chapters.

- COMMENT: Incorporate current research findings into stream crossing and culvert-design practices (e.g., arch culverts, bridges, etc.).

  RESPONSE: We describe current culvert design practices in a box titled "Culvert Mitigation" in Chapter 10.

  Dennis D. Dauble- I appreciate that new research findings were incorporated in the Revised Draft document, primarily in section 10.3.2.3 (which appeared somewhat biased negatively towards potential magnitude of risks). Given that culvert failure is one risk to

fish populations from development of the transportation corridor, this risk should be specified in paragraph one of section 10.3 Potential Risks to Fish Habitats and Populations. I would argue that current culvert design practices are not covered in Box 10.2. Rather, this box (with the exception of the Tier 1-Stream Simulation Design which is not alluded to in the text) provides useful detail on regulations associated with culvert design and placement.

- COMMENT: Recognize in the assessment that risk and impact are not equivalent. Risk may be low, but the potential impact could be huge (e.g., in the case of a TSF failure).

  RESPONSE: Risk has been defined in many ways, even by risk assessors. The commenter seems to define risk as probability. To avoid that potential source of confusion, we use the term "probability" for that concept. Similarly, the commenter seems to use "impact" where we use "effect" or "magnitude of effect". We use "risk" to refer to both concepts combined—that is, an event or effect and its probability).

  Dennis D. Dauble- I am comfortable with the terminology and definitions of risk as provided in the Revised Draft Assessment.

- COMMENT: Recognize and justify chronic behavioral endpoints, such as those potentially affecting survival and long-term success of fish populations.

  RESPONSE: The chronic behavioral effects of copper on salmonids, the primary endpoint of concern, were described in Chapter 5 and are now described in Chapter 8. Although those effects occur at lower levels of copper than conventional survival, growth and reproduction endpoints for salmonids, they are less sensitive than the conventional endpoints for aquatic invertebrates.

  Dennis D. Dauble- I noted additional text related to behavioral effects in Chapter 8. While of value in providing for perhaps a greater level of protection, behavior (such as avoidance or olfactory response) is a much more difficult endpoint to measure and extrapolate to the real world than endpoints such as survival, growth and reproduction. I am comfortable with the level of detail provided in the Revised Draft Assessment as it relates to potential behavioral effects on salmonids.

Wildlife

- COMMENT: Recognize that the draft assessment did not account for all levels of ecology, such as the individual (e.g., a bald eagle nest), population, community, ecosystem, and landscape levels. Fold other levels of organization into the stressors assessment where appropriate or justify a more limited approach.

  RESPONSE: As is appropriate for an ecological risk assessment (as opposed to an environmental impact assessment), this assessment focuses on a specific, limited set of endpoints as defined in Chapter 5. We have added text in Chapters 2 and 5 to explain both why these endpoints were selected, and that responses other than those considered in the assessment, at multiple levels of ecological organization, are likely but are outside the scope of the assessment.

  Dennis D. Dauble-I agree that the number of individual endpoints and levels of

organization must be limited in an assessment that covers such a broad geographic area.

- COMMENT: Discuss in the document fishes other than salmonids The assessment focuses on risks to sockeye salmon in the Bristol Bay watershed (and also considers anadromous salmonids, rainbow trout, and Dolly Varden), but does not account for potential impacts to other members of the resident fish community. Further, primary and secondary production, including nutrient flux was not addressed. Expanding the assessment to consider other levels of organization, including direct as well as indirect effects on wildlife and other fish, would provide additional context in the assessment of mine-related impacts.

  RESPONSE: See response to comment above; we also incorporated additional information from Appendices A, B, and C into the Chapter 5 text, to provide additional detail on the area's biota. We chose our endpoints for reasons described in Chapters 2 and 5. Other endpoints, including indirect effects on fish and wildlife, are now discussed more explicitly, but are generally considered outside the scope of the assessment.

  Dennis D. Dauble-This bullet is actually two separate comments. I am now comfortable with the amount of information provided in the main document on fishes other than salmonids. A remaining weakness, however, is lack of discussion of mining leachates on primary production. While fish are the principal species of concern, the role of algal/periphyton communities in streams potentially impacted by mining activities should be acknowledged. Specifically, scouring by sediments and flocculation due to leachates are likely impacts to algal and invertebrate production that would affect fish populations due to reduced food supply.

Human Cultures

- COMMENT: Use case histories to provide insight and anticipate mining impacts on Alaska Natives (e.g., those exemplifying the Exxon Valdez oil spill impacts, cumulative effects of oil and gas development in the North Slope region, and social impacts related to mining development in Alaska).

  RESPONSE: Examples from applicable case studies, including the Exxon Valdez oil spill, are cited in Chapter 12 of the revised assessment.

  Dennis D. Dauble-The Exxon Valdez oil spill case study, as presented in Chapter 12, is relevant.

- COMMENT: As noted above (Scope of the Document), clarify why the scope was limited to fish-mediated effects. The potential direct and indirect impacts for human cultures extend far beyond fish-mediated impacts (e.g., potential complete loss of the subsistence way of life). The rationale for this narrow focus should be fully explained. In addition, a clear explanation should be given for why fish-mediated human impacts focused only on Alaska Native cultures.

  RESPONSE: The assessment focuses on a specific, limited set of endpoints as defined in Chapter 5. We have added text to explain both why these endpoints were selected, and that RESPONSEs other than those considered in the assessment are likely but are outside the scope of the assessment. The assessment was expanded (Chapters 5 and 12) to

acknowledge that there are a wide range of potential direct and indirect impacts to indigenous culture, but they are outside of the scope of this assessment. The discussion of potential effects to indigenous cultures was expanded to explain that a loss of subsistence resources would extend beyond a loss of food resources to social, cultural, and spiritual disruption. The text has been expanded to acknowledge the strong cultural ties of many non-Alaska Natives to the region, and potential effects on all residents from loss of a subsistence way of life. However, the focus of the assessment remains on effects on indigenous cultures resulting from effects on salmon.

Dennis D. Dauble-Chapter 5 outlines (using EPA jargon not necessarily translatable to the general public , e.g., Section 5.1), how assessment endpoints were selected and how they relate to Alaska Native cultures. Chapter 5, while emphasizing fish-mediated effects on Alaska Natives, also includes several graphics and supporting test that relates to recreational fisheries.

Water Balance/Hydrology

- COMMENT: Better characterize water resources and assess the potential effect of mine development on these resources by (1) generating a diagram similar to the conceptual models beginning on page 3-7 to illustrate the potential effects of mine construction and operation on surface- and ground-water hydrology; (2) developing a quantitative water balance and identifying water gains and losses; (3) identifying seasonality of hydrologic processes, including frozen soils and their associated values (e.g., mm/yr) for each component of the water balance; (4) incorporating these processes into a landscape characterization; (5) evaluating how global climate change will influence these hydrologic processes and rates; and 6) using this characterization to demonstrate the expected hydrologic modification associated with the mine scenarios and infrastructure development.

  RESPONSE: The original Figure 4-9 (new Figure 6-5) has been revised to more clearly show water management in the assessment's mine scenarios. In addition, three schematics illustrating water flows under each of the mine size scenarios (Figures 6-8 through 6-10) have been added to Chapter 6, as have quantitative water balances for each mine size scenarios. A qualitative discussion of climate change is included in Chapters 3 (Section 3.8) and 14 (Box 14-2).

  Dennis D. Dauble- Figure 6.5 is a excellent general schematic of water management and water balance processes for the mine scenarios. Figures 6.8-6.11 are quite helpful in understanding local processes related to groundwater and surface water movement. The summary of water balance flows in Table 6.3 provides additional specific detail. Overall, the discussion of water balance/hydrology is much improved.

- COMMENT: Demonstrate the interconnectedness of groundwater, surface water, hyporheic zone, and its importance to fish habitat. Address how interconnectedness changes over time – seasonally, and with varying weather (e.g., wet vs. dry summers or years, and over the long term as climate changes).

RESPONSE: We lack the data to demonstrate this interconnectedness in a spatially and temporally uniform manner, but do include examples of known points of high connectivity (Chapter 7) and qualitatively discuss the potential role of climate change (Chapter 3).

Dennis D. Dauble- Simply acknowledging that these interconnections exist and their relative importance to fish habitat such as spawning and rearing satisfies this reviewer.

- COMMENT: Provide information on all rivers, including ephemeral and intermittent streams, and first-order to main-stem streams that could be potentially influenced by the proposed mine, its ancillary facilities, and the transportation corridor.

  RESPONSE: Due to lack of consistent coverage, we rely on the NHD hydrography layer in this analysis, and can only address ephemeral and intermittent streams qualitatively (Chapter 7).

  Dennis D. Dauble- I found the amount of detail provided on the stream network to be sufficient given the limitation of comprehensive stream survey and other hydrographic data.

- COMMENT: Emphasize the importance of a thorough characterization of the leaching potential of acid-generating and non-acid generating waste rock and tailings, given the low buffering capacity and mineral content in the streams and wetlands that could receive runoff and treated water from the proposed mine. Recognize that collection and treatment of runoff and leachate generated will be critical to maintain baseline water chemistry in these streams and wetlands.

  RESPONSE: We agree that these are important issues, and the discussion of leachate from waste rocks and tailings has been expanded in the revised assessment (Chapter 8).

  Dennis D. Dauble- I appreciate that issues associated with water collection, treatment and discharge are now discussed separately in Chapter 8. Although failure of the tailings dam would be catastrophic, the liklihood of such an event is much lower than those impacts occurring from normal operations. Consequently, the expanded discussion of impacts of leachates from all possible sources is relevant.

<u>Geochemistry/Metals</u>

- COMMENT: Reference the most current geochemistry data on potentially acid-generating, non-acid generating, and metal leaching so as to describe any potential effects of seepage and changes to surface- and ground-water quality via non-catastrophic failure.

  RESPONSE: We used the geochemistry data in PLP's Environmental Baseline Document, as summarized by the USGS in Appendix H. The effects of seepage on water quality are analyzed in Chapter 8 of the revised assessment.

  Dennis D. Dauble-These changes are noted and are appropriate.

- COMMENT: Explain how contaminants/metals were selected (and others ignored) by EPA as causes for concern. Information should be included on additional metals and their toxicity so as to assess impacts of potential leachates. The Pebble Limited Partnership baseline document presented additional metals that might be useful to include in the assessment.

RESPONSE: The revised assessment describes the selection of contaminants and other stressors of concern in Section 6.4.2. Additional metals, process chemicals and dissolved solids are now included.

Dennis D. Dauble- Agreed that other contaminants of concern are now mentions. But, why was section 6.4 Conceptual Models placed in Chapter 6 Mine Scenarios? While I agree it might serve as a transition or setup to the risk assessment chapters that follow, it is too important to be included as a add-on to Chapter 6. I think this section (which is mostly methodology) should either be moved to the end of Chapter 5 Endpoints or made a separate chapter. This change would only require slight re-wording of text in the paragraph on p. 6-36 that begins with "In this section…."

Mitigation Measures

- COMMENT: Incorporate the critical mitigation information from Appendix I into the main report's mine scenarios. Include standard mitigation measures that could provide insight into how well they might work in this context. If this information is not included in the main report, then justify its absence.

  RESPONSE: Mitigation measures incorporated into design and operation to minimize potential impacts were included in the assessment, as were some reclamation measures for closure; these measures are made clearer in the revised assessment. These mitigation measures were a sub-set of those presented in Appendix I. The assessment assumes that measures chosen for the scenarios would be effective. Mitigation to compensate for effects on aquatic resources that cannot be avoided or minimized by mine design and operation would be addressed through a regulatory process that is beyond the scope of this assessment. Nevertheless, in RESPONSE to public and peer comments we have included a discussion of compensatory mitigation in Appendix J of the revised assessment.

  Dennis D. Dauble-Appendix I lacks a summary or conclusion section, otherwise it reads well. Appendix J provides a good description of regulatory requirements and methodology. Considerations and potential mitigation measures were carefully and clearly described. The opportunities for mitigation (against the regulatory backdrop) were summarized within the watershed and challenges outlined. One suggestion is to strength the last statement within the Conclusion section. Revise to perhaps something more along the lines of "No viable alternatives could be identified to address impacts of this type and magnitude."

- Emphasize mitigation measures (e.g., minimization, compensation, reclamation) in the main report, as they ultimately influence the range of mining impacts and consider time frames of mitigation or reclamation measures (e.g., immediate RESPONSE, long-term reclamation).

  RESPONSE: See response to previous comment. Mitigation measures are discussed at greater length in the revised assessment report (e.g., Chapter 4 and Appendix J).

  Dennis D. Dauble- The discussion of mitigation measures in Chapter 4 and Appendices I and J seems adequate.

Uncertainties and Limitations

- COMMENT: Clarify the uncertainty vs. certainty in Chapter 8 by (1) defining levels of uncertainty and (2) assessing the certainty of some mine impacts. Discuss data limitations in the context of uncertainty.

  RESPONSE: The individual analysis chapters and the revised Integrated Risk Characterization (Chapter 14) discuss certainties and data limitations to a greater extent, as suggested.

  Dennis D. Dauble- Chapters 8 through 12 each have uncertainty sections. Chapter 7 includes a section on uncertainties and assumptions. The Integrated Risk Assessment (Chapter 14) covers uncertainties and data limitations. Thus, I believe this topic is covered.

- COMMENT: Articulate early in the document how much uncertainty is acceptable. The assessment provides little insight with respect to the decisions the document is intended to support.

  RESPONSE: Acceptable levels of uncertainty can be defined prior to an assessment if a decision and a decision maker are identified and if data will be collected by a specified design to implement a specified model, as described in the EPA's Data Quality Objectives process, However, because this assessment is based on available data and is intended as a background scientific document rather than a decision document, it is not possible to specify the amount of uncertainty that is acceptable. Rather, the available data determine the uncertainty and if the assessment is subsequently used to inform a decision, the decision maker must determine whether the level of uncertainty is acceptable.

  Dennis D. Dauble- I agree with the EPA response.

Editorial Suggestions:

- COMMENT: The title of the document leads one to believe that the assessment addresses the entire Bristol Bay watershed; rather, the report deals with two major rivers and their watersheds, the Nushagak and Kvichak. Thus, the title should be changed to reflect the emphasis on these two rivers and their watersheds. A possible title may be "An Examination (or identification) of the Potential Impacts of Mining and Mining Associated Activities on Salmon Ecosystems in the Nushagak River and Kvichak River watersheds, Bristol Bay."

  RESPONSE: The assessment addresses multiple scales: the Bristol Bay watershed, the Nushagak and Kvichak River watersheds, the watersheds of the three streams draining the Pebble deposit, and the watersheds crossed by the transportation corridor. These multiple scales, and how they are used throughout the assessment, are described more clearly in the revision (Chapter 2).

  Dennis D. Dauble- I was not one for changing the title, rather suggested an expanded description of geographic scope. One issue I have with the revised Assessment was the use of the phrase "multiple spatial scales" (second full paragraph p. ES-2). This term is commonly used by stream ecologists to describe different measurement scales of habitat assessments (i.e., individual, reach, watershed). As such, the term suggests a hierarchical approach, which was not the case for this assessment. I prefer the term first used on p. 1-3 (third full paragraph Chapter 1 of the main document) "multiple geographic scales." I

suggest relevant wording in the E.S. be revised to be consistent with the description used throughout the Introduction of the main document. In addition, please revise text under section 2.2.2 Spatial Scales and Table 2.1 to show that data was considered across five "geographic scales."

- COMMENT: Revise the Executive Summary to more precisely reflect the findings in the document.

  RESPONSE: The Executive Summary has been rewritten to reflect the revised assessment findings.

  Dennis D. Dauble-I was impressed with the revised Executive Summary (ES.) This section might be the most important part of the revised Draft Assessment since due to being the only thing some people will read. Thus, it is important that it be an accurate, yet synthetic, version of the main document. Supporting graphics, e.g., Tables ES.3, ES.4 and Figure ES.6 are excellent choices. Note, however, that topics in the E.S. are not presented in parallel format or in the same sequence of topics (in terms of heading structure) with those in the main document. Headings in the E.S. include the word "risks" while comparable sections in the main document do not. The E.S. uses the term common-mode failures, which I infer is the same topic as those discussed in Chapter 8 of the main document.

- COMMENT: The appendices contain detailed and useful information that should be summarized and included in the main document (e.g., Appendix E: Economics, Appendix G: Road and Pipelines, and Appendix I: Mitigation). Additionally, consider expanding the preface to include information on the use of the appendices. If the information is not included in the main report, then justify its absence.

  RESPONSE: More information from the appendices was brought forward into appropriate chapters of the revised report. The purpose of the appendices—to provide the detailed background characterization necessary for the ecological risk assessment—has also been clarified in Chapter 2. The document no longer contains a preface because that material has been incorporated into Chapters 1 and 2.

  Dennis D. Dauble-I noted several examples where specific Appendices were cited in the main document as a source for more detailed information. It was also apparent that material was brought forward where appropriate.

- COMMENT: Discuss in more detail the instructive and well-thought-out conceptual models (pages 3-7 to 3-11) illustrating the impacts of mining on Bristol Bay ecosystem processes. Also, consider expanding the conceptual models to include wildlife, fish-wildlife interactions, vegetation/terrestrial habitat, and hydrologic processes. Allow them to guide the text because they appear detailed and complete.

  RESPONSE: Additional information on the use of conceptual models throughout the assessment has been incorporated into Chapter 2. The more comprehensive conceptual models presented in Chapter 6 (Chapter 3 in the first draft) have been broken into their relevant component parts throughout the risk analysis and characterization chapters, to better frame the specific pathways addressed in each chapter. Additional conceptual

models considering impacts on wildlife, Alaska Native populations, and cumulative effects of multiple mines have been added to Chapters 12 and 13.

Dennis D. Dauble-This reviewer considers the conceptual models as an attempt to provide a visual representation of a more much complicated (and largely unquantifiable) process than can be described in words. It was helpful to include a separate model for separate chapters. This representation simplified the thought process. One challenge is that Box 2.1 (so-called guide to conceptual model diagrams) was presented well before the first (complicated) model in Chapter 6. Thus, the reader is forced to refer to the box to sort out elements that composed the various pathways, modifiers, etc. One thing that would help Box 2.1 is to provide specific examples of modifying factors (note the description is not exactly in layman's terms), for example, temperature. Also, perhaps a short version of what is included under "When viewing these diagrams,…" could be added to the legend of each individual conceptual model to aid the reader. For example "Arrows leading from one shape to another indicate a cause-effect relationship with bold lines, arrows and outlines indicating high-priority pathways that were evaluated. Finally, there are up/down arrows within most boxes. The legend should state what these mean.

- COMMENT: Incorporate the information contained in the conceptual models into a formal framework, such as a Bayesian or other decision-analysis models.

  RESPONSE: This is an excellent suggestion for future efforts, but is beyond the scope of the current assessment. Creating a Bayesian Belief Network would require that the Agency convene experts to subjectively estimate the probabilities of each transition in the conceptual models. In contrast, this assessment is intended to elucidate the risks from potential mining based on available data and analyses of those data. A Decision Analysis would require that alternative outcomes be specified, the utility of each outcome for a decision maker be defined and the probabilities of each outcome be estimated for each possible decision so that the expected utilities of each outcome can be calculated. Because this assessment is not a decision document, these requirements are not feasible or appropriate.

  Dennis D. Dauble- I agree with EPA's comment.

- COMMENT: Generate a standard operating protocol for significant figures and use it throughout the document.

  RESPONSE: The authors have carefully addressed this issue. Numbers from the literature or from the PLP EBD retain the number of significant figures in the original. Numbers derived for this assessment have the appropriate number of significant figures given the precision of the input data and uncertainties due to modeling and extrapolation.

  Dennis D. Dauble- I am convinced proper homework was done on this topic.

- COMMENT: Remove all references to Mount St. Helens as a surrogate for a TSF failure. Using a non-human-caused release of material into the ecosystem as an analogue for a mine failure is not comparable in terms of likelihood or risk for a human-caused release. It would be more appropriate to extrapolate from the impacts of known mine failures.

RESPONSE: We are puzzled by this comment. The Mount Saint Helens data were used strictly to address the rate of benthic habitat recovery from a massive deposition of fine mineral particles. The hydrological processes that determine the recovery of substrate texture and the requirements of fish or aquatic invertebrates are not known to depend on whether mineral particles were from a natural event or an anthropogenic event. We have reviewed the literature on known mine failures. They studied tailings spills in terms of toxicity but not in terms of physical habitat effects, which is why we used Mount Saint Helens data. Nevertheless, we have removed references to Mount St. Helens in the revised assessment to eliminate concern.

Dennis D. Dauble- The issue was raised primarily because of concern raised by some members of the peer review panel that more relevant examples were available and should be used. I have no issue if these references are used in the context of deposition of mineral particles similar in nature to those that could be released during a TSF failure.

- COMMENT: Ensure that the draft assessment remains part of the public record, allowing the document history to remain intact.

  RESPONSE: All drafts of the watershed assessment will remain part of the public record.

  Dennis D. Dauble- No comment.

<u>**Research Needs:**</u>

- COMMENT: What are the acute and chronic impacts of mixtures of contaminants, including metals, acid mine drainage, etc., on the fauna and flora of the Nushagak River and Kvichak River watersheds? What species are most sensitive and might surrogate species exist for those for which we do not have data? Review the European literature and regulatory requirements for additional data.

  RESPONSE: The acute and chronic impacts of contaminant mixtures, including metals and acid mine drainage (i.e., metals in low pH-waters) were addressed using concentration additivity models in the leachate chemistry tables in Chapters 5 and 6 (now Chapters 8 and 11). Additional toxicity data were obtained by searches of the EU and OECD database eChem, the EPA's ECOTOX and the Environment Canada site. More metals are now included. In general, metals are most toxic to aquatic arthropods rather than fish, as discussed for copper.

  Dennis D. Dauble- What I found in the Revised Assessment was considerably more toxicity data, including information from the most recent open-literature publications. The potential risk of exposures to contaminant mixtures (a complicated topic) was addressed using the additive model, which is about all you can do without having specific mixture data.

- COMMENT: Can an inventory of nutrients, total organic carbon, and dissolved organic carbon inputs to aquatic environments be developed that demonstrates their relative magnitude and spatial variation from headwaters to Bristol Bay? What is the relative importance of marine-derived nutrients relative to other nutrients from watershed and terrestrial sources? What is the current atmospheric input of nutrients?

RESPONSE: These data would be very useful in the risk assessment, but are not currently available for the Bristol Bay region. We agree this is a research need.

Dennis D. Dauble-Given the emphasis in this document on the importance of marine-derived nutrients from salmon populations on the Bristol Bay watershed, it would be instructive if an example or two was provided from the literature on the relative magnitude and/or importance of nutrient inputs to watersheds from anadromous fish populations, terrestrial, atmospheric and/or autochthonous sources.

- COMMENT: What are the locations of subsistence areas and can these areas be characterized and differentiated by collecting local environmental and ecological knowledge (e.g., fish overwintering areas, climate change, ecological shifts, etc.)?

  RESPONSE: The revised assessment incorporated current data on subsistence use areas available from ADF&G. EPA acknowledges that these data are incomplete and would encourage additional collection of subsistence data and Traditional Ecological Knowledge.

  Dennis D. Dauble- No comment.

- COMMENT: What impact might mining have on other important wildlife species in the basin (e.g., freshwater seals in Iliamna Lake)?

  RESPONSE: The scope of the assessment is focused on potential risks to salmon from large-scale mining and salmon-mediated effects to indigenous culture and wildlife. Direct effects on wildlife from large-scale mining are likely to be important and Appendix C (now a stand-alone US Fish and Wildlife report) provides useful information for a future evaluation of direct effects on wildlife from large-scale mining. We agree that this is an important area for future research.

  Dennis D. Dauble- No comment

- COMMENT: What is the comprehensive hydrologic regime of the specific project mining area, and the broader watershed system as characterized by baseline monitoring, spatial distribution, and quantitative flow of surface- and ground-waters?

  RESPONSE: Comprehensive spatial estimates of mean annual flow are now presented in Chapter 3. Quantification of spatial and temporal patterns of groundwater flows is an acknowledged highly desirable product, but it not feasible within the scope of this assessment. Results of an independent groundwater-surface water modeling effort are described in Chapter 7.

  Dennis D. Dauble- It is apparent that the hydrological description was much expanded. These additions are appropriate and informative.

- COMMENT: What is the cumulative impact of commercial fisheries on the Bristol Bay watershed, especially in an ecosystem context as related to marine-derived nutrient and energy flow? Acknowledge that commercial fishing has had an impact on the amount of marine-derived nutrients returned to the watersheds.

  RESPONSE: The impact of commercial fisheries on the watershed is not within the scope of this assessment. Information on commercial fisheries management has been added in

Box 5-2. However, the purpose of this assessment is not to assess the relative effects of potential mining and commercial fishing—it is to evaluate potential effects on endpoints if a mine were to be developed, given existing conditions and activities in the region.

Dennis D. Dauble- I am satisfied with the additional information on commercial fisheries management practices included in the assessment.

WRITTEN PEER REVIEW COMMENTS- DENNIS D. DAUBLE

1. GENERAL IMPRESSIONS

• COMMENT: Overall, the main report and each of the accompanying appendices were well written. I was unable to identify major inaccuracies or bias in the material as presented. There were shortcomings in the main report, however. For example, some topics would benefit by being expanded (Sections 5.6 and 8.7), while others have more detail than appeared necessary (Section 6.1). The assessment effectively addressed three appropriate time periods: (1) operation, (2) post-closure, and (3) perpetuity. Potential effects are bounded by a minimum and maximum mine size, which is also appropriate. Inclusion of inference by analogy strengthened the conclusions reached in the assessment and helped validate results obtained from model predictions.

RESPONSE: Previous Section 5.6 (wildlife and culture) has now been expanded and treated as a stand-alone chapter (Chapter 12). The summary of risks from the mine scenarios (previous Section 8.7, now Chapter 14) has been expanded to include fish-mediated risks to wildlife and culture, and more numerical results are included.

Dennis D. Dauble- These changes are all improvements to the May 2012 Draft Assessment. Each chapter now begins with a clear description of what it includes. On a more editorial note, Chapters 7, 8, 11, 12, and 14 begin with an overview of what follows, but have no heading. In contrast, Chapters 9 and 13 begin with an Introduction or Overview heading. These differences may have been due to different authors and different writing styles.

• COMMENT: Most figures and tables were useful. The conceptual models and accompanying illustrations of potential habitat effects (Figs 3-2A and C) are important because they provide a view of complicated pathways and relationships among potential activities and environmental attributes. However, these relationships are not revisited in any detail later in the document. I recommend discussing the conceptual models in more detail in the main report (Section 3.6) and summary section in Chapter 8.

RESPONSE: Additional information on the use of conceptual models throughout the assessment has been incorporated into Chapter 2. The more comprehensive conceptual models presented in Chapter 6 (previously in Chapter 3) have been broken into their relevant component parts throughout the risk analysis and characterization chapters, to better frame the specific pathways addressed in each chapter.

Dennis D. Dauble- Having separate (and less complicated) conceptual models relevant to specific risk scenarios is an improvement.

• COMMENT: The Integrated Risk Assessment (Chapter 8) did a creditable job of summarizing habitat losses and risks from mine operations. What is missing, however, are quantitative descriptions of habitat lost relative to total habitat available in the larger watershed and individual systems. Habitat loss should be further discussed in terms of salmonid life stage and productivity (i.e., not all stream miles are equal).

RESPONSE: Unfortunately, no salmon habitat characterization is available for the region. The State of Alaska has not even identified all anadromous streams in the region. Productivity data are not available, even for the streams studied by the PLP. However, the

revised Chapter 14 contains tables summarizing habitat loss in stream lengths and wetland areas.

Dennis D. Dauble- My question may have been misinterpreted (or poorly worded). What I found in the revised Draft Assessment is a much improved description of habitat use by salmonids of concern, including stream miles and locations for both spawning and rearing (where known). I did not expect that habitat information was available for the entire watershed. There was some information on productivity in terms of the range of returning adults.

• COMMENT: If anything, the conclusions could be strengthened. The summary of uncertainties and limitations (Section 8.5) dwells on things that "could not be quantified" due to lack of information, model limitations, or insufficient resources. Thus, this reader was left somewhat in limbo as to the potential magnitude of effects from mining activities. (Note that this "neutral voice" is carried throughout the Executive Summary). Many people might interpret such statements of uncertainty as no proven effect. My point is that probable environmental consequences of mining activities are much greater than this report alludes to, given that consequences are likely, even if their magnitude is "uncertain."

RESPONSE: We use a neutral voice throughout the document to convey the neutral scientific perspective of this scientific assessment. We tried to convey the qualitative likelihood of occurrence when quantitative probabilities were not obtainable. This section has been edited in Chapter 14 of the revised version to make the relationship between uncertainty and probability of occurrence clearer.

Dennis D. Dauble- I am content with changes made to Chapter 14.

• COMMENT: Section 8.7 is perhaps the most important section of the report. It should be comprehensive, i.e., cover all resources and be more quantitative. Missing from the summary were impacts on wildlife, human culture, resident fish, and other ecological resources. Essential details from Appendices A, C, E, F, and I, for example, could be synthesized and moved into the main report.

RESPONSE: The summary of risks from the mine scenarios (Chapter 14 in the revised version) has been expanded to include fish-mediated risks to wildlife and culture and more numerical results.

Dennis D. Dauble- Chapter 14 is a much improved version of what was formerly in Chapter 8.

2. RESPONSES TO CHARGE QUESTIONS

Question 1. ***The EPA's assessment focused on identifying the impacts of potential future large-scale mining to the fish habitat and populations in these watersheds. The assessment brought together information to characterize the ecological, geological, and cultural resources of the Nushagak and Kvichak watersheds. Did this characterization provide appropriate background information for the assessment? Was this characterization accurate? Were any significant literature, reports, or data missed that would be useful to complete this characterization, and if so what are they?***

• COMMENT: As noted in the approach, characterization of and risk to ecological resources emphasized salmon and other important sport and commercial fish species. Consequently, the description of non-salmonid species generally lacked estimates of population size, except for sport and subsistence catch statistics. There was a long list of other resident fish in Appendix A, but their role in the Bristol Bay watershed (including the Nushagak River and Kvichak River watersheds) is not described in any detail there or in the main report. Available data on known or perceived ecological interactions among salmonid and resident fish should be included in the assessment.

RESPONSE: The assessment endpoints—salmonid fishes and their effects on wildlife and Alaska Native cultures—have been clarified in Chapters 2 and 5; other fish species are thus outside the scope of the assessment. However, we recognize in the text that other fishes (as well as other biota) are important components of the ecosystem, and have included a table of all documented fish species in the region in Chapter 5 to better reflect the fish fauna in the region.

Dennis D. Dauble- While I understand why many fish species are outside the scope of the assessment, what's still missing is information on known ecological interactions (i.e., predation, competition) within the fish community. It's possible these interactions have as much influence on the salmonid fish population as mining impacts or global climate change might have, for example. Table 5.1 is a start. Another table or brief description of the ecological role of each important or abundant fish species in the Bristol Bay watershed-in relation to salmonids- would be useful

• COMMENT: Another limitation to the salmon-centric assessment is that risk assessment endpoints, described in Chapter 3 of the main report, do not address other aquatic ecological resources. Consequently, while there was acknowledgment of ecological dependencies among salmon, other fishes, and land mammals, very little information was provided on primary and secondary production processes of aquatic communities. For example, the relative importance of marine-derived nutrients (MDN) in the form of salmon eggs and carcasses is discussed, but there is only brief mention of aquatic insects in the diet salmonid species. What nutrient levels occur in these stream systems with and without MDN?

RESPONSE: We recognize that nutrient status, and more important prey availability, is a critical component of habitat capacity for fish in these systems, and may be strongly driven by salmon derived nutrients. We concur that more information is needed regarding potential limiting factors for salmon productivity and capacity, and that food availability may be one such factor. The role of aquatic invertebrates in the diet of salmonids receives more attention in the revised draft, and is an essential part of the risk assessment for water treatment and discharge, given the relatively high sensitivities of aquatic invertebrate taxa to metals. However, because water chemistry data may not provide a complete picture of trophic status, particularly where direct consumption of salmon flesh, eggs, and fry is of such high importance as it is in many of the area streams, we determined that nutrient status of area streams is outside the scope of this assessment.

Dennis D. Dauble- I defer to EPA's judgment on this topic.

• COMMENT: A description of major groups of aquatic invertebrates in terms of biomass and seasonal abundance should be included in the main report. Further, aquatic and terrestrial food webs and linkages need more embellishment. One approach might be to add narrative text with the conceptual model discussion, including descriptions of community structure, function, and biomass.

**** RESPONSE: Additional detail on food webs is beyond the scope of this assessment (as detailed in Chapters 2 and 5). Further, available data are inadequate to assess risks at that level of specificity. For example, there are no acute copper toxicity data for any aquatic insects and only one old chronic value for a caddisfly.***

Dennis D. Dauble- I don't agree that detail on food webs as it relates to salmonids is beyond the scope of the assessment. No acute copper toxicity data for any aquatic insects? Note that effects on primary production were also ignored in the document.

• COMMENT: More detail on river and lake limnology would be helpful. For example, the hydrology of the watershed is mainly limited to a brief discussion of salmonid habitats. The geology of the basin emphasizes geology of mining areas and mineral processes. A more landscape-based description is warranted given the importance of geology to surface water processes and groundwater movement. The report would benefit from having a summary table listing lake size/volume and river length/discharge for watersheds potentially affected (and not affected) by mining activities.

RESPONSE: We now include maps of geology and estimated mean annual flow for the study region (Chapter 3).

Dennis D. Dauble- River length can be easily inferred from new, detailed maps of the watershed and specific water bodies. Mean annual flows are also now presented in Chapter 3. Consequently, this comment was largely resolved.

• COMMENT: Also missing were specific habitat requirements for rearing of juvenile salmon. A brief description of where pink and chum salmon spawn and rear in the Bristol Bay watershed relative to other salmon species should be included in the main report. There was nothing in Appendix A on where coho, pink, and chum salmon reside within the Bristol Bay watershed.

RESPONSE: Identified spawning and rearing habitats for the five Pacific salmon species are reflected in Figures 5-3 through 5-8, and additional text on salmon life histories has been included in Chapter 5.

Dennis D. Dauble- Figures 5-3 through 5-8 and supporting narrative text are excellent additions to the main document.

• COMMENT: Each appendix has a wealth of supporting information and could serve as a stand-alone document. However, having to work back-and-forth between the main report and appendices to interpret critical aspects of the assessment presents a challenge. Don't assume the average reader will read (and interpret) these appendices. To help remedy, the authors of the main report should strive to directly cite relevant information (and/or a specific appendix) that supports their conclusions.

RESPONSE: Additional information from Appendices A and B has been pulled into Chapter 5 of the main assessment. In addition, the purpose of the appendices has been clarified in Chapter 2.

Dennis D. Dauble- This approach is now apparent throughout the main document and is both informative and helpful to the reader.

Question 2. ***A formal mine plan or application is not available for the porphyry copper deposits in the Bristol Bay watershed. EPA developed a hypothetical mine scenario for its risk assessment, based largely on a plan published by Northern Dynasty Minerals. Given the type and location of copper deposits in the watershed, was this hypothetical mine scenario realistic and sufficient for the assessment? Has EPA appropriately bounded the magnitude of potential mine activities with the minimum and maximum mine sizes used in the scenario? Are there significant literature, reports, or data not referenced that would be useful to refine the mine scenario, and if so what are they?***

• COMMENT: The hypothetical mine scenario initially appeared realistic and useful in terms of potential project scope. However, it was apparent during the public hearing, and upon further discussion between members of the panel, that assumptions on mine size should be revisited based on deposit characteristics and extraction potential. Also, assumed practices and operations should be verified against current best-practice and State of Alaska permitting guidelines.

**** RESPONSE: : The revised assessment includes a smaller sized mine that is based on the median-sized porphyry copper mine on a worldwide basis. The State of Alaska does not have permitting guidelines that address the size of a mining operation. Land use activities were previously subject to stipulations meant to minimize surface damage or disturbance under 11 Alaska Administrative Code (AAC) 96.140, but this regulation was repealed in December 2002. The State does have statutory and/or regulatory requirements for an approved Plan of Operations (11 AAC 86.800), a Reclamation Plan (Alaska Statute (AS) 27.19.30) and appropriate Financial Assurance (AS 27.19.040).***

Dennis D. Dauble- The three mine scenarios as presented in the revised Assessment cover a realistic range of potential development.

• COMMENT: Referenced literature provides appropriate context, however, I cannot help believe that information on environmental impacts from past mining activities conducted in the Rocky Mountain metal belt would be relevant to this assessment in some cases. It is also possible that recent published information from Holden Mine in northern Washington State would help establish context for effects of leachates and model results that predict downstream transport of tailing material in a wilderness setting, for example.

RESPONSE: Environmental impacts from historic mining are the basis for understanding that risks from hazards of mining need evaluation. Modeling of tailings transport was based on the expected characteristics of tailings for the Pebble deposit. There is an expanse of literature on Superfund sites and interactions of metals associated with sediments and their leaching. We included a number of selected sites in our background information, but to include all possible sites would get further away from the scope of the assessment, which was to evaluate potential effects within the Bristol Bay watershed.

Dennis D. Dauble- In this reviewer's opinion, the writers did an adequate job of providing comparative information from other mineral development sites.

Question 3. ***EPA assumed two potential modes for mining operations: a no-failure mode of operation and a mode involving one or more types of failures. Is the no-failure***

mode of operation adequately described? Are engineering and mitigation practices sufficiently detailed, reasonable, and consistent? Are significant literature, reports, or data not referenced that would be useful to refine these scenarios, and if so what are they?

Dennis D. Dauble, Ph.D.

• COMMENT: The description of the no-failure mode for mine operation appears adequate in terms of potential mitigation measures that might be employed. I have limited knowledge of current engineering practices and subsequent risks to the environment from best practices of modern mines, including those operating under optimal conditions. However, it would be helpful to include a short discussion on which mitigation measures would be most applicable to mining activities in the Bristol Bay watershed.

RESPONSE: Standard design mitigation measures considered feasible, appropriate, and 'permittable' (as per Ghaffari et al. 2011) were considered and are discussed in Chapter 6 and Appendix I of the revised assessment; these are standard measures common to other copper porphyry mines. Evaluation of measures that would be proposed for an actual mine would occur through the regulatory process. Whether these same measures would be appropriate for all locations within the Bristol Bay watershed would depend on the given site's specific characteristics.

Dennis D. Dauble- The topic of mitigation is adequately covered in Chapter 6 as well as Appendices I and J of the revised assessment.

Question 4. ***Are the potential risks to salmonid fish due to habitat loss and modification and changes in hydrology and water quality appropriately characterized and described for the no-failure mode of operation? Does the assessment appropriately describe the scale and extent of risks to salmonid fish due to operation of a transportation corridor under the no-failure mode of operation?***

• COMMENT: The assessment describes the number of stream miles impacted under each mode of operation, including miles blocked and eliminated. Less specific were descriptions of impacts due to sedimentation and leachates. What is lacking is quantitative estimates of spawning and rearing habitat that would be lost relative to the total habitat available. Having this information would help provide perspective of overall risk to individual watersheds and the Bristol Bay watershed as a whole. Risks to salmonid fish due to changes in water quality (i.e., toxic materials) need to consider differences in sensitivity and behavioral response according to salmonid life stage.

RESPONSE: Stream habitat losses are now characterized in relation to the distribution of habitat conditions throughout the larger watersheds (Chapters 3 and 7). The assessment of risks from aqueous toxicity distinguishes overt toxic effects on early life stages from behavioral effects on adults.

Dennis D. Dauble- Stream habitat losses and toxicity are well-described in terms of life stage and species for each of the identified risk areas described in Chapters 7 through 11. One problem is that many tables (e.g., 8.4-8.8) lack narrative text. These tables are somewhat complicated and not self-explanatory and should not be introduced to the reader

as a citation without supporting narrative text. For example, what are quotients? Does a low quotient value relative to the CMC or CC indicative of no risk? Not until Box 8.3 (or 20 pages after tables 8-4 to 8-8 is an explanation provided so that readers might know what the data in these tables means. Strongly suggest that Box 8.3 be moved forward in this chapter and that narrative text be added to the document.

• COMMENT: Surface water characteristics of site watersheds within the area of probable impact are detailed in Table 5-17, but not so for other streams and lakes in the broader watershed. More information should be presented where available. It is not clear whether potentially affected streams and lakes might be nutrient limited (seems that they might be given their dependence on MDN). For example, include N or P concentrations and some discussion about primary and secondary productivity.

RESPONSE: We recognize that nutrient status, and more importantly prey availability, is a critical component of habitat capacity for fish in these systems, and may be strongly driven by salmon derived nutrients. We concur that more information is needed regarding potential limiting factors for salmon productivity and capacity, and that food availability may be one such factor. However, because water chemistry data may not provide a complete picture of trophic status, particularly where direct consumption of salmon flesh, eggs, and fry is of such high importance, and because nutrient status is a water quality or habitat parameter not directly influenced by mining operations as outlined in our conceptual models (e.g., Figure 7-1), we determined that nutrient status of area streams is outside the scope of this assessment.

Dennis D. Dauble- The amount of additional detail in Chapter 8 on stream hydrology is impressive and useful for this reviewer. While nutrient status of the watershed relative to mining impacts may be outside the scope of the assessment, this information should be included as part of the characterization process.

• COMMENT: I found risks to salmonid fish due to operation of the transportation corridor well-described with respect to spatial distribution of fish and their habitats.

RESPONSE: No changes suggested or required.

Dennis D. Dauble- No comment.

Question 5. ***Do the failures outlined in the assessment reasonably represent potential system failures that could occur at a mine of the type and size outlined in the mine scenario? Is there a significant type of failure that is not described? Are the probabilities and risks of failures estimated appropriately? Is appropriate information from existing mines used to identify and estimate types and specific failure risks? If not, which existing mines might be relevant for estimating potential mining activities in the Bristol Bay watershed?***

• COMMENT: My experience in system failure of mines of the size and type outlined in the scenario is limited. However, what does seem to be missing is the long-term effects of leachates to receiving water bodies in any type of risk scenario, including both non-failure and failure modes. That is, assuming no catastrophic failure, how might tailings constituents interact with aquatic habitats seasonally, such as during periods of snowmelt and severe rainfall events?

RESPONSE: The original draft assessment contained a scenario in which tailings leachate was not fully contained and reached a stream (Section 6.3 in the May 2012 draft). The revised assessment includes estimates of leachate escaping from the TSFs and from the waste rock piles, bypassing the collection systems, and entering the streams (Chapter 8). The estimated loadings of copper and other elements from these leachate flows are included in stream concentration estimates. The assessment discusses the impacts of these concentrations on the aquatic habitat and biota. The commenter is correct that we did not include a scenario in which the dam does not fail, but snowmelt and severe rainfall would result in overtopping and release of untreated water. That is very plausible, but there are just too many possible failure scenarios to include more than a few of them.

Dennis D. Dauble- If the scenario is plausible, it should be included in the assessment. However, if the potential risk is covered based on a similar or parallel scenario, then it should be stated as such.

Question 6. ***Does the assessment appropriately characterize risks to salmonid fish due to a potential failure of water and leachate collection and treatment from the mine site? If not, what suggestions do you have for improving this part of the assessment? Are significant literature, reports, or data not referenced that would be useful to characterize these risks, and if so what are they?***

• COMMENT: More information on local hydrology, including seasonal runoff patterns (e.g., peak flows) and groundwater movement would be useful. I found no description of existing water quality characteristics of potential receiving waters, except what is included in Table 5-17 of the main report. Are these values (such as hardness, which moderates metal toxicity) consistent throughout the watersheds, including downstream lakes? Other questions include: What volumes of leachates might be collected and treated versus volumes not captured and subsequently released downstream? Is copper the only constituent of concern to aquatic animals? Are there processing chemicals that would also be toxic?

RESPONSE: Monthly flow patterns for area streams are now presented in Chapter 7. The three streams described in Table 7-17 are the three potential receiving waters for any site effluents. The water balance, including leachate volumes, is now described in the assessment (Chapter 6). Copper is the primary contaminant of concern. Others are described in the new Section 6.4.2.3 and discussed in Chapters 8 and 11.

Dennis D. Dauble- I noted hardness values were now included in Chapter 3. Also, several new maps (Figures 6 1 to 6 3 and 6 8 to 6 11) provide sufficient detail of regional and local hydrology that flow paths for receiving waters are clearly understandable.

• COMMENT: The assessment should also consider and discuss relative risk to aquatic ecosystems from downstream transport of sediment-bound metals to Iliamna Lake, if deemed probable.

RESPONSE: Although metals in aqueous emissions would partition to sediment, and the sediment would mobilize during high flows and eventually reach the lake, this route is not

judged to be significant. Toxicity is caused by dissolved metals, and concentrations from release of metals from transported sediment to lake water are likely to be minor.

Dennis D. Dauble- I defer to EPA's judgment on this topic.

Question 7. ***Does the assessment appropriately characterize risks to salmonid fish due to culvert failures along the transportation corridor? If not, what suggestions do you have for improving this part of the assessment? Are significant literature, reports, or data not referenced that would be useful to characterize these risks, and if so what are they?***

• COMMENT: Mitigation practices, such as new culvert design, was well described, as was bridging of roadways and porous fills to mitigate risks due to culvert failure along the transportation corridor. This assessment also included appropriate risk characterization for both the no-failure and failure scenarios. There should be literature available from the Washington State Department of Transportation on fish passage relative to culvert placement and design. Otherwise, I have no suggestions for improvement.

RESPONSE: We have examined literature on fish passage relative to culverts from the Washington State Department of Transportation. Culvert failure frequencies from their 2012 paper, in which approximately 62% of culverts were identified as total or partial barriers, were not used in the assessment because we could not determine the age of examined roads.

Dennis D. Dauble- I had no serious issues with the assessment of potential culvert failures. However, I can't help but believe that data on timing of road construction for WA State DOT projects would be available. In terms of aquatic invasive species (Section 10.3.6.1), no plausible vector was described for their transport. What types of construction equipment or mining infrastructure would be expected to lead to the introduction of aquatic invasive species? Typical examples would be recreational vehicles, such as boat, but that does not seem applicable. Suggest you introduce the topic but tone down the risk relative to mining operations.

Question 8. ***Does the assessment appropriately characterize risks to salmonid fish due to pipeline failures? If not, what suggestions do you have for improving this part of the assessment? Are significant literature, reports, or data not referenced that would be useful to characterize these risks, and if so what are they?***

• COMMENT: The risks to salmonid fish due to release of pipeline concentrate/slurry and leachates (as return water) are well described. However, risks of a diesel fuel spill are not. More detail could be provided on reclaimed water. For example, what toxic constituents (and at what volumes) would be released to the environment if these pipelines failed?

RESPONSE: A diesel pipeline failure and resultant spill into two creeks has been added in Chapter 11 in the revised assessment. New data on concentrate leachate in the slurry have been added, and it is assumed to also describe the return water.

Dennis D. Dauble- I appreciate the addition to the assessment. What's missing, however, is an explanation of which mine scenario was selected for the pipeline discussion and why.

Not until section 11.3.4.4 was it stated that pipeline failures would be likely under the Pebble 6.5 scenario. What about Pebble 0.25 and 2.0? Were they considered? If not, please state why. Also, the last two bullets under 11.5.5 Uncertainties appear as conclusion statements, not uncertainties.

Question 9. ***Does the assessment appropriately characterize risks to salmonid fish due to a potential tailings dam failure? If not, what suggestions do you have for improving this part of the assessment? Are significant literature, reports, or data not referenced that would be useful to characterize these risks, and if so what are they?***

• COMMENT: Tailings deposition is described in Chapter 4 of the main report, but I could not find anything that described potential risks to fishes, including effects to aquatic food webs and loss of fish spawning and rearing habitat.

RESPONSE: The TSF failure description and the assessment of risks were presented in separate chapters in the original draft assessment, but have now been moved into one location (Chapter 9) for clarity.

Dennis D. Dauble- This change is a big improvement over the previous draft. What I like is the inclusion of analogous sites: Clark Fork, Coeur d'Alene River, and Soda Butte Creek to the discussion. The summary of evidence concerning risks (Table 9.11) was also helpful.

• COMMENT: As noted in the text, the sediment transport model used could only simulate sediment transport and deposition ~30 km downstream of the mine site. Thus, potential effects to fish habitats were not well quantified for the mainstem Koktuli River (and beyond), in addition to the Mulchatna and Nushagak rivers. Is there likelihood that any tailings material might reach Lake Iliamna? If not, say so in the document. It is equally useful to say where impacts will not occur (as it relates to sensitive habitat) as it is to describe where impacts are likely and reasonable.

RESPONSE: None of the 3 TSFs are in the watershed of Iliamna Lake. The hydrology of the site has been clarified and better maps added to clarify this issue. Risks to Iliamna Lake from water treatment failures, even if they occur in the Nushagak drainage, are now noted (e.g., transport of toxic leachate from the South Fork Koktuli to Upper Talarik Creek via groundwater exchange between theses basins; Chapter 8). However, sediment (i.e., tailings) would not follow that route.

Dennis D. Dauble- The new maps are a welcome addition. It was useful to learn tailings sediments would not likely reach Lake Iliamna and that transport of toxic leachates from groundwater exchange would be a minor pathway.

• COMMENT: The assessment deemed that it was "not possible" to determine how far the initial slurry deposition would extend, how far re-suspended sediments would travel, and how long erosion processes would continue. I believe information from other mine closure sites could be included by assessment authors to infer effect by analogy. The statement alluding to potential sediment run out distance at the bottom of page 4-56 of the main report should be included in the summary of effects. This is an important point.

RESPONSE: The revised assessment now includes a clearer description of the magnitude and duration of effects. We apply the runout distance equations of Rico et al. (2008) to conclude that under Pebble 2.0 scenario dam failure conditions, runout distance exceeds 307 km (190 miles), reaching the marine waters of Bristol Bay (Section 9.3.2).

Dennis D. Dauble- The new description is now sufficient, given the limitations of modeling.

Question 10. ***Does the assessment appropriately characterize risks to wildlife and human cultures due to risks to fish? If not, what suggestions do you have for improving this part of the assessment? Are significant literature, reports, or data not referenced that would be useful to characterize these risks, and if so what are they?***

• COMMENT: There is considerable detailed information in Appendices D and E relating to impacts of the project to the economy. This information includes how salmon affect all segments of the population, such as cultural resources of Native Peoples. However, not addressed in detail were long-term impacts to Native Peoples that might occur after losing a way of life that includes salmon. The description of potential impacts to their health and welfare should be expanded. There are numerous examples of how Columbia River tribes have been negatively impacted due to loss of fish resources (and fishing as a lifestyle) as a result of dam construction. These impacts go beyond simple economics.

RESPONSE: EPA recognizes that there is a great deal of information about cultural and health effects on indigenous populations from loss of fish resources. We have referenced some case studies in the assessment (with a primary focus on Alaska), and have expanded the discussion of potential effects from a loss of salmon resources in Chapter 12.

Dennis D. Dauble- The case studies are helpful. I agree that Alaska's native peoples are a unique situation.

• COMMENT: The report should include a discussion of effects specific to unique user groups. That is, some communities rely almost solely on sockeye; kings are more important to others. These impacts could be segregated by watershed, for example. Also, some groups have more option for subsistence gathering if sockeye and Chinook salmon resources are impacted. Potential impacts of a declining salmon population due to mining operations would be less for them than groups "on the edge" who currently rely mainly on salmon.

RESPONSE: The text of the revised assessment (Section 5.4.2.2) has been expanded to acknowledge the differences between communities with regard to use and reliance on salmon and other fish resources.

Dennis D. Dauble- Although text was revised in Chapter 5 to acknowledge differences in reliance between Chinook and sockeye salmon, these differences were not brought forward to risk assessment discussions in Chapter 12. Discussion in section 12.2.3 should address the declining state of economy for some upper watershed cultures and specify which resident group expressed a desire for jobs and development.

• COMMENT: Disturbance of wildlife from noise and roadways should be included with respect to migration corridors and critical habitat. Highlight species most likely at risk from human disturbance, habitat loss/displacement (from the project footprint), and loss of salmon. For instance, do some piscivorous species have the ability to shift their diet to include another source of protein? If so, how would this shift affect the human culture with reference to a subsistence lifestyle?

RESPONSE: EPA recognizes that there are potential direct effects on wildlife from large-scale mining operations, including disturbances from noise and roadways; however direct effects on wildlife are outside of the scope of the assessment, as explained in Chapter 2. We would expect that a full evaluation of any future mining permit applications and subsequent National Environmental Policy Act Environmental Impact Statements would consider these direct effects on wildlife.

Dennis D. Dauble- It would be informative (and in my opinion within the scope of the assessment) to include additional narrative text on wildlife species having the greatest dependency on salmon as a prey base.

Question 11. ***Does the assessment appropriately describe the potential for cumulative risks from multiple mines? If not, what suggestions do you have for improving this part of the assessment?***

• COMMENT: Individual risk is described in varying levels of detail with overall risk or effects considered to be largely additive. However, the relative magnitude of the effects of mining each ore deposit is difficult to discern. It is possible that one of the smaller ore sites could be developed within an acceptable risk scenario, but it is difficult to determine given that the assessment is largely built on potential impacts of the Pebble Mine. To put things in perspective (individually and cumulatively), there should be a discussion of habitat lost given each individual mine footprint, during normal operation (includes water treatment and withdrawal) and as a result of pollutant exposure. Also, Section 7.4.1 of the main report provides estimates of stream miles affected due to blockage and elimination, but provides nothing quantitative for other direct and indirect impacts of mine operation. The cumulative risk discussion in Chapter 7 could be expanded to link up with the conceptual model described in Chapter 3.

RESPONSE: We cannot reliably predict the habitat loss due to additional mines. We have tried to describe plausible examples of where additional mines could be developed on the basis of active exploration on existing claim blocks. In the revised assessment (Chapter 13) we predicted aquatic resource impacts based on a typical mine footprint being constructed anywhere in the block and an average stream and wetlands density. We also expanded discussion of the impacts of ancillary mine infrastructure and induced development. This provides a conservative estimate of the cumulative effects of multiple mines and sheds light on whether cumulative effects are a significant concern. We have developed a specific conceptual model for cumulative impacts and used it to enhance the discussion.

Dennis D. Dauble- The expanded discussion on cumulative impacts and re-organization of the document largely resolves my questions on this topic. However, it would be informative to define what "more than minimal" means in Table 13.1, and to include the area or footprint of each individual site. Note that area of each site are included later in narrative text, but in different subsections. This information should be included in the Description, not in Potentially Affected Waters. Finally, I think human development in the Pacific Northwest is a poor analogy with respect to cascading effects on salmon populations (i.e., last paragraph of 13.5 Summary). Either remove this discussion or make a stronger

argument that mining development in Alaska is equivalent to hydro development +irrigation +deforestation+ over-fishing in the Columbia Basin.

Question 12. ***Are there reasonable mitigation measures that would reduce or minimize the mining risks and impacts beyond those already described in the assessment? What are those measures and how should they be integrated into the assessment? Realizing that there are practical issues associated with implementation, what is the likelihood of success of those measures?***

• COMMENT: Potential mitigation measures are well described in Appendix I. I have no suggestions for additional measures. Implementation of mitigation measures is entirely dependent on the regulatory framework for operations and the oversight and monitoring practices that would be mandated as a condition of the mining activity. Thus, some discussion of how/which mitigation practices would be most applicable in the Bristol Bay watershed (and limitations thereof), given constraints and characteristics of local hydrology and geology, is warranted.

RESPONSE: The mitigation measures proposed within the mine scenarios are those that could reasonably be expected to be proposed for a real mine, are a subset of options presented in Appendix I, and were presented as appropriate for the Pebble deposit in Ghaffari et al. (2011). Evaluation of alternative strategies (e.g., other options presented in Appendix I for the mitigation of the same issue) should be done during a permitting process for a specific mining plan. Permit applicant mitigation measures that reduce the risks identified in the assessment would be welcome during the application process.

Dennis D. Dauble- The addition of Ghaffari et al (2011) helps substantiate the discussion of potential mitigation measures. Further, this topic is well-covered in both Appendices I and J, as well as Chapter 7 of the main document.

Question 13. ***Does the assessment identify and evaluate the uncertainties associated with the identified risks?***

• COMMENT: The most likely scenarios and probabilities of failure are described based on assumptions of project size and magnitude. For the most part, estimated risks are conservative (i.e., effects are stated as “likely” if no further information is available). A weakness of Integrated Risk Characterization (Chapter 8 of the main report) is having a long list of identified uncertainties, which leads one to speculate, “so what do we know?” Not being familiar with the formal risk assessment process, it appears this “assessment” (which is loosely based on a risk assessment framework), falls short of providing something with any degree of certainty.

RESPONSE: The assessment does not state that effects are likely if no further information is available. The assessment, as far as the available information allows, identifies potential events and their effects, their probabilities of occurrence, and possible ranges. Uncertainties, inherent in any risk assessment or mine plan, are clearly identified in the assessment.

Dennis D. Dauble- Either I have an improved understanding of risk assessment jargon as a result of reviewing the document or the revised Assessment does a better job of explaining the process.

Question 14. ***Are there any other comments concerning the assessment, which have not yet been addressed by the charge questions, which panel members would like to provide?***

• COMMENT: Based on public comments and discussions that took place by panel members in Anchorage August 7-9 of this year, this report confuses in both intent and approach. Is the intent of EPA's assessment to characterize potential impacts to the Bristol Bay watershed (title) or does it address a more defined portion of the Nushagak River and Kvichak River watersheds (objective statement)? Was the approach an "assessment" (a fairly broad term) or an "ecological risk assessment" (suggests a specific scientific framework was applied to the risk/effects analyses)? These shortcomings should be addressed in the final assessment document.

RESPONSE: We have revised the discussion of purpose, scope and endpoints in response to this and other similar comments (see Chapters 1 through 5 of the revised assessment). The assessment addresses multiple spatial scales, as detailed in Chapter 2. It is an ecological risk assessment, but that term is usually shortened to assessment to make the document more readable.

Dennis D. Dauble- My concerns and questions on the intent and approach of the assessment were adequately addressed.

3. SPECIFIC OBSERVATIONS BY DENNIS D. DAUBLE

1. COMMENT: Appendix B, Page 30: Table 1. I suggest adding a column to indicate relative abundance, for example, if individual fish species listed are abundant, common or rare. Also, are there known differences in distribution and abundance for the Nushagak and Kvichak watersheds relative to those watersheds unlikely to be affected by mining activities?

   RESPONSE: This information, when known, has been added to Appendix B.

   Dennis D. Dauble- More important, Table 5.1 includes a list of anadromous and resident fish species reported in the Nushagak and Kvichak River watersheds and their relatives abundance.

2. COMMENT: Appendix A, Page 42: The statement that diminished salmon runs present a "negative feedback loop" where spawner abundance declines, appears to conflict with the last paragraph on page 41.

   RESPONSE: The text describes bottom-up effects of MDN on stream ecosystems and points out that these linkages have not been empirically established. The negative feedback loop mentioned in the following paragraph could result from reductions in salmon-based resources that promote either bottom-up (i.e., a reduction in salmon-derived N and P) or direct (i.e., a reduction in salmon eggs and flesh that can be consumed by fish) benefits to juvenile fishes. Further, the fact that bottom-up effects of MDN have not been firmly

established does not negate considerable circumstantial evidence for bottom-up nutritional deficits in Columbia Basin spawning streams. Edits have been made to help clarify.

Dennis D. Dauble- You present a convoluted argument. I could not find specific edits but recognize the topic is more complicated than some might imagine. As long as it is acknowledged somewhere that MDN is most important in systems that would otherwise be nutrient-deficient and that this input may be more important in lentic systems than lotic systems, I'm happy.

3. COMMENT: Appendix F, Page 3: Is there significant sediment transport from the Bristol Bay watershed to the Nushegak and Togiak Bays/estuaries?

   RESPONSE: A new section was added to Appendix F that discusses the importance of estuary habitat to salmon populations.

   Dennis D. Dauble- The response did not address my question. Also, note that the peer review panel did not receive copies of revised Appendices. I did, however, find a reference in the main document about potential for sediments to be transported to estuarine habitats.

4. COMMENT: Appendix F, Page 7: What is the juvenile salmon resident time in Bristol Bay? How quickly (and at what size/time of year) do they move from shallow nearshore to offshore habitats?

   RESPONSE: A new section was added to Appendix F that discusses the importance of estuary habitat to salmon populations.

   Dennis D. Dauble- Hopefully, this new section addresses my question.

5. COMMENT: Page 8-15 (L2): Suggest deleting "likely." There will be impacts.

   RESPONSE: We believe this language is consistent with the uncertainties explained in the assessment. No change has been made.

   Dennis D. Dauble- No comment.

Dr. Gordon Reeves,
USDA Pacific Northwest Research Station

PEER REVIEW FOLLOW-ON COMMENTS ON THE APRIL 2013 DRAFT OF

AN ASSESSMENT OF POTENTIAL MINING IMPACTS ON SALMON ECOSYSTEMS OF BRISTOL BAY, ALASKA

From: Reeves, Gordie -FS [mailto:greeves@fs.fed.us]
Sent: Monday, August 05, 2013 1:18 PM
To: Thomas, Jenny
Subject: RE: Bristol Bay Peer Review - Confidentiality Reminder

Jenny: Here is my review.

Gordie Reeves

Dr. Gordon Reeves

Department of Agriculture **Service** **Northwest Research Station** [redacted]

Date: 5 August 2013

Subject: Comments on the revised EPA Bristol Bay report

To: To Whom It May Concern

From: Gordie Reeves

EPA did a good job with the revision. All of the primary issues that I raised appear to have been considered but there were a few that I with which I did not agree with the response (See below).

Response to EPA's response to G. Reeves' comments on first draft:

p. 7. #1. There is no need to build an IP model from scratch. Rather, EPA could draw from results of studies that have employed the concept. Generally, a small proportion of the landscape is responsible for a large proportion of the production. See the attached draft of Bidlack et al., which is in review, on Chinook salmon in the upper Copper River. Simply stating the amount of miles of stream/habitat that may be affected may not accurately represent the impact of mine operations.

#2. The discussion of the potential impact of climate change in the revised document is good. I have two additional suggestions. First, changes in temperature are presented for air temperature only. You should attempt to discuss what this means for water temperatures. Generally, a two degree change in air temperature translates to a one degree change in water temperature. Or, at least state that there is not a corresponding one-to-one degree change in air and water temperature so that the reader is aware of the potential change in water temperature. Second, I think that it would be good to include Fig. 3 from McCollugh (1999. EPA-910-R-99-010). This figure shows the relation between changes in water temperature and time of emergence of fry, which is potential impact of increasing water temperatures from climate change and the altered water temperatures from mining operations.

p. 10. #1. Highlight more prominently in the document (Ch. 7) the fact that the NHD layer does not accurately represent smaller streams, which may be important ecologically, and the consequences of this to the analysis.

p. 22. I agree that Furniss et al. (1991) is a seminal paper on road and their impacts on aquatic organisms and ecosystems. However, it deals with forest roads that are much different in many ways from the roads considered in this assessment. The differences should be made more explicit. Also, you should look at Lee et al. (1997 USDA Forest Service Gen. Tech. Report. PNW-GTR-405, vol. III pp. 1057-1713) for additional potential impacts of roads. Again, this pertains to forest roads and limitation of the application to Bristol Bay should be acknowledged.

Specific comments on revised report:

p. 3-44-45. See comment p. 7 #2 above. You need to talk more explicitly about the potential impacts of warmer winters.

p. 3-45. Good point about the importance of genetic diversity.

p. 7-16. You should make the point that the percent of stream affected does not necessarily accurately reflect the potential impact. See comment on p. 7 #1 above.

p. 7-32. I think that is important not to just list potential mitigation measures but to also assess the potential for success. I think that you would be hard pressed to find examples where mitigation has even compensated for a fraction of the impact of given activities. Particularly present assessments from mining.

p. 10-6. This is a particularly good diagram.

Dr. Charles Slaughter, University of Idaho

Peer Review Follow-On Comments on the April 2013 Draft of

An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska

From: [redacted]
Sent: Tuesday, July 30, 2013 4:40 PM
To: Thomas, Jenny; White, Jessica
Cc: Frithsen, Jeff
Subject: CWS review of 2013 draft Bristol Bay docs

July 30, 2012
[redacted]

Jenny Thomas and Jessica White
Office of Wetlands, Oceans, and Watersheds US Environmental Protection Agency
1200 Pennsylvania Ave NW
Washington, DC 20460
Thomas.Jenny@epa.gov
White.Jessica@epa.gov

Dear Jenny and Jessica,

Attached are my comments in response to the Statement of Work regarding review of the documents: (1) EPA Response to Peer Review Report, External Peer Review of EPAs Draft Document An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska, and (2)EPA 910-R-12-re004Ba, April 2013, An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay Alaska, Volume 1;, Second External Review Draft

As you had recommended, my comments are appended to appropriate sections of the first document.

My "review" of the larger main report was limited to checking specific points, evaluating degree of incorporation of reviewers' 2012 recommendations into the revision, and gaining an overall impression of the present state of the draft assessment. The time allotted did not permit a truly comprehensive, paragraph-by-paragraph review of that document (nor was such review requested).

Nevertheless, I must compliment the authors for their work. The revised Assessment is a major (almost "quantum leap) improvement over the 2012 effort, incorporating much new analysis and discussion. The many conceptual models, flow charts, maps, figures and tables are very useful.
I specifically applaud (1) the decision to add chapters on the transportation corridor, cumulative impacts, and integrated risk characterization, and (2) the integration of uncertainty and risk characterization considerations into the topical chapters.

I trust that these review comments will prove useful to EPA. Please don't hesitate to contact me ([redacted] [preferred right now, as I am in SE Washington with only occasional internet access], or
[redacted] with any questions or concerns about this submission.

Thanks for the opportunity to again review this important body of work.

Sincerely yours,

Chuck
Charles W. Slaughter, PhD

SUMMARY OF KEY RECOMMENDATIONS FROM PEER REVIEWERS

This section summarizes the significant general recommendations put forth by the peer reviewers regarding EPA's draft assessment. In developing these recommendations, peer reviewers provided input on three major areas of the assessment: (1) scope, (2) technical content and (3) editorial suggestions. Reviewers also identified research needs for EPA to consider. Please note that this summary of peer review comments did not reflect a consensus or group perspective, but was compiled from a discussion of individual peer reviewer recommendations. Additional details, including references cited, can be found in the reviewers' individual comments in Section III.

CWS Comments July 2013

Scope of the Document:

• Articulate the purpose of the document more clearly via a primer on the Ecological Risk Assessment process. If the purpose of the assessment is to inform EPA as the decision maker, then the level of detail should correspond to this purpose. The authors should justify and explain what level of detail is required.

RESPONSE: Additional information on both the purpose of the assessment and ecological risk assessment (ERA) in general has been added to Chapters 1 and 2, as well as the Executive Summary. Section 1.2 includes information about the use of the assessment. The assessment has been reorganized into two major sections (problem formulation, risk analysis and characterization) to clarify where different chapters fall in the typical ERA process.

CWS Comment July 2013: *Chapter 1 provides a clear statement of the rationale underlying the Assessment – why it was undertaken, an overview of how the Assessment was developed, and a brief statement on how it might be used.*

• Include a statement upfront about the role of risk managers and other audiences, such as project managers/engineers, regulators, mine owners/operators. Knowing their role ensures inclusion of information necessary for any risk assessment by (1) describing the need for a risk assessment, (2) listing those decisions influenced, and (3) characterizing what risk managers require from the risk assessment.

RESPONSE: Section 1.2 of the revised assessment discusses the use of the assessment.

CWS Comment July 2013: *Section 1.2 discusses possible use of the assessment, but does not identify or define "risk managers" per se. Section 1.1 mentions "ecological risk assessment", "risk assessors" ,"risk assessments", "risk analysis and characterization", "potential risks" and "risks to assessment endpoints" -- so who or what are "risk managers" – project engineers, regulatory authorities, actuaries, industry funding entities, indigenous people living in the watershed?*

• Explain why the scope for human and wildlife impacts was limited to fish-mediated effects, as well as why fish-mediated effects on humans were limited to Alaska Native cultures. Reviewing effects beyond fish-mediated ones (e.g., potential for complete loss of the subsistence way of life) would improve the assessment.

RESPONSE: The scope of the assessment has been clarified throughout the document, particularly in Chapters 1 and 2. Throughout the assessment we acknowledge that direct effects of large-scale mining on wildlife and Alaska Native cultures may be significant, but that these direct effects are outside the scope of the current assessment.

CWS Comment July 2013: *Despite the primary focus of the Assessment on salmonids, the authors have done a creditable job of identifying probable (actually, inevitable and irreversible) consequences for Alaska Native culture of a PLP-style mineral extraction project in the Bristol Bay watershed. Similarly, consequences for wildlife populations are identified. Both topics received careful attention in appendices to the 2012 draft of the Assessment; incorporation of materials from those appendices into appropriate sections of this revised Assessment is commended.*

• Be more consistent throughout the document in terms of the level of detail provided for the different scenarios and stressors. For example, the document has devoted 36 pages to the discussion of catastrophic Tailings Storage Facility (TSF) failure, while sections on the pipeline, water treatment, and road/culvert failures are brief. Indeed, the long discussion on the TSF failure belies a certainty and understanding of dam failure dynamics that is inaccurate.

RESPONSE: The final document includes more failure scenarios (e.g., diesel pipeline failure, wastewater treatment plant failure, and refined seepage scenarios) in Chapter 8. It also explains why these specific failure scenarios were chosen, and discusses these scenarios in greater detail than the previous draft (i.e., to more closely match the level of detail originally provided only for the TSF failure scenario). Also see detailed responses to comments on Peer Review Question 5.

CWS Comment July 2013: *The more detailed and expanded treatment in Chapters 7, 8, 9, 10 and 11 of the revised Assessment is greatly appreciated. The new Assessment gives more balanced and appropriate consideration to potential failure scenarios which are in many ways at least in equal importance with potential TSF failure.*

Technical Content:

<u>Mine Scenario</u>

• Consider the document to be a screening-level assessment of all potential stressors. Focusing on failure mode overemphasizes catastrophic events (e.g., TSF failing), rather than considering all potential stressors, such as holding mine owners strictly accountable for their day-to-day activities with regard to best practices.

RESPONSE: Additional information on the purpose and scope of the assessment has been added to Chapters 1 and 2. A screening of all potential stressors, including individual chemicals, is

presented in Section 6.4.2. Also see detailed responses to Peer Review Question 2 on the use of "best practices" and responses to Peer Review Question 5 on failure scenarios.

CWS Comment July 2013: *The greater detail and much more comprehensive in-depth analysis in Chapter 6 and in the subsequent topic-specific chapters greatly enhance the utility and credibility of the Assessment.*

• Reexamine the document's use of historical data and case studies to describe and estimate the risk of failure for certain mine facilities (including the TSF, pipeline, water treatment, etc.), as these examples from extant mines may not be an appropriate analog for a new mine in the Bristol Bay watershed.

RESPONSE: The TSF failure range was, and still is, based on design goals, not the historical data. The historical TSF failure data are provided as background. The pipeline failure rates are based on the most relevant historical data from the petroleum industry. They are directly relevant to the diesel pipeline, and experiences at the Alumbrera mine (described in the previous draft) and the Antamina and Bingham Canyon mines (added to this draft) suggest that they also are relevant to the product concentrate pipeline. Water treatment failure rates were not quantified. However, recent reviews cited in the revised draft indicate that water collection and treatment failures have been reported at nearly all analogous mines in the U.S. The estimation of culvert failure frequencies has been revised and is now based on only recent literature (2002 and later). We believe that these estimates are appropriate.

CWS Comment July 2013: *RE pipeline failures, the revised Assessment does reference both the 2012 Ft. Knox AK incident, and the 2010 Klamazoo MI (Enbridge Energy) pipeline failure (p. 11-6). The Alumbrera, Antamina, and Bingham Canyon incidents discussed on pp. 11-14 to 11-16 are instructive, as they are considered modern, current-practice mines. The detailed analyses of hypothetical Knutson and Chinkelyes creeks spills are well thought out and helpful. The analysis of possible waste-water treatment facility failure in Chapter 8 is useful, as is the discussion of the Fraser River as an (inappropriate) analogue for Bristol Bay waterways. The culvert discussions in Chapter 10 are appropriately expanded in comparison with the 2012 draft Assessment.*

• Expand the discussion on the use of "best" management practices, as the document states that the mine scenario employs "good," but not necessarily "best" practice. For a mine developed in the Bristol Bay watershed, only "best" practice likely would be appropriate and anything less may not be permitted. Even so, without a track record of "best" practice (e.g., new technologies), we cannot assume that technology, by itself without appropriate operational management controls, can always mitigate risk.

RESPONSE: The term "best management practices" is a term generally applied to specific measures for managing non-point source runoff from storm water (40 CFR Part 130.2(m)). Measures for minimizing and controlling sources of pollution in other situations often are referred to as best practices, state of the practice, good practice, conventional, or simply mitigation measures. We assume that these types of measures would be applied throughout a mine as it is constructed, operated, closed, and post-closure, and have used the term "conventional modern" throughout the assessment to refer to these measures. To remove any ambiguity related to the

subjectiveness of terms "good" or "best", we have removed them in the revision and have provided definitions for relevant terms used in Box 4-1.

CWS Comment July 2013: *OK*

• Adopt a broader range of mine scenarios (not only minimum and maximum) so as to bound potential impacts, especially at smaller mine sizes (e.g., 50th percentile). Underground mine development, with its different impacts, also should be considered and included in the assessment.

RESPONSE: A third mine size scenario (250 million tons) has been added to the assessment, to represent the worldwide median sized porphyry copper mine (based on Singer et al. 2008).

CWS Comment July 2013: *OK*

• Based on the hypothetical mine scenario, perpetual management of the geotechnical integrity of the waste rock and tailings storage facilities, as well as perpetual water treatment and monitoring, will most likely be necessary (i.e., a "walk away" closure scenario after mining ends may not be possible). Therefore, emphasize how monitoring and management of the geotechnical integrity of waste rocks and tailing storage facilities should continue "In Perpetuity" (i.e., for at least tens of thousands of years). Discuss what conditions would need to be met to allow "walk away" closure in the Bristol Bay environment gaining insight into these observations from mines where perpetual treatment and monitoring are ongoing (e.g., the Equity Silver Mine in British Columbia).

RESPONSE: The conditions for closure and the potential need for perpetual site management are discussed in general terms in the revised assessment. The primary condition assumed to be required is water chemistry that meets all criteria and permit conditions and that is stable or improving. However, even though there are some facilities with "perpetual treatment" conditions in place, there is obviously no information about how these facilities perform over very long periods of time.

CWS Comment July 2013: *The revised Assessment repeatedly acknowledges that there is no extant precedent for "perpetual" monitoring, facility maintenance, and treatment if required to maintain either ecosystem function or simply maintain acceptable water quality.*

• Identify, in technical detail, how exploratory effects (e.g., drill holes, blasting, overflight, etc.) were managed. This includes roads, airstrips, helipads, camps, fuel dumps, and ATV trails that have already been developed or imposed on the watershed, and what "mitigation" already has been undertaken on those sites. Assess the consequences/impacts of these activities in the Cumulative Risks section.

RESPONSE: The effects of exploratory activities are outside of the scope of this assessment.

CWS Comment July 2013: *This statement simply acknowledges that this Assessment is **not** truly comprehensive. Exploratory activities (e.g., drill holes, blasting, helicopter and fixed-wing overflights, etc.) , including "pioneer" roads or airstrips, helipads, camps, fuel dumps, and ATV trails that have already been developed or imposed on the watershed, are an inevitable precursor to* *project implementation and "pave the way" for the project(s). Such activities are thus an integral component of a project such as the potential Pebble mining development, and clearly are directly relevant to this Assessment. I recall hearing reference to such ongoing activities in public testimony during the 2012 Anchorage meeting, and anecdotal evidence is available from many sources, such as Carter (2012).*

Risks to Salmonid Fish

• Place potential mining impacts in the context of the entire Bristol Bay watershed by emphasizing the relative magnitude of impacts. For example, of the total salmon habitat, assess the proportion lost due to mining. Further, reflect on the non-linear nature of the relationship between habitat and salmon production; 5% of the habitat could be critical and thus responsible for 20% or more of salmon recruitment. Intrinsic potential, which measures the ability of particular habitats to support fishes, would lend credibility to this analysis.

RESPONSE: We are unable to build a complete Intrinsic Potential (IP) model, as this would require validation and more elaborate construction of metrics appropriate to this region. Our preliminary characterization provides the building blocks for assessing the distribution of key habitat-forming and constraining features across these watersheds. We now include a characterization of the major drivers of habitat potential across the watershed and place the mine-site specific effects in this context (Chapters 3, 7, and 10).

CWS Comment July 2013: *This is an appropriate response.*

• Include a section on the impact of Global Climate Change with explicit reference to a monitoring program that will allow scientists, if the mine is built, to distinguish between effects of climate change and mining effects on the physical and biological components of this ecosystem.

RESPONSE: Climate change projections and potential impacts are now included in Chapter 3, and as important external factors in the risk analyses presented in Chapters 7, 9, 10, and 14. Development of a monitoring program to distinguish between mining and climate change effects is outside of the scope of the assessment.

CWS Comment July 2013: *Incorporation of potential climate change consequences into the body of the Assessments is appropriate, and the discussions are well-considered and reasonable.*

• Explicitly recognize that the transportation corridor and all associated ancillary development, including future resource developments made possible by the initial mining project, will necessarily and inevitably have impacts (hydrologic, noise, dust, emissions, etc.). These impacts will vary in duration, intensity, severity, relative importance, spatial dispersion, and inevitably expand geographically through time with further "development." These impacts should be incorporated into the Cumulative Risks section.

RESPONSE: The cumulative risk section (Chapter 13) has been expanded to include the multiple transportation corridors, ancillary mining development and secondary development associated with multiple mines in a qualitative discussion. The issues addressed in the assessment of the

transportation corridor (Chapter 10) have also been expanded to include chemical spills, dust, invasive species, and road treatment salts.

CWS Comment July 2013: *The addition of Chapter 10 is greatly appreciated. Chapter 13 is largely successful in attempting a comprehensive overview of cumulative effects; that chapter will hopefully not be treated as an "afterword" but rather will be viewed as equally important as the topic-focused chapters that precede it. Induced and cumulative consequences will be inevitable upon construction of the initial mine project and transportation corridor, and will be irreversible for the Bristol Bay watershed, ecosystem, and human population (Alaska Native and others), let alone effects on salmonids.*

• Incorporate current research findings into stream crossing and culvert-design practices (e.g., arch culverts, bridges, etc.).

RESPONSE: We describe current culvert design practices in a box titled "Culvert Mitigation" in Chapter 10.

CWS Comment July 2013: *OK*

• Recognize in the assessment that risk and impact are not equivalent. Risk may be low, but the potential impact could be huge (e.g., in the case of a TSF failure).

RESPONSE: Risk has been defined in many ways, even by risk assessors. The commenter seems to define risk as probability. To avoid that potential source of confusion, we use the term "probability" for that concept. Similarly, the commenter seems to use "impact" where we use "effect" or "magnitude of effect". We use "risk" to refer to both concepts combined—that is, an event or effect and its probability).

CWS Comment July 2013: *To repeat my earlier comment: Section 1.2 discusses possible use of the assessment, but does not identify or define "risk managers" per se. Section 1.1 mentions "ecological risk assessment", "risk assessors" ,"risk assessments", "risk analysis and characterization", "potential risks" and "risks to assessment endpoints" -- so who or what are "risk managers" – project engineers, regulatory authorities, actuaries, industry funding entities, indigenous people living in the watershed?*

• Recognize and justify chronic behavioral endpoints, such as those potentially affecting survival and long-term success of fish populations.

RESPONSE: The chronic behavioral effects of copper on salmonids, the primary endpoint of concern, were described in Chapter 5 and are now described in Chapter 8. Although those effects occur at lower levels of copper than conventional survival, growth and reproduction endpoints for salmonids, they are less sensitive than the conventional endpoints for aquatic invertebrates.

CWS Comment July 2013: *The detailed discussion of leachate toxicity and exposure-response for aquatic organisms, including salmonids, in Chapter 8 was very helpful. The careful discussion of uncertainties in Chapter 8 (and throughout the revised Assessment) is also appreciated.*

<u>Wildlife</u>

• Recognize that the draft assessment did not account for all levels of ecology, such as the individual (e.g., a bald eagle nest), population, community, ecosystem, and landscape levels. Fold other levels of organization into the stressors assessment where appropriate or justify a more limited approach.

RESPONSE: As is appropriate for an ecological risk assessment (as opposed to an environmental impact assessment), this assessment focuses on a specific, limited set of endpoints as defined in Chapter 5. We have added text in Chapters 2 and 5 to explain both why these endpoints were selected, and that responses other than those considered in the assessment, at multiple levels of ecological organization, are likely but are outside the scope of the assessment.

CWS Comment July 2013: *The authors do recognize that the full ecological web of Bristol Bay and its watershed is the ultimate "receptor" of whatever activities take place. I accept that a more comprehensive analysis at all levels is "outside the scope of the assessment."*

• Discuss in the document fishes other than salmonids The assessment focuses on risks to sockeye salmon in the Bristol Bay watershed (and also considers anadromous salmonids, rainbow trout, and Dolly Varden), but does not account for potential impacts to other members of the resident fish community. Further, primary and secondary production, including nutrient flux was not addressed. Expanding the assessment to consider other levels of organization, including direct as well as indirect effects on wildlife and other fish, would provide additional context in the assessment of mine-related impacts.

RESPONSE: See response to comment above; we also incorporated additional information from Appendices A, B, and C into the Chapter 5 text, to provide additional detail on the area's biota. We chose our endpoints for reasons described in Chapters 2 and 5. Other endpoints, including indirect effects on fish and wildlife, are now discussed more explicitly, but are generally considered outside the scope of the assessment.

CWS Comment July 2013: *OK -- The authors do recognize that the full ecological web of Bristol Bay and its watershed is the ultimate "receptor" of whatever activities take place. Other fish are mentioned in the draft Assessment. I accept that a more comprehensive analysis at all levels is "outside the scope of the assessment."*

<u>Human Cultures</u>

• Use case histories to provide insight and anticipate mining impacts on Alaska Natives (e.g., those exemplifying the Exxon Valdez oil spill impacts, cumulative effects of oil and gas development in the North Slope region, and social impacts related to mining development in Alaska).

RESPONSE: Examples from applicable case studies, including the Exxon Valdez oil spill, are cited in Chapter 12 of the revised assessment.

Dr. Charles Slaughter

CWS Comment July 2013: *Section 12.2, while relatively short in relation to the importance of the issue, does provide an overview of consequences for Alaska Natives, and acknowledges that those consequences would be long-lasting and effectively irreversible.*

 As noted above (Scope of the Document), clarify why the scope was limited to fish-mediated effects. The potential direct and indirect impacts for human cultures extend far beyond fish-mediated impacts (e.g., potential complete loss of the subsistence way of life). The rationale for this narrow focus should be fully explained. In addition, a clear explanation should be given for why fish-mediated human impacts focused only on Alaska Native cultures.

RESPONSE: The assessment focuses on a specific, limited set of endpoints as defined in Chapter 5. We have added text to explain both why these endpoints were selected, and that responses other than those considered in the assessment are likely but are outside the scope of the assessment. The assessment was expanded (Chapters 5 and 12) to acknowledge that there are a wide range of potential direct and indirect impacts to indigenous culture, but they are outside of the scope of this assessment. The discussion of potential effects to indigenous cultures was expanded to explain that a loss of subsistence resources would extend beyond a loss of food resources to social, cultural, and spiritual disruption. The text has been expanded to acknowledge the strong cultural ties of many non-Alaska Natives to the region, and potential effects on all residents from loss of a subsistence way of life. However, the focus of the assessment remains on effects on indigenous cultures resulting from effects on salmon.

CWS Comment July 2013: *OK – Chapters 12 and 13 do address the broader direct and indirect effects on Bristol Bay watershed residents.*

Water Balance/Hydrology

• Better characterize water resources and assess the potential effect of mine developmvcent on these resources by (1) generating a diagram similar to the conceptual models beginning on page 3-7 to illustrate the potential effects of mine construction and operation on surface- and ground-water hydrology; (2) developing a quantitative water balance and identifying water gains and losses; (3) identifying seasonality of hydrologic processes, including frozen soils and their associated values (e.g., mm/yr) for each component of the water balance; (4) incorporating these processes into a landscape characterization; (5) evaluating how global climate change will influence these hydrologic processes and rates; and 6) using this characterization to demonstrate the expected hydrologic modification associated with the mine scenarios and infrastructure development.

RESPONSE: The original Figure 4-9 (new Figure 6-5) has been revised to more clearly show water management in the assessment's mine scenarios. In addition, three schematics illustrating water flows under each of the mine size scenarios (Figures 6-8 through 6-10) have been added to Chapter 6, as have quantitative water balances for each mine size scenarios. A qualitative discussion of climate change is included in Chapters 3 (Section 3.8) and 14 (Box 14-2).

CWS Comment July 2013: *The much more comprehensive hydrologic analyses of the revised Assessment are welcome. These allow more detailed consideration of the hydrologic aspects of* *the various mine scenarios presented. While there can still remain questions (not detailed in this review) about the many necessary assumptions involved in those analyses, they do appear realistic and point out the significant consequences of alternative scenarios.*

• Demonstrate the interconnectedness of groundwater, surface water, hyporheic zone, and its importance to fish habitat. Address how interconnectedness changes over time – seasonally, and with varying weather (e.g., wet vs. dry summers or years, and over the long term as climate changes).

RESPONSE: We lack the data to demonstrate this interconnectedness in a spatially and temporally uniform manner, but do include examples of known points of high connectivity (Chapter 7) and qualitatively discuss the potential role of climate change (Chapter 3).

CWS Comment July 2013: *Given the lack of site-specific hard data, the revised Assessment does fairly acknowledge the importance of surface water/groundwater interactions.*

• Provide information on all rivers, including ephemeral and intermittent streams, and first-order to main-stem streams that could be potentially influenced by the proposed mine, its ancillary facilities, and the transportation corridor.

RESPONSE: Due to lack of consistent coverage, we rely on the NHD hydrography layer in this analysis, and can only address ephemeral and intermittent streams qualitatively (Chapter 7).

CWS Comment July 2013: *The NHD data are necessarily broad-brush; I recognize that on-the-ground work would be required to adequately understand finer-scale hydrologic issues including ephemeral and intermittent streamflow. Nevertheless, such "small" features can be significant in streamflow generation, in transport of nutrients or contaminants, and in immediate sensitivity to perturbation, be that human-caused, seasonal weather, or climate change. Simply glancing at the streams and landscapes shown in figures 3-8 and 3-11 allows one to visualize the finer-grain flowpaths which cannot be discerned at the scale of those photos or the accompanying maps.*

• Emphasize the importance of a thorough characterization of the leaching potential of acid-generating and non-acid generating waste rock and tailings, given the low buffering capacity and mineral content in the streams and wetlands that could receive runoff and treated water from the proposed mine. Recognize that collection and treatment of runoff and leachate generated will be critical to maintain baseline water chemistry in these streams and wetlands.

RESPONSE: We agree that these are important issues, and the discussion of leachate from waste rocks and tailings has been expanded in the revised assessment (Chapter 8).

CWS Comment July 2013: *Leachates are extensively considered in the revised Assessment.*

<u>Geochemistry/Metals</u>

• Reference the most current geochemistry data on potentially acid-generating, non-acid generating, and metal leaching so as to describe any potential effects of seepage and changes to surface- and ground-water quality via non-catastrophic failure.

RESPONSE: We used the geochemistry data in PLP's Environmental Baseline Document, as summarized by the USGS in Appendix H. The effects of seepage on water quality are analyzed in Chapter 8 of the revised assessment.

CWS Comment July 2013: *OK*

• Explain how contaminants/metals were selected (and others ignored) by EPA as causes for concern. Information should be included on additional metals and their toxicity so as to assess impacts of potential leachates. The Pebble Limited Partnership baseline document presented additional metals that might be useful to include in the assessment.

RESPONSE: The revised assessment describes the selection of contaminants and other stressors of concern in Section 6.4.2. Additional metals, process chemicals and dissolved solids are now included.

CWS Comment July 2013: *To me (lacking expertise in this field) the consideration of contaminants and stressors in the revised Assessment appears comprehensive and competent.*

Mitigation Measures

• Incorporate the critical mitigation information from Appendix I into the main report's mine scenarios. Include standard mitigation measures that could provide insight into how well they might work in this context. If this information is not included in the main report, then justify its absence.

RESPONSE: Mitigation measures incorporated into design and operation to minimize potential impacts were included in the assessment, as were some reclamation measures for closure; these measures are made clearer in the revised assessment. These mitigation measures were a sub-set of those presented in Appendix I. The assessment assumes that measures chosen for the scenarios would be effective. Mitigation to compensate for effects on aquatic resources that cannot be avoided or minimized by mine design and operation would be addressed through a regulatory process that is beyond the scope of this assessment. Nevertheless, in response to public and peer comments we have included a discussion of compensatory mitigation in Appendix J of the revised assessment.

CWS Comment July 2013: *The mitigation measures discussed in Appendix I are, as stated, "conventional." Despite the statement above that "The assessment assumes that measures chosen for the scenarios would be effective", after again reviewing Appendix I it seems to me that there is large uncertainty that all those measures would be effective in actual practice in the Bristol Bay watershed environment. Many of the measures discussed in Appendix I are generalities – i.e Sections 1.1, 3.1, 5.0,, 7.1, 8.1, 9.1 -- with questionable applicability to a potential Pebble project.*

• Emphasize mitigation measures (e.g., minimization, compensation, reclamation) in the main report, as they ultimately influence the range of mining impacts and consider time frames of mitigation or reclamation measures (e.g., immediate response, long-term reclamation).

RESPONSE: See response to previous comment. Mitigation measures are discussed at greater length in the revised assessment report (e.g., Chapter 4 and Appendix J).

CWS Comment July 2013: *See previous comment. Appendix J (to my reading) strongly indicates that compensatory mitigation is essentially inapplicable to the Bristol Bay watershed.*

Uncertainties and Limitations

• Clarify the uncertainty vs. certainty in Chapter 8 by (1) defining levels of uncertainty and (2) assessing the certainty of some mine impacts. Discuss data limitations in the context of uncertainty.

RESPONSE: The individual analysis chapters and the revised Integrated Risk Characterization (Chapter 14) discuss certainties and data limitations to a greater extent, as suggested.

CWS Comment July 2013: *Throughout the revised Assessment, the discussions of "risk characterization" and "uncertainty" are well-thought-out and useful – for example, Sections 8.2.5, 8.3.3, 8.3.4, 10.5.*

• Articulate early in the document how much uncertainty is acceptable. The assessment provides little insight with respect to the decisions the document is intended to support.

RESPONSE: Acceptable levels of uncertainty can be defined prior to an assessment if a decision and a decision maker are identified and if data will be collected by a specified design to implement a specified model, as described in the EPA's Data Quality Objectives process, However, because this assessment is based on available data and is intended as a background scientific document rather than a decision document, it is not possible to specify the amount of uncertainty that is acceptable. Rather, the available data determine the uncertainty and if the assessment is subsequently used to inform a decision, the decision maker must determine whether the level of uncertainty is acceptable.

CWS Comment July 2013: *Concur with the above response; the various discussions of uncertainty in the body of the revised Assessment provide a "feel" for the unknown or unpredictable, without attempting to quantify specific boundaries or levels.*

Editorial Suggestions:

• The title of the document leads one to believe that the assessment addresses the entire Bristol Bay watershed; rather, the report deals with two major rivers and their watersheds, the Nushagak and Kvichak. Thus, the title should be changed to reflect the emphasis on these two rivers and their watersheds. A possible title may be "An Examination (or identification) of the Potential Impacts of Mining and Mining Associated Activities on Salmon Ecosystems in the Nushagak River and Kvichak River watersheds, Bristol Bay."

RESPONSE: The assessment addresses multiple scales: the Bristol Bay watershed, the Nushagak and Kvichak River watersheds, the watersheds of the three streams draining the Pebble deposit, and the watersheds crossed by the transportation corridor. These multiple scales, and how they are used throughout the assessment, are described more clearly in the revision (Chapter 2).

CWS Comment July 2013: *OK*

• Revise the Executive Summary to more precisely reflect the findings in the document.

RESPONSE: The Executive Summary has been rewritten to reflect the revised assessment findings.

CWS Comment July 2013: *The Executive Summary of the revised Assessment is provides a comprehensive overview. (I still question the discussion of probabilities in relation to TSF dam failure (p. ES-21), as noted in my other comments.)*

• The appendices contain detailed and useful information that should be summarized and included in the main document (e.g., Appendix E: Economics, Appendix G: Road and Pipelines, and Appendix I: Mitigation). Additionally, consider expanding the preface to include information on the use of the appendices. If the information is not included in the main report, then justify its absence.

RESPONSE: More information from the appendices was brought forward into appropriate chapters of the revised report. The purpose of the appendices—to provide the detailed background characterization necessary for the ecological risk assessment—has also been clarified in Chapter 2. The document no longer contains a preface because that material has been incorporated into Chapters 1 and 2.

CWS Comment July 2013: *I support the decision to incorporate much of the previous Appendix information into the body of the Assessment (as recommended in 2012).*

• Discuss in more detail the instructive and well-thought-out conceptual models (pages 3-7 to 3-11) illustrating the impacts of mining on Bristol Bay ecosystem processes. Also, consider expanding the conceptual models to include wildlife, fish-wildlife interactions, vegetation/terrestrial habitat, and hydrologic processes. Allow them to guide the text because they appear detailed and complete.

RESPONSE: Additional information on the use of conceptual models throughout the assessment has been incorporated into Chapter 2. The more comprehensive conceptual models presented in Chapter 6 (Chapter 3 in the first draft) have been broken into their relevant component parts throughout the risk analysis and characterization chapters, to better frame the specific pathways addressed in each chapter. Additional conceptual models considering impacts on wildlife, Alaska Native populations, and cumulative effects of multiple mines have been added to Chapters 12 and 13.

CWS Comment July 2013: *The addition of conceptual models and flow charts throughout the revised Assessment is really appreciated – they add clarity to the issues.*

• Incorporate the information contained in the conceptual models into a formal framework, such as a Bayesian or other decision-analysis models.

RESPONSE: This is an excellent suggestion for future efforts, but is beyond the scope of the current assessment.
Creating a Bayesian Belief Network would require that the Agency convene experts to subjectively estimate the probabilities of each transition in the conceptual models. In contrast, this assessment is intended to elucidate the risks from potential mining based on available data and analyses of those data.
A Decision Analysis would require that alternative outcomes be specified, the utility of each outcome for a decision maker be defined and the probabilities of each outcome be estimated for each possible decision so that the expected utilities of each outcome can be calculated. Because this assessment is not a decision document, these requirements are not feasible or appropriate.

CWS Comment July 2013: *OK*

• Generate a standard operating protocol for significant figures and use it throughout the document.

RESPONSE: The authors have carefully addressed this issue. Numbers from the literature or from the PLP EBD retain the number of significant figures in the original. Numbers derived for this assessment have the appropriate number of significant figures given the precision of the input data and uncertainties due to modeling and extrapolation.

CWS Comment July 2013: *OK*

• Remove all references to Mount St. Helens as a surrogate for a TSF failure. Using a non-human-caused release of material into the ecosystem as an analogue for a mine failure is not comparable in terms of likelihood or risk for a human-caused release. It would be more appropriate to extrapolate from the impacts of known mine failures.

RESPONSE: We are puzzled by this comment. The Mount Saint Helens data were used strictly to address the rate of benthic habitat recovery from a massive deposition of fine mineral particles. The hydrological processes that determine the recovery of substrate texture and the requirements of fish or aquatic invertebrates are not known to depend on whether mineral particles were from a natural event or an anthropogenic event. We have reviewed the literature on known mine failures. They studied tailings spills in terms of toxicity but not in terms of physical habitat effects, which is why we used Mount Saint Helens data. Neverpotheless, we have removed references to Mount St. Helens in the revised assessment to eliminate concern.

CWS Comment July 2013: *I was not enthusiastic about removal of* ***all*** *reference to Mount St. Helens, simply because that event does provide a case history of massive sediment loading and long-term stream and landscape response. However, I think I understand the concern that heavy reference to Mount St. Helens might imply that the volcanic eruption was analogous to a TSF dam failure, though the causes would be unrelated. I would be comfortable with again utilizing the sediment remobilization, channel and habitat "recovery" information from Mount St. Helens research in generalizing about consequences of a major TSF dam failure.*

• Ensure that the draft assessment remains part of the public record, allowing the document history to remain intact.

RESPONSE: All drafts of the watershed assessment will remain part of the public record.

CWS Comment July 2013: *OK*

Research Needs:

• What are the acute and chronic impacts of mixtures of contaminants, including metals, acid mine drainage, etc., on the fauna and flora of the Nushagak River and Kvichak River watersheds? What species are most sensitive and might surrogate species exist for those for which we do not have data? Review the European literature and regulatory requirements for additional data.

RESPONSE: The acute and chronic impacts of contaminant mixtures, including metals and acid mine drainage (i.e., metals in low pH-waters) were addressed using concentration additivity models in the leachate chemistry tables in Chapters 5 and 6 (now Chapters 8 and 11). Additional toxicity data were obtained by searches of the EU and OECD database eChem, the EPA's ECOTOX and the Environment Canada site. More metals are now included. In general, metals are most toxic to aquatic arthropods rather than fish, as discussed for copper.

CWS Comment July 2013: *This seems to be well covered in the revised Assessment.*

• Can an inventory of nutrients, total organic carbon, and dissolved organic carbon inputs to aquatic environments be developed that demonstrates their relative magnitude and spatial variation from headwaters to Bristol Bay? What is the relative importance of marine-derived nutrients relative to other nutrients from watershed and terrestrial sources? What is the current atmospheric input of nutrients?

RESPONSE: These data would be very useful in the risk assessment, but are not currently available for the Bristol Bay region. We agree this is a research need.

CWS Comment July 2013: *OK*

• What are the locations of subsistence areas and can these areas be characterized and differentiated by collecting local environmental and ecological knowledge (e.g., fish overwintering areas, climate change, ecological shifts, etc.)?

RESPONSE: The revised assessment incorporated current data on subsistence use areas available from ADF&G. EPA acknowledges that these data are incomplete and would encourage additional collection of subsistence data and Traditional Ecological Knowledge.

CWS Comment July 2013: *That is probably all that you can do at this stage. Figure 5-12 attempts to show generalized subsistence use.*

• What impact might mining have on other important wildlife species in the basin (e.g., freshwater seals in Iliamna Lake)?

RESPONSE: The scope of the assessment is focused on potential risks to salmon from large-scale mining and salmon-mediated effects to indigenous culture and wildlife. Direct effects on wildlife from large-scale mining are likely to be important and Appendix C (now a stand-alone US Fish and Wildlife report) provides useful information for a future evaluation of direct effects on wildlife from large-scale mining. We agree that this is an important area for future research.

CWS Comment July 2013: *OK*

• What is the comprehensive hydrologic regime of the specific project mining area, and the broader watershed system as characterized by baseline monitoring, spatial distribution, and quantitative flow of surface- and ground-waters?

RESPONSE: Comprehensive spatial estimates of mean annual flow are now presented in Chapter 3. Quantification of spatial and temporal patterns of groundwater flows is an acknowledged highly desirable product, but it not feasible within the scope of this assessment. Results of an independent groundwater-surface water modeling effort are described in Chapter 7.

CWS Comment July 2013: *The revised hydrologic analyses of the Assessment are explained well and are very useful. Admittedly, much site-specific data would be required to thoroughly understand the complete surface water/groundwater system, in its current state and potentially during and after mine implementation.*

• What is the cumulative impact of commercial fisheries on the Bristol Bay watershed, especially in an ecosystem context as related to marine-derived nutrient and energy flow? Acknowledge that commercial fishing has had an impact on the amount of marine-derived nutrients returned to the watersheds.

RESPONSE: The impact of commercial fisheries on the watershed is not within the scope of this assessment. Information on commercial fisheries management has been added in Box 5-2. However, the purpose of this assessment is not to assess the relative effects of potential mining and commercial fishing—it is to evaluate potential effects on endpoints if a mine were to be developed, given existing conditions and activities in the region.

CWS Comment July 2013: *I note that commercial and subsistence harvest are both considered in Chapter 5. The Assessment thus does reference commercial harvest, even if not evaluating the long-term consequences of that harvest, with or without mining activity in the Bristol Bay watershed.*

Dr. Charles Slaughter

CWS RESPONSE TO:

DRAFT
EPA Response to Peer Review Report
External Peer Review of EPA's Draft Document
An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska

Executive Summary – 2013 Revision

CWS Comment July 2013:
p. ES-4, last para: The clarification that "This assessment does not consider all impacts associated with future large-scale mining in the Bristol Bay watershed" is appreciated. A deep-water port, electrical generation capabilities (or electricity import via now non-existent transmission lines from a potential new hydroelectric facility being considered on the Susitna River), one (or more) airports and associated infrastructure, extended road and ORV networks, and the gamut "induced development" and support services associated with increased activity and worker populations (and, later, sport and recreational visitations), will all have a cumulative and enduring impact on the Bristol Bay watershed and environs and its present human, wildlife, and fisheries systems, which temporally and spatially will extend far beyond the posited PLP operation itself.

Thus, the question is left hanging – if this assessment does not or cannot address the full suite of probable consequences of the PLP project, what agency or entity does have that responsibility?

Maps – the ES maps are clear and are appreciated.

Figure ES-3 – at least on my print (and computer screen) the subtle shadings of blue or green associated with regions re difficult to distinguish – but the message of the figure is clear that Bristol Bay is the major sockeye salmon producer, and the Nushagak and Kvichak rivers dominate that production.

Table ES-4 -- (1) The attempted clarification of your use of probability analysis for TSF failure, provided in the main body of the assessment, is appreciated. However, this reviewer still questions the message sent, both in the Executive Summary and in the larger report, that a TSF failure has a "recurrence frequency of 2500 to 250,000 years." This strongly implies to a reader of the ES (and most decision-makers will read or skim only the Executive Summary) that with 2500 years as the shorter time span stated, no one should worry about a possible TSF *failure, despite the report's documentation of actual failure incidents elsewhere. I suggest eliminating reference to "recurrence interval" in this discussion. (I personally have seen a 100-year recurrence interval (based on period of record) flood occur twice in one year in one watershed, belying any suggestion that recurrence interval is related to prediction of event occurrence.)*

Table ES-4 – (2) Pipeline spill possibilities – based on the "probability" column, if there is a 95% probability of a product concentrate pipeline failure over 25 years, and the same applies to the return water and diesel pipelines, then there is 95% probability of three pipeline failures over 25 years, or nine in the 78-year Pebble 6.5 scenario.

p. ES-26—bottom para -- The statement that "Although remediation would be considered if spills contaminated streams, features of the Pebble deposit area would make remediation difficult" suggests that remediation would be only considered but not required, because remediation would be infeasible – so what then? The difficulty is acknowledged, but no solution is suggested – such stream-contaminating spills would simply be accepted as a cost of doing business, or collateral damage?

The final sentence suggests that unspecified "compensatory mitigation" might be considered, - but the analysis provided in Appendix J suggests that compensatory mitigation is simply not an alternative in the Bristol Bay watershed system. Suggest revising or eliminating this sentence.

Finally, I must compliment the authors on the overall comprehensive coverage of the Executive Summary. As mentioned above, many users of this document will only go to the ES. My own preference might be for even more emphasis in the ES on the long-term unavoidable cumulative effects, but I concede that the text does a good job of summarizing those consequences in individual sections.

1. General impressions

CWS comment

The Assessment (Volume 1 – Main Report) provides a fairly comprehensive review of fisheries-driven issues, from the perspective of salmonids. Appendices (Volumes 2 and 3) are very

informative. The high significance of the Bristol Bay watershed, specifically of the Nushagak and Kvichak river systems, for commercial fisheries on the global scale and for sport and subsistence fisheries at the regional and local scales, was appropriately described.
RESPONSE: No changes suggested or required.

CWS Comment July 2013: *OK*

The potential risks and impacts are fairly and succinctly stated. Given the extremely long-term nature of the projected Pebble project, and the irreversible changes which would be imposed to the region, the risks seem, if anything, understated. I attribute this to the decision to focus this Assessment on salmon and anadromous fisheries, with less attention on "salmon-mediated" impacts – i.e., effects on indigenous culture, on wildlife other than salmon, etc.
RESPONSE: No changes suggested or required.

CWS Comment July 2013: *OK*

Chapter 2 (Characterization of Current Condition) provides only a superficial overview of the landscape of the Bristol Bay watersheds; a reader would preferably have access to Wahrhaftig (1965) or Selkregg (1976), as only two (relatively dated) suggestions, to gain a more comprehensive understanding of the region.
RESPONSE: Additional information on the physical environment of the region (e.g., geology, vegetation, etc.), along with an expanded treatment of the regional landscape, has been incorporated into Chapter 3 (e.g., Figures 3-4 through 3-7). Chapter 3 also includes the suggested citations.

CWS Comment July 2013: *Chapter 3 is a great improvement. The detailed maps and discussions of the physiographic setting, hydrologic landscapes, aquatic habitats, water quality, seismicity, and existing development of the region are comprehensive and informative. Explanation of methodology, as in Box 3.1, Box 3.3, and throughout the entire document, is very helpful. This chapter now allows a reader to gain a more realistic understanding of the Bristol Bay watershed setting.*

The "Water Management" section (4.3.7) seems cursory, highly generalized, and optimistic. Statements such as "uncontrolled runoff would be eliminated"; "water from these upstream reaches would be diverted around and downstream of the mine where practicable"; and "Precipitation…would be collected and stored…" do not indicate actual (proposed) practices or techniques, nor inspire confidence that actual runoff events during "normal" conditions, let alone during hydrologic extremes (such as a rain-on-snow event with underlying soils still frozen), would be planned for or actually managed adequately.
RESPONSE: Water management measures are more clearly described and discussed in Section 6.1.2.5 of the revised draft, and in sub-sections for the mine components in the scenarios. The assessment no longer contains a no failure scenario, so complete water collection is not longer assumed. Rather, standard and common practices are incorporated.

CWS Comment July 2013: *The revised Section 6.1.2.5 does provide a better discussion of water handling. Since this is all hypothetical, we must accept such statements as "If contaminated groundwater was detected, monitoring wells would be converted to collection wells or new recovery* *wells would be installed, and water from the well field would be pumped back into the TSF or treated and released to stream channels." (p. 6-12). Easier said than done!*

The last sentence on p. 6-13 states "Runoff at the port site would be pumped to the mine site in the return water pipeline, contributing to the mine's water supply and avoiding the need for treatment at the port." What runoff at the port site is being considered – surface runoff from impervious surfaces at the port itself? Or does this suggest that streamflow at or in the general vicinity of the port would be captured and utilized to augment water supply at the mine? If the latter, then a separate evaluation of hydrologic resources, and permitting, would be necessary.

Para. 6.2.2.3 – The generality that water released to streams "would comply with permitted discharge requirements", but may differ from "natural stream water" in actual characteristics, locale, rates, or timing, would not be reassuring to issues of salmon sustainability -- based on information provided elsewhere in the assessment concerning extreme sensitivity of salmon (and other organisms) to seemingly minor or very localized water characteristics.

Para. 6.2.2.3 – The last sentence summarizes percentage of water to be reintroduced to streams; it would also be appropriate to emphasize that this envisions LOSS of 26%, 60%, and 30% of total flows under the three scenarios.

Perhaps I missed it, but I found no acknowledgment of the potential presence of or consequences of perennially frozen soils – permafrost – in the Bristol Bay watershed, or more specifically in the Pebble ore deposit locale or the proposed transportation corridor. Selkregg (1976), Fig. 136, shows soils of the Pebble locale as INT/2g, INT/1g – HYP, or SOU/2g-HYP – that is, well-drained gravelly soils (INT) or well-drained acidic soils (SOU) with interspersed peaty, poorly-drained shallow discontinuous permafrost. There is abundant literature on the influence of permafrost on engineered structures, roads, hydrology, etc. Even if the bulk of the terrain involved in the proposed Pebble mine, road and infrastructure project is founded on well-drained gravelly soils, any interspersed permafrost-underlain terrain can prove problematic in terms of landscape stability, potential erosion, and consequent structural, engineering, hydrologic and water quality issues. See Specific Observations for a few suggested references in**.**
RESPONSE: We have expanded our characterization of the soils and permafrost distribution in the Bristol Bay watershed in Chapter 3 of the revised assessment. As part of this expansion, we summarize the nature and distribution of permafrost by physiographic region.

CWS Comment July 2013: *The inclusion of detailed maps and information from Selkregg (1974) is appreciated. Figure 3.4 now acknowledges the possibility of isolated permafrost presence in both the Pebble locale and through the entire proposed transportation corridor.*

Note that presence of perennially frozen ground (permafrost) is not necessarily detrimental to construction; fine-grained (silts) high ice content frozen soils pose major problems, but coarse-grained soils with low frozen water content can be stable upon thawing.

While there is extensive discussion of a proposed transportation corridor, there was no mention of construction of a major airfield. A project of this magnitude would undoubtedly require development of a facility in close proximity to the mine(s) capable of handling C130 and commercial jet passenger and cargo traffic, at least to the 737 class, if not 747. I don't know what the footprint for such an airfield would be, but it would be substantial, and with requisite roads, fuel handling, etc., would be a major project in itself. This would seem to be a logical component of a comprehensive assessment of the potential Pebble project.
RESPONSE: The scope of the assessment has been clarified in Chapter 2, and construction and operation of a new airport is considered outside the scope of the assessment. We would expect that a full evaluation of any future mining permit applications and subsequent National Environmental Policy Act Environmental Impact Statements would consider these effects if a new airport is proposed.

CWS Comment July 2013: *Again – if this assessment does not or cannot address the full suite of probable consequences of the PLP project, what agency or entity does have that responsibility? Is this just putting off the responsibility for truly comprehensive evaluation to (presumed) future NEPA review?*

As noted in the Executive Summary, the Assessment does NOT address several major components of the (hypothetical) Pebble project, including electrical generation and transmission, a deep-water port, or "secondary development" and associated infrastructure which would follow an initial mining project. A truly comprehensive analysis should incorporate full analysis of these aspects. This Assessment is thus inadequate in terms of considering potential broader consequences for the Bristol Bay watershed system.

RESPONSE: The scope of the assessment has been clarified in Chapter 2, and we have stated throughout the text that areas outside of scope may also be important factors.

CWS Comment July 2013: *Again – if this assessment does not or cannot address the full suite of probable consequences of the PLP project, Is this just putting off the responsibility for truly comprehensive evaluation to (presumed) future NEPA review?*

RESPONSES TO CHARGE QUESTIONS

Question 1. ***The EPA's assessment focused on identifying the impacts of potential future large-scale mining to the fish habitat and populations in these watersheds. The assessment brought together information to characterize the ecological, geological, and cultural resources of the Nushagak and Kvichak watersheds. Did this characterization provide appropriate background information for the assessment? Was this characterization accurate? Were any significant literature, reports, or data missed that would be useful to complete this characterization, and if so what are they?***

Dr. Charles Slaughter

CWS comment

If only Volume 1 (the Main Report) is considered, the characterization of some aspects of the Nushagak and Kvichak watersheds would have to be termed cursory. Chapter 2, Volume 1 (Characterization of Current Condition) provides only a superficial overview of the landscape of the Bristol Bay watersheds; a reader would preferably have access to Wahrhaftig (1965) or Selkregg (1976), as only two (relatively dated) suggestions, to gain a more comprehensive understanding of the region. Similarly, Volume 1 provides a relatively superficial discussion of non-fish wildlife concerns, or human/cultural concerns

RESPONSE: Additional information on the region's physical environment from Selkregg (1974) has been included in Chapter 3. We have also clarified that our discussion of biological communities focuses on the assessment endpoints, as defined in Chapters 2 and 5.

CWS Comment July 2013: *Chapter 3 is a great improvement. The detailed maps and discussions of the physiographic setting, hydrologic landscapes, aquatic habitats, water quality, seismicity, and existing development of the region are comprehensive and informative. Explanation of methodology, as in Box 3.1, Box 3.3, and throughout the entire document, is very helpful. This chapter now allows a reader to gain a more realistic understanding of the Bristol Bay watershed setting.*

By contrast, the information provided in Appendices A-H appears to be comprehensive and complete for each subject field. (Appendix I appears to be a general "template" summary, not tailored to the Bristol Bay watershed environment).

RESPONSE: The purpose of the appendices vs. the main assessment document has been clarified in Chapter 2. Appendix I is not meant to be specific to any given region, but discusses options that are possible and notes that their applicability is dependent on site-specific constraints. What would be chosen for the Bristol Bay watershed environment, given a mining plan and permit application, also would be dependent on regulatory decisions.

CWS Comment July 2013: *OK The clarification is appreciated, as is the inclusion of much material from the appendices into the narrative of the revised Assessment.*

As noted in the Executive Summary, the Assessment does NOT address several major components of the (hypothetical) Pebble project, including electrical generation and transmission, a deep-water port, or "secondary development" and associated infrastructure, which would follow an initial mining project. A truly comprehensive analysis should incorporate a full analysis of these aspects.

RESPONSE: The scope of this assessment was tailored to its purpose, as clarified in the first two chapters. We would expect that a full evaluation of any future mining permit applications and subsequent National Environmental Policy Act Environmental Impact Statements would consider these components.

CWS Comment July 2013: *Again – to me, this simply means that this assessment does not (or cannot, presumably because of limited EPA authority) address the full suite of probable* *consequences of the PLP project. Permit application and NEPA review hopefully* ***would*** *be more adequate and comprehensive.*

Question 2. ***A formal mine plan or application is not available for the porphyry copper deposits in the Bristol Bay watershed. EPA developed a hypothetical mine scenario for its risk assessment, based largely on a plan published by Northern Dynasty Minerals. Given the type and location of copper deposits in the watershed, was this hypothetical mine scenario realistic and sufficient for the assessment? Has EPA appropriately bounded the magnitude of potential mine activities with the minimum and maximum mine sizes used in the scenario? Are there significant literature, reports, or data not referenced that would be useful to refine the mine scenario, and if so what are they?***

CWS comment

Given the available information base for the ore deposits of the Bristol Bay watershed, and the publicity which has attended the Pebble planned development over the past several years, the Assessment's hypothetical mine scenario seems fairly realistic. Further, it is appropriate that the Assessment consider the probable impacts of other future mineral development projects once an initial entry (presumably Pebble-Northern Dynasty Minerals) has been accomplished. Such subsequent development – "cumulative effects over a long time period" – could (and should) receive **more** emphasis than is accorded in the Assessment.

RESPONSE: The assessment of cumulative effects of multiple mines is given more emphasis in the new Chapter 13.

CWS Comment July 2013: *Given the present relatively un-altered state of the Bristol Bay watershed, the inevitable and irreversible cumulative effects – on salmon and on the entire human-landscape-wildlife biota complex -- of additional mines and ancillary and induced development are certainly as significant in the long term as is the initial (proposed) Pebble mine scenario(s). Chapter 13 is a great improvement to the Assessment, and does recognize many probable consequences and cumulative effects of multiple mines and "induced development". The attempt to provide an overview of the primary current mining claims is appreciated. This leads to another question: Does EPA, or any other State or Federal entity, have legal or "moral" standing to more fully evaluate such long-term cumulative impact on this large, undeveloped, presently controversial piece of the United States?*

Question 3. ***EPA assumed two potential modes for mining operations: a no-failure mode of operation and a mode involving one or more types of failures. Is the no-failure mode of operation adequately described? Are engineering and mitigation practices sufficiently detailed, reasonable, and consistent? Are significant literature, reports, or data not referenced that would be useful to refine these scenarios, and if so what are they?***

CWS comment

Based on the actual history of other major resource extraction projects in Alaska and throughout the world, a "no failure" assumption seems unrealistic. Rather, the assumption should be that there will be failures, of varying modes and magnitudes, over the life of the project. This reality is recognized in several sections of text.

RESPONSE: Our intention for the "no-failure" scenario was to identify and evaluate the unavoidable environmental effects if all systems and mitigation measures operated perfectly, and to separate those effects from a scenario where systems periodically failed. The "no failure" chapter has been eliminated. The revised assessment differentiates between potential effects from the footprint of a mine (Chapter 7), water treatment (Chapter 8), TSF failures (Chapter 9), the transportation corridor (Chapter 10), and pipeline failures (Chapter 11).

CWS Comment July 2013: *The revision appropriately recognizes that in any human-designed and engineered system there will be glitches or failures; I applaud the decision to eliminate the no-failure scenario. The chapters cited do more adequately outline potential consequences of those specific features (mine footprint, water treatment, and so on).*

In some sections in the Assessment, presumed "mitigation practices" are either cursory, optimistic, or so general as to be un-supported. Examples include Section 4.3.7's cursory, generalized statements about handling water: "Uncontrolled runoff would be eliminated…The mine operator would capture and collect surface runoff and either direct it to a storage location…or reuse or release it after testing and any necessary treatment"; "…water from these upstream reaches would be diverted around and downstream of the mine where practicable"; "precipitation would be collected and stored…"; and "Assuming no water collection and treatment failures, this excess captured water would be treated to meet existing water standards and discharged to nearby streams, partially mitigating flow lost from eliminated or blocked upstream reaches." Other examples from Chapter 6: "…assuming no water collection and treatment failures" and "excess captured water would be treated…and discharged to nearby streams..."

RESPONSE: Water management (mitigation) measures are more clearly described and discussed in the revised Section 6.1.2.5, and in sub-sections for the mine components in the scenarios. However, the intent of the assessment is not to specify technologies, beyond those already identified by the existing preliminary mining plans. Rather, the assessment focuses on the environmental outcomes of conventional modern mining practices and effluents.

CWS Comment July 2013: *The revised assessment does more clearly articulate possible hydrologic (water management or "water balance") issues, as in Section 6.2.2.3, Section7.3.2, and Chapter 8. Given the relatively limited quantitative data available, the writers are to be commended for their efforts. However, I must confess to a remaining impression of optimistic generalities concerning some aspects of the water issues (perhaps inevitable because this is all speculation on a possible project, rather than evaluation of a specific proposal). Examples: in Section 6.2.2.3, "This released water may differ from natural stream water in chemistry and temperature, but would comply with permitted discharge requirements. Water may be reintroduced at locations, flow rates,* *or times of year that differ from baseline condition." And in Section 6.2.2.4, "….This water would be expected to be relatively clean and, if properly managed t control turbidity, could most likely be released without chemical treatment to maintain or augment streamflow." And Section 6,3.4, (Post-closure), assumptions about monitoring runoff from NAG waste piles, establishment of constructed wetlands, and a presumably adequate well field downstream of the TSF to monitor water quality.*

Question 4. *Are the potential risks to salmonid fish due to habitat loss and modification and changes in hydrology and water quality appropriately characterized and described for the no-failure mode of operation? Does the assessment appropriately describe the scale and extent of risks to salmonid fish due to operation of a transportation corridor under the no-failure mode of operation?*

CWS comment

Yes, the risks to salmonids are well characterized with regard to the hypothetical mine operation itself. However, I suggest that the concept of "no failure," if taken as applying to the entire operation from inception through operation, is not realistic.
RESPONSE: The "no failure" scenario was not meant to represent a realistic scenario. Rather, it was meant to illuminate the effects that would occur solely from a mine footprint, even in the absence of accidents or failure. The revised assessment no longer uses the term "no-failure", but simply presents effects from scenarios having higher probability and lesser magnitude (e.g., failure to collect or treat leachate water) and those having lower probability and higher magnitude (e.g., TSF failure).

CWS Comment July 2013: *OK*

The Assessment makes a fair start toward considering the risks to salmonids from the potential transportation corridor. However, the many issues regarding stream and wetlands directly or indirectly affected by roads and pipelines are not fully explored. The extent (length, area) of streams and wetlands affected, as outlined in the text, should be considered a very optimistic lower estimate. The specific issues mentioned, such as bridge or road maintenance, culvert blockage or failure, erosion from cuts, fills, and the roadway itself, are all significant. I simply suggest that the potential consequences of imposition of the (hypothetical) transportation corridor, and future expansions consequent to ancillary infrastructure development and further additional resource extraction projects, would be broader, more severe and of more consequence (and thus should receive more emphasis) than the Assessment indicates. I suggest more fully incorporating Frissell and Shaftel's Appendix G into the body of the Assessment.
RESPONSE: The revised assessment notes that the characterization of both stream length and wetland area affected likely represents a conservative estimate of the potential effects of the transportation corridor on hydrologic features of this area. The cumulative risk section (Chapter 13) has been expanded to include the transportation corridor, ancillary mining development and

secondary development. Additional information from Appendix G is incorporated into the main text, and the appendix is referenced in a number of places.

CWS Comment July 2013: *Acknowledgement of the conservative (low) estimate of wetland and stream impacts is appropriate. Chapter 13 is a good addition to the Assessment. As noted previously, the transportation corridor and "ancillary" or "induced" development activities are, over the long term, as problematic for the Bristol Bay watershed and region as is the initial PLP (proposed) mine.*

Question 5. ***Do the failures outlined in the assessment reasonably represent potential system failures that could occur at a mine of the type and size outlined in the mine scenario? Is there a significant type of failure that is not described? Are the probabilities and risks of failures estimated appropriately? Is appropriate information from existing mines used to identify and estimate types and specific failure risks? If not, which existing mines might be relevant for estimating potential mining activities in the Bristol Bay watershed?***

CWS comment

Potential failures seem reasonable, based on history of other mining operations. However, the consequences of hydrologic extremes during winter (frozen soil) conditions are not adequately addressed. The possibility of the mining operation and the transportation network encountering discontinuous permafrost is not mentioned, although at least some soils maps indicate permafrost presence.

RESPONSE: Warhaftig (1965) reports that permafrost is sporadic or absent in the Nushagak-Bristol Bay Lowland (Table 3-1). If permafrost were detected during project development or construction, the designs would need to address any potential impacts on the infrastructure and potential impacts of the infrastructure on the permafrost. Frozen soil could improve vehicular access to parts of the project site and minimize the disturbance from such access.

The occurrence of an extreme hydrologic event, such as heavy rainfall on frozen soil or heavy rain on an existing snowpack, could produce unusually heavy runoff and higher than normal stream flows. We analyzed the impact of a tailings dam failure during the Probable Maximum Precipitation (PMP) event, thereby generating the Probable Maximum Flood (PMF). The increased flow due to precipitation was, in most of the scenarios, small compared to the flow released from the TSF. Any increases in the peak runoff due to frozen soil or melting snowpack would also be small relative to the TSF release, so the modeled scenario can be considered a reasonable bounding estimate. ***Relative to a TSF failure flow release, agree.***

Designs for the components of the mine infrastructure would need to consider the natural cold region conditions and incorporate appropriate design features and safety factors to achieve an acceptable level of performance. Ghaffari et al. (2011) says "The Pebble deposit is located under rolling, permafrost-free terrain in the Iliamna region of southwest Alaska..." and "The deposit is situated approximately 1,000 ft amsl, in an area characterized by tundra, gently rolling hills and the absence of permafrost." Ghaffari et al. (2011) describes the transportation corridor thusly: "The road route traverses terrain generally amenable to road development. ...There are no

significant occurrences of permafrost or areas of extensive wetlands." Nevertheless, if sporadic areas of permafrost are discovered, the designs will need to address the interactions between the infrastructure and the permafrost.

CWS Comment July 2013: *Recognition of the Warhaftig and Selkregg references in the revised Assessment is appreciated. Concern with encountering permafrost involves both engineering questions – ie, soil stability upon thawing (dependent on grain size and distribution), frequency of freeze/thaw occurrences, and broader "ecosystem" questions of landscape dynamics and ecosystem function if previously perennially frozen ground warms – as is probable both upon surface disturbance and consequent to long-term climate warming.*

I don't understand your statement, "**Frozen soil could improve vehicular access to parts of the project site and minimize the disturbance from such access .**" *Perhaps you are suggesting that winter-only off-road vehicular access (with adequate snow cover) would be a management option, as has been implemented in sectors of the North Slope and along the Dalton Highway? While existence of a deep snowpack can improve over-snow vehicle travel (snow machines, tracked vehicles), I fail to see how either perennially or seasonally frozen soil might either "improve vehicular access" or "minimize disturbance." See* Slaughter C.W., C.W. Racine, D.W. Walker, L.A. Johnson, and G. Abele. 1988. Use of off-road vehicles and the consequences for Alaska permafrost environments: a review. Environmental Management 14(1):63-72. , *or* Slaughter, C.W., and J.W. Aldrich. 1989. Annotated bibliography on soil erosion and erosion control in subarctic and high-latitude regions of North America. PNW-GTR-253, Pacific Northwest Research Statin, USDA Forest Service, Portland OR. 234 p., *among many possible references.*

You cite Ghaffari et al. (2011) as saying: "The road route traverses terrain generally amenable to road development. ...There are no significant occurrences of permafrost or areas of extensive wetlands." Based on your Figure 3.4, there should be only limited (if any) permafrost encountered, and of course, engineering measures would be taken with whatever soil or geologic conditions are actually encountered. But given your estimates throughout the Assessment of the length of streams and areas of wetlands which would be encountered in the transportation corridor (i.e., Section 10.3.1, Box 10.1) , do you concur with Ghaffari's characterization (almost dismissal) of wetlands encountered by the road route?

The probability approach outlined for potential TSF dam failure is unpersuasive. It is difficult to relate to a number like "0.00050 failures per dam year," or to the implication on p. 4-47 that one can expect a tailings dam failure only once in 10,000 to one million "dam years." This could suggest to the casual reader that failure of the hypothesized TSF1 dam (for which one "dam year" is one year) should not be anticipated in either the time of human occupation of North America, or the span of human evolution.

RESPONSE: The commenter is correct. The proposed dams, if designed, built, and maintained to current engineering best practices, would be anticipated to have a low annual probability of failure. However, the failure probability would not be zero. The writers concur with the commenter that these low probability numbers may be difficult for the casual reader to grasp, so we now also present estimates of probability in terms of probability failure over different time periods. The discussion of this issue has been expanded to clarify that the failure rate is a design goal and is not based on empirical evidence.

CWS Comment July 2013: *The revised and expanded discussion of Chapter 9 helps. Section 9.1.2 does clarify your reasoning. Box 9.1 and Table 9.1 demonstrate that failures can and do occur. I remain uncomfortable with employing the terminologies of "dam year" or "mine year" which allow suggesting one failure every 2000 mine years, or every 714 to 1754 mine years. A cursory reading might well allow the impression that this means* ***2000 or 714 or 1754 years of TSF1 at Pebble****, and therefore possible failure is of no concern to the current or next ten to one hundred generations. See also Table 14.1, which states that a tailings dam failure has a recurrence frequency of 2500 to 250,000 years – allowing the interpretation a Pebble TSF won't occur for the next 2500 years, so why worry?. Could the text and/or an addendum to the relevant tables and boxes, explicitly differentiate between your "probabilities" and "recurrence frequencies", versus "predictions"? A calculated recurrence interval says nothing about an event actually occurring this year, next year, or 2500 years in the future; I still suspect that some readers and decision makers may not immediately understand this.*

Box 4-6 suggests that the Operating Basis Earthquake (OBE) for a 7.5-magnitude event at the Pebble locale has an estimated return period of 200 years. Such a return interval probability is difficult to interpret, given the lack of historical seismic records for the region; in any event, such a return period estimate is in no way predictive of future seismic activity, in year 2012 or year 2212. (The suggested 200-year return period should also be viewed in light of the 79-year suggested operating life of the hypothetical Pebble operation, probable longer-time operations at other mineral extraction sites which would be developed following implementation of Pebble and building from the infrastructure associated with Pebble, and also the projected very long persistence of the TSFs following cessation of active mining).
RESPONSE: Box 9-2 in the revised assessment (Box 4-6 in the May 2012 draft of the assessment) provided the OBE and return period determined by NDM in the Preliminary Assessment. A detailed engineering design and safety evaluation is outside the scope of this assessment. The discussion of seismicity (Section 3.6) addresses the uncertainty in interpreting and predicting earthquake magnitude and recurrence in the Pebble area.

CWS Comment July 2013: *Figure 3.15 is particularly helpful, as is the revised discussion offered in Section 3.6. Of course, I concur with elimination of the reference to a 200-year return period for a 7.5-magnitude event.*

Box 4-6 does note that "The return periods stated in Alaska dam safety guidance are inconsistent with the expected conditions for a large porphyry copper mine developed in the Bristol Bay watersheds, and represent a minimal margin of safety."
RESPONSE: The return periods used are consistent with the Alaska Dam Safety Guidance, however the operator could include additional margin of safety in the design for critical structures. The return period and seismic safety factors do not inform the failure analysis in this assessment, but would be important considerations during the review process for any future mine plan.

CWS Comment July 2013: *OK*

Question 6. ***Does the assessment appropriately characterize risks to salmonid fish due to a potential failure of water and leachate collection and treatment from the mine site? If not, what suggestions do you have for improving this part of the assessment? Are significant literature, reports, or data not referenced that would be useful to characterize these risks, and if so what are they?***

CWS comment

No. Text suggests that a monitoring well field downslope from the TSF (and presumably from all hypothetical TSFs) would detect seepage; such seepage would then be intercepted and either returned to the TSF or "treated and released to the stream channel." Either action presupposes adequacy of monitoring seepage and subsurface flow (both spatially and temporally); returning such water to the stream further presupposes fully adequate treatment to meet both regulatory and aquatic biota requirements for water quality and flow regime.

RESPONSE: The water treatment and leachate capture discussions have been expanded and are now detailed and quantified in Chapter 8 of the revised assessment.

CWS Comment July 2013: *The extensive revisions and added analysis of Chapter 8 are very helpful. Qualifications and cautions in the text are also appropriate – such as "Even a small number of flowpaths with higher than expected hydraulic conductivity could significantly affect the direction and quantity of flow" (p. 8-11); "Wells would not catch all flows from the mine site given its geological complexity and the permeability of surficial layers" (p. 8-12); the last sentence in Box 8.1 (p. 8-20); "…although post-closure water treatment failures would be less consequential, they also would be less likely to be promptly detected and corrected" (p. 8-21); "…it is much too soon to know whether mines that are permitted for perpetual water collection and treatment….can actually carry out those functions in perpetuity" (p. 8-22); "…releases of water contaminated beyond permit limits would be likely over the life of any mine at the Pebble deposit"(p. 8-22).*

Assumptions are very generalized and optimistic: "assuming no water collection and treatment failures" and "excess captured water would be treated…and discharged to nearby streams…" – this assumes both "no failures" over the life of the operation, and that such treated "excess captured water" could be successfully treated before release to fully meet both regulatory water quality criteria and the possibly more sensitive biological requirements of individual invertebrates and fish stocks (Appendices A & B).

RESPONSE: Water management (mitigation) measures are more clearly described and discussed in Section 6.1.2.5 of the revised assessment, and in sub-sections for the mine components in the scenarios. Our intention for the "no-failure" scenario was to identify and evaluate the unavoidable environmental effects if all systems and mitigation measures operated perfectly, and to separate those effects from a scenario where systems periodically failed. However, the "no failure" scenario is no longer included. The purpose of the assessment is to describe the potential adverse environmental effects that could exist even with appropriate and effective site mitigation

measures. The assessment is not intended to duplicate or replace a regulatory process, which is where required permit discharge limits for water quality would be determined.

CWS Comment July 2013: *Agree that the brief discussion in Section 6.1.2.5, in concert with Chapter 8, more comprehensively treats water management and hydrologic issues. I still suggest that current or future regulatory water quality criteria may not be adequate to meet and sustain the possibly more sensitive biological requirements of aquatic invertebrates and fish stocks.*

Question 7. ***Does the assessment appropriately characterize risks to salmonid fish due to culvert failures along the transportation corridor? If not, what suggestions do you have for improving this part of the assessment? Are significant literature, reports, or data not referenced that would be useful to characterize these risks, and if so what are they?***

CWS comment

No. The Assessment does not adequately address the road/stream crossing/culvert issue. Given the projected transportation corridor, Pebble locale to Cook Inlet, and the inevitability of a further network of "minor" roads in the mine and TSF locale, plus additional infrastructure linkages, road/culvert/stream crossings are a major concern for aquatic habitat and fisheries. Readers of the Assessment should be directed to Frissell and Shaftel's Appendix G for a more comprehensive discussion of this important topic.

RESPONSE: The revised assessment addresses the road/stream crossing/culvert issue in detail. Secondary development is now described qualitatively in Chapter 13 of the revised assessment. The reader is repeatedly directed to Appendix G for more details.

CWS Comment July 2013*: Chapter 10 now provides much better information on the entire culvert issue. Fish passage, proper (or improper) culvert design and construction, maintenance requirements, and consequences of failure are more adequately outlined.*

The specific consequences of a failure on salmonid habitat and biology are portrayed well.

RESPONSE: No changes suggested or required.

CWS Comment July 2013: *OK*

Question 8. ***Does the assessment appropriately characterize risks to salmonid fish due to pipeline failures? If not, what suggestions do you have for improving this part of the assessment? Are significant literature, reports, or data not referenced that would be useful to characterize these risks, and if so what are they?***

CWS comment

No. Concerns with pipelines crossing streams, watercourses and wetlands are similar to those earlier expressed for the road corridor. On-site investigation may well reveal many more “watercourses,” including intermittent and ephemeral streams, than the 70 crossings cited; possible pipeline failures thus may have much wider potential for impacting salmonids than is indicated in the Assessment.
RESPONSE: The document has been edited to indicate that 70 is a minimum value.

CWS Comment July 2013: *OK*

The “probability” argument on p. 6-32 is an understandable attempt at quantification, but is unpersuasive. Given the spill history of TAPS, pipelines in the Prudhoe Bay field, and recently in Montana (?), suggesting the probability (with what confidence limits?) that there would be only 1.5 stream-contaminating spills or two wetland-contaminating spills over 78 years of operation seems wildly optimistic (and what is half a spill?).
RESPONSE: If you think of the mine as a repeated experiment (i.e., many mines with concentrate pipelines of that length and duration), we would expect a mean frequency of 1.5 spills. A more straightforward explanation is that we expect 1 or 2 spills, given the scenario. These frequencies are based on a large data set, not just the TAPS experience (which is an atypical pipeline design and much larger than the diesel line) or the spill in the Yellowstone River (which is a single event). An explanation of the frequency has been added in Section 11.1 of the revised assessment.

CWS Comment July 2013: *The narrative of Section 11.1 is helpful. Many uncontrolled variables inevitably affect the length/duration/failure analysis; I can envision an argument that the transportation corridor pipelines will be in a tightly-controlled (at least in early years) setting and subject to stringent inspection and maintenance, in contrast to many thousands of miles of pipeline in more urban or trafficked locales, with much more opportunity for vandalism, ignorance (ignoring the “do not dig here” warnings), or accidental damage – so the PLP corridor pipelines should be more reliable than the historical record might indicate.*

Of course, the TAPS line is much larger, insulated, partially above-ground on thermopiles and partially buried, and atypical in size; it may also be atypical in that at time of construction, it was designed with state-of-art flow and pressure sensors, automated control systems, regular aerial patrol inspection, etc – yet still experiences incidents, as does the network of gathering lines on the North Slope . And of course, the Yellowstone river spill was a single event – as is every spill -- so does not of itself provide frequency analysis.

Given three pipelines (excluding the natural gas line) and your failure probability estimates on p. 11-5, is it fair to say that under the 25-year PLP 2.0 scenario 8 or 9 spills would be expected (3 x 2.8), and under the 78-year PLP 6.5 scenario 24 to 27 spills would be expected (3 x 8.6)? This would seem in accord with your estimate of virtual certainty (99.9% chance) that at least one pipeline would fail, regardless of mine size.

Assuming that any spill (over the 78-year project span) would last only two minutes (p. 6-32, p. 6-34), with a consequent minimal volume of spilled material, also seems highly optimistic. Even highly-automated systems, with redundant sensors and automatic responses, are susceptible to error or failure, and the Bristol Bay watershed environment is not benign with regard to mechanical apparatus. The authors appear to recognize this with their discussion of the Alumbrera incident. ***RESPONSE: The scenario has been modified to a 5-minute response. Also, more information has been added about the possibility of system failure or human error in response to this and similar comments. The uncertainty discussion in Chapter 11 indicates that the exposure scenario is predicated on the successful operation of a remote shutoff. There may be extreme weather or geological events that render the remote shutoff system inoperable. We did not evaluate those events, so the assessment may underestimate these risks.***

CWS Comment July 2013: *OK. The hypothesized Chinkelyes and Knutson analyses seem quite appropriate, and provide good illustrations of the possible consequences of a spill at a water crossing. I also appreciate the discussion of potential human error, Section 11.3.4.2,, and Table 11.9, and Section 11.5.5. There may well be optimism about SCADA systems, but something or someone can always mess up!*

The specific **consequences** of a failure on salmonid habitat and biology are portrayed well.
RESPONSE: No changes suggested or required.

CWS Comment July 2013: *OK*

Question 9. *Does the assessment appropriately characterize risks to salmonid fish due to a potential tailings dam failure? If not, what suggestions do you have for improving this part of the assessment? Are significant literature, reports, or data not referenced that would be useful to characterize these risks, and if so what are they?*

CWS comment

Yes. Physical consequences of TSF dam failure are fairly portrayed. I would only suggest that effects of initial sediment deposition and long-term remobilization and redeposition would extend beyond the spatial and temporal limits of the modeling used in the Assessment.
RESPONSE: Agreed. We now more clearly state that remobilization and deposition could be extensive; potentially reaching Bristol Bay.

CWS Comment July 2013: *I concur that the revised Assessment provides a much better characterization of potential TSF dam failure. The difficulties with quantitatively analyzing sediment deposition and remobilization further downstream are appreciated.*

Employing advanced eco-hydraulic modeling tools such as MIKE-11, MIKE-SHE (DHI, Copenhagen), and consultation with state-of-art practitioners (IAHR-International Association for Hydraulics Research, UI Center for Ecohydraulics Research, and others), along with improved high-resolution input data such as LIDAR survey of the complete Kvichak and Koktuli/Nushagak systems, would allow a more complete estimate of potential hydrologic and sedimentation (and consequently biotic) consequences of TSF dam failure for the entire river system, headwaters to Bristol Bay.

RESPONSE: We agree that LIDAR survey data would greatly improve the understanding of the project area topography. Alternative modeling platforms coupled with LIDAR have the potential to improve the estimates provided in this assessment, but these data collection and modeling efforts were not within the scope of this project.

CWS Comment July 2013: *Understood – your mandate was not to do such field work and subsequent analysis, which takes a lot of time, expertise, dollars, and advanced modeling capabilities. Such an effort could be a future task as the project (potentially) moves forward.*

Question 10. *Does the assessment appropriately characterize risks to wildlife and human cultures due to risks to fish? If not, what suggestions do you have for improving this part of the assessment? Are significant literature, reports, or data not referenced that would be useful to characterize these risks, and if so what are they?*

CWS comment

No. The Assessment clearly qualified that its objective was to consider risks to salmonids, and only inferentially consider "salmon-mediated" effects.
RESPONSE: No change suggested or required.

CWS Comment July 2013: *The revised Assessment does provide a better consideration of both wildlife and human culture aspects – at least in part in response to other review comments on the first draft. Sections 12.2 and 12.3 are succinct summaries, which should be considered by all decision makers regarding this or other "development" proposals. The final bullet of p. 12-17, though it might have been re-worded, appropriately states that mitigation for lost subsistence resources or cultural values is not feasible.*

Appendix C provides a comprehensive discussion of non-fish wildlife and the relation of those populations to salmon. However, the Assessment itself (Volume 1) provides only a brief summary in Chapter 2.2.3, which could allow a cursory reader to perhaps conclude that wildlife populations have little risk of impact from the hypothetical Pebble project. Is this the intent of the Assessment authors? A more in-depth reading of Appendix C allows inferring potential consequences to wildlife and birds of "salmon-mediated" impacts of mining development.
RESPONSE: We have clarified assessment endpoints and provided additional background information from Appendices A and B in Chapter 5. Direct effects on wildlife are outside the scope of the assessment (as stated in Chapter 2), but their potential importance is acknowledged in Chapter 12.

The assessment has been expanded to include more information from Appendix C of the draft report (now an independent U. S. Fish and Wildlife Report).

The scope of the assessment is focused on potential risks to salmon from large-scale mining and salmon-mediated effects to indigenous culture and wildlife. EPA recognizes the complexity of potential direct, secondary, and cumulative effects on wildlife. We would expect that a full evaluation of any future mining permit applications and subsequent National Environmental Policy Act Environmental Impact Statements would consider these complexities and utilize the information in U.S. Fish and Wildlife report (Appendix C of the draft report.)

USFWS RESPONSE: We acknowledge the comment about the comprehensive discussion of wildlife and the relation of selected species to salmon in Appendix C. Appendix C could be used as the basis of an assessment of potential impacts of mining on wildlife, but decisions related to assessment scope with regard to potential impacts of mining on wildlife is the responsibility of EPA.

CWS Comment July 2013: *OK. Inclusion of these materials in the body of the Assessment, rather than simply in an Appendix, strengthens the document.*

Appendix D provides a comprehensive and useful discussion of the indigenous people of the Bristol Bay region and of their traditional ecological knowledge and cultures. Appendix D clearly lays out the vulnerabilities and risks (summarized on p. 4-5 and pp. 150-153) associated with the (hypothetical) major resource extraction projects. However, the Assessment (Volume 1) provides only cursory consideration of these human aspects of the potential project – on p. ES-23, and in Section 2.2.5. Presumably, this is because the EPA mandate is to conduct an ecological risk assessment, rather than assessment of consequences for human populations, whether indigenous, native, resident, non-native, non-resident, or the larger cash economy world as represented by the State of Alaska, Northern Dynasty Minerals, or Pebble Limited Partnership.

RESPONSE: The scope of the assessment related to Alaska Native cultures is limited to salmon-mediated effects—that is, potential effects on indigenous culture if there are negative effects on salmon. The assessment draws on the more comprehensive information in Appendix D to evaluate these risks. The text of the revised assessment has been expanded to include and discuss the vulnerabilities and risks to Alaska Native culture from potential large-scale mining.

CWS Comment July 2013: *OK. The revised text in Sections 12.2 and 13.4.2, while brief, do add substance to the Assessment. (I make the assumption that the original Appendices A-H are still a part of the overall Assessment.)*

Question 11. ***Does the assessment appropriately describe the potential for cumulative risks from multiple mines? If not, what suggestions do you have for improving this part of the assessment?***

CWS comment

Yes – but a qualified "yes." The Assessment appropriately outlines the probability of additional resource extraction projects beyond Pebble itself, and recognizes that additional resource opportunities (beyond the claims depicted in Figure 4-6), currently unknown or unverified, could become viable or desirable to some interests in the future. Section 7.4 summarizes many of the risks. However, the brief coverage (16 pages) accorded the entire subject of "cumulative risks" is **not** consonant with the very long-term, spatially dispersed (and presumably linked by transportation and communication corridors) impacts and risks of multiple mines (and associated infrastructure) in many different sectors of the Bristol Bay watershed.

RESPONSE: We have added to the cumulative effects section (now Chapter 13) by discussing the effects of induced development, including transportation corridors, and the effects of increased overall access in the watersheds (Box 6-1 discusses cumulative effects in terms of a single mine). The cumulative effects assessment is not a definitive, quantitative evaluation. It is, instead, a plausible example of how a mining district could develop and a conservative estimate of the impacts to aquatic resources and fish. It is intended to shed light on whether cumulative effects are a significant concern.

***CWS Comment July 2013*:** Chapter 13 is a welcome and appropriate addition to the Assessment. The detailed attention paid to other known mining claims or prospects is appreciated. This chapter properly highlights the potential consequences of those mining developments, which will become more likely (and economically feasible) if the initial PLP project at Pebble proceeds as proposed.

(It was interesting to me to note the existence of Pebble South, which apparently directly abuts Iliamna Lake; I don't recall any reference to that potential development during the August 2012 meeting in Anchorage, nor any discussion during public testimony of the likelihood of its proceeding if the initial Pebble project goes forward.)

While "induced development" is briefly considered (Section 13.3), that text is limited to generalities. The discussion is appropriate, as far as it goes. However, a major long-term consequence of actually implementing the PLP proposal, under any of the three scenarios, will be the ancillary and "induced" activities which will inevitably follow. More in-depth consideration of this broad topic, including second- and third-order effects on salmon and "fish-mediated" cultural and wildlife values, should be undertaken in a truly comprehensive assessment of the broader Bristol Bay watershed

Question 12. ***Are there reasonable mitigation measures that would reduce or minimize the mining risks and impacts beyond those already described in the assessment? What are those measures and how should they be integrated into the assessment? Realizing that there are practical issues associated with implementation, what is the likelihood of success of those measures?***

CWS comment

If it is assumed that the PLP project, or some similar development, were to go forward, I cannot suggest mitigation measures beyond those discussed above. Since a major concern for salmonids – perhaps THE major concern – is with consequences of the transportation corridor, simply having the mine without the roads/pipelines would alleviate much potential risk. However, there is presumably no practical, economically feasible way to not have the transportation corridor; air transport of all materials to and from the site might technically be possible, but would not be economically feasible.
RESPONSE: We agree that it would be infeasible to have a mine in this location without also having road access. No change suggested or required.

CWS Comment July 2013: *OK. One other off-the-wall thought, having recently again used the Seattle monorail – might it be worth a brief look at life-of-project costs of establishing an elevated monorail in lieu of the road system – thus avoiding many of the stream/culvert/wetland issues (except during construction), possibly providing lower total $/ ton-mile freight costs Cook Inlet to Pebble, considering the many truck trips (>50/day) projected annually, providing tighter control of access, and concurrently providing a platform for the four pipelines? Just a "Popular Mechanics-style" thought…..*

Question 13. *Does the assessment identify and evaluate the uncertainties associated with the identified risks?*

CWS comment

Yes. The authors fairly attempt (pp. ES-24-26, and in each chapter) to note the various uncertainties and assumptions incorporated into the Assessment. Sections 8.5 and 8.6 briefly summarize those uncertainties. A question remains concerning the "uncertainties" associated with assigning probabilities to various failure scenarios; I remain unconvinced that those probabilities have real meaning or significance for decision-making (see response to Question 5, above).
RESPONSE: As explained in the assessment (particularly in Chapter 14), the probabilities have various sources and different interpretations, which we have tried to make clear. Some of them are more useful in decision making than others, but all are the best values that could be derived from available information. Most are based on empirical frequencies, but some are engineering goals or regulatory targets.

CWS Comment July 2013: *The revised Assessment does fairly discuss uncertainties associated with each sector; the authors have done a good job of outlining assumptions, data limitations, and the suite of "unknowns" contributing to uncertainty in projections. Similarly, as mentioned earlier, the expanded discussion of use of probability analysis has been helpful.*

Question 14. ***Are there any other comments concerning the assessment, which have not yet been addressed by the charge questions, which panel members would like to provide?***

CWS comment

I would simply re-emphasize that a truly comprehensive assessment of the potential consequences of a large-scale mineral extraction project, be it the "hypothetical" Pebble-like project or a different endeavor, should fully consider both the immediate project-specific impacts, and the long-term watershed-wide consequences of "ancillary" developments – such as other mines, which might become economic once the primary project's infrastructure is in place. There should be full recognition of the irreversible nature of such developments, and of the potential and limitations of possible reclamation or mitigation measures for the full suite of resources and ecosystem "services" involved, both short-term and long-term.

RESPONSE: Ecological risk assessments generally have more limited scopes than comprehensive environmental impact statements. This document is not meant to be a comprehensive evaluation of all impacts potentially stemming from a large-scale mine, and its scope has been more clearly defined in Chapter 2. We have added discussion to the cumulative assessment chapter (Chapter 13) to emphasize the long-term watershed-wide consequences of ancillary or induced development. We have added a discussion of compensatory mitigation in Appendix J.

CWS Comment July 2013: *Concur with the response. The entire Assessment is a major step forward from the 2012 draft. The detail provided in all sectors, particularly in the hydrologic ("water balance"), water quality, and cumulative effects sectors, is really appreciated.*

3. SPECIFIC OBSERVATIONS

[NOTE: in the page notations below, S = Section, P = Paragraph, L = line]

CWS comment

1. Global: Provision of full color versions of all figures would have been helpful to this review. The selected color versions supplied here were useful – we should have had them all.

RESPONSE: Comment noted.

CWS Comment July 2013: *The many figures and maps provided are greatly helpful.*

2. Page 2-4: Color codes are confusing – use of different colors for same "moisture state" in the five regions doesn't make sense (to me).

RESPONSE: Figure 2-2 (Figure 3-1 in the revised assessment) depicts hydrologic landscapes across the Nushagak and Kvichak watersheds separated into their physiographic divisions as defined by Wahrhaftig (1965), combined with their climate class as defined by Feddema (2005).

Each color group (e.g., yellow, green, red, etc) represents a separate physiographic division while color intensity (e.g., light green to dark green) represents the climate class within a given physiographic division. The use of different colors is intended to show the variety of climate classes within a given physiographic division, while also depicting similarities in climate class across different physiographic divisions (e.g., darkest red and darkest green show that two areas having different physiographic characteristics are alike in their climate class).

CWS Comment July 2013: *The new figures and maps are very well thought out and presented, throughout the revised Assessment.*

3. Page 3-4 (S3.4, L1): …when mine ***is*** active

RESPONSE: Correct (now in Section 4.2.4).

CWS Comment July 2013: *OK*

4. Page 4-5 (last P): Refers to Fig. 3-1, but "existing road segments" listed are not shown on Fig. 3-1, nor are several cited locales: Williams Port, Pile Bay, King Salmon, and Naknek.

RESPONSE: This reference has been deleted.

CWS Comment July 2013: *OK*

5. Page 4-11 (first P): "The vast majority of tailings dams are less than 30 m in height…" DOES THIS REFER TO TAILINGS DAMS AT ALL KNOWN MINING OPERATIONS, OR TAILINGS DAMS ENVISIONED OR PROBABLY TO BE USED IN BRISTOL BAY WATERSHED?

RESPONSE: The sentence refers to all known mining operations. The text was changed from "The vast majority of tailings dams..." to "The majority of existing tailings dams..." (Chapter 4).

CWS Comment July 2013: *OK*

6. Page 4-11 (first P): "Although upstream construction is considered unsuitable for impoundments intended to be very high or to contain large volumes of water or solids….this method is still routinely employed." ARE THE TSFs SUGGESTED IN THIS ASSESSMENT CONSIDERED "UPSTREAM," "DOWNSTREAM," OR "CENTERLINE"? Para. 1, Section 4.3.5 (p. 4-21), states that "the most plausible sites" for TSFs are "the higher mountain," which suggests that these TSFs would be "upstream" facilities, therefore "considered unsuitable…"

RESPONSE: The TSFs suggested in the scenarios would be constructed using the downstream method and then switched to a centerline method. It is true that in this location, the upstream construction would be unsuitable. The discussion of the upstream method was intended for background and has been moved to Chapter 4 in the revision, with the scenario-specific suggestions discussed in Chapter 6.

***CWS Comment July 2013**: The revisions in Chapter 4 and Chapter 6 are helpful in clarifying this.*

7. Page 4-23 (P2): Text suggests that a monitoring well field downslope from the TSF (and presumably from all hypothetical TSFs) would detect seepage; such seepage would then be intercepted and either returned to the TSF or "treated and released to the stream channel." Either action presupposes adequacy of monitoring seepage and subsurface flow (both spatially and temporally); returning such water to the stream further presupposes fully adequate treatment to meet both regulatory and aquatic biota requirements for water quality and flow regime.

RESPONSE: Yes, the well fields would be downstream from all embankments for all TSFs and this has been clarified in the revision. It is assumed for the scenarios that mitigation measures are operated appropriately. Text has been clarified in the new Chapter 6 to indicate that water would be treated to meet permit requirements. Scenarios in the revised assessment evaluate effects from uncaptured seepage during routine operations from both the TSFs and waste rock piles.

***CWS Comment July 2013:** The text acknowledges that well fields would not expect to either detect or capture all seepage waters. Recognition of effects of uncaptured seepage is appropriate. There remain (possibly unavoidable) generalized and optimistic statements, such as "If contaminated groundwater was detected, monitoring wells would be converted to collection wells or new recovery wells would be installed and water from the well field would be pumped back into the TSF or treated and released to stream channels." (p.6-12), or "…excess captured water would be treated to meet existing water quality standards and discharged to nearby streams, partially mitigating flow lost from eliminated or blocked upstream reaches." (p. 6-15 -6-16).*

8. P4-26 to 4-28 (S4.3.7): This "Water Management" section seems cursory, highly generalized, and optimistic. Statements such as "uncontrolled runoff would be eliminated"; "water from these upstream reaches would be diverted around and downstream of the mine where practicable"; and "Precipitation…would be collected and stored…." do not indicate actual (proposed) practices or techniques, nor inspire confidence that actual runoff events during "normal" conditions, let alone during hydrologic extremes (such as a rain-on-snow event with underlying soils still frozen) would be planned for or actually managed adequately.

RESPONSE: Water management measures are more clearly described and discussed in the revision (Section 6.1.2.5), and in sub-sections for the mine components in the scenarios. Measures are standard and common to existing mine sites.
Collection and diversion structures would need to be designed and built to handle the anticipated flows over the life of the mine, including during extreme weather events. The details of these collection and conveyance systems are beyond the scope of this assessment and are more properly in the domain of the permitting process when a specific mine plan is proposed.

***CWS Comment July 2013:** The revised Assessment devotes much more attention to hydrology and water management. The many analyses, figures and tables provide a great deal of useful information, and undoubtedly would be utilized by PLP engineers if they proceed to permit application and final design. The calculations and figures of Section 7.3 seem quite reasonable, as* *are the findings of Sections 7.3.2 , the statement of uncertainties (Section 7.3.1.5), and the summary (Section 7.4) .*

9. P4-29 (P1): Suggests that 20% more water than available would be required "during startup," and that difference would be satisfied "from water stored in the TSF"; if 20% more than is available would be needed, where would it come from to be available from the TSF?
RESPONSE: The water balance has been revised in Chapter 6. The mine operation would capture more water than needed during all phases of operation. Water could be stored in the TSF as soon as the starter embankment is operational. Ghaffari et al. (2011) further explain: "Once the TSF starter embankment construction is complete, site water will be diverted into this facility to ensure adequate make-up water for process plant start-up. At this time, advanced open pit dewatering will commence. This water will either be treated and discharged or diverted to the TSF, depending on environmental requirements."

CWS Comment July 2013: *The revision is appropriate. Given the sensitivity of salmonids and aquatic invertebrates to seemingly-minor or low-level perturbations of water quality and timing, the statement from Ghaffari et al (2011) that "This water will either be treated and discharged or diverted to the TSF, depending on environmental requirements" is not particularly reassuring.*

10. Page 4-29 (P3): Assumptions are very generalized and optimistic: "assuming no water collection and treatment failures" and "excess captured water would be treated…and discharged to nearby streams..." – this assumes both "no failures" over the life of the operation, and that such treated "excess captured water" could be successfully treated before release to fully meet both regulatory water quality criteria and the possibly more sensitive biological requirements of individual invertebrates and fish stocks (Appendices A & B).

RESPONSE: Water management measures are more clearly described and discussed in the revision in Section 6.1.2.5, and in sub-sections for the mine components in the scenarios. Measures are standard and common to existing mine sites. The revised assessment considers water treatment failure quantitatively and includes refined scenarios with new data for seepage from TSFs and waste rock piles.

CWS Comment July 2013: *The revisions are appropriate. The revised Assessment devotes much more attention to hydrology and water management. The many analyses, figures and tables provide a great deal of useful information.*

11. Section 4.3.8: This and the previous section mention (but in my view, do not adequately stress) the extremely long time frame for post-mining active management and oversight. Many hundreds of years of active management is a longer time than many industrial, corporate or governmental entities are capable of really embracing – witness the current US Congressional practice of "kicking the can down the road" – a human trait.

RESPONSE: This issue is addressed in Section 4.2.4 of the revised assessment.

CWS Comment July 2013: *I have noted that the long time frame, and the potential frailty of human institutions over that time frame, is now acknowledged in several places in the revised Assessment.*

12. Page 4-32 (S4.3.8.2, P3): Suggests that pyritic tailings could be "shipped off site" – i.e., to where? Deep ocean dumping, or Yucca Mountain?

RESPONSE: For smaller amounts of tailings, the option of shipping them to an off-site location for disposal might be an option; however, this is less likely with large mines with high volumes of tailings, so has been removed in the revised assessment.

CWS Comment July 2013: *OK*

13. Page 4-34 to 4-37 (S4.3.9): This reviewer finds the short Transportation Corridor sub-chapter to be succinct, but inadequate and superficial in view of the long-term consequences of imposition of the transportation corridor as portrayed. These deficiencies are addressed, in part, in other sectors of the Assessment, most comprehensively in Appendix G.

RESPONSE: The transportation corridor analysis has been substantially expanded, and is now found in its own chapter (Chapter 10).

CWS Comment July 2013: *This revision and upgrading to Chapter status is quite appropriate. The more detailed considerations found in Chapter 10 more accurately reflect the concerns of this (and other) reviewers about the potential transportation corridor.*

14. Page 4-38 (Box 4-3, P2): Para. 2 states that the southwest extension of the Lake Clark Fault is currently understood to extend to perhaps 16 +/- km from the Pebble ore deposit; however, this is not reflected in Figure 4-11, which suggests that the Lake Clark Fault terminates perhaps 100 km northeast of the Pebble locale. Elsewhere in Box 4.3, there is acknowledgement that, while there is no evidence of recent tectonic activity in the immediate Pebble vicinity, there is relatively little site-specific data or long-term historical seismic record. I infer that any predictions concerning seismicity or earthquake occurrence of any magnitude would have very high uncertainty.

RESPONSE: Figure 4-11 (now Figure 3-15) has been revised to more accurately illustrate the current understanding of the terminus of the Lake Clark Fault. Section 3.6 describes the uncertainties in predicting seismicity in the Pebble region.

CWS Comment July 2013: *OK. The discussion of Section 3.6 is appropriate and is appreciated.*

15. Page 4-41 (Box 4-4): Note that in each of the four tailing dam failure examples, the failed structure was roughly an order of magnitude **smaller** (in height) than the hypothetical TSF-1 structure, yet those failures had major negative consequences.

RESPONSE: Text was added to Section 9.1.1 in the revised assessment to indicate that the dams in these failure examples were significantly smaller than the dams proposed in our mine scenarios."

CWS Comment July 2013: *The revision was noted.*

16. Page 4-45 to 4-47 (S4.4.2.2): The probability approach to tailing dam failure is unpersuasive as presented. It is difficult to relate to a number like "0.00050 failures per dam year," or to the implication (p. 4-47) that one can expect a tailings dam failure only once in 10,000 to one million "dam years." This could suggest to the casual reader that failure of the hypothesized TSF1 dam (for which one "dam year" is one year) should not be anticipated in either the time of human occupation of North America, or the span of human evolution.

RESPONSE: The proposed dams, if designed, built, and maintained to current engineering best practices, would be anticipated to have a low annual probability of failure but the failure probability would not be zero. We concur with the commenter that these low probability numbers may be difficult for the casual reader to grasp, so we also present the estimates of probability in terms of probability failure over different time periods. For example, an annual probability of failure of 0.0005 equates to a 5% probability of failure over 100 years and a 39% probability of failure over 1000 years. Text was also added to clarify the basis for our failure rates.

CWS Comment July 2013: *The clarification of probability analysis for TSF failure, provided in the main body of the assessment, is appreciated. However, I still question the message sent, both in the Executive Summary and in the larger report, that a TSF failure has a "recurrence frequency of 2500 to 250,000 years." This might imply to a reader that with 2500 years as the shorter time span stated, no one should worry about a possible TSF failure, despite the report's documentation of actual failure incidents elsewhere. I suggest eliminating reference to "recurrence interval" in this discussion.*

17. Page 4-48 (Box 4-6): Box 4-6 suggests that the Operating Basis Earthquake (OBE) for a 7.5-magnitude event at the Pebble locale has an estimated return period of 200 years. Such a return interval probability is difficult interpret, given the lack of historical seismic record for the region; in any event, such a return period estimate is in no way predictive of future seismic activity, in year 2012 or year 2212.

Box 4-6 does note that "The return periods stated in Alaska dam safety guidance are inconsistent with the expected conditions for a large porphyry copper mine developed in the Bristol Bay watersheds, and represent a minimal margin of safety..

RESPONSE: The return periods used are consistent with the Alaska Dam Safety Guidance, but the operator could include an additional margin of safety in the design for critical structures. The return period and seismic safety factors do not inform the failure analysis in this assessment.

CWS Comment July 2013: *The discussion in the revised Assessment Section 3.6, along with Table 3.5 and Figure 3.15, is quite helpful. It clarifies known seismic history and acknowledges the "high degree of uncertainty" on this topic for the Bristol Bay watershed.*

18. Page 4-50 to 4-60 (S4.4.2.4): The modeled hydrologic consequences of overtopping/flooding of the hypothetical TSF1 dam/reservoir seem reasonable, given the relatively limited hydrologic data set available for model input. Probable Maximum Precipitation and Probable Maximum Flood results should be approximately "correct" and within the same order of magnitude of potential storm and flood events. The potential consequences outlined (peak flow volume, sediment transport and deposition, length of stream corridor impacted) appear realistic for the scenario. I suggest that this topic and hypothetical result should be given more visibility and emphasis in the assessment.

RESPONSE: The dam failure was modeled as an overtopping event since the possibility could exist. However, the magnitude of the PMP run-off as compared to the resulting failure flood wave is very small. We agree that an actual dam design will consider additional information, but this assessment did not investigate the hydrology of the PMF in greater detail.

CWS Comment July 2013: *As initially noted, the hydrologic sectors of the revised Assessment, including this discussion of PMP and PMF in relation to volumes which would be released by a TSF dam failure, are reasonable.*

19. Page 4-62 to 4-63 (S4.4.4): While accurate, this section does not adequately address the road/stream crossing/culvert issue. Given the projected transportation corridor, Pebble locale to Cook Inlet, and the inevitability of a further network of "minor" roads in the mine and TSF locale, plus additional infrastructure linkages, road/culvert/stream crossings are a major concern for aquatic habitat and fisheries. This issue receives more attention in Sections 5.4 and 6.4, and is mentioned elsewhere in Volume 1 (e.g., Table 8.1, Box 8-1, para. 8.1.2.4.). Readers of the Assessment should be directed to Frissell and Shaftel's Appendix G for a more comprehensive discussion of this important topic.

RESPONSE: This issue is now analyzed in more detail in its own chapter (Chapter 10). The appendix is cited.

CWS Comment July 2013*:* *I fully agree with the decision to highlight the transportation corridor with a stand-alone chapter. The importance is readily indicated, simply by reference the Figures 10.2, 10.5 and 10.6.\; this importance fully justifies the more comprehensive treatment of transportation corridor issues provided in Chapter 10. Inclusion of issues such as dust control and invasive species is appropriate.*

20. Chapter 5: Assumes scenario of "no failure" for entire project, over complete project life. Is this a realistic scenario, given experience with industrial developments in real-world settings subject to vagaries of equipment, landscape, geology, weather, local climate, and human judgment and decision making/execution?

RESPONSE: The "no failure" scenario has been eliminated in response to several comments, and is now considered in terms of mine footprint impacts in Chapter 7.

CWS Comment July 2013: *OK*

21. Page 5-1 (S5.1.1): Question: is "sampling extensively for summer fish distribution over several years" adequate for characterizing fish populations, given the wide fluctuations in salmon escapement and return note elsewhere in the Assessment (e.g., Table 5-1, para. 5.1.2)?

RESPONSE: The answer to this question is of course dependent upon the objectives of the characterization. For the purposes of this section of the assessment, identifying species distributions within the study area, sampling was adequate for minimally characterizing the distribution of salmon, Dolly Varden, and rainbow trout within the project area, including known spawning areas.

CWS Comment July 2013: *Can't disagree, since you qualify this as "minimally characterizing distribution".*

22. Page 5-12 to 5-48 (S5.2): Estimates of habitat, wetland and stream blockage or loss seem reasonable, but, as noted in the text, are probably conservative or "at the low end."

RESPONSE: Agreed. No change suggested or required.

CWS Comment July 2013: *OK*

Estimates of probable streamflow diminution (p. 5-25) seem reasonable, but make no reference to seasonality.
RESPONSE: We assume a constant seasonal demand, thus streamflow changes follow baseline seasonal patterns under this analysis. We clarify that water managers may alter holding and release of water to address environmental flow needs.

CWS Comment July 2013: *The text, tables and figures of Section 7.3 demonstrate the author's cognizance of seasonality of streamflow. The analysis seems thorough. I note that (as in the earlier draft), projected streamflows do not meet the 20% sustainability boundary for flow alterations (as in Figure 7-19).*

23. Page 5-29 to 5-30 (thermal regimes): This section makes no mention of aufeis or "nalyds," ice accumulations which can exert major control on spring and early summer habitat availability and thermal conditions. For examples, see Slaughter (1990), among many other references.

RESPONSE: Citation and text have been added in Section 7.3.2.

CWS Comment July 2013: *Aufeis is not only a concern for culvert blockage, though that is a major concern for roads and highways – see Figures 1, 3 and 4 in Ashton and Griffiths (1990).*

Aufeis can be widespread in natural channels and floodplains (see Figures 1, 3, 6, 10 and 11 in Slaughter (1990)), and may be induced by seemingly-minor modification of natural water flow during winter conditions.

24. Page 5-30 to 5-31: Concur that maintenance of natural flow regime is the desirable target; the "sustainability boundary" approach is a way to attempt managing within the "natural" bounds of variability. Note: Figure 5-9 is map of streams and wetlands lost, not predicted flow alteration hydrograph (see last sentence, p. 5-31).

RESPONSE: Figure references have been updated.

CWS Comment July 2013: *OK*

25. Page 5-37 (Figure 5-10): UT100D – predicted flow is ALWAYS below lower 20% sustainability boundary. UT100C, UT100C1, UTC100B –predicted flows are always within the 20% +/- sustainability boundaries.

RESPONSE: Figure has been revised, and data now presented in Table 8-1.

CWS Comment July 2013: *Table 8-1 does* ***not*** *provide indication of predicted flows in relation to 20% sustainability boundaries. Figures 7-15, 7-16 and 7-17 do depict potential flow alterations which would exceed the 10% and 20% sustainability boundaries; these flow alterations are also noted; however, exceedances of sustainability boundaries not highlighted) in the last column of Tables 7-16, 7-17, and 7-18.*

26. Page 5-38 (Figure 5-11): Predicted flow for two upper gages (SK100G, SK100F) is always below the 20% sustainability boundary. Predicted flow at other gages appears to be near or within the 10% and 20% lower sustainability boundary.

RESPONSE: Figure has been revised, and data now presented in Table 8-2.

CWS Comment July 2013: *See preceding comment.*

27. Page 5-39 (Figure 5-12): Predicted high flow for NK119A is far below the lower 20% sustainability boundary throughout the open water season. From onset of snowmelt, flow at other gages is roughly at or within the lower 20% sustainability boundary.

RESPONSE: Figure has been revised, and data now presented in Table 8-3

. ***CWS Comment July 2013:*** *see preceding comment*.

28. Page 5-41: Gage NK119A – is the estimated decrease of streamflow (minimum mine size) 63% (Table 5-13) or 73% (text)?

RESPONSE: Values have been updated.

CWS Comment July 2013: *OK*

29. Page 5-41: In any case, text is clear: predicted flow reductions for North and South Forks Koktuli River are materially below the lower 20% sustainability boundary. Text suggests that while upper Talarik Creek would be essentially obliterated in this hypothetical scenario, lower gaging stations on Talarik Creek might have partial augmentation of reduced flows, from small tributary flows and groundwater; without supporting data, this suggestion seems unsupportable.

RESPONSE: Revised text illustrates important trans-watershed groundwater contributions to lower Upper Talarik Creek.

CWS Comment July 2013: *OK – but the trans-watershed groundwater contributions are still hypothetical.*

30. Page 5-42 to 5-45: These pages fairly summarize the potential for substantive alterations to streamflow regime and surface water/groundwater relationships.

RESPONSE: No change suggested or required.

CWS Comment July 2013: *OK*

31. Page 5-44 (P3): "Once the mine is no longer a net consumer of water, we assume that flow regulation through the water treatment facility could be designed to somewhat approximate natural hydrologic regimes, which could provide appropriate timing and duration of connectivity with off-channel habitats." I suggest that this is a highly optimistic assumption, and does not address water quality questions (which are raised elsewhere in the Assessment).

RESPONSE: We emphasize that the ability to manage flows will be dependent upon sufficient infrastructure and flexibility in water management.

CWS Comment July 2013: *OK –I'm not sure that you could do much more, since this is all potential and hypothetical, and remains an optimistic assumption of future "sufficient infrastructure and flexibility in water management."*

32. Page 5-45 (S5.2.3): This entire paragraph should receive greater emphasis.

RESPONSE: This section (now Section 7.3.3) has been expanded.

CWS Comment July 2013: *The risk characterization (Section 7.3.3), while brief, is written well and provides the recommended emphasis.*

33. Page 5-46 (P4): Ignores variable-source-area concepts, which are widely accepted in hydrologic and watershed analysis.

RESPONSE: We respectfully disagree. The variable source area concept presents the idea about the expansion and contraction of saturated areas that are the immediate source of streamflow during storms. In does not invalidate the notion that the total drainage area contributes with long flowpaths to streams. These long flowpaths ultimately contribute to saturated zones that support perennial streamflows.

CWS Comment July 2013: *Of course the total drainage area* **may** *contribute to streamflow; the contributing area may shrink or expand depending on incoming precipitation (or meltout of seasonal snowpack). Your "long flowpaths" may expand or contract seasonally; I fail to see any argument here.*

34. Page 5-46 (P5): Assumes requirement for more water than is available, but leaves hanging the question of where that more water might be sourced. Given that the site is a watershed headwaters, what might be tapped as additional water supply, and what might be the impacts on that source(s)?

RESPONSE: The revised water balance indicates that the mine would have the capability to capture more water than it needs during all operational phases, including start-up, from within the mine footprint.

CWS Comment July 2013**:** *If we accept the revised water balance, then you would not be looking for additional water supply.*

35. Page 5-59 to 5-63 (S5.4): See earlier cautions concerning stream crossings, culverts. Note that road cuts and culverts are particularly susceptible to development of aufeis ("icings"), often resulting from blockage or alteration of subsurface water movement during cold conditions, as witnessed by long-standing AKODT maintenance issues – Richardson, Steese, Dalton highways, for example.

RESPONSE: The potential for culvert blockage by aufeis is discussed in Chapter 10 of the revised assessment.

CWS Comment July 2013: : *Aufeis is not only a concern for culvert blockage, though that is a major concern for roads and highways – see Figures 1, 3 and 4 in Ashton and Griffiths (1990). Aufeis can be widespread in natural channels and floodplains (see Figures 1, 3, 6, 10 and 11 in Slaughter (1990)), and may be induced by seemingly-minor modification of natural water flow during winter conditions.*

36. Page 5-60 (S5.4.2, P1): The statement that "…it is unlikely that a mine access road would have sufficient traffic to significantly contaminate runoff with metals or oil" is unsupported; it might be instructive to look at traffic loads for the access road from the Steese Highway to the Ft. Knox mine, a much smaller operation than the proposed Pebble development.

RESPONSE: This statement no longer occurs in the assessment.

CWS Comment July 2013: *OK*

37. Page 5-60 (S5.4.2, P2): First sentence is correct. Second sentence is unsupported and probably incorrect (see Appendix G). Yes, runoff from roads is location-specific; that **does not** mean that runoff from roads would be insignificant to salmonids, given the very large number of streams (perennial, intermittent, and ephemeral), and wetlands, which would be intersected by the total road system of the Pebble project. This also seems to be contradicted by Section 5.4.3.

RESPONSE: This issue is now given more attention in Chapter 10.

CWS Comment July 2013**:** Again, I concur with the decision to address the transportation corridor more comprehensively in a free-standing chapter.

38. Page 5-60 (S5.4.4.1): There are many more water or seep crossings than 34 – see USGS topog sheets, ACME Mapper, or Google Earth.

RESPONSE: The number of crossings has been updated in the revised assessment.

CWS Comment July 2013: *OK*

39. Page 5-61 (S5.4.4.2 and 5.4.4.3): Development of aufeis ("icings") consequent to partial or full culvert blockage, or induced by soil mantle compaction (i.e., by roads or off-road vehicle traffic) can partially or wholly block stream channels. Such blockage, in association with ice on the streambed, may last long past snowmelt and persist well into early summer, possibly affecting fish movement.

RESPONSE: The potential impact of aufeis on stream channels and potential existence past breakup is discussed in Chapter 10 of the revised assessment.

CWS Comment July 2013: *I can only assume (hope?) that conditions in the Bristol Bay watershed may be less conducive to aufeis or nalyd ("icings") formation than in interior and northern Alaska. Aufeis is not only a concern for culvert blockage, though that is a major concern for roads and highways – see Figures 1, 3 and 4 in Ashton and Griffiths (1990). Aufeis can be widespread in natural channels and floodplains (see Figures 1, 3, 6, 10 and 11 in Slaughter (1990)), and may be induced by seemingly-minor modification of natural water flow during winter conditions.*
I

40. Page 5-62 (S5.4.5): While I don't have the specific citations at hand, there are published analyses of dust effects associated with the North Slope haul road and Prudhoe Bay road network. Obvious effects include accelerated snowmelt along the road corridor, and nutrient or pollutant contributions to road corridor environs.

RESPONSE: The revised assessment includes information from published literature on dust effects in the Arctic (Chapter 10).

CWS Comment July 2013: *The added information in Chapter 10 is appropriate.*

41. Page 5-63 (S5.4.6.3): Should it read "…*impacting* 270.3 km of stream…"? (Incidentally, it is interesting that this coarse assessment finds it possible to state impact to within 100-meter resolution.)

RESPONSE: The revised assessment notes that risks to salmonids from de-icing salts and dust suppressants could be locally significant, but we cannot state that the entire stream length between potential road crossings and Iliamna Lake would be affected.

CWS Comment July 2013: *OK*

42. Page 5-65 (S5.4.7.3 and 5.4.8.3): Viewing the transportation corridor landscape, via maps, Google Earth or ACME Mapper, gives me the impression that the estimate of 4.9 km^2 wetlands directly impacted is a very low number. It is easy to play with the numbers given on pp. 5-69 - 5-70, regardless of their accuracy; 66 km of road impacting wetlands, assuming a 10-meter roadway footprint, yields 0.66 km^2 of wetlands "under the road" (vs. 0.18 km^2 in the text). The 200-meter proximity to wetlands cited, over 66 km of road, yields some 13 km^2 of wetland impact (vs. 7.3 km^2 in the text). 80 km of road within 200 m of streams or wetlands yields 16 km^2 of road/wetland impact. Since these are all assumptions and estimates, it is not possible to conclude that any of these figures would be the "true" area impacted.

RESPONSE: The 0.18 km^2 refers to the area of wetlands which would be filled by the roadbed "intersecting" wetlands (19.4 km length of roadbed x 9.1 m width of roadbed), and does not include roadbed adjacent to wetlands (note that this area is 0.11 km^2 in the revised assessment due to a slight change in methodology for measuring road length). The 4.9 km^2 (not 7.3 km^2) area of wetland within 200 m of the length of road (on both sides) within the study area is based on actual National Wetland Inventory (NWI) data (the calculation methodology is described in Box 10-1 of the revised assessment).
Though NWI data were utilized in this analysis, the 200 m road buffer was derived from a literature estimate of the road-effect zone for secondary roads.

CWS Comment July 2013: *OK. Since these are all assumptions and estimates (including the NWI data), it is not possible to conclude that any of these figures would be the "true" area impacted.*

43. Page 5-74 (S5.4.10): Should this say ***impact*** rather than "risk"?

RESPONSE: "Impact" could be used here, but we chose to use "risk" to note the probability rather than certainty that salmon would be affected by the corridor-associated activities/events listed

CWS Comment July 2013: *OK*

Text implies that even this "no-failure" scenario will impact salmonids; however, it is apparently not possible to estimate specific changes or the magnitude of such changes.
RESPONSE: The no-failure scenario has been eliminated in response to several comments; effects resulting from the mine footprint are now discussed in Chapter 7. The exact magnitudes of changes in fish productivity, abundance and diversity cannot be estimated at this time, but the species, abundances, and distributions that would potentially be affected are summarized in Chapter 10 of the revised Assessment.

CWS Comment July 2013: *OK – as noted before, Chapter 10 is a valuable addition to the Assessment.*

44. Page 5-74 to 5-77 (S5.6): This section seems cursory and understated, particularly in view of the extensive discussion of Appendix D.

RESPONSE: The discussion of fish-mediated effects on Alaska Native culture has been expanded and is now in Chapter 12.

CWS Comment July 2013: *The expanded discussion in Chapter 12 is appreciated.*

45. Section 6.1: Concur with general overview statements, and with conclusions regarding immediate consequences of TSF dam failure, which would likely be as severe as or more severe than stated in 6.1.2.1.
P. 6-6, first sentence – note that the failure scenario predicts over 70% fines < 0,1 mm, vs. the 6% "natural" fines concentrations.
P. 6-13, last para. – the assumption that overtopping would not occur in winter is not warranted, as the authors admit when citing the Nixon Fork Mine incident. In the Bristol Bay environment, a major rain-on-snow event in winter or spring is within the realm of possibility, and of course human error is, if not inevitable, always possible.
RESPONSE: We clarify that the scenario we chose to illustrate overtopping did not occur during low-flow conditions, but was in response to a flood. We acknowledge that failure at other times, and in response to other events, is possible (Section 9.3).

CWS Comment July 2013: *OK – suggest that the brief statement on p. 9-15 that "an overtopping event is only one potential failure mechanism" might be fleshed out a bit – what other hydrologic events or conditions might lead to failure?*

46. Page 6-15 (Box 6.2): Box text implies that human error, lack of timely oversight and correction was responsible – but never directly says "human error." The apparent assumption that there is no hydrologic activity after freeze-up (or perhaps, after an ice cover forms on the pool) was naïve and incorrect. At least in that case, it appears that both dam and spillway design (not adequately considering winter and ice conditions) and operation/inspection (human error) were responsible.

RESPONSE: The comment is probably correct. However, we have no evidence that the commenter's conclusion that both engineering error and operator error were responsible was correct.

CWS Comment July 2013: *OK*

47. Section 6.1.4.1: Appropriately recognizes the long time period for exposure, over extended stream lengths, through both initial deposition and multiple re-mobilization and redeposition events.

RESPONSE: Agreed. No change suggested or required.

CWS Comment July 2013: *OK*

48. Page 6-28 (S6.1.5 and Table 6-6): Seems jargon-laden and does not add to strength of the Assessment.

RESPONSE: Opinion has been divided concerning this explicit weighing of evidence. Given that the analysis of risks to fish from exposure to spilled tailings involves six separate lines of evidence, the EPA intended to show and discuss how the evidence was weighed.

CWS Comment July 2013: *OK. It seems that the revised Assessment has better wording and explanation.*

49. Page 6-29 (S6.1.7): Concur that remediation "…would be particularly difficult and damaging…"

RESPONSE: No changes suggested or required.

CWS Comment July 2013: *OK*

50. Page 6-30 (S6.2): Even though "We do not assess failures of the natural gas or diesel pipelines…," those pipelines would be equally susceptible to failure as the slurry line. Concerns with pipelines crossing streams, watercourses and wetlands are similar to those earlier expressed for the road corridor. Similarly, I suspect that careful inspection would reveal many more "watercourses," including intermittent and ephemeral streams, than the 70 crossings cited.

RESPONSE: A diesel spill has been added to the assessment, but it was judged that a gas leak would not pose a potential risk to fish (Chapter 11).

CWS Comment July 2013: *OK*

The "probability" argument on p. 6-32 is an understandable attempt at quantification, but is unpersuasive. Given the spill history of TAPS, pipelines in the Prudhoe Bay field, and recently in

Montana (?), suggesting the probability (with what confidence limits?) that there "should be" only 1.5 stream-contaminating spills in78 years of operation seems wildly optimistic.

RESPONSE: These probabilities and frequencies are based on a large data set, not just the TAPS experience (which is an atypical pipeline design and much larger than the diesel line) or the spill in the Yellowstone River (which is a single event).

CWS Comment July 2013: *The narrative of Section 11.1 is helpful. Many uncontrolled variables inevitably affect the length/duration/failure analysis; I can envision an argument that the transportation corridor pipelines will be in a tightly-controlled (at least in early years) setting and subject to stringent inspection and maintenance, in contrast to many thousands of miles of pipeline in more urban or trafficked locales, with much more opportunity for vandalism, ignorance (ignoring the "do not dig here" warnings), or accidental damage – so the PLP corridor pipelines should be more reliable that the historical record might indicate.*

Of course, the TAPS line is much larger, insulated, partially above-ground on thermopiles and partially buried, and atypical in size; it may also be atypical in that at time of construction, it was designed with state-of-art flow and pressure sensors, automated control systems, regular aerial patrol inspection, etc – yet still experiences incidents, as does the network of gathering lines on the North Slope . And of course, the Yellowstone river spill was a single event – as is every spill -- so does not of itself provide frequency analysis.

Assuming that any spill (over the 78-year project span) would last only two minutes (pp. 6-32, 6-34), with a consequent minimal volume of spilled material, also seems highly optimistic. Even highly-automated systems, with redundant sensors and automatic responses, are susceptible to error or failure, and the Bristol Bay watershed environment is not benign with regard to mechanical apparatus.
RESPONSE: The EPA agrees with this comment and has increased the response time to 5 minutes.

CWS Comment July 2013: *OK – I still think that even 5 minutes is optimistic.*

The authors appear to recognize this with their discussion of the Alumbrera incident.
RESPONSE: No change suggested or required.

CWS Comment July 2013: *OK*

51. Section 6.4: Potential road/culvert failures are recognized (again, not that ice issues are not discussed). Extended periods for repair/rebuilding might be anticipated – witness the repeated problems with the highway to Eagle, AK over the past several years – and that is a State of Alaska responsibility, not that of a private company.

RESPONSE: We agree with the commenter that extended periods for repair/rebuilding might be anticipated. Chapter 10 of the revised assessment notes that long-term fixes to a road that was

damaged by erosional failure of a culvert may not be possible until conditions are suitable to replace a culvert or bridge crossing. Further, multiple failures, such as might occur during an extreme precipitation event, would likely require longer to repair.

CWS Comment July 2013: *Chapter 10 appropriately addresses this.*

Potential for multiple simultaneous or concurrent failures is appropriate. Non-Alaska examples would be the Pacific Northwest flood events of 1964 and 1996, both major precipitation events with widespread flooding and road failures, in a region with much more developed infrastructure and response capacity.
RESPONSE: We agree with the commenter with respect to the likelihood for multiple simultaneous or concurrent failures during extreme precipitation events. This is alluded to in the assessment.

CWS Comment July 2013: *This is mentioned on p. ES-24*

52. Chapter 7: Recognition of probable additional mining activity, in the wake of a Pebble project, is appropriate. Assessment is necessarily limited to currently-known potential mining projects. The cumulative and irreversible consequences of multiple developments, with associated road, power, housing, communications infrastructure ("secondary development") should be more heavily emphasized, even though it is not possible to quantify all those consequences.

RESPONSE: The cumulative impacts of multiple developments, road corridors, and secondary or induced development have been emphasized through additional discussion in Chapter 13.

CWS Comment July 2013: *The addition of Chapter 13 with its detailed analysis of several possible scenarios, is welcome and appropriate*.

53. Chapter 8: Section 8.1.2 – note many potential failure modes not analyzed; the lack of analysis in this Assessment should not be taken to mean that such failure could not or will not occur.

RESPONSE: Because the number of potential failures is extremely large, it is necessary to choose a representative set of failure scenarios. The focus of the assessment was on potential effects to salmon. The revised assessment includes more failure scenarios (e.g., diesel pipeline failure, quantitative water treatment failure, and refined seepage scenarios) and explains why these particular failure scenarios were chosen. Section 14.1.2 in the revised assessment explains that the assessment only presents a few failure scenarios. The EPA agrees with the commenter that lack of analysis should not imply a failure could or will not occur.

CWS Comment July 2013: *I did notice your statements on this, and appreciate the thought given to Chapters 13 and 14.*
54. Table 8-1 (Row 2): The reasoning behind the statement that "Most [product concentrate pipeline] failures would occur between stream or wetland crossing [sic] and might have little effect on fish" is hard to understand; stream crossings, whether via elevated utilidors or via sub-channel borings or

utilidors, are locales of angular change, piping connections and joints, and subject to stresses of hydrologic extreme events – so why would such sites be less subject to potential pipeline failure?

RESPONSE: Most of the corridor is not at or adjacent to a stream or wetland. Therefore, failures are most likely to occur between streams or wetlands rather than at streams or wetlands. The statement is not about probabilities per unit length.

CWS Comment July 2013: *I fail to understand your response that "* ***The statement is not about probabilities per unit length."*** *If you are saying that failure at stream crossings or wetlands is not probable, because such crossings are a small proportion of the total length of pipeline, then you must be referring to "probability per unit length." My previous comment holds: stream crossings, whether via elevated utilidors or via sub-channel borings, are locales of angular change, piping connections and joints, and subject to stresses of hydrologic extreme events (which are not likely to occur between stream crossings) – so why would such sites be less subject to potential pipeline failure?*

55. Page 8-4 (Box 8-1): As noted elsewhere, the probability arguments for TSF dam failure are not persuasive, and seem designed to imply that a TSF dam failure would not occur within the next 10,000 years (or 3,000 to 300,000 years with three TSFs operational). This implication is difficult to square with information on actual past failures presented in Box 4-4 and Table 4-8.

RESPONSE: The discussion of this issue has been expanded to clarify that the failure rate is a design goal and is not based on empirical evidence.

CWS Comment July 2013: *The revised wording addresses this issue. Section 9.1.2 does clarify your reasoning. Box 9.1 and Table 9.1 demonstrate that failures can and do occur. I remain uncomfortable with employing the terminologies of "dam year" or "mine year" which allow suggesting one failure every 2000 mine years, or every 714 to 1754 mine years. A cursory reading might well allow the impression that this means* ***2000 or 714 or 1754 years of TSF1 at Pebble****, and therefore possible failure is of no concern to the current or next ten to one hundred generations. See also Table 14.1, which states that a tailings dam failure has a recurrence frequency of 2500 to 250,000 years – allowing the interpretation a Pebble TSF won't occur for the next 2500 years, so why worry?. Could the text and/or an addendum to the relevant tables and boxes, explicitly differentiate between your "probabilities" and "recurrence frequencies", versus "predictions"? A calculated recurrence interval says nothing about an event actually occurring this year, next year, or 2500 years in the future; I still suspect that some readers and decision makers may not immediately understand this.*

A final note on this: P. 9-7 states that there were 88 observed or reported tailing dam failures in the period 1960 to 2010; an average 1.7 failures per year, 1987 to 2007; "2 to 5 major tailings am failures annually from 1970 to 2001"; and 49 tailings dam failures in the U.S (over an unstated period). These actual failures occurred within one human life span, not within a span of 714 or 1754 or 2000 years. The calculated recurrence frequencies or probabilities based on "dam years" or "mine years" can appear reassuring; actual records of failures are not, given the irreversible consequences of such a failure in the Bristol Bay watershed.

56. Chapter 8: The potential risks and impacts are fairly and succinctly stated. Given the extremely long-term nature of the projected Pebble project, and the irreversible changes which would be imposed to the region, the risks seem, if anything, understated. I attribute this to the decision to focus this Assessment on salmon and anadromous fisheries, with some attention on salmon-mediated impacts – i.e., effects on indigenous culture, on wildlife other than salmon, etc.

RESPONSE: No change suggested or required.

CWS Comment July 2013: *OK*

Dr. John Stednick, Colorado State University

Peer Review Follow-On Comments on the April 2013 Draft of

An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska

From: Stednick,John [mailto:John.Stednick@colostate.edu]
Sent: Tuesday, September 03, 2013 3:31 PM
To: Thomas, Jenny
Cc: Frithsen, Jeff
Subject: RE: Revised BBA Peer Review Follow-on

Hi Jenny and Jeff,

As promised by today, attached is my review of the Bristol Bay assessment. Please feel free to ask if any questions. This summer has been very busy with fire-related research and most of my summer plans were changed. Thank you for your patience. I look forward to reading the compiled reviewer comments.

Cheers,
John

John D. Stednick, Ph.D.
Professor, Watershed Science
College of Natural Resources
Colorado State University
Fort Collins, CO 80523-1472
970.491.7248

Dr. John Stednick

Date: 26 August 2013

To: Jeff Frithsen, Ph.D.
National Center for Environmental Assessment
Office of Research and Development
US Environmental Protection Agency
Washington, DC
20460

From: John D. Stednick, Ph.D.
Colorado State University
dba/ Mountain River Associates, Inc.
Fort Collins CO
80523

Subject: Technical review of:
An Assessment of potential mining impacts on salmon ecosystems of Bristol Bay, Alaska. Second External Review Draft. US Environmental Protection Agency, Seattle WA. April 2013. EPA 910-R-12-004Ba.

Introduction

This technical review is on the above referenced document. General comments are presented here, and chapter-specific comments or critiques are presented below. The document has now been written as an environmental risk assessment and thus has eliminated the previous confusion as a Clean Water Act 404(c) evaluation. The theoretical models (as figures) are excellent, yet scarcely referenced or used. As pointed out in the review of the first draft, the appendices provide very useful information and data that are often not fully incorporated or included in the text. Admittedly the appendices vary in quantitative information, but currently the reader is directed to the appendix rather than having data or main points presented directly. Through out the document, I found a lack of coordination between the written text and the tables and figures in the main text body. Tables or figures were casually referenced with no presentation or little discussion of main points. Tables and figures should stand independently, that is information is presented in such a manner that the reader can make the same conclusion as the authors. Similarly, the text should be able to 'stand alone' whereby enough information is presented in the text as summary statistics or other quantitative points that the reader makes the same conclusion. I found that considerable time was needed to understand the figure/table point(s) as related to the text. This can be addressed with text editing and some reorganization.

Abstract

The abstract states the purpose of the document is a risk assessment evaluating the environmental risk of mining in the area. The first document was criticized because there was not a specific mine plan. There needs to be a better description of how the three different levels of mining activity were determined. The mine plan alternatives (Pebble 0.25. 2.0 and 6.5) and associated quantitative effects are listed as respectively but are hard to follow. Sentence structure could be improved. Discussion of this range of 'alternatives' needs to be expanded.

Executive Summary

The Executive Summary order of findings does not parallel the assessment order; i.e. culvert failure, streamflow modification, TSF failure.

ES-2. Pebble 0.25, 2.0, and 6.5 are not 'defined' until page ES-10. As in the abstract a 'better' defense or justification of these values would be useful.

ES-11 PAG and NAG are not defined in this chapter.

ES-14. Hard to follow the sentences with the 'respectively' areas or km affected by alternative plans.

ES-15. Where are the data for the copper toxicity? Would be helpful to present these data.

ES-16. Culvert failure rate seems excessive.

ES-17. The mitigation or prevention of spills is to use impact-resistant containers is an oversimplification. What about handling and other spill containment facilities?

ES-17. PLP is never defined in this section.

ES-17. Would be helpful to better separate the TSF failures for scenarios Pebble 2.0 and 6.5.

ES-17. Table suggests that there is no copper toxicity to fish under Pebble 0.25.

ES-18. Wetland loss unquantified or unquantifiable? Low culvert failure, yet failure rate is 47%?

ES-21. The comparison of the TSF height to national landmarks is anthropocentric. Suggest that reference be deleted.

ES-22. Copper toxicity to fish is less clear. Does this refer to the risk assessment or the literature? Literature is well established, so why the disconnect?

ES-23. Why would Pebble 2.0 extend further and last longer?

Dr. John Stednick

ES-24. Reference for a diesel spill recovery in 1-3 years in cold environments?

ES-25. …effects…..of a large mine on salmon. The use of the word single in this sentence is confusing.

ES-26. The inclusion of a groundwater drawdown in Pebble 0.25 increased the amount of wetland loss by 84%. Similar results for the other scenarios. State the approximate acreage, the use of percentages is often misleading.

ES-28. *Standard leaching test data are available for test tailings and waste rocks from the Pebble deposit, but these results are uncertain predictors of the actual composition of leachate from tailings impoundments, tailings deposited in streams and on their floodplains, and waste rock piles*. This statement is confusing and does little to support any findings of the potential effects of metals, especially copper being mobile in the aquatic environment. Suggest this be reworked.

Chapter 1.Introduction
General comments:
Introduction to purpose of document. Identification of risk assessment endpoints.

Specific comments:
1-1. High hydrologic diversity is apparently a new term as related to a diverse fish population. Diverse as well as productive?
1-2. Is the document for a 404(c) decision or a risk assessment? Confusing still.
1-3. Salmon is the endpoint. Wildlife and culture are secondary endpoints. Does this change the effects of stressors on these endpoints?
1-4. Inform the public of the biologic and mineral resources of Bristol Bay. Only based on the readily available materials. I doubt that PLP is showing all the mineral deposit data.
1-5. This document is not to invoke CWA 404(c), but is a risk assessment. One cannot equate open pit mine impact as filling of wetlands only.

Chapter 2. Overview assessment
General comments:
Introduction to assessment, including mine alternatives and data sources.

Specific comments:
2-2. Some minor data sources were used without peer review? Identify.
2-3. Reference to Ghaffari report, please identify where or what data were exclusively available in said report.
2-4. Endpoint based on decision maker needs. Suggest that the outcome is pre-determined. Change the endpoints, change the conclusion. Similarly on 2-7. stressors outside the scope could have environmental consequences. Reference to Challenger event is not needed and suggest it be deleted.

Dr. John Stednick

2-8. Reference to HUC's seems out of place.

Dr. John Stednick

Chapter 3. Region.
General comments: Introduction to the study site setting, with a strong emphasis on physical attributes. A reader unfamiliar with the setting would be hard pressed to understand all the physical, biological, and cultural resources present. Materials can be gleaned from the appendices and add to the chapter utility. I would argue for presentation of more data for site characterization. The surface water –groundwater connection is significant hydrologically and biologically. Much of the impact assessment is loss or disruption of these hyporheic flows. I think elaboration on the determination and areal extent of this is important and should be included in this chapter.

Specific comments:
Figures 3.1 to 3.7 have useful information and data that are not developed in the text per se. These should be presented to the reader via text as well as figure.

3-12. Based on *extensive* studies in the Pebble area….. I am always uncomfortable with value judgments of this sort. When or what is extensive? Does this imply that the PLP data are the sole source, the best etc?

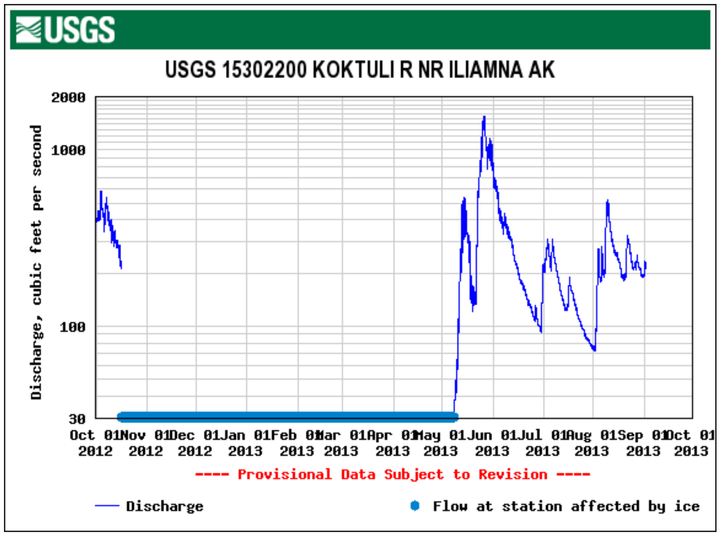
3-13. The hydrologic landscape as related to the physiographic landscape elements? Hydrologic landscapes defined by calculating the water surplus, which is an obtuse definition of streamflow. Yet the next section discusses the importance of groundwater exchange for salmonid habitat. And earlier it was stated that*: Permeable shallow aquifers, upwards hydraulic gradients, and strong local relief indicate that local and intermediate groundwater flow systems dominate regional groundwater flow systems. Crosscutting faults with high hydraulic conductivities….*

Groundwater exchange and flow stability make for more stable habitat? Meaning is unclear.

Large and small lakes support flows that are more stable than …other salmon streams. What is the definition of stable here? What represents a departure from stability?

Mixed messages. Need to characterize the system hydrology including groundwater components with hyporheic exchanges, then relate to salmonid habitat. This section is the description of the Region, yet few data are presented and the inference of hydrology to habitat is unclear. Suggest a chapter reorganization to improve overall chapter flow and logic.

There are considerable data that are available that would could improve this section. For example the USGS collects streamflow, precipitation, and temperature data. Daily plots of these data would provide a better site characterization. For example:



When coupled with precipitation data this better illustrates both snowmelt and rainfall events. The monthly hydrograph time steps do little to illustrate the system dynamics.

3-18. *Differences in hydrology, geology, and climate across…create the regions diverse hydrologic landscapes …ultimately shaping aquatic habitats. These diverse habitats support a high level of biological complexity, in part supported by enhanced ecosystem productivity associated with salmon runs, contributing to the environmental integrity and resilience of the watersheds integrity and resilience on the watershed's ecosystems.* Although I do not disagree with this statement as a summary or concluding statement, an introductory statement it is unsupported. Although citations are given (out of order—list by date), I think the development of this statement is lacking in this section. This is again a value judgment that may not necessarily be repeated by the outside reader.

Habitat complexity. Abundant and diverse array of aquatic habitats. Change in terminology. Are these terms precise?

Section needs to be developed in a more logical fashion, so reader can be lead to the same conclusions.

3-18. Streamflows are listed as mean annual flow (m^3/sec). Figure 3.10 shows streamflow as monthly runoff in mm.

3-18. ..correlated flow paths?
How were these four gradient classes determined? How many are in each class? How do these compare to physiographic landscape elements and hydrologic landscapes?

3-19. Box 3.1. Why start with the statement that the measured gradient of the NHD flow lines were not accurate compared to the topography defined by the DEM? We have seen this inconsistency repeatedly with these comparative methods (including streams that go up and over the watershed ridge). This text box (and others) read more like the user manual for the GIS operator and I would submit should only be briefly commented on in the text. The findings could be better presented in the text box, which is the 'take-home' message.

3-21. …*indicate significant spatial variability in thermal regimes*. Why not define and present this material?

3-24. Mean annual flow is a metric of stream size. So is peak flow. How the streamflow classes selected and what were the ranges of the watersheds measured?

3-25. Text box expresses mean annual flow as cubic feet per second—not metric. The equation makes no sense and uses British units as well.

Below the text box is a paragraph that suggests that the salmonid species propensity for small streams varies. What is the relation between salmonid habitat and stream size? If the usage varies, why the exercise in stream classification by MAF? This paragraph does not flow with the present section organization.

3-26. Specifically define each scale. What is scale 1? Why are scales 3, 4, and 5 listed but presented later? Edit section.

3-28. Water quality section is wanting. There has been a large water quality data acquisition effort done by numerous parties in the study area. A summary table of mean concentrations for 3 large river systems is an underrepresentation of that effort and does not provide an adequate water quality characterization for risk analysis. These data are listed as background concentrations. Are all samples above areas of mineralization? Changes over time now that the area has been drilled? Groundwater chemistry values? Concentration relations to streamflow? No nutrient data, but nutrient return from spawning salmon was presented as significant for system productivity. Are metals dissolved or total? TDS values cannot be reproduced by addition of presented analytes. What are the precipitation chemistry inputs? What are the changes over time (years?). Speculation on climate change influence on water quality? If significant spatial variability in thermal regimes, would the same be expected or seen in water quality?

3-28. Seismicity section is out of place.

3-36. Climate change. A generic description of climate change scenarios, but little linkage to changes in hydrologic processes in the study area. Are such potential changes addressed later? Scenarios of changes in precipitation and temperature due to climate change (using SNAP); what is the existing record and variability in temperature and precipitation? Streamflow records could be used to better illustrate past variability. Have salmon runs been related to streamflow conditions? How variable is the system using existing records? I think this section is too qualitative and was disappointed with the effort.

Chapter 4. Type of development.

General comments
Overview of mining processes and terminology.

Specific comments:
4-1. Reference to Table 13-1 and Figure 13-1? Could include in this section or consider repeating same figures.
4-2. Table 4.1 Data source?
4-3. Units? T or Mg, metric ton=Mg
4-5. Chemistry and associated risks? Or potential environmental risks?

Chapter 5. Endpoints
General comments:
This chapter presents the assessment endpoints. A broad discussion of salmon and fish populations, wildlife, and viability of Alaskan Native cultures. Salmon and other fish resources are the primary endpoint used.

Specific comments:
5-2. Line 9. 8watersheds. Correct typo.
5-3. Data sources?

Chapter 6. Mine scenarios
General comments: The mine scenarios are reasonable approximations of site activity. The text reads in generalities, yet the tables and figures suggest a greater certainty given the numbers, and significant figures used in tables. The conceptual models (Figure 6.12, 13, and 14) are excellent and need more references made to them.

Specific comments:
6-10. Data source is Ghaffari et al., 2011?
6-11. Comparison of TSF height to human-made structures is anthropocentric. Suggest omit such reference.
6-12. *Actual water quality in the tailings impoundments may differ significantly from what is estimated (Appendix H).* This may be true, however this is the best available technology to estimate water quality changes and sentence should be reworded as the approximation of leachate water quality and potential uncertainty in the test results as applied to SW Alaska, rather uncertainty in method itself.
6-13. *Water treated to meet effluents*. Good opportunity to explain receiving water quality standards versus effluent discharge limits (permit conditions).

Dr. John Stednick

6-15. Data sources for Table 6.3?
Unclear why little change in TSF stored pore water in alternatives 2 and 3?
Similarly, the changes in total consumptive losses for 2 and 3.
Why the large increase in WWTP return flows between 2 and 3?
TSF pore water accounts for >90 percent of the mine operations water demand. How was this conclusion made, I cannot reconstruct that value.
6-18. Pile Bay road reference? What road standards were applied and what was the precipitation event? Or is this meant to be geographically significant?
6-23. 6.2.2. Water balance [via streamflow and precipitation] and out [via surface….. add ']' after precipitation
6-24. first paragraph is unclear. How were streamflow values used to estimate net precipitation? Area weighted average of ***net*** runoff of 840mm? Methodology is unclear.
6-25. *Calculations of inflow agree closely to those provided by Ghaffari et al., 2011*. What were those methods and those results?
6-26. How was the regression line fit to the data?
6-27. 6.2.2.3. Uncontrolled leachate escapes suggests a controlled leachate escape?
6-35. References to premature mine closures? First paragraph under 6.3.5.

Chapter 7. Mine footprint.
General comments: Chapter is mislabeled. *This chapter addresses the stream habitat and flow risks associated with routine operations of the mine.... It considers the unavoidable environmental effects associated with the footprint of each mine scenario….*
Flow should be changed to streamflow to avoid any confusion with energy flow, nutrient flow or other flows. This chapter like other chapters has considerable quantitative information and data in tables and figures that are not communicated in the text. Often the text is written in generalities, yet there are many more specifics in the tables.

Specific comments:
7-13. Given the numerous fish inventories for the study area, why are only 4 years of data presented (2004-2008)? In general the number of counts was highest in 2008 and thus had the higher inventory counts. Is this to be considered the baseline?

Figure 15.1-2 as cited in PLP 2011 should be repeated here. The significance of the stream segments as opposed to watershed level inventories is not developed. Were these differences included in the approximation of the unavoidable effects from routine mine operations?

7-15. The cumulative frequency plots are befuddling. I would like to see a better presentation of this information, both in the text and graphically.

7-16. Separation or evaluation criteria are 5 and 10%, while flow separation criteria are 10 and 20% (7-51). Explain difference and cite appropriate references.

Dr. John Stednick

7-27. Headwater streams. Can these be considered all streams with mean annual flows <0.15 m^3/sec?

7-28. Streamflow modification. Streamflows reduced by the loss of the percentage of the expected area lost to each mien footprint ***and*** the water yield efficiency for that basin (m^3/sec/km^2)?

7-45. The annual hydrograph figure is monthly time steps. As part of the site characterization (Chapter 3), daily hydrographs would be more illustrative of hydrologic responses to precipitation events as snow, rain, or rain on snow.

7-55. Maintaining the connectivity of the stream to off-channel habitats is important; however the suggestion that the WWTP discharge could be used as compensatory mitigation may not be the best mitigation. WWTP discharge concentrations need to be evaluated for toxicity of fish species and life stage. WWTP discharges are finite and cannot be used to address all lost off-channel habitat connectivity.

7-60. Why the detailed comparison between the EPA results and those from Wobus et al., 2012? Other EPA efforts in earlier chapters were not compared to other scientific works. The Wobus work cited is an unpublished review draft from a consulting company.

Chapter 8. Water collection, treatment, and discharge
General Comments: A broad approach to water collection and treatment. Toxicity analysis based on harness and biological ligand model water quality standards are presents and discussed. Copper is the primary metal of concern, but other metal toxicities are evaluated, most often as a toxicity quotient. The tables and figures contain a large amount of quantitative data, yet the writing, like so many chapters tends to be qualitative. The text could be improved by incorporating more of the quantitative results.

Specific comments:
8-1. Suggest better identifying water quality standards as being promulgated, and water quality criteria as recommendations. Discuss the role of the state government and state-based standards as compared to federal recommendations of water quality criteria. Standard exceedance may result in civil or criminal penalties, criteria exceedance do not.

8-11. First paragraph discusses the range of hydraulic conductivities and suggestion of bedrock fractures for groundwater conveyance. The second paragraph then states that the risk assessment considered no flow below 100m. Why the inconsistency?
The water volumes should be 10^6—super position the 6.

8-12. It is unclear where the estimates of 84% of PAG and 84% of waste rock leachate would be captured by the pit and wells of Pebble 2.0. This represents a significant volume of water moving into the groundwater system, coupled with the mine waste chemistry; this represents a significant environmental risk already.

Dr. John Stednick

The estimated pit wall leachate compared to the mean tertiary NAG waste rock as percentages is confusing. The percentage values suggest that numeric data are available, thus a tabular comparison of these numbers would be much more informative.

8-18. Table 8.9 Awkward format in presentation of contaminants of concern, i.e. 323/338/590.

8-25. Table 8.10. More water quality data! The coefficient of variation is helpful, but I suggest the standard deviation may be a better measure of central tendency. Would like to see these data in Chapter 3. Description of region.

8-43. Table 8.18 is empty (at least in my version of the assessment).

8-52. Section 8.2.3.7. The analogous mine discussion could be expanded. It appears to be an extensive data base. Could the mines be separated by geography and mine age, to glean more information of the efficiency and effectiveness of mine operations on environmental quality. The assessment takes issue with the comparison of the Pebble Mine to the Fraser River (Box 8.4), but does not offer a mine alternative.

8-60. *These differences of interpretation of data can be an important source of uncertainty in environmental modeling.*
Under the uncertainties section, a discussion is presented comparing the EPA risk assessment estimate of copper concentrations of waster rock leachate to results obtained by another study (Wobus et al, 2012) that is a draft report from a consulting company. Why the comparison? I suspect that there are other reports with other results of waste rock leachate chemistries. I reviewed the Wobus report earlier. In my estimation there are 3 major issues in that report: 1) the use of a stable copper release rate is an oversimplification of the chemical dynamics that occur in the tailings/waste rock. The physical environment in Bristol Bay will significantly affect the chemical weathering processes and rates; 2) since the humidity cell test did not follow ASTM procedures, the leachate concentrations was increased by 1 standard deviation. No justification for this inflation was provided; 3) The report inseparably links copper concentrations to streamflow rates by stating that copper was treated as a conservative constituent, which is incorrect given the water quality in the study area and hence speciation of copper. Their report stated that the addition of 1 standard deviation to the copper concentration was to compensate for not following ASTM procedures, not because the high values and potential episodic exposures would be underrepresented by the mean. Why does EPA feel that they have to defend their results to this unpublished consulting report? Same comment as above in Chapter 7.

Chapter 9. Tailings dam failure

General comments:

Dr. John Stednick

Flood simulation using the SCS runoff method. Significant lack of detail in streamflow generation assumptions and results. Sediment pulse model simplified TSF release of sediment with HEC-RAS modeling of deposition downstream.

Specific comments:
9-5. Another excellent conceptual model of potential pathways linking TSF failure to salmonid risk, but the text does not parallel nor address all pathways.

9-13. *flooding to create the overtopping is 2.5% of the total peak flow in the Pebble 0.25 failure and 0.1% of the total peak flow in the Pebble 2.0 failure.* How were these numbers generated? What assumptions made? The reader cannot make the same conclusion based on the materials presented.

9-14. Chapter 3 needs more data presentation of meteorological conditions. Maps of annual precipitation and plots of monthly hydrographs do little to prepare the reader to understand this chapter for a rain driven storm hydrograph. The probable maximum precipitation of 356mm (14 inches) is for a 24 hour event of presumably a 100 year recurrence interval. Checking the cited reference (Miller 1963), such a storm depth was significantly larger than any found for the study area. Please explain the difference. How much precipitation data re available from the study site, and can these data be used for comparative purposes on Technical Paper No. 47 (Miller, 1963) for more frequent precipitation events. Defend the selection of a Type I precipitation distribution. When do rain storms occur and are they over wet soils? How does permafrost and discontinuous frozen soils affect the calculation of curve numbers? We read later that the example has a watershed area of 14 km^2. Where are the other data? Channel slope, time to concentrate, Manning's n etc. The storm event cannot be reproduced without these data.

Why no comparison to flood events based on regression equations? Estimating the Magnitude and Frequency of Peak Streamflows for Ungaged Sites on Streams in Alaska and Conterminous Basins in Canada. Janet H. Curran, David F. Meyer, and Gary D. Tasker. 2003.

9-15. …….*producing a peak flood immediately downstream of the dam of 11,637 m^3/sec for the Pebble 0.25*…A frightening event, nonetheless how was this peak flow determined? A comparison of a sediment laden pulse event versus the 'modest' peak flow event. Watch significant figures.

9-34 to 9-48. This section of the chapter presents important materials, but the quality of writing needs improvement. I had to reread several sections to understand the point of each section. The sections do not flow in a logical sequence and the coverage quality is variable.

Chapter 10. Transportation corridor

Dr. John Stednick

General comments: A thorough presentation of the risks associated with the development and use of a transportation corridor as related to road corridor encroachment on wetlands, streams, and riparian areas road drainage, road runoff, as related to fish habitat and fish behavior.

Specific comments: As commented on the first external review draft, the failure rate of culverts of 47 % seems high and may be the result of using older references. A recent best management practices audit here showed that culverts and bridge crossings were over 95% effective in maintaining water quality. The reference to ADOT could be expanded to include more site specific standards.

10-9. Cumulative frequency of stream channel lengths…
I think this figure will leave many readers confused. Even with colored lines, the take home message is unclear. The text does little to support the figure as well. The mean annual flow 'breakpoints' need to be presented and clarified earlier. The reach gradient breakpoints were not identified earlier, and finally the 5% floodplain potential is arbitrary. Nonetheless, when and where are their significant differences? Not in MAF. Were stream gradients? The tables present more detailed data, or numeric values that can be bettered compared, suggest the writing team reevaluate the 'cumulative frequency figures'.

Chapter 11. Pipeline failures.
General comments: A thorough presentation of the estimation of risks from pipeline failure and associated environmental risks as related to concentrate and diesel in the aquatic environment.

Specific comments: None.

Chapter 12. Fish-mediated effects.
General comments. The primary discussion is the indirect effects on wildlife and Native cultures that are fish-mediated. A change in the title to better reflect the chapter purpose? Another chapter with good conceptual models (Figures 12.1 and 12.2 that are not followed up in the text. In my estimation, the figures are excellent, and deserve more coverage in the text than currently afforded (often none).

Specific comments:
12-5. I am certain there are better references to bio-concentration factors in fish than an unpublished report.

Chapter 13. Cumulative effects of large-scale mining
General comments. Identification of other potential mineral plays in the study area. Using statistics from the Pebble mine (NWI, NHD, etc.) impacts of other potential mines were approximated. Vulnerability of salmon stocks was identified with the need for healthy watersheds and the 4 H's used in the Pacific Northwest.

Dr. John Stednick

Specific comments: This chapter used Tables 13.2 to 13.8 (11 pages total) to inventory the waters, fish, and subsistence uses potentially affected by the various mine prospects. Comparisons between mines are difficult when using tabular formats. I suggest that a GIS generated map would be more illustrative of areas affects and would allow for easier mine comparisons. The waters, fish habitats, and subsidence uses could be identified and then the mine 'footprint' overlaid. Figure 13.3 is such an example.

Table 13.8 is a compilation of the 6 potential mine sites effect on the various resources. If all water, and all fishes, and all subsistence uses are equal, this is a fair comparison; however that was not supported.

The cumulative effects of the mine projects (Section 13.2.7) is a simple reiteration of the various potential processes as affects by mine development; i.e. loss of fish habitat from the mine footprint, loss of streamflow waters by water withdrawal. There is little evaluation or discussion of cumulative effects—*cumulative results result from individually minor but collectively significant actions taking place over a period of time* (p. 13-2). This current risk assessment suggests that cumulative effects would occur with the presence of the Pebble Mine and additional mine operations would simply add to that impact. If that is the conclusion of the EPA, then that theme should be consistent. Wording such as *leading to increased release of contaminated waters downstream* (p. 13-31); *the relatively ephemeral nature of human institutions* (p. 13-31*), more susceptible to trespassing, poaching, and illegal dumping* (p. 13-32) are in contradiction to statements such as *opportunities for employment at mines or mine-related services would contribute to growth in nearby communities* (p. 13-31). *Induced development following the advent of large scale mining would undoubtedly bring very welcome economic development to the region* (p. 13-32). The cumulative impact analysis sections, lacks a defined methodology and the chapter lacks objectivity.
The last sentence in this chapter states *Even in the coastal population centers of Alaska, hatcheries are supplementing salmon returns* (p. 13-35). How is this related to cumulative effects? I was disappointed in the quality of this chapter.

Chapter 14. Integrated risk characterization
General comments:
This chapter summarizes the risk analysis results organized by endpoint, Limitations and uncertainties are identified.

Specific comments: It would be useful to have more references to the previous section in the assessment to more easily direct the reader to earlier sections.
14-1…. *local habitat loss leading to losses of local unique populations*. I do not remember reading about genetic uniqueness in the assessment earlier.
Explain differences between mine footprint loss of 38, 90, and 145km and habitat loss of 8, 24, and 35km.

Dr. John Stednick

Explain the threshold exceedance of 20% again and better clarify to show a decrease in streamflow (mean annual flows).
Altered streamflow would result in an unquantified loss of riparian floodplain wetland habitat, yet next section quantifies the wetland loss and reduced off-channel salmonid habitat. Seems inconsistent.
Shift in groundwater and surface water balance in streams makes the stream less suitable for spawning and rearing in winter due to decreased winter flow?
14-3. …. *suggest the need for additional mitigation measures*. Suggest stronger wording such as more aggressive mitigation.
Possible introduction of invasive species? Plants or animals?
14-4. …….*the lower bound is purely aspirational*. If it is aspirational then it should not be considered. Realistic bounds should be used always.
Last paragraph in this section should be moved up front as identification of assumptions in the assessment.
14-7…..*scouring the valley and depositing tailings*. Seems inconsistent as written, you do not scour by depositing sediment. Needs expansion.
14-13. …*an initial outflow beyond the 30km limit of the model*. The 30km was the model boundary used, not the model limitation.

Chapter 15. References.
Better inclusion of references suggested in review of the first draft.

Appendices
A casual read of the appendices showed that certain appendices were edited or updated. We were specifically asked to review Appendix I: Conventional water quality mitigation practices for mine design, construction, operation and closure and Appendix J: Compensatory mitigation and large-scale hardrock mining in the Bristol; Bay watershed. Appendix I was a well –referenced document explaining conventional water quality best management practices (BMPs). The document was easy to read and covered the subject well. Appendix J identified compensatory mitigation from the federal and Alaska state levels. It addresses specific comments from public hearings on the Pebble Project as related to compensatory mitigation.

Both of these appendices contain useful information, which needs to be incorporated in the main text of the assessment, rather than be relegated to an appendix. A concern that I have frequently expressed.

<u>Final thoughts</u>
The second review draft is a significant improvement from the first draft, but is still in need of editing rewriting to address review comments. The second draft addressed several points that were brought about in the first review, including the effects of atmospheric N inputs from blasting and global climate change. Conversely EPA decided not to address other points including the effects of precipitation timing on variably frozen soils on streamflow generation, and the transport of total and dissolved organic matter on

metal transport. Another point to consider in the next version is the potential for TENORMs--technologically enhanced naturally occurring radioactive materials being present or causing risk (see EPA report 402-R-99-002).

Process observations

For the second external review, the US Environmental Protection Agency elected to negotiate and contract with the external reviewers individually. The pay rate and estimated time to complete the review were significantly less than original estimates. A concern also shared by other external reviewers. As much as I argued that the interdisciplinary approach experienced in Anchorage produced a better document review, EPA was not interested in allowing collaboration or wanting a 'consensus' opinion. The former I support, the later I never did. The purpose of any collaboration is to better foster interdisciplinary discussions and appreciation of alternative views, all to make a better environmental risk assessment. In my estimation, this is an opportunity lost and a lesson to be heeded in future external reviews.

Dr. Roy Stein, The Ohio State University

PEER REVIEW FOLLOW-ON COMMENTS ON THE APRIL 2013 DRAFT OF

AN ASSESSMENT OF POTENTIAL MINING IMPACTS ON SALMON ECOSYSTEMS OF BRISTOL BAY, ALASKA

From: Stein, Roy [mailto:stein.4@osu.edu]
Sent: Friday, July 12, 2013 9:58 AM
To: Thomas, Jenny
Subject: RE: Bristol Bay Peer Review - Confidentiality Reminder

Friday, June 12, 2012

Good Morning Jenny,

Attached please find my Peer Review Comments on EPA's Draft Document, Second External Review Draft, EPA 910-R-12-004Ba, April 2013 entitled *An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska* in letter form. I hope the EPA authors find my review useful as they revise this second draft. Let me know if I can provide an additional information and what the format of the invoice might be.

Have a good day and a great weekend, Roy

Roy A. Stein, Professor Emeritus
Aquatic Ecology Lab
Department of Evolution, Ecology, and Organismal Biology
The Ohio State University
1314 Kinnear Road, Columbus, OH 43212-1156
Voice: 614/292-1613; Fax: 614/292-10181
e-mail: stein.4@osu.edu
Visit our web page at www.ael.osu.edu

Dr. Roy Stein

Aquatic Ecology Laboratory

1314 Kinnear Road
Columbus, OH 43212-1156

Phone 614-292-1613
FAX 614-292-0181
e-mail: stein.4@osu.edu

July 12, 2013

Ms. Jenny Thomas
Office of Wetlands, Oceans, and Watersheds
US Environmental Protection Agency
1200 Pennsylvania Ave NW
Washington, DC 20460

Dear Ms. Thomas:

I am submitting my Peer Review Comments on EPA's Draft Document, Second External Review Draft, EPA 910-R-12-004Ba, April 2013 entitled *An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska*. All of my comments can be found below with appropriate page numbers and/or table/figure numbers. I did not follow your suggestion in a recent e-mail to arrange my comments around my initial concerns regarding EPA's First Draft Document simply because 1) I had already begun my review without following this advice, 2) I note that the Second Draft has been completely rewritten, reorganized, and revised and therefore did not neatly follow my initial concerns, and most importantly, 3) the EPA authors dealt fully and completely with all of my concerns. In fact, I carefully reviewed the EPA Response to our Peer Review Report, concluding that I am quite satisfied with how the EPA authors revised the text of this Second Draft in response to my comments. Even so, I still have additional comments that grew out of my review of the Second External Review Draft.

1. **Executive Summary (ES).** I liked the summary, especially the tone, the emphasis on quantitative statements (with supporting tables, maps and figures), the ecological services that the Bristol Bay watershed provides, the multiple scales at which the problem was examined, the 4000-year history of subsistence (and sustainable) fishing by Native Alaskans, the wildlife resources beyond the salmon and trout (some consideration of their macroinvertebrate food supply as well), the three different scenarios re the Pebble Mine, the words and probabilities that surrounded the discussion of Tailings Storage Facilities (TSF) failures (and other failures, as documented from the scientific as well as the grey literature), the idea that current technologies are simply insufficiently developed (page ES-15) to capture a sufficient proportion of the waste water to prevent salmon impacts, and the expectation that the Pebble Mine will likely lead to a "mining district". I believe EPA has struck just the right balance with regard to summarizing the state of the probable mine impacts on the ecological and cultural resources of the Bristol Bay Watershed. I have provided only a few comments for consideration by the EPA authors.

a. Figure ES-2. My presumption here is that the "blue" streams are ones for which we simply do not know if we have salmon in them or not…likely yes, but no one has documented their presence. Is this correct?
b. Figure ES-3. This figure could use some improvement. It should be pointed out that these are not truly run sizes but rather proportions of run sizes for comparative purposes. I think spending a bit of text comparing Bristol Bay production to other areas of the world (Part A of Figure ES-3) would be useful for it emphasizes the unique nature of the Bristol Bay Watershed.
c. On page ES -8, you argue that "the Yup'ik and Dena'ina are two of the last intact, sustainable salmon-based cultures in the world". And what does "last" mean in this context? How many more are out there? Some context would benefit the reader and the report.
d. On page ES-9, do we have any idea what the proportion of Native Alaskans find this hard-rock mining approach to be preferable over salmon or other subsistence ways of life? Do we have good polling numbers that summarize the point of view of Native Alaskans re this project?
e. Page ES-14 talks about "streams known to provide spawning or rearing habitats". Isn't this quite a conservative way to go? How does the reader account for reality in these statements?
f. "In perpetuity" seems to be danced about a bit here, but I am happy that it is indeed discussed and emphasized here in the Executive Summary. Of course, I would like to see more definitive statements re this issue here in the Executive Summary.

2. Unfortunately, the **Abstract** on page 1, given its shorter format and lack of detail, simply misses the mark. Here the same items mentioned in the Executive Summary should be mentioned in some form here. Clearly, the 29 pages of the ES allows for space to discuss the most important issues. Within the abstract, I suggest that the EPA authors abstract the current ES and in so doing work to capture most of the relevant, even critical, points made therein. Emphasize the ecological and cultural resources in this watershed, the greatest sockeye population ion the world, the leakiness of the habitat (with groundwater shared among many streams), meaning that mine impacts will stray far beyond where toxic wastes might first be generated. I don't think the authors should concentrate on impacts that are "at a minimum"; rather the abstract should discuss failures and their impacts. Add something about Illiamna Lake, about the TSF having to be maintained "in perpetuity", and the many other points made in the ES. I recognize that the authors are limited by space considerations within the abstract, which makes this a difficult section of the report to write. I'm afraid that EPA authors have done what many of us have done: write the abstract last, after all other sections of the report have been written, typically having to generate this quite important section under intense time constraints. I urge the authors to rewrite this section with an eye toward my comments above, thus allowing the reader to appreciate the high points of this revised draft document.

3. **Introduction (page 1-1).**
a. Page 1-2. I very much like the idea that this document has been defined as an Ecological Risk Assessment or ERA; hence, those who understand the role of these documents in the review process re the Clean Water Act can now place this document in its appropriate context (i.e., essentially used to inform environmental decision-making).

How resources of interest (salmon and their habitat) are influenced by stressors generated by an activity (namely, copper mining). In this case, salmon are the primary assessment endpoint and wildlife (owing to marine-derived nutrients) and Alaska Native cultures (owing to their request to have the EPA enter the fray) are secondary endpoints---some confusion existed about the choice of these variables in the first draft. We now have an explicit rationale for these choices, which should then permit a better understanding by readers of the role of this document in the decision-making process re the Pebble Mine.

4. **Chapter 2. Overview of Assessment.**
   a. Page 2-2. I liked the conceptual model diagrams.
   b. Page 2-2. The emphasis on peer-reviewed publications is appropriate for a science-based assessment, even given that all of the data herein cannot come from this source, for we know so little about the Bristol Bay Watershed. I like how EPA characterized under what situations one could use data from the Fraser River mining operations, or those from Idaho and Montana; context here is immensely useful, helping to guide the reader through the set-up of the report.
   c. Page 2-4. I liked how EPA anticipated the criticism from developers re how risk assessment from "old" technologies cannot be used to estimate risk for newer technologies and then used the Challenger accident to show how new, improved technology can fail too. The justification for using historical failure rates (because new technologies may have new ways to fail) is compelling. This argument is critical to the readers.
   d. Page 2-8. I liked the various scales used and the fact that EPA provided a number identified as percentage of the scale above, for it helped me judge absolute and relative sizes of geographic areas represented in these scales. Table 2.1 should have a title associated with it and the mine scenario formats should decline in size per the scales in the table. Just seeing Figure 2.2 does help me envision the situation. I wondered about the Transportation Corridor in Figure 2.2 inset thinking that indeed it covered the entire watershed of all streams, rivers, and wetlands influenced by the road from the Pebble site to Cook Inlet. That was eye-opening and reflects the impact of the road on the watershed, reinforcing some who believe that the road has an impact far beyond its seemingly narrow footprint. Figures 2.2 through 2.7 are stellar and a valuable addition to the ERA.
   e. Figure 2.6 (page 2-13): How are we to distinguish 'wetlands' from other water-body types in this figure. The legend doesn't help us much here but I guess I could envision (if I squint) wetlands as compared to lakes or rivers/streams. Using colors that exhibit more contrast could aid in interpretation of this figure.
   f. Page 2-14. I appreciated the references to National Hydrography Dataset but worry that it adds detail that I simply do not get. "HUC 12 Level" is what, indeed? Could there be one additional inset box that might explain to the novice (especially if this document is to inform the citizenry), serving to define the terminology?

5. **Chapter 3. Region.**
   a. Pages 3-13 and 3-14. I liked how the text relates groundwater flow and flow stability and communication among rivers streams and wetlands to the success of salmonid

fishes. This certainly is a critical feature of these two watersheds. Following this idea through the document is critical, in my mind, to assessing the impact of the Pebble development on native salmon.

b. Pages 3-35. I can see how you came to the conclusion that it difficult to predict how many and what magnitude earthquakes will play in the Pebble Mine development.
c. Page 3-36. I was extremely pleased to see climate change predictions and just how the environment might change. You compared your conclusions re change to those generated by other scientists and all fell within a range that lent credence to your results. Nicely done.
d. I also liked the idea of doing multiple scenarios re the extent of climate change.
e. Page 3-45. The conclusion generated with regard to the impact of climate change is a relevant one. Salmon will only persist in the face of climate change by using all of the genetic and life history diversity that they now have. Reducing this variability (i.e., via the impact of the Pebble Mine) can only lead to loss of stocks.

6. **Chapter 4: Type of Development.**
   a. Figure 4.1. While most all of the figures (and especially the maps) are much improved from the first draft, Figure 4.1 needs some work. Perhaps the way to handle it is to divide it into multiple figures, such that the reader could actually see the distribution of copper-deposit mining throughout the world. I applaud the authors for including this deep background and context for it helps us understand the "need" for a mine such as the Pebble.
   b. Box 4.1 clarifies the multiple terms that caused our expert panel some angst. The terms now seem to reflect a good deal of insight into how various practices will be used within the context of copper mining at the Pebble facility. This improves the presentation dramatically.
   c. Page 4-10, Box 4.3. As I read through this box, I worried just a little about the multiple jurisdictions involved in mine oversight, such as the Bureau of Land Management, the Alaskan Department of Environmental Conservation, the Bureau of Indian Affairs (and all of the associated tribal authorities), the State of Alaska, the Alaska Department of Fish and Game, the Alaska Department of Natural Resources, Federal EPA, etc. I list these organizations here as only a partial list of those agencies who have a "horse in the race". I worry about how they will interact, the extent of their historical interactions, and just whether they, collectively, with all of their different mandates and associated stakeholders, can present a cooperative, united front in dealing with hard-rock mining in Alaska. Or might there be sufficient "turf" issues that Pebble Corporation could take advantage of these differences to exploit these resources without minding all of the regulations from all of these regulatory bodies. Text that might serve to assure the reader that all is well (if this is the case) in this arena would be helpful. Or perhaps some text to reflect on how these jurisdictional issues have been successfully handled in other complex environmental projects.
   d. Pages 4-16 and beyond. I liked the discussion of TSF's, their construction, their limitations, etc., though this would have been the place that I would have liked to have seen some mention of the groundwater issues in the Bristol Bay watershed and how communication among water bodies (i.e., streams, rivers, wetlands, ponds, lakes, etc.) can compromise the usefulness of a TSF. Note point 5a above.

e. Page 4-17. Certainly, given these on-the-ground parameters, a fully lined TSF (even when there will be multiple ones) should be required. The size of the first TSF to be built may cause some to say that lining costs would be prohibitive, but I see no alternative given the hydrology of the Bristol Bay Watershed. Having said all this, the comments about the length of life of geo-membranes (for example) is short (perhaps as long as 600 years) compared to the required life of the TSF before water can be released (30,000 years). Dry stack tailings may be the only feasible alternative to TSF. Even so, because of the low grade of ore, the immense amount of tailings, the "wet" nature of the environment, and the acid-producing nature of the tailings, dry stacking may not be feasible either (and consider the immense area required for storage, see Response Document. This is real conundrum for the siting of this mine. It might serve the reader well to emphasize this central limitation to the siting of this mine in the Bristol Bay Watershed.

f. Page 4-19. I liked the final discussion on "Timeframes". This sets the reader up for later, more in-depth, discussion of these issues. Nicely done.

7. **Chapter 5. Endpoints.**
   a. Pages 5-1 and 5-2. The justification for making salmon the primary endpoint was missing in the original draft and now is nicely summarized and justified here.
   b. Table 5-1. The list of fishes present in the Bristol Bay watershed is far more complete and I believe more accurate than in the first draft. Good work here.
   c. Figures 5-1 and 5-2 help the reader assess the distribution of salmon relative to the variety of fisheries that occur in the watershed, though I must say that Figure 5-2 is a bit difficult to interpret. Revision with attention to colors and symbols used might improve its message.
   d. Additional detail re one topic or another. This practice should be extended to all references to appendices in the Main Report.
   e. Table 5.3, Page 5-11, should include percentages for the numbers coming from each river system for then the reader could gain some quantitative appreciation for the contribution of the two river systems that will be impacted by the Pebble Mine.
   f. Figures 5-3 to 5-11 nicely summarize what we know about the distribution of "salmonids" in the Bristol Bay watershed. My only concern here is that given that the Nushagak and Kvichak rivers provide 50% of the sockeye salmon harvest, can the EPA now say what proportion of this harvest might be lost due to the construction of the mine? In other words, use these numbers, percentages, etc., later in the report to provide context as to what will be lost if the mine is built.

8. **Chapter 6. Mine Scenarios.**
   a. Page 6-15. I find it a little hard to imagine that water could be treated and then discharged into streams. Would the water quality of this discharge even begin to match the extremely high-quality water of extant streams prior to mine operation? This seems a little beyond the ability of an on-site, waste-treatment facility. A bit more detail here to convince the reader this is even possible would be valuable here.
   b. Page 6-31. The idea that post-closure TSF water would need to the treated for 100's to 1000's of years begs the question just a little. Work done suggests that we are talking 10's of thousands of years rather than these shorter time periods. One could certainly

make the argument that there is no real difference between these two lengths of time, simply because human institutions do not last this long and the likelihood of TSF failure sometime during even the 100's of years projected life is nearly inevitable, i.e., because no one is watching. Of course, having contaminated water flow downstream via streams in the Bristol Bay Watershed will likely make these streams uninhabitable for salmon for a very long time.

c. Page 6-35. What incentives exist for any company to continue to invest in the monitoring and maintenance of tailings storage facilities (but see Box 4.3 on Financial Assurance, for the nub of the issue is dollars, isn't it?)? If well fields downstream of the TSF began to demonstrate that contaminated water is flowing from the TSF, then why would the company work to eliminate this source of contamination, save for an oversight organization such as a state or federal regulatory institution? I think I get it, that there is to be financial assurances that will support ongoing monitoring and appropriate maintenance post-closure. The greater risk seems to evolve from "…chemical or tailings spills…" (Box 4.3, page 4-10) which these assurances do not cover; how does one assure the public that these mishaps can be cleaned up?
d. Pages 6-35 to 6-36. I appreciate the discussion of financial assurances and how they have not worked particularly well in the past. The commitment to making these sums actually reflect the costs of remediation is critical to any permitting that might occur via the State of Alaska. Should this point be made more explicitly?
e. Page 6-36, for example. Each time the authors came to a "what if" scenario, they then provided the "then" statement, usually followed by an example from the real world. This is nicely demonstrated on page 6-36 when they discuss a situation when a mine re-opens after being closed for some time thus leading to a change in mining practices. The authors cite the example of the Gibraltar Mine in British Columbia in which it was first permitted as a zero discharge operation and then re-permitted allowing for treated water to be discharged. These real-world examples lend credence to the "what if" scenarios and help the reader understand just what might occur with the establishment of a mine such as Pebble.
f. Table 6-9 helped me understand EPA's regulatory role in applying the Clean Water Act to the establishment of the Pebble Mine.
g. The conceptual diagrams (Figures 6-12, 6-13, and 6-14) helped me visualize the interactions that lead from mining impacts to salmon. They were clear and well put together.

9. **Chapter 7. Mine Footprint.**
    a. In Box 7.1, the authors argue that stream lengths and wetland area reflect a lower bound on the estimate lost to the footprint of the mine. In turn, the estimates of the number of salmonids in these same streams are likely underestimated by 50%. Hence, this suggests that the number of salmonids eliminated by the footprint of the mine is likely 4X what is reported. I agree. To remedy these underestimates, the authors should revise both the Executive Summery and the Abstract, pointing out that these are either lower bounds to these estimates or are increased by some metric to better reflect true abundance. Or, at the very least, point out in these sections that the numbers reported are substantial underestimates of what likely is out there.

b. Because it is small headwater streams that are eliminated by the mine footprints, it would be appropriate to argue that Coho Salmon and Dolly Varden are differentially affected simply because they spawn in these smaller streams (page 7-22). Is there any way this can be better quantified?
c. In Table 7-5, Dolly Varden are not mentioned; is there a reason for this? Do we simply not know the distribution of Dolly Varden in these streams (see page 7-26)?
d. Pages 7-27 and 7-28. The difference between the first draft of this report and this second draft is dramatically demonstrated by the number of peer-reviewed references cited on pages 7-27 and 7-28 when the authors are discussing general salmonid ecology relevant to the Bristol Bay Watershed. The text becomes so much more convincing when most all statements re the ecology of these species are supported by multiple literature citations.

10. **Water Collection, Treatment, and Discharge**
a. Page 8-3, Figure 8-1. I liked this figure and most all that followed in proceeding chapters for they aided in setting the stage for the discussion to follow.
b. Page 8-4. The argument that during mine operations, 10-49 million m^3 of treated water would be discharged per year (Table 6-3). Though there is concern about the quality of the water overall as well as the quality of this water as influenced by accidents, poorly functioning equipment, environmental conditions that exceed the specifications of the various wells, etc., there is real concern about the waste leachate and how it might directly influence salmon populations. I worry that the metals, acid, and sediments in this released water during mine operations will likely cause major impacts on the extant salmon populations (with the most extreme being direct mortality on through less extreme impacts on growth, physiology, migration patterns, distribution throughout the watershed, etc., etc.). Then, the impact of this waste leachate post-closure will undoubtedly be dramatic if not in the first 50 years, most certainly in years beyond the time we (as the mine operators, the State of Alaska, the EPA, Native Alaskans, Commercial Fishers, etc.) are watching, i.e., monitoring, assessing, and maintaining water-treatment facilities.
c. Page 8-11. In the last sentence of the first paragraph, the comment about groundwater conveyances suggests that toxicants can be transported just about anywhere in the watersheds of the two affected rivers. This feature of the landscape, mentioned explicitly elsewhere as well, makes the placement of the mine here in the Bristol Bay Watershed suspect. And, of course, it is this very groundwater that supports the reproduction of all of the salmonids in the basin.
d. Page 8-11. Given our inability to predict where surface water, collected as wastewater, might flow (third paragraph on this page) via the groundwater makes this an even more intractable issue when one is trying to protect water quality in the Bristol Bay Watershed.
e. Page 8-11. Combine the above two points with the water chemistry of the natural waters of Bristol Bay Watershed (i.e., extremely high quality but not well-buffered) and one has the makings of a dramatic negative impact on the salmonids upon siting of this copper mine. I would like to see an increased emphasis on these aspects of the potential effects of the Pebble Mine.

f. Page 8-20. Has there truly been any thought or consideration given to a reverse osmosis treatment of wastewater at this site?
g. Page 8-21. Given that mines continue to be operated even when those responsible for operations know they are not meeting water quality criteria for wastewater, what assurances do we have from Pebble Limited that their operators will differ from the past (i.e., in a good way)?
h. Page 8-31. And even given that standards now in place for the quality of water that is discharged from the site during operations, these standards appear not to protect macroinvertebrates, food for young salmon. Disrupting the food supply will indeed compromise salmonid success.
i. Table, 8.22, for example. As the mine grows larger and into the economies of scale that the company requires, the impact on water quality and ergo the fish becomes more and more dramatic (i.e., more fish kills, etc.)…and this is during normal operations without any infrastructure failures. Can this truly be tolerated and a permit issued? Sadly, the monitoring of ongoing operations at extant copper mines has not been done (see first partial paragraph on page 8-53); so then how can we anticipate the ecological effects of the Pebble Mine even under the best of conditions?
j. Page 8-55. More than 500 million salmonids will be affected by the Pebble effluent; doesn't this tell the story in one sentence. Impacts on resident and anadromous salmonids will be negative, large, and long-term.
k. Page 8-63. Changes in stream temperatures means a disruption in the various life history characteristics dependent on temperature, such as growth, survival, migration, movement, etc. Hence, negative impacts on salmonids will indeed be huge, largely negating the portfolio characteristics of these species (down to specific life histories within populations) that have allowed these salmon to be so successful over their history.
l. Page 8-65. Actually, we know quite a lot about how temperature influences salmonid success. For example, quantitative energetic models have been built and tested in the lab and field. While we may not have specific information on every species in the watershed, the fact remains that we have a pretty good conceptual framework backed up by solid work to help us understand the impact of temperature on salmonid success.

11. **Chapter 9. Tailings Dam Failure.**
    a. Page 9-1. Not only would this failure eliminate spawning grounds and rearing habitat forever, the method for remediation (and even the wisdom of any sort of remediation, given constraints) is not immediately apparent. Streams may well be too small to float a dredge and because this whole area is road-less with long winters and innumerable streams, rivers and wetlands, actually getting equipment to these remote sites may be near impossible. I encourage the authors to emphasize these points.
    b. Page 9-3. A failure of this sort is not simply conjecture for these failures have occurred the world over. And these failures, while dramatic, long-lasting, and impactful, reflect dams that are less than half the height of the planned Pebble TSF at its largest footprint. Some emphasis on this point would be useful.
    c. Pages 9-3 and 9-4. One piece of good news re the "in perpetuity" nature of minding the TFS is that these facilities seem to stabilize through time, resulting in fewer failures as compared to active TSFs. On the other hand, what is the longest period that has been

monitored for a dam post-operation   Likely, this would be less than 100 years and prior to these dams being built, engineering standards would no longer be applicable. Rather much of a conundrum, wouldn't you say?

d. Table 9-2, Page 9-8. The classification scheme Alaska uses to determine the amount of engineering that must be done according to the risk of losing lives seems a bit inappropriate in this context. The risk here to the livelihood of individuals is paramount and I worry that Alaska's scheme may not protect the salmonids, the Native Alaskan subsistence way of life, and the tremendously productive Bristol Bay commercial and sport fisheries.
e. Page 9-31. TSF failure is postulated to reduce the Chinook Salmon run by 60% and this run is one that produces a large proportion of the Chinook on the West Coast, and is the one least influenced (at present) by habitat loss, etc. Protecting this run is paramount for Alaska, the nation, and the world.
f. Box 9.6, Page 9-35. I like this box and many of the others that provided brief synopses re case histories applicable to the Pebble Mine. I appreciate the comparisons and caveats. In addition, based on results from other mines sites, it is clear that tailings toxicants, traveling downstream, not only reside in the stream for decades to hundreds of years, they also have been documented to move 210 km in one system. Because nearly all of these TSFs are smaller than the Pebble one, impacts are even likely to exceed these measured effects. Making this point more explicitly would enhance the message.
g. Table 9-11, Page 9-50. I liked the attempt at weighing the different lines of evidence, then drawing conclusions based on best scientific judgment. This "weighing of evidence" helps the reader understand the limitations of the data while simultaneously being able to draw what valid conclusions one might draw from such an analysis.

12. **Chapter 10: Transportation Corridor**
    a. Figure 10-1, Page 10-3 was a little difficult to interpret, given its scale and the colors (where are the ponds, for example). So, I much appreciated the next figure (Figure 10-2) that zoomed in on some critical areas and these maps were far easier to interpret and to gain some perspective on the impact of this road on the aquatic environment.
    b. Page 10-8. The work demonstrating divergences in populations in close proximity (Quinn et al., 2012) suggest that the road indeed will have a major impact if any migratory routes are compromised, if spills occur that prevent animals from moving via their historical pathways, etc. Making this point explicit would improve the document.
    c. Figure 10-5, Page 10-11 was a useful one demonstrating the overlap between the road and Sockeye Salmon. This is a much improved presentation from the first draft.
    d. Page 10-26. Given the very high failure rate of culverts, would it make sense to install more bridges or more arch-only culverts to protect salmon populations? It just seems that traditional culverts are a poor alternative to bridges and arched culverts.
    e. General Point. Throughout the text (see first complete paragraph on page 10-37 dealing with what we might expect with invasive species coming to the environment with the building of the road, as just one example), both in this chapter and others, the authors have demonstrated a knowledge of the recent literature which is used throughout to justify their assumptions, confidence, and risks. This allowed me to

appreciate and evaluate with a more discerning eye the product of this ecological assessment. Nice work.

f. Calculations of dust production on pages 10-35 and 10-36 reflect a nice quantitative, with appropriate caveats, assessment, demonstrating that dust could have a real impact on the salmonid streams in close proximity to the road.
g. Pages 10-40 to 10-42. I liked the uncertainty section that dealt with the transportation corridor; issues that I did not anticipate were covered nicely.

13. **Chapter 11: Pipeline Failures.**

a. Pages 11-2 to 11-4. These conceptual figures are useful (throughout the document) to help the reader envision the majority of the interactions within the context of pipeline failures.
b. Page11-5. I liked how the authors quantitatively developed their best estimates for the probability of pipeline failures, based on similar situations with other mines and with other pipelines. In turn, the authors typically laid out the caveats re the comparative nature of the data: was the pipeline similar, did it exist in a similar environment, was it designed with Best Management Practices in mind, were there other issues that might allow estimates of pipeline failure to be higher or lower than what might be expected at the Pebble Mine?. This sort of quantitative, transparent analysis gives the reader faith that the EPA has no hidden agenda, no ax to grind, and no previously decided-upon conclusions. I applaud the authors for these revisions.
c. Page11-6. The whole idea of human mistakes or accidents is intriguing for this suggests that no matter how good the infrastructure might be, we still will have human error and it looks to be quite a prevalent cause of failures in the case histories of mines presented. What I reflected upon was how one can incorporate this knowledge into current measures of pipeline failures. The authors did not separate human error from infrastructure failure and that indeed might be quite a useful exercise. Indeed, how do mining companies work to reduce this source of failure? Training? A safety-first attitude that includes strong provisions for reinforcing the idea of doing things "right" in the field, even when time is of utmost importance. And I guess it would be modification of worker mind-set that would replace "time" as the most important driver to "infrastructure protection" as the most important one. I would very much like to see what Northern Dynasty has to say about this issue. Finally, I would have liked to have seen a discussion of "human error" in all of the sections dealing with failure. Is this as prominent an issue with regard to the TSF as it is with pipelines?
d. Page 11-15. Though I have seen just a few typos, there is one on page 11-15 that requires correcting…next to the last paragraph reports 14,00 gallons when it is likely that this number should be 14,000 gallons. See also a typo in the first paragraph on page 11-26. See page 11-30, last complete paragraph on the page.
e. Page 11-18. During the course of this chapter, the authors make the point that release of contaminants into the environment would be more amenable to mitigation at low flows rather high ones. True, but the authors fail to point out that "dilution" will be more of a factor at high flows and thereby may reduce or even negate contaminant impacts. Some recognition of this in the text would improve the presentation.
f. Page 11-19, second bullet point at top of page. Why choose the 5-min spill duration and not the more common, 11.5 min, as suggested by O'Brien's Response Management

publication? It certainly seems this would be more defensible than arguing as the authors do, that their estimates may underestimate the impact of spills on the environment.

g. Page 11-20. The whole idea of diesel fuel being so variable relative to its constituents bothered me some. If this is the case, can no one in a position to review permits judge its composition and therefore judge its potential impact on the environment? This section was unsatisfying to me re how a failure of this pipeline might influence nearby wetlands, streams, rivers, ponds, and lakes.
h. Table 11-10, Page 11-3. Though I liked tables of this sort, I became just a little confused by the nomenclature, what with a "positive" response having negative consequences. I think I did get it figured out and I may even now understand your usage here, I worry a little about how a lay audience or even Northern Dynasty will interpret this text. One example of this confusion can be found on page 11-29, last paragraph. Note the quote from the text, "Overall, the available lines of evidence for effects of a diesel spill are positive for the occurrence of acute toxic effects (Table 11-10)." Really? I trust the authors get my concern here.
i. General Point. One piece of information that I would like to see added to this draft is some sort of time period for recovery of the negative impacts of a spill. Most studies (being Masters theses) typically study these impacts for 1-2 years and by this time, 80% or so of the macroinvertebrates are back (but maybe not the diversity) and fish have recovered but not completely. If we think about extrapolating these studies out (certainly there must be one that goes beyond just a year or two), then when would we expect full recovery? This is an extremely important point and may provide insight into longer-term impacts of a spill when the effects of the contaminants are relatively short-lived (i.e., much, much, much shorter than what is predicted for a TSF breach, for example). Contrasting impacts of pipeline failure with other infrastructure failures would lend more credence to the work of the EPA authors.

14. **Fish-Mediated Effects on Native Alaskan Culture**

a. Page 12-1. The title of the chapter seems to me to be incomplete, in other words, I think the title should be "Fish-mediated effects on Native Alaskan Culture". This better encompasses the content of the chapter.
b. Page 12-1. I would like the authors to add about a page of text to set the stage for Native Alaskans, e.g., a culture that is 4,000 years old, a sustainable culture dependent on subsistence harvesting (different than a one-time exploitation by a mining company), the fact that the jobs generated will only last for a generation or a generation and one half…far less than 100 years. This text would then set the stage for the chapter and better provide context for this examination as well as the purpose of this chapter (as stated on page 12-1).
c. Page 12-6. Throughout this chapter I noted the many "trade-offs" that are inherent in the establishment of a mine of this type and size. Cash economy versus subsistence, short-term rewards versus long-term ones, culture-enhanced activities versus culture-negating ones, split-time activities (i.e., part-time work) versus full-time subsistence activities, etc. Some recognition of this might improve the message being sent with this chapter.

d. Page 12-9. The idea that the mine will come in, extract valuable minerals, and then leave occurs throughout but I think it is insufficiently emphasized that the physical degradation to the environment stays…typically in perpetuity. Yes, the text makes this point but it is somewhat buried, in my view. Can the authors increase its impact and thereby its visibility?
e. Page 12-10, first complete paragraph. The fact that small changes to movement of terrestrial organisms can have dramatic impacts on the Native Alaskan culture is a good one. Like the previous point, I would like a bit more explanation as well as more detail, coupled with a historical example or two. This information would increase the power of this paragraph.
f. Page 12-11 and 12-12. These are powerful arguments for the whole idea of job enticement for Native Alaskans, running the gamut from bigotry to compromising subsistence. This is an impressive argument and takes much away from the argument that this mining operation will bring a much-needed (in the eyes of the mine operators) cash jobs to a "depressed" region of the state. Indeed, based on the case history of North Slope, less than 1% of the work force was made up of Inupiat. These points are made almost too dispassionately in text (even recognizing that EPA is attempting to maintain a "neutral" voice throughout the report).
g. Page 12-17. I am not sure how we manage to emphasize even more the confounding effects of mining and climate change on subsistence fisheries by Native Alaskans for I think this is extremely important and (as alluded to in text) extremely difficult to forecast. Couple these effects with the "portfolio" features of the salmonid populations, and I think we have real reason for concern, i.e., while these seven species of salmonids have a full range of life history strategies and flexibilities evolutionarily adapted to the historical environmental variation in the Bristol Bay Watershed, nothing in their history (or their portfolio) prepares them for either the mining or the climate-change impacts on the environment. Consequently, even given their tremendous life history variation, these salmonids are ill-prepared (evolutionarily speaking) for these future changes. Life history specialists will be completely lost due to mining and its complicated interactions with climate change.

15. **Chapter 13: Cumulative Effects of Large-Scale Mining**

a. Page 13-2, Table 13-1. Could the authors add approximate sizes of these mines that could be developed in the future? I appreciate the fact that the total area, at 1,300 km^2, is provided on page 13-7.
b. Page 13-5. Once again the conceptual model does a nice job of setting the stage for the sorts of interactions that would likely occur following the initial establishment of the Pebble Mine in the Bristol Bay Watershed. After a review of this model, the reader is then prepared for the text to follow.
c. Page 13-7, first paragraph under 13.2. Impossible to predict the future of mine development, including the order of mines that might come online and their respective impacts. It is, however, safe to say that additional development of mines will indeed occur if Pebble is permitted to move forward; this is certainly inevitable. Too many caveats here may provide fodder for suggesting that the EPA does not know that a mining district will develop. What would help us here is what has been done in

previous chapters, i.e., the documentation of case histories where initial mining ultimately led to a mining district.

d. Page 13-8. Median mine size of 0.25 Pebble is assumed in the context of predicting the impacts of new mines. Can this assumption be justified a bit more? Do the authors sense that this is a conservative estimate for new mines, a reasonable one (this is the sense that I get from the tone of the text), or a liberal estimate?
e. Page 13-9, Box 13-1. Breaking out methods in boxes like this has served this document well, making it easy for the reader to capture the essence of the conclusions without getting bogged down in too many methodological details.
f. Tables 13-2 to 13-8. These tables provide a nice combination of qualitative and quantitative data to support conclusions generated for cumulative impacts of additional mining development. Good work with limited information.
g. Page 13-23, Big Chunk North, as just one example. I like the fact that the authors did multiple scenarios when they were unsure as to whether a future mine would use an already established TSF or one that the future mine would build on its site. In this fashion, the EPA has bounded the impact of future development, allowing the reader to see both minimal and maximal effects of new mines, a technique that could productively be used elsewhere in this chapter.
h. General Point re Chapter 13. On the one hand, the writing here is dispassionate and objective, as I presume it should be with scientific writing. Even so, I would like the authors to make some judgment calls re the impacts of these six different mines on the environment. Those that have high densities of streams, wetlands, and ponds would undoubtedly experience greater degradation to the salmonids than one that has a far lower density (is this true?). In turn, one could ask if there are other characteristics of the environment that make one mine worse in terms of its negative impact than another. Bringing out these comparative statements would help the reader understand the individual impacts of new mines. As just one other example of this issue, it is often noted that streams are "strongly meandering"; one additional statement that would help the reader would argue something along the lines of "making road development far more difficult and likely to have a greater impact on salmonid populations".
i. Page 13-28, third paragraph. I think that the last sentence of this paragraph requires some modification for it now reads "…diminishing the biological complexity of salmon stocks and lead to the portfolio effect…". The fact is that because of the diversity of life histories within species across populations within stocks, salmonids do well even as environmental conditions change from year to year. Here the authors are arguing in this last sentence that reductions in biological complexity will "lead to the portfolio effect" but rather this decrease will compromise the portfolio effect by eliminating stocks with specific life history characteristics. Cleaning up this text will improve its presentation.
j. Page 13-29, Impervious Surface Increase. No citations are provided here. Do we know anything about 10% being a useful metric for increasing negative impacts on stream flow and flooding?
k. Page 13-35. Indeed, we now require salmon hatcheries in some urbanized areas within Alaska. Is this point worth emphasizing? Are the hatcheries really required because the nearshore environment has been degraded? A box detailing this example with

some hard data might go a long way toward making the point that development means loss of important locally adapted salmon stocks.

l. General Point re Chapter 13. I am not sure how to handle this concern. When the authors discuss the various impacts of different infrastructural features in a cumulative sense, they do not review all of the issues each contributes. For example, there is no mention of dust or invasive species when discussing roads. Similarly, when discussing pipelines, nothing is said about accidents. The authors certainly cannot be expected to review all features of all of these infrastructural impacts, but some recognition of all of their impacts might be warranted, perhaps as a sidebar or briefly highlighted in an associated box (as done so successfully in previous chapters).

16. **Chapter 14: Integrated Risk Characterization**

a. Page 14-3. Conventional mining practices may be sufficient for the smallest footprint for the Pebble Mine, i.e., 0.25 but beyond this size, conventional mining practices do not protect the environment to the extent required to protect salmonids, Hence the commercial and sport fisheries, and specifically the subsistence fisheries by Native Alaskans are threatened. Given this conclusion, permitting of this mine would be suspect at best.

17. **EPA Response Document.**

a. General Point I. Overall, I was impressed with how the team of authors dealt with our reviews. For each point, there was succinct, explicit, and reasoned response. Not always did our concerns receive full treatment in the revision. However, if they did not, the EPA response included an explanation that was well crafted and justified.

b. General Point II. Because there are no data on the management of water quality "In Perpetuity" (i.e., we have no experiences in this area simply because we do not have mines that have been closed for a sufficiently long period of time (>100 years) to gain this experience), the EPA cannot write about what might be expected in the "long term". Even so, no one is optimistic. Without the profit incentive, corporate entities are not likely to monitor, treat, and maintain these facilities. Indeed, corporations are likely to go out of business in their current structure and therefore this responsibility will fall to the State of Alaska, whose record is not the most enviable in this arena. It seems to me that TSFs will fail, given enough changes in responsibility over time. Impacts on the salmon, the subsistence Native Alaskan culture, the commercial/sport fisheries, and the entire ecosystem will be large, long-lasting (at least multiple hundreds of years), and not preventable. With this certain knowledge in hand, I can only conclude that the Pebble copper mine and Bristol Bay salmon cannot coexist. The mine will indeed eliminate the salmon runs in the areas affected by a catastrophic failure of the Tailings Storage Facility. This mine should not be built in the Bristol Bay Watershed for it will have nearly irreparable impacts on the water quality of this watershed.

c. General Point III. Though we do not have long-term data from any mines post-closure, what do the short-term data tell us? They tell us that insidious effects of the facilities that remain after mining compromise water quality to the extent that it influences ecosystem functioning eliminates the ability of streams affected to support fishes intolerant of poor-quality water. We have experience that tells us that this has occurred and thus has an extremely high probability of re-occurrence in the Pebble area.

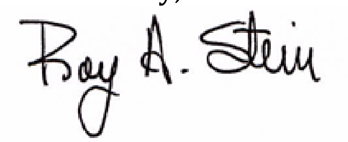
d. General Point IV. Even though we have the experiences noted in items 17a-b, the Bristol Bay Watershed is even more vulnerable that the other systems studied, in that it is an extremely wet environment with ground-water operating to communicate among streams (inter-connectedness). With this inter-connectedness come the increasing widespread effects of mine pollution and thus an increased impact on the whole of the Bristol Bay Watershed.
e. General Point V. The Nushagak and Kvichak rivers are exceptional salmonid streams, even for the Bristol Bay Watershed. Loss of these populations would likely negatively influence salmon populations that are available for harvest. That the headwaters of these two rivers lie in the middle of the Pebble Mine impacts argues for a precautionary approach to the permitting process.
f. Page 13, EPA Response to Peer Review Report. I agree with the team of authors when they suggest that including the Mount St Helens data re recovery of stream communities makes sense. At present, they have removed these data; I would like to see them included as they can help make the case re the impact of a TSF failure on Bristol Bay Watershed streams.
g. Some inconsistency exists within the "Response Document". On page 7 the team argues that development of a monitoring program to distinguish between mining and climate change effects is outside the scope of the assessment". Yet, on page 44, the authors argue that "… Chapter 3 and Box 14-2 include a discussion of the need for future monitoring to differentiate climate change effects from large-mining effects". Clearly, Box 14-2 seeks to present the importance of the monitoring program in light of the comparative effects of mining versus global climate change. The text of the "Response Document" should be revised to reflect these goals to maintain consistency.
h. Page 63, third full paragraph, Response Document. I am surprised that the answer to this question does not include the reference to Box 4.1 in the Second Draft that defines all of the relevant terms. For the sake of completeness, this box should be referenced here.
i. As I read through the Response Document (see top of page 79 as just one example of many), I am troubled by the ongoing conversation that suggests that we might know too little specific information about the salmonids in the two river systems affected that the mine proponents can argue that they will have a minimal impact, thus allowing the mine and its operations to be permitted by the State of Alaska. I have no solution to this conundrum, but it bothers me that the burden of proof lies with the EPA and other regulatory bodies to demonstrate negative impacts on the extant salmonid populations. I do wish the system was reversed, i.e., that the company proposing this development would be required to demonstrate "no effect" on the salmonid populations before permitting could occur.
j. Page 100, Response Document. I agree that the EPA has substantially strengthened the arguments associated with "future technology" as being the solution to all of the issues that lay before Pebble LLC in Chapter 9. These arguments are critically important to the assessment of whether the mine will indeed compromise water quality and therefore salmonid success. To allow the company to argue that historical failure rates of various portions of the mine are not appropriate because newer technology will prevent these failures is simply not right, i.e., in the context of any evaluation of the environmental impact of a proposed mining facility.

k. Page 130, Response Document. Under comments about the transportation corridor, it is appropriate to note that 70 crossings have been changed in the revised document to a minimum of 70 crossings. This particularly seems pertinent to these responses to the Expert Panel concerns as expressed.
l. Question 10 dealing with risks to wildlife and human cultures, page 139, Response Document. To this point, I did think that the responses by EPA were complete and well-thought-out. Reponses to the critique by the Expert Panel to Question 10 were less well developed without (typically) references to specific passages in specific chapters. I believe the EPA authors handled most all of the concerns expressed herein, especially so after sharpening the scope of their Ecological Assessment. Even so, the EPA failed to explicitly lay out exactly how they handled each of the concerns expressed by the Expert Panel, which is too bad because I think that they did deal reasonably well with these issues in their revised draft. Note just a few examples:
    i. Page 141, top of page. In the first response, there are no references to the revised text.
    ii. Page 141, middle of page. In the second and third responses on this page, little detail is provided; the EPA authors only refer to Chapter 12 when indeed they could have provided an insightful short paragraph that would explain precisely how they handled these issues (for they did, as I recall, in the revised text).
    iii. Page 151, second response on the page. Here a more complete answer would have included references to all of the NEW conceptual models that were developed <u>and discussed</u> in the revised Second Draft.
    iv. Given what I have read to this point re responses, I was disappointed in the this section re EPA responses…for they are rather perfunctory rather than explicit and detailed, and this is especially true for the responses to Dr. Paul Whitney's comments and concerns.
    v. Finally, one can appreciate my concern by simply comparing EPA responses to concerns expressed by the Expert Panel regarding Question 10 versus Question 11.
m. Page 177, Response Document. I appreciate the response the authors have generated relative to the ideas surrounding uncertainty. Their revised draft considerably improves their presentation of the topic and the response on the middle of page 177 helps me understand their point of view with regard to uncertainty (see response comment on page 178 where the EPA argues that putting forward "reasonable and typical scenarios" to characterize risk and then the uncertainty surrounding that risk (I agree with this approach)).

18. **General comment on my comments.** All comments were seriously considered by the EPA authors and were either appropriately dealt with in their revised text or explained that the concern did not fall under the "scope of the ecological assessment". Thus, I am pleased with the revision as it relates to my initial concerns about the first draft of the Main Report. Though I cannot speak for my colleagues as to the adequacy of EPA's response to their concerns, my reading of the Response Document demonstrates that I found most all of EPA's responses well-reasoned, consistent across questions and concerns, and overall well done (save for Question 10, see comments above).

Thank you for the opportunity to review EPA's Second External Review Draft, EPA 910-R-12-004Ba, April 2013 entitled *An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska*. I trust my comments will be useful as EPA finalizes its assessment of potential mining effects in the Bristol Bay Watershed.

Sincerely,



Roy A. Stein, Professor Emeritus
Department of Evolution, Ecology, and Organismal Biology
The Ohio State University

Dr. William Stubblefield, Oregon State University

Peer Review Follow-On Comments on the April 2013 Draft of

An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska

From: Stubblefield, William [mailto:Bill.Stubblefield@oregonstate.edu]
Sent: Thursday, August 01, 2013 5:43 AM
To: Thomas, Jenny
Subject: Stubblefield comments

Jenny
I was not entirely sure about the form that you wanted this document in. I tried to follow your guidance from the other day. If this is not appropriate or does not address all of the aspects that were requested, let me know and I will revise it accordingly.
Cheers
Bill

William Stubblefield
Dept of Environmental and Molecular Toxicology
Oregon State University
1007 Agriculture and Life Sciences Bldg
Corvallis, OR 97331

[redacted]
Bill.Stubblefield@oregonstate.edu

Evaluation of EPA responses to external reviewer (William Stubblefield, PhD) comments:
An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska (April 2013)

General Impressions:

Based on my review of the second external review draft of the Bristol Bay assessment document it is my impression that the USEPA has committed substantial time and effort to revising the original assessment document resulting in a greatly improved report. For the most part, all of the technical and editorial comments made regarding the original document have been satisfactorily addressed in the current revision. Substantial improvements in the organization and content of the document were made including:

- Incorporation of background information regarding the use of a risk assessment-based approach to addressing the issues,
- Inclusion of an explanation for the inception of the assessment and its ultimate utility to risk decision-makers,
- Addition of a clear discussion of the uncertainties associated with the assessment and the potential implications of those uncertainties, and
- Inclusion of an evaluation and application of the "state-of-the-science" regarding the assessment of metals toxicity in the aquatic environment, inclusion of “new” European REACH regulation-based data, and the importance of consideration of bioavailability have been addressed.

Although additional changes and incorporation of additional "new" data and recent scientific literature would further benefit the document, I think, in its current form, it more fairly represents the current "state-of-the-science." Therefore, I would commend the USEPA for its efforts in revising the original assessment report.

WRITTEN PEER REVIEW COMMENTS

1. GENERAL IMPRESSIONS

The document, "An Assessment Of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska," is a well-written, comprehensive document that employs a risk assessment-type approach to an *a priori* evaluation of potential environmental effects on the ecosystem and potential receptor species (e.g., salmon) that may be affected by a potential copper mine located in the Bristol Bay area of Alaska. This document is somewhat unique, in that no actual mine has been proposed at the location and few site- or project-specific data are available. Therefore, no specific information about development plans and potential operational and closure activities associated with the mine are available. Rather, the authors have attempted to develop a hypothetical mine and attempted to assess possible environmental effects associated with mine development, operation, and closure. Although interesting, the potential reality of the assessment is somewhat questionable. It is also unclear why EPA undertook this evaluation, given that a more realistic assessment could probably have been conducted once an actual mine was proposed and greater detail about operational parameters available. The approach taken in the document attempted to be comprehensive and evaluated a variety of scenarios that may affect aquatic resources in the Bristol Bay region. Given the importance of salmon populations in the area, both from a financial and societal perspective, it is important that a comprehensive evaluation of potential environmental effects associated with mine development and operations be conducted. The authors have attempted to conduct such a comprehensive evaluation and have attempted to quantify (to the extent possible) the probability of adverse effects occurring. Implementation of this approach is proper, and with the correct data, can provide a comprehensive evaluation of potential environmental effects. Unfortunately, because of the hypothetical nature of the approach employed, the uncertainty associated with the assessment, and therefore the utility of the assessment, is questionable.

RESPONSE: The EPA respectfully disagrees that the hypothetical nature of the approach compromises the utility of the assessment. All mining plans are hypothetical. They change in response to the results of assessments, regulatory requirements, public input, and unforeseen conditions and events. They cease to be hypothetical only after the mine is closed. At every step in the process, assessments of the current plan are useful even though plans will change. This assessment is based largely on a preliminary plan, published by Northern Dynasty Minerals (Ghaffari et al. 2011). Although layout of mining components in a future mine plan may differ somewhat from the preliminary plan or the EPA scenarios, the main components of mining would remain the same for open-pit mining (and underground mining would face the same waste issues).

It would appear that on this topic the reviewer and the US EPA authors are likely to continue to disagree. The hypothetical nature of the approach presented in the original assessment document was sufficiently vague that the degree of confidence in the assessment may limit its utility to risk decision-makers due to the high degree of uncertainty associated with the evaluation. By increasing the information upon which environmental exposure concentrations and environmental effects concentrations are estimated and taking into account site-specific environmental conditions, a more robust assessment with less uncertainty can be developed. This does not suggest that the original "screening level" approach has no utility; it merely suggests that the degree of certainty associated with the assessment may not have been sufficient to provide risk decision-makers with sufficient information upon which to make long-term project decisions.

A variety of uncertainties and data needs were identified as a result of this effort and this alone may provide sufficient value to justify the document and approach. For example, the authors note that there is not an abundance of chronic toxicity data considered in deriving the EPA's ambient water quality criteria for copper and that there is an uncertainty associated with whether the biotic ligand model (BLM) adequately protects species of concern in Bristol Bay. It would seem appropriate for EPA (perhaps in concert with industry) to develop the data to improve our understanding of copper toxicity and to ensure that regulatory standards are, in fact, appropriate for their intended use. A substantial body of data evaluating copper chronic toxicity has been developed by the copper industry as a result of regulatory requirements driven by the European REACH regulations. It may be beneficial for EPA to examine these data, thus resulting in a reduction in any uncertainty associated with the evaluation of environmentally acceptable metals concentrations. It should also be noted that similar datasets and biotic ligand models exist for number of other metals that may be of concern at the Bristol Bay site.

RESPONSE: The EPA has examined the EU's 2008 Voluntary Risk Assessment of Copper (the relevant REACH document). Although they do derive a chronic species sensitivity distribution, it is because of the way they include and aggregate data, rather than the generation of new data. In particular, they have no data for sensitive aquatic insects, so the EU does not resolve that problem. The BLM was used for copper because copper is the contaminant of greatest concern and because the copper BLM has been approved by the EPA Office of Water. Other metals with BLMs, such as zinc and nickel, occur at much lower levels in leachates.

The EU's copper voluntary risk assessment does, in fact, include additional data than that considered in the US EPA's original copper Ambient Water Quality Criteria. For example, data for freshwater mussels represent a "new" species that was included in the EU's document. The assessment authors are correct, however, in that new data are not available for additional insect species, especially, representatives from *Ephemeroptera*, *Plecoptera or Tricoptera* orders (i.e., EPT species). Field population data suggest that these organisms may have greater sensitivity to the effects of copper than those currently considered in the existing species sensitivity distribution. Currently no standardized (i.e., OECD, ASTM or EPA) laboratory test methodologies exist for conducting chronic toxicity test with EPT species. US EPA may want to consider the possibility of conducting or funding a research program aimed at the development of chronic tests methodologies for these species in order to assure that they are adequately protected by AWQC.

One suggestion that would improve the document is that EPA should include a basic description of the risk assessment process and the relationship between the risk assessor and the risk manager, i.e., the decision maker. They must include a discussion of why the assessment is being conducted, the decisions that will be informed, and what information they need from the risk assessor.

RESPONSE: Additional contextual information for the assessment has been included in Chapter 1, and additional information on ecological risk assessment has been incorporated into Chapters 1 and 2. The assessment has also been restructured into problem formulation and risk analysis and characterization sections, to make the assessment's structure as an ecological risk assessment clearer.

Substantial improvements were made in the revised assessment to address the concerns raised in my initial review comments. Through a combination of revision, reorganization, and expansion in Chapters 1 and 2, the authors have provided the appropriate background and description of the approach used in the preparation of this assessment.

Taken from the USEPA's Guidelines for Ecological Risk Assessment (EPA630/R-95/002F; April 1998). Note 2nd sentence re: the role of the risk manager.

"2.1. THE ROLES OF RISK MANAGERS, RISK ASSESSORS, AND INTERESTED PARTIES IN PLANNING

During the planning dialogue, risk managers and risk assessors each bring important perspective to the table. ***Risk managers, charged with protecting human health and the environment, help ensure that risk assessments provide information relevant to their decisions by describing why the risk assessment is needed, what decisions it will influence, and what they want to receive from the risk assessor.*** *It is also helpful for managers to consider and communicate problems they have encountered in the past when trying to use risk assessments for decision making.*

In turn, risk assessors ensure that scientific information is effectively used to address ecological and management concerns. Risk assessors describe what they can provide to the risk manager, where problems are likely to occur, and where uncertainty may be problematic. In addition, risk assessors may provide insights to risk managers about alternative management options likely to achieve stated goals because the options are ecologically grounded."

RESPONSE: Section 1.2 in the revised assessment discusses uses of the assessment.

I concur, the revised Chapter 1 adequately describes the purpose and use of the assessment.

2. RESPONSES TO CHARGE QUESTIONS

Question 1. ***The EPA's assessment focused on identifying the impacts of potential future large-scale mining to the fish habitat and populations in these watersheds. The assessment brought together information to characterize the ecological, geological, and cultural resources of the Nushagak and Kvichak watersheds. Did this characterization provide appropriate background information for the assessment? Was this***

characterization accurate? Were any significant literature, reports, or data missed that would be useful to complete this characterization, and if so what are they?

The EPA's assessment document presents a seemingly comprehensive compilation of the data associated with the ecological, geological, economic, and cultural resources of the Bristol Bay area. The characterization as presented seems to provide appropriate background information for the assessment considering the hypothetical nature of the evaluation. Without having specific knowledge of the area in question, it is not possible to provide an assessment as to whether the characterization was accurate. I'm unaware of significant literature, reports, or data that were specific to the site and would be useful for consideration. The assessment should be expanded to include greater detail regarding the environmental aspects of the site.

RESPONSE: Additional information on the physical environment of the region and assessment endpoints has been incorporated into Chapters 3 and 5.

I agree, substantial additional information on the physical environment of the region in the assessment endpoints has been incorporated into Chapters 3 and 5. This helps in the overall description of the Bristol Bay environment and helps characterize potential environmental concerns.

Question 2. ***A formal mine plan or application is not available for the porphyry copper deposits in the Bristol Bay watershed. EPA developed a hypothetical mine scenario for its risk assessment, based largely on a plan published by Northern Dynasty Minerals. Given the type and location of copper deposits in the watershed, was this hypothetical mine scenario realistic and sufficient for the assessment? Has EPA appropriately bounded the magnitude of potential mine activities with the minimum and maximum mine sizes used in the scenario? Are there significant literature, reports, or data not referenced that would be useful to refine the mine scenario, and if so what are they?***

No comments on this question.

No additional comments on this question

Question 3. ***EPA assumed two potential modes for mining operations: a no-failure mode of operation and a mode involving one or more types of failures. Is the no-failure mode of operation adequately described? Are engineering and mitigation practices sufficiently detailed, reasonable, and consistent? Are significant literature, reports, or data not referenced that would be useful to refine these scenarios, and if so what are they?***

It is interesting and appropriate that the EPA has included both modes of operation in conducting this assessment. This approach provides some degree of "bounding" for the assessment; however, the degree of accuracy (i.e., predictability) for either scenario cannot be known at this time. The document appropriately acknowledges that there are a variety of potential mitigating factors (e.g., acts of God, accidents, market changes) that may render the assumptions used in this assessment incorrect.

RESPONSE: Our intention for the "no-failure" scenario was to identify and evaluate the unavoidable environmental effects if all systems and mitigation measures operated perfectly, and to separate those effects from a scenario where systems periodically failed. There were a number of comments on this approach so the revised assessment no longer uses the term "no-failure" and addresses effects from the foot print (i.e., the no failure scenario), failure scenarios having higher probability and lesser magnitude (e.g., failure to collect or treat leachate water), and failure scenarios having lower probability and higher magnitude (e.g., TSF failure).

No change suggested or required.

I agree with the new approach suggested by EPA.

Question 4. ***Are the potential risks to salmonid fish due to habitat loss and modification and changes in hydrology and water quality appropriately characterized and described for the no-failure mode of operation? Does the assessment appropriately describe the scale and extent of risks to salmonid fish due to operation of a transportation corridor under the no-failure mode of operation?***

The document appears to adequately address potential questions associated with habitat loss due to hydrologic changes, especially considering the hypothetical nature of the mine and the lack of specific detailed information regarding an actual proposed facility and all of the associated operational details of the facility. The assessment of potential impacts and ecosystem protection parameters is predominately based upon the publication of Richter et al. (2011). Additional support and evaluation of these recommendations for fisheries populations in the Bristol Bay area should be closely evaluated.

RESPONSE: Prompted by this comment, we consulted with regional biologists and hydrologists to evaluate the suitability of the sustainability boundary approach for flows. We asked them if there was any reason that fish populations in these streams, or the specific hydrology of the area, made it exceptional with regard to this approach (e.g., was there any reason to think that the Richter approach was not applicable here). We received uniform support for applying this approach to Bristol Bay streams. We strengthen our emphasis that this is a precautionary approach, and that the detailed hydrologic and habitat modeling work that PLP contractors have begun will help provide a useful basis for more sophisticated flow-habitat modeling.

This response seems to adequately address the initial comment.

Question 5. ***Do the failures outlined in the assessment reasonably represent potential system failures that could occur at a mine of the type and size outlined in the mine scenario? Is there a significant type of failure that is not described? Are the probabilities and risks of failures estimated appropriately? Is appropriate information***

from existing mines used to identify and estimate types and specific failure risks? If not, which existing mines might be relevant for estimating potential mining activities in the Bristol Bay watershed?

The scope of failures described in the assessment seems to be sufficiently comprehensive and all likely failure-types are considered. The probabilities and risks for failure seem to be adequately estimated, given the state-of-the-science; however, these estimates are likely to be very sensitive to site-specific concerns and operational considerations. Once site-specific information is available, it is likely that much better estimates of failure potential at a site can be developed.

RESPONSE: We agree that more site-specific information could support more site-specific estimates. No change required.

I concur, the US EPA authors have acknowledged the benefit of more site-specific information and until that information becomes available there is little additional that can be done to estimate failure potential.

Question 6. ***Does the assessment appropriately characterize risks to salmonid fish due to a potential failure of water and leachate collection and treatment from the mine site? If not, what suggestions do you have for improving this part of the assessment? Are significant literature, reports, or data not referenced that would be useful to characterize these risks, and if so what are they?***

The risk assessment attempts to consider the effects of metal discharges for water and leachate from the mine site. This assessment is based on metals concentrations measured in potentially “similar” mine waters from other sites; concentrations of metals are likely to differ based on source material and operational differences. The effects concentrations used in the evaluation are based on US EPA ambient water quality criteria (AWQC) for metals, and this approach is appropriate for “screening level” evaluations. It should be noted that exceedence of an AWQC does not portend the occurrence of adverse effects. Ambient water quality criteria are derived in such a way that they are intended to represent “safe concentrations.” In other words, if environmental concentrations remain below the AWQC, it is assumed that unacceptable adverse effects will not occur; exceedence of an AWQC suggests that adverse effects may occur to some species, but that this must be evaluated more closely. Salmonid species are not the most sensitive organisms in the copper AWQC species sensitivity distribution (SSD); therefore, direct effects on salmon are even less likely at concentrations in the range of the AWQC.

RESPONSE: Effluents or ambient waters from mines at other sites were not used. The leachate concentrations used (except for the product concentrate leachate) are from available results of material leaching tests from the Pebble deposit. Otherwise, the Agency agrees with these comments. The assessment used criteria for screening, but then examines the toxicity data more closely, including field data to determine potential effects (e.g., aversion, sensory inhibition, mortality and reduced reproductive success of salmonid fish). The greater sensitivity of aquatic insects was described in the May 2012 draft of the assessment and is further highlighted in the revised assessment. The protectiveness of the copper criterion is considered in both the original and revised assessments.

Section 8.2.2.1 provides a good discussion of the copper standard used in conducting the Bristol Bay assessment. It describes the existing state standard, the incorporation of the biotic ligand model calculations and its effect on site-specific copper criteria, the importance of "nonstandard" endpoints (e.g., olfactory concerns), and the concerns that the US EPA has about the "protectiveness" of the existing criteria. The authors identify a group of recent scientific publications that have *"identified effects on aquatic insect populations and invertebrate communities at concentrations below water quality criteria for the dominant metals (cadmium copper and zinc)."* This is an intriguing finding that may run counter to previous assumptions regarding the protection afforded by water quality criteria. It could also have far-reaching consequences for water quality criteria and their derivation procedures. Field-based assessments are frequently difficult to evaluate due to confounding factors. Because of this alternative approaches, such as mesocosms, are frequently used to assess community or population level concerns under more "controlled" environmental conditions. A number of mesocosm studies have been conducted with copper in recent years and these studies should be evaluated and considered in assessing the adequacy of the copper criteria.

One statement contained in Chapter 8, Section 8.2.2.1 suggests that the EPA may believe that the AWQC for copper may be significantly underprotective. That statement indicates that: *"Based on the literature cited above and the author's experience, resolution of this uncertainty by additional research and testing is likely to lower the chronic criterion by approximately a factor of 2 and not as much as a factor of 10."*
This is a concerning statement especially when one considers the ramifications if this is in fact correct. For example, the table below presents the BLM copper criteria based on the mean water chemistries in the mine scenario watersheds (taken from Table 8.11) with consideration of a 2-10 fold "uncertainty" factor. These values are compared to background copper concentrations in the same river segments (taken from Table 8.19). All values are in µg/L.

Stream	CMC	CMC (2-10 factor)	CCC	CCC (2-10 factor)	Background range
South Fork Koktuli River	2.4	1.2-0.24	1.5	0.75-0.15	0.42-2.4
North Fork Koktuli River	1.7	0.85-0.17	1.1	0.55-0.11	0.31-0.61
Upper Talaric Creek	2.7	1.35-0.27	1.7	0.85-0.17	0.21-0.5

This assessment suggests that if the BLM chronic criteria concentrations are "under-protective" by the suggested 2-10 factor, a significant portion of the streams would be in violation of the copper criteria based on only background concentrations.

It is interesting to note that the risk assessment document states that copper is one of the "best-supported criteria. However, it is always possible that it would not be protective in particular cases due to unstudied conditions or responses." Further, the document goes on to suggest that organisms such as mayflies etc. are important to the aquatic ecosystem but are not considered in the copper AWQC and therefore may not be sufficiently protective. It also suggests that because an acute-chronic ratio approach is employed to correct the final acute value to obtain a final chronic value, there may be increased uncertainty associated with the protectiveness of the chronic criterion. This appears to be an area where EPA might benefit by conducting research (either alone or in concert with industry) to reduce uncertainty in the criteria to an acceptable level. In addition, additional chronic toxicity data may be available from research conducted in response to the European REACH regulations and consideration of this research may reduce the level of uncertainty in the criteria. Bioavailability correction via the BLM approach is only considered for copper in the risk assessment; biotic ligand models have been developed for a number of metals (e.g., zinc, nickel) and these should be considered in the assessment as well. Finally, the assessment approach seems to use a sum TU-based approach for assessing "metals mixture" impacts. This is based on an assumption of additive interactions among the metals. Although this is probably the best assumption in going forward, limited data are available to support this approach.

RESPONSE: The EPA has examined the EU's 2008 Voluntary Risk Assessment of Copper (the relevant REACH document). Although the authors could derive a chronic species sensitivity distribution, that is because the way that they include and aggregate data differs from the EPA's method. They apparently did not generate new test data for the assessment. In particular, they have no data for sensitive aquatic insects, so the EU assessment does not resolve that problem. The BLM was used for copper because it is the contaminant of greatest concern and because the copper BLM has been approved by the EPA Office of Water. Other metals with BLMs, such as zinc and nickel, occur at lower levels in leachates relative to their toxicities, so BLM modeling was not justified.

The US EPA authors are to be commended for taking the time to review the EU's voluntary risk assessment of copper. This document represents the most recent evaluation of copper environmental toxicity that this reviewer is aware of. Additional data that were generated as part of the copper industry environmental research program are reflected in this document (e.g., data for freshwater mussels). Differences do exist between the US EPA and EU approach for endpoint assessment (EC10 vs EC20), aggregating data, and statistically deriving "thresholds." However, the data are available to permit threshold calculation using either method. EPA is to be commended for the use of the copper BLM in conducting this assessment; it represents the current state-of-the-science and provides the most accurate method for deriving thresholds considering site-specific physicochemical parameters. BLMs for other metals such as zinc, nickel, and cobalt exist in the peer-reviewed scientific literature, but have not yet gained regulatory acceptance by the EPA Office of Water. It is anticipated that this will come with time. EPA did not consider the BLMs for these other "lessor" metals because of their "lower levels in leachates relative to their toxicities." This may be a reasonable approach; however, when using an additivity-based approach (ΣTU) when assessing metal mixtures, it may be advisable to "correct" for bioavailability in even the "lessor" metals, when possible.

Areas where additional research would be beneficial include:

- Mixtures: Information regarding the potential interactive effects of multiple metal exposures would be useful and would reduce assessment uncertainty.
- Species sensitivity concerns: there is extremely limited data (esp. chronic data) on all of the salmon species of concern in Bristol Bay
- Additional data, especially chronic toxicity data and data for additional metals for which no water quality criteria exists, would be extremely helpful.

RESPONSE: The EPA agrees that these are good research topics. No change is suggested or required.

To the extent possible, EPA may want to consider conducting these research programs or funding others to do so. Also, based on the comments/revisions in the Bristol Bay assessment there may be concern that the US EPA's current ambient water quality criteria for copper, and perhaps other substances, do not adequately address potential effects to "sensitive" insect species (e.g., *Ephemeroptera*, *Plecoptera or Tricoptera orders*). Currently no standardized (i.e., OECD, ASTM or EPA) laboratory test methodologies exist for conducting chronic toxicity test with EPT species. EPA may want to develop methods that could be used to assess toxicity to these organisms.

Question 7. ***Does the assessment appropriately characterize risks to salmonid fish due to culvert failures along the transportation corridor? If not, what suggestions do you have for improving this part of the assessment? Are significant literature, reports, or data not referenced that would be useful to characterize these risks, and if so what are they?***

Potential effects on salmonid populations were evaluated due to culvert blockage and failures. Culvert blockages will prevent salmon passage leading to possible effects on reproductive success. Literature data for the incidence of culvert failures were used in assessing failure probability. This seems to be an appropriate approach given the hypothetical nature of the mine used in the assessment; however, this is not my area of expertise and I am not aware of additional data that should be considered.

RESPONSE: No change suggested or required.

No additional comment on this question

Question 8. ***Does the assessment appropriately characterize risks to salmonid fish due to pipeline failures? If not, what suggestions do you have for improving this part of the assessment? Are significant literature, reports, or data not referenced that would be useful to characterize these risks, and if so what are they?***

Potential effects on salmonid populations were evaluated due to potential pipeline failures as part of the risk assessment. This evaluation focused on potential failures associated with the pipelines for the product concentrate slurry and return water. No consideration of the natural gas or diesel pipelines was presented, stating that such pipelines "are common and the risks are well-known." Although I would acknowledge the failures in natural gas and petroleum pipelines are common, I would not discount the potential effects to salmon populations associated with such spills.

RESPONSE: A diesel pipeline failure and resultant spill into two creeks has been added in Chapter 11. Natural gas is not a contaminant of concern because it would vaporize and, at worst, burn, which would not pose a significant risk to salmonid fish.

The revised document evaluates the potential effects to aquatic organism populations as a result of a petroleum diesel fuel spill. The document attempts to examine the available literature and characterizing the acute and chronic effects of diesel fuel on aquatic organisms. However, it is apparent is that there is little high quality information available that has been gathered in any sort of consistent manner that would permit an adequate quantitative evaluation of the effects of a diesel fuel spill. Inconsistent approaches in characterizing hydrocarbon exposures (i.e., differing analytical methods) and inconsistent approaches in conducting toxicity tests make it virtually impossible to apply a quantitative approach to the evaluation of diesel fuel spill effects at this time. Hydrocarbon toxicity models such as the Target Lipid Model (DiToro et al. 2000 a,b) or PETROTOX (Redman et al 2012) offer the best approach to assess hydrocarbon mixture toxicity; however, substantial analytical characterization of hydrocarbon concentrations are needed. For purposes of the Bristol Bay assessment the approach taken is probably adequate given that conclusions can be reached about the potential effects of a diesel spill. It should be recognized, however, that the state of the science for evaluating hydrocarbon mixture toxicity is somewhat lacking and additional research is needed.

Di Toro DM, McGrath JA, Hansen DJ. 2000a. Technical basis for narcotic chemicals and polycyclic aromatic hydrocarbon criteria. I. Water and tissue. *Environ Toxicol Chem* 19:1951-1970.

Di Toro DM, McGrath JA. 2000b. Technical basis for narcotic chemicals and polycyclic aromatic hydrocarbon criteria. II. Mixtures and sediments. *Environ Toxicol Chem* 19:1971-1982.

Evaluation of potential impacts due to a spill of product concentrate slurry or return water was based on extant data from an existing copper mine in Sweden; to the extent that this slurry and return water is representative of similar materials coming from the Pebble mine, this approach is appropriate. The assumptions used in the amount of material that might possibly be spilled seems appropriate and based on past experience and realistic assumptions; however, these assumptions need to be reconsidered if and when a real mine plan is prepared.

RESPONSE: The Aitik leachate is no longer used to estimate the aqueous phase of the slurry, in response to other comments. Because the slurry would be alkaline, appropriate analytical data were obtained from Rio Tinto (Section 11.3.2.1). However, the Aitik data are still used for the leaching of the concentrate in a stream or wetland where neutral water would be the leaching agent. No other relevant data are available.

As previously stated, to the extent that the slurry and return water used in the assessment is representative of similar materials coming from the Pebble mine, this approach is appropriate.

Question 9. ***Does the assessment appropriately characterize risks to salmonid fish due to a potential tailings dam failure? If not, what suggestions do you have for improving this part of the assessment? Are significant literature, reports, or data not referenced that would be useful to characterize these risks, and if so what are they?***

Potential effects on salmonid populations were evaluated due to tailings dam failures. Tailings dam failure would potentially result in the release of large volumes of mine tailings and associated contaminated waters, leading to possible acute and long-term effects on salmon populations. It is also important to note that direct effects on salmon may be very species dependent, due to life-cycle differences, and the time at which the dam failure occurs. Potential effects due to sediment inundation/impaction can adversely affect habitat, leading to decreased spawning. Evaluation of the potential for tailings dam failure effects considered acute and chronic risks due to aqueous exposures, chronic risks due to sediment exposures, and risks due to dietary exposures. All of these seem to be appropriate exposure pathways and all were adequately considered, although site-specific information will improve risk predictions.

RESPONSE: Agreed. No change suggested or required.

No additional comments are provided.

Question 10. ***Does the assessment appropriately characterize risks to wildlife and human cultures due to risks to fish? If not, what suggestions do you have for improving this part of the assessment? Are significant literature, reports, or data not referenced that would be useful to characterize these risks, and if so what are they?***

Potential effects to wildlife and human cultures are briefly addressed in the risk assessment. No "quantitative" assessment of potential effects is provided. For the most part, it appears that potential affects to both wildlife and human cultural endpoints are directly proportional to the injury suffered by salmon populations as a result of any spills or failures. Given the level of detail available at this point in time regarding mine operations and closure, that is probably about as far as any assessment could go. I'm not aware of any literature reports or data that would assist in further characterization of these potential injuries.

RESPONSE: No change suggested or required.

No additional comments are provided.

Question 11. ***Does the assessment appropriately describe the potential for cumulative risks from multiple mines? If not, what suggestions do you have for improving this part of the assessment?***

The potential for cumulative risks associated with the development of multiple mines in the Bristol Bay watershed is not treated with a great degree of detail. Although each of the potential stressors (e.g., water withdrawal, habitat illumination, road and stream crossings) are acknowledged and addressed, little quantitative consideration is given to the potential effects associated with development of multiple mines. This, however, is probably appropriate given the hypothetical nature of the single mine scenario and the potential for greater impacts associated with the development of multiple lines. Short of concluding that "failures at one mine could be bad and failures at multiple mines could be worse," little else could be concluded. It is noted that the multiple mines scenario leads to multiple tailings impoundments, more roads and culverts, increased discharge potential of contaminated waters and increased habitat loss and reduction of water resources and all of these lead to potentially greater environmental injury as a result of failures.

RESPONSE: We have added to the cumulative effects section (now Chapter 13) by discussing the effects of induced development, including transportation corridors, and the effects of increased overall access in the watersheds (Box 6-1 discusses cumulative effects in terms of a single mine). The cumulative effects assessment is not a definitive, quantitative evaluation. It is, instead, a plausible example of how a mining district could develop and a conservative estimate of the impacts to aquatic resources and fish. It is intended to shed light on whether cumulative effects are a significant concern.

Based upon the available information and some reasonable assumptions, it appears that the EPA has addressed the comment satisfactorily.

Question 12. ***Are there reasonable mitigation measures that would reduce or minimize the mining risks and impacts beyond those already described in the assessment? What are those measures and how should they be integrated into the assessment? Realizing that there are practical issues associated with implementation, what is the likelihood of success of those measures?***

I'm sure there are number of technological/engineering measures that could be implemented to reduce the potential for environmental injury associated with development of mining in the Bristol Bay watershed. The development of this *a priori* risk assessment provides useful information in identifying were potential risks may exist and should provide mine development professionals with the degree of guidance about the types of risks and potential consequences of mine activity failures. Perhaps by recognizing the magnitude of adverse consequences associated with potential failures, steps can be taken to implement safety measures early in the planning process that would render mine development more acceptable. In addition, using the assessment to define areas of uncertainty my provide direction for future research that would be beneficial for the project. Again, because of the lack of detail associated with the hypothetical mine scenario, it is impossible to estimate the likelihood of success of any mine control activities.

RESPONSE: One purpose of this assessment is to inform future decisions concerning mine design and required mitigation. The purposes of the assessment are clarified in the revised introduction (Chapter 1).

I agree with the US EPA comment, Section 1.2 of the document does an adequate job of clarifying several of the potential uses for this document. The question originally posed asks "if there are mitigation measures that would reduce or minimize mining risks and impacts beyond those described in the assessment." In my reading of Section 1.2 I find no mention of this assessment providing information to industry engineers/environmental scientists/decision-makers that would help inform them about potential risks (or regulatory/stakeholder concerns) that may be mitigated by design/practice considerations. This would appear to be an important use of this assessment. If industry is aware of potential risks and/or concerns early in the development of a project it may be possible to take steps to incorporate actions to mitigate identified environmental risks/concerns. My expertise is not appropriate for evaluating possible mining mitigation measures but I'm sure others on the review panel had that particular expertise.

Question 13. ***Does the assessment identify and evaluate the uncertainties associated with the identified risks?***

The risk assessment attempts to identify and evaluate the uncertainties associated with each of the recognized potential risks. The authors have, for the most part, successfully identified a number of uncertainties that may affect the accuracy and conclusions of the risk assessment. Clearly, this information should provide a basis for prospective mine planners and regulatory authorities to focus their efforts to minimize potential environmental risks. In some cases the uncertainties identified are probably best addressed through the development of additional data and this should guide future research efforts undertaken prior to mine development and operation.

RESPONSE: No change suggested or required.

As discussed in my previous comments, the evaluation and documentation of assessment uncertainties is critical to any risk assessment. This document has clearly delineated the uncertainties associated with the various risk scenarios (both in the executive summary and in the individual chapters). The revisions to the uncertainty section(s) in this draft of the Bristol Bay assessment have been expanded, where appropriate, to address concerns associated with revised assessment techniques. If I could offer one suggestion associated with uncertainties would be that in the executive summary section "Summary of Uncertainties and Limitations in the Assessment" some more specific mention should be made of the uncertainties associated with the evaluation a toxicological endpoints and the uncertainties associated with toxicological benchmarks. Most of these are delineated and discussed in Chapter 8, Section 8.2.5. However, statements contained in the document like that in Section 8.2.2.1 that states: *"Based on the literature cited above and the author's experience, resolution of this uncertainty by additional research and testing is likely to lower the chronic criterion by approximately a factor of 2 and not as much as a factor of 10"* suggests that the US EPA believes that ambient water quality criteria may be significantly under protective of aquatic organisms. If this is the case, clearly it is a source of major uncertainty and should be identified as such.

Question 14. ***Are there any other comments concerning the assessment, which have not yet been addressed by the charge questions, which panel members would like to provide?***

None

No additional comments are provided.

3. SPECIFIC OBSERVATIONS

[NOTE: in the page notations below, S = Section, P = Paragraph, L = line]

William A. Stubblefield, Ph.D.

None

No additional comments are provided.

Dr. Dirk van Zyl, University of British Columbia

Peer Review Follow-On Comments on the April 2013 Draft of

An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska

From: Van Zyl, Dirk [redacted]
Sent: Sunday, August 04, 2013 9:25 PM
To: Thomas, Jenny
Subject: Re: Bristol Bay Review Check-In

Dear Jenny,

I attach my letter report in fulfillment of the contract. Please let me know if you need anything else at this time. Please also advise on how to handle the invoicing.

Regards,

Dirk van Zyl

Revised Draft Bristol Bay Assessment

Peer Review Follow-On

Review Comments by Dirk van Zyl

1. **Introduction**

This peer review follow-on of the Revised Draft Bristol Bay Assessment is provided in fulfillment of an agreement with the US Environmental Protection Agency. It specifically responds to the following requirement from the Scope of Work for the task:

> *The contractor shall provide a letter report evaluating how well the revised draft Bristol Bay Assessment addresses both the key recommendations provided in the Executive Summary of the peer review report and the specific comments provided by the Contractor in the peer review report.*

While Volume 1 of the Revised Draft Bristol Bay Assessment was completely reviewed, the evaluation below focuses narrowly on the aspects required by the Scope of Work. The report provides some overall review comments in the next section followed by two sections providing a few comments on the Executive Summary and the specific comments provided by this author in the 2012 peer review report.

The Scope of Work did not request or propose any specific format for the compilation of this review. One approach would be to repeat the original comments and the EPA responses before providing the comments from this review. It is clear that this approach will result in a very extensive document. The author decided on the following approach to reduce the length of this document[1]:

- In Section 3 below a specific topic and page number will be referred, the latter as: “EPA Response, p#”.

[1] Note that for the for the first two bullets it is assumed that the page numbers in the final public version of the EPA Responses will be the same as the Draft available for this review.

- In Section 4 below the specific question will be referred to plus the page number as follows: "EPA Response Q#, p#".
- References to the Second External Review Draft Documents will be to page numbers as follows: "Second Draft, p#".

2. Overall Review Comments

The restructuring and revisions presented in the Revised Bristol Bay Assessment resulted in a much improved document that provides better motivation for selection of specific hypothetical project elements and assumptions. It also provides further detail information, maps and summaries that improve the logic and approach of the document and associated analyses.

The document also strives to provide transparent information about the use of input data, e.g. reports by non-governmental organizations. It is stated that the "*USEPA subjected some of these documents to external review before incorporating this information into the assessment*" (Second Draft, p. 2-3). These reports and the reviews are available at http://cfpub.epa.gov/ncea/bristolbay/recordisplay.cfm?deid=182065. While the reports and reviews are provided for broad review, the value of the described external review will undoubtedly be questioned for its independence and credibility. It is also interesting to note that many reports from other credible sources were provided to the public record in 2012 but that none of them were apparently considered "useful" to EPA in their preparation of the Revised Draft. The author questions the objectivity of this process and therefore the overall scientific value of the review report by EPA.

3. Executive Summary Comments

- Global Climate Change (EPA Response, p. 7): The author would suggest that the comment about "an explicit reference to a monitoring program" did not imply that EPA should develop such a plan as part of the Second Draft. The main insight of this comment is that environmental effects from potential future mining in Bristol Bay can be related to climate change as well as mining and that specific monitoring plans should be developed for mining projects in Bristol Bay to allow clearly distinguishing between these effects. It is recommended that this comment be included in the final document.

- Mount St. Helens as a surrogate (EPA Response, p.13): The author would like to provide some further input about the use of Mount St. Helens data as a surrogate for the *"rate of benthic habitat recovery from a massive deposition of fine mineral particles".* The geochemical composition, particle size and the temperature at the time of deposition of the fine materials from the Mount St. Helens event must be compared to that of tailings before this event can be used as a surrogate. The EPA Responses indicate that "*we have removed references to Mount St. Helens in the revised assessment to eliminate concerns",* however on p. 9-27 of the Second Draft there is a reference to Major et al. (2000). On p. 15-40 of the Second Draft this reference is given as: Major, J., T. Pierson, R. L. Dinehart, and J. E. Costa. 2000. Sediment yield following severe volcanic disturbance — A two-decade perspective from Mount St. Helens. *Geology* 28: 819–822. This seems to still refer to Mount St. Helens in terms of long-term sediment transport. There seems to be a disconnect between the statement in the EPA Responses and the Second Draft that must be corrected.

4. Specific Comments

- EPA Responses Q1, p.31 and 32: no further comments
- Good practices vs. best practices (EPA Response Q2, p. 57 and 58): the author agrees that from a regulatory perspective "best management practices" (BMP's) is typically used for non-point source runoff. However, the term is also in much broader use in practice to refer to other activities and this is somewhat recognized. Addition of Box 4-1 helps to clarify this point.

- Tailings Management Technologies (EPA Response Q2, p. 59): The response refers to a “rule of thumb” from the SME Mining Engineering Handbook (1973) about allotment of space for dry tailings. The author is not aware of any hard rock dry tailings management projects in the 1970’s, these really came to being in the 1980’s and 1990’s. It is therefore not clear what experience base was used to establish this “rule of thumb”. The author has not reviewed the reference, however assuming 100 pcf density for the dry tailings the rule indicates a height of tailings stack of about 130 ft. This clearly is dependent on the topography and there is no reason not to construct stacks that are higher. There is no reason why the overall area covered by dry tailings should be larger than the footprint of a slurry tailings deposit as the dry density of placed and compacted tailings will be higher than that of slurry tailings. The statement that “*dry stack tailings disposal at this site would create additional surface area loss versus the scenario’s traditional dam*” contained in the present response is not correct and should be reconsidered as a reason to dismiss this option.

  Please also note that the comments in the responses are inconsistent with that in the Second Draft on p. 4-18:

  > *Dry stack tailings management in which tailings are filtered and “stacked” for long-term storage, is a newer, less commonly used tailings disposal method. Dry stacked tailings require a smaller footprint, are easier to reclaim, and have lower potential for structural failure and environmental impacts (Martin et al. 2002). However, the high-energy cost of dry stack technology remains a barrier for mining low-grade ores such as porphyry copper. In addition, this type of storage is inappropriate for acid-generating tailings and is less feasible in larger operations, where tailings impoundments serve to store water as well as tailings. It is most applicable in arid regions, although dry stacks are also used in wet climates or in cold regions where water handling is difficult (Martin*

et al. 2002). Currently, the only mines in Alaska that use dry stack disposal of tailings are underground mines with high-grade ore and relatively low quantities of tailings (e.g. Greens Creek, a lead, silver, zinc mine in southeast Alaska; and Pogo, a gold mine in eastern interior Alaska).

It should also be noted that it is not only higher energy costs but also capital and other operating costs that make this technology more expensive. However, if this tailings management method results in lower environmental risks then is should be seriously considered and potentially included in project considerations, even if only to enumerate the lower risks, e.g. the tailings failure scenario will nor occur because there is no fluid stored and all surface water can be diverted. The issue of acid drainage can also be addressed in the design of the facility, note that acid drainage collection and treatment from the tailings impoundment is included in the present assessment.

- Tailings density (EPA Responses Q2, p. 61 and Second Draft p. 6-33): The author indicated in his 2012 that the analogy to consolidation of oil sand tailings is incorrect. The Second Draft includes the following statements: *"Although oil sands are different from porphyry copper tailings, the principle is the same. Lack of data specific to porphyry copper tailings suggests a cautious approach, so we do not assume that the tailings consolidate to a fully stable land form. Thus the system may require continued monitoring to ensure hydraulic and physical integrity in perpetuity".* The author agrees that the principles are the same, however where it is estimated to take 200 years plus for a mature fine oil sand tailings facility to consolidate, a hard rock facility will consolidate during the operational life (refer to Caldwell et al, 1984; Oliveira and van Zyl, 2006a and 2006b). While long-term monitoring will be required, especially if the decision is made to store water on the impoundment, the tailings will be completely consolidated, i.e. no excess pore pressures will remain.

- Tailings specific gravity (Second Draft p. 9-12): The report notes that the specific gravity of the bulk tailings is 2.61 and that of the pyritic tailings is the same. This is incorrect. The specific gravity of pure pyrite is about 5.0, however when mixed with other minerals as in tailings one can typically use a value of 4.2 to 4.5. Please correct this and update the calculations on p. 9-12.
- EPA Responses Q3, p.73 and 75: no further comments
- Significance of risk: EPA Responses Q4, p. 89: the response indicates that: "*The purpose of the assessment is not to assign significance to the risks, but to provide information for decision-makers on the consequences of mining".* It is the author's opinion that the decision-makers will also need some context of comparative information to make a realistic decision. It seems to the author that providing acute and chronic quotients in Chapter 8 effectively provides significance of risks. Please consider the consistency of approaches.
- EPA Responses Q5, p.101 and 102: no further comments
- EPA Responses Q6, p.112 and 113: no further comments
- EPA Responses Q7, p. 120 and 121: no further comments
- EPA Responses Q8, p. 128 and 129: no further comments
- EPA Responses Q9, p. 136 and 137: no further comments
- EPA Responses Q10, p. 146 and 147: no further comments
- EPA Responses Q11, p. 159 and 160: no further comments
- Financial assurance Chapter 4 (EPA Responses Q12, p. 170): Box 4-3 on Financial Assurance is a good addition to the report. The author would like to suggest a reworking of part of the introductory paragraph, namely: *"Thus, regulations also serve to hold an operator accountable for potential future impacts, through establishment of financial assurance requirements and imposition of fines for non-compliance with permit requirements".* This sentence can be read to indicate that financial assurance can be used to non-compliance with permit requirements. The author suggests that the sentence be modified to clarify the concepts, e.g. to (suggested inserts

highlighted): *"Thus, regulations also serve to hold an operator accountable for potential future impacts, through establishment of financial assurance requirements for closure and reclamation of the mine and imposition of fines for non-compliance with permit requirements during mine operations".*

- Double-walled pipes (EPA Responses Q12, p. 170): the comment that a double-walled pipeline along the entire length of the pipeline "*may not be feasible or cost effective to do this given the length of the pipeline"* is puzzling. This seems like a design comment not a risk assessment comment. Clearly if that is the best option to reduce risks then it becomes part of the cost of doing business, unless another option having similar low risks can be proposed. Please reconsider.
- EPA Responses Q13, p. 177 and 178: no further comments
- Stakeholder process (EPA Responses Q14, p. 185): the addition of Box 1-1 provides very useful information for readers of the Second Draft.

5. References

Caldwell, J.A., Ferguson, K., Schiffman, R.L. and Van Zyl, D.(1984) Application of Finite Strain Consolidation Theory for Engineering Design and Environmental Planning of Mine Tailings Impoundments, Sedimentation/Consolidation Models - Predictions and Validation, R.W. Yong and F.C. Townsend (Ed.), ASCE, pp. 581-606.

Oliveira, W. and Van Zyl, Dirk (2006a) Modeling Discharge of Interstitial Water from Tailings Following Deposition – Part 1: Phenomenology and Model description. Brazilian Journal on Soil & Rocks, Vol. 29, No. 2, August.

Oliveira, W. and Van Zyl, Dirk (2006b) Modeling Discharge of Interstitial Water from Tailings Following Deposition – Part 2: Application. Brazilian Journal on Soil & Rocks, Vol. 29, No. 2, August.

Dr. Phyllis Weber Scannell

Peer Review Follow-On Comments on the April 2013 Draft of

An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska

From: Phyllis [[redacted]
Sent: Monday, July 08, 2013 11:14 AM
To: Thomas, Jenny; White, Jessica
Subject: transmittal of comments on Bristol Bay Assessment

Attached please find two documents:
A cover letter transmitting my final comments on the Bristol Bay Environmental Assessment and a document containing the final comments.
Should you have any questions about these documents, please contact me.
Respectfully submitted,
Phyllis Weber Scannell

Dr. Phyllis Weber Scannell

July 8, 2013

Jessica White
USEPA Headquarters
Ariel Rios Building
1200 Pennsylvania Avenue, NW
Washington, DC 20460

Jenny Thomas
USEPA
Ariel Rios Building
1200 Pennsylvania Avenue, NW
Washington, DC 20460

Dear Ms White and Ms Thomas:
Attached by email is a document titled FinalCommentsPWS.docx. This comments contains the summary evaluation of EPA's response to the September 2012 peer review report of the revised Bristol Bay Environmental Assessment. This document fulfills tasks 2.1, 2.2 and 2.3 of the Statement of Work. Note that Task 1 was fulfilled by email on June 14, 2013 and EPA's acknowledgement of that email on June 17, 2013.

I have structured the referenced document in a way that I believe is most useful to EPA. The document contains the initial comment to the earlier Assessment, the EPA response, my response to the comment and my comments on how the revised Assessment satisfied the initial concerns. Should you have any questions about the information I have provided, please contact me by email or telephone. Thank you.

Respectfully submitted,

Phyllis Weber Scannell
[redacted]

Dr. Phyllis Weber Scannell

DRAFT

EPA Response to Peer Review Report

External Peer Review of EPA's Draft Document

An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska

Task 2(1):

Using the final peer review report, review comments and suggestions made on the May 2012 draft. The contractor should specifically review key suggestions provided by the Contractor in Section III

Task 2(2):

Review the EPA's response to comments document that details how EPA responded to specific comments and suggestions provided in the peer review report.

Task 2(3):

Review the revised draft Bristol Bay Assessment (Documents 3 [revised Bristol Bay Environmental Assessment] and 4 [revised Appendix I and new Appendix J]) to assess how EPA's responses to comments and suggestions were implemented in the revised draft.

.

Initial Comments by Phyllis Weber Scannell (August, 2012)
Responses by US EPA
follow on comments by
Phyllis Weber Scannell

Contents

SUMMARY OF KEY RECOMMENDATIONS FROM PEER REVIEWERS

This section summarizes the significant general recommendations put forth by the peer reviewers regarding EPA's draft assessment. In developing these recommendations, peer reviewers provided input on three major areas of the assessment: (1) scope, (2) technical content and (3) editorial suggestions. Reviewers also identified research needs for EPA to consider. Please note that this summary of peer review comments did not reflect a consensus or group perspective, but was compiled from a discussion of individual peer reviewer recommendations. Additional details, including references cited, can be found in the reviewers' individual comments in Section III.

Scope of the Document

Initial Comment from Review Team

Articulate the purpose of the document more clearly via a primer on the Ecological Risk Assessment process. If the purpose of the assessment is to inform EPA as the decision maker, then the level of detail should correspond to this purpose. The authors should justify and explain what level of detail is required.

EPA Response

Additional information on both the purpose of the assessment and ecological risk assessment (ERA) in general has been added to Chapters 1 and 2, as well as the Executive Summary. Section 1.2 includes information about the use of the assessment. The assessment has been reorganized into two major sections (problem formulation, risk analysis and characterization) to clarify where different chapters fall in the typical ERA process.

Reviewer Response

The reviewer believes that this comment has been addressed in the revised Assessment. Of particular value is the description of the authority under which the Assessment has been conducted (Section 1.1, page 1-2). The discussion of limitations of the Assessment clarifies what is addressed and what is not.

Initial Comment from Review Team

Include a statement upfront about the role of risk managers and other audiences, such as project managers/engineers, regulators, mine owners/operators. Knowing their role ensures inclusion of information necessary for any risk assessment by (1) describing the need for a risk assessment, (2) listing those decisions influenced, and (3) characterizing what risk managers require from the risk assessment.

EPA Response
Section 1.2 of the revised assessment discusses the use of the assessment.

Reviewer Response
This reviewer is satisfied that the initial comments have been addressed by Section 1.2.

Initial Comment from Review Team

Explain why the scope for human and wildlife impacts was limited to fish-mediated effects, as well as why fish-mediated effects on humans were limited to Alaska Native cultures. Reviewing effects beyond fish-mediated ones (e.g., potential for complete loss of the subsistence way of life) would improve the assessment.

EPA Response
The scope of the assessment has been clarified throughout the document, particularly in Chapters 1 and 2. Throughout the assessment we acknowledge that direct effects of large-scale mining on wildlife and Alaska Native cultures may be significant, but that these direct effects are outside the scope of the current assessment.

Reviewer Response
The reviewer understands the limitations of the Assessment and is satisfied.

Initial Comment from Review Team

Be more consistent throughout the document in terms of the level of detail provided for the different scenarios and stressors. For example, the document has devoted 36 pages to the discussion of catastrophic Tailings Storage Facility (TSF) failure, while sections on the pipeline, water treatment, and road/culvert failures are brief. Indeed, the long discussion on the TSF failure belies a certainty and understanding of dam failure dynamics that is inaccurate.

EPA Response
The final document includes more failure scenarios (e.g., diesel pipeline failure, wastewater treatment plant failure, and refined seepage scenarios) in Chapter 8. It also explains why these specific failure scenarios were chosen, and discusses these scenarios in greater detail than the previous draft (i.e., to more closely match the level of detail originally provided only for the TSF failure scenario). Also see detailed responses to comments on Peer Review Question 5.

Reviewer Response
As discussed under Peer review Question 5, the additional information on other failures is an important component of the revised Assessment. I note that failures also are discussed in

Appendix I. I also commend EPA for including references to possible long-term management of the site.

Initial Comment from Review Team

Consider the document to be a screening-level assessment of all potential stressors. Focusing on failure mode overemphasizes catastrophic events (e.g., TSF failing), rather than considering all potential stressors, such as holding mine owners strictly accountable for their day-to-day activities with regard to best practices.

EPA Response

Additional information on the purpose and scope of the assessment has been added to Chapters 1 and 2. A screening of all potential stressors, including individual chemicals, is presented in Section 6.4.2. Also see detailed responses to Peer Review Question 2 on the use of "best practices" and responses to Peer Review Question 5 on failure scenarios.

Reviewer Response

The additional information that was included in the revised assessment satisfies my concerns that were stated in the initial comment. I am especially pleased that the revised Assessment includes discussions of ions other than copper and of chemicals typically used in this type of mining.

Initial Comment from Review Team

Reexamine the document's use of historical data and case studies to describe and estimate the risk of failure for certain mine facilities (including the TSF, pipeline, water treatment, etc.), as these examples from extant mines may not be an appropriate analog for a new mine in the Bristol Bay watershed.

EPA Response

The TSF failure range was, and still is, based on design goals, not the historical data. The historical TSF failure data are provided as background. The pipeline failure rates are based on the most relevant historical data from the petroleum industry. They are directly relevant to the diesel pipeline, and experiences at the Alumbrera mine (described in the previous draft) and the Antamina and Bingham Canyon mines (added to this draft) suggest that they also are relevant to the product concentrate pipeline. Water treatment failure rates were not quantified. However, recent reviews cited in the revised draft indicate that water collection and treatment failures have been reported at nearly all analogous mines in the U.S. The estimation of culvert failure frequencies has been revised and is now based on only recent literature (2002 and later). We believe that these estimates are appropriate.

Reviewer Response

The discussion of pipeline failures in the revised Assessment also includes failures from human error. The revised Assessment contains more comprehensive discussions of different failures. I am satisfied that the revisions have addressed the initial comment.

Initial Comment from Review Team

Expand the discussion on the use of "best" management practices, as the document states that the mine scenario employs "good," but not necessarily "best" practice. For a mine developed in the Bristol Bay watershed, only "best" practice likely would be appropriate and anything less may not be permitted. Even so, without a track record of "best" practice (e.g., new technologies), we cannot assume that technology, by itself without appropriate operational management controls can always mitigate risk.

EPA Response

The term "best management practices" is a term generally applied to specific measures for managing non-point source runoff from storm water (40 CFR Part 130. 2(m)). Measures for minimizing and controlling sources of pollution in other situations often are referred to as best practices, state of the practice, good practice, conventional, or simply mitigation measures. We assume that these types of measures would be applied throughout a mine as it is constructed, operated, closed, and post-closure, and have used the term "conventional modern" throughout the assessment to refer to these measures. To remove any ambiguity related to the subjectiveness of terms "good" or "best", we have removed them in the revision and have provided definitions for relevant terms used in Box 4-1.

Reviewer Response

I agree with the changes; however, I also note the valuable information provided in Appendix I. Appendix I includes discussion of different methods for tailings disposal and the related stabilities, discussions of conventional practices for different aspects of the mining operation and discussions of "best" practices that could be used (e.g. selective flotation, page 10 of Appendix I). The information in this Appendix is a valuable contribution to the Assessment.

Initial Comment from Review Team

Adopt a broader range of mine scenarios (not only minimum and maximum) so as to bound potential impacts, especially at smaller mine sizes (e.g., 50th percentile). Underground mine development, with its different impacts, also should be considered and included in the assessment.

EPA Response

A third mine size scenario (250 million tons) has been added to the assessment, to represent the worldwide median sized porphyry copper mine (based on Singer et al. 2008).

Reviewer Response

The reviewer notes the addition of the 250-million tons mine scenario and the expanded discussions of other deposits in the region that could possibly be developed.

Initial Comment from Review Team

Based on the hypothetical mine scenario, perpetual management of the geotechnical integrity of the waste rock and tailings storage facilities, as well as perpetual water treatment and monitoring, will most likely be necessary (i.e., a “walk away” closure scenario after mining ends may not be possible). Therefore, emphasize how monitoring and management of the geotechnical integrity of waste rocks and tailing storage facilities should continue “In Perpetuity” (i.e., for at least tens of thousands of years). Discuss what conditions would need to be met to allow “walk away” closure in the Bristol Bay environment gaining insight into these observations from mines where perpetual treatment and monitoring are ongoing (e.g., the Equity Silver Mine in British Columbia).

EPA Response

The conditions for closure and the potential need for perpetual site management are discussed in general terms in the revised assessment. The primary condition assumed to be required is water chemistry that meets all criteria and permit conditions and that is stable or improving. However, even though there are some facilities with “perpetual treatment” conditions in place, there is obviously no information about how these facilities perform over very long periods of time.

Reviewer Response

In the response to the initial comments (Charge questions), I have noted various places in the document where reference to perpetual treatment and a need for sufficient bonding has been added. My initial concerns were that this issue had not been adequately highlighted. The revisions to the Assessment satisfy those concerns.

Initial Comment from Review Team

Identify, in technical detail, how exploratory effects (e.g., drill holes, blasting, overflight, etc.)

were managed. This includes roads, airstrips, helipads, camps, fuel dumps, and ATV trails that have already been developed or imposed on the watershed, and what “mitigation” already has been undertaken on those sites. Assess the consequences/impacts of these activities in the Cumulative Risks section.

EPA Response
The effects of exploratory activities are outside of the scope of this assessment.

Reviewer Response
No additional comments.

Risks to Salmonid Fish

Initial Comment from Review Team
Place potential mining impacts in the context of the entire Bristol Bay watershed by emphasizing the relative magnitude of impacts. For example, of the total salmon habitat, assess the proportion lost due to mining. Further, reflect on the non-linear nature of the relationship between habitat and salmon production; 5% of the habitat could be critical and thus responsible for 20% or more of salmon recruitment. Intrinsic potential, which measures the ability of particular habitats to support fishes, would lend credibility to this analysis.

EPA Response
We are unable to build a complete Intrinsic Potential (IP) model, as this would require validation and more elaborate construction of metrics appropriate to this region. Our preliminary characterization provides the building blocks for assessing the distribution of key habitat-forming and constraining features across these watersheds. We now include a characterization of the major drivers of habitat potential across the watershed and place the mine-site specific effects in this context (Chapters 3, 7, and 10).

Reviewer Response

The reviewer notes the additional information provided in Chapters 3, 7 and 10.

Initial Comment from Review Team

Include a section on the impact of Global Climate Change with explicit reference to a monitoring program that will allow scientists, if the mine is built, to distinguish between effects of climate change and mining effects on the physical and biological components of this ecosystem.

EPA Response

Climate change projections and potential impacts are now included in Chapter 3, and as important external factors in the risk analyses presented in Chapters 7, 9, 10, and 14. Development of a monitoring program to distinguish between mining and climate change effects is outside of the scope of the assessment.

Reviewer Response

The revised Assessment contains different references to climate change and resulting risks to the aquatic environment. For example, an increase in precipitation and flooding is discussed on page 7-59 of the revised Assessment. Possible risks from increased summer temperatures are discussed on page 8-63. The reviewer is satisfied that the issue of climate change has been integrated into the Assessment.

Initial Comment from Review Team

Explicitly recognize that the transportation corridor and all associated ancillary development, including future resource developments made possible by the initial mining project, will necessarily and inevitably have impacts (hydrologic, noise, dust, emissions, etc.). These impacts will vary in duration, intensity, severity, relative importance, spatial dispersion, and inevitably expand geographically through time with further "development." These impacts should be incorporated into the Cumulative Risks section.

EPA Response

The cumulative risk section (Chapter 13) has been expanded to include the multiple transportation corridors, ancillary mining development and secondary development associated with multiple mines in a qualitative discussion. The issues addressed in the assessment of the transportation corridor (Chapter 10) have also been expanded to include chemical spills, dust, invasive species, and road treatment salts.

Reviewer Response

The reviewer is satisfied with these changes.

Initial Comment from Review Team

Incorporate current research findings into stream crossing and culvert-design practices (e.g., arch culverts, bridges, etc.).

EPA Response

We describe current culvert design practices in a box titled “Culvert Mitigation” in Chapter 10.

Reviewer Response

The reviewer is satisfied with these changes.

Initial Comment from Review Team

Recognize in the assessment that risk and impact are not equivalent. Risk may be low, but the potential impact could be huge (e.g., in the case of a TSF failure).

EPA Response

Risk has been defined in many ways, even by risk assessors. The commenter seems to define risk as probability. To avoid that potential source of confusion, we use the term “probability” for that concept. Similarly, the commenter seems to use “impact” where we use “effect” or “magnitude of effect”. We use “risk” to refer to both concepts combined—that is, an event or effect and its probability).

Reviewer Response

Perhaps including a box with these definitions would be helpful.

Initial Comment from Review Team

Recognize and justify chronic behavioral endpoints, such as those potentially affecting survival and long-term success of fish populations.

EPA Response

The chronic behavioral effects of copper on salmonids, the primary endpoint of concern, were described in Chapter 5 and are now described in Chapter 8. Although those effects occur at lower levels of copper than conventional survival, growth and reproduction endpoints for salmonids, they are less sensitive than the conventional endpoints for aquatic invertebrates.

Reviewer Response

The reviewer is satisfied.

Wildlife

Initial Comment from Review Team

Recognize that the draft assessment did not account for all levels of ecology, such as the individual (e.g., a bald eagle nest), population, community, ecosystem, and landscape levels. Fold other levels of organization into the stressors assessment where appropriate or justify a more limited approach.

EPA Response

As is appropriate for an ecological risk assessment (as opposed to an environmental impact assessment), this assessment focuses on a specific, limited set of endpoints as defined in Chapter 5. We have added text in Chapters 2 and 5 to explain both why these endpoints were selected, and that responses other than those considered in the assessment, at multiple levels of ecological organization, are likely but are outside the scope of the assessment.

Reviewer Response

The additional information in Chapters 2 and 5 clarify the use of different endpoints. The reviewer is satisfied.

Initial Comment from Review Team

Discuss in the document fishes other than salmonids The assessment focuses on risks to sockeye salmon in the Bristol Bay watershed (and also considers anadromous salmonids, rainbow trout, and Dolly Varden), but does not account for potential impacts to other members of the resident fish community. Further, primary and secondary production, including nutrient flux was not addressed. Expanding the assessment to consider other levels of organization, including direct as well as indirect effects on wildlife and other fish, would provide additional context in the assessment of mine-related impacts.

EPA Response

See response to comment above; we also incorporated additional information from Appendices A, B, and C into the Chapter 5 text, to provide additional detail on the area's biota. We chose our endpoints for reasons described in Chapters 2 and 5. Other endpoints, including indirect effects on fish and wildlife, are now discussed more explicitly, but are generally considered outside the scope of the assessment.

Reviewer Response

My initial comments requested that some of the information in these Appendices be integrated into the main body of the Assessment. I note that this was done and believe that the expanded discussions in Chapters 2 and 5 address my initial comments.

Human Cultures

Initial Comment from Review Team

Use case histories to provide insight and anticipate mining impacts on Alaska Natives (e.g., those exemplifying the Exxon Valdez oil spill impacts, cumulative effects of oil and gas development in the North Slope region, and social impacts related to mining development in

Alaska).

EPA Response
Examples from applicable case studies, including the Exxon Valdez oil spill, are cited in Chapter 12 of the revised assessment.

Reviewer Response
Although the area of human cultures is outside my area of expertise, I note expanded discussions in Chapter 12.

Initial Comment from Review Team
As noted above (Scope of the Document), clarify why the scope was limited to fish-mediated effects. The potential direct and indirect impacts for human cultures extend far beyond fish-mediated impacts (e.g., potential complete loss of the subsistence way of life). The rationale for this narrow focus should be fully explained. In addition, a clear explanation should be given for why fish-mediated human impacts focused only on Alaska Native cultures.

EPA Response
The assessment focuses on a specific, limited set of endpoints as defined in Chapter 5. We have added text to explain both why these endpoints were selected, and that responses other than those considered in the assessment are likely but are outside the scope of the assessment. The assessment was expanded (Chapters 5 and 12) to acknowledge that there are a wide range of potential direct and indirect impacts to indigenous culture, but they are outside of the scope of this assessment. The discussion of potential effects to indigenous cultures was expanded to explain that a loss of subsistence resources would extend beyond a loss of food resources to social, cultural, and spiritual disruption. The text has been expanded to acknowledge the strong cultural ties of many non-Alaska Natives to the region, and potential effects on all residents from loss of a subsistence way of life. However, the focus of the assessment remains on effects on indigenous cultures resulting from effects on salmon.

Reviewer Response
The area of human resources is outside my area of expertise; I have no further comment.

Water Balance/Hydrology

Initial Comment from Review Team

Better characterize water resources and assess the potential effect of mine development on these resources by (1) generating a diagram similar to the conceptual models beginning on page 3-7 to illustrate the potential effects of mine construction and operation on surface- and ground-water hydrology; (2) developing a quantitative water balance and identifying water gains and losses;

(3) identifying seasonality of hydrologic processes, including frozen soils and their associated values (e.g., mm/yr) for each component of the water balance; (4) incorporating these processes into a landscape characterization; (5) evaluating how global climate change will influence these hydrologic processes and rates; and 6) using this characterization to demonstrate the expected hydrologic modification associated with the mine scenarios and infrastructure development.

EPA Response

The original Figure 4-9 (new Figure 6-5) has been revised to more clearly show water management in the assessment's mine scenarios. In addition, three schematics illustrating water flows under each of the mine size scenarios (Figures 6-8 through 6-10) have been added to Chapter 6, as have quantitative water balances for each mine size scenarios. A qualitative discussion of climate change is included in Chapters 3 (Section 3.8) and 14 (Box 14-2).

Reviewer Response

The revisions to the draft Assessment help clarify the water management issues. This reviewer is pleased that water flows are shown for each mine scenario.

Initial Comment from Review Team

Demonstrate the interconnectedness of groundwater, surface water, hyporheic zone, and its importance to fish habitat. Address how interconnectedness changes over time – seasonally, and with varying weather (e.g., wet vs. dry summers or years, and over the long term as climate changes).

EPA Response

We lack the data to demonstrate this interconnectedness in a spatially and temporally uniform manner, but do include examples of known points of high connectivity (Chapter 7) and qualitatively discuss the potential role of climate change (Chapter 3).

Reviewer Response

Section 7.3.2.1 of the revised Assessment (page 7-51) discusses the complex groundwater-surface water connectivity in the deposit area and the lack of information to describe linkages and possible changes with mine development. This chapter also discusses using the sustainability boundary approach (page 7-51). I believe the initial comment was written, in part, to request that the Assessment recognize the importance of these interconnected systems. The discussion of the sustainability boundary approach includes possible risks to aquatic habitats. I recognize the paucity of information to model these linkages and believe the general discussion presented in this section of the Assessment addresses the initial comment.

Initial Comment from Review Team

Provide information on all rivers, including ephemeral and intermittent streams, and first-order to main-stem streams that could be potentially influenced by the proposed mine, its ancillary facilities, and the transportation corridor.

EPA Response

Due to lack of consistent coverage, we rely on the NHD hydrography layer in this analysis, and can only address ephemeral and intermittent streams qualitatively (Chapter 7).

Reviewer Response

This comment highlights the need for on-the-ground surveys of potentially affected areas should mine development proceed. The need for more information was discussed in various sections of the revised Assessment.

Initial Comment from Review Team

Emphasize the importance of a thorough characterization of the leaching potential of acid-generating and non-acid generating waste rock and tailings, given the low buffering capacity and mineral content in the streams and wetlands that could receive runoff and treated water from the proposed mine. Recognize that collection and treatment of runoff and leachate generated will be critical to maintain baseline water chemistry in these streams and wetlands.

EPA Response

We agree that these are important issues, and the discussion of leachate from waste rocks and tailings has been expanded in the revised assessment (Chapter 8).

Reviewer Response

The reviewer is satisfied with the additional information.

Initial Comment from Review Team

Reference the most current geochemistry data on potentially acid-generating, non-acid generating, and metal leaching so as to describe any potential effects of seepage and changes to surface- and ground-water quality via non-catastrophic failure.

EPA Response

We used the geochemistry data in PLP's Environmental Baseline Document, as summarized by the USGS in Appendix H. The effects of seepage on water quality are analyzed in Chapter 8 of the revised assessment.

Reviewer Response
No further comment.

Initial Comment from Review Team
Explain how contaminants/metals were selected (and others ignored) by EPA as causes for concern. Information should be included on additional metals and their toxicity so as to assess impacts of potential leachates. The Pebble Limited Partnership baseline document presented additional metals that might be useful to include in the assessment.

EPA Response
The revised assessment describes the selection of contaminants and other stressors of concern in Section 6.4.2. Additional metals, process chemicals and dissolved solids are now included.

Reviewer Response
The additional discussion of other elements, process chemicals and dissolved solids addresses the initial comment.

Mitigation Measures

Initial Comment from Review Team
Incorporate the critical mitigation information from Appendix I into the main report's mine scenarios. Include standard mitigation measures that could provide insight into how well they might work in this context. If this information is not included in the main report, then justify its absence.

EPA Response
Mitigation measures incorporated into design and operation to minimize potential impacts were included in the assessment, as were some reclamation measures for closure; these measures are made clearer in the revised assessment. These mitigation measures were a sub-set of those presented in Appendix I. The assessment assumes that measures chosen for the scenarios would be effective. Mitigation to compensate for effects on aquatic resources that cannot be avoided or minimized by mine design and operation would be addressed through a regulatory process that is beyond the scope of this assessment. Nevertheless, in response to public and peer comments we have included a discussion of compensatory mitigation in Appendix J of the revised assessment.

Reviewer Response
The revised Assessment now includes more information on mitigation measures; the revised Appendix I is a valuable addition to the Assessment. The reviewer is satisfied with these changes.

Initial Comment from Review Team

Emphasize mitigation measures (e.g., minimization, compensation, reclamation) in the main report, as they ultimately influence the range of mining impacts and consider time frames of mitigation or reclamation measures (e.g., immediate response, long-term reclamation).

EPA Response

See response to previous comment. Mitigation measures are discussed at greater length in the revised assessment report (e.g., Chapter 4 and Appendix J).

Reviewer Response

The reviewer is satisfied. Further note: Appendix J presents a realistic summary of possible mitigation measures and their value in the subject area.

Uncertainties and Limitations

Initial Comment from Review Team

Clarify the uncertainty vs. certainty in Chapter 8 by (1) defining levels of uncertainty and (2) assessing the certainty of some mine impacts. Discuss data limitations in the context of uncertainty.

EPA Response

The individual analysis chapters and the revised Integrated Risk Characterization (Chapter 14) discuss certainties and data limitations to a greater extent, as suggested.

Reviewer Response

The reviewer is satisfied with the changes.

Initial Comment from Review Team

Articulate early in the document how much uncertainty is acceptable. The assessment provides little insight with respect to the decisions the document is intended to support.

EPA Response

Acceptable levels of uncertainty can be defined prior to an assessment if a decision and a decision maker are identified and if data will be collected by a specified design to implement a specified model, as described in the EPA's Data Quality Objectives process, However, because this assessment is based on available data and is intended as a background scientific document rather than a decision document, it is not possible to specify the amount of uncertainty that is acceptable. Rather, the available data determine the uncertainty and if the assessment is subsequently used to inform a decision, the decision maker must determine whether the level of uncertainty is acceptable.

Reviewer Response
The information presented in the Executive Summary and Chapter 1 clarify this. The reviewer accepts that this is an appropriate approach, given the amount of available data.

Editorial Suggestions

Initial Comment from Review Team
The title of the document leads one to believe that the assessment addresses the entire Bristol Bay watershed; rather, the report deals with two major rivers and their watersheds, the Nushagak and Kvichak. Thus, the title should be changed to reflect the emphasis on these two rivers and their watersheds. A possible title may be "An Examination (or identification) of the Potential Impacts of Mining and Mining Associated Activities on Salmon Ecosystems in the Nushagak River and Kvichak River watersheds, Bristol Bay."

EPA Response
The assessment addresses multiple scales: the Bristol Bay watershed, the Nushagak and Kvichak River watersheds, the watersheds of the three streams draining the Pebble deposit, and the watersheds crossed by the transportation corridor. These multiple scales, and how they are used throughout the assessment, are described more clearly in the revision (Chapter 2).

Reviewer Response
The reviewer has no further comment and accepts the title as is.

Initial Comment from Review Team

Revise the Executive Summary to more precisely reflect the findings in the document.

EPA Response
The Executive Summary has been rewritten to reflect the revised assessment findings.

Reviewer Response
The reviewer is satisfied with the expanded Executive Summary.

Initial Comment from Review Team

The appendices contain detailed and useful information that should be summarized and included in the main document (e.g., Appendix E: Economics, Appendix G: Road and Pipelines, and Appendix I: Mitigation). Additionally, consider expanding the preface to include information on the use of the appendices. If the information is not included in the main report, then justify its absence.

EPA Response

More information from the appendices was brought forward into appropriate chapters of the revised report. The purpose of the appendices—to provide the detailed background characterization necessary for the ecological risk assessment—has also been clarified in that material has been incorporated into Chapters 1 and 2.Chapter 2. The document no longer contains a preface because that material has been incorporated into Chapters 1 and 2.

Reviewer Response

In the response to charge questions, the reviewer noted the additional information in the main body of the document. The changes enhance the discussions and provide valuable information. The concerns of this reviewer have been satisfied.

Initial Comment from Review Team

Discuss in more detail the instructive and well-thought-out conceptual models (pages 3-7 to 3-11) illustrating the impacts of mining on Bristol Bay ecosystem processes. Also, consider expanding the conceptual models to include wildlife, fish-wildlife interactions, vegetation/terrestrial habitat, and hydrologic processes. Allow them to guide the text because they appear detailed and complete.

EPA Response

Additional information on the use of conceptual models throughout the assessment has been incorporated into Chapter 2. The more comprehensive conceptual models presented in Chapter 6 (Chapter 3 in the first draft) have been broken into their relevant component parts throughout the risk analysis and characterization chapters, to better frame the specific pathways addressed in each chapter. Additional conceptual models considering impacts on wildlife, Alaska Native populations, and cumulative effects of multiple mines have been added to Chapters 12 and 13.

Reviewer Response

Chapter 6 contains an expanded and clarified discussion of conceptual models used in the Assessment. Although Figure 3.2A-D in the earlier draft presented figures representing the conceptual models used in the Assessment, these diagrams were difficult to interpret without sufficient accompanying information. Discussions on conceptual models in the current revision have been augmented by the list of stressors (Table 6-9) and following text. The discussions in

Chapters 12 and 13 also help clarify the potential stressors and endpoints. The reviewer is satisfied that the initial comments have been addressed.

Initial Comment from Review Team

Incorporate the information contained in the conceptual models into a formal framework, such as a Bayesian or other decision-analysis models.

EPA Response

This is an excellent suggestion for future efforts, but is beyond the scope of the current assessment. Creating a Bayesian Belief Network would require that the Agency convene experts to subjectively estimate the probabilities of each transition in the conceptual models. In contrast, this assessment is intended to elucidate the risks from potential mining based on available data and analyses of those data.

A Decision Analysis would require that alternative outcomes be specified, the utility of each outcome for a decision maker be defined and the probabilities of each outcome be estimated for each possible decision so that the expected utilities of each outcome can be calculated. Because this assessment is not a decision document, these requirements are not feasible or appropriate.

Reviewer Response

The reviewer accepts the EPA response.

Initial Comment from Review Team

Generate a standard operating protocol for significant figures and use it throughout the document.

EPA Response

The authors have carefully addressed this issue. Numbers from the literature or from the PLP EBD retain the number of significant figures in the original. Numbers derived for this assessment have the appropriate number of significant figures given the precision of the input data and uncertainties due to modeling and extrapolation.

Reviewer Response

Perhaps a statement in the text could be added to explain this (there may already be such clarification, but I did not find it.)

Initial Comment from Review Team

Remove all references to Mount St. Helens as a surrogate for a TSF failure. Using a nonhuman-caused release of material into the ecosystem as an analogue for a mine failure is not comparable in terms of likelihood or risk for a human-caused release. It would be more appropriate to extrapolate from the impacts of known mine failures.

EPA Response

We are puzzled by this comment. The Mount Saint Helens data were used strictly to address the rate of benthic habitat recovery from a massive deposition of fine mineral particles. The hydrological processes that determine the recovery of substrate texture and the requirements of fish or aquatic invertebrates are not known to depend on whether mineral particles were from a natural event or an anthropogenic event. We have reviewed the literature on known mine failures. They studied tailings spills in terms of toxicity but not in terms of physical habitat effects, which is why we used Mount Saint Helens data. Nevertheless, we have removed references to Mount St. Helens in the revised assessment to eliminate concern.

Reviewer Response

The reviewer is satisfied with this change; removing reference to Mt. St. Helens eliminates potential confusions.

Initial Comment from Review Team

Ensure that the draft assessment remains part of the public record, allowing the document history to remain intact.

EPA Response

All drafts of the watershed assessment will remain part of the public record.

Reviewer Response

The reviewer appreciates that this is being done.

Research Needs

Initial Comment from Review Team

What are the acute and chronic impacts of mixtures of contaminants, including metals, acid mine drainage, etc., on the fauna and flora of the Nushagak River and Kvichak River watersheds? What species are most sensitive and might surrogate species exist for those for which we do not have data? Review the European literature and regulatory requirements for additional data.

EPA Response
The acute and chronic impacts of contaminant mixtures, including metals and acid mine drainage (i.e., metals in low pH-waters) were addressed using concentration additivity models in the leachate chemistry tables in Chapters 5 and 6 (now Chapters 8 and 11). Additional toxicity data were obtained by searches of the EU and OECD database eChem, the EPA's ECOTOX and the Environment Canada site. More metals are now included. In general, metals are most toxic to aquatic arthropods rather than fish, as discussed for copper.

Reviewer Response
The reviewer is satisfied, but realizes that should mine development go forward, it may be necessary for permit applicants to conduct specific toxicity studies. These potential studies are beyond the scope of the Assessment.

Initial Comment from Review Team

Can an inventory of nutrients, total organic carbon, and dissolved organic carbon inputs to aquatic environments be developed that demonstrates their relative magnitude and spatial variation from headwaters to Bristol Bay? What is the relative importance of marine-derived nutrients relative to other nutrients from watershed and terrestrial sources? What is the current atmospheric input of nutrients?

EPA Response
These data would be very useful in the risk assessment, but are not currently available for the Bristol Bay region. We agree this is a research need.

Reviewer Response
The reviewer agrees with the EPA response; this is a research need that should be fulfilled at the permitting stage.

Initial Comment from Review Team
What are the locations of subsistence areas and can these areas be characterized and differentiated by collecting local environmental and ecological knowledge (e.g., fish overwintering areas, climate change, ecological shifts, etc.)?

EPA Response
The revised assessment incorporated current data on subsistence use areas available from ADF&G. EPA acknowledges that these data are incomplete and would encourage additional collection of subsistence data and Traditional Ecological Knowledge.

Reviewer Response

This comment is outside my area of expertise. I defer to the other reviewers who are more qualified to comment on subsistence issues.

Initial Comment from Review Team

What impact might mining have on other important wildlife species in the basin (e.g., freshwater seals in Iliamna Lake)?

EPA Response

The scope of the assessment is focused on potential risks to salmon from large-scale mining and salmon-mediated effects to indigenous culture and wildlife. Direct effects on wildlife from large-scale mining are likely to be important and Appendix C (now a stand-alone US Fish and Wildlife report) provides useful information for a future evaluation of direct effects on wildlife from large-scale mining. We agree that this is an important area for future research.

Reviewer Response

The reviewer is satisfied.

Initial Comment from Review Team

What is the comprehensive hydrologic regime of the specific project mining area, and the broader watershed system as characterized by baseline monitoring, spatial distribution, and quantitative flow of surface- and ground-waters?

EPA Response

Comprehensive spatial estimates of mean annual flow are now presented in Chapter 3. Quantification of spatial and temporal patterns of groundwater flows is an acknowledged highly desirable product, but it not feasible within the scope of this assessment. Results of an independent groundwater-surface water modeling effort are described in Chapter 7.

Reviewer Response

This reviewer acknowledges that in-depth discussions of groundwater and surface water are beyond the scope of the Assessment and beyond the availability of information at this time. In-depth data on flows will be required should the project proceed to the permitting stage. The reviewer is satisfied that sufficient available data have been used in the Assessment.

Initial Comment from Review Team

What is the cumulative impact of commercial fisheries on the Bristol Bay watershed, especially in an ecosystem context as related to marine-derived nutrient and energy flow? Acknowledge that commercial fishing has had an impact on the amount of marine-derived nutrients returned to the watersheds.

EPA Response

The impact of commercial fisheries on the watershed is not within the scope of this assessment. Information on commercial fisheries management has been added in Box 5-2. However, the purpose of this assessment is not to assess the relative effects of potential mining and commercial fishing—it is to evaluate potential effects on endpoints if a mine were to be developed, given existing conditions and activities in the region.

Reviewer Response

One of the intents of the review committee in making this comment was to state that this is not a completely unaltered watershed; that there have been effects to the ecosystem by fishing and subsequent removal of nutrients. However, the EPA statement “given existing conditions” serves to separate pristine from existing conditions. Perhaps a statement in the Executive Summary that the Assessment examines impacts of mining activities in the existing conditions of the Bristol Bay region (for example, Page ES-4, paragraph 3: “This is not an in-depth assessment . . .”) would clarify this issue.

RESPONSES TO CHARGE QUESTIONS

Question 1

The EPA's assessment focused on identifying the impacts of potential future large-scale mining to the fish habitat and populations in these watersheds. The assessment brought together information to characterize the ecological, geological, and cultural resources of the Nushagak and Kvichak watersheds. Did this characterization provide appropriate background information for the assessment? Was this characterization accurate? Were any significant literature, reports, or data missed that would be useful to complete this characterization, and if so what are they?

Initial Comment by Reviewer

The Environmental Assessment presents a well-documented discussion of the fish and wildlife resources of the Nushagak River and Kvichak River Watersheds, with more limited discussions of the remainder of the Bristol Bay Watershed. The document discusses interactions among species, including nutrient flows and the importance of groundwater systems; however, information on contributions of marine-derived nutrients and existing pressures on the environment are not as complete, or lacking. The information is general in nature. Should mine development go forward, it will be necessary to obtain ecological information specific to the potentially affected areas. The information should include timing of fish spawning, egg hatch, in-migration and out-migration, and similar specific life-history information for important wildlife species.

Response by EPA:

We have clarified the use of information at different scales (Bristol Bay watershed and Nushagak and Kvichak River watersheds in the problem formulation chapters, smaller spatial scales in the risk analysis and characterization chapters). General information on assessment endpoints is included in Chapter 5, with more detailed information included in the appendices.

Reviewer Response

Reviewer is satisfied with this approach.

Reviewer Response to Revised Bristol Bay Assessment

The revised draft contains new sections 2.2.1 Topical Scope and 2.2.2 Spatial Scales. The section 2.2.1 defines the limits of the assessment ("we do not consider all potential sources of risk . . . ") and the focus ("potential effects on freshwater habitats").

Section 2.2.2 defines the five spatial scales used in the Assessment and the use of broader special scales for describing the physical, chemical and biological environments and effects of multiple mines.

These two sections provide needed clarity to the Assessment and satisfy the initial concerns expressed by this reviewer.

Question 2

A formal mine plan or application is not available for the porphyry copper deposits in the Bristol Bay watershed. EPA developed a hypothetical mine scenario for its risk assessment, based largely on a plan published by Northern Dynasty Minerals. Given the type and location of copper deposits in the watershed, was this hypothetical mine scenario realistic and sufficient for the assessment? Has EPA appropriately bounded the magnitude of potential mine activities with the minimum and maximum mine sizes used in the scenario? Are there significant literature, reports, or data not referenced that would be useful to refine the mine scenario, and if so what are they?

Initial Comment by Reviewer, Question 2(1)

The Environmental Assessment discusses a hypothetical mine (given that mine plans have not been developed). Page 4-5 of the document states that "rocks associated with porphyry copper deposits tend to straddle the boundary between net acidic and net alkaline . . ." The Pebble Project Environmental Baseline Report (SRK 2011, Chapter 11) summarizes testing on the samples from the pre-Tertiary porphyry mineralized rock in Pebble East Zone (PEZ) and Pebble West Zone (PWZ). The metals leaching/acid rock drainage study showed acidic conditions occurring immediately in core with low NP, but the average delay to onset of acidic conditions was estimated to be about 20 years. Copper was leached in the highest concentrations, but Co, Cd, Ni, and Zn also leached from samples from PEZ. Wacke (sedimentary rock) samples from PEZ and PWZ leached As, Sb, and Mo, in addition to Cu. (SRK, page 58). The available information on acid generation and metals leaching appears to be preliminary. Development and permitting of a viable mine plan will require extensive sampling and data analysis of ore samples, plans for classifying waste rock (as PAG and NAG), and, possibly, plans for collecting and treating runoff and seepage waters.

Response by EPA:

EPA agrees that developing and permitting a viable mine would require extensive information. The assessment is not a mining plan. The scenario presents a suggested treatment option for mining influenced water and settling ponds for water that is simply storm water runoff. No change required.

Reviewer Response

Reviewer agrees that no change is required; however, reviewer still believes that the available information on metals leaching was not adequately addressed in the initial draft Environmental Assessment. Perhaps some statement in the Assessment that addresses the need for in-depth sampling for acid generation and metals leaching would suffice. The primary concern of this reviewer is that the Assessment did not adequately discuss potential leaching of metals other than Cu and that much of the information contained in the SRK report was not used.

Reviewer Response to Revised Bristol Bay Assessment

The reviewer notes that Section 8.2.2.2 Other Metals has been added to the revised draft Assessment. This new section provides much needed information on the toxicity of elements other than Cu and recognition that these elements may be of concern. New Section 8.2.2.3 addresses concerns of total dissolved solids, a potentially significant stressor to aquatic communities. Inclusion of these two sections greatly strengthens the revised Assessment.

Initial Comment by Reviewer, Question 2(2)

The Environmental Assessment seems a bit premature in making an assessment of the potential for acid rock drainage (ARD) or metals leaching (ML). Data on metals other than Cu are insufficient and possible toxicities to fish are not addressed. Further, the description of the potential mine may not reflect a likely mine scenario. It is difficult to calculate potential risks to the environment without a specific mine plan. The section of the Environmental Assessment should be revised as more data on ARD and ML become available.

Response by EPA:

The assessment uses the geochemistry data that are available from the Pebble Limited Partnership. Copper was emphasized in the review draft because the EPA believed, and still believes, that it is the contaminant of greatest concern. Toxicities to fish of the other metals were not discussed because they had been screened out. However, the revised assessment explains the screening process and the selection of copper in more detail in a new section on the identification of stressors of concern (Section 6.4.2) and more metals have been added to the screening assessment. The toxicities of all metals reported in the leachate are now addressed either as individual elements or, in the case of major ions, as contributors to total dissolved solids. The mine scenario is based on the most recent preliminary plan released by Northern Dynasty Minerals (Ghafari et al. 2011).

Reviewer Response

The reviewer is pleased that this additional information has been added.

Reviewer Response to Revised Bristol Bay Assessment

The reviewer notes the additional information on different elements and total dissolved solids, as noted above (Comment 2(1)).

Question 3

EPA assumed two potential modes for mining operations: a no-failure mode of operation and a mode involving one or more types of failures. Is the no-failure mode of operation adequately described? Are engineering and mitigation practices sufficiently detailed, reasonable, and consistent? Are significant literature, reports, or data not referenced that would be useful to refine these scenarios, and if so what are they?

Initial Comment by Reviewer, Question 3(1)

Chapter 4 provides a detailed description of a hypothetical mine design for a porphyry copper deposit in the Bristol Bay watershed. Some of the assumptions appear to be somewhat inconsistent with mines in Alaska. In particular, the descriptions of effects on stream flows from dewatering and water use do not account for recycling process water, bypassing clean water around the project, or treating and discharging collected water.

Response by EPA:

The issues mentioned were discussed in Sections 4.2.3 (tailings storage) and 4.3.7 (water management) in the original draft document. They are now addressed in Chapter 6 of the revised document, which describes the mine scenarios, and in Chapter 4, which provides generic background on porphyry copper deposits and mining. Stream flow effects presented in Chapter 7 now reflect a complete water balance, including water capture and re-use, bypass, and discharge from the wastewater treatment facility, as suggested by the treatment.

Reviewer Response

The reviewer is pleased that this additional information has been added.

Reviewer Response to Revised Bristol Bay Assessment

Chapter 4 of the revised Assessment contains an expanded description of the chemistry and associated risks of porphyry Cu deposits (Section 4.2.2) and an expanded overview of the mining process (Section 4.2.3). Chapter 6 of the revised Assessment presents descriptions of potential mine development alternatives. The revised document has been reorganized to provide in-depth descriptions of plausible mine scenarios (Chapter 6). The descriptions of mine scenarios include expanded discussions of mining processes, ore processing, waste rock management, tailings storage facilities, and water management. Chapter 6 of the revised document provides an in-depth and needed background to the document. The reviewer also is pleased that there is recognition of the possibility of activities extending in perpetuity (page 6-16).

Much of the discussion of fish distribution has been moved to Chapter 7 of the revised Assessment. This discussion has been revised and now includes more in-depth discussions relating potential habitat loss and stressors to the mine scenarios.

The revisions to chapters 4, 6 and 7 satisfy the initial concerns raised by the reviewer.

Initial Comment by Reviewer, Question 3(2)

Section 4.3.8, Post-closure Site Management, raises critically important issues – can a mine in this area be designed for closure? Is it acceptable to develop and operate a mine that will require essentially perpetual treatment? It is my belief that these are the essential questions that should be addressed during any mine permitting process.

Response by EPA:
EPA agrees that these are important questions to be addressed, but they are risk management, not risk assessment, questions. The purpose of the assessment is to evaluate risks to the salmon fishery from large-scale mining. Risk management decisions will be made during the permitting process. Thus, no changes to the assessment were made in response to this comment.

Reviewer Response
The reviewer still believes that there is a potential risk to the salmon fishery from large-scale disturbance of a mineralized area and that the sources of risk may change over time as weathering of the exposed minerals occurs.

Reviewer Response to Revised Bristol Bay Assessment
The reviewer notes some references to the possibility of perpetual treatment in the revised document (e.g. page 6-16). I realize that the concerns raised in this comment are issues of risk management; however, I believe it was necessary to suggest the possibility for long-term management of the site.

Initial Comment by Reviewer, Question 3(3)

Section 4.3.8.1 raises concerns about long term water quality and quantity from the mine pit. These concerns need to be addressed during a mine permitting process. Pit water quality depends on how the pit is developed, what reclamation will occur, if reclamation will be concurrent with mining, and what kinds of water treatment will be used. Tailings storage facility (TSF) water quality depends on how the mine tailings are managed; it may be possible to use dry stack tailings with sulfide removal rather than submerged tailings.

Response by EPA:
EPA agrees that water quality can be influenced by design and reclamation, but when the latter entails creating a pit lake there is little flexibility for reclamation concurrent with mining. How tailings are managed within the impoundment can affect water chemistry, and a dry stack with sulfides removed may produce the best water quality results after reclamation if the fate of the

sulfide tailings is never considered. According to Ghaffari et al. (2011), 14% of the tailings produced will be pyritic, which equates to an average of 28,000 tpd in a 200,000 tpd mining operation (over 255 million tons during a 25 year mine life). These tailings need to be managed in such a manner that oxidation does not lead to acidic drainage, so the most effective way is to deposit them subaqueously. Some suggested common mitigation measures for management of the pit at and post closure are included in the revised assessment (Chapter 6).

Reviewer Response
The reviewer is pleased that a discussion of the need for mitigation and management of the pit at post closure has been included.

Reviewer Response to Revised Bristol Bay Assessment
The discussion of the mine pit (Section 6.3.1) satisfies the concerns raised in the initial comment.

Question 4

Are the potential risks to salmonid fish due to habitat loss and modification and changes in hydrology and water quality appropriately characterized and described for the no-failure mode of operation? Does the assessment appropriately describe the scale and extent of risks to salmonid fish due to operation of a transportation corridor under the no-failure mode of operation?

Initial Comment by Reviewer, Question 4(1)

The no-failure model makes a number of assumptions about how the mine will be developed – some may be accurate, some may be considerably different. It is important to take under consideration that Pebble is currently a prospect, not a mine. Should this project proceed to mine development, it will be incumbent on the mining company to develop a rigorous mine plan that includes detailed information on all aspects of a future project. This mine plan will be reviewed by state and federal staff with experience in large project development.

Response by EPA:
The EPA agrees with this comment. No changes suggested or required.

Reviewer Response
The reviewer is satisfied.

Reviewer Response to Revised Bristol Bay Assessment
The expanded descriptions of different mine scenarios contained in the revised Assessment clarify the possible sources of risk to salmonid fish.

Initial Comment by Reviewer, Question 4(2)

The no-failure model discusses the amount of riverine habitat that will be lost to mining by the mine pit, tailing storage facility, and waste rock dumps. Anadromous fish habitat is protected under Alaska Statute 16.05.840-870. The statute requires review of a project potentially affecting fish habitat and, where necessary, avoidance, mitigation, or compensation. A project must provide free passage of fish; the project cannot be placed in such a way that fish are prohibited from moving into the upstream reaches. Estimates of habitat loss from the mine footprint are not possible without a more detailed plan of operations for the mine.

Response by EPA:

The scenarios presented are meant to represent those expected as typical for mining of porphyry copper deposits of this type, and are based on preliminary mine plans from NDM (Ghafari et al. 2011). Although layout of mining components at a site may differ somewhat from what we present in the scenarios, the main components of mining will remain the same for open-pit mining. Given stream density in the area, direct losses of stream and wetland habitat of a similar magnitude would be inevitable with projects of the specified magnitudes.

Reviewer Response

The reviewer agrees.

Reviewer Response to Revised Bristol Bay Assessment

The expanded discussions of the possible mine scenarios are important additions and help clarify possible effects to the aquatic environment.

Initial Comment by Reviewer, Question 4(3)

There are many aspects of the development of a large mine project that need thorough review to ensure that habitats are protected. These include, but are not limited to: classification and storage of waste rock, lower grade ore, overburden, and high grade ore; development and maintenance of tailings storage facilities; development and concurrent reclamation of disturbed areas, including stripped areas and mine pits; collection and treatment of point and non-point source water; quantity and timing of discharges of treated water; monitoring of ground water, seepage water and surface water; and biomonitoring. The transportation corridor will require review and permitting of every stream crossing of fish-bearing waters. In addition, plans should be developed for truck wheel-washing to minimize transport of contaminated materials.

Response by EPA:
The EPA agrees that these aspects would need to be subject to a thorough review during the development and approval of a detailed mining plan. No changes suggested or required.

Reviewer Response
The reviewer is satisfied.

Reviewer Response to Revised Bristol Bay Assessment
The revised Assessment provides some discussion of the in-depth reviews that would be required during the permitting process. This information addresses the concerns raised by the reviewer.

Question 5

Do the failures outlined in the assessment reasonably represent potential system failures that could occur at a mine of the type and size outlined in the mine scenario? Is there a significant type of failure that is not described? Are the probabilities and risks of failures estimated appropriately? Is appropriate information from existing mines used to identify and estimate types and specific failure risks? If not, which existing mines might be relevant for estimating potential mining activities in the Bristol Bay Watershed?

Initial Comment by Reviewer, Question 5(1)

This section focuses on catastrophic failures; however, there are a number of non-catastrophic failures that can occur at a mine site. Non-catastrophic failures include leakage of contaminated water to ground or surface waters from PAG waste rock, the tailing storage facility, and exposed ore surfaces, and from emergency discharge of untreated water from the TSF and ore spills from trucking accidents. Such failures can be minimized or prevented with good site planning and monitoring. An additional “failure” has been experienced at a mine in Alaska when the water elevation of the tailing pond was sufficiently high to cause groundwater flow across a natural divide into an opposite drainage.

Response by EPA:
Because the number of potential failures is extremely large, it is necessary to choose a representative set of failure scenarios. The review draft contained a scenario in which tailings leachate was not fully contained and reached a stream (Section 6.3 in the May 2012 draft). The revised assessment document includes more failure scenarios (e.g., diesel pipeline failure, truck accidents, quantitative water treatment failure, and refined seepage scenarios) in Chapters 8, 10 and 11 and explains why these particular failure scenarios were chosen.

Reviewer Response
The reviewer is pleased that this section has been expanded.

Reviewer Response to Revised Bristol Bay Assessment

The sections of the revised draft that address potential failures have been substantially revised and expanded. The current draft Assessment is much improved and satisfies the concerns initially expressed by this reviewer. In particular, I note the following sections as providing important information:

Chapter 8, Section 8.1.3 provides an in-depth discussion of post-closure sources of contamination, primarily from the pit lake. This section concludes: "In sum, failure to collect and treat waters from the waste rock piles, TSFs, or mine pit could expose biota in the streams draining the post-closure mine site to contaminated water." It is important to recognize that these risks may extend in perpetuity.

Chapter 10 provides an expanded description of the transportation corridor. The explanation of bridges and culverts has been clarified (Section 5.4.1 in the previous draft; section 10.3.2.1 in the current draft).

Chapter 10, Chemical Contaminants in Stormwater Runoff (Section 10.3.3 in the current draft; Section 5.4.2 in the previous draft) has been revised. The current revision provides more thorough explanations of possible risks from storm water.

Question 6

Does the assessment appropriately characterize risks to salmonid fish due to a potential failure of water and leachate collection and treatment from the mine site? If not, what suggestions do you have for improving this part of the assessment? Are significant literature, reports, or data not referenced that would be useful to characterize these risks, and if so what are they?

Initial Comment by Reviewer, Question 6(1)

This section of the report provides an in-depth discussion of possible sources and fates of contaminated water. Chapter 6.3 discusses possible adverse effects from early mine closure or prematurely shutting down a water treatment system. These issues highlight the need for a mine plan that includes concurrent reclamation, sufficient bonding to conduct reclamation in the event of an early shut down, and plans and specifications for collection and bypass of clean water and collection and diversion to a water treatment system of contaminated water.

Response by EPA:

The EPA agrees with this comment. No change suggested or required.

Reviewer Response

The reviewer is satisfied.

Reviewer Response to Revised Bristol Bay Assessment
The reviewer agrees that no changes are needed to the Assessment. The reviewer notes information in the revised assessment that supports the need for a rigorous review and permitting process (Box 4.2) and financial assurance (Box 4.3) and references to the Red Dog Mine as requiring perpetual treatment. This additional information addresses the concerns raised by the reviewer in her initial comments.

Initial Comment by Reviewer, Question 6(2)

The Risk Characterization (Section 6.3.3) discusses possible contaminant loads to downstream waters. As stated in this section, it “serves to indicate the large potential risk from improperly managed waste rock leachate.” This statement highlights the need for an in-depth mine plan with sufficient monitoring and fail-safe provisions. An emergency discharge of untreated waters from a tailings storage facility could be made to a collection pond for later treatment or the tailings pond could be engineered to accommodate a higher flood event so the likelihood of overtopping is minimized.

Response by EPA:
The waste rock leachate scenario referenced by the commenter has been eliminated and replaced with a more detailed and realistic scenario for waste rock leachate collection and treatment (Chapter 8).

Reviewer Response
The reviewer is satisfied that this issue has been addressed.

Reviewer Response to Revised Bristol Bay Assessment
The additional information in Chapter 8 satisfies the concerns initially raised by the reviewer.

Initial Comment by Reviewer, Question 6(3)
Section 6.3.3 (Risk Characterization) states “Alternatively, water collection and treatment failure could be a result of an inadequately designed water treatment system which could result in the release of inadequately treated water as at the Red Dog Mine, Alaska (Ott and Scannell 1994, USEPA 1998, 2008). In that case, the failure could continue for years until a new or upgraded treatment system is designed and constructed.” This statement is misleading and overly simplistic; the water treatment system at the Red Dog Mine was designed to treat the predicted flows. However, the stream bypass and collection systems were constructed in 1991 to intercept seepage waters. The additional water that was collected and treated dictated construction of a second water treatment system in 1992. Sand filters were added in 1993 to remove fine particulate Zn. The issue was not that the water treatment was inadequate, but that the pre-

mining hydrologic data was insufficient and that state, federal, and mine officials lacked experience in mine construction on permafrost soils.

Response by EPA:
The water treatment failure at Red Dog was, as the commenter describes, the result of an unintended failure to design a plant that was adequate for the mine and site. The passage has been expanded to clarify the nature of the failure.

Reviewer Response
The reviewer is satisfied that this issue has been addressed.

Reviewer Response to Revised Bristol Bay Assessment
The description of water treatment failure at Red Dog (Chapter 8) is sufficiently detailed and accurate for the goals of this Assessment. The reviewer is satisfied that the initial comment has been addressed.

Initial Comment by Reviewer, Question 6(4)

Overall, the discussions of risks to salmonid fish due to a potential failure of water and leachate collection and treatment from the mine site highlight the need for more comprehensive information on groundwater, including delineating flow pathways, depth to surface, and water volumes. Additional information is needed on water collection, storage, and treatment at future mine facilities.

Response by EPA:
Discussions of wastewater collection and treatment have been considerably expanded in Chapter 8.

Reviewer Response
The reviewer is satisfied that this issue has been addressed.

Reviewer Response to Revised Bristol Bay Assessment
The discussions of wastewater collection and treatment contained in Chapter 8 of the revised Assessment are a valuable addition to the document. The initial concerns expressed by the reviewer have been addressed.

Question 7

Does the assessment appropriately characterize risks to salmonid fish due to culvert failures along the transportation corridor? If not, what suggestions do you have for improving this part of the assessment? Are significant literature, reports, or data not referenced that would be useful to characterize these risks, and if so what are they?

Initial Comment by Reviewer

The risks to salmonid fish due to culvert failures would be minimized by implementation of permits by Alaska Department of Fish and Game (ADF&G), Habitat Division. Under A.S. 16.05.840-870, Alaska has some of the most protective laws for fish and fish habitat in the United States. Further, given the lack of specific information on road alignments, construction methods and stream crossings, it is not possible to calculate lengths of affected streams, quantify loss of fish habitats, or predict failures of culverts, side slopes, etc. The document would be strengthened if it included specific information on locations of spawning and rearing habitats and estimated the contribution of fish habitats in the Nushagak River and Kvichak River Watersheds to the Bristol Bay fishery.

Response by EPA:

Best management practices (BMPs) or mitigation measures that would be used to minimize potential impacts to salmon ecosystems from construction and operation of the proposed transportation corridor are now discussed in text boxes throughout Chapter 10. Box 10-2 specifically refers to fish habitat regulations under Title 16.

As noted in the revised assessment, uncertainty exists in the characterization of streams and wetlands affected by the proposed transportation corridor. Based on the chosen road alignment scenario (which agrees with that proposed in Ghaffari et al. 2011) we feel that we are justified in estimating the potential footprint of the proposed corridor and its potential impact on fish habitats and populations. We note in the revised assessment that "Although this route (the one proposed in the EPA scenario) is not necessarily the only option for corridor placement, the assessment of potential environmental risks would not be expected to change substantially with minor shifts in road alignment. Along any feasible route, the proposed transportation corridor would cross many streams, rivers, wetlands, and extensive areas with shallow groundwater, including numerous mapped (and likely more unmapped) tributary streams to Iliamna Lake (Figures 10-1 and 10-2)."

Specific information on locations of spawning and rearing habitats along the proposed transportation corridor is difficult to obtain; as noted in the revised assessment, the Alaska Anadromous Waters Catalog and Alaska Freshwater Fish Inventory do not necessarily characterize all potential fish-bearing streams because of limited sampling along the corridor. Nonetheless, the revised assessment summarizes the species, abundances, and distributions that would potentially be affected, and places the streams along the transportation corridor into the context of the entire Nushagak and Kvichak River watersheds with respect to important watershed attributes such as discharge, channel gradient, and floodplain potential. As far as placing potential mining impacts in the context of the entire Bristol Bay watershed, we are unable to build a complete IP model, as this would require validation and more elaborate construction of metrics appropriate to this region. However, our preliminary characterization provides the building blocks for assessing the distribution of key habitat-forming and constraining features across these watersheds.

Reviewer Response

The reviewer agrees with the EPA response; however, it is important to note that extensive fish sampling before project development will be necessary to provide adequate protection to the fishery.

Reviewer Response to Revised Bristol Bay Assessment

The discussions of fish and fish habitats have been revised and expanded in the 2013 draft Assessment. Chapter 10 presents a more thorough discussion of fish presence, what sampling has been done and where there is a lack of information. This revised chapter relates the information on fish presence, abundance (where known) and habitat use to different scales of the Nushagak and Kvichak River watersheds. As presented, the reader is better able to understand the potential loss of habitat, especially with development of a transportation corridor. EPA is to be commended for this revision; Chapter 10 strengthens the entire Assessment.

Question 8

Does the assessment appropriately characterize risks to salmonid fish due to pipeline failures? If not, what suggestions do you have for improving this part of the assessment? Are significant literature, reports, or data not referenced that would be useful to characterize these risks, and if so what are they?

Initial Comment by Reviewer, Question 8(1)

This section of the document focuses on effects of pipeline failures; however, without a viable mine plan, descriptions of pipelines and estimates of possible effects are speculative. The resource developer may opt to build a pipeline to transport fuel from the coast to the mine site or slurry concentrate to the port. Construction of any pipelines would require review and approval by state and federal agencies, such approvals would likely contain monitoring plans to ensure pipeline integrity. However, the risks of pipeline failures should not be minimized; the Fort Knox Mine near Fairbanks recently experienced a 45,000 gallon spill of cyanide solution after a bulldozer struck a supply line (Fairbanks Daily News Miner, August 24, 2012).

Response by EPA:

The EPA agrees that the specific locations of pipelines and requirements for monitoring may differ from our scenario, which is based on preliminary mine plans (Ghaffari et al. 2011). However, we believe our scenario is plausible and allows an evaluation of potential impacts from pipeline failures. The Fort Knox spill has been added to the assessment as an example of spills due to human error in Section 11.1.

Reviewer Response

The reviewer is pleased that the Fort Knox spill was added as an example of human error; including the Fort Knox example demonstrates that pipeline failures can and do happen.

Reviewer Response to Revised Bristol Bay Assessment

No further comment; my concerns have been addressed.

Initial Comment by Reviewer, Question 8(2)

The risks of a pipeline failure to salmonid fish depend on the duration of the spill, the type of material spilled (return water or concentrate), the location of the spill (in the uplands or in a waterway), and the timing. The effects of a pipeline failure in a waterway when juvenile salmon are present would be far more severe than a pipeline failure in an upland area.

Response by EPA:

EPA agrees with this comment. Discussion of spill location and life stage exposed has been expanded in Section 11.3, and the other issues have been carried over from the May 2012 draft.

Reviewer Response

The reviewer is pleased that this discussion has been expanded.

Reviewer Response to Revised Bristol Bay Assessment

The revised draft Assessment has expanded the information on pipeline failures to include clearer explanation of different types of failures, probability of failure and possible effects to fish at different life stages. The arguments presented in this section (Chapter 11) are made stronger by discussing the role of human failure (page 11-6). The sections on exposure (11.3.2) and exposure-response (section 11.3.3) are well-documented and a valuable contribution to this chapter. This reviewer is pleased with the revisions made to this section; the concerns expressed in the initial comments have been satisfied.

Initial Comment by Reviewer, Question 8(3)

Given that there currently is no information on road alignments or locations of future pipelines, it is not possible to estimate the number of stream crossings (70, page 6-30) or an exact length (269 km, page 6-30) of potentially affected waterways. The risks from pipeline failures outlined in the draft document should be revised when more specific information on the mine plan of operations becomes available.

Response by EPA:
The road alignment and length in Northern Dynasty Mineral's preliminary mine plan (Ghafari et al. 2011) were used in this assessment. The number of stream crossings was also detailed in that plan, and was checked by the EPA using USGS data. We would expect that risks would be re-evaluated as part of a future specific transportation corridor plan. No change required.

Reviewer Response
The reviewer agrees that no change is required.

Reviewer Response to Revised Bristol Bay Assessment
The reviewer agrees that this comment has been adequately addressed.

Question 9
Does the assessment appropriately characterize risks to salmonid fish due to a potential tailings dam failure? If not, what suggestions do you have for improving this part of the assessment? Are significant literature, reports, or data not referenced that would be useful to characterize these risks, and if so what are they?

Initial Comment by Reviewer, Question 9(1)

The assessment considers two possible failures of the tailings dam: a partial-volume failure occurring during mine operations and a catastrophic failure occurring during or after mine operations. The partial-volume failure (as modeled in the assessment) would result in a greater than 1,000-fold increase in discharge and the catastrophic failure in a greater than 6,500-fold discharge.

Response by EPA:
No change suggested or required.

Reviewer Response
The reviewer agrees that no change is required.

Reviewer Response to Revised Bristol Bay Assessment
The reviewer agrees that this comment has been adequately addressed.

Initial Comment by Reviewer, Question 9(2

The discussion of tailings dam failures describes possible changes in channel and floodplain morphology and briefly mentions that the tailings deposition would be a source of easily transportable, potentially toxic material.

Response by EPA:
No change suggested or required.

Reviewer Response
The reviewer agrees that no change is required.

Reviewer Response to Revised Bristol Bay Assessment
The reviewer agrees that this comment has been adequately addressed.

Initial Comment by Reviewer, Question 9(3)

The potential for increased metals loadings to river and lake systems is understated. Although there are no current predictions of tailings water quality, the water quality of tailings water from similar mines could be used to model increases in metals loading from dam failures.

Response by EPA:
The original draft and the revised assessment use tailings leachate data from the PLP EBD (see Chapter 8). We believe that is more defensible than use of tailings leachates from other mines.

Reviewer Response
The reviewer agrees that no change is required.

Reviewer Response to Revised Bristol Bay Assessment
The reviewer agrees that this comment has been adequately addressed.

Initial Comment by Reviewer, Question 9(4)

In addition to the partial-volume failure and the catastrophic failure, there are other possible sources of metals loadings from the tailings pond. Examples are emergency releases of untreated tailings water, seepage of tailings water into the groundwater, and flow from the tailings pond to groundwater in an adjacent drainage as the head (i.e. hydrostatic pressure) is increased as the tailings pond is filled. The last example was experienced at the Red Dog Mine when the increased elevation of the tailings pond caused water to flow underground into the Bonns Creek drainage instead of the Red Dog Creek drainage. Interception ditches were installed after the increases in metals loading to Bonns Creek were detected.

Response by EPA:
Because the number of potential failures is extremely large, it is necessary to choose a representative set of failure scenarios. The original and revised drafts of the assessment include "seepage of tailings water into the groundwater, and flow from the tailings pond to groundwater in an adjacent drainage" but not emergency releases of tailings water.

Reviewer Response
The reviewer is satisfied.

Reviewer Response to Revised Bristol Bay Assessment
The reviewer agrees that this comment has been adequately addressed. The reviewer notes that sections on potential failures have been expanded. The current draft contains much valuable information that is presented in a clear and defensible way.

Question 10

Does the assessment appropriately characterize risks to wildlife and human cultures due to risks to fish? If not, what suggestions do you have for improving this part of the assessment? Are significant literature, reports, or data not referenced that would be useful to characterize these risks, and if so what are they?

Initial Comment by Reviewer

The document focuses on effects to wildlife that would occur from failures – tailings dam failure, pipeline failure, etc. There are other sources of disturbance to wildlife that should be addressed in a future mine plan and agency review and permitting. Other mines in Alaska limit truck traffic on the haul road during caribou migrations, incinerate all kitchen waste, educate workers on bear safety, and prohibit inappropriate disposals of food containers or other wildlife attractants. Other factors that might need to be addressed to protect wildlife are limiting air traffic and noise during certain times of the year. Unless addressed, these issues are more likely to cause detrimental effects to wildlife than dam or pipeline failures.

Response by EPA:
No change suggested or required. The EPA agrees with the reviewer that any future mine plan would require an evaluation of, and mitigation for, direct effects on wildlife.

Reviewer Response
The reviewer agrees that no change is required.

Reviewer Response to Revised Bristol Bay Assessment
The reviewer is satisfied with the revised Assessment.

Question 11

Does the assessment appropriately describe the potential for cumulative risks from multiple mines? If not, what suggestions do you have for improving this part of the assessment?

Initial Comment by Reviewer, Question 11(1)

There are two issues that should be considered: cumulative effects from a single mine and cumulative effects from multiple mines. Cumulative effects from a single mine might include aquatic habitat degradation from non-point sources, including run-off from exposed mineralized rock, seepage from the tailings impoundment, contaminated dust, noise, and other forms of disturbance.

Response by EPA:
We added a discussion on the cumulative effects from a single mine (Box 6-1), as well as discussion of multiple transportation corridors, induced development and increased access (Chapter 13).

Reviewer Response
The reviewer is satisfied that these items have been added.

Reviewer Response to Revised Bristol Bay Assessment
The additional information on cumulative effects contained in the revised Assessment satisfies the initial concerns of the reviewer.

Initial Comment by Reviewer, Question 11(1)

Cumulative effects from multiple mines are difficult to predict because there are too many unknowns. It is frequently to the advantage of a mining company to take advantage of existing infrastructure, without building new camps, new mills, etc. It is also possible to use an old mine pit for tailings or waste rock disposal from a new site; however, none of these features can be determined until there is sufficient exploration to determine if mining is feasible, to characterize the deposit, and to develop a detailed mine plan. To date, there is not sufficient information to predict cumulative effects from multiple mines.

Response by EPA:
We have expanded the discussion of cumulative impacts from multiple mines in Chapter 13. The analysis of cumulative effects is largely qualitative rather than predictive. It is a plausible example of future cumulative effects that can shed light on whether cumulative effects is an important topic for consideration as plans for mining in the Nushagak and Kvichak River watersheds move forward.

Reviewer Response
The reviewer is pleased that this discussion has been expanded.

Reviewer Response to Revised Bristol Bay Assessment
A number of changes have been made to the discussion of cumulative impacts from multiple mines. I note the following changes that are particularly valuable:

The revised assessment has expanded table 7.1 (now Table 13.1), a list of known prospects in the region. Each of these prospects is described in detail in the following text.

Tables 13.2 through 13.7 summarize the potential effects to different fish species and subsistence uses by development of different prospects in the region. These tables increase the understanding of possible cumulative effects.

The final section of Chapter 7 (Section 7.4.7 of the original draft) has been expanded to include a more in-depth discussion of the cumulative impacts of multiple mines. This discussion now includes a more thorough description of possible habitat loss (Section 13.2.7.1) and water quality degradation (13.2.7.3). The section on potential effects on assessment endpoints (Section 13.4.1) is an especially valuable contribution to the Cumulative Impacts chapter.

The changes to the Cumulative Impacts discussion address the concerns I raised in my initial comments.

Question 12

Are there reasonable mitigation measures that would reduce or minimize the mining risks and impacts beyond those already described in the assessment? What are those measures and how should they be integrated into the assessment? Realizing that there are practical issues associated with implementation, what is the likelihood of success of those measures?

Initial Comment by Reviewer, Question 12(1)

There are many avoidance or mitigation measures that would be implemented to reduce or minimize mining risks. I have described some possible approaches when answering the previous questions. To summarize:

The two most important questions for reducing or minimizing mining risks are:

Can a mine in this area be designed for closure?

Is it acceptable to develop and operate a mine that will require essentially perpetual treatment?

Response by EPA:
EPA agrees that these are key questions that must be addressed in the regulatory process. Our purpose in the assessment is to evaluate the risks resulting from a mine operated with modern conventional mitigation measures for design, operation, monitoring and maintenance, and closure. The regulatory process addresses significant and unacceptable risks. Chapter 4 of the revised assessment discusses regulatory and financial assurance requirements for mining in Alaska.

Reviewer Response
This comment by the reviewer was intended to highlight the importance of a rigorous regulatory process and the potential for long term risks to the environment; she understands and agrees with the intent of EPA's risk evaluation.

Reviewer Response to Revised Bristol Bay Assessment
The reviewer is pleased that Chapter 4 now includes a discussion of regulatory and financial assurance requirements.

Initial Comment by Reviewer, Question 12(2)
Specific Measures that can be taken to minimize risk include:

Limiting metals contamination and acid drainage:

- Design the mine pit to limit oxidation on pit walls. Where feasible, conduct concurrent reclamation.
- Develop plans for classification and storage of waste rock, lower grade ore, overburden, and high grade ore.
- Develop and maintain tailings storage facilities with fail-safe provisions. An emergency discharge of untreated waters from a tailings storage facility could be made to a collection pond for later treatment or the tailings pond could be engineered to accommodate a higher flood event so the likelihood of overtopping is minimized. Consider alternate methods for tailings disposal (dry stack following sulfide removal, etc.).
- Implement concurrent reclamation of disturbed areas, including stripped areas and mine pits.
- Collect and treat point and non-point source water.

- Design and implement plans for the quantity and timing of discharges of treated water; especially if the treated water is high in total dissolved solids. Monitor ground water, seepage water, and surface water.
- Design system for collection and bypass of clean water and collection and diversion of contaminated water to a water treatment system.
- Require stations for truck wheel washing.

Response by EPA:

Many of the measures presented here were included in the scenarios and in Appendix I and are mitigation measures commonly included for mining of this type. Other bullets noted here are good suggestions for things to address during the regulatory process, should a permit application be submitted.

Reviewer Response

The reviewer agrees that many of the issues listed above should be addressed during the regulatory process. The comment was initially made to highlight the importance of a rigorous regulatory review.

Reviewer Response to Revised Bristol Bay Assessment

The reviewer is satisfied and finds that the concerns have been addressed by additional information in the revised Assessment.

Initial Comment by Reviewer, Question 12(3)

Protection of Fish Habitat:

- Review all in-stream activities in waters important to the spawning, rearing or migration of anadromous and resident fish.
- Design and implement a biomonitoring program.
- Review every road crossing of fish bearing waters to ensure free passage of fish.
- Design and implement a biomonitoring program

Response by EPA:

Suggestions noted for consideration during any future regulatory permitting process.

Reviewer Response

The reviewer agrees that many of the issues listed above should be addressed during the regulatory process. The comment was initially made to highlight the importance of a rigorous regulatory review.

Reviewer Response to Revised Bristol Bay Assessment

The reviewer is satisfied and finds that the concerns have been addressed by additional information in the revised Assessment.

Initial Comment by Reviewer, Question 12(4)

Possible Measures to Limit Effects to Wildlife:

- At the planning stages, design aspects of the project to create or enhance wetland and aquatic habitats for fish, bird, and wildlife species.
- Limit truck traffic on the haul road during migrations.
- Incinerate all kitchen waste
- Educate workers on bear (or other wildlife) safety.
- Limit air traffic and noise during critical times of the year.

Response by EPA:

Suggestions noted for consideration during any future regulatory permitting process.

Reviewer Response

The reviewer agrees that many of the issues listed above should be addressed during the regulatory process. The comment was initially made to highlight the importance of a rigorous regulatory review.

Reviewer Response to Revised Bristol Bay Assessment

The reviewer is satisfied and finds that the concerns have been addressed by additional information in the revised Assessment.

Question 13

Does the assessment identify and evaluate the uncertainties associated with the identified risks?

Initial Comment by Reviewer, Question 13(1)

The important features of the Environmental Assessment are to describe the fish, wildlife, and human use of the subject area and to define possible risks from development of a large porphyry copper mine. There are many uncertainties associated with the identified risks and most were identified in the document. The document could be strengthened by putting a greater emphasis on sources of contamination (such as mine seepage, poorly designed collection systems, exposed pit walls, etc.) in relation to the permeability of the soils.

Response by EPA:
The revised assessment includes more emphasis on sources of contamination (e.g., diesel pipeline failure, quantitative wastewater treatment plant failure, and a refined seepage scenario) and their potential hydrologic transport including through permeable soil and rock.

Reviewer Response
The reviewer is pleased that the revised Assessment included more in-depth discussions of sources of contamination.

Reviewer Response to Revised Bristol Bay Assessment
The reviewer is satisfied and finds that the concerns have been addressed by additional information in the revised Assessment.

Initial Comment by Reviewer, Question 13(2)

The 5th bullet on page 8-11 outlines important uncertainties for protecting fish species. These uncertainties include life-stage-specific sensitivities to temperature, habitat structure, prey availability, and sublethal toxicities. These factors must be considered should a mining project go forward.

Response by EPA:
The EPA agrees with this comment. No change suggested or required.

Reviewer Response
The reviewer agrees that no change is required.

Reviewer Response to Revised Bristol Bay Assessment
The reviewer is satisfied and finds that the concerns have been addressed by additional information in the revised Assessment.

Initial Comment by Reviewer, Question 13(3)

The 6th bullet on this page discusses the preliminary nature of leaching test data. These tests must be sufficiently comprehensive to predict both short term and long term water quality from all sources, including PAG and NAG waste rock, pit walls, and pyritic tailings.

Response by EPA:
The EPA used the available leaching test data and agrees with the comments about future tests.

Reviewer Response
The reviewer agrees that no change is required.

Reviewer Response to Revised Bristol Bay Assessment
The reviewer is satisfied and finds that the concerns have been addressed by additional information in the revised Assessment.

Question 14

Are there any other comments concerning the assessment, which have not yet been addressed by the charge questions, which panel members would like to provide?

Initial Comment by Reviewer, Question 14(1)

At present, Pebble remains a prospect and there is no plan of operations for the mine. Should the project move forward to development of a mine, it will be necessary to develop an in-depth mining plan of operations. The mining plan should include the following:

- Transportation – of equipment and personnel and for shipping ore. Transportation of ore, including loading facilities, wheel washing, and other measures to prevent ore spillage and contamination.
- Siting of mine facilities, including tailings ponds, waste rock storage areas, concentrate storage area, bypass systems for clean water, and collection systems for contaminated water.
- Mill operations, including a description of the process for concentrating ore.
- Chemical and fuel storage and Spill Prevention and Contingency Plans.
- Personnel housing, including handling of domestic waste (sewage, garbage).
- Water treatment plant. Processes that will be used, anticipated concentrations of metals and TDS, anticipated discharge volumes, and predicted mass loadings.
- Monitoring plans for seepage from tailings ponds, waste rock storage areas, etc. Monitoring likely will include a series of wells and possibly, a pump-back system. •
- Predictions for acid rock generation and measures that will be put in place during mining to minimize future seepage from the mine site.
- Plans for concurrent reclamation and future closure of the mine.
- Specifications for sufficient bonding to provide site stabilization and water treatment in the event of a premature or temporary shut-down and reclamation at closure.

Response by EPA:
The commenter is correct that these are important points that should be considered in evaluation of a mining plan once submitted. No change suggested or required.

Reviewer Response

The reviewer agrees that many of the issues listed above should be addressed during the regulatory process. The comment was initially made to highlight the importance of an in-depth mining plan and rigorous regulatory review.

Reviewer Response to Revised Bristol Bay Assessment

The concerns raised by the reviewer in Question 14 have been addressed by the additional information contained in the revised Assessment. The reviewer especially notes the expanded descriptions of waste water management and potential failures, the descriptions of permitting for large mines in Alaska (Box 4.2), the need for more in-depth sampling for PAG and NAG and the expanded descriptions of potential sources of toxicity.

Initial Comment by Reviewer, Question 14(1)

After the Mine Plan of Operations is developed, an environmental assessment plan should be developed that identifies potential effects to fish and wildlife and their habitats from specific components of the mine (as listed above). In addition, the assessment should include cumulative effects of nearby mines (if appropriate) on fish and wildlife habitats and water quality.

Response by EPA:

The commenter is correct and we would expect these things to be considered during the regulatory permitting process. No change suggested or required.

Reviewer Response

The reviewer agrees that many of the issues listed above should be addressed during the regulatory process. The comment was initially made to highlight the importance of an in-depth mining plan and a rigorous regulatory review.

Reviewer Response to Revised Bristol Bay Assessment

The concerns raised by the reviewer in Question 14(1) have been addressed by the additional information contained in the revised Assessment. The reviewer especially notes the expanded descriptions of waste water management and potential failures, the descriptions of permitting for large mines in Alaska (Box 4.2), the need for more in-depth sampling for PAG and NAG and the expanded descriptions of potential sources of toxicity. In addition, Box 4.2 describes permit requirements.

Initial Comment by Reviewer, Question 14(2)

Among the most important issues that must be addressed are transportation, potential for acid mine drainage and metals leachate, control of point and non-point pollution, and developing the mine for future closure.

Response by EPA:
The commenter is correct and we would expect these things to be considered in more detail during the regulatory permitting process. No change suggested or required.

Reviewer Response
The reviewer agrees with the EPA response. The comment was initially made to highlight the importance of an in-depth mining plan and a rigorous regulatory review.

Reviewer Response to Revised Bristol Bay Assessment
The concerns raised by the reviewer in Question 14(2) have been addressed by the additional information contained in the revised Assessment. The reviewer especially notes the expanded and clarified descriptions of possible effects from transportation (including roads and culverts) and metals toxicity to fish.

3. SPECIFIC OBSERVATIONS

[NOTE: in the page notations below, S = Section, P = Paragraph, L = line]

Page 4-11:

Initial Reviewer Comment
The document states "geomembranes are generally estimated by manufactures to last 20 to 30 years when covered by tailings (North pers. comm.)." Unless North is a P.E. with experience in geomembranes, the statement needs a stronger reference. For example, Erickson et al (2008)* discuss the quality issues with geomembranes related to manufacture, installation and application of a soil-based cover (such as bentonite).

EPA RESPONSE:
The reference is appreciated, but others were chosen for use related to time of life for liners. The discussion of liners has been expanded and moved to Chapter 4 (Section 4.2.3.4) in the revision, and includes additional material and references on lifetime. The personal communication reference has been removed.

Reviewer Response
Reviewer agrees with this change, provided the appropriate references were given. North pers. comm. is not an appropriate reference, unless as stated in the initial comment, North is a PE with recognized experience pertaining to geomembranes.

Reviewer Response to Revised Bristol Bay Assessment
The reviewer notes that more appropriate citations were used in revised Section 4.2.3.4.

Page 4-23 (L1):

Initial Comment

This first sentence is confusing and implies that oxygen has low solubility because it is in the tailings pond. Suggested change: eliminate the first phrase "In a TSF".

EPA Response
The change has been made in the revised assessment.

Reviewer Response
Satisfied with change.

Reviewer Response to Revised Bristol Bay Assessment
The revised Assessment has been corrected.

Page 6-36 (P3):

Initial Comment
Last sentence states: [water] treatment would continue until institutional failures ultimately resulted in abandonment of the system, at which time untreated leachate discharges would occur. This statement is not supported by any documentation and is not clear what is being implied. Failure of governments? As stated in my response to questions, any mine plan must include sufficient bonding and plans for reclamation, including necessary water treatment.

EPA RESPONSE:
Bonding and a perpetual trust could result in treatment for some period, but it possible that long-term funding will not last to the end of time.

Reviewer Response
Satisfied with recognition that this is a potential problem.

Reviewer Response to Revised Bristol Bay Assessment
Reviewer notes that the issue of long-term or perpetual treatment is mentioned in the revised Assessment. The initial comment has been addressed.

Page 6-37 (P4):

Initial Comment

End of paragraph states "premature closure could leave waste rock piles in place." Again, there is a need for plans for mine closure, concurrent reclamation and sufficient bonding.

EPA RESPONSE:
The premature closure scenario is intended to address the possibility that the closure plan is not followed. It highlights the need for adequate bonding and for plans that include closure by some agency.

Reviewer Response
Satisfied with recognition that this is a potential problem. Adequate bonding and plans for unexpected (temporary or permanent) closure are critical.

Reviewer Response to Revised Bristol Bay Assessment
The reviewer is satisfied with the approach used in the revised Assessment.

App G, Page 5 (P 1, last line):

Initial Comment
Document states: "…other short road segments connect Dillingham to Aleknagik and Naknek to King (Figure 1)." Shouldn't King be King Salmon?

EPA RESPONSE:
Corrected.

Reviewer Response
Satisfied with correction.

Reviewer Response to Revised Bristol Bay Assessment
The revised Assessment has been corrected.

App G, Page 5 (P3):

Initial Comment

Dolly Varden should be capitalized throughout the document. The list of fish species should contain scientific names or reference a table of common and scientific names.

EPA RESPONSE:
Corrected.

Reviewer Response
Satisfied with correction.

Reviewer Response to Revised Bristol Bay Assessment
The revised Assessment has been corrected.

Initial Comment

> The document states "In the most comprehensive published field inventory, Woody and O'Neal (2010) reported." Because the authors have not reviewed other documents on field inventories, the phrase "most comprehensive" should be changed to "a comprehensive"

EPA RESPONSE:
Corrected.

Reviewer Response
Satisfied with correction.

Reviewer Response to Revised Bristol Bay Assessment
The revised Assessment has been corrected.

Additional comment on revised Assessment

The revised Assessment has been substantially re-organized and includes important additional information. EPA is to be commended for an excellent job. The revised Assessment is thoroughly documented, contains better explanations and incorporates the concerns of this reviewer.

Comments on Revised Appendix I

Revised Appendix I: Conventional Water Quality Mitigation Practices for Mine Design, Construction, Operation and Closure

Many of the comments I raised in the initial review focused on the need for sufficient planning, design, construction, management and closure of waste and water containment and for testing materials for acid rock drainage (ARD) and metals leaching (ML). I stated these concerns in the context of a need for an in-depth mining plan of operations. Appendix I addresses these concerns; Page 1, paragraph 2 states: "The most important aspects of mitigation for any mining site are proper planning, design, construction, operation, management, and closure of waste and water containment and treatment facilities, and monitoring and maintenance over all mine-life phases, including following closure." On page 3, the author addresses the issue of progressive reclamation, an additional issue I raised in my initial comments. The information contained in this Appendix satisfies many of the concerns I had with the initial Assessment. I have a few minor comments, as listed below.

Page 5, Section 1.2 Accidents and Failures.

The author states "If waste rock piles are designed properly with appropriate mitigation measures, monitored and maintained, release of contaminants is possible, but unlikely . . . " I would like to add "and the waste rock is adequately tested to classify as non-acid producing and non-metals leaching." There are examples of mines in Alaska where supposedly benign waste rock was used to construct berms, etc and later proved to be both metals leaching and acid producing because the testing to classify the rock was inadequate to predict long-term chemistry.

Section 2.1.1 Operational Phase, page 8, paragraphs 3 and 4.

The author discusses different methods for constructing tailings impoundments and their relative stabilities and the design criterion to potential earthquakes. This discussion addresses concerns raised by the review committee in our initial review.

Section 2.1.2 Closure and Post-Closure

The author states "Sufficient capital is required to finance inspections, maintenance, and repairs in post-closure for as long as the tailings exist." This section of Appendix I recognizes many of my initial comments about treatment into perpetuity and a need for sufficient bonding. I am pleased that the discussions of closure and post-closure have been included.

Overall Comments

Appendix I contains a well-documented, thorough and informative discussion of possible mitigation practices for mine design, construction, operation and closure along with possible sources of failure. The appendix is an important contribution to the Assessment and addresses many of the comments and concerns I raised in the initial review.

Comments on New Appendix J

Appendix J: Compensatory Mitigation and Large-Scale Hardrock Mining in the Bristol Bay Watershed

Appendix J provides the legal framework for compensatory mitigation (Section 1) followed by a discussion of different approaches. Section 2 relates more directly to the Bristol Bay area. Section 2 contains a summary of the important ecological functions of the headwater streams and associated wetlands in this region. These sections (1 and 2) provide background and authority for compensatory mitigation and are important additions to the revised Assessment. The Appendix next presents different opportunities for mitigation, most of which would not be beneficial. The arguments presented in this section are well-documented and clearly describe the limitations. The author concludes “There are significant challenges regarding the potential efficacy of compensation measures proposed by commenters for use in the Bristol Bay region, raising questions as to whether sufficient compensation measures exist that could address impacts of this type and magnitude.

I found this discussion to be realistic, well-documented and defensible. There are no changes I would recommend. In fact, it is well-written and provides important supporting information to the Assessment.

Dr. Paul Whitney

Peer Review Follow-On Comments on the April 2013 Draft of

An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska

From: Paul Whitney [redacted]
Sent: Wednesday, July 10, 2013 9:16 AM
To: Thomas, Jenny
Subject: Bristol Bay Peer Review

Jenny,

Here are my responses incorporated into the Peer Review document. As I have mentioned before, word processing is not a strength. You might want to have a word processor touch up my responses? Let me know if you or others have any questions.

Do I need to submit an invoice or is this submittal adequate to get the compensation going?

Paul

Dr. Paul Whitney

DRAFT
EPA Response to Peer Review Report
External Peer Review of EPA's Draft Document
An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska

11 June 2013

U.S. Environmental Protection Agency

Seattle, WA

Dr. Paul Whitney

EPA DRAFT RESPONSE TO PEER REVIEW COMMENTS

An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska

---

OVERVIEW

In May 2012, the U.S. Environmental Protection Agency (EPA) released the draft assessment entitled *An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska* (hereafter, the assessment). Because this document is considered a highly influential scientific assessment, it has strict requirements for peer review as laid out in the *EPA's Peer Review Handbook* (3rd Edition). These requirements included peer review by external expert reviewers and documentation of how peer review comments are incorporated into the revised work product.

From May to August 2012, this draft assessment was evaluated by twelve external expert reviewers; comments from these reviewers were incorporated into a final peer report, which was submitted to the EPA in September 2012. This document details the EPA's draft responses to the peer review comments received on the May 2012 draft of the report, as provided in the final peer review report. Please note that this is a draft document, and that it should not be distributed beyond the EPA and the peer reviewers. It is considered deliberative material and intended for internal use only, as the assessment continues to undergo revision. Once the assessment has been finalized, a final draft of this document will be completed and released to the public.

STRUCTURE OF THE DRAFT RESPONSE TO COMMENTS DOCUMENT

This draft response to comments document follows the structure of the final peer review report for the assessment. It is organized into two main sections:

(1) **Summary of Key Recommendations from Peer Reviewers**. This section details general big-picture issues raised by the peer reviewers in the August 2012 peer review meeting.

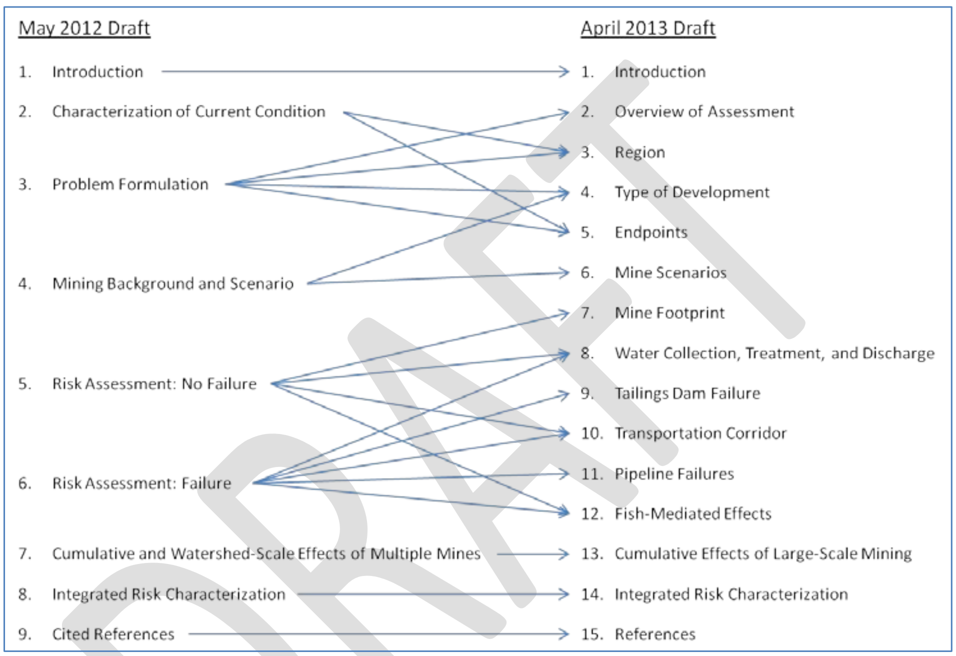
(2) **Written Peer Review Comments**. This section details each reviewer's individual comments on the assessment, organized according to general impressions, responses to charge questions, and specific observations.

Within each section, the original text from the final peer review report is included here, followed by EPA responses to the comments contained in that text (in bold italics). The EPA considered all comments provided in the final peer review report, although not all comments resulted in changes to the draft assessment. The EPA responses provided in this document explain either how the assessment was revised to address the comment, or why the assessment was not changed in response to the comment.

Dr. Paul Whitney

ORGANIZATION OF THE APRIL 2013 DRAFT ASSESSMENT

In response to several comments, the revised April 2013 draft of the assessment has been reorganized to highlight its foundation as an ecological risk assessment, improve overall clarity, and reduce redundancy. A cross-walk between chapters of the May 2012 and April 2013 drafts is provided below to help illustrate where material from the May 2012 can be found in the revised assessment.



Dr. Paul Whitney

SUMMARY OF KEY RECOMMENDATIONS FROM PEER REVIEWERS

This section summarizes the significant general recommendations put forth by the peer reviewers regarding EPA's draft assessment. In developing these recommendations, peer reviewers provided input on three major areas of the assessment: (1) scope, (2) technical content and (3) editorial suggestions. Reviewers also identified research needs for EPA to consider. Please note that this summary of peer review comments did not reflect a consensus or group perspective, but was compiled from a discussion of individual peer reviewer recommendations. Additional details, including references cited, can be found in the reviewers' individual comments in Section III.

PHW Response: The revised assessment is responsive to many of the suggestions offered by the peer review members. As a result the revised assessment is much improved.

My comments on the EPA Draft Assessment were made before I met the other members of the peer review group and before I was -familiar with their expertise. Once I was able to discuss my many concerns with other members of the peer review group it became clear that many of my concerns would be addressed by reviewers with more expertise in a particular area. For example, I was concerned about the level of detail given to water balance calculations, cone of depression and water routing. Others with mine engineering and hydrology expertise expressed similar concerns, outlined specific problems and offered more detailed suggestions for ways to improve the assessment. In this current review, I mostly defer my responses to EPA responses to those with more expertise. As a result, for the most part, I limit my responses to issues related to wildlife. If I do not offer a comment regarding an EPA response, one can assume I agree with the EPA information offered or have addressed the topic in another place in this document.

Needless to say, I do not agree with the EPA decision not to include direct impacts on wildlife and wildlife functions in their assessment. The decision to only address fish mediated impacts on wildlife side steps the facts that wildlife are an important component of the salmon ecosystem and that impacts on wildlife mediate impacts on fish. I doubt if EPA will change their position/decision based on my lone voice for a true Bristol Bay ecosystem analysis that includes direct impacts on fish and wildlife and their habitats. None-the-less, I state my contrary opinions as I feel so moved based on my scientific training. My contrary opinions are expressed one time in the following PHW Responses. I save my time and EPA's time by not repeating the same contrary opinions over and over.

Scope of the Document:

- Articulate the purpose of the document more clearly via a primer on the Ecological Risk Assessment process. If the purpose of the assessment is to inform EPA as the decision maker, then the level of detail should correspond to this purpose. The authors should justify and explain what level of detail is required.

  RESPONSE: Additional information on both the purpose of the assessment and ecological risk assessment (ERA) in general has been added to Chapters 1 and 2, as well as the

Dr. Paul Whitney

Executive Summary. Section 1.2 includes information about the use of the assessment. The assessment has been reorganized into two major sections (problem formulation, risk analysis and characterization) to clarify where different chapters fall in the typical ERA process.

- Include a statement upfront about the role of risk managers and other audiences, such as project managers/engineers, regulators, mine owners/operators. Knowing their role ensures inclusion of information necessary for any risk assessment by (1) describing the need for a risk assessment, (2) listing those decisions influenced, and (3) characterizing what risk managers require from the risk assessment.

  RESPONSE: Section 1.2 of the revised assessment discusses the use of the assessment.

- Explain why the scope for human and wildlife impacts was limited to fish-mediated effects, as well as why fish-mediated effects on humans were limited to Alaska Native cultures. Reviewing effects beyond fish-mediated ones (e.g., potential for complete loss of the subsistence way of life) would improve the assessment.

  RESPONSE: The scope of the assessment has been clarified throughout the document, particularly in Chapters 1 and 2. Throughout the assessment we acknowledge that direct effects of large-scale mining on wildlife and Alaska Native cultures may be significant, but that these direct effects are outside the scope of the current assessment.

  PHW Response: The revised assessment does a better job of clarifying that direct effects of mining on wildlife are outside the scope of the current assessment but does not explain why direct effects on wildlife are outside the scope of work. The concept that wildlife are not a component of the salmon ecosystem is not addressed. If wildlife are thought not to be a component of the salmon ecosystem, the assessment should explain why this is the case.

- Be more consistent throughout the document in terms of the level of detail provided for the different scenarios and stressors. For example, the document has devoted 36 pages to the discussion of catastrophic Tailings Storage Facility (TSF) failure, while sections on the pipeline, water treatment, and road/culvert failures are brief. Indeed, the long discussion on the TSF failure belies a certainty and understanding of dam failure dynamics that is inaccurate.

  RESPONSE: The final document includes more failure scenarios (e.g., diesel pipeline failure, wastewater treatment plant failure, and refined seepage scenarios) in Chapter 8. It also explains why these specific failure scenarios were chosen, and discusses these scenarios in greater detail than the previous draft (i.e., to more closely match the level of detail originally provided only for the TSF failure scenario). Also see detailed responses to comments on Peer Review Question 5.

Technical Content:

Mine Scenario

- Consider the document to be a screening-level assessment of all potential stressors. Focusing on failure mode overemphasizes catastrophic events (e.g., TSF failing), rather than considering all potential stressors, such as holding mine owners strictly accountable for their day-to-day activities with regard to best practices.

RESPONSE: Additional information on the purpose and scope of the assessment has been added to Chapters 1 and 2. A screening of all potential stressors, including individual chemicals, is presented in Section 6.4.2. Also see detailed responses to Peer Review Question 2 on the use of "best practices" and responses to Peer Review Question 5 on failure scenarios.

- Reexamine the document's use of historical data and case studies to describe and estimate the risk of failure for certain mine facilities (including the TSF, pipeline, water treatment, etc.), as these examples from extant mines may not be an appropriate analog for a new mine in the Bristol Bay watershed.

  RESPONSE: The TSF failure range was, and still is, based on design goals, not the historical data. The historical TSF failure data are provided as background. The pipeline failure rates are based on the most relevant historical data from the petroleum industry. They are directly relevant to the diesel pipeline, and experiences at the Alumbrera mine (described in the previous draft) and the Antamina and Bingham Canyon mines (added to this draft) suggest that they also are relevant to the product concentrate pipeline. Water treatment failure rates were not quantified. However, recent reviews cited in the revised draft indicate that water collection and treatment failures have been reported at nearly all analogous mines in the U.S. The estimation of culvert failure frequencies has been revised and is now based on only recent literature (2002 and later). We believe that these estimates are appropriate.

- Expand the discussion on the use of "best" management practices, as the document states that the mine scenario employs "good," but not necessarily "best" practice. For a mine developed in the Bristol Bay watershed, only "best" practice likely would be appropriate and anything less may not be permitted. Even so, without a track record of "best" practice (e.g., new technologies), we cannot assume that technology, by itself without appropriate operational management controls, can always mitigate risk.

  RESPONSE: The term "best management practices" is a term generally applied to specific measures for managing non-point source runoff from storm water (40 CFR Part 130.2(m)). Measures for minimizing and controlling sources of pollution in other situations often are referred to as best practices, state of the practice, good practice, conventional, or simply mitigation measures. We assume that these types of measures would be applied throughout a mine as it is constructed, operated, closed, and post-closure, and have used the term "conventional modern" throughout the assessment to refer to these measures. To remove any ambiguity related to the subjectiveness of terms "good" or "best", we have removed them in the revision and have provided definitions for relevant terms used in Box 4-1.

- Adopt a broader range of mine scenarios (not only minimum and maximum) so as to bound potential impacts, especially at smaller mine sizes (e.g., 50^{th} percentile). Underground mine development, with its different impacts, also should be considered and included in the assessment.

Dr. Paul Whitney

RESPONSE: A third mine size scenario (250 million tons) has been added to the assessment, to represent the worldwide median sized porphyry copper mine (based on Singer et al. 2008).

- Based on the hypothetical mine scenario, perpetual management of the geotechnical integrity of the waste rock and tailings storage facilities, as well as perpetual water treatment and monitoring, will most likely be necessary (i.e., a "walk away" closure scenario after mining ends may not be possible). Therefore, emphasize how monitoring and management of the geotechnical integrity of waste rocks and tailing storage facilities should continue "In Perpetuity" (i.e., for at least tens of thousands of years). Discuss what conditions would need to be met to allow "walk away" closure in the Bristol Bay environment gaining insight into these observations from mines where perpetual treatment and monitoring are ongoing (e.g., the Equity Silver Mine in British Columbia).

  RESPONSE: The conditions for closure and the potential need for perpetual site management are discussed in general terms in the revised assessment. The primary condition assumed to be required is water chemistry that meets all criteria and permit conditions and that is stable or improving. However, even though there are some facilities with "perpetual treatment" conditions in place, there is obviously no information about how these facilities perform over very long periods of time.

- Identify, in technical detail, how exploratory effects (e.g., drill holes, blasting, overflight, etc.) were managed. This includes roads, airstrips, helipads, camps, fuel dumps, and ATV trails that have already been developed or imposed on the watershed, and what "mitigation" already has been undertaken on those sites. Assess the consequences/impacts of these activities in the Cumulative Risks section.

  RESPONSE: The effects of exploratory activities are outside of the scope of this assessment.

PHW Response: If exploratory activities are outside the scope of the assessment it may not be possible to conduct a Cumulative Assessment that should address **past** activities.

Formatted: Font: Bold

Risks to Salmonid Fish

- Place potential mining impacts in the context of the entire Bristol Bay watershed by emphasizing the relative magnitude of impacts. For example, of the total salmon habitat, assess the proportion lost due to mining. Further, reflect on the non-linear nature of the relationship between habitat and salmon production; 5% of the habitat could be critical and thus responsible for 20% or more of salmon recruitment. Intrinsic potential, which measures the ability of particular habitats to support fishes, would lend credibility to this analysis.

  RESPONSE: We are unable to build a complete Intrinsic Potential (IP) model, as this would require validation and more elaborate construction of metrics appropriate to this region. Our preliminary characterization provides the building blocks for assessing the distribution of key habitat-forming and constraining features across these watersheds. We now include a characterization of the major drivers of habitat potential across the watershed and place the mine-site specific effects in this context (Chapters 3, 7, and 10).

Dr. Paul Whitney

- Include a section on the impact of Global Climate Change with explicit reference to a monitoring program that will allow scientists, if the mine is built, to distinguish between effects of climate change and mining effects on the physical and biological components of this ecosystem.

  RESPONSE: Climate change projections and potential impacts are now included in Chapter 3, and as important external factors in the risk analyses presented in Chapters 7, 9, 10, and 14. Development of a monitoring program to distinguish between mining and climate change effects is outside of the scope of the assessment.

- Explicitly recognize that the transportation corridor and all associated ancillary development, including future resource developments made possible by the initial mining project, will necessarily and inevitably have impacts (hydrologic, noise, dust, emissions, etc.). These impacts will vary in duration, intensity, severity, relative importance, spatial dispersion, and inevitably expand geographically through time with further "development." These impacts should be incorporated into the Cumulative Risks section.

  RESPONSE: The cumulative risk section (Chapter 13) has been expanded to include the multiple transportation corridors, ancillary mining development and secondary development associated with multiple mines in a qualitative discussion. The issues addressed in the assessment of the transportation corridor (Chapter 10) have also been expanded to include chemical spills, dust, invasive species, and road treatment salts. PHW Response: The Cumulative Risk Section does not address the impact of commercial fishing. Merely stating that the commercial fishery is sustainable and closely monitored does not mean that it has no impact on the salmon ecosystem. I cited Hilborn's (2005 – citation in original coments) opinion that fishing has an impact in my first set of comments and I commented that commercial fishing reduces the amount of MDN returned to the salmon ecosystem. Neither of these points are addressed.

  Formatted: Font: Not Bold, Not Italic

- Incorporate current research findings into stream crossing and culvert-design practices (e.g., arch culverts, bridges, etc.).

  RESPONSE: We describe current culvert design practices in a box titled "Culvert Mitigation" in Chapter 10.

- Recognize in the assessment that risk and impact are not equivalent. Risk may be low, but the potential impact could be huge (e.g., in the case of a TSF failure).

  RESPONSE: Risk has been defined in many ways, even by risk assessors. The commenter seems to define risk as probability. To avoid that potential source of confusion, we use the term "probability" for that concept. Similarly, the commenter seems to use "impact" where we use "effect" or "magnitude of effect". We use "risk" to refer to both concepts combined—that is, an event or effect and its probability).

- Recognize and justify chronic behavioral endpoints, such as those potentially affecting survival and long-term success of fish populations.

  RESPONSE: The chronic behavioral effects of copper on salmonids, the primary endpoint of concern, were described in Chapter 5 and are now described in Chapter 8. Although

those effects occur at lower levels of copper than conventional survival, growth and reproduction endpoints for salmonids, they are less sensitive than the conventional endpoints for aquatic invertebrates.

Wildlife

- Recognize that the draft assessment did not account for all levels of ecology, such as the individual (e.g., a bald eagle nest), population, community, ecosystem, and landscape levels. Fold other levels of organization into the stressors assessment where appropriate or justify a more limited approach.

  RESPONSE: As is appropriate for an ecological risk assessment (as opposed to an environmental impact assessment), this assessment focuses on a specific, limited set of endpoints as defined in Chapter 5. We have added text in Chapters 2 and 5 to explain both why these endpoints were selected, and that responses other than those considered in the assessment, at multiple levels of ecological organization, are likely but are outside the scope of the assessment.

  PHW Response: The revised assessment does a much better job of defining endpoints. Yet more work needs to be done to define the salmon ecosystem. For example, if multiple levels of ecological organization, such as "ecosystem" are outside the scope of the assessment as stated above, EPA should consider changing the current title of the document that focuses the assessment on "salmon ecosystems".

  EPA's assessment discusses a few ecosystem functions and passes over many others. For example, salmon perform an important ecosystem function by returning MDNs to the watershed portion of the Bristol Bay ecosystem. I can't help wonder why this ecosystem function is discussed in detail but is supposedly "outside the scope of the assessment." Wildlife provide a variety of ecosystem functions in the salmon ecosystems but are judged to be "outside the scope of the assessment." So it appears that some ecosystem functions such as returning MDNs are within the scope of work but some aspects of returning the MDN (i.e., movement of MDN to terrestrial components of the watershed are outside the scope of work. Are wildlife a component of the salmon ecosystem or not? If they are not, don't mention wildlife's role in the MDN processes. I'm not clear where the salmon ecosystem (structure and function) starts and where it stops in the watersheds.

  The assessment title states "…salmon ecosystems of Bristol Bay…" but has not included the impact of a major predator in the salmon ecosystems, commercial fishing, in Bristol Bay, as part of the analysis. Not including the impact of commercial fishing in the assessment and not comparing the impact of commercial fishing to potential impact(s) of the mine appears to side step a very important issue that should be explicitly addressed in any direct or cumulative assessment of mining impacts. Would the mine bring an end to commercial fishing in Bristol Bay? greatly reduce commercial fishing? slightly reduce commercial fishing? or have little or no effect on commercial fishing? The answer to these questions seem critical to a CWA assessment.

Formatted: Font: 11 pt, Not Bold, Not Italic

- Discuss in the document fishes other than salmonids The assessment focuses on risks to sockeye salmon in the Bristol Bay watershed (and also considers anadromous salmonids, rainbow trout, and Dolly Varden), but does not account for potential impacts to other members of the resident fish community. Further, primary and secondary production, including nutrient flux was not addressed. Expanding the assessment to consider other levels of organization, including direct as well as indirect effects on wildlife and other fish, would provide additional context in the assessment of mine-related impacts.

RESPONSE: See response to comment above; we also incorporated additional information from Appendices A, B, and C into the Chapter 5 text, to provide additional detail on the area's biota. We chose our endpoints for reasons described in Chapters 2 and 5. Other endpoints, including indirect effects on fish and wildlife, are now discussed more explicitly, but are generally considered outside the scope of the assessment.

<u>Human Cultures</u>

- Use case histories to provide insight and anticipate mining impacts on Alaska Natives (e.g., those exemplifying the Exxon Valdez oil spill impacts, cumulative effects of oil and gas development in the North Slope region, and social impacts related to mining development in Alaska).

  RESPONSE: Examples from applicable case studies, including the Exxon Valdez oil spill, are cited in Chapter 12 of the revised assessment.

- As noted above (Scope of the Document), clarify why the scope was limited to fish-mediated effects. The potential direct and indirect impacts for human cultures extend far beyond fish-mediated impacts (e.g., potential complete loss of the subsistence way of life). The rationale for this narrow focus should be fully explained. In addition, a clear explanation should be given for why fish-mediated human impacts focused only on Alaska Native cultures.

  RESPONSE: The assessment focuses on a specific, limited set of endpoints as defined in Chapter 5. We have added text to explain both why these endpoints were selected, and that responses other than those considered in the assessment are likely but are outside the scope of the assessment. The assessment was expanded (Chapters 5 and 12) to acknowledge that there are a wide range of potential direct and indirect impacts to indigenous culture, but they are outside of the scope of this assessment. The discussion of potential effects to indigenous cultures was expanded to explain that a loss of subsistence resources would extend beyond a loss of food resources to social, cultural, and spiritual disruption. The text has been expanded to acknowledge the strong cultural ties of many non-Alaska Natives to the region, and potential effects on all residents from loss of a subsistence way of life. However, the focus of the assessment remains on effects on indigenous cultures resulting from effects on salmon.

<u>Water Balance/Hydrology</u>

- Better characterize water resources and assess the potential effect of mine development on these resources by (1) generating a diagram similar to the conceptual models beginning on page 3-7 to illustrate the potential effects of mine construction and operation on surface- and ground-water hydrology; (2) developing a quantitative water balance and identifying water gains and losses; (3) identifying seasonality of hydrologic processes, including frozen soils and their associated values (e.g., mm/yr) for each component of the water balance; (4) incorporating these processes into a landscape characterization; (5) evaluating how global climate change will influence these hydrologic processes and rates; and 6) using this characterization to demonstrate the expected hydrologic modification associated with the mine scenarios and infrastructure development.

RESPONSE: The original Figure 4-9 (new Figure 6-5) has been revised to more clearly show water management in the assessment's mine scenarios. In addition, three schematics illustrating water flows under each of the mine size scenarios (Figures 6-8 through 6-10) have been added to Chapter 6, as have quantitative water balances for each mine size scenarios. A qualitative discussion of climate change is included in Chapters 3 (Section 3.8) and 14 (Box 14-2).

- Demonstrate the interconnectedness of groundwater, surface water, hyporheic zone, and its importance to fish habitat. Address how interconnectedness changes over time – seasonally, and with varying weather (e.g., wet vs. dry summers or years, and over the long term as climate changes).

  RESPONSE: We lack the data to demonstrate this interconnectedness in a spatially and temporally uniform manner, but do include examples of known points of high connectivity (Chapter 7) and qualitatively discuss the potential role of climate change (Chapter 3).

- Provide information on all rivers, including ephemeral and intermittent streams, and first-order to main-stem streams that could be potentially influenced by the proposed mine, its ancillary facilities, and the transportation corridor.

  RESPONSE: Due to lack of consistent coverage, we rely on the NHD hydrography layer in this analysis, and can only address ephemeral and intermittent streams qualitatively (Chapter 7).

- Emphasize the importance of a thorough characterization of the leaching potential of acid-generating and non-acid generating waste rock and tailings, given the low buffering capacity and mineral content in the streams and wetlands that could receive runoff and treated water from the proposed mine. Recognize that collection and treatment of runoff and leachate generated will be critical to maintain baseline water chemistry in these streams and wetlands.

  RESPONSE: We agree that these are important issues, and the discussion of leachate from waste rocks and tailings has been expanded in the revised assessment (Chapter 8).

Geochemistry/Metals

- Reference the most current geochemistry data on potentially acid-generating, non-acid generating, and metal leaching so as to describe any potential effects of seepage and changes to surface- and ground-water quality via non-catastrophic failure.

  RESPONSE: We used the geochemistry data in PLP's Environmental Baseline Document, as summarized by the USGS in Appendix H. The effects of seepage on water quality are analyzed in Chapter 8 of the revised assessment.

Dr. Paul Whitney

- Explain how contaminants/metals were selected (and others ignored) by EPA as causes for concern. Information should be included on additional metals and their toxicity so as to assess impacts of potential leachates. The Pebble Limited Partnership baseline document presented additional metals that might be useful to include in the assessment.

  RESPONSE: The revised assessment describes the selection of contaminants and other stressors of concern in Section 6.4.2. Additional metals, process chemicals and dissolved solids are now included.

Mitigation Measures

- Incorporate the critical mitigation information from Appendix I into the main report's mine scenarios. Include standard mitigation measures that could provide insight into how well they might work in this context. If this information is not included in the main report, then justify its absence.

  RESPONSE: Mitigation measures incorporated into design and operation to minimize potential impacts were included in the assessment, as were some reclamation measures for closure; these measures are made clearer in the revised assessment. These mitigation measures were a sub-set of those presented in Appendix I. The assessment assumes that measures chosen for the scenarios would be effective. Mitigation to compensate for effects on aquatic resources that cannot be avoided or minimized by mine design and operation would be addressed through a regulatory process that is beyond the scope of this assessment. Nevertheless, in response to public and peer comments we have included a discussion of compensatory mitigation in Appendix J of the revised assessment.

  PHW Response: Any discussion of CWA Section 404 should at least mention "No Net Loss" and the likelihood that No Net Loss could be achieved. The top of page 12 of Appendix J implies that No Net Loss cannot be achieved with in the salmon ecosystems of Bristol Bay. If this is the case, it should be clearly stated.

  I am pleased that Appendix J discounts the proposal to remove beaver dams.

  The EPA response to the (rhetorical) suggestion for discussion of the concept that commercial fishing could be reduced as a mitigation measure (Appendix J Section 3.3.2.6) seems to assume that commercial fishing is not at all related to or concerned with the potential impact(s) of the mine. I, on the other hand, consider commercial fishing to be an important component of the salmon ecosystem of Bristol Bay. EPAs broad jump in logic from Hilborn's paleontological analysis to the conclusion of no opportunity for mitigation is VERY wide and appears to obfuscate Hilborn's (2005) statements that fishing, as most human activities, has a negative impact on biodiversity. As stated above and below, the revised assessment would be improved by addressing commercial fishing for several reasons:

  1. A cumulative impact analysis should consider past impacts and commercial fishing has had a past impact on the salmon ecosystem.
  2. Some commercial fishermen are likely native Americans and a reduction in the commercial take could be a fish mediated impact.

Formatted: List Paragraph, Numbered + Level: 1 + Numbering Style: 1, 2, 3, … + Start at: 1 + Alignment: Left + Aligned at: 0.5" + Indent at: 0.75"

Dr. Paul Whitney

3. Commercial fishing has definitely reduced the number of fish returning to spawn and returning MDNs to the ecosystem.
4. The assessment certainly addresses the positive importance of MDNs to the salmon ecosystem. If it addresses the positive importance, it should also address the negative importance of the past loss of MDNs due to the commercial take.

Formatted: Font:

I was hoping to see some analysis of using diversion ditches as opportunities to mitigate for both wetland and riparian impacts. What I saw was a general statement that spawning channels are not good mitigation. I realize that some mitigation measures are not successful but my experience is that with proper engineering and biological success criteria plus a good monitoring program it is possible to achieve effective wetland, riparian and fish mitigation. A good example is the Weyerhaeuser Headquarters Landfill in Washington where Interfluve Consultants created good habitat for cutthroat trout out of a run-on-diversion channel around the landfill footprint. There are many more examples of effective fish mitigatin in created channels that a brief conversation with Interfluve (Hood River, Oregon) could provide.

Formatted: Font: Not Bold, Not Italic

- Emphasize mitigation measures (e.g., minimization, compensation, reclamation) in the main report, as they ultimately influence the range of mining impacts and consider time frames of mitigation or reclamation measures (e.g., immediate response, long-term reclamation).

  RESPONSE: See response to previous comment. Mitigation measures are discussed at greater length in the revised assessment report (e.g., Chapter 4 and Appendix J).

Uncertainties and Limitations

- Clarify the uncertainty vs. certainty in Chapter 8 by (1) defining levels of uncertainty and (2) assessing the certainty of some mine impacts. Discuss data limitations in the context of uncertainty.

  RESPONSE: The individual analysis chapters and the revised Integrated Risk Characterization (Chapter 14) discuss certainties and data limitations to a greater extent, as suggested.

- Articulate early in the document how much uncertainty is acceptable. The assessment provides little insight with respect to the decisions the document is intended to support.

  RESPONSE: Acceptable levels of uncertainty can be defined prior to an assessment if a decision and a decision maker are identified and if data will be collected by a specified design to implement a specified model, as described in the EPA's Data Quality Objectives process, However, because this assessment is based on available data and is intended as a background scientific document rather than a decision document, it is not possible to specify the amount of uncertainty that is acceptable. Rather, the available data determine the uncertainty and if the assessment is subsequently used to inform a decision, the decision maker must determine whether the level of uncertainty is acceptable.

Editorial Suggestions:

Dr. Paul Whitney

- The title of the document leads one to believe that the assessment addresses the entire Bristol Bay watershed; rather, the report deals with two major rivers and their watersheds, the Nushagak and Kvichak. Thus, the title should be changed to reflect the emphasis on these two rivers and their watersheds. A possible title may be "An Examination (or identification) of the Potential Impacts of Mining and Mining Associated Activities on Salmon Ecosystems in the Nushagak River and Kvichak River watersheds, Bristol Bay."

  RESPONSE: The assessment addresses multiple scales: the Bristol Bay watershed, the Nushagak and Kvichak River watersheds, the watersheds of the three streams draining the Pebble deposit, and the watersheds crossed by the transportation corridor. These multiple scales, and how they are used throughout the assessment, are described more clearly in the revision (Chapter 2).

- Revise the Executive Summary to more precisely reflect the findings in the document.

  RESPONSE: The Executive Summary has been rewritten to reflect the revised assessment findings.

- The appendices contain detailed and useful information that should be summarized and included in the main document (e.g., Appendix E: Economics, Appendix G: Road and Pipelines, and Appendix I: Mitigation). Additionally, consider expanding the preface to include information on the use of the appendices. If the information is not included in the main report, then justify its absence.

  RESPONSE: More information from the appendices was brought forward into appropriate chapters of the revised report. The purpose of the appendices—to provide the detailed background characterization necessary for the ecological risk assessment—has also been clarified in Chapter 2. The document no longer contains a preface because that material has been incorporated into Chapters 1 and 2.

- Discuss in more detail the instructive and well-thought-out conceptual models (pages 3-7 to 3-11) illustrating the impacts of mining on Bristol Bay ecosystem processes. Also, consider expanding the conceptual models to include wildlife, fish-wildlife interactions, vegetation/terrestrial habitat, and hydrologic processes. Allow them to guide the text because they appear detailed and complete.

  RESPONSE: Additional information on the use of conceptual models throughout the assessment has been incorporated into Chapter 2. The more comprehensive conceptual models presented in Chapter 6 (Chapter 3 in the first draft) have been broken into their relevant component parts throughout the risk analysis and characterization chapters, to better frame the specific pathways addressed in each chapter. Additional conceptual models considering impacts on wildlife, Alaska Native populations, and cumulative effects of multiple mines have been added to Chapters 12 and 13.

  PHW Response: The conceptual wildlife model in Chapter 12 is a good addition and clearly shows that direct effects on wildlife are outside the scope of the current assessment. See comments above and below for the need to explain **why** direct impacts on wildlife are outside the scope and why wildlife species are not a part of the salmon ecosystems of Bristol Bay.

Formatted: Font: Bold

Formatted: Font: Not Bold, Not Italic

Dr. Paul Whitney

- Incorporate the information contained in the conceptual models into a formal framework, such as a Bayesian or other decision-analysis models.

  RESPONSE: This is an excellent suggestion for future efforts, but is beyond the scope of the current assessment.

  Creating a Bayesian Belief Network would require that the Agency convene experts to subjectively estimate the probabilities of each transition in the conceptual models. In contrast, this assessment is intended to elucidate the risks from potential mining based on available data and analyses of those data.

  A Decision Analysis would require that alternative outcomes be specified, the utility of each outcome for a decision maker be defined and the probabilities of each outcome be estimated for each possible decision so that the expected utilities of each outcome can be calculated. Because this assessment is not a decision document, these requirements are not feasible or appropriate.

- Generate a standard operating protocol for significant figures and use it throughout the document.

  RESPONSE: The authors have carefully addressed this issue. Numbers from the literature or from the PLP EBD retain the number of significant figures in the original. Numbers derived for this assessment have the appropriate number of significant figures given the precision of the input data and uncertainties due to modeling and extrapolation.

- Remove all references to Mount St. Helens as a surrogate for a TSF failure. Using a non-human-caused release of material into the ecosystem as an analogue for a mine failure is not comparable in terms of likelihood or risk for a human-caused release. It would be more appropriate to extrapolate from the impacts of known mine failures.

  RESPONSE: We are puzzled by this comment. The Mount Saint Helens data were used strictly to address the rate of benthic habitat recovery from a massive deposition of fine mineral particles. The hydrological processes that determine the recovery of substrate texture and the requirements of fish or aquatic invertebrates are not known to depend on whether mineral particles were from a natural event or an anthropogenic event. We have reviewed the literature on known mine failures. They studied tailings spills in terms of toxicity but not in terms of physical habitat effects, which is why we used Mount Saint Helens data. Nevertheless, we have removed references to Mount St. Helens in the revised assessment to eliminate concern.

- Ensure that the draft assessment remains part of the public record, allowing the document history to remain intact.

  RESPONSE: All drafts of the watershed assessment will remain part of the public record.

<u>Research Needs:</u>

- What are the acute and chronic impacts of mixtures of contaminants, including metals, acid mine drainage, etc., on the fauna and flora of the Nushagak River and Kvichak River watersheds? What species are most sensitive and might surrogate species exist for those for which we do not have data? Review the European literature and regulatory requirements for additional data.

RESPONSE: The acute and chronic impacts of contaminant mixtures, including metals and acid mine drainage (i.e., metals in low pH-waters) were addressed using concentration additivity models in the leachate chemistry tables in Chapters 5 and 6 (now Chapters 8 and 11). Additional toxicity data were obtained by searches of the EU and OECD database eChem, the EPA's ECOTOX and the Environment Canada site. More metals are now included. In general, metals are most toxic to aquatic arthropods rather than fish, as discussed for copper.

- Can an inventory of nutrients, total organic carbon, and dissolved organic carbon inputs to aquatic environments be developed that demonstrates their relative magnitude and spatial variation from headwaters to Bristol Bay? What is the relative importance of marine-derived nutrients relative to other nutrients from watershed and terrestrial sources? What is the current atmospheric input of nutrients?

  RESPONSE: These data would be very useful in the risk assessment, but are not currently available for the Bristol Bay region. We agree this is a research need.

- What are the locations of subsistence areas and can these areas be characterized and differentiated by collecting local environmental and ecological knowledge (e.g., fish overwintering areas, climate change, ecological shifts, etc.)?

  RESPONSE: The revised assessment incorporated current data on subsistence use areas available from ADF&G. EPA acknowledges that these data are incomplete and would encourage additional collection of subsistence data and Traditional Ecological Knowledge.

- What impact might mining have on other important wildlife species in the basin (e.g., freshwater seals in Iliamna Lake)?

  RESPONSE: The scope of the assessment is focused on potential risks to salmon from large-scale mining and salmon-mediated effects to indigenous culture and wildlife. Direct effects on wildlife from large-scale mining are likely to be important and Appendix C (now a stand-alone US Fish and Wildlife report) provides useful information for a future evaluation of direct effects on wildlife from large-scale mining. We agree that this is an important area for future research.

- What is the comprehensive hydrologic regime of the specific project mining area, and the broader watershed system as characterized by baseline monitoring, spatial distribution, and quantitative flow of surface- and ground-waters?

  RESPONSE: Comprehensive spatial estimates of mean annual flow are now presented in Chapter 3. Quantification of spatial and temporal patterns of groundwater flows is an acknowledged highly desirable product, but it not feasible within the scope of this assessment. Results of an independent groundwater-surface water modeling effort are described in Chapter 7.

- What is the cumulative impact of commercial fisheries on the Bristol Bay watershed, especially in an ecosystem context as related to marine-derived nutrient and energy flow?

Dr. Paul Whitney

Acknowledge that commercial fishing has had an impact on the amount of marine-derived nutrients returned to the watersheds.

RESPONSE: The impact of commercial fisheries on the watershed is not within the scope of this assessment. Information on commercial fisheries management has been added in Box 5-2. However, the purpose of this assessment is not to assess the relative effects of potential mining and commercial fishing—it is to evaluate potential effects on endpoints if a mine were to be developed, given existing conditions and activities in the region.

PHW Response: The logic used here is not clear. The logic assumes commercial fishing is sustainable and therefore has no impact on salmon or the salmon ecosystem and therefore commercial fishing can be ignored without an adverse consequence to the assessment. Such an assumption is not factual. Commercial fishing kills70% of the sockeye every year. This has to have an impact on the salmon ecosystems of Bristol Bay. If this is not the case explain why and explain why Hilborn (2005) as cited in my original comments is wrong.

Dr. Paul Whitney

WRITTEN PEER REVIEW COMMENTS

1. GENERAL IMPRESSIONS

David A. Atkins, M.S.

The Bristol Bay Watershed Assessment (the Assessment) presents a comprehensive overview of current conditions in the watershed and establishes the uniqueness and global importance of the area to global salmon ecology (e.g., the report states that nearly 50% of the global sockeye salmon population comes from Bristol Bay and nearly 50% of the salmon in Bristol Bay come from the Nushagak and Kvichak Rivers, which encompass nearly half of the watershed area). The report also describes in detail the importance of the fishery to Native Alaska cultures, the importance and uniqueness of subsistence activities, and the scale of the commercial fishery. Furthermore, the report also outlines the reliance of the local economy on the salmon fishery.

RESPONSE: No change suggested or required.

There is no question that a mine, especially of the type and magnitude analyzed in the Assessment, could have significant impacts and that if these impacts are not or cannot be properly managed and/or mitigated, the consequences could be profound. The Assessment presents a mining scenario based on preliminary documents prepared for the Pebble Project, which sets out a conventional approach for development of a very large mine that includes open-pit and block-cave underground mining methods and conventional waste rock and tailings management. Development of the mine as proposed would eliminate streams and wetlands in the project area permanently. The importance of this impact is not put in context of the watershed as a whole, so it is not possible to determine the magnitude of the risk to salmon. The Assessment also did not consider whether there are any methods that could effectively minimize, mitigate or compensate for these impacts.

RESPONSE: A characterization of the landscape factors influencing salmon habitat potential is now included to provide context for the stream habitat impacts described in the document (Chapter 3). The assessment describes the magnitude of risks to salmon habitat. Due to lack of knowledge of limiting factors, ascribing comprehensive risks to salmon populations is not feasible in this assessment. Mitigation to compensate for effects on aquatic resources that cannot be avoided or minimized by mine design and operation would be addressed through a regulatory process that is beyond the scope of this assessment. Nevertheless, in response to public and peer review comments we have included a discussion of compensatory mitigation in Appendix J of the revised assessment.

The Assessment also focuses on the risk of failure of the tailings storage facility, a low probability, but high impact scenario. The Assessment further describes the potential for long-term acid and metals production from waste rock and the necessity for water treatment. Under the mining scenario as described, perpetual management of the geotechnical integrity of the waste rock and tailings storage facilities and perpetual water treatment could be necessary. In addition, failure is always a possibility, albeit a possibility that is difficult to quantify with any degree of certainty as explained in the Assessment. The Assessment also does not consider alternative engineering strategies (so called 'best practice' approaches) that could lessen the risk of failure and possibly the necessity for perpetual management and water treatment. As such, the report could be considered a screening level assessment that presents the likelihood of occurrence and corresponding consequences of failures under the presented development scenario, but does not describe the magnitude of risk to salmon.

RESPONSE: With regard to the terminology of "best", "good", or other terms for the practices used, what was intended to be conveyed in the assessment is that we assumed modern mining technology and operations. Measures for minimizing and controlling sources of pollution, outside of stormwater requirements, may be referred to as best practices, state of the practice, good practice, conventional, or simply mitigation measures. We have added a text box in the revision (Chapter 4) to discuss terms. Mitigation measures considered feasible, appropriate, and 'permittable' (as per Ghaffari et al. 2011) were considered in the assessment, and these are measures common to other copper porphyry mines. Evaluation of alternative strategies (e.g., other options presented in Appendix I) is outside the scope of this assessment, but such evaluation should be part of the permitting process for a specific mining plan. The assessment describes the magnitude of risks to salmon habitat. Due to lack of knowledge of limiting factors, production, and demographics, ascribing comprehensive risks to salmon populations is not feasible for this assessment.

Steve Buckley, M.S., CPG

The assessment attempts to evaluate the potential impacts of mining development in the Nushagak and Kvichak watersheds. The main deficiency in the assessment is that it uses only two hypothetical mine scenarios to bracket the potential impacts of mining activities on the ecological resources in the watershed. Both of these mine scenarios are larger than the 90th percentile of all porphyry copper deposits in the world. In order to properly assess the potential effects of mining activities, in the absence of any specific mining proposal, a minimum mine scenario on the order of the 50th percentile of worldwide porphyry copper deposits would be more appropriate. Three or four mine scenarios would allow for a broad range of analysis, and the reader would be able to put the potential impacts of mining development in wider perspective.

RESPONSE: A third mine size scenario (Pebble 0.25, 250 million tons) is included in the revised assessment, to represent the worldwide median size porphyry copper mine (Singer et al. 2008).

A large part of the assessment provides information related to catastrophic potential system failures such as tailings dam failures and pipeline ruptures. There is inadequate information on, and analysis of, potential mitigation measures at the early stages of mine development, which would attempt to reduce the impacts of mining activities on fish and water quality. The bulk of the document is dedicated to evaluating the impacts of tailings dam failure on aquatic resources and yet in Chapter 4, the assessment provides a probability of tailings dam failure at 1 in every 2,000 mine years.

RESPONSE: Mitigation measures were included in the draft assessment and are more clearly identified in the revision. Analysis of alternative mitigation measures would be part of a

permitting process and is outside the scope of this assessment. A discussion of compensatory mitigation in the Bristol Bay watershed has been added as Appendix J in the revised assessment.

While failures of a TSF might be rare, they do happen, their effects may be very damaging, and they could be devastating to local communities; thus, the assessment evaluates what risks might be evident should such an event occur. The revised assessment also expands the evaluation of risks for some lesser magnitude, but higher probability, events.

The assessment identifies the interconnectivity of groundwater, surface water, and fish habitat as being a major component of the quality of the fishery in the watershed yet puts relatively little effort into the analysis of the detailed relationships between groundwater, surface water, water quality, and fish habitat, even though this is likely the most important factor in assessing the potential impacts of mining activities on the fisheries in the watershed.

RESPONSE: We lack the data to demonstrate this interconnectedness in a spatially and temporally uniform manner, but do include examples of known points of high connectivity and modeled locations of high groundwater-surface water interaction (Chapter 7).

Additional mine scenarios and a more detailed investigation of the geomorphology, surface, and groundwater hydrology and their relation to fish habitat would provide the reader with a more accurate and more useful scope of analysis.

RESPONSE: We now describe the broad geomorphic context for stream habitat in the Nushagak and Kvichak River watersheds by characterizing gradient and watershed terrain (Chapter 3). The revised scenarios include an additional mine size (representative of the worldwide median size).The revision includes more failure scenarios (e.g., diesel pipeline failure, quantitative water treatment failure, and refined seepage scenarios) and explains why these particular failure scenarios were chosen.

Courtney Carothers, Ph.D.

Synopsis: EPA's draft document examines the potential impacts of large-scale mining development on the quality, quantity, and genetic diversity of salmonid fish species in the Nushagak River and Kvichak River watersheds of Bristol Bay, Alaska. To the extent that both wildlife and Alaska Native communities in the region depend upon salmonids, fish-mediated impacts to these other "endpoints of interest" are also explored. A hypothetical mining scenario, informed by current exploration, planning, and study in the Pebble deposit area, is described using minimum and maximum estimates for mine production and includes the construction of a transportation corridor to Cook Inlet. Even in the absence of any failures or accidents, construction and operation of such a mine would have significant impacts to salmonids in stream systems proximate to the mine footprint with some related impacts to wildlife and human communities. At least one or more accidents or failures are expected to occur over the long lifetime of the mine. Immediate and long-term severe impacts to salmonids are expected to occur with any significant failure, with relatedly pronounced impacts to wildlife and Alaska Native communities in the region. Multiple mines in the region would amplify these impacts.

RESPONSE: No change suggested or required.

Dr. Paul Whitney

General impressions: Overall, the main report is well-written and presents information in multiple ways, including: narrative, conceptual models, images, figures, and tables. The report synthesizes a large amount of information, much of which is described in detail in the report's appendices. The report highlights the unique characteristics of this watershed: incredibly productive and sustainable salmon fisheries, relatively little large-scale modification of the natural environment, and active subsistence-based indigenous cultures still occupying their homelands and many still using their Native language. Making central these features of the watershed, the tone of the report suggests that some negative impacts to salmonids, wildlife, and Alaska Native cultures are necessarily expected to accompany any large-scale mining development and operation in this region.

RESPONSE: No change suggested or required.

The document should provide a clear articulation of the scope of human impacts considered in this assessment. The main report considers only *fish-mediated* impacts to *Alaska Native cultures*. The restriction of scope to only fish-mediated impacts should be further clarified. A host of social, cultural, and economic impacts would accompany large-scale mining development in this region. These direct and indirect human impacts, both positive and negative, were the focus of many public comments on the EPA draft document, yet they fall outside of the scope of consideration in this report. If the narrowed scope of fish-mediated impacts is justified, these other impacts should be clearly identified as outside of the scope of this report. At times in the report (e.g., p. 5-77), these other impacts are superficially mentioned. Unless a full treatment of these impacts is included (including a presentation of a large literature explores these impacts internationally, e.g., Ballard and Banks 2003), this cursory discussion should be removed. If maintained, the narrow scope should be reiterated throughout the report to remind the reader that these larger human impacts are not considered.

RESPONSE: The scope of the assessment has been more clearly articulated in Chapter 2, which also now contains an overview conceptual model diagram demonstrating which potential sources, stressors, and responses associated with large-scale mining were considered outside of scope. The fact that direct impacts to Alaska Native cultures are not within the scope of the assessment does not imply that they will not occur or that they are unimportant, and this has been clarified in Chapters 2 and 12.

The report should articulate more clearly why Alaska Native cultures are the only human groups included in the assessment of fish-mediated human impacts. The report notes: "because…Alaska Native cultures are intimately connected and dependent upon fish, …the culture and human welfare of indigenous peoples, as affected by changes in the fisheries are additional endpoints of the assessment" (ES-1-2). This suggests that the limitation of fish-mediated human considerations to Alaska Native cultures is not due to government-to-government relationship between tribes and the federal government, nor the special status afforded by environmental justice concerns, but rather because of their close connections to, and dependence on fish. Arguably, other human groups also have connections to fish and depend upon on salmon in this region in various ways, but are excluded from analysis of potential impact in this report. This comment is not meant to detract from the importance of the focus on Alaska Native cultures and the primarily indigenous communities in this region for assessing fish-related impacts. Rather, the comment is made to suggest the inclusion of a clear justification for this focus, or the broadening of scope to include other human groups who are also connected to, and dependent upon, salmon in this region (e.g., substantial information on the economic dimensions of salmon resources in this region is summarized in Appendix E, but little is presented in the main report). Additionally, the assessment of fish-mediated effects to Alaska Native cultures is primarily focused on subsistence fisheries. More discussion of the role of commercial engagements in salmon fisheries (e.g., commercial harvesting, processing, recreational fishing businesses and employment) in the watershed communities in this region would be helpful.

RESPONSE: EPA focused on the Alaska Native communities in response to the original request we received from nine federally recognized tribal governments. The text (Chapter 12) has been expanded to acknowledge the strong cultural ties of many non-Alaska Natives to the region, and potential effects on all residents from loss of a subsistence way of life. However, the focus of the assessment remains on effects on indigenous cultures. The importance of the commercial fishery to the regional culture has been added to the text.

Dennis D. Dauble, Ph.D.

Overall, the main report and each of the accompanying appendices were well written. I was unable to identify major inaccuracies or bias in the material as presented. There were shortcomings in the main report, however. For example, some topics would benefit by being expanded (Sections 5.6 and 8.7), while others have more detail than appeared necessary (Section 6.1). The assessment effectively addressed three appropriate time periods: (1) operation, (2) post-closure, and (3) perpetuity. Potential effects are bounded by a minimum and maximum mine size, which is also appropriate. Inclusion of inference by analogy strengthened the conclusions reached in the assessment and helped validate results obtained from model predictions.

RESPONSE: Previous Section 5.6 (wildlife and culture) has now been expanded and treated as a stand-alone chapter (Chapter 12). The summary of risks from the mine scenarios (previous Section 8.7, now Chapter 14) has been expanded to include fish-mediated risks to wildlife and culture, and more numerical results are included.

Most figures and tables were useful. The conceptual models and accompanying illustrations of potential habitat effects (Figs 3-2A and C) are important because they provide a view of complicated pathways and relationships among potential activities and environmental attributes. However, these relationships are not revisited in any detail later in the document. I recommend discussing the conceptual models in more detail in the main report (Section 3.6) and summary section in Chapter 8.

RESPONSE: Additional information on the use of conceptual models throughout the assessment has been incorporated into Chapter 2. The more comprehensive conceptual models presented in Chapter 6 (previously in Chapter 3) have been broken into their relevant component parts throughout the risk analysis and characterization chapters, to better frame the specific pathways addressed in each chapter.

The Integrated Risk Assessment (Chapter 8) did a creditable job of summarizing habitat losses and risks from mine operations. What is missing, however, are quantitative descriptions of habitat lost relative to total habitat available in the larger watershed and individual systems. Habitat loss should be further discussed in terms of salmonid life stage and productivity (i.e., not all stream miles are equal).

RESPONSE: Unfortunately, no salmon habitat characterization is available for the region. The State of Alaska has not even identified all anadromous streams in the region. Productivity data are not available, even for the streams studied by the PLP. However, the revised Chapter 14 contains tables summarizing habitat loss in stream lengths and wetland areas.

If anything, the conclusions could be strengthened. The summary of uncertainties and limitations (Section 8.5) dwells on things that "could not be quantified" due to lack of information, model limitations, or insufficient resources. Thus, this reader was left somewhat in limbo as to the potential magnitude of effects from mining activities. (Note that this "neutral voice" is carried throughout the Executive Summary). Many people might interpret such statements of uncertainty as no proven effect. My point is that probable environmental consequences of mining activities are much greater than this report alludes to, given that consequences are likely, even if their magnitude is "uncertain."

RESPONSE: We use a neutral voice throughout the document to convey the neutral scientific perspective of this scientific assessment. We tried to convey the qualitative likelihood of occurrence when quantitative probabilities were not obtainable. This section has been edited in Chapter 14 of the revised version to make the relationship between uncertainty and probability of occurrence clearer.

Section 8.7 is perhaps the most important section of the report. It should be comprehensive, i.e., cover all resources and be more quantitative. Missing from the summary were impacts on wildlife, human culture, resident fish, and other ecological resources. Essential details from Appendices A, C, E, F, and I, for example, could be synthesized and moved into the main report.

RESPONSE: The summary of risks from the mine scenarios (Chapter 14 in the revised version) has been expanded to include fish-mediated risks to wildlife and culture and more numerical results.

Gordon H. Reeves, Ph.D.

The purpose of the report is unclear, which makes it difficult to assess. The report focused on the potential impact of a hypothetical mine on salmon and salmon habitat in two watersheds in Bristol Bay, AK. However, it is not clear whether the analysis was intended to be a case study of the potential impacts of a hypothetical mine under the various scenarios presented or whether the intent was to develop a framework for assessing mining scenarios. These are two very different objectives, which makes it critical that the purpose be clearly stated in the beginning of the document so that reviewers and others understand the purpose of the document. There certainly was much confusion among members of the review panel and the people who commented on the report because of this.

RESPONSE: We have clarified the purpose of the assessment in Chapters 1 and 2.

Dr. Paul Whitney

I think that the credibility of the report could be improved substantially if the analyses were formalized and more clearly articulated and defined. The authors could consider using a decision support process, such as a Bayesian approach (see Marcot, B.G., J.D. Steventon, G.D. Sutherland, and R.K. McCann. 2006. Guidelines for developing and updating Bayesian belief networks applied to ecological modeling and conservation. Canadian Journal of Forest Research 36: 3063-3074). This would provide more transparency to any analysis and allow others to better understand how results and conclusions were derived. Also, it would identify critical relations that should be considered and provide insight about the consequences of not considering them. This will undoubtedly take additional time and effort, but I believe it would be well worthwhile. Examples of where such analysis has been done are in: (1) Armstrup et al. 2008. A Bayesian Network Modeling Approach to Forecasting the 21st Century Worldwide Status of Polar Bears. Pages 213-268. *In* E.T. DeWeaver et al., editors. Artic Sea Ice Decline: Observations, Projections, Mechanisms, and Implications. Geophysical Monograph 180. American Geophysical Union, Washington, D.C.; and (2) Lee, D.C. et al. 1997. Broadscale Assessment of Aquatic Species and Habitats. Vol. III, Chapter 4. U.S. Forest Service, General Technical Report PNW-GTR-405. Portland, Oregon.

RESPONSE: Creating a Bayesian Belief Network would require that the Agency convene experts to subjectively estimate the probabilities of each transition in the conceptual models. In contrast, this assessment is intended to elucidate the risks from potential mining based on available data and analyses of those data.

I thought one of the strongest aspects of the report were the conceptual diagrams of relations between the various aspects of the development and operation of a mine and the components of the ecosystem that influence salmon and their habitat (Chapter 3). These diagrams show the components of the ecosystem, the relation among them, and how mine impacts could potentially influence given parts of the ecosystem directly or indirectly as a result of cascading effects. They are a good first step in developing a decision support framework, as suggested in the previous paragraph. There was, however, little discussion about them in the text and it was not clear if or how they were used or considered in the analyses. The authors should, at the very least, clearly identify which parts of the networks were considered and why these particular avenues were pursued and others were not. This would provide additional insights into potential limitations of the analyses and results.

RESPONSE: The more comprehensive conceptual models presented in Chapter 6 (previously in Chapter 3) have been broken into their relevant component parts throughout the risk analysis and characterization chapters, to better frame the specific pathways addressed in each chapter.

If this was a case study, the report appeared to have considered available literature and reports on all aspects of the mine, its operation and the parameters that could be affected by it. I am not familiar with this literature so it is not possible for me to comment on the adequacy of the literature and reports considered. Assumptions about the location and operation of the mine seemed reasonable and the authors clearly articulated limitations of available data and other information concerning the mine's location and operation. I found the consideration of the mine during the various phases of development and operation and the discussion about potential development of other mines in the area particularly insightful. Inclusion of experiences from other mining operations was also helpful in understanding the conclusions about potential impacts of the mine and its operation over time. Additionally, the consideration of the potential development of other mines in the area was particularly insightful and provided a good picture, albeit not in depth, of potential cumulative effects on aquatic resources in the Bristol Bay area.

RESPONSE: No changes suggested or required.

Parts of the report on the ecology of fish and aquatic ecosystems, road, and culverts – topics that I am familiar with – were covered very well and the conclusions about potential impacts of the mine and its operation generally seemed justified. The authors presented available data and information on fish distribution and abundance relative to the presumed location of the various components of the mine operation. Their analyses were appropriate but rather cursory, which is not unexpected given the restrictions of time and available data. However, there are some additional considerations and analyses that could be done, which I think would improve the report. I identify these in answers to specific charge questions. Limitations of the results were readily acknowledged. However, as mentioned above, there are additional limitations that resulted from only considering selected potential avenues of impacts. These should be discussed in the revision.

RESPONSE: The discussion of scope (Chapter 2), endpoints (Chapter 5), and uncertainties (throughout the risk analysis and characterization chapters) has been expanded in the revised assessment.

The authors do a good job of summarizing the scientific literature on salmon ecosystems, roads, and culverts. Most of this is from studies in areas outside of Bristol Bay. Interpretations of the findings were accurate. However, there was no discussion about potential limitations on the application of the studies to the area being considered. For example, Furniss et al. (1991) deals with roads in forest and rangeland settings. These are very different environments than Bristol Bay, which suggests that road impacts will likely differ. Much attention is given to "headwater streams" and their ecological importance (p. 5-19 – 5-21). Headwater streams for the area of consideration need to be defined so that appropriateness of the application of the literature can be better judged.

RESPONSE: Headwater streams in the study area are now more fully described (Chapter 7). Because the potential mining described in the assessment would take place in an undeveloped area, much of the literature is necessarily from areas outside of Bristol Bay. However, to the extent possible we used examples from representative environments. With respect to Furniss et al. (1991), though it focuses on forest and rangeland roads, it is a seminal publication on the potential effects of roads, particularly as they relate to salmon. The general conclusions of that paper should be applicable to the transportation corridor described in the assessment.

A major component that is missing from the report is consideration of the potential impacts of climate change. Climate change is identified as a factor in the conceptual model of potential habitat and water quality effects associated with mine accidents and catastrophic failures (Fig. 3-2D). However, I believe that it is a key factor that will have influence in all aspects of the assessment, not just failures and natural disturbance events (Fig. 3-2C). It needs to be considered in other aspects, such as water quality and availability. Climate change should also be included in any analysis because it will be critical to build it into any monitoring program that is developed in order to be able to differentiate its impact on salmon and their habitat from potential impacts of the mine.

RESPONSE: Climate change projections and potential impacts are now included in Chapter 3 (Section 3.8). It is mentioned as an important external factor in the risk analyses presented in Chapters 7, 9, and 10, and the issue is summarized in Box 14-2.

Charles Wesley Slaughter, Ph.D.

The Assessment (Volume 1 – Main Report) provides a fairly comprehensive review of fisheries-driven issues, from the perspective of salmonids. Appendices (Volumes 2 and 3) are very informative. The high significance of the Bristol Bay watershed, specifically of the Nushagak and Kvichak river systems, for commercial fisheries on the global scale and for sport and subsistence fisheries at the regional and local scales, was appropriately described.

RESPONSE: No changes suggested or required.

The potential risks and impacts are fairly and succinctly stated. Given the extremely long-term nature of the projected Pebble project, and the irreversible changes which would be imposed to the region, the risks seem, if anything, understated. I attribute this to the decision to focus this Assessment on salmon and anadromous fisheries, with less attention on "salmon-mediated" impacts – i.e., effects on indigenous culture, on wildlife other than salmon, etc.

RESPONSE: No changes suggested or required.

Chapter 2 (Characterization of Current Condition) provides only a superficial overview of the landscape of the Bristol Bay watersheds; a reader would preferably have access to Wahrhaftig (1965) or Selkregg (1976), as only two (relatively dated) suggestions, to gain a more comprehensive understanding of the region.

RESPONSE: Additional information on the physical environment of the region (e.g., geology, vegetation, etc.), along with an expanded treatment of the regional landscape, has been incorporated into Chapter 3 (e.g., Figures 3-4 through 3-7). Chapter 3 also includes the suggested citations.

The "Water Management" section (4.3.7) seems cursory, highly generalized, and optimistic. Statements such as "uncontrolled runoff would be eliminated"; "water from these upstream reaches would be diverted around and downstream of the mine where practicable"; and "Precipitation…would be collected and stored…" do not indicate actual (proposed) practices or techniques, nor inspire confidence that actual runoff events during "normal" conditions, let alone during hydrologic extremes (such as a rain-on-snow event with underlying soils still frozen), would be planned for or actually managed adequately.

RESPONSE: Water management measures are more clearly described and discussed in Section 6.1.2.5 of the revised draft, and in sub-sections for the mine components in the scenarios. The assessment no longer contains a no failure scenario, so complete water collection is not longer assumed. Rather, standard and common practices are incorporated.

Dr. Paul Whitney

Perhaps I missed it, but I found no acknowledgment of the potential presence of or consequences of perennially frozen soils – permafrost – in the Bristol Bay watershed, or more specifically in the Pebble ore deposit locale or the proposed transportation corridor. Selkregg (1976), Fig. 136, shows soils of the Pebble locale as INT/2g, INT/1g – HYP, or SOU/2g-HYP – that is, well-drained gravelly soils (INT) or well-drained acidic soils (SOU) with interspersed peaty, poorly-drained shallow discontinuous permafrost. There is abundant literature on the influence of permafrost on engineered structures, roads, hydrology, etc. Even if the bulk of the terrain involved in the proposed Pebble mine, road and infrastructure project is founded on well-drained gravelly soils, any interspersed permafrost-underlain terrain can prove problematic in terms of landscape stability, potential erosion, and consequent structural, engineering, hydrologic and water quality issues. See Specific Observations for a few suggested references in**.**

RESPONSE: We have expanded our characterization of the soils and permafrost distribution in the Bristol Bay watershed in Chapter 3 of the revised assessment. As part of this expansion, we summarize the nature and distribution of permafrost by physiographic region.

While there is extensive discussion of a proposed transportation corridor, there was no mention of construction of a major airfield. A project of this magnitude would undoubtedly require development of a facility in close proximity to the mine(s) capable of handling C130 and commercial jet passenger and cargo traffic, at least to the 737 class, if not 747. I don't know what the footprint for such an airfield would be, but it would be substantial, and with requisite roads, fuel handling, etc., would be a major project in itself. This would seem to be a logical component of a comprehensive assessment of the potential Pebble project.

RESPONSE: The scope of the assessment has been clarified in Chapter 2, and construction and operation of a new airport is considered outside the scope of the assessment. We would expect that a full evaluation of any future mining permit applications and subsequent National Environmental Policy Act Environmental Impact Statements would consider these effects if a new airport is proposed.

As noted in the Executive Summary, the Assessment does NOT address several major components of the (hypothetical) Pebble project, including electrical generation and transmission, a deep-water port, or "secondary development" and associated infrastructure which would follow an initial mining project. A truly comprehensive analysis should incorporate full analysis of these aspects. This Assessment is thus inadequate in terms of considering potential broader consequences for the Bristol Bay watershed system.

RESPONSE: The scope of the assessment has been clarified in Chapter 2, and we have stated throughout the text that areas outside of scope may also be important factors.

John D. Stednick, Ph.D.

The purpose of the document is not clearly stated in either the Executive Summary or the Introduction. Need to specifically identify the document as an environmental risk assessment. There is a misconception that it is a CWA Section 404(c) review, rather than an environmental risk assessment. The document should have the utility to inform future users of the risk to the watershed resources from mining activities in the watershed. The assessment can be used by others for decision making purposes, and includes current and appropriate methodologies for all identified stressors, such that study results can be duplicated. And all stressors are evaluated to a similar level of detail.

RESPONSE: Additional information on both the purpose of the assessment and ecological risk assessment (ERA) in general has been added to Chapters 1 and 2, as well as the Executive Summary. Section 1.2 includes information about the use of the assessment. The assessment has been reorganized into two major sections (problem formulation, risk analysis and characterization) to clarify where different chapters fall in the typical ERA process.

The document characterizes the potential environmental effects of an open pit mine over a copper porphyry complex in southwest Alaska using a hypothetical mine design based on similar ore deposits and mine complexes elsewhere. Proposed mine activity has been identified by the Pebble Limited Partnership though Northern Minerals Dynasty and should be cited to improve applicability of the risk assessment. Furthermore, a wider range of mining scenarios should be developed and analyzed for environmental risk assessment. Environmental consequences were estimated by the environmental risk assessment model approach for both 'no-failure' and 'failure' scenarios. The Executive Summary concluded that the effects of mine development resulted in significant salmon habitat losses. Potential effects on other aquatic species were not identified. The assessment evaluated environmental risks under the development and closure scenarios using large catastrophic events and did not include smaller, yet more frequent excursions or system failures. Nor did the assessment look at the full range of mine development scenarios, specifically what are the risks associated with a smaller underground operation?

RESPONSE: The assessment used the Pebble deposit and its characteristics, as described by Northern Dynasty Minerals in the Ghaffari et al. (2011) report. That report is cited extensively in both the original review draft and the revision. A median-sized mine (based on worldwide mine sizes) has been added to the scenarios in the revised assessment. Because the number of potential failures is extremely large, it is necessary to choose a representative set of failure scenarios. The final document includes more failure scenarios (e.g., diesel pipeline failure, quantitative water treatment failure, and refined seepage scenarios) and explains why the particular failure scenarios were chosen. Underground mining is a potential for any mining site that has high-quality ore located at depth, but sources of potential impact considered in scope for the assessment would be common for either a surface or an underground mine (e.g., water withdrawal, tailings dam failure, water treatment failure, seepage, etc).

The conclusions of the Executive Summary are strongly worded (e.g., pages ES 13 to 24), yet the uncertainties presented later in the report make the strong conclusions tenuous. An expanded discussion of uncertainties and limitations may temper those 'conclusions.'

RESPONSE: Each risk analysis chapter of the revised assessment now includes an uncertainty section. The Executive Summary has been rewritten to reflect the revised assessment text.

Site characterization/description of current conditions is too brief. More information is needed for a full site characterization. Any reader unfamiliar with the setting would not fully understand the physical, biological, or ecological inventories and linkages in the study area. The risk assessment of failure and no failure are covered in Chapters 5 and 6 with varying levels of detail and substantiation of conclusions. Statements like "salmon is important in the human diet, thus a salmon loss affects human health" seem like a weak argument, especially when additional information in the appendix suggests a larger effect.

RESPONSE: Additional information on the region's physical environment has been added to Chapter 3 (e.g., Figures 3-4 through 3-7), and additional information on the region's biological communities from Appendices A through C has been incorporated into the main text. The purpose of the appendices—to provide the detailed background characterization necessary for the ecological risk assessment—has also been clarified in Chapter 2.

The Pebble Limited Partnership has a large environmental baseline database (EBD), but does not appear to be cited or used. Justification for the inclusion or exclusion of these data should be made. Reference is often made to various data, but these data were not presented.

RESPONSE: The EBD was used and cited more than 70 times in the May 2012 review draft and even more in the revised assessment. Data from the PLP EBD concerning hydrology, water quality, and biology of the streams on the site and along the transportation corridor have been extensively incorporated into the assessment in the analyses in Chapters7 through 11. However, to the extent possible, the assessment relies on peer-reviewed literature.

Review and revise the water balance section, which would include: 1) generating a diagram or conceptual figure similar to page 3-7 to illustrate the potential effects of mine construction and operation on surface and groundwater hydrology; 2) developing a quantitative water balance for surface and groundwater resources; 3) incorporating seasonality (especially assessing the role of frozen soil); 4) identifying hydrologic processes and their associated values (e.g., mm/yr) for each component of the water balance in time and space, and then incorporating into a landscape characterization; 5) demonstrating the interconnectedness of groundwater, surface water, and the importance to fish habitat and stream productivity; 6) evaluating the influence of global climate change on these hydrologic processes and rates; and 7) using this characterization demonstrate the expected hydrologic modification associated with the mine scenarios and infrastructure development and closure scenarios.

RESPONSE:
1) We included schematics to illustrate potential effects of mine construction and operation of surface hydrology, including effects via groundwater changes (e.g., Figure 6-5, Figures 6-8 through 6-10).
2) Our water balance focuses on surface water hydrology (including interactions with groundwater). A comprehensive groundwater hydrology water balance is beyond the scope of the assessment.
3) The core of our analyses is an annual water balance, but we have maintained the simple approach to seasonality used in the first draft of the assessment.
4) We have adopted a basic approach to representing the dominant hydrologic processes at the mine site; a comprehensive representation of all hydrologic processes is beyond the scope of this assessment.
5) Throughout the assessment, we have identified and quantified the interconnectedness of surface water, groundwater, and their importance to fish habitat and stream productivity.

Dr. Paul Whitney

6) A section on potential climate change effects has been added to Chapter 3.
7) We have used our updated water balance and hydrologic modeling approaches to estimate expected responses of mine scenarios, infrastructure development and closure scenarios.

One common theme that emerged from the public comment session during the peer review meeting in Anchorage, AK was the questioning of the document timing, from draft release to the public comment period to the unannounced completion of a final document. These concerns should be addressed in the new document.

RESPONSE: This type of contextual information is not directly relevant to the ecological risk assessment, but clarification of the timing and use of the assessment has been included in Chapter 1.

Roy A. Stein, Ph.D.

Accuracy of Presentation. Overall, I was pleased with the accuracy of the presentation. Typically, peer-reviewed citations to the scientific literature were cited as supportive documentation for most all of the factual information (though the well-developed appendices, e.g., Appendix E: Economics; Appendix I: Mitigation, could be used to far better advantage, see below). Unfortunately, in the main report, many data are missing, especially with regard to salmonid populations, their diversity (both across species wand within species across populations), their relative population sizes, their distribution across the watershed, their vital rates (i.e., recruitment, growth, and survival across life stages), and to what extent the Pebble Mine and its associated activities will reduce these populations (for there is no question they will indeed be reduced through both the mine footprint and all allied operations in the drainage), both through impacts on individual populations and the overall production of salmonids (and other fishes) in the Bristol Bay watershed.

RESPONSE: We now include figures showing reported salmon species distributions and salmon diversity by HUC-12 watersheds across the Nushagak and Kvichak River watersheds (Figures 5-3 through 5-8). Information on population sizes and vital rates are limited for the region, but are reported where known. Due to lack of comprehensive estimates of limiting factors across the impacted watersheds, population-level effects could not be quantitatively estimated except for the most severe cases, where total losses of runs could be reasonably assumed.

Whereas I am relatively confident about accuracy of the fisheries information included, I cannot comment in detail regarding the accuracy of the mining information or impacts on the Native Alaskan cultures (though the impact of the mine on this culture was confined to fish-mediated effects). That a Native Alaskan culture 4,000 years old is in jeopardy bothers me greatly; might this complete subsistence way of life in the Bristol Bay watershed be eliminated with the exploitation of the copper via open-pit mining? In turn, what impacts might there be on subsistence users, other than Native Alaskans? Even though these sections seemed reasonably well presented (with caveats above) and appropriately supported with citations, they do lie beyond my expertise.

RESPONSE: No changes suggested or required.

Dr. Paul Whitney

My concerns about the document revolve around issues that were not considered, i.e., Global Climate Change, "In Perpetuity" issues, groundwater-surface water exchange issues (owing to missing information), impacts of Routine Mine Operations in a more realistic setting, the seemingly undue influence on a failure of the Tailings Storage Facility, and other somewhat more minor issues (see comments below). With any revision, the authors should include this information by eliminating redundancy (see below), thereby not increasing document length.

RESPONSE: We have thoroughly revised our approach to quantifying hydrologic responses to the mine scenarios. We explicitly include groundwater-mitigated effects on surface waters. Climate change projections and potential impacts are now included in Chapter 3 (Section 3.8), and are considered as important external factors in the risk analyses as summarized in Box 14-2. See responses to the commenter's specific comments and to Dr. Stednick's hydrologic comments below.

Clarity of Presentation. Generally speaking, I believe that the writing was intelligent, reasonably insightful, and, more specifically, on task. One significant criticism with regard to the presentation revolves around the organization of the document. As detailed below, the organizational scheme lent itself to redundancy, from the Introduction through the various chapters to the Integrated Risks Characterization chapter. Owing to this redundancy, the report is likely too long by about 20% and any revision and shortening should serve to improve its impact on readers.

RESPONSE: The assessment has been reorganized to eliminate redundancy and help clarify the structure of the document.

The conceptual block and arrow diagrams (pages 3-7 to 3-11) were quite instructive. They nicely demonstrate the interactions that occur within this mining scenario. The main report would be much improved if text were to review this set of interactions. Clearly, a tremendous amount of time, effort, and thought went into generating these diagrams and it is indeed a true shortcoming of the main report that essentially no text was spent stepping through these diagrams.

RESPONSE: Additional information on the use of conceptual models in the assessment has been incorporated into Chapter 2. The more comprehensive conceptual models presented in Chapter 6 (previously in Chapter 3) have been broken into their relevant component parts throughout the risk analysis and characterization chapters, to better frame the specific pathways addressed in each chapter. Additional conceptual models considering impacts on wildlife, Alaska Native populations, and cumulative effects of multiple mines have been added to Chapters 12 and 13.

Soundness of Conclusions. The conclusions were well supported, where there were published data to support them. Many statements that could be interpreted as conclusions were often more qualitative than desirable in a review document such as this one, owing to the lack of information (percent of salmonids lost owing to routine mine operations, impacts of mining and the transportation corridor on wetlands, extent of groundwater-surface water disruptions, just to name a few). Consequently, the soundness of the conclusions are somewhat compromised by a lack of information.

Dr. Paul Whitney

RESPONSE: No changes suggested or required.

In addition, what would aid readers is a succinct statement of the purpose (risk assessment?, impact on water quality and then through to fishes and beyond?, etc.) and scope (relatively narrow impact of the mine on salmonids and ripple effects out from there) of the document early in the initial chapter. In so doing, both reviewers and readers will be informed as to the direction of the document and thus better informed as they move through the document.

RESPONSE: Additional information on both the purpose of the assessment and ecological risk assessment (ERA) in general has been added to Chapters 1 and 2, as well as the Executive Summary.

Finally, a portion of the public testimony complained about the process, specifically about the time allowed for document review, the data reviewed, the validity of the hypothetical mine, etc. Though I found most all comments to be somewhat disingenuous, I still would offer the following advice: Provide a section upfront that deals with process issues surrounding the review, i.e., explaining the constraints under which EPA was operating; without a section like this, complaints, such as those described above (coming from just one segment of the public), will go unanswered.

RESPONSE: Chapters 1 and 2 now clarify the purpose of the assessment and document how public participation was incorporated into the process (e.g., Box 1-1).

William A. Stubblefield, Ph.D.

The document, "An Assessment Of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska," is a well-written, comprehensive document that employs a risk assessment-type approach to an *a priori* evaluation of potential environmental effects on the ecosystem and potential receptor species (e.g., salmon) that may be affected by a potential copper mine located in the Bristol Bay area of Alaska. This document is somewhat unique, in that no actual mine has been proposed at the location and few site- or project-specific data are available. Therefore, no specific information about development plans and potential operational and closure activities associated with the mine are available. Rather, the authors have attempted to develop a hypothetical mine and attempted to assess possible environmental effects associated with mine development, operation, and closure. Although interesting, the potential reality of the assessment is somewhat questionable. It is also unclear why EPA undertook this evaluation, given that a more realistic assessment could probably have been conducted once an actual mine was proposed and greater detail about operational parameters available. The approach taken in the document attempted to be comprehensive and evaluated a variety of scenarios that may affect aquatic resources in the Bristol Bay region. Given the importance of salmon populations in the area, both from a financial and societal perspective, it is important that a comprehensive evaluation of potential environmental effects associated with mine development and operations be conducted. The authors have attempted to conduct such a comprehensive evaluation and have attempted to quantify (to the extent possible) the probability of adverse effects occurring. Implementation of this approach is proper, and with the correct data, can provide a comprehensive evaluation of potential environmental effects. Unfortunately, because of the hypothetical nature of the approach employed, the uncertainty associated with the assessment, and therefore the utility of the assessment, is questionable.

RESPONSE: The EPA respectfully disagrees that the hypothetical nature of the approach compromises the utility of the assessment. All mining plans are hypothetical. They change in response to the results of assessments, regulatory requirements, public input, and unforeseen conditions and events. They cease to be hypothetical only after the mine is closed. At every step in the process, assessments of the current plan are useful even though plans will change. This assessment is based largely on a preliminary plan, published by Northern Dynasty Minerals (Ghaffari et al. 2011). Although layout of mining components in a future mine plan may differ somewhat from the preliminary plan or the EPA scenarios, the main components of mining would remain the same for open-pit mining (and underground mining would face the same waste issues).

A variety of uncertainties and data needs were identified as a result of this effort and this alone may provide sufficient value to justify the document and approach. For example, the authors note that there is not an abundance of chronic toxicity data considered in deriving the EPA's ambient water quality criteria for copper and that there is an uncertainty associated with whether the biotic ligand model (BLM) adequately protects species of concern in Bristol Bay. It would seem appropriate for EPA (perhaps in concert with industry) to develop the data to improve our understanding of copper toxicity and to ensure that regulatory standards are, in fact, appropriate for their intended use. A substantial body of data evaluating copper chronic toxicity has been developed by the copper industry as a result of regulatory requirements driven by the European REACH regulations. It may be beneficial for EPA to examine these data, thus resulting in a reduction in any uncertainty associated with the evaluation of environmentally acceptable metals concentrations. It should also be noted that similar datasets and biotic ligand models exist for number of other metals that may be of concern at the Bristol Bay site.

RESPONSE: The EPA has examined the EU's 2008 Voluntary Risk Assessment of Copper (the relevant REACH document). Although they do derive a chronic species sensitivity distribution, it is because of the way they include and aggregate data, rather than the generation of new data. In particular, they have no data for sensitive aquatic insects, so the EU does not resolve that problem. The BLM was used for copper because copper is the contaminant of greatest concern and because the copper BLM has been approved by the EPA Office of Water. Other metals with BLMs, such as zinc and nickel, occur at much lower levels in leachates.

One suggestion that would improve the document is that EPA should include a basic description of the risk assessment process and the relationship between the risk assessor and the risk manager, i.e., the decision maker. They must include a discussion of why the assessment is being conducted, the decisions that will be informed, and what information they need from the risk assessor.

RESPONSE: Additional contextual information for the assessment has been included in Chapter 1, and additional information on ecological risk assessment has been incorporated into Chapters 1 and 2. The assessment has also been restructured into problem formulation and risk analysis and characterization sections, to make the assessment's structure as an ecological risk assessment clearer.

Dr. Paul Whitney

Taken from the USEPA's Guidelines for Ecological Risk Assessment (EPA630/R-95/002F; April 1998). Note 2nd sentence re: the role of the risk manager.

> *"2.1. THE ROLES OF RISK MANAGERS, RISK ASSESSORS, AND INTERESTED PARTIES IN PLANNING*
>
> *During the planning dialogue, risk managers and risk assessors each bring important perspective to the table.* ***Risk managers, charged with protecting human health and the environment, help ensure that risk assessments provide information relevant to their decisions by describing why the risk assessment is needed, what decisions it will influence, and what they want to receive from the risk assessor.*** *It is also helpful for managers to consider and communicate problems they have encountered in the past when trying to use risk assessments for decision making.*

In turn, risk assessors ensure that scientific information is effectively used to address ecological and management concerns. Risk assessors describe what they can provide to the risk manager, where problems are likely to occur, and where uncertainty may be problematic. In addition, risk assessors may provide insights to risk managers about alternative management options likely to achieve stated goals because the options are ecologically grounded."

RESPONSE: Section 1.2 in the revised assessment discusses uses of the assessment.

Dirk van Zyl, Ph.D., P.E.

Planning and designing a large mine, and especially one in a sensitive environmental setting such as Bristol Bay, involves many iterations before a design evolves that is provided for further public considerations. The EPA elected to use a design, developed for Northern Dynasty Minerals Ltd. in a preliminary assessment prepared following the guidance of National Instrument (NI) 43-101, as the basis for extensive evaluations in their risk assessment. The resulting risk assessment can be at best characterized as preliminary, screening level, or conceptual. There are both technical and process issues that must be addressed before this risk assessment can be considered complete or of sufficient credibility to be the basis for a better understanding of the impacts of mining in the Bristol Bay watershed.

RESPONSE: The EPA respectfully disagrees that the hypothetical nature of the approach compromises the utility of the assessment. All mining plans are hypothetical. They change in response to the results of assessments, regulatory requirements, public input, and unforeseen conditions and events. They cease to be hypothetical only after the mine is closed. At every step in the process, assessments of the current plan are useful even though plans will change. This assessment is based largely on a preliminary plan, published by Northern Dynasty Minerals (Ghaffari et al. 2011). Although layout of mining components in a future mine plan may differ somewhat from the preliminary plan or the EPA scenarios, the main components of mining would remain the same for open-pit mining (and underground mining would have the same waste issues).

With respect to the proposed transportation corridor, we note in the assessment that "Although this route (the one proposed in the EPA scenario) is not necessarily the only option for corridor placement, the assessment of potential environmental risks would not be expected

to change substantially with minor shifts in road alignment. Along any feasible route, the proposed transportation corridor would cross many streams, rivers, wetlands, and extensive areas with shallow groundwater, including numerous mapped (and likely more unmapped) tributary streams to Iliamna Lake (Figures 10-1 and 10-2)."

There are a number of items that require specific attention prior to finalizing the report. While my comments below provide further details, from a global perspective the following aspects must be addressed:

- A better sense about the range of impacts from a mining project that use not only different technologies but also different lay-out options in its development than that assumed in the EPA Assessment;
- More attention to the use of appropriate order of magnitude numbers reflective of the quality of data, e.g. less accuracy is obtained when 1:62,500 scale vs. 1:12,500 scale maps are used;
- Correction of errors associated with misquoting and incorrect use of information in the literature; and
- A critical review and rewrite of the Executive Summary to reflect the tone, terminology, information sources and results of the main body of the report. One example of an error and one of inconsistent terminology are:
  - Page ES-10: "Thus, the mine draws on plans published by the Pebble Limited Partnership (PLP)", this is incorrect as the plans that were used were prepared for Northern Dynasty Minerals Ltd.
  - Page ES-10: "…our scenario reflects the general characteristics of mineral deposits in the watershed, contemporary mining technologies and best practices…" The main body of the report emphasizes on a number of occasions (such as Page 4-1, 4-17) that "Our mine scenario represents current good, but not necessarily best, mining practices".

My comments contained above and below are based on a single review of the report, i.e. contractual time constraints were such that I could not afford a second review of the report. It is therefore possible that there are other errors remaining in the report that I did not observe in my review. It is therefore recommended that after making these corrections and edits that EPA subject the report again to a rigorous independent review.

RESPONSE: The scenarios evaluated are meant to represent those expected to be present as typical for mining porphyry copper deposits of this type. Although layout of mining components at a site may differ somewhat from what we present in the scenarios, the main components of mining would remain the same for open-pit mining (and underground mining would have the same waste issues). Therefore, no change is required for technologies presented in the original assessment, and we have noted in the assessment that there could be different layouts than what we have presented.

Errors and inconsistencies in sections of the document are noted and have been corrected in the revised assessment. With regard to the terminology of "best", "good", or other terms for the practices used, what was intended to be conveyed is that we have assumed modern mining technology and operations. The terms are qualitative when generally interpreted, or have a regulatory meaning (for example, "best management practices" applies to the setting of

stormwater control, but not specific to mining sites), and thus we have eliminated their use in the revised assessment. The assessment is being re-reviewed by the external expert reviewers.

Phyllis K. Weber Scannell, Ph.D.

My comments on EPA's draft document, *An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska,* follow a three-day peer review meeting in Anchorage, AK. On the first day of the meeting, the Peer Review Team heard testimony on the importance of the resources in the potentially affected area and on possible effects of mineral development on the fish and wildlife resources and on local residents. The issues of mineral development are complex, particularly with respect to protecting the environment and the interests of local residents. I understand and appreciate the complexity of these issues; however, the charge of the Peer Review Team is to review EPA's draft document, *An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska,* and offer suggestions to strengthen the report. My comments, included below, are focused on the accuracy and thoroughness of the draft document.

The document "An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska" and the accompanying appendices provide an in-depth and thoroughly documented description of the environment and resources of the areas under consideration for mineral development, although not in the entire Bristol Bay region. Appendices A and B are particularly thorough in describing the salmon and non-salmon fishes in the region; the discussion of species specific fish sensitivities to certain toxicants adds important information for future consideration of project development.

RESPONSE: No change suggested or required.

The assumptions for developing and operating large porphyry copper mine may not be aligned with features of a future mining project. Too much emphasis was placed on effects of catastrophic failures, such as failure of a tailings dam or pipeline, and too little emphasis on the need to identify and control seepage water, run-off from PAG (potentially acid generating) and NAG (not acid generating) waste rock areas, and water treatment.

RESPONSE: Because the number of potential failures is extremely large, it is necessary to choose a representative set of failure scenarios. The revised assessment includes more failure scenarios (e.g., diesel pipeline failure, quantitative water treatment failure, and refined seepage scenarios) and explains why the particular failure scenarios were chosen.

The document discussed effects of dewatering on suppressing stream flows and groundwater inputs but did not consider effects of the discharge of treated wastewater. The section on hydrology illustrates the need for more complete hydrologic information before any project development. The need for bypassing all clean water sources around a development site should be addressed.

RESPONSE: The revised assessment more clearly presents that clean water would be diverted around the site, retained in settling ponds, and released following settling and/or treatment, if required. Discharge of treated wastewater is analyzed and discussed in greater depth in the

new Chapter 8, Water Collection, Treatment, and Discharge. The assessment is based on the best hydrologic information available for the site; however, additional hydrologic information may be available and/or acquired for any future mine plan in this watershed. We agree that detailed hydrologic information is critically important for responsible project development. We have updated our hydrologic analyses to represent the probable influence of mine scenarios on surface water/groundwater interaction.

As stated in my response to charge questions, I believe that the two most important questions for mineral development in this region are: can a mine be designed and operated for future closure? and, if not, is it acceptable to develop a large porphyry copper mine in a region of high value salmon habitat that will essentially require perpetual treatment? These two questions must be addressed when considering protection of the fish, wildlife, and human resources of the region.

RESPONSE: We agree that these are important questions to be addressed but they are risk management, not risk assessment, questions. The purpose of the assessment is to evaluate risks to the salmon fishery from large-scale mining. Risk management decisions will be made during the permitting process. No changes to the assessment were made in response to this comment.

Paul Whitney, Ph.D.

Response (with a wildlife perspective) – The main document is fish centric and it should be, given the importance of salmon in the Bristol Bay ecosystem. Wildlife (aquatic, wetland and upland species) and terrestrial resources related to potential mine and haul road impacts are glossed over. The summary write ups for several species of wildlife (Appendix C) are very good regarding natural history and some potential impacts. Information in Appendix C tends to focus on the proposed mine site and less on the proposed haul road and game management units in the Kenai Mountains.

RESPONSE: Direct effects on wildlife and terrestrial resources are outside the scope of the assessment, as clarified in Chapter 2. Effects on wildlife are now treated in Chapter 12.

PHW Response: The clarification provided in Chapter 2 is not tight. For example, the statement "We focus on freshwater habitats, because the most exceptional ecological feature of the Bristol Bay watershed is its fish populations" (p 2-5, para 3, lines 2 and 3) is subjective at best and is in the eye of the beholder. What is clear to me is that the decision not to consider direct impacts to wildlife is political and relates to the Clean Water Act. Asserting that "exceptional" has an ecological or scientific meaning and explains why direct impacts on wildlife are not considered confuses rather than clarifies. .

Formatted: Font: Not Bold, Not Italic

USFWS RESPONSE: We acknowledge the comment regarding quality of Appendix C. Information in Appendix C is intended to focus on the entire Nushagak and Kvichak River watersheds to the extent that data exist. To the extent that a potential mining-related road is within the Nushagak and Kvichak River watersheds, information about selected wildlife species is included in Appendix C. Information about selected wildlife species on the Cook Inlet side of the Chigmit Mountains is not included in the wildlife report. The Kenai Mountains are not in the Nushagak and Kvichak River watersheds.

Dr. Paul Whitney

PHW Response: Appendix C is what it is but the above response is circular. Direct impacts on wildlife are outside the scope of the assessment so it really doesn't matter that wildlife resources along the entire road are not discussed. Is one to assume that impacts along the road segments outside the Bristol Bay watersheds are not significant? The circular reasoning in the above responses is of little consequence here but circular reasoning in other responses is more of a concern.

Formatted: Font: Not Bold, Not Italic

A variety of authors have obviously contributed to the documents and it appears that the direction given to them or their interpretation of goal statements varies. For example, if one of the goals of the assessment is to evaluate the risk to wildlife due to risk to fish (Executive Summary, page 1, last para) it's not clear why so much verbiage in Appendix C (wildlife) is devoted to species such as caribou that are not closely associated with fish. Information in Appendix C could be used to assess direct impacts if the scope of the assessment is expanded. For example, if the goal is to assess the impact of potential mining on the ecosystem (see Executive Summary page 1, para 1), the information on caribou in Appendix C is more relevant. The apparent diversity of goal statements cited in the main assessment gives mixed messages regarding the clarity of the presentation (see more detailed discussion below).

RESPONSE: As the commenter notes, the scope of the assessment is focused on potential risks to salmon from large-scale mining and salmon-mediated effects to indigenous culture and wildlife. EPA agrees with the commenter that direct effects on wildlife are likely to be important and that Appendix C (now a stand-alone USFWS document) provides useful information for an evaluation of direct effects on wildlife from large-scale mining. We would expect that a full evaluation of any future mining permit applications and subsequent National Environmental Policy Act Environmental Impact Statements would consider these direct effects. The revised assessment acknowledges the potential for direct effects on wildlife as well as risks due to fish, but states that these effects are outside the scope of the assessment.

PHW Response: Please reread the last sentence in the above Response. What does it mean that risks due to fish are outside the scope?

Formatted: Font: Not Bold, Not Italic

USFWS RESPONSE: The scope of Appendix C is broader than that of EPA's assessment because it is a USFWS document prepared to serve various purposes, including statewide or regional land use planning, completion of environmental documentation for permitting of development projects, and activities related to Landscape Conservation Cooperatives in Alaska. The former Appendix C is now a separate USFWS report which is cited by the assessment but is no longer an appendix of the assessment. However, information in the USFWS report document has been used by EPA to provide a more complete assessment of overall watershed resources at risk due to potential mining, and to strengthen the assessment of risks to wildlife from fish-mediated effects of the mine in the revised assessment.

The charge question related to wildlife asks for an evaluation of the risk to wildlife due to the risk to fish. If the risk to fish cannot be quantified because there is little or no demographic information, then any evaluation of risk to wildlife can't be quantified and must be qualitative. Merely stating that a qualitative increased risk for fish will also result in a qualitative increased risk for wildlife is not adequate. I am not satisfied with such an obvious and general conclusion. I do not understand why the scope of the main document is limited to an indirect evaluation of fish-caused risk to wildlife. The following responses to charge questions leans more toward an ecosystem evaluation that includes, not only risk of fish to wildlife, but also risk of direct wildlife and vegetation loss to fish and other direct risks to wildlife, such as noise and human presence.

RESPONSE: EPA acknowledges that there are numerous potential direct risks to wildlife from large-scale mining. However, this evaluation is outside of the scope of the assessment. The revised assessment provides a clearer explanation of the reasons for its defined scope.

PHW Response: See other responses in this document.

Formatted: Font: Not Bold, Not Italic

Dr. Paul Whitney

2. RESPONSES TO CHARGE QUESTIONS

Question 1. ***The EPA's assessment focused on identifying the impacts of potential future large-scale mining to the fish habitat and populations in these watersheds. The assessment brought together information to characterize the ecological, geological, and cultural resources of the Nushagak and Kvichak watersheds. Did this characterization provide appropriate background information for the assessment? Was this characterization accurate? Were any significant literature, reports, or data missed that would be useful to complete this characterization, and if so what are they?***

David A. Atkins, M.S.

Based on my general understanding of the watersheds, I consider the general background information presented in the Assessment accurate and sufficiently complete for the endpoints of this watershed assessment in the following areas:

- General view of Pacific salmon populations
- General view of resident (non-anadromous) fish
- Wildlife populations
- Native cultures

RESPONSE: No change suggested or required.

The Assessment also describes the current economics of the watershed, including commercial and sport fishing and subsistence activities.

RESPONSE: No change suggested or required.

Additionally, the report highlights several general aspects of the area that make the fishery unique in both its abundance and diversity:

- The unique hydrology of the area (strong groundwater and surface water interaction) that contributes to stable flows and temperatures favorable for salmon reproduction.
- The importance of anadromous fish in transferring marine-derived nutrients to upland areas and thus providing nutrients to areas that would naturally be nutrient poor.
- The lack of roads and infrastructure that make the area unique as one of the few intact ecosystems remaining in the world, and possibly unique for this type of fishery.

RESPONSE: No change suggested or required.

It would be helpful in the background section to better describe the uniqueness of the Bristol Bay watershed ecosystem in the Pacific Northwest. This could include a description of other similar ecosystems in the region that have undergone development and documentation of any changes in fish populations associated with this development. The Assessment does mention the Fraser River as an analogue, but the scale of development in this watershed, and even the success of the salmon fishery, seems to be a point of contention, with some saying mining and fish coexist, and other saying the impacts are severe.

Dr. Paul Whitney

RESPONSE: The unique conservation value of Bristol Bay fisheries is now discussed in Chapter 5.

It would also be helpful to better explain fish resources in the proposed project area in comparison to other areas within the watershed. I understand some of the necessary data may not be available for the project area. It would be helpful to know, however, if the habitat in the project area is typical, exceptional, or inferior to that in other areas of the watershed.

RESPONSE: We now include figures showing reported salmon species distributions and salmon diversity by HUC-12 watershed, across the Nushagak and Kvichak River watersheds (Figure 5-3; Figures 5-4 through 5-8). It is informative to note that salmonid diversity is relatively high in the project area. Information on population sizes and vital rates are limited for the region, but are reported where known. In addition, we include summary statistics and figures of stream and valley characteristics across the assessment area (Section 3.4), and compare stream attributes in the project area to those of the larger watersheds (Section 7.2.1). These results generally illustrate that the project area contains streams of a size and gradient well within the range of suitability for salmon, as amply demonstrated by the distribution of spawning and rearing salmon within the project area streams (Figures 5-4 through 5-8).

Regarding geological resources, the report describes the Pebble deposit and five other mineral deposits in the Nushagak and Kvichak watersheds. It would be helpful to know if there are other mineral resources or oil and gas resources in the Bristol Bay watershed as a whole that could also be exploited. It would also be helpful to describe the portion of the watershed that is off-limits to development due to park and protected area status vs. those lands that are open to mineral development.

RESPONSE: The scope of the assessment was to evaluate the potential impacts from large-scale mining on salmon resources; thus, consideration of prospective oil or gas development in the area was outside the scope. The mineral resources identified in the assessment are those in the Bristol Bay watershed that have had some level of identification or exploration at this time. Mine claims within the Nushagak and Kvichak River watersheds are shown in Figure 13-1 and discussed in greater detail throughout Chapter 13. The assessment assumes that mining would occur on lands open to mineral development.

Protected areas within the Bristol Bay watershed and the Nushagak and Kvichak River watersheds are shown in Figures 2-3 and 2-4. We have clarified in the text that the Nushagak and Kvichak River watersheds represent the least-protected area of the Bristol Bay watershed. Other state documents exist that map out areas in the Bristol Bay watershed off-limits to development.

Steve Buckley, M.S., CPG

The background information presented in the characterization of the ecologic, hydrologic, and geologic resources is overly broad in scope. Specifically, the descriptions of the relationship between landforms, streams, and surface water and the interaction with groundwater are mentioned as very important to fish in the watersheds, yet there is insufficient detail to assess these interactions and consequently, the characterization of these resources is weak. There is more detailed information available in the Environmental Baseline Document (EBD) regarding the relation between landforms, streams, groundwater, and fish habitat in the watershed.

RESPONSE: Descriptions of the region's physical environment have been expanded in Chapter 3. We provide additional detail on the broad-scale habitat characteristics of the watersheds, but providing the detail necessary to assess groundwater interactions comprehensively is beyond the scope of this document, and data are not available to do so.

Courtney Carothers, Ph.D.

The background information presented on the ecological and geological resources of the Nushagak and Kvichak watersheds appears to be appropriate and accurate. The report notes that there is a lack of quantitative data on salmonid populations in this region, a lack of a full identification and characterization of salmon presence, spawning, and rearing areas, and a lack of detailed understanding of how local stream and river system features (e.g., temperature, habitat structure, predator-prey relationships, limiting factors) affect salmonid production in the region. Further, climate change is noted to be affecting local conditions. These unknowns are important to stress throughout the report.

RESPONSE: Each risk analysis chapter of the revised assessment now includes an uncertainty section. Climate change is now incorporated more explicitly as an important external factor that could interact with mining impacts (Box 14-2).

The cultural characterization presented in Appendix D presents detailed information on historical and contemporary Yup'ik and Dena'ina communities of this region, stressing the centrality of salmon and subsistence in these cultures. This assessment benefits from the time-depth of relationships developed by Boraas and Knott. Overall, this section of the report is based on standard ethnographic methods, although the research design and analysis could be explained in more detail (and described in a separate methods section). The "voices of the people" sections are helpful to present directly the perspectives given by local people. These quotes reveal the complexity of subsistence and contemporary village concerns in this region. At times, the cultural assessment can minimize this complexity.

RESPONSE: Additional detail was added to the methodology section of Appendix D.

As detailed in the specific comments below, potential risks and impacts to subsistence are underestimated and at times framed in the report as primarily ones of physical health and economic factors. As described in Appendix D, harvesting, processing, sharing, and consuming wild foods are central to social, cultural, spiritual, psychological, and emotional well-being in Yup'ik and Dena'ina cultures. The subsistence lifestyle is considered central to the health of the people and communities of this region. This is particularly important to note for indigenous communities who continue to cope with the legacies of colonialism. This point is made in Appendix D (but at times could also be strengthened there, as suggested below), and is articulated in some of the quoted interview material.

RESPONSE: The assessment text regarding the importance of the subsistence way of life has been expanded to recognize the centrality of subsistence to the social, cultural, and spiritual well-being of the indigenous cultures.

Dr. Paul Whitney

Recent data on subsistence harvests, use areas, and local context collected for the PLP Environmental Baseline Document (as well as evaluation and discussion of such data, e.g., Langdon et al. 2006) and by the Alaska Department of Fish and Game (e.g., Fall et al. 2012) would be a useful addition to the cultural characterization. Other studies of local traditional ecological knowledge (e.g., Kenner 2005) may help to supplement the assessment of the abundance and distribution of fish species in this region, or to supply information on other less-studied freshwater fishes. Recent research on the contemporary salmon-based livelihoods of the region (e.g., Holen 2011, 2009a, and 2009b; Hebert 2008; Donkersloot 2005) would also be helpful to include. An inclusion of case studies of salmon-based cultures that have suffered depletions of their resource base would add to the presentation of likely fish-mediated impacts to culture (e.g., Colombi and Brooks 2012).

RESPONSE: The suggested references were consulted during the revision of the report and the discussion of subsistence has been expanded. In addition, case studies have been cited where applicable in the discussion of potential effects to indigenous cultures in Chapter 12.

Appendix E also characterized the economic baseline of the region. Why is this dimension not asked about here?

RESPONSE: The focus of the assessment is potential effects on salmon from large-scale mining. There are two secondary endpoints: salmon-mediated effects on wildlife and Alaska Native culture. The economics related to potential salmon-mediated effects are not evaluated because they are outside the scope of the ecological risk assessment. Appendix E presents information regarding the economic value of salmon is presented as background for the descriptive material in Chapter 5, and could be used as a basis for future analyses. However, this assessment does not include an economic endpoint.

Dennis D. Dauble, Ph.D.

As noted in the approach, characterization of and risk to ecological resources emphasized salmon and other important sport and commercial fish species. Consequently, the description of non-salmonid species generally lacked estimates of population size, except for sport and subsistence catch statistics. There was a long list of other resident fish in Appendix A, but their role in the Bristol Bay watershed (including the Nushagak River and Kvichak River watersheds) is not described in any detail there or in the main report. Available data on known or perceived ecological interactions among salmonid and resident fish should be included in the assessment.

RESPONSE: The assessment endpoints—salmonid fishes and their effects on wildlife and Alaska Native cultures—have been clarified in Chapters 2 and 5; other fish species are thus outside the scope of the assessment. However, we recognize in the text that other fishes (as well as other biota) are important components of the ecosystem, and have included a table of all documented fish species in the region in Chapter 5 to better reflect the fish fauna in the region.

Another limitation to the salmon-centric assessment is that risk assessment endpoints, described in Chapter 3 of the main report, do not address other aquatic ecological resources. Consequently, while there was acknowledgment of ecological dependencies among salmon, other fishes, and land mammals, very little information was provided on primary and secondary production processes of aquatic communities. For example, the relative importance of marine-derived nutrients (MDN) in the form of salmon eggs and carcasses is discussed, but there is only brief mention of aquatic insects in the diet salmonid species. What nutrient levels occur in these stream systems with and without MDN?

RESPONSE: We recognize that nutrient status, and more important prey availability, is a critical component of habitat capacity for fish in these systems, and may be strongly driven by salmon derived nutrients. We concur that more information is needed regarding potential limiting factors for salmon productivity and capacity, and that food availability may be one such factor. The role of aquatic invertebrates in the diet of salmonids receives more attention in the revised draft, and is an essential part of the risk assessment for water treatment and discharge, given the relatively high sensitivities of aquatic invertebrate taxa to metals. However, because water chemistry data may not provide a complete picture of trophic status, particularly where direct consumption of salmon flesh, eggs, and fry is of such high importance as it is in many of the area streams, we determined that nutrient status of area streams is outside the scope of this assessment.

A description of major groups of aquatic invertebrates in terms of biomass and seasonal abundance should be included in the main report. Further, aquatic and terrestrial food webs and linkages need more embellishment. One approach might be to add narrative text with the conceptual model discussion, including descriptions of community structure, function, and biomass.

RESPONSE: Additional detail on food webs is beyond the scope of this assessment (as detailed in Chapters 2 and 5). Further, available data are inadequate to assess risks at that level of specificity. For example, there are no acute copper toxicity data for any aquatic insects and only one old chronic value for a caddisfly.

More detail on river and lake limnology would be helpful. For example, the hydrology of the watershed is mainly limited to a brief discussion of salmonid habitats. The geology of the basin emphasizes geology of mining areas and mineral processes. A more landscape-based description is warranted given the importance of geology to surface water processes and groundwater movement. The report would benefit from having a summary table listing lake size/volume and river length/discharge for watersheds potentially affected (and not affected) by mining activities.

RESPONSE: We now include maps of geology and estimated mean annual flow for the study region (Chapter 3).

Also missing were specific habitat requirements for rearing of juvenile salmon. A brief description of where pink and chum salmon spawn and rear in the Bristol Bay watershed relative to other salmon species should be included in the main report. There was nothing in Appendix A on where coho, pink, and chum salmon reside within the Bristol Bay watershed.

RESPONSE: Identified spawning and rearing habitats for the five Pacific salmon species are reflected in Figures 5-3 through 5-8, and additional text on salmon life histories has been included in Chapter 5.

Dr. Paul Whitney

Each appendix has a wealth of supporting information and could serve as a stand-alone document. However, having to work back-and-forth between the main report and appendices to interpret critical aspects of the assessment presents a challenge. Don't assume the average reader will read (and interpret) these appendices. To help remedy, the authors of the main report should strive to directly cite relevant information (and/or a specific appendix) that supports their conclusions.

RESPONSE: Additional information from Appendices A and B has been pulled into Chapter 5 of the main assessment. In addition, the purpose of the appendices has been clarified in Chapter 2.

Gordon H. Reeves, Ph.D.

The assessment, which included the report and appendices, was comprehensive and thorough regarding the ecological resources of the Nushagak and Kvichak watersheds. The best available data on fish numbers and distribution (Alaska Dept. of Fish and Game's aerial escapement counts, records from the Anadromous Waters Catalog and Alaska Freshwater Fish Inventory, and the Environmental Baseline Document of the Pebble Limited Partnership (2011)) were used for the assessment. These data formed the foundation for much of the assessment on potential impacts to anadromous salmonids and their freshwater habitat in these watersheds and their characterization appeared to be accurate. The authors also appeared to have thoroughly identified and considered all of the appropriate literature.

RESPONSE: No change suggested or required.

Charles Wesley Slaughter, Ph.D.

If only Volume 1 (the Main Report) is considered, the characterization of some aspects of the Nushagak and Kvichak watersheds would have to be termed cursory. Chapter 2, Volume 1 (Characterization of Current Condition) provides only a superficial overview of the landscape of the Bristol Bay watersheds; a reader would preferably have access to Wahrhaftig (1965) or Selkregg (1976), as only two (relatively dated) suggestions, to gain a more comprehensive understanding of the region. Similarly, Volume 1 provides a relatively superficial discussion of non-fish wildlife concerns, or human/cultural concerns

RESPONSE: Additional information on the region's physical environment from Selkregg (1974) has been included in Chapter 3. We have also clarified that our discussion of biological communities focuses on the assessment endpoints, as defined in Chapters 2 and 5.

By contrast, the information provided in Appendices A-H appears to be comprehensive and complete for each subject field. (Appendix I appears to be a general "template" summary, not tailored to the Bristol Bay watershed environment).

RESPONSE: The purpose of the appendices vs. the main assessment document has been clarified in Chapter 2. Appendix I is not meant to be specific to any given region, but discusses options that are possible and notes that their applicability is dependent on site-specific

constraints. What would be chosen for the Bristol Bay watershed environment, given a mining plan and permit application, also would be dependent on regulatory decisions.

As noted in the Executive Summary, the Assessment does NOT address several major components of the (hypothetical) Pebble project, including electrical generation and transmission, a deep-water port, or "secondary development" and associated infrastructure, which would follow an initial mining project. A truly comprehensive analysis should incorporate a full analysis of these aspects.

RESPONSE: The scope of this assessment was tailored to its purpose, as clarified in the first two chapters. We would expect that a full evaluation of any future mining permit applications and subsequent National Environmental Policy Act Environmental Impact Statements would consider these components.

John D. Stednick, Ph.D.

The site characterization needs to be expanded. The report needs to better characterize the physical setting. There are a variety of data sources that can be used to better describe the physical setting. It would be useful to see geology, geomorphology, soils, vegetation, digital elevation maps, hypsometric curves of the watersheds in question, streamflow data, and precipitation data—especially storm events and water quality data for surface and groundwater over time and space. Various geographical information system maps would be useful here.

RESPONSE: Maps displaying information about the physical setting have been added in Chapter 3.

The salmon populations and habitat linkage needs to be better documented since many of the mine impacts are resulted from hydrologic modification. Figures 3-2A to 3-2E represent good thinking and an understanding of the linkages and potential effects of mining on these resources. The linkages to indigenous peoples is illustrated in Figure 3-2E, but little text is presented, referring the reader to the Appendix. The other conceptual models are not adequately addressed in the text. These flow charts provide an opportunity to present processes and linkages as related to potential effects of mine development activity and need to be developed within the text. Indeed, they seem to stand alone with little discussion of potential effects. Additionally, not all charts have adequate materials in the appendix for coverage, thus the variability in resource coverage is inconsistent and infers either a writing bias or data (lack of) bias.

RESPONSE: Conceptual models are now linked with relevant text, and are included in each of the risk analysis and characterization chapters.

The assessment concludes that a hydrologic modification will have detrimental salmon habitat consequences. The groundwater contributions to streamflows are important, both hydrologically and ecologically. Additional streamflow and groundwater data are needed to represent this linkage. Similarly, additional water quality data over time and space are needed and should include water hardness for metal standards. Depth to groundwater as related to streamflow, age dating of waters, and streamflow modeling would all be useful to illustrate the groundwater upwelling and hyporheic exchanges.

Dr. Paul Whitney

RESPONSE: We have incorporated a figure illustrating modeled and observed groundwater upwelling zones (Chapter 7).

Site disturbance will be significant, yet there is no discussion of soil erosion. Soil erosion and subsequent suspended sediment transport would have the potential to have significant effects on water quality, channel delivery efficiency, salmon, salmon habitat, and metal transport. There is a generic discussion of road construction related to erosion, but road standards, road location, road usage, road maintenance (salting, grading, or watering), and length of roads would help in the risk assessment.

RESPONSE: Soil erosion on the mine site is not assessed because the scenario prescribes that runoff will be directed to retention basins. Salts used to reduce dust and improve winter traction on roads are discussed in Section 10.3.3 (Chemical Contaminants in Stormwater Runoff). Road usage and length are also factored into the risk assessment (e.g., in the assessment of chemical spills (Section 10.3.3) and potential impacts from dust (Section 10.3.5)). Potential mitigation measures for stormwater runoff, erosion, and sedimentation are discussed in Box 10-3.

Are any endangered or threatened species present, either state or federally listed?

RESPONSE: Text has been added to Chapter 5 stating that there are no state or federal endangered or threatened species in the region.

<u>Roy A. Stein, Ph.D.</u>

Overall Characterization. The characterization of the resources of the Nushagak and Kvichak watersheds was appropriate and accurate in the ecological arena save for the issues discussed below. Geological and cultural resources seemed adequately characterized, but they are not within my expertise. Finally, given the emphasis on these two watersheds (not the entire Bristol Bay watershed), might there be some consideration of a more circumscribed document title?

RESPONSE: The assessment deals with multiple spatial scales (now clarified in Chapter 2). The Bristol Bay watershed is the largest spatial scale considered in the assessment, and it is the only one that encompasses all of the issues discussed in the document.

Broad Scale Comments:

Global Climate Change I. Risks to salmonids seem far greater than what is reviewed throughout this portion of the document. Missing, in my view, is any consideration of Global Climate Change, especially in light of the expected life of the mine (25-78 years), applied directly to the Bristol Bay Watershed (save for a brief mention on page 5-28, 2nd full paragraph). Given our current understanding, general changes likely include more intense precipitation events and increased temperature (and then of course, all that follows from these two changes and as models become more sophisticated, more specific geographically localized impacts could be assessed). With more intense storms come a greater likelihood of a failure of Tailings Storage Facilities (i.e., commensurate with more frequent and more intense flooding), more acidity from Pre-Tertiary waste rock (which will enter quite vulnerable, poorly buffered streams), and greater sediment influx into streams (and increasing fines in the gravel by as little as 5%, quite a small proportion, "…causes unacceptable effects on salmonid reproduction" (page 8-6; also see Chapter 7), which could occur during "routine operations", especially in light of the fact that sediment influx into streams is a cumulative process). Increased stream temperatures, depending on the absolute increase over a period of 78 years (and beyond, see "in perpetuity" comments below), could lead to reductions in salmon spawning success, as extant populations are specifically adapted to the current temperature regime. As is apparent, both increasing intensity of storms and increasing temperature will likely compromise salmon spawning success, and growth and survival of their offspring in the freshwater environment of Nushagak and Kvichak rivers.

RESPONSE: Climate change projections and potential impacts are now included and discussed in Chapter 3 and are included as important external factors in the risk analyses presented in Chapters 7, 9, 10 and 14.

What this would entail, at the very least, is a discussion of a monitoring system to quantify the impacts of Global Climate Change whose impacts on the ecosystem can then be differentiated from mine impacts. My concern is that if the mine is built, all negative impacts of the mine on salmonids, etc., could be attributed to Global Climate Change rather than the true culprit which would be the mining activities.

RESPONSE: Climate change projections and potential impacts are now included in Chapter 3, and Box 14-2 includes a discussion of the need for future monitoring to differentiate climate change effects from large-scale mining effects.

Global Climate Change II. Indeed, climate change is affecting Alaskan salmon as demonstrated (in a paper that just appeared online July 11, 2012) by a loss of a late-migrating population of pink salmon in a small stream near Juneau, in favor of an early-migrating one. Genetic evidence supports this explanation for Kovach et al. (2012) had 17 generations of data (since 1979) showing the reduction of the September spawners in favor of the late-August ones in response to increasing stream temperatures. As Kovach et al. (2012) write in their concluding paragraph:

> "We no longer observe the clear phenotypic distinction between early- and late-migrating individuals that was once present in the system. Apparently, the very-late-migrating phenotype has been greatly reduced or potentially lost. Although microevolution may have allowed this population to successfully track environmental change, it may have come at the cost of a decrease of within-population biocomplexity – the loss of the late run. This is not a surprising result; by definition, directional selection will decrease genetic variation. However, it does highlight the importance of maintaining sufficient genetic and phenotypic variation within populations in order for them to have the ability to respond to environmental change."

The ramifications of this work are obvious. As pointed out in the report (pages ES-8, 2-22, 5-28 as just a few examples), the exceptional quality of the Bristol Bay salmon stocks depend on the pristine quality of a set of quite diverse aquatic habitats, which has led to the development of genetically diverse stocks of salmon within species, each uniquely adapted to particular habitats. Reducing this variability by mining on top of the rivers that produce >50% of the wild sockeye salmon in Bristol Bay serves to reduce the flexibility with which these stocks respond to any environmental change (most notably Global Climate Change), and most notably during the time course of the Pebble Mine.

RESPONSE: Climate change projections and potential impacts are now discussed in Chapter 3 and include these points.

Groundwater Exchange. One of the key aspects of this system is the importance of groundwater exchange with surface streams and this groundwater contributes mightily to salmonid egg incubation success and survival (page 2-21). Simultaneous with this is the fact that the water demands of the proposed mine will require more than just surface waters available to it, but rather the mine will have to exploit groundwater resources to support its operations. This is yet another risk to salmonid success for reduction in the availability of groundwater will lead to increased temperatures in summer (see pages 3-7, 5-28, 5-29) and less inviting overwinter habitats (pages 5-20, 5-29), further exacerbating both mining and climate change effects.

RESPONSE: We have updated our hydrologic analyses to represent the probable influence of mine scenarios on surface water/groundwater interaction. Climate change projections and potential impacts are now discussed in Chapter 3.

Exploration Effects. During the public testimony segment, several Alaskan Natives argued that impacts owing to exploration have already occurred. A series of points were made: 1) exploration equipment was left behind, despoiling the landscape, 2) noise from helicopters frightened moose making them less vulnerable to exploitation, and 3) habitat change has already begun just due to exploration activities.

RESPONSE: EPA acknowledges this testimony, but potential or actual impacts of exploration activities are outside the scope of the assessment as defined in Chapter 2.

"In Perpetuity." Following up on the idea of increased risk (see previous points) to salmon, I struggled with the idea of this mine being monitored and maintained "in perpetuity" (e.g., pages ES-2, 4-32, 4-34). First, this relates directly to the Global Climate Change issues, in that these changes likely will continue to build through time, further exacerbating negative impacts on salmon. Even without climate change, salmon are in peril from mining operations in the Nushagak and Kvichak rivers; with climate change, the cards are stacked against them.

RESPONSE: The post-closure phase of mining begins when reclamation is completed and monitoring and maintenance commences using the controls put into place during closure; exactly how long the site would require monitoring and maintenance is unknown, and thus may be 'in perpetuity'. There are no existing examples from which to evaluate success of treatment in perpetuity. No mine in Alaska has maintained a tailings pond into post-closure, although one small mine did maintain a pond during a many year hiatus from operations. Under AS 72.90.040, financial assurance is required to be sufficient to cover expenses for as long as treatment need is predicted, even into perpetuity (e.g., Red Dog Mine). Maintaining a water cover over the tailings is a part of the reclamation and closure plan for the Red Dog Mine. The comment is noted and understood. No changes suggested or required.

Second, what regulatory or institutional mechanisms currently available place the responsibility of these efforts on the corporation "in perpetuity"? Because mining companies come and go, might there be mechanisms that come into play if this particular company goes bankrupt? Might there be some sort of bonding process that protects the environment from the mine's remains into the long-term future? If not, should new legislation be pursued? Acknowledgement of this important issue should be front and center in the document, in my view.

RESPONSE: There are many requirements that have to be met including compliance with the CWA § 404(b)(1) Guidelines and adequate financial assurance under AS 72.90.040. The former would lead to the least environmentally damaging, preferred alternative and the latter to having adequate financial resources to cover the cost of perpetual treatment. These issues would be addressed in a permit process. Our purpose in the assessment is to evaluate the potential effects of the primary features of a mine, assuming conventional modern mitigation measures. Additional information on the regulations and financial assurance issues associated with mining has been added in Chapter 4 (Boxes 4-2 and 4-3). The comment is noted and understood.

Third, I began the review process with idea that the mine would be built, would capture its resources, and then would end by restoring the site. The scenario that includes monitoring and maintenance 1,000 years into the future continues to bother me. One solution that comes to mind is that Federal or state government would be charged with these monitoring and long-term maintenance activities, paid for by a hefty tax on the minerals removed from this site.

RESPONSE: Currently, the solution is the requirement and provision of adequate financial assurance (under AS 72.90.040, when speaking specifically about Alaska) by the company. The comment is noted and understood. No change suggested or required.

Finally, I am not encouraged by any of the text surrounding this issue, the two most relevant quotes (pages 4-31 and 5-45, respectively) being:

> "There are no examples of such successful, long-term collection and treatment systems for mines, because these time periods (100's to 1000's of year) exceed the lifespan of most past large-scale mining activities, as well as most human institutions."
>
> "We know of no precedent for the long-term management of water quality and quantity on this scale at an inactive mine."

RESPONSE: The post-closure phase of mining begins when reclamation is completed and monitoring and maintenance commences using the controls put into place during closure; exactly how long the site would require monitoring and maintenance is unknown, and thus may be 'in perpetuity'. There are no existing examples from which to evaluate success of treatment in perpetuity. No mine in Alaska has maintained a tailings pond into post-closure although one small mine did maintain a pond during a many year hiatus from operations. Under AS 72.90.040, financial assurance is required to be sufficient to cover expense for as long as treatment need is predicted, even into perpetuity (e.g., Red Dog Mine). Maintaining a water cover over the tailings is a part of the reclamation and closure plan for the Red Dog Mine. The comment is noted and understood. No changes suggested or required.

And, finally, a quote from Chapter 8 on page 8-13:

Dr. Paul Whitney

> "The promises of today's mine developers may not be carried through by future generations of operators whose sole obligation is to the shareholders of their time (Blight 2010)."

RESPONSE: The comment is noted and understood. No changes suggested or required.

William A. Stubblefield, Ph.D.

The EPA's assessment document presents a seemingly comprehensive compilation of the data associated with the ecological, geological, economic, and cultural resources of the Bristol Bay area. The characterization as presented seems to provide appropriate background information for the assessment considering the hypothetical nature of the evaluation. Without having specific knowledge of the area in question, it is not possible to provide an assessment as to whether the characterization was accurate. I'm unaware of significant literature, reports, or data that were specific to the site and would be useful for consideration. The assessment should be expanded to include greater detail regarding the environmental aspects of the site.

RESPONSE: Additional information on the physical environment of the region and assessment endpoints has been incorporated into Chapters 3 and 5.

Dirk van Zyl, Ph.D., P.E.

The geological information was taken from documents prepared to conform to and in compliance with the standards set by National Instrument 43-101 (NI 43-101) (Ghaffari et al., 2011). This regulatory instrument emphasizes resource information for projects. While I cannot comment on the accuracy of the regional geological information, the document should reflect accurate geological information of the Pebble District as known at the time when the report was prepared.

RESPONSE: The assessment uses geological information available for the Pebble site area. Geological information from Selkregg (1974) has been incorporated into Chapter 3.

My review did not include the Environmental Baseline Document (EBD) of the PLP. However, in scanning that document, it seems that more site-specific information on site hydrogeology may be available than was described in the EPA Assessment. While the latter refers to the EBD extensively in terms of fish populations, etc., it does not refer to it for much of the site physical characterization. EPA should address this in edits to the Draft Assessment.

RESPONSE: Additional site-specific hydrogeology information has been incorporated in Chapters 3and 7 and in the calculation of water quality values in Chapter 8. EBD data were used along with USGS data for hydrologic analysis in both drafts of the assessment, but the sources of data were not discussed as extensively in the previous draft.

Phyllis K. Weber Scannell, Ph.D.

Dr. Paul Whitney

The Environmental Assessment presents a well-documented discussion of the fish and wildlife resources of the Nushagak River and Kvichak River Watersheds, with more limited discussions of the remainder of the Bristol Bay Watershed. The document discusses interactions among species, including nutrient flows and the importance of groundwater systems; however, information on contributions of marine-derived nutrients and existing pressures on the environment are not as complete, or lacking. The information is general in nature. Should mine development go forward, it will be necessary to obtain ecological information specific to the potentially affected areas. The information should include timing of fish spawning, egg hatch, in-migration and out-migration, and similar specific life-history information for important wildlife species.

RESPONSE: We have clarified the use of information at different scales (Bristol Bay watershed and Nushagak and Kvichak River watersheds in the problem formulation chapters, smaller spatial scales in the risk analysis and characterization chapters). General information on assessment endpoints is included in Chapter 5, with more detailed information included in the appendices.

Paul Whitney, Ph.D.

Fish Population Estimates. There are several places in the text where impacts of the loss and degradation of habitat on fish populations was not quantified because of the lack of demographic data for salmonids (e.g., page ES-26, third bullet). These statements are only partially accurate. It is true that population models such as life tables or Leslie matrices require population age class data to estimate population numbers. However, even if demographic data are available, these population models do not relate population estimates to habitat quality. Incomplete data and relating fish population estimates to habitat quality are not an uncommon problem in ecology and there are many approaches for dealing with this issue. Approaches such as Ecosystem Diagnosis and Treatment (McElhany et al. 2010), Expert Panels (Marcot et al. 2012), Bayesian nets (Lee and Reiman 1997), Discussion with experts (Appendix G), or Weighing Lines of Evidence (Section 6.1.5) are just some of the methods for relating habitat quality to fish abundance. Models and expert opinions, of course, bring their own uncertainties but it seems better to have quantitative estimates (and discussion of the estimates) of all the potential fish losses due to habitat loss than no estimate at all.

RESPONSE: Approaches such as EDT, mentioned above, were considered, but rejected due to lack of stream-reach specific information needed to provide the sort of quantitative estimates desired. Expert panels and Bayesian Belief Networks are recognized as potentially providing useful guidance for identifying key uncertainties and directing future research and monitoring efforts. However, this was deemed outside the scope of this assessment, and we instead focus on the risks associated with the types of habitat change that would be expected under the mining scenarios outlined. We restrict quantitative estimates of population level effects to the most severe cases where total losses of runs could be reasonably assumed.

Even though the Executive Summary indicates that the impacts of loss and degradation of habitat on fish populations could not be quantified, the text does provide some estimates. For example, the assessment (page 6-11, first full para) estimates “that the combined effects of direct losses of habitat in the North Fork Koktuli, down stream in the mainstem Koktuli and beyond, and impacts on macroinvertebrate prey for salmon could adversely affect 30 to 50% of Chinook salmon returning to spawn in the Nushagak River watershed." This type of statement, and the basis for the statement followed by a discussion of uncertainty, is a good example of the estimates that would better describe possible impacts of the example mine on salmonids. Another example estimate appears on page 6-39 for four species of salmon.

RESPONSE: We restrict quantitative estimates of population level effects to the most severe cases where total losses of runs could be reasonably assumed, such as the example given above. The text of the revised assessment has been clarified for consistency regarding feasibility of estimates.

Question 2. ***A formal mine plan or application is not available for the porphyry copper deposits in the Bristol Bay watershed. EPA developed a hypothetical mine scenario for its risk assessment, based largely on a plan published by Northern Dynasty Minerals. Given the type and location of copper deposits in the watershed, was this hypothetical mine scenario realistic and sufficient for the assessment? Has EPA appropriately bounded the magnitude of potential mine activities with the minimum and maximum mine sizes used in the scenario? Are there significant literature, reports, or data not referenced that would be useful to refine the mine scenario, and if so what are they?***

David A. Atkins, M.S.

The hypothetical mining scenario presented in the Assessment is based on a "Preliminary Assessment Technical Report" of the Pebble deposit prepared for Northern Dynasty Minerals by Wardrop (referred to as Ghaffari et al. 2011), in conformance with Canadian National Instrument 43-101 (NI 43-101) which is used to set standards for public disclosure of scientific and technical information about mineral projects of companies on bourses supervised by the Canadian Securities Administrators. By most accounts, the Pebble deposit is a world-class deposit and the Wardrop report counts nearly 11 billion tonnes of total resource. It is unlikely that all the ore currently identified would be mined, so 11 billion tonnes would be an upper bound for this particular deposit. It is also certain that exploiting the Pebble deposit would have to be at a scale large enough to justify the capital investment to build an infrastructure in such a remote area. Although the Assessment is ostensibly about any mining development in the Bristol Bay watershed, the use of the Wardrop scenario for Pebble effectively makes the report an assessment of mining the Pebble deposit.

RESPONSE: The purpose of the assessment is to estimate potential impacts of large-scale surface porphyry copper mining on salmon ecosystems in the Bristol Bay watershed. The preliminary plan for mining the Pebble deposit was used as the basis for the assessment because that deposit is the most likely to advance in the near term. Also, the Agency believes that mining of other porphyry copper deposits in the watershed would proceed with a similar approach, since the scenarios used are similar to what has been done at other porphyry copper deposits. Therefore, it is appropriate to use Northern Dynasty Mineral's 2011 plan for the Pebble deposit (Ghaffari et al. 2011) as the basis for the scenarios; however, a final mining

plan may differ from what is presented in Ghaffari et al. (2011). Chapter 13 of the revised assessment also considers the potential cumulative effects of additional smaller copper porphyry mines in the watershed. No change suggested or required.

The question then becomes what size mine is feasible from a technical and economic point of view. The Pebble deposit mine plan, as presented in the Wardrop report, outlines three scenarios:

- An "investment decision case" for a 25-year mine life that would mine 2 billion tonnes of ore;
- A "reference case" for a 45-year mine life that would mine 3.8 billion tonnes of ore; and
- A "resource case" for a 78-year mine life that would mine 6.5 billion tonnes of ore, or 55% of the total measured, indicated and inferred resource.

The Assessment chose minimum and maximum mine sizes of 2 billion and 6.5 billion tonnes of ore, respectively. Thus, the resource estimate used for the Assessment is the same as that for the two end members presented by Wardrop. This would make the mine one of the largest in the world, exceeding the size of the 10th percentile of global porphyry copper deposits by an order of magnitude (see Appendix H of the Assessment). Mines that ultimately become this size usually expand by increments, as exploration discovers new ore zones and expansion permits are granted.

RESPONSE: Yes, the scenarios represent large-scale mines. The purpose of the assessment is to estimate potential impacts of large-scale surface porphyry copper mining on salmon ecosystems in the Bristol Bay watershed, so large mine sizes are appropriate. It is quite likely that large mines would be created in increments, but this would not influence our assessment, as we have evaluated impacts based on volumes of material released in the event of failures or accidents and on material processed as proposed in Ghaffari et al. (2011) as reasonable for a deposit of this size, regardless of the time period for mine operation. However, we have included a third, smaller mine in our revision to represent the median-sized porphyry copper mine on a worldwide basis (250 million tons).

The Wardrop report further delineates Pebble West as a low-grade deposit near the surface that would most efficiently be mined using open-pit methods, with Pebble East as a deeper, higher-grade deposit that would most efficiently be mined using underground methods (specifically block-caving). Mine facilities, as outlined in the Wardrop report, would include:

- Open-pit mining utilizing conventional drill, blast and truck-haul methods for near-surface deposits.
- Underground, block-cave methods for deeper deposits.
- A process plant with throughput of 200,000 tonnes/day that utilizes conventional crush-grid-float technology with secondary gold recovery.
- Other mine-site facilities, including:
    - Tailings storage.
    - Waste rock storage (the estimated waste/ore strip ratio is 2:1).
    - A natural-gas fired power plant.
    - Shop, office, and camp buildings.
    - Pipelines to ship ore concentrate slurry to the port facility; return water from the tailings slurry after separation at the port facility; and fuel.

Dr. Paul Whitney

RESPONSE: No change suggested or required.

This mining and ore processing approach is conventional, and the Assessment includes these elements. A mine developer may present alternative plans that could vary or alter how the mine is developed, but the fundamental components would most likely remain the same.

RESPONSE: The EPA agrees with this comment. No change suggested or required.

Because the Assessment is presented as a general assessment of mining risks and impacts in Bristol Bay and not a specific analysis of the Pebble Project, reliance on the scenario presented in Wardrop makes the assessment overly specific. Further, Chapter 7 provides more specific information on "Cumulative and Watershed-Scale Effects of Multiple Mines," which presents analysis of potential impacts from mining five additional deposits in various stages of development (presumably from early exploration to pre-feasibility). The information presented in Chapter 7 seems more like another mining scenario than a cumulative impacts assessment. Therefore, I would suggest a broader range of potential mining scenarios be organized as follows, with the detail of assessment necessarily becoming more speculative with each subsequent scenario in the list (due to the lack of geologic and engineering information on the other deposits):

- Development of one, average-sized porphyry copper deposit (50^{th} percentile or 250 million tonnes of ore as described in Appendix H) in the location of the Pebble deposit.
- Development of a mega-mine in the location of the Pebble deposit (of the range between 2 and 6.5 billion tons of ore) that may develop after multiple expansion and permitting cycles.
- Development of a mining district consisting of an average-sized Pebble mine and other potential mines (i.e., those presented in Chapter 7).
- Maximum development of all identified potential resources to their most likely ultimate extent.

Considering this broader range of scenarios would help the reader to better understand the range of potential risks and impacts.

RESPONSE: The Pebble deposit is located in the watershed of interest, the deposit is similar to other copper porphyry deposits in the world, and components of the scenarios are common and anticipated for any such deposit of this type; thus, we feel that use of the Pebble deposit characteristics and location is appropriate. The revised assessment includes an additional mine size scenario (Pebble 0.25), representing the worldwide median size porphyry copper mine (Singer et al. 2008). The revised assessment expands the cumulative impacts discussion (Chapter 13) further by including transportation corridors and secondary impacts.

Steve Buckley, M.S., CPG

Additional mine scenarios are necessary to appropriately bound the magnitude of potential mine activities. The maximum mine size in the mine scenario seems appropriate given the existing public information on the Pebble deposit. The minimum mine size of 2 billion tons exceeds the 90^{th} percentile of global porphyry copper deposits. Using a minimum mine scenario in the range of 250 million tons or in the 50th percentile range of global porphyry copper deposits would be more appropriate to bound the lower end of the magnitude of potential mine activities. It would also be useful to include some variation in mining methods. This could include incremental development of a smaller open pit in the lower grade zones of a deposit, along with a portion of the higher grade deposit being mined by underground block caving methods to further assess the minimum potential impact of the mine scenario.

RESPONSE: The revised assessment includes a mine size scenario (Pebble 0.25) representing the worldwide median-sized porphyry copper mine as presented in Singer et al (2008). The revision does not evaluate risks from hazards for underground mining, but a brief discussion of underground mining is included in Chapter 4. The failures assessed would apply whether the mining technique were underground or surface.

Courtney Carothers, Ph.D.

The hypothetical mine scenario was closely based on a probable mine prospect under development. As such, it appears to be realistic and sufficient, if challenging to conceptualize as fully hypothetical given this association.

RESPONSE: No change suggested or required.

The report notes that the Pebble deposit may exceed 11 billion metric tons (4-17). The rationale for choosing 6.5 billion metric tons as a maximum size is based "most likely mine to be developed (4-19)." The rationale for not choosing a higher potential maximum could be explained.

RESPONSE: Both the 2 and the 6.5 billion ton scenarios were presented in Ghaffari et al. (2011) as economically viable, technically feasible, and permittable. The purpose of the assessment was to estimate potential impacts of large-scale surface porphyry copper mining on salmon ecosystems in the Bristol Bay watershed; the 6.5 billion ton mine is a large mine. Because this size mine is on the lower bound of a maximum size, it is a conservative assumption for the risk assessment. Thus, for the purposes of the assessment, it is not necessary to hypothesize an even larger mine.

Dennis D. Dauble, Ph.D.

The hypothetical mine scenario initially appeared realistic and useful in terms of potential project scope. However, it was apparent during the public hearing, and upon further discussion between members of the panel, that assumptions on mine size should be revisited based on deposit characteristics and extraction potential. Also, assumed practices and operations should be verified against current best-practice and State of Alaska permitting guidelines.

RESPONSE: The revised assessment includes a smaller sized mine that is based on the median-sized porphyry copper mine on a worldwide basis. The State of Alaska does not have permitting guidelines that address the size of a mining operation. Land use activities were previously subject to stipulations meant to minimize surface damage or disturbance under 11

Dr. Paul Whitney

Alaska Administrative Code (AAC) 96.140, but this regulation was repealed in December 2002. The State does have statutory and/or regulatory requirements for an approved Plan of Operations (11 AAC 86.800), a Reclamation Plan (Alaska Statute (AS) 27.19.30) and appropriate Financial Assurance (AS 27.19.040).

Referenced literature provides appropriate context, however, I cannot help believe that information on environmental impacts from past mining activities conducted in the Rocky Mountain metal belt would be relevant to this assessment in some cases. It is also possible that recent published information from Holden Mine in northern Washington State would help establish context for effects of leachates and model results that predict downstream transport of tailing material in a wilderness setting, for example.

RESPONSE: Environmental impacts from historic mining are the basis for understanding that risks from hazards of mining need evaluation. Modeling of tailings transport was based on the expected characteristics of tailings for the Pebble deposit. There is an expanse of literature on Superfund sites and interactions of metals associated with sediments and their leaching. We included a number of selected sites in our background information, but to include all possible sites would get further away from the scope of the assessment, which was to evaluate potential effects within the Bristol Bay watershed.

Gordon H. Reeves, Ph.D.

No comments on this question.

Charles Wesley Slaughter, Ph.D.

Given the available information base for the ore deposits of the Bristol Bay watershed, and the publicity which has attended the Pebble planned development over the past several years, the Assessment's hypothetical mine scenario seems fairly realistic. Further, it is appropriate that the Assessment consider the probable impacts of other future mineral development projects once an initial entry (presumably Pebble-Northern Dynasty Minerals) has been accomplished. Such subsequent development – "cumulative effects over a long time period" – could (and should) receive **more** emphasis than is accorded in the Assessment.

RESPONSE: The assessment of cumulative effects of multiple mines is given more emphasis in the new Chapter 13.

John D. Stednick, Ph.D.

The document does not adequately bound the range of mine scenarios. The minimum mine development scenario is not adequately addressed. A frequent criticism during the public comment session was that mine plans presented in the assessment are not representative of current standards. A *compilation* of existing world porphyry mine complexes as well as other types of mines specific to Alaska would better inform the reader of mining processes and potential risks. The physical setting in Southwest Alaska is not the same as the Bingham Mine in Salt Lake City. Currently, the document refers to a particular mine in a particular risk assessment (stressor), e.g., the Fraser River for salmon, Aitika for chemistry, and Altiplano for pipeline failures.

RESPONSE: The revision includes a smaller mine size that represents the worldwide median size for a porphyry copper mine (Singer et al. 2008), to help with the issue of the range of scenarios. EPA disagrees that the mine scenarios evaluated are not representative of current standards. This view apparently stems from use of the term "good" rather than "best" practices in the draft assessment. The reason for using that term is that the term "best management practices" is a term generally applied to specific measures for managing non-point source runoff from stormwater (40 CFR Part 130.2(m)). Measures for minimizing and controlling sources of pollution in other situations are often referred to as best practices, state of the practice, good practice, conventional practice, or simply mitigation measures. We assume that these types of measures would be applied throughout a mine as it is constructed, operated, closed, and maintained post-closure, regardless of the qualifier that one wishes to place with it. A text box was added to the revised Chapter 4 that discusses terms to help clarify our intention for descriptors used. The Fraser River example was considered because it had been used as an analogue by others, but was dismissed as not representative of Bristol Bay. Other mines that are noted in the assessment are illustrative of specific issues only and not used for risk evaluation in the Bristol Bay watershed. While physical settings are not the same, the components and the impacts are similar and thus included to help a reader understand where and how these things occur.

The Bureau of Land Management has identified certain lands that will be excluded from development. This reference needs to be followed up.

RESPONSE: The purpose of the assessment was to estimate potential impacts of large-scale surface porphyry copper mining on salmon ecosystems in the Bristol Bay watershed. This presupposes that our mine scenarios are located in areas that are not excluded from development. The majority of land in the two watersheds is state land that is available for mine development, and Figures 2-3 and 2-4 now indicate protected areas within the Bristol Bay watershed.

Roy A. Stein, Ph.D.

Hypothetical Mine Scenario. Though mining does not lie within my area of expertise, I thought that this scenario helped me understand the potential impact of a mine of this magnitude in a wilderness, pristine watershed. I find it difficult to comment as to whether this scenario is realistic and sufficient, though I did use this scenario to guide my comments below. From the text, it is apparent that this is a realistic scenario, based on documents filed by the company with the Canadian government. This makes this scenario the most realistic one could expect.

a. **Minimum and Maximum Mine Size.** For me, as an ecologist, this bounding helped me to understand the potential impacts of the Pebble Mine, though I did not understand what the probability of either mine size happening in the near term. Understanding these probabilities would be helpful to the readers.

Dr. Paul Whitney

b. **Mine-Size Continuum**. Is it more likely that the initial Pebble Mine will be maximum or minimum in size? Wouldn't it be far better to review a continuum of mine sizes from the smallest that is economically feasible to one that is intermediate in size and then to one (or two) that would take to the largest realistic mine size? With this continuum, the reader begins to understand the overall impact of various mine sizes on the Bristol Bay ecosystem. Some reflection on these mines sizes and their impacts would have helped me interpret the Environmental Risk Assessment with some additional insight.

RESPONSE: The State of Alaska does not have permitting guidelines that address the size of a mining operation. Many identified deposits never become developed mines for various reasons, and it is unknown how many deposits exist and are economically viable for exploration of mining feasibility. Once it is decided to develop a site, there are a number of things that must occur before a mine begins operation. Thus, it is not possible to predict the probability of either mine size happening in a specific period, at least with any certainty. All we can say is that there are deposits that have the potential to be mined in the future.

It is more likely that an initial mine would begin at a smaller scale and become larger and perhaps be permitted in stages of increasing size. However, there are different approaches in how plans are presented and these depend on multiple factors, including economics and projected costs/gains in prices of the metal being mined. For example, if it were not economically viable to mine only a small part of a known large deposit, a larger mine would be proposed and planned for. The revised assessment includes a size scenario that represents the worldwide median-sized mine to provide more of a continuum of sizes.

One Watershed. Given the productivity of salmon from these two river systems (50% of the sockeye salmon in Bristol Bay are produced from these rivers), might there be some thought given to limiting the mining operations to a single watershed, either the Nushagak or the Kvichak (page ES-2)? In so doing, in a single stroke, the impact of this mine on salmon is reduced by 50% or more. Could the Pebble Mine be confined to one watershed, such as where the majority now falls – in the Nushagak River (both the north and south forks of the Koktull River) watershed? Even so, this suggestion becomes especially pertinent to Chinook salmon spawning in the Nushagak River, for this run is "near the world's largest" (page ES-5), but yet the Nushagak watershed is small relative to other watersheds (such as the Kuskokwim and the Yukon) where Chinook salmon are abundant. As a result, any impacts to the watershed by a mine of this size are magnified, another concern when considering this location. Without mining expertise, I cannot judge whether it would be possible to mine in only one of the watersheds, rather than both. Even so, some consideration should be given to this suggestion.

RESPONSE: Restricting impacts to one watershed would change the risks, and could be a part of future mine plans. We chose to represent a suite of realistic mine scenarios based upon preliminary mining plans and the location of the ore deposit which lies in both watersheds.

William A. Stubblefield, Ph.D.

No comments on this question.

Dr. Paul Whitney

Dirk van Zyl, Ph.D., P.E.

The hypothetical mine scenario adopted by the EPA relied almost exclusively on the document prepared for Northern Dynasty Minerals (NDM), one of the partners of the Pebble Limited Partnership. Developing a mine plan for a specific ore body is a large task and is undertaken by a large team of engineers and scientists. In the process of developing a mine plan many options are considered for each facility and its components, including mining methods, process design options, waste rock management options, tailings management options, shipment of product, etc. The hypothetical mine scenario was prepared by an independent consulting company for one of the partners and this plan does not necessarily represent the design and management options that will be selected for developing this ore body. Because of ore grades and the deposit style, it is most likely that an open pit mine will be developed as assumed in the report for the western lower grade ore body and that underground mining will be used for the eastern higher grade ore body. The size of the ore body and the strip ratio for an open pit mine are completely dependent on metal prices and production costs at the time of mine development. Metal prices and production costs will also be a major factor in deciding whether to first develop an underground mine instead of an open pit mine. While some of the components of the final mine may contain elements of the conceptual mine, it is impossible to know whether the hypothetical mine scenario is realistic, as will be further discussed in the comments below.

RESPONSE: It is acknowledged in the assessment that the mine scenarios might not look exactly like a mine presented in a mining plan. The assessment is not a mining plan and is not an evaluation of a mining plan; it simply uses current information for the Pebble deposit because it is a large ore deposit which has had extensive exploration with potential for development in the near future. An additional scenario has been included in the revision to match the worldwide median mine size and show a better continuum of scenarios possible. We consider our scenarios to be realistic, as they were presented as possible layouts for the Pebble deposit and stated in Ghaffari et al. (2011) as being "economically viable, technically feasible, and permittable".

To address the issue of sufficiency it is necessary to understand the range of potential outcomes related to the various options. For the most part, the EPA study used the information from the NDM document for evaluating impacts to salmonids. Using different options, both technological as well as site selection, for some or many of the facilities could result in impacts that are different from those described in the report. I would therefore suggest that using only the present hypothetical mine scenarios is insufficient. There could be a range of impacts, such as the surface areas of facilities, which in some cases could be smaller than what was chosen and in other cases larger. However, this does not mean that the hypothetical mine represents "average conditions." I therefore consider the mine scenario not sufficient for the assessment.

RESPONSE: It is acknowledged in the assessment that the components in the mine scenarios might not be exactly what would be proposed in a mining permit application for this location or for other locations within the Bristol Bay watershed. The purpose of the assessment was to evaluate potential impacts of large-scale surface porphyry copper mining in the Bristol Bay watershed, so the assessment was not meant to represent "average conditions". However, an additional mine size scenario has been included in the revision to match the worldwide median porphyry copper mine size and show a better continuum of scenarios possible.

Dr. Paul Whitney

The minimum and maximum mine sizes selected by EPA are 2 billion tonnes mined over 25 years and 6.5 billion tonnes mined over 78 years; in both cases, the daily ore processing rate is 200,000 tonnes. As indicated above, the final economic mine size at the time of development will be determined by metal prices and production costs. Note that production costs, as used here, include all the considerations related to regulatory, environmental and social aspects of the mine and its environs. Mining companies typically make investment decisions for periods of 20 to 30 years. It is seldom, if ever, that a new investment will be made based on a 78 year mine life; however, the upside potential will be taken into account when an investment for a shorter mine life is made. It is also unlikely that environmental regulatory agencies will consider issuing a permit, including closure plans, etc. for a 78-year project. Furthermore, even if the mine ultimately continues for 78 years, it is certain that the operating and environmental control technologies and societal expectations will change in that period and therefore the elements used by EPA for the maximum size hypothetical mine will certainly not be valid for such a long mine life. It is therefore my conclusion that assuming the development of a 2 billion tonne ore body is realistic, but that assuming development of a 6.8 billion tonne ore body, using static technology assumptions, is not.

RESPONSE: While it is true that an actual mine likely would be permitted in increments, the assessment never stated that the 78-yr scenario would not be done this way. In fact, the assessment does not discuss how such scenarios would be permitted at all, and to do so is outside the scope of the assessment. The purpose of the assessment is to estimate potential impacts of large-scale surface mining of copper porphyry on salmon ecosystems in the Bristol Bay watershed, and that necessarily assumes that the mine scenarios are permitted. It is true that some technologies would have advanced over time from 'day one' of mine scenario development, and we acknowledge this in our assessment. It is impossible to predict, however, how impacts from use of future technologies would differ from those in use today, or how they would change conditions existing at the time they began being used. We can only present and predict potential impacts based on use of the most appropriate technologies available at the current time. No change suggested or required.

The EPA assessment report includes a range of the literature and reports in evaluating the selected mine scenario. However, I have a number of specific comments about various aspects of the report as well as the references.

Good practice vs. best practice. On p. 4-1 of the report, the EPA states: "Described mining practices and our mine scenarios reflect the current practice for porphyry copper mining around the world, and represent current good, but not necessarily best, mining practices". EPA does not clarify this decision, nor does the report clarify the distinction between "good" and "best" practices. It can only be concluded that "best" will be better than "good". On the basis of this, it is inconceivable to me that the Bristol Bay communities, the Alaska regulatory authorities as well as Federal Regulatory Authorities will not demand that the company follow "best mining practices", however that is defined at the time. It is also inconceivable to me that the company will not follow "best mining practices" in the design and development of such a mine. During the engagement processes, the stakeholders will have to agree what represents "best" practice in the design of the mining project. It is important to note that most of the failure statistics used as a basis for the evaluations in the report are derived from data gathered over the last 50 years or so (e.g. refer to p. 4-45 of report). It may be argued that this information is mostly for mines following "good" practices and, in many cases, for projects that had a lower standard of care. To my knowledge, there are no statistics available that compare failure rates of facilities designed and operated under "good" practice to those designed and operated under "best" practices, whatever definitions are used for "good" and "best".

RESPONSE: The term "best management practices" is a term generally applied to specific measures for managing non-point source runoff from stormwater (40 CFR Part 130.2(m)). Measures for minimizing and controlling sources of pollution in other situations often are referred to as best practices, state of the practice, good practice, conventional, or simply mitigation measures. We assume that these types of measures would be applied throughout a mine as it is constructed, operated, closed, and post-closure, regardless of the qualifier that one wishes to place with it. To remove any ambiguity and subjectiveness of terms "good" or "best", we have removed them in the revision and have added Box 4-1, which includes definitions for several terms used.

The EPA also is not aware of any statistics available that compare dams designed (and/or operated) under different standards; however, the probabilities for dam failure used in the assessment were not derived solely from the historical record. Historical failures were discussed as supporting background information and present a defensible upper bound on the failure probabilities. The failure probabilities used in the assessment are based on Alaska's dam classification and required safety factors applied to the method of Silva et al. (2008). The data presented by Silva et al. (2008) consider only the annual probability of failure from slope instability, but the methodology is equally applicable to other failure modes. The discussion of failure probabilities in the revision (Chapter 9) is expanded to clarify this issue.

Mine scenarios. The executive summary indicates (p. ES-11): "The mine scenario includes minimum and maximum mine sizes, based on the amount of ore processed (2 billion metric tons vs. 6.5 billion metric tons), and approximately corresponding mine life spans of 25 to 78 years, respectively". This seems to indicate that the mine life cycle in the first case consists of 25 years of operational life followed by closure and, similarly for the second case, 78 years of operational life followed by closure. However, a careful review of the water management section (section 4.3.7) indicates that this is not the case. The EPA water balance calculations are simplified to a set of deterministic values in Table 4-5 for four water management stages during the overall mine life cycle: start-up, operations minimum mine (25 years), operations maximum mine (78 years), and post-closure. For post-closure, only the 78-year mine life numbers are used. It therefore seems that EPA is not considering that the 25-year mine will close, but that its life will automatically be extended to 78 years. Does this mean that the EPA really does not evaluate the minimum mine size completely, i.e. the 25-year mine life followed by closure? It is important that this be clarified as it would be inconsistent not to evaluate closure of the 25-year mine. It is possible that additional evaluations, or at least additional explanations, will be required to clarify this.

RESPONSE: The reviewer is correct. Our water balance calculations only explicitly present the closure of the Pebble 6.5 scenario. The water balance for the Pebble 0.25 and the Pebble 2.0 scenarios would be similar, but in those scenarios there would be no water captured in TSF 2 or TSF 3 and the amounts captured in the pit would be proportionally smaller, as they are in the operating scenarios. While the pit is filling in each of the three scenarios, the total amount of water captured is slightly less than the amount captured during operations, and

about 35% to 45% of the water captured is available for reintroduction to the streams. Once the pit is full, the amount captured at the mine pit area drops substantially and 100% of the captured water is reintroduced. Post closure flows for the three mine scenarios are presented in Table 6-8.

Tailings management technologies. Ongoing technology development has resulted in a broader range of tailings management options than only slurry tailings disposal. Filtered dry stack tailings can be considered as a realistic option, even for mines with higher production rates. Flotation of remaining sulfides in the tailings before deposition is also a realistic option for mines; it has been done successfully at the Thompson Creek Mine in Idaho for the last 18 plus years. While these technologies are mentioned, they are not selected for reasons such as technology not being appropriate for the climatic conditions and concerns with disposal of pyrite waste. Both of these are not insurmountable technical issues and adopting such management options will reduce failure probabilities and potential impacts following a failure. The failure mode of a filtered dry stack facility not containing sulfides will be completely different from a slurry impoundment and the potential environmental impacts of these other tailings management options will definitely be far smaller than those for the selected mine scenario using slurry tailings disposal.

RESPONSE: Selective flotation to lower the pyrite content has been added to the discussion of processing in Chapter 4 and referenced in Chapter 6 as being done in the assessment scenarios. How tailings are managed within the impoundment can affect water chemistry and a dry stack with sulfides removed may produce the best water quality results after reclamation if the fate of the sulfide tailings is never considered. According to Ghaffari et al. (2011), 14% of the tailings produced would be pyritic (with the selective flotation method used), which equates to an average of 28,000 tons/day in a 200,000 tons/day mining operation, or over 255 million tons during a 25-year estimated lifetime for that scenario. These tailings need to be managed in such a manner that oxidation does not lead to acidic drainage and the most effective way is to deposit them subaqueously. Additionally, a "rule of thumb" for design of dry stack tailings is to allot 25 acres for every thousand dry tons of tailings per day over the life of a 20-year operation (SME Mining Engineering Handbook 1973). Assuming our scenario of 200,000 tons per day processed and that 99% of this material was waste tailings, this would amount to 4900 acres (25 *200,000 *.99/1000) or 19.8 km^2 over 20 years. This exceeds the internal surface area taken up by the TSF for tailings deposited over 25 years for the same mass of material processed per day by 5.6 km^2; thus, even if there were not a risk of the PAG tailings acidic leaching potential, dry stack tailings disposal at this site would create additional surface area loss versus the scenario's traditional dam.

Waste rock management. The waste rock management plan on p. 4-13 calls for the potentially acid generating (PAG) waste rock to be separated from the rest of the waste rock and states that the "PAG waste rock might be placed in the open pit at closure to minimize oxidation of sulfide minerals and generation of acid drainage". However, on p. 4-33 it is stated that: "PAG waste rock will be processed through the flotation mill prior to mine closure, with tailings placed into the TSF (tailings storage facility) or the mine pit." These two alternatives represent completely different management, economic and environmental conditions and are not consistent. Milling the PAG waste rock represents a higher cost than placing the PAG rock in the pit and placing the PAG waste rock tailings in the TSF will increase the size of the TSF. Placing the PAG tailings in the pit will set up a completely different management scenario than placing the PAG waste rock in the pit. The EPA should clarify which option or range of options they select for evaluation and use that consistently in the assessment.

RESPONSE: These statements have been made consistent. The revised assessment scenarios include processing the PAG waste rock over the course of operations to minimize the length of time a PAG waste rock pile would be on the surface, and thus minimize its potential for oxidation and subsequent release of acidic leachate. There is no longer mention of PAG rock being disposed in the pit at closure (Section 6.3.3).

Water balance and management – waste rock. Mine site water balance and management is a very complex issue as recognized by the EPA on p. 4-27: "…water balance development is challenging and requires a number of assumptions". Because of these uncertainties, complex probabilistic dynamic models are employed at mines where the site details are better defined than that of the EPA hypothetical mine scenario. The information in Box 4-2 indicates that the "captured flows include water captured at the mine site and the TSFs (Table 4-5). The total amount of water captured at the mine site includes net precipitation (precipitation minus evapotranspiration [footnote: during operations most of these areas will not be covered with vegetation and the correct terminology here is "evaporation"]) over the areas of the mine pit, the waste rock piles, and the cone of depression (without double-counting any areas of overlap)". On p. 4-23 it is stated that: "Monitoring and recovery wells and seepage cut-off walls would be placed downstream of the piles to manage seepage, with seepage directed either into the mine pit or collection ponds". Figure 4-9 shows this schematically where leachate from the waste rock enters the groundwater that then flows to the mine pit or to the monitoring and collection well. However, if net precipitation only includes the components above (precipitation minus evapotranspiration), effectively excluding infiltration, and if this net precipitation is captured from that waste rock pile (as stated in Box 4-2), then there should not be any water available to infiltrate into the waste rock pile, i.e. there should not be any leachate. All references to seepage from the waste rock piles are incorrect following the EPA's assumptions of total capture of net precipitation. In addition, the approach that is used in the water balance is inconsistent with observed field performance and descriptions in the literature, as is it difficult to imagine a case where there is zero infiltration into a porous waste rock pile (e.g. Nichol et al., 2005 and Fretz et al., 2011). The EPA must clarify the whole water balance model and the evaluations. For the assessment to have any credibility, the water balance and management evaluations should reflect realistic conditions.

RESPONSE: The term "evapotranspiration" has been corrected to 'evaporation' in the revised assessment when discussing the operational phase. Total precipitation equals the sum of evaporation, transpiration (where applicable), runoff, and infiltration. Net precipitation included in the water balance includes all water falling onto the site components minus water leaving only via evaporation (i.e. it includes both runoff and infiltration). Leachate/seepage water originates from precipitation which has infiltrated the waste rock piles or tailings onto which it fell. Therefore, the discussion of seepage is not incorrect, and there is no indication that the scenarios represent "zero infiltration", as we discuss (as noted in the comment made) how seepage and leachate is managed. However, the water balance section has been revised for clarity (new Section 6.2.2). As the commenter notes, the assessment discusses seepage collection systems. However, the assessment does not assume total capture. Our water balance assumes that 50% of the leachate that is lost from the TSFs and from the portion of the waste

rock piles outside the drawdown zone of the pit escapes into the groundwater and eventually into the streams.

Dam failure – tailings storage facilities. During operations, “water falling within the perimeter of a TSF would be captured directly in the TSF, but runoff from catchment areas up-gradient of the TSF would be diverted downstream” (p. 4-27). At closure, water would be removed from the TSF providing more storage, but also maintaining a small pool to “keep the core of the tailings hydrated and isolated from oxidation” (p. 4-32). This seems to assume that the diversion systems will be kept in place and most likely will be upgraded to divert up-gradient surface water around the tailings impoundment. It is likely that the design criterion for the upgraded diversion system during the post-closure period will be the probable maximum flood (PMF) as is done at a number of mines. Dam failure analyses were done assuming that the flood leaving the TSF includes the PMF inflow from the up-gradient catchment, excess water on top of the tailings and 20% of the tailings volume (Box 4-8). While one can argue that a failure including all these materials may be a plausible, although a very low likelihood event during operations, it seems less probable that such a failure will take place for the mine closure period when an upgraded diversion system is in place. Also, during the closure phase, the tailings will consolidate and be less mobile. Note that the densification behavior of oil sand tailings referred to on p. 4-32 (i.e. the Wells, 2011 reference) does not apply to copper tailings. The presence of clay minerals and bitumen in the mature fine tailings portion of the oil sand tailings is the source of the different behavior (Znidarčić et al., 2011).

RESPONSE: It is assumed that post closure scenarios will have drainage facilities in place that could safely pass storm events. However, the decision was made to assume a failure that was consistent for both the operational and post operation scenarios. The PMF would overtop the main dam of the TSF and drain into the North Fork Koktuli as a representative failure, assuming that drainage facilities were either not yet operational or had failed. It is important to note that the PMF peak flow generated only 291 cms, which is small when compared to the peak flow release at the failing dam (149,263 cms and 11,637 cms for the large and small failures, respectively). 20% was selected to represent the volume released from the TSF because it fell within a reasonable range when compared to release volumes of historic failures. The 20% volume included both solids and pore water.

Reclamation slope of waste rock. On p. 4-32 it is stated that: “We assume that NAG waste rock would be sloped to a stable angle (less than 15%) (Blight and Fourie, 2003)”. I contacted Profs. Geoff Blight and Andy Fourie about this statement and received the following response from Prof. Blight: “The only reference to 15 degrees (not 15 %) slopes is the following, talking about the outer tailings, not waste rock covered, slopes of decommissioned TSFs: “it must be remembered that the outer slopes will need to be rehabilitated, and that for vegetation to be stable, and surface erosion minimal, the maximum outer slope should not exceed 15 degrees.” This error in reference must be corrected; it is recommended that more typical closure slopes of about 30% (or 3H:1V, about 18 degrees) for waste rock should be used in the evaluations.

RESPONSE: The text has been changed to correctly read 15 degrees in Chapter 4 and Appendix I.

Dr. Paul Whitney

Phyllis K. Weber Scannell, Ph.D.

The Environmental Assessment discusses a hypothetical mine (given that mine plans have not been developed). Page 4-5 of the document states that "rocks associated with porphyry copper deposits tend to straddle the boundary between net acidic and net alkaline . . ." The Pebble Project Environmental Baseline Report (SRK 2011, Chapter 11) summarizes testing on the samples from the pre-Tertiary porphyry mineralized rock in Pebble East Zone (PEZ) and Pebble West Zone (PWZ). The metals leaching/acid rock drainage study showed acidic conditions occurring immediately in core with low NP, but the average delay to onset of acidic conditions was estimated to be about 20 years. Copper was leached in the highest concentrations, but Co, Cd, Ni, and Zn also leached from samples from PEZ. Wacke (sedimentary rock) samples from PEZ and PWZ leached As, Sb, and Mo, in addition to Cu. (SRK, page 58). The available information on acid generation and metals leaching appears to be preliminary. Development and permitting of a viable mine plan will require extensive sampling and data analysis of ore samples, plans for classifying waste rock (as PAG and NAG), and, possibly, plans for collecting and treating runoff and seepage waters.

RESPONSE: EPA agrees that developing and permitting a viable mine would require extensive information. The assessment is not a mining plan. The scenario presents a suggested treatment option for mining influenced water and settling ponds for water that is simply stormwater runoff. No change required.

The Environmental Assessment seems a bit premature in making an assessment of the potential for acid rock drainage (ARD) or metals leaching (ML). Data on metals other than Cu are insufficient and possible toxicities to fish are not addressed. Further, the description of the potential mine may not reflect a likely mine scenario. It is difficult to calculate potential risks to the environment without a specific mine plan. The section of the Environmental Assessment should be revised as more data on ARD and ML become available.

RESPONSE: The assessment uses the geochemistry data that are available from the Pebble Limited Partnership. Copper was emphasized in the review draft because the EPA believed, and still believes, that it is the contaminant of greatest concern. Toxicities to fish of the other metals were not discussed because they had been screened out. However, the revised assessment explains the screening process and the selection of copper in more detail in a new section on the identification of stressors of concern (Section 6.4.2) and more metals have been added to the screening assessment. The toxicities of all metals reported in the leachate are now addressed either as individual elements or, in the case of major ions, as contributors to total dissolved solids. The mine scenario is based on the most recent preliminary plan released by Northern Dynasty Minerals (Ghaffari et al. 2011).

Paul Whitney, Ph.D.

Reclamation Plan. I am not familiar with the Northern Dynasty Minerals mine plan. I wonder if their mine plan includes a Reclamation Plan. If not, why not? If their mine plan includes a Reclamation Plan, why isn't it presented as part of the Bristol Bay Assessment? The feasibility of reclaiming the waste rock and tailings areas and possibility the pit (page 4-23, last para, last sentence) seems important for evaluating the acceptability of the example mine. I am not aware of any mine regulating agency that does not require a Reclamation Plan as part of a mine application. I wonder if a Reclamation Plan that involved placing waste rock and tailings back in the pit and reducing surface infiltration would greatly reduce the need for water treatment.

RESPONSE: The assessment is not a mine plan. The NDM document relied upon for information in the assessment (Ghaffari et al. 2011) is a preliminary mine plan and does include conceptual reclamation measures which we have used in our scenarios. The State of Alaska requires a Reclamation Plan of all mining facilities unless they are very small (AS 27.19.010). EPA's revised scenarios utilize blending throughout the mine life to eliminate the need for long-term storage of PAG waste rock. Reclamation activities for the scenarios are discussed more clearly in the revision and are activities that are considered feasible and common at other similar existing mining sites. The scenarios in the assessment assume that reclamation is properly completed, but concentrates the discussion on impacts that are expected even with such activities.

<u>Best Mining Practices.</u> The assessment refers to the example mine plan as having both the "best" mining practices (e.g., page ES-10, five lines from the bottom) and "not necessarily best" mining practices (e.g., page 4-17, four lines from the top). Both of these statements can't be accurate.

RESPONSE: With regard to the terminology of "best", "good", or other terms for the practices used, what was intended to be conveyed is that we have assumed modern mining technology and practices. The terms are qualitative when generally interpreted, or have a regulatory meaning (best management practices), and thus we have eliminated their use in the revised assessment to avoid confusion.

<u>Noise Levels.</u> The mine plan should provide information on the location, frequency, and size of blasting, sound level isopleths around the mine, and efforts to minimize sound levels as the mine develops. I wonder if a majority of the sound levels will attenuate as mining activities move deeper into the ground or if will there be a hundred years of blasting at the surface level. The interviews with the villagers indicate that blasting and helicopter noise is a concern (Appendix D, Cultural Characterization, page 94). A characterization of current noise levels in relation to the area and timing of current <u>and past</u> wildlife use would help to determine if the whole or parts of the watersheds are less than pristine.

RESPONSE: Noise from large-scale mines is outside of the scope of this assessment because it is not known to affect salmonid populations. EPA agrees that a full evaluation of any future mining permit applications and subsequent National Environmental Policy Act Environmental Impact Statements would consider these direct effects on wildlife.

<u>Water treatment during the winter.</u> I wonder if it will be possible to treat water during the winter. Will such treatment have to occur in a warm building? If so, what are the temperature consequences of releasing warm treated water into streams?

RESPONSE: Although water quality standards for temperature are directed toward summer maximum temperatures, we emphasize the importance of the year-round thermal regime to which salmon are adapted. Abnormally warm temperatures could accelerate egg maturation and reduce survival of incubating salmon. We state that a protective approach would

discharge water that met baseline thermal regime conditions throughout the year, and describe the risks associated with failure to meet this regime.

Yes, it is possible to treat water during the winter, and treatment facilities would be contained in structures to prevent freezing of the treatment plant. While the Alaska water quality standards (18 AAC 70) do contain maximums for water temperature, even the most stringent of these (13°C) may be too high for winter-time discharge. Very likely, following a permit application, ADF&G would determine an appropriate temperature for winter discharge and the facility would have to meet this value, especially for discharges to anadromous streams. Temperature can be easily lowered during the winter by exposure to ambient air.

<u>Cone of Depression.</u> I have worked on pit mines where hydrogeologists model the lateral extent of the cone of depression and have mapped the lateral extent as an area around the pit. The lateral extent of the cone of depression, illustrated in Figure 4-9, appears to be underestimated and has no effect on streams or wetlands. The figure has no scale. Is the lateral extent of the cone of depression in Figure 4-9 based on modeling (see Box 4-2, para 3, last sentence)? If so, how many NWI wetlands and meters of stream are in the area used for the model? If there are wetlands or streams in the modeled area, how far down stream will the cone of depression influence stream flow and wetland hydrology?
The information in Box 4-2 doesn't clearly (at least to me) deal with the proportions of run-on and run-off water. If the diverted run-on water is supposed to mitigate the cone of depression. will it be available for down stream resources? Why won't diverted water seep back into the near-by pit versus mitigating the cone of depression? The answer to these questions is on page 5-72, but merely indicating there will be a reduction is not very informative.

RESPONSE: The cone of depression is now projected to dewater streams and wetlands with which it intersects. These losses are incorporated into the water balance calculations used to estimate changes in downstream streamflow presented in Chapter 7. The lateral extent of the cone of depression was estimated using the Dupuit-Forcheimer discharge formula for steady-state radial flow into a fully penetrating well in a phreatic aquifer with a diameter equal to the average mine pit diameter. The radius of influence was determined by balancing the net precipitation falling within the cone of depression with the calculated flow into the mine pit. Section 6.2.2.1 and Box 6-2 in the revised draft (Section 4.3.7 and Box 4-2 in the original draft assessment) contain additional details on the methodology.
Our estimate of the mine pit inflow agrees closely with the estimate provided in Ghaffari et al. (2011). The estimated cone of depression would extend about 1.2 km beyond the pit rim. The water within the cone of depression that would flow to the mine pit is included in the water balance. The revised assessment presents estimates of the changes in streamflow at individual downstream gages.

Figure 4-9 (now Figure 6-5) is merely a schematic of the flows and is not to be interpreted as an exact representation of the expected flow regime. The figure is not to scale and is not based on modeling.

All of the precipitation falling within the cone of depression is considered to flow into the mine pit. These losses are incorporated into the water balance calculations used to estimate changes in downstream streamflow presented in Chapter 7. Streams within the cone of depression would dry up. The assessment assumes that water from streams upstream of the cone of

depression would be diverted through pipes or channels to locations on streams downstream of the cone of depression. The diverted water would not seep or flow into the mine pit.

Run-on and run-off water terminology. I am used to referring to up gradient or adjacent water that runs onto the pit or tailings facilities as run-on water and to water from the mine or storage facilities as run-off water. The assessment doesn't always distinguish these two types of water. For example, on page 4-13, line 6 refers to precipitation run-off water as up gradient water. On page 4-26, the first bullet refers to run-off water as water running off mine facilities. The terminology overlap makes it difficult (at least for me) to understand how the run-on and run-off water will be captured and diverted around the mine facilities or used for other purposes. In addition to calculations, diagrams of the diversions would be helpful. Will there be parallel diversion ditches around the facilities, one for run-on and one for run-off water? Will one or both of these ditches be lined? How will the water in these ditches be influenced by the cone of depression? These questions are alluded to in the discussion on page 4-27(second para), but are not explicitly addressed. I am sure engineers can and have answered these questions for other mines with water balance analyses. It would be interesting to see an explicit summary of the water balance for the various facilities. Such analyses would be good for the example mine plan during operation and once the mine is no longer a net consumer of water (page 5-44, para 2). Without the water balance analyses, potential impacts are not easily understood or quantifiable.

RESPONSE: A single diversion ditch intercepts up-gradient surface water and routes it around the areas disturbed by mining, preventing it from mixing with waters that have encountered site materials. The revised assessment includes a more detailed water balance (Chapter 6).

Some ideas for how to manage and separate run-on and run-off water might help determine which streams might dry up and what type of mitigation measures (i.e., lining ditches) could minimize the impact. In addition, if run-on water can be maintained in a diversion ditch, what is the opportunity for developing a reclamation plan for the ditches? Such plans might be able to minimize and partially compensate for lost reaches of headwater streams.

RESPONSE: The revised assessment does include some possible reclamation activities for closure, although others could be proposed for an actual mining plan. Water would continue to be diverted around areas where the water could encounter contaminants. Mitigation to compensate for lost streams would be addressed through a regulatory process that is beyond the scope of this assessment. Nevertheless, in response to public and peer comments we have included a discussion of compensatory mitigation in Appendix J of the revised assessment.

PHW Response: See my response to Mitigation Measures on page 12.

Formatted: Font: Not Bold, Not Italic, Font color: Red

Protective approach. A "protective approach" is mentioned on page 5-30 (para 3, last sentence). This has something to do with water management and would be good to explain.

RESPONSE: This has been clarified in Chapter 7.

Dr. Paul Whitney

Question 3. ***EPA assumed two potential modes for mining operations: a no-failure mode of operation and a mode involving one or more types of failures. Is the no-failure mode of operation adequately described? Are engineering and mitigation practices sufficiently detailed, reasonable, and consistent? Are significant literature, reports, or data not referenced that would be useful to refine these scenarios, and if so what are they?***

David A. Atkins, M.S.

The no-failure scenario attempts to quantify the impacts from developing the footprint of the project alone. In reality, various failures and accidents inevitably occur, and they may have a range of impacts from inconsequential to large. So this scenario is presented to describe the minimum impact that could be expected from project development assuming everything works as planned.

RESPONSE: This comment is a correct interpretation of our "no-failure" scenario. Because this distinction was not clear to many other readers, the revision no longer uses the term "no failure". The no-failure scenario from the draft assessment has been changed to a chapter on the effects of the footprint of a mining operation, without regard for operational problems (Chapter 7).

The mine will, by necessity, remove those streams and wetlands that are beneath the pit, waste rock, tailings and processing plant development areas. There should be some flexibility in siting facilities other than the pit or underground workings. For the 'no-failure' scenario, the Assessment presents lengths of stream and areas of wetlands that would be lost due to physical displacement of the aquatic resources from mine development and reduction in flows from mine water management. The assessment presents the following resources that would be lost and that have been shown to be spawning or rearing habitat for coho, Chinook, and sockeye salmon, or have resident populations of rainbow trout and Dolly Varden:

	25-year scenario	78-year scenario
Eliminated or blocked streams (km)	87.5	141.4
Reduced flow (>20%; km)	2	10
Eliminated wetlands (km^2)	10.2	17.3

Given the range of uncertainty with the proposed mine plan, presenting stream lengths and wetland areas to the tenth place implies unrealistic accuracy. Significant figures should be checked and consistent throughout the document, and ranges should be presented if known (e.g., results for the pits could be presented with more accuracy since we know where they will be, whereas other facilities that could be located in different areas should be presented with an appropriate range of uncertainty).

RESPONSE: The authors have carefully addressed this issue. Numbers from the literature or from the PLP EBD retain the number of significant figures in the original. Numbers derived for this assessment have the appropriate number of significant figures given the precision of the input data and uncertainties due to modeling and extrapolation.

Dr. Paul Whitney

The impacts as presented appear substantial, mainly because of the very large nature of the project. However, it would be helpful to describe the significance of this loss, specifically with regard to the following questions:

- What impact would the loss to streams and wetlands have on the fishery within the Nushagak and Kvichak basins?

RESPONSE: Impacts of habitat loss and alteration are very difficult to quantify given the lack of information on limiting factors, production and capacity estimates. We were unable to comprehensively evaluate impacts at the population level, except for the most severe cases where total losses of runs could be reasonably assumed.

- Is this loss significant in comparison to the fishery as a whole?

RESPONSE: Losses of streams and wetlands under the mine footprint could not be related to the fishery due to reasons listed above. For the TSF failure scenario that completely eliminates or blocks access to suitable habitat in the North Fork Koktuli River, we estimate that the entire Koktuli portion of the run (~28% of Nushagak escapement) could be lost. Higher proportional losses would occur if significant downstream effects occurred due to transport of toxic tailings fines beyond the Koktuli as modeled under the Pebble 2.0 TSF failure.

- Are there local communities that could be affected by this specific loss?

RESPONSE: Wildlife and resident fish communities would be affected by reductions in spawning salmon. Local communities would also be affected by the reduction, which is now discussed in Chapters 12 and 13 (e.g., Chapter 13 now contains tables which refer to specific subsistence resources used by individual communities).

- Is fragmentation of the resource from this loss a significant impact (i.e., are there stocks that are unique to the project area)?

RESPONSE: Stock structure and genetic diversity are not well known at the project scale, but based on evidence from other parts of Bristol Bay watersheds, local adaptation is highly likely. Discussion of fragmentation effects is now included in Chapters 7 and 10.

There is no discussion of engineering and mitigation practices in this section. The responsible regulatory authority would require the project proponent to present a mitigation plan to compensate for these impacts before permitting. Measures would include minimization of impact through facility siting, reclamation if possible, and compensation if reclamation were not feasible. A thorough analysis of possible mitigation approaches and the likelihood of their success are necessary to fully evaluate impacts from the 'no-failure' scenario.

RESPONSE: Mitigation measures for design and operation are more clearly called out in the revised assessment. While measures chosen here may differ from what is required during the regulatory process, the assessment is not a mining plan and not an evaluation of a mining plan. The assessment assumes that measures chosen for the scenarios would be as effective as possible and examines only accidental failures rather than a failure to choose a proper mitigation measure. Mitigation to compensate for effects on aquatic resources that cannot be

avoided or minimized by mine design and operation would be addressed through a regulatory process that is beyond the scope of this assessment. Nevertheless, in response to public and peer comments we have included a discussion of compensatory mitigation in Appendix J of the revised assessment.

Steve Buckley, M.S., CPG

The engineering and mitigation designs associated with the no-failure mode of operation are inadequate. There is no detailed discussion of engineering practices. There is insufficient discussion of any potential mitigation measures and there is a lack of any detailed research into applicable engineering and mitigation methods. Appendix I provides some engineering and mitigation practices along with water quality mitigation and monitoring during closure; however, these are not discussed or accounted for in the main assessment document.

RESPONSE: Mitigation measures, including wastewater treatment and closure and post-closure monitoring and maintenance, were included as part of the mine scenarios in the draft assessment, and this discussion has been expanded in the revised assessment. The mitigation measures proposed within the mine scenarios are those that could reasonably be expected to be proposed for a real mine (they are a subset of options presented in Appendix I), all of which were presented as appropriate for the Pebble deposit in Ghaffari et al. (2011). Mitigation to compensate for effects on aquatic resources that cannot be avoided or minimized by mine design and operation would be addressed through a regulatory process that is beyond the scope of this assessment. Nevertheless, in response to public and peer comments we have included a discussion of compensatory mitigation in Appendix J of the revised assessment.

Courtney Carothers, Ph.D.

The no-failure mode of operation appears to be described adequately. The engineering and mitigation practices appear to be sufficiently detailed, reasonable, and consistent, although I have no particular expertise with which to evaluate this part of the assessment.

RESPONSE: No change suggested or required.

It would be helpful to have a clear statement about how well the local (geotechnical, hydrologic, and environmental) conditions in this region have been studied and characterized. How much is understood about the seasonal variation in these conditions and how those variations would affect these scenarios? How well are statistics from mines and TSFs constructed in very different environments likely to apply here?

RESPONSE: TSF failure probabilities are based on Alaska's dam classification and required safety factors applied to the method of Silva et al. (2008). The discussion of failure probabilities is expanded to clarify this issue. Therefore, the failure is not a consequence of any specific site conditions or seasonal phenomena. However, the discussion of local and regional conditions has been expanded in the revised assessment. It is recognized that some issues such as hydrology are very complex and additional information will be useful in future analysis of any mine plans.

Dr. Paul Whitney

Dennis D. Dauble, Ph.D.

The description of the no-failure mode for mine operation appears adequate in terms of potential mitigation measures that might be employed. I have limited knowledge of current engineering practices and subsequent risks to the environment from best practices of modern mines, including those operating under optimal conditions. However, it would be helpful to include a short discussion on which mitigation measures would be most applicable to mining activities in the Bristol Bay watershed.

RESPONSE: Standard design mitigation measures considered feasible, appropriate, and 'permittable' (as per Ghaffari et al. 2011) were considered and are discussed in Chapter 6 and Appendix I of the revised assessment; these are standard measures common to other copper porphyry mines. Evaluation of measures that would be proposed for an actual mine would occur through the regulatory process. Whether these same measures would be appropriate for all locations within the Bristol Bay watershed would depend on the given site's specific characteristics.

Gordon H. Reeves, Ph.D.

No comments on this question.

Charles Wesley Slaughter, Ph.D.

Based on the actual history of other major resource extraction projects in Alaska and throughout the world, a "no failure" assumption seems unrealistic. Rather, the assumption should be that there will be failures, of varying modes and magnitudes, over the life of the project. This reality is recognized in several sections of text.

RESPONSE: Our intention for the "no-failure" scenario was to identify and evaluate the unavoidable environmental effects if all systems and mitigation measures operated perfectly, and to separate those effects from a scenario where systems periodically failed. The "no failure" chapter has been eliminated. The revised assessment differentiates between potential effects from the footprint of a mine (Chapter 7), water treatment (Chapter 8), TSF failures (Chapter 9), the transportation corridor (Chapter 10), and pipeline failures (Chapter 11).

In some sections in the Assessment, presumed "mitigation practices" are either cursory, optimistic, or so general as to be un-supported. Examples include Section 4.3.7's cursory, generalized statements about handling water: "Uncontrolled runoff would be eliminated…The mine operator would capture and collect surface runoff and either direct it to a storage location…or reuse or release it after testing and any necessary treatment"; "…water from these upstream reaches would be diverted around and downstream of the mine where practicable"; "precipitation would be collected and stored…"; and "Assuming no water collection and treatment failures, this excess captured water would be treated to meet existing water quality

Dr. Paul Whitney

standards and discharged to nearby streams, partially mitigating flow lost from eliminated or blocked upstream reaches." Other examples from Chapter 6: "…assuming no water collection and treatment failures" and "excess captured water would be treated…and discharged to nearby streams..."

RESPONSE: Water management (mitigation) measures are more clearly described and discussed in the revised Section 6.1.2.5, and in sub-sections for the mine components in the scenarios. However, the intent of the assessment is not to specify technologies, beyond those already identified by the existing preliminary mining plans. Rather, the assessment focuses on the environmental outcomes of conventional modern mining practices and effluents.

John D. Stednick, Ph.D.

The no-failure mode is not adequately described. Assessment of the effects of the mine is based on large risk failures of low probability and did not include low risk failures of higher probability. The report concludes (and emphasizes) that the mine footprint will disrupt/disturb contributing watershed and wetland areas and result in hydrologic modification. The hydrologic modification affects salmonid habitats, particularly in low flow conditions. Regulatory oversight will include the State of Alaska, and certainly mitigation measures would be required. The task is to address the adequacy of these mitigation measures.

RESPONSE: Our intention for the "no-failure" scenario was to identify and evaluate the unavoidable environmental effects if all systems and mitigation measures operated perfectly, and to separate those effects from a scenario where systems periodically failed. The revised assessment no longer uses the term "no-failure", and does address effects from scenarios having higher probability and lesser magnitude (e.g., failure to collect or treat leachate water) in addition to those with lower probability and higher magnitude (e.g., TSF failure). Mitigation to compensate for effects on aquatic resources that cannot be avoided or minimized by mine design and operation would be addressed through a regulatory process that is beyond the scope of this assessment. Nevertheless, in response to public and peer comments we have included a discussion of compensatory mitigation in Appendix J of the revised assessment.

Pollutant/toxicity assessment focused on copper. Other metals can be presented to show the range of metal concentrations for chronic and acute toxicity. Suitability of treatment processes for all wastewaters can be included to address potential effects on receiving waters.

RESPONSE: Although copper is emphasized due to its dominance of the toxicity of leachates, other metals were and are presented (Chapter 8).

The discussion of roads is mostly related to fish blockage and some soil erosion. Information on current design standards was not included and tended to relay on dated references from logging roads

RESPONSE: The discussion of roads covers risks related to filling and alteration of wetlands, stream crossings, fine sediments, dust deposition, runoff contaminants, and invasive species. Information on current design standards is now included within text boxes throughout Chapter 10, and relies on recent literature. The failure frequencies cited in the assessment are from modern roads and not restricted to forest roads. One of the papers used for general

information (Furniss et al. 1991) focuses on forest and rangeland roads, but it is a seminal publication on the potential effects of roads, particularly as they relate to salmon.

There were no engineering or mitigation practices described in this section or in the document.

RESPONSE: Mitigation measures, including wastewater treatment and closure and post-closure monitoring and maintenance, were included in discussion of the mine scenarios in the draft assessment as part of the design. This discussion has been expanded in the revised assessment.

Roy A. Stein, Ph.D.

No Failure Operations and Their Impact. What about the failure of continued monitoring, of continual inspection, of continual, rigorous oversight? This is more insidious than a catastrophic failure of some sort, but perhaps just as dangerous (in fact, one research geochemist testified during public testimony that of 150 hard-rock mines, none operated without leakage of leachate). How can we be sure that mine operators will be held strictly accountable for their actions with regard to best mining practices (a point emphasized by those who testified in favor of the Pebble Mine that indeed best management practices would be used), meeting all the various and sundry regulations, and communicating all of these activities back to the regulatory organization? Will there be a force of will on the part of EPA or other regulatory body to be sure that all activities of the operator are appropriate and within regulatory limits? The down-side of poor monitoring and lack of rigorous oversight is the loss of salmonid populations. These losses are, in my view, less important than compromising human health and life. Yet, at the Upper Big Branch Mine in West Virginia, dust standards have been exceeded for years, leading to a dust explosion that killed 29 miners on April 5, 2010. In turn, even surviving miners were not immune to these dust impacts, for they suffer from "black lung", a condition that literally shortens their life by decades. In turn, much of the monitoring of these conditions has historically been the responsibility of the owner corporation, rather than an independent regulatory body, much like "the fox guarding the chickens". Here at the Pebble Mine site, where only fish (but, of course, Native Alaskan subsistence users, plus other human users as well) are at stake, would one expect rigorous oversight by appropriate regulatory bodies? Skepticism leads to cynicism when contemplating the Upper Big Branch Mine case history in the context of the Pebble Mine proposal.

RESPONSE: Our intention for the "no-failure" scenario was to identify and evaluate the unavoidable environmental effects if all systems and mitigation measures operated perfectly, and to separate those effects from a scenario where systems periodically failed. The "no failure" chapter has been eliminated. The revised assessment differentiates between potential effects from the footprint of a mine (Chapter 7) water treatment (Chapter 8), TSF failures (Chapter 9), the transportation corridor (Chapter 10), and pipeline failures (Chapter 11). Holding the mining company accountable is done through the regulatory process and is outside scope of this assessment.

Engineering Practices and Mitigation. I did not think that mitigation was well described in text, but Appendix I is quite well developed and was instructive to me as I moved through the documents. I would suggest including the ideas in Appendix I in the mitigation section of the main report. Other comments on mitigation issues can be found below associated with Question 12.

RESPONSE: Mitigation measures for design and operation are included in the assessment (Chapter 6), and are those that reasonably could be expected to be proposed for a real copper porphyry mine (they are a subset of options presented in Appendix I). Many, if not all, of these measures were presented as appropriate for the Pebble deposit in Ghaffari et al. (2011). Mitigation to compensate for effects on aquatic resources that cannot be avoided or minimized by mine design and operation would be addressed through a regulatory process that is beyond the scope of this assessment. Nevertheless, in response to public and peer comments we have included a discussion of compensatory mitigation in Appendix J of the revised assessment. Mitigation measures have been explained more clearly throughout the revised assessment.

William A. Stubblefield, Ph.D.

It is interesting and appropriate that the EPA has included both modes of operation in conducting this assessment. This approach provides some degree of "bounding" for the assessment; however, the degree of accuracy (i.e., predictability) for either scenario cannot be known at this time. The document appropriately acknowledges that there are a variety of potential mitigating factors (e.g., acts of God, accidents, market changes) that may render the assumptions used in this assessment incorrect.

RESPONSE: Our intention for the "no-failure" scenario was to identify and evaluate the unavoidable environmental effects if all systems and mitigation measures operated perfectly, and to separate those effects from a scenario where systems periodically failed. There were a number of comments on this approach so the revised assessment no longer uses the term "no-failure" and addresses effects from the foot print (i.e., the no failure scenario), failure scenarios having higher probability and lesser magnitude (e.g., failure to collect or treat leachate water), and failure scenarios having lower probability and higher magnitude (e.g., TSF failure).

No change suggested or required.

Dirk van Zyl, Ph.D., P.E.

The no-failure mode of operation failures is based on surface disturbances and potential blockages caused by the various facilities. For example, for the mine pit, TSF and waste rock facility, the surface areas of these facilities are used as a basis for calculating the streams and wetlands affected by the mining activities. While the failure mode is adequately described, engineering and mitigation practices are not adequately described by EPA.

RESPONSE: Mitigation measures associated with the mine components (e.g., waste rock pile, TSF, etc.) were discussed in the sections presenting those components. They were not repeated in the section on failures. These measures are included again in the revised assessment (Chapters 4 and 6), but are described in greater detail. However, the emphasis of the

assessment is on the consequences of failures rather than on the details of how inadequate mitigation may cause the failures.

The EPA Assessment states on p. 8-1 "Routine operations are defined as mine operations conducted according to conventional practices, including common mitigation measures, and that meet applicable criteria and standards". The adverse effects listed are: direct impacts as a result of removal of streams in footprint of mine pit and waste storage areas; reduced streamflow resulting from water retention; removal of wetlands in the footprint of the mine; indirect impacts of stream and wetland removal; diminished habitat quality in streams below road crossings; and inhibition of salmonid movement from culverts that may block or diminish use of full stream length.

RESPONSE: No change suggested or required.

Any mine in Bristol Bay will have to undergo a rigorous and lengthy regulatory review and permitting process. I do not know of a process that will exclude consideration of the impact of all mine facilities on the streams and wetlands in the region. Therefore, I would suggest that the full implications of "mine operations conducted according to conventional practices, including common mitigation measures, and that meet applicable criteria and standard" should have been addressed in the report. The EPA (2003) document on Generic Ecological Assessment Endpoints for Ecological Risk Assessment specifically details the applicability of Section 404 of the CWA in addressing community and ecosystem-level endpoints. "The CWA provides authority for the Corps to require permit application to avoid and minimize wetlands impacts and requires EPA to develop, in coordination with the Corps, the criteria used for Section 404 decisions. When damages to wetlands are unavoidable, the Corps can require permitees to provide compensatory mitigation". It is unclear why this was not included in the evaluations.

RESPONSE: This is not a permitting document. The purpose of the assessment is to evaluate the effects of the operation of a mine on salmon ecosystems in the Bristol Bay watershed, while following conventional practices, including common mitigation measures. Once those effects are described, then it is appropriate to determine 1) if unacceptable environmental effects are likely to occur and 2) whether those effects can be offset (made acceptable from a regulatory standpoint) with compensatory mitigation. In other words, compensatory mitigation is a next step and not within the scope of this assessment. Nevertheless, we have included a discussion of compensatory mitigation in Appendix J in the revised assessment.

Similarly, one would expect that the regulatory reviews will require that the impacts resulting from loss of streams, streamflow and road crossings will be addressed through engineering designs, proposed mitigation measures, as well as regulatory and community engagement best mining practices (see discussion above on "good" vs. "best" practices).

RESPONSE: Our scenarios included mitigation measures through engineering design and operations to reflect standard industry practices. The purpose of the assessment was to evaluate risks in the presence of these measures. The commenter is correct that alternatives for such measures would be evaluated during the permitting (regulatory) process. No change suggested or required.

Dr. Paul Whitney

On p. 4-33, it is stated that "Environmental impacts associated with premature closure may be more significant than those associated with planned closure, as mine facilities may not be at the end condition anticipated in the closure plan and there may be uncertainty about future reopening of the mine". Further text describes potential negative impacts from such a premature closure. One of the outcomes of the regulatory review and permitting will be the establishment of financial assurance that will provide State and Federal Regulatory Agencies with the financial resources to accommodate a closure. These obligations are typically reviewed on a 3 or 5-year interval to also make sure that they are adequate to cover premature closures. If the mining company is still managing the site, then they will have responsibilities under all Federal and State Regulations and the dire picture painted by the EPA Assessment should not come to pass.

RESPONSE: The revision includes language that addresses financial assurance (Box 4-3).

Because of this major oversight of the realities when permitting and operating a mine it is essential that the scenarios be reviewed by evaluating the effects that regulatory requirements and resulting mitigation methods would have on the no-failure conditions before completely reworking the no-failure mode of operations and their impacts. Other significant reports and data that should be reviewed include typical permitting documents and resulting requirements for similar mines in the US and Canada to obtain a range of potential outcomes. The results from such an evaluation will also contribute significantly to the discussions in Alaska when the Pebble Mine and other mines in Bristol Bay are brought forward to permitting.

RESPONSE: Our intention for the "no-failure" scenario was to identify and evaluate the unavoidable environmental effects if all systems and mitigation measures operated perfectly, and to separate those effects from a scenario where systems periodically failed. The revised assessment no longer uses the term "no-failure", but simply presents effects from scenarios having higher probability and lesser magnitude (e.g., failure to collect or treat leachate water) as well as those having lower probability and higher magnitude (e.g., TSF failure).

Phyllis K. Weber Scannell, Ph.D.

Chapter 4 provides a detailed description of a hypothetical mine design for a porphyry copper deposit in the Bristol Bay watershed. Some of the assumptions appear to be somewhat inconsistent with mines in Alaska. In particular, the descriptions of effects on stream flows from dewatering and water use do not account for recycling process water, bypassing clean water around the project, or treating and discharging collected water.

RESPONSE: The issues mentioned were discussed in Sections 4.2.3 (tailings storage) and 4.3.7 (water management) in the original draft document. They are now addressed in Chapter 6 of the revised document, which describes the mine scenarios, and in Chapter 4, which provides generic background on porphyry copper deposits and mining. Streamflow effects presented in Chapter 7 now reflect a complete water balance, including water capture and re-use, bypass, and discharge from the wastewater treatment facility, as suggested by the commenter.

Section 4.3.8, Post-closure Site Management, raises critically important issues – can a mine in this area be designed for closure? Is it acceptable to develop and operate a mine that will require essentially perpetual treatment? It is my belief that these are the essential questions that should be addressed during any mine permitting process.

RESPONSE: EPA agrees that these are important questions to be addressed, but they are risk management, not risk assessment, questions. The purpose of the assessment is to evaluate risks to the salmon fishery from large-scale mining. Risk management decisions will be made during the permitting process. Thus, no changes to the assessment were made in response to this comment.

Section 4.3.8.1 raises concerns about long term water quality and quantity from the mine pit. These concerns need to be addressed during a mine permitting process. Pit water quality depends on how the pit is developed, what reclamation will occur, if reclamation will be concurrent with mining, and what kinds of water treatment will be used. Tailings storage facility (TSF) water quality depends on how the mine tailings are managed; it may be possible to use dry stack tailings with sulfide removal rather than submerged tailings.

RESPONSE: EPA agrees that water quality can be influenced by design and reclamation, but when the latter entails creating a pit lake there is little flexibility for reclamation concurrent with mining. How tailings are managed within the impoundment can affect water chemistry, and a dry stack with sulfides removed may produce the best water quality results after reclamation if the fate of the sulfide tailings is never considered. According to Ghaffari et al. (2011), 14% of the tailings produced will be pyritic, which equates to an average of 28,000 tpd in a 200,000 tpd mining operation (over 255 million tons during a 25 year mine life). These tailings need to be managed in such a manner that oxidation does not lead to acidic drainage, so the most effective way is to deposit them subaqueously. Some suggested common mitigation measures for management of the pit at and post closure are included in the revised assessment (Chapter 6).

Paul Whitney, Ph.D.

Mitigation Plan. Most mine permit applications I have worked on include both mitigation to minimize environmental impact and mitigation to compensate for environmental impact. The assessment outlines a variety of mitigation measures to minimize impact, but no compensatory mitigation. This is a concern, for I wonder if compensatory mitigation for the example mine is even possible in the watersheds.

RESPONSE: The purpose of the assessment is to evaluate the effects of the footprint and operation of a mine that follows conventional practices, including common mitigation measures. Once those effects are described, then it is appropriate to determine 1) if unacceptable environmental effects are likely to occur and 2) whether those effects can be offset (made acceptable) with compensatory mitigation. Determining compensatory mitigation is a next step and outside the scope of this assessment; however, we have included a discussion of compensatory mitigation in Appendix J in the revised assessment.

The watersheds are characterized with descriptors such as “pristine” (e.g., page 6-29, last para, second line), “nearly pristine” (e.g., pages 2-25 and 7-2) and “exceptional quality” (page 2-20). It is also stated that the return of the salmon “fuel” (i.e., provide energy to) the terrestrial food web.

Dr. Paul Whitney

If in fact the watersheds are pristine or nearly pristine, the habitat is high quality and there is little, if any, opportunity for compensatory mitigation (i.e., improving low quality habitat) in the terrestrial and fresh water environments. For example, if 55 miles of streams and streamside wetlands are lost to the mine footprint (page ES 15, first bullet), is it possible to find miles of very degraded stream to plan for and implement compensatory mitigation? If one assumes a mitigation ratio of 3:1 for enhancement, one might have to find 165 miles of degraded stream for compensation. I suspect (but don't know) that there are very few (if any) miles of degraded stream where compensatory mitigation could occur in the Bristol Bay watershed(s). If this is the case, it might not be possible to demonstrate no net loss for waters of the US, and this is something EPA should be interested in.

RESPONSE: The comment is correct in stating that the exceptional quality of the Bristol Bay environment leaves little opportunity for compensatory mitigation. Determining compensatory mitigation is outside the scope of this assessment; however, we have included a discussion of compensatory mitigation in Appendix J in the revised assessment.

I agree that the ecological resources can be ranked as having high quality because the human footprint on the habitat is small (i.e., few roads and villages), but from an energetics (i.e., fuel) and food web perspective, the pristine characterization may not be accurate. The commercial catch of approximately 27.5 million fish each year (up to 70% of the total number of sockeye produced) is a lot of calories that are not flowing through the ecological foodwebs of the watersheds. Granted, some of the commercial catch (if not caught) might not enter the watersheds, but some and perhaps a lot would, especially in good run years. While the harvest level might be sustainable, the loss of energy to commercial fishing causes pause to characterize the watersheds as pristine or nearly pristine. The potential impact of fisheries on energy flow has been addressed by Pauly et al. (2000) and Libralato et al. (2008). I wonder if it is technically possible that a reduction in the commercial fishery is a compensatory mitigation measure.

RESPONSE: Compensatory mitigation requirements address the need for project proponents to replace aquatic resources and ecosystem functions that their project has impacted. Reduced fishing harvests would not replace lost spawning and rearing habitat. Further, it would remove the burden of compensation from the party that caused the damage. Determining compensatory mitigation is outside the scope of this assessment; however, we have included a discussion of compensatory mitigation in Appendix J in the revised assessment.

PHW Response: Pointing out that reducing commercial harvest would not replace lost spawning and rearing habitat is very good and I appreciate the insight. None-the-less EPA seems to have a hard time acknowledging much less discussing the negative impact commercial fishing has on ecosystem energetics and nutrient cycling. Acknowledging these past, current and future impacts would greatly improve the Cumulative Impact part of the EPA assessment.

Formatted: Font: Not Bold, Not Italic

Effluent treatment. Water quality information in the assessment for benchmarks, background, and leachate is extensive. A thorough review of the water quality and toxicity information is beyond the scope of work of this review. After several reads of this information, it appears that the work is good for copper. For example, work on salmonid olfaction and copper conducted by McCarthy et al. (2007) is potentially important and is cited. The inhibiting effects of copper on olfactory receptor neurons cited by McCarthy et al. (2007) at or above 2 µg/L are lower than the Alaska hardness-based standards and the biotic ligand model (BLM) standard in Table 5-14, but are above the biotic ligand model standard in Tables 5-15 and 5-16. I assume this is due to differences in binding of copper by dissolved organics but I am not sure. Whether one decides to use the 2 µg/L benchmark, or the even lower BLM benchmarks that are in some cases below background values in Table 5-19, I think the key question is whether proposed leachate processing can cost-effectively achieve benchmarks that hover around background concentrations. The answer is beyond my level of expertise.

RESPONSE: BLM-derived copper criteria are derived for the different leachates. The values depend on the co-occurring ions, which differ considerably among leachates and, in the case of ambient waters, on dissolved organic matter. The low copper benchmarks would be achievable with treatment by reverse osmosis, which has been used at other mines. Whether it is economically feasible to achieve benchmarks close to background concentrations is outside the scope of the assessment. No change suggested or required.

I do not agree with the assessment's critical question – whether or not effects are observed at these low levels (page 5-57, Exposure-Response Data from Analogous Sites, second sentence). If effects are observed at background concentrations, it seems unreasonable to ask for an even lower benchmark than background concentrations. The uncertainties assessment at the bottom of page 5-57 also seems unreasonable. The possibility that background concentrations are not protective in particular cases seems highly unlikely for one of the most productive salmon communities in the world.

RESPONSE: The passages cited by the reviewer refer to the possibility of effects at copper concentrations below criteria, not below background. Similarly, the studies mentioned found effects below criteria levels but above background concentrations.

PHW Response: This isn't the way I read Table 5-19 – please recheck.

Formatted: Font: Not Bold, Not Italic

I can think of many questions that are more critical than looking for effects on salmonids at background or near background concentrations of copper. For example, it might be more important to ask what concentrations of copper will result in a significant impact on the salmonid populations and to ask what impact a mixing zone would have on salmonid populations. Last but not least, what are the potential impacts of all toxics on the many other non-salmonid species?

RESPONSE: See response to previous comment regarding background concentrations versus water quality criteria. Because water quality is so high at the site, the threshold for copper toxicity is low based on the biotic ligand model. Effects on salmonid populations from exceeding toxic thresholds cannot be estimated because the available monitoring data do not characterize salmonid demographics or productivity in the streams draining the site. However, the analysis has been expanded to include estimates of kilometers of stream habitat that would be exposed to copper levels sufficient to cause aversion, sensory deprivation, decreased reproduction, or kills. Mixing zones are not allowed by the State of Alaska for water quality compliance in anadromous streams, and the available stream data are not sufficient for mixing zone modeling. However, a discussion of mixing zones, including the amount of mixing that would be required to reach nontoxic levels, has been added. Non-salmonid fish are not included as endpoint species. However, because copper and most other metals are most toxic to arthropods, the assessment implicitly addresses non-salmonid fish (which depend on arthropods in the food web) as well.

Dr. Paul Whitney

Question 4. ***Are the potential risks to salmonid fish due to habitat loss and modification and changes in hydrology and water quality appropriately characterized and described for the no-failure mode of operation? Does the assessment appropriately describe the scale and extent of risks to salmonid fish due to operation of a transportation corridor under the no-failure mode of operation?***

David A. Atkins, M.S.

For the no-failure mode of mine operation, the risks to salmonid fish due to habitat loss and modification in the vicinity of the project are described in terms of loss of lengths of stream or areas of wetlands. Project proponents state that the mine will only impact a very small fraction of the watershed (under a no-failure scenario). It is important to establish whether the modeled impact (e.g., the loss of 87.5 km of streams) is significant, both in terms of the absolute impact, as well as the effect on ecosystem fragmentation.

RESPONSE: Footprint effects on habitat loss are now characterized in relation to the distribution of habitat conditions throughout the larger watersheds. Fragmentation effects are not anticipated at the mine site, apart from blockage of headwater streams as described, but are anticipated in the case of the transportation corridor (Chapter 10) and TSF failure (Chapter 9).

In addition, project proponents often state they will preserve and even improve the fishery. As mentioned in the answer to the previous question, it would be helpful to know what kinds of mitigation efforts could be employed – minimization, reclamation and compensation – and have some assessment of the potential effectiveness.

RESPONSE: Mitigation measures, including wastewater treatment and closure and post-closure monitoring and maintenance, were included in discussion of the mine scenarios in the draft assessment, and this discussion has been expanded in the revised assessment. The mitigation measures proposed within the mine scenarios are those that could reasonably be expected to be proposed for a real mine (they are a subset of options presented in Appendix I), all of which were presented as appropriate for the Pebble deposit in Ghaffari et al. (2011). Reclamation is not mitigation, but the revised assessment includes also some suggested measures to be used in closure/post-closure to reclaim the disturbed areas. Mitigation to compensate for effects on aquatic resources that cannot be avoided or minimized by mine design and operation would be addressed through a regulatory process that is beyond the scope of this assessment. Nevertheless, in response to public and peer comments we have included a discussion of compensatory mitigation in Appendix J of the revised assessment.

The Assessment determines that construction of the transportation corridor could alter the habitat, chemistry, and the migration path across the corridor for the over 30 streams that the corridor will cross or come near. The report further states that the corridor could affect 270 km of streams below the corridor and 240 km of streams above, but that there is no way to assess the magnitude. Therefore, the impacts of the corridor on fish populations are unknown, and this impact is not described in a way that can allow a reviewer to draw any conclusion.

Dr. Paul Whitney

RESPONSE: The revised assessment states that "the exact magnitudes of changes in fish productivity, abundance and diversity cannot be estimated at this time," but summarizes the species, abundances, and distributions that would potentially be affected. Also, the assessment concludes that, assuming typical maintenance practices after mine operations, approximately 15 of 32 culverted streams with restricted upstream habitat would be entirely or in part blocked at any time. "As a result, salmonid passage—and ultimately production—would be reduced in these streams, and they would likely not be able to support long-term populations of resident species such as rainbow trout or Dolly Varden."

Further, the references for road design and construction practices seem to be more representative of forest and rangeland roads than the type of road that would likely be constructed for this type of project. It would be helpful to cite experience from other transportation corridors constructed for mining and oil and gas projects and developed recently in Alaska.

RESPONSE: Because the proposed mining would take place in an undeveloped area, the literature is necessarily from areas outside of Bristol Bay. Further, we found no data concerning the performance of culverts for mining or oil and gas projects in the region. However, to the extent possible we used examples from representative environments. The failure frequencies cited in the assessment are not restricted to forest roads. One of the papers used for general information (Furniss et al. 1991) focuses on forest and rangeland roads, but it is a seminal publication on the potential effects of roads, particularly as they relate to salmon. The general conclusions of that paper should be applicable to the transportation corridor considered in the assessment. Information on current design standards is now included within throughout Chapter 10, and relies on recent literature.

Steve Buckley, M.S., CPG

Risks to fish due to habitat loss and modification and changes in hydrology and water quality are overly simplified given the broad parameters used to model these potential risks. More specific details on the water balance would help define potential risks to fish from dewatering and habitat loss. For example, there is no attempt to identify groundwater flow paths or the specific response of various landforms to seasonal changes in precipitation and runoff, yet 34 pages are dedicated to an attempt to quantify these impacts. More detailed information is needed to accurately quantify the changes in anticipated runoff and infiltration in the proposed area to determine potential impacts to hydrology and water quality.

RESPONSE: A revised and much more detailed water balance and streamflow analysis is now incorporated in the assessment (Chapters 6 and 7). The revised draft also includes estimates of the specific changes in flow at individual gages. The commenter is correct that the assessment does not specifically address the potential changes in landforms or, for that matter, to vegetation in the land areas such as the drawdown zone which would be among the areas most affected by the mine development. We consider that any such changes would have only a secondary impact on salmon relative to the impacts that the assessment does address.

Dr. Paul Whitney

Additional ecological information on the contributing watershed area for each fish bearing stream crossing would help identify the potential impacts to fish due to the construction and operation of a transportation corridor.

RESPONSE: Additional information on watershed attributes (discharge, channel gradient, floodplain potential) of streams crossed by the transportation corridor, and their importance to salmonids, is now included in the analysis presented in Chapter 10.

Courtney Carothers, Ph.D.

Six key direct and indirect mechanisms are identified to pose potential risk to salmonid fish species: eliminated or blocked streams (87.5-141.4 km), reduced stream flow, removal of wetlands (10.2-17.3 km), indirect effects of stream and wetlands removal (downstream effects likely diminishing fish production), diminished habitat quality downstream of road crossings, and blocked movement of salmonids at road crossings. These mechanisms are described clearly. The report appears to appropriately describe the scale and extent of risks under a no-failure mode of operation, although I have no particular expertise with which to evaluate this assessment.

RESPONSE: No change suggested or required.

Dennis D. Dauble, Ph.D.

The assessment describes the number of stream miles impacted under each mode of operation, including miles blocked and eliminated. Less specific were descriptions of impacts due to sedimentation and leachates. What is lacking is quantitative estimates of spawning and rearing habitat that would be lost relative to the total habitat available. Having this information would help provide perspective of overall risk to individual watersheds and the Bristol Bay watershed as a whole. Risks to salmonid fish due to changes in water quality (i.e., toxic materials) need to consider differences in sensitivity and behavioral response according to salmonid life stage.

RESPONSE: Stream habitat losses are now characterized in relation to the distribution of habitat conditions throughout the larger watersheds (Chapters 3 and 7). The assessment of risks from aqueous toxicity distinguishes overt toxic effects on early life stages from behavioral effects on adults.

Surface water characteristics of site watersheds within the area of probable impact are detailed in Table 5-17, but not so for other streams and lakes in the broader watershed. More information should be presented where available. It is not clear whether potentially affected streams and lakes might be nutrient limited (seems that they might be given their dependence on MDN). For example, include N or P concentrations and some discussion about primary and secondary productivity.

RESPONSE: We recognize that nutrient status, and more importantly prey availability, is a critical component of habitat capacity for fish in these systems, and may be strongly driven by salmon derived nutrients. We concur that more information is needed regarding potential limiting factors for salmon productivity and capacity, and that food availability may be one

such factor. However, because water chemistry data may not provide a complete picture of trophic status, particularly where direct consumption of salmon flesh, eggs, and fry is of such high importance, and because nutrient status is a water quality or habitat parameter not directly influenced by mining operations as outlined in our conceptual models (e.g., Figure 7-1), we determined that nutrient status of area streams is outside the scope of this assessment.

I found risks to salmonid fish due to operation of the transportation corridor well-described with respect to spatial distribution of fish and their habitats.

RESPONSE: No changes suggested or required.

Gordon H. Reeves, Ph.D.

The potential risks to the freshwater habitat of anadromous salmonids are appropriately characterized and described for the no-failure mode of operation. The report considered the primary potential impacts of mine development and operation that could impact habitat and quantified the impacts where possible. The analyses seemed sound and logical, given the acknowledged limitations about the actual mine location and operation.

RESPONSE: No change suggested or required.

One possible factor that could influence the results was the use of the USGS 1:63,360 maps for developing the stream network. These maps generally underrepresent the amount of small streams, which can be ecologically important contributors to the overall productivity of the freshwater habitat of anadromous salmonids. This is acknowledged in the limitations (p. 5-46). Thus, the potential loss and modification of habitat that the report describes could be considered minimal at this time. It would be prudent to confirm the accuracy of the stream layer developed from the 1:63,360 maps in any future analysis.

RESPONSE: The EPA agrees with this comment. No change to the assessment suggested or required.

The potential impact of the mine development and operation on the productive capacity of the various river systems could be developed more fully to gain better insights into potential impacts of the mine. The authors considered the amount of habitat that could potentially be impacted by mine development and operation by estimating the stream length that would be impacted and by considering the percent of spawners of the various species (from ADF&G surveys) observed in potentially impacted areas. However, the productive capacity of given stream reaches for a given fish species can vary widely. Any additional analysis could consider using Intrinsic Potential (IP) (Burnett et al. 2007. Ecological Applications 17:66–80), which considers local geomorphic features to estimate the potential of a given stream reach to provide high quality habitat for a given species. The concept, developed for use in the Pacific Northwest (PNW), has been applied successfully for Chinook salmon in the upper Copper River (A. Bidlack, EcoTrust, Cordova, AK, unpublished). The IP model for Chinook salmon from the PNW that was used in the Copper River was modified after discussion with local biologists. Similar modification may be needed for the PNW IP model for coho salmon to be used in Bristol Bay.

Dr. Paul Whitney

RESPONSE: We now include a characterization of stream channel gradient, watershed terrain (% flatland), and mean annual flow for all streams in the two watersheds. We are unable to build a complete IP model, as this would require validation and more elaborate construction of metrics appropriate to this region, but our preliminary characterization provides the building blocks for assessing the distribution of key habitat-forming and constraining features across these watersheds.

Another factor that I believe merits further consideration is the potential impact of altered thermal regimes of discharge water from treatment facilities (p. 5-28). Warmer water could have potential ecological impacts, particular during the time when eggs are in the gravel. Eggs could develop more quickly and fry could emerge earlier as a result of even minor changes in water temperatures (see: McCullough, D.A. 1999. A review and synthesis of effects of alternations to water temperature regime on freshwater life stages of salmonids, with special reference to Chinook salmon. US Environmental Protection Agency, Seattle, EPA 910-R-99-010. 279 p.; and McCullough, D.A., J.M. Bartholow, H.I. Jager, and 11 co-authors. 2009. Research in thermal biology: burning questions for coldwater stream fishes. Reviews in Fisheries Science 17: 90-113.). These changes could be significant ecologically.

RESPONSE: This is now addressed in Chapter 8.

The report noted in several places that the potential impact on groundwater flows was not understood at this time but that disruptions of flow paths could have critical impacts on aquatic resources. One impact that was not mentioned is the loss of over-wintering habitat. K.M. Burnett (U.S.D.A. Forest Service, PNW Research Station, Corvallis, OR., draft report) found that the major overwintering areas for coho salmon in the Nome River, AK were at points of groundwater inputs. The groundwater influx created areas that were less likely to freeze during winter.

RESPONSE: Overwintering effects from thermal changes are now described in Chapter 7.

Charles Wesley Slaughter, Ph.D.

Yes, the risks to salmonids are well characterized with regard to the hypothetical mine operation itself. However, I suggest that the concept of "no failure," if taken as applying to the entire operation from inception through operation, is not realistic.

RESPONSE: The "no failure" scenario was not meant to represent a realistic scenario. Rather, it was meant to illuminate the effects that would occur solely from a mine footprint, even in the absence of accidents or failure. The revised assessment no longer uses the term "no-failure", but simply presents effects from scenarios having higher probability and lesser magnitude (e.g., failure to collect or treat leachate water) and those having lower probability and higher magnitude (e.g., TSF failure).

The Assessment makes a fair start toward considering the risks to salmonids from the potential transportation corridor. However, the many issues regarding stream and wetlands directly or indirectly affected by roads and pipelines are not fully explored. The extent (length, area) of streams and wetlands affected, as outlined in the text, should be considered a very optimistic lower estimate. The specific issues mentioned, such as bridge or road maintenance, culvert blockage or failure, erosion from cuts, fills, and the roadway itself, are all significant. I simply suggest that the potential consequences of imposition of the (hypothetical) transportation corridor, and future expansions consequent to ancillary infrastructure development and further additional resource extraction projects, would be broader, more severe and of more consequence (and thus should receive more emphasis) than the Assessment indicates. I suggest more fully incorporating Frissell and Shaftel's Appendix G into the body of the Assessment.

RESPONSE: The revised assessment notes that the characterization of both stream length and wetland area affected likely represents a conservative estimate of the potential effects of the transportation corridor on hydrologic features of this area. The cumulative risk section (Chapter 13) has been expanded to include the transportation corridor, ancillary mining development and secondary development. Additional information from Appendix G is incorporated into the main text, and the appendix is referenced in a number of places.

John D. Stednick, Ph.D.

To address this question, a water balance needs to be developed for the study area watersheds. Develop a water balance that includes all the principal components and how they may vary in time and space. The site characterization needs significant improvement, particularly as related to hydrologic inventories and processes. Little to no data are presented on temperature, precipitation, evaporation, frozen soils, soil moisture storage, and groundwater storage and movements. The data that are presented often have unreasonable significant figures. The linkage between surface and groundwater needs to be better demonstrated. Hyporheic exchanges are recognized as being important, but the assessment does not demonstrate this linkage.

RESPONSE: A complete annual water balance with patterns of temporal variability has been developed and incorporated into the revised assessment. Detailed temporal variability is beyond the scope of the assessment. The significant figures of reported data and analysis results have been reduced to a reasonable number. Detailed data presentations on temperature, precipitation, evaporation, frozen soils, soil moisture storage, and groundwater storage and movements are generally not reported. We cite sources of information, and data are cited and reported as needed for assumptions of analyses conducted for the assessment. Additional information on surface water- groundwater interactions has been added.

Iliamna Lake hydrology needs to be characterized. What are the inflows, outflows, and turnover rates? What is the existing water quality in the lake? Aquatic life should be characterized as well. What is the risk of pollutants entering the lake from the road corridor or upstream mine development operations?

RESPONSE: The overall hydrology of the lake was not included because none of the scenarios would result in a change in the hydrology or water quality of the lake as a whole. Rather, any effects in the lake would be limited to the vicinity of outflows from the affected streams. Risks from contamination of tributaries to Iliamna Lake are discussed in Chapters 8, 10 and 11of the revised assessment.

Dr. Paul Whitney

Climate variability is recognized as a game changer. What are the potential future scenarios for temperature and precipitation changes in southwest Alaska, and how will these scenarios affect the water balance? How will climate change affect the availability of water for mine operations, including processing and potable uses?

RESPONSE: Climate change projections and potential impacts are now discussed in Chapter 3.

Similarly, a complete water quality characterization is lacking. What is the water quality in surface waters, groundwaters, in time, and in space? What is the definition of background water quality? Numerous exploratory activities have taken place in the watershed and have the potential to affect water resources. How were these separated or addressed? Given the geologic and geomorphologic settings for the study area, are we comfortable that the watershed ridges delineate the watershed area? Groundwater movements may ignore the physical watershed area boundary and follow groundwater gradients. Streamflow measurements from the gauged watersheds could be useful in answering this question. Similarly, the linkage of groundwater and hyporheic exchange needs to be better demonstrated. Do these exchanges occur in all stream segments and gradients? What effect does the groundwater have on stream temperatures? Are depth to groundwater readings available? Is a groundwater monitoring program in place?

RESPONSE: The water quality described as background by the PLP in their Environmental Baseline Document was accepted as such in the assessment. Water quality in the three streams that drain the site was presented in Table 5-17 (now Table 3-4). The assessment now includes information on estimated groundwater interaction strength across the project area streams (Figure 7-14).

The tables and hydrographs (pages 5-32 to 5-39) are unclear. What streamflow changes are associated with what salmon species and life stage? A boundary condition for adults is different than for fry.

RESPONSE: Maps of species distributions in relation to affected stream segments are now included in Chapter 7. The environmental flow analyses are not species or life stage specific, but assume an overall risk associated with proportional deviations from the baseline flow regime.

The proposed mine will use large quantities of water in ore processing and transport. How much is required and how will this affect water resources; both surface and groundwater?

RESPONSE: The water balance has been extensively revised (Chapters 6 and 7), and updated estimates are incorporated into the streamflow computations provided in Chapter 7. Effects on groundwater resources are explicitly incorporated in the analysis of the pit dewatering, associated cone of depression, leachate leakage from the TSF and the waste rock piles, and interbasin groundwater transfers.

The no-failure mode of operation is predicted to change the watershed contributing area and hence streamflow, and uses the boundary condition of a 20% change in streamflow as significant salmonid habitat loss. The assessment assumes a liner response between watershed area and streamflow contribution, and a linear response between habitat productivity and watershed area.

Dr. Paul Whitney

RESPONSE: A more comprehensive water balance is now used to estimate streamflows, which incorporates losses and additions due to pit dewatering, and wastewater treatment plant processing and distribution, such that the relationship of watershed area and streamflow is not linear. We do not assume a linear response between habitat productivity and watershed area.

Upland settings are probably more productive in terms of productivity and should be addressed as such.

RESPONSE: Relative productivity of aquatic habitats has not been extensively documented across the region.

Toxin assessment focused on copper, and other metals can be presented to show the range of metal concentrations for chronic and acute toxicity, i.e., arsenic, molybdenum, silver, barium, and lead. Given the very clean waters (low hardness and organic carbon), the chronic toxicity of various metals should be evaluated. Water quality varies in time and space in the study area, and a better characterization of water quality could be developed. Metal loads could be calculated with streamflow records. What is the proportioning of dissolved versus total metals? Are metals transported with sediments? Do organic carbon fluxes change in space or time?

RESPONSE: The influence of receiving water chemistry was incorporated to the extent that current science allows. The toxicity of copper was corrected for water chemistry using the biotic ligand model, and the toxicity of other metals was corrected for hardness, when models were available. In each case, water chemistry of the individual receiving stream was used for the correction, Also, instream concentrations are based on streamflows, including changes in streamflows due to mine operations. Both sediment and organic matter concentrations are quite low in all three streams at the Pebble site, so copper remains dissolved in the model and other metals in leachates are likely to remain dissolved as well.

Salmonid risk from travel corridor: The proposed road location has the potential to affect 270 km of stream between stream crossings and Lake Iliamna. The expected road erosion and sediment production has known effects on salmonid resources. The discussion of the travel corridor does not include the potential for road failures, landslides, blocked culverts, or ditch failure. The discussion does not talk about traffic volume or the potential of hazardous material transport on the travel corridor. Need to address road maintenance, fugitive road dust, and road chemicals either dust or ice control.

RESPONSE: The original draft assessment included discussion of the potential for road and slope failures, blocked culverts, and soil erosion from road cuts, borrow areas, road surfaces, shoulders, cut-and-fill surfaces, and drainage ditches. The revised assessment factors traffic estimates into assessments of chemical spills from transport truck accidents (Section 10.3.3) and impacts from dust (Section 10.3.5). Salts used for to reduce dust and improve winter traction are discussed in Section 10.3.3. Potential mitigation measures for stormwater runoff, erosion, and sedimentation are discussed in Box 10-3.

There is no discussion of water processing after delivery of the slurry to the sea port and return of waters back to the mine site.

Dr. Paul Whitney

RESPONSE: Section 6.1.2.5 of the revised assessment discusses that the water would be returned to the process water ponds. The scenarios indicate that slurry water would be returned to the site without treatment other than removal of solids.

Roy A. Stein, Ph.D.

No-Failure Mode of Operation. My comments regarding the no-failure mode of operations and their impact on salmon can be found under Question 3.

RESPONSE: See response to Question 3.

Road Use I: Page 5-60. Beyond calcium chloride, how can we be confident that the typical chemicals that derive from highway use will not occur on this mine road (as noted on page 5-60)? Is it because the low volume of traffic? If so, would not we expect accumulation through time…over the 78 years of the mine operation (see Appendix G for some detailed analysis: should some of this material be added to the main report?)? What about the impact of road dust on nearby aquatic systems (wetlands, streams, rivers, etc.)?

RESPONSE: The text relating to traffic and contaminated runoff has been modified in the revised assessment to read: "It is unlikely that the potential transportation corridor would have sufficient traffic to significantly contaminate runoff with metals or oil, but stormwater runoff from roads at the mine site itself might contain sufficient metal concentrations to affect stream water quality." Though traffic-associated contaminants may be expected to increase over time, they would probably not be as significant as stormwater runoff-associated metals from the mine site. As noted in the revised assessment, the main impact of dust from the transportation corridor on salmonids would likely be a reduction in riparian vegetation and subsequent increase in fine bed sediment. The main impact of dust at the mine site would be a direct increase in fine bed sediment due to mine construction and operation (the effects of increased sediment loading are discussed in Section 10.3.4).

Road Use II: Page 5-62 to 5-63 (plus Appendix G: again, as with other appendices, include more of this information in the main report). Will there be frost heave of the road bed such that specific structures will have to be installed to prevent this movement of the road bed? These roads will be treated with chemicals, such as calcium chloride, to keep the dust down and contribute to an ice-free condition, but no data are available for the impacts of these chemicals on nearby streams. How then do we deal with this issue (page 5-62 and 5-63)? The suggestion is that one needs to have roads built at least 8 meters from streams, but this cannot be the case in this situation, simply because of the large number of streams, rivers, and wetlands along the road corridor? More detail as to the impact of the transportation corridor should be added, including issues, such as truck accidents, fuel spills, other chemical spills, etc.

RESPONSE: The assessment does not address potential frost heave of the road bed, although this factor will need to be considered during design of a road. Additional information has been added to the revised assessment on the potential impact of calcium chloride on nearby vegetation, surface water, groundwater and aquatic species. According to the USDA Forest Service (1999), application of chloride salts should be avoided within 8 m of water bodies. We agree that the 8 m buffer zone for salts would be difficult to maintain, but it could be achieved

at some cost in dust suppression and winter road salting. It would not require keeping roads out of that zone.

Additional information from Appendix G is incorporated into the main text, and the appendix is referenced in a number of places. The revised assessment contains greater detail on the potential impact of the transportation corridor. For example, the assessment now factors traffic estimates into assessments of chemical spills from transport truck accidents (Section 10.3.3) and potential impacts from dust (Section 10.3.5). Fuel spills are covered in Chapter 11.

Road Use III: page 5-71 (plus Appendix G). The road will intersect multiple streams and rivers along the northern end of Iliamna Lake, where as many as one third of the sockeye salmon in this lake spawn. And this is where the causeway across Iliamna Lake will be built as well. From my perspective, it seems that impacts on spawning sockeye will be large in this area (without saying anything about causeway: will there be culverts or bridges to allow water and fish to communicate with the rest of the lake)? I would argue this is important, given salmon are attracted to certain odors and water-flows and these odors and water-flows are coming from inlets streams into Iliamna Lake. Preventing any sort of blockage of water flow or salmon migration would be the goal. Are there other issues that should be considered when building this causeway?

RESPONSE: The assessment makes no mention of a causeway across Iliamna Lake. We believe the commenter is referring to a proposed causeway over the upper end of Iliamna Bay, which is part of Cook Inlet. Culverts or bridges would be built to allow fish access between streams crossed by the proposed road and Iliamna Lake. The issue of culvert blockage is discussed in the assessment.

Road Use IV. Points made by public testimony reinforces the idea that as this area is opened to the public, the opportunity for new, invasive species to colonize this pristine ecosystem increases dramatically, likely to 100%. Simply put, invasive species will now be carried by humans via the road, inadvertently, into this previously inaccessible watershed.

RESPONSE: EPA assumes that the proposed road would be closed to the public during mining operations but potentially could become a public road after mining operations cease. Even when not open to the public, construction and operation of the proposed transportation corridor increase the probability that new terrestrial and aquatic species will be transported to and potentially establish themselves in the Bristol Bay region. If the road were opened to the public, the probability of colonization by invasive species may increase further, but rates of introduction by industrial and public vehicles cannot be distinguished given available information. Invasive species are addressed in Section 10.3.6 of the revised assessment.

William A. Stubblefield, Ph.D.

The document appears to adequately address potential questions associated with habitat loss due to hydrologic changes, especially considering the hypothetical nature of the mine and the lack of specific detailed information regarding an actual proposed facility and all of the associated operational details of the facility. The assessment of potential impacts and ecosystem protection parameters is predominately based upon the publication of Richter et al. (2011). Additional support and evaluation of these recommendations for fisheries populations in the Bristol Bay area should be closely evaluated.

RESPONSE: Prompted by this comment, we consulted with regional biologists and hydrologists to evaluate the suitability of the sustainability boundary approach for flows. We asked them if there was any reason that fish populations in these streams, or the specific hydrology of the area, made it exceptional with regard to this approach (e.g., was there any reason to think that the Richter approach was not applicable here). We received uniform support for applying this approach to Bristol Bay streams. We strengthen our emphasis that this is a precautionary approach, and that the detailed hydrologic and habitat modeling work that PLP contractors have begun will help provide a useful basis for more sophisticated flow-habitat modeling.

Dirk van Zyl, Ph.D., P.E.

Chapter 5 of the EPA Assessment is entitled: "Risk Assessment: No Failure". Chapter 5 presents an evaluation of habitat loss and modification resulting from the hypothetical mine. A summary of the "risks" associate with the "no failure" case is provided in Chapter 8. There is specific focus on evaluating the magnitudes of the losses and modifications to the environment.

RESPONSE: No change requested or required.

A risk assessment addresses three questions (Kaplan and Garrick, 1981):

- What can happen? (i.e., What can go wrong?)
- How likely is it that that will happen?
- If it does happen, what are the consequences?

There are a large number of risk assessment methods and it is common to express the magnitude of risk as a combination of likelihood of occurrence and consequences (IEC, 2009). This is the typical outcome for engineering assessments of systems. For example, in the case of a Failure Mode and Effects Analysis (FMEA), it would be typical to develop a risk matrix to combine likelihood of occurrence and consequences to express the level or magnitude of risk in qualitative terms (Robertson and Shaw, 2012).

The EPA Assessment describes the two components of risk but does not provide any information on the magnitude of the risk. For example, for the no-failure condition it describes the length of streams, areas of wetlands, etc. that will be impacted by developing the mine, i.e. the consequences. One may argue that the likelihood of occurrence of these consequences is unity (or certainty) if the mine is developed, as this is not specifically addressed by the report.

RESPONSE: The risk assessment does address engineering risks in the manner specified, including magnitudes of spills, leakage, etc., and the consequences for water and habitat quality. We now explicitly clarify that losses of stream length are unavoidable for a project of this magnitude (Chapter 7). The magnitude of the risk or the likelihood that the stream lengths will be lost if the mine is constructed is 100%.

One would next expect an expression of the magnitude of this risk based on some comparison of the consequences to a set of outcomes that could result in acceptable or unacceptable risks. The

Dr. Paul Whitney

EPA suggests this as an approach in its 1998 Guidelines for Ecological Risk Assessment (EPA, 1998): "In some cases, professional judgment or other qualitative evaluation techniques may be used to rank risks using categories, such as low, medium, and high, or yes and no". Quantitative approaches such as fuzzy logic has also been used to develop expressions of magnitude of risk as described by EPA (1998): "For example, Harris et al. (1994) evaluated risk reduction opportunities in Green Bay (Lake Michigan), Wisconsin, employing an expert panel to compare the relative risk of several stressors against their potential effects. Mathematical analysis based on fuzzy set theory was used to rank the risk from each stressor from a number of perspectives, including degree of immediate risk, duration of impacts, and prevention and remediation management. The results served to rank potential environmental risks from stressors based on best professional judgment".

RESPONSE: Although the 1998 ERA Guidelines describe professional judgments as an acceptable method for ranking risks in appropriate circumstances, it is not appropriate for this assessment. The purpose of this watershed assessment is not to rank risks. It is to estimate, as far as existing data and knowledge allow, the risks associated with proposed and potential mining activities in the Bristol Bay watershed. EPA decided during the problem formulation that this assessment would be based on published science. An assessment based on elicitation of expert judgment could be performed in the future, if desired.

It is unclear to the reader how significant a loss of 87.5 km of streams in the Nushagak River and Kvichak River watersheds is to the overall ecosystem. Are there any criteria that can be used to develop such an expression? Can a multi-stakeholder workshop (as is often done) be used to develop such criteria and expressions of risk magnitude? Without having such expressions of risk magnitude it is impossible for those without specific expertise in salmonids to evaluate whether this is a significant risk. Price et al. (2010) states that: "Between 1999 and 2008, 3,500 fish passage barrier culverts were replaced with fish-passable structures, reportedly opening nearly 5,955 km of fish habitat in Washington streams (Governor's Salmon Recovery Office 2008)". Comparing the loss of 85 km to this gain of 5,955 km seems to imply that 85 km loss may represent a relatively small risk, which may not be the case at all. However, the EPA Assessment does not provide any insight in the magnitude of risk except to provide a value for the consequences.

RESPONSE: The purpose of the assessment is not to assign significance to the risks, but to provide information for decision-makers on the consequences of mining.

The EPA did conduct a multi-stakeholder conference to determine the significant endpoints and exposure pathways for the assessment. However, the EPA decided during the problem formulation that this assessment would be based on published science. Therefore, a multi-stakeholder workshop would not be an appropriate mechanism to estimate risks or their significance.

Comparing the potential loss of salmon-supporting streams in the Nushagak and Kvichak River watersheds to restoration of streams in Washington for salmon recovery may not be very useful. The comment does illustrate that seemingly inconsequential or insignificant losses have frequently led to diminished or even lost salmon stocks. In the example cited, apparently 3,500 seemingly inconsequential actions had to be remedied at public expense because of their cumulative impacts.

Dr. Paul Whitney

Similar comments can be made with respect to the relative risks associated with the other losses of ecological functions for other failure modes.

RESPONSE: See response to previous comment.

It is recognized that it is important to maintain separation between the risk assessment and risk management functions. As expressed by the National Research Council Panel in their report on Science and Decisions (NRC, 2009): “The committee is mindful of concerns about political interference in the process, and the framework maintains the conceptual distinction between risk assessment and risk management articulated in the Red Book. It is imperative that risk assessments used to evaluate risk-management options not be inappropriately influenced by the preferences of risk managers”.

RESPONSE: The EPA agrees with this comment and its implication that assessors should not judge significance. No changes suggested or required.

Providing an expression of risk magnitude should not interfere at all in the separation of risk assessment and risk management, but should provide the risk manager with one extra level of analysis and insight from the expert assessor of the problem at hand. Multi-stakeholder interaction will only serve to enhance the value of the risk ranking.

RESPONSE: See response to previous comment on this topic.

On p. 4-33, it is stated that after closure: “No PAG waste rock would remain on the surface”. It is also stated in Chapter 4 that PAG and NAG waste will be segregated. On p. 5-48, it is stated that: “However, the primary concern during routine operation would be waste rock leachate. That leachate would become more voluminous as the waste rock piles and uses of waste rock for construction increased during operation. After mine closure, it would be a major source of routinely generated wastewater along with water pumped from the TSF and pit. Leachate composition from tests of the three waste rock types (Tertiary, East Pre-Tertiary, West Pre-Tertiary) is presented in Tables 5-14 through 5-16”. There is no specific indication which of these waste rock types could be described as PAG or NAG and Chapter 5 seems to assume that these 3 samples are representative of the total amount of waste rock, about 4 billion tonnes for one mine scenario. If all the PAG material will be removed from the surface, as stated in the scenario in Chapter 4, and the NAG will not generate acid drainage, then it is difficult to understand why the waste rock piles and waste rock used for construction (supposedly all NAG at this stage) would be the major source of “routinely generated wastewater.”
Note that it is further unclear why there would be water pumped from the tailings and the pit if the TSF were closed, as discussed above, and if it will take the mine pit 100 to 300 years to fill. Some clarification is in order.

RESPONSE: This issue has been clarified in the revised document. PAG and NAG waste rocks would be identified during the course of mining, but the available test results indicate that pre-Tertiary rock is PAG. The PAG waste rock would be segregated and none would remain at mine closure. However, some will be on the surface during operation. In addition, the NAG waste rock produces potentially toxic leachates that must be collected and treated. Water could be pumped from the TSFs and the pit for treatment before discharge. Treatment of pit water would occur once it is a source rather than a sink.

Dr. Paul Whitney

A further reference to the fate of waste rock after closure is found on p. 5-77 of the EPA Assessment: “Under the mine scenario, the mine pit, waste rock piles, and TSF would remain on the landscape in perpetuity and thus represents permanent habitat loss.” It should be noted that the scenario states that PAG will not remain on the surface, whatever volume and area of land surface that represents.

RESPONSE: Section 6.3.3 of the revised assessment clarifies that no PAG waste would remain on the surface.

The descriptions of exposure and exposure-response resulting from the transportation corridor in Section 5-4 of the EPA Assessment focus on potential impacts and make use of references that are clearly not representative of the expected road construction. A number of these references date from 1975 and 1976 (p. 5-59) and are not necessarily representative of road design and construction practices in 2012. On p. 5-62, the following statement and reference is given: “Sediment loading from roads can severely affect streams below the right-of-way (Furniss et al., 1991 and references therein)”. This reference is specifically focused on forest and rangeland roads, clearly not representative of a major transportation road between a mine and the port facilities from where its products are shipped. This publication contains many recommendations specifically for forest and rangeland roads and some of them are indicative that it is not applicable to the transportation corridor for a major mine access road: “Design cut slopes to be as steep as practical. Some sloughing and bank failure is usually an acceptable trade-off for the reduced initial excavation required” (p. 306); and “stream crossings can be considered dams that are designed to fail. The risk of failure is substantial for most crossings, so *how* they fail is of critical importance” (p. 310). The reference also refers to the application of oil as a dust abatement additive on p. 312, which is hardly acceptable practice. In my review, I did not find that any of the references used in the EPA Assessment refer specifically to mine roads such as those considered for the transportation corridor at the Pebble Mine scenario.

RESPONSE: The information cited from the two publications noted by the commenter is still true today. The first use of Darnell (1976) was incorrect, and has been changed to Furniss et al. (1991). Although Furniss et al. (1991) focuses on forest and rangeland roads, it is a seminal publication on the potential effects of roads, particularly as they relate to salmon. The general conclusions of that paper should be applicable to the transportation corridor described in the assessment. Furniss et al. (1991) lists a number of guidelines for road design and construction that will help minimize adverse effects on salmonid habitats. It does not specifically advocate the application of oil as a dust abatement additive. It merely states that whatever chemicals are used, they should be applied so as not to enter streams, and that subsequent transport of these substances into water courses should be evaluated.

The failure frequencies cited in the revised assessment are from modern roads and not restricted to forest roads. Because the proposed mining would take place in an undeveloped area, the literature used in the assessment is necessarily from areas outside of Bristol Bay. However, we used recent literature from representative environments to the extent possible. Lastly, information on current design standards that would be used along the proposed transportation corridor is now included within text boxes throughout Chapter 10.

It is further interesting that it is stated on p. 5-60 that there will be 20 bridges and 14 culverts along the road without referring to this as an assumption, and no reference is cited for this information. Will there be a change in impact if the decision is made to build 30 bridges and 4 culverts or 34 bridges and no culverts?

RESPONSE: The estimate of 20 bridges came from Ghaffari et al. (2011). In the revised assessment, crossings that would be bridged (now 18) are based on mean annual stream flows, as explained in the text. If a decision was made to build more bridges and fewer culverts, there would be a change in impact, but scenarios with 30 or more bridges are probably not realistic.

The discussion on the potential impacts of the transportation corridor on salmonids serves the purpose of highlighting some aspects that engineers and fish biologists must take into account when designing and maintaining the final transportation corridor for the Pebble Mine and other mines in the Bristol Bay area. However, this assessment does not appropriately describe the scale and extent of the risks to salmonid fish due to operation of a transportation corridor under the no-failure mode of operation.

RESPONSE: The "no failure" mode of operation was meant to illuminate the effects that would occur solely from a mine footprint, even in the absence of accidents or failure. This term has been eliminated in the revised assessment. The no-failure scenario from the draft assessment has been changed to a section on the effects of the footprint of a mining operation, without regard for operational problems (Chapter 7). The revised assessment places the streams along the transportation corridor into the context of the entire Nushagak and Kvichak River watersheds with respect to important watershed attributes such as discharge, channel gradient, and floodplain potential. Potential risks to fish habitats and populations associated with the proposed corridor are then evaluated in some detail.

Phyllis K. Weber Scannell, Ph.D.

The no-failure model makes a number of assumptions about how the mine will be developed – some may be accurate, some may be considerably different. It is important to take under consideration that Pebble is currently a prospect, not a mine. Should this project proceed to mine development, it will be incumbent on the mining company to develop a rigorous mine plan that includes detailed information on all aspects of a future project. This mine plan will be reviewed by state and federal staff with experience in large project development.

RESPONSE: The EPA agrees with this comment. No changes suggested or required.

The no-failure model discusses the amount of riverine habitat that will be lost to mining by the mine pit, tailing storage facility, and waste rock dumps. Anadromous fish habitat is protected under Alaska Statute 16.05.840-870. The statute requires review of a project potentially affecting fish habitat and, where necessary, avoidance, mitigation, or compensation. A project must provide free passage of fish; the project cannot be placed in such a way that fish are prohibited from moving into the upstream reaches. Estimates of habitat loss from the mine footprint are not possible without a more detailed plan of operations for the mine.

RESPONSE: The scenarios presented are meant to represent those expected as typical for mining of porphyry copper deposits of this type, and are based on preliminary mine plans from NDM (Ghaffari et al. 2011). Although layout of mining components at a site may differ somewhat from what we present in the scenarios, the main components of mining will remain

Dr. Paul Whitney

the same for open-pit mining. Given stream density in the area, direct losses of stream and wetland habitat of a similar magnitude would be inevitable with projects of the specified magnitudes.

There are many aspects of the development of a large mine project that need thorough review to ensure that habitats are protected. These include, but are not limited to: classification and storage of waste rock, lower grade ore, overburden, and high grade ore; development and maintenance of tailings storage facilities; development and concurrent reclamation of disturbed areas, including stripped areas and mine pits; collection and treatment of point and non-point source water; quantity and timing of discharges of treated water; monitoring of ground water, seepage water and surface water; and biomonitoring. The transportation corridor will require review and permitting of every stream crossing of fish-bearing waters. In addition, plans should be developed for truck wheel-washing to minimize transport of contaminated materials.

RESPONSE: The EPA agrees that these aspects would need to be subject to a thorough review during the development and approval of a detailed mining plan. No changes suggested or required.

Paul Whitney, Ph.D.

Material Resource Areas. Material resource areas, mentioned on page 4-34, for the road and pipelines should be discussed in more detail. Will aggregate be required? If so, where are the aggregate resources in relation to floodplains? I spent a summer surveying material resource areas for a proposed arctic and subarctic pipeline and access road. Suitable material resource areas are sizeable and are often important (e.g., aggregate) for wildlife (such as bears that hibernate or survive the winter in dens) and fishery resources. Sometimes dens can only be excavated in non-permafrost (i.e., aggregate) soils. It appears the project area is in a zone of discontinuous permafrost, but permafrost could be more continuous in the higher elevations along the road through the Kenai Mountains. An accurate assessment should determine the permafrost location(s), as well as the area and importance of material resources for fish and wildlife. In addition, Reclamation Plans for the material resource areas should be briefly discussed to ensure that areas mined for aggregate will not avulse and capture streams.

RESPONSE: EPA agrees with this commenter that the impacts of material resource areas to wildlife, fishery and other subsistence resources could be significant and must be addressed in an environmental impact statement and as part of the 404 permit review. Review of potential material resource areas was not included in the scope of this assessment.

Water for Dust Control. Dust control for the 86-mile proposed haul road will likely require a lot of water. Where will this water come from? Withdrawal from streams crossed by the haul road could have impingement and flow reduction consequences. Adequate screening could solve the impingement issue. Some back-of-the-envelope calculations could determine if water withdrawals for dust control could alter the projected hydrographs when salmonids are present in the streams.

Dr. Paul Whitney

RESPONSE: We expect water for dust control to be a small amount from any one source. Permits would be required from the State of Alaska that would address impingement issues. We do not expect this to be a major issue.

Question 5. ***Do the failures outlined in the assessment reasonably represent potential system failures that could occur at a mine of the type and size outlined in the mine scenario? Is there a significant type of failure that is not described? Are the probabilities and risks of failures estimated appropriately? Is appropriate information from existing mines used to identify and estimate types and specific failure risks? If not, which existing mines might be relevant for estimating potential mining activities in the Bristol Bay watershed?***

David A. Atkins, M.S.

The Assessment focuses on some low probability, high impact failures (e.g., TSF failure), and presents summaries of failures at existing mines. The majority of the focus is on catastrophic failures, such as TSF, pipeline, water collection and treatment, and road and culvert. Anecdotal information regarding mine failures is numerous, but often not well documented, so it is difficult to get information on the details of failures of other projects. It is also difficult to extrapolate the probability of failure from one site to the next, and the report stresses the wide range of uncertainty, depending on design and environment. Without a more detailed understanding of the mine plan and associated engineering, as well as additional detailed analysis, it is difficult to determine if the failure probability estimates presented in the Assessment are reasonable.

RESPONSE: The authors concur with the commenter that it can be "difficult to get information on the details of failures of other projects". The statistics for historic tailings dam failures are derived from the largest available database and include many tens of thousands of dam-years. The pipeline failure data cover millions of kilometer-years of pipeline experience. The data on failures of water collection and treatment systems and of culverts are less extensive. We also recognize that even with detailed engineering and design information, the prediction of failure probabilities is extremely difficult. Finally, since all of these low-probability failures are statistical phenomena, the actual experience at any one site could be vastly different than another similar site, even when the failure probabilities have the same distribution.

The focus on catastrophic failures also takes attention away from what is probably a more likely scenario. Every project is subject to accidents and smaller, non-catastrophic failures that have varying degrees of consequence. Sometimes these failures are easily identified and fixed and other times they can go un-noticed for periods of time.

RESPONSE: Because the number of potential failures is extremely large, it is necessary to choose a representative set of failure scenarios. The revised assessment includes more failure scenarios (e.g., diesel pipeline failure, quantitative wastewater treatment plant failure, truck

accidents and spills, and refined leachate seepage scenarios) and explains why these particular failure scenarios were chosen.

It would be helpful to describe some smaller-scale failures that have occurred at mine sites. A partial list includes: accidents and spills along the transportation corridor or within the mine site; unanticipated seepage of contaminated water that may be difficult to detect, collect and treat; movement of water along preferential flow pathways that are difficult to characterize; temporary failure of water collection and treatment systems; mistakes in engineering analysis that underestimate the volume of water that must be collected and treated or overestimate the volume of water available for use; and designing based on incomplete data and understanding of climate conditions.

RESPONSE: There is a wide variety of failures that could occur, including those provided by the commenter. Because the number of potential failures is extremely large, it is necessary to choose a representative set of failure scenarios. The revised assessment includes more failure scenarios (e.g., diesel pipeline failure, quantitative wastewater treatment plant failure, truck accidents and spills, and refined seepage scenarios) and explains why these particular failure scenarios were chosen.

Steve Buckley, M.S., CPG

The engineering failures reasonably represent potential system failures outlined in the mine scenario based on historic porphyry copper deposits of this type. It is less clear if the failures reasonably represent a mine scenario based on state of the art engineering and mitigation practices. Appendix I provides some information related to potential system failures and possible mitigation measures designed to minimize these risks but these are not treated in any detail in the assessment. It would be difficult to pull together the most modern engineering and mitigation practices from around the world but it could help bound the risks associated with modern mine development.

RESPONSE: Our purpose in the assessment is to evaluate the risks from hazards resulting from a mine operated with appropriate mitigation measures for design, operation, monitoring and maintenance, and closure. Accidents and failures happen regardless of mitigation measures; thus, effects of several failures are evaluated. Mitigation measures related to our mine scenarios are now clearly discussed in Chapter 6.

The Red Dog mine in northwest Alaska might be relevant for estimating potential mining activities in the watershed. Although the characteristics of the deposit differ significantly, at roughly 150 million tons it is half the size of a reasonable minimum mine scenario and would be helpful to characterize some minimum mine development scenario.

RESPONSE: A third mine size scenario, representing the worldwide median size porphyry copper mine (Singer et al. 2008), is included in the revised assessment.

Courtney Carothers, Ph.D.

Dr. Paul Whitney

The potential failures outlined in this assessment include: tailings dam failures, pipeline failures, water collection and treatment failures, and road and culvert failures. These failures appear to represent the key potential failures for this mining scenario, their risks appear to be estimated reasonably, and statistics from existing mines appear to be used appropriately, although I have no particular expertise with which to evaluate this assessment. As we discussed in our peer review panel, the focus here is on catastrophic failure. More detail should be provided on likely non-catastrophic failures, ones that would be more difficult to detect.

RESPONSE: Because the number of potential failures is extremely large, it is necessary to choose a representative set of failure scenarios. The revised assessment includes more failure scenarios (e.g., diesel pipeline failure, quantitative water treatment failure, and refined leachate seepage scenarios) and explains why these particular failure scenarios were chosen. We did include leachate seepage scenarios (Chapter 8), which would be more difficult to detect than catastrophic failures.

Dennis D. Dauble, Ph.D.

My experience in system failure of mines of the size and type outlined in the scenario is limited. However, what does seem to be missing is the long-term effects of leachates to receiving water bodies in any type of risk scenario, including both non-failure and failure modes. That is, assuming no catastrophic failure, how might tailings constituents interact with aquatic habitats seasonally, such as during periods of snowmelt and severe rainfall events?

RESPONSE: The original draft assessment contained a scenario in which tailings leachate was not fully contained and reached a stream (Section 6.3 in the May 2012 draft). The revised assessment includes estimates of leachate escaping from the TSFs and from the waste rock piles, bypassing the collection systems, and entering the streams (Chapter 8). The estimated loadings of copper and other elements from these leachate flows are included in stream concentration estimates. The assessment discusses the impacts of these concentrations on the aquatic habitat and biota. The commenter is correct that we did not include a scenario in which the dam does not fail, but snowmelt and severe rainfall would result in overtopping and release of untreated water. That is very plausible, but there are just too many possible failure scenarios to include more than a few of them.

Gordon H. Reeves, Ph.D.

No comments on this question

Charles Wesley Slaughter, Ph.D.

Potential failures seem reasonable, based on history of other mining operations. However, the consequences of hydrologic extremes during winter (frozen soil) conditions are not adequately addressed. The possibility of the mining operation and the transportation network encountering discontinuous permafrost is not mentioned, although at least some soils maps indicate permafrost presence.

RESPONSE: Warhaftig (1965) reports that permafrost is sporadic or absent in the Nushagak-Bristol Bay Lowland (Table 3-1). If permafrost were detected during project development or construction, the designs would need to address any potential impacts on the infrastructure and potential impacts of the infrastructure on the permafrost. Frozen soil could improve vehicular access to parts of the project site and minimize the disturbance from such access. The occurrence of an extreme hydrologic event, such as heavy rainfall on frozen soil or heavy rain on an existing snowpack, could produce unusually heavy runoff and higher than normal stream flows. We analyzed the impact of a tailings dam failure during the Probable Maximum Precipitation (PMP) event, thereby generating the Probable Maximum Flood (PMF). The increased flow due to precipitation was, in most of the scenarios, small compared to the flow released from the TSF. Any increases in the peak runoff due to frozen soil or melting snowpack would also be small relative to the TSF release, so the modeled scenario can be considered a reasonable bounding estimate.

Designs for the components of the mine infrastructure would need to consider the natural cold region conditions and incorporate appropriate design features and safety factors to achieve an acceptable level of performance. Ghaffari et al. (2011) says "The Pebble deposit is located under rolling, permafrost-free terrain in the Iliamna region of southwest Alaska..." and "The deposit is situated approximately 1,000 ft amsl, in an area characterized by tundra, gently rolling hills and the absence of permafrost." Ghaffari et al. (2011) describes the transportation corridor thusly: "The road route traverses terrain generally amenable to road development. ...There are no significant occurrences of permafrost or areas of extensive wetlands." Nevertheless, if sporadic areas of permafrost are discovered, the designs will need to address the interactions between the infrastructure and the permafrost.

The probability approach outlined for potential TSF dam failure is unpersuasive. It is difficult to relate to a number like "0.00050 failures per dam year," or to the implication on p. 4-47 that one can expect a tailings dam failure only once in 10,000 to one million "dam years." This could suggest to the casual reader that failure of the hypothesized TSF1 dam (for which one "dam year" is one year) should not be anticipated in either the time of human occupation of North America, or the span of human evolution.

RESPONSE: The commenter is correct. The proposed dams, if designed, built, and maintained to current engineering best practices, would be anticipated to have a low annual probability of failure. However, the failure probability would not be zero. The writers concur with the commenter that these low probability numbers may be difficult for the casual reader to grasp, so we now also present estimates of probability in terms of probability failure over different time periods. The discussion of this issue has been expanded to clarify that the failure rate is a design goal and is not based on empirical evidence.

Box 4-6 suggests that the Operating Basis Earthquake (OBE) for a 7.5-magnitude event at the Pebble locale has an estimated return period of 200 years. Such a return interval probability is difficult to interpret, given the lack of historical seismic records for the region; in any event, such a return period estimate is in no way predictive of future seismic activity, in year 2012 or year 2212. (The suggested 200-year return period should also be viewed in light of the 79-year suggested operating life of the hypothetical Pebble operation, probable longer-time operations at other mineral extraction sites which would be developed following implementation of Pebble and building from the infrastructure associated with Pebble, and also the projected very long persistence of the TSFs following cessation of active mining).

RESPONSE: Box 9-2 in the revised assessment (Box 4-6 in the May 2012 draft of the assessment) provided the OBE and return period determined by NDM in the Preliminary Assessment. A detailed engineering design and safety evaluation is outside the scope of this assessment. The discussion of seismicity (Section 3.6) addresses the uncertainty in interpreting and predicting earthquake magnitude and recurrence in the Pebble area.

Box 4-6 does note that "The return periods stated in Alaska dam safety guidance are inconsistent with the expected conditions for a large porphyry copper mine developed in the Bristol Bay watersheds, and represent a minimal margin of safety."

RESPONSE: The return periods used are consistent with the Alaska Dam Safety Guidance, however the operator could include additional margin of safety in the design for critical structures. The return period and seismic safety factors do not inform the failure analysis in this assessment, but would be important considerations during the review process for any future mine plan.

John D. Stednick, Ph.D.

The assessment reasonably addresses potential large system failures, but should include a variety of smaller and perhaps more frequent failures (see Question 4). A large tailings storage facility failure compared to a blocked road drainage culvert. The level of detail in the assessment of the potential system failures varies considerably and baits the question--why? Does this demonstrate lack of understanding of failure prediction, lack of failure prediction, or writing team expertise?

RESPONSE: The EPA does not believe that a blocked culvert requires or deserves the same level of analysis as a tailings dam failure and spill. The latter is a much more complex phenomenon with multiple consequences that require evidence and analysis such as the potential toxicity of the spilled tailings. In contrast, blockage of a culvert is a relatively straightforward phenomenon. Further, a TSF failure poses a much greater concern for stakeholders and local communities due to the large magnitude of potential effects.

<u>Tailings storage facility</u>: The liquefaction phenomenon, internal and external erosion, seepage, and overtopping are some of the main failure modes of tailings storage facilities. A large quantity of stored water is the primary factor contributing to most tailings storage failures. The risk of physical instability for a conventional tailings facility can be reduced by having good drainage and little (if any) ponded water. Some suggest that the tailing pond freeboard should be able to accommodate the 100-year, 72-hour storm/streamflow event. What are the State of Alaska standards? Discuss the probability of failure of a TSF from other than overtopping by a precipitation/streamflow event. The potential of seismic activity and its effect on tailings storage and other earthworks needs to be addressed.

RESPONSE: The historic failure probabilities for tailings dams presented in the assessment include all modes of failure, including slope instability, liquefaction, overtopping, erosion, and

seismic activity. Historical failures were discussed as supporting background information and present a defensible upper bound on the failure probabilities. The failure probabilities used in the assessment are based on Alaska's dam classification and required safety factors applied to the method of Silva et al. (2008). The data presented by Silva et al. (2008) consider only the annual probability of failure from slope instability, but the methodology is equally applicable to other failure modes. The discussion of failure probabilities in the revision (Chapter 9) is expanded to clarify this issue.

Chemical transport spill: Mine development and ore processing will require significant loads of petroleum and chemical products. Although the exact processing formulations are not given, most copper porphyry mines use similar formulation in ore flotation and processing. How will chemicals be stored, transported, and recycled? What are the opportunities for accidents to occur?

RESPONSE: Storage of chemicals is addressed in the assessment. Petroleum transport is by pipeline and an assessment of the risk of spills has been added in Chapter 11 of the revised assessment. Process chemicals would be transported by truck. Discussion of truck transport and potential for accidents has been included in Chapter 10, including a quantitative analysis of the risk of wrecks and of wrecks that cause spills into streams or wetlands.

Roy A. Stein, Ph.D.

Failures Appropriate for Mines of this Size and Type. Given my background, I can't answer with any authority, though the comparisons seemed appropriate, though clearly no extant mines are as large as the one proposed herein. Some of the public testimony spoke directly to comparisons with existing mines in dry areas would be completely inappropriate because it is the hydrology of the Bristol Bay watershed that would make it so very vulnerable to mining impacts.

RESPONSE: No change suggested or required.

Failures Not Described? I speak to failures associated with routine operations previously in this review, as well as chemical spills along the transportation corridor. Also included herein should be impacts of the Cook Inlet Port and potential spills, accidents, etc., on the marine ecosystem.

RESPONSE: Because the number of potential failures is extremely large, it is necessary to choose a representative set of failure scenarios. The revised assessment includes more failure scenarios (e.g., diesel pipeline failure, quantitative water treatment failure, and refined seepage scenarios) and explains why these particular failure scenarios were chosen. Discussion of transport and potential for accidents has been included in Chapter 10, but risks are not evaluated. Potential impacts in Cook Inlet are important and should be considered in the regulatory process should a company submit a permit. However, because this is an assessment of the Bristol Bay watershed, evaluation of impacts from the port (and transportation corridor outside the Nushagak and Kvichak River watersheds) is outside the scope of this assessment.

Dr. Paul Whitney

Probabilities and Risks of Failures. These seemed reasonably well documented, though again this falls outside of my expertise. Even though out of my realm, I still would have liked a more quantitative assessment of these risks, developed in a rigorous, defensible way. I am discouraged when I understand that history (in the eyes of the mining company) is not a good predictor of the future because technology has taken us so much farther along, reducing risks of whatever failure significantly. In my view, this is a specious argument and one that should be roundly put to bed by the authors of this report. History is indeed the absolute best predictor of the future and technological changes that have occurred since past mines must be absolutely and critically evaluated to determine if indeed risks do go down. This is a serious issue and one that should be addressed with some rigor by the authors.

RESPONSE: Historical failures were discussed as supporting background information. The failure probabilities used in the assessment are based on Alaska's dam classification and required safety factors applied to the method of Silva et al. (2008). The EPA has strengthened the discussion of failure probabilities (Chapter 9) to the extent that available evidence allows.

Existing Mines as Comparisons. Given my background, I can't answer with any authority, though the comparisons seemed appropriate, though clearly no extant mines are as large as the one proposed herein (nor does it incorporate all we have learned in the mining business since the last mine for which we have data). Even so, I again caution the authors that these existing, historical mines provide the best data we have to estimate risks of failure and that, under no circumstances, should one accept the indefensible argument that progress with mine safety (speaking broadly, not just human health) has progressed to the point that these risks, previously quantified in these older mines, are now small. As suggested above, we have no other quantitative values for risk, except for existing mines and we cannot simply erroneously lower the risk based on new, **untested** technologies.

RESPONSE: We agree that it is appropriate to include in our scenarios technologies that are in current use and not those that are untested, and thus have done so. No change suggested or required.

Proportional Losses of Salmon. Is it possible to estimate the proportion of the salmon runs compromised in the face of major failures in tailing storage facilities or other failures? In other words, I would recommend adding a chapter that uses best estimates of salmon produced within the Bristol Bay watershed and then assess the maximum impact of, let's say, a Tailing Storage Facility failure---with this failure, might we lose 10%, 40%, or 75% of our salmon productivity? In addition to this estimate, one might estimate the number of stocks or unique genetic units lost with a major failure? I know these numbers are difficult to get, but if one begins with escapement from these systems as well as insights from harvest, we may be able to bound these impacts. Only in this fashion can we put these data into context. This exercise also will serve to counter the argument by the mining company that they are only destroying some small percentage of salmon habitat and hence (assuming a linear relationship between habitat lost and salmon eliminated) only some very small percentage of salmon. Because losing 2% of critical headwaters habitat may translate to huge losses of salmon (say 20%), one simply cannot assume a linear relationship between habitat and salmon. Explicitly making this argument improves the rigor of the main report.

Dr. Paul Whitney

RESPONSE: The fact that salmon productivity cannot be assumed to be linearly related to habitat has been more explicitly elaborated in the revised assessment. Due to lack of comprehensive estimates of limiting factors across the impacted watersheds, population level effects could not be quantitatively estimated, except in the most severe cases where total losses of runs could be reasonably assumed. Our ability to estimate population level effects was limited to situations that were assumed to completely eliminate habitat productivity and capacity in an entire watershed for which estimates of escapement could be inferred. For this assessment, these conditions are only met in the TSF failure scenario that completely eliminates or blocks access to suitable habitat in the North Fork Koktuli River. In that case, we estimate that the entire Koktuli portion of the run (~28% of Nushagak escapement) could be lost. Higher proportional losses would occur if significant downstream effects occurred due to transport of toxic tailings fines beyond the Koktuli as modeled under the Pebble 2.0 TSF failure.

Correlations between Ocean and Terrestrial Conditions. From the literature (see Irwin and Fukuwaka. 2011. ICES *J. Mar. Sci*. 68: 1122 as just one example), we know what climatic conditions lead to poor rearing conditions in the ocean, thus compromising growth and ultimately survival of salmon. Given these ocean conditions, might we have correlative effects in the terrestrial environment, thus leading to a cumulative effect of ocean and terrestrial impacts? For example, if particular oceanic conditions underlie poor survival, might this correlate with an increased probability of flooding, leading to a higher probability of a Tailings Storage Facility failure, leading to a cumulative synergistic effect that could be multiplicative in its negative impact on salmon populations? Was there any attempt to correlate these impacts? Just how realistic is it to reflect on these sorts of multiplicative effects? Might these effects have a catastrophic effect on salmon populations?

RESPONSE: Pursuing this hypothesis would require a research effort that is beyond the scope of this assessment.

William A. Stubblefield, Ph.D.

The scope of failures described in the assessment seems to be sufficiently comprehensive and all likely failure-types are considered. The probabilities and risks for failure seem to be adequately estimated, given the state-of-the-science; however, these estimates are likely to be very sensitive to site-specific concerns and operational considerations. Once site-specific information is available, it is likely that much better estimates of failure potential at a site can be developed.

RESPONSE: We agree that more site-specific information could support more site-specific estimates. No change required.

Dirk van Zyl, Ph.D., P.E.

Failure modes outlined in the EPA Assessment do not reasonably represent the potential failures that could occur at a mine of the type and size outlined in the mine scenario.
The EPA Assessment considers a series of large, or catastrophic, type failures. The failure modes

considered in the mine scenario include four major items: tailings management facility; pipelines; water collection and treatment; and, road and culvert. These failure modes are included in the risk assessments for a mine of this type and size, either qualitatively as is typically done in FMEA, or quantitatively. However, the range of failure modes will also consider many other types of failures that can also occur during regular mine operations. These other types of failures may result in the full spectrum of risks (from insignificant to very high) depending on site and mine life-cycle conditions. Performing extensive analyses for the four major items implies that they could occur and that they are the only failure modes that will be significant.

RESPONSE: It is true that any of the failures analyzed could occur, as based on historic and current knowledge of mining; however, a focus on these failures does not imply that they are the only failures that will be significant. Because the number of potential failures is extremely large, it is necessary to choose a representative set of failure scenarios. The revised assessment includes more failure scenarios (e.g., diesel pipeline failure, quantitative water treatment failure, and refined seepage scenarios) and explains why these particular failure scenarios were chosen.

Responses to the other parts of the current question (Are the probabilities and risks of failures estimated appropriately? Is appropriate information from existing mines used to identify and estimate types and specific failure risks? If not, which existing mines might be relevant for estimating potential mining activities in the Bristol Bay watershed?) are further discussed in my responses to other questions below.

RESPONSE: No change suggested or required.

Phyllis K. Weber Scannell, Ph.D.

This section focuses on catastrophic failures; however, there are a number of non-catastrophic failures that can occur at a mine site. Non-catastrophic failures include leakage of contaminated water to ground or surface waters from PAG waste rock, the tailing storage facility, and exposed ore surfaces, and from emergency discharge of untreated water from the TSF and ore spills from trucking accidents. Such failures can be minimized or prevented with good site planning and monitoring. An additional "failure" has been experienced at a mine in Alaska when the water elevation of the tailing pond was sufficiently high to cause groundwater flow across a natural divide into an opposite drainage.

RESPONSE: Because the number of potential failures is extremely large, it is necessary to choose a representative set of failure scenarios. The review draft contained a scenario in which tailings leachate was not fully contained and reached a stream (Section 6.3 in the May 2012 draft). The revised assessment document includes more failure scenarios (e.g., diesel pipeline failure, truck accidents, quantitative water treatment failure, and refined seepage scenarios) in Chapters 8, 10 and 11 and explains why these particular failure scenarios were chosen.

Paul Whitney, Ph.D.

Dr. Paul Whitney

<u>Sediment Transport</u>. The failure analysis indicates a sediment transport study was beyond the scope of the assessment. Not only is such a study important for fish resources, it is important for all ecological resources, especially plant community succession along the stream and a delta into Bristol Bay.

RESPONSE: EPA agrees that a sediment transport study is important to fully characterize the watershed and potential impacts from large-scale mining. The scenarios indicate that runoff eroding sediment from the site would be directed to sediment retention basins. Sediment runoff from the road is considered in Chapter 10. The development and implementation of a model of sediment (i.e., tailings) transport after the initial tailings outflow would require a research and development effort that is beyond the scope of this assessment.

This might seem extreme, but the failure analysis indicates the Koktuli, Mulchatna, and Nushagak Rivers would stabilize into a new channel after a failure and not continue to work their way across the floodplain and eventually transport materials hundreds of miles down river. The Mount St. Helens eruption, given as an analogy in the assessment (page 6-3), certainly moved sediment into the Columbia River Channel, the Columbia River Estuary, and Pacific Ocean over a hundred miles away. Copper concentrations in the Columbia River estuary as a result of the eruption ranged from 1 to 43 µg/L (Lee 1996). The upper limit of the range is approximately 20 times greater than the no-effect benchmark listed in the assessment. The down stream consequences of changes in sediment transport and water/sediment chemistry for fish and wildlife are sometimes very large, not anticipated (see Peace Athabasca Delta response below), and costly to remediate. Solutions for the Peace Athabasca Delta involving check dam construction may not be directly applicable to a tailings dam failure analysis in the assessment but may have some value short of dredging. I'm not sure how it would work, but a mitigation effort (page 4-32, para 3, last sentence) using bulk tailings would apparently be placed down gradient to catch tailings in the event of a failure. Is this a safety check dam? It is possible that the assessment could be improved if this and other redundant efforts to minimize risk could be discussed in more detail and considered in the failure analysis.

RESPONSE: We have clarified this in Chapter 9 of the revised assessment. Our intent was to describe a channel becoming reestablished in the deposited tailings and slowly reworking the entire valley bottom, moving the fine material downstream. We agree that tailings would be carried downstream to Bristol Bay over the long term with adverse impact to waters. The mitigation addressed in the comment, where a levee was created downstream to capture the flow of tailings, was not our intent. We described a reclamation scenario where the tailings are dewatered and sloped to eliminate the chances of mass failure of the impoundment. Mitigating impoundment failure by creating a second dam downstream would greatly increase the mine footprint on salmon habitat.

I agree with the assessment's statement on page 6-11 (6 lines down) that impacts of a tailings dam failure to fish would extend down the mainstem Koktuli River and possibly further. If the Mount St. Helens analogy is a good one, the impacts could reach Bristol Bay. Even if the Mount St Helens analogy is not a good one, I suspect sediments would continue to move down river as the river(s) moved across their floodplains through time. I also agree with the assessment's statement that the time to reach dilution approaching background would be very long, as the sediments in tributary rivers to Bristol Bay will be continually reworked (page 6-25) and resuspended.

RESPONSE: EPA agrees with the commenter. No change suggested or required.

As a terrestrial ecologist, I have always been impressed by the impact of Bennett Dam on sediment transport in the Peace Athabasca Delta ecosystem over 600 miles away (Cordes 1975). The assessment does mention the potential impact of toxics on the likelihood of plant community succession on deposited tailings (page 6-10), but this causal pathway was not assessed. Given the increases in metal concentrations in the Columbia River Estuary cited by Lee (1996) for the Mount St. Helens eruption, an assessment of down stream sedimentation and changes in sediment chemistry should be addressed. The likelihood that far reaching impacts of a failure could influence plant succession and wildlife habitat quality is probably not anticipated but given the Mount St. Helens analogy and the lessons learned from Bennett Dam, the likelihood of such impacts deserve more attention.

RESPONSE: This comment recommends expanding the scope of the assessment to include direct effects on terrestrial plants and wildlife habitat. The scope was set during the planning and problem formulation processes to encompass the expressed concerns of the Alaska Native organizations that asked the Agency to address potential mining in the Bristol Bay watershed, as well as the needs of the Agency's decision makers. This scoping process is in keeping with the Guidelines for Ecological Risk Assessment (USEPA 1998). The commenter may be more familiar with Environmental Impact Statements, which are full disclosure documents and therefore are more broadly focused.

PHW Response: The reasons for not including direct impacts on wildlife given here do not align with statements provided by natives that impacts on wildlife are more important than impacts on salmon (page 5-77 in first draft). The reason(s) for not including wildlife should be consistent. I can't help but wonder if the Alaska Native organizations are not interested in direct impacts to wildlife. While living in Alaska I recall that a variety of birds and mammals and their parts were and still are important for nutrition, warmth, adornment and trade. For example ermine and short tailed weasels are used in a variety of ways on ceremonial dress.

Sediment Benchmarks. Once again, as a terrestrial ecologist with ecological risk assessment experience, I know that sediment chemistry and determining toxic benchmarks for sediments is very complex and subject to varied opinions. I admire the MacDonald et al. (2000) effort to reach consensus on sediment benchmarks but I have three concerns. First, the consensus values listed in MacDonald et al. (2000) are geometric means of values from several sources. The mean consensus values likely do not equate to No Observed Effect Concentrations, which would probably be lower than the mean values. Second, the lack of observed effects was sometimes for a "majority" of sediment dwelling organisms, but not all (MacDonald et al. 2000, Table 1). Third, some of the sources used for the mean values included interstitial water, but apparently not all (Table 1). I will always remember Dr. John Stein (currently the acting director of NOAA's Northwest Fisheries Science Center in Seattle) standing up at a workshop for the Columbia River Channel Deepening Project. He had a small bottle of sediment and water in his hand and, while shaking it, he said something to this effect: It's the pore water we are interested in. Considering that a proposed mine, at some point, will be reviewed by NOAA, it seems appropriate to consult with NOAA regarding benchmarks for all the species of sediment/pore water-dwelling organisms likely to occur in the potentially effected watersheds addressed in the assessment.

RESPONSE: The EPA agrees that pore water concentrations are generally useful predictors of toxic effects of sediment, and sediment pore water toxicity is addressed in the assessment. However, the MacDonald et al. (2000) benchmarks are also a useful line of evidence. NOAA has been consulted during the development of this assessment. No change required.

Question 6. ***Does the assessment appropriately characterize risks to salmonid fish due to a potential failure of water and leachate collection and treatment from the mine site? If not, what suggestions do you have for improving this part of the assessment? Are significant literature, reports, or data not referenced that would be useful to characterize these risks, and if so what are they?***

David A. Atkins, M.S.

Water treatment failures of varying scale occur at virtually every site that treats water, and mine sites are no exception. The risk of failure of water treatment described in the assessment is useful as background, but as the report states, the risk is highly uncertain. A non-catastrophic water treatment system failure is fairly likely to occur at some point during the mine life, and, hence, requires a detailed assessment. The treatment in the Assessment is cursory (less than one page). This type of failure is much more likely than a TSF failure (which receives more than 20 pages of analysis), and therefore requires a much more thorough treatment given the probability of occurrence and likelihood of impact to salmon species.

RESPONSE: The wastewater treatment failure scenario has been expanded and is now detailed and quantified in Chapter 8 of the revised assessment. Additionally, the non-catastrophic failures of seepage collection from the TSF and waste rock piles also have been included as scenarios with new and refined analyses.

The background water chemistry indicates mineral concentrations are very low. Therefore, water treatment will be challenging if background conditions are to be met. Treatment will be especially challenging given the sensitivity of the species of concern to concentrations of copper, for instance, as well as the sensitivity to temperature that may be difficult to match in a water treatment system.

RESPONSE: A mine would not necessarily have to match the low background concentrations, but would at minimum be held to the water quality standards that protect the existing and designated uses of the waterbodies where a discharge might occur. In the Bristol Bay area, all waterbodies are protected for all uses and permit limitations would be derived to be protective of the most stringent applicable Alaska Water Quality Standards (WQS). In addition, we believe that compliance with the more recent Federal Water Quality Criterion for copper would be necessary to protect aquatic life.

Dr. Paul Whitney

During mine operation, a lapse in treatment would likely be identified and addressed quickly. This type of treatment failure is ephemeral and would likely have a short-term impact on the fishery, depending on the time of year of occurrence. It is likely that any impacts to the fishery could recover in subsequent years after the problem is fixed. The site will require water treatment long after closure, possibly in perpetuity. This period is more problematic, as a water treatment failure could go unnoticed for some time or the resources may not be available to correct it quickly, depending on how long after closure the failure occurs and the stewardship of the treatment system.

RESPONSE: A failure during operation would be corrected quickly only if it did not require extensive repairs or the manufacture and import of replacement equipment. The EPA agrees that water collection and treatment failures after mine closure would be less likely to be corrected in a timely manner. In addition, events after closure, such as filling of the pit, would affect water quantities and qualities in ways that would affect treatment success. A discussion of this issue has been added to Chapter 8 of the revised assessment. A discussion of financial assurance has been added in Box 4-3.

Steve Buckley, M.S., CPG

Less than a page (4-39) is devoted to the failure of water and leachate collection and treatment. This seems inadequate given it would be one of the main systems that could impact fish at the potential mine site. In contrast, 20 pages are devoted to tailings dam failure (p.4-39 to 4-60).

RESPONSE: The wastewater treatment failure scenario has been expanded and is now detailed and quantified in Chapter 8 of the revised assessment.

Courtney Carothers, Ph.D.

The report concludes that wastewater and leachate treatment and collection failures could expose local streams to mildly to highly toxic water harmful to invertebrates and fish species. Depending on the type of failures, these exposures could last from a period of hours to years. The report notes that in the case of Red Dog Mine, Alaska, the water treatment system was inadequately designed, but does not discuss why such a design was approved and allowed to be implemented, nor does it discuss the likelihood of replicating such a design flaw in future mining scenarios.

RESPONSE: The Red Dog Mine's treatment system was inadequately designed because the amount of water to be treated was underestimated. Mine site hydrology is often difficult to predict and treatment systems may fail despite the intent of mining companies and regulators.

Dennis D. Dauble, Ph.D.

More information on local hydrology, including seasonal runoff patterns (e.g., peak flows) and groundwater movement would be useful. I found no description of existing water quality characteristics of potential receiving waters, except what is included in Table 5-17 of the main report. Are these values (such as hardness, which moderates metal toxicity) consistent throughout the watersheds, including downstream lakes? Other questions include: What volumes of leachates might be collected and treated versus volumes not captured and subsequently released downstream? Is copper the only constituent of concern to aquatic animals? Are there processing chemicals that would also be toxic?

RESPONSE: Monthly flow patterns for area streams are now presented in Chapter 7. The three streams described in Table 7-17 are the three potential receiving waters for any site effluents. The water balance, including leachate volumes, is now described in the assessment (Chapter 6). Copper is the primary contaminant of concern. Others are described in the new Section 6.4.2.3 and discussed in Chapters 8 and 11.

The assessment should also consider and discuss relative risk to aquatic ecosystems from downstream transport of sediment-bound metals to Iliamna Lake, if deemed probable.

RESPONSE: Although metals in aqueous emissions would partition to sediment, and the sediment would mobilize during high flows and eventually reach the lake, this route is not judged to be significant. Toxicity is caused by dissolved metals, and concentrations from release of metals from transported sediment to lake water are likely to be minor.

Gordon H. Reeves, Ph.D.

The report focused primarily on the lethal effects of the contamination from leachate and water treatment and collection failures. However, could there be ecological consequences to fish and invertebrates that are not directly lethal but that could have ecological consequences over the long term? I suggest that this needs to be considered more fully in this assessment.

RESPONSE: The report addresses both acute lethal effects and chronic lethal and nonlethal toxic effects to both fish and the invertebrates on which they feed. It is highlighted in the text when estimated concentrations are sufficient to cause acute lethality. Such effects are important not only because they are severe but also because they could occur during episodic exposures.

Sockeye salmon are most abundant salmon in Bristol Bay and a primary species of focus in this analysis. The direct impacts of mine and mine-related activities have been considered but there appears to be a lack of consideration of the impact on zooplankton, the food source for sockeye. If this were a deliberate omission, then a statement about why it was omitted is required. The revision should include this if it was an oversight.

RESPONSE: Any effluents would be released to the streams draining the site. In those ecosystems, zooplankton are rare and the primary food organisms for fish are benthic invertebrates. However, the toxicological data used to assess effects on invertebrates are dominated by planktonic crustaceans. Therefore, if toxic concentrations of metals reach Iliamna or other lakes, the toxicity assessment would actually be more relevant to the plankton that occur there than to the insects in the receiving streams. Hence, the numerous references to effects on aquatic invertebrates are relevant to zooplankton and no new analyses are needed.

Dr. Paul Whitney

Charles Wesley Slaughter, Ph.D.

No. Text suggests that a monitoring well field downslope from the TSF (and presumably from all hypothetical TSFs) would detect seepage; such seepage would then be intercepted and either returned to the TSF or "treated and released to the stream channel." Either action presupposes adequacy of monitoring seepage and subsurface flow (both spatially and temporally); returning such water to the stream further presupposes fully adequate treatment to meet both regulatory and aquatic biota requirements for water quality and flow regime.

RESPONSE: The water treatment and leachate capture discussions have been expanded and are now detailed and quantified in Chapter 8 of the revised assessment.

Assumptions are very generalized and optimistic: "assuming no water collection and treatment failures" and "excess captured water would be treated…and discharged to nearby streams…" – this assumes both "no failures" over the life of the operation, and that such treated "excess captured water" could be successfully treated before release to fully meet both regulatory water quality criteria and the possibly more sensitive biological requirements of individual invertebrates and fish stocks (Appendices A & B).

RESPONSE: Water management (mitigation) measures are more clearly described and discussed in Section 6.1.2.5 of the revised assessment, and in sub-sections for the mine components in the scenarios. Our intention for the "no-failure" scenario was to identify and evaluate the unavoidable environmental effects if all systems and mitigation measures operated perfectly, and to separate those effects from a scenario where systems periodically failed. However, the "no failure" scenario is no longer included. The purpose of the assessment is to describe the potential adverse environmental effects that could exist even with appropriate and effective site mitigation measures. The assessment is not intended to duplicate or replace a regulatory process, which is where required permit discharge limits for water quality would be determined.

John D. Stednick, Ph.D.

The TSF is designed to hold the tailings under water to minimize the oxidation of pyritic materials and limit ARD or AMD production. The TSF will be underlain by hypalon to capture leakage waters. There is the possibility of failure to collect waters from the TSF—either surface runoff or leakage with or without storm (precipitation) events. There is also the possibility of failure of the treatment plant to treat the wastewater. Such treatment systems in Colorado usually have a bypass pond to temporarily hold waters for later pump back and treatment as a result of power failure, plant going off-line, storm events, or plant maintenance.

RESPONSE: The original draft assessment contained a scenario in which tailings leachate was not fully contained and reached a stream (Section 6.3 in the May 2012 draft); however, this has been refined with new data in the revision for seepage from the TSF and waste rock piles that escapes capture from the mitigation measures (Chapter 8). Additionally, the scenario presents a suggested treatment option for mining influenced water and settling ponds for

stormwater runoff. A wastewater treatment plant failure scenario in the revised assessment assumes emergency storage capacity has been exceeded or the bypass system fails.

The waters in the study area have very low buffering capacity; metal toxicity would occur at low concentrations and dilution of metals would require time and space. The maximum index counts on page 6-39 are confusing and not well related to the risk characterization. Copper was used as an example metal, but other metals are also toxic and further characterization of the waste rock can be presented. Further analysis of a water and leachate collection failure can be made over time: the effects of dilution flows over the various months with low flows, or when adult salmon are present in the stream as opposed to juveniles – or, when juveniles are emerging. The toxicity quantification is difficult and appears more of an academic exercise here, rather than site specific.

RESPONSE: Undiluted leachate concentrations are used to calculate the hazard quotients (we assume that is what the reviewer means by "maximum index counts"), to screen the constituents for contaminants of concern, and because the State of Alaska does not allow mixing zones in anadromous streams. However, dilution was considered in the failure scenarios for waste rock leachates and tailings leachates. Copper was emphasized because it is by far the most toxic metal relative to concentrations in rock, tailings and concentrate leachates. Site specific water chemistry was used to estimate the toxicological benchmarks for copper and for metals with hardness-dependent toxicity. More detailed analyses of dilution are included in Chapter 8 of the revised assessment.

Leachate collection from the tailings area is only briefly described. What are the State of Alaska standards for collection and treatment? What are the potential effects of not collecting or treating the tailings leachate waters? Compare the detail and length of leachate discussion to the TSF failure discussion (see earlier comments).

RESPONSE: There are no specific AK State standards for collection and treatment of tailings leachate, but any discharge to waters of the United States requires a Clean Water Act Section 402 (CWA § 402) permit. In Alaska, the Department of Environmental Conservation issues these permits under the Alaska Pollutant Discharge Elimination System program. Such permits would contain effluent limitations that are protective of the State WQS. The original draft assessment contained a scenario in which tailings leachate was not fully contained and reached a stream (Section 6.3 of the May 2012 draft); however, this has been refined with new data in the revision (Chapter 8) for seepage from the TSF and waste rock piles that escapes capture from the mitigation measures.

Given the hydrologic connection between surface and groundwaters, what effect will interception of all waters on the TSF do to the surrounding wetlands and groundwater levels? Again the lack of a water balance does not let the reader determine if this water interception is significant or will have significant resource effects.

RESPONSE: The water balance presented in the revised assessment quantifies the amount of water captured at each TSF under each scenario. The assessment also presents the percentage change in streamflow at existing gages in the North Fork Koktuli, the South Fork Koktuli, and the Upper Talarik.

Dr. Paul Whitney

The water balance presented in the assessment looks at the overall amount of water dedicated to consumptive uses, which therefore would no longer be available to contribute to groundwater recharge or stream flow. Furthermore, the assessment attempts to quantify the annual amount of and percentage increase or decrease in streamflow for individual stream reaches. These stream flow results are presented in Chapter 7 of the revised assessment.

Our analysis does not attempt to explicitly calculate groundwater levels or drawdown except within the cone of depression around the mine pit. Our analysis assumes that all precipitation that falls outside the actual mine footprint (i.e., the physically disturbed areas) would continue to contribute to groundwater recharge and stream flow, although the exact flow patterns would change due to collection of surface runoff and stream diversions. Areas within the footprint would most likely see some decrease in the groundwater levels due to the collection, management, and possible treatment of surface runoff, with some potential increases downstream of the points of water release from the wastewater treatment plant. Overall, the cumulative reduction in streamflow would be approximately equal to the amount of water retained on the site as tailings pore water.

Most, if not all of these failures are the result of human error. What safeguards will be in place? What are the best mining practices to minimize human error?

RESPONSE: The mitigation measures proposed within the mine scenarios are those that could reasonably be expected to be proposed for a real mine (they are a subset of options presented in Appendix I), all of which were presented as appropriate for the Pebble deposit in Ghaffari et al. (2011). We assume that these types of measures would be applied throughout a mine as it is constructed, operated, closed, and maintained through post-closure. Because the possibility for human error is inherent in any activity in which a human is involved, accidents and failures happen. Human error-caused accidents and failures are minimized when the humans involved follow careful and responsible management of the mining site. No change suggested or required.

<u>Roy A. Stein, Ph.D.</u>

Groundwater Connectivity and TSF Construction I. Extensive connectivity between surface water and groundwater means that any failure will allow contaminated waters to flow quickly to areas of importance for salmon. And, indeed how does one build a tailings pond (coarse textured glacial drift in the Pebble Mine area) with this much permeability? Why would one only line the tailings dam; shouldn't the entire Tailings Storage Facility be lined? Would not this be "Best Practice"?

RESPONSE: Our estimates of the expected leakage from the full TSFs range from about 2 to 6 m^3/min. If a mine at the Pebble deposit goes forward, the design of the TSFs should include a more thorough flow analysis that would calculate the expected rate of flow and associated flow paths from the TSFs. If the calculated leakage rates were unsatisfactory from an environmental, operational, or economic perspective, the designer could incorporate other design elements (e.g., a liner) to reduce the expected leakage rate. Full liners beneath TSFs are not always used; however, there is a growing requirement to use liners to minimize risks of groundwater contamination, with new mines in Australia being required to justify why one

wouldn't be required (Commonwealth of Australia 2007). Liners are not required in the US. Whether something is "best" depends on the specifics of the site. The mitigation measures proposed within the mine scenarios are those that could reasonably be expected to be proposed for a real mine (they are a subset of options presented in Appendix I), all of which were presented as appropriate for the Pebble deposit in Ghaffari et al. (2011). Evaluation of different mitigation measures to determine if lining the facility would be "best" for this site would be part of the regulatory process and thus is outside the scope of this assessment.

Groundwater Connectivity and TSF Construction II: A water-impermeable barrier will be installed only on the interior dam face and nowhere else. To prevent communication between these facilities and the groundwater, is it feasible to map groundwater inputs before the facility is filled, place barriers over these areas, and thereby reduce influx of groundwater into the facility and perhaps prevent movement of toxic water into the groundwater? I make this point with some hesitation, given the point made on page 5-29:

> "Projecting specific mining-associated changes to groundwater and surface water interactions in the mine area is not feasible at this time."

RESPONSE: See response to previous comment.

Failure of Leachate and Water Collections. See my comments under Question 12 below. In addition, I see this as a huge undertaking for which monitoring and response (mitigation) are clearly as important as the actual plan to capture these wastes.

RESPONSE: EPA agrees with this comment. No change suggested or required.

William A. Stubblefield, Ph.D.

The risk assessment attempts to consider the effects of metal discharges for water and leachate from the mine site. This assessment is based on metals concentrations measured in potentially "similar" mine waters from other sites; concentrations of metals are likely to differ based on source material and operational differences. The effects concentrations used in the evaluation are based on US EPA ambient water quality criteria (AWQC) for metals, and this approach is appropriate for "screening level" evaluations. It should be noted that exceedence of an AWQC does not portend the occurrence of adverse effects. Ambient water quality criteria are derived in such a way that they are intended to represent "safe concentrations." In other words, if environmental concentrations remain below the AWQC, it is assumed that unacceptable adverse effects will not occur; exceedence of an AWQC suggests that adverse effects may occur to some species, but that this must be evaluated more closely. Salmonid species are not the most sensitive organisms in the copper AWQC species sensitivity distribution (SSD); therefore, direct effects on salmon are even less likely at concentrations in the range of the AWQC.

RESPONSE: Effluents or ambient waters from mines at other sites were not used. The leachate concentrations used (except for the product concentrate leachate) are from available results of material leaching tests from the Pebble deposit. Otherwise, the Agency agrees with these comments. The assessment used criteria for screening, but then examines the toxicity data more closely, including field data to determine potential effects (e.g., aversion, sensory inhibition, mortality and reduced reproductive success of salmonid fish). The greater

sensitivity of aquatic insects was described in the May 2012 draft of the assessment and is further highlighted in the revised assessment. The protectiveness of the copper criterion is considered in both the original and revised assessments.

It is interesting to note that the risk assessment document states that copper is one of the "best-supported criteria. However, it is always possible that it would not be protective in particular cases due to unstudied conditions or responses." Further, the document goes on to suggest that organisms such as mayflies etc. are important to the aquatic ecosystem but are not considered in the copper AWQC and therefore may not be sufficiently protective. It also suggests that because an acute-chronic ratio approach is employed to correct the final acute value to obtain a final chronic value, there may be increased uncertainty associated with the protectiveness of the chronic criterion. This appears to be an area where EPA might benefit by conducting research (either alone or in concert with industry) to reduce uncertainty in the criteria to an acceptable level. In addition, additional chronic toxicity data may be available from research conducted in response to the European REACH regulations and consideration of this research may reduce the level of uncertainty in the criteria. Bioavailability correction via the BLM approach is only considered for copper in the risk assessment; biotic ligand models have been developed for a number of metals (e.g., zinc, nickel) and these should be considered in the assessment as well. Finally, the assessment approach seems to use a sum TU-based approach for assessing "metals mixture" impacts. This is based on an assumption of additive interactions among the metals. Although this is probably the best assumption in going forward, limited data are available to support this approach.

RESPONSE: The EPA has examined the EU's 2008 Voluntary Risk Assessment of Copper (the relevant REACH document). Although the authors could derive a chronic species sensitivity distribution, that is because the way that they include and aggregate data differs from the EPA's method. They apparently did not generate new test data for the assessment. In particular, they have no data for sensitive aquatic insects, so the EU assessment does not resolve that problem. The BLM was used for copper because it is the contaminant of greatest concern and because the copper BLM has been approved by the EPA Office of Water. Other metals with BLMs, such as zinc and nickel, occur at lower levels in leachates relative to their toxicities, so BLM modeling was not justified.

Areas where additional research would be beneficial include:

- Mixtures: Information regarding the potential interactive effects of multiple metal exposures would be useful and would reduce assessment uncertainty.
- Species sensitivity concerns: there is extremely limited data (esp. chronic datat) on all of the salmon species of concern in Bristol Bay
- Additional data, especially chronic toxicity data and data for additional metals for which no water quality criteria exists, would be extremely helpful.

RESPONSE: The EPA agrees that these are good research topics. No change is suggested or required.

Dirk van Zyl, Ph.D., P.E.

Dr. Paul Whitney

The EPA Assessment does not identify or appropriately characterize the risks to salmonid fish due to a potential failure of water and leachate collection and treatment from the mine site. It only estimates the likelihoods of occurrence and the consequences. See discussion under Question 4 above regarding suggestions for improving estimation and expression of the magnitude of risks to salmonid fish due to potential failure of water and leachate collection and treatment from the mine site.

RESPONSE: The EPA believes that the likelihood of an occurrence and its consequences constitute an appropriate and generally accepted definition of risk. We have estimated those to the extent that existing information allows. We have added to the discussion of leachate contamination, including estimation of the magnitude of leachate escaping the collection system and entering surface waters (Chapter 8).

Water collection and treatment failure likelihood. An estimate is presented for the amount of seepage that may flow from the TSF. Similar estimates are not presented for the waste rock piles. The effects of the effective exclusion of oxygen from the saturated or partially saturated tailings should be considered in developing an estimate of the water quality of the resulting seepage. It may be an important factor in reducing the oxidation of sulfide minerals remaining in the interior of the TSF. This same effect could also mitigate the release of poor water quality in the long-term following closure. The precipitation on the site may be sufficient to effectively retain a suction saturated profile in parts of the TSF.

RESPONSE: The revised assessment presents an estimate of the amount of seepage from the waste rock piles (Table 6-3). The water quality of the leachate from the TSF was modeled with the concentrations reported from the tailings humidity cell tests. The reported copper concentration of 0.00533 mg/l is lower than some of the reported groundwater concentrations, and is the same order of magnitude as the highest reported stream concentration of 0.0013 mg/l. The TSF at closure was modeled with free standing water at the surface and with downward flow with an estimated gradient between 0.07 and 0.12.

Water collection and treatment failure consequences. Water collection and treatment is being done at a number of mines in North America. Past experience at the Red Dog mine is quoted; however, there are many other examples that could have been examined. An important example is that of the Equity Silver Mine in British Columbia (Aziz and Meints, 2012): "Acid Rock Drainage (ARD) was discovered at the Equity Silver Mine in the interior of British Columbia in 1981. The latest water treatment plant was installed in 2003, 9 years after the mine closed in 1994, and is the fourth successive treatment plant for the site that has treated ARD for a period of over 30 years. Discharge water quality was maintained since 1991 except during two high flows associated with freshet conditions in 1997 and 2002. ARD collection and treatment system upgrades were installed after 2002 and these have performed well through three large freshet conditions in 2007, 2011 and 2012. The timeframe for treatment is perpetuity and financial assurance is in place for a total amount of $56.291 million through a long-term security bond (letter of credit) with the BC Provincial Regulatory Authority. The security bond is reviewed by stakeholders every 5 year". Collection and treatment at Equity Silver indicates that companies are committing to long-term water treatment of ARD and that regulatory frameworks are in place to protect water quality in downstream streams and rivers. It is recommended that EPA perform a more thorough review of other sites where water treatment occurs to better characterize this failure mode.

Dr. Paul Whitney

RESPONSE: We have been unable to obtain a copy of the cited report. The 2010 Sustainability Report, which is available, does not contain these specifics. This mine apparently has begun perpetual water treatment. A comprehensive review of mine sites with water treatment systems is beyond the scope of this assessment.

Phyllis K. Weber Scannell, Ph.D.

This section of the report provides an in-depth discussion of possible sources and fates of contaminated water. Chapter 6.3 discusses possible adverse effects from early mine closure or prematurely shutting down a water treatment system. These issues highlight the need for a mine plan that includes concurrent reclamation, sufficient bonding to conduct reclamation in the event of an early shut down, and plans and specifications for collection and bypass of clean water and collection and diversion to a water treatment system of contaminated water.

RESPONSE: The EPA agrees with this comment. No change suggested or required.

The Risk Characterization (Section 6.3.3) discusses possible contaminant loads to downstream waters. As stated in this section, it "serves to indicate the large potential risk from improperly managed waste rock leachate." This statement highlights the need for an in-depth mine plan with sufficient monitoring and fail-safe provisions. An emergency discharge of untreated waters from a tailings storage facility could be made to a collection pond for later treatment or the tailings pond could be engineered to accommodate a higher flood event so the likelihood of overtopping is minimized.

RESPONSE: The waste rock leachate scenario referenced by the commenter has been eliminated and replaced with a more detailed and realistic scenario for waste rock leachate collection and treatment (Chapter 8).

Section 6.3.3 (Risk Characterization) states "Alternatively, water collection and treatment failure could be a result of an inadequately designed water treatment system which could result in the release of inadequately treated water as at the Red Dog Mine, Alaska (Ott and Scannell 1994, USEPA 1998, 2008). In that case, the failure could continue for years until a new or upgraded treatment system is designed and constructed." This statement is misleading and overly simplistic; the water treatment system at the Red Dog Mine was designed to treat the predicted flows. However, the stream bypass and collection systems were constructed in 1991 to intercept seepage waters. The additional water that was collected and treated dictated construction of a second water treatment system in 1992. Sand filters were added in 1993 to remove fine particulate Zn. The issue was not that the water treatment was inadequate, but that the pre-mining hydrologic data was insufficient and that state, federal, and mine officials lacked experience in mine construction on permafrost soils.

RESPONSE: The water treatment failure at Red Dog was, as the commenter describes, the result of an unintended failure to design a plant that was adequate for the mine and site. The passage has been expanded to clarify the nature of the failure.

Overall, the discussions of risks to salmonid fish due to a potential failure of water and leachate collection and treatment from the mine site highlight the need for more comprehensive information on groundwater, including delineating flow pathways, depth to surface, and water volumes. Additional information is needed on water collection, storage, and treatment at future mine facilities.

RESPONSE: Discussions of wastewater collection and treatment have been considerably expanded in Chapter 8.

Paul Whitney, Ph.D.

No comment on this question.

Question 7. ***Does the assessment appropriately characterize risks to salmonid fish due to culvert failures along the transportation corridor? If not, what suggestions do you have for improving this part of the assessment? Are significant literature, reports, or data not referenced that would be useful to characterize these risks, and if so what are they?***

David A. Atkins, M.S.

The description of culvert failure is necessarily general because there are currently no designs. The general data on culvert failures presented for the types of culverts described in the references cited (principally for forest and range land) indicate a high probability of failure (30-66% failure rate). It is probable, however, that the transportation corridor for the project would be constructed to a higher standard than most of the roads included in these papers. It would be helpful to know if similar data are available for highly engineered roads of the type likely to be built for the project.

RESPONSE: The assessment assumes modern mining technology and operations. We did not find information explicitly from highly engineered roads, but to the extent possible we used recent literature from representative environments. The failure frequencies cited in the revised assessment are from modern roads and are not restricted to forest or rangeland roads. Information on current design standards is now included in text boxes throughout Chapter 10.

Steve Buckley, M.S., CPG

The references provided in this section emphasize culvert failures in the Pacific Northwest and Tongass National Forest. The streams and culverts in these regions are heavily influenced by large woody debris loading. It would be more appropriate to classify the various potential stream crossings by watershed and the amount of large woody debris available to be recruited to the stream and influence culvert blockage.

RESPONSE: Many of the references in the assessment relate to the Pacific Northwest, because much work on culverts and potential impacts on salmon have been performed there.

Dr. Paul Whitney

Flanders et al. (2000) has been deleted in the revised assessment. The failure frequencies cited in the revised assessment are from the best available literature concerning modern roads, and are not restricted to forest roads.

Courtney Carothers, Ph.D.

Culvert failures due to blockage and erosion are noted to be common and are likely to occur in this scenario. Culvert failures would prevent the movement of fish, which could eliminate a year class from blocked stream systems and fragment upstream and downstream populations, increasing likelihood of localized population depletions and extinctions. Monitoring and maintenance of culverts can be expected to decrease after mine operation, increasing the risks of these failures. The report appears to appropriately characterize risks to salmonid fish due to culvert failures along the transportation corridor, although I have no particular expertise with which to evaluate this assessment.

RESPONSE: No change suggested or required.

Dennis D. Dauble, Ph.D.

Mitigation practices, such as new culvert design, was well described, as was bridging of roadways and porous fills to mitigate risks due to culvert failure along the transportation corridor. This assessment also included appropriate risk characterization for both the no-failure and failure scenarios. There should be literature available from the Washington State Department of Transportation on fish passage relative to culvert placement and design. Otherwise, I have no suggestions for improvement.

RESPONSE: We have examined literature on fish passage relative to culverts from the Washington State Department of Transportation. Culvert failure frequencies from their 2012 paper, in which approximately 62%of culverts were identified as total or partial barriers, were not used in the assessment because we could not determine the age of examined roads.

Gordon H. Reeves, Ph.D.

The literature review of culverts and their potential impacts on fish and fish habitat is very thorough and the presentation of results is accurate. However, most of the cited material is from studies done in areas outside of Bristol Bay and the direct applicability of results is problematic. This should be done in the revision.

RESPONSE: Because the proposed mining would take place in an undeveloped area, much of the literature is necessarily from areas outside of Bristol Bay. However, to the extent possible we used examples from representative environments, and applied the results to the proposed mine.

I think that there are potential mitigation measures that were not presented. The primary one, besides the use of bridges, as suggested in the report, is making all culverts be arch culverts.

Dr. Paul Whitney

These culverts make use of the stream bottom, which reduces the potential for the culverts to become perched and impede upstream movement, and are less likely to change the gradient than other culvert types. All culverts could, as recommended in the report, be at least one bank width, which is larger than required by the state of Alaska. This would minimize the possibility of plugging with debris.

RESPONSE: A number of culvert types (e.g., arch culverts) may be used on the proposed transportation corridor; it is not in EPA's purview to suggest which ones should be used. However, culvert design approaches specified in the Memorandum of Agreement between the Alaska Department of Fish and Game and the Alaska Department of Transportation and Public Facilities (ADF&G and ADOT 2001) are described in Box 10-2 of the revised assessment.

The review of potential road impacts lacked two possible consequences. One is that roads could be corridors for the introduction of invasive species, plants and animals. The consequences of the successful establishment of non-native species could have critical ecological impacts on native species and the ecosystem. The second consequence is that a road will allow greater access to streams where access was previously limited. Fish populations could be more easily and intensively harvested in sport and subsistence fisheries, which adds additional stresses to the populations. Lee et al. (1997. Assessment of the condition of aquatic ecosystems in the Interior Columbia River basin. Chapter 4. Eastside Ecosystem Management Project. PNW-GTR-405. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.) found a direct relation between road access and the status of salmonid populations in the Columbia Basin.

RESPONSE: We agree with the commenter that roads could be corridors for the introduction of invasive species. The potential impacts of invasive species as a result of construction and operation of the proposed transportation corridor are discussed in Section 10.3.6 in the revised assessment. With respect to stream access, EPA assumes that the proposed road would be closed to the public during mining operations but potentially could become a public road after mining operations cease. If that were the case, there would be greater access to streams and fish populations. However, the potentially important impact to fish would likely occur from secondary (induced) development, or development resulting from the introduction of industry, roads and infrastructure associated with mining. This is briefly discussed in Section 13.3 in the revised assessment. Improved accessibility would increase hunting and fishing pressure, as well as competition with existing subsistence users.

Charles Wesley Slaughter, Ph.D.

No. The Assessment does not adequately address the road/stream crossing/culvert issue. Given the projected transportation corridor, Pebble locale to Cook Inlet, and the inevitability of a further network of "minor" roads in the mine and TSF locale, plus additional infrastructure linkages, road/culvert/stream crossings are a major concern for aquatic habitat and fisheries. Readers of the Assessment should be directed to Frissell and Shaftel's Appendix G for a more comprehensive discussion of this important topic.

Dr. Paul Whitney

RESPONSE: The revised assessment addresses the road/stream crossing/culvert issue in detail. Secondary development is now described qualitatively in Chapter 13 of the revised assessment. The reader is repeatedly directed to Appendix G for more details.

The specific consequences of a failure on salmonid habitat and biology are portrayed well.

RESPONSE: No changes suggested or required.

John D. Stednick, Ph.D.

No. It is unclear how the estimate that 50% of the culverts would fail was obtained, given that the literature shows a range of 30 to 60% (Section 4.4.4). What literature was used? Are road BMPs satisfactory in this environment? Have the Alaska BMPs been audited? Culvert repair taking a week to several repairs in a month seems high. If the road crosses a critical salmon rearing stream, conservative pipe sizing or bridgework could be considered. The direct loss or inaccessibility of upstream salmon habitat does not necessarily translate to salmon loss. Timing of culvert blocking event with salmon migration and duration of blockage should be considered. Need to include references to Alaska Department of Natural Resources and Alaska Department of Transportation.

RESPONSE: The literature showed a range of 30 to 66%, with an average of roughly 50%. The literature used was noted in Section 10.3.2.1. However, Flanders et al. 2000 was deleted in the revised assessment, bringing the average culvert failure frequency to 47%.

Best management practices (BMPs) or mitigation measures would be used to minimize potential impacts to salmon ecosystems from construction and operation of the proposed transportation corridor. These BMPs, and their likely effectiveness, are now discussed in text boxes throughout Chapter 10 (e.g., Box 10-2). Environmental characteristics along the transportation corridor would likely render the effectiveness of standard or even "state of the art" mitigation measures highly uncertain. Further discussion on this is contained in Box 10-5 of the revised Assessment.

We are not aware of any audits of Alaska BMPs.

The text relating to culvert repair considers that the proposed mining would occur in an often harsh, remote environment.

Design considerations (including sizing) for culverts are now discussed in Box 10-2. Culverts would be designed in accordance with guidance in Alaska Highway Drainage Manual (ADOT 1995) and the Memorandum of Agreement between the Alaska Department of Fish and Game and the Alaska Department of Transportation and Public Facilities (ADF&G and ADOT 2001). Both of these documents are cited within Box 10-2.

Blockage of a culvert by debris or downstream erosion would prevent the in-and-out migration of salmon and the movement of other fish among seasonal habitats. The direct loss or inaccessibility of upstream salmon habitat does not necessarily translate to loss of a population of salmon, but production would ultimately be reduced. If blockage of a culvert by debris or downstream erosion occurred during in-migration of salmon and persisted for several days, it would result in the loss of spawning and rearing habitat. If it occurred during

out-migration and persisted for several days, it could cause the loss of a year class of salmon from a stream.

What are the design considerations for the culverts? What precipitation/streamflow relationships will be used for sizing purposes? What are the usual casual mechanisms for culvert failure? How much woody material do these streams carry? Do culverts fail from debris plugging, road slumps, or overtopping by storm events? What road BMPs will be implemented?

RESPONSE: Design considerations (including sizing) for culverts are now discussed in Box 10-2. Culverts would be designed in accordance with guidance in Alaska Highway Drainage Manual (ADOT 1995) and the Memorandum of Agreement between the Alaska Department of Fish and Game and the Alaska Department of Transportation and Public Facilities (ADF&G and ADOT 2001).

As noted in Section 10.3.2, culverts are deemed to have failed if culverts (and thus fish passage) are blocked (e.g., by debris, ice, or beaver activity) or if stream flow exceeds culvert capacity, resulting in overtopping and potential road washout. The causal mechanisms for culvert failure are briefly discussed in Section 10.3.2.

We do not have an estimate of the amount of woody material carried by streams in the assessment area.

BMPs (e.g., stormwater runoff and fine sediment mitigation) that would be implemented are now discussed in text boxes throughout Chapter 10 of the revised assessment.

Roy A. Stein, Ph.D.

Sizing Culverts: Page 5-61. Here the suggestion is that "Culverts must be 0.9 times the ordinary high-water width…" and where the channel slope is less than 5%, the "the culvert is allowed to be 0.75 times" this same metric. Does this take into account global climate changes, which would mean higher flow rates than historically has been the case? Shouldn't culverts be sized larger than what historical flow rates would suggest, given that Climate Change will likely result in more intense storms and therefore greater stream flows than has historically been the case?

RESPONSE: The commenter makes a good point. We do not believe that the sizing suggestions noted by the commenter (found in the Memorandum of Agreement between the Alaska Department of Fish and Game and the Alaska Department of Transportation and Public Facilities (ADF&G and ADOT 2001) take into account global climate change. Climate change projections and potential impacts are now included in Chapter 3. We note in Chapter 10 of the revised assessment that climate-related changes, such as increased flood frequency and shorter return interval for major flood events, would likely undermine the structure of the proposed transportation corridor and stream crossings. The variability and magnitude of stream flows could also enhance other impacts described in the chapter. Interactions between climate change and mining risks are discussed in Box 14-2.

Culvert Failures: Page 6-42. Culvert failure rates of 30-66% suggest we are doing something wrong with establishing these culverts to maintain stream flow under a road. How might we reduce this rate of failure (larger culverts? placement issues? solutions of any sort?)? In fact, if indeed 50% of the culverts will be blocked (see bottom of page 6-43), are we not dealing with an unacceptable solution of running streams under roads? Might there be some replacement of these culverts with bridges; certainly, bridges are more expensive to build, but they simply do not have the failure (i.e., blockage) rate that culverts do. Might there be a trade-off here between initial investment costs (high for bridges) and salmon protection (fewer blockage events)? What would Best Management Practices tell us in this context?

RESPONSE: In the revised assessment, culvert failure frequencies are reported as 30 to 58%, with an average failure estimate of 47%. The likelihood of extended blockages would be low during mine operations because the roadway would be monitored daily to ensure that failures could be rapidly identified and repaired. However, the likelihood would increase after mine operations cease, if inspection and maintenance frequencies declined to those of typical roads.

Best management practices (BMPs) or mitigation measures would be used to minimize potential impacts to salmon ecosystems from construction and operation of the proposed transportation corridor. These BMPs, and their likely effectiveness, are now discussed in text boxes throughout Chapter 10.

Bridges would generally have less impact on salmon than culverts, but can result in the loss of long riparian side channels if they do not span the entire floodplain. The actual decision as to what type of structure (bridge versus culvert) would be constructed at each crossing would be made by industry engineers in consultation with state permitting staff.

William A. Stubblefield, Ph.D.

Potential effects on salmonid populations were evaluated due to culvert blockage and failures. Culvert blockages will prevent salmon passage leading to possible effects on reproductive success. Literature data for the incidence of culvert failures were used in assessing failure probability. This seems to be an appropriate approach given the hypothetical nature of the mine used in the assessment; however, this is not my area of expertise and I am not aware of additional data that should be considered.

RESPONSE: No change suggested or required.

Dirk van Zyl, Ph.D., P.E.

Road and culvert failure likelihood. The likelihood of road and culvert failures is discussed in Section 4.4.4 (p. 4-62). This section relies on the paper by Furniss et al. (1991) for a number of aspects. As was pointed out above, this paper is focused on forest and rangeland roads and is not applicable to the access road for the Pebble Mine. It is recommended that further evaluations be done of similar roads at mines constructed between mines and port facilities to update this section.

RESPONSE: Furniss et al. (1991) does focus on forest and rangeland roads, but it is a seminal publication on the potential effects of roads, particularly as they relate to salmon. The general conclusions of that paper should be applicable to the transportation corridor proposed in the assessment. The failure frequencies cited in the revised assessment are from modern

roads and not restricted to forest roads. Because the proposed mining would take place in an undeveloped area, much of the literature used in the assessment is necessarily from areas outside of Bristol Bay. However, to the extent possible we used recent literature from representative environments. We found no literature concerning the operational success of culverts on roads between mines or connecting mines and ports.

Road and culvert failure consequences. The failure consequences discussed in Section 6.4 seem to be based on almost total regulatory failure during and after operations. The information also serves to highlight the aspects that should be considered when designing, operating and maintaining the access road during operations and subsequently during closure.

RESPONSE: In the revised assessment, consequences of failures and routine operations are covered in Chapter 10. The failure consequences are not based on almost total regulatory failure. Rather, they take into account the use of best management practices (BMPs) or mitigation measures that are discussed in text boxes throughout Chapter 10. Nonetheless, environmental characteristics along the transportation corridor would likely render the effectiveness of standard or even "state of the art" mitigation measures highly uncertain. Further discussion on this is contained in Box 10-5 of the revised assessment.

Phyllis K. Weber Scannell, Ph.D.

The risks to salmonid fish due to culvert failures would be minimized by implementation of permits by Alaska Department of Fish and Game (ADF&G), Habitat Division. Under A.S. 16.05.840-870, Alaska has some of the most protective laws for fish and fish habitat in the United States. Further, given the lack of specific information on road alignments, construction methods and stream crossings, it is not possible to calculate lengths of affected streams, quantify loss of fish habitats, or predict failures of culverts, side slopes, etc. The document would be strengthened if it included specific information on locations of spawning and rearing habitats and estimated the contribution of fish habitats in the Nushagak River and Kvichak River Watersheds to the Bristol Bay fishery.

RESPONSE: Best management practices (BMPs) or mitigation measures that would be used to minimize potential impacts to salmon ecosystems from construction and operation of the proposed transportation corridor are now discussed in text boxes throughout Chapter 10. Box 10-2 specifically refers to fish habitat regulations under Title 16.

As noted in the revised assessment, uncertainty exists in the characterization of streams and wetlands affected by the proposed transportation corridor. Based on the chosen road alignment scenario (which agrees with that proposed in Ghaffari et al. 2011) we feel that we are justified in estimating the potential footprint of the proposed corridor and its potential impact on fish habitats and populations. We note in the revised assessment that "Although this route (the one proposed in the EPA scenario) is not necessarily the only option for corridor placement, the assessment of potential environmental risks would not be expected to change substantially with minor shifts in road alignment. Along any feasible route, the proposed transportation corridor would cross many streams, rivers, wetlands, and extensive areas with shallow groundwater, including numerous mapped (and likely more unmapped) tributary streams to Iliamna Lake (Figures 10-1 and 10-2)."

Dr. Paul Whitney

Specific information on locations of spawning and rearing habitats along the proposed transportation corridor is difficult to obtain; as noted in the revised assessment, the Alaska Anadromous Waters Catalog and Alaska Freshwater Fish Inventory do not necessarily characterize all potential fish-bearing streams because of limited sampling along the corridor. Nonetheless, the revised assessment summarizes the species, abundances, and distributions that would potentially be affected, and places the streams along the transportation corridor into the context of the entire Nushagak and Kvichak River watersheds with respect to important watershed attributes such as discharge, channel gradient, and floodplain potential. As far as placing potential mining impacts in the context of the entire Bristol Bay watershed, we are unable to build a complete IP model, as this would require validation and more elaborate construction of metrics appropriate to this region. However, our preliminary characterization provides the building blocks for assessing the distribution of key habitat-forming and constraining features across these watersheds.

Paul Whitney, Ph.D.

Criteria for bridge versus culvert installations along the proposed haul road. The dynamic process of beaver dams causing streams to move across the floodplain should also be a criterion for determining if and where culverts are installed for a potential road (pages 4-36 and 4-63). Even if salmonids are not present at a stream crossing, the mosaic of active and decayed beaver ponds in the floodplain can be important rearing areas for forage fish and benthic drift that are utilized by salmonids (Snodgrass and Meffe, 1997; Schlosser and Kallemeyn, 2000). If beaver dams (but not salmonids) are present above proposed stream crossings, bridges or causeways that allow the streams to move across the floodplain should be recommended versus a culvert.

RESPONSE: Our revised assessment is based on the assumption that crossings over streams with mean annual flows greater than 0.15m^3/s would be bridged. However, the actual decision as to what type of structure (bridge versus culvert) would be constructed at each crossing would be made by industry engineers in consultation with state permitting staff. We agree with the reviewer that beavers can have an important influence of channel location and morphology. However, beavers move frequently, so over the life of the road the locations of beaver dams would change and therefore seem unlikely to provide a good criterion for crossing designs.

Beaver are known to block culverts at the upstream ends. Beaver-proof culverts are an option, but all the designs I am aware of would certainly hinder, if not block, movement of forage fish and benthic drift. Causeways or bridges are the best way to encourage beaver activity (i.e., functions) and all the benefits that accrue.

RESPONSE: The actual decision as to what type of structure (bridge versus culvert) would be constructed at each crossing would be made by industry engineers in consultation with state permitting staff.

Toxic plume. Spills of transported chemicals are not quantified in the culvert failure section of the assessment. I have participated in a mine risk assessment and a landfill risk assessment where spills of cyanide and landfill leachate have been modeled. While I did not conduct the plume movement analyses, stream hydrologists readily calculated how far spilled materials would move down stream until the concentrations of chemicals in streams reached acceptable benchmarks. The longevity of a spill of chemicals for copper processing should be calculated. It appears that the Water Treatment failure assessment on page 6-39 conducted some sort of plume analysis to determine the potential for an impact on Iliamna Lake. Perhaps it is possible to use this analysis, or at least the model, to address the consequence of a spill of transported chemicals.

RESPONSE: We have modeled the transport of spills from pipeline failures and emissions from the wastewater treatment plant and leakage of leachates. In Section 10.3.3.1 of the revised assessment we estimate the number of reagent spills that would occur over the roughly 25-year life of Pebble 2.0 scenario. We did not conduct a plume analysis for a spill of transported chemicals, but given the toxicity of sodium ethyl xanthate (Section 6.4.2.3) we expect that a spill of this compound into a stream along the transportation corridor would cause a fish kill. Given the uncertainty concerning the nature and magnitude of a truck accident and spill, we decided that a quantitative analysis of transport and fate would not materially contribute to the value of the assessment.

Question 8. ***Does the assessment appropriately characterize risks to salmonid fish due to pipeline failures? If not, what suggestions do you have for improving this part of the assessment? Are significant literature, reports, or data not referenced that would be useful to characterize these risks, and if so what are they?***

David A. Atkins, M.S.

The discussion of pipeline failures is based on published failure rates, principally for oil and gas pipelines. This analysis results in a pipeline failure rate of one per 1,000 km per annum. This is a pretty generic number that does not consider actual pipeline design. Rather it indicates that pipelines designed using standard practices do fail with a fairly high frequency. The Assessment does not apply this failure rate to the gas and diesel pipelines because "they are not particularly associated with mining." Without the mine, there would be no pipeline. So given that this rate of failure is quantifiable based on good data and that the pipeline would be built to serve the project, this risk should be considered.

RESPONSE: The assessment assumes that pipeline design follows standard ASME practices. A diesel pipeline failure and resultant spill into two creeks has been added in Chapter 11 in the revised assessment. A gas leak is considered but is not analyzed because of the lack of significant causal linkage to fish production.

A concentrate pipeline spill would have differing impacts depending on when and where the spill occurred, with deposition in Lake Iliamna likely being the worst outcome. As noted in the report, it is likely that a pipeline spill would be detected rapidly and that the volume of the spill would be limited and amenable to remediation. A better description of how concentrate pipeline failures have occurred would be helpful to better understand the risk for this project (e.g., the July 2012 Antamina concentrate pipeline failure, although this pipeline would operate under a much different pressure regime due to extreme altitude change).

Dr. Paul Whitney

RESPONSE: Consolidated, statistically representative data on concentrate pipeline failures are not readily available, although anecdotal evidence from some case studies can be found. The pipeline failure statistics reviewed for the assessment come primarily from oil and gas pipelines, but also include some water and hazardous liquid pipelines. The performance of mining concentrate pipelines is not expected to be better than the performance of oil pipelines, because concentrate pipelines would be expected to be more susceptible to internal corrosion and abrasion. The 2012 Antamina concentrate pipeline failure in Peru was reportedly caused by the rupture of a pipe elbow in a valve station. The regulatory, geographic, and operating conditions of the Antamina pipeline may differ greatly from those of the concentrate pipeline in the assessment scenarios. A discussion of causes and probabilities of pipeline failures is included in Section 11.1 of the revised assessment. The revised assessment also includes discussions of concentrate spills at the Bingham Canyon, Utah, and Alumbrera, Argentina, copper mines (Section 11.3.4.2).

Steve Buckley, M.S., CPG

The assessment does generally describe the potential risks to fish from hypothetical pipeline failures.

RESPONSE: No changes suggested or required.

Courtney Carothers, Ph.D.

A pipeline failure would be expected to release toxic leachate into stream systems in the transportation corridor, none of which would dilute the leachate enough to prevent severe toxic effects (both immediate and long-term). The report discusses three pipeline failures in the Bajo de la Alumbrera mine in Argentina. The largest pipeline failure lasted two hours (compared to only two minutes of exposure hypothesized in the current mine scenario). The report could more clearly describe this case and its likely effects. The report appears to appropriately characterize risks to salmonid fish due to pipeline failures, although I have no particular expertise with which to evaluate this assessment.

RESPONSE: The EPA agrees that it would be desirable to have more information on the effects of the largest Bajo de la Alumbrera spill, but we have included all information on that failure that is available.

Dennis D. Dauble, Ph.D.

The risks to salmonid fish due to release of pipeline concentrate/slurry and leachates (as return water) are well described. However, risks of a diesel fuel spill are not. More detail could be provided on reclaimed water. For example, what toxic constituents (and at what volumes) would be released to the environment if these pipelines failed?

Dr. Paul Whitney

RESPONSE: A diesel pipeline failure and resultant spill into two creeks has been added in Chapter 11 in the revised assessment. New data on concentrate leachate in the slurry have been added, and it is assumed to also describe the return water.

Gordon H. Reeves, Ph.D.

Assuming that characterizations of the pipeline failure are accurate, the potential impacts on fish and fish habitat are appropriate and reasonable. It was clear that the effects of a pipeline failure could be major, depending on the duration and timing of the spill, because of the concentration of metals in the slurry, the particular life-stage present, flow conditions, and the reduced potential to fully remove the material from a stream or wetland afterwards.

RESPONSE: No change suggested or required.

The one question that I had about this section was the potential impact on phytoplankton and zooplankton in Lake Iliamna, particularly at the local scale. I assume that any spill from pipeline failure would have potential impacts on the lake and on phytoplankton and zooplankton, the major food for juvenile sockeye salmon. The ecological consequences would depend on the extent and intensity of any spill and on how juvenile sockeye use areas near tributary streams. I would expect that a spill could be particularly detrimental if juvenile sockeye use the area near or adjacent to natal streams when they enter the lake. I think this should be considered in more detail in any additional analysis.

RESPONSE: The toxicity data for species sensitive to copper and most other potentially toxic metals are derived from planktonic crustaceans, so it is already addressing planktonic lake species more directly than stream benthic species. However, the more detailed analyses of aqueous releases in the revised assessment (Chapter 11) provide a better basis for addressing the risk of exposure in Iliamna Lake. Because the aqueous phase of the product concentrate slurry would enter the stream briefly and would be rapidly diluted in the lake, it is not judged to be a major risk to plankton relative to the potentially sustained direct effects on salmon eggs and larvae of the deposited solid phase or relative to stream invertebrates, which would have much less benefit of dilution.

Charles Wesley Slaughter, Ph.D.

No. Concerns with pipelines crossing streams, watercourses and wetlands are similar to those earlier expressed for the road corridor. On-site investigation may well reveal many more "watercourses," including intermittent and ephemeral streams, than the 70 crossings cited; possible pipeline failures thus may have much wider potential for impacting salmonids than is indicated in the Assessment.

RESPONSE: The document has been edited to indicate that 70 is a minimum value.

The "probability" argument on p. 6-32 is an understandable attempt at quantification, but is unpersuasive. Given the spill history of TAPS, pipelines in the Prudhoe Bay field, and recently in Montana (?), suggesting the probability (with what confidence limits?) that there would be

Dr. Paul Whitney

only 1.5 stream-contaminating spills or two wetland-contaminating spills over 78 years of operation seems wildly optimistic (and what is half a spill?).

RESPONSE: If you think of the mine as a repeated experiment (i.e., many mines with concentrate pipelines of that length and duration), we would expect a mean frequency of 1.5 spills. A more straightforward explanation is that we expect 1 or 2 spills, given the scenario. These frequencies are based on a large data set, not just the TAPS experience (which is an atypical pipeline design and much larger than the diesel line) or the spill in the Yellowstone River (which is a single event). An explanation of the frequency has been added in Section 11.1 of the revised assessment.

Assuming that any spill (over the 78-year project span) would last only two minutes (p. 6-32, p. 6-34), with a consequent minimal volume of spilled material, also seems highly optimistic. Even highly-automated systems, with redundant sensors and automatic responses, are susceptible to error or failure, and the Bristol Bay watershed environment is not benign with regard to mechanical apparatus. The authors appear to recognize this with their discussion of the Alumbrera incident.

RESPONSE: The scenario has been modified to a 5-minute response. Also, more information has been added about the possibility of system failure or human error in response to this and similar comments. The uncertainty discussion in Chapter 11 indicates that the exposure scenario is predicated on the successful operation of a remote shutoff. There may be extreme weather or geological events that render the remote shutoff system inoperable. We did not evaluate those events, so the assessment may underestimate these risks.

The specific **consequences** of a failure on salmonid habitat and biology are portrayed well.

RESPONSE: No changes suggested or required.

John D. Stednick, Ph.D.

The pipeline corridor consists of four pipelines over a distance of 86 miles. No information was provided on pipeline structure or placement, other than mentioning of stream crossings. The pipeline failure of concentrate slurry was modeled using chemistry from the Aitik (Sweden) mine. Is this best approximation? That mine is about 80 years old and is processing ore from the edge of the pit, with much lower sulfur content than Pebble.

RESPONSE: More information on the pipeline structure and placement was provided in Section 6.1.3.2 of the revised assessment. We have replaced the USGS leachate data from the Aitik product with analyses from actual concentrate slurry provided by Rio Tinto to describe the aqueous phase of the slurry and the return water, which would be alkaline (Section 11.3.2.1). However, the Aitik data are used to estimate the risks from deposition of the product in a stream or wetland. The environmental leaching of the concentrate would resemble the USGS's leaching test of the concentrate, not the alkaline solution in the pipeline slurry. To the best of our knowledge, no other aqueous leach test of a porphyry copper product concentrate is available.

Dr. Paul Whitney

Pipeline failures can be significant in any environment and spill or pipe break prevention requires significant monitoring. Will automatic shutoff controls be included? Are workers stationed 24 hours/day every day? Some of the past Alaska failures were in winter conditions, when things were not easily visible--under ice or snow cover. How will this be addressed?

RESPONSE: Our scenarios include remotely-operated valves tied to a supervisory control and data acquisition (SCADA) continuous monitoring system tied to a continuously staffed control room. The remotely-operated valves could be triggered either manually or through software, but we expect that except in the event of a clear rupture of the pipeline, the SCADA signals would trigger an alarm that would initiate manual intervention by the operator. Consistent with best management practices, we have assumed that the pipeline would be visually inspected along its full length at least daily, and that the inspection protocols would consider the difficulties of detecting a spill under snow or ice. Potential remedial actions for cleanup up of diesel, product concentrate and return water spills are discussed in Chapter 11.

The toxicity approach seems reasonable. What is the anticipated chemistry of the return waters? Diesel spill monitoring? The geometric mean of three values (which references) indicates that there is a 14% probability of failure in each pipeline in each year. This is not acceptable at any level.

RESPONSE: The return water is assumed to be the same as the aqueous phase of the slurry water. A diesel spill scenario has been added in Chapter 11. The pipeline failure rate reported in the assessment is similar to the rates calculated in studies by others and represents several large datasets. Some of the reported failures are due to corrosion, which tends to result in small releases; some of the failures are due to mechanical impacts, which tend to produce larger releases; some are due to other causes. The buried pipelines in our scenarios would be expected to have a lower incidence of rupture from third party activities, but may have a higher incidence of rupture due to landslides or earthquakes than the overall dataset. Corrosion or corrosion leaks could go undetected for longer periods of time compared to an aboveground pipeline.

<u>Roy A. Stein, Ph.D.</u>

Pipeline Failures I. What dictates 14 km between automatic shut-off valves; shouldn't this distance be shorter as the pipe becomes larger, i.e., related to the amount of liquid/slurry that would be spilled upon pipe failure? Shouldn't all of these pipelines be double-walled? What would Best Management Practices tell us in this context?

RESPONSE: The distance between valves appears to be consistent with current practices. The pipelines are described as double-walled in above-ground reaches. A double-walled pipeline along the entire length of a pipeline might be desired from a purely environmental protection standpoint; however, it may not be feasible or cost effective to do this. Therefore, we have proposed the most commonly used (and accepted method) of double-walled construction over any water bodies. There are a large number of factors that go into standard practices for design, construction, and testing of pipelines. In the draft assessment, we included a selected number of these factors as examples of our design mitigation measures. In the revised assessment (Section 6.1.3.2), we have included a statement that the design would follow the

Dr. Paul Whitney

standards of the American Society of Mechanical Engineers, to indicate that modern mitigation measures would be included.

Pipeline Failures II. Like all other failures, it seems to me that "Standard Operating Procedures (SOP)" for mitigation should be in place in anticipation of any future spill or contamination of the environment. I do not think that these procedures need to be in this report, but an acknowledgement of their presence and that mining companies will follow these SOPs in response to any spills that occur, be it pipeline, TSF, truck, leachate bed, etc.

RESPONSE: The EPA agrees that a mining company should have an SOP for remediating spills, but we have not been able to find such an SOP for remediating a product concentrate pipeline spill.

William A. Stubblefield, Ph.D.

Potential effects on salmonid populations were evaluated due to potential pipeline failures as part of the risk assessment. This evaluation focused on potential failures associated with the pipelines for the product concentrate slurry and return water. No consideration of the natural gas or diesel pipelines was presented, stating that such pipelines "are common and the risks are well-known." Although I would acknowledge the failures in natural gas and petroleum pipelines are common, I would not discount the potential effects to salmon populations associated with such spills.

RESPONSE: A diesel pipeline failure and resultant spill into two creeks has been added in Chapter 11. Natural gas is not a contaminant of concern because it would vaporize and, at worst, burn, which would not pose a significant risk to salmonid fish.

Evaluation of potential impacts due to a spill of product concentrate slurry or return water was based on extant data from an existing copper mine in Sweden; to the extent that this slurry and return water is representative of similar materials coming from the Pebble mine, this approach is appropriate. The assumptions used in the amount of material that might possibly be spilled seems appropriate and based on past experience and realistic assumptions; however, these assumptions need to be reconsidered if and when a real mine plan is prepared.

RESPONSE: The Aitik leachate is no longer used to estimate the aqueous phase of the slurry, in response to other comments. Because the slurry would be alkaline, appropriate analytical data were obtained from Rio Tinto (Section 11.3.2.1). However, the Aitik data are still used for the leaching of the concentrate in a stream or wetland where neutral water would be the leaching agent. No other relevant data are available.

Dirk van Zyl, Ph.D., P.E.

The EPA Assessment does not identify or appropriately characterize the risks to salmonid fish due to pipeline failures. It only estimates the likelihoods of occurrence and the consequences. See discussion under Question 4 above regarding suggestions for improving estimation and expression of the magnitude of risks to salmonid fish due to pipeline failures.

Dr. Paul Whitney

RESPONSE: The EPA believes that the likelihood of an occurrence and its consequences constitute an appropriate and generally accepted definition of risk. We have estimated those to the extent that existing information allows.

Pipelines failure likelihood. The EPA Assessment focuses on the failure of the concentrate pipeline because "We do not assess failures of the natural gas or diesel pipelines here because such pipelines are common, their risks are well known and they are not particularly associated with mining". I find this statement puzzling because all pipeline failures should be of concern. It is further puzzling because the likelihood of pipeline failures for the concentrate pipeline is derived from the failure statistics for pipelines in the oil and gas industry (p. 4-60). Failure of the Baja de la Alumbrera concentrate pipeline in Argentina is suggested as an analog, indicating that such failures can occur; however, I disagree that "it suggests that concentrate pipeline failures are common at a modern copper mine." This last statement is not supported by any further analysis of concentrate pipeline failures at other modern copper mines. It is recommended that such analyses be performed or that the text be edited to indicate this shortcoming.

RESPONSE: The revised assessment contains an analysis of the risks of a diesel pipeline spill in Section 11.5. Natural gas is not a contaminant of concern because it would vaporize and, at worst, burn off, which would not pose a significant risk to salmonid fish (Chapter 11). The quoted statement is literally correct. Baja de la Alumbrera is a modern copper mine and pipeline failures are common there. This suggests that failures are common. Further, concentrate pipeline failures at the Antamina and Bingham Canyon mines are now discussed. However, the statement in the revised assessment has been weakened by changing "common" to "not uncommon." To support that statement, a review of pipeline failures at U.S. porphyry copper mines has been added (Section 11.1). However, the EPA has not found a sufficient record of product concentrate pipeline operations to develop a probability of failure that is specific to that pipeline type.

Pipelines failure consequences. Failure consequences are focused on the release of concentrate into water. As indicated in Appendix H of the report, the analog concentrate from the Aitik mine is dominated by chalcopyrite, a sulfide mineral which contains the copper. If the concentrate is submerged under water in relatively slow flowing streams then very little long-term release of the copper will occur, as the water does not contain sufficient oxygen to allow for sulfide oxidation. It is only when the concentrate is transported to locations above the water level that oxidation and release of metals will occur.

RESPONSE: Subaqueous oxidation of sulfides does occur in well oxygenated waters as this comment recognizes by stipulating "relatively slow moving streams". However, as the flow data in the spill scenario indicate, these are not slow moving streams. Subaqueous leachate column tests are conducted to assess the potential for subaqueous oxidation. Tests conducted by the Pebble partnership indicate the potential for subaqueous oxidation. Salmonids require high dissolved oxygen levels, so salmonid streams are necessarily well oxygenated. For example, the EBD states that mean dissolved oxygen levels for the North Fork Koktuli River was 10.2 ppm. This oxygen would oxidize the sulfides.

Phyllis K. Weber Scannell, Ph.D.

Dr. Paul Whitney

This section of the document focuses on effects of pipeline failures; however, without a viable mine plan, descriptions of pipelines and estimates of possible effects are speculative. The resource developer may opt to build a pipeline to transport fuel from the coast to the mine site or slurry concentrate to the port. Construction of any pipelines would require review and approval by state and federal agencies, such approvals would likely contain monitoring plans to ensure pipeline integrity. However, the risks of pipeline failures should not be minimized; the Fort Knox Mine near Fairbanks recently experienced a 45,000 gallon spill of cyanide solution after a bulldozer struck a supply line (Fairbanks Daily News Miner, August 24, 2012).

RESPONSE: The EPA agrees that the specific locations of pipelines and requirements for monitoring may differ from our scenario, which is based on preliminary mine plans (Ghaffari et al. 2011). However, we believe our scenario is plausible and allows an evaluation of potential impacts from pipeline failures. The Fort Knox spill has been added to the assessment as an example of spills due to human error in Section 11.1.

The risks of a pipeline failure to salmonid fish depend on the duration of the spill, the type of material spilled (return water or concentrate), the location of the spill (in the uplands or in a waterway), and the timing. The effects of a pipeline failure in a waterway when juvenile salmon are present would be far more severe than a pipeline failure in an upland area.

RESPONSE: EPA agrees with this comment. Discussion of spill location and life stage exposed has been expanded in Section 11.3, and the other issues have been carried over from the May 2012 draft.

Given that there currently is no information on road alignments or locations of future pipelines, it is not possible to estimate the number of stream crossings (70, page 6-30) or an exact length (269 km, page 6-30) of potentially affected waterways. The risks from pipeline failures outlined in the draft document should be revised when more specific information on the mine plan of operations becomes available.

RESPONSE: The road alignment and length in Northern Dynasty Mineral's preliminary mine plan (Ghaffari et al. 2011) were used in this assessment. The number of stream crossings was also detailed in that plan, and was checked by the EPA using USGS data. We would expect that risks would be re-evaluated as part of a future specific transportation corridor plan. No change required.

Paul Whitney, Ph.D.

Refer to comments/responses to Questions 2 and 7.

RESPONSE: See responses to those questions.

Question 9. ***Does the assessment appropriately characterize risks to salmonid fish due to a potential tailings dam failure? If not, what suggestions do you have for improving***

this part of the assessment? Are significant literature, reports, or data not referenced that would be useful to characterize these risks, and if so what are they?

David A. Atkins, M.S.

The Assessment generically describes tailings dam failures and the potential impact in detail. It also uses some site-specific information on tailings supernatant and humidity cell leachate. There is no question that a tailings dam failure would be catastrophic for the fishery and the project, and although low probability, is the single largest risk to the fishery. A tailings dam failure could harm a very large area of the watershed for a very long period of time and could require a massive and expensive remediation effort.

RESPONSE: Agreed. No change suggested or required.

The tailings deposition and storage methods outlined in the Wardrop NI 43-101 report and presented in the Assessment are conventional for the industry and comply with Alaska State regulations. Because of the dire consequences of a failure in this highly sensitive and unique environment, it would be necessary to employ state of the art methods for tailings management and go 'beyond compliance' when designing and constructing this facility. This may include employing methods that are novel, incur significant additional cost for construction, and lead to a more stable and lower maintenance facility in the long term, such as dry stack or paste rock tailings (blending waste rock in with tailings in the impoundment to provide extra geotechnical stability). These methods, however, are not common practice and in some instances are still under development.

RESPONSE: The assessment addresses state of practice methods to identify potential risks that could result from such practices. The EPA agrees that there is a possibility that a mining proponent could design and propose practices that go beyond the state of practice in order to reduce potential risks.

Steve Buckley, M.S., CPG

The assessment does generally describe the potential risks to fish from tailings dam failures.

RESPONSE: No change suggested or required.

Courtney Carothers, Ph.D.

In the event of a tailings spill, invertebrates and fish would be exposed to toxic tailings and leachate. Actual tailings failure examples suggest the range of exposure would spread to an area more than 100 km. Copper would be especially toxic to invertebrates, fish eggs and larvae. Toxicity would last for decades. The report appears to appropriately characterize risks to salmonid fish due to a potential tailings dam failure, although I have no particular expertise with which to evaluate this assessment.

RESPONSE: No change suggested or required.

Dr. Paul Whitney

Dennis D. Dauble, Ph.D.

Tailings deposition is described in Chapter 4 of the main report, but I could not find anything that described potential risks to fishes, including effects to aquatic food webs and loss of fish spawning and rearing habitat.

RESPONSE: The TSF failure description and the assessment of risks were presented in separate chapters in the original draft assessment, but have now been moved into one location (Chapter 9) for clarity.

As noted in the text, the sediment transport model used could only simulate sediment transport and deposition ~30 km downstream of the mine site. Thus, potential effects to fish habitats were not well quantified for the mainstem Koktuli River (and beyond), in addition to the Mulchatna and Nushagak rivers. Is there a likelihood that any tailings material might reach Lake Illiamna? If not, say so in the document. It is equally useful to say where impacts will not occur (as it relates to sensitive habitat) as it is to describe where impacts are likely and reasonable.

RESPONSE: None of the 3 TSFs are in the watershed of Iliamna Lake. The hydrology of the site has been clarified and better maps added to clarify this issue. Risks to Iliamna Lake from water treatment failures, even if they occur in the Nushagak drainage, are now noted (e.g., transport of toxic leachate from the South Fork Koktuli to Upper Talarik Creek via groundwater exchange between theses basins; Chapter 8). However, sediment (i.e., tailings) would not follow that route.

The assessment deemed that it was "not possible" to determine how far the initial slurry deposition would extend, how far re-suspended sediments would travel, and how long erosion processes would continue. It seems that information from other mine closure sites could be used by assessment authors to infer effect by analogy. The statement alluding to potential sediment run out distance at the bottom of page 4-56 of the main report should be included in the summary of effects. This is an important point.

RESPONSE: The revised assessment now includes a clearer description of the magnitude and duration of effects. We apply the runout distance equations of Rico et al. (2008) to conclude that under Pebble 2.0 scenario dam failure conditions, runout distance exceeds 307 km (190 miles), reaching the marine waters of Bristol Bay (Section 9.3.2).

Gordon H. Reeves, Ph.D.

Assuming that characterizations of the dam failure are accurate, the potential impacts on fish and fish habitat are appropriate and reasonable. Impacts, like those of a pipeline failure, are likely to be widespread in the watershed and to be long lasting, resulting from inundation of areas by sediments and contaminants in the water. I think that potential impacts across the broader scale could be developed and highlighted more fully. Also, consideration of Intrinsic Potential (see response to Question 4) could provide additional insights into potential impacts of a tailings dam failure.

Dr. Paul Whitney

RESPONSE: While we were unable to conduct a full Intrinsic Potential modeling exercise, we have quantified the distribution of classes of gradient, mean annual flow, and % flatland for reaches of the site watersheds where TSFs would be placed. As highlighted in the report, streams – especially those downstream of the TSFs in the mainstem North Fork Koktuli and South Fork Koktuli – are low-gradient, floodplain prone channels that currently support spawning populations of several salmon species, rainbow trout, and Dolly Varden.

I think that potential consequences of climate change on hydrographs should have been considered in this section. More precipitation is projected to occur as rain in the winter rather than snow for many parts of AK. How would this potentially impact the tailings dam facilities? This seems to be a key piece of information that is needed to better understand the risk of dam failure and the potential for impacts on aquatic resources.

RESPONSE: Climate change projections and potential impacts are described in Chapter 3, and referenced here as a key uncertainty for in perpetuity management of the TSFs and other mine infrastructure. The probabilities for dam failure discussed in this assessment involve dams constructed in a variety of climates. Any potential increase in precipitation due to climate change is but one of the conditions for which the dams would need to be designed. A design developed to handle a higher level of precipitation would be expected to have a similar failure probability to one designed for an area of lower precipitation as long as the same design standards, e.g. the safety factor against overtopping, were used in both designs. Of course, if the design did not consider the possibility of increased precipitation as a design factor, and climate change did cause such an increase, then the probability of failure would be higher.

I thought that results to date of the impacts of the volcanic eruption at Mt. St. Helens, while not exactly the same as a mine operation, were not useful in considering long-term impacts and the response of aquatic ecosystems to such major disturbances. The impacts on streams are still more prevalent and extensive than what is described in the report. Most stream systems are transporting large amounts of fine sediment and areas of exposed gravels are rare.

RESPONSE: Extensive discussion of the Mount St. Helens analogy has been removed at the prompting of several reviewer comments including this one. We have retained key references from the region that are illustrative for considerations of likelihood of fine sediment transport and recovery (or lack thereof).

Charles Wesley Slaughter, Ph.D.

Yes. Physical consequences of TSF dam failure are fairly portrayed. I would only suggest that effects of initial sediment deposition and long-term remobilization and redeposition would extend beyond the spatial and temporal limits of the modeling used in the Assessment.

RESPONSE: Agreed. We now more clearly state that remobilization and deposition could be extensive; potentially reaching Bristol Bay.

Employing advanced eco-hydraulic modeling tools such as MIKE-11, MIKE-SHE (DHI, Copenhagen), and consultation with state-of-art practitioners (IAHR-International Association for Hydraulics Research, UI Center for Ecohydraulics Research, and others), along with improved high-resolution input data such as LIDAR survey of the complete Kvichak and Koktuli/Nushagak systems, would allow a more complete estimate of potential hydrologic and sedimentation (and consequently biotic) consequences of TSF dam failure for the entire river system, headwaters to Bristol Bay.

RESPONSE: We agree that LIDAR survey data would greatly improve the understanding of the project area topography. Alternative modeling platforms coupled with LIDAR have the potential to improve the estimates provided in this assessment, but these data collection and modeling efforts were not within the scope of this project.

John D. Stednick, Ph.D.

The tailings dam failure was modeled and the distance of sediment transport was estimated. The modeled tailings dam failure used an estimate of 20% mobilization from the tailings ponds. How was this value determined? The model was run to a stream length of 30 km (the rivers confluence), yet the report acknowledges that a sediment pulse could run for hundreds of kilometers. The moisture content of the tailings is estimated to be 45% by volume (page 4-50); the 20% volume of sediment may be underestimated. This initial risk to salmonid fish is clear, but the persistence of the sediment affect could be discussed.

RESPONSE: 20% was selected as a reasonable estimate, falling within the range of historic failure release volumes (e.g., Azam and Li 2010 state 1/5 (i.e., 20%) and Dalpatram 2011 states 20-40%). We agree that the total volume released during a failure would vary depending on water content, consolidation of tailings, and meteorological conditions in the valley during the time of the failure. We also agree that the sediment initially deposited on the valley floodplains and the sediment that remains downstream of the failed dam would become a continuous source of tailings, with the potential to re-suspend during each subsequent rainfall-runoff event that occurs before any sort of mitigation/clean-up efforts could be implemented to control this process. The 20% used was based on recent literature for the amount that is generally released from these types of dam failures. The tailings dam failure was intended to be a conservative analysis to shed light on whether a failure is a significant concern in the Nushagak River watershed.

The Mount St. Helens analogy is inappropriate for a variety of reasons and such comparisons should be removed from the assessment.

RESPONSE: Use of the Mount St. Helens analogy has been removed.

The probable maximum precipitation (PMP) value was extrapolated from Miller (1963) and the assessment commented how this value might be reduced upon further analysis. Conversely, additional data could increase this value. There was no discussion of the recurrence interval of this 24-hour storm.

RESPONSE: The assessment used the published PMP from Technical Paper No. 47 (the current guidance available from NOAA, at www.nws.noaa.gov/oh/hdsc/studies/pmp.html). Within TP 47 the 24- hour PMP values presented exceed those provided for the 100-year 24-hour event. While actual planning, design, and construction of a TSF dam will require

additional study, for the purposes of this assessment we relied on readily available information and current published guidance for the determination of a design storm event with the magnitude that would likely be considered during design of the dam. The published PMP was applied to a Type-1 storm within HEC-HMS to determine a flood hydrograph that would result in the watershed located above the TSF as described for the purposes of this assessment. This hydrograph is expected to peak at 291 cms and was applied to the hydraulic model to cause an overtopping and subsequent failure of the TSF dam. The flood wave generated by the dam failure had a peak flow of 149,263 cms and 11,637 cms (large and small dam failures respectively). The hydrology discussed and applied related to the dam failure represents a precipitation and runoff event of the magnitude that the dam would be expected to accommodate, but in this assessment was used as a mode of failure.

No hydrologic data were provided. The streamflow gauging stations operated by the US Geological Survey near the study area suggest peak streamflow rates from snow melt and from rain events. The hydrograph shape and magnitude help determine if rain or snowmelt dominated. In the assessment, the peak flow estimate from the Natural Resources Conservation Service runoff method used a Type 1a storm distribution, the least intense precipitation distribution, but the literature would suggest that a Type 1 distribution would be more appropriate for Alaska. How does this storm event compare to the measured flood at Ekwok (page 4-50)? The curve number (CN) was not identified, nor the methods used to calculate that value. Similarly, the watershed slope, time to peak, hydraulic length, channel routing functions, and channel resistance methods or results were not presented. What precipitation data are available? The design of culverts, bridges, and storm water ponds all require good precipitation records and the confidence in that estimate is based on record length.

RESPONSE: We agree that the Type-1 storm is appropriate for Alaska. This has been corrected and updated. Additional hydrologic parameters were also included in the update to better describe the development of the HEC-HMS model. It is important to note that this hydrologic event was used to provide a mode of failure for the dam. The flood wave generated by the dam dwarfs the PMP hydrograph and the runoff from the storm event is not relevant.

The comparison is unclear for a 3,313 m^3/s flow in a 2,551 km^2 watershed area to the TSF flow of 1,862 m^3/s and an area of 1.4 km^2. What was the precipitation and recurrence interval for the Ekwok storm? The relation of groundwater flows to streamflow during storm events needs to be evaluated. The flood producing precipitation events in this area no doubt add to groundwater flows.

RESPONSE: This discussion was provided to help the reader understand the magnitude of the dam failure flood wave relative to an event that was experienced by a local community. We also wanted to draw attention to the fact that such a failure would occur in the upper end of the watershed where typical storm events do not generate floods of such magnitude. We acknowledge that the two watersheds are not similar and the intent was not to draw comparisons of runoff potential from one watershed to another, just to help the reader gain context.

With a new estimate of precipitation depth of known recurrence interval, the design storm could result in a higher flood event with greater velocities and greater sediment transport ability, along with a greater sediment volume released from the TSF, resulting in a greater risk to salmonid fish and habitats.

RESPONSE: We agree. The tailings dam failure was intended to be a conservative analysis to shed light on whether a failure is a significant concern in the Nushagak River watershed. No change suggested or required.

Roy A. Stein, Ph.D.

TSF Failure and Remediation. The text on pages 6-1 to 6-2 states:

> "Remediation may occur following a tailings spill, but it is uncertain. A spill would flow into a roadless area and into streams and rivers that are too small to float a dredge, so the proper course of remediation is not obvious."

At this juncture in time, this statement points to the fact that we do not have the technology, or the appropriate operating procedures, in place to remediate a TSF spill. Does this essentially let the mine operator "off the hook"? Should we be promulgating mining activities in locations where we cannot remediate spills, given our current state of knowledge or ability to apply current techniques? What guidance would "Best Management Practices" provide for this situation?

RESPONSE: The intent of the statement is to point out the challenges of remediation of a large-scale tailings spill in a remote area. Large-scale tailings cleanup is challenging even in urban and more developed rural areas where there is road/rail access for equipment and transport of contaminated sediment. In the assessment watersheds, the only current access to downstream areas is provided by the rivers themselves, which are generally too small for large-scale dredging equipment.

William A. Stubblefield, Ph.D.

Potential effects on salmonid populations were evaluated due to tailings dam failures. Tailings dam failure would potentially result in the release of large volumes of mine tailings and associated contaminated waters, leading to possible acute and long-term effects on salmon populations. It is also important to note that direct effects on salmon may be very species dependent, due to life-cycle differences, and the time at which the dam failure occurs. Potential effects due to sediment inundation/impaction can adversely affect habitat, leading to decreased spawning. Evaluation of the potential for tailings dam failure effects considered acute and chronic risks due to aqueous exposures, chronic risks due to sediment exposures, and risks due to dietary exposures. All of these seem to be appropriate exposure pathways and all were adequately considered, although site-specific information will improve risk predictions.

RESPONSE: Agreed. No change suggested or required.

Dirk van Zyl, Ph.D., P.E.

Dr. Paul Whitney

The EPA Assessment does not identify or appropriately characterize the risks to salmonid fish due to a potential tailings dam failure. It only estimates the likelihoods of occurrence and the consequences. See discussion under Question 4 above regarding suggestions for improving estimation and expression of the magnitude of risks to salmonid fish due to potential tailings dam failure.

RESPONSE: The EPA believes that the likelihood of an occurrence and its consequences constitute an appropriate and generally accepted definition of risk. In this case we have estimated those for a tailings dam failure to the extent that existing information allows. Although fish abundance data are limited for this region, we did identify the potential magnitude of a tailings dam failure to the Chinook run of the Nushagak River.

TSF failure likelihood. The failure statistics given on p. 4-45 are based on tailings failure statistics over the last 50 years or so. Was there also a review of the operational histories, and therefore failures, of tailings impoundments designed and constructed in the last 10 to 15 years? It is recognized that one of the failures identified in Box 4-4 (Aurul S.A. Mine, Baie Mare, Romania) falls in this category. However, many of the failures included in the analyses are associated with older tailings facilities, especially those associated with large releases of tailings solids. A significant improvement in tailings management is the implementation of an Independent Tailings Dam Review Board (ITRB) for large mining projects (Morgenstern, 2010). An example of the activities of an ITRB is given in Minera Panamá (2012). Morgenstern (2010) provides a listing of tailings failures from 2001 and 2010 and comments that "in no case, to the knowledge of the Writer, was there systematic third party review" of the failed facilities as would be the case when an ITRB is active. I expect that a tailings review board will also be used for the Pebble Mine and the behavior of a tailings management facility designed and operated under these conditions will be more representative of the potential failure likelihoods expected for such a facility. It is expected that this likelihood will be much lower than those used in the evaluations of the scenario in the EPA Assessment.

RESPONSE: The probabilities for dam failure used in the assessment were not derived solely from the historical record. Historical failures were discussed as supporting background information and present a defensible upper bound on the failure probabilities. The failure probabilities used in the assessment are based on Alaska's dam classification and required safety factors applied to the method of Silva et al. (2008) which compares dams designed, constructed, and/or operated under different standards. The discussion of failure probabilities in the revision (Chapter 9) is expanded to try to clarify this issue.

TSF failure consequences. It is difficult to estimate the volume of tailings that will be released when a tailings impoundment fails. The release of 20 percent of tailings from a slurry deposited TSF may be realistic when it contains a large pool and is subjected to a large flood, but it is unrealistically high for a TSF containing a small or no pool (such as in the case of a filtered dry stack). I would consider the assumption that a release of 20% of the tailings material for the Pebble mine scenario is on the high side, even during operations. When the mine is closed and the tailings reclaimed I would consider the 20% release assumption as unrealistic, especially if the closure implementation included a diversion system designed for the PMF. It is further unrealistic to assume that the released tailings will remain in the downstream channels and flood plains following the failure. In the case of the Aznalcóllar Tailings Dam failure in Spain, all the released tailings downstream of the mine were removed. While such a removal action will impact parts of the watershed, it will help to recover the area faster than leaving all the tailings in place and will also reduce the longer-term impacts on downstream water quality. I therefore disagree with the assumption on p. 6-2 that "the assessment assumes that significant amounts of tailings would remain in the receiving watershed for some time and remediation may not occur at all." Box 6-1 provides "background on relevant analogous tailings spill sites" and three historic sites are used as analogs. These are not realistic analogs, as they all relate to historic mining under completely different scenarios. While the material historically released in these streams were from base metal mines, the circumstances of their release, especially in the case of the Clark Fork and the Coeur D'Alene Rivers, were very different. Long-term uncontrolled releases occurred in these river systems due to regulatory circumstances or historically acceptable practices that differ significantly from those in the 21st Century.

RESPONSE: We concur with the commenter that the estimation of the potential release volume is difficult and inexact. The release of 20% of impounded tailings used in our analysis is well below the reports of 30% to 66% in the historic record. Dry stacking was not proposed in the Ghaffari et al. (2011) report and has not been proposed in our scenarios. Ghaffari et al. (2011) proposed maintaining a pond on the top of the TSF to keep the pyritic tailings submerged, implying that the bulk of the tailings would remain saturated. We acknowledge that there are other tailing management strategies that could reduce the potential risk of failure.

The remediation of the 1998 Aznalcóllar Tailings Dam failure in Spain was completed within the 6 months between the April failure and the onset of heavy rains in October. The Aznalcóllar area, near Seville, has a much drier and warmer climate than the Bristol Bay area. It is also a heavily farmed area with flatter topography and far better access. The success at removing the tailings from the Aznalcóllar failure would be difficult to replicate in the Bristol Bay area, and significant amounts of tailings would remain in the receiving watershed for some time.

Box 6-1 in the original draft assessment (now Box 9-1) clearly states that the analogs presented "provide evidence concerning the nature of exposures to aquatic biota". They are not used to address the probability of a tailings dam failure or other aspects of the release of tailings.

Phyllis K. Weber Scannell, Ph.D.

The assessment considers two possible failures of the tailings dam: a partial-volume failure occurring during mine operations and a catastrophic failure occurring during or after mine operations. The partial-volume failure (as modeled in the assessment) would result in a greater than 1,000-fold increase in discharge and the catastrophic failure in a greater than 6,500-fold discharge.

RESPONSE: No change suggested or required.

The discussion of tailings dam failures describes possible changes in channel and floodplain morphology and briefly mentions that the tailings deposition would be a source of easily transportable, potentially toxic material.

Dr. Paul Whitney

RESPONSE: No change suggested or required.

The potential for increased metals loadings to river and lake systems is understated. Although there are no current predictions of tailings water quality, the water quality of tailings water from similar mines could be used to model increases in metals loading from dam failures.

RESPONSE: The original draft and the revised assessment use tailings leachate data from the PLP EBD (see Chapter 8). We believe that is more defensible than use of tailings leachates from other mines.

In addition to the partial-volume failure and the catastrophic failure, there are other possible sources of metals loadings from the tailings pond. Examples are emergency releases of untreated tailings water, seepage of tailings water into the groundwater, and flow from the tailings pond to groundwater in an adjacent drainage as the head (i.e. hydrostatic pressure) is increased as the tailings pond is filled. The last example was experienced at the Red Dog Mine when the increased elevation of the tailings pond caused water to flow underground into the Bonns Creek drainage instead of the Red Dog Creek drainage. Interception ditches were installed after the increases in metals loading to Bonns Creek were detected.

RESPONSE: Because the number of potential failures is extremely large, it is necessary to choose a representative set of failure scenarios. The original and revised drafts of the assessment include "seepage of tailings water into the groundwater, and flow from the tailings pond to groundwater in an adjacent drainage" but not emergency releases of tailings water.

Paul Whitney, Ph.D.

Duration. I agree with the assessment that it would take a "very long time" (page 6-25, first full para, last line) to reach concentrations that would not exceed threshold exposure levels. A "very long time" could mean hundreds of years to one person or geological time (i.e., millions of years) to another person. The assessment could be improved if some sidebars are put on the time likely required for no risk dilution or "more normal channel and floodplain." One suggestion would be to estimate the amount of time it would take the river/stream to move across the floodplain in the "relatively undisturbed" Bristol Bay watershed. I would also like to know whether reclamation or rip rap or rock weirs in areas with spilled tailings would reduce or extend the time to reach "more normal" conditions.

RESPONSE: We agree that geomorphic analyses of channel/floodplain recovery following a TSF failure would help improve the estimation of recovery time, but such an analysis would be a research and development effort beyond the scope of this assessment. Analogous examples of recovery following massive contributions of sediment to stream systems were explored (e.g., Mount St. Helens) but were not uniformly valued by reviewers, and were dropped from the assessment.

Question 10. ***Does the assessment appropriately characterize risks to wildlife and human cultures due to risks to fish? If not, what suggestions do you have for***

improving this part of the assessment? Are significant literature, reports, or data not referenced that would be useful to characterize these risks, and if so what are they?

David A. Atkins, M.S

The assessment does a good job analyzing the importance of fish resources to other wildlife and to Alaska Native communities. The lack of site-specific information in the report results in only very general conclusions that there 'would be some effect.' Of course, wildlife in the project area and any traditional use of these lands would be affected by project construction under the no-failure scenario. However, due to the lack of information, it is unclear if this is an area rich in other wildlife or if there are traditional native land users that rely on the area. Although the conclusion of this section is necessarily general, it would be helpful to have more detailed characterization of wildlife and native use in the project area.

RESPONSE: More information about subsistence harvest use in the area of the mine scenarios and other areas of the watershed that may be affected by mining activities has been added to the report. Because the scope of the assessment includes potential effects to Alaska Native communities related to salmonids, this has been the focus of the evaluation of potential effects on indigenous cultures. However, EPA recognizes that there are potential effects due to loss of subsistence harvest areas for other species, as well as potential effects on non-Alaska Natives who practice a subsistence way of life. This is clarified in the revised assessment (particularly in Chapters 12 and 13).

As the commenter notes, there is limited information about the use of specific mining claim areas by wildlife. The Pebble Limited Partnership Environmental Baseline Data Report includes data on the presence/absence of wildlife species around the Pebble claim, but we are not aware of any data on abundance of wildlife, so a more detailed characterization of a specific mine claim area may not be possible. There is some information about subsistence use of the mining claim areas which has been published by Alaska Department of Fish and Game. General areas of wildlife harvests have been added as a figure to the revised assessment.

Under the failure scenario, a tailings dam failure, in particular, would be catastrophic for wildlife and Alaska Native communities that use the area.

RESPONSE: A new Figure 5-2 illustrates that subsistence use of fish is extensive in areas downstream of the TSF in the Mulchatna and Nushagak Rivers, and this fact is now referenced. Effects of a TSF failure on wildlife are now discussed in Section 12.1.

Steve Buckley, M.S., CPG

No comments on this section.

Courtney Carothers, Ph.D.

Dr. Paul Whitney

Wildlife: The sections discussing risk to wildlife resulting from effects on salmonids are fairly short. Those animals that directly feed on these fish are likely to be impacted, as well as those that depend on other resources enhanced by the marine-derived nutrients supplied by salmon carcasses. The report concludes that the primary aquatic contaminant is copper (5-75), but notes that the ore processing chemicals are unknown, as are their toxicities (5-59). These unknowns could be noted as potential contaminants.

RESPONSE: Section 8.2.2.5 now includes a discussion of ore processing chemicals and their toxicity.

Human cultures: Overall, the main report (and Appendix D) describes the central role that salmon play in both Yup'ik and Dena'ina culture, both traditionally and in contemporary communities. As noted above, the scope of the assessment focusing on these two cultural groups should be made more clearly. Appendix E, for example, focuses on other human groups local to this region, and those who migrate to the region for commercial fishing and recreation, who may also be affected by risk to fish in this region. The vulnerabilities listed in Appendix D (p. 4-5) could be listed in the main report more clearly as risks.

RESPONSE: The assessment text has been expanded to identify these vulnerabilities.

Literature on the effects of contaminated or declining resources on subsistence communities could be utilized to describe likely impacts in more detail. For example, the report notes: "the actual responses of Alaska Native cultures to any impacts of the mine scenario is uncertain" (ES-26). While the specific responses are uncertain, likely responses can be predicted (and many are articulated in Appendix D). There are data on the psychological, social, cultural, and economic disruptions caused by the Exxon Valdez oil spill (e.g., Braund and Kruse 2009; Palinkas et al. 1993), the cumulative effects of oil and gas development in the North Slope region (e.g., Braund and Associates 2009; NRC 2003), and social impacts related to mining development in Alaska (e.g., TetraTech 2009; Storey and Hamilton 2004). Drawing on some of this literature could help provide likely scenarios for impacts to Alaska Native subsistence-based communities from decreased quality, quantity, or diversity of salmonids. Current and recent responses to salmon shortages in the Yukon-Kuskowkim region may also be helpful to include.

RESPONSE: The references provided have been reviewed and information from case studies used where appropriate to provide data on responses of Alaska Native communities to disruptions in subsistence resources (see Chapter 12).

Clearly the impacts to subsistence are not just lost food sources, but loss of healthy subsistence lifeways, loss of practices, loss of cultural connections to the past, loss of connection to specific places, loss of teaching and learning, loss of sharing networks, loss of individual, community, and cultural identity, among others as detailed in Appendix D. This point could be made more forcefully. As noted above and detailed in the specific comments below, subsistence is framed at times in the report as primarily important for physical health and economic necessity. The cultural, social, psychological, and spiritual aspects of subsistence livelihoods should also be consistently highlighted.

RESPONSE: The assessment has been expanded to bring forward more information on the psychological, cultural, social, and spiritual connections between Alaska Native cultures and fish.

Dr. Paul Whitney

As discussed Appendix D, Alaska Native cultures in this region and other regions in the state are also dependent upon the cash economy, both for subsistence production and for other needs. The role of commercial salmon fishing or other wage engagements related to salmon in the study communities, while discussed in Appendix E, is not given much discussion in the main report. How dependent is the subsistence economy upon commercial and recreational fisheries and in this region?

RESPONSE: Additional information about the connections between the subsistence way of life and the commercial and recreational fisheries has been added to the text of the revised assessment.

There is a brief mention of non-fish related impacts to Alaska Native communities in the main report (5-77). Unless a full treatment of these impacts (positive and negative) is included, these paragraphs should be removed. While in general, I am supportive of an increased scope (i.e., it is incredibly difficult to isolate only salmon-mediated impacts to Alaska Native communities), these other economic, social, and cultural impacts are not presented fully in the analysis, nor was the ethnographic research designed to investigate these impacts, so passing mention of them here does not seem appropriate.

RESPONSE: The text of the assessment has been clarified to indicate the scope of the assessment does not include an evaluation of direct effects on indigenous culture or human welfare, because it is limited to aquatic pathways and impacts. However, the fact that there would be direct effects is acknowledged in Chapter 12, consistent with comments from peer reviewers and the public.

Dennis D. Dauble, Ph.D.

There is considerable detailed information in Appendices D and E relating to impacts of the project to the economy. This information includes how salmon affect all segments of the population, such as cultural resources of Native Peoples. However, not addressed in detail were long-term impacts to Native Peoples that might occur after losing a way of life that includes salmon. The description of potential impacts to their health and welfare should be expanded. There are numerous examples of how Columbia River tribes have been negatively impacted due to loss of fish resources (and fishing as a lifestyle) as a result of dam construction. These impacts go beyond simple economics.

RESPONSE: EPA recognizes that there is a great deal of information about cultural and health effects on indigenous populations from loss of fish resources. We have referenced some case studies in the assessment (with a primary focus on Alaska), and have expanded the discussion of potential effects from a loss of salmon resources in Chapter 12.

The report should include a discussion of effects specific to unique user groups. That is, some communities rely almost solely on sockeye; kings are more important to others. These impacts could be segregated by watershed, for example. Also, some groups have more option for subsistence gathering if sockeye and Chinook salmon resources are impacted. Potential impacts of a declining salmon population due to mining operations would be less for them than groups "on the edge" who currently rely mainly on salmon.

RESPONSE: The text of the revised assessment (Section 5.4.2.2) has been expanded to acknowledge the differences between communities with regard to use and reliance on salmon and other fish resources.

Disturbance of wildlife from noise and roadways should be included with respect to migration corridors and critical habitat. Highlight species most likely at risk from human disturbance, habitat loss/displacement (from the project footprint), and loss of salmon. For instance, do some piscivorous species have the ability to shift their diet to include another source of protein? If so, how would this shift affect the human culture with reference to a subsistence lifestyle?

RESPONSE: EPA recognizes that there are potential direct effects on wildlife from large-scale mining operations, including disturbances from noise and roadways; however direct effects on wildlife are outside of the scope of the assessment, as explained in Chapter 2. We would expect that a full evaluation of any future mining permit applications and subsequent National Environmental Policy Act Environmental Impact Statements would consider these direct effects on wildlife.

Gordon H. Reeves, Ph.D.

These topics are outside my area of expertise so I cannot comment on if the report adequately characterizes the risk to wildlife and human cultures. I am familiar with some of the literature on the importance of salmon to wildlife and the report represents the finding fairly and accurately. I cannot provide any additional literature, reports, or data.

RESPONSE: No change suggested or required.

Charles Wesley Slaughter, Ph.D.

No. The Assessment clearly qualified that its objective was to consider risks to salmonids, and only inferentially consider "salmon-mediated" effects.

RESPONSE: No change suggested or required.

Appendix C provides a comprehensive discussion of non-fish wildlife and the relation of those populations to salmon. However, the Assessment itself (Volume 1) provides only a brief summary in Chapter 2.2.3, which could allow a cursory reader to perhaps conclude that wildlife populations have little risk of impact from the hypothetical Pebble project. Is this the intent of the Assessment authors? A more in-depth reading of Appendix C allows inferring potential consequences to wildlife and birds of "salmon-mediated" impacts of mining development.

RESPONSE: We have clarified assessment endpoints and provided additional background information from Appendices A and B in Chapter 5. Direct effects on wildlife are outside the scope of the assessment (as stated in Chapter 2), but their potential importance is acknowledged in Chapter 12.

Dr. Paul Whitney

The assessment has been expanded to include more information from Appendix C of the draft report (now an independent U. S. Fish and Wildlife Report).

The scope of the assessment is focused on potential risks to salmon from large-scale mining and salmon-mediated effects to indigenous culture and wildlife. EPA recognizes the complexity of potential direct, secondary, and cumulative effects on wildlife. We would expect that a full evaluation of any future mining permit applications and subsequent National Environmental Policy Act Environmental Impact Statements would consider these complexities and utilize the information in U.S. Fish and Wildlife report (Appendix C of the draft report.)

USFWS RESPONSE: We acknowledge the comment about the comprehensive discussion of wildlife and the relation of selected species to salmon in Appendix C. Appendix C could be used as the basis of an assessment of potential impacts of mining on wildlife, but decisions related to assessment scope with regard to potential impacts of mining on wildlife is the responsibility of EPA.

Appendix D provides a comprehensive and useful discussion of the indigenous people of the Bristol Bay region and of their traditional ecological knowledge and cultures. Appendix D clearly lays out the vulnerabilities and risks (summarized on p. 4-5 and pp. 150-153) associated with the (hypothetical) major resource extraction projects. However, the Assessment (Volume 1) provides only cursory consideration of these human aspects of the potential project – on p. ES-23, and in Section 2.2.5. Presumably, this is because the EPA mandate is to conduct an ecological risk assessment, rather than assessment of consequences for human populations, whether indigenous, native, resident, non-native, non-resident, or the larger cash economy world as represented by the State of Alaska, Northern Dynasty Minerals, or Pebble Limited Partnership.

RESPONSE: The scope of the assessment related to Alaska Native cultures is limited to salmon-mediated effects—that is, potential effects on indigenous culture if there are negative effects on salmon. The assessment draws on the more comprehensive information in Appendix D to evaluate these risks. The text of the revised assessment has been expanded to include and discuss the vulnerabilities and risks to Alaska Native culture from potential large-scale mining.

John D. Stednick, Ph.D.

The effect on wildlife section largely focuses on the return of nutrients to the land in various shapes and forms and adds little to the risk discussion. Other than marine-derived nutrients, other stressors exist. What are the consequences of the mine operation on other wildlife habitats? Habitat fragmentation? Noise and light disruptions, etc.?

RESPONSE: The scope of the assessment is focused on potential risks to salmon from large-scale mining and salmon-mediated effects to indigenous culture and wildlife. The EPA recognizes the complexity of potential direct, secondary, and cumulative effects on wildlife and would expect that a full evaluation of any future mining permit applications and subsequent National Environmental Policy Act Environmental Impact Statements would consider these

complexities. The final assessment acknowledges the potential for direct effects on wildlife (Chapter 12).

Mine development will require the use of explosives. What are the effects of the nitrate and ammonia in the air following each detonation? The National Trends Network data suggest that the area receives about 1 kg/ha/yr of nitrogen in precipitation. Thus, the increase in atmospheric inputs from the explosions may exceed the marine-derived nutrients. What are the consequences?

RESPONSE: See response to previous comment. Also, stressors evaluated were based on how they would significantly affect our primary endpoint of interest (the region's salmon resources) and their relevance to EPA's regulatory authority and decision-making context. Although atmospheric inputs from mining operations are a potential source of contamination to streams, they are not considered as significant as other stressors and are not regulated under the Clean Water Act. Finally, because of terrestrial nitrogen fixation, nitrogen is not believed to be the most important marine derived nutrient.

The potential loss or change in lifestyles of indigenous peoples is important, but this information seems relegated to Appendix D. Include more of this information in the main body of the text. Actually, there is a significant amount of information in the appendices that should be brought forward.

It is unclear why there is such variability in the detail or depth of assessment of each of the stressors. Why does the TSF failure section have 34 pages while the section on potential effects on native peoples only has a few pages with a reference to an appendix? The unevenness of the coverage needs to be addressed.

RESPONSE: The text of the revised assessment has been expanded to incorporate more of the background information from Appendix D and a more comprehensive evaluation of potential salmon-mediated risks to indigenous culture. The assessment's primary endpoint is the abundance and production of salmonid fish, so effects on those receptors are treated in more depth than the secondary endpoints, fish-mediated effects on wildlife and Alaska Native cultures.

Roy A. Stein, Ph.D.

Risks to Wildlife. The importance of salmon in bringing Marine Derived Nutrients (MDN) into these freshwater ecosystems and watersheds and their role in influencing wildlife and associated interactions between wildlife and human cultures was well described. Loss of these nutrients would severely compromise wildlife, and thereby human (through reductions of subsistence harvest), populations. The appendix dealing with wildlife was quite detailed and well done and it would serve the main report well for the authors to include critical information from this appendix.

RESPONSE: No change suggested or required.

Dr. Paul Whitney

USFWS RESPONSE: We acknowledge the comment regarding the quality of Appendix C. Comments related to the scope of the assessment are not specific to Appendix C and are the responsibility of EPA.

Risks to Native Alaskan Culture I. I thought that the assessment could be approved if the same approach used for the mine, i.e., a case history approach, was used for human cultures. Surely, there exist situations where salmon have declined or have been reduced by development/exploitation (the Fraser River, perhaps?) where subsistence by Native Alaskans was historically paramount. Once the salmon were reduced, what was the impact on the Native Alaskans subsistence culture? How did the Native Peoples respond? From whence did they get sustenance, cash, etc.? What sort of displacement occurred?

RESPONSE: The EPA recognizes that there is a great deal of information about cultural and health effects on indigenous populations from loss of fish resources. We have referenced some case studies in the assessment (with a primary focus on Alaska), and have expanded the discussion of potential effects from a loss of salmon resources.

Risks to Native Alaskan Culture II. The only risks reviewed here came via salmon-mediated impacts on the culture of Native Alaskans. Direct impacts of the mine through jobs (potentially positive), wildlife (likely negative), etc. all could be discussed briefly, serving to broaden the overall impact of the mine and its associated activities on Native Alaskans.

RESPONSE: The EPA acknowledges that the scope of the assessment is limited to salmon-mediated risks to indigenous culture and that there would be many other potential effects (positive and negative) from development of large-scale mining in the region. Direct impacts to Alaska Native culture have been acknowledged in the revised report, but are outside of the scope of the assessment.

Risks to Other Cultures. I was a little surprised that little text was spent on recreational anglers, commercial fishers, subsistence users (other than Native Alaskans), etc. Appendices provide some guidance here and this text need not be voluminous, but mentioning these impacts of the mine on these groups would improve the main report.

RESPONSE: The discussion in the revised assessment has been expanded to acknowledge potential effects on non-Alaska Native subsistence users. The EPA acknowledges that there are potential impacts on recreational anglers and commercial fishers. However, because the assessment focused on fish-related effects to Alaska Native culture, an evaluation of potential impacts to the recreational and commercial sectors is outside of the scope of this assessment.

William A. Stubblefield, Ph.D.

Potential effects to wildlife and human cultures are briefly addressed in the risk assessment. No "quantitative" assessment of potential effects is provided. For the most part, it appears that potential affects to both wildlife and human cultural endpoints are directly proportional to the injury suffered by salmon populations as a result of any spills or failures. Given the level of detail available at this point in time regarding mine operations and closure, that is probably about as far as any assessment could go. I'm not aware of any literature reports or data that would assist in further characterization of these potential injuries.

RESPONSE: No change suggested or required.

Dirk van Zyl, Ph.D., P.E.

The EPA Assessment does not identify or appropriately characterize the risks to wildlife and human cultures due to risks to fish. It only estimates the likelihoods of occurrence and the consequences. See discussion under Question 4 above regarding suggestions for improving estimation and expression of the magnitude of risks to wildlife and human cultures due to risks to fish.

RESPONSE: The EPA believes that the likelihood of an occurrence and its consequences constitute an appropriate and generally accepted definition of risk. We have estimated those to the extent that existing information allows.

Phyllis K. Weber Scannell, Ph.D.

The document focuses on effects to wildlife that would occur from failures – tailings dam failure, pipeline failure, etc. There are other sources of disturbance to wildlife that should be addressed in a future mine plan and agency review and permitting. Other mines in Alaska limit truck traffic on the haul road during caribou migrations, incinerate all kitchen waste, educate workers on bear safety, and prohibit inappropriate disposals of food containers or other wildlife attractants. Other factors that might need to be addressed to protect wildlife are limiting air traffic and noise during certain times of the year. Unless addressed, these issues are more likely to cause detrimental effects to wildlife than dam or pipeline failures.

RESPONSE: No change suggested or required. The EPA agrees with the reviewer that any future mine plan would require an evaluation of, and mitigation for, direct effects on wildlife.

Paul Whitney, Ph.D.

Problem Formulation for Wildlife. If one addresses the problem formulation for wildlife at face value, the answer is pretty straight forward. The assessment tells us that the consequences of loss and degradation of habitat on fish populations could not be quantified because of the lack of quantitative information concerning salmon, char, and trout populations (page ES-26, third bullet). Furthermore, we learn that indirect effects, such as risks to wildlife, cannot be quantified (page 5-75, para 1, last line). Stating that reduced salmon production would reduce the abundance and production of wildlife (page 5-75, para 1, last sentence) is accurate but not appropriate for a document that is intended to provide a scientific and technical foundation for future decision making (page ES-1, para 1, last sentence). It is certainly possible to provide a more complete scientific and technical response to a question regarding impact to wildlife. I respectfully suggest that the first step in developing a more complete scientific and technical response is to modify Question 10 by deleting the words “due to risks to fish” and to separate the risk analysis for wildlife from the risk analysis for human culture. A revised wildlife question should address both indirect and direct risks. A revised human culture question should address (among many other risks) both direct and indirect risks to fish and wildlife.

RESPONSE: As the reviewer notes, the scope of the assessment is focused on potential risks to salmon from large-scale mining and salmon-mediated effects to indigenous culture and wildlife. The EPA agrees with the reviewer that direct effects on wildlife are likely to be important. We would expect that a full evaluation of any future mining permit applications and subsequent National Environmental Policy Act Environmental Impact Statements would consider these direct effects. The revised assessment acknowledges the potential for direct effects on wildlife as well as risks due to fish.

Mixed Messages. The assessment and questions given to the review committee give mixed messages regarding the scope of work. A variety of statements and conclusions in the assessment are inter-related, as one would expect for a document that addresses ecosystem issues. While acknowledging the overlapping issues and responses, I offer the following discrete points that give me mixed messages regarding the scope of work and an appropriate characterization of risks to wildlife. Since these points are related, there is some repetition of information but each of the following items address a discrete issue.

1. The PREFACE (para 2) clearly states “Our goals in conducting this assessment are to complete an objective assessment of the potential impacts of large scale mining on aquatic resources in the Bristol Bay watershed.” This statement is subject to wide interpretation by this reviewer and by the document itself. For example, aquatic resources include many species of wildlife and the Cederholm papers indicate that there are 137 species of wildlife that are associated or closely associated with fish. Wildlife species and their associations are aquatic resources but have been glossed over in the assessment. The lack of follow-through in implementing the above goal statement (i.e., not addressing aquatic wildlife and wildlife associated with fish) is problematic. One can readily understand that timing and budget constraints result in some statements indicating that data are just not available or that certain types of modeling, while possible, were not conducted. However, it is difficult to understand why potential impacts to wildlife are limited to indirect effects due to loss of fish if the assessment was truly conducted as an assessment of aquatic resources. The message is mixed because the goal is to assess aquatic resources, but many aquatic resources are not assessed.

   RESPONSE: The assessment has been revised and reorganized to better explain the goals and objectives of the assessment. As stated in previous responses to comments, the focus of the wildlife assessment is limited to salmon-mediated effects.

2. The assessment was supposedly conducted as an ecological risk assessment (Abstract, line 5). One of the first steps of an ecological risk assessment is to state well defined endpoints. Suter (1993, page 22) presents 5 criteria that any endpoint should satisfy. My notes are in brackets.
    a. Societal relevance (Assessment appears to do a good job of identifying concerns of people living near the area of the proposed mine. Yet, many of the potential endpoints listed in site models (e.g., Figure 3-2E) are not addressed.

The reason for not assessing endpoints in the site models (such as wildlife quality and quantity) should be provided. Better yet, clearly state both direct and indirect endpoints for wildlife.)

b. Biological relevance (The biological – especially ecological – relevance is incomplete. Wildlife and the functions they provide are relevant in that wildlife comprise many of the secondary and tertiary consumer species in the ecosystem. The upland and aquatic habitats utilized by wildlife are the indirect and direct sources of many nutrient and energy inputs to fish in the Bristol Bay ecosystem. The upland components of the Bristol Bay ecosystem should be assessed in more detail to provide a biologically relevant assessment. If not, the assessment should directly indicate why not).
c. Unambiguous operational definition (Overall a good job for a hypothetical mine. See response to Question 2 for suggestions).
d. Accessibility to prediction and measurement (The inability to estimate the impact on salmon numbers is problematic. Is the inability due to a lack of population data, the unwillingness to utilize peer-reviewed methods other than demographic population modeling, or some other reason? Furthermore, the potential reduction in marine-derived nutrients and the potential impact on wildlife can be assessed and predicted – see below).
e. Susceptibility to the hazardous agent (The assessment does a good job on the hazards for aquatic resources but not susceptibility to wildlife biotic (e.g., loss of habitat) and abiotic stressors (e.g., ice dams and scouring, as well as hydrographs and sedimentation influence on ecological succession). Furthermore, an adequate ecological risk assessment should address ALL ecological stressors (e.g., loss of habitat and disturbance) not just toxics).

Suter's five criteria should be addressed when selecting endpoints. All the endpoints selected and illustrated in figures should be assessed. The incomplete assessment of quantitative estimates of all the impacts on salmon, non-salmonid fish, wildlife, as well as community and ecosystem parameters should be remedied.

RESPONSE: The criteria above apply to the specific assessment endpoints considered in the assessment, as described in Chapter 5. Each of these endpoints meets the above criteria, and additional information describing endpoints within the ecological risk assessment process has been added to the beginning of Chapter 5.

3. A complete assessment of aquatic resources as stated in the PREFACE should address both direct and indirect risks to the many species of wildlife and wildlife habitat that are aquatic resources and closely associated to aquatic resources. The list of all the aquatic species and habitat is lengthy. A partial list of categories of wildlife and wildlife habitats that are aquatic resources includes grebes, ducks, shorebirds, beaver, muskrat, otter, mink, and riparian, emergent, and aquatic vegetation. The impact of mining on all of the aquatic resources is given scant coverage in the assessment, with the possible exception of impact to wetlands. The PREFACE provides wide ranging goals but the assessment has many gaps, and I wonder why.

RESPONSE: The latest draft of the assessment has been revised and reorganized to better explain the goals and objectives of the assessment. Those goals and objectives focus the assessment on salmonid fish and a limited qualitative discussion of the

salmon-mediated effects on wildlife and Alaska Native cultures. The EPA acknowledges and agrees with the reviewer that there will be direct and indirect effects of mining on wildlife, but the detailed evaluation of those effects will be left to the NEPA and permitting processes should a mine be proposed.

4. The Executive Summary (para 1) indicates "…USEPA launched this assessment to determine the significance of Bristol Bay's ecological resources and evaluate the potential impacts of large-scale mining on these resources." The emphasis on salmonids does not fairly represent the entirety of ecological resources. To me, ecological resources should include ecological parameters such as plant community succession, species diversity, energy flow, and structure and function, in addition to the information on salmonids.

   RESPONSE: The scope of the assessment has been clarified in Chapter 2, and the specific endpoints considered in the assessment are described in Chapter 5. We recognize throughout the text that other ecosystem components are important and potentially will be affected by large-scale mining, but fall outside this assessment's scope. Ecological risk assessments focus on endpoints that are important to decision makers and stakeholders, are susceptible to the stressors, and meet other criteria; they do not attempt to cover all ecosystem components (Suter 1993, EPA 1998).

5. The Scope of the assessment (ES-,1 last para) indicates that "wildlife … as affected by changes in the fisheries are additional endpoints of the assessment." This informs the reader that only wildlife species that are affected by changes in the fisheries will be an endpoint. Yet many species of wildlife that are affected by changes in the fisheries are not addressed. In addition, such an endpoint glosses over the importance of assessing fish that are affected by changes in wildlife. For example, beaver modify aquatic habitat and terns prey on fish. The scope of the assessment seems to brush over many of the important fish and wildlife interactions discussed by Cederholm et al. (2000) and Cederholm et al. (2001) and to focus mainly on marine-derived nutrients. I am pleased with the discussion of the marine-derived nutrients but am not clear how the emphasis on this one interaction, which is not quantified in the assessment, furthers the understanding of potential mining impact on the Bristol Bay ecosystem.

   RESPONSE: The EPA agrees with the reviewer that there are many complex fish and wildlife interactions in the study area and the revised assessment acknowledges this fact. The assessment focused on loss of MDN to the system and on potential loss of fish as a food source for wildlife as important potential salmon-mediated effects on wildlife. We would expect that a full evaluation of any future mining permit applications and subsequent National Environmental Policy Act Environmental Impact Statements would include analysis of other potential causes of effects on wildlife.

6. Gende et al. (2004) use a variety of methods to quantify both the marine-derived nutrients and energy that transfer from salmon to terrestrial wildlife and habitats. For example, they determined that bears moved nearly 50% of the salmon-derived nutrients and energy from streams by capturing salmon and dragging the carcasses from the stream. Gende has also worked with University of Alaska Associate Professor Mark Wipfli (Gende et al. 2002) on the relationship of salmon to terrestrial habitats. Alaskan and national experts

are likely available to assist EPA in quantifying the movement of marine-derived nutrients to the terrestrial ecosystem.

RESPONSE: The references are appreciated. The EPA acknowledges that a more quantitative evaluation of salmon-derived nutrients to the terrestrial ecosystem may be possible. However, this type of evaluation would require further data collection and significant analysis, which is beyond the scope of this assessment. A detailed evaluation of the movement of marine-derived nutrients to the terrestrial ecosystem is not needed to assess the impacts of mining on salmonids, and is more detailed than is needed for a qualitative discussion of the salmon-mediated effects on wildlife and Alaska Native culture. We would expect that a full evaluation of any future mining permit applications and subsequent National Environmental Policy Act Environmental Impact Statements would address potential effects to salmon-derived nutrients.

7. As mentioned above, the assessment does a fine job of emphasizing the importance of marine-derived nutrients transported to the terrestrial environment but has relatively little information on the importance of terrestrial-derived allochthonous nutrients transported to the aquatic environment. Doucett et al. (2007) discuss methods for measuring terrestrial subsidies to aquatic food webs using stable isotopes of hydrogen. The potential loss of terrestrial subsidies due to mining might be as great as a potential reduction of marine-derived nutrients. It would be informative to discuss the relative importance of marine-derived, autochthonous, and allochthonous nutrients. Such information might influence "best mining practices" and reclamation that can partially compensate for lost allochthonous inputs.

   RESPONSE: See response to previous comment.

   PHW Response: The revised EPA text does address this issue but not in a relative way.

   Formatted: Font: Not Bold, Not Italic

8. Figure 3-2E indicates wildlife quality, quantity or genetic diversity, as well as wildlife predation are important to Alaska Native Cultures. Tribal elders are said to have concern for "potential direct effects on other subsistent resources" (which includes wildlife and vegetation). In addition, Appendix D comments on concerns regarding wildlife (e.g., caribou) and vegetation (e.g., berry gathering) that are not directly linked to the fisheries. An assessment of the direct impact of potential mining and the ongoing exploration on wildlife and vegetation would address the concerns mentioned above. Once again, I wonder why the site model figures outline so much detail that is not addressed in the assessment text.

   RESPONSE: The conceptual models were drafted to gain an understanding of all potential sources, stressors, and effects from large-scale mining and have been revised to clarify the scope of the assessment. The EPA focused the assessment on potential risks to salmonids and subsequent salmon-mediated effects on indigenous culture and wildlife. There are many other potential risk pathways which are outside the scope of this assessment, including potential loss of plant and wildlife subsistence and other cultural resources (see Figure 2-1).

Dr. Paul Whitney

The conceptual models have been modified to more accurately reflect issues within the assessment's scope, and to more clearly identify those pathways considered outside of scope when they are included.

PHW Response: The revised models more clearly identify those pathways considered outside the scope. EPA might want to revise para 2 on page 5-1 that states "(2) the abundance, productivity, or diversity of the region's wildlife populations" is one of three endpoints in the revised assessment.

9. Comments in the main assessment Volume 1 (page 5-76, first lines) indicate that information on wildlife and potential direct impacts are being collected but are not included. Including measures of direct wildlife impact in addition to indirect impact as a result of changes in fisheries would greatly improve the assessment. There are many ways to estimate the impact of habitat loss on wildlife (Morrison et al. 1998). A better understanding of impacts on wildlife would presumably provide a better technical basis for designing a reclamation plan.

    RESPONSE: The scope of the assessment is focused on potential risks to salmon from large-scale mining and salmon-mediated effects to indigenous culture and wildlife. EPA agrees with the reviewer that direct effects on wildlife are important and that there are ways to estimate effects related to habitat loss. We would expect that a full evaluation of any future mining permit applications and subsequent National Environmental Policy Act Environmental Impact Statements would consider these direct effects. The revised assessment acknowledges the potential for direct effects on wildlife. The assessment does not include a reclamation plan and is not intended to support the development of a reclamation plan.

10. The assessment (page 5-77, last sentence) states: "Although this assessment is focused on salmon, the non-salmon-related impacts on native cultures from routine mine operation are likely to be more significant…" If this is in fact the case, what better reason could there be for increasing the scope to include wildlife, vegetation, community, and ecosystem structure and function (i.e., non-salmon)? Methods and mine-related examples for assessing such an increased scope are available from the Northwest Habitat Institute (nwhi.org) in Corvallis. Discussions with Tom O'Neil, Executive Director, indicate that available data from the Alaska GAP Analysis Project and the Alaska Natural Heritage Program could likely be used to make such assessments.

    RESPONSE: See response to previous comment. This type of evaluation would be valuable but would require further data collection and significant analysis, which is beyond the scope of this assessment.

    PHW Response: If the statement in item 10 above is true and the non-salmon-related impacts are more important to native cultures it seems inconsistent to say that Alaska Native organizations only asked for the assessment to address salmon-mediated impacts on wildlife.

11. The risk assessment's focus on "indirect effects on wildlife" (page 5-1, para 2) is consistent with some of the several goal statements that lean toward fish influence on wildlife. I have difficulty reconciling this emphasis because further on in the text (page 5-

75, para 1, last line) it is stated that the "indirect effects cannot be quantified." If the indirect effects cannot be quantified, one should think it is even more important to get a handle on the direct effects, which can be assessed by any one of several wildlife methodologies (Morrison et al. 1998).

RESPONSE: Wildlife is not a main focus of this assessment. We agree that a more detailed assessment of direct and indirect impacts of mining to wildlife will have to be done as part of the NEPA and permitting processes. This assessment is focused on salmon because of the world class, outstanding salmon fisheries in Bristol Bay. Further, as a keystone species, salmon serve as an excellent indicator of overall impacts to the ecosystem.

PHW Response: If you are a hammer, everything looks like a nail. When the hammer hits the nail all is well. If you are a fisheries biologist everything looks like harvest/escapement.When harvest and escapement hit goals all is well. If you are a fishery ecologist, the welfare of the salmon ecosystem looks like biodiversity, structure and function. If it is possible that biodiversity, structure and function have changed, you want to know why and what the consequences might be, The above EPA responses are definitely made by a fishery biologist.

Does the above EPA response assume that all species of salmon are keystone species and that no wildlife species are keystone? The keystone species concept may be a valid reason for a fisheries biologist but various wildlife species such as sea otter, wolf, and beaver have been considered keystone species. While the keystone species concept allows ecologists to communicate with other ecologists and the public, the keystone concept is a hypothesis and oversimplifies the complexity of ecosystem biodiversity, structure and function.

Formatted: Font: Not Bold, Not Italic

The Clean Water Act, as far as I know, doesn't focus on fish populations but rather ecosystem function. It is hoped decision makers give due consideration to the importance wildlife has to ecosystem functions as they relate to salmon.

12. The assessment indicates the exceptional quality of the fish populations and their importance to the region's wildlife is due to five key characteristics. The fourth characteristic is "the increased ecosystem productivity associated with anadromous salmon runs" (page 2-20, Section 2.3). Similar statements are made by Woolington (2009). How is this increase measured, and what is the baseline for the increase? I am sure the biologists that wrote about the increase are trying to convey the concept that the energy and marine-derived nutrients provided by salmonids is incorporated into the primary and secondary production in the terrestrial ecosystems in the Bristol Bay watersheds. I am not sure that such a statement considers the loss of energy and marine-derived nutrients as a result of commercial fishing. Is it possible that commercial harvest may decrease ecosystem productivity compared to productivity prior to pre-European (e.g., 200 hundred years ago) harvests? Perhaps it would be more accurate to delete the word "increase." On the surface, this might seem like a small edit but this edit is one of many edits needed to address, not only the existing conditions in the watersheds, but also the existing conditions relative to "pre-European conditions." My understanding of a Cumulative Impact Analysis is that it includes past assessments of ecosystem resources

and functions as well as current and future conditions (see discussion of Cumulative Impacts in response to Question 11).

RESPONSE: The purpose of the assessment is to evaluate potential effects of large-scale mining on the fishery, not the effects of commercial fishing. Therefore, the potential effects on wildlife associated with loss of marine-derived nutrients considers the present condition of the watershed and fishery as a baseline for an evaluation of potential future effects of large-scale mining.

13. Pauly et al. (2000) and Libralato et al. (2008) address the energy impacts of fisheries. I would be interested to know if the impact of fisheries on marine-derived nutrients and energy available to the wildlife and terrestrial ecosystems in the Bristol Bay watersheds could be compared to the potential impact of the example mine on marine-derived nutrients and energy available to the watersheds. Is the potential impact of the mine small in relation to the impact of commercial fishing or very large compared to commercial fishing? Such information would be informative for determining acceptability of risks. It is possible that such a comparison could stimulate discussion of the possibility of compensatory mitigation for losses due to mining.

    RESPONSE: Compensatory mitigation for losses of aquatic resources from mining is governed by a regulatory process outside the scope of this project. Nevertheless, in response to public and peer comments we have included a discussion of compensatory mitigation in Appendix J of the revised assessment.

    PHW Response: This EPA response is consistent with previous responses but does not address my question.

    Formatted: Font: Not Bold, Not Italic

14. The assessment could be greatly improved if more of the linkages and pathways illustrated in the various Conceptual Models were addressed and if impacts on ecological parameters, such as community succession (down gradient, in the lake and on tailings and waste rock) and aquatic and upland structure and function, were addressed. For example, Site Reclamation is illustrated and highlighted as orange boxes in three places on Figure 3-2C (I'm not sure what the orange highlighting signifies, for there is no legend on this figure). Information on possible wildlife limiting factors (e.g., calving and nesting habitat) and plant communities in the watershed could improve the quality of Site Reclamation. A Reclamation Plan needs to address the likelihood that reclamation can be implemented and if so what benefits it might accrue through time. This type of information would likely result in a better risk assessment.

    RESPONSE: EPA agrees that more detailed information on wildlife limiting factors would need to be collected and evaluated as a part of a site reclamation plan. We would expect that a full evaluation of any future mining permit applications and subsequent National Environmental Policy Act Environmental Impact Statements would include this information as a basis for a site reclamation plan.

15. The discussion of wildlife species in Appendix C is very good but little of the insight provided in these descriptions of hunted or trapped species is reflected in the assessment of impact of potential mining practices on wildlife. I cannot help but wonder (i.e., mixed message) why Appendix C is so thick and so little of the good information in Appendix C

is reflected in the assessment document. For example, the impact of noise and human presence related to mining and roads is addressed on page 54 (Appendix C). Such an impact on certain sensitive species could be equal to or greater than the loss of wildlife habitat in the mine footprint. Woolington (2009) indicates that the Red Dog Mine in Alaska has implemented certain measures that have reduced the impact of the haul road on wildlife. It would be good to know what these measures are and if such measures would be equally effective for a road relatively close to Anchorage.

RESPONSE: The purpose of the appendices vs. the main assessment document has been clarified in Chapter 1. The former Appendix C has now been published as a separate US Fish and Wildlife Service document because it serves purposes for the USFWS beyond the scope of the EPA's assessment.

USFWS RESPONSE: We acknowledge the comment about the quality of Appendix C. Comments related to the scope of the watershed assessment are not specific to Appendix C and are the responsibility of EPA.

Will the proposed haul road to the mine be closed to the public and hunting? If so, the impact of the road may not be high. I can remember Val Geist saying that wildlife behave the way one teaches them to behave. Examples are deer in the streets of Banff Park during the daytime and big horn sheep and elk foraging along the Trans Canada Highway in the Park. The big horn sheep often stop traffic as people stop to observe them. Outside the Park, where deer and elk are hunted, one is less likely to see deer and elk along the highway and deer take on a more nocturnal existence.

RESPONSE: For purposes of the assessment, EPA assumes that the road would be closed to the public during mining operations but potentially could become a public road after mining operations cease. About 80% of the transportation corridor is on private land owned by various Alaska Native Village Corporations, with which the Pebble Limited Partnership has existing commercial partnerships. Alaska Native Regional Corporations are charged with managing land and resources within their control in the best interests of their shareholders. Chapter 13 includes a discussion on the potential impacts of increased access due to additional roads.

The scope of the assessment is focused on potential risks to salmon from large-scale mining and salmon-mediated effects to indigenous culture and wildlife. EPA has not evaluated direct effects from a transportation corridor on wildlife. We would expect that a full evaluation of any future mining permit applications and subsequent National Environmental Policy Act Environmental Impact Statements would consider the direct effects of the transportation corridor on wildlife.

16. As an arctic and sub arctic small-mammal wonk, I anticipate that any discussion of Alaskan ecosystems will include some discussion of the less charismatic fauna (small mammals and songbirds) and the functions they provide. Such discussion is given little attention in the assessment.

    RESPONSE: These issues are outside the scope of the assessment, as specified in Chapter 2. Appendix C (now an independent US Fish and Wildlife report) selected key

> ***wildlife species for characterization, based on their direct dependence on salmon or on their roles in distributing marine derived nutrients through the ecosystem. It was not possible to fully characterize every species. The EPA recognizes that there are multiple species that were not fully characterized and that have important functions in the terrestrial and aquatic ecosystem. We would expect that a full evaluation of any future mining permit applications and subsequent National Environmental Policy Act Environmental Impact Statements would consider all species present in these watersheds.***
>
> ***USFWS RESPONSE: The USFWS selected key species to include in Appendix C and the selection method is described in the report. We certainly concur that small mammals are important from an ecosystem perspective, but they are less linked to fish or to public concerns than the selected species. Songbirds were included in the wildlife report under landbirds.***

Question 11. ***Does the assessment appropriately describe the potential for cumulative risks from multiple mines? If not, what suggestions do you have for improving this part of the assessment?***

David A. Atkins, M.S

According to the Assessment, cumulative risks result from the potential development of at least five additional prospects: Humble, Big Chunk, Groundhog, Sill, and 38 Zone. Exploiting these prospects would amount to development of a mining district (see discussion for Question 2 in regards to appropriateness of the mining scenario).

RESPONSE: No change suggested or required.

The Assessment quantifies the loss of stream lengths and wetland areas that potentially support salmon and resident fish from the development of these projects under a ‘no-failure’ scenario. The assessment is highly speculative given that mine development plans are not available for these prospects.

RESPONSE: Cumulative impacts assessments evaluate past, present and reasonably foreseeable future actions that are temporally and spatially linked to the project under consideration. The potential mines in the revised assessment are reasonably foreseeable based on State of Alaska planning documents and industry exploration activities. We have expanded the discussion of cumulative impacts in Chapter 13.

As with the Pebble scenario, it would be helpful to put this loss of resource in perspective in terms of the fish resources as a whole. It would also be helpful to describe any mitigation measures that are feasible to offset the impact of loss of streams and wetlands. Furthermore, it would be helpful to better understand the role these developments could have in further fragmenting salmon populations.

Dr. Paul Whitney

RESPONSE: Due to lack of comprehensive estimates of limiting factors across the impacted watersheds, population level effects could not be quantitatively estimated except for the most severe cases where total losses of runs could be reasonably assumed. Our ability to estimate population level effects was limited to situations that were assumed to completely eliminate habitat productivity and capacity in an entire watershed for which estimates of escapement could be inferred. For this assessment, these conditions are only met in the TSF failure scenario that completely eliminates and blocks access to suitable habitat in the North Fork Koktuli River. In that case, we estimate that the entire Koktuli portion of the run (~28% of Nushagak escapement) could be lost. Higher proportional losses would occur if significant downstream effects occurred due to transport of toxic tailings fines beyond the Koktuli as modeled under the full TSF failure.

Compensatory mitigation is governed by a regulatory process outside the scope of this assessment but will be an important part of any permitting process. Nevertheless, in response to public and peer comments we have included a discussion of compensatory mitigation in Appendix J of the revised assessment.

We have expanded the cumulative effects discussion (Chapter 13) to give a broader description of streams, wetlands and fish at risk and have incorporated a discussion of the possible effects on biological complexity and fragmenting salmon populations.

The following potential subsidiary impacts from development of a mining district of this scale should also be described in more detail or at least mentioned:

- The extensive road network required to support mines in the area and the attendant development associated with this network.
- The camps associated with the project, in migration of workers to the project areas, and the demand for resources to be imported from outside the area.
- Invasive species that may follow this scale of development.

RESPONSE: The discussion about the cumulative effects of roads (including invasive species), secondary development, and mining camps has been expanded in Chapter 13.

Steve Buckley, M.S., CPG

The assessment does describe the potential for cumulative risks from the development of multiple mines in the area; however, the section is misleading in that it describes specific mine footprints and tailings disposal sites at these prospects where there is no information on the size or character of the potential future mine sites. The assessment does not describe the cumulative effects of mine development.

RESPONSE: We have modified the descriptions of potential future mines to make them less specific (e.g., recognizing that mining infrastructure could go anywhere in the subject claim blocks). We have expanded the discussion of potential cumulative effects to include the cumulative effects of multiple mines and development induced by the advent of large scale mining in the watershed (Chapter 13).

Dr. Paul Whitney

Courtney Carothers, Ph.D.

In general, the report suggests that effects from multiple mines would increase the prevalence and cumulative impacts of the risks described for the one-mine scenario. Again, for the cultural assessment, the conclusion is made that effects on humans would be primarily "direct and indirect loss of food sources" (7-15). As the number of large-scale mines increases in this region, the entire subsistence way of life could come under threat. This would be a much larger impact than lost food sources.

RESPONSE: The text of the revised report (Chapter 12) has been expanded to clarify that a loss of the subsistence way of life goes well beyond the loss of food resources.

Dennis D. Dauble, Ph.D.

Individual risk is described in varying levels of detail with overall risk or effects considered to be largely additive. However, the relative magnitude of the effects of mining each ore deposit is difficult to discern. It is possible that one of the smaller ore sites could be developed within an acceptable risk scenario, but it is difficult to determine given that the assessment is largely built on potential impacts of the Pebble Mine. To put things in perspective (individually and cumulatively), there should be a discussion of habitat lost given each individual mine footprint, during normal operation (includes water treatment and withdrawal) and as a result of pollutant exposure. Also, Section 7.4.1 of the main report provides estimates of stream miles affected due to blockage and elimination, but provides nothing quantitative for other direct and indirect impacts of mine operation. The cumulative risk discussion in Chapter 7 could be expanded to link up with the conceptual model described in Chapter 3.

RESPONSE: We cannot reliably predict the habitat loss due to additional mines. We have tried to describe plausible examples of where additional mines could be developed on the basis of active exploration on existing claim blocks. In the revised assessment (Chapter 13) we predicted aquatic resource impacts based on a typical mine footprint being constructed anywhere in the block and an average stream and wetlands density. We also expanded discussion of the impacts of ancillary mine infrastructure and induced development. This provides a conservative estimate of the cumulative effects of multiple mines and sheds light on whether cumulative effects are a significant concern. We have developed a specific conceptual model for cumulative impacts and used it to enhance the discussion.

Gordon H. Reeves, Ph.D.

I found this chapter well done, even though the analysis was less extensive than what was done for the Pebble Mine. It is clear that multiple populations would be put at varying degrees of risk simultaneously if mine development occurs as is portrayed in this report. This certainly could compromise the "portfolio effect" (Schindler et al. 2010 Nature 465|3 June 2010|doi:10.1038/nature09060), which has maintained the long-term productivity of sockeye salmon in Bristol Bay.

Dr. Paul Whitney

RESPONSE: We have added the portfolio effect to the discussion of the potential effect of multiple mines.

Charles Wesley Slaughter, Ph.D.

Yes – but a qualified "yes." The Assessment appropriately outlines the probability of additional resource extraction projects beyond Pebble itself, and recognizes that additional resource opportunities (beyond the claims depicted in Figure 4-6), currently unknown or unverified, could become viable or desirable to some interests in the future. Section 7.4 summarizes many of the risks. However, the brief coverage (16 pages) accorded the entire subject of "cumulative risks" is **not** consonant with the very long-term, spatially dispersed (and presumably linked by transportation and communication corridors) impacts and risks of multiple mines (and associated infrastructure) in many different sectors of the Bristol Bay watershed.

RESPONSE: We have added to the cumulative effects section (now Chapter 13) by discussing the effects of induced development, including transportation corridors, and the effects of increased overall access in the watersheds (Box 6-1 discusses cumulative effects in terms of a single mine). The cumulative effects assessment is not a definitive, quantitative evaluation. It is, instead, a plausible example of how a mining district could develop and a conservative estimate of the impacts to aquatic resources and fish. It is intended to shed light on whether cumulative effects are a significant concern.

John D. Stednick, Ph.D.

Cumulative risks can result from multiple risks (effects) from a single mine or individual risks from multiple mines. This chapter identified potential risks from proposed mine activities; without consideration of design standards or performance criteria, which is difficult without specific mine designs/plans. Environmental risks were weighted equally – a TSF failure as compared to a blocked culvert. The simple addition of stream length, as affected by various mine footprints, does not represent a cumulative risk.

RESPONSE: We have added to the cumulative effects section (now Chapter 13) by discussing the effects of induced development, including transportation corridors, and the effects of increased overall access in the watersheds (Box 6-1 discusses cumulative effects in terms of a single mine). The cumulative effects assessment is not a definitive, quantitative evaluation. It is, instead, a plausible example of how a mining district could develop and a conservative estimate of the impacts to aquatic resources and fish. It is intended to shed light on whether cumulative effects are a significant concern.

Roy A. Stein, Ph.D.

Cumulative Risks from Multiple Mines. Clearly, as amply demonstrated in the Environmental Risk Assessment, cumulative risks would be greater than those from just the Pebble Mine, even though these risks are difficult to quantify. Important points made in this section deal with the economies of scale that would benefit additional mines coming to the Bristol Bay watershed. After the first mine, new mines become more profitable simply because some of the infrastructure (roads, power, fuel pipelines, etc.) has already been provided, thus reducing cost outlays for the establishment of new mines. To me, this seems as quite an insidious process, for once the door is swung open for the first mine, then many more will follow owing to infrastructure considerations; with these additional mines come far greater cumulative environmental risks. Quantifying these risks would help the reader and the public understand what the ramifications of allowing one mine to begin operations might be. More text attempting to quantify these cumulative impacts would be useful and instructive.

RESPONSE: We have added to the cumulative effects section (now Chapter 13) by discussing the effects of induced development, including transportation corridors, and the effects of increased overall access in the watersheds (Box 6-1 discusses cumulative effects in terms of a single mine). The cumulative effects assessment is not a definitive, quantitative evaluation. It is, instead, a plausible example of how a mining district could develop and a conservative estimate of the impacts to aquatic resources and fish. It is intended to shed light on whether cumulative effects are a significant concern.

William A. Stubblefield, Ph.D.

The potential for cumulative risks associated with the development of multiple mines in the Bristol Bay watershed is not treated with a great degree of detail. Although each of the potential stressors (e.g., water withdrawal, habitat illumination, road and stream crossings) are acknowledged and addressed, little quantitative consideration is given to the potential effects associated with development of multiple mines. This, however, is probably appropriate given the hypothetical nature of the single mine scenario and the potential for greater impacts associated with the development of multiple lines. Short of concluding that “failures at one mine could be bad and failures at multiple mines could be worse,” little else could be concluded. It is noted that the multiple mines scenario leads to multiple tailings impoundments, more roads and culverts, increased discharge potential of contaminated waters and increased habitat loss and reduction of water resources and all of these lead to potentially greater environmental injury as a result of failures.

RESPONSE: We have added to the cumulative effects section (now Chapter 13) by discussing the effects of induced development, including transportation corridors, and the effects of increased overall access in the watersheds (Box 6-1 discusses cumulative effects in terms of a single mine). The cumulative effects assessment is not a definitive, quantitative evaluation. It is, instead, a plausible example of how a mining district could develop and a conservative estimate of the impacts to aquatic resources and fish. It is intended to shed light on whether cumulative effects are a significant concern.

Dirk van Zyl, Ph.D., P.E.

The EPA Assessment does not appropriately describe the potential for cumulative risks from multiple mines. In fact, the assessment does not identify the risks, only the likelihood of occurrence and the consequences. See discussion under Question 4 above about estimating and expressing the magnitude of risks and what is required to appropriately describe the potential for cumulative risks from multiple mines.

RESPONSE: The EPA believes that the likelihood of an occurrence and its consequences constitute an appropriate and generally accepted definition of risk. We have estimated those to the extent that existing information allows.

The cumulative assessment is very conceptual at best, as there are no specific proposals from any of the other potential resource areas. Cumulative impacts can only be evaluated once further details about other potential mines and their plans are available. At this time, this section can at best be seen as speculation.

RESPONSE: The cumulative effects discussion is not meant to be a definitive, quantitative evaluation. We have presented a plausible example of how a mining district could develop and a simple estimate of the impacts to aquatic resources and fish. It is intended to shed light on whether cumulative effects are a significant concern.

It is impossible to improve this part of the assessment with the information on mine development currently available; it can only be done when further information is published by the various mining companies.

RESPONSE: Definitive quantitative risk assessments of future mines will need to wait for more information on those mines and on the resources they could potentially impact. This assessment is meant to identify potential issues of concern with development of large scale mining in the two watersheds. Based on the information available now, is the possibility of cumulative impacts from multiple mines and induced development a significant concern? We have utilized the existing information on the number of mining claims, the extent of recent exploration activities, local and state land use plans, and the ubiquitous nature of fish habitat in the watersheds to shed light on that question. Future environmental impact statements will provide more definitive analyses. We have tried to improve the cumulative analysis by discussing the potential impacts from entire mine footprints, transportation corridors, induced development and increased access.

Phyllis K. Weber Scannell, Ph.D.

There are two issues that should be considered: cumulative effects from a single mine and cumulative effects from multiple mines. Cumulative effects from a single mine might include aquatic habitat degradation from non-point sources, including run-off from exposed mineralized rock, seepage from the tailings impoundment, contaminated dust, noise, and other forms of disturbance.

RESPONSE: We added a discussion on the cumulative effects from a single mine (Box 6-1), as well as discussion of multiple transportation corridors, induced development and increased access (Chapter 13).

Cumulative effects from multiple mines are difficult to predict because there are too many unknowns. It is frequently to the advantage of a mining company to take advantage of existing infrastructure, without building new camps, new mills, etc. It is also possible to use an old mine pit for tailings or waste rock disposal from a new site; however, none of these features can be determined until there is sufficient exploration to determine if mining is feasible, to characterize the deposit, and to develop a detailed mine plan. To date, there is not sufficient information to predict cumulative effects from multiple mines.

RESPONSE: We have expanded the discussion of cumulative impacts from multiple mines in Chapter 13. The analysis of cumulative effects is largely qualitative rather than predictive. It is a plausible example of future cumulative effects that can shed light on whether cumulative effects is an important topic for consideration as plans for mining in the Nushagak and Kvichak River watersheds move forward.

Paul Whitney, Ph.D.

Need to Address Past Impacts. EPA's guidance for reviewing cumulative impact analyses (EPA 1999 – most recent guidance on EPA's website) asks that past, present and reasonably foreseeable actions be considered. The assessment's coverage of cumulative risks from multiple mines certainly addresses "reasonably foreseeable" mines. Not addressed in the analysis is past impact(s) and how such impact(s) might be additive to current and foreseeable impacts. As commented above, commercial fisheries remove a lot of the salmon (up to 70% - over 10 million fish) annually from the drainages associated with the mine. The continual annual reduction, or loss of energy and nutrients that might otherwise return to the ecosystems, should be considered a past impact as part of the cumulative impact analysis.

RESPONSE: The purpose of the assessment is to evaluate potential effects of large-scale mining on the fishery, not the effects of commercial fishing. Therefore, the assessment considers the present condition of the watershed and fishery as a baseline for an evaluation of potential future effects of large-scale mining. We have expanded the discussion on past, present and reasonably foreseeable actions in Chapter 13. Since the fishery has sustained itself for over 100 years despite commercial fish harvesting, it is unclear to what degree reduced escapement to the watersheds has had negative impacts. As Hilborn (2006) states, "Recent paleoecological analysis of returns to Bristol Bay show no indication of decreased production since commercial exploitation began." Furthermore, the fishery is tightly managed by the Alaska Department of Fish and Game, which reduces the harvest to increase escapement when necessary.

PHW Response: I'm just citing EPA guidance for Cumulative Impact Analyses . I'm taken back that it is "unclear" to what degree reduced escapement to the watersheds has had negative impacts. Page ES-24 of the revised assessment clearly states that "The loss of these nutrients from a reduction in salmon would likely reduce the production of riparian or upland species." So it must be clear to EPA that the loss of MDNs due to a mine would likely reduce ecosystem productivity in the watersheds. If this is clear for mining, I can't understand why it is not clear to EPA that reduced escapement to the watersheds from past, current and future commercial fishing has had negative effects.

Dr. Paul Whitney

Several citations (including Hilborn 2005, Pauly et al. (2000, and Libralato et al. (2008) were provided in my original comments that address the negative impact of fisheries on biodiversity, energy flow and nutrient cycling in the ecosystem. If these citations are “unclear” and my previous comments about the impact of reduced MDN are unclear, there is not much else I can do to explain that reduced escapement will result in less energy and MDN in the watersheds. To me this is an obvious impact or as stated in Table 9 11 (9-50) a “Logical Implication”. Perhaps the fishery has sustained itself but a sustainable fishery is not evidence that there is no impact of the fishery on the aquatic, riparian and terrestrial ecosystems of the Bristol Bay watershed.

Formatted: Font: Not Bold, Not Italic

I have prepared/managed cumulative impact analyses of fish and wildlife for a relatively small (e.g., a 200-acre aggregate mine) and a relatively large 7,100-acre coal mine in Washington. A cumulative impact analysis of past, present, and future fish and wildlife losses for the coal mine expansion in a large watershed indicated cumulative impacts of the expansion were less than one percent of past mining, agriculture, urban and forest activities in the watershed. In addition, the cumulative loss could be fully mitigated by compensatory restoration. I would be interested to know what the estimated fish and wildlife loss is due to the example copper mine in comparison to the loss related to the commercial fishery. In addition, I would be interested to know if potential fish and wildlife losses due to mining could be fully mitigated. If the watershed is pristine or nearly pristine, the opportunity for compensatory mitigation may be low. If the past impact of the commercial fishery is large and the watersheds are not pristine, there may be opportunities. There is not much degraded habitat that could be improved by a mitigation plan. If such a cumulative impact analysis were conducted, it may stimulate conversation about reducing commercial fishing to compensate for impact losses due to mining.

RESPONSE: Mitigation to compensate for effects on aquatic resources that cannot be avoided or minimized by mine design and operation would be addressed through a regulatory process that is beyond the scope of this assessment. Nevertheless, in response to public and peer comments we have included a discussion of compensatory mitigation in Appendix J of the revised assessment. Appendix J includes a discussion of the challenges of creating equivalent habitat for anadromous and resident fish and why this would be particularly challenging in the context of the Bristol Bay watershed. Compensatory mitigation requirements address the need for project proponents to replace aquatic resources and ecosystem functions that their project has impacted. Reduced fishing harvests would not replace lost spawning and rearing habitat. Further, it would remove the burden of compensation from the party that caused the damage.

PHW Response: My intent for mentioning a reduction in commercial harvest to compensate for potential impat(s) due to a large mine is more rhetorical than substantive. My intent was to “stimulate conversation about reducing commercial fishing” or “wondering if it was technically feasible” not to recommend it. The above EPA response is a good start at a discussion. Potential impacts of the proposed mine could definitely reduce harvest and escapement and what is the recourse? Some options for “out of kind” and “off site” compensations are discussed in the recently added mitigation discussion and this is good.

Dr. Paul Whitney

Question 12. ***Are there reasonable mitigation measures that would reduce or minimize the mining risks and impacts beyond those already described in the assessment? What are those measures and how should they be integrated into the assessment? Realizing that there are practical issues associated with implementation, what is the likelihood of success of those measures?***

David A. Atkins, M.S.

The Assessment describes what is considered to be conventional 'good' mining practice, but does not adequately describe and assess mitigation measures that could be required by the permitting and regulatory process. A thorough analysis of possible mitigation measures as employed for other mining projects and the likelihood that they could be successful in this environment would be necessary.

RESPONSE: With regard to the terminology of "best", "good", or other terms for the practices used, what was intended to be conveyed in the assessment is that we assumed modern mining technology and operations. The terms are qualitative when generally interpreted, or have a regulatory meaning. The term "best management practices" is a term generally applied to specific measures for managing non-point source runoff from stormwater (40 CFR Part 130.2(m)). Measures for minimizing and controlling sources of pollution in other situations are referred to as best practices, state of the practice, good practice, conventional, or simply mitigation measures. We have added a text box in the revision Chapter 4 to discuss terms. Mitigation measures considered feasible, appropriate, and 'permittable' (as per Ghaffari et al. 2011), were considered in the assessment, and these are measures common to other copper porphyry mines. Evaluation of alternative strategies (e.g., other options presented in Appendix I for the mitigation of the same issue) should be part of the permitting process for a specific mining plan. The State of Alaska does have statutory and/or regulatory requirements for an approved Plan of Operations (11 AAC 86.800), a Reclamation Plan (Alaska Statute (AS) 27.19.30) and appropriate Financial Assurance (AS 27.19.040) and the revised Chapter 4 notes these requirements.

It is highly likely that for mines located in the Bristol Bay watershed, conventional engineering practices would not be sufficient. Therefore, it is important to consider mitigation on numerous fronts when determining the viability of the project. A section on innovative and state-of-the-art approaches for both mitigation and construction of mine facilities would be helpful to better understand if risks can be minimized or eliminated given sufficient funds.

RESPONSE: The EPA agrees generally that conventional engineering practices may not be sufficient, but it may not be appropriate to test innovative approaches in a watershed such as the Bristol Bay watershed. The EPA is not aware of innovative mitigation measures that have sufficient history to be applicable to this location.

Under the no-failure scenario, the footprint of the mine (open pit, block-cave subsidence zone, waste rock and tailings areas) will by necessity destroy habitat. There may be ways to create equivalent habitat to compensate for lost habitat in areas within the watershed that are currently not productive for fish. This form of mitigation may work for resident fish, but it is unclear if it would work for anadromous fish that return to very specific locations to spawn.

Dr. Paul Whitney

RESPONSE: Mitigation to compensate for effects on aquatic resources that cannot be avoided or minimized by mine design and operation would be addressed through a regulatory process that is beyond the scope of this assessment. Nevertheless, in response to public and peer comments we have included a discussion of compensatory mitigation in Appendix J of the revised assessment. Appendix J includes a discussion of the challenges of creating equivalent habitat for anadromous and resident fish and why this would be particularly challenging in the context of the Bristol Bay watershed.

It is also becoming common practice to offset impacts from project development with preservation of equivalent habitat areas that are also at risk from development (http://bbop.forest-trends.org/). It is unclear if this is a feasible consideration for this project as this could involve allowing one development (e.g., Pebble), while potentially taking away the development rights of others (presumably for proper compensation).

RESPONSE: See response to above comment. The potential efficacy of using habitat preservation as a form of compensatory mitigation for impacts in the Bristol Bay watershed is discussed in Appendix J.

Steve Buckley, M.S., CPG

There are many reasonable mitigation measures that could reduce the risks and impacts beyond those described in the assessment. Some of these are contained in the Appendices and referenced therein but not discussed in detail or described in the assessment. It is beyond the time constraints provided in this review to develop an exhaustive research list of these potential mitigation measures; however, EPA could include measures designed to: reduce the mine footprint and limit the number of potentially affected watersheds; reduce, isolate, or eliminate the amount of potentially acid generating waste; provide secondary containment measures for all pipeline corridors; and use natural streambed arch culverts and bridges at fish bearing stream crossings.

RESPONSE: The mitigation measures proposed within the mine scenarios are a subset of options presented in Appendix I, all of which were presented as appropriate for the Pebble deposit in Ghaffari et al. (2011). Appendix I includes multiple options for each source of contamination, with some having specific applicability (e.g., site and material characteristics) and others being more broadly applicable. Some additional mitigation measures have been added to the scenarios in Chapter 6 of the revised assessment (e.g., processing PAG waste rock over the life of the mine and selective flotation to minimize pyrite in tailings). Mitigation to compensate for effects on aquatic resources that cannot be avoided or minimized by mine design and operation (e.g., by reducing the footprint or limiting the number of affected wetlands) would be addressed through a regulatory process that is beyond the scope of this assessment. Nevertheless, in response to public and peer comments we have included a discussion of compensatory mitigation in Appendix J of the revised assessment.

Courtney Carothers, Ph.D.

Dr. Paul Whitney

While I do not have knowledge of mitigation measures, a more thorough discussion of mitigation measures could be included. Even if mitigation measures are largely deemed to be ineffective in this case, they should be presented and evaluated as such.

RESPONSE: The EPA agrees with this comment and Appendix I is intended to provide that discussion. The mitigation measures proposed within the mine scenarios are those that could reasonably be expected to be proposed for a real mine (they are a subset of options presented in Appendix I), all of which were presented as appropriate for the Pebble deposit in Ghaffari et al. (2011). Evaluation of alternative strategies (e.g., other options presented in Appendix I for the mitigation of the same issue) should be done during a permitting process for a specific mining plan. The assessment assumes that measures chosen for the scenarios would be as effective as possible.

Dennis D. Dauble, Ph.D.

Potential mitigation measures are well described in Appendix I. I have no suggestions for additional measures. Implementation of mitigation measures is entirely dependent on the regulatory framework for operations and the oversight and monitoring practices that would be mandated as a condition of the mining activity. Thus, some discussion of how/which mitigation practices would be most applicable in the Bristol Bay watershed (and limitations thereof), given constraints and characteristics of local hydrology and geology, is warranted.

RESPONSE: The mitigation measures proposed within the mine scenarios are those that could reasonably be expected to be proposed for a real mine, are a subset of options presented in Appendix I, and were presented as appropriate for the Pebble deposit in Ghaffari et al. (2011). Evaluation of alternative strategies (e.g., other options presented in Appendix I for the mitigation of the same issue) should be done during a permitting process for a specific mining plan. Permit applicant mitigation measures that reduce the risks identified in the assessment would be welcome during the application process.

Gordon H. Reeves, Ph.D.

I identified one potential mitigation for culverts – the use of open arch types that are at least one bankfull width in size. As described in my response to Question 7, this could reduce many of the potential impacts raised by the authors.

RESPONSE: Suggestion noted. In our scenarios (Chapter 6), we assumed state-of-the-art practices for design, construction, and operation of the road infrastructure, including design of bridges and culverts for fish passage.

Charles Wesley Slaughter, Ph.D.

If it is assumed that the PLP project, or some similar development, were to go forward, I cannot suggest mitigation measures beyond those discussed above. Since a major concern for salmonids – perhaps THE major concern – is with consequences of the transportation corridor, simply having the mine without the roads/pipelines would alleviate much potential risk. However, there is presumably no practical, economically feasible way to not have the transportation corridor; air transport of all materials to and from the site might technically be possible, but would not be economically feasible.

RESPONSE: We agree that it would be infeasible to have a mine in this location without also having road access. No change suggested or required.

John D. Stednick, Ph.D.

The purpose of this assessment is not to identify mitigation measures. This suggests that things can be fixed by mitigation. Risks were identified for a variety of situations, and the preventative measures would better address the mining impacts. Mitigation measures are also a mining cost that needs to be determined by the mining company and compliance with state and Federal regulatory authorities.

RESPONSE: Comment noted. We agree that mitigation measures required for an actual mine would be determined through the regulatory process. No change suggested or required.

Roy A. Stein, Ph.D.

Mitigation: Complete Tailings Storage Facility (TSF) Failure. In some ways, some of the failures reviewed herein are not really subject to mitigation. For example, if a Tailings Storage Facility (TSF) completely fails, options for mitigation become limited very quickly. With a complete failure, it is "game over", with toxic sediments flowing into the Nushagak River all the way to Bristol Bay, thereby destroying the entirety of salmonid spawning habitat in this river by redirecting the channel and inundating the gravel/cobble steam bed with sediment (meters in depth). Mitigation under these circumstances is impossible, in my view. Given this scenario, I was surprised that the impacts were only assessed 30 km downstream of the TSF failure; is this realistic? I think not, given what we know of other mines.

RESPONSE: We acknowledge the limitations of the hydrologic modeling. We now emphasize more clearly the potential for the effects of TSF failure to extend to Bristol Bay. The potential for remediation (and associated risks) are discussed in Section 9.7.

The amount of text dedicated to a TSF failure is large (36 pages) as compared to other failures. I suggest this section be shortened to bring it more in line with other sections. Briefly summarizing impacts would focus the text and help the reader appreciate what it would mean to have a TSF failure without having to wade through so much text.
RESPONSE: We have revised this section of the assessment. However, given its importance to stakeholders, local communities, and decision makers, it was not significantly shortened. Other accidents and failures are now addressed in more detail.

Dry Stacking Mine Tailings: Appendix I, page 9. Given the horrific impact of a TSF dam failure, should mine operators consider a relatively new technique incorporating "paste tailings technology"? Here, tailings are thickened by water removal (down to 20% water) and filtering;

tailings are then dry stacked onto a lined disposal site. These stacks "have a lower potential for structural failure and environmental impacts" (Martin et al. 2002). I would encourage the authors to argue for this substitute for the more traditional TSF for this solves at least two problems: 1) eliminates the possibility of a TSF failure (a huge gain!) and 2) reduces the amount of monitoring and maintenance of the waste tailings "In Perpetuity" (another major gain). Finally, what does "Best Management Practices" have to say about these two approaches to the storage of tailings waste?

RESPONSE: We agree that dry stack storage and paste storage are options for mine proponents to consider. Although the option of using paste tailings is one that might be explored, the type of tailings disposal that operators propose is generally based on two things: the type of mine and the quantity of tailings. A balance would need to be considered between the low risk/high impact of a tailings dam failure and the certainty of increased area of disposal and the increased cost of tailings handling for paste tailings. A "rule of thumb" for design of dry stack tailings is to allot 25 acres for every thousand dry tons of tailings per day over the life of a 20 year operation (SME Mining Engineering Handbook 1973). This would amount to 4,900 acres (25 *200000 *.99/1000). Since paste tailings are more voluminous than dry and the scenario contains a 25 year mine life rather than 20 years, the area of a paste tailings facility would exceed the calculated amount resulting in over a 1/3 increase in the area occupied by tailings than contemplated in the current mine scenario. With a paste tailings facility, the monitoring and maintenance of a large dam is removed but that is replaced by the monitoring and perhaps treatment of the leachate draining through the tailings pile (that contains 20% water) as well as the long-term maintenance of the cap that is placed over the tailings at the end of the mine life. The choice of a tailings disposal methodology may be affected by the need to avoid or minimize effects to wetlands or the technical feasibility of constructing the structural components of the project.

Mitigation: Partial TSF Failure. If a TSF partially fails or is discovered beginning to fail, then I believe mine operators have a chance to save the dam and thereby protect the river, but only if: 1) the appropriate Standard Operating Procedures (SOP) for an emergency response are in place, 2) the necessary equipment (my presumption here is that heavy, earth-moving equipment would be required), materials, and supplies are onsite near the facility, and 3) trained personnel (meaning that they have practiced these repair SOPs in the preparation for such an event) are available for immediate action. One might argue that these procedures are more proactive than mitigating and I would agree, reflecting the near impossibility of invoking any mitigation measures associated with TSF failure.

RESPONSE: Our scenarios presuppose that there are mitigation measures in place, but examines the effects of a failure of those measures. EPA agrees that SOPs are part of a mining operation and plan; however, inclusion of SOPs and details for emergency responses to a failing dam were outside the scope of this assessment. No change suggested or required.

Dredging: Post TSF Failure. In the text (pages 6-1 to 6-2), a reference is made to dredging materials out of the river post spill. I can't imagine this would mitigate any losses of spawning substrate for salmon. Indeed, because only 5% fines in gravel substrates compromise salmon reproductive success (and perhaps even selection of these areas for spawning in the first place), removal of meters of sediment with a dredge doesn't seem to be a solution. Whereas dredging might, in a best-case scenario, reduce the time to recovery of the substrate, I don't believe it will hasten recovery significantly. Dredging also serves to bring toxic sediments up into the water column perhaps compromising all organisms in the system. By not dredging, we allow the natural system to recover, which, in my view, would be preferable to any sort of "dredging mitigation". Some reflection by the authors on this issue would be valuable.

RESPONSE: Agreed. Adverse effects of dredging are discussed in Section 9.7.

Mitigation: Pipeline Failure. With automatic shut-off valves stationed along all four pipelines, we would expect to know precisely just how much effluent will be spilled during any single event. With this information in hand, mine operators can easily anticipate spill size, toxicant characteristics and thereby judge what equipment, materials, and supplies would be necessary for mitigating any spill. As with the TSF failure, mine operators should have in place: 1) the appropriate Standard Operating Procedures (SOP) for an emergency response, 2) the necessary equipment, materials, and supplies onsite near the pipeline (given the length of the road, these items should be cached at several locations along the road, such that response time is minimized), and 3) trained personnel (meaning that they have practiced these mitigation SOPs in the preparation for such an event) are available for immediate action. Shouldn't pipes be double-walled? Again, what would "Best Mining Practices" say in this context?

RESPONSE: The draft assessment included pipeline failure scenarios that quantified the magnitude of spill events. The draft included the most commonly used and accepted practice of using double walled pipes where above ground and water. There is, to the best of our knowledge, no standard SOP for a product concentrate slurry spill. As is discussed in the assessment, terrestrial spills would be excavated. Spills to streams might also be excavated, although the physical damage to habitat would be considerable and the efficacy of excavation would depend on how far stream flow had spread the material. An assessment of diesel spills has been added to the revised assessment in Chapter 11, and it refers to a NOAA and API report for standard remedial practices.

Mitigation: Failure of Water and Leachate Collection. This failure differs from TSF and pipeline failure, where failures are more akin to catastrophic, for here failure is somewhat more gradual in coming (my guess is). Proactive vigilance is the watch phrase here where continual, careful monitoring will indicate when failure begins. Because the "spill potential" is relatively small (certainly compared to a TSF failure), less urgency is required on the part of mine operators. However, as pointed out previously, just because the potential is small, over time the impacts could be great. Hence, the mitigation undertaken with water and leachate collections would require (one would hope) just the tweaking of the collection system in place to eliminate leakage through time. Again, personnel trained in how to respond to these gradual increases in water and leachate leaks are required to stay ahead of this issue, thus preventing any toxic materials from flowing downstream into the Nushagak and Kvichak rivers.

RESPONSE: The revised assessment acknowledges that the leachate capture system is not likely to capture all leachate during routine operations and shows that water quality standards would be exceeded in a considerable stream length as a result. Mitigation measures that ensure or maximize the detection of leachate in groundwater before it reaches surface waters would be vital.

Dr. Paul Whitney

William A. Stubblefield, Ph.D.

I'm sure there are number of technological/engineering measures that could be implemented to reduce the potential for environmental injury associated with development of mining in the Bristol Bay watershed. The development of this *a priori* risk assessment provides useful information in identifying were potential risks may exist and should provide mine development professionals with the degree of guidance about the types of risks and potential consequences of mine activity failures. Perhaps by recognizing the magnitude of adverse consequences associated with potential failures, steps can be taken to implement safety measures early in the planning process that would render mine development more acceptable. In addition, using the assessment to define areas of uncertainty my provide direction for future research that would be beneficial for the project. Again, because of the lack of detail associated with the hypothetical mine scenario, it is impossible to estimate the likelihood of success of any mine control activities.

RESPONSE: One purpose of this assessment is to inform future decisions concerning mine design and required mitigation. The purposes of the assessment are clarified in the revised introduction (Chapter 1).

Dirk van Zyl, Ph.D., P.E.

Yes, there are reasonable mitigation measures that would reduce or minimize the mining risks and impacts beyond those already described and incorporated by the EPA in the assessment. There are a host of measures that are not addressed in the assessment and lists of these are identified below under the headings of regulatory and engineering. This list is by no means exhaustive.

RESPONSE: See response under the commenter's headings of "Regulatory" and "Engineering" below.

While the EPA Assessment presents a series of potential mitigation measures in the main report, the majority were rejected. Appendix J [sic] to the report also includes a generic discussion of mitigation measures. The Main Report does not address the application or implications of these in any project specific details, e.g. compensatory mitigation for wetlands, streams and other aquatic resources.

RESPONSE: The EPA did not reject the majority of potential mitigation options mentioned in the report. The mitigation measures proposed within the mine scenarios are those that could reasonably be expected to be proposed for a real mine. They are a subset of options presented in Appendix I, were presented as appropriate for the Pebble deposit in Ghaffari et al. (2011), and are common with mining of porphyry copper deposits. Mine design for the scenarios is closely based on that presented in Ghaffari et al. (2011) and incorporates the mitigation measures included in that mine design. Mitigation to compensate for effects on aquatic resources that cannot be avoided or minimized by mine design and operation would be addressed through a regulatory process that is beyond the scope of this assessment. Nevertheless, in response to public and peer comments we have included a discussion of compensatory mitigation in Appendix J of the revised assessment.

Dr. Paul Whitney

Multi-stakeholder engagement processes, such as Failure Mode and Effects Analysis, can be used to further expand on these mitigation measures. It is recommended that EPA recognize these and potentially other measures that may be proposed in the public comments and make a serious effort in including the potential effects of these on failure likelihoods, consequences and risk magnitudes. It is an important aspect of improving on the range of potential outcomes.

RESPONSE: The EPA recognizes that other mitigation measures and mine designs have the potential to address impacts and risks identified in the assessment. Evaluating the risks of all potential mitigation measures and mine designs is not a goal of this assessment, which identifies potential risks of concern from plausible mine scenarios based on current practices and a recent plan (Ghaffari et al. 2011). A permit applicant's mitigation measures that further reduce the risks identified in the assessment are appropriate for the application process.

Regulatory. The EPA Assessment neglects the typical outcomes resulting from the permitting and regulatory processes for new mines, where permit stipulations may require specific actions resulting from discussions, public comments and regulatory frameworks. The following is a partial list of these:

- Section 404 of the CWA (See discussion under Question 3 above).
- Permitting stipulations and requirements for monitoring. Using permit stipulations for monitoring can reduce a large number of the consequences identified in the report. For example, the consequences associated with blocked culverts, etc. can be significantly reduced by permit monitoring requirements and subsequent enforcement.
- Financial assurance will be required for mine closure. Financial assurance can be a very beneficial tool during operations, premature closures, mine closure, as well as post-closure monitoring and maintenance. Experience gained during operations can help develop the closure and post-closure financial assurance requirements.

RESPONSE: The assessment is intended to identify impacts and risks of concern which may inform future NEPA and permitting processes. The revised assessment presents basic discussion of financial assurance and listings of requirements for permitting a mine in Chapter 4. The assessment is not a mining plan and is not meant to replace the regulatory process for development of mining plans for these prospects, but can inform that process about important risks that should be addressed.

Engineering. A number of engineering options are mentioned in the report but discounted in many cases. Many of these engineering mitigations are currently used in the industry. The following may repeat a number of those mentioned in the report:

- Redundancy, e.g. additional embankments may be considered downstream of the TSF to contain tailings and supernatant that may be transported as a result of TMF failure. While this may result in a larger local surface impact, it will protect downstream waters in the case of a failure resulting in tailings discharge.
- Further processing of tailings to remove the remaining sulfides.
- Tailings management options other than slurry deposition, such as production and management of filter cake.
- Waste rock management options to reduce releases during operations, e.g. addition of lime to the PAG rock.
- High standards implemented for road design, construction, monitoring and maintenance.

- Double containment of all pipes containing concentrate and other materials. This is already required under the International Cyanide Code for all pipelines containing cyanide solutions.

RESPONSE: The revised assessment presents background information on mining, including a sub-set of mitigation measures from Appendix I, in Chapter 4 and the scenario-specific information in Chapter 6. The option of selective flotation to reduce the amount of sulfide in the bulk tailings, as well as processing of PAG waste rock over the course of operations, have been included in Chapter 6. In the draft assessment, selective flotation was discussed in the background information, but was missed in the scenarios. A double-walled pipeline along the entire length of a pipeline might be desired from a purely environmental protection standpoint; however, it may not be feasible or cost effective to do this given the length of the pipeline. Therefore, the assessment proposed the most commonly used (and accepted method) of double-walled construction over any water bodies. While the EPA opted not to include redundancy in tailings embankments in the scenarios, this option, as well as full pipeline double-wall construction, could be evaluated for appropriateness during the regulatory process for any future permit application.

The likelihood of success of these proposed and other potential mitigation measures can be evaluated by considering their impacts on the overall project. A range of alternative project technical alternatives and facility-siting locations will have to be developed instead of using only the hypothetical scenario.

RESPONSE: The purpose of the assessment is to describe the potential adverse environmental effects that could exist even with appropriate and effective site mitigation measures. Considering alternative options is part of a permit application process and outside the scope of this assessment. No change required.

Phyllis K. Weber Scannell, Ph.D.

There are many avoidance or mitigation measures that would be implemented to reduce or minimize mining risks. I have described some possible approaches when answering the previous questions. To summarize:

The two most important questions for reducing or minimizing mining risks are:
- Can a mine in this area be designed for closure?
- Is it acceptable to develop and operate a mine that will require essentially perpetual treatment?

RESPONSE: EPA agrees that these are key questions that must be addressed in the regulatory process. Our purpose in the assessment is to evaluate the risks resulting from a mine operated with modern conventional mitigation measures for design, operation, monitoring and maintenance, and closure. The regulatory process addresses significant and unacceptable risks. Chapter 4 of the revised assessment discusses regulatory and financial assurance requirements for mining in Alaska.

Specific Measures that can be taken to minimize risk include:

Dr. Paul Whitney

Limiting metals contamination and acid drainage:

- Design the mine pit to limit oxidation on pit walls. Where feasible, conduct concurrent reclamation.
- Develop plans for classification and storage of waste rock, lower grade ore, overburden, and high grade ore.
- Develop and maintain tailings storage facilities with fail-safe provisions. An emergency discharge of untreated waters from a tailings storage facility could be made to a collection pond for later treatment or the tailings pond could be engineered to accommodate a higher flood event so the likelihood of overtopping is minimized. Consider alternate methods for tailings disposal (dry stack following sulfide removal, etc.).
- Implement concurrent reclamation of disturbed areas, including stripped areas and mine pits.
- Collect and treat point and non-point source water.
- Design and implement plans for the quantity and timing of discharges of treated water; especially if the treated water is high in total dissolved solids. Monitor ground water, seepage water, and surface water.
- Design system for collection and bypass of clean water and collection and diversion of contaminated water to a water treatment system.
- Require stations for truck wheel washing.

RESPONSE: Many of the measures presented here were included in the scenarios and in Appendix I and are mitigation measures commonly included for mining of this type. Other bullets noted here are good suggestions for things to address during the regulatory process, should a permit application be submitted.

Protection of Fish Habitat:

- Review all in-stream activities in waters important to the spawning, rearing, or migration of anadromous and resident fish.
- Design and implement a biomonitoring program.
- Review every road crossing of fish bearing waters to ensure free passage of fish.

RESPONSE: Suggestions noted for consideration during any future regulatory permitting process.

Possible Measures to Limit Effects to Wildlife:

- At the planning stages, design aspects of the project to create or enhance wetland and aquatic habitats for fish, bird, and wildlife species.
- Limit truck traffic on the haul road during migrations.
- Incinerate all kitchen waste.
- Educate workers on bear (or other wildlife) safety.
- Limit air traffic and noise during critical times of the year.

RESPONSE: Suggestions noted for consideration during any future regulatory permitting process.

Dr. Paul Whitney

Paul Whitney, Ph.D.

Comments on Mitigation. The key word here is "reasonable." What is reasonable to a person not involved in mining on a day to day basis will likely not be reasonable to a mining company executive or mining engineer. The likelihood that "reasonable" means different things to different people is exacerbated by the mixed messages regarding "best" mining practices (e.g., page ES-10, five lines from the bottom) versus "not necessarily best" mining practices (e.g., page 4-17, four lines from the top). As mentioned above, both of these statements can't be accurate. For purposes of this discussion, I am assuming that there are many more mining practices that could be proposed to address many of the uncertainties mentioned in the assessment. First of all, most of the mitigation measures mentioned in the assessment provide one line of protection and I suspect there are many types of redundant mitigation that could be implemented. Redundant protection such as: double-walled pipes in all sections that cross floodplains (above and below grade); poly liner/vegetated caps to soak up and capture run off water before it contacts waste rock; redundant clay, glacial till (waste360.com/mag/waste_landfills_glacial_till); poly liners; and secondary liquid collection systems.

RESPONSE: The EPA has revised the assessment to better explain the qualifying terms. What was intended is that we have assumed modern conventional mining technology and operations. The terms are qualitative when generally interpreted, or have a regulatory meaning ("best management practices"), and thus we have eliminated their use in the revised assessment. Measures for minimizing and controlling sources of pollution in other situations often are referred to as best practices, state of the practice, good practice, conventional, or simply mitigation measures. We assume that these types of measures would be applied throughout a mine as it is constructed, operated, closed, and post-closure, regardless of the qualifier that one wishes to place with it. To remove any ambiguity and subjectiveness of terms "good" or "best", we have removed them in the revision and have added Box 4-1, which includes definitions for several terms used. Double-walled pipelines were included in the scenarios for sections above or beneath water bodies. Redundant mitigation measures are appropriate for consideration during the permitting process.

I appreciate the assessment's discussion of the potential difficulties of using poly liners, but the discussion might benefit from a review of Koerner et al. (2005) that provides another perspective on the life of HDPE liners. The relationship of liner life to temperature is presented in their Table 2 and a summary in the text indicates that covered liners have a "half life of 446 years at 20 degrees Centigrade." This is a lot different from the 20 to 30 year estimate of service life cited in the assessment on page 4-11(last para). Appendix I does cite a 2011 version of the Koerner et al. (2005) paper and appears to misquote it (page 9, last para, last full sentence). The Koerner et al. (2005) paper estimates a "halflife of 446 years" not a "lifetime" of 446 years, as cited in Appendix I. Perhaps Koerner updated his 2005 estimate in the 2011 version.

RESPONSE: In the 2011 Koerner reference, there is conflicting text – the 446 years is listed as the "lifetime", and later also as "half-life"; "449" years is also stated as the half-life and one is referred to the Table in the report with the title of "Lifetime", where there is no such number. It appears the author is using the terms half-life and lifetime to mean the same thing. Later in the white paper, there is text that states "…its predicted lifetime (as measured by its half-life)…". The following text has been used in Appendix I and is consistent with the

Dr. Paul Whitney

reference: "…Koerner et al. (2011) presents that a nonexposed HDPE liner could have a predicted lifetime ("as measured by its half-life") of 69 years at 40 °C to 446 years at 20 °C."

The discussion of liners has been moved to Chapter 4 in the revised assessment and includes 69 to 600 years as half-lives, based on Rowe 2005 and Koerner et al. 2011. The personal communication reference has been removed.

PHW Response: Thanks for looking into this issue and updating the text. EPA might want to consider under what circumstances a non-exposed liner would experience 40 degree C temperatures in the Bristol Bay watershed. 20 degree C might even be warmer than a non-exposed liner would experience.

Formatted: Font: Not Bold, Not Italic

I assume a mining engineer (if asked) could design a series of smaller impoundments or innovative lined impoundments that could avoid a lot of the problems cited in the assessment. The trade-off might be increased loss of natural resources due to a larger footprint and increased construction cost, but the risk cited in the assessment and the risk of a catastrophic failure might be greatly lowered.

RESPONSE: An engineer could design a series of smaller impoundments that would likely decrease the risk of catastrophic failure, but would impact a larger footprint and increase construction costs. However, cumulative risk of failure would increase. More than one dam, even if they are smaller, means a higher risk of failures, even if they contain less volume, as well as more points where water management systems could fail, even if the dam itself does not.

I would be interested to know what THE BEST mining practices are. If the mitigation measures mentioned in Appendix I are, in fact, the best, it should be so stated and taken into consideration in the assessment. For example, page 4-21 of the assessment indicates the TSF would be unlined and not have an impermeable barrier between the tailings and groundwater. Appendix I, page 9 indicates TSFs can be lined if problems are expected. There is a lot of good information in the Koerner et al. (2005) paper and Appendix I. It seems the types of mitigation measures in Appendix I could be better captured in the main report.

RESPONSE: The terms "best", "good" or other are qualitative when generally interpreted, or have a regulatory meaning (best management practices when referring to storm water measures). Measures for minimizing and controlling sources of pollution in other situations often are referred to as best practices, state of the practice, good practice, conventional, or simply mitigation measures. The multiple measures presented in Appendix I are options that might be "best", depending on the site-specific conditions and any other constraints. More discussion on mitigation measures has been added to the scenarios in Chapter 6 of the revised assessment.

Compensatory mitigation and reclamation are briefly mentioned in the assessment. A more detailed discussion of the opportunities and feasibility of reclamation and compensatory mitigation might reduce the likelihood of potential impacts of the example mine plan (see response to Question 3).

RESPONSE: Mitigation to compensate for effects on aquatic resources that cannot be avoided or minimized by mine design and operation would be addressed through a regulatory process

that is beyond the scope of this assessment. Nevertheless, in response to public and peer comments we have included a discussion of compensatory mitigation in Appendix J of the revised assessment.

Question 13. ***Does the assessment identify and evaluate the uncertainties associated with the identified risks?***

David A. Atkins, M.S

The Assessment states: the 'range of failures is wide, and the probability of occurrence of any of them cannot be estimated from available data.' Uncertainty is addressed throughout the report, typically with a qualitative discussion. There is a high degree of uncertainty with respect to how the mine would be developed, operated and closed, as well as how any impacts would be mitigated. This large uncertainty makes assessing risk difficult.

RESPONSE: No change suggested or required.

Steve Buckley, M.S., CPG

The assessment identifies some of the uncertainties associated with the identified risks but does not evaluate these in great detail.

RESPONSE: No change suggested or required.

Courtney Carothers, Ph.D.

The report includes specific sub-sections to discuss uncertainties for the risks associated with habitat modification (Section 5.2.4), pollutants (5.3.4), and water collection and treatment failure (6.3.4). Uncertainties related to abundance and distribution of fish in the watershed draining the mine site, road and stream crossings, salmon-mediated effects on wildlife, salmon-mediated effects on human welfare and Alaska Native cultures, tailings dam failure, pipeline failure, and road and culvert failures are not discussed in separate sections; however, several uncertainties related to these risks are noted throughout the report, and in summary sections (Sections 8.5 and 8.6).

RESPONSE: We have added separate uncertainty sections to each of the major topics in the risk assessment chapters.

The "sensitivity relative to overall results" of the key assumptions and uncertainties presented in Table 4.8 in Appendix E (pp. 193-195) would be a helpful model to employ in the main report. For non-experts in the technical dimensions of mine construction and operation, uncertainty rankings would be useful. For example, "We are 'highly uncertain' about the accuracy of these predictions given this unknown factor," or "We expect this uncertainty has a negligible effect on the model we employ to calculate this risk."

RESPONSE: The assessment has been restructured to consider certain impacts resulting from the mine footprint (Chapter 7) separately from less certain impacts resulting from potential failures (e.g., Chapters 8 and 9). For uncertainties considered in each chapter, we also have, when possible, indicated a general categorization of (1) the level of uncertainty, and (2) the sensitivity of our conclusions to this uncertainty.

Dennis D. Dauble, Ph.D.

The most likely scenarios and probabilities of failure are described based on assumptions of project size and magnitude. For the most part, estimated risks are conservative (i.e., effects are stated as "likely" if no further information is available). A weakness of Integrated Risk Characterization (Chapter 8 of the main report) is having a long list of identified uncertainties, which leads one to speculate, "so what do we know?" Not being familiar with the formal risk assessment process, it appears this "assessment" (which is loosely based on a risk assessment framework), falls short of providing something with any degree of certainty.

RESPONSE: The assessment does not state that effects are likely if no further information is available. The assessment, as far as the available information allows, identifies potential events and their effects, their probabilities of occurrence, and possible ranges. Uncertainties, inherent in any risk assessment or mine plan, are clearly identified in the assessment.

Gordon H. Reeves, Ph.D.

Uncertainties and limitations are explicitly identified and acknowledged for topics that I am familiar with (fish and aquatic ecology and fish habitat) throughout the report. These are summarized succinctly and clearly and the consequences to the findings are articulated.

RESPONSE: No change suggested or required.

Charles Wesley Slaughter, Ph.D.

Yes. The authors fairly attempt (pp. ES-24-26, and in each chapter) to note the various uncertainties and assumptions incorporated into the Assessment. Sections 8.5 and 8.6 briefly summarize those uncertainties. A question remains concerning the "uncertainties" associated with assigning probabilities to various failure scenarios; I remain unconvinced that those probabilities have real meaning or significance for decision-making (see response to Question 5, above).

RESPONSE: As explained in the assessment (particularly in Chapter 14), the probabilities have various sources and different interpretations, which we have tried to make clear. Some of them are more useful in decision making than others, but all are the best values that could be

derived from available information. Most are based on empirical frequencies, but some are engineering goals or regulatory targets.

John D. Stednick, Ph.D.

The uncertainties are presented adequately.

RESPONSE: No change suggested or required.

Roy A. Stein, Ph.D.

Uncertainties. I think that the Environmental Risk Assessment did a nice job of identifying uncertainties surrounding this presentation, but a relatively poor job of quantifying them (at least partially due to a lack of information). As a consequence, I found this section more than disconcerting. Certainly, the authors have worked hard to present an accurate portrayal of the impact of a large-scale open pit mine in the watershed of Bristol Bay. Even so, upon review of the list of uncertainties with regard to this effort (pages 8-10 to 8-13), I conclude that we know little of what the impact of this mine will be in any quantitative sense. Clearly, from the Environmental Risk Assessment, we do know qualitatively what is likely to occur when a mine of this size and type will be put into operation in this environment.

RESPONSE: The goal of the assessment is to evaluate risks from large-scale mining to salmon populations and secondary effects of salmon losses. Where applicable information was available, we quantified our uncertainties to the extent possible. Where information was lacking, we provided a qualitative assessment. This approach also reveals missing information that will be needed for any future environmental assessment.

However, from the list of uncertainties, we are operating at the outside edge (and beyond in many cases) of the semi-predictive models used in anticipating the impacts of the mine footprint, the routine operations of the mine, and the impacts of failures of TSF, pipelines, and water/leachate collections on extant salmon populations. And our knowledge of the baseline populations of the seven species of salmonids is no better, for we do not know the size, diversity, distribution, or vital rates (i.e., recruitment, growth, and survival across life stage) of these fishes.

RESPONSE: The EPA agrees that we do not know everything we would like to know about fish populations in the project area, but we do know the approximate extent of various species, and we do know that spawning and rearing by salmon, Dolly Varden, and rainbow trout occur in the project area. We summarize the types of risks to fish from plausible mine scenarios.

Couple these two sets of uncertainty and the prognosis outlined in the report is suspect, at the very least, and somewhat anticipatory at best (I cannot bring myself to use the word “predictive”). I fully realize that these are the cards the authors were dealt (I do applaud the authors for making the best of an information-poor environment), but it seems to me that we are on tenuous ground when we attempt to predict the impact of the Pebble Mine on salmon, associated wildlife, and Native Alaskan cultures in the Bristol Bay Watershed.

Dr. Paul Whitney

RESPONSE: EPA agrees that the assessment is not a definitive quantified prediction of all impacts to salmon, wildlife, and Alaska Native cultures of large scale mining. However, the revised draft does develop more quantitative estimates of the implications of the mine scenarios than the first review draft. The point of a risk assessment is to make the best prognostication possible given the available information. The complexity of a large mine and of the receiving ecosystems, as well as the unpredictability of the natural processes and human errors that would challenge the integrity of a mine, make prediction tenuous even with the most detailed mine plan. However, the assessment evaluates the likely impacts of a set of plausible mine scenarios, thereby highlighting potential risks and impacts of concern. This will inform decisions going forward and any NEPA or permitting processes in the future.

William A. Stubblefield, Ph.D.

The risk assessment attempts to identify and evaluate the uncertainties associated with each of the recognized potential risks. The authors have, for the most part, successfully identified a number of uncertainties that may affect the accuracy and conclusions of the risk assessment. Clearly, this information should provide a basis for prospective mine planners and regulatory authorities to focus their efforts to minimize potential environmental risks. In some cases the uncertainties identified are probably best addressed through the development of additional data and this should guide future research efforts undertaken prior to mine development and operation.

RESPONSE: No change suggested or required.

Dirk van Zyl, Ph.D., P.E.

The EPA Assessment does not identify the risks, only the likelihood of occurrence and the consequences. See discussion under Question 4 above about risk. Uncertainties are identified and evaluated for the likelihoods of occurrence and in some cases for the consequences. However, because the magnitudes of the risks are not expressed, their uncertainties are also not explicitly expressed.

RESPONSE: The EPA believes that the likelihood of an occurrence and its consequences constitute an appropriate and generally accepted definition of risk. We have estimated those to the extent that existing information allows.

The report identifies uncertainties in a number of sections, including in Chapter 8. In many cases, these uncertainties are expressed in qualitative terms and are not quantified. The biggest uncertainty/variability in the evaluation of a hypothetical project is associated with the potential range of design features, waste management options and operational details that could be included. This was completely overlooked in the analysis by assuming a specific design for the hypothetical mine. The failure likelihoods and consequences on salmonid fish are very dependent on the assumptions for the hypothetical mine. These uncertainties are neither clearly identified nor included in the evaluations. This is a major shortcoming of the present analysis.

Dr. Paul Whitney

RESPONSE: The comment is correct in stating that the scenarios are a major source of uncertainty with respect to what might be implemented if an actual mine were developed. However, the scenarios are intended to represent a mine using modern conventional practices and are based on the preliminary mining plan put forward by Northern Dynasty Minerals as "permittable" (Ghaffari et al. 2011). Any future plans put forward would undoubtedly differ, and a permitted mine plan would differ from that put forward by the mining companies. The actual operation of a mine, in turn, inevitably differs from the approved plans. Rather than attempt to estimate the uncertainties in predicting all of those changes in plan, the EPA chose to put forward reasonable and typical scenarios, estimate some associated risks, and describe the uncertainties associated with the risk estimation. Identification of the risks associated with a typical mine can inform initial mine design and the NEPA and permitting processes. The revised draft makes this clear.

Phyllis K. Weber Scannell, Ph.D.

The important features of the Environmental Assessment are to describe the fish, wildlife, and human use of the subject area and to define possible risks from development of a large porphyry copper mine. There are many uncertainties associated with the identified risks and most were identified in the document. The document could be strengthened by putting a greater emphasis on sources of contamination (such as mine seepage, poorly designed collection systems, exposed pit walls, etc.) in relation to the permeability of the soils.

RESPONSE: The revised assessment includes more emphasis on sources of contamination (e.g., diesel pipeline failure, quantitative wastewater treatment plant failure, and a refined seepage scenario) and their potential hydrologic transport including through permeable soil and rock.

The 5th bullet on page 8-11 outlines important uncertainties for protecting fish species. These uncertainties include life-stage-specific sensitivities to temperature, habitat structure, prey availability, and sublethal toxicities. These factors must be considered should a mining project go forward.

RESPONSE: The EPA agrees with this comment. No change suggested or required.

The 6th bullet on this page discusses the preliminary nature of leaching test data. These tests must be sufficiently comprehensive to predict both short term and long term water quality from all sources, including PAG and NAG waste rock, pit walls, and pyritic tailings.

RESPONSE: The EPA used the available leaching test data and agrees with the comments about future tests.

Paul Whitney, Ph.D.

Uncertainty summary. The discussion of uncertainties in the assessment is, in most cases, appropriate. It seems that one could use these discussions as a scope for additional work needed prior to an assessment that would properly assess risk of the example mine. As the uncertainty discussion appears in the assessment, this reader wonders what to make of it. There is a lot of uncertainty in this world that we find acceptable; the ultimate goal seems to determine if the cumulative uncertainty is acceptable or not. Such an evaluation remains to be made and I'm not sure how it could be made based on the level of information presented in the assessment and the current state of the uncertainty discussions.

RESPONSE: The goal of the risk assessor is to describe the uncertainty, not determine whether it is acceptable. The acceptability of existing uncertainty is a judgment made by the risk manager, who must decide whether to make a decision or defer the decision until more information is available.

The summaries of uncertainty included in Sections 8.5 and 8.6 could be improved if some sort of realistic and useful conclusion(s) could be presented. The Section 8.6 summary seems to "pile on" uncertainties, rather than summarize the uncertainties in the assessment. While piling on is informative, it is not the sort of summary I was looking for. Conclusions in the Section 8.5 summary of conclusions remind us that the effects of mining on fish populations could not be quantified and, as a substitute, the effects on habitat were used as a surrogate. So we are left with an estimate of 87.5 to 141.4 km of streams that would be removed and this would cause an adverse effect. Based on this very general risk conclusion, we learn that "In summary, it is unlikely that there would be significant loss of salmon subsistent resources related to the mine footprint" (page 5-77, last paragraph). First, it's not clear how this conclusion was reached. Second, if such a conclusion was possible for subsistent resources based on the data available, why couldn't such a conclusion be reached for sport and commercial fisheries? Third, does it follow that no significant loss to salmon subsistence resources would result in no significant loss to wildlife that utilize this resource? If so, such an indirect analysis is not informative regarding an environmental assessment for the example mine. Alternatively, a direct assessment of the loss of habitat using habitat-based population models for both fish and wildlife would be much more informative.

RESPONSE: Uncertainties are now discussed in each chapter of the assessment so they can be more closely associated with a particular topic.

Additional information on the geographic scope of subsistence use in the area has been added to the assessment and the conclusions clarified accordingly. Although there is some (incomplete) information on subsistence use areas, similar data are lacking for the geographic scope of sport and commercial fishing in the watershed.

PHW Response: The above response doesn't answer my question. Does EPA stand by its conclusion of unlikely significant loss of salmon subsistent resources related to the mine footprint?

Formatted: Font: Not Bold, Not Italic

There is not sufficient data to quantify the loss of salmon as a subsistence resource under various scenarios or to quantify the fish-mediated effects to wildlife. Discussions of these topics have been expanded to illustrate the complexity of the interactions and provide further qualitative assessment. Direct effects on wildlife from habitat loss related to large-scale mining are outside of the scope of this assessment.

Dr. Paul Whitney

Adaptive Management. Holling (1978) in his Adaptive Environmental Assessment and Management book discusses political uncertainty and how adaptive management might be able to address the issue. Considering that the mine being proposed is a multi-century system, it's poignant to realize that Alaska was owned by Russia about 150 years ago and Oregon was being claimed by the Spanish about 200 years ago.

RESPONSE: The commenter is correct in pointing out the inapplicability of adaptive management to decisions like whether to permit large scale mine development in the Bristol Bay watershed. Not only is the time horizon inappropriate, but mine permitting decisions cannot be remade iteratively like the resource management decisions for which Hollings and Walters developed adaptive management (e.g., setting annual fishing limits). However, careful monitoring and revision of permit conditions, although not literally adaptive management, could have some of its benefits. Monitoring requirements and provisions for modifying permits are beyond the scope of this assessment.

Adaptive management is a tool designed to deal with uncertainties in risk evaluations (Ruhl and Fischmann 2010). If implemented properly, with testable hypotheses of risk, adaptive management may be something to consider for the example mine. My experience with adaptive management is that adequate funds are seldom allocated to learn by doing, to test hypotheses and to implement new management if hypotheses are not met. Formalizing financial instruments to ensure that funds are available is equally difficult to negotiate. Nonetheless, I agree with Ruhl and Fischmann that the theory of adaptive management is sound and may be the only way to deal with uncertainties such as climate change. Considering the number of uncertainties identified in the assessment, for the scope of work to clearly state hypotheses, to address the uncertainties, to fund studies to test the hypotheses, and to fund alternative management if hypotheses are not met is cumulatively daunting. For example, there are about 50 state variables in each of the Site Model Figures (3-2A, B, C and D). All totaled, that's about 200 (50 x 4 figures) state variables for salmon alone. Considering there are 100s more species, that's about 20,000 (200 x 100 species) state variables. Then there are fluxes/linkages between the state variables and that is another 20,000 fluxes/linkages that should be monitored. For adaptive management to work, clear goals and hypotheses to assess whether observed data meet the goals should be stated for approximately 40,000 variables and linkages. Then there is the task of defining the monitoring methods and statistics to determine whether or not goals for the variables and linkages are being met. I acknowledge that there are probably ways to trim down the monitoring effort, but one can start to imagine the enormity of implementing a monitoring plan for adaptive management. Then there is also what to do if goals are not realized. I am not aware of any alternative to adaptive management other than contingency planning which often lacks the "learn by doing" feature of adaptive management.

RESPONSE: See response to previous comment.

Important wordsmithing. So many of the uncertainty evaluations make statements about certain parameters that "could not be predicted" (page ES-20, para 4); "could not be quantified" (e.g., page 6-11, second full para); or are "unpredictable" (page 5-44, para, line 8). These are just a few of many examples. It would be more acceptable, at least to me, to state that estimates were not included in the assessment. This type of wording occurs in some parts of the assessment and might be more accurate.

Dr. Paul Whitney

RESPONSE: Changes have been made in Chapter 7 (formerly Chapter 5) and Chapter 9 (formerly Chapter 6).

Vague wording. The assessment includes a lot language that seems vague, at least to me. The list is long but includes: "highly pure water"; "other ecological responses"; "key wildlife"; "essential wildlife"; "overall ecosystem functioning"; "serious population-level consequences"; "different thermal characteristics"; "could be locally significant"; and "very long time." Lackey (2001) acknowledges the need for scientists to communicate with the public using normative science but expresses concerns that normative descriptors such as ecosystem health are subject to wide interpretation. He suggests that the most direct alternative to using normative science is to simply and clearly describe what is being discussed. The assessment would benefit if the normative type words used above (any many more) were quantified with estimates, a range or some type of measureable or testable parameter.

RESPONSE: The authors have tried to be precise with the language of the assessment and avoid normative terms. Changes to the text of the revised assessment have been made with this comment in mind.

Question 14. ***Are there any other comments concerning the assessment, which have not yet been addressed by the charge questions, which panel members would like to provide?***

David A. Atkins, M.S.

Long-term risks from development of an open pit have not been characterized. It is difficult to predict the chemistry of the lake that will form in the open pit, but there is some potential that water quality will be poor, which may be exacerbated by pit backfilling with waste rock. The pit lake could impact waterfowl and may have some impact on groundwater if there is outflow when the lake reaches an equilibrium level.

RESPONSE: The potential pit was not assessed because it is not anticipated that salmon or other fish (the primary assessment endpoint) would reach it. Therefore, it is out of scope. However, a pit lake as a potential source of water to streams is briefly considered in the revised Chapter 8. The scenarios no longer include the placement of acid generating waste rock in the pit at closure.

Steve Buckley, M.S., CPG

None.

Courtney Carothers, Ph.D.

Dr. Paul Whitney

None.

Dennis D. Dauble, Ph.D.

Based on public comments and discussions that took place by panel members in Anchorage August 7-9 of this year, this report confuses in both intent and approach. Is the intent of EPA's assessment to characterize potential impacts to the Bristol Bay watershed (title) or does it address a more defined portion of the Nushagak River and Kvichak River watersheds (objective statement)? Was the approach an "assessment" (a fairly broad term) or an "ecological risk assessment" (suggests a specific scientific framework was applied to the risk/effects analyses)? These shortcomings should be addressed in the final assessment document.

RESPONSE: We have revised the discussion of purpose, scope and endpoints in response to this and other similar comments (see Chapters 1 through 5 of the revised assessment). The assessment addresses multiple spatial scales, as detailed in Chapter 2. It is an ecological risk assessment, but that term is usually shortened to assessment to make the document more readable.

Gordon H. Reeves, Ph.D.

The major issue that was not considered in the assessment was the potential impact of climate change, particularly regarding the form and timing of precipitation. Admittedly, there is uncertainty about the magnitude of changes that will result from climate change, which makes it difficult to consider. However, the potential consequences of climate changes on such topics as tailing site facilities, water availability, and culvert failure seem appropriate. It will also be important to consider potential impacts of climate change so their signal can be distinguished from potential mine impacts during any monitoring that occurs.

RESPONSE: Climate change projections, including increases in precipitation, are addressed in Chapter 3 of the revised assessment. Projected precipitation increases are used as the basis for a qualitative discussion of the link among changes in precipitation, hydrology, and mining including site facilities, water availability, and culverts (Box 14-2). This box also discusses the importance of monitoring impacts of climate change to distinguish between potential impacts of climate change and potential impacts from the mine.

Charles Wesley Slaughter, Ph.D.

I would simply re-emphasize that a truly comprehensive assessment of the potential consequences of a large-scale mineral extraction project, be it the "hypothetical" Pebble-like project or a different endeavor, should fully consider both the immediate project-specific impacts, and the long-term watershed-wide consequences of "ancillary" developments – such as other mines, which might become economic once the primary project's infrastructure is in place. There should be full recognition of the irreversible nature of such developments, and of the potential and limitations of possible reclamation or mitigation measures for the full suite of resources and ecosystem "services" involved, both short-term and long-term.

RESPONSE: Ecological risk assessments generally have more limited scopes than comprehensive environmental impact statements. This document is not meant to be a comprehensive evaluation of all impacts potentially stemming from a large-scale mine, and its scope has been more clearly defined in Chapter 2. We have added discussion to the cumulative assessment chapter (Chapter 13) to emphasize the long-term watershed-wide consequences of ancillary or induced development. We have added a discussion of compensatory mitigation in Appendix J.

John D. Stednick, Ph.D.

There are several references to streamflow measurements that would be especially helpful to better characterize the site. The US Geological Survey has some streamflow gauging stations and precipitation records that would complement the analysis. Annual precipitation values were derived apparently from a computer model used to analyze global climate change at University of Alaska Fairbanks. How do these data compare to field measurements? The prediction of a 10, 50, 100, or larger event using a short-term precipitation record, results in a larger error term on the predicted streamflow. How common is the occurrence of rain on snow (ROS) streamflow events?

RESPONSE: U.S. Geological Survey and PLP data are presented in Chapter 7 of the assessment. We believe the SNAP data used in the assessment to be the best available for summarizing precipitation inputs to large areas; these data have been updated from the May 2012 draft of the assessment. We used accepted, published data to estimate the size of the probable maximum flood. We do not make estimates of 10, 50, or 100 year events.

Dust production and transport: A variety of mining processes will generate dust. What are the wind patterns, chemical composition, and opportunity to land in surface waters or wetland areas? What potential is there for metal or toxin transport? Overburden removal will require explosives that leave nitrate, ammonia, and often sulfur in the air. What about this transport? Or rain out?

RESPONSE: Stressors evaluated in the assessment were based on how they would significantly affect our primary endpoint of interest (the region's salmon resources) and their relevance to EPA's regulatory authority and decision-making context. Although fugitive dusts from mining operations are a potential source of contamination to streams, and should be considered in a regulatory permitting process, they are not considered as significant as other stressors chosen for the assessment and are not regulated under the Clean Water Act. Discussions of transport dust and associated potential impacts are now included in Chapter 10.

The literature cited is often dated or lacking. The technical review panel has proposed numerous references that can be used to strengthen the document.

RESPONSE: We have reviewed all references suggested by the peer reviewers to the extent possible, and have incorporated information where applicable.

Dr. Paul Whitney

Roy A. Stein, Ph.D.

- **IN PERPETUITY**
  Sustainable Salmon vs. One-Time Mine. Some irony exists as one considers the trade-off between salmon and this mining operation (and make no mistake, we cannot have both mining and productive salmon stocks in the Bristol Bay watershed). We are trading sustainable salmon stocks that, with science-driven management, rigorous regulatory oversight, and limited exploitation, should provide salmon literally 1000s of years into the future against the development of a mine that will provide minerals in the relative short term (within 25 to 78 years). As a result of the mining operation, the government (and likely it will be the state or Federal government) will be saddled with a 1000 years (at a minimum, based on the assessment) of monitoring and maintenance of this closed-mine site.

  RESPONSE: No change suggested or required.

- **MINERAL NEEDS**
- **Strategic Needs.** I was surprised that no section of the Environmental Risk Assessment included any justification for why copper (does mining copper fulfill a strategic need for the United States; most all sites I researched do not list copper as a strategic mineral for our country), gold, molybdenum, and some additional rare earth elements were needed within the context of our economy. Are other sources available? Are these specific elements in short supply? Are they required for the United States to compete in worldwide markets regarding cell phones, other electronic devices, or solar panels? For example, rhenium is used in the aviation industry and some web sites suggest it is critical to our defense industry. Some justification would have helped me understand this huge undertaking.

  RESPONSE: The EPA agrees that the strategic need for these resources should be discussed in the broader NEPA environmental assessment process, but this topic is beyond the scope of this assessment.

- **ORGANIZATIONAL ISSUES**
  Page 5-59. I struggled throughout the document with organizational issues. As I read more and more text, I had the sense that I had read these facts or these perspectives previously. I mention this above but it is here on page 5-59 that the issue is nicely summarized. Note the text in the last paragraph of the page, where it discusses all of the important issues associated with roads and stream crossings. My suggestion would be that these sections (for every topic) be combined such that one section would exist for Roads, one for the Pipelines, etc. In so doing, the reader can capture all of the relevant information about a specific aspect of the mine in a single section of the report. I believe this would improve impact, readability, and shorten the report substantially (and also serve to reduce what seems to be a fair amount of redundancy).

  RESPONSE: We have reorganized the document in response to this and similar comments to improve readability and clarity.

  Pages 6-10 to 6-11. These pages reflect another example of redundancy. Text to this point discussed and reviewed just how long we might expect the fine sediments to persist in rivers and streams post tailings dam failure. Yet, here again, on pages 6-10 to 6-11, these numbers are reiterated. Combining these sections would help the reader and reduce redundancy.

RESPONSE: The TSF failure analysis was formerly split between two chapters and has now been combined into one (Chapter 9).

Section 6.3, Pages 6-36 to 6-42. Not to beat a dead horse, but in this section, nearly all of the citations to tables and figures are to those tables and figures that are found in sections of the report other than Section 6. This organizational scheme is what makes the report cumbersome to read and follow the logic and the argument.

RESPONSE: The assessment has been completely reorganized, as suggested by reviewers.

William A. Stubblefield, Ph.D.

None

Dirk van Zyl, Ph.D., P.E.

The EPA Assessment mentions twice that "interactions with regional stakeholders" and interactions with members of the Intergovernmental Technical Team were used to refine the analysis, etc. (p. ES-2 and p. 3-6). A robust stakeholder process includes careful documentation of the stakeholders identified during the project (which may include stakeholder mapping), records of meetings (attendee lists, meeting notes, etc.), resolution of differences, etc. The EPA Assessment does not contain any references to any such materials, which implies to me that the stakeholder process was informal and not robust.

RESPONSE: Details on stakeholder involvement in the assessment process have been added in Box 1-1.

Phyllis K. Weber Scannell, Ph.D.

At present, Pebble remains a prospect and there is no plan of operations for the mine. Should the project move forward to development of a mine, it will be necessary to develop an in-depth mining plan of operations. The mining plan should include the following:

- Transportation – of equipment and personnel and for shipping ore. Transportation of ore, including loading facilities, wheel washing, and other measures to prevent ore spillage and contamination.
- Siting of mine facilities, including tailings ponds, waste rock storage areas, concentrate storage area, bypass systems for clean water, and collection systems for contaminated water.
- Mill operations, including a description of the process for concentrating ore.
- Chemical and fuel storage and Spill Prevention and Contingency Plans.
- Personnel housing, including handling of domestic waste (sewage, garbage).

Dr. Paul Whitney

- Water treatment plant. Processes that will be used, anticipated concentrations of metals and TDS, anticipated discharge volumes, and predicted mass loadings.
- Monitoring plans for seepage from tailings ponds, waste rock storage areas, etc. Monitoring likely will include a series of wells and possibly, a pump-back system.
- Predictions for acid rock generation and measures that will be put in place during mining to minimize future seepage from the mine site.
- Plans for concurrent reclamation and future closure of the mine.
- Specifications for sufficient bonding to provide site stabilization and water treatment in the event of a premature or temporary shut-down and reclamation at closure.

RESPONSE: The commenter is correct that these are important points that should be considered in evaluation of a mining plan once submitted. No change suggested or required.

After the Mine Plan of Operations is developed, an environmental assessment plan should be developed that identifies potential effects to fish and wildlife and their habitats from specific components of the mine (as listed above). In addition, the assessment should include cumulative effects of nearby mines (if appropriate) on fish and wildlife habitats and water quality.

RESPONSE: The commenter is correct and we would expect these things to be considered during the regulatory permitting process. No change suggested or required.

Among the most important issues that must be addressed are transportation, potential for acid mine drainage and metals leachate, control of point and non-point pollution, and developing the mine for future closure.

RESPONSE: The commenter is correct and we would expect these things to be considered in more detail during the regulatory permitting process. No change suggested or required.

Paul Whitney, Ph.D.

Here are a number of other comments that do not fit neatly under the first 13 questions:

1. Unquantifiable wetland and riparian loss. There are many parameters that are supposedly unquantifiable. An example "unquantifiable" parameter is the area of riparian floodplain (page ES-14). Another example is the "unquantifiable area of riparian floodplain and wetland habitat that would be lost…" (page 8-2, first sentence). There are many methods to characterize or delineate riparian floodplain and wetland. For example, information in Table 5-23 and associated text on page 5-69 characterize wetland loss within 100 and 200 meters of the road. This is a rather crude method but it is at least an estimate. Perhaps it would be accurate to say that the area of riparian floodplain and wetland habitat lost was not characterized. Such a statement would be more internally consistent with statements that the natural system is "incompletely characterized" (page ES-25). Better yet, characterize the wetland and riparian habitat losses using one of the many existing methods. Section 8.2 is a good start. An explicit list of wetland and riparian loss estimates seems important for an EPA review. Once a list of potential wetland and riparian losses is tallied, the next question is whether or not it would be possible to compensate for such an impact. If it is not possible, it might not be possible to achieve no net loss of wetland

resources.

RESPONSE: The EPA agrees that greater quantification of wetland and riparian losses is essential for the NEPA and permitting processes that oversee compensatory mitigation and "no net loss". This assessment is based on existing information (including wetland inventories) and, as the commenter has pointed out, reveals the areas where existing information is lacking.

2. <u>Combinations and Permutations of analyses.</u> The review of the assessment is somewhat complicated by the relationship of certain analyses to following analyses and so on. Take, for example, the use of the Mount St. Helens eruption as a surrogate for a tailings dam failure. One could assume that such an analogy is inappropriate and recommend that it be deleted from the assessment. If this recommendation was followed for an initial baseline, all subsequent information on distance moved, toxicity, remediation, and duration of impact would no longer apply and would presumably be deleted. Alternatively, EPA might further develop the Mount St. Helens eruption analogy and demonstrate why it is a useful part of the assessment. If this is the case, the related following (i.e., secondary) information presented on distance moved, toxicity, remediation, and duration would be retained. Then, it is appropriate for a reviewer to comment on the adequacy of the following secondary information. Then, it is a possibility that the secondary or following information is not accurate and the reviewer has to consider that it could be dropped or retained. Soon, a reviewer of the assessment document is wondering how to address an unwieldy and hard to follow combination of initial, secondary, and tertiary events. More likely than not, most reviewers do not consider all the combinations and recommendations. As a result, the reviewers' comments could fall short of adequately addressing the restructuring of the main assessment. In short, EPA should not assume that following the reviewers' comments will result in an assessment that addresses the next iteration of initial, secondary, and tertiary comments.

   RESPONSE: The EPA believes that this comment raises an important point. We did delete the analogy to Mount Saint Helens ash, as recommended by other peer reviewers. However, as the comment indicates, that leaves the assessment with no analysis of recovery of salmonid streams from the deposition of large volumes of fine particulate material.

3. <u>Address all levels of ecology.</u> Ecological resources can be characterized at many levels of organization. Populations are often characterized by birth and death rates. Communities are often characterized by species diversity, succession, and associations of species. Ecosystems are often characterized by structure, function, nutrient cycling, and energy flow. From a wildlife perspective, the assessment does a fine job of discussing marine-derived nutrients but concludes that "…the fish mediated risk to wildlife – cannot be quantified given available data…" The assessment could be improved if information regarding community and ecosystem parameters were quantified (or at least addressed at the level that marine-derived nutrients were addressed). Woolington (2009) comments on the importance of certain seral stages for wildlife. I am confident that an interview with him, reclamation specialists, and others at ADF&G could provide a lot of information on community succession, plant diversity, and wildlife habitat relationships. This information, in addition to the insight provided in Appendix C, would provide a much

better understanding of possible mine impacts and opportunities for compensatory mitigation. It is also possible that traditional knowledge of villagers might provide insight to understanding plant community and ecosystem parameters.

RESPONSE: Ecological risk assessments are not intended to address all levels of biological organization. Rather, as described in the Guidelines for Ecological Risk Assessment (USEPA 1998), they focus on a limited number of assessment endpoints that are most likely to influence a decision because of their importance and susceptibility. The endpoints were selected in consultation with stakeholders and decision makers. Further, even if more consideration of the effects of marine-derived nutrients on terrestrial plant communities were included, the salmon-mediated effects of the mine on wildlife still could not be quantified. We have clarified the assessment scope, and recognize that numerous other important ecosystem components also could be affected.

4. Ecosystem evaluation. The Ecosystem Integrity Section (2.3.5) seems to miss the mark. It mentions the "nearly pristine conditions," with the caveat that approximately 70% of salmon returning to spawn are commercially harvested. This is then described as a managed and sustainable landscape. Maintaining a sustainable resource is not an accurate characterization of a nearly pristine ecosystem. First of all, sustainability means a lot of different things to different people. For example, forests in the Pacific Northwest are managed in a sustainable way but the ecosystem is hardly pristine. Hilborn (2005) discusses the multiple definitions of sustainability. Instead of deciding which definition he likes the best, he indicates that sustainability is like good art – it's hard to describe but we know it when we see it. Second, Hilborn (2005) states: "The record shows clearly that almost all forms of human activity – agriculture, forestry, urbanization, industrialization, and migration – reduce biodiversity of natural flora and fauna. This is almost certainly the case with fishing as well." Hilborn acknowledges the sustainability of the Bristol Bay fishery but I doubt if he would claim that there is no impact of the fishery on the ecosystem of Bristol Bay.

RESPONSE: Additional information on commercial fisheries management has been added to Chapter 5 of the revised assessment. However, the purpose of this assessment is not to assess the relative effects of potential mining and commercial fishing—it is to evaluate potential effects on endpoints if a mine were to be developed, given existing conditions and activities in the region.

PHW Response: Hilborn clearly states that fishing most certainly has a negative impact on biodiversity which is a negative impact. The negative past, current and future impact of the Bristol Bay Fishery should be addressed in the Cumulative Impact Analysis.

Rather than emphasizing the nearly pristine conditions and sustainability of the fishery, I suggest that other measureable characterizations of the aquatic and terrestrial ecosystem be measured and quantified. For example, a description of plant communities and succession would provide the reader with a better understanding of how plant communities are naturally maintained, and subsequently, how possible mining activities might alter the successional processes. Failure to address and understand such relationships led to unexpected consequences for down stream plant communities, wildlife diversity, and village residents in the Peace Athabasca (Cordes 1975) Delta when the Bennett Dam was built hundreds of miles up stream on the Peace River. The drastic changes in the ecosystem function were related to changes in just a few inches of water in the delta at certain times of the year. The Bristol Bay assessment would be improved if the expected changes in the hydrographs and sediment transport were related to the successional processes that maintain early successional plant associations such as the alder-willow association, which is important for moose. The write up for moose (Appendix C, page 33) indicates that these early successional associations are maintained by bank scouring. It would be good to know the role of ice dams and anchor ice on current levels of scouring and how changes due to mining might alter these important sustainable functions. The assessment's emphasis on fish and fish mediated impacts runs the risk of missing possible impacts on the terrestrial environment and down stream sedimentation that would not only influence human culture but also the aquatic environment. The impact on terrestrial resources and wildlife is not inconsequential to aquatic resources, at least in my opinion. Throughout my evaluation, I cite references that discuss the importance of specific associations between fish and wildlife.

RESPONSE: A comprehensive assessment of potential impacts of large-scale mining would need to consider all levels of ecological organization. The scope of this assessment, however, is much narrower, as described throughout the problem formulation chapters (Chapters 1-6). We clarified the assessment scope, and recognize that numerous other important ecosystem components also could be affected.

5. <u>Multi-directional fish and wildlife relationships</u>. The assessment's emphasis on marine-derived nutrients and the reduction of this salmon-derived resource only looks at a one-way fish to wildlife interaction. Wildlife to fish functions, such as beaver dam building, are very important wildlife to fish interactions. Both salmonid fish, as well as forage fish, receive benefits from beaver functions such as tree felling, dam building, and food storage (Snodgrass and Meffe, 1997; Schlosser and Kallemeyn, 2000). This issue is briefly mentioned in Section 5.2.1.2 (para 1) and discussed on pages 5-19 and 5-22, but needs to be expanded to address the benefits for fish. The dynamic process of dam construction and dam decay is important, not only for moving streams across the flood plain, but also for creating a mosaic of plant associations and wildlife (e.g., moose) habitat in and near the floodplain. In addition, such activities create a mosaic of habitat for forage fish. An accurate characterization of the impact of a potential mine and road necessitates, not only an assessment of the loss of fish on wildlife, but also the loss of wildlife and their functions on fish. The influence of wildlife and terrestrial processes and functions on fish discussed in the Cederholm papers needs to be included in the problem formulation step. The dynamic process of beaver dams causing creeks to move across the floodplain should also be a criteria for determining if and where culverts , versus bridges or causeways) are installed for a potential road (pages 4-36 and 4-63).

RESPONSE: Additional text has been added discussing the functional role of beaver dams in Chapter 7. The discussion of wildlife in Chapter 5 has been expanded to acknowledge the complexity of fish/wildlife interactions in the watersheds. Please note

that the assessment does not use beaver activity as a criterion for determining what type of structure (bridge vs. culvert) would be constructed at each crossing. The revised assessment assumes that crossings over streams with mean annual flows greater than 0.15m^3/s would be bridged. However, the actual decision as to what type of structure would be constructed at each crossing would be made by industry engineers in consultation with state permitting staff.

PHW Response: Go Beavers!!! Nice job.

Formatted: Font: Not Bold, Not Italic

6. (i.e.Measuring fish wildlife interactions. Understanding and addressing the multi-directional interaction of fish and wildlife are facilitated by an approach developed by the Northwest Habitat Institute, introduced in Johnson and O'Neil (2000) and elaborated on the Northwest Habitat Institute web site (nwhi.org). The Interactive Biodiversity Information System (IBIS) database allows an assessment of fish and wildlife interactions and functional characterizations (i.e., ecosystem functions). The IBIS database is a logical extension of the Jack Ward Thomas Wildlife Habitat Relationships and the GAP analysis for the Pacific Northwest. Such an analysis could build on information in the Alaska GAP database and the Natural Heritage Program database in Alaska.

   RESPONSE: A comprehensive assessment of potential impact of large-scale mining would need to consider all levels of ecological organization and interaction. The scope of this assessment, however, is much narrower, as described throughout the problem formulation chapters (Chapters 1-6). We clarified the assessment scope, and recognize that numerous other important ecosystem components also could be affected.

7. Ecological risk assessment for toxic chemicals. The amount of information in the assessment pertaining to ecological toxics risk is impressively large. The amount of time and team expertise needed to adequately review this information is well beyond the scope of the proposed review. If a team was assembled to review this information, I would ask them to consider:

   a. The applicability of a probabilistic risk assessment to address some of the uncertainty associated with the deterministic information presented in the assessment;
   b. Stressors in addition to toxics (e.g., habitat loss, noise, human disturbance, light, and water warming in the winter); and
   c. The relationship of stressors to populations in addition to no observed effect levels.

   I have worked on large scale impact assessments where the stress of habitat loss far exceeds the potential stress of toxics. I would think EPA would want to know whether or not this is the case for the example mine in their assessment.

   RESPONSE: The revised assessment evaluates the potential impacts from habitat loss and toxic releases from plausible mine scenarios based on existing information about the watersheds. The review panel includes an expert on aquatic toxicology who did provide an excellent review of that material.

   PHW Response: Stubblefield is an excellent resource but I don't recall him assessing the relative importance of toxic risk to loss of habitat risk. I remember asking Stubblefield during one of the Anchorage Meetings with the peer group: Should risk to habitat be addressed in an ecological risk assessment". He said yes. So it seems that a salmon endpoint based on habitat should be considered jointly with the toxicological component of the risk assessment.

The first draft mentioned gold as a resource but after talking to other peer reviewers I was assured that gold ore would not be processed on site. The revised draft indicates that pyrite tailings would be processed on site using a cyanide heap leach process. Given this addition, it seems appropriate to mention the possibility of an accident while transporting cyanide to the processing site. Similar analyses for the Crown Jewel Project in Washington indicated a cyanide transportation spill into or near a creek would have acute short-term impacts for many miles downstream. I would like to know if ethyl xanthate, the primary chemical of concern in the revised assessment, is more toxic than cyanide?

Formatted: Font: Not Bold, Not Italic

8. My only regret in this review is that I could not visit the proposed mine site and watersheds during the summer and the winter. I have flown over the Bristol Bay watersheds while working for other mines in Alaska, but I have never been on the ground in these watersheds. I am concerned that if I did visit the proposed sites my assessment points above might change and even change dramatically. It is hoped that all the EPA staff and biologists working on the assessment are able to visit the watersheds in the summer and winter.

   RESPONSE: No changes suggested or required.

3. SPECIFIC OBSERVATIONS

[NOTE: in the page notations below, S = Section, P = Paragraph, L = line]

David A. Atkins, M.S.

1. Global: All significant figures should be reviewed to make sure they are reflective of the level of uncertainty (i.e., using an estimate of 141.4 km of streams eliminated when this value is probably realistically +/- 50%).

   RESPONSE: All significant figures in calculations and measurements made by EPA have been reviewed and changed to reflect the uncertainty of the analysis. For example km of stream is reported to the km. Significant figures from cited documents are as reported in the document.

2. Global: Many references cited in the text are not included in the reference list.

   RESPONSE: References have been updated.

3. Global: The executive summary, main report, and appendices, in many instances, present different information with sometimes different implications. These three levels of detail of information should be more cohesive.

Dr. Paul Whitney

RESPONSE: We have re-written the executive summary and main report to make them more consistent with each other and the appendices.

4. Page ES-24 (P2): Suggest changing 'Cumulative Risks' to 'Cumulative Effects of Multiple Mine Development.'

   RESPONSE: The title of the chapter (now Chapter 13 was changed.

5. Page 3-2 (P1): The justification for excluding ancillary development from the assessment should be better explained. In some instances, opening up an area for natural resource development has had as much or more impact on the environment and ecosystems as the development itself (for example, oil and gas development in some areas of the Amazon Basin)

   RESPONSE: Discussion of ancillary mining infrastructure (in addition to the pit, TSFs, waste rock piles, roads and pipelines) has been added to Box 6-1, and discussion of induced development (development which follows initial development in an unimproved setting) has been added to Chapter 13.

6. Page 3-7 to 3-11: The conceptual models are quite helpful, but are not referenced or utilized sufficiently when discussing impacts. It would be helpful to more fully incorporate them into the assessment.

   RESPONSE: Sub-components of the conceptual models have been included at the outset of the risk analysis chapters, to better frame the pathways evaluated in each chapter.

7. Page 4-1 (P1, L9): Why does the assessment describe current 'good' and not 'best' practice? The rationale for this decision needs to be described. In addition, it is likely that anything other than 'best' practice would not be permitted in this context.

   RESPONSE: With regard to the terminology of "best", "good", or other terms for the practices used, what was intended to be conveyed in the assessment is that we assumed modern mining technology and operations. The terms are qualitative when generally interpreted, or have a regulatory meaning. The term "best management practices" is a term generally applied to specific measures for managing non-point source runoff from storm water (40 CFR Part 130.2(m)). Measures for minimizing and controlling sources of pollution in other situations are referred to as best practices, state of the practice, good practice, conventional, or simply mitigation measures. We have added a text box in the revision Chapter 4 to discuss terms. Mitigation measures considered feasible, appropriate, and 'permittable' (as per Ghaffari et al. 2011) were considered in the assessment, and these are measures common to other copper porphyry mines.

8. Page 4-11 (P3, L10): The liner lifetime is quite low, and given the importance of this assumption, would warrant more than a personal communication that does not appear in the references (North pers. comm.).

   RESPONSE: The discussion of liners has been expanded and moved to Chapter 4 (Section 4.2.3.4) in the revision. The personal communication reference has been removed.

Dr. Paul Whitney

9. Page 4-21 (P1, L4): Is the assumption about the TSF locations from the authors or from the Wardrop 43-101 report?

   RESPONSE: The location of the TSFs is a combination of alternative sites described in Ghaffari et al. 2011 (the Wardrop report), in the NDM 2006 Water Rights Application (see reference list for Chapter 6), and our knowledge of site characteristics suitable for tailings impoundments.

10. Page 4-26 (S4.3.7-Water Managment): It would help to provide appropriate ranges for numbers (e.g., the precipitation at the mine and TDF is 803 and 804 mm/yr, respectively, which implies an unrealistic degree of certainty). It would also be helpful to include a diagram. I am uncertain why 'cooling tower' water losses would be included in the mine water balance since power generation would likely be at a remote location and other impacts from power generation are not considered in this assessment.

    RESPONSE: In general, we have presented our best estimates for the parameter values discussed in the assessment and have used these estimates in our analyses and calculations. A full uncertainty analysis is beyond the scope of this assessment, so we have provided ranges only for critical parameters such as the mine size. We followed the Ghaffari et al. (2011) mine plan in placing power generation on the site, which is the reason for the natural gas pipeline. Therefore, water use for cooling is appropriate.

    Net precipitation at the mine site has been recalculated. The monthly mean flows for each gage were summed across the year, producing an area-weighted average of 860 mm/yr. Ghaffari et al. (2011) describe the construction of a combined-cycle natural gas-fired gas turbine power plant at the mine site and estimate the cooling tower evaporative and drift losses from the plant. The cooling tower losses were included because they would constitute a substantial consumptive water use.

11. Page 4-31 (P3, L6): How was the filling time of 100 to 300 years for the pit estimated? What constitutes full (e.g., within x% of the pre-mining water table)?

    RESPONSE: The filling time was calculated from the estimated inflow rate to the empty pit. Most of the groundwater infiltration would come from the uppermost 100 m and the direct precipitation rate would be constant, so the filling rate would not decrease significantly until the water level was close to the surface compared to the pit depths. We recognize that as the water level approached the surface, the cone of depression would shrink and the filling rate would decrease. We have not attempted to refine our analysis to account for this decrease in rate and the available data do not merit such a refinement.

    The filling time was simply calculated by dividing the pit volume by the inflow rate. In practice, when the pit was full the pit level would be maintained below the overflow level by pumping if treatment were required or be allowed to establish a natural outlet at its low point if treatment was not necessary.

12. Page 4-52: The PMP is based on the Miller (1963) reference (not included in the reference list). How was it estimated?

    RESPONSE: The PMP was based on Technical Paper No. 47 (http://www.nws.noaa.gov/oh/hdsc/PMP_documents/TP47.pdf). This PMP was used as the

precipitation input to a Type-1 (for Alaska) HEC-HMS simulation to calculate a runoff hydrograph. 291 cms was determined to be the peak discharge from this 24-hour design storm.

13. Page 5-22: Should refer to 'recapture efficiency' rather than 'recovery rate'. How were the values of 16% and 63% derived?

    RESPONSE: The words "recovery rate" were meant to be descriptive and not as a defined technical term. There is no standard term in widespread usage for the parameter reported (i.e. the percentage of excess water available for reintroduction into the streams versus the total amount captured by the mine processes). In the revised assessment, we have changed the wording to "reintroduced" (Table 6-3, Section 6.1.2.5). The reintroduction percentages were calculated as part of the water balance. The water balance totaled all the sources of water captured per year and then subtracted all of the annual consumptive water losses. The remaining annual volume of water is excess water that the mine does not need for operations and which is available for reintroduction to the streams. The ratio of the annual reintroduced volume to the annual captured volume yields the reintroduction percentage.

14. Page 5-23: The mean annual unit runoff values are not reproducible from the values given for drainage area and measured mean annual flow.

    RESPONSE: These values have been corrected.

15. Page 5-32 to 5-39: Tables showing flow changes for different mine sizes and figures for minimum mine size are difficult to interpret. A different presentation method and/or narrative description would help.

    RESPONSE: Tables, figures, and text for this section have been revised.

16. Page 5-45 (S5.2.3): The preceding section (Section 5.2.2) focuses on 'Effects of Downstream Flow Changes' and Section 5.2.3 focuses on wastewater treatment. It is not clear why this is the sole focus of Section 5.2.3. In addition, only a short paragraph is included in this section. Certainly there are other possible risks beyond water treatment, and even this discussion is too cursory given the importance of the issue.

    RESPONSE: Discussion of water treatment has been expanded in Chapter 8 (a new chapter in the revised assessment).

17. Page 5-45 (S5.2.4): This section states a number of assumptions that could result in under or over estimating impacts on stream flow from the mine footprint. This section leaves the impression there is a lot of uncertainty, both with assumptions behind the estimation and with how successful any attempts at mitigation may be. Therefore, we are left with very large error bars on estimates that should be reflected in the numbers presented for loss of length of streams and areas of wetlands.

    RESPONSE: We have improved the rigor of the analyses regarding the impact of mining on streamflow. We have attempted to be very explicit about our assumptions and approaches, and we believe the analyses are appropriate and defensible.

Dr. Paul Whitney

18. Page 5-46 (P3): This paragraph discusses the possibility that estimates of stream length blocked by mine construction may be overestimated if engineered diversion channels are successful. This is an important form of mitigation that needs to be evaluated further. It would be helpful to evaluate mitigation efforts in similar types of systems to determine if reconstructing streams is feasible and could be successful.

    RESPONSE: Appendix J includes a discussion of the efficacy of constructed spawning channels. There is little evidence in the scientific literature to suggest that such channels are effective at creating suitable spawning habitat. Furthermore, there is nothing in the scientific literature that suggests salmon streams could be successfully reconstructed in landscapes where significant alternations in area soils, hydrology and groundwater flow paths have occurred, such as would be the case with the mine scenarios described in the assessment.

19. Page 5-59 (Bullet 4): Whole effluent toxicity (WET) testing and downstream biotic community monitoring would likely be part of any discharge permit. This requirement would not preclude developing a better understanding of protective discharge chemistry and temperature requirements before permitting, especially given the quality of the receiving water.

    RESPONSE: Appropriate WET testing and downstream biotic monitoring would be desirable if a mine were permitted. Additional studies of site specific chemistry and temperature tolerances may also be desirable. No change required.

20. Page 5-60 (S5.4.2): The statement that mine traffic will not be a large enough volume to affect runoff needs support. Do we know the road will only be used for mine traffic? Can we estimate the volume of mine traffic for a mine of this size and then look at runoff from an analog system?

    RESPONSE: This statement has been deleted from the assessment. However, we found no analogous data that would allow us to quantify runoff.

21. Page 5-60 (S5.4.4.1): How was the number of stream crossings determined (e.g., what criteria were used to define a stream vs. a channel)?

    RESPONSE: All USGS designated streams were included. No artificial channels were identified and all natural channels are streams.

22. Page 5-65 to 5-68 (S5.4.8.2): Text states that 240 km of stream upstream of the transportation corridor has a gradient greater than 10% and, therefore, is likely to support fish. Should this be less than 10% (as stated in the header to Table 5-22 and Table 6-9)? If so, how was the <10% value chosen?

    RESPONSE: The comment is correct, though in the revised assessment we use <12% as the criterion and cite a relevant source.

23. Page 5-74 (S5.5): Salmon-mediated effects on wildlife seems under-analyzed in the report, particularly when compared to the information presented in Appendix C.

Dr. Paul Whitney

RESPONSE: The discussion of potential salmon-mediated effects on wildlife has been expanded (Chapter 12).

24. Page 5-75 (S5.6): As above, salmon-mediated effects on Alaska Native Cultures seems under-analyzed in the report, particularly when compared to the information presented in Appendix D.

    RESPONSE: The discussion of potential salmon-mediated effects on Alaska Native cultures has been expanded (Chapter 12).

25. Page 6-3 (S6.1.2.1): I don't find the Mt. St. Helens analogy useful.

    RESPONSE: It has been removed.

26. Page 6-9 (P1, L1): Why would 'present' resident and anadromous fish not suffer habitat loss in the event of a TSF failure? Are they upstream of the area inundated?

    RESPONSE: Yes, these populations are upstream of the TSF-affected area. However, they may be impacted by barriers to seasonal movement or fragmented by loss of connectivity. This has been clarified in the text.

27. Page 6-28 (S6.1.5): The 'Weighing Lines of Evidence' section is not well developed and not particularly useful. It also does not inform the risk characterization and uncertainty discussion.

    RESPONSE: The EPA believes that it is important to weigh all relevant lines of evidence. An explicit weighing allows readers and reviewers to see what was weighed and how it was weighted. Such transparency is desirable in general. Therefore, the weighing of evidence has been expanded and the method is better explained.

28. Page 6-30 (P1, L2): The statement that risks of failure of the gas and diesel pipelines are not considered because they are not particularly associated with mining makes no sense. Without the mine, there would be no need for the pipeline. And if the types of failures and risks are well known, then this is one of the areas that could actually be assessed with some degree of certainty.

    RESPONSE: Diesel pipeline failure has been added. A gas pipeline is still not assessed because it is judged to not pose a potentially significant risk to fish (see Chapter 11).

29. Page 6-36 (S6.3, P2): Designating closure as 'premature closure,' 'planned closure,' and 'perpetuity' with water treatment ceasing immediately, continuing until permits are exhausted or water is nontoxic, or until institutions fail does not seem reasonable. Any of these closure scenarios would be planned, and would involve regulatory compliance reviews, bonding, etc. Walking away without continuing to collect and treat water would be an unlikely scenario. The issue of treatment in perpetuity is a larger issue that needs to be treated in detail.

    RESPONSE: The premature closure scenario is intended to address the possibility that the closure plan is not followed. It highlights the need for adequate bonding and for plans that include closure by the bond-holding agency.

Dr. Paul Whitney

30. Page 6-37 (P4, L4): The report states that (acid generating) waste rock could be left in place in the event of premature closure. This scenario should be addressed in the mine closure plan and during the closure bonding process.

    RESPONSE: The premature closure scenario is intended to address the possibility that the closure plan is not followed. It highlights the need for adequate bonding and for plans that include closure by the bond-holding agency.

31. Page 8-1 to 8-2: Given that this chapter discusses overall risk to salmon, it would be helpful to put the estimates of km lost in terms of the total stream or watershed available habitat. We need some context and metric for assessing significance.

    RESPONSE: In Table 2-1, we have explicitly expressed the relative areas of each spatial scale as % of the scale above it (e.g., the % of the entire Bristol Bay watershed made up of the Nushagak and Kvichak River watersheds, the % of the Nushagak and Kvichak River watersheds made up of the mine scenario watersheds, etc.).

32. Page 8-2 (S8.1.2): The focus on a few types of catastrophic failures does not reflect the current typical mining scenario. Based on experience at other mines, it is more likely that smaller-impact failures and accidents would occur during the mine life. It would be helpful to use some current case studies to illustrate this point.

    RESPONSE: The number of possible types, magnitudes and combinations of failures and accidents is virtually infinite. Therefore, we used a bounding strategy. The potential effects are bounded by those of routine operations and a realistic severe failure or accident. We also cite case studies from recent reviews of mining failures and individual failure cases to indicate some of the possibilities.

33. Page 8-3 (T8-1): Why would most concentrate pipeline failures occur between stream and wetland crossings?

    RESPONSE: Most of the transportation corridor is not on or adjacent to a stream or wetland. Therefore, most failures would occur in those areas between stream and wetland crossings.

Steve Buckley, M.S., CPG

1. Page xii: ICF is referred to in the document page xvi, but not listed as acronym or abbreviation.

    RESPONSE: ICF is the name of one of the contracting companies that has worked on the assessment, and is only referred to as ICF in the introductory material (thus is not included as an acronym or abbreviation).

2. Page ES-2 (P2, L5-6): "altered by geologic processes by would not degrade…" is unclear

Dr. Paul Whitney

RESPONSE: Metals do not degrade but their chemical form may be altered (via speciation, binding, formation of salts, etc.). This is explained in the revised Executive Summary.

3. Page ES-24 (P4, L2): "geologic defects" in unclear.

   RESPONSE: This was clarified in the revised assessment.

4. Page 1-1 (P3, L1): "17 existing mine claims…" should read "existing claim blocks"

   RESPONSE: Corrected.

5. Page 4-11 (P3, L10): "North pers. comm." There is no reference, date, or information on North.

   RESPONSE: The discussion of liners has been expanded and moved to Chapter 4 (Section 4.2.3.4) of the revised assessment, and includes additional material and references on liner lifetime. The personal communication reference has been removed.

6. Page 5-20 (P4, L3): The "northeastern United States" not comparable to western Alaska.

   RESPONSE: We agree that these two regions differ in many important ways, but the general patterns of headwater contributions of nutrients and other resources is shared between them, as reflected in the numerous citations of studies from Alaska that follow in this paragraph.

7. Page 7-1 (P1, L5): "claims blocks" should read "claim blocks."

   RESPONSE: Corrected.

8. Page 7-3 (P3, L4): As above

   RESPONSE: Corrected.

9. Page 7-6 (P2, L5): As above

   RESPONSE: Corrected.

10. Page 7-7 (P2, P4): As above

    RESPONSE: Corrected.

11. Page 8-1,2 (P2, P3): In the discussion of removal of stream kilometers and wetlands it would be helpful to express these numbers in a percentage of the overall watershed stream kilometers and wetlands to put perspective on these numbers.

    RESPONSE: In Table 2-1, we have explicitly expressed the relative areas of each spatial scale as % of the scale above it (e.g., the % of the entire Bristol Bay watershed made up of the Nushagak and Kvichak River watersheds, the % of the Nushagak and Kvichak River watersheds made up of the mine scenario watersheds, etc.).

Dr. Paul Whitney

Courtney Carothers, Ph.D.

1. Page ES-2 (P3): "wildlife and the Alaska Native cultures *of this region*."

   RESPONSE: The Executive Summary has been rewritten to incorporate this change.

2. Page ES-5 (P2): "Chief among these resources are world-class commercial, sport, *and subsistence* fisheries for Pacific salmon…"

   RESPONSE: Language added to the revised assessment.

3. Page ES-8 (last P): 1. Should Alutiiq (Sugpiaq) cultural group also be included? Alutiiq residents noted in Igiugig and Kokhanok (Appendix D, p 15). 2. Change 2nd sentence to: "In contrast, the salmon base upon which indigenous peoples in the Pacific Northwest depend is severely threatened."

   RESPONSE: 1. Although there are residents of other cultural groups in the watersheds, the predominant cultures are Yup'ik and Dena'ina, so we have focused on these groups but have added mentioned of the Aleut/Alutiiq. 2. This sentence has been edited.

4. Page ES-9 (P1): "Salmon are integral to the entire way of life in these cultures as subsistence food, *fishing and subsistence-based livelihoods*, and as the foundation for…"

   RESPONSE: Language added to the revised assessment.

5. Page ES-9 (P2): "52% of the subsistence harvest*, although for some communities this proportion is substantially higher*" (e.g., noted to be as high as 82% on pg 93 of Appendix D).

   RESPONSE: Language added to the revised assessment.

6. Page ES-10 (P1): Could also add replacement value for subsistence resources or for salmon, and the range of estimates for economic valuation of subsistence presented in Appendix E, noting of that economic valuations do not fully capture the value of these practices.

   RESPONSE: Language added to the revised assessment.

7. Page ES-14 (#1): Are these all the fish spp. at risk, or only the one deemed to be commercially, recreationally valuable? Subsistence spp also include others. Should make clear what the focus is.

   RESPONSE: This sentence refers to the sockeye being particularly at risk because they spawn and rear below the road. Commercial or recreational value is not considered.

8. Page ES-23 (P3): As noted above, other mines in Alaska (e.g., Red Dog) and oil and gas development studies on North Slope may be useful to include predictions about how subsistence practices will change with mining development and perceived impacts. Including citations with these statements would be helpful.

   RESPONSE: Chapter 12 has been expanded to include discussions of and references to studies of impacts to subsistence practices from resource extraction industries.

Dr. Paul Whitney

9. Page ES-23,24 (last P): "if salmon quality or quantity is adversely affected *(or perceived to be affected*)"

   RESPONSE: Language added to the revised assessment.

10. Page ES-26 (last bullet): There is much data on cultural disruptions caused by the Exxon Valdez oil spill, and cumulative effects of oil and gas development in North Slope region, current salmon shortages in Yukon-Kuskowkim. Clearly subsistence is not about lost food, but about lost lifeways, loss of practices, loss of teaching/learning, and loss of identity. This point could be made more forcefully. While the specific impacts may not be entirely predictable, there are likely outcomes that could be included based on experiences in other regions of the state and/or world.

    RESPONSE: The point suggested was made more forcefully in Chapter 12 of the revised assessment.

11. Page 1-2 (P2): "this assessment does not provide an economic *or social* cost/benefit analysis…"

    RESPONSE: Language added to the revised assessment.

12. Page 2-15 (P1): Other important subsistence fish spp not listed in Table 2-5, e.g., whitefish and winter freshwater fish are listed as integral subsistence species in Appendix D. Again make focus here clear.

    RESPONSE: Scope of the assessment and the specific assessment endpoints considered have been clarified in Chapters 2 and 5. Table 5-1 has been incorporated from Appendix B to give a more complete view of the fish species found in the watershed.

13. Page 2-18 (S2.2.4): The net economic valuation ranges presented in Table 73, Appendix E would be helpful to include here.

    RESPONSE: Because the assessment is not meant to be a cost-benefit analysis, we only briefly consider the economic value of the assessment endpoints. In addition, Table 73 deals with the economic value of moose, caribou, and brown bear, which are only considered in terms of fish-mediated effects.

14. Page 2-19 (last sentence): "because no alternative food sources are economic viable." This is a bit of a misrepresentation. The point is that people choose to live subsistence lifestyles. Even if food at the stores was cheap, many would choose not to substitute for subsistence hunting, fishing and gathering. This narrow economic framing misses the cultural and lifestyle component of subsistence, and frames it merely as food procurement. This is not the case throughout the document, but in this instance I would suggest changing this sentence to reflect the irreplaceability of the subsistence lifestyle (dependent on access to high-quality foods) rather than the economic viability of substituting alternative food sources.

    RESPONSE: The revised assessment expands the discussion of the cultural and lifestyle importance of subsistence (Chapters 5 and 12). The economic viability of alternative foods is mentioned in Chapter 12, but in the context of a variety of benefits of subsistence.

Dr. Paul Whitney

15. Page 2-20 (first sentence): Here and in Appendix D, the legal framework for federal and state definitions of subsistence should be clarified. Several times in Appendix D an indigenous subsistence priority is noted (e.g., pg 88: "No other state in the United States so broadly grants a subsistence priority to wild foods to indigenous peoples as does Alaska."). The authors should clarify what they mean by indigenous preference (i.e., as opposed to rural preference?) in state and federal subsistence management. They should include particular references and additional clarifying information.

    RESPONSE: Citations were included in Appendix D in response to this comment.

16. Page 3-2 (P1): "would be benign or have no effect on the environmental *or social systems,*"

    RESPONSE: Discussion of scope has been rewritten (Chapter 2).

17. Page 3-4 (P1): "…provide subsistence for Alaska Natives *and others*." Particularly because subsistence is defined as a rural right in Alaska, all subsistence users should be included as potentially affected groups.

    RESPONSE: References to non-Alaska Natives who practice a subsistence way of life have been included in the assessment. However, the focus remains on Alaska Natives.

18. Page 3-11 (Fig 3-2E): This conceptual model appears less developed than the others. It would interesting to work on expanding it out to include missing dimensions; e.g., add health and healing activity (in addition to nutrition), cultural continuity (alongside social relations and linked to language and traditional ways of teaching). With a decrease in economic opportunities comes an increase in reliance on transfer payments. Overall it is a nice illustration, but strikes me as less complete than the others.

    RESPONSE: The conceptual model has been revised and expanded in response to this comment.

19. Page 4-15 (Table 4-3): Estimation of 200,000 metric tons of ore processed per day is much higher rate than any of the other mining operations listed in Table 4-4. Is this due to the low/moderate quality of the ore?

    RESPONSE: Initially, EPA utilized the ore production rate that was available in Ghaffari et al. (2011), but we have added a smaller sized scenario to the revised assessment to be similar to the worldwide median-sized porphyry copper mine. Processing throughput is generally a function of the quality of ore and the cost of mining and processing the ore. Ghaffari et al. (2011) state: "The process is based on conventional grind-crush-float technology, using proven plant equipment of the largest sizes that have been industrially installed", which suggests that mining rates are limited also by the size of proven mineral processing equipment.

20. Page 4-21 (last P): 208 m high dam is "much higher than most existing tailings dams." What are average dam heights? Or how much higher than most existing tailings dams? Does this high height affect probability of failures?

Dr. Paul Whitney

RESPONSE: Table 4-1 presents dam heights at other Alaska mines, all of which are significantly lower than 209 m. Higher dams mean larger impoundments, storing more tailings; thus, if failure occurs, more waste material can be released.

21. Page 4-23 (P2): "a well field spanning the valley floor." This is unclear. Could it be added to Fig 4-7? How often would groundwater be monitored?

    RESPONSE: The revision clarifies this sentence, adding that installation would be at the downstream base of all tailings dams to monitor groundwater flowing into the valley. It was not added to the revised figures primarily to keep the figure from becoming too "busy".

22. Page 5-48 (P1): "effluents would be required to meet criteria." How different is treated discharged water from unaffected water?

    RESPONSE: Estimates of wastewater composition have been added to the assessment (Table 8-9). Background surface water data are presented in Table 8-10.

23. Page 5-59 (2nd bullet): Is there any information available on ore processing chemicals, how much are used, and likely toxicities?

    RESPONSE: The toxicity of sodium ethyl xanthate, the primary processing contaminant of concern, is now considered (Section 8.2.2.5). However, its concentration in tailings and concentrate slurries cannot be estimated with any reasonable confidence due to the lack of publicly available information.

24. Page 5-76 (bullet list): The list of cultural factors that may be negatively impacted could include others: individual, community, and cultural identity; sense of place and place attachments; community sustainability; cultural unity/conflict avoidance.

    RESPONSE: The list of cultural factors that could be negatively impacted was expanded in the revised assessment.

25. Page 6-46 (bullet list): In addition to the two listed, another should be added noted that subsistence practices (harvesting, processing, sharing, consuming) are important for psychological, social, emotional, and cultural health and well-being.

    RESPONSE: This section was clarified to focus on nutritional benefits. The discussion of health benefits from subsistence practices was expanded elsewhere.

26. Page 6-47 (P1): "…the physical, *psychological, social, and cultural* benefits of engaging in a subsistence lifestyle…"

    RESPONSE: Revision made.

27. Page 6-47 (P1): References should be added (and were included earlier in the report) for the statement: "would likely employ a small fraction of Alaska Natives."

    RESPONSE: This section has been revised and references the experience of other Alaska Native communities.

Dr. Paul Whitney

28. COMMENTS SPECIFIC TO APPENDIX D

a. Single-space for consistency with the rest of appendices

RESPONSE: Appendix D has been single spaced.

b. The title is a bit misleading. Only eight pages in the report discuss traditional ecological knowledge, and here not in much depth.

RESPONSE: The TEK section was expanded.

c. The research design, methods, and data analysis should be described in more detail. Clarify sampling procedure (both for communities and individuals). For example, it is unclear if younger generations, particularly active subsistence harvesters, were targeted as well as elders and culture bearers. Interview protocol should be included clearly as an Appendix.

RESPONSE: The methodology section has been expanded. Villages were asked to identify Elders and culture bearers for interviews. Younger generations and/or subsistence harvesters were not targeted but could have been included by villages for interviews.

d. This section may make a few overstatements (e.g., "only in Alaska are wild salmon abundant").

RESPONSE: comment noted and taken into consideration during revisions.

e. P12 – "those outside of the state." Change to "outside the region," as many urban Alaskans are not familiar with subsistence communities.

RESPONSE: The text has been revised.

f. P12 – "Since the questions dealt with a cultural standard, there were few alternative points of views." Should cultural agreement be a matter of investigation rather than assumed? This statement needs to be justified. Perhaps with the authors' 40+ years of experience working with these communities they have come to expect cultural agreement, especially among elders. If this is the case, that should be clarified. To what extent did group interviews (2-6 people interviewed together, except for one single interview) also contribute to cultural agreement? These details are important given that the results are given on an agree/disagree format.

RESPONSE: The text has been revised to clarify this point.

g. P17 – 2,738 is listed in Table 2 and 2,329 is listed here.

RESPONSE: The discrepancy has been corrected.

h. P19 – Here is perhaps another example of overstatement – 100% of the population has access to waters of the rivers and lakes. What is meant here? For subsistence, this access depends upon having transportation and gear or social relations. Do 100% of people have this in this region?

RESPONSE: The text has been revised and a table added to clarify that the topic is access to drinking water.

i. P20 – Reword "the archaeological work is largely due to five projects."

RESPONSE: The text has been revised to clarify.

Dr. Paul Whitney

j. P26 – "located along a salmon stream indicates salmon were *likely* a primary resource."

RESPONSE: Text has been revised.

k. P31-32 – Several of these quotes focus on social changes (e.g., elimination of dog teams, relationships to commercial fishing changing over time). People likely harvest less fish now because they do not support dog teams, yet now they need more money for fuel and equipment. These are important considerations for understanding contemporary mixed economy. These points are mentioned in this cultural characterization, but perhaps could be made a bit more clearly. At times, even the contemporary characterization reads a bit like "timeless" traditional cultural relationships to the land and resources, yet it is important to accurately characterize the subsistence-based communities in their full contemporary realities and complexities.

RESPONSE: The quotes in the section focus on history and culture.

l. P34 – "Large disruptions to the population *have not been documented to* occur until epidemic…"

RESPONSE: Text has been revised to clarify.

m. P34/5 – Both kashgee and qasgiq are used for men's house – it is also defined three times over these first few pages of this section.

RESPONSE: The text was revised.

n. P35 – "earlier bow and arrow wards" should either be explained or omitted.

RESPONSE: Reference omitted from the revised text.

o. P38, first full paragraph, last sentence – What is meant by "observe the practice?" This general statement is not adequately supported. Authors should provide specific instances or more discussion if this point is to be included. As written, it risks conveying a static view of TEK and practice and culture. Many indigenous communities in Alaska, e.g., Kodiak villages, while exploited by a colonial economic system, also strategically adapted to benefit from those systems in ways compatible with their village lifestyles (e.g., cannery and village co-dependencies that elder fishermen in this region remember fondly; Carothers 2010). It would be helpful to have more information on this context in this region (e.g., Hébert 2008; Donkersloot 2005).

RESPONSE: Text omitted from the revised draft.

p. P40 – More information would be useful on Alaska Native participation in commercial fishing in this historic period up through the present.

RESPONSE: Additional reference to Alaska Native participation in commercial fishing has been added to the assessment text.

q. P47-48 – Ellam yua and tnughit are defined twice.

RESPONSE: Comment noted. No change made.

r. P81-84, Table 9 – Second/third part of questions no explained. Since this is an agree/disagree table, remove other questions for which no information is presented. All questions would ideally be contained in an interview protocol attached as an appendix.

RESPONSE: This change has not been made. The authors chose to both identify the interview questions and the summary responses in this table. As identified in the introduction the semi-structured interview format was not a "survey" in which one would ask everyone the same set of questions (as required by structured interview protocol), but the protocol called for respondents to talk about the subject elicited by the question. This is a very standard interview technique in anthropology.

s. P87 – 'non-monetize' – but important to note that the modern subsistence economy now depends upon cash inputs (ATVs, boats, snow machines, gas, parts, repairs, guns, nets, etc.).

RESPONSE: The relationship between the modern subsistence way of life and the market economy has been acknowledged in the appendix and the assessment text.

t. P88 – First full sentence, last sentence poorly worded.

RESPONSE: This section has been slightly reworded for clarity.

u. P89-90 – The subsistence discussion is confusing.

RESPONSE: No suggestions for revisions were made.

v. P92-93, Tables – Update with recent data if possible.

RESPONSE: Tables 12 and 13 contain the most recent data available to the public.

w. P100 – If percentage of working age population not in labor force is a better measure, it should be included rather than official employment rates (or in addition to).

RESPONSE: These data were added to the appendix.

x. P110 – "Villagers in the study also eat store-bought foods, but do not prefer them" – make clear again that most residents interviewed were elders or identified culture bearers. A concern for many subsistence villages in other regions of Alaska is the displacement of younger generations from fish camp and other subsistence practices, and preferences for store foods, particularly candy and soda. If this region is unique in that regard, make that clear here.

RESPONSE: The text was revised to make it clear that the interviewees expressed preference for subsistence foods. The section on nutrition was also expanded.

y. Section C "Physical and Mental Well-being" – Subsistence for emotional/mental health should be added as a sub-section here. Given the high rates of social problems in Alaska Native villages (e.g., suicide, violence, addiction), many cultures talk about subsistence practices as being healing activities or producing emotion, spiritual and/or mental health. This important aspect isn't covered in the other sub-sections.

RESPONSE: The discussion of suicide was expanded and a discussion on behavioral and mental health was added to the "Social Relations" section. The text of the assessment was expanded to acknowledge the social and spiritual aspects of the subsistence way of life.

z. P113 – Makhoul et al. is listed as 2010 in references.

RESPONSE: This error was corrected.

Dr. Paul Whitney

aa. P114 – Change Local Wild Fish *and Local Practices*, and "ecologically, *socially, culturally, spiritually*, and possibly even evolutionarily." Point is that subsistence salmon are not just vehicles for protein and nutrition, but form the basis of incredibly important subsistence ways of life that are irreplaceable.

RESPONSE: The revision was made and the discussion of social and spiritual values of the subsistence way of life was expanded in the appendix and the assessment.

bb. P115 – Add 'cultural and social disruption' to the list of risks.

RESPONSE: This revision was made.

cc. P152, 2nd and last bullet points – These are risks of mining development, not of decreased quality/quantity of fish (defined as outside the scope of this assessment). The last bullet point would apply to fish-effects if reworded – some community members may decide it is not safe to eat fish, causing factions of those who express concern and those who do not. Others to possibly include: cultural loss as younger generations do not learn the practices of subsistence; stress on other areas and communities of the region where people may target subsistence resources; and health risks of eating contaminated fish.

RESPONSE: Comment noted. These topics were discussed in the assessment text (Chapter 12).

dd. P156 – Sing to sign.

RESPONSE: Correction made.

ee. Several grammatical errors throughout.

RESPONSE: Every effort was made to correct grammatical errors.

29. COMMENTS SPECIFIC TO APPENDIX E

a. P9 – Components of total value should include indigenous homeland for Alaska Native cultural groups.

RESPONSE: The value of indigenous homeland and the value of being able to bequest that homeland and cultural traditions onto future generations is included in the net economic value analysis presented in Section 5. Section 5.2 discusses and attempts to quantify the cultural value of engaging in a subsistence livelihood, referred to as the "activity value". Additionally, Section 5.6 discusses the importance of the existence and bequest value of the resource, and the challenges encountered in estimating these values.

b. P12 – Clarify usage of Aleut (Alutiiq/Sugpiaq?).

RESPONSE: The Bristol Bay region includes Alutiiq and Sugpiaq Native Alaskans. This has been clarified in the text of Appendix E.

c. P22 and 26 – Change Boraas citations to Boraas and Knott.

RESPONSE: This change has been incorporated.

d. P32 – Much of recreational use is non-market and could be included in the list at end of 2nd paragraph.

RESPONSE: Because we do estimate the value of recreational fishing, sport hunting, and non-consumptive wildlife viewing, these are not identified as non-market values in this paragraph.

e. P96 – Citation for typical crew share of 10%?

RESPONSE: This estimate is based on the author's interviews with crew members. Appendix E has been revised to make this clear.

f. P122 – Reasons for differences in earnings between local residents and others is important. The mixed subsistence-cash economy and cultural ideas about commercial work in this region may offer an explanation. See: Koslow 1986, Langdon 1986, Carothers 2010.

RESPONSE: These references have been added to Appendix E and a brief discussion has been incorporated in the document.

g. P134 – Ugashik, Egegik, and South Naknek have over 30.

RESPONSE: Thank you for noting that these communities have over 30 permit holders per 100 residents. We have emphasized this in the text.

h. P136, last paragraph – This paragraph seems abrupt/misplaced. A more thorough discussion is needed here to include these points.

RESPONSE: This paragraph describes information in Table 39, which appears immediately below the paragraph. The earnings data in Table 39 is from the US Census as well as the Alaska Commercial Fisheries Entry Commission. As earnings data is limited and the reasons for variation in earnings are not apparent, an additional discussion was not incorporated.

i. P178, Section 4.3 – No discussion of role of regional and village Native corporations or the Community Development Quota program for federally-managed fisheries.

RESPONSE: Section 4.3 provides a broad overview of the economy of the Bristol Bay Region. Although specific entities and programs like the Native corporations and Community Development Quota program are not named, the relative importance of government at a state, regional, and local level is considered. There are many other entities that participate in the economy and government programs that support it. This model of the regional economy does not identify specific government entities or programs.

j. P191 – While the majority of formal sector jobs are taken by nonresidents, may want to note that local economy – subsistence – is all local and highly dependent on resources of the region.

RESPONSE: We appreciate this comment, and this section of Appendix E discusses the local and regional importance of subsistence in paragraph 3. Because this information is covered in detail in paragraph 3, additional information was not incorporated into the paragraph summarizing jobs captured by the market.

k. P193 – 2009 is mentioned as an unrepresentative year and given a sensitivity ranking of "high." More information should be included on the anomalous 2009 – in what direction should we expect to interpret data from this year compared to more average years, or those at other ends of the extremes?

Dr. Paul Whitney

RESPONSE: The yearly variation in the commercial fishing industry is described in detail in Chapter 3. The 2009 fishing data is given a sensitivity rating of high as the data presented in Chapter 4 estimating commercial fishing wages and jobs rely on inputs from the 2009 fishing season.

There is no reason to believe that 2009 is inherently an unrepresentative year for the fishery, but it is impossible to know if it is a representative year for the future performance of the fishery. In order for the wage and job estimates presented in Chapter 4 to be representative of future performance, the 2009 data used to represent the base year would need to also be representative of future performance of the commercial fishery.

To clarify that this is a potential bias as the future of the commercial fishery cannot be predicted, the text associated with this item has been rephrased.

l. P195 – Number of households engaged in subsistence – ADF&G data should provide estimates.

RESPONSE: The analysis relies on data from ADF&G; however, the item listed here identifying the potential bias of the number of households engaged in subsistence acknowledges that the data from ADF&G is purely an estimate. Should the data relied on from ADF&G be found to be inaccurate for some reason, this analysis that relies on those data would be biased accordingly.

m. P198 – ATV, snow machines, should be added to "boats and trucks"; work by Robert Wolfe and others (Wolfe et al. 2009) suggests that about one third of households in Alaska Native villages harvest the majority of subsistence foods (and share, especially with the least active households). How does this finding affect these estimates?

RESPONSE: We recognize that ATVs and snow machines are frequently used in the subsistence harvest. The original data source used to develop these expenditure estimates did not specify expenditures for these machines, and thus they are not identified in the quantified expenditures. In this analysis the total expenditure estimates drive the analysis, not the composition of what these expenditures purchased. Differences in the composition of expenditures would have a negligible bias, as identified in Section 4.8.

The finding from the Wolfe 2009 citation provided above would not affect these findings. This analysis relied on the assumption that all native households are participating in the subsistence harvest, and estimated expenditures based on that assumption. If some native households are more active than others, the expenditures by less active native households will be lower than those estimated here, but this will be offset by higher expenditures by more active native households.

n. P202 – Explain why % of adults with 4+ years of college is used in this model? The model was not explained clearly enough for me to understand it.

RESPONSE: The percentage of adults with four or more years of college education is used in the model along with other relevant regional variables to predict adjusted gross income per capita for each community. This instrumental variable is included in the analysis because it is a variable that is relevant for

predicting adjusted gross income per capita in each community. For additional information on the analysis used, please see Duffield (1997).

o. Some fisheries, e.g., crab fisheries, are not included in the economic analysis, yet depend in part of Bristol Bay ecosystems, as discussed in Appendix F.

RESPONSE: As noted in the assessment, there are other species present that support a commercial fishery, such as the crab fishery the commenter notes. Although Appendix E is predominately focused on the importance of the salmon fishery, some considerations for the commercial and subsistence value of these fisheries is included.

Section 4.3 of Appendix E provides an overview of the regional economy, which fish harvesting and processing. Table 53 estimates employment in the fish harvesting and processing sector. As identified in the footnote to Table 53, these employment estimates include fisheries in addition to the salmon fishery.

Appendix E also acknowledges and considers that subsistence harvests may include species other than salmon. In Section 2.2 of Appendix E the general distribution of subsistence harvest by Bristol Bay residents is presented. As identified in this section, Bristol Bay subsistence harvest includes salmon, non-salmon fish, birds and eggs, vegetation, marine mammals, marine invertebrates, and land mammals. Subsistence expenditures are estimated based on the number of native households and expenditure estimates from Goldsmith (1998). Goldsmith's expenditures consider subsistence expenditures more broadly, thus these other species are included in the economic analysis.

p. References – Peterson et al. 1992 and Brown and Burch 1992 not included in references.

RESPONSE: Change has been incorporated.

30. COMMENTS SPECIFIC TO APPENDIX G

a. Mitigation measures are largely concluded to be ineffective. Would be helpful to compare mitigation measures and their success/failure in other mining examples.

RESPONSE: Appendix G contains available information about mitigation measures generally related to roads and pipelines. Mitigation measures are not specific to mining operations.

31. COMMENTS SPECIFIC TO APPENDIX H

a. P7 – Exposure of groundwater and waterfowl to chemical contaminants are listed as main environmental concerns from tailings storage facilities. Impacts to human health from ingesting contaminated water or birds. Clarify in report that direct risks to human health are not accessed (only through reduction or elimination of subsistence harvests?).

RESPONSE: The assessment language has been clarified to acknowledge that there are potential direct risks to human health, but that the scope of the assessment is limited to potential effects to indigenous cultures related to salmon. An evaluation of human health effects from ingestion of contaminated non-salmon

subsistence foods is not within the scope of the assessment. EPA expects that a full evaluation of any future mining permit applications and subsequent National Environmental Policy Act Environmental Impact Statements would consider these direct effects.

Dennis D. Dauble, Ph.D.

1. Appendix B, Page 30: Table 1. I suggest adding a column to indicate relative abundance, for example, if individual fish species listed are abundant, common or rare. Also, are there known differences in distribution and abundance for the Nushagak and Kvichak watersheds relative to those watersheds unlikely to be affected by mining activities?

   RESPONSE: This information, when known, has been added to Appendix B.

2. Appendix A, Page 42: The statement that diminished salmon runs present a "negative feedback loop" where spawner abundance declines, appears to conflict with the last paragraph on page 41.

   RESPONSE: The text describes bottom-up effects of MDN on stream ecosystems and points out that these linkages have not been empirically established. The negative feedback loop mentioned in the following paragraph could result from reductions in salmon-based resources that promote either bottom-up (i.e., a reduction in salmon-derived N and P) or direct (i.e., a reduction in salmon eggs and flesh that can be consumed by fish) benefits to juvenile fishes. Further, the fact that bottom-up effects of MDN have not been firmly established does not negate considerable circumstantial evidence for bottom-up nutritional deficits in Columbia Basin spawning streams. Edits have been made to help clarify.

3. Appendix F, Page 3: Is there significant sediment transport from the Bristol Bay watershed to the Nushegak and Togiak Bays/estuaries?

   RESPONSE: A new section was added to Appendix F that discusses the importance of estuary habitat to salmon populations.

4. Appendix F, Page 7: What is the juvenile salmon resident time in Bristol Bay? How quickly (and at what size/time of year) do they move from shallow nearshore to offshore habitats?

   RESPONSE: A new section was added to Appendix F that discusses the importance of estuary habitat to salmon populations.

5. Page 8-15 (L2): Suggest deleting "likely." There will be impacts.

   RESPONSE: We believe this language is consistent with the uncertainties explained in the assessment. No change has been made.

Gordon H. Reeves, Ph.D.

1. Page 6-9 (P1): Why would resident fish not "suffer" immediate loss of habitat as a result of

dam failure like anadromous fish would?

RESPONSE: This statement refers to fish located upstream of TSF failure and affected downstream reaches. This has been clarified in the text.

2. Couldn't fish move to another stream if a culvert is blocked and prevents upstream movement? This may eliminate the fish from a particular stream for a year but it might not reduce the overall productivity.

   RESPONSE: This comment is based on the assumption that spawning and rearing habitat are not limiting. We believe that they area.

Charles Wesley Slaughter, Ph.D.

1. Global: Provision of full color versions of all figures would have been helpful to this review. The selected color versions supplied here were useful – we should have had them all.

   RESPONSE: Comment noted.

2. Page 2-4: Color codes are confusing – use of different colors for same "moisture state" in the five regions doesn't make sense (to me).

   RESPONSE: Figure 2-2 (Figure 3-1 in the revised assessment) depicts hydrologic landscapes across the Nushagak and Kvichak watersheds separated into their physiographic divisions as defined by Wahrhaftig (1965), combined with their climate class as defined by Feddema (2005). Each color group (e.g., yellow, green, red, etc) represents a separate physiographic division while color intensity (e.g., light green to dark green) represents the climate class within a given physiographic division. The use of different colors is intended to show the variety of climate classes within a given physiographic division, while also depicting similarities in climate class across different physiographic divisions (e.g., darkest red and darkest green show that two areas having different physiographic characteristics are alike in their climate class).

3. Page 3-4 (S3.4, L1): …when mine ***is*** active

   RESPONSE: Correct (now in Section 4.2.4).

4. Page 4-5 (last P): Refers to Fig. 3-1, but "existing road segments" listed are not shown on Fig. 3-1, nor are several cited locales: Williams Port, Pile Bay, King Salmon, and Naknek.

   RESPONSE: This reference has been deleted.

5. Page 4-11 (first P): "The vast majority of tailings dams are less than 30 m in height…" DOES THIS REFER TO TAILINGS DAMS AT ALL KNOWN MINING OPERATIONS, OR TAILINGS DAMS ENVISIONED OR PROBABLY TO BE USED IN BRISTOL BAY WATERSHED?

RESPONSE: The sentence refers to all known mining operations. The text was changed from "The vast majority of tailings dams..." to "The majority of existing tailings dams..." (Chapter 4).

6. Page 4-11 (first P): "Although upstream construction is considered unsuitable for impoundments intended to be very high or to contain large volumes of water or solids….this method is still routinely employed." ARE THE TSFs SUGGESTED IN THIS ASSESSMENT CONSIDERED "UPSTREAM," "DOWNSTREAM," OR "CENTERLINE"? Para. 1, Section 4.3.5 (p. 4-21), states that "the most plausible sites" for TSFs are "the higher mountain," which suggests that these TSFs would be "upstream" facilities, therefore "considered unsuitable…"

   RESPONSE: The TSFs suggested in the scenarios would be constructed using the downstream method and then switched to a centerline method. It is true that in this location, the upstream construction would be unsuitable. The discussion of the upstream method was intended for background and has been moved to Chapter 4 in the revision, with the scenario-specific suggestions discussed in Chapter 6.

7. Page 4-23 (P2): Text suggests that a monitoring well field downslope from the TSF (and presumably from all hypothetical TSFs) would detect seepage; such seepage would then be intercepted and either returned to the TSF or "treated and released to the stream channel." Either action presupposes adequacy of monitoring seepage and subsurface flow (both spatially and temporally); returning such water to the stream further presupposes fully adequate treatment to meet both regulatory and aquatic biota requirements for water quality and flow regime.

   RESPONSE: Yes, the well fields would be downstream from all embankments for all TSFs and this has been clarified in the revision. It is assumed for the scenarios that mitigation measures are operated appropriately. Text has been clarified in the new Chapter 6 to indicate that water would be treated to meet permit requirements. Scenarios in the revised assessment evaluate effects from uncaptured seepage during routine operations from both the TSFs and waste rock piles.

8. P4-26 to 4-28 (S4.3.7): This "Water Management" section seems cursory, highly generalized, and optimistic. Statements such as "uncontrolled runoff would be eliminated"; "water from these upstream reaches would be diverted around and downstream of the mine where practicable"; and "Precipitation…would be collected and stored…." do not indicate actual (proposed) practices or techniques, nor inspire confidence that actual runoff events during "normal" conditions, let alone during hydrologic extremes (such as a rain-on-snow event with underlying soils still frozen) would be planned for or actually managed adequately.

   RESPONSE: Water management measures are more clearly described and discussed in the revision (Section 6.1.2.5), and in sub-sections for the mine components in the scenarios. Measures are standard and common to existing mine sites.

   Collection and diversion structures would need to be designed and built to handle the anticipated flows over the life of the mine, including during extreme weather events. The details of these collection and conveyance systems are beyond the scope of this assessment

and are more properly in the domain of the permitting process when a specific mine plan is proposed.

9. P4-29 (P1): Suggests that 20% more water than available would be required "during startup," and that difference would be satisfied "from water stored in the TSF"; if 20% more than is available would be needed, where would it come from to be available from the TSF?

   RESPONSE: The water balance has been revised in Chapter 6. The mine operation would capture more water than needed during all phases of operation. Water could be stored in the TSF as soon as the starter embankment is operational. Ghaffari et al. (2011) further explain: "Once the TSF starter embankment construction is complete, site water will be diverted into this facility to ensure adequate make-up water for process plant start-up. At this time, advanced open pit dewatering will commence. This water will either be treated and discharged or diverted to the TSF, depending on environmental requirements."

10. Page 4-29 (P3): Assumptions are very generalized and optimistic: "assuming no water collection and treatment failures" and "excess captured water would be treated…and discharged to nearby streams..." – this assumes both "no failures" over the life of the operation, and that such treated "excess captured water" could be successfully treated before release to fully meet both regulatory water quality criteria and the possibly more sensitive biological requirements of individual invertebrates and fish stocks (Appendices A & B).

    RESPONSE: Water management measures are more clearly described and discussed in the revision in Section 6.1.2.5, and in sub-sections for the mine components in the scenarios. Measures are standard and common to existing mine sites. The revised assessment considers water treatment failure quantitatively and includes refined scenarios with new data for seepage from TSFs and waste rock piles.

11. Section 4.3.8: This and the previous section mention (but in my view, do not adequately stress) the extremely long time frame for post-mining active management and oversight. Many hundreds of years of active management is a longer time than many industrial, corporate or governmental entities are capable of really embracing – witness the current US Congressional practice of "kicking the can down the road" – a human trait.

    RESPONSE: This issue is addressed in Section 4.2.4 of the revised assessment.

12. Page 4-32 (S4.3.8.2, P3): Suggests that pyritic tailings could be "shipped off site" – i.e., to where? Deep ocean dumping, or Yucca Mountain?

    RESPONSE: For smaller amounts of tailings, the option of shipping them to an off-site location for disposal might be an option; however, this is less likely with large mines with high volumes of tailings, so has been removed in the revised assessment.

13. Page 4-34 to 4-37 (S4.3.9): This reviewer finds the short Transportation Corridor sub-chapter to be succinct, but inadequate and superficial in view of the long-term consequences of imposition of the transportation corridor as portrayed. These deficiencies are addressed, in part, in other sectors of the Assessment, most comprehensively in Appendix G.

Dr. Paul Whitney

RESPONSE: The transportation corridor analysis has been substantially expanded, and is now found in its own chapter (Chapter 10).

14. Page 4-38 (Box 4-3, P2): Para. 2 states that the southwest extension of the Lake Clark Fault is currently understood to extend to perhaps 16 +/- km from the Pebble ore deposit; however, this is not reflected in Figure 4-11, which suggests that the Lake Clark Fault terminates perhaps 100 km northeast of the Pebble locale. Elsewhere in Box 4.3, there is acknowledgement that, while there is no evidence of recent tectonic activity in the immediate Pebble vicinity, there is relatively little site-specific data or long-term historical seismic record. I infer that any predictions concerning seismicity or earthquake occurrence of any magnitude would have very high uncertainty.

    RESPONSE: Figure 4-11 (now Figure 3-15) has been revised to more accurately illustrate the current understanding of the terminus of the Lake Clark Fault. Section 3.6 describes the uncertainties in predicting seismicity in the Pebble region.

15. Page 4-41 (Box 4-4): Note that in each of the four tailing dam failure examples, the failed structure was roughly an order of magnitude **smaller** (in height) than the hypothetical TSF-1 structure, yet those failures had major negative consequences.

    RESPONSE: Text was added to Section 9.1.1 in the revised assessment to indicate that the dams in these failure examples were significantly smaller than the dams proposed in our mine scenarios."

16. Page 4-45 to 4-47 (S4.4.2.2): The probability approach to tailing dam failure is unpersuasive as presented. It is difficult to relate to a number like "0.00050 failures per dam year," or to the implication (p. 4-47) that one can expect a tailings dam failure only once in 10,000 to one million "dam years." This could suggest to the casual reader that failure of the hypothesized TSF1 dam (for which one "dam year" is one year) should not be anticipated in either the time of human occupation of North America, or the span of human evolution.

    RESPONSE: The proposed dams, if designed, built, and maintained to current engineering best practices, would be anticipated to have a low annual probability of failure but the failure probability would not be zero. We concur with the commenter that these low probability numbers may be difficult for the casual reader to grasp, so we also present the estimates of probability in terms of probability failure over different time periods. For example, an annual probability of failure of 0.0005 equates to a 5% probability of failure over 100 years and a 39% probability of failure over 1000 years. Text was also added to clarify the basis for our failure rates.

17. Page 4-48 (Box 4-6): Box 4-6 suggests that the Operating Basis Earthquake (OBE) for a 7.5-magnitude event at the Pebble locale has an estimated return period of 200 years. Such a return interval probability is difficult interpret, given the lack of historical seismic record for the region; in any event, such a return period estimate is in no way predictive of future seismic activity, in year 2012 or year 2212.
    Box 4-6 does note that "The return periods stated in Alaska dam safety guidance are inconsistent with the expected conditions for a large porphyry copper mine developed in the Bristol Bay watersheds, and represent a minimal margin of safety..

Dr. Paul Whitney

RESPONSE: The return periods used are consistent with the Alaska Dam Safety Guidance, but the operator could include an additional margin of safety in the design for critical structures. The return period and seismic safety factors do not inform the failure analysis in this assessment.

18. Page 4-50 to 4-60 (S4.4.2.4): The modeled hydrologic consequences of overtopping/flooding of the hypothetical TSF1 dam/reservoir seem reasonable, given the relatively limited hydrologic data set available for model input. Probable Maximum Precipitation and Probable Maximum Flood results should be approximately "correct" and within the same order of magnitude of potential storm and flood events. The potential consequences outlined (peak flow volume, sediment transport and deposition, length of stream corridor impacted) appear realistic for the scenario. I suggest that this topic and hypothetical result should be given more visibility and emphasis in the assessment.

    RESPONSE: The dam failure was modeled as an overtopping event since the possibility could exist. However, the magnitude of the PMP run-off as compared to the resulting failure flood wave is very small. We agree that an actual dam design will consider additional information, but this assessment did not investigate the hydrology of the PMF in greater detail.

19. Page 4-62 to 4-63 (S4.4.4): While accurate, this section does not adequately address the road/stream crossing/culvert issue. Given the projected transportation corridor, Pebble locale to Cook Inlet, and the inevitability of a further network of "minor" roads in the mine and TSF locale, plus additional infrastructure linkages, road/culvert/stream crossings are a major concern for aquatic habitat and fisheries. This issue receives more attention in Sections 5.4 and 6.4, and is mentioned elsewhere in Volume 1 (e.g., Table 8.1, Box 8-1, para. 8.1.2.4.). Readers of the Assessment should be directed to Frissell and Shaftel's Appendix G for a more comprehensive discussion of this important topic.

    RESPONSE: This issue is now analyzed in more detail in its own chapter (Chapter 10). The appendix is cited.

20. Chapter 5: Assumes scenario of "no failure" for entire project, over complete project life. Is this a realistic scenario, given experience with industrial developments in real-world settings subject to vagaries of equipment, landscape, geology, weather, local climate, and human judgment and decision making/execution?

    RESPONSE: The "no failure" scenario has been eliminated in response to several comments, and is now considered in terms of mine footprint impacts in Chapter 7.

21. Page 5-1 (S5.1.1): Question: is "sampling extensively for summer fish distribution over several years" adequate for characterizing fish populations, given the wide fluctuations in salmon escapement and return note elsewhere in the Assessment (e.g., Table 5-1, para. 5.1.2)?

    RESPONSE: The answer to this question is of course dependent upon the objectives of the characterization. For the purposes of this section of the assessment, identifying species distributions within the study area, sampling was adequate for minimally characterizing

the distribution of salmon, Dolly Varden, and rainbow trout within the project area, including known spawning areas.

22. Page 5-12 to 5-48 (S5.2): Estimates of habitat, wetland and stream blockage or loss seem reasonable, but, as noted in the text, are probably conservative or "at the low end."

    RESPONSE: Agreed. No change suggested or required.

    Estimates of probable streamflow diminution (p. 5-25) seem reasonable, but make no reference to seasonality.

    RESPONSE: We assume a constant seasonal demand, thus streamflow changes follow baseline seasonal patterns under this analysis. We clarify that water managers may alter holding and release of water to address environmental flow needs.

23. Page 5-29 to 5-30 (thermal regimes): This section makes no mention of aufeis or "nalyds," ice accumulations which can exert major control on spring and early summer habitat availability and thermal conditions. For examples, see Slaughter (1990), among many other references.

    RESPONSE: Citation and text have been added in Section 7.3.2.

24. Page 5-30 to 5-31: Concur that maintenance of natural flow regime is the desirable target; the "sustainability boundary" approach is a way to attempt managing within the "natural" bounds of variability. Note: Figure 5-9 is map of streams and wetlands lost, not predicted flow alteration hydrograph (see last sentence, p. 5-31).

    RESPONSE: Figure references have been updated.

25. Page 5-37 (Figure 5-10): UT100D – predicted flow is ALWAYS below lower 20% sustainability boundary. UT100C, UT100C1, UTC100B –predicted flows are always within the 20% +/- sustainability boundaries.

    RESPONSE: Figure has been revised, and data now presented in Table 8-1.

26. Page 5-38 (Figure 5-11): Predicted flow for two upper gages (SK100G, SK100F) is always below the 20% sustainability boundary. Predicted flow at other gages appears to be near or within the 10% and 20% lower sustainability boundary.

    RESPONSE: Figure has been revised, and data now presented in Table 8-2.

27. Page 5-39 (Figure 5-12): Predicted high flow for NK119A is far below the lower 20% sustainability boundary throughout the open water season. From onset of snowmelt, flow at other gages is roughly at or within the lower 20% sustainability boundary.

    RESPONSE: Figure has been revised, and data now presented in Table 8-3.

28. Page 5-41: Gage NK119A – is the estimated decrease of streamflow (minimum mine size) 63% (Table 5-13) or 73% (text)?

    RESPONSE: Values have been updated.

Dr. Paul Whitney

29. Page 5-41: In any case, text is clear: predicted flow reductions for North and South Forks Koktuli River are materially below the lower 20% sustainability boundary. Text suggests that while upper Talarik Creek would be essentially obliterated in this hypothetical scenario, lower gaging stations on Talarik Creek might have partial augmentation of reduced flows, from small tributary flows and groundwater; without supporting data, this suggestion seems unsupportable.

    RESPONSE: Revised text illustrates important trans-watershed groundwater contributions to lower Upper Talarik Creek.

30. Page 5-42 to 5-45: These pages fairly summarize the potential for substantive alterations to streamflow regime and surface water/groundwater relationships.

    RESPONSE: No change suggested or required.

31. Page 5-44 (P3): "Once the mine is no longer a net consumer of water, we assume that flow regulation through the water treatment facility could be designed to somewhat approximate natural hydrologic regimes, which could provide appropriate timing and duration of connectivity with off-channel habitats." I suggest that this is a highly optimistic assumption, and does not address water quality questions (which are raised elsewhere in the Assessment).

    RESPONSE: We emphasize that the ability to manage flows will be dependent upon sufficient infrastructure and flexibility in water management.

32. Page 5-45 (S5.2.3): This entire paragraph should receive greater emphasis.

    RESPONSE: This section (now Section 7.3.3) has been expanded.

33. Page 5-46 (P4): Ignores variable-source-area concepts, which are widely accepted in hydrologic and watershed analysis.

    RESPONSE: We respectfully disagree. The variable source area concept presents the idea about the expansion and contraction of saturated areas that are the immediate source of streamflow during storms. In does not invalidate the notion that the total drainage area contributes with long flowpaths to streams. These long flowpaths ultimately contribute to saturated zones that support perennial streamflows..

34. Page 5-46 (P5): Assumes requirement for more water than is available, but leaves hanging the question of where that more water might be sourced. Given that the site is a watershed headwaters, what might be tapped as additional water supply, and what might be the impacts on that source(s)?

    RESPONSE: The revised water balance indicates that the mine would have the capability to capture more water than it needs during all operational phases, including start-up, from within the mine footprint.

35. Page 5-59 to 5-63 (S5.4): See earlier cautions concerning stream crossings, culverts. Note that road cuts and culverts are particularly susceptible to development of aufeis ("icings"), often resulting from blockage or alteration of subsurface water movement during cold

conditions, as witnessed by long-standing AKODT maintenance issues – Richardson, Steese, Dalton highways, for example.

RESPONSE: The potential for culvert blockage by aufeis is discussed in Chapter 10 of the revised assessment.

36. Page 5-60 (S5.4.2, P1): The statement that "…it is unlikely that a mine access road would have sufficient traffic to significantly contaminate runoff with metals or oil" is unsupported; it might be instructive to look at traffic loads for the access road from the Steese Highway to the Ft. Knox mine, a much smaller operation than the proposed Pebble development.

    RESPONSE: This statement no longer occurs in the assessment.

37. Page 5-60 (S5.4.2, P2): First sentence is correct. Second sentence is unsupported and probably incorrect (see Appendix G). Yes, runoff from roads is location-specific; that **does not** mean that runoff from roads would be insignificant to salmonids, given the very large number of streams (perennial, intermittent, and ephemeral), and wetlands, which would be intersected by the total road system of the Pebble project. This also seems to be contradicted by Section 5.4.3.

    RESPONSE: This issue is now given more attention in Chapter 10.

38. Page 5-60 (S5.4.4.1): There are many more water or seep crossings than 34 – see USGS topog sheets, ACME Mapper, or Google Earth.

    RESPONSE: The number of crossings has been updated in the revised assessment.

39. Page 5-61 (S5.4.4.2 and 5.4.4.3): Development of aufeis ("icings") consequent to partial or full culvert blockage, or induced by soil mantle compaction (i.e., by roads or off-road vehicle traffic) can partially or wholly block stream channels. Such blockage, in association with ice on the streambed, may last long past snowmelt and persist well into early summer, possibly affecting fish movement.

    RESPONSE: The potential impact of aufeis on stream channels and potential existence past breakup is discussed in Chapter 10 of the revised assessment.

40. Page 5-62 (S5.4.5): While I don't have the specific citations at hand, there are published analyses of dust effects associated with the North Slope haul road and Prudhoe Bay road network. Obvious effects include accelerated snowmelt along the road corridor, and nutrient or pollutant contributions to road corridor environs.

    RESPONSE: The revised assessment includes information from published literature on dust effects in the Arctic (Chapter 10).

41. Page 5-63 (S5.4.6.3): Should it read "…*impacting* 270.3 km of stream…"? (Incidentally, it is interesting that this coarse assessment finds it possible to state impact to within 100-meter resolution.)

Dr. Paul Whitney

RESPONSE: The revised assessment notes that risks to salmonids from de-icing salts and dust suppressants could be locally significant, but we cannot state that the entire stream length between potential road crossings and Iliamna Lake would be affected.

42. Page 5-65 (S5.4.7.3 and 5.4.8.3): Viewing the transportation corridor landscape, via maps, Google Earth or ACME Mapper, gives me the impression that the estimate of 4.9 km^2 wetlands directly impacted is a very low number. It is easy to play with the numbers given on pp. 5-69 - 5-70, regardless of their accuracy; 66 km of road impacting wetlands, assuming a 10-meter roadway footprint, yields 0.66 km^2 of wetlands "under the road" (vs. 0.18 km^2 in the text). The 200-meter proximity to wetlands cited, over 66 km of road, yields some 13 km^2 of wetland impact (vs. 7.3 km^2 in the text). 80 km of road within 200 m of streams or wetlands yields 16 km^2 of road/wetland impact. Since these are all assumptions and estimates, it is not possible to conclude that any of these figures would be the "true" area impacted.

    RESPONSE: The 0.18 km^2 refers to the area of wetlands which would be filled by the roadbed "intersecting" wetlands (19.4 km length of roadbed x 9.1 m width of roadbed), and does not include roadbed adjacent to wetlands (note that this area is 0.11 km^2 in the revised assessment due to a slight change in methodology for measuring road length). The 4.9 km^2 (not 7.3 km^2) area of wetland within 200 m of the length of road (on both sides) within the study area is based on actual National Wetland Inventory (NWI) data (the calculation methodology is described in Box 10-1 of the revised assessment).

    Though NWI data were utilized in this analysis, the 200 m road buffer was derived from a literature estimate of the road-effect zone for secondary roads.

43. Page 5-74 (S5.4.10): Should this say ***impact*** rather than "risk"?

    RESPONSE: "Impact" could be used here, but we chose to use "risk" to note the probability rather than certainty that salmon would be affected by the corridor-associated activities/events listed

    Text implies that even this "no-failure" scenario will impact salmonids; however, it is apparently not possible to estimate specific changes or the magnitude of such changes.

    RESPONSE: The no-failure scenario has been eliminated in response to several comments; effects resulting from the mine footprint are now discussed in Chapter 7. The exact magnitudes of changes in fish productivity, abundance and diversity cannot be estimated at this time, but the species, abundances, and distributions that would potentially be affected are summarized in Chapter 10 of the revised Assessment.

44. Page 5-74 to 5-77 (S5.6): This section seems cursory and understated, particularly in view of the extensive discussion of Appendix D.

    RESPONSE: The discussion of fish-mediated effects on Alaska Native culture has been expanded and is now in Chapter 12.

45. Section 6.1: Concur with general overview statements, and with conclusions regarding immediate consequences of TSF dam failure, which would likely be as severe as or more severe than stated in 6.1.2.1.

Dr. Paul Whitney

P. 6-6, first sentence – note that the failure scenario predicts over 70% fines < 0,1 mm, vs. the 6% “natural” fines concentrations.
P. 6-13, last para. – the assumption that overtopping would not occur in winter is not warranted, as the authors admit when citing the Nixon Fork Mine incident. In the Bristol Bay environment, a major rain-on-snow event in winter or spring is within the realm of possibility, and of course human error is, if not inevitable, always possible.

RESPONSE: We clarify that the scenario we chose to illustrate overtopping did not occur during low-flow conditions, but was in response to a flood. We acknowledge that failure at other times, and in response to other events, is possible (Section 9.3).

46. Page 6-15 (Box 6.2): Box text implies that human error, lack of timely oversight and correction was responsible – but never directly says “human error.” The apparent assumption that there is no hydrologic activity after freeze-up (or perhaps, after an ice cover forms on the pool) was naïve and incorrect. At least in that case, it appears that both dam and spillway design (not adequately considering winter and ice conditions) and operation/inspection (human error) were responsible.

    RESPONSE: The comment is probably correct. However, we have no evidence that the commenter’s conclusion that both engineering error and operator error were responsible was correct.

47. Section 6.1.4.1: Appropriately recognizes the long time period for exposure, over extended stream lengths, through both initial deposition and multiple re-mobilization and redeposition events.

    RESPONSE: Agreed. No change suggested or required.

48. Page 6-28 (S6.1.5 and Table 6-6): Seems jargon-laden and does not add to strength of the Assessment.

    RESPONSE: Opinion has been divided concerning this explicit weighing of evidence. Given that the analysis of risks to fish from exposure to spilled tailings involves six separate lines of evidence, the EPA intended to show and discuss how the evidence was weighed.

49. Page 6-29 (S6.1.7): Concur that remediation “…would be particularly difficult and damaging…”

    RESPONSE: No changes suggested or required.

50. Page 6-30 (S6.2): Even though “We do not assess failures of the natural gas or diesel pipelines…,” those pipelines would be equally susceptible to failure as the slurry line. Concerns with pipelines crossing streams, watercourses and wetlands are similar to those earlier expressed for the road corridor. Similarly, I suspect that careful inspection would reveal many more “watercourses,” including intermittent and ephemeral streams, than the 70 crossings cited.

    RESPONSE: A diesel spill has been added to the assessment, but it was judged that a gas leak would not pose a potential risk to fish (Chapter 11).

Dr. Paul Whitney

The "probability" argument on p. 6-32 is an understandable attempt at quantification, but is unpersuasive. Given the spill history of TAPS, pipelines in the Prudhoe Bay field, and recently in Montana (?), suggesting the probability (with what confidence limits?) that there "should be" only 1.5 stream-contaminating spills in78 years of operation seems wildly optimistic.

RESPONSE: These probabilities and frequencies are based on a large data set, not just the TAPS experience (which is an atypical pipeline design and much larger than the diesel line) or the spill in the Yellowstone River (which is a single event).

Assuming that any spill (over the 78-year project span) would last only two minutes (pp. 6-32, 6-34), with a consequent minimal volume of spilled material, also seems highly optimistic. Even highly-automated systems, with redundant sensors and automatic responses, are susceptible to error or failure, and the Bristol Bay watershed environment is not benign with regard to mechanical apparatus.

RESPONSE: The EPA agrees with this comment and has increased the response time to 5 minutes.

The authors appear to recognize this with their discussion of the Alumbrera incident.

RESPONSE: No change suggested or required.

51. Section 6.4: Potential road/culvert failures are recognized (again, not that ice issues are not discussed). Extended periods for repair/rebuilding might be anticipated – witness the repeated problems with the highway to Eagle, AK over the past several years – and that is a State of Alaska responsibility, not that of a private company.

    RESPONSE: We agree with the commenter that extended periods for repair/rebuilding might be anticipated. Chapter 10 of the revised assessment notes that long-term fixes to a road that was damaged by erosional failure of a culvert may not be possible until conditions are suitable to replace a culvert or bridge crossing. Further, multiple failures, such as might occur during an extreme precipitation event, would likely require longer to repair.

    Potential for multiple simultaneous or concurrent failures is appropriate. Non-Alaska examples would be the Pacific Northwest flood events of 1964 and 1996, both major precipitation events with widespread flooding and road failures, in a region with much more developed infrastructure and response capacity.

    RESPONSE: We agree with the commenter with respect to the likelihood for multiple simultaneous or concurrent failures during extreme precipitation events. This is alluded to in the assessment.

52. Chapter 7: Recognition of probable additional mining activity, in the wake of a Pebble project, is appropriate. Assessment is necessarily limited to currently-known potential mining projects. The cumulative and irreversible consequences of multiple developments, with associated road, power, housing, communications infrastructure ("secondary development") should be more heavily emphasized, even though it is not possible to quantify all those consequences.

Dr. Paul Whitney

RESPONSE: The cumulative impacts of multiple developments, road corridors, and secondary or induced development have been emphasized through additional discussion in Chapter 13.

53. Chapter 8: Section 8.1.2 – note many potential failure modes not analyzed; the lack of analysis in this Assessment should not be taken to mean that such failure could not or will not occur.

    RESPONSE: Because the number of potential failures is extremely large, it is necessary to choose a representative set of failure scenarios. The focus of the assessment was on potential effects to salmon. The revised assessment includes more failure scenarios (e.g., diesel pipeline failure, quantitative water treatment failure, and refined seepage scenarios) and explains why these particular failure scenarios were chosen. Section 14.1.2 in the revised assessment explains that the assessment only presents a few failure scenarios. The EPA agrees with the commenter that lack of analysis should not imply a failure could or will not occur.

54. Table 8-1 (Row 2): The reasoning behind the statement that "Most [product concentrate pipeline] failures would occur between stream or wetland crossing [sic] and might have little effect on fish" is hard to understand; stream crossings, whether via elevated utilidors or via sub-channel borings or utilidors, are locales of angular change, piping connections and joints, and subject to stresses of hydrologic extreme events – so why would such sites be less subject to potential pipeline failure?

    RESPONSE: Most of the corridor is not at or adjacent to a stream or wetland. Therefore, failures are most likely to occur between streams or wetlands rather than at streams or wetlands. The statement is not about probabilities per unit length.

55. Page 8-4 (Box 8-1): As noted elsewhere, the probability arguments for TSF dam failure are not persuasive, and seem designed to imply that a TSF dam failure would not occur within the next 10,000 years (or 3,000 to 300,000 years with three TSFs operational). This implication is difficult to square with information on actual past failures presented in Box 4-4 and Table 4-8.

    RESPONSE: The discussion of this issue has been expanded to clarify that the failure rate is a design goal and is not based on empirical evidence.

56. Chapter 8: The potential risks and impacts are fairly and succinctly stated. Given the extremely long-term nature of the projected Pebble project, and the irreversible changes which would be imposed to the region, the risks seem, if anything, understated. I attribute this to the decision to focus this Assessment on salmon and anadromous fisheries, with some attention on salmon-mediated impacts – i.e., effects on indigenous culture, on wildlife other than salmon, etc.

    RESPONSE: No change suggested or required.

John D. Stednick, Ph.D.

Dr. Paul Whitney

1. Page ES-9: Economics of Ecological Resources – section seems weak.

   RESPONSE: Economic data were included as background only. Economic effects of mining are not assessed.

2. Page ES-14: Overall risk to salmon and other fish. Never really separates fish species out in other discussions. Dolly varden more sensitive to metals?

   RESPONSE: The distributions of the salmonid species can be and are distinguished by species, but not by their sensitivities to metals. For copper and some other metals, data are available for rainbow trout that can be applied to other salmonids. Dolly Varden have not been used as a test species.

3. Page 2-3 (P3): Four climate classes. Why this classification system? Perhaps easier to identify by watershed maps?

   RESPONSE: Climate classes are used as defined from Feddema (2005) to give the average annual moisture index. The Feddema Index was used as it broadly characterizes a given landscape location on a spectrum of wetter to drier conditions due to the effects of precipitation and evapotranspiration. Climate classes are used independent of watershed boundaries, as this classification system allows one to compare regions that are either alike or dissimilar across watershed boundaries and highlight that, depending on scale, watersheds can be quite heterogeneous in their degree of water availability from headwaters to mouth. The revised assessment now has five classes ranging from semiarid to very wet as shown in Figure 3-1.

4. Page 2-5: Precipitation values – significant figures?

   RESPONSE: Precipitation values as shown in Figure 2-3 (Figure 3-2 in the revised assessment) are calculated from SNAP data. SNAP data report monthly values of precipitation to the nearest mm. During calculations, all precipitation values are rounded to the nearest whole mm.

5. Page 2-23: Monthly values of streamflow. Would be nice to see average or daily streamflows somewhere.

   RESPONSE: The purpose of this figure is to show the general pattern of annual streamflows in this region. More detailed information (e.g., daily flows) are readily available for the USGS gages, but those data are not necessary to illustrate general annual trends.

6. Pages 3-7 to 3-11: Would like to see more discussion of conceptual models. If a picture is worth a 1000 words……

   RESPONSE: Conceptual models have been revised and new models developed, and these models now appear in each of the risk analysis chapters to clarify the pathways considered in each chapter.

7. Page 4-1 (P1): …*represent current good, but not necessarily best, mining practices*. Why not use the best methods or state of the art methods?

Dr. Paul Whitney

RESPONSE: With regard to the terminology of "best", "good", or other terms for the practices used, what was intended to be conveyed in the assessment is that we assumed modern mining technology and operations. The terms are qualitative when generally interpreted, or have a regulatory meaning. The term "best management practices" is a term generally applied to specific measures for managing non-point source runoff from storm water (40 CFR Part 130.2(m)). Measures for minimizing and controlling sources of pollution in other situations are referred to as best practices, state of the practice, good practice, conventional, or simply mitigation measures. We have added a text box in the revised Chapter 4 to discuss terms.

8. Page 4-18: Shaded relief. Perhaps contour lines in another figure?

   RESPONSE: This figure is showing shaded relief of the landscape in Figure 4-6 and is consistently used across multiple figures as a common base map for figures in this assessment. It was decided to use shaded relief as opposed to contour lines to keep the figure(s) cleaner in appearance, while also showing general topographic features. The focus of this figure is on significant mineral deposits within the assessment watersheds and not topography, therefore we have decided to keep the background as currently shown.

9. Page 4-21 (P1): *…most plausible sites given geotechnical, hydrologic, and environmental considerations.* Can this be elaborated?

   RESPONSE: This sentence was intended to convey that these locations have similar geotechnical, hydrologic, and environmental conditions to the site of TSF 1. A more comprehensive overview of the geologic and geomorphic setting of the Nushagak and Kvichak River watersheds is now provided in Chapter 3.

10. Page 4-21 (P2): *The TSF would be unlined other than on the upstream dam face and there would be no impermeable barrier constructed between tailings and underlying groundwater.* Is this correct? I thought I read the whole TSF would be underlain by liner?

    RESPONSE: The assessment states that TSF embankments would have an engineered liner, but the impoundment is not lined in our scenarios. A full liner is possible, but with very large TSFs, stability with a liner may become an issue and benefits must be weighed against other potential adverse outcomes, as well as costs. This is something that could be considered in a regulatory permitting process. No change required.

11. Page 4-24: *Leachate Recovered*. This refers to only the leachate collected from the dam face?

    RESPONSE: No, this box refers to leachate from tailings and waste rock. The text "leachate recovered" in the formula included in the box refers to the leachate recovered in testing conducted by the PLP. No change required.

12. Page 4-26: Water management. This is confusing. Collect precipitation for processing, yet divert upstream waters around the mine and not use? Where are the leachate recovery wells, and are they just a safeguard?

    RESPONSE: Water management measures are now clearly described and discussed in the revision (Section 6.1.2.5), and in sub-sections for the mine components in the scenarios.

Dr. Paul Whitney

Upstream water sources would be diverted around a mining site to minimize losses of that water source to the environment, as it could remain uncontaminated. The leachate monitoring wells are to monitor groundwater downstream from the TSFs and waste rock piles that would experience infiltration of their surfaces by precipitation falling on them. Those wells could be converted to recovery wells, or new recovery wells placed, if it were found that seepage from these structures had contaminated the groundwater. Measures are standard and common to existing mine sites.

13. Page 4-28: Significant figures on precipitation estimates? What is the ET and how is it calculated?

    RESPONSE: The water balance is now discussed in detail in Section 6.2.2 and the water inputs discussed in Section 6.2.2.1. In the revised assessment, we used the three known USGS gages draining the Pebble deposit site [NK100A (USGS 15302250) on the North Fork Koktuli, SK100B (USGS 15302200) on the South Fork Koktuli, and UT100B (USGS 15300250) on the Upper Talarik] to calculate monthly mean flows at each gage over their period of record. Monthly mean flows for each gage were summed across the year and then averaged across the three gauges weighted by their watershed area to produce an area-weighted average of net (Precipitation – ET) yearly runoff of 860 mm/year for the general deposit area. All data were presented to the nearest whole mm.

14. Page 4-31 (P3): *...the mine pit would take approximately 100 to 300 years to fill.* From groundwater inflow only? Why such a large range of the estimate?

    RESPONSE: The time for the pit to fill was based on groundwater infiltration and direct precipitation into the pit and was presented as an approximate range. The lower end of the range of estimates pertained to the Pebble 2.0 scenario and the higher end pertained to the Pebble 6.5 scenario. Current estimates are approximately 20 years, 80 years, and 300 years for the Pebble 0.25, Pebble 2.0, and Pebble 6.5 scenarios, respectively.

15. Page 4-50 (P3): This peak flow calculation and discussion is confusing and needs clarification.

    RESPONSE: Presentation of the peak flow calculations and hydrologic modeling of the TSF failure scenarios has been revised and clarified. This is now presented in Section 9.3.

16. Page 4-52: What is the recurrence interval of the 356 mm?

    RESPONSE: The recurrence interval is not reported in the reference cited. The PMP 24-hr is greater than the reported 100-yr 24-hr (see Technical Paper No.47). http://www.nws.noaa.gov/oh/hdsc/studies/pmp.html http://www.nws.noaa.gov/oh/hdsc/PMP_documents/TP47.pdf

17. Page 4-60 (P4): Why a geometric mean using three values?

    RESPONSE: The three values were chosen because they represented subsets of the available data that better represented the conditions of the proposed pipelines (i.e., pipelines less than 20 cm in diameter, pipelines in northern climates, and pipelines run by small operators). Focusing on these three subsets reduced the range of the estimated

probability of failure. The geometric mean was used because the comparison involved ratios with potentially significant differences in magnitude in the denominators. Using the geometric mean typically reduces the bias that a small dataset can introduce into an arithmetic mean. In this case, the difference between the two means (0.0010 vs. 0.0011) is immaterial and small with respect to the range of failure probabilities.

18. Page 5-10: Define *highest reported index spawner*.

    RESPONSE: Section 7.1.2 defines this as the highest count of salmon reported in the EBD for selected index reaches.

19. Page 5-20 (P1): …*salmon abundance related to pool size….and beaver ponds provide particularly large pools*. Are data available to characterize the stream type? Are beaver present?

    RESPONSE: We now provide a characterization of stream gradient, mean annual flow, and % flatland to characterize general stream and valley characteristics. Beaver are present in the area (Chapter 7).

20. Page 5-22 (P2): *Assuming that no natural flow or uncontrolled runoff would be generated from the mine footprint.* Is all precipitation is intercepted or does this refer to the subsurface streamflow generation mechanisms?

    RESPONSE: In our scenarios, we assume that all precipitation that falls within the mine footprint (except the fraction of the TSF and waste rock leachate that bypasses the groundwater interception and collection systems) is managed by the operator by collection and routing leading to either storage in a TSF or testing, potential treatment, and release to the environment. Any water consumed or stored on site would reduce the total streamflow below baseline conditions, although some stream reaches would receive increased stream flows due to discharges from the wastewater treatment plant. Groundwater and streamflows are inextricably interdependent throughout the site, so one could anticipate that areas with lower streamflows would also have lower groundwater levels.

21. Page 5-23: It appears that the mean annual unit runoff is calculated incorrectly.

    RESPONSE: This has been corrected.

22. Page 5-24: Table shows flow returned from footprint. Does not fit with page 5-22?

    RESPONSE: Water balance descriptions, tables, and figures have been extensively revised.

23. Page 5-29 (P2): Groundwater-surface water connectivity. Are data available to show this connection throughout the watersheds or does the groundwater only return to the hyporheic in the low gradient areas? Similarly, where are the temperature data that suggest the lake and groundwater connection or this reference by incorporation?

    RESPONSE: Figure 7-14 is now included to illustrate areas of modeled upwelling strength. We provide several examples of groundwater-moderated temperatures from the

EBD data. But water temperature data are not generally summarized here and we refer the reader to the extensive data provided in the EBD.

24. Pages 5-32 to 5-39: The tables and hydrographs illustrating the potential flow changes are difficult to appreciate or interpret. Another means of presentation?

    RESPONSE: We now include figures (7-10 through 7-17) illustrating the locations, extent and magnitude of flow changes.

25. Page 5-41 (Table 5-13): The value of 0.15 km affected by the maximum mine size is questioned.

    RESPONSE: Stream lengths are now rounded to 1 km

26. Page 5-52 (Table 5-17): Can we see summary statistics on water quality, not just means? Plot of concentrations vs. streamflow?

    RESPONSE: Coefficients of variation have been added to the table (now Table 8-10). Plots of concentrations versus other variables are available in PLP's Environmental Baseline Document, Chapter 9.

27. Page 5-55: *These effluent specific values are higher than those for background surface water because of the higher content of mineral ions.* This sentence needs clarification.

    RESPONSE: The sentence has been rewritten to clarify that it refers to differences in the BLM-derived criteria.

28. Page 6-6 (Table 6-1): Last line. What is the +/- value after the mean?

    RESPONSE: + or – one standard deviation are reported for the basin-wide samples; this has been clarified in the table.

29. Page 6-13 (P3): …*an intense local storm.* Why use the Type 1a distribution for precipitation distribution?

    RESPONSE: This has been corrected to Type 1 per SCS guidance for Alaska.

<u>Roy A. Stein, Ph.D.</u>

1. Global (see Table 5-3 as example): Some thought should be given to significant figures for the numerical values given in the report, especially so for Chapter 5, where much uncertainty exists regarding stream lengths blocked (for example) by the mine footprint: "…34.9 km of first- through third-order streams…" will be eliminated. Rounding in this context makes sense for we really do not know this impact to the nearest 0.1 km. I would encourage a thorough review of these values throughout the report.

    RESPONSE: Significant figures for calculations and measurements by EPA have been changed to reflect uncertainty (for example, stream length is reported to the km). Significant figures from literature are not revised.

Dr. Paul Whitney

2. Page 2-17: Salmon populations are closely managed by Alaska Department of Fish and Game; how closely and what do we know of the populations that are managed regarding numbers, resilience, variability, etc.? A box summarizing the fishery management practiced by Alaska Department of Fish and Game would help put biological resources in perspective.

   RESPONSE: Box 5-2 has been added in Chapter 5, providing an overview of commercial fisheries management in Bristol Bay.

3. Page 2-17: The importance of salmonids to marine predators is likely not an issue, given the very large numbers of salmon stocked in the Pacific.

   RESPONSE: No changes suggested or required.

4. Page 2-20: Nushagak and Kvichak rivers contain >58,000 km of streams; 13% is anadromous fish habitat, but this is likely underestimated. How do we know this is an underestimate? What proportion of this >58,000 km has been surveyed?

   RESPONSE: ADF&G estimates that the current listing of Waters Important for the Spawning, Rearing and Migration of Anadromous Fishes represents "less than 50% of the streams, rivers and lakes actually used by anadromous species" (ADF&G AWC database, available at: www.adfg.alaska.gov/sf/SARR/AWC/)). This clarification has been added to the assessment in Box 7-1.

5. Page 2-25 (bottom of page): I wonder if a bit more couldn't be written about the idea of a salmon sanctuary, fleshing out the ideas of Rahr and Pinsky here.

   RESPONSE: The creation of salmon sanctuaries in the Bristol Bay region is a management decision, and thus outside the scope of this assessment; therefore, no change is necessary.

6. Page 3-2: With all the items in the first full paragraph eliminated from consideration (e.g., power generations, worker housing, Cook Inlet Port), might the analysis herein be considered minimal impact on the Bristol Bay watershed?

   RESPONSE: The scope of the assessment has been clarified throughout the document, particularly in Chapters 1 and 2. It is true that this assessment only considers a subset of potential impacts from large-scale mining.

7. Pages 3-7 to 3-11: These conceptual models might best be placed in the chapter to which they refer; in so doing, it is easier for the reader to follow along. In turn, these models did not seem to be discussed in text to the extent that they drove the impacts generated. Add more explanatory text.

   RESPONSE: In the revised assessment, conceptual models are presented and discussed in the appropriate chapters.

8. Page 4-5 (bottom of page): Typically, when citing a figure in another chapter, i.e., one not near the current text, the format should be "see Figure 3-1" to keep the reader on track.

Dr. Paul Whitney

RESPONSE: Comment noted. Figure references have been retained in parentheses.

9. Page 4-8: Is there some chance of "block caving" here? Some text clarifying this point here would be appropriate.

   RESPONSE: Additional information on block caving is provided in Chapter 4 (Section 4.2.3.1 and Box 4-4).Block-caving is a possibility for mining deposits that are deeper. Sources of hazards assessed for risks, however, would be similar, as block-caving and surface mining both create tailings, waste rock (block-caving does have a smaller amount of waste rock), and sources of contamination to the water.

10. Chapter 4: Could these data and insights be productively moved to Chapter 5, thus reducing redundancy? The organization would be 1) a description of the mine features relevant to the text, then 2) a discussion of salmon and the mining impacts on their habitat. Separating these into chapters seems artificial.

    RESPONSE: Revision of the assessment has included organization of material into additional chapters and the EPA believes this new organization is easier to follow.

11. Page 5-20 (P3): What does the phrase, "free-water area" mean? Ice free, perhaps?

    RESPONSE: Removed.

12. Pages 5-20 to 5-21: Paragraphs on these two pages reflect some of the redundancy that I saw throughout the report. In the 3rd full paragraph on page 5-20, text begins with "…groundwater inputs may be critical…" and in turn on page 5-21 in the first full paragraph, the topic sentence begins "…groundwater-influenced stream flow…likely benefit fish…" Both deal with the same topic. Hence, these two paragraphs could easily be combined, serving to shorten the text, reduce redundancy, and improve readability.

    RESPONSE: These paragraphs have been combined.

13. Page 5-22: Similarly, the text on page 5-22 includes citations (at the end of the same sentences) to both sections and tables and figures in Chapter 4. This suggests to me that the text is not only overlapping, it is redundant and better overall report organization would serve its presentation well.

    RESPONSE: Chapters have been reorganized, but some cross-chapter referencing remains necessary. In this case, it is important that the reader be able to refer back to the mine scenarios and operations chapter if desired, to better understand the complex water management system and budget that drives the analysis in Chapter 7.

14. Page 5-23 (Table 5-5): Some explanation in the table title would benefit the reader, as to where these gages are placed in the stream. The labeling is arcane at best UT100D; letters suggest Upper Talarik Cr., but what is 100D. Now, I figured out from text that the first ones were high in the watershed and then they proceeded downstream (increasing drainage area gave me a hint as well). Use better descriptors (such as SK1 through SK5 from low to high stream order) or explain the ones that are being used.

Dr. Paul Whitney

RESPONSE: New figures illustrating gage locations are included. Gage names remain consistent with EBD usage for consistency.

15. Page 5-26 (Table 5-7): I cannot find any bold in this table that would reflect the pre-mining condition. Is that the same column as "Pre-Mining" as it is in Table 5-8 on page 5-34 (and the next few tables as well)?

    RESPONSE: Corrected.

16. Page 5-27: Cite Figure 5-8 in text any time the stream gages are mentioned. The reader then has the ability to easily refer back to stream gage locations.

    RESPONSE: Corrected.

17. Pages 5-32 to 5-39: How do these tables and figures differ? Might they be 10% reduction in flow, 11-20% reduction inflow and >20% reduction in flow, as suggested in text? If so, then these table and figure titles need to reflect this information and be better described in the legends of the figures. Finally, do we need both tables and figures?

    RESPONSE: Figures have been removed, with exception on one illustration to clarify process.

18. Page 5-31: The Richter et al. (2011) reference, which underpins this section is incomplete in the Literature Cited (Chapter 9), suggesting only March as the publication date. Update in any revision.

    RESPONSE: Citation has been updated.

19. Page 5-31: It should be made clear that the Richter et al. (2011) sets quite specific bounds for all rivers regarding ecosystem function and does not provide any specific insight into salmon production (made somewhat clear in the last sentence of the next to the last paragraph on page 5-43). I think an additional caveat stating this explicitly on page 5-31 would improve the text.

    RESPONSE: Additional clarification has been added.

20. Page 5-46: Stream flow losses due to the mine footprint are discussed first as underestimated, then as overestimated, and then a conclusion that they are underestimated (i.e., because the mine will need more water than is available from surface run-off). If this is the case, why go through the other scenarios…to seem even-handed? I am not sure all of this text is required.

    RESPONSE: Uncertainties and assumptions sections have been revised.

21. Page 5-46: Mine start-up will require more water than is available from the footprint of the mine itself. Hence, water will be captured from other streams than just those associated with the mine, which will influence stream flow and groundwater supplies. Are there estimates of the amount beyond the surface water that will be required?

    RESPONSE: An extensively-revised water balance description and accounting are now used. Indirect effects of groundwater loss to pumping are incorporated.

Dr. Paul Whitney

22. Pages 5-53 to 5-58: I am a little confused by this section. The implication throughout is that copper toxicity will be based on the response of aquatic invertebrates (which would then be protective of direct effects on salmon). However, near the end of this section, there is a discussion about zooplankton being most sensitive and a comment about the reliance of juvenile sockeye rearing in lakes on these zooplankton. Yet, there is no resolution of what criteria will be used for toxicity values…will it be aquatic invertebrates or the more sensitive zooplankton? Clarification is required here.

    RESPONSE: Zooplankton are aquatic invertebrates. The same criteria apply to both invertebrates in the benthos and those that drift in the lake.

23. Page 5-59: "Discharge permits for mine in the Bristol Bay watershed should include relevant whole-effluent toxicity testing and monitoring of biotic communities in receiving streams". Does this quote solve the problem mentioned in the previous comment? Is this a realistic expectation for mine operators before permits are issued?

    RESPONSE: The statement reflects the hopes of the assessment authors. They do not constitute an obligation upon the State of Alaska. This is clarified in the revised assessment.

24. Page 5-68 (Table 5-22): >10% rather than <10% in the table title.

    RESPONSE: The reference was correct in the draft. Table 10-8 now shows streams with gradients <12% likely to support salmon.

25. Chapter 6: Rivers is lower case when multiple rivers are listed.

    RESPONSE: Comment noted.

26. Page 6-1: Why assume that only 20% of the tailings stored would be mobilized with any dam failure? Is there a justification for this important assumption? Yes, see Appendix I, page 14 for citation to Dalpatram (2011); this should be cited in the main report in Chapter 6.

    RESPONSE: Citations of Dalpatram (2011) and Azam and Li (2010) have been added, drawn from Appendix I.

27. Page 6-4: Add map showing the impact of the failed TSF 1, i.e., distribution of sediments and impact downstream.

    RESPONSE: Because we are not predicting specific sediment depths in this revision, we have determined that this information was best presented by a description in the text and tables.

28. Page 6-42: The sentence in mid-paragraph (3rd complete paragraph on this page) "…multiple failures such as might occur…" My guess is that an example should follow the phrase "such as."

    RESPONSE: Culvert failures are described in the preceding paragraphs (in greater detail in the revised assessment), so an example is not needed here.

Dr. Paul Whitney

29. Page 7-2: The sentence at the end of the last full paragraph on the page makes little sense: "The overall consequences are diminished and extinct salmon populations."

    RESPONSE: This sentence has been clarified.

30. Page 8-6 (last sentence of 2nd complete para): "further" should be "farther"; sorry, I just couldn't help myself…

    RESPONSE: Text revised.

William A. Stubblefield, Ph.D.

None

Dirk van Zyl, Ph.D., P.E.

I have indicated a number of specifics in the text above and do not have any others to list.

Phyllis K. Weber Scannell, Ph.D.

1. Page 4-11: The document states "geomembranes are generally estimated by manufactures to last 20 to 30 years when covered by tailings (North pers. comm...)." Unless North is a P.E. with experience in geomembranes, the statement needs a stronger reference. For example, Erickson et al (2008)* discuss the quality issues with geomembranes related to manufacture, installation and application of a soil-based cover (such as bentonite).

   RESPONSE: The reference is appreciated, but others were chosen for use related to time of life for liners. The discussion of liners has been expanded and moved to Chapter 4 (Section 4.2.3.4) in the revision, and includes additional material and references on lifetime. The personal communication reference has been removed.

2. Page 4-23 (L1): This first sentence is confusing and implies that oxygen has low solubility because it is in the tailings pond. Suggested change: eliminate the first phrase "In a TSF".

   RESPONSE: The change has been made in the revised assessment.

3. Page 6-36 (P3): Last sentence states: [water] treatment would continue until institutional failures ultimately resulted in abandonment of the system, at which time untreated leachate discharges would occur. This statement is not supported by any documentation and is not clear what is being implied. Failure of governments? As stated in my response to questions, any mine plan must include sufficient bonding and plans for reclamation, including necessary water treatment.

   RESPONSE: Bonding and a perpetual trust could result in treatment for some period, but it possible that long-term funding will not last to the end of time.

Dr. Paul Whitney

4. Page 6-37 (P4): End of paragraph states "premature closure could leave waste rock piles in place." Again, there is a need for plans for mine closure, concurrent reclamation and sufficient bonding.

   RESPONSE: The premature closure scenario is intended to address the possibility that the closure plan is not followed. It highlights the need for adequate bonding and for plans that include closure by some agency.

5. App G, Page 5 (P1, last line): Document states: "…other short road segments connect Dillingham to Aleknagik and Naknek to King (Figure 1)."
   Shouldn't King be King Salmon?

   RESPONSE: Corrected.

6. App G, Page 5 (P3): Dolly Varden should be capitalized throughout the document. The list of fish species should contain scientific names or reference a table of common and scientific names.

   RESPONSE: Corrected.

   The document states "In the most comprehensive published field inventory, Woody and O'Neal (2010) reported." Because the authors have not reviewed other documents on field inventories, the phrase "most comprehensive" should be changed to "a comprehensive"

   RESPONSE: Corrected.

Paul Whitney, Ph.D.

A lot of page and paragraph comments are included the above responses to charge questions. I have no further comment.