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

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Appendix J: Compensatory Mitigation and Large-Scale Hardrock Mining in the Bristol Bay Watershed

NOTICE

THIS DOCUMENT IS AN EXTERNAL REVIEW DRAFT. It has not been formally released by the U.S. Environmental Protection Agency and should not be construed to represent Agency policy. It is being circulated for comment on its technical accuracy and policy implications.

U.S. Environmental Protection Agency

Seattle, WA

Appendix J
Compensatory Mitigation and Large-Scale Hardrock Mining in the Bristol Bay Watershed

Palmer Hough
U.S. Environmental Protection Agency
Office of Water
Office of Wetlands, Oceans and Watersheds

Heather Dean
U.S. Environmental Protection Agency
Region 10
Alaska Operations Office

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Office of Research and Development
U.S. Environmental Protection Agency
Washington, DC

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Comments from the public and peer review members on the May 2012 draft Bristol Bay Assessment raised concerns that the topic of compensatory mitigation was not adequately addressed, in particular that the discussion of compensatory mitigation included in Appendix I of the May 2012 draft assessment did not discuss the efficacy of potential compensatory mitigation measures. In response to these comments, this appendix, which focuses exclusively on compensatory mitigation, has been added to the Bristol Bay Assessment. This appendix provides an overview of Clean Water Act Section 404 compensatory mitigation requirements for unavoidable impacts to aquatic resources and discusses an array of measures that various entities have proposed as having the potential to compensate for the unavoidable impacts to wetlands, streams, and fish identified in the Bristol Bay Assessment. Please note that any formal determinations regarding compensatory mitigation can only take place in the context of a regulatory action. The Bristol Bay Assessment is not a regulatory action, and thus a complete evaluation of compensatory mitigation is considered outside the scope of the assessment.

1 Overview of Clean Water Act Section 404 Compensatory Mitigation Requirements

Compensatory mitigation refers to the restoration, establishment, enhancement, and/or preservation of wetlands, streams, or other aquatic resources conducted specifically for the purpose of offsetting authorized impacts to these resources (Hough and Robertson, 2009). Compensatory mitigation regulations jointly promulgated by the U.S. Environmental Protection Agency (EPA) and the U.S. Army Corps of Engineers (ACOE) (40 CFR §§ 230.91 - 230.98 and 33 CFR §§ 332.1 - 332.8) state that "the fundamental objective of compensatory mitigation is to offset environmental losses resulting from unavoidable impacts to waters of the United States authorized by [Clean Water Act Section 404 permits issued by the ACOE]" (40 CFR Part 230.93(a)(1)). Compensatory mitigation enters the analysis only after a proposed project has incorporated all appropriate and practicable means to avoid and minimize adverse impacts to aquatic resources (40 CFR Part 230.91(c)).

Section 404 permitting requirements for compensatory mitigation are based on what is "practicable and capable of compensating for the aquatic resource functions that will be lost as a result of the permitted activity" (40 CFR Part 230.93(a)(1)). In determining what compensatory mitigation will be "environmentally preferable," the ACOE "must assess the likelihood for ecological success and sustainability, the location of the compensation site relative to the impact site and their significance within the watershed, and the costs of the compensatory mitigation project"(40 CFR Part 230.93(a)(1)). Furthermore, compensatory mitigation requirements must be commensurate with the amount and type of impact associated with a particular Section 404 permit (40 CFR Part 230.93(a)(1)). The regulations recognize that there may be instances when the ACOE cannot issue a permit "because of the lack of appropriate and practicable compensatory mitigation options" (40 CFR Part 230.91(c)(3)).

1.1 Compensatory Mitigation Methods

Compensatory mitigation can occur through four methods: aquatic resource restoration, establishment, enhancement, or in certain circumstances, preservation (40 CFR Part 230.93(a)(2)). Restoration is the reestablishment or rehabilitation of a wetland, stream, or other aquatic resource with the goal of returning natural or historic functions and characteristics to a former or degraded aquatic resource. When it is an option, restoration is generally the preferred method, due in part to its higher likelihood of success as measured by gain in aquatic resource function, area, or both. Establishment, or creation, is the development of a wetland or other aquatic resource where one did not exist previously, with success measured as a net gain in both area and function of the aquatic resource.

Enhancement includes activities conducted within existing aquatic resources that heighten, intensify, or improve one or more aquatic resource functions, without increasing the area of the aquatic resource. Examples include improved floodwater retention or wildlife habitat. Preservation is the permanent protection of aquatic resources and/or upland buffers or riparian areas through legal and physical mechanisms, such as conservation easements and title transfers. Because preservation does not replace lost aquatic resource area or functions, regulations limit its use to situations in which the resources to be preserved provide important functions for and contribute significantly to the ecological sustainability of the watershed, and those resources are under threat of destruction or adverse modification (40 CFR Part 230.93(h)).

1.2 Compensatory Mitigation Mechanisms

There are three general mechanisms for achieving the four methods of compensatory mitigation (listed in order of preference as established in 40 CFR 230.93(b)): mitigation banks, in-lieu fee programs, and permittee-responsible mitigation. A mitigation bank is a site with restored, established, enhanced, or preserved aquatic resources, riparian areas and/or upland buffers that the ACOE has approved for use to compensate for losses from future permitted activities. The bank approval process establishes the number of available compensation credits, which permittees may purchase upon ACOE approval that the bank represents appropriate compensation. The bank sponsor is responsible for the success of these mitigation sites.

For in-lieu fee mitigation, a permittee provides funds to an in-lieu fee program sponsor who conducts compensatory mitigation projects under agreement with the ACOE, typically after pooling funds from multiple permittees. The in-lieu fee program sponsor is responsible for the success of these mitigation sites.

In permittee-responsible mitigation, the permittee undertakes and bears full responsibility for the implementation and success of the mitigation. Mitigation may

occur either at the site where the regulated activity caused the loss of aquatic resources (on-site) or at a different location (off-site), preferably within the same watershed.

Although it is the permit applicant's responsibility to propose an appropriate compensatory mitigation option, mitigation banks and in-lieu fee programs are the federal government's preferred forms of compensatory mitigation as they "usually involve consolidating compensatory mitigation projects where ecologically appropriate, consolidating resources, providing financial planning and scientific expertise (which often is not practical for permittee-responsible compensatory mitigation projects), reducing temporal losses of functions, and reducing uncertainty over project success" (40 CFR 230.93(a)(1); *see also* 40 CFR 230.93(b)).

1.3 Watershed Approach and the Location, Type, and Amount of Compensation

Regulations regarding compensatory mitigation require the use of a watershed approach to "establish compensatory mitigation requirements in [Department of the Army] permits to the extent practicable and appropriate" (40 CFR 230.93(c)(1)). Under the regulations, the watershed approach to compensatory mitigation site selection and planning is an analytical process for making compensatory mitigation decisions that support the sustainability or improvement of aquatic resources in a watershed. It involves consideration of watershed needs, and how locations and types of compensatory mitigation projects address those needs (40 CFR 230.92). The regulations specifically state that compensatory mitigation generally should occur within the same watershed as the impact site and in a location where it is most likely to successfully replace lost functions and services (40 CFR 230.93(b)(1)). The goal of this watershed approach is to "maintain and improve the quality and quantity of aquatic resources within watersheds through strategic selection of compensatory mitigation sites" (40 CFR 230.93(c)(1)).

The regulations emphasize using existing watershed plans to inform compensatory mitigation decisions, when such plans are determined to be appropriate for use in this context (40 CFR 230.93(c)(1)). Watershed plans that could support compensatory mitigation decision-making are typically:

> "…developed by federal, tribal, state, and/or local government agencies or appropriate non-governmental organizations, in consultation with relevant stakeholders, for the specific goal of aquatic resource restoration, establishment, enhancement and preservation. A watershed plan addresses aquatic resource conditions in the watershed, multiple stakeholder interests, and land uses. Watershed plans may also identify priority sites for aquatic resource restoration and protection" (40 CFR 230.92).

Where appropriate plans do not exist, the regulations describe the types of considerations and information that should be used to support a watershed approach to

compensation decision-making. Central to the watershed approach is consideration of how the types and locations of potential compensatory mitigation projects would sustain aquatic resource functions in the watershed. In order to achieve that goal, the regulations emphasize that mitigation projects should, where practicable, replace the suite of functions typically provided by the affected aquatic resource, rather than focusing on specific individual functions (40 CFR 230.93(c)(2)). For this purpose, "watershed" means an "area that drains to a common waterway, such as a stream, lake, estuary, wetland, or ultimately the ocean" (40 CFR 230.92). Although there is flexibility in defining geographic scale, the watershed "should not be larger than is appropriate to ensure that the aquatic resources provided through compensation activities will effectively compensate for adverse environmental impacts resulting from [permitted] activities" (40 CFR 230.93(c)(4)).

With regard to type, in-kind mitigation (i.e., involving resources similar to those being impacted) is generally preferable to out-of-kind mitigation, because it is most likely to compensate for functions lost at the impact site (40 CFR 230.93(e)(1)). Furthermore, the regulations recognize that, for difficult-to-replace resources such as bogs, fens, springs, and streams, in-kind "rehabilitation, enhancement, or preservation" should be the compensation of choice, given the greater likelihood of success of those types of mitigation (40 CFR 230.93(e)(3)).

The amount of compensatory mitigation required must be, to the extent practicable, "sufficient to replace lost aquatic resource functions" (40 CFR 230.93(f)(1)), as determined through the use of a functional or condition assessment. If an applicable assessment methodology is not available, the regulations require a minimum one-to-one acreage or linear foot compensation ratio (40 CFR 230.93(f)(1)). Certain circumstances require higher ratios, even in the absence of an assessment methodology (e.g., use of preservation, lower likelihood of success, differences in functionality between the impact site and compensation project, difficulty of restoring lost functions, the distance between the impact and compensation sites) (40 CFR 230.93(f)(2)).

1.4 Compensatory Mitigation Guidance for Alaska

In addition to the federal regulations regarding compensatory mitigation, the agencies have also developed compensatory mitigation guidance applicable specifically to Alaska. In their 1994 Alaska Wetlands Initiative Summary Report, EPA and the Department of the Army concluded that it was not necessary to provide "broad exemptions" from mitigation sequencing in Alaska, given the "inherent flexibility provided by" the regulations and associated guidance. The agencies also recognized that "it may not always be practicable to provide compensatory mitigation through wetlands restoration or creation in areas where there is a high proportion of land which is wetlands. In cases where potential compensatory mitigation sites are not available due to the abundance of wetlands in a region and lack of enhancement or restoration sites, compensatory mitigation is not required under the [Section 404(b)(1)] Guidelines" (EPA et al., 1994). In

promulgating the compensatory mitigation regulations in 2008, EPA and the ACOE specifically referenced the 1994 policy and reiterated the flexibility and discretion available to decision-makers (e.g., 40 CFR 230.91(a)(1), 40 CFR 230.93(a)(1)).

While opportunities for wetland restoration and creation continue to be rather limited in Alaska, a number of other wetland compensatory mitigation options (e.g., mitigation banks, in-lieu fee programs) have become available since 1994. Moreover, it is important to note that the 1994 policy applies only to compensatory mitigation for impacts to wetlands and is silent with regard to compensatory mitigation for impacts to Alaska streams. Furthermore, subsequent guidance issued by the ACOE' Alaska District in 2009 clarifies that fill placed in streams or in wetlands adjacent to anadromous fish streams in Alaska will require compensatory mitigation (ACOE 2009). A 2011 supplement to the Alaska District's 2009 guidance further recommends that projects in "difficult to replace" wetlands, fish-bearing waters, or wetlands within 500 feet of such waters will also likely require compensatory mitigation, as will "large scale projects with significant aquatic resource impacts," such as "mining development" (ACOE 2011).

The ACOE's 2009 Alaska guidance also provides sample compensatory mitigation ratios based on the type of mitigation and the ecological value of the impacted resource (high, moderate, or low). These guidelines include streams in the high quality category, indicating compensation ratios of 2:1 for restoration and/or enhancement and 3:1 for preservation (ACOE 2009).

2 Compensatory Mitigation Considerations for the Bristol Bay Assessment

2.1 Important Ecological Functions and Services Provided by Affected Streams and Wetlands

Bristol Bay's stream and wetland resources support a world-class commercial and sport fishery for Pacific salmon and other important fish. They have also supported a salmon-based culture and subsistence-based lifestyle for Alaska Natives in the watershed for at least 4,000 years. Bristol Bay's streams and wetlands support production of 35 species of fish including all five species of Pacific salmon found in North America: sockeye (*Oncorhynchus nerka*), coho (*O. kisutch*), Chinook or king (*O. tshawytscha*), chum (*O. keta*), and pink (*O. gorbuscha*). Because no hatchery fish are raised or released in the watershed, Bristol Bay's salmon populations are entirely wild. These fish are anadromous, hatching and rearing in freshwater systems, migrating to the sea to grow to adult size, and returning to freshwater systems to spawn and die. Bristol Bay's streams and wetlands support a diverse array of salmon populations that are unique to specific drainages within the Bay and this population diversity is key to the stability of the overall Bristol Bay salmon fishery (i.e., the portfolio effect) (Schindler et al. 2010).

As discussed in detail in the Bristol Bay Assessment (see Chapter 7), streams and wetlands that would be lost as a result of the mine footprints described in the

assessment's scenarios provide important ecological functions. These headwater streams and associated wetlands provide spawning habitat for coho and sockeye salmon and likely spawning habitat for anadromous and resident forms of Dolly Varden. They also provide rearing habitat for chum salmon, sockeye salmon, Chinook salmon, coho salmon, Dolly Varden, rainbow trout, Arctic grayling, slimy sculpin, northern pike, and ninespine stickleback (Johnson and Blanche in press, ADFG 2012a).

In addition to providing habitat for stream fishes, headwater streams and wetlands serve an important role in the stream network by contributing nutrients, water, organic material, and macroinvertebrates downstream, to higher order streams in the watershed. In the northeastern United States, headwaters contribute approximately 70% of the water volume and 65% of the nitrogen flux to second-order streams and 55% of the volume and 40% of the nitrogen flux to fourth- and higher-order rivers (Alexander et al. 2007). The contributions of headwaters to downstream systems results from their high density in the dendritic stream network. Headwater streams also have high rates of instream nutrient processing and storage due to extensive hyporheic zone interactions resulting from a large bed surface area compared to the volume of the overlying water (Alexander et al. 2007).

Both invertebrates and detritus are exported from headwaters to downstream reaches and provide an important energy subsidy for juvenile salmonids (Wipfli and Gregovich 2002). Headwater wetlands and associated wetland vegetation can also be important sources of dissolved organic matter, particulate organic matter, and macroinvertebrate diversity (King et al. 2012), contributing to the chemical, physical, and biological condition of downstream waters (Shaftel et al. 2011, Dekar et al. 2012, Walker et al. 2012). The losses of headwater streams and wetlands due to the mine footprint would reduce inputs of organic material, nutrients, water, and macroinvertebrates to reaches downstream of the mine footprints.

2.2 Identifying the Appropriate Watershed Scale for Compensatory Mitigation

As previously noted, the regulations regarding compensatory mitigation specifically state that compensatory mitigation generally should occur within the same watershed as the impact site and in a location where it is most likely to successfully replace lost functions and services (40 CFR 230.93(b)(1)).

For the mine scenarios evaluated in the Bristol Bay Assessment, the lost functions and services occur in the watersheds that drain to the North Fork Koktuli (NFK) and South Fork Koktuli (SFK) Rivers and Upper Talarik Creek (UTC). Accordingly, the most appropriate geographic scale at which to compensate for any unavoidable impacts resulting from such a project would be within these same watersheds, as this location would offer the greatest likelihood that compensation measures would replace the "suite of functions typically provided by the affected aquatic resource" (40 CFR 230.93(c)(2)). An important consideration is that compensation projects within these

watersheds appear to offer the only opportunity to address impacts to salmon populations that are unique to these drainages (Yocom and Bernard 2013) and thus sustain the population diversity that is key to the stability of the overall Bristol Bay salmon fishery (i.e., the portfolio effect) (Schindler et al. 2010).

If there are no practicable or appropriate opportunities to provide compensation in these watersheds, it may be appropriate to explore options in adjoining watersheds. However, defining the watershed scale too broadly would likely fail to ensure that wetland, stream and associated fish losses from the mine scenario are effectively offset, because compensation in a different watershed(s) would not address impacts to the portfolio effect from losses in the impacted watersheds. Similarly, compensation in different watersheds would not address impacts to the subsistence fishery where users depend on a specific temporal and spatial distribution of fish to ensure nutritional needs and cultural values are maintained (see Bristol Bay Assessment Chapter 12).

3 Potential Compensatory Mitigation Measures in Bristol Bay

The mine scenarios evaluated in the Bristol Bay Assessment identify that the mine footprints alone will result in the loss of (i.e., filling, blocking or otherwise eliminating) hundreds to thousands of acres of high-functioning wetlands and tens of miles of salmon-supporting streams. Such extensive habitat losses could also result in the loss of unique salmon populations, potentially eroding the genetic diversity that is essential to the stability of the overall Bristol Bay salmon fishery (i.e. reduction in the "portfolio effect").

The public and peer review comments on the draft Bristol Bay Assessment identified an array of compensation measures that commenters believed could potentially offset these impacts to wetlands, streams, and fish. Yocom and Bernard (2013) recently reviewed the likely efficacy of a subset of these potential measures at offsetting potential adverse effects. The following discussion does so for the complete array of compensation measures proposed by commenters, in the order that the regulations prescribe for considering compensation mechanisms: (1) mitigation bank credits; (2) in-lieu fee program credits; and (3) variations of permittee-responsible mitigation.

3.1 Mitigation Bank Credits

There are currently no approved mitigation banks with service areas[1] that cover the impact site for the mine scenarios; thus, no mitigation bank credits are available. Should one or more bank sponsors pursue the establishment of mitigation bank sites to

[1] The service area is the watershed, ecoregion, physiographic province, and/or other geographic area within which the mitigation bank or in-lieu fee program is authorized to provide compensatory mitigation (40 CFR 230.98(d)(6)(ii)(A)).

address the impacts associated with the mine scenario, they would likely encounter the same challenges described below in section 3.3.

3.2 In-Lieu Fee Program Credits

There is currently one in-lieu fee program approved to operate in the Bristol Bay watershed, administered by The Conservation Fund (TCF) since 1994. The TCF program operates statewide, and the Bristol Bay watershed falls within one of its service areas. According to TCF, its compensation projects consist almost entirely of wetland preservation. To date, TCF has completed four wetland preservation projects in the Bristol Bay watershed, financed in part with in-lieu fee funds. The majority of in-lieu fees collected by the TCF program have been for relatively small impacts to aquatic resources. Statewide, TCF has accepted in-lieu fees to compensate for a few projects with over 50 acres of impacts; to date, the largest impact represented in the TCF program is the loss of 267 acres of wetlands associated with the development of the Point Thomson natural gas production/processing facilities on Alaska's Beaufort Sea coast. Thus, it is not clear if this program could effectively provide the magnitude of compensation necessary to address the loss of hundreds to thousands of acres of high functioning wetlands and tens of miles of salmon-supporting streams associated with the mine scenario. In addition, it is likely that any in-lieu fee sponsor seeking to address the impacts associated with the mine scenario would encounter the same challenges described below in section 3.3.

3.3 Permittee-Responsible Compensatory Mitigation

Currently, there is no watershed plan for the NFK, SFK, or UTC, or other components of the Nushagak or Kvichak River drainages that could serve as a guide to permittee-responsible compensatory mitigation, by identifying degraded aquatic resources or immediate or long-term aquatic resource needs that a mitigation project could address. In the absence of such a plan, the regulations call for the use of a watershed approach that considers information on watershed conditions and needs, including potential sites and priorities for restoration and preservation (40 CFR 230.93(c)). When a watershed approach is not practicable, the next option is to consider on-site (i.e., the same site as the impacts, or adjoining land) and in-kind compensatory mitigation for project impacts, taking into account both practicability and compatibility with the proposed project (40 CFR 230.93(b)(5)). When such measures would be impracticable, incompatible, or inadequate, the last resort would be off-site and/or out-of-kind mitigation opportunities (40 CFR 230.93(b)(6)).

3.3.1 Opportunities within the NFK, SFK, and UTC Watersheds

In the context of the mine scenario, the primary challenge to both a watershed approach and on-site compensatory mitigation is the absence of existing degraded resources and watershed needs within the NFK, SFK and UTC watersheds. Specifically,

these three watersheds are largely unaltered by human activities, and there appear to be no sites that a mitigation project could restore or enhance to offset the magnitude of impacts expected from the mine scenarios.

Here we discuss other specific suggestions for potential compensation measures within the NFK, SFK and UTC watersheds provided in the public and peer review comments.

3.3.1.1 Beaver Dam Removal

One commenter suggested the removal of beaver dams as a potential compensation measure. Beavers preferentially colonize headwater streams because of their shallow depths and narrow widths (Collen and Gibson 2001, Pollock et al. 2003). An aerial survey of active beaver dams in the mine area, conducted in October 2005, mapped a total of 113 active beaver colonies (PLP 2011). Presumably, the rationale for this recommendation is that beaver dams can block fish passage, limiting fish access to otherwise suitable habitat and, therefore, the removal of beaver dams could increase the amount of available fish habitat. This rationale is based upon early research that led to the common fish management practice of removing beaver dams in order to protect certain fish populations like trout (Saylor 1935, Reid 1952, *in* Pollock et al. 2004). However, more recent research has documented numerous benefits of beaver ponds to fish populations and habitat (Pollock et al. 2003, Murphy et al. 1989). For example, Bustard and Narver (1975) found that a series of beaver ponds on Vancouver Island had a survival rate for overwintering juvenile coho salmon that was twice as high as the 35% estimated for the entire stream. Also, compared to historical levels, Pollock et al. (2004) estimated a 61% reduction in summer habitat capacity for coho salmon in one Washington watershed, largely as the result of the loss of beaver ponds.

Kemp et al. (2012) recently published a definitive review of the effects of beaver in stream systems, indicating that they have a positive impact on sockeye, coho, and Chinook salmon as well as Dolly Varden, rainbow trout, and steelhead. Using meta-analysis and weight-of-evidence methodology, the review showed that most (71.4%) negative effects, such as low dissolved oxygen and impediment to fish movement, lack supportive data and are speculative in nature, whereas the majority (51.1%) of positive impacts cited are quantitative in nature and well-supported by data (Kemp et al. 2012). In addition to increased invertebrate (i.e., food) production and habitat heterogeneity, the study cited the importance of beaver ponds as rearing habitat due to the increased cover and protection that higher levels of woody material and overall structural diversity provide. Other studies have identified beaver ponds as excellent salmon rearing habitat because they have high macrophyte cover, low flow velocity, and increased temperatures, and they trap organic materials and nutrients (Nickelson et al. 1992, Collen and Gibson 2001, Lang et al. 2006). Studies in Oregon have shown that salmon abundance is positively related to pool size, especially during low flow conditions (Reeves et al. 2011), and beaver ponds provide particularly large pools.

During winter, beaver ponds typically retain liquid water below the frozen surface, providing refugia for coho salmon (Nickelson et al. 1992, Cunjak 1996).

Beaver dams generally do not constitute significant barriers to salmonid migration even though their semi-permeability may temporarily limit fish movement during periods of low stream flow (Pollock and Werner 2003, Rupp 1954, Gard 1961, Bryant 1984, Pollock and Werner 2003). Even when beaver dams impede fish movements seasonally (i.e., under low flow conditions), the effects are typically temporary , with higher flows from storm events ultimately overtopping them or blowing them out (Leidholt-Bruner et al. 1992, Kemp et al. 2012). Even the temporary effect may be limited, when seasonal rainfall is at least average (Snodgrass and Meffe 1998, Kemp et al. 2012). Adding to the body of evidence, Pacific salmon and other migratory fish species commonly occur above beaver dams. One study in southeast Alaska documented coho salmon upstream of all surveyed beaver dams, including one that was two meters high; in fact, the survey recorded highest coho densities in streams with beaver (Bryant 1984). Other surveys have documented both adult and juvenile sockeye salmon, steelhead, cutthroat, and char upstream of beaver dams (Bryant 1984, Swales et al. 1988, Murphy et al. 1989, Pollock et al. 2003).

The current body of literature describing the effects of beaver dams on salmonid species shows that there are generally more positive associations with beaver dam activity than negative associations (Kemp et al. 2012). Hence, removal of beaver dams as a means of compensatory mitigation could lead to a net negative impact on salmonid abundance, growth, and productivity. Moreover, since the mine scenario would eliminate or block several streams with active beaver colonies in the headwaters of the SFK and UTC, the benefits provided by those habitats would be part of the suite of functions that compensatory mitigation should aim to offset.

3.3.1.2. Flow Management

One commenter suggested that fish habitat productivity could be improved through careful water management at the mine scenario site, including the storage and strategic delivery of excess water to streams and aquifers without adverse impacts such as seasonally incompatible temperatures. Although flow management has been performed at certain mine sites with limited success (e.g., Red Dog Mine, Alaska), we are unaware of any documentation of successful attempts to control the temperature of water releases at mine sites. Purposeful release of low temperature water has been a common practice downstream of hydroelectric dams in the Pacific Northwest. However, in contrast to tailings impoundments, these hydroelectric reservoirs generally contain cold, relatively clean water at the depth from which they release water. According to the Bristol Bay Assessment, large amounts of water would be necessary to mimic natural flow conditions in the NFK, SFK, and UTC watersheds, posing enormous logistical challenges to operators, particularly in attempting to mimic periods of natural high flow (i.e., spring runoff or fall rain events). Highly experimental and unpredictable

activities are generally discouraged as compensatory mitigation (40 CFR 230.93(a)(1); *see also* 73 FR 19633). However, if specific flow management plans prove to be feasible and ecologically beneficial, such measures would likely be required to minimize the impacts of flow reduction (e.g., aquatic habitat loss) resulting from water use at the mine, rather than compensating for unavoidable impacts.

3.3.1.3 Spawning Channel Construction

One commenter suggested the creation of spawning channels as a means to compensate for lost salmon spawning areas. The intent of a constructed spawning channel is to simulate a natural salmon stream by regulating flow, gravel size, and spawner density (Hilborn 1992). There is some history of using constructed spawning channels to mitigate for the impacts of various development projects on fish, based on the premise that they would produce fry, which would result in more adult fish returning. However, there are very few studies regarding the efficacy of such channels in the published literature. Hilborn (1992) indicates that success, measured by increased production of adult fish from such channels, is unpredictable and generally unmonitored. Constructed spawning channels also require annual maintenance and cleaning, and salmon using them can be prone to disease outbreaks (Mulcahy et al. 1982). The need for frequent maintenance would be contrary to the regulations' intent that compensatory mitigation projects be self-sustaining (40 CFR 230.97(b)). In light of their uncertain track record, it does not appear that constructed spawning channels would provide reliable and sustainable fish habitat.

3.3.1.4 Preservation

As described above, preservation as compensatory mitigation for the mine scenarios would require a site that is very large, performs similarly important aquatic functions, and is under threat of destruction or adverse modification. No commenters identified specific potential preservation sites, either within these watersheds or elsewhere in Bristol Bay. One challenge in identifying appropriate preservation sites is the high percentage of state and federal land ownership in the area. Public lands can provide mitigation, but only if the mitigating measure—in this case, preservation—is "over and above [that] provided by public programs already planned or in place" (40 CFR 230.93(a)(3)). Further, the aquatic functions of any preservation site downstream from the proposed mine scenario would be subject to degradation from the direct, secondary, and cumulative effects of the mine itself. These factors could limit most properties of adequate area and similar aquatic function from serving as acceptable mitigation sites. Moreover, there is no precedent for such a preservation-dominated compensation approach in the context of this type and magnitude of ecological losses.

3.3.2 Off-site and/or Out-of-Kind Opportunities

There are a few scattered degraded sites in more distant portions of the Nushagak and Kvichak River watersheds that could potentially benefit from restoration or enhancement.

3.3.2.1 Old Mine Site Remediation

The U.S. Geologic Survey (USGS) identifies four small mine sites within the Nushagak and Kvichak River watersheds: Red Top (in the Wood River drainage), Bonanza Creek (a Mulchatna River tributary), Synneva or Scynneva Creek (a Bonanza Creek tributary), and Portage Creek (in the Lake Clark drainage) (USGS 2008, 2012). These sites could provide opportunities for performing ecological restoration or enhancement. However, due to their relatively small size and distant location, it is unlikely that these sites could provide sufficient restored or enhanced acreage or ecological function to offset what would be lost at the mine scenario site. Further, some mitigation measures have already occurred at these mines; for example, there have been some remediation activities at Red Top mine, although traces of mercury and diesel-range organics remain in soils (BLM 2000). Resolution of liability and contamination issues at these old mines would be necessary before they could serve as compensatory mitigation sites for other projects.

3.3.2.2 Road Removal

Another potential type of off-site restoration in the region is the removal of existing or abandoned roads. As described in detail in Appendix G, roads have persistent, multifaceted impacts on ecosystems and can strongly affect water quality and fish habitat. Common long-term impacts from roads include: 1) permanent loss of natural habitat; 2) increased surface runoff and reduced groundwater flow; 3) channelization or structural simplification of streams and hydrologic connectivity; and 4) persistent changes in the chemical composition of water and soil (Darnell et al. 1976). More recent literature identifies three other categories of impact common to roads: 1) disruption of movements of animals, including fishes and other freshwater species; 2) aerial transport of pollutants via road dust; and 3) disruption of near-surface groundwater processes, including interception or re-routing of hyporheic flows, and conversion of subsurface slope groundwater to surface flows (Trombulak and Frissell 2000, Forman 2004). Road removal, thus, could facilitate not only the reestablishment of former wetlands and stream channels, but also the enhancement of nearby aquatic resources currently degraded by the road(s).

Commenters did not offer specific suggestions for potential road removal sites. As Appendix G highlights, the Nushagak and Kvichak River watersheds are almost entirely roadless areas (see Figure 1). Further, it is unlikely that local communities would support removal of any segments of the few existing roads in the watersheds. Thus, it would appear there are very few, if any, viable opportunities to provide environmental benefits through road removal.

3.3.2.3 Road Stream Crossing Retrofits

Another potential type of off-site enhancement in the region is to retrofit existing road stream crossings to improve fish passage through these man-made features. Stream crossings can adversely impact spawning, rearing (Sheer and Steel 2006, Davis and Davis 2011), and refuge habitats (Price et al. 2010), as well as reduce genetic diversity (Wofford et al. 2005, Neville et al. 2009). These changes can in turn reduce long-term sustainability of salmon populations (Hilborn et al. 2003, Schindler et al. 2010). Fish passage is a well-documented problem commonly associated with declines in salmon and other fish populations in many regions of the United States (Nehlsen et al. 1991, Bates et al. 2003), including Alaska (ADFG 2012b).

Removing and replacing failing crossings that serve as barriers to fishes could improve fish passage and re-open currently inaccessible habitat. However, as noted in Section 3.3.2.2, the Nushagak and Kvichak River watersheds are almost entirely roadless areas, and thus offer few, if any, viable opportunities to provide the extent of environmental benefits necessary to offset the magnitude of impacts associated with the mine scenario and associated development. Further, prior to concluding that any effort to retrofit existing stream crossings would be appropriate compensatory mitigation, it would first be necessary to determine that no other party has responsibility for the maintenance of fish passage at those stream crossings (e.g., through the terms or conditions of a Section 404 permit that authorized the crossing).

Alone, the transportation corridor for the mine scenario would create approximately 70 <u>new</u> stream crossings between the mine site and Cook Inlet (Appendix G). Of the 64 stream crossings within the Nushagak and Kvichak River basins, 20 would be over streams listed as supporting anadromous fishes in the State of Alaska's Anadromous Waters Catalog and an additional 33 would be over streams that are likely to support salmonid fishes based on a stream gradient of < 12% (Table 10-8). As detailed in the Bristol Bay Assessment, there will be numerous challenges associated with ensuring that these stream crossings do not create new barriers to fish that would expand and exacerbate adverse impacts associated with the mine footprint.

3.3.2.4 Hatchery Construction

One commenter referenced the potential use of hatcheries as a compensation measure. Such a proposal would be very problematic, particularly in the context of Bristol Bay, where the current salmon population is entirely wild. There are several concerns over the introduction of hatchery-produced salmon to the Bristol Bay watershed, best expressed by the National Oceanic and Atmospheric Administration's Northwest Fisheries Science Center:

> Over the past several decades, wild salmon populations have declined dramatically, despite, and perhaps sometimes because of, the contribution of

> hatcheries. Many salmon stocks in Washington and Oregon are now listed as either threatened or endangered under the U.S. Endangered Species Act. With this decline has come an increased focus on the preservation of indigenous wild salmon stocks.
>
> Hatcheries have the potential to assist in the conservation of wild stocks, but they also pose some risks. At this time, scientists still have many questions about the extent to which hatchery programs enhance or threaten the survival of wild populations. Additional research and investigation is needed (NOAA 2012).

Many of the potential risks associated with fish hatcheries concern reductions in fitness, growth, health, and productivity that result from decreases in genetic diversity when hatchery-reared stocks hybridize with wild salmon populations. Hatchery-raised salmon have lower genetic diversity than wild salmon (Christie et al. 2011, Yu et al. 2012). Consequently, when hatchery-raised salmon hybridize with wild salmon, the result can be a more genetically homogenous population, leading to decreases in genetic fitness (Waples 1991). In some cases, wild populations can become genetically "swamped" by hatchery stocks. Zhivitovsky et al. (2012) found evidence of such swamping in a wild chum salmon population in Kurilskiy Bay, Russia during a two-year period of high rates of escaped hatchery fish. This genetic homogenization is of concern because hatchery-raised fish stocks are considered less genetically "fit" and therefore could increase the risk of collapse of salmon fisheries. This concern is supported by a review of 14 studies by Araki et al. (2008), which suggests that nonlocal hatchery stocks reproduce very poorly in the wild. The authors of this review also found that wild stocks reproduce better than both hatchery stocks and hatchery stocks that use wild, local fish.

Hatchery fish can also compete directly for food and resources with wild salmon populations in both freshwater and marine environments (Rand et al. 2012). Ruggerone et al. (2012) examined the effect that Asian hatchery chum salmon have had on wild chum salmon in Norton Sound since the early 1980's. They found that an increase in adult hatchery chum salmon abundance from 10 million to 80 million adult fish led to a 72% reduction in the abundance of the wild chum salmon population. They also found smaller adult length-at-age, delayed age-at-maturation, and reduced productivity were all associated with greater production of Asian hatchery chum since 1965 (Ruggerone et al. 2012). In addition to this competition for resources, hatchery-raised subyearling salmon can also predate upon wild subyearling salmon, which tend to be smaller in size (Naman and Sharpe 2012).

Despite extensive efforts to restore federally listed Pacific Northwest salmon populations, they remain imperiled, and hatchery fish stocks may be a contributing stressor (Kostow 2009). Given the exceptional productivity of the wild Bristol Bay salmon population, hatcheries, while they can produce fish, would appear to pose greater ecological risks than benefits to this unique and valuable wild salmon population.

3.3.2.5 Fish Stocking

Since many of the fish used in fish stocking originate in hatcheries, fish stocking raises many of the same concerns as hatcheries and thus would also be a problematic form of compensatory mitigation in the context of the Bristol Bay. Although stocking has been a common practice in other regions, even in previously fishless habitats (e.g., Red Dog Mine, Alaska), a large body of literature describes widespread impacts of such management decisions. Fish stocking throughout western North America and worldwide has had documented impacts on other fish (Townsend 2003, Knapp et al. 2001), nutrient cycling (Eby et al. 2006, Schindler et al. 2001, Johnson et al. 2010), primary production (Cucherousset and Olden 2011, Townsend 2003), aquatic macroinvertebrates (Cucherousset and Olden 2011, Dunham et al. 2004, Pope et al. 2009), amphibians (Finlay and Vredenberg 2007, Pilliod and Peterson 2001), and terrestrial species (Epanchin et al. 2010). While fish stocking has provided limited benefits in certain circumstances, it would appear from the growing body of literature that the ecological costs of fish stocking far outweigh any potential benefits.

3.3.2.6 Commercial Fishery Harvest Reductions

One commenter suggested reducing commercial fishery harvests to compensate for fish losses due to large-scale mining. The State of Alaska currently manages the Bristol Bay commercial fisheries for Maximum Sustained Yield, allowing the fishery to harvest the surplus production (i.e., fish that would not have contributed to the reproductive output of the population due to competition) from the stocks. The populations managed with this approach are those of the Nushagak and Kvichak Rivers, rather than their individual tributaries. Due to the density-dependent self-regulation of populations in individual tributaries, increasing escapement into the Nushagak and/or Kvichak Rivers would address neither localized reductions in carrying capacity or productivity due to habitat loss or degradation from the mine scenarios, nor resulting reductions in the overall productivity of the system as a whole. Furthermore, although there has been some concern that harvest of returning salmon has reduced ecosystem productivity in this region, Hilborn (2006) found that paleoecological analysis of returns does not indicate decreased production due to commercial fishing. In light of these considerations, reducing the commercial fishery harvest would not appear to be an effective mechanism to offset impacts to fish productivity associated with mining.

3.3.2.7 Other Suggested Compensation Measures

Comments also included suggestions that compensatory mitigation for impacts to fish and other aquatic resources could take the form of making payments to organizations that support salmon sustainability or investing in various public education, outreach, or research activities designed to promote salmon sustainability. Although these kinds of initiatives can provide benefits in other contexts, compensatory mitigation for impacts

authorized under Section 404 of the Clean Water Act can only be provided through purchasing credits from an approved mitigation bank or in-lieu fee program or conducting permittee-responsible compensatory mitigation projects (40 CFR 230.92).

4 Conclusion

The mine scenarios evaluated in the Bristol Bay Assessment show that the mine footprint alone will result in the loss (i.e., filling, blocking or otherwise eliminating) of hundreds to thousands of acres of high-functioning wetlands and tens of miles of salmon-supporting streams. In addition to these direct losses, these mine scenarios would also result in extensive adverse secondary and cumulative impacts to wetlands, streams, and fish that would have to be addressed. Such extensive habitat losses and degradation could also result in the loss of unique salmon populations, potentially eroding the genetic diversity essential to the stability of the overall Bristol Bay salmon fishery. 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.

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