# Appendix A

How to construct PVC housings for water temperature sensors with cable installations

**Appendix A (Mauger 2008)**

**Housing Construction**
PVC housings are very simple to make, inexpensive ($10-15), provide total shade for the logger, protect the logger from moving debris, and provide for secure attachment with a cable.

The data logger is suspended in a PVC pipe that allows stream water to flow through but prevents solar radiation to penetrate. Black PVC provides more camouflage than white PVC for sites where vandalism is a concern. In clear water streams, heat absorption by the dark surface may be an issue so white PVC is recommended.

Here's a supply list to make the housings:

2" Sch 40 ABS pipe (1' length)
2" DWV clean out plug (2)
2" DWV female adaptor (2)
3/8 " x 4" ZC eye bolt (1)
8" cable ties
Multi purpose cement
Assorted nuts and bolts

Glue the female adapters to each end of the PVC pipe. Drill a hole for one eyebolt to go through a clean out plug. Drill at least 20 holes in PVC to allow water flow. Secure the eye bolt through the clean out plug with appropriate-sized nuts and bolt. Use a cable tie through drilled holes to suspend the data logger in the housing. Additional cable ties can be used to secure rocks in the bottom of the housing to weigh it down. Screw the clean out plugs into the female adapters.

# Appendix B

How to make and install homemade radiation shields for air temperature sensors

# Air Temperature Sensor Installation Instructions

Zack Holden; email: zaholden@fs.fed.us (406) 274.6766

Instructions for building the radiation shield can be found at: www.youtube.com/watch?v=LkVmJRsw5vs

## STEP 1: Mount radiation shield cover

The radiation shield should be installed at a height of 6 feet on the north-facing side of a large (> 12 inch diameter) tree. A coniferous tree that does not lose its leaves in winter is preferred. Bend and fold the triangular tabs of the radiation shield cover downward to create angled “wings”. Nail the cover to the tree using aluminum nails (FIGURE 1). Hammer nail until nail head touches plastic, or for trees with thin bark, bend the nail sideways against the plastic shield to hold the shield firmly against the tree. Make sure the nail goes through both the triangular tab and rectangular back cover. This will give the shield extra support. Note that the angle of the cover wings *can be adjusted depending on the size of the tree. The cover should be approximately perpendicular* to the bole of the tree (level to the ground) as shown in FIGURE 2. However, when mounted on smaller trees, the shield will naturally bend downward, point toward the ground, which is not a problem.

FIGURE 1

FIGURE 2

## STEP 2: Record Logtag sensor ID number

Each Logtag temperature sensor has a unique 10 digit ID number located just above the barcode sticker (FIGURE 3). Record the ID number and the GPS location on a datasheet (Lat /Long or UTM X/Y, include the DATUM).

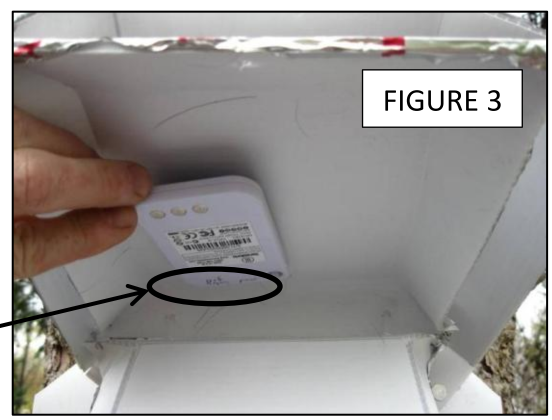

FIGURE 3

Sensor ID: 9900301054

## STEP 3: Secure Logtag to the 2-plate shield

You will see two holes drilled into the top piece of the 2-plate shield. Using a 4 or 6 inch zip tie, insert the zip tie through the top piece, through the logtag hole, then back up through the top piece. Secure the zip tie. Make sure to close the zip tie **AS TIGHTLY AS POSSIBLE.** The top corner of the logtag must be pulled snugly against the top of the plastic cover. The opposing corner should hang down and touch the bottom piece of the 2-plate shield. It is critical to minimize direct surface contact between the sensor and the plastic shield pieces and to allow as much air flow as possible past the sensor.

## STEP 4: Hang shielded sensor beneath the cover

Using 8 inch zip ties, suspend the 2-plate shield (logtag sensor is now housed inside) from the large mounted radiation shield cover as follows: push the 8 inch zip ties through the pre-drilled holes in the top cover and loop them through the 6 inch zip ties that are holding the 2-plate shield together (FIGURE 4 and FIGURE 5).

FIGURE 4

FIGURE 5

## STEP 4: Close and adjust radiation shield

Using an 8 inch zip tie, secure the front of the 2-plate shield to the front of the shield cover (FIGURE 6) as follows: insert the zip tie through the top of the cover, downward through each of the two plates below, and then bring it back up and close the zip tie. It is important that there be adequate space between the 2 plates that surround the temperature sensor to allow air flow. Use your hands to create a gap between the two lower plates. Adjust as necessary, using the friction of the ziptie to maintain space between the 2 lower plates housing the air sensor. There should be approximately a 1.25-1.5 inch gap between the two plates when you're finished. The shield should be approximately parallel with the ground and sit approximately 6 feet (or higher) off the ground. When completed, it should look like FIGURE 6.

FIGURE 6

# Appendix C

Temperature sensor calibration forms

**Table C1**. Form for doing a multiple-point temperature calibration in which temperature sensors and field thermometers are checked against a NIST-certified thermometer.

| # | Initials | Date | Time | Temperature (°C) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | NIST Thermometer | Field Thermometer | Field Thermometer | Sensor | Sensor | Sensor | Sensor | Sensor |
| | | | | S/N - | S/N - | S/N - | S/N - | S/N - | S/N - | S/N - | S/N - |
| 1 | | | | | | | | | | | |
| 2 | | | | | | | | | | | |
| 3 | | | | | | | | | | | |
| 4 | | | | | | | | | | | |
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| 14 | | | | | | | | | | | |
| 15 | | | | | | | | | | | |

**Table C2**. Form for checking temperature sensor readings against one another.

**Technician:**
**Date/s of calibration check:**

**Overall mean temperature (all sensors) (°C):**

| Sensor S/N | Mean Temperature (°C) | Difference from overall mean | Minimum Temperature (°C) | Maximum Temperature (°C) | Notes |
|---|---|---|---|---|---|
| | | | | | |
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# Appendix D

## Temperature sensor deployment & tracking forms

(fill out one for each sensor)

S/N:

Water or air:

Programmed launch date & time:

Deployment date and time:

Expected retrieval date:

Battery type:

Configuration

Recording interval:

Units:

Start time:

Station number:

Waterbody name:

GPS coordinates for sensor

Longitude (dec. degrees):

Latitude (dec. degrees):

Datum:

File names of photos:

Installation technique:

Description of location (e.g. type of structure it is attached to; type of habitat (riffle, run))

Hand-drawn map (and/or attach print out of annotated photo)

| **Task** | **Date** | **Time** | **Technician** | **Notes** |
|---|---|---|---|---|
| Pre-deployment accuracy check | | | | |
| Launch/start | | | | |
| Deployment (in the water) | | | | |
| Mid-deployment accuracy check (in Notes, write down NIST-calibrated field thermometer reading and sensor reading) | | | | |
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| Data download | | | | |
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| | | | | |
| | | | | |
| Sensor Retrieval | | | | |
| Pre-deployment accuracy check | | | | |

# Appendix E

Equipment lists for temperature sensor procedures

These are equipment lists for various phases of deployment. These lists do NOT include health and safety equipment or personal gear like waders**.**

**Equipment needs for the pre-deployment accuracy check.**

| Task | Supplies List |
|---|---|
| Performing the calibration procedure | • Temperature sensor/s<br>• National Institute of Standards and Technology (NIST) traceable or calibrated reference thermometer with an accuracy of ±0.2°C<br>• Field (i.e. red liquid) thermometers (optional)<br>• Containers to hold the sensors<br>• Water<br>• Refrigerator<br>• Clock or watch |
| Recording measurements | • Calibration data sheet (Attachment C)<br>• Computer that has the appropriate software for reading the temperature sensor |

**Equipment list for doing underwater epoxy installations (Isaak et al. 2010).**

| Task | Supplies list |
|---|---|
| Installation | • Temperature sensor<br>• Radiation shield (PVC canister, 1-1/2” with screw top, mid-section and base)<br>• Underwater epoxy (FX-764 Splash Zone Epoxy)<br>• Jars for mixing the epoxy<br>• Underwater viewing box<br>• Lead weights, ¼ oz<br>• Neoprene, 3mm<br>• Rubber gloves<br>• Wire brush<br>• Zip ties, 4”<br>• Metal mirror |
| Monument | • Metal forestry tags<br>• Spray paint<br>• GPS<br>• Camera<br>• Field form |

**Equipment list for doing cable installations (Ward 2011, Mauger 2008).**

| Task | Supplies list |
|---|---|
| Installation | • Temperature sensor<br>• Radiation shield (see Attachment A (Mauger 2008))<br>• Cable<br>• Rebar (3/8 to 1/2", 2-4 ft lengths)<br>• Rebar pounder (for custom design, see Ward 2011 – Attachment B)<br>• For more information see checklist in Ward 2011 (Attachment A) and/or Attachment G (Mauger 2008) |

**Equipment list for documenting sites.**

| Task | Supply list |
|---|---|
| Georeferencing & monumenting | • GPS<br>• Camera<br>• Map and/or gazetteer<br>• Metal forestry tags<br>• Field form |
| Measuring temperature and depth | • NIST-calibrated field thermometer and/or multi-probe meter<br>• Meter ruler or calibrated rod/pole (i.e. surveyor's rod)<br>• Measuring tape |

**Equipment list for conducting maintenance/mid-deployment checks and data downloads.**

| Task | Supply list |
|---|---|
| Relocating sensor | • GPS<br>• Map and/or gazetteer<br>• Annotated photos and/or hand-drawn map with landmark references (see Section 3.3.3) |
| Documenting on-site-conditions | • Camera<br>• Field form (similar to Attachment E) |
| Data offloads | • Base station or portable shuttle<br>• Laptop (if practical) & data back-up device (e.g. flash drive) |
| Measuring temperature and depth | • NIST-calibrated field thermometer and/or multi-probe meter<br>• Meter ruler or calibrated rod/pole (i.e. surveyor's rod)<br>• Measuring tape |
| Back-up equipment (in case a sensor needs to be replaced) | • Calibrated replacement sensors and other necessary deployment equipment |

# Appendix F

Examples of alternate installation techniques

**Appendix F**

**Rebar Method (Mauger 2008)**
This method is preferred for streams with moderate movement of the streambed during high flows. The protective case or PVC housing is attached by a cable to a rebar stake sunk 3 feet into the stream bed.

Secure an eyebolt to the rebar (approximately 1 foot from an end) with hose clamps. Secure one end of the cable to the eyebolt with a wire rope clip. Secure the other end to the protective case or PVC housing using a wire rope clip. Use a stake pounder to sink the rebar 3 feet into the stream bottom near a large rock or other landmark.

Materials:
1/2" rebar (4' length)
3/8 " x 4" ZC eye bolt (1)
9/16 - 1 1/16 hose clamp (3)
1/8" wire rope clip (2)
1/8" RL uncoated cable (2' length)

**Stream Bank-Secured Cable Method (Mauger 2008)**
This method is preferred for streams with significant movement of the streambed during high flows. In this method the logger in its protective case or PVC housing is secured to the stream bank vegetation using plastic-coated wire rope.

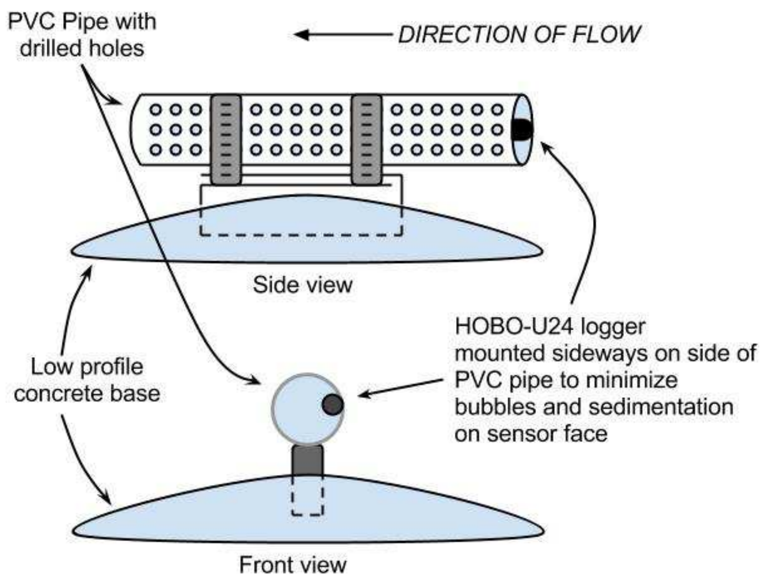
The logger is secured to the wire rope (1/8” to 3/8” diameter and 12 feet long) using a wire rope clip. Upon deployment the cable is wrapped around a large tree, rocks, bridge supports, or other secure object within or on the stream bank. The logger is then placed within the stream channel. Large stream rocks can be placed on top of the cable near the logger to hold the logger in place within the stream. The cable should be hidden under bank vegetation to avoid vandalism or accidental disturbance. Try to avoid locations where the cable will cross active fishing or wildlife trails.

**Sand Bag Method (Mauger 2008)**
This method is preferred for streams with minimal movement of the streambed during high flow events.

Sturdy sand bags can be purchased at most hardware stores. Fill the bag on site with any mineral material (large rocks, cobbles or sand). Avoid organic material which is often buoyant. The logger, in its protective case or PVC housing, can be attached to the bag by weaving a cable tie through the mesh. The bag can be tied off with a rope to the stream bank for extra security. The rope should be hidden under bank vegetation to avoid vandalism or accidental disturbance. Try to avoid locations where the rope will cross active fishing or wildlife trails.

**Delaware River Basin Commission (DRBC) Low Profile Concrete Base Technique**

DRBC uses this technique for year-round deployment of conductivity, temperature and dissolved oxygen sensors. Some of their sensors have been deployed for more than 2 years with minimal maintenance.




The general protocol is as follows:

- To make the concrete base, pour 40-lbs of mixed concrete into a saucer snow sled (the sled is used as a mold and can be reused). Add some metal to the concrete to provide mounting points for the protective shield.

Making a concrete base for sensor deployment. Photo taken by John Yagecic.

- Using metal straps, mount the protective shield to the concrete base.

- Attach the sensor to the protective shield with zip ties. The sensor is affixed to the side of the shield such that the sensor face is held in the vertical plane. This is consistent with the manufacturer's recommendations and reduces build-up of silt or bubbles on the sensor face.

Photo provided by the Delaware River Basin Commission.

- When placing the unit in the water, orient the base in such a way that flowing water will encounter the sensor first. This should reduce any mild impacts to water chemistry from water flowing over the shield or base. The end of the shield that points upstream should protrude a little further than the downstream end. The photo below shows an old-style base. For the last few years, DRBC has oriented the bars in the other direction and has bent them flush with the top surface of the concrete base. The PVC pipe is then attached to the bars using large hose clamps. The new configuration is lower profile and more secure.

Deployed sensor. Photo taken by Don Hamilton.

- Data are downloaded and conductivity and temperature sensors are cleaned about once every 3 weeks.
- Manufacturer's recommendations for pre- and post-deployment data adjustment are followed.

**For more information, contact John Yagecic (John.Yagecic@drbc.state.nj.us) and Eric Wentz (Eric.Wentz@drbc.state.nj.us) from the DRBC.**

# Appendix G

Mid-deployment/maintenance check form

(fill out one for each mid-deployment site visit)

Date:

Time:

Technicians:

Data offload (yes/no):

Battery life:

Station Number:

Waterbody Name:

Water temperature S/N:

Air temperature S/N:

Photo file names:

**MAINTENANCE CHECK**

Are there any signs of physical damage, vandalism or disturbance? If yes, describe.

______________________________________________________________________

Is the water temperature sensor dewatered? If yes, describe.

______________________________________________________________________

Is the water temperature sensor buried in sediment? If yes, describe.

______________________________________________________________________

Is there evidence of fouling (i.e. debris, aquatic vegetation, algae)? If yes, describe.

______________________________________________________________________

**ACCURACY CHECK**

Temperature measurements should be taken with a NIST-calibrated field thermometer.

Field thermometer S/N:

| | Water | | Air | |
|---|---|---|---|---|
| | Field Thermometer | Sensor | Field Thermometer | Sensor |
| Date | | | | |
| Time | | | | |
| Temperature (°C) | | | | |

## DEPTH MEASUREMENTS

| **Measurement** | **Value** | **Units** |
|---|---|---|
| Total stream depth at the sensor: | | |
| Distance from the stream bottom up to the sensor: | | |
| Distance from water surface to the sensor: | | |
| Wetted width along a transect that intersects the sensor: | | |

(Optional) Cross sectional survey of stream temperature (taken along a transect that intersects the sensor with a NIST-calibrated field thermometer)

| **#** | **Distance from bank** | **Temperature (°C)** | **Depth (m)** | **Notes** |
|---|---|---|---|---|
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |
| 4 | | | | |
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| 9 | | | | |
| 10 | | | | |

# Appendix H

QA/QC checklist for temperature sensor data

**QA/QC CHECK – TEMPERATURE SENSOR DATA**

Technician conducting QA/QC check:

Sensor S/N: Station number:

Water or air: Waterbody name:

| **Sensor** | **Date** | **Time** | **Technician** |
|---|---|---|---|
| Programmed launch/start | | | |
| Deployment (in water) | | | |
| Retrieval | | | |

| **Accuracy checks** | **Pass/fail** | **Notes** |
|---|---|---|
| Pre-deployment | | |
| Mid-deployment | | |
| Post-deployment | | |

Describe how you addressed flagged data

______________________________________________________________________

Did you save the original data (pre-'cleaned')? If so, what is the file name and where is it located?

______________________________________________________________________

What is the file name of the ‘cleaned data’ and where is it located?

______________________________________________________________________

Did you back up both the original and ‘cleaned’ data files? If so, where are the back-up files located?

______________________________________________________________________

| Checklist | | Yes/No | Notes |
|---|---|---|---|
| Did you check the units to ensure that they were consistent throughout the period of deployment (should be °C)? | | | |
| Were there missing data? If so, in the Notes field, describe how you addressed these data and why you think they occurred | | | |
| Did you remove observations recorded before and after the sensor was correctly positioned in the stream channel? (e.g. if it was programmed to launch before it was deployed in the stream) | | | |
| Did you flag values if they met the conditions below? (If you used different thermal limits, write what you used in the Notes field) | | | |
| | > 25 °C | | |
| | < −1 °C | | |
| | > daily change of 10 °C | | |
| | > upper 5th percentile of the overall distribution | | |
| | < lower 5th percentile of the overall distribution | | |
| Did you plot individual data points to look for abnormalities? | | | |
| Did you compare the data to other datasets (see below)? | | | |
| | vs. air temperature | | |
| | vs. other sites | | |
| | vs. other years | | |
| | vs. flow data (if available) | | |

# Appendix I

Equipment checklists for pressure transducer protocols

**Equipment list for staff gage installation.**

| Location | Supplies list |
|---|---|
| All | · Staff gage<br>· Gage board<br>· Screws (stainless steel or brass)<br>· Screwdriver<br>· Assorted drill bits for wood and PVC<br>· Level<br>· Stepladder (if installing more than one section of a staff gage)<br>· Datasheets and field notebook<br>· Survey equipment (auto level or laser level and stadia rod, paint marker or nails for marking benchmarks) |
| Fixed Object – additional items | · Concrete wedge anchor and nuts (stainless steel or galvanized)<br>· Hammer or rotary drill<br>· Concrete drill bit<br>· Hammer |
| Streambed – additional items | · Galvanized or stainless steel pole with cap<br>· Galvanized or stainless steel conduit straps<br>· Pole driver or sledge hammer<br>· Pry bar |

**Equipment list for transducer installation.**

| Location | Supplies list |
| --- | --- |
| All | · PVC pipe for transducer (drilled with ½” or larger holes)<br>· PVC pipe for data logger or barometric pressure logger<br>· Galvanized or stainless steel conduit straps, hangars, and hose clamps<br>· Zip ties/cable ties<br>· Screws (stainless steel or brass)<br>· Screwdriver<br>· Drill<br>· Assorted drill bits for wood and PVC<br>· Level<br>· Datasheets and field notebook<br>· Survey equipment (see Section 4.3.5).<br><br>*If using a non-vented transducer, you also need:*<br>· Non-stretch cable or wire<br>· Wire rope clamps<br>· Long bolt and wing nut<br>· Extra-long PVC (should extend out of water in high flows)<br>· Solar shield (if using barometric logger for air temperature data, see Attachment B for instructions)<br>· PVC with caps for barometric transducer<br><br>*If using a vented transducer, you also need:*<br>· Garden staples<br>· PVC pipe for data logger<br>· PVC cap or locking well cap<br>· Stainless steel conduit straps<br>· Long lag screws<br>· Wire cable |
| Fixed object – additional items | · Hammer or rotary drill<br>· Concrete drill bit<br>· Concrete wedge anchor and nuts (stainless steel or galvanized)<br>· Hammer |

**Equipment list for elevation surveys.**

| Supplies list |
| --- |
| • Auto level or laser level<br>• Tripod<br>• Stadia rod<br>• Survey paint<br>• Survey nails<br>• Datasheet |

**Equipment list for taking discharge measurements.**

| **Supplies list** |
|---|
| • Current meter/s<br>• Wading rods<br>• Measuring tape and stakes<br>• Discharge measurement form |

**Equipment list for generating a profile of the channel cross-section.**

| **Supplies list** |
|---|
| • Automatic level or electronic total station and tripod or a clinometer<br>• Stadia rod<br>• Measuring tape and stakes |

# Appendix J

Field forms for water level and flow measurements

# Elevation/Staff Gauge Survey Sheet

**Site:**________________________________ **Date:**________________________

**Crew:**________________________________ **Gage (ft):**____________________

Notes:

BS = backsite, HI = height of instrument, FS = foresite, BM = benchmark, TP = turning point
H.I. = B.S. + Elevation, Elevation = H.I. -F.S.

| BM # | Location | BS | HI (+) | FS (-) | Elevation |
|---|---|---|---|---|---|
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Notes and Site Sketch:

## Transducer Download Field Data Sheet

**Site:** ______________________________

**Date:** ______________ **Time:** ______________

**Crew:** ______________________________

**Weather:** ______________________________

**Gage (ft.):** ______________ **Transducer (ft):** ______________

**Photos taken?** ______________ **Gage Survey?** ______________

**Battery Status:** ______________ **Batteries Changed?** ______________

**File name:** ______________________________

**Notes:**

# Discharge Measurement Field Data Sheet - Marsh McBirney

Site: ______________________________

Date: ______________________________

Crew: ______________________________

Weather: ______________________________

Start time: ______________ Finish time: ______________

Gage before (ft.): ______________ Gage after (ft): ______________

Equipment: ______________ Photos taken? ______________

Gage Survey? ______________

Notes:

| Point | Tape Distance (ft) | [Cell width (ft)] | Depth (ft) | [Velocity (fps)] | [Q (cfs)] | % of Q | Notes |
|---|---|---|---|---|---|---|---|
| 1 | | | | | | | |
| 2 | | | | | | | |
| 3 | | | | | | | |
| 4 | | | | | | | |
| 5 | | | | | | | |
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| 32 | | | | | | | |
| 33 | | | | | | | |
| 34 | | | | | | | |
| 35 | | | | | | | |
| | | | | | Total Q (cfs): | | |

# Discharge Measurement Field Data Sheet - Pygmy/Price Meter

Site: ______________________

Date: ______________________

Crew: ______________________

Weather: ______________________

Start time: ______________ Finish time: ______________

Spin before (seconds): ______________ Spin after (seconds): ______________

Gage before (ft.): ______________ Gage after (ft): ______________

Equipment: ______________ Photos taken? ______________

Gage Survey? ______________

| Point | Tape Distance (ft) | [Cell width (ft)] | Depth (ft) | Clicks/ 40 sec | [Velocity (fps)] | [Q (cfs)] | % of Q | Notes |
|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | | | |
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| 32 | | | | | | | | |
| 33 | | | | | | | | |
| 34 | | | | | | | | |
| 35 | | | | | | | | |
| | | | | | Total Q (cfs): | | | |