

MaineDOT ENVIRONMENTAL OFFICE

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Project: Howland Rt 116 Large Culvert (WIN 18826.00) Habitat Connectivity Design Report
Date: October 3, 2018

This memo describes the stream assessment information collected by MaineDOT and the proposed Habitat Connectivity Design (HCD) of a large culvert replacement project in Howland (WIN 18826.00). The project is located where Route 116 crosses Emerson Runaround, a tributary of the Penobscot River, approximately 0.31 miles north of the Edinburg town line (Figure 1). A longitudinal profile survey of the stream channel was prepared by MaineDOT staff and used to confirm that the crossing design is in accordance with the standards in the Maine ATS Programmatic Agreement (hereafter MAP) Appendix B – Habitat Connectivity Design Protocol. The project is in DPS Critical Habitat (CH) and a MAP Tier 1 area.

Existing Structure

The existing culvert is a 6-foot diameter by 66-foot long corrugated metal pipe (CMP) with an average slope less than 0.1% (MaineDOT Asset ID LC-46276). Water depths between 1 and 1.75 feet were measured at the outlet at the time of site visits in fall of 2015 and summer 2018.

Bankfull Width Determination

MaineDOT staff were unable to measure representative bankfull widths upstream of the crossing because of ponded conditions and very soft soils. The inlet was partially blocked with 6 to 12 inches of woody material at the time of site visits in 2015 and 2017 which helps create a shallow overwidened channel upstream. Therefore, MaineDOT relied on measured values taken from the downstream channel to size the replacement structure, as summarized below:

Watershed Area	W_{bkf} (measured)	$1.2 \times W_{bkf}$	Proposed Structure Size
2.6 mi ²	Avg = 12.2 feet	14.6 feet	15 foot span box culvert

Longitudinal Profile

In July 2018, MaineDOT ENV staff used an autolevel to collect additional stream profile data to supplement points previously collected by a MaineDOT Survey crew in 2015. The additional survey extended the longitudinal profile more than 20 times the average bankfull width both upstream and downstream of the crossing. The survey extended over 400 feet downstream to a large boulder step that controls the water surface elevation in the lower portion of the downstream channel. The backwater conditions and soft soils in the upstream channel limited the

number of points that could be collected. This section of Emerson Runaround is a very low gradient channel with an average overall (combined upstream and downstream) slope of about 0.2%. (Figure 2).

Stream Channel Characteristics

Route 116 crosses this section of Emerson Runaround at about a 45 degree angle. This skew will be maintained in the proposed design to keep the culvert aligned as closely as possible with the existing channel.

Upstream of the culvert, the channel is overwidened due to the shallow (approx. 1 to 3 feet deep) ponded conditions (photos 1, 2 and 3). Forested uplands border both banks and a patch of emergent wetland vegetation occurs along a portion of the right bank. Water depth appears to have been controlled over time by both woody material that collects at the inlet and raises the upstream water level, and by the elevation of natural grade control features in the bed downstream of the culvert. These features appear to maintain typical water depths in the culvert of 1 to 2 feet, based on observations made during site visits. The shallow ponding, and very low slope have resulted in the extensive deposition of fine textured sediment that covers and obscures any preexisting streambed features located upstream.

Downstream of the culvert, a section of straight to slightly curved riffle-pool channel extends about 400 feet downstream before reaching a very stable grade control point (rock step) made up of large to very large boulders (photos 4, 5, 6 and 7). At the culvert outlet there is an approximately 10-foot wide by 15-foot long by 1.5-foot deep pool with a stable gravel-cobble push bar. Below the push bar, the downstream channel is bordered by forested uplands along the left bank and a densely vegetated emergent wetland floodplain along the right bank (Photos 2 and 3). The channel has a variable bed that includes both cobble-gravel substrate and deposits of finer textured sediment in pool bottoms. Several shallow pool-and-riffle features with an irregular spacing of about 50 to 60 feet were present.

Pebble Count

Measuring particle sizes with a standard pebble count was not practicable at the time of the site visit in November 2017 due to cold temperatures and water depths greater than 1 foot. Instead, a composite bulk sample was collected from several points in the bed of the downstream channel by shovel, and a set of square mesh sieves was used in the field to estimate the particle size distribution (Photo 8). The bed was armored with a well embedded layer of very coarse gravel to large cobbles that were underlain by a mix of gravel, sand and some fines. The riffle crests and scattered individual feature rocks were comprised of small cobbles to boulders typically ranging in size from about 64 mm up to 400 mm. The D50 particle size of the downstream channel was estimated to be between 16 and 23 mm (medium to coarse gravel) (Figure 3.).

Proposed Habitat Connectivity Design

Based on an evaluation of the long profile survey and the results of the geomorphic assessment, a **Habitat Connectivity Design (HCD)** approach is proposed for this crossing. The proposed

HCD replaces the existing 6-foot culvert with a 15-foot span by 6-foot rise by 152-foot-long reinforced concrete box culvert that will have culvert streambed material (CSM) placed along the bottom. The 15-foot span is more than 1.2 times the average measured bankfull width of 12.2 feet.

The proposed culvert will be set at a flat design slope (Figure 2). This slope was selected because of the slightly higher elevation of the riffle crests in the downstream channel compared to upstream, and to improve constructability. The average bed elevation will be set slightly lower than the first downstream riffle crest. This will maintain a minimum of several inches of water in the culvert during low flow conditions. This approach fits the overall slope of this section of the existing channel, and meets the following design objectives: 1) maintain backwater depths in the culvert similar to existing conditions to allow for aquatic organism passage under low/no flow conditions, and 2) mimic channel morphology in the reference reach downstream.

In accordance with the typical HCD approach under the MAP, the replacement culvert will include a minimum 24-inch thick layer of culvert streambed material (CSM). The cross-sectional design of the streambed in the culvert will provide for a low flow channel, and banklines to maintain the channel shape and provide hydraulic roughness and flow diversity along the edges. The banklines will be shaped during construction to form a smooth flow transition at the inlet and outlet of the culvert and will be fit to field conditions. The banklines will extend outside of the culvert and tie-in to the existing natural streambanks where present.

The gradation of the streambed material will be based on the results of the particle size analysis, and may be adjusted to account for differences in anticipated flow conditions between the existing channel and the proposed culvert in accordance with the MAP references. The design goal is to provide a moderately stable bed, that has similar characteristics to the downstream reference reach.

The final streambed design will include several low transverse rock ribs or rock bands to provide grade control, help retain bed material in the culvert during peak flows, and initiate limited step-pool formation in the culvert streambed. During final design, the D84 and D50 particle sizes of the CSM will be selected such that they have similar mobility/stability as the bed material sizes in the downstream channel at the estimated bankfull flow (approx. 14 cfs). The materials used to form the banklines inside the culvert will be checked for stability at flows up to the Q100 design flow (approx. 223 cfs).

Vertical Adjustment Potential (VAP)

The lower Vertical Adjustment Potential (VAP) of the channel section through the replacement culvert was evaluated based on the characteristics of the downstream reach. The upstream channel was not included because of the limited survey data that could be collected due to site conditions. The downstream profile clearly shows the presence of low crests and shallow pools in the streambed surface.

A lower VAP line was determined based on the largest residual pool depth (RPD) in the downstream channel of about 0.8 feet, using the methods described in the USFS stream simulation guidance documents referenced in the MAP. Using the maximum RPD and an adjustment factor of 1.75 for a riffle-pool channel with a gravel-cobble substrate results in an estimated scour depth of 1.4 feet in the channel during peak flows.

The results of the VAP analysis confirm that the proposed culvert inverts will be below the lower VAP line and suggests that the proposed 24 inches of streambed material will provide adequate depth of material should local scour occur within the culvert.

Hydraulic Capacity

In accordance with the MAP, the hydraulic capacity of the proposed design was checked with the Federal Highway Administration (FHWA) HY-8 Culvert Analysis Program to confirm that it meets MaineDOT's headwater depth standard of less than or equal to 1 (i.e. the inlet headwater is at or below the top of the culvert) at the estimated Q100 peak flow.

References

Dudley, R.W., 2004, Hydraulic-geometry relations for rivers in coastal and central Maine: U.S. Geological Survey Scientific Investigations Report 2004-5042, 30p.

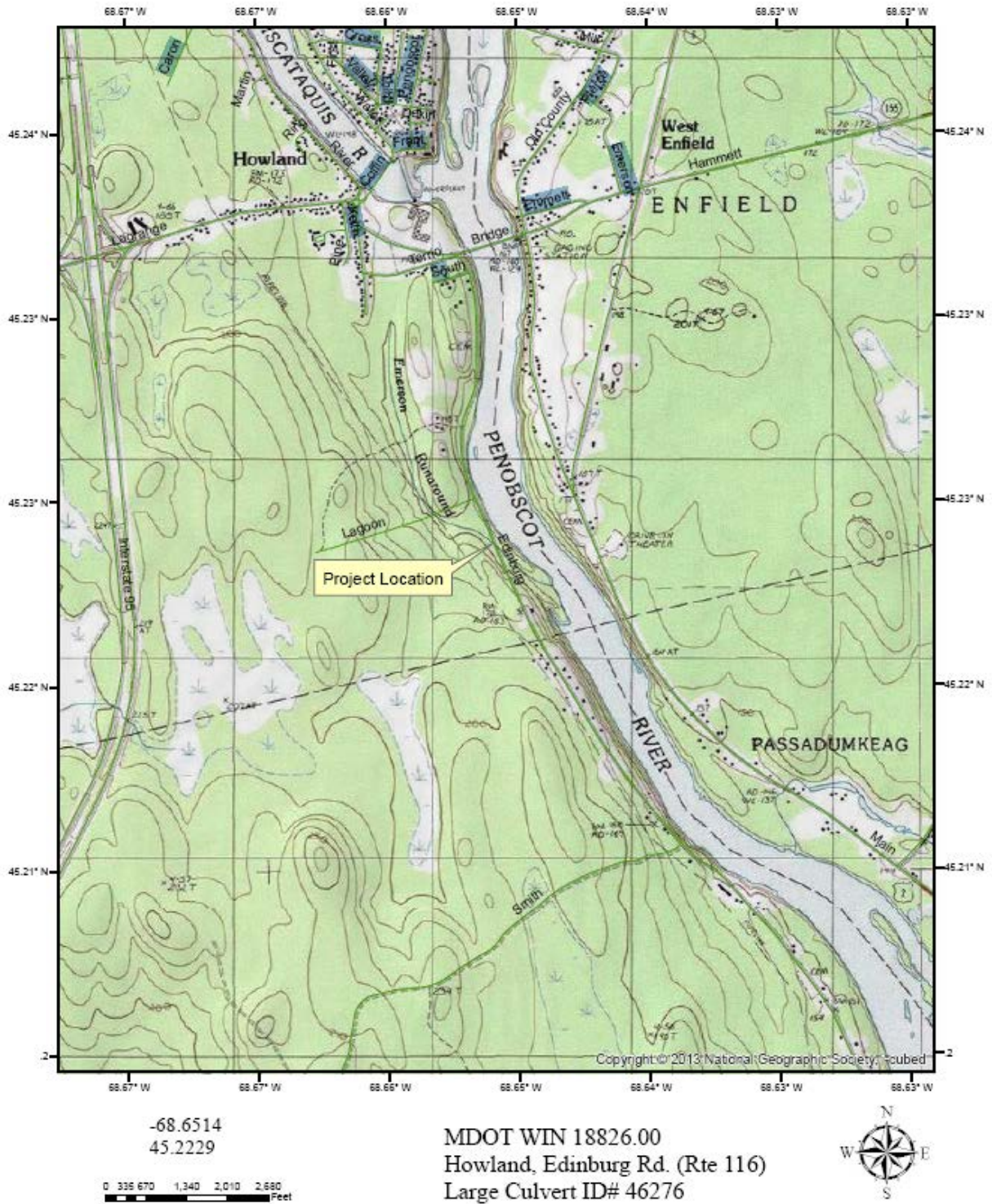


Figure 1. Location map of a proposed HCD culvert replacement project (MaineDOT WIN 18826.00).

Howland Rt 116 - Emerson Runaround (WIN 18826.00)
 Longitudinal Stream Profile and Proposed HCD Culvert
 (based on DOT Survey and ENV stream survey data;
 Culvert locations based on draft PDR)

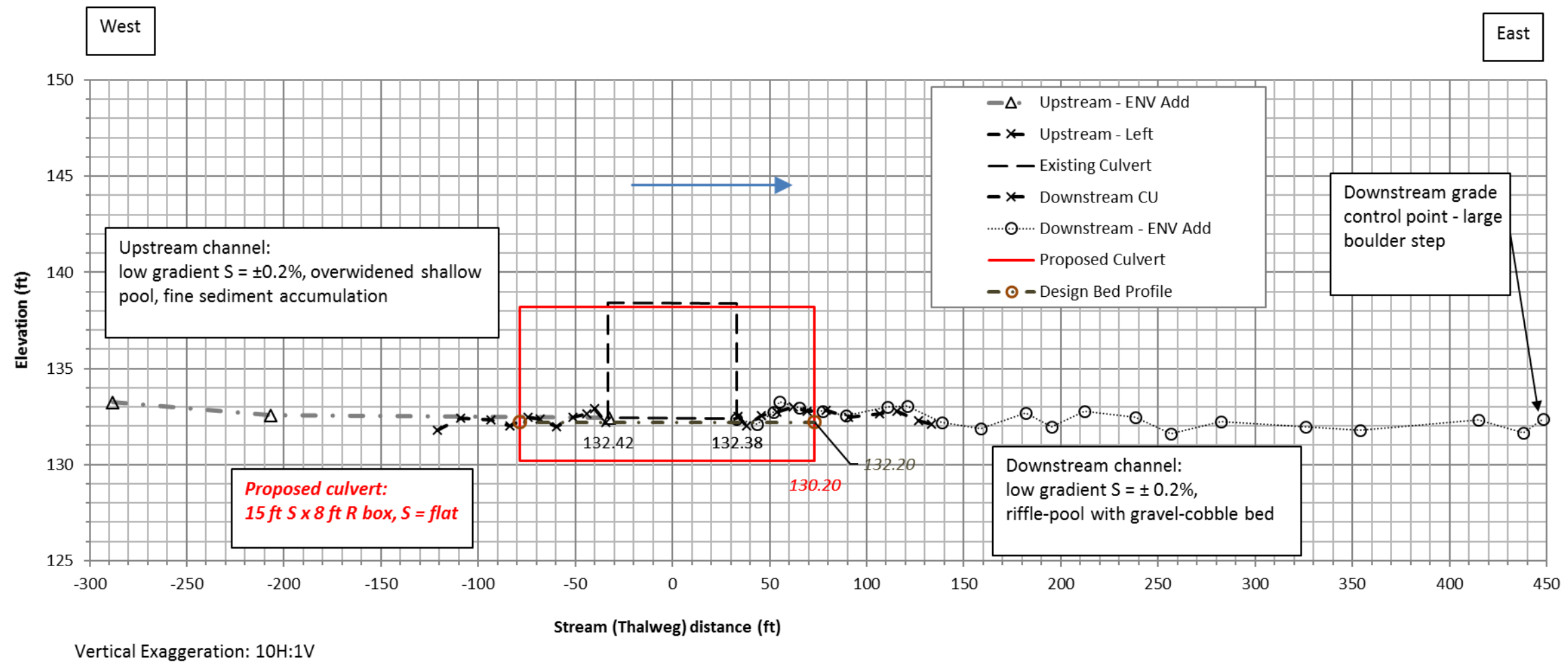


Figure 2. Longitudinal profile showing channel, and existing and proposed culvert inverts.

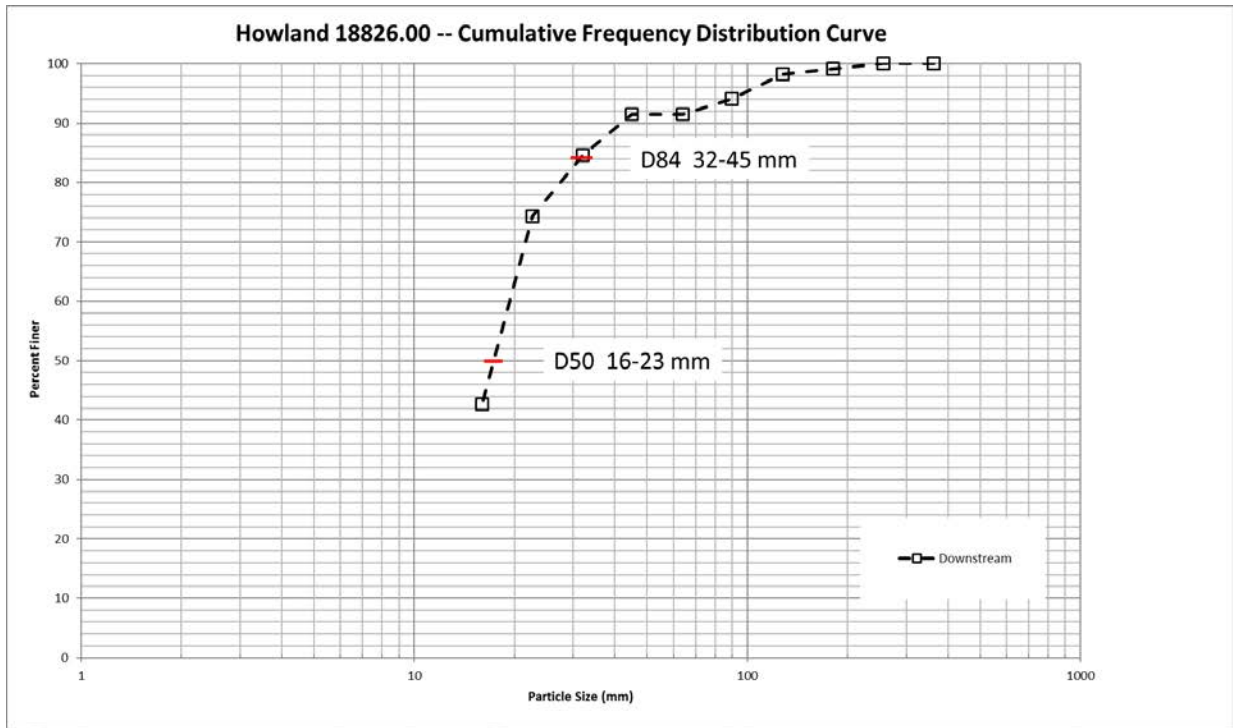


Figure 3. Downstream particle size distribution curve based on bulk sample and field sieve analysis.



Photo 1. Culvert inlet (A. Walsh 11/23/2015).



Photo 2. View looking downstream toward culvert inlet (red arrow) (8/7/2018).



Photo 3. View upstream from location of Photo 2. (8/7/2018).



Photo 4. Culvert outlet and scour pool (A. Walsh 11/23/2015).



Photo 5. View of upper portion of downstream channel from road (A. Walsh 11/23/2015).



Photo 6. View of downstream channel looking upstream toward outlet (8/7/2018).



Photo 7. View of lower downstream channel with large rocks (in distance – red arrow) that provide grade control (8/7/2018).



Photo 8. Streambed particles collected from downstream reference reach (11/29/2017).