Streams-Fish Habitat Question 2b Appendix – Fish Passage

Fish Passage Monitoring Report

This appendix reports on information relative to fish passage at road crossings, in accordance with the streams-fish habitat goals of the Forest Plan. The supplemental information in this section provides a summary as well as details of the monitoring results in the 2012 reference report.

Overview of Stream Crossings Monitored in 2012

As part of a multi-year monitoring project, seventeen stream crossings were monitored in FY2012 to assess their ability to provide fish passage. These culverts were installed, reinstalled or retrofitted in fish streams within approximately the last decade and are located on Zarembo and Prince of Wales Island. From 2009 thru 2011, 97 similar culverts were monitored on Kupreanof, Kuiu, Wrangell, Mitkof and Prince of Wales Island. The 114 crossings monitored to date as part of this assessment constitutes approximately 44 percent of the culverts recently installed, reinstalled or retrofitted in fish streams on the Tongass National Forest. The results from all years are provided in this report.

Ninety-four percent of the stream crossings monitored to date have met the acceptable passage criteria established in the Region 10 Passage Matrix (see table 2 in resource report). They are consistent with State of Alaska juvenile fish passage standards and are assumed to provide unimpeded juvenile and adult fish passage (see table 2 in reference report).

Picture 1. Time Series of Culvert Replacement for Fish Passage Remediation

The majority (86 percent) of the 117 stream crossings monitored were installed between 2000 and 2005. Eighty-two percent of the crossings used stream simulation designs, four percent were installed using a simplified stream simulation approach, two percent are open bottom arches, four percent are hydraulically designed baffled culverts, four percent utilized a no-slope design and four percent were incorrectly designed without fish passage considerations.

Table 1. USFS Alaska Region Juvenile Fish Passage Criteria Matrix

Structure Group #	Structure Group	GREEN CRITERIA	GRAY CRITERIA	RED CRITERIA
1	Bottomless pipe arch OR embedded[1] pipe arch OR embedded CMP.	Culvert span to bed width ratio >= 0.75 AND no blockage OR backwatered [3] AND no blockage.	Culvert span to bed width ratio of 0.5 to 0.75 OR blockage >0% but <=10%.	Culvert span to bed width ratio <0.5 OR blockage >10%
2	Non-embedded pipe arches AND culvert span <= 144" OR non-embedded CMP AND culvert span > 48" AND <=144".	Culvert gradient <0.5% AND no perch [2] AND no blockage AND culvert span to bed width ratio > 0.75 OR backwatered AND no blockage.	Culvert gradient between 0.5% - 2.0% OR perch >0.0' but <=4" OR blockage >0% but <=10% OR culvert span to bed width ratio between 0.5 to 0.75.	Culvert gradient >2.0% OR >4" perch OR blockage >10% OR culvert span to bed width ratio <0.5.
3	Non-embedded CMP AND <= 48" span.	Culvert gradient <0.5% AND no perch AND no blockage AND culvert span to bed width ratio > 0.75 OR backwatered AND no blockage	Culvert gradient between 0.5% - 1.0% OR perch >0.0' but <=4" OR blockage >0% but <=10% OR culvert span to bed width ratio between 0.5 to 0.75.	Culvert gradient >1.0% OR >4" perch OR blockage >10% OR culvert span to bed width ratio <0.5.
4	Non-embedded culvert AND culvert span >144"	Culvert gradient <1.0% AND no perch AND no blockage AND culvert span to bank full ratio > 0.75 OR backwatered AND no blockage.	Culvert gradient between 1.0% - 2.0% OR perch >0.0' but <=4" OR blockage >0% but <=10% OR culvert span to bed width ratio between 0.5 to 0.75.	Culvert gradient >2.0% OR >4" perch OR blockage >10% OR culvert span to bed width ratio <0.5.
5	Baffled Culverts	Backwatered AND no blockage OR newly installed baffled culverts with current design criteria.	All baffled culverts that do not meet Green OR Red criteria	Baffled culverts AND blockage >10%
6 & 7	Bridges OR fords OR removed structures	No road fill caused blockage	Not Applicable	Road fill causing blockage. Water piping through road fill
8	Multiple drainage structures in same channel	Multiple structures are assessed as other similar structures with the exception that constriction is calculated by dividing the stream bed width by the sum of all the structure widths. The structure with the best passage performance is used to determine the passage capability of the entire array.		

Results and Evaluation of Data

Four of the seven culverts determined not to be consistent with State of Alaska juvenile fish passage standards were most likely not identified as crossings requiring passage at the time of installation. Two of the culverts not consistent with passage standards had some length of it completely scoured free of bedload and one culvert was blocked by woody debris.

Of the culverts that were determined to be consistent with passage standards, most were ideal installations. They contained appropriate bedload depth and material, were not blocked with debris, were not perched at the outlet and did not constrict the channel or cause any undesirable channel modifications.

Picture 2. Survey crew monitoring stream simulation designed culvert on Prince of Wales Island.

However, some of the crossings determined to be consistent with passage with standards had some issues associated with them that required or may require some action. Four of the culverts had woody debris blockages in them but were subsequently cleared. Several of the culverts which have bedload retaining weirs installed in them are not retaining bedload to the desirable amount. This causes slight vertical drops at the weirs and may provide a less than an ideal amount of channel roughness within the culvert. One culvert had a section of subsurface flow within the culvert which was most likely due to an insufficient amount of finer bedload material. However, this stream channel also had a section of naturally occurring interrupted flow directly downstream of the culvert.

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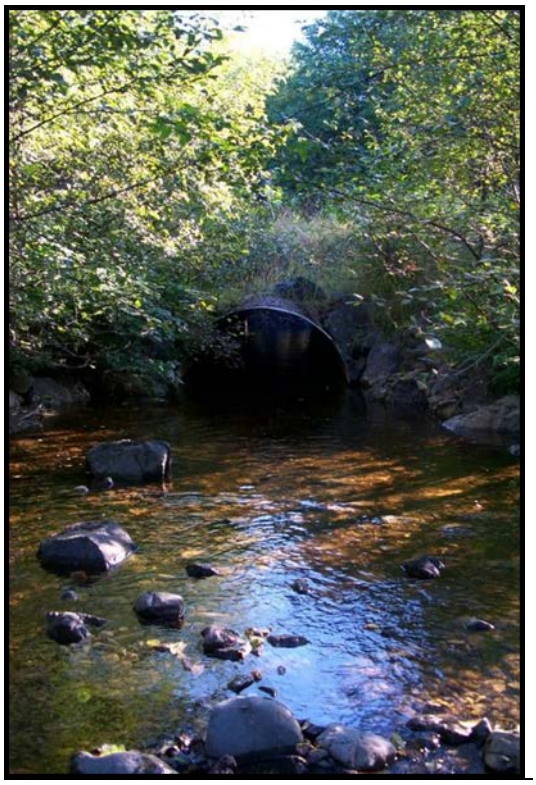


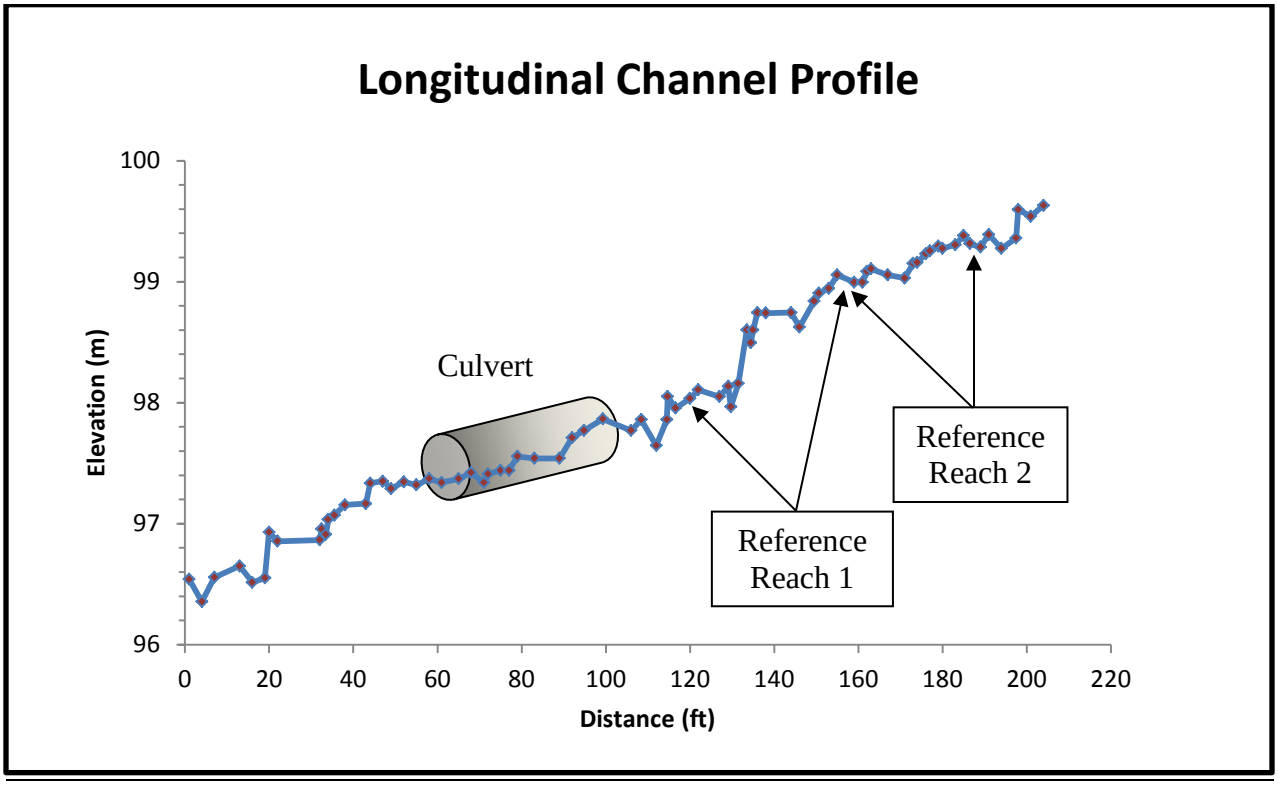
Picture 3. Typical culvert installation in fish stream

In addition to evaluating the stream crossings against the criteria of the Alaska Region's Juvenile Fish Passage Criteria Matrix several stream simulated designed crossings were also assessed by comparing them to adjacent reference reaches. Three culverts crossings were evaluated by measuring and comparing longitudinal profiles, cross sectional profiles, particle size composition and salt tracer rates.

Road 40000 milepost 2.492

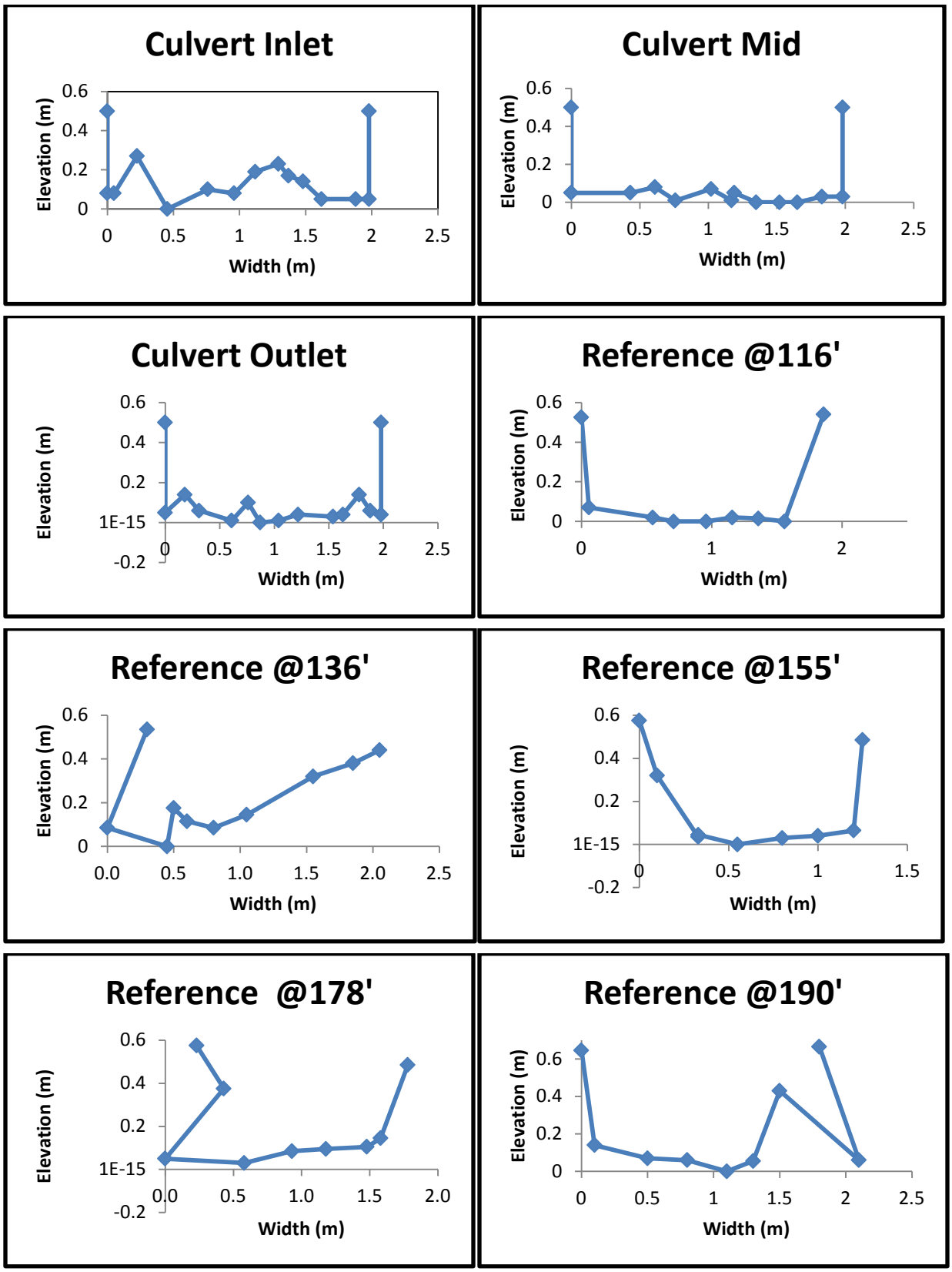
The 78 inch round corrugated metal culvert installation on road 40000 milepost 2.492 was installed in 2002 and was evaluated by comparing it to two upstream reference reaches. Reference reach 1 is located 21 feet upstream of the culvert inlet and extends to 60 feet upstream of the culvert. Reference reach 2 begins at 60 feet upstream of the culvert inlet and extends to 99 feet upstream of the culvert. The natural stream channel in the vicinity of the culvert, including at the two references reaches, is well contained and has a step-pool bedform. The average channel gradient at reference reach 1 is 9.4 percent, reference reach 2 is 3.1 percent and the channel within the culvert is 3.8 percent (figure 1).

Figure 1. Longitudinal Channel Profile - Road 40000 milepost 2.492



Cross sectional channel profiles were surveyed at three locations within the culvert and at five locations within the upstream reference reaches (figure 2). The channel within the culvert does not have rock banks formed or undercut banks but does have the general rectangular shape of that measured in the reference reaches. Stream bed and bankfull width in the culvert is controlled by the culvert walls and closely matches that found within the natural channel. The culvert channel width is 2.0 meters and the average width in the upstream references is 1.8 meters.

Figure 2. Cross Sectional Culvert and Channel Reference Profiles - Road 40000 milepost 2.492



Particle size distribution was measured within the culvert and within the upstream reference reaches. Both the reference reaches and the culvert particle distribution were well graded. However, the reference reaches had a greater percent of finer particle size (figure 3). The median particle size (D_{50}) in the culvert is 59 mm while in both reference reaches it is 30 mm (figure 4).

Figure 3. Particle Size Histogram - Road 40000 milepost 2.492

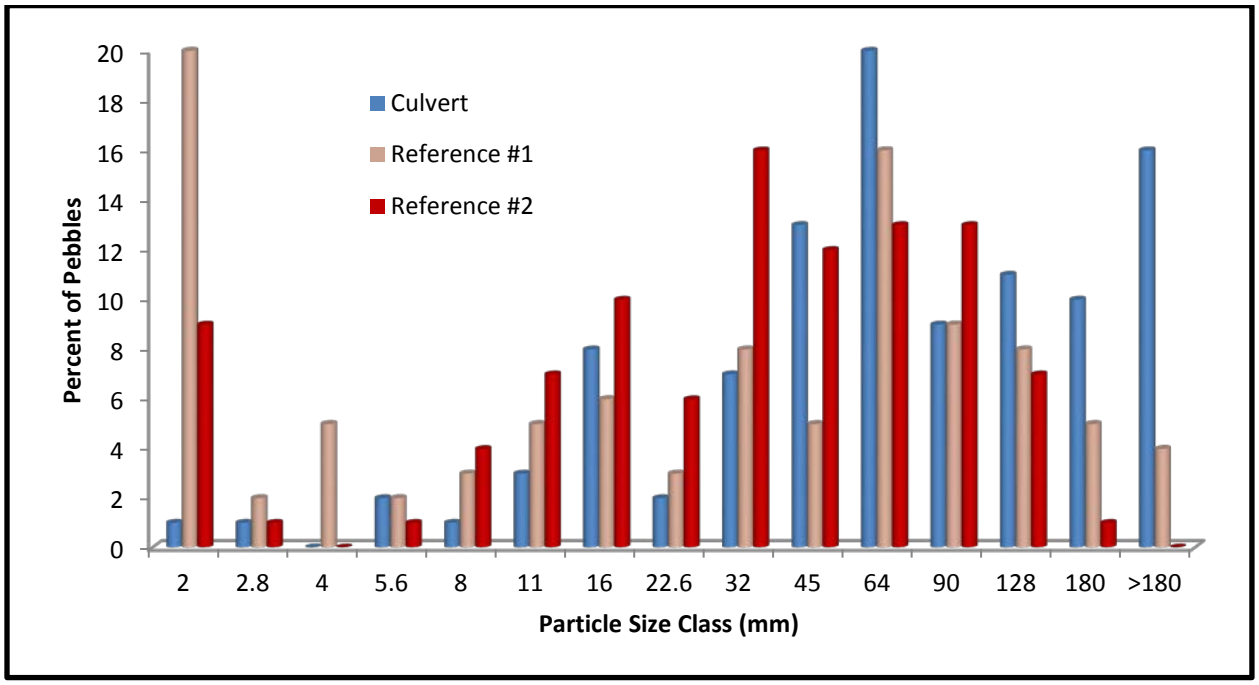
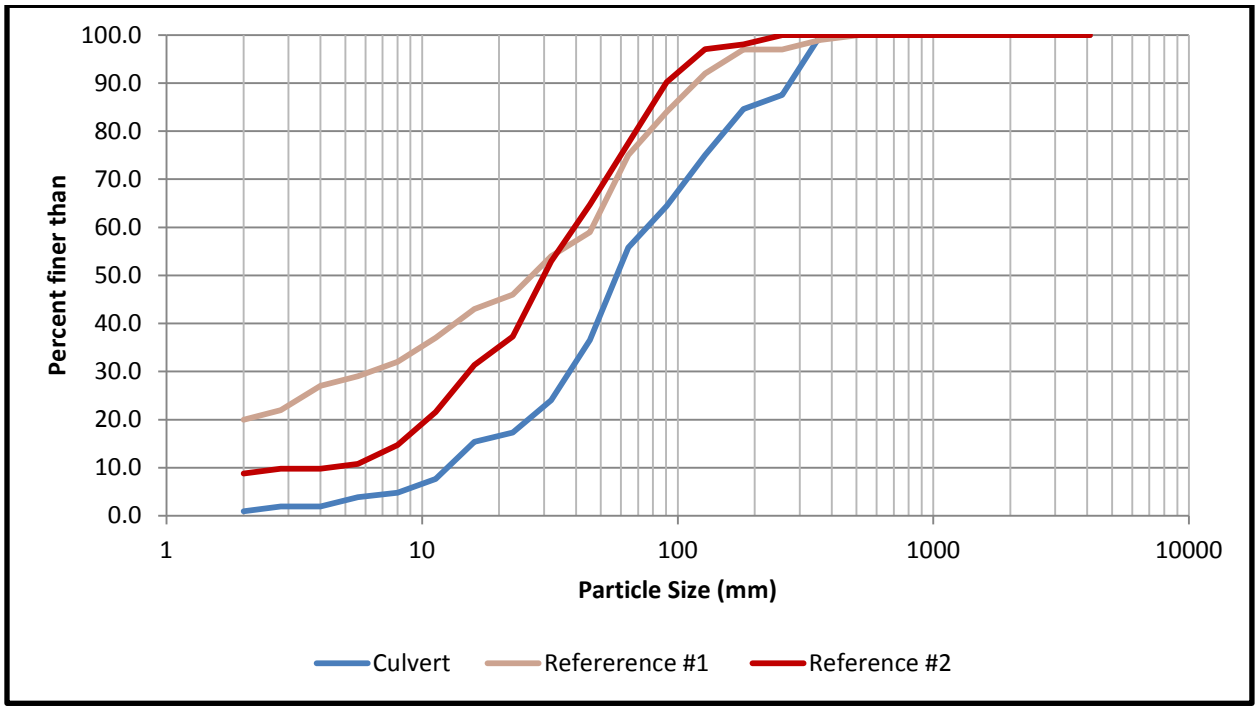


Figure 4. Particle Size Cumulative Frequency - Road 40000 milepost 2.492



Water velocity is obviously an important factor influencing upstream fish movement. A comparison of stream velocities within the culvert to two reference reaches was completed using a salt tracer (pictures 4-6, figure 5, table 3). This was accomplished by injecting a slug of sodium chloride solution into the stream and measuring changes over time in conductivity. The sodium chloride solution for the culvert reach was injected at the inlet of the culvert and conductivity (mS/cm) was measured every 5 seconds at the culvert outlet until it returned to base levels. Similarly, a sodium chloride solution was injected at the upstream end of each reference reach and conductivity was measured downstream at similar distances as that of the culvert. This method provides a simple means of obtaining a velocity profile in a stream reach with high variability of channel geometry and roughness characteristics.

Picture 4. Reference Reach 1

Picture 5. Reference Reach 2

Picture 6. Culvert Bedload, Road 40000 milepost 2.492

The results of the salt tracer comparison indicated a similar pattern in the flow characteristics within the culvert and reference reaches (figure 5). Three measures of flow velocity were computed. The travel time of the leading edge of the salt cloud was a measure of the maximum velocity through the culvert and reference reach. The center of mass or centroid of the salt cloud represents the mean velocity and the trailing edge of the salt tracer was a measure of the minimum velocity in the reaches (table 3).

Figure 5. Salt Tracer- Road 40000 milepost 2.492

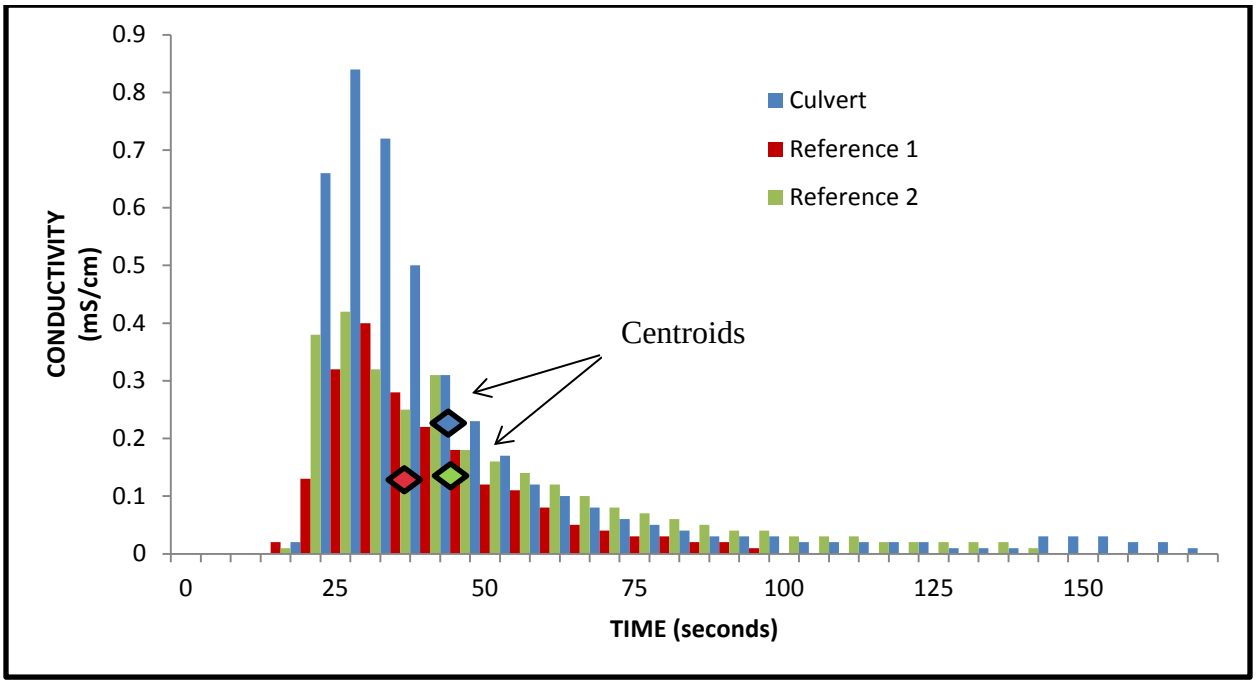


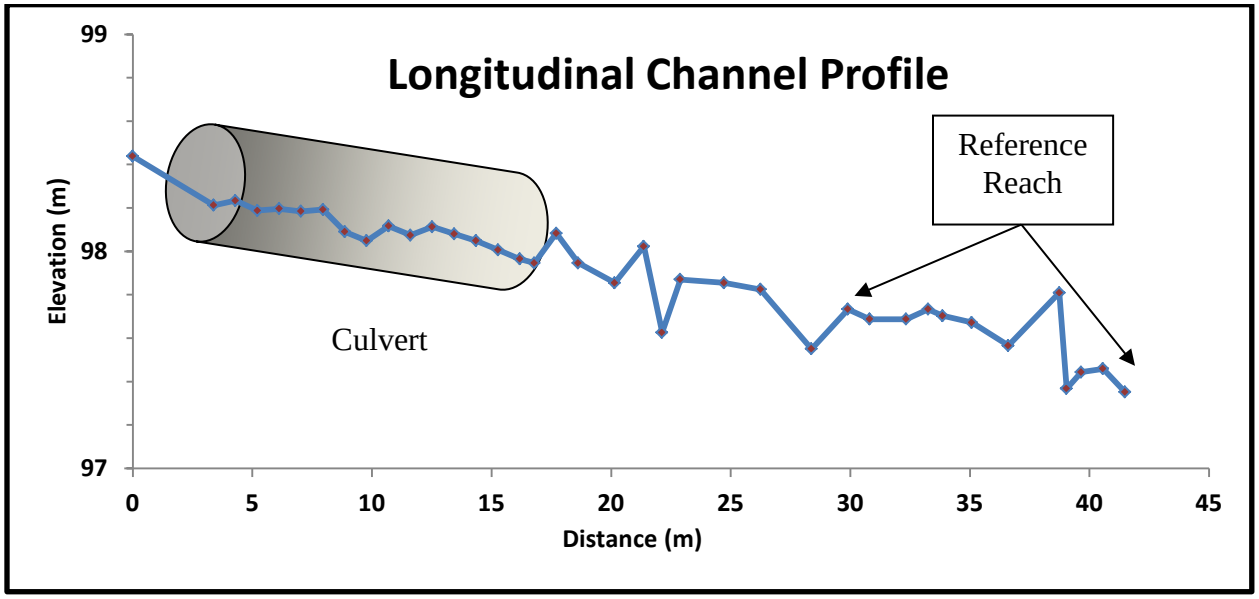
Table 3. Road 40000 milepost 2.492 Salt Tracer Velocities

Reach	Maximum Velocity	Centroid Velocity	Minimum Velocity
Culvert	0.58 meters /sec	0.23 meters/sec	0.08 meters/sec
Reference 1	0.68 meters /sec	0.27 meters/sec	0.12 meters/sec
Reference 2	0.79 meters /sec	0.22 meters/sec	0.08 meters/sec

Road 2054000 milepost 3.780

The 60 inch round corrugated metal culvert installation on road 2054000 milepost 3.780 was installed in 2002 and was evaluated by comparing it to one downstream reference reach. The reference reach is 13 meters in length and extends from 23 to 36 meters downstream of the culvert. The natural stream channel downstream of the culvert is low gradient with shallow containment and alluvial deposition with a pool-riffle bedform. While upstream of the culvert the channel is palustrine and ponded. The average channel gradient at the reference reach is 2.7 percent and within the culvert it is 2.4 percent (figure 6).

Figure 6. Longitudinal Channel Profile - Road 2054000 milepost 3.780



Cross sectional channel profiles were surveyed at three locations within the culvert and at the reference reach (figure 7). Stream bed and bankfull width in the culvert is obviously controlled by the culvert walls and substantially more contained than the reference reach as is evidenced by the well developed flood plain at the reference reach. The bedwidth in the culvert is 1.5 meters and the average bedwidth in the reference reach is 1.3 meters.

Particle size distribution was measured within the culvert and within the reference reach. Both the reference reach and the culvert particle distribution were well graded. However, the reference reach had a greater percent of finer particle size (figure 8). The median particle size (D_{50}) in the culvert is 22 mm while in the reference reach it is 16 mm (figure 9).

Picture 7. Culvert Inlet, Road 2054000 Milepost 3.780

Figure 7. Cross Sectional Culvert and Channel Reference Profiles - Road 2054000 milepost 3.780

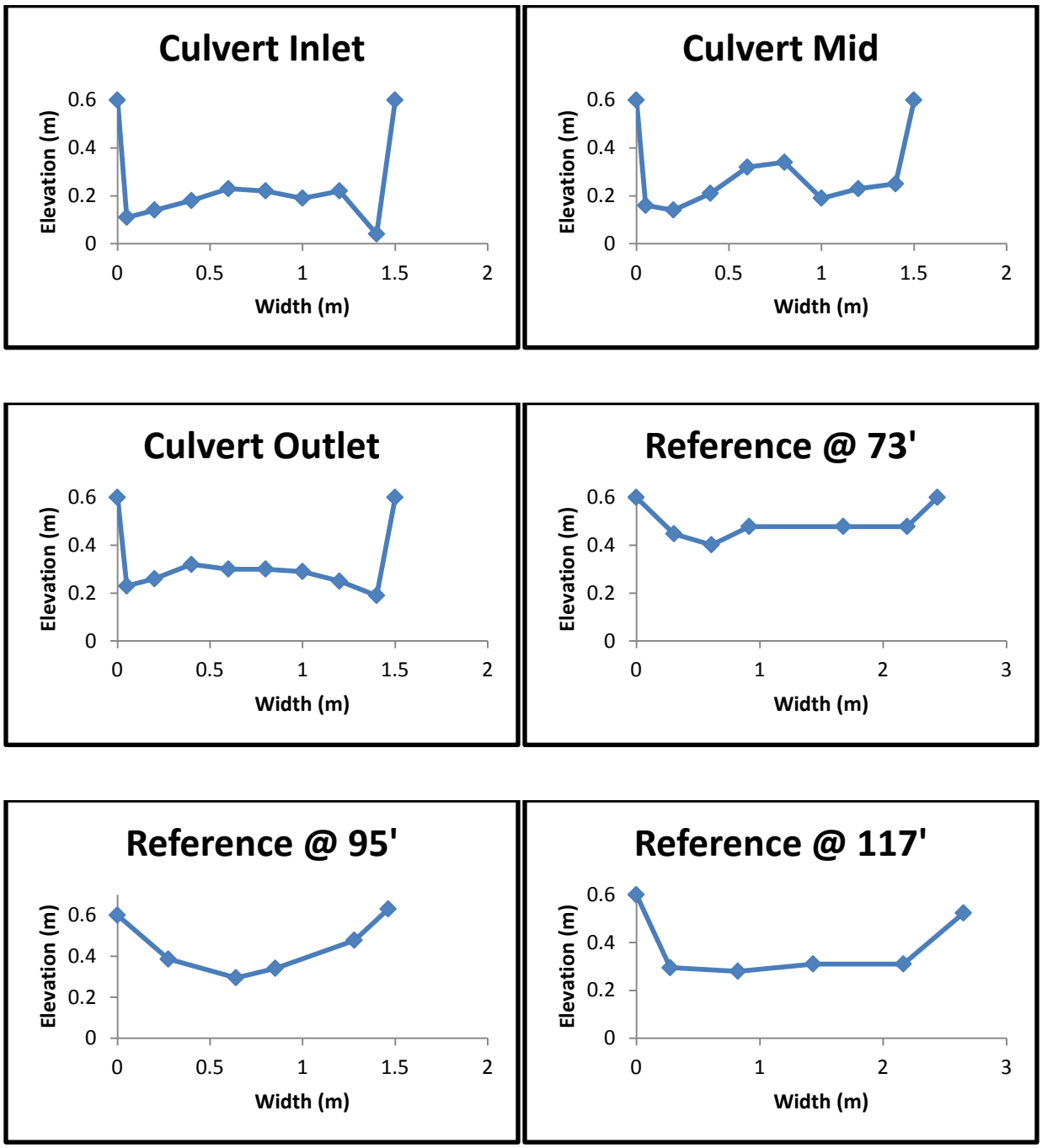


Figure 8. Particle Size Histogram - Road 2054000 milepost 3.780

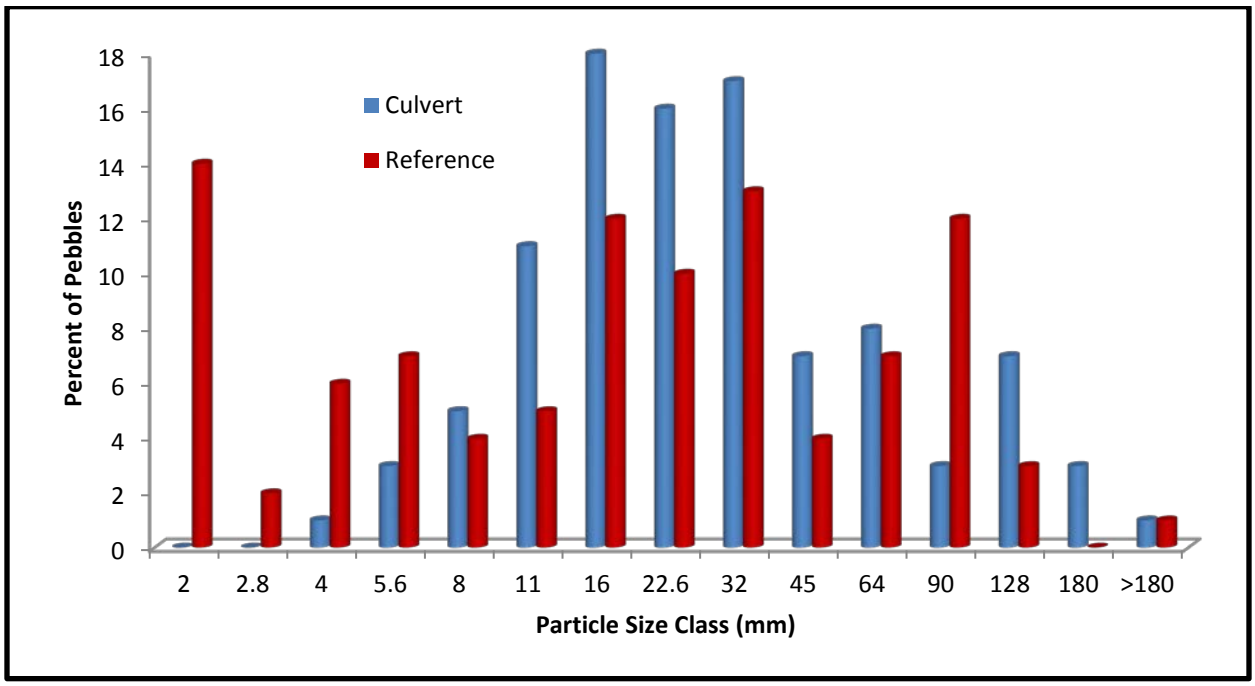
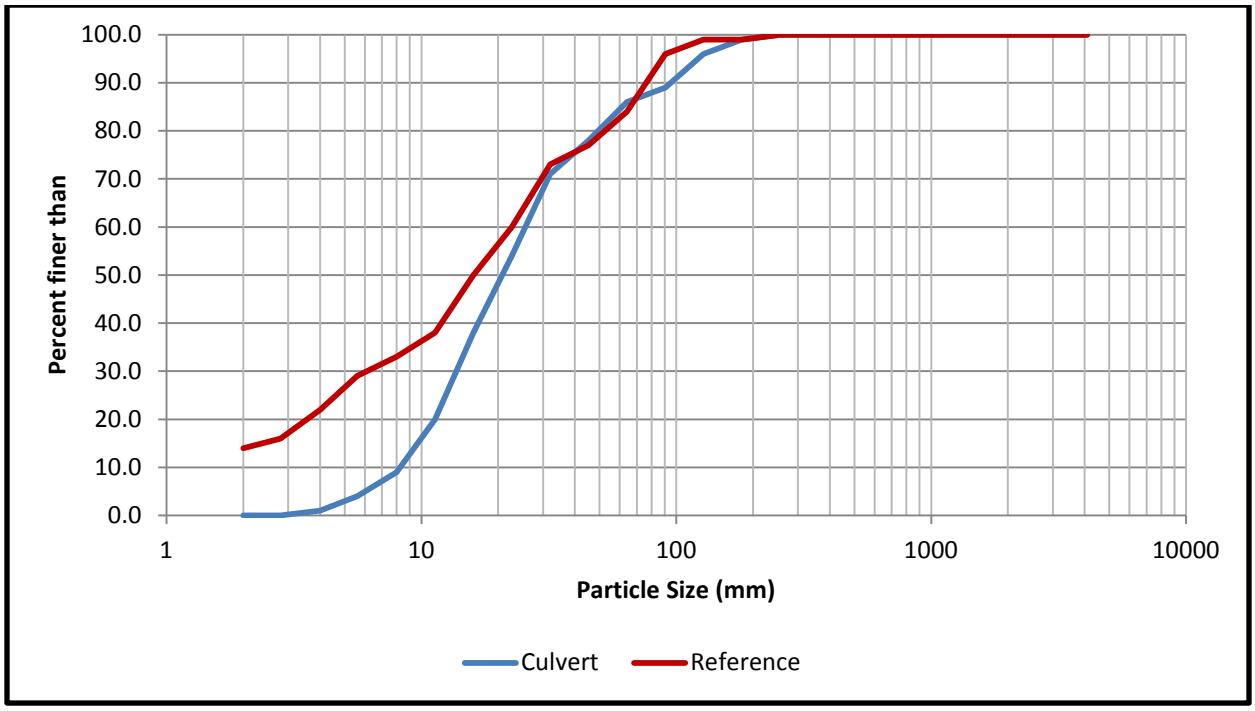


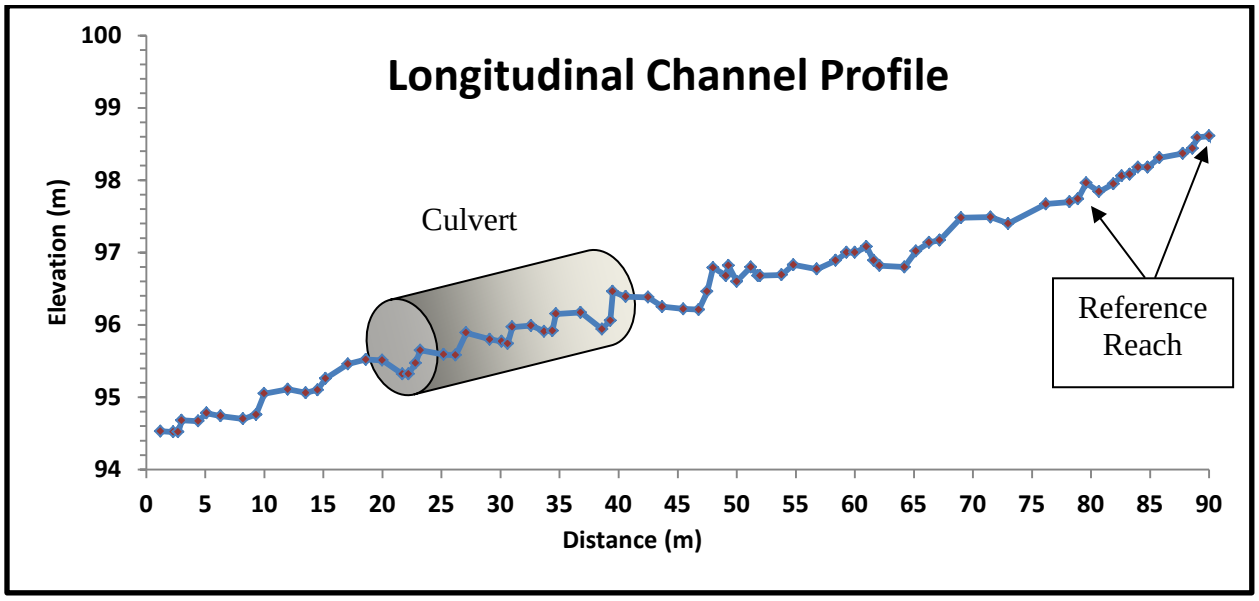
Figure 9. Particle Size Cumulative Frequency - Road 2054000 milepost 3.780



Road 3015250 milepost 0.030

The 144 inch round corrugated metal culvert installation on road 3015250 milepost 0.030 uses a stream simulated design and was installed in 2010. It was evaluated by comparing it to an upstream reference reach representative of this section of the stream. The channel in the vicinity of the culvert is a moderate gradient channel with mixed bedrock and alluvium control with a pool-riffle bedform. The channel gradient within the reference reach is 5.8 percent and within the culvert it is 4.8 percent (figure 10).

Figure 10. Longitudinal Channel Profile - Road 3015250 milepost 0.030



Cross sectional channel profiles were surveyed at three locations within the culvert and in the reference reach (figure 11). Stream bed and bankfull width in the culvert is obviously more controlled by the culvert walls and is more contained than the reference reach. Channel bedwidths and profiles within the culvert and reference reach were fairly similar. The bedwidth in the culvert is 3.9 meters and the average bedwidth in the reference reach is 3.1 meters.

Particle size distribution was measured within the culvert and within the upstream reference reach. Both the reference reach and the culvert particle distribution were well graded and similar (figure 12). The median particle size (D_{50}) in the culvert as well as in the reference reach is 22.6 mm. (figure 13).

Figure 11. Cross Sectional Culvert and Channel Reference Profiles - Road 3015250 milepost 0.030

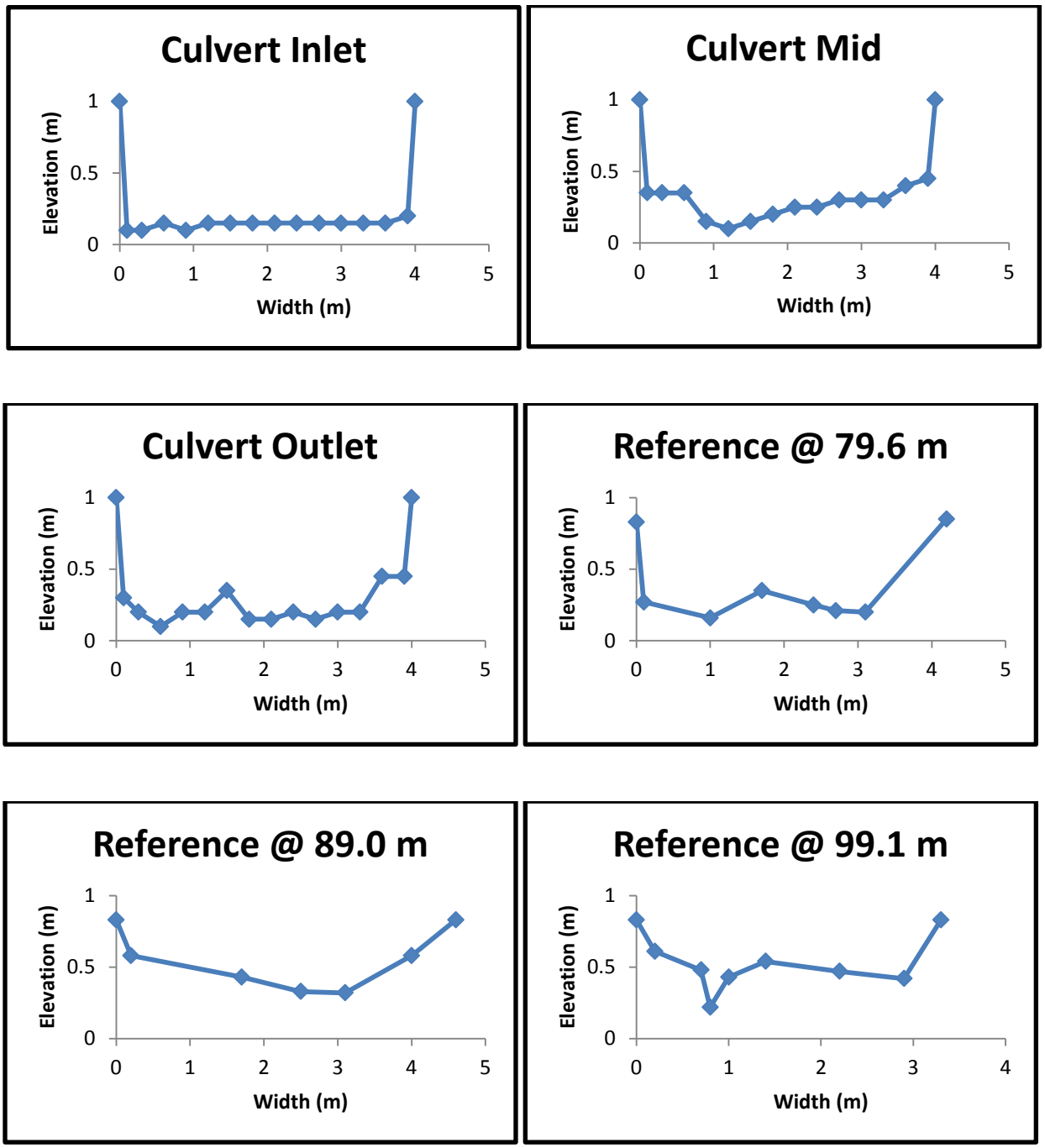


Figure 12. Particle Size Histogram - Road 3015250 milepost 0.030

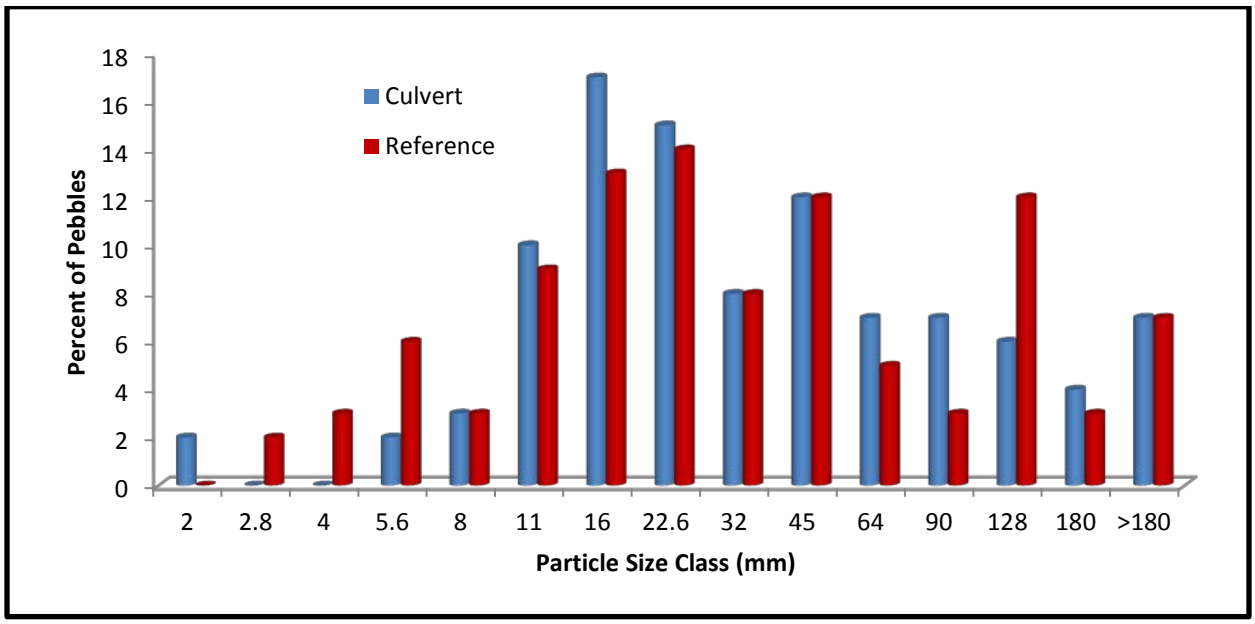
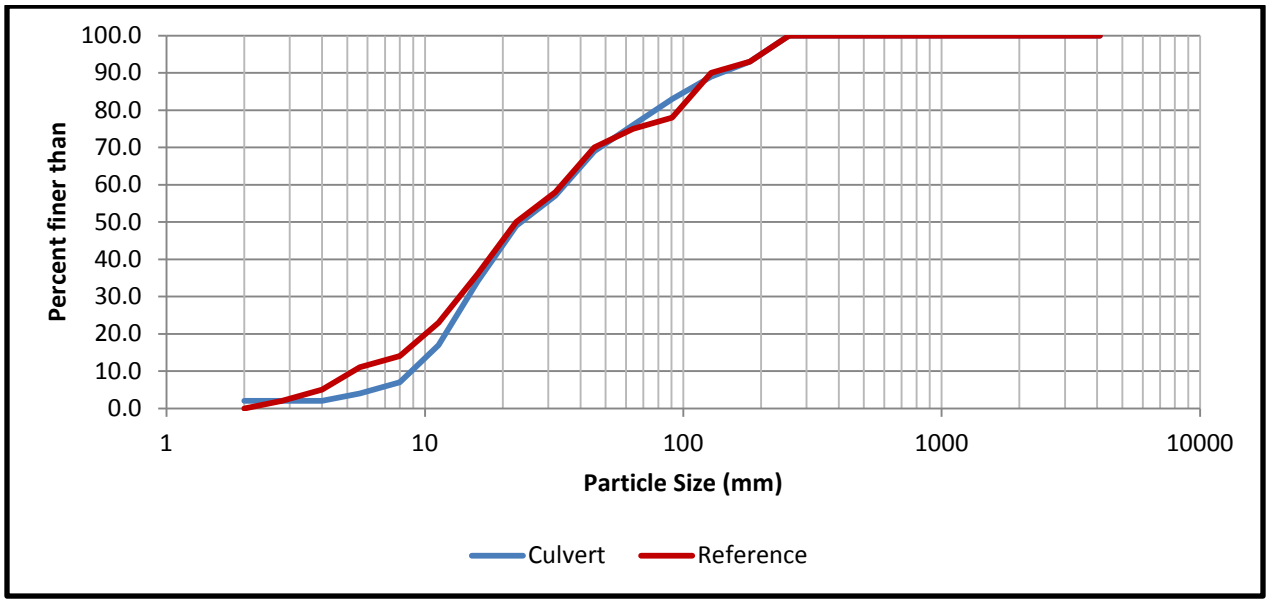


Figure 13. Particle Size Cumulative Frequency - Road 3015250 milepost 0.030



The results of the salt tracer comparison indicated a very similar pattern in the flow characteristics within the culvert and reference reach (figure 14). Results from the calculation of minimum, mean and maximum flow velocities also indicates similar conditions in the culvert and the reference reach (table 4).

Picture 8. Culvert Inlet, Road 3015250 Milepost 0.030

Picture 9. Culvert Bedload, Road 3015250 Milepost 0.030

Figure 14. Salt Tracer- Road 3015250 milepost 0.030

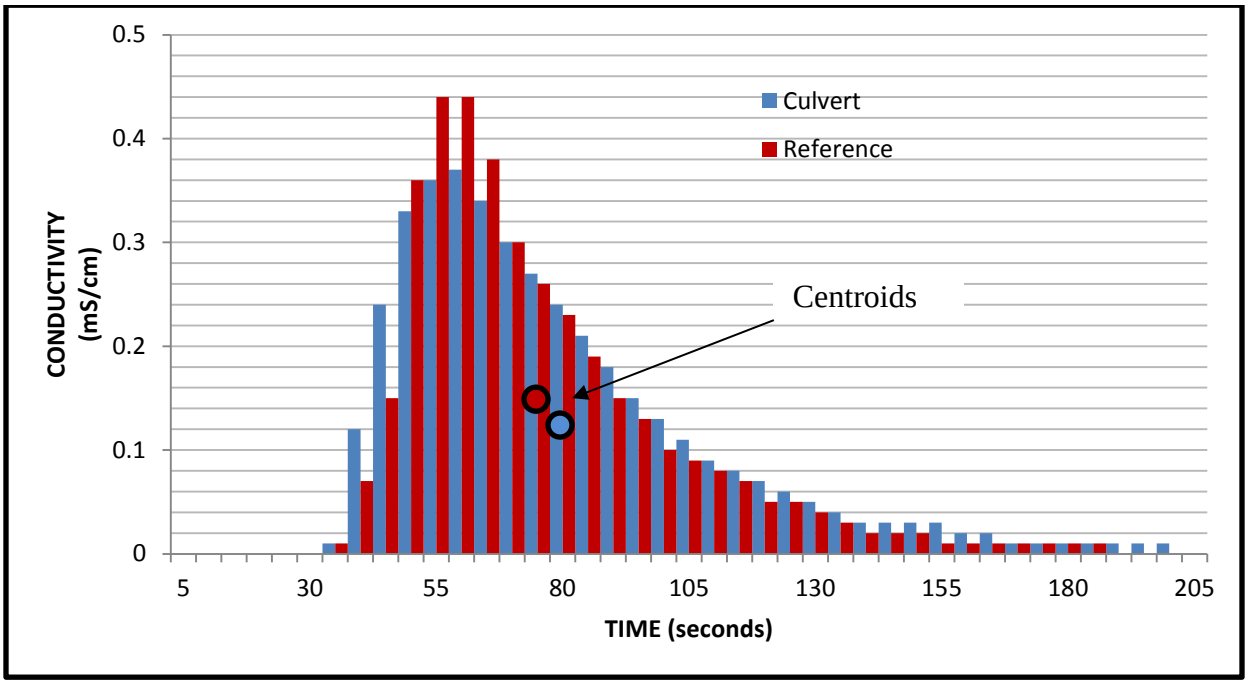


Table 4. Road 3-15250 Milepost 0.030 Salt Tracer Velocities

Reach	Maximum Velocity	Centroid Velocity	Minimum Velocity
Culvert	0.52 meters /sec	0.25 meters/sec	0.09 meters/sec
Reference	0.52 meters /sec	0.26 meters/sec	0.10 meters/sec

Additional Culvert Installations Assessed with Salt Tracing

Three additional stream simulated, remediated culverts and one unremediated "red" culvert were assessed by comparing salt trace patterns within the culvert to that within reference reaches. The evaluation of the sole Red culvert was done to provide a relative comparison to that of the remediated culverts.

Road 40000 Milepost 3.706

This culvert is an unremediated stream crossing that does not meet fish passage standards (i.e., Red crossing). The culvert is within a high gradient contained channel with a channel gradient of 8 percent and a bedwidth of 11.7 feet. The structure is a 48 inch round corrugated metal culvert installed at 7 percent with no bedload retention and has a 0.7' outlet perch. The culvert is undersized for the channel and the culvert width to channel bedload width ratio is 0.34 (picture 10).

Picture 10. "Red Culvert", Road 40000 Milepost 3.706

Picture 11. Reference Reach, Road 40000, Milepost 3.706

The salt trace results very clearly shows the substantial differences in flow velocities between the culvert and an upstream reference reach (picture 11, figure 15). Obviously this culvert does not match the flow conditions found within the reference reach and is assumed to impair the efficient passage of fish. The maximum, centroid and minimum velocities of the sodium chloride solution are not similar (table 5).

Figure 15. Salt Tracer- Road 40000 milepost 3.706

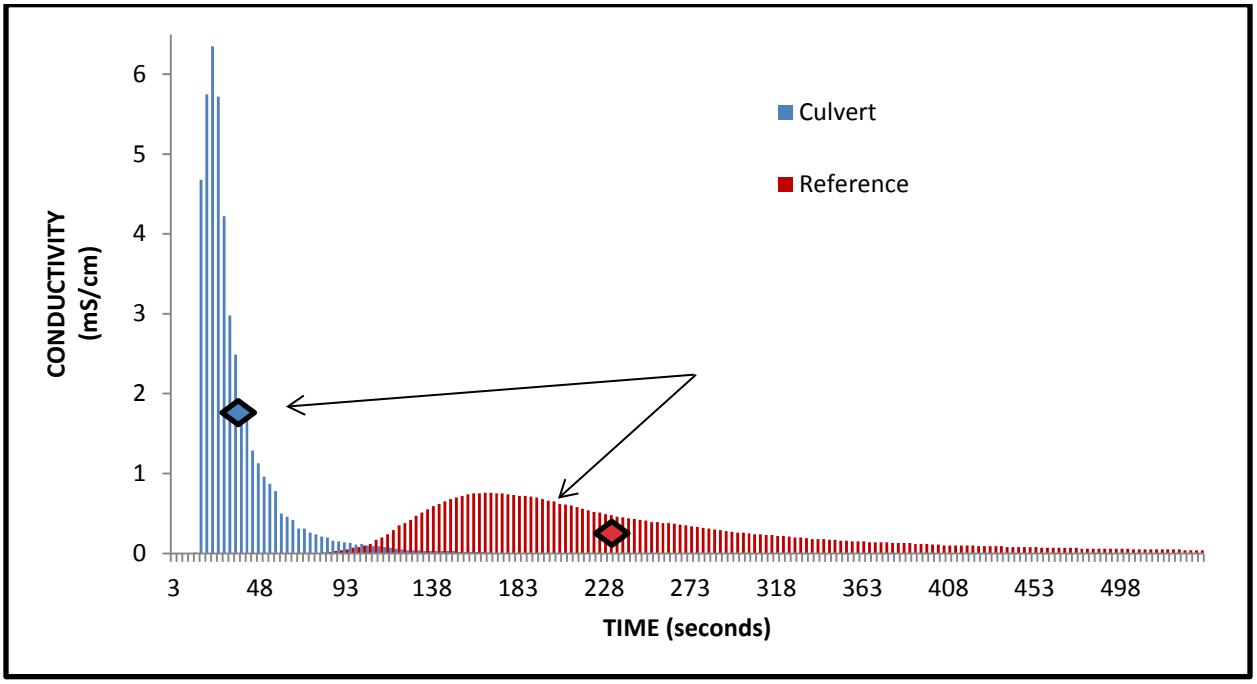


Table 5. Road 40000 Milepost 3.706 Salt Tracer Velocities

Reach	Maximum Velocity	Centroid Velocity	Minimum Velocity
Culvert	0.97 meters /sec	0.41 meters/sec	0.09 meters/sec
Reference	0.68 meters /sec	0.06 meters/sec	0.02 meters/sec

Picture 12. Culvert Bedload, Road 6235 Milepost 15.846

Road 6235 Milepost 15.846

This stream simulated 120 inch round corrugated metal culvert was installed in 2002 to restore fish passage. It is located in a 9.9' bedwidth, low gradient, coarse gravel-cobble flood plain channel. The culvert currently is embedded at 42 percent of its rise and the bedload particle size and bedwidth is similar to that of a downstream reference reach (pictures 12 and 13, figure 16). The salt trace velocity patterns within the culvert and in a downstream reference reach are almost identical (figure 16). The minimum, mean and maximum calculated water velocities are also similar (table 6).

Picture 13. Reference Reach, Road 6235 Milepost 15.846

Figure 16. Salt Tracer - Road 6235 milepost 15.846

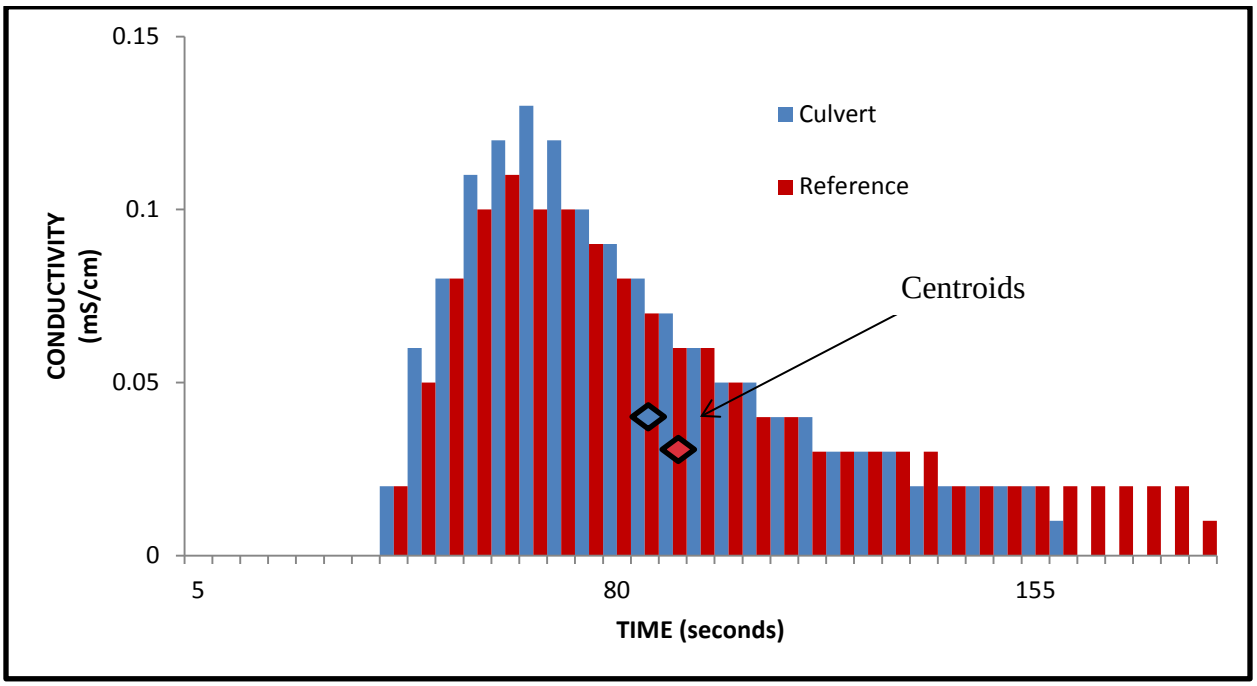


Table 6. Road 6235 Milepost 15.846 Salt Tracer Velocities

Reach	Maximum Velocity	Centroid Velocity	Minimum Velocity
Culvert	0.36 meters /sec	0.17 meters/sec	0.09 meters/sec
Reference	0.38 meters /sec	0.16 meters/sec	0.08 meters/sec

Road 6245 Milepost 8.562

The stream simulated, 96 inch round corrugated metal culvert on road 6245 at milepost 8.562 was installed in 2003. It has a gradient of 6.4 percent, is embedded 31 percent of the culvert rise, the bedload material in the culvert is predominately large cobble and boulder and the culvert width to channel bedwidth ratio is approximately 0.71 (pictures 14 and 15, figure 17, table 7). The culvert is located in a high gradient (7 percent) contained channel and has similar bedload particle size as that of the culvert (picture 15).

Picture 14. Culvert Bedload, Road 6245 Milepost 8.562

Picture 15. Reference Reach, Road 6245 Milepost 8.562

The salt trace comparison between the culvert and the upstream reference reach indicated slight differences in their patterns (figure 17). The minimum, mean and maximum velocities within the culvert were fairly similar (table 7).

Figure 17. Salt Tracer- Road 6245 milepost 8.562

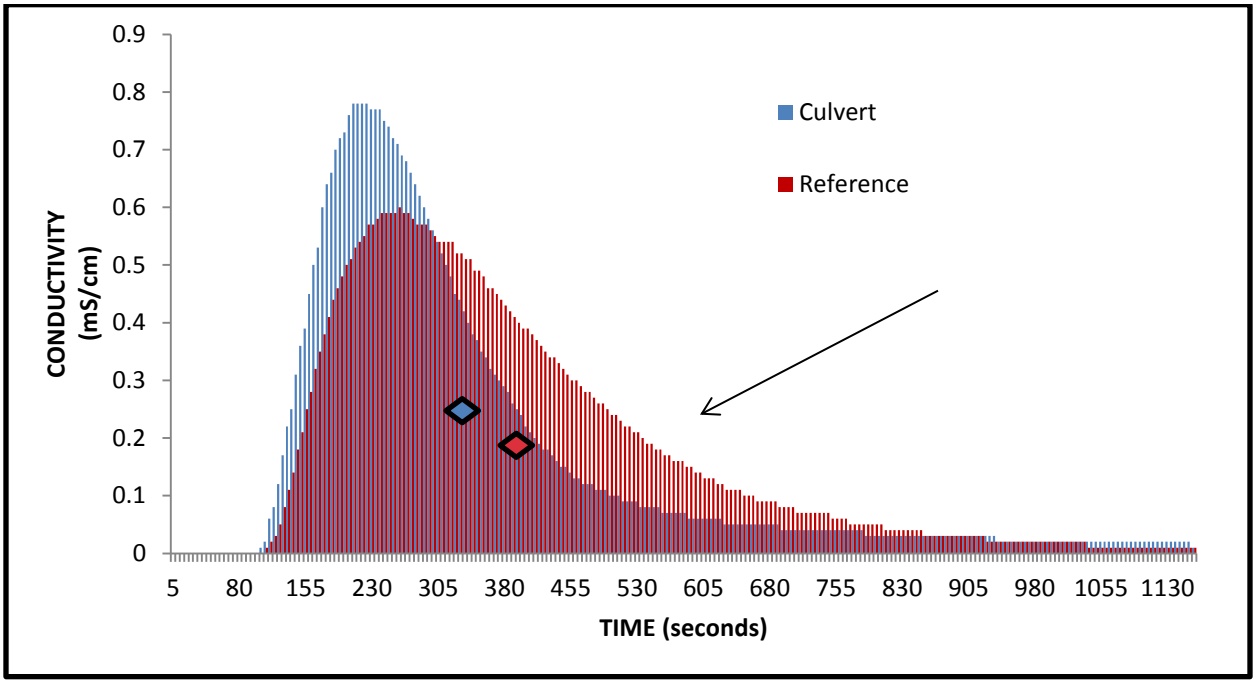


Table 7. Road 6245 Milepost 8.562 Salt Tracer Velocities

Reach	Maximum Velocity	Centroid Velocity	Minimum Velocity
Culvert	0.15 meters /sec	0.05 meters/sec	0.01 meters/sec
Reference	0.14 meters /sec	0.04 meters/sec	0.01 meters/sec

Road 3015000 Milepost 6.830

The stream simulated, 72 inch round corrugated metal culvert on road 3015000 milepost 6.830 was installed in 2010. It has a gradient of 5.5 percent, is embedded 29 percent of the culvert rise, the bedload material in the culvert is predominately cobble, boulder and gravel and the culvert width to channel bedwidth ratio is approximately 1.22 (figure 18). The culvert is located in Moderate Mixed Control channel with a gradient of 4 percent and the bedload material is less coarse than that in the culvert and consists of gravel and sand (picture 16).

Picture 16. Culvert Bedload, Road 3015000 Milepost 6.830

The salt trace comparison of the culverts flow velocities with that within a reference reach indicates somewhat similar patterns with the culvert water velocities tending to be less. This difference is most likely due to the larger substrate particle size in the culvert (figure 18). The maximum calculated velocity in the reference reach is 0.21 meters/sec while that in the culvert is 0.08 meters/sec (table 8).

Figure 18. Salt Tracer- Road 3015000 milepost 6.830

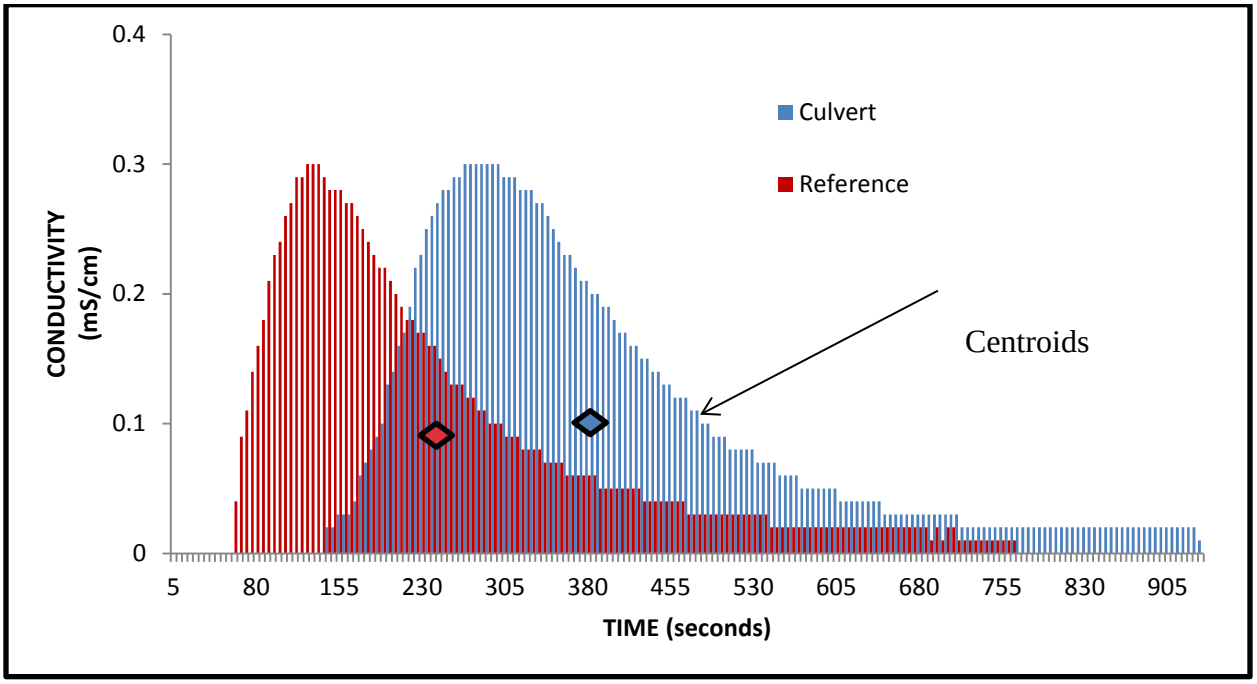


Table 8. Road 3015000 Milepost 6.830 Salt Tracer Velocities

Reach	Maximum Velocity	Centroid Velocity	Minimum Velocity
Culvert	0.08 meters /sec	0.03 meters/sec	0.01 meters/sec
Reference	0.21 meters /sec	0.05 meters/sec	0.02 meters/sec

Simplified Stream Simulated Remediated Culverts

In an effort to reduce the significant costs associated with the design and installation of culverts intended to provide fish passage, the Tongass National Forest has installed four culverts on Prince of Wales Island in 2012 using a process coined "Simplified Stream Simulation."

This approach strives to produce, overtime, stream conditions in the culvert that are reasonably similar to that found in the natural stream. Similar to traditional stream simulated designed culverts, the goal is to create fish passage conditions in the culvert which mirror that of the natural channel by matching stream gradient, width and bedload roughness. The general process involves embedding a properly sized culvert, creating a downstream control and then depositing (surcharging) bedload material, sized to be capable of mobilizing at high flows, in the channel immediately upstream of the culvert. The expectation is that the material will mobilize, be deposited and retained in the embedded culvert. Traditional stream simulation design typically meticulously and immediately places well sorted bedload material in the culvert in a manner to reproduce the natural channels bedform with its range of flow velocities and depth.

The four simplified stream simulated culverts were monitored in 2012, the same year of installation but after a flow event significant enough to mobilize the upstream deposited material.

Road 3015000 Milepost 1.773

This simplified stream simulated 46 inch x 60 inch arch culvert is installed at 3.4 percent, the culvert width to channel bedwidth ratio is 0.76 and bedload material has been deposited within 100 percent of the culverts length. The bedload particle size is gravel, cobble and sand. The coarser bedload material tends to be in the upstream end of the culvert. The depth of the bedload is 14 percent of the culvert rise at the inlet and 9 percent at the outlet. There was no observed headcutting upstream of the culvert. Surface stream flow existed throughout the culverts length and no issues with surface permeability were observed. Pictures 17 - 20 provide views of the culvert inlet, outlet and bedload within the culvert.

Picture 17. Culvert Outlet

Picture 18. Culvert Inlet

Picture 19. Culvert bedload looking downstream

Picture 20. Culvert bedload looking upstream

Following a high flow a substantial amount of the surcharged material deposited upstream of the culvert still remained (picture 21). Much of this material is above bankfull and will most likely not be mobilized into the culvert during usual high flow events.

Picture 21. Surcharged bedload material remaining upstream of culvert. Road 3015000 Milepost 1.773

The natural channel upstream of the culvert is Moderate Mixed Control with a stream gradient of approximately 6 percent. The bedload particle size consists of gravel, sand and cobble.

A comparison of salt trace concentrations and velocities within the culvert and a reference reach indicates a potentially significant difference in stream flow patterns. The flow conditions in the culvert were less conducive to fish passage then those in the reference reach (figure 19). Both the maximum and mean velocities in the culvert were approximately twice that of the reference reach (table 9). The culvert did meet State of Alaska juvenile fish passage standards when evaluated using the Alaska Region Juvenile Fish Passage Criteria Matrix.

Figure 19. Salt Tracer- Road 3015000 milepost 1.773

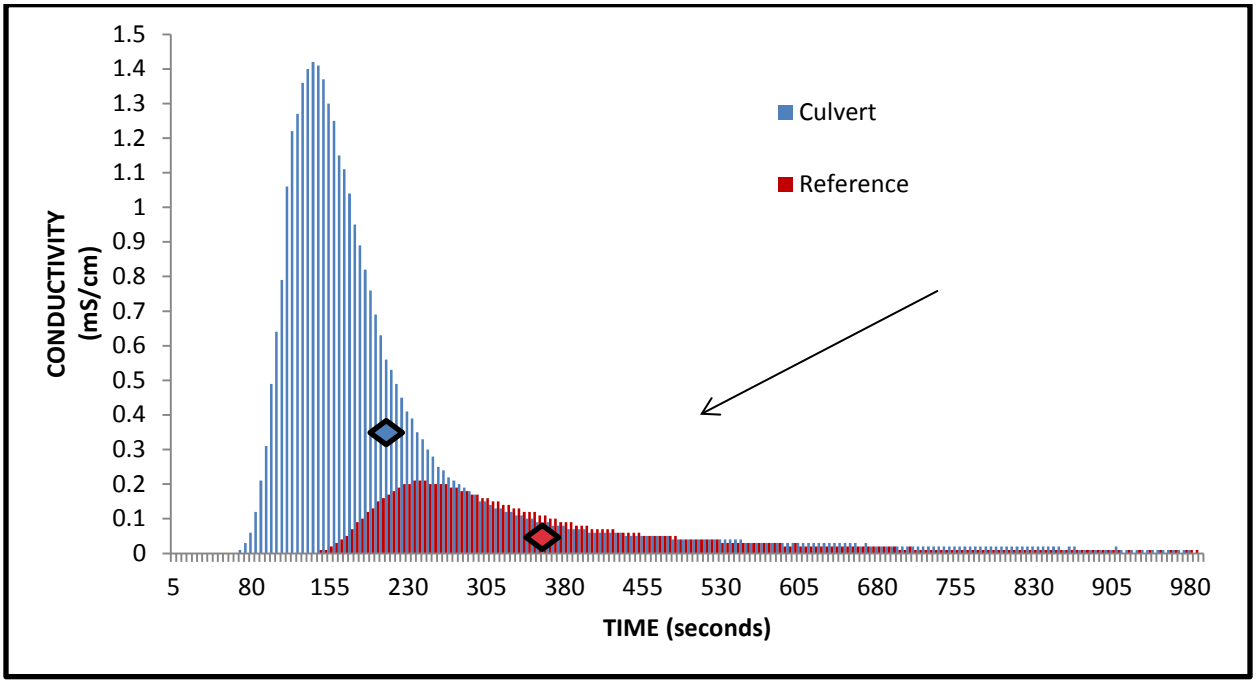


Table 9. Road 3015000 Milepost 1.773 Salt Tracer Velocities

Reach	Maximum Velocity	Centroid Velocity	Minimum Velocity
Culvert	0.17 meters /sec	0.06 meters/sec	0.01 meters/sec
Reference	0.08 meters /sec	0.03 meters/sec	0.01 meters/sec

Road 3015 Milepost 8.743

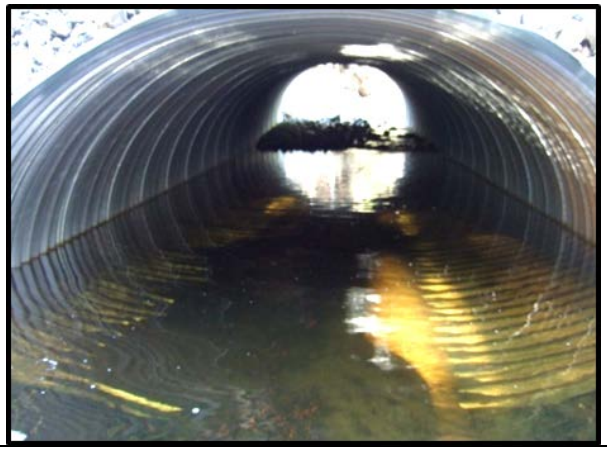
This simplified stream simulated 63 inch by 87 inch arch culvert is installed at 4.4 percent, the culvert width to channel bedwidth ratio is 1.34 and bedload material has been deposited in only 50 percent of the culverts length and is located in the upstream half of the culvert. The depth of the bedload at the inlet is 30 percent of the culvert rise and 0 percent at the outlet. The bedload material that does exist is gravel, cobble and sand. The downstream half of the culvert without bedload was backwatered. There was no observed headcutting upstream of the culvert. Surface stream flow existed throughout the culverts' length and no issues with surface permeability were observed. Pictures 22-25 provide views of the culvert outlet inlet and bedload conditions within the culvert.

Following a high flow a substantial amount of the surcharged material deposited upstream of the culvert still remained (picture 26). Much of this material is above bankfull and will most likely not be mobilized into the culvert during usual high flow events. The culvert did meet State of Alaska juvenile fish passage standards when evaluated using the Alaska Region Juvenile Fish Passage Criteria Matrix.

Picture 22.
Culvert outlet, Road 3015000 Milepost 8.743

Picture 23.
Culvert inlet, Road 3015000 Milepost 8.743

Picture 24. Culvert bedload, looking downstream



Picture 25. Culvert bedload, looking upstream

Picture 26.
Surcharged bedload material remaining upstream of culvert

Road 2700000 Milepost 0.710

This simplified stream simulated 71 inch by 103 inch arch culvert is installed at 3.0 percent, the culvert width to channel bedwidth ratio is 1.36 and bedload material has been deposited in only 45 percent of the culverts length and is located in the upstream end of the culvert. The depth of the bedload at the inlet is 31 percent of the culvert rise and 0 percent at the outlet. The downstream half of the culvert without bedload was backwatered. There was no observed headcutting upstream of the culvert. Surface stream flow existed throughout the culverts length and no issues with surface permeability were observed. Pictures 27 - 30 provide views of the culvert outlet inlet and bedload conditions within the culvert.

Following a high flow a substantial amount of the surcharged material deposited upstream of the culvert still remained (picture 31). Much of this material is above bankfull and will most likely not be mobilized into the culvert during usual high flow events. The culvert did meet State of Alaska juvenile fish passage standards when evaluated using the Alaska Region Juvenile Fish Passage Criteria Matrix.

Picture 27. Culvert Inlet

Picture 28. Culvert Outlet

Picture 29. Culvert bedload, looking upstream

Picture 30. Culvert bedload, looking downstream

Picture 31. Surcharged bedload material remaining upstream of culvert. Road 2700000 Milepost 0.710

Road 2000000 Milepost 102.907

This simplified stream simulated 110 inch by 171 inch arch culvert is installed at 0.9 percent, the culvert width to channel bedwidth ratio is 0.94 and bedload material has been deposited in 100 percent of the culverts length. The depth of the bedload at the inlet is 12 percent of the culvert rise and 18 percent at the outlet. The culvert flow is backwatered for the entire length of the culvert. There is no observed headcutting upstream of the culvert. Surface stream flow existed throughout the culverts length and no issues with surface permeability were observed. Pictures 32 - 35 provide views of the culvert outlet inlet and bedload conditions within the culvert.

Following a high flow a portion of the surcharged material previously deposited upstream of the culvert still remained (picture 36). Much of this material is above bankfull and will most likely not be mobilized into the culvert during usual high flow events. The culvert did meet State of Alaska juvenile fish passage standards when evaluated using the Alaska Region Juvenile Fish Passage Criteria Matrix.

Picture 32. Culvert Inlet

Picture 33. Culvert Outlet

Picture 34. Culvert barrel, looking downstream

Picture 35. Culvert barrel, looking upstream

Picture 36.
Culvert inlet with surcharged bedload material remaining upstream

Ninety-four percent of the culverts monitored and assessed via the Alaska Region Juvenile Fish Passage Matrix met State of Alaska passage standards and are assumed not to impede the passage of juvenile or adult fish. The seven crossings (six percent) determined not to be consistent with juvenile passage standards can be attributed to three different reasons. 1) Four of the seven culverts were installed without fish passage design considerations apparently because they were not adequately identified at the time of installation as crossings requiring fish passage. Three of the four crossings installed without passage considerations were associated with new road construction on Kupreanof Island and were not known to be fish streams until after the construction was completed. The other crossing apparently installed without fish passage design considerations was a culvert re-installed on Prince of Wales Island and was previously identified as a fish stream. However personnel responsible for the installation were not apparently aware of its fish crossing status. 2) Two of the culverts not consistent with passage standards had some length of it completely scoured free of bedload. 3) One culvert was blocked by woody debris and to date has not been cleared.

The more comprehensive surveys of a subset of the crossing on road 40000 milepost 2.492, road 2054000 milepost 3.780 and road 3015250 milepost 0.030 indicate that the stream simulated culverts continue to satisfactorily mimic that of the natural stream channel. Similarities in measurements of channel width, gradient, longitudinal and cross-sectional profile and velocity between the culvert and a reference reach, provides support that fish passage conditions are also similar and therefore adequate. Similar indications of achieving stream simulation was found by measuring and comparing stream velocities by use a salt tracer at three other crossings (Road 6235 milepost 15.846; 6245 milepost 8.562 and 3015000 milepost 6.830).

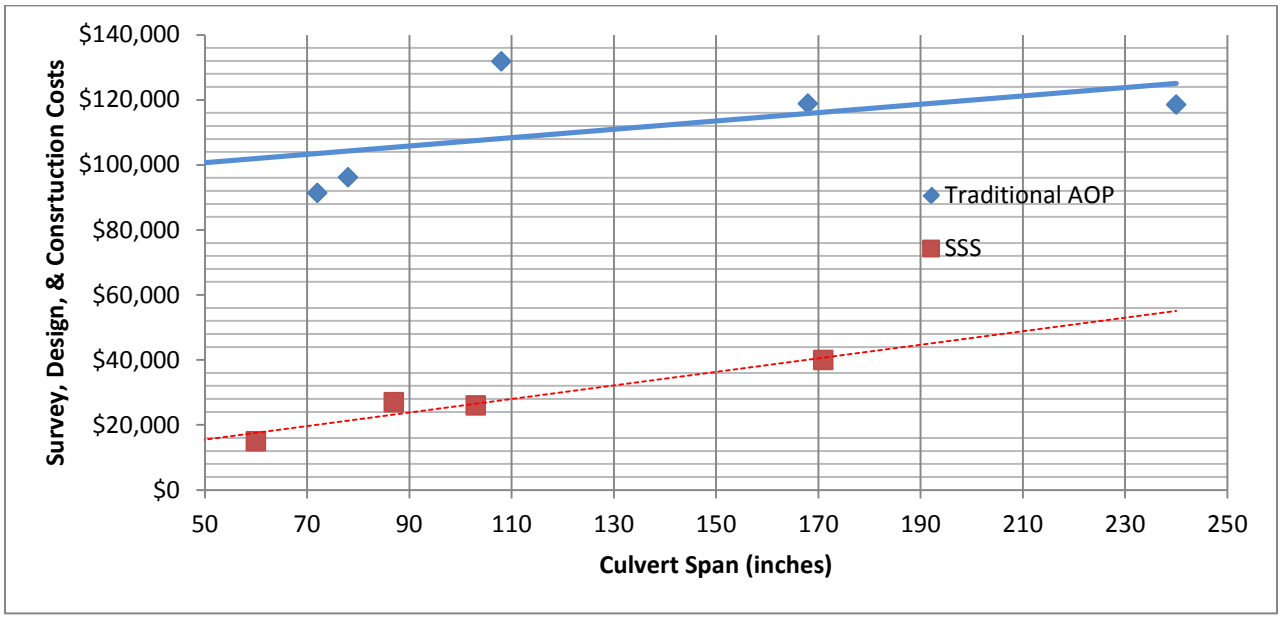
In an effort to reduce the significant costs associated with designing and installing culverts which provide fish passage, the Tongass National Forest is evaluating an approach coined simplified stream simulation. Similar to traditional stream simulation design, the goal is to create fish passage conditions in the culvert which mirror that of the natural channel by matching stream gradient, width and bedload roughness. Unlike traditional stream simulation, simplified stream simulation does not actively place bedload material into the culvert but instead relies on it being deposited from surcharged material placed upstream. In 2012, four simplified stream simulated culverts were installed and monitored.

All four simplified stream simulation culverts installed and monitored met State of Alaska fish passage standards. However, the results of the initial monitoring indicate that they did not simulate the conditions of the natural channel as well as that of traditional stream simulation. Monitoring was performed during the same year of installation and overtime it is anticipated that additional bedload material will accumulate within the culvert and more closely resemble that of the natural channel.

A substantial amount of the deposited surcharged material remains above bankfull height upstream of the simplified stream simulation culverts and will most likely not be mobilized downstream during most high flow events. The material was originally placed above bankfull height because there was not enough volume in the active channel to accommodate the amount required. To fill the culverts with bedload to the design depth it may be necessary to actively move the remaining surcharged material that remains above bankfull height into the active channel and potentially add additional material.

A cost comparison between traditional stream simulation and simplified stream simulation approaches indicates that simplified stream simulation is significantly less expensive. If survey, design and construction cost are compared simplified stream simulation was approximately 16 percent to 45 percent of the cost of traditional stream simulation culverts depending on the size of the culvert. The cost differential tended to be greater with smaller culverts (figure 20).

Figure 20. Traditional Stream Simulation vs. Simplified Steam Simulation (SSS) Costs.



In addition to experimenting with simplified stream simulation the Tongass National Forest has in recent years been trending toward using fewer culverts and more bridges for fish passage restoration projects where site conditions allow. For example, glulam timber bridges are used as a cost effective means to provide fish passage.

Recommendations

We do not recommend any changes to Forest Plan standards and guidelines in response to preliminary monitoring results. Project plans include monitoring additional sites in following years with annual monitoring of all simplified stream simulation culvert installations.