# Turbidity Changes During Culvert to Bridge Upgrades at Carmen Creek, Idaho

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***Abstract**: Carmen Creek, a tributary to the Salmon River in Idaho, was the site of two culvert to bridge upgrade operations in September and October 2011. Both locations were upgraded from multiple, large diameter culverts to bridge crossings. Turbidity readings measured at the end of the mixing zone during the nearly three weeks of upgrade construction activities did not exceed the Idaho state instantaneous criteria of 50 NTU above the background. The sediment mitigation measures of diverting the creek around the road crossing and temporary in-creek dams were effective in keeping the turbidity values within state regulatory requirements.*

At the time of construction, Forest Service, BLM, and state forest roads provided access for timber harvest and recreational use. Culverts used on these roads were historically designed to convey water under the road with little attention given to passage of aquatic organisms. In the past decade or so, driven largely by the Endangered Species listing of sockeye salmon in the Pacific Northwest, culverts have been designed and installed to accommodate passage of aquatic species. Many existing culverts designed under the old criteria are impediments to passage and are replaced with culverts or bridges designed to accommodate aquatic species passage. Managers weigh the short-term negatives of sediment in the stream during culvert replacement against the positive long-term impacts of improved passage when considering which culverts to replace. Regulatory agencies such as National Marine Fisheries Service are requiring improved quantification of the short and long-term impacts. One frequently used metric for the short-term impacts is turbidity. Allowable turbidity standards for surface water quality are set individually by each state. Idaho state criterion for cold water aquatic habitat require that turbidity not exceed the background level by more than 50 NTU instantaneously or more than 25 NTU for more than 10 consecutive days (IDEQ, 1994). To answer the short-term impacts question, the BLM, the State of Idaho, and the U.S. Forest Service partnered to conduct a study of two culvert-to-bridge upgrades on an anadromous fish bearing stream in Idaho by measuring stream turbidity during the upgrade.

Carmen Creek (Figure 1), a Rosgen B3 channel type, is a tributary of the Salmon River with an average annual flow of 3 to 7 cfs in the summer, fall and winter, and can peak as high as 150 cfs during spring run-off and early summer. Carmen Creek elevation changes from approximately 5200 feet to 3840 feet at the confluence with the Salmon River, for an average gradient 142 feet per mile over approximately 9.5 miles of stream with the majority of the elevation drop in the first 2 to 3 miles of the creek.

Culverts at some road crossings were barriers to fish migration, preventing fish passage above the culvert during low flows. During spring run-off, large woody debris was continually pinned against the culverts, allowing large amounts of debris to catch in the culvert and create a barrier for aquatic species. Parmenter Lane, Figure 2, and Archie Lane, Figure 3, were two of these fish barrier road-stream crossings.

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Between September 14 and 27, 2011 the Parmenter Lane road crossing was upgraded from multiple 6 and 7 foot diameter CMP culverts to a pre-fabricated steel bridge 24 feet wide and 50 feet in length. Between October 4 and 13, 2011 the Archie Lane road crossing was upgraded from multiple 6 and 7 foot diameter CMP culverts to a pre-fabricated steel bridge, 16 feet wide and 45 feet in length. Before and after photographs are shown in Figures 2 and 3.

**METHODS**

The culvert upgrade procedure was similar at both locations. The first step was to install a 36 inch diameter plastic culvert to accept the creek flow and divert it around the work area. Next, temporary dams above and below the road crossing were created using four foot diameter bags filled with gravel. These dams diverted the creek into the culvert and kept water from flowing through the work area. Once the stream was flowing in the bypass culvert, any fish trapped between the dams were caught and relocated out of the work area. A pump between the dams and upstream of the road crossing assisted in dewatering the work area. To allow vehicles to cross Carmen Creek during the construction, a temporary bypass road and culvert were installed between the two temporary dams. Removal of the old culverts and installation of the new bridge required 10 to 12 days. In-stream activity by excavators or other machinery was minimized. Upon completion of the bridge installation, the bypass road was removed; the downstream bags were removed followed by removal of the upstream bags allowing the stream to flow beneath the new bridge. The bypass culvert was then removed. Figure 4 is a representation of these sediment mitigation techniques.

Turbidity measurements were made using two HANNA HI 93703 Turbidity Meters. Both meters were calibrated with zero and 10 NTU standard solutions. A turbidity sample was taken above the upper temporary diversion dam at the beginning and again at the end of each work day to establish the background turbidity. A second sampling point was located 10 m downstream of the bypass culvert outlet. This point was representative of the maximum turbidity immediately downstream of the construction activity. A third sampling point was located 100 m downstream of the bypass culvert outlet. This point was chosen with the expectation that it was near the end of the mixing zone. Inspection of the sediment plume during construction activities verified that it satisfied the “end of mixing zone” requirement. Location of the three sampling points is indicated in Figure 5. Samples were taken in 10 ml cuvets at a depth of 6 inches in the center of the channel. Turbidity readings were taken immediately after sampling.

Sampling criteria for the Parmenter Lane location was every 15 minutes or when the turbidity visually increased. When the turbidity was visually high, a sample was taken at least every 5 minutes until the stream cleared up. The sampler located at the upper point recorded a description of the construction activity.

Based on the results of the Parmenter Lane sampling, the Archie Lane sampling criteria was modified to a sample every 30 minutes or when the turbidity visually increased. Construction activity was again recorded.

**RESULTS**

Flow in Carmen Creek during the Parmenter Lane work was 0.70 cfs on September 14, 0.72 cfs on September 15, 0.50 cfs on September 26, and 0.46 cfs on September 27. For the Archie Lane crossing, the flows were 0.35 cfs on October 4 and 1.6 cfs on October 13. Water velocities were approximately 1.25 feet per second at both locations.

***Parmenter Lane***: The Parmenter Lane location did not exceed the Idaho state turbidity regulations at the end of the mixing zone. The maximum turbidity measured 100 m downstream from the lower temporary dam was 45 NTU when the final portions of the lower temporary dam were removed.

On September 14, 2011 the turbidity measurement 10 m downstream from the lower temporary dam exceed 50 NTU for 15 minutes at the Parmenter Lane location. These samples were taken in the most turbid portion of the stream. During this time the excavator was physically in the stream digging a hole for the bypass suction pump. The turbidity dropped below 50 NTU above background after the excavator moved out of the stream. During the 15 minutes that the turbidity was elevated at the point adjacent to the downstream dam, the maximum turbidity 100 m downstream was 31 NTU.

Figure 6 shows the turbidity samples taken at the Parmenter Lane location. All of the peaks occurred when one of the following activities occurred

- Excavator physically in the creek
- Excavator out of the creek but moving rocks in the creek
- Excavator out of the creek but placing vegetation immediately adjacent to the creek
- Final remnants of the lower temporary dam being removed.

***Archie Lane***: The Archie Lane location did not exceed 50 NTU above background at the end of the mixing zone. The maximum turbidity measured 100 m downstream from the lower temporary dam was 50 NTU when the lower temporary dam was removed. Note that the background turbidity, measured above the upstream diversion dam, averaged 1 NTU during the removal of the lower temporary dam, therefore, the state requirement was narrowly avoided.

Figure 7 shows the turbidity samples taken at the Archie Lane location. All of the peaks occurred when one of the following activities occurred

- Work on installing the bypass dams
- Releasing water from bypass dams after completion of bridge installation.

Figure 8 provides a visual illustration of the range of turbidity readings from 40 to 1 NTU in Carmen Creek. The pictures were taken at the 100 m downstream point at the Parmenter Lane location.

**CONCLUSIONS**

The Carmen Creek road crossing upgrades from large diameter CMP culverts to bridges was completed without exceeding the Idaho turbidity requirement of 50 NTU above background measured at the end of the mixing zone. Immediately adjacent to the downstream temporary dams, turbidity measurements exceed 50 NTU for 15 minutes on a single day, September 14, with a maximum value of 125 NTU. At the same time, turbidity values 100 m downstream were less than 50 NTU above background. All of the peak values occurred when the excavator was physically in the creek, when the excavator was moving stream bed rocks or placing vegetation on the creek banks, or when the lower temporary dam was removed at the end of the project. While we have no measurements of what the turbidity values would have been without the temporary dams, the measured turbidity values strongly suggest that sedimentation mitigation techniques were successful in reducing turbidity values. Short-term impacts at these two sites were within the state of Idaho criteria for maximum instantaneous turbidity.

**ACKNOWLEDGEMENTS**

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**REFERENCES**

IDEQ (Idaho Department of Environmental Quality), 1997. Rules of the Department of Environmental Quality, IDAPA 58.0102 "Water Quality Standards" in Surface Water Quality Criteria for Aquatic Life Use Designations, Section e. Available at <http://adminrules.idaho.gov/rules/current/58/0102.pdf>. Accessed February 24, 2012.


**Figure 1 - Location of Carmen Creek.**

**Figure 2 - Parmenter Lane road crossing before and after culvert to bridge replacement.**

**Figure 3 - Archie Lane road crossing before culvert to bridge replacement. Bridge here similar to Parmenter Lane.**

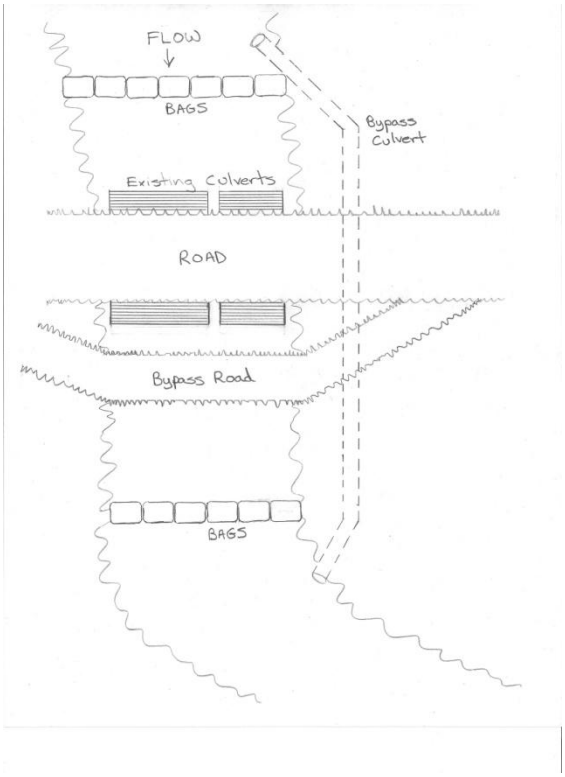


**Figure 4 - Sketch of sediment mitigation techniques used at Parmenter Lane. Similar ones were used at Archie Lane.**


Figure 5 - Sampling locations at Parmenter Lane Crossing.

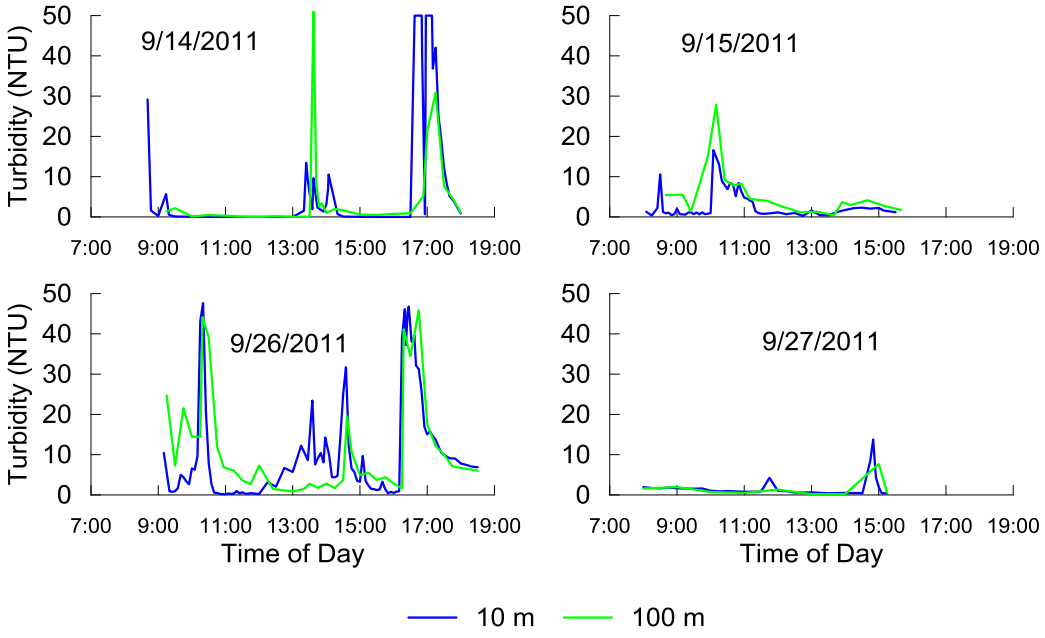


Figure 6 - Turbidity for Parmenter Lane location. Each graph scaled to 50 NTU maximum. Note that 9/14/2011 has truncated peaks.

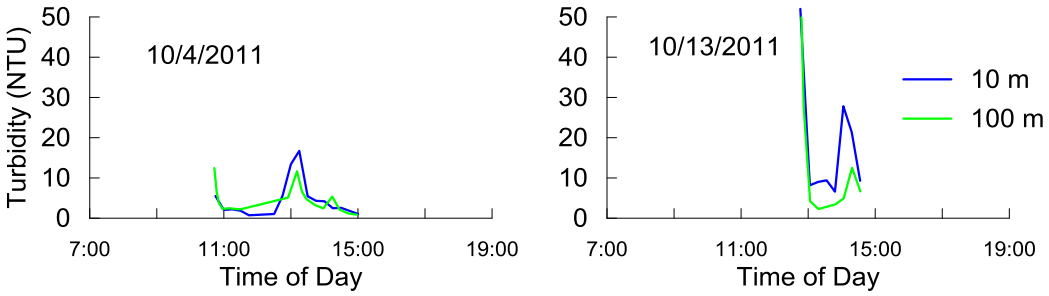


Figure 7 - Turbidity readings for Archie Lane location. Each graph scaled to 50 NTU.

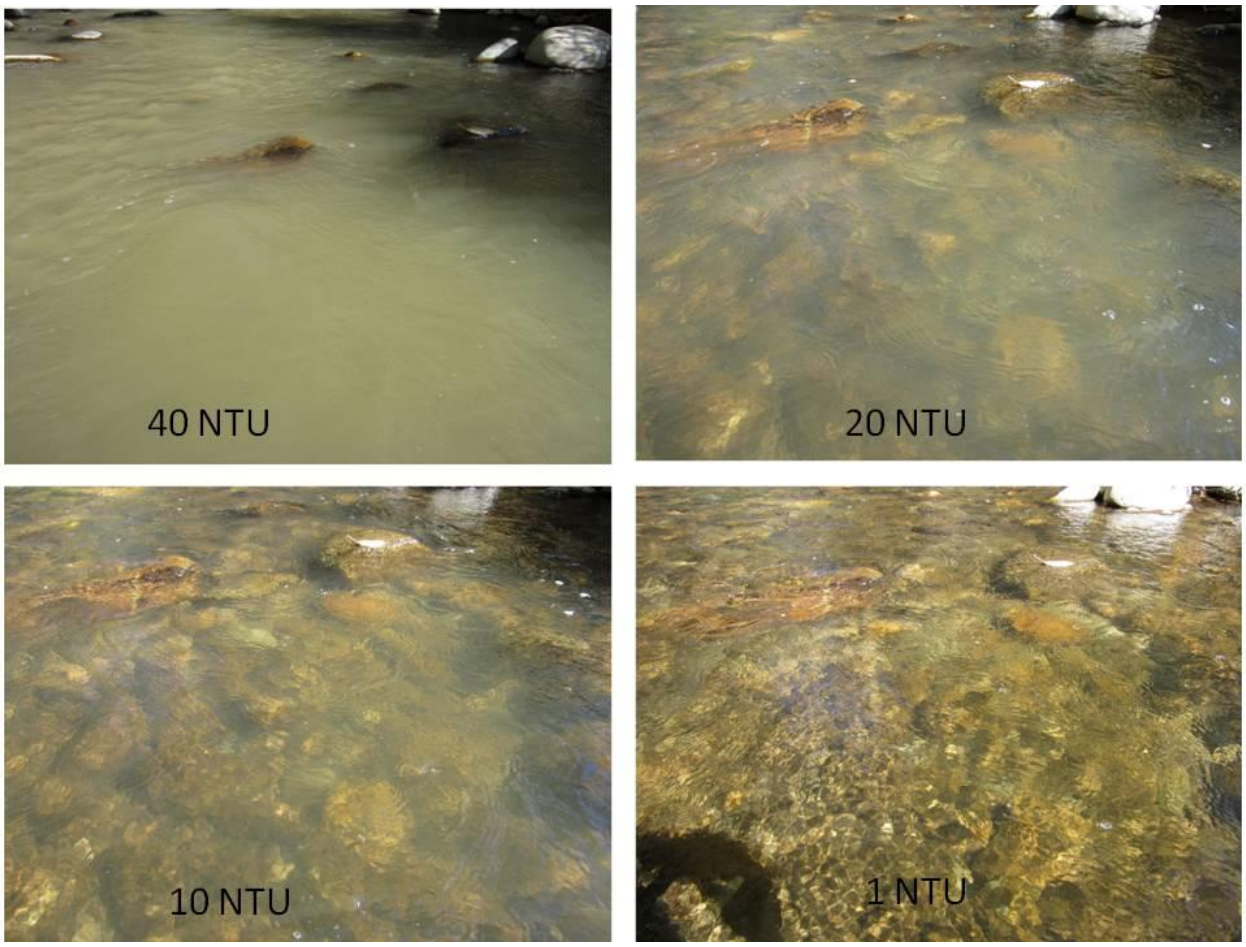


Figure 8 - Turbidity levels in Carmen Creek during Parmenter Lane culvert upgrade.