2016 Annual Monitoring Report for the North Platte River Restoration Project

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ABSTRACT

In 2016, the Wyoming Game and Fish Department (WGFD) conducted the first annual monitoring effort to evaluate improvements in geomorphology, fish habitat, and bank stability resulting from the restoration project on the North Platte River through Casper. As noted in the monitoring plan (WGFD 2017), this is a multi-phase project that includes seven project sites that will potentially be constructed over the course of several years. In the fall of 2016, construction at one site, Site 1 – Morad Park, was complete and monitored by the WGFD. Construction on Sites 2 and 3 was on-going and those sites will be monitored beginning in 2017.

Monitoring efforts revealed that the reconstruction of the river channel achieved the primary geomorphology, fish habitat, and bank stability goals of the restoration project in the Morad Park site. All parameters fell within the expected range defined in the monitoring plan. The river channel was narrowed and deepened with corresponding changes in entrenchment ratio, bank-height ratio, width-to-depth ratio and cross-sectional area that were within the range of values proposed in the project plans. These channel changes have improved floodplain access for the river. New fisheries habitat was created in the form of a toe-wood structure adjacent to a pool along one bank and two deep pools were excavated in the project site. Fish sampling indicated a substantial increase in the number of trout in the project reach compared with unmodified control reaches upstream of the project area. The visual assessment suggests improvements in channel dimension have stabilized stream banks and reduced shear stress along the banks. All structures associated with the channel reconstruction were functioning as intended with no movement or obvious sediment deposition or erosion around any of the features. The one area where the project did not have success in the first year is reestablishment of the riparian vegetation along the banks; a combination of vandalism and a long period of high spring flows appear to be the primary culprits.

An additional four years of monitoring in this project site will provide an opportunity to better evaluate vegetation reestablishment and also ensure that the channel changes remain stable. This effort will help identify whether any monitored parameter falls outside of the expected range described in the monitoring plan and require maintenance efforts. Similar monitoring efforts will be employed on each new project site throughout the overall project area as each is completed.

INTRODUCTION

The City of Casper (City) and several partners, including the Wyoming Game and Fish Department (WGFD), have invested significant resources into developing and implementing restoration projects within a 13.5 mile stretch of the North Platte River through the City. The

WGFD is working with the City of Casper and project engineers to monitor constructed projects to evaluate where the projects sites are meeting their goals and objectives over a five year period (WGFD 2017). Construction at the Morad Park site was completed in 2016 and geomorphic and fisheries monitoring were conducted in 2016 and 2017 following construction. In order to verify that these efforts met the intended goals of the project and to evaluate whether future maintenance efforts will be needed, a comprehensive annual monitoring plan was developed (WGFD 2017). This report provides the results of 2016 annual monitoring efforts.

Five years of annual monitoring is planned for each study site one year after construction is completed and for four additional years to document the benefits of the project and to assess the condition of the stream channel and structures used to maintain the desired conditions within this study site. These efforts will help determine whether any maintenance efforts may be needed.

METHODS

Monitoring was completed on Site 1- Morad Park in 2016; data were collected following the protocol outlined in the monitoring plan (WGFD 2017) between October 26, 2016 and November 30, 2016. In addition to field data collected by the Wyoming Game and Fish Department (WGFD), the monitoring evaluation also used data from an as-built survey provided by Stantec, the engineering firm responsible for construction oversight. That survey was conducted to confirm that all structures were in place and that the constructed channel was consistent with the design plans. The data from that survey were combined with field efforts by WGFD to provide the comprehensive monitoring effort presented in this report.

Site Conditions

This first year of monitoring occurred after a higher than average flow event in the North Platte River, which had the potential to alter the geomorphic conditions of the project site. Flow in the project area exceeded 7,100 cfs during spring runoff in 2016 and remained above bankfull flow (4,300 cfs) with the river overtopping its banks and inundating the floodplain for approximately 35 days.

Visual Assessment

One key component of annual monitoring is to provide an opportunity to look at the general condition of the channel, structures, and riparian vegetation to see if there are any obvious problem areas or concerns that may not be adequately captured in the other monitoring methods. This includes both photos and a rapid assessment of the integrity of each structure installed during construction.

Seven photo monitoring stations were established in Site 1 – Morad Park during this monitoring effort (Table 1) and each will be re-visited annually for documenting change over time. The seven locations were roughly equivalent to the same number of locations monitored before, during, and immediately after the construction phase by the engineering design firm, Stantec. Several of the points were moved closer to the stream edge (above bankfull) than was monitored during construction. In each location, one photo was taken looking upstream and one downstream. The points are spaced closely enough that there are overlapping features in successive photographs; all portions of the project site are included in these images.

Table 1. Coordinates (UTM NAD83 Zone 13) of Site 1 – Morad Park photo monitoring points.

Point Number	Northing	Easting
PHOTO1	4741896.947	387613.082
PHOTO2	4741956.809	387725.115
PHOTO3	4742107.165	387843.150
PHOTO4	4742225.440	387939.963
PHOTO5	4742329.492	387976.079
PHOTO6	4742235.797	387863.577
PHOTO7	4742083.227	387753.463

The rapid assessment procedure of Miller and Kochel (2013) was used to evaluate the condition of eight structures in the Morad Park project site. Structures were numbered 1-8 and included (in downstream order) a toe-wood bank stabilization structure, three rock vanes, and four constructed riffle vane arms. As noted in the monitoring plan (WGFD 2017) the procedure requires a visual assessment of the integrity of each structure (i.e., evaluating whether it is damaged in any way that affects its intended function). Structural integrity is ranked on a score of 1-4 which are described as 'Intact', 'Damaged', 'Impaired', and 'Failed' (Miller and Kochel 2013). Erosion or deposition associated with each structure is ranked on a scale of 0-5; rock and wood features are ranked on the same scale but use different descriptions for each rank (Miller and Kochel 2013).

Geomorphology

There are three primary goals associated with modification to the geomorphology characteristics of the river including narrowing and deepening the shallow, over-widened channel, improving fisheries habitat, and stabilizing the stream banks. Data were collected to evaluate each of these goals in 2016 in accordance with the monitoring plan (WGFD 2017).

A longitudinal profile of the project site was completed and four cross-sections were selected, including two pools and two riffles (Figure 1). Of the two riffle cross-sections, the downstream one was deeper than expected and a review of a comprehensive topographic map of the site (acquired after these monitoring data were collected) revealed that there may be a better location for a second riffle cross-section. The possibility of relocating the second riffle cross-section will be explored in 2017, but the results below are based on data collected from the two riffle cross-sections selected in 2016. Figures displaying the longitudinal profile and cross-section profiles are presented in Appendix B.

Using data from the two riffle cross-sections, the entrenchment ratio, bankfull height ratio, width-to-depth ratio, and cross-sectional area were calculated to evaluate goal 1, narrowing the over-widened channel.

To evaluate goal 2, improve fisheries habitat, the toe-wood feature was scored using the instream structure assessment protocol described above and the maximum pool depth was calculated for the two pools excavated in this project site. The maximum pool depth was evaluated using sonar depth sounding equipment. Initial attempts to survey the pools by wading were unsuccessful due to pool depths. The sonar data was provided by a surveying firm, CEPI, who was hired by the engineering consultant to complete an as-built survey of the project site.

For goal 3, stabilize streambanks, the monitoring plan indicates that the BANCS modeling tools will be used to evaluate streambank stability in years three and five after project construction to allow the new vegetation a chance to become established. The objective to decrease bank erosion from 885 tons/year to 63.6 tons/year will be evaluated when those data are collected. A visual assessment was conducted in the Morad Park project site in 2016 and a map of the bankfull line (both banks) was collected for comparisons to future monitoring efforts.

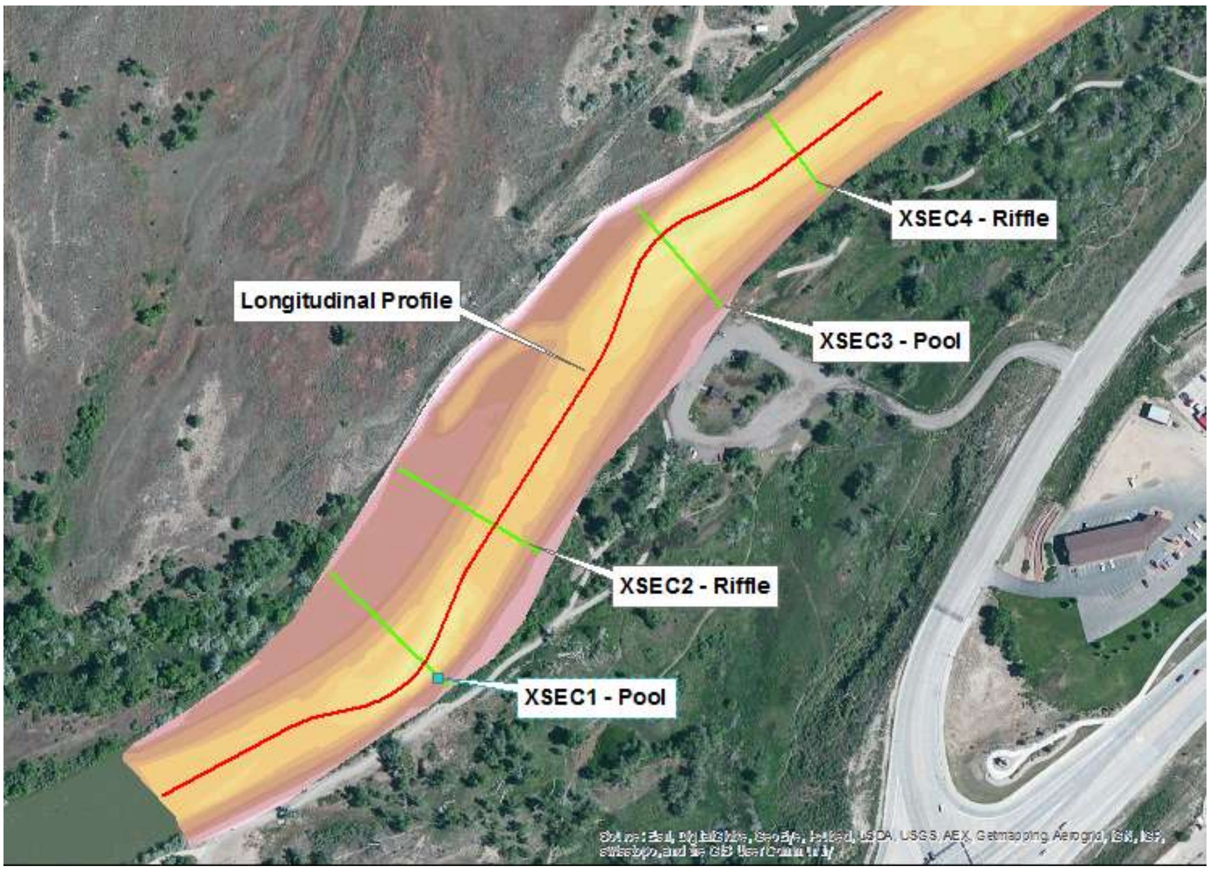

FIGURE 1 – Morad Park project site including the longitudinal profile, which delineates the project reach and cross-sections including: two pools and two riffles.

Fisheries

One of the primary goals of the Platte River Restoration project was to enhance the trout fishery through the city. Single-pass electrofishing was conducted by Casper regional fisheries management personnel in October 2016 to compare upstream control reaches with the Morad park reach to detect differences in trout abundance and size structure before and after project construction. The control reach consists of five stations (approximately 3,000 ft each) beginning at the Robertson Road Bridge and ending at the Wyoming Game and Fish office. The Morad Park station encompasses the entire re-constructed reach. Electrofishing was conducted after the river returned to 500 cfs using a single jet boat and two netters. Trout catch per unit of effort (CPUE) was expressed as the number of fish captured in a reach extrapolated to 1 mile. Proportional stock density (PSD) was used to compare size structure of the rainbow trout population.

RESULTS

Visual Assessment

Photo Monitoring

The most obvious feature from the photographs taken in fall 2016 (Appendix A) is that the channel has been narrowed considerably relative to pre-project conditions. Another clear feature is that riparian vegetation did not become established between planting and the end of the first growing season. A few locations had some growth of riparian vegetation, but most of the reach had very little growth of individual plants.

In-stream Structure Assessment

A close inspection of each rock structure (three arm vanes and four constructed riffle vanes) reveal that each is in the appropriate location relative to the design plans and each is located at the level of the surrounding bed such that the rock features are not within the water column. Each arm has appropriate backfill material between the arm and the shoreline and a ‘dropoff’ on the downstream side into a scour pool below. Each constructed riffle vane has sorted substrate (cobble-sized) deposited around the feature such that the large boulders are not easily visible (the feature appears ‘buried’). In all cases the ‘arms’ of each feature that are visible up on the bank. A review of the design plans show that this is the intent of these features; each should be exactly at the elevation of the surrounding stream bed and not protrude up into the water column. Footer boulders associated with each structure are buried below the ‘header’ boulders according the plan designs, but this cannot be visually evaluated once the structures are installed.

Using the rapid assessment procedure, all features scored a 1 on structural integrity (Intact) and all scored a 0 on erosion/deposition (none visible).

Table 2. Structure assessment ratings for 2016 monitoring of Site 1 – Morad Park.

Structure Description	Number	Structural Integrity Rating (1-4)	Erosion Rating (0-5)
Toe Wood	1	1	0
Rock Vane (1)	2	1	0
Rock Vane (2)	3	1	0
Rock Vane (3)	4	1	0
Constructed Riffle (1)	5	1	0
Constructed Riffle (2)	6	1	0
Constructed Riffle (3)	7	1	0
Constructed Riffle (4)	8	1	0

Geomorphology

A summary of all geomorphic monitoring data is presented in Table 3.

Goal 1 – Narrow Over-Widened Channel

The average entrenchment ratio, calculated as the width of the channel at an elevation that is twice the maximum bankfull depth divided by the width of the channel at the bankfull elevation, was 4.3 in project site 1 – Morad Park. Estimates were 5.0 for the upper end of the constructed riffle and 3.5 for the riffle at the downstream end of the study site. The minimum expected value was 2.2 and preferred value was greater than 3.0.

The bank-height ratio, an indicator of channel incision, was determined to be 1.0 at each of the two riffle cross-sections; the desired value was 1.0 – 1.2.

The width-to-depth ratio of the reconstructed channel was 31.6 in the constructed riffle and 23.2 in the downstream riffle; the goal was 35 to 48. One concern with these data is that the downstream riffle was much deeper than expected when the data were collected. The width-to-depth calculation is strongly impacted by selection of an appropriate riffle and the downstream cross-section used for monitoring in 2016 does not provide the appropriate conditions for this calculation. Therefore, only the results of the cross-section over the constructed riffle will be considered for the width-to-depth calculation this year.

Cross-sectional area varied between approximately 1300 and 1460 square feet in the Morad Park site before construction and was reduced to an average of 873 square feet in the two riffle cross-sections (808 and 937 square feet respectively) after the channel was re-shaped (Appendix B, Figures B3 and B5), which is close to the 950 square feet design plan.

Goal 2 – Improve Fisheries Habitat

The one toe-wood structure in this project site was evaluated as part of the in-stream structure assessment described above and it received a value of 1 for structural integrity (Intact) and 0 for deposition/erosion (none visible).

The topographic survey data indicate that the two deep pools excavated during construction were approximately 11.1 (upstream pool) and 10.6 (downstream pool) feet deep. These values are greater than the pre-construction maximum pool depth of about 8.5 feet but not as deep as the project design (about 12.2 feet each) (Appendix B, Figures B2 and B4). The observed depths represent approximately 90% and 87% of the project design depths.

Goal 3 – Stabilize Streambanks

No BEHI or NBS data was collected in 2016 as per the monitoring plan. A visual assessment of the project site reveals that there are no longer steep banks adjacent to the river; these areas have been modified as part of the narrowing of the active channel and development of the floodplain.

Both sides of the river were surveyed to create a continuous bankfull line for each bank on November 2, 2016 when discharge was approximately 485 cfs (Figure 2).

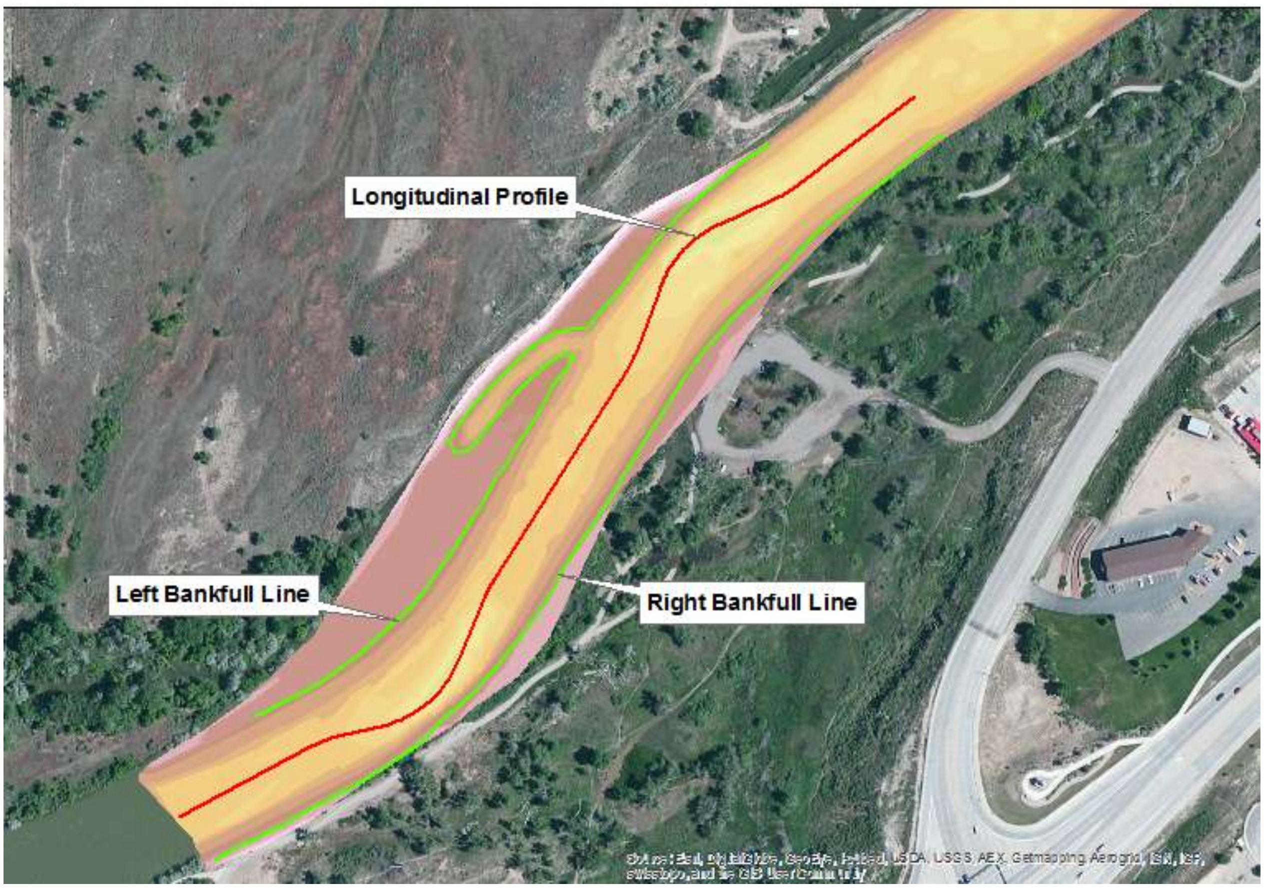

Figure 2. Map displaying the longitudinal profile line (thalweg) and left and right bankfull lines. The location of each of these lines may be compared annual to determine whether any lateral migration occurs.

Table 3. Summary of geomorphologic data collected in Site 1 – Morad Park in 2016.

Monitoring Parameter	2016 Observations	Criterion
Goal 1: Narrow channel		
Entrenchment Ratio	Average = 4.3	Minimum ratio >2.2; preferred ≥3.0
Channel Incision	Average = 1.0	Average bank-height ratio value 1.0-1.2
Width to Depth Ratio	31.6	Between 35 and 48
Cross-Sectional Area	808 and 937 sq. ft	Value for each riffle cross-section should not vary by more than 10% year to year or by more than 15% across all sites.
Goal 2: Improve fisheries habitat		
Toe-Wood	Scores: 1 and 0	Rapid assessment procedure; all structures should rank 1-2 on integrity and 0-2 on erosion/deposition.
Maximum Pool Depths	11.1 and 10.6 ft	Deepest point in each pool should remain at least 75% of project design depth (9.2 ft).
Goal 3: Stabilize Streambanks		
BEHI and NBS	To be completed in 2018	All areas should be moderate or lower.
Map bankfull line	Map in Figure 2	Track lateral channel migration.

Fisheries

There was no difference in catch rate of trout between the control reaches and the Morad Park reach in 2015 pre-construction ($t=0.67$, $p=0.54$). Conversely, CPUE for trout was significantly higher in the Morad Park reach compared with the control reaches one-year post construction in 2016 ($t = 11.2$, $p < 0.001$; Figure 3). There were no significant differences in size structure (PSD) of the rainbow trout population between the control and Morad Park reaches in either 2015 ($p=0.69$) or 2016 ($p=0.82$). Species composition was similar across years and among reaches with rainbow trout representing around 90% of trout standing stock and brown trout comprising the remaining 10%.

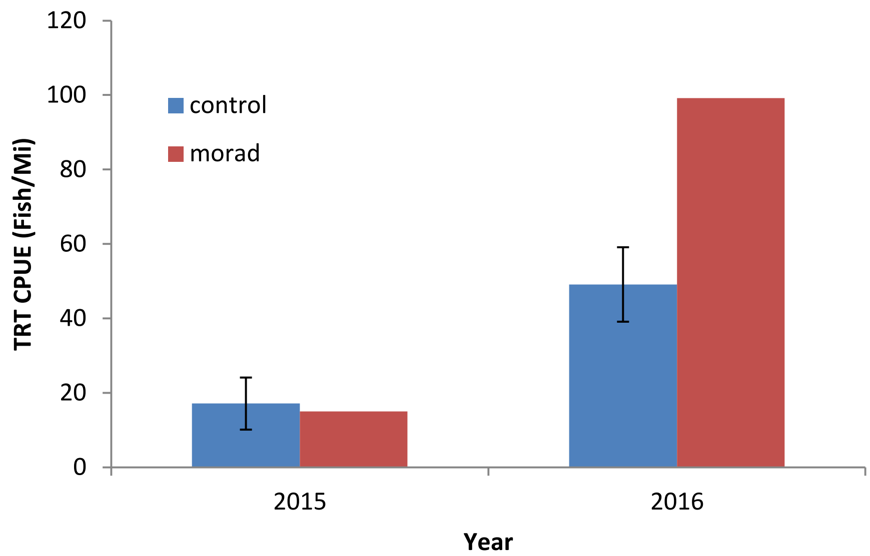

FIGURE 3. Catch per unit effort (fish/mile) for trout captured with single-pass electrofishing on the North Platte River, September 2015 and October 2016. Error bars represent ± 1 standard deviation for the five control stations. The Morad park reconstructed reach is a single station.

DISCUSSION

The high flows in the project area between the completion of construction activities in the river and the first monitoring event provided a good opportunity to evaluate the stability of the modified channel. The overall assessment is that the channel reconstruction is stable and has accomplished the desired results. This channel should be more efficient at transporting sediment inputs from upstream and have minimal bank erosion and lateral channel migration. Monitoring this project site for the next few years will help ensure that these improved conditions are stable and will maintain an a properly functioning river corridor in the foreseeable future.

The instream structures are working as intended. The low flow conditions during monitoring allowed a good opportunity to assess these features and all three rock vane arms are diverting flows back toward the center of the channel and away from the bank. Each of the four constructed riffle vanes appears to be maintaining grade as intended (visual evidence is that there is turbulence over each arm suggesting a riffle feature with deeper ‘troughs’ between each arm). The toe-wood bank stabilization feature is stable and providing complex habitat within the low-flow channel for fish to use as cover. This is the first year of monitoring, so it should be expected that structures are still in place and functioning as intended, but considering that a significant flow event occurred between construction and this first year of monitoring, there is good evidence that the structures are well-designed and located appropriately to withstand high-flows. Future monitoring efforts will allow an opportunity to evaluate whether these structures will continue to function as intended over time.

The data from this effort indicate success on all three of the primary goals associated with the modification to the geomorphology characteristics of the river. Previously, the river had restricted access to the floodplain because the channel was so wide and the floodplain was relatively narrow. With the reconstructed channel, the greater entrenchment ration means that this broad floodplain will allow high flows to disperse over a larger area and reduce shear stress along banks that leads to instability. Similarly, the new channel has a bank-height ratio of 1.0 throughout the reach, which means the low bank is now the same as the bankfull elevation throughout the entire project site, the river is able to get out onto its broad floodplain in all locations and disperse the energy that was previously causing erosion along certain portions of the stream banks. Previous values of 1.1 – 1.7 in this reach indicated that the channel was slightly-to-deeply incised in some areas which prevented access to the floodplain and resulted in high shear stress and instability along the banks. It is not likely that either the entrenchment ratio or bank-height ratio will change during the course of the planned monitoring period; however, the study site will be evaluated each year to recognize any potential problem areas that may warrant maintenance efforts.

Also related to the first goal of narrowing the channel, both the width to depth ratio and cross-sectional area values were improved to within the planned range. Unfortunately, field efforts resulted in collecting data at a cross-section that was designated riffle, but too deep to be representative of that feature type. Some effort to relocate the cross-section in the field to a shallower spot was not successful (data were collected in a spot that was ultimately downstream of the project reach and not considered). This resulted in a width-to-depth value that was outside of the desired range for this deeper cross-section, but the better riffle cross-section yielded a ratio of 31.6. The desired range was 35 to 48 and pre-construction values ranged from 52 to 100 so the improvement was notable. This was one of the most significant geomorphic changes (and clearly visible in before and after photos that show the change in channel width) associated with the restoration efforts that results in a channel that is able to pass sediment more effectively and to reduce the likelihood of accumulating sediments in the middle of the channel. The new cross-sectional area of 873 square feet was also close to the design value of 950 square feet. Future monitoring efforts will enable an evaluation of whether this value remains stable and varies by less than 10% in this project site, as desired, or within the 15% variation among all sites.

The second primary goal of the channel geomorphology modification was to improve fisheries habitat. In addition to the changes in the channel dimensions that enhance fish habitat, the two primary features to accomplish this goal were the toe-wood structure and excavated pools. The toe-wood structure was stable, functioning as intended, and providing good fish habitat. The rock arm vane immediately upstream of the toe-wood structure is designed to maintain the scour pool adjacent to the toe-wood; this combination of complex woody debris in the channel and adjacent pool should be excellent for trout. Both excavated pools were not as deep as originally designed, but still within the goal of 75% of the project design (9.2 feet deep) as described in the monitoring plan. It is not surprising that the pools may have experienced some deposition during the high flow runoff period in spring; deposition will likely occur until the pools reach a state of equilibrium within the new channel configuration. Monitoring in future years will help determine whether the project design is successful in maintaining the desired depths.

The third goal was to stabilize the streambanks and a visual inspection shows that the project was successful on this goal as well. The high shear stress on the outside bends of the river that were observed prior to restoration efforts are no longer present, which should substantially reduce streambank erosion rates through this reach. More detailed evaluation of stability using the Bank Erosion Hazard Index (BEHI) and Near-Bank Stress (NBS) tools (Rosgen 1996) will be collected three years after construction and again in the fifth year of monitoring at which time it will also be possible to evaluate the objective to reduce bank erosion from 885 tons/year to 63.6 tons/year. The delayed monitoring period will allow time for the project, particularly riparian vegetation, to become established and for the evaluation to be a true measure of the project success. In the first two years, visual observations will provide sufficient information to detect deficiencies in the project site. The bankfull line was mapped on both sides of the river for the first time in 2016 and this map can be compared in each successive year of monitoring to evaluate whether there is any channel migration and to quantify the rate. If a substantial change is observed in future monitoring efforts, corrective actions may be implemented before a dramatic change occurs.

Fish population monitoring through the project site was compared to an unmodified control reach upstream and indicates that there are far more trout per unit of distance, about two times as many, in the project site. However, it appears that the sampling effort may actually be underestimating the true trout density in the project site. The reconstruction resulted in the creation of much deeper water than the upstream controls. It was apparent while electrofishing that many fish were successfully evading the electrical field in the deep water versus in upstream control reaches with much shallower pool depths. Hence the data showing a doubling in catch per unit effort in this reach versus upstream controls should be viewed as a minimum comparison. Future monitoring will employ multiple-pass depletion methodology which will generate actual population estimates, rather than CPUE density indices.

Unfortunately, all aspects of the restoration efforts in Site 1 – Morad Park were not successful. In a good portion of the reach, vandalism of live stakes sabotaged any opportunity for short-term establishment of a riparian plant community. In addition, the high water elevation in the spring and early summer of 2016 appears to have affected viability and growth of the vegetation. Additional efforts may be needed to ensure successful establishment of riparian vegetation in the project site.

Recommendations

The first year of monitoring the Platte River restoration project indicated that the project met nearly all goals. However future monitoring will help determine the success of riparian vegetation reestablishment. Monitoring efforts should be continued for the full five year window for Site 1 – Morad Park as described in the monitoring plan (WGFD 2017) and monitoring efforts should be initiated the first year after each new site is constructed. No additional monitoring is needed on cross-section 4 because it is technically not a riffle.

ACKNOWLEDGEMENTS

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APPENDIX A. MONITORING PHOTOS

Site 1 – Morad Park

Figure A1. Approximate location of seven photo monitoring points on Site 1- Morad Park. Note that the imagery from Google Earth to display these locations was taken prior to construction efforts associated with the restoration project.

Figure A2. Upstream (left) and downstream (right) view from photo point 1 taken on November 4, 2016. Looking upstream, the image shows some deposition of sediment along the near shore and creation of a cobble/gravel bar. This portion of the river is just upstream of the project site. Vandalism affected vegetation plantings all along this bank.

Figure A3 Upstream (left) and downstream (right) view from photo point 2 taken on November 4, 2016. The lack of vegetation is clear on the upstream photo, but looking downstream, there is some willow growth along the toe-wood structure evident in the center of the photo. There is a rock vane arm in the foreground of the downstream-facing image and another in the far-ground of the same image. It’s not clear in these photos, but during the field assessment, the current was observed to be re-directed back in toward the center of the channel, away from the near bank.

Figure A4. Upstream (left) and downstream (right) view from photo point 3 taken on November 4, 2016. Very little vegetation is evident along this portion of the bank as this is the most accessible area from the parking lot and all live stakes were removed. The turbulence in these two images correspond to the constructed riffle arms; each created a distinct riffle feature that appears to be holding the grade of the stream bed as intended.

Figure A5. Upstream (left) and downstream (right) view from photo point 4 taken on November 4, 2016. A few live stakes remained in this section, but like the other sections of this bank, most have been removed and it will be difficult to establish any vegetation along this bank.

Figure A6. Upstream (left) and downstream (right) view from photo point 5 taken on November 2, 2016. On this side of the river, live stakes remain (it's inaccessible to the public), but most did not appear to fare well. Some seem to be alive and growing small leaves, but growth is slow and may take a while to establish.

Figure A7. Upstream (left) and downstream (right) view from photo point 6 taken on November 2, 2016. Many more live stakes are evident in these photos. It is difficult to assess survival and growth from these photos. The upstream image does include the constructed riffle vanes, but it is not easy to see these from this vantage point. In the foreground of the upstream image is the downstream-most rock arm located where the large boulder is visible. This vantage point does not allow a very good evaluation of its integrity, but a close visual inspection in the field showed that the current was being re-directed away from the bank and toward the center of the channel.

Figure A8. Upstream (left) and downstream (right) view from photo point 7 taken on November 2, 2016.

APPENDIX B. LONGITUDINAL PROFILE AND CROSS-SECTION PROFILES

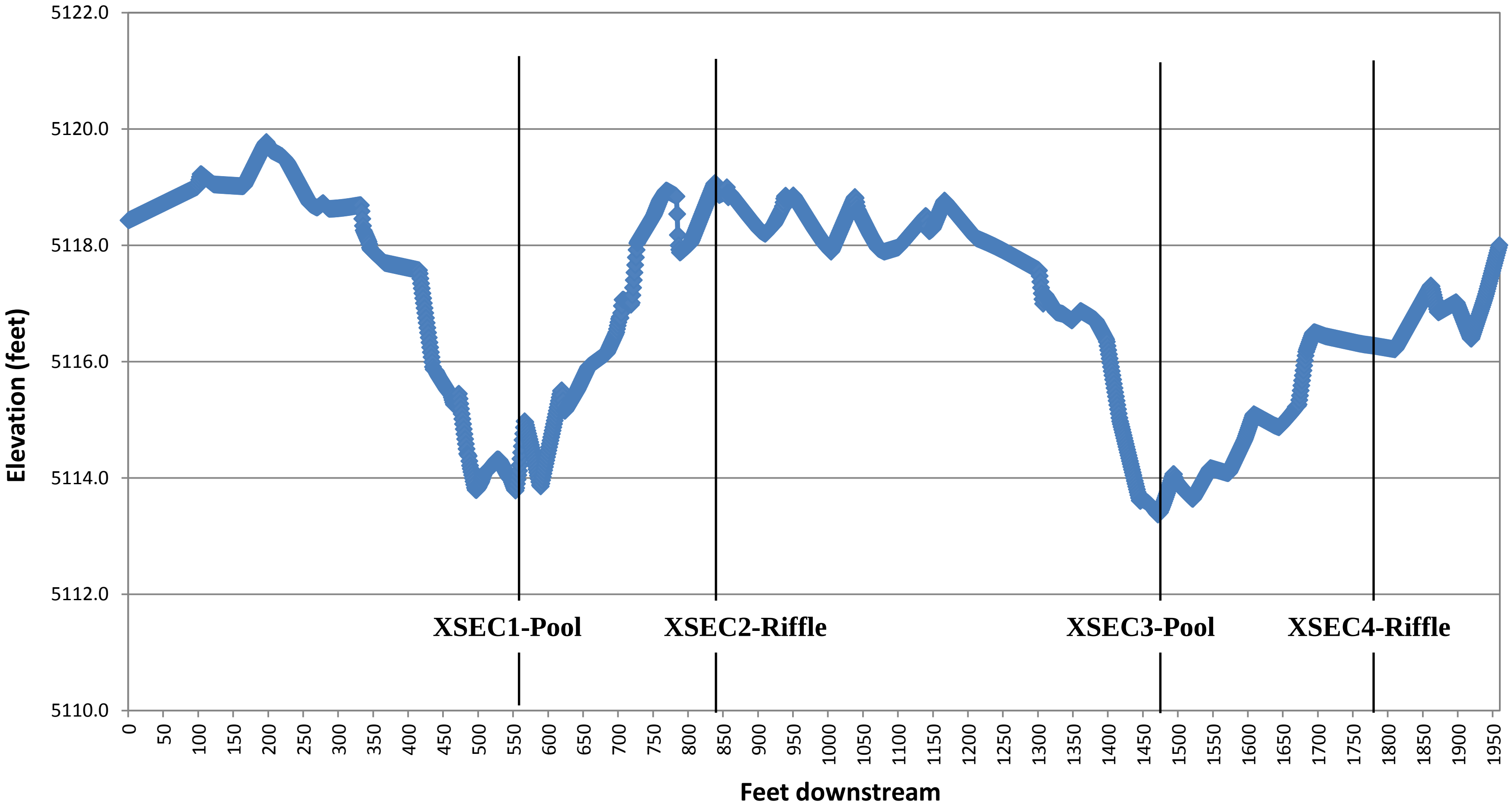

Figure B1. Longitudinal profile of Site 1 – Morad Park collected in October 2016. The approximate location of each cross-section (XSEC) is noted.

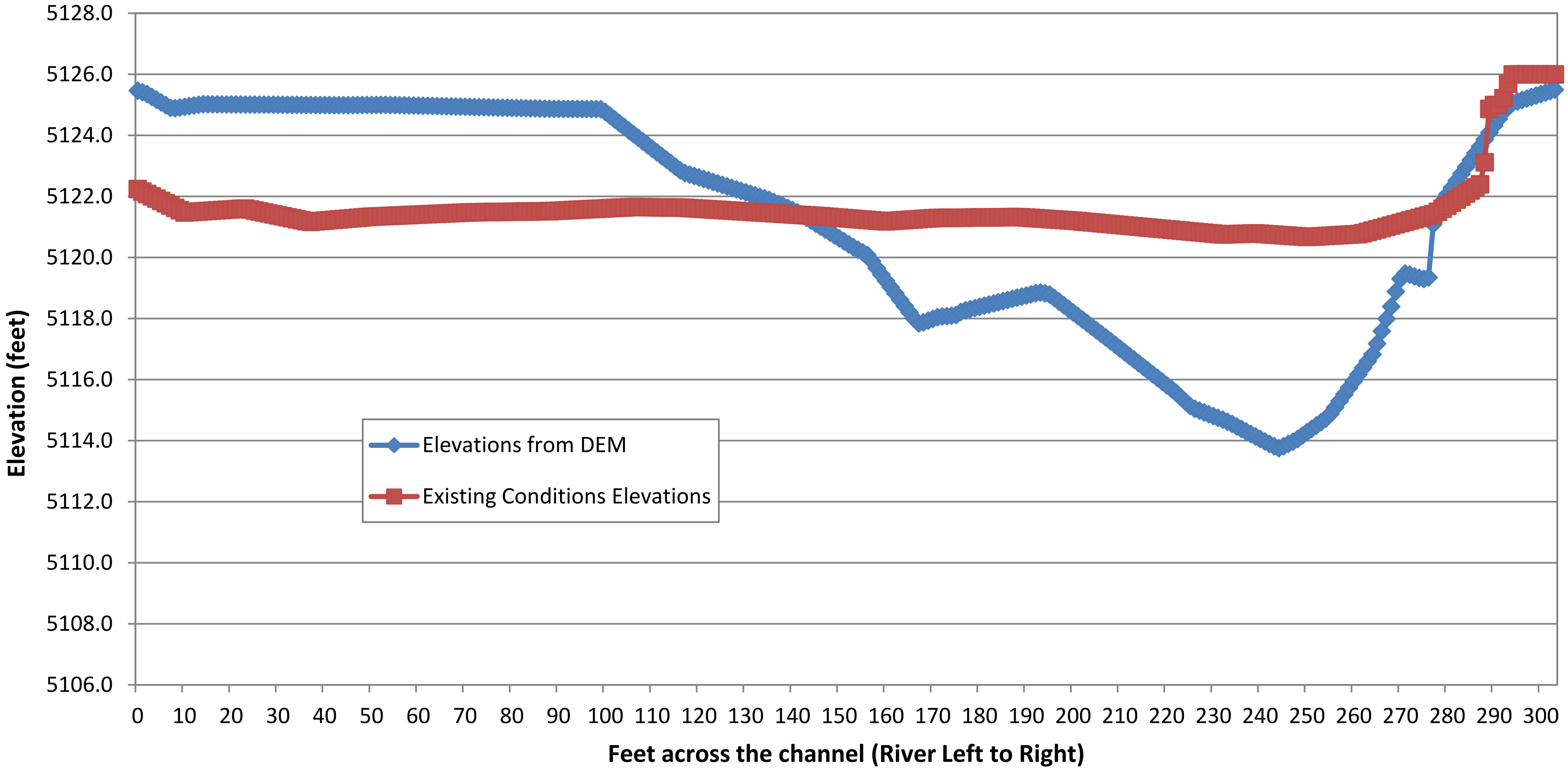

Figure B2. Profile of cross-section 1 (pool) collected in October 2016. No data were taken by WGFD in the field at this site; these data were extracted from the pre-existing conditions and digital elevation model (DEM) of the final as-built topographic survey maps of the river bed.

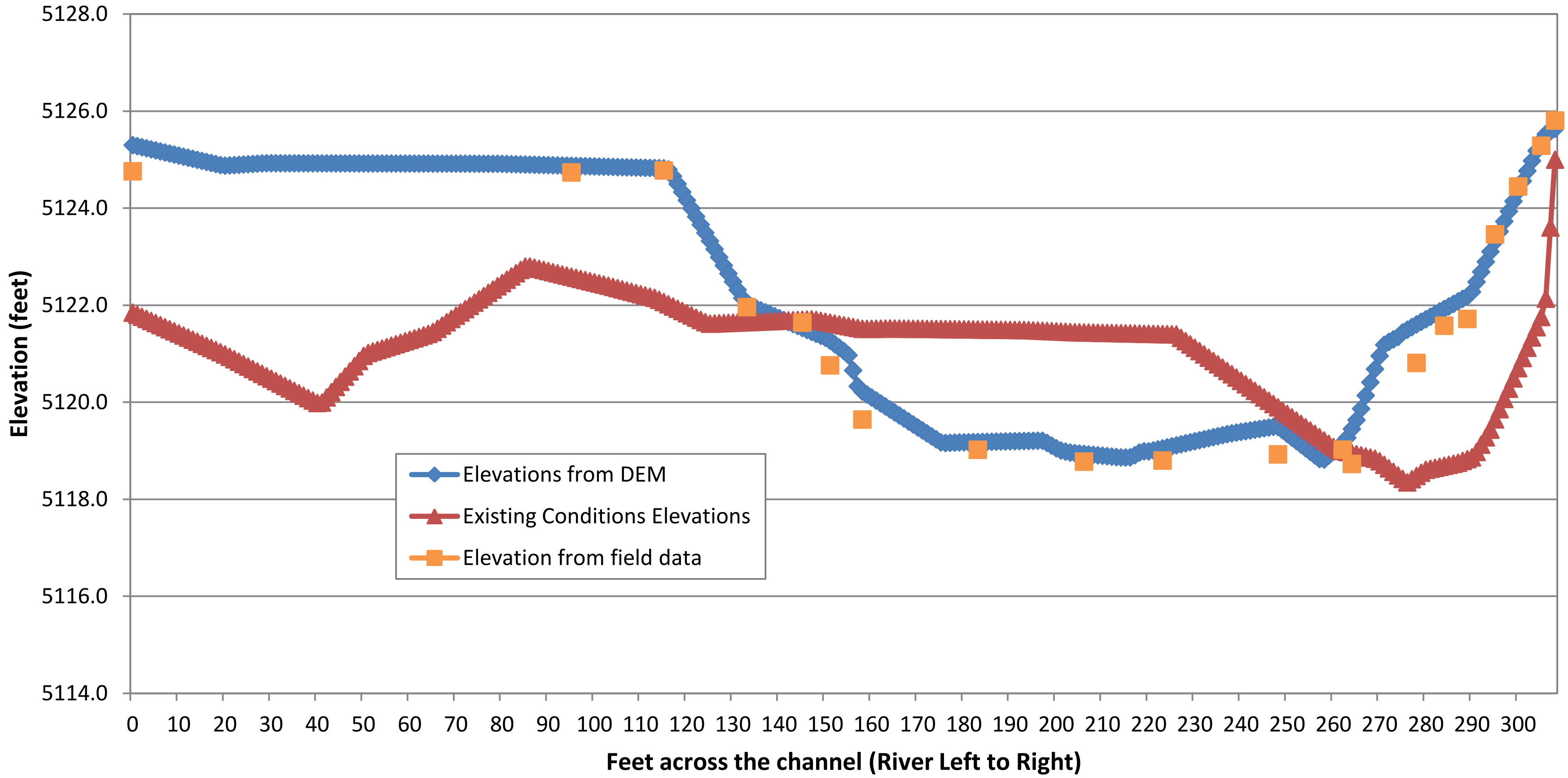

Figure B3. Profile of cross-section 2 (riffle) collected in October 2016. In addition to field data collected by WGFD, data were extracted from the pre-existing conditions and digital elevation model (DEM) of the final as-built topographic survey maps of the river bed.

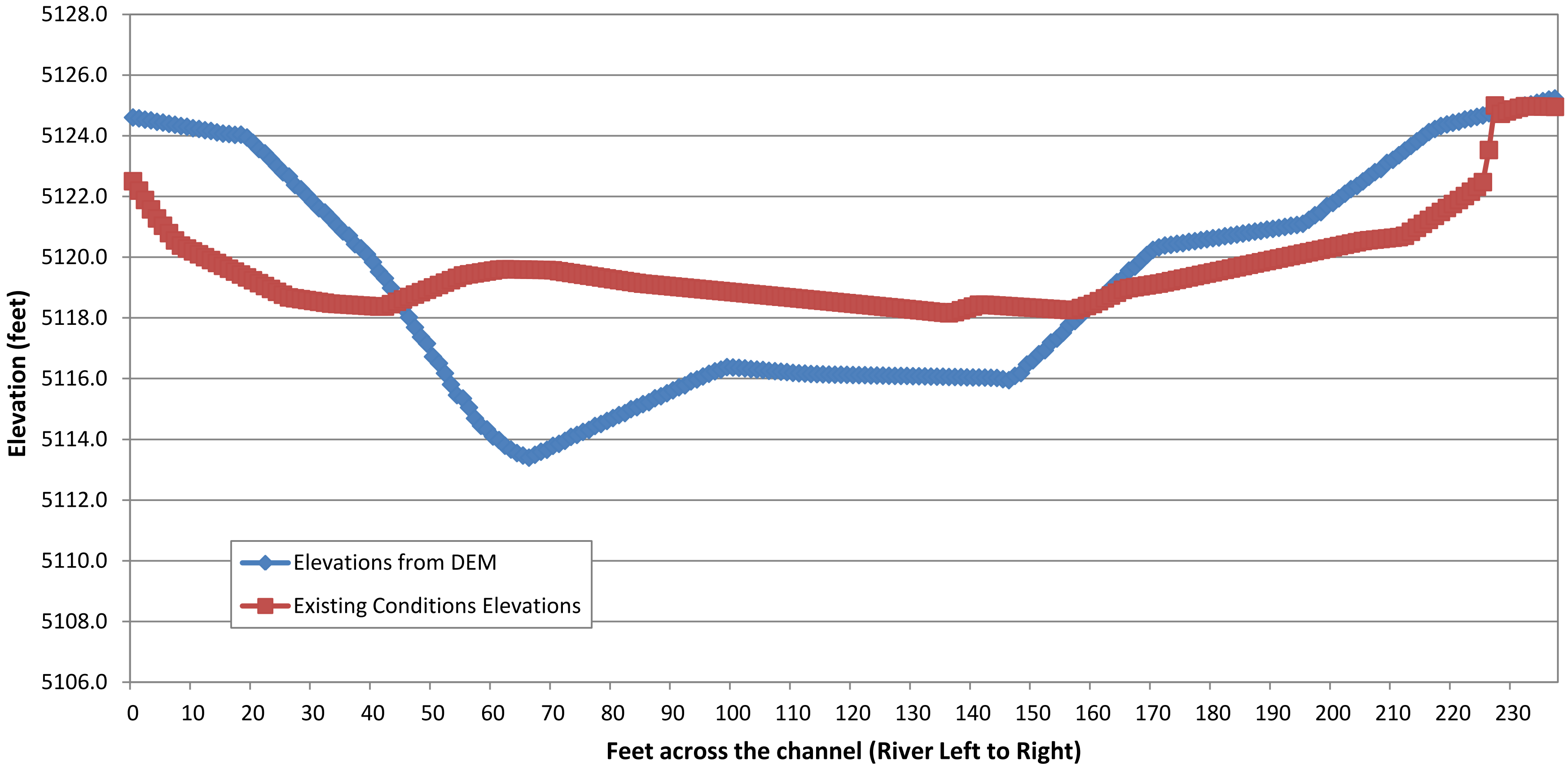

Figure B4. Profile of cross-section 3 (pool) collected in October 2016. No data were taken by WGFD in the field at this site; these data were extracted from the pre-existing conditions and digital elevation model (DEM) of the final as-built topographic survey maps of the river bed.

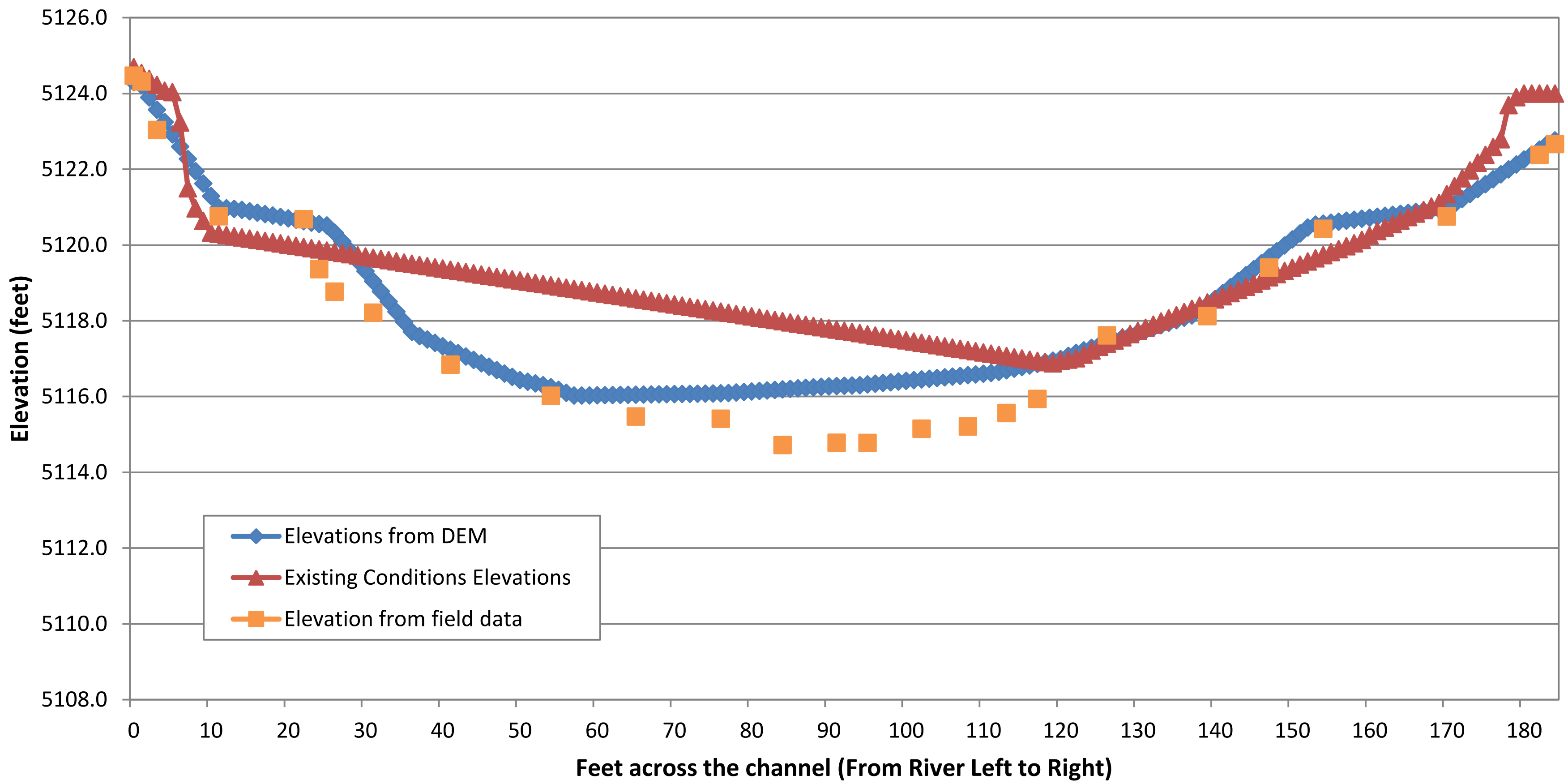

Figure B5. Profile of cross-section 4 (riffle) collected in October 2016. Field data collected by WGFD were deeper in the center of the channel than the topographic survey results of the river bed. In addition, data were extracted from the pre-existing conditions and digital elevation model (DEM) of the final as-built topographic survey maps of the river bed.