INVENTORY AND ASSESSMENT OF POINDEXTER SLOUGH IN THE BEAVERHEAD RIVER DRAINAGE NEAR DILLON, MONTANA

Prepared For:
Mr. Matt Jaeger
Montana Fish, Wildlife and Parks
Dillon, Montana 59725

Prepared By:
Environmental Sciences Department
The University of Montana Western
Dillon, Montana 59725

Submitted:
October 18, 2017

Environmental Sciences Department

Attention: Mr. Matt Jaeger
Montana Fish, Wildlife and Parks
Dillon, Montana 59725

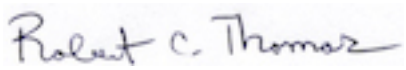
Subject: Inventory and Assessment
Poindexter Slough
Dillon, Montana

Mr. Jaeger,

In accordance with your authorization, the Environmental Field Studies students at the University of Montana Western conducted a post-restoration inventory and assessment of the entire length of Poindexter Slough over the period of 9/25/17 to 10/18/17.

The accompanying report presents our data, analyses and recommendations regarding stream morphology, in-stream macroinvertebrates, riparian vegetation and stream habitat on Poindexter Slough. If you have questions, contact my office at your convenience.

Cordially,



Robert C. Thomas, Ph.D.
Principal Geologist
Environmental Sciences Department
The University of Montana Western
Dillon, Montana 59725
rob.thomas@umwestern.edu

Staff Scientists:

Nathan Matteson	Adam Jensen	Megan Tarmichael
Cory Martinez	Mariah Jones	Trepper Osburn

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EXECUTIVE SUMMARY

From 9/25/17 through 10/18/17, six students in the Environmental Field Studies class at the University of Montana Western (UMW) in Dillon, Montana conducted a post restoration inventory and assessment of stream morphology, in-stream macroinvertebrates, and stream habitat (including a vegetation survey) over the 4.73-mile length of Poindexter Slough, located 3.0 miles south of Dillon, MT (Figure 1).

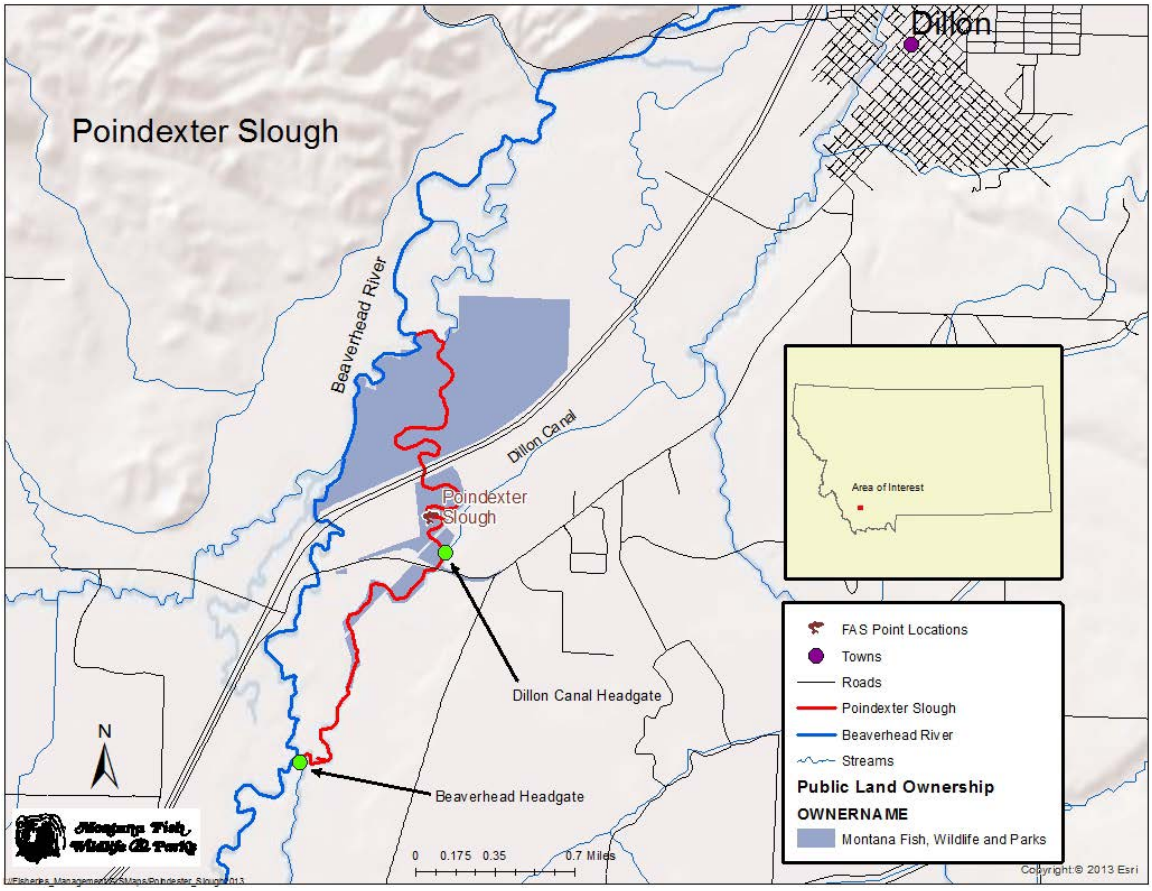


Figure 1. Location map of Poindexter Slough (Jaeger and Flowers, 2014).

Poindexter Slough is a low-gradient side channel, likely a former channel of the Beaverhead River, fed primarily by the diversion of water from the Beaverhead River through a head gate located at the headwaters of the slough. The slough loses approximately 35 ft^3s^{-1} to irrigation demands and up to 60 ft^3s^{-1} from diversion into the

Dillon Canal during peak irrigation season. An upgrade to the diversion gate was installed in 2016; this upgrade was intended to reduce the sediment input from the Beaverhead River.

The purpose of the UMW study was to gather comparative data to assess the riparian restoration and fish habitat improvement project completed in 2015 by Montana Fish, Wildlife and Parks and The Beaverhead Watershed Committee. The data collected in 2017 were compared to pre restoration (2014) and post restoration (2015 and 2016) data to provide recommendations for management. The data were collected, analyzed and synthesized into this report by six students from the University of Montana Western and supervised by Dr. Robert C. Thomas, professor of geology in the Environmental Sciences Department. The report is available at https://umwestern.academia.edu/RobThomas or upon request via email to rob.thomas@umwestern.edu.

The 2018 Poindexter Slough study consisted of a total of 10 cross-sections placed on riffle/pool pairs at five locations. Due to access constraints and a limited workforce, the cross sections chosen only included sites 4, 5, 6, 8 and 10 as labeled in reports from preious studies (Figure 2). The riffle cross sections are labeled with an "a" and the pool cross sections are labeled with a "b" throughout the report (e.g., 4a = riffle, 4b = pool). The original cross sections were chosen in consultation with Mr. Matt Jaeger at Montana Fish, Wildlife and Parks to achieve a good assessment change on the Poindexter Slough. The cross sections at the riffle-pool pairs (looking downstream) were temporarily marked with wooden stakes (removed due to recreational use of this area) and permanently recorded with GPS units for relocation of the cross sections for future assessment (**GPS Datum = NAD 83, position formats: hddd°mm'ss.s"**).

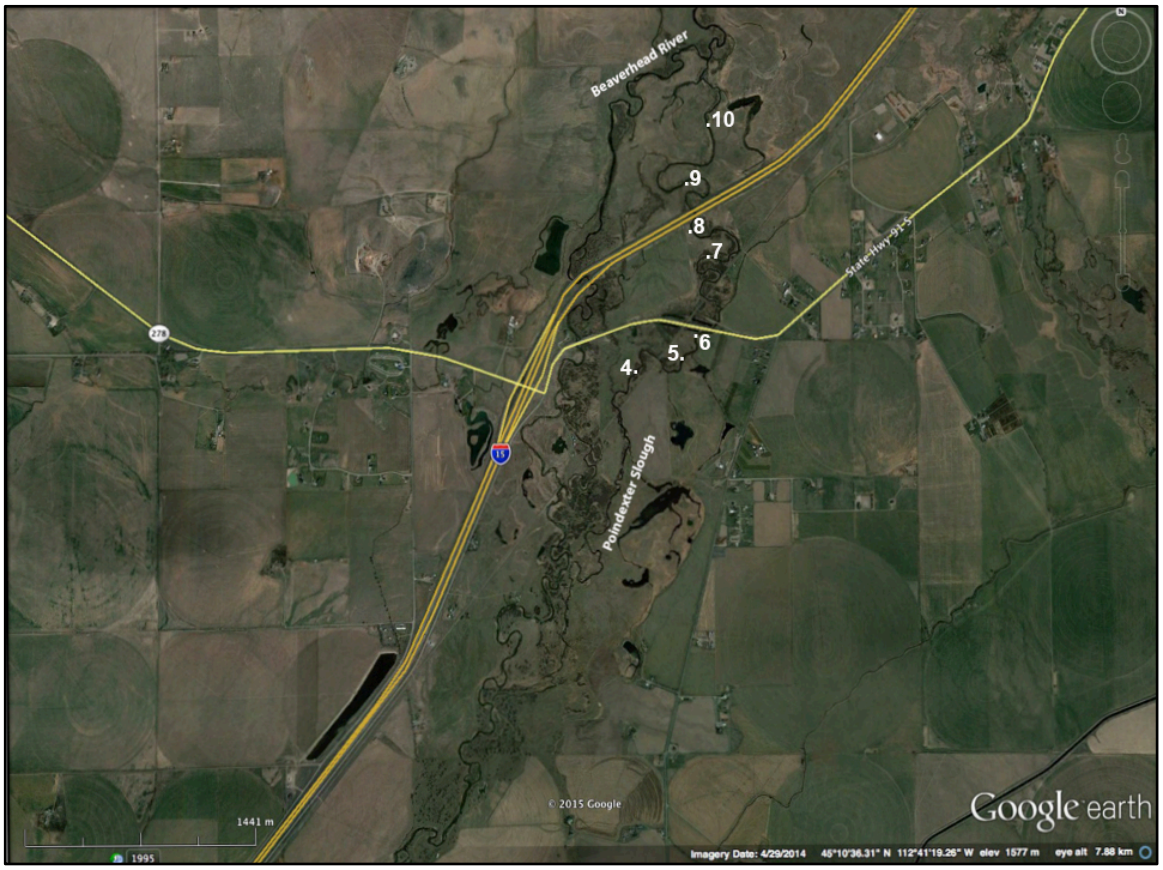


Figure 2. Cross section locations for 2018 (Jaeger and Flowers, 2014).

The restoration work included replacement of the irrigation infrastructure, mechanically removing fine-grained sediment from the channel, modifying channel dimensions and transplanting riparian vegetation (Jaeger & Flowers, 2014). The restoration of Poindexter's Slough took place over two years; in spring 2015, the upper portion of the site was restored. In the spring of 2016 the restoration of the system was completed. As of the 2017 study, the whole system has been restored.

An important component of the restoration project is the incorporation of "flushing flows" to provide adequate sediment transport in the slough. The proposal from Confluence Consulting (2014) calls for a flushing flow of 200 ft^3s^{-1} every two to five years. These flushing flows mimic natural peak flows, which are necessary to prevent fine-

grained sediment accumulation. In order to produce a flushing flow and meet irrigation demands, discharge on the Beaverhead River needs to be approximately 530 ft^3s^{-1} at the Poindexter Slough head gate. Since discharge in the Beaverhead River can be unpredictable, flushing flows will only be done when a combination of Clark Canyon dam releases, East Bench Irrigation withdraws, and groundwater inputs provide the necessary discharge of 530 ft^3s^{-1} at the Poindexter Slough head gate. Because these conditions have not yet been met, a flushing flow has not yet been carried out (as of 09/25/2017).

Poindexter Slough was functioning as an A4 stream, as of 2014, using Rosgen's stream classification system (Rosgen, 1996). Given the gradient of Poindexter Slough, Confluence Consulting advised prior to the restoration that it should be functioning as a C4 stream, with greater asymmetry, sinuosity and less fine-grained sediment load. Based on our data from 2017, this is now the case. The width-to-depth ratios were far too large for the relatively low flows in 2014, which vary along the length of the slough from about 40 to 80 cfs (Confluence Consulting, 2014). This has now changed, with the appropriate width-to-depth ratio for a C4 stream. A "C" stream is a riffle/pool stream with a well-developed floodplain, meander, and point bars. "C" streams have a width/depth ratio greater than 12 and are moderately entrenched (Harman and Jennings, 2016).

At the time of the 2014 assessment, fine-grained sediments were a concern. We assume that most of this fine-grained sediment was removed during the restoration work, so the fine-grained sediment load documented in 2017 is likely new and from the headgate on the Beaverhead River. Since this headgate opens from the bottom, it is likely allowing bedload sediment transport into Poindexter Slough. Much of the fine-grained sediment load documented in 2017 is in the fine-grained sand fraction and is moving as

bedload as shown by bedforms like asymmetrical ripples (Figure 3). The fine-grained sediment load is concentrated primarily on point bars due to helical flow, which is depositing the finest-grained sediment fraction on the low-velocity (low boundary shear stress) point bars (Figure 4). Silt and clay-sized particles are also accumulating on point bars, resulting in anoxia and sulphate-reducing bacteria, as shown by the sulphurous or "rotten egg" odor on all of these point bars. The fine-grained sediments seem to be an optimal environment for the growth of very dense aquatic vegetation, which was an issue prior to the restoration work. The density of this vegetation and its growth right to the water surface makes fishing difficult, so its expansion should be monitored going forward (Figure 5).

Figure 3. Fine-grained sand on a point bar in Poindexter Slough.

Figure 4. Muddy point bar deposition with aquatic vegetative growth.

Figure 5. Vegetative growth on point bar mud.

The infaunal and epifaunal macroinvertebrate data were collected to assess the quantity and diversity associated with gravel and mud. In past years, assessment focused on riffles, runs, pools and glides, but since the data were not showing trends, the team decided to focus on the impacts of increasing fine-grained sediment load on macroinvertebrates. The data show that total umbers of individuals are larger in mud, probably due to vegetation, but the diversity is poor. Diversity is high in gravel substrates, with consistent numbers of individuals. Future work should continue to monitor the macroinvertebrates associated with the mud substrates, since the absence of diversity may negatively impact food resources for trout.

Riparian vegetation remains abundant and diverse along Poindexter Slough, however we did not conduct a systematic evaluation of plant species this year due to an inadequate workforce. The team did assess the percentage of willow, grass and bare ground in the Stream Habitat Survey, which showed that there is very limited bare ground and the banks are nearly covered with grasses. Thistle remains an issue on the site, but the percentage was not systematically determined (Figure 6).

Figure 6. Thistle growth on a disturbed cutbank surface.

The Stream Habitat Survey shows that the restoration work did an excellent job of producing a functioning stream with recognizable riffles, runs, pools and glides. Overall, the riffles have increased in length and the pools have shortened and deepened. These changes are in the best interest of Brown trout (*Salmo trutta*), which are the most abundant trout species and the most important for recreational fishing in the slough. We remain concerned about the growth of point bars due to accumulation of anoxic mud. These environments are growing, and are likely not beneficial to Brown trout. We are monitoring the growth of a mud point bar at cross section site 6B going forward to see what will be the impact of accretion so mud on point bars. We predict the stream will narrow, because the stable cut banks are not likely to erode due to the low velocity of the flows and the absence of flooding on this controlled system.

RECOMMENDATIONS

Based on the data collected and analyzed by The University of Montana Western team in 2017, and after comparing those data to the baseline study and subsequent analyses, we have prioritized the following management recommendations. The primary concern is the continued influx of fine-grained sediment from the Beaverhead River. This sediment is primarily in the sand-sized fraction, so is moving as bed load and may not be possible to remove with the proposed flushing flows. We plan to have a future class do sediment transport calculations to test this model. In addition, these sediments are accumulating on point bars, narrowing the channel and providing a substrate for growing thick, aquatic vegetation. The accumulation of silt and clay is causing anoxia, so the macro invertebrates in these point-bar "muds" show very low diversity. Ultimately, we believe the sediment source must be controlled. Since this can't be done on the Beaverhead River

system itself, we highly recommend that this issue be resolved from the head gate and downstream on Poindexter Slough. In addition, we think that an interpretive sign should be placed in the main parking lot to inform the public about the work being done and the importance of long-term assessment of the restoration to make adjustments at a point when problems are easier and less expensive to resolve. So, in order to resolve the fine-grained sediment issue, we recommend the following five actions be considered:

1. To prevent the bed load fraction from entering Poindexter Slough, the head gate should be replaced with one that releases water from the top.
2. Build low-velocity sediment traps near the head gate to trap silt and clay fraction before it can settle in the Slough.
3. Encourage beavers and muskrats, because they are naturally making low-velocity sediment traps along the length of Poindexter Slough.
4. Monitor the suspended and bed load sediment transport during the spring at each end of the Slough in order to determine what percentage is getting trapped.
5. Consider flushing Poindexter Slough when the Beaverhead River has a low sediment load, and reduce inflows during times when it is carrying high sediment loads.

PROJECT BACKGROUND

An inventory and assessment of Poindexter Slough, a former channel of the Beaverhead River located approximately 3.0 miles south of Dillon, MT, was conducted by the Environmental Field Studies class at the University of Montana Western (UMW) from 9/22/14 through 10/15/14. Sixteen students conducted a baseline inventory and assessment of the stream morphology, in-stream macro invertebrates, riparian vegetation and stream habitat over the 4.73-mile length of the slough. This was a primary investigation to assess current conditions prior to a restoration project on this stream. According to Montana Fish, Wildlife and Parks, restoration efforts began on Poindexter Slough starting in the winter and spring months of 2014 and 2015.

The Poindexter Slough restoration project was aimed at improving "water quantity, habitat quality, sediment transport, and the fishery" throughout the length of the slough. According to the Flow Management Plan prepared by Confluence Consulting, Bozeman, Montana, the project will restore and protect the stream and riparian corridor, with the emphasis on expanding fishery benefits (Confluence Consulting, 2014). The proposed work included replacing existing irrigation infrastructure, modifying channel dimensions, conducting flushing flows to remove sediment, and planting riparian vegetation to improve fisheries habitat and restore the natural processes that maintain these habitats (Jaeger and Flowers, 2014).

Poindexter Slough is a low-gradient stream that is fed through a combination of groundwater and water diverted from the Beaverhead River through a head gate located at the headwaters of the slough. Up to 60 cfs of the water is diverted out of Poindexter

Slough during the peak irrigation season into the Dillon Canal, with typical irrigation demands amounting to approximately 35 cfs.

An important component of the restoration project is the incorporation of "flushing flows" to provide adequate sediment transport in the slough. The proposal from Confluence Consulting (2014) calls for a flushing flow of 200 cfs every two to five years. In order to produce a flushing flow and meet irrigation demands, discharge on the Beaverhead River needs to be approximately 530 cfs at the Poindexter Slough head gate. Since discharge in the Beaverhead River can be unpredictable, flushing flows will only be done when a combination of Clark Canyon dam releases, East Bench Irrigation withdraws, and groundwater inputs provide the necessary discharge of 530 cfs at the Poindexter Slough head gate (Confluence Consulting, 2014).

An "adaptive management plan" has been developed to monitor discharges and resulting changes to the stream channel. The plan calls for (1) installing staff gages, (2) measuring the influence of groundwater/surface water inputs to Poindexter Slough, (3) optimizing aquatic habitat during base flows, and monitoring channel responses following the flushing flows (Confluence Consulting, 2014).

The University of Montana Western will supply for long term studies of Poindexter Slough. Starting in 2014 with a prerestoration assessment, in 2015 with a mid-restoration assessment, in 2016 a short-term post restoration assessment was performed, and in 2017 a secondary post restoration assessment was made. A total of ten stream cross-sections were studied along the length of Poindexter Slough (Figures 7-12). At each cross section, the assessments included surveys of: (1) stream morphology, (2) macroinvertibrates in gravels and fine-sediments, (3) stream habitats. The working group

consisted of Adam Jensen, Mariah Jones, Cory Martinez, Nathan Matteson, Trepper Osburn and Megan Tarmichael. Dr. Robert C. Thomas, Professor of Geology and Regents' Professor in the Environmental Sciences Department at the University of Montana Western in Dillon, Montana, supervised the project.

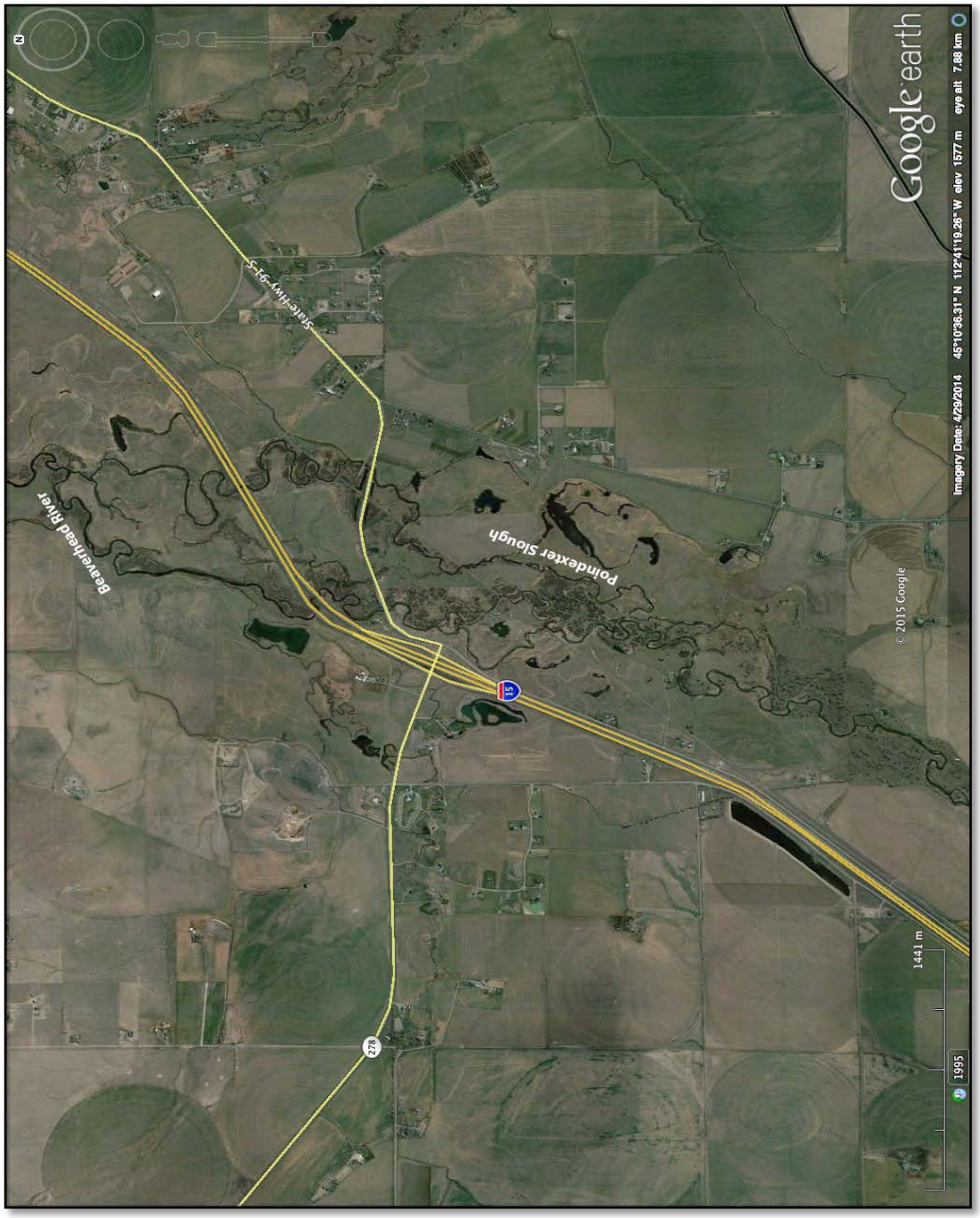
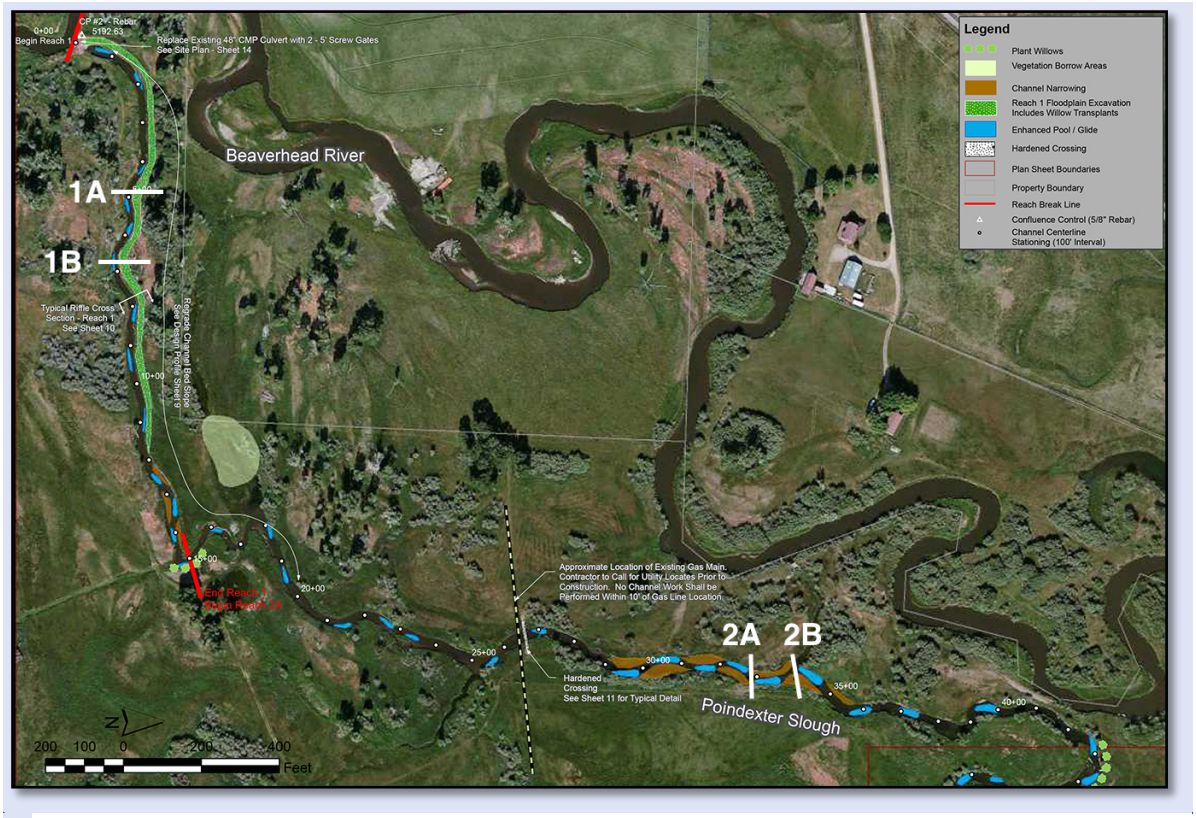


Figure 7. Location map showing Poindexter Slough and the Beaverhead River (Google Earth, 2015).



[1]Figure 8. Location of cross sections 1A, 1B, 2A, and 2B, and restoration applications.

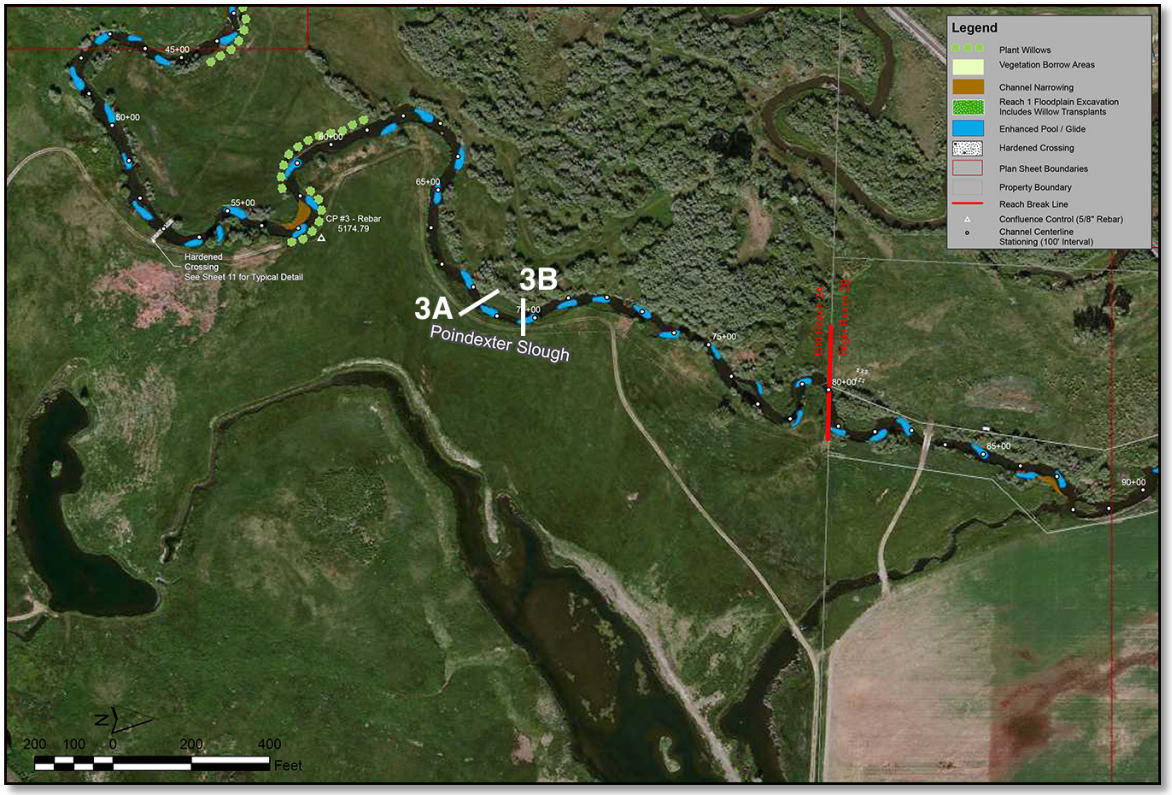


Figure 9. Location of cross sections 3A and 3B, and restoration applications.

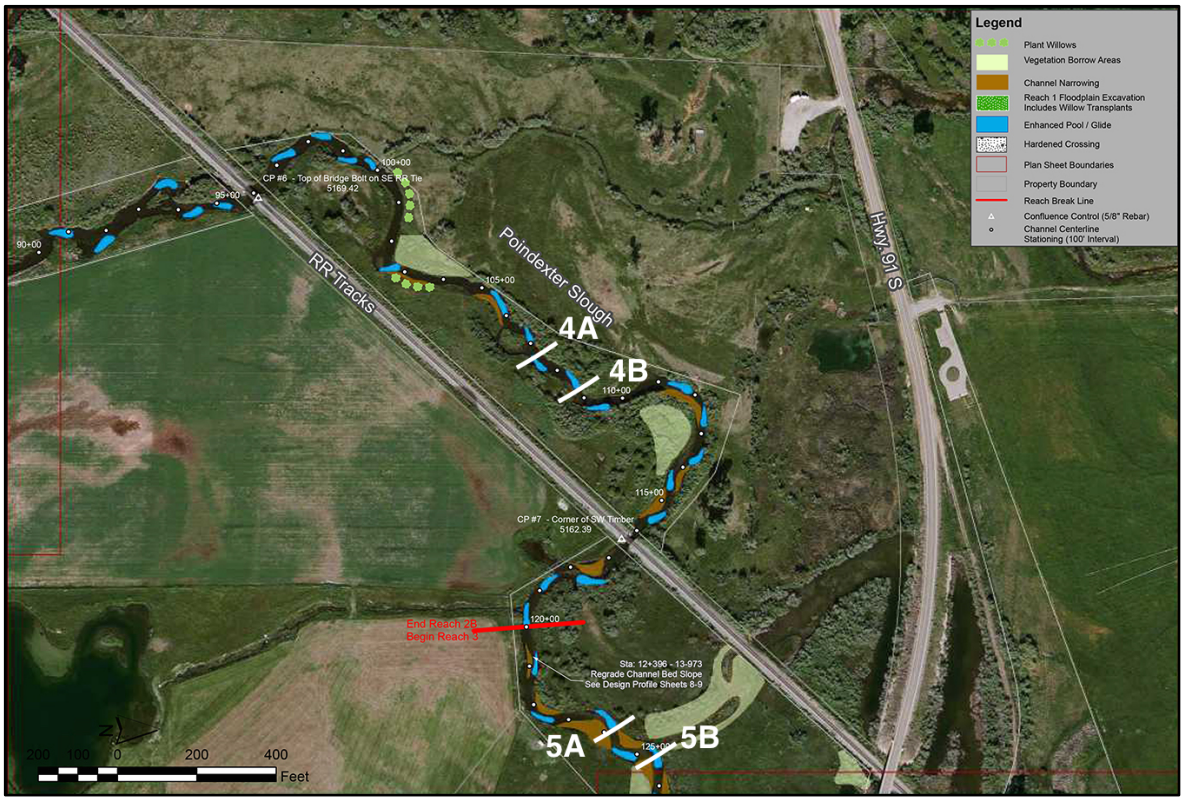


Figure 10. Location of cross sections 4A, 4B, 5A and 5B, and restoration applications.

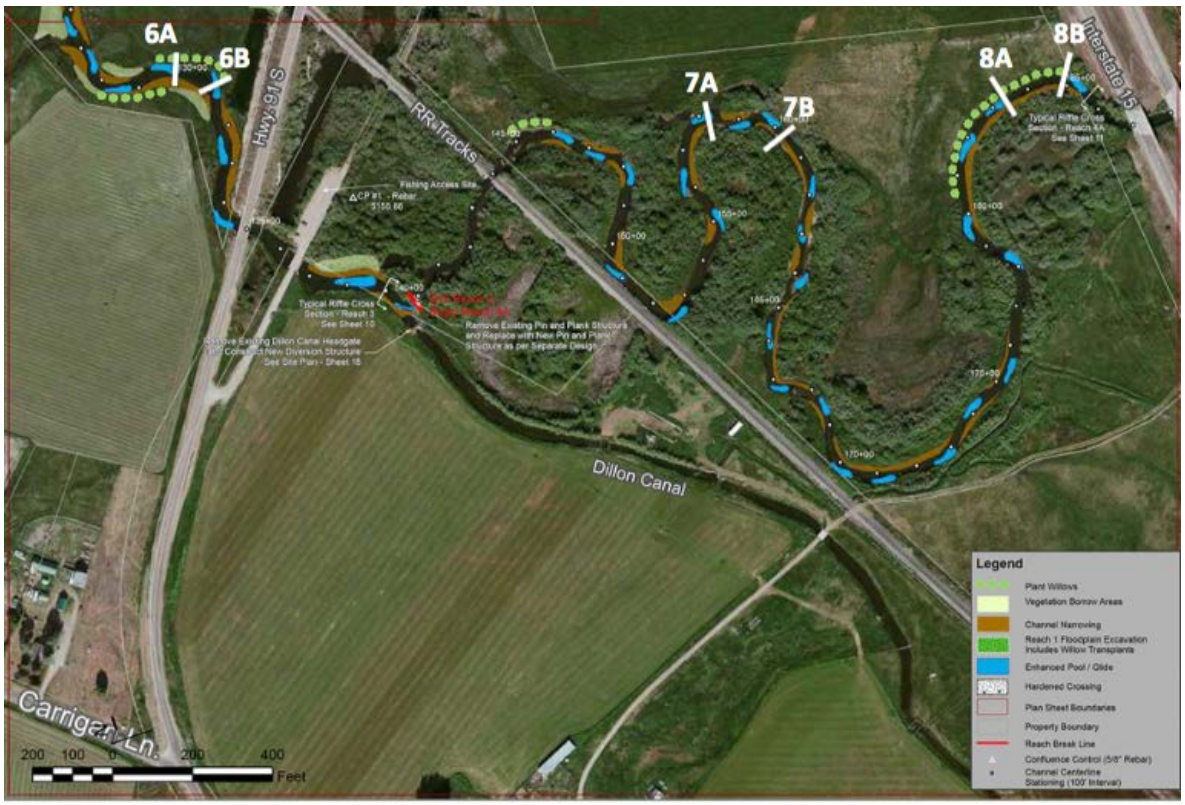


Figure 11. Location of cross section 6A, 6B, 7A, 7B, 8A, and 8B, and restoration applications.

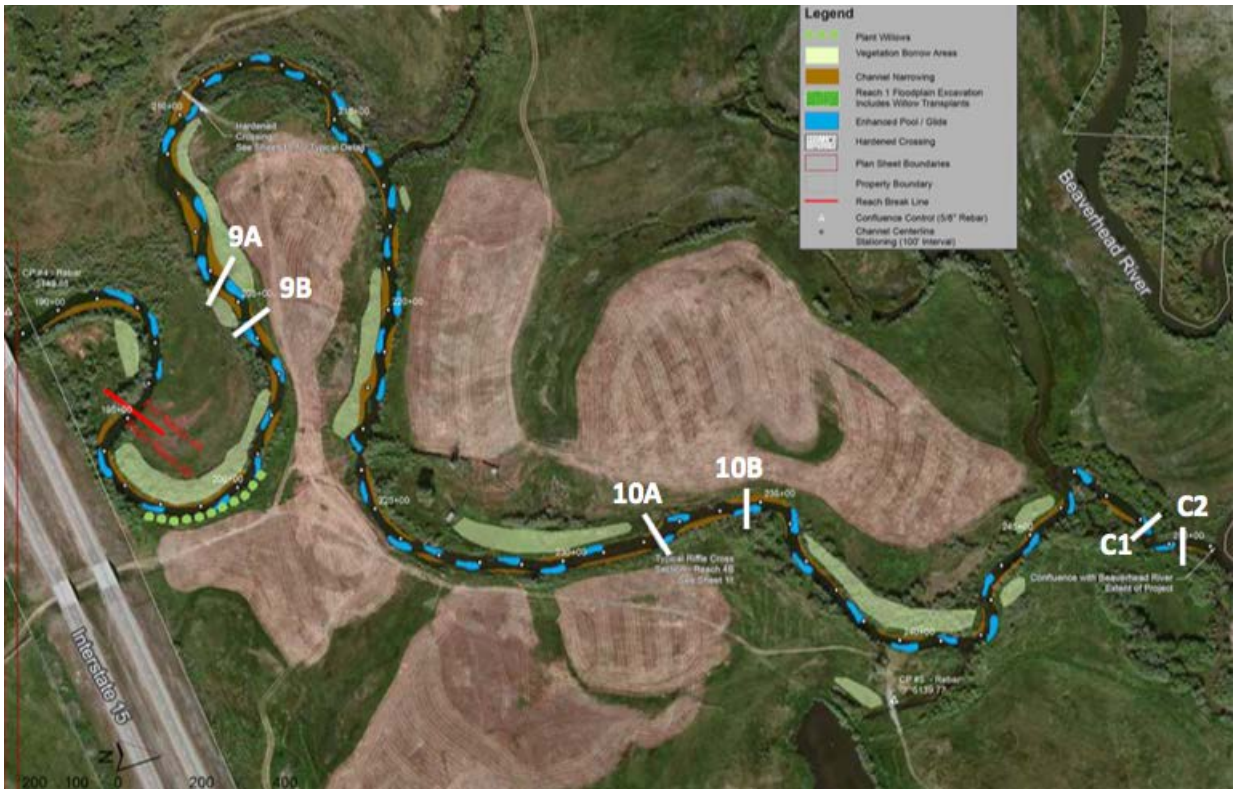


Figure 12. Location of cross section 9A, 9B, 10A, 10B, C1 and C2, and restoration applications.

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STREAM MORPHOLOGY SURVEY

INTRODUCTION

Morphology monitoring consisted of surveying the cross sections and gather stream data at the cross sections of the riffles and pools. There are five monitoring sites each with one riffle and one pool. The riffles were always located upstream of the pool. The data collected was Bank Erosion Hazard Index (BEHI), pebble count, cross section profile, sinuosity, a fine grain to coarse grain ratio and water surface gradient. Monitoring data collected will help FWP determine how well the stream is functioning since the restoration. Stream morphology is critical for determining the function of a stream system and plays a critical role in the success of spawning Brown Trout in Poindexter Slough. The system has been altered by the sediment load from the Beaverhead River and nutrient input from surrounding agriculture. This is the third year that the University of Montana Western's Environmental Field Studies class has helped the FWP with this project.

STREAM MORPHOLOGY

Stream morphology is critical for determining the function of a stream system and plays a critical role in the success of spawning brown trout in the Poindexter Slough. Optimal conditions for brown trout include several factors, involving asymmetric stream morphology, overhanging vegetation and associated water temperature and minimal fine sediment in riffles/spawning area. Since brown trout are localized spawners, they need riffles dominated by gravel and sand to successfully reproduce in the area in which they build spawning redds. Brown trout females use their tails to displace gravel and

vegetation covered rocks to create an indentation in the streambed in which they deposit their eggs. After the eggs have been deposited the male brown trout will compete to fertilize the eggs within the redd. After fertilization the trout will physically cover the redd with gravel to protect the young till hatching. During incubation it is imperative that the redd does not become covered with sediment so the eggs have plenty of oxygen. Since the restoration, there are increased areas of gravels in riffles for brown trout spawning.

Bank stability at Poindexter is sufficient due to the large amount of vegetation and lack of grazing. Banks consist of a thin A horizon resting on a thick layer of cobbles and glacial outwash. A pebble count was conducted at each cross section, collecting forty random pebble samples per cross section. Much of the A horizon is stabilized by vegetation. Large bars of vegetated sediment exist within the stream. These were likely caused by sediment input from the Beaverhead, as Poindexter does not posses a thick enough A horizon to have been able to produce such large amounts of in stream sediment.

A single water surface gradient was determined for each of the five sites, as well as the control. The water surface gradient was measured using the transit and a measuring rod. Points were 100 feet from either side of the first cross-section line and measured from the water's surface. Downstream was then subtracted from the upstream measurement to give the difference. The percentage of slope was computed by multiplying the ratio by 100.

Sinuosity was calculated by establishing the number of paces a person has per 50 feet. Measurements started at the first cross section, walking the entire reach of the site to approximately 500 from the last cross section following the deepest part, or thalweg, of the stream. A straight line was walked from the end point back to the starting point on the

bank. The straight-line distance is the denominator for the ratio of sinuosity, for example 500/250 (straight line distance after 500 feet). This sinuosity value is always above 1, as 1 indicates a reach that has no sinuosity and is perfectly straight.

FIELD METHODS

Stream Morphology Field Methods Quick Guide (Field Sheets in Appendix A)

Cross Section Survey

- Tools needed
  - Topcon Green Label Auto Level AT-G6 Transit
  - Keson 330 foot measuring tape
  - Measuremark F/G Stadia Rod graduated in 10ths of feet
  - Inclinometer
- Stretch measuring tape perpendicular to stream from river left (RL) to river right (RR). Attach one stake on each bank about 5 meters back from each bank
- River right and left are determined by standing in the creek and facing downstream. Your left side is river left and your right side is river right
- Record height of transit
- Begin measuring from RL stake and end at RR stake
- Measure at one foot increments along the tape to build a stream profile, can use smaller or larger increments if necessary to build an accurate profile of the stream
- Record start, end, bankfull, and wetted edge for both right and left sides

BEHI- 6 measurements per cross section- 3 on left bank, 3 on right bank

- Tools needed
  - Measuremark F/G Stadia Rod graduated in 10ths
  - Inclinometer
  - Refer to Figure 13 for variables
- Choose locations 10 ft. upstream, 10 ft. downstream, and at cross section
- Bank full height (feet)
  - Bankfull is defined as the maximum water level the banks in your cross section can contain before the water overflows onto the floodplain
  - Bankfull is measured by placing the stadia rod at the point on your cross section that is the maximum amount of water the bank can contain.
- Root depth measurement (feet)
  - Use stadia rod to determine root depth from ground level to where roots first appear
- Root density (%)
  - Look at exposed bank and determine what percentage visible is root mass
  - If no exposed bank then an estimation of the root density of the undercut bank is made
- Bank angle (°)
  - Bank angle is measured using the inclinometer.
  - An undercut bank is measured as an angle less than 90°
  - A bank which is laid back will have an angle greater than 90°

- Surface protection (%)
  - Visual observation made of ground cover vegetation
  - If bank is completely covered then 100%; if bare then 0%
  - Estimate in between coverage %

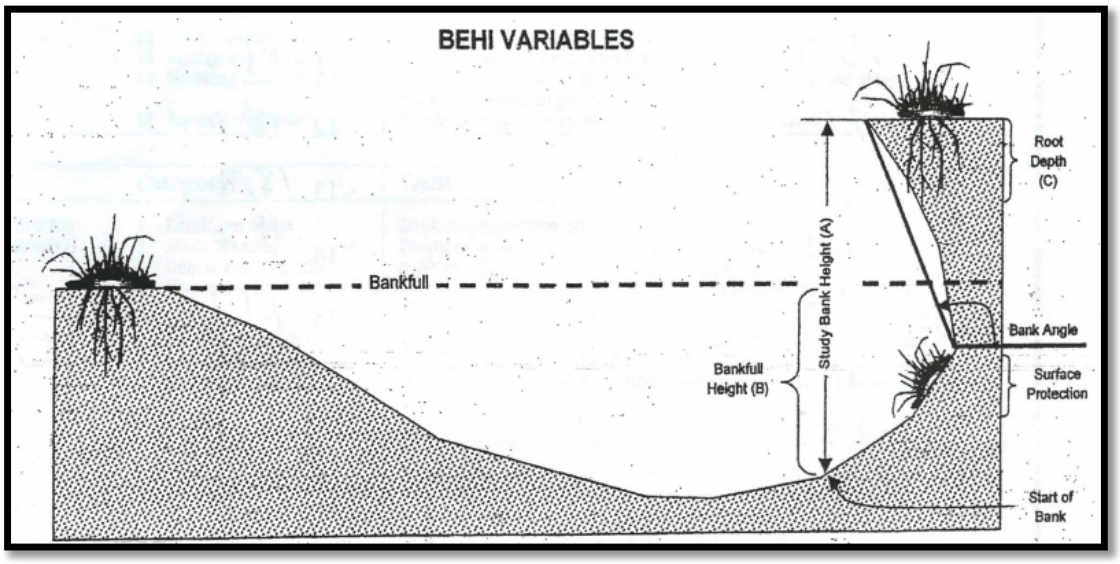


Figure 13. BEHI variables (Google Images, 2017). Note that the dotted line indicates bankfull height rather than water level.

Sinuosity-Measure once for entire reach

- Establish an individual's pace count per 50 feet
- Choose starting point
- Walk 500 feet along the deepest part of the stream
- Turn around- return to starting point along a straight line. Use following calculation to determine sinuosity: sinuosity= 500 ft/straight line distance (ft)

Width/Depth Ratio- Measure once for entire reach

- Tools needed
  - Keson 330 foot measuring tape
  - Measuremark F/G Stadia Rod graduated in 10ths
- Measure width of stream from bankfull to bankfull at 10 foot intervals for a total of 10 measurements
- Measure depth by recording three water depths across the channel at each 10 foot interval. These will be averaged.

Pebble Count- 40 Pebbles Sampled per Cross Section

- Tools needed
  - Wildlife Supply Company Part #: 14-D40 Pebble Grid
- Measure pebbles at four transects per cross section, 2 transects upstream and 2 transects downstream at 10 ft intervals
- Sample ten pebbles equally spaced from each other in a line perpendicular to the stream flow
- Choose pebble by the first that is touched by the index finger
- Measure size using pebble grid
- Record using a tally sheet (this makes calculating your percentages at the end easier)

Water Surface Gradient- Measure once for entire reach

- Tools needed
  - Topcon Green Label Auto Level AT-G6 Transit
  - Keson 330 foot measuring tape
  - Measuremark F/G Stadia Rod graduated in 10ths
- Measure two points- one 100 feet upstream of the cross section, and one 100 feet downstream of cross section
- Subtract downstream from upstream and divide by 200 ft. (Down-Up)/200 for gradient ratio. Multiply by 100 for percentage.

Fine/ Course grain sediments:

- Tools needed
  - Keson 330 foot measuring tape
- Measure two points- one 100 feet upstream of the cross section, and one 100 feet downstream of cross section
- Walk in stream on both the left and right side of the stream from 100 feet downstream to 100 feet upstream in a zig zag pattern.
- Estimate fine mud sediment to course sediment relationship every 10 feet along the 200-foot reach.
- Average percentages to get an overall fine/ course sediment in the 200-foot reach.

Point Bar Area Mesurement

- Tools needed
  - Kensen 330 foot measuring tape
- Measure maximum length from the bank to furthest point reached by point bar (height)
- Measure distance along bank for length of point bar at the base. (length)
- Using the height and length calculate the area using triangle method, (½ base x height)

METHODS

For a field guide with step-by-step instructions please refer to the Field Methods Quick Guide (Field Methods). Field methods are adapted from Rosgen's Stream Classification System and Fish, Wildlife, and Parks Protocol. Additional tools include field data collection sheets and BEHI Rating Sheet (See Appendix A). All measurements referenced as river left and river right are based on a downstream direction.

The cross-section surveys were conducted using a Topcon Green Label Auto Level AT-G6 Transit, a Keson 330 foot measuring tape and a Measuremark F/G measuring rod graduated in 10ths. At each cross section, the measuring tape was stretched perpendicular to the stream current from river left to river right. The tape is attached to a wooden stake in the ground on each sides of the stream approximately five meters from the stream bank to accommodate the vegetation survey. The stake was located by GPS in latitude and longitude with the map datum NAD 83 Conus on both river left and river right to mark the cross-section locations for future work on this project (see cross sections in this chapter for GPS location data). A transit measurement is used to measure the increments across the stream and is valuable for data processing. The height of the transit is recorded when taking increment measurements from river left to river right. The transit height should be recorded at this time by holding the stadia rod next to the tripod at the cross hairs of the level. This height provides a level basis across the stream profile and gives the true reading of the elevation.

Figure 14. UMW students conducting a cross section of Poindexter Slough.

The channel profile was determined by plotting the lineal position of the tape against the vertical position of the measuring rod in one-foot increments or in relative topographic changes. The cross section should capture measurements from floodplain to floodplain across the stream with streambed and bank measurements to capture the profile of the cross section. In addition, other topographic features such as the position of bank full, bank edge and water surface level closest to each bank were recorded. Bank full is described as the height of the water when the channel is full before flooding. The stadia rod is placed at this location and recorded as bank full. Bank height is determined by measuring from the bottom of the streambed directly next to the bank and reading the stadia rod measurement. Water height is measured from the water's surface by holding the stadia rod at the water's surface and recording the height. The stream cross sections were generated using the "Bevenger's Spread Sheet," an Excel document.

Bank Stability (BEHI) was rated by taking measurements at six locations, three on the left side and three on the right side at each cross section. These locations are determined with measurements ten feet upstream of the cross section, at the cross section, and ten feet downstream of the cross section. The measurements recorded to evaluate BEHI include; bank full height (feet), bank height (feet), root depth (feet), root density (%), bank angle (°) and surface protection (%) within the determined section (Figure 13). Bank full height and bank height were directly measured using the stadia rod from the streambed. Root depth was measured with the stadia rod from streambed to root depth. The root density was determined by looking at the exposed bank and estimating the percentage of visible root mass. If no exposed bank was seen, and if the bank was undercut, then root density of the undercut was estimated. An inclinometer was used to determine angle of the banks. If the bank was undercut the angle was less than 90º, and if the bank was laid back then the angle was greater than 90 degrees. The surface protection was measured by estimating how much of the bank, from water's edge to the top of the bank is protected by vegetation. If the bank was completely bare of vegetation then a 0% was recorded, and if the bank was completely covered with vegetation, then a 100% is recorded. BEHI measurements were calculated and evaluated using the BEHI Rating Guide (Figure 15).

Stream Bank Hazard or Risk Rating		Bank Height to Bankfull Height (Ratio)	Root Depth to Bank Height (Ratio)	Root Density (%)	Bank Angle (Degrees)	Surface Protection (%)	Index Totals
	Value	1.0-1.1	1.0-0.9	100-80	0-20	100-80	
Very Low	*Index*	1.0-1.9	1.0-1.9	1.0-1.9	1.0-1.9	1.0-1.9	5-9.5
	Value	1.11-1.19	0.89-0.5	79-55	21-60	79-55	
Low	*Index*	2.0-3.9	2.0-3.9	2.0-3.9	2.0-3.9	2.0-3.9	10-19.5
	Value	1.2-1.5	0.49-0.3	54-30	61-80	54-30	
Moderate	*Index*	4.0-5.9	4.0-5.9	4.0-5.9	4.0-5.9	4.0-5.9	20-29.5
	Value	1.6-2.0	0.29-0.15	29-15	81-90	29-15	
High	*Index*	6.0-7.9	6.0-7.9	6.0-7.9	6.0-7.9	6.0-7.9	30-39.5
	Value	2.1-2.8	0.14-0.05	14-5.0	91-119	14-10	
Very High	*Index*	8.0-9.0	8.0-9.0	8.0-9.0	8.0-9.0	8.0-9.0	40-45
	Value	> 2.8	< 0.05	< 5	< 119	< 10	
Extreme	*Index*	10	10	10	10	10	46-50

Figure 15. BEHI measurement descriptions (Google Images, 2017). For this study soil stratification and particle size were not measured.

The width and depth of the stream were calculated for each reach. This was done by measuring the width of the stream from left to right bankfull in 10 foot intervals beginning approximately 50 feet above the riffle cross section and ending approximately 50 feet below the pool cross section. This process was completed once for each site given the proximately of the riffle and pool cross sections. The depth was determined by recording three water depth measurements across the width of the channel. The three depths are later averaged for data processing.

Figure 16. UMW student taking pebble counts at a cross section. Note the measuring tape spanning the channel.

The pebble count sampling was adapted from Fish, Wildlife, and Parks protocol using the Wildlife Supply Company Part #: 14-D40 Pebble Grid. Pebble counts were conducted at four transects for each cross section, with two transects upstream and two transects downstream of the cross section. Each cross section was ten feet apart from another. At each transect ten pebbles were sampled evenly from river left to river right across the channel. A total of 40 pebbles were sampled for each cross section. Sampling and measuring was conducted by collecting the first rock touched by the tip of the index finger placed on the bottom of the streambed following each step across the stream. If the stream was too deep an estimate was made. Pebble size was determined by measuring using the pebble grid and a tally of each pebble size was recorded (Figure 18). The pebbles were then classified according the Bevenger's pebble classification table (Appendix A).

A single water surface gradient was determined for each site given the proximity of the riffle and pool cross sections. The water surface gradient was measured using the Topcon Green Label Auto Level AT-G6 Transit and stadia rod. Gradient measurements were taken 100 feet upstream and 100 feet downstream of the cross sections. The stadia rod was held at water's surface next to the banks and read through the transit level. Downstream was then subtracted from the upstream measurement to give the difference. The total length of the tape, 200 feet, was used as the denominator of the gradient ratio. The percentage of slope was computed by multiplying the ratio by 100. Data was processed using Microsoft Excel 2011.

Pebble Classifications		
Material	Size	Range (mm)
Silt / Clay	0	0.062
Very Fine Sand	0.062	0.13
Fine Sand	0.13	0.25
Medium Sand	0.25	0.5
Coarse Sand	0.5	1
Very Coarse Sand	1	2
Very Fine Gravel	2	4
Fine Gravel	4	6
Fine Gravel	6	8
Medium Gravel	8	11
Medium Gravel	11	16
Coarse Gravel	16	22
Coarse Gravel	22	32
Very Coarse Gravel	32	45
Very Coarse Gravel	45	64
Small Cobble	64	90
Medium Cobble	90	128
Large Cobble	128	180
Very Large Cobble	180	256
Small Boulder	256	362
Small Boulder	362	512
Medium Boulder	512	1024
Large Boulder	1024	2048
Very Large Boulder	2048	4096
Bedrock		

Figure 17. Bevenger's pebble size classifications show the size categories in millimeters (Google Images, 2017).

Figure 18. UMW student using a gravelometer while collecting a pebble count.

Sinuosity was calculated by establishing the number of paces a person has per 50 feet. Measurements started at the first cross section, walking the entire reach of the site to approximately 500 feet following the deepest part, or thalweg, of the stream. A straight line was walked from the end point back to the starting point on the bank. The straight-line paces are calculated into feet and is used as the denominator for the ratio of sinuosity. Data was processed using Microsoft Excel 2011 for Mac.

An evalution of sediment was conducted to monitor the accumulation or decrease in fine sediments. The study was done by walking in the stream on both the left and right side of the reach from 100ft. up stream of the cross section to 100ft. down stream of the cross section in a zig zag pattern. Every ten feet a visual/ feel estimate of fine/ course sediment was made for that section of the stream. The percentage of fine sediments and course sediments was then averaged for the entire 200ft. sample site. Data will be

compared in future studies to demonstration if fine grain sediments are accumulating and causing siltation in low velocity areas, or if they are staying static making it not an issue of concern.

BEHI Category	Bank Height/ Bankfull Height	BH/BFH Score	Root Depth (% of BFH)	Root Depth Score	Root Density (%)	Root Density Score	Surface Protection (Avg. %)	Surface Protection Score	Bank Angle (degrees)	Bank Angle Score	Total Score, by Category
Very low	1.0-1.1	1.45	90-100	1.45	80-100	1.45	80-100	1.45	0-20	1.45	≤ 7.25
Low	1.11-1.19	2.95	50-89	2.95	55-79	2.95	55-79	2.95	21-60	2.95	7.26 – 14.75
Moderate	1.2-1.5	4.95	30-49	4.95	30-54	4.95	30-54	4.95	61-80	4.95	14.76 – 24.75
High	1.6-2.0	6.95	15-29	6.95	15-29	6.95	15-29	6.95	81-90	6.95	24.76 – 34.75
Very high	2.1-2.8	8.5	5-14	8.5	5-14	8.5	10-14	8.5	91-119	8.5	34.76 – 42.50
Extreme	>2.8	10	< 5	10	< 5	10	< 10	10	> 119	10	42.51 - 50

Figure 19. Chart used to calculate BEHI index (Google Images, 2017).

DATA

Introduction

The data gathered for stream morphology on Poindexter Slough consisted of 5 different sites. Each site consisted of two cross sections, one riffle and one pool. The two different cross sections in each site were paired and distinguished by labeling riffles as "A" and pools as "B". Each site consisted of cross-section measurements, pebble counts, and BEHI measurements for each individual cross section. One measurement of sinuosity, stream gradient, and width-depth ratios were made given the proximity of the riffle and pool. The sites below are outlined from upstream to downstream with each site and the cross section pair data, followed by the combined measurements for the site. All data is listed in Appendix A.

Site 4

Cross Section 4A Riffle

The latitude/longitude coordinates for Site 4A Cross Section Riffle: river left stake at N 45° 10' 49.0" W 112° 41' 03.5" and the river right stake at N 45° 10' 48.7" W 112° 41' 02.5" (Figure 20 and 21). The tripod was placed on river right at N 45° 10' 48.7" and W 112° 41' 02.5" and readings for gradient and profile were from this location. The cross-section length measured 68.4 feet from the river left stake to the river right stake (Figure 22). The location of this riffle was upstream about a mile from the parking lot. The cross section channel was primarily composed of course gravel (Figure 23).

Figure 2. Site 4 Cross Section 4A Riffle looking upstream.

Figure21. Site 4 Cross Section 4A Riffle looking downstream.

Site 4A Cross Section Profile

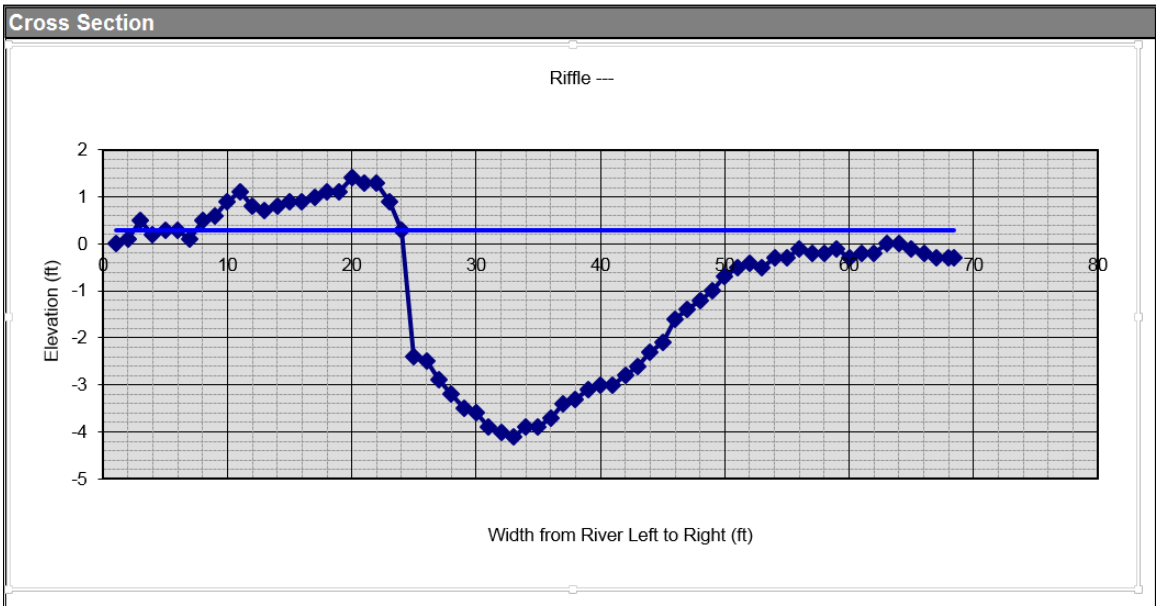
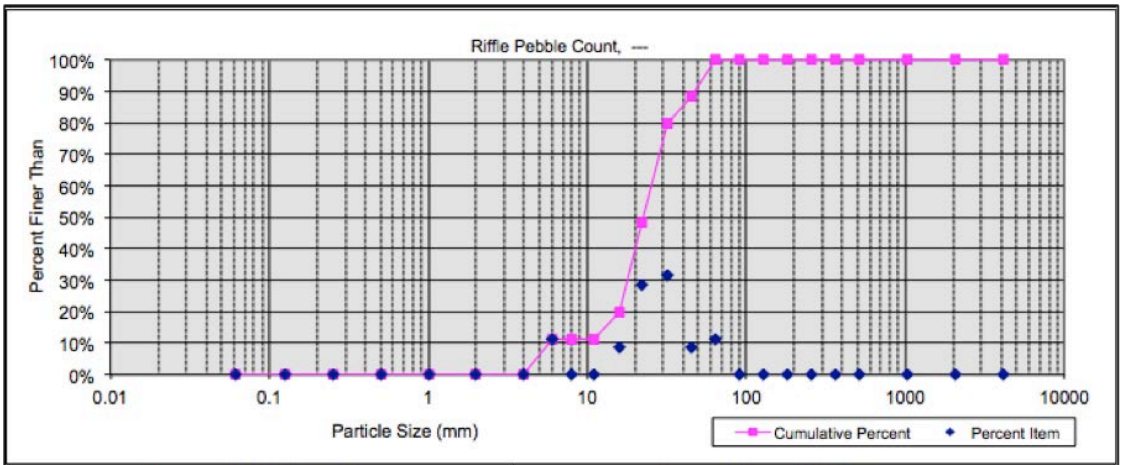


Figure 22. The 2017 stream profile at Site 4A Riffle. The latitude/longitude coordinates for the left stake is N 45° 10' 49.0" W 112° 41' 03.5" and the right stake N 45° 10' 48.7" W 112° 41' 02.5". The linear blue line represents the bankfull stage.



Size percent less than (mm)					Percent by substrate type					
D16	D35	D50	D84	D95	silt/clay	sand	gravel	cobble	boulder	bedrock
13.433	18.91	22.4	38	55	0%	0%	100%	0%	0%	0%

Figure 23. The Site 4A Riffle yielded a total of 40 pebbles collected. The riffle site was primarily very coarse gravel.

Cross Section 4B Pool

The latitude/longitude coordinates for Site 4B Cross Section Pool: river left stake at N 45° 10’ 49.5" W 112° 41’ 2.3” and the river right stake at N 45° 10’ 49.3” W 112° 41’ 1.7” (Figures 24 and 25). The tripod was placed on river left at N 45° 10’ 49.2” and W 112° 41’ 1.8” and readings for gradient and profile were from this location. The cross-section length measured 49 feet from the river left stake to the river right stake (Figure 26). The location of this pool was upstream about a mile from the parking lot at a bend in the slough. The cross section channel was composed of course gravel (Figure 27).

Figure 24. Site 4 Cross Section 4B Pool looking upstream.

Figure 25. Site 4 Cross Section 4B Pool looking downstream.

Site 4B Cross Section Profile

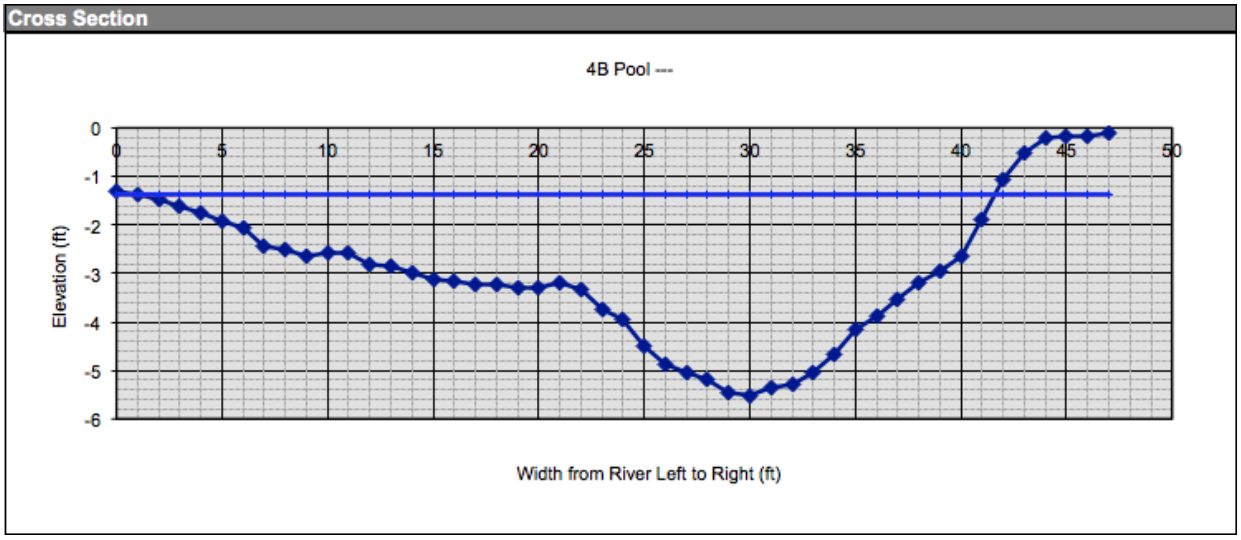
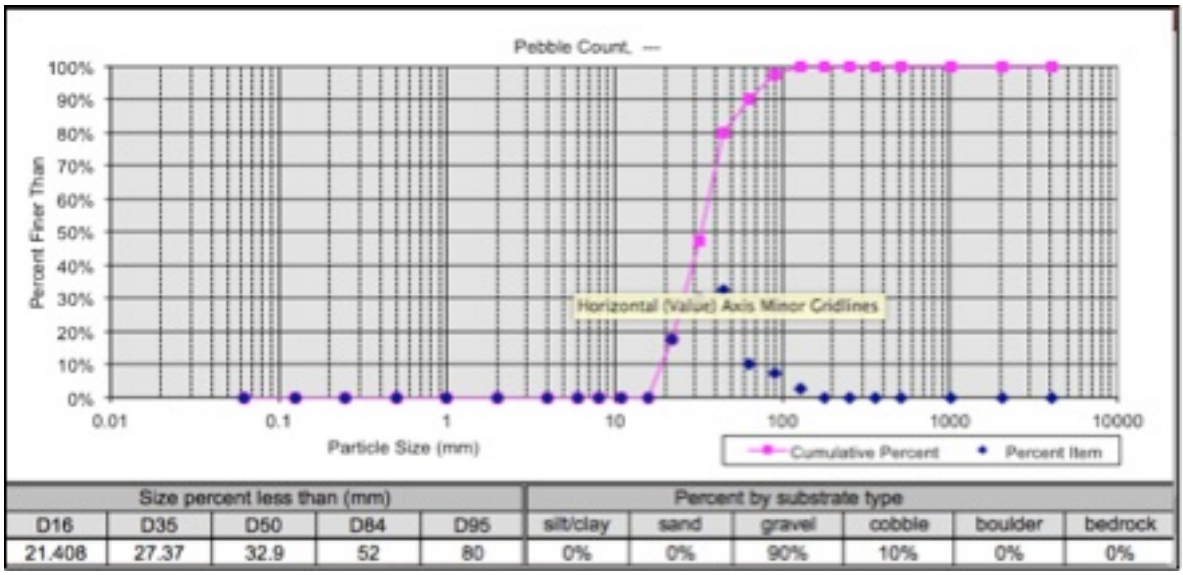


Figure 26. The 2017 stream profile at Site 4B Pool. The latitude/longitude coordinates for the left stake is N 45° 10' 59.5" W 112° 41' 2.3" and the right stake N 45° 10' 49.3" W 112° 41' 1.7". The linear blue line represents the bankfull stage.

Site 4B Pebble Count



Size percent less than (mm)					Percent by substrate type					
D16	D35	D50	D84	D95	silt/clay	sand	gravel	cobble	boulder	bedrock
21.408	27.37	32.9	52	80	0%	0%	90%	10%	0%	0%

Figure 27. The Site 4B Pool yielded a total of 40 pebbles collected. The pool site was primarily composed of gravel and cobble.

Combined Site 4 Data

Given the proximity of the riffle and pool cross sections, widths, depths, gradient, and sinuosity were collected as a whole. The average water depth for Site 4 was 1.61 ft and the average width 28.06 ft (Figures 28 and 29). The sinuosity for the site was 1.41 and the gradient 0.35%.

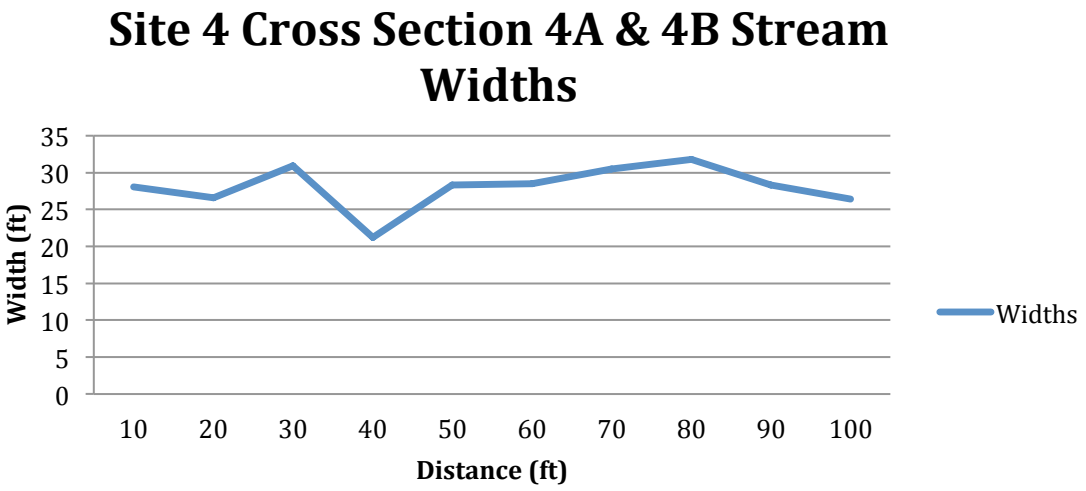


Figure 28. The combined widths at Site 4 shows the average width at 28.06 ft. Widths were collected at ten evenly spaced locations that covered the riffle and pool sites

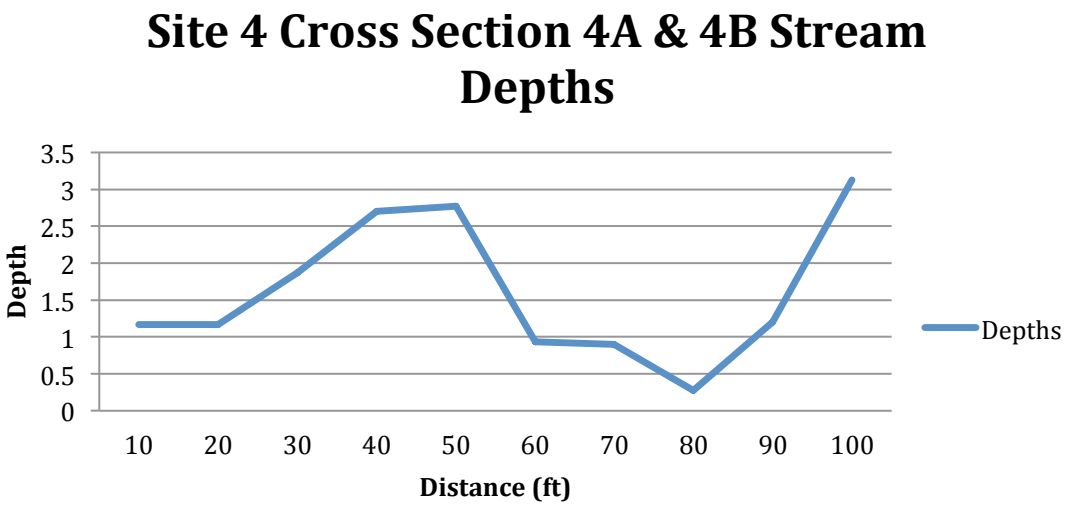


Figure 29. The combined depths at Site 4 shows the average depth at 1.61 ft. Three depths were taken and averaged at ten evenly spaced locations that covered the riffle and pool sites.

Site 5

Cross Section 5A Riffle

The latitude/longitude coordinates for Site 5A Cross Section Riffle: river left stake at N 45° 10’ 50.4” W 112° 40’ 51.2” and the river right stake at N 45° 10’ 26.0” and W 112° 40’ 27.0” (Figures 30 and 31). The tripod was placed on river left at N 45° 10’ 50.4” and W 112° 40’ 51.2” UTM 12T 0367937 5004395 and readings for gradient and profile were from this location. The cross-section length measured 67.4 feet from the river left stake to the river right stake (Figure 32). The location of this riffle was along a straight channel located on Poindexter Slough. Banks were relatively stable, fully vegetated with no sign of erosion. The cross section channel was primarily composed of course gravel (Figure 33).

Figure 30. Site 5 Cross Section 5A Riffle looking upstream.

Figure 31. Site 5 Cross Section 5A Riffle looking downstream.

Site 5A Cross Section Profile

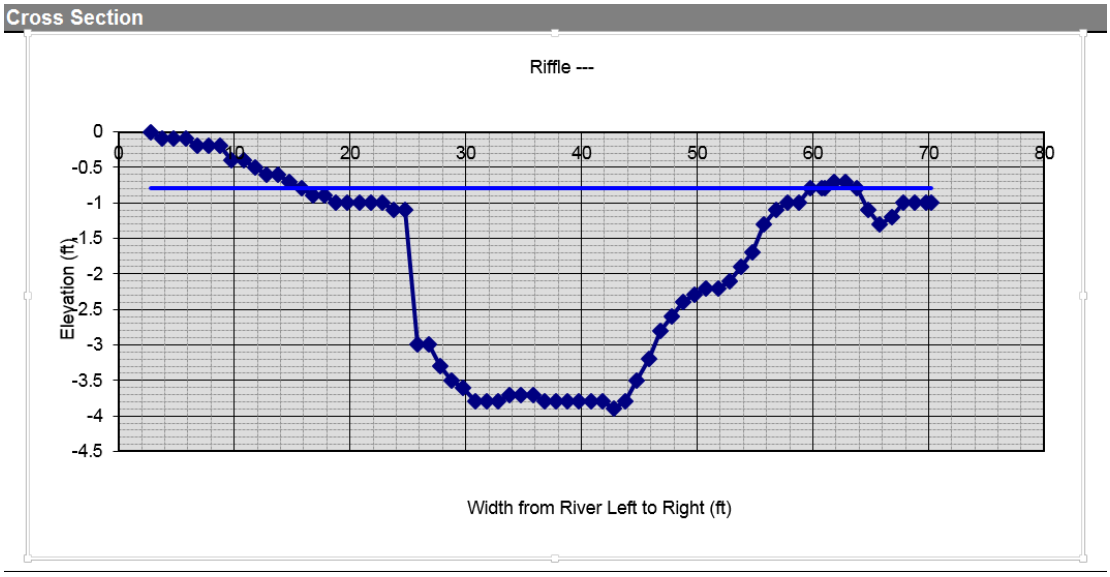
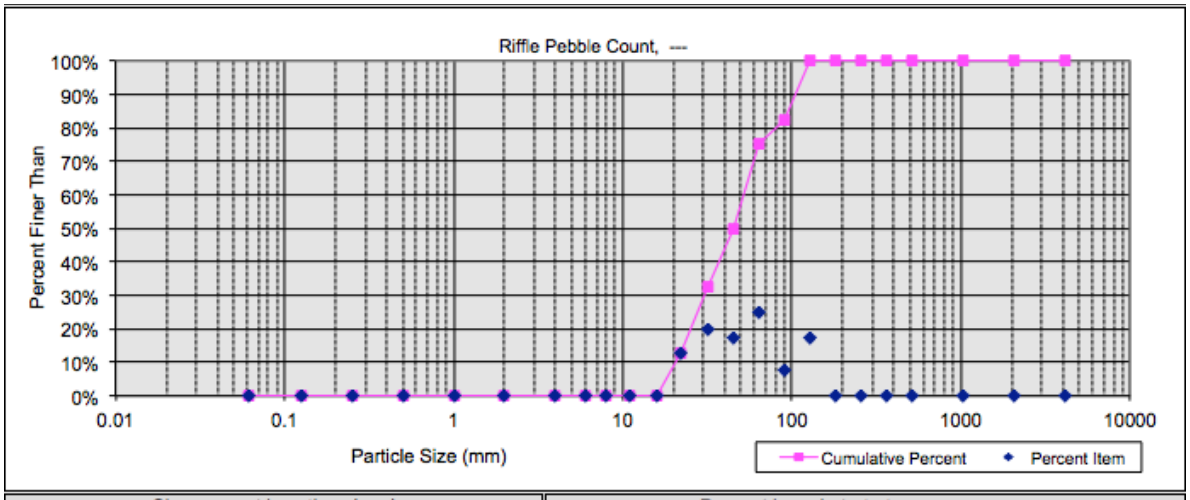


Figure 3. The 2017 stream profile at Site 5A Riffle. The latitude/longitude coordinates for the left stake is N 45° 10' 50.4" W 112° 40' 51.2" and the right stake N 45° 10' 26.0" W 112° 40' 27.0". The linear blue line represents the bankfull stage.



Size percent less than (mm)					Percent by substrate type					
D16	D35	D50	D84	D95	silt/clay	sand	gravel	cobble	boulder	bedrock
23.491	33.60	45.0	93	116	0%	0%	75%	25%	0%	0%

Figure 4. The Site 5A Riffle yielded a total of 40 pebbles collected. The pool site was primarily composed of very coarse gravel, silt and clay, and coarse gravel.

Site 5

Cross Section 5B Pool

The latitude/longitude coordinates for Site 5B Cross Section Pool: river left stake at N 45° 10’ 52.0” W 112° 40’ 49.0” and the river right stake at N 45° 10’ 51.5” and W 112° 40’ 48.6” (Figures 34 and 35). The tripod was placed on river left at N 45° 10’ 52.1” and W 112° 40’ 48.6” and readings for gradient and profile were from this location. The cross-section length measured 60.1 feet from the river left stake to the river right stake (Figure 36). The location of this riffle was along a relatively straight channel. Banks were relatively stable, fully vegetated with no sign of erosion. The cross section channel was primarily composed of course gravel (Figure 37).

Figure 34. Site 5 Cross Section 5B Pool looking upstream.

Figure 35. Site 5 Cross Section 5B Pool looking downstream.

Site 5B Cross Section Profile

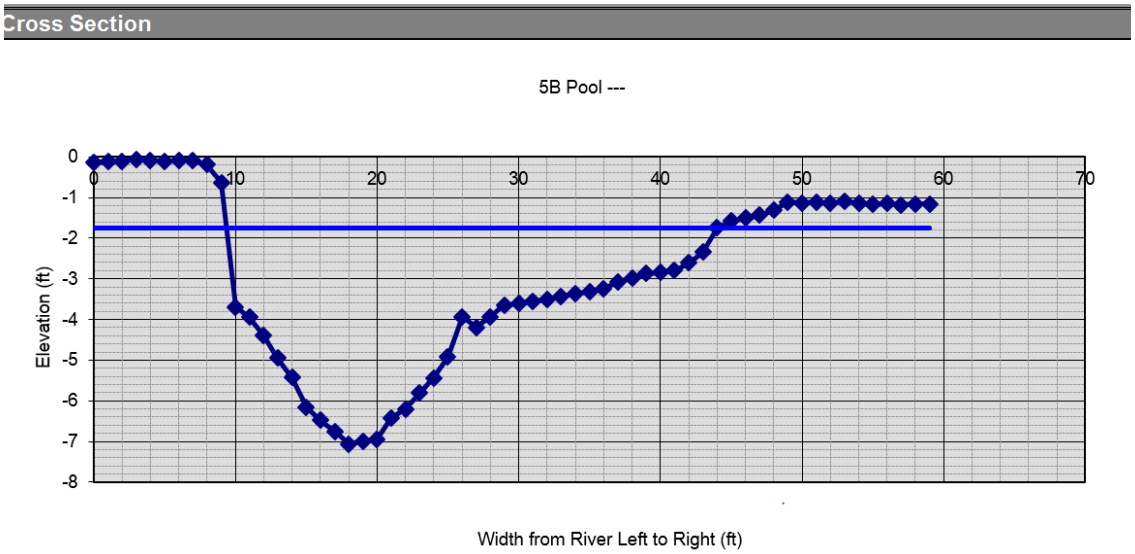
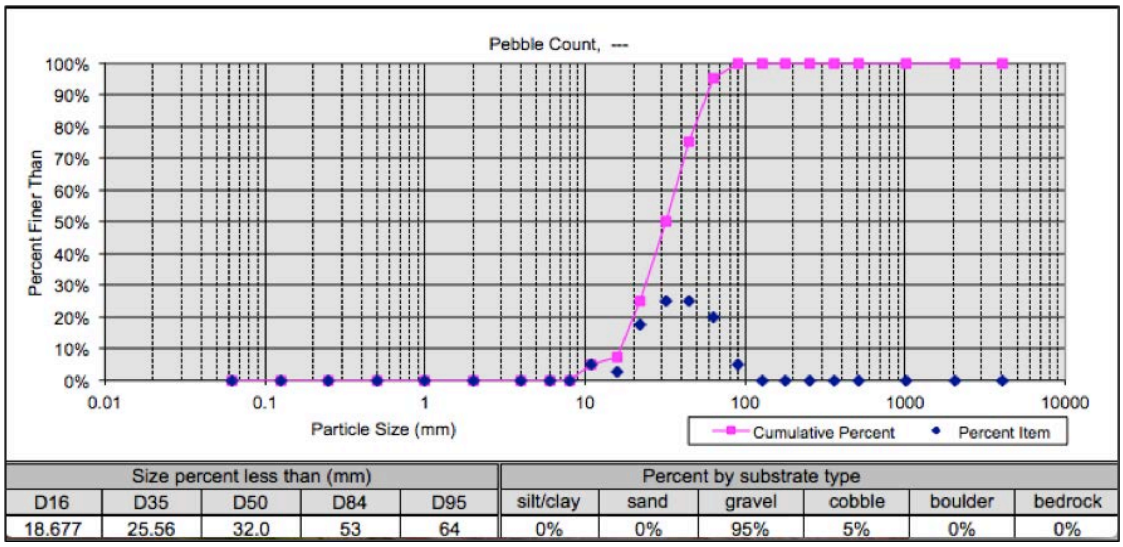


Figure 36. The 2017 stream profile at Site 5B Pool. The latitude/longitude coordinates for the left stake is N 45° 10' 52.0" W 112° 40' 49.0" and the right stake N 45° 10' 51.5" W 112° 40' 48.6". The linear blue line represents the bank full stage.

Site 5B Pebble Count



Size percent less than (mm)					Percent by substrate type					
D16	D35	D50	D84	D95	silt/clay	sand	gravel	cobble	boulder	bedrock
18.677	25.56	32.0	53	64	0%	0%	95%	5%	0%	0%

Figure 37. The Site 5B Pool yielded a total of 40 pebbles collected. The pool site was primarily composed of gravel and cobble.

Combined Site 5 Data

Given the proximity of the riffle and pool cross sections, widths, depths, gradient, and sinuosity were collected as a whole. The average water depth for Site 5 was 1.9 ft and the average width 33.47 ft (Figures 38 and 39). The sinuosity for the site was 1.29 and the gradient 0.17%.

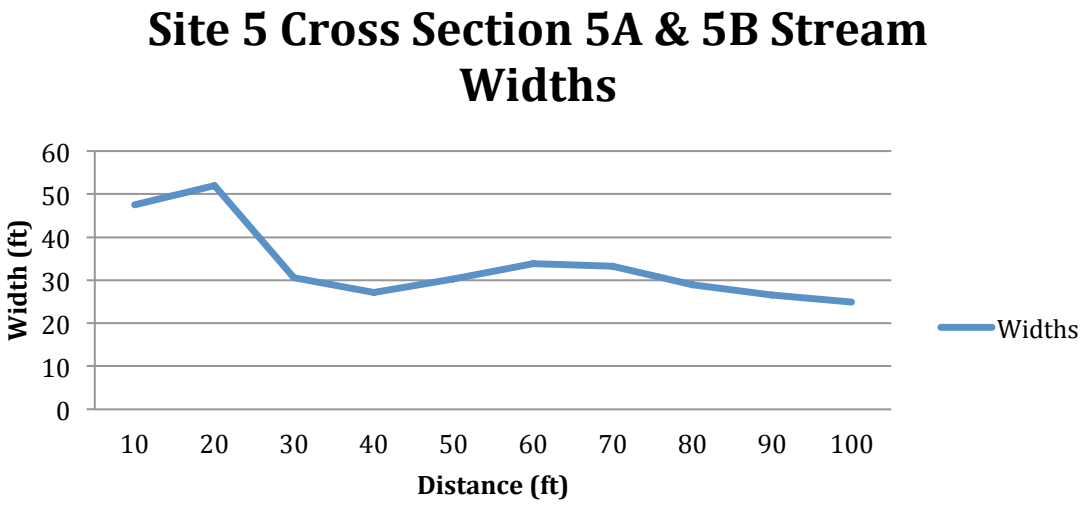


Figure 38. The combined widths at Site 5 shows the average width at 33.47 ft. Widths were collected at ten evenly spaced locations that covered the riffle and pool sites.

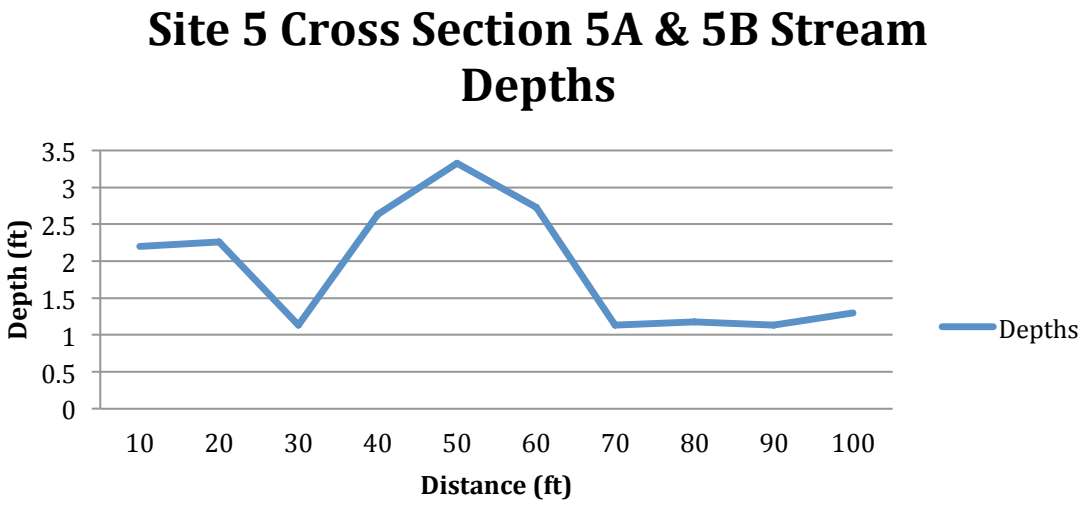


Figure 39.The combined depths at Site 5 shows the average depth at 1.9 ft. Three depths were taken and averaged at ten evenly spaced locations that covered the riffle and pool sites.

Site 6

Cross Section 6A Riffle

The latitude/longitude coordinates for Site 6A Cross Section Riffle: river left stake at N 45° 10’ 54.3” W 112° 40’ 46.8” and the river right stake at N 45° 10’ 54.4" W 112° 40’ 46.2 (Figures 40 and 41). The tripod was placed on river left at N 45° 10’ 54.3” and W 112° 40’ 46.8” and readings for gradient and profile were from this location. The cross-section length measured 85 feet from the river left stake to the river right stake (Figure 42). The location of this riffle was just upstream from the bridge before the parking lot. The cross section channel was primarily composed of course gravel (Figure 43).

Figure 40. Site 6 Cross Section 6A Riffle looking upstream.

Figure 41. Site 6 Cross Section 6A Riffle looking downstream.

Site 6A Cross Section

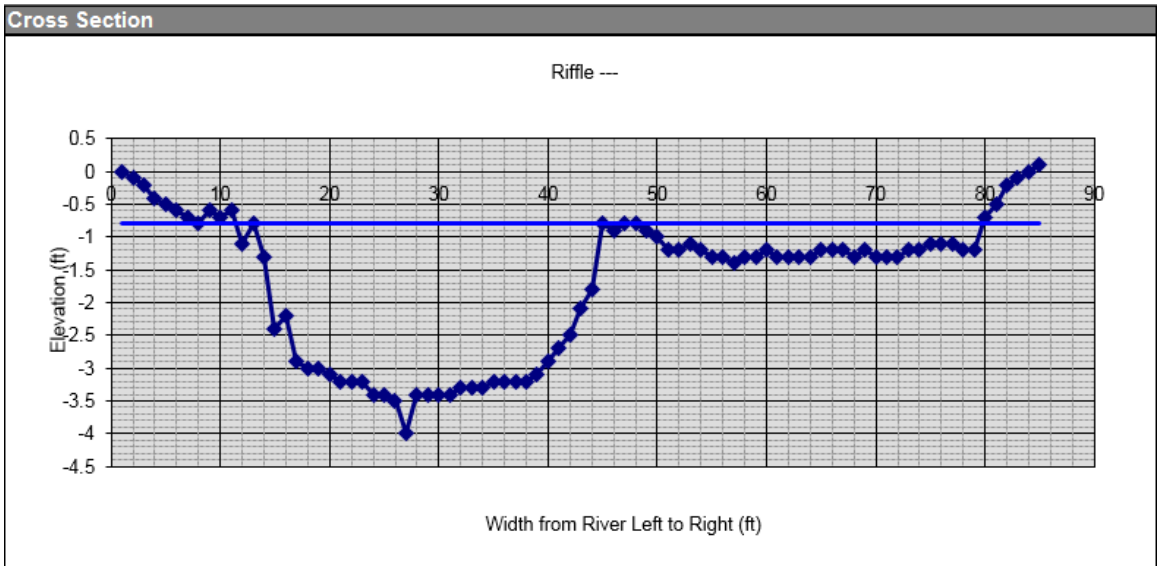
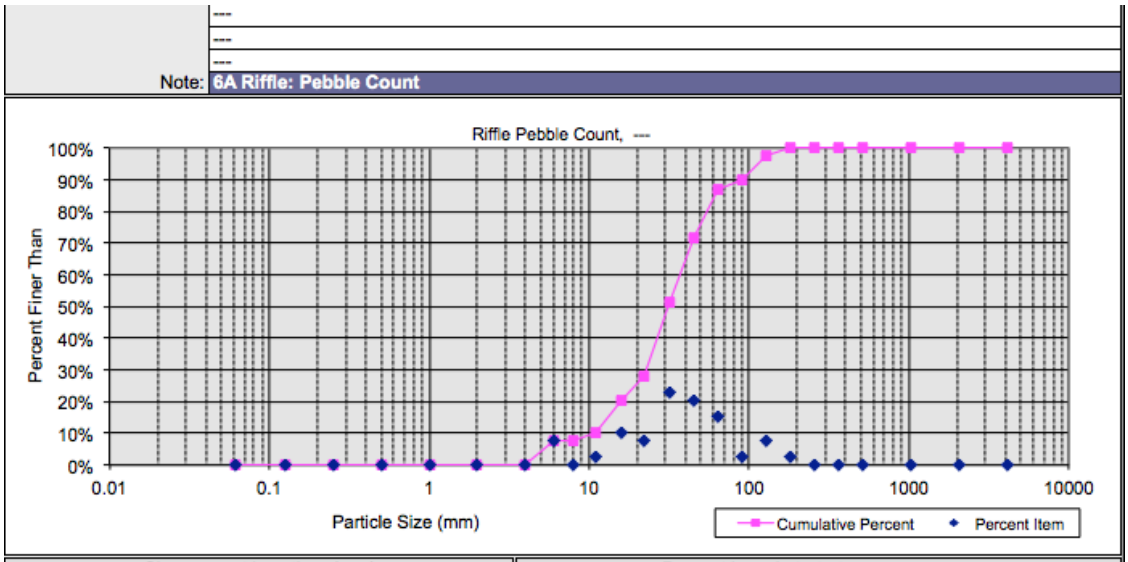


Figure 42. The 2017 stream profile at Site 6A Riffle. The latitude/longitude coordinates for the left stake is N 45° 10' 54.3" W 112° 40' 46.8" and the right stake N 45° 10' 54.4" W 112° 40' 46.2".



Size percent less than (mm)					Percent by substrate type					
D16	D35	D50	D84	D95	silt/clay	sand	gravel	cobble	boulder	bedrock
13.568	24.57	31.3	60	114	0%	0%	87%	13%	0%	0%

Figure 43. The Site 6A Riffle yielded a total of 40 pebbles collected. The riffle site was primarily composed of very coarse gravel.

Site 6

Cross Section 6B Pool

The latitude/longitude coordinates for Site 6A Cross Section Pool: river left stake at N 45° 10’ 55.4" W 112° 40’ 46.1” and the river right stake at N 45° 10’ 55.0” W 112° 40’ 45.9” (Figures 44 and 45). The tripod was placed on river left at N 45° 10’ 55.5” and W 112° 40’ 45.7” and readings for gradient and profile were from this location. The cross-section length measured 48 feet from the river left stake to the river right stake (Figure 46). The location of this pool was just upstream from the bridge before the parking lot. The cross section channel was composed of course gravel, large cobble, and silt and clay (Figure 47).

Figure 44. Site 6 Cross Section 6B Pool looking upstream.

Figure 45. Site 6 Cross Section 6B Pool looking downstream.

Site 6B Cross Section Profile

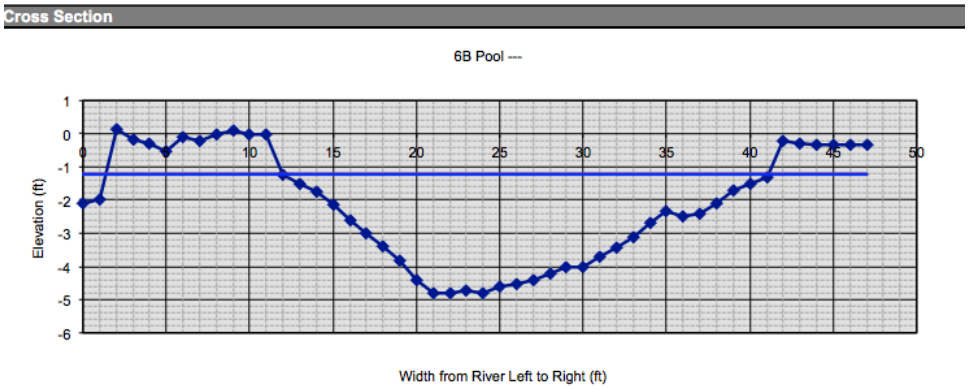
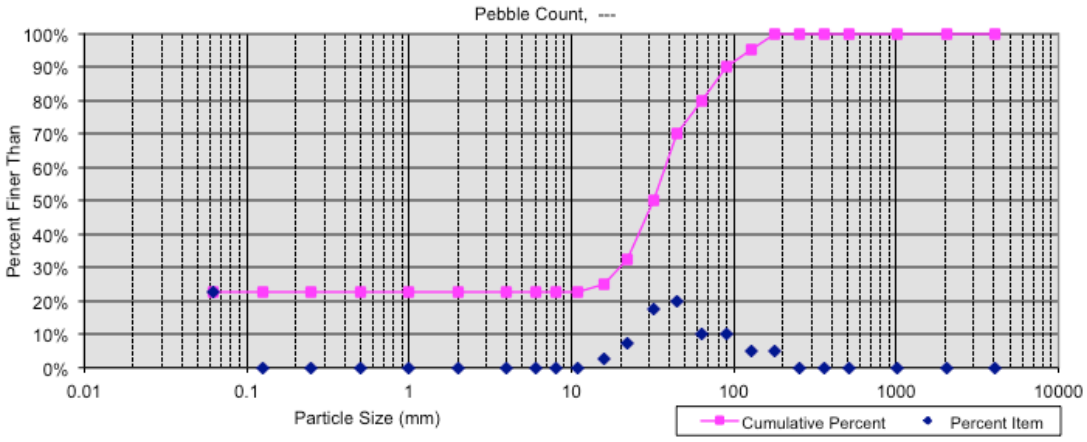


Figure 46. The 2017 stream profile at Site 6B Pool. The latitude/longitude coordinates for the left stake is N 45° 10' 55.4" W 112° 40' 46.1" and the right stake N 45° 10' 55" W 112° 40' 45.9". The linear blue line represents the bankfull stage.

Site 6B Pebble Count



Size percent less than (mm)					Percent by substrate type					
D16	D35	D50	D84	D95	silt/clay	sand	gravel	cobble	boulder	bedrock
#N/A	23.21	32.0	73	128	23%	0%	58%	20%	0%	0%

Figure 47. The Site 6B Pool yielded a total of 40 pebbles collected. The pool site was primarily composed of gravel and cobble with a fair amount of silt and clay.

Combined Site 6 Data

Given the proximity of the riffle and pool cross sections, widths, depths, gradient, and sinuosity were collected as a whole. The average water depth for Site 6 was 2.105 ft and the average width 28.35 ft (Figures 48 and 49). The sinuosity for the site was 1.48 and the gradient 0.31%.

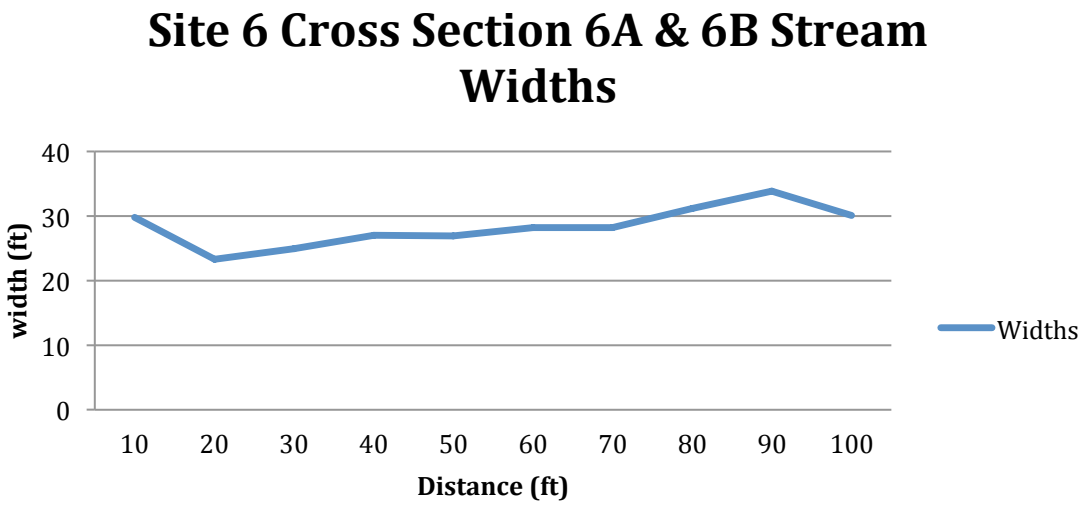


Figure 48. The combined widths at Site 6 show the average width at 28.35 ft. The widths were taken at 10 evenly spaced locations that covered the riffle and pool sites.

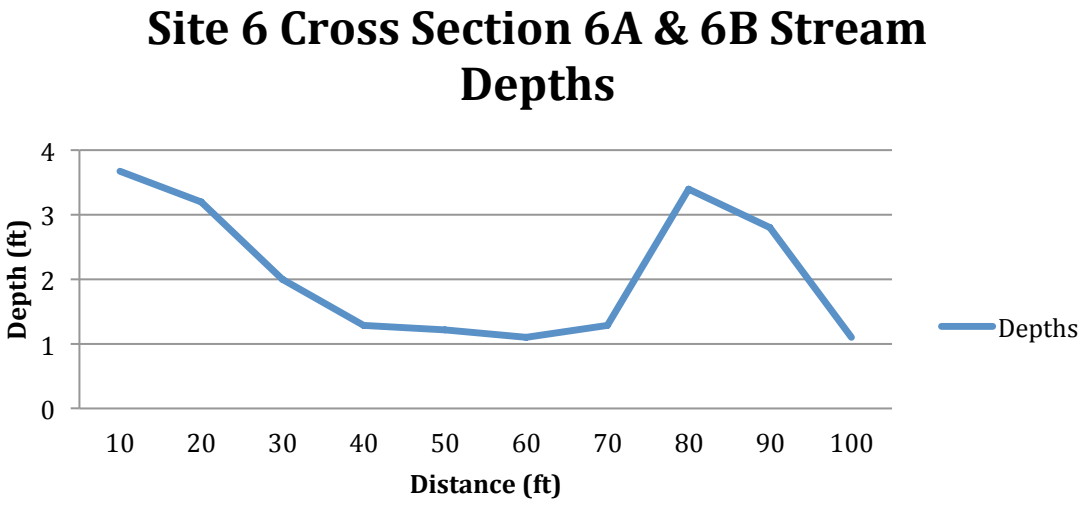


Figure 49. The combined depths at Site 6 shows the average depth at 2.105 ft. Depths were collected at three positions at ten evenly spaced locations that covered the riffle and pool sites.

In this section 6B there is a significant point bar that we calculated the area for. This point bar is created by helical flow in the stream (Figure 50). This point bar was selected for its large size and should be continoulsy measured to monitor deposition on the point bar.

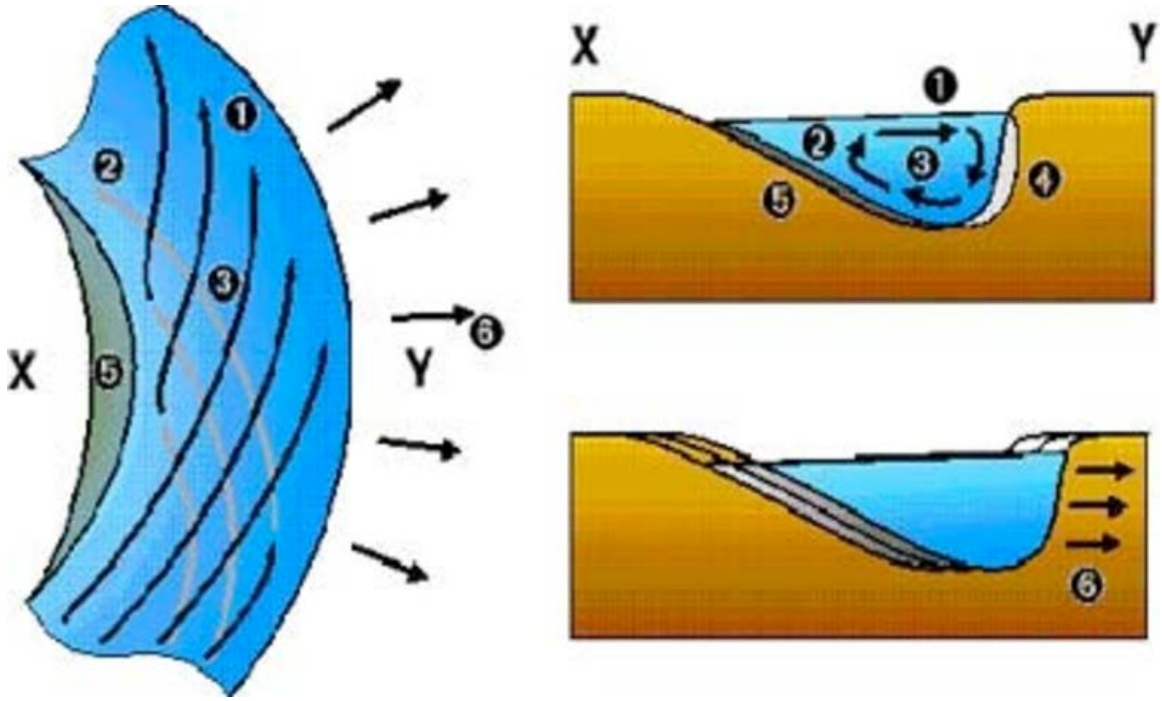


Figure 50. Diagram showing helical flow in a cut bank section of the stream with point 5 being the point bar being created. (Google Images 2017)

The height measured was 11ft and the length along the bank was measured at 43ft making the total area of this point bar 236.5ft.

Site 8
Cross Section 8A Riffle

The latitude/longitude coordinates for Site 8A Cross Section Riffle: river left stake at N 45° 11’ 16.2” W 112° 40’ 47.8” and the river right stake at N 45° 11’ 16.2" W 112° 40’ 47.3 (Figures 51 and 52). The tripod was placed on river left at N 45° 11’ 16.2” and W 112° 40’ 47.8” and readings for gradient and profile were from this location. The cross-section length measured 72 feet from the river left stake to the river right stake (Figure 53). The cross section channel was primarily composed of sand and silt with small patches of gravel on either side of the sediment bars (Figure 54).

Figure 51. Site 8 Cross Section 8A Riffle looking upstream.

Figure 52. Site 8 Cross Section 8A Riffle looking downstream.

Site 8A Cross Section Profile

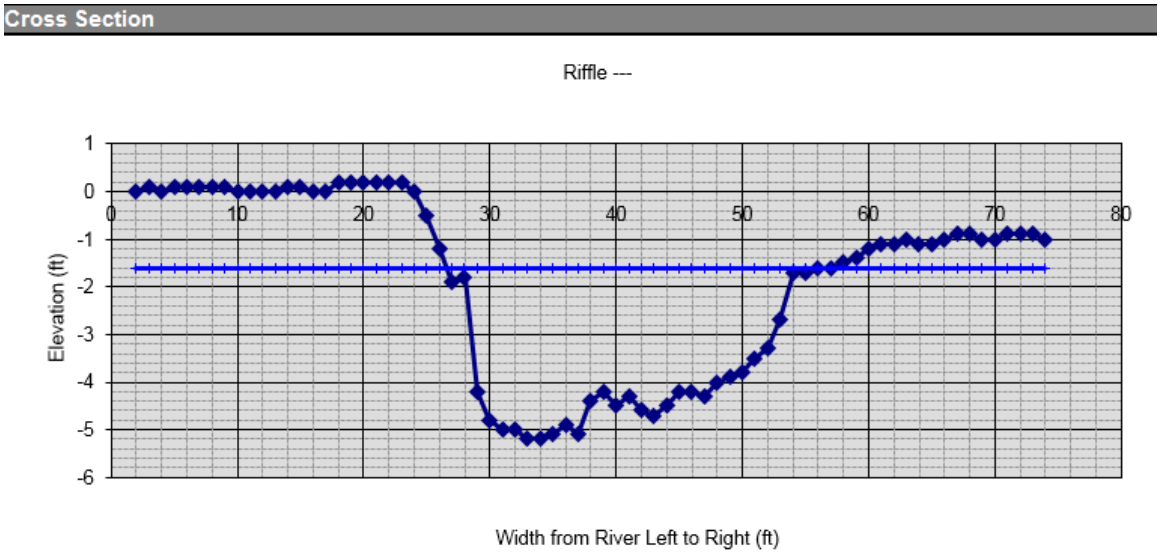
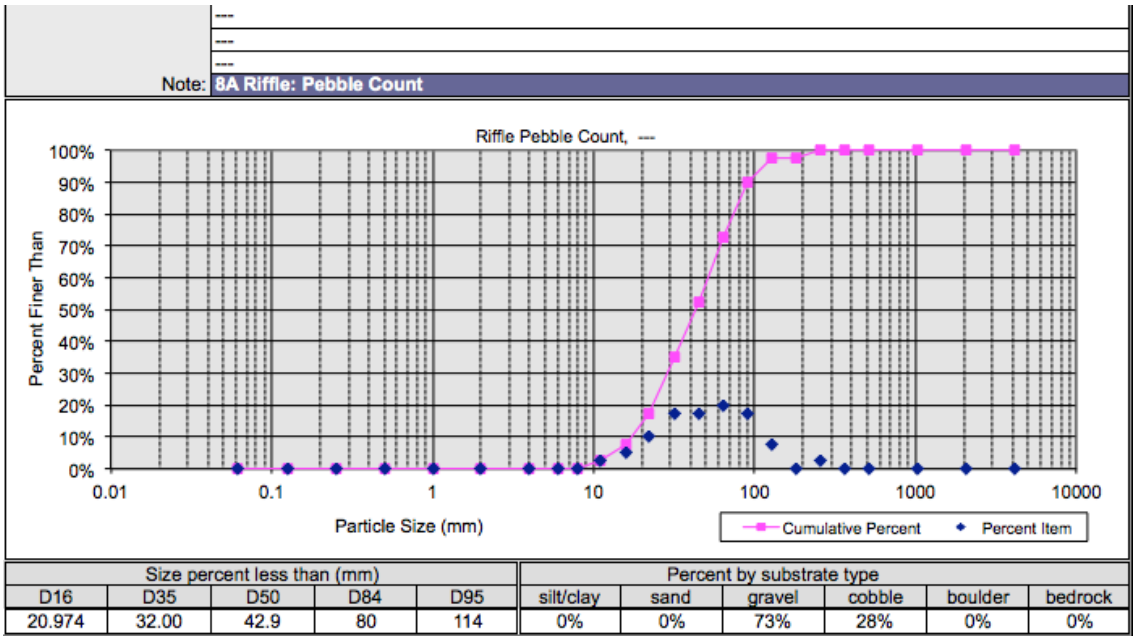


Figure 53. The 2017 stream profile at Site 8A Riffle. The latitude/longitude coordinates for the left stake is N 45° 11' 16.2" W 112° 40' 47.8" and the right stake N 45° 11' 16.2" W 112° 40' 47.3".



Size percent less than (mm)					Percent by substrate type					
D16	D35	D50	D84	D95	silt/clay	sand	gravel	cobble	boulder	bedrock
20.974	32.00	42.9	80	114	0%	0%	73%	28%	0%	0%

Figure 54. The Site 8A Riffle yielded a total of 40 pebbles collected. The pool site was primarily composed of silt and clay.

Site 8

Cross Section 8B Pool

The latitude/longitude coordinates for Site 8B Cross Section Pool: river left stake at N 45° 11’ 16.2” W 112° 40’ 40.8” and the river right stake at N 45° 11’ 16.2" W 112° 40’ 47.1” (Figures 55 and 56). The tripod was placed on river left at N 45° 11’ 15.9” and W 112° 40’ 48.1” and readings for gradient and profile were from this location. The cross-section length measured 64 feet from the river left stake to the river right stake (Figure 57). The cross section channel was primarily composed of sand and silt (Figure 58).

Figure 55. Site 8 Cross Section 8B Pool looking upstream.

Figure 56. Site 8 Cross Section 8B Pool looking downstream.

Site 8B Cross Section Profile

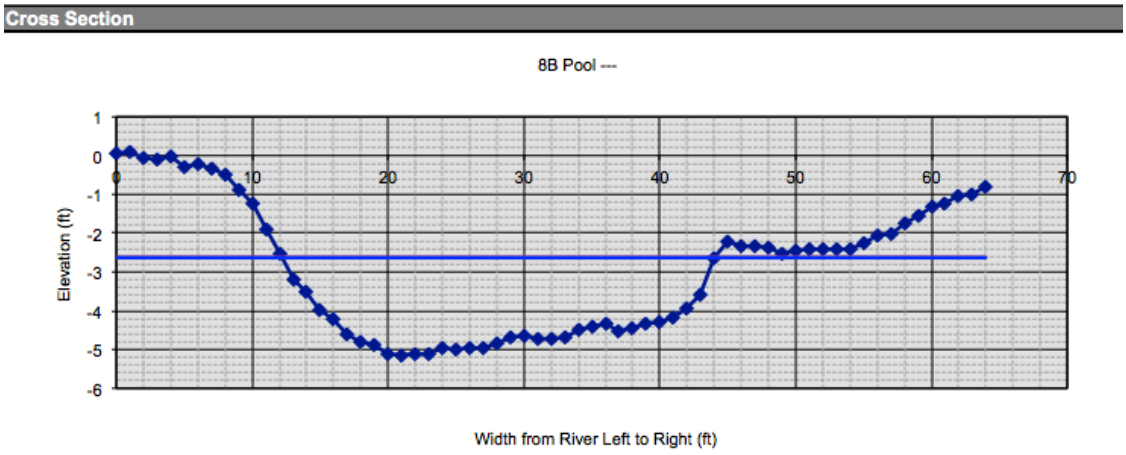
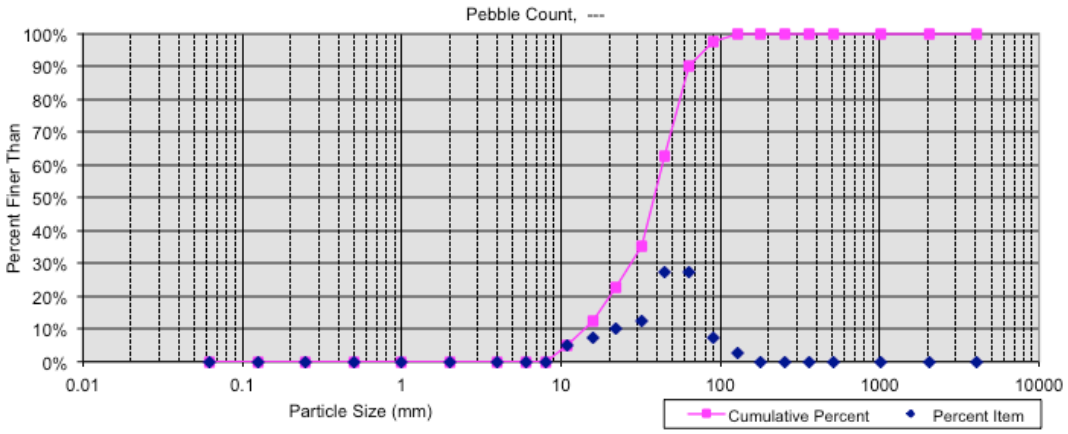


Figure 57. The 2017 stream profile at Site 8B Pool. The latitude/longitude coordinates for the left stake is N 45° 11' 16.2" W 112° 40' 48" and the right stake N 45° 11' 16.2" W 112° 40' 47.1". The linear blue line represents the bankfull stage.

Site 8B Pebble Count



Size percent less than (mm)					Percent by substrate type					
D16	D35	D50	D84	D95	silt/clay	sand	gravel	cobble	boulder	bedrock
17.887	32.00	38.5	59	80	0%	0%	90%	10%	0%	0%

Figure 58. The Site 8B Pool yielded a total of 40 pebbles collected. The pool site was entirely composed of gravel and a small percentage of cobble.

Combined Site 8 Data

Given the proximity of the riffle and pool cross sections, widths, depths, gradient, and sinuosity were collected as a whole. The average water depth for Site 8 was 1.57 ft and the average width 38.2 ft (Figures 59 and 60). The sinuosity for the site was 1.25 and the gradient 0.05%.

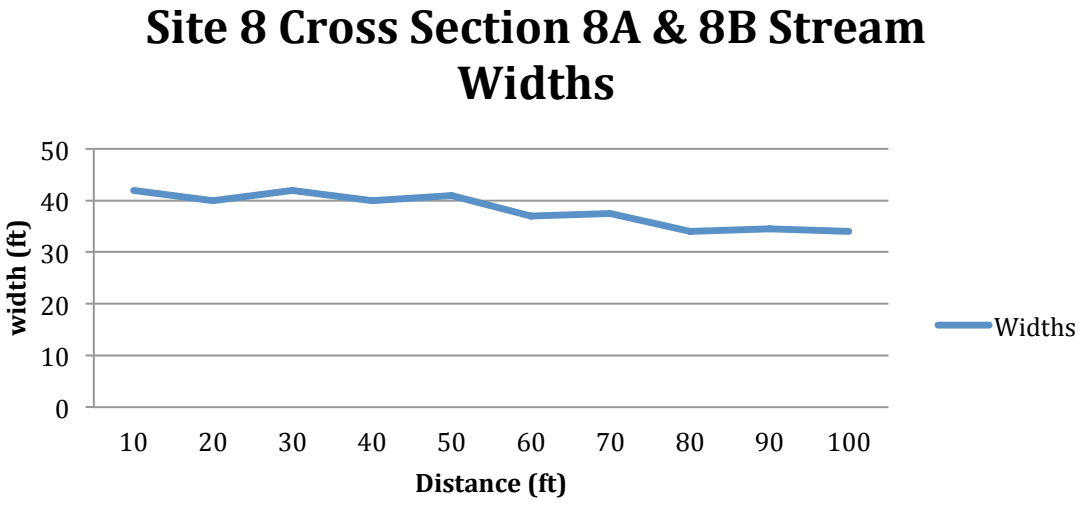


Figure 59. The combined widths at Site 8 shows the average width at 38.2 ft. The widths were taken at 10 evenly spaced locations that covered the riffle and pool sites.

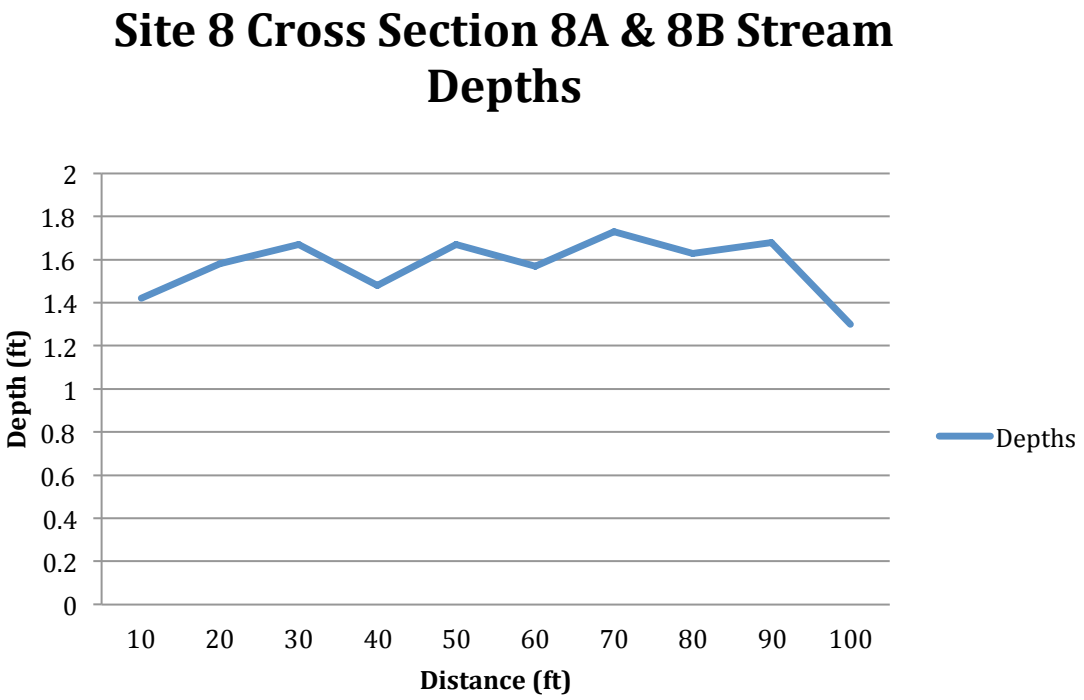


Figure 60. The combined depths at Site 8 shows the average depth of 1.57 ft. The depths were taken from three positions at 10 evenly spaced locations that covered the riffle and pool sites.

Site 10

Cross Section 10A Riffle

The latitude/longitude coordinates for Site 10A Cross Section Riffle: river left stake at N 45° 11’ 36.8” W 112° 40’ 43.4” and the river right stake at N 45° 11’ 36.8” and W 112° 40’ 42.5” (Figures 61 and 62). The tripod was placed on river left at N 45° 11’ 36.8” and W 112° 40’ 43.4” and readings for gradient and profile were from this location. The cross-section length measured 72 feet from the river left stake to the river right stake (Figure 63). The location of this riffle was along a straight channel near to the Confluence Project cross section. Banks were relatively stable, fully vegetated with no sign of erosion. The cross section channel was primarily composed of course gravel (Figure 64).

Figure 61. Site 10 Cross Section 10A Riffle looking upstream.

Figure 62. Site 10 Cross Section 10A Riffle looking downstream.

Site 10A Cross Section Profile

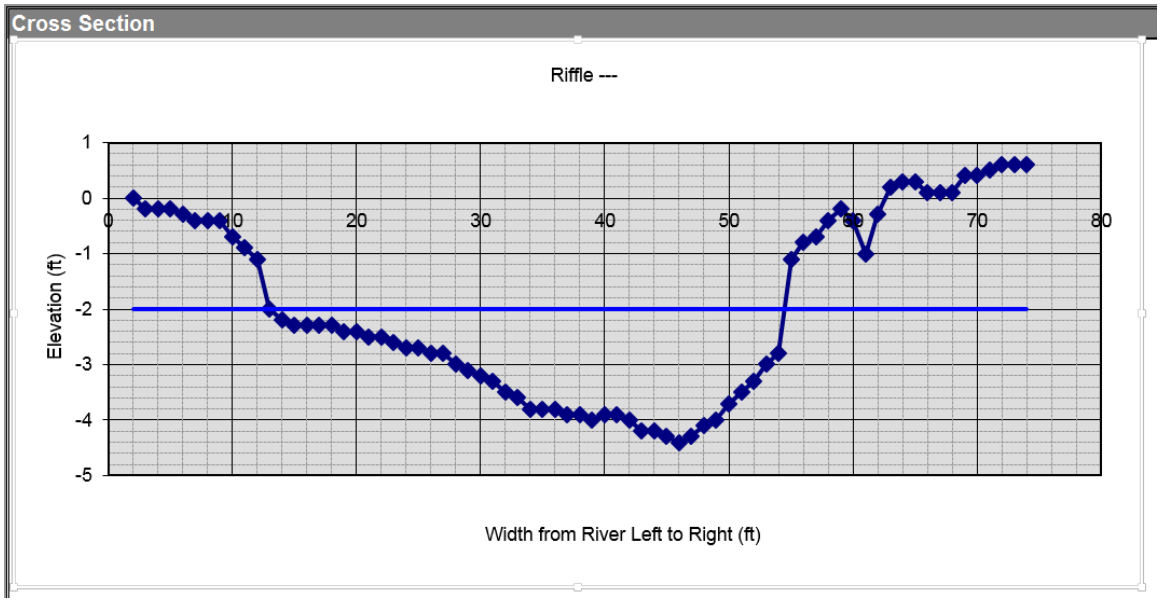
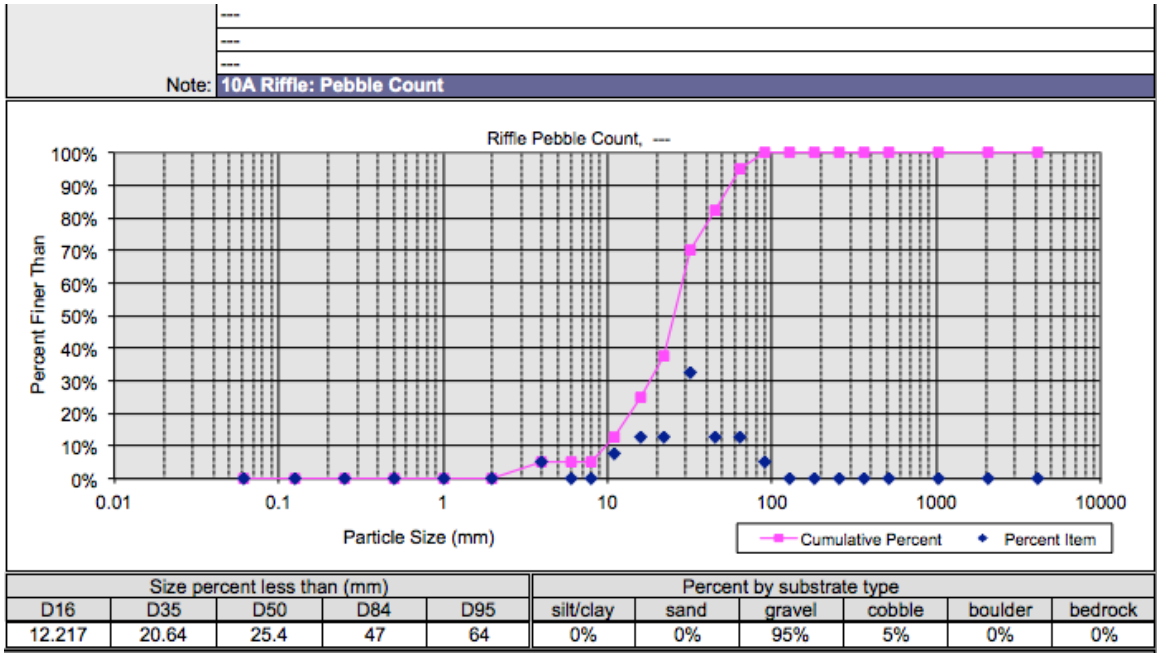


Figure 63. The 2017 stream profile at Site 10A Riffle. The latitude/longitude coordinates for the left stake is N 45° 11' 36.8" W 112° 40' 43.4" and the right stake N 45° 11' 36.8" and W 112° 40' 42.5". The linear red line represents the bankfull stage.



Size percent less than (mm)					Percent by substrate type					
D16	D35	D50	D84	D95	silt/clay	sand	gravel	cobble	boulder	bedrock
12.217	20.64	25.4	47	64	0%	0%	95%	5%	0%	0%

Figure 64. The Site 10A Riffle yielded a total of 40 pebbles collected. The riffle site was primarily composed of coarse gravel.

Cross Section 10B Pool

The latitude/longitude coordinates for Site 10B Cross Section Pool: river left stake at N 45° 11’ 36.8” W 112° 40’ 43.4” and the river right stake at N 45° 11’ 36.9” and W 112° 40’ 42.6” (Figure 65 and 66). The tripod was placed on river left at N 45° 11’ 36.6” and W 112° 40’ 43.4” and readings for gradient and profile were from this location. The cross section length measured 59 feet from the river left stake to the river right stake (Figure 67). The location of this pool was along a straight channel before a curve. Banks were relatively stable, fully vegetated with no sign of erosion. The cross section channel was primarily composed of silts and clays (Figure 68).

Figure 65. Site 10 Cross Section 10B Pool looking upstream.

Figure 66. Site 10 Cross Section 10B Pool looking downstream.

Site 10B Cross Section Profile

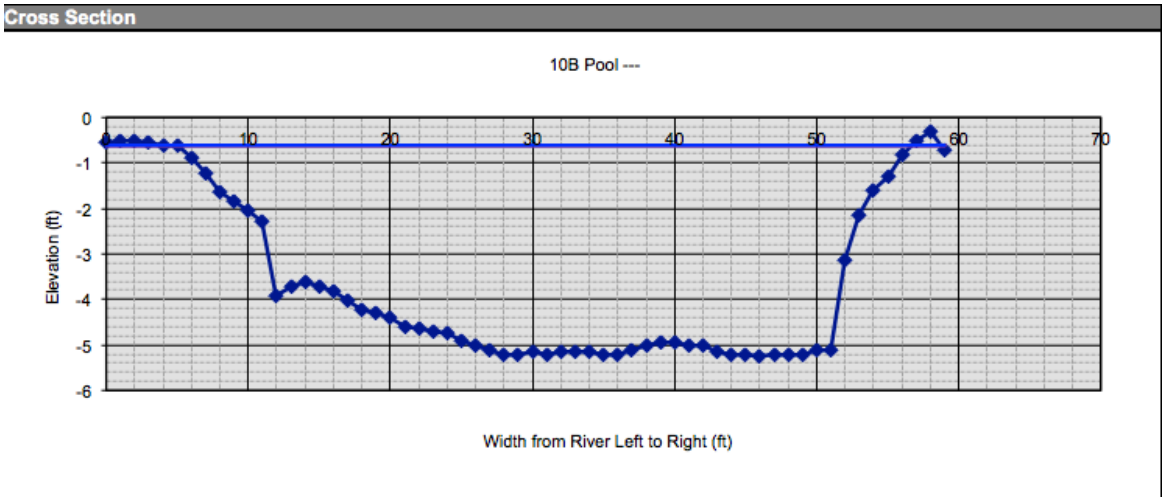
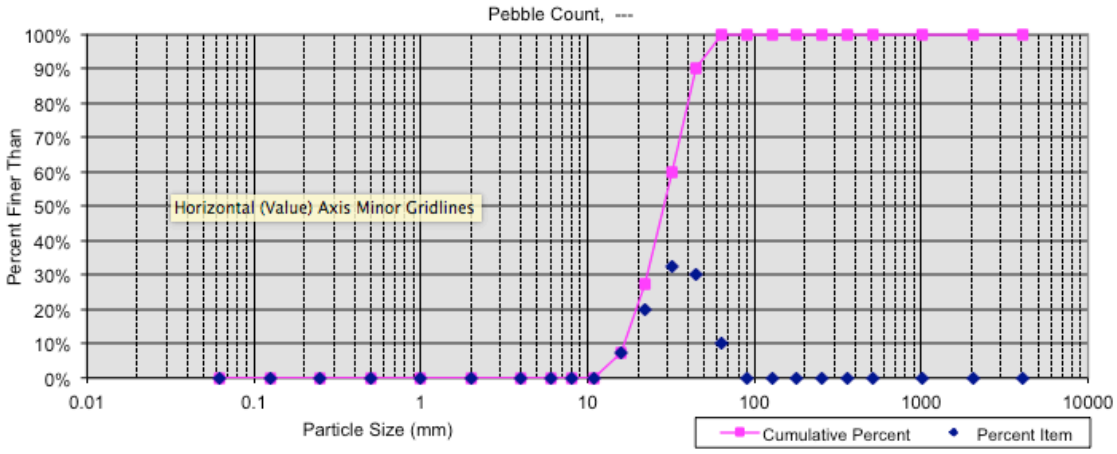


Figure 67. The 2017 stream profile at Site 10B Pool. The latitude/longitude coordinates for the left stake is N 45° 11' 36.8" W 112° 40' 43.4" and the right stake N 45° 11' 36.9" and W 112° 40' 42.6". The linear blue line represents the bankfull stage.

Site 10B Pebble Count



Size percent less than (mm)					Percent by substrate type					
D16	D35	D50	D84	D95	silt/clay	sand	gravel	cobble	boulder	bedrock
18.319	23.99	28.5	42	54	0%	0%	100%	0%	0%	0%

Figure 68. The Site 10B Pool yielded a total of 40 pebbles collected. The pool site was entirely composed of gravel.

Combined Site 10 Data

Given the proximity of the riffle and pool cross sections, widths, depths, gradient, and sinuosity were collected as a whole. The average water depth for Site 10 was 1.59 ft and the average width 43.01 ft (Figures 69 and 70). The sinuosity for the site was 1.48 and the gradient 0.12%.

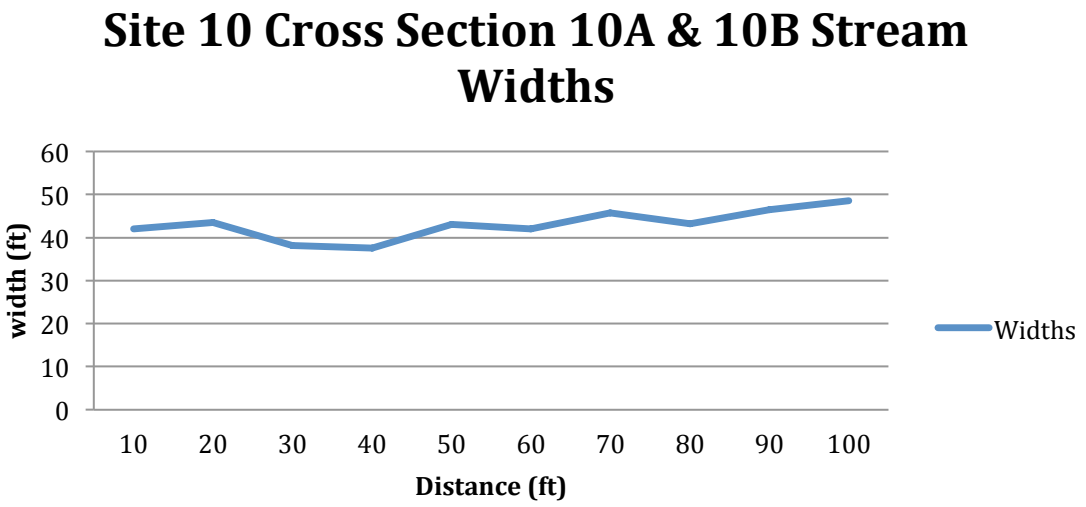


Figure 69. The combined widths at Site 10 shows the average width at 43.01 ft. The widths were taken at 10 evenly spaced locations that covered the riffle and pool sites.

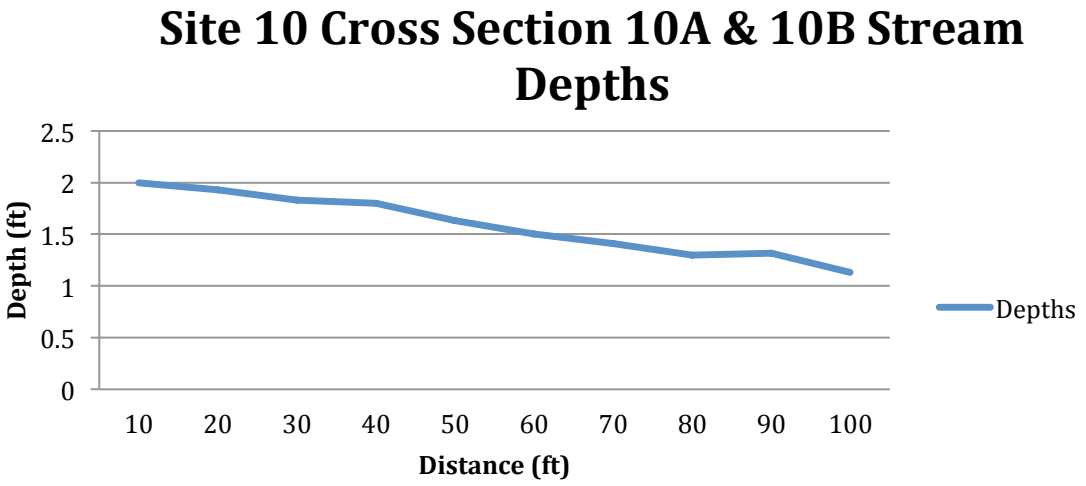


Figure 70. The combined depths at Site 10 shows the average depth of 1.59 ft. The depths were taken from three positions at 10 evenly spaced locations that covered the riffle and pool sites.

The sinuosity of Poindexter Slough is 1.39 (Figure 71). This indicates that the stream is not very sinuous. It cannot be expected for the Poindexter Slough to become much more sinuous on its own due to the stable, highly vegetated banks. The gradient of Poindexter Slough is 0.18% and is unlikely to change (Figure 72). This low gradient may contribute to the deposition of sediments in the streambed.

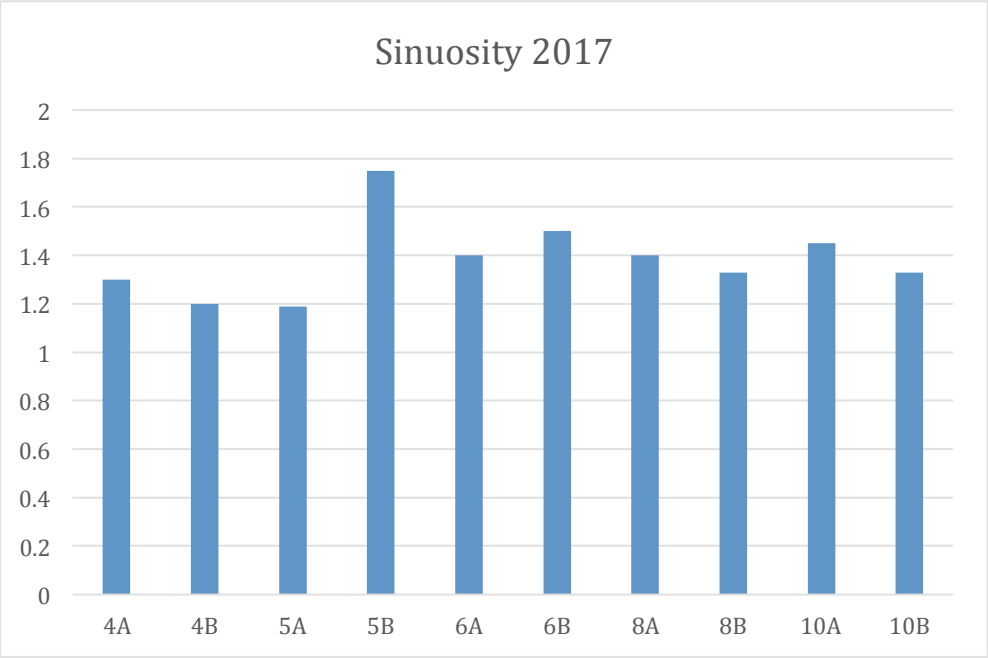


Figure 71. Sinuosity of Poindexter Slough at sites 4 through 10.

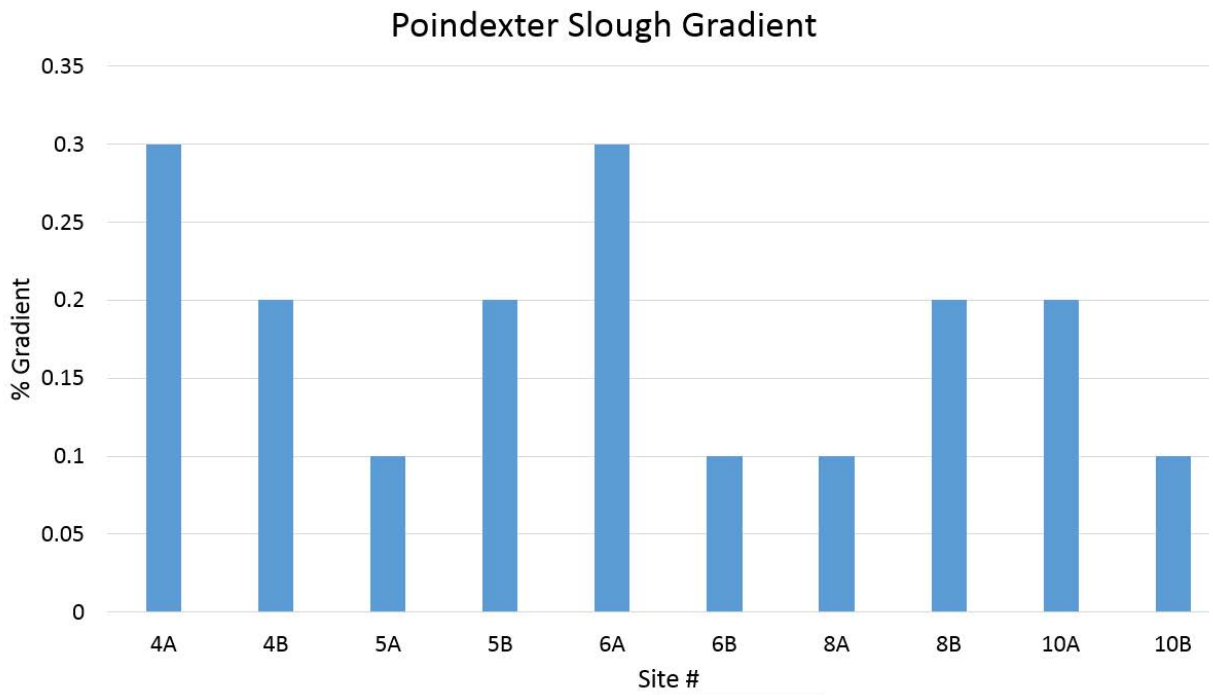


Figure 72. Gradient of Poindexter Slough at sites 4 through 10.

The width to depth ratio of Poindexter Slough is 20.3 (Figure 73). This shows that majority of Poindexter Slough is narrow with a consistent depth. This type of stream provides more shade and protection compared to the more "U shaped" stream bed found currently on Poindexter Slough. A "C type" stream also provides better habitat under low flow conditions compared to the current conditions at Poindexter Slough.

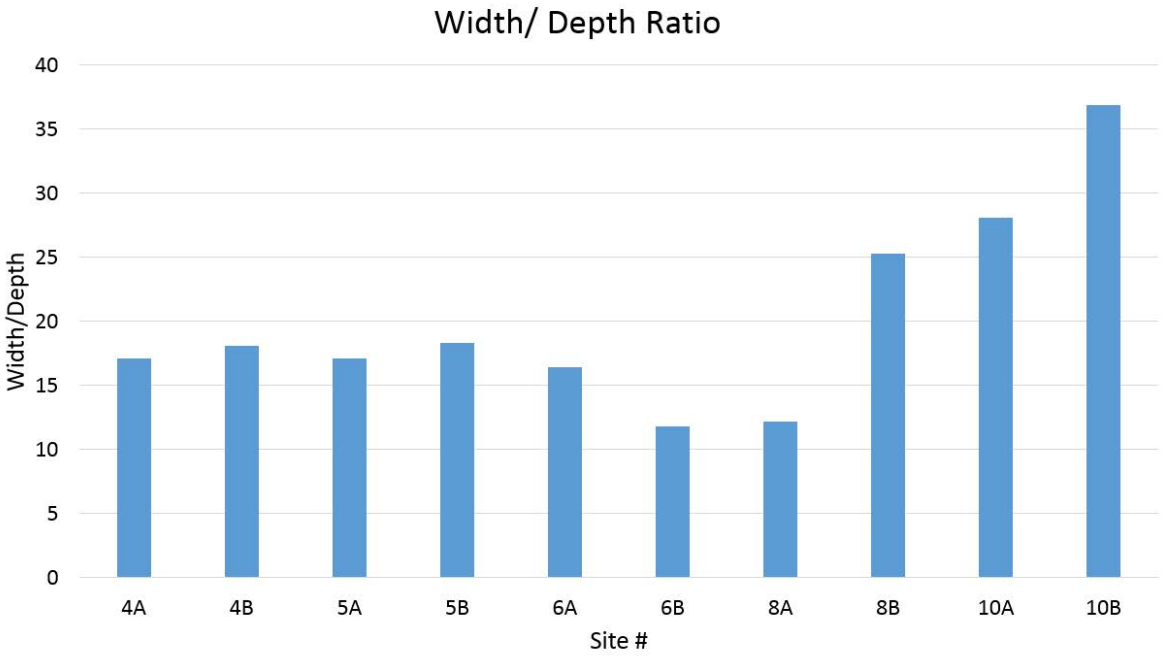


Figure 73. The width depth ratios at Poindexter Slough for sites 4 through 10.

ANALYSIS

In Fall 2014 Poindexter Slough was divided into ten cross sections as well as one control cross section and assessed by the 2014 University of Montana Western Field Studies class. At each cross section a stream profile, pebble size assessment, and BEHI measurements were recorded in a pool and a riffle. Since then the upper half of the slough, sites 1 through six, has been mechanically altered from the Poindexter Slough diversion head gate to the Dillon Canal head gate. Sites 7 through 10 from the Dillon canal to the Poindexter Slough Beaverhead River confluence has been unaltered since the 2014 class recorded their data. There has been a significant change in the stream profile and sediment sizes in the first six sites due to this mechanical alteration. The 2017 University of Montana Western Field Studies Class gathered data at cross sections 4, 5, 6, 8, and 10 at the same locations as the 2014 class. Below is a comparison of stream morphology from 2014 to 2017, before and after the stream had been mechanically altered.

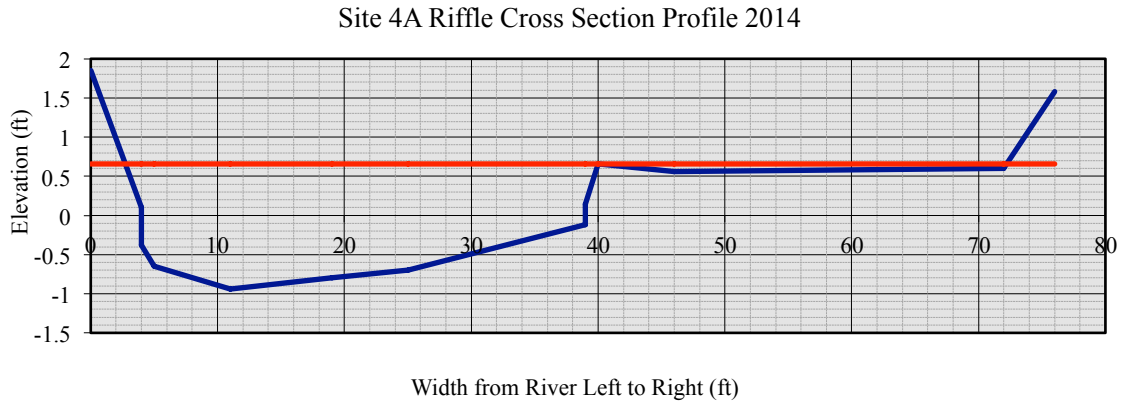
COMPARISON OF SITES 4 THROUGH 10

During the winter 2014, sites 1 through 6 were mechanically altered in an effort to reduce fine-grained sediments and restore the streams natural fishery. The cross sections generated from the 2014 survey showed that the stream profiles were symmetric and full of fine-grained sediments. The sediment was not sufficient habitat for spawning and provided poor conditions for a productive fishery. The work done during the winter of 2014 has returned the stream to an asymmetric profile dominated by gravel instead of fine sediments. Figures below show the stream profile at sites 4, 5, 6, 8, and 10 in 2017 compared to 2014, each site shows this comparison at a riffle and a pool.

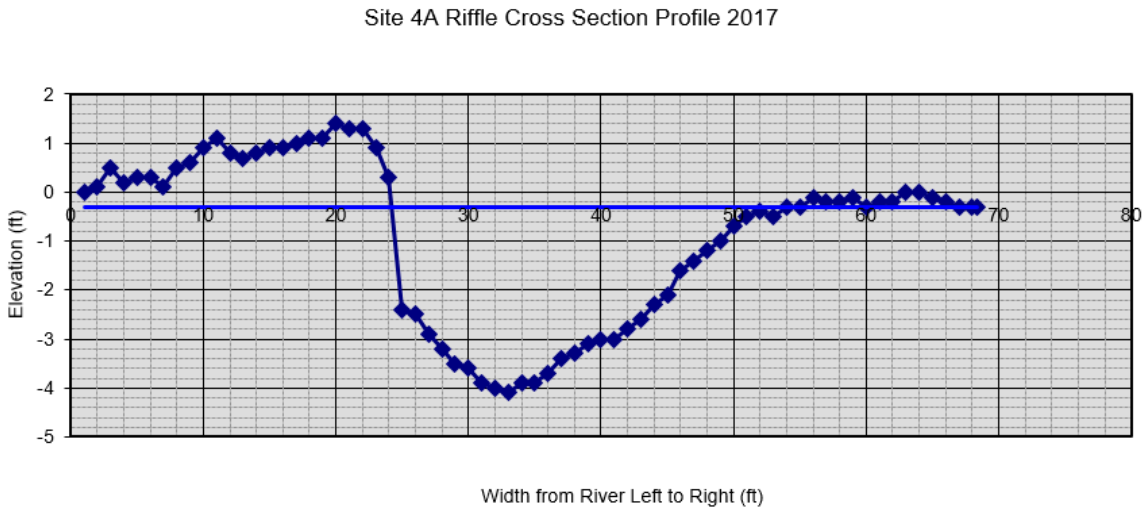
Site 4

Riffle Comparison

2014:



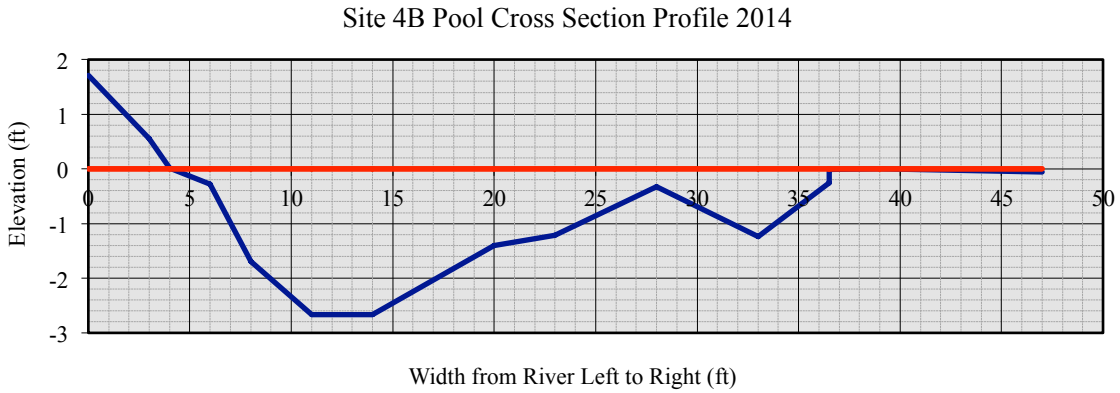
2017:



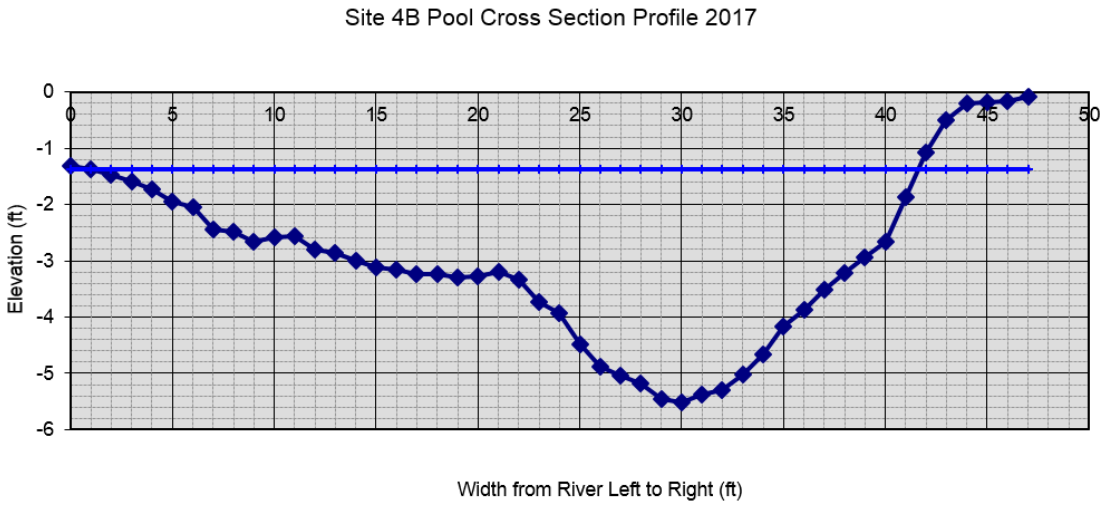
Site 4

Pool Comparison

2014:



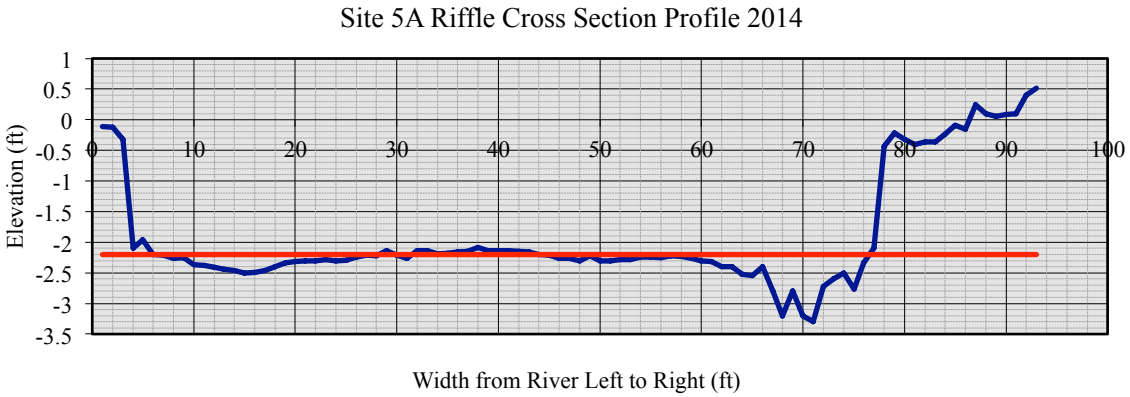
2017:



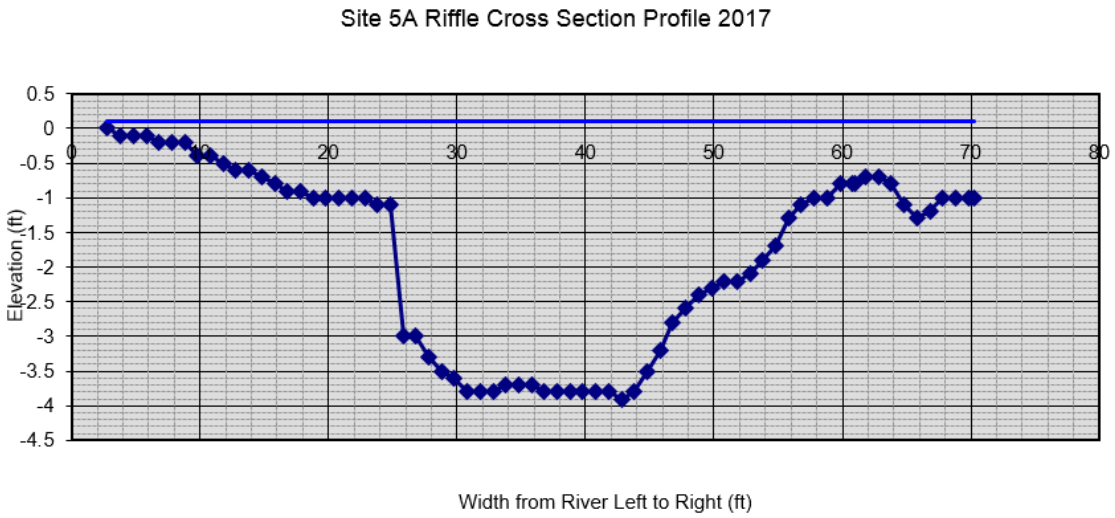
Site 5

Riffle Comparison

2014:



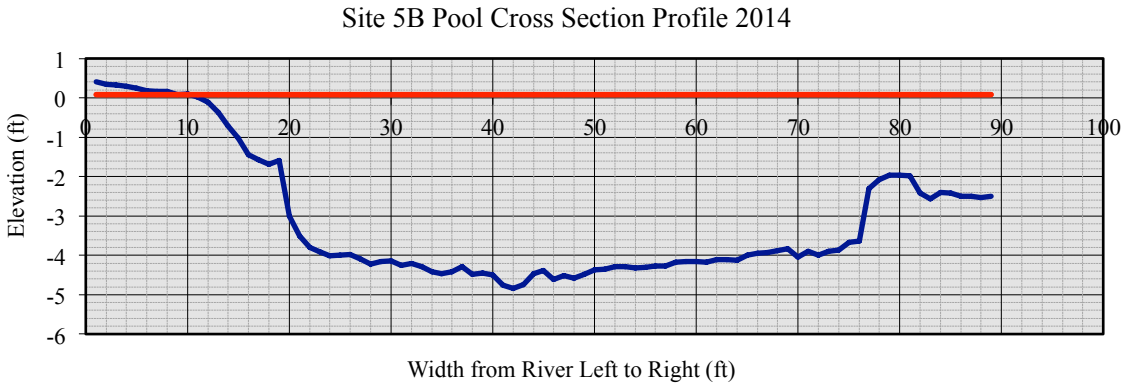
2017:



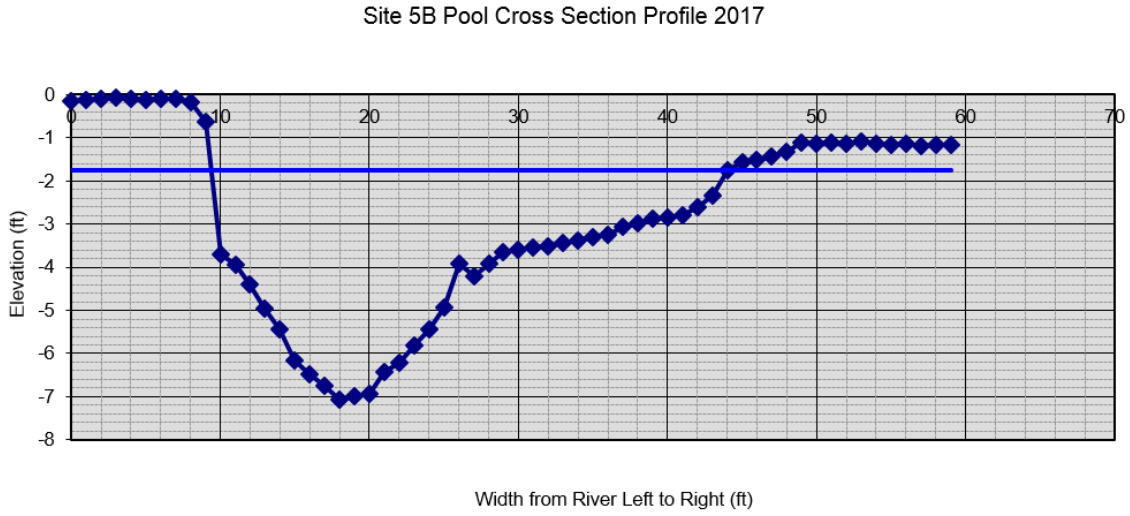
Site 5

Pool Comparison

2014:



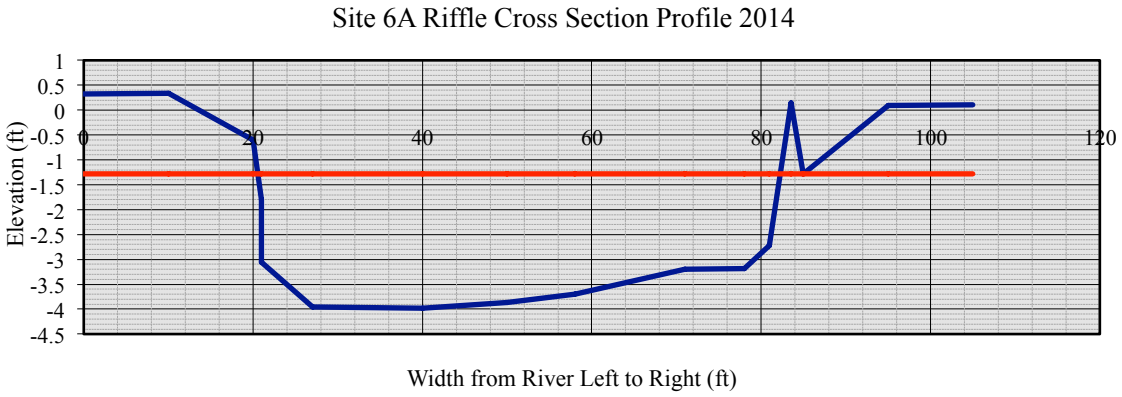
2017:



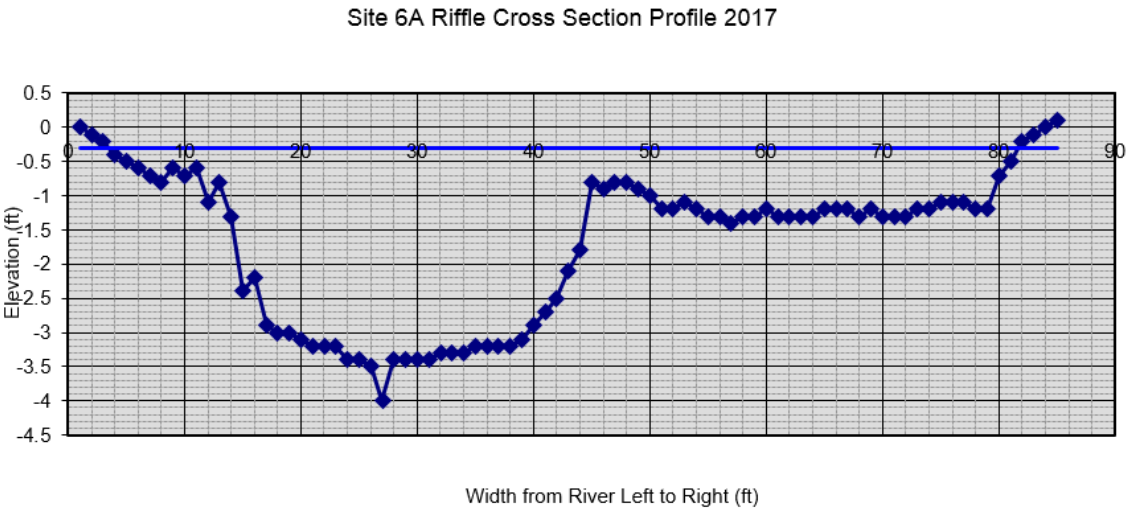
Site 6

Riffle Comparison

2014:



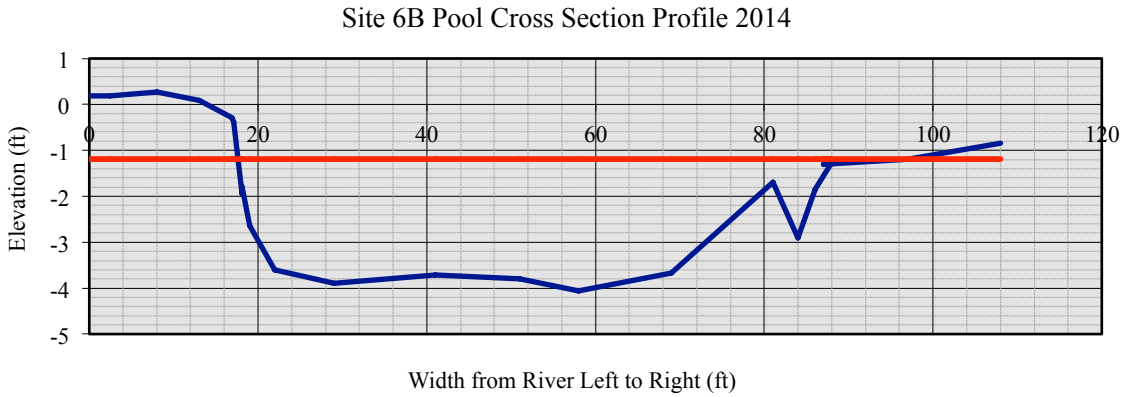
2017:



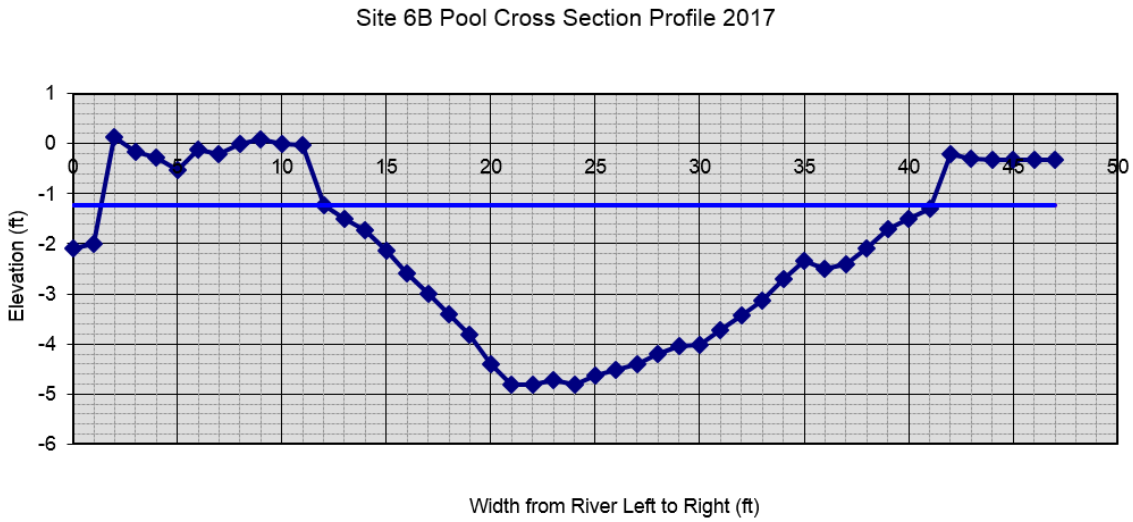
Site 6

Pool Comparison

2014:



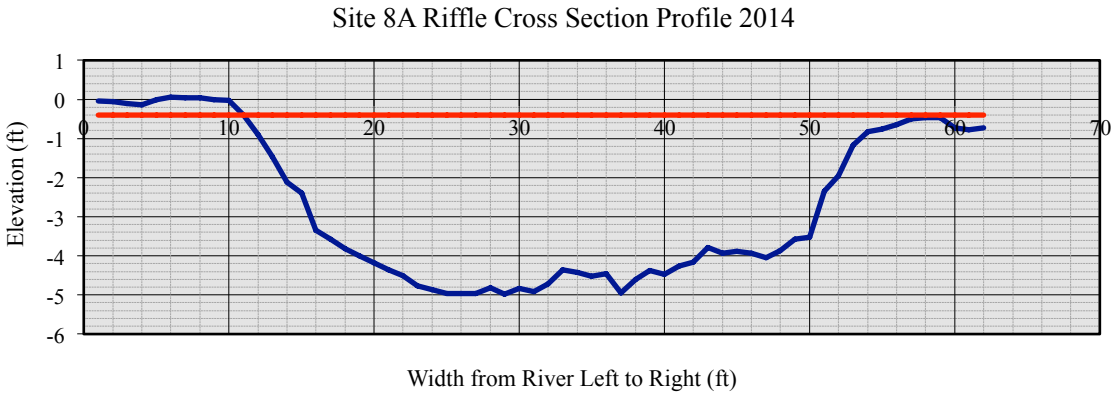
2017:



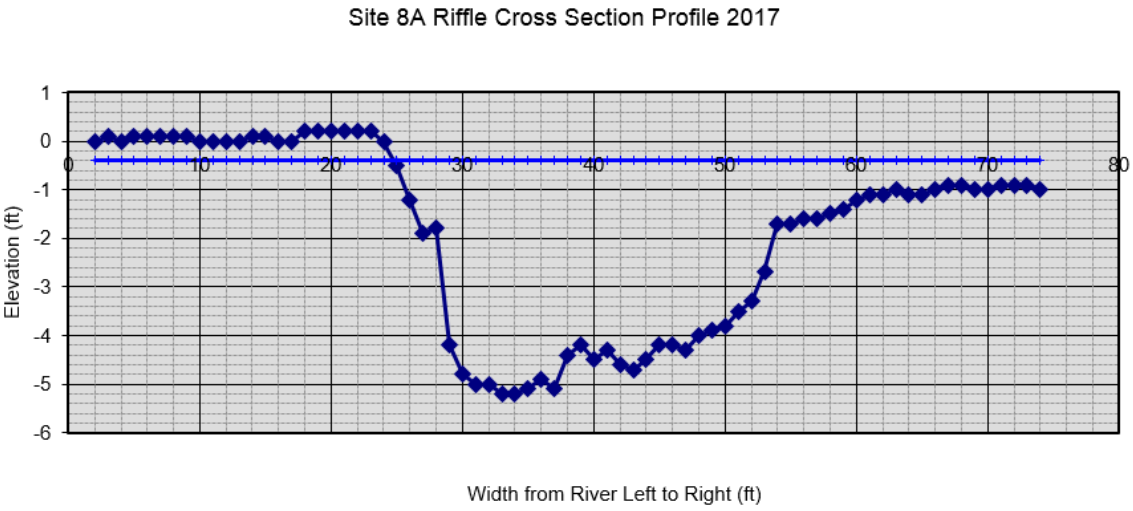
Site 8

Riffle Comparison

2014:



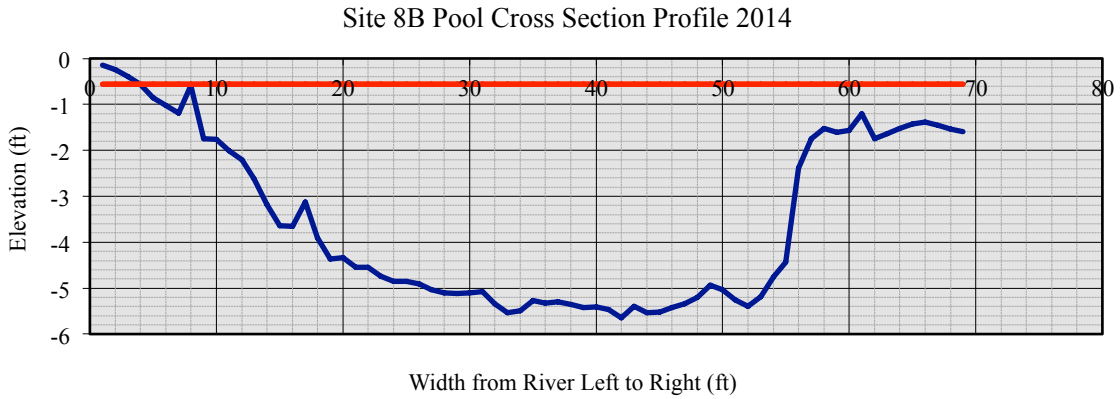
2017:



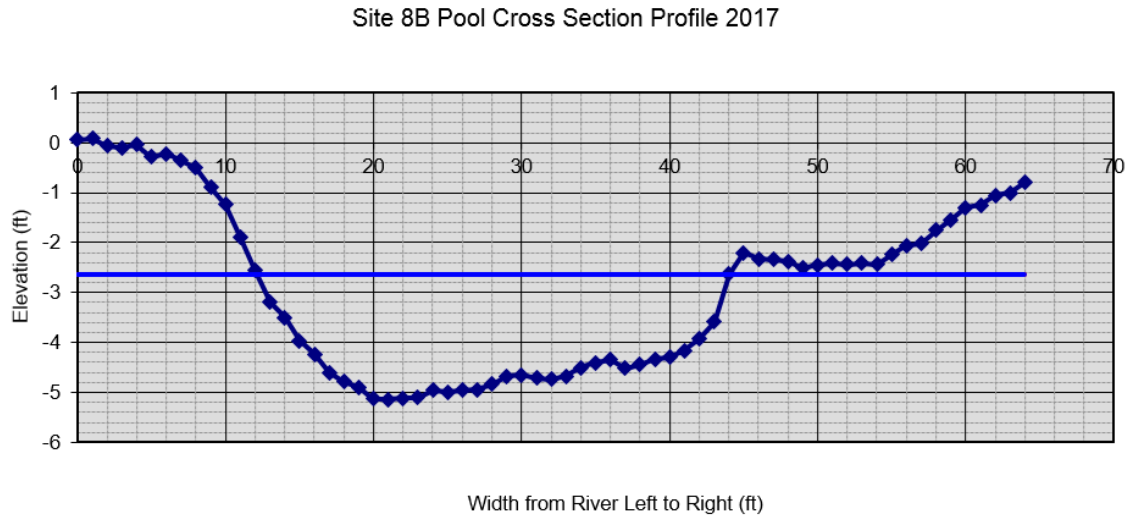
Site 8

Pool Comparison

2014:



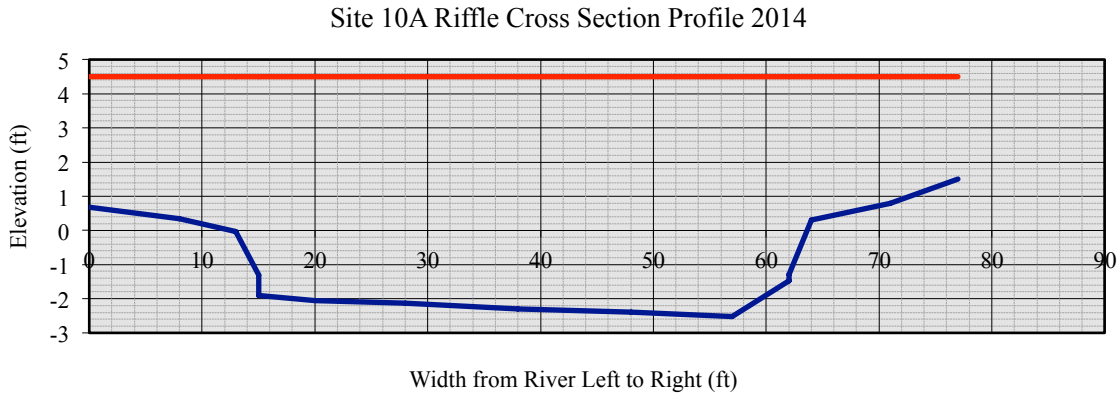
2017:



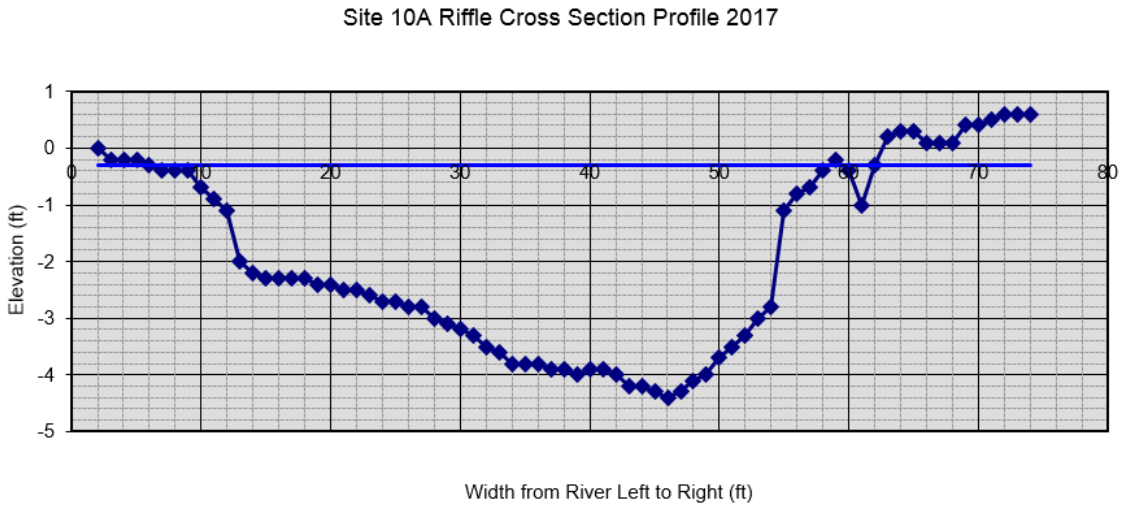
Site 10

Riffle Comparison

2014:



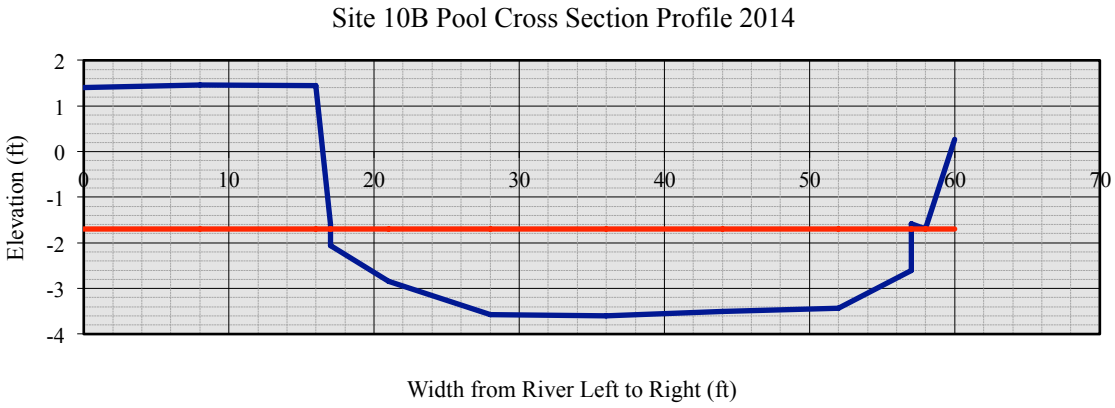
2017:



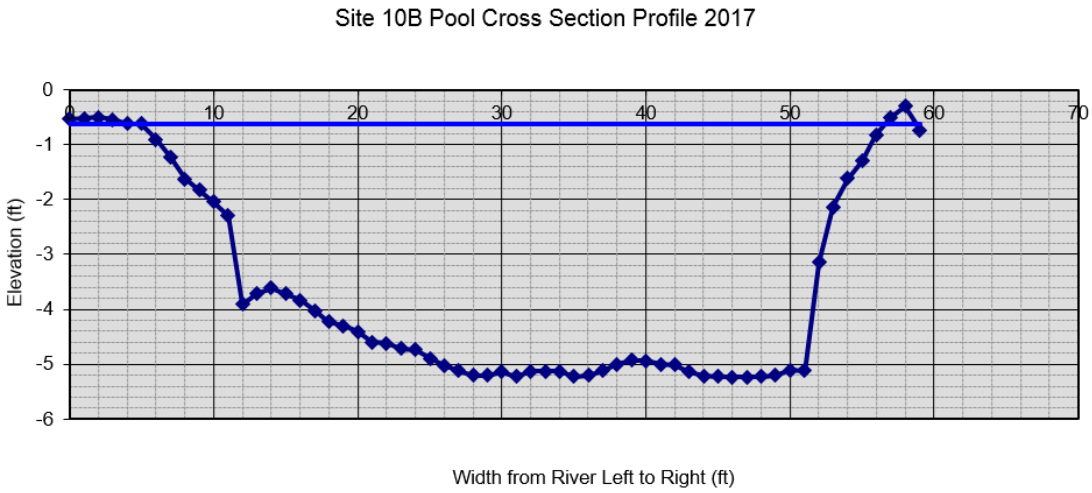
Site 10

Pool Comparison

2014:



2017:



MACROINVERTEBRATE SURVEY

INTRODUCTION

The purpose of the macroinvertebrate survey was to determine the types and relative percentages of macroinvertebrates in the restored segments of Poindexter Slough. This was a comparative study, for restoration work completed by Montana Fish Wildlife and Parks, made for determining the effects of the restoration project on Poindexter Slough. For this study, a total of 20 samples were taken from five sites throughout Poindexter Slough. A sample was obtained from a gravel site and a mud site at each cross section for the five different reaches. A total of two samples were collected at each of the two cross sections for sites 4, 5, 6, 8, and 10. Macroinvertebrates were quantitatively and systematically sampled by substrate type in order to better understand the environment different species inhabit.

The sampling sites were chosen from the basic substrate components of the stream itself (i.e., gravel and mud). Samples taken from specific substrate types creates a more accurate estimate of how organisms are distributed, both in diversity and abundance. More importantly, different habitats and cross sections respond differently to the restoration efforts, so it is important to assess how changes in morphology changed macroinvertebrate abundance and diversity. This data will provide insight into how the macroinvertebrate population responded to the restoration work on Poindexter Slough. In order to determine the familial diversity and richness on Poindexter Slough, Simpson's Similarity Index and Margalef's Richness Index values were calculated for each cross section measured in this study.

METHODS

Four samples were taken at five sites of Poindexter Slough. The samples were collected directly above or below each cross section depending on the proximity to the cross section markers. The samples were taken using a Serber Stream Bottom Sampler (Figure 74). The sampler was placed in the substrate type being sampled in an area with high enough flow to carry the debris into the net. A metal trowel was used to disrupt and loosen the macroinvertebrates inside the one square-foot area of the sampler for four minutes. The loose rocks were then cleaned by hand for one minute. The total sampling time was five minutes.

Figure 74. Using the Serber Sampler to take macroinvertebrate samples.

The contents of the substrate inside the one-foot square of the Serber Sampler were then washed into a connected net where they were trapped due to the current. The sampler was then removed from the water and held upside down and emptied into a white pan. While the net was inverted, a water bottle was used to pour water along the inside of the net to wash out the contents into the sample pan (Figure 75).

Figure 75. Washing the inverted net to remove remaining debris before removing macroinvertebrates into jars.

The contents of the net were picked through and organisms were collected using tweezers and pipets until movement was no longer noticed or until the time limit of 15 minutes was reached (Figure 76). The organisms were then placed into collection jars, which were filled with a 10% ethyl alcohol, 90% water solution and labeled. A separate collection jar was used for every sample taken from each gravel and mud site.

Figure 76. Macroinvertebrate samples being picked and placed into sample jars.

The jars of collected organisms were taken back to the lab for decanting and identification then organized and separated down to the family level in the majority of cases. The identifications were made by observing organisms under a dissecting microscope, while using a macroinvertebrate key for identification (Davies, 1994). Each organism was organized into separate, smaller sample jars and labeled using the cross section site number, as well as their family name (Figure 77).

The contents of each sample jar were counted and the number of specimens in each family was recorded. For classes Oligochaeta and Nematoda, and order Amphipoda, samples were not broken down to the Familial level due to difficulty in identification.

Figure 77. Sorting of samples into families using a dissecting microscope.

SIMPSON'S DIVERSITY INDEX

Once counted and identified, the Simpson's Diversity Index was used to measure familial diversity at each site. The Simpson's equation is as follows:

Part One:

$$D = \frac{\sum (n\,(n-1))}{(N\,(N-1))}$$

∑ = summation of numerator

n= number of individuals in the family/order

N = total number of individuals in the sample

Part two:

$$1 - D$$

This equation can be broken down into a few steps in the Excel program. Follow these step-by-step instructions referencing the example chart to complete the Simpsons Index. In column A list the name of the species found in the sample. In column B list the total number of organism's corresponding with each name. In cell C3, enter the function =B3*(B3-1) into the entry bar, this will take the value from column B and produce a value needed for the top line of the Simpsons equation. Once the function is entered into C3, move the cursor of the mouse to the bottom right corner of C3 cell to produce a black cross with no arrows. Click and drag the cursor down to the last name listed and this will complete the function for each cell a value is given. To produce a total of Column C, enter the formula =SUM(C3:C10) in cell C11. This value is the end value for the top half of the Simpsons equation. Enter a similar function into cell B11 to get the total for all B values. Cell B12 is the total in B11 minus 1. In cell B13 enter the function =B11*B12 to produce the end value for the bottom half of the Simpsons equation. To find the final Simpsons Index value, in cell D13 enter the function =1-(C11/B13). To repeat this process for all sites tested, copy and paste the working table to a new sheet and enter the new data. The functions will transfer over and will work even if rows are added for additional data.

	A	B	C	D
1	5BM	n	n(n-1)	
2	Species			
3	Lymnaeidae	1	0	
4	Corixidae	1	0	
5	Chironomidae	8	56	
6	Nematoda	1	0	
7	Amphipoda	10	90	
8	Isopoda	90	8010	
9		0	0	
10		0	0	
11		111	8156	
12		110		
13		12210		0.33202293

Figure 78. Excell spreadsheet format

This index allows for reference of diversity based on abundance of organisms (families, orders and classes) at each site. Once Simpson's Index numbers are calculated it is possible to generalize stream health. Since Simpson's Diversity Index represents the probability that invertebrates sampled from a community will belong to different families. The values range from zero to one. One represents perfect "evenness" which means individuals from the sample are even in abundance across the families collected. Therefore, the more even a sample is the higher the probability that the invertebrates belongs to a different family, and consequently represent more diversity. The Simpson's values for the 20 sites collected are shown in (Figure 79) using G to denote gravel and M to denote mud samples..

Simpson's Diversity Index

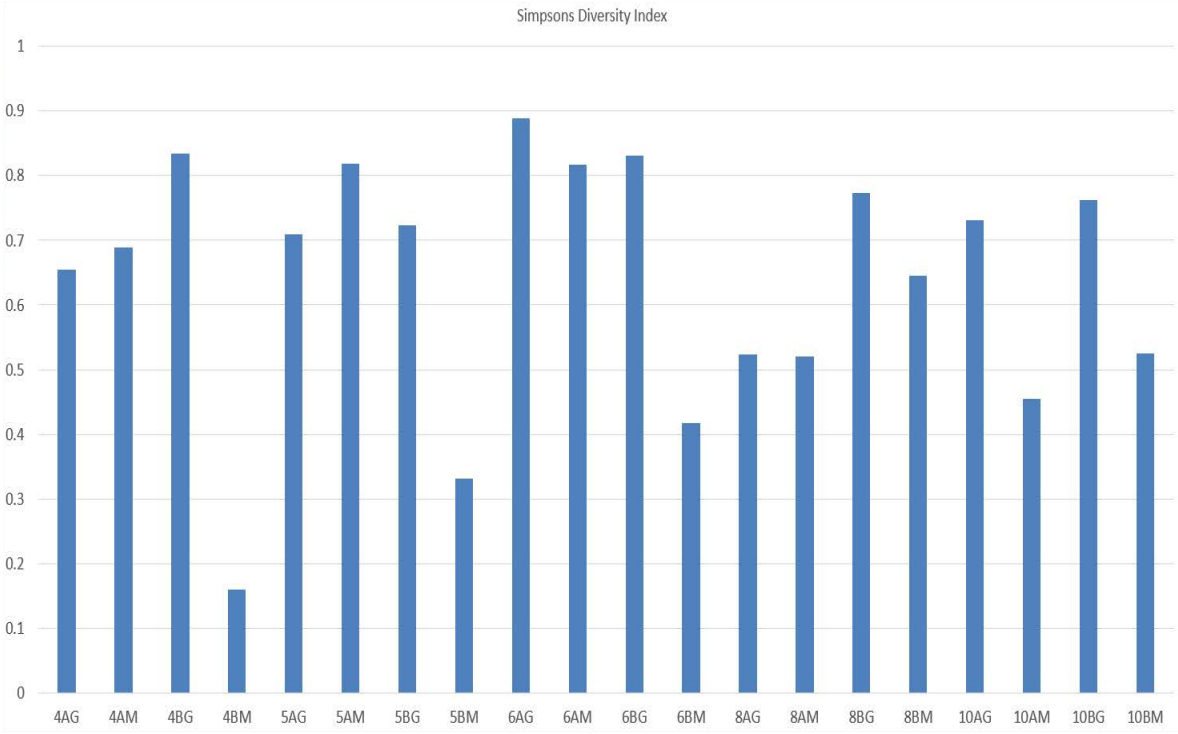


Figure 79. Simpson's Diversity Index values at the familial level for each cross section.

MARGALEF'S RICHNESS INDEX

Margalef's Richness Index was calculated to determine richness of orders weighted by total number of individuals. The Margalef's Index equation is as follows:

$$D = \frac{S-1}{\ln(N)}$$

S = total number of families with in cross section

In = natural log

N = total number of individuals in cross section

To double check the value computed from the Margalefs equation an online source was used. This source can be found at, https://www.easycalculation.com/statistics/margalef-richness-index-biodiversity.php Once computed the Margalef's Richness Index can be used to assess community richness based on total invertebrate population and number of families to which these invertebrates are assigned. Therefore, the higher the Margalef's Index number, the higher the community's family diversity or richness. It is possible to have a high richness count, but a low diversity count. Consider a high Margalef's Index number, which would imply that there are a high number of macroinvertebrate families, however if the total population "evenness" in this sample is skewed toward one family, the Simpson's Index will show low diversity because the population is dominated by one family. The Margalef's values for the 20 sites collected are shown in (Figure 80) using G to denote gravel and M to denote mud samples.

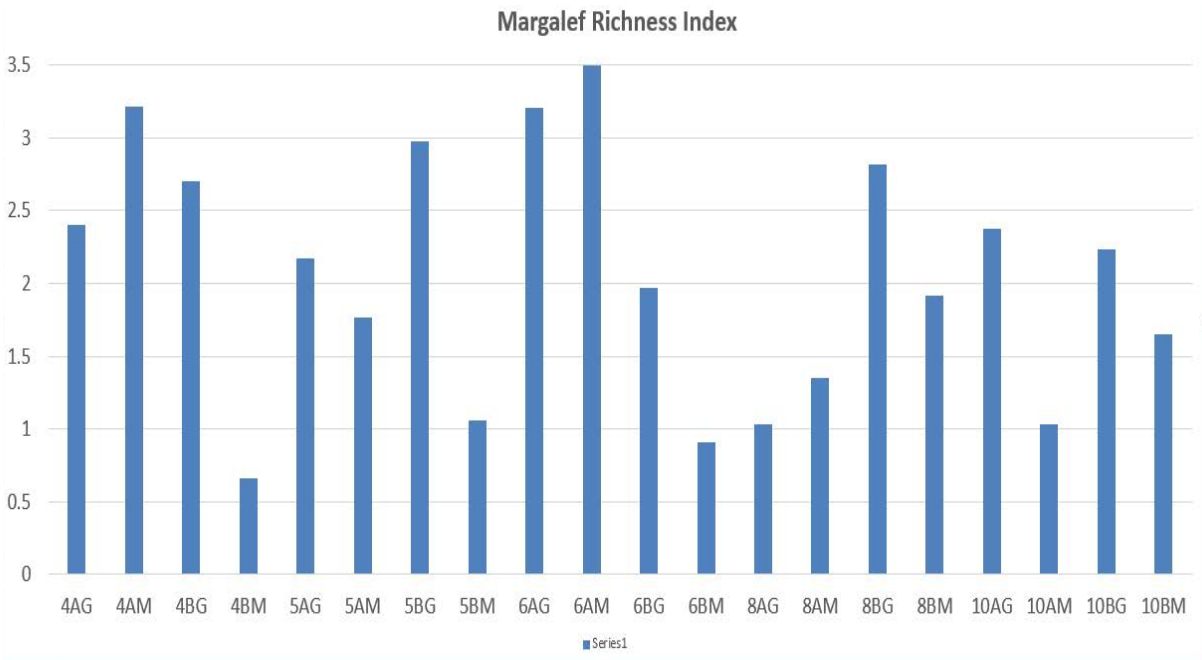


Figure 80. Margalef's Richness Index values at the familial level for each cross section.

DATA

The data shows the taxonomy and percent abundance of macroinvertebrates collected at each site. The samples were then picked on site using tweezers and pipets. The invertebrates were placed in a solution of ethyl alcohol and saved for later identification in the lab. For each cross section a Simpson's and Margalef's Index data as well as a pie diagram is shown to identify the percentage of every macroinvertebrates collected at that site. Because riparian macroinvertebrates are difficult to identify using morphology, they were classified to the level of family in this study. In few cases it was only possible to identify down to the class or order level. Families are named as they appear in the sample in a breakdown of the population percentages.

CROSS SECTIONS

Cross-Section 4A:

For Cross-Section 4A Gravel the Simpson's Similarity Index for this sample shows a taxonomic diversity value of 0.65. The Margalef's Index shows a taxonomic richness value of 2.40. A breakdown of the substrate type in this cross-section follows (Figure 81).

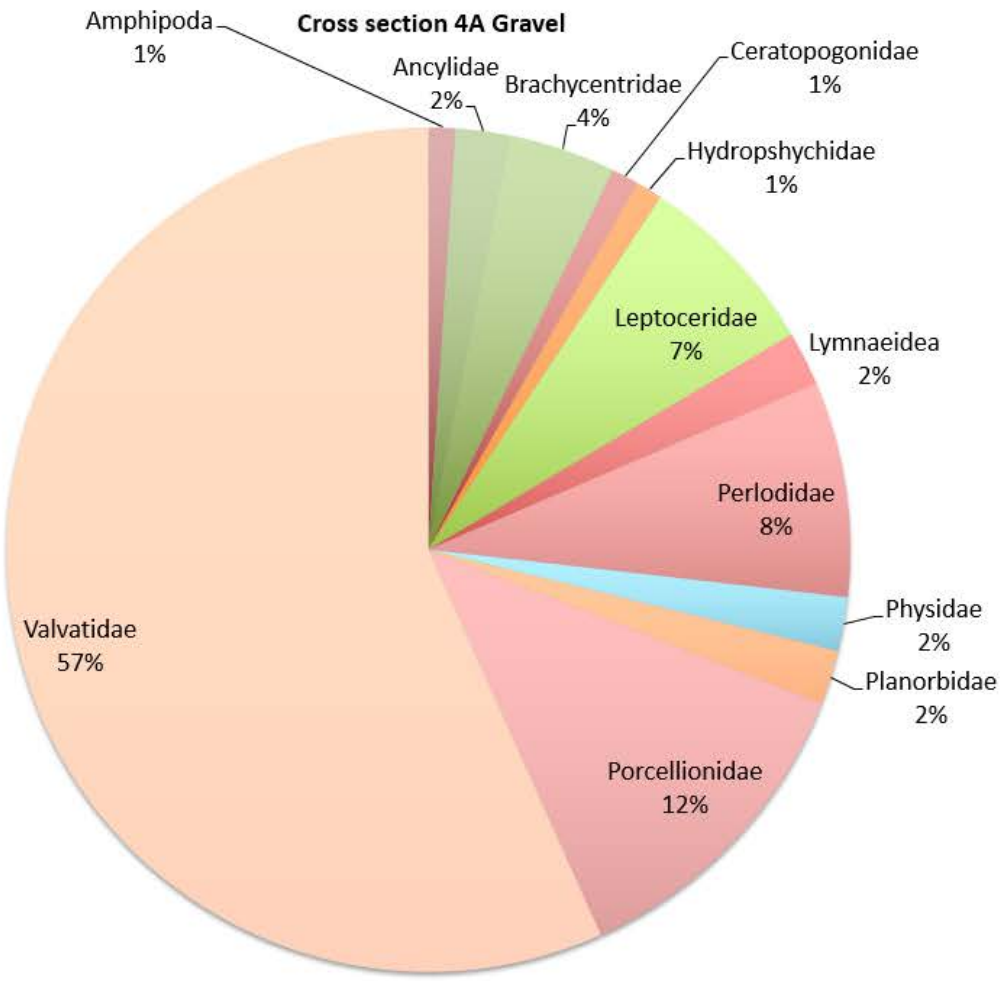


Figure 81. Section 4A Gravel was dominated by 57% Valvatidae, 12% Porcellionidae, and 8% Perlodidae. There were a total of 97 specimens collected

For Cross-Section 4A Mud the Simpson's Similarity Index for this sample shows a taxonomic diversity value of 0.69. The Margalef's Index shows a taxonomic richness value of 3.21. A breakdown of the substrate type in this cross-section follows (Figure 82).

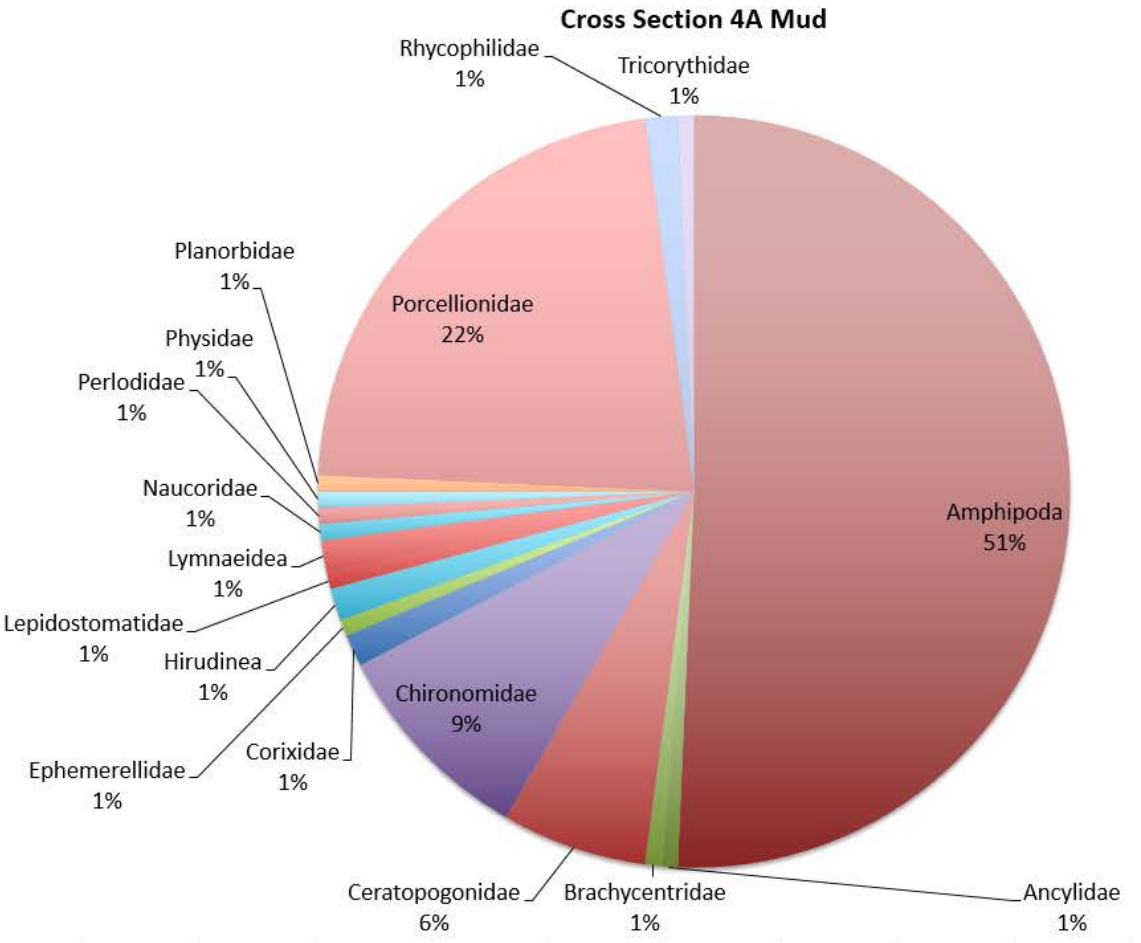


Figure 82. Section 4A Mud was dominated by 51% Amphipoda, 22% Porcellionidae, and 9% Chironomidae. There were a total of 144 specimens collected.

Cross Section 4B:

For Cross Section 4B Gravel the Simpsons Diversity Index for this sample shows a taxonomic diversity value of 0.83.The Margalef's Index shows a taxonomic richness value of 2.70. A breakdown of the substrate type in this cross-section follows (Figure 83).

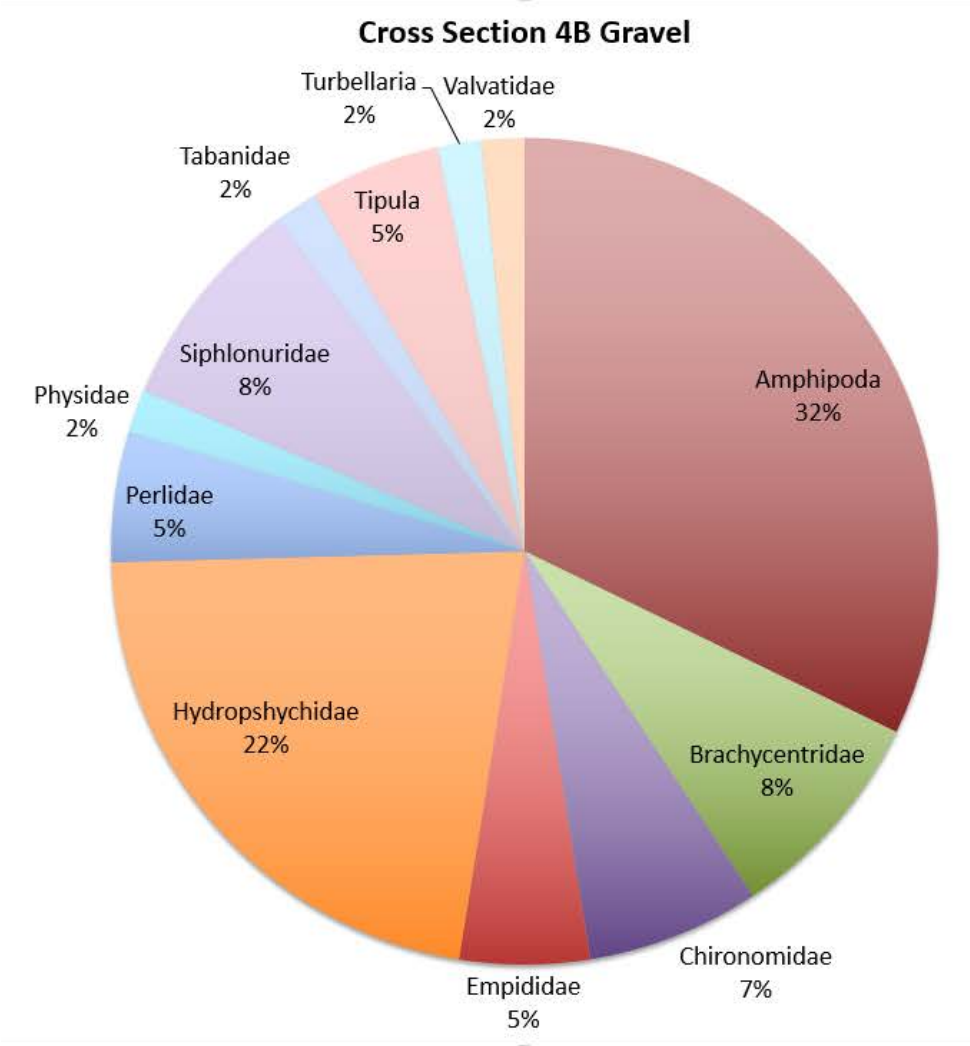


Figure 83. Section 4B Gravel was dominated by 32% Amphipoda, 22% Hydropshychidae, and 8% Brachycentridae and Siphlonuridae. There were a total of 59 specimens collected.

For Cross-Section 4B Mud the Simpson's Similarity Index for this sample shows a taxonomic diversity value of 0.16. The Margalef's Index shows a taxonomic richness value of 0.66. A breakdown of the substrate type in this cross-section follows (Figure 84).

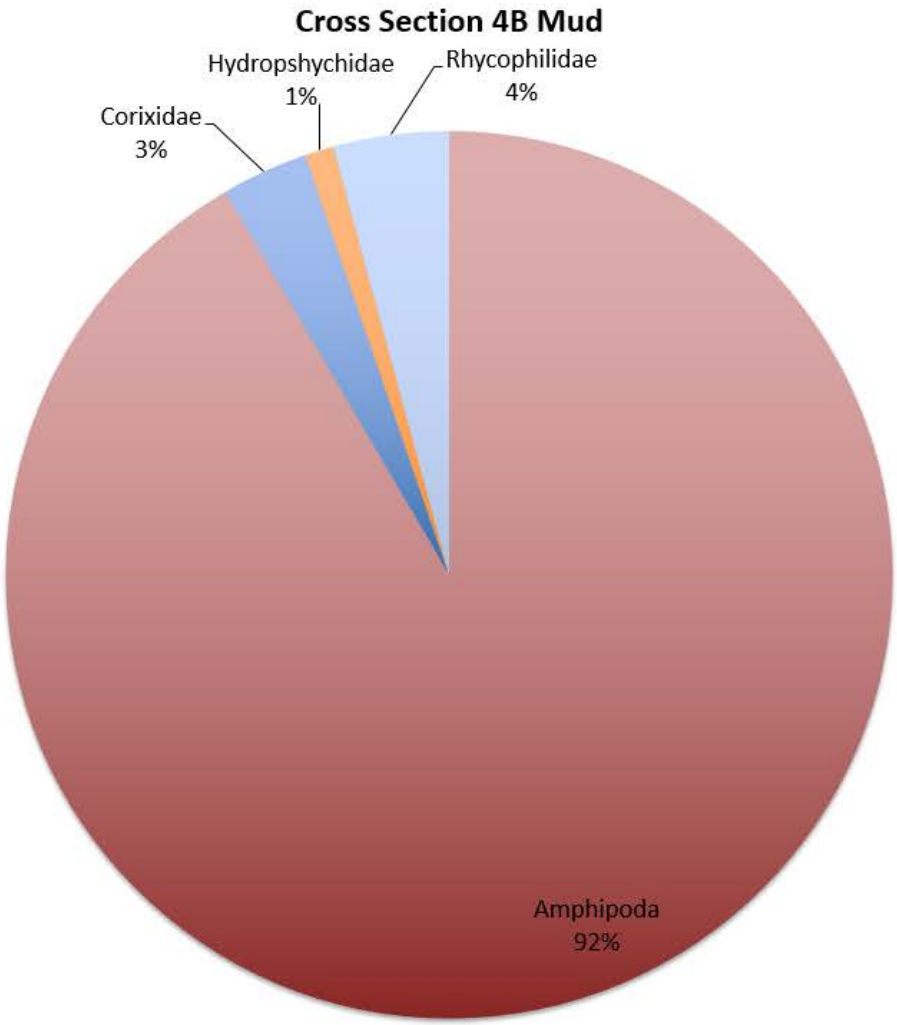


Figure 84. Section 4B Mud was dominated by 92% Amphipoda (Order), 4% Rhycophilidae, and 3% Corixidae. There were a total of 95 specimens collected.

Cross Section 5A:

For Cross Section 5A Gravel the Simpsons Diversity Index for this sample shows a taxonomic diversity value of .71. The Margalef's Index shows a taxonomic richness value of 2.17. A breakdown of the substrate type in this cross-section follows (Figure 85).

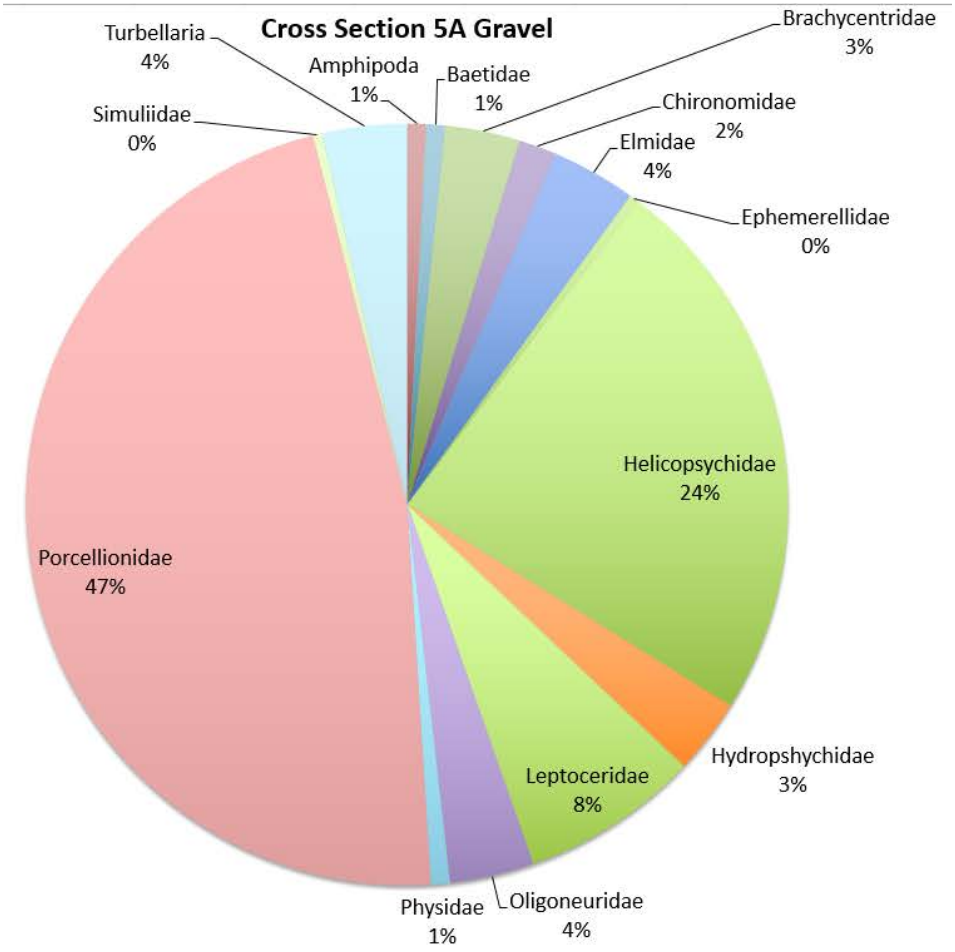


Figure 85. Section 5A Gravel was dominated by 47% Porcellionidae, 24% Helicopsychidae, and 8% Leptoceridae. There were a total of 251 specimens collected.

For Cross-Section 5A Mud the Simpson's Similarity Index for this sample shows a taxonomic diversity value of 0.82. The Margalef's Index shows a taxonomic richness value of 1.76. A breakdown of the substrate type in this cross-section follows (Figure 86).

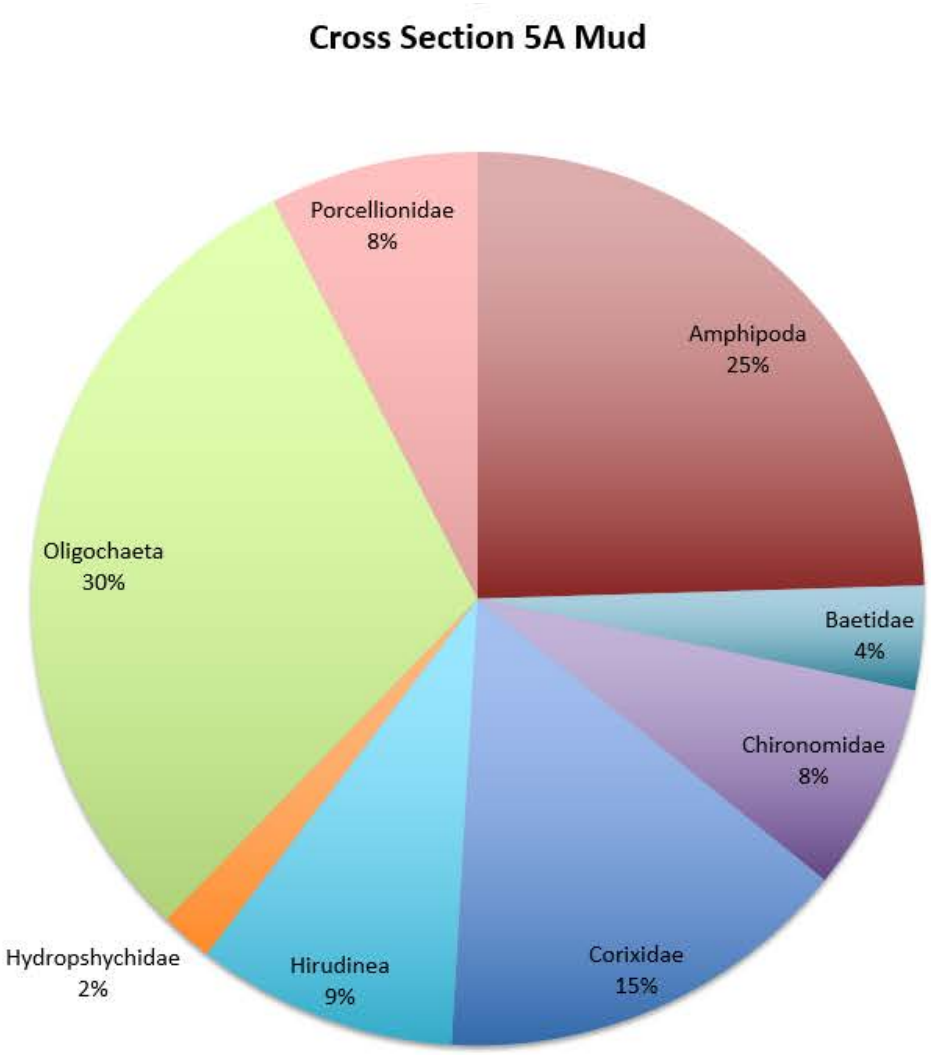


Figure 86. Section 5A Mud was dominated by 30% Oligochaeta, 25% Amphipoda, and 15% Corixidae. There were a total of 53 Specimans collected.

Cross-Section 5B:

For Cross Section 5B Gravel the Simpson's Similarity Index for this sample shows a taxonomic diversity value of 0.72. The Margalef's Index shows a taxonomic richness value of 2.98. A breakdown of the substrate type in this cross-section follows (Figure 87).

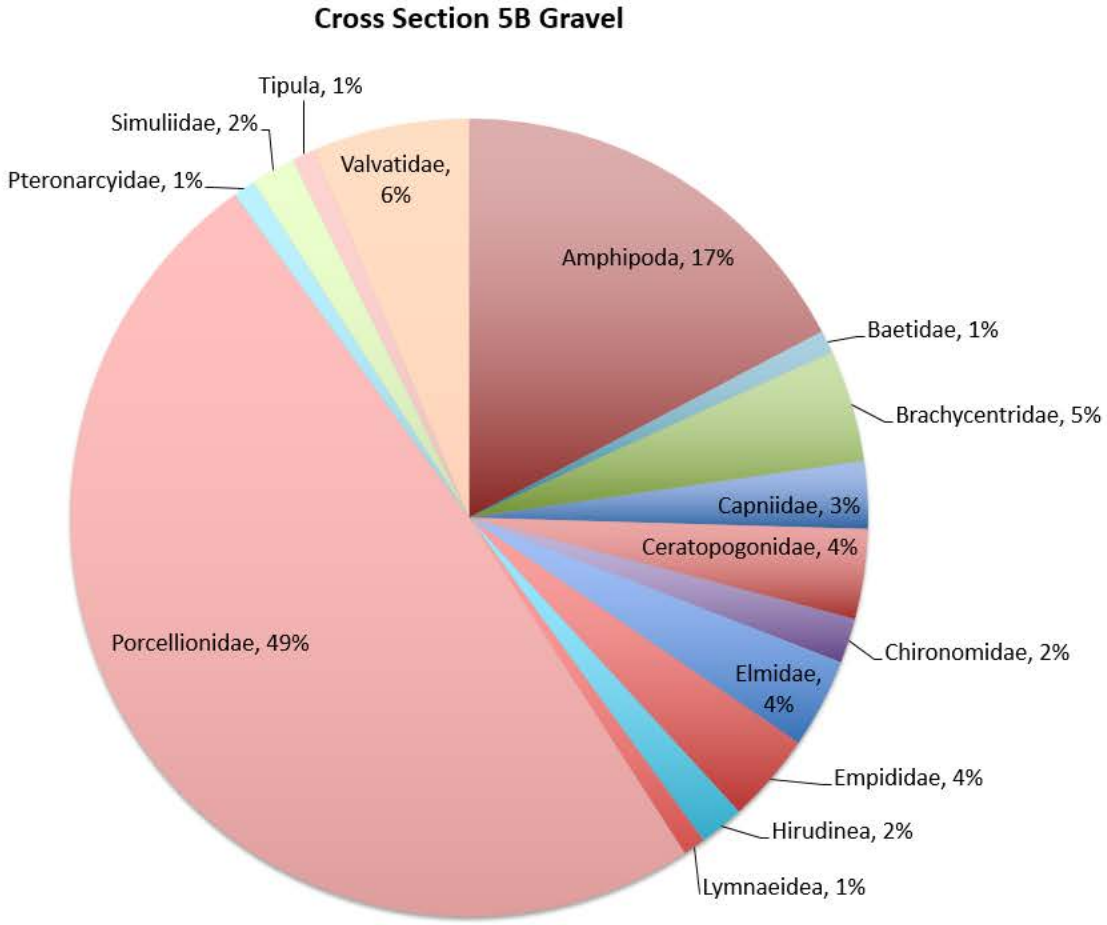


Figure 87. Section 5B Gravel was dominated by 49% Porcellionidae, 17% Amphipoda, and 6% Valvatidae. There were a total of 110 specimens collected.

For Cross-Section 5B Mud the Simpson's Similarity Index for this sample shows a taxonomic diversity value of 0.33. The Margalef's Index shows a taxonomic richness value of 1.06. A breakdown of the substrate type in this cross-section follows (Figure 88).

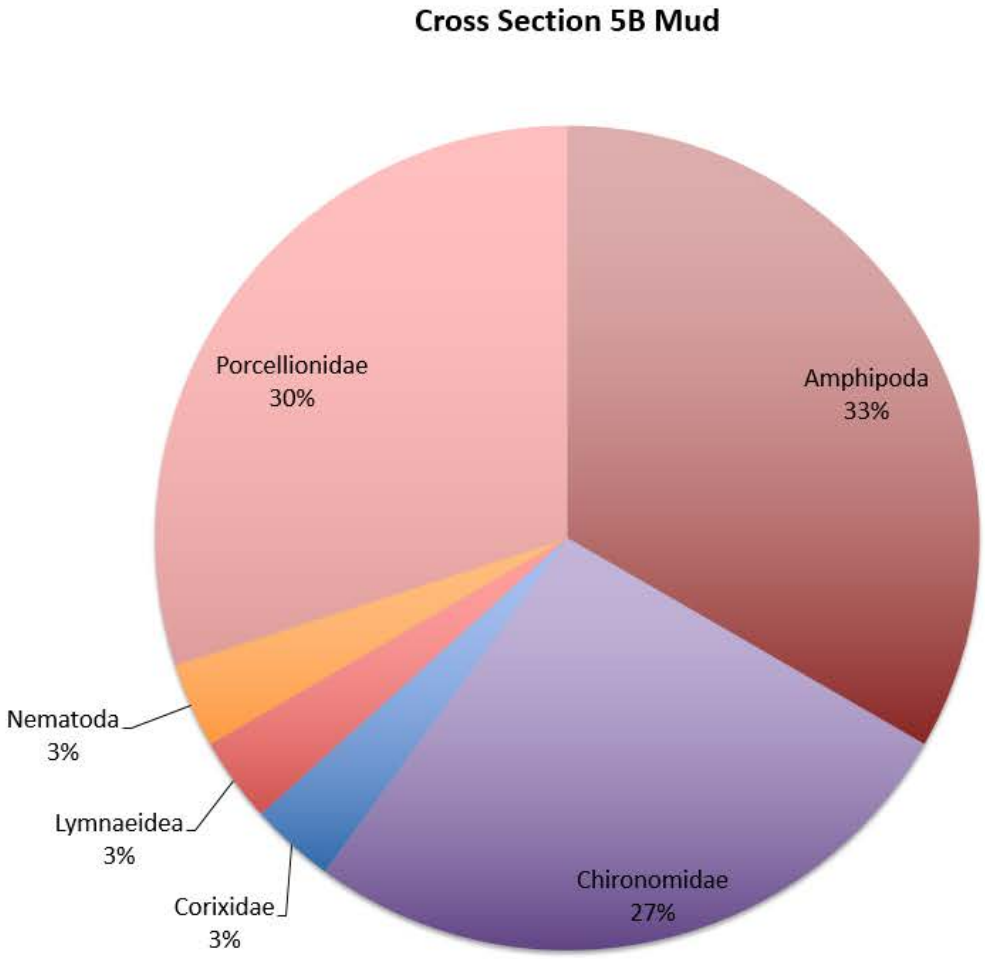


Figure 88. Section 5B Mud was dominated by 33% Amphipoda, 30% Porcellionidae, 27% Chironomidae. There were a total of 30 specimens collected.

Cross-Section 6A:

For Cross Section 6A Gravel the Simpson's Similarity Index for this sample shows a taxonomic diversity value of 0.89. The Margalef's Index shows a taxonomic richness value of 3.20. A breakdown of the substrate type in this cross-section follows (Figure 89).

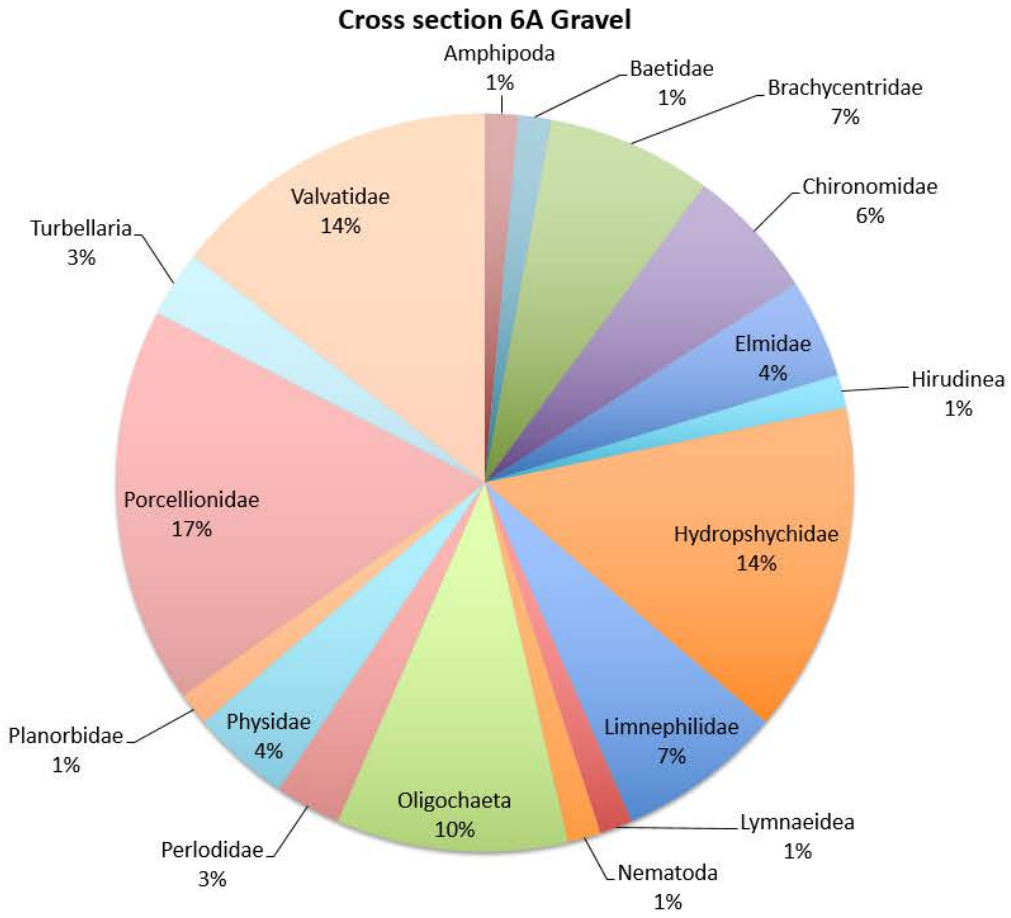


Figure 89. Section 6A Gravel was dominated by 17% Porcellionida, 14% Valvatidae, and 14% Hydropshychidae. There were total 69 specimens collected.

For Cross-Section 6A Mud the Simpson's Similarity Index for this sample shows a taxonomic diversity value of 0.82. The Margalef's Index shows a taxonomic richness value of 3.49. A breakdown of the substrate type in this cross-section follows (Figure 90).

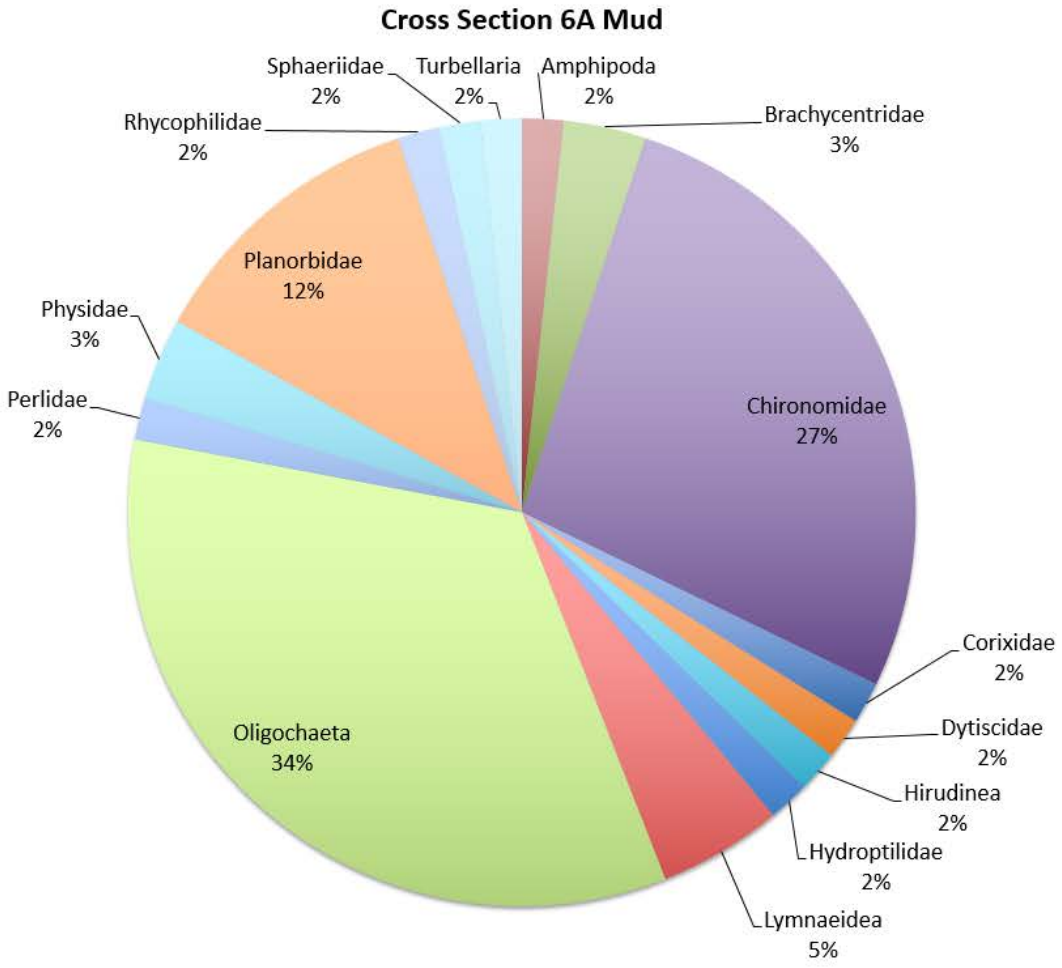


Figure 90. Section 6A Mud was dominated by 34% Oligochaeta, 27% Chironomidae, and 12% Planorbidae. There were a total of 59 specimens collected.

Cross-Section 6B:

For Cross-Section 6B Gravel the Simpson's Similarity Index for this sample shows a taxonomic diversity value of 0.83. The Margalef's Index shows a taxonomic richness value of 1.97. A breakdown of the substrate type in this cross-section follows (Figure 91).

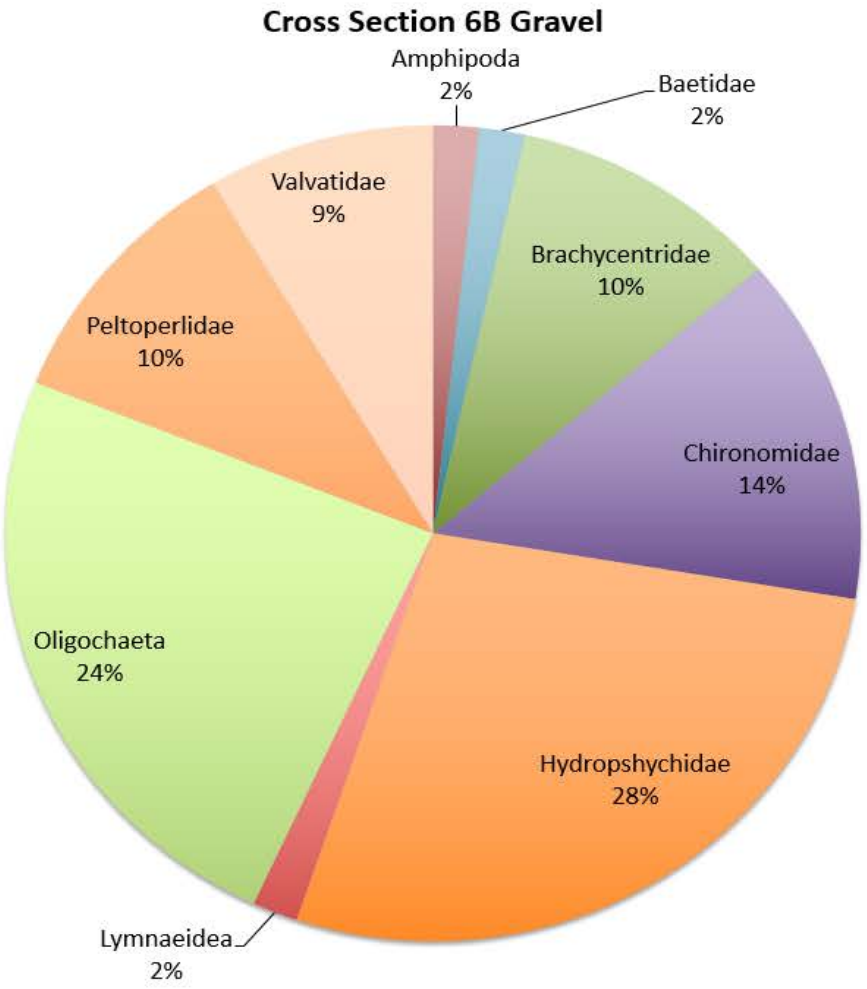


Figure 91. Section 6B Gravel was dominated by 28% Hydropshychidae, 24% Oligochaeta, and 14% Chironomidae. There were a total of 58 specimens collected.

For Cross-Section 6B Mud the Simpson's Similarity Index for this sample shows a taxonomic diversity value of 0.42. The Margalef's Index shows a taxonomic richness value of 0.91. A breakdown of the substrate type in this cross-section follows (Figure 92).

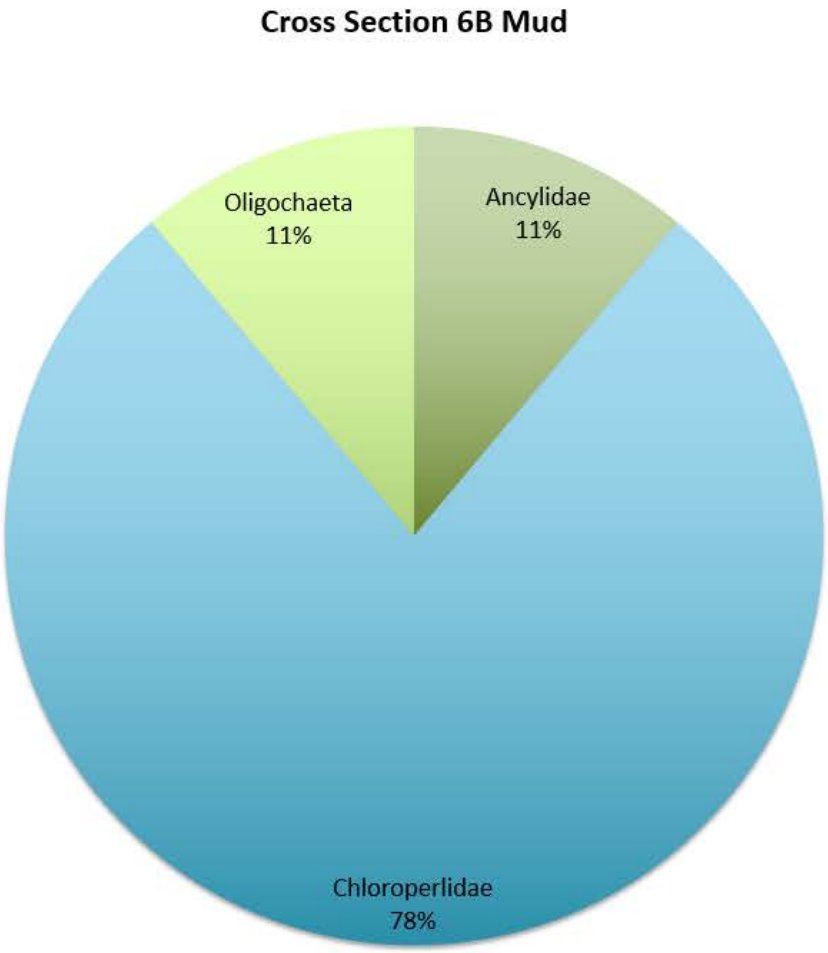


Figure 92. Section 6B Mud was dominated by 78% Chloroperlidae, 11% Oligochaeta, and 11% Ancylidae. There were a total of 9 specimens collected.

Cross-Section 8A:

For Cross Section 8A Gravel the Simpson's Similarity Index for this sample shows a taxonomic diversity value of 0.52. The Margalef's Index shows a taxonomic richness value of 1.03. A breakdown of the substrate type in this cross-section follows (Figure 93)

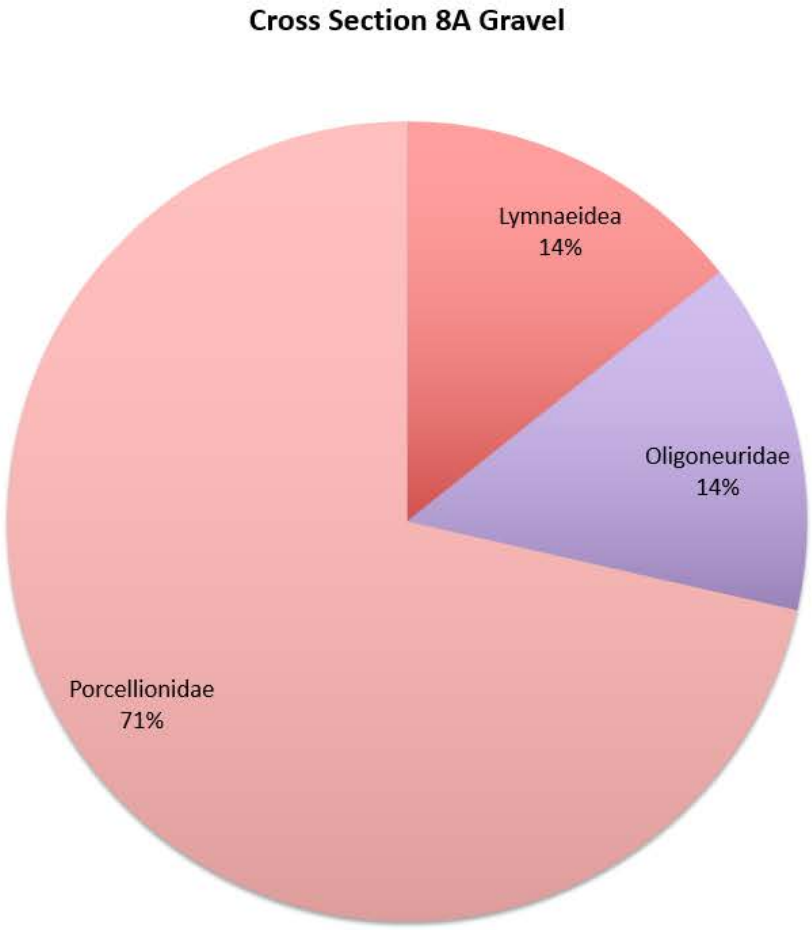


Figure 93. Section 8A Gravel was dominated by 71% Porcellionidae, 14% Lymnaeidea, and 14% Oligoneuridae. There were a total of 7 specimens collected.

For Cross-Section 8A Mud the Simpson's Similarity Index for this sample shows a taxonomic diversity value of 0.52. The Margalef's Index shows a taxonomic richness value of 1.35. A breakdown of the substrate type in this cross-section follows (Figures 94).

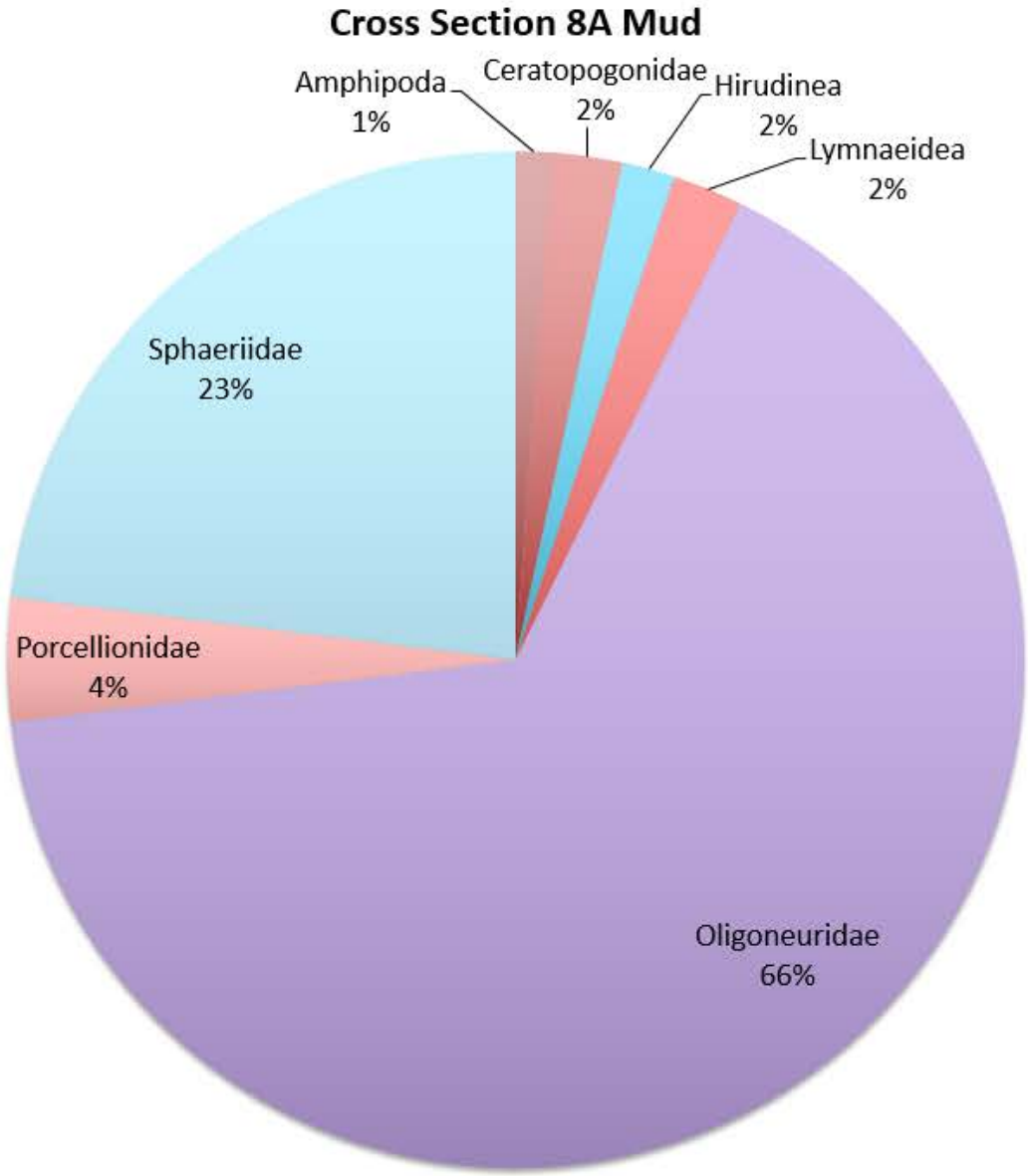


Figure 94. Section 8A Mud was dominated by 66% Oligoneuridae, 23% Sphaeriidae, and 4% Porcellionidae. There were a total of 178 specimens collected.

Cross-Section 8B:

For Cross Section 8B Gravel the Simpson's Similarity Index for this sample shows a taxonomic diversity value of 0.77. The Margalef's Index shows a taxonomic richness value of 2.81. A breakdown of the substrate type in this cross-section follows (Figure 95).

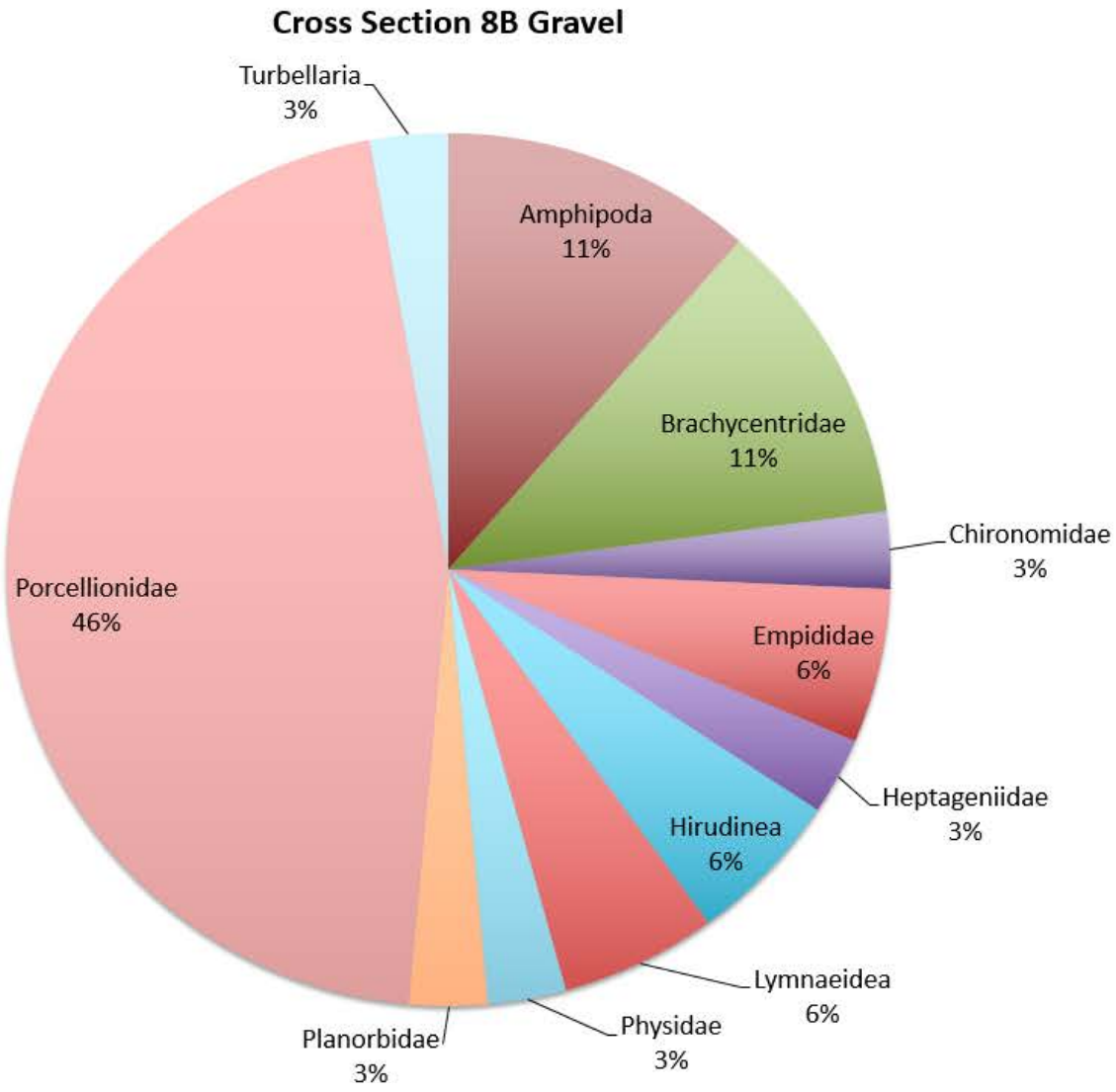


Figure 95. Section 8B Gravel was dominated by 46% Porcellionidae, 11% Amphipoda, and 11% Brachycentridae. There were a total of 35 specimens collected.

For Cross-Section 8B Mud the Simpson's Similarity Index for this sample shows a taxonomic diversity value of 0.65. The Margalef's Index shows a taxonomic richness value of 1.91. A breakdown of the substrate type in this cross-section follows (Figure 96).

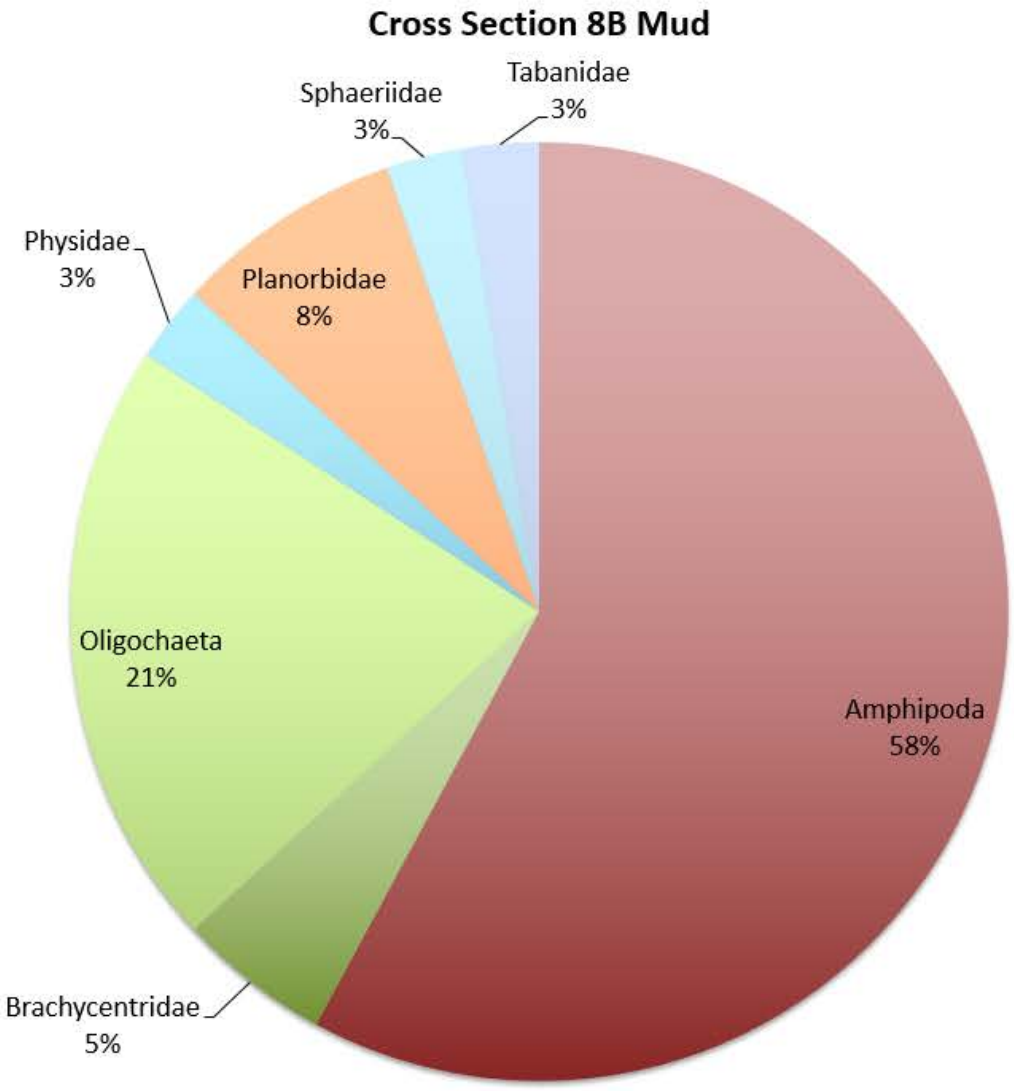


Figure 96. Section 8B Mud was dominated by 58% Amphipoda (Order), 21% Oligochaeta, and 8% Planoribidae. There were a total of 38 specimens collected.

Cross-Section 10A:

For Cross Section 10A Gravel the Simpson's Similarity Index for this sample shows a taxonomic diversity value of 0.73. The Margalef's Index shows a taxonomic richness value of 2.38. A breakdown of the substrate type in this cross-section follows (Figure 97).

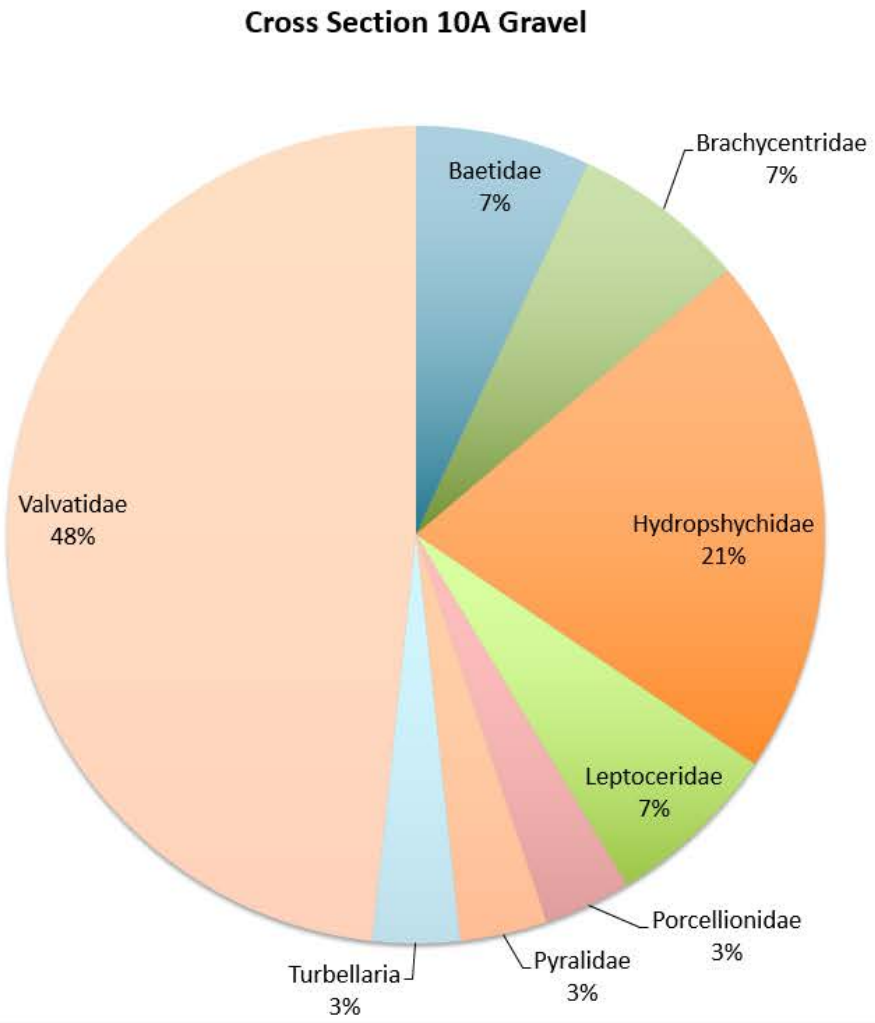


Figure 97. Section 10A Gravel was dominated by 48% Valvatidae, 21% Hydropshychidae, and 7% Baetidae, Leptoceridae, and Brachycentidae. There were a total of 29 specimens collected.

For Cross-Section 10A Mud the Simpson's Similarity Index for this sample shows a taxonomic diversity value of 0.45. The Margalef's Index shows a taxonomic richness value of 1.03. A breakdown of the substrate type in this cross-section follows (Figures 98).

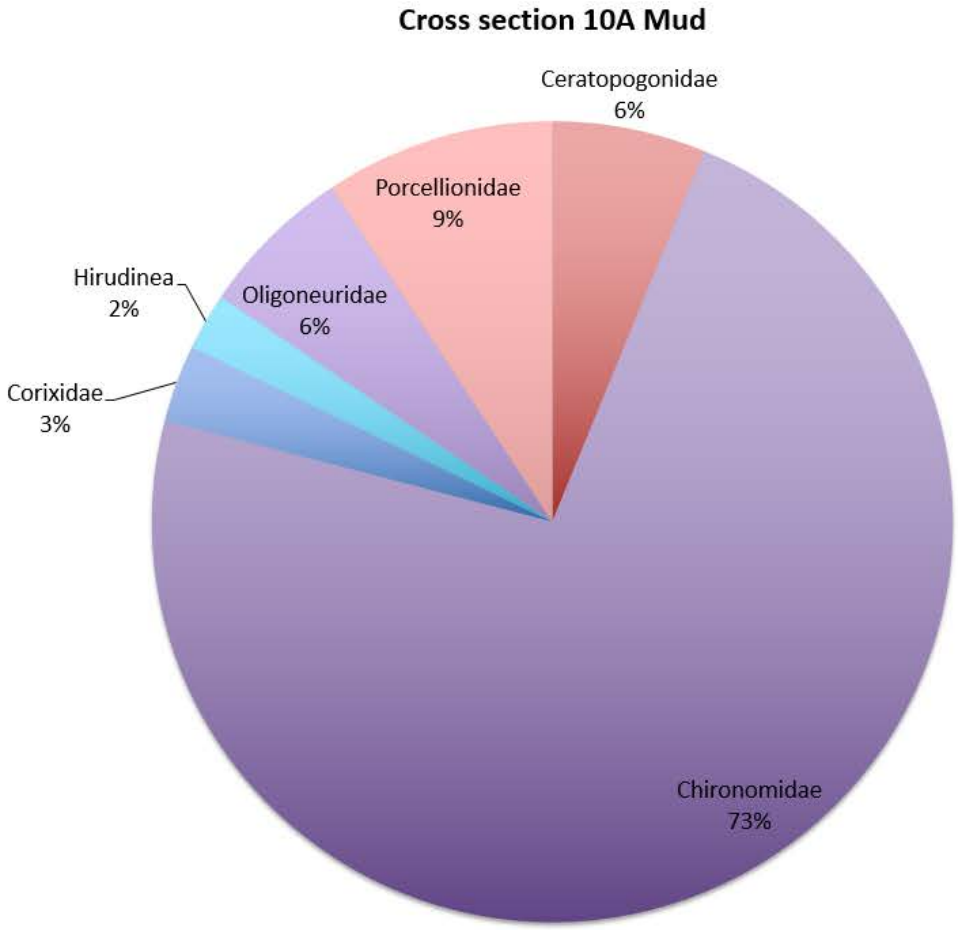


Figure 98. Section 10A Mud was dominated by 73% Chironomidae, 9% Porcellionidae, and 6% Ceratopogonidae and Oligoneuridae. There were a total of 129 specimens collected.

Cross-Section 10B:

For Cross Section 10B Gravel the Simpson's Similarity Index for this sample shows a taxonomic diversity value of 0.76. The Margalef's Index shows a taxonomic richness value of 2.23. A breakdown of the substrate type in this cross-section follows (Figure 99).

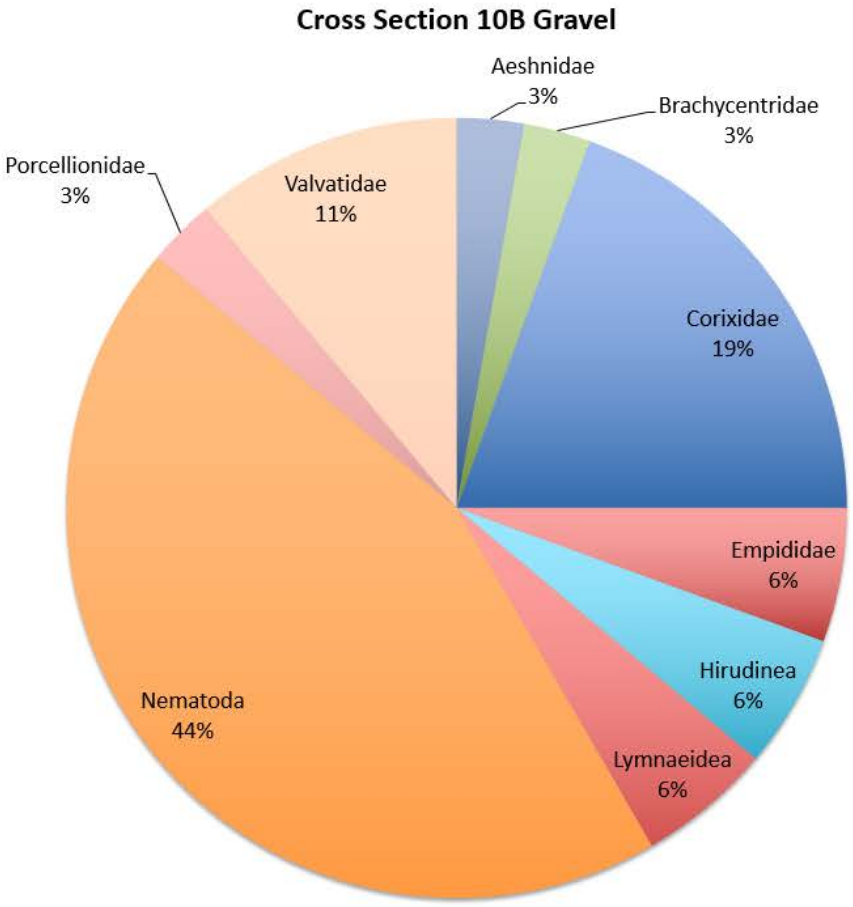


Figure 99. Section 10B Gravel was dominated by 44% Nematoda, 19% Corixidae, and 11% Valvatidae. There were a total of 36 specimens collected.

For Cross-Section 10B Mud the Simpson's Similarity Index for this sample shows a taxonomic diversity value of 0.52. The Margalef's Index shows a taxonomic richness value of 1.65. A breakdown of the substrate type in this cross-section follows (Figure 100).

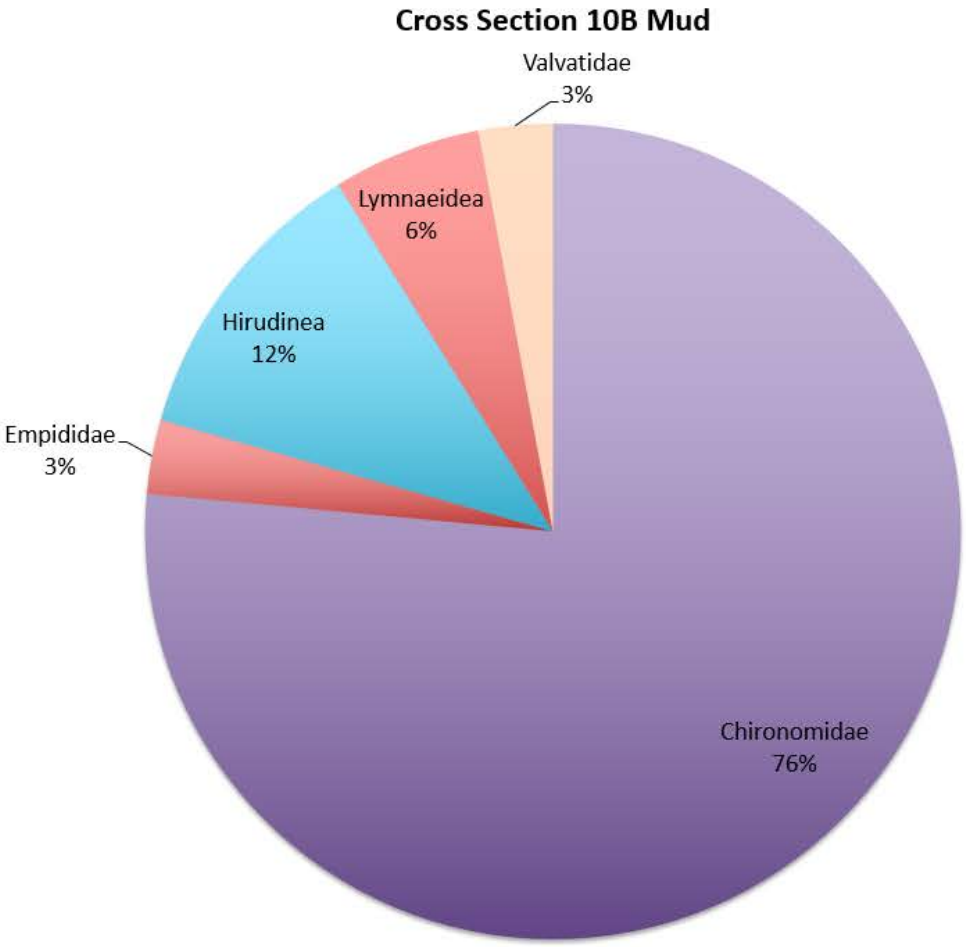


Figure 100. Section 10B Mud was dominated by 76% Chironomidae, 12% Hirudinea, and 6% Lymnaeidea. There were a total of 34 specimens collected.

ANALYSIS

For the comparative analysis the total percentages of macroinvertebrates throughout the entire slough was compared from the 2014 data collection to the 2017 data collection (Figure). The percentages were compared because the data was collected in a different manner than previous years to try and see how siltation may affect these macroinvertebrates in the future. The comparison yielded an overall increase in the majority of the percentages, and a similar array of species being collected. Species such as Oligochaeta and Chironomidae were much more abundant in the 2017 collections due to the fact that they were mostly observed in the mud samples which were not taken in previous years.

It was observed that the vegetation growing on the mud sites is likely what contained the macroinvertebrates collected. Pure mud sites containing no vegetation yielded very few macroinvertebrates such as site 6B where only 9 specimens were collected (Figure 101). Future studies will give a better representation of the gravel diversity and richness versus the mud diversity and richness.

Figure 101. Pure mud sample obtained from site.

Comparison of Families from 2014 to 2107:

Family	2014%	2017%
Aeshnidae	0.01%	0.07%
Amphipoda	4.90%	17.16%
Ancylidae	0.49%	0.27%
Athericidae	0.03%	0.00%
Baetidae	0.48%	0.61%
Belostomatidae	0.00%	0.00%
Bivalvia	0.00%	0.00%
Blephariceridae	0.00%	0.00%
Brachycentridae	0.00%	3.03%
Caenidae	0.38%	0.00%
Calopterygidae	0.00%	0.00%
Capniidae	0.00%	0.70%
Ceratopogonidae	0.08%	1.21%
Chaoboridae	0.00%	2.62%
Chironomidae	2.51%	8.48%
Chloroperlidae	0.10%	0.00%
Coenagrionidae	0.00%	0.61%
Corixidae	0.04%	1.14%
Culicidae	0.04%	0.00%
Decapoda	0.00%	0.00%
Dixidae	0.01%	0.00%
Dryopidae	0.00%	0.07%
Dytiscidae	0.00%	0.47%
Elmidae	0.88%	1.14%
Empididae	0.05%	0.20%
Ephemerellidae	1.09%	0.13%
Gerridae	0.00%	0.00%
Glossosomatidae	0.00%	0.00%
Gomphidae	0.00%	0.00%
Gyrinidae	0.00%	0.00%
Haliplidae	0.47%	0.00%
Helicopsychidae	0.15%	4.04%
Heptageniidae	0.72%	0.74%
Hirudinea	0.00%	2.42%
Hydropshychidae	0.49%	2.09%

Family	2014%	2017%
Limnephilidae	2.04%	1.08%
Lymnaeidea	2.79%	0.27%
Mesoveliidae	0.00%	0.00%
Molannidae	0.00%	0.00%
Naucoridae	0.01%	1.28%
Nematoda	1.22%	0.00%
Nemouridae	0.03%	0.00%
Notonectidae	0.13%	3.36%
Oligochaeta	0.00%	9.02%
Oligoneuridae	0.00%	1.14%
Pelecorhynchidae	0.54%	0.40%
Peltoperlidae	0.01%	0.07%
Perlidae	0.31%	0.34%
Perlodidae	0.01%	0.61%
Philopotamidae	0.00%	0.00%
Phryganeidae	0.26%	0.47%
Physidae	2.12%	1.21%
Planorbidae	2.21%	0.20%
Polycentripodidae	0.00%	7.00%
Porcellionidae	56.37%	12.05%
Psychodidae	0.00%	0.00%
Psychomyiidae	0.00%	0.07%
Pteronarcyidae	0.00%	0.00%
Pyralidae	0.00%	0.13%
Rhyacophilidae	0.63%	0.40%
Sialidae	0.00%	0.13%
Simuliidae	0.01%	0.07%
Siphlonuridae	0.00%	3.23%
Sphaeriidae	0.72%	0.00%
Stratiomyidae	0.00%	0.07%
Tabanidae	0.68%	0.13%
Tipula	4.64%	0.20%
Tipulidae	0.00%	0.00%
Tricorythidae	0.85%	0.34%
Turbellaria	0.00%	2.49%

Hydroptilidae	0.28%	0.00%
Lepidostomatidae	0.25%	0.07%
Leptoceridae	0.34%	1.88%
Leptophlebiidae	0.00%	0.00%
Lestidae	0.00%	0.00%
Libellulidae	0.00%	0.34%

Valvatidae	2.56%	4.71%
Hirundinidae	1.56%	
Hydrachnidiae	0.82%	
Hydrophilidae	0.45%	
Glossiphoniidae	5.24%	

When you compare the percentages from the 2014 macroinvertebrate count to the percentages from the 2017 count, it shows that there is much more diversity in the familial numbers throughout the Slough as a whole (Figure 102).

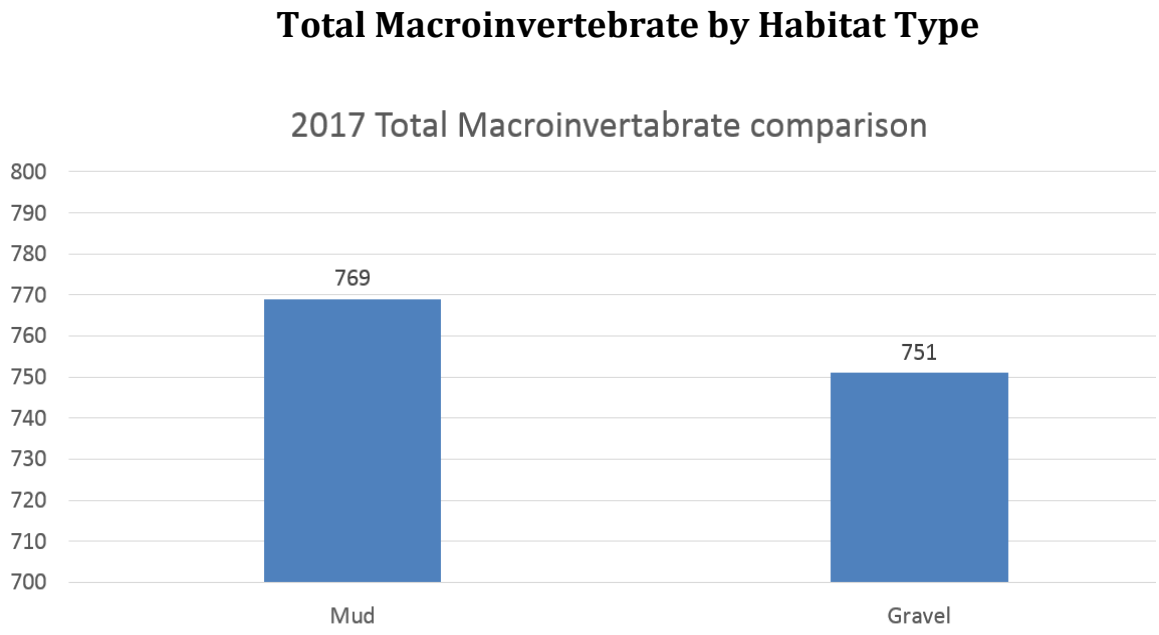


Figure 102. Poindexter Slough habitat type total macroinvertebrate data.

These data show that there were a higher number of macroinvertebrates collected from the mud samples throughout the 5 sites, but Simpsons diversity index and Margelefs Richness index indicate that the gravel samples were more diverse and rich in the majority of the sites.

MACROINVERTEBRATE SYSTEMATICS

The organism living in a stream, provide the best indicators of that stream's overall health and ecological condition. They represent an enormous diversity of habitats, survival strategies, and food availability, which in turn indicates a healthy ecosystem. Human activities that alter a watershed and interfere with the natural processes of a stream have immediate as well as long-lasting effects on the animals that live in the stream. Our macroinvertebrate survey shows the effect on the restored sections of Poindexter slough. Many invertebrates require clear, cool water, adequate oxygen, stable flows, and a steady source of food in order to complete their life cycles. These organisms are one of the most if not the most important part of a fishery, as they must provide a healthy variety of food for the fish.

Excellent Stream Type

In an excellent stream type there should be a variety of organisms with very different body shapes and ways of making a living. High biodiversity (or taxa richness) indicates a site with low human influence. Several different taxa of stoneflies, mayflies, and caddis flies indicate a healthy site. More than one type of riffle beetle may also be identifiable. Some caddis flies are tolerant of degradation, so a large number of caddis flies do not necessarily indicate a good site, especially if they are the same species.

Moderate Stream Site

The total number of different types of organisms (taxa richness) declines as degradation increases. About half to two-thirds the number of taxa found at an

excellent site are found in a moderate site. The primary change from an excellent site is that there will be fewer taxa of stoneflies. Mayflies will be present, but probably fewer taxa as well. Several types of caddis flies may be present depending on the type of degradation. The relative proportions of soft-bodied worms, Baetidae mayflies, and limuloid flies, or amphipods may increase. Beetles are still present; mollusks are not.

Poor Stream Site

The total number of taxa will be low. Most of the taxa found are soft-bodied animals (e.g., fly larvae, midges, ect.), and in very poor sites, leeches and planaria. Stoneflies are absent entirely. The only mayflies present are probably baetidae. Caddis flies may be present, but only a few tolerant types. Amphipods are often present. There may be a large proportion of a single type of animal. In general, animals present may be smaller than those found at an excellent site.

Descriptions:

Order Plecoptera (Stonefly)

Figure 103. A Perlidae nymph, with gills along the thorax and tail-like cerci at the end of the abdomen (Google Images, 2017).

Stoneflies are one of the most common and successful macroinvertebrates on the planet. They have been around for almost 300 million years and occupy every continent besides Antarctica. Stonefly nymphs require clean water with lots of oxygen and are an indictor species of stream health. They can grow several centimeters in length and were some of the largest macroinvertebrates we found in the slough. The Order name, Plecoptera means "braided wings" in Greek, and refers to the long braided appearance of the wings on adults. Nymphs typically spend 1 to 4 years crawling along the bottoms of streams and lakes until they hatch into adults and reproduce for several weeks before they die. They can go through as many as 36 molts during their nymph stage and have long, tail-like appendages called cerci. Perlidae is wider than other stoneflies and has a golden coloring making it easy to distinguish them from other stoneflies.

Order Ephemeroptera (Mayfly)

Figure 104. Baetidae, a small species of Ephemeroptera, has gills running along the abdomen (Google Images, 2017).

Mayflies are descendants of the oldest winged insects on Earth, with their ancestor's wingspans reaching up to 18 inches during the late Carboniferous, over

300 million years ago! They probably resemble the first winged insects with wings that do not fold over the abdomen, similar to their relative's, dragonflies and damselflies. Mayflies are known for their huge hatches, which attract fishermen. They are also sensitive to pollution and their presence indicates good stream health. Ten segments run along the abdomen, which is often lined with gills in the nymph. The nymph survives for 2 to 3 years until it molts into an adult. Unique to mayflies, the winged adult first emerges as a sexually immature subimago for a few days before molting again into the sexually mature imago. The imago usually survives less than 24 hours in its attempt to reproduce, as it has no functioning mandibles and its digestive tract is filled with air to assist in flying. Mayflies have two distinct "tails", which helps to distinguish it from stoneflies. The most common family in Poindexter Slough, Baetidae rarely grow over 10 mm in length. We are confident that our identifications for Baetidae, Ephemerellidae and Tricorythidae were correct. However, these animals can be extremely small and difficult to tell apart, even under a dissecting microscope.

Order Trichoptera (Caddisfly)

The caddisfly family belongs to the order Trichoptera, of which four different families were found to be the most populous in Poindexter Slough. Those families include Hyrdropshychidae, Lepidostomatidae, Brachycentridae and Helicopsychidae. The caddisfly larvae will take anywhere from 2 months to 2 years to change from larvae in the water to adult out of water. Once the larvae are ready to transform to an adult, they prepare a cocoon in the water.

Caddisfly larvae make a silk thread that they use to build structures, which help them survive. These case-like structures are both stationary and portable, and give the larvae protection while allowing them to circulate water through their gills. They also build nets to help them collect food. Caddis Flies live in a wide range of streams and aquatic environments. Caddis flies can be organized into groups based on feeding habits. These groups include Shredders, Scrapers, Collector-Gatherers, Collector-Filterers and Predators. Shredders eat decaying plant material, Scrapers eat algae off the streambed, Collector-Gathers eat fine organic material, and Collector-Filterers eat fine organic material from flowing water, while Predators eat other invertebrates. Caddis flies are a good indicator of water quality because they live within a diversity of habitats (Peckarsky, 1990).

Order Trichoptera, Family Hydropsychidae

Hydropshychidae are not case builders, but rather have a permanent silk shell with which they attach to rocks and logs. Some of the identifying characteristics include three plates on the neck, ventral abdomen, gills and free pro-legs with tufts of hair. They were the most abundant type of caddisfly in the slough.

Figure 105. Hydropsychidae nymph (Google Images, 2017).

Order Trichoptera, Family Lepidostomatidae

Lepidostomatidae are among the case builders in the caddisfly family. They use surrounding rocks and sticks to create a case for protection. Some of the identifying characteristics include two plates on the neck, side humps, spotted head, and varying cases. The Lepidostomatidae family was fond the least frequently of all caddisfly families present in Poindexter Slough.

Figure 106. Lepidostomidae nymph (Google Images, 2017).

Order Trichoptera, Family Brachycentridae

Brachycentridae have two plates on the neck, absence of humps, and deep side-grooves. The Brachycentridae were the second common caddisfly in the slough.

Figure 107. Brachycentridae nymph (Google Images, 2017).

Order Trichoptera, Family Helicopsychidae

Helicopsychidae uses small pieces of sand to create a case in a spiral shape. Identifying characteristics include two plates on the neck and a spiral case.

Figure 108. Helicopsychidae (Google Images, 2017).

Subphylum Crustacea, Order Isopoda (Sowbug)

Two types of crustaceans were observed in Poindexter Slough, including sow bugs and scuds. A few of the defining characteristics for crustaceans include possession of a hard exoskeleton, bilateral symmetry, more than four pairs of jointed appendages, and a segmented body. Isopoda live their lives in about one year and underwater. Isopoda have a flat body with seven pairs of legs and two pairs of antennae. They are omnivores and good indicators of a recovering habitat.

Figure 109. Isopoda, commonly known as sowbugs (Google Images, 2017).

Subphylum Crustacea, Order Amphipoda (Scuds)

Similar to Isopoda, Amphipoda live their entire life – roughy one year – under water. Amphipoda have two pairs of long antennae, a flattened body, and seven pairs of legs. These omnivores are commonly found in lakes, streams, and ponds, and provide a good source of food for fish.

Figure 110. Amphipoda or scuds from Poindexter Slough.

Class Gastropoda

Two families of the Mollusca phylum were observed in Poindexter Slough. Both families belong to the class Gastropoda, the largest class of the Mollusca phylum and one of the most diverse classes among all animals. Gastropoda inhabit all marine environments and feed on a wide variety of food sources ranging from plants to living animals. Fresh water Gastropoda, typically called Scrapers, eat algae from the streambeds.

Class Gastropoda, Family Lymnaidae (Gilled Snail)

Its right-facing shell opening identifies Lymnaidae, one of the most common families of Gastropoda. This snail is able to obtain oxygen from the water and utilizes a type of trap door over its shell opening.

*Figure 111. Lymnaidae, the "gilled snail" (Google Images, 2017).***Class: Gastropoda, Family Physidae (Pouch Snail)**

Physidae, the second most commonly identified family of Gastropoda, is distinguished from Lymnaidae by its left-facing shell opening and lack of trap door over the shell opening. Similar to Lymnaidae, Physidae obtains oxygen from water.

Figure 112. Physidae, the "pouch snail" (Google Images, 2017).

Class Oligochaeta (Aquatic Worm)

Oligochaeta or aquatic worms are difficult to identify beyond class due to small characteristics. They live from several weeks to several years. Oligochaeta are soft-bodied, segmented creatures without eyespots. Oligochaeta primarily eat by decomposing plants and animals, and are therefore are more commonly found in slow-moving or stagnant water.

Figure 113. Oligochaete, commonly known as worms (Google Images, 2017).

Family Glossiphonidae (Leech)

Leeches are identified by a flat, dark colored body with a sucker at each end. Freshwater leeches inhabit lakes, streams, marshes, ponds and springs. Most leeches are predators or parasites.

Figure 114. A common leech Glossiphonidae (Google Images, 2017).

Family Planariidae

Planariidae is a flatworm characterized by a flat, soft, un-segmented body with an arrow shaped head. Planariidae exhibit the ability to regenerate severed body parts and can survive in both fresh and saltwater habits.

Figure 115. Planaridae an unsegmented flatworm (Google Images, 2017).

Order Diptera (True Fly)

Diptera is a fly that utilizes one set of wings in order to fly. Diptera have a mobile head, compound eyes, and mouthparts suitable for piercing, sucking, or lapping. Three families of Diptera were found in Poindexter Slough.

Figure 116. Order Diptera or true fly in the larval stage (Google Images, 2017).

Order Diptera, Family Simuliidae (Black Fly)

All Simuliidae found in the slough were in the larval stage. Simuliidae larvae attach themselves to rocks underwater before advancing to the next stages of life, which take place out of the water. Simuliidae larva are highly sensitive to water pollution and will not successfully breed in highly polluted areas.

Figure 117. Family Simuliidae in the larval stage (Google Images, 2017).

Order: Diptera, Family: Athericidae (Snipe Fly)

Athericidae are the most commonly observed true fly. They have no distinct head, eight pro-legs, and abdomens with two fringed projections. Athericidae, which were found in the larval stage, are found in fast-moving water, and feed on smaller invertebrates.

Figure 118. Athericidae in the larval stage (Google Images, 2017).

Order: Diptera, Family: Tipulidae (Crane Fly)

Tipula, which was entirely found in the larval stage, have no distinct head, a cylindrical body, and variously shaped lobes at the end of the abdomen. Tipula larvae, which process organic material, are valuable in maintaining a healthy soil ecosystem.

Figure 119. Tipulidae in the larval stage (Google Images, 2017).

STREAM HABITAT SURVEY

INTRODUCTION

An essential part of the assessment of Poindexter Slough is the collection of data on stream habitats that are suitable for fish and other aquatic species. For the purposes of this study, the stream was divided into four segments: (1) riffles, (2) runs, (3) pools, and (4) glides. For each of these features, the length, width, and depth were carefully measured and recorded (Figure 120). In addition, the average percentage of the vegetative cover along the banks of Poindexter Slough was assessed for the entire study area. These data provide an excellent overview of the entire stream, rather than just the cross-section data, which represent the impacts at those specific localities rather than the stream as a whole.

Figure 120. Collecting stream habitat data on Poindexter Slough, 2017.

FISH HABITAT

Poindexter Slough contains abundant populations of Brown trout (*Salmo trutta*), Mountain Whitefish (*Prosopium williamsoni*) and Rocky Mountain Sculpin (*Cottus bondi*) (previously known as the Mottled Sculpin). Rare or unknown populations of fish species in Poindexter Slough may include Rainbow Trout (*Oncorhynchus mykiss*), Brook Trout (*Salvelinus fontinalis*) and Longnosed Dace (*Rhinichthys cataractae)*; (Montana Fish Wildlife and Parks MFISH system, 2014).

The Brown trout or German Trout (*Salmo trutta*) (Figure 121) is a species introduced to the Pere Marquette River in Michigan from Europe for the purpose of sport fishing in 1883. After its introduction the species spread through human introductions and aquaculture throughout the various river systems of North America. The success of the Brown trout is due in part to its popularity as a sport fish and adaptability to various conditions that are not always habitable to native species (Lauterbach, 2006).

Figure 121. Brown trout Illustration (Courtesy of Vermont Fish & Wildlife Dept., 2017).

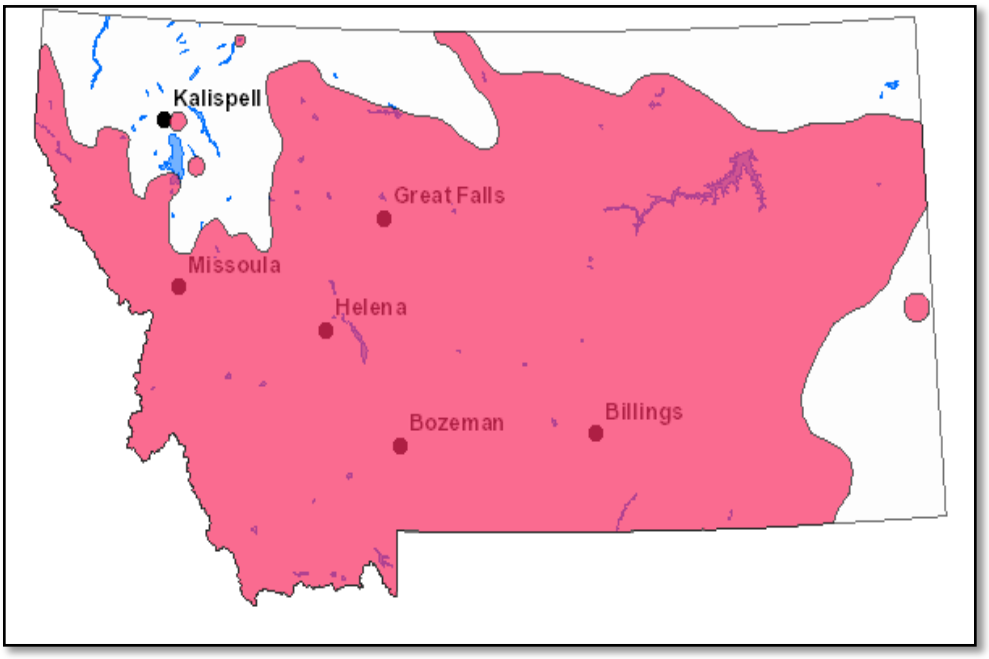


Figure 122. Distribution of Brown trout in Montana (Montana Field Guide, 2014).

In Montana, Brown trout are widely distributed through the major drainage systems on both sides of the continental divide (see Figure 122) and are the most abundant game fish species in the study area. Electroshock data from 2013 show a total number of 793 Brown trout captured from miles 1.5 to 6.2 of Poindexter Slough (Jaeger, 2013). Brown trout tend to tolerate higher water temperatures, 60 to 70 degrees, during the summer months due to low flows, than many other species (Montana Field Guide).

Spawning Brown trout require highly oxygenated water with large gravel areas that allow for the proper spawning redds to be built during the fall spawning

period. With added sediment from the Beaverhead River many of the historic spawning areas have become filled in with sediment, which contributes to vegetation growth over vital spawning areas.

Dietary needs of Brown trout consist mostly of aquatic invertebrates with some presence of smaller fish (cannibalized Brown trout) found in stomach samples (French, 2013). The presence of juvenile Brown trout in the diet show a more aggressive and opportunistic feeding style, which fits well into the current environment type.

Habitat use of Brown trout has been found to vary between both male and female members of the species, males were found to mostly inhabit pools while either males or females were found to inhabit the shallower water features (Greenberg, 2001). Areas of use also vary from daytime to nighttime to allow for feeding habits of the species. Some studies found that more time spent in shallower areas during the daytime results in a positive growth rate while nighttime habits did not affect growth rate (Greenberg, 2001). Some species of trout are highly dependent on overhanging vegetation from the bank but Brown trout do not require or favor large amounts of overhanging vegetation as habitat (Heggenes, 1988). Overhanging vegetation can, however, result in lower or more constant water temperatures, which aid fish species during exceptionally warm periods.

The fish habitat for Brown trout in Poindexter Slough above the Dillon canal head gate has been greatly improved with the restoration project of the upper 2.25 miles in early 2015. Several modifications to the stream bed were made with the help of heavy equipment. The restored reach of the slough was cleared of years of

fine sediments deposited by the Beaverhead River. The removal of the oxygen deprived sediment deposits, which are often relatively void of macro invertebrate life has not only improved aquatic insect habitat, but also fish habitat. These sediment deposits did not allow for the production of an optimal amount of macro invertebrates and in turn reduced the number of Brown trout that could live in the study area with improved invertebrate habitat. Stream banks were narrowed, pools were deepened and a substantial amount of gravel was deposited on the streambed. These modifications have created a more defined natural stream structure that creates a higher oxygen environment for aquatic species. The invertebrates found in samples throughout our study area at Poindexter slough during this study suggest increased feeding opportunities for greater populations of brown trout.

METHODS

Data was collected on stream morphology and bank vegetation. Stream habitat was divided into riffles, runs, pools, and glides (Figure 123). The team measured the length, width and depth of each habitat type starting at site 4A and ending just past site 6B. The data was then recorded (Figure 124). The team also determined the bank profile in order to maintain data consistency. The team estimated the percentage of vegetation along both banks of an entire riffle, run, pool, and glide set. Three categories were used for the estimates: (1) grass, (2) willow, and (3) bare ground.

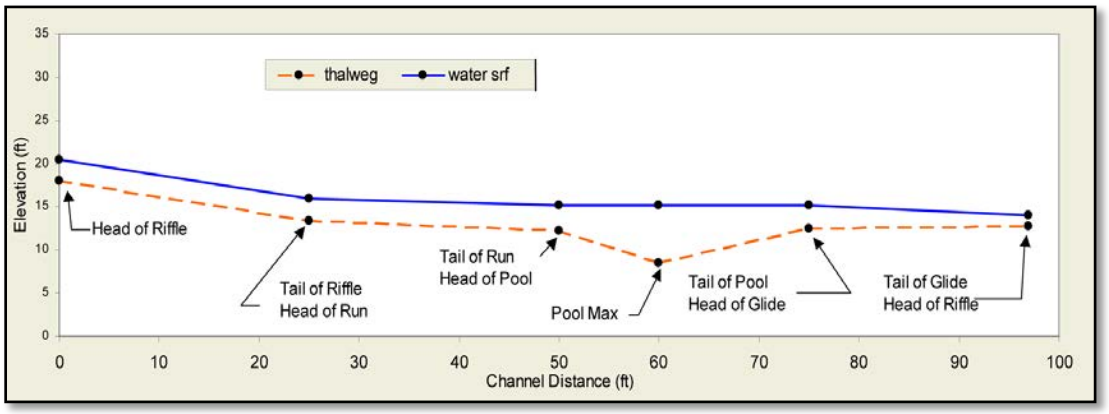


Figure 123. Profile of slope and depth characteristics of habitat types (Vermont Stream Geomorphic Assessment, 2004).

	Riffle	Run	Pool	Glide
Length				
Depth				
Width				
Plants	Grass	Willow	Bare Ground	
Left Bank				
Right Bank				

Figure 124. Example of the layout for stream habitat data gathering in the notebook.

Vegetation estimates were placed in the Left Bank/Right Bank columns. Estimates were determined by looking downstream from the start of the riffle to the end of the glide/start of the next riffle. The vegetation was estimated within the wall of the bank (not the top of the bank), as measured from the waterline to the inflection of the bank or the point where the bank changes from the vertical rise to the horizontal floodplain. If vegetation is located at the inflection point, as willow commonly is located, that is counted in the vegetation estimate. If the willow root is not located at the point of the inflection, but the willow is overhanging the bank and/or water, it is counted in the vegetation estimate (Figure 125).

Figure 125. Estimations of vegetation were taken from water levels to bank full.

Classification of streambed features starts with identifying the beginning and end of each feature. A riffle begins where the bed no longer shallows and the current flows more swiftly. Riffles don't have a highly defined thalweg (the line of maximum depth in a stream). The riffle remains until the current slows and the stream starts to get deeper. This indicates the start of the "run," which is the transition from a riffle to a pool. A run ends when the flow decreases as the bed continues to deepen. Usually a defined thalweg accompanies the run. A pool is the deepest and slowest area of the stream. The end of a pool and the beginning of a glide can be determined through an increase in flow velocity and gradual decrease in water depth. The thalweg becomes less defined in this transition. The end of the glide is determined

where the water depth stabilizes and a riffle begins (Vermont Agency of Natural Resources, 2004).

Two measuring devices were used during the survey, a 100 ft. Keson fiberglass measuring tape and a CST/Berger aluminum (telescoping) rod. The lengths were determined by measuring from the beginning to the end of each feature along the thalweg. The widths were determined by measuring the center width of each feature from bank full to bank full. The CST/Berger aluminum (telescoping) rod was used to determine the depth of each habitat feature. The rod was graduated in tenths of feet, and measurements were taken at the center of each feature. Pools were the only exception, where depths were measured at the deepest reachable point.

DATA

Data was collected from Poindexter Slough starting at site 4A and ending just past site 6B at the Highway 91 South overpass. The total distance measured was 0.72 miles. The average length of Poindexter Slough's riffles was 42.71 feet, the average width was 32.34 feet, and the average depth was 1.47 feet. The average length of the runs on Poindexter Slough was 14.25 feet, the average width was 34.26 feet, and the average depth was 3.22 feet. The average length of pools was 32.61 feet, the average width was 33.94 feet, and the average depth was 5.25 feet. The average length of glides was 19.55 feet, the average width was 32.27 feet, and the average depth was 3.75 feet (Figures 126-128).

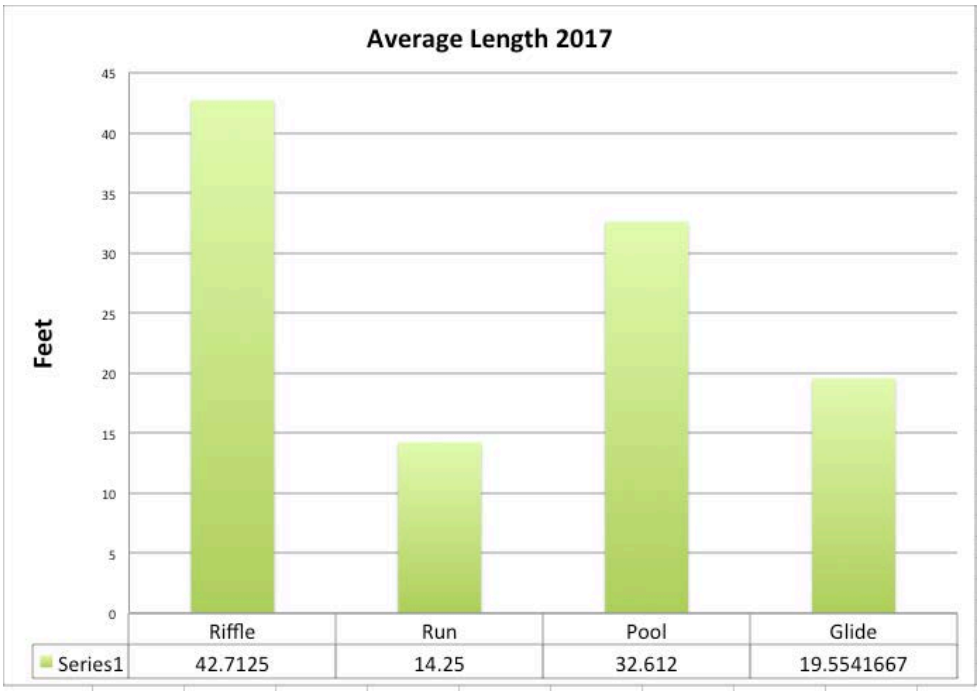


Figure 126. Average lengths of stream habitat types on Poindexter Slough in 2017.

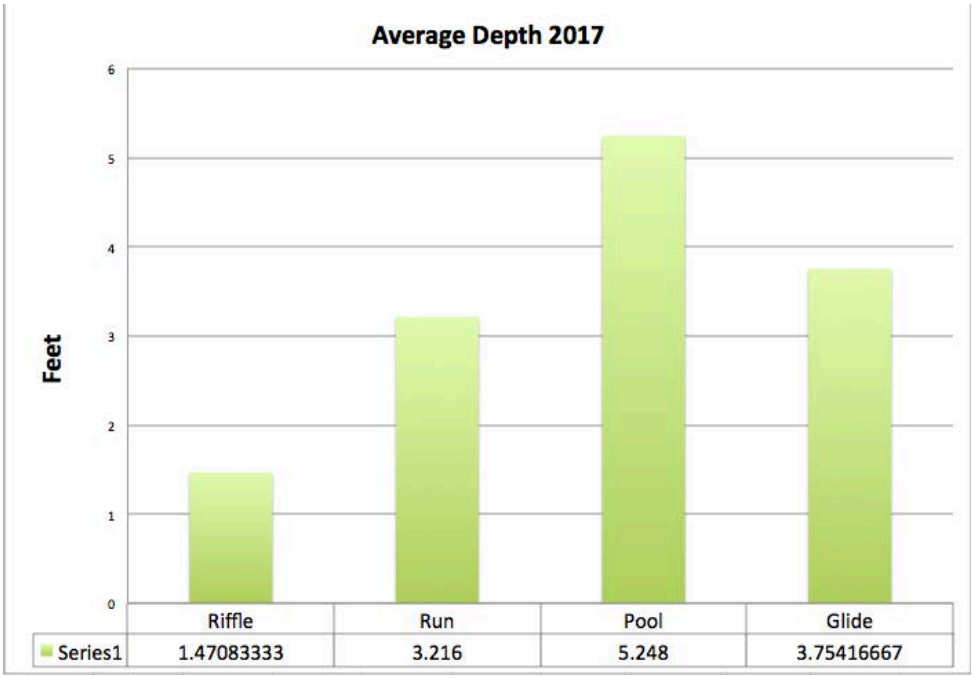


Figure 127. Average depths of stream habitat types on Poindexter Slough in 2017.

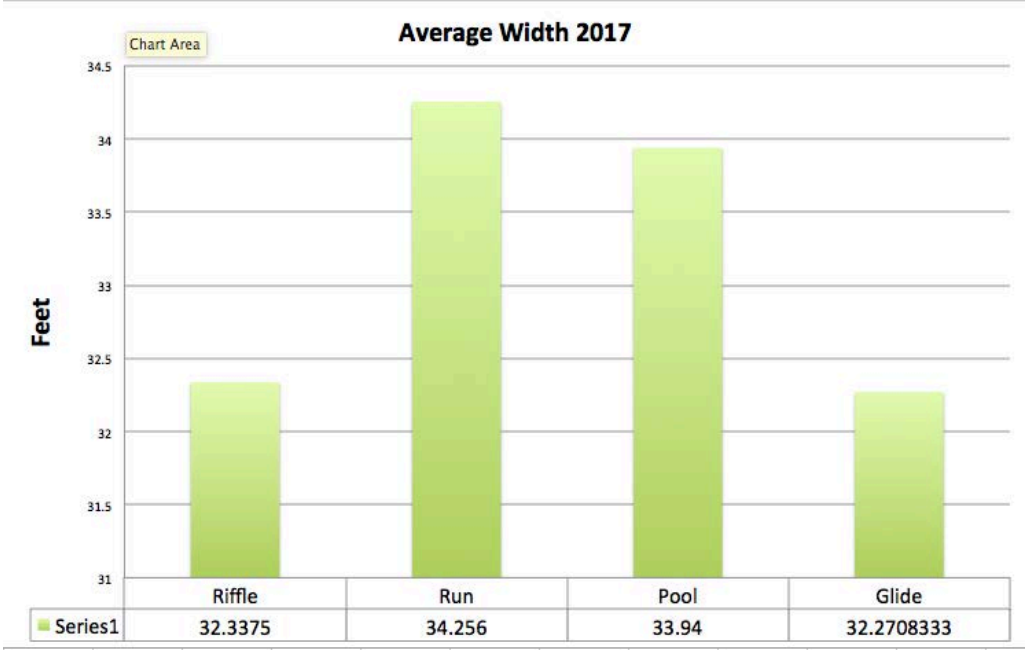


Figure 128. Average widths of stream habitat types on Poindexter Slough in 2017.

Vegetation

Our vegetation surveys were taken looking downstream at Poindexter Slough. We recorded how much grass, willow, and bare ground covered the banks of Poindexter Slough. We recorded the data in percentages. Example: 75% grass, 15% willow, and 10% bare ground to total 100%. Vegetation surveys showed willow, grass, and bare ground which are the most common vegetation occurrences. (Figures 129-134)

Figure 129. Bare ground on Poindexter Slough, 2017.

Figure 130. Grass bank on Poindexter Slough, 2017.

Figure 131. Willow bank on Poindexter Slough, 2017.

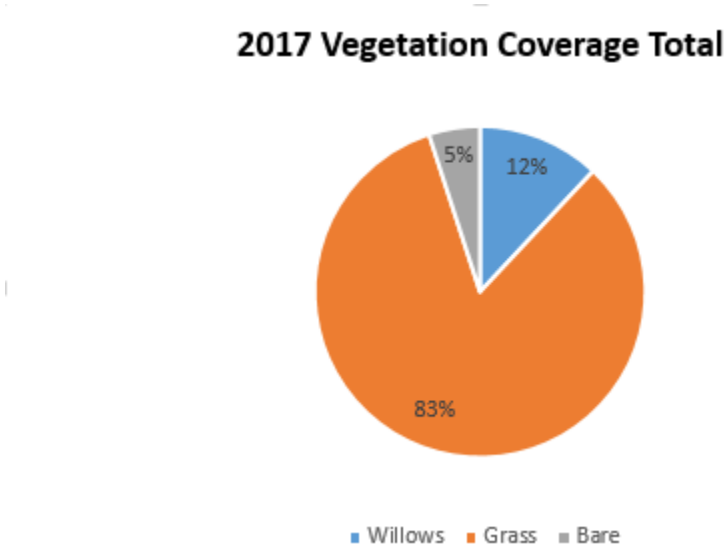


Figure 132. Total Bank Vegetation for Poindexter Slough 2017.

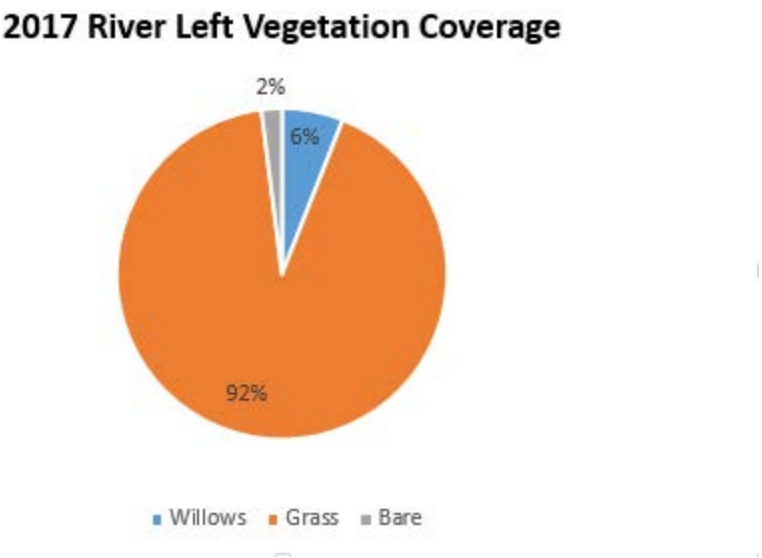


Figure 133. Total left bank vegetation for Poindexter Slough 2017.

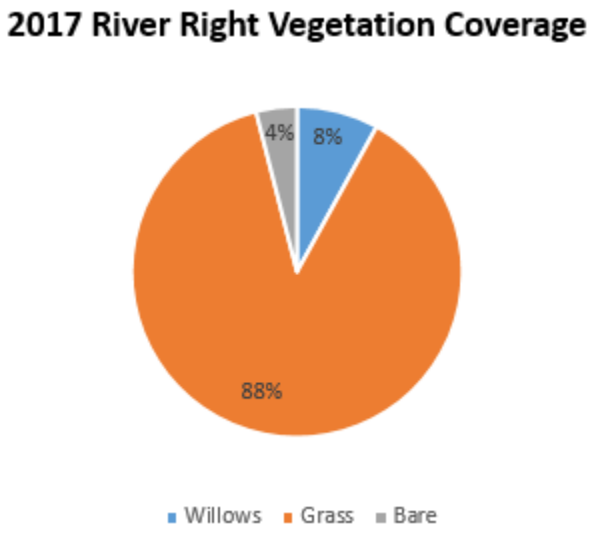


Figure 134. Total right bank vegetation for Poindexter Slough 2017.

ANALYSIS

The data collected from Poindexter Slough included the length, width, and depth of every riffle, run, pool, and glide from site 4A to just past site 6B, is used to evaluate the effectiveness of the stream restoration as improvement of aquatic habitat for aquatic invertebrates and fish.

The 2017 analysis shows that the riffles, runs, pools and glides are more distinguishable than the 2014 baseline study. Gravel is more present in the streambed currently than it was pre-restoration in 2014 where thick silt and sand was dominant due to sediment build up from the Beaverhead River. The riffles, although slightly deeper on average (.09 feet increase in depth), are composed of gravel therefore creating a more oxygen rich environment. The pools are considerably deeper (2.11 feet increase in depth) than previous analysis. However, it should be noted that current buildup of sediment from the Beaverhead River may still be occurring as the amount of thick silt and sand appears to be growing abnormally fast. Fish and aquatic invertebrate habitat has been greatly improved. The previous layer of built-up sediment, removed during the restoration, limited the amount of oxygen as well as bug, fish, and spawning habitat. Future fish shocking should back up our prediction of improved fish numbers (Figure 135).

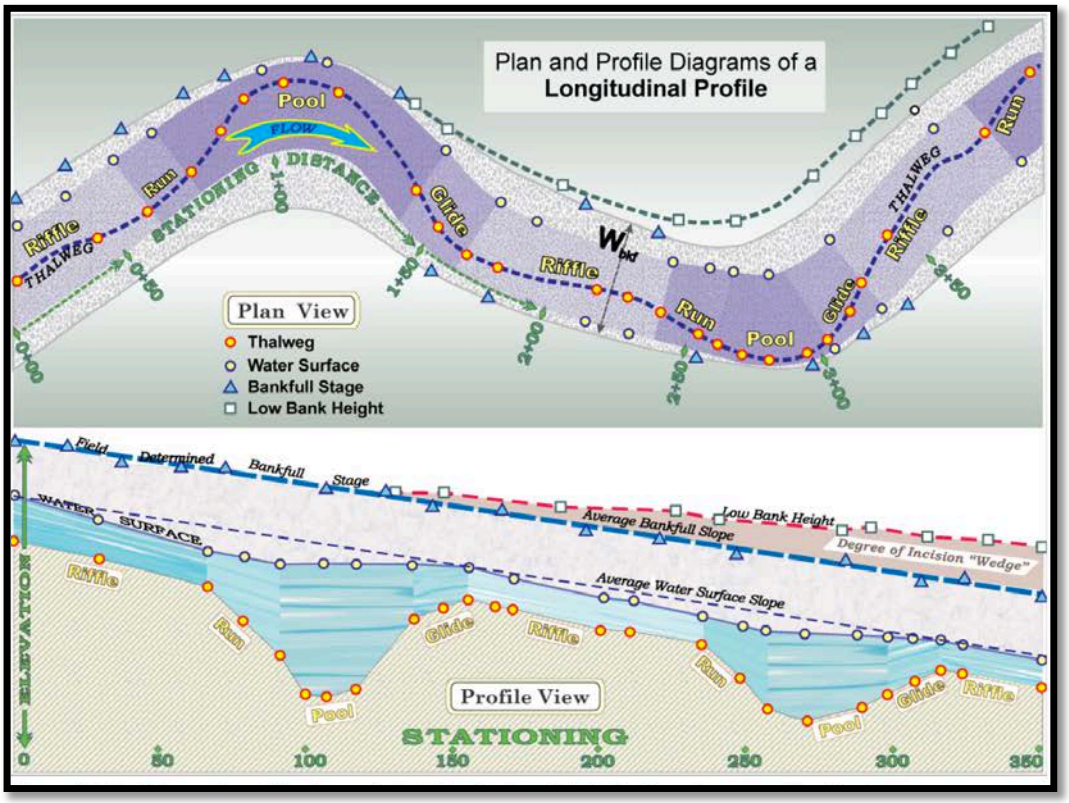


Figure 135. Shows pool depth and follow on habitat (Google images 2014).

COMPARATIVE DATA

Comparative data of the habitat type measurements between the 2017 averages of Poindexter Slough and 2014 baseline averages of Poindexter Slough was worth taking a look at. It is important to note that the area surveyed during this 2017 study (0.72 miles, from site 4A to just past Site 6B) is significantly smaller than the area surveyed during the 2014 baseline study (3.9 miles, from the head gate on the Beaverhead River to the confluence of Poindexter Slough). This difference in area size was due to time constraints as a result of a significantly smaller survey team during this study.

In general, all habitat types in the 2017 data differ significantly from the 2014 baseline data. Overall, each habitat type has been shortened and in most cases narrowed (with the exception of pools which appear to have widened on average). All habitat types appear to have deepened on average, significantly so in the case of runs, pools and glides while riffles show only a slight average increase in depth. (Figures 136-138).

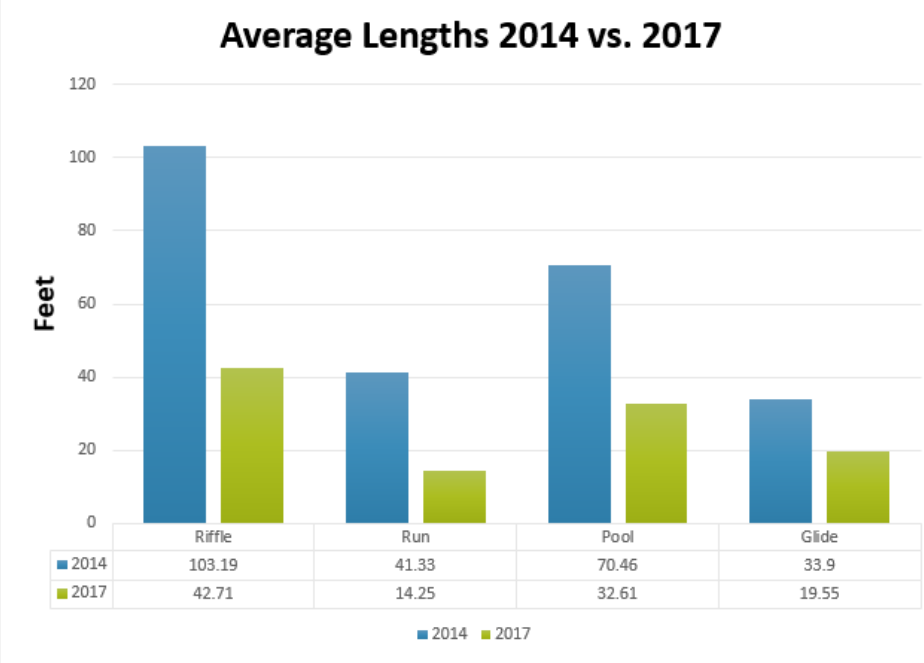


Figure 136. This graph illustrates comparative length averages of Poindexter Slough from 2014 baseline data to 2017 data. Lengths of each type of habitat underwent a decrease.

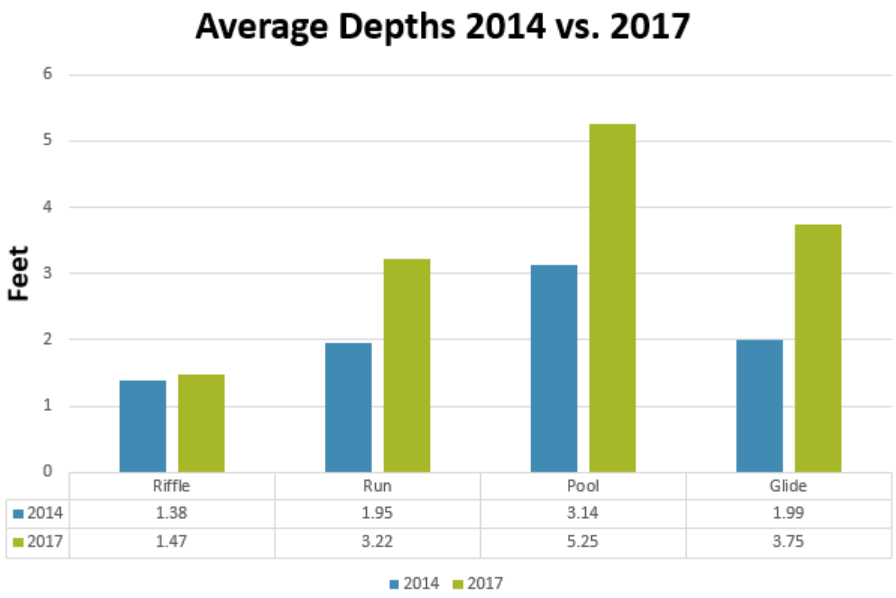


Figure 137. This graph illustrates comparative depth averages of Poindexter Slough from 2014 baseline data to 2017 data. Depths of each type of habitat underwent an increase.

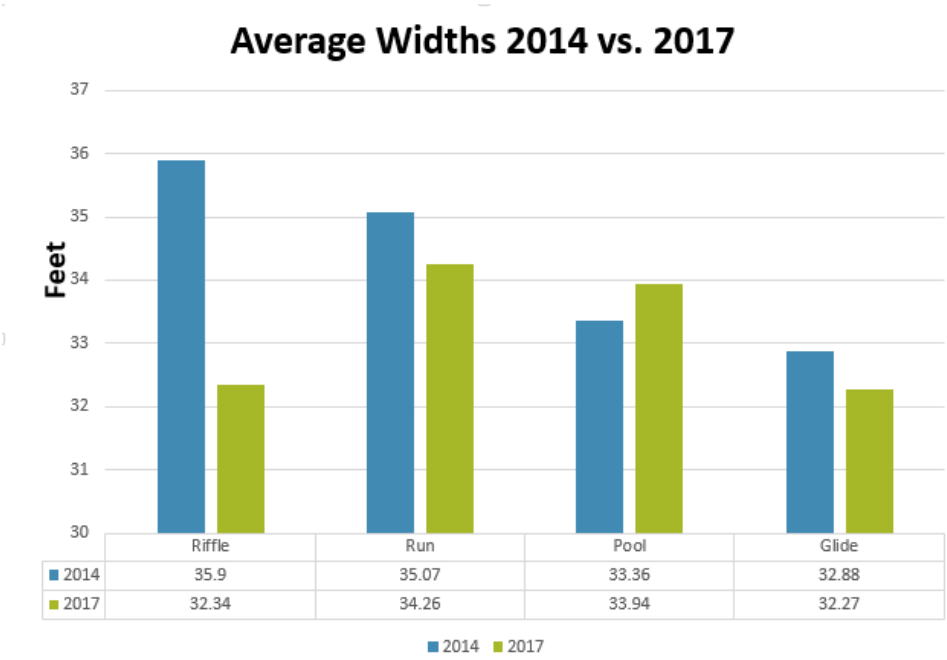


Figure 138. This graph illustrates comparative width averages of Poindexter Slough from 2014 baseline data to 2017 data. Widths of Riffles, Runs and Glides underwent a decrease while widths of Pools underwent a slight increase.

Comparative data of the vegetation on the banks of Poindexter Slough shows that total coverage of willows, grass and bare ground are extremely similar (Figures 139 and 140). This data suggests that the riparian vegetation has made a recovery to pre-restoration coverage. Willows were more abundant pre-restoration, in the 2017 vegetation coverage estimates, willows saw a 7% decrease in prevalence on Poindexter Slough. The differences seen could be from disturbance from the restoration, or from less data collected in 2017 because of lack of student-power and time constraints. An increase in willows could be beneficial to the system for bank stabilization and woody debris for fish habitat. Grasses are the most abundant in both studies and supply the main source of bank stabilization along Poindexter Slough (Figure 141).

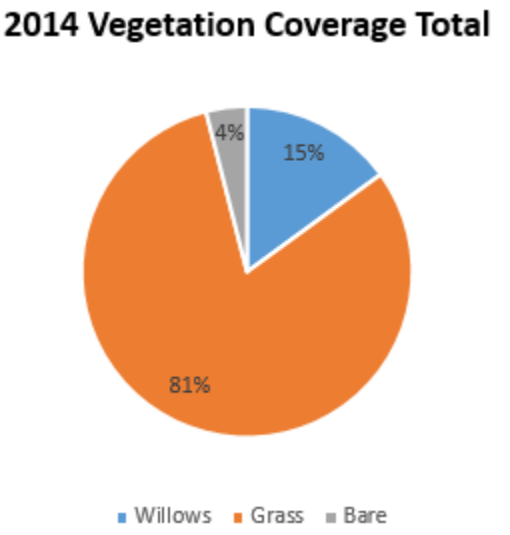


Figure 139. Total bank vegetation for 2014.

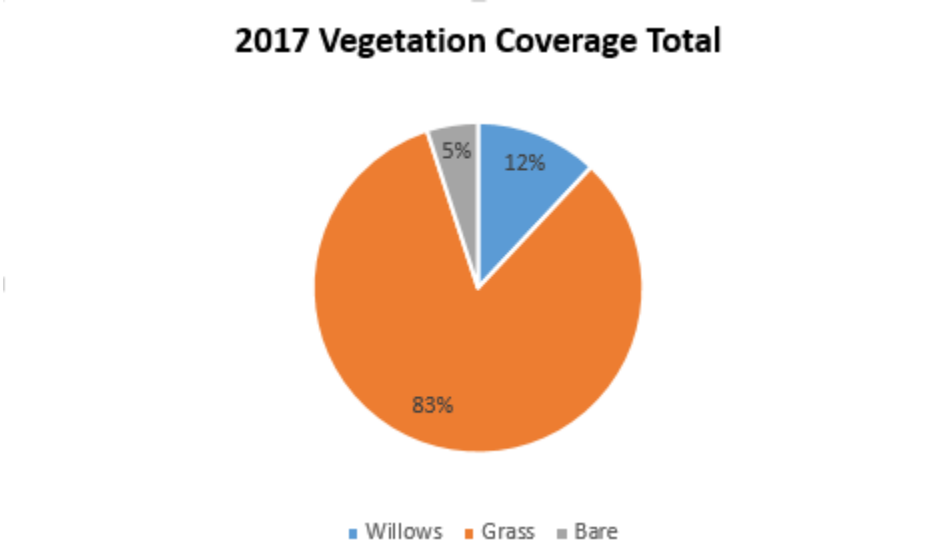


Figure 140. Total bank vegetation for 2017.

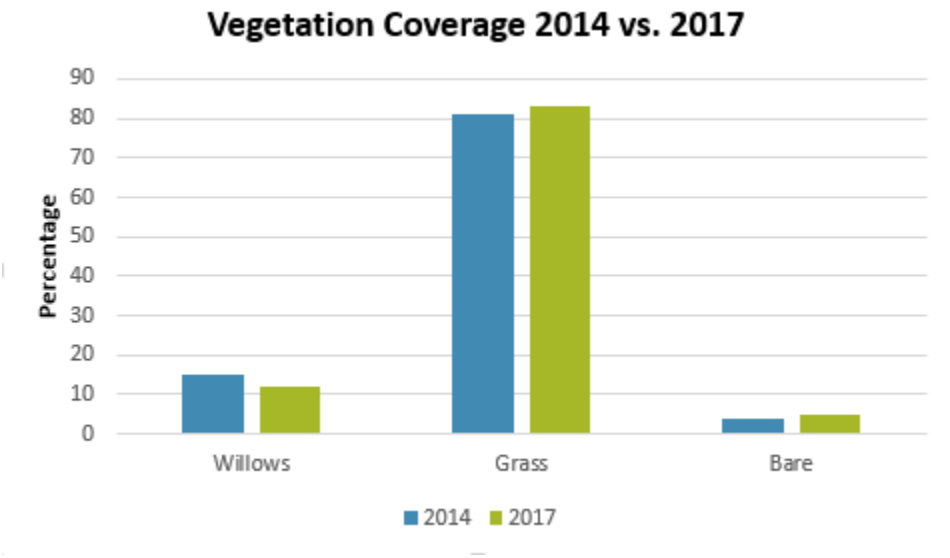


Figure 141. A side-by-side column chart comparison of 2014 and 2017 data.

CITED REFERENCES

Caddisflies (Trichoptera), 2016. http://www.dec.ny.gov/animals/30965.html.

Davies, Jill, 1983. *Families of common Macroinvertebrates found in Northern Rocky Mtn. Streams*. Bug Guide. Aquatic Entomology. Jones and Bartlett.

Dep.wv.gov., 2017. Macroinvertebrate References. Available at: http://www.dep.wv.gov/WWE/getinvolved/sos/Pages/Ref.aspx

Dolloff, Andrew C., 2016. *Summary of Stream Habitat Inventories on the Blue Ridge and Chattooga River Districts of the Chattahoochee National Forest.* United States Department of Agriculture Forest Service. Blacksburg, VA. 2015.

Greenberg L.A., and Giller P.S., 2001, Individual variation in habitat use and growth of male and female brown trout: Ecography, v. 24, no. 2, p. 212-224.

Hauer H. and Resh H., 1996. Methods in Stream Ecology. Academic Press, San Diego, CA.

Heggenses J., and Traaen, T., 1988, Daylight responses to overhead cover in stream channels for fry of four salmonid species: Holarctic Ecology, v. 11, no. 3, p. 194-201.

https://www.easycalculation.com/statistics/margalef-richness-index-biodiversity.php

Jaeger M., and Flowers, P.J., 2014, Draft Environmental Assessment, Poindexter Slough Habitat Restoration: Unpublished document, 56p.

Lauterbach, S., 2014, Introduced species summary project brown trout (Salmo trutta): Web article: www.columbia.edu/itc/cerc/danoffburg/invasion_bio/inv_spp_summ/Salmo_trutta.htm.

"Learn Your Benthics! | EcoSpark." *Learn Your Benthics! | EcoSpark*. Web. 13 Oct. 2015. <http://www.ecospark.ca/changingcurrents/benthics.

Levine, Rebekah, 2016, *Inventory and Assessment of Poindexter Slough in the Beaverhead River Drainage Near Dillon, Montana*. Prepared for Matt Jaeger, Montana Fish, Wildlife and Parks, Unpublished document.

McCafferty, W. P., 1998. *Aquatic entomology: the fishermens and ecologits*. Sudbury, MA: Jones and Bartlett.

Montana Fish wildlife and Parks MFISH system, 2014.

Thomas, R., et al., 2014, *Inventory and Assessment of Poindexter Slough in the Beaverhead River Drainage Near Dillon, Montana.* Prepared for Matt Jaeger, Montana Fish, Wildlife and Parks, Unpublished document.

Thomas, R., et al., 2015, *Inventory and Assessment of Poindexter Slough in the Beaverhead River Drainage Near Dillon, Montana.* Prepared for Matt Jaeger, Montana Fish, Wildlife and Parks, Unpublished Document.

Vermont Fish & Wildlife Department, 2017, *Brown trout,* (Web: 2017): http://www.vtfishandwildlife.com/fish/fishing_opportunities/sportfish_of_vermont/brown_trout/

Wikipedia. Wikimedia Foundation. Web. 13 Oct. 2015. <https://www.wikipedia.org/>.

APPENDIX A
STREAM MORPHOLOGY SURVEY

4A RIFFLE

Eyepiece 4.7

Height

Distance		Height	Distance		Height
1	RL Stake	**4.7**	35		**8.6**
2		**4.6**	36		**8.4**
3		**4.2**	37		**8.1**
4		**4.5**	38		**8.0**
5		**4.4**	39		**7.8**
6		**4.4**	40		**7.7**
7		**4.6**	41		**7.7**
8		**4.2**	42		**7.5**
9		**4.1**	43		**7.3**
10		**3.8**	44		**7.0**
11		**3.6**	45		**6.8**
12		**3.9**	46		**6.3**
13		**4.0**	47		**6.1**
14		**3.9**	48		**5.9**
15		**3.8**	49		**5.7**
16		**3.8**	50		**5.4**
17		**3.7**	51		**5.2**
18		**3.6**	52		**5.1**
19		**3.6**	53		**5.2**
20		**3.3**	54		**5.0**
21		**3.4**	55		**5.0**
22		**3.4**	56	RR WP	**4.8**
23		**3.8**	57		**4.9**
24	RL BF/WP	**4.4**	58		**4.9**
25		**7.1**	59		**4.8**
26		**7.2**	60	RR BF	**5.0**
27		**7.6**	61		**4.9**
28		**7.9**	62		**4.9**
29		**8.2**	63		**4.7**
30		**8.3**	64		**4.7**
31		**8.6**	65		**4.8**
32		**8.7**	66		**4.9**
33		**8.8**	67		**5.0**
34		**8.6**	68	RR Stake	**5.0**

4B POOL

Eyepiece height 5.0

Distance		Height	Distance		Height
0	RL Stake	**6.32**	24		**8.94**
1	RL BF	**6.37**	25		**9.48**
2		**6.48**	26		**9.89**
3		**6.60**	27		**10.04**
4		**6.74**	28		**10.18**
5	RL WP	**6.94**	29		**10.45**
6		**7.05**	30		**10.51**
7		**7.44**	31		**10.37**
8		**7.49**	32		**10.30**
9		**7.66**	33		**10.03**
10		**7.59**	34		**9.66**
11		**7.56**	35		**9.16**
12		**7.80**	36		**8.88**
13		**7.86**	37		**8.52**
14		**8.0**	38		**8.21**
15		**8.11**	39		**7.94**
16		**8.15**	40		**7.66**
17		**8.24**	41		**6.88**
18		**8.24**	42		**6.07**
19		**8.29**	43	RR WP	**5.50**
20		**8.28**	44		**5.20**
21		**8.20**	45		**5.18**
22		**8.34**	46	RR BF	**5.17**
23		**8.74**	47	RR Stake	**5.09**

5A RIFFLE

Eyepiece 5.1

Height

Distance		Height	Distance		Height
2.8	RL Stake	**5.1**	36.8		**8.9**
3.8		**5.2**	37.8		**8.9**
4.8		**5.2**	38.8		**8.9**
5.8		**5.2**	39.8		**8.9**
6.8		**5.3**	40.8		**8.9**
7.8		**5.3**	41.8		**8.9**
8.8		**5.3**	42.8		**9.0**
9.8		**5.5**	43.8		**8.9**
10.8		**5.5**	44.8		**8.6**
11.8		**5.6**	45.8		**8.3**
12.8		**5.7**	46.8		**7.9**
13.8		**5.7**	47.8		**7.7**
14.8		**5.8**	48.8		**7.5**
15.8	RL BF	**5.9**	49.8		**7.4**
16.8		**6.0**	50.8		**7.3**
17.8		**6.0**	51.8		**7.3**
18.8		**6.1**	52.8		**7.2**
19.8		**6.1**	53.8		**7.0**
20.8		**6.1**	54.8	RR WP	**6.8**
21.8		**6.1**	55.8		**6.4**
22.8		**6.1**	56.8		**6.2**
23.8		**6.2**	57.8		**6.1**
24.8	RL WP	**6.2**	58.8		**6.1**
25.8		**8.1**	59.8		**5.9**
26.8		**8.1**	60.8		**5.9**
27.8		**8.4**	61.8	RR BF	**5.8**
28.8		**8.6**	62.8		**5.8**
29.8		**8.7**	63.8		**5.9**
30.8		**8.9**	64.8		**6.2**
31.8		**8.9**	65.8		**6.4**
32.8		**8.9**	66.8		**6.3**
33.8		**8.8**	67.8		**6.1**
34.8		**8.8**	68.8		**6.1**
35.8		**8.8**	69.8		**6.1**
			70.2	RR Stake	**6.1**

5B POOL

Eyepiece Height 4.9

Distance		Height	Distance		Height
0	RL Stake	**5.04**	30		**8.51**
1		**5.02**	31		**8.45**
2		**5.01**	32		**8.41**
3		**4.96**	33		**8.33**
4		**4.99**	34		**8.27**
5		**5.02**	35		**8.21**
6		**4.99**	36		**8.15**
7		**5.00**	37		**7.97**
8		**5.09**	38		**7.89**
9		**5.53**	39		**7.77**
10	RL WP/BF	**8.6**	40		**7.74**
11		**8.85**	41		**7.70**
12		**9.30**	42		**7.51**
13		**9.85**	43		**7.24**
14		**10.33**	44	RR WP	**6.65**
15		**11.06**	45		**6.48**
16		**11.38**	46	RR BF	**6.41**
17		**11.65**	47		**6.34**
18		**11.97**	48		**6.22**
19		**11.89**	49		**6.01**
20		**11.84**	50		**6.04**
21		**11.33**	51		**6.01**
22		**11.11**	52		**6.05**
23		**10.71**	53		5.99
24		**10.34**	54		6.05
25		**8.83**	55		6.07
26		**9.50**	56		6.05
27		**9.10**	57		6.08
28		**8.83**	58		6.06
29		**8.55**	59	RR Stake	6.06

6A RIFFLE

Eyepiece Height 4.7

Distance		Height	Distance		Height
1	RL Stake	**4.7**	44	RR WP	**6.5**
2		**4.8**	45	RR BF	**5.5**
3		**4.9**	46		**5.6**
4		**5.1**	47		**5.5**
5		**5.2**	48		**5.5**
6		**5.3**	49		**5.6**
7		**5.4**	50		**5.7**
8		**5.5**	51		**5.9**
9		**5.3**	52		**5.9**
10		**5.1**	53		**5.8**
11		**5.3**	54		**5.9**
12		**5.8**	55		**6.0**
13		**5.8**	56		**6.0**
14	RL BF	**6.0**	57		**6.1**
15	RL WP	**7.1**	58		**6.0**
16		**6.9**	59		**6.0**
17		**7.6**	60		**5.9**
18		**7.7**	61		**6.0**
19		**7.7**	62		**6.0**
20		**7.8**	63		**6.0**
21		**7.9**	64		**6.0**
22		**7.9**	65		**5.9**
23		**7.9**	66		**5.9**
24		**8.1**	67		**5.9**
25		**8.1**	68		**6.0**
26		**8.2**	69		**5.9**
27		**8.7**	70		**6.0**
28		**8.1**	71		**6.0**
29		**8.1**	72		**6.0**
30		**8.1**	73		**5.9**
31		**8.1**	74		**5.9**
32		**8.0**	75		**5.8**
33		**8.0**	76		**5.8**
34		**8.0**	77		**5.8**
35		**7.9**	78		**5.9**
36		**7.9**	79		**5.9**
37		**7.9**	80		**5.4**
38		**7.9**	81		**5.2**
39		**7.8**	82		**4.9**
40		**7.6**	83		**4.8**
41		**7.4**	84		**4.7**
42		**7.2**	85	RR Stake	**4.6**
43		**6.8**			

6B POOL

Eyepiece height 5.2

Distance		Height	Distance		Height
0	RLStake	**7.3**	24		**10.0**
1	RL BF	**7.2**	25		**9.82**
2		**5.08**	26		**9.72**
3		**5.37**	27		**9.61**
4		**5.49**	28		**9.41**
5		**5.73**	29		**9.23**
6		**5.31**	30		**9.21**
7		**5.40**	31		**8.92**
8		**5.21**	32		**8.63**
9		**5.12**	33		**8.33**
10		**5.21**	34		**7.9**
11		**5.24**	35		**7.53**
12	RL BF/WP	**6.42**	36		**7.7**
13		**6.71**	37		**7.6**
14		**6.93**	38		**7.3**
15		**7.33**	39		**6.9**
16		**7.80**	40		**6.7**
17		**8.2**	41	RR BF/WP	**6.5**
18		**8.6**	42		**5.42**
19		**9.02**	43		**5.5**
20		**9.6**	44		**5.53**
21		**10.02**	45		**5.53**
22		**10.0**	46		**5.53**
23		**9.93**	47	RR Stake	**5.53**

8A RIFFLE

Eyepiece Height 4.6

Distance		Height	Distance		Height
2	RL Stake	**4.6**	39		**8.8**
3		**4.5**	40		**9.1**
4		**4.6**	41		**8.9**
5		**4.5**	42		**9.2**
6		**4.5**	43		**9.3**
7		**4.5**	44		**9.1**
8		**4.5**	45		**8.8**
9		**4.5**	46		**8.8**
10		**4.6**	47		**8.9**
11		**4.6**	48		**8.6**
12		**4.6**	49		**8.5**
13		**4.6**	50		**8.4**
14		**4.5**	51		**8.1**
15		**4.5**	52		**7.9**
16		**4.6**	53	RR WP	**7.3**
17		**4.6**	54		**6.3**
18		**4.4**	55		**6.3**
19		**4.4**	56	RR BF	**6.2**
20		**4.4**	57		**6.2**
21		**4.4**	58		**6.1**
22		**4.4**	59		**6.0**
23		**4.4**	60		**5.8**
24		**4.6**	61		**5.7**
25		**5.1**	62		**5.7**
26		**5.8**	63		**5.6**
27	RL BF	**6.5**	64		**5.7**
28		**6.4**	65		**5.7**
29	RL WP	**8.8**	66		**5.6**
30		**9.4**	67		**5.5**
31		**9.6**	68		**5.5**
32		**9.6**	69		**5.6**
33		**9.8**	70		**5.6**
34		**9.8**	71		**5.5**
35		**9.7**	72		**5.5**
36		**9.5**	73		**5.5**
37		**9.7**	74	RR Stake	**5.6**
38		**9.0**			

8B POOL

Eyepiece height 4.9

Distance		Height	Distance		Height
0	RL Stake	**4.84**	33		**9.58**
1		**4.81**	34		**9.40**
2		**4.96**	35		**9.31**
3		**5.00**	36		**9.24**
4		**4.94**	37		**9.42**
5		**5.18**	38		**9.34**
6		**5.12**	39		**9.23**
7		**5.25**	40		**9.19**
8		**5.40**	41		**9.06**
9		**5.79**	42		**8.83**
10		**6.14**	43	RR WP	**8.49**
11		**6.79**	44	RR BF	**7.53**
12		**7.44**	45		**7.10**
13		**8.10**	46		**7.23**
14	RL BF/WP	**8.40**	47		**7.24**
15		**8.86**	48		**7.28**
16		**9.13**	49		**7.41**
17		**9.50**	50		**7.35**
18		**9.69**	51		**7.31**
19		**9.80**	52		**7.33**
20		**10.30**	53		**7.31**
21		**10.04**	54		**7.33**
22		**10.02**	55		7.14
23		**10.00**	56		6.95
24		**9.86**	57		6.92
25		**9.89**	58		6.65
26		**9.86**	59		6.44
27		**9.85**	60		6.20
28		**9.74**	61		6.15
29		**9.58**	62		5.95
30		**9.55**	63		5.90
31		**9.61**	64	RR Stake	5.69
32		**9.64**			

10A RIFFLE

Eyepiece Height 4.7

Distance		Height	Distance		Height
2	RL Stake	**4.7**	39		**8.7**
3		**4.9**	40		**8.6**
4		**4.9**	41		**8.6**
5		**4.9**	42		**8.7**
6		**5.0**	43		**8.9**
7		**5.1**	44		**8.9**
8		**5.1**	45		**9.0**
9		**5.1**	46		**9.1**
10		**5.4**	47		**9.0**
11		**5.6**	48		**8.8**
12		**5.8**	49		**8.7**
13	RL BF	**6.7**	50		**8.4**
14	RL WP	**6.9**	51		**8.2**
15		**7.0**	52		**8.0**
16		**7.0**	53		**7.7**
17		**7.0**	54	RR WP/BF	**7.5**
18		**7.0**	55		**5.8**
19		**7.1**	56		**5.5**
20		**7.1**	57		**5.4**
21		**7.2**	58		**5.1**
22		**7.2**	59		**4.9**
23		**7.3**	60		**5.1**
24		**7.4**	61		**5.7**
25	RL BF	**7.4**	62		**5.0**
26		**7.5**	63		**4.5**
27	RL WP	**7.5**	64		**4.4**
28		**7.7**	65		**4.4**
29		**7.8**	66		**4.6**
30		**7.9**	67		**4.6**
31		**8.0**	68		**4.6**
32		**8.2**	69		**4.3**
33		**8.3**	70		**4.3**
34		**8.5**	71		**4.2**
35		**8.5**	72		**4.1**
36		**8.5**	73		**4.1**
37		**8.6**	74	RR Stake	**4.1**
38		**8.6**			

10B POOL

Eyepiece height 4.8

Distance		Height	Distance		Height
0	RL Stake	**5.33**	30		**9.94**
1		**5.32**	31		**10.02**
2		**5.30**	32		**9.93**
3		**5.34**	33		**9.93**
4		**5.42**	34		**9.93**
5	RL BF	**5.42**	35		**10.02**
6		**5.70**	36		**10.00**
7		**6.02**	37		**9.92**
8		**6.43**	38		**9.80**
9		**6.63**	39		**9.73**
10		**6.84**	40		**9.74**
11		**7.10**	41		**9.80**
12	RL WP	**8.71**	42		**9.81**
13		**8.52**	43		**9.94**
14		**8.41**	44		**10.01**
15		**8.52**	45		**10.02**
16		**8.63**	46		**10.04**
17		**8.83**	47		**10.03**
18		**9.03**	48		**10.02**
19		**9.10**	49		**10.00**
20		**9.21**	50		**9.91**
21		**9.40**	51	RR WP	**9.92**
22		**9.42**	52		**7.94**
23		**9.52**	53		**6.94**
24		**9.54**	54	RR BF	**6.42**
25		**9.70**	55		**6.10**
26		**9.82**	56		**5.62**
27		**9.92**	57		**5.30**
28		**10.00**	58		**5.10**
29		**10.00**	59	RR Stake	**5.53**

BEHI Reference

4A

Cross Section		Bank Height	Root Depth	Root Density	Bank Angle	Surface Protection	
Up	RL	-	1.4	90%	130°	100%	
At	RL	1.2	1.8	90%	120°	100%	
Down	RL	-	2.0	90%	110°	100%	
Up	RR	-	0.4	90%	20°	100%	
At	RR	.6	0.3	90%	10°	100%	
Down	RR	-	0.5	80%	5°	100%	
Total Avg.		1.8	1.07	89%	66°	100%	BEHI Total
BEHI Score		6.95	1.45	1.45	4.95	1.45	16.25

4B

Cross Section		Bank Height	Root Depth	Root Density	Bank Angle	Surface Protection	
Up	RL	1.2	0.2	10%	85°	10%	
At	RL	1.7	-	-	90°	100%	
Down	RL	0.3	-	-	170°	100%	
Up	RR	2.5	-	-	165°	100%	
At	RR	1.8	1.0	40%	135°	90%	
Down	RR	1.6	-	-	45°	100%	
Total Avg.		1.52	0.6	25%	115°	83.33%	BEHI Total
BEHI Score		6.0	1.0	6.2	8.88	1.8	23.88

BEHI Reference

5A

Cross Section		Bank Height	Root Depth	Root Density	Bank Angle	Surface Protection	
Up	RL	-	0.6	90%	80°	100%	
At	L	1.9	0.5	90%	50°	100%	
Down	L	-	0.4	90%	45°	100%	
Up	RR	-	0.6	90%	10°	100%	
At	R	1.3	0.4	90%	25°	100%	
Down	R	-	0.4	90%	40°	100%	
Total Avg.		3.20	0.48	90%	41.7°	100%	BEHI Total
BEHI Score		10	10	1.45	2.95	1.45	25.85

5B

Cross Section		Bank Height	Root Depth	Root Density	Bank Angle	Surface Protection	
Up	RL	0.9	-	-	135°	100%	
At	RL	2.3	0.5	40%	70°	100%	
Down	RL	1.9	1.9	30%	90°	90%	
Up	RR	1.05	-	-	135°	100%	
At	RR	0.8	0.11	5%	100°	90%	
Down	RR	1.1	-	-	160°	100%	
Total Avg.		1.34	0.84	25%	115°	97%	BEHI Total
BEHI Score		5.0	2.2	6.4	8.88	1.2	23.68

BEHI Reference

6A

Cross Section		Bank Height	Root Depth	Root Density	Bank Angle	Surface Protection	
Up	RL	-	1.3	90%	110°	100%	
At	RL	1.1	0.9	90%	90°	100%	
Down	RL	-	1.3	90%	120°	100%	
Up	RR	-	1.2	90%	30°	10%	
At	RR	1.0	1.0	90%	90°	0%	
Down	RR	-	1.1	90%	90°	25%	
Total Avg.		2.1	1.13	90%	88.3°	55%	BEHI Total
BEHI Score		8.5	10	1.45	6.95	2.95	29.85

6B

Cross Section		Bank Height	Root Depth	Root Density	Bank Angle	Surface Protection	
Up	RL	1.5	0.3	20%	90°	70%	
At	RL	0.9	0.1	60%	135°	100%	
Down	RL	1.1	0.4	10%	160°	40%	
Up	RR	0.8	0.2	50%	90°	100%	
At	RR	1.1	0.2	30%	90°	100%	
Down	RR	1.5	-	-	90°	100%	
Total Avg.		1.15	0.24	34%	109°	85%	BEHI Total
BEHI Score		3.2	6.5	5.7	8.5	1.6	25.5

BEHI Reference

8A

Cross Section		Bank Height	Root Depth	Root Density	Bank Angle	Surface Protection	
Up	RL	-	1.6	90%	105°	0%	
At	RL	2.3	0.8	90%	95°	100%	
Down	RL	-	1.8	90%	130°	100%	
Up	RR	-	1.1	90%	90°	100%	
At	RR	1.1	1.3	90%	90°	5%	
Down	RR	-	1.0	90%	90°	100%	
Total Avg.		3.4	1.27	90%	99.2°	67%	BEHI Total
BEHI Score		10	10	1.45	8.5	2.95	32.90

8B

Cross Section		Bank Height	Root Depth	Root Density	Bank Angle	Surface Protection	
Up	RL	2.1	0.4	40%	110°	100%	
At	RL	1.3	0.1	10%	155°	100%	
Down	RL	1.7	0.1	50%	150°	90%	
Up	RR	1.1	0.3	10%	110°	30%	
At	RR	1.3	0.5	20%	90°	100%	
Down	RR	1.4	-	-	135°	100%	
Total Avg.		1.5	0.3	26%	125°	87%	BEHI Total
BEHI Score		5.9	5.9	6.2	10	1.6	29.6

BEHI Reference

10A

Cross Section		Bank Height	Root Depth	Root Density	Bank Angle	Surface Protection	
Up	RL	-	0.5	80%	5°	85%	
At	RL	1.9	0.8	75%	5°	75%	
Down	RL	-	0.6	65%	5°	100%	
Up	RR	-	1.1	75%	90°	100%	
At	RR	0.5	1.3	75%	150°	100%	
Down	RR	-	1.2	75%	115°	100%	
Total Avg.		2.4	0.92	74%	61.7°	93%	BEHI Total
BEHI Score		8.5	10	2.95	4.95	1.45	27.85

10B

Cross Section		Bank Height	Root Depth	Root Density	Bank Angle	Surface Protection	
Up	RL	1.2	-	-	90°	100%	
At	RL	2.2	0.8	90%	45°	100%	
Down	RL	2.2	0.9	70%	75°	100%	
Up	RR	2.6	0.4	90%	95°	100%	
At	RR	2.7	0.9	40%	90°	100%	
Down	RR	2.4	0.7	100%	80°	100%	
Total Avg.		2.2	0.74	78%	79°	100%	BEHI Total
BEHI Score		8.1	2.9	2.1	5.9	1.0	20.0

Sinuosity

4A

Sinuosity = 500 ft / Straight line distance (ft)

Pace = 20 steps for 50 ft

= 200 steps for 500 ft

Sinuosity = 500 ft / 650 ft
straight line ft

Sinuosity = 1.3

4B

Sinuosity = 500 ft / Straight line distance (ft)

Pace = 17 steps for 50 ft

= 167 steps for 500 ft

Sinuosity = 500 ft / 418 ft
straight line ft

Sinuosity = 1.20

Sinuosity

5A

Sinuosity = 450 ft / Straight line distance (ft)

Pace = 16 steps for 50 ft

= 150 steps for 450 ft

Sinuosity = 450 ft / 534 ft
straight line ft

Sinuosity = 1.19

5B

Sinuosity = 500 ft / Straight line distance (ft)

Pace = 17 steps for 50 ft

= 167 steps for 500 ft

Sinuosity = 500 ft / 286 ft
straight line ft

Sinuosity = 1.75

Sinuosity

6A

Sinuosity = 500 ft / Straight line distance (ft)

Pace = 20 steps for 50 ft

= 200 steps for 500 ft

Sinuosity = 500 ft / 722.5 ft
straight line ft

Sinuosity = 1.4

6B

Sinuosity = 500 ft / Straight line distance (ft)

Pace = 17 steps for 50 ft

= 167 steps for 500 ft

Sinuosity = 500 ft / 333 ft
straight line ft

Sinuosity = 1.5

Sinuosity

8A

Sinuosity = 500 ft / Straight line distance (ft)

Pace = 20 steps for 50 ft

= 200 steps for 500 ft

Sinuosity = 500 ft / 700 ft
straight line ft

Sinuosity = 1.4

8B

Sinuosity = 500 ft / Straight line distance (ft)

Pace = 17 steps for 50 ft

= 167 steps for 500 ft

Sinuosity = 500 ft / 375 ft
straight line ft

Sinuosity = 1.33

Sinuosity

10A

Sinuosity = 630 ft / Straight line distance (ft)

Pace = 20 steps for 50 ft

= 252 steps for 630 ft

Sinuosity = 630 ft / 915 ft
straight line ft

Sinuosity = 1.45

10B

Sinuosity = 500 ft / Straight line distance (ft)

Pace = 17 steps for 50 ft

= 167 steps for 500 ft

Sinuosity = 500 ft / 375 ft
straight line ft

Sinuosity = 1.33

Width/Depth Ratio Measurements

Site/Cross Section Name: **4A Riffle**

US=Upstream
DS=Downstream
XS=Cross Section

	Bankfull Distance (ft)	Water Depths (ft)			
		1	2	3	AVERAGE
US XS 70'	**37.0**	**1.3**	**2.9**	**3.3**	**2.5**
US XS 60'	**35.0**	**2.7**	**2.6**	**0.9**	**2.1**
US XS 50'	**27.0**	**1.9**	**2.9**	**2.7**	**2.5**
US XS 40'	**27.0**	**2.2**	**2.1**	**0.8**	**1.7**
US XS 30'	**29.0**	**1.0**	**1.8**	**2.0**	**1.6**
US XS 20'	**34.0**	**1.8**	**1.4**	**1.6**	**1.6**
US XS 10'	**37.0**	**1.3**	**1.2**	**1.5**	**1.3**
DS XS 10'	**37.0**	**1.1**	**1.1**	**1.3**	**1.2**
DS XS 20'	**39.0**	**2.3**	**1.6**	**1.2**	**1.7**
DS XS 30'	**40.0**	**3.9**	**3.8**	**3.7**	**3.8**

Width/Depth Ratio Measurements

Site/Cross Section Name: **4B Pool**

US=Upstream
DS=Downstream
XS=Cross Section

	Bankfull Distance (ft)	Water Depths (ft)			
		1	2	3	AVERAGE
US XS 50'	**30.00**	**1.31**	**1.51**	**1.69**	**1.50**
US XS 40'	**32.00**	**1.71**	**1.72**	**1.01**	**1.48**
US XS 30'	**30.00**	**0.96**	**1.36**	**2.36**	**1.56**
US XS 20'	**34.00**	**1.55**	**1.38**	**0.41**	**1.11**
US XS 10'	**41.00**	**1.76**	**1.48**	**1.60**	**1.61**
DS XS 10'	**31.00**	**0.44**	**3.15**	**4.25**	**2.61**
DS XS 20'	**25.00**	**3.98**	**2.21**	**0.78**	**2.32**
DS XS 30'	**26.00**	**0.72**	**2.10**	**2.34**	**1.72**
DS XS 40'	**28.00**	**1.65**	**1.43**	**1.68**	**1.59**
DS XS 50'	**29.00**	**0.95**	**1.54**	**1.70**	**1.40**

Width/Depth Ratio Measurements

Site/Cross Section Name: **5A Riffle**

US=Upstream
DS=Downstream
XS=Cross Section

	Bankfull Distance (ft)	Water Depths (ft)			
		1	2	3	AVERAGE
US XS 50'	**34.7**	**3.2**	**4.0**	**0.4**	**2.5**
US XS 40'	**39.1**	**3.3**	**5.0**	**0.5**	**2.9**
US XS 30'	**34.4**	**3.3**	**4.4**	**0.4**	**2.7**
US XS 20'	**37.5**	**1.9**	**3.0**	**1.1**	**2.0**
US XS 10'	**39.5**	**1.4**	**2.2**	**0.5**	**1.4**
DS XS 10'	**32.3**	**1.9**	**4.6**	**1.5**	**2.7**
DS XS 20'	**31.1**	**1.4**	**1.5**	**1.4**	**1.4**
DS XS 30'	**29.5**	**1.5**	**1.4**	**1.5**	**1.5**
DS XS 40'	**31.9**	**1.7**	**1.5**	**1.5**	**1.6**
DS XS 50'	**31.5**	**1.7**	**1.4**	**1.5**	**1.5**

Width/Depth Ratio Measurements

Site/Cross Section Name: **5B Pool**

US=Upstream
DS=Downstream
XS=Cross Section

	Bankfull Distance (ft)	Water Depths (ft)			
		1	2	3	AVERAGE
US XS 50'	**34.40**	**1.80**	**1.70**	**1.40**	**1.63**
US XS 40'	**35.00**	**1.50**	**1.50**	**1.40**	**1.47**
US XS 30'	**53.00**	**1.30**	**1.60**	**4.50**	**2.47**
US XS 20'	**45.00**	**1.40**	**2.10**	**4.80**	**2.77**
US XS 10'	**39.30**	**1.00**	**5.00**	**5.00**	**3.10**
DS XS 10'	**31.00**	**0.70**	**1.70**	**3.30**	**1.90**
DS XS 20'	**29.00**	**0.80**	**1.40**	**2.40**	**1.53**
DS XS 30'	**28.20**	**0.70**	**1.30**	**2.30**	**1.43**
DS XS 40'	**28.00**	**1.00**	**1.50**	**1.50**	**1.33**
DS XS 50'	**24.60**	**1.10**	**1.30**	**1.80**	**1.40**

Width/Depth Ratio Measurements

Site/Cross Section Name: **6A Riffle**

US=Upstream
DS=Downstream
XS=Cross Section

	Bankfull Distance (ft)	Water Depths (ft)			
		1	2	3	AVERAGE
US XS 50'	**28.0**	**1.4**	**1.4**	**1.2**	**1.3**
US XS 40'	**29.0**	**1.4**	**1.6**	**1.6**	**1.5**
US XS 30'	**28.0**	**1.5**	**1.5**	**1.5**	**1.5**
US XS 20'	**28.0**	**1.6**	**1.6**	**1.5**	**1.6**
US XS 10'	**26.0**	**1.7**	**1.8**	**1.7**	**1.7**
DS XS 10'	**29.0**	**1.4**	**1.5**	**2.0**	**1.6**
DS XS 20'	**31.0**	**1.7**	**1.2**	**1.2**	**1.4**
DS XS 30'	**33.0**	**1.2**	**1.7**	**2.5**	**1.9**
DS XS 40'	**31.0**	**3.3**	**2.6**	**1.5**	**2.1**
DS XS 50'	**32.0**	**4.4**	**3.4**	**1.5**	**3.1**

Width/Depth Ratio Measurements

Site/Cross Section Name: **6B Pool**

US=Upstream
DS=Downstream
XS=Cross Section

	Bankfull Distance (ft)	Water Depths (ft)			
		1	2	3	AVERAGE
US XS 50'	**27.00**	**3.40**	**5.20**	**1.70**	**3.43**
US XS 40'	**27.00**	**2.40**	**5.50**	**3.10**	**3.67**
US XS 30'	**29.30**	**3.20**	**6.20**	**1.10**	**3.50**
US XS 20'	**29.80**	**0.60**	**3.00**	**5.90**	**3.17**
US XS 10'	**28.00**	**2.80**	**4.70**	**0.90**	**2.80**
DS XS 10'	**28.80**	**1.60**	**2.20**	**1.50**	**1.77**
DS XS 20'	**28.50**	**1.80**	**1.60**	**1.10**	**1.50**
DS XS 30'	**27.00**	**1.60**	**1.30**	**1.20**	**1.37**
DS XS 40'	**29.50**	**1.50**	**1.60**	**1.40**	**1.50**
DS XS 50'	**30.00**	**1.20**	**1.50**	**1.40**	**1.37**

Width/Depth Ratio Measurements

Site/Cross Section Name: **8A Riffle**

US=Upstream
DS=Downstream
XS=Cross Section

	Bankfull Distance (ft)	Water Depths (ft)			
		1	2	3	AVERAGE
US XS 50'	**28.0**	**3.0**	**2.2**	**2.0**	**2.4**
US XS 40'	**28.0**	**1.6**	**1.7**	**3.0**	**2.1**
US XS 30'	**29.0**	**2.9**	**2.4**	**1.9**	**2.4**
US XS 20'	**26.0**	**1.9**	**2.1**	**3.1**	**2.4**
US XS 10'	**26.0**	**2.7**	**2.6**	**2.1**	**2.4**
DS XS 10'	**27.0**	**1.6**	**2.3**	**2.6**	**2.2**
DS XS 20'	**27.0**	**2.0**	**3.2**	**1.2**	**2.1**
DS XS 30'	**27.0**	**1.6**	**2.3**	**2.8**	**2.2**
DS XS 40'	**28.0**	**2.4**	**2.2**	**1.5**	**2.0**
DS XS 50'	**28.0**	**1.8**	**2.2**	**2.6**	**2.2**

Width/Depth Ratio Measurements

Site/Cross Section Name: **8B Pool**

US=Upstream
DS=Downstream
XS=Cross Section

	Bankfull Distance (ft)	Water Depths (ft)			
		1	2	3	AVERAGE
US XS 50'	**42.00**	**1.60**	**1.30**	**1.00**	**1.30**
US XS 40'	**42.00**	**0.80**	**1.20**	**1.70**	**1.23**
US XS 30'	**42.50**	**1.40**	**1.60**	**0.90**	**1.30**
US XS 20'	**41.00**	**0.90**	**1.40**	**1.40**	**1.23**
US XS 10'	**37.70**	**1.40**	**1.30**	**1.00**	**1.23**
DS XS 10'	**35.50**	**1.50**	**1.20**	**0.70**	**1.13**
DS XS 20'	**34.70**	**0.90**	**1.50**	**1.40**	**1.27**
DS XS 30'	**34.00**	**1.60**	**1.20**	**0.60**	**1.13**
DS XS 40'	**28.00**	**2.80**	**1.60**	**0.90**	**1.77**
DS XS 50'	**29.00**	**1.40**	**3.20**	**4.00**	**2.87**

Width/Depth Ratio Measurements

Site/Cross Section Name: **10A Riffle**

US=Upstream
DS=Downstream
XS=Cross Section

	Bankfull Distance (ft)	Water Depths (ft)			
		1	2	3	AVERAGE
US XS 50'	**44.0**	**1.1**	**1.6**	**1.8**	**1.5**
US XS 40'	**42.0**	**0.9**	**1.6**	**2.0**	**1.5**
US XS 30'	**44.0**	**1.2**	**1.6**	**2.0**	**1.6**
US XS 20'	**43.0**	**2.0**	**1.5**	**0.9**	**1.5**
US XS 10'	**43.0**	**0.4**	**1.5**	**2.1**	**1.3**
DS XS 10'	**42.0**	**1.8**	**1.4**	**2.6**	**1.9**
DS XS 20'	**38.0**	**1.2**	**1.7**	**0.8**	**1.2**
DS XS 30'	**33.0**	**1.1**	**1.4**	**0.9**	**1.1**
DS XS 40'	**33.0**	**1.0**	**1.6**	**1.0**	**1.2**
DS XS 50'	**31.0**	**1.0**	**1.7**	**0.8**	**1.2**

Width/Depth Ratio Measurements

Site/Cross Section Name: **10B Pool**

US=Upstream
DS=Downstream
XS=Cross Section

	Bankfull Distance (ft)	Water Depths (ft)			
		1	2	3	AVERAGE
US XS 50'	**47.00**	**0.29**	**1.35**	**1.56**	**1.07**
US XS 40'	**40.20**	**1.55**	**1.38**	**0.13**	**1.02**
US XS 30'	**41.70**	**0.20**	**1.45**	**1.45**	**1.03**
US XS 20'	**41.20**	**1.14**	**1.49**	**0.03**	**0.89**
US XS 10'	**46.21**	**0.02**	**1.70**	**1.21**	**0.98**
DS XS 10'	**43.50**	**0.65**	**1.39**	**1.40**	**1.15**
DS XS 20'	**44.59**	**1.53**	**1.82**	**0.85**	**1.40**
DS XS 30'	**45.20**	**1.00**	**1.97**	**1.43**	**1.47**
DS XS 40'	**47.25**	**1.15**	**2.10**	**0.98**	**1.41**
DS XS 50'	**45.50**	**1.60**	**2.06**	**1.12**	**1.59**

	SIZE (MM)	Pebble Count PERCENT
4A		
Very Coarse Sand	2.8	0%
Fine Gravel	4-5.6	10%
Medium Gravel	8-11.0	7.5%
Coarse Gravel	16-22.6	52.5%
Very Coarse Gravel	32- 45	17.5%
Small Cobble	64	12.5%
Medium Cobble	90	0%
Large Cobble	128	0%
Very Large Cobble	180	0%
Small Boulder	>180	0%

4B		
Very Coarse Sand	2.8	0%
Fine Gravel	4-5.6	0%
Medium Gravel	8-11.0	0%
Coarse Gravel	16-22.6	17.5%
Very Coarse Gravel	32- 45	62.5%
Small Cobble	64	10%
Medium Cobble	90	10%
Large Cobble	128	0%
Very Large Cobble	180	0%
Small Boulder	>180	0%

	SIZE (MM)	Pebble Count PERCENT
5A		
Silt/Clay	2	0%
Very Coarse Sand	2.8	0%
Fine Gravel	4-5.6	0%
Medium Gravel	8-11.0	0%
Coarse Gravel	16-22.6	32.5%
Very Coarse Gravel	32- 45	42.5%
Small Cobble	64	7.5%
Medium Cobble	90	17.5%
Large Cobble	128	0%
Very Large Cobble	180	0%
Small Boulder	>180	0%

5B		
Silt/Clay	2	0%
Very Coarse Sand	2.8	0%
Fine Gravel	4-5.6	0%
Medium Gravel	8-11.0	5%
Coarse Gravel	16-22.6	20%
Very Coarse Gravel	32- 45	50%
Small Cobble	64	20%
Medium Cobble	90	5%
Large Cobble	128	0%
Very Large Cobble	180	0%
Small Boulder	>180	0%

	SIZE (MM)	Pebble Count PERCENT
6A		
Silt/Clay	2	2.5%
Very Coarse Sand	2.8	0%
Fine Gravel	4-5.6	7.5%
Medium Gravel	8-11.0	12.5%
Coarse Gravel	16-22.6	30%
Very Coarse Gravel	32- 45	35%
Small Cobble	64	2.5%
Medium Cobble	90	7.5%
Large Cobble	128	2.5%
Very Large Cobble	180	0%
Small Boulder	>180	0%

6B		
Silt/Clay	2	22.5%
Very Coarse Sand	2.8	0%
Fine Gravel	4-5.6	0%
Medium Gravel	8-11.0	0%
Coarse Gravel	16-22.6	10%
Very Coarse Gravel	32- 45	37.5%
Small Cobble	64	10%
Medium Cobble	90	10%
Large Cobble	128	5%
Very Large Cobble	180	5%
Small Boulder	>180	0%

	SIZE (MM)	Pebble Count PERCENT
8A		
Silt/Clay	2	0%
Very Coarse Sand	2.8	0%
Fine Gravel	4-5.6	0%
Medium Gravel	8-11.0	7.5%
Coarse Gravel	16-22.6	27.5%
Very Coarse Gravel	32- 45	37.5%
Small Cobble	64	17.5%
Medium Cobble	90	7.5%
Large Cobble	128	0%
Very Large Cobble	180	2.5%
Small Boulder	>180	

8B		
Silt/Clay	2	0%
Very Coarse Sand	2.8	0%
Fine Gravel	4-5.6	0%
Medium Gravel	8-11.0	5%
Coarse Gravel	16-22.6	17.5%
Very Coarse Gravel	32- 45	40%
Small Cobble	64	27.5%
Medium Cobble	90	7.5%
Large Cobble	128	2.5%
Very Large Cobble	180	0%
Small Boulder	>180	0%

	SIZE (MM)	Pebble Count PERCENT
10A		
Silt/Clay	2	0%
Very Coarse Sand	2.8	0%
Fine Gravel	4-5.6	0%
Medium Gravel	8-11.0	12.5%
Coarse Gravel	16-22.6	25%
Very Coarse Gravel	32- 45	35%
Small Cobble	64	22.5%
Medium Cobble	90	2.5%
Large Cobble	128	2.5%
Very Large Cobble	180	0%
Small Boulder	>180	0%

10B		
Silt/Clay	2	0%
Very Coarse Sand	2.8	0%
Fine Gravel	4-5.6	0%
Medium Gravel	8-11.0	0%
Coarse Gravel	16-22.6	27.5%
Very Coarse Gravel	32- 45	62.5%
Small Cobble	64	10%
Medium Cobble	90	0%
Large Cobble	128	0%
Very Large Cobble	180	0%
Small Boulder	>180	0%

Water Surface Gradient

4A

Downstream Height = 5.5 ft

Upstream Height = 4.9 ft

Gradient Ratio = (5.5 - 4.9) / 200 ft = 0.6 ft
(Downstream height; Upstream height)

Percent Grade = 0.003 x 100 = 0.3 %
(Gradient Ratio)

4B

Downstream Height = 7.22 ft

Upstream Height = 6.78 ft

Gradient Ratio = (7.22 - 6.78) / 200 ft = 0.0022 ft
(Downstream height; Upstream height)

Percent Grade = 0.0022 x 100 = 0.22 %
(Gradient Ratio)

Water Surface Gradient

5A

Downstream Height = 6.9 ft

Upstream Height = 6.7 ft

Gradient Ratio = (6.9 - 6.7) / 200 ft = 0.2 ft
(Downstream height, Upstream height)

Percent Grade = 0.001 (Gradient Ratio) x 100 = 0.1 %

5B

Downstream Height = 7.38 ft

Upstream Height = 7.06 ft

Gradient Ratio = (7.38 - 7.06) / 200 ft = 0.0016 ft
(Downstream height, Upstream height)

Percent Grade = 0.0016 (Gradient Ratio) x 100 = 0.16 %

Water Surface Gradient

6A

Downstream Height = 6.8 ft

Upstream Height = 6.2 ft

Gradient Ratio = (6.8 - 6.2) / 200 ft = 0.6 ft
(Downstream height, Upstream height)

Percent Grade = 0.003 (Gradient Ratio) x 100 = 0.3 %

6B

Downstream Height = 6.51 ft

Upstream Height = 6.25 ft

Gradient Ratio = (6.51 - 6.25) / 200 ft = 0.0013 ft
(Downstream height, Upstream height)

Percent Grade = 0.0013 (Gradient Ratio) x 100 = 0.13 %

Water Surface Gradient

8A

Downstream Height = 7.3 ft

Upstream Height = 7.1 ft

Gradient Ratio = (7.3 - 7.1) / 200 ft = 0.2 ft
(Downstream height, Upstream height)

Percent Grade = 0.001 (Gradient Ratio) x 100 = 0.1 %

8B

Downstream Height = 8.60 ft

Upstream Height = 8.20 ft

Gradient Ratio = (8.60 - 8.20) / 200 ft = 0.002 ft
(Downstream height, Upstream height)

Percent Grade = 0.002 (Gradient Ratio) x 100 = 0.2 %

Water Surface Gradient

10A

Downstream Height = 7.3 ft

Upstream Height = 6.9 ft

Gradient Ratio = (7.3 - 6.9) / 200 ft = 0.4 ft
(Downstream height, Upstream height)

Percent Grade = 0.002 (Gradient Ratio) x 100 = 0.2 %

10B

Downstream Height = 8.61 ft

Upstream Height = 8.40 ft

Gradient Ratio = (8.61 - 8.40) / 200 ft = 0.0011 ft
(Downstream height, Upstream height)

Percent Grade = 0.0011 (Gradient Ratio) x 100 = 0.11 %

Fine/Course Relationship

4A

Average fine	Average course
32.5%	67.5%

4B

Average fine	Average course
39.5%	60.5%

5A

Average fine	Average course
31%	69%

5B

Average fine	Average course
38.7%	61.3%

6A

Average fine	Average course
15%	85%

6B

Average fine	Average course
44%	56%

8A

Average fine	Average course
87.5%	12.5%

8B

Average fine	Average course
35.5%	64.5%

10A

Average fine	Average course
20.5%	79.5%

10B

Average fine	Average course
26.5%	73.5%

6B Point Bar Area

Length: 11ft

Height: 43ft

Area: 236.5ft

Stream Morphology Field Sheet

Site Information

Site Name: Reach Name: Cross Section:

Sample Date:

GPS Number/Name:
GPS Datum:

Cross Section Name:

GPS Waypoint Name: GPS Waypoint Name:

Lat (RL): N Lat (RR): N

Long (RL): W Long (RR): W

Elevation: Elevation:

Cross Section Name:

GPS Waypoint Name: GPS Waypoint Name:

Lat (RL): N Lat (RR): N

Long (RL): W Long (RR): W

Elevation: Elevation:

Tripod Placement: RR RL

GPS Waypoint Name:

Lat: N

Long: W

Elevation:

Cross Section Profile

Cross Section Name:

GPS Waypoint Name: GPS Waypoint Name:
Lat (RL): N Lat (RR):
Long (RL): W Long (RR):
Transit Level Height (ft):

Comment section to include Bankfull, water's edge, bank edge, start, and end. Indicate whether on river left or river right.

Increment along tape (ft)	Height on Rod (ft)	Comment

Cross Section Profile

Cross Section Name:

GPS Waypoint Name: GPS Waypoint Name:
Lat (RL): N Lat (RR):
Long (RL): W Long (RR):
Transit Level Height (ft):

Comment section to include Bankfull, water's edge, bank edge, start, and end. Indicate whether on river left or river right.

Increment along tape (ft)	Height on Rod (ft)	Comment

Pebble Count

Cross Section:

Particle Size (mm)	T1	T2	T3	T4	Total
2					
2.8					
4					
5.6					
8					
11					
16					
22.6					
32					
45					
64					
90					
128					
180					
>180					

Cross Section:

Particle Size (mm)	T1	T2	T3	T4	Total
2					
2.8					
4					
5.6					
8					
11					
16					
22.6					
32					
45					
64					
90					
128					
180					
>180					

Sinuosity

Sinuosity = 500 ft / Straight line distance (ft)

Pace = _____ steps for 50 ft

= _____ steps for 500 ft

Straight line : _____ steps

Straight Line ft = (_____ x 50 ft) / _____ = _____ft
Total straight line steps 50 ft pace

Sinuosity = 500 ft / _____ ft
straight line ft

Sinuosity = _____

Water Surface Gradient

Downstream Height = _____ ft

Upstream Height = _____ft

Gradient Ratio = (_____ - _____) / 200 ft = _____ ft
Downstream height Upstream height

Percent Grade = _____ x 100 = _____ %
Gradient Ratio

Width/Depth Ratio Measurements

Site/Cross Section Name:

US=Upstream
DS=Downstream
XS=Cross Section

	Bankfull Distance (ft)	Water Depths (ft)			
		1	2	3	AVERAGE
US XS 50'					
US XS 40'					
US XS 30'					
US XS 20'					
US XS 10'					
DS XS 10'					
DS XS 20'					
DS XS 30'					
DS XS 40'					
DS XS 50'					

BEHI

Cross Section:

	Bank					
	RL			RR		
	1	2	3	1	2	3
Bankfull Height (ft)						

Bank Height (ft)						
Root Depth (ft)						
Root Density (%)						
Bank Angle (<90° or >90°)						
Surface Protection (%)						

Cross Section:

	Bank					
	RL			**RR**		
	1	**2**	**3**	**1**	**2**	**3**
Bankfull Height (ft)						
Bank Height (ft)						
Root Depth (ft)						
Root Density (%)						
Bank Angle (<90° or >90°)						
Surface Protection (%)						

Bank Erodibilty Hazard Index Rating Guide

Stream Bank Hazard or Risk Rating		Bank Height to Bankfull Height (Ratio)	Root Depth to Bank Height (Ratio)	Root Density (%)	Bank Angle (Degrees)	Surface Protection (%)	Index Totals
	Value	1.0-1.1	1.0-0.9	100-80	0-20	100-80	
Very Low	*Index*	1.0-1.9	1.0-1.9	1.0-1.9	1.0-1.9	1.0-1.9	5-9.5
	Value	1.11-1.19	0.89-0.5	79-55	21-60	79-55	
Low	*Index*	2.0-3.9	2.0-3.9	2.0-3.9	2.0-3.9	2.0-3.9	10-19.5
	Value	1.2-1.5	0.49-0.3	54-30	61-80	54-30	
Moderate	*Index*	4.0-5.9	4.0-5.9	4.0-5.9	4.0-5.9	4.0-5.9	20-29.5
	Value	1.6-2.0	0.29-0.15	29-15	81-90	29-15	
High	*Index*	6.0-7.9	6.0-7.9	6.0-7.9	6.0-7.9	6.0-7.9	30-39.5
	Value	2.1-2.8	0.14-0.05	14-5.0	91-119	14-10	
Very High	*Index*	8.0-9.0	8.0-9.0	8.0-9.0	8.0-9.0	8.0-9.0	40-45
	Value	> 2.8	< 0.05	< 5	< 119	< 10	
Extreme	*Index*	10	10	10	10	10	46-50

APPENDIX B
MACROINVERTEBRATE SURVEY

APPENDIX

The following data represent the raw counts from each site on Poindexter Slough. The data are categorized according to site number and habitat or substrate type. Data are presented at the familial level except where otherwise noted. Simpson's and Margalef's values are also presented below.

	MARGALEF'S RICHNESS INDEX	SIMPSON'S DIVERSITY INDEX
Cross-Section 4AG	2.405	0.65
Cross-Section 4AM	3.215	0.68
Cross-Section 4BG	2.698	0.83
Cross-Section 4BM	0.659	0.16
Cross-Section 5AG	2.175	0.71
Cross-Section 5AM	1.763	0.82
Cross-Section 5BG	2.978	0.72
Cross-Section 5BM	1.062	0.33
Cross-Section 6AG	3.202	0.89
Cross-Section 6AM	3.493	0.82
Cross-Section 6BG	1.970	0.83
Cross-Section 6BM	0.910	0.42
Cross-Section 8AG	1.028	0.52
Cross-Section 8AM	1.349	0.52
Cross-Section 8BG	2.813	0.77
Cross-Section 8BM	1.911	0.65

Cross-Section 10AG	2.376	0.73
Cross-Section 10AM	1.029	0.45
Cross-Section 10BG	2.232	0.76
Cross-Section 10BM	1.649	0.52

Cross-Section 4A Gravel

Amphipoda	**1**
Ancylidae	**2**
Brachycentridae	**4**
Ceratopogonidae	**1**
Hydropshychidae	**1**
Leptoceridae	**7**
Lymnaeidea	**2**
Perlodidae	**8**
Physidae	**2**
Planorbidae	**2**
Porcellionidae	**12**
Valvatidae	**55**

Cross-Section 4A Mud

Amphipoda	**73**
Ancylidae	**1**
Brachycentridae	**1**
Ceratopogonidae	**9**
Chironomidae	**13**
Corixidae	**2**
Ephemerellidae	**1**
Hirudinea	**2**
Lepidostomatidae	**1**
Lymnaeidea	**2**
Naucoridae	**1**
Perlodidae	**1**
Physidae	**1**
Planorbidae	**1**
Porcellionidae	**32**
Rhycophilidae	**2**
Tricorythidae	**1**

Cross-Section 4B Gravel

Amphipoda	**19**
Brachycentridae	**5**
Chironomidae	**4**
Empididae	**3**
Hydropshychidae	**13**
Perlidae	**3**
Physidae	**1**
Siphlonuridae	**5**
Tabanidae	**1**
Tipula	**3**
Turbellaria	**1**
Valvatidae	**1**

Cross-Section 4B Mud

Amphipoda	**87**
Corixidae	**3**
Hydropshychidae	**1**
Rhycophilidae	**4**

Cross-Section 5A Gravel

Amphipoda	**2**
Baetidae	**2**
Brachycentridae	**8**
Chironomidae	**4**
Elmidae	**9**
Ephemerellidae	**1**
Helicopsychidae	**59**
Hydropshychidae	**8**
Leptoceridae	**19**
Oligoneuridae	**9**
Physidae	**2**
Porcellionidae	**118**
Simuliidae	**1**
Turbellaria	**9**

Cross-Section 5A Mud

Amphipoda	**13**
Baetidae	**2**
Chironomidae	**4**
Corixidae	**8**
Hirudinea	**5**
Hydropshychidae	**1**
Oligochaeta	**16**
Porcellionidae	**4**

Cross-Section 5B Gravel

Amphipoda	**19**
Baetidae	**1**
Brachycentridae	**5**
Capniidae	**3**
Ceratopogonidae	**4**
Chironomidae	**2**
Elmidae	**4**
Empididae	**4**
Hirudinea	**2**
Lymnaeidea	**1**
Porcellionidae	**54**
Pteronarcyidae	**1**
Simuliidae	**2**
Tipula	**1**
Valvatidae	**7**

Cross-Section 5B Mud

Amphipoda	**10**
Chironomidae	**8**
Corixidae	**1**
Lymnaeidea	**1**
Nematoda	**1**
Porcellionidae	**9**

Cross-Section 6A Gravel

Amphipoda	**1**
Baetidae	**1**
Brachycentridae	**5**
Chironomidae	**4**
Elmidae	**3**
Hirudinea	**1**
Hydropshychidae	**10**
Limnephilidae	**5**
Lymnaeidea	**1**
Nematoda	**1**
Oligochaeta	**7**
Perlodidae	**2**
Physidae	**3**
Planorbidae	**1**
Porcellionidae	**12**
Turbellaria	**2**
Valvatidae	**10**

Cross-Section 6A Mud

Amphipoda	**1**
Brachycentridae	**2**
Chironomidae	**16**
Corixidae	**1**
Dytiscidae	**1**
Hirudinea	**1**
Hydroptilidae	**1**
Lymnaeidea	**3**
Oligochaeta	**20**
Perlidae	**1**
Physidae	**2**
Planorbidae	**7**
Rhycophilidae	**1**
Sphaeriidae	**1**
Turbellaria	**1**

Cross-Section 6B Gravel

Amphipoda	**1**
Baetidae	**1**
Brachycentridae	**6**
Chironomidae	**8**
Hydropshychidae	**16**
Lymnaeidea	**1**
Oligochaeta	**14**
Peltoperlidae	**6**
Valvatidae	**5**

Cross-Section 6B Mud

Ancylidae	**1**
Chlroperlidae	**7**
Oligochaeta	**1**

Cross-Section 8A Gravel

Lymnaeidea	**1**
Oligoneuridae	**1**
Porcellionidae	**5**

Cross-Section 8A Mud

Amphipoda	**2**
Ceratopogonidae	**4**
Hirudinea	**3**
Lymnaeidea	**4**
Oligoneuridae	**117**
Porcellionidae	**7**
Sphaeriidae	**41**

Cross-Section 8B Gravel

Amphipoda	**4**
Brachycentridae	**4**
Chironomidae	**1**
Empididae	**2**
Heptageniidae	**1**
Hirudinea	**2**
Lymnaeidea	**2**
Physidae	**1**
Planorbidae	**1**
Porcellionidae	**16**
Turbellaria	**1**

Cross-Section 8B Mud

Amphipoda	**22**
Brachycentridae	**2**
Oligochaeta	**8**
Physidae	**1**
Planorbidae	**3**
Sphaeriidae	**1**
Tabanidae	**1**

Cross-Section 10A Gravel

Baetidae	**2**
Brachycentridae	**2**
Hydropshychidae	**6**
Leptoceridae	**2**
Porcellionidae	**1**
Pyralidae	**1**
Turbellaria	**1**
Valvatidae	**14**

Cross-Section 10A Mud

Ceratopogonidae	**8**
Chironomidae	**94**
Corixidae	**4**
Hirudinea	**3**
Oligoneuridae	**8**
Porcellionidae	**12**

Cross-Section 10B Gravel

Aeshnidae	**1**
Brachycentridae	**1**
Corixidae	**7**
Empididae	**2**
Hirudinea	**2**
Lymnaeidea	**2**
Nematoda	**16**
Porcellionidae	**1**
Valvatidae	**4**

Cross-Section 10B Mud

Chironomidae	**26**
Empididae	**1**
Hirudinea	**4**
Lymnaeidea	**2**
Valvatidae	**1**

APPENDIX C
STREAM HABITAT SURVEY

1	Riffle	Run	Pool	Glide
Length	21	6	31.5	15
Depth	1.1	2.2	5	4
Width	30.5	31.5	32	31

	Grass %	Willow %	Bare Ground %
Plants- Left Bank	9	90	1
Plants-Right Bank	100	0	0

2	Riffle	Run	Pool	Glide
Length	45.8	20	40.7	20
Depth	1.7	3.1	4.4	4
Width	28	33	30.9	45.5

	Grass %	Willow %	Bare Ground %
Plants- Left Bank	93	5	2
Plants-Right Bank	10	90	0

3	Riffle	Run	Pool	Glide
Length	29	7	12.4	15.9
Depth	1.3	3	3.4	2
Width	37	27.4	28	31.5

	Grass %	Willow %	Bare Ground %
Plants- Left Bank	95	5	0
Plants-Right Bank	10	90	0

4	Riffle	Run	Pool	Glide
Length	47	14.5	36	12.5
Depth	1.3	4	6.5	4.8
Width	37.3	50	35.7	46

	Grass%	Willow %	Bare Ground %
Plants- Left Bank	85	5	10
Plants-Right Bank	95	5	0

5	Riffle	Run	Pool	Glide
Length	39.3	17.5	49.5	11
Depth	1.6	3.3	5.5	4
Width	30.6	28	31	31.9

	Grass %	Willow %	Bare Ground %
Plants- Left Bank	95	5	0
Plants-Right Bank	95	5	0

6	Riffle	Run	Pool	Glide
Length	34.6	16	40.8	12
Depth	1.3	3.1	5	4.2
Width	36.5	35.6	46.5	33

	Grass %	Willow %	Bare Ground %
Plants- Left Bank	75	20	5
Plants-Right Bank	95	0	5

7	Riffle	Run	Pool	Glide
Length	41.5	15	43	10
Depth	1.2	3	6	5
Width	30.5	38	36.3	33

	Grass %	Willow %	Bare Ground %
Plants- Left Bank	100	0	0
Plants-Right Bank	100	0	0

8	Riffle	Run	Pool	Glide
Length	26.7	13	35	17.5
Depth	1.3	3.3	6.5	4.8
Width	31.5	33	36	27

	Grass %	Willow %	Bare Ground %
Plants- Left Bank	100	0	25
Plants-Right Bank	5	95	0

9	Riffle	Run	Pool	Glide
Length	17.6	5	13.4	X
Depth	1.3	2.3	3	X
Width	25.8	27.5	27	X

	Grass %	Willow %	Bare Ground %
Plants- Left Bank	100	0	0
Plants-Right Bank	100	0	0

10	Riffle	Run	Pool	Glide
Length	X	7.6	25	15.4
Depth	X	4.5	6.1	2.4
Width	X	36.5	45.5	44.9

	Grass %	Willow %	Bare Ground %
Plants- Left Bank	90	10	0
Plants-Right Bank	100	0	0

11	Riffle	Run	Pool	Glide
Length	13.4	7.7	5.7	27
Depth	1.3	4.2	4.4	3.7
Width	37.6	35	35.9	31.1

	Grass %	Willow %	Bare Ground %
Plants- Left Bank	85	5	0
Plants-Right Bank	100	0	0

12	Riffle	Run	Pool	Glide
Length	46.5	13	7	16
Depth	3	2.8	4.5	3.5
Width	31	47	38.5	30

	Grass %	Willow %	Bare Ground %
Plants- Left Bank	100	0	0
Plants-Right Bank	95	5	0

13	Riffle	Run	Pool	Glide
Length	63	16.5	24.5	25
Depth	1.6	2.4	5.2	4
Width	35.6	29	28.8	32

	Grass %	Willow %	Bare Ground %
Plants- Left Bank	100	0	0
Plants-Right Bank	85	10	5

14	Riffle	Run	Pool	Glide
Length	49	31.5	33.8	22.5
Depth	1.6	4	5.3	4
Width	31.5	37.5	28.8	28

	Grass %	Willow %	Bare Ground %
Plants- Left Bank	85	5	10
Plants-Right Bank	100	0	0

15	Riffle	Run	Pool	Glide
Length	63	36	42	25.5
Depth	1.6	3	5.2	4.1
Width	33.8	31.3	30.5	28

	Grass %	Willow %	Bare Ground %
Plants- Left Bank	100	0	0
Plants-Right Bank	15	0	85

16	Riffle	Run	Pool	Glide
Length	37.5	17	26.5	24.5
Depth	1.4	3.3	5.5	4.5
Width	35	31.6	34.5	32.9

	Grass %	Willow %	Bare Ground %
Plants- Left Bank	95	0	5
Plants-Right Bank	100	0	0

17	Riffle	Run	Pool	Glide
Length	68	20	45	16.5
Depth	1.5	4.2	5.4	3.6
Width	31.4	35.5	35	30.9

	Grass %	Willow %	Bare Ground %
Plants- Left Bank	95	0	5
Plants-Right Bank	100	0	0

18	Riffle	Run	Pool	Glide
Length	34	6	16	30
Depth	1.3	2	5.5	2.4
Width	37	42.5	38	28

	Grass %	Willow %	Bare Ground %
Plants- Left Bank	100	0	0
Plants-Right Bank	100	10	0

19	Riffle	Run	Pool	Glide
Length	45	10	37.5	40
Depth	1.4	4.5	6	4
Width	29	37	39.6	29

	Grass %	Willow %	Bare Ground %
Plants- Left Bank	100	0	0
Plants-Right Bank	100	0	0

20	Riffle	Run	Pool	Glide
Length	48.5	9.5	81	14
Depth	2.1	3.5	6.5	5.8
Width	30	29	28	27

	Grass %	Willow %	Bare Ground %
Plants- Left Bank	100	0	0
Plants-Right Bank	95	0	5

21	Riffle	Run	Pool	Glide
Length	45	5	16	10
Depth	1.4	3.7	5	2.2
Width	29	35	35	32

	Grass %	Willow %	Bare Ground %
Plants- Left Bank	100	0	0
Plants-Right Bank	100	0	0

22	Riffle	Run	Pool	Glide
Length	52	22.7	25	20.5
Depth	2.4	4	6.3	3
Width	30.5	27.5	26.5	31.5

	Grass %	Willow %	Bare Ground %
Plants- Left Bank	100	0	0
Plants-Right Bank	100	0	0

23	Riffle	Run	Pool	Glide
Length	25.5	13	13	28
Depth	1.4	3	4	2.1
Width	28	34	34	29

	Grass %	Willow %	Bare Ground %
Plants- Left Bank	100	0	0
Plants-Right Bank	100	0	0

24	Riffle	Run	Pool	Glide
Length	27	12.5	40	16.5
Depth	1.2	2	5.5	4
Width	33.5	29	28.5	29.4

	Grass %	Willow %	Bare Ground %
Plants- Left Bank	100	0	0
Plants-Right Bank	100	0	0

25	Riffle	Run	Pool	Glide
Length	91	19	75	24
Depth	1.5	2	5.5	4
Width	35.5	35	38	31.9

	Grass %	Willow %	Bare Ground %
Plants- Left Bank	100	0	0
Plants-Right Bank	100	0	0