River Falls Hydroelectric Project Riverine Habitat Evaluation below Powell Falls

SUBMITTED TO

City of River Falls Municipal Utilities

January 2021

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1. Introduction

Powell Falls and Junction Falls Dams impound the Kinnickinnic River within the City of River Falls, Wisconsin, approximately 10 miles upstream of the river's confluence with the St. Croix River and 30 miles downstream from its headwaters in central St. Croix County. The Powell Falls Dam creates the downstream Lake Louise and the Junction Falls Dam creates the upstream Lake George. Both dams are currently licensed under Federal Energy Regulatory Commission (FERC) Project No. 10489. River Falls Municipal Utilities is proposing to relicense the Junction Falls Development and decommission the Powell Falls Development with dam removal. As part of these efforts, a riverine habitat survey was conducted downstream of the Powell Falls Dam to the river's confluence with the St. Croix River (Figure 1). Past habitat and geomorphic evaluations which partially cover the study area were completed by Inter-Fluve (2017) and the Wisconsin Department of Natural Resources (WDNR; 1998, 2015).

The purpose of this habitat evaluation is to document baseline habitat conditions prior to the proposed decommissioning and removal of the Powell Falls Dam. To evaluate habitat conditions, Inter-Fluve and Gulf South Research Corporation (GSRC) staff assessed and mapped mesohabitat features (pools, riffles, runs), large wood, sediment characteristics, channel dimensions, and floodplain deposits within the study area.

2. Background

The WDNR has determined that the Kinnickinnic River contains an exceptionally high quality and high-density brown trout population throughout the main stem. According to the WDNR, the Kinnickinnic River and South Fork of the Kinnickinnic River are considered outstanding Class I trout waters, and the Kinnickinnic River downstream of Powell Falls Dam is classified as an Outstanding Resource Water (WDNR 2015). The entire Kinnickinnic River outside of the impounded areas is designated as an Area of Special Natural Resource Interest (ASNRI). Brown trout densities and the number of large size trout (12 inches and greater) have been consistently above the 95 percentiles for the State of Wisconsin (WDNR 2015). During the 2015 survey, the survey station just downstream of the River Falls dams ranked in the 78th percentile among Wisconsin streams for adult brown trout Catch Per Effort (CPE; 937 fish/mile). Longer term (1996 –2014) trend data from

the lower Kinnickinnic River show adult brown trout densities consistently greater than the 95th percentile.

The following paragraphs contain a summary of Hunt (1969), Miller (1974), Carline (1980), and Power (1992) and provide brief overview of trout habitat requirements. Three main habitat requirements for a natural trout population to exist are food, shelter, and reproductive substrate.

Trout are opportunistic feeders and will feed on a variety of prey ranging in size from small fish to terrestrial invertebrates. However, their main food source throughout the year are aquatic invertebrates. High quality aquatic invertebrate populations occur with diverse stream habitat conditions. In a stream, a variety of conditions including water velocity, streambed substrate, water depth, water temperature, bank material, and vegetation will create diverse aquatic invertebrate communities that will provide food for trout. Of particular importance to trout's diets are benthic (i.e., bottom-dwelling) macroinvertebrates, that are most abundant in areas with gravel and cobble substrate. Deposition of sand and other fine sediment can embed and bury gravel and cobble substrates, and can therefore limit benthic macroinvertebrate population densities.

Instream structures such as large boulders, undercut banks, overhead vegetation, and large wood, provide shelter for fish to hide from predators, ambush prey, and rest. Deep pools can also provide shelter or contribute to the effectiveness of sheltering structures. Because trout are visual predators and often compete with each other for limited food resources, complexity of habitat is important in maintaining visual separation.

Trout need a gravel substrate to lay their eggs to naturally reproduce. Female trout create nests, or redds, by excavating sand and silt from gravels with their tail. Redds are typically found just downstream of a pool (pool tail out) and upstream of a riffle. Eggs incubate in these well oxygenated gravel substrates until they are ready to hatch. Fry (newly hatched fish) emerge from the gravel and quickly move to low velocity stream areas with suitable food and complex shelter.

Rivers and riparian habitat are also of great importance to many native flora and fauna. Animals such as bats, deer, and waterfowl use rivers as travel corridors while many birds, amphibians, reptiles, fish, and mollusks also reside in rivers and riparian areas. The biodiversity within these areas is due to the diversity of habitat and ecologic resources offered by such systems. Diversity in

soil types and hydrology in these systems leads to greater diversity in plant communities. The plant communities attract pollinators and other insect life which can be preyed upon by birds, amphibians, and other animals. Complexity within the channel of the river and on its banks also creates the variety needed for greater species diversity. Mollusks, crustaceans, and benthic macroinvertebrates all thrive in streams with greater variability in depth, flow, and substrate material. A wide range of bank shape and material leads to habitat improvements for animals such as muskrats, beavers, and turtles.

3. Methods

A habitat survey from Powell Falls to the confluence with the St. Croix River was conducted by Inter-Fluve and GSRC staff from September 21 to 24, 2020. Air temperatures varied between 60 and 80 degrees Fahrenheit and it was generally partly cloudy to clear. Rain occurred on the afternoon of September 22. The mean daily discharge at the United States Geological Survey (USGS) stream gage 05342000 located at the County Road F crossing varied between 136 and 138 cubic feet per second (cfs) which is within the typical baseflow for this river. Field data collection used the following methods:

- An Apple iPad with a Bad Elf Bluetooth global positioning system (GPS) receiver was used to collect the location of mesohabitat features, survey cross-section end points, and pebble count locations.
- At pools, riffles, and runs, the surveyors performed a visual estimate of the bankfull width, the length of unstable bank, canopy cover, and floodplain confinement. Bankfull depth was measured using a graduated rod carried by the observer. Where water velocity or depth was unsafe for surveying (e.g., excessively deep pools), the observer either estimated depth and/or measured as close to the thalweg as possible.
- For this habitat survey, “side-channels” are considered naturally wetted flow paths connected to the mainstem channel at their upstream and downstream ends at average annual flow. Side channel units were identified when the main channel split to form a stable island with soil or fine sediment accumulations and with establishing vegetation older than 2 to 3 years.

- A total station was used to collect relative elevations of cross-sections located across a minimum of two pools and two riffle/runs per subreach. Edge of water was surveyed and approximate bankfull elevation was determined based on topographic indicators.
- Bed material and bar material was assessed by pebble count in representative subreaches and visually estimated throughout all reaches. One pebble count of 100 clasts was conducted at a representative riffle in each study reach. In addition, a pebble count of 100 clasts was conducted on one depositional bar in each reach.
- Large wood pieces were counted along the length of the study area. For the purpose of this assessment, large wood is considered any piece of wood greater than 6 inches in diameter and greater than 4 feet long.
- Geotagged photos were collected at the approximate downstream terminus of each riffle and pool.
- River stations were developed based on the reach lines used in the desktop analysis completed by TRC (2019). The river stations measure the distance in feet upstream from the St. Croix River confluence (Station 0+00) and are used to locate the various features described in the evaluation. Maps showing river stations are provided in Appendix C.
- Errors (+/-) are given as 1 standard deviation about the mean of the data.

4. Reach Summaries

Five reaches below Powell Falls were delineated in a previous desktop analysis (TRC 2019). In the field, Inter-Fluve and GSRC staff selected a representative subreach in each reach and described, photographed, and surveyed the subreach. It should be noted, that though the selected subreaches are called "representative" per the Scope of Work, there is inherent heterogeneity within the individual reaches. Representative subreaches are rather intended to provide general insights into habitat forms and geomorphic processes occurring within the reach. Additional data on representative subreaches can be found in Appendix A, pebble count data can be found in Appendix B, field maps with stationing are provided in Appendix C, and field data and photographs can be found in Appendix D.

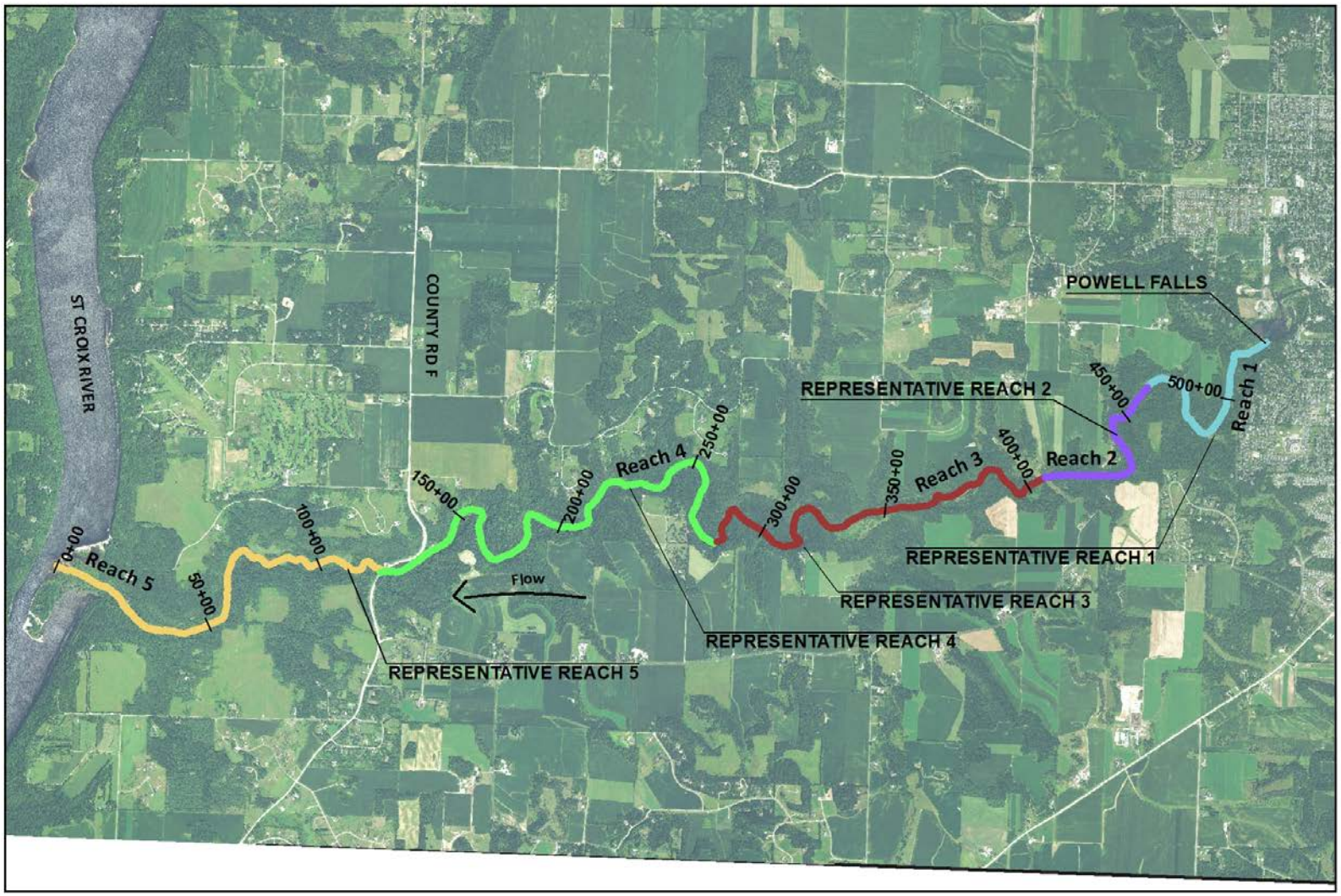

Figure 1: Location of riverine habitat evaluation study area with reaches delineated and showing location of representative reaches.

4.1 REACH 1

Reach 1 stretched from station 460+00 to 520+00. The downstream boundary was gradual (not at a distinct feature such as a road crossing) to Reach 2 and the upstream boundary was the Powell Falls Dam. The reach had a pool-riffle morphology and had a naturally confined floodplain. Large gravels and cobbles in riffles were on average 20% embedded. There was a bedrock-controlled riffle at station 512+00. Riverside trails were present on river left throughout the reach and were maintained to the Rocky Branch Confluence (station 448+00). There was an 800-foot long well-sorted sandy run downstream of the Rocky Branch Confluence. There were on average 0.6 large wood pieces located per 100 feet (32 large wood pieces per mile). There were 9 pools with an average residual depth of 2 feet, and average bankfull depth of 6 feet (+/- 1 foot). Typical pool-pool spacing was 700 feet. Approximately 20% of the channel was shaded by deciduous trees and shrubs. Typically, the reach contained relatively low density of habitat with few pieces of large wood, and few deep pools. Fish cover from vegetation was abundant. Bank erosion was limited. Fine sediment was present and typically embedded riffle material.

4.1.1 Representative subreach 1

Representative subreach 1 was from station 484+00 to 500+00. Banks in representative reach 1 were typically vegetated. From Station 489+80 to Station 500+00 (approximately 120 feet), the left bank was bare and likely actively eroding. Exposed bank sediments were composed of sandy loam. Streambanks were generally stable and active erosion was interpreted as a result of the natural lateral migration of the river channel in response to flood events. For approximately 450 feet on river left, the river ran adjacent to a maintained trail and near a historic lime kiln. This portion of the bank was stabilized with riprap below the ordinary high water. A 300-foot long, 40-foot wide vegetated island was present within the reach. The island was vegetated with reed canary grass and a cluster of four 3-to-6-inch diameter deciduous trees. Bankfull widths averaged 66 feet (+/- 4.5 feet), wetted width averaged 59 feet (+/- 3.4 feet), and bankfull thalweg depth averaged 4 feet (+/- 0.5 feet). Riffles were typically composed of poorly sorted sand to cobble with cobbles typically embedded by smaller material and had bankfull depths which averaged 2 feet. Depth of refusal on riffles was generally between 2 and 3 feet. Pools were typically composed of well sorted sand or gravel with residual depths of 2 feet (+/- 0.5 feet). Valley width was estimated to be 400 feet. Overbank

sedimentation was common, with sediments composed of well sorted fine sand and typically deposited as sand sheets in low lying floodplain forest and were thickest in areas associated with the Rocky Branch. There was on average one large wood piece per 100 feet. This subreach contained a low density of habitat features with few large wood pieces and overhanging vegetation. Undercut banks were absent. Pools were typically shallow. The main habitat feature within this subreach was coarse riffle substrate and boulders associated with the riprap bank.

Figure 2: Typical photo collected at station 490+00 in representative subreach 1.

4.2 REACH 2

Reach 2 stretched from station 405+00 to 460+00. The upstream boundary was gradual, and the downstream boundary was an existing power line right-of-way. The reach had a pool-riffle morphology and had a naturally confined floodplain. The upstream portion of the reach (from station 428+00) had a pool-pool spacing of approximately 400 feet. Downstream of station 428+00, pool-pool spacing increased to approximately 1200 feet. Large gravels and cobbles in riffles were on average 20% embedded. There was a private access route on river right at station 432+00. There were

on average 0.9 large wood pieces located per 100 feet (49 large wood pieces per mile). There were 8 pools with an average residual depth of 2 feet, and average bankfull depth of 7 feet (+/- 2 feet). Approximately 25% of the channel was shaded by deciduous trees and shrubs. Typically, the reach contained a low density of habitat features with few pieces of large wood, and few deep pools. Fish cover from vegetation was abundant along stream edges. Bank erosion was limited. Fine sediment was present and typically embedded riffle material.

4.2.1 Representative subreach 2

Representative subreach 2 was from station 434+00 to 444+00. Banks in representative subreach 2 were approximately 80% vegetated with alternating banks exposed. Where exposed, bank sediments consisted of poorly sorted sand and gravel. Streambanks were generally stable and active erosion was interpreted as a result of the natural lateral migration of the river channel in response to flood events. Bankfull widths averaged 67 feet (+/- 6.2 feet), wetted width averaged 63 feet (+/- 7.0 feet), and bankfull thalweg depth averaged 4 feet (+/- 1.3 feet). Riffles were typically composed of poorly sorted sand to cobble with cobbles typically embedded by smaller material and had bankfull depths which averaged 2.5 feet. Depth of refusal on riffles was generally between 1 and 2 feet. Pools were typically composed of well sorted sand or gravel with residual depths of 2 feet (+/- 1 foot). Valley width was estimated to be 450 feet. Overbank sedimentation was common with sediments composed of well sorted fine sand. A mid-channel bar was present near the upstream terminus of the reach and was composed of poorly sorted sand to boulders. There was on average 0.4 large wood pieces per 100 feet in this reach. This subreach contained a low density of habitat features with few large wood pieces, boulders, and overhanging vegetation. Undercut banks were absent. Pools were typically shallow. The main habitat feature within this subreach was coarse riffle substrate.

Figure 3: Typical photo collected at station 445+00 in representative subreach 2.

4.3 REACH 3

Reach 3 stretched from station 278+00 to 405+00. The upstream boundary was an existing power line right-of-way and the downstream boundary was gradual. The reach had a pool-riffle morphology and had a naturally confined to unconfined floodplain. Some pools were transitional with runs. Large gravels and cobbles in riffles were on average 10% embedded and some riffles were armored. There were approximately 5 pool-riffle sequences consisting of closely (approximately 200 feet) spaced riffles separated by short pools. These pool-riffle sequences were generally separated by long straight pools. There was cleared private land on river left from station 340+00 to 350+00. There was on average 1 large wood piece located per 100 feet (54 large wood pieces per mile). There were 17 pools with an average residual depth of 2 feet, and an average bankfull depth of 6 feet (+/- 1 foot). Approximately 20% of the channel was shaded by deciduous trees and shrubs. Typically, the reach contained a low density of habitat features with few pieces of large wood, and few deep pools. Fish cover from vegetation was abundant. Bank erosion was limited. Fine sediment was present and typically embedded riffle material.

4.3.1 Representative subreach 3

Representative subreach 3 was from station 305+00 to 316+00. Banks in representative reach 3 were approximately 60% vegetated with alternating banks exposed. Where exposed, bank sediments consisted of sandy loam overlaying poorly sorted sand and gravel or bedrock. Streambanks were generally stable and active erosion was interpreted as a result of the natural lateral migration of the river channel in response to flood events. Bankfull widths averaged 61 feet (+/- 10.1 feet), wetted width averaged 42 feet (+/- 16.7 feet), and bankfull thalweg depth averaged 4 feet (+/- 1.5 feet). Riffles were typically composed of poorly sorted sand to cobble with cobbles typically embedded by smaller material and had bankfull depths which averaged 2 feet. Depth of refusal on riffles were generally between 2 and 3 feet. Pools were typically composed of well sorted sand with residual depths of 2 feet (+/- 1 feet). Valley width was estimated to be 550 feet. Overbank sedimentation was common with sediments composed of well sorted fine sand and typically deposited as sand sheets on the inside of meander bends. Several mid-channel bars were presented and were composed of poorly sorted sand to cobbles with higher portions vegetated. There was on average 1.5 large wood pieces per 100 feet in this subreach. This subreach contained a low density of habitat features with few large wood pieces, boulders, and overhanging vegetation. Undercut banks were absent. Pools were typically shallow. The main habitat feature within this subreach was coarse riffle substrate.

Figure 4: Typical photo collected at station 315+00 in representative subreach 3.

4.4 REACH 4

Reach 4 stretched from station 121+00 to 405+00. The upstream boundary was gradual and the downstream boundary was the County Road F bridge. The reach had a pool-riffle morphology and had a naturally confined floodplain. Large gravels and cobbles in riffles were on average 10% embedded. Bedrock was exposed on the outside of meander bends and commonly hosted groundwater seeps. There were on average 0.2 large wood pieces located per 100 feet (12 large wood pieces per mile). There were 23 pools with an average residual depth of 2 feet, and an average bankfull depth of 8 feet (+/- 1 foot). Approximately 25% of the channel was shaded by deciduous trees and shrubs. Typically, the reach contained a moderate density of habitat features with abundant deep pools, bedrock, and boulder cover, but few pieces of large wood. Fish cover from vegetation was abundant. Bank erosion was limited. Fine sediment was present and typically embedded riffle material.

4.4.1 Representative subreach 4

Representative subreach 4 was from station 220+00 to 233+00. Banks in representative subreach 4 were 85% vegetated. Where exposed, bank sediments consisted of sandy loam overlaying poorly sorted sand and gravel. Streambanks were generally stable and active erosion was interpreted as a result of the natural lateral migration of the river channel in response to flood events. Bankfull widths averaged 67 feet (+/- 5.4 feet), wetted width averaged 60 feet (+/- 4.6 feet), and bankfull thalweg depth averaged 4 feet (+/- 0.2 feet). Riffles were typically composed of poorly sorted sand to cobble with cobbles typically embedded by smaller material and had bankfull depths which averaged 2.5 feet. Depth of refusal on riffles was generally between 3 and 4 feet. Pools were typically composed of well sorted sand with residual depths of 1 foot (+/- 0.5 feet). Bars were transitional between alternate and points bars and were composed of poorly sorted sand to cobbles with higher portions vegetated. Valley width was estimated to be 250 feet. There were on average 0.3 large wood pieces per 100 feet in this subreach. This subreach contained a low density of habitat features with few large wood pieces, boulders, and overhanging vegetation. Undercut banks were absent. Pools were typically shallow. The main habitat feature within this subreach was coarse riffle substrate.

Figure 5: Typical photo collected at station 229+00 in representative subreach 4.

4.5 REACH 5

Reach 5 stretched from station 0+00 to 121+00. The upstream boundary was the County Road F bridge and the downstream boundary was the St. Croix River confluence. There were two distinct reaches within reach 5. The upstream reach stretched from station 70+00 to 121+00. This reach consisted of a pool-riffle morphology with a naturally confined floodplain. The river location between station 180+00 and 115+00 at the time of the survey differed from the location shown in aerial photographs dated to 2018 (shown in Appendix C) and it was assumed that the June 2020 floods caused the avulsion of the river in this location. Massive sand deposits were present throughout this reach and large wood was abundant. Downstream of station 70+00 to the St. Croix River confluence the river had a run-riffle morphology with a naturally confined to unconfined floodplain. Sand was abundant in this reach and was commonly ripple marked. A graduated rod was driven 5 feet into the sandy bed substrate without hitting refusal. In reach 5, there were on average 2 large wood pieces located per 100 feet (105 large wood pieces per mile). There were 12 pools with an average residual depth of 2 feet, and an average bankfull depth of 9 feet (+/- 2 feet). The majority of large wood and all pools were located within the upstream reach. Approximately 20% of the channel was shaded by deciduous trees and shrubs. Typically, the upstream reach contained a relatively high density of habitat features with abundant deep pools, and pieces of large wood. Bank erosion was extensive. Fine sediment was present and typically embedded riffle material. Typically, the downstream reach contained a low density of habitat features with few pieces of large wood, and was absent of deep pools. Fish cover from vegetation was abundant. Bank erosion was limited. Fine sediment was present and typically embedded riffle material.

4.5.1 Representative subreach 5

Representative subreach 5 was from station 100+00 to 108+00. Banks in representative subreach 5 were 60% vegetated. Where exposed, bank sediments consisted of sandy loam. Streambanks were generally stable and active erosion was interpreted as a result of the natural lateral migration of the river channel in response to flood events. Bankfull widths averaged 100 feet (+/- 58.3 feet), wetted width averaged 71 feet (+/- 28.2 feet), and bankfull thalweg depth averaged 5 feet (+/- 0.8 feet). Riffles were typically composed of poorly sorted sand to cobble with cobbles typically embedded by smaller material and had bankfull depths which averaged 2.5 feet. Depth of refusal on riffles was generally greater than 5 feet. Pools were typically composed of well sorted sand with residual depths of 2 feet (+/- 1 feet). Point bars were composed of poorly sorted sand to gravels with higher

portions vegetated. Valley width was estimated to be 300 feet. There were on average 1.8 large wood piece per 100 feet in this subreach. This subreach contained a low density of habitat features with few large wood pieces, boulders, and overhanging vegetation. Undercut banks were absent. Pools were typically shallow. The main habitat feature within this subreach was coarse riffle substrate.

Figure 6: Typical photo collected at station 106+00 in representative subreach 5.

5. Additional Observations

Additional observations which can be used to interpret geomorphic processes and subsequent habitat development were noted throughout all reaches. These observations provide a more comprehensive view of past and present fluvial processes occurring on the Kinnickinnic River which may influence the natural development of aquatic habitat.

A large flood occurred on the Kinnickinnic on June 29, 2020, which caused discharge to rise to a maximum of 6,220 cfs at the USGS gage on County Road F. Coarse and large wood racked against existing trees, and overbank deposits consisting of fine sand were noted throughout all reaches and were interpreted to be a result of the recent flood. Racked flood debris was up to 8 feet above the existing bankfull elevation, suggesting the maximum elevation of recent flooding (Figure 7). The

USGS gage at County Road F indicates that the gage height was over 10 feet higher than the normal gage height. Overbank sedimentation of fine sand was noted in all reaches and varied in thickness from less than 1 inch to 4 feet (Figure 8). The thickest deposits were typically associated with tributary confluences, particularly the Rocky Branch, or associated with gullies. These deposits were typically 1-2 feet thick but were up to 4 feet thick at the leading edge of sand sheets. Thinner deposits (typically less than 6 inches thick) were observed throughout the remainder of the floodplain.

Legacy sand deposits overlaying soil horizons were also noted, and were commonly associated with tributary gullies in Reach 4 (Figure 9). The surface of these areas was forested, so the deposition of the sand must be older than the trees currently growing on the surface. It was interpreted that the deposition of the sand on top of the soil horizon is a result of land clearing by Euro-American settlers which destabilized upland surfaces and caused sediment to wash into the Kinnickinnic Gorge where it was deposited on the floodplain. This is similar to observations in other Driftless Area streams (Dauwalter et al. 2019). The result of this historic deposition is a floodplain that has aggraded in areas and is now elevated above the natural floodplain. The river is still actively moving these legacy sediments downstream in addition to contemporary sediment inputs, and overtime will construct a new, lower floodplain.

Reed canary grass, an invasive species common in wetland areas throughout the country and in the upstream watershed, was present through all reaches of the Kinnickinnic survey and was typically present on point and mid-channel bars (Figure 10). Reed canary grass forms a monoculture stand in open floodplain and channel areas, shading out competing plants and limiting diversity and habitat for a variety of fauna. In addition, reed canary grass can stabilize what would normally be mobile sand and gravel bars, which results in increased roughness, decreased cross-sectional area and can increase bank erosion by forcing the channel away from the stabilized mid-channel bar.

Figure 7: Flood debris wracked behind several trees. Photo collected at station 334+00.

Figure 8: Sand deposited near the Rocky Branch confluence following recent floods. Photo collected at station 483+00.

Figure 9: Photo of cutbank showing pre-settlement soil horizon and post-settlement alluvial deposits. Photo collected at station 168+00.

Figure 10: Mid-channel bar showing colonization of reed canary grass and the stabilization of the bar. Photo collected at station 313+00.

6. Discussion and Conclusions

A summary of select field identified reach attributes is provided in Table 1. These attributes we analyzed to determine the habitat conditions in the study area.

Table 1: Summary table of select reach attributes.

Reach	1	2	3	4	5
Reach Length (ft)	6213	5488	12693	15693	12119
Bankfull Width Average (ft)	84	73	60	76	80
Average Bankfull Depth (ft)	5	6	5	7	7
Average Bankfull Pool Depth (ft)	6	7	6	8	9
Average Bankfull Riffle Depth (ft)	4	5	5	5	4
Average Residual Pool Depth (ft)	2	2	1	3	5
Floodplain type	Naturally Confined	Naturally Confined	Naturally Confined	Naturally Confined	Naturally Confined
Riffle Count	7	7	17	22	13
Pool Count	9	8	17	23	12
Run Count	1	1	1	0	4
Percent algae cover	57	47	38	21	6
Percent exposed bank	21	25	15	16	28
Percent macrophyte cover	1	0	2	0	2
Percent shade cover	19	25	21	24	17
Riparian landuse	forest	forest	forest	forest	forest
Percent embeddedness	18	22	11	8	6
Large Wood (LW) piece count	38	51	130	37	240
LW count per linear mile	32	49	54	12	105
LW count per 100 ft	1	1	1	0	2

In-stream habitat complexity was limited in the lower Kinnickinnic River. This study found that although the channel bed form was relatively stable, there was a general lack of complexity due to the absence of structure such as boulders, large wood and undercut banks. The June 2020 flooding may have contributed to plane bed conditions or lengthening of riffle features (reduced bed complexity), and impacted complexity by moving large wood downstream and relocating it from in channel to floodplain and upper bank areas.

Embedment and local deposition of fine sediment in the channel occurred following the most recent flooding. These effects appear to be temporary, but it was not possible to discern between post 2020 flood sediment inputs and annual sediment loads. Aggradation of floodplain areas by overbank sedimentation was noted, and was widespread. Pools were not completely filled with fine sediment, but residual pool depths were often limited to less than 2 feet. Limited pool depth due to sediment infilling was also noted in the Inter-Fluve (2017) geomorphic assessement, so this is likely a chronic problem in the lower Kinni and not a result of the 2020 flood.

Sand accumulation, the embedment of gravel substrate, and subsequent establishment of reed canary grass resulted in increased channel erosion in select locations. Embedment of gravel and cobble riffle substrate and overbank sedimentation was common in all reaches. In addition, buried soil horizons were observed in Reach 4. These observations are typical of a river unable to effectively transport existing sediment within the river channel and floodplain, but may also be a temporary result of large flood events. Increased sediment input from upstream, upland, and bank erosion may further fill existing pools thus limiting deep water habitat and increase embedment of coarse riffle substrate. Embedment of coarse river substrate is of special concern since it can negatively impact spawning habitat and macroinvertebrate densities. Subsequent surveys could determine annual versus event-based inputs. It should be noted, both bed complexity and in channel large wood will increase over time as smaller (5-yr flood events or less) floods redistribute both bed material and large wood.

Overbank sedimentation on floodplains as a result of recent flooding was observed. Overbank sedimentation, if widespread and rapid, limits floodplain connectivity by raising floodplain elevations (Knox 2006). This has been a consistent problem in Driftless Area streams since European settlement (Dauwalter 2019). In the lower Kinnickinnic River, it appears that the majority of post-

European settlement sediment accumulation was concentrated in alluvial fans near tributary gullies and was not widespread across the floodplain. In addition, the thickest deposits of recent overbank sediment were also associated with tributaries and gullies. This suggests that sediment coming from upland sources is typically transported through gullies and tributaries and stored in alluvial fans and deltas on the floodplain and that widespread floodplain aggradation, as observed in other Driftless Area streams, has not occured. This does not mean that floodplain aggradation will not occur in the future, especially if a large amount of sediment moves into the lower Kinnickinnic River.

The Kinnickinnic River supports a relatively high number of brown trout as compared to other regional streams. This may be driven partly by water quality, partly by the size of the stream, being larger than many regional trout streams, and partly by food abundance. The lower Kinnickinnic River, despite having low habitat complexity, has an abundance of gravel substrate. Gravel substrates hold the highest densities of macroinvertebrates as compared to other streambed material. Gravel bed rivers can also support high densities of spawning fish, which results in large numbers of juveniles. Because brown trout are both insectivores and piscivores, the combination of high macrovinvertebrate production and juvenile fish production may be resulting in high food densities that can support large numbers of trout despite marginal habitat cover. As the surrounding forests mature and large wood inputs increase, habitat complexity will subsequently increase and could positively impact fish populations. However, if an increase in sediment supply occurs (such as an unregulated release of sediment during dam removal) the sediment may bury gravel substrate with fine grain material and negatively impact fish populations.

The most significant factor limiting habitat for birds, reptiles, amphibians, and mammals was the predominance of invasive reed canary grass in the riparian area. Reed canary grass has formed understory monocultures in riparian areas and on mid-channel bars in all reaches. Reed canary grass stands stabilize formerly mobile substrate, increase roughness and decrease channel cross sectional area, all of which can drive increased bank erosion. In addition, since reed canary grass establishes itself as an understory monoculture, it can limit the regeneration of diverse plant assemblages and prevent the growth of trees and shrubs that provide shade and stabilize banks. Limiting sediment

inputs from upstream and upland sources and planting native species in riparian areas will help the Kinnickinnic River continue to be a home to a diverse array of species.

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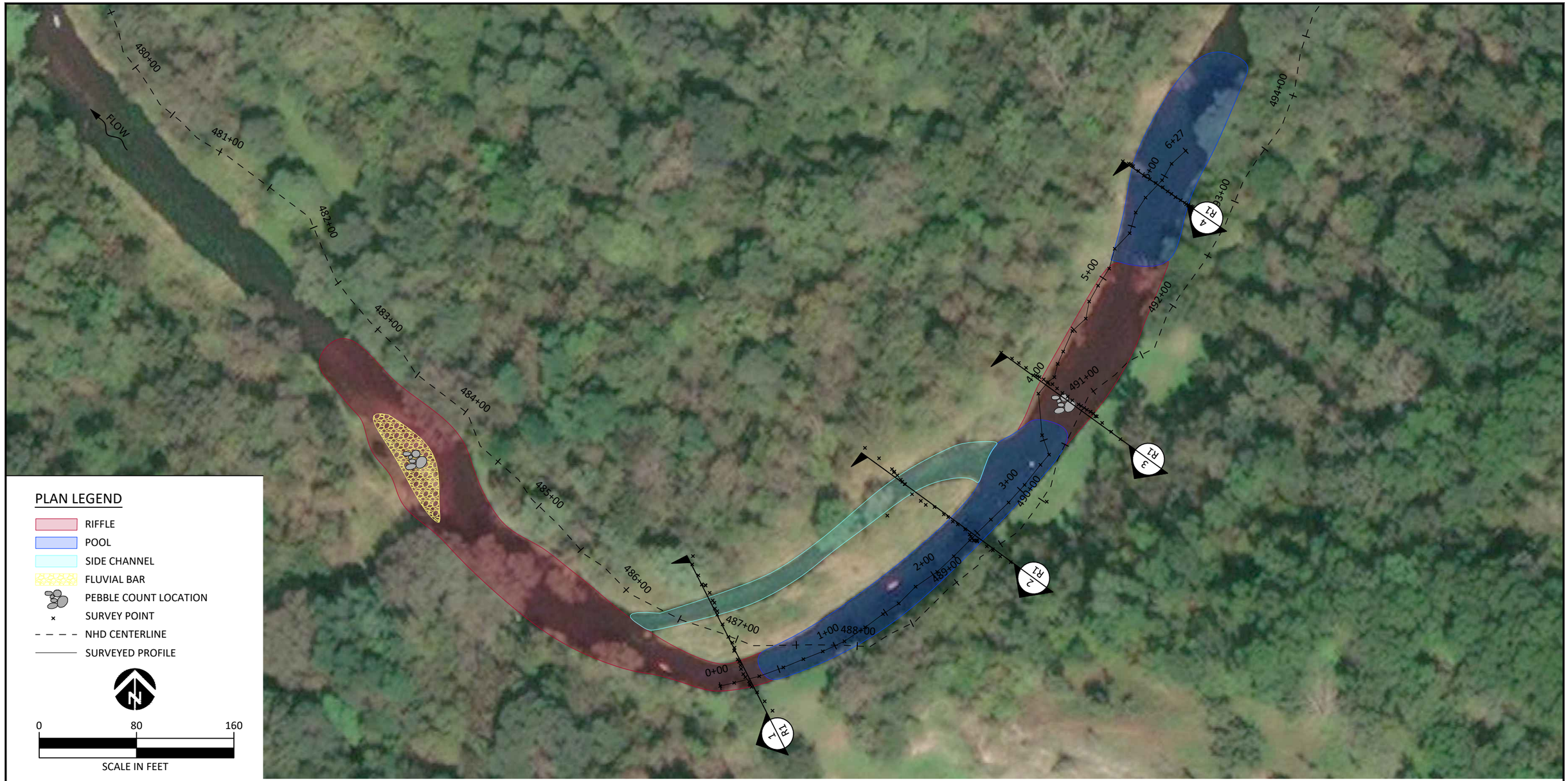
8. Appendix A – Representative Reach Surveys



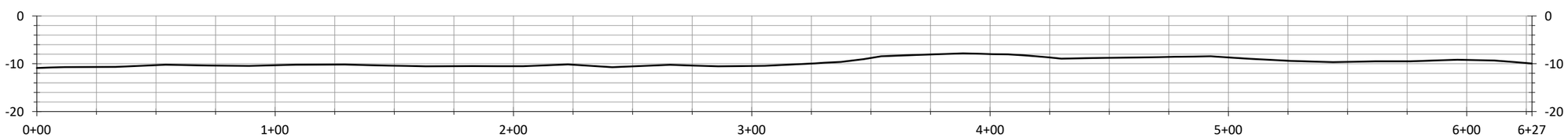
PLAN LEGEND

- RIFFLE
- POOL
- SIDE CHANNEL
- FLUVIAL BAR
- PEBBLE COUNT LOCATION
- SURVEY POINT
- NHD CENTERLINE
- SURVEYED PROFILE

N

0 80 160

SCALE IN FEET



LONGITUDINAL PROFILE

UNREFERENCED VERTICAL SCALE

NOTE: FIELD WORK CONDUCTED BY SEAN MORRISON, GARRET SHEAR (INTER-FLUVE) AND ROSS HARRIS (GRSC) ON THE KINNICKINNICK RIVER BETWEEN 9/21/2020 AND 9/24/2020.

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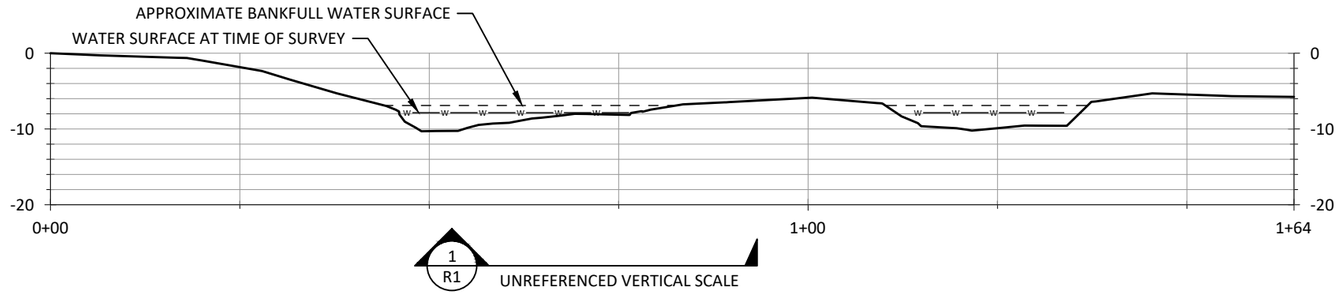
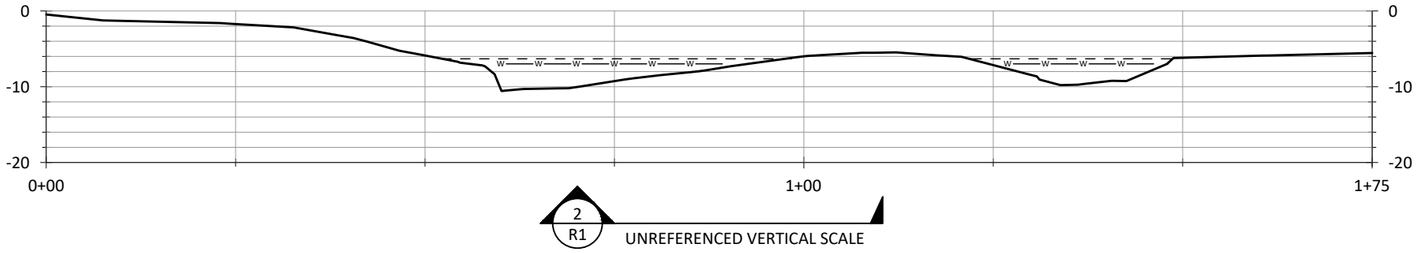
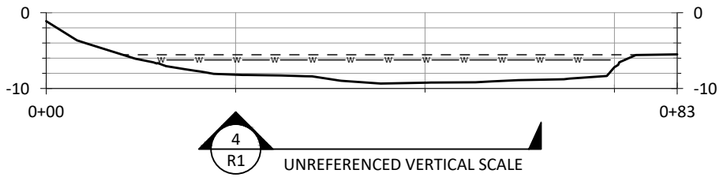
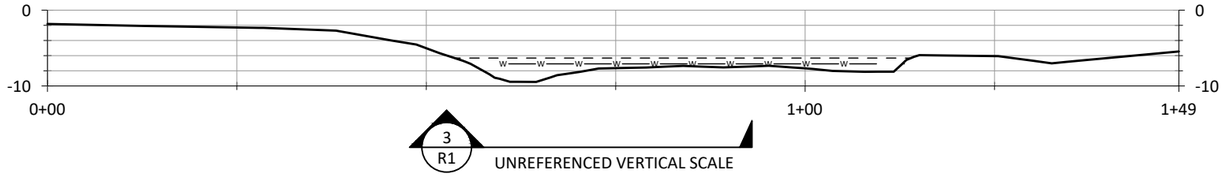
REPRESENTATIVE REACH 1









NOTE: FIELD WORK CONDUCTED BY SEAN MORRISON, GARRET SHEAR (INTER-FLUVE) AND ROSS HARRIS (GRSC) ON THE KINNICKINNICK RIVER BETWEEN 9/21/2020 AND 9/24/2020.

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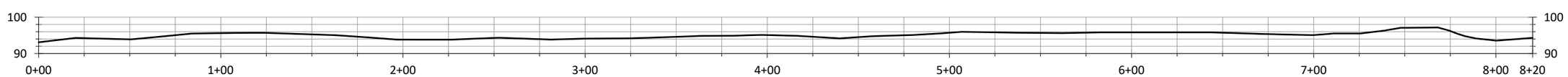
REPRESENTATIVE REACH 1
CROSS-SECTIONS

PLAN LEGEND

- RIFFLE
- POOL
- SIDE CHANNEL
- FLUVIAL BAR
- PEBBLE COUNT LOCATION
- SURVEY POINT
- NHD CENTERLINE
- SURVEYED PROFILE

0 80 160

SCALE IN FEET



LONGITUDINAL PROFILE

UNREFERENCED VERTICAL SCALE

NOTE: FIELD WORK CONDUCTED BY SEAN MORRISON, GARRET SHEAR (INTER-FLUVE) AND ROSS HARRIS (GRSC) ON THE KINNICKINNICK RIVER BETWEEN 9/21/2020 AND 9/24/2020.

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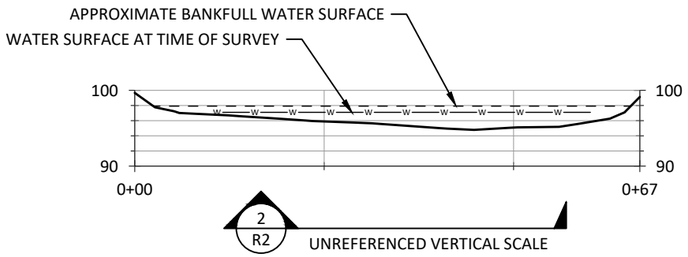
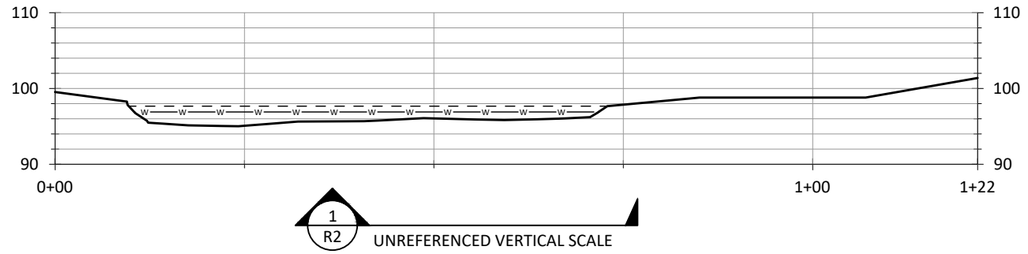
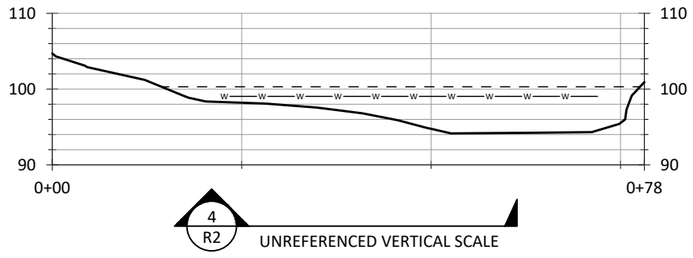
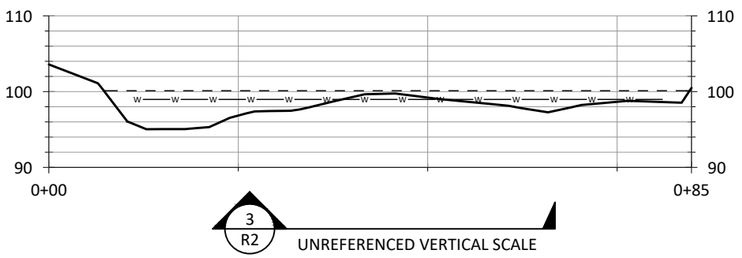
REPRESENTATIVE REACH 2









NOTE: FIELD WORK CONDUCTED BY SEAN MORRISON, GARRET SHEAR (INTER-FLUVE) AND ROSS HARRIS (GRSC) ON THE KINNICKINNICK RIVER BETWEEN 9/21/2020 AND 9/24/2020.

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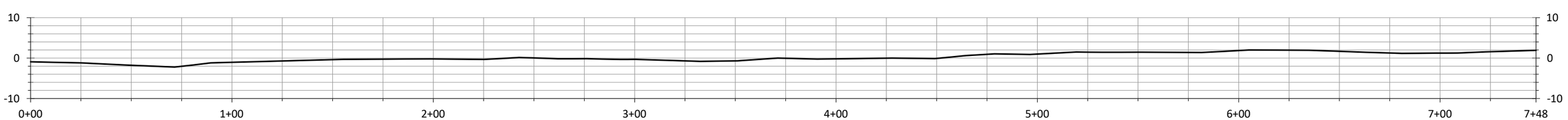
REPRESENTATIVE REACH 2
CROSS-SECTIONS



LONGITUDINAL PROFILE
UNREFERENCED VERTICAL SCALE

NOTE: FIELD WORK CONDUCTED BY SEAN MORRISON, GARRET SHEAR (INTER-FLUVE) AND ROSS HARRIS (GRSC) ON THE KINNICKINNICK RIVER BETWEEN 9/21/2020 AND 9/24/2020.

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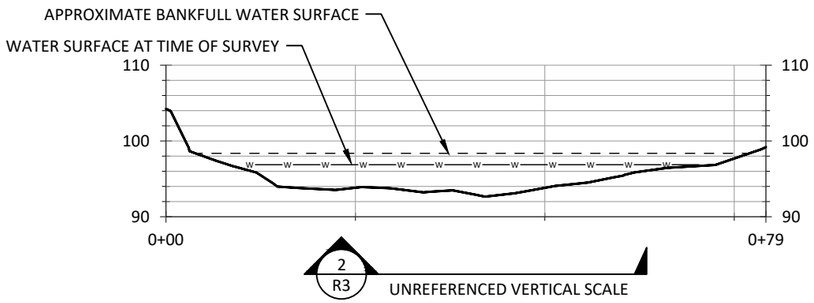
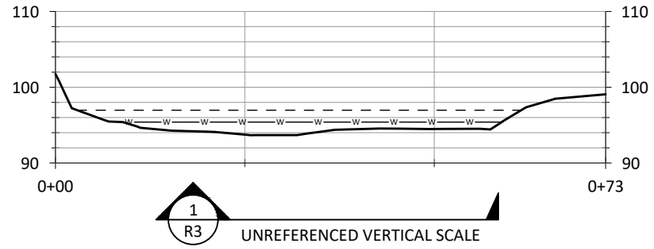
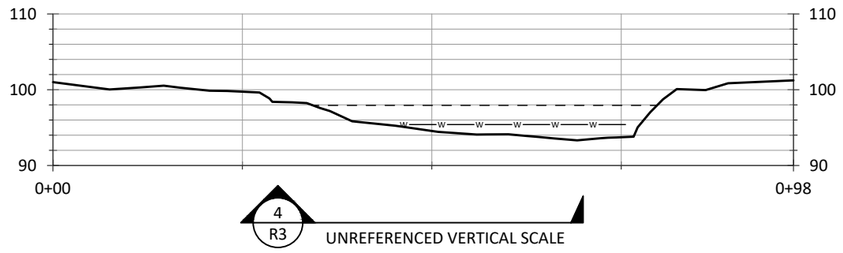
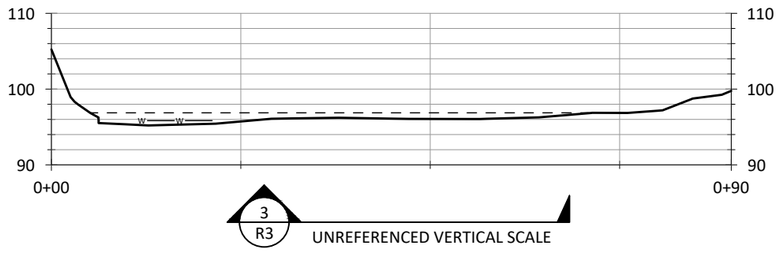
REPRESENTATIVE REACH 3









NOTE: FIELD WORK CONDUCTED BY SEAN MORRISON, GARRET SHEAR (INTER-FLUVE) AND ROSS HARRIS (GRSC) ON THE KINNICKINNICK RIVER BETWEEN 9/21/2020 AND 9/24/2020.

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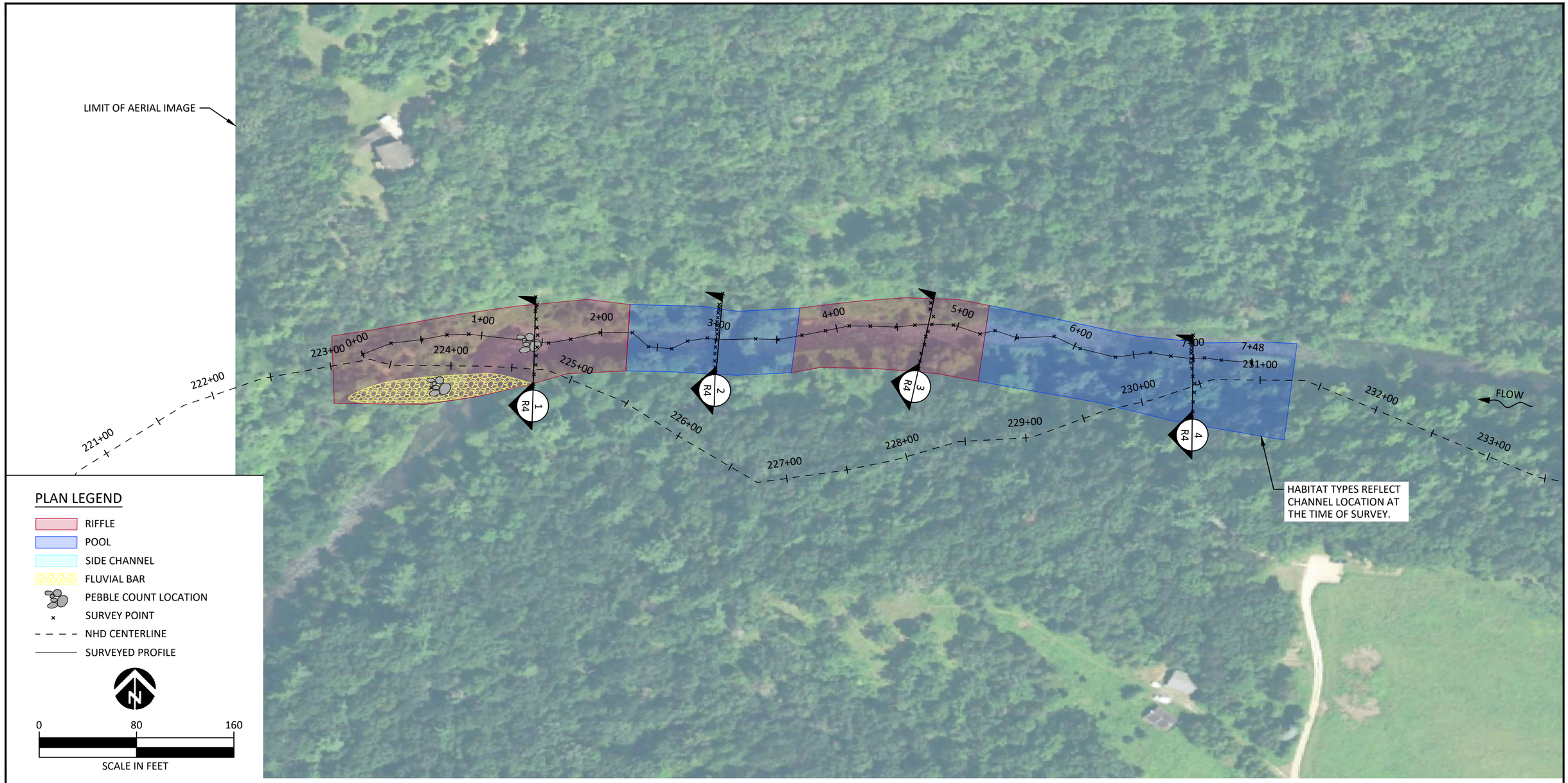
REPRESENTATIVE REACH 6
CROSS-SECTIONS

SHEET
6 OF 10



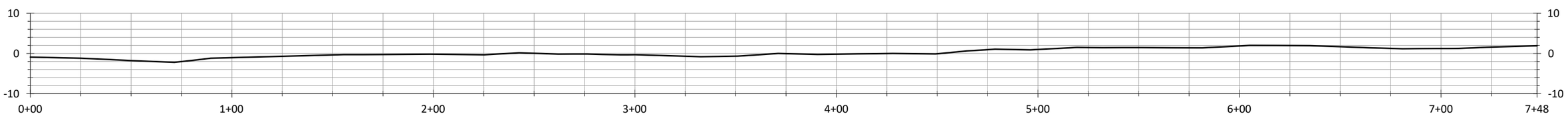
PLAN LEGEND

- RIFFLE
- POOL
- SIDE CHANNEL
- FLUVIAL BAR
- PEBBLE COUNT LOCATION
- SURVEY POINT
- NHD CENTERLINE
- SURVEYED PROFILE

N

0 80 160

SCALE IN FEET



LONGITUDINAL PROFILE

UNREFERENCED VERTICAL SCALE

NOTE: FIELD WORK CONDUCTED BY SEAN MORRISON, GARRET SHEAR (INTER-FLUVE) AND ROSS HARRIS (GRSC) ON THE KINNICKINNICK RIVER BETWEEN 9/21/2020 AND 9/24/2020.

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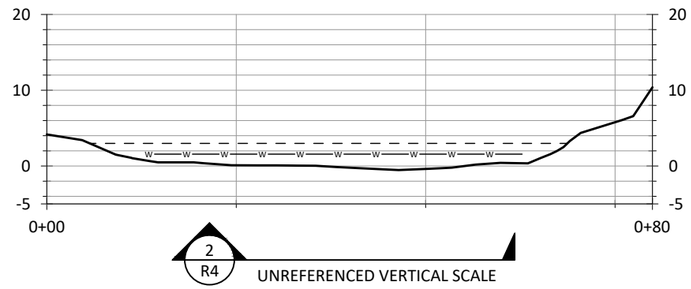
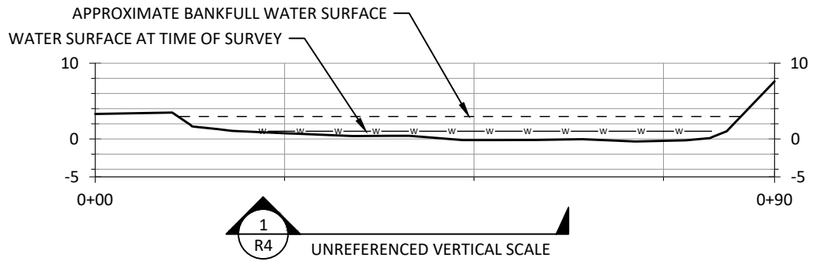
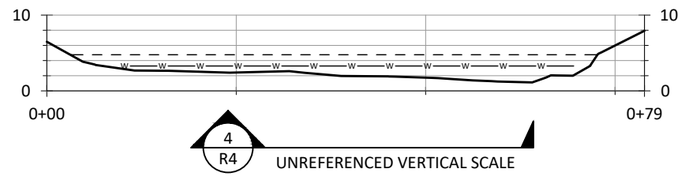
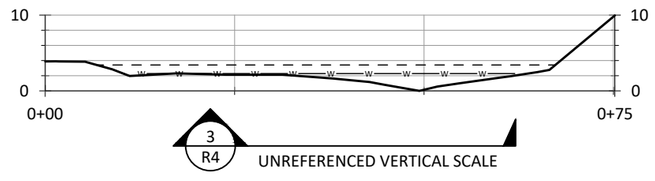
REPRESENTATIVE REACH 4









NOTE: FIELD WORK CONDUCTED BY SEAN MORRISON, GARRET SHEAR (INTER-FLUVE) AND ROSS HARRIS (GRSC) ON THE KINNICKINNICK RIVER BETWEEN 9/21/2020 AND 9/24/2020.

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REPRESENTATIVE REACH 4
CROSS-SECTIONS

HABITAT TYPES REFLECT CHANNEL LOCATION AT THE TIME OF SURVEY.

FLOW

95+00 100+00 101+00 102+00 103+00 104+00 105+00 106+00 107+00 108+00 99+00 98+00

0+00 1+00 2+00 3+00 4+00 5+00 5+50

1 R5 2 R5 3 R5 4 R5

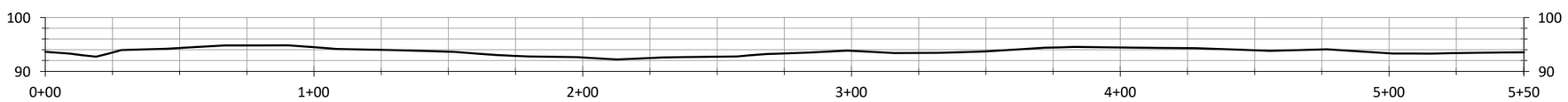
PLAN LEGEND

- RIFFLE
- POOL
- SIDE CHANNEL
- FLUVIAL BAR
- PEBBLE COUNT LOCATION
- SURVEY POINT
- NHD CENTERLINE
- SURVEYED PROFILE

N

0 80 160

SCALE IN FEET



LONGITUDINAL PROFILE

UNREFERENCED VERTICAL SCALE

NOTE: FIELD WORK CONDUCTED BY SEAN MORRISON, GARRET SHEAR (INTER-FLUVE) AND ROSS HARRIS (GRSC) ON THE KINNICKINNICK RIVER BETWEEN 9/21/2020 AND 9/24/2020.

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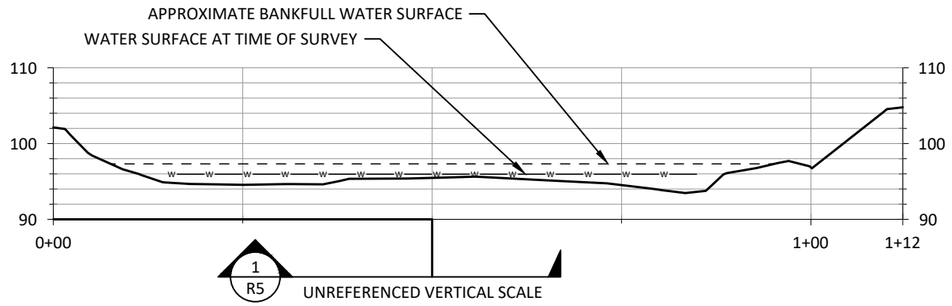
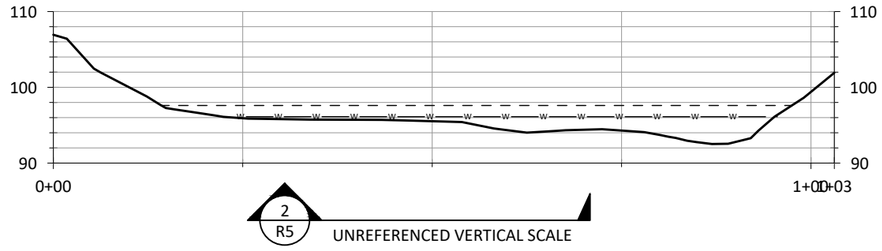
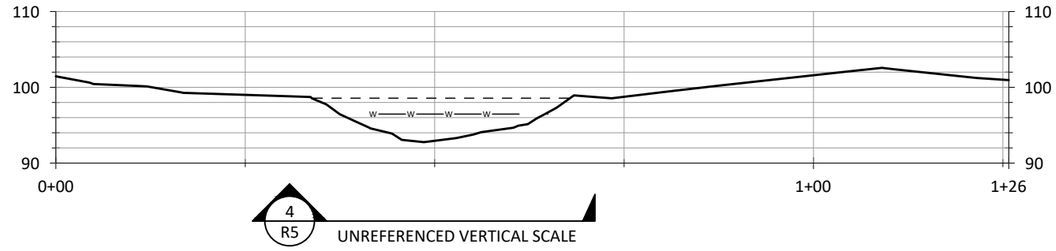
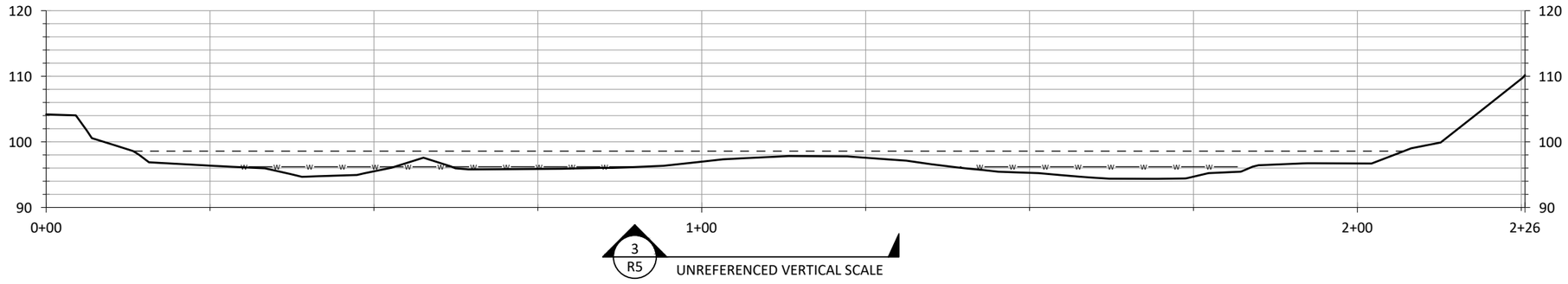
REPRESENTATIVE REACH 5









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BELOW POWELL FALLS

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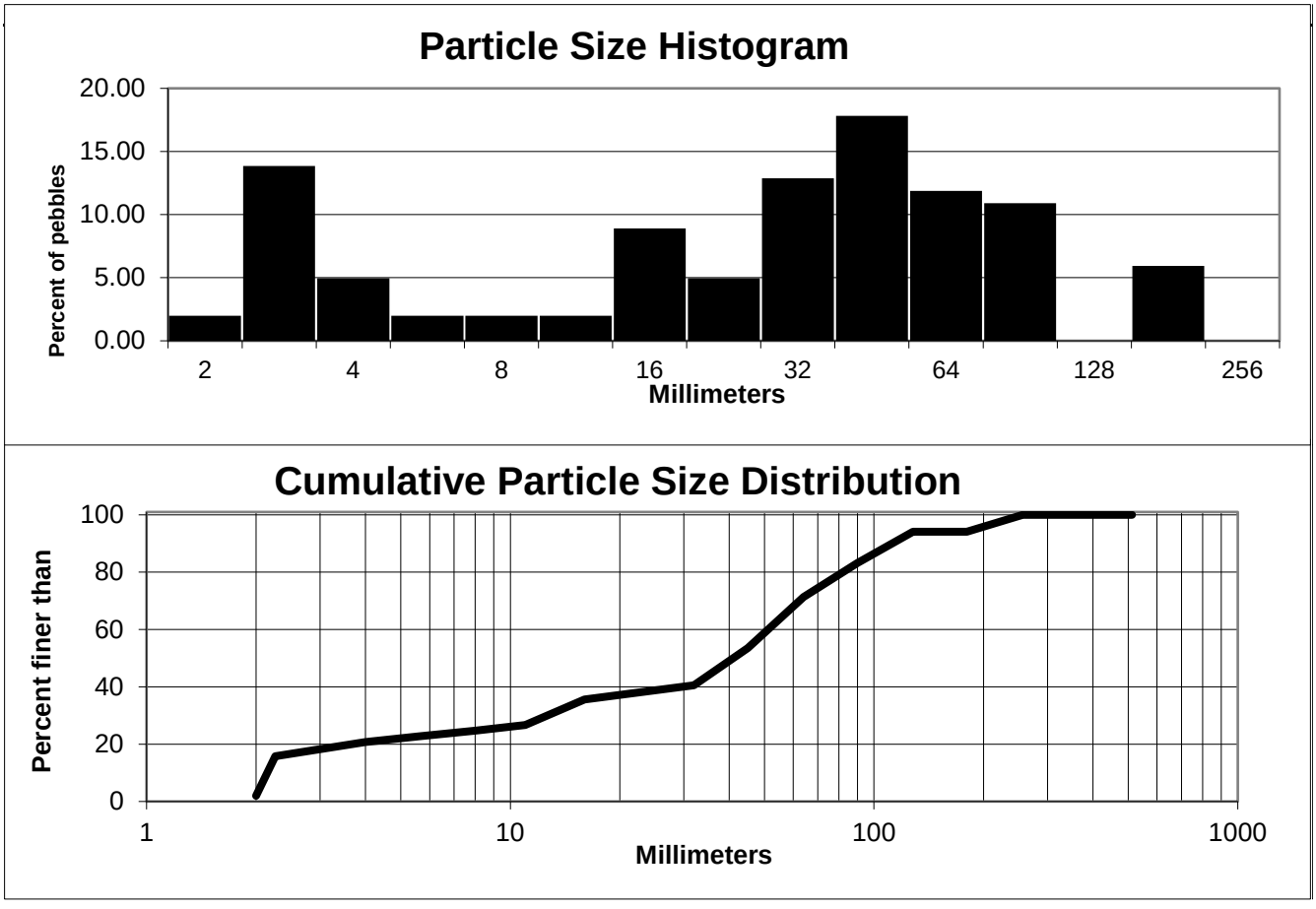
REPRESENTATIVE REACH 5
CROSS-SECTIONS

9. Appendix B – Pebble Counts

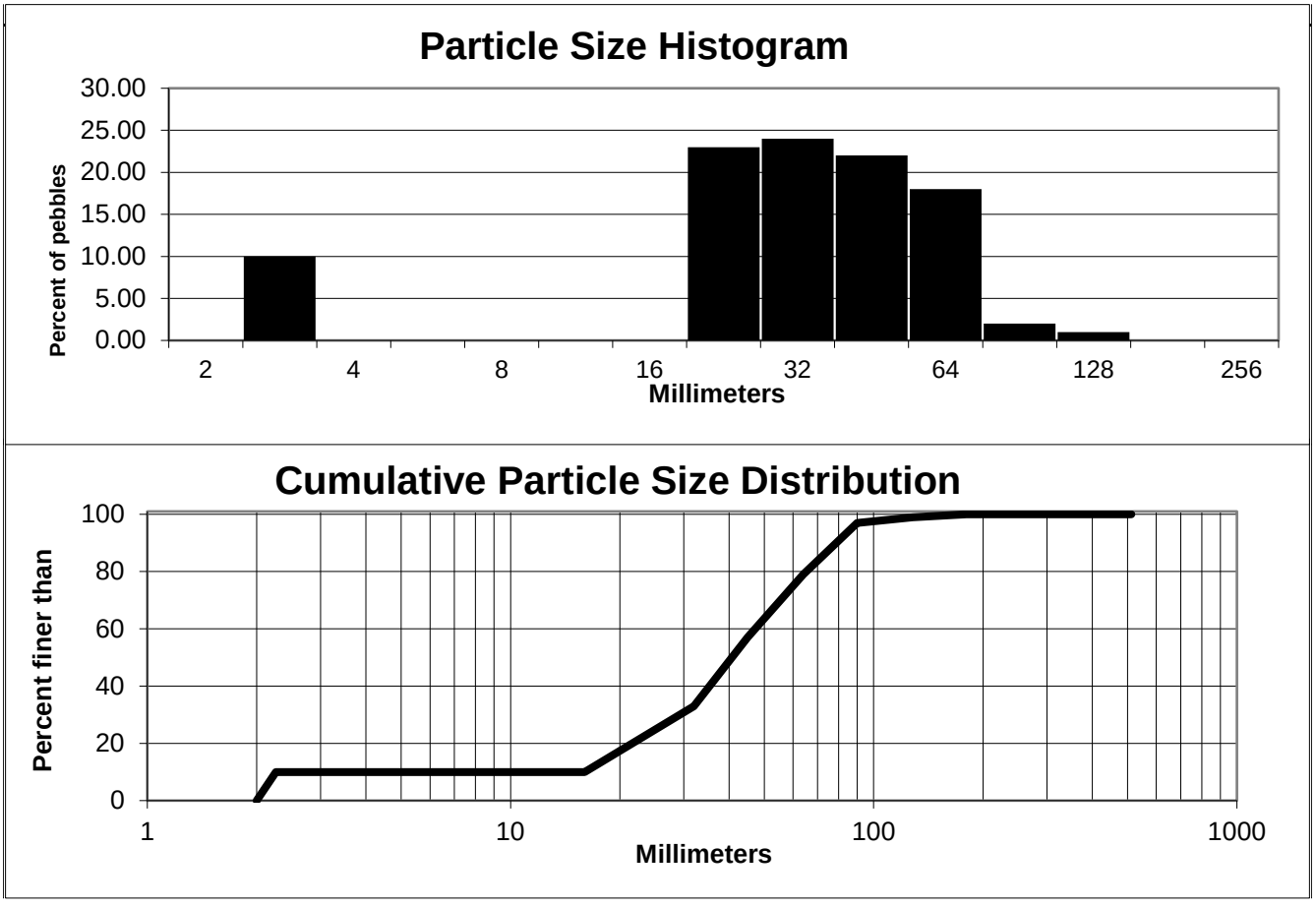
Pebble Count Name: Reach 1 Riffle
Sampling Method: Random Walk
Geomorphic Position: Riffle
Stratigraphic Position: Surface

Sediment size (mm)	Particle Count	Total Percent	Cumulative Percent
2	2	1.98	1.98
2.26	14	13.86	15.84
4	5	4.95	20.79
5.6	2	1.98	22.77
8	2	1.98	24.75
11	2	1.98	26.73
16	9	8.91	35.64
32	5	4.95	40.59
45	13	12.87	53.47
64	18	17.82	71.29
90	12	11.88	83.17
128	11	10.89	94.06
180	0	0.00	94.06
256	6	5.94	100.00
512	0	0.00	100.00
Total:	101	100	



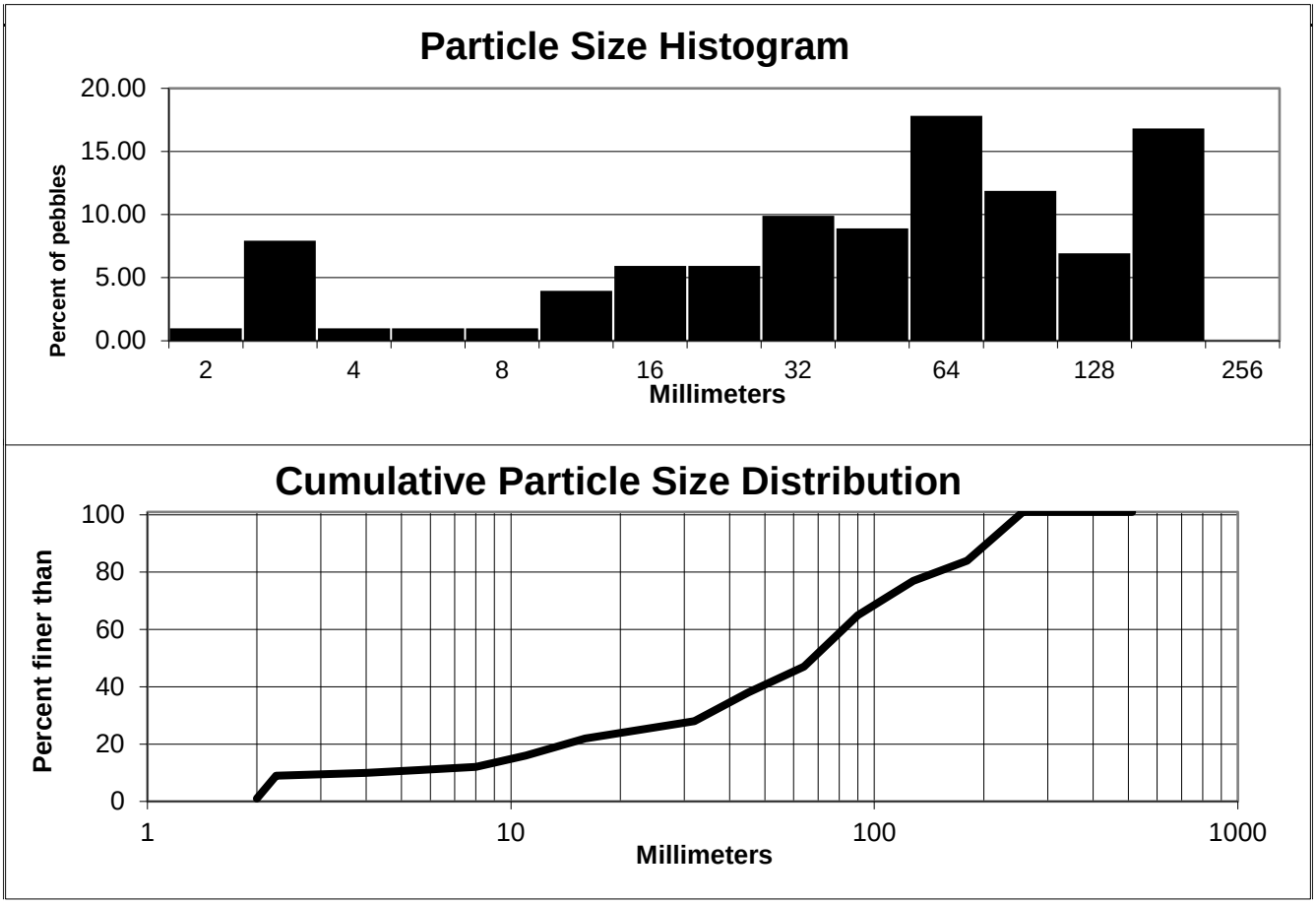
Pebble Count Name: Reach 1 Bar
Sampling Method: Random Walk
Geomorphic Position: Bar
Stratigraphic Position: Surface

Sediment size (mm)	Particle Count	Total Percent	Cumulative Percent
2	0	0.00	0.00
2.26	10	10.00	10.00
4	0	0.00	10.00
5.6	0	0.00	10.00
8	0	0.00	10.00
11	0	0.00	10.00
16	0	0.00	10.00
32	23	23.00	33.00
45	24	24.00	57.00
64	22	22.00	79.00
90	18	18.00	97.00
128	2	2.00	99.00
180	1	1.00	100.00
256	0	0.00	100.00
512	0	0.00	100.00
Total:	100	100	



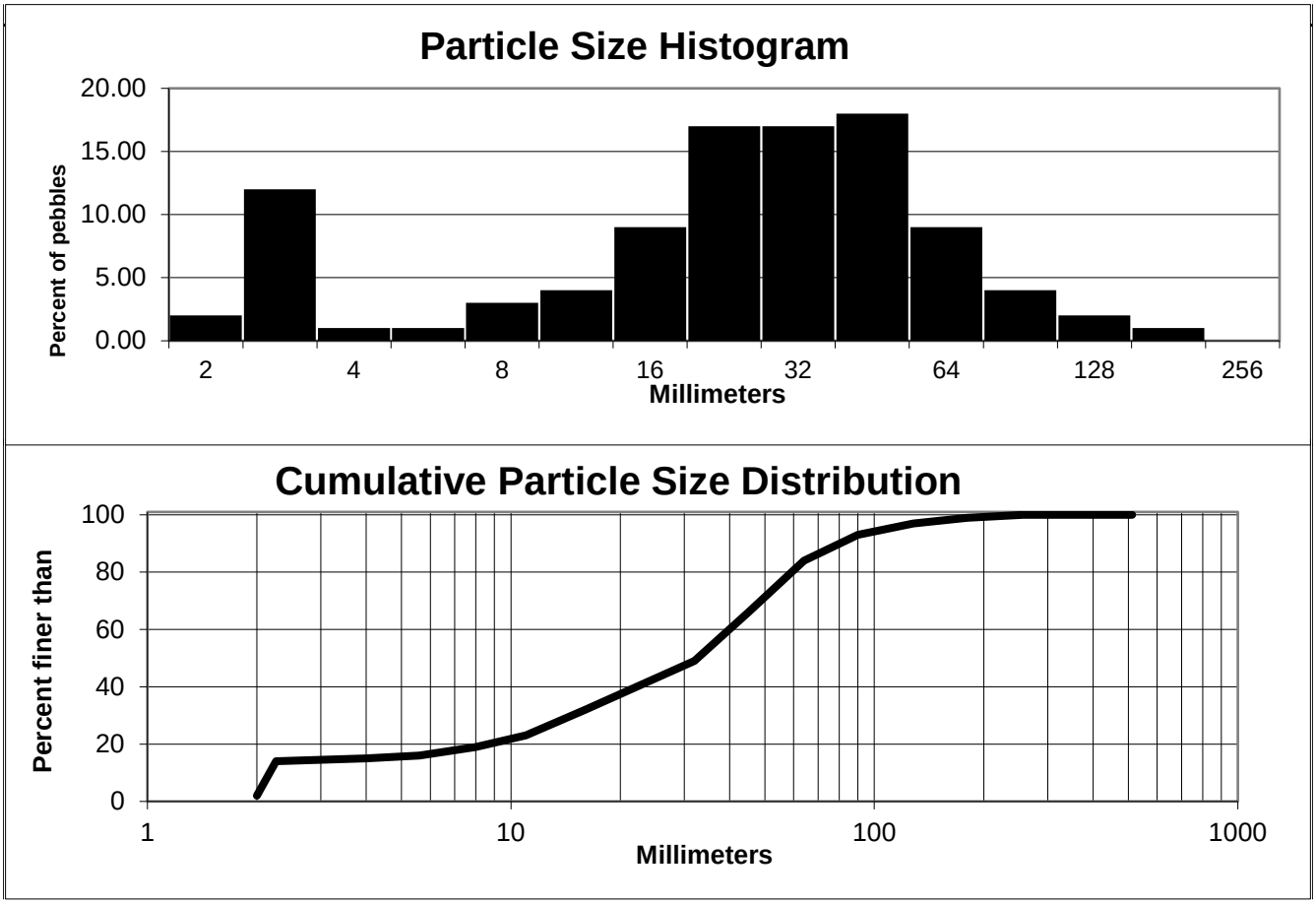
Pebble Count Name: Reach 2 Bar
Sampling Method: Random Walk
Geomorphic Position: Bar
Stratigraphic Position: Surface

Sediment size (mm)	Particle Count	Total Percent	Cumulative Percent
2	1	0.99	1.00
2.26	8	7.92	9.00
4	1	0.99	10.00
5.6	1	0.99	11.00
8	1	0.99	12.00
11	4	3.96	16.00
16	6	5.94	22.00
32	6	5.94	28.00
45	10	9.90	38.00
64	9	8.91	47.00
90	18	17.82	65.00
128	12	11.88	77.00
180	7	6.93	84.00
256	17	16.83	101.00
512	0	0.00	101.00
Total:	101	100	



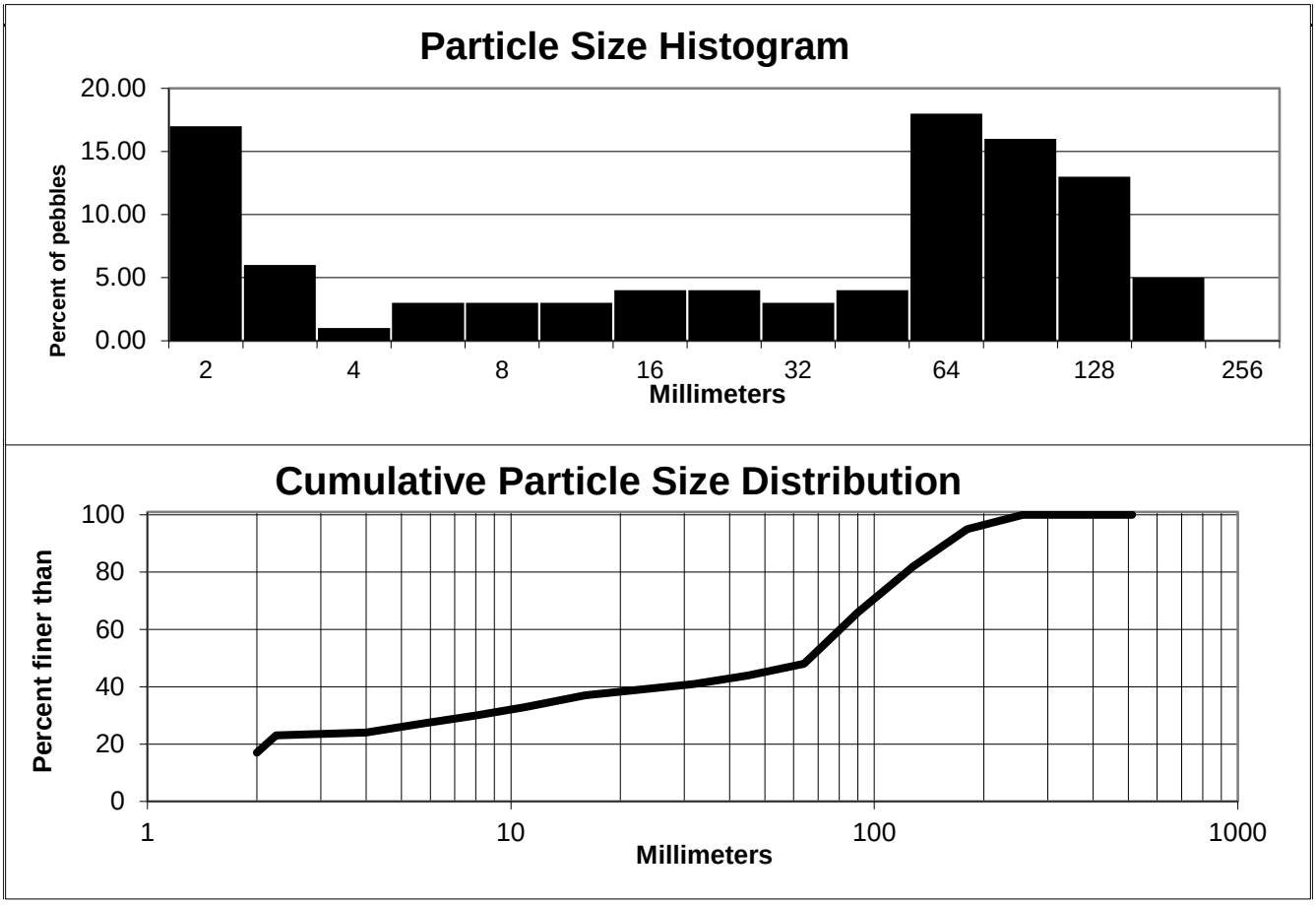
Pebble Count Name: Reach 2 Riffle
Sampling Method: Random Walk
Geomorphic Position: Riffle
Stratigraphic Position: Surface

Sediment size (mm)	Particle Count	Total Percent	Cumulative Percent
2	2	2.00	2.00
2.26	12	12.00	14.00
4	1	1.00	15.00
5.6	1	1.00	16.00
8	3	3.00	19.00
11	4	4.00	23.00
16	9	9.00	32.00
32	17	17.00	49.00
45	17	17.00	66.00
64	18	18.00	84.00
90	9	9.00	93.00
128	4	4.00	97.00
180	2	2.00	99.00
256	1	1.00	100.00
512	0	0.00	100.00
Total:	100	100	



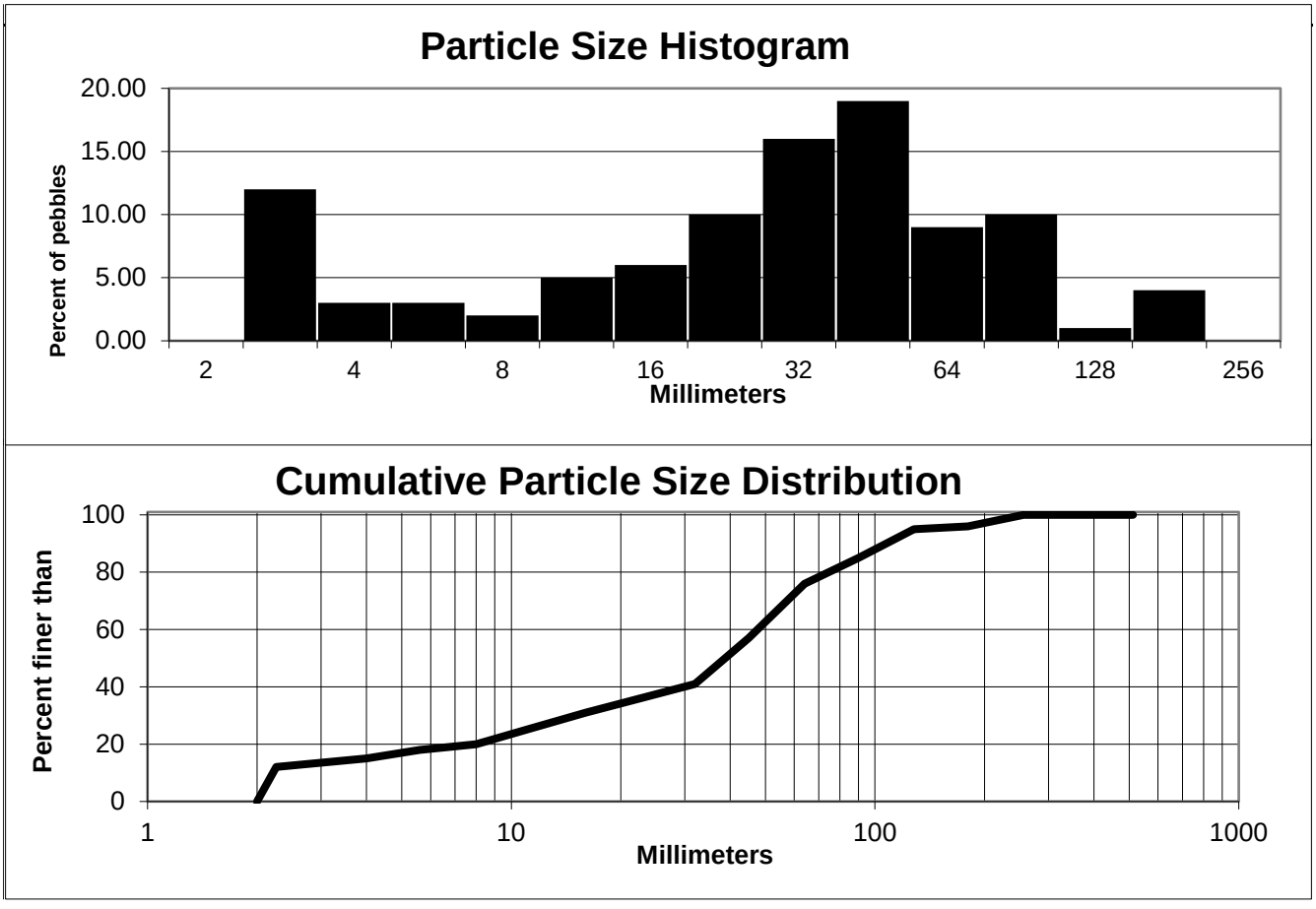
Pebble Count Name: Reach 3 Riffle
Sampling Method: Random Walk
Geomorphic Position: Riffle
Stratigraphic Position: Surface

Sediment size (mm)	Particle Count	Total Percent	Cumulative Percent
2	17	17.00	17.00
2.26	6	6.00	23.00
4	1	1.00	24.00
5.6	3	3.00	27.00
8	3	3.00	30.00
11	3	3.00	33.00
16	4	4.00	37.00
32	4	4.00	41.00
45	3	3.00	44.00
64	4	4.00	48.00
90	18	18.00	66.00
128	16	16.00	82.00
180	13	13.00	95.00
256	5	5.00	100.00
512	0	0.00	100.00
Total:	100	100	



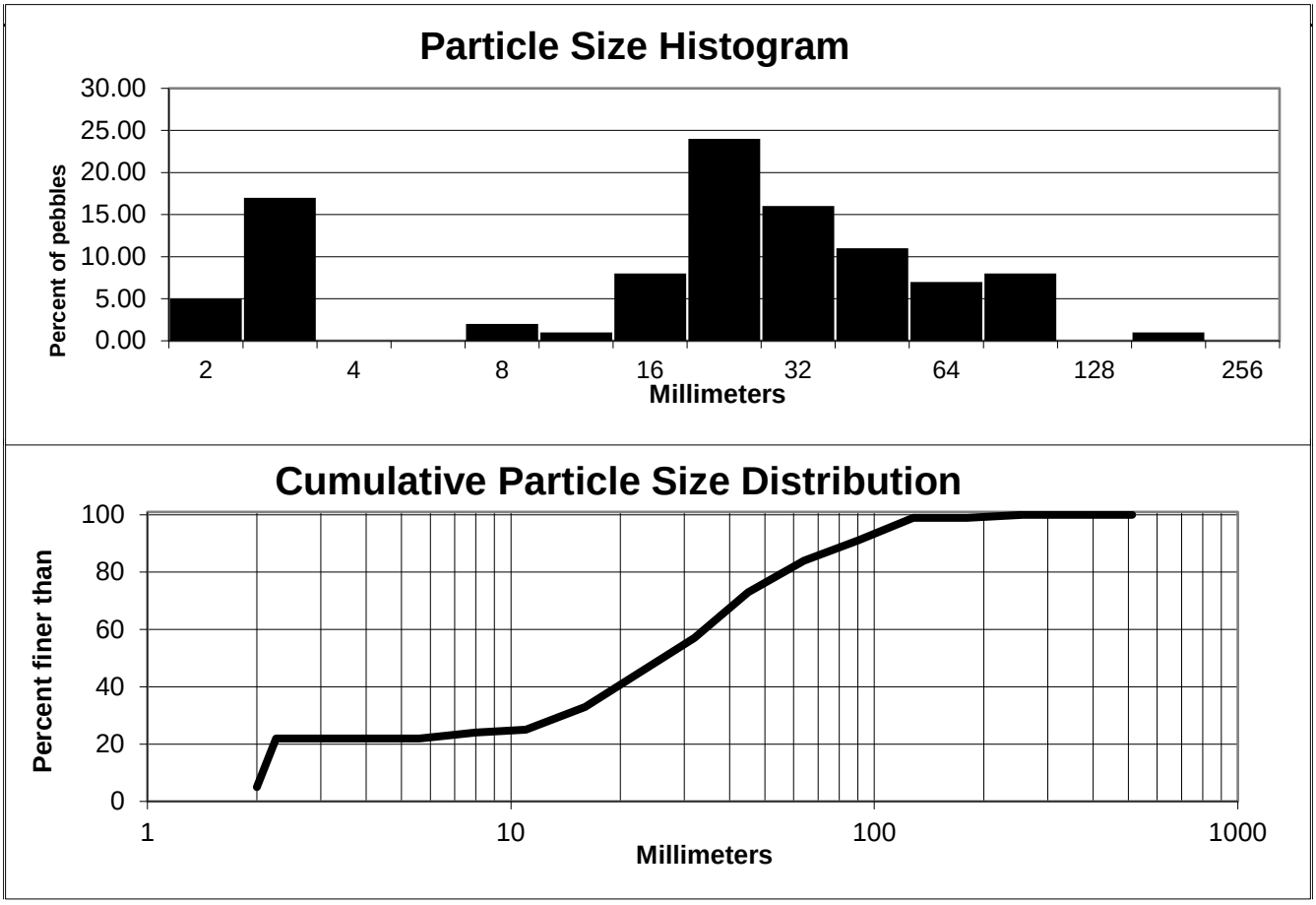
Pebble Count Name: Reach 3 Bar
Sampling Method: Random Walk
Geomorphic Position: Riffle
Stratigraphic Position: Surface

Sediment size (mm)	Particle Count	Total Percent	Cumulative Percent
2	0	0.00	0.00
2.26	12	12.00	12.00
4	3	3.00	15.00
5.6	3	3.00	18.00
8	2	2.00	20.00
11	5	5.00	25.00
16	6	6.00	31.00
32	10	10.00	41.00
45	16	16.00	57.00
64	19	19.00	76.00
90	9	9.00	85.00
128	10	10.00	95.00
180	1	1.00	96.00
256	4	4.00	100.00
512	0	0.00	100.00
Total:	100	100	



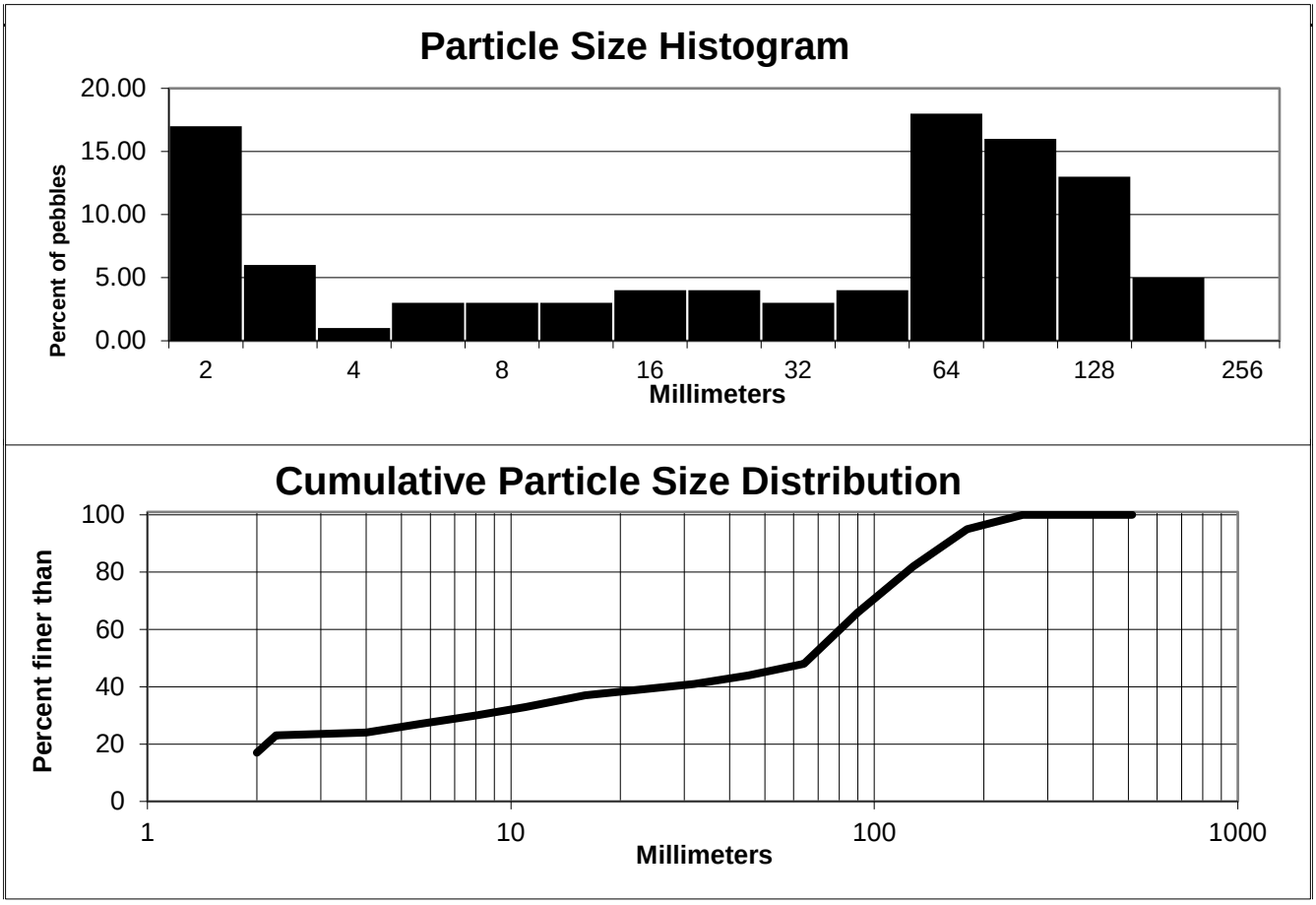
Pebble Count Name: Reach 4 Bar
Sampling Method: Random Walk
Geomorphic Position: Bar
Stratigraphic Position: Surface

Sediment size (mm)	Particle Count	Total Percent	Cumulative Percent
2	5	5.00	5.00
2.26	17	17.00	22.00
4	0	0.00	22.00
5.6	0	0.00	22.00
8	2	2.00	24.00
11	1	1.00	25.00
16	8	8.00	33.00
32	24	24.00	57.00
45	16	16.00	73.00
64	11	11.00	84.00
90	7	7.00	91.00
128	8	8.00	99.00
180	0	0.00	99.00
256	1	1.00	100.00
512	0	0.00	100.00
Total:	100	100	



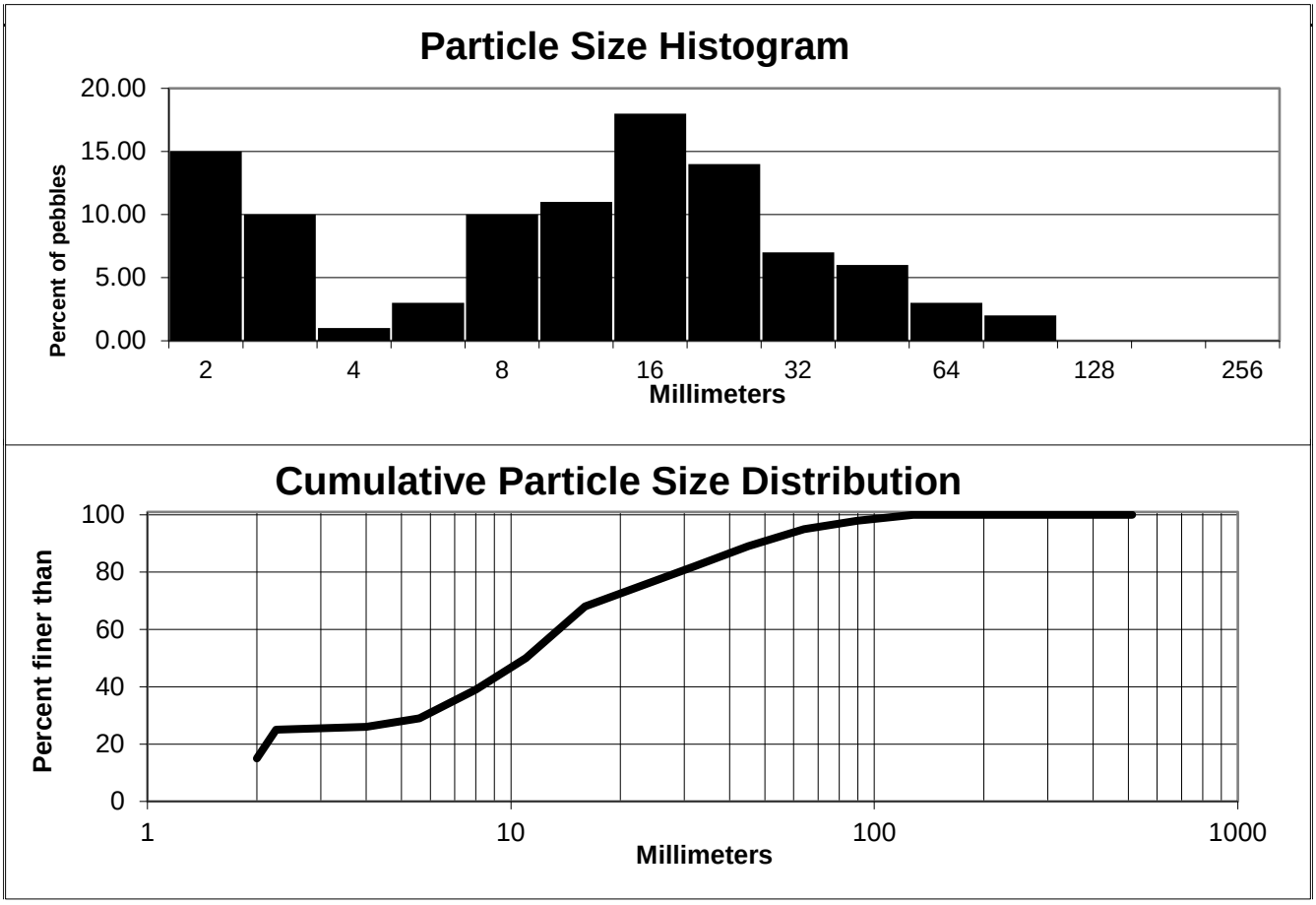
Pebble Count Name: Reach 4 Riffle
Sampling Method: Random Walk
Geomorphic Position: Riffle
Stratigraphic Position: Surface

Sediment size (mm)	Particle Count	Total Percent	Cumulative Percent
2	3	3.00	3.00
2.26	3	3.00	6.00
4	1	1.00	7.00
5.6	3	3.00	10.00
8	3	3.00	13.00
11	3	3.00	16.00
16	4	4.00	20.00
32	11	11.00	31.00
45	20	20.00	51.00
64	12	12.00	63.00
90	14	14.00	77.00
128	16	16.00	93.00
180	6	6.00	99.00
256	1	1.00	100.00
512	0	0.00	100.00
Total:	100	100	



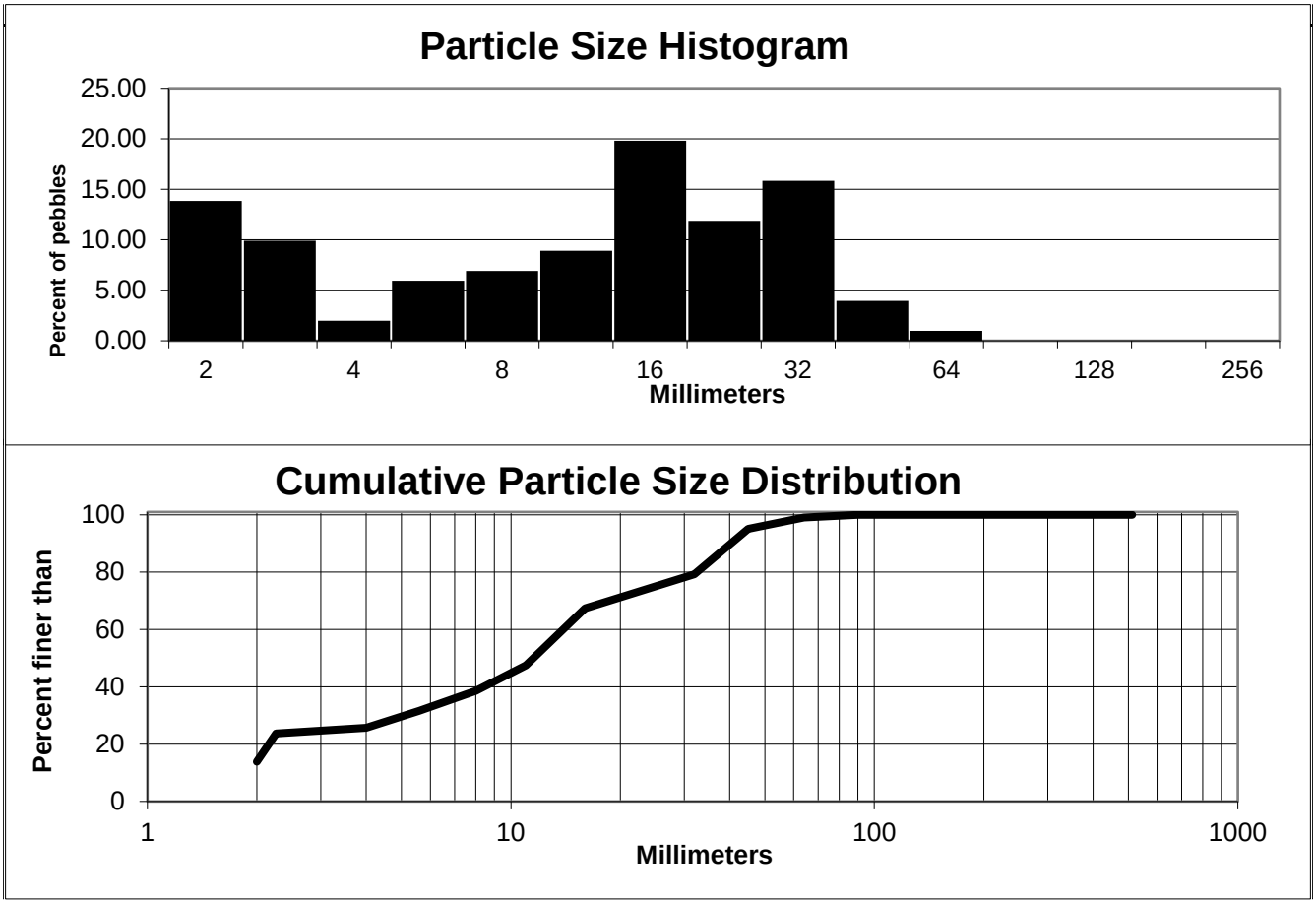
Pebble Count Name: Reach 5 Riffle
Sampling Method: Random Walk
Geomorphic Position: Riffle
Stratigraphic Position: Surface

Sediment size (mm)	Particle Count	Total Percent	Cumulative Percent
2	15	15.00	15.00
2.26	10	10.00	25.00
4	1	1.00	26.00
5.6	3	3.00	29.00
8	10	10.00	39.00
11	11	11.00	50.00
16	18	18.00	68.00
32	14	14.00	82.00
45	7	7.00	89.00
64	6	6.00	95.00
90	3	3.00	98.00
128	2	2.00	100.00
180	0	0.00	100.00
256	0	0.00	100.00
512	0	0.00	100.00
Total:	100	100	

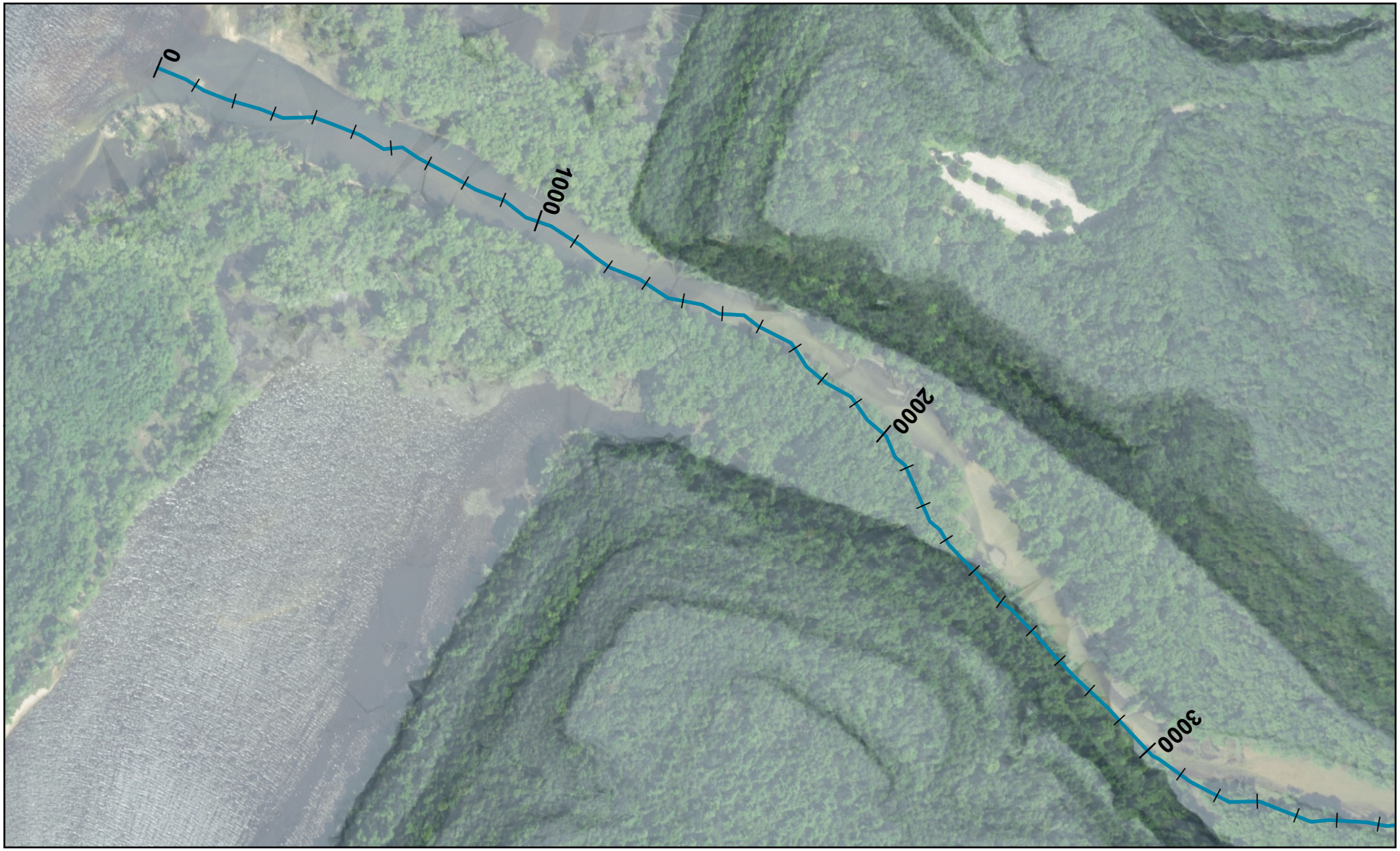


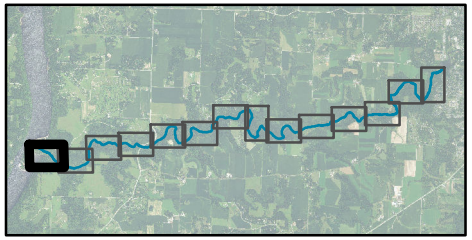
Pebble Count Name: Reach 5 Bar
Sampling Method: Random Walk
Geomorphic Position: Bar
Stratigraphic Position: Surface

Sediment size (mm)	Particle Count	Total Percent	Cumulative Percent
2	14	13.86	13.86
2.26	10	9.90	23.76
4	2	1.98	25.74
5.6	6	5.94	31.68
8	7	6.93	38.61
11	9	8.91	47.52
16	20	19.80	67.33
32	12	11.88	79.21
45	16	15.84	95.05
64	4	3.96	99.01
90	1	0.99	100.00
128	0	0.00	100.00
180	0	0.00	100.00
256	0	0.00	100.00
512	0	0.00	100.00
Total:	101	100	



10. Appendix C – Field Maps





Feet
0 500
Scale 1:4000

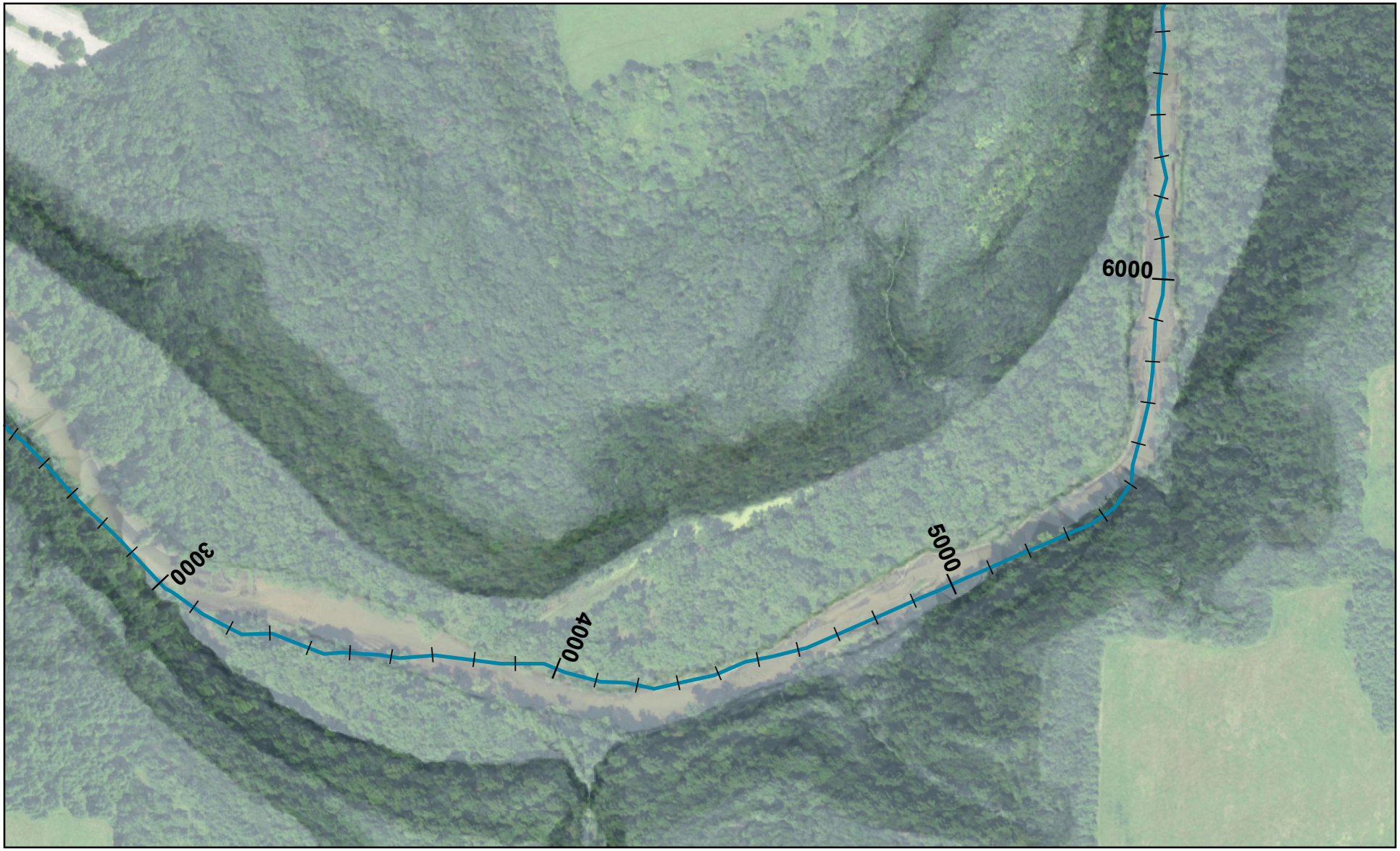
Coordinate System : NAD 1983
StatePlane Wisconsin Central
FIPS 4802 Feet

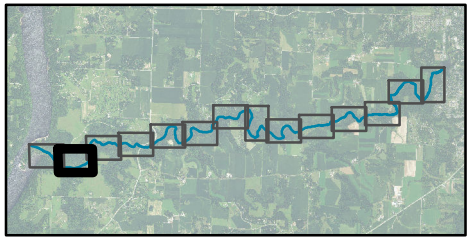
N

River Falls Habitat Assessment
Map 1

Notes:
1. Aerial Imagery from Landsat 2018
2. LiDAR derived slope data collected 2015
3. River stationing derived from river centerline Riverine Habitat Evaluation below Powell Falls - Desktop Evaluation Summary

Pierce County
Wisconsin





Feet
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Scale 1:4000

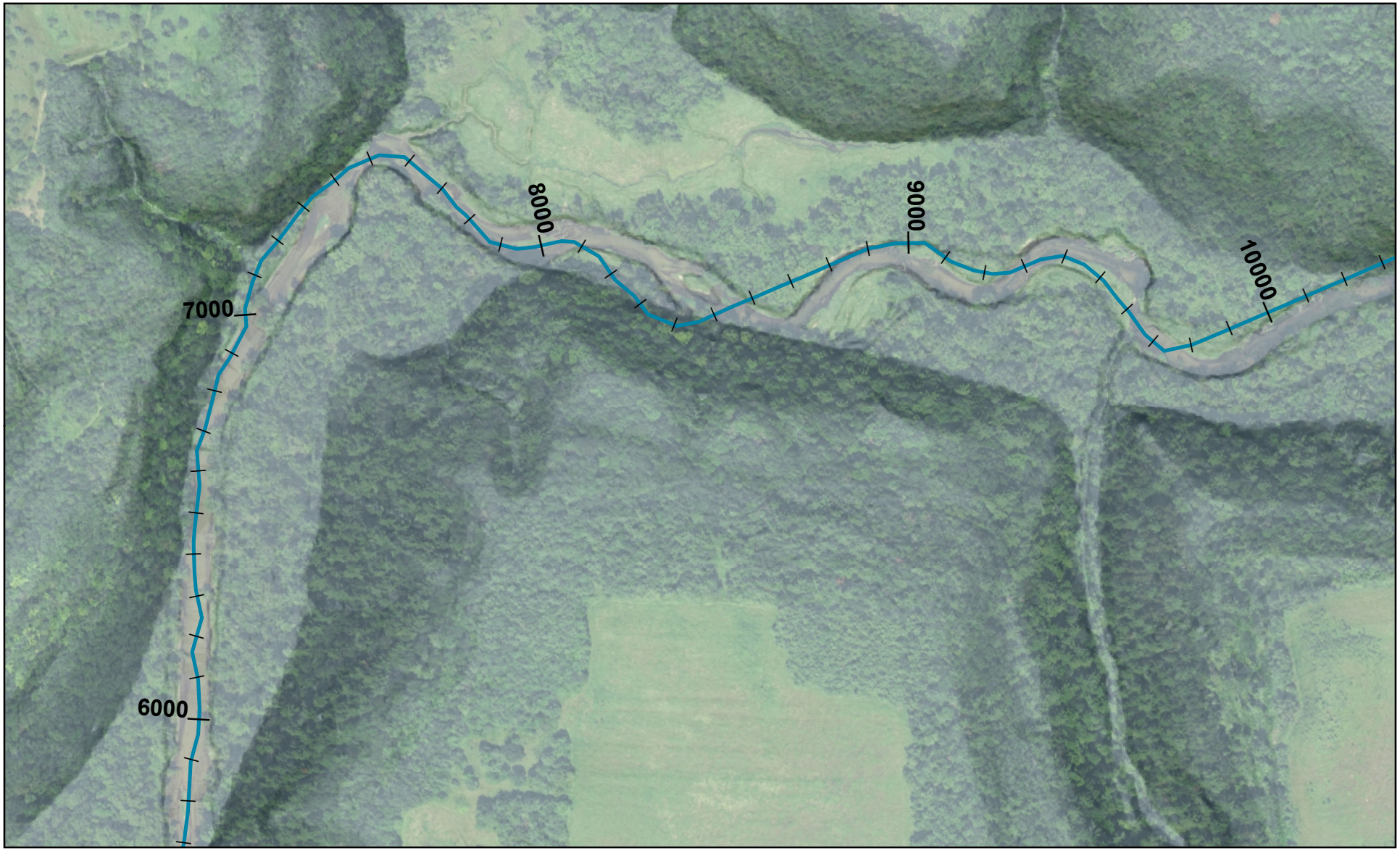
Coordinate System : NAD 1983
StatePlane Wisconsin Central
FIPS 4802 Feet

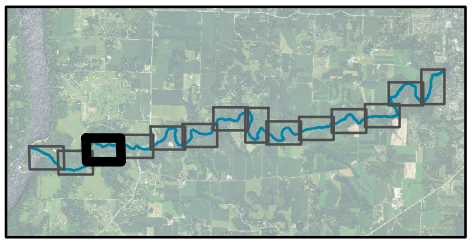
N

River Falls Habitat Assessment
Map 2

Notes:
1. Aerial Imagery from Landsat 2018
2. LiDAR derived slope data collected 2015
3. River stationing derived from river centerline Riverine Habitat Evaluation below Powell Falls - Desktop Evaluation Summary

Pierce County
Wisconsin





Feet
0 500
Scale 1:4000

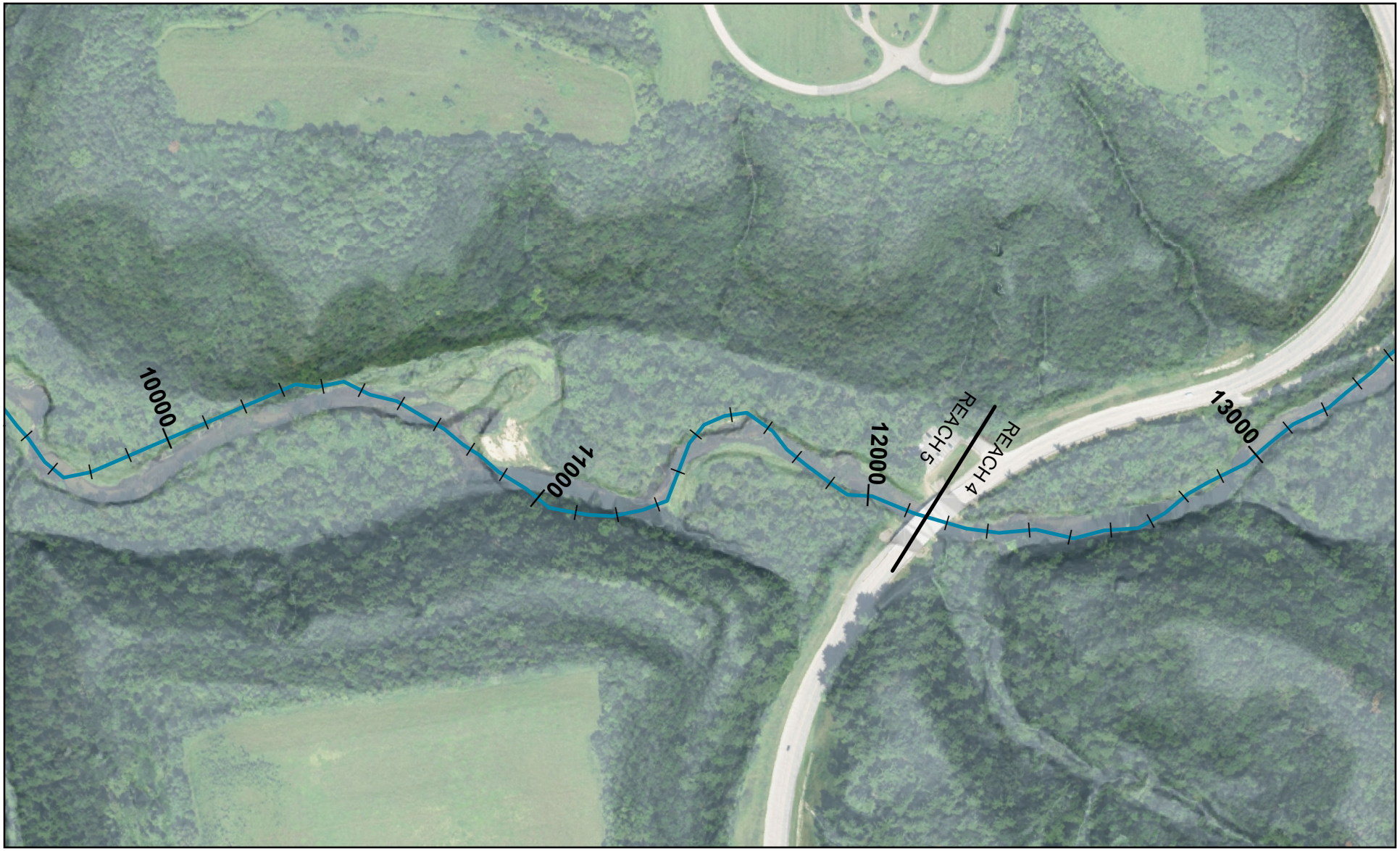
Coordinate System : NAD 1983
StatePlane Wisconsin Central
FIPS 4802 Feet

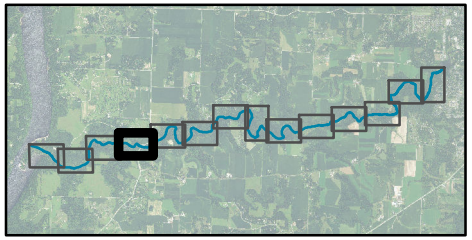
N

River Falls Habitat Assessment
Map 3

Notes:
1. Aerial Imagery from Landsat 2018
2. LiDAR derived slope data collected 2015
3. River stationing derived from river centerline Riverine Habitat Evaluation below Powell Falls - Desktop Evaluation Summary

Pierce County
Wisconsin





Feet
0 500
Scale 1:4000

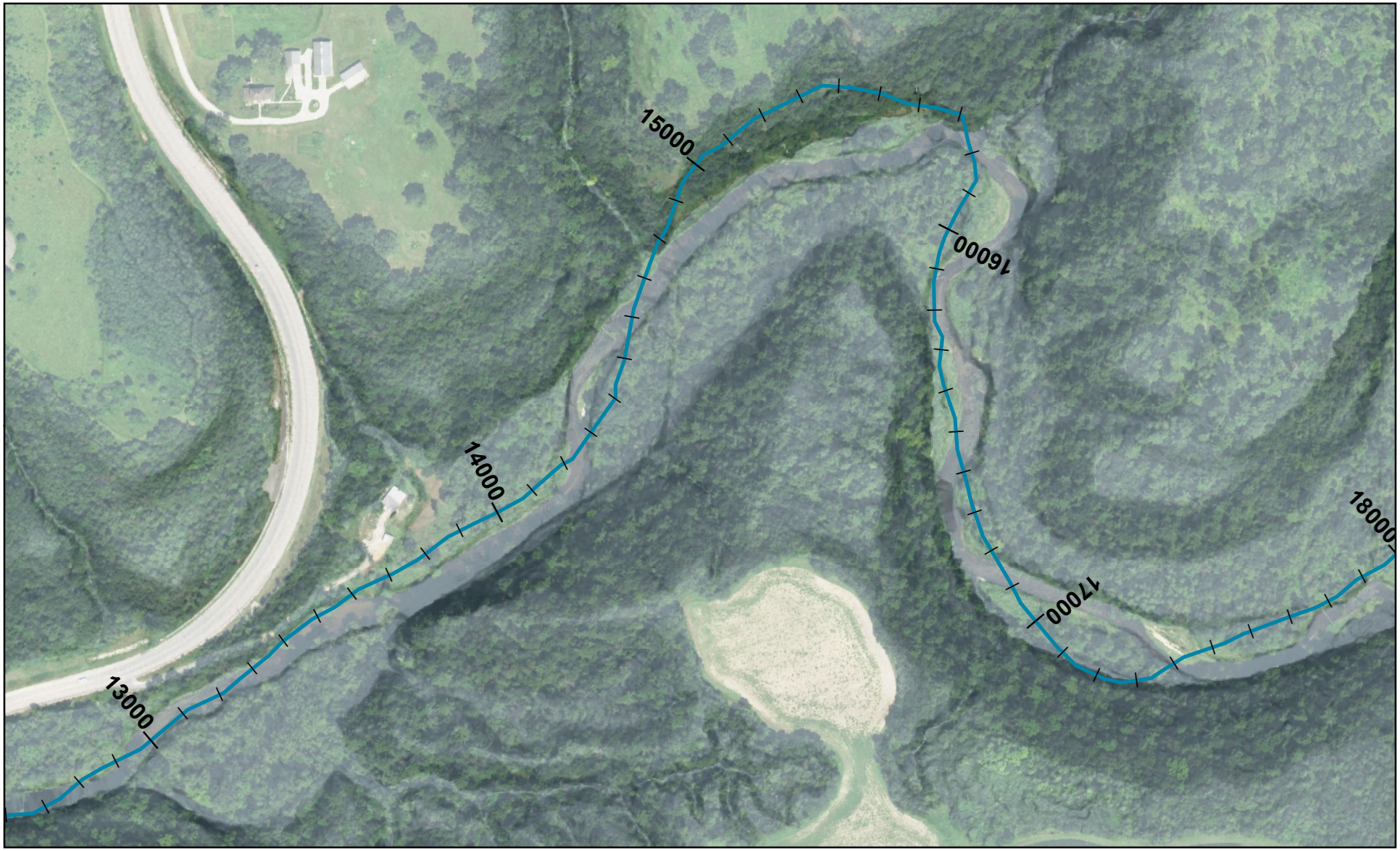
Coordinate System : NAD 1983
StatePlane Wisconsin Central
FIPS 4802 Feet

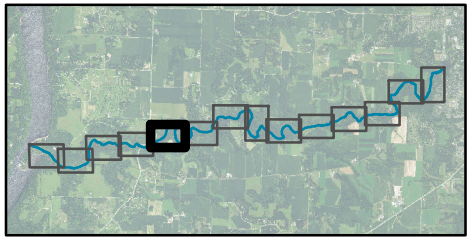
N

River Falls Habitat Assessment
Map 4

Notes:
1. Aerial Imagery from Landsat 2018
2. LiDAR derived slope data collected 2015
3. River stationing derived from river centerline Riverine Habitat Evaluation below Powell Falls - Desktop Evaluation Summary

Pierce County
Wisconsin





Feet
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Scale 1:4000

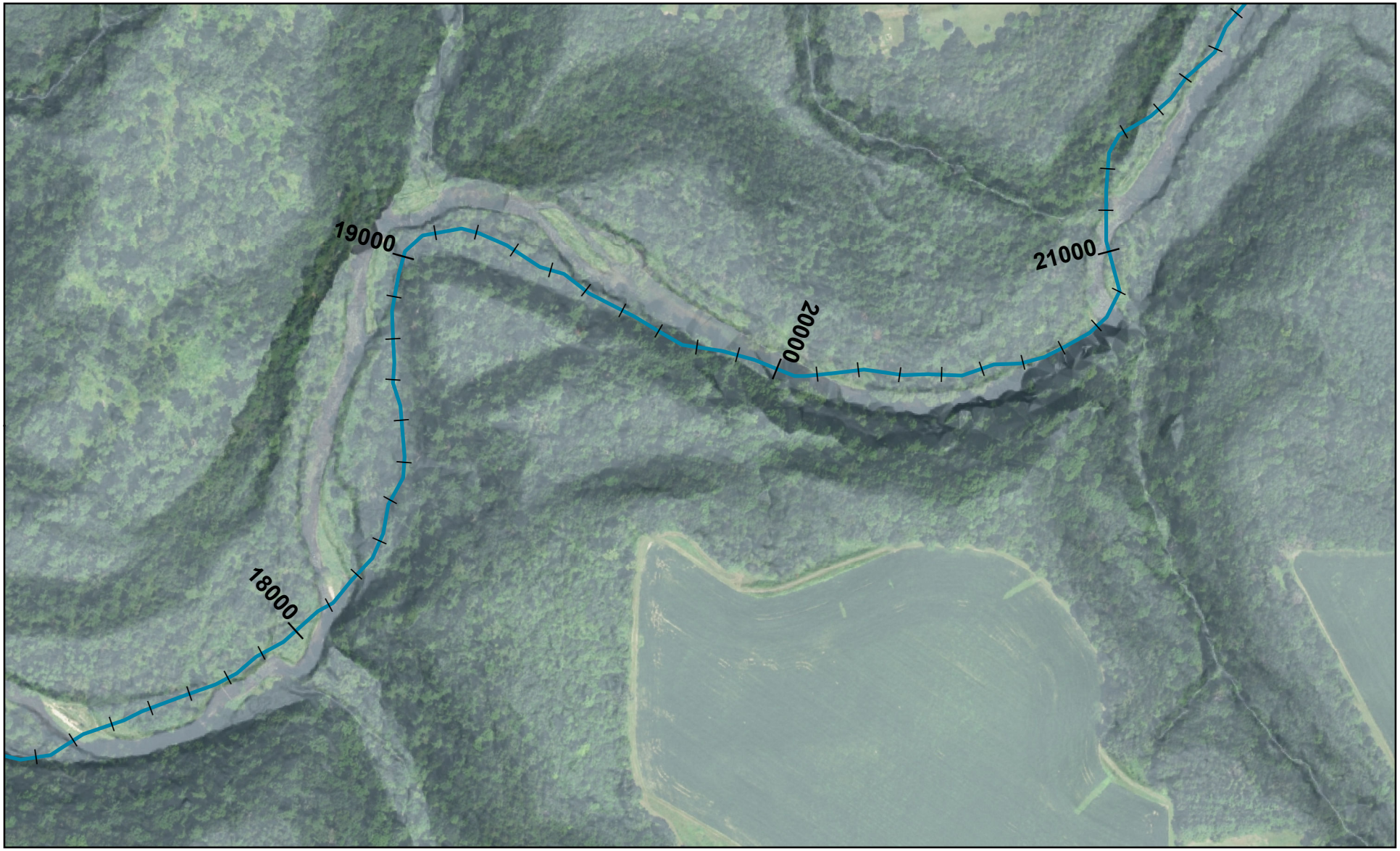
Coordinate System : NAD 1983
StatePlane Wisconsin Central
FIPS 4802 Feet

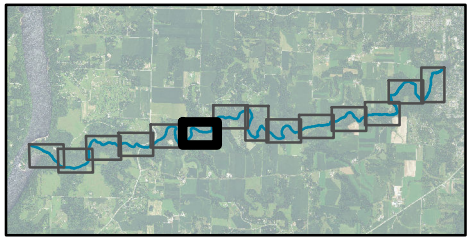
N

River Falls Habitat Assessment
Map 5

Notes:
1. Aerial Imagery from Landsat 2018
2. LiDAR derived slope data collected 2015
3. River stationing derived from river centerline Riverine Habitat Evaluation below Powell Falls - Desktop Evaluation Summary

Pierce County
Wisconsin





Feet
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Scale 1:4000

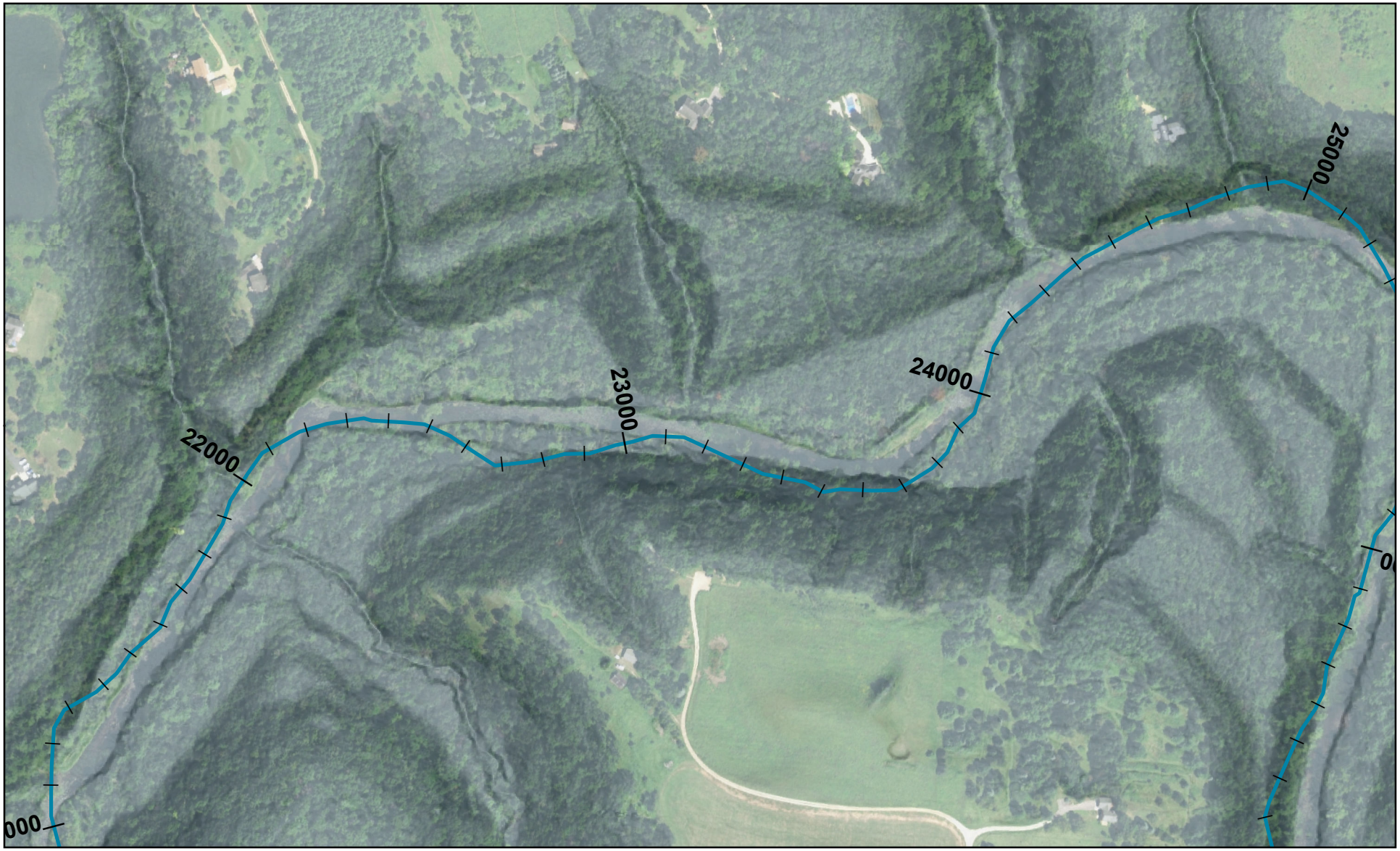
Coordinate System : NAD 1983
StatePlane Wisconsin Central
FIPS 4802 Feet

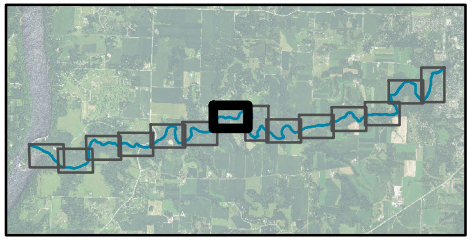
N

River Falls Habitat Assessment
Map 6

Notes:
1. Aerial Imagery from Landsat 2018
2. LiDAR derived slope data collected 2015
3. River stationing derived from river centerline Riverine Habitat Evaluation below Powell Falls - Desktop Evaluation Summary

Pierce County
Wisconsin





Feet
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Scale 1:4000

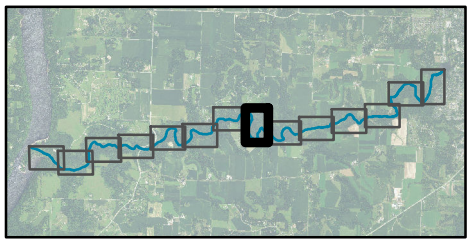
Coordinate System : NAD 1983
StatePlane Wisconsin Central
FIPS 4802 Feet

N

River Falls Habitat Assessment
Map 7

Notes:
1. Aerial Imagery from Landsat 2018
2. LiDAR derived slope data collected 2015
3. River stationing derived from river centerline Riverine Habitat Evaluation below Powell Falls - Desktop Evaluation Summary

Pierce County
Wisconsin



Feet
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Scale 1:4000

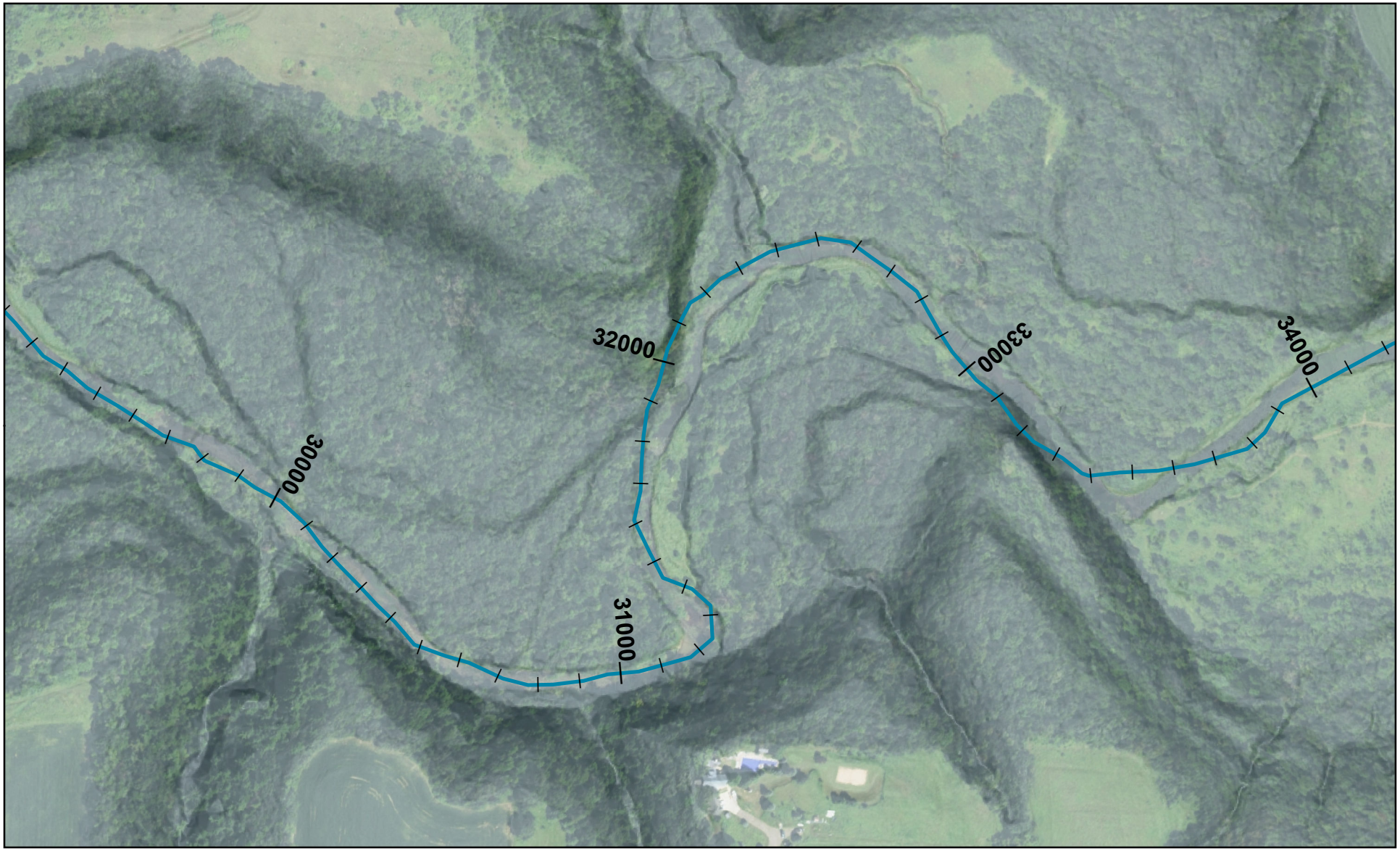
Coordinate System : NAD 1983
StatePlane Wisconsin Central
FIPS 4802 Feet

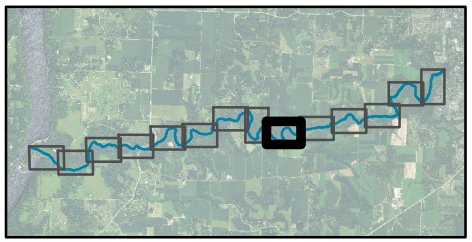
N

River Falls Habitat Assessment
Map 8

Notes:
1. Aerial Imagery from Landsat 2018
2. LiDAR derived slope data collected 2015
3. River stationing derived from river centerline Riverine Habitat Evaluation below Powell Falls - Desktop Evaluation Summary

Pierce County
Wisconsin





Feet
0 500
Scale 1:4000

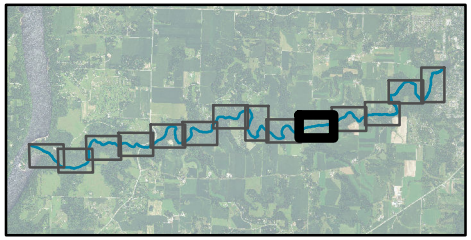
Coordinate System : NAD 1983
StatePlane Wisconsin Central
FIPS 4802 Feet

N

River Falls Habitat Assessment
Map 9

Notes:
1. Aerial Imagery from Landsat 2018
2. LiDAR derived slope data collected 2015
3. River stationing derived from river centerline Riverine Habitat Evaluation below Powell Falls - Desktop Evaluation Summary

Pierce County
Wisconsin



Feet
0 500
Scale 1:4000

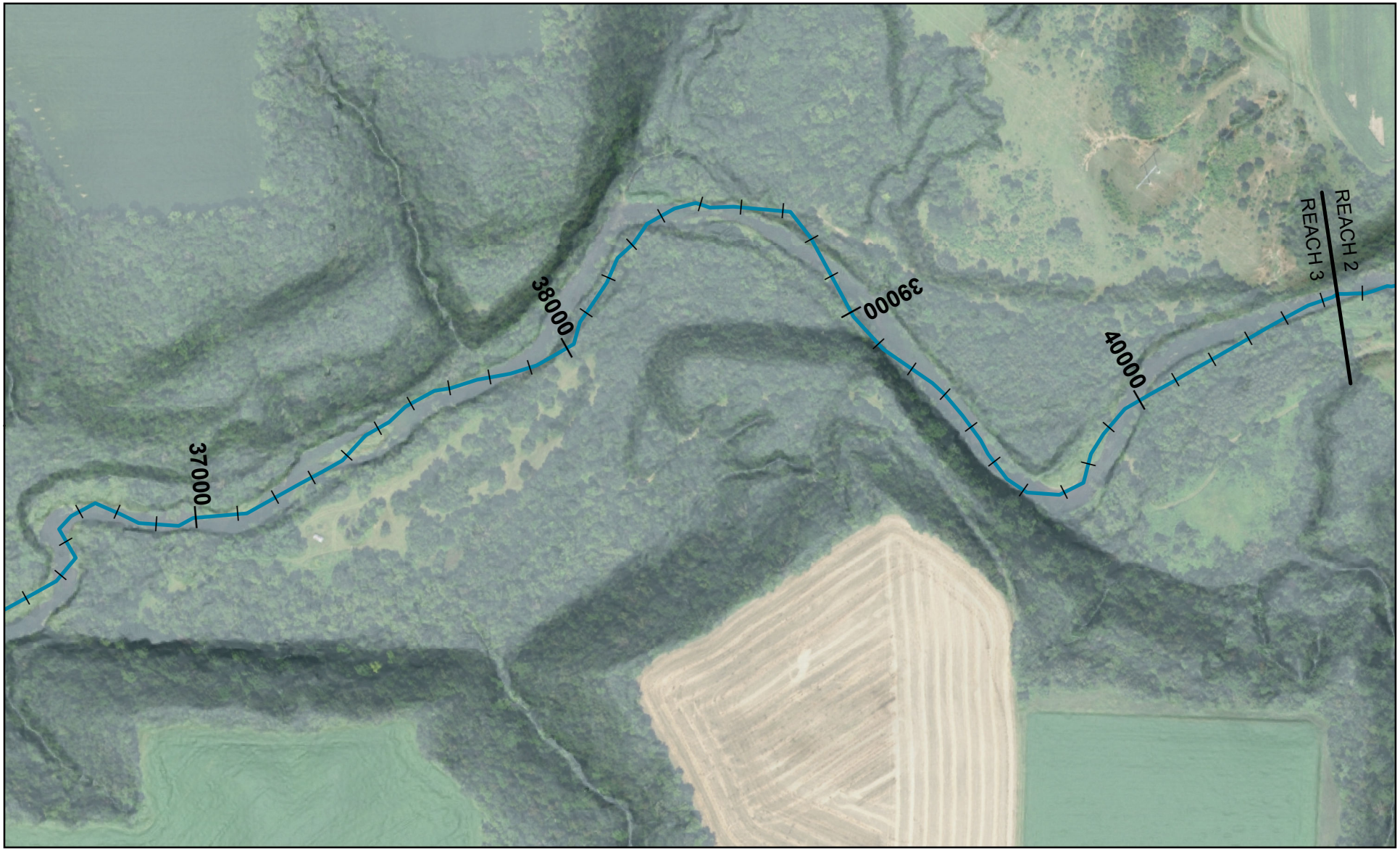
Coordinate System : NAD 1983
StatePlane Wisconsin Central
FIPS 4802 Feet

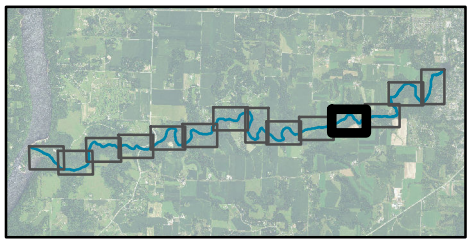
N

River Falls Habitat Assessment
Map 10

Notes:
1. Aerial Imagery from Landsat 2018
2. LiDAR derived slope data collected 2015
3. River stationing derived from river centerline Riverine Habitat Evaluation below Powell Falls - Desktop Evaluation Summary

Pierce County
Wisconsin





Feet
0 500
Scale 1:4000

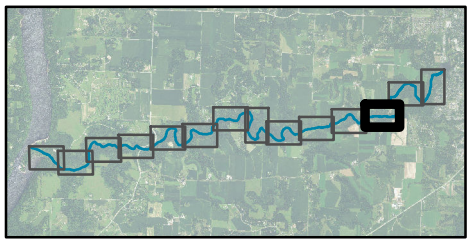
Coordinate System : NAD 1983
StatePlane Wisconsin Central
FIPS 4802 Feet

N

River Falls Habitat Assessment
Map 11

Notes:
1. Aerial Imagery from Landsat 2018
2. LiDAR derived slope data collected 2015
3. River stationing derived from river centerline Riverine Habitat Evaluation below Powell Falls - Desktop Evaluation Summary

Pierce County
Wisconsin



Feet
0 500
Scale 1:4000

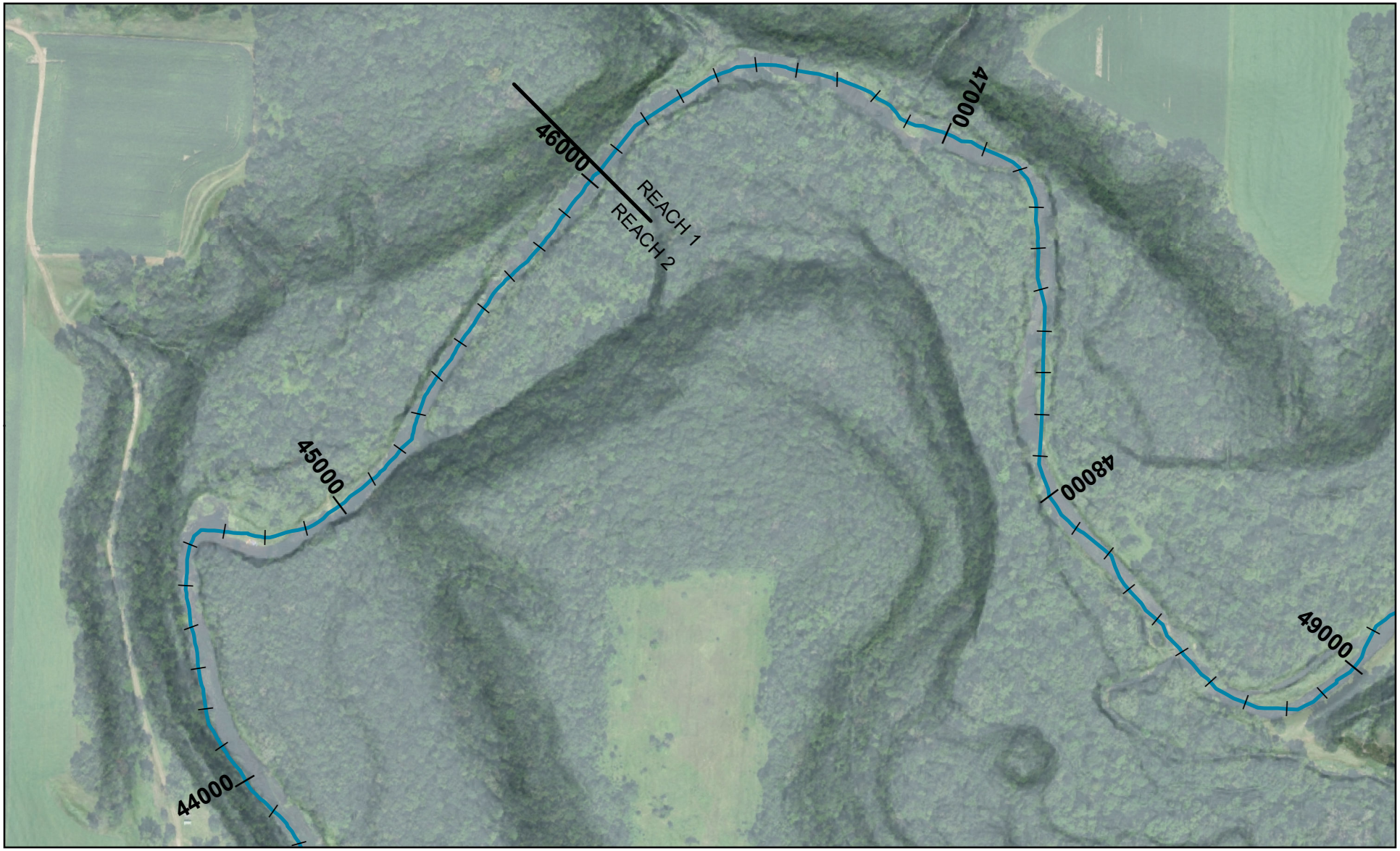
N

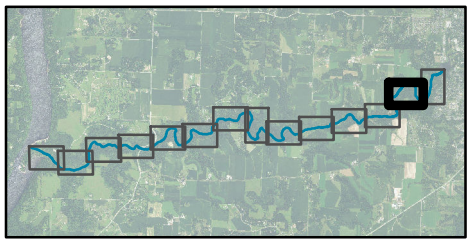
Coordinate System : NAD 1983
StatePlane Wisconsin Central
FIPS 4802 Feet

River Falls Habitat Assessment
Map 12

Notes:
1. Aerial Imagery from Landsat 2018
2. LiDAR derived slope data collected 2015
3. River stationing derived from river centerline Riverine Habitat Evaluation below Powell Falls - Desktop Evaluation Summary

Pierce County
Wisconsin





Feet
0 500
Scale 1:4000

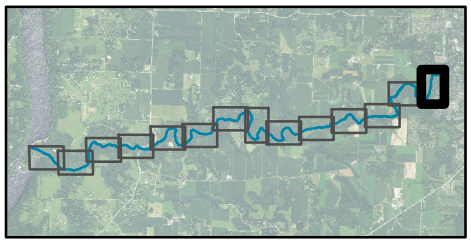
Coordinate System : NAD 1983
StatePlane Wisconsin Central
FIPS 4802 Feet

N

River Falls Habitat Assessment
Map 13

Notes:
1. Aerial Imagery from Landsat 2018
2. LiDAR derived slope data collected 2015
3. River stationing derived from river centerline Riverine Habitat Evaluation below Powell Falls - Desktop Evaluation Summary

Pierce County
Wisconsin



Feet
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Scale 1:4000

Coordinate System : NAD 1983
StatePlane Wisconsin Central
FIPS 4802 Feet

N

River Falls Habitat Assessment
Map 14

Notes:
1. Aerial Imagery from Landsat 2018
2. LiDAR derived slope data collected 2015
3. River stationing derived from river centerline Riverine Habitat Evaluation below Powell Falls - Desktop Evaluation Summary

Pierce County
Wisconsin

11. Appendix D – Digital Deliverables

Digital deliverables include:

1 – Spreadsheet of habitat information, survey points, and pebble counts

2 – Digital photographs collected during the survey