Badin Inn
Stream Restoration
Stanly County, North Carolina
Year 5 Monitoring Report

Monitoring Year: 2013
Measurement Year 5
As-Built Date 2009
NCEEP Project Number 92666

January 2014

BADIN INN STREAM RESTORATION
YEAR 5 MONITORING REPORT

CONDUCTED FOR THE NORTH CAROLINA DEPARTMENT
OF
ENVIRONMENT AND NATURAL RESOURCES

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I. EXECUTIVE SUMMARY/PROJECT ABSTRACT

The Badin Inn project consists of 4,174 linear feet of Priority 1 stream restoration located on the golf course of the Badin Inn Golf Resort and Club in the Town of Badin, North Carolina. Construction on the site was completed in April of 2009. The following report provides the Year 5 monitoring information.

The project consists of a portion of an unnamed tributary to Little Mountain Creek (UT to Little Mountain Creek), a tributary to the Yadkin River. It is located entirely on land owned by the Badin Inn Golf Resort and Club and drains into Little Mountain Creek in Stanly County, North Carolina. The watershed area for this project is approximately 0.5 square miles.

UT to Little Mountain Creek is a 2nd order stream, as several small 1st order tributaries flow into it near the top of the watershed. As it passes through the town, the channel has uniform rectangular dimensions and is lined with concrete. As the primary drainage feature in the Town of Badin, it receives discharge from numerous stormwater pipes from houses and townhouse complexes. The channelization of this stream occurred during the development of Badin by ALCOA during the early 1920's, and has since served as the primary stormwater conveyance system for a portion of the town.

Prior to restoration, the stream entered a much larger, concrete-lined channel that traveled straight down the valley until joining with Little Mountain Creek. The Priority 1 restoration involved removal of the concrete channel and adjustment of the stream dimension, pattern, and profile to allow the stream to more fully transport its water and sediment load. A combination of bedform transformations, channel dimension adjustments, pattern alterations, and structure installations were used to accomplish this. The natural meander patterns were restored and rock and log grade control vanes were incorporated for aquatic habitat enhancement and bed and bank stability. The tributary was also restored using a Priority 1 restoration. The riparian area also underwent buffer restoration with plantings and is protected with a permanent easement. Construction of the restored channel and planting of the riparian vegetation was completed in April 2009.

The Year 5 monitoring revealed that the stream has remained stable and riparian vegetation is becoming well established. No problem areas such as stream bank erosion, unstable structures, excessive aggradation or degradation, or changes in channel morphology were identified. Supplemental plantings consisting of 125 container grown river birch (*Betula nigra*) were installed in March 2013 to augment several areas that had been mown by the golf course as well as sparse areas identified during the Year 4 monitoring.

II. PROJECT BACKGROUND

A. Location and Setting

The Badin Inn project site is located in the Town of Badin in northeast Stanly County. (Figure 1). The headwaters of the project originate approximately 0.8 miles to the northeast of the restoration site. From the headwaters, UT to Little Mountain Creek flows for approximately 1.5 miles before emptying into Little Mountain Creek. One tributary enters UT Little Mountain Creek along its project extent.

The watershed of the project stream is approximately 0.5 square miles (346 acres) and is oriented northeast to southwest. The project is located within a conservation easement that occurs on private land owned by Badin Inn Golf Resort and Club. The upper portions of the watershed are comprised of the western slope of a ridgeline in the Uwharrie Mountains chain. Further down, the watershed contains part of the Town of Badin, and includes residential areas, and the Badin Inn Golf Resort and Club, the golf course property on which the project is located. Although the town is small, it possesses a densely developed area of townhouse complexes and houses that were built as residences for the workers of ALCOA, the large aluminum manufacturer that built the Town of Badin in the early part of the twentieth century. Most of this densely developed area lies within the watershed of UT to Little Mountain Creek.

If traveling from the north (Raleigh, Greensboro, Winston-Salem), proceed southwest on NC 49 from Asheboro. After passing over the Yadkin River/Badin Lake, head south on NC 8 until reaching New London, where NC 8 merges with US Highway 52. Shortly after the merger, turn left onto NC 740 towards Badin. In Badin, after passing the ALCOA plant, turn left on Nantahala Street, then turn right on Henderson Street (SR 1720), which becomes Valley Drive. The beginning of the project is on the right, where the road passes through the fairways of the golf course.

If coming from the south (Charlotte), take NC 24/27 towards Albemarle, then in Albemarle proceed north on NC 740 towards Badin. In Badin, turn right on Nantahala Street, then right on Henderson Street (SR 1720), which becomes Valley Drive. The beginning of the project is on the right, where the road passes the fairways of the golf course.

B. Mitigation Structures and Objectives

The Priority 1 restoration involved removal of the concrete lining and construction of a stream with a proper dimension, pattern, and profile to allow the stream to more fully transport its water and sediment load. A combination of bedform transformations, channel dimension and pattern restoration, and structure installations were used to restore the stream. Natural meander patterns were added and rock and log grade control vanes were incorporated for aquatic habitat enhancement and bed and bank stability. The tributary was restored using Priority 1 restoration. The Priority 1 restoration involved converting the concrete-lined channel into a sinuous channel that meanders for a total of 3,994 linear feet of stream as measured along the centerline (Table I). A riparian buffer was planted in April 2009 and is

protected by a Conservation Easement. This monitoring report follows the template of Version 1.2 to keep reporting consistent with the MY1 report (also in Version 1.2).

The project had the goal of accomplishing the following objectives:

1. Restore 3,994 linear feet of UT to Little Mountain Creek and 180 linear feet of a small unnamed tributary to Little Mountain Creek.
2. Provide a stable stream channel that neither aggrades nor degrades while maintaining its dimension, pattern, and profile with the capacity to transport its watershed's water and sediment load.
3. Improve water quality and reduce erosion by stabilizing the stream banks.
4. Reconnect the stream to its floodplain.
5. Improve aquatic habitat with the use of natural material stabilization structures such as root wads, rock vanes, woody debris, and a riparian buffer.
6. Provide aesthetic value, wildlife habitat, and bank stability through the creation or enhancement of a riparian zone.

Table I. Project Restoration Components Badin Inn Stream Restoration - EEP Project No. 92666								
Project Component or Reach ID	**Existing Feet/Acres**	**Type**	**Approach**	**Footage or Acreage**	**Mitigation Ratio**	**Mitigation Units**	**Stationing**	**Comment**
UT to Little Mountain Creek	3,540 feet	R	PI	3,994 feet	1.0	3,994	10+00 - 50+22	Construction started 28 feet from the start of stationing
Tributary	141 feet	R	PI	180 feet	1.0	180	10+00 - 11+80	
Mitigation Unit Summations								
Stream (lf)	Riparian Wetland (Ac)	Nonriparian Wetland (Ac)	Total Wetland (Ac)	Buffer (Ac)	Comment			
4,174	NA	NA	NA	0.0				

R = Restoration
PI = Priority I

C. Project History and Background

The Badin Inn Stream Restoration Project is located in the Town of Badin in Stanly County, North Carolina and is situated entirely within the golf course of the Badin Inn Golf Resort and Club (Figure 1). The project site encompasses a perennial, unnamed tributary to Little Mountain Creek (UT to Little Mountain Creek) and a small, first-order intermittent tributary of UT to Little Mountain Creek (Tributary) and the associated floodplain through which these channels flow. Prior to restoration, the channel of UT to Little Mountain Creek consisted of approximately 3,700 feet of a concrete-lined and straightened perennial stream that had been in its altered state for nearly a century. The Tributary consisted of approximately 141 feet of an intermittent channel routed through a culvert from where it entered the golf course property until it's confluence with UT to Little Mountain Creek.

UT to Little Mountain Creek is a 2nd order stream, as several small 1st order tributaries flow into it near the top of the watershed. As it passes through the town, the channel has uniform rectangular dimensions and is lined with concrete. As the primary drainage feature in the Town of Badin, it receives discharge from numerous stormwater pipes from houses and townhouse complexes. The channelization of this stream occurred during the development of Badin by ALCOA during the early 1920's, and has since served as the primary stormwater conveyance system for a portion of the town. Where the stream enters the Badin Inn Golf Resort and Club golf course, the stream is confined to a narrow, stone-lined channel for roughly 700 feet. It continues in this form until reaching the conservation easement and the upstream end of the project reach, after passing through a 48" culvert under Henderson Street (State Road 1720).

Prior to restoration, the stream entered a much larger, concrete-lined channel at this point, which traveled straight down the valley until joining with Little Mountain Creek. An intermittent tributary that was routed underground through a culvert entered the main channel approximately 500 feet downstream of the beginning of the project. The relict floodplain of the pre-restoration channel was covered by fairways of the Badin Inn Golf Resort and Club golf course, and some modification to the valley had been done to create bunkers, greens and tee boxes. In addition, a network of drains, pipes and irrigation systems had been installed within the valley, and numerous stormwater outfalls discharged into the stream.

The project is located in the Yadkin River Basin 8-digit Catalogue Unit 03040104 and the 14-digit hydrological unit 03040104010010. This watershed was identified by the NC Ecosystem Enhancement Program (EEP) as a Targeted Local Watershed and is also classified by the NC Division of Water Quality (NCDWQ) as a Water Supply Watershed (WSIV). The receiving stream, Little Mountain Creek, is listed on the 303(d) list for biological impairment (NCDENR, 2012).

The project site is located in the Carolina Slate Belt ecoregion (Griffith *et. al*, 2002). The primary adjacent land use throughout the project watershed consists of managed herbaceous areas (which consists mainly of the Badin Inn golf course), developed areas, including much of the residential areas of the Town of Badin, and forested areas on the slopes above the town.

Table II. Project Activity and Reporting History Badin Inn Stream Restoration - EEP Project No. 92666		
Activity or Report	**Data Collection Complete**	**Actual Completion or Delivery**
Restoration Plan	9/1/2007	July 2008
Final Design – 90%	July 2008	December 2008
Construction	NA	April 2009
Temporary S&E mix applied to entire project area	NA	4/1/2009
Permanent seed mix applied to entire project area	NA	4/1/2009
Containerized, B&B, and livestake plantings	4/1/2009	4/1/2009
Mitigation Plan / As-built (Year 0 Monitoring – baseline)	July 2009	August 2009
Year 1 Monitoring	January 2010	January 2010
Year 2 Monitoring	February 2011	March 2011
Year 3 Monitoring	November 2011	December 2011
Year 4 Monitoring	December 2012	January 2013
Year 5 Monitoring	December 2013	January 2014

Figure 1. Vicinity Map

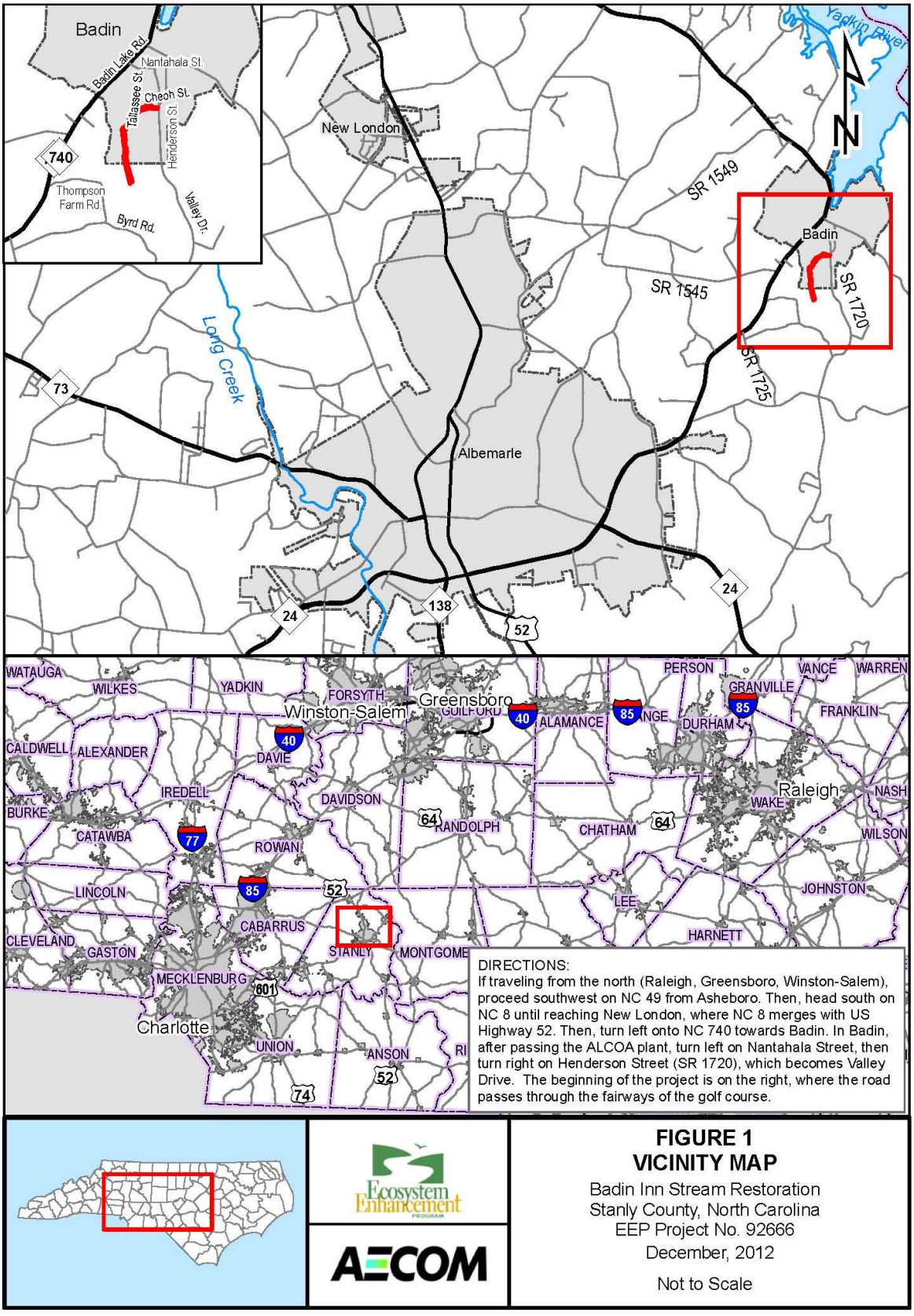


Table III. Project Contacts Table Badin Inn Stream Restoration - EEP Project No. 92666	
Designer	AECOM 701 Corporate Center Drive, Suite 475 Raleigh, NC 27607 Phone: (919) 854-6200
Construction Contractor	River Works, Inc. 8000 Regency Parkway, Suite 200 Cary, NC 27511 Phone: (919) 459-9001
Survey Contractor	AECOM 701 Corporate Center Drive, Suite 475 Raleigh, NC 27607 Phone: (919) 854-6200
Planting Contractor	Efird Landscaping, Inc 42759 Greenview Dr. Albemarle, NC 28001 Phone: (704) 985-6559
Seeding Contractor	Efird Landscaping, Inc 42759 Greenview Dr. Albemarle, NC 28001 Phone: (704) 985-6559
Seed Mix Sources	Mellow Marsh Farm, Inc. 1312 Woody Store Rd. Siler City, NC 27344 Phone: (919) 742-1200
Nursery Stock Suppliers	Arborgen LLC 5594 Highway 38 Blenheim, SC 29516 Phone: (843) 528-9669 Carolina Wetland Services 550 E. Westinghouse Blvd. Charlotte, NC 28273 Phone: (704) 527-1177
Monitoring Performers	AECOM 701 Corporate Center Drive, Suite 475 Raleigh, NC 27607
Stream Monitoring	AECOM Phone: (919) 854-6200
Vegetation Monitoring	AECOM Phone: (919) 854-6200

Table IV. Project Background Table Badin Inn Stream Restoration - EEP Project No. 92666		
	UT to Little Mountain Creek	Tributary
Project County	Stanly County	Stanly County
Drainage Area	0.5 sq miles	0.05 sq. miles
Drainage impervious cover estimate (%)	5%	15%
Stream order	2nd	1st
Physiographic Region	Piedmont	Piedmont
Ecoregion	Carolina Slate Belt	Carolina Slate Belt
Rosgen Classification of As-built	C4	C
Cowardin Classification	Riverine	Riverine
Dominant soil types	Oakboro/Kirksey Silt loams	Oakboro/Kirksey Silt loams
Reference site ID	Spencer Creek and UT Meadow Fork	Spencer Creek and UT Meadow Fork
USGS HUC for Project and Reference	03040104 (Project) 03040101 (UT Meadow Fork) 03040103 (Spencer Creek	03040104 (Project) 03040101 (UT Meadow Fork) 03040103 (Spencer Creek
NCDWQ Sub-basin for Project and Reference	03-07-08 (Project)	03-07-08 (Project)
NCDWQ classification for Project and Reference	WS-IV (UT Little Mountain Creek) C (Spencer Creek) B Tr+ (UT Meadow Fork)	WS-IV (UT Little Mountain Creek) C (Spencer Creek) B Tr+ (UT Meadow Fork)
Any portion of any project segment 303(d) listed?	No	No
Any portion of any project upstream of a 303d listed segment	Yes	Yes
Reasons for 303d listing or stressor	Low dissolved oxygen and high conductivity	Low dissolved oxygen and high conductivity
% of project easement fenced	100	100

III. PROJECT CONDITION AND MONITORING RESULTS

A. Vegetation Assessment

Vegetation success is based on the criteria established in the USACE Stream Mitigation Guidelines (2003). Planted stem density minimums of 320 stems/acre through year three, 288 stems/acre in year four, and 260 stems/acre in year five are required. Vegetation monitoring was performed using the CVS-EEP Level 2 protocol.

1. *Vegetative Problem Areas*

One minor vegetation problem area was noted during Year 5 monitoring. As a whole the vegetation plantings have been very successful though a few areas of concern were noted where survival has been less than optimal, primarily due to shading from existing large loblolly pines and surface exposure of dense rocky debris/soil compaction. Except for a

small area at a golf cart crossing no mowing of the easement by golf course personnel was observed this year. The mowed area included a corner area approximately 4-5 feet square at the northeastern corner of the easement. See Table 6 and Photo 1 in Appendix A-1. This violation is minor compared to ones in years past and it seems that the golf course personnel are adhering to the requirements of the easement overall. Supplemental plantings consisting of 75 3-gallon and 50 7-gallon container-grown river birch (*Betula nigra*) saplings were installed in March 2013, to address areas of concern identified during the Year 4 monitoring.

Sparse vegetative growth was noted occurring under large, mature, pre-existing trees in three locations. These areas were replanted in the spring of 2011 to increase the density of vegetation. Due to the shade from the existing trees, survival of the plantings in these areas was less than optimal. This situation is not likely to change unless the large trees are removed which would be counter-productive. Although these areas are not developing a dense undergrowth of shrubby vegetation we are no longer considering them problem areas since the trees in these locations represent an approximate basal area of 116 sq. ft/acre which is within the range of a mature forest. The ground surface is covered with leaf/needle litter and some herbaceous vegetation is becoming established. No surface erosion is present. The current site conditions of the areas of large pine and oak trees represent similar conditions to what one would expect to find under mature oak-pine forest. Additionally, the nutrient reduction qualities and quality as a buffer are equivalent of a mature vegetated hardwood/pine forest. Because these areas have mature trees, are already providing nutrient reduction, and no erosion is occurring, they are no longer classified as problem areas.

Invasive exotic vegetation had been noted in previous reports as occurring within the easement but never in amounts that warranted concern. This remains true and it appears that the density of the invasive exotics species in the easement has declined over the past year. Chinese privet (*Ligustrum sinense*) is the primary species with small amounts of Japanese honeysuckle (*Lonicera japonica*) also present in the area. Multiflora rose (*Rosa multiflora*) is also present in the area where the UT enters Little Mountain Creek. The density of these three species remains low and does not warrant control at this point. The area surrounding vegetation monitoring plot VP 5 is now dominated with Bermuda grass (*Cynodon dactylon*) which has spread since Year 3 when it was first observed in the plot. The Bermuda grass appears to be localized and grass was not observed in other areas of the easement. Planted stem survival has been reduced in this vegetation monitoring plot either from the Bermuda grass or trampling by golfers that is invited by its more open character when compared to the rest of the easement.

2. *Stem Counts*

Baseline vegetation plots were established in April 2009 after vegetative planting was completed. Nine (9) vegetation monitoring plots were staked out in the floodplain and terrace along UT Little Mountain Creek within the project area. Each plot measured 10m X 10m with an area of $100m^2$. Stems were flagged and counted to establish baseline and yearly stem counts. Year 5 vegetation monitoring was performed on September 25, 2013.

Year 5 monitoring revealed an average of 418 woody stems per acre. This average exceeds the required Year 5 threshold of 260 stems per acre for the project. The range of stem densities encountered on the mitigation site varied from 283 to 647 stems per acre. All nine vegetation monitoring plots contain a density greater than the 260 planted stems per acre for the required final threshold for Year 5. Vegetation density is lower in some individual plots (4 and 6) due to shading from large adjacent trees and possible soil compaction. Plots 5 and 6 exhibit a density of 283 stems per acre, a drop from last year but still above the five year threshold of 260 stems per acre. Lower survival in plot 5 is likely due to a combination of Bermuda grass encroachment and possible golfer trampling. In April 2011 approximately 0.9 acres were replanted with 600 bare root trees and 50 container-sized trees to address low survivability in areas within and adjacent to Plots 4 and 6. These supplemental plantings were not very successful and survival remains lower in these areas due to shading and possible soil compaction. There have been no further attempts to replant areas within and adjacent to Plots 4 and 6 since overall stem survival for the project is above required minimum densities and previous attempts were unsuccessful. As noted above, these areas are no longer considered to be problem areas. Species counts of 6 or fewer species now occur in seven of the nine sampling plots (Plots 1, 2, 3, 5, 6, 7, 8, and 9).

Physical damage was even lower in occurrence this year than previous years. One hundred and eighteen (79%) of all stems had no damage visible. Insects caused the majority of damage but this was minor and represented a decline from last year (10.9% to 8.7%). Deer activity is still occurring in the easement but does not seem to be causing much of a problem. Only one stem had damage that appeared to be a result of human trampling. Though this number is low, it is still possible that some of the dead or missing stems are a result of trampling. Sturdier fencing was installed in spring 2012 and has reduced the golf course maintenance intrusions into the easement but this doesn't impede people from searching for missing golf balls in the easement. We do not foresee this problem getting worse but actually improving, especially as vegetation gets taller and less likely to be trampled.

The soft rush (*Juncus effuses*) plugs and live stakes are thriving and the live stakes, in particular, are exhibiting rapid growth with little evidence of difficulty. Many willow shrubs (*Salix* sp.) were observed that were over 20 feet in height. Native dog fennel (*Eupatorium capillifolium*), river birch (*Betula nigra*), loblolly pine (*Pinus taeda*), and sweetgum (*Liquidambar styraciflua*) have begun colonizing the easement in large numbers and are reaching significant heights (5-15 feet). 2013 had an unusually wet summer and the vegetation growth in some areas was significantly more than in past years.

Table V. Vegetation Plot Stem Count Summary

Species		Plots*									MY5 Totals	MY4 Totals	MY3 Totals	MY2 Totals	MY1 Totals	Baseline Totals
Scientific Name	**Common Name**	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**						
Shrubs																
Sambucus canadensis	Elderberry					1					1	***1***	***1***	*1*	*1*	*5*
Callicarpa americana	American Beautyberry	2				2		3	1	6	14	***16***	***18***	*15*	*15*	*16*
Prunus americana	American plum										0	***0***	***1***	*3*	*1*	*1*
Viburnum nudum	Possumhaw										0	***1***	***0***	*0*	*0*	*0*
	Total Shrubs	***2***	***0***	***0***	***0***	***3***	***0***	***3***	***1***	***6***	15	***18***	***20***	*19*	*17*	*22*
Trees																
Cercis canadensis	Redbud		2	2	1		3	1	2		11	***13***	***11***	*15*	*23*	*22*
Carpinus caroliniana	Ironwood	1									1	***1***	***2***	*7*	*3*	*4*
Quercus alba	White oak	4		1		1					6	***7***	***7***	*5*	*4*	*4*
Quercus nigra	Water oak										0	***0***	***0***	*0*	*2*	*2*
Quercus velutina	Black oak										0	***2***	***2***	*2*	*5*	*6*
Nyssa sylvatica	Black gum				1		1				2	***0***	***2***	*5*	*6*	*7*
Asimina triloba	Paw Paw									10	10	***10***	***9***	*11*	*9*	*10*
Quercus phellos	Willow oak			1	1						*2*	***4***	***4***	*4*	*5*	*3*
Cornus florida	Flowering dogwood										0	***1***	***1***	*3*	*4*	*6*
Castanea pumila	Chinquapin			2	1	1	1	1	3		9	***8***	***9***	*17*	*34*	*32*
Diospyros virginiana	American persimmon		2	4			1	2	3		12	***14***	***17***	*11*	*11*	*11*
Morus rubra	Red mulberry	2	1	1	3			2			9	***7***	***10***	*6*	*5*	*5*
Betula nigra	River birch				1	1	1		2		5	***3***	***2***	*4*	*2*	*3*
Fraxinus pennsylvanica	Green ash										0	***0***	***0***	*1*	*1*	*0*
Robiniana pseudoacacia	Black locust		7								7	***7***	***7***	*5*	*0*	*0*
Hamamelis virginiana	Witchhazel				1				1		2	***1***	***1***	*0*	*2*	*0*
Crataegus	Hawthorn species										0	***0***	***0***	*1*	*0*	*0*
Ulmus rubra	Slippery elm										0	***1***	***1***	*0*	*2*	*0*
Quercus sp.	Oak species										0	***0***	***0***	*1*	*0*	*0*
Alnus serrulata	Tag alder	1									1	***1***	***0***	*0*	*0*	*0*
Acer negundo	Box elder					1					1	***1***	***0***	*0*	*0*	*0*
	Total Trees	***8***	***12***	***11***	***9***	***4***	***7***	***6***	***11***	***10***	78	***81***	***85***	*98*	*118*	*116*
TABLE SUMMARY	*Total WoodyStems*	10	12	11	9	7	7	9	12	16	93	99	***105***	*117*	*134*	*138*
	% Shrubs	20%	0%	0%	0%	43%	0%	33%	8%	38%	16%	***18%***	***19%***	*16%*	*13%*	*16%*
	% Trees	80%	100%	100%	100%	57%	100%	67%	92%	63%	84%	***82%***	***80%***	*84%*	*87%*	*84%*
	Current Density															
	Shrubs per acre	81	0	0	0	121	0	121	40	243	67	***81***	***90***	*85*	*76*	*99*
	Shrubs per hectare	200	0	0	0	300	0	300	100	600	167	***200***	***222***	*211*	*189*	*244*
	Trees per acre	324	486	445	364	162	283	243	445	405	351	***364***	***382***	*441*	*531*	*522*
	Trees per hectare	800	1200	1100	900	400	700	600	1100	1000	867	***900***	***944***	*1089*	*1311*	*1289*
	Total stems per acre	***405***	***486***	***445***	***364***	***283***	***283***	***364***	***485***	***648***	***418***	***445***	***472***	*526*	*607*	*621*
	Total stems per hectare	***1000***	***1200***	***1100***	***900***	***700***	***700***	***900***	***1200***	***1600***	***1034***	***1100***	***1166***	*1300*	*1500*	*1533*

B. Stream Assessment

The stream remains in excellent condition. No problem areas were noted this year. Overall, the stream is remaining close to as-built morphology and no signs of bank or structure instability were noted. A slight degradation noted in the MY2 report in the left floodplain of the riffle at Cross Section 9 has remained stable since that time. Slight changes from as-built morphology are to be expected as time progresses and ultimate stability is achieved.

1. Morphometric Criteria

Considering the 5 year timeframe of standard mitigation monitoring, restored streams should demonstrate morphologic stability in order to be considered successful. Stability does not equate to an absence of change, but rather to sustainable rates of change or stable patterns of variation. Restored streams often demonstrate some level of initial adjustment in the several months that follow construction and some change/variation subsequent to that is to also be expected. However, the observed change should not indicate a high rate or be unidirectional over time such that a robust trend is evident. If some trend is evident, it should be very modest or indicate migration to another stable form. Examples of the latter include depositional processes resulting in the development of constructive features on the banks and floodplain, such as an inner berm, slight channel narrowing, modest natural levees, and general floodplain deposition. Annual variation is to be expected, but over time this should demonstrate maintenance around some acceptable central tendency while also demonstrating consistency or a reduction in the amplitude of variation. Lastly, all of this must be evaluated in the context of hydrologic events to which the system is exposed over the monitoring period.

For channel dimension, cross-sectional overlays and key parameters such as cross-sectional area and the channel's width to depth ratio should demonstrate modest overall change and patterns of variation that are in keeping with above. For the channels' profile, the reach under assessment should not demonstrate any consistent trends in thalweg aggradation or degradation over any significant continuous portion of its length. Over the monitoring period, the profile should also demonstrate the maintenance or development of bedform (facets) more in keeping with reference level diversity and distributions for the stream type in question. It should also provide a meaningful contrast in terms of bedform diversity against the pre-existing condition. Bedform distributions, riffle/pool lengths and slopes will vary, but should do so with maintenance around design/As-built distributions. This requires that the majority of pools are maintained at greater depths with lower water surface slopes and riffles are shallow with greater water surface slopes. Substrate measurements should indicate the progression towards, or the maintenance of, the known distributions from the design phase.

Cross-section and longitudinal surveys were performed on December 18 – 19, 2013. Ten cross-sections and approximately 3,700 linear feet of UT Little Mountain Creek and 130 linear feet of the unnamed tributary were surveyed and photographs were taken at all permanent photo points. Pebble counts were performed on November 21, 2013.

A monitoring baseline was established in the Year 0 (Baseline) monitoring effort, and was stationed from 10+00 at the culvert under Valley Drive to 50+22 at the end of the constructed portion of the project. The stationing of this baseline is used to identify locations along the restored portion of UT Little Mountain Creek throughout this report. Tributary stationing is the same in the monitoring as the construction documents.

The assessment included the survey of ten cross-sections, as well as the longitudinal profile. Cross-sections are marked with rebar and are located at the following locations:

- Cross-Section #1. UT Little Mountain Creek, Station 47+67, riffle
- Cross-Section #2. UT Little Mountain Creek, Station 43+05, pool
- Cross-Section #3. UT Little Mountain Creek, Station 38+26, riffle
- Cross-Section #4. UT Little Mountain Creek, Station 33+72, riffle
- Cross-Section #5. UT Little Mountain Creek, Station 29+78, pool
- Cross-Section #6. UT Little Mountain Creek, Station 25+39, riffle
- Cross-Section #7. UT Little Mountain Creek, Station 20+45, pool
- Cross-Section #8. UT Little Mountain Creek, Station 16+50, pool
- Cross-Section #9. UT Little Mountain Creek, Station 13+61, riffle
- Cross-Section #10. Tributary, Station 10+85, riffle

2. Hydrologic Criteria

Monitoring requirements state that at least two bankfull events must be documented through the five-year monitoring period. To assist in documenting bankfull events a stream crest gauge was installed on UT Little Mountain Creek. One documented bankfull event occurred on December 25, 2009 following a heavy rainfall event. A second bankfull event occurred in the fall of 2010 and was documented by the observation of wrack deposits and vegetation lying flat as a result of flooding. A third observed bankfull event from the 2011 monitoring year was presumed due to the presence of wrack deposits prior to the 2011 monitoring effort. Evidence of a bankfull event was once again observed on the site during the 2012 monitoring period. Photo 1 shows wrack deposits and vegetation laying flat as a result of flooding prior to December 13, 2012.

Table VI. Verification of Bankfull Events Badin Inn Stream Restoration - EEP Project No. 92666			
Date of Data Collection	**Date of Occurrence**	**Method**	**Photo # (if applicable)**
2009	12-25-09	Photographed on-site	Photo 1 - MY1 Report
2010	Before 9-30-10	Photographed on-site	Photo 1 - MY2 Report
2011	Before 9-26-11	Photographed on-site	Photo 1 - MY3 Report
2012	Before 12-13-12	Photographed on-site	Photo 1

Photo 1. Photo evidence of bankfull event prior to 12-13-12.

Table VII. Categorical Stream Feature Visual Stability Assessment **Badin Inn Stream Restoration – EEP Project No. 92666**					
Feature	**Initial**	**MY-01**	**MY-02**	**MY-03**	**MY-04**
A. Riffles	100%	99%	100%	100%	100%
B. Pools	100%	100%	100%	100%	100%
C. Thalweg	100%	100%	100%	100%	100%
D. Meanders	100%	100%	100%	100%	100%
E. Bed General	100%	100%	100%	100%	100%
F. Vanes/J Hooks etc.	100%	100%	100%	100%	100%
G. Wads and Boulders	100%	100%	100%	100%	100%

IV. METHODOLOGY

The survey of the cross-sections and longitudinal profile were accomplished using RTK survey-grade GPS and/or total station survey equipment to detect thalweg, bankfull, and

water surface elevations of the UT to Little Mountain Creek. A monitoring baseline was established in the Year 0 monitoring effort, and was stationed from the downstream end of the constructed portion of the project upstream to approximately station 10+00. The stationing of this baseline is used to identify locations along the restored portion of UT Little Mountain Creek throughout this report. Approximately the entire length of the tributary is surveyed annually. Baseline cross sections were established for ten cross sections. During monitoring year 1, it was found that one or more pins were "removed" from cross sections 5 and 8. These missing pins were reset and the monitoring year 1 data is used as the new baseline data for these two cross sections.

Data was entered into the stream morphology applications program, Rivermorph, to obtain the dimensions of the cross sections and parameters applicable to the longitudinal profile. Reports generated by Rivermorph are used in this report to display and summarize stream survey data.

V. Biological Functional Uplift/Benthic Macroinvertebrate Sampling

Photo 2. UT Little Mountain Creek before restoration

The UT Little Mountain Creek stream restoration project reintroduced natural stream characteristics to a reach that was previously confined by a cement-lined channel. The stream in this condition had no groundwater or floodplain interaction, lacked a functioning riparian zone, and provided little habitat variability for aquatic life. This stream restoration project reintroduced a riparian zone, created a variety of in-stream habitats and reconnected the stream with its floodplain. Because of these changes it was anticipated that there would be a significant uplift of the biotic functions of the stream. To assist in the evaluation of these functions and as part of the monitoring program, AECOM voluntarily sampled the benthic macroinvertebrate community to gather data to utilize as an index for demonstrating functional uplift in the restored reach. General observations of other aspects of the streamside and in-stream biota were also noted during the monitoring period.

Methodology

Macroinvertebrate sampling was performed at three locations (sites) in November 2008 prior to channel restoration. The sites were located near the upstream limit, midpoint, and downstream limit of the project. The sample sites were selected because there were only a few locations within the channel that had accumulated sediment and leaf pack that allowed for sampling. The majority of the channel did not contain substrate or leaf pack that could be sampled. Following restoration activities five sample locations were established, four along

the main channel and one on the small tributary. Sampling was performed in October/November each year following channel restoration.

The Qual-4 method was used to collect invertebrates since it is designed to sample small streams (drainage area less than or equal to 3.0 square miles). Qual-4 consists of one kick net sample, one sweep net sample, 1 leaf pack sample, and visual sampling at each location (NCDWQ 2012). As specified by the Qual-4 sampling technique for small streams, all organisms captured were collected. Specimens were preserved in ethanol and sent to Watershed Science Inc. for identification.

The North Carolina Biotic Index (BI) was calculated for the sample to help evaluate if changes in the macroinvertebrate assemblage's pollution tolerance was taking place as a result of restoration activities. BI is typically used as an independent method of bioclassification used in water quality assessments. Biotic Index was calculated for every site each sampling period to measure overall macroinvertebrate community pollution tolerance. Higher BI values indicate a more pollution tolerant species assemblage (Violin *et al.*, 2011).

Results

Little change was observed in the Biotic Index value (BI) throughout the monitoring period. Biotic index values fluctuated slightly at all sites over the monitoring period, with no defined trend of improvement or decline. Values were typically in the 7.5 to 8.5 range on a scale of 1-10. A value of 0 represents the highest water quality and a value of 10 represents the lowest.

Table VIII. Biotic Index Values During the 5 Year Monitoring Period
Badin Inn Stream Restoration - EEP Project No. 92666

	Pre	Year 1	Year 2	Year 3	Year 4	Year 5
Site 1	7.7	8.1	8.4	7.6	8.1	8.2
Site 2	7.6	7.3	7.2	7.9	7.6	8
Site 3	8.2	6.6	7.5	8.2	7.9	Dry
Site 4	NA	7.2	7.5	8	7.7	7
Site 5	NA	8.2	8.6	8.2	7.8	8.4
Average	**7.8**	**7.5**	**7.8**	**8.0**	**7.8**	**7.9**

Values recorded at the site pre and post restoration place the stream in the Fair-Poor bioclassification.

Discussion

Macroinvertebrate species composition and abundance (factors that go into calculating BI) are influenced by many factors. Research across the eastern United States shows similar results in the benthic community response from stream restoration projects and little improvement has been observed in water quality indices following restoration activities in

the Piedmont of North Carolina and Virginia (Selvakumar, O'Connor, and Struck, 2010; Violin *e. al.*, 2011). Habitat metrics of restored streams were found to be more similar to urban degraded streams than forested reference reaches (Violin *et al.*, 2011). It has also been suggested that traditional water quality sensitive criteria may not be the best approach in evaluating the success of restoration projects toward enhancing benthic habitats. Reach-scale restoration is not able to address upstream water quality problems that will still influence the restored section and limit its benthic invertebrate community development. Success in improving the benthic community is largely influenced by upstream watershed conditions and the influence of poor upstream water quality typically obscures effects of habitat improvement in restored reaches (Tullos, Penrose, and Jennings, 2006; Tullos *et al.*, 2009).

It is difficult to quantify the "Biological Functional Uplift" of a project by utilizing just one metric such as the Biotic Index. The US EPA developed the Rapid Bioassessment Protocols for Use in Stream and Wadable Rivers (Barbour *et al.*,1999) to perform a number of functions one of which is to help evaluate the effectiveness of restoration activities. One of the tools developed for the protocol, the Habitat Assessment Field Data Sheet, can be useful in evaluating the quality of habitat a stream provides. The habitat assessment process involves rating 10 parameters as optimal, suboptimal, marginal, or poor based on the criteria included on the Habitat Assessment Field Data Sheets. A visual habitat assessment and a Habitat Assessment Field Data Sheet was completed for the stream both pre and post restoration. Pre restoration the channel scored a 59 while at the 5 year monitoring point the post restoration channel scored 171. This indicates that significantly higher quality habitat is present in the stream following restoration efforts. Copies of the data sheets can be found in Appendix D.

UT to Little Mountain Creek previously flowed through a concrete-lined channel that is now restored to resemble a natural channel. A variety of habitats are now present in the restored reach that should over time begin to be occupied by a more diverse macroinvertebrate faunal assemblage. The riparian buffer now supports a variety of wildlife that were not able to utilize the golf course environs that abutted the concrete channel before restoration activities. A wide variety of songbirds, rodents, and whitetail deer (*Odocoileus virginianus*) are commonly encountered and regularly utilize the riparian buffer. Evidence of amphibian colonization of the stream and surrounding floodplain wetland pools has increased since the project began. Salamander larvae (*Desmognathus sp.* and *Eurycea sp.*) have become increasingly common in the restored stream, being captured in the dozens in some samples in Year 5. Green frogs (*Lithobates clamitans*) are present and observed as adults and tadpoles throughout the stream. A variety of fish are frequently captured in the pools within the restored reach. Mosquitofish (*Gambusia affinis*), sunfish (*Lepomis* sp.), and madtom (*Noturus sp.*) were captured on occasion in the pools. The riparian buffer vegetation is growing well with large number of loblolly pine (*Pinus taeda*), sweetgum (*Liquidambar styraciflua*), winged elm (*Ulmus alata*), and river birch (*Betula nigra*) appearing and thriving as is evidenced in the vegetation plot sampling data.

It is apparent that significant functional uplift has occurred within the restored reach of UT Little Mountain Creek. Although benthic macroinvertebrate sampling data was inconclusive, functional uplift has occurred to the in-stream and streamside communities within the reach

as a whole. Prior to restoration only several small reaches within the concrete lined channel provided suitable habitat for macroinvertebrate colonization. Now the entire restored channel (over 3,900 feet) provides suitable habitat. Prior research suggests that benthic macroinvertebrate monitoring may not show an improvement in the invertebrate community in a restored stream if the upstream water quality stressors are not corrected. The monitoring period is likely concluding prior to the time period when research shows more noticeable improvements in the benthic macroinvertebrate communities often occur. A wide variety of aquatic and terrestrial species now utilize the stream and riparian zone more than ever before and direct and indirect inputs of nutrients from the adjacent golf course are now being filtered by the restored riparian zone that was absent when the stream was confined to a concrete channel. Further maturation of the vegetation in the riparian zone will decrease the in-stream water temperatures and contribute increased woody debris, thus improving the habitat quality of the restored reach for benthic macroinvertebrates.

Table IX. Baseline Stream Data Summary

Badin Inn Stream Restoration - EEP Project No. 92666
Reach I UT to Little Mountain Creek and Tributary(4,174 feet)

Parameter	Gauge	Regional Curve			Pre-Existing Condition			Reference Reach UT to Meadow Fork Creek			Reference Reach Spencer Creek			Design UT to Little Mountain Creek			Design Tributary			As-Built UT to Little Mountain Creek			As-Built Tributary		
Dimension and Substrate - Riffle		Min	Max	Med	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg
Bankfull Width (ft)	NA			10.2						11.81			12.3			10			5.6	9.4	11.6	10.9			6.29
Floodprone Width (ft)																				44.5	53.4	48.7			46.9
Bankfull Cross Sectional Area (ft^2)	NA			13.1						15.34			10.8			7			3.2	7.2	9	8.0			2.64
Bankfull Mean Depth (ft)	NA			1.3						1.3			0.88			0.7			0.57	0.65	0.8	0.73			0.42
Bankfull Max Depth (ft)	NA									2.11			1.8			1			0.7	1.04	1.25	1.19			0.56
Width/Depth Ratio	NA									9.08			13.98			14.3			9.82	12.17	17.89	14.99			14.98
Entrenchment Ratio	NA									28.11			>2.2			>2.2			>2.2	3.97	5.37	4.49			7.45
Bank Height Ratio	NA							1.03	1.05	1.04			1.1			1			1			1			1
Wetted Perimeter (ft)	NA							NA	NA	NA			NA			NA			NA			NA			NA
Hydraulic Radius (ft)	NA							NA	NA	NA			NA			NA			NA			NA			NA
Pattern																									
Channel Beltwidth (ft)								22	57.1	37.2	24	52	38	18.6	48.3	33.4	10.4	27.1	18.7	18.6	48.3	33.5	10.4	27.1	18.7
Radius of Curvature (ft)								18	42.8	25	5.4	22.1	12.9	22.1	42.3	32.2	12.4	23.7	18.0	22.1	42.3	32.2	12.4	23.7	18.03
Meander Wavelength (ft)								78.5	149.9	107.1	54	196	125	43.9	159.3	101.6	24.6	89.2	56.9	43.9	159.4	101.6	24.6	89.2	56.9
Meander Width Ratio								1.86	4.83	3.15	1.95	4.23	3.09	1.86	4.83	3.35	1.86	4.83	3.35	1.86	4.83	3.35	1.86	4.83	3.35
Profile																									
Riffle Length (ft)								NA	NA	NA	NA	NA	NA	14.3	154.4	49.0	18.9	28.5	24.8	18.2	121.0	54.0	17.2	22.5	20.9
Riffle Slope (ft/ft)								0.011	0.021	0.017	0.02	0.036	0.026	0.012	0.037	0.019	0.022	0.04	0.03	0.0053	0.0205	0.0143	0.0162	0.0505	0.0275
Pool Length (ft)								12.9	20.8	18.0	9.3	23.9	17.8	18.3	31	24.6	10.2	17.3	13.8	14.8	41.8	22.1	10.9	25.7	16.3
Pool Spacing (ft)								79.4	96.9	88.2	13	46.5	24.2	68.4	83.1	75.7	5.9	21.1	13.5	36.3	148.0	66.6	36.6	39.7	38.1
Substrate																									
d50(mm)	NA							NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.04	26.7	10.9	NA	NA	28.6
d84 (mm)	NA							NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.83	68.3	38.5	NA	NA	32
Additional Reach Parameters																									
Valley length (ft)					3540			200			235			3820			157								
Channel length (ft)					3540			288			266			3994			180			3994			180		
Sinuosity (ft)					1			1.4			1.1			1.05			1.03			1.05			1.03		
Water Surface Slope (Channel) (ft/ft)	NA				0.0178			0.0122			0.0132			0.0134			0.0147			0.012			0.012		
BF slope (ft/ft)	NA				0.0178			0.0122			0.0132			0.0134			0.0147			0.012			0.012		
Rosgen Classification	NA				NA			E4			C4			C4			C4			C4			C4		
Habitat Index					N/A			N/A			N/A														
Macrobenthos					N/A			N/A			N/A														

NOT APPLICABLE. STREAM IS COMPLETELY MODIFIED

Table X. Morphology and Hydraulic Monitoring Summary
Badin Inn Stream Restoration/ EEP Project No. 92666
Reach I UT to Little Mountain Creek and Tributary(4,174 feet)

Parameter	Cross Section 1					Cross Section 2					Cross Section 3					Cross Section 4					Cross Section 5				
	Riffle					Pool					Riffle					Riffle					Pool				
Dimension	MY1	MY2	MY3	MY4	MY5	MY1	MY2	MY3	MY4	MY5	MY1	MY2	MY3	MY4	MY5	MY1	MY2	MY3	MY4	MY5	MY1	MY2	MY3	MY4	MY5
BF Width (ft)	11.6	11.8	11.9	12.2	11.5	10.4	12.3	8.5	9.3	9.3	10.5	9.9	9.9	11.8	12.1	9.9	10.1	10.2	9.9	9.6	7.6	9.3	10.1	8.9	8.8
Floodprone Width (ft) (approx)	50.0	52.6	52.6	52	52	40.5	44.8	44.2	44	44	45.9	53.7	51.5	54.6	53.8	44.9	46.8	47.2	47.2	47.6	40.3	51.1	51.6	51.6	51.1
BF Cross-Sectional Area (ft^2)	6.5	9.4	8.3	9.2	8.2	7.8	8.3	6.6	7.2	6.9	5.8	6.0	5.9	7.2	7.0	6.7	8.1	8.5	8.4	7.9	8.1	9.3	11.8	9.6	13.2
BF Mean Depth (ft)	0.6	0.8	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.7	0.6	0.6	0.6	0.6	0.6	0.7	0.8	0.8	0.8	0.8	1.1	1.0	1.1	1.1	1.5
BF Max Depth (ft)	1.0	1.4	1.4	1.5	1.3	1.4	1.5	1.3	1.4	1.4	0.9	0.9	0.9	1.0	1.0	1.2	1.2	1.3	1.4	1.3	1.9	1.9	1.9	1.9	2.2
Width/Depth Ratio	20.6	14.7	17.1	16.2	16.2	13.8	18.4	10.9	12.1	12.6	19.0	16.6	16.6	18.0	20.8	14.5	12.6	12.1	11.6	11.6	7.1	9.2	8.6	8.2	5.9
Entrenchment Ratio	4.3	4.4	4.4	4.3	4.5	3.9	3.6	5.2	4.7	4.7	4.4	5.4	5.2	4.6	4.5	4.5	4.6	4.6	4.7	4.9	5.3	5.5	5.1	5.8	5.8
Wetted Perimeter (ft)	11.8	12.2	12.4	12.6	11.9	10.9	12.7	9.1	9.8	9.9	10.8	10.2	10.2	12.1	12.4	10.2	10.6	10.6	10.4	10.2	9.4	10.2	10.9	9.8	10.6
Hydraulic radius (ft)	0.55	0.78	0.67	0.73	0.69	0.71	0.65	0.73	0.73	0.7	0.54	0.59	0.58	0.6	0.56	0.66	0.76	0.8	0.81	0.78	0.86	0.92	1.08	0.98	1.25
Bank Height Ratio (ft/ft)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Substrate																									
d50 (mm)	29.1	22.6	14.8	33.1	16	9.6	23.5	12.8	48.8	14	8.7	51.3	8	54.5	19	1	9.6	17.1	72	0.2	0.6	18.2	0.1	0.06	18.5
d84 (mm)	77	128	77	78	98	34	168	88	128	121	45	277	45	138	122	71	139	78	159	142	16	56	16	27	153

Parameter	MY-01 (2009)				MY-02 (2010)				MY-03 (2011)				MY-04 (2012)				MY-05 (2013)				MY+ (2014)			
Pattern	Min	Max	Med		Min	Max	Med		Min	Max	Med		Min	Max	Med		Min	Max	Med		Min	Max	Med	
Channel Beltwidth (ft)	18.6	48.3	33.4		18.6	48.3	33.4		18.6	48.3	33.4		18.6	48.3	33.4		18.6	48.3	33.4					
Radius of Curvature (ft)	22.1	42.3	32.2		22.1	42.3	32.2		22.1	42.3	32.2		22.1	42.3	32.2		22.1	42.3	32.2					
Meander Wavelength (ft)	43.9	159.3	101.6		43.9	159.3	101.6		43.9	159.3	101.6		43.9	159.3	101.6		43.9	159.3	101.6					
Meander Width Ratio	1.86	4.83	3.35		1.86	4.83	3.35		1.86	4.83	3.35		1.86	4.83	3.35		1.86	4.83	3.35					
Profile																								
Riffle Length (ft)	18.2	121.0	54.0		35.2	151.3	92.2		12.5	90.1	41.7		9.5	76.3	40.8		9.9	113	35.7					
Riffle Slope (ft/ft)	0.0053	0.0205	0.014		0.0090	0.0359	0.0179		0.0083	0.0263	0.0171		0.007	.0277	0.0177		0.005	0.05	0.019					
Pool length (ft	14.8	41.9	22.1		23.9	47.2	32.2		18.7	61.8	32.7		7.63	46.3	22.9		12.2	45.3	24.5					
Pool spacing (ft)	36.3	148.1	66.6		58.6	151.3	92.2		48.3	115.3	69.4		20.3	125.9	65.9		22.3	141.6	61.3					
Additional Reach Parameters																								
Valley Length (ft)	3820				3820				3820				3820				3820							
Channel Length (ft)	3994				3994				3994				3994				3994							
Sinuosity	1.05				1.05				1.05				1.05				1.05							
Water Surface Slope (ft/ft)	0.012				0.012				0.012				0.012				0.012							
BF Slope (ft/ft)	0.012				0.012				0.012				0.012				0.012							
Rosgen Classification	C4				C4				C4				C4				C4							
Habitat Index	NA				NA				NA				NA				NA							
Macrobenthos	NA				NA				NA				NA				NA							

Table X. Morphology and Hydraulic Monitoring Summary
Badin Inn Stream Restoration/ EEP Project No. 92666
Reach I UT to Little Mountain Creek and Tributary(4,174 feet)

Parameter	Cross Section 6					Cross Section 7					Cross Section 8					Cross Section 9					Cross Section10				
	Riffle					Pool					Pool					Riffle					Tributary - Riffle				
Dimension	MY1	MY2	MY3	MY4	MY5	MY1	MY2	MY3	MY4	MY5	MY1	MY2	MY3	MY4	MY5	MY1	MY2	MY3	MY4	MY5	MY1	MY2	MY3	MY4	MY5
BF Width (ft)	10.5	9.9	9.9	9.5	11.8	16.4	14.4	13.9	14.1	14.2	8.9	13.9	8.5	8.8	9.2	10.1	11.1	9.8	10.0	11.8	5.8	8.3	7.1	5.9	7.7
Floodprone Width (ft) (approx)	39.5	52.5	53.0	53.0	52.2	40.0	40.5	40.5	40.5	40.5	49.3	60.0	62.5	62.5	63.8	39.7	47.3	48.8	48.8	47.2	46.9	47.9	48.0	48.0	47.5
BF Cross-Sectional Area (ft^2)	7.6	7.6	7.6	7.1	7.2	20.0	18.5	17.6	19.1	18.8	5.5	14.6	12.3	12.2	13.6	8.9	9.6	8.4	10.1	9.1	1.9	3.3	3.1	2.2	3.7
BF Mean Depth (ft)	0.7	0.8	0.8	0.8	0.6	1.2	1.3	1.3	1.4	1.3	0.6	1.1	1.4	1.4	1.5	0.9	0.9	0.9	1.0	0.8	0.3	0.4	0.4	0.4	0.5
BF Max Depth (ft)	1.1	1.1	1.1	1.1	1.2	2.5	2.5	2.6	2.7	2.6	1.9	2.3	2.7	2.5	2.6	1.3	1.5	1.5	1.6	1.5	0.6	0.7	0.7	0.5	0.6
Width/Depth Ratio	14.6	13.1	12.9	12.6	19.3	13.4	11.2	11.0	10.4	10.8	15.3	13.2	5.9	6.4	6.3	11.5	11.3	11.4	9.9	15.3	16.9	20.7	16.1	15.9	16.4
Entrenchment Ratio	3.7	5.3	5.3	5.6	4.4	2.4	1.6	3.0	2.9	2.9	5.6	4.3	7.3	7.1	6.7	3.9	4.3	5.0	4.9	4.0	8.1	5.8	6.8	8.1	6.2
Wetted Perimeter (ft)	11.0	10.3	10.3	9.9	12.6	17.3	15.7	15.4	15.8	15.9	10.2	14.9	10.3	10.4	11.1	10.7	11.9	10.4	10.8	12.6	6.0	8.5	7.3	6.1	7.9
Hydraulic radius (ft)	0.69	0.74	0.74	0.72	0.57	1.15	1.18	1.14	1.21	1.18	0.51	0.97	1.19	1.17	1.23	0.83	0.81	0.81	0.93	0.72	0.33	0.39	0.42	0.36	0.46
Bank Height Ratio (ft/ft)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Substrate																									
d50 (mm)	31.4	40.4	20.9	58.6	25.3	0.06	0.04	8.8	10.2	24.6	0.05	0.05	0 .06	0.05	4.0	38.5	0.04	26.9	12.5	62.3	13.2	92.7	25.3	33.6	24.9
d84 (mm)	62	7	44	127	102	19	19	32	42	107	6	48	16	43	68	81	19	83	103	267	34	168	52	96	83

VI. REFERENCES

Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C.

Moore, A. A. and M. A. Palmer. 2005. Invertebrate biodiversity in agricultural and urban headwater streams: implications for conservation and management. Ecological Applications 15:1169-1177.

North Carolina Department of Environment and Natural Resources. 2012. Division of Water Quality. Environmental Sciences Section.

Orzette, L. L., R. C. Jones, and R. F. Murphy. 2010. Stream condition in piedmont streams with restored riparian buffers in the Chesapeake Bay watershed. Journal of the American Water Resources Association 46:473-485.

Selvakumar, A., T. P. O'Connor, and S. D. Struck. 2010. Role of stream restoration on improving benthic macroinvertebrates and in-stream water quality in an urban watershed: case study. Journal of Environmental Engineering, January 2010: 127-139.

Tullos, D. D., D. L. Penrose, G. D. Jennings. 2006. Development and application of a bioindicator for benthic habitat enhancement in the North Carolina Piedmont. Ecological Engineering 27: 228-241.

Tullos, D. D., D. L. Penrose, G. D. Jennings, and W. Gregory Cope. 2009. Analysis of functional traits in reconfigured channels: implications for the bioassessment and disturbance of river restoration. Journal of the North American Benthological Society 28:80-92.

Violin C. R. , P. Cada, E. B. Sudduth, B. A. Hassett, D. L. Penrose, and E. S. Bernhardt. 2011. Effects of urbanization and urban stream restoration on the physical and biological structure of stream ecosystems. Ecological Applications, 21:1932-1949.

APPENDIX A

1. Vegetation Data Tables

   Table 1. Vegetation Metadata
   Table 2. Vegetation Vigor by Species
   Table 3. Vegetation Damage by Species
   Table 4. Vegetation Damage by Plot
   Table 5. Stem Count by Plot and Species
   Table 6. Vegetation Problem Areas Tables

2. Vegetation Monitoring Plot Photos

Table 1. Vegetation Metadata
Badin Inn Stream Restoration/ EEP No. 92666
Appendix A

Report Prepared By	Kevin Lapp
Date Prepared	12/18/2013 16:18
database name	AECOM-2008-0.mdb
database location	Q:\99255\Monitoring\Vegetation
computer name	USRAL3LT064
file size	46923776
DESCRIPTION OF WORKSHEETS IN THIS DOCUMENT----------	
Metadata	Description of database file, the report worksheets, and a summary of project(s) and project data.
Proj, planted	Each project is listed with its PLANTED stems per acre, for each year. This excludes live stakes.
Proj, total stems	Each project is listed with its TOTAL stems per acre, for each year. This includes live stakes, all planted stems, and all natural/volunteer stems.
Plots	List of plots surveyed with location and summary data (live stems, dead stems, missing, etc.).
Vigor	Frequency distribution of vigor classes for stems for all plots.
Vigor by Spp	Frequency distribution of vigor classes listed by species.
Damage	List of most frequent damage classes with number of occurrences and percent of total stems impacted by each.
Damage by Spp	Damage values tallied by type for each species.
Damage by Plot	Damage values tallied by type for each plot.
ALL Stems by Plot and spp	A matrix of the count of total living stems of each species (planted and natural volunteers combined) for each plot; dead and missing stems are excluded.
PROJECT SUMMARY----------	
Project Code	92666
project Name	Badin Inn
Description	
River Basin	Yadkin-Pee Dee
length(ft)	4174
stream-to-edge width (ft)	42
area (sq m)	32570
Required Plots (calculated)	9
Sampled Plots	9

Table 2. Vegetation Vigor by Species Badin Inn Stream Restoration/ EEP No. 92666 Appendix A								
	Species	4	3	2	1	0	Missing	Unknown
	Alnus serrulata	1						
	Asimina triloba	1	2	7			1	
	Betula nigra	5					1	
	Callicarpa americana	9	3	1	1	2	3	
	Castanea pumila	3	4	2		1	11	
	Cornus florida						3	
	Diospyros virginiana	10	4	1		2	2	
	Fraxinus pennsylvanica						1	
	Nyssa sylvatica	1	1				2	
	Quercus alba	5	1				1	
	Quercus phellos	2					2	
	Quercus velutina						3	
	Robinia pseudoacacia	5	1		1		1	
	Sambucus canadensis				1			
	Ulmus rubra						1	
	Viburnum nudum						1	
	Morus rubra	2	2	2		2	4	
	Carpinus caroliniana				1			
	Cercis canadensis	1	6	3	1	1	10	
	Hamamelis virginiana	2						
	Prunus serotina						1	
	Acer negundo		1					
TOT	22	47	25	16	5	8	48	

Table 3. Vegetation Damage by Species
Badin In Stream Restoration/EEP No. 92666
Appendix A

	SPECIES	All Damage Categories	No Damage	Other damage	Deer	Human Trampled	Insects	Unknown Animal	Unknown
	Acer negundo	1					1		
	Alnus serrulata	1	1						
	Asimina triloba	11	8	1			2		
	Betula nigra	6	6						
	Callicarpa americana	19	16	1		1	1		
	Carpinus caroliniana	1		1					
	Castanea pumila	21	18	2			1		
	Cercis canadensis	22	13	5	1		3		
	Cornus florida	3	3						
	Diospyros virginiana	19	16		1		2		
	Fraxinus pennsylvanica	1	1						
	Hamamelis virginiana	2	2						
	Morus rubra	12	8		1		1	2	
	Nyssa sylvatica	4	3				1		
	Prunus serotina	1	1						
	Quercus alba	7	6	1					
	Quercus phellos	4	4						
	Quercus velutina	3	3						
	Robinia pseudoacacia	8	7				1		
	Sambucus canadensis	1							1
	Ulmus rubra	1	1						
	Viburnum nudum	1	1						
TOT:	22	149	118	11	3	1	13	2	1

Table 4. Vegetation Damage by Plot
Badin Inn Stream Restoration/EEP No. 92666
Appendix A

	PLOT	All Damage Categories	No Damage	Other Damage	Deer	Human Trampled	Insects	Unknown Animal	Unknown
	92666-01-0001-year:4	10	6	2	1		1		
	92666-01-0002-year:4	17	13	1			3		
	92666-01-0003-year:4	18	14	3			1		
	92666-01-0004-year:4	14	11		1		2		
	92666-01-0005-year:4	18	16				1		1
	92666-01-0006-year:4	16	15				1		
	92666-01-0007-year:4	24	21	1				2	
	92666-01-0008-year:4	15	11	2	1		1		
	92666-01-0009-year:4	17	11	2		1	3		
TOT:	9	149	118	11	3	1	13	2	1

Table 5. Stem Count by Plot and Species
Badin Inn Stream Restoration/ EEP No. 92666
Appendix A

	Species	Total Planted Stems	# plots	Avg# stems	Plot 92666-01-0001-year:4	Plot 92666-01-0002-year:4	Plot 92666-01-0003-year:4	Plot 92666-01-0004-year:4	Plot 92666-01-0005-year:4	Plot 92666-01-0006-year:4	Plot 92666-01-0007-year:4	Plot 92666-01-0008-year:4	Plot 92666-01-0009-year:4
	Acer negundo	1	1	1					1				
	Alnus serrulata	1	1	1	1								
	Asimina triloba	10	1	10									10
	Betula nigra	5	4	1.25				1	1	1		2	
	Callicarpa americana	14	5	2.8	2				2		3	1	6
	Carpinus caroliniana	1	1	1	1								
	Castanea pumila	9	6	1.5			2	1	1	1	1	3	
	Cercis canadensis	11	6	1.83		2	2	1		3	1	2	
	Diospyros virginiana	15	6	2.5		2	4	3		1	2	3	
	Hamamelis virginiana	2	2	1				1				1	
	Morus rubra	6	4	1.5	2	1	1				2		
	Nyssa sylvatica	2	2	1				1		1			
	Quercus alba	6	3	2	4		1		1				
	Quercus phellos	2	2	1			1	1					
	Robinia pseudoacacia	7	1	7		7							
	Sambucus canadensis	1	1	1					1				
TOT:	16	93	16		10	12	11	9	7	7	9	12	16

Table 6. Vegetation Problem Areas Badin Inn Stream Restoration/ EEP No. 92666 Appendix A			
Feature/Issue	Station#/Range	Probable Cause	Photo #
Mechanical cutting	N/A	Golf course maintenance crews cutting within posted boundary of easement	1

Photo 1. Small area of mowed vegetation at easement Corner.

Badin Inn Stream Restoration Site
Year 5 Monitoring Report
Appendix A-2
Vegetation Sampling Plot Photos


Vegetation Plot 1 facing 210˚.


Vegetation Plot 2 facing 150˚.


Vegetation Plot 3 facing 210˚.


Vegetation Plot 4 facing 160˚.


Vegetation Plot 5 facing 180˚.


Vegetation Plot 6 facing 260˚.


Vegetation Plot 7 facing 260˚.


Vegetation Plot 8 facing 310˚.


Vegetation Plot 9 facing 340˚.

APPENDIX B

1. Stream Problem Areas Plan View (not included, incorporated into Appendix C)
2. Table B.1. Stream Problem Areas Table
3. Representative Stream Problem Area Photos
4. Stream Photo Station Photos
5. Table B.2. Visual Morphological Stability Assessment
6. Annual Overlays of Cross Section Plots
7. Annual Overlays of Longitudinal Plots
8. Annual Overlays of Pebble Count Frequency Distribution Plots

B-1 Stream Problem Areas Plan View has been incorporated into Appendix C (Integrated Plan View)

Table B.1. Stream Problem Areas Badin Inn Stream Restoration/ EEP No. 92666 Appendix B			
Feature/Issue	**Station#/Range**	**Probable Cause**	**Photo #**
None Observed	NA	NA	NA

No problem areas were observed during Year 5 monitoring

Badin Inn Stream Restoration Site
Year 5 Monitoring Report
Appendix B-4
Stream Photo-Station Photos


Photo Point 1. Upstream From Cross Section 1.


Photo Point 1. Downstream from Cross Section 1.


Photo Point 2. Upstream from Cross Section 2.


Photo Point 2. Downstream from Cross Section 2.


Photo Point 3. Upstream from Cross Section 3.


Photo Point 3. Downstream from Cross Section 3.

Photo Point 4. Upstream from Cross Section 4.

Photo Point 4. Downstream from Cross Section 4.

Photo Point 5. Upstream from Cross Section 5.

Photo Point 5. Downstream from Cross Section 5.

Photo Point 6. Upstream from Cross Section 6.

Photo Point 6. Downstream from Cross Section 6.

Photo Point 7. Upstream from Cross Section 7.

Photo Point 7. Downstream from Cross Section 7.

Photo Point 8. Upstream from Cross Section 8.

Photo Point 8. Downstream from Cross Section 8.

Photo Point 9. Upstream from Cross Section 9.

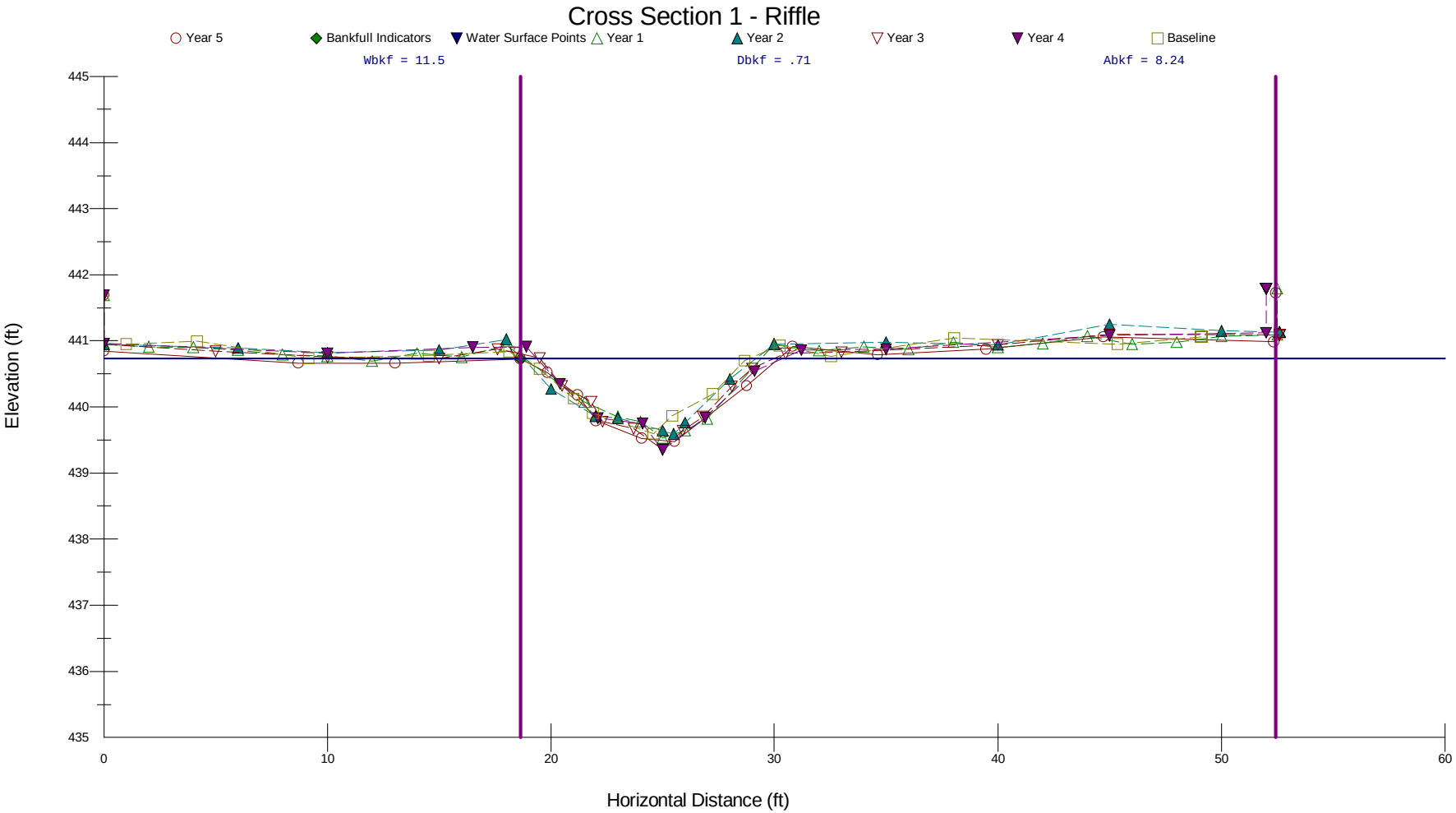
Photo Point 9. Downstream from Cross Section 9.

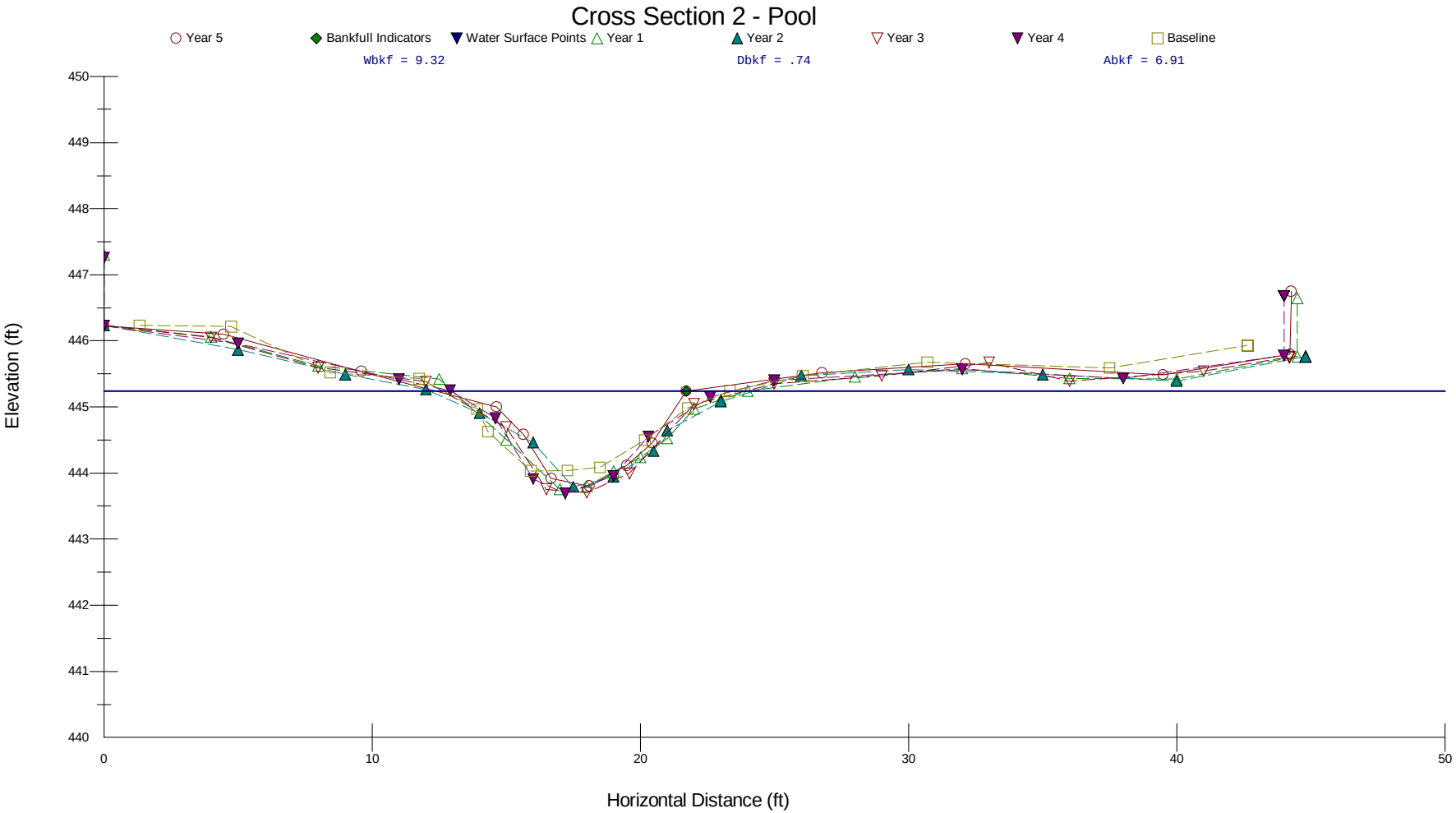
Photo Point 10. Upstream from Cross Section 10 (Tributary).

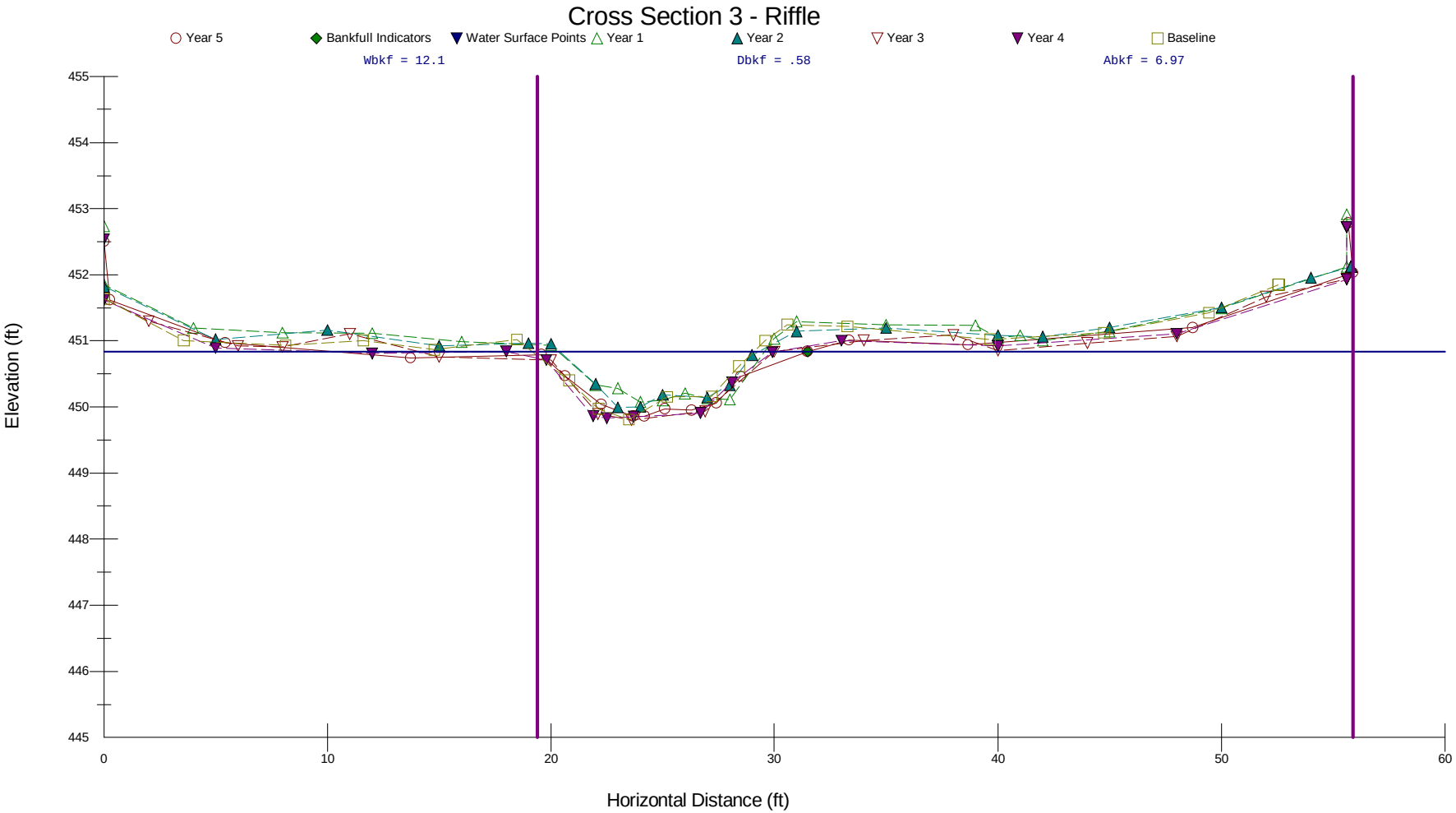
Photo Point 10. Downstream from Cross Section 10 (Tributary).

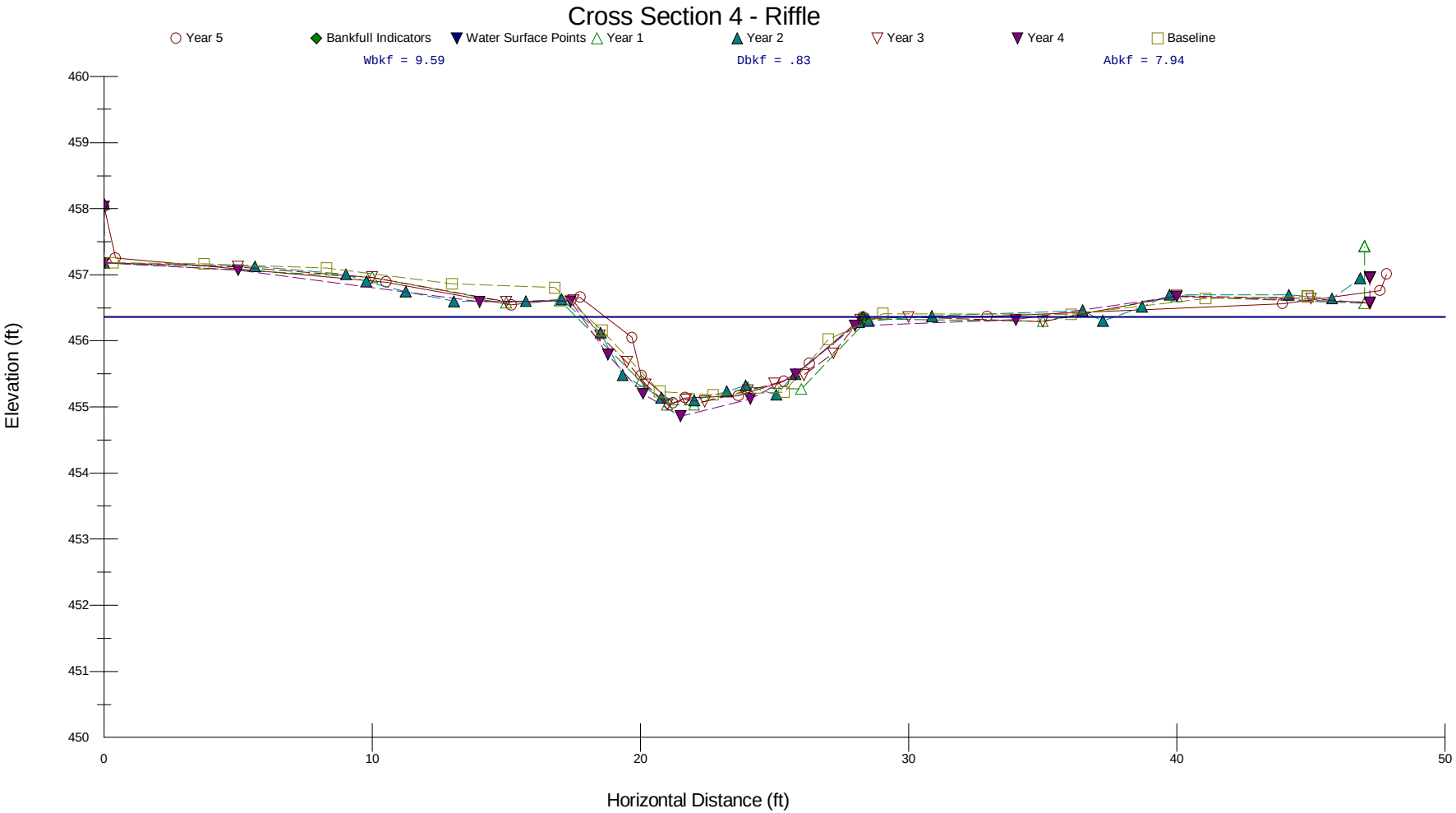
Table B2. Visual Morphological Stability Assessment Badin Inn Stream Restoration/ EEP Number 92666 UT Little Mountain Creek/ 4,022 feet						
Feature Category	Metric (Per As-built and reference baselines)	# Stable Number Perform. as Intended	Total No. per As-built	Total Number/ feet in unstable state	% Perform. in stable condition	Feature Perform. Mean or Total
A. Riffles	1. Present?	58	58	0	100	100
	2. Armor stable (e.g. no displacement)	58	58	0	100	100
	3. Facet grade appears stable	58	58	0	100	100
	4. Minimal evidence of embedding/fining	58	58	0	100	100
	5. Length appropriate	58	58	0	100	100
B. Pools	1. Present? (e.g. not subject to severe aggrad. Or migrat.?)	58	58	0	100	100
	2. Sufficiently deep (Max Pool D:Mean Bkf>1.6?	NA	NA	NA	NA	NA
	3. Length appropriate?	58	58	0	100	100
C. Thalweg	1. Upstream of meander bend (run/inflection) centering?	NA	NA	NA	NA	NA
	2. Downstream of meander (glide/inflection) centering?	NA	NA	NA	NA	NA
D. Meanders	1. Outer bend in state of limited/controlled erosion?	44	44	0	100	100
	2. Of those eroding, # w/concomitant point bar formation?	NA	NA	NA	NA	NA
	3. Apparent Rc within spec?	44	44	0	100	100
	4. Sufficient floodplain access and relief?	44	44	0	100	100
E. Bed General	1. General channel bed aggradation areas (bar formation)	NA	NA	0	100	100
	2. Channel bed degradation - areas of increasing down-cutting or headcutting	NA	NA	0	100	100
F. Bank	1. Actively eroding, wasting, or slumping bank	NA	NA	0	100	100
G. Vanes	1. Free of back or arm scour?	17	17	0	100	100
	2. Height appropriate?	17	17	0	100	100
	3. Angle and geometry appear appropriate?	17	17	0	100	100
	4. Free of piping or other structural failures?	17	17	0	100	100
H. Wads/ Boulders	1. Free of scour?	NA	NA	NA	NA	NA
	2. Footing stable?	NA	NA	NA	NA	NA

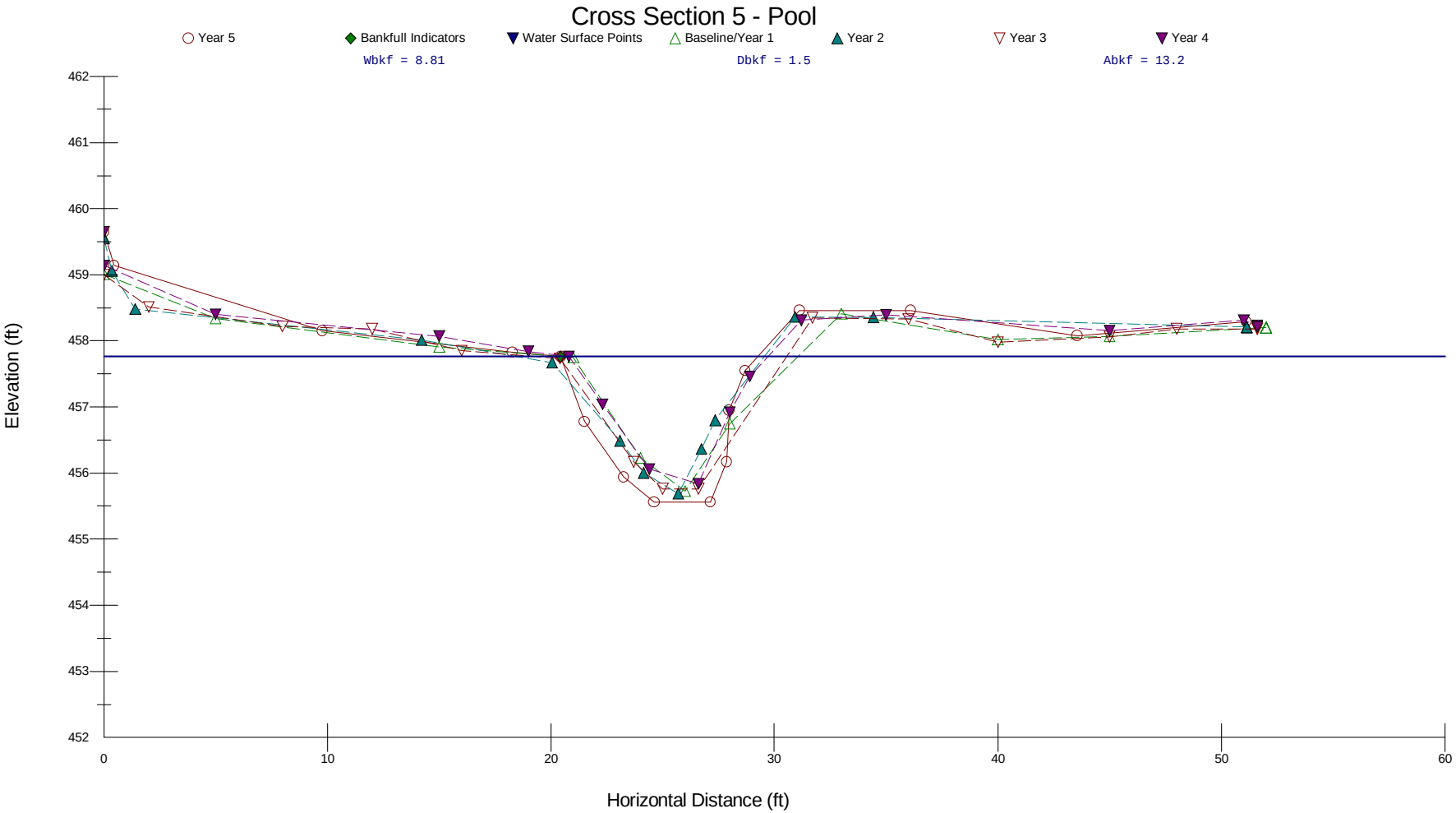
Table B2. Visual Morphological Stability Assessment Badin Inn Stream Restoration/ EEP Number 92666 Tributary/ 180 feet						
Feature Category	Metric (Per As-built and reference baselines)	# Stable Number Perform. as Intended	Total No. per As-built	Total Number/ feet in unstable state	% Perform. in stable condition	Feature Perform. Mean or Total
A. Riffles	1. Present?	4	4	0	100	100
	2. Armor stable (e.g. no displacement)	4	4	0	100	100
	3. Facet grade appears stable	4	4	0	100	100
	4. Minimal evidence of embedding/fining	4	4	0	100	100
	5. Length appropriate	4	4	0	100	100
B. Pools	1. Present? (e.g. not subject to severe aggrad. Or migrat.?)	4	4	0	100	100
	2. Sufficiently deep (Max Pool D:Mean Bkf>1.6?	NA	NA	NA	NA	NA
	3. Length appropriate?	4	4	0	100	100
C. Thalweg	1. Upstream of meander bend (run/inflection) centering?	NA	NA	NA	NA	NA
	2. Downstream of meander (glide/inflection) centering?	NA	NA	NA	NA	NA
D. Meanders	1. Outer bend in state of limited/controlled erosion?	4	4	0	100	100
	2. Of those eroding, # w/concomitant point bar formation?	NA	NA	NA	NA	NA
	3. Apparent Rc within spec?	4	4	0	100	100
	4. Sufficient floodplain access and relief?	4	4	0	100	100
E. Bed General	1. General channel bed aggradation areas (bar formation)	NA	NA	0	100	100
	2. Channel bed degradation - areas of increasing down-cutting or headcutting	NA	NA	0	100	100
F. Bank	1. Actively eroding, wasting, or slumping bank	NA	NA	0	100	100
G. Vanes	1. Free of back or arm scour?	NA	NA	NA	NA	NA
	2. Height appropriate?	NA	NA	NA	NA	NA
	3. Angle and geometry appear appropriate?	NA	NA	NA	NA	NA
	4. Free of piping or other structural failures?	NA	NA	NA	NA	NA
H. Wads/ Boulders	1. Free of scour?	NA	NA	NA	NA	NA
	2. Footing stable?	NA	NA	NA	NA	NA

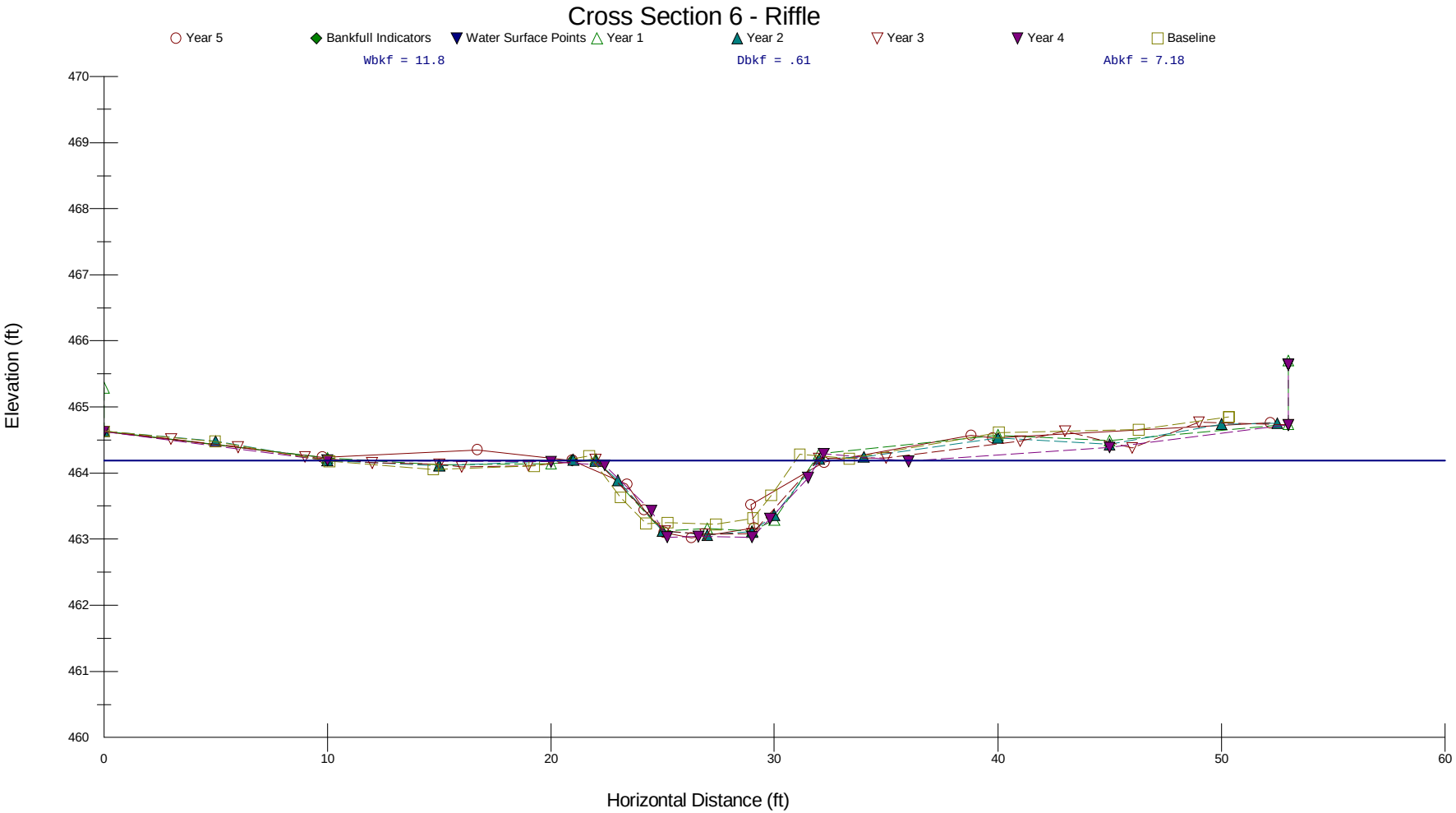

Cross Section 1 - Riffle
Year 5
Bankfull Indicators
Water Surface Points
Year 1
Year 2
Year 3
Year 4
Baseline
Wbkf = 11.5
Dbkf = .71
Abkf = 8.24
Elevation (ft)
445
444
443
442
441
440
439
438
437
436
435
0
10
20
30
40
50
60
Horizontal Distance (ft)

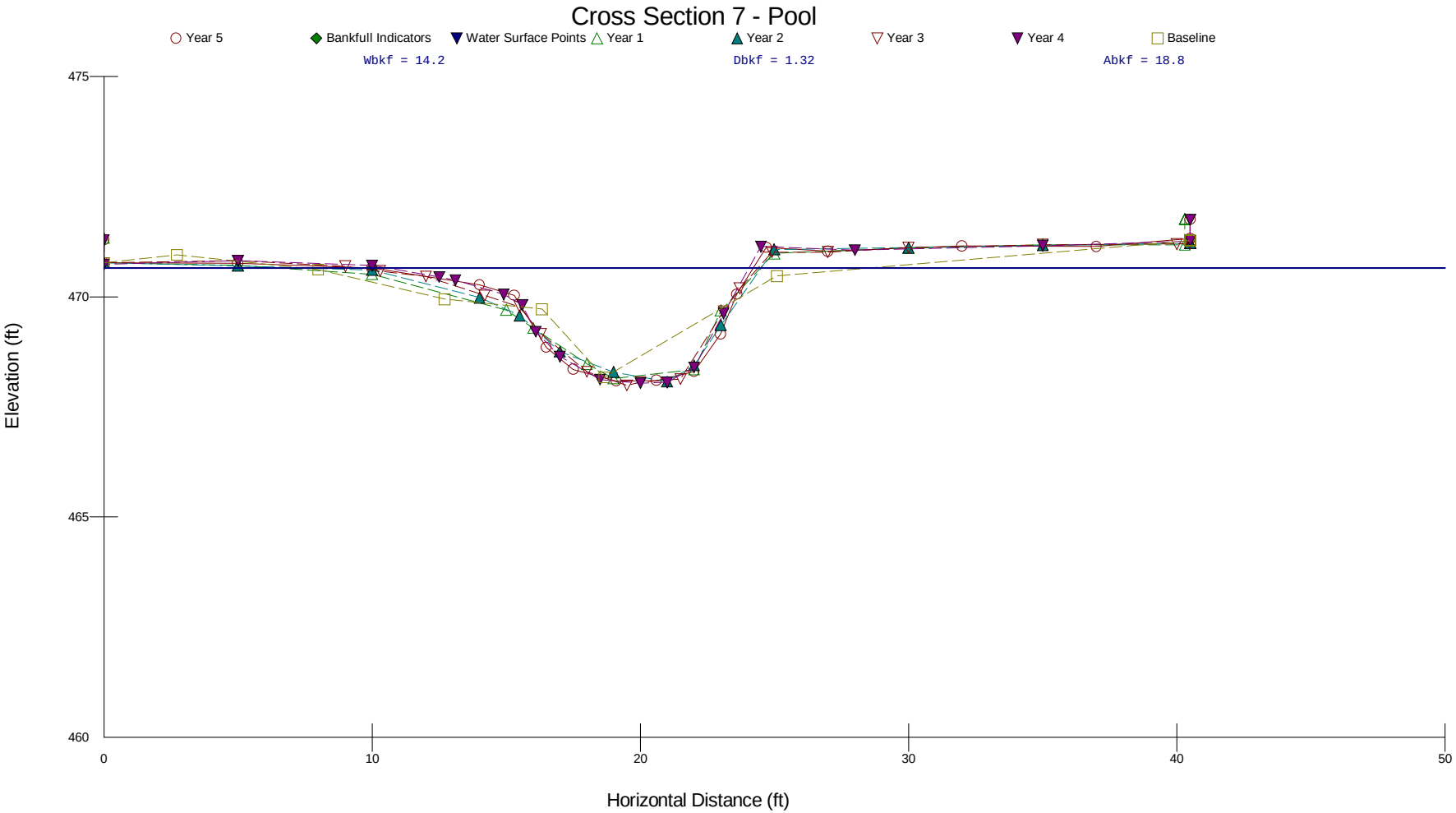

Cross Section 2 - Pool
Year 5
Bankfull Indicators
Water Surface Points
Year 1
Year 2
Year 3
Year 4
Baseline
Wbkf = 9.32
Dbkf = .74
Abkf = 6.91
Elevation (ft)
450
449
448
447
446
445
444
443
442
441
440
0
10
20
30
40
50
Horizontal Distance (ft)

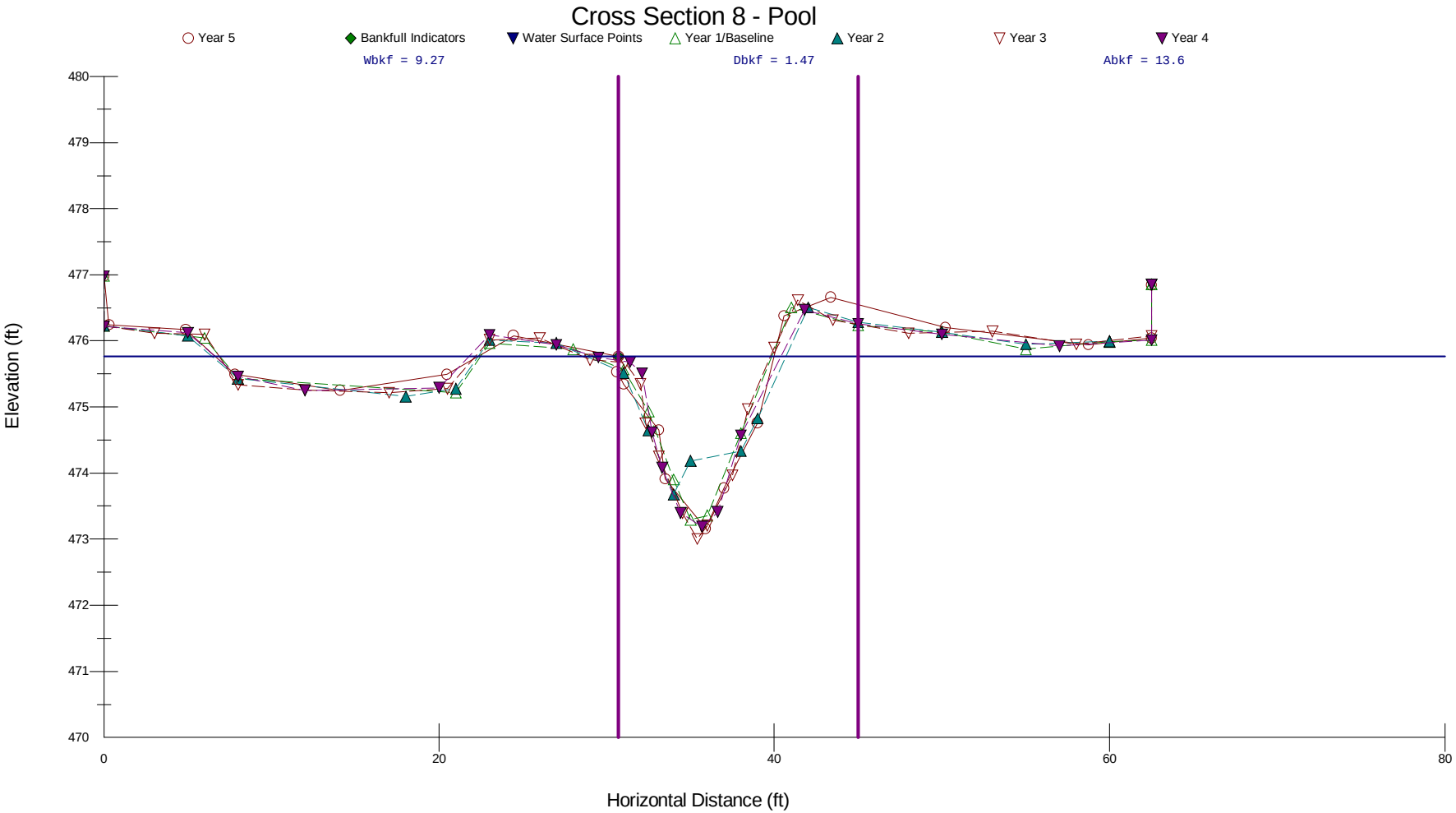

Cross Section 3 - Riffle
Year 5
Bankfull Indicators
Water Surface Points
Year 1
Year 2
Year 3
Year 4
Baseline
Wbkf = 12.1
Dbkf = .58
Abkf = 6.97
Elevation (ft)
455
454
453
452
451
450
449
448
447
446
445
0
10
20
30
40
50
60
Horizontal Distance (ft)

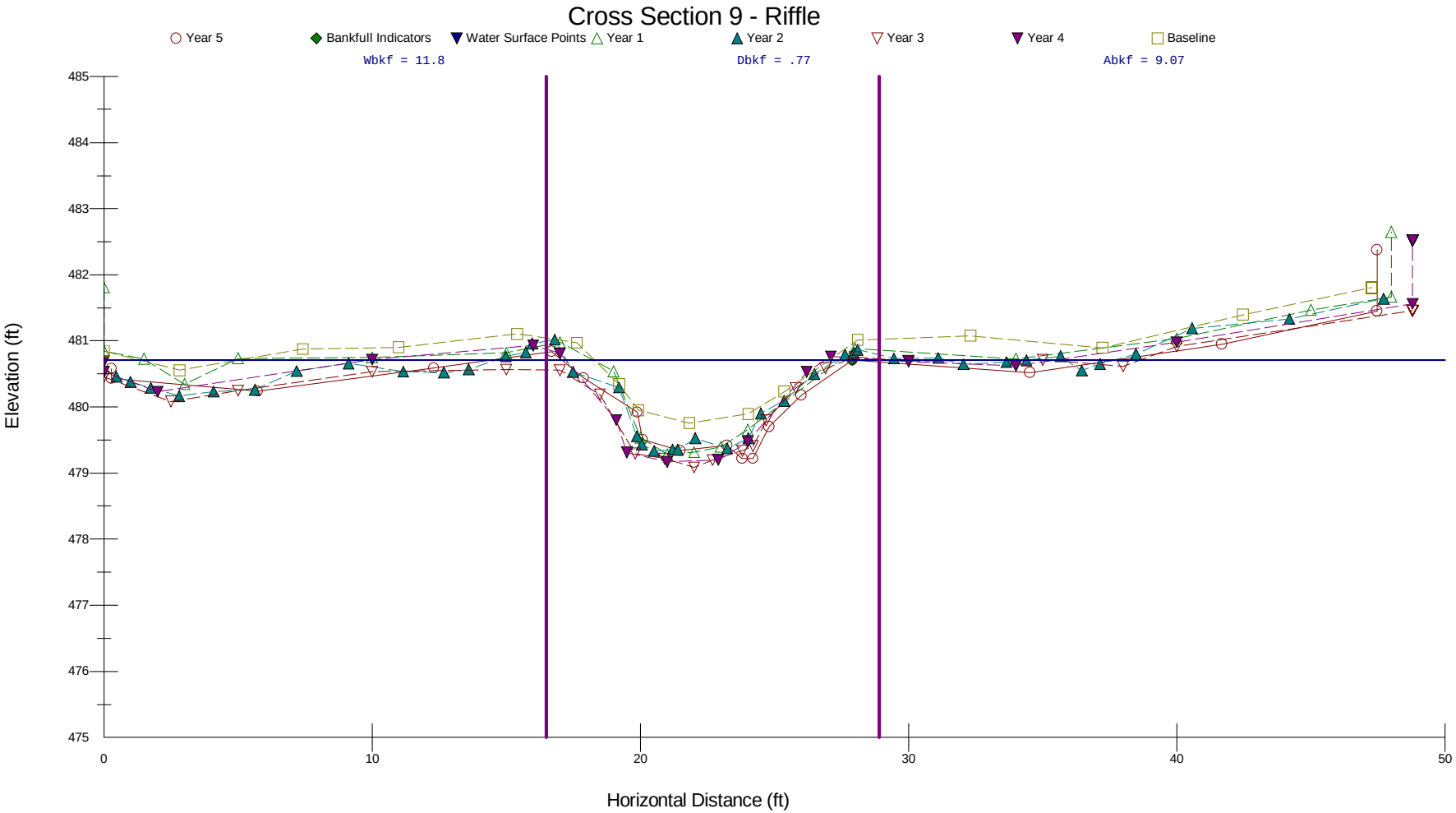

Cross Section 4 - Riffle
Year 5
Bankfull Indicators
Water Surface Points
Year 1
Year 2
Year 3
Year 4
Baseline
Wbkf = 9.59
Dbkf = .83
Abkf = 7.94
460
459
458
457
456
455
454
453
452
451
450
Elevation (ft)
0
10
20
30
40
50
Horizontal Distance (ft)

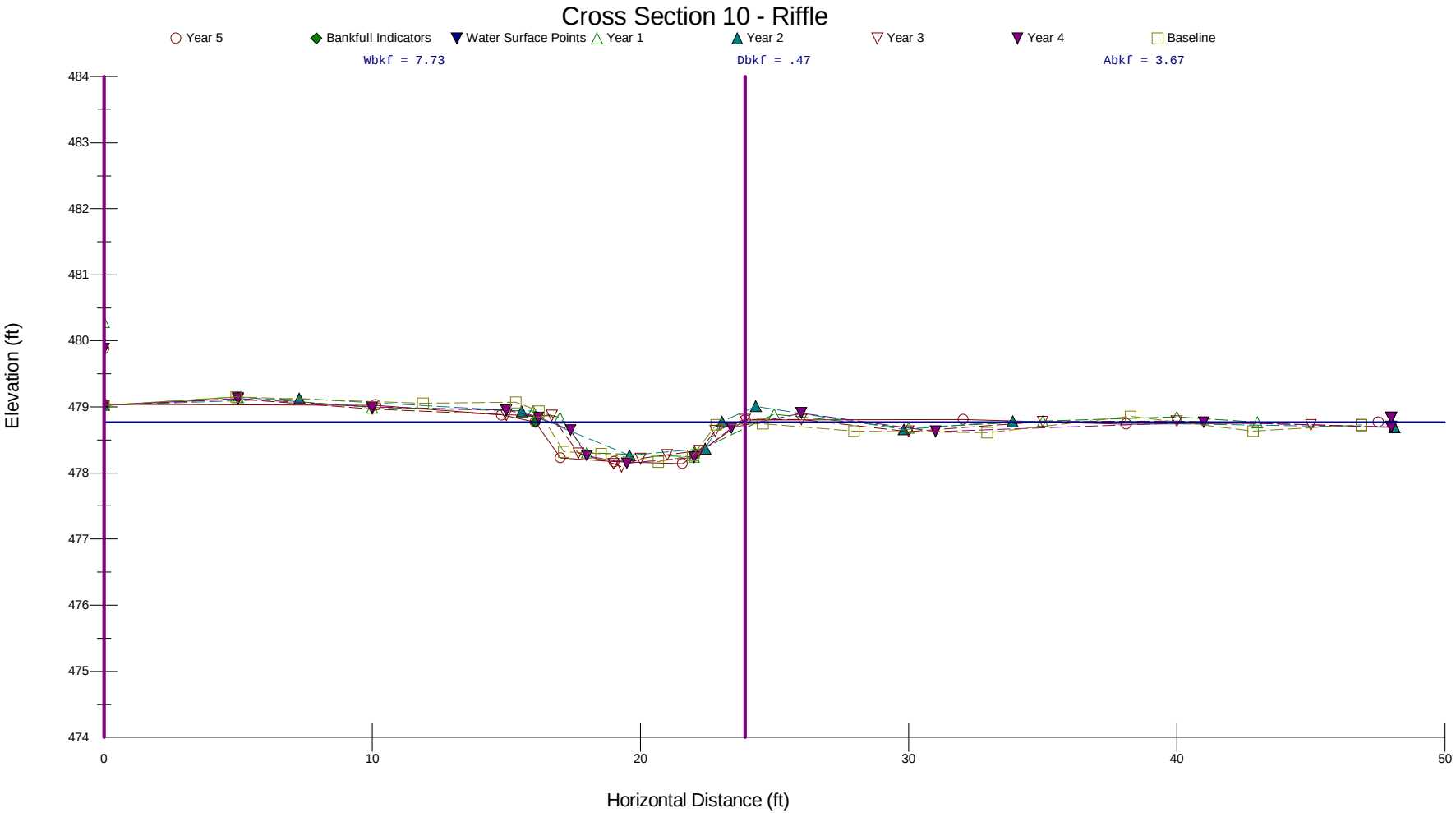

Cross Section 5 - Pool
Year 5
Bankfull Indicators
Water Surface Points
Baseline/Year 1
Year 2
Year 3
Year 4
Wbkf = 8.81
Dbkf = 1.5
Abkf = 13.2
Elevation (ft)
462
461
460
459
458
457
456
455
454
453
452
0
10
20
30
40
50
60
Horizontal Distance (ft)

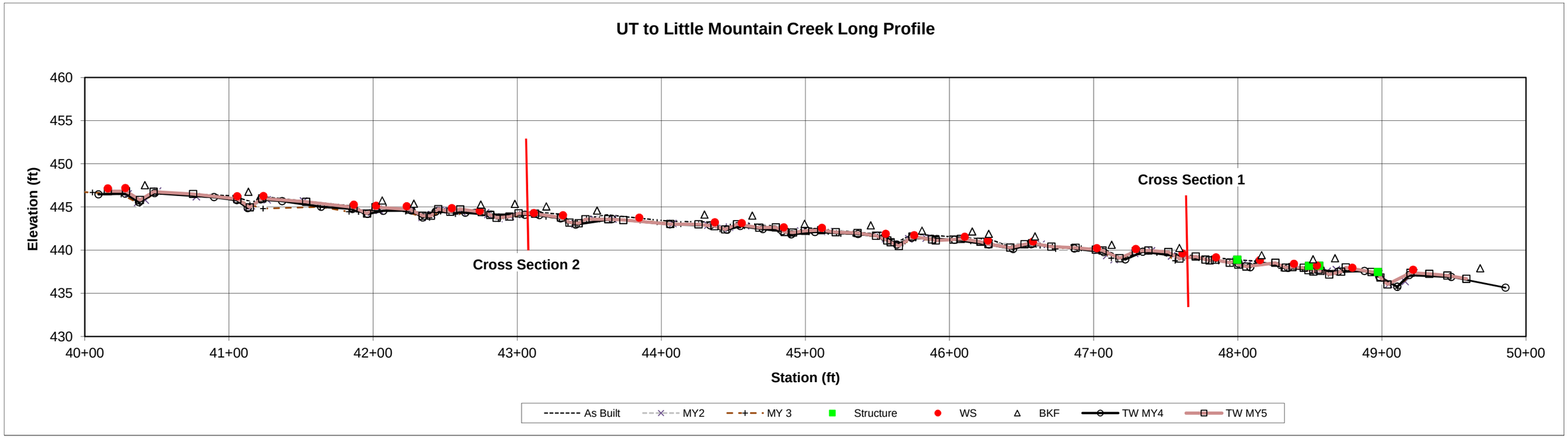

Cross Section 6 - Riffle
Year 5
Bankfull Indicators
Water Surface Points
Year 1
Year 2
Year 3
Year 4
Baseline
Wbkf = 11.8
Dbkf = .61
Abkf = 7.18
Elevation (ft)
470
469
468
467
466
465
464
463
462
461
460
0
10
20
30
40
50
60
Horizontal Distance (ft)

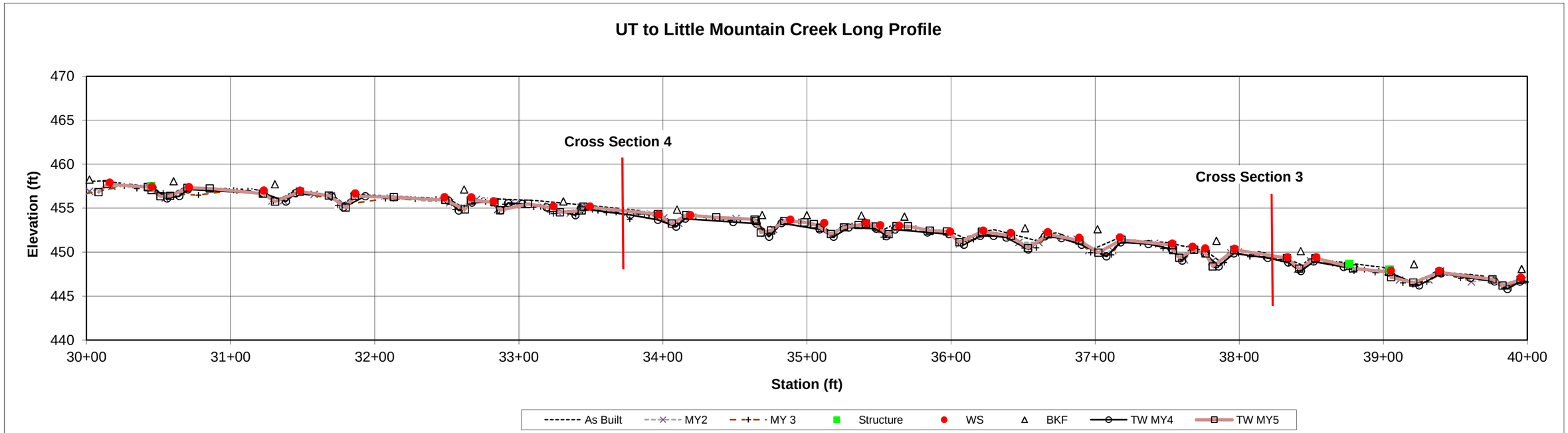

Cross Section 7 - Pool
Year 5
Bankfull Indicators
Water Surface Points
Year 1
Year 2
Year 3
Year 4
Baseline
Wbkf = 14.2
Dbkf = 1.32
Abkf = 18.8
475
470
465
460
Elevation (ft)
0
10
20
30
40
50
Horizontal Distance (ft)

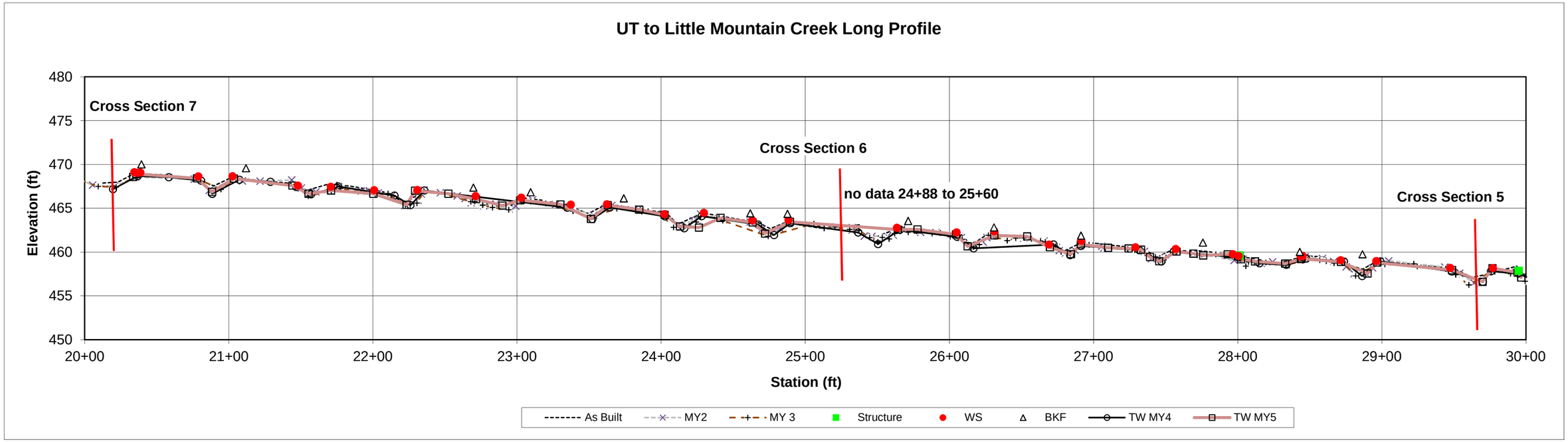

Cross Section 8 - Pool
Year 5
Bankfull Indicators
Water Surface Points
Year 1/Baseline
Year 2
Year 3
Year 4
Wbkf = 9.27
Dbkf = 1.47
Abkf = 13.6
Elevation (ft)
480
479
478
477
476
475
474
473
472
471
470
0
20
40
60
80
Horizontal Distance (ft)

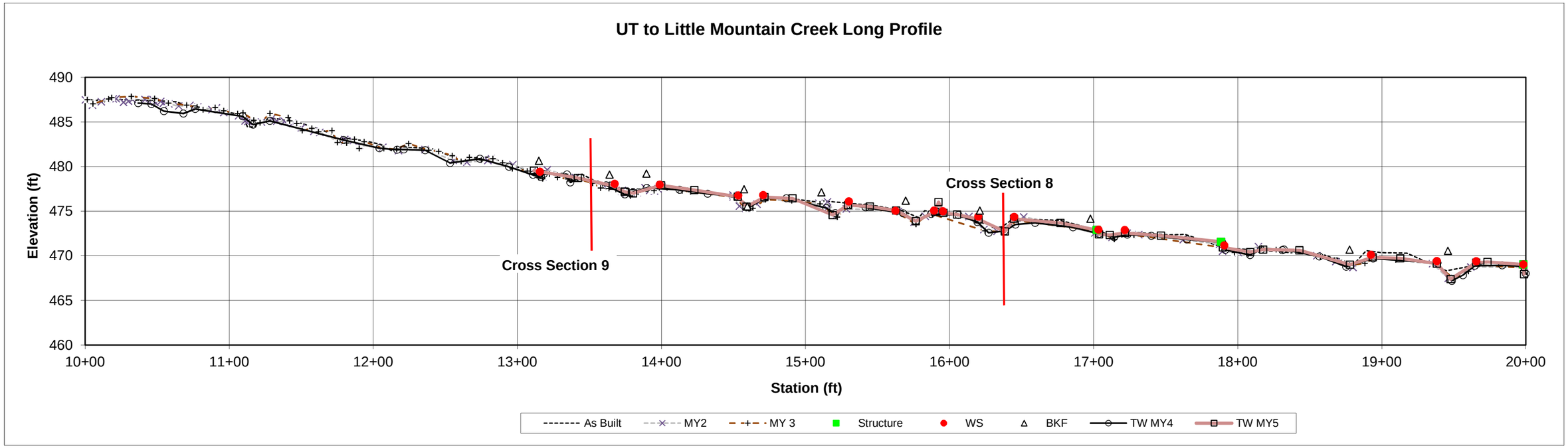

Cross Section 9 - Riffle
Year 5
Bankfull Indicators
Water Surface Points
Year 1
Year 2
Year 3
Year 4
Baseline
Wbkf = 11.8
Dbkf = .77
Abkf = 9.07
Elevation (ft)
485
484
483
482
481
480
479
478
477
476
475
0
10
20
30
40
50
Horizontal Distance (ft)

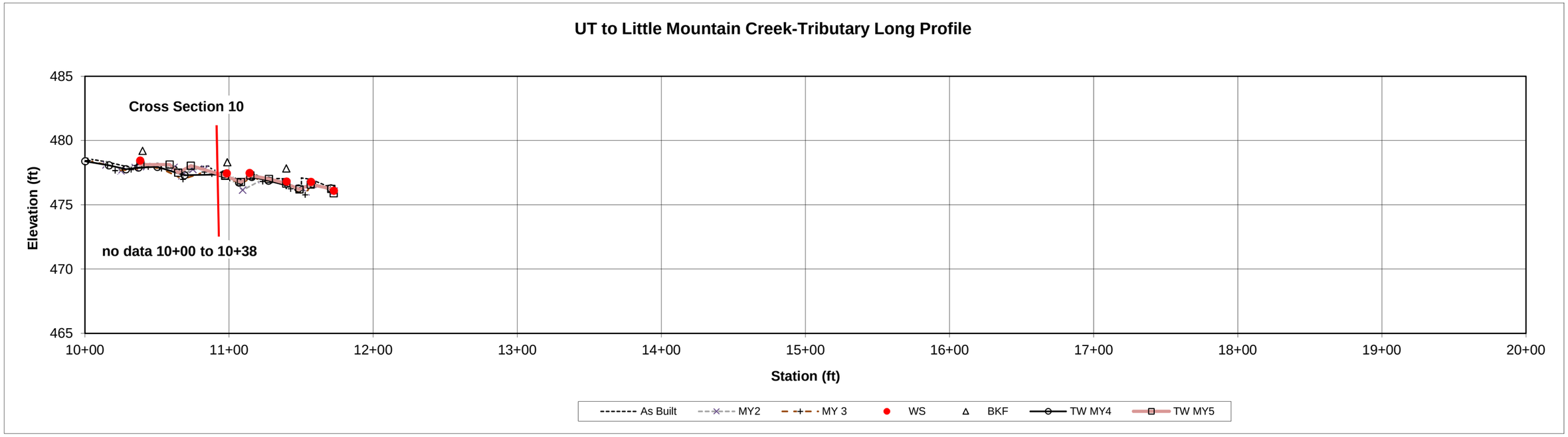

Cross Section 10 - Riffle
Year 5
Bankfull Indicators
Water Surface Points
Year 1
Year 2
Year 3
Year 4
Baseline
Wbkf = 7.73
Dbkf = .47
Abkf = 3.67
Elevation (ft)
484
483
482
481
480
479
478
477
476
475
474
0
10
20
30
40
50
Horizontal Distance (ft)


UT to Little Mountain Creek Long Profile
Elevation (ft)
460
455
450
445
440
435
430
40+00
41+00
42+00
43+00
44+00
45+00
46+00
47+00
48+00
49+00
50+00
Station (ft)
Cross Section 1
Cross Section 2
As Built
MY2
MY 3
Structure
WS
BKF
TW MY4
TW MY5


UT to Little Mountain Creek Long Profile
Elevation (ft)
470
465
460
455
450
445
440
30+00
31+00
32+00
33+00
34+00
35+00
36+00
37+00
38+00
39+00
40+00
Station (ft)
Cross Section 4
Cross Section 3
As Built
MY2
MY 3
Structure
WS
BKF
TW MY4
TW MY5


UT to Little Mountain Creek Long Profile
Cross Section 7
Cross Section 6
no data 24+88 to 25+60
Cross Section 5
Elevation (ft)
480
475
470
465
460
455
450
20+00
21+00
22+00
23+00
24+00
25+00
26+00
27+00
28+00
29+00
30+00
Station (ft)
As Built
MY2
MY 3
Structure
WS
BKF
TW MY4
TW MY5


UT to Little Mountain Creek Long Profile
Elevation (ft)
490
485
480
475
470
465
460
10+00
11+00
12+00
13+00
14+00
15+00
16+00
17+00
18+00
19+00
20+00
Station (ft)
Cross Section 8
Cross Section 9
As Built
MY2
MY 3
Structure
WS
BKF
TW MY4
TW MY5

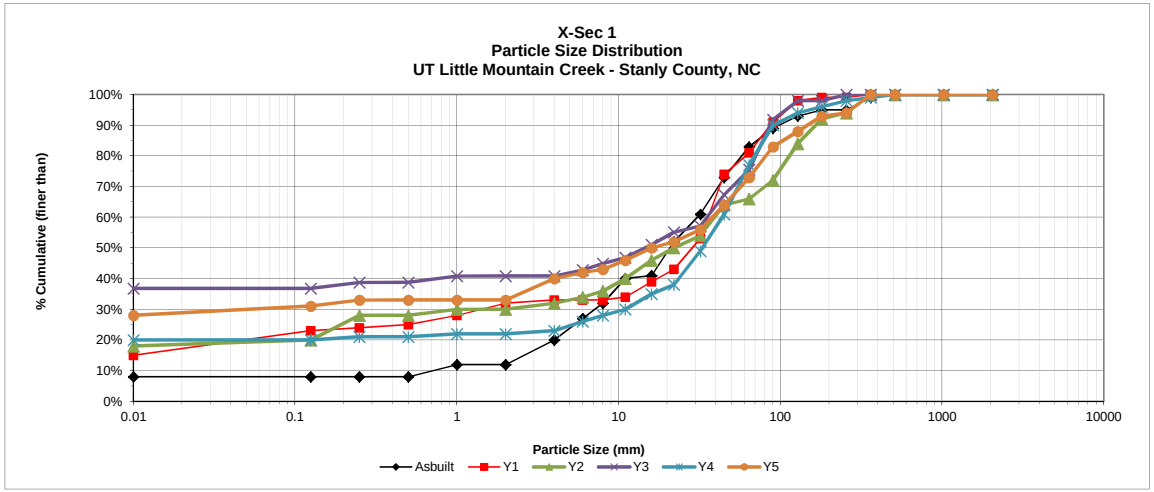

UT to Little Mountain Creek-Tributary Long Profile
Cross Section 10
no data 10+00 to 10+38
Elevation (ft)
485
480
475
470
465
10+00
11+00
12+00
13+00
14+00
15+00
16+00
17+00
18+00
19+00
20+00
Station (ft)
As Built
MY2
MY 3
WS
BKF
TW MY4
TW MY5

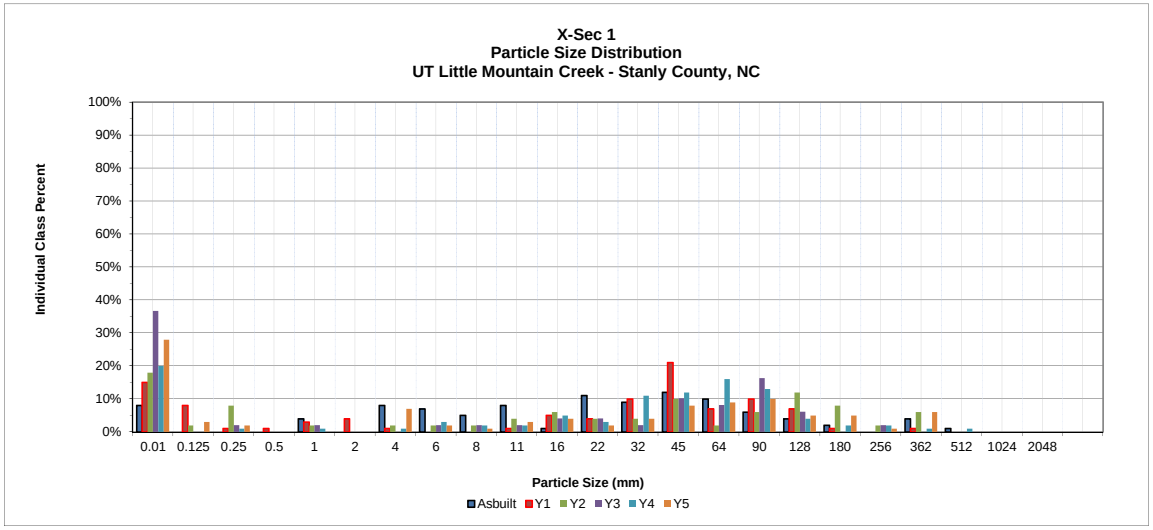
Cross - Section Pebble Count

Project Name : Badin Inn
Cross Section: 1
Feature: Riffle

Description	Particle	Millimeter	Total #	Item %	Cum %
S/C	Silt/Clay	< 0.062	28	28%	28%
S	Very Fine	.062 - .125	3	3%	31%
A	Fine	.125 - .25	2	2%	33%
N	Medium	.25 - .50	0	0%	33%
D	Coarse	.50 - 1.0	0	0%	33%
S	Very Coarse	1.0 - 2.0	0	0%	33%
	Very Fine	2.0 - 4.0	7	7%	40%
G	Fine	4.0 - 5.7	2	2%	42%
R	Fine	5.7 - 8.0	1	1%	43%
A	Medium	8.0 - 11.3	3	3%	46%
V	Medium	11.3 - 16.0	4	4%	50%
E	Coarse	16.0 - 22.6	2	2%	52%
L	Coarse	22.6 - 32.0	4	4%	56%
S	Very Coarse	32.0 - 45.0	8	8%	64%
	Very Coarse	45.0 - 64.0	9	9%	73%
C	Small	64 - 90	10	10%	83%
O	Small	90 - 128	5	5%	88%
B	Large	128 - 180	5	5%	93%
L	Large	180 - 256	1	1%	94%
B	Small	256 - 362	6	6%	100%
L	Small	362 - 512	0	0%	100%
D	Medium	512 - 1024	0	0%	100%
R	Lrg- Very Lrg	1024 - 2048	0	0%	100%
BDRK	Bedrock		0	0%	100%
Totals			100	100%	

Summary Data	
D50	16
D84	97
D95	273



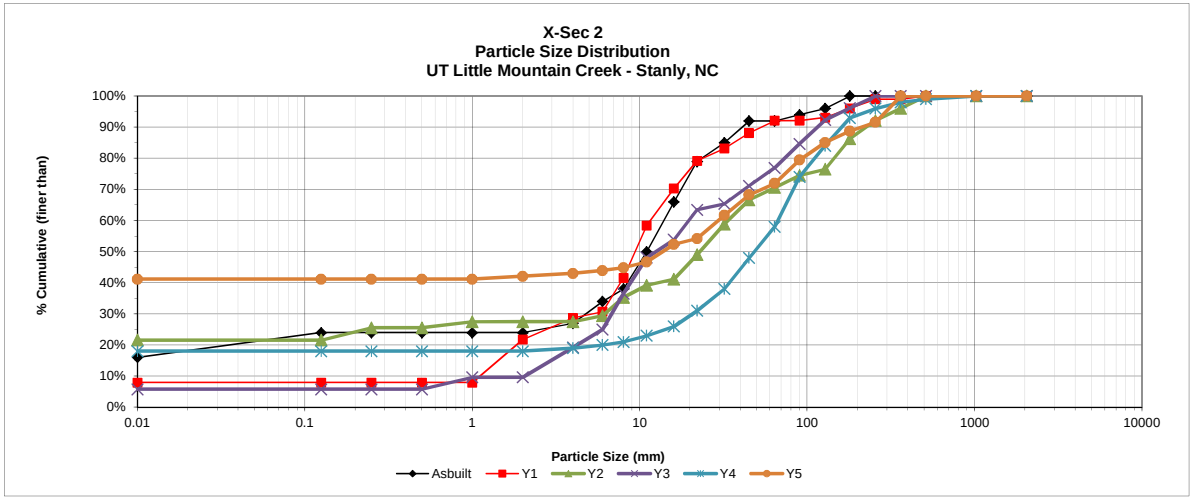


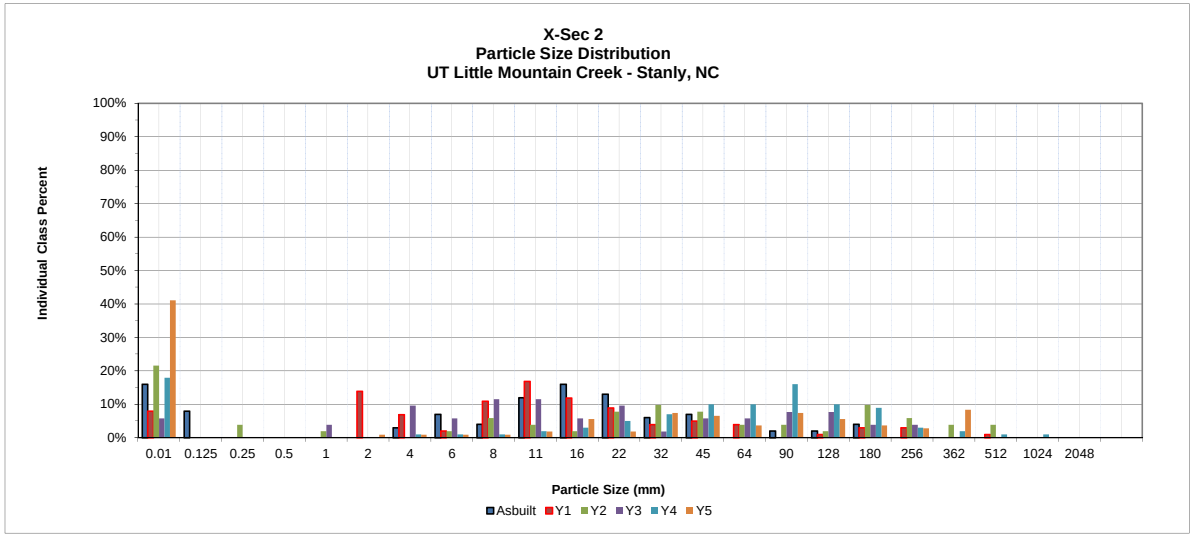
Cross - Section Pebble Count

Project Name : Badin Inn
Cross Section: 2
Feature: Pool

Description	Particle	Millimeter	Total #	Item %	Cum %
S/C	Silt/Clay	< 0.062	44	41%	41%
S	Very Fine	.062 - .125	0	0%	41%
A	Fine	.125 - .25	0	0%	41%
N	Medium	.25 - .50	0	0%	41%
D	Coarse	.50 - 1.0	0	0%	41%
S	Very Coarse	1.0 - 2.0	1	1%	42%
	Very Fine	2.0 - 4.0	1	1%	43%
G	Fine	4.0 - 5.7	1	1%	44%
R	Fine	5.7 - 8.0	1	1%	45%
A	Medium	8.0 - 11.3	2	2%	47%
V	Medium	11.3 - 16.0	6	6%	52%
E	Coarse	16.0 - 22.6	2	2%	54%
L	Coarse	22.6 - 32.0	8	7%	62%
S	Very Coarse	32.0 - 45.0	7	7%	68%
	Very Coarse	45.0 - 64.0	4	4%	72%
C	Small	64 - 90	8	7%	79%
O	Small	90 - 128	6	6%	85%
B	Large	128 - 180	4	4%	89%
L	Large	180 - 256	3	3%	92%
B	Small	256 - 362	9	8%	100%
L	Small	362 - 512	0	0%	100%
D	Medium	512 - 1024	0	0%	100%
R	Lrg- Very Lrg	1024 - 2048	0	0%	100%
BDRK	Bedrock		0	0%	100%
Totals			107	100%	

Summary Data	
D50	14
D84	121
D95	299



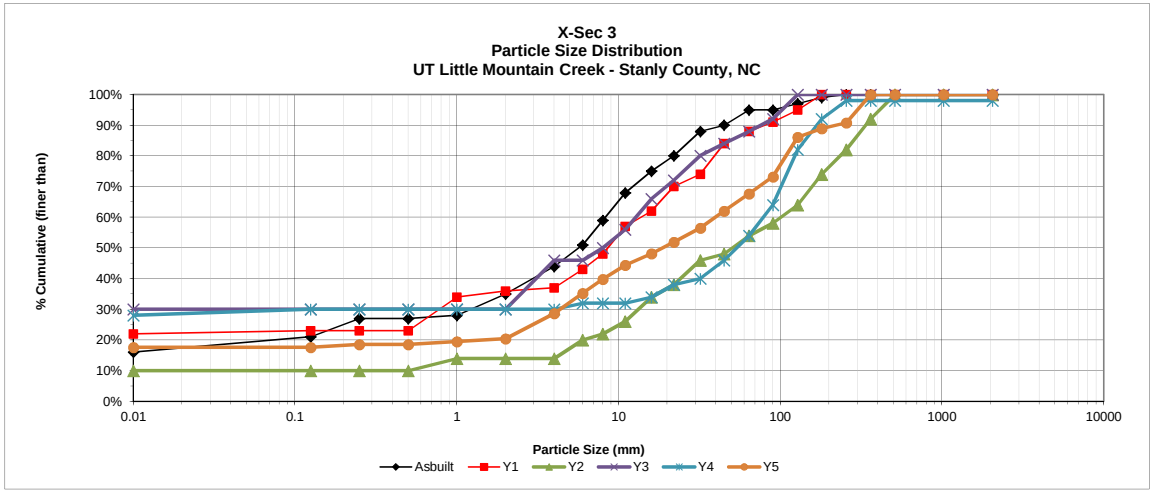


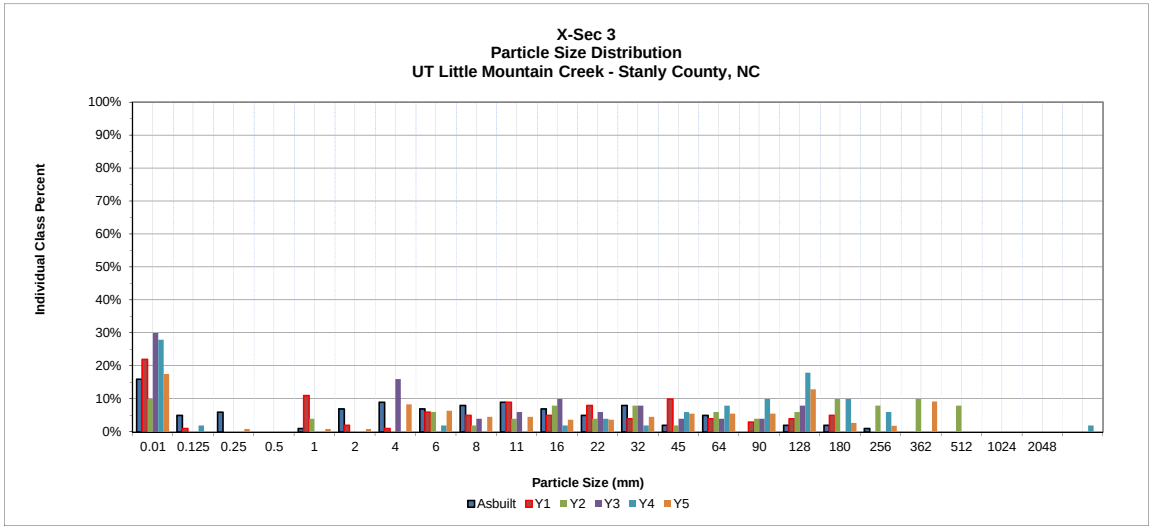
Cross - Section Pebble Count

Project Name : Badin Inn
Cross Section: 3
Feature: Riffle

Description	Particle	Millimeter	Total #	Item %	Cum %
S/C	Silt/Clay	< 0.062	19	18%	18%
S	Very Fine	.062 - .125	0	0%	18%
A	Fine	.125 - .25	1	1%	19%
N	Medium	.25 - .50	0	0%	19%
D	Coarse	.50 - 1.0	1	1%	19%
S	Very Coarse	1.0 - 2.0	1	1%	20%
	Very Fine	2.0 - 4.0	9	8%	29%
G	Fine	4.0 - 5.7	7	6%	35%
R	Fine	5.7 - 8.0	5	5%	40%
A	Medium	8.0 - 11.3	5	5%	44%
V	Medium	11.3 - 16.0	4	4%	48%
E	Coarse	16.0 - 22.6	4	4%	52%
L	Coarse	22.6 - 32.0	5	5%	56%
S	Very Coarse	32.0 - 45.0	6	6%	62%
	Very Coarse	45.0 - 64.0	6	6%	68%
C	Small	64 - 90	6	6%	73%
O	Small	90 - 128	14	13%	86%
B	Large	128 - 180	3	3%	89%
L	Large	180 - 256	2	2%	91%
B	Small	256 - 362	10	9%	100%
L	Small	362 - 512	0	0%	100%
D	Medium	512 - 1024	0	0%	100%
R	Lrg- Very Lrg	1024 - 2048	0	0%	100%
BDRK	Bedrock		0	0%	100%
Totals			108	100%	

Summary Data	
D50	19
D84	122
D95	304



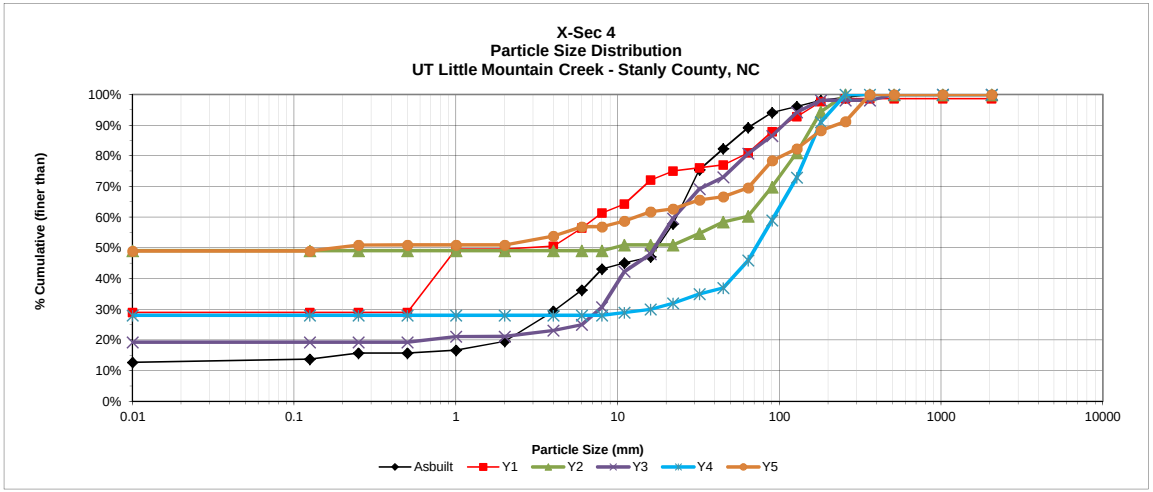


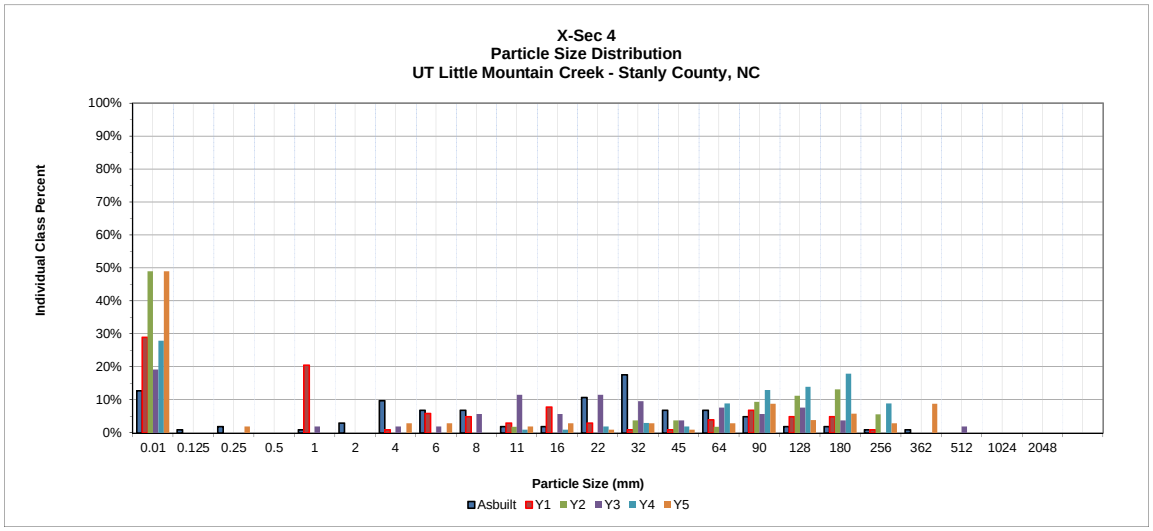
Cross - Section Pebble Count

Project Name : Badin Inn
Cross Section: 4
Feature: Riffle

Description	Particle	Millimeter	Total #	Item %	Cum %
S/C	Silt/Clay	< 0.062	50	49%	49%
S	Very Fine	.062 - .125	0	0%	49%
A	Fine	.125 - .25	2	2%	51%
N	Medium	.25 - .50	0	0%	51%
D	Coarse	.50 - 1.0	0	0%	51%
S	Very Coarse	1.0 - 2.0	0	0%	51%
	Very Fine	2.0 - 4.0	3	3%	54%
G	Fine	4.0 - 5.7	3	3%	57%
R	Fine	5.7 - 8.0	0	0%	57%
A	Medium	8.0 - 11.3	2	2%	59%
V	Medium	11.3 - 16.0	3	3%	62%
E	Coarse	16.0 - 22.6	1	1%	63%
L	Coarse	22.6 - 32.0	3	3%	66%
S	Very Coarse	32.0 - 45.0	1	1%	67%
	Very Coarse	45.0 - 64.0	3	3%	70%
C	Small	64 - 90	9	9%	78%
O	Small	90 - 128	4	4%	82%
B	Large	128 - 180	6	6%	88%
L	Large	180 - 256	3	3%	91%
B	Small	256 - 362	9	9%	100%
L	Small	362 - 512	0	0%	100%
D	Medium	512 - 1024	0	0%	100%
R	Lrg- Very Lrg	1024 - 2048	0	0%	100%
BDRK	Bedrock		0	0%	100%
Totals			102	100%	

Summary Data	
D50	0.2
D84	142
D95	302



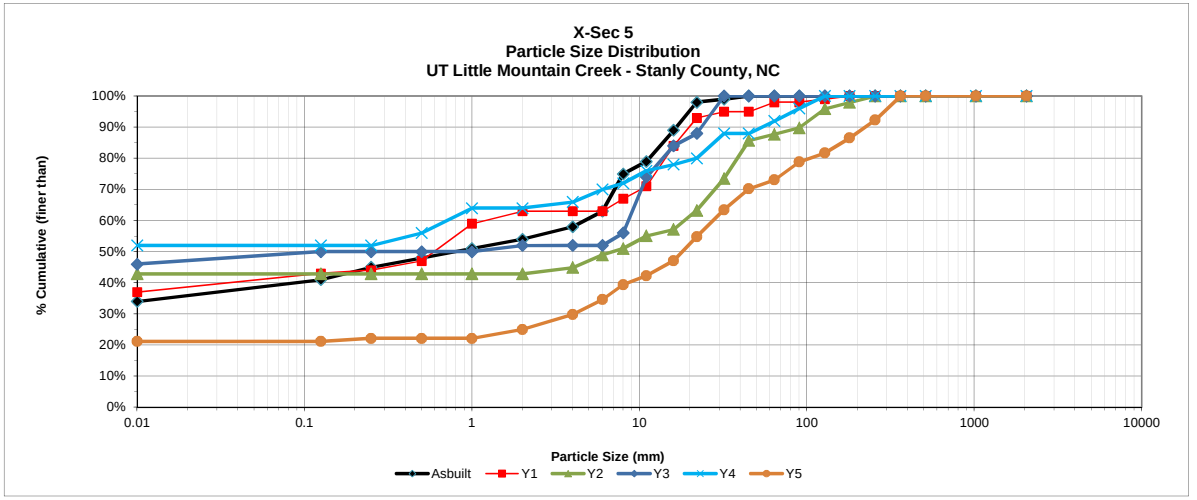


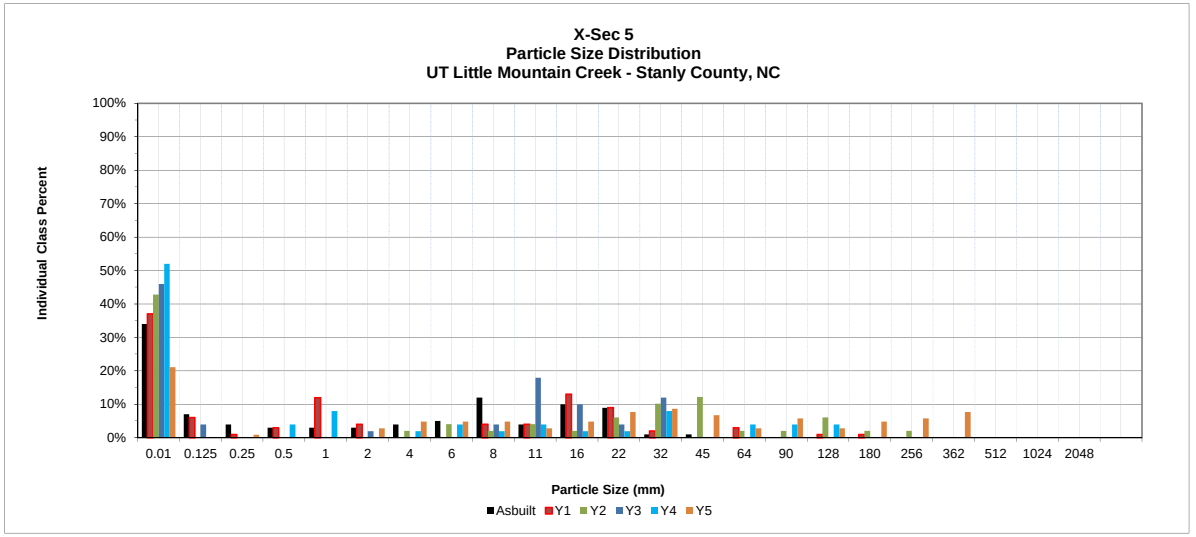
Cross - Section Pebble Count

Project Name : Badin Inn
Cross Section: 5
Feature: Pool

Description	Particle	Millimeter	Total #	Item %	Cum %
S/C	Silt/Clay	< 0.062	22	21%	21%
S	Very Fine	.062 - .125	0	0%	21%
A	Fine	.125 - .25	1	1%	22%
N	Medium	.25 - .50	0	0%	22%
D	Coarse	.50 - 1.0	0	0%	22%
S	Very Coarse	1.0 - 2.0	3	3%	25%
	Very Fine	2.0 - 4.0	5	5%	30%
G	Fine	4.0 - 5.7	5	5%	35%
R	Fine	5.7 - 8.0	5	5%	39%
A	Medium	8.0 - 11.3	3	3%	42%
V	Medium	11.3 - 16.0	5	5%	47%
E	Coarse	16.0 - 22.6	8	8%	55%
L	Coarse	22.6 - 32.0	9	9%	63%
S	Very Coarse	32.0 - 45.0	7	7%	70%
	Very Coarse	45.0 - 64.0	3	3%	73%
C	Small	64 - 90	6	6%	79%
O	Small	90 - 128	3	3%	82%
B	Large	128 - 180	5	5%	87%
L	Large	180 - 256	6	6%	92%
B	Small	256 - 362	8	8%	100%
L	Small	362 - 512	0	0%	100%
D	Medium	512 - 1024	0	0%	100%
R	Lrg- Very Lrg	1024 - 2048	0	0%	100%
BDRK	Bedrock		0	0%	100%
Totals			104	100%	

Summary Data	
D50	18
D84	153
D95	293



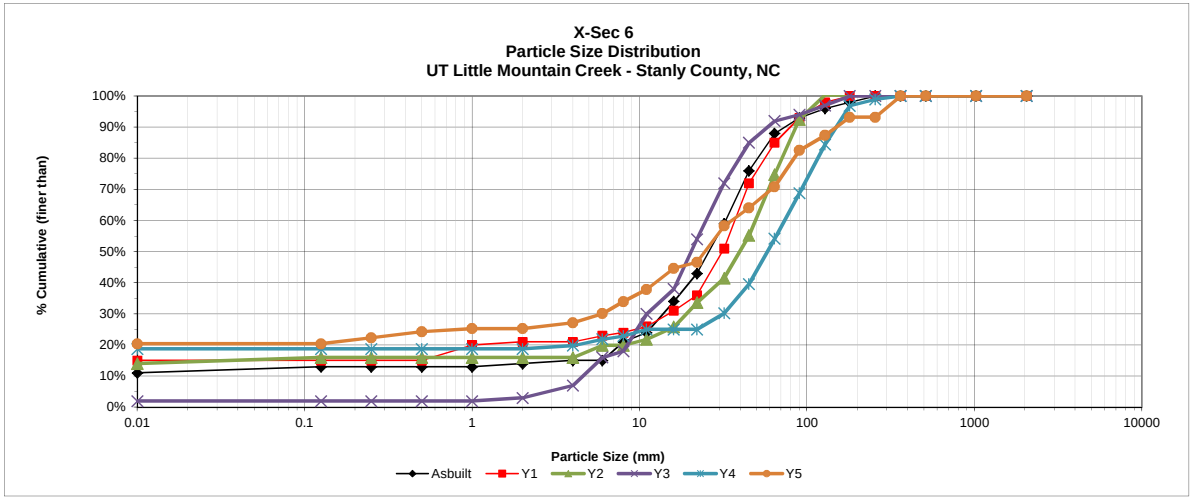


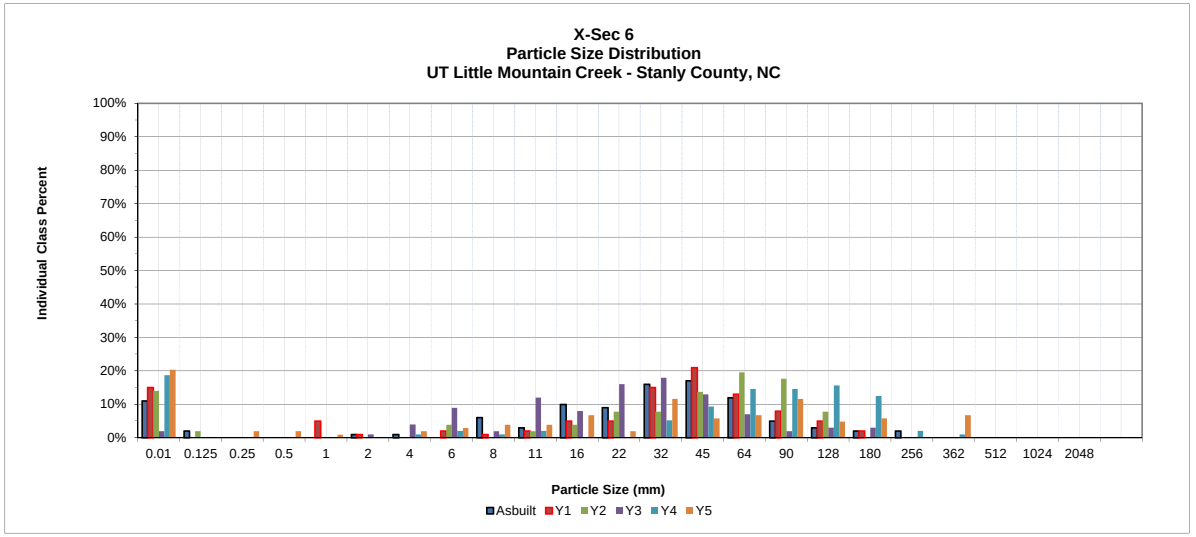
Cross - Section Pebble Count

Project Name : Badin Inn
Cross Section: 6
Feature: Riffle

Description	Particle	Millimeter	Total #	Item %	Cum %
S/C	Silt/Clay	< 0.062	21	20%	20%
S	Very Fine	.062 - .125	0	0%	20%
A	Fine	.125 - .25	2	2%	22%
N	Medium	.25 - .50	2	2%	24%
D	Coarse	.50 - 1.0	1	1%	25%
S	Very Coarse	1.0 - 2.0	0	0%	25%
	Very Fine	2.0 - 4.0	2	2%	27%
G	Fine	4.0 - 5.7	3	3%	30%
R	Fine	5.7 - 8.0	4	4%	34%
A	Medium	8.0 - 11.3	4	4%	38%
V	Medium	11.3 - 16.0	7	7%	45%
E	Coarse	16.0 - 22.6	2	2%	47%
L	Coarse	22.6 - 32.0	12	12%	58%
S	Very Coarse	32.0 - 45.0	6	6%	64%
	Very Coarse	45.0 - 64.0	7	7%	71%
C	Small	64 - 90	12	12%	83%
O	Small	90 - 128	5	5%	87%
B	Large	128 - 180	6	6%	93%
L	Large	180 - 256	0	0%	93%
B	Small	256 - 362	7	7%	100%
L	Small	362 - 512	0	0%	100%
D	Medium	512 - 1024	0	0%	100%
R	Lrg- Very Lrg	1024 - 2048	0	0%	100%
BDRK	Bedrock		0	0%	100%
Totals			103	100%	

Summary Data	
D50	25
D84	101
D95	284



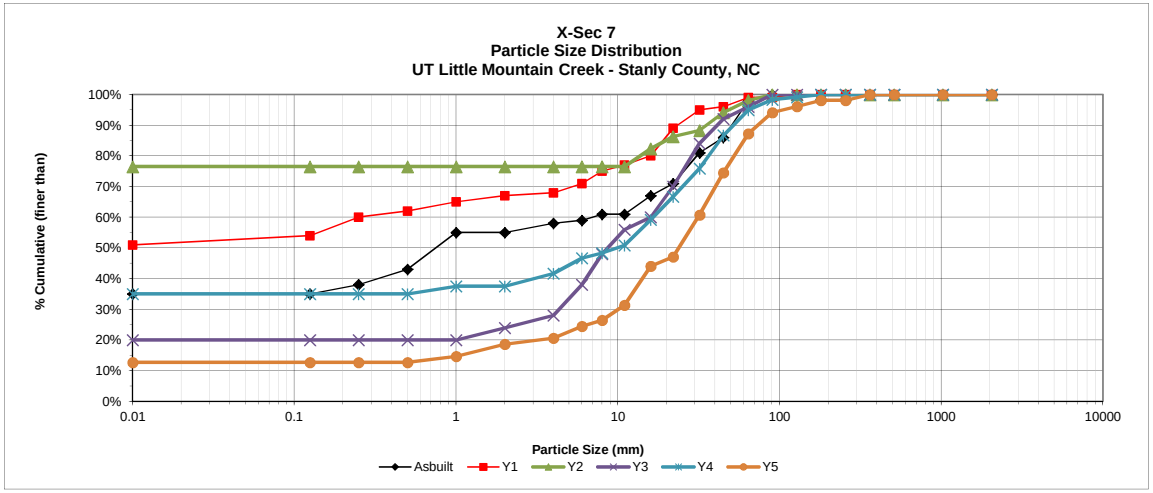


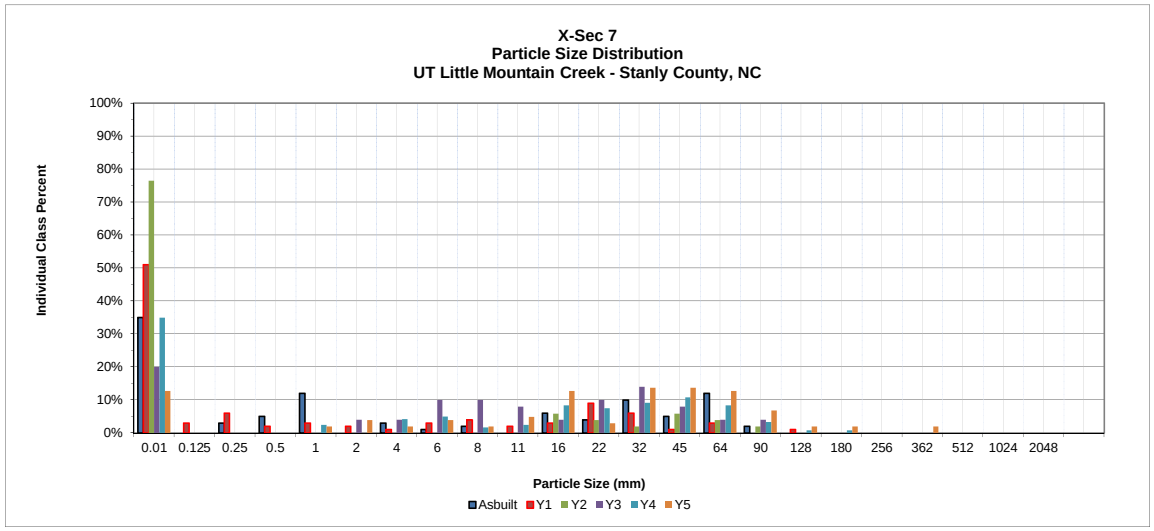
Cross - Section Pebble Count

Project Name : Badin Inn
Cross Section: 7
Feature: Pool

Description	Particle	Millimeter	Total #	Item %	Cum %
S/C	Silt/Clay	< 0.062	13	13%	13%
S	Very Fine	.062 - .125	0	0%	13%
A	Fine	.125 - .25	0	0%	13%
N	Medium	.25 - .50	0	0%	13%
D	Coarse	.50 - 1.0	2	2%	15%
S	Very Coarse	1.0 - 2.0	4	4%	19%
	Very Fine	2.0 - 4.0	2	2%	21%
G	Fine	4.0 - 5.7	4	4%	25%
R	Fine	5.7 - 8.0	2	2%	26%
A	Medium	8.0 - 11.3	5	5%	31%
V	Medium	11.3 - 16.0	13	13%	44%
E	Coarse	16.0 - 22.6	3	3%	47%
L	Coarse	22.6 - 32.0	14	14%	61%
S	Very Coarse	32.0 - 45.0	14	14%	75%
	Very Coarse	45.0 - 64.0	13	13%	87%
C	Small	64 - 90	7	7%	94%
O	Small	90 - 128	2	2%	96%
B	Large	128 - 180	2	2%	98%
L	Large	180 - 256	0	0%	98%
B	Small	256 - 362	2	2%	100%
L	Small	362 - 512	0	0%	100%
D	Medium	512 - 1024	0	0%	100%
R	Lrg- Very Lrg	1024 - 2048	0	0%	100%
BDRK	Bedrock		0	0%	100%
Totals			102	100%	

Summary Data	
D50	25
D84	59
D95	107



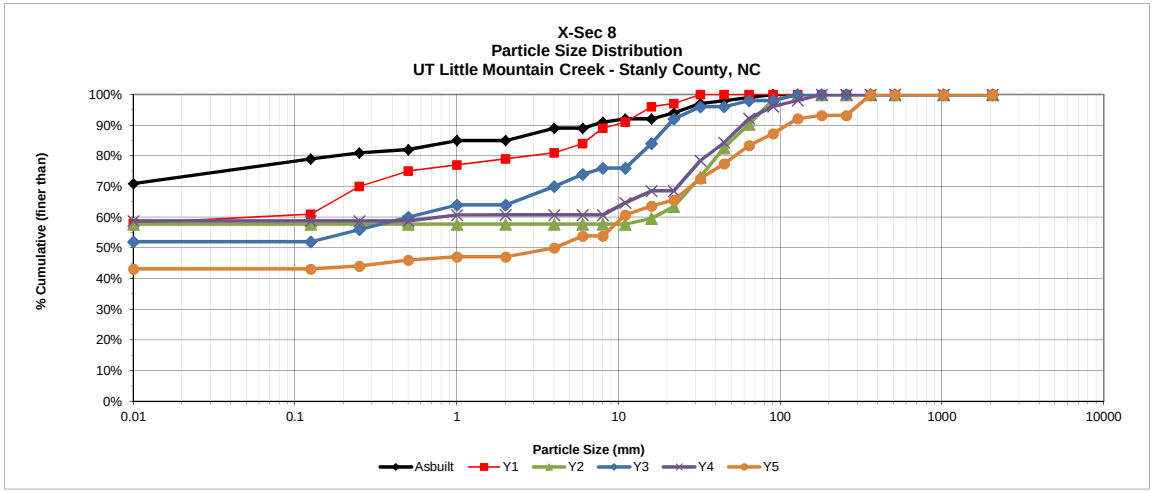


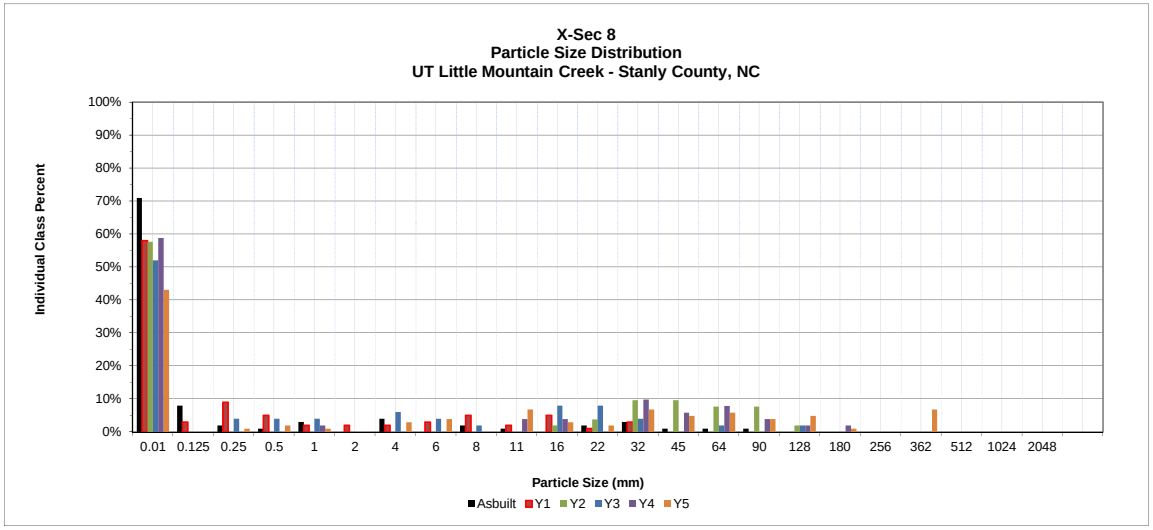
Cross - Section Pebble Count

Project Name : Badin Inn
Cross Section: 8
Feature: Pool

Description	Particle	Millimeter	Total #	Item %	Cum %
S/C	Silt/Clay	< 0.062	44	43%	43%
S	Very Fine	.062 - .125	0	0%	43%
A	Fine	.125 - .25	1	1%	44%
N	Medium	.25 - .50	2	2%	46%
D	Coarse	.50 - 1.0	1	1%	47%
S	Very Coarse	1.0 - 2.0	0	0%	47%
	Very Fine	2.0 - 4.0	3	3%	50%
G	Fine	4.0 - 5.7	4	4%	54%
R	Fine	5.7 - 8.0	0	0%	54%
A	Medium	8.0 - 11.3	7	7%	61%
V	Medium	11.3 - 16.0	3	3%	64%
E	Coarse	16.0 - 22.6	2	2%	66%
L	Coarse	22.6 - 32.0	7	7%	73%
S	Very Coarse	32.0 - 45.0	5	5%	77%
	Very Coarse	45.0 - 64.0	6	6%	83%
C	Small	64 - 90	4	4%	87%
O	Small	90 - 128	5	5%	92%
B	Large	128 - 180	1	1%	93%
L	Large	180 - 256	0	0%	93%
B	Small	256 - 362	7	7%	100%
L	Small	362 - 512	0	0%	100%
D	Medium	512 - 1024	0	0%	100%
R	Lrg- Very Lrg	1024 - 2048	0	0%	100%
BDRK	Bedrock		0	0%	100%
Totals			102	100%	

Summary Data	
D50	4
D84	68
D95	285



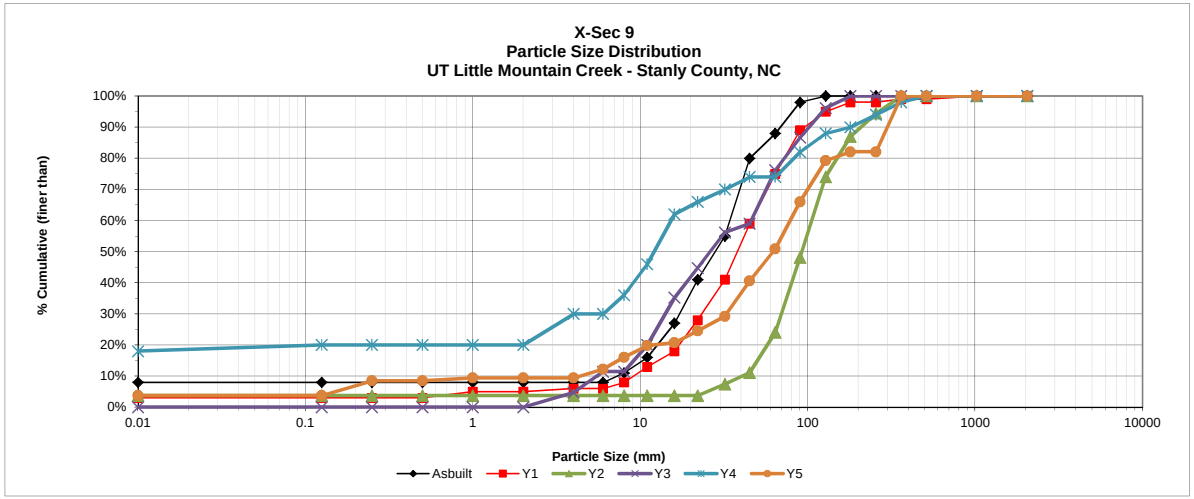


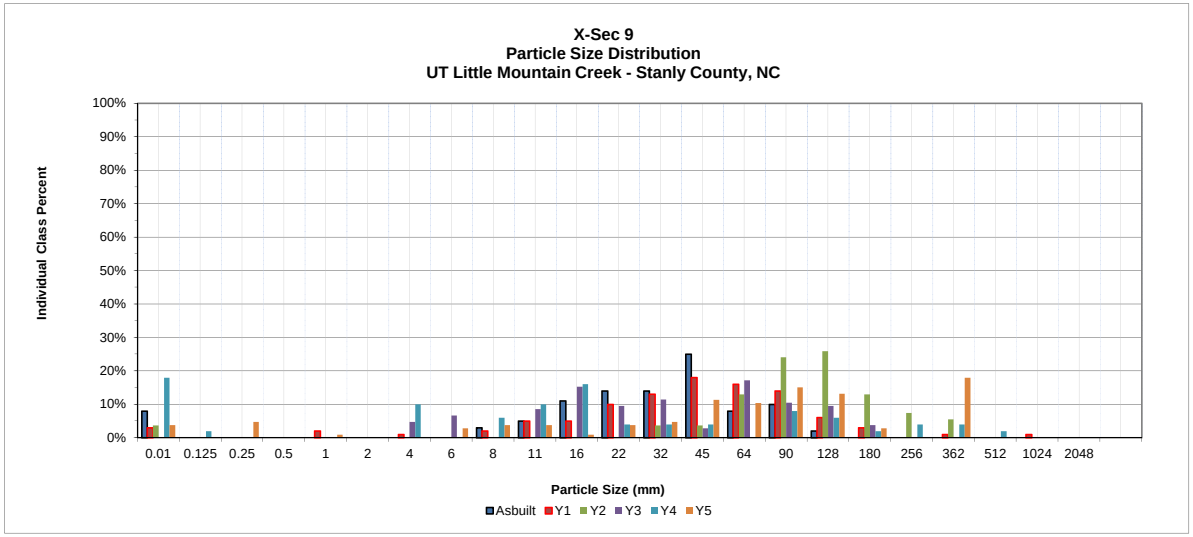
Cross - Section Pebble Count

Project Name : Badin Inn
Cross Section: 9
Feature: Riffle

Description	Particle	Millimeter	Total #	Item %	Cum %
S/C	Silt/Clay	< 0.062	4	4%	4%
S	Very Fine	.062 - .125	0	0%	4%
A	Fine	.125 - .25	5	5%	8%
N	Medium	.25 - .50	0	0%	8%
D	Coarse	.50 - 1.0	1	1%	9%
S	Very Coarse	1.0 - 2.0	0	0%	9%
	Very Fine	2.0 - 4.0	0	0%	9%
G	Fine	4.0 - 5.7	3	3%	12%
R	Fine	5.7 - 8.0	4	4%	16%
A	Medium	8.0 - 11.3	4	4%	20%
V	Medium	11.3 - 16.0	1	1%	21%
E	Coarse	16.0 - 22.6	4	4%	25%
L	Coarse	22.6 - 32.0	5	5%	29%
S	Very Coarse	32.0 - 45.0	12	11%	41%
	Very Coarse	45.0 - 64.0	11	10%	51%
C	Small	64 - 90	16	15%	66%
O	Small	90 - 128	14	13%	79%
B	Large	128 - 180	3	3%	82%
L	Large	180 - 256	0	0%	82%
B	Small	256 - 362	19	18%	100%
L	Small	362 - 512	0	0%	100%
D	Medium	512 - 1024	0	0%	100%
R	Lrg- Very Lrg	1024 - 2048	0	0%	100%
BDRK	Bedrock		0	0%	100%
Totals			106	100%	

Summary Data	
D50	62
D84	267
D95	332



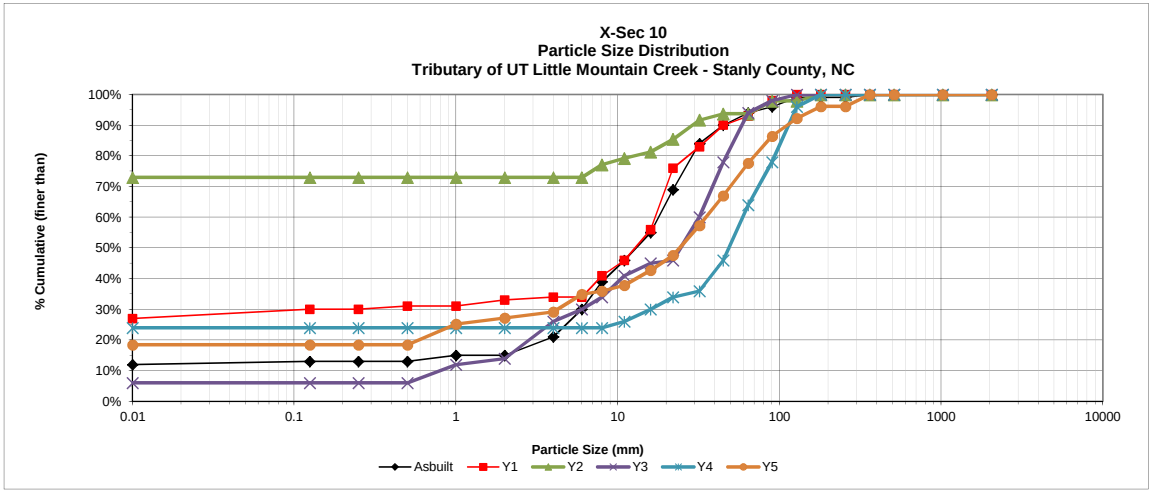


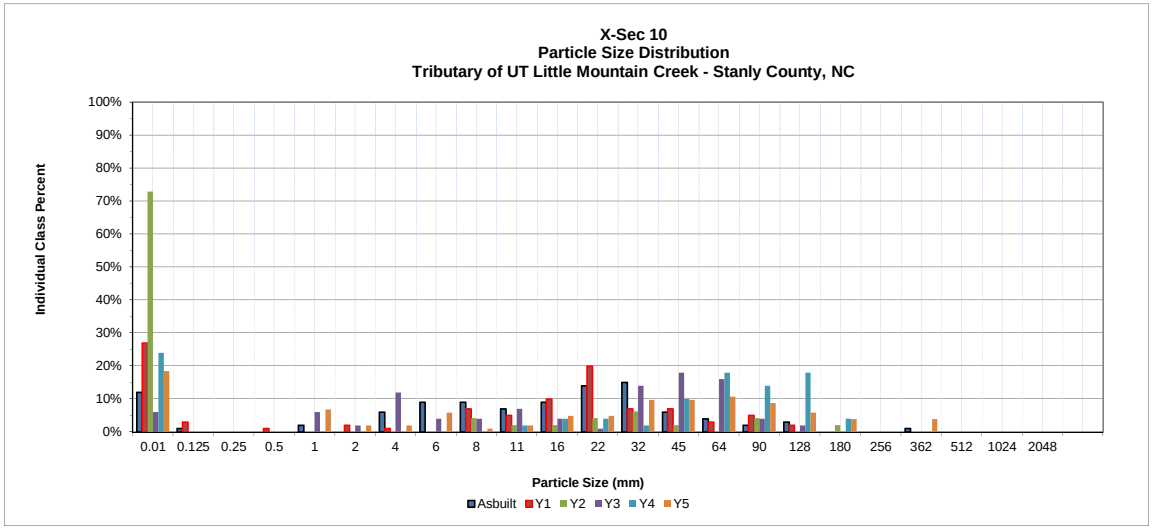
Cross - Section Pebble Count

Project Name : Badin Inn
Cross Section: 10 (Tributary)
Feature: Riffle

Description	Particle	Millimeter	Total #	Item %	Cum %
S/C	Silt/Clay	< 0.062	19	18%	18%
S	Very Fine	.062 - .125	0	0%	18%
A	Fine	.125 - .25	0	0%	18%
N	Medium	.25 - .50	0	0%	18%
D	Coarse	.50 - 1.0	7	7%	25%
S	Very Coarse	1.0 - 2.0	2	2%	27%
	Very Fine	2.0 - 4.0	2	2%	29%
G	Fine	4.0 - 5.7	6	6%	35%
R	Fine	5.7 - 8.0	1	1%	36%
A	Medium	8.0 - 11.3	2	2%	38%
V	Medium	11.3 - 16.0	5	5%	43%
E	Coarse	16.0 - 22.6	5	5%	48%
L	Coarse	22.6 - 32.0	10	10%	57%
S	Very Coarse	32.0 - 45.0	10	10%	67%
	Very Coarse	45.0 - 64.0	11	11%	78%
C	Small	64 - 90	9	9%	86%
O	Small	90 - 128	6	6%	92%
B	Large	128 - 180	4	4%	96%
L	Large	180 - 256	0	0%	96%
B	Small	256 - 362	4	4%	100%
L	Small	362 - 512	0	0%	100%
D	Medium	512 - 1024	0	0%	100%
R	Lrg- Very Lrg	1024 - 2048	0	0%	100%
BDRK	Bedrock		0	0%	100%
Totals			103	100%	

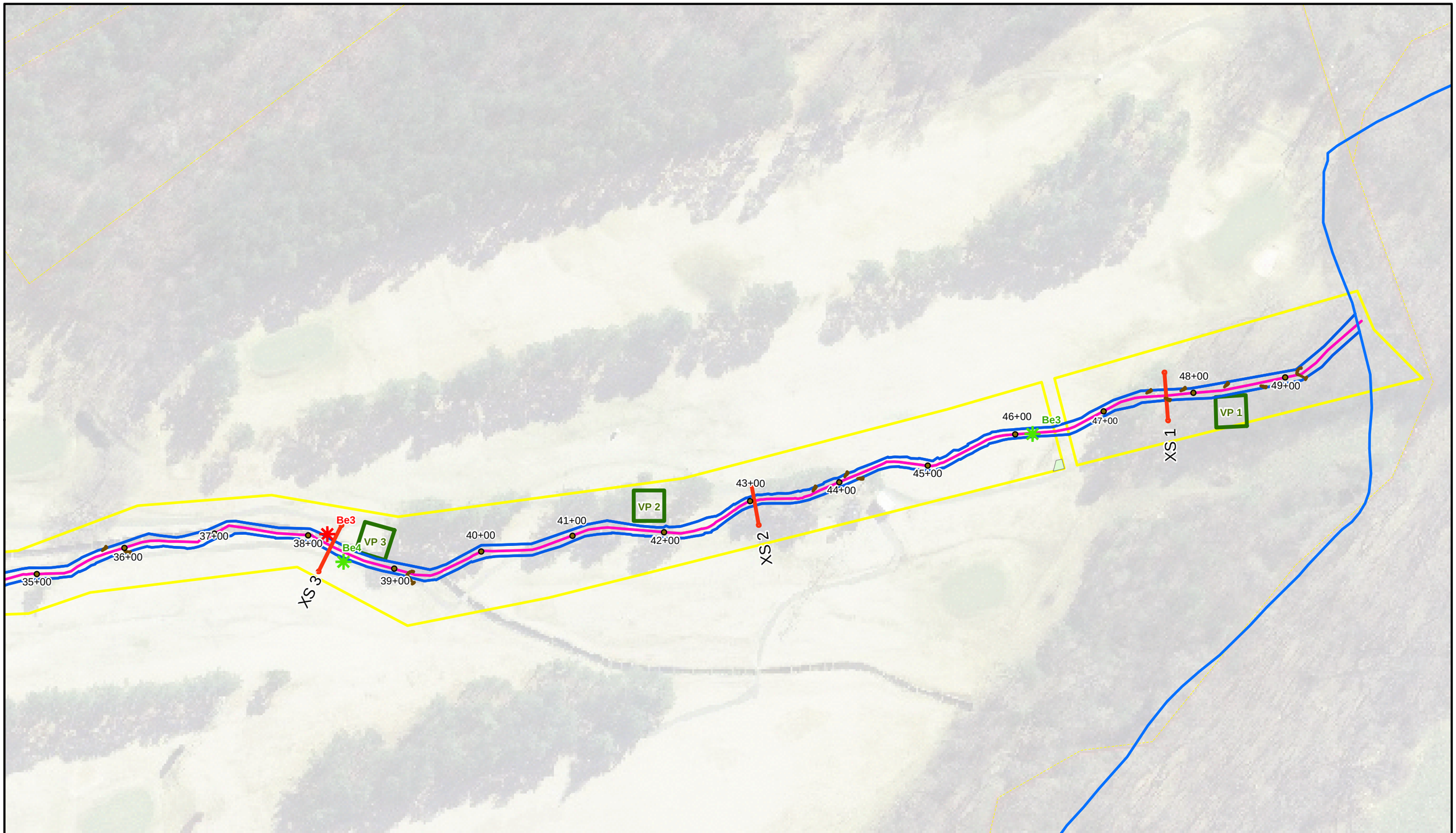
Summary Data	
D50	25
D84	83
D95	165





APPENDIX C

1. Integrated Plan View

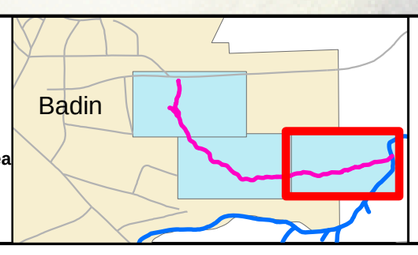


N

0 100 200 Feet

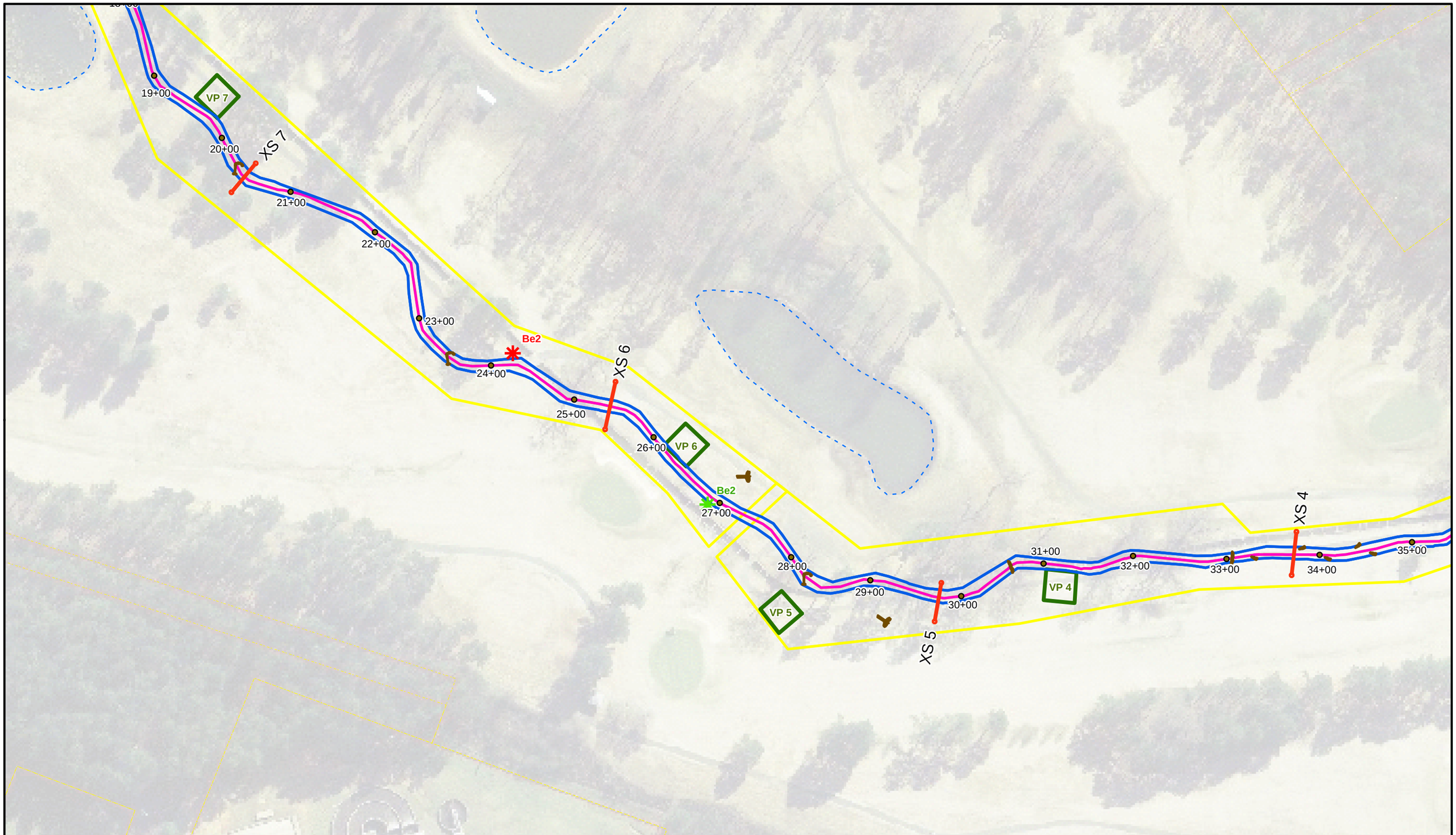
Legend

- Stations
- Pre-construction Benthic Monitoring Sites
- Benthic Monitoring Sites
- Structures
- Roads
- Cross Sections
- Restored Bankfull
- Restored Thalweg
- Vegetation Problem Area
- Vegetation Plots



APPENDIX C-3
Integrated Plan View

Date		Project No.
1-14	Badin Inn Stream Restoration Stanly County, North Carolina	92666

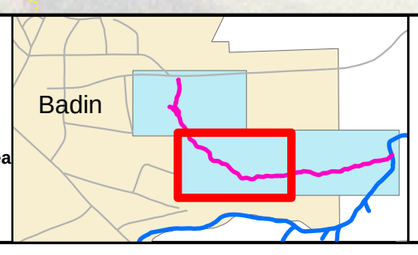


Legend

- Stations
- Pre-construction Benthic Monitoring Sites
- Benthic Monitoring Sites
- Structures
- Roads
- Cross Sections
- Restored Bankfull
- Restored Thalweg
- Vegetation Problem Area
- Vegetation Plots

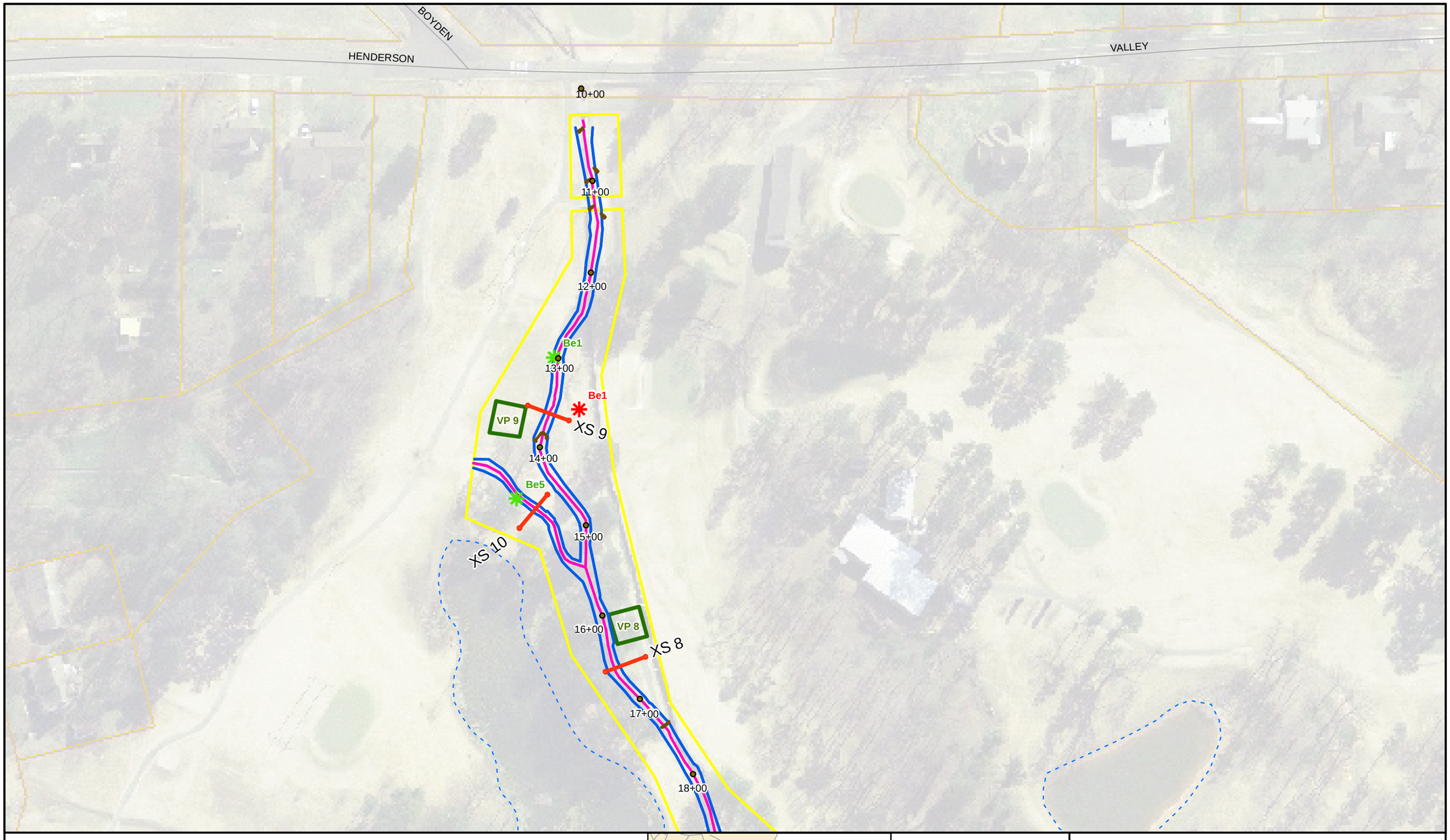
N

0 100 200 Feet



APPENDIX C-3
Integrated Plan View

Date		Project No.
1-14	Badin Inn Stream Restoration Stanly County, North Carolina	92666

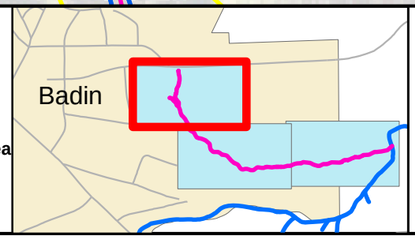


N

0 100 200 Feet

Legend

- Stations
- Pre-construction Benthic Monitoring Sites
- Benthic Monitoring Sites
- Structures
- Roads
- Cross Sections
- Restored Bankfull
- Restored Thalweg
- Vegetation Problem Area
- Vegetation Plots



APPENDIX C-3
Integrated Plan View

Date		Project No.
1-14	Badin Inn Stream Restoration Stanly County, North Carolina	92666

APPENDIX D

1. Habitat Assessment Field Data Sheets

HABITAT ASSESSMENT FIELD DATA SHEET—HIGH GRADIENT STREAMS (FRONT)

STREAM NAME UT Little Mt Creek	LOCATION Badin Inn
STATION # _____ RIVERMILE _____	STREAM CLASS
LAT _____ LONG _____	RIVER BASIN Yadkin
STORET #	AGENCY
INVESTIGATORS	
FORM COMPLETED BY Ron Johnson	DATE _____ TIME _____ AM PM
REASON FOR SURVEY PRE RESTORATION	

Parameters to be evaluated in sampling reach

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
1. Epifaunal Substrate/ Available Cover	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE 3	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 (3) 2 1 0
2. Embeddedness	Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment. Layering of cobble provides diversity of niche space.	Gravel, cobble, and boulder particles are 25-50% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 50-75% surrounded by fine sediment.	Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment.
SCORE 2	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 (2) 1 0
3. Velocity/Depth Regime	All four velocity/depth regimes present (slow-deep, slow-shallow, fast-deep, fast-shallow). (Slow is < 0.3 m/s, deep is > 0.5 m.)	Only 3 of the 4 regimes present (if fast-shallow is missing, score lower than if missing other regimes).	Only 2 of the 4 habitat regimes present (if fast-shallow or slow-shallow are missing, score low).	Dominated by 1 velocity/ depth regime (usually slow-deep).
SCORE 3	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 (3) 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than 5% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 50% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE 15	20 19 18 17 16	(15) 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE 8	20 19 18 17 16	15 14 13 12 11	10 9 (8) 7 6	5 4 3 2 1 0

HABITAT ASSESSMENT FIELD DATA SHEET—HIGH GRADIENT STREAMS (BACK)

Parameters to be evaluated broader than sampling reach

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE 2	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 (2) 1 0
7. Frequency of Riffles (or bends)	Occurrence of riffles relatively frequent; ratio of distance between riffles divided by width of the stream <7:1 (generally 5 to 7); variety of habitat is key. In streams where riffles are continuous, placement of boulders or other large, natural obstruction is important.	Occurrence of riffles infrequent; distance between riffles divided by the width of the stream is between 7 to 15.	Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of the stream is between 15 to 25.	Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is a ratio of >25.
SCORE 2	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 (2) 1 0
8. Bank Stability (score each bank) Note: determine left or right side by facing downstream.	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE 10 (LB)	Left Bank (10) 9	8 7 6	5 4 3	2 1 0
SCORE 10 (RB)	Right Bank (10) 9	8 7 6	5 4 3	2 1 0
9. Vegetative Protection (score each bank)	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE 1 (LB)	Left Bank 10 9	8 7 6	5 4 3	2 (1) 0
SCORE 1 (RB)	Right Bank 10 9	8 7 6	5 4 3	2 (1) 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE 1 (LB)	Left Bank 10 9	8 7 6	5 4 3	2 (1) 0
SCORE 1 (RB)	Right Bank 10 9	8 7 6	5 4 3	2 (1) 0

Total Score 59

HABITAT ASSESSMENT FIELD DATA SHEET—HIGH GRADIENT STREAMS (FRONT)

STREAM NAME UT Little Mt Ck	LOCATION Badin Inn
STATION # _____ RIVERMILE _____	STREAM CLASS
LAT _____ LONG _____	RIVER BASIN Yadkin
STORET #	AGENCY
INVESTIGATORS	
FORM COMPLETED BY Ron Johnson	DATE _____ TIME _____ AM PM
REASON FOR SURVEY Post Restoration	

Parameters to be evaluated in sampling reach

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
1. Epifaunal Substrate/ Available Cover	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE 16	20 19 18 17 (16)	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Embeddedness	Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment. Layering of cobble provides diversity of niche space.	Gravel, cobble, and boulder particles are 25-50% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 50-75% surrounded by fine sediment.	Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment.
SCORE 18	20 19 (18) 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Velocity/Depth Regime	All four velocity/depth regimes present (slow-deep, slow-shallow, fast-deep, fast-shallow). (Slow is < 0.3 m/s, deep is > 0.5 m.)	Only 3 of the 4 regimes present (if fast-shallow is missing, score lower than if missing other regimes).	Only 2 of the 4 habitat regimes present (if fast-shallow or slow-shallow are missing, score low).	Dominated by 1 velocity/ depth regime (usually slow-deep).
SCORE 18	20 19 (18) 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than 5% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 50% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE 16	20 19 18 17 (16)	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE 13	20 19 18 17 16	15 14 (13) 12 11	10 9 8 7 6	5 4 3 2 1 0

HABITAT ASSESSMENT FIELD DATA SHEET—HIGH GRADIENT STREAMS (BACK)

Parameters to be evaluated broader than sampling reach

Habitat Parameter	Condition Category: Optimal	Suboptimal	Marginal	Poor
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE 19	20 (19) 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Frequency of Riffles (or bends)	Occurrence of riffles relatively frequent; ratio of distance between riffles divided by width of the stream <7:1 (generally 5 to 7); variety of habitat is key. In streams where riffles are continuous, placement of boulders or other large, natural obstruction is important.	Occurrence of riffles infrequent; distance between riffles divided by the width of the stream is between 7 to 15.	Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of the stream is between 15 to 25.	Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is a ratio of >25.
SCORE 19	20 (19) 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (score each bank) Note: determine left or right side by facing downstream.	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE 9 (LB)	Left Bank 10 (9)	8 7 6	5 4 3	2 1 0
SCORE 9 (RB)	Right Bank 10 (9)	8 7 6	5 4 3	2 1 0
9. Vegetative Protection (score each bank)	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE 10 (LB)	Left Bank (10) 9	8 7 6	5 4 3	2 1 0
SCORE 10 (RB)	Right Bank (10) 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE 7 (LB)	Left Bank 10 9	8 (7) 6	5 4 3	2 1 0
SCORE 7 (RB)	Right Bank 10 9	8 (7) 6	5 4 3	2 1 0

Total Score 171