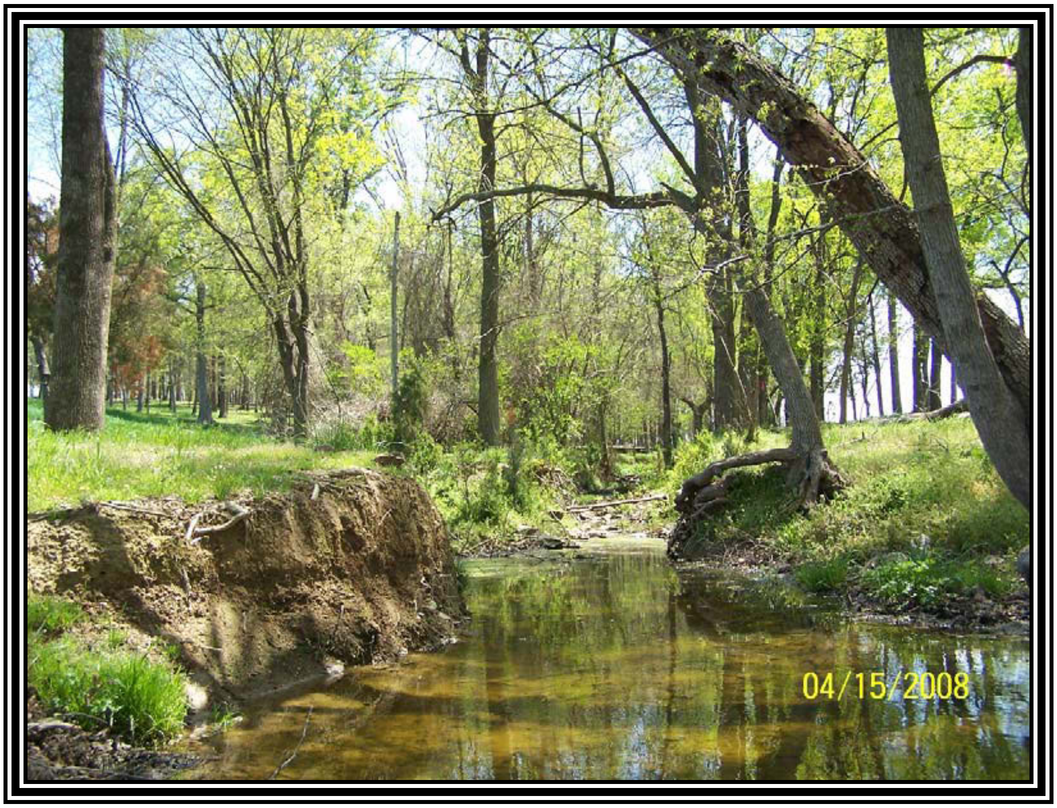
Davis Branch and Unnamed Tributary
Restoration Plan

Union County, North Carolina
SCO # D06054-F



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Submitted: June 23, 2008

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EXECUTIVE SUMMARY

For this project, the goal and objective is to restore physical and biological integrity beyond current stream conditions. Current conditions consist of channelized, modified and impaired stream reaches, exacerbated by nutrient loading from agricultural land use and streambank denuding, destabilization and erosion from cattle intrusion. Restoration of the streams, utilizing methodical and varying mitigation approaches, will provide the desired habitat and stability features necessary to improve the quality of the streams. Objectives to meet these goals are listed below.

- Provide stable stream channels with features characteristic of a biologically diverse environment
- Restore the connection between the bankfull width and floodprone width of the channels by improving the floodplain area
- Stabilize eroding streambanks
- Provide functional, native riparian corridors where deficient, and preserve existing forested corridors
- Improve physical aquatic habitat features
- Minimize land development impacts to the streams
- Provide long-term protection of the stream corridors via perpetual conservation easements

The restoration measures proposed for Davis Branch mainstem and Unnamed Tributary 1 (UT1) will provide the attributes described above by incorporating mitigation approaches to the levels required to support stability and biological diversity essential to ecosystem enhancement. Presently, these features are absent or diminished within the project stream reaches and corridors.

The restoration of the Davis Branch mainstem and UT1 includes assessing and quantifying stable geomorphologic reference reach conditions that is the foundation for the design and construction of stable natural channels. Considerations that have been applied to the design of this project are listed below.

- Channels designed with appropriate bankfull dimensions, cross-sectional areas and profile gradients to convey predicted bankfull flows and entrain bedload readily available to the streams, without aggrading or degrading.
- Channel pattern, profile and dimension extrapolated from data collected at a stable reference reach within the same watershed, physiographic province, ecoregion, geologic setting and valley type as the Davis Branch project reaches.
- Grade control and bank stabilization structures to enhance environmental and ecological attributes of the stream channels through the use of natural materials and indigenous, native revetment.
- In-stream aquatic habitat features, such as riffle-run-pool-glide complexes, and re-establishment of instream, overbank and riparian zone vegetation will provide shade and streambank stability.
- In-stream structures, such as cross-vanes, bank stabilization enhancements, or combinations thereof, constructed using native rock and log structures will be utilized where needed to alleviate near-bank shear stress, provide grade control, stabilize streambanks and create aquatic habitat.
- Reconnection of the stream channels to functional floodplains by making improvements to the stream channels, floodprone areas and riparian zones that restores dimension, pattern and profile based on reference reach conditions.

- Establishment of indigenous instream, overbank and riparian herbaceous ground cover, shrub, understory and canopy species throughout the project riparian corridors, where deficient. Existing vegetation present along the streams will be preserved to the maximum extent practicable.

Proven natural geometry relationships, as described by Newbury, Leopold, Wolman, Miller, Rosgen and others, provide the basis for designing stable, self-maintaining stream channels. Empirical and quantitative relationships between drainage area, discharge, channel pattern, profile and dimension form the foundation for restoring the physical and biological functions of streams. Stream mitigation approaches including preservation, enhancement, and full-scale restoration has been thoroughly evaluated for each project reach, as defined in the multi-agency April 2003 Stream Mitigation Guidelines. Mitigation approaches were evaluated in terms of meeting stated project goals and objectives. Due to historical stream modifications (channelization) and existing agricultural land use impacts (nutrient laden runoff and livestock encroachment), restoring dimension and profile only will not achieve the required level of ecological enhancement needed to return the each of the impaired project reaches to stable, natural conditions.

To achieve the most beneficial outcome, from an ecosystem enhancement perspective, a combination of Preservation, Level I Enhancement and Priority Level I/II restoration is proposed on Davis Branch mainstem. A combination of Enhancement Level II and Priority Level I restoration is proposed for Davis Branch UT1. On the mainstem reach, approximately 766 linear feet (l.f.) will be preserved, 1,802 l.f. will be restored utilizing a Priority Level I/II approach, and 1,229 l.f. will be restored utilizing an Enhancement Level I approach. Approximately 396 l.f. of stream will be restored on UT1, utilizing an Enhancement Level II approach. The final 450 l.f. on UT-1 will be restored utilizing a Priority Level I restoration approach. The sum of the proposed total restored stream lengths designated in this restoration plan is approximately 4,718 l.f. Pre-existing and proposed stream lengths and restoration approach are summarized in the following table, including proposed Stream Mitigation Units (SMUs):

Davis Branch and Unnamed Tributary 1 Restoration Summary
Project Number D06054-F (Davis Branch and Unnamed Tributary 1)

Reach/Approach	Existing Length	Proposed Length	Credit Ratio	SMUs
Davis Branch Preservation	781 l.f.	766 l.f.*	5	153
Davis Branch Priority Level I/II Restoration	1,562 l.f.	1,802 l.f.	1	1,802
Davis Branch Enhancement Level I	1,289 l.f.	1,229 l.f.*	1.5	819
UT1 Enhancement Level II	396 l.f.	396 l.f.	2.5	158
UT1 Priority Level I Restoration	334 l.f.	450 l.f.	1	450
Totals	**4,361 l.f.**	**4,718 l.f.**		**3,383**

*Proposed channel lengths are within the recorded, permanent conservation easement and excludes permanent easement crossings.

The stream restoration project will be monitored for a period of five consecutive years or until the required success criteria has been met as determined by the North Carolina Ecosystem Enhancement Program (EEP), Division of Water Quality (DWQ) and the U.S. Army Corps of Engineers (USACE), Wilmington District. Parameters that will be documented during annual stream monitoring, to ensure the success of the stream restoration project, will include longitudinal profiles and monumented cross-sections stream channel surveys, channel substrate particle distribution analysis, fixed station photography, and vegetation surveys along the stream corridors and riparian buffer zones.

1.0 PROJECT SITE IDENTIFICATION AND LOCATION

1.1 Directions to Project Site

The proposed project is located southeast of Olive Branch Road and west of Marshville-Olive Branch Road, 7.8 miles north-northeast of the town of Marshville, Union County, North Carolina. The site location and vicinity map is presented on **Figure 1**. The project is located on properties owned by Edward Bruce Staton and wife Deborah H. Staton, and Keith Bunyan Staton and wife Phyllis Griffin. The project includes restoration activities along Davis Branch mainstem and one unnamed tributary stream, designated as UT1 throughout this document.

To travel to the site from U.S. Route 74 in Marshville, North Carolina, turn onto North Elm Street (SR 205) and travel 5.3 miles to Olive Branch Road (SR 1006). Turn right onto Olive Branch Road and travel 3.9 miles to 9406 Olive Branch Road (Edward and Deborah Staton Residence). Turn right onto the Staton's driveway, the dedicated egress/ingress access to the recorded EEP Conservation Easement Areas on the Davis Branch and Unnamed Tributary, Stream Restoration Project.

1.2 USGS Hydrologic Unit Code and NCDWQ River Basin Designations

The Davis Branch watershed is located within the USGS 14-digit HUC watershed 03040105070080. Davis Branch is a tributary to Gourdvine Creek, to Richardson Creek to the Rocky River in the Lower Yadkin-Pee Dee River Subbasin 03-07-14, as shown on **Figure 2**. The project is not located within a North Carolina Wetland Restoration Program (WRP) targeted watershed; however, it is located immediately north of Beaverdam Creek WRP Targeted Watershed 81030. The project stream reaches are mapped on North Carolina Department of Transportation, Light Detection and Ranging (LiDAR) March 2005 coverage for Union County, North Carolina as shown on **Figure 3**.

2.0 WATERSHED CHARACTERIZATION

2.1 Drainage Area

The drainage area tributary to the downstream limits of the project on Davis Branch mainstem is 0.3352 square miles or 214.50 acres. The drainage area tributary to the downstream limits of UT1 is 0.0721 square miles or 46.12 acres. The project contribution drainage areas watershed map is presented on **Figure 3**. Drainage areas for the project reaches are summarized in **Table 1**.

TABLE 1
Drainage Areas
Project Number D06054-F (Davis Branch and Unnamed Tributary 1)

Reach	Drainage Area (Acres)
Davis Branch Mainstem (downstream project limits)	214.50
UT1 to Davis Branch*	46.12
Total	214.50

*UT1 drainage area is part of the total drainage area for the project

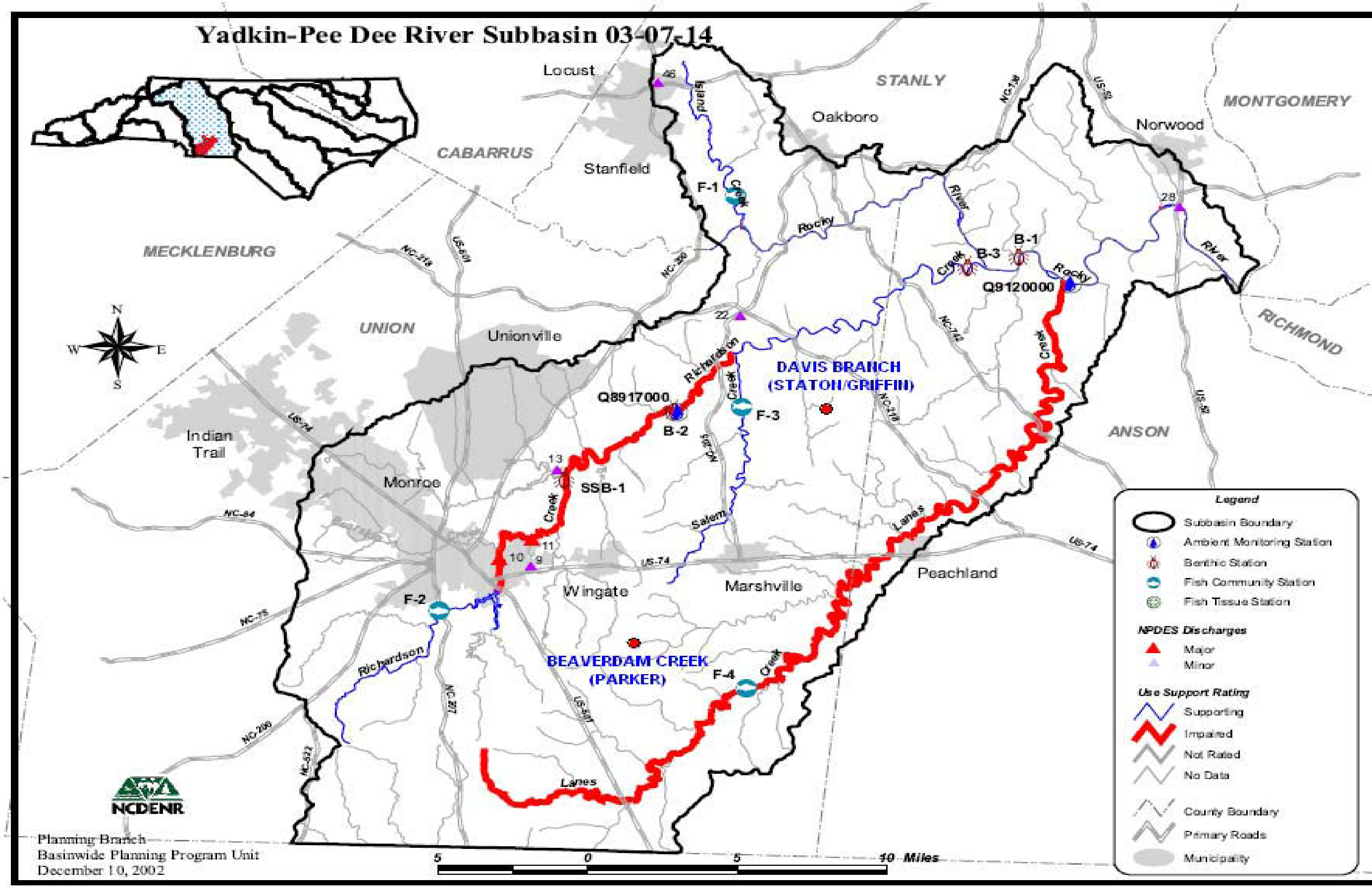
2.2 Surface Water Classification/ Water Quality

As noted in Section 1.2, the Davis Branch watershed is located within the USGS 14-digit HUC Watershed 030401050-70080. Davis Branch and UT1 are first and second order headwater tributaries to Gourdvine Creek of Richardson Creek of the Rocky River in the Lower Yadkin-Pee Dee River Subbasin 03-07-14. Subbasin 03-07-14 includes a portion of the Rocky River including the Richardson Creek and Lanes Creek Watersheds. The Rocky River cuts across the northeast corner of this subbasin from the confluence of Long Creek (Subbasin 03-07-13) to the Pee Dee River. Richardson Creek and Lanes Creek flow in a northeasterly direction into this lowest segment of the Rocky River catchment. Most of the subbasin lies in Union County. Major municipalities include Unionville and Monroe to the west and southwest, respectively. Smaller municipalities include Marshville and Wingate, North Carolina, to the south and south-southwest, respectively.

The Yadkin-Pee Dee River Basin Watershed Restoration Plan (December 2003) notes water quality cannot be generalized across the 420 square mile Rocky River, Richardson Creek and Lanes Creek Watersheds. Based on DWQ monitoring between 1998 and 2001, there are no High Quality or Outstanding Resource Waters in this subbasin. While the Davis Branch restoration project is not located within a targeted WRP watershed in the subbasin, it is a headwater tributary in the Richardson Creek catchment impaired, in large part, by non-point source nutrient and sediment loading from agricultural runoff. Richardson Creek is impaired due to low dissolved oxygen concentrations, excess nutrients and sedimentation. Water chemistry data show extremely high nutrient levels, with high nitrate/nitrite and total phosphorus concentrations. Portions of Richardson Creek are currently listed on the state's draft 303(d) list as of December 2003.

Restoring the project streams and their riparian corridors will help improve instream water quality in the Richardson Creek catchment. This will be accomplished by reducing the volume of erosion of nutrient enriched soils from vertical to undercut, incised streambanks, excluding livestock from the riparian corridors, providing sediment and nutrient storage along the revegetated floodplain areas and riparian corridors, where deficient. and by protecting the restored stream corridors via the recorded, perpetual, 150-feet wide, 13.12 acre conservation easement granted to the State of North Carolina on August 24, 2007, at Deed Book 4666, Page 306 and Deed Book 4666, Page 315, and shown on a Plat of survey at Book K Page 173, Union County Register of Deeds.

The following map shows the Davis Branch and UT1 stream restoration project (NC EEP Project Number D06054-F) in relation to Wetland Resource Center's NC EEP full delivery stream restoration project, Beaverdam Creek and Unnamed Tributaries (NC EEP Project Number D06054-C), in relation to physically and biologically impaired reaches of Richardson Creek and Lanes Creek, respectively. Three USGS 14-digit HUC WRP Targeted Watersheds (03040105-081010, -081020, and -081030) in the adjacent Lanes Creek watershed, southeast from the Davis Branch and Unnamed Tributary project site, have been prioritized as areas with the need and opportunity for stream and wetland restoration efforts by the NC DWQ and NC EEP. The map is from Section B, Chapter 14 of the Yadkin-Pee Dee River Basin Watershed Restoration Plan (December 2003). The Beaverdam Creek project is located in 14-digit HUC 03040105-081030.


Yadkin-Pee Dee River Subbasin 03-07-14
Locust
Stanfield
Oakboro
STANLY
MONTGOMERY
Norwood
CABARRUS
MECKLENBURG
UNION
Unionville
RICHMOND
ANSON
Indian Trail
Monroe
Wingate
Marshville
Peachland
DAVIS BRANCH (STATON/GRIFFIN)
BEAVERDAM CREEK (PARKER)
Q8917000
Q9120000
F-1
F-2
F-3
F-4
B-1
B-2
B-3
SSB-1
Rocky River
Richardson Creek
Lanes Creek
Salem Creek
Island Creek
US-74
NC-200
NC-218
NC-75
NC-84
NC-205
NC-742
NC-218
US-601
US-52
NC-138
Legend
Subbasin Boundary
Ambient Monitoring Station
Benthic Station
Fish Community Station
Fish Tissue Station
NPDES Discharges
Major
Minor
Use Support Rating
Supporting
Impaired
Not Rated
No Data
County Boundary
Primary Roads
Municipality
NCDENR
Planning Branch
Basinwide Planning Program Unit
December 10, 2002
5 0 5 10 Miles

Davis Branch, typical of many of the headwater streams in the Richardson Creek and Lanes Creek catchments, is primarily agricultural land with dug-out impoundments or dammed headwater tributaries used as farm ponds to water livestock. The cited December 2003 basin-wide restoration plan. addressing surface water quality issues in the Richardson and Lanes Creek watersheds, recommends the following actions be taken to improve instream water quality: Reduce nutrients from all sources (agriculture, wastewater infrastructure, and stormwater runoff); widespread implementation of BMPs to control nonpoint sources of pollution, ***particularly from agricultural activities***, throughout the watersheds, and no new discharges of oxygen consuming wastes be permitted on Richardson Creek above the Monroe WWTP. The following photograph, taken at the bottom of the Davis Branch mainstem project reach on March 9, 2006, graphically shows nutrient laden agricultural runoff exacerbated by livestock intrusion, and hoof-shear streambank destabilization leading to erosion and offsite discharge of oxygen consuming agricultural runoff and sedimentation.

Prolific algae bloom and anaerobic stream conditions at the outlet end of the culvert carrying nutrient laden agricultural runoff from the project site under Olive Branch Road, approximately 1,140 l.f. upstream from the confluence of Davis Branch with Gourdvine Creek (August 8, 2006).

The preceding photographs shows the impacts of nutrient enriched runoff and sedimentation from agricultural lands, typical in the Rocky River, Richardson Creek and Lanes Creek Watersheds. Restoration and protection of headwater streams and their riparian corridors, such as proposed in this restoration plan for Davis Branch and UT1, throughout Subbasin 03-07-14 will have a cumulative, positive impact on improving instream water quality, riparian and aquatic habitat.

2.3 Physiography, Geology, and Soils

Physiography

The Davis Branch watershed is located in the Piedmont Physiographic Province of south central North Carolina in the Carolina Slate Belt Ecoregion (Draft Level III and Level IV Ecoregions of North Carolina, USEPA, USDA-NRCS & NCDENR, August 17, 2000). Valley Type VIII (Rosgen, 1996) is most readily identified landform along the lower 2,100 l.f. reach on the mainstem corridor, with subtle terraces positioned laterally along the broad valley (site specific floodprone width varies from 120 to 150 feet) with moderate, down-valley elevation relief. Alluvial terraces and floodplains are the predominant depositional features in this fluvial geomorphologic system and produce a high sediment supply as the landform evolves. On UT1 and the upstream east-west trending reach on the mainstem, the valley narrows and transitions to a moderately steep, gentle sloping side slopes Type II colluvial valley. As shown on **Figure 2** and **Figure 3** the first and second order Davis Branch stream reaches are headwater streams to Richardson Creek. Existing valley slopes for the project reaches range from 0.0170 ft/ft to 0.0249 ft/ft with elevations from the upstream watershed boundary to the mouth of Davis Branch ranging from 526 feet to 390 feet (NAVD 88), with a total watershed elevation relief of 136 feet.

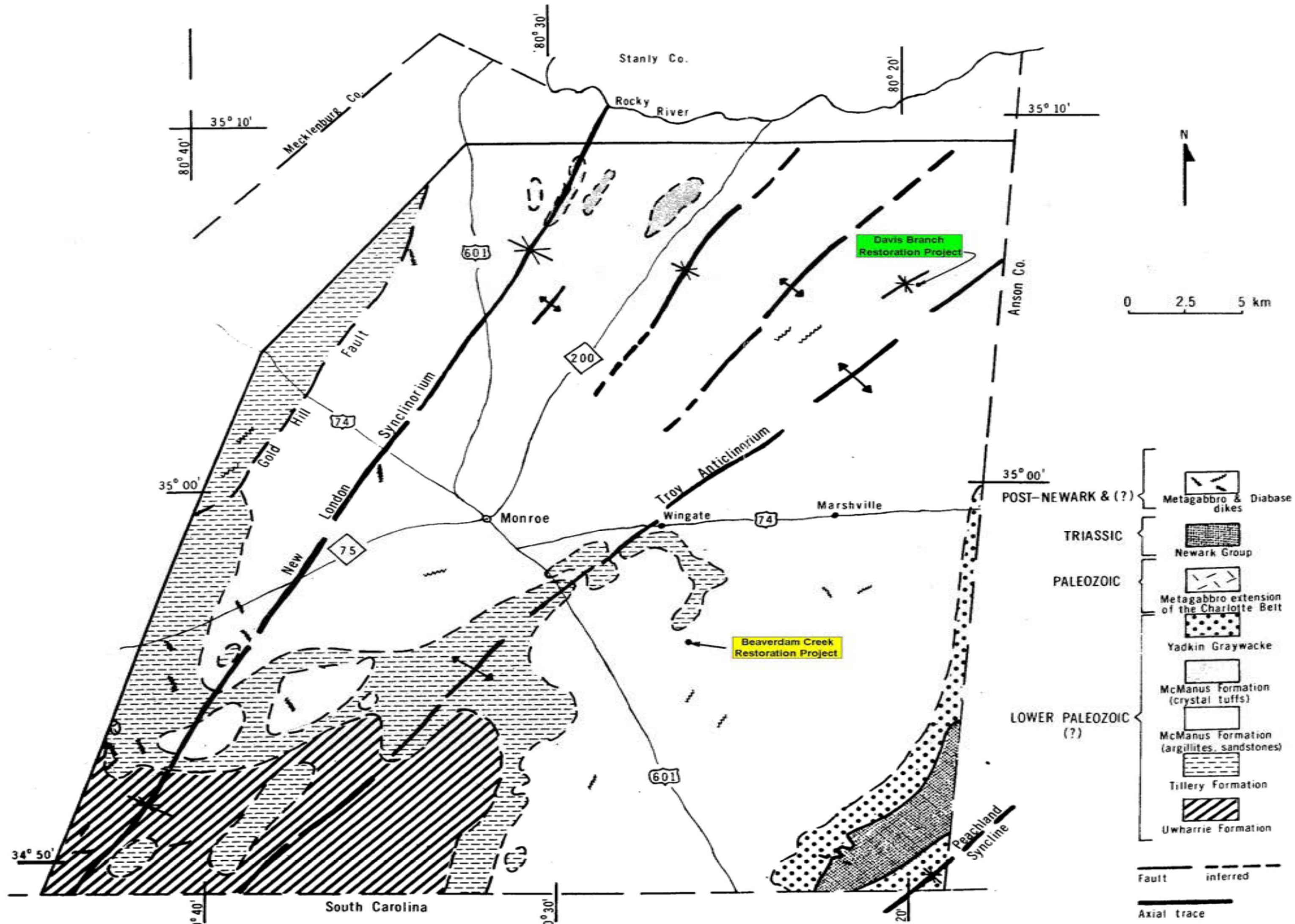
Geology

In the project vicinity, bedrock consists of heated and deformed (metamorphosed) sedimentary and volcanic rock. Bedrock is exposed and outcrops in the streambeds along the mainstem and the lower segment of UT1 where the channels have incised to bedrock. Exposed bedrock is dense, crystalline on a microscopic scale (i.e., grains not visible to the naked eye), slate. The Carolina Slate Belt was the site of a series of oceanic volcanic islands about 550 – 650 million years ago (Pre-Cambrian and Cambrian Systems). Metamorphic rocks that occur in this region include meta-mudstone and meta-argillite (slate), thin to thick bedded, bedding planes and axial-planar cleavage common; interbedded with meta-sandstone, meta-conglomerate and meta-volcanic rock. The project site geology map is presented on **Figure 4** (general bedrock descriptions and mapped extent are from the Geologic Map of North Carolina, NCGS, 1985).

The site is located on the northwest limb of the northeast-southwest trending Troy Anticlinorium. The axial plane strikes N49^{o}E (i.e., fold crest orientation), with a regional bedding plane dip angle of 37^{o} to the northwest. Across the fold axis to the southeast, the regional bedding plane dip angle is somewhat less steep, 29^{o} to the southeast. The Troy Anticlinorium represents a series of local anticlines (upward folded arches) and synclines (downward folded troughs) that regionally form a large anticline. The local folds are open and predominantly asymmetric, mimicking the asymmetric bedding plane geometries of the parent fold. Axial plane cleavage (rock splitting planes essentially parallel to the axial plane of the fold) is best developed where only argillites (i.e., slate - metamorphosed, fine-grained mudstone and clay) are involved in the folding.

Four formations are recognized in the Union County portion of the Carolina Slate Belt – from oldest to youngest, the Uwharrie Formation, Tillery Formation, McManus Formation and Yadkin Formation, that together comprise over 16,500 feet of the Lower Paleozoic Section in south-central North Carolina. The Uwharrie Formation represents a period of extensive volcanism with the formation of crystal lithic and devitrified tuffs, a rock formed from compacted volcanic fragments, generally smaller than four millimeters in diameter, incorporated in a micro-crystalline groundmass. The Tillery Formation consists of thin bedded, laminated argillite with some interbedded non-laminated argillite and sandstone. Thick bedded, tuffaceous argillite characterizes the McManus Formation which also contains an appreciable amount of crystal tuff and very fine-grained sandstone. The youngest unit is the is the Yadkin Graywacke which consists of thick bedded graywacke and laminated argillite. Quartz and igneous intrusions are found in all of the units. The age of the rocks studied is Early Paleozoic, probably Cambrian or Ordovician.

Locally, the site is underlain by the McManus Formation which comprises approximately 11,600 feet, or approximately 70 percent of the Carolina Slate Belt section in Union County, North Carolina. Bedrock is exposed and outcrops in the streambed along the mainstem and the lower segment of UT1 where the channel is incised to bedrock. The Davis Branch reference reach, located on the north side of Olive Branch Road, exhibits strong slate bedrock control. Bedrock exposed in the streambeds is dense, crystalline on a microscopic scale (grains not visible to the naked eye), moderately to steeply dipping fractured, thin to medium bedded slate. (Detailed local structure and stratigraphy from Randazzo, A.F., Petrography and Stratigraphy of the Carolina Slate Belt, Union County, North Carolina, Ph.D. Thesis, University of North Carolina at Chapel Hill, 1968). The structural geologic map on the following page is published in the cited thesis. The following photograph shows typical bedrock streambed conditions on the upper section of the mainstem Enhancement Level I reach.



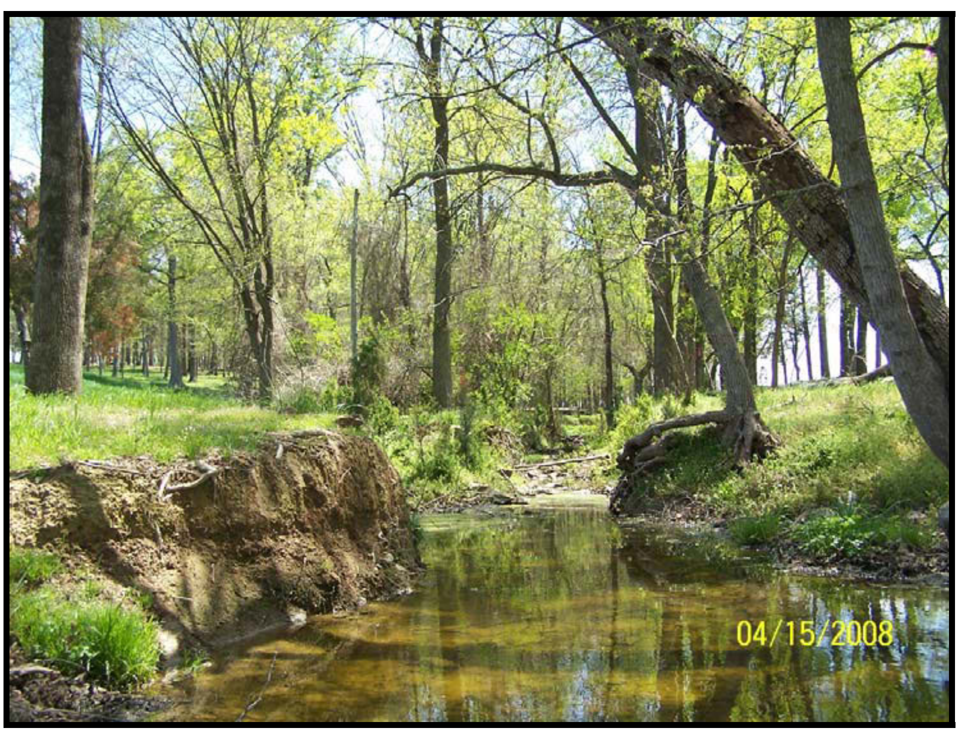
(Randazzo, A.F., 1968)

GEOLOGIC MAP OF THE CAROLINA SLATE BELT, UNION CO., NC

Soils

Figure 5 shows the boundaries of mapped soil units within the project site and vicinity. Soils mapping and taxonomic descriptions are from the USDA NRCS, Soil Survey of Union County, North Carolina (USDA - NRCS, January 1996). The soils along Davis Branch mainstem and UT1 have been derived from and developed over fine-grained metamorphic rock formations (i.e., meta-mudstone and meta-argillite, geologic nomenclatures synonymous with slate).

The predominant soil type mapped on the Davis Branch mainstem is the Cid channery silt loam (map symbol – CmB on Figure 5), 1 to 5 percent slopes. This map unit consists mainly of moderately deep, moderately well drained and somewhat poorly drained, nearly level and gently sloping Cid and similar soils on flats, on ridges in the uplands, in depressions and in headwater drainageways. Typically, the surface layer is light brownish gray channery silt loam 4 inches thick. The subsurface layer is a pale yellow channery silt loam 5 inches thick. The subsoil is 18 inches thick. In the upper part, it is light olive brown silty clay that has light brownish gray mottles. In the lower part, it is mottled grayish brown and light olive brown channery silty clay. Weathered, fractured slate bedrock is encountered at a depth of about 27 inches. Hard, fractured slate bedrock is encountered at a depth of about 32 inches. Permeability is slow in the Cid soil. Average water capacity is low or moderate. The shrink-swell potential is moderate. A seasonal high water table is perched between 1.5 to 2.5 feet below ground surface from December through May. The depth to hard bedrock ranges from 20 to 40 inches. The hazard of erosion is moderate on construction sites if the ground cover is removed. This map unit is used mainly as cropland, hay, pasture or woodland. The following photograph shows the entire Cid pedon section, exposed to erosion along the east (river right) bank of Davis Branch, taken on April 15, 2008, facing upstream.



The next photograph, taken at the bottom of the mainstem reach on March 9, 2006, shows the Cid pedon section, with nutrient laden water, as evidenced by prolific algae bloom, attributed to agricultural runoff exacerbated by livestock intrusion, and hoof-shear streambank destabilization leading to erosion.

Included with the Cid soils on site are areas of Badin channery silt loam (map symbol - BaB), 2 to 8 percent slopes, mapped on river left along the mainstem Priority Level I/II restoration reach on the Staton property and along the mainstem preservation reach on the Griffin property.

The Badin map unit consists mainly of moderately deep, well drained undulating soils on convex upland ridges that are highly dissected by intermittent drainageways. Individual areas are irregular in shape and range from 5 to more than 100 acres in size.

Typically, the surface layer is brown Channery silt loam 7 inches thick. The subsoil is 21 inches thick. In the upper part, it is red silty clay. In the lower part, it is red Channery silty clay loam that has yellow and strong brown mottles. Weathered, fractured slate bedrock is encountered at a depth of about 28 inches. Hard, fractured slate bedrock is at a depth of about 41 inches. In some eroded areas where the upper part of the subsoil has been mixed with the surface soil by plowing, the surface layer is reddish brown Channery silty clay loam.

Permeability is moderate in the Badin soil. Available water capacity is low or moderate. The shrink-swell potential is moderate. The hazard of erosion is moderate in bare or unprotected areas. Flat slate fragments on the surface helps to control erosion. The depth to weathered bedrock ranges from 20 to 40 inches. The depth to hard, fractured slate bedrock is greater than 40 inches. This map unit is used mainly for cropland, pasture and woodland.

An area of Badin Channery silty clay loam, 2 to 8 percent, eroded (map symbol - BdC2) is present along the lower Enhancement Level 1 mainstem reach on Davis Branch. The soil taxonomy is essentially identical to the BaB map unit described in the preceding paragraph. Some primary differences are the BdC2 map unit is poorly suited to cultivated crops because of slope constraints and the eroded surface layer. The hazard of further erosion is very severe. Weathered, fractured slate bedrock is encountered at a depth of about 29 inches. Hard, fractured slate bedrock is encountered at a depth of about 41 inches. The following photograph, taken on April 15, 2008 looking upstream on Davis Branch mainstem Enhancement Level 1 reach, shows the erodible nature of the Badin, BdC2 soil pedon on site, with streambank sloughing in the foreground and vertical, denuded streambanks upstream attributed to cattle intrusion.

Goldston-Badin complex soils (map symbols - GsB and GsC), 2 to 8 and 8 to 15 percent slopes, respectively, are the mapped units on UT-1. GsB soils are mapped along the upper third of the project reach. GsC soils are mapped to the confluence of UT-1 with Davis Branch mainstem.

The GsB component of the mapped unit consists mainly of shallow and moderately deep, well drained to excessively drained, undulating Goldston and Badin soils on ridges in the uplands. The topography is highly dissected by intermittent drainageways. The unit is about 45 percent Goldston soil and about 40 percent Badin soil. The two soils occur as areas so intricately mixed that mapping them separately at the selected scale in not practical. Individual areas are irregular in shape and range from 5 to more than 100 acres in size.

Typically, the surface layer of the Goldston soil is brown very channery silt loam 5 inches thick. The subsoil is light yellow brown very channery silt loam 11 inches thick. Weathered, fractured slate bedrock is typically encountered at a depth of 27 inches. In some places bedrock is exposed at ground surface, resulting in narrow, scattered bands of weathered slate outcrops. In other areas, flagstones (flat slabs of slate) are in and on the surface layer.

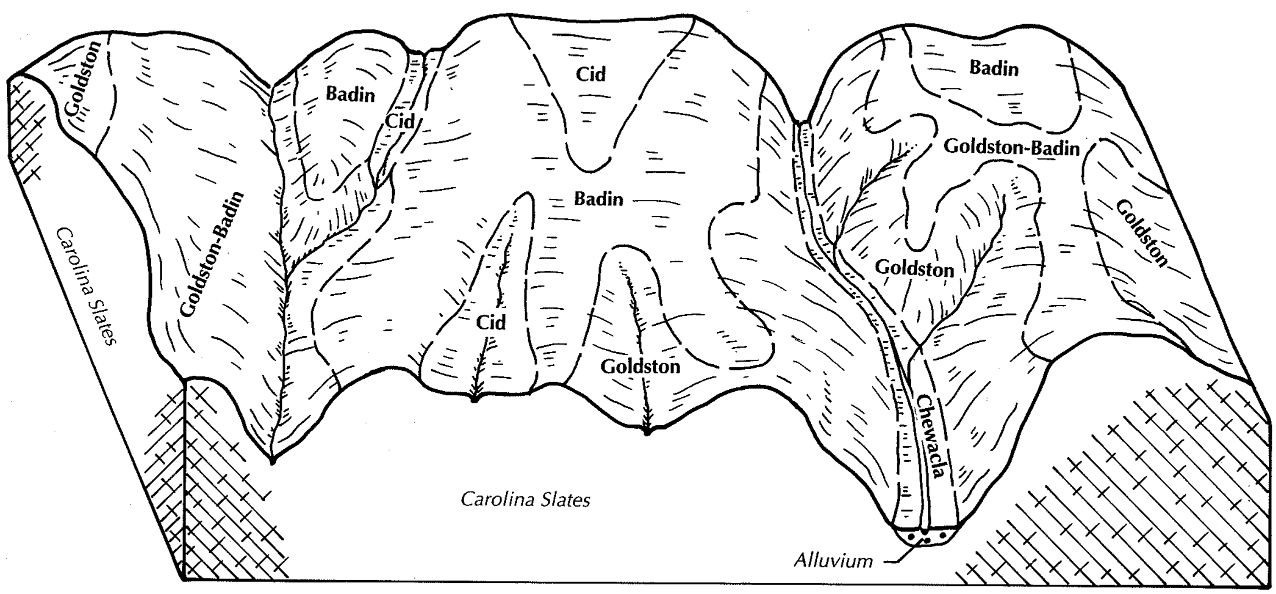
Permeability is moderately rapid in the Goldston soil. Available water capacity is low. The hazard of erosion is moderate in bare or unprotected areas. Flat slate fragments on the surface create a "mulch effect" that helps to hold water in the soil and helps to control erosion. The depth to weathered bedrock ranges from 10 to 20 inches. The depth to hard, fractured slate bedrock ranges from 20 to 40 inches.

The Badin soil is well drained. Typically, the surface layer is brown channery silt loam 7 inches thick. The subsoil is 21 inches thick. In the upper part, it is red silty clay. In the lower part, it is red channery silty clay loam that has yellow and strong brown mottles. Weathered, fractured slate bedrock is encountered at a depth of about 28 inches. Hard, fractured slate bedrock is at a depth of about 41 inches. In some eroded areas where the upper part of the subsoil has been mixed with the surface soil by plowing, the surface layer is reddish brown channery silty clay loam. Permeability is moderate in the Badin soil. Available water capacity is low or moderate. The shrink-swell potential is moderate. The hazard of erosion is moderate in bare or unprotected areas. Flat slate fragments on the surface helps to control erosion. The depth to weathered bedrock ranges from 20 to 40 inches. The depth to hard, fractured slate bedrock is greater than 40 inches. This map unit is used mainly for cropland, pasture and woodland.

The GsB component of Goldston-Badin complex, 8 to 15 percent slopes is mapped along the lower two-thirds of the UT-1 project reach to its confluence with Davis Branch. The GsB mapped soil unit consists mainly of shallow and moderately deep, well drained to excessively drained, undulating Goldston and Badin soils on hillside valley slopes, as opposed to the GsC (2 to 8 percent slopes) soils mapped on ridges in upland areas. The topography is highly dissected by intermittent drainageways. The unit is about 55 percent Goldston soil and about 30 percent Badin soil. The two soils occur as areas so intricately mixed that mapping them separately at the selected scale in not practical. Individual areas are irregular in shape and range from 4 to more than 25 acres in size.

The Goldston soil is well drained to excessively drained and is shallow over bedrock. Typically, the surface layer of the Goldston soil is brown very channery silt loam 5 inches thick. The subsoil is light yellow brown very channery silt loam 11 inches thick. Weathered, fractured slate bedrock is typically encountered at a depth of 16 inches. Hard, fractured slate bedrock is encountered at approximately 27 inches below ground surface In some places bedrock is exposed at ground surface, resulting in narrow, scattered bands of weathered slate outcrops. In other areas, flagstones are in and on the surface layer. Other than shallower accumulated soil thickness attributed to hill slope landform geomorphologic processes associated with steeper land surface slope, as described above, with the GsB component containing a proportionately higher composition of Goldston soil based on slope position, the GsB pedon is otherwise identical to the GsC pedon. The following photograph shows soil conditions near the mouth of UT-1, partially obscured to vegetation on April 15, 2008, characteristic of the on site GsB soil pedon section.

The following block diagram from the cited Soil Survey of Union County is representative of the occurrence of mapped Goldston-Badin-Cid soils on site.



Pattern of soils and parent material in the Goldston-Badin-Cid general soil map unit.

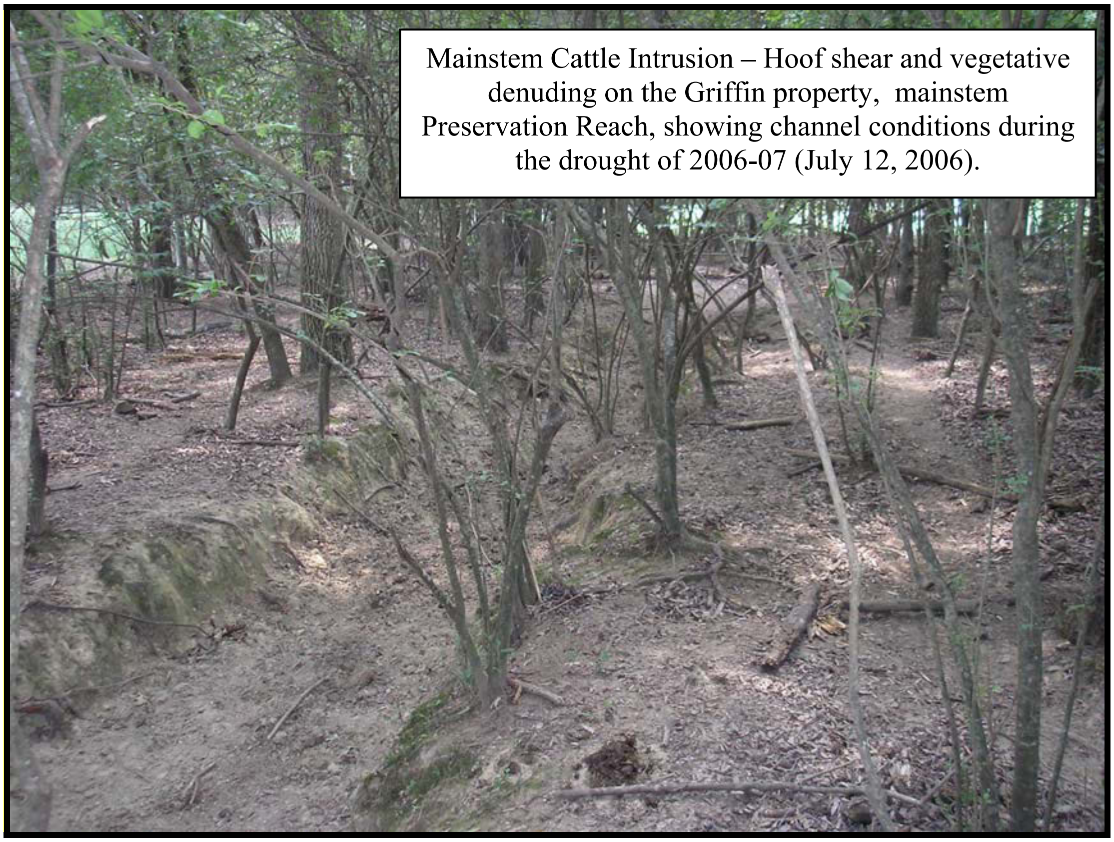
2.4 Historical Land Use and Development Trends

The land surrounding the restoration project is cattle pasture and hay land. Cattle have direct access to the project stream reaches for drinking water, and in areas where established riparian canopy exist, cattle access the project corridors for shade. Presently, the cattle access the stream randomly and, in doing so, have denuded and destabilized streambanks due to grazing, browsing and associated hoof shear. The unstable streambanks and denuded riparian corridors are contributing large quantities of nutrient laden sediment to the project stream reaches. Eroded sediment from the unstable streambanks is transported downstream and off site into the larger Davis Branch, Gourdvine Creek and Richardson Creek watersheds.

Runoff from agricultural land use together with cattle intrusion along the project corridors provides direct nutrient pathways into the project stream reaches. Currently, the upper reach of UT1 has sparse riparian vegetation along its stream corridor. Vegetation along the existing stream corridors is nonfunctional with respect to bank stabilization, nutrient uptake and sediment removal from overland flow (i.e., non-point source pollutants). The approximate lower third of UT1 and the upper Davis Branch mainstem reaches have established hardwood forested riparian corridors. However, cattle intrusion has denuded herbaceous groundcover, and adversely impaired shrub and mid-story canopy vegetation. Cattle intrusion is the primary cause of stream instability on site. This photograph shows the adverse impacts of browsing and grazing of shrub and herbaceous ground cover (vegetative denuding), hoof shear, leading to erosion from destabilized overland sheet flow and streambanks, respectively.

Cattle Intrusion – Denuded mainstem herbaceous ground cover and understory within forested riparian corridor, causing sheet erosion and nutrient laden runoff (July 12, 2006).

Mainstem Cattle Intrusion – Hoof-shear leading to vertical denuded eroding streambanks.



Mainstem Cattle Intrusion – Hoof shear and vegetative denuding on the Griffin property, mainstem Preservation Reach, showing channel conditions during the drought of 2006-07 (July 12, 2006).

The photograph on the following page, taken on April 15, 2008 near the mouth of UT1 shows channel incision, hoof-shear streambank destabilization, and nutrient loading (algae proliferation) from livestock intrusion and agricultural runoff from adjacent, fertilized pasture and hay land.


04/15/2008

Table 2 presents a breakdown of land use within the local watershed and is based upon the USGS National Land Cover Dataset (NLCD, 2001). Land cover within the watershed is presented spatially on **Figure 6**.

TABLE 2
Watershed Land Use Summary
Davis Branch and Unnamed Tributary 1
Project Number D06054-F (Davis Branch and Unnamed Tributary 1)

Description	Count	Sq Meters	Acres	Sq Mi	Percent
Developed, open space	4	3,731	0.9	0.0015	0.43
Developed, Low Intensity	6	4,989	1.2	0.0019	0.57
Deciduous Forest	157	137,202	33.9	0.0530	15.80
Evergreen Forest	28	24,037	5.9	0.0093	2.77
Grassland/Herbaceous	9	9,070	2.2	0.0035	1.04
Hay/Pasture	750	679,913	167.9	0.2624	78.31
Cultivated Crops	14	9,300	2.3	0.0036	1.07
	Totals	**868,241**	**214.5**	**0.3352**	**100.00**

UT1 – Algae proliferation attributed to nutrient enriched runoff from adjacent, fertile pasture and hay land, exacerbated by cattle intrusion.

2.5 Endangered/ Threatened Species

The species listed in **Table 3** are Federally-listed Threatened or Endangered Species in Union County, North Carolina, according to the U.S. Fish and Wildlife Service (FWS) website (http://nc-es.fws.gov/es/countyfr.html):

TABLE 3
Federal Threatened and Endangered Species in Union County
Project Number D06054-F (Davis Branch and Unnamed Tributary 1)

Common Name	Scientific Name	Federal Status	Known Occurrences
Schweinitz's Sunflower	*Helianthus schweinitzii*	Endangered	Current
Carolina heelsplitter	*Lasmigona decorata*	Endangered	Current
Michaux's Sumac	*Rhus michauxii*	Endangered	Current

The "Known Occurrences" column refers to the last time the species was observed in a particular county, according to the species distribution maps from the North Carolina Natural Heritage Program dataset. "Current" means that the species was seen in the county within the last 20 years.

As part of the National Environmental Policy Act (NEPA) compliance procedure for the project, a scoping letter was submitted to the US Fish and Wildlife Service on July 11, 2006 to request information on these species and any comments with respect to endangered species that may arise as a result of this project. This scoping letter included language specifying that a lack of response within 30 days would be assumed to mean the USFWS had no comments or recommendations regarding this project. No response was received within the 30 day period ending August 14, 2006.

A scoping letter was also sent to the National Oceanic and Atmospheric Administration (NOAA)-Fisheries Service, Beaufort Field Office, on July 18, 2006 for comments on any issues related to endangered species of essential fish habitat. During a telephone conversation on July 31, 2006, Mr. Ron Sechler of the NOAA-Fisheries Office stated that he had no comments related to this project.

A request for a site-specific search of the North Carolina Natural Heritage Program Database was made to the North Carolina Department of Environmental and Natural Resources (NCDENR). The search results returned on March 6, 2006 indicated that the database had no record of rare species, significant natural communities, or priority natural areas at the site nor within 1 mile of the project area.

Based on a review of available information, including a site visit, no habitat for any of species listed in Table 3 is apparent on the site. Due to a lack of available habitat, the Davis Branch project is not likely to have an adverse effect on any Federally-listed threatened or endangered species. This information was presented in the Categorical Exclusion report submitted to and accepted by the Federal Highway Administration and State of North Carolina on September 18, 2006.

2.6 Cultural Resources

A scoping letter was submitted to the North Carolina Department of Cultural Resources, State Historic Preservation Office (SHPO) for review. In correspondence dated July 27, 2006, the SHPO indicated that they were aware of no historic resources that would be affected by the project. The SHPO had no comments on the undertaking as proposed.

2.7 Potential Constraints

There are no constraints that have potential to adversely impact or limit improvements associated with the restoration of Davis Branch and Unnamed Tributary 1.

2.7.1 Property Ownership History and Boundary

The project site lies entirely within lands owned by Edward and Deborah Staton (9406 Olive Branch Road, Marshville, North Carolina, 28103), and Keith and Phyllis Griffin (4827 Marshville-Olive Branch Road, Marshville, North Carolina, 28103). The project, in its entirety, is located southeast of Olive Branch Road and west of Marshville-Olive Branch Road, north of the town of Marshville, Union County, North Carolina.

2.7.2 Site Access

The project site is located on properties owned by Edward Bruce Staton and wife Deborah H. Staton (213+/- acres being conveyed to Grantor by deed as recorded in Estate File 5E0057 of the Union County Registry), and Keith Bunyan Staton and wife Phyllis Griffin (20+/- acres being conveyed to Grantor by deed as recorded in Deed Book 797, Page 32 of the Union County Registry). The project includes stream restoration activities along Davis Branch mainstem and one unnamed tributary stream, designated as UT1.

To travel to the dedicated access to the site, from U.S. Route 74 in Marshville, North Carolina, turn onto North Elm Street (SR 205) and travel 5.3 miles to Olive Branch Road (SR 1006). Turn right onto Olive Branch Road and travel 3.9 miles to 9406 Olive Branch Road (Edward and Deborah Staton Residence). Turn right onto the Staton's driveway, which is the dedicated egress/ingress access to the site.

Site access is provided in Conservation Easement Deeds recorded and on file at the Union County, North Carolina Register of Deeds Office in Deed Book, 4666 Page 306 (Staton Parcel), and Deed Book 4666, Page 315 (Griffin Parcel). Site access is shown on a plat of survey entitled "CONSERVATION EASEMENT FOR THE STATE OF NORTH CAROLINA ECOSYSTEM ENHANCEMENT PROGRAM FOR DAVIS BRANCH AND UNNAMED TRIBUTARY" dated May 7, 2007, certified by Steven A. Amos, PLS L-4520, and recorded in Map Book K, Page 173, Union County Register of Deeds on August 24, 2007.

Additionally, the dedicated site egress/ingress is shown on restoration plan sheets RP-01/20 and RP-02/20 in **Appendix 1**.

2.7.3 Utilities

To the best of our knowledge, the project stream reaches and the perpetual conservation easement areas are neither encumbered nor encroached upon by either overhead or underground utilities.

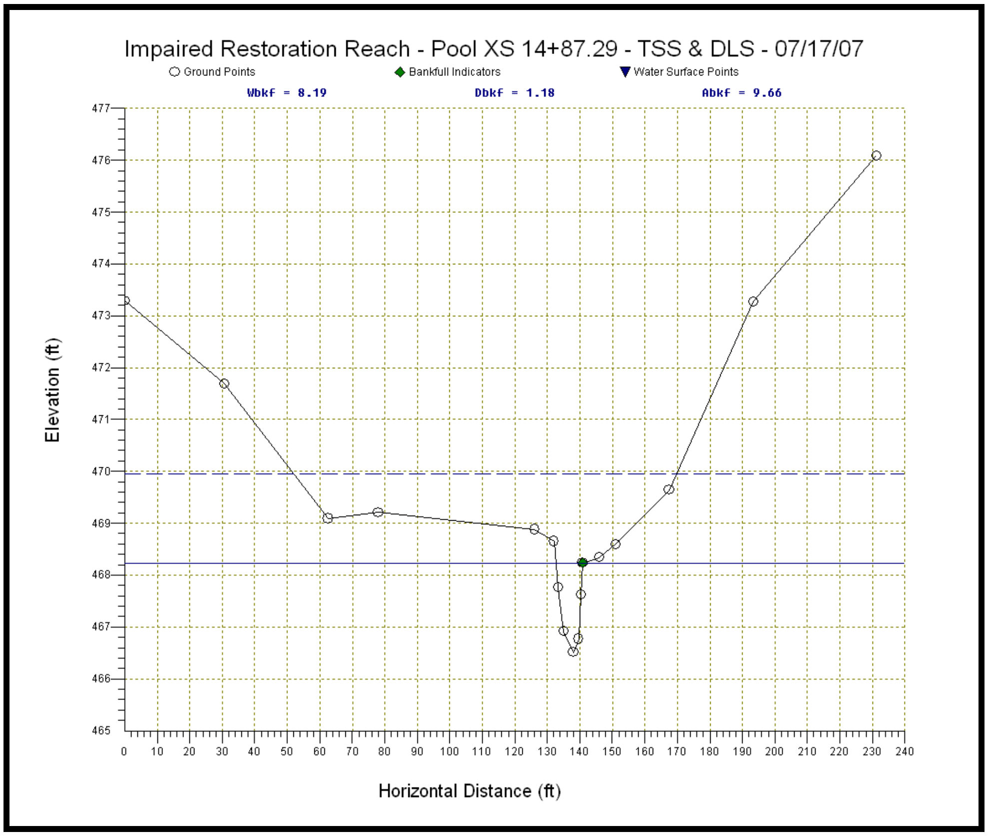
3.0 PROJECT SITE STREAMS

3.1 Channel Classification

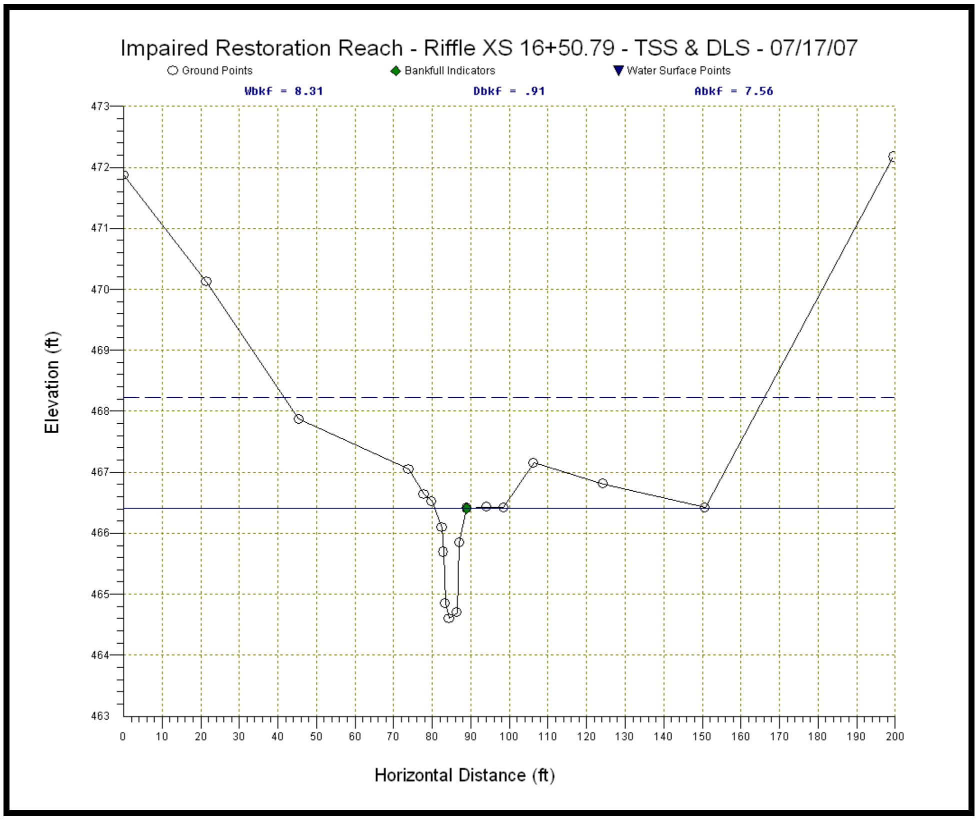
Davis Branch Impaired Mainstem - Priority Level I/II Restoration Reach

North Carolina Division of Water Quality (DWQ) Stream Classification Form was completed for the Davis Branch mainstem and is included in **Appendix 2**. The mainstem received a score of 33.5, classifying it as a perennial channel. The stable, natural channel form for the Davis Branch mainstem restoration reach is a Rosgen E4/1 stream type, based on a detailed Rosgen Level III, quantitative analysis of stable reference reach conditions on August 8-9, 2006. The reference reach is located downstream from the site, beginning at the outlet end of the culvert carrying Davis Branch under Olive Branch Road to the confluence of Davis Branch with Gourdvine Creek. Detailed geomorphologic surveys were conducted along representative segments of each of the impaired project reaches on July 17, 2007.

A number of anthropogenic factors have impacted the stream channel and riparian corridor along the impaired upper mainstem restoration reach, resulting in its present unstable, moderately incised and braided condition. Bank height ratios (BHR) calculated at impaired pool cross-section 14+87.29 and impaired riffle cross-section 16+50.79, located 706 feet and 870 feet downstream from the mainstem preservation reach on the Griffin property, are 1.38 and 1.41, respectively (BHR = Low Bank Height/Bankfull Maximum Depth). Deep channel incision is attributed to uncontrolled cattle intrusion (herbaceous groundcover grazing, shrub vegetation browsing and hoof shear) resulting in a denuded riparian landscape and destabilized, eroding streambanks. Multiple thread channels, created by hydraulic forces that reroute the channel around woody debris and detritus jams (channel avulsions) are present at locations throughout the reach. (Degree of Channel Incision, River Restoration and Natural Channel Design, Rosgen Level 4 Course Field Manual, Rosgen, D.L, 2006).



Impaired Pool Cross-Section 14+87.29, facing upstream, taken during the drought of 2007 (July 17, 2007).



Davis Branch Impaired Riffle Cross-Section 16+50.79, looking upstream at debris jam, taken during the drought of 2007 (July 17, 2007).

In its existing impaired state, upper Davis Branch is transitioning from E4/1 channel dimensions (i.e., width/depth ratio < 12; entrenchment ratio > 2.2) to a multiple thread Rosgen DA4/1 (i.e., width/depth ration < 40; entrenchment ratio > 2.2) stream type albeit under incised conditions along the reach. In addition to cattle intrusion, channelization (impaired conditions sinuosity = 1.12), and an average channel slope of 1.58 percent has increased hydraulic forces (shear stress) acting on the streambed and banks during verified bankfull flows (Q_{bkf} = 24.8 feet^3/sec with a mean velocity of 5.26 feet/sec under impaired conditions). The following impaired conditions cross-section 18+42.50 graphically shows the braided, multi-thread channel characteristic of stream segments throughout the reach.

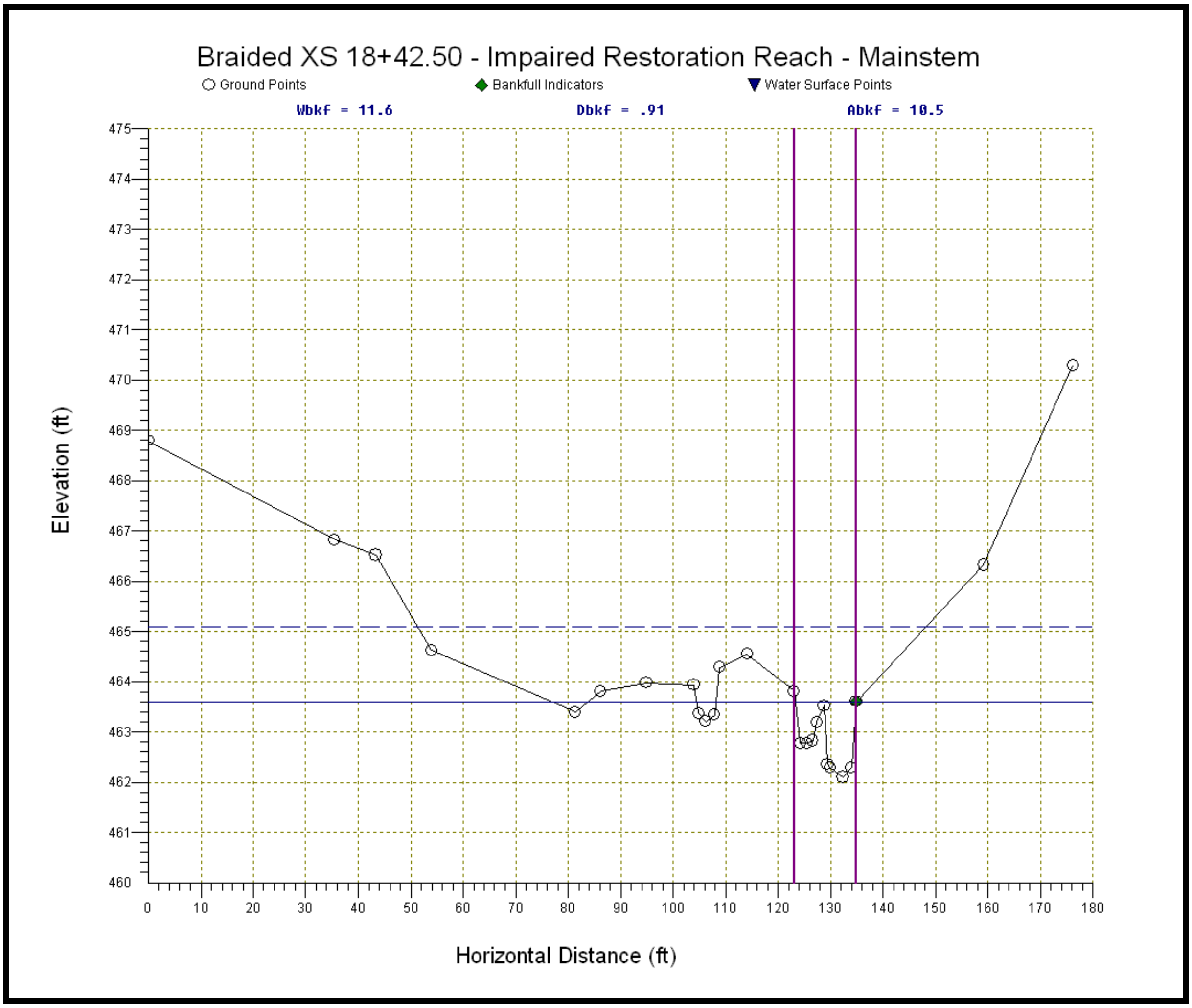
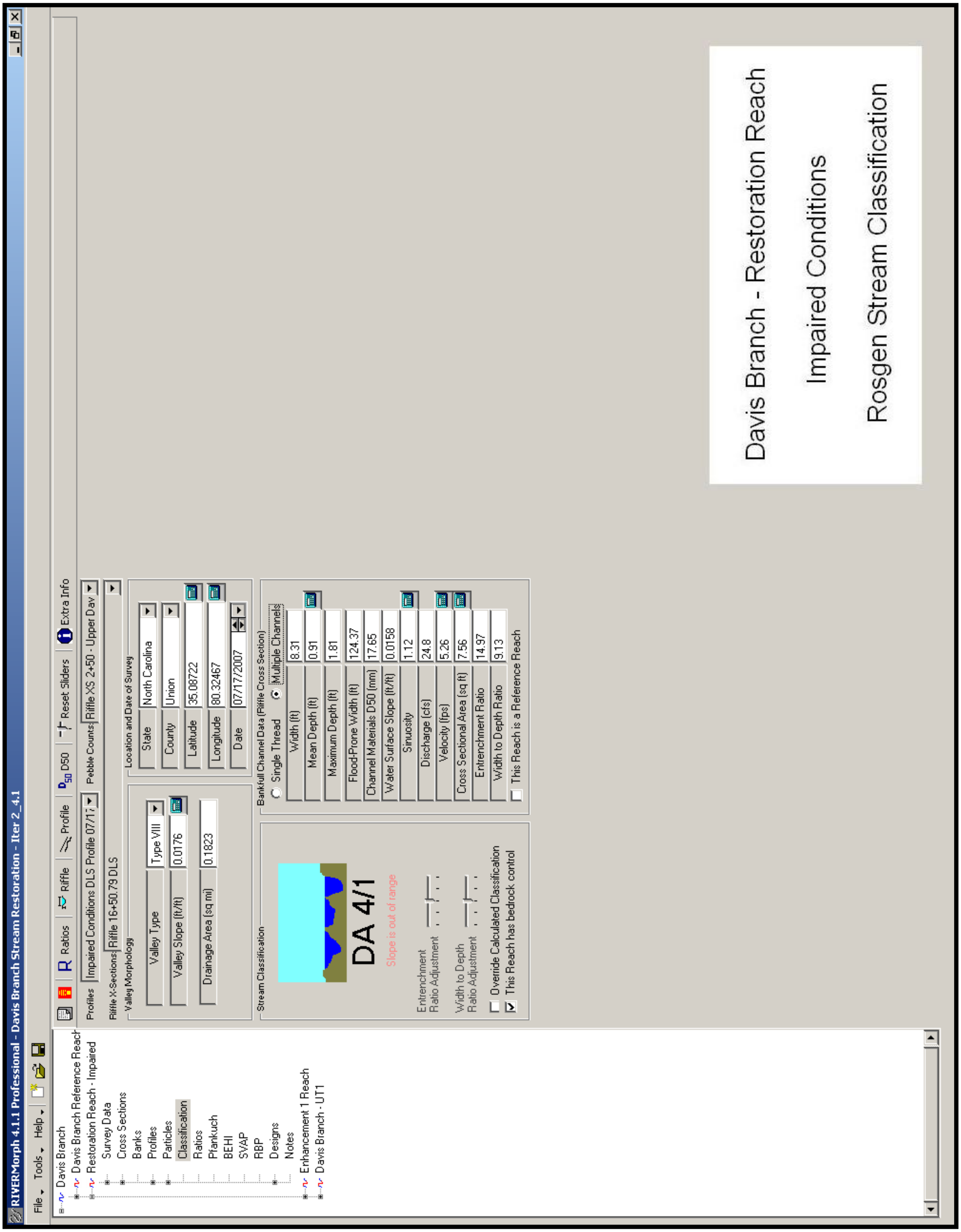
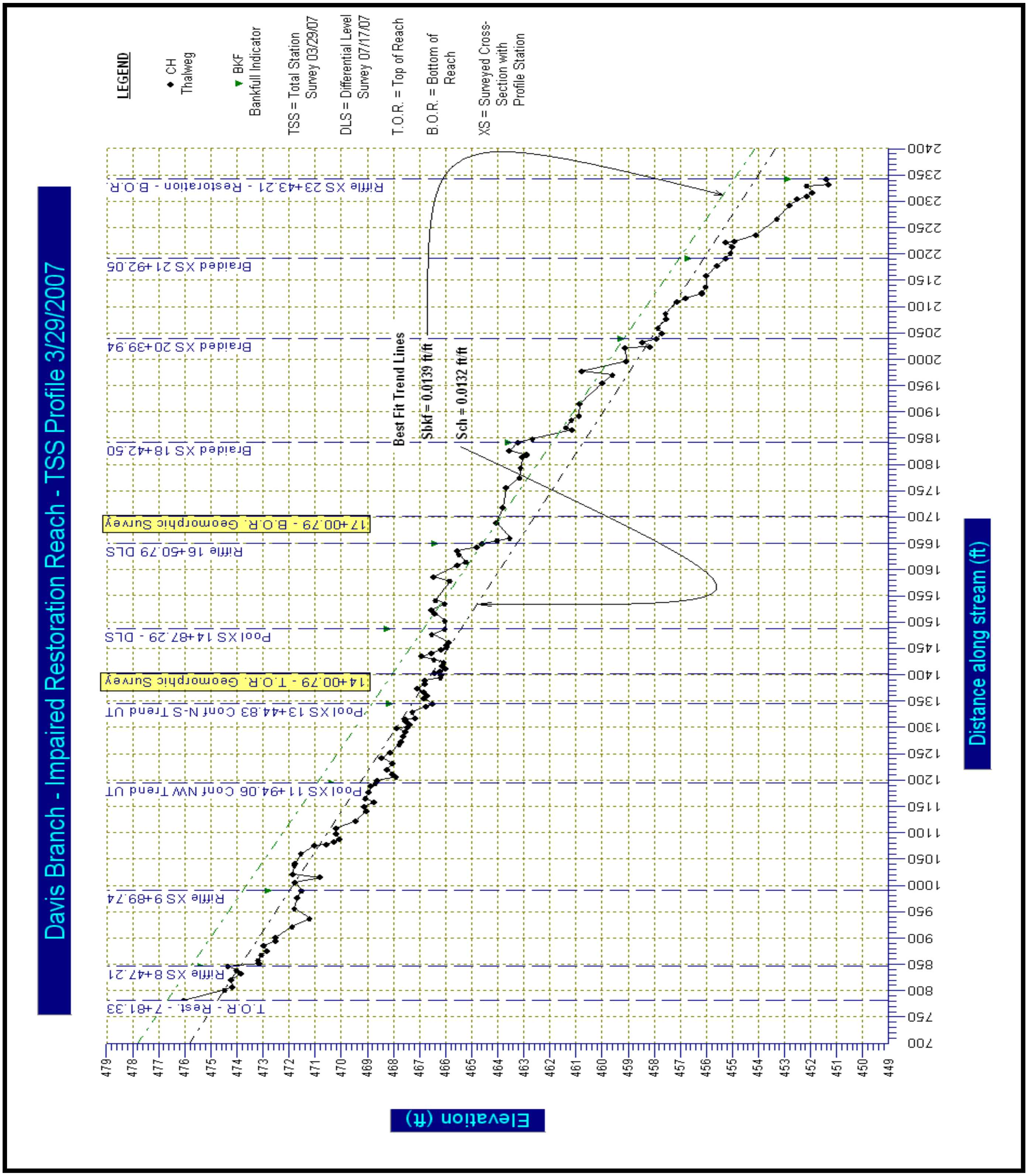


Table 4a provides baseline morphologic and hydraulic summaries for reference, existing and proposed channel dimension, pattern, profile and substrate, along with additional reach parameters for upper Davis Branch. The following screenshot from RiverMorph v. 4.1.1, shows impaired project reach Rosgen stream channel classification, dominant substrate materials readily available to the stream, and morphologic and hydraulic impaired conditions on the Davis Branch mainstem restoration reach. The impaired mainstem restoration reach longitudinal profile is presented following the Rosgen Classification screen capture. Supporting impaired conditions documentation is included with the information in **Appendix 3**.


RIVERMorph 4.1.1 Professional - Davis Branch Stream Restoration - Iter 2_4.1
Davis Branch - Restoration Reach
Impaired Conditions
Rosgen Stream Classification
Davis Branch Reference Reach
Restoration Reach - Impaired
Survey Data
Cross Sections
Banks
Profiles
Particles
Classification
Ratios
Pfankuch
BEHI
SVAP
RBP
Designs
Notes
Enhancement 1 Reach
Davis Branch - UT1
Profiles: Impaired Conditions DLS Profile 07/17
Pebble Counts: Riffle XS 2+50 - Upper Dav
Riffle X-Sections: Riffle 16+50.79 DLS
Valley Morphology
Valley Type: Type VIII
Valley Slope (ft/ft): 0.0176
Drainage Area (sq mi): 0.1823
Location and Date of Survey
State: North Carolina
County: Union
Latitude: 35.08722
Longitude: 80.32467
Date: 07/17/2007
Stream Classification
DA 4/1
Slope is out of range
Entrenchment Ratio Adjustment
Width to Depth Ratio Adjustment
Override Calculated Classification
This Reach has bedrock control
Bankfull Channel Data (Riffle Cross Section)
Single Thread
Multiple Channels
Width (ft): 8.31
Mean Depth (ft): 0.91
Maximum Depth (ft): 1.81
Flood-Prone Width (ft): 124.37
Channel Materials D50 (mm): 17.65
Water Surface Slope (ft/ft): 0.0158
Sinuosity: 1.12
Discharge (cfs): 24.8
Velocity (fps): 5.26
Cross Sectional Area (sq ft): 7.56
Entrenchment Ratio: 14.97
Width to Depth Ratio: 9.13
This Reach is a Reference Reach

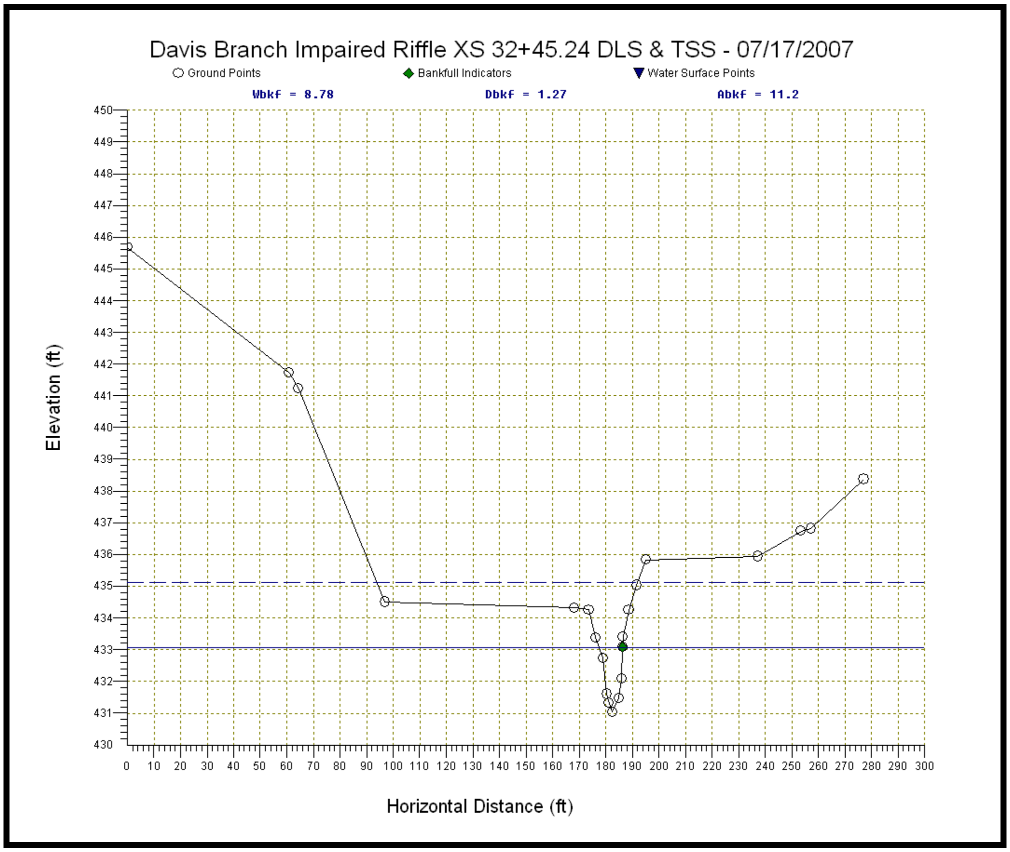


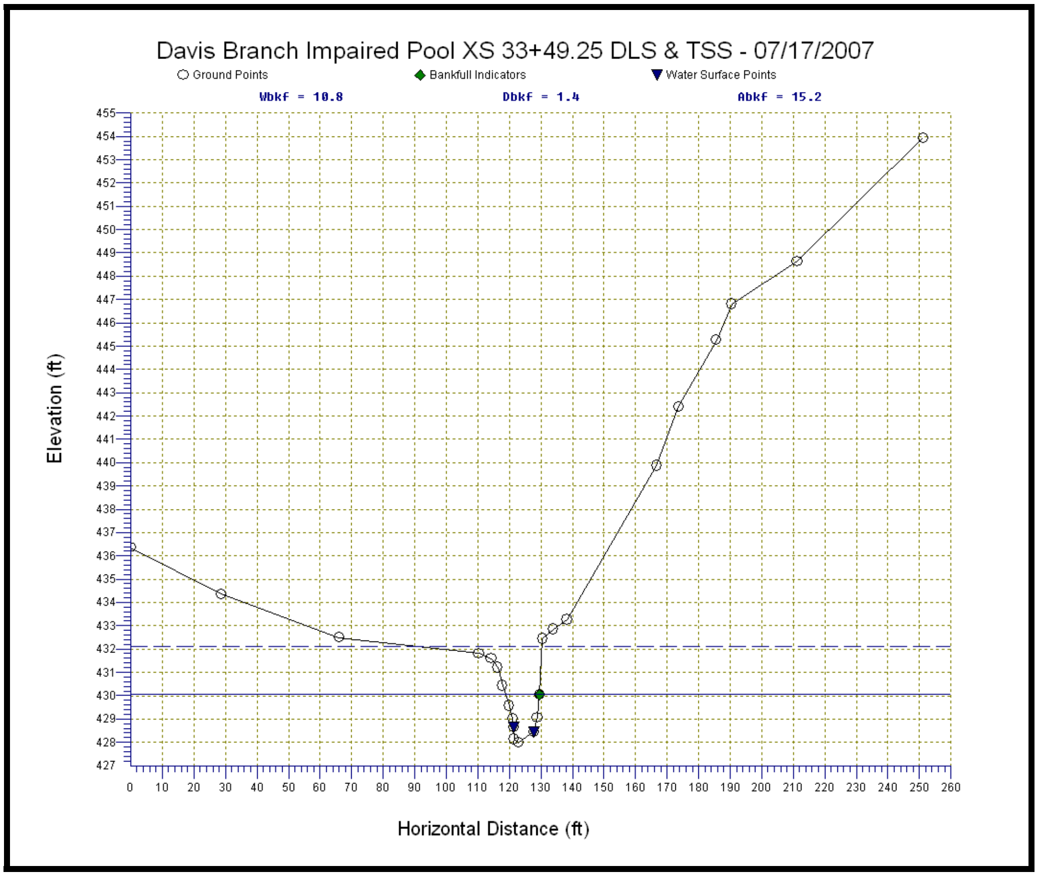
Davis Branch - Impaired Restoration Reach - TSS Profile 3/29/2007
Elevation (ft)
Distance along stream (ft)
LEGEND
CH Thalweg
BKF Bankfull Indicator
TSS = Total Station Survey 03/29/07
DLS = Differential Level Survey 07/17/07
T.O.R. = Top of Reach
B.O.R. = Bottom of Reach
XS = Surveyed Cross-Section with Profile Station
Best Fit Trend Lines
Sbkf = 0.0139 ft/ft
Sch = 0.0132 ft/ft
T.O.R. - Rest. - 7+81.33
Riffle XS 8+47.21
Riffle XS 9+89.74
Pool XS 11+94.06 Conf NW Trend UT
Pool XS 13+44.83 Conf N-S Trend UT
14+00.79 - T.O.R. Geomorphic Survey
Pool XS 14+87.29 - DLS
Riffle 16+50.79 DLS
17+00.79 - B.O.R. Geomorphic Survey
Braided XS 18+42.50
Braided XS 20+39.94
Braided XS 21+92.05
Riffle XS 23+43.21 - Restoration - B.O.R.

Davis Branch Enhancement Level II Reach

North Carolina Division of Water Quality (DWQ) Stream Classification Form was completed for the Davis Branch mainstem and is included in **Appendix 2**. The mainstem received a score of 33.5, classifying it as a perennial channel. The stable, natural channel form for the Davis Branch mainstem Enhancement Level II reach is a Rosgen E3/1b stream type, based on a detailed Rosgen Level III, quantitative analysis of a stable reference reach conditions on August 8-9, 2006. A detailed geomorphic survey on the impaired project reach was conducted on July 17, 2007.

A number of anthropogenic factors have impacted the stream channel and riparian corridor along the impaired lower mainstem enhancement reach, resulting in its present unstable, channelized, deeply incised condition. Bank height ratios were calculated at impaired riffle cross-section 32+45.24 and impaired pool cross-section 33+49.25, located 85.3 and 187.5 feet downstream from the confluence of UT1 with the mainstem, are 1.58 and 1.86, respectively. Deep channel incision is attributed to uncontrolled cattle intrusion (streambank hoof shear destabilization), steep channel gradient (2.13 percent), linear channel alignment (channel sinuosity = 1.06). The cumulative effect of these factors has resulted in nearly 5 feet high, vertical eroding streambanks on the lower Davis Branch mainstem reach. Cross-section photographs, facing downstream, were taken during the impaired conditions geomorphic survey on August 17, 2007.

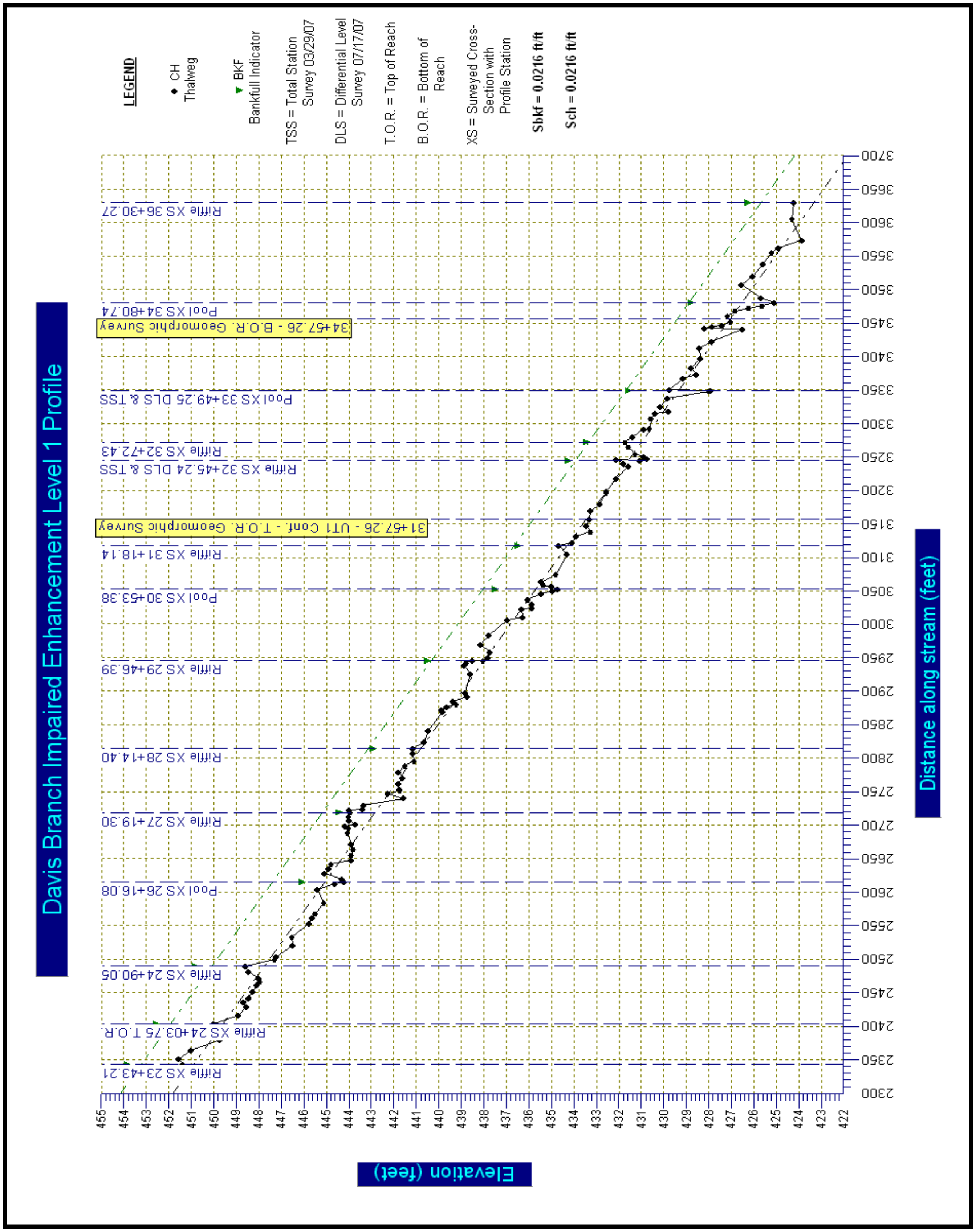

Davis Branch Impaired Riffle XS 32+45.24 DLS & TSS - 07/17/2007
Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 8.78
Dbkf = 1.27
Abkf = 11.2
Elevation (ft)
Horizontal Distance (ft)

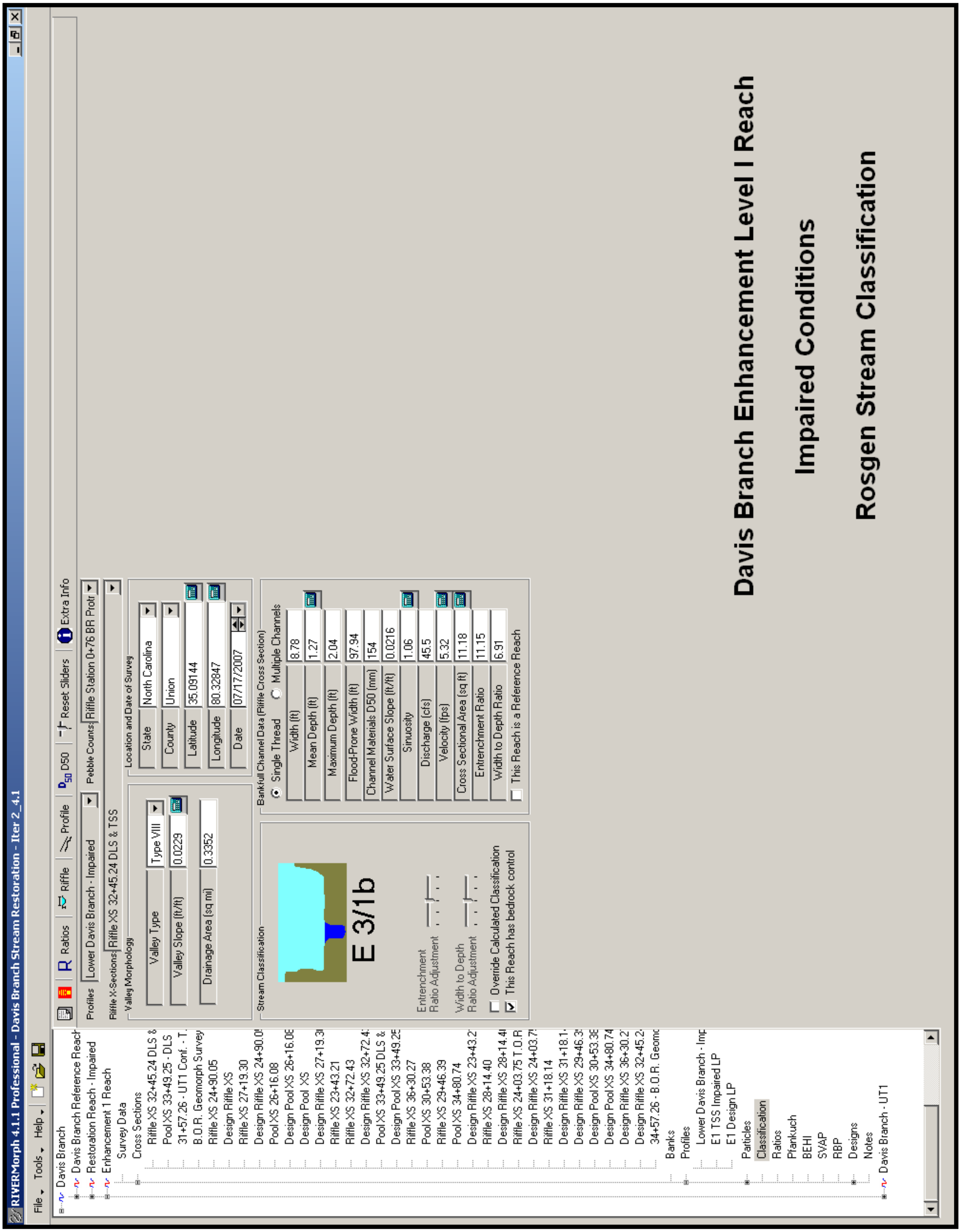

Davis Branch Impaired Pool XS 33+49.25 DLS & TSS - 07/17/2007
Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 10.8
Dbkf = 1.4
Abkf = 15.2
Elevation (ft)
Horizontal Distance (ft)

,

With a linear channel sinuosity of 1.06, an average profile slope of 2.16 percent, verified bankfull discharge at 45.5 cubic feet per second, and mean bankfull velocity approaching 5.5 feet per second, the channel has incised (degraded) to bedrock. With no pattern to decrease gradient velocity, the channel has compensated by eroding away its vertically confined streambanks, resulting in an over-widened, over-deepened channel with unstable width/depth relationships.

Under reference reach boundary conditions downstream on Davis Branch, where Rosgen stream type, width/depth, pool to pool spacings, riffle lengths, riffle slopes, average profile slope, channel dimensions and pattern relationships are within normal ranges for the Carolina Slate Belt ecologic, geologic and physiographic region, the streambed and banks are inherently stable. The challenging design approach to stabilize the final 1,289 linear feet of the mainstem project reach, without the benefit of decreasing velocity gradient by adding pattern, is presented in Section 5.0. **Table 4b** provides baseline morphologic and hydraulic summaries for reference, existing and proposed channel dimension, profile and substrate, along with additional reach parameters for lower Davis Branch. The following longitudinal profile, created in RiverMorph v. 4.1.1, shows the Enhancement Level I impaired mainstem project reach, with locations of impaired conditions cross-sections shown on the profile. Following the impaired conditions longitudinal profile, the impaired conditions Rosgen stream channel classification, dominant substrate materials readily available to the lower mainstem reach, and geomorphologic parameters and hydraulic geometries from representative impaired riffle cross-section 32+45.24, surveyed in the field on July 17, 2007 utilizing differential level survey (DLS) techniques, are presented. Supporting documentation for the impaired conditions geomorphic assessment on the mainstem Enhancement Level I reach is presented in **Appendix 3**.

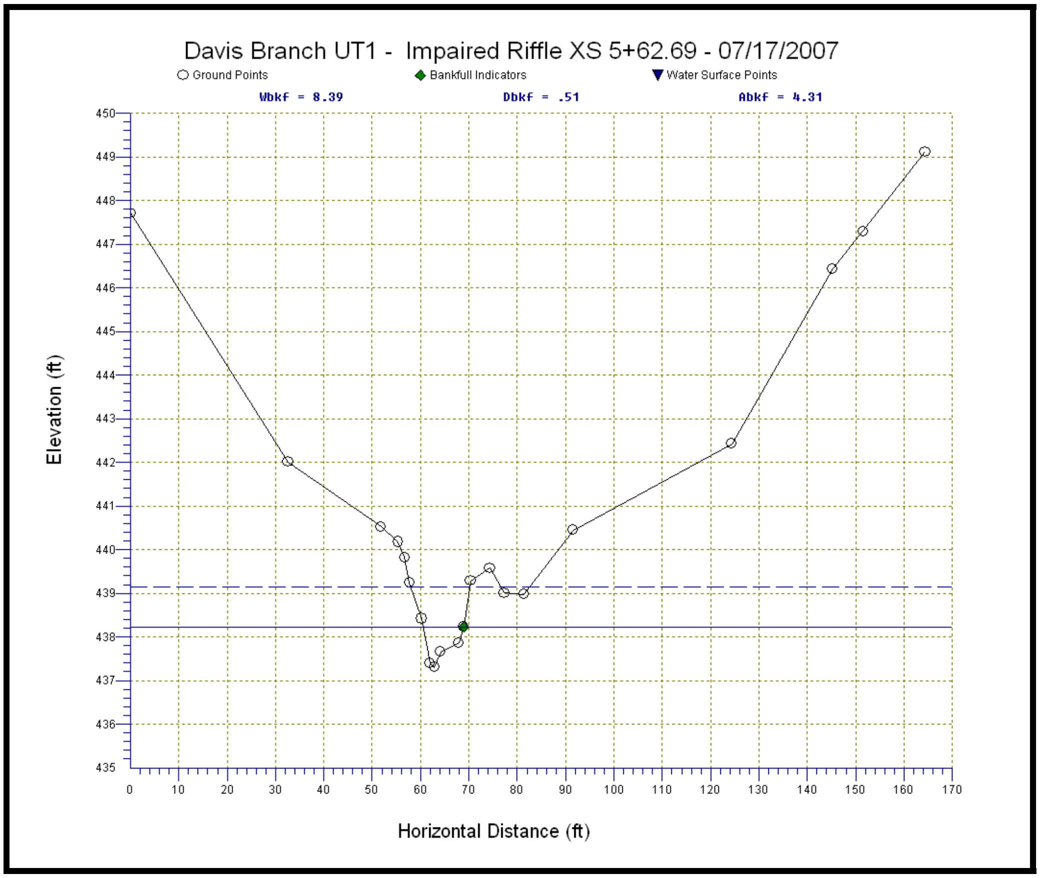

Davis Branch Impaired Enhancement Level 1 Profile
LEGEND
CH Thalweg
BKF Bankfull Indicator
TSS = Total Station Survey 03/29/07
DLS = Differential Level Survey 07/17/07
T.O.R. = Top of Reach
B.O.R. = Bottom of Reach
XS = Surveyed Cross-Section with Profile Station
Sbkf = 0.0216 ft/ft
Sch = 0.0216 ft/ft
Riffle XS 36+30.27
Pool XS 34+80.74
34+57.26 - B.O.R. Geomorphic Survey
Pool XS 33+49.25 DLS & TSS
Riffle XS 32+72.43
Riffle XS 32+45.24 DLS & TSS
31+57.26 - UT1 Conf. - T.O.R. Geomorphic Survey
Riffle XS 31+18.14
Pool XS 30+53.38
Riffle XS 29+46.39
Riffle XS 28+14.40
Riffle XS 27+19.30
Pool XS 26+16.08
Riffle XS 24+90.05
Riffle XS 24+03.75 T.O.R.
Riffle XS 23+43.21
Elevation (feet)
Distance along stream (feet)

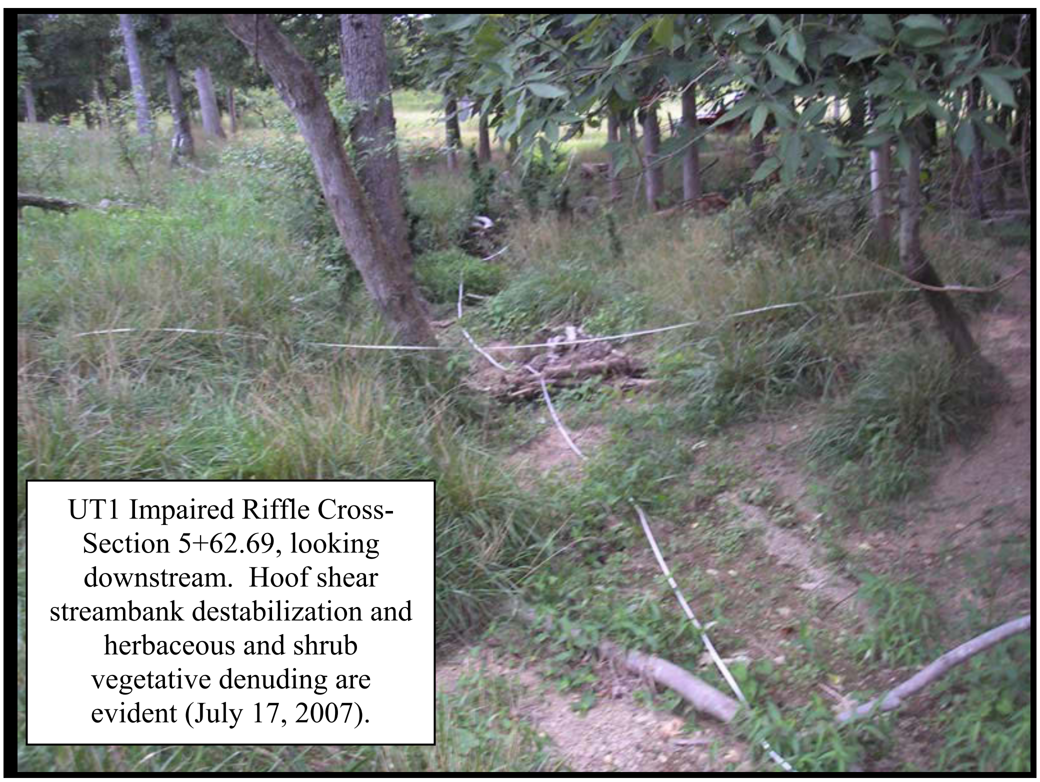

RIVERMorph 4.1.1 Professional - Davis Branch Stream Restoration - Iter 2_4.1
Davis Branch Enhancement Level I Reach
Impaired Conditions
Rosgen Stream Classification
E 3/1b
State North Carolina
County Union
Latitude 35.09144
Longitude 80.32847
Date 07/17/2007
Valley Type Type VIII
Valley Slope (ft/ft) 0.0229
Drainage Area (sq mi) 0.3352
Width (ft) 8.78
Mean Depth (ft) 1.27
Maximum Depth (ft) 2.04
Flood-Prone Width (ft) 97.94
Channel Materials D50 (mm) 154
Water Surface Slope (ft/ft) 0.0216
Sinuosity 1.06
Discharge (cfs) 45.5
Velocity (fps) 5.32
Cross Sectional Area (sq ft) 11.18
Entrenchment Ratio 11.15
Width to Depth Ratio 6.91

UT1 to Davis Branch

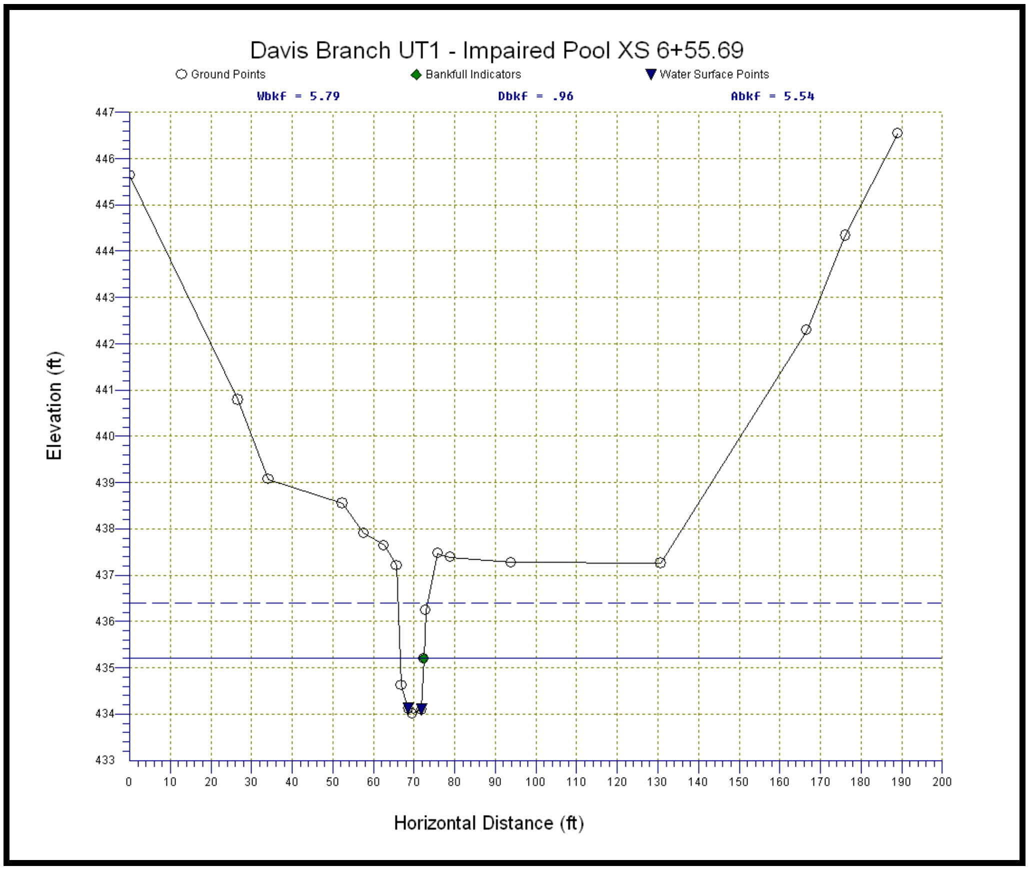
The North Carolina DWQ Stream Classification Form was completed for UT1 and is included in **Appendix 2**. UT1 received a score of 34, classifying it as a perennial channel. The stable, natural channel form for the Davis Branch UT1 reach is a Rosgen E4/1b stream type, based on a detailed Rosgen Level III, quantitative analysis of a stable reference reach conditions on August 8-9, 2006 combined with a detailed geomorphic survey of the final 240 linear feet of the impaired project reach, conducted on July 17, 2007.

A number of anthropogenic factors have impacted the stream channel and riparian corridor along the impaired UT1 reach (existing conditions profile station 0+00.00 to 7+29.60) resulting in its present channelized, deeply incised unstable condition. Bank height ratios were calculated at impaired profile stations 5+62.69, 6+13.69 and 7+24.30 corresponding to representative existing conditions riffle cross-section locations. Low bank heights ranged from 1.78 to 3.45 feet, with a mean of 2.50 feet. Corresponding bank height ratios are 2.47, 3.67 and 2.32, respectively, with a mean BHR of 2.82. The extreme degree of channel incision is attributed to uncontrolled cattle intrusion (hoof shear), steep profile gradient (0.0230 ft/ft), linear channel alignment (sinuosity = 1.09) and high bankfull mean velocity (6.58 ft/sec). The cumulative effects of these impacts has resulted in nearly 4 feet high, vertical, unstable eroding streambanks on the impaired UT1 reach. Impaired pool cross-section 6+55.69 and riffle cross-section 5+62.69, located 71 and 164 feet upstream from the confluence of UT1 with Davis Branch mainstem, respectively, are presented below. Photographs at the line of section, facing downstream, were taken during the impaired conditions geomorphic survey on July 17, 2007 under extreme drought conditions. The degree of channel incision increases from the top to the bottom of the reach as shown by the best fit trend lines through low bank elevation points plotted on the impaired conditions longitudinal profile, presented following the impaired conditions riffle and pool cross-sections.

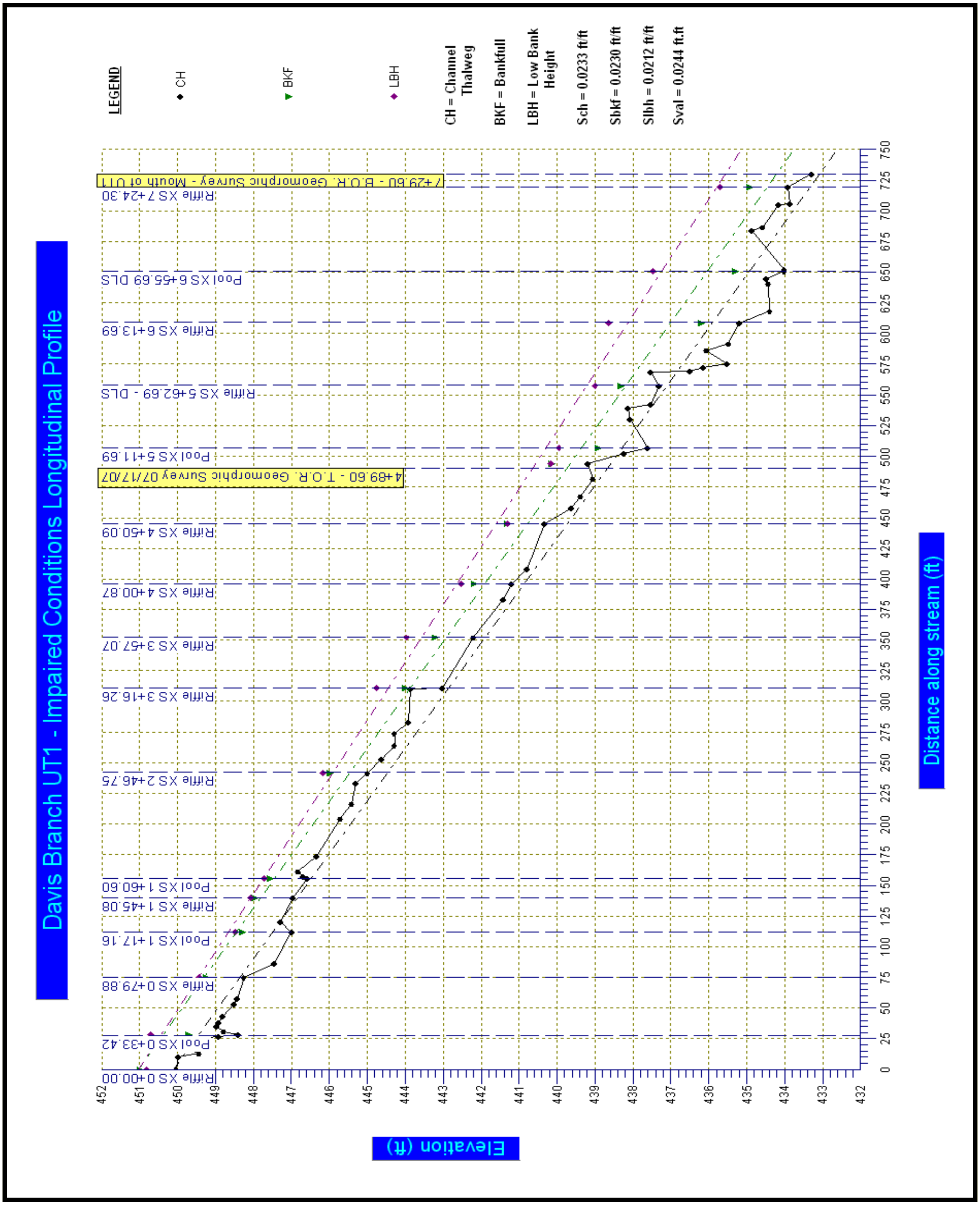


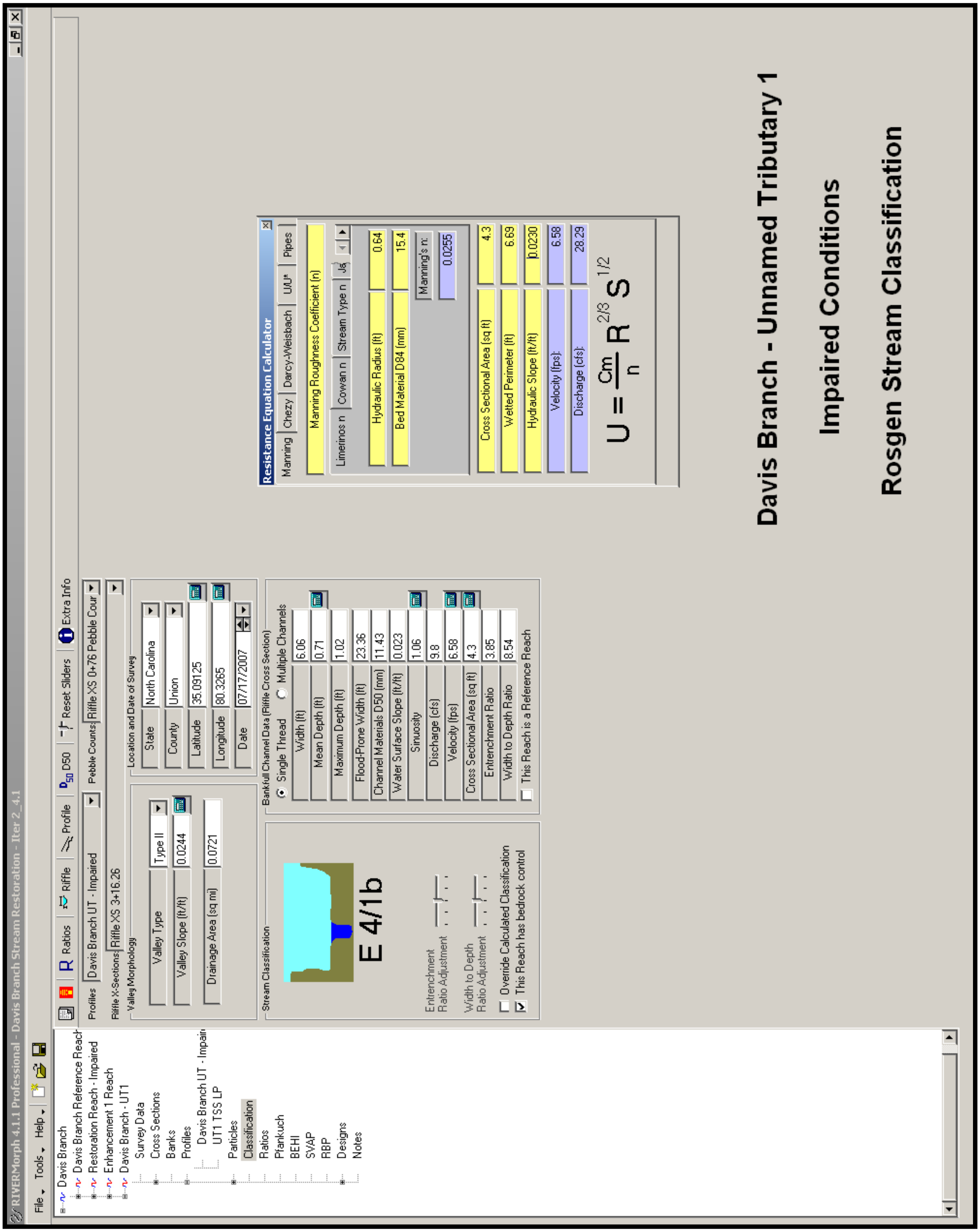


UT1 Impaired Riffle Cross-Section 5+62.69, looking downstream. Hoof shear streambank destabilization and herbaceous and shrub vegetative denuding are evident (July 17, 2007).



Impaired pool cross-section 6+55.69, 71 feet upstream from the confluence of UT1 with Davis Branch (July 17, 2007).


Davis Branch UT1 - Impaired Conditions Longitudinal Profile
LEGEND
CH
BKF
LBH
CH = Channel Thalweg
BKF = Bankfull
LBH = Low Bank Height
Sch = 0.0233 ft/ft
Sbkf = 0.0230 ft/ft
Slbh = 0.0212 ft/ft
Sval = 0.0244 ft.ft
7+29.60 - B.O.R. Geomorphic Survey - Mouth of UT1
4+89.60 - T.O.R. Geomorphic Survey 07/17/07
Riffle XS 0+00.00
Pool XS 0+33.42
Riffle XS 0+79.88
Pool XS 1+17.16
Riffle XS 1+45.08
Pool XS 1+60.60
Riffle XS 2+46.75
Riffle XS 3+16.26
Riffle XS 3+57.07
Riffle XS 4+00.87
Riffle XS 4+50.09
Pool XS 5+11.69
Riffle XS 5+62.69 - DLS
Riffle XS 6+13.69
Pool XS 6+55.69 DLS
Riffle XS 7+24.30
Elevation (ft)
Distance along stream (ft)


RIVERMorph 4.1.1 Professional - Davis Branch Stream Restoration - Iter 2_4.1
Resistance Equation Calculator
Manning Roughness Coefficient (n)
Hydraulic Radius (ft) 0.64
Bed Material D84 (mm) 15.4
Manning's n: 0.0255
Cross Sectional Area (sq ft) 4.3
Wetted Perimeter (ft) 6.63
Hydraulic Slope (ft/ft) 0.0230
Velocity (fps): 6.58
Discharge (cfs): 28.29
E 4/1b
Davis Branch - Unnamed Tributary 1
Impaired Conditions
Rosgen Stream Classification

In its existing impaired state, UT1 maintains E4/1b channel morphology, based on dimensions measured at impaired reach riffle cross-sections, albeit under incised conditions. **Tables 4c** and **Table 4d** provide baseline geomorphologic and hydraulic summary for reference, existing and proposed channel dimension, pattern and profile, along with addition reach parameters. The preceding screenshot from RiverMorph v. 4.1.1, shows impaired project reach Rosgen stream channel classification, dominant substrate materials, together with geomorphologic and hydraulic parameters for UT1.

3.2 Discharge

Bankfull discharge for the project stream reaches was quantified and verified from measured reference reach boundary conditions and compared to empirical relationships using data published with the *Bankfull Hydraulic Relationships for North Carolina Streams*, Rural Piedmont Regional Curve Database (Multi-Agency *Stream Mitigation Guidelines*, April 2003). The rural Piedmont regional curve database includes data for streams with drainage areas ranging from 0.2 to 128 square miles. Regression equations, derived from stratified E type stream data published in the cited document, were used to empirically evaluate hydraulic geometry relationships at bankfull discharge, width, mean depth, cross-sectional area and return interval for the Davis Branch Reference Reach. The stratified regional E stream type data Log-Pearson Type III distributions, regression equations and coefficients of determination (R^2) were analyzed using the regional curve data editor algorithm in RiverMorph v.4.1.1.

Based on detailed quantitative analysis of reference reach boundary conditions at a stable, bedrock controlled riffle cross-section on Davis Branch, located 43 feet upstream from the confluence of Davis Branch with Gourdvine Creek, the stratified rural Piedmont regional curve data very closely matches quantitatively measured and analyzed bankfull discharge and channel geometry relationships quantified under reference reach boundary conditions. **Appendix 4** contains quantified and verified regional curve data analyses performed during the Davis Branch Reference Reach, Rosgen Level III stream assessment. Regional curve, reference, impaired and proposed channel discharge, dimension, pattern, profile and substrate data are summarized in **Table 4c** and **Table 4d**.

3.3 Channel Morphology

See Section 3.1 and 3.4 for discussion of existing stream reaches channel morphology. **Tables 4a – 4d** on the following pages present baseline morphologic and hydraulic dimension, pattern and profile data for reference reach, existing and proposed conditions. Regional curve empirical relationships comparison to reference and impaired reach conditions is summarized in **Tables 4a – 4d** and discussed in greater detail in Section 3.5. Reference reach dimensionless ratios used to size and design project reach channels are included in **Appendix 4**.

In **Tables 4a – 4d, w**here no min/max values are provided, and only one value was measured or computed, that value is presented as the mean or median value. Where only two measurements were measured or computed, no mean or median value is presented.

Table 4a: Baseline Geomorphologic and Hydraulic Summary
Davis Branch and Unnamed Tributary Restoration / EEP Project No. D06054-F
Station/Reach: Davis Branch Priority Level I/II Restoration Reach Station 7+81.24 to 25+83.35 (1802.11 linear feet)

Parameter	Regional Curve Data			Davis Branch Reference Reach			Pre-Existing Condition			Design		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Median
Dimension												
Drainage Area (mi^2)			0.5172			0.5172			0.1823			0.1823
Bankfull Discharge (cfs)			80.0			77.6			24.8			24.8
BF Width (ft)			11.77			12.91			8.31			9.00
Floodprone Width (ft)						50.00	52.12	165.18	106.28	63.19	238.17	117.44
BF Cross Sectional Area (ft^2)			15.85			15.65			7.56			7.92
BF Mean Depth (ft)			1.35			1.21			0.91			0.88
BF Max Depth (ft)						1.61			1.81			1.20
Width/Depth Ratio			8.72			10.67			9.13			10.23
Entrenchment Ratio						3.87	6.27	19.88	12.79	7.02	26.46	13.05
Bank Height Ratio						1.00	1.38	1.41	1.40			1.00
Wetted Perimeter (ft)			14.47			13.72			9.84			9.57
Hydraulic Radius (ft)			1.10			1.14			0.77			0.83
Pattern												
Channel Beltwidth (ft)				27.80	53.00	38.00	Linear Incised/Braided Channel					50.00
Radius of Curvature (ft)				16.40	45.30	29.40	Linear Incised/Braided Channel			10.65	35.00	19.70
Meander Wavelength (ft)				80.10	116.50	99.20	Linear Incised/Braided Channel			49.94	101.80	77.76
Meander Width Ratio				2.15	4.11	2.94	Linear Incised/Braided Channel					5.56
Profile												
Riffle Length (ft)				12.0	18.5	15.0	25.0	31.0	27.0	7.7	45.2	21.3
Riffle Slope (ft/ft)				0.0283	0.0799	0.0520	0.0208	0.0629	0.0450	0.0227	0.0762	0.0399
Pool Length (ft)				12.0	29.1	21.2	19.5	29.8	22.9	17.1	36.8	23.9
Pool Spacing (ft)				33.4	43.7	38.6	35.3	43.7	40.0	24.9	78.1	48.5
Substrate												
D50 (mm)						69.2			17.7			17.7
D84 (mm)						140.1			28.9			28.9
Additional Reach Parameters												
Valley Length (ft)						974			1,397			1,397
Channel Length (ft)						1129			1,562			1,802
Sinuosity						1.2			1.12			1.29
Water Surface Slope (ft/ft)						0.0311			0.0158			0.0132
Valley Slope (ft/ft)						0.0326			0.0176			0.0170
Rosgen Classification			E			E3/1b*			DA4/1			E4/1
*Habitat Index												
*Macrobenthos												

Notes: *E channel morphology, large cobble substrate with bedrock control, bankfull slope greater than 0.02 ft/ft.
Reference reach dimensionless ratios used to design project reach channels are included with the information in **Appendix 4**.

Table 4b: Baseline Geomorphologic and Hydraulic Summary
Davis Branch and Unnamed Tributary Restoration / EEP Project No. D06054-F
Station/Reach: Davis Branch Enhancement Level I Reach Station 25+83.35 to 38+72.07 (1,288.71 linear feet)**

Parameter	Regional Curve Data			Davis Branch Reference Reach			Pre-Existing Condition			Design		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Median
Dimension												
Drainage Area (mi^2)			0.5172			0.5172			0.3352			0.3352
Bankfull Discharge (cfs)			80.0			77.6			45.5			45.5
BF Width (ft)			11.77			12.91			8.78			10.00
Floodprone Width (ft)						50.00	21.57	97.94	62.74	70.58	144.67	104.34
BF Cross Sectional Area (ft^2)			15.85			15.65			11.18			11.52
BF Mean Depth (ft)			1.35			1.21			1.27			1.15
BF Max Depth (ft)						1.61			2.04			1.60
Width/Depth Ratio			8.72			10.67			6.91			8.70
Entrenchment Ratio						3.87	2.46	11.15	7.15	7.06	14.47	10.43
Bank Height Ratio						1.00	1.58	1.86	1.72			1.00
Wetted Perimeter (ft)			14.47			13.72			10.21			10.85
Hydraulic Radius (ft)			1.10			1.14			1.10			1.06
Pattern												
Channel Beltwidth (ft)				27.80	53.00	38.00	Incised Linear Channel			Linear Channel		
Radius of Curvature (ft)				16.40	45.30	29.40	Incised Linear Channel			Linear Channel		
Meander Wavelength (ft)				80.10	116.50	99.20	Incised Linear Channel			Linear Channel		
Meander Width Ratio				2.15	4.11	2.94	Incised Linear Channel			Linear Channel		
Profile												
Riffle Length (ft)				12.0	18.5	15.0	57.9	85.3	67.1	24.0	57.0	45.0
Riffle Slope (ft/ft)				0.0283	0.0799	0.0520	0.0264	0.0518	0.0393	0.0098	0.0549	0.0504
Pool Length (ft)				12.0	29.1	21.2	29.5	48.8	39.2	6.0	40.0	22.5
Pool Spacing (ft)				33.4	43.7	38.6	92.2	103.0	97.6	40.0	88.0	68.5
Substrate												
D50 (mm)						69.2			154.0			154.0
D84 (mm)						140.1			207.4			207.4
Additional Reach Parameters												
Valley Length (ft)						974			1213			1213
Channel Length (ft)						1129			1289			1289
Sinuosity						1.2			1.06			1.06
Water Surface Slope (ft/ft)						0.0311			0.0216			0.0216
Valley Slope (ft/ft)						0.0326			0.0229			0.0229
Rosgen Classification			E			E3/1b*			E3/1b			E3/1b
*Habitat Index												
*Macrobenthos												

Notes: *E channel morphology, large cobble substrate with bedrock control, bankfull slope greater than 0.02 ft/ft.
Reference reach dimensionless ratios used to design project reach channels are included with the information in **Appendix 4**.

Table 4c: Baseline Geomorphologic and Hydraulic Summary
Davis Branch and Unnamed Tributary Restoration / EEP Project No. D06054-F
Station/Reach: Davis Branch UT1 Enhancement Level II Reach Station 0+00.00 to 3+95.76 (395.76 linear feet)

Parameter	Regional Curve Data			Davis Branch Reference Reach			Pre-Existing Condition**			Design		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Median	Min	Max	Median
Dimension												
Drainage Area (mi^2)			0.5172			0.5172			0.0721			0.0721
Bankfull Discharge (cfs)			80.0			77.6			9.8			9.8
BF Width (ft)			11.77			12.91	6.85	8.39	7.82			6.20
Floodprone Width (ft)						50.00	7.17	78.27	28.42	32.37	105.76	47.40
BF Cross Sectional Area (ft^2)			15.85			15.65	4.27	4.31	4.30			4.45
BF Mean Depth (ft)			1.35			1.21	0.51	0.63	0.55			0.72
BF Max Depth (ft)						1.61	0.77	0.92	0.88			1.00
Width/Depth Ratio			8.72			10.67	10.87	16.45	14.37			8.61
Entrenchment Ratio						3.87	0.92	10.01	3.63	5.22	17.06	7.65
Bank Height Ratio						1.00	2.32	3.67	2.82			1.00
Wetted Perimeter (ft)			14.47			13.72	7.28	8.74	8.15			6.73
Hydraulic Radius (ft)			1.10			1.14	0.49	0.59	0.53			0.66
Pattern												
Channel Beltwidth (ft)				27.80	53.00	38.00	Incised Linear Channel					26.20
Radius of Curvature (ft)				16.40	45.30	29.40	Incised Linear Channel			Linear Channel		
Meander Wavelength (ft)				80.10	116.50	99.20	Incised Linear Channel			Linear Channel		
Meander Width Ratio				2.15	4.11	2.94	Incised Linear Channel					4.23
Profile												
Riffle Length (ft)				12.0	18.5	15.0	1.1	305.7	30.6	1.1	305.7	30.6
Riffle Slope (ft/ft)				0.0283	0.0799	0.0520	0.0372	0.1001	0.0586	0.0372	0.1001	0.0586
Pool Length (ft)				12.0	29.1	21.2	7.2	31.9	19.2	7.2	31.9	19.2
Pool Spacing (ft)				33.4	43.7	38.6	15.6	324.8	76.9	15.6	324.8	76.9
Substrate												
D50 (mm)						69.2			11.4			11.4
D84 (mm)						140.1			15.4			15.4
Additional Reach Parameters												
Valley Length (ft)						974			362			362
Channel Length (ft)						1129			396			396
Sinuosity						1.2			1.09			1.09
Water Surface Slope (ft/ft)						0.0311			0.0230			0.0230
Valley Slope (ft/ft)						0.0326			0.0252			0.0252
Rosgen Classification			E			E3/1b*			C4/1b-E4/1b			E4/1b
*Habitat Index												
*Macrobenthos												

Notes: *E channel morphology, large cobble substrate with bedrock control, bankfull slope greater than 0.02 ft/ft.
Reference reach dimensionless ratios used to design project reach channels are included with the information in **Appendix 4**.

Table 4d: Baseline Geomorphologic and Hydraulic Summary
Davis Branch and Unnamed Tributary Restoration / EEP Project No. D06054-F
Station/Reach: Davis Branch UT1 Restoration Reach Station 3+95.76 to 8+45.98 (450.22 linear feet)

Parameter	Regional Curve Data			Davis Branch Reference Reach			Pre-Existing Condition			Design		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Median
Dimension												
Drainage Area (mi^2)			0.5172			0.5172			0.0721			0.0721
Bankfull Discharge (cfs)			80.0			77.6			9.8			9.8
BF Width (ft)			11.77			12.91	6.85	8.39	7.82			6.20
Floodprone Width (ft)						50.00	7.17	78.27	28.42	32.37	105.76	47.40
BF Cross Sectional Area (ft^2)			15.85			15.65	4.27	4.31	4.30			4.45
BF Mean Depth (ft)			1.35			1.21	0.51	0.63	0.55			0.72
BF Max Depth (ft)						1.61	0.77	0.92	0.88			1.00
Width/Depth Ratio			8.72			10.67	10.87	16.45	14.37			8.61
Entrenchment Ratio						3.87	0.92	10.01	3.63	5.22	17.06	7.65
Bank Height Ratio						1.00	2.32	3.67	2.82			1.00
Wetted Perimeter (ft)			14.47			13.72	7.28	8.74	8.15			6.73
Hydraulic Radius (ft)			1.10			1.14	0.49	0.59	0.53			0.66
Pattern												
Channel Beltwidth (ft)				27.80	53.00	38.00	Incised Linear Channel					50.00
Radius of Curvature (ft)				16.40	45.30	29.40	Incised Linear Channel			11.10	18.00	12.60
Meander Wavelength (ft)				80.10	116.50	99.20	Incised Linear Channel			50.53	58.82	52.60
Meander Width Ratio				2.15	4.11	2.94	Incised Linear Channel					8.06
Profile												
Riffle Length (ft)				12.0	18.5	15.0	1.1	305.7	30.6	9.0	23.0	17.1
Riffle Slope (ft/ft)				0.0283	0.0799	0.0520	0.0372	0.1001	0.0586	0.0278	0.0486	0.0314
Pool Length (ft)				12.0	29.1	21.2	7.2	31.9	19.2	12.8	22.8	18.7
Pool Spacing (ft)				33.4	43.7	38.6	15.6	324.8	76.9	24.6	41.5	34.7
Substrate												
D50 (mm)						69.2			11.4			11.4
D84 (mm)						140.1			15.4			15.4
Additional Reach Parameters												
Valley Length (ft)						974			362			343
Channel Length (ft)						1129			396			450
Sinuosity						1.2			1.09			1.31
Water Surface Slope (ft/ft)						0.0311			0.0230			0.0201
Valley Slope (ft/ft)						0.0326			0.0252			0.0264
Rosgen Classification			E			E3/1b*			C4/1b-E4/1b			E4/1b
*Habitat Index												
*Macrobenthos												

Notes: *E channel morphology, large cobble substrate with bedrock control, bankfull slope greater than 0.02 ft/ft.
Reference reach dimensionless ratios used to design project reach channels are included with the information in **Appendix 4**.

3.4 Channel Stability Assessment

Davis Branch Mainstem, Impaired Restoration Reach

In its present state, the stream's high degree of channel incision (BHR range 1.38 - 1.41), low sinuosity (K = 1.12), denuded and destabilized streambanks, relatively steep average profile slope (0.0158 ft/ft, or 83.4 ft/mi) has resulted in a deeply incised, unstable channel with a high sediment supply. The incised vertical to undercut streambanks, accelerate streambank erosion. Utilizing the near bank stress bank erosion hazard index (BEHI) algorithm in RiverMorph® v.4.1.1, it is estimated 31 cubic yards per year (or 40 tons per year) of sediment is being eroded from the unstable, vertical to undercut streambanks along the upper mainstem impaired reach. This estimate was calculated using the bank height (2.14 ft) measured at impaired pool cross-section 14+87.29 and the upper mainstem impaired reach length of 1,562 linear feet and represents an estimated bank erosion rate 0.25 ft/yr. BEHI and sediment export, bank erosion rate estimates, together with bank stability evaluation, BHR calculations, with RiverMorph® model inputs and results are presented in **Appendix 4**.

Davis Branch Mainstem, Impaired Enhancement Level I Reach

In its present state, the stream's high degree of channel incision (BHR range 1.58 - 1.86), low sinuosity (K = 1.06), denuded and destabilized streambanks, relatively steep average profile slope (0.0216 ft/ft, or 114.0 ft/mi) has resulted in a deeply incised, unstable channel with a high sediment supply. The incised vertical to undercut streambanks, accelerate streambank erosion. Utilizing the near bank stress bank erosion hazard index (BEHI) algorithm in RiverMorph® v.4.1.1, it is estimated 46 cubic yards per year (or 56 tons per year) of sediment is being eroded from the unstable, vertical to undercut streambanks along the lower mainstem impaired reach. This estimate was calculated using the bank height (3.84 ft) measured at impaired pool cross-section 33+49.25 and the lower mainstem impaired reach length of 1,289 linear feet and represents an estimated bank erosion rate 0.25 ft/yr. BEHI and sediment export, bank erosion rate estimates, together with bank stability evaluation, BHR calculations, with RiverMorph® model inputs and results are presented in **Appendix 4**.

UT1 Restoration Reach

In its present state, the stream's extreme degree of channel incision along the final 300 linear feet (BHR range 2.32 – 3.67), low sinuosity (K = 1.09), denuded and destabilized streambanks, steep profile slope (0.0230 ft/ft, or 121.4 ft/mi) has resulted in a deeply incised, unstable channel with a high sediment supply. The incised vertical to undercut denuded streambanks, accelerate erosion rates. Utilizing the near bank stress bank erosion hazard index (BEHI) algorithm in RiverMorph® v.4.1.1, it is estimated 11 cubic yards per year (or 14 tons per year) of sediment is being eroded from the unstable, vertical to undercut streambanks along the final 300 linear feet of the UT1 impaired reach. This estimate was calculated using the bank height (3.46 ft) measured at impaired pool cross-section 6+55.69 and the lower UT1 impaired reach length of 334 linear feet (total reach length = 729.60 feet). This represents an estimated bank erosion rate 0.25 ft/yr. BEHI and sediment export, bank erosion rate estimates, together with bank stability evaluation, BHR calculations, with RiverMorph® model inputs and results are presented in **Appendix 4**.

Channel Stability Summary

Summing the sediment export estimates for each of the project reaches, it is estimated the impaired streams have the potential to contribute approximately 88 cubic yards (or 114 tons) of nutrient laden sediment off site into the larger Davis Branch, Gourdvine Creek and Richardson Creek watersheds on an annual basis.

The consequence of channelization, cattle intrusion, confinement (lateral containment), major floods, changes in sediment regime, and loss of riparian vegetation are attributed causes and effects for existing conditions along the impaired project reaches. The effects of these anthropogenic changes are accelerated streambank erosion, channel incision, land loss, aquatic habitat loss, lowering of the water table, land productivity reduction and in-stream and downstream sedimentation and nutrient loading.

Given the impaired condition of project reaches, the estimated annual rates of streambank erosion are reasonable. High, sustained flows typical of heavy rainfall events associated with stalled or slow moving tropical depressions, associated with hurricanes, come close enough to North Carolina to influence weather about twice during an average year. Once in 10 years, on average, hurricanes strike a part of the State with sufficient force to cause severe damage to inland property. The average annual rainfall east of the Blue Ridge Mountains generally ranges between 40 and 55 inches. In North Carolina the most severe weather is due to summer thunderstorms, with July being the wettest month. These storms usually affect localized areas, with hail, high winds and lightning occurring with some of them, accounting for an average yearly loss of over $5 million in property damage. At any given locality, 40 or 50 thunderstorms can be expected in a given year. (Source: State Climate Office of North Carolina). Under prevailing regional climatic patterns, the existing conditions of impaired site streams will continue to deteriorate and contribute significantly to offsite sedimentation and nutrient loading without intervention.

3.5 Bankfull Verification

As noted in Section 3.2, for project stream reaches, bankfull discharge was evaluated through quantitative analysis of stable reference reach data and calculated bankfull discharge through a stable, bedrock controlled riffle cross-section located on Davis Branch 43 feet upstream from its confluence with Gourdvine Creek as shown on **Figure 3A** and **Figure 7**. Discharge versus drainage area relationships for the reference reach riffle cross-section were compared to *Bankfull Hydraulic Geometry Relationships for North Carolina Streams (Rural Piedmont)* regional curve dataset. Through this analysis, it was determined the rural Piedmont regional curves underestimate bankfull discharge and geometric relationships for project reach streams without stratifying the data by stream type. After recompiling the E stream type data from the cited publication, and performing Log-Pearson Type III distribution analyses for bankfull discharge and channel geometry relationships, the Davis Branch reference reach quantitative data very closely matches the empirical relationships, based on stream type. Empirical and quantified data are summarized in **Table 4**. The Rural Piedmont "E type stream" regional curve data and analysis is presented in Appendix 4.

Calculated bankfull discharge for the surveyed reference reach riffle cross-section, was computed using hydraulic radius, wetted perimeter, channel slope and a relative roughness (u/u*) method based on the average protrusion height of the steeply dipping bedrock bedding planes (Rosgen, 1998). Additionally, a particle distribution was collected from the large angular cobble deposited along the reference reach riffle bed. Based on an average protrusion height of 0.57 feet (or 174 mm), bankfull discharge is quantified at 77.6 cfs and very closely matches the stratified Rural Piedmont Regional Curve dataset predicted bankfull discharge (80.0 cfs). The D84 particle size from the stable riffle particle distribution is 140.1 mm and is consistent with the observed bed thickness, axial splitting planes and joint sets in the folded and deformed slate bedrock.

3.6 Vegetation

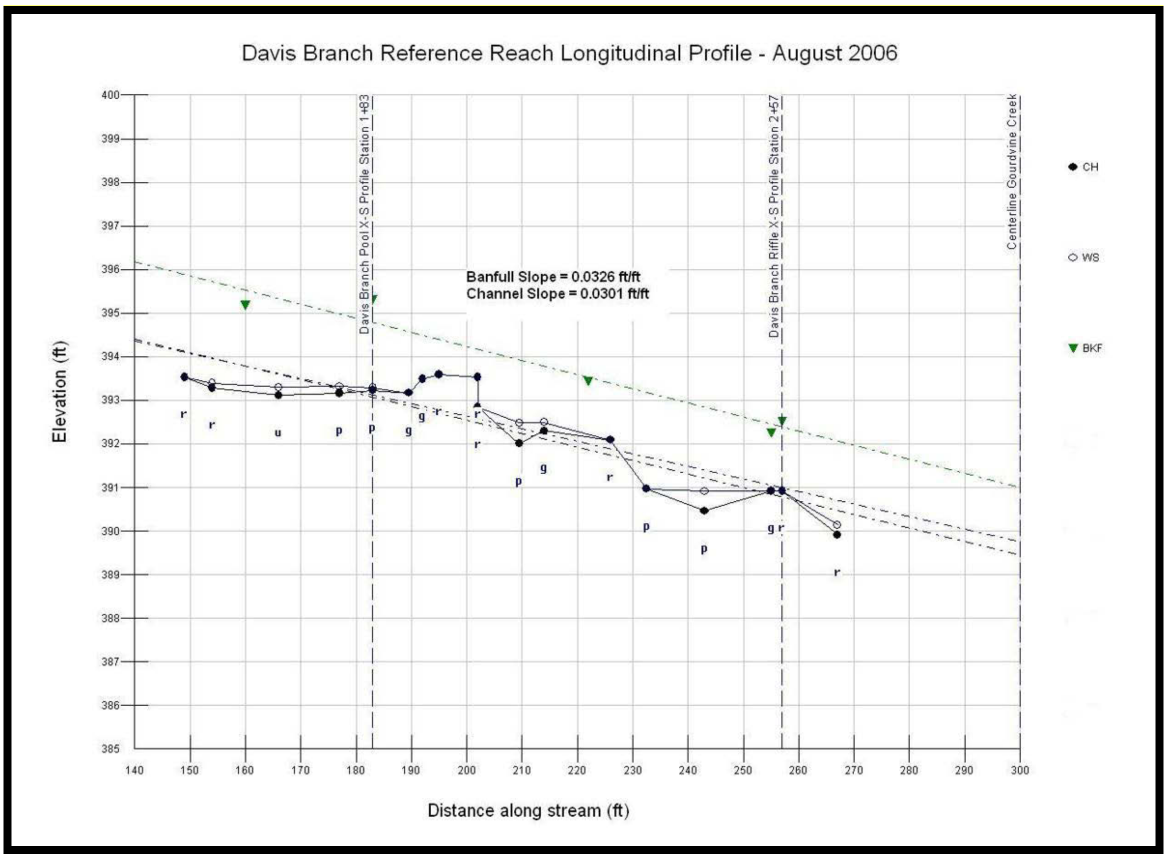
Portions of Davis Branch and UT1 exist with a mature, wooded riparian corridor dominated by *Fraxinus* spp. (ash), *Carya* spp. (hickories), *Quercus* spp. (oak), *Platanus occidentalis* (American sycamore), *Acer saccharinum* (silver maple), and *Juniperus virginiana* (Eastern red cedar) in the tree canopy. Active pasturelands surround the project, and cattle have unrestricted access to the streams. This cattle intrusion has resulted in substantial damage to the native understory, which is essentially absent. The width of the existing riparian zone varies along the project corridor, as is visible on the aerial photography provided on the plan sheets in Appendix 1. In some areas, particularly the downstream portion of Davis Branch, the riparian zone is absent and pasture grasses and *Ranunculus* spp. (buttercup) grow along the stream. No potential wetlands were observed along the project corridor. Representative photos of the existing corridor were provided in Section 2.4.

4.0 REFERENCE STREAMS

4.1 Watershed Characterization

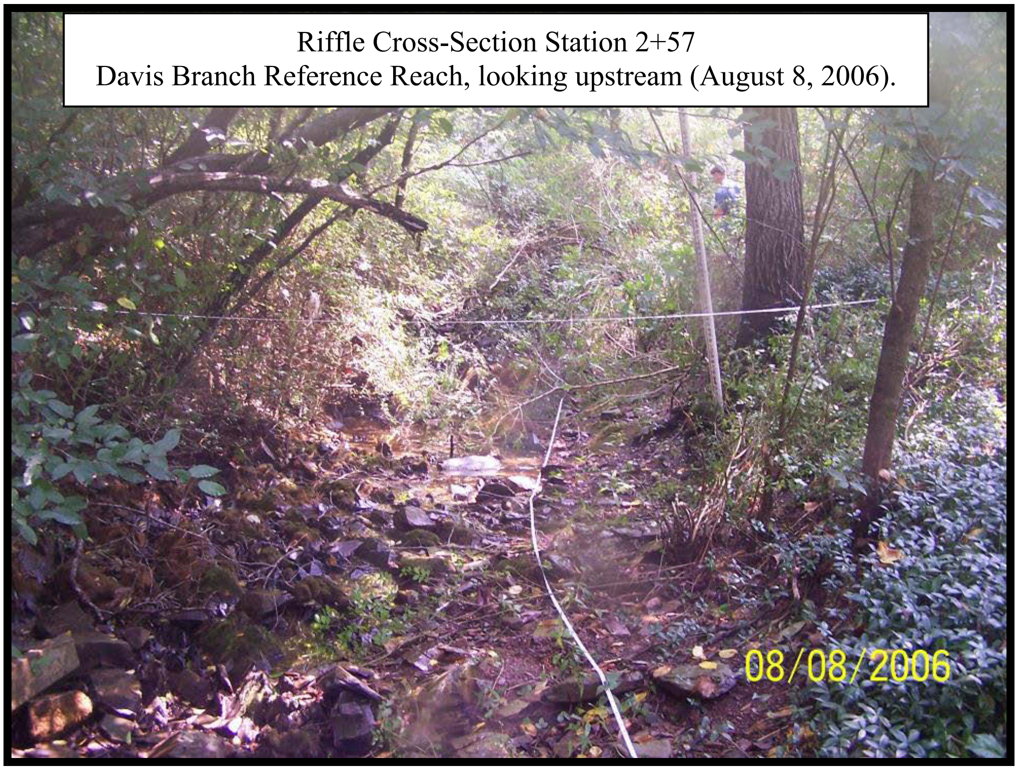
Davis Branch Reference Reach

For Davis Branch, bankfull discharge was determined through a quantitative assessment and analysis of reference reach boundary conditions and comparison of predicted bankfull discharge through a stable riffle cross-section located on Davis Branch 43 feet upstream from its confluence with Gourdvine Creek. The reference reach is a Rosgen Valley Type VIII, E3/1b stream type (i.e., E channel morphology, large cobble substrate with strong bedrock control, profile gradient greater than 2 percent). The reference reach is located within a healthy, deciduous hardwood forested riparian corridor. A comprehensive Rosgen Level III watershed assessment and analysis of the reference reach conditions was conducted during August 8 and 9, 2006. The longitudinal profile that follows, analyzed using RiverMorph® version 4.0.1, shows the best fit trend lines of the streambed, water surface and bankfull indicators:



The healthy, robust vegetation and root mass along the reference reach riparian corridor, extending overbank into the channel, is extremely stable and resistant to streambank erosion. The streambed is stable due to hard bedrock control. Large cobble deposited on top of the bedrock is a secondary substrate, resulting from physical weathering of the highly fractured, steeply dipping, thin- to thick-bedded slate bedrock (dominant bedding plane orientation strikes N65°E, with a mean dip angle of 55° to the northwest, average protrusion height 0.57 feet or 174 mm based on field measurements). Due to extremely thick riparian vegetation during August 2006, it was possible to collect profile and cross-section data along a relatively short length of the stable 1,129 linear feet reach. The following photographs depict field conditions at the time of the field survey and reference reach Rosgen Level III assessment.

Thick vegetative cover, Davis Branch Reference Reach, Rosgen Level III Assessment (August 8-9, 2006).



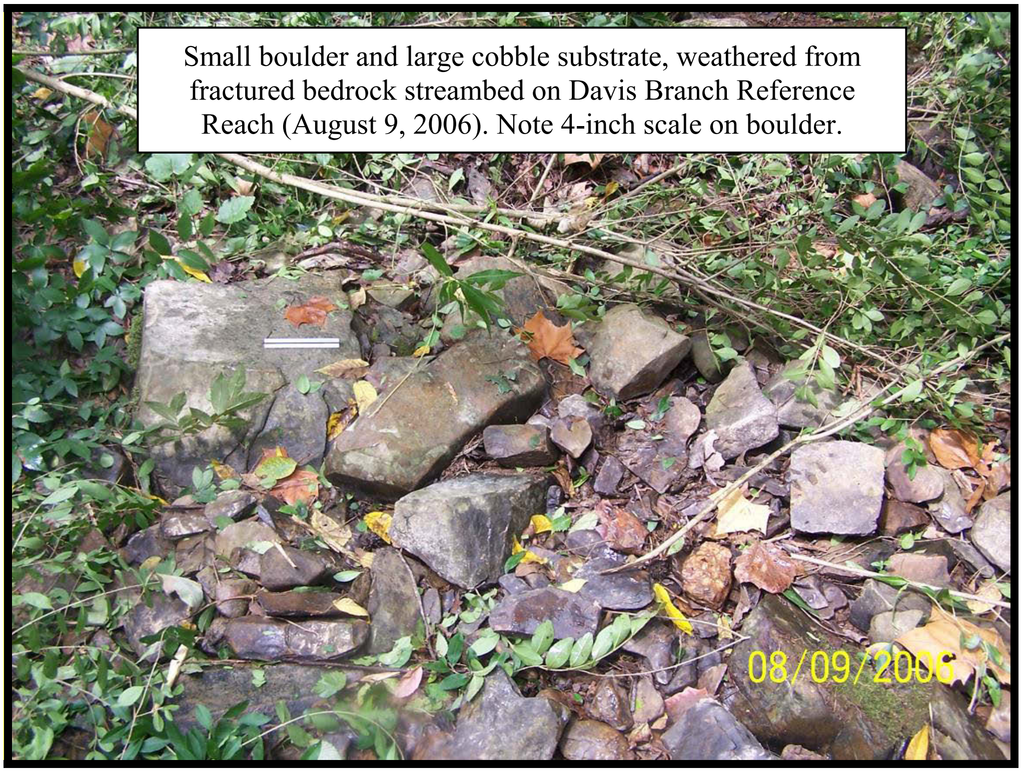
Riffle Cross-Section Station 2+57
Davis Branch Reference Reach, looking upstream (August 8, 2006).

EMH&T staff were able to clear line of site 151 feet deep into the overgrown Davis Branch Reference Reach, accessing the stream from its confluence with Gourdvine Creek. Due to backwater from Gourdvine Creek at the mouth of Davis Branch, 118 linear feet of profile, capturing three pool and four riffle sequences, with one representative riffle and pool cross-section being surveyed in the field. Geologic structural controls and lithology, fluvial geomorphologic processes, depositional materials, climatic influence, riparian vegetation, depositional patterns, debris occurrence, meander pattern, channel stability rating, sediment supply, streambed stability and width/depth ratio state were evaluated following Rosgen Level III stream assessment protocols. Visibility was limited in the field to dense vegetative cover along the Davis Branch Reference Reach; therefore, Union County orthoimagery (February 2004) was used to measure stream pattern. The high-resolution (1 pixel = 6 inches) orthoimagery is included on **Figures 3A** and **7**. The entire 1,129 linear feet reach was assessed for stream state and condition parameters consistent with Rosgen Level III assessment protocols. The assessment included spatial analysis of GPS data collected in the field to evaluate channel pattern upstream from the surveyed reach, beyond the point where further differential level surveying was impracticable and channel pattern could not be discerned due to dense forested cover shown on recent aerial imagery.

The Davis Branch Reference Reach is located approximately 900 feet downstream from the bottom of the mainstem Enhancement Level I project reach. The reference reach was studied from the north side of Olive Branch Road to its confluence with Gourdvine Creek. The reference reach is located on the same structural geologic feature, the Troy Anticlinorium (northwest limb near the axial plane of an unnamed syncline), in the same geologic formation, the McManus Formation, and is mapped on similar soils (Chewacla silt loam, Goldston soils and Cid channery silt loam). The reference reach is shown at watershed scale on **Figure 3A** and at reach scale on **Figure 7**.

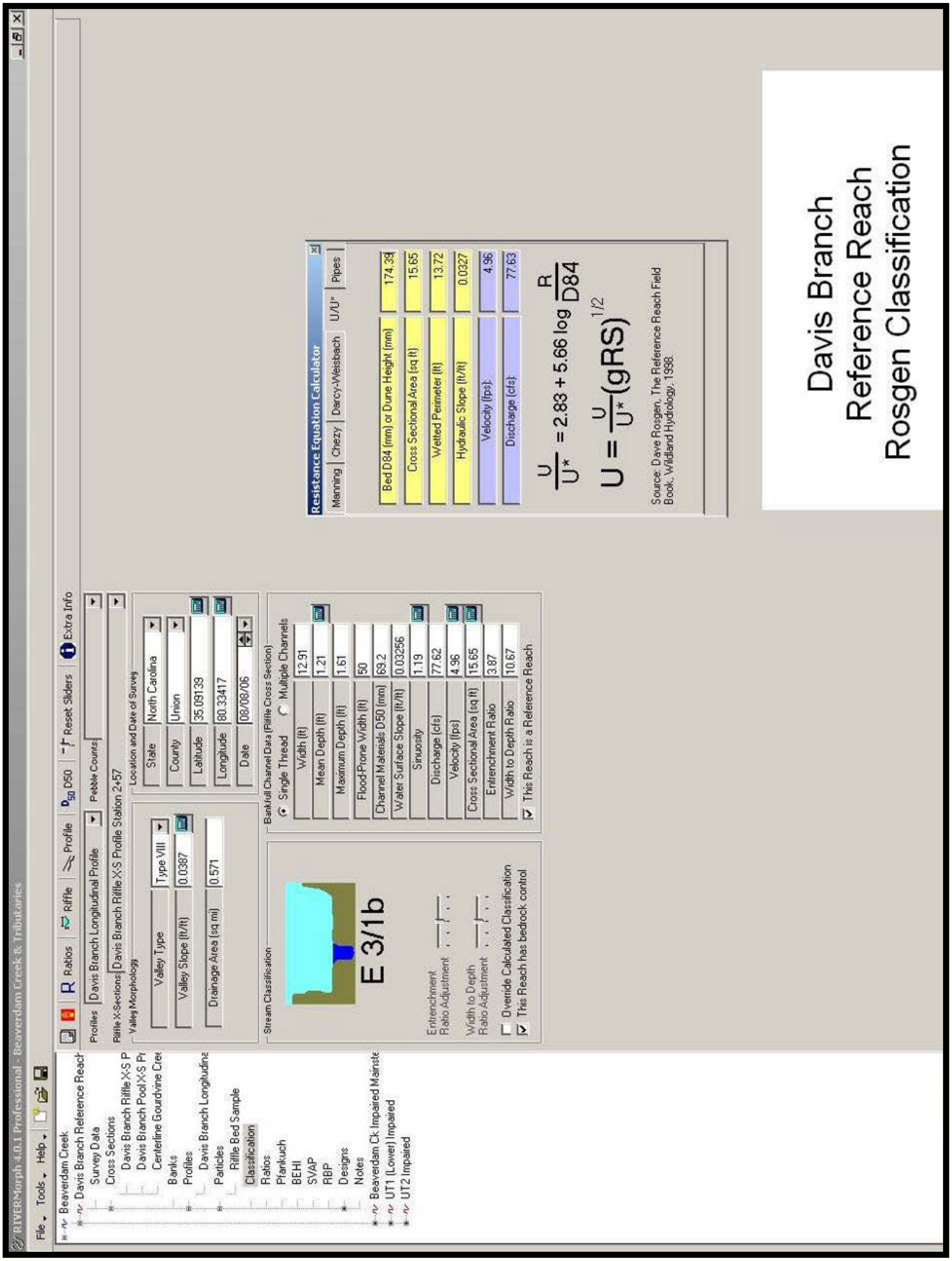
Calculated bankfull discharge for the surveyed reference reach riffle cross-section, was computed using hydraulic radius, wetted perimeter, channel slope and a relative roughness (u/u*) method based on the average protrusion height of the steeply dipping bedrock bedding planes (Rosgen, 1998). Additionally, a particle distribution was collected from the large angular cobble deposited along the reference reach riffle bed. Based on an average bedrock protrusion height of 0.57 feet (or 174 mm), bankfull discharge is quantified at 77.6 cfs, and closely matches the stratified Rural Piedmont Regional Curve dataset predicted bankfull discharge (80.0) cfs. The D84 particle size from the stable riffle particle distribution is 140.1 mm and is consistent with the observed bed thickness, axial splitting planes and joint sets in the folded and deformed slate bedrock, as shown on the photographs that follow:

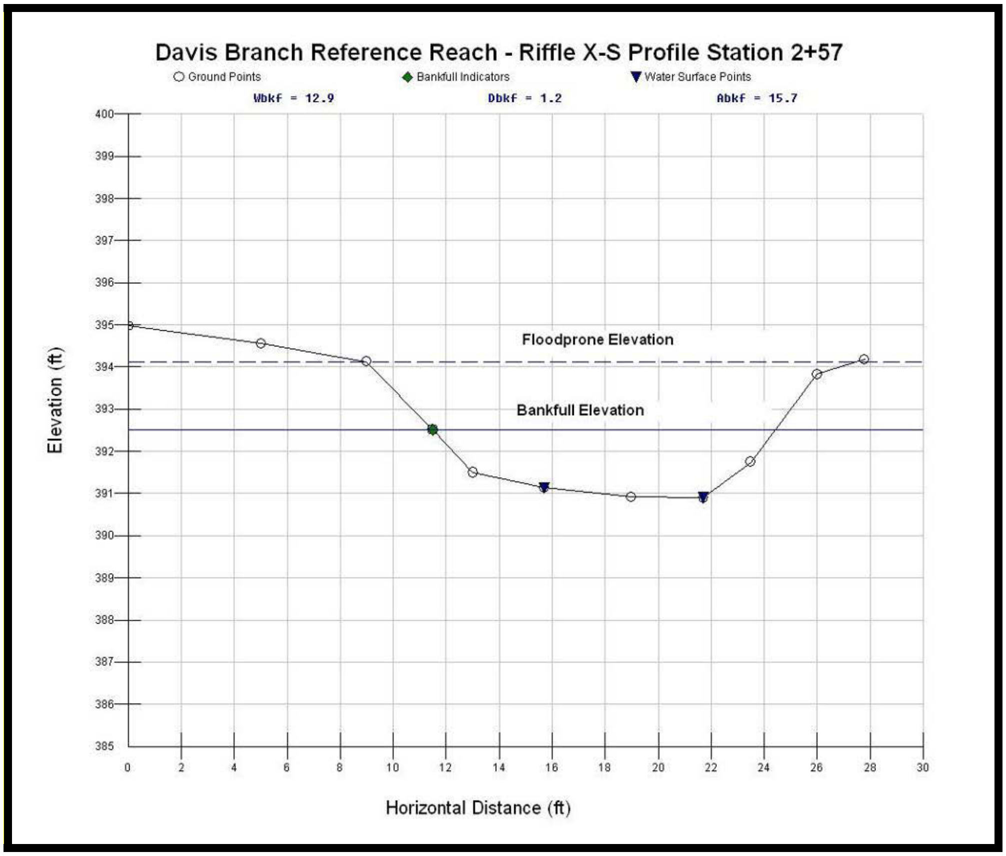
Steeply dipping argillaceous slate bedrock, Davis Branch Reference Reach, looking upstream (August 8, 2006).



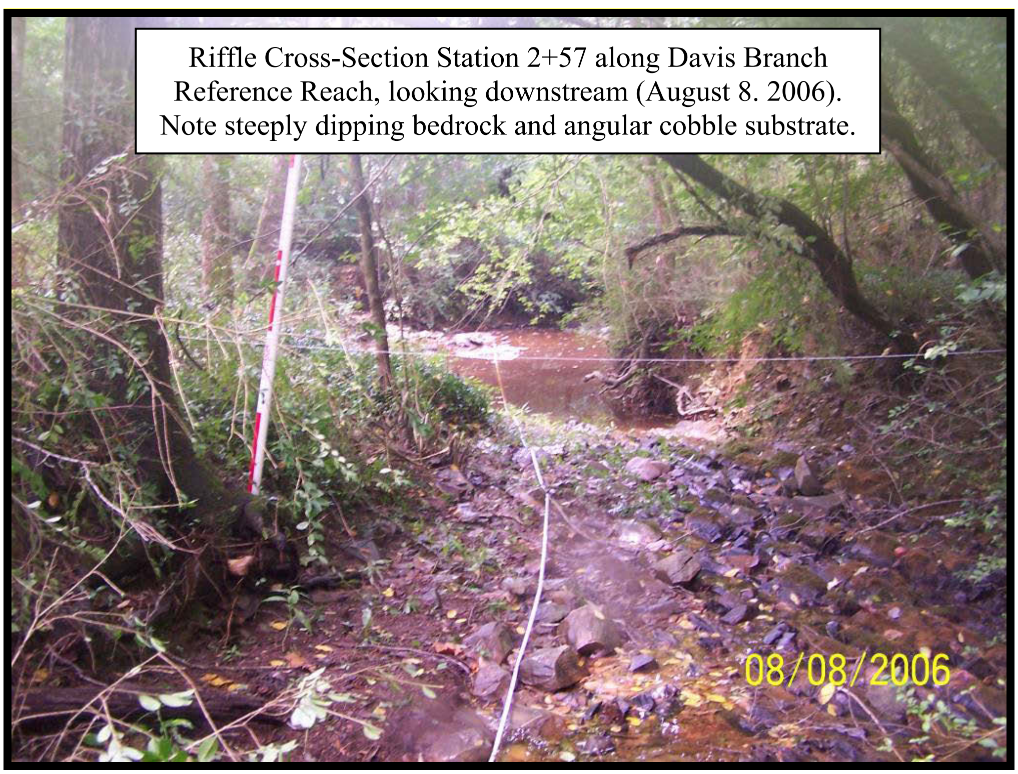
Small boulder and large cobble substrate, weathered from fractured bedrock streambed on Davis Branch Reference Reach (August 9, 2006). Note 4-inch scale on boulder.

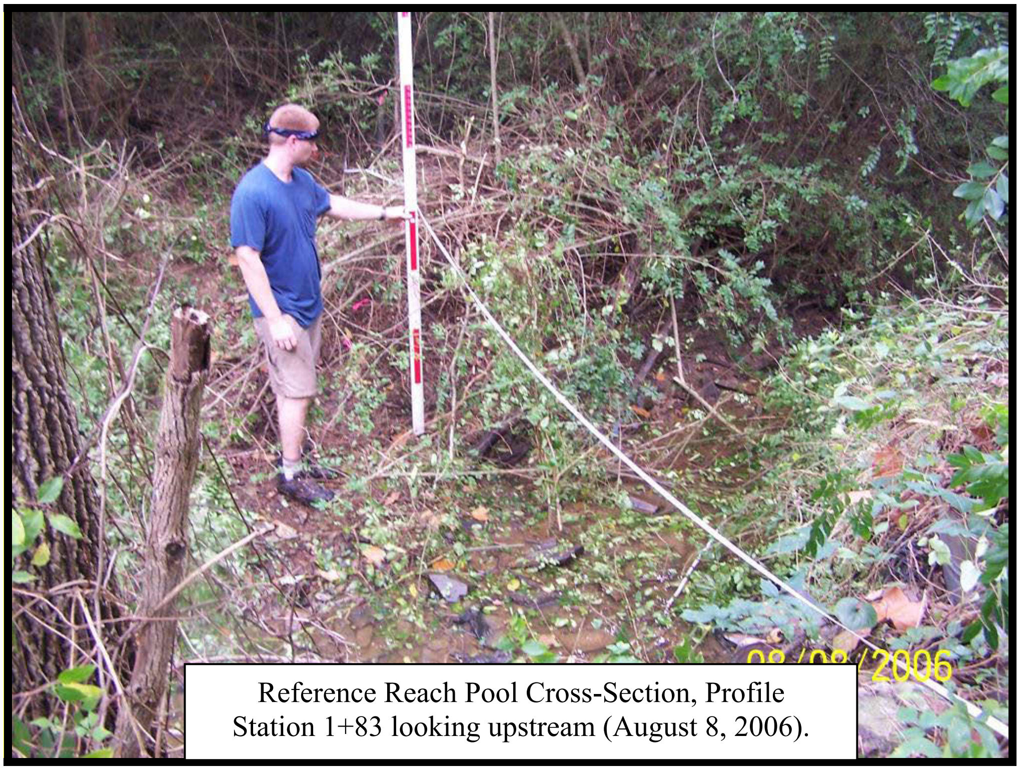
The following screen shot from RiverMorph® shows the boundary conditions and calculated bankfull discharge and mean flow velocity through the reference reach riffle cross-section:


RIVERMorph 4.0.1 Professional - Beaverdam Creek & Tributaries
Davis Branch Longitudinal Profile
Davis Branch Riffle X-S Profile Station 2+57
Valley Type Type VIII
Valley Slope (ft/ft) 0.0387
Drainage Area (sq mi) 0.571
State North Carolina
County Union
Latitude 35.09139
Longitude 80.33417
Date 08/08/06
Width (ft) 12.91
Mean Depth (ft) 1.21
Maximum Depth (ft) 1.61
Flood-Prone Width (ft) 50
Channel Materials D50 (mm) 69.2
Water Surface Slope (ft/ft) 0.03256
Sinuosity 1.19
Discharge (cfs) 77.62
Velocity (fps) 4.96
Cross Sectional Area (sq ft) 15.65
Entrenchment Ratio 3.87
Width to Depth Ratio 10.67
This Reach is a Reference Reach
E 3/1b
Resistance Equation Calculator
Bed D84 (mm) or Dune Height (mm) 174.39
Cross Sectional Area (sq ft) 15.65
Wetted Perimeter (ft) 13.72
Hydraulic Slope (ft/ft) 0.0327
Velocity (fps) 4.96
Discharge (cfs) 77.63
Source: Dave Rosgen, The Reference Reach Field Book, Wildland Hydrology, 1998
Davis Branch
Reference Reach
Rosgen Classification

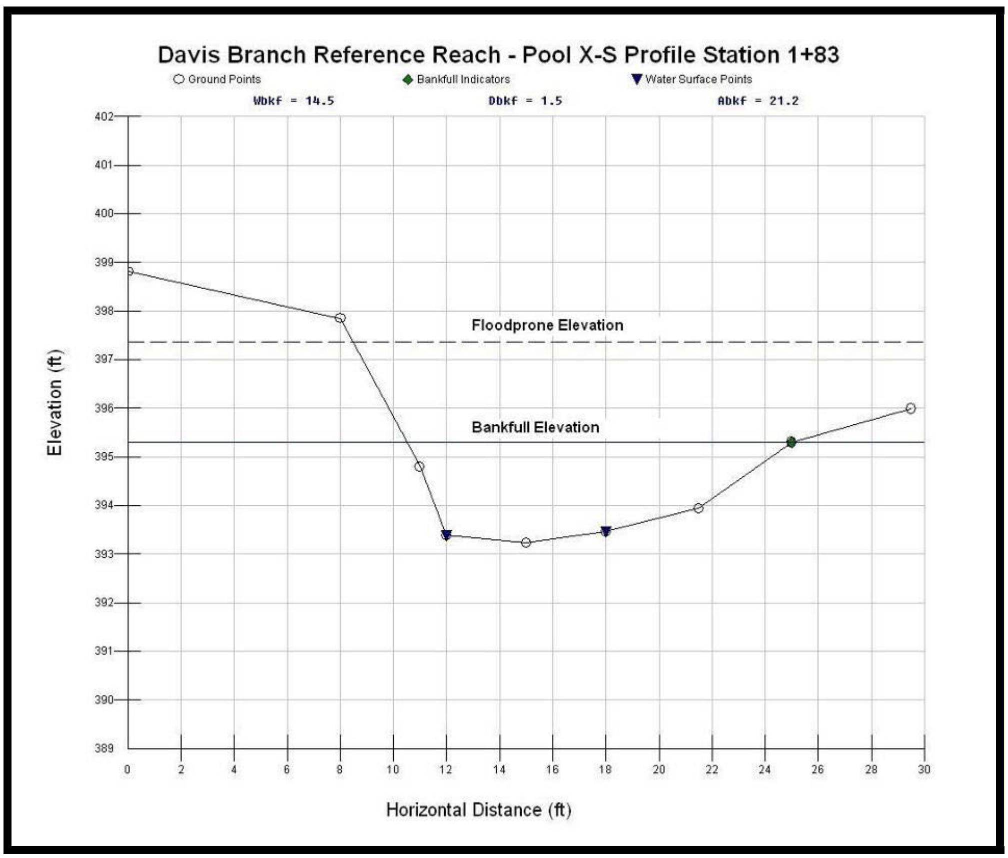


Riffle Cross-Section Station 2+57 along Davis Branch Reference Reach, looking downstream (August 8. 2006). Note steeply dipping bedrock and angular cobble substrate.





Reference Reach Pool Cross-Section, Profile Station 1+83 looking upstream (August 8, 2006).



The Davis Branch reference reach classification, data summary reports and supporting documentation are presented in **Appendix 3**.

4.2 Channel Stability Assessment

Reference reach channel stability was analyzed using the vertical velocity near-bank stress method algorithm in RiverMorph® v.4.0.1 and reach streambank observations and channel morphology from reference reach Pool Cross-Section 1+83, located on Davis Branch 117 feet upstream from its confluence with Gourdvine Creek. The predicted annual erosion rate estimate was calculated for the entire 1129 linear feet of stream evaluated as part of the Rosgen Level III reference reach study. Based on reference reach conditions, the predicted sediment loss is 3.23 cubic yards or 4.2 tons per year. This equates to 0.0043 tons/year per foot of reach, or two one hundredths of a foot (0.02 ft) streambank erosion on an annual basis. The near-bank adjective rating (0.35) is very low for the reference reach, indicating extremely stable channel conditions. The quantitative inputs and analytical results from the reference reach channel stability assessment are included with the information in **Appendix 4**.

4.3 Discharge

Reference reach quantified and verified discharge estimates are presented in Sections 3.2, 3.5 and 4.1. Detailed data analysis and the quantified results from that data are presented in **Appendix 4**.

4.4 Channel Morphology

Reference reach channel morphology is discussed in detail in Section 4.1. Detailed data analysis is presented in **Appendix 4**. Morphologic and hydraulic summary data for the reference reach is presented in **Tables 4a – 4d**.

4.5 Bankfull Verification

See Section 3.2, 3.5 and 4.1 for reference reach bankfull verification details and supporting documentation in **Appendix 4**.

4.6 Vegetation

Davis Branch Reference Reach

The Davis Branch reference reach flows through a deciduous hardwood forest area, which provides a wide riparian corridor. The canopy layer is dominated by native tree species including: *Carya* spp, *Platanus occidentalis*, *Fraxinus* spp. and *Carpinus caroliniana* (ironwood). The shrub/ sapling and herbaceous understory provides significant protection against bank erosion. Native species such as *Alnus serrulata* (hazel alder), *Cornus florida* (flowering dogwood), *Sambucus canadensis* (elderberry), *Symplocos tinctoria* (common sweetleaf), *Smilax bona-nox* (saw greenbrier) are present within the understory. Non-native, invasive *Ligustrum sinense* (Chinese privet) was also observed within the reference reach understory. The underlying herbaceous layer is divers an included species such as *Impatiens capensis* (jewelweed), *Arisaema triphyllum* (Jack-in-the-pulpit), *Woodwardia aerolata* (netted chain fern), *Polystichum acrostichoides* (Christmas fern), *Athyrium felix-femina* (Southern lady fern), *Parthenocissus quinquefolia* (Virginia creeper), *Pilea pumila* (clearweed), and *Lobelia cardinalis* (cardinal flower). Photographs of the reference reach corridor are provided within **Section 4.1**.

5.0 PROJECT SITE RESTORATION PLAN

5.1 Restoration Project Goals and Objectives

Restoration goals and objectives for the project are to return degraded streams to a more natural condition that it is ecologically productive, aesthetically appealing, physically stable, and valuable from a conservation perspective. Project restoration goals and objectives will be achieved by restoring stable pattern, profile and dimension along the upper 1802 linear feet (profile stations 7+81.24 to 25+83.35) on the Davis Branch mainstem and the lower 450 linear feet (profile stations 3+95.76 to 8+45.98) on UT1 restoration stream reaches, utilizing an off-line, Priority Level I/II mitigation approach to restore the connection of the vertically confined incised existing stream channels with their floodplains.

Channel profile and dimension will be restored on the mainstem Enhancement Level I reach (profile stations 25+83.35 to 38+72.07) to stabilize existing over-widened and incised channel conditions. Dimension will be restored on the upper 396 linear feet (profile stations 0+00.00 t0 3+95.76) Enhancement Level II reach on UT1, with grade control structures (rock sills) constructed, as needed, together with placement of appropriately sized substrate material to reduce critical shear stress in the near-bank region while maintaining flow velocities and critical depths required to entrain medium gravel (D84 particle size = 15.4 mm), based on analysis of a particle distribution sample collected from a representative UT1 riffle streambed feature. Channel bankfull mean velocity on UT1 is moderately retarded by instream vegetation. Manning's coefficient for UT1 took into account observed vegetative channel field conditions. Restoration Plan Design Sheets are located in **Appendix 1**.

Channel reinforcement materials will be used in high shear stress regions (i.e., along outside meander bends). Reinforcement materials will consist of a combination of: rock toe, coir log, coconut fiber geotextile matting held in place with hardwood stakes and soil nails; live branch plantings; and aggressive seeding, mulching and revetment of streambanks and the riparian corridor. Channel reinforcement methods are shown as Detail 'C' on Restoration Plan Sheet RP-13/20 and Planting Plan on RP-19 & 20/20 in **Appendix 1**.

The existing forested riparian corridor will be protected along the realigned Davis Branch mainstem reach and UT1 to enhance streambank stability, provide sediment and nutrient storage, and enhance terrestrial and aquatic habitat. Any portion of the existing corridor that is disturbed for project-related construction will be replanted. Denuded areas within the limits of the project conservation easement will be fully planted to reestablish a native riparian corridor. The stream corridors will be protected by the installation of livestock exclusion fencing placed at the edge of the conservation easement boundary. The project planting plan is presented in Section 5.5.

5.1.1 Designed Channel Classification

The proposed designed Davis Branch mainstem and UT1 channels are stable E channels, with restored pattern, profile and dimension, as set forth in this report, to entrain bedload readily available to the reaches. The design is based on extrapolation of downstream reference reach boundary conditions to on site impaired conditons. **Table 5** summarizes the restoration structure and objectives for Davis Branch mainstem and UT1.

TABLE 5
Restoration Structure and Objectives
Project Number D06054-F (Davis Branch and Unnamed Tributary 1)

<table>
<tr><th>Reach/Approach</th><th>Existing Length</th><th>Proposed Length</th><th>Stationing</th><th>Comment</th></tr>
<tr><td>Mainstem Priority Level I/II Restoration</td><td>1,562 lf</td><td>1,802 lf</td><td>7+81 – 24+83</td><td rowspan="2">Restore stable channel pattern profile, dimension, substrate
Restore connection to existing floodplain
Riparian plantings
Livestock exclusion fencing</td></tr>
<tr><td>UT1 Priority Level I Restoration</td><td>334 lf</td><td>450 lf</td><td>3+96 - 8+46</td></tr>
<tr><td>Mainstem Enhancement Level I Reach</td><td>1,289 lf</td><td>1,289 lf</td><td>24+83 – 38+72</td><td>Restore stable channel profile, dimension, substrate
Restore connection to existing floodplain
Riparian plantings
Livestock exclusion fencing</td></tr>
<tr><td>UT1 Enhancement Level II Reach</td><td>396 lf</td><td>396 lf</td><td>0+00 – 3+96</td><td>Restore stable channel dimension, substrate, grade control
Restore connection to existing floodplain
Riparian plantings
Livestock exclusion fencing</td></tr>
</table>

Note: Proposed stream lengths include lengths within the permanent conservation easement. Refer to the Restoration Summary Table in the Executive Summary for stream lengths adjusted for breaks in the perpetual NC EEP Conservation Easement recorded for the project and shown on Restoration Plan Sheet RP-01 & 02/20.

5.1.2 Target Buffer Communities

The target buffer community for both riparian planting areas along Davis Branch and UT1 is of the Piedmont/Low Mountian Alluvial Forest community type, as described in *Classification of the Natural Communities of North Carolina* (Schafale and Weakley, 1990). According to the Schafale and Weakley publication, hydrology of these areas is palustrine, seasonally or intermittently flooded on various alluvial soils. Important characteristics regarding the Piedmont/Low Mountain Alluvial forest Community according to Schafale and Weakley, 1990 include the following:

- *Flood carried sediment provides nutrient input to these communities, as well as serving as a natural disturbance factor.*

- *Variation is probably most related to frequency and recentness of destructive flooding. Sites may vary due to different alluvial material and its effect on soil fertility but almost all alluvial sites are more fertile than surrounding uplands.*

- *Piedmont/Low Mountain alluvial forests may be distinguished from mesic communities by location in a floodplain and by the presence of alluvial species such as Platanus occidentalis, Betula nigra, and Acer negundo.*

- *Piedmont Alluvial Forests may be distinguished from Montane Alluvial Forests by the presence of low elevation alluvial species such as Liquidambar styraciflua, Acer negundo, Fraxinus pennsylvanica, Ulmus americana, and Ulmus alata.*

5.2 Sediment Transport Analysis

5.2.1 Methodology

The modified Shields Equation was used to calculate the largest entrainable particle size, based on reach-specific design boundary conditions for the Davis Branch mainstem, and UT1 (Rosgen, 1994; Williams and Rosgen, 1989; Andrews, 1984).

5.2.2 Calculations and Discussion

Shields (1936) described shear stress as:

$\tau = \gamma RS$

where:

τ = shear stress (lbs/sq. ft.)
γ = specific weight of water (62.4 lbs/cu. ft.)
R = hydraulic radius (ft.), and
S = channel slope (ft./ft.).

To test the relationship between shear stress and mean stream velocity at multiple flow levels, Rosgen (1994) used an aggregate data set for six stream types. By plotting discharge (cfs) vs. bedload (lbs/sec) it was demonstrated a significant relationship was not found for the aggregate data set. Rosgen found, however, there is a significant empirical relationship when the same data set was stratified by stream type and shear stress (lbs/sq. ft.) was plotted vs. mean velocity (ft/sec) on a log-log scale.

The associated critical dimensionless shear stress (τ_{ci}*) was calculated based on the D50 particle distribution collected at impaired individual reach riffle cross-sections and composite

D50 particle distributions approximated by combining particle distributions from both riffles and pools on each reach, respectively.

The critical dimensionless shear stress, returned from RiverMorph®, is calculated using the following equation (Williams & Rosgen, 1989):

$$\tau_{ci}* = 0.0834(D50_{BED}/D50_{COMP})^{-0.872}$$

The following equation is used to predict the depth and slope needed to move the largest size of sediment available to the channel:

$$d = \frac{(\tau_{ci}*)\ (\gamma_S)\ (D50_{COMP})}{S}$$

Where:

γ_S = submerged specific weight of sediment
$D50_{COMP}$ = median diameter of composite sample
d = mean depth
S = mean water surface slope at bankfull

The bankfull critical shear stress, under design conditions, using the Rosgen Modified Shields Curve, and the entrainable particle diameter for each reach is summarized in the following table:

TABLE 6
Sediment Transport Analysis – Design Conditions
Project Number D06054-F (Davis Branch and Unnamed Tributary 1)

Reach	Critical Shear Stress (lbs/sq. ft.)	Particle Diameter (mm)
Upper Davis Branch Restoration Reach	0.68	114.9
Lower Davis Branch Enhancement Level I Reach	1.43	197.6
UT1 Enhancement Level II Reach	0.95	146.1
UT1 Restoration Reach	0.83	132.3

The required bankfull surface slope, hydraulic geometries and critical depths are included with the information in **Appendix 5**. Design particle size by reach are presented in Tables 4a through 4d. The particle distributions, collected and analyzed in field, are presented in the appendices.

5.3 Stormwater Best Management Practices

5.4.1 Site-Specific Stormwater Concerns

Properly installed and well maintained Best Management Practices (BMP) applications shall adequately mitigate the impact of sediment laden stormwater flows within the project corridors. The stormwater BMP erosion and sediment control narrative, practices, schedule, contractor responsibilities, inspection, maintenance and soil stabilization measures are presented on restoration plan sheets RP-15/20 through RP-18/20in **Appendix 1**. All BMP applications will be inspected and maintained throughout the construction process and until the site is stabilized per the planting plan shown on sheets RP-19/20 and RP-20/20 in **Appendix 1** and as described in Section 5.5.

5.5 Natural Plant Community Restoration

5.5.1 Plant Community Restoration Plan

The proposed riparian planting plan was developed by integrating the native plant species observed on site, species recommended within the *Guidelines for Riparian Buffer Restoration* (NCDENR – DWQ, 1/2001), as well selected species known to inhabit the Piedmont/Low Mountain alluvial forest community type as described in *Classification of the Natural Communities of North Carolina* (Schafale and Weakley, 1990) to institute species diversity. Table 7 presents the designed vegetative communities by zone along the streams. Where there is no pre-existing riparian corridor, the restored stream reaches will be fully replanted with the appropriate native species in the form of live stakes or bare-root material, along with some larger specimens (1 gallon container size). Planting zones (Zones 1 – 4) have been designated for the project as described in the tables on the following page. Where a woody riparian corridor is already present along the restoration and enhancement reaches, the existing corridor will be preserved to the maximum extent practicable and only Zone 1 and 2 plantings will be installed to provide vegetative cover immediately along the newly restored channel. The existing riparian corridor will be maintained along the preservation reach along the upstream portion of Davis Branch. Cattle exclusion fencing will be installed along the boundaries of the conservation easement corridor to protect the pre-existing and newly planted riparian vegetation. It is anticipated that the installation of cattle exclusion fence along the stream easement corridors will allow the impaired understory to eventually redevelop within existing wooded areas. Sheets RP-19/20 and RP-20/20 in **Appendix 1** indicate the approximate extent of full riparian restoration plantings (Zones 1-4), supplemental plantings (Zones 1-2), and preserved existing corridor.

Riparian plantings will be installed during the fall and/or spring season, as soon as possible after the completion of the earthwork associated with the restoration and enhancement efforts. Supplemental shrub and tree species will be planted if survival rates of previous plantings fall below target densities. Final species selection will be based upon availability. In addition to plantings described in Table 7, temporary and permanent seeding will occur in Zones 2, 3 & 4. The planting plan is presented in the schematic engineering drawings, included on design sheets RP-20 and RP-21 in **Appendix 1**.

TABLE 7: Designed Vegetative Communities by Zone
Project Number D06054-F (Davis Branch and Unnamed Tributary 1)

- Zone 1 – Stream Edge

Live Branches, 3x3' centers

Common Name	Scientific Name
Buttonbush	*Cephalanthus occidentalis*
Silky dogwood	*Cornus amomum*
Black willow	*Salix nigra*
Silky willow	*Salix sericea*
Elderberry	*Sambucus canadensis*

- Zone 2 – Streamside Shrubs and Trees

Shrubs, Bareroot Material **-** 4x4' centers

Common Name	Scientific Name
Painted buckeye	*Aesculus sylvatica*
Tag alder	*Alnus serrulata*
Red chokeberry	*Aronia arbutifolia*
Silky dogwood	*Cornus amomum*
American holly	*Ilex opaca*
Black willow	*Salix nigra*
Elderberry	*Sambucus canadensis*

Trees, 1 Gallon Containers - 100 foot spacing

Common Name	Scientific Name
River birch	*Betula nigra*
Sugarberry	*Celtis laevigata*
Green ash	*Fraxinus pennsylvanica*
Tulip poplar	*Liriodendron tulipifera*
Sycamore	*Platanus occidentalis*
Water oak	*Quercus nigra*
Willow oak	*Quercus phellos*
American elm	*Ulmus americana*

TABLE 7 (cont.)
Designed Vegetative Communities by Zone
Project Number D06054-F (Davis Branch and Unnamed Tributary 1)

- Zone 3 – Floodplain

Bareroot Material - 8x8' centers

Common Name	Scientific Name
Red chokeberry	*Aronia arbutifolia*
Pawpaw	*Asimina triloba*
River birch	*Betula nigra*
American hornbeam	*Carpinus caroliniana*
Sugarberry	*Celtis laevigata*
Green ash	*Fraxinus pennsylvanica*
Tulip poplar	*Liriodendron tulipifera*
Black gum	*Nyssa sylvatica*
Sycamore	*Platanus occidentalis*
American elm	*Ulmus americana*

- Zone 4 – 30' Riparian Buffer

Bareroot Material - 10x10' centers

Common Name	Scientific Name
Pignut hickory	*Carya glabra*
Flowering dogwood	*Cornus florida*
White ash	*Fraxinus americana*
Black walnut	*Juglans nigra*
Tulip poplar	*Liriodendron tulipifera*
Eastern hophornbeam	*Ostrya virginiana*
Black cherry	*Prunus serotina*
White oak	*Quercus alba*
Smooth sumac	*Rhus glabra*
Winged elm	*Ulmus alata*

5.5.2 On-Site Invasive Species Management

This project proposes to treat and eradicate exotic woody vegetation by appropriate means. This will help meet one of the overall goals of the restoration project by enhancing buffers and creating habitat for birds and animals. By eradicating non-native vegetation, native vegetation will be allowed to colonize and provide a better food source for the local fauna.

Before treatment, a vegetation assessment would be performed to determine the presence and extent of invasive vegetation. The most appropriate treatment options will be determined after the assessment. Invasive species that may colonize the site after construction will be identified during post-construction monitoring events, and appropriate eradication methods will be employed. Possible treatments for invasive exotic vegetation include application of appropriate herbicides either through stem cut and spray or spraying of the actively photosynthesizing leaves. This work would most likely be done in the fall or winter, during the dormant season of most native vegetation. The initial treatment would likely take a week to complete. Follow up and maintenance is critical in order to eradicate any root sprouts that may occur in the following seasons.

6.0 PERFORMANCE CRITERIA

6.1 Streams

As discussed in the original proposal, the restoration goal for the stream is to restore the physical and biological integrity beyond current stream conditions. Current conditions consist of modified or impaired stream channels. Objectives to meet that goal of restoring these stream channels are listed below:

- Provide a stable stream channel with features characteristic of a biologically diverse environment
- Restore the connection between the bankfull width and floodprone width of the channels by improving the floodplain area
- Stabilize eroding streambanks
- Provide a functional, native riparian corridor where deficient, and preserve existing forested corridors
- Improve the physical aquatic habitat features
- Minimize land development impacts to the streams
- Provide long-term protection of the stream corridors, including preservation of existing wooded corridors

Restoration will provide desired habitat and stability features necessary to improve the quality of project streams. There are several long-term benefits associated with the restoration of the streams, such as:

- Reversing the effects of channel incision
- Stabilizing eroding streambanks
- Development of instream habitat features
- Revegetation of the riparian corridor with native vegetation that can be utilized by local wildlife
- Improving stream channel connection to the floodplain, providing the benefits of sediment and nutrient storage

The restoration techniques proposed for the project stream reaches will provide the attributes described above by incorporating a variety of features recognized to support the stability and biological diversity that are essential to restoration and ecosystem enhancement. Presently, these features are diminished within Davis Branch and the associated Unnamed Tributary.

The restoration of the streams includes assessing and predicting the morphological features that will become the foundation for the construction of a stable natural channels. Considerations that have been applied to the design of this project are listed on the following page.

- Bankfull channels designed with the appropriate dimension, pattern and profile to convey bankfull flows and entrain bedload material readily available to the streams.
- Stable channel pattern (sinuosity) extrapolated from stable reference reach boundary conditions.
- Grade control and bank stabilization structures to enhance the environmental and ecological attributes of the stream channels though the use of natural materials and native plantings.
- In-stream habitat features such as pool/riffle complexes, cross-vanes, bank stabilization structures, and re-establishment of the appropriate substrate material.
- Improved connections between stream channels and functional floodplains.
- Installation of woody plantings where the riparian corridor is currently deficient, or where it is disturbed for construction. Existing woody vegetation present along the streams will be preserved to the maximum extent practicable.

Proven natural stream geometry relationships as described by Newbury, Leopold, Wolman, Miller, Rosgen and others, is the basis for designing a stable, self-maintaining channel. The empirical relationships between channel pattern, profile and dimension and stream flow form the foundation for the restoration of the physical and biological functions natural streams.

6.2 Stormwater Management Devices

Properly installed and well maintained Best Management Practices (BMP) applications shall adequately mitigate the impact of sediment laden stormwater flows within the project corridors. The stormwater BMP erosion and sediment control narrative, practices, schedule, contractor responsibilities, inspection, maintenance and soil stabilization measures are presented on restoration plan sheet RP-15/20 through RP-18/20 in **Appendix 1**. All BMP applications as shown on these plan sheets will be inspected and maintained throughout the construction process and until the site is stabilized per the planting plan shown on sheets RP-19/20 and RP-20/20 in **Appendix 1** and as described in Section 5.5.

6.3 Vegetation

The target density for the riparian buffer is to establish a minimum of 320 stems per acre after 3 years, with a minimum of 260 stems per acre at the end of the 5-year monitoring period within the planted areas. This would represent a minimum survival rate of 80% of the plantings.

6.4 Monitoring Schedule and Reporting

The restoration site will be monitored for five consecutive years or until the required success criteria have been met as determined by the EEP, NC DWQ, and USACE. As-built survey data will be collected immediately after construction. Year 1 Monitoring activities will begin will be conducted al least 6 months after the as-built survey. Planting will occur during the fall of 2008 or no later than the spring of 2009; therefore, the riparian buffer restoration will be monitored the following growing season (September 2009). Monitoring activities will follow the guidelines presented in the request for proposal for this project.

Parameters that will be included in the annual stream monitoring to ensure the success of the restoration activities will include stream channel surveys (longitudinal and cross-sectional profiles), pebble counts, photographs, and vegetation surveys. Monitoring reports will be prepared following the EEP Monitoring Report Format, Version 1.2 dated 11/16/06.

Following the submittal of the monitoring reports to the appropriate agency representatives, the recipients of the report will be contacted for the purpose of discussing the monitoring data, required success criteria and whether or not the site is functioning as expected. If the site is not functioning as expected, a site visit will be scheduled with the review agencies so that consideration can be given to whether a remediation plan should be created and implemented. The remediation plans, if required, will directly reflect the requested alterations as discussed with the regulatory agencies, if it is determined that such alterations will correct any identified deficiencies.

<u>Stream Channels</u>

Stream channel stability will be physically monitored by establishing permanent, monumented cross-sections located approximately every 500 feet along the restored and enhanced channel reaches (or no more than 2 per thousand feet). This will include four (4) cross-sections along the Davis Branch Restoration reach and three (3) along the mainstem Enhancement Level I reach. One (1) monumented cross-section will be surveyed along the UT1 Restoration reach and one (1) along the Enhancement II reach. Cross-sections will be equally distributed between riffles and pools on the project reaches. Each cross-section will be monumented for future identification and survey. Monumented cross-sections will be utilized as photographic points. Cross-section locations to be monitored will be established immediately following construction during the completion of the "as-built" survey. A longitudinal profile survey will be conducted along the entire lengths of the mainstem Davis Branch Restoration and Enhancement 1 reaches (3,091 linear feet total), and the entire 450 linear feet of the UT1 Restoration reach (noting permanent easement crossing locations). The "as-built" mitigation plan will include the constructed stream channels dimension, pattern, and longitudinal profile. This data will be utilized as baseline to compare future monitoring surveys and subsequently to determine channel stability and natural adjustments over time. Streambed particle distribution data will be collected and analyzed at monumented cross-section bedform features. Surveyed vegetative plots will be utilized to monitor the success of riparian plantings and vegetation conditions. Annual inspection of in-stream structures will also occur to verify proper function and channel stability. Stream channel monitoring surveys will be completed annually for five consecutive years, starting on Year 1 after completion of the project.

The performance standards for the restoration project are those mandated in the multi-agency *Stream Mitigation Guidelines* (USACE Wilmington District, et al., April 2003). Performance goals for the site are listed on the following page.

- Minimal or negligible development of instream bar deposits.
- Minimal or negligible change in channel pattern, profile and dimension in comparison to As-Built conditions. Adjustments may occur and some may be indicative of stability, for example moderate reductions in width/depth ratios as a result of slight channel narrowing, natural sorting and shaping of bed materials and features, respectively.
- Maintenance of floodplain connectivity (only reductions or very small increases will be considered acceptable).
- Target density of 320 stems per acre after 3 years and 260 stems per acre after 5 years for planted woody vegetation (represents 80% survival after 5 years).

Subsequent monitoring reports will address the attainment of performance goals. If goals are not be attained, then the monitoring reports will document any remedial actions taken during the monitoring period and the success of these actions.

Riparian Buffers

Vegetation within the restored riparian buffer will be monitored for five consecutive years. A total of 10 ten by ten meter square plots will be permanently established within planted areas following completion of the planting phase. At least two opposing corners will be marked and surveyed for future location in the field.

Approximately 2.78% of the project area will be monitored following the CVS-EEP Level 1 Protocol for Recording Vegetation, Version 4.0 (Lee et al., 2006). A stem count of planted species will be performed within each monitoring plot. The species, location, size, density, survival rates, and cause of mortality if identifiable will be reported for each planted species in each plot. Vegetation plots will be sampled annually and reported every year along with the data collected during the physical monitoring of the channel. The primary focus of the vegetative monitoring will be on the planted individuals in the tree and shrub strata. Vegetation monitoring will occur during the month of September.

Monitoring reports and discussions of remedial actions will take place with EEP. EEP will review the monitoring documents and make them available to the agencies after the review period. Decision making regarding remediation will be between EEP and WRC and its agents or representatives. Agency interaction will take place through permit requests for maintenance should they become necessary. Agency interaction will take place at the end of the monitoring period.

7.0 REFERENCES

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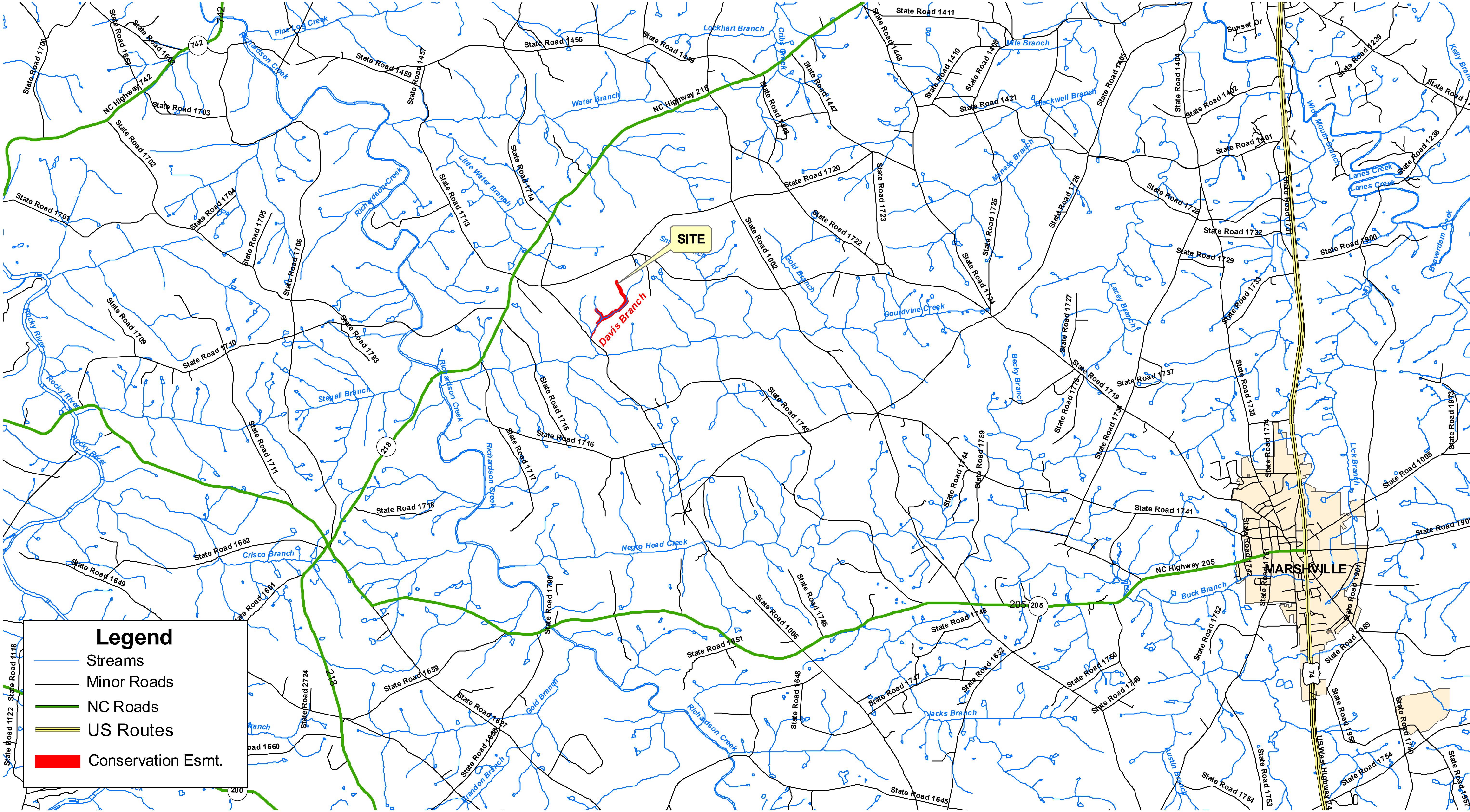
8.0 FIGURES



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UNION COUNTY, NORTH CAROLINA

DAVIS BRANCH & UNNAMED TRIBUTARY
SITE VICINITY MAP
FIGURE 1

Scale: 1" = 5000'

0 2,500 5,000 10,000 15,000 Feet

Sources:
- Roads and Property lines, - Union County GIS Dept
- Streams and Lakes - National Hydrography Dataset (medium resoultion)

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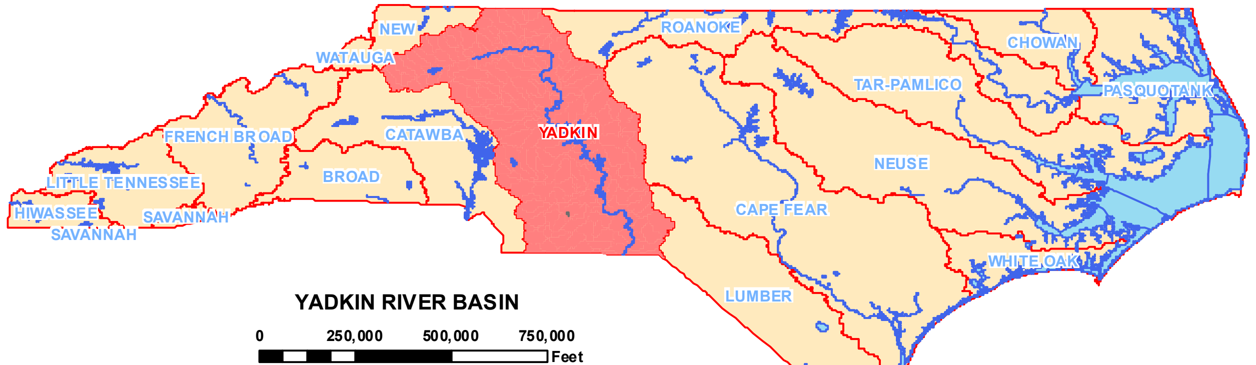

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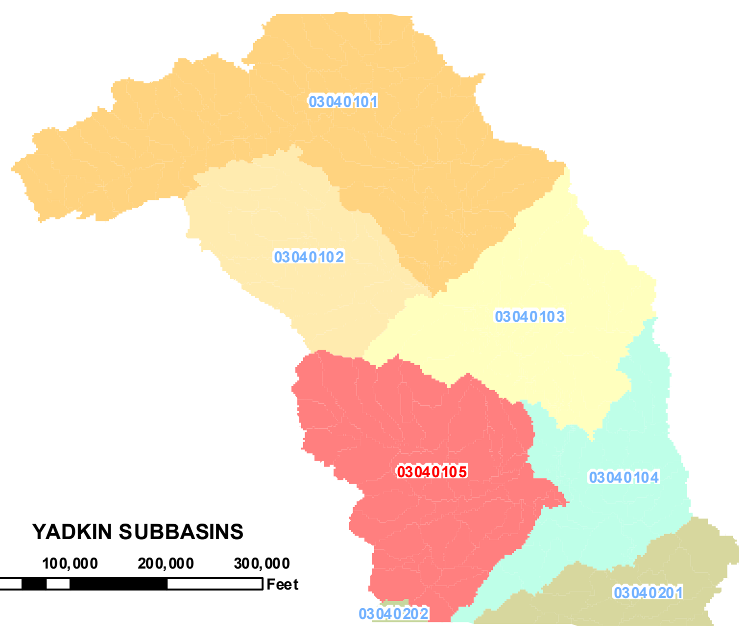

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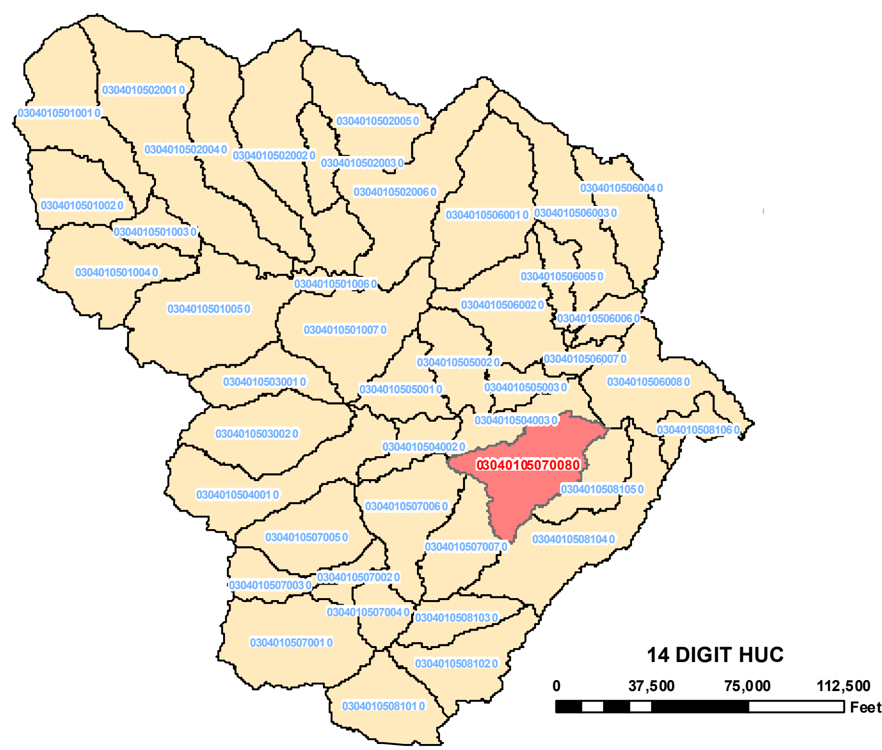

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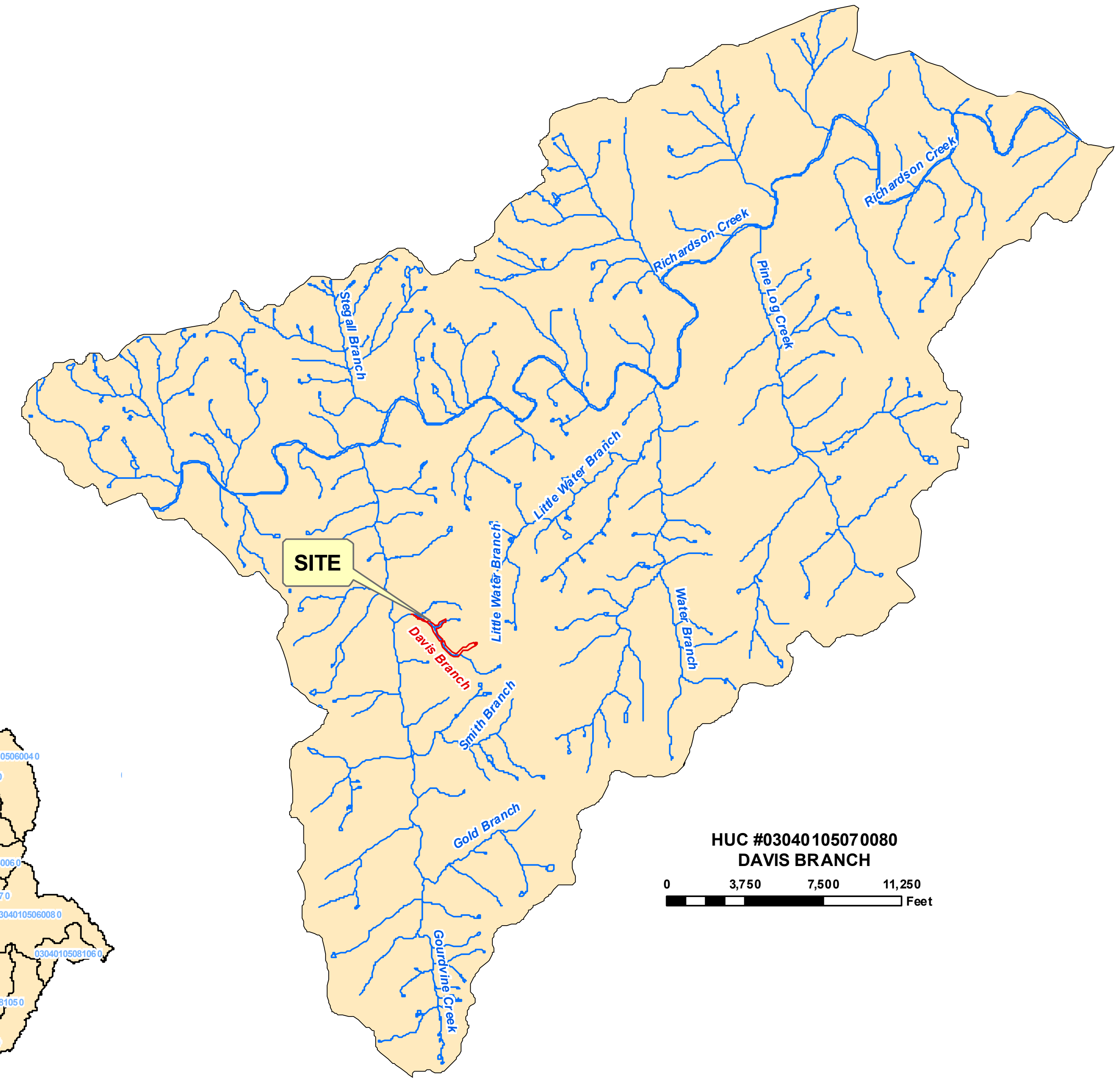

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DAVIS BRANCH & UNNAMED TRIBUTARY
TARGETED LOCAL WATERSHED SUBBASIN MAP
FIGURE 2

SOURCE:
- Hydrology subbasin data obtained from North Carolina Center for Geographic Information and Analysis

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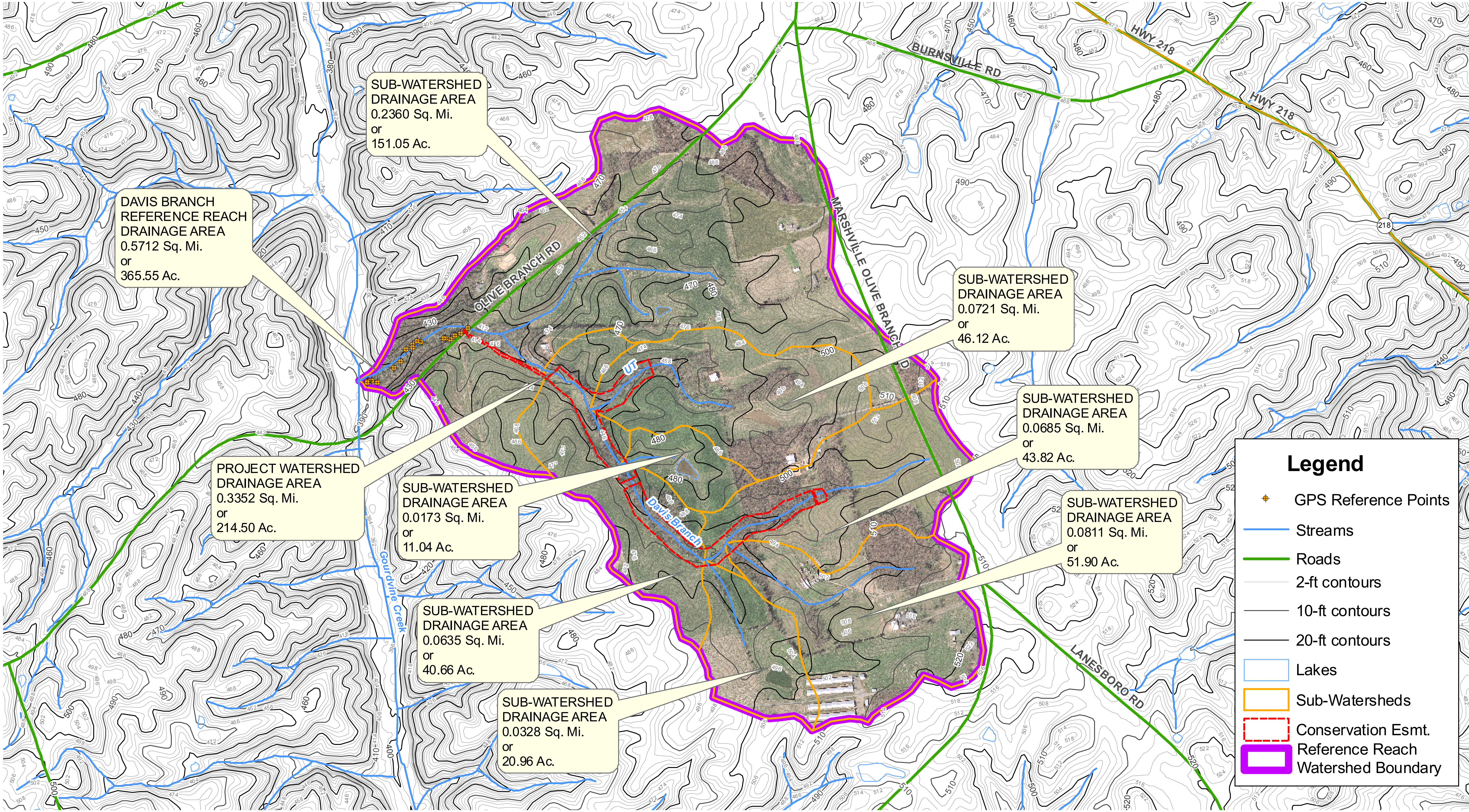

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Scale: 1" = 800'
0 400 800 1,600 2,400 Feet

UNION COUNTY, NORTH CAROLINA

DAVIS BRANCH & UNNAMED TRIBUTARY REFERENCE REACH AND SITE WATERSHED MAP
FIGURE 3

Sources:
- Contours - NCDOT GIS Branch, based on the Flood Mapping LIDAR data Mar 2005
- Lakes, Streams, Road Centerlines, - Union County GIS Dept
- Stream Names - National Hydrography Dataset (medium resoultion)

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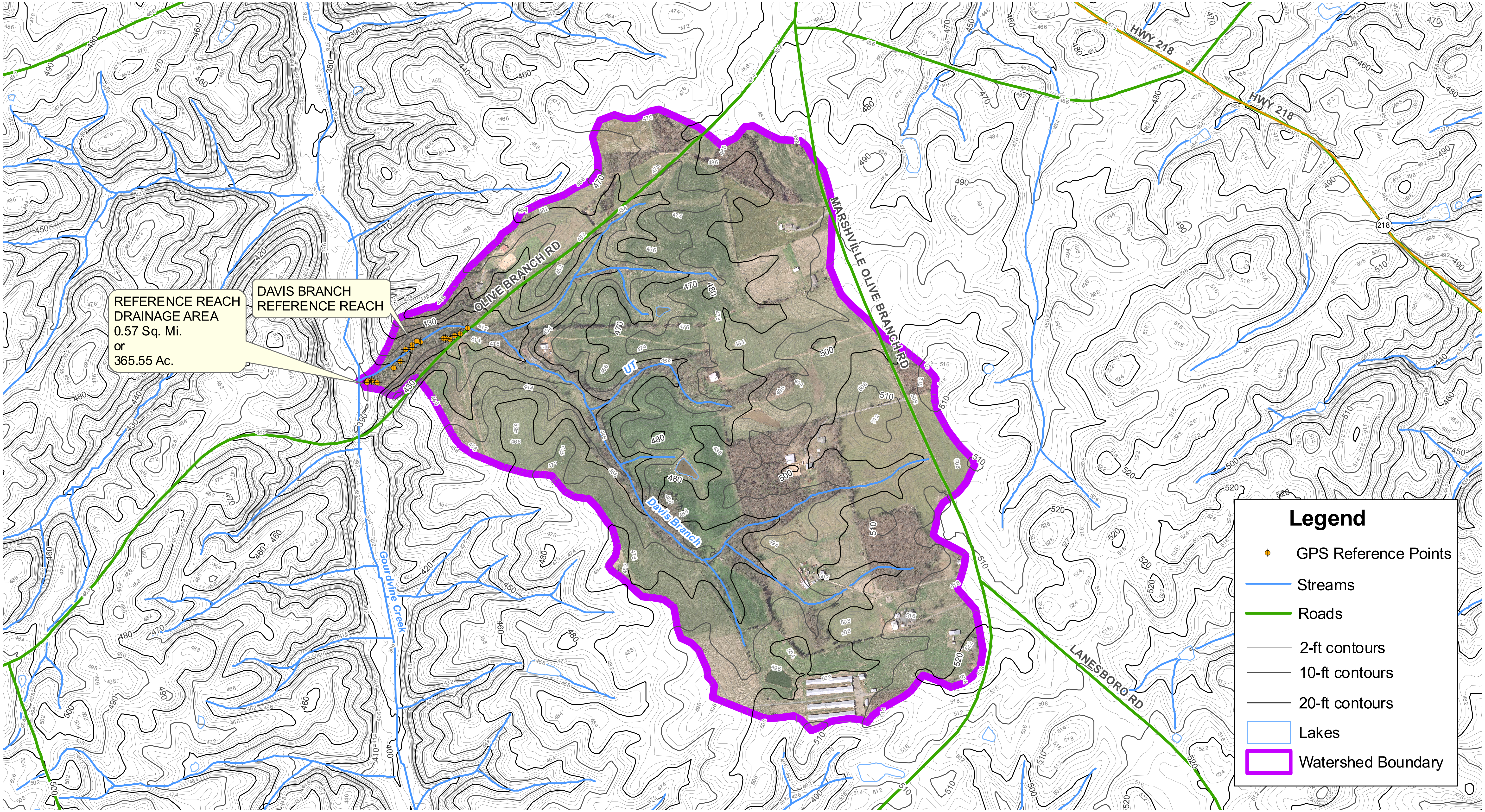

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UNION COUNTY, NORTH CAROLINA

Scale: 1" = 800'

0 400 800 1,600 2,400 Feet

DAVIS BRANCH REFERENCE REACH AND SITE WATERSHED MAP
FIGURE 3A

Sources:
- Contours - NCDOT GIS Branch, based on the Flood Mapping LIDAR data Mar 2005
- Lakes, Streams, Road Centerlines, - Union County GIS Dept
- Stream Names - National Hydrography Dataset (medium resoultion)

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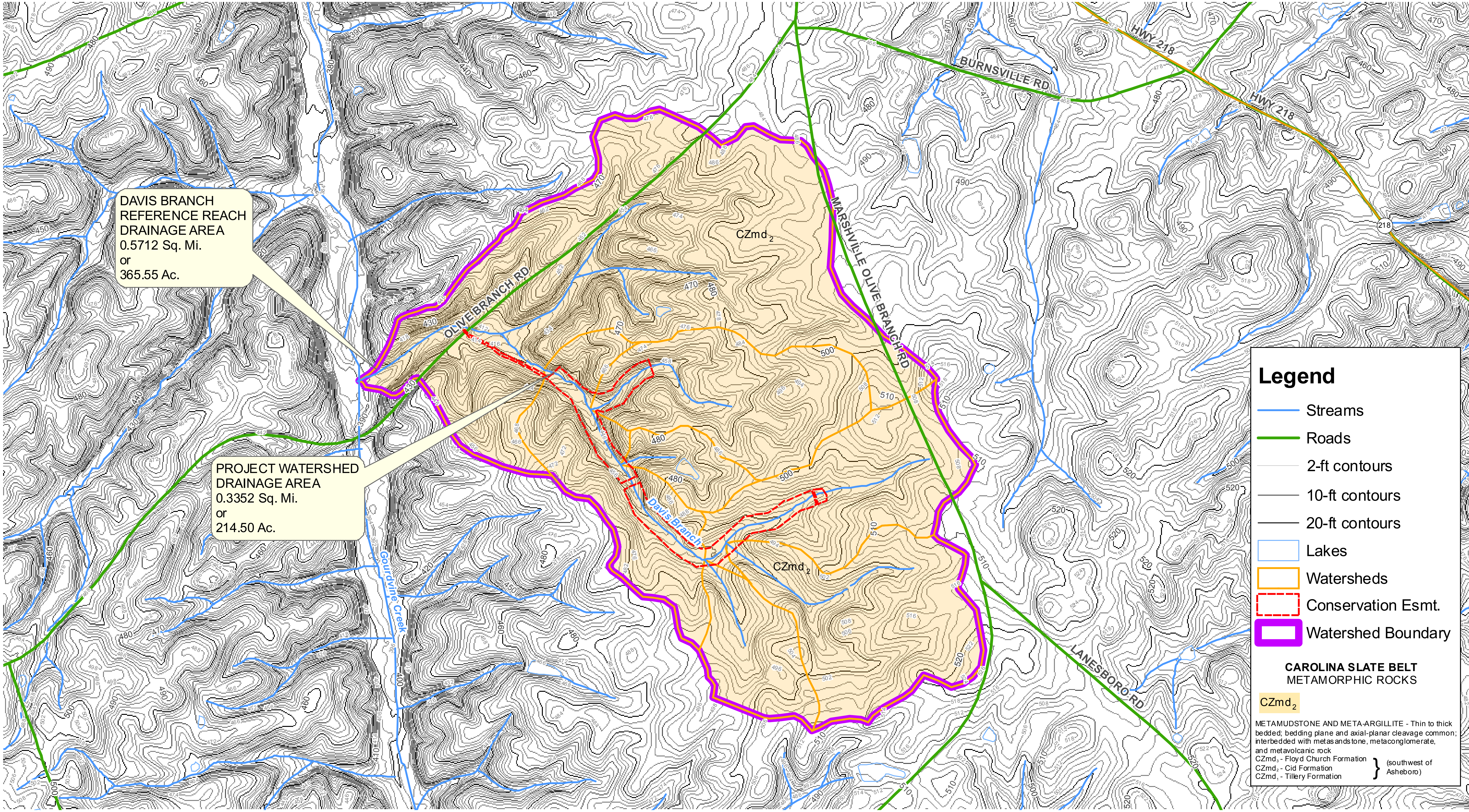

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Scale: 1" = 800'

0 400 800 1,600 2,400 Feet

UNION COUNTY, NORTH CAROLINA

DAVIS BRANCH & UNNAMED TRIBUTARY
SITE GEOLOGY MAP
FIGURE 4

Sources:
- Geology map - NC Department of Natural Resources and Community Development (1985)
- Contours - NCDOT GIS Branch, based on the Flood Mapping LIDAR data Mar 2005
- Lakes, Streams, Road Centerlines, - Union County GIS Dept
- Stream Names - National Hydrography Dataset (medium resoultion)

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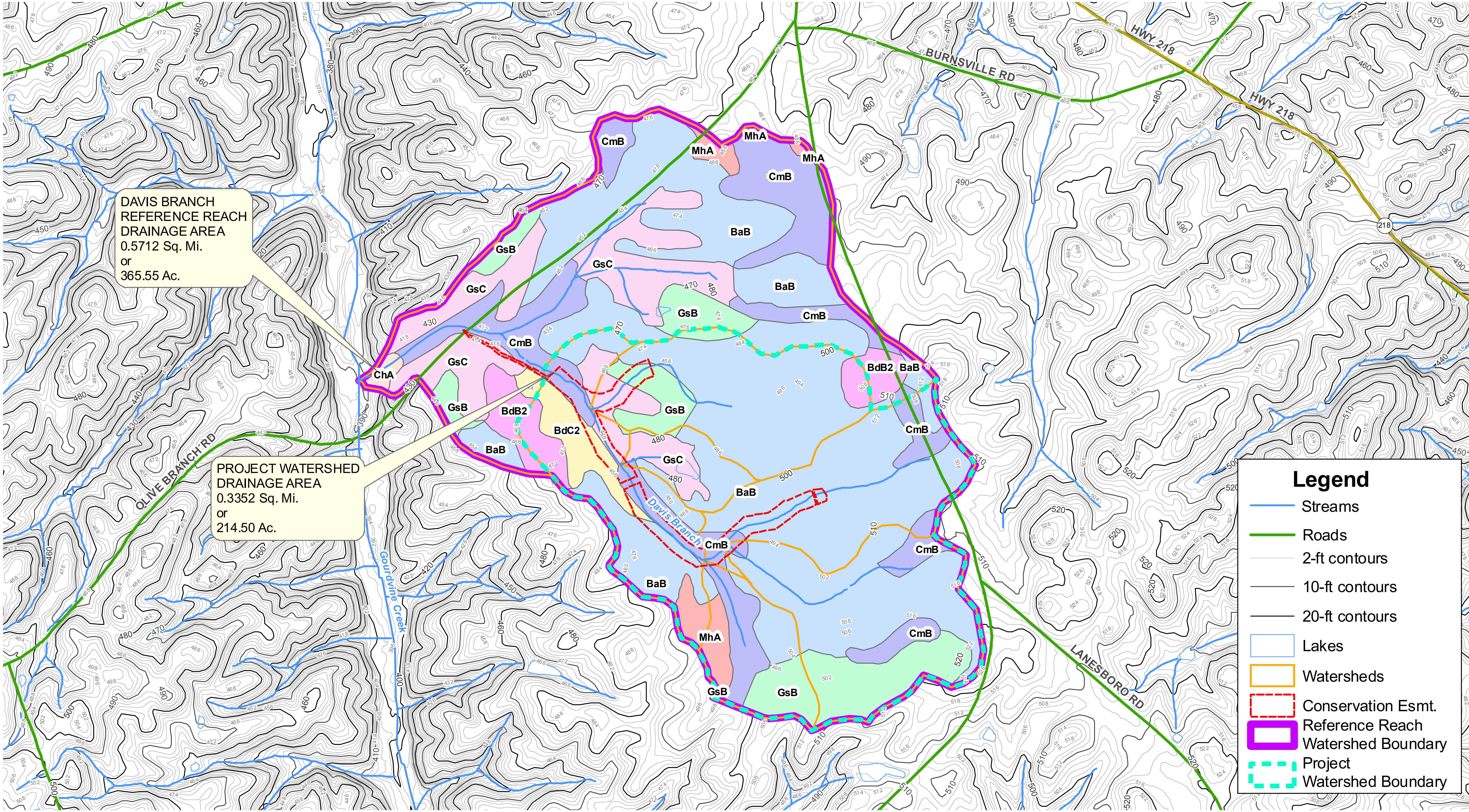

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Scale: 1" = 800'

0 400 800 1,600 2,400 Feet

UNION COUNTY, NORTH CAROLINA

DAVIS BRANCH & UNNAMED TRIBUTARY
NRCS SOIL SURVEY MAP
FIGURE 5

Sources:
- Soils data - NRCS SSURGO, 2006
- Contours - NCDOT GIS Branch, based on the Flood Mapping LIDAR data Mar 2005
- Lakes, Streams, Road Centerlines, - Union County GIS Dept
- Stream Names - National Hydrography Dataset (medium resoultion)

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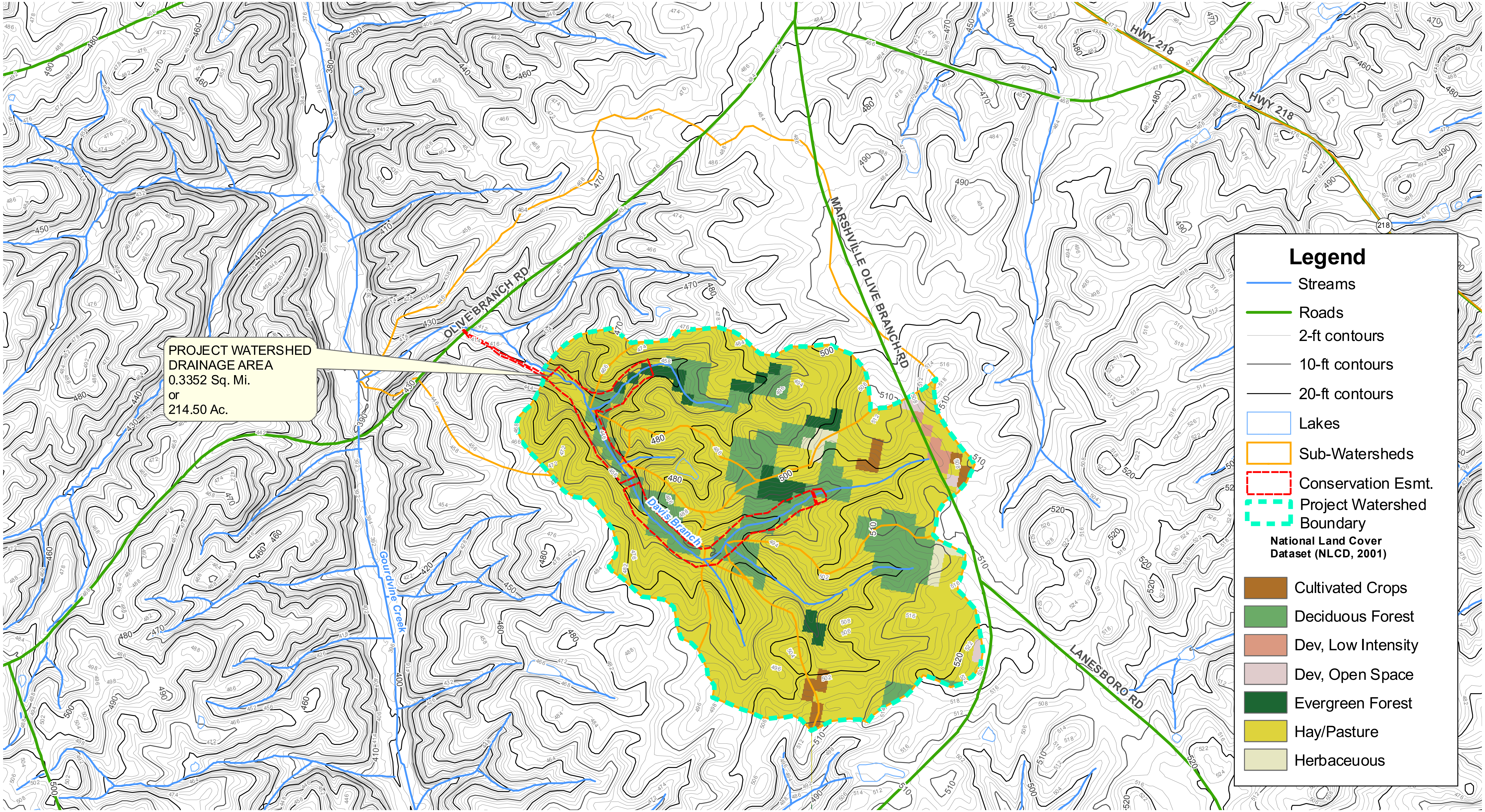

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Scale: 1" = 800'
0 400 800 1,600 2,400 Feet

UNION COUNTY, NORTH CAROLINA

DAVIS BRANCH & UNNAMED TRIBUTARY
SITE NATIONAL LAND COVER DATASET MAP
FIGURE 6

Sources:
- Contours - NCDOT GIS Branch, based on the Flood Mapping LIDAR data Mar 2005
- Lakes, Streams, Road Centerlines, - Union County GIS Dept
- Stream Names - National Hydrography Dataset (medium resoultion)
- Land Cover - National Land Cover Dataset, 2001

N

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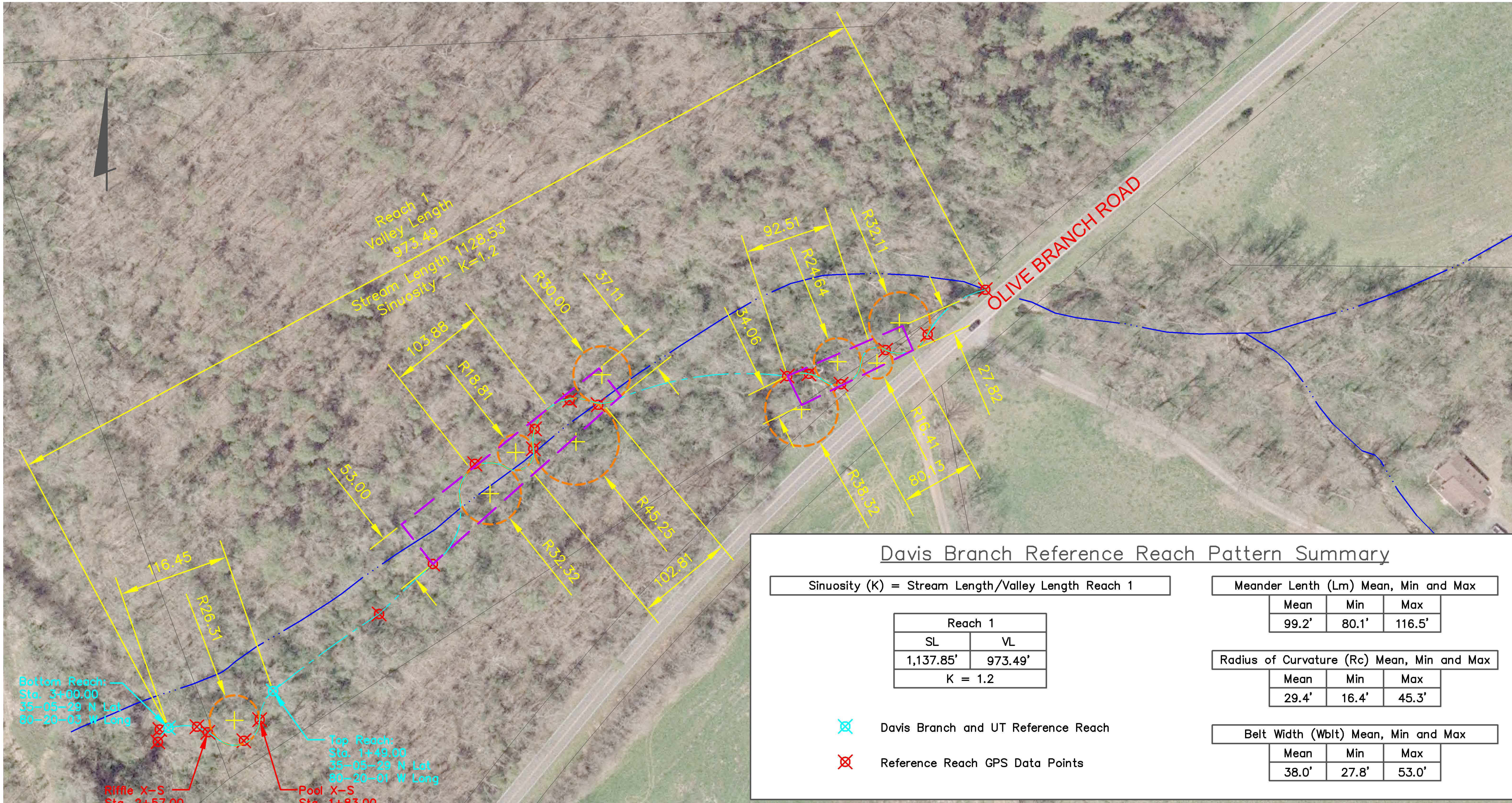

Davis Branch Reference Reach Pattern Summary

Sinuosity (K) = Stream Length/Valley Length Reach 1

Reach 1	
SL	VL
1,137.85'	973.49'
K = 1.2	

Davis Branch and UT Reference Reach

Reference Reach GPS Data Points

Meander Lenth (Lm) Mean, Min and Max

Mean	Min	Max
99.2'	80.1'	116.5'

Radius of Curvature (Rc) Mean, Min and Max

Mean	Min	Max
29.4'	16.4'	45.3'

Belt Width (Wblt) Mean, Min and Max

Mean	Min	Max
38.0'	27.8'	53.0'

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UNION COUNTY, NORTH CAROLINA

DAVIS BRANCH & UNNAMED TRIBUTARY RESTORATION

REFERENCE REACH AND PATTERN SUMMARY EXHIBIT

FIGURE 7

Date:	February, 2008
Scale:	1" = 100'
Job No:	2006-1397

9.0 APPENDICES

APPENDIX 1

Restoration Plan Design Sheets

UNION COUNTY, NORTH CAROLINA

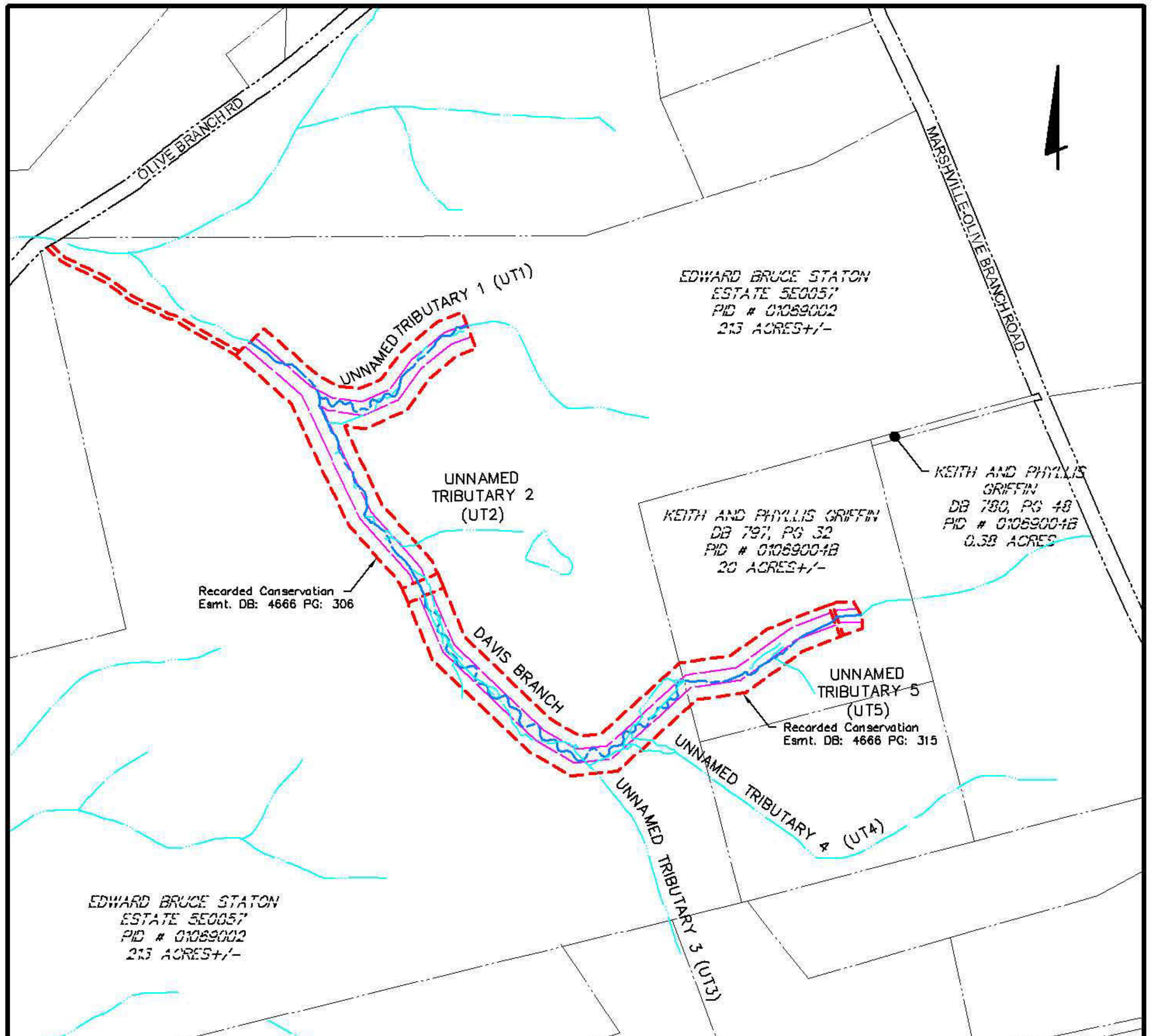
STREAM RESTORATION PLAN

FOR

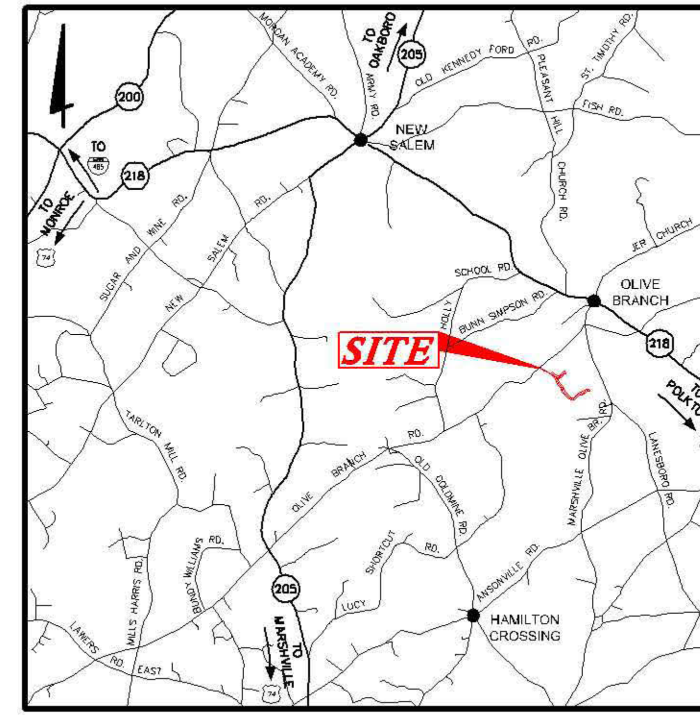
DAVIS BRANCH AND UNNAMED TRIBUTARY

2008

INDEX OF SHEETS



LOCATION MAP
Scale: 1"=600'



VICINITY MAP
Not To Scale

DAVIS BRANCH & UNNAMED TRIBUTARY – STREAM DESIGN STATISTICS

Parameters	Davis Branch Restoration	Davis Branch Enhancement I	Unnamed Tributary
Drainage Area at Downstream Limits (mi^2)	0.1823	0.3352	0.0721
Average Sinuosity	1.29	1.06	1.31
Bankfull Width (ft.)	9.0	10.0	6.2
Bankfull Mean Depth (ft.)	0.8	1.1	0.7
Bankfull Max Depth (ft.)	1.2	1.6	1.0
Bankfull Area ($ft.^2$)	7.6	11.3	4.3
Width/Depth Ratio	10.7	8.8	9.0
Beltwidth (ft.)	50	50	50
Bankfull Discharge (cfs)	25.5	46.9	10.1
Mean Velocity (ft./sec)	X.0	X.0	X.0

MARK | DATE | DESCRIPTION
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UNION COUNTY, NORTH CAROLINA
STREAM RESTORATION PLAN
FOR
DAVIS BRANCH
AND UNNAMED TRIBUTARY
STREAM RESTORATION PROJECT
TITLE SHEET

Date: May, 2008
Scale: As Noted
Job No.: 2006-1397
Sheet: RP-01/20

INDEX MAP

Scale: 1" = 400'

LEGEND

EX. UTILITY POLE

EX. TREE

EX. TREE TO BE REMOVED

EX. TREE LINE

EX. 1 FOOT CONTOURS

EX. 5 FOOT CONTOURS

EX. FENCE

EX. PROPERTY LINE

EX. RIGHT OF WAY

EX. STREAM

PROP. THALWEG

PROP. BANKFULL

PROP. BELTWIDTH

PROP. CONSERVATION EASEMENT

LIMITS OF DISTURBANCE

TEMPORARY SEDIMENT FENCE

PROP. WIRE FENCE (LIVESTOCK EXCLUSION)

PROP. STREAM CROSSING

PROP. EARTHEN PLUG

PROP. BANK REINFORCEMENT

PROP. RIFFLE

PROP. POOL

PROP. LOG SILL

UNION COUNTY, NORTH CAROLINA
STREAM RESTORATION PLAN
FOR
DAVIS BRANCH AND UNNAMED TRIBUTARY
STREAM RESTORATION PROJECT
INDEX MAP

Job No.	2006-1397
Sheet	**RP-02/20**
Date	May, 2008
Scale	1" = 400'

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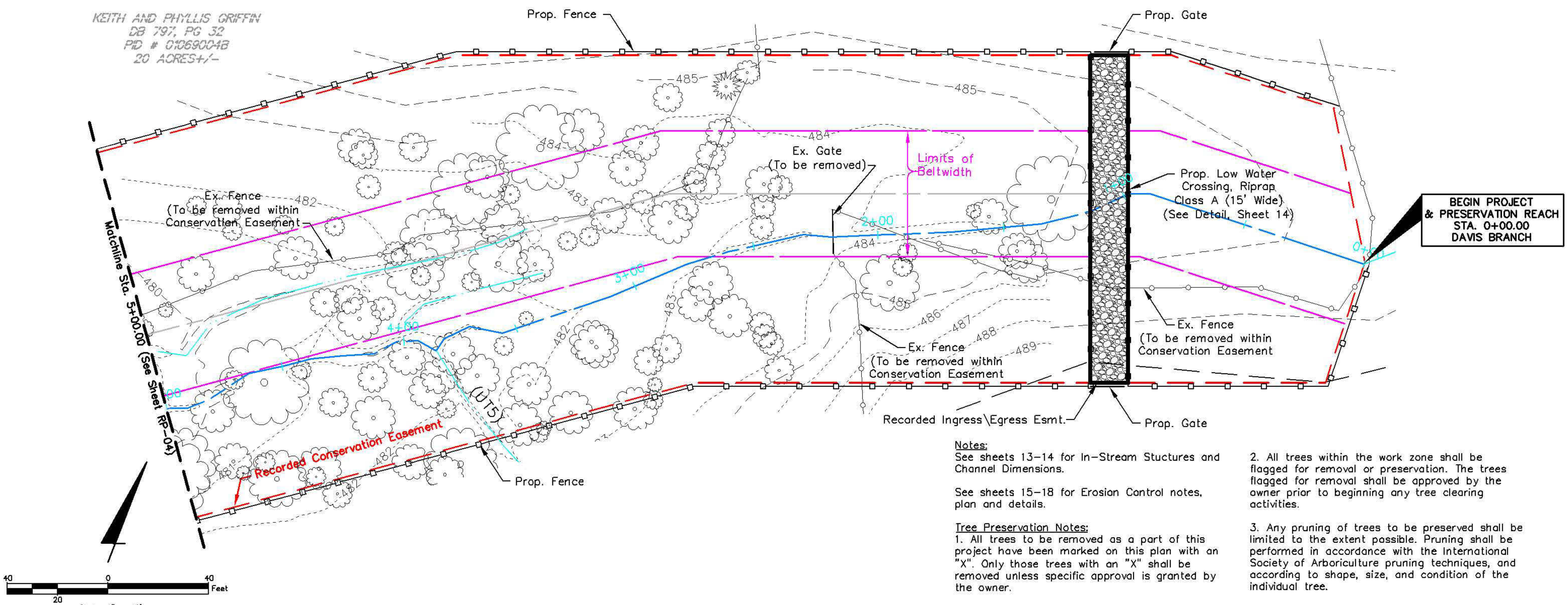
\\CMHDATA\ENVIRON\PROJECT\2006\1397.ENV\DWG\RESTORATION PLAN\61397RP02.DWG<RP-02> - 2 XREFS: 61397XTS, 61397XBS(UPDATE) - LAST SAVED BY JCRAMER [5/16/2008 10:21:35 AM] - PLOTTED BY JCRAMER [5/16/2008 2:56:39 PM]



Notes:
See sheets 13–14 for In–Stream Stuctures and Channel Dimensions.

See sheets 15–18 for Erosion Control notes, plan and details.

Tree Preservation Notes:
1. All trees to be removed as a part of this project have been marked on this plan with an "X". Only those trees with an "X" shall be removed unless specific approval is granted by the owner.

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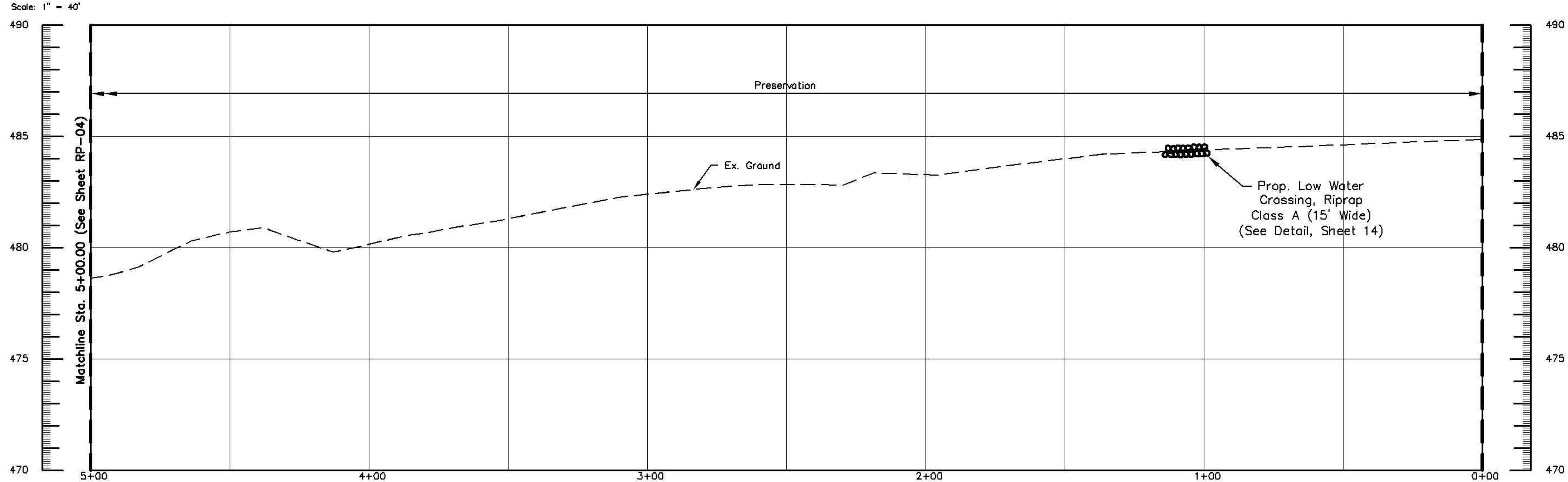

UNION COUNTY, NORTH CAROLINA
STREAM RESTORATION PLAN
FOR
DAVIS BRANCH AND UNNAMED TRIBUTARY
STREAM RESTORATION PROJECT
PLAN & PROFILE - DAVIS BRANCH

Job No. 2006-1397
Sheet RP-03/20
Date May, 2008
Scale Hor: 1" = 40' Ver: 1" = 5'

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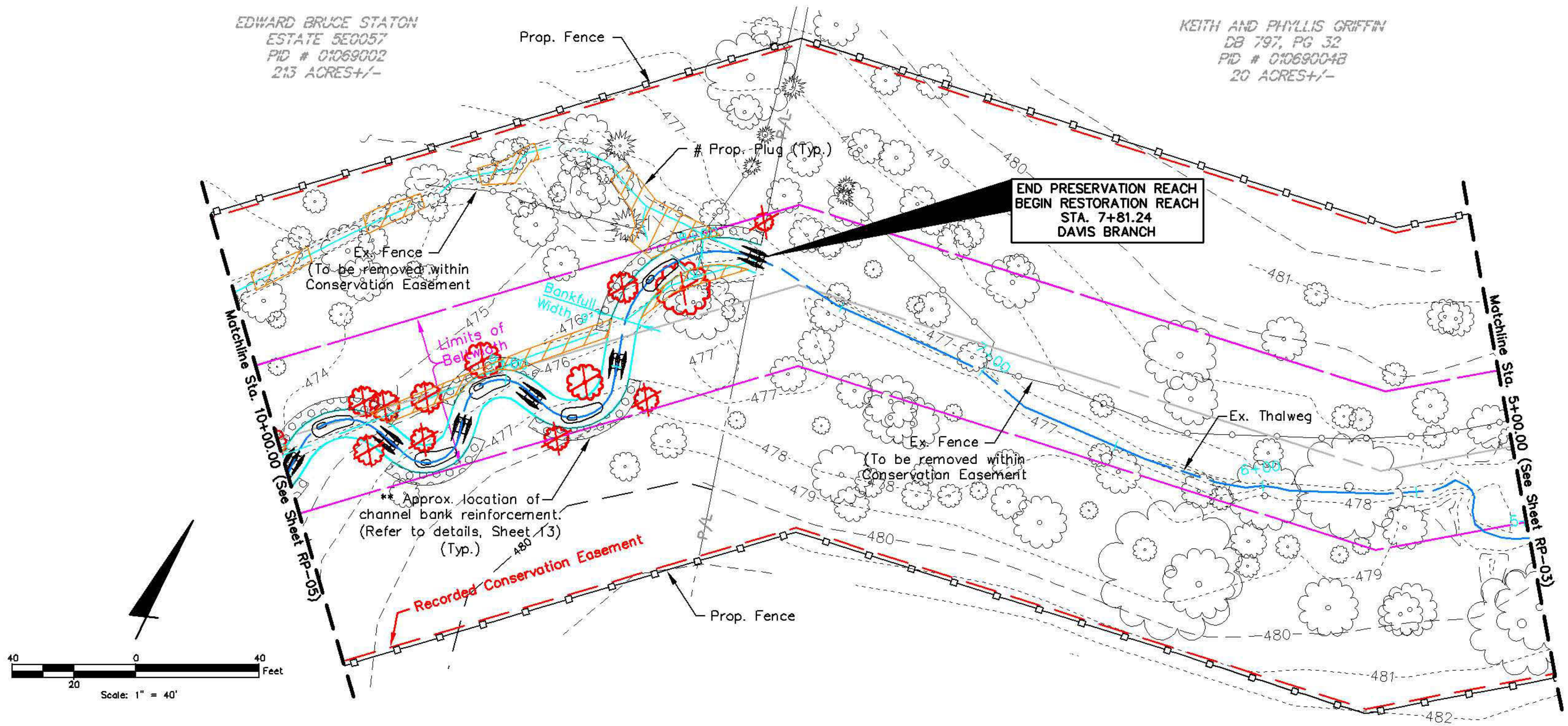

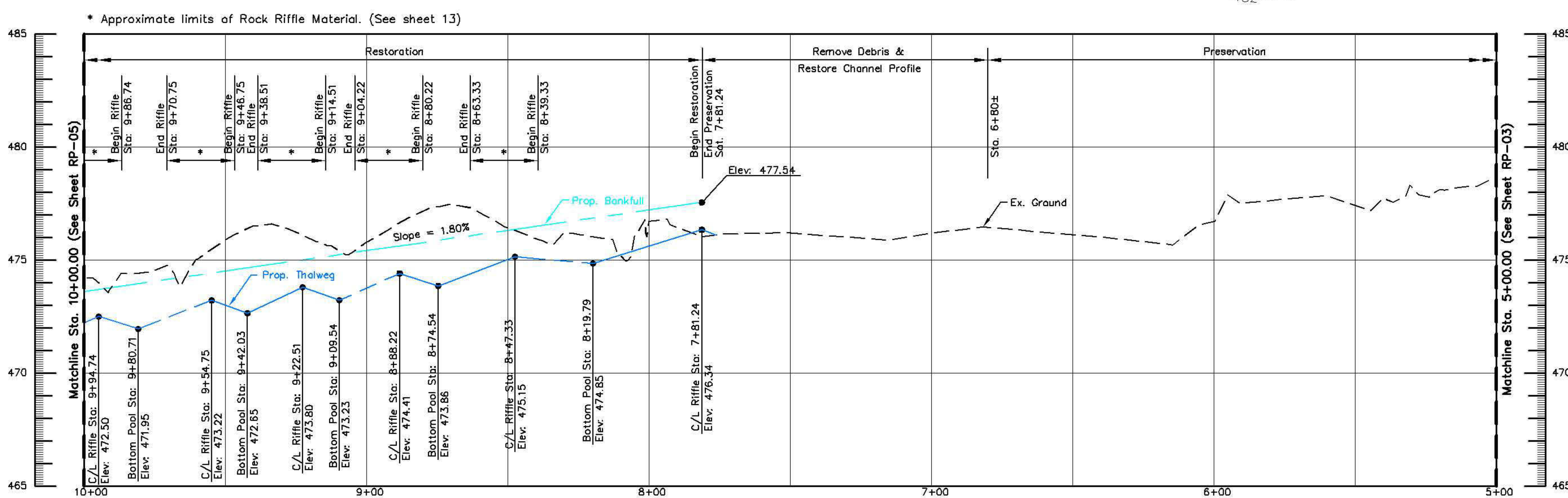

Notes:

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See sheets 15-18 for Erosion Control notes, plan and details.

** Channel Reinforcement shall begin 5 feet above the end of the upstream riffle and extend 3 feet below the beginning of the downstream riffle. Refer to riffle stations on profile.

The Existing stream within the Beltwidth shall be plugged with a combination of compacted cohesive clay soil and Plain Riprap, Class 1. The existing stream outside the Beltwidth shall be plugged every 40' to promote overland flow to the proposed channel.

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Job No. 2006-1397
Sheet RP-04/20
Date May, 2008
Scale Hor: 1" = 40' Ver: 1" = 5'

UNION COUNTY, NORTH CAROLINA
STREAM RESTORATION PLAN
FOR
DAVIS BRANCH
AND UNNAMED TRIBUTARY
STREAM RESTORATION PROJECT
PLAN & PROFILE - DAVIS BRANCH

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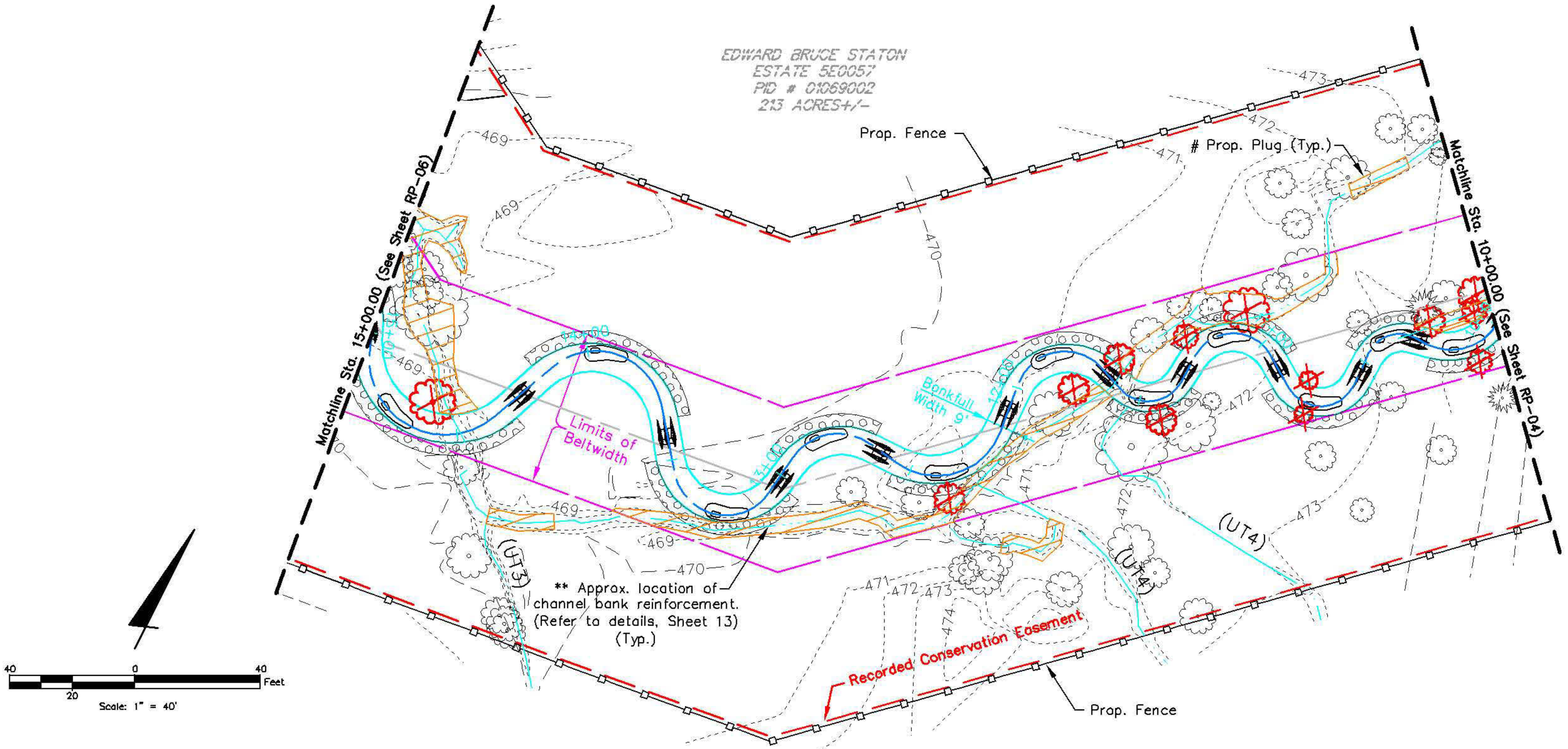

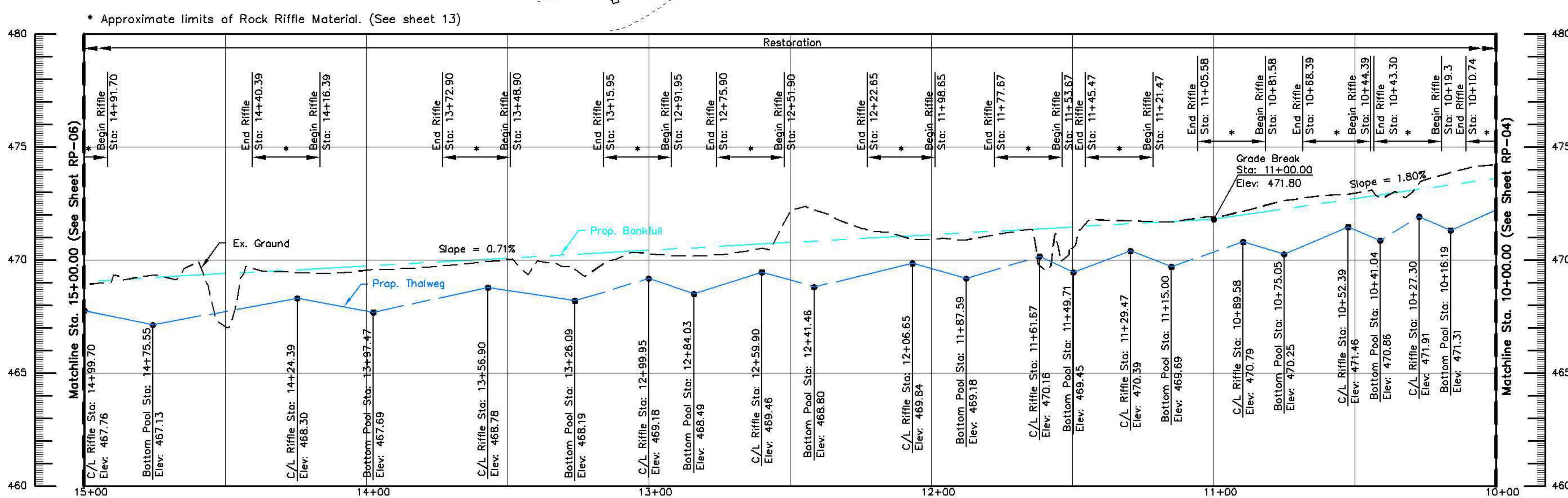

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UNION COUNTY NORTH CAROLINA
STREAM RESTORATION PLAN
FOR
DAVIS BRANCH AND UNNAMED TRIBUTARY
STREAM RESTORATION PROJECT
PLAN & PROFILE - DAVIS BRANCH

Job No. 2006-1397
Date: May, 2008
Scale: Hor: 1" = 40' Ver: 1" = 5'
Sheet: RP-05/20

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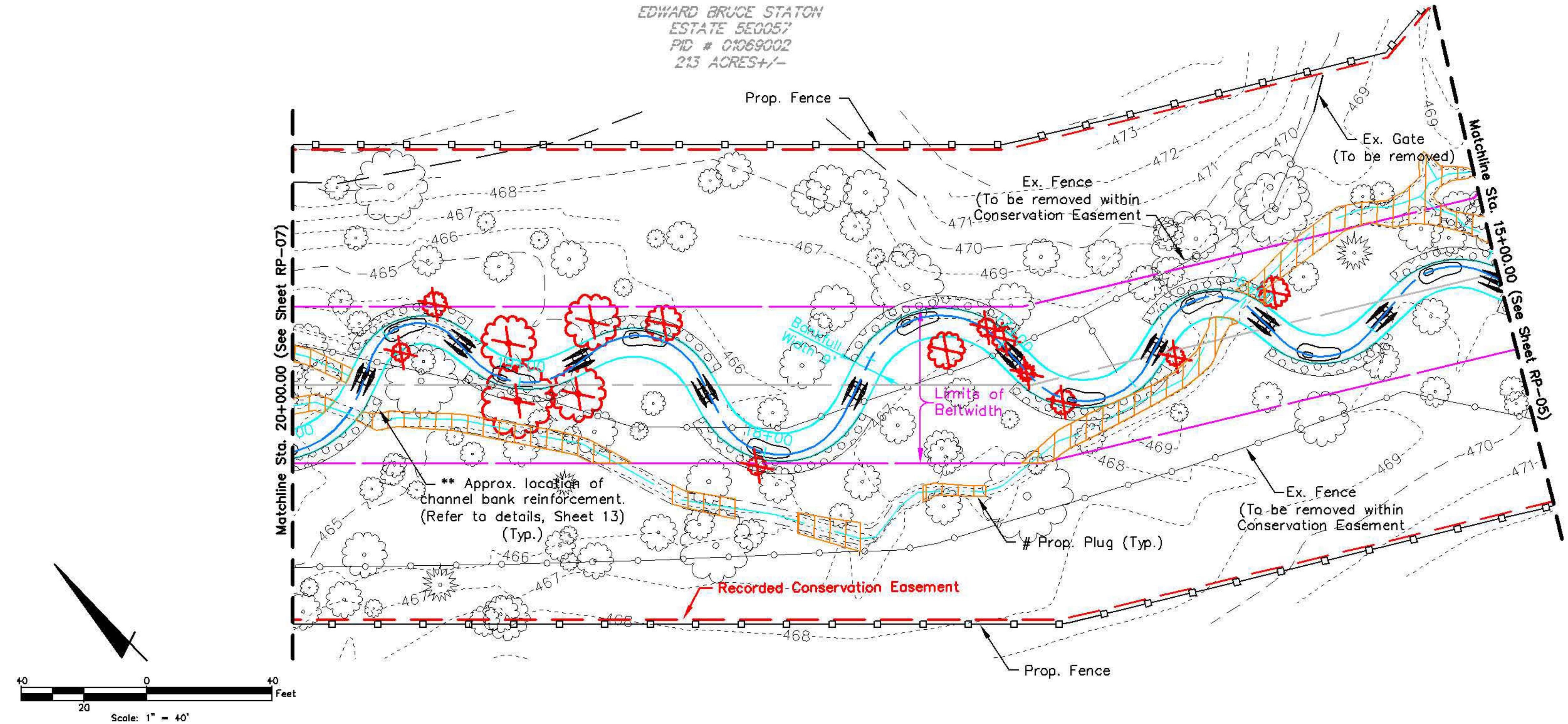

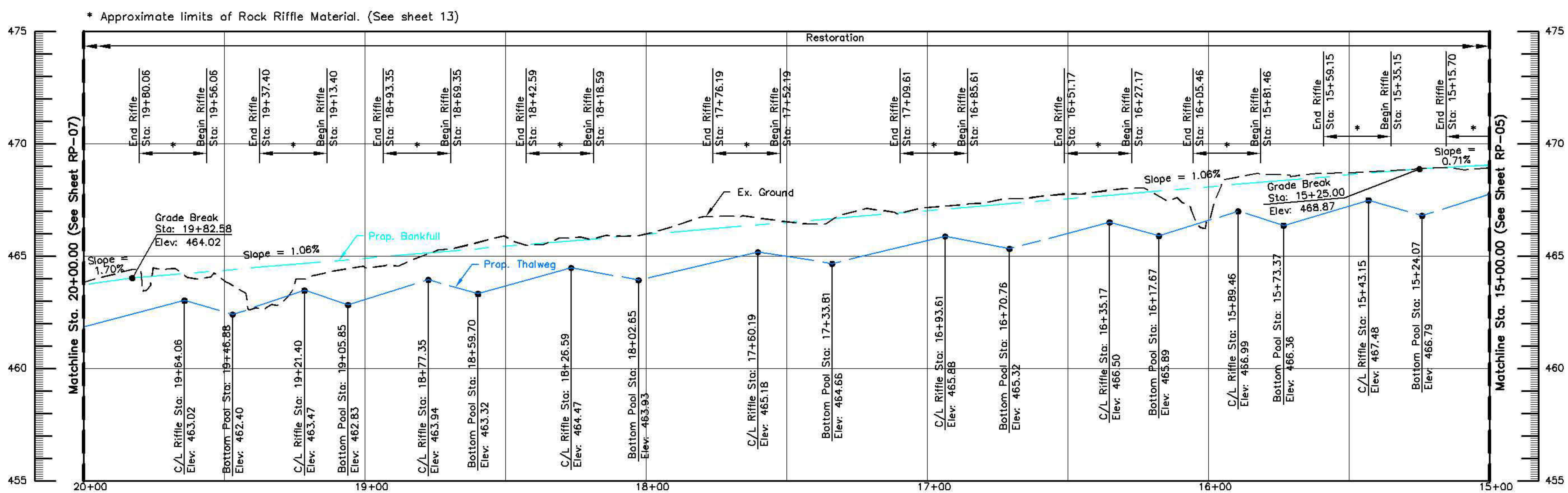

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Job No. 2006-1397
Sheet RP-06/20
Date May, 2008
Scale Hor: 1" = 40' Ver: 1" = 5'

UNION COUNTY, NORTH CAROLINA
STREAM RESTORATION PLAN
FOR
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AND UNNAMED TRIBUTARY
STREAM RESTORATION PROJECT
PLAN & PROFILE - DAVIS BRANCH

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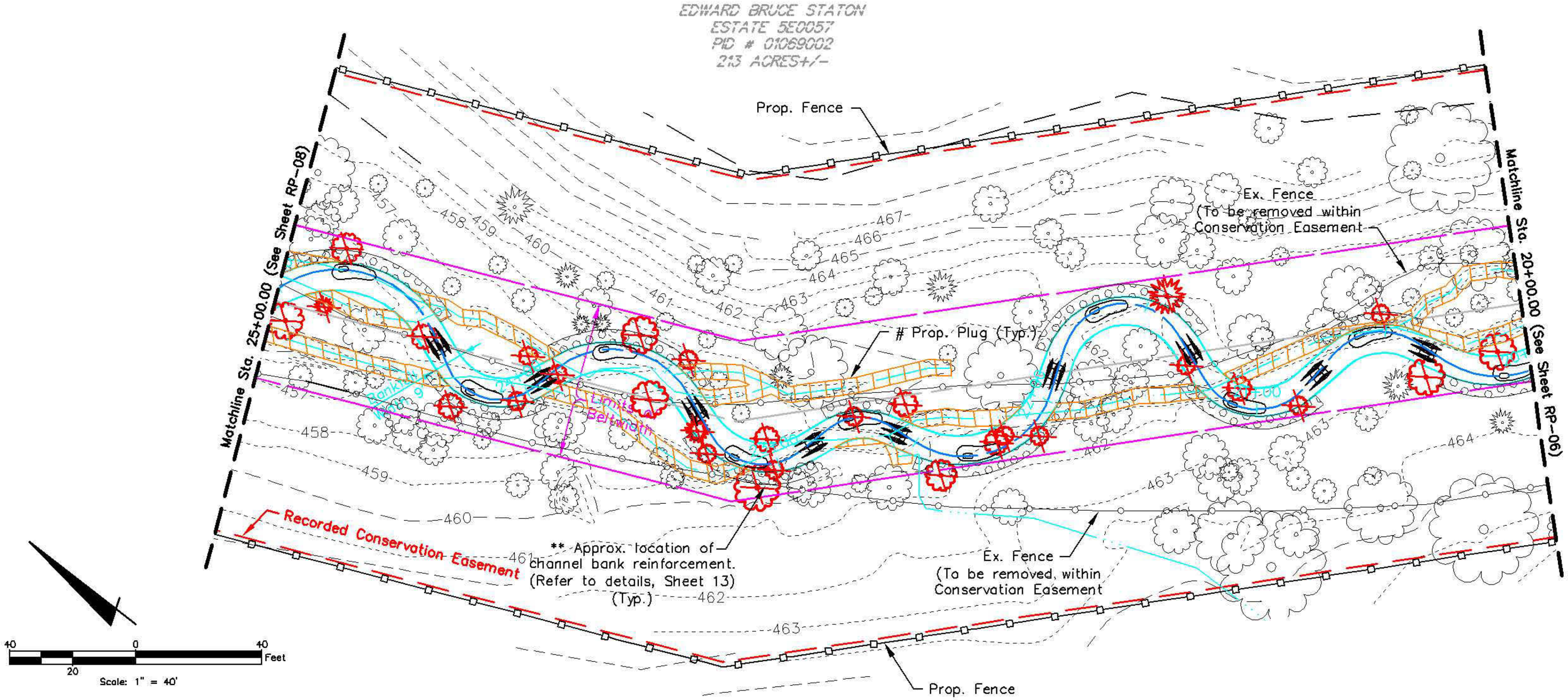
MARK DATE DESCRIPTION



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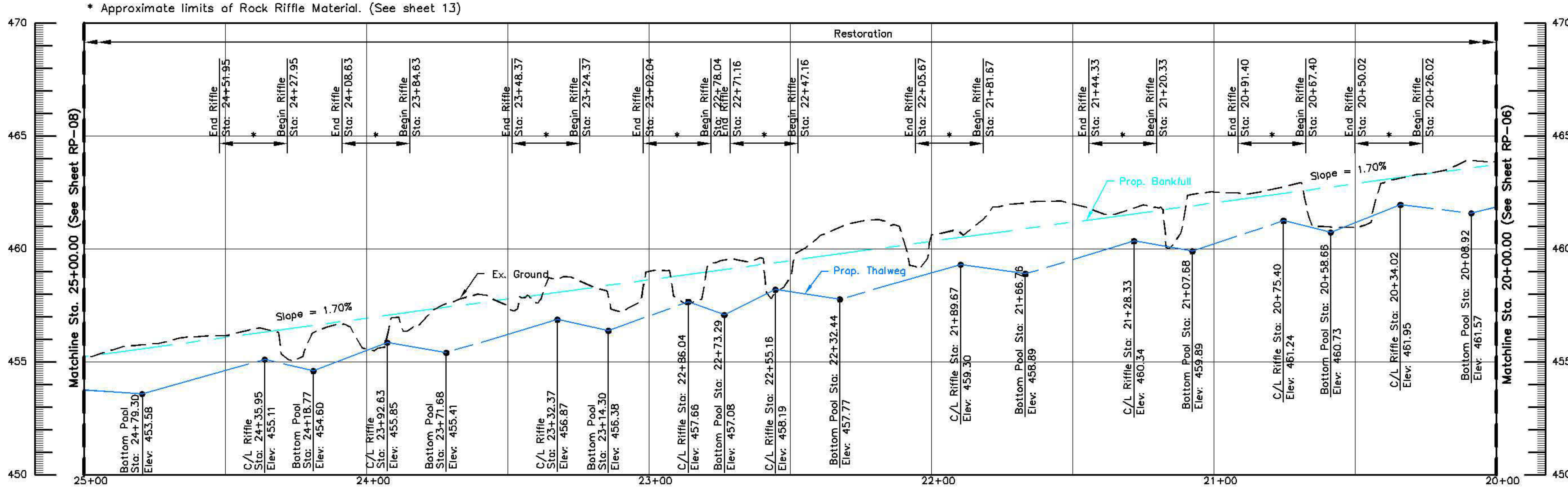
* Approximate limits of Rock Riffle Material. (See sheet 13)



Job No. 2006-1397
Sheet RP-07/20
Date May, 2008
Scale Hor: 1" = 40' Ver: 1" = 5'

UNION COUNTY, NORTH CAROLINA
STREAM RESTORATION PLAN
FOR
DAVIS BRANCH
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STREAM RESTORATION PROJECT
PLAN & PROFILE - DAVIS BRANCH

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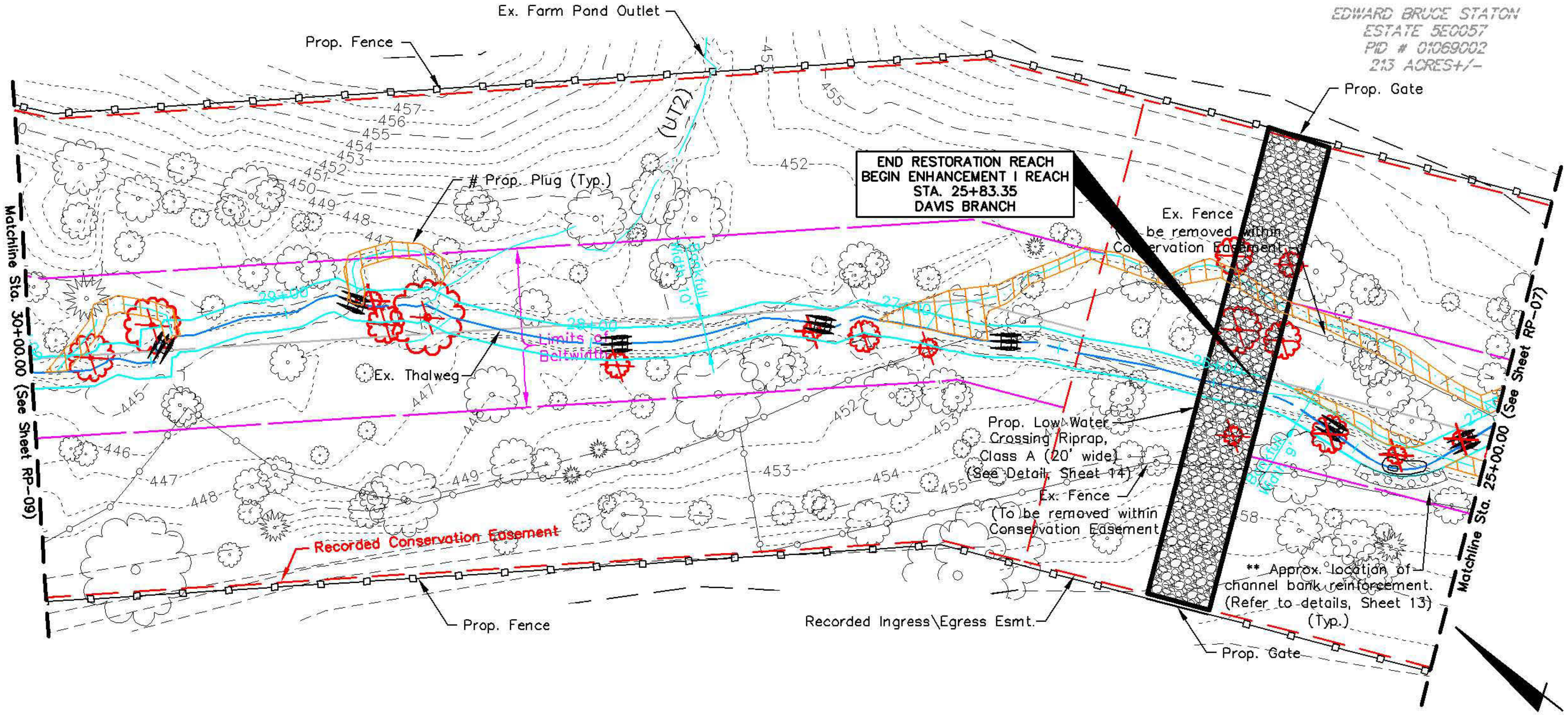


Notes:
See sheets 13–14 for In-Stream Stuctures and Channel Dimensions.

See sheets 15–18 for Erosion Control notes, plan and details.

** Channel Reinforcement shall begin 5 feet above the end of the upstream riffle and extend 3 feet below the beginning of the downstream riffle. Refer to riffle stations on profile.

The Existing stream within the Beltwidth shall be plugged with a combination of compacted cohesive clay soil and Plain Riprap, Class 1. The existing stream outside the Beltwidth shall be plugged every 40' to promote overland flow to the proposed channel.

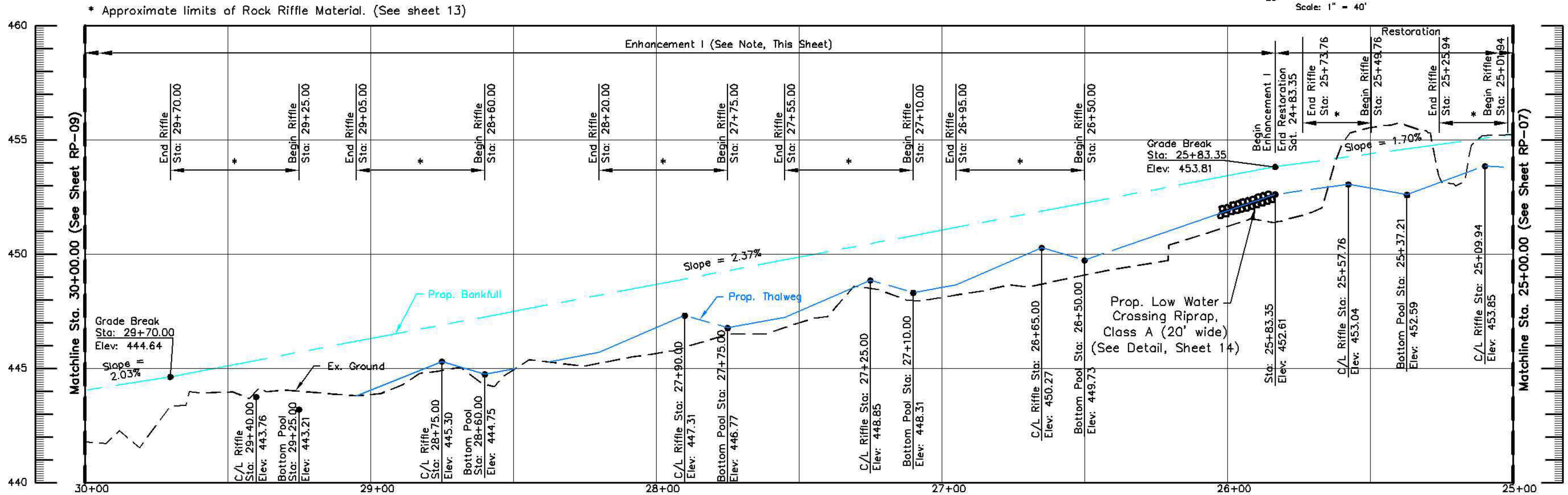
Tree Preservation Notes:
1. All trees to be removed as a part of this project have been marked on this plan with an "X". Only those trees with an "X" shall be removed unless specific approval is granted by the owner.

2. All trees within the work zone shall be flagged for removal or preservation. The trees flagged for removal shall be approved by the owner prior to beginning any tree clearing activities.

3. Any pruning of trees to be preserved shall be limited to the extent possible. Pruning shall be performed in accordance with the International Society of Arboriculture pruning techniques, and according to shape, size, and condition of the individual tree.

Enhancement I Note:
The enhancement level I reach of Davis Branch will consist of the following work:
- Re-grading and stabilizing the channel banks to obtain the appropriate channel dimensions.
- Raising the channel profile by adding riffle grade control, this will also connect the channel to its natural floodplain.

* Approximate limits of Rock Riffle Material. (See sheet 13)



UNION COUNTY, NORTH CAROLINA
STREAM RESTORATION PLAN
FOR
DAVIS BRANCH AND UNNAMED TRIBUTARY
STREAM RESTORATION PROJECT
PLAN & PROFILE - DAVIS BRANCH

Job No. 2006-1397 | Sheet RP-08/20
Date May, 2008 | Scale Hor: 1" = 40' Ver: 1" = 5'

Ecosystem Enhancement PROGRAM

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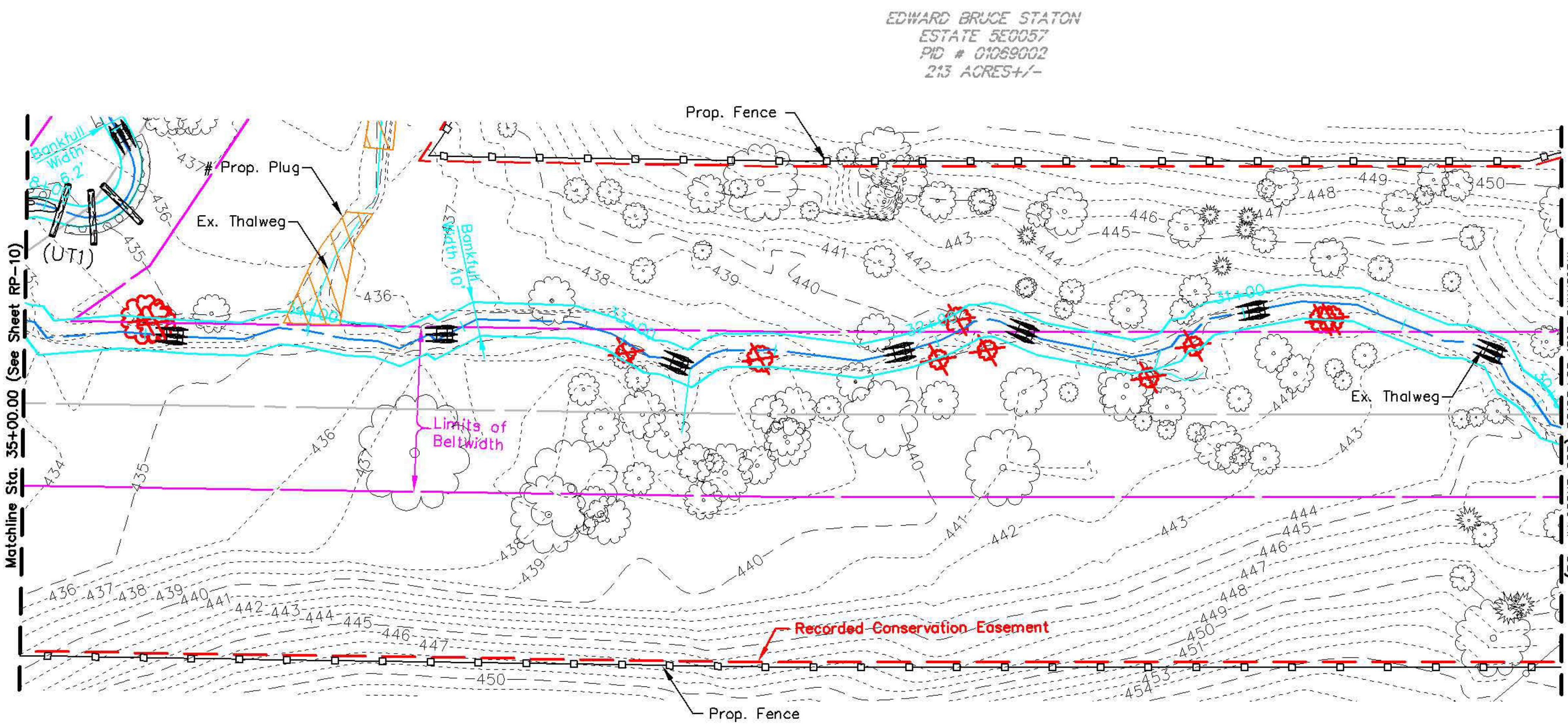
REVISIONS



Notes:

See sheets 13–14 for In-Stream Stuctures and Channel Dimensions.

See sheets 15–18 for Erosion Control notes, plan and details.

The Existing stream within the Beltwidth shall be plugged with a combination of compacted cohesive clay soil and Plain Riprap, Class 1. The existing stream outside the Beltwidth shall be plugged every 40' to promote overland flow to the proposed channel.

Tree Preservation Notes:

1. All trees to be removed as a part of this project have been marked on this plan with an "X". Only those trees with an "X" shall be removed unless specific approval is granted by the owner.

2. All trees within the work zone shall be flagged for removal or preservation. The trees flagged for removal shall be approved by the owner prior to beginning any tree clearing activities.

3. Any pruning of trees to be preserved shall be limited to the extent possible. Pruning shall be performed in accordance with the International Society of Arboriculture pruning techniques, and according to shape, size, and condition of the individual tree.

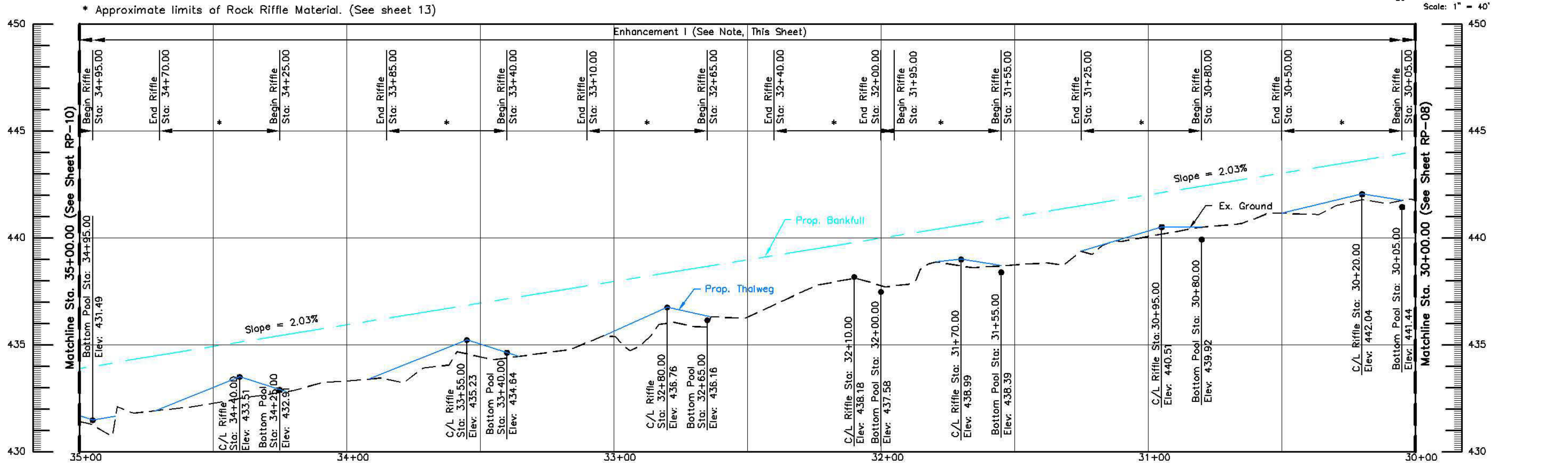
Enhancement I Note:

The enhancement level I reach of Davis Branch will consist of the following work:

- Re-grading and stabilizing the channel banks to obtain the appropriate channel dimensions.
- Raising the channel profile by adding riffle grade control, this will also connect the channel to its natural floodplain.

Scale: 1" = 40'

* Approximate limits of Rock Riffle Material. (See sheet 13)



UNION COUNTY, NORTH CAROLINA
STREAM RESTORATION PLAN
FOR
DAVIS BRANCH AND UNNAMED TRIBUTARY
STREAM RESTORATION PROJECT
PLAN & PROFILE - DAVIS BRANCH

Ecosystem Enhancement PROGRAM

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Job No. 2006-1397
Sheet RP-09/20
Date May, 2008
Scale Hor: 1" = 40' Ver: 1" = 5'

PRELIMINARY NOT FOR CONSTRUCTION

REVISIONS

MARK	DATE	DESCRIPTION

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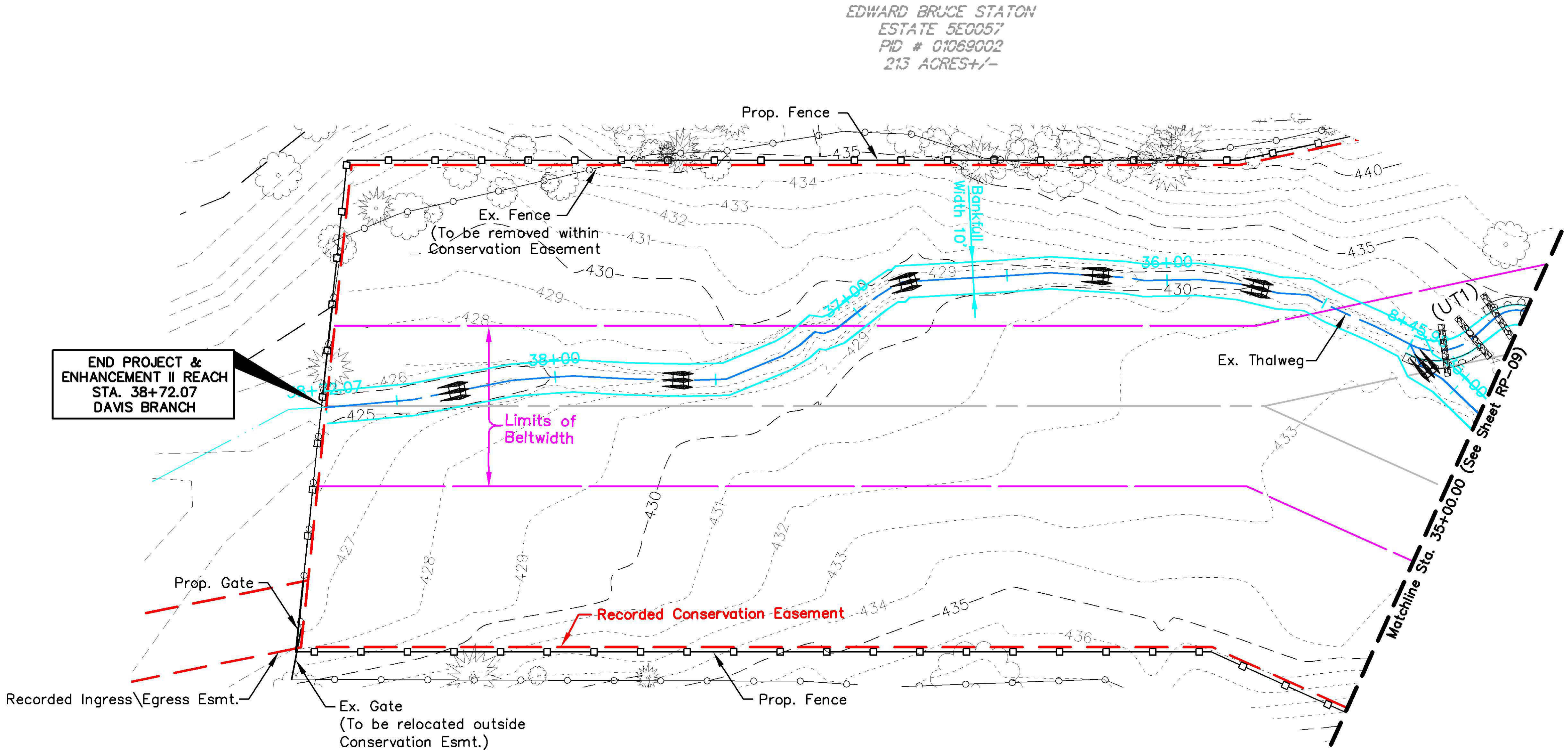
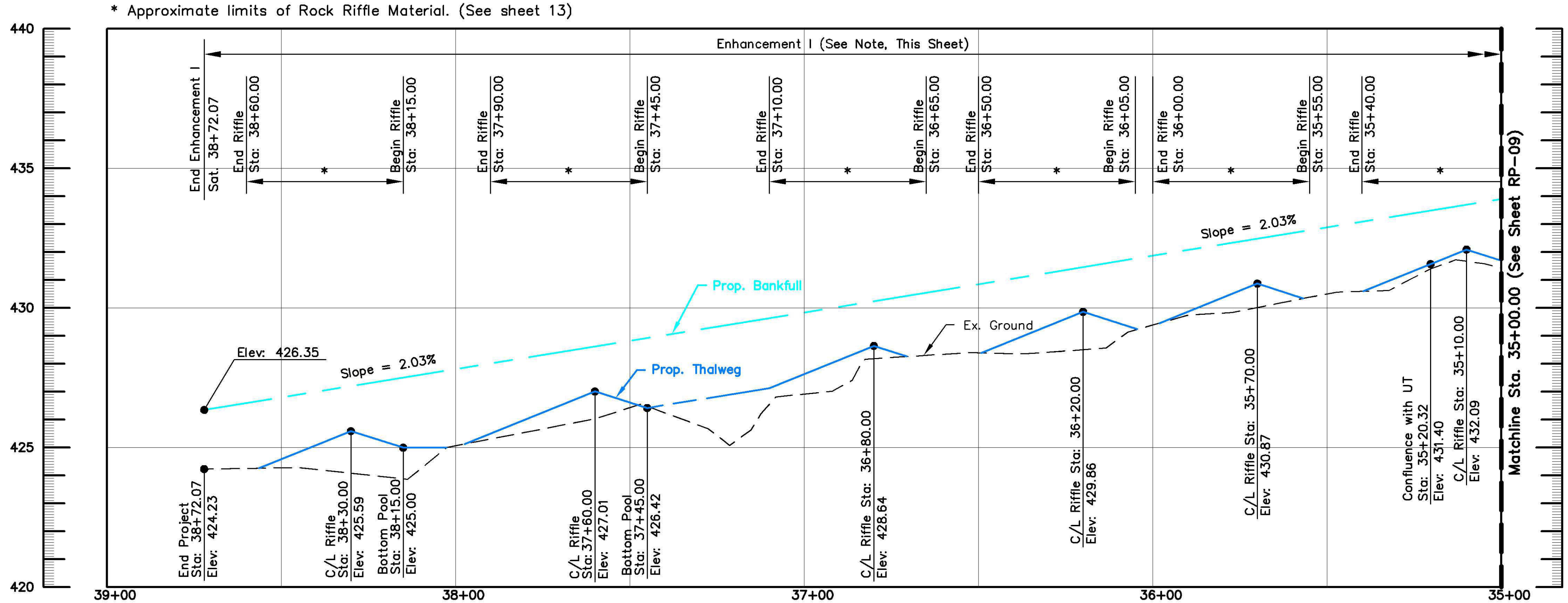


* Approximate limits of Rock Riffle Material. (See sheet 13)



Notes:
See sheets 13–14 for In-Stream Stuctures and Channel Dimensions.

See sheets 15–18 for Erosion Control notes, plan and details.

Tree Preservation Notes:
1. All trees to be removed as a part of this project have been marked on this plan with an "X". Only those trees with an "X" shall be removed unless specific approval is granted by the owner.

2. All trees within the work zone shall be flagged for removal or preservation. The trees flagged for removal shall be approved by the owner prior to beginning any tree clearing activities.

3. Any pruning of trees to be preserved shall be limited to the extent possible. Pruning shall be performed in accordance with the International Society of Arboriculture pruning techniques, and according to shape, size, and condition of the individual tree.

Enhancement I Note:
The enhancement level I reach of Davis Branch will consist of the following work:
- Re-grading and stabilizing the channel banks to obtain the appropriate channel dimensions.
- Raising the channel profile by adding riffle grade control, this will also connect the channel to its natural floodplain.

40 0 20 40 Feet
Scale: 1" = 40'

Job No. 2006-1397
Sheet RP-10/20
Date May, 2008
Scale Hor: 1" = 40' Ver: 1" = 5'

UNION COUNTY, NORTH CAROLINA
STREAM RESTORATION PLAN
FOR
DAVIS BRANCH
AND UNNAMED TRIBUTARY
STREAM RESTORATION PROJECT
PLAN & PROFILE - DAVIS BRANCH

Ecosystem Enhancement PROGRAM

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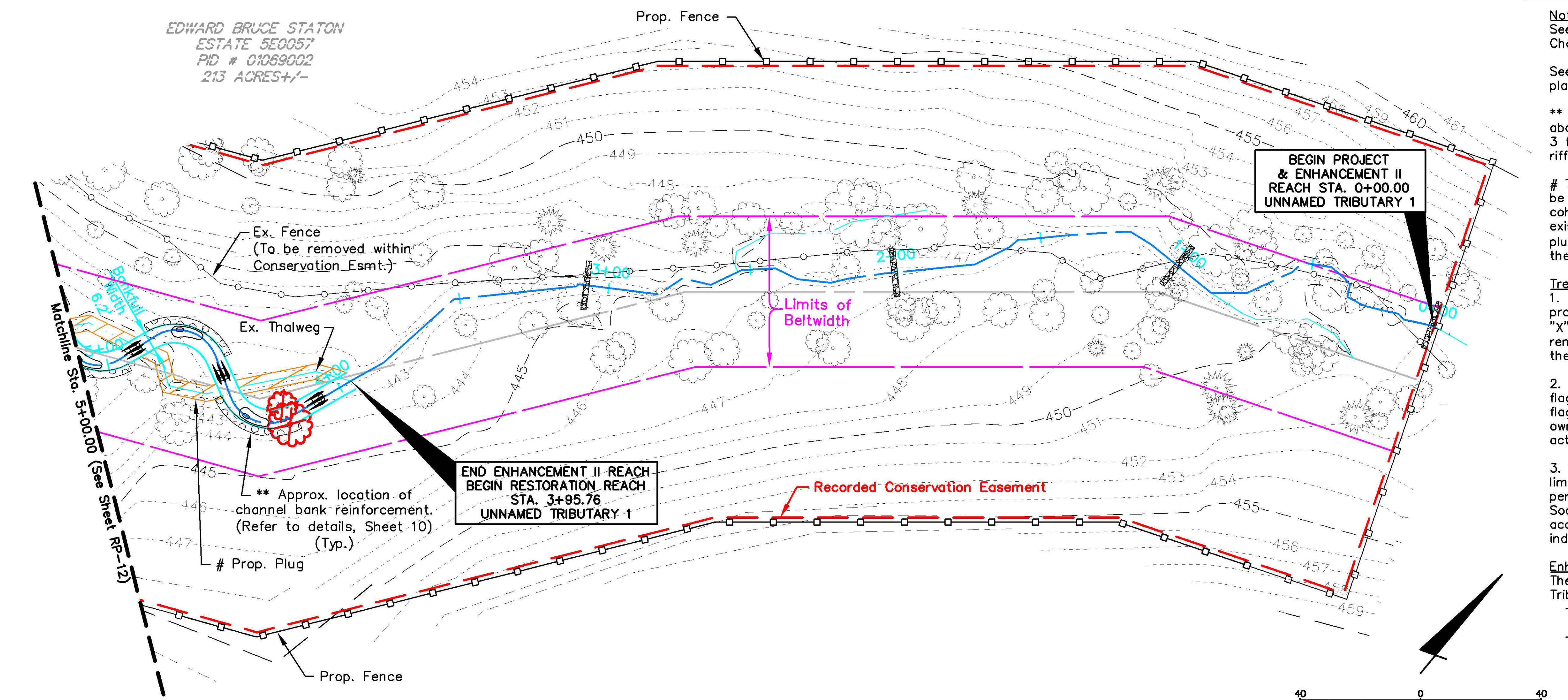
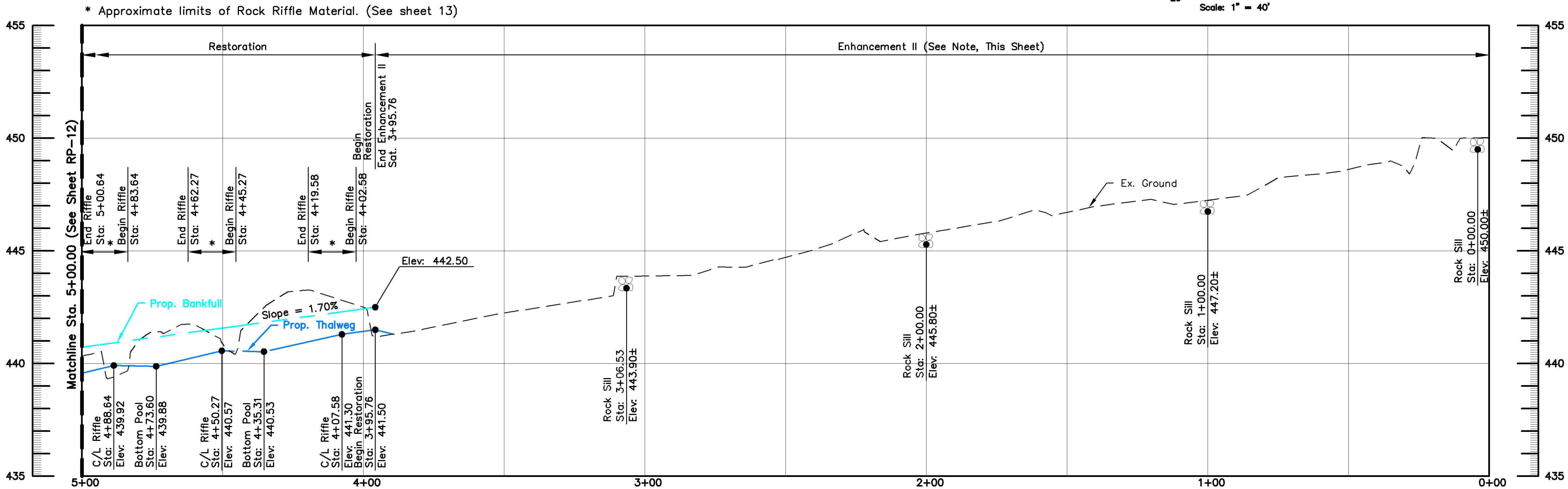
Engineers • Surveyors • Planners • Scientists
5500 New Albany Road, Columbus, OH 43054

REVISIONS
MARK | DATE | DESCRIPTION

PRELIMINARY
NOT FOR CONSTRUCTION



* Approximate limits of Rock Riffle Material. (See sheet 13)



Notes:
See sheets 13–14 for In–Stream Stuctures and Channel Dimensions.

See sheets 15–18 for Erosion Control notes, plan and details.

** Channel Reinforcement shall begin 5 feet above the end of the upstream riffle and extend 3 feet below the beginning of the downstream riffle. Refer to riffle stations on profile.

\# The Existing stream within the Beltwidth shall be plugged with a combination of compacted cohesive clay soil and Plain Riprap, Class 1. The existing stream outside the Beltwidth shall be plugged every 40' to promote overland flow to the proposed channel.

Tree Preservation Notes:
1. All trees to be removed as a part of this project have been marked on this plan with an "X". Only those trees with an "X" shall be removed unless specific approval is granted by the owner.

2. All trees within the work zone shall be flagged for removal or preservation. The trees flagged for removal shall be approved by the owner prior to beginning any tree clearing activities.

3. Any pruning of trees to be preserved shall be limited to the extent possible. Pruning shall be performed in accordance with the International Society of Arboriculture pruning techniques, and according to shape, size, and condition of the individual tree.

Enhancement II Note:
The enhancement level II reach of the Unnamed Tributary will consist of the following work:
- Re–grading and stabilizing the channel banks in areas where it is needed.
- Stabilizing the channel profile by adding log sill grade control where needed.

Job No. 2006-1397
Sheet RP-11/20
Date May, 2008
Scale Hor: 1" = 40' Ver: 1" = 5'

UNION COUNTY, NORTH CAROLINA
STREAM RESTORATION PLAN
FOR
DAVIS BRANCH
AND UNNAMED TRIBUTARY
STREAM RESTORATION PROJECT
PLAN & PROFILE - UT1

Ecosystem Enhancement PROGRAM

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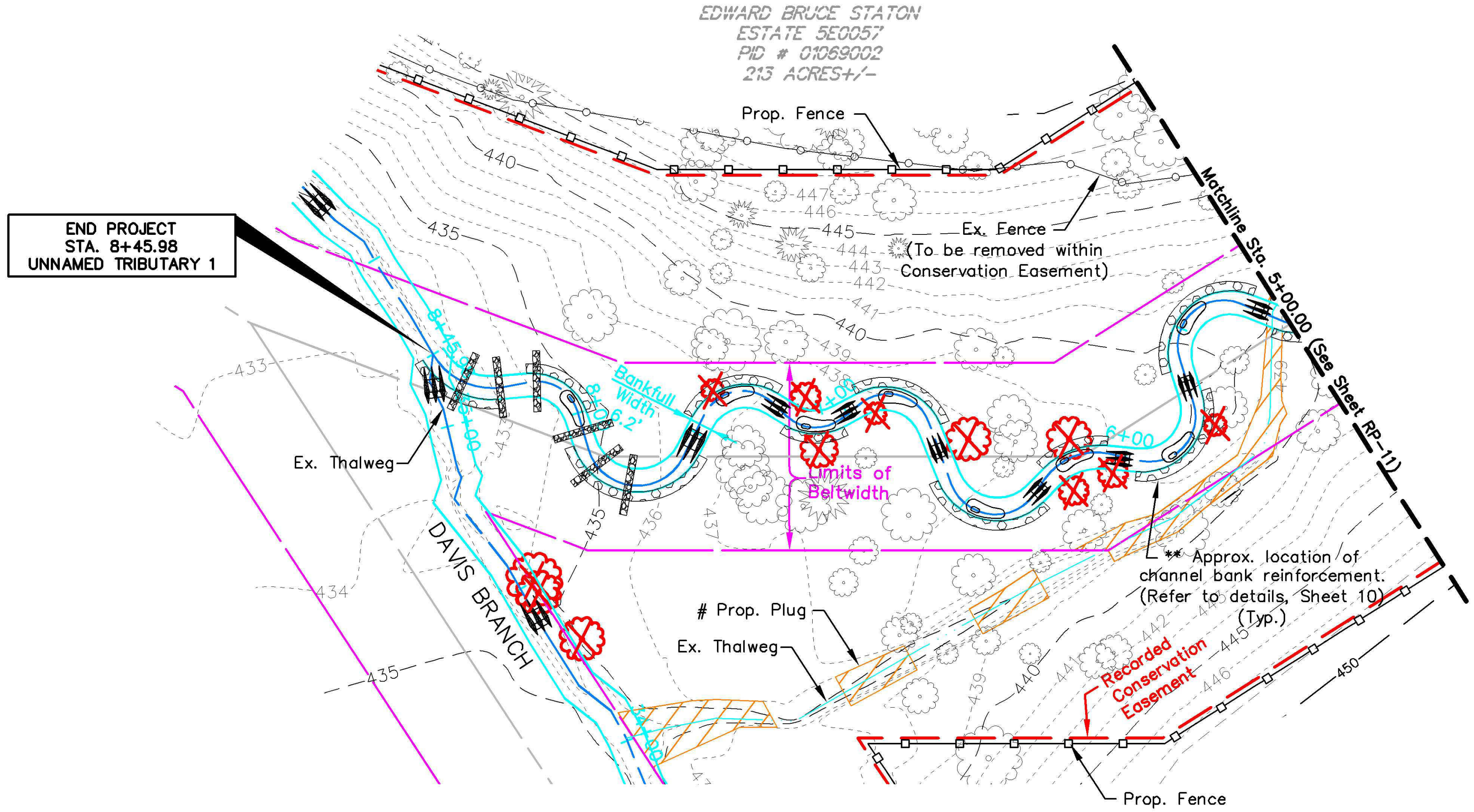
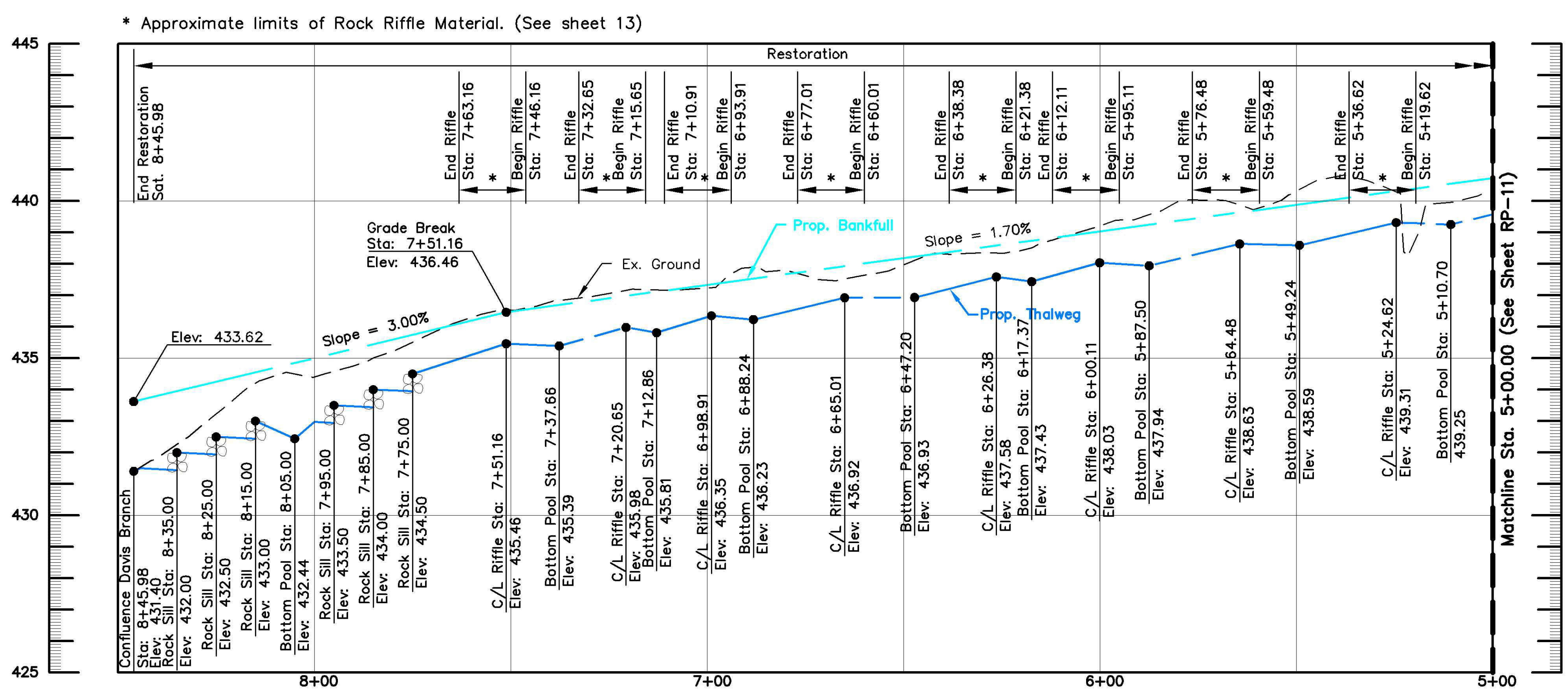
NOT FOR CONSTRUCTION

MARK	DATE	DESCRIPTION

REVISIONS





Notes:
See sheets 13–14 for In-Stream Stuctures and Channel Dimensions.

See sheets 15–18 for Erosion Control notes, plan and details.

** Channel Reinforcement shall begin 5 feet above the end of the upstream riffle and extend 3 feet below the beginning of the downstream riffle. Refer to riffle stations on profile.

The Existing stream within the Beltwidth shall be plugged with a combination of compacted cohesive clay soil and Plain Riprap, Class 1. The existing stream outside the Beltwidth shall be plugged every 40' to promote overland flow to the proposed channel.

Tree Preservation Notes:
1. All trees to be removed as a part of this project have been marked on this plan with an "X". Only those trees with an "X" shall be removed unless specific approval is granted by the owner.

2. All trees within the work zone shall be flagged for removal or preservation. The trees flagged for removal shall be approved by the owner prior to beginning any tree clearing activities.

3. Any pruning of trees to be preserved shall be limited to the extent possible. Pruning shall be performed in accordance with the International Society of Arboriculture pruning techniques, and according to shape, size, and condition of the individual tree.

40 0 20 40 Feet
Scale: 1" = 40'

Job No. 2006-1397
Sheet RP-12/20
Date May, 2008
Scale Hor: 1" = 40' Ver: 1" = 5'

UNION COUNTY, NORTH CAROLINA
STREAM RESTORATION PLAN
FOR
DAVIS BRANCH
AND UNNAMED TRIBUTARY
STREAM RESTORATION PROJECT
PLAN & PROFILE - UT1

Ecosystem Enhancement PROGRAM

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REVISIONS
MARK DATE DESCRIPTION

PRELIMINARY
NOT FOR CONSTRUCTION

ROCK RIFFLES:

All support, crest, and fill stone will be slate material quarried on-site. No construction rubble is permissible. See Riffle Materials Table for descriptions and sizes of materials.

1.0 CREST STONE

The crest height is determined in the field by measuring the elevation of the toe of the proceeding upstream riffle. The crest elevation must pool water back to the base of the upstream riffle/run.

Installation:
The crest height must be determined and the center weir stone installed first. Trench into the stream bed approximately 1.5 feet and place the stone(s) so that the center weir stone reaches the crest elevation. Trench and install the remaining crest stones across the stream, elevating them into the banks the specified distance.

2.0 SUPPORT STONE

Installation:
Support stone must be placed tightly on both sides of the crest stone paying close attention to fit on the downstream side. Proper elevation of the support stone must be maintained and must be as high as the crest stone. Ten (10) feet downstream of the crest stone the support stone will be laid more loosely to create turbulence of flow across the riffle. At this point, the stone should start to become trenched into the streambed. At the end of the riffle, the support stone will be trenched fully into the stream bed to a depth of approximately 1.5 feet. Finished elevations of the support stone must concentrate flows across the riffle and create non-laminar (turbulent) flow. Support stones will continue up the banks to the final elevation. Support stone will be trenched into the banks to support the crest stone.

3.0 FILL STONE

Installation:
After the installation of the larger crest and support stones, fill all voids with fill stone materials and compact with an excavator bucket. Final grading and transition with the upper bank area can be accomplished using this stone size.

BOULDER TOE:

1.0 Material:
The boulder toe material may consist of quarried stone (no construction rubble is permissible). The Contractor shall review samples of this material with the Engineer for approval prior to installation. The size of this material shall be consistent with the gradation of Class 2 riprap rock channel protection.

2.0 Installation:
The boulder toe material shall be imbedded into the channel bottom and channel bank to the minimum depths shown on Detail 'C'. Filter fabric material. shall be included in the construction of the boulder toe reinforcement, as demonstrated on Detail 'C'. Over-excavation of the channel bank to install the boulder toe reinforcement shall be back-filled with compactable material that is placed in lifts and graded to conform to the designed channel bank, and reinforced with the geotextile material specified by this plan.

COIR ROLL:

1.0 Material:
Rolls shall consist of biodegradable material 12-inches in diameter with a density of 7 lbs./cu.ft. The coir roll outer netting shall consist of a biodegradable twine 0.24 inches in diameter with the breaking strength of 90 lbs. Hardwood stakes to anchor the coir rolls shall be 2"x2"x36" in size. The specified length is a minimum and may need to be adjusted to allow for sufficient anchoring.

The Contractor may contact RoLanka Products at 800-760-3215 (fax: 770-506-0391) as a supplier of the specified coir roll material.

2.0 Installation:
Refer to Detail 'A' for a schematic of the location of the coir roll material along the channel and Detail 'C' for a schematic of the location of the coir rolls with respect to the other bank reinforcement materials.

The coir rolls shall be installed after the boulder toe is in place. The upstream and downstream ends of the coir roll installation shall be bent back into the channel bank to prevent stream flow from cutting behind the Rolls. The ends of abutting coir rolls shall be tied together with twine. Hardwood stakes shall be driven into the native, undisturbed soil behind the Rolls. The Rolls shall be tied to the stakes with twine. Stakes shall be placed at the beginning and end of each Roll and at a maximum spacing of 2 feet.

*** Coir Rolls may be eliminated and replaced with additional Boulder Toe material.

LIVE BRANCHES:

1.0 Material:
Live branch material shall be dormant and gathered locally (within or in proximity to the project site) or purchased from a reputable commercial supplier. The contractor may contact Ernst Conservation Seeds at 814-336-5191 (fax: 800-873-3321) as a supplier of live branch material. This material shall be planted only during its natural dormancy period, extending from late fall through early spring.

Branches shall be 1/2 to 2-inches in diameter, 2 to 3 feet in length, and living based on the presence of young buds and green bark. Prior to installation, the branches shall be cut so that they are angled on the bottom and flush on the top.

All harvested or purchased live branch material shall be preserved in a cool, moist environment until installation. Plant material that has been allowed to dry out or is not preserved in a dormant state prior to installation shall be discarded.

See Sheet 20 for Plant Material List.

2.0 Installation:
Refer to Detail 'A' for a schematic of the location of the live branches along the channel and Detail 'C' for a schematic of the location of the live branches with respect to the other bank reinforcement materials.

Live branches shall be installed in two rows, with 2.0 foot spacing, between the stakes. Three-fourths of the stake is to be imbedded within the channel bank. The angle of the imbedded branch to the channel bank shall be between 30 and 60 degrees. When installed, at least two (2) buds should remain above the ground surface and those buds shall be oriented upwards.

Live branches that split or become bent or broken during installation shall be removed from the channel bank and discarded

STOCKPILE COBBLE MATERIAL:

Remove and stockpile any available stream bed material through the reach of the existing stream channel to be excavated/relocated. Stockpiled material shall be replaced within excavated /relocated stream bed upon completion. Cost of this work to be included in the price bid for the various related items.

GEOTEXTILES:

The specified geotextile shall meet the specifications identified on this plan, unless otherwise approved by the Engineer.

Geotextile shall be placed in accordance with manufacturer's recommendations.

The geotextile Rolls shall be furnished with suitable wrapping for protection against moisture and extended ultraviolet exposure prior to placement. Each Roll shall be labeled or tagged to provide product identification sufficient for field inventory and quality control purposes. Rolls shall be stored in a manner which provides identification, as well as protection from the elements. If stored outdoors, the Rolls shall be elevated and protected with a waterproof cover.

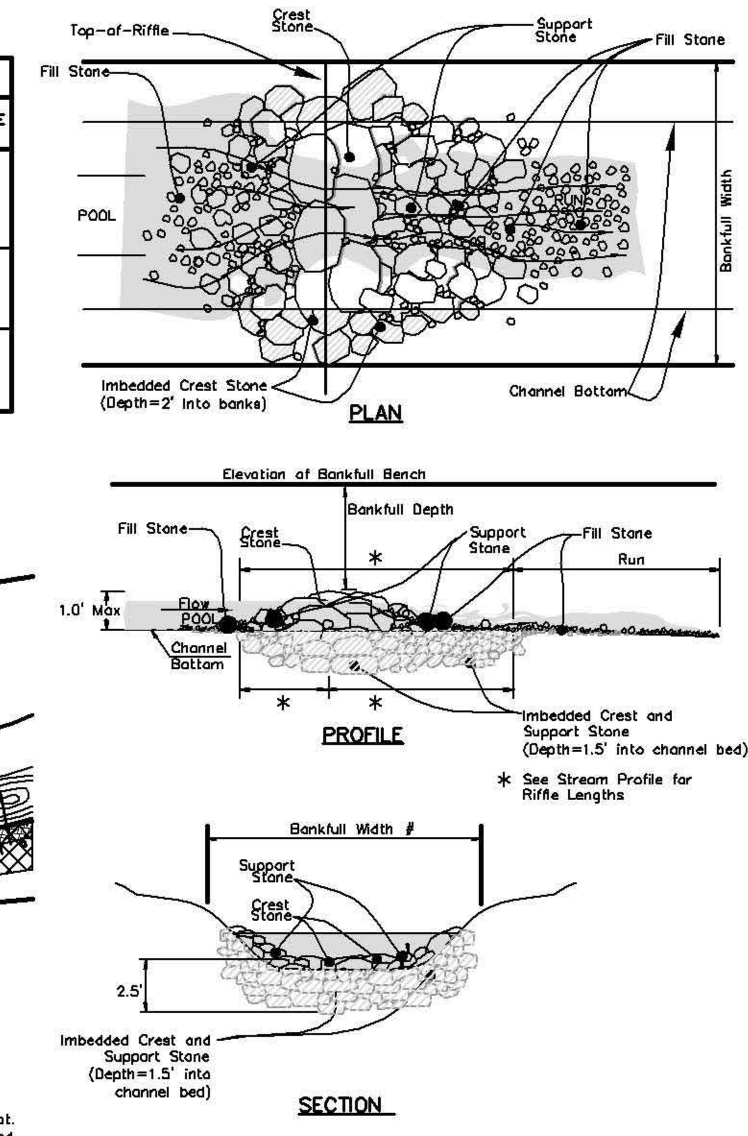
INSTALLATION:

- Over-excavation of the channel bank may be necessary to accomplish the installation of the rock toe protection. The rock toe protection shall be imbedded into the bottom of the channel to the depth specified on this detail.
- The live branches shall be placed on top of the imbedded boulder toe material protruding into the native, undisturbed soil of the channel bank.
- Soil material, including the specified top soil, shall be placed to backfill the over-excavted channel bank.
- The specified seeding shall be applied to the disturbed/restored soil material.
- The first (lowest) row of the geotextile material shall be anchored to the restored soil material.
- The coir roll material shall be installed and secured with the hardwood stakes protruding into the native, undisturbed soil of the channel bank.
- Any remaining rows of geotextile material shall be installed and anchored to the channel bank, with the last (highest) row "trenched" in to the bank.

RIFFLE MATERIAL TABLE

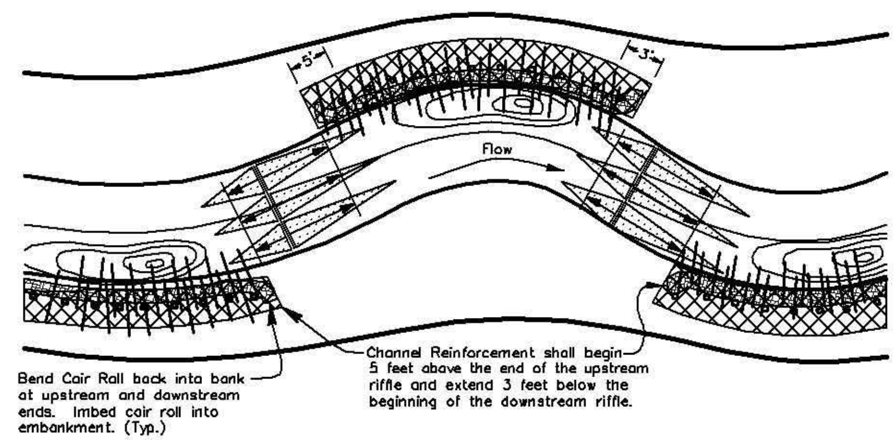
I.D.	DESCRIPTION	SIZE	% OF RIFFLE VOLUME
Crest \$ Stone	Crest stone should be angular in shape.	Plain Riprap, Class 1 Class 1 shall consist of sizes such that at least 85 percent of the total material by weight shall be larger than 5 inch but less than an 17 inch square opening.	30%
Support \$ Stone	Angular stone that supports the crest stone.	Support Stone shall have a gradation of sizes such that at least 85% of the material by weight shall be between 4" and 8" in diameter.	50%
Fill Stone	Angular stone that fills the voids between the larger stone.	Fill stone shall have a gradation of sizes such that at least 85% of the material by weight shall be between 1" and 4" in diameter.	20%

\$ In lieu of crest/support stone, Contractor may use embedded log to establish riffle crest



ROCK RIFFLE DETAIL – DETAIL 'B'

Not to Scale



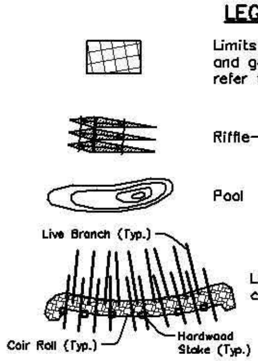
TYPICAL GEOTEXTILE LOCATION PLAN– DETAIL 'A'

Not to Scale

CHANNEL RESTORATION DIMENSION TABLE

	DAVIS BRANCH RESTORATION	UNNAMED TRIBUTARY 1 RESTORATION
From Station	7+81.24	3+95.78
To Station	25+83.35	8+45.98
Bkf Max. Depth – Riffle	1.2'	1.6'
Bkf Max. Depth – Pool	2.0'	2.5'
Bkf Width – Riffle	9.0'	10.0'
Bkf Width – Pool	10'	12'
Side Slopes Riffle	2:1	1.5:1
Side Slopes Pool	2:1	1.75:1

LEGEND



Limits of boulder toe, coir roll, and geotextile reinforcement*; refer to Detail "C", (This Sheet).

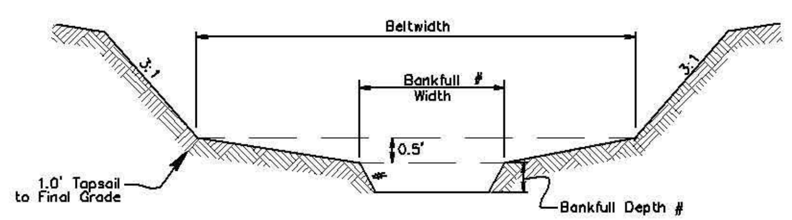
Riffle-Run Complex

Pool

Limits of boulder toe, coir roll & live branches.

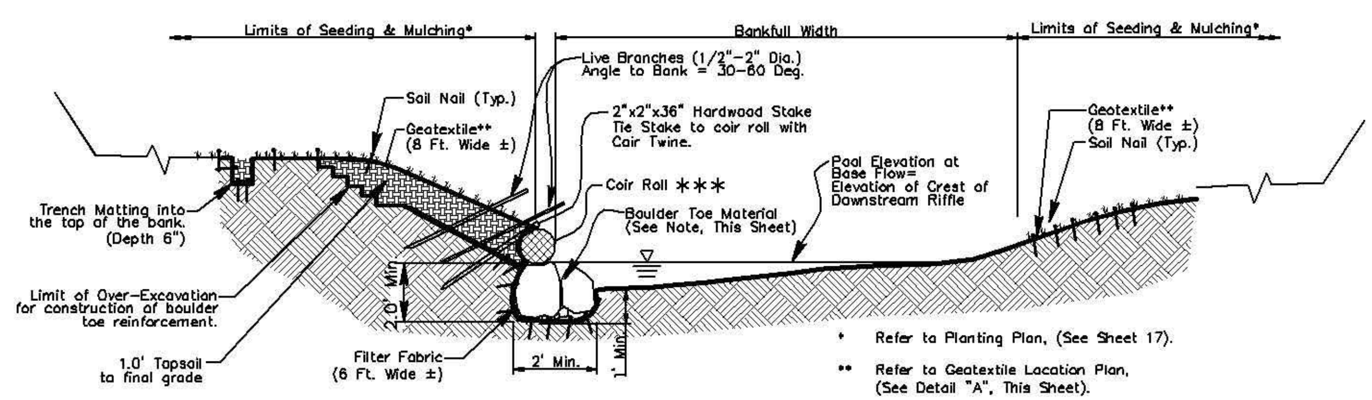
NOTES

- * Geotextile shall be an Erosion Control Mat. Such as Geocoir/Dekowe 700, or approved equivalent.



TYPICAL RESTORATION RIFFLE SECTION (See Detail 'B')

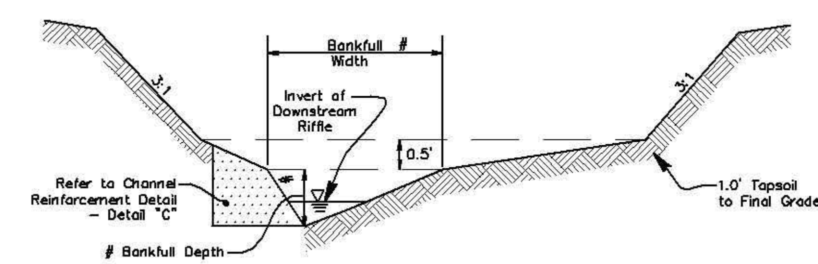
Not to Scale



- * Refer to Planting Plan, (See Sheet 17).
- ** Refer to Geotextile Location Plan, (See Detail "A", This Sheet).
- *** Coir Rolls may be eliminated and replaced with additional Boulder Toe material.

CHANNEL REINFORCEMENT DETAIL – DETAIL 'C'

Not to Scale



TYPICAL RESTORATION POOL SECTION (See Detail 'C')

Not to Scale

\# –See Channel Restoration Dimension Table (This Sheet)

UNION COUNTY, NORTH CAROLINA
STREAM RESTORATION PLAN
FOR
DAVIS BRANCH AND UNNAMED TRIBUTARY
STREAM RESTORATION PROJECT
STRUCTURE DETAILS

Ecosystem Enhancement PROGRAM

EMH&T

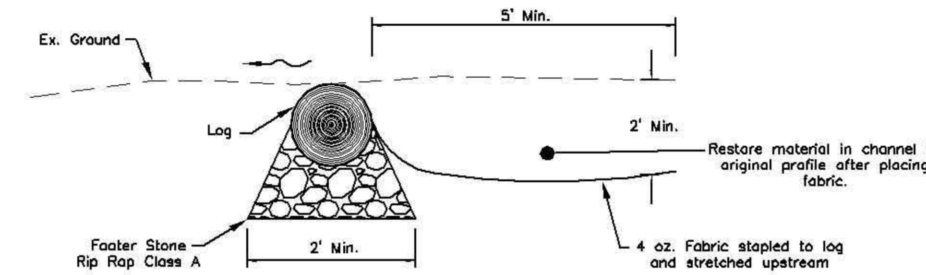
Job No.	2006-1397
Sheet	RP-13/20
Date	May, 2008
Scale	Not To Scale

PRELIMINARY NOT FOR CONSTRUCTION

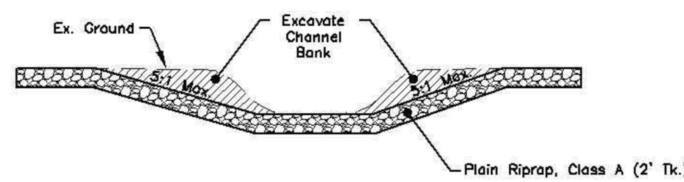
REVISIONS

Log Sill Construction Specifications:

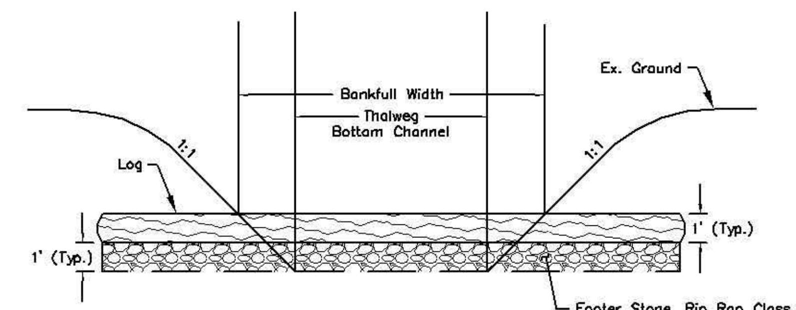
1. Final location, extent, and nature of in stream bed features to be determined during construction with consultation of designer.
2. Final placement of rocks in structures to be determined by stream restoration specialist in the field.
3. Dimension slopes and deflection angles of structures may be adjusted by designer based on field conditions during construction.



PROFILE
Not to Scale

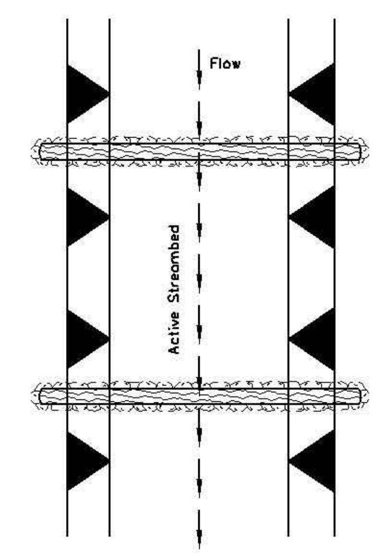


LOW WATER CROSSING DETAIL
Not to Scale



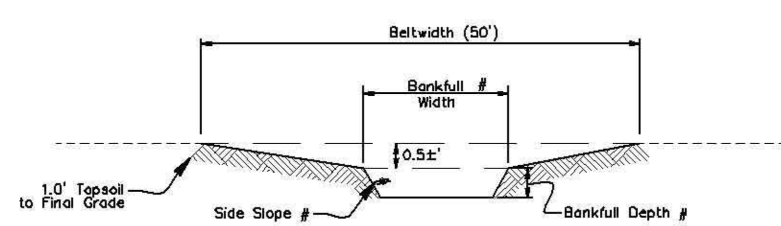
CROSS SECTION
Not to Scale

CHANNEL ENHANCEMENT DIMENSION TABLE		
	DAVIS BRANCH ENHANCEMENT	UNNAMED TRIBUTARY ENHANCEMENT
From Station	25+83.35	0+00.00
To Station	38+72.07	3+95.78
Bkf Max. Depth - Riffle	1.6'	1.0'
Bkf Max. Depth - Pool	2.5'	1.3'
Bkf Width - Riffle	10'	6.2'
Bkf Width - Pool	12'	7.0'
Side Slopes Riffle	1.75:1	2:1
Side Slopes Pool	1.5:1	2:1



PLAN VIEW
Not to Scale

LOG SILL DETAIL
Not to Scale



TYPICAL ENHANCEMENT SECTION
Not to Scale

-See Channel Enhancement Dimension Table (This Sheet)

Job No. 2006-1397
Date May, 2008
Sheet RP-14/20
Scale Not To Scale

UNION COUNTY, NORTH CAROLINA
STREAM RESTORATION PLAN
FOR
DAVIS BRANCH AND UNNAMED TRIBUTARY
STREAM RESTORATION PROJECT
STRUCTURE DETAILS

Ecosystem Enhancement PROGRAM

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Engineers • Surveyors • Planners • Scientists

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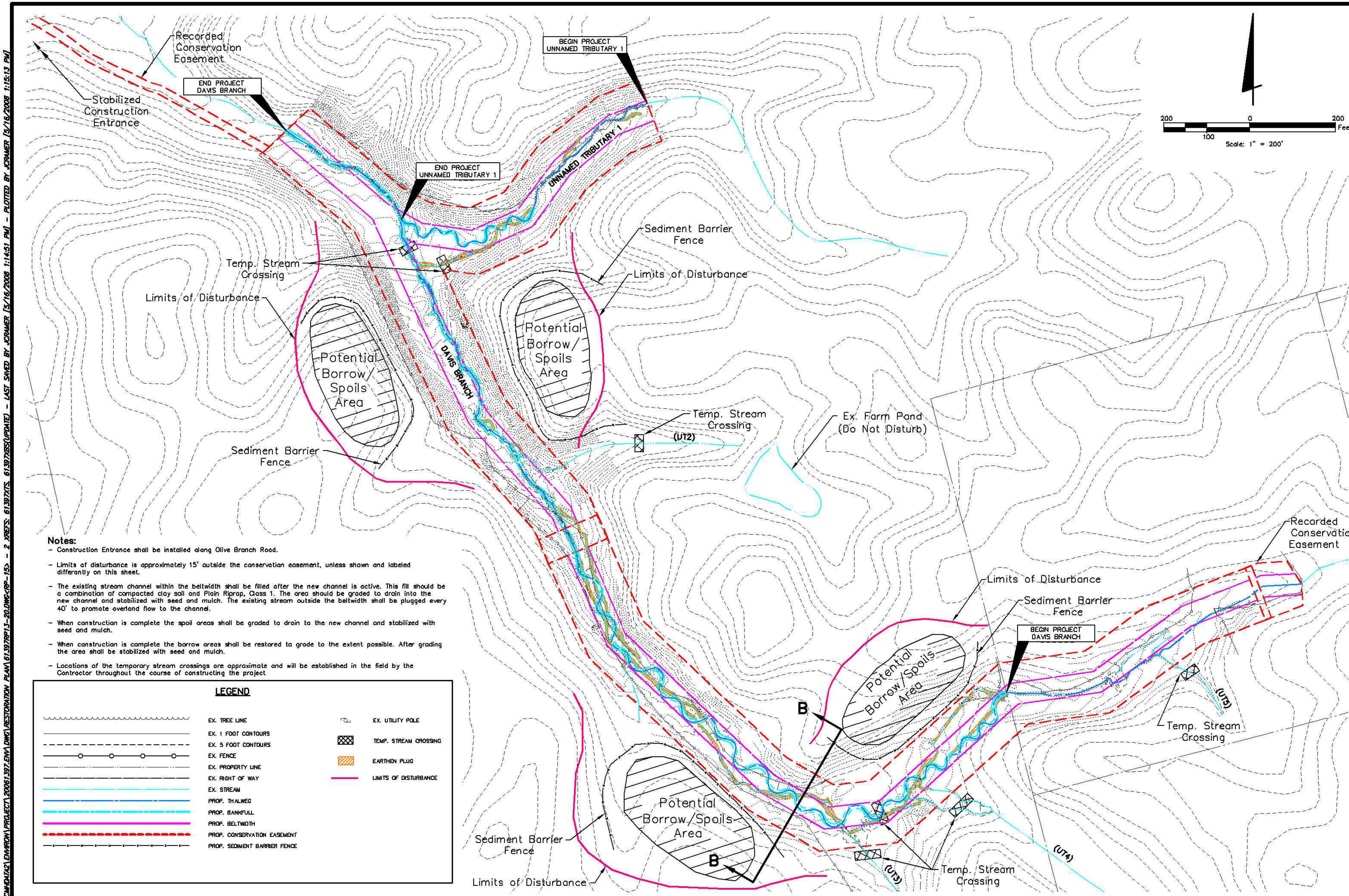

Notes:

- Construction Entrance shall be installed along Olive Branch Road.
- Limits of disturbance is approximately 15' outside the conservation easement, unless shown and labeled differantly on this sheet.
- The existing stream channel within the beltwidth shall be filled after the new channel is active. This fill should be a combination of compacted clay soil and Plain Riprap, Class 1. The area should be graded to drain into the new channel and stabilized with seed and mulch. The existing stream outside the beltwidth shall be plugged every 40' to promote overland flow to the channel.
- When construction is complete the spoil areas shall be graded to drain to the new channel and stabilized with seed and mulch.
- When construction is complete the borrow areas shall be restored to grade to the extent possible. After grading the area shall be stabilized with seed and mulch.
- Locations of the temporary stream crossings are approximate and will be established in the field by the Contractor throughout the course of constructing the project

LEGEND

EX. TREE LINE	EX. UTILITY POLE
EX. 1 FOOT CONTOURS	TEMP. STREAM CROSSING
EX. 5 FOOT CONTOURS	EARTHEN PLUG
EX. FENCE	LIMITS OF DISTURBANCE
EX. PROPERTY LINE	
EX. RIGHT OF WAY	
EX. STREAM	
PROP. THALWEG	
PROP. BANKFULL	
PROP. BELTWIDTH	
PROP. CONSERVATION EASEMENT	
PROP. SEDIMENT BARRIER FENCE	

MARK	DATE	DESCRIPTION

REVISIONS

PRELIMINARY NOT FOR CONSTRUCTION

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Evans, Mechwart, Hambleton & Tilton, Inc.
Engineers • Surveyors • Planners • Scientists
5500 New Albany Road, Columbus, OH 43054

Ecosystem Enhancement PROGRAM

UNION COUNTY, NORTH CAROLINA
STREAM RESTORATION PLAN
FOR
DAVIS BRANCH AND UNNAMED TRIBUTARY
STREAM RESTORATION PROJECT
EROSION CONTROL PLAN

Date: May, 2008	Job No. 2006-1397
Scale: 1" = 200'	Sheet: RP-15/20

EROSION AND SEDIMENT CONTROL NARRATIVE

PLAN DESIGNER:
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PROJECT OWNER
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3970 Bowen Rd
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SITE CONTACT
Bob Koone
South Mountain Forestry
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Morganton, NC 28655
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PROJECT LOCATION
The project is located within Union County.

PROJECT DESCRIPTION
The project consists of the restoration and enhancement of stream channels, indicated as Davis Branch and Unnamed tributary on the restoration plan. The existing eroded stream banks and the stream buffer corridors of the watercourse shall be planted with a variety of trees, shrubs and seedings as indicated on the planting plan.

AREA OF PROJECT SITE & AREAS OF DISTURBANCE
Project Area: 13.7 Acres
Estimated Area of Disturbance: 35.3 Acres

EXISTING SITE CONDITIONS
Existing stream corridors predominantly consist of a narrow riparian buffer with adjoining pasture lands.

ADJACENT AREAS
The adjacent areas are predominately pasture or wooded areas. The wooded areas will be protected to the extent possible.

DESCRIPTION OF SOILS
The predominant soil type mapped on the Davis Branch mainstem is the Cid channery silt loam, 1 to 5 percent slopes. This map unit consists mainly of moderately deep, moderately well drained and somewhat poorly drained, nearly level and gently sloping Cid and similar soils on flats, on ridges in the uplands, in depressions and in headwater drainageways.

Included with the Cid soils on site are areas of Badin channery silt loam, 2 to 8 percent slopes, mapped on river left along the mainstem restoration reach on the Staton property and along the mainstem preservation reach on the Griffin property. The Badin map unit consists mainly of moderately deep, well drained undulating soils on convex upland ridges that are highly dissected by intermittent drainageways.

Goldston-Badin complex soils, 2 to 8 and 8 to 15 percent slopes, respectively, are the mapped units on UT-1. GsB soils are mapped along the upper third of the project reach. GsC soils are mapped to the confluence of UT-1 with Davis Branch mainstem. The GsB and GsC component of the mapped unit consists mainly of shallow and moderately deep, well drained to excessively drained, undulating Goldston and Badin soils.

RECEIVING STREAM/SURFACE WATER
Davis Branch

EROSION AND SEDIMENT CONTROL PRACTICES
Sediment Fence:
Sediment fence will be placed before construction begins to prevent sediment from the borrow/spoil areas from entering the existing stream.

Dewatering Sediment Trap:
Dewatering Sediment traps shall be used to dewater the existing channel during the pump around process. Sediment laden water within the work area will be trapped by a temporary plug and pumped into the dewatering sediment trap. The trap should be located so that filtered water flows through existing vegetation before re-entering the existing stream downstream of the work area. These sediment traps will be abandoned once the work area is stabilized. Any accumulated sediment will be removed or stabilized in-place. Filter fabric sediment bags can be used instead of sediment traps, if needed.

The location of these traps will be determined in the field by the Contractor.

EROSION CONTROL SCHEDULE
This project shall be constructed in the dry using temporary earthen plugs and pumps. With this method clean water shall be pumped around the construction area and turbid water shall be pumped to a dewatering sediment trap or filter bag. With this method the project shall be constructed in sections small enough that the entire section can be completed and stabilized within 5 working days. The following sequence describes the steps that will need to be repeated for each section.

1. Construct a temporary earthen plug at the upstream end of the section to be constructed and begin pumping clean water around the work area and to an outlet stabilization structure before it re-enters the existing stream.

2. Construct a temporary earthen plug at the downstream end of the section and pump any turbid water to a dewatering sediment trap or filter bag.

3. Excavate the valley and channel, construct the in-stream structures.

4. Stabilize the valley with seed, fertilize, mulch and matting per the seeding table and stabilization details.

CONTRACTOR RESPONSIBILITIES
Details have been provided on this plan in an effort to help the Contractor provide erosion and sedimentation control. The details shown on the plan shall be considered a minimum. Erosion and sediment control features indicated on the relocation plan shall be installed per the State of North Carolina Department of Transportation details. The Contractor shall be solely responsibility for providing necessary and adequate measures for proper control of erosion and sediment runoff from the site along with proper maintenance and inspection in compliance with with the North Carolina Department of Environment and Natural Resources erosion and sediment control regulations.

The Contractor shall provide a schedule of operations to the Owner. The schedule should include a sequence of the placement of the sedimentation and erosion control measures that provides for continual protection of the site throughout the earth moving activities.

Prior to Construction Operations in a particular area, all sedimentation and erosion control features shall be in place. Field adjustments with respect to locations and dimensions may be made by the Engineer.

It may become necessary to remove portions of sedimentation controls during construction to facilitate the grading operations in certain areas. However, the controls shall be replaced upon completion of grading or during any inclement weather.

The Contractor shall be responsible to have the current Erosion Control Plan immediately available or posted on site.

The Contractor shall be responsible to ensure that off-site tracking of sediments by vehicles and equipment is minimized. All such off-site sediment shall be cleaned up daily.

The Contractor shall be responsible to ensure that no solid or liquid waste is discharged into the stream tributaries. Untreated sediment-laden runoff shall not flow off of site without being directed through a sediment control practice.

INSPECTIONS
The Owner/Contractor shall provide qualified personnel to conduct site inspections ensuring proper functionality of the erosion and sedimentation controls. All erosion and sedimentation controls are to be inspected once every seven (7) calendar days or within 24 hours of a 1/2 inch storm event or greater. Records of the site inspections shall be kept and made available to jurisdictional agencies if requested.

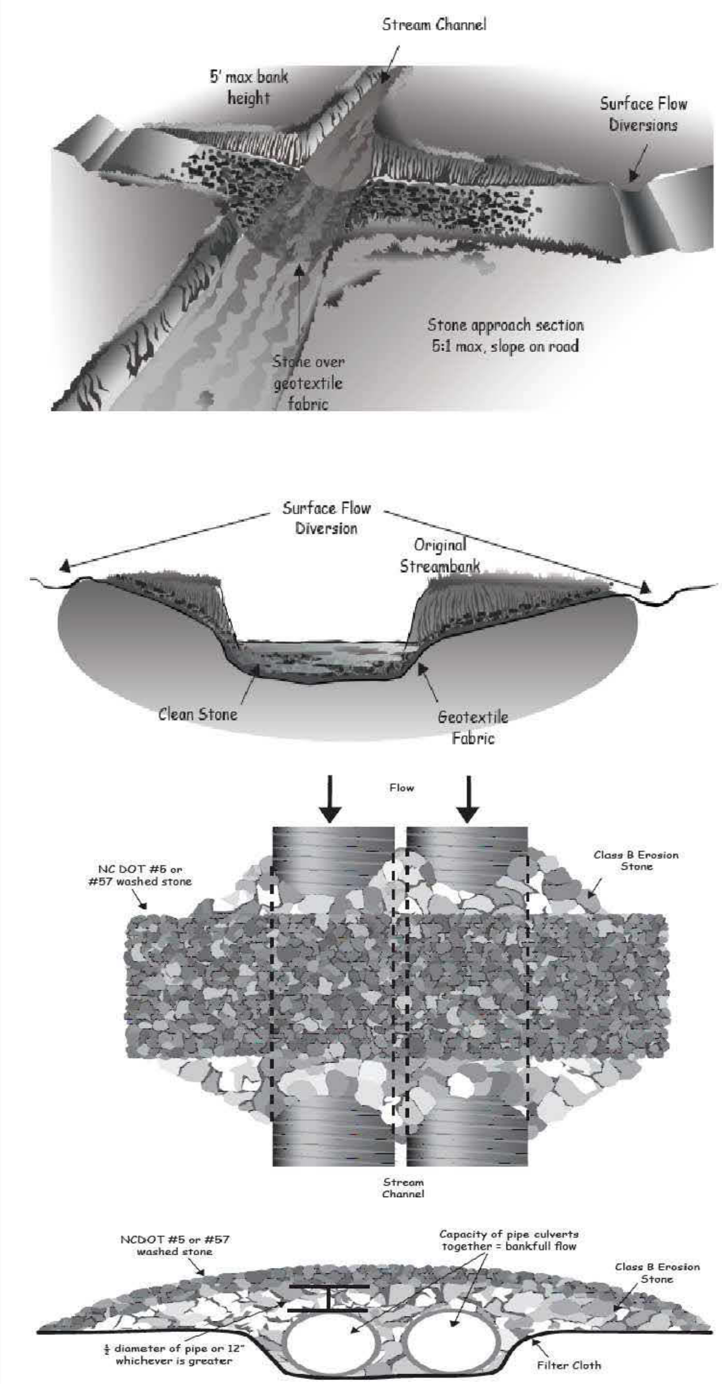
MAINTENANCE
It is the Contractor's responsibility to maintain the sedimentation and erosion control features on this project. Any sediment or debris that has reduced the efficiency of a control shall be removed immediately. Upon conducting an erosion control inspection, the Contractor shall repair or replace structures if it is determined that the structure is damaged and/or overwhelmed with sediment.

SOIL STABILIZATION
The Contractor shall stabilize disturbed slopes within 15 working days or 21 calendar days following completion of any phase of grading, permanent ground cover shall be established for all disturbed areas within 15 working days or 90 calendar days (whichever is shorter) following completion of construction or development.

Disturbed areas within the conservation easement shall be stabilized per deadline listed in the erosion control schedule on this sheet.

Disturbed slopes shall be stabilized per the stream channel bank stabilization details and the planting plan.

TEMPORARY STREAM CROSSING



Construction Specifications

1. Keep clearing and excavation of the stream banks and bed and approach sections to a minimum.

2. Divert all surface water from the construction site onto undisturbed areas adjoining the stream.

3. Keep stream crossings at right angles to the stream flow.

4. Align road approaches with the center line of the crossing for a minimum distance of 30 feet. Raise bridge abutments and culvert fills a minimum of 1 foot above the adjoining approach sections to prevent erosion from surface runoff and to allow flood flows to pass around the structure.

5. Stabilize all disturbed areas subject to flowing water, including planned overflow areas, with riprap or other suitable means if design velocity exceeds the allowable for the in-place soil (Table 8.05a, Appendix 8.05).

6. Ensure that bypass channels necessary to dewater the crossing site are stable before diverting the stream. Upon completion of the crossing, fill, compact, and stabilize the bypass channel appropriately.

7. Remove temporary stream crossings immediately when they are no longer needed. Restore the stream channel to its original cross-section, and smooth and appropriately stabilize all disturbed areas.

8. Any in-stream sediment control measures must be removed upon stabilization of the area.

Maintenance

Inspect temporary stream crossings after runoff-producing rains to check for blockage in channel, erosion of abutments, channel scour, riprap displacement, or piping. Make all repairs immediately to prevent further damage to the installation.

Note: Details on this sheet are from the North Carolina Erosion and Sediment Control Planning and Design Manual

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Ecosystem Enhancement PROGRAM

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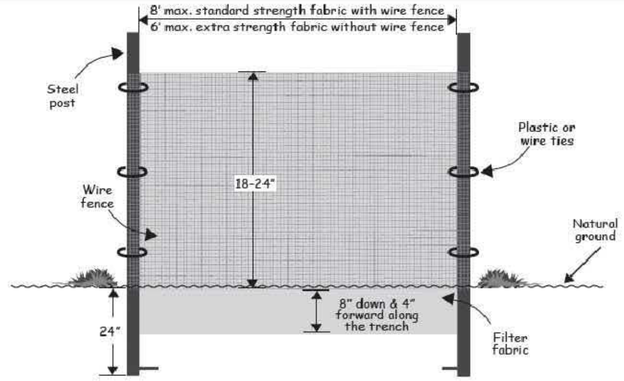
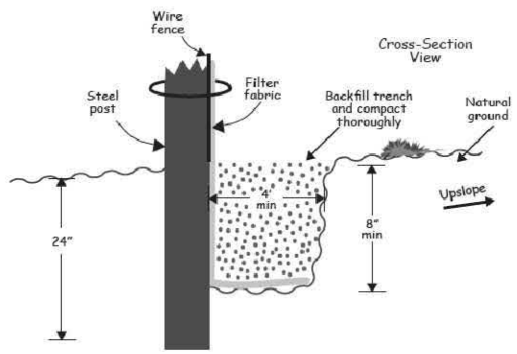
REVISIONS

MARK	DATE	DESCRIPTION

PRELIMINARY
NOT FOR CONSTRUCTION

SEDIMENT FENCE





Construction Specifications

MATERIALS

1. Use a synthetic filter fabric of at least 95% by weight of polyolefins or polyester, which is certified by the manufacturer or supplier as conforming to the requirements in ASTM D 6461, which is shown in part in Table 6.62b.

Synthetic filter fabric should contain ultraviolet ray inhibitors and stabilizers to provide a minimum of 6 months of expected usable construction life at a temperature range of 0 to 120° F.

2. Ensure that posts for sediment fences are 1.33 lb/linear ft steel with a minimum length of 5 feet. Make sure that steel posts have projections to facilitate fastening the fabric.

3. For reinforcement of standard strength filter fabric, use wire fence with a minimum 14 gauge and a maximum mesh spacing of 6 inches.

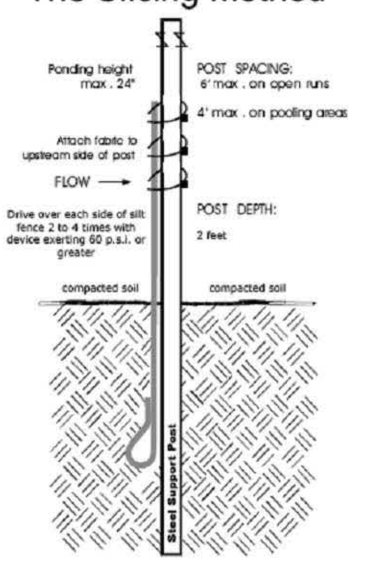
Table 6.62b Specifications For Sediment Fence Fabric

Temporary Silt Fence Material Property Requirements

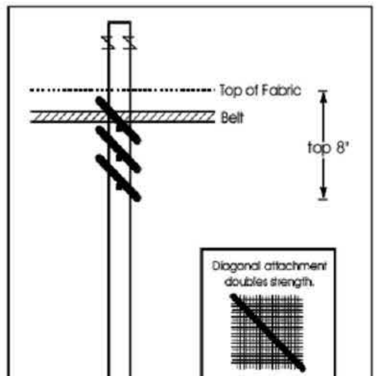
	Test Material	Units	Supported[1] Silt Fence	Un-Supported[1] Silt Fence	Type of Value
Grab Strength	ASTM D 4632	N (lbs)			
Machine Direction			400	550	MARV
			(90)	(90)	
X-Machine Direction			400	450	MARV
			(90)	(90)	
Permittivity[2]	ASTM D 4491	sec-1	0.05	0.05	MARV
Apparent Opening Size[2]	ASTM D 4751	mm	0.60	0.60	Max. ARV[3]
		(US Sieve #)	(30)	(30)	
Ultraviolet Stability	ASTM D 4355	% Retained Strength	70% after 500h of exposure	70% after 500h of exposure	Typical

[1] Silt Fence support shall consist of 14 gage steel wire with a mesh spacing of 150 mm (6 inches), or prefabricated poylmer mesh of equivalent strength.
[2] These default values are based on empirical evidence with a variety of sediment. For environmentally sensitive areas, a review of previous experience and/or site or regionally specific geotextile tests in accordance with Test Method D 5141 should be performed by the agency to confirm suitability of these requirements.
[3] As measured in accordance with Test Method D 4632.

The Slicing Method

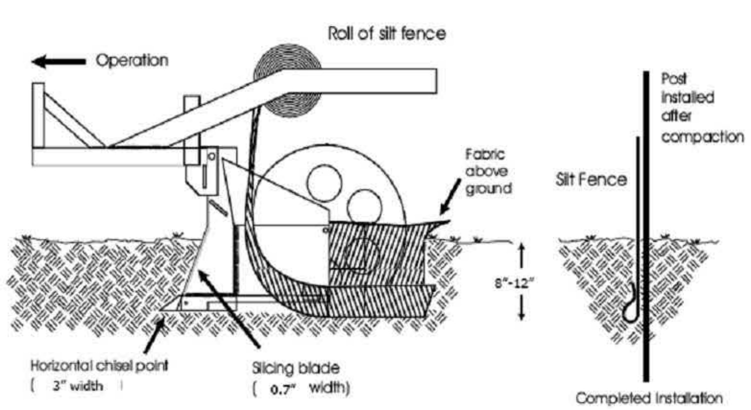


No more than 24" of a 36" fabric is allowed above ground.



ATTACHMENT DETAILS:

- Gather fabric at posts, if needed.
- Utilize three ties per post, all within top 8" of fabric.
- Position each tie diagonally, puncturing holes vertically a minimum of 1" apart.
- Hang each tie on a post nipple and tighten securely. Use cable ties (50lbs) or soft wire.



Vibratory plow is not acceptable because of horizontal compaction

Construction

1. Construct the sediment barrier of standard strength or extra strength synthetic filter fabrics.

2. Ensure that the height of the sediment fence does not exceed 24 inches above the ground surface. (Higher fences may impound volumes of water sufficient to cause failure of the structure.)

3. Construct the filter fabric from a continuous roll cut to the length of the barrier to avoid joints. When joints are necessary, securely fasten the filter cloth only at a support post with 4 feet minimum overlap to the next post.

4. Support standard strength filter fabric by wire mesh fastened securely to the upslope side of the posts. Extend the wire mesh support to the bottom of the trench. Fasten the wire reinforcement, then fabric on the upslope side of the fence post. Wire or plastic zip ties should have minimum 50 pound tensile strength.

5. When a wire mesh support fence is used, space posts a maximum of 8 feet apart. Support posts should be driven securely into the ground a minimum of 24 inches.

6. Extra strength filter fabric with 6 feet post spacing does not require wire mesh support fence. Securely fasten the filter fabric directly to posts. Wire or plastic zip ties should have minimum 50 pound tensile strength.

7. Excavate a trench approximately 4 inches wide and 8 inches deep along the proposed line of posts and upslope from the barrier (Figure 6.62a).

8. Place 12 inches of the fabric along the bottom and side of the trench.

9. Backfill the trench with soil placed over the filter fabric and compact. Thorough compaction of the backfill is critical to silt fence performance.

10. Do not attach filter fabric to existing trees.

SEDIMENT FENCE INSTALLATION USING THE SLICING METHOD
Instead of excavating a trench, placing fabric and then backfilling trench, sediment fence may be installed using specially designed equipment that inserts the fabric into a cut sliced in the ground with a disc (Figure 6.62b).

Installation Specifications

1. The base of both end posts should be at least one foot higher than the middle of the fence. Check with a level if necessary.

2. Install posts 4 feet apart in critical areas and 6 feet apart on standard applications.

3. Install posts 2 feet deep on the downstream side of the silt fence, and as close as possible to the fabric, enabling posts to support the fabric from upstream water pressure.

4. Install posts with the nipples facing away from the silt fabric.

5. Attach the fabric to each post with three ties, all spaced within the top 8 inches of the fabric. Attach each tie diagonally 45 degrees through the fabric, with each puncture at least 1 inch vertically apart. Also, each tie should be positioned to hang on a post nipple when tightened to prevent sagging.

6. Wrap approximately 6 inches of fabric around the end posts and secure with 3 ties.

7. No more than 24 inches of a 36 inch fabric is allowed above ground level.

8. The installation should be checked and corrected for any deviations before compaction.

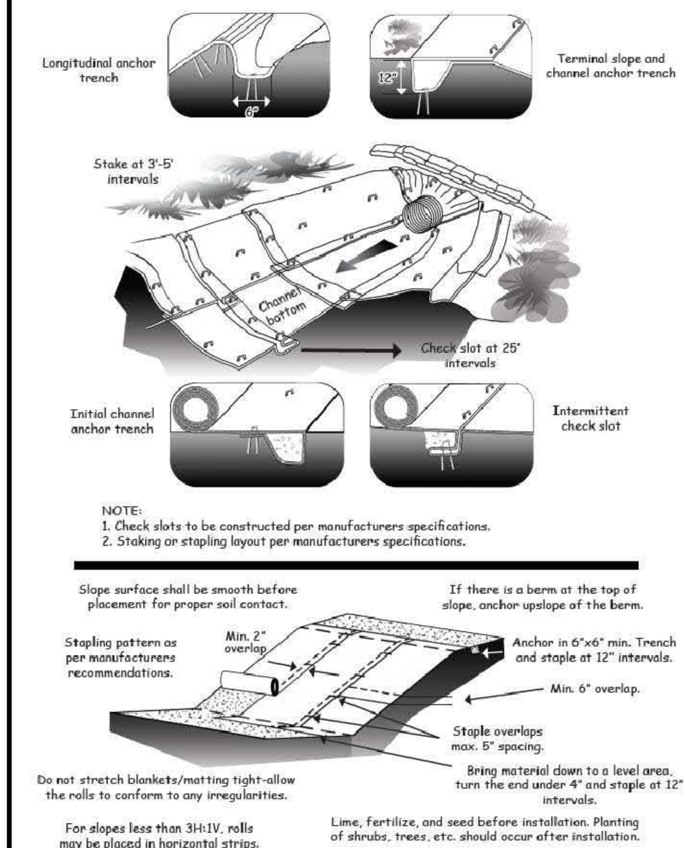
9. Compaction is vitally important for effective results. Compact the soil immediately next to the silt fence fabric with the front wheel of the tractor, skid steer, or roller exerting at least 60 pounds per square inch. Compact the upstream side first, and then each side twice for a total of 4 trips.

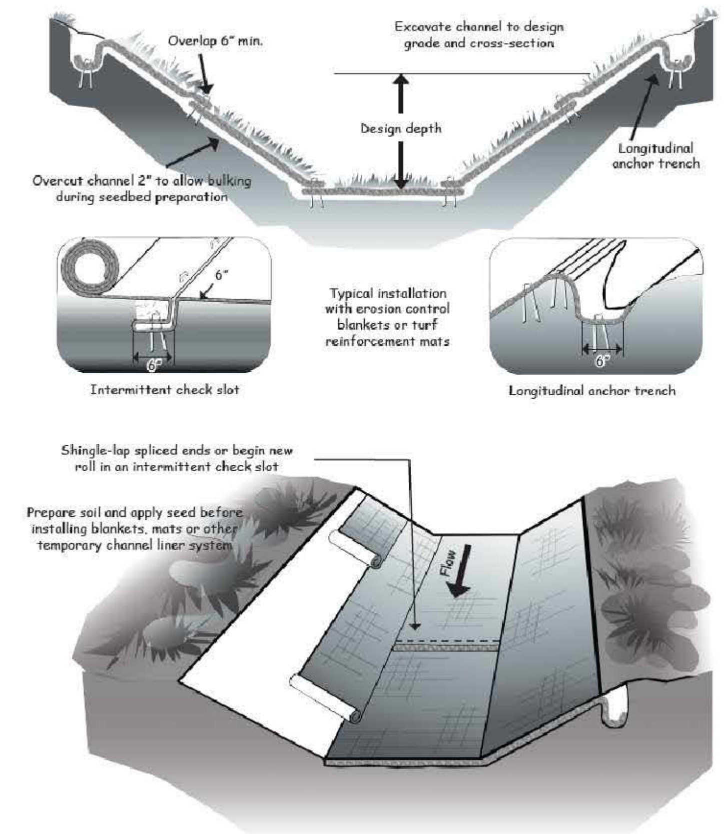
Maintenance

Inspect sediment fences at least once a week and after each rainfall. Make any required repairs immediately. Should the fabric of a sediment fence collapse, tear, decompose or become ineffective, replace it promptly. Remove sediment deposits as necessary to provide adequate storage volume for the next rain and to reduce pressure on the fence. Take care to avoid undermining the fence during cleanout. Remove all fencing materials and unstable sediment deposits and bring the area to grade and stabilize it after the contributing drainage area has been properly stabilized.

Note: Details on this sheet are from the North Carolina Erosion and Sediment Control Planning and Design Manual

ROLLED EROSION CONTROL PRODUCTS





NOTES:
1. Design velocities exceeding 2 ft/sec require temporary blankets, mats or similar liners to protect seed and soil until vegetation becomes established.
2. Grass-lined channels with design velocities exceeding 6 ft/sec should include turf reinforcement mats

Installation

Installation for Slopes– Place the RECP 2–3 feet over the top of the slope and into an excavated end trench measuring approximately 12 inches deep by 6 inches wide. Pin the RECP at 1 foot intervals along the bottom of the trench, backfill, and compact. Unroll the RECP down (or along) the slope maintaining direct contact between the soil and the RECP. Overlap adjacent rolls a minimum of 3 inches. Pin the RECP to the ground using staples or pins in a 3 foot center–to–center pattern. Less frequent stapling/pinning is acceptable on moderate slopes.

Installation in Channels– Excavate terminal trenches (12 inches deep and 6 inches wide) across the channel at the upper and lower end of the lined channel sections. At 25–foot intervals along the channel, anchor the RECP across the channel either in 6 inch by 6 inch trenches or by installing two closely spaced rows of anchors. Excavate longitudinal trenches 6 inches deep and wide along channel edges (above water line) in which to bury the outside RECP edges. Place the first RECP at the downstream end of the channel. Place the end of the first RECP in the terminal trench and pin it at 1 foot intervals along the bottom of the trench.

Note: The RECP should be placed upside down in the trench with the roll on the downstream side of the bench.

Once pinned and backfilled, the RECP is deployed by wrapping over the top of the trench and unrolling upstream. If the channel is wider than the provided rolls, place ends of adjacent rolls in the terminal trench, overlapping the adjacent rolls a minimum of 3 inches. Pin at 1 foot intervals, backfill, and compact. Unroll the RECP in the upstream direction until reaching the first intermittent trench. Fold the RECP back over itself, positioning the roll on the downstream side of the trench, and allowing the mat to conform to the trench.

Then pin the RECP (two layers) to the bottom of the trench, backfill, and compact. Continue up the channel (wrapping over the top of the intermittent trench) repeating this step at other intermittent trenches, until reaching the upper terminal trench. At the upper terminal trench, allow the RECP to conform to the trench, secure with pins or staples, backfill, compact and then bring the mat back over the top of the trench and onto the existing mat (2 to 3 feet overlap in the downstream direction), and pin at 1 foot intervals across the RECP. When starting installation of a new roll, begin in a trench or shingle–lap ends of rolls a minimum of 1 foot with upstream RECP on top to prevent uplifting. Place the outside edges of the RECP(s) in longitudinal trenches, pin, backfill, and compact.

Anchoring Devices–11 gauge, at least 6 inches length by 1 inch width staples or 12 inch minimum length wooden stakes are recommended for anchoring the RECP to the ground.

Drive staples or pins so that the top of the staple or pin is flush with the ground surface. Anchor each RECP every 3 feet along its center. Longitudinal overlaps must be sufficient to accommodate a row of anchors and uniform along the entire length of overlap and anchored every 3 feet along the overlap length. Roll ends may be spliced by overlapping 1 foot (in the direction of water flow), with the upstream/upslope mat placed on top of the downstream/downslope RECP. This overlap should be anchored at 1 foot spacing across the RECP. When installing multiple width mats heat seamed in the factory, all factory seams and field overlaps should be similarly anchored.

Maintenance

1. Inspect Rolled Erosion Control Products at least weekly and after each significant (1/2 inch or greater) rain fall event repair immediately.

2. Good contact with the ground must be maintained, and erosion must not occur beneath the RECP.

3. Any areas of the RECP that are damaged or not in close contact with the ground shall be repaired and stapled.

4. If erosion occurs due to poorly controlled drainage, the problem shall be fixed and the eroded area protected.

5. Monitor and repair the RECP as necessary until ground cover as established.

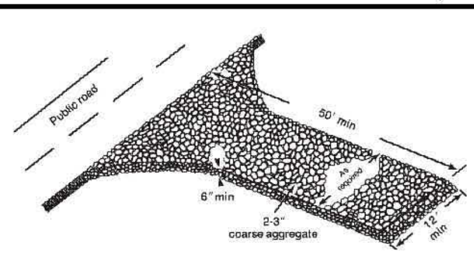
References

Sprague, C. Joel. TRI/ Environmental, Inc. "Green Engineering, Design principles and applications using rolled erosion control products"

Storm Water Management Manual for Western Washington, Washington State Department of Ecology, Water Quality Program http://www.ecy.wa.gov/programs/wq/stormwater/index.html

Erosion Control Technology Council, http://www.ectc.org

TEMPORARY GRAVEL CONSTRUCTION ENTRANCE/EXIT



Construction Specifications

1. Clear the entrance and exit area of all vegetation, roots, and other objectionable material and properly grade it.

2. Place the gravel to the specific grade and dimensions shown on the plans, and smooth it.

3. Provide drainage to carry water to a sediment trap or other suitable outlet.

4. Use geotextile fabrics because they improve stability of the foundation in locations subject to seepage or high water table.

Maintenance

Maintain the gravel pad in a condition to prevent mud or sediment from leaving the construction site. This may require periodic topdressing with 2–inch stone. After each rainfall, inspect any structure used to trap sediment and clean it out as necessary. Immediately remove all objectionable materials spilled, washed, or tracked onto public roadways.

UNION COUNTY, NORTH CAROLINA
STREAM RESTORATION PLAN
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1" = 200'	RP-17/20

EMH&T
Evans, Mechwart, Hambleton & Tilton, Inc.
Engineers • Surveyors • Planners • Scientists
5500 New Albany Road Columbus, OH 43054

Ecosystem Enhancement PROGRAM

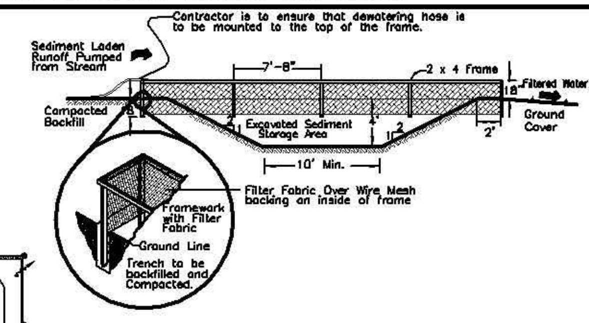
MARK	DATE	DESCRIPTION

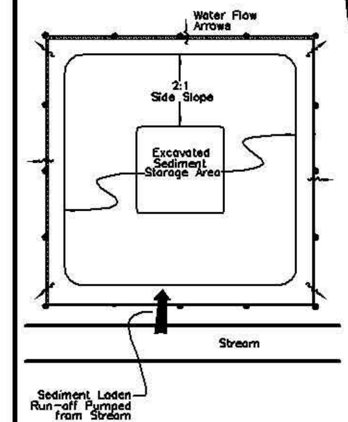
REVISIONS

Notes:

- Construction Entrance shall be installed along Olive Branch Road.
- Limits of disturbance is approximately 15' outside the conservation easement, unless shown and labeled differently on this sheet.
- The existing stream channel within the beltwidth shall be filled after the new channel is active. This fill should be a combination of compacted clay soil and Plain Riprap, Class 1. The area should be graded to drain into the new channel and stabilized with seed and mulch. The existing stream outside the beltwidth shall be plugged every 100' to promote overland flow to the channel.
- When construction is complete the spoil areas shall be graded to drain to the new channel and stabilized with seed and mulch.
- When construction is complete the borrow areas shall be restored to grade to the extent possible. After grading the area shall be stabilized with seed and mulch.
- Locations of the temporary stream crossings are approximate and will be established in the field by the Contractor throughout the course of constructing the project

TEMPORARY DEWATERING SEDIMENT TRAP DETAIL





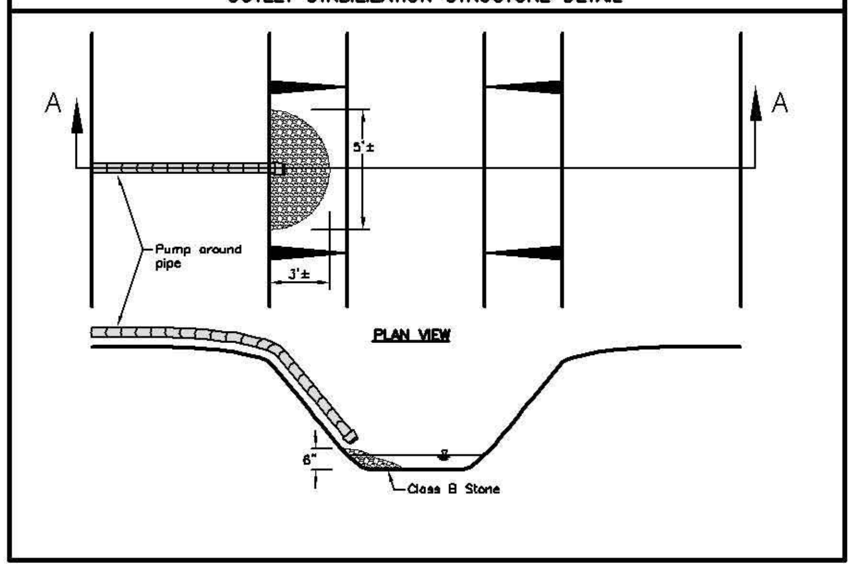
Dewatering within excavated areas, if required, shall be performed in accordance with the details shown on this plan. Alternative methods of dewatering may require prior approval of the Engineer.

Contractor is to pump turbid water from the stream to the sediment trap enclosure to provide sediment control during construction of the stream.

All sedimentation and erosion control devices shall be inspected immediately after each rainfall and at least daily during prolonged rainfall. Contractor shall utilize sediment trap enclosure prior to discharge from site for all excavation dewatering activities. Outfall shall be through native ground cover. No untreated stormwater will be released from the site. Accumulated sediment shall be removed and properly disposed of in an area beyond the floodway and properly stabilized, as necessary.

Specific Application:
Do not exceed 23 gallons per minute pumping rate or the seepage capacity of the filter fabric enclosure, whichever is less. Filter fabric shall have an equivalent opening size (EOS) of 40 – 80 sieve (0.3 gal/min/sf maximum). Filter fabric and wire mesh backing shall extend 18" below grade and shall be covered with compacted backfill. Temporary sediment storage shall be provided within the excavated portion of the sediment trap. Excavated side slopes shall not be steeper than 2 horiz :1 vert. Depth of excavation shall be 4-feet below natural grade. Sediment trap shall be re-excavated when the holding area becomes half-full of sediment.

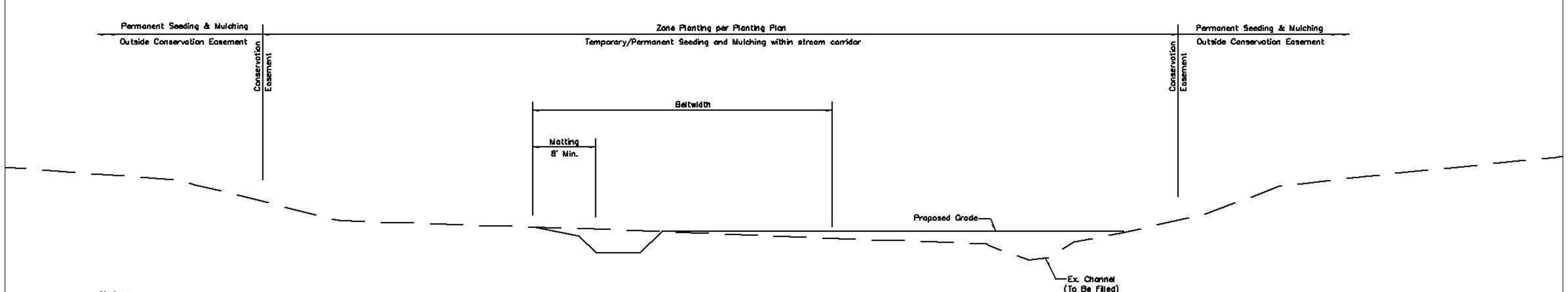
OUTLET STABILIZATION STRUCTURE DETAIL



SEEDING TABLE OUTSIDE CONSERVATION EASEMENT

TYPE		APPLICATION RATES	APPLICATION DATES
TEMPORARY SEED: Rye (Grain)	*(Secale cereale)*	120 lbs/acre	June–August
PERMANENT SEED: Big Bluestem	*(Andropogon gerardii)*	15 lbs/acre of mixture	September – May
Tall Fescue	*(Festuca arundinacea)*		
Kentucky Bluegrass	*(Poa pratensis)*		
Korean Lespedeza	*(Lespedeza stipulacea)*		
Sericea Lespedeza	*(Lespedeza cuneata)*		
Redtop	*(Agrostis gigantea)*		
Indiangrass	*(Sorghastrum nutans)*		

CHANNEL STABILIZATION DETAIL – SECTION B-B



Notes:
- Typical Section B-B is from left to right looking downstream, see sheet 16 for location.
- Matting shall be placed along the outside of the meander bends, see channel reinforcement detail on sheet 13.
- See sheet 15 for a detailed erosion control schedule.
- See plan view on sheet 16 for location of each erosion control feature.
- Matting shall be installed per NCDOT Item 1631.3 and detail, sheet 17.
- Straw mulch shall be applied at a ratio 1-2 tons per acre, and shall be anchored using a mulch anchoring tool or other approved method.

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EROSION CONTROL PLAN

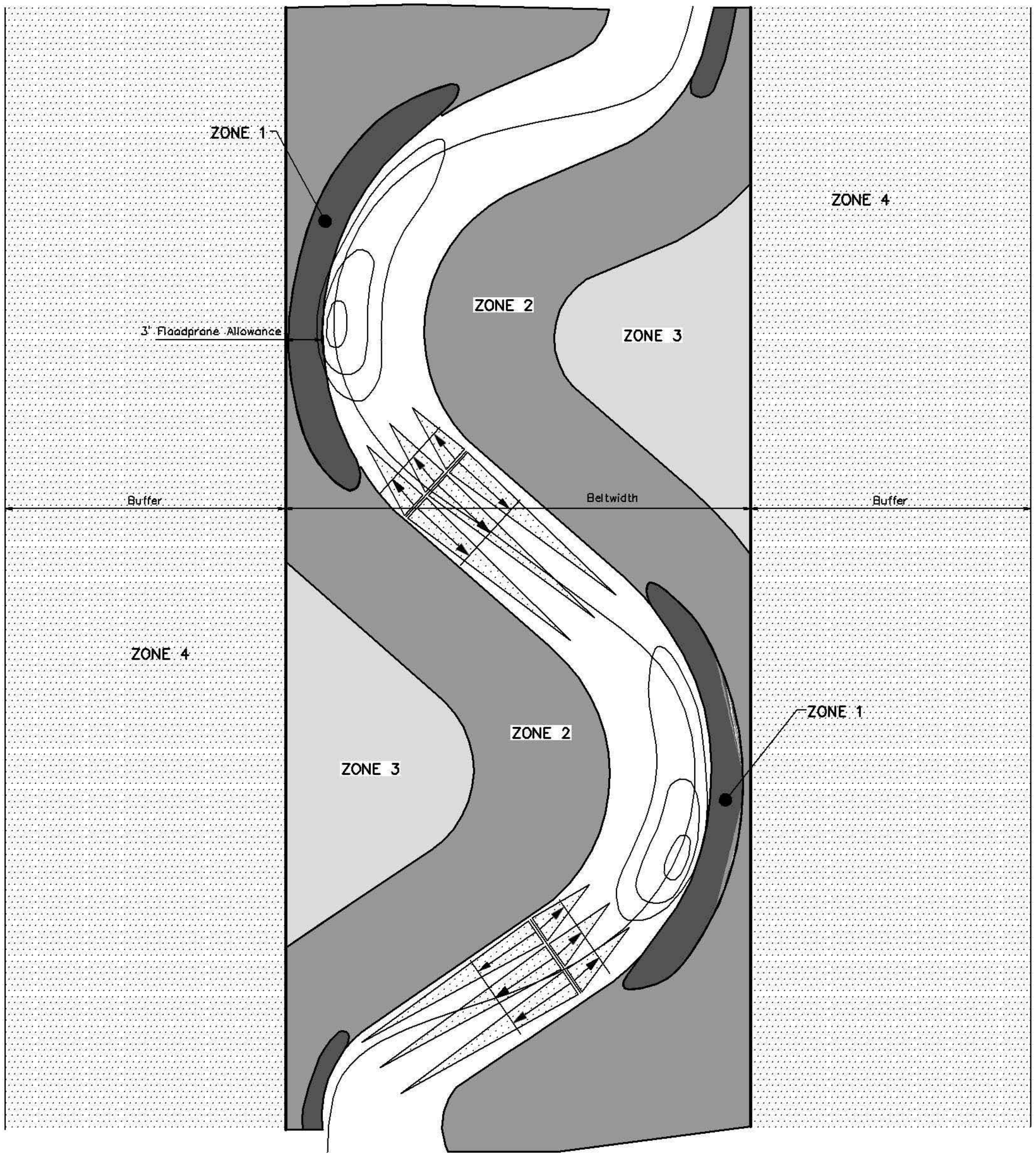
Ecosystem Enhancement PROGRAM

EMH&T

Date	Job No.
May, 2008	2006-1397
Scale: Not To Scale	Sheet: RP-18/20

REVISIONS

PRELIMINARY NOT FOR CONSTRUCTION



PLANTING ZONES
Not to Scale

PLANTING ZONES

- *Zone 1 - Stream Edge*

Live Branches , *3x3' centers*

Common Name	*Scientific Name*
Buttonbush	*Cephalanthus occidentalis*
Silky dogwood	*Cornus amomum*
Black willow	*Salix nigra*
Silky willow	*Salix sericea*
Elderberry	*Sambucus canadensis*

- *Zone 2 - Streamside Shrubs and Trees*

Shrubs. *Bareroot Material - 4x4' centers*

Common Name	*Scientific Name*
Painted buckeye	*Aesculus sylvatica*
Tag alder	*Alnus serrulata*
Red chokeberry	*Aronia arbutifolia*
Silky dogwood	*Cornus amomum*
American holly	*Ilex opaca*
Black willow	*Salix nigra*
Elderberry	*Sambucus canadensis*

Trees. *1 Gallon Containers - 100 foot spacing*

Common Name	*Scientific Name*
River birch	*Betula nigra*
Sugarberry	*Celtis laevigata*
Green ash	*Fraxinus pennsylvanica*
Tulip poplar	*Liriodendron tulipifera*
Sycamore	*Platanus occidentalis*
Water oak	*Quercus nigra*
Willow oak	*Quercus phellos*
American elm	*Ulmus americana*

- *Zone 3 - Floodplain*

Bareroot Material - 8x8' centers

Common Name	*Scientific Name*
Red chokeberry	*Aronia arbutifolia*
Paw paw	*Asimina triloba*
River birch	*Betula nigra*
American hornbeam	*Carpinus caroliniana*
Sugarberry	*Celtis laevigata*
Green ash	*Fraxinus pennsylvanica*
Tulip poplar	*Liriodendron tulipifera*
Black gum	*Nyssa sylvatica*
Sycamore	*Platanus occidentalis*
American elm	*Ulmus americana*

- *Zone 4 - 30' Riparian Buffer*

Bareroot Material - 10x10' centers

Common Name	*Scientific Name*
Pignut hickory	*Carya glabra*
Flowering dogwood	*Cornus florida*
White ash	*Fraxinus americana*
Black walnut	*Juglans nigra*
Tulip poplar	*Liriodendron tulipifera*
Eastern hophornbeam	*Ostrya virginiana*
Black cherry	*Prunus serotina*
White oak	*Quercus alba*
Smooth sumac	*Rhus glabra*
Winged elm	*Ulmus alata*

In addition to planting described above, temporary and permanent seeding will occur in Zones 2, 3 & 4. See seeding table, this sheet.

Final species selection will be based upon availability.

Notes

- The existing wooded portions of Davis Branch and Unnamed Tributary 1 will only contain planting zones 1 and 2. See sheet 20.

STREAM CORRIDOR SEEDING TABLE

TYPE	APPLICATION RATES	APPLICATION DATES
TEMPORARY SEED: Rye (Grain) *(Secale cereale)*	40 lbs/acre	June–August
PERMANENT SEED: Big Bluestem *(Andropogon gerardii)* Broomsedge *(Andropogon virginicus)* Deertongue *(Panicum clandestinum)* Little Bluestem *(Schizachyrium scoparium)* Indiangrass *(Sorghastrum nutans)*	15 lbs/acre of mixture	September – May
OVERSEED: Pearl Millet *(Pennisetum glaucum)*	15 lbs/acre	June–August

Job No. 2006-1397
Sheet RP-19/20
Date May, 2008
Scale Not To Scale

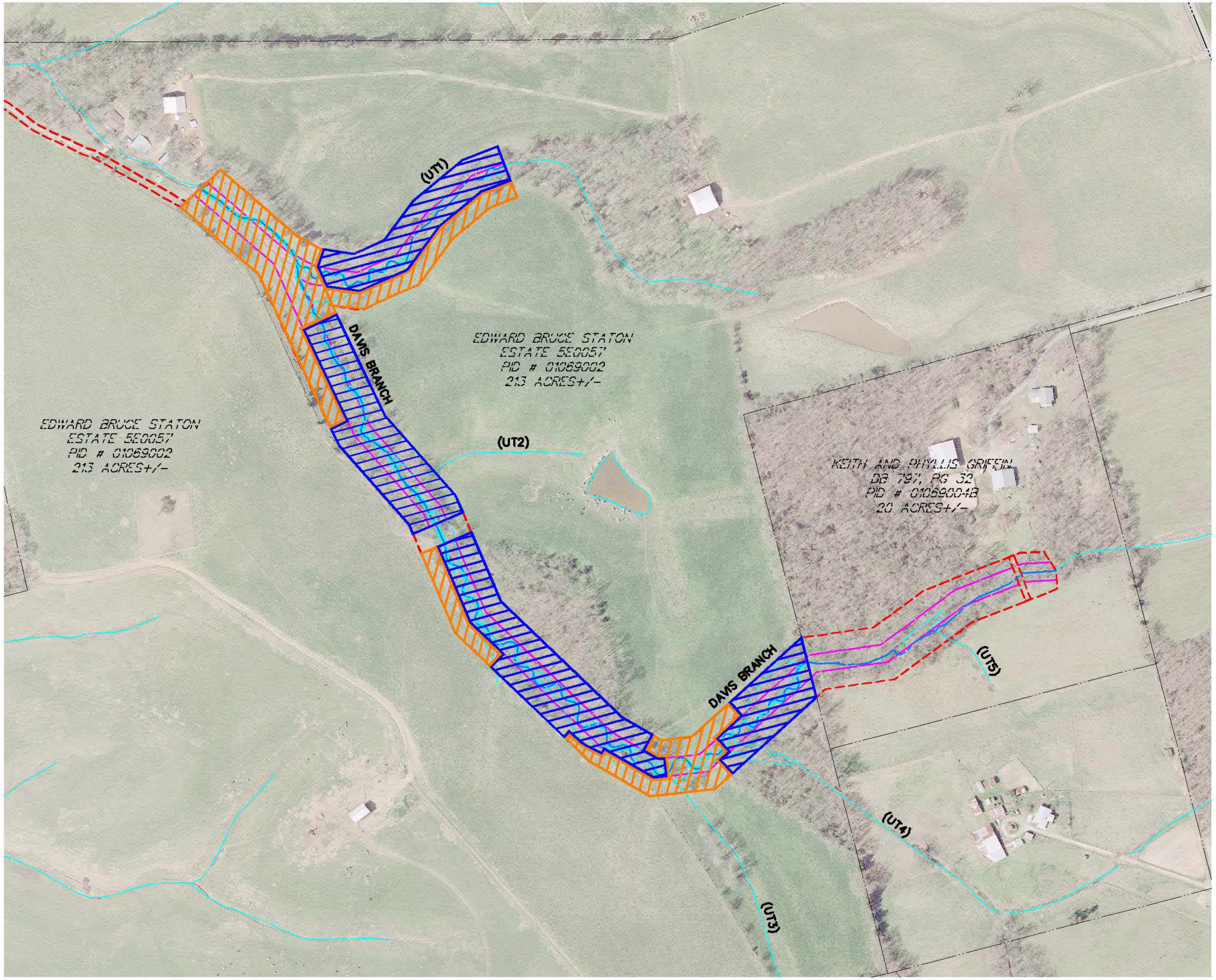
UNION COUNTY, NORTH CAROLINA
STREAM RESTORATION PLAN
FOR
DAVIS BRANCH AND UNNAMED TRIBUTARY
STREAM RESTORATION PROJECT
PLANTING PLAN

Ecosystem Enhancement PROGRAM

EMH&T
Evans, Mechwart, Hambleton & Tilton, Inc.
Engineers • Surveyors • Planners • Scientists

REVISIONS
MARK DATE DESCRIPTION

PRELIMINARY NOT FOR CONSTRUCTION



PLANTING ZONES
Scale: 1" = 300'

LEGEND

PLANTING ZONES 1-4

PLANTING ZONES 1 & 2 ONLY

NOTE:
See Planting Plan Zones and Planting List, Sheet 19.

MARK	DATE	DESCRIPTION

REVISIONS

PRELIMINARY
NOT FOR CONSTRUCTION

EMH&T
Evans, Mechwart, Hambleton & Tilton, Inc.
Engineers • Surveyors • Planners • Scientists
5500 New Albany Road, Columbus, OH 43054
Phone: 614.775.4500 Fax: 614.775.4800

Ecosystem Enhancement PROGRAM

UNION COUNTY, NORTH CAROLINA
STREAM RESTORATION PLAN
FOR
DAVIS BRANCH
AND UNNAMED TRIBUTARY
STREAM RESTORATION PROJECT
PLANTING PLAN

Date: May, 2008
Scale: 1" = 300'
Job No.: 2006-1397
Sheet: **RP-20/20**

\\CMHDATA2\ENVIRON\PROJECT\20061397.ENV\DWG\RESTORATION PLAN\61397RP13-20.DWG<RP-20> - 2 XREFS: 61397XTS, 61397XBS(UPDATE) - LAST SAVED BY JCRAMER (5/16/2008 1:14:51 PM) - PLOTTED BY JCRAMER (5/16/2008 1:14:58 PM)

APPENDIX 2

Project Site NCDWQ Stream Classification Forms

North Carolina Division of Water Quality – Stream Identification Form; Version 3.1

Date: 4/11/07	**Project:** Davis Br. & UT1	**Latitude:**
Evaluator: S. Peffer, EMH+T	**Site:** Davis Br. Mainstem	**Longitude:**
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30* 33.5	**County:** Union	**Other** *e.g. Quad Name:*

A. Geomorphology (Subtotal = 19)

	Absent	Weak	Moderate	Strong
1[a]. Continuous bed and bank	0	1	2	3
2. Sinuosity	0	1	2	3
3. In-channel structure: riffle-pool sequence	0	1	2	3
4. Soil texture or stream substrate sorting	0	1	2	3
5. Active/relic floodplain	0	1	2	3
6. Depositional bars or benches	0	1	2	3
7. Braided channel	0	1	2	3
8. Recent alluvial deposits	0	1	2	3
9[a] Natural levees	0	1	2	3
10. Headcuts	0	1	2	3
11. Grade controls	0	0.5	1	1.5
12. Natural valley or drainageway	0	0.5	1	1.5
13. Second or greater order channel on existing USGS or NRCS map or other documented evidence.	No = 0		Yes = 3	

[a] Man-made ditches are not rated; see discussions in manual

B. Hydrology (Subtotal = 7.5)

14. Groundwater flow/discharge	0	1	2	3
15. Water in channel and > 48 hrs since rain, **or** Water in channel – dry or growing season	0	1	2	3
16. Leaflitter	1.5	1	0.5	0
17. Sediment on plants or debris	0	0.5	1	1.5
18. Organic debris lines or piles (Wrack lines)	0	0.5	1	1.5
19. Hydric soils (redoximorphic features) present?	No = 0		Yes = 1.5	

C. Biology (Subtotal = 7)

20[b]. Fibrous roots in channel	3	2	1	0
21[b]. Rooted plants in channel	3	2	1	0
22. Crayfish	0	0.5	1	1.5
23. Bivalves	0	1	2	3
24. Fish	0	0.5	1	1.5
25. Amphibians	0	0.5	1	1.5
26. Macrobenthos (note diversity and abundance)	0	0.5	1	1.5
27. Filamentous algae; periphyton	0	1	2	3
28. Iron oxidizing bacteria/fungus.	0	0.5	1	1.5
29[b]. Wetland plants in streambed	FAC = 0.5; FACW = 0.75; OBL = 1.5 SAV = 2.0; Other = 0			

[b] Items 20 and 21 focus on the presence of upland plants, Item 29 focuses on the presence of aquatic or wetland plants.

Notes: (use back side of this form for additional notes.)

Sketch:

North Carolina Division of Water Quality – Stream Identification Form; Version 3.1

Date: 4/11/07	Project: Davis Br. + UT1	Latitude:
Evaluator: S. Peffer, EMH+T	Site: UT1	Longitude:
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30* 34	County: Union	Other *e.g. Quad Name:*

A. Geomorphology (Subtotal = 22)

	Absent	Weak	Moderate	Strong
1[a]. Continuous bed and bank	0	1	2	3
2. Sinuosity	0	1	2	3
3. In-channel structure: riffle-pool sequence	0	1	2	3
4. Soil texture or stream substrate sorting	0	1	2	3
5. Active/relic floodplain	0	1	2	3
6. Depositional bars or benches	0	1	2	3
7. Braided channel	0	1	2	3
8. Recent alluvial deposits	0	1	2	3
9[a] Natural levees	0	1	2	3
10. Headcuts	0	1	2	3
11. Grade controls	0	0.5	1	1.5
12. Natural valley or drainageway	0	0.5	1	1.5
13. Second or greater order channel on existing USGS or NRCS map or other documented evidence.	No = 0		Yes = 3	

[a] Man-made ditches are not rated; see discussions in manual

B. Hydrology (Subtotal = 7)

	Absent	Weak	Moderate	Strong
14. Groundwater flow/discharge	0	1	2	3
15. Water in channel and > 48 hrs since rain, or Water in channel -- dry or growing season	0	1	2	3
16. Leaflitter	1.5	1	0.5	0
17. Sediment on plants or debris	0	0.5	1	1.5
18. Organic debris lines or piles (Wrack lines)	0	0.5	1	1.5
19. Hydric soils (redoximorphic features) present?	No = 0		Yes = 1.5	

C. Biology (Subtotal = 5)

	Absent	Weak	Moderate	Strong
20[b]. Fibrous roots in channel	3	2	1	0
21[b]. Rooted plants in channel	3	2	1	0
22. Crayfish	0	0.5	1	1.5
23. Bivalves	0	1	2	3
24. Fish	0	0.5	1	1.5
25. Amphibians	0	0.5	1	1.5
26. Macrobenthos (note diversity and abundance)	0	0.5	1	1.5
27. Filamentous algae; periphyton	0	1	2	3
28. Iron oxidizing bacteria/fungus.	0	0.5	1	1.5
29[b]. Wetland plants in streambed	FAC = 0.5; FACW = 0.75; OBL = 1.5 SAV = 2.0; Other = 0			

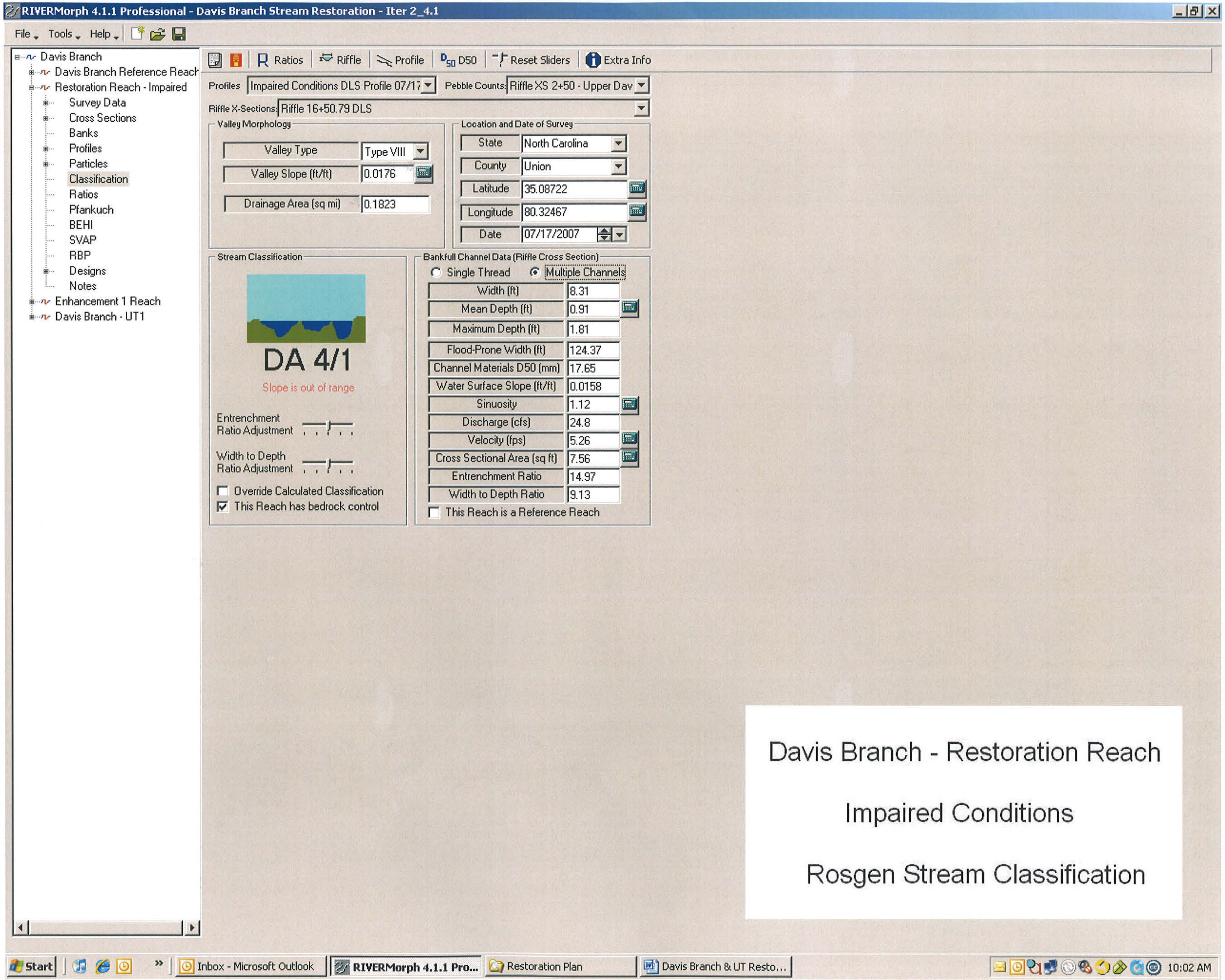
[b] Items 20 and 21 focus on the presence of upland plants, Item 29 focuses on the presence of aquatic or wetland plants.

Notes: (use back side of this form for additional notes.)

Sketch:

APPENDIX 3

Impaired Project Stream Reaches, Rosgen Level III Assessment Documentation



Davis Branch - Restoration Reach

Impaired Conditions

Rosgen Stream Classification

Worksheet 5-3. Field form for Level II stream classification (Rosgen, 1996; Rosgen and Silvey, 2005).

Stream:	**Davis Branch, Impaired Restoration Reach**
Basin:	**Yadkin - Pee Dee River** Drainage Area: **116.672** acres **0.1823** mi^2
Location:	**Staton Property, North of Marshville, NC**
Twp.&Rge: **;**	Sec.&Qtr.: **;**
Cross-Section Monuments (Lat./Long.):	**35.08722 Lat / 80.32467 Long** Date: **07/17/07**
Observers:	**M.F. Hebert, W.E. Knotts, J.M. Hines, S.T. Peffer** Valley Type: VIII

Bankfull WIDTH (W_{bkf}) WIDTH of the stream channel at bankfull stage elevation, in a riffle section.	**8.31**	ft
Bankfull DEPTH (d_{bkf}) Mean DEPTH of the stream channel cross-section, at bankfull stage elevation, in a riffle section ($d_{bkf} = A / W_{bkf}$).	**0.91**	ft
Bankfull X-Section AREA (A_{bkf}) AREA of the stream channel cross-section, at bankfull stage elevation, in a riffle section.	**7.56**	ft^2
Width/Depth Ratio (W_{bkf} / d_{bkf}) Bankfull WIDTH divided by bankfull mean DEPTH, in a riffle section.	**9.13**	ft/ft
Maximum DEPTH (d_{mbkf}) Maximum depth of the bankfull channel cross-section, or distance between the bankfull stage and Thalweg elevations, in a riffle section.	**1.81**	ft
WIDTH of Flood-Prone Area (W_{fpa}) Twice maximum DEPTH, or ($2 \times d_{mbkf}$) = the stage/elevation at which flood-prone area WIDTH is determined in a riffle section.	**124.37**	ft
Entrenchment Ratio (ER) The ratio of flood-prone area WIDTH divided by bankfull channel WIDTH (W_{fpa} / W_{bkf}) (riffle section).	**14.97**	ft/ft
Channel Materials (Particle Size Index) D_{50} The D_{50} particle size index represents the mean diameter of channel materials, as sampled from the channel surface, between the bankfull stage and Thalweg elevations.	**17.65**	mm
Water Surface SLOPE (S) Channel slope = "rise over run" for a reach approximately 20–30 bankfull channel widths in length, with the "riffle-to-riffle" water surface slope representing the gradient at bankfull stage.	**0.0124**	ft/ft
Channel SINUOSITY (k) Sinuosity is an index of channel pattern, determined from a ratio of stream length divided by valley length (SL / VL); or estimated from a ratio of valley slope divided by channel slope (VS / S).	**1.12**	

Stream Type **DA4/1** (See **Figure 2-14**)

Worksheet 5-4. Morphological relations, including dimensionless ratios of river reach sites (Rosgen and Silvey, 2005).

Stream:	Davis Branch Impaired Restoration Reach			Location:	Davis Branch - Staton Property		
Observers:	Hebert, Knotts, Hines & Peffer	Date:	07/17/07	Valley Type:	VIII	Stream Type:	E 4/1

River Reach Summary Data

Channel Dimension

Mean Riffle Depth (d_{bkf})	0.91	ft	Riffle Width (W_{bkf})	8.31	ft	Riffle Area (A_{bkf})	7.56	ft²
Mean Pool Depth (d_{bkfp})	1.18	ft	Pool Width (W_{bkfp})	8.19	ft	Pool Area (A_{bkfp})	9.66	ft²
Mean Pool Depth/Mean Riffle Depth	1.30	d_{bkfp}/d_{bkf}	Pool Width/Riffle Width	0.99	W_{bkfp}/W_{bkf}	Pool Area / Riffle Area	1.28	A_{bkfp}/A_{bkf}
Max Riffle Depth (d_{mbkf})	1.81	ft	Max Pool Depth (d_{mbkfp})	1.72	ft	Max Riffle Depth/Mean Riffle Depth	1.99	
Max Pool Depth/Mean Riffle Depth	1.89					Point Bar Slope	N/A	
Streamflow: Estimated Mean Velocity at Bankfull Stage (u_{bkf})				5.26	ft/s	Estimation Method	Mannings Eq.	
Streamflow: Estimated Discharge at Bankfull Stage (Q_{bkf})				24.8	cfs	Drainage Area	0.1823	mi²

Channel Pattern

Geometry	Mean	Min	Max		Dimensionless Geometry Ratios	Mean	Min	Max
Meander Length (Lm)				ft	Meander Length Ratio (Lm/W_{bkf})			
Radius of Curvature (Rc)				ft	Radius of Curvature/Riffle Width (Rc/W_{bkf})			
Belt Width (W_{blt})				ft	Meander Width Ratio (W_{blt}/W_{bkf})			
Individual Pool Length	22.94	19.52	29.8	ft	Pool Length/Riffle Width	2.76	2.35	3.58
Pool to Pool Spacing	39.99	35.25	43.7	ft	Pool to Pool Spacing/Riffle Width	4.81	4.24	5.26
Riffle Length	26.99	24.99	31	ft	Riffle Length/Riffle Width	3.25	3.01	3.73

Channel Profile

Valley Slope (VS)	0.0176	ft/ft	Average Water Surface Slope (S)	0.0158	ft/ft	Sinuosity (VS/S)	1.12
Stream Length (SL)	1562	ft	Valley Length (VL)	1397	ft	Sinuosity (SL/VL)	1.12

Low Bank Height (LBH)	start	2.37 ft	Max Riffle Depth	start	1.72 ft	Bank-Height Ratio (BHR) (LBH/Max Riffle Depth)	start	1.38	
	end	2.55 ft		end	1.81 ft		end	1.41	

Facet Slopes	Mean	Min	Max		Dimensionless Slope Ratios	Mean	Min	Max
Riffle Slope (S_{rif})	0.0449	0.0208	0.0629	ft/ft	Riffle Slope/Average Water Surface Slope (S_{rif}/ S)	2.84	1.32	3.98
Run Slope (S_{run})				ft/ft	Run Slope/Average Water Surface Slope (S_{run} / S)			
Pool Slope (S_p)	0.0010	0.0003	0.0027	ft/ft	Pool Slope/Average Water Surface Slope (S_p / S)	0.06	0.02	0.17
Glide Slope (S_g)				ft/ft	Glide Slope/Average Water Surface Slope (S_g / S)			

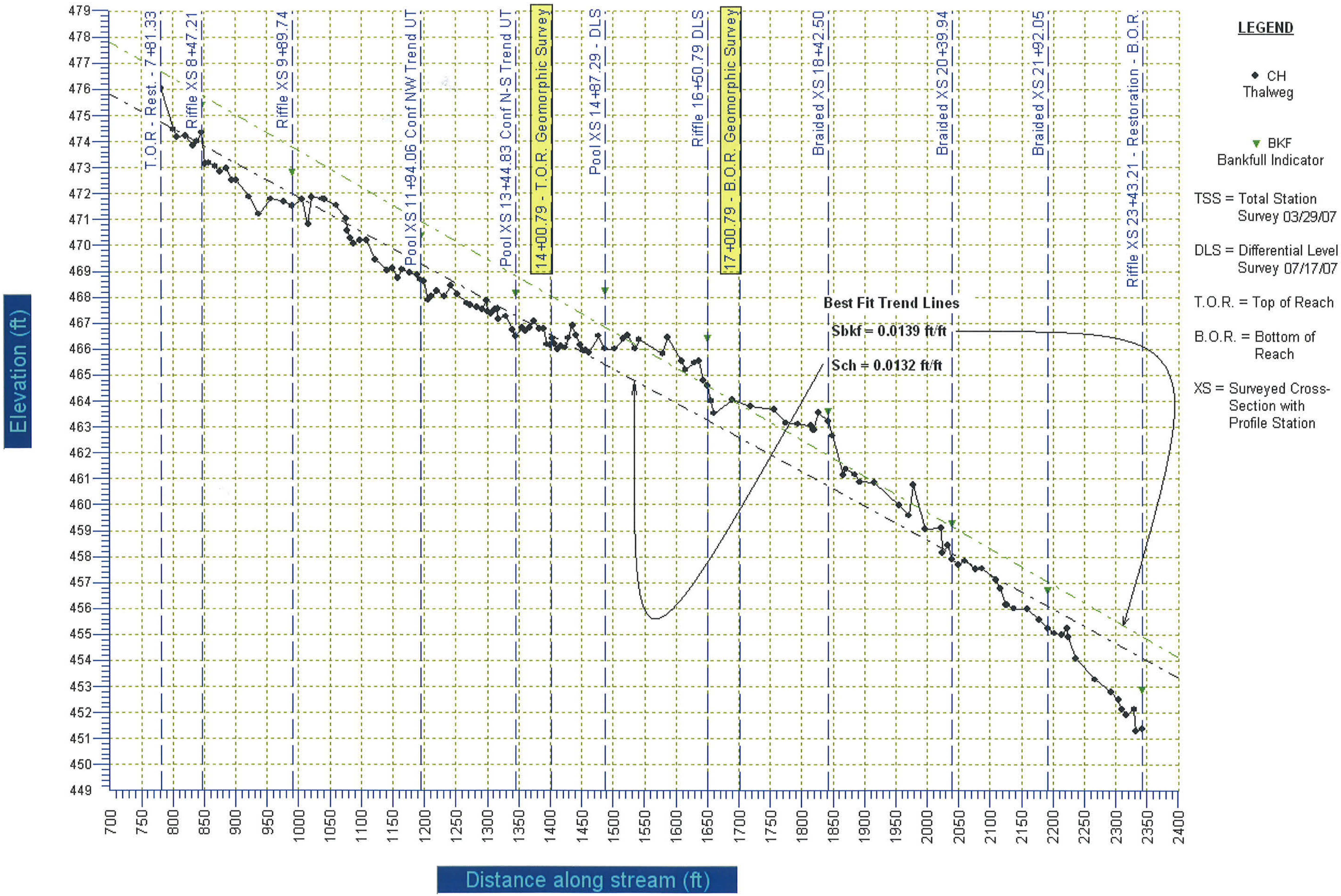
Feature Midpoint [a]	Mean	Min	Max		Dimensionless Depth Ratios	Mean	Min	Max
Riffle Depth (d_{rif})	1.81	1.81	1.81	ft	Riffle Depth/Mean Riffle Depth (d_{rif} / d_{bkf})	1.99	1.99	1.99
Run Depth (d_{run})				ft	Run Depth/Mean Riffle Depth (d_{run} / d_{bkf})			
Pool Depth (d_p)	1.72	1.72	1.72	ft	Pool Depth/Mean Riffle Depth (d_p / d_{bkf})	1.89	1.89	1.89
Glide Depth (d_g)				ft	Glide Depth/Mean Riffle Depth (d_g / d_{bkf})			

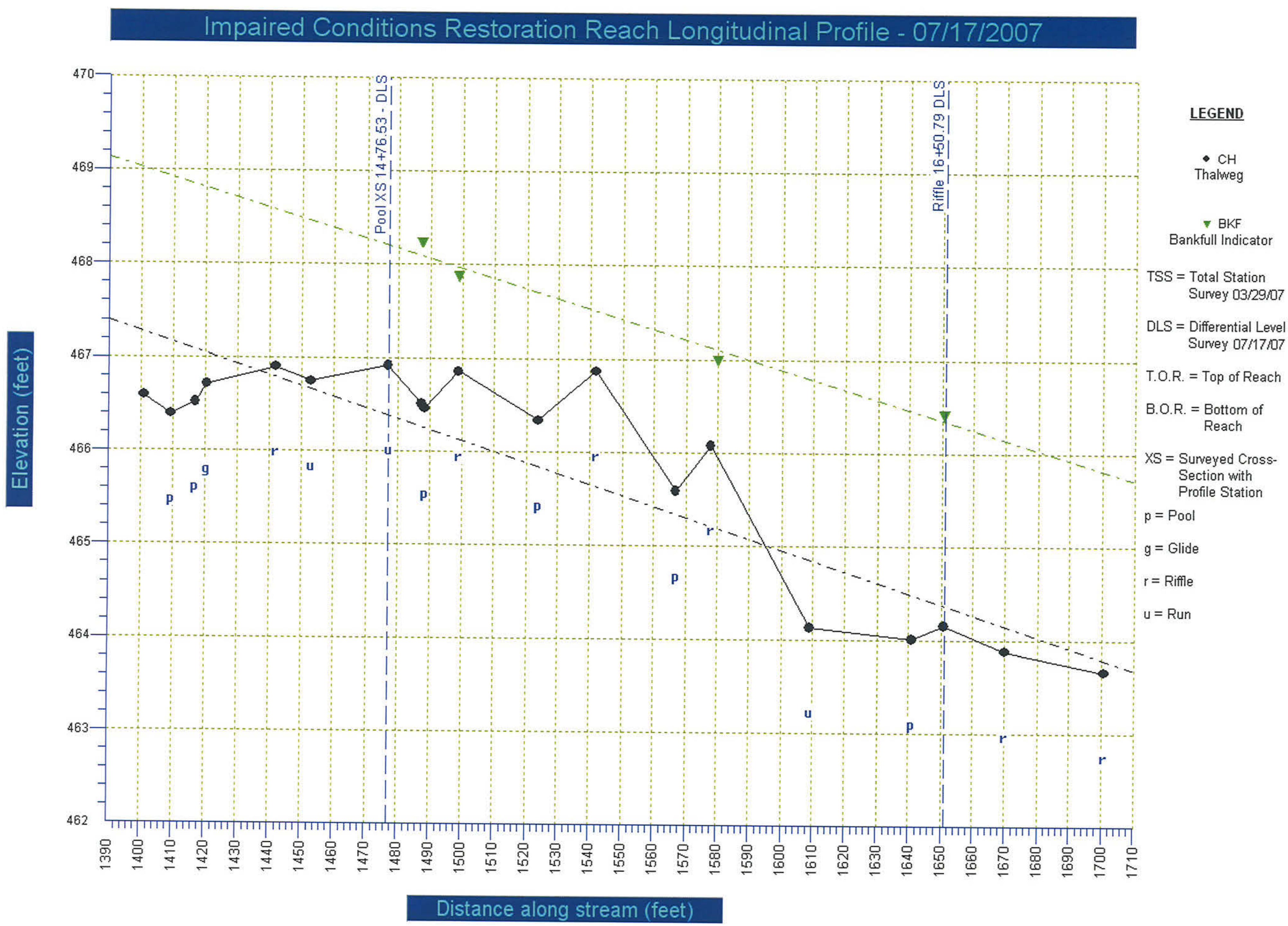
Channel Materials

	Reach[b]	Riffle[c]	Bar		Reach[b]	Riffle[c]	Bar	Protrusion Height[d]	
% Silt/Clay	0			D_{16}	9.83			80.64	mm
% Sand	0			D_{35}	14.12			138.4	mm
% Gravel	100			D_{50}	17.65			154	mm
% Cobble	0			D_{84}	28.88			207.36	mm
% Boulder	0			D_{95}	47.54			240.8	mm
% Bedrock	0			D_{100}	64			256	mm

a Min, max, mean depths are the average mid-point values except pools, which are taken at deepest part of pool.
b Composite sample of riffles and pools within the designated reach.
c Active bed of a riffle.
d Height of roughness feature above bed.

Davis Branch - Impaired Restoration Reach - TSS Profile 3/29/2007




Impaired Conditions Restoration Reach Longitudinal Profile - 07/17/2007
Elevation (feet)
470
469
468
467
466
465
464
463
462
Distance along stream (feet)
1390
1400
1410
1420
1430
1440
1450
1460
1470
1480
1490
1500
1510
1520
1530
1540
1550
1560
1570
1580
1590
1600
1610
1620
1630
1640
1650
1660
1670
1680
1690
1700
1710
Pool XS 14+76.53 - DLS
Riffle 16+50.79 DLS
LEGEND
CH Thalweg
BKF Bankfull Indicator
TSS = Total Station Survey 03/29/07
DLS = Differential Level Survey 07/17/07
T.O.R. = Top of Reach
B.O.R. = Bottom of Reach
XS = Surveyed Cross-Section with Profile Station
p = Pool
g = Glide
r = Riffle
u = Run

Impaired Restoration Reach LP Summary Rpt.txt
RIVERMORPH PROFILE SUMMARY

River Name: Davis Branch
Reach Name: Restoration Reach - Impaired
Profile Name: Davis Br Restoration Reach - Impaired
Survey Date: 07/17/2007

Survey Data

DIST	CH	WS	BKF	P1	P2	P3	P4
0	7.07						
8.5	7.27						
16	7.14						
19.5	6.95						
41	6.76						
43							
52	6.91						
76	6.74						
86.5	7.15		5.43				
87.5	7.2						
98	6.8		5.79				
123	7.32						
141	6.79						
166	8.07						
177	7.58						
179			6.67				
208	7.41						
240	7.53						
250	7.39		5.58				
269	7.66						
300	7.88						

Cross Section / Bank Profile Locations

Name	Type	Profile Station
Pool XS Station 0+86.5	Pool XS	86.5
Riffle XS Station 2+50	Riffle XS	250

Measurements from Graph

Bankfull Slope: 0.0132

Variable	Min	Avg	Max
S riffle	0.0208	0.04494	0.06289
S pool	0.0003	0.00098	0.00274
S run	0	0	0
S glide	0	0	0
P - P	35.25	39.99	43.71
Pool length	19.52	22.94	29.78
Riffle length	24.99	26.99	30.98
Dmax riffle	1.25	1.29	1.33
Dmax pool	1.84	2.06	2.28
Dmax run	0	0	0
Dmax glide	0	0	0
Low bank ht	1.72	1.78	1.83

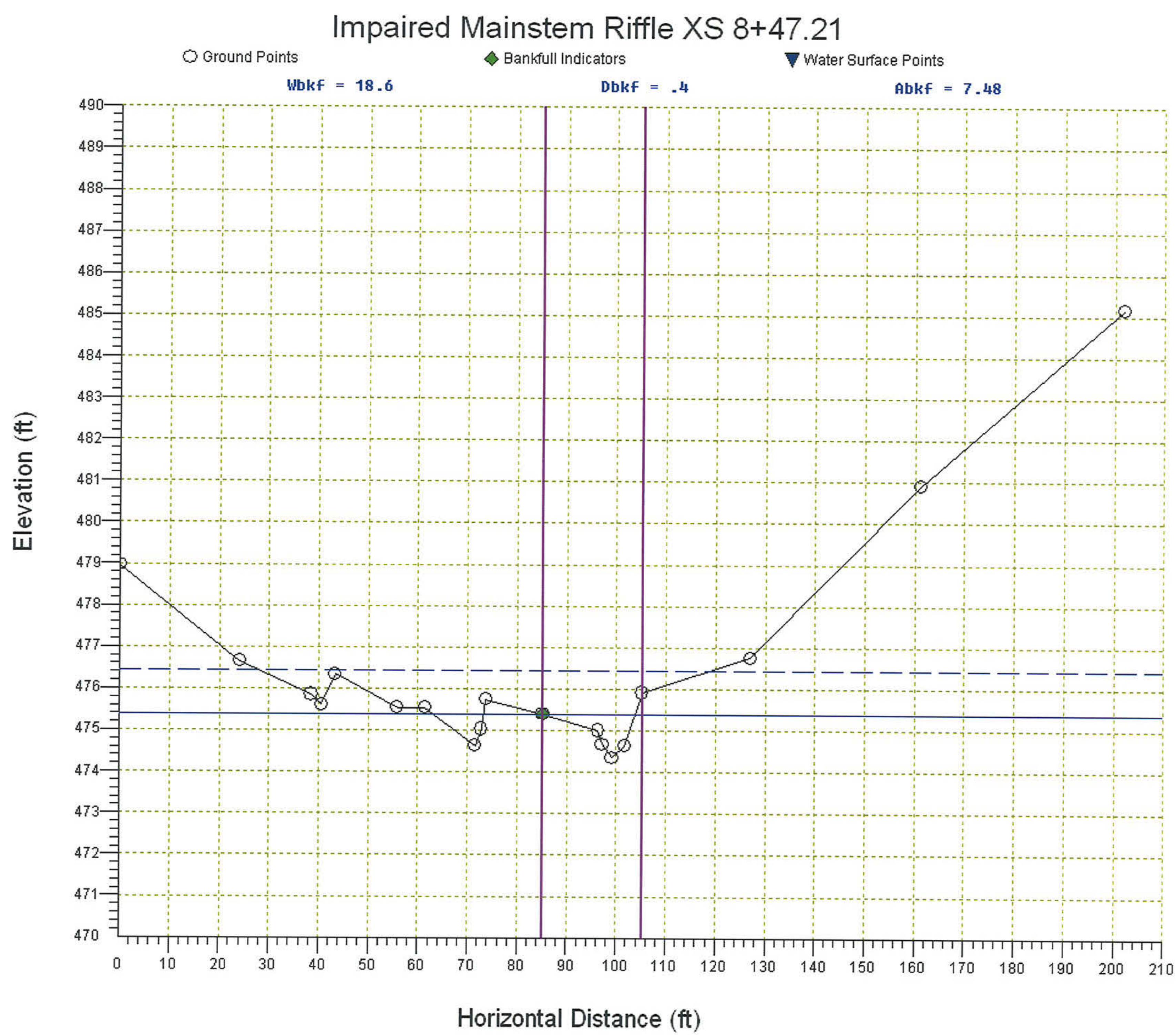
Length and depth measurements in feet, slopes in ft/ft.

RIVERMORPH PROFILE SUMMARY

Notes

River Name: Davis Branch
Reach Name: Restoration Reach - Impaired
Profile Name: Davis Br Restoration Reach - Impaired
Survey Date: 07/17/2007

DIST	Note
8.5	p
16	p
19.5	g
41	r
43	bkf
52	p
76	g
86.5	p xs
87.5	p
98	r
123	p
141	r
166	p
177	r
179	bkf
208	p
240	r
250	r xs
269	r
300	r


Impaired Mainstem Riffle XS 8+47.21
Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 18.6
Dbkf = .4
Abkf = 7.48
Elevation (ft)
490
489
488
487
486
485
484
483
482
481
480
479
478
477
476
475
474
473
472
471
470
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
Horizontal Distance (ft)

RIVERMORPH CROSS SECTION SUMMARY

River Name: Davis Branch
Reach Name: Restoration Reach - Impaired
Cross Section Name: Riffle XS 8+47.21
Survey Date: 04/28/2008

Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0	0	478.97	
24.15	0	476.65	
38.57	0	475.85	
40.59	0	475.61	
43.44	0	476.34	
55.93	0	475.54	
61.45	0	475.54	
71.63	0	474.63	
72.82	0	475.03	
73.76	0	475.74	
85.22	0	475.39	BKF
96.34	0	475	LB
97.22	0	474.67	
99.18	0	474.34	TW
101.71	0	474.63	
105.27	0	475.91	RB
127.04	0	476.75	
161.18	0	480.9	
202.01	0	485.17	

Cross Sectional Geometry

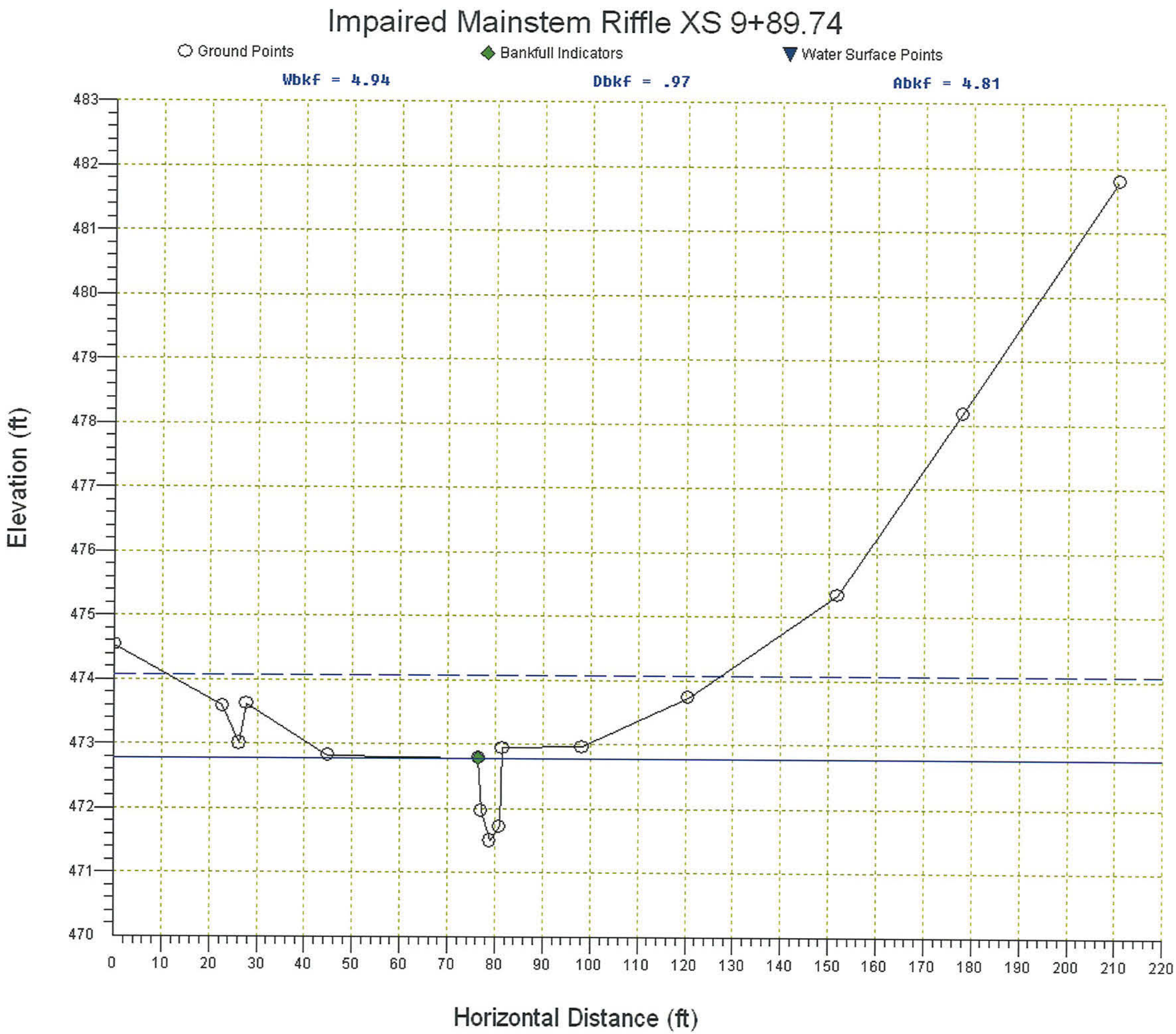
	Channel	Left	Right
Floodprone Elevation (ft)	476.44	476.44	476.44
Bankfull Elevation (ft)	475.39	475.39	475.39
Floodprone Width (ft)	91.07	-----	-----
Bankfull Width (ft)	18.6	9.3	9.3
Entrenchment Ratio	4.9	-----	-----
Mean Depth (ft)	0.4	0.16	0.64
Maximum Depth (ft)	1.05	0.33	1.05
Width/Depth Ratio	46.5	58.13	14.53
Bankfull Area (sq ft)	7.48	1.52	5.97
Wetted Perimeter (ft)	18.85	9.63	9.86
Hydraulic Radius (ft)	0.4	0.16	0.6
Begin BKF Station	85.22	85.22	94.52
End BKF Station	103.82	94.52	103.82

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.0139	0	0
Shear Stress (lb/sq ft)	0.35		

Movable Particle (mm) 69.8


Impaired Mainstem Riffle XS 9+89.74
Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 4.94
Dbkf = .97
Abkf = 4.81
Elevation (ft)
483
482
481
480
479
478
477
476
475
474
473
472
471
470
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
Horizontal Distance (ft)

RIVERMORPH CROSS SECTION SUMMARY

River Name: Davis Branch
Reach Name: Restoration Reach - Impaired
Cross Section Name: Riffle XS 9+89.74
Survey Date: 04/29/2008

Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0	0	474.53	
22.72	0	473.59	
26.25	0	473	
27.79	0	473.62	
44.86	0	472.82	
76.49	0	472.78	BKF
77.06	0	471.96	
78.86	0	471.5	TW
80.93	0	471.72	
81.51	0	472.94	RB
98.26	0	472.96	
120.54	0	473.73	
151.77	0	475.33	
177.85	0	478.17	
210.45	0	481.79	

Cross Sectional Geometry

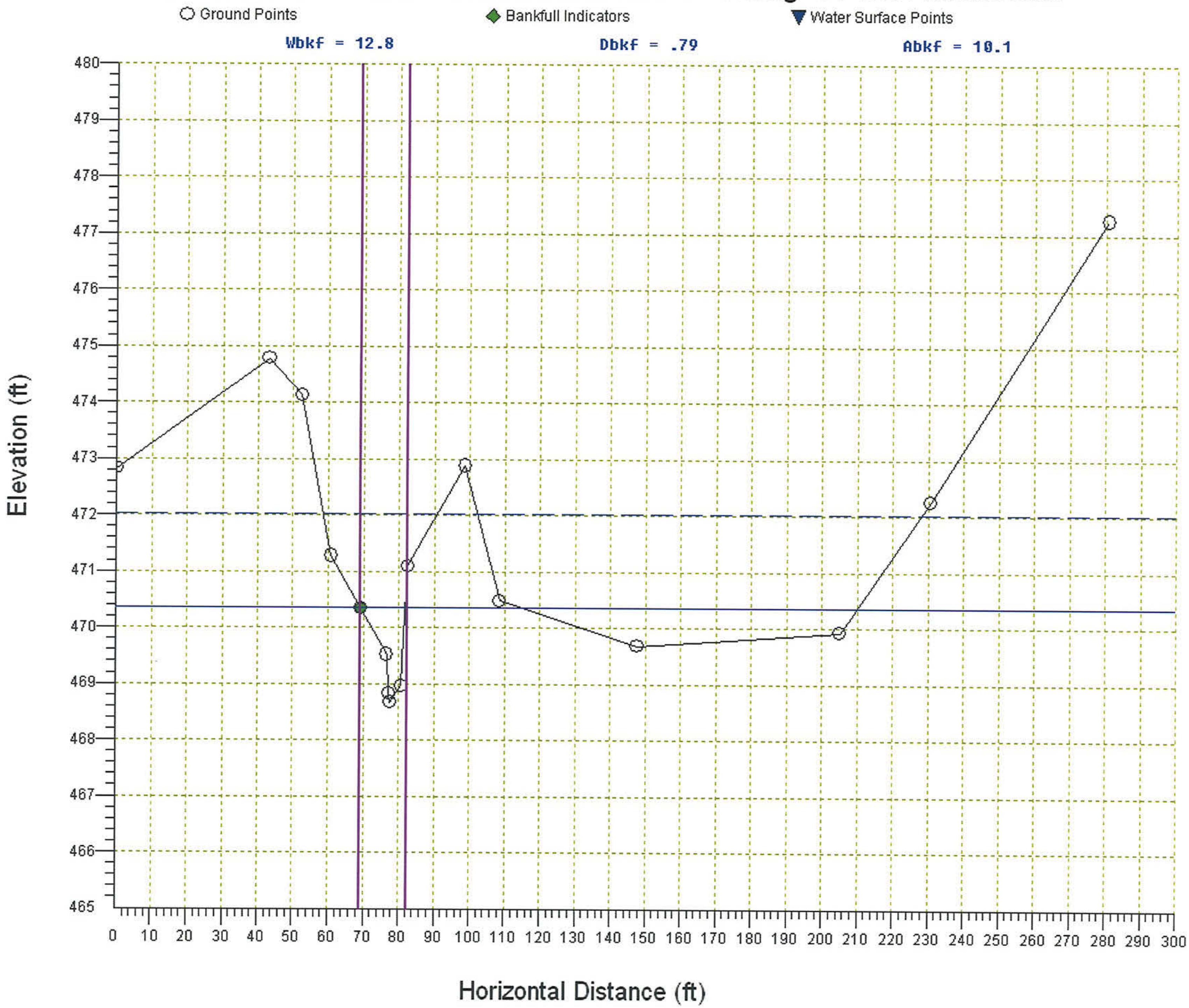
	Channel	Left	Right
Floodprone Elevation (ft)	474.06	474.06	474.06
Bankfull Elevation (ft)	472.78	472.78	472.78
Floodprone Width (ft)	115.62	-----	-----
Bankfull Width (ft)	4.94	2.47	2.47
Entrenchment Ratio	23.39	-----	-----
Mean Depth (ft)	0.97	0.91	1.04
Maximum Depth (ft)	1.28	1.28	1.27
Width/Depth Ratio	5.09	2.71	2.38
Bankfull Area (sq ft)	4.81	2.25	2.56
Wetted Perimeter (ft)	6.11	4.23	4.42
Hydraulic Radius (ft)	0.79	0.53	0.58
Begin BKF Station	76.49	76.49	78.96
End BKF Station	81.43	78.96	81.43

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.0139	0	0
Shear Stress (lb/sq ft)	0.69		
Movable Particle (mm)	115.1		

Pool XS 11+94.83 - Confluence NW Trending UT with Mainstem



Pool XS 11+94.06 - Impaired.txt
RIVERMORPH CROSS SECTION SUMMARY

River Name: Davis Branch
Reach Name: Restoration Reach - Impaired
Cross Section Name: Pool XS 11+94.06 Conf NW Trend UT
Survey Date: 04/28/2008

Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0	0	472.82	
43.17	0	474.78	
52.4	0	474.13	
60.75	0	471.28	
69.17	0	470.35	BKF
76.67	0	469.52	LB
77.27	0	468.82	
77.64	0	468.67	TW
80.82	0	468.96	
82.52	0	471.1	RB
98.7	0	472.88	
108.67	0	470.48	
147.66	0	469.68	
205.1	0	469.92	
230.61	0	472.26	
280.75	0	477.26	

Cross Sectional Geometry

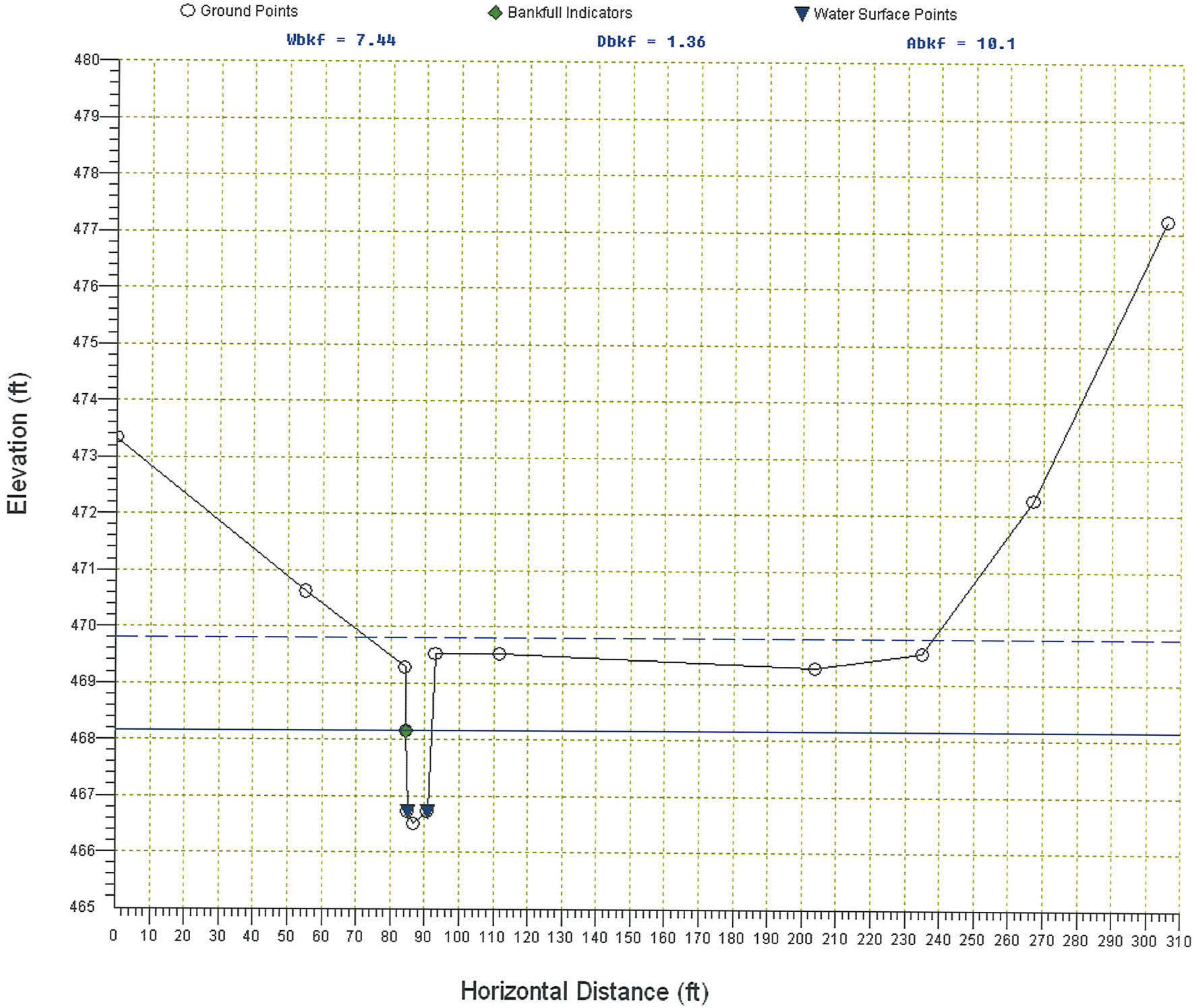
	Channel	Left	Right
Floodprone Elevation (ft)	472.03	472.03	472.03
Bankfull Elevation (ft)	470.35	470.35	470.35
Floodprone Width (ft)	158.29	-----	-----
Bankfull Width (ft)	12.75	9.83	2.92
Entrenchment Ratio	12.41	-----	-----
Mean Depth (ft)	0.79	0.67	1.18
Maximum Depth (ft)	1.68	1.68	1.56
Width/Depth Ratio	16.14	14.67	2.47
Bankfull Area (sq ft)	10.06	6.61	3.45
Wetted Perimeter (ft)	13.84	11.79	5.16
Hydraulic Radius (ft)	0.73	0.56	0.67
Begin BKF Station	69.17	69.17	79
End BKF Station	81.92	79	81.92

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.0139	0	0
Shear Stress (lb/sq ft)	0.63		
Movable Particle (mm)	108.6		

Pool XS 13+44.83 - Confluence N-S Trending UT & Mainstem



RIVERMORPH CROSS SECTION SUMMARY

River Name: Davis Branch
Reach Name: Restoration Reach - Impaired
Cross Section Name: Pool XS 13+44.83 Conf N-S Trend UT
Survey Date: 04/28/2008

Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0	0	473.33	
55.34	0	470.62	
84.3	0	469.27	LB
84.61	0	468.15	BKF
85.03	0	466.72	LEW
86.69	0	466.5	TW
90.83	0	466.72	REW
93.21	0	469.51	RB
111.72	0	469.51	
203.87	0	469.27	
235.05	0	469.54	FP
267.11	0	472.26	
305.74	0	477.21	

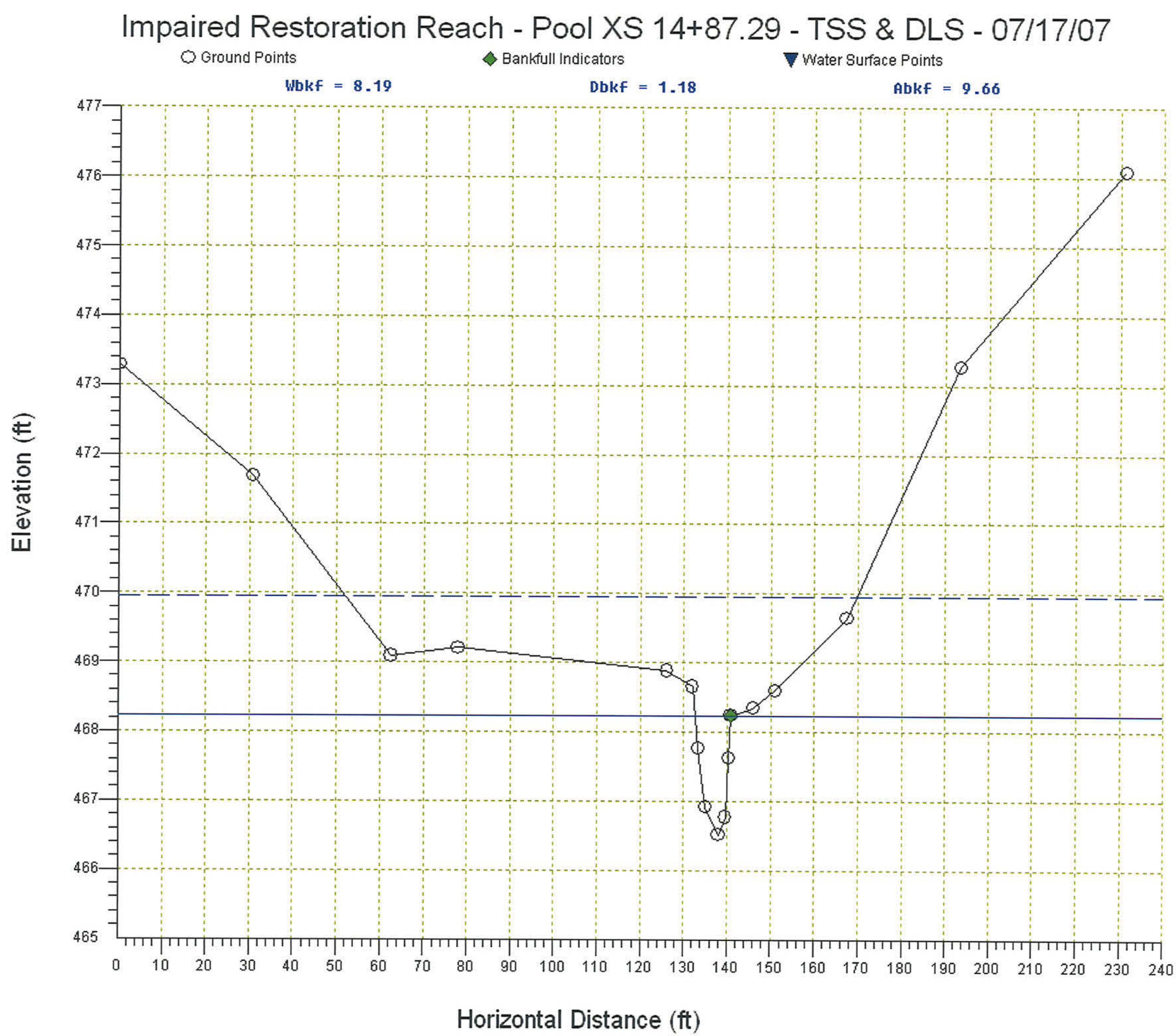
Cross Sectional Geometry

	Channel	Left	Right
Floodprone Elevation (ft)	469.8	469.8	-----
Bankfull Elevation (ft)	468.15	468.15	-----
Floodprone Width (ft)	165.18	-----	-----
Bankfull Width (ft)	7.44	10.08	-----
Entrenchment Ratio	22.2	-----	-----
Mean Depth (ft)	1.36	1.36	-----
Maximum Depth (ft)	1.65	1.65	-----
Width/Depth Ratio	5.47	7.41	-----
Bankfull Area (sq ft)	10.1	10.1	-----
Wetted Perimeter (ft)	9.19	9.19	-----
Hydraulic Radius (ft)	1.1	1.1	-----
Begin BKF Station	84.61	84.61	-----
End BKF Station	92.05	92.05	-----

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.0139	0	0
Shear Stress (lb/sq ft)	0.95		
Movable Particle (mm)	146.9		



Impaired Restoration Reach - Pool XS 14+87.29 - TSS & DLS - 07/17/07
Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 8.19
Dbkf = 1.18
Abkf = 9.66
Elevation (ft)
477
476
475
474
473
472
471
470
469
468
467
466
465
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
Horizontal Distance (ft)

Pool XS 14+87.29 DLS - Impaired.txt
RIVERMORPH CROSS SECTION SUMMARY

River Name: Davis Branch
Reach Name: Restoration Reach - Impaired
Cross Section Name: Pool XS 14+87.29 - DLS
Survey Date: 07/17/2007

Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0	0	473.29	
30.63	0	471.69	
62.53	0	469.09	
78	0	469.21	
126.07	0	468.88	FP
132.07	0	468.65	LB
133.37	0	467.76	
135.07	0	466.91	SB
138.07	0	466.51	TW
139.67	0	466.77	SB
140.37	0	467.62	
140.87	0	468.23	BKF
146.07	0	468.34	FP
151.07	0	468.59	FP
167.5	0	469.64	
193.36	0	473.27	
231.29	0	476.08	

Cross Sectional Geometry

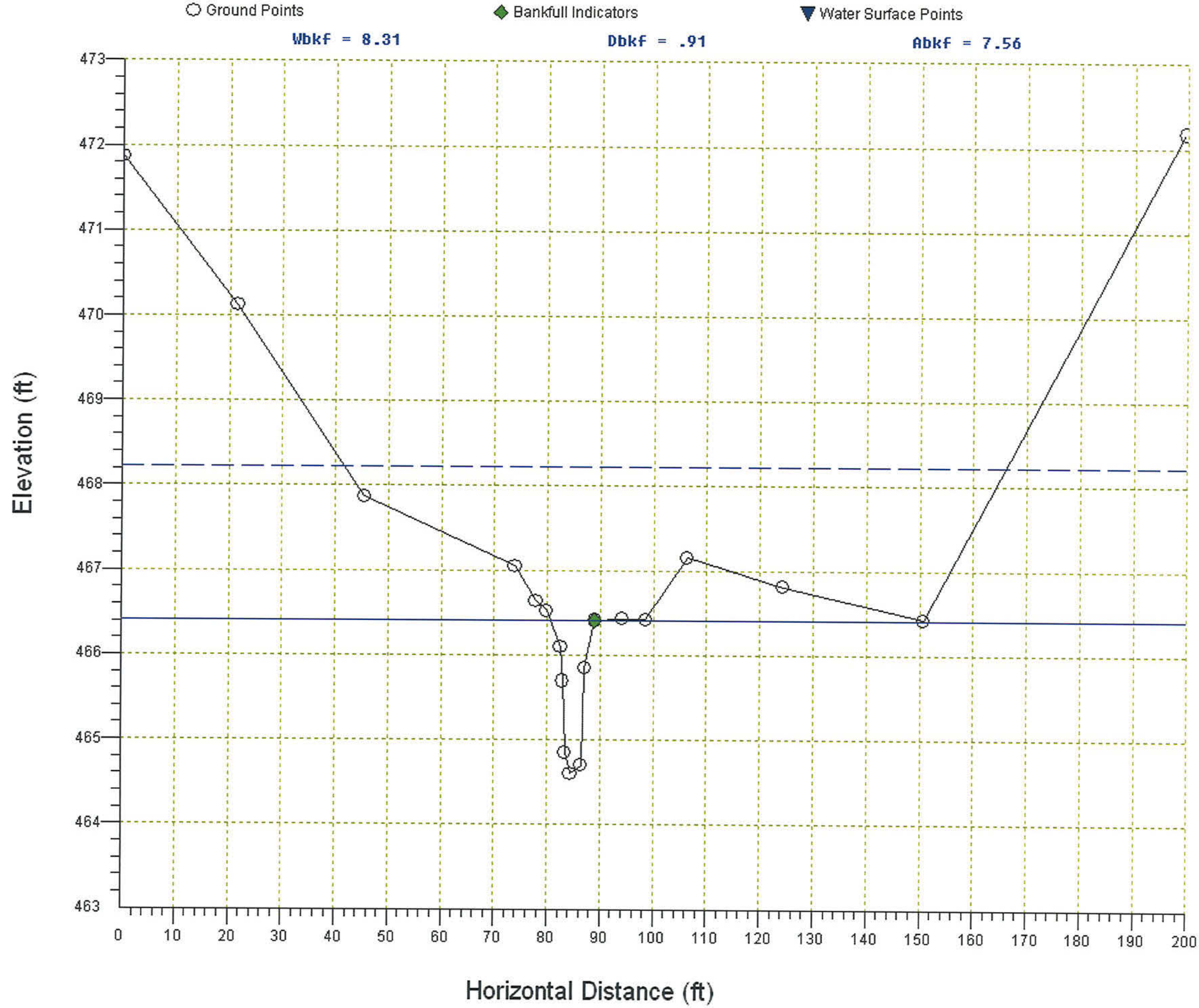
	Channel	Left	Right
Floodprone Elevation (ft)	469.95	469.95	469.95
Bankfull Elevation (ft)	468.23	468.23	468.23
Floodprone Width (ft)	117.73	-----	-----
Bankfull Width (ft)	8.19	7.32	0.87
Entrenchment Ratio	14.38	-----	-----
Mean Depth (ft)	1.18	1.26	0.53
Maximum Depth (ft)	1.72	1.72	1.06
Width/Depth Ratio	6.94	5.81	1.64
Bankfull Area (sq ft)	9.66	9.2	0.46
Wetted Perimeter (ft)	9.27	8.96	2.43
Hydraulic Radius (ft)	1.04	1.03	0.19
Begin BKF Station	132.68	132.68	140
End BKF Station	140.87	140	140.87

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.0139	0	0
Shear Stress (lb/sq ft)	0.90		
Movable Particle (mm)	140.9		

Impaired Restoration Reach - Riffle XS 16+50.79 - TSS & DLS - 07/17/07



RIVERMORPH CROSS SECTION SUMMARY

River Name: Davis Branch
Reach Name: Restoration Reach - Impaired
Cross Section Name: Riffle 16+50.79 DLS
Survey Date: 07/17/2007

Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0	0	471.87	
21.48	0	470.12	
45.41	0	467.87	FP
73.88	0	467.05	FP
77.88	0	466.64	FP
79.88	0	466.52	FP
82.58	0	466.09	LB
82.98	0	465.69	ON LB
83.38	0	464.85	SB
84.38	0	464.6	TW
86.48	0	464.7	SB
87.08	0	465.84	RB
88.88	0	466.41	BKF
94.08	0	466.43	FP
98.48	0	466.42	FP
106.34	0	467.15	
124.32	0	466.81	
150.79	0	466.42	FP
199.57	0	472.17	

Cross Sectional Geometry

	Channel	Left	Right
Floodprone Elevation (ft)	468.22	468.22	468.22
Bankfull Elevation (ft)	466.41	466.41	466.41
Floodprone Width (ft)	124.37	-----	-----
Bankfull Width (ft)	8.31	4.65	3.66
Entrenchment Ratio	14.97	-----	-----
Mean Depth (ft)	0.91	0.9	0.93
Maximum Depth (ft)	1.81	1.81	1.77
Width/Depth Ratio	9.13	5.17	3.94
Bankfull Area (sq ft)	7.56	4.17	3.39
Wetted Perimeter (ft)	9.84	7.17	6.21
Hydraulic Radius (ft)	0.77	0.58	0.55
Begin BKF Station	80.57	80.57	85.22
End BKF Station	88.88	85.22	88.88

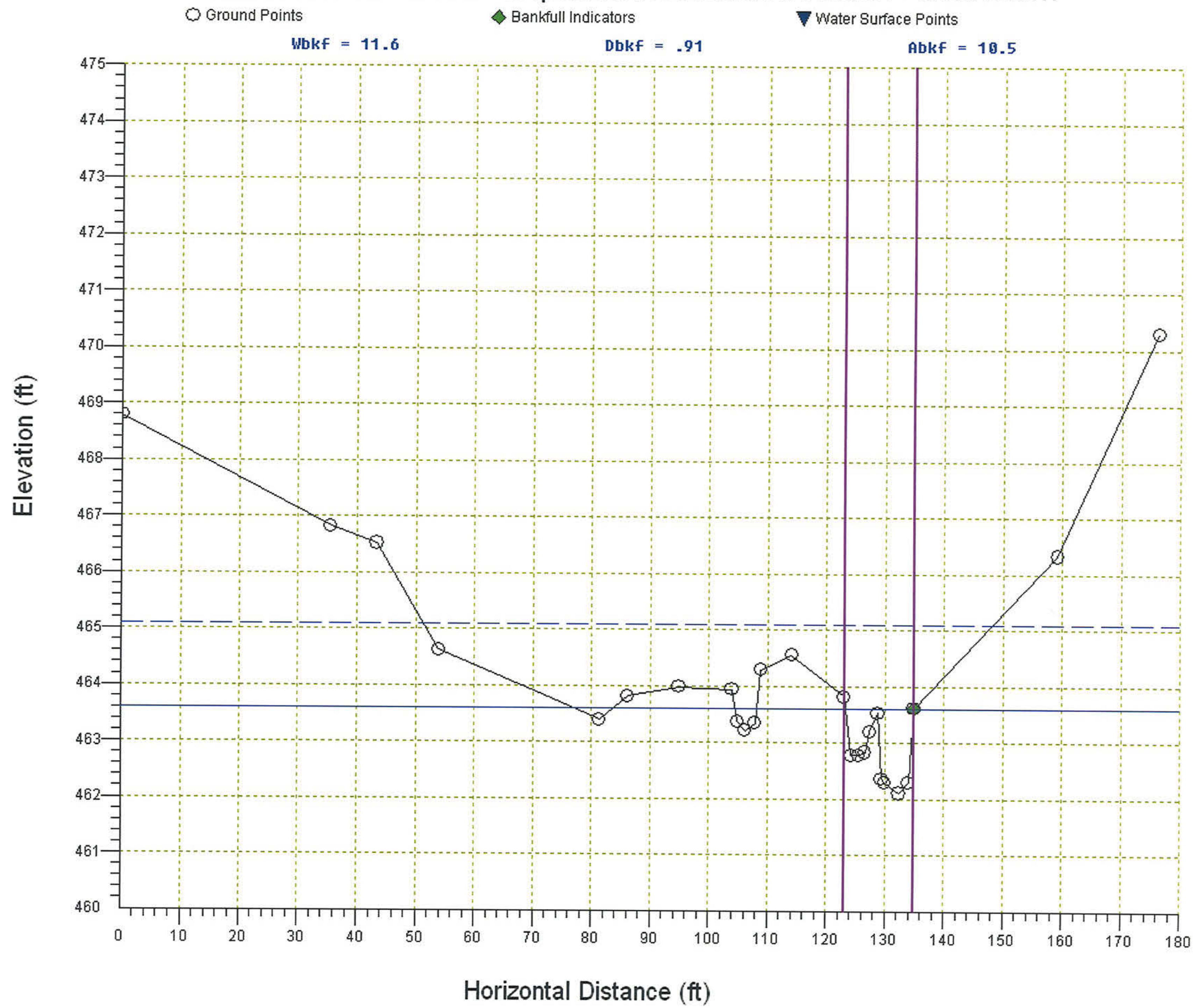
Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.0139	0	0
Shear Stress (lb/sq ft)	0.67		

Movable Particle (mm) 113.0

Braided XS 18+42.50 - Impaired Restoration Reach - Mainstem



RIVERMORPH CROSS SECTION SUMMARY

River Name:	Davis Branch
Reach Name:	Restoration Reach - Impaired
Cross Section Name:	Braided XS 18+42.50
Survey Date:	04/25/2008

Cross Section Data Entry

BM Elevation:	0 ft
Backsight Rod Reading:	0 ft

TAPE	FS	ELEV	NOTE
0	0	468.79	
35.53	0	466.82	
43.36	0	466.52	
53.99	0	464.62	
81.35	0	463.39	
86.24	0	463.81	
94.92	0	463.98	
104	0	463.93	
104.83	0	463.37	
106.19	0	463.21	
107.91	0	463.34	
108.89	0	464.28	
114.13	0	464.55	
123.03	0	463.81	LB
124.26	0	462.77	
125.54	0	462.77	
126.63	0	462.83	
127.4	0	463.19	
128.77	0	463.52	
129.43	0	462.36	
129.99	0	462.28	
132.36	0	462.1	TW
134.01	0	462.29	
134.88	0	463.6	BKF
159.12	0	466.32	
176.26	0	470.29	

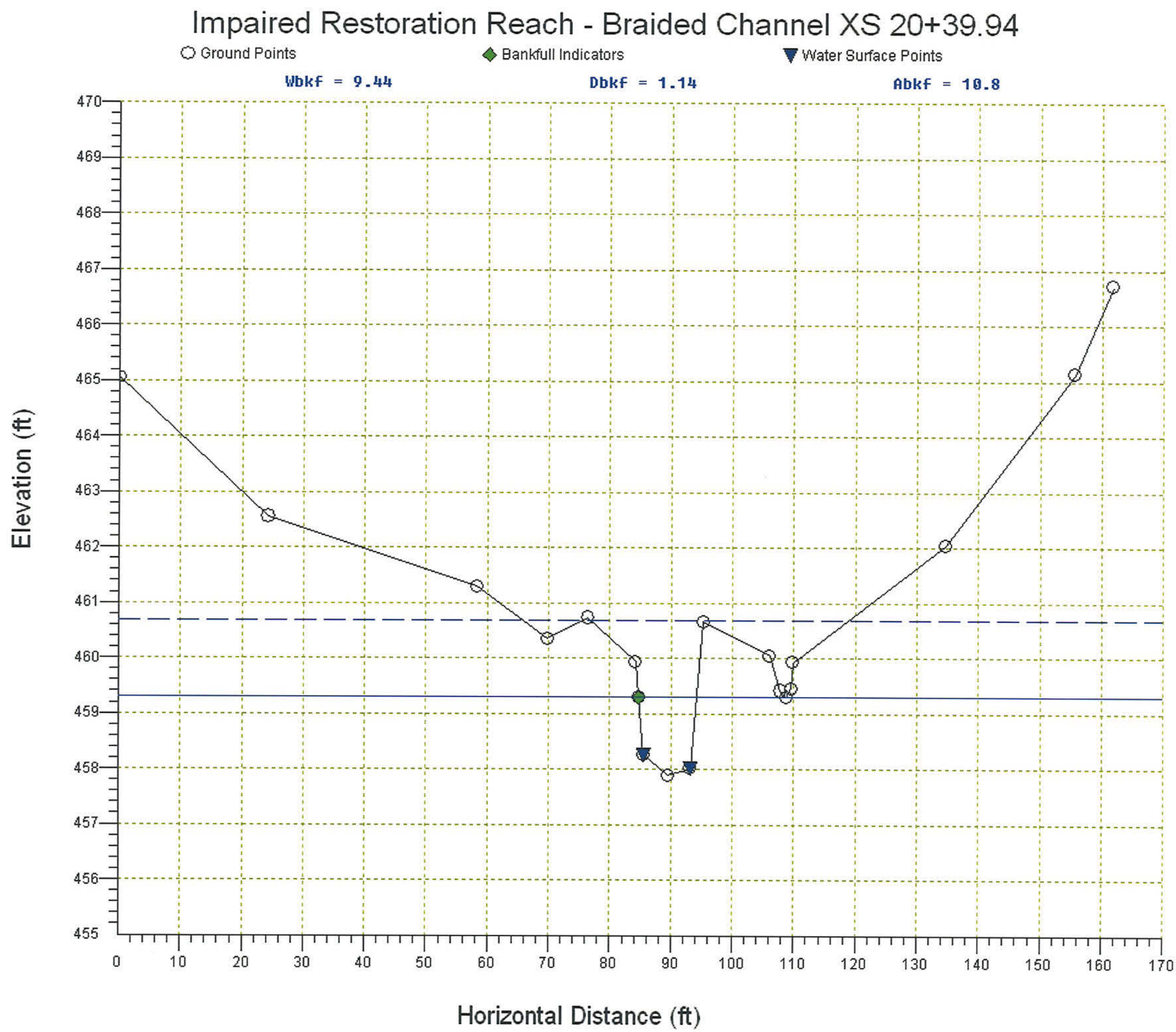
Cross Sectional Geometry

	Channel	Left	Right
Floodprone Elevation (ft)	465.1	465.1	465.1
Bankfull Elevation (ft)	463.6	463.6	463.6
Floodprone Width (ft)	96.94	-----	-----
Bankfull Width (ft)	11.6	8.54	3.06
Entrenchment Ratio	8.36	-----	-----
Mean Depth (ft)	0.91	0.8	1.2
Maximum Depth (ft)	1.5	1.46	1.5
Width/Depth Ratio	12.75	10.68	2.55
Bankfull Area (sq ft)	10.51	6.83	3.69
Wetted Perimeter (ft)	13.43	11.11	5.23
Hydraulic Radius (ft)	0.78	0.61	0.7
Begin BKF Station	123.28	123.28	131.82
End BKF Station	134.88	131.82	134.88

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.0139	0	0
Shear Stress (lb/sq ft)	0.68		
Movable Particle (mm)	114.0		


Impaired Restoration Reach - Braided Channel XS 20+39.94
Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 9.44
Dbkf = 1.14
Abkf = 10.8
Elevation (ft)
470
469
468
467
466
465
464
463
462
461
460
459
458
457
456
455
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
Horizontal Distance (ft)

RIVERMORPH CROSS SECTION SUMMARY

River Name: Davis Branch
Reach Name: Restoration Reach - Impaired
Cross Section Name: Braided XS 20+39.94
Survey Date: 04/29/2008

Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0	0	465.05	
24.25	0	462.55	
58.31	0	461.29	
69.84	0	460.35	
76.41	0	460.73	
84.23	0	459.93	LB
84.72	0	459.29	BKF
85.51	0	458.26	LEW
89.47	0	457.89	TW
93.13	0	458.01	REW
95.26	0	460.65	RB
106.11	0	460.04	
107.77	0	459.41	
108.83	0	459.29	
109.54	0	459.45	
109.85	0	459.92	
134.7	0	462.04	
155.6	0	465.13	
161.75	0	466.71	

Cross Sectional Geometry

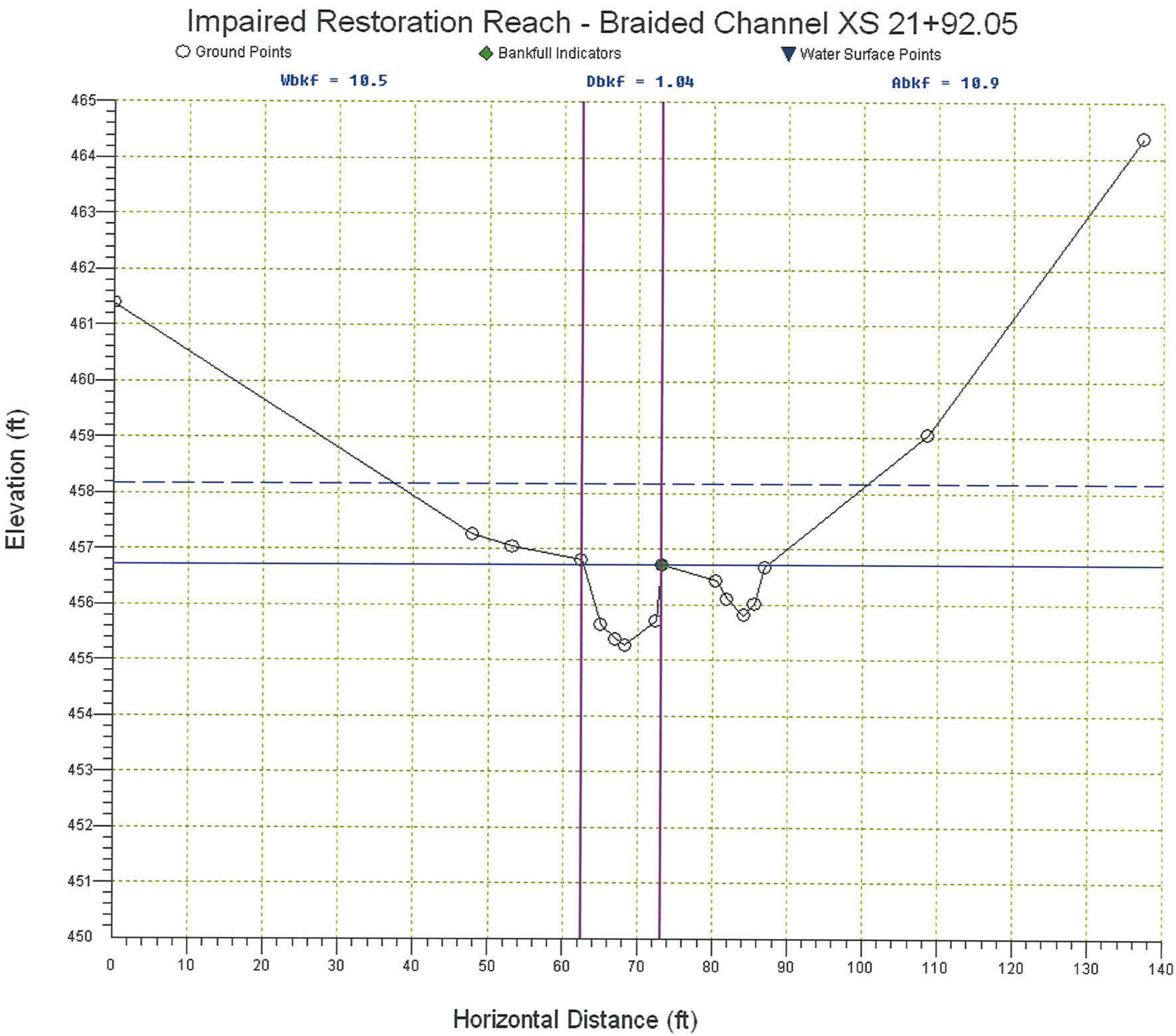
	Channel	Left	Right
Floodprone Elevation (ft)	460.69	460.69	460.69
Bankfull Elevation (ft)	459.29	459.29	459.29
Floodprone Width (ft)	52.12	-----	-----
Bankfull Width (ft)	9.44	4.72	4.72
Entrenchment Ratio	5.52	-----	-----
Mean Depth (ft)	1.14	1.1	1.19
Maximum Depth (ft)	1.4	1.4	1.4
Width/Depth Ratio	8.28	4.29	3.97
Bankfull Area (sq ft)	10.78	5.18	5.61
Wetted Perimeter (ft)	10.58	6.64	6.73
Hydraulic Radius (ft)	1.02	0.78	0.83
Begin BKF Station	84.72	84.72	89.44
End BKF Station	94.16	89.44	94.16

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.0139	0	0
Shear Stress (lb/sq ft)	0.88		

Movable Particle (mm) 138.9


Impaired Restoration Reach - Braided Channel XS 21+92.05
Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 10.5
Dbkf = 1.04
Abkf = 10.9
Elevation (ft)
Horizontal Distance (ft)
465
464
463
462
461
460
459
458
457
456
455
454
453
452
451
450
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140

RIVERMORPH CROSS SECTION SUMMARY

River Name: Davis Branch
Reach Name: Restoration Reach - Impaired
Cross Section Name: Braided XS 21+92.05
Survey Date: 04/29/2007

Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0	0	461.38	
47.86	0	457.26	
53.21	0	457.04	
62.51	0	456.8	LB
65.11	0	455.63	
67.03	0	455.37	
68.31	0	455.26	TW
72.47	0	455.7	
73.21	0	456.71	BKF
80.5	0	456.42	
81.97	0	456.1	
84.18	0	455.8	
85.6	0	456.01	
86.96	0	456.67	
108.65	0	459.04	
137.28	0	464.36	

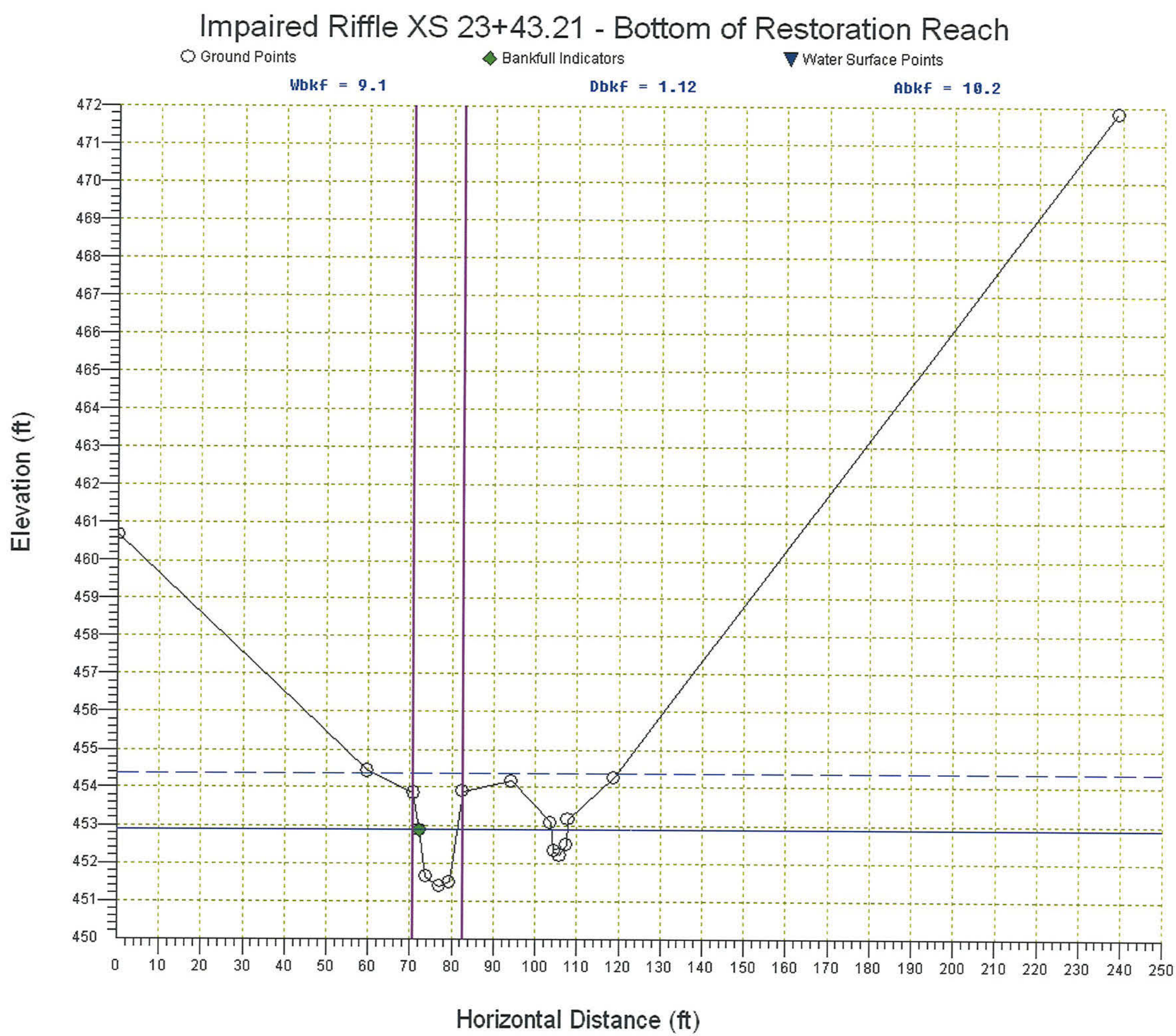
Cross Sectional Geometry

	Channel	Left	Right
Floodprone Elevation (ft)	458.16	458.16	458.16
Bankfull Elevation (ft)	456.71	456.71	456.71
Floodprone Width (ft)	63.19	-----	-----
Bankfull Width (ft)	10.5	5.75	4.75
Entrenchment Ratio	6.02	-----	-----
Mean Depth (ft)	1.04	0.98	1.11
Maximum Depth (ft)	1.45	1.45	1.43
Width/Depth Ratio	10.1	5.87	4.28
Bankfull Area (sq ft)	10.9	5.62	5.27
Wetted Perimeter (ft)	11.29	7.44	6.72
Hydraulic Radius (ft)	0.97	0.76	0.79
Begin BKF Station	62.71	62.71	68.46
End BKF Station	73.21	68.46	73.21

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.0139	0	0
Shear Stress (lb/sq ft)	0.84		
Movable Particle (mm)	133.9		



Impaired Riffle XS 23+43.21 - Bottom of Restoration Reach
Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 9.1
Dbkf = 1.12
Abkf = 10.2
Elevation (ft)
472
471
470
469
468
467
466
465
464
463
462
461
460
459
458
457
456
455
454
453
452
451
450
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250
Horizontal Distance (ft)

Riffle XS 23+43.21 - BOR - Impaired.txt
RIVERMORPH CROSS SECTION SUMMARY

River Name: Davis Branch
Reach Name: Restoration Reach - Impaired
Cross Section Name: Riffle XS 23+43.21 - Restoration - B.O.R.
Survey Date: 04/29/2008

Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0	0	460.68	LT
59.84	0	454.44	FP
70.85	0	453.86	LB
72.16	0	452.88	BKF
73.78	0	451.64	
76.99	0	451.38	TW
79.43	0	451.5	
82.62	0	453.9	RB
94.3	0	454.16	FP
103.63	0	453.07	TRIB LB
104.49	0	452.32	
105.78	0	452.21	CL
107.48	0	452.48	
107.88	0	453.16	TRIB RB
118.89	0	454.26	FP
238.89	0	471.84	BM 3357

Cross Sectional Geometry

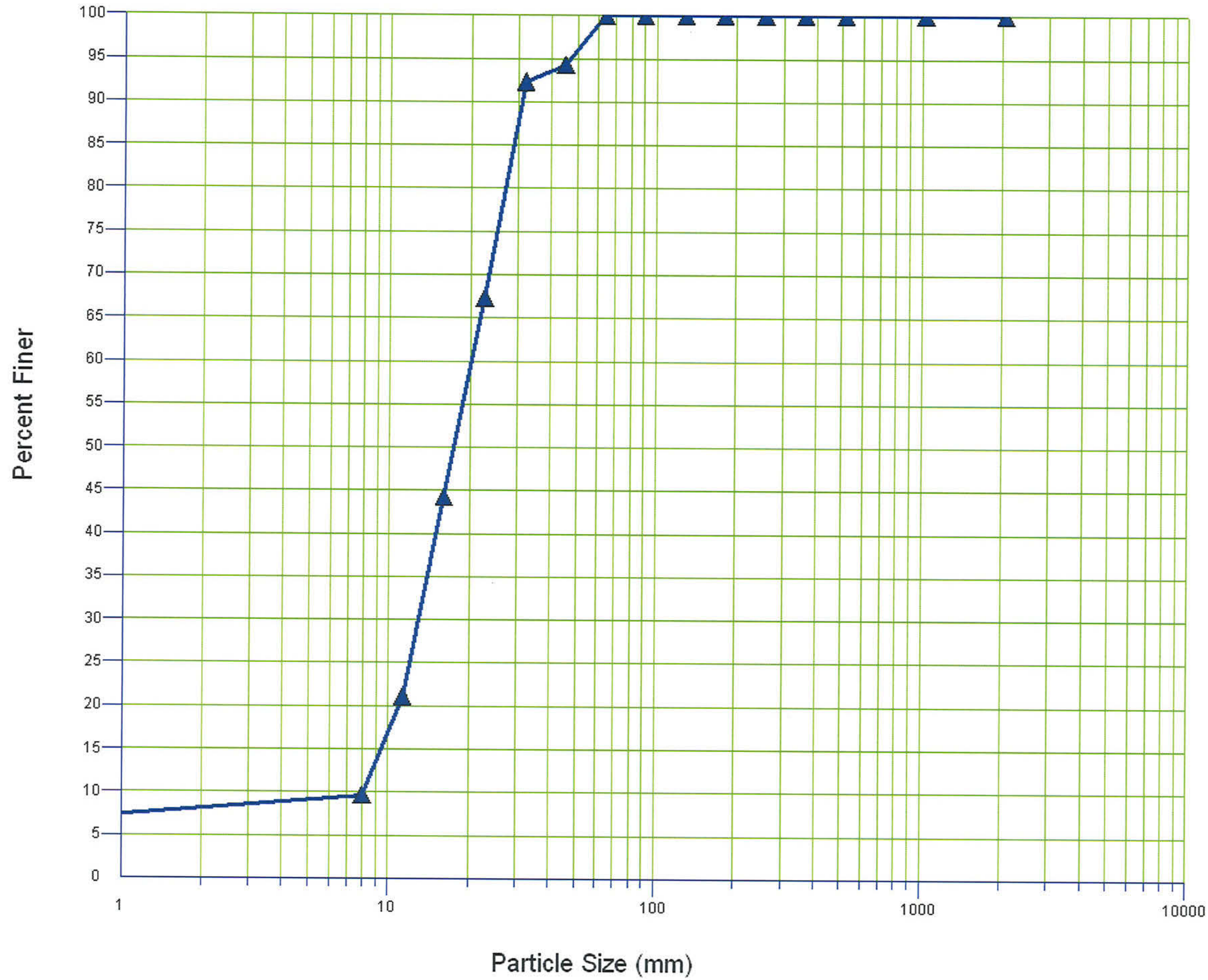
	Channel	Left	Right
Floodprone Elevation (ft)	454.38	454.38	454.38
Bankfull Elevation (ft)	452.88	452.88	452.88
Floodprone Width (ft)	58.73	-----	-----
Bankfull Width (ft)	9.1	4.55	4.55
Entrenchment Ratio	6.45	-----	-----
Mean Depth (ft)	1.12	1.1	1.14
Maximum Depth (ft)	1.5	1.48	1.5
Width/Depth Ratio	8.12	4.14	3.99
Bankfull Area (sq ft)	10.18	4.99	5.2
Wetted Perimeter (ft)	10	6.46	6.49
Hydraulic Radius (ft)	1.02	0.77	0.8
Begin BKF Station	72.16	72.16	76.71
End BKF Station	81.26	76.71	81.26

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.0139	0	0
Shear Stress (lb/sq ft)	0.88		
Movable Particle (mm)	138.9		

Upper Davis Branch - Impaired Riffle XS - Station 16+50.79



RIVERMORPH PARTICLE SUMMARY

River Name: Davis Branch
Reach Name: Davis Branch Restoration Reach - Impaired Conditions
Sample Name: Riffle XS 16+50.79
Survey Date: 07/17/2007

Size (mm)	TOT #	ITEM %	CUM %
0 - 0.062	0	0.00	0.00
0.062 - 0.125	0	0.00	0.00
0.125 - 0.25	0	0.00	0.00
0.25 - 0.50	0	0.00	0.00
0.50 - 1.0	0	0.00	0.00
1.0 - 2.0	0	0.00	0.00
2.0 - 4.0	0	0.00	0.00
4.0 - 5.7	0	0.00	0.00
5.7 - 8.0	5	9.62	9.62
8.0 - 11.3	6	11.54	21.15
11.3 - 16.0	12	23.08	44.23
16.0 - 22.6	12	23.08	67.31
22.6 - 32.0	13	25.00	92.31
32 - 45	1	1.92	94.23
45 - 64	3	5.77	100.00
64 - 90	0	0.00	100.00
90 - 128	0	0.00	100.00
128 - 180	0	0.00	100.00
180 - 256	0	0.00	100.00
256 - 362	0	0.00	100.00
362 - 512	0	0.00	100.00
512 - 1024	0	0.00	100.00
1024 - 2048	0	0.00	100.00
Bedrock	0	0.00	100.00

D16 (mm)	9.83
D35 (mm)	14.12
D50 (mm)	17.65
D84 (mm)	28.88
D95 (mm)	47.54
D100 (mm)	64
Silt/Clay (%)	0
Sand (%)	0
Gravel (%)	100
Cobble (%)	0
Boulder (%)	0
Bedrock (%)	0

Total Particles = 52 (need at least 60).

RIVERMorph 4.1.1 Professional - Davis Branch Stream Restoration - Iter 2_4.1

File Tools Help

- Davis Branch
  - Davis Branch Reference Reach
  - Restoration Reach - Impaired
    - Survey Data
    - Cross Sections
    - Banks
    - Profiles
    - Particles
    - Classification
    - Ratios
    - Pfankuch
    - BEHI
      - 14+87.29
    - SVAP
    - RBP
    - Designs
    - Notes
  - Enhancement 1 Reach
  - Davis Branch - UT1

Report | Rosgen WARSSS Worksheets: 5-8 5-9 5-10

Input Data

06/03/2008

Bankfull Height (ft)	1.72
Bank Height (ft)	2.14
Root Depth (ft)	0.5
Root Density (%)	5
Bank Angle (degrees)	90
Surface Protection (%)	5
Total Bank Length (ft)	1562
Total Reach Ln (ft) *	1562
Bank Material Adjustment	Silt/Clay (0)
Bank Stratification Adjustment	Yes (3)

- Use Colorado Erosion Data (1989)
- Use Yellowstone Erosion Data (1989)
- (selected) User Specified Bank Erosion Rates
  Erosion Rate: 0.25 (ft/yr)

* Note: This includes the entire length of the reach and not just the individual BEHI length. Length must be the same for all BEHIs.

Select a Near Bank Stress Method

NBS Method #6: Near-Bank Shear Stress

Mean Depth (ft)	0.91
Average Slope (ft/ft)	0.0158
NB Max. Depth (ft)	1.5
NB Slope (ft/ft)	0.0158
Shear Stress (lb/sq ft)	0.90
NB Shear Stress (lb/sq ft)	1.48
Stress Ratio	1.65

Links: #1 #2 #3 #4 #5 #6 #7

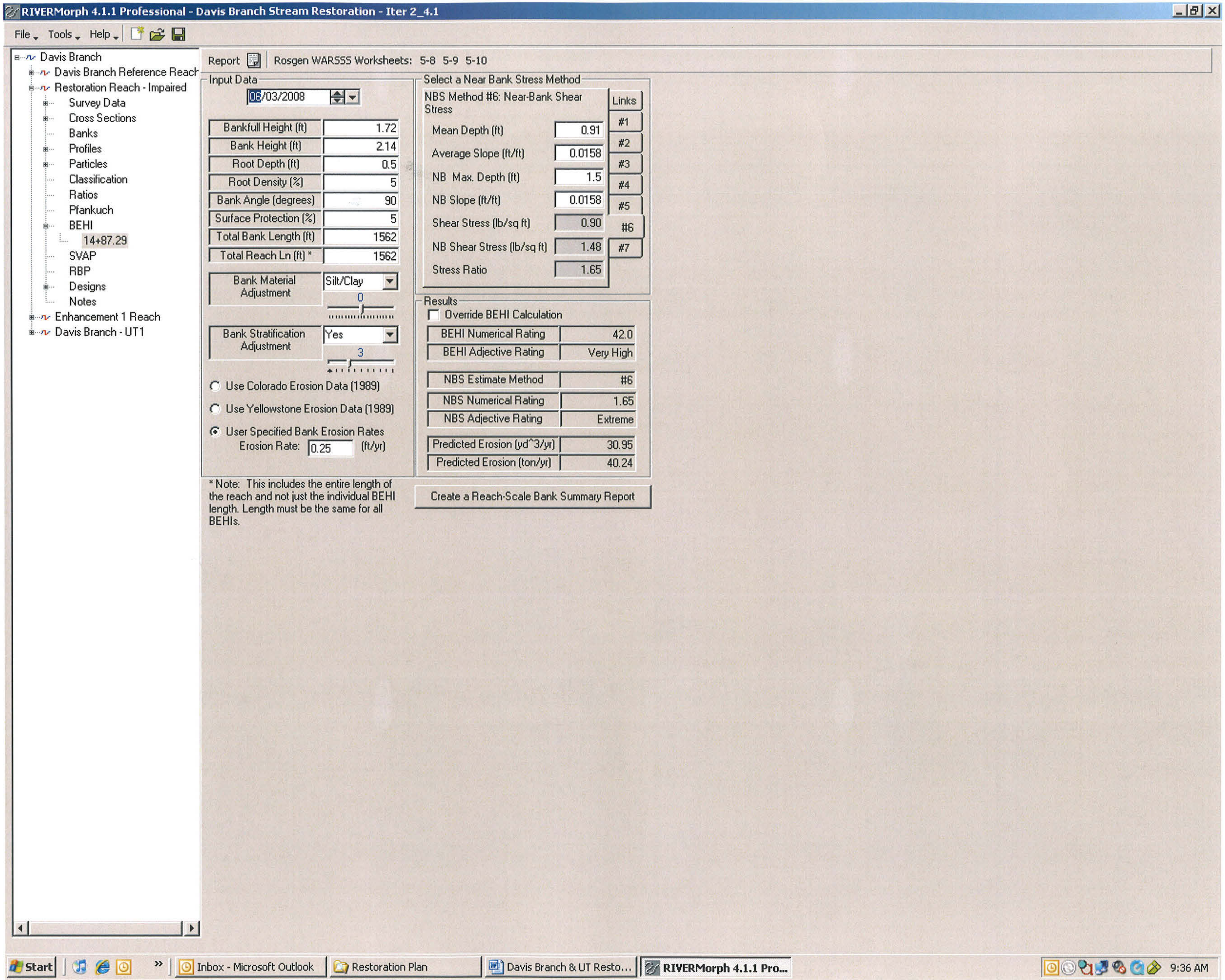
Results

Override BEHI Calculation

BEHI Numerical Rating	42.0
BEHI Adjective Rating	Very High
NBS Estimate Method	#6
NBS Numerical Rating	1.65
NBS Adjective Rating	Extreme
Predicted Erosion (yd^3/yr)	30.95
Predicted Erosion (ton/yr)	40.24

Create a Reach-Scale Bank Summary Report

Start | Inbox - Microsoft Outlook | Restoration Plan | Davis Branch & UT Resto... | RIVERMorph 4.1.1 Pro... | 9:36 AM


RIVERMorph 4.1.1 Professional - Davis Branch Stream Restoration - Iter 2_4.1
File Tools Help
Davis Branch
Davis Branch Reference Reach
Restoration Reach - Impaired
Survey Data
Cross Sections
Banks
Profiles
Particles
Classification
Ratios
Pfankuch
BEHI
14+87.29
SVAP
RBP
Designs
Notes
Enhancement 1 Reach
Davis Branch - UT1
Report
Rosgen WARSSS Worksheets: 5-8 5-9 5-10
Input Data
06/03/2008
Bankfull Height (ft) 1.72
Bank Height (ft) 2.14
Root Depth (ft) 0.5
Root Density (%) 5
Bank Angle (degrees) 90
Surface Protection (%) 5
Total Bank Length (ft) 1562
Total Reach Ln (ft) * 1562
Bank Material Adjustment Silt/Clay
0
Bank Stratification Adjustment Yes
3
Use Colorado Erosion Data (1989)
Use Yellowstone Erosion Data (1989)
User Specified Bank Erosion Rates
Erosion Rate: 0.25 (ft/yr)
* Note: This includes the entire length of the reach and not just the individual BEHI length. Length must be the same for all BEHIs.
Select a Near Bank Stress Method
NBS Method #6: Near-Bank Shear Stress
Links
#1
#2
#3
#4
#5
#6
#7
Mean Depth (ft) 0.91
Average Slope (ft/ft) 0.0158
NB Max. Depth (ft) 1.5
NB Slope (ft/ft) 0.0158
Shear Stress (lb/sq ft) 0.90
NB Shear Stress (lb/sq ft) 1.48
Stress Ratio 1.65
Results
Override BEHI Calculation
BEHI Numerical Rating 42.0
BEHI Adjective Rating Very High
NBS Estimate Method #6
NBS Numerical Rating 1.65
NBS Adjective Rating Extreme
Predicted Erosion (yd^3/yr) 30.95
Predicted Erosion (ton/yr) 40.24
Create a Reach-Scale Bank Summary Report
Start
Inbox - Microsoft Outlook
Restoration Plan
Davis Branch & UT Resto...
RIVERMorph 4.1.1 Pro...
9:36 AM

RIVERMORPH BEHI SUMMARY REPORT

River Name: Davis Branch
Reach Name: Restoration Reach - Impaired

Table 1. Bank Identification Summary

Bank	Name
1	14+87.29

Table 2. Predicted Annual Bank Erosion Rates

Bank	BEHI Numeric Rating	BEHI Adjective Rating	NBS Adjective Rating	Length ft	Loss cu yds/yr	Loss tons/yr
1	42	Very High	Extreme	1562	30.95	40.24
Totals				1562	30.95	40.24

Total Reach Ln: 1562   Total Loss (tons/yr) per ft of Reach: 0.0258

RIVERMORPH BANK EROSION HARZARD INDEX (BEHI)

River Name: Davis Branch
Reach Name: Restoration Reach - Impaired
BEHI Name: 14+87.29
Survey Date: 06/03/2008

Bankfull Height: 1.72 ft
Bank Height: 2.14 ft
Root Depth: 0.5 ft
Root Density: 5 %
Bank Angle: 90 Degrees
Surface Protection: 5 %

Bank Material Adjustment: Silt/Clay 0

Bank Stratification Adjustment: Yes 3

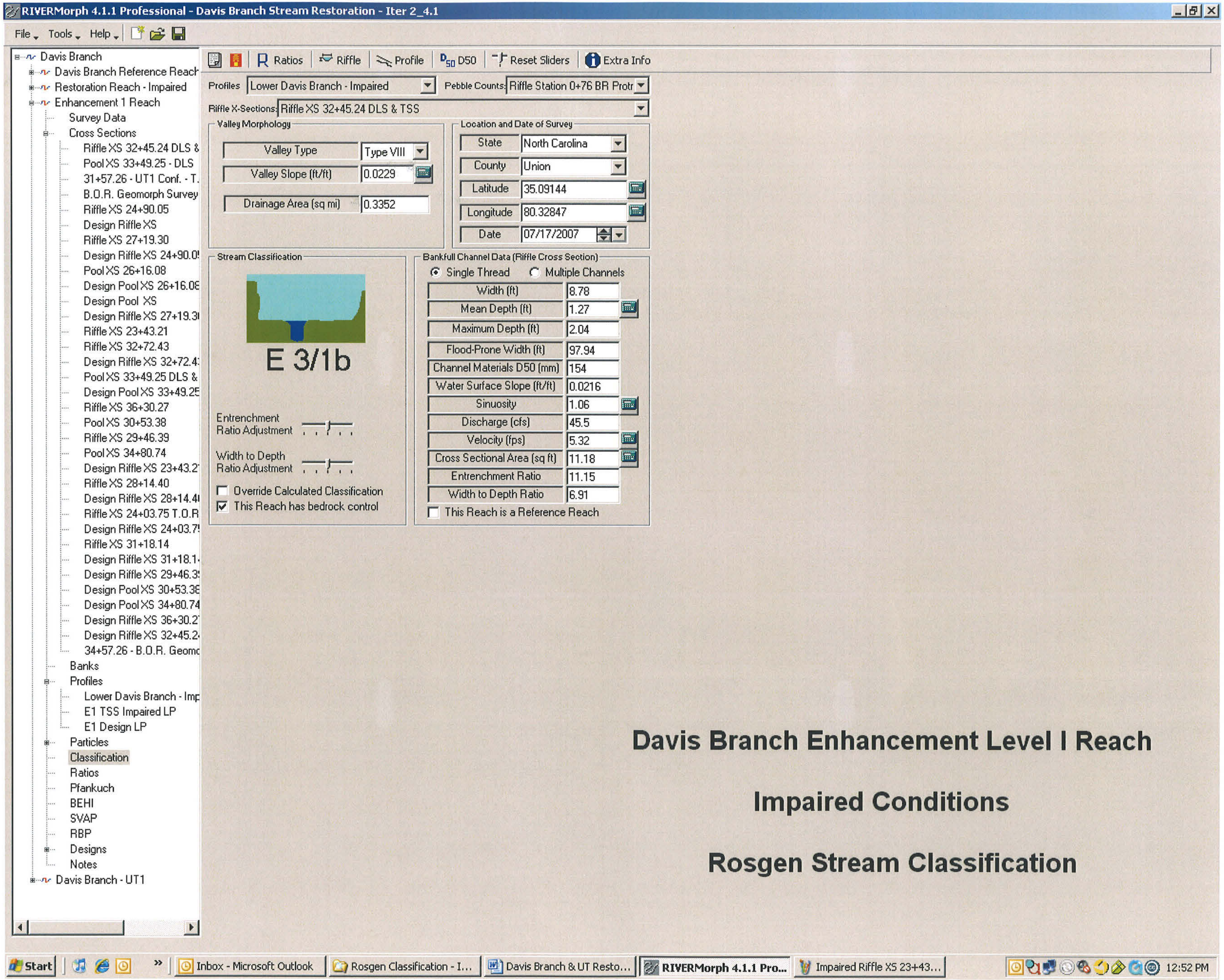
Erosion Loss Curve: Yellowstone

NBS Method #6: Near-Bank Shear Stress

Mean Depth: 0.91 ft
NB Max Depth: 1.5 ft
Shear Stress: 0.90 lb/sq/ft
Stress Ratio: 1.65

Average Slope: 0.0158 ft/ft
NB Slope: 0.0158 ft/ft
NB Shear Stress: 1.48 lb/sq/ft

BEHI Numerical Rating: 42.0
BEHI Adjective Rating: Very High
NBS Numerical Rating: 1.65
NBS Adjective Rating: Extreme
Total Bank Length: 1562 ft
Estimated Sediment Loss: 30.95 Cu Yds per Year
Estimated Sediment Loss: 40.24 Tons per Year



Davis Branch Enhancement Level I Reach

Impaired Conditions

Rosgen Stream Classification

Worksheet 5-3. Field form for Level II stream classification (Rosgen, 1996; Rosgen and Silvey, 2005).

Stream:	**Davis Branch - Impaired Enhancement Level 1 Reach**
Basin:	**Yadkin - Pee Dee** Drainage Area: **214.50** acres **0.3352** mi^2
Location:	**Staton Property, North of Marshville, NC**
Twp.&Rge: **;**	Sec.&Qtr.: **;**
Cross-Section Monuments (Lat./Long.): **35.09144 Lat / 80.32847 Long**	Date: **07/17/07**
Observers: **Hebert, Knotts, Hines, Peffer**	Valley Type: VIII

Bankfull WIDTH (W_{bkf}) WIDTH of the stream channel at bankfull stage elevation, in a riffle section.	**8.78**	ft
Bankfull DEPTH (d_{bkf}) Mean DEPTH of the stream channel cross-section, at bankfull stage elevation, in a riffle section ($d_{bkf} = A / W_{bkf}$).	**1.27**	ft
Bankfull X-Section AREA (A_{bkf}) AREA of the stream channel cross-section, at bankfull stage elevation, in a riffle section.	**11.18**	ft^2
Width/Depth Ratio (W_{bkf} / d_{bkf}) Bankfull WIDTH divided by bankfull mean DEPTH, in a riffle section.	**6.91**	ft/ft
Maximum DEPTH (d_{mbkf}) Maximum depth of the bankfull channel cross-section, or distance between the bankfull stage and Thalweg elevations, in a riffle section.	**2.04**	ft
WIDTH of Flood-Prone Area (W_{fpa}) Twice maximum DEPTH, or (2 x d_{mbkf}) = the stage/elevation at which flood-prone area WIDTH is determined in a riffle section.	**97.94**	ft
Entrenchment Ratio (ER) The ratio of flood-prone area WIDTH divided by bankfull channel WIDTH (W_{fpa} / W_{bkf}) (riffle section).	**11.15**	ft/ft
Channel Materials (Particle Size Index) D_{50} The D_{50} particle size index represents the mean diameter of channel materials, as sampled from the channel surface, between the bankfull stage and Thalweg elevations.	**154**	mm
Water Surface SLOPE (S) Channel slope = "rise over run" for a reach approximately 20–30 bankfull channel widths in length, with the "riffle-to-riffle" water surface slope representing the gradient at bankfull stage.	**0.0216**	ft/ft
Channel SINUOSITY (k) Sinuosity is an index of channel pattern, determined from a ratio of stream length divided by valley length (SL / VL); or estimated from a ratio of valley slope divided by channel slope (VS / S).	**1.06**	

Stream Type **E 3/1b** (See **Figure 2-14**)

Worksheet 5-4. Morphological relations, including dimensionless ratios of river reach sites (Rosgen and Silvey, 2005).

Stream: **Impaired Enhancement 1 Reach**		Location: **Davis Branch Mainstem, Staton Property**	
Observers: **Hebert, Knotts, Hines, Peffer**	Date: **07/17/07**	Valley Type: **VIII**	Stream Type: **E 3/1b**

River Reach Summary Data

Channel Dimension

Mean Riffle Depth (d_{bkf})	**1.27**	ft	Riffle Width (W_{bkf})	**8.78**	ft	Riffle Area (A_{bkf})	**11.18**	ft^2
Mean Pool Depth (d_{bkfp})	**1.4**	ft	Pool Width (W_{bkfp})	**10.8**	ft	Pool Area (A_{bkfp})	**15.15**	ft^2
Mean Pool Depth/Mean Riffle Depth	**1.10**	d_{bkfp}/d_{bkf}	Pool Width/Riffle Width	**1.23**	W_{bkfp}/W_{bkf}	Pool Area / Riffle Area	**1.36**	A_{bkfp}/A_{bkf}
Max Riffle Depth (d_{mbkf})	**2.04**	ft	Max Pool Depth (d_{mbkfp})	**2.06**	ft	Max Riffle Depth/Mean Riffle Depth	**1.61**	
Max Pool Depth/Mean Riffle Depth	**1.62**					Point Bar Slope	**N/A**	
Streamflow: Estimated Mean Velocity at Bankfull Stage (u_{bkf})				**5.32**	ft/s	Estimation Method	**U/U***	
Streamflow: Estimated Discharge at Bankfull Stage (Q_{bkf})				**45.5**	cfs	Drainage Area	**0.3352**	mi^2

Channel Pattern

Geometry	Mean	Min	Max		Dimensionless Geometry Ratios	Mean	Min	Max
Meander Length (Lm)				ft	Meander Length Ratio (Lm/W_{bkf})			
Radius of Curvature (Rc)				ft	Radius of Curvature/Riffle Width (Rc/W_{bkf})			
Belt Width (W_{blt})				ft	Meander Width Ratio (W_{blt}/W_{bkf})			
Individual Pool Length	**39.15**	**29.52**	**48.8**	ft	Pool Length/Riffle Width	**4.46**	**3.36**	**5.56**
Pool to Pool Spacing	**97.61**	**92.2**	**103**	ft	Pool to Pool Spacing/Riffle Width	**11.12**	**10.50**	**11.73**
Riffle Length	**67.08**	**57.94**	**85.3**	ft	Riffle Length/Riffle Width	**7.64**	**6.60**	**9.71**

Channel Profile

Valley Slope (VS)	**0.0224**	ft/ft	Average Water Surface Slope (S)	**0.0211**	ft/ft	Sinuosity (VS/S)	**1.06**	
Stream Length (SL)	**1289**	ft	Valley Length (VL)	**1213**	ft	Sinuosity (SL/VL)	**1.06**	
Low Bank Height (LBH) start	**2.48**	ft	Max Riffle Depth start	**1.42**	ft	Bank-Height Ratio (BHR) (LBH/Max Riffle Depth) start	**1.75**	
Low Bank Height (LBH) end	**2.31**	ft	Max Riffle Depth end	**1.30**	ft	Bank-Height Ratio (BHR) (LBH/Max Riffle Depth) end	**1.78**	

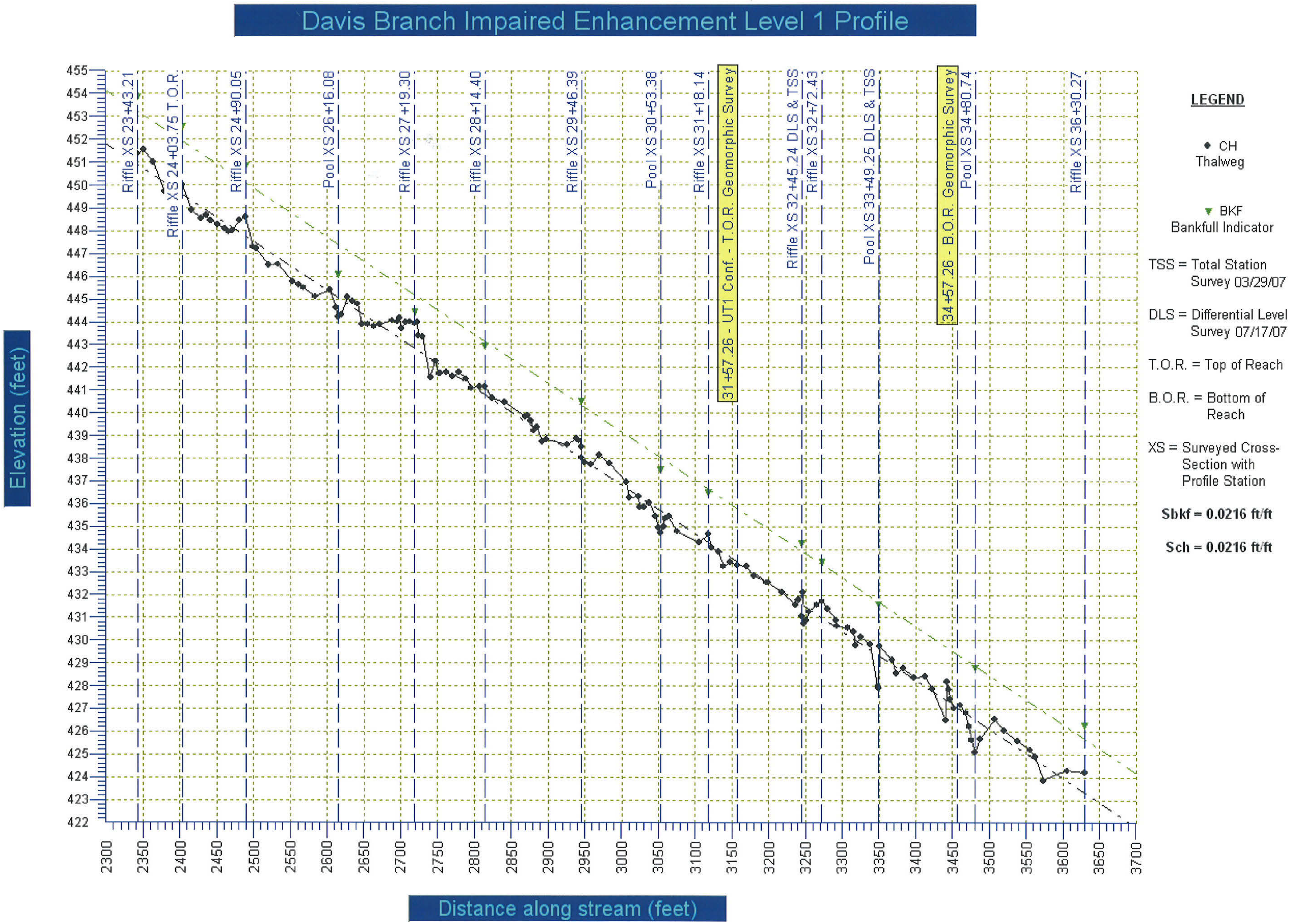
Facet Slopes	Mean	Min	Max		Dimensionless Slope Ratios	Mean	Min	Max
Riffle Slope (S_{rif})	**0.0393**	**0.0264**	**0.0518**	ft/ft	Riffle Slope/Average Water Surface Slope (S_{rif} / S)	**1.86**	**1.25**	**2.46**
Run Slope (S_{run})				ft/ft	Run Slope/Average Water Surface Slope (S_{run} / S)			
Pool Slope (S_p)	**0.0005**	**0.0003**	**0.0006**	ft/ft	Pool Slope/Average Water Surface Slope (S_p / S)	**0.02**	**0.02**	**0.03**
Glide Slope (S_g)				ft/ft	Glide Slope/Average Water Surface Slope (S_g / S)			

Feature Midpoint [a]	Mean	Min	Max		Dimensionless Depth Ratios	Mean	Min	Max
Riffle Depth (d_{rif})	**1.26**	**1.03**	**1.54**	ft	Riffle Depth/Mean Riffle Depth (d_{rif} / d_{bkf})	**0.99**	**0.81**	**1.21**
Run Depth (d_{run})				ft	Run Depth/Mean Riffle Depth (d_{run} / d_{bkf})			
Pool Depth (d_p)	**2.36**	**2.12**	**2.59**	ft	Pool Depth/Mean Riffle Depth (d_p / d_{bkf})	**1.86**	**1.67**	**2.04**
Glide Depth (d_g)				ft	Glide Depth/Mean Riffle Depth (d_g / d_{bkf})			

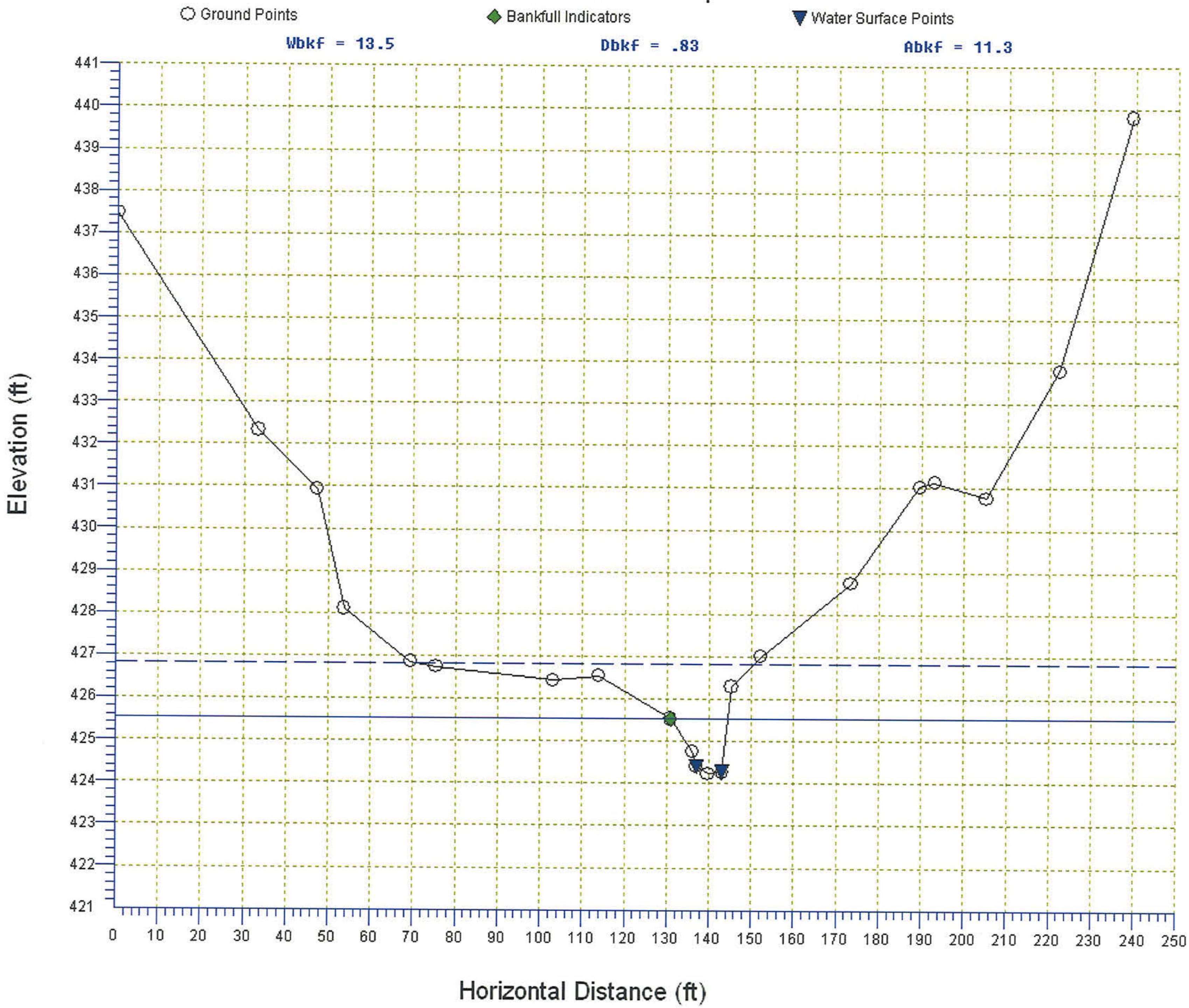
Channel Materials

	Reach [b]	Riffle [c]	Bar		Reach [b]	Riffle [c]	Bar	Protrusion Height [d]	
% Silt/Clay	**0**		**0**	D_{16}	**80.64**		**28.78**	80.64	mm
% Sand	**0**		**0**	D_{35}	**138.4**		**52.6**	138.4	mm
% Gravel	**0**		**45**	D_{50}	**154**		**69.2**	154	mm
% Cobble	**100**		**50**	D_{84}	**207.36**		**140.12**	207.36	mm
% Boulder	**0**		**5**	D_{95}	**240.8**		**256**	240.8	mm
% Bedrock	**0**		**0**	D_{100}	**256**		**362**	256	mm

a Min, max, mean depths are the average mid-point values except pools, which are taken at deepest part of pool.
b Composite sample of riffles and pools within the designated reach.
c Active bed of a riffle.
d Height of roughness feature above bed.


Davis Branch Impaired Enhancement Level 1 Profile
Elevation (feet)
Distance along stream (feet)
Riffle XS 23+43.21
Riffle XS 24+03.75 T.O.R.
Riffle XS 24+90.05
Pool XS 26+16.08
Riffle XS 27+19.30
Riffle XS 28+14.40
Riffle XS 29+46.39
Pool XS 30+53.38
Riffle XS 31+18.14
31+57.26 - UT1 Conf. - T.O.R. Geomorphic Survey
Riffle XS 32+45.24 DLS & TSS
Riffle XS 32+72.43
Pool XS 33+49.25 DLS & TSS
34+57.26 - B.O.R. Geomorphic Survey
Pool XS 34+80.74
Riffle XS 36+30.27
LEGEND
CH Thalweg
BKF Bankfull Indicator
TSS = Total Station Survey 03/29/07
DLS = Differential Level Survey 07/17/07
T.O.R. = Top of Reach
B.O.R. = Bottom of Reach
XS = Surveyed Cross-Section with Profile Station
Sbkf = 0.0216 ft/ft
Sch = 0.0216 ft/ft

Riffle XS 36+30.27 - Impaired



RIVERMORPH CROSS SECTION SUMMARY

River Name: Davis Branch
Reach Name: Enhancement 1 Reach
Cross Section Name: Riffle XS 36+30.27
Survey Date: 03/29/2007

Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0	0	437.47	
33.34	0	432.33	
47.28	0	430.93	
53.64	0	428.11	
69.36	0	426.86	
75.41	0	426.74	
103.06	0	426.43	
113.87	0	426.54	
130.89	0	425.53	BKF
136.05	0	424.76	LB
137	0	424.41	LEW
139.77	0	424.23	TW
143.04	0	424.27	REW
145.25	0	426.29	RB
152.21	0	427.01	
173.36	0	428.74	
189.57	0	431.04	
193.05	0	431.14	
205.23	0	430.77	
222.29	0	433.79	
239.36	0	439.81	

Cross Sectional Geometry

	Channel	Left	Right
Floodprone Elevation (ft)	426.83	426.83	426.83
Bankfull Elevation (ft)	425.53	425.53	425.53
Floodprone Width (ft)	79.6	-----	-----
Bankfull Width (ft)	13.53	6.45	7.08
Entrenchment Ratio	5.88	-----	-----
Mean Depth (ft)	0.83	0.51	1.13
Maximum Depth (ft)	1.3	1.14	1.3
Width/Depth Ratio	16.3	12.65	6.27
Bankfull Area (sq ft)	11.29	3.27	8.02
Wetted Perimeter (ft)	14.14	7.71	8.72
Hydraulic Radius (ft)	0.8	0.42	0.92
Begin BKF Station	130.89	130.89	137.34
End BKF Station	144.42	137.34	144.42

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side

Slope	0.02162	0	0
Shear Stress (lb/sq ft)	1.08		
Movable Particle (mm)	160.8		

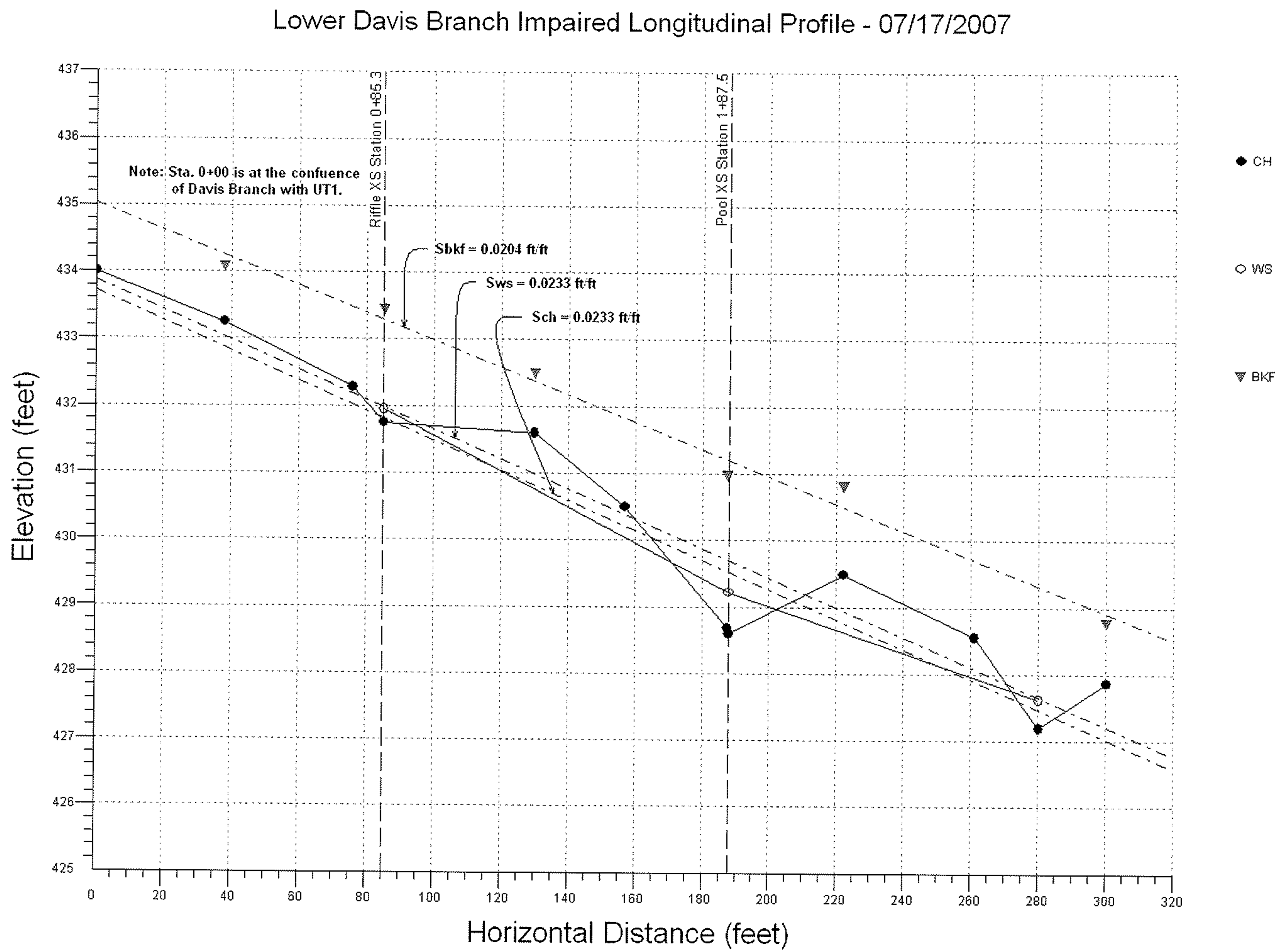
LDB Riffle XS 0+76 BR Protrusion Summary Rpt.txt
RIVERMORPH PARTICLE SUMMARY

River Name: Davis Branch
Reach Name: Davis Branch UT - Impaired
Sample Name: Riffle XS 0+76 Bedrock Protrusion Heights
Survey Date: 07/17/2007

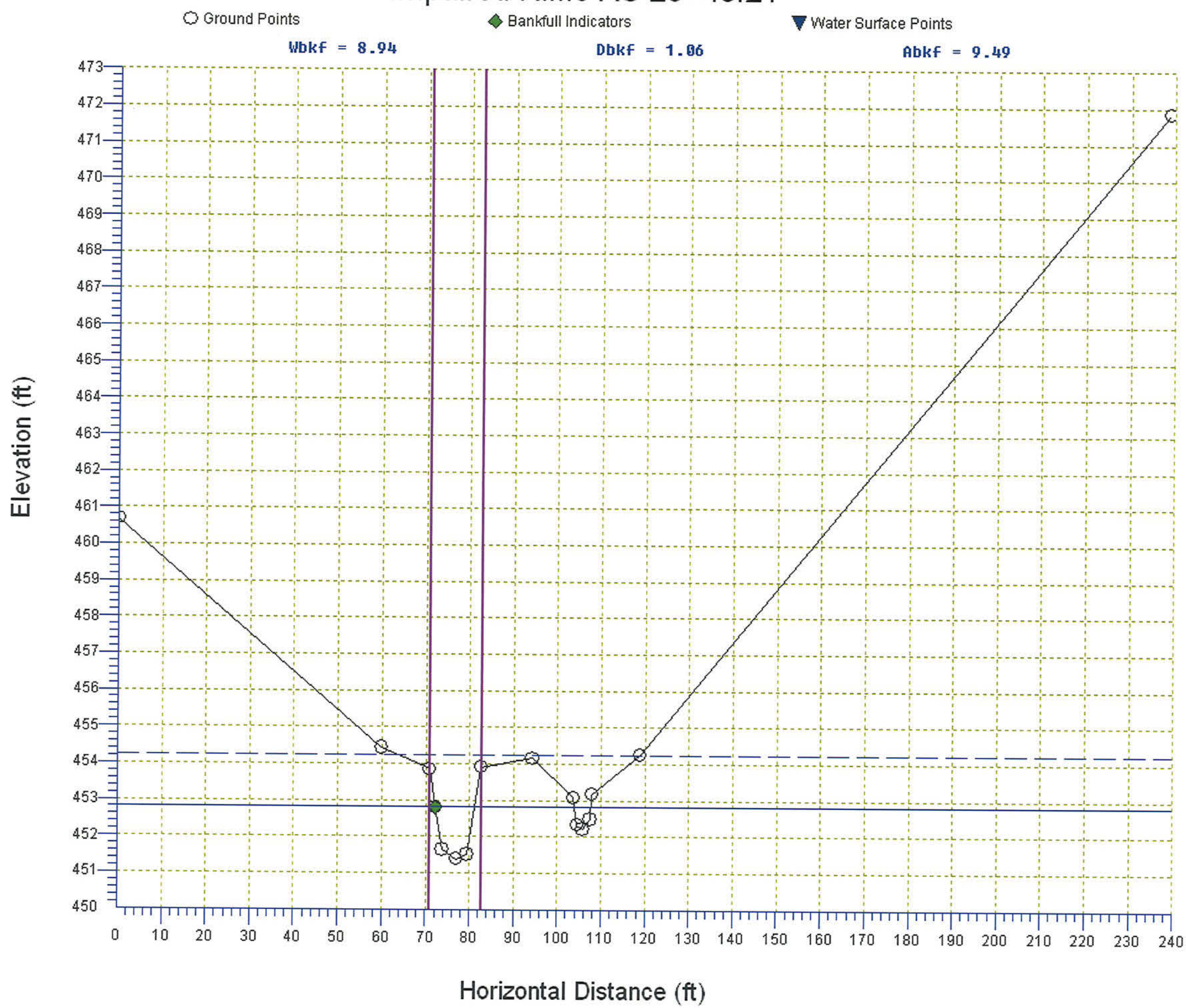
Size (mm)	TOT #	ITEM %	CUM %
0 - 0.062	0	0.00	0.00
0.062 - 0.125	0	0.00	0.00
0.125 - 0.25	0	0.00	0.00
0.25 - 0.50	0	0.00	0.00
0.50 - 1.0	0	0.00	0.00
1.0 - 2.0	0	0.00	0.00
2.0 - 4.0	0	0.00	0.00
4.0 - 5.7	0	0.00	0.00
5.7 - 8.0	0	0.00	0.00
8.0 - 11.3	0	0.00	0.00
11.3 - 16.0	0	0.00	0.00
16.0 - 22.6	0	0.00	0.00
22.6 - 32.0	0	0.00	0.00
32 - 45	0	0.00	0.00
45 - 64	0	0.00	0.00
64 - 90	15	25.00	25.00
90 - 128	0	0.00	25.00
128 - 180	30	50.00	75.00
180 - 256	15	25.00	100.00
256 - 362	0	0.00	100.00
362 - 512	0	0.00	100.00
512 - 1024	0	0.00	100.00
1024 - 2048	0	0.00	100.00
Bedrock	0	0.00	100.00

D16 (mm)	80.64
D35 (mm)	138.4
D50 (mm)	154
D84 (mm)	207.36
D95 (mm)	240.8
D100 (mm)	256
Silt/Clay (%)	0
Sand (%)	0
Gravel (%)	0
Cobble (%)	100
Boulder (%)	0
Bedrock (%)	0

Total Particles = 60.


Lower Davis Branch Impaired Longitudinal Profile - 07/17/2007
Note: Sta. 0+00 is at the confuence of Davis Branch with UT1.
Riffle XS Station 0+85.3
Pool XS Station 1+87.5
Sbkf = 0.0204 ft/ft
Sws = 0.0233 ft/ft
Sch = 0.0233 ft/ft
CH
WS
BKF
Elevation (feet)
Horizontal Distance (feet)
437
436
435
434
433
432
431
430
429
428
427
426
425
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320

Impaired Riffle XS 23+43.21



Impaired Riffle XS 23+43.21.txt
RIVERMORPH CROSS SECTION SUMMARY

River Name: Davis Branch
Reach Name: Enhancement 1 Reach
Cross Section Name: Riffle XS 23+43.21
Survey Date: 03/29/2007

Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0	0	460.68	LT
59.84	0	454.44	FP
70.85	0	453.86	LB
72.22		452.8	BKF
73.78	0	451.64	
76.99	0	451.38	TW
79.43	0	451.5	
82.62	0	453.9	RB
94.3	0	454.16	FP
103.63	0	453.07	TRIB LB
104.49	0	452.32	
105.78	0	452.21	CL
107.48	0	452.48	
107.88	0	453.16	TRIB RB
118.89	0	454.26	FP
238.89	0	471.84	BM 3357

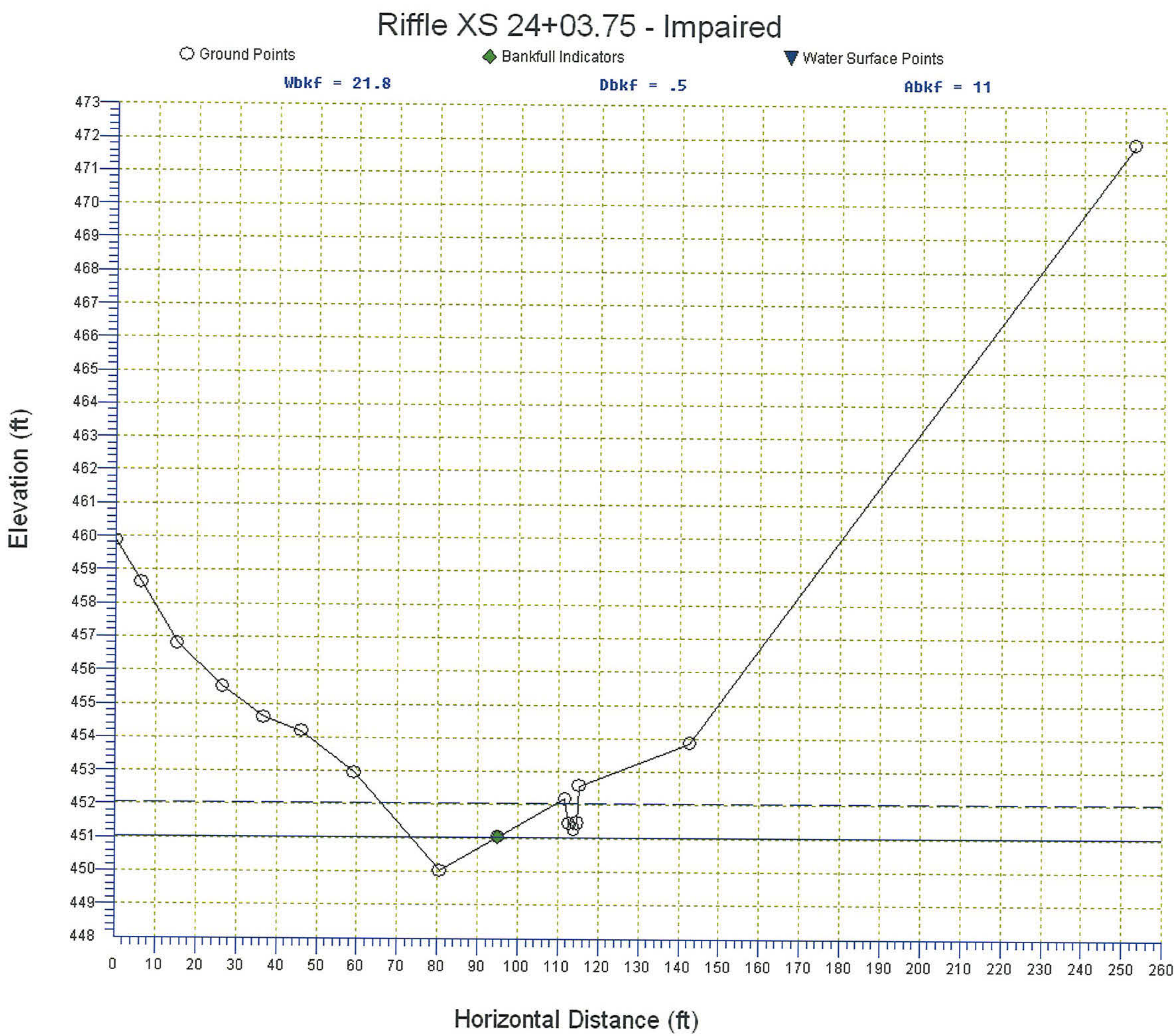
Cross Sectional Geometry

	Channel	Left	Right
Floodprone Elevation (ft)	454.22	454.22	454.22
Bankfull Elevation (ft)	452.8	452.8	452.8
Floodprone Width (ft)	54.47	-----	-----
Bankfull Width (ft)	12.67	4.49	30.96
Entrenchment Ratio	4.3	-----	-----
Mean Depth (ft)	0.88	1.04	0.79
Maximum Depth (ft)	1.42	1.4	1.42
Width/Depth Ratio	14.4	4.32	39.19
Bankfull Area (sq ft)	11.11	4.65	6.46
Wetted Perimeter (ft)	13.89	6.28	10.4
Hydraulic Radius (ft)	0.8	0.74	0.62
Begin BKF Station	72.22	72.22	76.71
End BKF Station	107.67	76.71	107.67

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.02162	0	0
Shear Stress (lb/sq ft)	1.08		
Movable Particle (mm)	160.8		



Riffle XS 24+03.75 - Impaired
Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 21.8
Dbkf = .5
Abkf = 11
Elevation (ft)
Horizontal Distance (ft)

Impaired Riffle XS 24+03.75.txt
RIVERMORPH CROSS SECTION SUMMARY

River Name: Davis Branch
Reach Name: Enhancement 1 Reach
Cross Section Name: Riffle XS 24+03.75 T.O.R.
Survey Date: 03/29/2007

Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0	0	459.88	
6.41	0	458.63	
15.42	0	456.81	
26.48	0	455.52	
36.79	0	454.6	
46.2	0	454.19	
59.27	0	452.96	
80.52	0	450.02	TW
94.99		451.03	BKF
111.64	0	452.19	LB
112.52	0	451.45	
113.83	0	451.28	CL
114.61	0	451.46	
115.22	0	452.57	RB
142.63	0	453.85	FP
252.52	0	471.84	

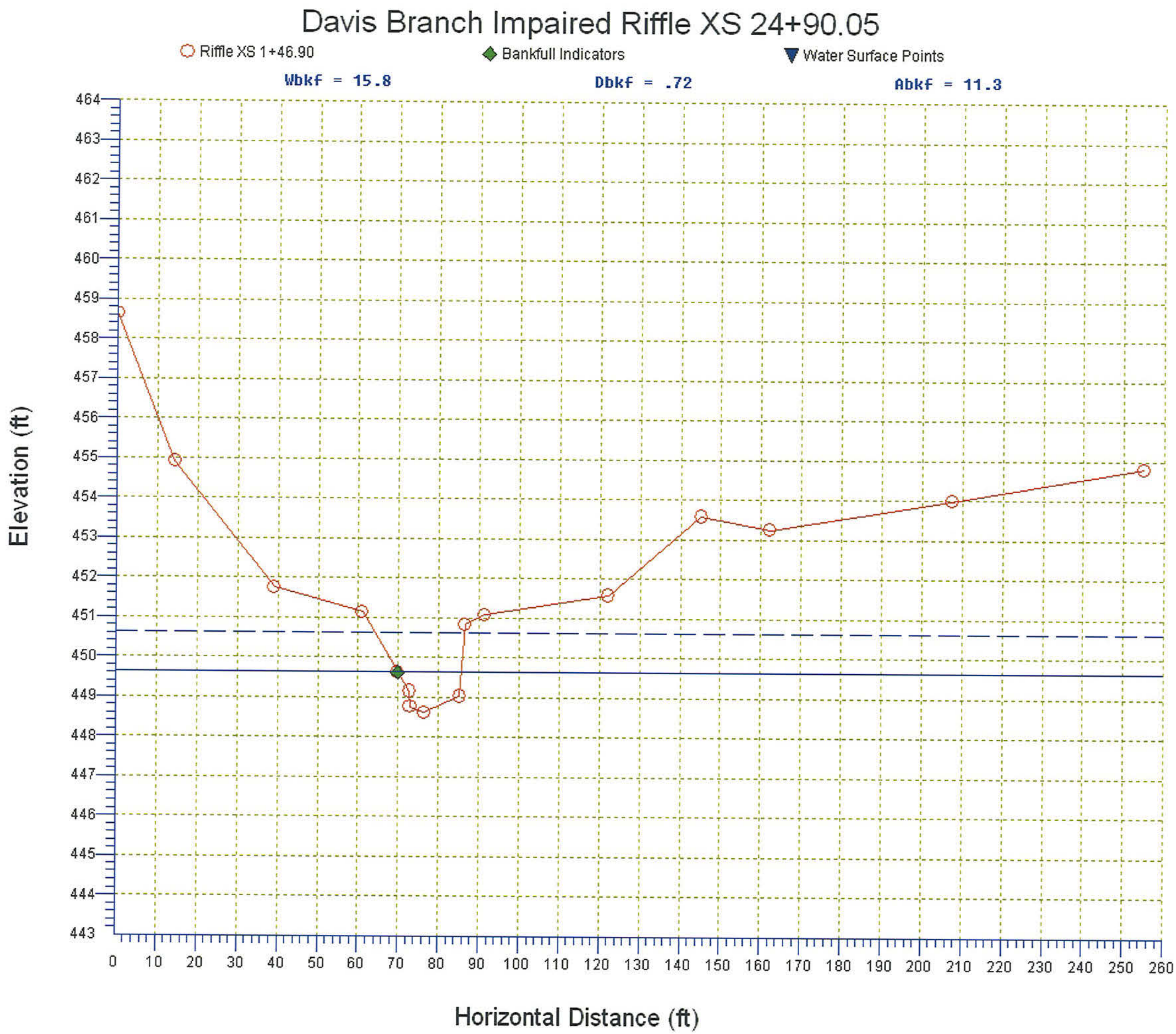
Cross Sectional Geometry

	Channel	Left	Right
Floodprone Elevation (ft)	452.04	452.04	452.04
Bankfull Elevation (ft)	451.03	451.03	451.03
Floodprone Width (ft)	46.68	-----	-----
Bankfull Width (ft)	21.77	11.78	9.99
Entrenchment Ratio	2.14	-----	-----
Mean Depth (ft)	0.5	0.64	0.35
Maximum Depth (ft)	1.01	1.01	0.7
Width/Depth Ratio	43.54	18.41	28.54
Bankfull Area (sq ft)	10.99	7.51	3.48
Wetted Perimeter (ft)	21.87	12.56	10.71
Hydraulic Radius (ft)	0.5	0.6	0.33
Begin BKF Station	73.22	73.22	85
End BKF Station	94.99	85	94.99

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.02162	0	0
Shear Stress (lb/sq ft)	0.67		
Movable Particle (mm)	113.8		



Davis Branch Impaired Riffle XS 24+90.05
Riffle XS 1+46.90
Bankfull Indicators
Water Surface Points
Wbkf = 15.8
Dbkf = .72
Abkf = 11.3
Elevation (ft)
Horizontal Distance (ft)

Impaired Riffle XS 24+90.05.txt
RIVERMORPH CROSS SECTION SUMMARY

River Name:	Davis Branch
Reach Name:	Enhancement 1 Reach
Cross Section Name:	Riffle XS 24+90.05
Survey Date:	03/29/2007

Cross Section Data Entry

BM Elevation:	0 ft
Backsight Rod Reading:	0 ft

TAPE	FS	ELEV	NOTE
0	0	458.65	FP
14.43	0	454.91	FP
39.19	0	451.75	FP
61.04	0	451.13	FP
69.85	0	449.62	BKF
72.68	0	449.14	LB
72.95	0	448.75	
76.36	0	448.61	TW
85.21	0	449.02	
86.48	0	450.82	
91.43	0	451.07	RB
122.14	0	451.57	FP
145.1	0	453.57	FP
162.21	0	453.25	FP
207.45	0	453.98	FP
254.94	0	454.8	FP

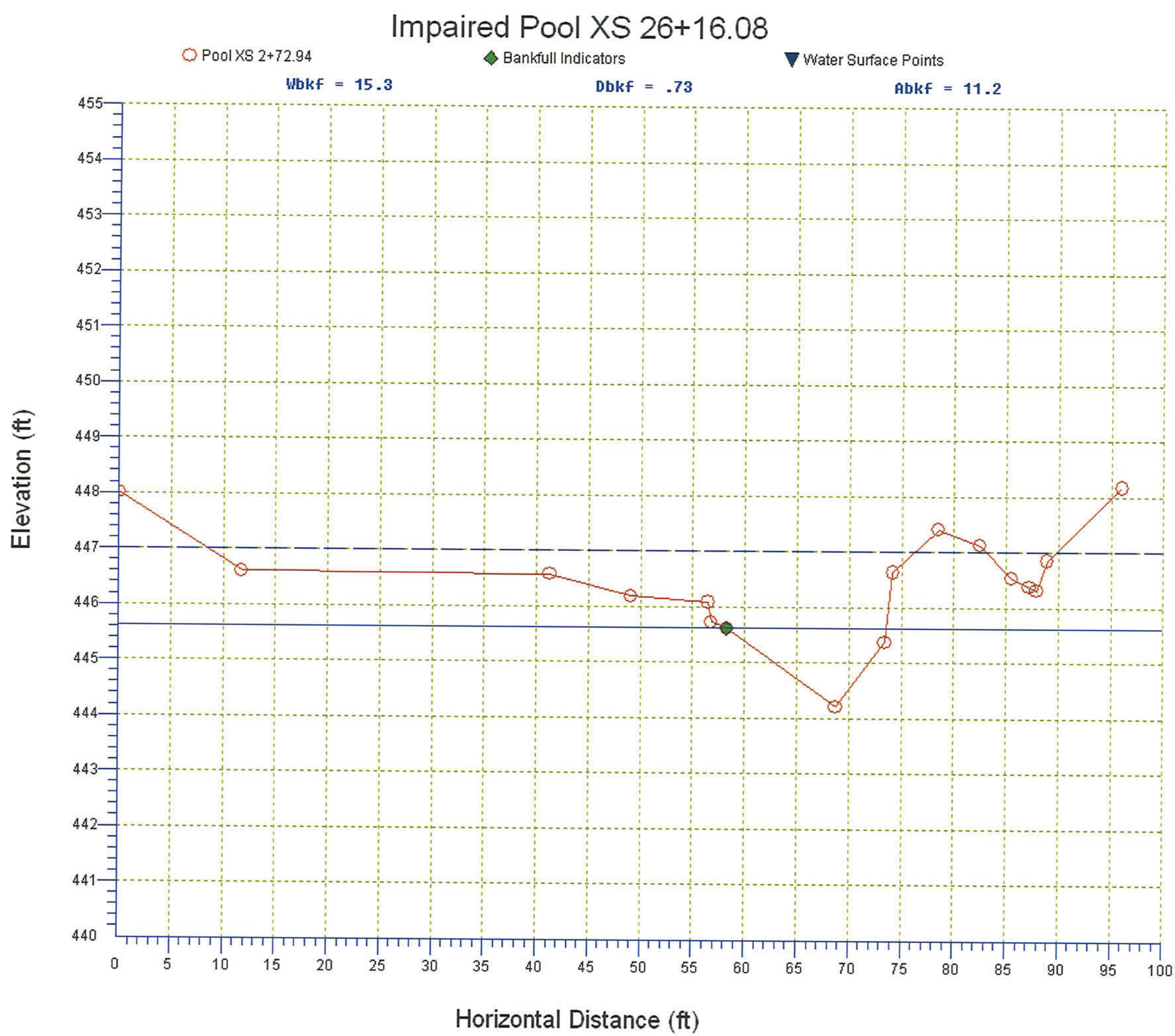
Cross Sectional Geometry

	Channel	Left	Right
Floodprone Elevation (ft)	450.63	450.63	450.63
Bankfull Elevation (ft)	449.62	449.62	449.62
Floodprone Width (ft)	22.39	-----	-----
Bankfull Width (ft)	15.78	7.95	7.83
Entrenchment Ratio	1.42	-----	-----
Mean Depth (ft)	0.72	0.69	0.75
Maximum Depth (ft)	1.01	1.01	0.94
Width/Depth Ratio	21.92	11.52	10.44
Bankfull Area (sq ft)	11.32	5.47	5.84
Wetted Perimeter (ft)	16.35	9.14	9.09
Hydraulic Radius (ft)	0.69	0.6	0.64
Begin BKF Station	69.85	69.85	77.8
End BKF Station	85.63	77.8	85.63

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.02162	0	0
Shear Stress (lb/sq ft)	0.93		
Movable Particle (mm)	144.2		



Impaired Pool XS 26+16.08
Pool XS 2+72.94
Bankfull Indicators
Water Surface Points
Wbkf = 15.3
Dbkf = .73
Abkf = 11.2
Elevation (ft)
Horizontal Distance (ft)

Impaired Pool XS 26+16.08.txt
RIVERMORPH CROSS SECTION SUMMARY

River Name: Davis Branch
Reach Name: Enhancement 1 Reach
Cross Section Name: Pool XS 26+16.08
Survey Date: 03/29/2007

Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0	0	448.01	
11.76	0	446.6	
41.25	0	446.57	
49.05	0	446.18	
56.47	0	446.08	
56.79	0	445.72	
58.26	0	445.61	BKF
68.75	0	444.21	TW
73.41	0	445.37	
74.15	0	446.63	LB
78.52	0	447.4	FP
82.49	0	447.12	
85.53	0	446.54	
87.23	0	446.37	
87.94	0	446.31	
88.94	0	446.85	
96.01	0	448.17	

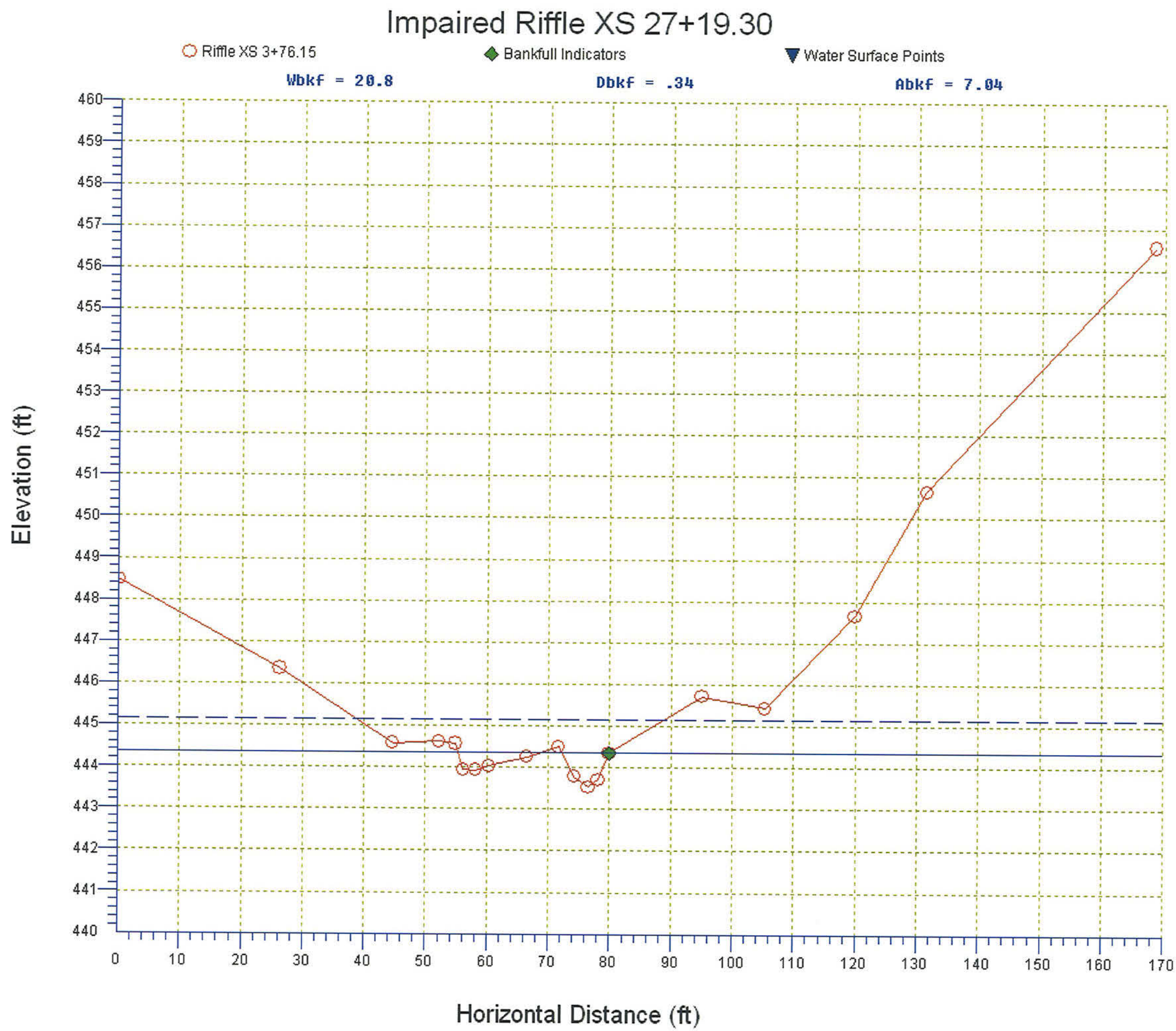
Cross Sectional Geometry

	Channel	Left	Right
Floodprone Elevation (ft)	447.01	447.01	-----
Bankfull Elevation (ft)	445.61	445.61	-----
Floodprone Width (ft)	74.7	-----	-----
Bankfull Width (ft)	15.29	23.2	-----
Entrenchment Ratio	4.89	-----	-----
Mean Depth (ft)	0.73	0.73	-----
Maximum Depth (ft)	1.4	1.4	-----
Width/Depth Ratio	20.95	31.78	-----
Bankfull Area (sq ft)	11.18	11.18	-----
Wetted Perimeter (ft)	15.66	15.66	-----
Hydraulic Radius (ft)	0.71	0.71	-----
Begin BKF Station	58.26	58.26	-----
End BKF Station	73.55	73.55	-----

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.02162	0	0
Shear Stress (lb/sq ft)	0.96		
Movable Particle (mm)	147.3		


Impaired Riffle XS 27+19.30
Riffle XS 3+76.15
Bankfull Indicators
Water Surface Points
Wbkf = 20.8
Dbkf = .34
Abkf = 7.04
Elevation (ft)
460
459
458
457
456
455
454
453
452
451
450
449
448
447
446
445
444
443
442
441
440
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
Horizontal Distance (ft)

RIVERMORPH CROSS SECTION SUMMARY

River Name: Davis Branch
Reach Name: Enhancement 1 Reach
Cross Section Name: Riffle XS 27+19.30
Survey Date: 03/29/2007

Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0	0	448.48	MT
26.27	0	446.35	LT
44.67	0	444.57	FP
52.19	0	444.61	FP
54.84	0	444.56	Top Bank
56.08	0	443.94	SB
58.11	0	443.93	SB
60.27	0	444.02	SB
66.52	0	444.25	SB
71.7	0	444.49	SB
74.17	0	443.78	Bot LB
76.5	0	443.52	TW
78.13	0	443.7	Bot RB
79.88	0	444.34	BKF
95.04	0	445.71	FP
105.27	0	445.43	LT
119.87	0	447.66	LT
131.47	0	450.64	MT
168.48	0	456.55	MT

Cross Sectional Geometry

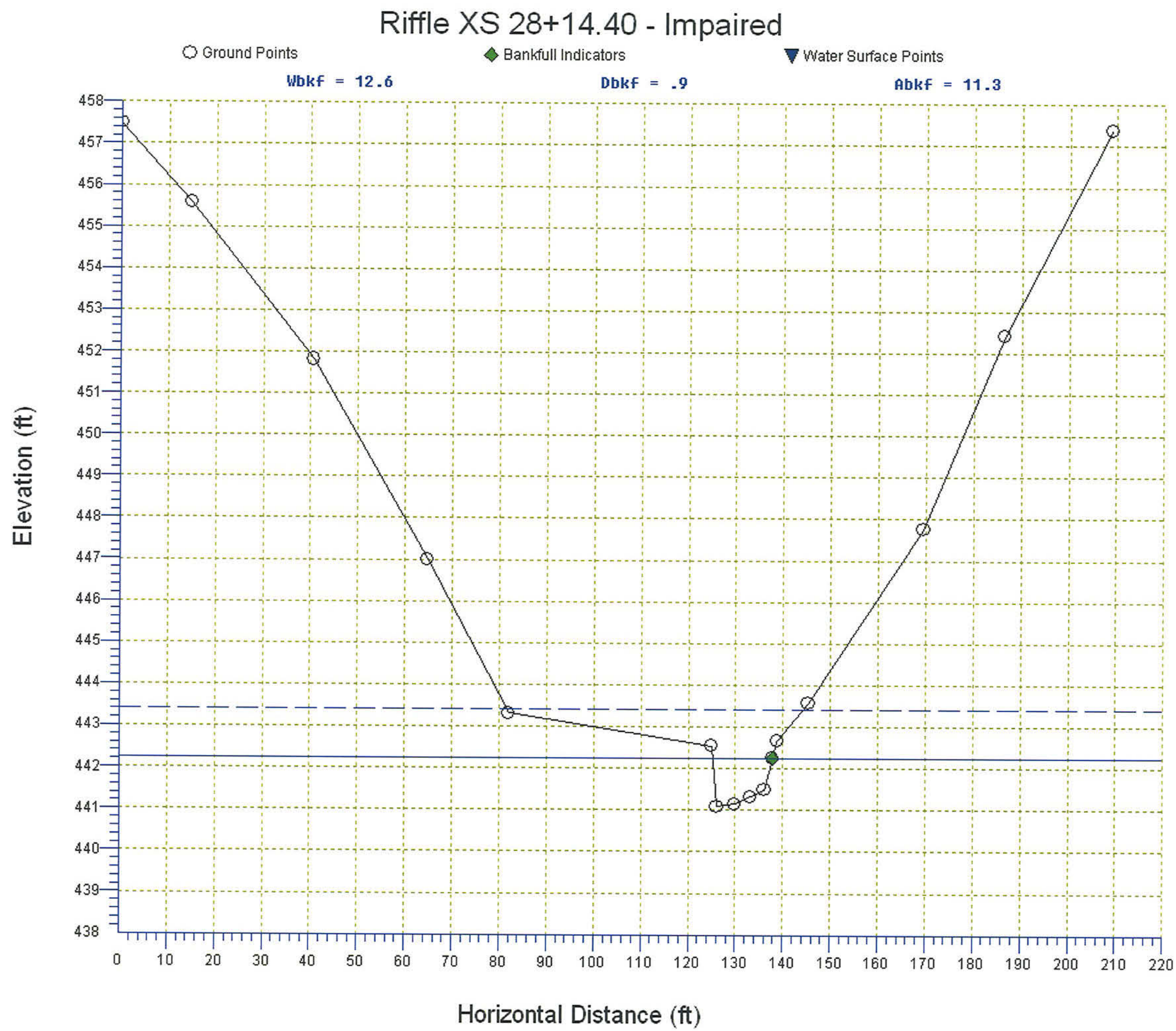
	Channel	Left	Right
Floodprone Elevation (ft)	445.16	445.16	445.16
Bankfull Elevation (ft)	444.34	444.34	444.34
Floodprone Width (ft)	50.38	-----	-----
Bankfull Width (ft)	20.84	20.51	4.09
Entrenchment Ratio	2.42	-----	-----
Mean Depth (ft)	0.34	0.28	0.56
Maximum Depth (ft)	0.82	0.74	0.82
Width/Depth Ratio	61.29	73.25	7.3
Bankfull Area (sq ft)	7.04	4.74	2.3
Wetted Perimeter (ft)	21.16	17.68	4.96
Hydraulic Radius (ft)	0.33	0.27	0.46
Begin BKF Station	55.28	55.28	75.79
End BKF Station	79.88	75.79	79.88

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.02162	0	0
Shear Stress (lb/sq ft)	0.45		

Movable Particle (mm)	83.8



Riffle XS 28+14.40 - Impaired
Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 12.6
Dbkf = .9
Abkf = 11.3
Elevation (ft)
458
457
456
455
454
453
452
451
450
449
448
447
446
445
444
443
442
441
440
439
438
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
Horizontal Distance (ft)

Impaired Riffle XS 28+14.40.txt
RIVERMORPH CROSS SECTION SUMMARY

River Name:	Davis Branch
Reach Name:	Enhancement 1 Reach
Cross Section Name:	Riffle XS 28+14.40
Survey Date:	03/29/2007

Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0	0	457.49	
14.79	0	455.6	
40.53	0	451.82	
64.73	0	447.01	
81.97	0	443.31	
124.92	0	442.54	LB
126.01	0	441.09	TW
129.81	0	441.15	CL
133.18	0	441.32	
136.06	0	441.48	
137.78		442.25	BKF
138.75	0	442.66	RB
145.34	0	443.56	
169.52	0	447.76	
186.41	0	452.42	
209.01	0	457.38	

Cross Sectional Geometry

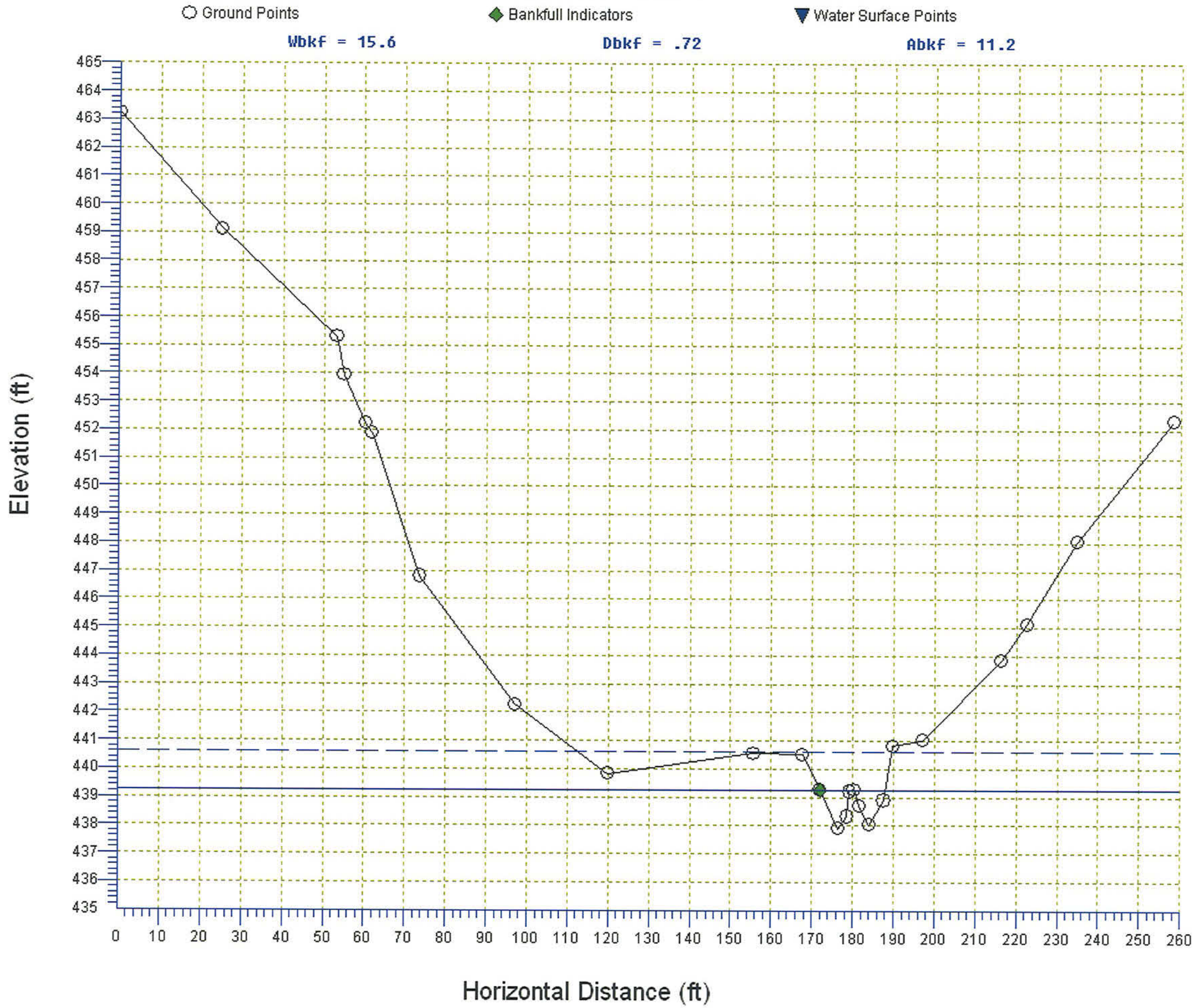
	Channel	Left	Right
Floodprone Elevation (ft)	443.41	443.41	443.41
Bankfull Elevation (ft)	442.25	442.25	442.25
Floodprone Width (ft)	62.74	-----	-----
Bankfull Width (ft)	12.64	6.56	6.08
Entrenchment Ratio	4.96	-----	-----
Mean Depth (ft)	0.9	1.03	0.75
Maximum Depth (ft)	1.16	1.16	1
Width/Depth Ratio	14.04	6.37	8.11
Bankfull Area (sq ft)	11.33	6.79	4.54
Wetted Perimeter (ft)	13.39	8.15	7.26
Hydraulic Radius (ft)	0.85	0.83	0.63
Begin BKF Station	125.14	125.14	131.7
End BKF Station	137.78	131.7	137.78

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.02162	0	0
Shear Stress (lb/sq ft)	1.15		
Movable Particle (mm)	168.1		

Riffle XS 29+46.39



RIVERMORPH CROSS SECTION SUMMARY

River Name: Davis Branch
Reach Name: Enhancement 1 Reach
Cross Section Name: Riffle XS 29+46.39
Survey Date: 03/29/2007

Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0	0	463.23	
25.11	0	459.11	
53.15	0	455.3	
55.03	0	453.94	
60.25	0	452.23	
61.94	0	451.88	
73.64	0	446.81	
97	0	442.27	
119.85	0	439.83	
155.67	0	440.56	
167.75	0	440.5	
171.95		439.25	BKF
176.44	0	437.89	
178.55	0	438.32	
179.2	0	439.2	
180.26	0	439.28	LB
181.59	0	438.7	
184.02	0	438.02	TW
187.59	0	438.89	
189.86	0	440.82	RB
197.12	0	441.02	
216.41	0	443.85	
222.65	0	445.12	
234.79	0	448.05	
258.22	0	452.31	

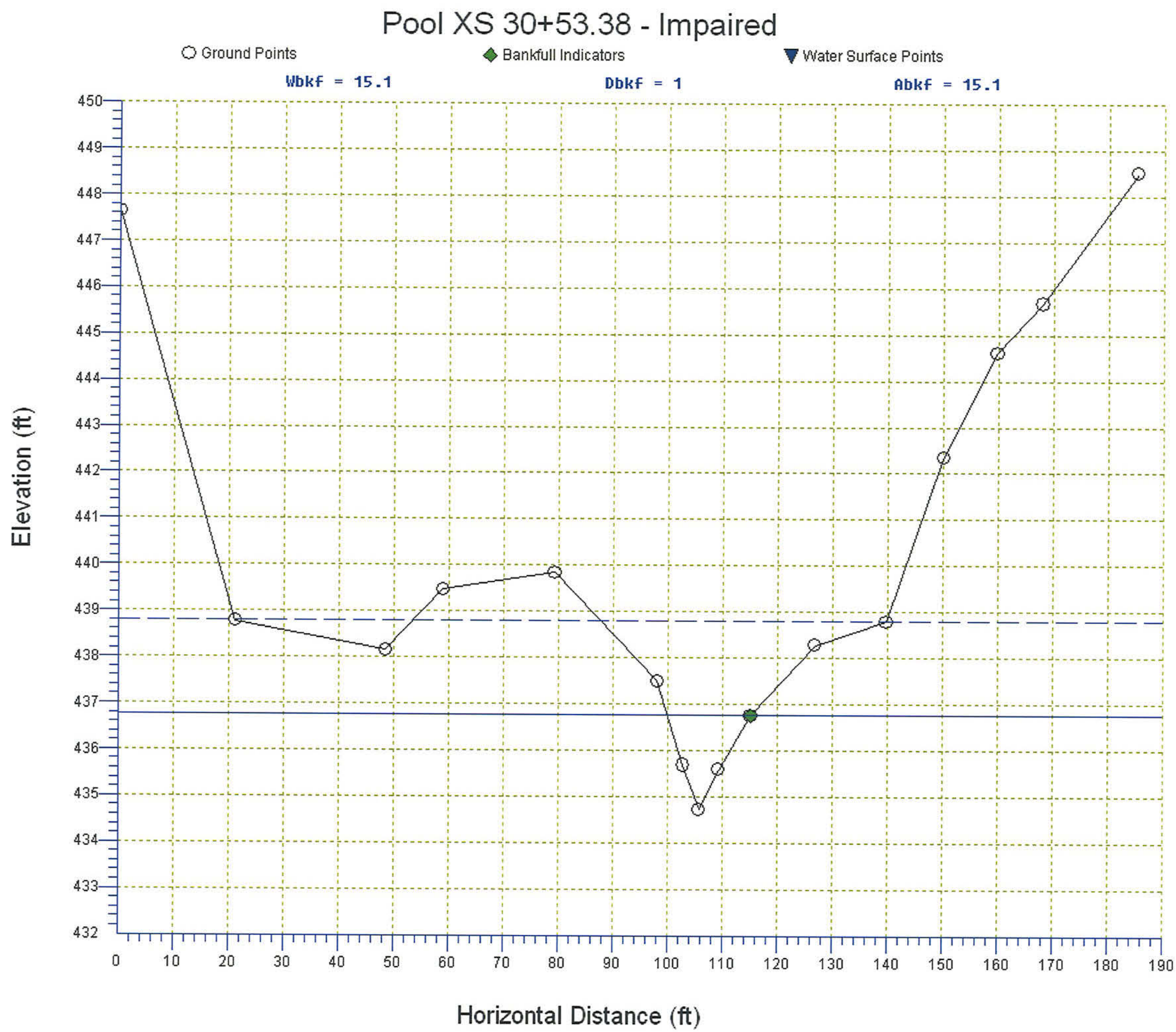
Cross Sectional Geometry

	Channel	Left	Right
Floodprone Elevation (ft)	440.61	440.61	440.61
Bankfull Elevation (ft)	439.25	439.25	439.25
Floodprone Width (ft)	77.07	-----	-----
Bankfull Width (ft)	15.6	6.67	9.39
Entrenchment Ratio	4.94	-----	-----
Mean Depth (ft)	0.72	0.83	0.64
Maximum Depth (ft)	1.36	1.36	1.23
Width/Depth Ratio	21.67	8.04	14.67
Bankfull Area (sq ft)	11.23	5.53	5.7
Wetted Perimeter (ft)	16.73	7.8	10.6
Hydraulic Radius (ft)	0.67	0.71	0.54
Begin BKF Station	171.95	171.95	178.62
End BKF Station	188.01	178.62	188.01

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.02162	0	0
Shear Stress (lb/sq ft)	0.90		
Movable Particle (mm)	141.1		



Pool XS 30+53.38 - Impaired
Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 15.1
Dbkf = 1
Abkf = 15.1
Elevation (ft)
450
449
448
447
446
445
444
443
442
441
440
439
438
437
436
435
434
433
432
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
Horizontal Distance (ft)

Impaired Pool XS 30+53.38.txt
RIVERMORPH CROSS SECTION SUMMARY

River Name: Davis Branch
Reach Name: Enhancement 1 Reach
Cross Section Name: Pool XS 30+53.38
Survey Date: 03/29/2007

Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0	0	447.65	
21.19	0	438.77	
48.45	0	438.15	
58.96	0	439.47	
79.32	0	439.84	
98.04	0	437.49	LB
102.75	0	435.68	
105.65	0	434.72	TW
109.21	0	435.58	
115.09	0	436.75	BKF
126.78	0	438.28	
139.74	0	438.78	
150.06	0	442.34	
159.7	0	444.62	
167.93	0	445.68	
185.18	0	448.51	

Cross Sectional Geometry

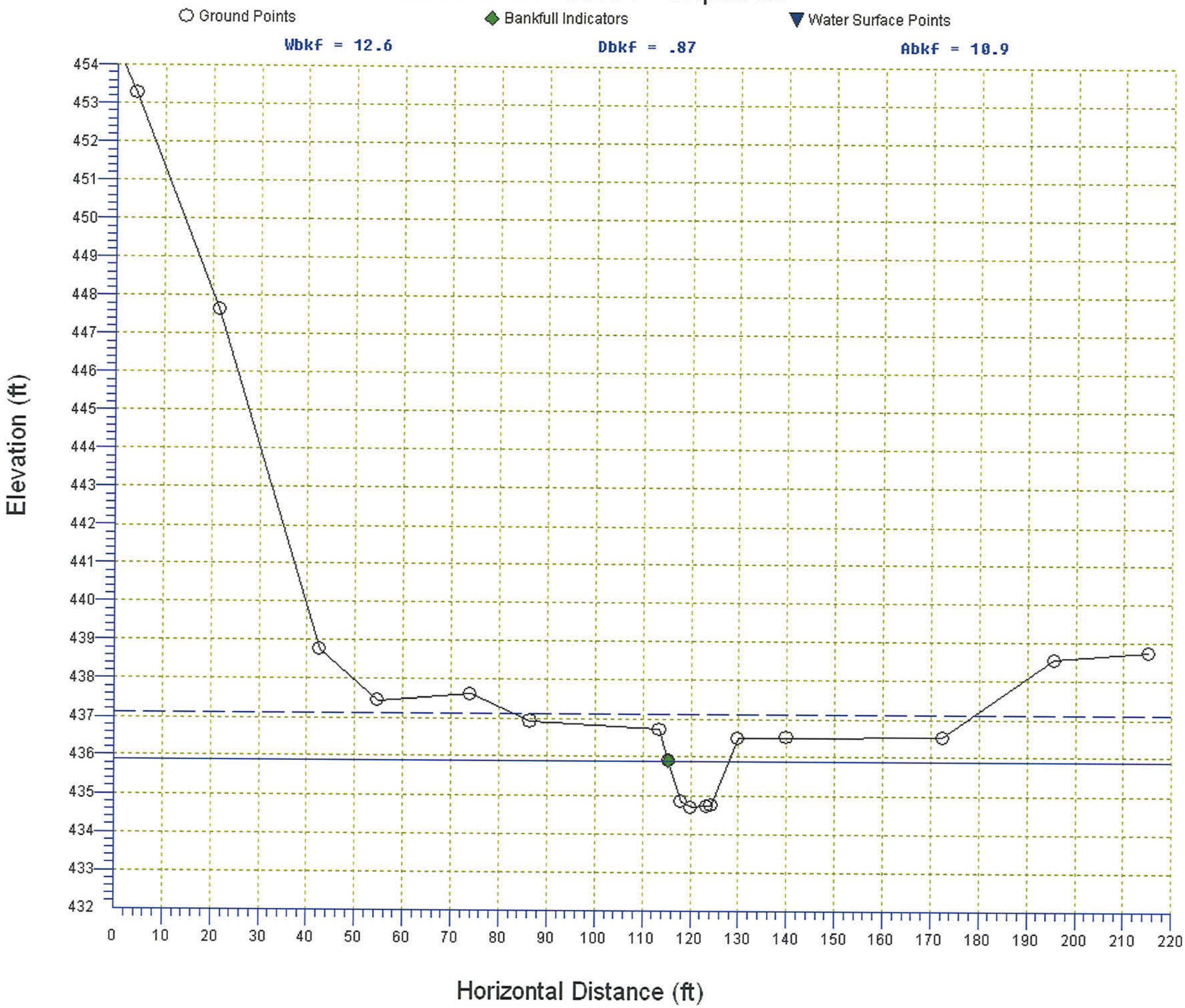
	Channel	Left	Right
Floodprone Elevation (ft)	438.78	438.78	438.78
Bankfull Elevation (ft)	436.75	436.75	436.75
Floodprone Width (ft)	84.28	-----	-----
Bankfull Width (ft)	15.12	9.42	5.7
Entrenchment Ratio	5.57	-----	-----
Mean Depth (ft)	1	1.26	0.57
Maximum Depth (ft)	2.03	2.03	1.13
Width/Depth Ratio	15.12	7.48	10
Bankfull Area (sq ft)	15.12	11.89	3.23
Wetted Perimeter (ft)	15.7	11.02	6.95
Hydraulic Radius (ft)	0.96	1.08	0.47
Begin BKF Station	99.97	99.97	109.39
End BKF Station	115.09	109.39	115.09

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.02162	0	0
Shear Stress (lb/sq ft)	1.30		
Movable Particle (mm)	183.9		

Riffle XS 31+18.14 - Impaired



Impaired Riffle XS 31+18.14.txt
RIVERMORPH CROSS SECTION SUMMARY

River Name:	Davis Branch
Reach Name:	Enhancement 1 Reach
Cross Section Name:	Riffle XS 31+18.14
Survey Date:	03/29/2007

Cross Section Data Entry

BM Elevation:	0 ft
Backsight Rod Reading:	0 ft

TAPE	FS	ELEV	NOTE
0	0	454.41	
4.14	0	453.28	
21.49	0	447.65	
42.68	0	438.77	
54.72	0	437.44	
74.01	0	437.62	
86.43	0	436.92	FP
113.44	0	436.72	LB
115.38	0	435.9	BKF
117.99	0	434.83	
120.05	0	434.68	TW
123.24	0	434.72	SB
124.27	0	434.74	
129.84	0	436.49	RB
139.92	0	436.51	FP
172.49	0	436.53	
195.58	0	438.55	
215.2	0	438.74	

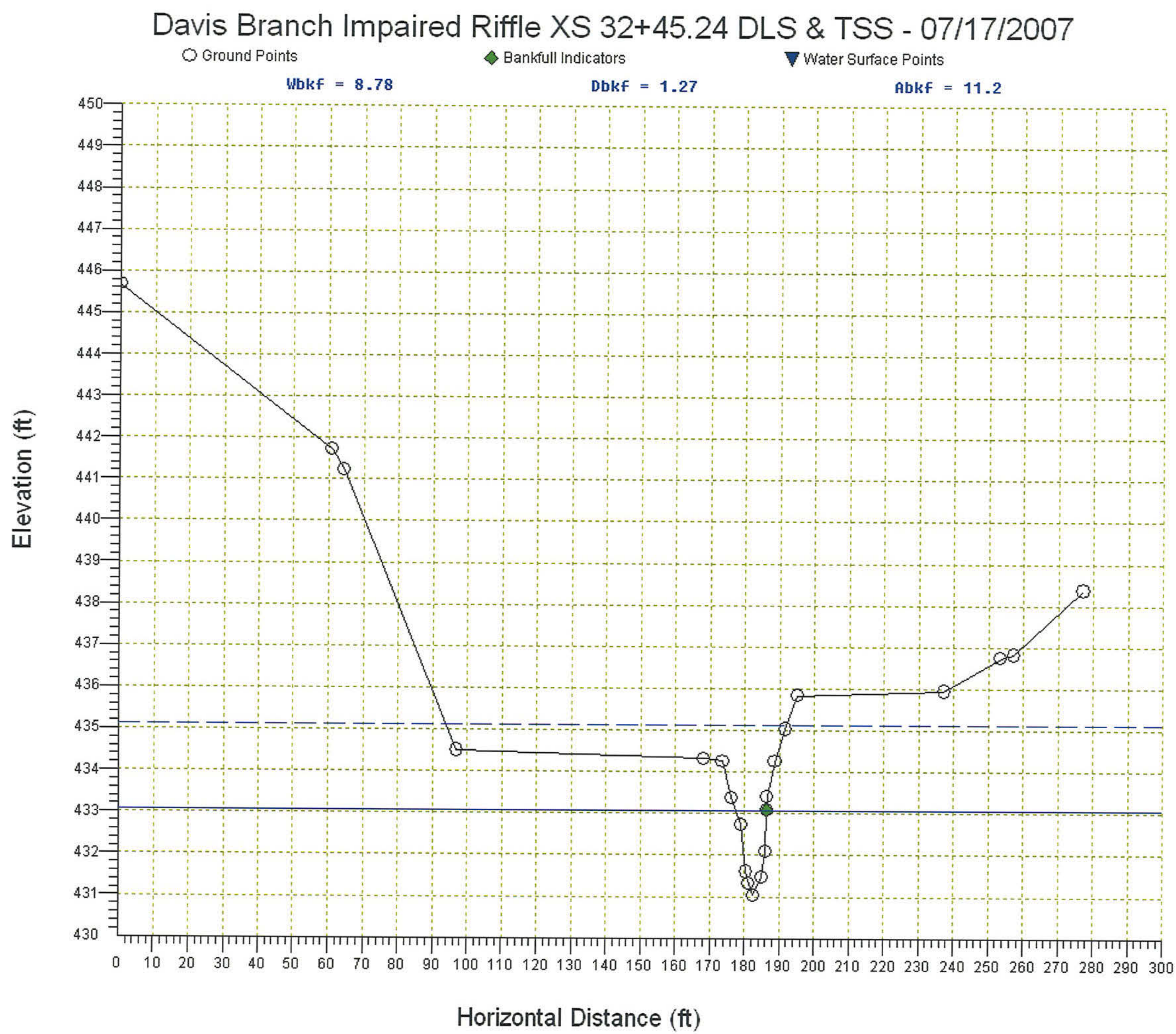
Cross Sectional Geometry

	Channel	Left	Right
Floodprone Elevation (ft)	437.12	437.12	437.12
Bankfull Elevation (ft)	435.9	435.9	435.9
Floodprone Width (ft)	96.35	-----	-----
Bankfull Width (ft)	12.58	6.54	6.04
Entrenchment Ratio	7.66	-----	-----
Mean Depth (ft)	0.87	0.92	0.81
Maximum Depth (ft)	1.22	1.22	1.2
Width/Depth Ratio	14.46	7.11	7.46
Bankfull Area (sq ft)	10.93	6.01	4.92
Wetted Perimeter (ft)	12.98	7.95	7.42
Hydraulic Radius (ft)	0.84	0.76	0.66
Begin BKF Station	115.38	115.38	121.92
End BKF Station	127.96	121.92	127.96

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.02162	0	0
Shear Stress (lb/sq ft)	1.13		
Movable Particle (mm)	166.7		


Davis Branch Impaired Riffle XS 32+45.24 DLS & TSS - 07/17/2007
Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 8.78
Dbkf = 1.27
Abkf = 11.2
Elevation (ft)
Horizontal Distance (ft)
450
449
448
447
446
445
444
443
442
441
440
439
438
437
436
435
434
433
432
431
430
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250
260
270
280
290
300

RIVERMORPH CROSS SECTION SUMMARY

River Name: Davis Branch
Reach Name: Enhancement 1 Reach
Cross Section Name: Riffle XS 32+45.24 DLS & TSS
Survey Date: 07/17/2007

Cross Section Data Entry

BM Elevation: 433.3 ft
Backsight Rod Reading: 6.42 ft

TAPE	FS	ELEV	NOTE
0	0	445.68	
60.92	0	441.72	
64.47	0	441.22	
96.94	0	434.5	FP
168.17	0	434.32	FP
173.57	0	434.26	LB
176.17	0	433.38	
179.07	0	432.74	
180.37	0	431.6	
181.27	0	431.32	Bot LB
182.57	0	431.03	TW
184.97	0	431.47	Bot RB
185.97	0	432.08	
186.35	0	433.07	BKF
186.47	0	433.41	RB
188.67	0	434.25	FP
191.57	0	435.03	FP
195.17	0	435.83	FP
237.14	0	435.94	
253.5	0	436.74	
257.26	0	436.82	
277.06	0	438.37	

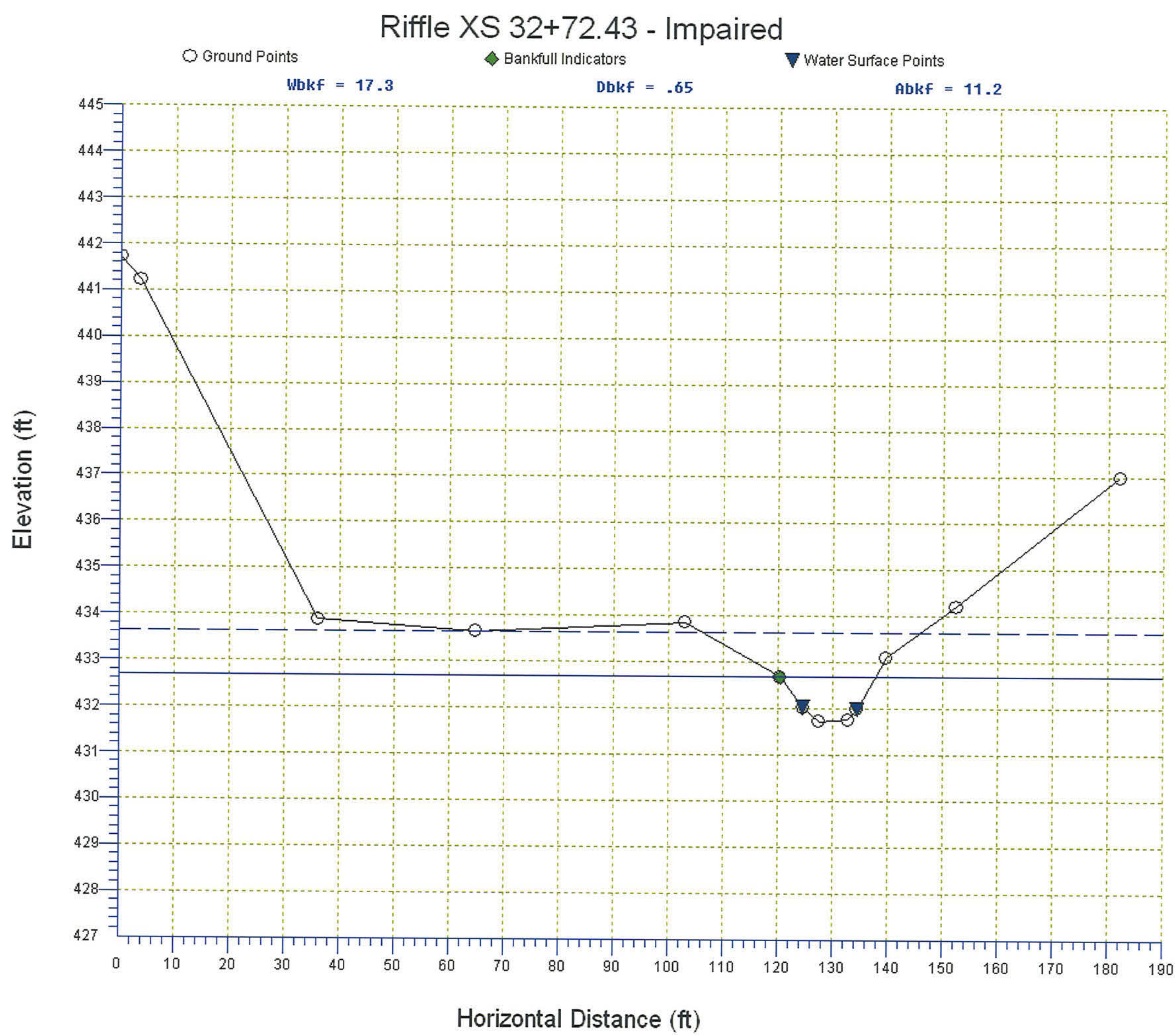
Cross Sectional Geometry

	Channel	Left	Right
Floodprone Elevation (ft)	435.11	435.11	435.11
Bankfull Elevation (ft)	433.07	433.07	433.07
Floodprone Width (ft)	97.94	-----	-----
Bankfull Width (ft)	8.78	5.07	3.71
Entrenchment Ratio	11.16	-----	-----
Mean Depth (ft)	1.27	1.08	1.54
Maximum Depth (ft)	2.04	2.04	2.03
Width/Depth Ratio	6.91	4.69	2.41
Bankfull Area (sq ft)	11.18	5.47	5.71
Wetted Perimeter (ft)	10.21	7.63	6.63
Hydraulic Radius (ft)	1.1	0.72	0.86
Begin BKF Station	177.57	177.57	182.64
End BKF Station	186.35	182.64	186.35

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.02162	0	0
Shear Stress (lb/sq ft)	1.48		
Movable Particle (mm)	203.2		



Riffle XS 32+72.43 - Impaired
Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 17.3
Dbkf = .65
Abkf = 11.2
Elevation (ft)
445
444
443
442
441
440
439
438
437
436
435
434
433
432
431
430
429
428
427
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
Horizontal Distance (ft)

Impaired Riffle XS 32+72.43.txt
RIVERMORPH CROSS SECTION SUMMARY

River Name: Davis Branch
Reach Name: Enhancement 1 Reach
Cross Section Name: Riffle XS 32+72.43
Survey Date: 03/29/2007

Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0	0	441.72	
3.55	0	441.23	
36.02	0	433.89	
64.78	0	433.64	
102.98	0	433.85	
120.36	0	432.68	BKF
124.45	0	432.03	LEW
127.43	0	431.72	TW
132.68	0	431.75	SB
134.35	0	431.98	REW
139.62	0	433.1	RB
152.38	0	434.21	
182.07	0	437.01	

Cross Sectional Geometry

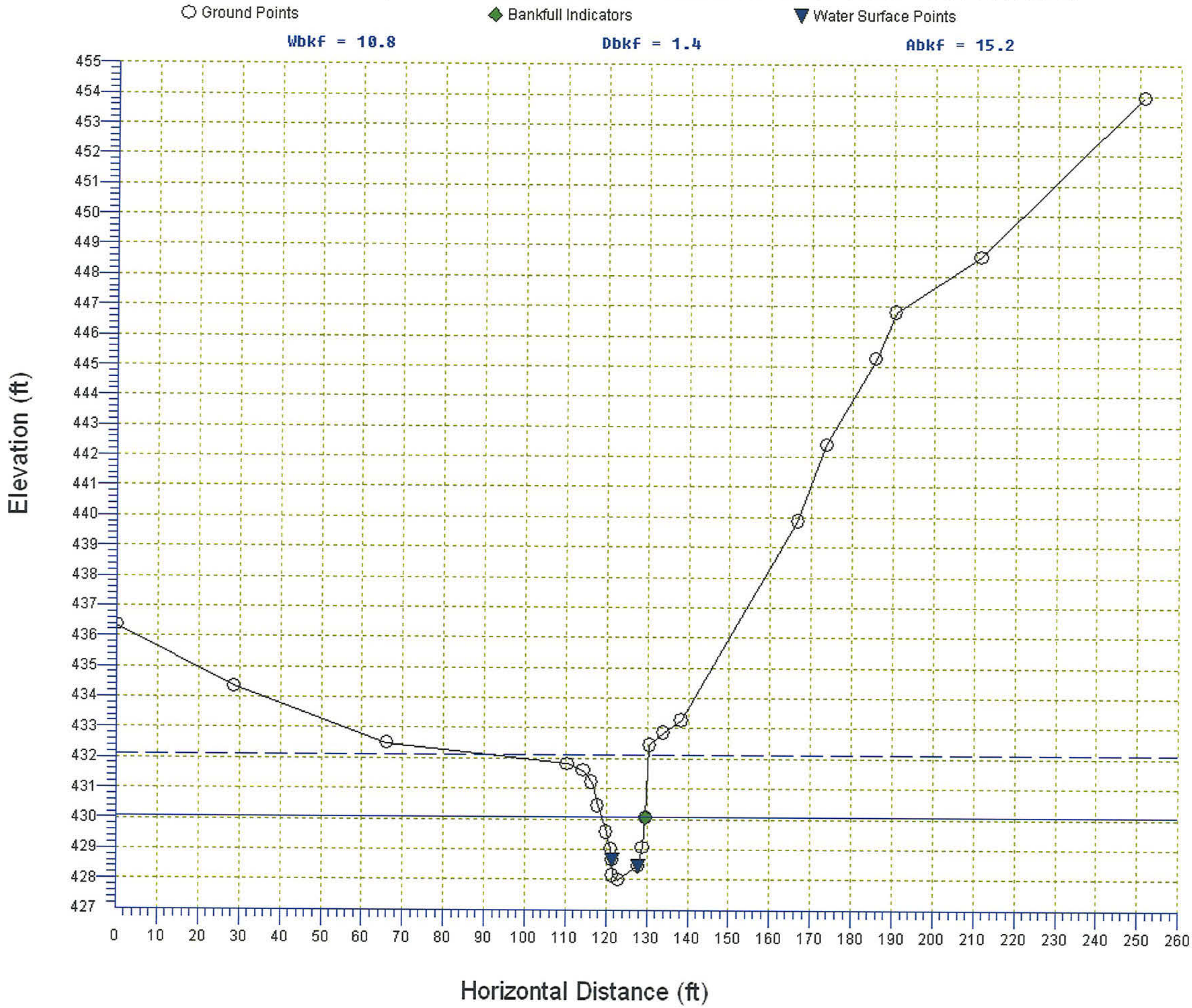
	Channel	Left	Right
Floodprone Elevation (ft)	433.64	433.64	433.64
Bankfull Elevation (ft)	432.68	432.68	432.68
Floodprone Width (ft)	39.73	-----	-----
Bankfull Width (ft)	17.28	8.51	8.77
Entrenchment Ratio	2.3	-----	-----
Mean Depth (ft)	0.65	0.6	0.7
Maximum Depth (ft)	0.96	0.96	0.95
Width/Depth Ratio	26.58	14.18	12.53
Bankfull Area (sq ft)	11.2	5.1	6.1
Wetted Perimeter (ft)	17.44	9.53	9.81
Hydraulic Radius (ft)	0.64	0.54	0.62
Begin BKF Station	120.36	120.36	128.87
End BKF Station	137.64	128.87	137.64

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.02162	0	0
Shear Stress (lb/sq ft)	0.86		
Movable Particle (mm)	136.5		

Davis Branch Impaired Pool XS 33+49.25 DLS & TSS - 07/17/2007



RIVERMORPH CROSS SECTION SUMMARY

River Name:	Davis Branch
Reach Name:	Enhancement 1 Reach
Cross Section Name:	Pool XS 33+49.25 DLS & TSS
Survey Date:	03/29/2007

Cross Section Data Entry

BM Elevation:	0 ft
Backsight Rod Reading:	0 ft

TAPE	FS	ELEV	NOTE
0	0	436.35	
28.69	0	434.36	
66.05	0	432.5	
110.33	0	431.82	LB
114.33	0	431.59	
116.33	0	431.21	
117.83	0	430.43	
119.93	0	429.57	
121.13	0	429	BR
121.33	0	428.63	LEW
121.53	0	428.13	SB
122.93	0	427.98	TW
127.73	0	428.45	REW
128.93	0	429.06	
129.58	0	430.04	BKF
130.53	0	432.44	RB
133.93	0	432.85	FP
138.33	0	433.26	FP
166.62	0	439.87	
173.68	0	442.39	
185.69	0	445.26	
190.47	0	446.8	
211.3	0	448.63	
251.19	0	453.93	

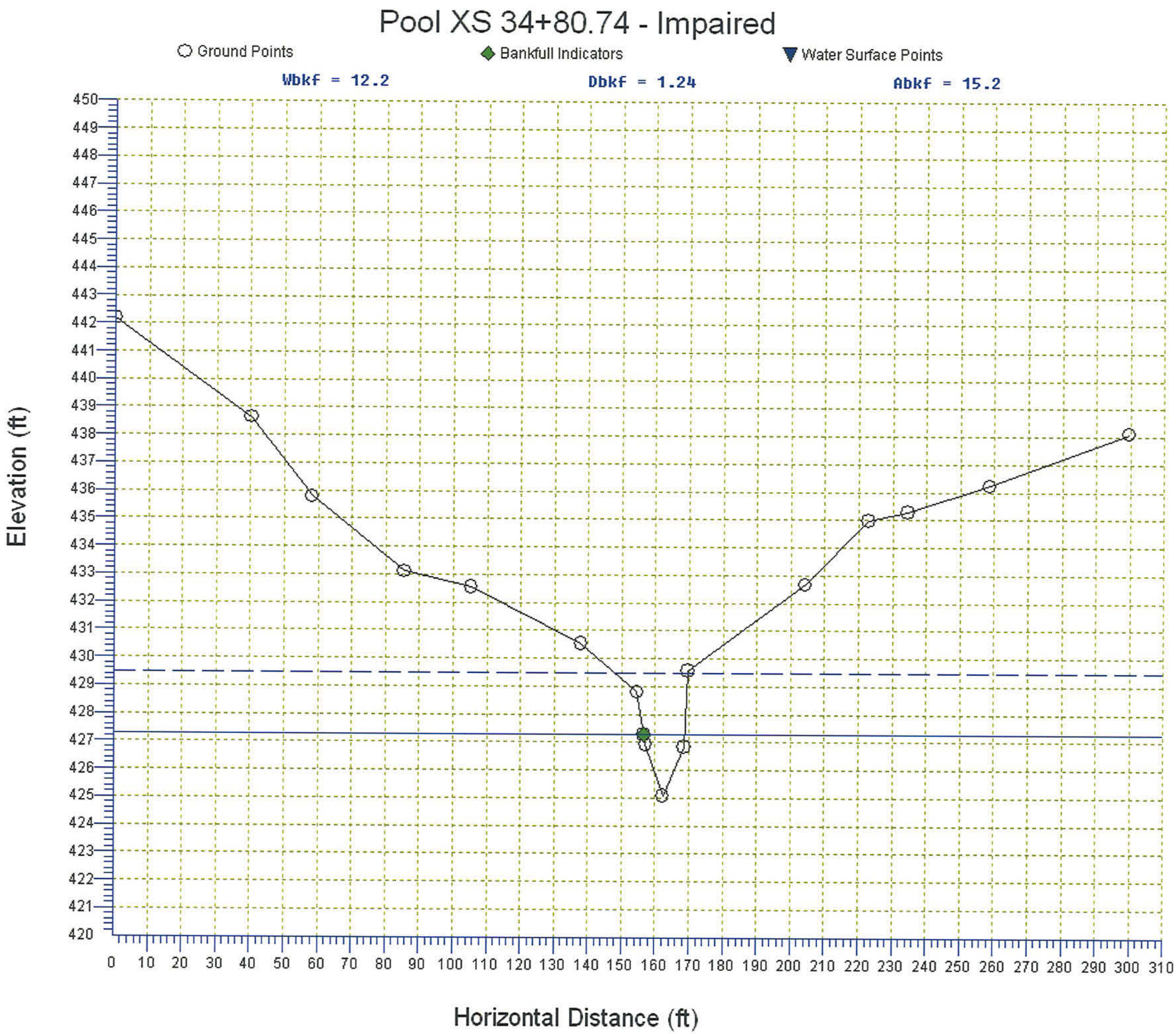
Cross Sectional Geometry

	Channel	Left	Right
Floodprone Elevation (ft)	432.1	432.1	432.1
Bankfull Elevation (ft)	430.04	430.04	430.04
Floodprone Width (ft)	38.3	-----	-----
Bankfull Width (ft)	10.8	10.38	0.42
Entrenchment Ratio	3.55	-----	-----
Mean Depth (ft)	1.4	1.45	0.32
Maximum Depth (ft)	2.06	2.06	0.63
Width/Depth Ratio	7.71	7.16	1.31
Bankfull Area (sq ft)	15.15	15.02	0.13
Wetted Perimeter (ft)	12.28	12.15	1.39
Hydraulic Radius (ft)	1.23	1.24	0.1
Begin BKF Station	118.78	118.78	129.16
End BKF Station	129.58	129.16	129.58

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.02162	0	0
Shear Stress (lb/sq ft)	1.66		
Movable Particle (mm)	220.6		



Pool XS 34+80.74 - Impaired
Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 12.2
Dbkf = 1.24
Abkf = 15.2
Elevation (ft)
Horizontal Distance (ft)

RIVERMORPH CROSS SECTION SUMMARY

River Name:	Davis Branch
Reach Name:	Enhancement 1 Reach
Cross Section Name:	Pool XS 34+80.74
Survey Date:	03/29/2007

Cross Section Data Entry

BM Elevation:	0 ft
Backsight Rod Reading:	0 ft

TAPE	FS	ELEV	NOTE
0	0	442.19	
40.19	0	438.63	
58.23	0	435.79	
85.53	0	433.11	
105.37	0	432.56	
137.86	0	430.53	
154.57	0	428.8	LB
156.55		427.28	BKF
157.02	0	426.93	
162.31	0	425.08	TW
168.6	0	426.84	
169.61	0	429.57	RB
204.28	0	432.68	
222.9	0	434.97	
234.52	0	435.28	
258.73	0	436.23	
299.61	0	438.11	

Cross Sectional Geometry

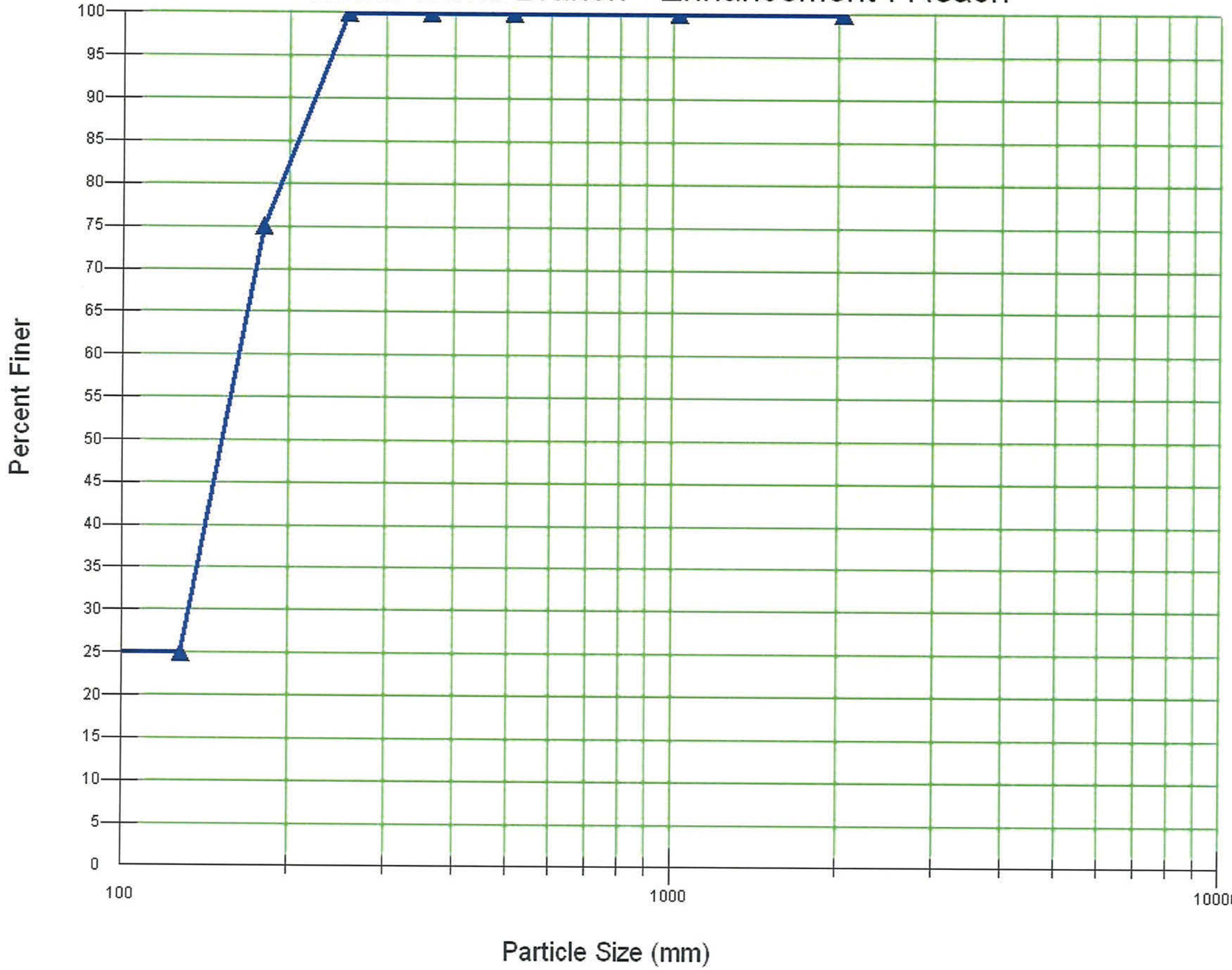
	Channel	Left	Right
Floodprone Elevation (ft)	429.48	429.48	429.48
Bankfull Elevation (ft)	427.28	427.28	427.28
Floodprone Width (ft)	21.57	-----	-----
Bankfull Width (ft)	12.21	5.4	6.81
Entrenchment Ratio	1.77	-----	-----
Mean Depth (ft)	1.24	1.12	1.34
Maximum Depth (ft)	2.2	2.07	2.2
Width/Depth Ratio	9.85	4.82	5.08
Bankfull Area (sq ft)	15.17	6.06	9.11
Wetted Perimeter (ft)	13.19	7.88	9.46
Hydraulic Radius (ft)	1.15	0.77	0.96
Begin BKF Station	156.55	156.55	161.95
End BKF Station	168.76	161.95	168.76

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.02162	0	0
Shear Stress (lb/sq ft)	1.55		
Movable Particle (mm)	210.0		

Riffle XS 0+76 Bedrock Protrusion Heights
07/17/2007
Lower Davis Branch - Enhancement I Reach



LDB Riffle XS 0+76 BR Protrusion Summary Rpt.txt
RIVERMORPH PARTICLE SUMMARY

River Name: Davis Branch
Reach Name: Davis Branch UT - Impaired
Sample Name: Riffle XS 0+76 Bedrock Protrusion Heights
Survey Date: 07/17/2007

Size (mm)	TOT #	ITEM %	CUM %
0 - 0.062	0	0.00	0.00
0.062 - 0.125	0	0.00	0.00
0.125 - 0.25	0	0.00	0.00
0.25 - 0.50	0	0.00	0.00
0.50 - 1.0	0	0.00	0.00
1.0 - 2.0	0	0.00	0.00
2.0 - 4.0	0	0.00	0.00
4.0 - 5.7	0	0.00	0.00
5.7 - 8.0	0	0.00	0.00
8.0 - 11.3	0	0.00	0.00
11.3 - 16.0	0	0.00	0.00
16.0 - 22.6	0	0.00	0.00
22.6 - 32.0	0	0.00	0.00
32 - 45	0	0.00	0.00
45 - 64	0	0.00	0.00
64 - 90	15	25.00	25.00
90 - 128	0	0.00	25.00
128 - 180	30	50.00	75.00
180 - 256	15	25.00	100.00
256 - 362	0	0.00	100.00
362 - 512	0	0.00	100.00
512 - 1024	0	0.00	100.00
1024 - 2048	0	0.00	100.00
Bedrock	0	0.00	100.00

D16 (mm)	80.64
D35 (mm)	138.4
D50 (mm)	154
D84 (mm)	207.36
D95 (mm)	240.8
D100 (mm)	256
Silt/Clay (%)	0
Sand (%)	0
Gravel (%)	0
Cobble (%)	100
Boulder (%)	0
Bedrock (%)	0

Total Particles = 60.

RIVERMorph 4.1.1 Professional - Davis Branch Stream Restoration - Iter 2_4.1

File Tools Help

- Davis Branch
  - Davis Branch Reference Reach
  - Restoration Reach - Impaired
  - Enhancement 1 Reach
    - Survey Data
    - Cross Sections
      - Riffle XS 32+45.24 DLS &
      - Pool XS 33+49.25 - DLS
      - 31+57.26 - UT1 Conf. - T.
      - B.O.R. Geomorph Survey
      - Riffle XS 24+90.05
      - Design Riffle XS
      - Riffle XS 27+19.30
      - Design Riffle XS 24+90.0
      - Pool XS 26+16.08
      - Design Pool XS 26+16.08
      - Design Pool XS
      - Design Riffle XS 27+19.3
      - Riffle XS 23+43.21
      - Riffle XS 32+72.43
      - Design Riffle XS 32+72.4
      - Pool XS 33+49.25 DLS &
      - Design Pool XS 33+49.25
      - Riffle XS 36+30.27
      - Pool XS 30+53.38
      - Riffle XS 29+46.39
      - Pool XS 34+80.74
      - Design Riffle XS 23+43.2
      - Riffle XS 28+14.40
      - Design Riffle XS 28+14.4
      - Riffle XS 24+03.75 T.O.R
      - Design Riffle XS 24+03.7
      - Riffle XS 31+18.14
      - Design Riffle XS 31+18.1
      - Design Riffle XS 29+46.3
      - Design Pool XS 30+53.38
      - Design Pool XS 34+80.74
      - Design Riffle XS 36+30.2
      - Design Riffle XS 32+45.2
      - 34+57.26 - B.O.R. Geomo
    - Banks
    - Profiles
    - Particles
    - Classification
    - Ratios
    - Pfankuch
    - BEHI
      - Pool XS 33+49.25
    - SVAP
    - RBP
    - Designs
    - Notes
  - Davis Branch - UT1

Report | Rosgen WARSSS Worksheets: 5-8 5-9 5-10

Input Data

06/05/2008

Bankfull Height (ft)	2.06
Bank Height (ft)	3.84
Root Depth (ft)	0.5
Root Density (%)	5
Bank Angle (degrees)	90
Surface Protection (%)	5
Total Bank Length (ft)	1289
Total Reach Ln (ft) *	1289
Bank Material Adjustment	Silt/Clay 0
Bank Stratification Adjustment	Yes 3

- ( ) Use Colorado Erosion Data (1989)
- ( ) Use Yellowstone Erosion Data (1989)
- (•) User Specified Bank Erosion Rates
  Erosion Rate: 0.25 (ft/yr)

* Note: This includes the entire length of the reach and not just the individual BEHI length. Length must be the same for all BEHIs.

Select a Near Bank Stress Method

NBS Method #6: Near-Bank Shear Stress

Mean Depth (ft)	1.4
Average Slope (ft/ft)	0.0216
NB Max. Depth (ft)	2.06
NB Slope (ft/ft)	0.0216
Shear Stress (lb/sq ft)	1.89
NB Shear Stress (lb/sq ft)	2.78
Stress Ratio	1.47

Links #1 #2 #3 #4 #5 #6 #7

Results

[ ] Override BEHI Calculation

BEHI Numerical Rating	46.3
BEHI Adjective Rating	Extreme
NBS Estimate Method	#6
NBS Numerical Rating	1.47
NBS Adjective Rating	Very High
Predicted Erosion (yd^3/yr)	45.83
Predicted Erosion (ton/yr)	59.58

Create a Reach-Scale Bank Summary Report

Start | Inbox - Microsoft Outlook | Cross-Section Summary ... | Davis Branch & UT Resto... | RIVERMorph 4.1.1 Pro... | Impaired Rest Reach Ero... | 10:07 AM

RIVERMORPH BANK EROSION HARZARD INDEX (BEHI)

River Name: Davis Branch
Reach Name: Enhancement 1 Reach
BEHI Name: Pool XS 33+49.25
Survey Date: 06/05/2008

Bankfull Height: 2.06 ft
Bank Height: 3.84 ft
Root Depth: 0.5 ft
Root Density: 5 %
Bank Angle: 90 Degrees
Surface Protection: 5 %

Bank Material Adjustment: Silt/Clay 0

Bank Stratification Adjustment: Yes 3

Erosion Loss Curve: Yellowstone

NBS Method #6: Near-Bank Shear Stress

Mean Depth: 1.4 ft
NB Max Depth: 2.06 ft
Shear Stress: 1.89 lb/sq/ft
Stress Ratio: 1.47

Average Slope: 0.0216 ft/ft
NB Slope: 0.0216 ft/ft
NB Shear Stress: 2.78 lb/sq/ft

BEHI Numerical Rating: 46.3
BEHI Adjective Rating: Extreme
NBS Numerical Rating: 1.47
NBS Adjective Rating: Very High
Total Bank Length: 1289 ft
Estimated Sediment Loss: 45.83 Cu Yds per Year
Estimated Sediment Loss: 59.58 Tons per Year

RIVERMORPH BEHI SUMMARY REPORT

River Name: Davis Branch
Reach Name: Enhancement 1 Reach

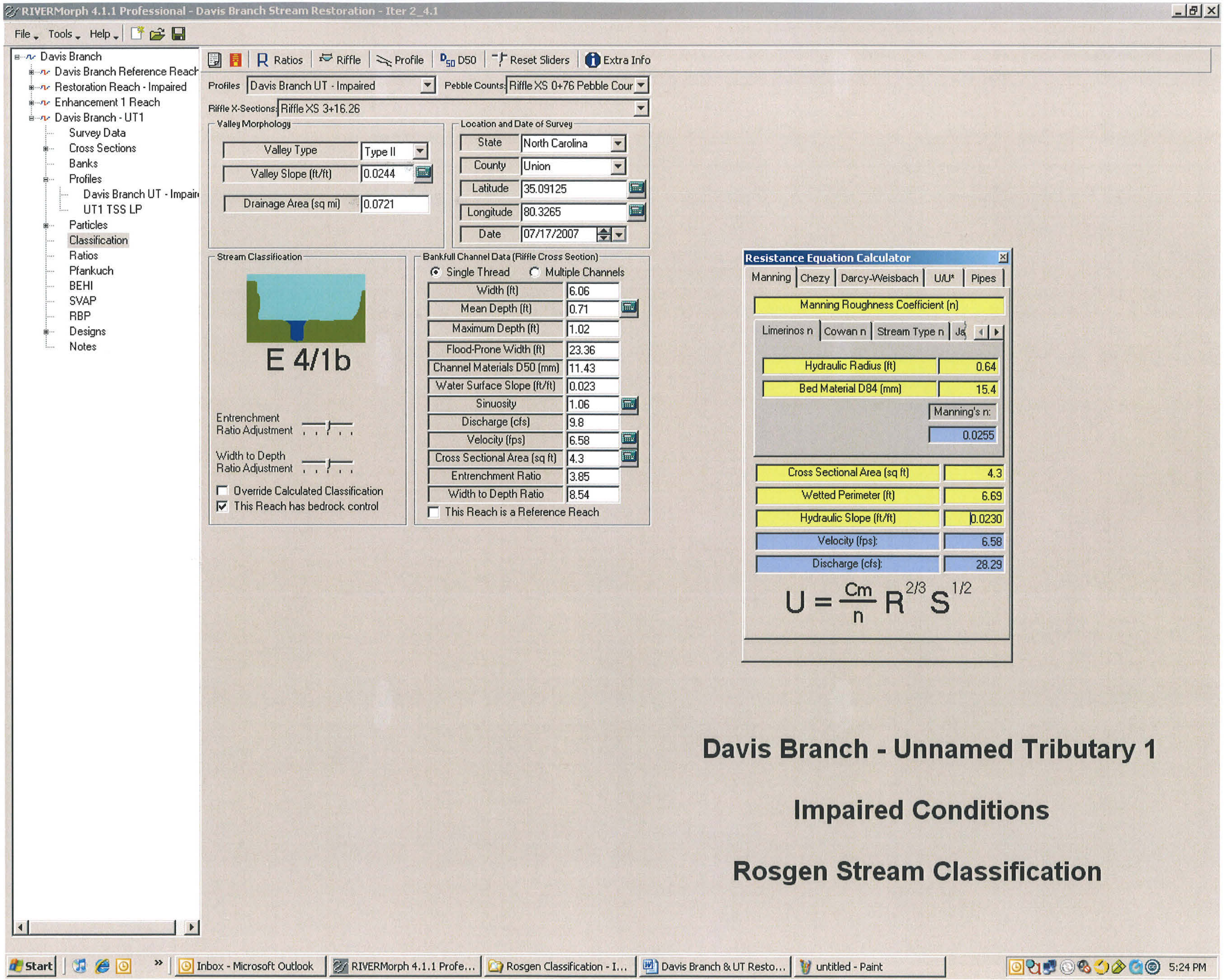
Table 1. Bank Identification Summary

Bank	Name
1	Pool XS 33+49.25

Table 2. Predicted Annual Bank Erosion Rates

Bank	BEHI Numeric Rating	BEHI Adjective Rating	NBS Adjective Rating	Length ft	Loss cu yds/yr	Loss tons/yr
1	46.3	Extreme	Very High	1289	45.83	59.58
Totals				1289	45.83	59.58

Total Reach Ln: 1289 Total Loss (tons/yr) per ft of Reach: 0.0462



Davis Branch - Unnamed Tributary 1

Impaired Conditions

Rosgen Stream Classification

Worksheet 5-3. Field form for Level II stream classification (Rosgen, 1996; Rosgen and Silvey, 2005).

Stream:	**Davis Branch - Unnamed Tributary 1 - Impaired Conditions**		
Basin:	**Yadkin - Pee Dee**	Drainage Area: **46.12** acres	**0.0721** mi^2
Location:	**Eddie Staton Property**		
Twp.&Rge: **;**		Sec.&Qtr.: **;**	
Cross-Section Monuments (Lat./Long.):	**35.09125 Lat / 80.3265 Long**		Date: **07/17/07**
Observers:	**M. Hebert, W. Knotts, J. Hines, S. Peffer**		Valley Type: II

Bankfull WIDTH (W_{bkf}) WIDTH of the stream channel at bankfull stage elevation, in a riffle section.	**6.06**	ft
Bankfull DEPTH (d_{bkf}) Mean DEPTH of the stream channel cross-section, at bankfull stage elevation, in a riffle section ($d_{bkf} = A / W_{bkf}$).	**0.71**	ft
Bankfull X-Section AREA (A_{bkf}) AREA of the stream channel cross-section, at bankfull stage elevation, in a riffle section.	**4.3**	ft^2
Width/Depth Ratio (W_{bkf} / d_{bkf}) Bankfull WIDTH divided by bankfull mean DEPTH, in a riffle section.	**8.54**	ft/ft
Maximum DEPTH (d_{mbkf}) Maximum depth of the bankfull channel cross-section, or distance between the bankfull stage and Thalweg elevations, in a riffle section.	**1.02**	ft
WIDTH of Flood-Prone Area (W_{fpa}) Twice maximum DEPTH, or (2 x d_{mbkf}) = the stage/elevation at which flood-prone area WIDTH is determined in a riffle section.	**23.36**	ft
Entrenchment Ratio (ER) The ratio of flood-prone area WIDTH divided by bankfull channel WIDTH (W_{fpa} / W_{bkf}) (riffle section).	**3.85**	ft/ft
Channel Materials (Particle Size Index) D_{50} The D_{50} particle size index represents the mean diameter of channel materials, as sampled from the channel surface, between the bankfull stage and Thalweg elevations.	**11.43**	mm
Water Surface SLOPE (S) Channel slope = "rise over run" for a reach approximately 20–30 bankfull channel widths in length, with the "riffle-to-riffle" water surface slope representing the gradient at bankfull stage.	**0.023**	ft/ft
Channel SINUOSITY (k) Sinuosity is an index of channel pattern, determined from a ratio of stream length divided by valley length (SL / VL); or estimated from a ratio of valley slope divided by channel slope (VS / S).	**1.06**	

Stream Type → **E 4/1b** ← (See **Figure 2-14**)

Worksheet 5-4. Morphological relations, including dimensionless ratios of river reach sites (Rosgen and Silvey, 2005).

Stream: **Davis Branch - UT1 - Impaired Conditions** Location: **Eddie Staton Property**

Observers: **Hebert, Knotts, Hines & Peffer** Date: **07/17/07** Valley Type: **II** Stream Type: **E 4/1b**

River Reach Summary Data

Channel Dimension

Mean Riffle Depth (d_{bkf})	0.72	ft	Riffle Width (W_{bkf})	6.2	ft	Riffle Area (A_{bkf})	4.3	ft^2
Mean Pool Depth (d_{bkfp})	0.83	ft	Pool Width (W_{bkfp})	7.00	ft	Pool Area (A_{bkfp})	5.51	ft^2
Mean Pool Depth/Mean Riffle Depth	1.10	d_{bkfp}/d_{bkf}	Pool Width/Riffle Width	1.13	W_{bkfp}/W_{bkf}	Pool Area / Riffle Area	1.24	A_{bkfp}/A_{bkf}
Max Riffle Depth (d_{mbkf})	1.00	ft	Max Pool Depth (d_{mbkfp})	2.00	ft	Max Riffle Depth/Mean Riffle Depth	1.39	
Max Pool Depth/Mean Riffle Depth	2.78					Point Bar Slope	N/A	
Streamflow: Estimated Mean Velocity at Bankfull Stage (u_{bkf})				6.58	ft/s	Estimation Method	Manning's	
Streamflow: Estimated Discharge at Bankfull Stage (Q_{bkf})				9.8	cfs	Drainage Area	0.0721	mi^2

Channel Pattern

Geometry	Mean	Min	Max		Dimensionless Geometry Ratios	Mean	Min	Max
Meander Length (Lm)				ft	Meander Length Ratio (Lm/W_{bkf})			
Radius of Curvature (Rc)				ft	Radius of Curvature/Riffle Width (Rc/W_{bkf})			
Belt Width (W_{blt})				ft	Meander Width Ratio (W_{blt}/W_{bkf})			
Individual Pool Length	19.2	7.22	31.86	ft	Pool Length/Riffle Width	3.10	1.16	5.14
Pool to Pool Spacing	76.87	15.56	324.84	ft	Pool to Pool Spacing/Riffle Width	12.40	2.51	52.39
Riffle Length	8.67	1.13	305.70	ft	Riffle Length/Riffle Width	1.40	0.18	49.31

Channel Profile

Valley Slope (VS)	0.0244	ft/ft	Average Water Surface Slope (S)	0.0230	ft/ft	Sinuosity (VS/S)	1.06
Stream Length (SL)	735	ft	Valley Length (VL)	693	ft	Sinuosity (SL/VL)	1.06
Low Bank Height (LBH) start	1.79	ft	Max Riffle Depth start	0.63	ft	Bank-Height Ratio (BHR) (LBH/Max Riffle Depth) start	2.84
Low Bank Height (LBH) end	3.45	ft	Max Riffle Depth end	1.11	ft	Bank-Height Ratio (BHR) (LBH/Max Riffle Depth) end	3.12

Facet Slopes	Mean	Min	Max		Dimensionless Slope Ratios	Mean	Min	Max
Riffle Slope (S_{rif})	0.0586	0.0372	0.1001	ft/ft	Riffle Slope/Average Water Surface Slope (S_{rif} / S)	2.55	1.62	4.35
Run Slope (S_{run})				ft/ft	Run Slope/Average Water Surface Slope (S_{run} / S)			
Pool Slope (S_p)	0.0016	0.0003	0.0023	ft/ft	Pool Slope/Average Water Surface Slope (S_p / S)	0.07	0.01	0.10
Glide Slope (S_g)				ft/ft	Glide Slope/Average Water Surface Slope (S_g / S)			

Feature Midpoint[a]	Mean	Min	Max		Dimensionless Depth Ratios	Mean	Min	Max
Riffle Depth (d_{rif})	0.52	0.35	0.72	ft	Riffle Depth/Mean Riffle Depth (d_{rif} / d_{bkf})	0.72	0.49	1.00
Run Depth (d_{run})				ft	Run Depth/Mean Riffle Depth (d_{run} / d_{bkf})			
Pool Depth (d_p)	0.83	0.57	2.00	ft	Pool Depth/Mean Riffle Depth (d_p / d_{bkf})	1.15	0.79	2.78
Glide Depth (d_g)				ft	Glide Depth/Mean Riffle Depth (d_g / d_{bkf})			

Channel Materials

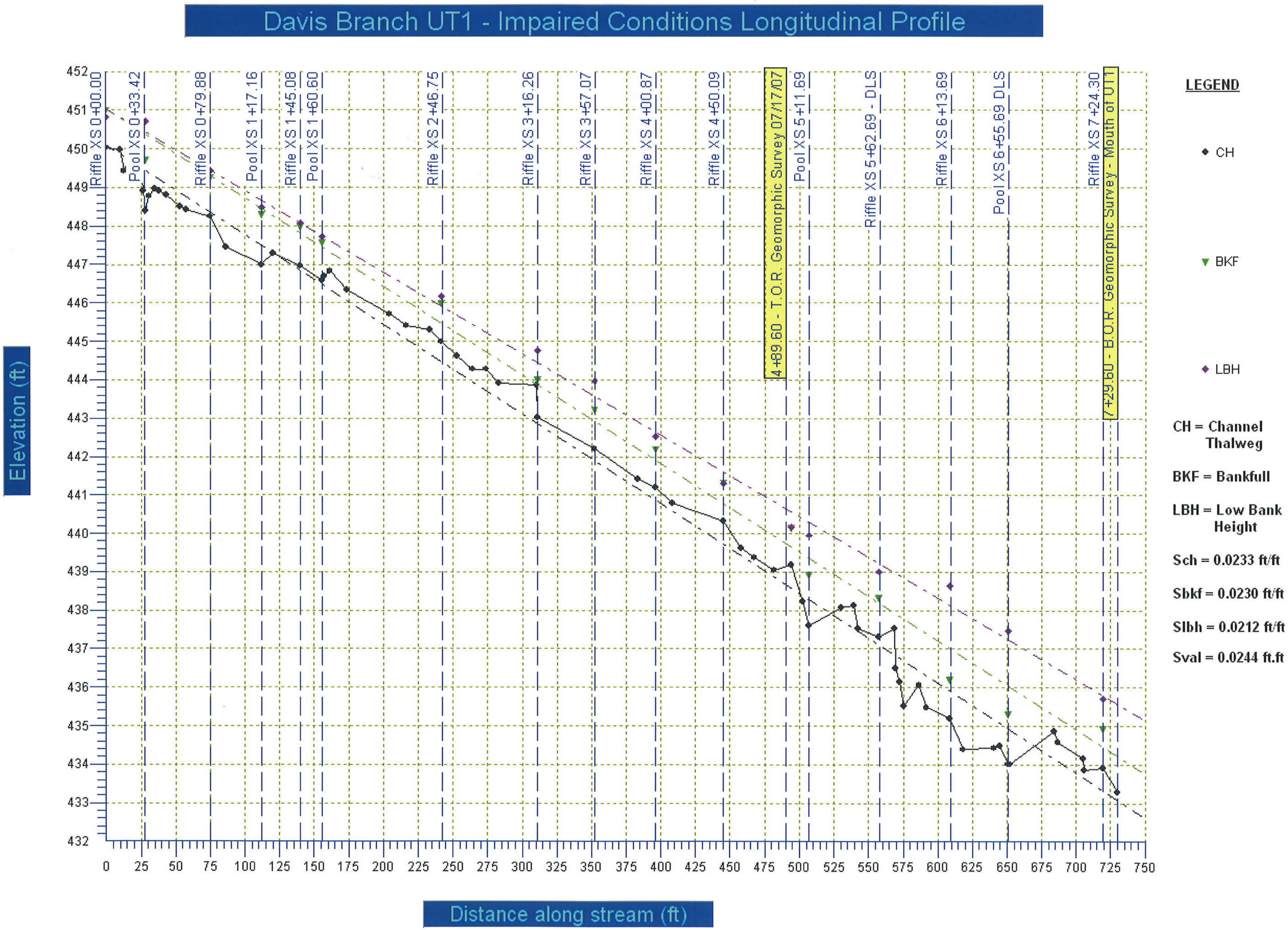
	Reach[b]	Riffle[c]	Bar		Reach[b]	Riffle[c]	Bar	Protrusion Height[d]	
% Silt/Clay	0			D_{16}	8.43			0	mm
% Sand	0			D_{35}	10.09			0	mm
% Gravel	100			D_{50}	11.43			0	mm
% Cobble	0			D_{84}	15.43			0	mm
% Boulder	0			D_{95}	20.54			0	mm
% Bedrock	0			D_{100}	32			0	mm

a Min, max, mean depths are the average mid-point values except pools, which are taken at deepest part of pool.

b Composite sample of riffles and pools within the designated reach.

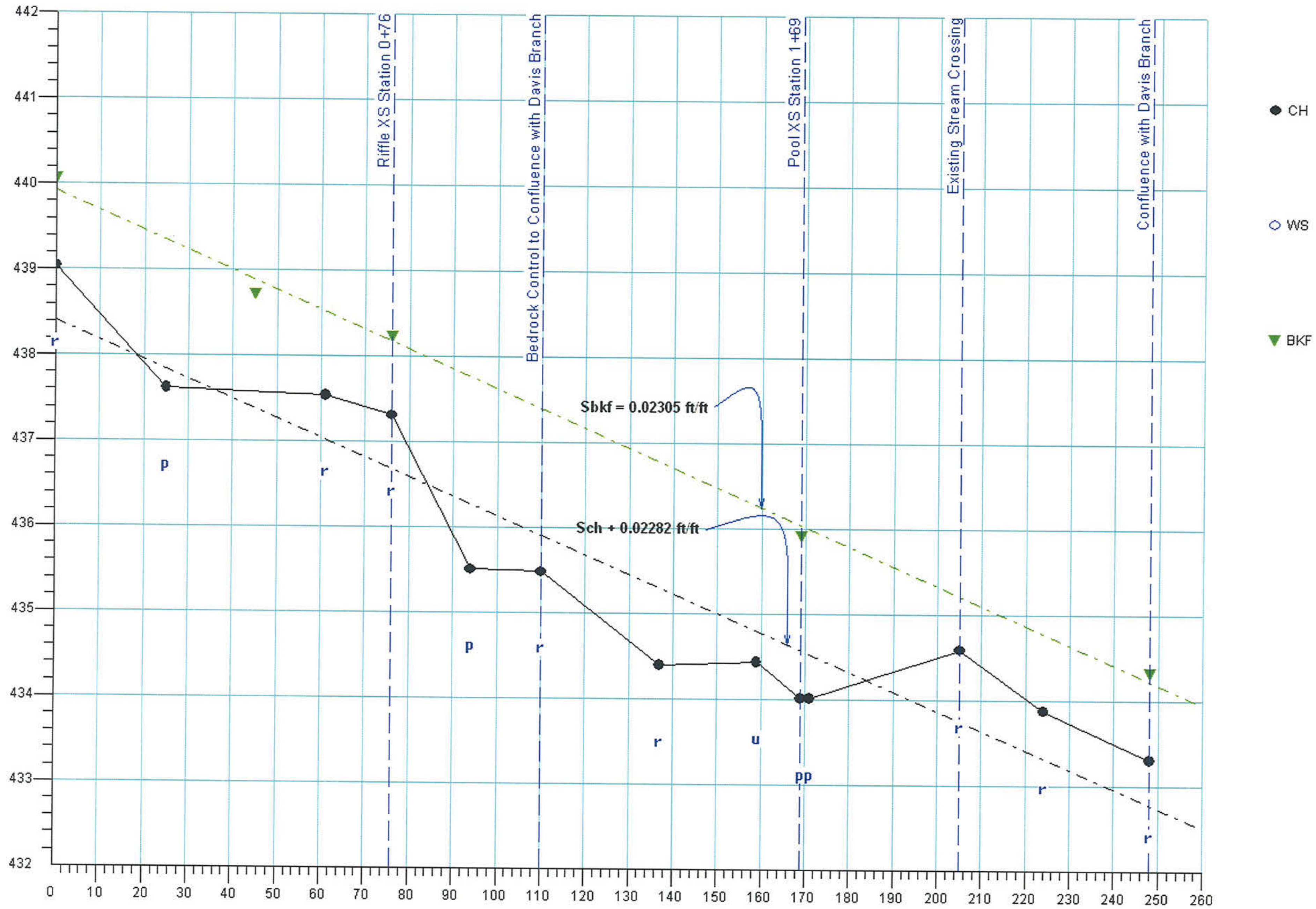
c Active bed of a riffle.

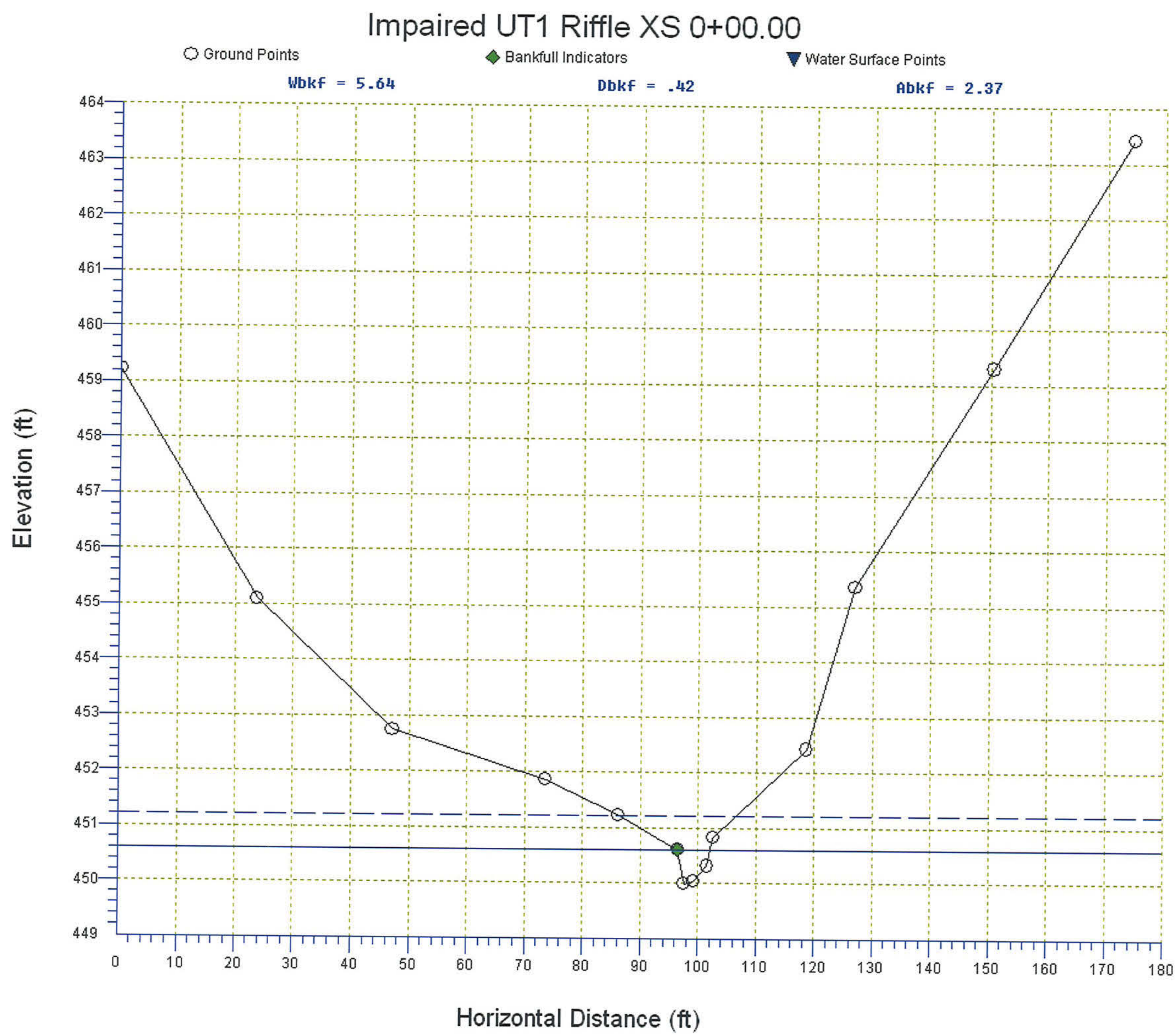
d Height of roughness feature above bed.



Davis Branch UT1 - Impaired Conditions Longitudinal Profile
Elevation (ft)
Distance along stream (ft)
Riffle XS 0+00.00
Pool XS 0+33.42
Riffle XS 0+79.88
Pool XS 1+17.16
Riffle XS 1+45.08
Pool XS 1+60.60
Riffle XS 2+46.75
Riffle XS 3+16.26
Riffle XS 3+57.07
Riffle XS 4+00.87
Riffle XS 4+50.09
4+89.60 - T.O.R. Geomorphic Survey 07/17/07
Pool XS 5+11.69
Riffle XS 5+62.69 - DLS
Riffle XS 6+13.69
Pool XS 6+55.69 DLS
Riffle XS 7+24.30
7+29.60 - B.O.R. Geomorphic Survey - Mouth of UT1
LEGEND
CH
BKF
LBH
CH = Channel Thalweg
BKF = Bankfull
LBH = Low Bank Height
Sch = 0.0233 ft/ft
Sbkf = 0.0230 ft/ft
Slbh = 0.0212 ft/ft
Sval = 0.0244 ft.ft

Davis Branch - UT1 - Impaired Conditions Profile - 07/17/2007





Impaired UT1 Riffle XS 0+00.00
Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 5.64
Dbkf = .42
Abkf = 2.37
Elevation (ft)
Horizontal Distance (ft)
464
463
462
461
460
459
458
457
456
455
454
453
452
451
450
449
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180

Impaired Riffle XS 0+00.00.txt
RIVERMORPH CROSS SECTION SUMMARY

River Name: Davis Branch
Reach Name: Davis Branch - UT1
Cross Section Name: Riffle XS 0+00.00
Survey Date: 03/29/2007

Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0	0	459.22	
23.72	0	455.09	
47.15	0	452.74	
73.58	0	451.85	
86.17	0	451.23	
96.48	0	450.6	BKF
97.62	0	449.99	TW
99.21	0	450.03	SB
101.53	0	450.31	
102.57	0	450.82	RB
118.61	0	452.42	
126.92	0	455.36	
150.49	0	459.3	
174.5	0	463.42	

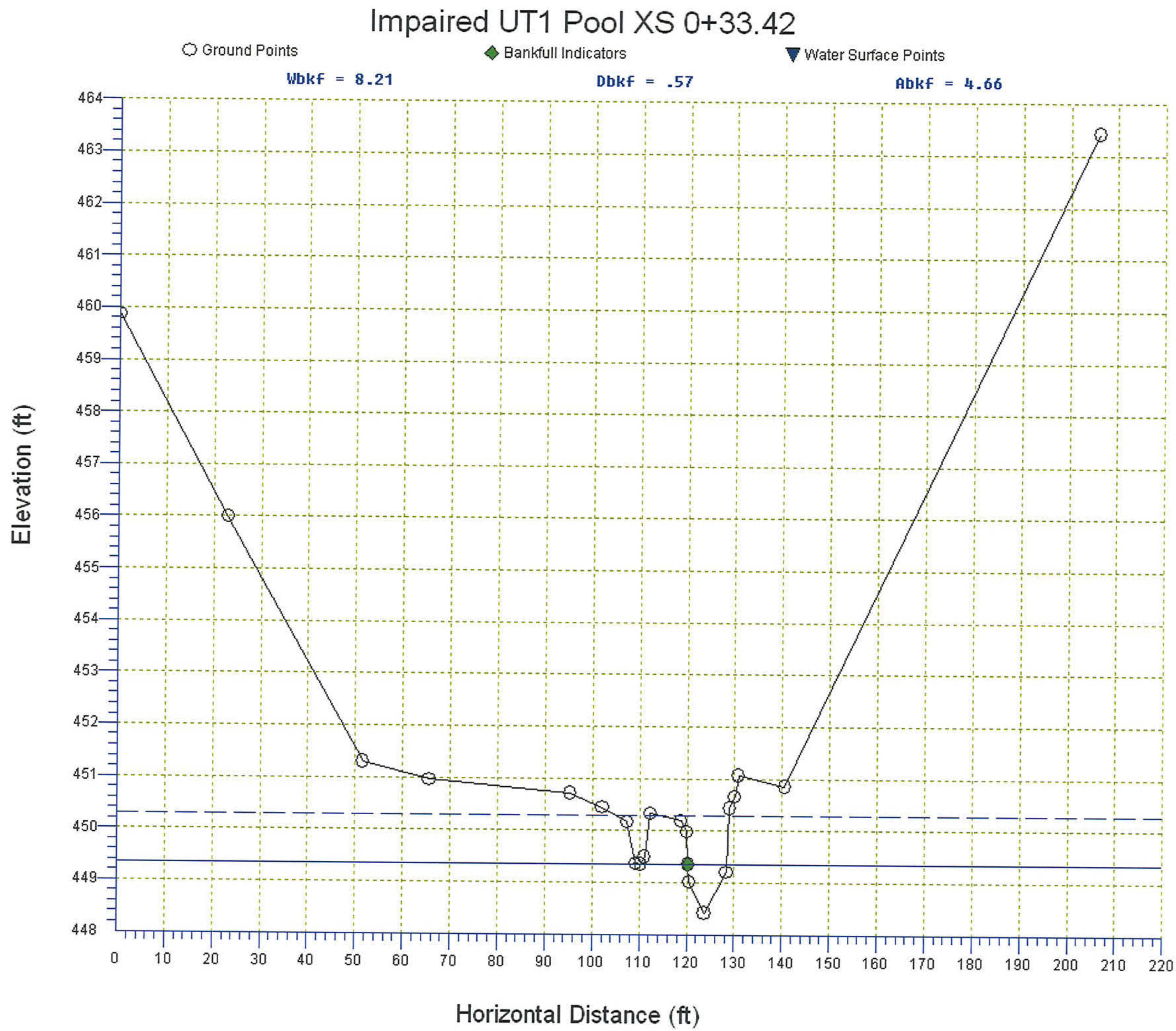
Cross Sectional Geometry

	Channel	Left	Right
Floodprone Elevation (ft)	451.21	451.21	451.21
Bankfull Elevation (ft)	450.6	450.6	450.6
Floodprone Width (ft)	19.98	-----	-----
Bankfull Width (ft)	5.64	1.24	4.4
Entrenchment Ratio	3.54	-----	-----
Mean Depth (ft)	0.42	0.33	0.45
Maximum Depth (ft)	0.61	0.61	0.61
Width/Depth Ratio	13.43	3.76	9.78
Bankfull Area (sq ft)	2.37	0.41	1.96
Wetted Perimeter (ft)	5.88	2	5.09
Hydraulic Radius (ft)	0.4	0.2	0.38
Begin BKF Station	96.48	96.48	97.72
End BKF Station	102.12	97.72	102.12

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.02297	0	0
Shear Stress (lb/sq ft)	0.57		
Movable Particle (mm)	101.0		


Impaired UT1 Pool XS 0+33.42
Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 8.21
Dbkf = .57
Abkf = 4.66
Elevation (ft)
464
463
462
461
460
459
458
457
456
455
454
453
452
451
450
449
448
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
Horizontal Distance (ft)

RIVERMORPH CROSS SECTION SUMMARY

River Name: Davis Branch
Reach Name: Davis Branch - UT1
Cross Section Name: Pool XS 0+33.42
Survey Date: 03/29/2007

Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0	0	459.87	
22.97	0	455.99	
51.68	0	451.3	
65.57	0	450.96	
95.21	0	450.71	
102.14	0	450.44	
107.33	0	450.16	
109.12	0	449.37	
110.2	0	449.35	
111.05	0	449.49	
112.17	0	450.33	
118.77	0	450.19	
119.94	0	449.98	LB
120.23		449.35	BKF
120.47	0	449.01	
123.75	0	448.41	TW
128.37	0	449.2	
128.96	0	450.43	RB
130.08	0	450.66	
130.81	0	451.06	
140.57	0	450.85	
206.15	0	463.42	

Cross Sectional Geometry

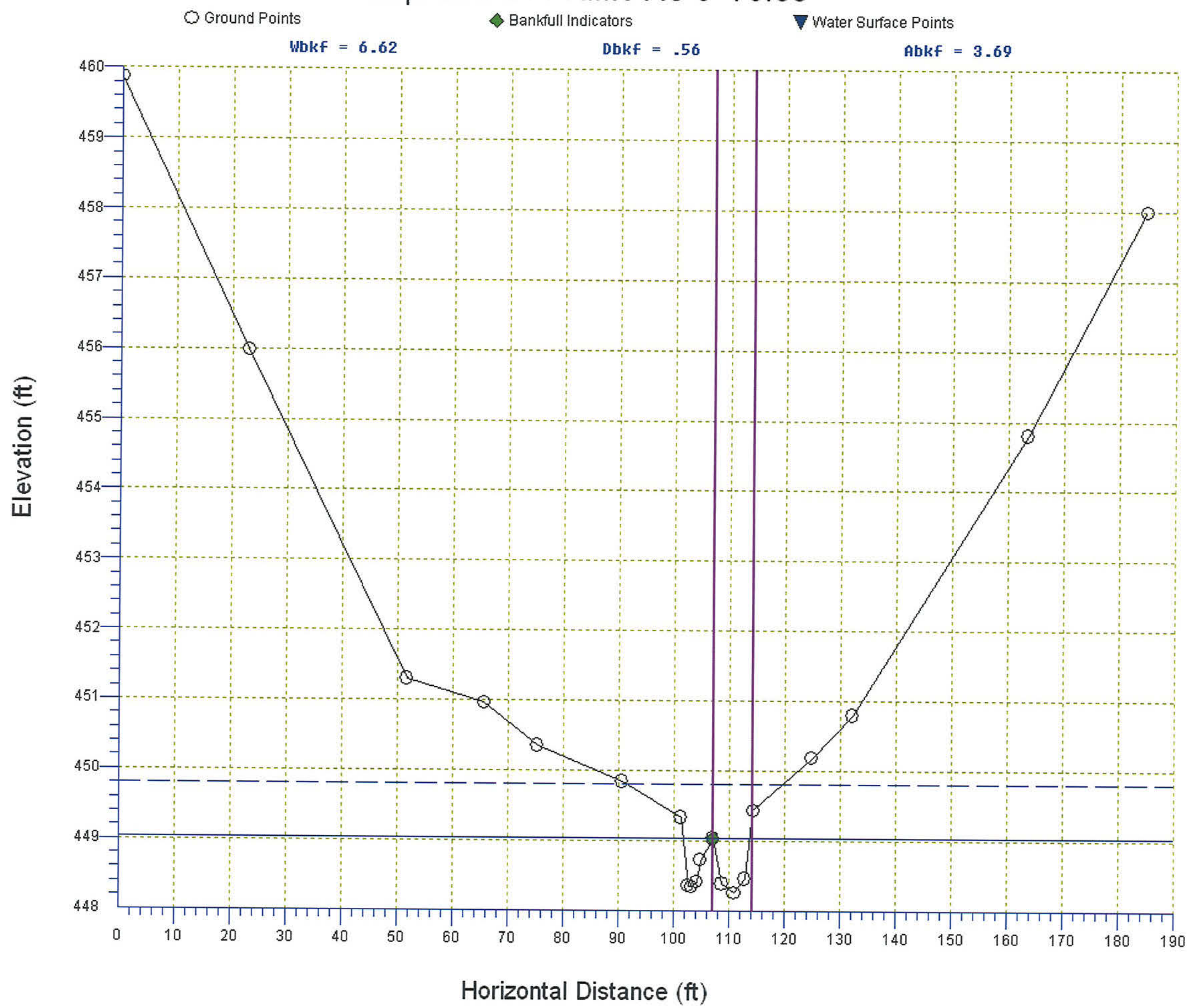
	Channel	Left	Right
Floodprone Elevation (ft)	450.29	450.29	450.29
Bankfull Elevation (ft)	449.35	449.35	449.35
Floodprone Width (ft)	22.03	-----	-----
Bankfull Width (ft)	8.21	4.11	4.1
Entrenchment Ratio	2.68	-----	-----
Mean Depth (ft)	0.57	0.65	0.49
Maximum Depth (ft)	0.94	0.94	0.84
Width/Depth Ratio	14.4	6.32	8.37
Bankfull Area (sq ft)	4.66	2.66	2
Wetted Perimeter (ft)	8.6	5.19	5.09
Hydraulic Radius (ft)	0.54	0.51	0.39
Begin BKF Station	120.23	120.23	124.34
End BKF Station	128.44	124.34	128.44

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0	0	0
Shear Stress (lb/sq ft)			
Movable Particle (mm)			

Impaired UT1 Riffle XS 0+79.88



Impaired Riffle XS 0+79.88.txt
RIVERMORPH CROSS SECTION SUMMARY

River Name: Davis Branch
Reach Name: Davis Branch - UT1
Cross Section Name: Riffle XS 0+79.88
Survey Date: 03/29/2007

Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0	0	459.87	
22.97	0	455.99	
51.68	0	451.3	
65.57	0	450.96	
75.24	0	450.35	
90.53	0	449.84	
101.25	0	449.33	
102.59	0	448.35	
103.25	0	448.34	
104.1	0	448.4	
104.8	0	448.72	
107.01	0	449.03	BKF
108.6	0	448.38	
110.84	0	448.25	TW
112.79	0	448.45	
114.21	0	449.43	RB
124.8	0	450.18	
132.08	0	450.79	
163.45	0	454.8	
184.68	0	457.99	

Cross Sectional Geometry

	Channel	Left	Right
Floodprone Elevation (ft)	449.81	449.81	449.81
Bankfull Elevation (ft)	449.03	449.03	449.03
Floodprone Width (ft)	28.42	-----	-----
Bankfull Width (ft)	6.62	3.31	3.31
Entrenchment Ratio	4.29	-----	-----
Mean Depth (ft)	0.56	0.52	0.59
Maximum Depth (ft)	0.78	0.75	0.78
Width/Depth Ratio	11.82	6.37	5.61
Bankfull Area (sq ft)	3.69	1.72	1.97
Wetted Perimeter (ft)	6.94	4.19	4.25
Hydraulic Radius (ft)	0.53	0.41	0.46
Begin BKF Station	107.01	107.01	110.32
End BKF Station	113.63	110.32	113.63

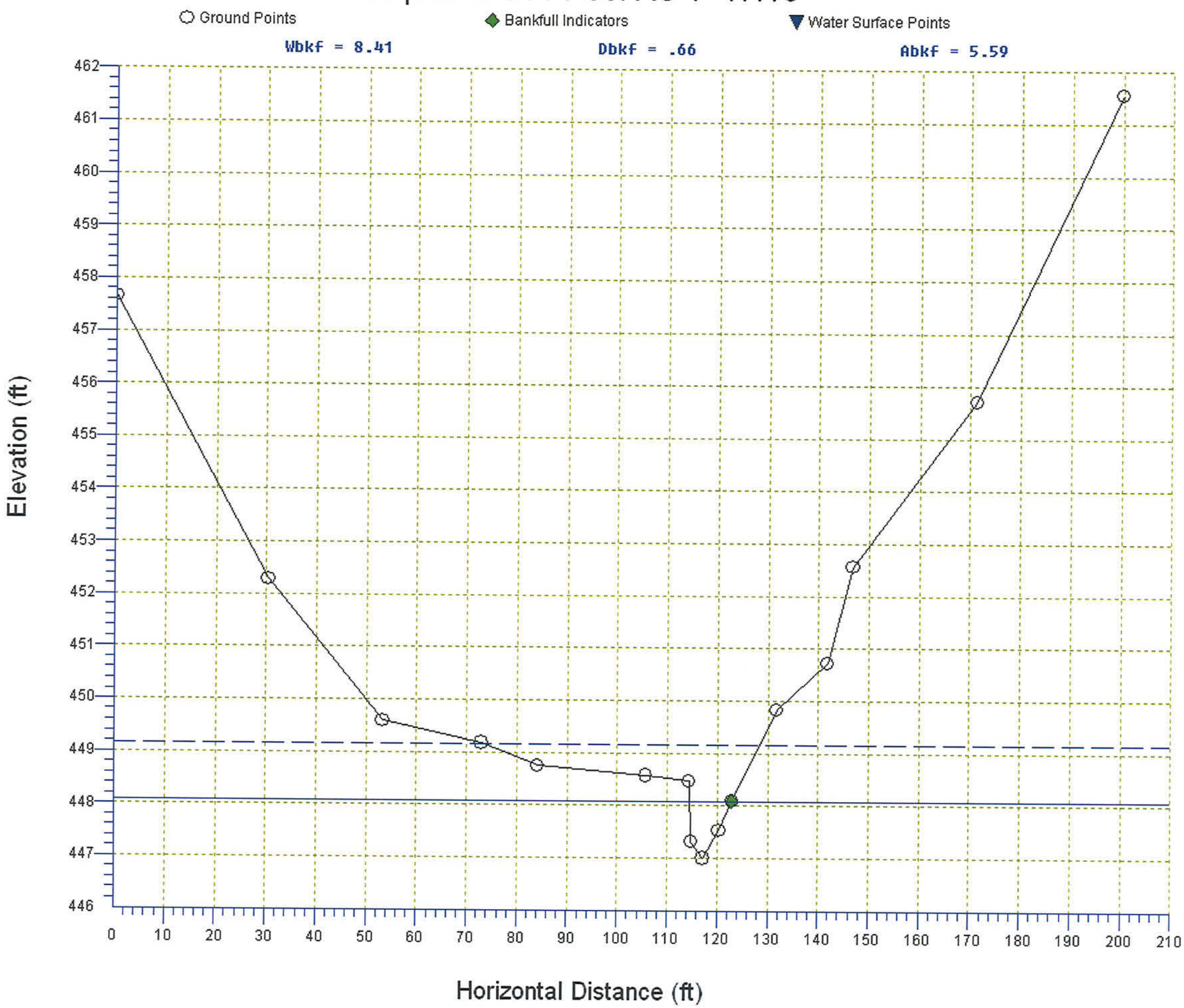
Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.02297	0	0

Shear Stress (lb/sq ft)	0.76
Movable Particle (mm)	124.2

Impaired UT1 Pool XS 1+17.16



Impaired Pool XS 1+17.16.txt
RIVERMORPH CROSS SECTION SUMMARY

River Name: Davis Branch
Reach Name: Davis Branch - UT1
Cross Section Name: Pool XS 1+17.16
Survey Date: 03/29/2007

Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0	0	457.66	
30.4	0	452.29	
53.33	0	449.59	
72.97	0	449.18	
84.16	0	448.75	
105.77	0	448.57	
114.29	0	448.47	LB
114.76	0	447.31	
117.14	0	447	TW
120.28	0	447.53	
122.86	0	448.08	BKF
131.78	0	449.83	
141.79	0	450.72	
146.82	0	452.56	
171.18	0	455.7	
199.99	0	461.55	

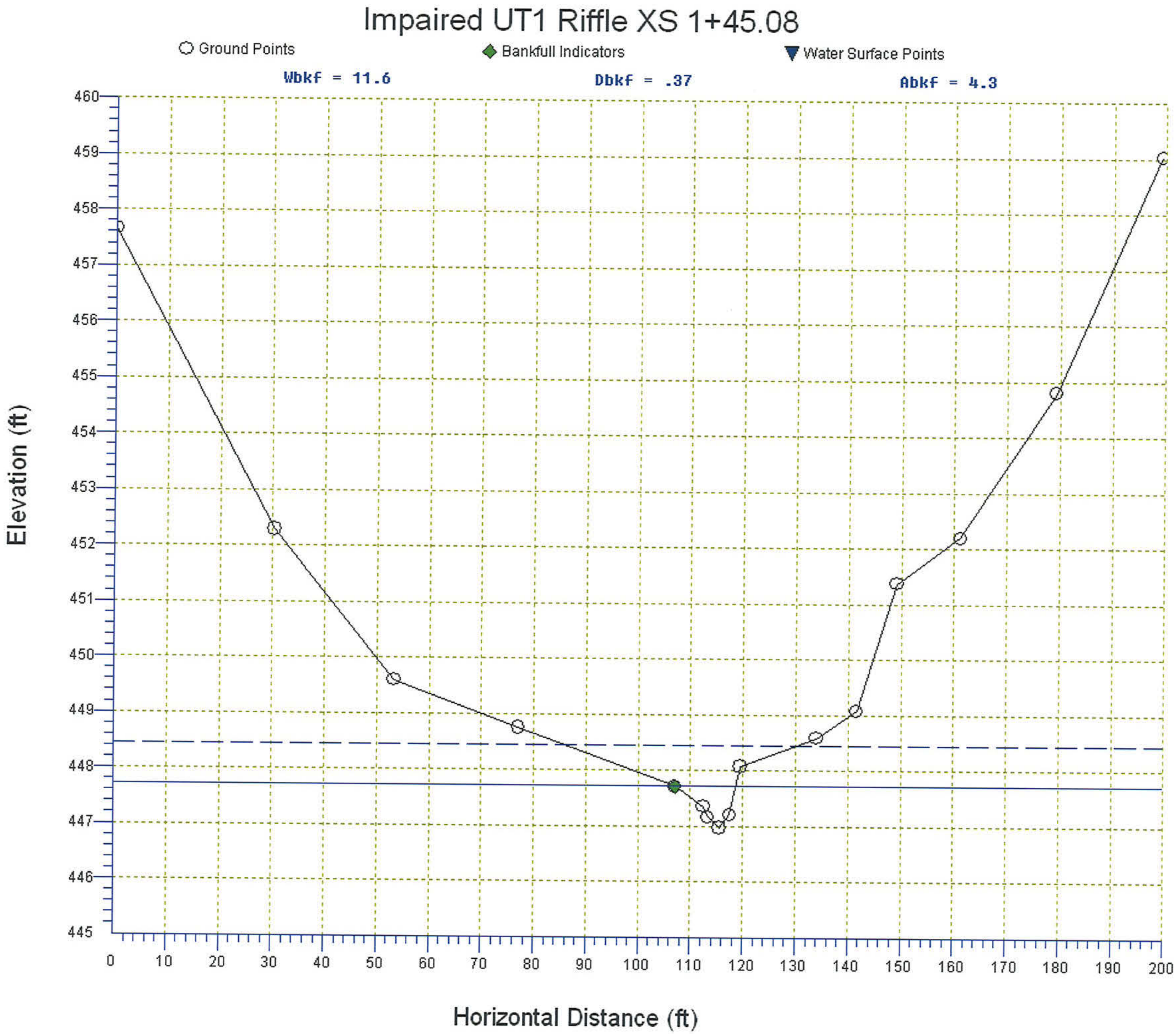
Cross Sectional Geometry

	Channel	Left	Right
Floodprone Elevation (ft)	449.16	449.16	449.16
Bankfull Elevation (ft)	448.08	448.08	448.08
Floodprone Width (ft)	54.87	-----	-----
Bankfull Width (ft)	8.41	4.23	4.18
Entrenchment Ratio	6.52	-----	-----
Mean Depth (ft)	0.66	0.89	0.43
Maximum Depth (ft)	1.08	1.08	0.82
Width/Depth Ratio	12.74	4.75	9.72
Bankfull Area (sq ft)	5.59	3.78	1.81
Wetted Perimeter (ft)	9.05	5.61	5.08
Hydraulic Radius (ft)	0.62	0.67	0.36
Begin BKF Station	114.45	114.45	118.68
End BKF Station	122.86	118.68	122.86

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.02305	0	0
Shear Stress (lb/sq ft)	0.89		
Movable Particle (mm)	139.7		



Impaired UT1 Riffle XS 1+45.08
Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 11.6
Dbkf = .37
Abkf = 4.3
Elevation (ft)
460
459
458
457
456
455
454
453
452
451
450
449
448
447
446
445
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
Horizontal Distance (ft)

Impaired Riffle XS 1+45.08.txt
RIVERMORPH CROSS SECTION SUMMARY

River Name: Davis Branch
Reach Name: Davis Branch - UT1
Cross Section Name: Riffle XS 1+45.08
Survey Date: 03/29/2007

Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0	0	457.66	
30.4	0	452.29	
53.33	0	449.59	
77.03	0	448.75	
107.02	0	447.71	BKF
112.47	0	447.35	LB
113.36	0	447.16	
115.52	0	446.97	TW
117.47	0	447.2	
119.51	0	448.07	RB
133.99	0	448.58	
141.68	0	449.07	
149.19	0	451.37	
161.21	0	452.2	
179.27	0	454.8	
199.28	0	459.03	

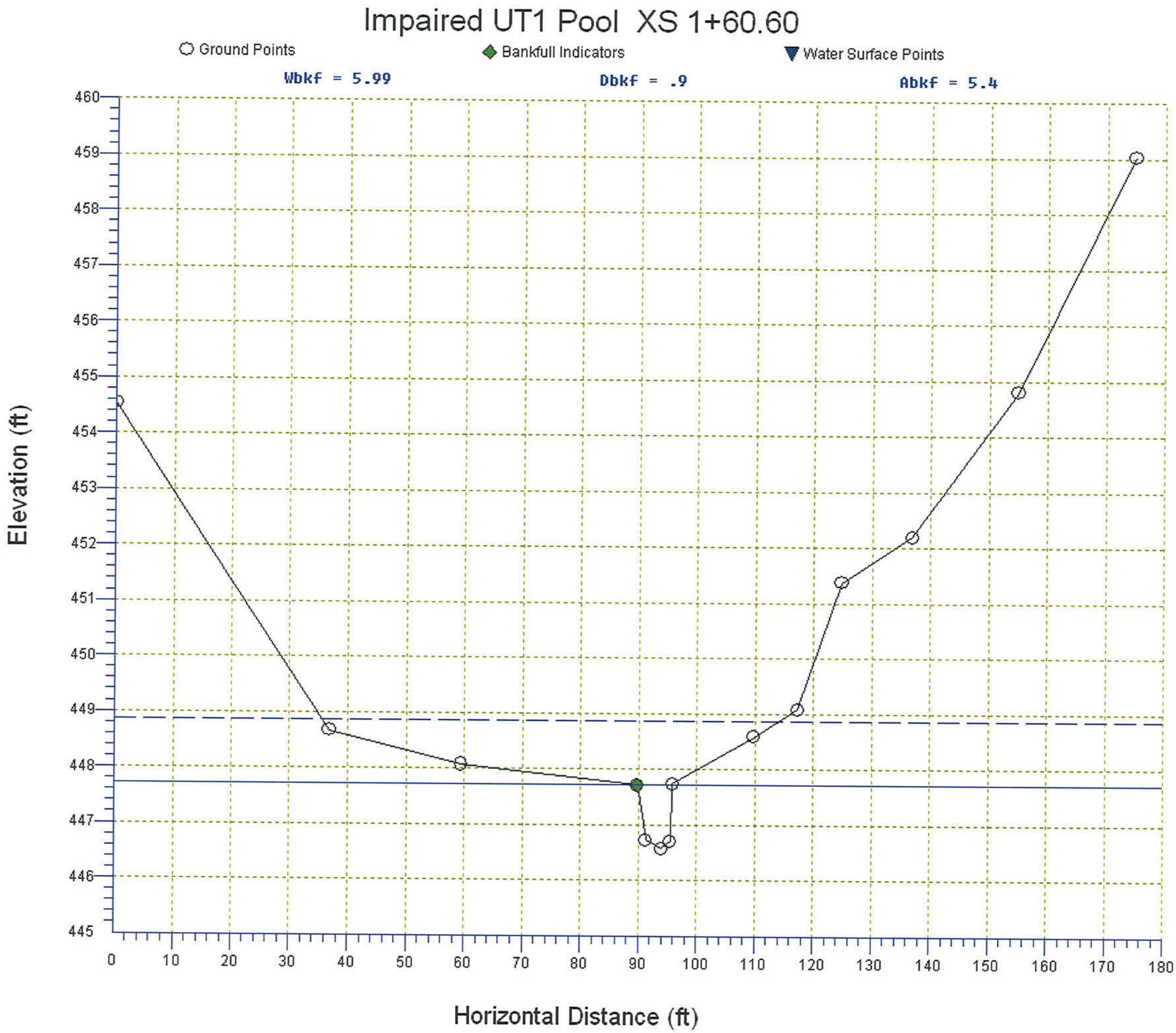
Cross Sectional Geometry

	Channel	Left	Right
Floodprone Elevation (ft)	448.45	448.45	448.45
Bankfull Elevation (ft)	447.71	447.71	447.71
Floodprone Width (ft)	44.62	-----	-----
Bankfull Width (ft)	11.65	8.13	3.52
Entrenchment Ratio	3.83	-----	-----
Mean Depth (ft)	0.37	0.31	0.51
Maximum Depth (ft)	0.74	0.71	0.74
Width/Depth Ratio	31.49	26.23	6.9
Bankfull Area (sq ft)	4.3	2.51	1.79
Wetted Perimeter (ft)	11.8	8.88	4.34
Hydraulic Radius (ft)	0.36	0.28	0.41
Begin BKF Station	107.02	107.02	115.15
End BKF Station	118.67	115.15	118.67

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.02305	0	0
Shear Stress (lb/sq ft)	0.52		
Movable Particle (mm)	93.7		



Impaired UT1 Pool XS 1+60.60
Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 5.99
Dbkf = .9
Abkf = 5.4
Elevation (ft)
Horizontal Distance (ft)
460
459
458
457
456
455
454
453
452
451
450
449
448
447
446
445
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180

RIVERMORPH CROSS SECTION SUMMARY

River Name: Davis Branch
Reach Name: Davis Branch - UT1
Cross Section Name: Pool XS 1+60.60
Survey Date: 03/29/2007

Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0	0	454.54	
36.8	0	448.67	
59.43	0	448.07	
89.8	0	447.71	BKF
91.24	0	446.72	
93.93	0	446.57	TW
95.48	0	446.7	
95.8	0	447.73	RB
109.82	0	448.58	
117.3	0	449.07	
124.81	0	451.37	
136.83	0	452.2	
154.89	0	454.8	
174.9	0	459.03	

Cross Sectional Geometry

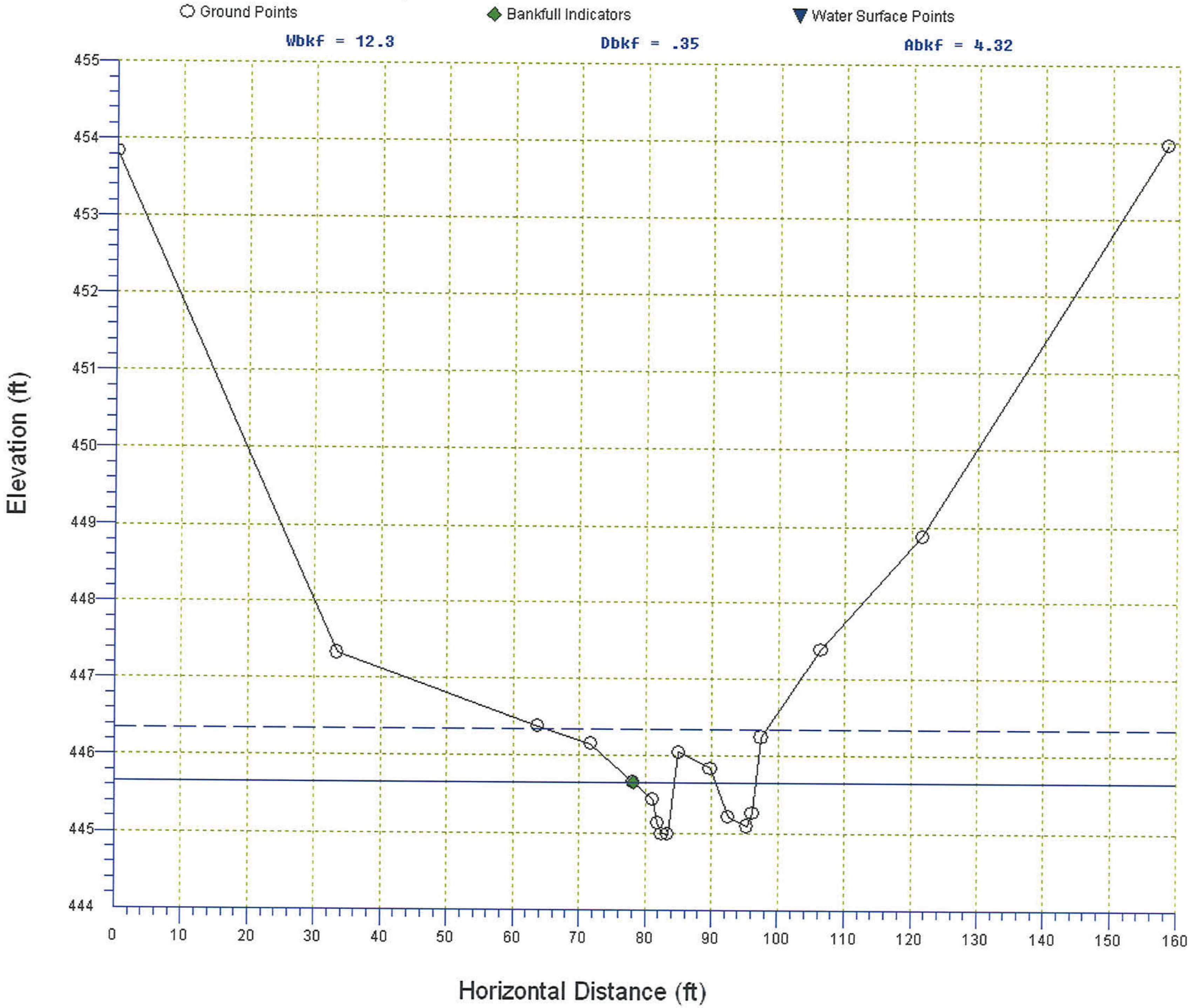
	Channel	Left	Right
Floodprone Elevation (ft)	448.85	448.85	448.85
Bankfull Elevation (ft)	447.71	447.71	447.71
Floodprone Width (ft)	78.27	-----	-----
Bankfull Width (ft)	5.99	3	2.99
Entrenchment Ratio	13.06	-----	-----
Mean Depth (ft)	0.9	0.78	1.03
Maximum Depth (ft)	1.14	1.08	1.14
Width/Depth Ratio	6.66	3.85	2.9
Bankfull Area (sq ft)	5.4	2.33	3.08
Wetted Perimeter (ft)	7.05	4.39	4.82
Hydraulic Radius (ft)	0.77	0.53	0.64
Begin BKF Station	89.8	89.8	92.8
End BKF Station	95.79	92.8	95.79

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.02297	0	0
Shear Stress (lb/sq ft)	1.10		
Movable Particle (mm)	163.5		

Impaired UT1 Riffle XS 2+46.75



Impaired Riffle XS 2+46.75.txt
RIVERMORPH CROSS SECTION SUMMARY

River Name: Davis Branch
Reach Name: Davis Branch - UT1
Cross Section Name: Riffle XS 2+46.75
Survey Date: 03/29/2007

Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0	0	453.83	
33.4	0	447.33	
63.76	0	446.38	
71.73	0	446.16	
78.16	0	445.66	BKF
81.15	0	445.43	LB
81.8	0	445.13	
82.5	0	444.99	SB
83.42	0	444.98	TW
84.97	0	446.05	
89.81	0	445.84	
92.57	0	445.21	
95.33	0	445.09	
96.14	0	445.26	
97.43	0	446.25	
106.45	0	447.39	
121.66	0	448.87	
158.37	0	453.97	

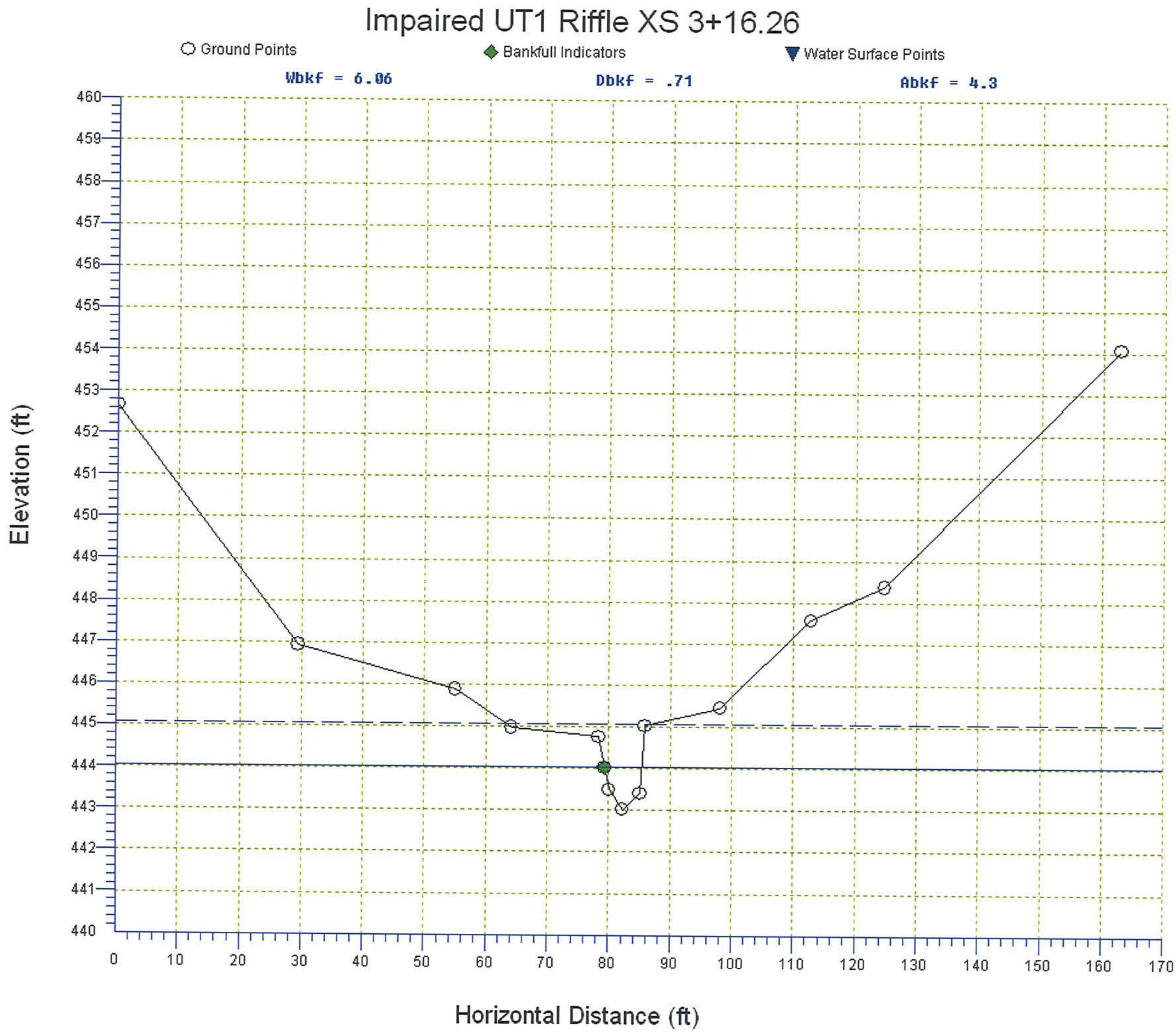
Cross Sectional Geometry

	Channel	Left	Right
Floodprone Elevation (ft)	446.34	446.34	446.34
Bankfull Elevation (ft)	445.66	445.66	445.66
Floodprone Width (ft)	32.93	-----	-----
Bankfull Width (ft)	12.31	7	11.5
Entrenchment Ratio	2.68	-----	-----
Mean Depth (ft)	0.35	0.31	0.39
Maximum Depth (ft)	0.68	0.68	0.57
Width/Depth Ratio	35.17	22.58	29.49
Bankfull Area (sq ft)	4.32	1.97	2.35
Wetted Perimeter (ft)	12.82	6.55	6.27
Hydraulic Radius (ft)	0.34	0.3	0.37
Begin BKF Station	78.16	78.16	90.6
End BKF Station	96.66	84.41	96.66

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.02305	0	0
Shear Stress (lb/sq ft)	0.49		
Movable Particle (mm)	89.8		



Impaired UT1 Riffle XS 3+16.26
Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 6.06
Dbkf = .71
Abkf = 4.3
Elevation (ft)
460
459
458
457
456
455
454
453
452
451
450
449
448
447
446
445
444
443
442
441
440
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
Horizontal Distance (ft)

Impaired Riffle XS 3+16.26.txt
RIVERMORPH CROSS SECTION SUMMARY

River Name: Davis Branch
Reach Name: Davis Branch - UT1
Cross Section Name: Riffle XS 3+16.26
Survey Date: 03/29/2007

Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0	0	452.66	
29.39	0	446.93	
55	0	445.88	
64.16	0	444.97	
78.32	0	444.75	LB
79.31		444.03	BKF
80.04	0	443.5	
82.21	0	443.01	TW
85.05	0	443.41	
85.87	0	445.02	RB
98.04	0	445.45	
112.77	0	447.57	
124.68	0	448.37	
162.82	0	454.06	

Cross Sectional Geometry

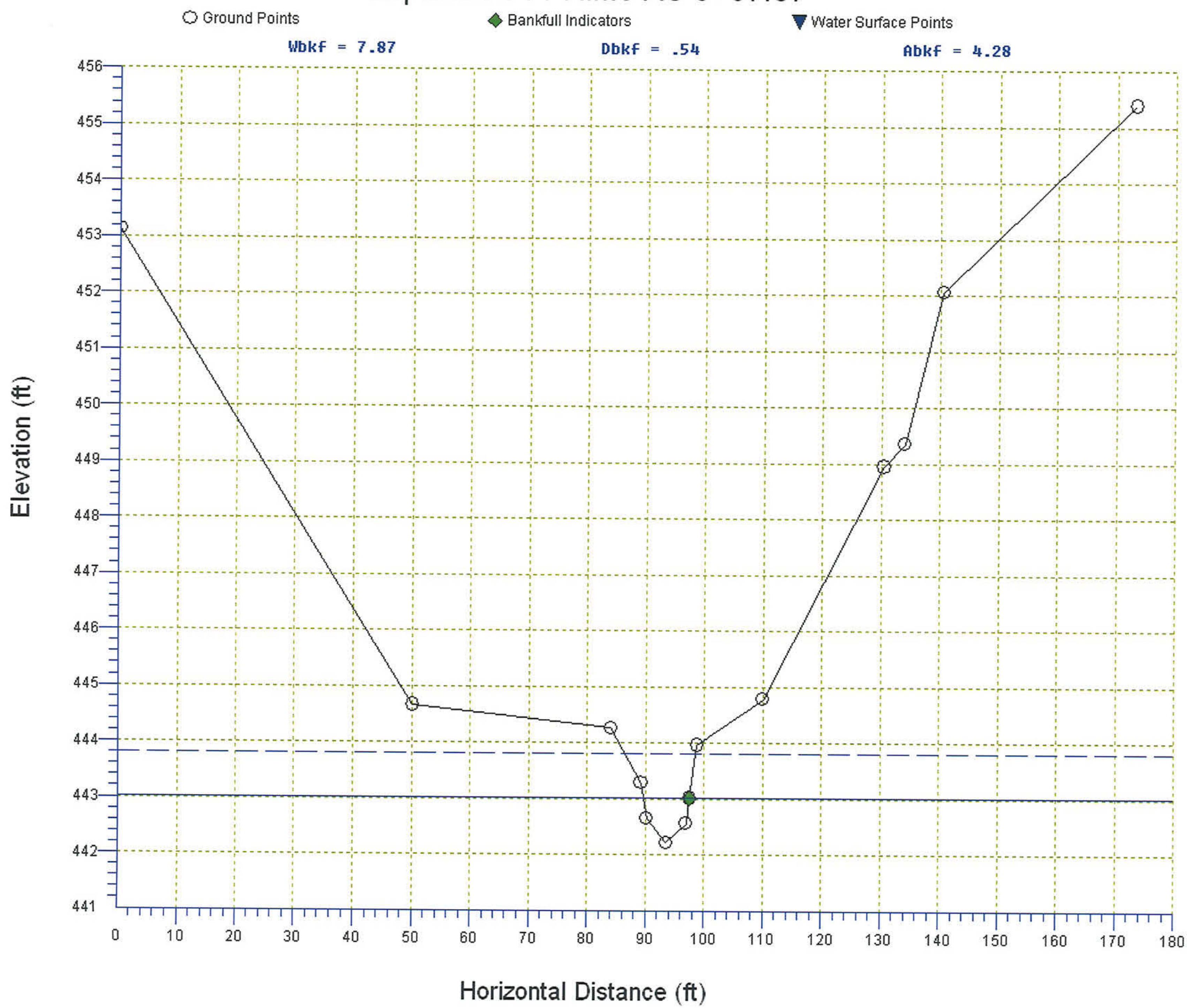
	Channel	Left	Right
Floodprone Elevation (ft)	445.05	445.05	445.05
Bankfull Elevation (ft)	444.03	444.03	444.03
Floodprone Width (ft)	23.36	-----	-----
Bankfull Width (ft)	6.06	2.72	3.34
Entrenchment Ratio	3.86	-----	-----
Mean Depth (ft)	0.71	0.62	0.78
Maximum Depth (ft)	1.02	0.98	1.02
Width/Depth Ratio	8.54	4.39	4.28
Bankfull Area (sq ft)	4.3	1.7	2.61
Wetted Perimeter (ft)	6.69	3.92	4.73
Hydraulic Radius (ft)	0.64	0.43	0.55
Begin BKF Station	79.31	79.31	82.03
End BKF Station	85.37	82.03	85.37

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.02305	0	0
Shear Stress (lb/sq ft)	0.92		
Movable Particle (mm)	143.0		

Impaired UT1 Riffle XS 3+57.07



Impaired Riffle XS 3+57.07.txt
RIVERMORPH CROSS SECTION SUMMARY

River Name: Davis Branch
Reach Name: Davis Branch - UT1
Cross Section Name: Riffle XS 3+57.07
Survey Date: 03/29/2007

Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0	0	453.13	
50.2	0	444.66	
84.06	0	444.26	
89.22	0	443.28	LB
90.22	0	442.65	
93.51	0	442.21	TW
96.92	0	442.56	
97.52		443.01	BKF
98.81	0	443.96	RB
109.98	0	444.78	
130.45	0	448.95	
134.03	0	449.35	
140.48	0	452.05	
173.31	0	455.39	

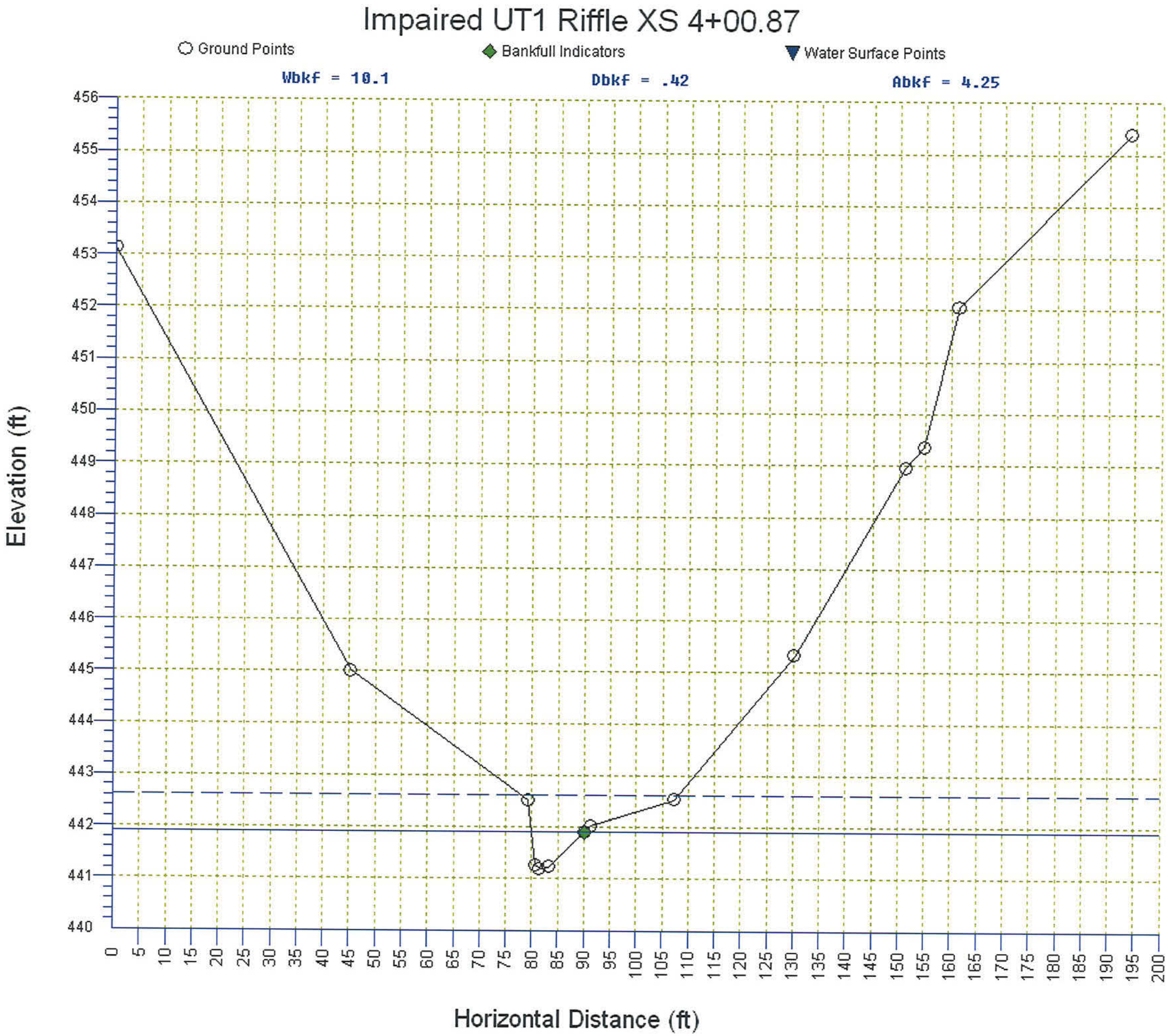
Cross Sectional Geometry

	Channel	Left	Right
Floodprone Elevation (ft)	443.81	443.81	443.81
Bankfull Elevation (ft)	443.01	443.01	443.01
Floodprone Width (ft)	12.18	-----	-----
Bankfull Width (ft)	7.87	3.91	3.96
Entrenchment Ratio	1.55	-----	-----
Mean Depth (ft)	0.54	0.52	0.56
Maximum Depth (ft)	0.8	0.8	0.79
Width/Depth Ratio	14.57	7.52	7.07
Bankfull Area (sq ft)	4.28	2.05	2.23
Wetted Perimeter (ft)	8.17	4.84	4.92
Hydraulic Radius (ft)	0.52	0.42	0.45
Begin BKF Station	89.65	89.65	93.56
End BKF Station	97.52	93.56	97.52

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.02297	0	0
Shear Stress (lb/sq ft)	0.75		
Movable Particle (mm)	122.5		


Impaired UT1 Riffle XS 4+00.87
Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 10.1
Dbkf = .42
Abkf = 4.25
Elevation (ft)
456
455
454
453
452
451
450
449
448
447
446
445
444
443
442
441
440
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
105
110
115
120
125
130
135
140
145
150
155
160
165
170
175
180
185
190
195
200
Horizontal Distance (ft)

Impaired Riffle XS 4+00.87.txt
RIVERMORPH CROSS SECTION SUMMARY

River Name: Davis Branch
Reach Name: Davis Branch - UT1
Cross Section Name: Riffle XS 4+00.87
Survey Date: 03/29/2007

Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0	0	453.13	
45.31	0	445	
79.32	0	442.52	LB
80.74	0	441.26	
81.56	0	441.19	TW
83.28	0	441.23	
90.08		441.9	BKF
91.3	0	442.02	RB
107.3	0	442.53	
130.14	0	445.32	
151.24	0	448.95	
154.82	0	449.35	
161.27	0	452.05	
194.1	0	455.39	

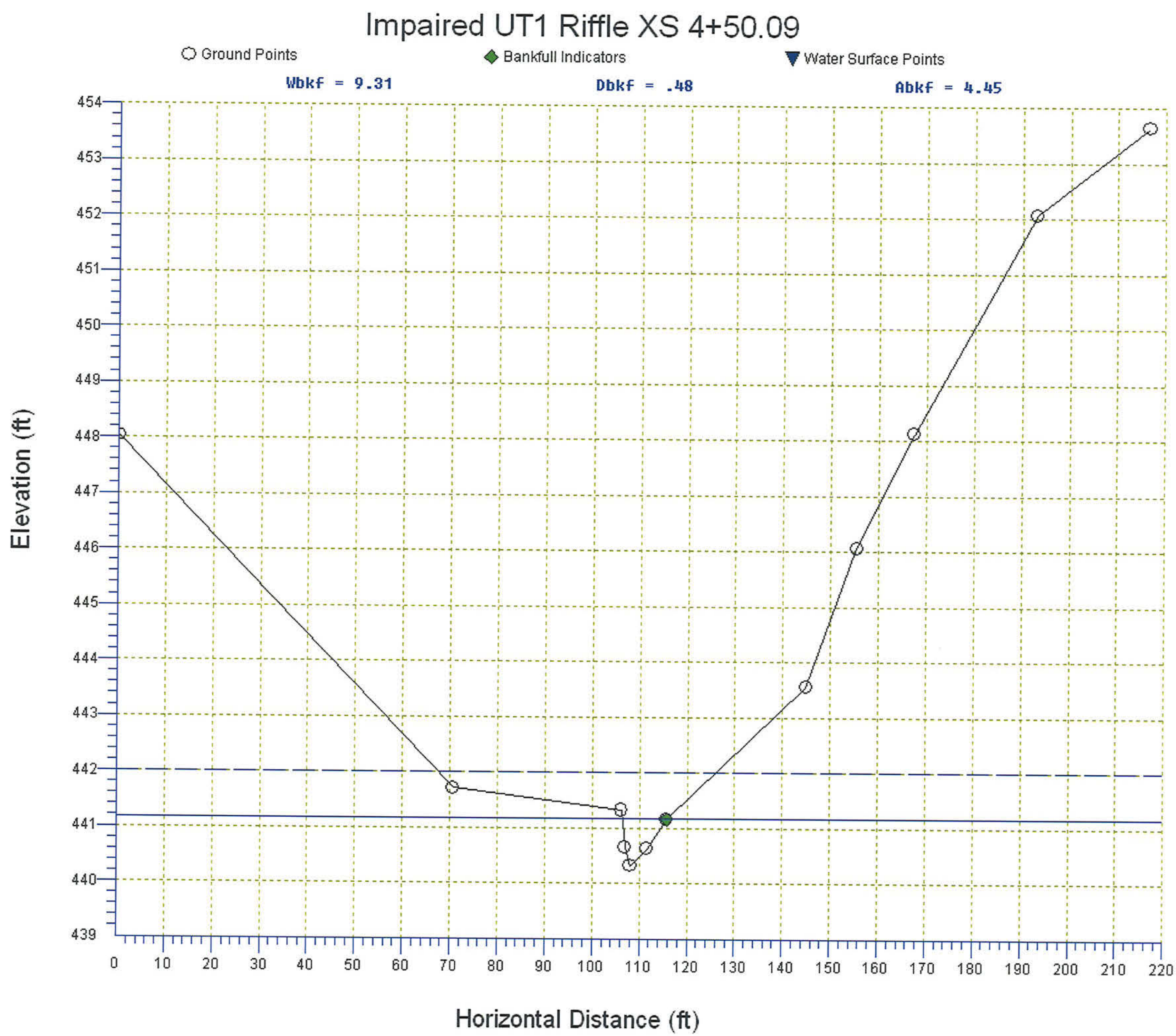
Cross Sectional Geometry

	Channel	Left	Right
Floodprone Elevation (ft)	442.61	442.61	442.61
Bankfull Elevation (ft)	441.9	441.9	441.9
Floodprone Width (ft)	29.87	-----	-----
Bankfull Width (ft)	10.06	2.5	7.56
Entrenchment Ratio	2.97	-----	-----
Mean Depth (ft)	0.42	0.58	0.37
Maximum Depth (ft)	0.71	0.71	0.69
Width/Depth Ratio	23.95	4.31	20.43
Bankfull Area (sq ft)	4.25	1.46	2.79
Wetted Perimeter (ft)	10.34	3.44	8.28
Hydraulic Radius (ft)	0.41	0.42	0.34
Begin BKF Station	80.02	80.02	82.52
End BKF Station	90.08	82.52	90.08

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.02297	0	0
Shear Stress (lb/sq ft)	0.59		
Movable Particle (mm)	102.8		


Impaired UT1 Riffle XS 4+50.09
Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 9.31
Dbkf = .48
Abkf = 4.45
Elevation (ft)
454
453
452
451
450
449
448
447
446
445
444
443
442
441
440
439
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
Horizontal Distance (ft)

RIVERMORPH CROSS SECTION SUMMARY

River Name: Davis Branch
Reach Name: Davis Branch - UT1
Cross Section Name: Riffle XS 4+50.09
Survey Date: 03/29/2007

Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0	0	448.04	
70.7	0	441.71	
106.1	0	441.32	LB
106.92	0	440.65	
107.99	0	440.32	TW
111.59	0	440.62	
115.61		441.16	BKF
144.9	0	443.55	
155.42	0	446.06	
167.35	0	448.12	
193.13	0	452.07	
216.58	0	453.64	

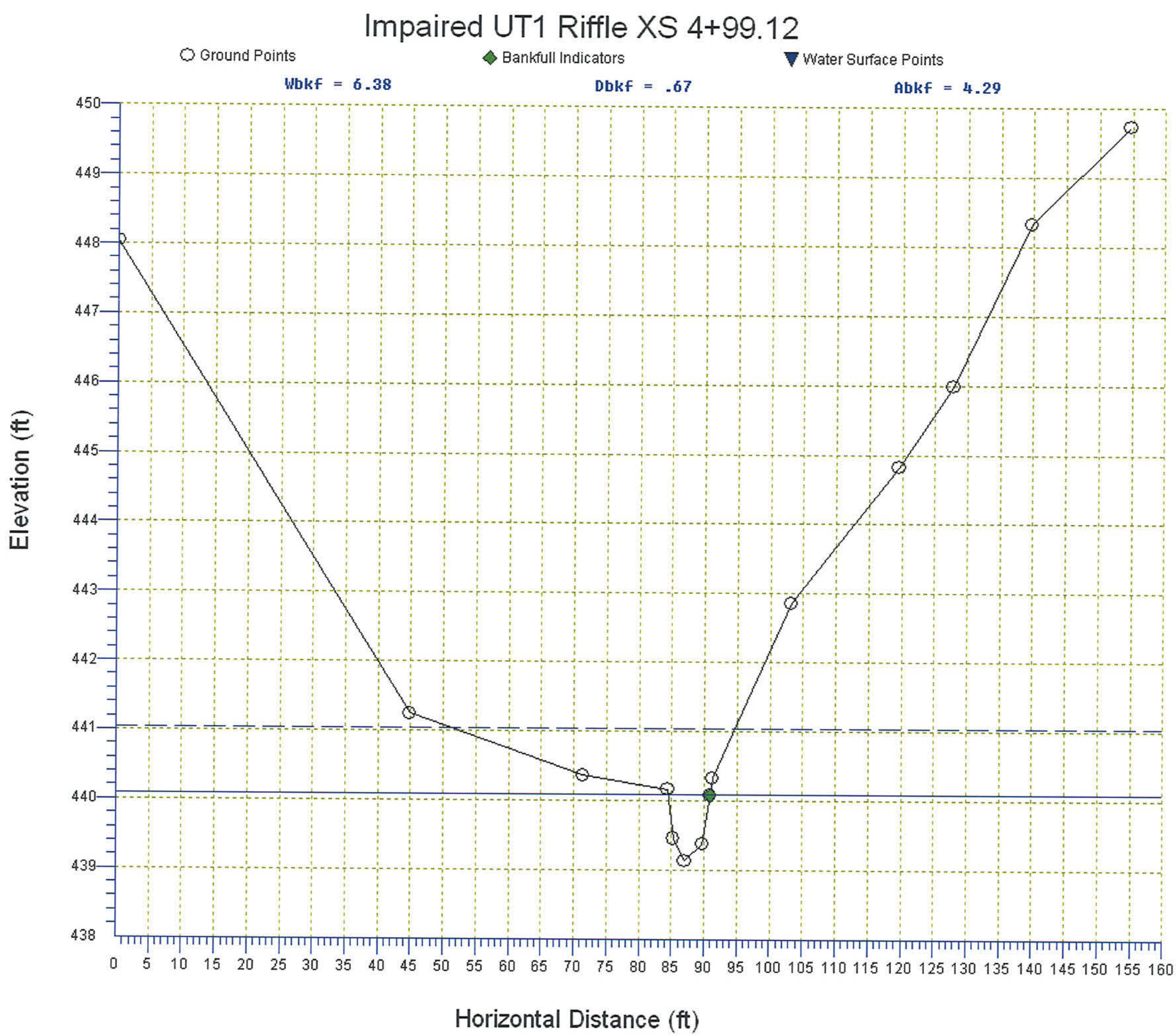
Cross Sectional Geometry

	Channel	Left	Right
Floodprone Elevation (ft)	442	442	442
Bankfull Elevation (ft)	441.16	441.16	441.16
Floodprone Width (ft)	58.44	-----	-----
Bankfull Width (ft)	9.31	3.86	5.45
Entrenchment Ratio	6.27	-----	-----
Mean Depth (ft)	0.48	0.65	0.36
Maximum Depth (ft)	0.84	0.84	0.66
Width/Depth Ratio	19.4	5.94	15.14
Bankfull Area (sq ft)	4.45	2.51	1.94
Wetted Perimeter (ft)	9.59	4.76	6.15
Hydraulic Radius (ft)	0.46	0.53	0.32
Begin BKF Station	106.3	106.3	110.16
End BKF Station	115.61	110.16	115.61

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.02297	0	0
Shear Stress (lb/sq ft)	0.66		
Movable Particle (mm)	111.9		


Impaired UT1 Riffle XS 4+99.12
Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 6.38
Dbkf = .67
Abkf = 4.29
Elevation (ft)
Horizontal Distance (ft)
450
449
448
447
446
445
444
443
442
441
440
439
438
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100 105 110 115 120 125 130 135 140 145 150 155 160

Impaired Riffle XS 4+99.12.txt
RIVERMORPH CROSS SECTION SUMMARY

River Name: Davis Branch
Reach Name: Davis Branch - UT1
Cross Section Name: Riffle XS 4+99.12
Survey Date: 03/29/2007

Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0	0	448.04	
44.87	0	441.24	
71.36	0	440.36	
84.36	0	440.16	LB
85.21	0	439.45	
86.95	0	439.13	TW
89.68	0	439.37	
90.84		440.08	BKF
91.26	0	440.33	RB
103.17	0	442.86	
119.53	0	444.82	
127.8	0	445.98	
139.7	0	448.33	
154.71	0	449.73	

Cross Sectional Geometry

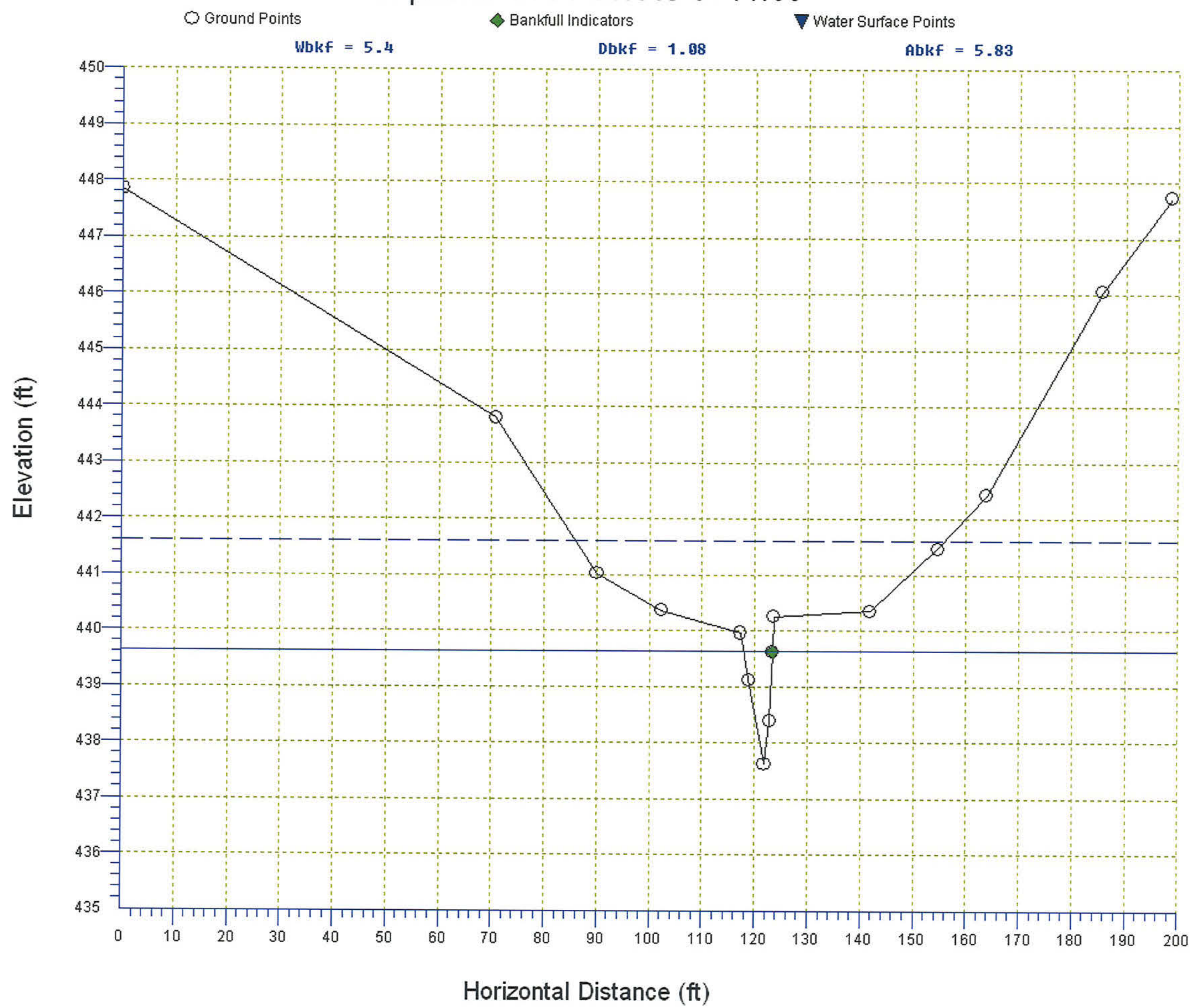
	Channel	Left	Right
Floodprone Elevation (ft)	441.03	441.03	441.03
Bankfull Elevation (ft)	440.08	440.08	440.08
Floodprone Width (ft)	43.36	-----	-----
Bankfull Width (ft)	6.38	3.21	3.17
Entrenchment Ratio	6.79	-----	-----
Mean Depth (ft)	0.67	0.71	0.64
Maximum Depth (ft)	0.95	0.95	0.89
Width/Depth Ratio	9.52	4.52	4.95
Bankfull Area (sq ft)	4.29	2.27	2.02
Wetted Perimeter (ft)	6.85	4.36	4.26
Hydraulic Radius (ft)	0.63	0.52	0.47
Begin BKF Station	84.46	84.46	87.67
End BKF Station	90.84	87.67	90.84

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.02297	0	0
Shear Stress (lb/sq ft)	0.90		
Movable Particle (mm)	141.0		

Impaired UT1 Pool XS 5+11.69



Impaired Pool XS 5+11.69.txt
RIVERMORPH CROSS SECTION SUMMARY

River Name: Davis Branch
Reach Name: Davis Branch - UT1
Cross Section Name: Pool XS 5+11.69
Survey Date: 03/29/2007

Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0	0	447.85	
70.7	0	443.8	
90.05	0	441.02	
102.31	0	440.36	
117.35	0	439.96	LB
118.89	0	439.12	
121.86	0	437.62	TW
122.82	0	438.39	
123.37		439.62	BKF
123.63	0	440.25	RB
141.89	0	440.35	
154.67	0	441.47	
163.83	0	442.43	
185.58	0	446.05	
198.71	0	447.73	

Cross Sectional Geometry

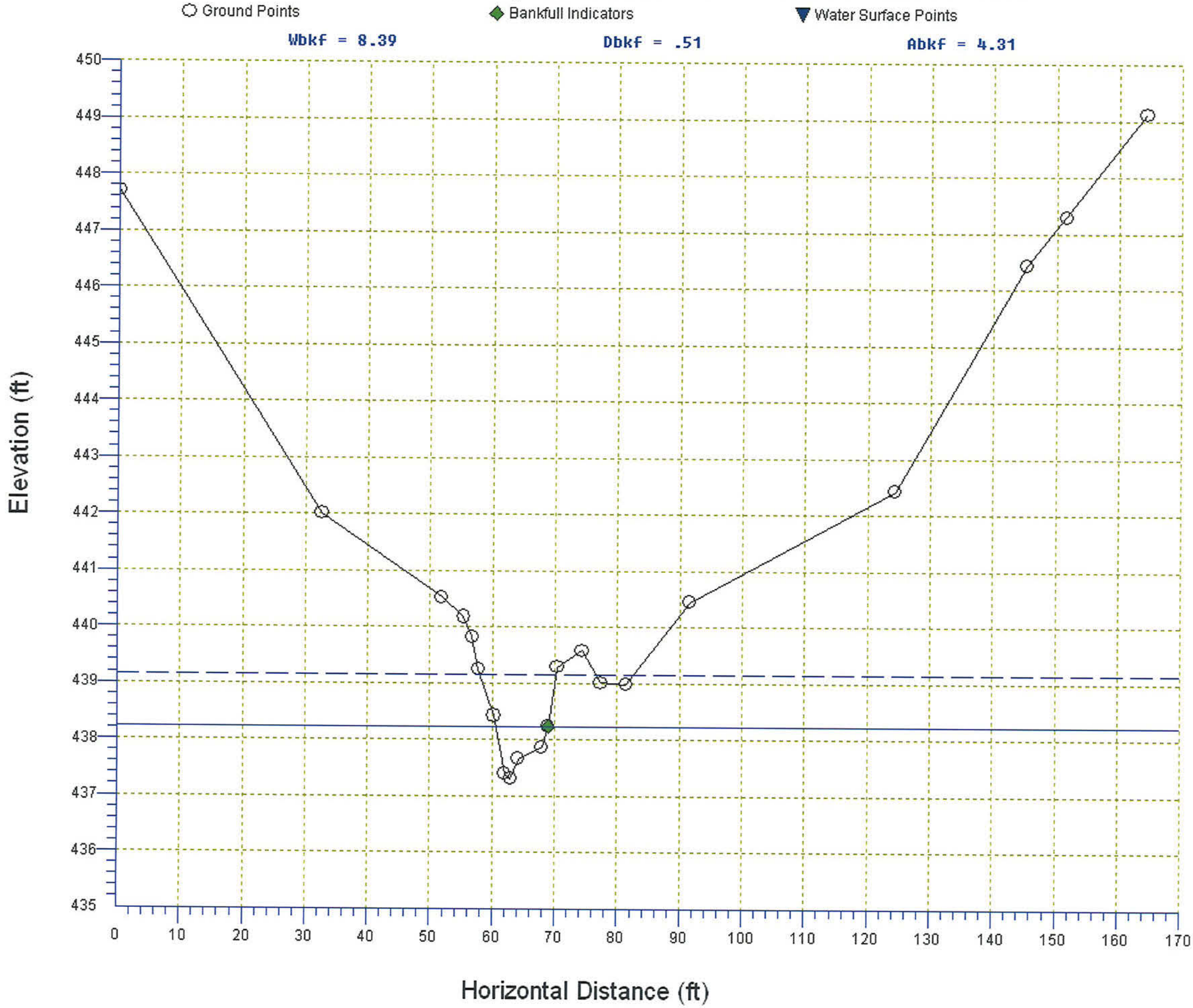
	Channel	Left	Right
Floodprone Elevation (ft)	441.62	441.62	441.62
Bankfull Elevation (ft)	439.62	439.62	439.62
Floodprone Width (ft)	70.23	-----	-----
Bankfull Width (ft)	5.4	2.7	2.7
Entrenchment Ratio	13.01	-----	-----
Mean Depth (ft)	1.08	0.71	1.45
Maximum Depth (ft)	2	1.4	2
Width/Depth Ratio	5	3.8	1.86
Bankfull Area (sq ft)	5.83	1.92	3.91
Wetted Perimeter (ft)	6.95	4.44	5.31
Hydraulic Radius (ft)	0.84	0.43	0.74
Begin BKF Station	117.97	117.97	120.67
End BKF Station	123.37	120.67	123.37

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0	0	0
Shear Stress (lb/sq ft)			
Movable Particle (mm)			

Davis Branch UT1 - Impaired Riffle XS 5+62.69 - 07/17/2007



RIVERMORPH CROSS SECTION SUMMARY

River Name: Davis Branch
Reach Name: Davis Branch - UT1
Cross Section Name: Riffle XS 5+62.69
Survey Date: 07/17/2007

Cross Section Data Entry

BM Elevation: 443.66 ft
Backsight Rod Reading: 0.01 ft

TAPE	FS	ELEV	NOTE
0	0	447.71	
32.61	0	442.01	
51.84	0	440.52	FP
55.34	0	440.18	FP
56.74	0	439.82	LB
57.74	0	439.24	
60.24	0	438.42	
61.94	0	437.39	Bot LB
62.84	0	437.31	TW
64.14	0	437.66	SB
67.94	0	437.86	Bot RB
68.94	0	438.23	BKF
70.34	0	439.28	RB
74.34	0	439.58	FP
77.34	0	439.01	FP
81.34	0	438.98	FP
91.6	0	440.45	
124.38	0	442.43	
145.21	0	446.44	
151.53	0	447.29	
164.38	0	449.12	

Cross Sectional Geometry

	Channel	Left	Right
Floodprone Elevation (ft)	439.15	439.15	439.15
Bankfull Elevation (ft)	438.23	438.23	438.23
Floodprone Width (ft)	18.08	-----	-----
Bankfull Width (ft)	8.39	4.2	4.19
Entrenchment Ratio	2.16	-----	-----
Mean Depth (ft)	0.51	0.64	0.39
Maximum Depth (ft)	0.92	0.92	0.54
Width/Depth Ratio	16.45	6.56	10.74
Bankfull Area (sq ft)	4.31	2.68	1.63
Wetted Perimeter (ft)	8.74	5.02	4.8
Hydraulic Radius (ft)	0.49	0.53	0.34
Begin BKF Station	60.55	60.55	64.75
End BKF Station	68.94	64.75	68.94

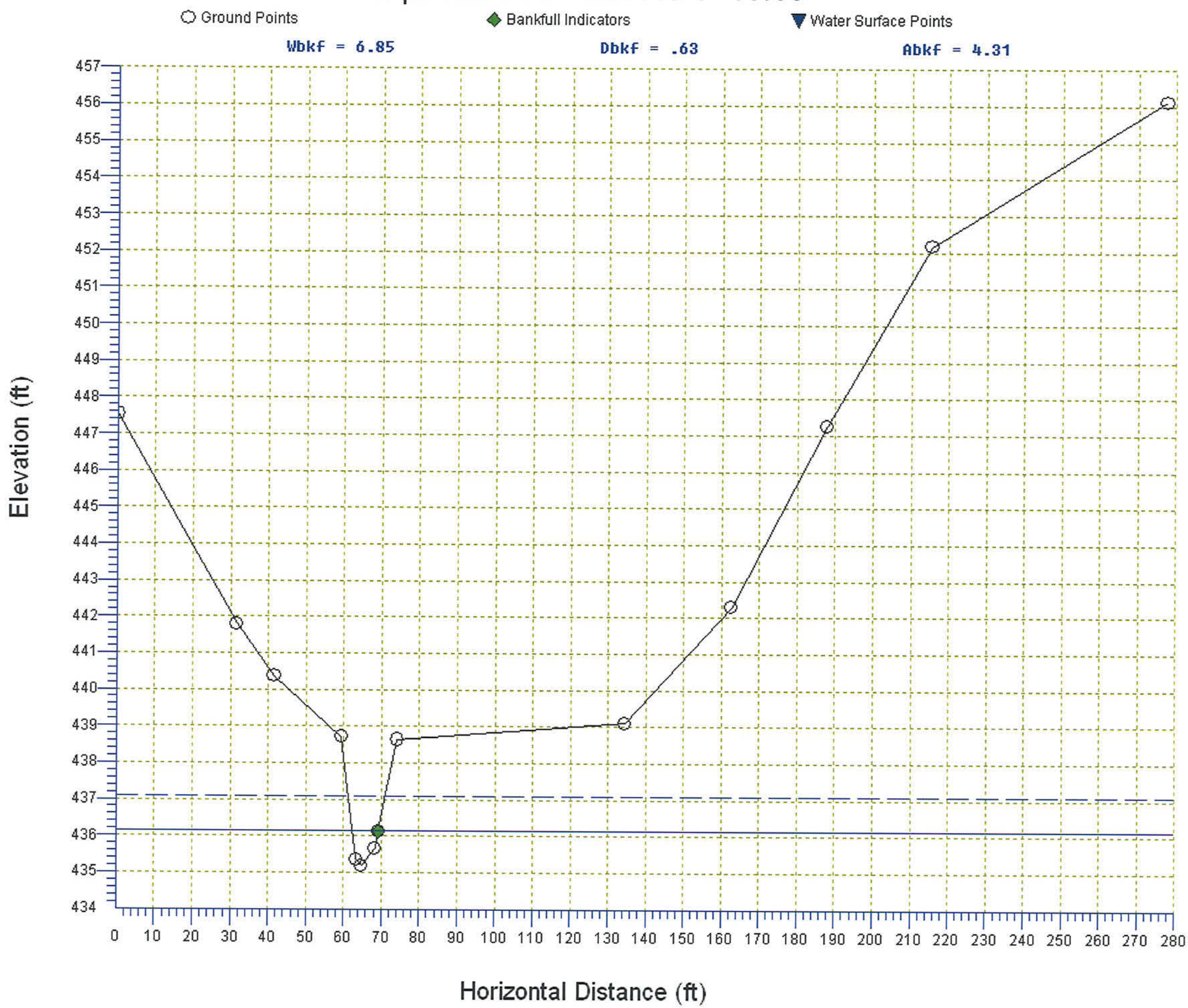
Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

Channel Left Side Right Side

Slope	0.023	0	0
Shear Stress (lb/sq ft)	0.70		
Movable Particle (mm)	117.3		

Impaired UT1 Riffle XS 6+13.69



RIVERMORPH CROSS SECTION SUMMARY

River Name: Davis Branch
Reach Name: Davis Branch - UT1
Cross Section Name: Riffle XS 6+13.69
Survey Date: 03/29/2007

Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0	0	447.54	
31.74	0	441.8	
41.55	0	440.37	
59.33	0	438.71	LB
63.28	0	435.35	
64.78	0	435.19	TW
68.28	0	435.67	
69.21		436.13	BKF
74.06	0	438.64	
134.52	0	439.1	
162.57	0	442.29	
187.89	0	447.26	
215.43	0	452.16	
277.64	0	456.12	

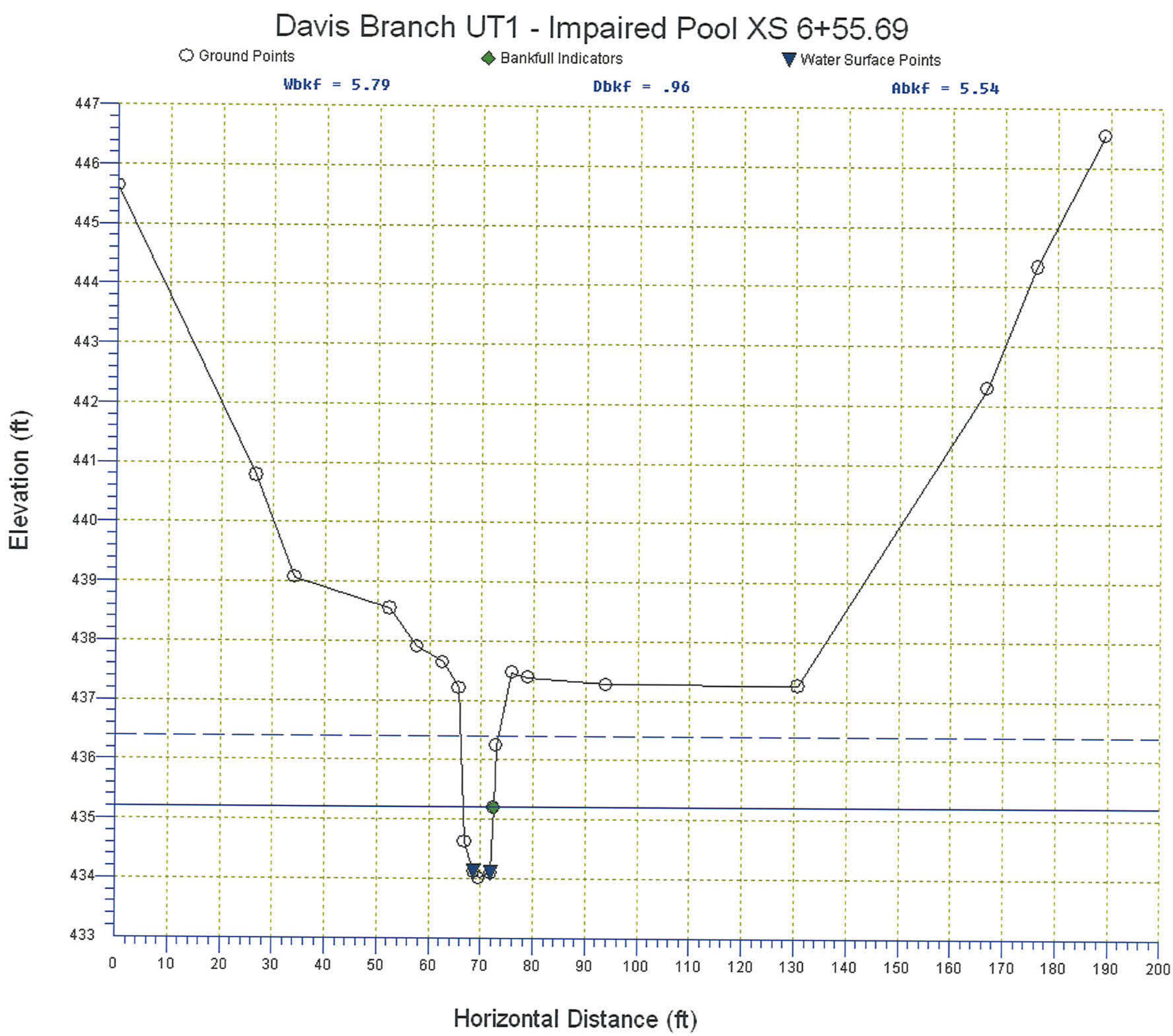
Cross Sectional Geometry

	Channel	Left	Right
Floodprone Elevation (ft)	437.07	437.07	437.07
Bankfull Elevation (ft)	436.13	436.13	436.13
Floodprone Width (ft)	9.77	-----	-----
Bankfull Width (ft)	6.85	3.47	3.38
Entrenchment Ratio	1.43	-----	-----
Mean Depth (ft)	0.63	0.74	0.52
Maximum Depth (ft)	0.94	0.94	0.8
Width/Depth Ratio	10.87	4.69	6.5
Bankfull Area (sq ft)	4.31	2.56	1.75
Wetted Perimeter (ft)	7.28	4.57	4.31
Hydraulic Radius (ft)	0.59	0.56	0.41
Begin BKF Station	62.36	62.36	65.83
End BKF Station	69.21	65.83	69.21

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.02297	0	0
Shear Stress (lb/sq ft)	0.85		
Movable Particle (mm)	134.4		



Davis Branch UT1 - Impaired Pool XS 6+55.69
Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 5.79
Dbkf = .96
Abkf = 5.54
Elevation (ft)
Horizontal Distance (ft)
447
446
445
444
443
442
441
440
439
438
437
436
435
434
433
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200

RIVERMORPH CROSS SECTION SUMMARY

River Name: Davis Branch
Reach Name: Davis Branch - UT1
Cross Section Name: Pool XS 6+55.69 DLS
Survey Date: 03/29/2007

Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0	0	445.64	
26.63	0	440.79	
34.15	0	439.07	
52.38	0	438.55	
57.6	0	437.91	FP
62.6	0	437.64	FP
65.7	0	437.21	LB
66.9	0	434.62	
68.6	0	434.12	LEW
69.6	0	434.01	TW
71.9	0	434.1	REW
72.42	0	435.2	BKF
72.9	0	436.24	
75.8	0	437.47	RB
78.9	0	437.39	FP
93.94	0	437.27	
130.73	0	437.26	
166.68	0	442.29	
176.17	0	444.34	
189.12	0	446.55	

Cross Sectional Geometry

	Channel	Left	Right
Floodprone Elevation (ft)	436.39	436.39	-----
Bankfull Elevation (ft)	435.2	435.2	-----
Floodprone Width (ft)	7.17	-----	-----
Bankfull Width (ft)	5.79	29.54	-----
Entrenchment Ratio	1.24	-----	-----
Mean Depth (ft)	0.96	0.96	-----
Maximum Depth (ft)	1.19	1.19	-----
Width/Depth Ratio	6.03	30.77	-----
Bankfull Area (sq ft)	5.54	5.54	-----
Wetted Perimeter (ft)	6.94	6.94	-----
Hydraulic Radius (ft)	0.8	0.8	-----
Begin BKF Station	66.63	66.63	-----
End BKF Station	72.42	72.42	-----

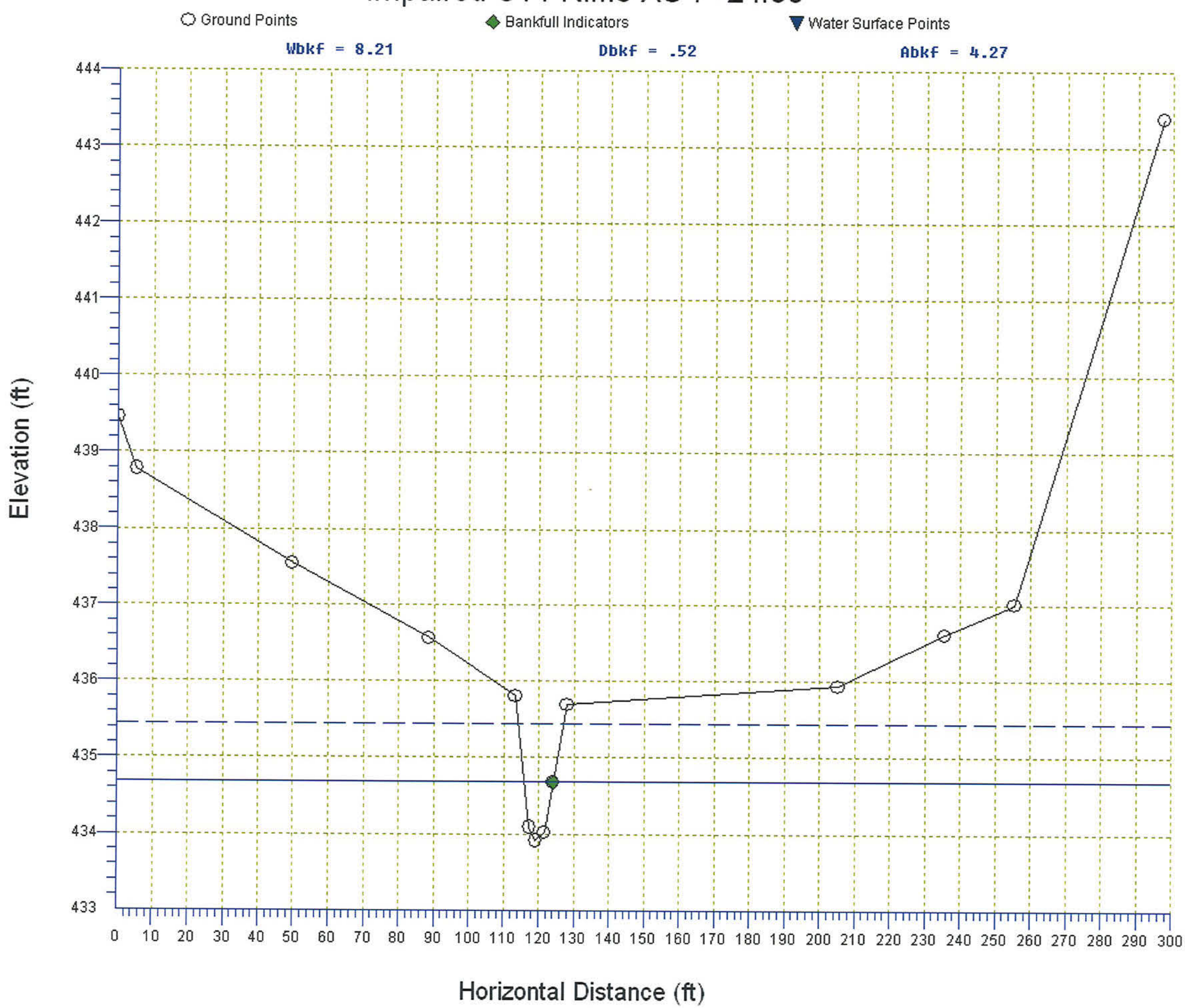
Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.02297	0	0

Shear Stress (lb/sq ft)	1.15
Movable Particle (mm)	168.1

Impaired UT1 Riffle XS 7+24.30



Impaired Riffle XS 7+24.30.txt

RIVERMORPH CROSS SECTION SUMMARY

River Name: Davis Branch
Reach Name: Davis Branch - UT1
Cross Section Name: Riffle XS 7+24.30
Survey Date: 03/29/2007

Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0	0	439.46	
5.3	0	438.78	
49.7	0	437.55	
88.58	0	436.57	
113.29	0	435.81	LB
117.22	0	434.09	
119.02	0	433.91	TW
121.55	0	434.02	
124.08		434.68	BKF
128.07	0	435.7	RB
205.15	0	435.94	
235.56	0	436.62	
255.37	0	437.01	
297.32	0	443.39	

Cross Sectional Geometry

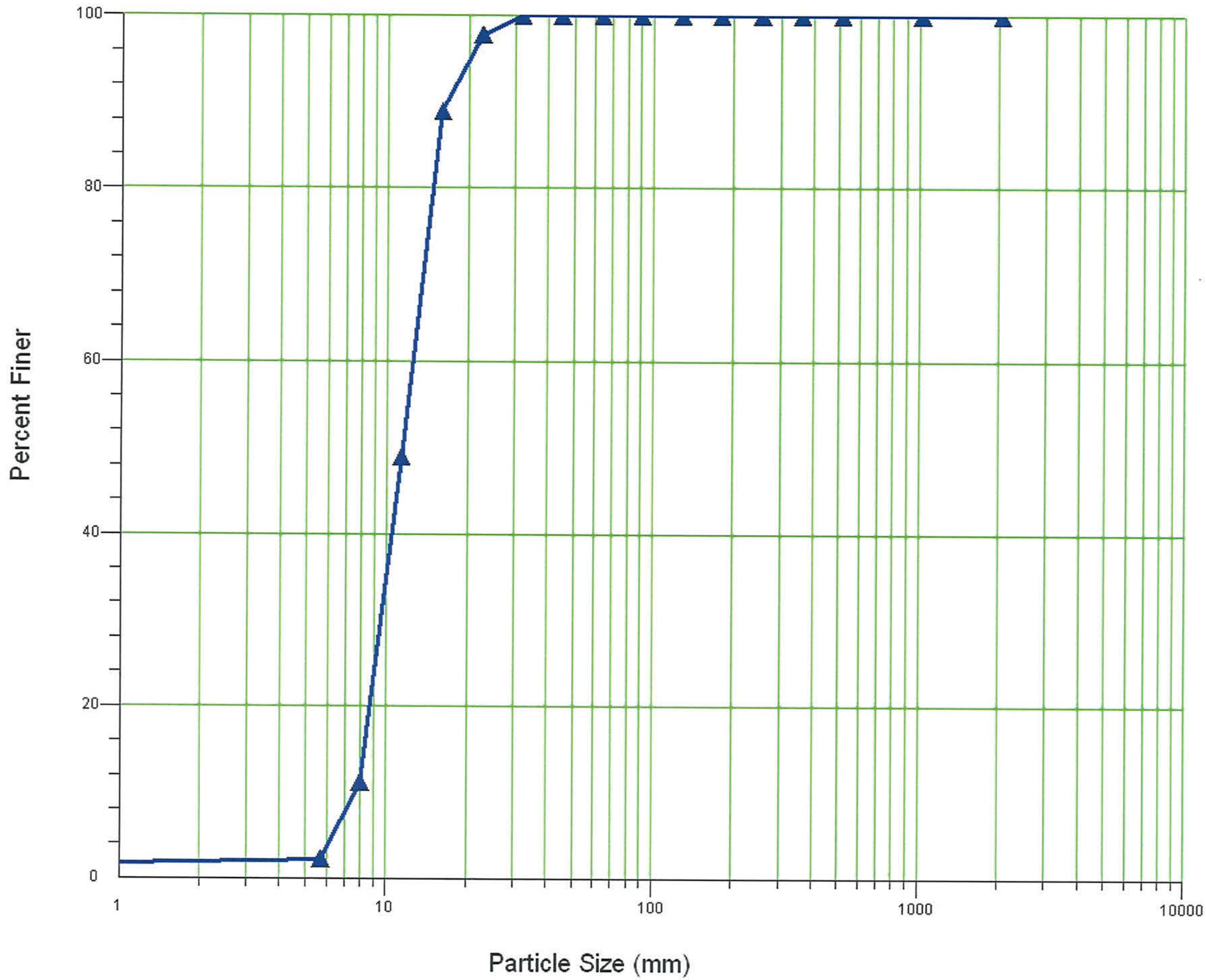
	Channel	Left	Right
Floodprone Elevation (ft)	435.45	435.45	-----
Bankfull Elevation (ft)	434.68	434.68	-----
Floodprone Width (ft)	12.98	-----	-----
Bankfull Width (ft)	8.21	22.47	-----
Entrenchment Ratio	1.58	-----	-----
Mean Depth (ft)	0.52	0.52	-----
Maximum Depth (ft)	0.77	0.77	-----
Width/Depth Ratio	15.79	43.21	-----
Bankfull Area (sq ft)	4.27	4.27	-----
Wetted Perimeter (ft)	8.43	8.43	-----
Hydraulic Radius (ft)	0.51	0.51	-----
Begin BKF Station	115.87	115.87	-----
End BKF Station	124.08	124.08	-----

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.02297	0	0
Shear Stress (lb/sq ft)	0.73		
Movable Particle (mm)	120.7		

Davis Branch UT - Riffle XS 0+76 - Substrate Pebble Count - 07/17/2007



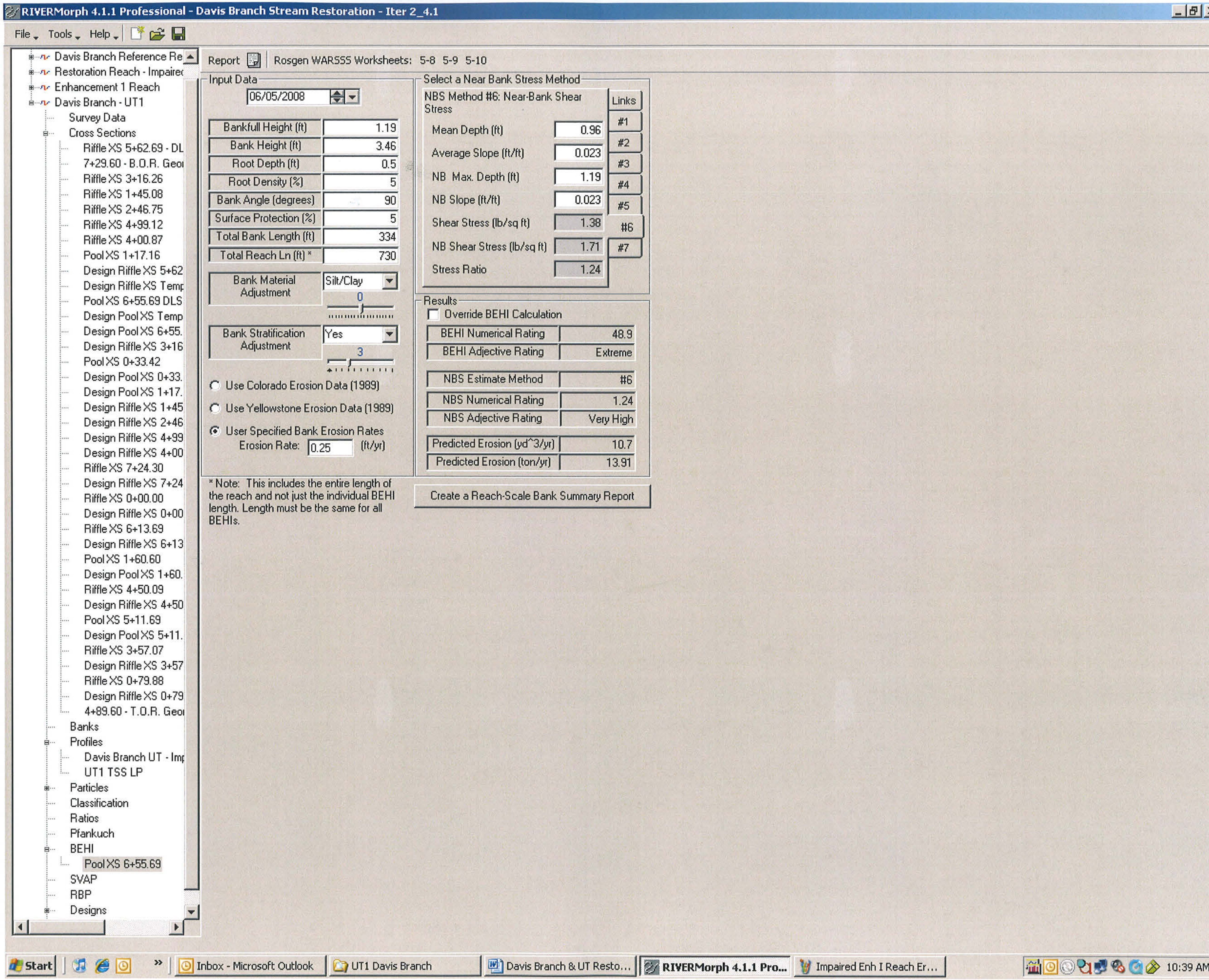
UT Riffle XS 0+76 Pebble Count RM Summary.txt
RIVERMORPH PARTICLE SUMMARY

River Name: Davis Branch
Reach Name: Davis Branch UT - Impaired
Sample Name: Riffle XS 0+76 Pebble Count
Survey Date: 07/17/2007

Size (mm)	TOT #	ITEM %	CUM %
0 - 0.062	0	0.00	0.00
0.062 - 0.125	0	0.00	0.00
0.125 - 0.25	0	0.00	0.00
0.25 - 0.50	0	0.00	0.00
0.50 - 1.0	0	0.00	0.00
1.0 - 2.0	0	0.00	0.00
2.0 - 4.0	0	0.00	0.00
4.0 - 5.7	1	2.22	2.22
5.7 - 8.0	4	8.89	11.11
8.0 - 11.3	17	37.78	48.89
11.3 - 16.0	18	40.00	88.89
16.0 - 22.6	4	8.89	97.78
22.6 - 32.0	1	2.22	100.00
32 - 45	0	0.00	100.00
45 - 64	0	0.00	100.00
64 - 90	0	0.00	100.00
90 - 128	0	0.00	100.00
128 - 180	0	0.00	100.00
180 - 256	0	0.00	100.00
256 - 362	0	0.00	100.00
362 - 512	0	0.00	100.00
512 - 1024	0	0.00	100.00
1024 - 2048	0	0.00	100.00
Bedrock	0	0.00	100.00

D16 (mm)	8.43
D35 (mm)	10.09
D50 (mm)	11.43
D84 (mm)	15.43
D95 (mm)	20.54
D100 (mm)	32
Silt/Clay (%)	0
Sand (%)	0
Gravel (%)	100
Cobble (%)	0
Boulder (%)	0
Bedrock (%)	0

Total Particles = 45 (need at least 60).


RIVERMorph 4.1.1 Professional - Davis Branch Stream Restoration - Iter 2_4.1
File Tools Help
Davis Branch Reference Re
Restoration Reach - Impairec
Enhancement 1 Reach
Davis Branch - UT1
Survey Data
Cross Sections
Riffle XS 5+62.69 - DL
7+29.60 - B.O.R. Geo
Riffle XS 3+16.26
Riffle XS 1+45.08
Riffle XS 2+46.75
Riffle XS 4+99.12
Riffle XS 4+00.87
Pool XS 1+17.16
Design Riffle XS 5+62
Design Riffle XS Temp
Pool XS 6+55.69 DLS
Design Pool XS Temp
Design Pool XS 6+55.
Design Riffle XS 3+16
Pool XS 0+33.42
Design Pool XS 0+33.
Design Pool XS 1+17.
Design Riffle XS 1+45
Design Riffle XS 2+46
Design Riffle XS 4+99
Design Riffle XS 4+00
Riffle XS 7+24.30
Design Riffle XS 7+24
Riffle XS 0+00.00
Design Riffle XS 0+00
Riffle XS 6+13.69
Design Riffle XS 6+13
Pool XS 1+60.60
Design Pool XS 1+60.
Riffle XS 4+50.09
Design Riffle XS 4+50
Pool XS 5+11.69
Design Pool XS 5+11.
Riffle XS 3+57.07
Design Riffle XS 3+57
Riffle XS 0+79.88
Design Riffle XS 0+79
4+89.60 - T.O.R. Geo
Banks
Profiles
Davis Branch UT - Imp
UT1 TSS LP
Particles
Classification
Ratios
Pfankuch
BEHI
Pool XS 6+55.69
SVAP
RBP
Designs
Report
Rosgen WARSSS Worksheets: 5-8 5-9 5-10
Input Data
06/05/2008
Bankfull Height (ft) 1.19
Bank Height (ft) 3.46
Root Depth (ft) 0.5
Root Density (%) 5
Bank Angle (degrees) 90
Surface Protection (%) 5
Total Bank Length (ft) 334
Total Reach Ln (ft) * 730
Bank Material Adjustment Silt/Clay 0
Bank Stratification Adjustment Yes 3
Use Colorado Erosion Data (1989)
Use Yellowstone Erosion Data (1989)
User Specified Bank Erosion Rates
Erosion Rate: 0.25 (ft/yr)
* Note: This includes the entire length of the reach and not just the individual BEHI length. Length must be the same for all BEHIs.
Select a Near Bank Stress Method
NBS Method #6: Near-Bank Shear Stress
Links
#1
#2
#3
#4
#5
#6
#7
Mean Depth (ft) 0.96
Average Slope (ft/ft) 0.023
NB Max. Depth (ft) 1.19
NB Slope (ft/ft) 0.023
Shear Stress (lb/sq ft) 1.38
NB Shear Stress (lb/sq ft) 1.71
Stress Ratio 1.24
Results
Override BEHI Calculation
BEHI Numerical Rating 48.9
BEHI Adjective Rating Extreme
NBS Estimate Method #6
NBS Numerical Rating 1.24
NBS Adjective Rating Very High
Predicted Erosion (yd^3/yr) 10.7
Predicted Erosion (ton/yr) 13.91
Create a Reach-Scale Bank Summary Report
Start
Inbox - Microsoft Outlook
UT1 Davis Branch
Davis Branch & UT Resto...
RIVERMorph 4.1.1 Pro...
Impaired Enh I Reach Er...
10:39 AM

RIVERMORPH BANK EROSION HARZARD INDEX (BEHI)

River Name: Davis Branch
Reach Name: Davis Branch - UT1
BEHI Name: Pool XS 6+55.69
Survey Date: 06/05/2008

Bankfull Height: 1.19 ft
Bank Height: 3.46 ft
Root Depth: 0.5 ft
Root Density: 5 %
Bank Angle: 90 Degrees
Surface Protection: 5 %

Bank Material Adjustment: Silt/Clay 0

Bank Stratification Adjustment: Yes 3

Erosion Loss Curve: Yellowstone

NBS Method #6: Near-Bank Shear Stress

Mean Depth: 0.96 ft
NB Max Depth: 1.19 ft
Shear Stress: 1.38 lb/sq/ft
Stress Ratio: 1.24

Average Slope: 0.023 ft/ft
NB Slope: 0.023 ft/ft
NB Shear Stress: 1.71 lb/sq/ft

BEHI Numerical Rating: 48.9
BEHI Adjective Rating: Extreme
NBS Numerical Rating: 1.24
NBS Adjective Rating: Very High
Total Bank Length: 334 ft
Estimated Sediment Loss: 10.7 Cu Yds per Year
Estimated Sediment Loss: 13.91 Tons per Year

RIVERMORPH BEHI SUMMARY REPORT

River Name: Davis Branch
Reach Name: Davis Branch - UT1

Table 1. Bank Identification Summary

Bank	Name
1	Pool XS 6+55.69

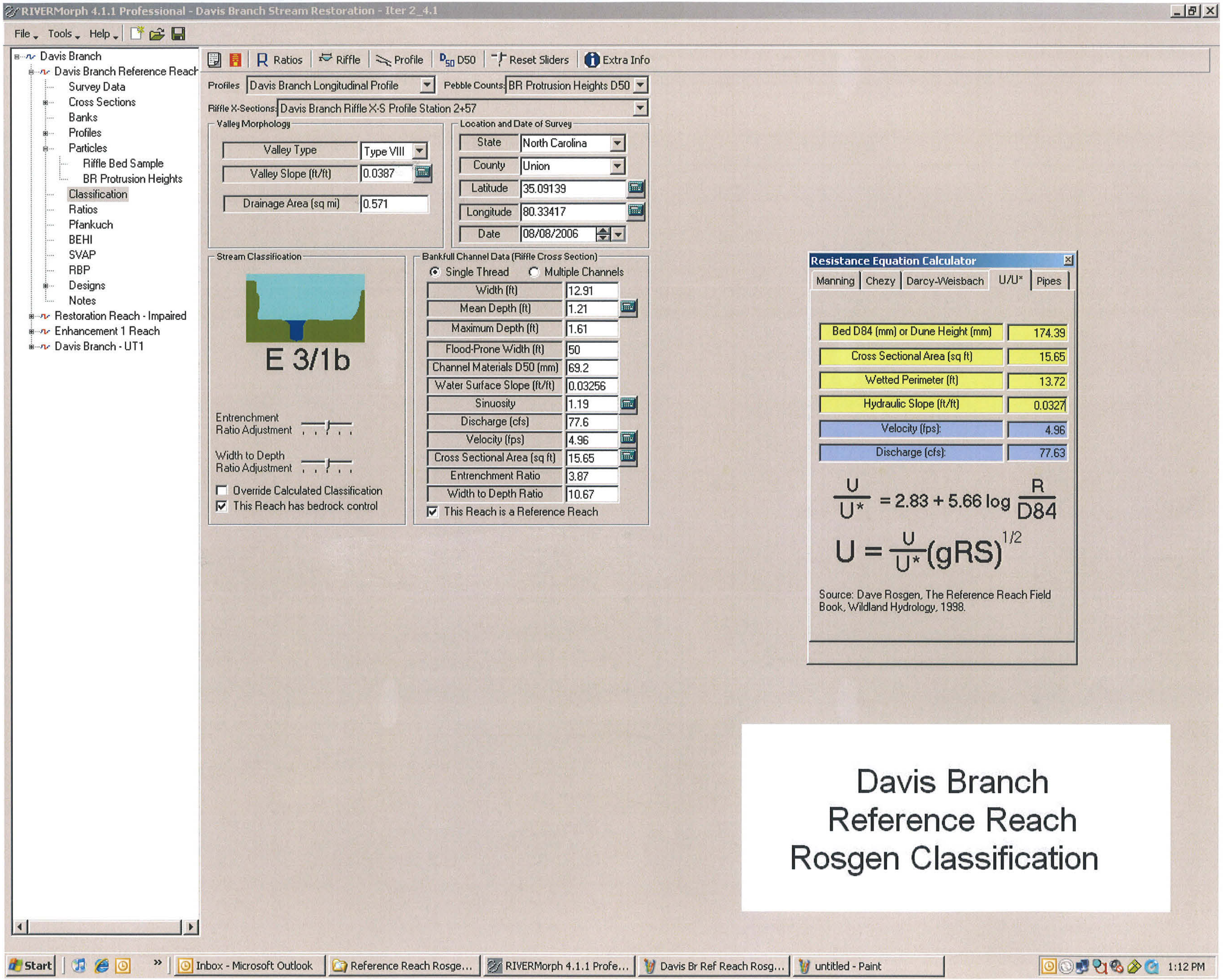
Table 2. Predicted Annual Bank Erosion Rates

Bank	BEHI Numeric Rating	BEHI Adjective Rating	NBS Adjective Rating	Length ft	Loss cu yds/yr	Loss tons/yr
1	48.9	Extreme	Very High	334	10.7	13.91
Totals				334	10.7	13.91

Total Reach Ln: 730 Total Loss (tons/yr) per ft of Reach: 0.0191

APPENDIX 4

Davis Branch Reference Reach, Rosgen Level III Assessment Documentation



Davis Branch
Reference Reach
Rosgen Classification

Davis Branch & Unnamed Tributary

North Carolina Rural Piedmont Regional Curve Analysis

Bankfull Hydraulic Relationships for North Carolina Streams, Rural Piedmont Dataset, Stratified by Rosgen "E" Stream Type

For estimating bankfull characteristics of rurul, unregulated streams in the Rural Piedmont of North Carolina[1]

Job Name:	**Davis Branch & Unnamed Tributary**
Job Number:	2006-1397
Stream Name:	**Davis Branch Reference Reach**

Drainage Area: 0.5721 Square Mile 365.54 Acres

EMPERICAL RELATIONSHIPS

Q_{BKF}	=	$111.28\ DA^{0.5878}$	=	80.01	$feet^3/sec$	Bankfull Discharge	$R^2 = 0.94$ [2]
A_{BKF}	=	$22.57\ DA^{0.6317}$	=	15.85	$feet^2$	Bankfull Area	$R^2 = 0.88$
W_{BKF}	=	$14.02\ DA^{0.3118}$	=	11.77	feet	Bankfull Width	$R^2 = 0.77$
D_{BKF}	=	$1.61\ DA^{0.3206}$	=	1.35	feet	Bankfull Mean Depth	$R^2 = 0.90$
R.I.	=	$1.53\ DA^{0.0016}$	=	1.5	years	Return Interval	$R^2 = 0.11$

[1]**North Carolina Multi-Agency Stream Mitigation Guidelines, April 2003.**
[2]**Log-Pearson Type III distributions, coefficients of determination (R^2) for E stream type data were calculated using the regional curve editor algorithm in RiverMorph v. 4.1.1.**

QUANTITATIVE RELATIONSHIPS[3]

Q_{BKF}	=	77.6	$feet^3/sec$
A_{BKF}	=	15.65	$feet^2$
W_{BKF}	=	12.91	feet
D_{BKF}	=	1.21	feet

[3]**Quantitative results from Davis Branch, Rosgen Level III - Reference Reach Assessment, 8-9 August 2006.**

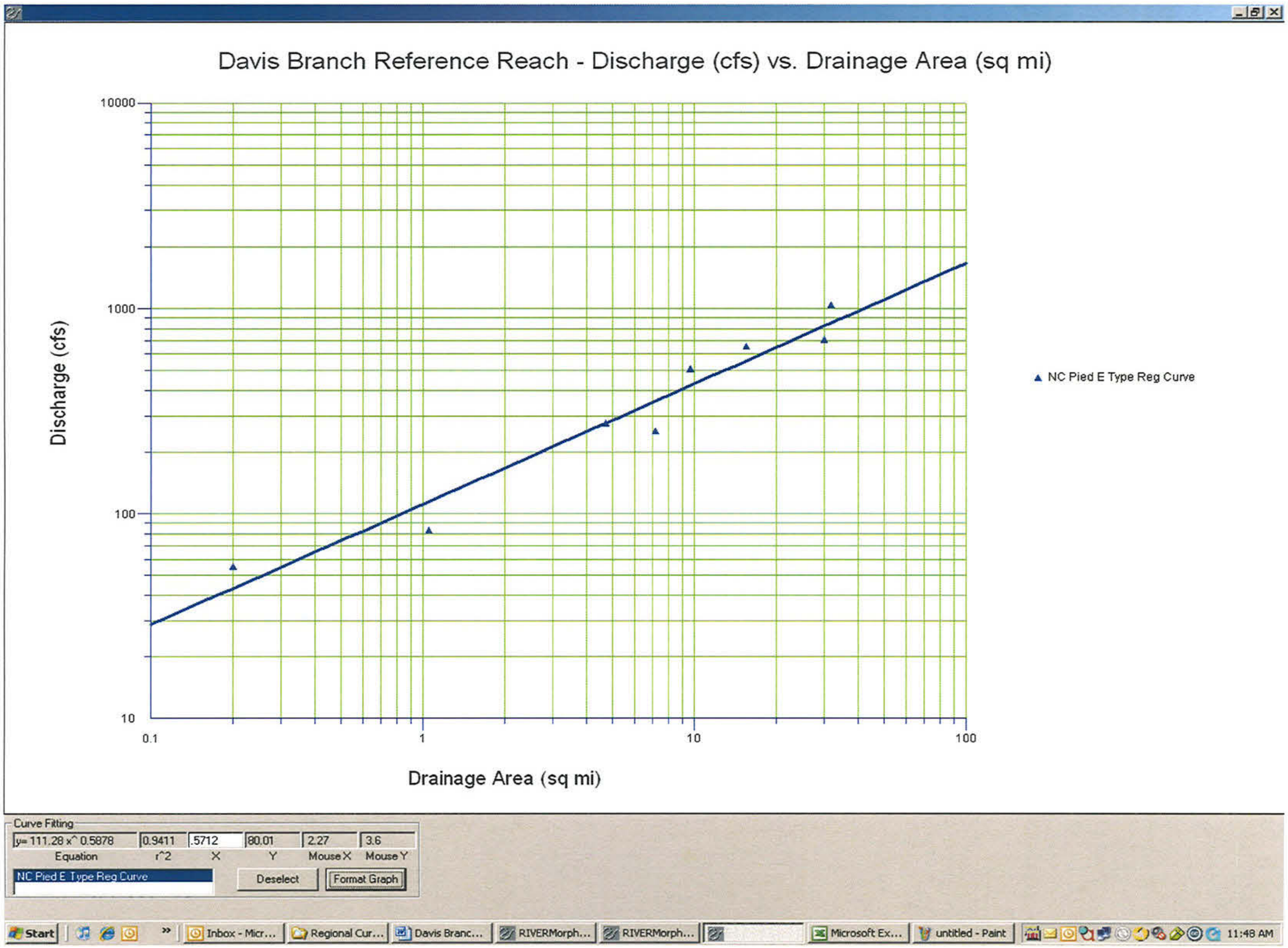
North Carolina Rural Peidmont Regional Curve Dataset[1]

Stream Name	Gage ID	Stream Type	DA	Qbkf	Abkf	Wbkf	Dbkf	Sws (ft/ft)	R.I. (yr)	Exceedance Probability (%)
Sal's Branch	Ref. Reach	E4	0.2	55.4	10.4	8.7	1.2	0.0109	0	0
Humpy Creek	2117030	E5	1.05	83	15.8	12	1.3	0.0060	1.7	59
Dutchmans	2123567	C5	3.44	85.1	45.6	23.5	1.9	0.0170	1	100
Mill Creek	Ref. Reach	E4	4.7	277	46.7	24.5	1.9	0.0080	0	0
Upper Mitchell River	Ref. Reach	B4c	6	356	62.5	29.2	2.1	0.0095	0	0
Norwood Creek	214253830	E5	7.18	253.7	98.8	32	3.1	0.0008	1.1	91
North Pott's Creek	2121180	E5	9.6	507.2	89.6	25.4	3.5	0.0012	1.7	59
Tick Creek	2101800	E	15.5	655.3	194	40.5	4.8	0.0005	1.3	77
Moon Creek	2075160	E5	29.9	708.8	162	33	4.9	0.0015	1.8	56
Long Creek	2144000	E5	31.8	1041	195	40	4.9	0.0010	1.4	71
Little Yadkin River	2114450	G5	42.8	2236	469	77.5	6	0.0018	1.4	71
Mitchell River	2112360	C	78.8	2681	377	77	4.9	0.0030	1.6	63
Fisher River	2113000	C3	128	3687	578	101	5.7	0.0023	1.4	71

North Carolina Rural Peidmont Regional Curve Dataset, Stratified by Rosgen E Stream Type Dataset

Stream Name	Gage ID	Stream Type	DA	Qbkf	Abkf	Wbkf	Dbkf	Sws (ft/ft)	R.I. (yr)	Exceedance Probability (%)
Sal's Branch	Ref. Reach	E4	0.2	55.4	10.4	8.7	1.2	0.0109	0	0
Humpy Creek	2117030	E5	1.05	83	15.8	12	1.3	0.0060	1.7	59
Mill Creek	Ref. Reach	E4	4.7	277	46.7	24.5	1.9	0.0080	0	0
Norwood Creek	214253830	E5	7.18	253.7	98.8	32	3.1	0.0008	1.1	91
North Pott's Creek	2121180	E5	9.6	507.2	89.6	25.4	3.5	0.0012	1.7	59
Tick Creek	2101800	E	15.5	655.3	194	40.5	4.8	0.0005	1.3	77
Moon Creek	2075160	E5	29.9	708.8	162	33	4.9	0.0015	1.8	56
Long Creek	2144000	E5	31.8	1041	195	40	4.9	0.0010	1.4	71

[1]**Bankfull Hydraulic Relationships for North Carolina Streams, Rural Peidmont Dataset,**
For estimating bankfull characteristics of rurul, unregulated streams in the Rural Peidmont of North Carolina, North Carolina Multi-Agency Stream Mitigation Guidelines, April 2003.
Hydaulic geometry, survey summary, and flood frequency analysis for gaged and ungaged stream reaches.


Davis Branch Reference Reach - Discharge (cfs) vs. Drainage Area (sq mi)
Discharge (cfs)
10000
1000
100
10
0.1
1
10
100
Drainage Area (sq mi)
NC Pied E Type Reg Curve
Curve Fitting
y= 111.28 x^ 0.5878
0.9411
.5712
80.01
2.27
3.6
Equation
r^2
X
Y
Mouse X
Mouse Y
NC Pied E Type Reg Curve
Deselect
Format Graph
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RIVERMorph...
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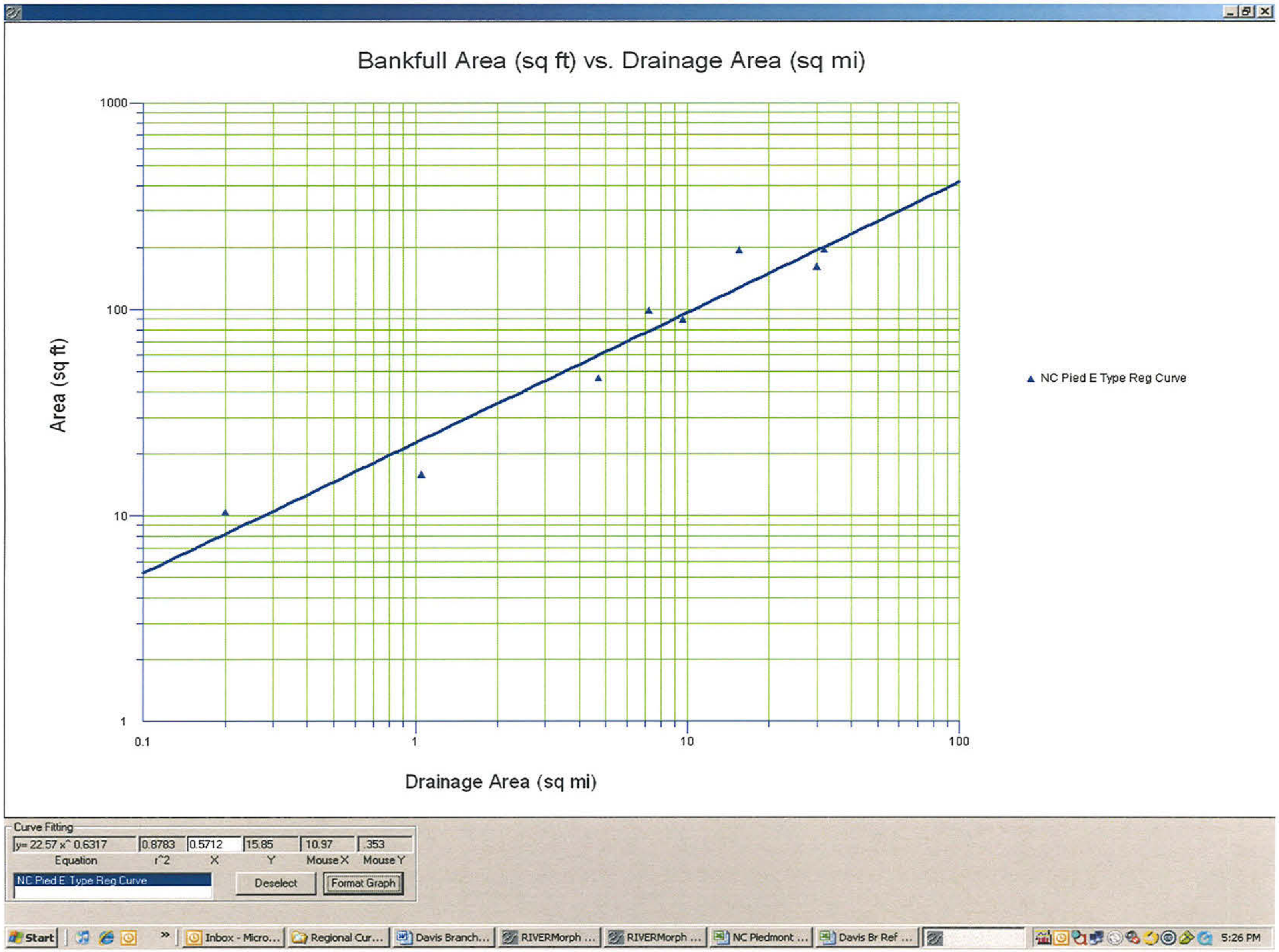
Bankfull Area (sq ft) vs. Drainage Area (sq mi)
Area (sq ft)
1000
100
10
1
0.1
1
10
100
Drainage Area (sq mi)
NC Pied E Type Reg Curve
Curve Fitting
y= 22.57 x^ 0.6317
0.8783
0.5712
15.85
10.97
.353
Equation
r^2
X
Y
Mouse X
Mouse Y
NC Pied E Type Reg Curve
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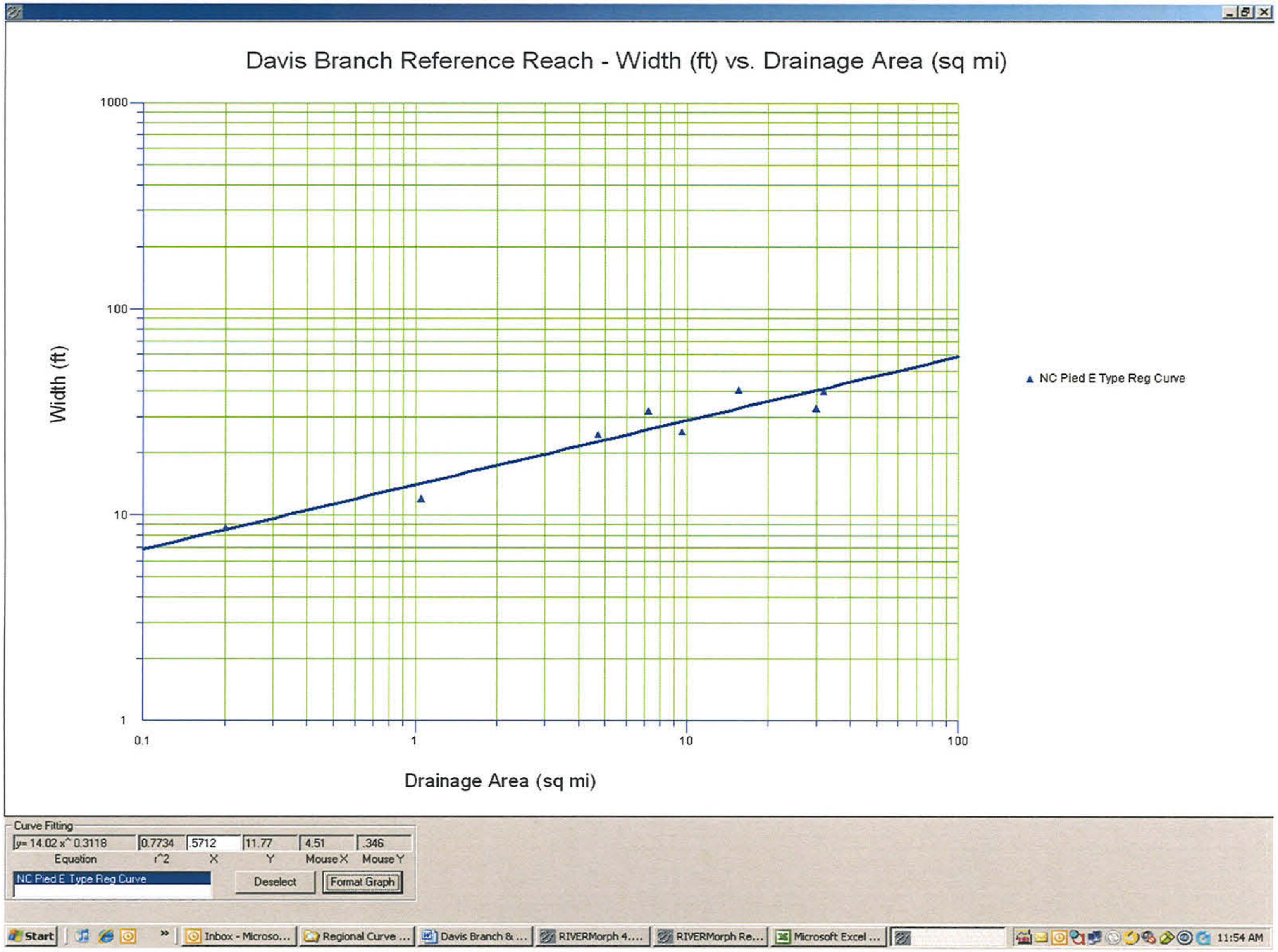

Davis Branch Reference Reach - Width (ft) vs. Drainage Area (sq mi)
Width (ft)
1000
100
10
1
0.1
1
10
100
Drainage Area (sq mi)
NC Pied E Type Reg Curve
Curve Fitting
y= 14.02 x^ 0.3118
0.7734
.5712
11.77
4.51
.346
Equation
r^2
X
Y
Mouse X
Mouse Y
NC Pied E Type Reg Curve
Deselect
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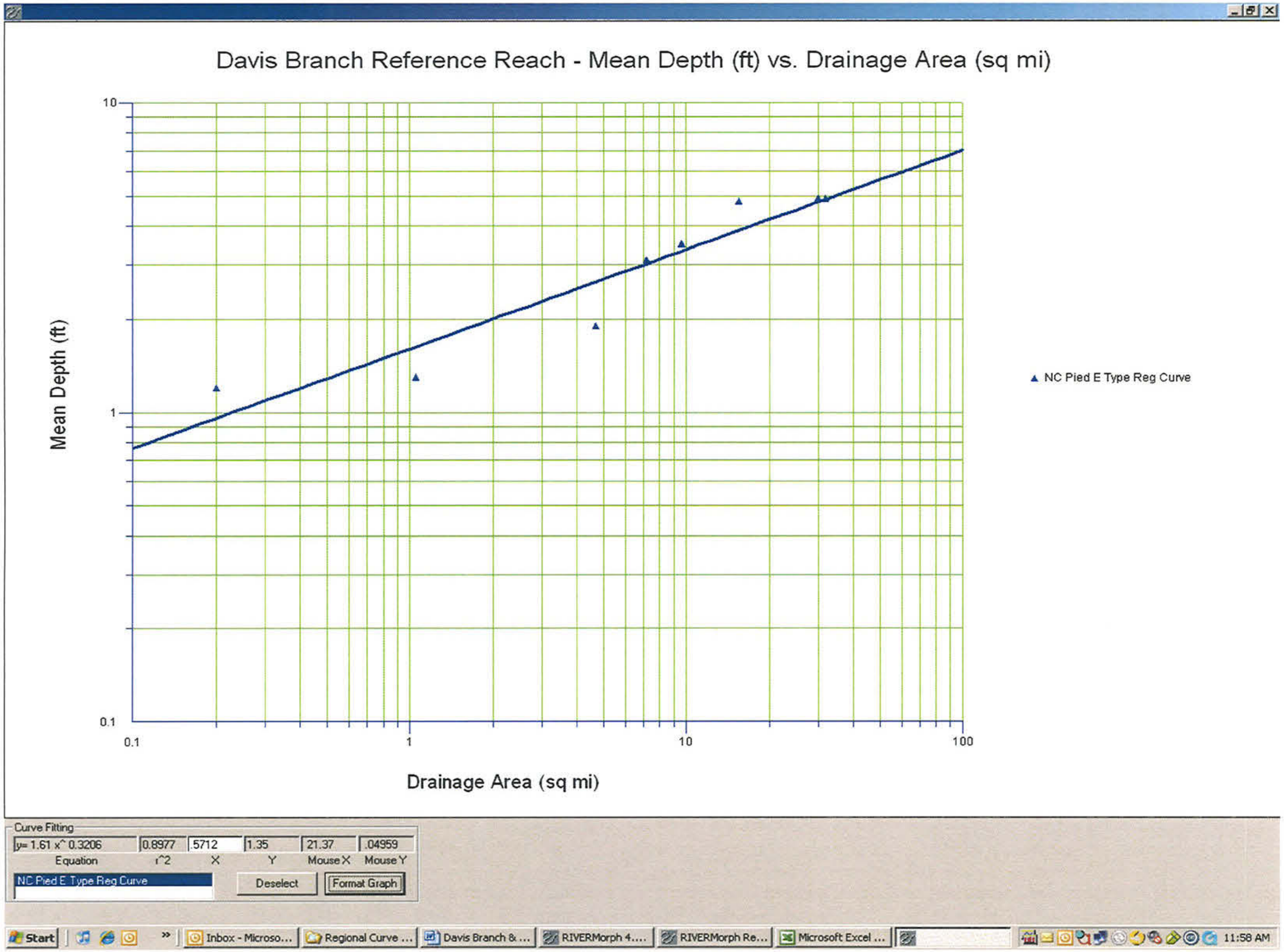

Davis Branch Reference Reach - Mean Depth (ft) vs. Drainage Area (sq mi)
Mean Depth (ft)
10
1
0.1
0.1
1
10
100
Drainage Area (sq mi)
NC Pied E Type Reg Curve
Curve Fitting
y= 1.61 x^ 0.3206
0.8977
.5712
1.35
21.37
.04959
Equation
r^2
X
Y
Mouse X
Mouse Y
NC Pied E Type Reg Curve
Deselect
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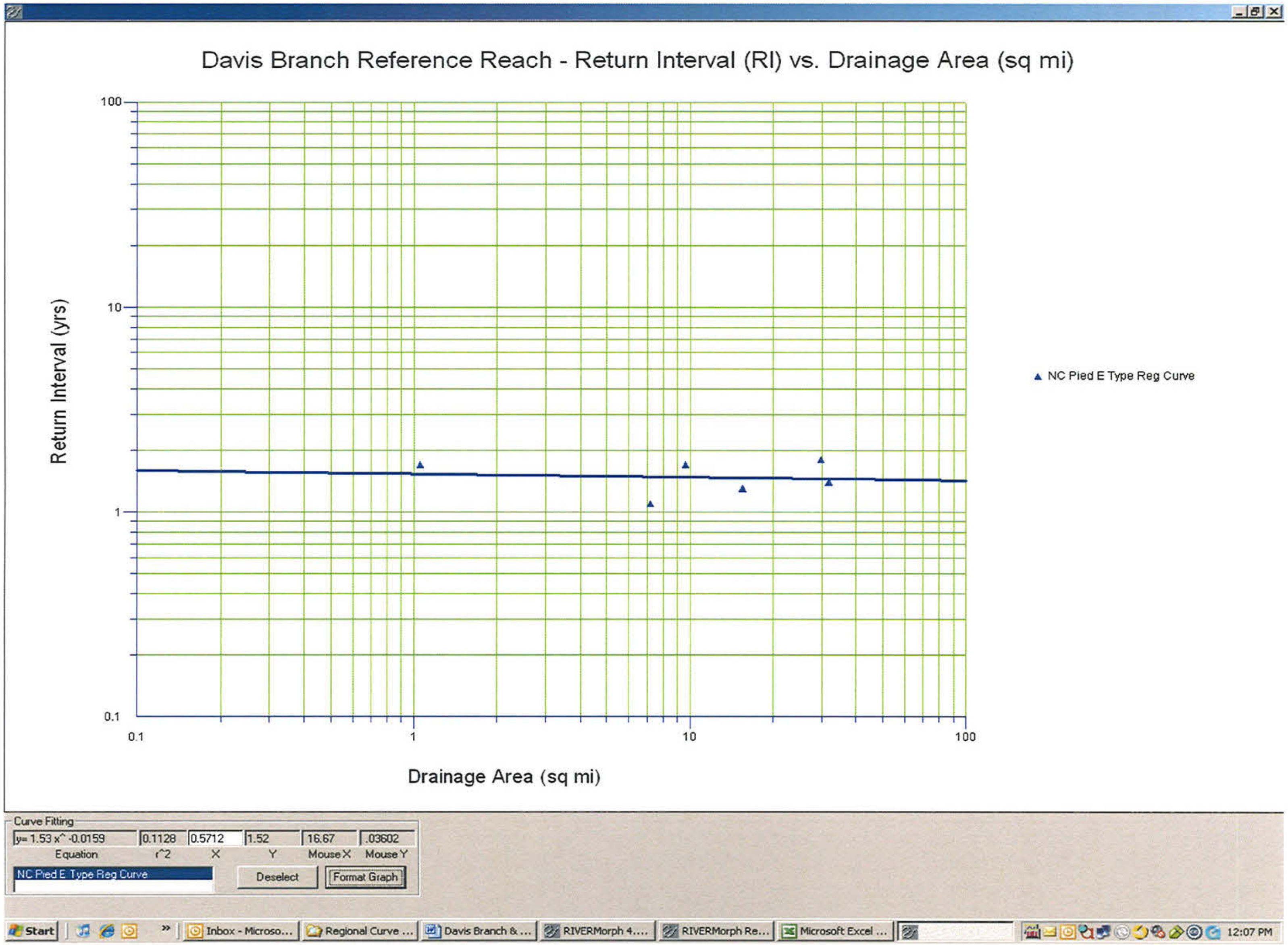

Davis Branch Reference Reach - Return Interval (RI) vs. Drainage Area (sq mi)
Return Interval (yrs)
100
10
1
0.1
0.1
1
10
100
Drainage Area (sq mi)
NC Pied E Type Reg Curve
Curve Fitting
y= 1.53 x^ -0.0159
0.1128
0.5712
1.52
16.67
.03602
Equation
r^2
X
Y
Mouse X
Mouse Y
NC Pied E Type Reg Curve
Deselect
Format Graph
Start
Inbox - Microso...
Regional Curve ...
Davis Branch & ...
RIVERMorph 4....
RIVERMorph Re...
Microsoft Excel ...
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Worksheet 5-3. Field form for Level II stream classification (Rosgen, 1996; Rosgen and Silvey, 2005).

Stream:	**Davis Branch Reference Reach**				
Basin:	**Yadkin - Pee Dee**	Drainage Area:	**365.54** acres	**0.5712**	mi^2
Location:	**Davis Branch Near Marshville, N.C.**				
Twp.&Rge:	**;**	Sec.&Qtr.:	**;**		
Cross-Section Monuments (Lat./Long.):	**35.09139 Lat / 80.33417 Long**			Date:	**08/08/06**
Observers:	**Warren E. Knotts, PG & Sean Peffer, Env. Sc.**			Valley Type:	VIII

Parameter	Value	Units
Bankfull WIDTH (W_{bkf}) WIDTH of the stream channel at bankfull stage elevation, in a riffle section.	**12.91**	ft
Bankfull DEPTH (d_{bkf}) Mean DEPTH of the stream channel cross-section, at bankfull stage elevation, in a riffle section ($d_{bkf} = A / W_{bkf}$).	**1.21**	ft
Bankfull X-Section AREA (A_{bkf}) AREA of the stream channel cross-section, at bankfull stage elevation, in a riffle section.	**15.65**	ft^2
Width/Depth Ratio (W_{bkf} / d_{bkf}) Bankfull WIDTH divided by bankfull mean DEPTH, in a riffle section.	**10.67**	ft/ft
Maximum DEPTH (d_{mbkf}) Maximum depth of the bankfull channel cross-section, or distance between the bankfull stage and Thalweg elevations, in a riffle section.	**1.61**	ft
WIDTH of Flood-Prone Area (W_{fpa}) Twice maximum DEPTH, or ($2 \times d_{mbkf}$) = the stage/elevation at which flood-prone area WIDTH is determined in a riffle section.	**50**	ft
Entrenchment Ratio (ER) The ratio of flood-prone area WIDTH divided by bankfull channel WIDTH (W_{fpa} / W_{bkf}) (riffle section).	**3.87**	ft/ft
Channel Materials (Particle Size Index) D_{50} The D_{50} particle size index represents the mean diameter of channel materials, as sampled from the channel surface, between the bankfull stage and Thalweg elevations.	**69.2**	mm
Water Surface SLOPE (S) Channel slope = "rise over run" for a reach approximately 20–30 bankfull channel widths in length, with the "riffle-to-riffle" water surface slope representing the gradient at bankfull stage.	**0.03256**	ft/ft
Channel SINUOSITY (k) Sinuosity is an index of channel pattern, determined from a ratio of stream length divided by valley length (SL / VL); or estimated from a ratio of valley slope divided by channel slope (VS / S).	**1.19**	

Stream Type → **E 3/1b** ← (See **Figure 2-14**)

Worksheet 5-4. Morphological relations, including dimensionless ratios of river reach sites (Rosgen and Silvey, 2005).

Stream: **Davis Branch Reference Reach**		Location: **Davis Branch Near Marshville, N.C.**	
Observers: **Warren E. Knotts, PG**	Date: **08/08/2006**	Valley Type: **VIII**	Stream Type: **E 3/1b**

River Reach Summary Data

Channel Dimension

Mean Riffle Depth (d_{bkf})	**1.21**	ft	Riffle Width (W_{bkf})	**12.91**	ft	Riffle Area (A_{bkf})	**15.65**	ft^2
Mean Pool Depth (d_{bkfp})	**1.46**	ft	Pool Width (W_{bkfp})	**14.49**	ft	Pool Area (A_{bkfp})	**21.16**	ft^2
Mean Pool Depth/Mean Riffle Depth	**1.207**	d_{bkfp}/d_{bkf}	Pool Width/Riffle Width	**1.12**	W_{bkfp}/W_{bkf}	Pool Area / Riffle Area	**1.35**	A_{bkfp}/A_{bkf}
Max Riffle Depth (d_{mbkf})	**1.72**	ft	Max Pool Depth (d_{mbkfp})	**2.04**	ft	Max Riffle Depth/Mean Riffle Depth	**1.42**	
Max Pool Depth/Mean Riffle Depth	**1.686**					Point Bar Slope	**0**	
Streamflow: Estimated Mean Velocity at Bankfull Stage (u_{bkf})				**4.96**	ft/s	Estimation Method	**u/u***	
Streamflow: Estimated Discharge at Bankfull Stage (Q_{bkf})				**77.62**	cfs	Drainage Area	**0.5712**	mi^2

Channel Pattern

Geometry	Mean	Min	Max		Dimensionless Geometry Ratios	Mean	Min	Max
Meander Length (Lm)	**99.2**	**80.1**	**117**	ft	Meander Length Ratio (Lm/W_{bkf})	**7.68**	**6.20**	**9.02**
Radius of Curvature (Rc)	**29.4**	**16.4**	**45.3**	ft	Radius of Curvature/Riffle Width (Rc/W_{bkf})	**2.28**	**1.27**	**3.51**
Belt Width (W_{blt})	**38**	**27.8**	**53**	ft	Meander Width Ratio (W_{blt}/W_{bkf})	**2.94**	**2.15**	**4.11**
Individual Pool Length	**21.2**	**12.04**	**29.1**	ft	Pool Length/Riffle Width	**1.64**	**0.93**	**2.25**
Pool to Pool Spacing	**38.56**	**33.42**	**43.7**	ft	Pool to Pool Spacing/Riffle Width	**2.99**	**2.59**	**3.38**
Riffle Length	**14.33**	**12**	**18.5**	ft	Riffle Length/Riffle Width	**1.11**	**0.93**	**1.43**

Channel Profile

Valley Slope (VS)	**0.0387**	ft/ft	Average Water Surface Slope (S)	**0.03256**	ft/ft	Sinuosity (VS/S)	**1.19**
Stream Length (SL)	**1159**	ft	Valley Length (VL)	**974**	ft	Sinuosity (SL/VL)	**1.19**
Low Bank Height (LBH) start	**1.33**	ft	Max Riffle Depth start	**1.33**	ft	Bank-Height Ratio (BHR) (LBH/Max Riffle Depth) start	**1**
Low Bank Height (LBH) end	**2.34**	ft	Max Riffle Depth end	**2.34**	ft	Bank-Height Ratio (BHR) (LBH/Max Riffle Depth) end	**1**

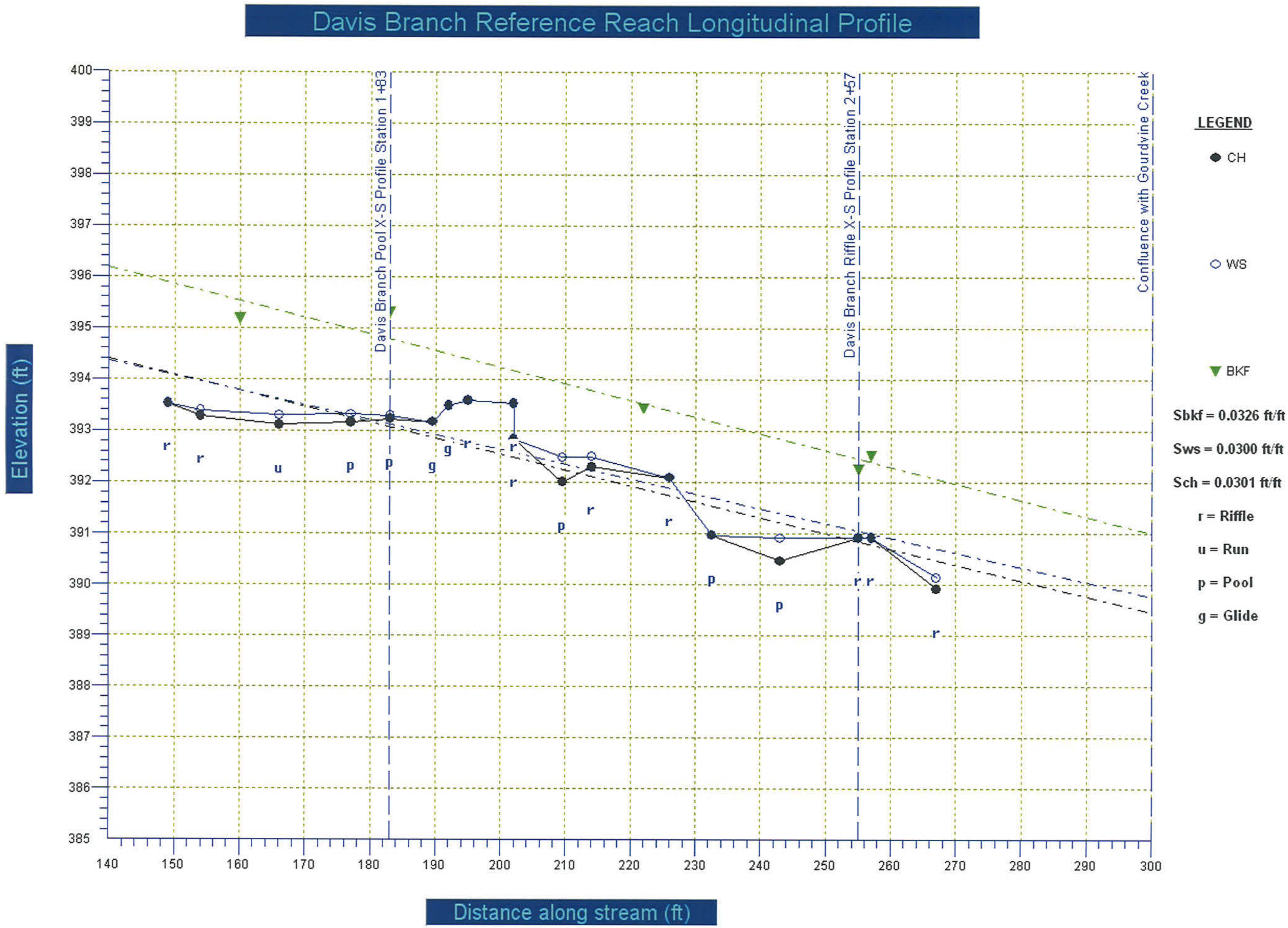
Facet Slopes	Mean	Min	Max		Dimensionless Slope Ratios	Mean	Min	Max
Riffle Slope (S_{rif})	**0.0520**	**0.0283**	**0.0799**	ft/ft	Riffle Slope/Average Water Surface Slope (S_{rif} / S)	**1.598**	**0.869**	**2.453**
Run Slope (S_{run})	**0.0076**	**0.0076**	**0.0076**	ft/ft	Run Slope/Average Water Surface Slope (S_{run} / S)	**0.232**	**0.232**	**0.232**
Pool Slope (S_p)	**0.0011**	**0.0010**	**0.0011**	ft/ft	Pool Slope/Average Water Surface Slope (S_p / S)	**0.033**	**0.032**	**0.035**
Glide Slope (S_g)	**0.0166**	**0.0166**	**0.0166**	ft/ft	Glide Slope/Average Water Surface Slope (S_g / S)	**0.510**	**0.510**	**0.510**

Feature Midpoint[a]	Mean	Min	Max		Dimensionless Depth Ratios	Mean	Min	Max
Riffle Depth (d_{rif})	**1.72**	**1.33**	**2.34**	ft	Riffle Depth/Mean Riffle Depth (d_{rif} / d_{bkf})	**1.42**	**1.1**	**1.93**
Run Depth (d_{run})	**1.97**	**1.64**	**2.29**	ft	Run Depth/Mean Riffle Depth (d_{run} / d_{bkf})	**1.63**	**1.36**	**1.89**
Pool Depth (d_p)	**2.04**	**1.83**	**2.38**	ft	Pool Depth/Mean Riffle Depth (d_p / d_{bkf})	**1.69**	**1.51**	**1.97**
Glide Depth (d_g)	**1.77**	**1.65**	**1.89**	ft	Glide Depth/Mean Riffle Depth (d_g / d_{bkf})	**1.46**	**1.36**	**1.56**

Channel Materials

	Reach[b]	Riffle[c]	Bar		Reach[b]	Riffle[c]	Bar	Protrusion Height[d]	
% Silt/Clay	**0**	**0**		D_{16}	**80.64**	**28.78**		80.64	mm
% Sand	**0**	**0**		D_{35}	**138.4**	**52.6**		138.4	mm
% Gravel	**0**	**45**		D_{50}	**154**	**69.2**		154	mm
% Cobble	**100**	**50**		D_{84}	**207.36**	**140.12**		207.36	mm
% Boulder	**0**	**5**		D_{95}	**240.8**	**256**		240.8	mm
% Bedrock	**0**	**0**		D_{100}	**256**	**362**		256	mm

a Min, max, mean depths are the average mid-point values except pools, which are taken at deepest part of pool.
b Composite sample of riffles and pools within the designated reach.
c Active bed of a riffle.
d Height of roughness feature above bed.


Davis Branch Reference Reach Longitudinal Profile
Elevation (ft)
Distance along stream (ft)
Davis Branch Pool X-S Profile Station 1+83
Davis Branch Riffle X-S Profile Station 2+57
Confluence with Gourdvine Creek
LEGEND
CH
WS
BKF
Sbkf = 0.0326 ft/ft
Sws = 0.0300 ft/ft
Sch = 0.0301 ft/ft
r = Riffle
u = Run
p = Pool
g = Glide

RIVERMORPH PROFILE SUMMARY

River Name: Davis Branch
Reach Name: Davis Branch Reference Reach
Profile Name: Davis Branch Longitudinal Profile
Survey Date: 08/08/2006

Survey Data

DIST	CH	WS	BKF	P1	P2	P3	P4
267	389.91	390.14					
257	390.92	390.92	392.51				
255	390.92	390.92	392.26				
243	390.46	390.91					
232.5	390.97	390.97					
226	392.09	392.09					
222			393.44				
214	392.3	392.5					
209.5	392.01	392.48					
202	392.84	392.84					
202	393.53	393.53					
195	393.59	393.59					
192	393.49	393.49					
189.5	393.17	393.17					
183	393.23	393.28	395.3				
177	393.16	393.32					
166	393.11	393.3					
160			395.18				
154	393.28	393.39					
149	393.53	393.53					

Cross Section / Bank Profile Locations

Name	Type	Profile Station
Davis Branch Riffle X-S Profile Station 2+57	Riffle XS	255
Davis Branch Pool X-S Profile Station 1+83	Pool XS	183
Confluence with Gourdvine Creek	Other XS	300

Measurements from Graph

Bankfull Slope: 0.03256

Variable	Min	Avg	Max
S riffle	0.02828	0.05202	0.07986
S pool	0.00104	0.00109	0.00113
S run	0.00756	0.00756	0.00756
S glide	0.0166	0.0166	0.0166
P - P	33.42	38.56	43.7
Pool length	12.04	21.2	29.09
Riffle length	12	14.33	18.49
Dmax riffle	1.33	1.72	2.34
Dmax pool	1.83	2.04	2.38
Dmax run	1.64	1.97	2.29
Dmax glide	1.65	1.77	1.89
Low bank ht	1.33	1.72	2.34

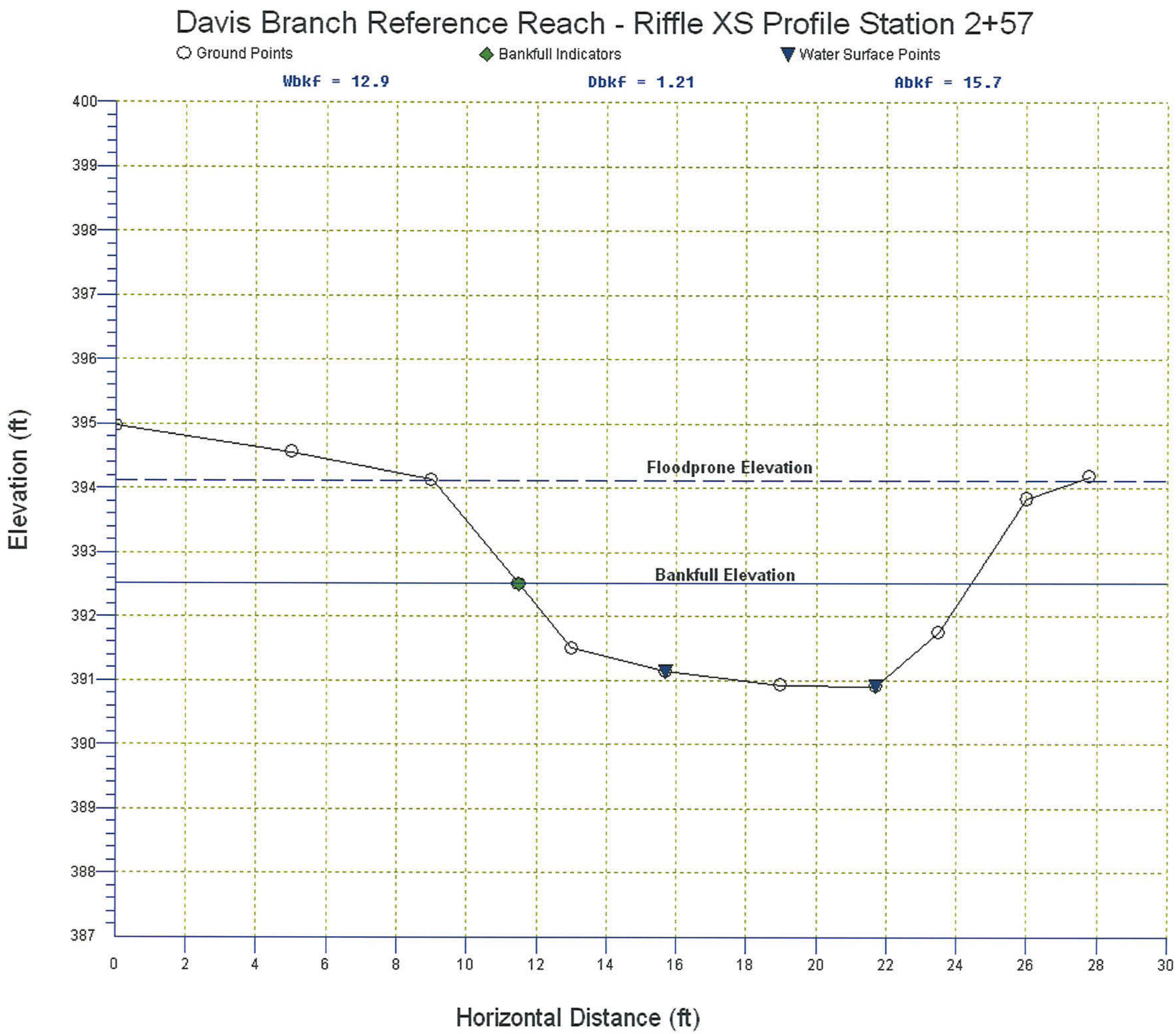
Length and depth measurements in feet, slopes in ft/ft.

RIVERMORPH PROFILE SUMMARY

Notes

River Name: Davis Branch
Reach Name: Davis Branch Reference Reach
Profile Name: Davis Branch Longitudinal Profile
Survey Date: 08/08/2006

DIST	Note
267	Riffle
257	Riffle at XS (Dry)
255	Riffle Top (Dry)
243	Pool
232.5	Pool Top (Dry)
226	Riffle Bottom (Dry)
222	BKF Indicator
214	Riffle Top
209.5	Pool Center
202	Riffle Bottom (Dry)
202	Riffle (Dry)
195	Riffle Top (Dry)
192	Glide (Dry)
189.5	Glide (Dry)
183	Pool at XS
177	Pool Top
166	Run Bottom
160	BKF Indicator
154	Riffle Bottom
149	Riffle Top (Dry)



Davis Branch Reference Reach - Riffle XS Profile Station 2+57
Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 12.9
Dbkf = 1.21
Abkf = 15.7
Floodprone Elevation
Bankfull Elevation
Elevation (ft)
Horizontal Distance (ft)
400
399
398
397
396
395
394
393
392
391
390
389
388
387
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30

RIVERMORPH CROSS SECTION SUMMARY

River Name: Davis Branch
Reach Name: Davis Branch Reference Reach
Cross Section Name: Davis Branch Riffle X-S Profile Station 2+57
Survey Date: 08/08/2006

Cross Section Data Entry

BM Elevation: 390 ft
Backsight Rod Reading: 9.48 ft

TAPE	FS	ELEV	NOTE
27.8	5.3	394.18	FP
26	5.65	393.83	RB
23.5	7.73	391.75	
21.7	8.58	390.9	REW
19	8.56	390.92	TW
15.7	8.34	391.14	LEW
13	7.98	391.5	SB
11.5	6.97	392.51	BKF
9	5.35	394.13	LB
5	4.92	394.56	FP
0	4.51	394.97	FP

Cross Sectional Geometry

	Channel	Left	Right
Floodprone Elevation (ft)	394.12	-----	-----
Bankfull Elevation (ft)	392.51	-----	-----
Floodprone Width (ft)	50	-----	-----
Bankfull Width (ft)	12.91	-----	-----
Entrenchment Ratio	3.87	-----	-----
Mean Depth (ft)	1.21	-----	-----
Maximum Depth (ft)	1.61	-----	-----
Width/Depth Ratio	10.67	-----	-----
Bankfull Area (sq ft)	15.65	-----	-----
Wetted Perimeter (ft)	13.72	-----	-----
Hydraulic Radius (ft)	1.14	-----	-----
Begin BKF Station	24.41	-----	-----
End BKF Station	11.5	-----	-----

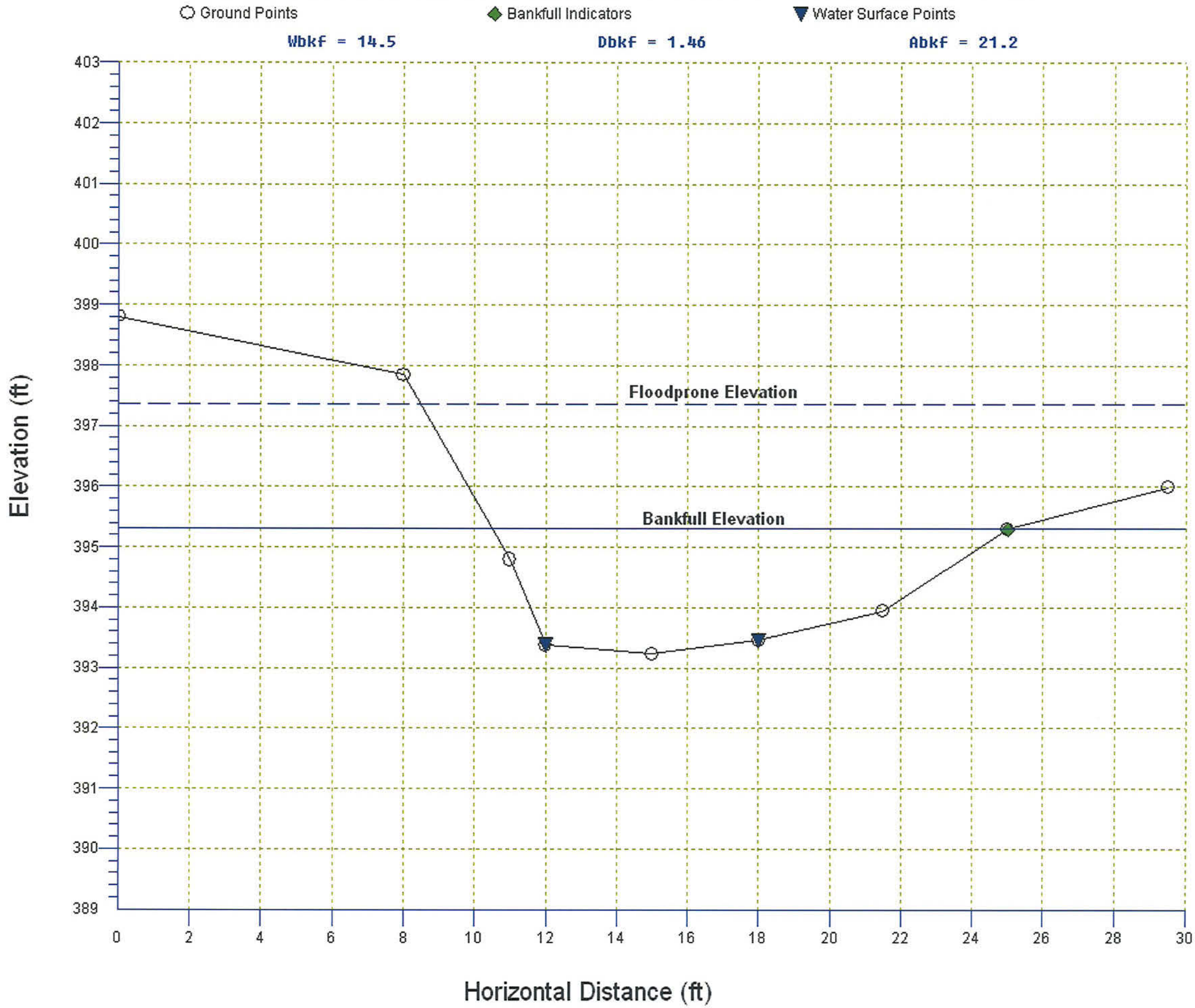
Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.03256	0	0
Shear Stress (lb/sq ft)	2.32		
Movable Particle (mm)	282.0		


08/08/2006

Davis Branch Reference Reach - Pool XS Profile Station 1+83



RIVERMORPH CROSS SECTION SUMMARY

River Name: Davis Branch
Reach Name: Davis Branch Reference Reach
Cross Section Name: Davis Branch Pool X-S Profile Station 1+83
Survey Date: 08/08/2006

Cross Section Data Entry

BM Elevation: 392.74 ft
Backsight Rod Reading: 10 ft

TAPE	FS	ELEV	NOTE
29.5	6.75	395.99	RB
25	7.44	395.3	BKF
21.5	8.8	393.94	PB
18	9.28	393.46	REW
15	9.51	393.23	TW
12	9.36	393.38	LEW
11	7.94	394.8	ON LB
8	4.89	397.85	LB
0	3.93	398.81	FP

Cross Sectional Geometry

	Channel	Left	Right
Floodprone Elevation (ft)	397.37	-----	-----
Bankfull Elevation (ft)	395.3	-----	-----
Floodprone Width (ft)	50	-----	-----
Bankfull Width (ft)	14.49	-----	-----
Entrenchment Ratio	3.45	-----	-----
Mean Depth (ft)	1.46	-----	-----
Maximum Depth (ft)	2.07	-----	-----
Width/Depth Ratio	9.92	-----	-----
Bankfull Area (sq ft)	21.16	-----	-----
Wetted Perimeter (ft)	15.74	-----	-----
Hydraulic Radius (ft)	1.34	-----	-----
Begin BKF Station	25	-----	-----
End BKF Station	10.51	-----	-----

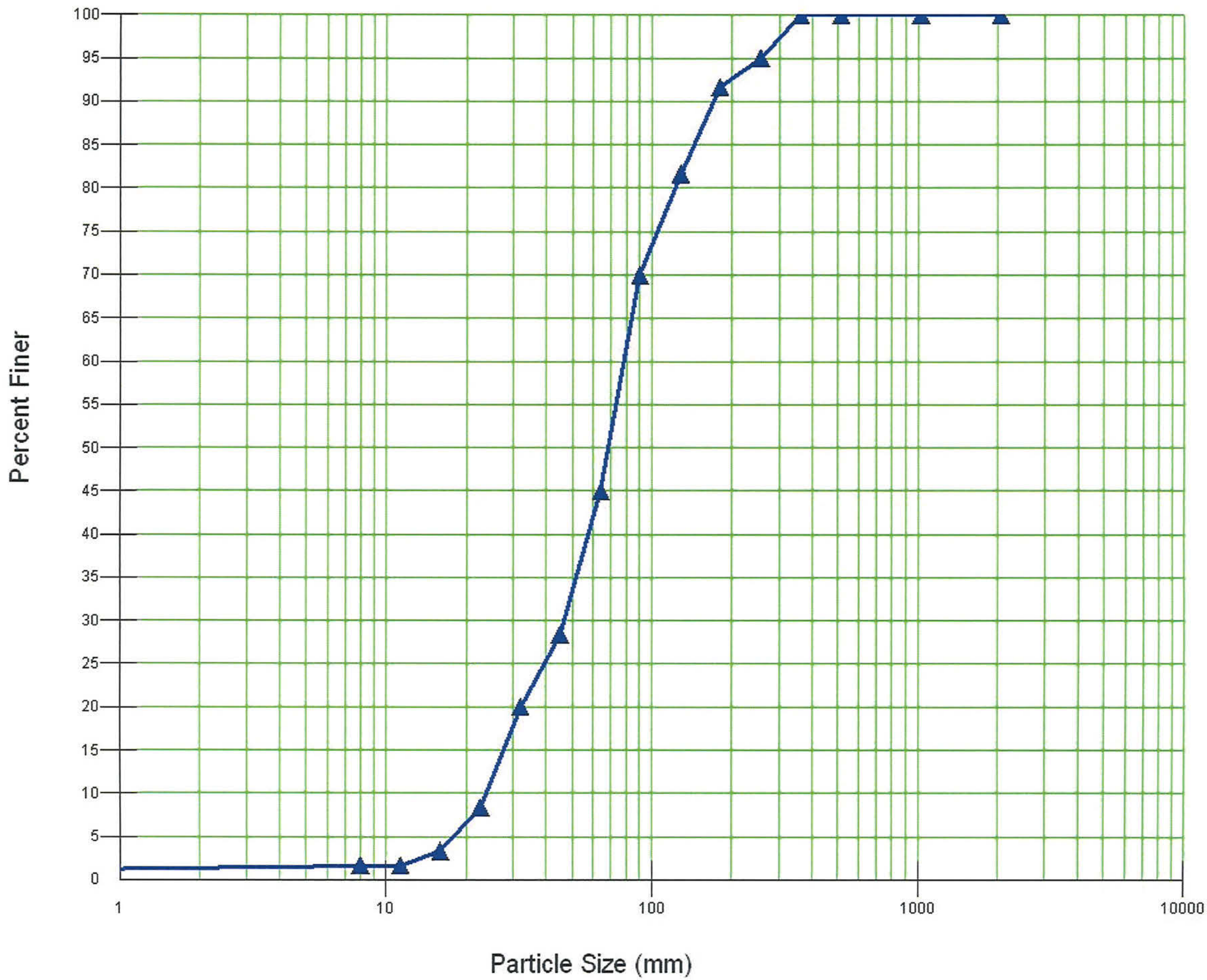
Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.03256	0	0
Shear Stress (lb/sq ft)	2.72		
Movable Particle (mm)	317.6		


08/08/2006

Davis Branch Reference Reach - Riffle Bed Sample



RIVERMORPH PARTICLE SUMMARY

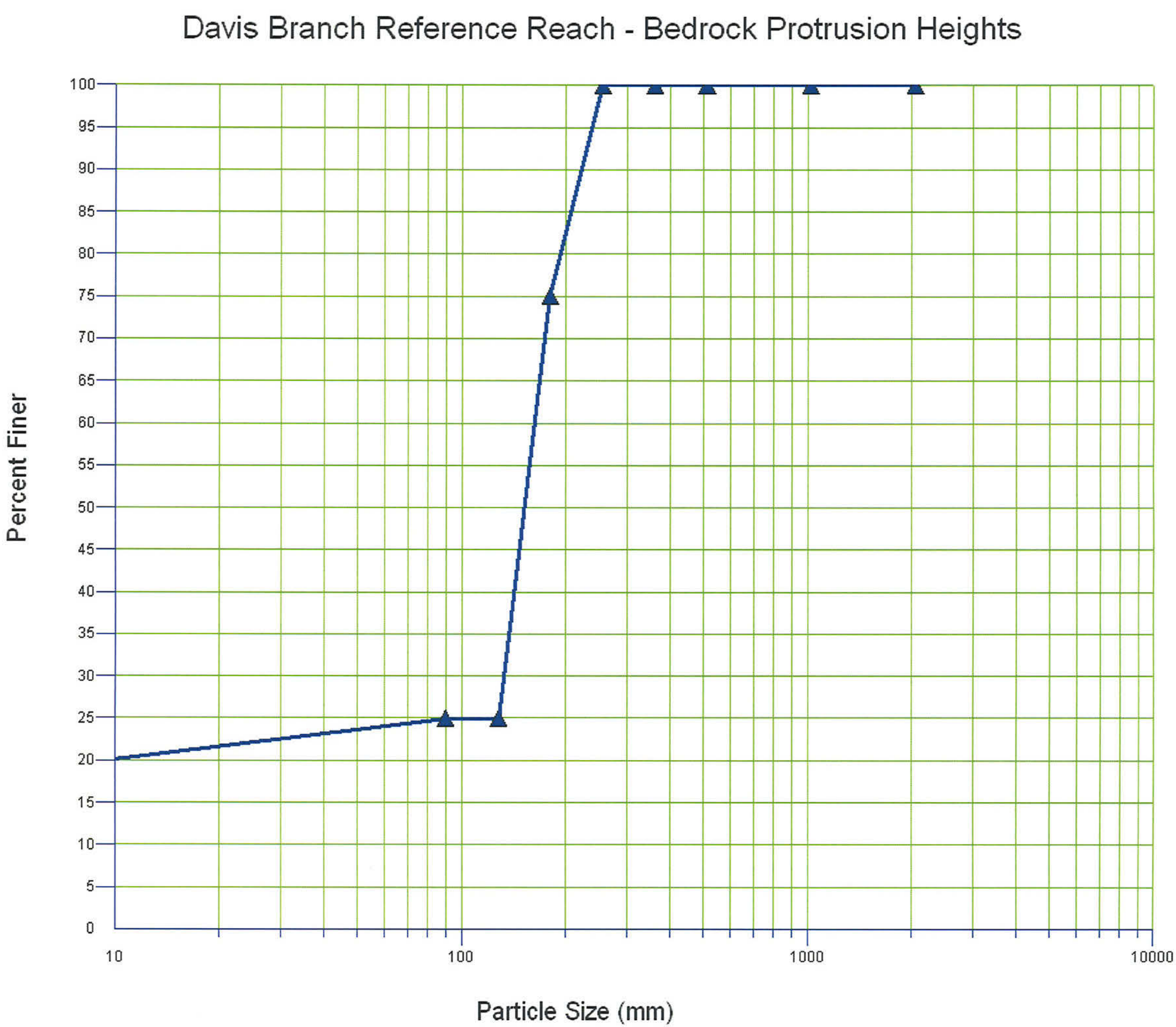
River Name:	Davis Branch
Reach Name:	Davis Branch Reference Reach
Sample Name:	Riffle Bed Sample
Survey Date:	08/08/2006

Size (mm)	TOT #	ITEM %	CUM %
0 - 0.062	0	0.00	0.00
0.062 - 0.125	0	0.00	0.00
0.125 - 0.25	0	0.00	0.00
0.25 - 0.50	0	0.00	0.00
0.50 - 1.0	0	0.00	0.00
1.0 - 2.0	0	0.00	0.00
2.0 - 4.0	0	0.00	0.00
4.0 - 5.7	0	0.00	0.00
5.7 - 8.0	1	1.67	1.67
8.0 - 11.3	0	0.00	1.67
11.3 - 16.0	1	1.67	3.33
16.0 - 22.6	3	5.00	8.33
22.6 - 32.0	7	11.67	20.00
32 - 45	5	8.33	28.33
45 - 64	10	16.67	45.00
64 - 90	15	25.00	70.00
90 - 128	7	11.67	81.67
128 - 180	6	10.00	91.67
180 - 256	2	3.33	95.00
256 - 362	3	5.00	100.00
362 - 512	0	0.00	100.00
512 - 1024	0	0.00	100.00
1024 - 2048	0	0.00	100.00
Bedrock	0	0.00	100.00

D16 (mm)	28.78
D35 (mm)	52.6
D50 (mm)	69.2
D84 (mm)	140.12
D95 (mm)	256
D100 (mm)	362
Silt/Clay (%)	0
Sand (%)	0
Gravel (%)	45
Cobble (%)	50
Boulder (%)	5
Bedrock (%)	0

Total Particles = 60.


08/09/2006



Davis Branch Reference Reach - Bedrock Protrusion Heights
Percent Finer
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
10
100
1000
10000
Particle Size (mm)

RIVERMORPH PARTICLE SUMMARY

River Name: Davis Branch
Reach Name: Davis Branch Reference Reach
Sample Name: BR Protrusion Heights
Survey Date: 08/08/2006

Size (mm)	TOT #	ITEM %	CUM %
0 - 0.062	0	0.00	0.00
0.062 - 0.125	0	0.00	0.00
0.125 - 0.25	0	0.00	0.00
0.25 - 0.50	0	0.00	0.00
0.50 - 1.0	0	0.00	0.00
1.0 - 2.0	0	0.00	0.00
2.0 - 4.0	0	0.00	0.00
4.0 - 5.7	0	0.00	0.00
5.7 - 8.0	0	0.00	0.00
8.0 - 11.3	0	0.00	0.00
11.3 - 16.0	0	0.00	0.00
16.0 - 22.6	0	0.00	0.00
22.6 - 32.0	0	0.00	0.00
32 - 45	0	0.00	0.00
45 - 64	0	0.00	0.00
64 - 90	15	25.00	25.00
90 - 128	0	0.00	25.00
128 - 180	30	50.00	75.00
180 - 256	15	25.00	100.00
256 - 362	0	0.00	100.00
362 - 512	0	0.00	100.00
512 - 1024	0	0.00	100.00
1024 - 2048	0	0.00	100.00
Bedrock	0	0.00	100.00

D16 (mm)	80.64
D35 (mm)	138.4
D50 (mm)	154
D84 (mm)	207.36
D95 (mm)	240.8
D100 (mm)	256
Silt/Clay (%)	0
Sand (%)	0
Gravel (%)	0
Cobble (%)	100
Boulder (%)	0
Bedrock (%)	0

Total Particles = 60.


08/08/2006

RIVERMORPH BANK EROSION HARZARD INDEX (BEHI)

River Name: Davis Branch
Reach Name: Davis Branch Reference Reach
BEHI Name: Pool XS 1+83
Survey Date: 08/08/06

Bankfull Height: 2.07 ft
Bank Height: 4.47 ft
Root Depth: 4 ft
Root Density: 95 %
Bank Angle: 47 Degrees
Surface Protection: 98 %

Bank Material Adjustment: Silt/Clay 0

Bank Stratification Adjustment: None 0

Erosion Loss Curve: Yellowstone

NBS Method #7: Vertical Velocity Near-Bank Shear Stress Method

Velocity at Surface: 4.96 fps
Depth: 2.07 ft
Bankfull Slope: 0.03256
NB Shear Stress: 0.97 lb/sq/ft

Velocity at Bed: 3.5 fps
Hydraulic Radius: 1.34 ft
Shear Stress: 2.72 lb/sq/ft
Shear Ratio: 0.35

BEHI Numerical Rating: 16.1
BEHI Adjective Rating: Low
NBS Numerical Rating: 0.35
NBS Adjective Rating: Very Low
Total Bank Length: 974 ft
Estimated Sediment Loss: 3.23 Cu Yds per Year
Estimated Sediment Loss: 4.2 Tons per Year

RIVERMORPH BEHI SUMMARY REPORT

River Name: Davis Branch
Reach Name: Davis Branch Reference Reach

Table 1. Bank Identification Summary

Bank	Name
1	Pool XS 1+83

Table 2. Predicted Annual Bank Erosion Rates

Bank	BEHI Numeric Rating	BEHI Adjective Rating	NBS Adjective Rating	Length ft	Loss cu yds/yr	Loss tons/yr
1	16.1	Low	Very Low	974	3.23	4.2
Totals				974	3.23	4.2

Total Reach Ln: 974   Total Loss (tons/yr) per ft of Reach: 0.0043

RIVERMORPH RAPID BIOASSESSMENT PROTOCOL SUMMARY

River Name: Davis Branch
Reach Name: Davis Branch Reference Reach

Epifaunal Substrate/Avail Cover:	17
Embeddedness:	20
Velocity/Depth Regime:	20
Sediment Deposition:	17
Channel Flow Status:	9
Channel Alteration:	18
Frequency of Riffles:	18
Bank Stability (LB):	9
Bank Stability (RB):	9
Vegetative Protection (LB):	10
Vegetative Protection (RB):	10
Riparian Veg. Zone Width (LB):	8
Riparian Veg. Zone Width (RB):	8

High Gradient Stream
Rating Criteria:
0-50 Poor
51-100 Marginal
101-150 Suboptimal
151-200 Optimal

Score - 173

RIVERMORPH STREAM VISUAL ASSESSMENT PROTOCOL SUMMARY

River Name: Davis Branch
Reach Name: Davis Branch Reference Reach
Survey Date: 08/08/06

Channel Condition:	10
Hydrologic Alteration:	9
Riparian Zone:	10
Bank Stability:	9
Water Appearance:	3
Nutrient Enrichment:	1
Barriers to Fish Movement:	10
Instream Fish Cover:	10
Pools:	7
Invertebrate Habitat:	8
Canopy Cover:	10
Manure Presence:	1
Salinity:	5
Riffle Embeddedness:	10
Macroinvertebrates:	6

Warmwater Fishery

Rating Criteria:
Poor < 6.0
Fair 6.1-7.4
Good 7.5-8.9
Excellent > 9.0

Overall Score (total divided by number scored) = 7.27

Suspected Cause of Observed Problems:
Nutrient loading & bank instability from uncontrolled livestock intrusion upstream.

Recommendations:
Restore stable pattern, profile, dimension & native riparian buffers along impaired reaches; livestock exclusion.

APPENDIX 5

Project Site Design Calculations, Spreadsheets and Summary Reports

Davis Branch & Unnamed Tributary

North Carolina Rural Piedmont
Regional Curve Analysis

Bankfull Hydraulic Relationships for North Carolina Streams, Rural Piedmont Dataset, Stratified by Rosgen "E" Stream Type

For estimating bankfull characteristics of rurul, unregulated streams in the Rural Piedmont of North Carolina[1]

Job Name:	Davis Branch & Unnamed Tributary
Job Number:	2006-1397
Stream Name:	Davis Branch Reference Reach

Drainage Area: 0.5721 Square Mile 365.54 Acres

EMPERICAL RELATIONSHIPS

Q_{BKF}	=	$111.28\ DA^{0.5878}$	=	80.01	$feet^3/sec$	Bankfull Discharge	$R^2 = 0.94$ [2]
A_{BKF}	=	$22.57\ DA^{0.6317}$	=	15.85	$feet^2$	Bankfull Area	$R^2 = 0.88$
W_{BKF}	=	$14.02\ DA^{0.3118}$	=	11.77	feet	Bankfull Width	$R^2 = 0.77$
D_{BKF}	=	$1.61\ DA^{0.3206}$	=	1.35	feet	Bankfull Mean Depth	$R^2 = 0.90$
R.I.	=	$1.53\ DA^{0.0016}$	=	1.5	years	Return Interval	$R^2 = 0.11$

[1]**North Carolina Multi-Agency Stream Mitigation Guidelines, April 2003.**
[2]**Log-Pearson Type III distributions, coefficients of determination (R^2) for E stream type data were calculated using the regional curve editor algorithm in RiverMorph v. 4.1.1.**

QUANTITATIVE RELATIONSHIPS[3]

Q_{BKF}	=	77.6	$feet^3/sec$
A_{BKF}	=	15.65	$feet^2$
W_{BKF}	=	12.91	feet
D_{BKF}	=	1.21	feet

[3]**Quantitative results from Davis Branch, Rosgen Level III - Reference Reach Assessment, 8-9 August 2006.**

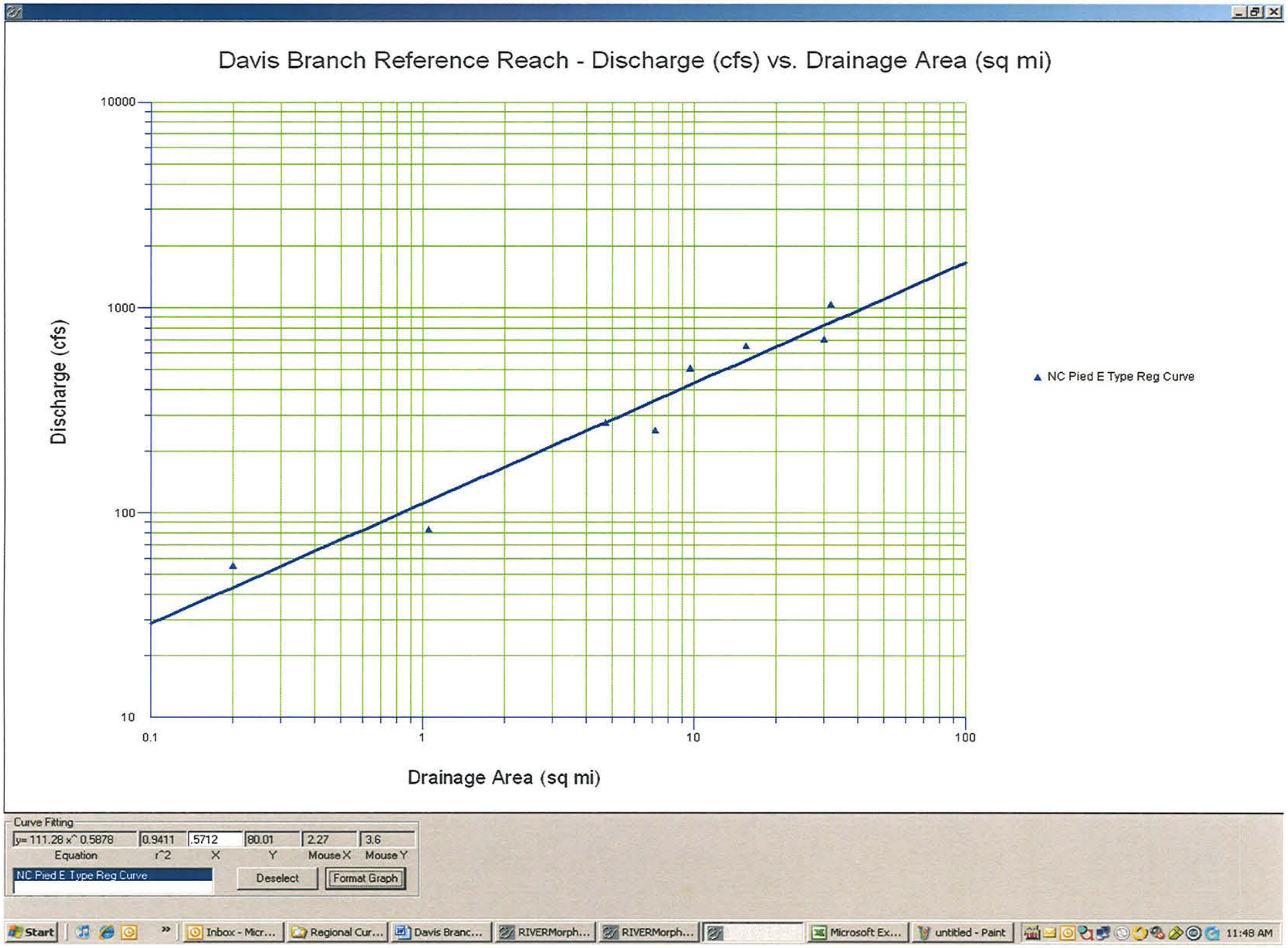
North Carolina Rural Peidmont Regional Curve Dataset[1]

Stream Name	Gage ID	Stream Type	DA	Qbkf	Abkf	Wbkf	Dbkf	Sws (ft/ft)	R.I. (yr)	Exceedance Probability (%)
Sal's Branch	Ref. Reach	E4	0.2	55.4	10.4	8.7	1.2	0.0109	0	0
Humpy Creek	2117030	E5	1.05	83	15.8	12	1.3	0.0060	1.7	59
Dutchmans	2123567	C5	3.44	85.1	45.6	23.5	1.9	0.0170	1	100
Mill Creek	Ref. Reach	E4	4.7	277	46.7	24.5	1.9	0.0080	0	0
Upper Mitchell River	Ref. Reach	B4c	6	356	62.5	29.2	2.1	0.0095	0	0
Norwood Creek	214253830	E5	7.18	253.7	98.8	32	3.1	0.0008	1.1	91
North Pott's Creek	2121180	E5	9.6	507.2	89.6	25.4	3.5	0.0012	1.7	59
Tick Creek	2101800	E	15.5	655.3	194	40.5	4.8	0.0005	1.3	77
Moon Creek	2075160	E5	29.9	708.8	162	33	4.9	0.0015	1.8	56
Long Creek	2144000	E5	31.8	1041	195	40	4.9	0.0010	1.4	71
Little Yadkin River	2114450	G5	42.8	2236	469	77.5	6	0.0018	1.4	71
Mitchell River	2112360	C	78.8	2681	377	77	4.9	0.0030	1.6	63
Fisher River	2113000	C3	128	3687	578	101	5.7	0.0023	1.4	71

North Carolina Rural Peidmont Regional Curve Dataset, Stratified by Rosgen E Stream Type Dataset

Stream Name	Gage ID	Stream Type	DA	Qbkf	Abkf	Wbkf	Dbkf	Sws (ft/ft)	R.I. (yr)	Exceedance Probability (%)
Sal's Branch	Ref. Reach	E4	0.2	55.4	10.4	8.7	1.2	0.0109	0	0
Humpy Creek	2117030	E5	1.05	83	15.8	12	1.3	0.0060	1.7	59
Mill Creek	Ref. Reach	E4	4.7	277	46.7	24.5	1.9	0.0080	0	0
Norwood Creek	214253830	E5	7.18	253.7	98.8	32	3.1	0.0008	1.1	91
North Pott's Creek	2121180	E5	9.6	507.2	89.6	25.4	3.5	0.0012	1.7	59
Tick Creek	2101800	E	15.5	655.3	194	40.5	4.8	0.0005	1.3	77
Moon Creek	2075160	E5	29.9	708.8	162	33	4.9	0.0015	1.8	56
Long Creek	2144000	E5	31.8	1041	195	40	4.9	0.0010	1.4	71

[1]**Bankfull Hydraulic Relationships for North Carolina Streams, Rural Peidmont Dataset,**
For estimating bankfull characteristics of rurul, unregulated streams in the Rural Peidmont of North Carolina, North Carolina Multi-Agency Stream Mitigation Guidelines, April 2003.
Hydaulic geometry, survey summary, and flood frequency analysis for gaged and ungaged stream reaches.


Davis Branch Reference Reach - Discharge (cfs) vs. Drainage Area (sq mi)
Discharge (cfs)
10000
1000
100
10
0.1
1
10
100
Drainage Area (sq mi)
NC Pied E Type Reg Curve
Curve Fitting
y= 111.28 x^ 0.5878
0.9411
.5712
80.01
2.27
3.6
Equation
r^2
X
Y
Mouse X
Mouse Y
NC Pied E Type Reg Curve
Deselect
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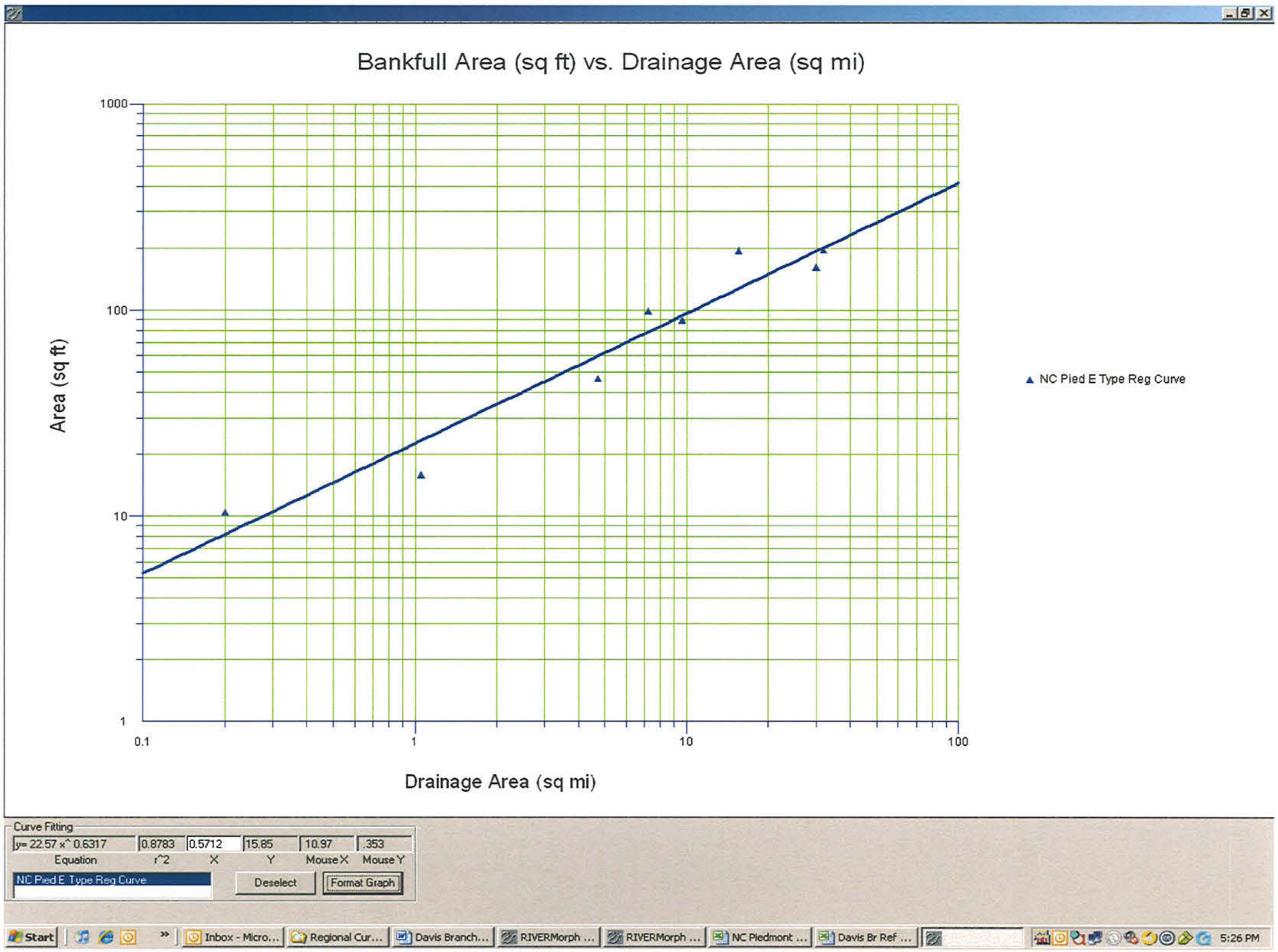

Bankfull Area (sq ft) vs. Drainage Area (sq mi)
Area (sq ft)
1000
100
10
1
0.1
1
10
100
Drainage Area (sq mi)
NC Pied E Type Reg Curve
Curve Fitting
y= 22.57 x^ 0.6317
0.8783
0.5712
15.85
10.97
.353
Equation
r^2
X
Y
Mouse X
Mouse Y
NC Pied E Type Reg Curve
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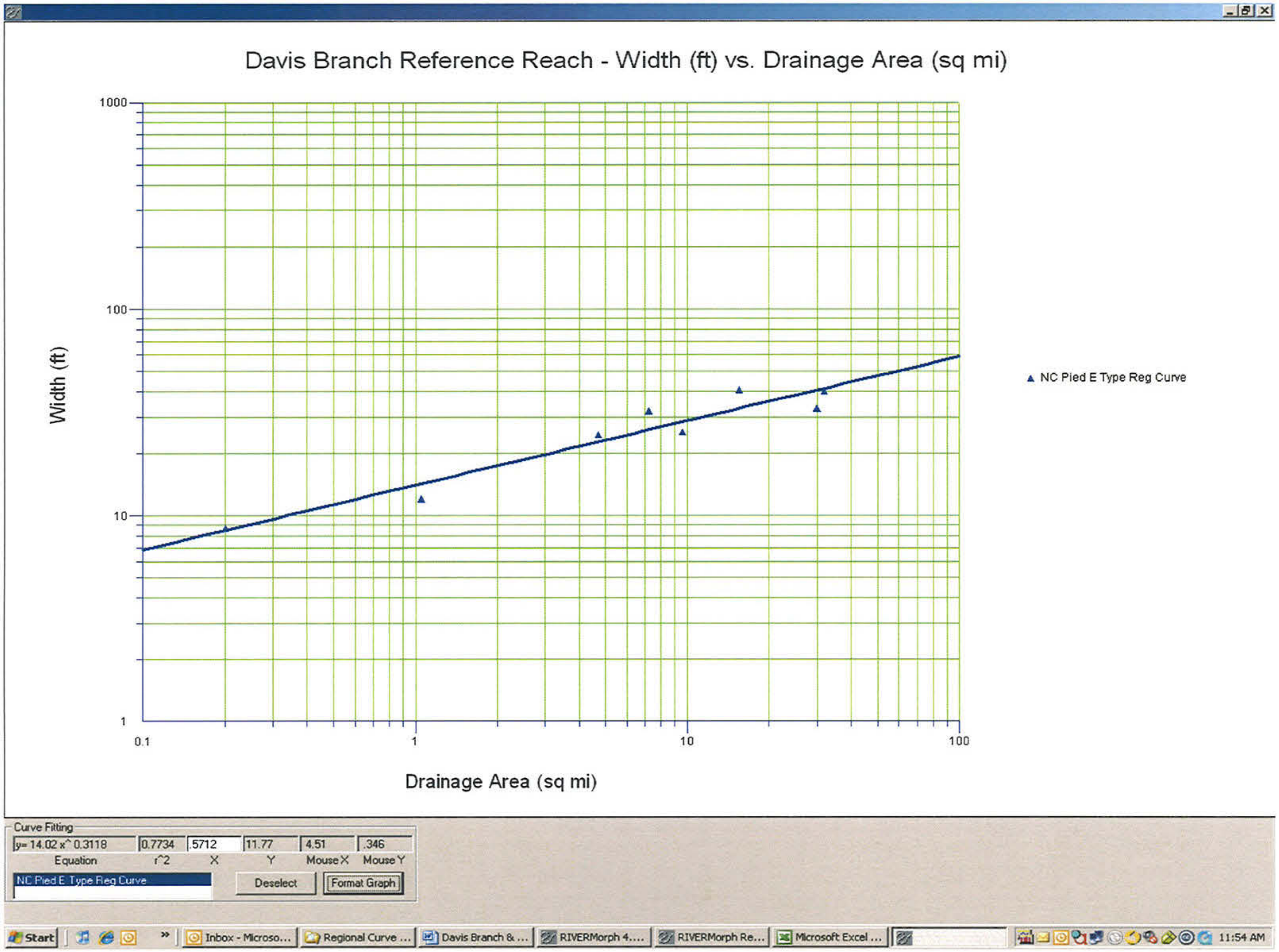
Davis Branch Reference Reach - Width (ft) vs. Drainage Area (sq mi)
Width (ft)
1000
100
10
1
0.1
1
10
100
Drainage Area (sq mi)
NC Pied E Type Reg Curve
Curve Fitting
y= 14.02 x^ 0.3118
0.7734
.5712
11.77
4.51
.346
Equation
r^2
X
Y
Mouse X
Mouse Y
NC Pied E Type Reg Curve
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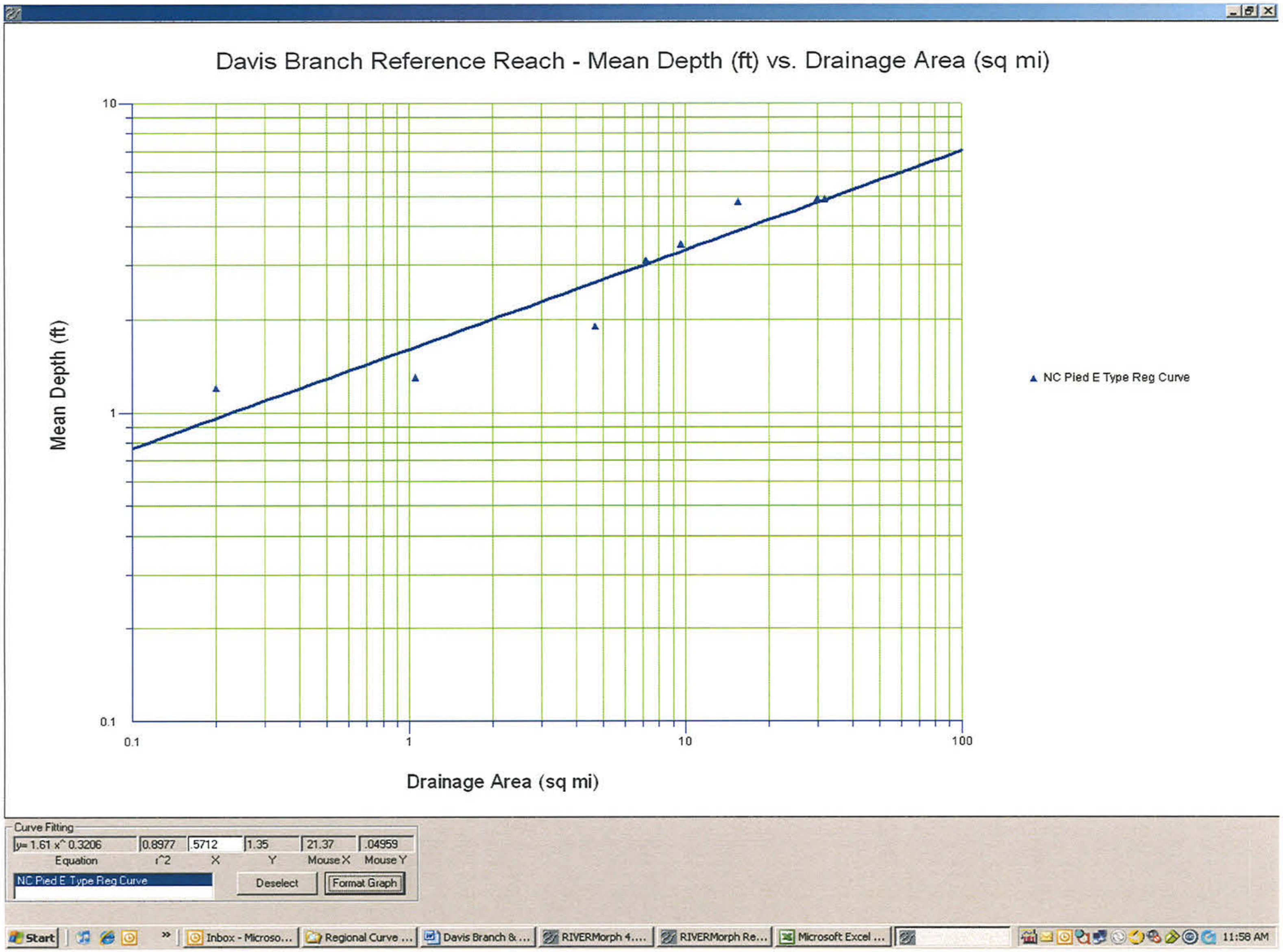
Davis Branch Reference Reach - Mean Depth (ft) vs. Drainage Area (sq mi)
Mean Depth (ft)
10
1
0.1
0.1
1
10
100
Drainage Area (sq mi)
NC Pied E Type Reg Curve
Curve Fitting
y= 1.61 x^ 0.3206
0.8977
.5712
1.35
21.37
.04959
Equation
r^2
X
Y
Mouse X
Mouse Y
NC Pied E Type Reg Curve
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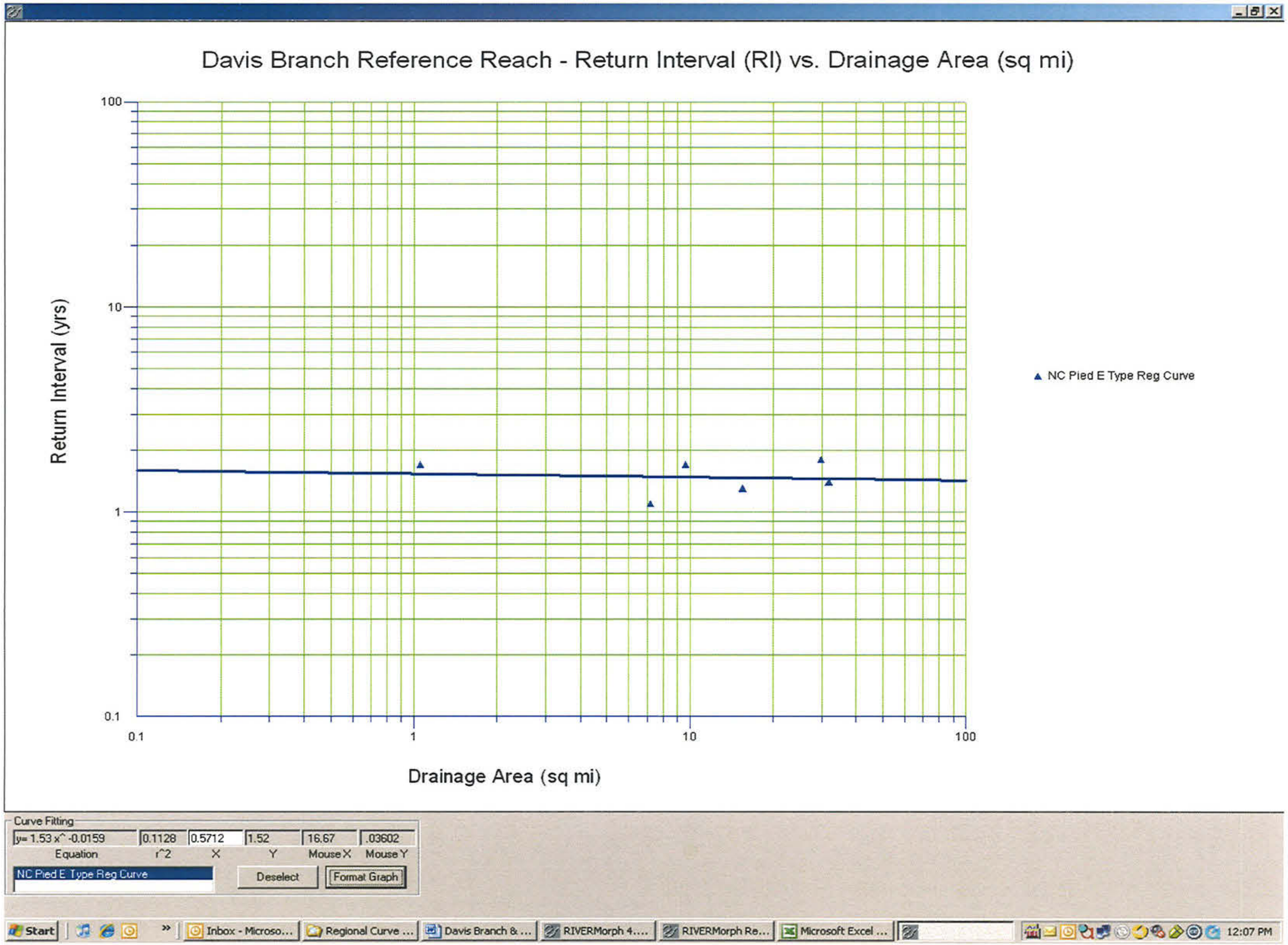
Davis Branch Reference Reach - Return Interval (RI) vs. Drainage Area (sq mi)
Return Interval (yrs)
100
10
1
0.1
0.1
1
10
100
Drainage Area (sq mi)
NC Pied E Type Reg Curve
Curve Fitting
y= 1.53 x^ -0.0159
0.1128
0.5712
1.52
16.67
.03602
Equation
r^2
X
Y
Mouse X
Mouse Y
NC Pied E Type Reg Curve
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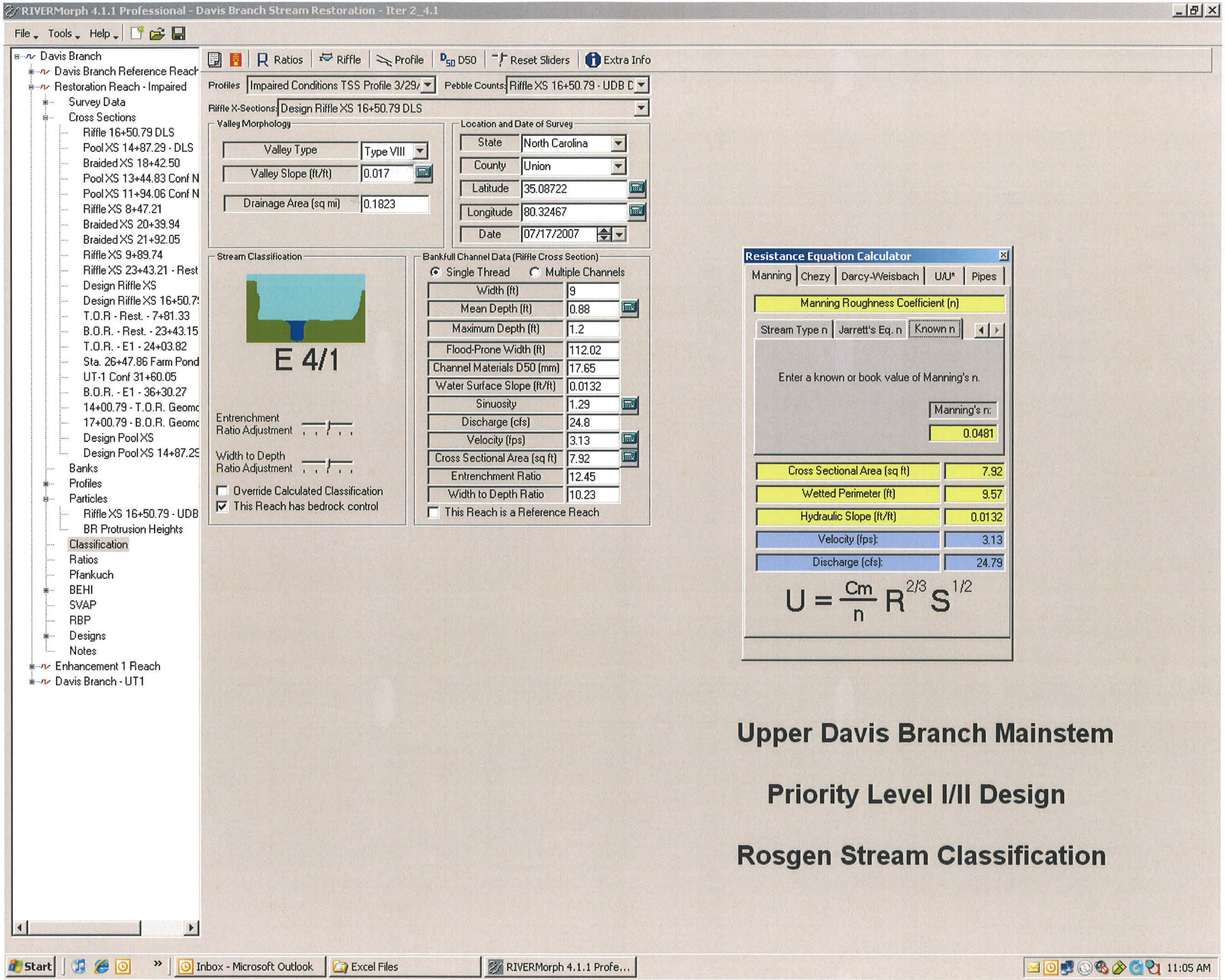


Upper Davis Branch Mainstem

Priority Level I/II Design

Rosgen Stream Classification

Worksheet 5-3. Field form for Level II stream classification (Rosgen, 1996; Rosgen and Silvey, 2005).

Stream:	**Davis Branch Mainstem Restoration Reach - Design Conditions**
Basin:	**Lower Yadkin - Pee Dee I** Drainage Area: **116.67** acres **0.1823** mi^2
Location:	**Davis Branch - Staton Property near Marshville, North Carolina**
Twp.&Rge: **;**	Sec.&Qtr.: **;**
Cross-Section Monuments (Lat./Long.): **35.08722 Lat / 80.32467 Long**	Date: **07/17/07**
Observers: **Hebert, Knotts, Hines, Peffer**	Valley Type: VIII

Bankfull WIDTH (W_{bkf}) WIDTH of the stream channel at bankfull stage elevation, in a riffle section.	**9**	ft
Bankfull DEPTH (d_{bkf}) Mean DEPTH of the stream channel cross-section, at bankfull stage elevation, in a riffle section ($d_{bkf} = A / W_{bkf}$).	**0.88**	ft
Bankfull X-Section AREA (A_{bkf}) AREA of the stream channel cross-section, at bankfull stage elevation, in a riffle section.	**7.92**	ft^2
Width/Depth Ratio (W_{bkf} / d_{bkf}) Bankfull WIDTH divided by bankfull mean DEPTH, in a riffle section.	**10.23**	ft/ft
Maximum DEPTH (d_{mbkf}) Maximum depth of the bankfull channel cross-section, or distance between the bankfull stage and Thalweg elevations, in a riffle section.	**1.2**	ft
WIDTH of Flood-Prone Area (W_{fpa}) Twice maximum DEPTH, or (2 x d_{mbkf}) = the stage/elevation at which flood-prone area WIDTH is determined in a riffle section.	**112.02**	ft
Entrenchment Ratio (ER) The ratio of flood-prone area WIDTH divided by bankfull channel WIDTH (W_{fpa} / W_{bkf}) (riffle section).	**12.45**	ft/ft
Channel Materials (Particle Size Index) D_{50} The D_{50} particle size index represents the mean diameter of channel materials, as sampled from the channel surface, between the bankfull stage and Thalweg elevations.	**17.65**	mm
Water Surface SLOPE (S) Channel slope = "rise over run" for a reach approximately 20–30 bankfull channel widths in length, with the "riffle-to-riffle" water surface slope representing the gradient at bankfull stage.	**0.0132**	ft/ft
Channel SINUOSITY (k) Sinuosity is an index of channel pattern, determined from a ratio of stream length divided by valley length (SL / VL); or estimated from a ratio of valley slope divided by channel slope (VS / S).	**1.29**	

Stream Type	**E 4/1**	(See **Figure 2-14**)

Worksheet 5-4. Morphological relations, including dimensionless ratios of river reach sites (Rosgen and Silvey, 2005).

Stream: **Davis Branch Restoration Reach - Design**		Location: **Davis Branch - Staton Property**	
Observers: **Hebert, Hines & Knotts**	Date: **06/05/2008**	Valley Type: **VIII**	Stream Type: **E 4/1**

River Reach Summary Data

Channel Dimension

Mean Riffle Depth (d_{bkf})	**0.88**	ft	Riffle Width (W_{bkf})	**9**	ft	Riffle Area (A_{bkf})	**7.92**	ft^2
Mean Pool Depth (d_{bkfp})	**1**	ft	Pool Width (W_{bkfp})	**10**	ft	Pool Area (A_{bkfp})	**10**	ft^2
Mean Pool Depth/Mean Riffle Depth	**1.14**	d_{bkfp}/d_{bkf}	Pool Width/Riffle Width	**1.11**	W_{bkfp}/W_{bkf}	Pool Area / Riffle Area	**1.26**	A_{bkfp}/A_{bkf}
Max Riffle Depth (d_{mbkf})	**1.2**	ft	Max Pool Depth (d_{mbkfp})	**2**	ft	Max Riffle Depth/Mean Riffle Depth	**1.36**	
Max Pool Depth/Mean Riffle Depth	**2.27**					Point Bar Slope	**0**	
Streamflow: Estimated Mean Velocity at Bankfull Stage (u_{bkf})				**3.13**	ft/s	Estimation Method	**Mannings Eq.**	
Streamflow: Estimated Discharge at Bankfull Stage (Q_{bkf})				**24.8**	cfs	Drainage Area	**0.1823**	mi^2

Channel Pattern

Geometry	Mean	Min	Max		Dimensionless Geometry Ratios	Mean	Min	Max
Meander Length (Lm)	**77.76**	**49.94**	**102**	ft	Meander Length Ratio (Lm/W_{bkf})	**8.64**	**5.55**	**11.31**
Radius of Curvature (Rc)	**19.7**	**10.65**	**35**	ft	Radius of Curvature/Riffle Width (Rc/W_{bkf})	**2.19**	**1.18**	**3.89**
Belt Width (W_{blt})	**50**	**50**	**50**	ft	Meander Width Ratio (W_{blt}/W_{bkf})	**5.56**	**5.56**	**5.56**
Individual Pool Length	**23.9**	**17.1**	**36.8**	ft	Pool Length/Riffle Width	**2.66**	**1.90**	**4.09**
Pool to Pool Spacing	**48.5**	**24.9**	**78.1**	ft	Pool to Pool Spacing/Riffle Width	**5.39**	**2.77**	**8.68**
Riffle Length	**21.3**	**7.7**	**45.2**	ft	Riffle Length/Riffle Width	**2.37**	**0.86**	**5.02**

Channel Profile

Valley Slope (VS)	**0.0170**	ft/ft	Average Water Surface Slope (S)	**0.0132**	ft/ft	Sinuosity (VS/S)		**1.29**
Stream Length (SL)	**1802**	ft	Valley Length (VL)	**1397**	ft	Sinuosity (SL/VL)		**1.29**
Low Bank Height (LBH)	start **1.2** / end **1.2**	ft	Max Riffle Depth	start **1.2** / end **1.2**	ft	Bank-Height Ratio (BHR) (LBH/Max Riffle Depth)	start / end	**1.0** / **1.0**

Facet Slopes	Mean	Min	Max		Dimensionless Slope Ratios	Mean	Min	Max
Riffle Slope (S_{rif})	**0.0399**	**0.0227**	**0.0762**	ft/ft	Riffle Slope/Average Water Surface Slope (S_{rif} / S)	**3.02**	**1.72**	**5.77**
Run Slope (S_{run})				ft/ft	Run Slope/Average Water Surface Slope (S_{run} / S)			
Pool Slope (S_p)	**0.0010**	**0.0003**	**0.0027**	ft/ft	Pool Slope/Average Water Surface Slope (S_p / S)	**0.07**	**0.02**	**0.21**
Glide Slope (S_g)				ft/ft	Glide Slope/Average Water Surface Slope (S_g / S)			

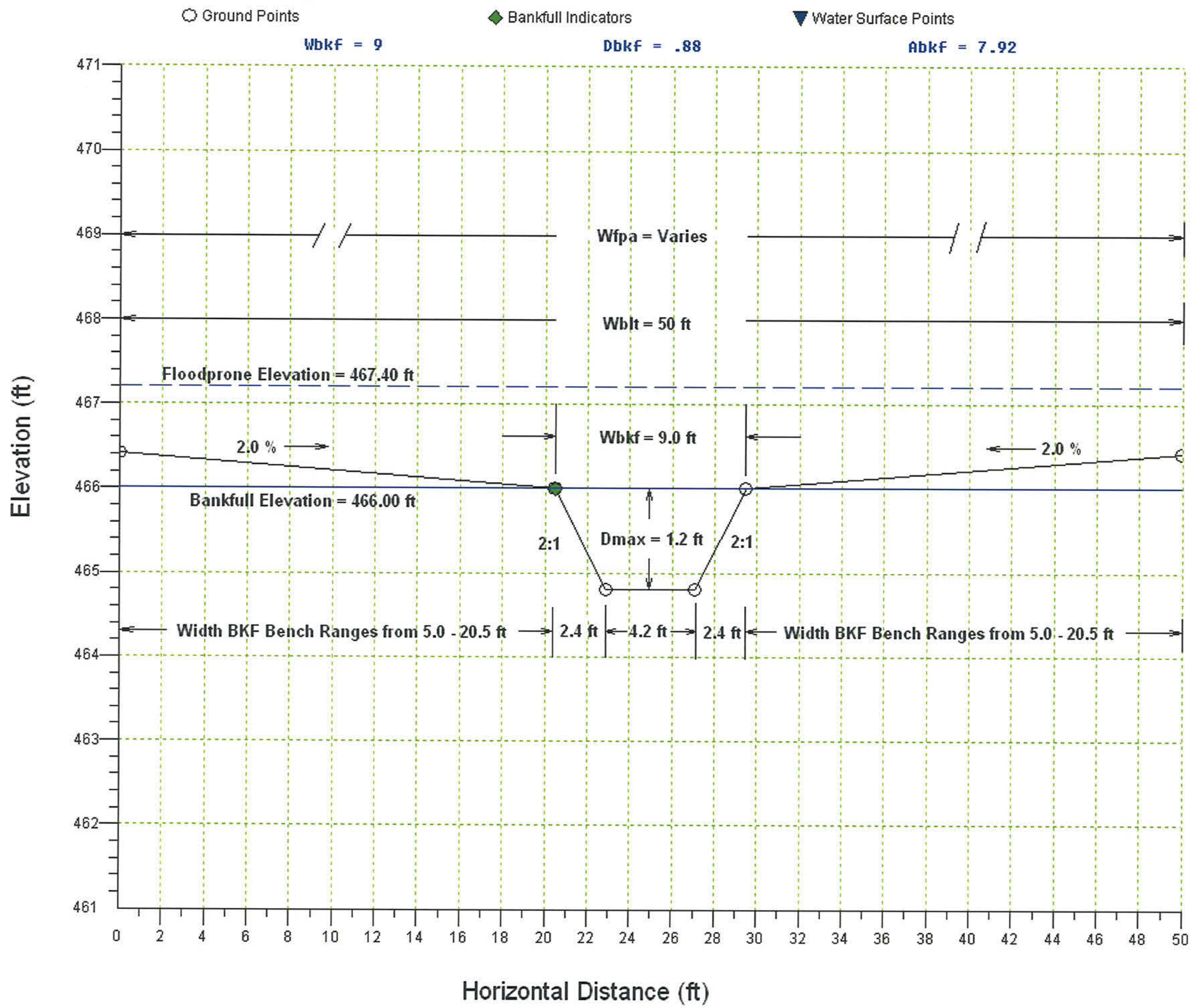
Feature Midpoint [a]	Mean	Min	Max		Dimensionless Depth Ratios	Mean	Min	Max
Riffle Depth (d_{rif})	**1.20**	**1.20**	**1.20**	ft	Riffle Depth/Mean Riffle Depth (d_{rif} / d_{bkf})	**1.36**	**1.36**	**1.36**
Run Depth (d_{run})				ft	Run Depth/Mean Riffle Depth (d_{run} / d_{bkf})			
Pool Depth (d_p)	**2.00**	**2.00**	**2.00**	ft	Pool Depth/Mean Riffle Depth (d_p / d_{bkf})	**2.27**	**2.27**	**2.27**
Glide Depth (d_g)				ft	Glide Depth/Mean Riffle Depth (d_g / d_{bkf})			

Channel Materials

	Reach [b]	Riffle [c]	Bar		Reach [b]	Riffle [c]	Bar	Protrusion Height [d]	
% Silt/Clay	**0**			D_{16}	**9.83**			80.64	mm
% Sand	**0**			D_{35}	**14.12**			138.4	mm
% Gravel	**100**			D_{50}	**17.65**			154	mm
% Cobble	**0**			D_{84}	**28.88**			207.36	mm
% Boulder	**0**			D_{95}	**47.54**			240.8	mm
% Bedrock	**0**			D_{100}	**64**			256	mm

a Min, max, mean depths are the average mid-point values except pools, which are taken at deepest part of pool.
b Composite sample of riffles and pools within the designated reach.
c Active bed of a riffle.
d Height of roughness feature above bed.

Design Riffle Cross-Section - Mainstem Restoration Reach



RIVERMORPH CROSS SECTION SUMMARY

River Name: Davis Branch
Reach Name: Restoration Reach - Impaired
Cross Section Name: Design Riffle XS
Survey Date: 05/01/2008

Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0	0	466.41	
20.5	0	466	BKF
22.9	0	464.8	TW
27.1	0	464.8	
29.5	0	466	RB
50	0	466.41	

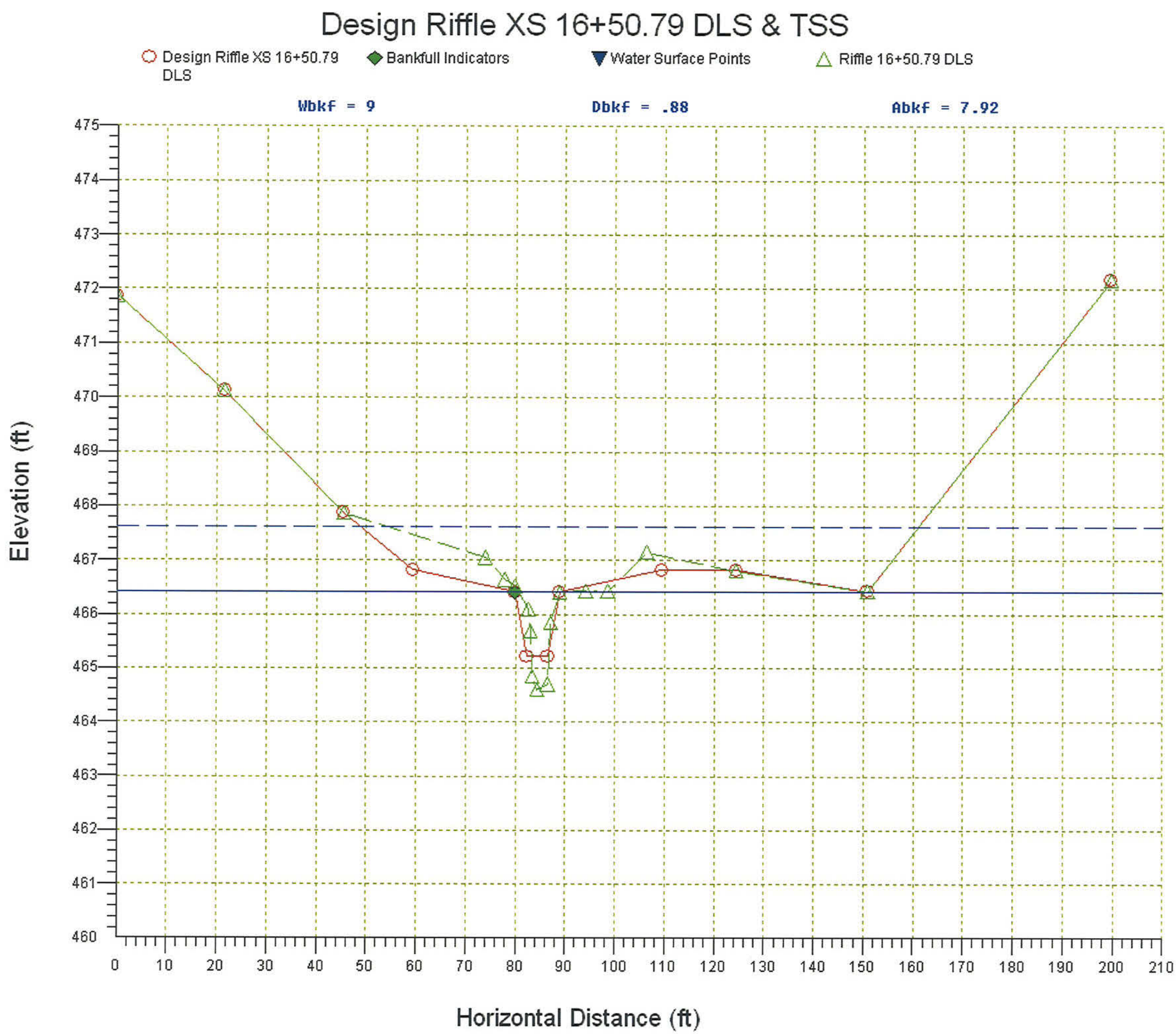
Cross Sectional Geometry

	Channel	Left	Right
Floodprone Elevation (ft)	467.2	467.2	467.2
Bankfull Elevation (ft)	466	466	466
Floodprone Width (ft)	50	-----	-----
Bankfull Width (ft)	9	4.5	4.5
Entrenchment Ratio	5.56	-----	-----
Mean Depth (ft)	0.88	0.88	0.88
Maximum Depth (ft)	1.2	1.2	1.2
Width/Depth Ratio	10.23	5.11	5.11
Bankfull Area (sq ft)	7.92	3.96	3.96
Wetted Perimeter (ft)	9.57	5.98	5.98
Hydraulic Radius (ft)	0.83	0.66	0.66
Begin BKF Station	20.5	20.5	25
End BKF Station	29.5	25	29.5

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.0132	0	0
Shear Stress (lb/sq ft)	0.68		
Movable Particle (mm)	114.9		


Design Riffle XS 16+50.79 DLS & TSS
Design Riffle XS 16+50.79 DLS
Bankfull Indicators
Water Surface Points
Riffle 16+50.79 DLS
Wbkf = 9
Dbkf = .88
Abkf = 7.92
Elevation (ft)
Horizontal Distance (ft)
475
474
473
472
471
470
469
468
467
466
465
464
463
462
461
460
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210

RIVERMORPH CROSS SECTION SUMMARY

River Name: Davis Branch
Reach Name: Restoration Reach - Impaired
Cross Section Name: Design Riffle XS 16+50.79 DLS
Survey Date: 05/01/2008

Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0	0	471.87	
21.48	0	470.12	
45.41	0	467.87	FP
59.38	0	466.82	
79.88	0	466.41	BKF
82.28	0	465.21	TW
86.48	0	465.21	
88.88	0	466.41	RB
109.38	0	466.82	
124.32	0	466.81	
150.79	0	466.42	FP
199.57	0	472.17	

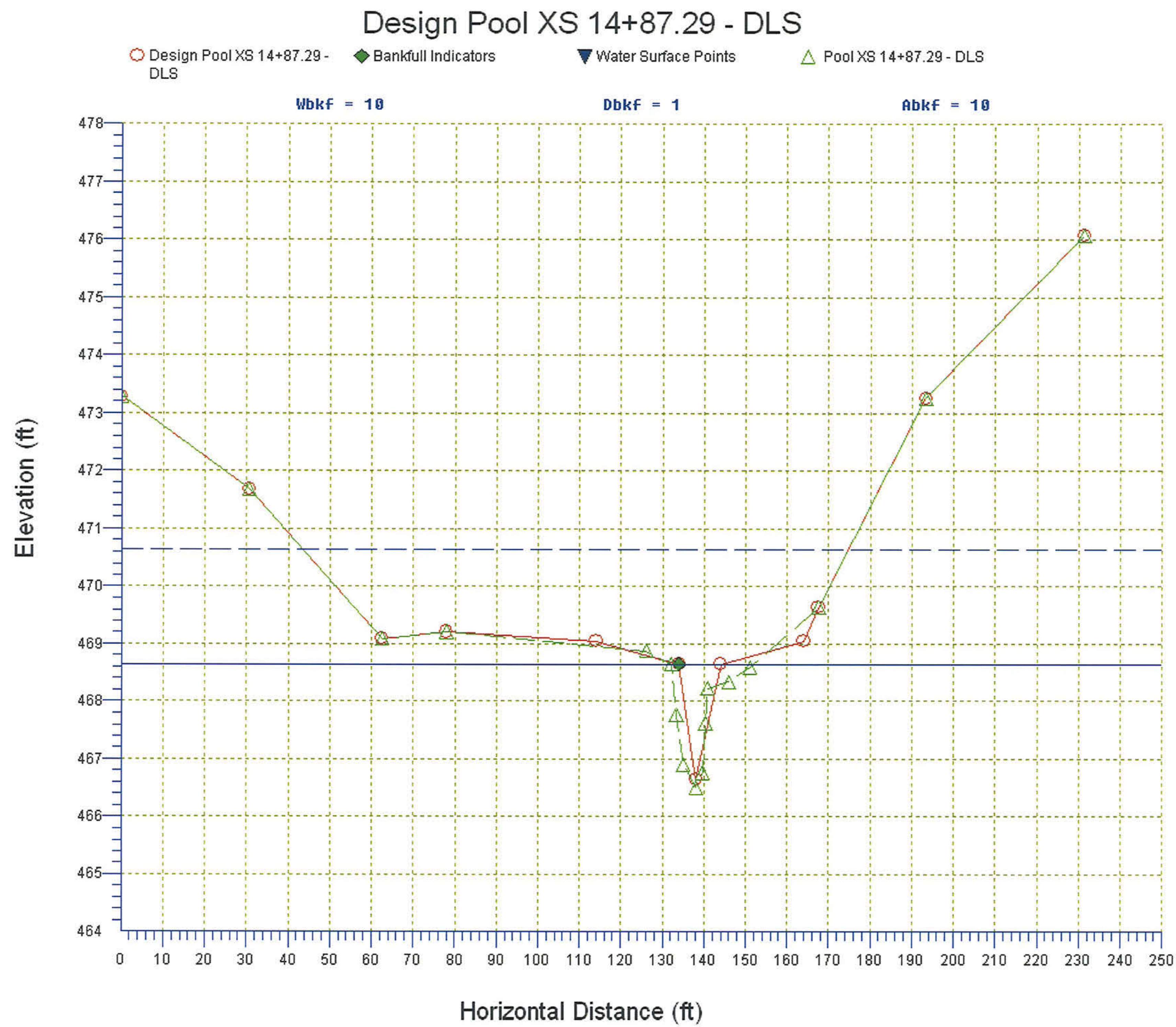
Cross Sectional Geometry

	Channel	Left	Right
Floodprone Elevation (ft)	467.61	467.61	467.61
Bankfull Elevation (ft)	466.41	466.41	466.41
Floodprone Width (ft)	112.02	-----	-----
Bankfull Width (ft)	9	4.5	4.5
Entrenchment Ratio	12.45	-----	-----
Mean Depth (ft)	0.88	0.88	0.88
Maximum Depth (ft)	1.2	1.2	1.2
Width/Depth Ratio	10.23	5.11	5.11
Bankfull Area (sq ft)	7.92	3.96	3.96
Wetted Perimeter (ft)	9.57	5.98	5.98
Hydraulic Radius (ft)	0.83	0.66	0.66
Begin BKF Station	79.88	79.88	84.38
End BKF Station	88.88	84.38	88.88

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.0132	0	0
Shear Stress (lb/sq ft)	0.68		
Movable Particle (mm)	114.9		



Design Pool XS 14+87.29 - DLS
Design Pool XS 14+87.29 - DLS
Bankfull Indicators
Water Surface Points
Pool XS 14+87.29 - DLS
Wbkf = 10
Dbkf = 1
Abkf = 10
Elevation (ft)
Horizontal Distance (ft)
478
477
476
475
474
473
472
471
470
469
468
467
466
465
464
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250

Design Pool XS 14+87.29 - DLS.txt
RIVERMORPH CROSS SECTION SUMMARY

River Name: Davis Branch
Reach Name: Restoration Reach - Impaired
Cross Section Name: Design Pool XS 14+87.29 - DLS
Survey Date: 05/16/2008

Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0	0	473.29	
30.63	0	471.69	
62.53	0	469.09	
78	0	469.21	
114.07	0	469.05	
134.07	0	468.65	BKF
138.07	0	466.65	TW
144.07	0	468.65	RB
164.07	0	469.05	
167.5	0	469.64	
193.36	0	473.27	
231.29	0	476.08	

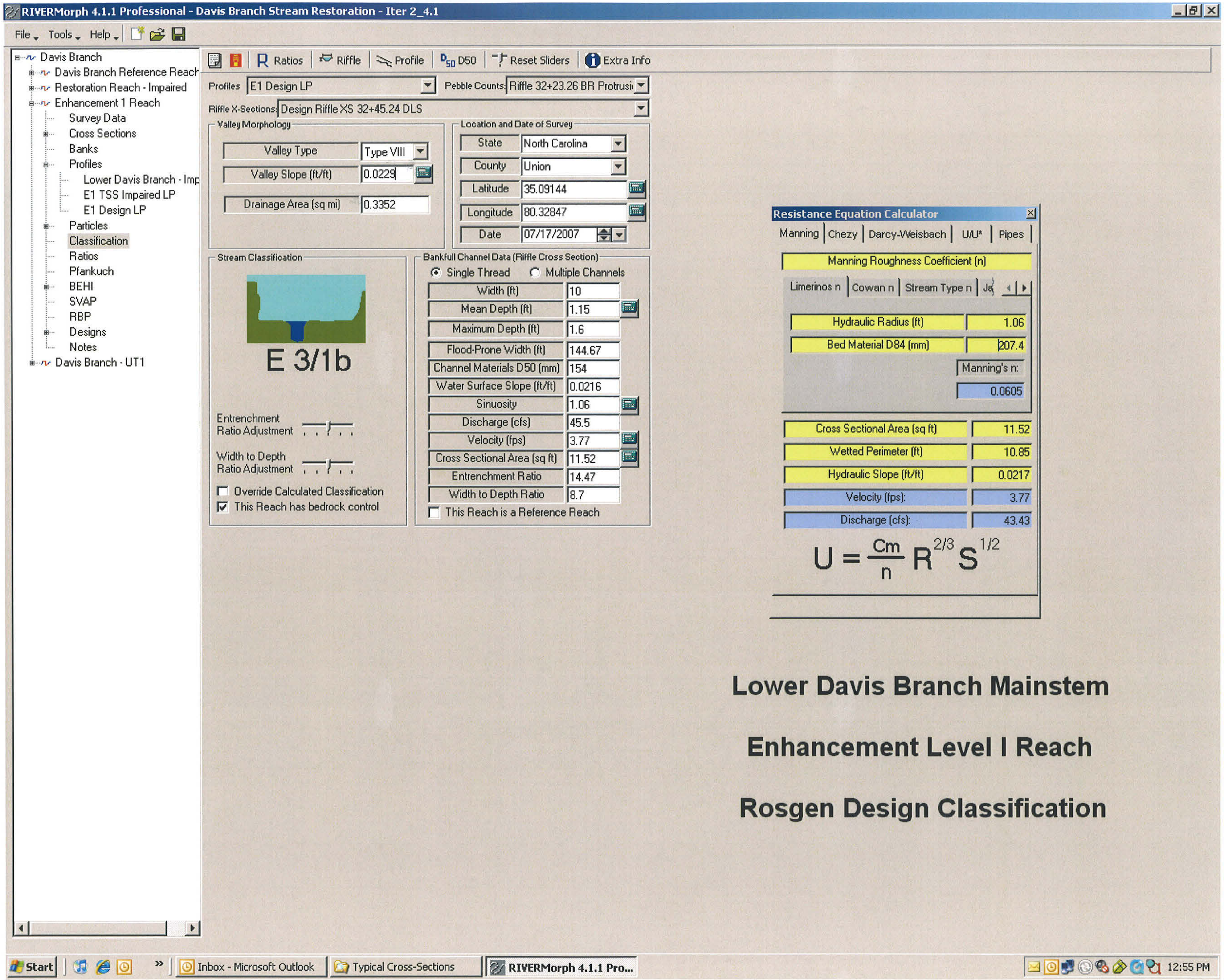
Cross Sectional Geometry

	Channel	Left	Right
Floodprone Elevation (ft)	470.65	470.65	470.65
Bankfull Elevation (ft)	468.65	468.65	468.65
Floodprone Width (ft)	131.31	-----	-----
Bankfull Width (ft)	10	5	5
Entrenchment Ratio	13.13	-----	-----
Mean Depth (ft)	1	1.17	0.83
Maximum Depth (ft)	2	2	1.67
Width/Depth Ratio	10	4.27	6.02
Bankfull Area (sq ft)	10	5.83	4.17
Wetted Perimeter (ft)	10.8	7.19	6.94
Hydraulic Radius (ft)	0.93	0.81	0.6
Begin BKF Station	134.07	134.07	139.07
End BKF Station	144.07	139.07	144.07

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.0132	0	0
Shear Stress (lb/sq ft)	0.77		
Movable Particle (mm)	125.0		



Lower Davis Branch Mainstem

Enhancement Level I Reach

Rosgen Design Classification

Worksheet 5-3. Field form for Level II stream classification (Rosgen, 1996; Rosgen and Silvey, 2005).

Stream:	**Davis Branch Enhancement I Reach - Design**			
Basin:	**Lower Yadkin - Pee Dee**	Drainage Area: **214.5** acres	**0.3352**	mi^2
Location:	**Eddie Staton Property**			
Twp.&Rge: **;**		Sec.&Qtr.: **;**		
Cross-Section Monuments (Lat./Long.):	**35.09144 Lat / 80.32847 Long**		Date: **05/02/08**	
Designers:	**Hebert, Hines & Knotts**		Valley Type: VIII	

Bankfull WIDTH (W_{bkf}) WIDTH of the stream channel at bankfull stage elevation, in a riffle section.	**10**	ft
Bankfull DEPTH (d_{bkf}) Mean DEPTH of the stream channel cross-section, at bankfull stage elevation, in a riffle section ($d_{bkf} = A / W_{bkf}$).	**1.15**	ft
Bankfull X-Section AREA (A_{bkf}) AREA of the stream channel cross-section, at bankfull stage elevation, in a riffle section.	**11.52**	ft^2
Width/Depth Ratio (W_{bkf} / d_{bkf}) Bankfull WIDTH divided by bankfull mean DEPTH, in a riffle section.	**8.7**	ft/ft
Maximum DEPTH (d_{mbkf}) Maximum depth of the bankfull channel cross-section, or distance between the bankfull stage and Thalweg elevations, in a riffle section.	**1.6**	ft
WIDTH of Flood-Prone Area (W_{fpa}) Twice maximum DEPTH, or (2 x d_{mbkf}) = the stage/elevation at which flood-prone area WIDTH is determined in a riffle section.	**144.67**	ft
Entrenchment Ratio (ER) The ratio of flood-prone area WIDTH divided by bankfull channel WIDTH (W_{fpa} / W_{bkf}) (riffle section).	**14.47**	ft/ft
Channel Materials (Particle Size Index) D_{50} The D_{50} particle size index represents the mean diameter of channel materials, as sampled from the channel surface, between the bankfull stage and Thalweg elevations.	**154**	mm
Water Surface SLOPE (S) Channel slope = "rise over run" for a reach approximately 20–30 bankfull channel widths in length, with the "riffle-to-riffle" water surface slope representing the gradient at bankfull stage.	**0.0216**	ft/ft
Channel SINUOSITY (k) Sinuosity is an index of channel pattern, determined from a ratio of stream length divided by valley length (SL / VL); or estimated from a ratio of valley slope divided by channel slope (VS / S).	**1.06**	

Stream Type **E 3/1b** (See **Figure 2-14**)

Worksheet 5-4. Morphological relations, including dimensionless ratios of river reach sites (Rosgen and Silvey, 2005).

Stream:	Davis Branch Enhancement 1 Reach - Design	Location:	Eddie Staton Property		
Observers:	Hebert, Hines & Knotts	Date: 05/02/08	Valley Type: VIII	Stream Type:	E 3/1b

River Reach Summary Data

Channel Dimension

Mean Riffle Depth (d_{bkf})	1.15	ft	Riffle Width (W_{bkf})	10	ft	Riffle Area (A_{bkf})	11.52	ft^2
Mean Pool Depth (d_{bkfp})	1.26	ft	Pool Width (W_{bkfp})	12	ft	Pool Area (A_{bkfp})	15.14	ft^2
Mean Pool Depth/Mean Riffle Depth	1.0957	d_{bkfp}/d_{bkf}	Pool Width/Riffle Width	1.2	W_{bkfp}/W_{bkf}	Pool Area / Riffle Area	1.31	A_{bkfp}/A_{bkf}
Max Riffle Depth (d_{mbkf})	1.6	ft	Max Pool Depth (d_{mbkfp})	1.9	ft	Max Riffle Depth/Mean Riffle Depth	1.39	
Max Pool Depth/Mean Riffle Depth	1.65					Point Bar Slope	0	
Streamflow: Estimated Mean Velocity at Bankfull Stage (u_{bkf})				3.77	ft/s	Estimation Method	Manning's Eq.	
Streamflow: Estimated Discharge at Bankfull Stage (Q_{bkf})				45.5	cfs	Drainage Area	0.3352	mi^2

Channel Pattern

Geometry	Mean	Min	Max		Dimensionless Geometry Ratios	Mean	Min	Max
Meander Length (Lm)				ft	Meander Length Ratio (Lm/W_{bkf})			
Radius of Curvature (Rc)				ft	Radius of Curvature/Riffle Width (Rc/W_{bkf})			
Belt Width (W_{blt})				ft	Meander Width Ratio (W_{blt}/W_{bkf})			
Individual Pool Length	22.5	6	40	ft	Pool Length/Riffle Width	2.25	0.60	4.00
Pool to Pool Spacing	68.5	40	88	ft	Pool to Pool Spacing/Riffle Width	6.85	4.00	8.80
Riffle Length	45	24	57	ft	Riffle Length/Riffle Width	4.50	2.40	5.70

Channel Profile

Valley Slope (VS)	0.0229	ft/ft	Average Water Surface Slope (S)	0.0216	ft/ft	Sinuosity (VS/S)	1.06
Stream Length (SL)	1289	ft	Valley Length (VL)	1213	ft	Sinuosity (SL/VL)	1.06
Low Bank Height (LBH) start	1.6	ft	Max Riffle Depth start	1.6	ft	Bank-Height Ratio (BHR) (LBH/Max Riffle Depth) start	1
Low Bank Height (LBH) end	1.6	ft	Max Riffle Depth end	1.6	ft	Bank-Height Ratio (BHR) (LBH/Max Riffle Depth) end	1

Facet Slopes	Mean	Min	Max		Dimensionless Slope Ratios	Mean	Min	Max
Riffle Slope (S_{rif})	0.0504	0.0098	0.0549	ft/ft	Riffle Slope/Average Water Surface Slope (S_{rif} / S)	2.33	0.45	2.54
Run Slope (S_{run})				ft/ft	Run Slope/Average Water Surface Slope (S_{run} / S)	0.00	0.00	0.00
Pool Slope (S_p)	0.0001	0.0000	0.0004	ft/ft	Pool Slope/Average Water Surface Slope (S_p / S)	0.00	0.00	0.02
Glide Slope (S_g)				ft/ft	Glide Slope/Average Water Surface Slope (S_g / S)	0.00	0.00	0.00

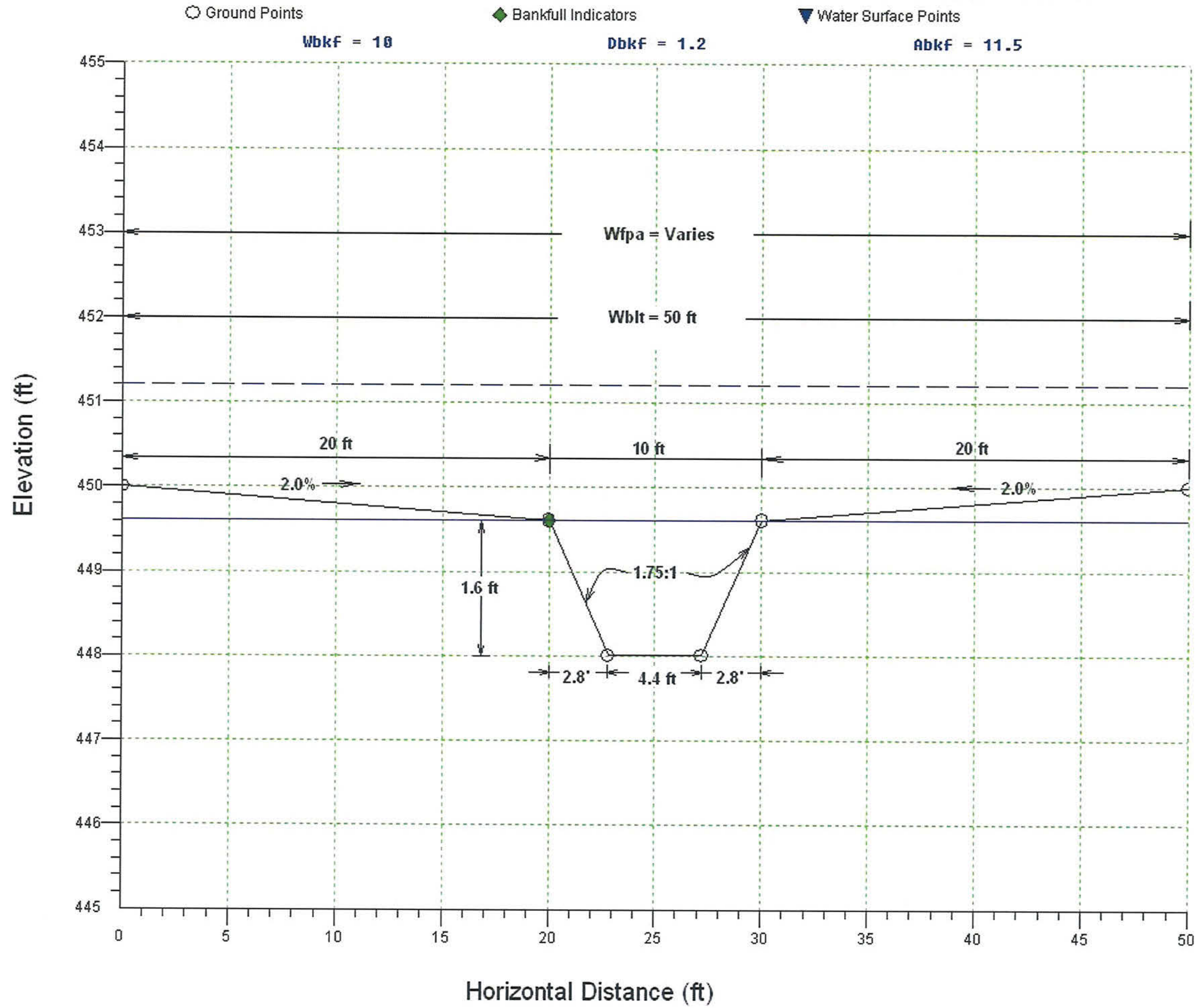
Feature Midpoint [a]	Mean	Min	Max		Dimensionless Depth Ratios	Mean	Min	Max
Riffle Depth (d_{rif})	1.6	1.6	1.6	ft	Riffle Depth/Mean Riffle Depth (d_{rif} / d_{bkf})	1.39	1.39	1.39
Run Depth (d_{run})				ft	Run Depth/Mean Riffle Depth (d_{run} / d_{bkf})			
Pool Depth (d_p)	1.9	1.9	1.9	ft	Pool Depth/Mean Riffle Depth (d_p / d_{bkf})	1.65	1.65	1.65
Glide Depth (d_g)				ft	Glide Depth/Mean Riffle Depth (d_g / d_{bkf})			

Channel Materials

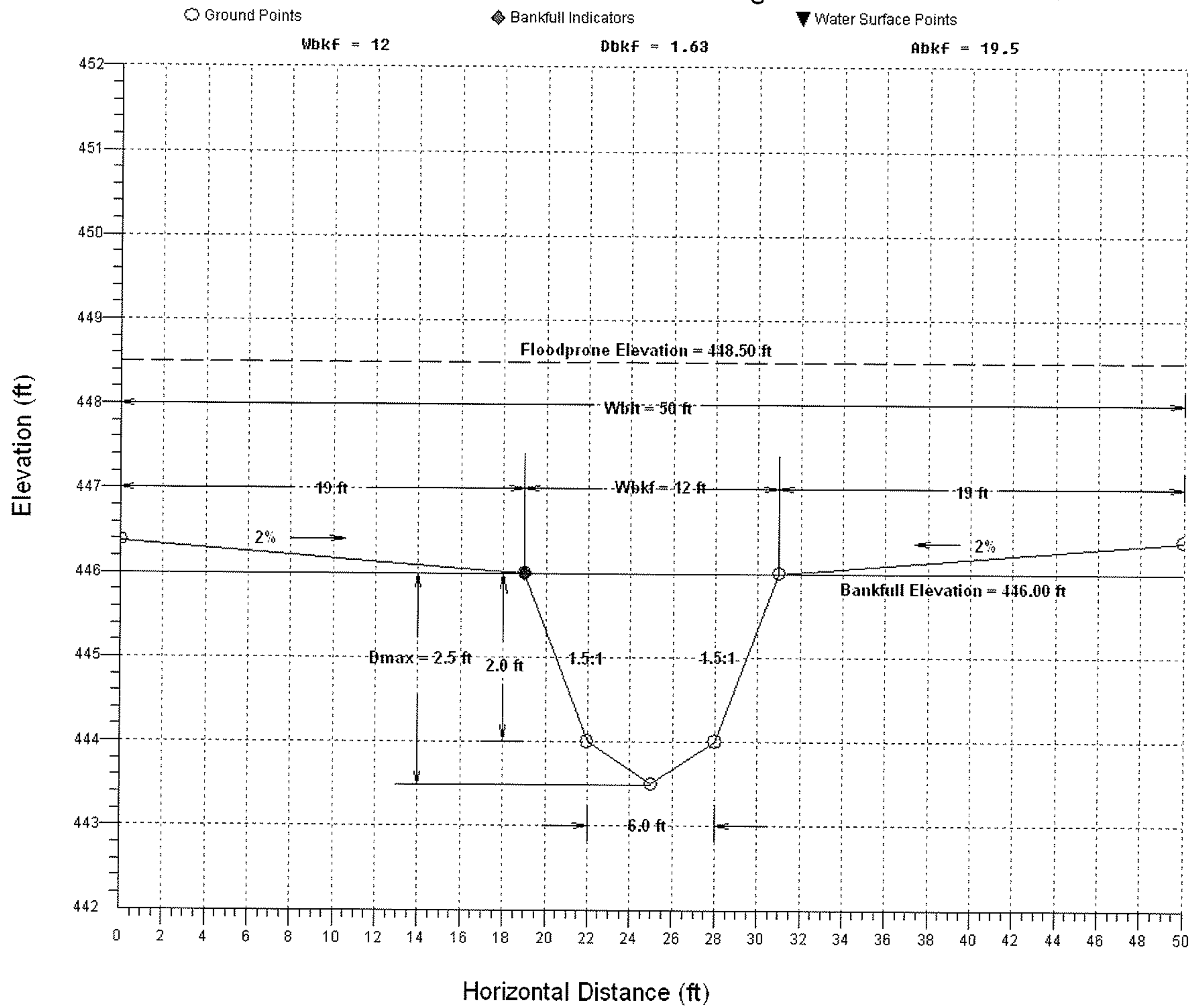
	Reach[b]	Riffle[c]	Bar		Reach[b]	Riffle[c]	Bar	Protrusion Height[d]	
% Silt/Clay	0		0	D_{16}	80.64		28.78	80.64	mm
% Sand	0		0	D_{35}	138.4		52.6	138.4	mm
% Gravel	0		45	D_{50}	154		69.2	154	mm
% Cobble	100		50	D_{84}	207.36		140.12	207.36	mm
% Boulder	0		5	D_{95}	240.8		256	240.8	mm
% Bedrock	0		0	D_{100}	256		362	256	mm

a Min, max, mean depths are the average mid-point values except pools, which are taken at deepest part of pool.
b Composite sample of riffles and pools within the designated reach.
c Active bed of a riffle.
d Height of roughness feature above bed.

Riffle Design Cross-Section - Davis Branch Enhancement Level I Reach



Davis Branch Enhancement Level I - Design Pool Cross-Section



RIVERMORPH CROSS SECTION SUMMARY

River Name: Davis Branch
Reach Name: Enhancement 1 Reach
Cross Section Name: Design Pool XS
Survey Date: 02/11/2008

Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0	0	446.38	
19	0	446	BKF
22	0	444	
25	0	443.5	TW
28	0	444	
31	0	446	RB
50	0	446.38	FP

Cross Sectional Geometry

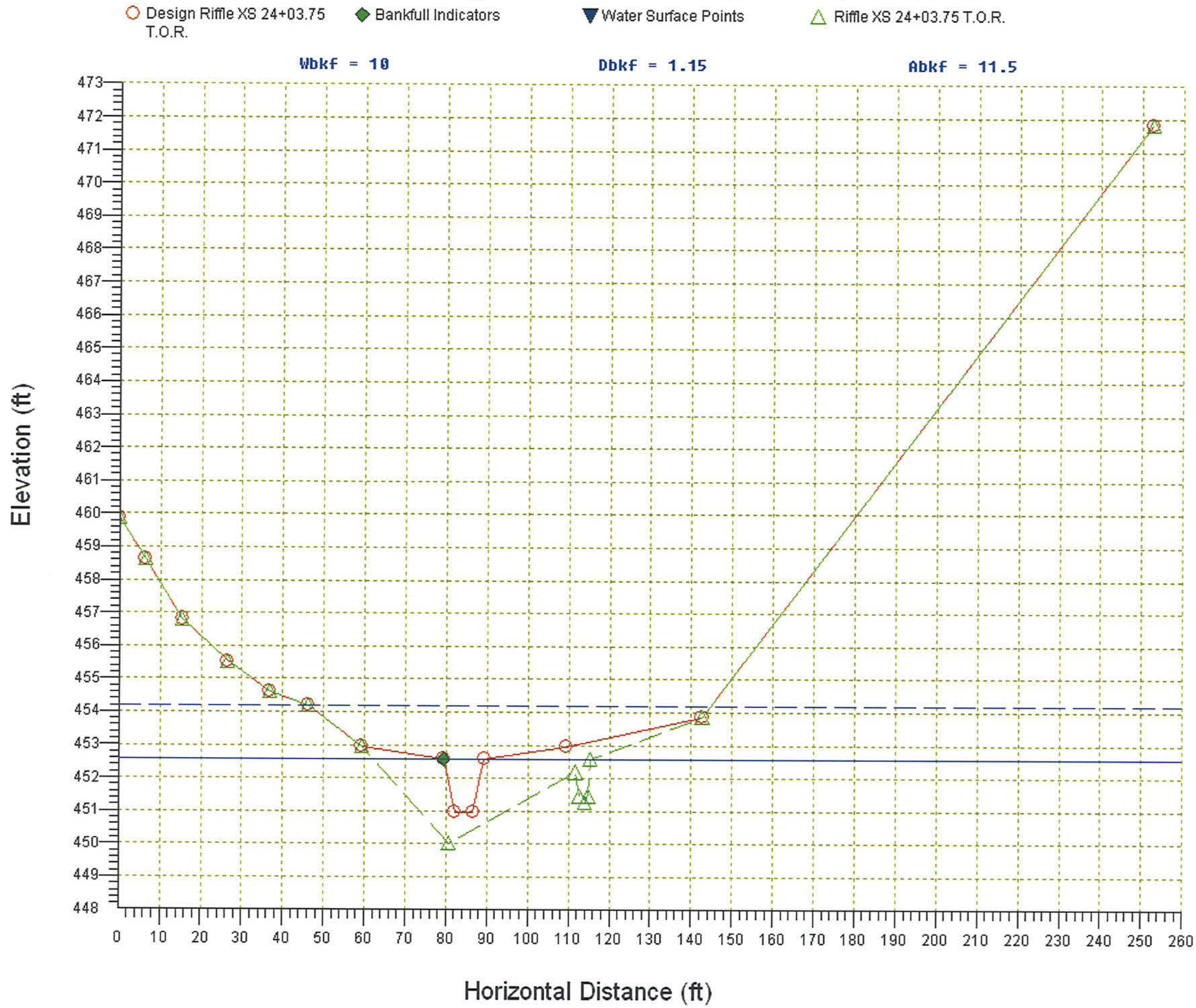
	Channel	Left	Right
Floodprone Elevation (ft)	448.5	448.5	448.5
Bankfull Elevation (ft)	446	446	446
Floodprone Width (ft)	50	-----	-----
Bankfull Width (ft)	12	6	6
Entrenchment Ratio	4.17	-----	-----
Mean Depth (ft)	1.63	1.63	1.63
Maximum Depth (ft)	2.5	2.5	2.5
Width/Depth Ratio	7.36	3.68	3.68
Bankfull Area (sq ft)	19.5	9.75	9.75
Wetted Perimeter (ft)	13.29	9.15	9.15
Hydraulic Radius (ft)	1.47	1.07	1.07
Begin BKF Station	19	19	25
End BKF Station	31	25	31

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.0213	0	0
Shear Stress (lb/sq ft)	1.95		
Movable Particle (mm)	248.8		

Davis Branch - Design Riffle XS 24+03.75 - Top of E1 Reach



RIVERMORPH CROSS SECTION SUMMARY

River Name: Davis Branch
Reach Name: Enhancement 1 Reach
Cross Section Name: Design Riffle XS 24+03.75 T.O.R.
Survey Date: 02/15/2008

Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0	0	459.88	
6.41	0	458.63	
15.42	0	456.81	
26.48	0	455.52	
36.79	0	454.6	
46.2	0	454.19	
59.27	0	452.96	FP
79.27	0	452.57	BKF
82.07	0	450.97	TW
86.47	0	450.97	
89.27	0	452.57	RB
109.27	0	452.96	FP
142.63	0	453.85	FP
252.52	0	471.84	

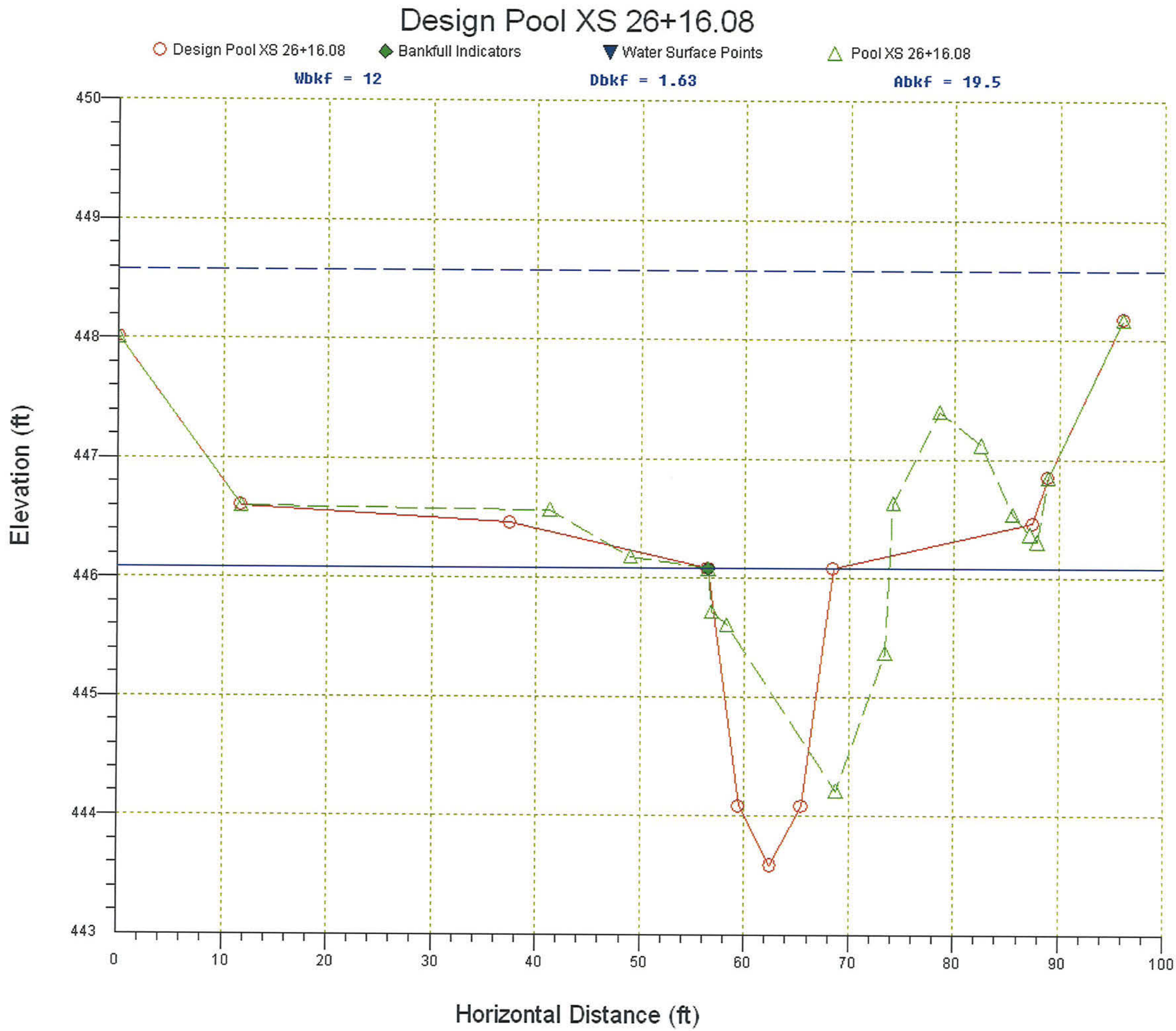
Cross Sectional Geometry

	Channel	Left	Right
Floodprone Elevation (ft)	454.17	454.17	454.17
Bankfull Elevation (ft)	452.57	452.57	452.57
Floodprone Width (ft)	98.17	-----	-----
Bankfull Width (ft)	10	5	5
Entrenchment Ratio	9.82	-----	-----
Mean Depth (ft)	1.15	1.15	1.15
Maximum Depth (ft)	1.6	1.6	1.6
Width/Depth Ratio	8.7	4.35	4.35
Bankfull Area (sq ft)	11.52	5.76	5.76
Wetted Perimeter (ft)	10.85	7.02	7.02
Hydraulic Radius (ft)	1.06	0.82	0.82
Begin BKF Station	79.27	79.27	84.27
End BKF Station	89.27	84.27	89.27

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.02171	0	0
Shear Stress (lb/sq ft)	1.44		
Movable Particle (mm)	198.4		


Design Pool XS 26+16.08
Design Pool XS 26+16.08
Bankfull Indicators
Water Surface Points
Pool XS 26+16.08
Wbkf = 12
Dbkf = 1.63
Abkf = 19.5
450
449
448
447
446
445
444
443
Elevation (ft)
0
10
20
30
40
50
60
70
80
90
100
Horizontal Distance (ft)

Design Pool XS 26+16.08.txt
RIVERMORPH CROSS SECTION SUMMARY

River Name: Davis Branch
Reach Name: Enhance 1 Reach - Impaired
Cross Section Name: Design Pool XS 26+16.08
Survey Date: 02/11/2008

Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0	0	448.01	
11.76	0	446.6	
37.47	0	446.46	FP
56.47	0	446.08	BKF
59.87	0	444.38	
62.47	0	444.21	TW
65.07	0	444.38	
68.47	0	446.08	RB
87.47	0	446.46	FP
88.94	0	446.85	
96.01	0	448.17	

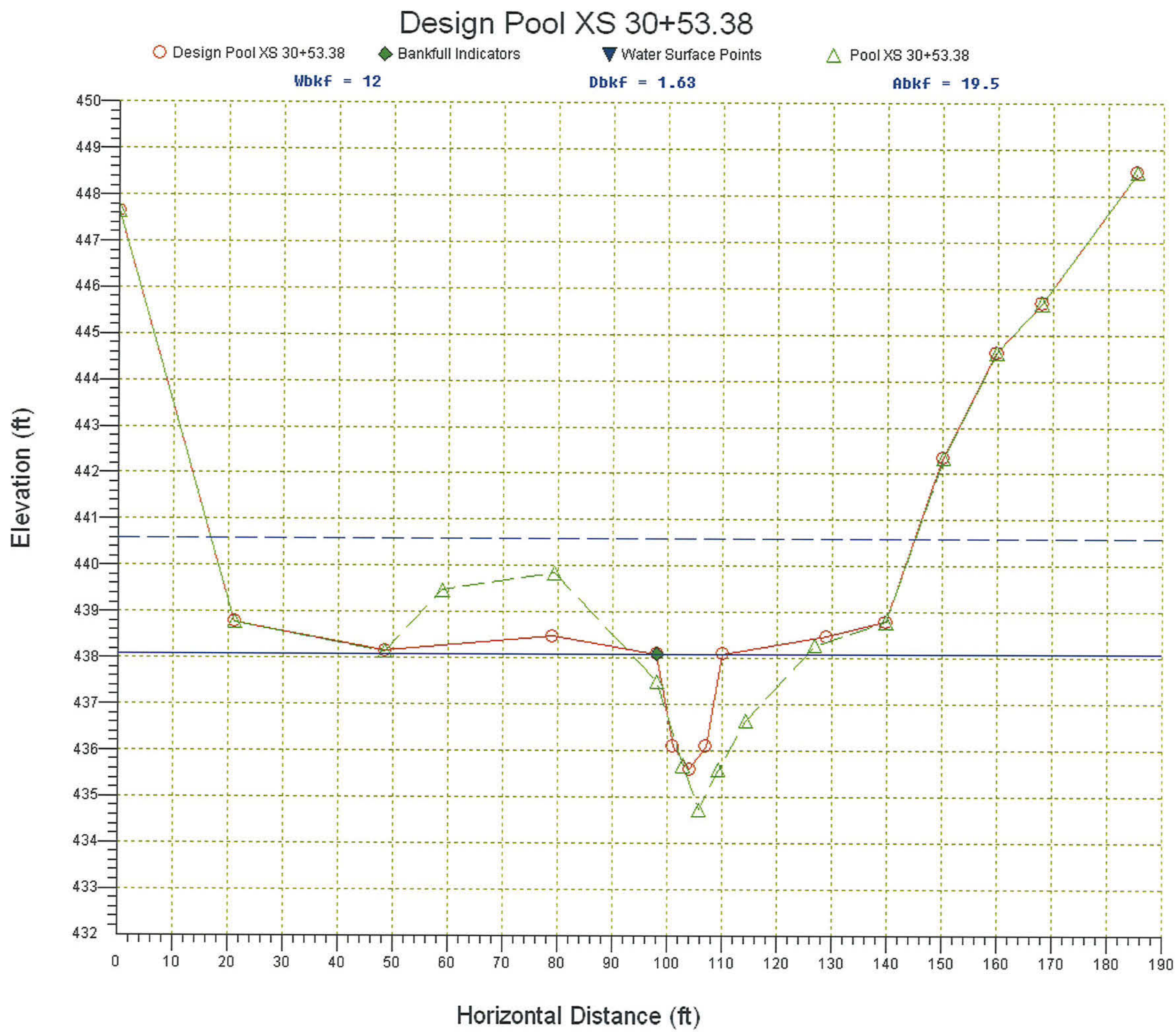
Cross Sectional Geometry

	Channel	Left	Right
Floodprone Elevation (ft)	447.95	447.95	-----
Bankfull Elevation (ft)	446.08	446.08	-----
Floodprone Width (ft)	94.33	-----	-----
Bankfull Width (ft)	12	22.31	-----
Entrenchment Ratio	7.86	-----	-----
Mean Depth (ft)	1.26	1.26	-----
Maximum Depth (ft)	1.87	1.87	-----
Width/Depth Ratio	9.52	17.71	-----
Bankfull Area (sq ft)	15.06	15.06	-----
Wetted Perimeter (ft)	12.81	12.81	-----
Hydraulic Radius (ft)	1.18	1.18	-----
Begin BKF Station	56.47	56.47	-----
End BKF Station	68.47	68.47	-----

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.02146	0	0
Shear Stress (lb/sq ft)	1.58		
Movable Particle (mm)	212.8		


Design Pool XS 30+53.38
Design Pool XS 30+53.38
Bankfull Indicators
Water Surface Points
Pool XS 30+53.38
Wbkf = 12
Dbkf = 1.63
Abkf = 19.5
Elevation (ft)
450
449
448
447
446
445
444
443
442
441
440
439
438
437
436
435
434
433
432
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
Horizontal Distance (ft)

RIVERMORPH CROSS SECTION SUMMARY

River Name: Davis Branch
Reach Name: Enhancement 1 Reach
Cross Section Name: Design Pool XS 30+53.38
Survey Date: 02/18/2008

Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0	0	447.65	
21.19	0	438.77	
48.45	0	438.15	
79.04	0	438.47	FP
98.04	0	438.09	BKF
101.04	0	436.09	
104.04	0	435.59	TW
107.04	0	436.09	
110.04	0	438.09	RB
129.04	0	438.47	
139.74	0	438.78	
150.06	0	442.34	
159.7	0	444.62	
167.93	0	445.68	
185.18	0	448.51	

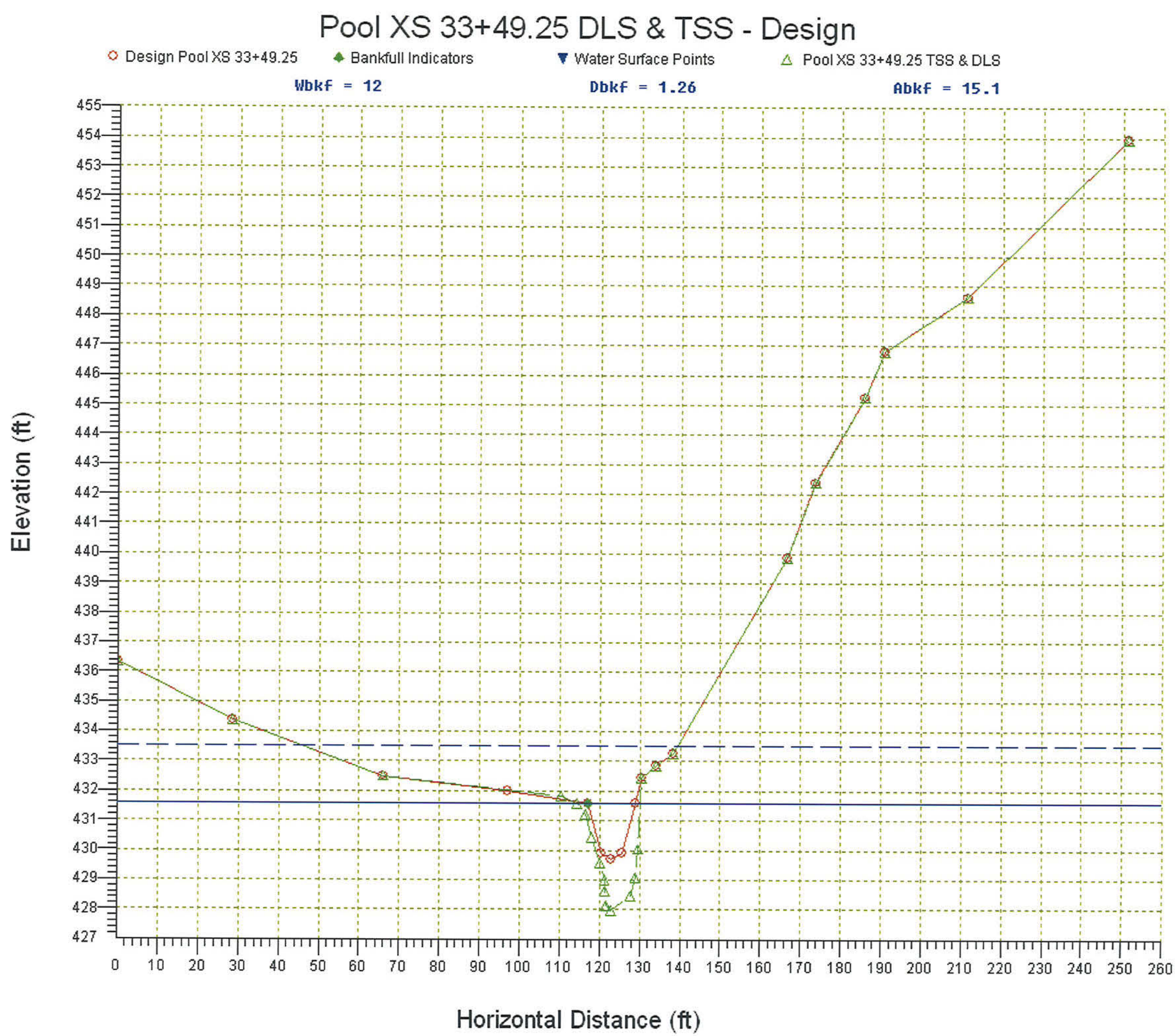
Cross Sectional Geometry

	Channel	Left	Right
Floodprone Elevation (ft)	440.59	440.59	440.59
Bankfull Elevation (ft)	438.09	438.09	438.09
Floodprone Width (ft)	128.14	-----	-----
Bankfull Width (ft)	12	1	11
Entrenchment Ratio	10.68	-----	-----
Mean Depth (ft)	1.63	0.33	1.74
Maximum Depth (ft)	2.5	0.67	2.5
Width/Depth Ratio	7.36	3.03	6.32
Bankfull Area (sq ft)	19.5	0.33	19.17
Wetted Perimeter (ft)	13.29	1.87	12.76
Hydraulic Radius (ft)	1.47	0.18	1.5
Begin BKF Station	98.04	98.04	99.04
End BKF Station	110.04	99.04	110.04

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.02171	0	0
Shear Stress (lb/sq ft)	1.99		
Movable Particle (mm)	252.3		



Pool XS 33+49.25 DLS & TSS - Design
Design Pool XS 33+49.25
Bankfull Indicators
Water Surface Points
Pool XS 33+49.25 TSS & DLS
Wbkf = 12
Dbkf = 1.26
Abkf = 15.1
Elevation (ft)
Horizontal Distance (ft)
455
454
453
452
451
450
449
448
447
446
445
444
443
442
441
440
439
438
437
436
435
434
433
432
431
430
429
428
427
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250
260

RIVERMORPH CROSS SECTION SUMMARY

River Name: Davis Branch
Reach Name: Enhancement 1 Reach
Cross Section Name: Design Pool XS 33+49.25
Survey Date: 02/13/2008

Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0	0	436.35	
28.69	0	434.36	
66.05	0	432.5	
96.93	0	431.99	FP
116.93	0	431.59	BKF
120.33	0	429.89	
122.93	0	429.69	TW
125.53	0	429.89	
128.93	0	431.59	RB
130.53	0	432.44	FP
133.93	0	432.85	FP
138.33	0	433.26	FP
166.62	0	439.87	
173.68	0	442.39	
185.69	0	445.26	
190.47	0	446.8	
211.3	0	448.63	
251.19	0	453.93	

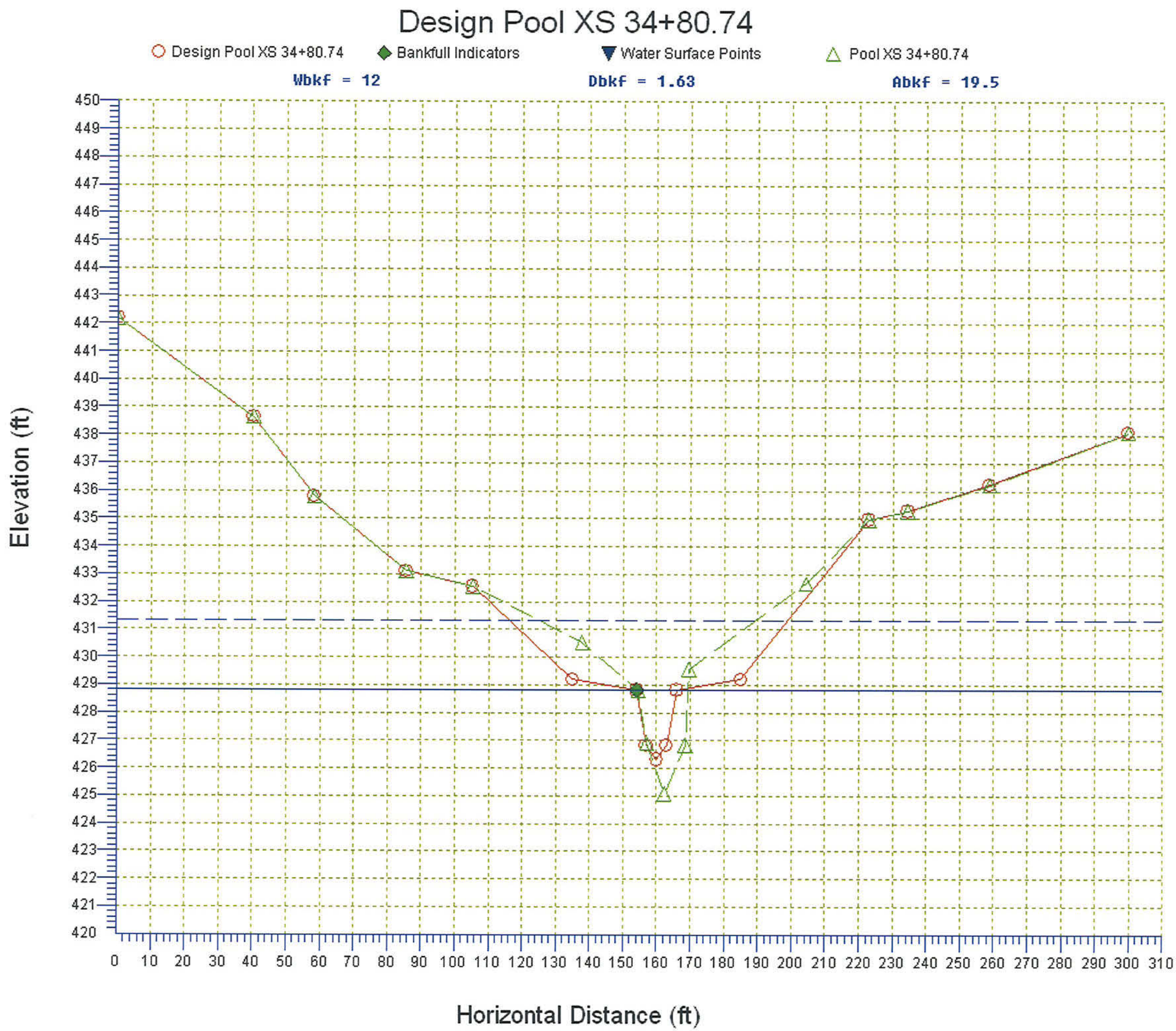
Cross Sectional Geometry

	Channel	Left	Right
Floodprone Elevation (ft)	433.49	433.49	433.49
Bankfull Elevation (ft)	431.59	431.59	431.59
Floodprone Width (ft)	93.15	-----	-----
Bankfull Width (ft)	12	5.34	6.66
Entrenchment Ratio	7.76	-----	-----
Mean Depth (ft)	1.26	1.19	1.32
Maximum Depth (ft)	1.9	1.85	1.9
Width/Depth Ratio	9.52	4.49	5.05
Bankfull Area (sq ft)	15.14	6.33	8.81
Wetted Perimeter (ft)	12.82	7.6	8.92
Hydraulic Radius (ft)	1.18	0.83	0.99
Begin BKF Station	116.93	116.93	122.27
End BKF Station	128.93	122.27	128.93

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.0213	0	0
Shear Stress (lb/sq ft)	1.57		
Movable Particle (mm)	211.7		



Design Pool XS 34+80.74
Design Pool XS 34+80.74
Bankfull Indicators
Water Surface Points
Pool XS 34+80.74
Wbkf = 12
Dbkf = 1.63
Abkf = 19.5
Elevation (ft)
Horizontal Distance (ft)

Design Pool XS 34+80.74.txt
RIVERMORPH CROSS SECTION SUMMARY

River Name: Davis Branch
Reach Name: Enhancement 1 Reach
Cross Section Name: Design Pool XS 34+80.74
Survey Date: 02/18/2008

Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0		442.19	
40.19		438.63	
58.23		435.79	
85.53		433.11	
105.37		432.56	
134.97		429.2	FP
153.97		428.82	BKF
156.97		426.82	
159.97		426.32	TW
162.97		426.82	
165.97		428.82	RB
184.97		429.2	FP
222.9		434.97	
234.52		435.28	
258.73		436.23	
299.61		438.11	
299.61		438.11	

Cross Sectional Geometry

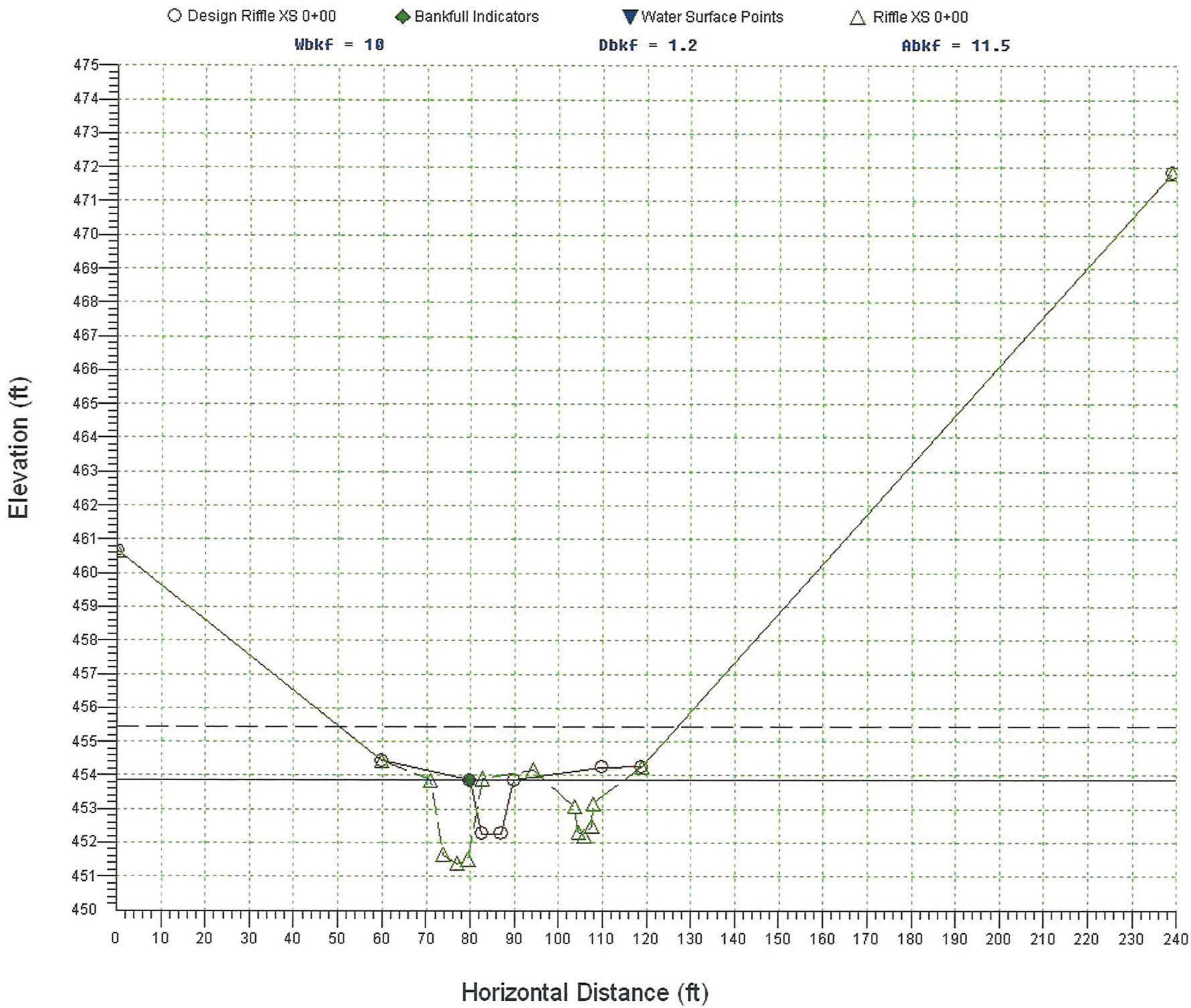
	Channel	Left	Right
Floodprone Elevation (ft)	431.32	431.32	431.32
Bankfull Elevation (ft)	428.82	428.82	428.82
Floodprone Width (ft)	82.61	-----	-----
Bankfull Width (ft)	12	6.7	5.3
Entrenchment Ratio	6.88	-----	-----
Mean Depth (ft)	1.63	1.71	1.52
Maximum Depth (ft)	2.5	2.5	2.38
Width/Depth Ratio	7.36	3.92	3.49
Bankfull Area (sq ft)	19.5	11.46	8.04
Wetted Perimeter (ft)	13.29	9.74	8.32
Hydraulic Radius (ft)	1.47	1.18	0.97
Begin BKF Station	153.97	153.97	160.67
End BKF Station	165.97	160.67	165.97

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.0213	0	0
Shear Stress (lb/sq ft)	1.95		
Movable Particle (mm)	248.8		

Design Riffle XS 23+43.21 (Upstream Limit 60-ft Easement Break)



RIVERMORPH CROSS SECTION SUMMARY

River Name:	Davis Branch
Reach Name:	Enhance 1 Reach - Impaired
Cross Section Name:	Design Riffle XS 23+43.21
Survey Date:	02/15/2008

Cross Section Data Entry

BM Elevation:	0 ft
Backsight Rod Reading:	0 ft

TAPE	FS	ELEV	NOTE
0	0	460.68	LT
59.84	0	454.44	FP
79.84	0	453.86	BKF
82.64	0	452.26	
87.04	0	452.26	
89.84	0	453.86	RB
109.84	0	454.25	FP
118.89	0	454.26	FP
238.89	0	471.84	BM 3357

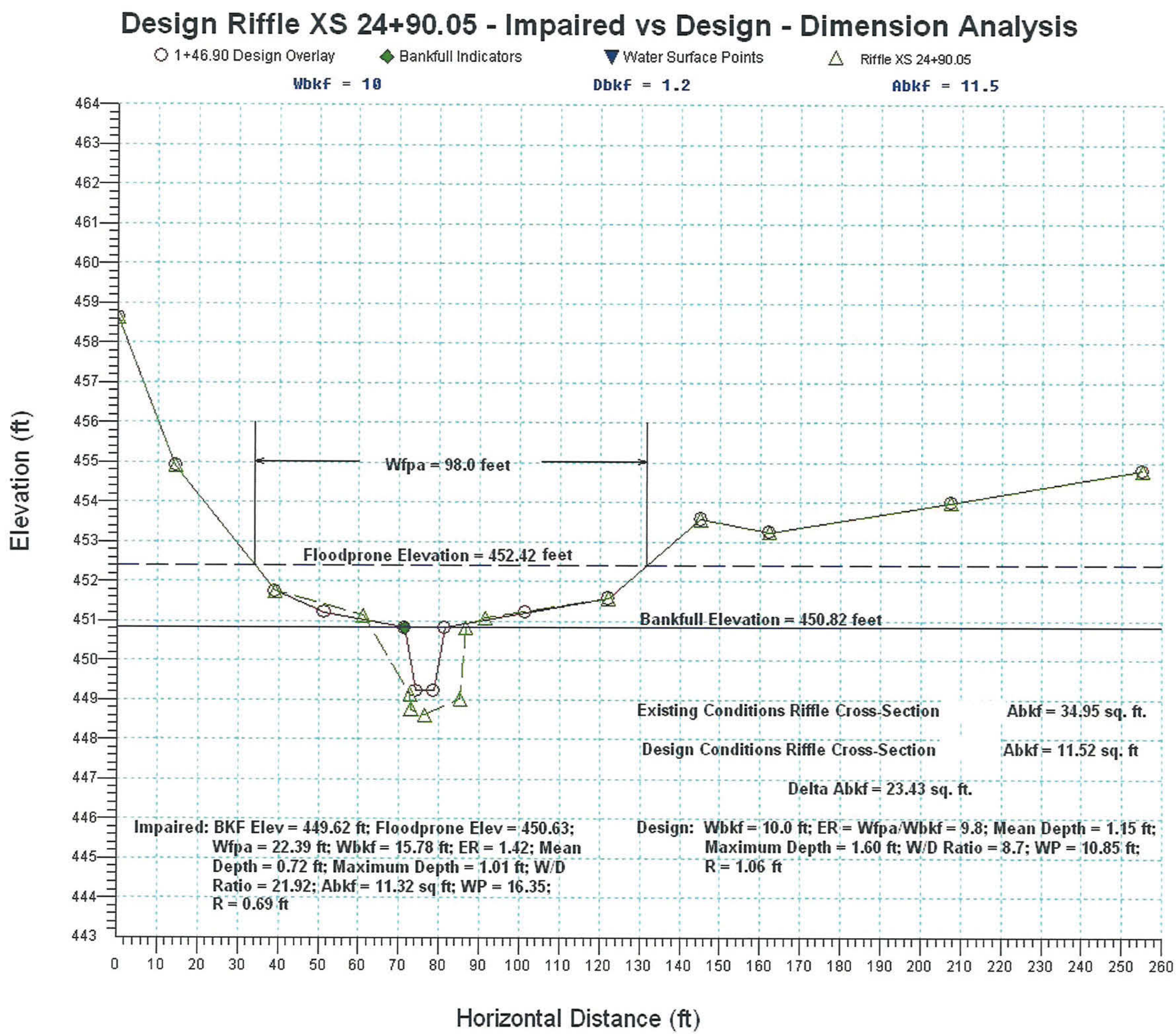
Cross Sectional Geometry

	Channel	Left	Right
Floodprone Elevation (ft)	455.46	455.46	455.46
Bankfull Elevation (ft)	453.86	453.86	453.86
Floodprone Width (ft)	77.02	-----	-----
Bankfull Width (ft)	10	5	5
Entrenchment Ratio	7.7	-----	-----
Mean Depth (ft)	1.15	1.15	1.15
Maximum Depth (ft)	1.6	1.6	1.6
Width/Depth Ratio	8.7	4.35	4.35
Bankfull Area (sq ft)	11.52	5.76	5.76
Wetted Perimeter (ft)	10.85	7.02	7.02
Hydraulic Radius (ft)	1.06	0.82	0.82
Begin BKF Station	79.84	79.84	84.84
End BKF Station	89.84	84.84	89.84

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.02146	0	0
Shear Stress (lb/sq ft)	1.42		
Movable Particle (mm)	196.7		


Design Riffle XS 24+90.05 - Impaired vs Design - Dimension Analysis
1+46.90 Design Overlay
Bankfull Indicators
Water Surface Points
Riffle XS 24+90.05
Wbkf = 10
Dbkf = 1.2
Abkf = 11.5
Wfpa = 98.0 feet
Floodprone Elevation = 452.42 feet
Bankfull Elevation = 450.82 feet
Existing Conditions Riffle Cross-Section Abkf = 34.95 sq. ft.
Design Conditions Riffle Cross-Section Abkf = 11.52 sq. ft
Delta Abkf = 23.43 sq. ft.
Impaired: BKF Elev = 449.62 ft; Floodprone Elev = 450.63; Wfpa = 22.39 ft; Wbkf = 15.78 ft; ER = 1.42; Mean Depth = 0.72 ft; Maximum Depth = 1.01 ft; W/D Ratio = 21.92; Abkf = 11.32 sq ft; WP = 16.35; R = 0.69 ft
Design: Wbkf = 10.0 ft; ER = Wfpa/Wbkf = 9.8; Mean Depth = 1.15 ft; Maximum Depth = 1.60 ft; W/D Ratio = 8.7; WP = 10.85 ft; R = 1.06 ft
Elevation (ft)
Horizontal Distance (ft)

RIVERMORPH CROSS SECTION SUMMARY

River Name: Davis Branch
Reach Name: Enhancement 1 Reach
Cross Section Name: Design Riffle XS 24+90.05
Survey Date: 02/08/2008

Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0	0	458.65	
14.43	0	454.91	
39.19	0	451.75	
51.4	0	451.21	
71.4	0	450.82	BKF
74.2	0	449.22	
78.6	0	449.22	TW
81.4	0	450.82	RB
101.4	0	451.21	
122.14	0	451.57	
145.1	0	453.57	
162.21	0	453.25	
207.45	0	453.98	
254.94	0	454.8	

Cross Sectional Geometry

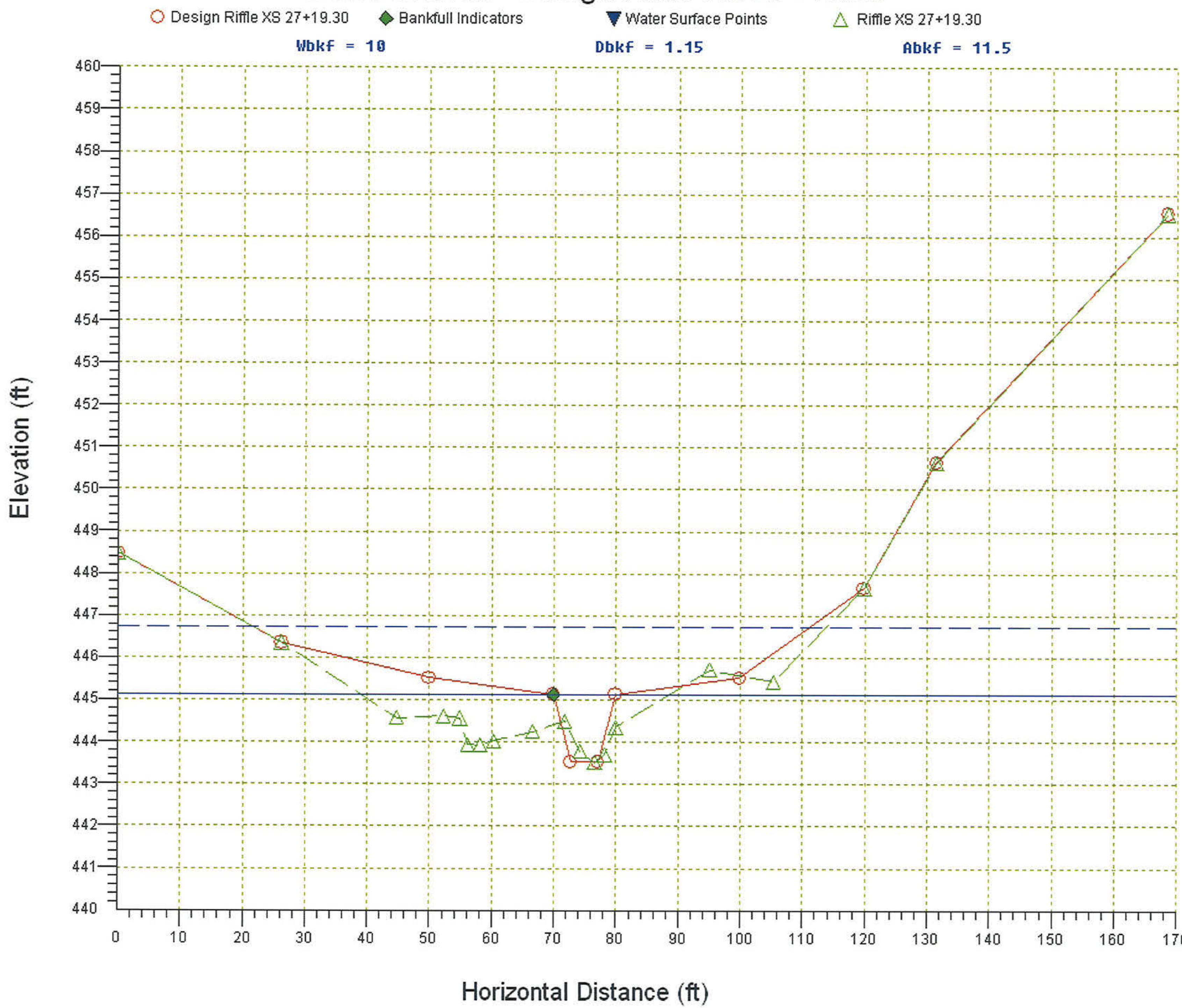
	Channel	Left	Right
Floodprone Elevation (ft)	452.42	452.42	452.42
Bankfull Elevation (ft)	450.82	450.82	450.82
Floodprone Width (ft)	97.96	-----	-----
Bankfull Width (ft)	10	5	5
Entrenchment Ratio	9.8	-----	-----
Mean Depth (ft)	1.15	1.15	1.15
Maximum Depth (ft)	1.6	1.6	1.6
Width/Depth Ratio	8.7	4.35	4.35
Bankfull Area (sq ft)	11.52	5.76	5.76
Wetted Perimeter (ft)	10.85	7.02	7.02
Hydraulic Radius (ft)	1.06	0.82	0.82
Begin BKF Station	71.4	71.4	76.4
End BKF Station	81.4	76.4	81.4

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.02171	0	0
Shear Stress (lb/sq ft)	1.44		
Movable Particle (mm)	198.4		

Davis Branch - Design Riffle XS 27+19.30



RIVERMORPH CROSS SECTION SUMMARY

River Name: Davis Branch
Reach Name: Enhancement 1 Reach
Cross Section Name: Design Riffle XS 27+19.30
Survey Date: 02/12/2008

Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0	0	448.48	MT
26.27	0	446.35	LT
49.89	0	445.52	FP
69.88	0	445.12	BKF
72.68	0	443.52	
77.08	0	443.52	TW
79.88	0	445.12	RB
99.88	0	445.52	FP
119.87	0	447.66	LT
131.47	0	450.64	MT
168.48	0	456.55	MT

Cross Sectional Geometry

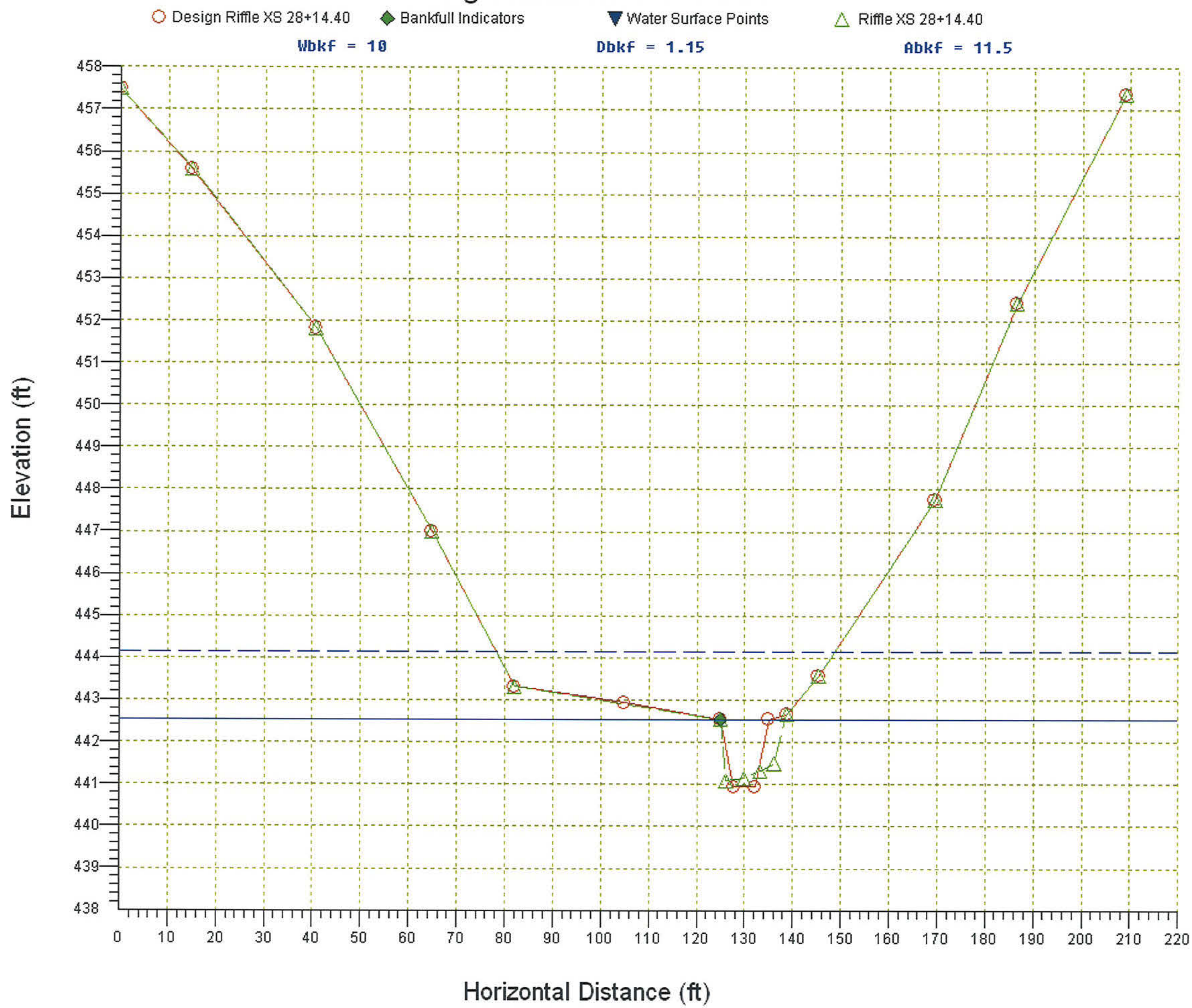
	Channel	Left	Right
Floodprone Elevation (ft)	446.72	446.72	446.72
Bankfull Elevation (ft)	445.12	445.12	445.12
Floodprone Width (ft)	89.38	-----	-----
Bankfull Width (ft)	10	5	5
Entrenchment Ratio	8.94	-----	-----
Mean Depth (ft)	1.15	1.15	1.15
Maximum Depth (ft)	1.6	1.6	1.6
Width/Depth Ratio	8.7	4.35	4.35
Bankfull Area (sq ft)	11.52	5.76	5.76
Wetted Perimeter (ft)	10.85	7.02	7.02
Hydraulic Radius (ft)	1.06	0.82	0.82
Begin BKF Station	69.88	69.88	74.88
End BKF Station	79.88	74.88	79.88

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.02171	0	0
Shear Stress (lb/sq ft)	1.44		
Movable Particle (mm)	198.4		

Design Riffle XS 28+14.40



RIVERMORPH CROSS SECTION SUMMARY

River Name: Davis Branch
Reach Name: Enhancement 1 Reach
Cross Section Name: Design Riffle XS 28+14.40
Survey Date: 02/15/2008

Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0	0	457.49	
14.79	0	455.6	
40.53	0	451.82	
64.73	0	447.01	
81.97	0	443.31	
104.92	0	442.93	FP
124.92	0	442.54	BKF
127.72	0	440.94	
132.12	0	440.94	
134.92	0	442.54	RB
138.75	0	442.66	
145.34	0	443.56	
169.52	0	447.76	
186.41	0	452.42	
209.01	0	457.38	

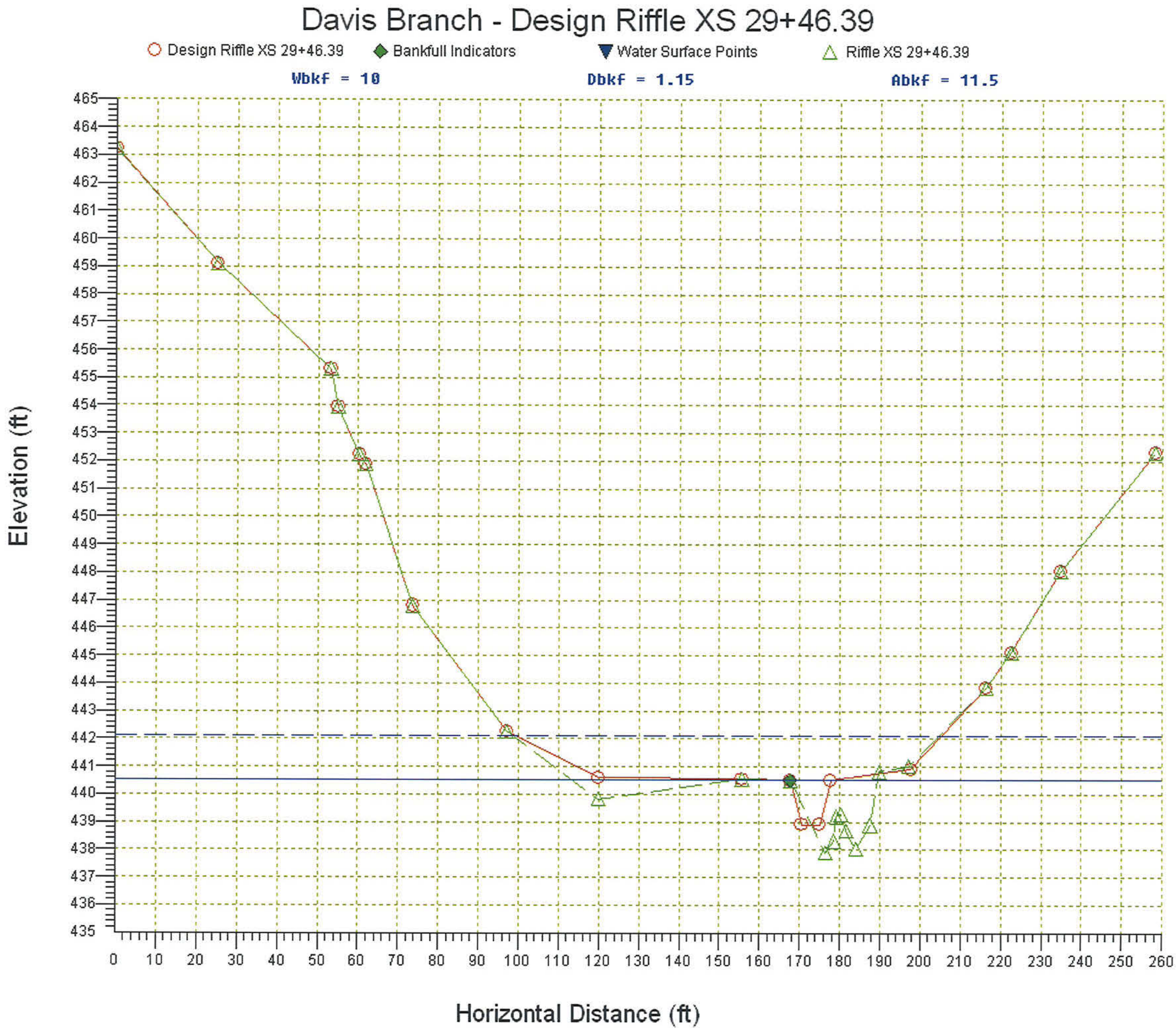
Cross Sectional Geometry

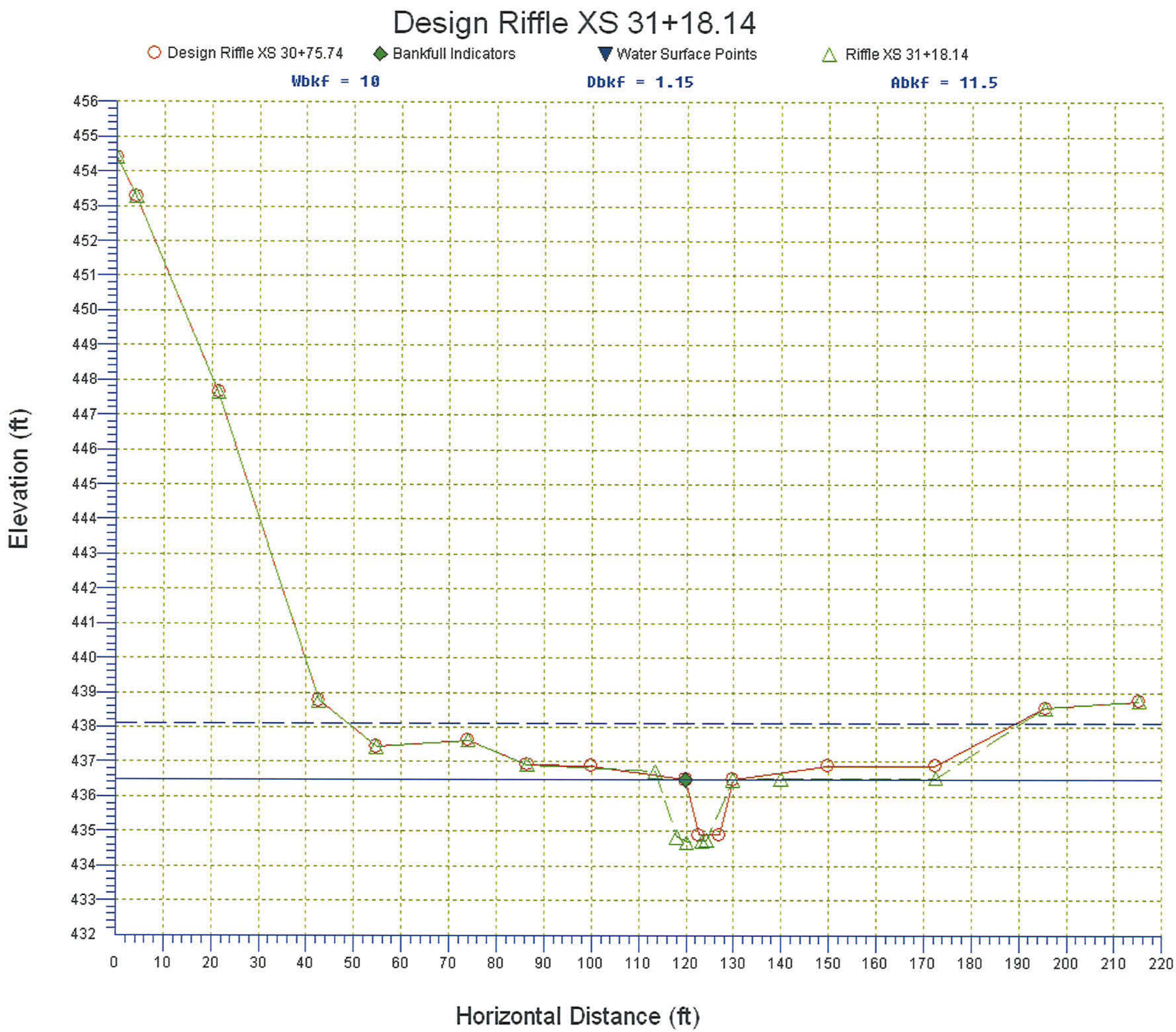
	Channel	Left	Right
Floodprone Elevation (ft)	444.14	444.14	444.14
Bankfull Elevation (ft)	442.54	442.54	442.54
Floodprone Width (ft)	70.58	-----	-----
Bankfull Width (ft)	10	5	5
Entrenchment Ratio	7.06	-----	-----
Mean Depth (ft)	1.15	1.15	1.15
Maximum Depth (ft)	1.6	1.6	1.6
Width/Depth Ratio	8.7	4.35	4.35
Bankfull Area (sq ft)	11.52	5.76	5.76
Wetted Perimeter (ft)	10.85	7.02	7.02
Hydraulic Radius (ft)	1.06	0.82	0.82
Begin BKF Station	124.92	124.92	129.92
End BKF Station	134.92	129.92	134.92

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.02171	0	0
Shear Stress (lb/sq ft)	1.44		
Movable Particle (mm)	198.4		


Davis Branch - Design Riffle XS 29+46.39
Design Riffle XS 29+46.39
Bankfull Indicators
Water Surface Points
Riffle XS 29+46.39
Wbkf = 10
Dbkf = 1.15
Abkf = 11.5
Elevation (ft)
Horizontal Distance (ft)



Design Riffle XS 31+18.14
Design Riffle XS 30+75.74
Bankfull Indicators
Water Surface Points
Riffle XS 31+18.14
Wbkf = 10
Dbkf = 1.15
Abkf = 11.5
Elevation (ft)
Horizontal Distance (ft)
456
455
454
453
452
451
450
449
448
447
446
445
444
443
442
441
440
439
438
437
436
435
434
433
432
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220

RIVERMORPH CROSS SECTION SUMMARY

River Name: Davis Branch
Reach Name: Enhancement 1 Reach
Cross Section Name: Design Riffle XS 31+18.14
Survey Date: 02/15/2008

Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0	0	454.41	
4.14	0	453.28	
21.49	0	447.65	
42.68	0	438.77	
54.72	0	437.44	
74.01	0	437.62	
86.43	0	436.92	FP
99.84	0	436.88	FP
119.84	0	436.49	BKF
122.64	0	434.89	
127.04	0	434.89	
129.84	0	436.49	RB
149.84	0	436.88	FP
172.49	0	436.88	
195.58	0	438.55	
215.2	0	438.74	

Cross Sectional Geometry

	Channel	Left	Right
Floodprone Elevation (ft)	438.09	438.09	438.09
Bankfull Elevation (ft)	436.49	436.49	436.49
Floodprone Width (ft)	140.38	-----	-----
Bankfull Width (ft)	10	7.61	2.39
Entrenchment Ratio	14.04	-----	-----
Mean Depth (ft)	1.15	1.3	0.68
Maximum Depth (ft)	1.6	1.6	1.37
Width/Depth Ratio	8.7	5.85	3.51
Bankfull Area (sq ft)	11.52	9.89	1.63
Wetted Perimeter (ft)	10.85	9.46	4.12
Hydraulic Radius (ft)	1.06	1.04	0.4
Begin BKF Station	119.84	119.84	127.45
End BKF Station	129.84	127.45	129.84

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.02171	0	0
Shear Stress (lb/sq ft)	1.44		
Movable Particle (mm)	198.4		

RIVERMORPH CROSS SECTION SUMMARY

River Name: Davis Branch
Reach Name: Enhancement 1 Reach
Cross Section Name: Design Riffle XS 29+46.39
Survey Date: 02/18/2008

Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0	0	463.23	
25.11	0	459.11	
53.15	0	455.3	
55.03	0	453.94	
60.25	0	452.23	
61.94	0	451.88	
73.64	0	446.81	
97	0	442.27	
119.85	0	440.6	
155.67	0	440.56	FP
167.75	0	440.5	BKF
170.55	0	438.9	
174.95	0	438.9	
177.75	0	440.5	RB
197.75	0	440.9	FP
216.41	0	443.85	
222.65	0	445.12	
234.79	0	448.05	
258.22	0	452.31	

Cross Sectional Geometry

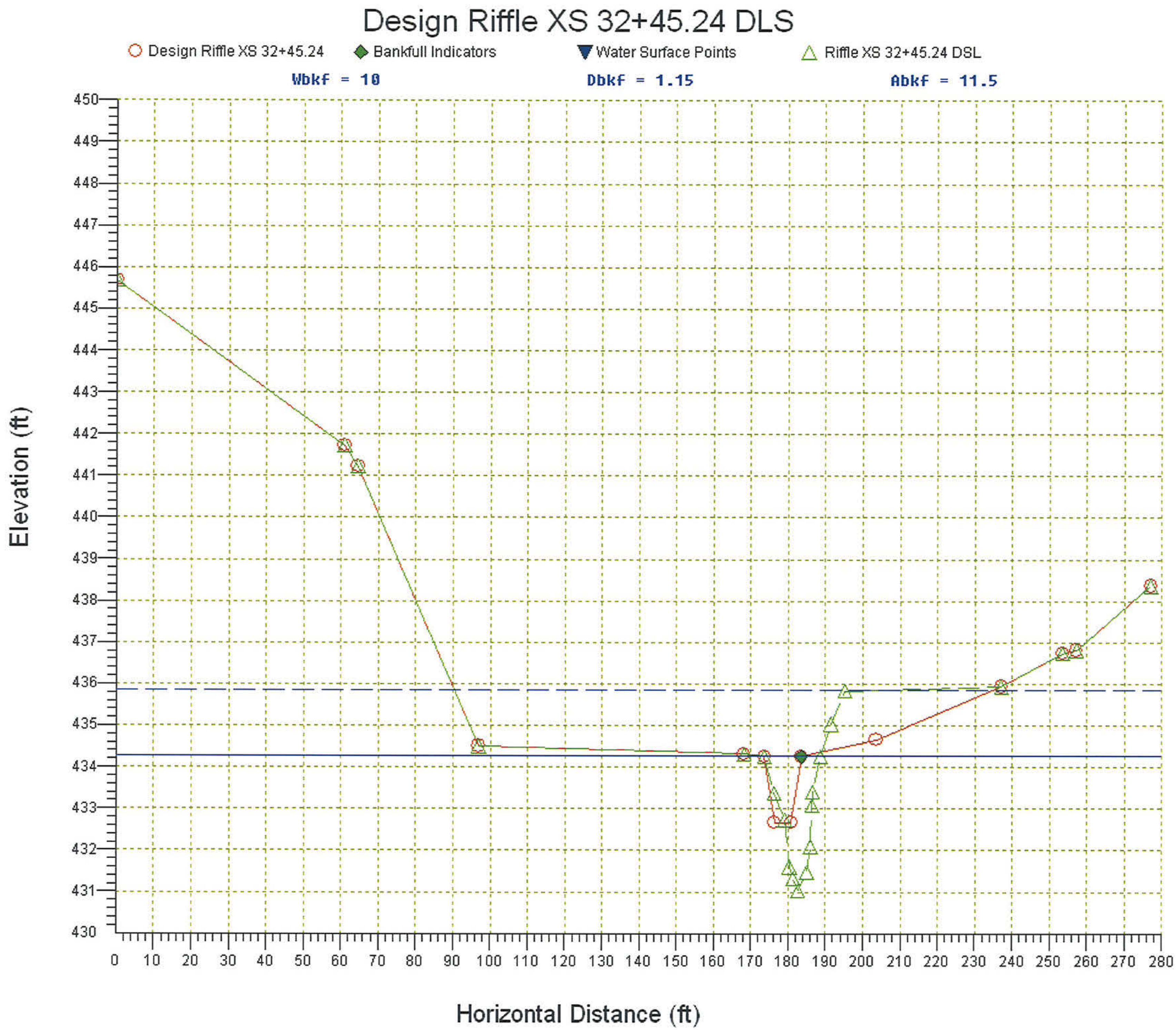
	Channel	Left	Right
Floodprone Elevation (ft)	442.1	442.1	442.1
Bankfull Elevation (ft)	440.5	440.5	440.5
Floodprone Width (ft)	106.01	-----	-----
Bankfull Width (ft)	10	5	5
Entrenchment Ratio	10.6	-----	-----
Mean Depth (ft)	1.15	1.15	1.15
Maximum Depth (ft)	1.6	1.6	1.6
Width/Depth Ratio	8.7	4.35	4.35
Bankfull Area (sq ft)	11.52	5.76	5.76
Wetted Perimeter (ft)	10.85	7.02	7.02
Hydraulic Radius (ft)	1.06	0.82	0.82
Begin BKF Station	167.75	167.75	172.75
End BKF Station	177.75	172.75	177.75

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.02171	0	0
Shear Stress (lb/sq ft)	1.44		

Movable Particle (mm) 198.4


Design Riffle XS 32+45.24 DLS
Design Riffle XS 32+45.24
Bankfull Indicators
Water Surface Points
Riffle XS 32+45.24 DSL
Wbkf = 10
Dbkf = 1.15
Abkf = 11.5
Elevation (ft)
Horizontal Distance (ft)
450
449
448
447
446
445
444
443
442
441
440
439
438
437
436
435
434
433
432
431
430
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250
260
270
280

RIVERMORPH CROSS SECTION SUMMARY

River Name:	Davis Branch
Reach Name:	Enhancement 1 Reach
Cross Section Name:	Design Riffle XS 32+45.24
Survey Date:	02/18/2008

Cross Section Data Entry

BM Elevation:	0 ft
Backsight Rod Reading:	0 ft

TAPE	FS	ELEV	NOTE
0		445.68	
60.92		441.72	
64.47		441.22	
96.94		434.5	FP
168.17		434.32	FP
173.57		434.26	LB
176.37		432.66	TW
180.77		432.66	
183.57		434.26	BKF
203.57		434.66	FP
237.14		435.94	
253.5		436.74	
257.26		436.82	
277.06		438.37	

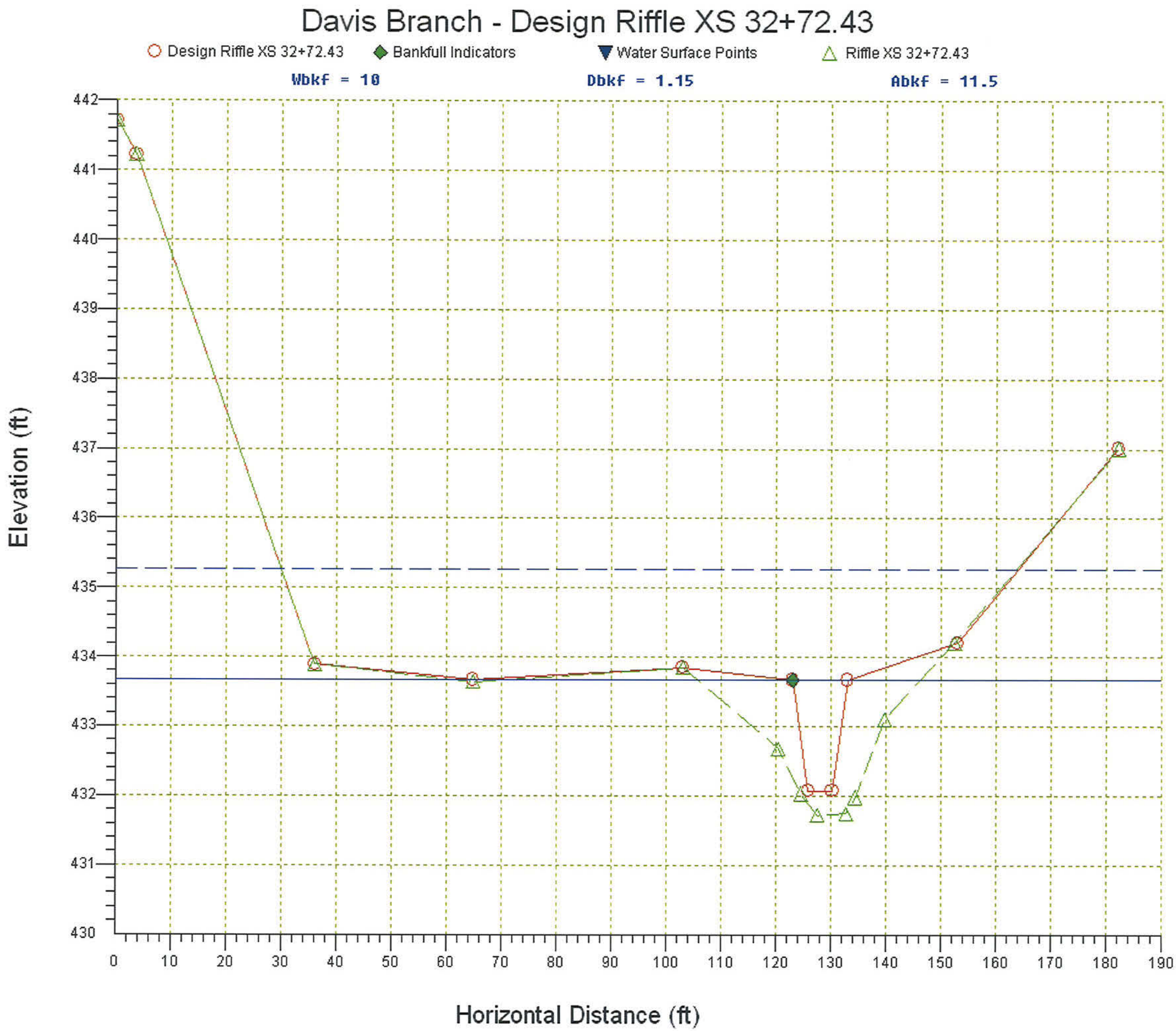
Cross Sectional Geometry

	Channel	Left	Right
Floodprone Elevation (ft)	435.86	435.86	435.86
Bankfull Elevation (ft)	434.26	434.26	434.26
Floodprone Width (ft)	144.67	-----	-----
Bankfull Width (ft)	10	5	5
Entrenchment Ratio	14.47	-----	-----
Mean Depth (ft)	1.15	1.15	1.15
Maximum Depth (ft)	1.6	1.6	1.6
Width/Depth Ratio	8.7	4.35	4.35
Bankfull Area (sq ft)	11.52	5.76	5.76
Wetted Perimeter (ft)	10.85	7.02	7.02
Hydraulic Radius (ft)	1.06	0.82	0.82
Begin BKF Station	173.57	173.57	178.57
End BKF Station	183.57	178.57	183.57

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.02171	0	0
Shear Stress (lb/sq ft)	1.44		
Movable Particle (mm)	198.4		


Davis Branch - Design Riffle XS 32+72.43
Design Riffle XS 32+72.43
Bankfull Indicators
Water Surface Points
Riffle XS 32+72.43
Wbkf = 10
Dbkf = 1.15
Abkf = 11.5
Elevation (ft)
Horizontal Distance (ft)
442
441
440
439
438
437
436
435
434
433
432
431
430
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190

RIVERMORPH CROSS SECTION SUMMARY

River Name: Davis Branch
Reach Name: Enhancement 1 Reach
Cross Section Name: Design Riffle XS 32+72.43
Survey Date: 02/12/2008

Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0	0	441.72	
3.55	0	441.23	
36.02	0	433.89	
64.78	0	433.67	
102.98	0	433.85	
122.98	0	433.67	BKF
125.78	0	432.07	TW
130.18	0	432.07	
132.98	0	433.67	RB
152.98	0	434.21	
182.07	0	437.01	

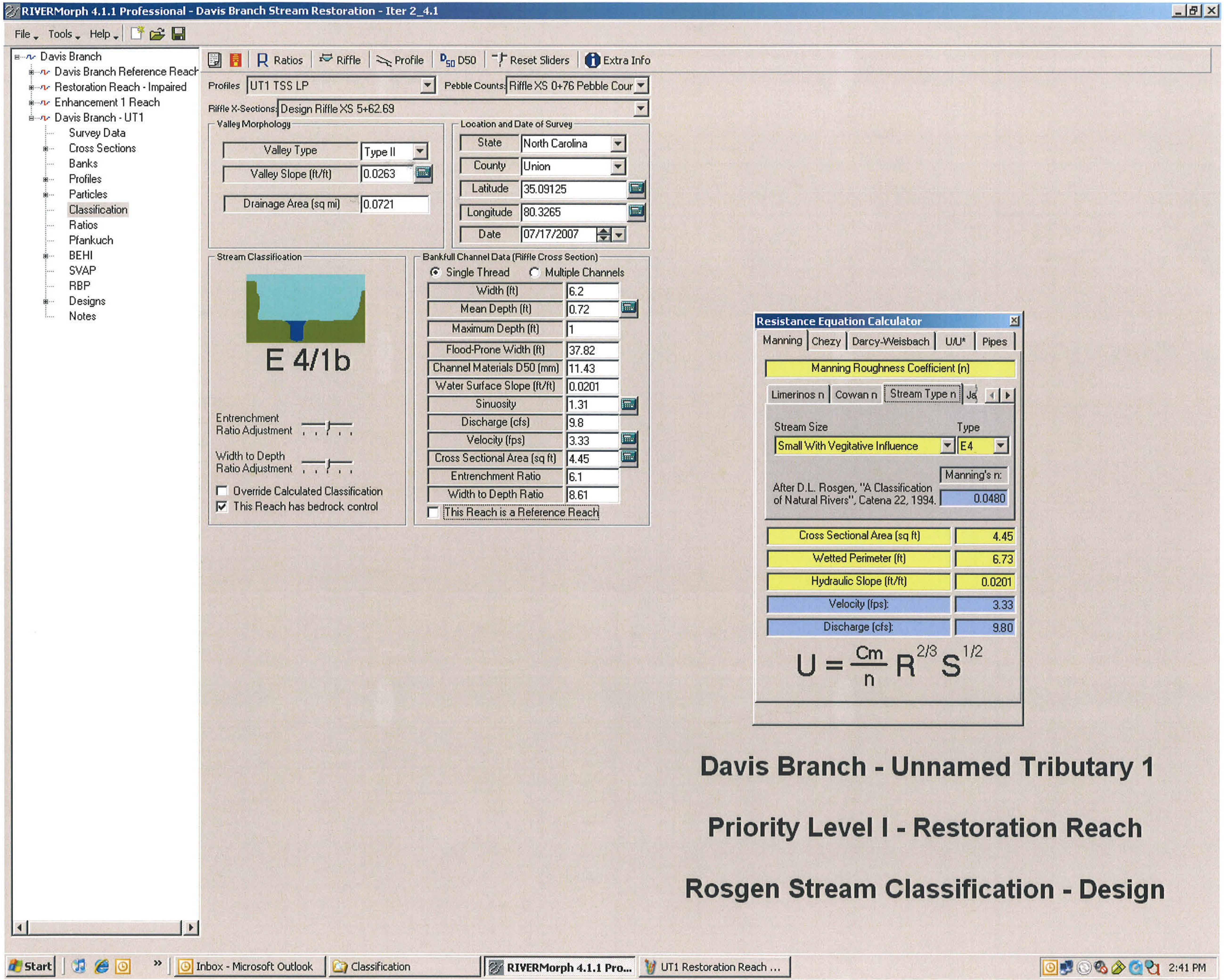
Cross Sectional Geometry

	Channel	Left	Right
Floodprone Elevation (ft)	435.27	435.27	435.27
Bankfull Elevation (ft)	433.67	433.67	433.67
Floodprone Width (ft)	134.08	-----	-----
Bankfull Width (ft)	10	5	5
Entrenchment Ratio	13.41	-----	-----
Mean Depth (ft)	1.15	1.15	1.15
Maximum Depth (ft)	1.6	1.6	1.6
Width/Depth Ratio	8.7	4.35	4.35
Bankfull Area (sq ft)	11.52	5.76	5.76
Wetted Perimeter (ft)	10.85	7.02	7.02
Hydraulic Radius (ft)	1.06	0.82	0.82
Begin BKF Station	122.98	122.98	127.98
End BKF Station	132.98	127.98	132.98

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.02171	0	0
Shear Stress (lb/sq ft)	1.44		
Movable Particle (mm)	198.4		



Davis Branch - Unnamed Tributary 1

Priority Level I - Restoration Reach

Rosgen Stream Classification - Design

Worksheet 5-3. Field form for Level II stream classification (Rosgen, 1996; Rosgen and Silvey, 2005).

Stream:	**Davis Branch - UT1 Restoration Reach - Design**		
Basin:	**Yadkin - Pee Dee**	Drainage Area: **46.144** acres	**0.0721** mi^2
Location:	**Eddie Staton Property**		
Twp.&Rge: **;**		Sec.&Qtr.: **;**	
Cross-Section Monuments (Lat./Long.):	**35.09125 Lat / 80.3265 Long**		Date: **07/17/07**
Observers:	**Hebert, Hines & Knotts**		Valley Type: II

Parameter	Value	Units
Bankfull WIDTH (W_{bkf}) WIDTH of the stream channel at bankfull stage elevation, in a riffle section.	**6.2**	ft
Bankfull DEPTH (d_{bkf}) Mean DEPTH of the stream channel cross-section, at bankfull stage elevation, in a riffle section ($d_{bkf} = A / W_{bkf}$).	**0.72**	ft
Bankfull X-Section AREA (A_{bkf}) AREA of the stream channel cross-section, at bankfull stage elevation, in a riffle section.	**4.45**	ft^2
Width/Depth Ratio (W_{bkf} / d_{bkf}) Bankfull WIDTH divided by bankfull mean DEPTH, in a riffle section.	**8.61**	ft/ft
Maximum DEPTH (d_{mbkf}) Maximum depth of the bankfull channel cross-section, or distance between the bankfull stage and Thalweg elevations, in a riffle section.	**1**	ft
WIDTH of Flood-Prone Area (W_{fpa}) Twice maximum DEPTH, or ($2 \times d_{mbkf}$) = the stage/elevation at which flood-prone area WIDTH is determined in a riffle section.	**37.82**	ft
Entrenchment Ratio (ER) The ratio of flood-prone area WIDTH divided by bankfull channel WIDTH (W_{fpa} / W_{bkf}) (riffle section).	**6.1**	ft/ft
Channel Materials (Particle Size Index) D_{50} The D_{50} particle size index represents the mean diameter of channel materials, as sampled from the channel surface, between the bankfull stage and Thalweg elevations.	**11.43**	mm
Water Surface SLOPE (S) Channel slope = "rise over run" for a reach approximately 20–30 bankfull channel widths in length, with the "riffle-to-riffle" water surface slope representing the gradient at bankfull stage.	**0.0201**	ft/ft
Channel SINUOSITY (k) Sinuosity is an index of channel pattern, determined from a ratio of stream length divided by valley length (SL / VL); or estimated from a ratio of valley slope divided by channel slope (VS / S).	**1.31**	

Stream Type **E 4/1b** (See **Figure 2-14**)

Worksheet 5-4. Morphological relations, including dimensionless ratios of river reach sites (Rosgen and Silvey, 2005).

Stream: **Davis Branch UT1 Restoration Reach Design**		Location: **Eddie Staton Property**	
Observers: **Hebert, Hines & Knotts**	Date: **05/02/08**	Valley Type: **II**	Stream Type: **E 4/1b**

River Reach Summary Data

Channel Dimension

Mean Riffle Depth (d_{bkf})	**0.72**	ft	Riffle Width (W_{bkf})	**6.2**	ft	Riffle Area (A_{bkf})	**4.45**	ft^2
Mean Pool Depth (d_{bkfp})	**0.79**	ft	Pool Width (W_{bkfp})	**7**	ft	Pool Area (A_{bkfp})	**5.51**	ft^2
Mean Pool Depth/Mean Riffle Depth	**1.10**	d_{bkfp}/d_{bkf}	Pool Width/Riffle Width	**1.13**	W_{bkfp}/W_{bkf}	Pool Area / Riffle Area	**1.24**	A_{bkfp}/A_{bkf}
Max Riffle Depth (d_{mbkf})	**1.0**	ft	Max Pool Depth (d_{mbkfp})	**1.3**	ft	Max Riffle Depth/Mean Riffle Depth	**1.39**	
Max Pool Depth/Mean Riffle Depth	**1.81**					Point Bar Slope	**0.1**	
Streamflow: Estimated Mean Velocity at Bankfull Stage (u_{bkf})				**3.33**	ft/s	Estimation Method	**U/U* (Rosgen 1998**	
Streamflow: Estimated Discharge at Bankfull Stage (Q_{bkf})				**9.8**	cfs	Drainage Area	**0.0721**	mi^2

Channel Pattern

Geometry	Mean	Min	Max		Dimensionless Geometry Ratios	Mean	Min	Max
Meander Length (Lm)	**52.6**	**50.5**	**58.8**	ft	Meander Length Ratio (Lm/W_{bkf})	**8.48**	**8.15**	**9.48**
Radius of Curvature (Rc)	**12.6**	**11.1**	**18.0**	ft	Radius of Curvature/Riffle Width (Rc/W_{bkf})	**2.03**	**1.79**	**2.90**
Belt Width (W_{blt})	**50**	**50**	**50**	ft	Meander Width Ratio (W_{blt}/W_{bkf})	**8.06**	**8.06**	**8.06**
Individual Pool Length	**18.7**	**12.8**	**22.8**	ft	Pool Length/Riffle Width	**3.02**	**2.06**	**3.68**
Pool to Pool Spacing	**34.7**	**24.6**	**34.7**	ft	Pool to Pool Spacing/Riffle Width	**5.60**	**3.97**	**5.60**
Riffle Length	**17.1**	**9.0**	**23.0**	ft	Riffle Length/Riffle Width	**2.76**	**1.45**	**3.71**

Channel Profile

Valley Slope (VS)	**0.0263**	ft/ft	Average Water Surface Slope (S)	**0.0201**	ft/ft	Sinuosity (VS/S)	**1.31**	
Stream Length (SL)	**450**	ft	Valley Length (VL)	**343**	ft	Sinuosity (SL/VL)	**1.31**	
Low Bank Height (LBH) start	**1.0**	ft	Max Riffle Depth start	**1.0**	ft	Bank-Height Ratio (BHR) (LBH/Max Riffle Depth) start	**1.0**	
Low Bank Height (LBH) end	**1.0**	ft	Max Riffle Depth end	**1.0**	ft	Bank-Height Ratio (BHR) (LBH/Max Riffle Depth) end	**1.0**	

Facet Slopes	Mean	Min	Max		Dimensionless Slope Ratios	Mean	Min	Max
Riffle Slope (S_{rif})	**0.0314**	**0.0278**	**0.0486**	ft/ft	Riffle Slope/Average Water Surface Slope (S_{rif}/S)	**1.56**	**1.38**	**2.42**
Run Slope (S_{run})				ft/ft	Run Slope/Average Water Surface Slope (S_{run}/S)			
Pool Slope (S_p)	**0.0006**	**0.0000**	**0.0011**	ft/ft	Pool Slope/Average Water Surface Slope (S_p/S)	**0.03**	**0.00**	**0.05**
Glide Slope (S_g)				ft/ft	Glide Slope/Average Water Surface Slope (S_g/S)			

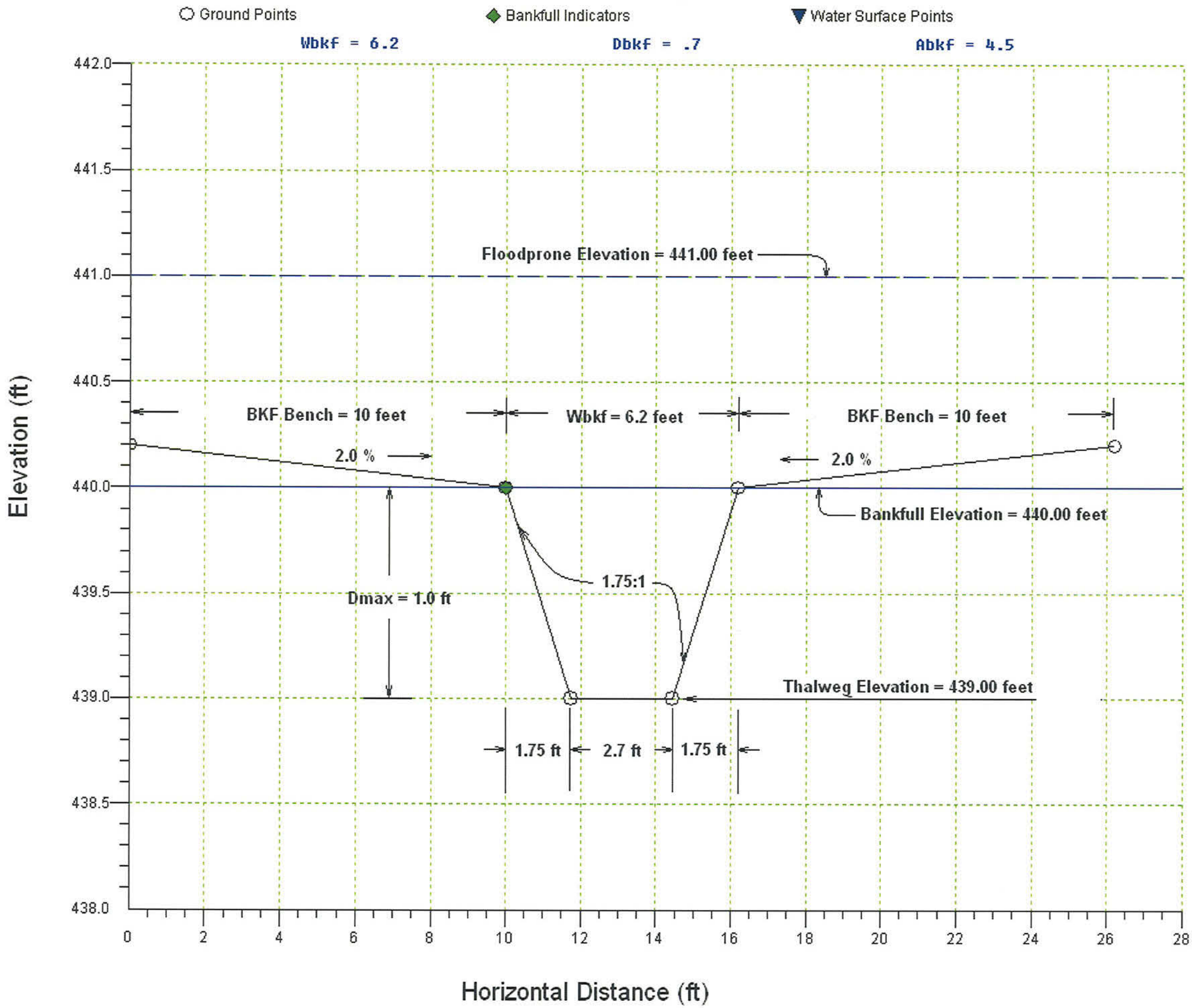
Feature Midpoint [a]	Mean	Min	Max		Dimensionless Depth Ratios	Mean	Min	Max
Riffle Depth (d_{rif})	**1.0**	**1.0**	**1.0**	ft	Riffle Depth/Mean Riffle Depth (d_{rif}/d_{bkf})	**1.39**	**1.39**	**1.39**
Run Depth (d_{run})				ft	Run Depth/Mean Riffle Depth (d_{run}/d_{bkf})			
Pool Depth (d_p)	**1.3**	**1.3**	**1.3**	ft	Pool Depth/Mean Riffle Depth (d_p/d_{bkf})	**1.81**	**1.81**	**1.81**
Glide Depth (d_g)				ft	Glide Depth/Mean Riffle Depth (d_g/d_{bkf})			

Channel Materials

	Reach[b]	Riffle[c]	Bar		Reach[b]	Riffle[c]	Bar	Protrusion Height[d]	
% Silt/Clay	**0**			D_{16}	**8.43**			0	mm
% Sand	**0**			D_{35}	**10.09**			0	mm
% Gravel	**100**			D_{50}	**11.43**			0	mm
% Cobble	**0**			D_{84}	**15.43**			0	mm
% Boulder	**0**			D_{95}	**20.54**			0	mm
% Bedrock	**0**			D_{100}	**32**			0	mm

a Min, max, mean depths are the average mid-point values except pools, which are taken at deepest part of pool.
b Composite sample of riffles and pools within the designated reach.
c Active bed of a riffle.
d Height of roughness feature above bed.

UT1 - Enhancement 2 Reach - Design Riffle Cross-Section



RIVERMORPH CROSS SECTION SUMMARY

River Name: Davis Branch
Reach Name: Davis Branch UT - Impaired
Cross Section Name: Design Riffle XS Template
Survey Date: 02/25/2008

Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0	0	440.2	
10		440	BKF
11.75		439	TW
14.45		439	
16.2		440	RB
26.2		440.2	

Cross Sectional Geometry

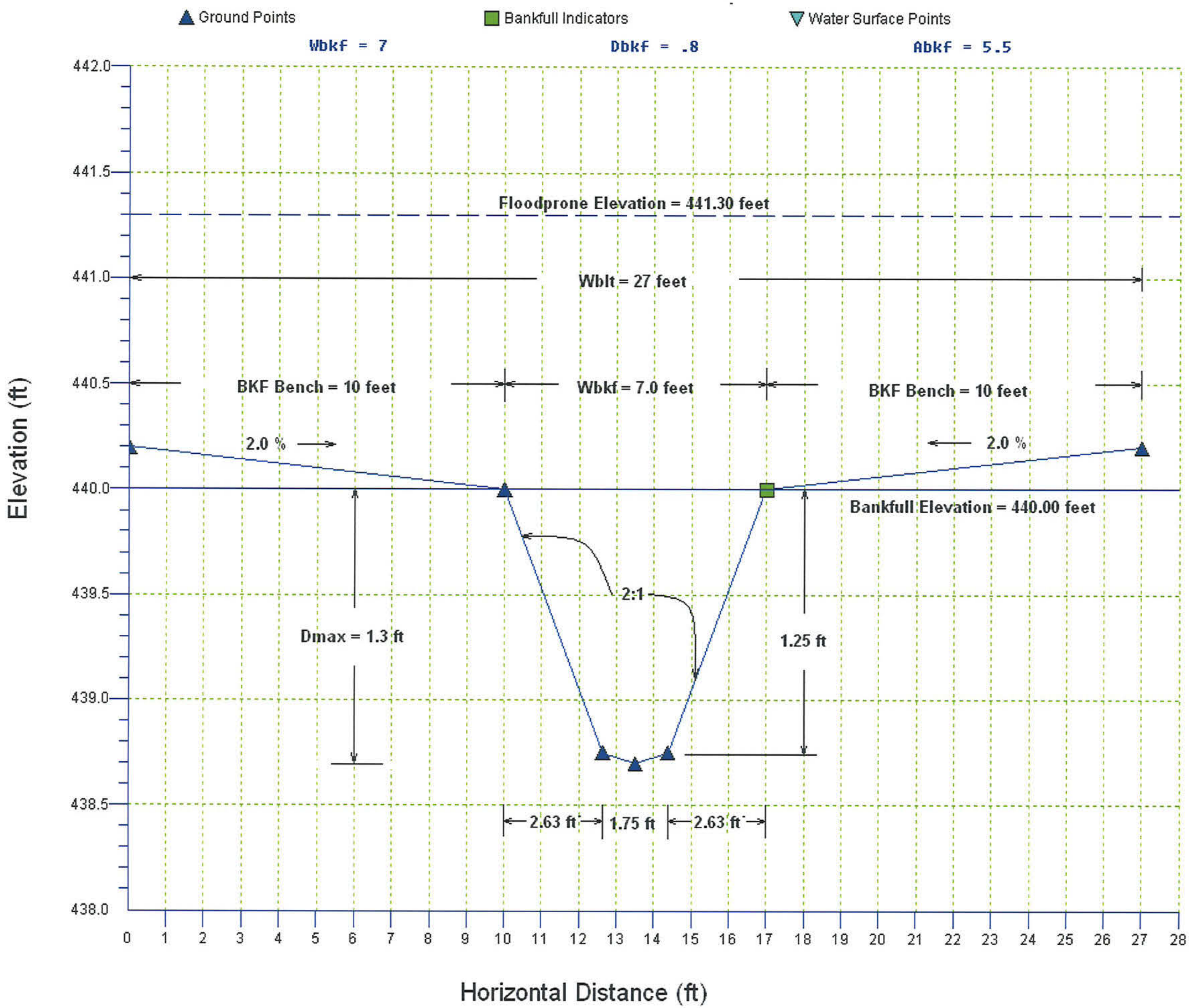
	Channel	Left	Right
Floodprone Elevation (ft)	441	441	441
Bankfull Elevation (ft)	440	440	440
Floodprone Width (ft)	26.2	-----	-----
Bankfull Width (ft)	6.2	3.1	3.1
Entrenchment Ratio	4.23	-----	-----
Mean Depth (ft)	0.72	0.72	0.72
Maximum Depth (ft)	1	1	1
Width/Depth Ratio	8.61	4.31	4.31
Bankfull Area (sq ft)	4.45	2.22	2.22
Wetted Perimeter (ft)	6.73	4.37	4.37
Hydraulic Radius (ft)	0.66	0.51	0.51
Begin BKF Station	10	10	13.1
End BKF Station	16.2	13.1	16.2

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.02297		
Shear Stress (lb/sq ft)	0.95		
Movable Particle (mm)	145.9		

UT1 - Enhancement 2 Reach - Design Pool Cross-Section



Design Pool XS Template.txt
RIVERMORPH CROSS SECTION SUMMARY

River Name: Davis Branch
Reach Name: Davis Branch UT - Impaired
Cross Section Name: Design Pool XS Template
Survey Date: 02/25/2008

Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0	0	440.2	
10		440	LB
12.63		438.75	
13.5		438.7	TW
14.38		438.75	
17		440	BKF
27		440.2	

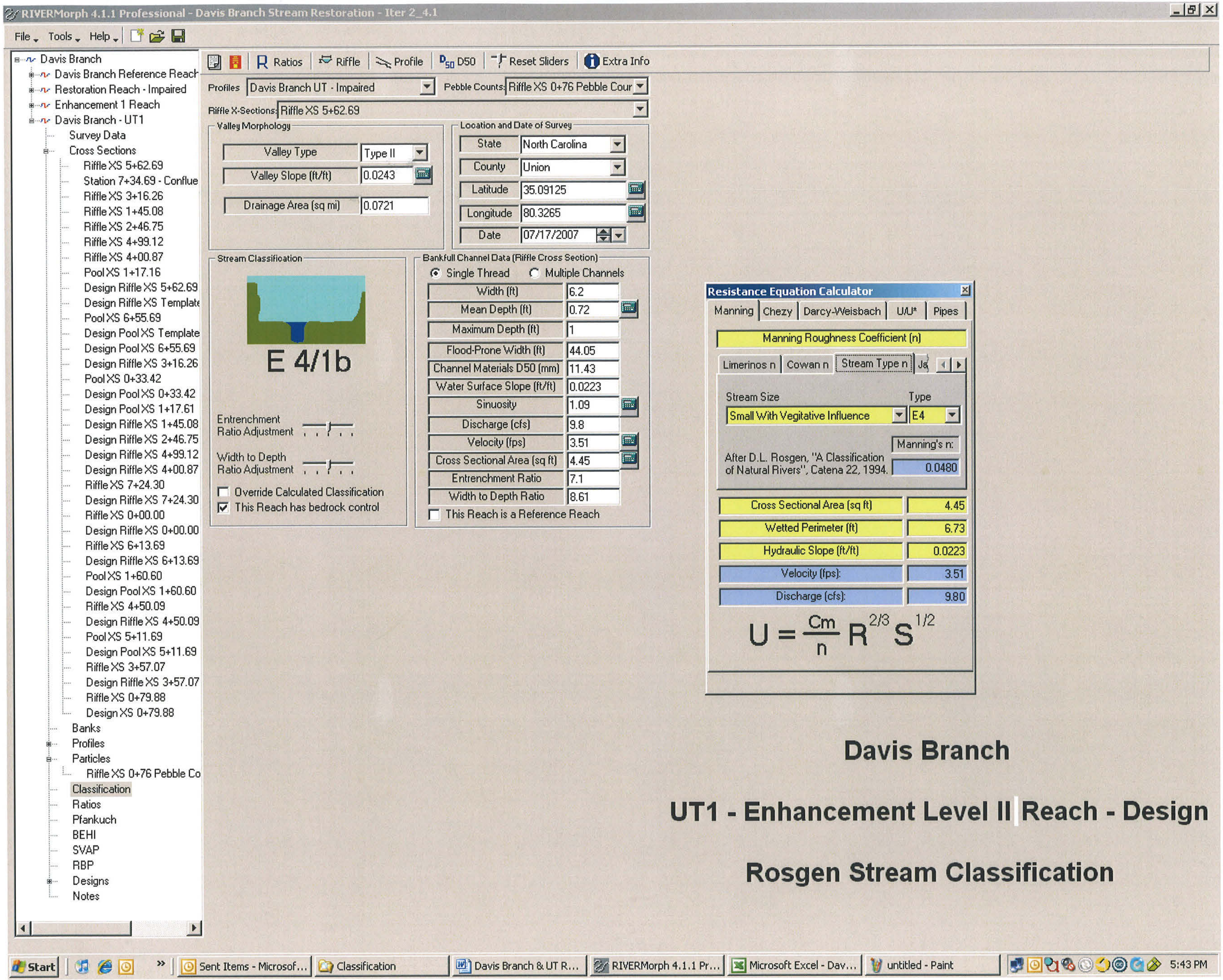
Cross Sectional Geometry

	Channel	Left	Right
Floodprone Elevation (ft)	441.3	441.3	441.3
Bankfull Elevation (ft)	440	440	440
Floodprone Width (ft)	27	-----	-----
Bankfull Width (ft)	7	2.5	4.5
Entrenchment Ratio	3.86	-----	-----
Mean Depth (ft)	0.79	0.59	0.89
Maximum Depth (ft)	1.3	1.19	1.3
Width/Depth Ratio	8.86	4.24	5.06
Bankfull Area (sq ft)	5.51	1.49	4.03
Wetted Perimeter (ft)	7.57	3.96	5.99
Hydraulic Radius (ft)	0.73	0.38	0.67
Begin BKF Station	10	10	12.5
End BKF Station	17	12.5	17

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

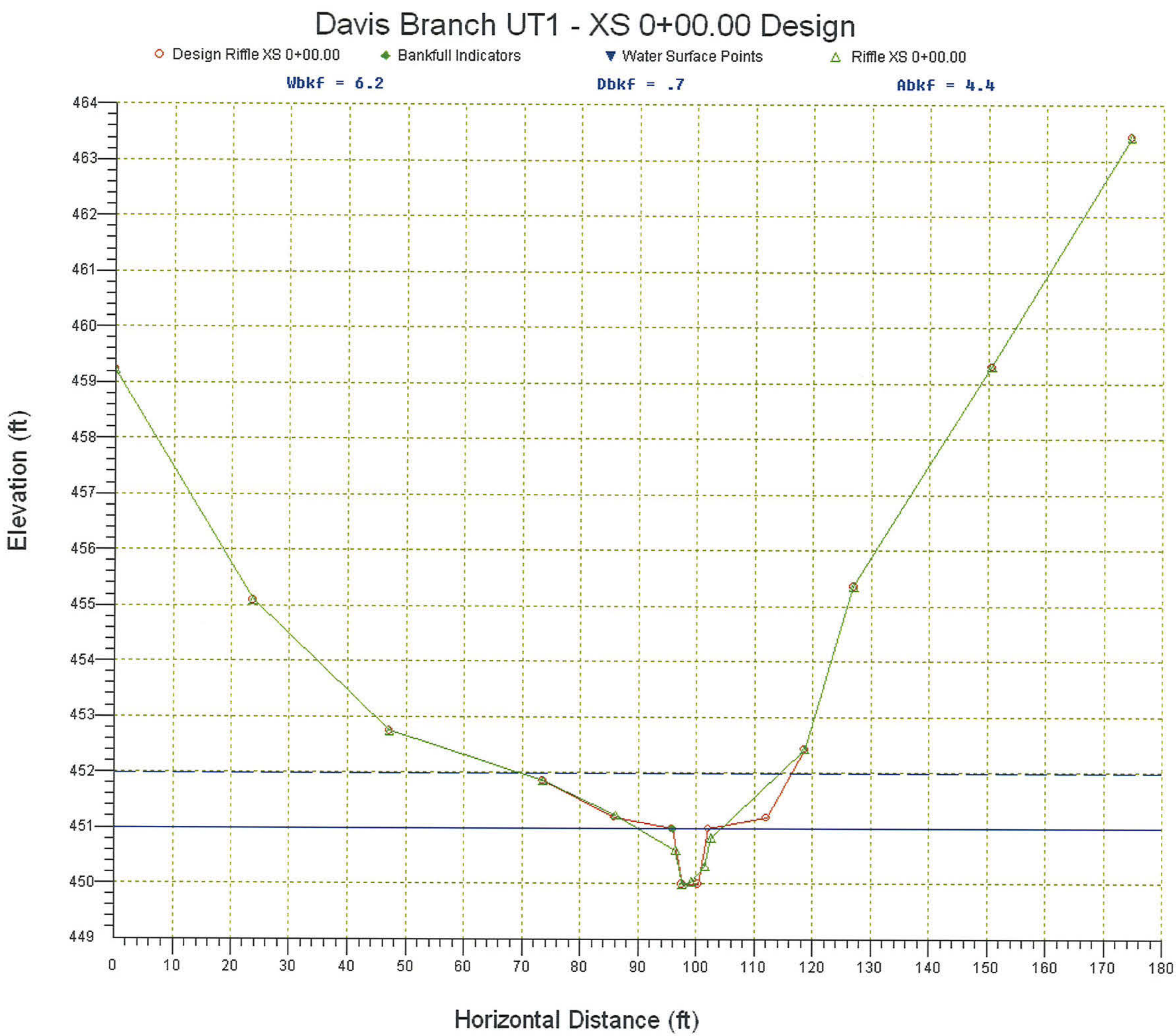
	Channel	Left Side	Right Side
Slope	0.02297		
Shear Stress (lb/sq ft)	1.05		
Movable Particle (mm)	157.2		

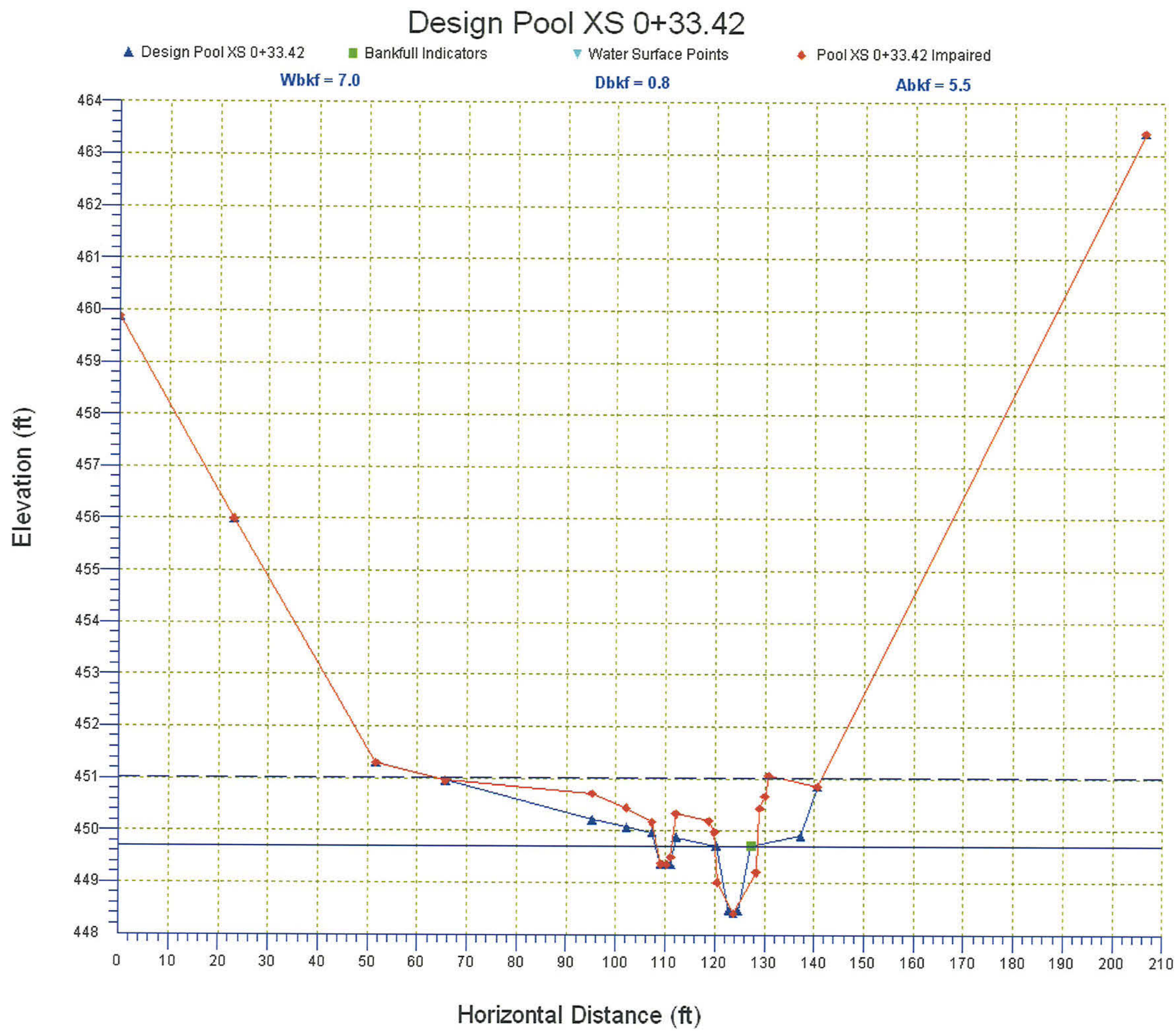


Davis Branch

UT1 - Enhancement Level II Reach - Design

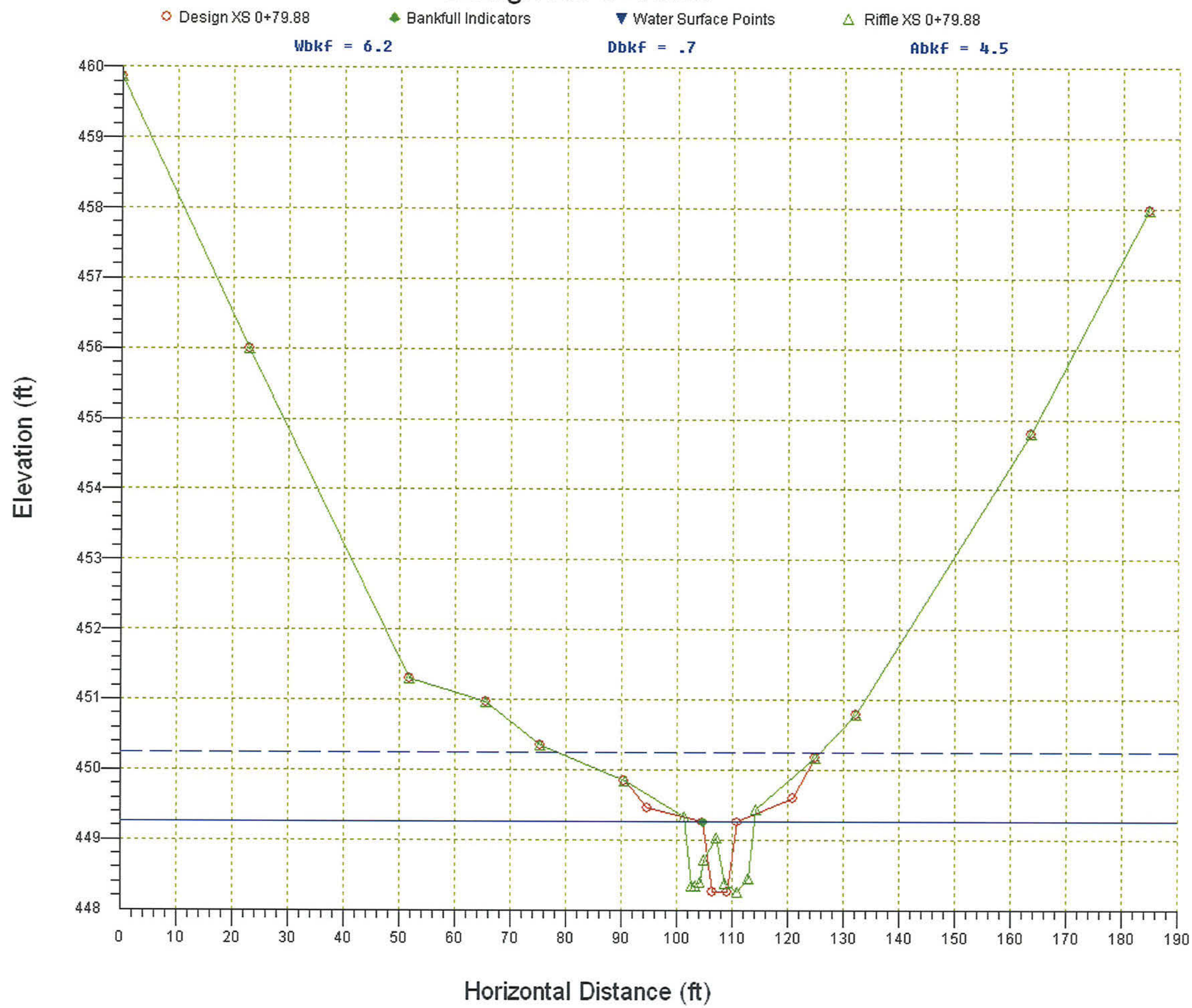
Rosgen Stream Classification

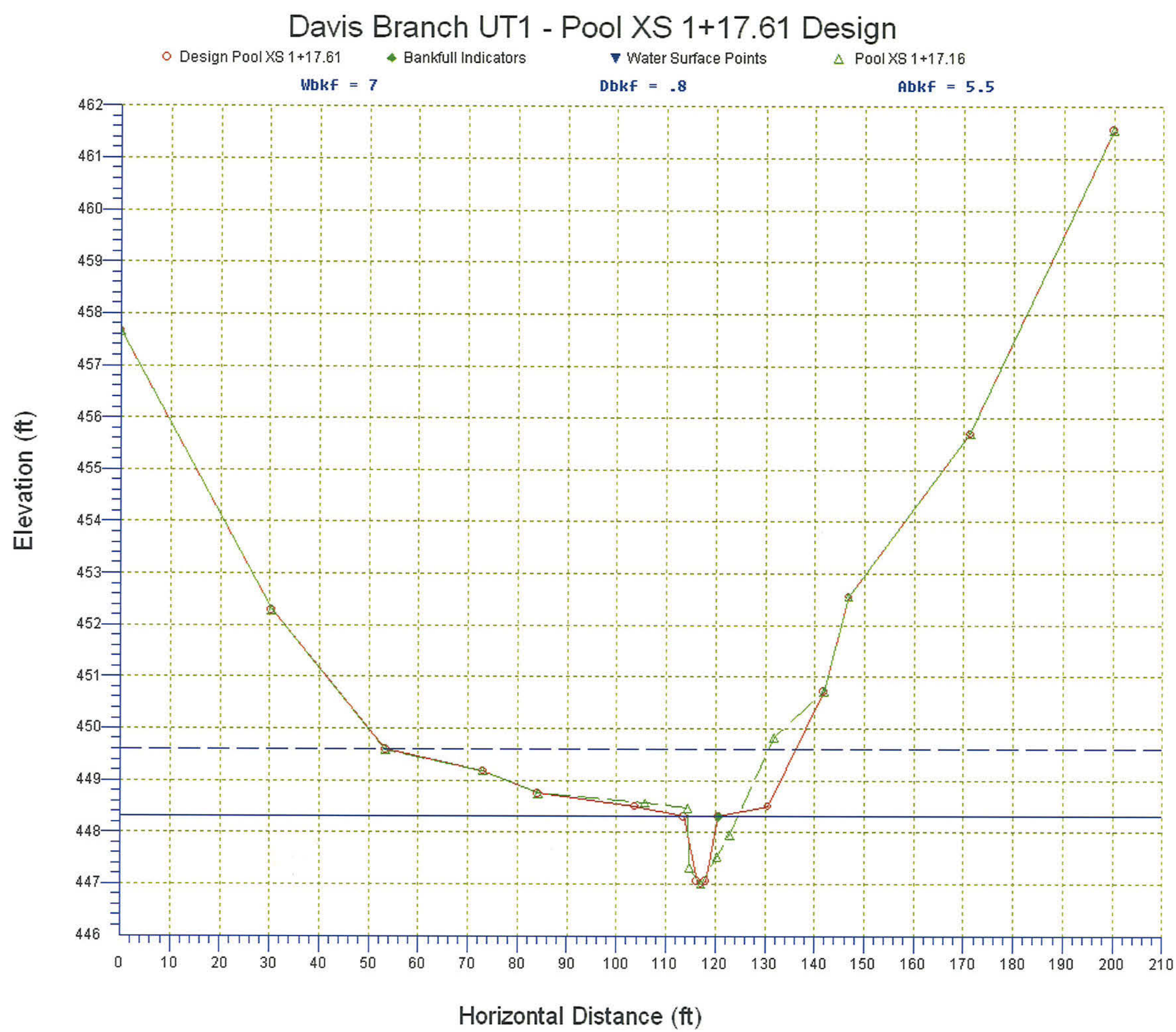

Davis Branch UT1 - XS 0+00.00 Design
Design Riffle XS 0+00.00
Bankfull Indicators
Water Surface Points
Riffle XS 0+00.00
Wbkf = 6.2
Dbkf = .7
Abkf = 4.4
Elevation (ft)
Horizontal Distance (ft)
464
463
462
461
460
459
458
457
456
455
454
453
452
451
450
449
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180

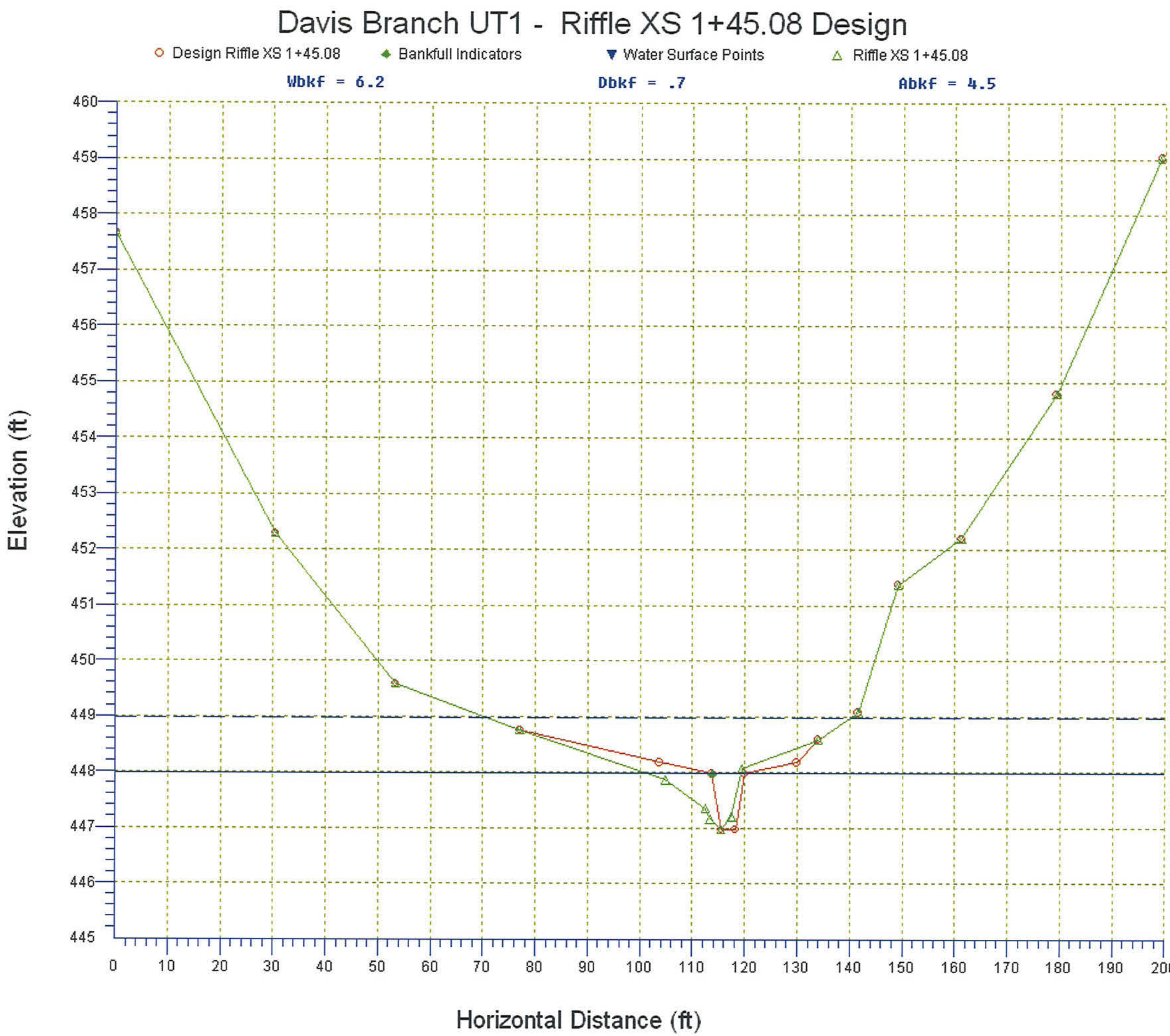


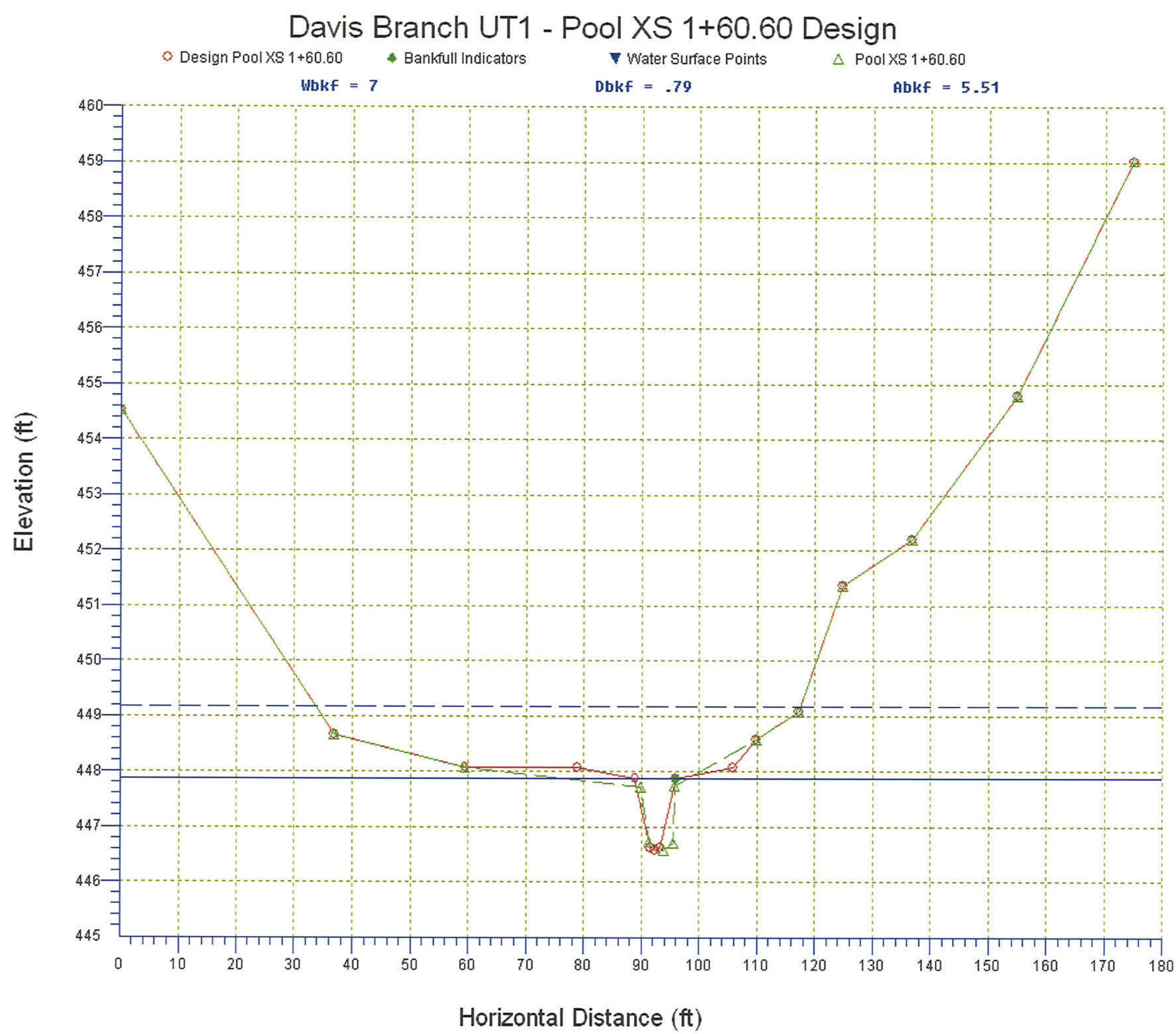
Design Pool XS 0+33.42
Design Pool XS 0+33.42
Bankfull Indicators
Water Surface Points
Pool XS 0+33.42 Impaired
Wbkf = 7.0
Dbkf = 0.8
Abkf = 5.5
Elevation (ft)
Horizontal Distance (ft)
464
463
462
461
460
459
458
457
456
455
454
453
452
451
450
449
448
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210

Design XS 0+79.88

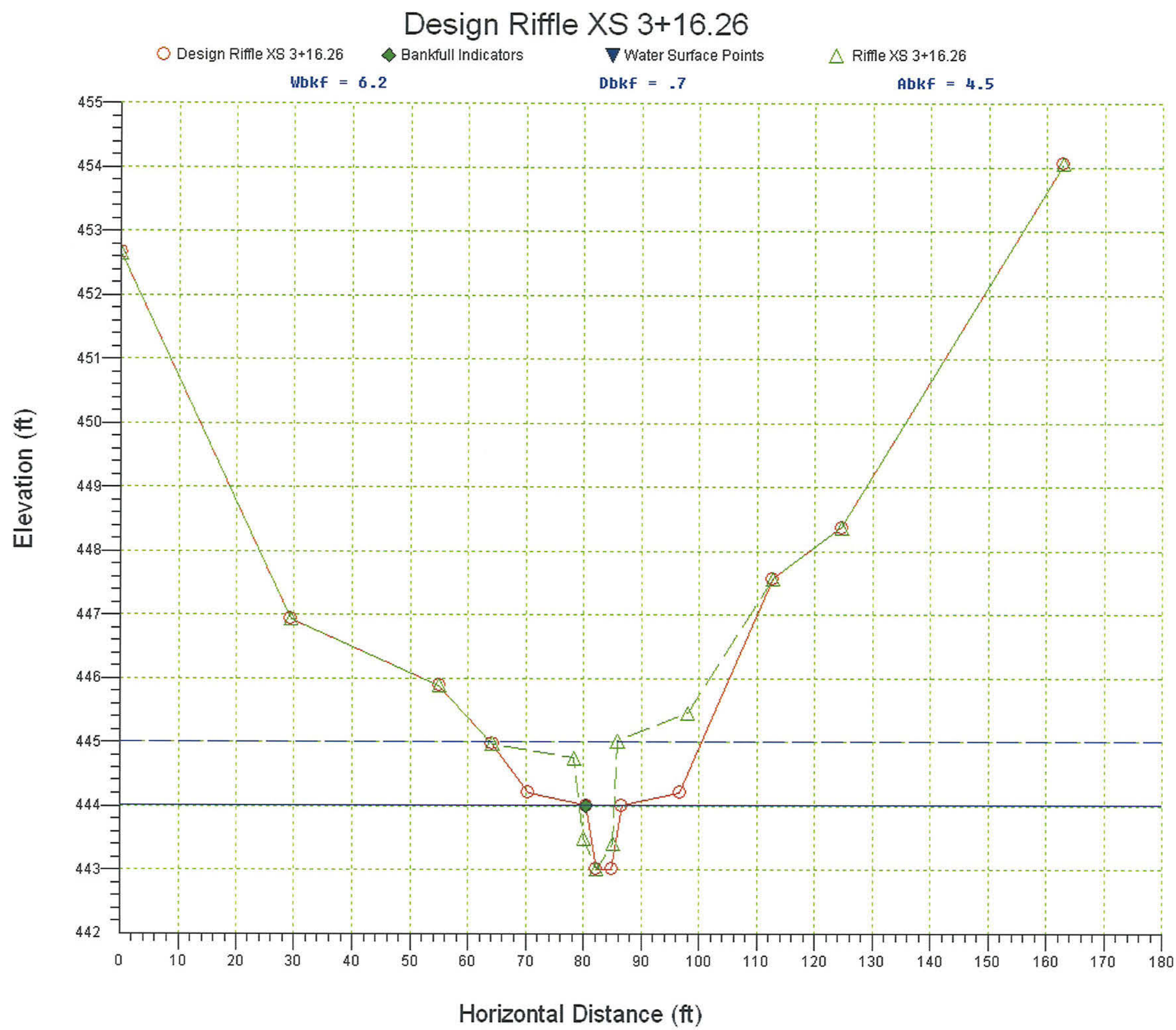


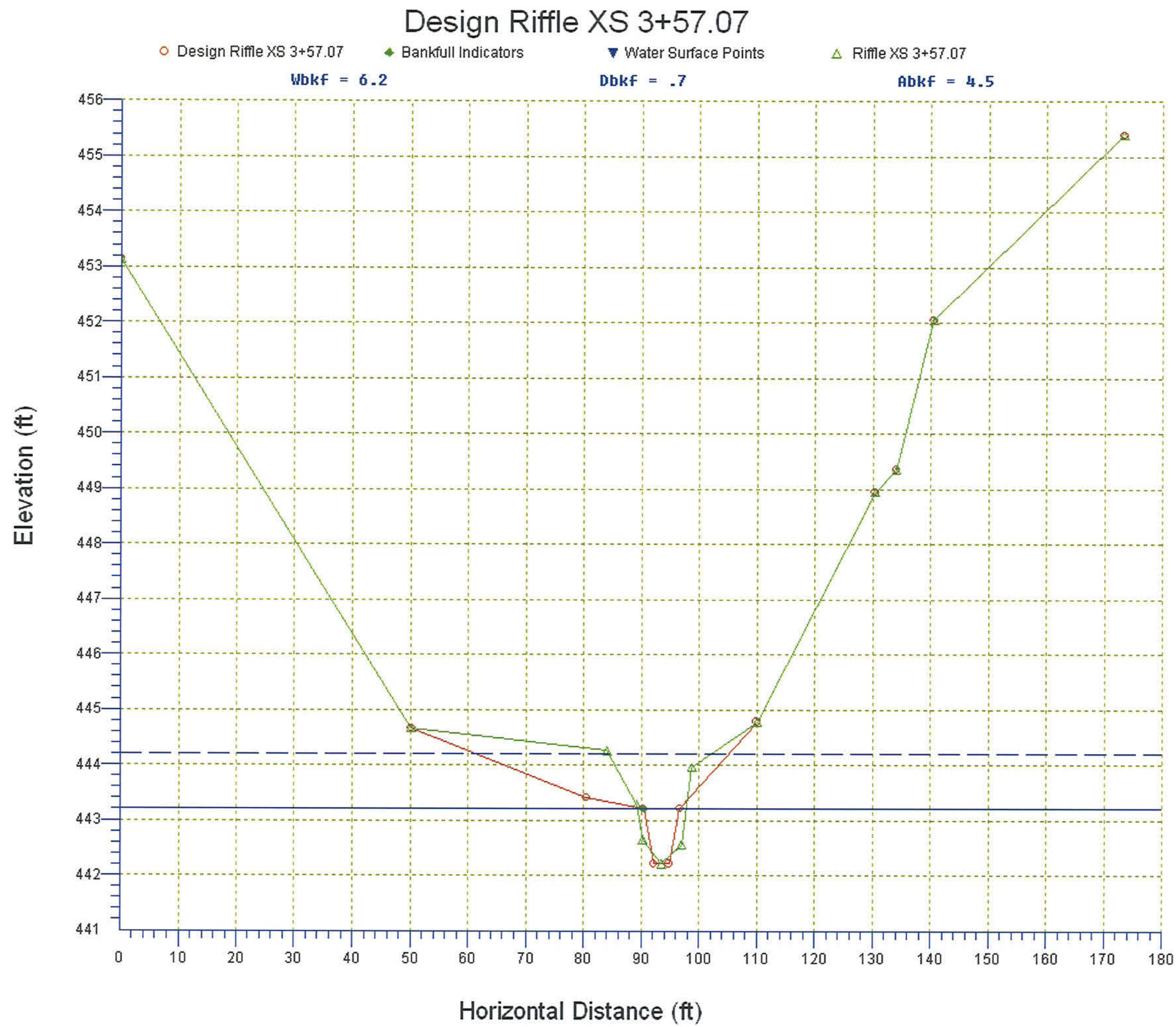

Davis Branch UT1 - Pool XS 1+17.61 Design
Design Pool XS 1+17.61
Bankfull Indicators
Water Surface Points
Pool XS 1+17.16
Wbkf = 7
Dbkf = .8
Abkf = 5.5
Elevation (ft)
Horizontal Distance (ft)
462
461
460
459
458
457
456
455
454
453
452
451
450
449
448
447
446
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210

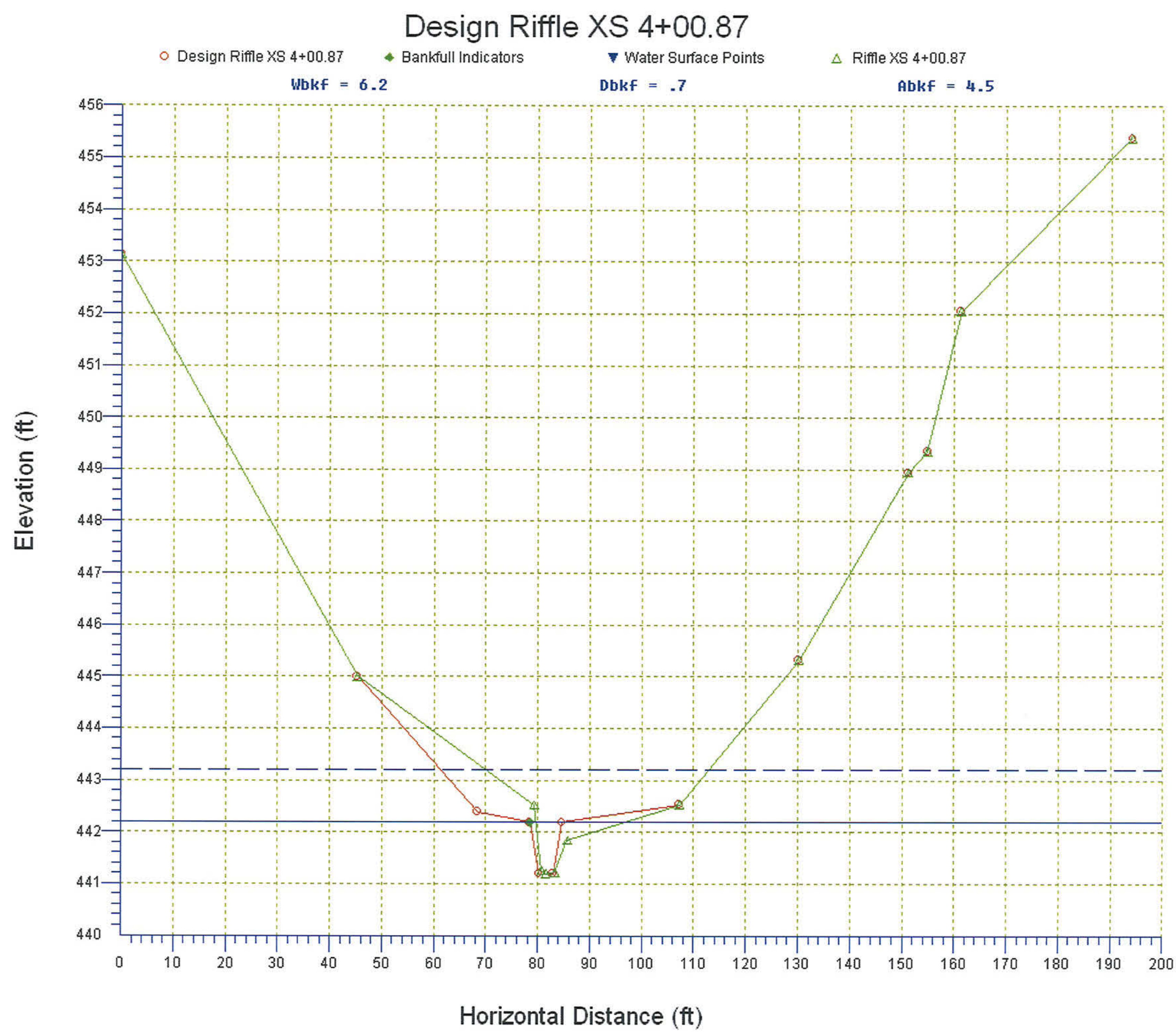

Davis Branch UT1 - Riffle XS 1+45.08 Design
Design Riffle XS 1+45.08
Bankfull Indicators
Water Surface Points
Riffle XS 1+45.08
Wbkf = 6.2
Dbkf = .7
Abkf = 4.5
Elevation (ft)
460
459
458
457
456
455
454
453
452
451
450
449
448
447
446
445
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
Horizontal Distance (ft)


Davis Branch UT1 - Pool XS 1+60.60 Design
Design Pool XS 1+60.60
Bankfull Indicators
Water Surface Points
Pool XS 1+60.60
Wbkf = 7
Dbkf = .79
Abkf = 5.51
Elevation (ft)
460
459
458
457
456
455
454
453
452
451
450
449
448
447
446
445
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
Horizontal Distance (ft)

Davis Branch UT1 - Riffle XS 2+46.75 Design
Design Riffle XS 2+46.75
Bankfull Indicators
Water Surface Points
Riffle XS 2+46.75
Wbkf = 6.2
Dbkf = .7
Abkf = 4.5
Elevation (ft)
Horizontal Distance (ft)
455
454
453
452
451
450
449
448
447
446
445
444
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160


Design Riffle XS 3+16.26
Design Riffle XS 3+16.26
Bankfull Indicators
Water Surface Points
Riffle XS 3+16.26
Wbkf = 6.2
Dbkf = .7
Abkf = 4.5
Elevation (ft)
455
454
453
452
451
450
449
448
447
446
445
444
443
442
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
Horizontal Distance (ft)


Design Riffle XS 3+57.07
Design Riffle XS 3+57.07
Bankfull Indicators
Water Surface Points
Riffle XS 3+57.07
Wbkf = 6.2
Dbkf = .7
Abkf = 4.5
Elevation (ft)
456
455
454
453
452
451
450
449
448
447
446
445
444
443
442
441
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
Horizontal Distance (ft)



Design Riffle XS 4+00.87
Design Riffle XS 4+00.87
Bankfull Indicators
Water Surface Points
Riffle XS 4+00.87
Wbkf = 6.2
Dbkf = .7
Abkf = 4.5
Elevation (ft)
456
455
454
453
452
451
450
449
448
447
446
445
444
443
442
441
440
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
Horizontal Distance (ft)

RIVERMORPH CROSS SECTION SUMMARY

River Name: Davis Branch
Reach Name: Davis Branch - UT1
Cross Section Name: Design Riffle XS 0+00.00
Survey Date: 02/28/2008

Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0		459.22	
23.72		455.09	
47.15		452.74	
73.58		451.85	
85.87		451.19	
95.87		450.99	BKF
97.62		449.99	TW
100.32		449.99	
102.07		450.99	RB
112.07		451.19	
118.61		452.42	
126.92		455.36	
150.49		459.3	
174.5		463.42	

Cross Sectional Geometry

	Channel	Left	Right
Floodprone Elevation (ft)	451.99	451.99	451.99
Bankfull Elevation (ft)	450.99	450.99	450.99
Floodprone Width (ft)	46.9	-----	-----
Bankfull Width (ft)	6.2	3.1	3.1
Entrenchment Ratio	7.56	-----	-----
Mean Depth (ft)	0.72	0.72	0.72
Maximum Depth (ft)	1	1	1
Width/Depth Ratio	8.61	4.31	4.31
Bankfull Area (sq ft)	4.45	2.22	2.22
Wetted Perimeter (ft)	6.73	4.37	4.37
Hydraulic Radius (ft)	0.66	0.51	0.51
Begin BKF Station	95.87	95.87	98.97
End BKF Station	102.07	98.97	102.07

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.02297		
Shear Stress (lb/sq ft)	0.95		
Movable Particle (mm)	145.9		

Design Pool XS 0+33.42.txt
RIVERMORPH CROSS SECTION SUMMARY

River Name: Davis Branch
Reach Name: Davis Branch UT - Impaired
Cross Section Name: Design Pool XS 0+33.42
Survey Date: 02/26/2008

Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0		459.87	
22.97		455.99	
51.68		451.3	
65.57		450.96	
95.21		450.21	
102.14		450.07	
107.33		449.97	
109.12		449.35	
111.05		449.35	
112.17		449.87	
120.25		449.71	LB
122.88		448.46	
123.75		448.41	TW
124.63		448.46	
127.25		449.71	BKF
137.25		449.91	
140.57		450.85	
206.15		463.42	

Cross Sectional Geometry

	Channel	Left	Right
Floodprone Elevation (ft)	451.01	451.01	451.01
Bankfull Elevation (ft)	449.71	449.71	449.71
Floodprone Width (ft)	77.88	-----	-----
Bankfull Width (ft)	7	3.5	3.5
Entrenchment Ratio	11.13	-----	-----
Mean Depth (ft)	0.79	0.79	0.79
Maximum Depth (ft)	1.3	1.3	1.3
Width/Depth Ratio	8.86	4.43	4.43
Bankfull Area (sq ft)	5.51	2.75	2.76
Wetted Perimeter (ft)	7.57	5.08	5.08
Hydraulic Radius (ft)	0.73	0.54	0.54
Begin BKF Station	120.25	120.25	123.75
End BKF Station	127.25	123.75	127.25

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.02297		
Shear Stress (lb/sq ft)	1.05		

Movable Particle (mm) 157.2

Design Riffle XS 0+79.88.txt
RIVERMORPH CROSS SECTION SUMMARY

River Name: Davis Branch
Reach Name: Davis Branch - UT1
Cross Section Name: Design Riffle XS 0+79.88
Survey Date: 03/10/2008

Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0	0	459.87	
22.97	0	455.99	
51.68	0	451.3	
65.57	0	450.96	
75.24	0	450.35	
90.53	0	449.84	
94.63	0	449.45	
104.63	0	449.25	BKF
106.38	0	448.25	TW
109.08	0	448.25	
110.83	0	449.25	RB
120.83	0	449.59	
124.8	0	450.18	
132.08	0	450.79	
163.45	0	454.8	
184.68	0	457.99	
184.68	0	457.99	

Cross Sectional Geometry

	Channel	Left	Right
Floodprone Elevation (ft)	450.25	450.25	450.25
Bankfull Elevation (ft)	449.25	449.25	449.25
Floodprone Width (ft)	47.4	-----	-----
Bankfull Width (ft)	6.2	3.1	3.1
Entrenchment Ratio	7.64	-----	-----
Mean Depth (ft)	0.72	0.72	0.72
Maximum Depth (ft)	1	1	1
Width/Depth Ratio	8.61	4.31	4.31
Bankfull Area (sq ft)	4.45	2.23	2.22
Wetted Perimeter (ft)	6.73	4.37	4.37
Hydraulic Radius (ft)	0.66	0.51	0.51
Begin BKF Station	104.63	104.63	107.73
End BKF Station	110.83	107.73	110.83

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.02297	0	0
Shear Stress (lb/sq ft)	0.95		
Movable Particle (mm)	145.9		

RIVERMORPH CROSS SECTION SUMMARY

River Name: Davis Branch
Reach Name: Davis Branch - UT1
Cross Section Name: Design Pool XS 1+17.61
Survey Date: 02/27/2008

Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0	0	457.66	
30.4	0	452.29	
53.33	0	449.59	
72.97	0	449.18	
84.16	0	448.75	
103.64	0	448.5	
113.64	0	448.3	LB
116.27	0	447.05	
117.14	0	447	TW
118.02	0	447.05	
120.64	0	448.3	BKF
130.64	0	448.5	
141.79	0	450.72	
146.82	0	452.56	
171.18	0	455.7	
199.99	0	461.55	

Cross Sectional Geometry

	Channel	Left	Right
Floodprone Elevation (ft)	449.6	449.6	449.6
Bankfull Elevation (ft)	448.3	448.3	448.3
Floodprone Width (ft)	82.92	-----	-----
Bankfull Width (ft)	7	3.5	3.5
Entrenchment Ratio	11.85	-----	-----
Mean Depth (ft)	0.79	0.79	0.79
Maximum Depth (ft)	1.3	1.3	1.3
Width/Depth Ratio	8.86	4.43	4.43
Bankfull Area (sq ft)	5.51	2.75	2.76
Wetted Perimeter (ft)	7.57	5.08	5.08
Hydraulic Radius (ft)	0.73	0.54	0.54
Begin BKF Station	113.64	113.64	117.14
End BKF Station	120.64	117.14	120.64

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.02297	0	0
Shear Stress (lb/sq ft)	1.05		
Movable Particle (mm)	157.2		

Design Riffle XS 1+45.02.txt
RIVERMORPH CROSS SECTION SUMMARY

River Name: Davis Branch
Reach Name: Davis Branch - UT1
Cross Section Name: Design Riffle XS 1+45.02
Survey Date: 02/27/2008

Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0		457.66	
30.4		452.29	
53.33		449.59	
77.03		448.75	
103.77		448.17	
113.77		447.97	BKF
115.52		446.97	TW
118.22		446.97	
119.97		447.97	RB
129.97		448.17	
133.99		448.58	
141.68		449.07	
149.19		451.37	
161.21		452.2	
179.27		454.8	
199.28		459.03	

Cross Sectional Geometry

	Channel	Left	Right
Floodprone Elevation (ft)	448.97	448.97	448.97
Bankfull Elevation (ft)	447.97	447.97	447.97
Floodprone Width (ft)	69.29	-----	-----
Bankfull Width (ft)	6.2	3.1	3.1
Entrenchment Ratio	11.18	-----	-----
Mean Depth (ft)	0.72	0.72	0.72
Maximum Depth (ft)	1	1	1
Width/Depth Ratio	8.61	4.31	4.31
Bankfull Area (sq ft)	4.45	2.23	2.22
Wetted Perimeter (ft)	6.73	4.37	4.37
Hydraulic Radius (ft)	0.66	0.51	0.51
Begin BKF Station	113.77	113.77	116.87
End BKF Station	119.97	116.87	119.97

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.02297		
Shear Stress (lb/sq ft)	0.95		
Movable Particle (mm)	145.9		

Design Pool XS 1+60.60.txt
RIVERMORPH CROSS SECTION SUMMARY

River Name: Davis Branch
Reach Name: Davis Branch - UT1
Cross Section Name: Design Pool XS 1+60.60
Survey Date: 02/29/2008

Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0	0	454.54	
36.8	0	448.67	
59.43	0	448.07	
78.93	0	448.07	
88.93	0	447.87	LB
91.56	0	446.62	
92.43	0	446.57	TW
93.31	0	446.62	
95.93	0	447.87	BKF
105.93	0	448.07	
109.82	0	448.58	
117.3	0	449.07	
124.81	0	451.37	
136.83	0	452.2	
154.89	0	454.8	
174.9	0	459.03	

Cross Sectional Geometry

	Channel	Left	Right
Floodprone Elevation (ft)	449.17	449.17	449.17
Bankfull Elevation (ft)	447.87	447.87	447.87
Floodprone Width (ft)	83.96	-----	-----
Bankfull Width (ft)	7	3.66	3.34
Entrenchment Ratio	11.99	-----	-----
Mean Depth (ft)	0.79	0.81	0.76
Maximum Depth (ft)	1.3	1.3	1.29
Width/Depth Ratio	8.86	4.52	4.39
Bankfull Area (sq ft)	5.51	2.96	2.55
Wetted Perimeter (ft)	7.57	5.23	4.91
Hydraulic Radius (ft)	0.73	0.57	0.52
Begin BKF Station	88.93	88.93	92.59
End BKF Station	95.93	92.59	95.93

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.02297	0	0
Shear Stress (lb/sq ft)	1.05		
Movable Particle (mm)	157.2		

RIVERMORPH CROSS SECTION SUMMARY

River Name: Davis Branch
Reach Name: Davis Branch - UT1
Cross Section Name: Design Riffle XS 2+46.75
Survey Date: 02/27/2008

Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0	0	453.83	
33.4	0	447.33	
63.76	0	446.38	
70.32	0	446.18	
80.32	0	445.98	BKF
82.07	0	444.98	TW
84.77	0	444.98	
86.52	0	445.98	RB
96.52	0	446.18	
106.45	0	447.39	
121.66	0	448.87	
158.37	0	453.97	

Cross Sectional Geometry

	Channel	Left	Right
Floodprone Elevation (ft)	446.98	446.98	446.98
Bankfull Elevation (ft)	445.98	445.98	445.98
Floodprone Width (ft)	58.5	-----	-----
Bankfull Width (ft)	6.2	3.1	3.1
Entrenchment Ratio	9.44	-----	-----
Mean Depth (ft)	0.72	0.72	0.72
Maximum Depth (ft)	1	1	1
Width/Depth Ratio	8.61	4.31	4.31
Bankfull Area (sq ft)	4.45	2.23	2.22
Wetted Perimeter (ft)	6.73	4.37	4.37
Hydraulic Radius (ft)	0.66	0.51	0.51
Begin BKF Station	80.32	80.32	83.42
End BKF Station	86.52	83.42	86.52

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.02297	0	0
Shear Stress (lb/sq ft)	0.95		
Movable Particle (mm)	145.9		

Design Riffle XS 3+16.26.txt
RIVERMORPH CROSS SECTION SUMMARY

River Name: Davis Branch
Reach Name: Davis Branch - UT1
Cross Section Name: Design Riffle XS 3+16.26
Survey Date: 02/26/2008

Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0	0	452.66	
29.39	0	446.93	
55	0	445.88	
64.16	0	444.97	
70.46	0	444.21	
80.46	0	444.01	BKF
82.21	0	443.01	TW
84.91	0	443.01	
86.66	0	444.01	RB
96.66	0	444.21	
112.77	0	447.57	
124.68	0	448.37	
162.82	0	454.06	

Cross Sectional Geometry

	Channel	Left	Right
Floodprone Elevation (ft)	445.01	445.01	445.01
Bankfull Elevation (ft)	444.01	444.01	444.01
Floodprone Width (ft)	36.74	-----	-----
Bankfull Width (ft)	6.2	3.1	3.1
Entrenchment Ratio	5.93	-----	-----
Mean Depth (ft)	0.72	0.72	0.72
Maximum Depth (ft)	1	1	1
Width/Depth Ratio	8.61	4.31	4.31
Bankfull Area (sq ft)	4.45	2.23	2.22
Wetted Perimeter (ft)	6.73	4.37	4.37
Hydraulic Radius (ft)	0.66	0.51	0.51
Begin BKF Station	80.46	80.46	83.56
End BKF Station	86.66	83.56	86.66

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0	0	0
Shear Stress (lb/sq ft)			
Movable Particle (mm)			

RIVERMORPH CROSS SECTION SUMMARY

River Name: Davis Branch
Reach Name: Davis Branch - UT1
Cross Section Name: Design Riffle XS 3+57.07
Survey Date: 03/10/2008

Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0	0	453.13	
50.2	0	444.66	
80.41	0	443.41	
90.41	0	443.21	BKF
92.16	0	442.21	TW
94.86	0	442.21	
96.61	0	443.21	RB
109.98	0	444.78	
130.45	0	448.95	
134.03	0	449.35	
140.48	0	452.05	
173.31	0	455.39	

Cross Sectional Geometry

	Channel	Left	Right
Floodprone Elevation (ft)	444.21	444.21	444.21
Bankfull Elevation (ft)	443.21	443.21	443.21
Floodprone Width (ft)	44.05	-----	-----
Bankfull Width (ft)	6.2	3.1	3.1
Entrenchment Ratio	7.1	-----	-----
Mean Depth (ft)	0.72	0.72	0.72
Maximum Depth (ft)	1	1	1
Width/Depth Ratio	8.61	4.31	4.31
Bankfull Area (sq ft)	4.45	2.23	2.22
Wetted Perimeter (ft)	6.73	4.37	4.37
Hydraulic Radius (ft)	0.66	0.51	0.51
Begin BKF Station	90.41	90.41	93.51
End BKF Station	96.61	93.51	96.61

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.02297	0	0
Shear Stress (lb/sq ft)	0.95		
Movable Particle (mm)	145.9		

RIVERMORPH CROSS SECTION SUMMARY

River Name: Davis Branch
Reach Name: Davis Branch - UT1
Cross Section Name: Design Riffle XS 4+00.87
Survey Date: 02/27/2008

Cross Section Data Entry

BM Elevation: 0 ft
Backsight Rod Reading: 0 ft

TAPE	FS	ELEV	NOTE
0	0	453.13	
45.31	0	445	
68.46	0	442.39	
78.46	0	442.19	BKF
80.21	0	441.19	TW
82.91	0	441.19	
84.66	0	442.19	RB
107.3	0	442.53	
130.14	0	445.32	
151.24	0	448.95	
154.82	0	449.35	
161.27	0	452.05	
194.1	0	455.39	

Cross Sectional Geometry

	Channel	Left	Right
Floodprone Elevation (ft)	443.19	443.19	443.19
Bankfull Elevation (ft)	442.19	442.19	442.19
Floodprone Width (ft)	51.34	-----	-----
Bankfull Width (ft)	6.2	3.1	3.1
Entrenchment Ratio	8.28	-----	-----
Mean Depth (ft)	0.72	0.72	0.72
Maximum Depth (ft)	1	1	1
Width/Depth Ratio	8.61	4.31	4.31
Bankfull Area (sq ft)	4.45	2.23	2.22
Wetted Perimeter (ft)	6.73	4.37	4.37
Hydraulic Radius (ft)	0.66	0.51	0.51
Begin BKF Station	78.46	78.46	81.56
End BKF Station	84.66	81.56	84.66

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.02297	0	0
Shear Stress (lb/sq ft)	0.95		
Movable Particle (mm)	145.9		

RIVERMORPH CROSS SECTION SUMMARY

River Name:	Davis Branch
Reach Name:	Davis Branch UT - Impaired
Cross Section Name:	Design Riffle XS Template
Survey Date:	02/25/2008

Cross Section Data Entry

BM Elevation:	0 ft
Backsight Rod Reading:	0 ft

TAPE	FS	ELEV	NOTE
0	0	440.2	
10		440	BKF
11.75		439	TW
14.45		439	
16.2		440	RB
26.2		440.2	

Cross Sectional Geometry

	Channel	Left	Right
Floodprone Elevation (ft)	441	441	441
Bankfull Elevation (ft)	440	440	440
Floodprone Width (ft)	26.2	-----	-----
Bankfull Width (ft)	6.2	3.1	3.1
Entrenchment Ratio	4.23	-----	-----
Mean Depth (ft)	0.72	0.72	0.72
Maximum Depth (ft)	1	1	1
Width/Depth Ratio	8.61	4.31	4.31
Bankfull Area (sq ft)	4.45	2.22	2.22
Wetted Perimeter (ft)	6.73	4.37	4.37
Hydraulic Radius (ft)	0.66	0.51	0.51
Begin BKF Station	10	10	13.1
End BKF Station	16.2	13.1	16.2

Entrainment Calculations

Entrainment Formula: Rosgen Modified Shields Curve

	Channel	Left Side	Right Side
Slope	0.02297		
Shear Stress (lb/sq ft)	0.95		
Movable Particle (mm)	145.9		