McKee Creek, Cabarrus County

Prepared for:

North Carolina Department of Environment and Natural Resources
Ecosystem Enhancement Program

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Restoration Plan

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Executive Summary

i. Project goals and objectives

The McKee Creek project is located in southwestern Cabarrus County near the Mecklenburg County line; the majority of the McKee Creek drainage basin is located in Mecklenburg County. The site lies in the Yadkin River Basin, within the Rocky River sub-basin (HUC8 – 03040105) and in the Reedy Creek local watershed (14-Digit HUC – 03040105010050). Approximately half of the Reedy Creek local watershed is located in eastern Mecklenburg County and the other half is in southwestern Cabarrus County. A Local Watershed Plan (LWP) has been developed for the Reedy Creek watershed; the plan is called *Watershed Management Plans & Recommendations – Lower Yadkin/ Upper Rocky River Basin Local Watershed Planning* (WMP&R – Lower Yadkin/ Upper Rocky River Basin LWP, 2004). The LWP describes the watershed as predominately rural in character, with the addition of the newly opened Interstate Route 485 beginning to foster development within the watershed. The Plan also states that the presence of several large tracts of land under single ownership makes the Reedy Creek local watershed a prime candidate for rapid residential and commercial development (WMP&R – Lower Yadkin/ Upper Rocky River Basin LWP, 2004). An assessment of the McKee Creek watershed while creating this restoration plan confirms that rapid development is underway along the Interstate 485 corridor.

The proposed project includes restoration work along two streams, McKee and Clear Creek. The majority of the project site consists of pasture land with a narrow forested buffer along portions of McKee Creek. Along the lower half of the project site livestock currently has unlimited access to McKee and Clear Creeks. The McKee Creek project was identified in the Lower Yadkin River Basin Local Watershed Plan. The functional improvement goals that were listed in the LWP for the project were to repair buffer disturbance, decrease/repair streambank erosion, prevent/limit livestock access, repair channel alteration, decrease turbidity, and remove/ control nutrients (WMP&R – Lower Yadkin/ Upper Rocky River Basin LWP, 2004). The proposed restoration plan for the McKee Creek project will achieve most of the LWP goals by fencing and removing livestock from the creeks, and establishing and protecting a vegetative buffer within a conservation easement. The goals pertaining to stabilization and erosion will be addressed by using in-stream structures and pattern re-alignment in selected areas along McKee Creek, and by restoring the dimension, pattern, and profile of Clear Creek.

The existing stream conditions within the project area are characterized by excess sedimentation, channel incision, bank degradation, and limited riparian buffer. Also, livestock have unlimited access to all of Clear Creek and a portion of the lower reach of McKee Creek, this has significantly contributed to the instability and poor water quality of the project reaches. The project design goals are to restore through stream enhancement (Level I and Level II) McKee Creek, and to restore Clear Creek (Priority I restoration). In order to achieve the design goals, the following objectives have been identified:

- Improve water quality by reducing bank erosion, restricting livestock access to the creeks, and re-establishing the riparian buffer;
- Stabilize McKee Creek through the use of in-stream structures and pattern re-alignment in selected areas;
- Restore the dimension, pattern, and profile of Clear Creek;
- Improve the floodplain functionality of Clear Creek by matching floodplain elevation with bankfull stage;

- Improve the wildlife habitat functions of the site through riparian buffer establishment, improved stream bedform diversity, and improved floodplain functionality.
- Protect the site through a permanent conservation easement along the project reaches.

In order to determine if the project design successfully achieves the objectives listed above, monitoring will be performed on the as-built condition for 5-years. The success of the design streams overall stability and functionality will be determined through cross-section and longitudinal surveys, pebble counts, and photo reference sites. Changes to the physical cross-section and/or longitudinal measurements will be evaluated to determine if they represent a movement toward a more unstable condition. The success of the buffer establishment objective will be measured through photo reference sites, plant survival plots, live stake counts, and tree counts.

ii. Existing amount of streams

McKee Creek has been divided into two reaches within the project site; McKee Creek – Reach 1 is upstream of Peach Orchard Road and McKee Creek – Reach 2 is downstream of the crossing. The existing stream lengths of McKee Creek – Reach 1 and Reach 2 are 3,733 linear feet (lf) and 847 lf, respectively. The third project reach is Clear Creek; it has an existing stream length of 1,513 lf. The total existing amount of stream within the project limits is 6,093 lf.

iii. Amount of streams designed

The proposed stream design will result in 1,641 lf of stream restoration on Clear Creek, and 1,096 lf of stream enhancement (Level I) and 3,240 lf of stream enhancement (Level II) on McKee Creek. The total proposed amount of streams designed is 5,977 lf.

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1.0 Project Site Identification and Location

1.1. Directions to Project Site

The project site is located approximately 3,000 feet southeast of the intersection of NCSR 1168 Robinson Church Road and NCSR 1169 Peach Orchard Road (Latitude: 35.2687˚N and Longitude: 80.6372˚W). Take US-64 West from the Raleigh area to Asheboro, and then take NC-49 approximately 54 miles south to Harrisburg. Once in Harrisburg, turn left off of NC-49 onto NCSR 1168 Robinson Church Road. Stay on Robinson Church for approximately 4 miles, and then turn left onto NCSR 1169 Peach Orchard Road. Peach Orchard Road intersects the project site.

The project site is currently used for agriculture; the majority of the floodplain consists of pasture and livestock grazing areas. The proposed easement area for the section of McKee Creek upstream of Peach Orchard Road has a narrow forested buffer with the remaining areas consisting mostly of pasture. The proposed easement area for the section of McKee Creek downstream of Peach Orchard Road and along Clear Creek maintains some forested areas, but the forested buffer in this area has been heavily disturbed by livestock intrusion. The total area for the proposed conservation easement is approximately 16.9 acres.

1.2. USGS Hydrologic Unit Code and NCDWQ River Basin Designations

The site lies in the Yadkin River Basin, within the North Carolina Division of Water Quality (NCDWQ) sub-basin 03-07-11 and United States Geologic Survey (USGS) hydrologic unit 03040105. The project is in the Reedy Creek local watershed (14-Digit HUC – 03040105010050).

1.3. Project Vicinity Map

Figure 1 in the appendix shows the project vicinity map. The project site is located in southwestern Cabarrus County near the Mecklenburg County line; it is approximately 8 miles northeast of downtown Charlotte.

2.0 Watershed Characterization

2.1. Drainage Area

The watershed boundaries and drainage area sizes for the three project reaches are shown on Figure 2 and Table 2. The McKee Creek drainage area at the downstream project limits is 6.6 mi^2, and the drainage area at the downstream limit of Clear Creek is 1.0 mi^2. The drainage basin areas were determined using Mecklenburg and Cabarrus County topography in GIS. The majority of the McKee Creek watershed extends into a developing area within Mecklenburg County; the Interstate 485 (I-485) corridor crosses the basin boundaries approximately 1 mile upstream of the project limits. The Clear Creek watershed drains a fairly rural section of Cabarrus County.

2.2. Surface Water Classification / Water Quality

The stream index number for Clear Creek is 13-17-8-4-1 and the water quality classification is "C". The stream index number for McKee Creek is 13-17-8-4 and the water quality classification is "C". According to the *Lower Yadkin River Basin Local Watershed Plan* (Lower Yadkin LWP – PFR, 2003 and WMP&R – Lower Yadkin LWP, 2004) both McKee Creek (from source to Reedy Creek) and Clear Creek (from source to McKee Creek) are 303(d) listed streams; McKee Creek for fecal coliform and sediment and Clear Creek for fecal coliform (NCDENR, 2004). According to NCDENR the potential sources of impairment for McKee Creek include minor non-municipal discharges, agriculture, land development, and urban runoff/ storm sewers, and for Clear Creek potential impairment sources include agriculture, land development, and urban runoff/ storm sewers (NCDENR, 2003b). It is stated in the LWP that DWQ studies of fecal coliform bacterial sources for McKee and Clear Creeks have indicated that livestock grazing is one of the contributing factors. There are two minor NPDES permitted discharges from private wastewater treatment plants that empty into McKee Creek that are located upstream of the project site. One of the discharges is located just upstream of the project limits.

2.3. Physiography. Geology and Soils

The physiographic region in which McKee and Clear Creeks are located is identified as the Piedmont; the southern outer piedmont ecoregion of the Piedmont. This region stretches from the base of the Blue Ridge east to the fall line and is characterized by soils which range from gravelly loams to clay. The underlying geology includes metamorphosed Mafic rock and metamorphosed Quartz Diorite; soil depth to bedrock can range from 5 to more than 15 feet.

The project site is located at approximately 605 feet above sea level and within the Mixed Felsic and Mafic Soil Systems. The soil series is Chewacla, a sandy loam that is somewhat poorly drained and found in floodplains (0-2% slope) throughout the Piedmont, encompasses both the McKee and Clear Creek project areas. Outside of the growing season, November through April, the water table in these piedmont floodplains can be within 0.5 feet of the surface depending upon rainfall. The average annual rainfall for Cabarrus County is 47.3 inches.

2.4. Historical Land Use and Development Trends

The land use and current impervious cover estimates for both the McKee and Clear Creek watersheds was determined using Mecklenburg and Cabarrus County GIS data, as well as available digital aerial photos. The historical land use information was determined from historical aerial photographs for Cabarrus County. The more recent land use trend information pertaining to urbanization was obtained from the *Lower Yadkin Local Watershed Plan (LWP) – Preliminary Findings Report* (Lower Yadkin LWP – PFR, 2003).

The historic land use within the project watersheds and within the project boundary is very consistent with a typical piedmont rural farm landscape. Dating back to 1938, and likely before this year due to the well defined established field boundaries, the historical land use adjacent to the project has consisted of pasture/hay fields (perennial grasses) and forested areas. The upland land use, determined by the soil type, has typically been dominated by pasture/hay fields, and the lower lying land (floodplain) has been dominated by a forested cover type. However, during review of the 1938 and 1956 aerial photographs, several fields directly adjacent to McKee Creek were cultivated. The photographs post 1956 and actual field reconnaissance indicate that cultivating farming practices seized and the fields were converted to either pasture or hay fields.

Generally, streams that are located within the historic land use areas described for the watershed and project site have been heavily impacted by channelization practices or livestock intrusion. Straightening, channelization, and/or channel relocation to the streams is very common in these areas because the historic landowners attempted to maximize the use of their lands for pasture, hay fields, and/or cultivation. This was usually done by relocating the stream channel to the unnatural valley edge, and using channelization practices in order to reduce the frequency in which storm events accessed the floodplain.

As previously stated above, the majority of the McKee Creek watershed is located in a developing region of Mecklenburg County. Tables 3 outlines a breakdown of the McKee Creek drainage basin's land use. Over half of the drainage area has already been developed; the majority of the development is single-family residential (52% of total drainage area). Approximately 42% consists of woods and pasture land that has not yet been developed. A large portion of the undeveloped land is adjacent to the I-485 corridor, and is mostly made up of large parcels of land. Due to this, it is highly likely that the woods and pasture lands will be developed in the near future. A large portion of the development in the watershed has occurred within the last 5 to 8 years. The *Lower Yadkin – LWP*, which included data mostly collected from the years 2000 to 2002, estimated the impervious cover to be 3.7% and for forested and agricultural lands to comprise 93% of the watershed (Lower Yadkin LWP – PFR, 2003). A current assessment of the land use estimates that the impervious cover is 10% to 12% and that woods and pasture now make up approximately 42% of the McKee Creek basin. This trend of development within the watershed is consistent with the *Lower Yadkin – LWP*, which projected population growth from 2000 to 2010 to be 19.8% and 15.5% within the Mecklenburg and Cabarrus County portions of the basin, respectively (Lower Yadkin LWP – PFR, 2003).

The Clear Creek watershed has some development, but is still mostly rural (83% woods and pasture land). A single-family residential development is currently under construction in the upper reaches of the watershed. The project reach has been exposed to higher than normal levels of fine sediments from the upstream reaches due to poor erosion control practices. Local and County officials are aware of the erosion control issues and have implemented closer monitoring and enforcement. Development trends within southwestern Cabarrus County indicate that the woods and pasture lands within the Clear Creek drainage basin will eventually be replaced with single-family residential subdivisions (probably within the next 10 to 15 years).

The projected future development, which will eventually change the watershed character from rural to more urban, could threaten the sustained stability of the proposed designs. However, it is anticipated that the project designs will maintain stability through the use of grade control, bank protection, and most importantly an established vegetative buffer. Also, the implementation of stormwater ordinances by Mecklenburg and Cabarrus Counties, and the Town of Harrisburg, which require the attenuation of runoff at each proposed development, should limit the increases in the peak discharges that are experienced by the design channels. The impacts that current and future development may have on stream stability and the bankfull discharge is further discussed in *Section 3.5 – Bankfull Verification.*

2.5. Endangered / Threatened Species

Scientific Name	Common Name	Status
Helianthus schweinitzii	Schweinitz's Sunflower	Endangered
Lasmigona decorata	Carolina Heelsplitter	Endangered

Schweinitz's Sunflower (*Helianthus schweinitzii*) - Federally Endangered**.**

The Schweinitz's sunflower is a perennial herb that often reaches the height of 3 to 6 feet. This herb usually forms a solitary stem in which branching occurs at or near mid-stem. Lanceolate pubescent leaves develop in an alternate pattern near the lower portion of the stem and an opposite pattern closer to the flower. These leaves usually have an entire leaf margin with the occasion serration and are approximately 5 times longer than they are wide. The flowering period occurs during late August and into early September were petals 0.75 to 1.25 inches long form around the small seed head. Preferred habitat of the Schweinitz's sunflower consists of areas that are maintained by fire or some other kind of disturbance. Habitat in which the Schweinitz's sunflower would be found today consists of old pastures, utility easements, and roadsides. The preferred soil type is a shallow clay soil produced from the parent material derived from mafic rocks (USFWS 1994).

No populations of Schweinitz's sunflower have been documented in the project area (NCNHP records).

Carolina Heelsplitter (*Lasmigona decorata*) - Federally Endangered.

Carolina Heelsplitter is a fresh water mussel (bivalve) that, as an adult can be 4.6 inches in length, 1.56 inches in width, and 2.7 inches high. The outer shell is usually a dark brown to a greenish brown. The inside portion of the shell in younger mussels is a white to a bluish white. Mature mussels have an orange tint to the inner shell. The desired habitat consists of mud, muddy sand, and muddy gravel near the banks of a stable well shaded stream.

No populations of the Carolina Heelsplitter have been documented in the project area (NCNHP records). Although a population was observed within one mile of the site, it was last observed prior to 1870, and is listed as extirpated in the NHP database.

In conclusion;

No suitable habitat or soils were observed that could potentially support populations of Schweinitz's sunflower, therefore, we believe that this project will have 'no affect' on populations of Schweinitz's sunflower.

Although a perennial stream is present in the project corridor, due to the fact that the stream has been degraded and the fact that the stream lacks a vegetated riparian corridor, it is unlikely that the Carolina Heelsplitter is present. Moreover, the occurrence reported by the NCNHP office is located in a tributary downstream of our project and listed as historic. The Heelsplitter has not been observed since 1870 and is listed as extirpated on the NHP database. Therefore, we believe that the restoration of McKee Creek and Clear Creek will have 'no affect' on populations of the Carolina Heelsplitter.

2.6. Cultural Resources

The project team utilized the resources provided by the North Carolina State Historic Preservation Office (NCSHPO) to research and identify any historic structures potentially located within the McKee Creek restoration project boundaries. The team also reviewed maps provided by the North Carolina Office of State Archaeology (NCOSA) to research and identify the presence, absence, or potential for any archaeological sites within or adjacent to the proposed restoration project. Additionally, the property owner was interviewed regarding any known structures existing in the vicinity of the restoration corridor. Visual investigations were conducted in the field to verify researched information.

No archaeological sites of interest requiring field evaluation were identified by NCSHPO or NCOSA during the records search for this project. Additionally, the determination of no historic architecture within the project boundary was confirmed visually during the existing conditions mapping. A letter dated August 9, 2007, was sent to the State Historic Preservation Office and the State Office of Archaeology requesting concurrence with our determination of no impact by the proposed restoration project on structures or sites listed on or potentially eligible for the Federal Register. We have recently received correspondence from the State Historic Preservation Office stating that they have 'no comment' on the project as proposed.

2.7. Potential Constraints

2.7.1. Property Ownership and Boundary

The project parcel that will be impacted is the A. Eugene Divine property located along NCSR 1169 Peach Orchard Road. The parcel is owned in fee simple by A. Eugene Divine as recorded in deed book 819, page 182 and contains 180 acres more or less. All sections of McKee Creek and Clear Creek that will be restored or enhanced fall completely within the Divine property boundary line. The downstream project limits for the designs on McKee and Clear Creeks will be at the property boundary between the A. Eugene Divine and Giant Peach, LLC properties. Since a portion of the shared property boundary falls within the confines of McKee Creek, it will be necessary to stake the property line during construction in order to minimize impact to the Giant Peach, LLC property.

2.7.2. Site Access

Two gated access points exist along NCSR 1169 Peach Orchard Road and provide limited entry to the project site. These entry points should be sufficient for construction and monitoring purposes with slight modification and reinforcement. A third access point along the road is the shared driveway for the Divine home. This is the sole entry point to the upstream section of McKee Creek from the project start point to the intersection with NCSR 1169. This entry point is sufficient for design and monitoring access purposes, but it cannot be used for construction. A replacement entry point will be planned in the project design to facilitate access to the upper reach of McKee Creek.

2.7.3. Utilities

The following utilities and easements were found to exist on or near the A. Eugene Divine parcel located along NCSR 1169 Peach Orchard Road. Several properties bordering Peach Orchard Road refer to a right-of-way claimed by the North Carolina Department of Transportation within their deed description. No deed dedicating this right-of-way has been found during record searches for the project. The lack of a deed does not preclude the existence of a right-of-way. Therefore, we may at this time safely infer from the limited evidence that NCDOT has only claimed a maintenance right-of-way for NCSR 1169 Peach Orchard Road. This right-of-way would encompass an area sufficient for maintaining the road and the bridge located at the intersection between McKee Creek and NCSR 1169. A maintenance right-of-way typically extends from back of ditch to back of ditch along the alignment of the roadway and usually does not exceed a 60 foot width. The maintenance right-of-way should not be affected by the project as all restoration activities are planned to be outside this area to mitigate any adverse effects to the roadway and bridge. The conservation easement will be created to have no overlap with the NCDOT right-of-way to ensure no future easement conflicts.

A twenty foot utility easement was granted to Public Service Company of North Carolina, INC. in deed book 670, page 306 for the purpose of laying, constructing, and maintaining a natural gas pipeline. The easement is aligned and centered on the pipeline as constructed. The easement is located within the maintenance right of way for NCSR 1169 and should not be affected by the project.

2.7.4. FEMA / Hydrologic Trespass

Hydraulic modeling with HEC-RAS has confirmed that hydraulic trespass will not be an issue on the McKee Creek Project. Hydraulic trespass was considered during the design of all the project stream reaches; the designs were altered in order to avoid trespass issues.

The section of McKee Creek within the project limits is located in a FEMA detailed floodplain. Stream enhancement (Level I) is proposed on sections of the project reach of McKee Creek. Some of the existing sections along McKee Creek project reaches have experienced channel deposition since the cross-sections were surveyed for the original FEMA flood model. Since our proposed design will remove some of the deposited sediment, the proposed 100-year water surface elevation is less than the corrected effective/ existing condition 100-year water surface elevation (decrease greater than 0.1 ft). As a result, it is anticipated that a FEMA Letter of Map Revision (LOMR) will be required at the conclusion of the project's construction; the LOMR will be submitted by the NC EEP. The local floodplain administrator for Cabarrus County was contacted (Mike Byrd). Mr. Byrd stated that what he required for us to show compliance was verification that our design would not cause hydraulic trespass issues to the adjacent properties (comparing proposed condition to the existing condition). The proposed design condition meets Mr. Byrd's standards for compliance. However, the NC EEP is mandated by the State of North Carolina to comply with the FEMA rules and regulations which currently state that if the proposed condition causes more than a 0.1 ft decrease when compared to the corrected effective/existing condition then a LOMR is required.

3.0 <u>Project Site Streams (existing conditions)</u>

The following report sections summarize the existing conditions of the project reaches. The project streams were divided into three different reaches; McKee Creek – Reach 1, McKee Creek – Reach 2, and Clear Creek. The McKee Creek reaches are separated by the bridge crossing at Peach Orchard Rd. Detailed maps of the existing site conditions are outlined on Sheets A through G within Section 11 of this report; Sheet A shows the location of the three project reaches. All stationing referenced in this section corresponds with the existing alignments shown on the existing site conditions sheets. McKee Creek and Clear Creek are identified as 3rd order streams by the Strahler Stream Order methodology (Lanfear, 1990). USGS Quadrangles were used in identifying the streams within the McKee and Clear Creek's upper watersheds.

3.1. Channel Classification

The existing project streams have been impacted by outside forces such as livestock, urbanization, and stabilization practices. Livestock on the property has unlimited access to all of Clear Creek and the majority of McKee Creek – Reach 2. The livestock traffic within the two reaches introduced excessive amounts of sediment into the streams, and caused the collapse and destabilization of many of the stream banks. It appeared in some areas within the project reaches, particularly in Clear Creek, that attempts were made to stabilize sections using rip rap or relocated stream bed cobble and stone. The introduction of excess sediment from upstream development within the drainage basins for both McKee and Clear Creeks influenced the existing streambed material as well.

McKee Creek – Reach 1 classifies as an E4 stream type in the Rosgen system. McKee Creek – Reach 1 is slightly entrenched, with high width/depth ratios, high sinuosity, and a gravel/cobble bed material. McKee Creek – Reach 1 is in a more stable condition than the other two project reaches mainly because its banks are not accessed by livestock, and it has more of an established and undisturbed vegetated buffer. A modified Wolman reach-wide pebble count (Rosgen, 1994) was performed on McKee Creek – Reach 1 in order to determine the streambed classification.

McKee Creek – Reach 2 classifies as an E4 stream type in the Rosgen system. McKee Creek – Reach 2 is slightly entrenched, with low width/depth ratios, very high sinuosity, and a gravel/cobble bed material. Due to the amount of sediment introduced to the project reach by livestock access and adjacent development practices, the majority of the sediment material on the streambed was coarse grained sand. Since there was so much fine sediment within the project reach, a reach-wide pebble count was not performed. There was evidence below the layer of finer sediments of some gravel and cobble; it is assumed that under normal/natural conditions that the reach will have a relatively similar streambed as McKee Creek – Reach 1, hence the gravel/cobble streambed classification.

Clear Creek classifies as an E/C5 stream type in the Rosgen system. Clear Creek is slightly entrenched, with low to high width/depth ratios, low sinuosity, and a very coarse sand bed material. Due the excessive degradation caused by livestock access, the reach dimensions varied which resulted in a range of width/depth ratios from 5.8 to 12.8. Therefore the project reach could be classified as either a Rosgen E or C stream type; more than likely without the livestock influences the stream would classify as an E stream type. Due to the excessive amount of fine sediment within Clear Creek, a reach-wide pebble count was not performed. A section of Clear Creek upstream of the project site had a streambed that consisted of fine to very fine gravel; although the upstream section was not stable, the streambed was in a more natural condition due to the absence of livestock intrusion. There was also evidence below the layer of finer sediments of some fine gravel within the project reach of Clear Creek. As a result, it is assumed that under undisturbed conditions that the Clear Creek design reach will have a fine to very fine gravel streambed.

3.2. Discharge (bankfull, trends)

Although the project reaches have started to become impacted by some urbanization, the overall impervious cover within the project watersheds is still relatively low. Some residential development is underway upstream of the Clear Creek project reach (only about 10% of the drainage area), but the watershed as a whole is very rural. Urbanization is underway in the McKee Creek watershed, particularly in the Mecklenburg County portions. However, the overall impervious cover within the watershed is estimated between 10% and 12%. Physical habitat degradation is generally considered to begin when the impervious cover within a drainage basin starts to increase above the 10% threshold (CWP, 2003). The field bankfull indicators and the HEC-RAS model confirm that McKee Creek should be treated as a rural system for the purpose of bankfull discharge determination.

It is anticipated that additional run-off volume generated from development within the last five years and in the future within the McKee Creek watershed has been and will continue to be attenuated by the Mecklenburg County Storm Water Ordinance. The ordinance requires that developments which exceed 24% built-upon area control the volume leaving the project site at post-development for the 1-year, 24-hour storm, and that peak control be installed for the appropriate storm frequency (i.e., 10, 25, 50 or 100-yr, 6-hr) as determined by the Storm Water Administrator based on a downstream flood analysis. Mecklenburg County estimates that controlling the 1-year, 24-hour volume achieves peak control for the 2-year, 6-hour storm (Mecklenburg County, 2007); it is generally estimated that bankfull discharge is approximately the 1.5-year storm. It should be noted that even though the stormwater structures implemented upstream of the project reaches will probably limit increases in the peak discharges that are experienced by the project site, there is still the possibility that some channel degradation caused by future urbanization may occur. In some instances stormwater controls that attenuate flows can cause receiving streams to become exposed to lower frequency flows for longer periods of time, which can be just as erosive as increased peak flows (e.g., the McKee Creek project reach could be exposed to the design bankfull flow for longer periods of time per each bankfull occurrence). Furthermore, the implementation of sound stormwater management can only minimize the impact to the project site from development in the upstream watershed. It is inevitable that the project reaches will be subjected to the forces from an urbanizing watershed such as larger magnitude peak flows, reduced lag times, more frequent bankfull events, and reduced baseflows. As upstream urbanization continues, it is anticipated that the proposed design will maintain stability through the use of structures which provide grade control and bank protection, an established vegetative buffer, and energy dissipation through floodplain connectivity.

3.3. Channel Morphology (pattern, dimension, profile)

The project reaches of McKee and Clear Creek are in moderately wide alluvial, low sloped valleys, and have well developed floodplains. The described valley type generally indicates the presence of Rosgen C and E type channels (Rosgen, 1996). The existing channels have been classified as C and E type channels, and the proposed design channels are C type channels.

McKee Creek – Reach 1 has developed some pattern at the upstream portions of the reach (sta 0+00 to 10+00), and is in the process of developing more pattern throughout the reach (sta 16+00 to 20+00; sta 25+00 to 32+00). Overall the project has a relatively high sinuosity (1.28), but it appears that some sections were straightened by past channelization practices (sta 13+00 to 16+00; sta 20+00 to 25+00). The majority of the reach is incised with bank height ratios that range from 1.4 to 2.0, and has cross-sectional dimensions that maintain moderate width/depth ratios that range from approximately 7 to 12 (sta 0+00 to 25+00). The cross-section dimension for the section of the reach from station 25+00 to 33+00 has been impacted by excessive deposition that appears to have resulted from backwater caused by a large tree that blocks the channel (near sta 33+00) and some potential beaver activity; this section has very high width/depth ratios that range from 10 to 44 (see Table 8). Besides the section that has experienced deposition, the profile for the majority of the reach appears to be controlled by bedrock in the channel bed (surveyed bedrock is shown on the existing site conditions sheets). Due to the deposition area from sta 25+00 to 33+00, a large section of the profile is almost completely flat from approximately station 18+50 to 25+00. This has resulted in a long pool section that maintains stagnated water during normal flow conditions (see photo #32 in Appendix 1), and it acts as a sediment trap that accumulates fine sediments.

McKee Creek – Reach 2 has a well developed pattern throughout the reach. Overall the project has a very high sinuosity (1.50), and in some instances the riffle sections flow in a direction that are almost perpendicular to the valley flow (sta 6+00 to 6+50; sta 13+00 to 14+00). The majority of the reach is slightly incised with bank height ratios that range from 1.0 to 1.2, and has cross-sectional dimensions that maintain moderate width/depth ratios that average from approximately 8 to 10. As stated in previous sections the reach dimensions have been impacted by livestock intrusion. The profile for the reach appears to be controlled by bedrock in the channel bed (surveyed bedrock is shown on the existing site conditions sheets). The high sinuosity within the reach has resulted in a relatively low slope for McKee Creek – Reach 2 (0.0018 ft/ft).

Clear Creek has very little developed pattern throughout the reach. Overall the project has a low sinuosity (1.12). The majority of the reach is highly incised with bank height ratios that range from 1.4 to 2.3, and has cross-sectional dimensions that maintain moderate width/depth ratios that range from approximately 5.8 to 12.8. The reach dimensions have been extremely impacted by livestock intrusion; the Clear Creek project reach appears to be frequently accessed by livestock. The profile grade for the reach appears to be controlled by an existing culvert crossing (sta 11+00), the confluence with McKee Creek, and areas throughout the reach in which rip rap/ stone has been added to the channel bed.

3.4. Channel Stability Assessment

For the purpose of describing the stability of McKee Creek – Reach 1, the project reach has been divided into six sections. Section 1 of the reach is from station 0+00 to 7+50. Section 1 is more sinuous and incised than the remainder of the reach. The majority of this section is laterally unstable; vertical instability appears to be limited due to several bedrock outcroppings in the channel bed. A visual inspection and the BEHI assessment of the section verify that degradation is prevalent as a result of the lateral instability. Based on the existing conditions, it appears that this section will continue eroding and depositing sediment before natural stability is achieved. Section 2 of the reach is from station 7+50 to 16+00. Section 2 is relatively straight and stable with low to moderate bank degradation and instability. This section does not seem to have any severe lateral or vertical stability issues. Section 3 of the reach is from station 16+00 to 20+00. Within this section McKee Creek is attempting to develop pattern. Although bedrock in the channel bed has limited vertical instability, it has forced the creek to dissipate its energy through lateral migration which has caused severe lateral instability in this section. Section 3 will continue eroding before natural stability is achieved; parts of the section could possibly avulse if not stabilized. Section 4 of the reach is from station 20+00 to 25+00. Section 4 is relatively straight and stable due to backwater impacts produced by downstream deposition and potential beaver activity. This section has very little bedform diversity; it is basically one long pool section. Under normal flow conditions this section maintains a pool of stagnant water, and acts as a sediment trap that collects fine sediment. Section 5 of the reach is from station 25+00 to 33+00. Section 5 is unstable due to excessive deposition that appears to have been caused by the backwater impacts from a large tree that lies across the channel near station 33+00. Large amounts of coarse gravel and small cobble have been deposited in this section which has resulted in very high width/depth ratios, and some areas have become braided as the channel attempts to redevelop its dimension and pattern. With its high width/depth ratios and continued backwater impacts, this section will continue depositing sediment and being unstable in the future. Also, it is important to note that the backwater caused by the excessive amounts of deposition directly impact the stagnant state of upstream section 4. Section 6 of the reach is from station 33+00 to the bridge crossing at Peach Orchard Road. This section is straight and stable; it is more stable than the other sections of McKee Creek – Reach 1. Section 6 will probably maintain lateral and vertical stability under the current conditions.

McKee Creek – Reach 2 is very sinuous, and livestock access to the creek has caused instability throughout the reach. Although bedrock in the channel bed has limited vertical instability, it has forced the creek to dissipate its energy through lateral migration which has caused some lateral instability in this reach. From station 1+00 to 6+00 the livestock traffic has caused some areas to become overly wide which has resulted in mid channel bars and poor sediment transport. The high sinuosity and low slope within the reach threatens to negatively impact the sediment transport capacity and competency. The lateral instability and process of erosion and deposition will continue before natural stability is achieved; especially if the livestock are not denied access to the creek. The current bedform for the reach is riffle dominated (approximately 80%); the majority of the pools have been caused by isolated debris jams.

Clear Creek has a low sinuosity, and livestock access to the creek has caused most of the instability throughout the reach. Most of the Clear Creek reach is extremely incised and has low width/depth ratios. There are signs throughout the reach that the creek is attempting to form pattern; the lateral instability is very erosive due the bare creek banks which maintain little to no vegetative cover. Even though the reach is mostly incised, further vertical stability issues appear to be limited due to grade control features such as a culvert crossing, the confluence with McKee Creek, and the use of rip rap/stone for bed stabilization. The lateral instability and process of erosion and deposition will continue before natural stability is achieved; especially if the livestock are not denied access to the creek. The current bedform for Clear Creek is riffle dominated (approximately 70%), and the channel incision does not allow flood flows to access the abandoned floodplain with natural regularity.

The degradation potential for the existing streams within the project site was estimated by assessing their channel evolutionary state. The Watershed Assessment of River Stability & Sediment Supply (WRASSS) model developed by David Rosgen was used to estimate the overall risk rating for their degradation potential (Rosgen, 2006). Both the Clear Creek and McKee Creek – Reach 2 project reaches are in the succession scenario in which the channel is unstable because it is evolving from an "E" toward a "C" type channel. The designated risk rating for this scenario is "moderate", and the degradation potential score for both reaches is on the higher end of the "moderate" range. The unstable upper portions of McKee Creek – Reach 1 are also evolving from an "E" toward a "C" type channel. The unstable lower portion for McKee Creek – Reach 1 has a very high width to depth ratio; it appears that this section is evolving from a "C" toward a "D" type channel. The degradation potential score for the unstable sections of McKee Creek – Reach 1 range from the middle to higher end of the "moderate" ranking. According to the WRASSS documentation; *"The moderate risk assessment allows the user to appropriately design measures that offset adverse consequences of specific land use practices/conditions. The resultant measures can be recommendations for stabilization, enhancement, resolution of conditions causing impairment, and/or restoration. Monitoring should be conducted to ensure that stream processes and/or land treatment are responding to mitigation measures implemented."* The proposed project design will use stabilization and enhancement practices along McKee Creek, and restoration along Clear Creek. The stream processes for the constructed channel improvements will then be monitored.

3.5. Bankfull Verification

During the survey of the project site an attempt was made to locate bankfull field indicators on all of the project reaches. Field identification of bankfull discharge was very difficult due to the extensive impacts to the project reaches. However, a complete compilation and comparison of all the bankfull indicators plotted along the reach profiles and cross-sections made it possible to estimate bankfull discharges for all the project reaches with some confidence. Bankfull indicators were apparent on all the project reaches, but the reliability of some was questionable due to the degraded and impacted condition of the reaches. For McKee Creek – Reach 2 and Clear Creek the influences of livestock traffic along the stream banks made determining field indicators challenging. For McKee Creek – Reach 1 backwater impacts from a large debris jam and alterations potentially made by beaver activity also made determining field indicators challenging.

In order to verify the bankfull discharges for the project reaches, hydraulic models were developed in HEC-RAS (see Tables 8 – 10). The cross-sections for the models were produced from the field topographic survey. Bankfull discharges were estimated for each project reach using a Mannings single section analysis for all of the surveyed riffle cross-sections. The estimated bankfull discharge was then entered into the HEC-RAS model for each project reach in order to verify the bankfull stage and riffle cross-sectional area. In some locations the HEC-RAS output showed a water surface elevation that was either higher or lower than the surveyed bankfull indicators, but overall the model appears to make an adequate analysis and verification of bankfull flow through the project reaches. The relationship of the project reaches' estimated bankfull discharges and cross-sectional areas compare favorably to the same relationships from the surveyed reference reach and the NC Piedmont Rural Regional Curve (see Tables 4a – c).

3.6. Vegetation

Large portions of the site have been altered from their natural state into pasture land. Most of which were probably dominated by the Piedmont Alluvial Forest type (Schafale and Weakley, 1990). With the excessive grazing by livestock, this community has been invaded by various exotic plant species (e.g. *Eulalia viminea* and *Rosa palustris*).

Tree species associated with this plant community consists of river birch (*Betula nigra*), American sycamore (*Platanus occidentalis*), sweetgum (*Liquidambar styraciflua*), hackberry/sugarberry (*Celtis laevigata*), black walnut (*Juglans nigra*), green ash (*Fraxinus pennsylvanica*), and tulip poplar (*Liriodendron tulipifera*). The herb layer is comprised of jewelweed (*Impatiens capensis*), Goldenrod (*Solidago sp.*), Jack in the pulpit (*Arisaema triphyllum*), bearsfoot (*Polymnia uvedalia*), and wingstem (*Verbesina alternifolia*). The soil type associated with this community type is typically a highly fertile alluvial soil. This soil type develops from multiple flooding events in which small disturbances occur and sediment is deposited in the floodplain, restoring the fertility of the soil.

4.0 <u>Reference Streams</u>

A section of Dixon Branch which is located in Mecklenburg County was used for the project reference reach. The reference reach is located within the Catawba River Basin; the reference stream's upper watershed boundary is the dividing line between the Catawba and Yadkin drainage basins. The reference reach has a valley slope, bed material, and watershed character that is similar to the project reaches. Attempts to find reference reaches closer to the project site failed. Dennis Testerman, the Senior Resource Conservation Specialist for Cabarrus County, was contacted to help locate potential reference reaches in the area. Mr. Testerman stated that he has been contacted about locating reference reaches on many occasions, but to his knowledge there are not any stream reaches worthy of this designation in the area. The majority of the streams have been disturbed in some way.

4.1. Watershed Characterization

The watershed boundaries and drainage area and vicinity map for the reference reach are shown on Figures 5 and 6. The Dixon Branch drainage area at the downstream survey limits is 0.55 mi^2 (350 acres). The drainage basin area was determined using Mecklenburg County topography in GIS. Like the project watersheds, the Dixon Branch drainage basin is partially developed and the areas adjacent to the reach are fairly rural. The Interstate 77 (I-77) corridor crosses through the basin, and most of the upper reaches of the basin is comprised of North Mecklenburg High School. The watershed is urbanizing and due to the presence of the I-77 corridor, development will probably continue at a rapid rate. The majority of the undeveloped property consists of larger tracts of land that is currently either pasture or forest lands. The upstream portion of the reference reach watershed is more developed than the project watersheds; the percent of impervious cover for the entire watershed is approximately 20%.

4.2. Channel Classification

Dixon Branch classifies as an E4 stream type in the Rosgen system. Dixon Branch is slightly entrenched, with low width/depth ratios, relatively high sinuosity, and a medium sized gravel bed material.

4.3. Discharge (bankfull, trends)

Field identification of bankfull stage was determined during the reference reach survey by using the bankfull indicators along Dixon Branch. The most consistent bankfull indicators were significant breaks in slope, the highest scour line, and in very few instances it was the top of the bank. A complete compilation and comparison of all the bankfull indicators plotted along the reach profile and cross-sections made it possible to estimate bankfull discharge for the surveyed reach of Dixon Branch with some confidence.

4.4. Channel Morphology (pattern, dimension, profile)

Dixon Branch has a relatively well developed pattern throughout the reach. Overall the project has a high sinuosity (1.30). The majority of the reach is slightly incised with bank height ratios that range from 1.1 to 1.5, and has cross-sectional dimensions that maintain low width/depth ratios that range from approximately 5.4 to 10.8. The profile for the reach appears to be controlled by some bedrock in the channel bed and the coarse materials in the riffle sections. The slope for the reach is moderately flat, but steeper than the project reaches (0.0055 ft/ft).

4.5. Channel Stability and Assessment

Overall Dixon Branch is a very stable reach that provides good habitat and bedform diversity. The coarse riffles and some presence of bedrock keep the profile stable, and the established pattern and vegetated buffer maintain lateral stability throughout the reach. It appears that impacts from upstream development have caused some of the streams bank slopes to start to move towards a slightly more vertical state. Also, the irregularities in flow direction and velocity caused by fallen trees in the creek and bedrock outcroppings have caused some isolated areas of bank erosion.

4.6. Bankfull Verification

The relationship of the project reaches' estimated bankfull discharges and cross-sectional areas compare favorably to the same relationships from the projects reaches and the NC Piedmont Rural Regional Curve. Although the reference reach has started to become impacted by some urbanization, the overall impervious cover within Dixon Branch's watershed is still relatively low. The field bankfull indicators confirm that the reference reach should be treated as a rural system for the purpose of bankfull discharge determination.

4.7. Vegetation

The plant community located adjacent to Dixon Branch most closely resembles a Piedmont Alluvial Forest (Schafale and Weakley, 1990). However, the species composition differs slightly from an undisturbed piedmont Alluvial Forest. This variation is likely due a timber harvest, which has allowed shade intolerant species such as tulip poplar (*Liriodendron tulipifera)* and red maple (*Acer rubrum)* to dominate, rather than river birch (*Betula nigra)*, black walnut (*Juglans nigra)*, and American sycamore (*Platanus occidentalis)*, commonly found in an alluvial forest.

Plant species observed in the riparian zone along Dixon Creek included the following canopy trees: red maple, sweetgum (*Liquidambar styraciflua*), green ash (*Fraxinus pennysylvanica*), tulip poplar, red oak (*Quercus falcata*), American beech (*Fagus grandifolia*). The mid-story was comprised of musclewood (*Carpinus caroliniana*), red cedar (*Juniperus virginiana*), black cherry (*Prunus serotina*), and American holly (*Ilex opaca*). Also noted was the presence of the invasive Chinese privette and Japanese honeysuckle. The soil type associated with this community type is typically a highly fertile alluvial soil (i.e. Chewalca). This soil type develops from multiple flooding events in which small disturbances occur and sediment is deposited in the floodplain, restoring the fertility of the soil.

5.0 Project Site Restoration Plan

The proposed project restoration includes enhancement (Level I and Level II) practices along McKee Creek and full stream restoration (Priority I) of Clear Creek. The Clear Creek project reach has been so severely degraded and altered by the unlimited access to the stream by livestock that its condition warrants restoration of its dimension, pattern, profile, and vegetated buffer in order for it to achieve the project goals and objectives. McKee Creek has several sections that are relatively stable, but maintain a limited riparian buffer. These more stable sections of McKee Creek will be improved by re-establishing portions of the vegetated buffer through stream enhancement (Level II) restoration. Other sections of McKee Creek, including all of Reach 2, that are unstable and degrading will require some restoration of the dimension and/or profile in order to achieve a more stable condition. These less stable sections of McKee Creek will be improved through stream enhancement (Level I) practices. The target community along the project site for the vegetated buffer establishment and improvements is the Piedmont alluvial forest.

The property owner currently uses portions of McKee Creek and all of Clear Creek as a water source for his livestock; the livestock have unlimited access to the creeks in these areas. As a result, the Cabarrus County Soil and Water Conservation District will be providing design and construction services for livestock exclusion fencing and alternative water sources.

5.1. Restoration Project Goals and Objectives

The existing stream conditions within the project area are characterized by excess sedimentation, channel incision, bank degradation, and limited riparian buffer. Also, livestock have unlimited access to all of Clear Creek and a portion of the lower reach of McKee Creek, this has significantly contributed to the instability and poor water quality of the project reaches. The project design goals are to restore through stream enhancement (Level I and Level II) McKee Creek, and to restore Clear Creek (Priority I restoration). In order to achieve the design goals, the following objectives have been identified:

- Improve water quality by reducing bank erosion, restricting livestock access to the creeks, and re-establishing the riparian buffer;
- Stabilize McKee Creek through the use of in-stream structures and pattern re-alignment in selected areas;
- Restore the dimension, pattern, and profile of Clear Creek;
- Improve the floodplain functionality of Clear Creek by matching floodplain elevation with bankfull stage;
- Improve the wildlife habitat functions of the site through riparian buffer establishment, improved stream bedform diversity, and improved floodplain functionality.
- Protect the site through a permanent conservation easement along the project reaches.

In order to determine if the project design successfully achieves the objectives listed above, monitoring will be performed on the as-built condition for 5-years. The success of the design streams overall stability and functionality will be determined through cross-section and longitudinal surveys, pebble counts, and photo reference sites. Changes to the physical cross-section and/or longitudinal measurements will be evaluated to determine if they represent a movement toward a more unstable condition. The success of the buffer establishment objective will be measured through photo reference sites, plant survival plots, live stake counts, and tree counts.

5.1.1. Designed Channel Classification

The majority of the Clear Creek design will involve the construction of a new meandering channel; most of the new channel will be placed in the natural low point of the valley. The majority of the design for the upstream section of Clear Creek (first approximately 400 ft of channel) will maintain the existing alignment; except for one severely degraded bend section near the property that will be straightened and stabilized. Due to the established trees, existing channel incision, and potential hydraulic trespass issues, designing a meandering channel was not a feasible option in this upstream section. The design will also maintain the existing channel alignment for the lower section of Clear Creek in order to preserve the existing forested buffer (from near the McKee Creek confluence to approximately 200 ft upstream). The restored Clear Creek stream type will be a Rosgen “C” channel. The “C” type stream results in a more conservative design cross-section that has a higher width/depth ratio or flatter more stable channel side-slopes than the “E” type reference reach. It is extremely challenging to maintain stability in a newly constructed channel that has a low width/depth ratio like an “E” type channel; the “C” type channel design allows the use of a higher and more stable width/depth ratio. Generally the “C” type channel that is designed will begin to narrow and take on the characteristics of the “E” type channel once vegetation has become established.

The design dimension and profile criteria for the Clear Creek design are based on a combination of the reference reach parameters, the project bankfull dimensions, ratios provided by the Army

Corps of Engineers (ACOE) Hydraulic Design of Stream Restoration Project Manual, and the NC Piedmont Rural Regional Curve (Exhibit 3 shows curve comparison). A comparison of the bankfull cross-sectional dimensions determined from the reference reach, project site channel surveys, and the site HEC-RAS hydraulic models relative to the NC Piedmont Rural Regional Curve showed a correlation with other Piedmont streams. This convergence of data provides confidence that the hydraulic geometry relationships used for the Clear Creek design are similar to other stable and properly functioning streams within the same physiographic region.

The design pattern criteria are based on a combination of the reference parameters and the ACOE Manual. Most of the pattern ratios used in the design are within the range of the higher more conservative ACOE values. In comparison to the ACOE values, the reference reach consistently has lower and less conservative pattern ratios due to its dense and established vegetated buffer which provides stability. The ACOE Manual's ratios are based on more of a design condition, or a newly constructed channel without an established vegetated buffer (see Table 4-a, b, and c for the design parameters). Understanding this relationship between the ACOE calculated and reference reach field measured ratios is important when determining the final design criteria.

The proposed Clear Creek design will allow stream flows larger than bankfull to spread onto the floodplain, dissipating flow energies and reducing stress on streambanks. The energy dissipation of the design is further discussed and demonstrated in Section 5.2.2. In-stream structures will be used throughout the reach to control streambed grade, protect banks, and provide bedform diversity for habitat development. Rock cross-vane structures will be needed at the downstream end of the Clear Creek design in order to "step" the restored stream down to the existing invert of the McKee Creek confluence. The streambanks will also be stabilized with a combination of erosion control matting and the planting techniques outlined in Section 5.4.1.

For the sections of McKee Creek that the pattern and/or dimension will be restored, the stream type used will be a Rosgen "C" channel. The design dimension, profile, and pattern criteria are based on the same procedures discussed in the above Clear Creek design paragraphs, but due to a variance in their watershed sizes the reference reach was not used when determining the McKee Creek design parameters. When possible the compiled design parameters were used during the McKee Creek design. However, since only certain pieces or sections of McKee Creek were restored, the design tie-in points of the upstream and downstream portions of the existing stream usually dictated the design profile, pattern, and some of the dimension parameters.

In-stream structures will be used selectively throughout the McKee Creek reaches to control streambed grade, protect banks, and provide bedform diversity for habitat development. Section 5.2.2 further justifies and explains the necessity of restoring certain sections of McKee Creek in order to improve its sediment transport capabilities. Where restoration practices are used on McKee Creek the streambanks will also be stabilized with a combination of erosion control matting and the planting techniques outlined in Section 5.4.1.

5.1.2. Target Buffer Communities

The target community along Clear Creek and Mckee Creek is the Piedmont alluvial forest, as described by Weakley and Schafale in "Classification of the Natural Communities of North Carolina (1990)". The canopy in this type of forest is a mixture of mesophytic and bottomland trees such as: river birch (*Betula nigra*), American sycamore (*Platanus occidentalis*), sweetgum (*Liquidambar styraciflua*), hackberry/sugarberry (*Celtis laevigata*), black walnut (*Juglans nigra*), green ash (*Fraxinus pennsylvanica*), and tulip poplar (*Liriodendron tulipifera*).

5.2. Sediment Transport Analysis

5.2.1. Methodology

A reach-wide pebble count on McKee Creek resulted in a median particle size of 49 mm, which results in a classification for the creek as a very coarse gravel bed stream. As previously stated in Section 3.1 the same design bed characteristics were assumed for both of the McKee Creek project reaches. Due to McKee Creek's classification as a gravel bed stream the design sections were checked for sediment competency, or the stream's ability to move particles of a given size. An aggradation analysis was done on both the existing and design conditions, the required depth and slope needed to transport the largest particle of the riffle subpavement for both conditions was then compared. The methodology for calculating critical dimensionless shear stress and required depth and slope needed to transport the largest particle of the riffle subpavement is from Rosgen's suggested sediment transport competency procedures (Rosgen 2001). The collection of the stream bed pavement and subpavement samples was done using procedures similar to those described by Bunte and Abt (2001). McKee Creek's existing flow conditions used to analyze the sediment transport competency were determined from the McKee Creek HEC-RAS bankfull models (see Tables 8 and 9 for the output).

As previously stated in Section 3.1 the Clear Creek project reach should be classified as a sand bed channel; a bulk sample taken along the project reach showed the median particle size to be coarse sand (D_{50} = 1.2 mm). Some fine gravel was present below the fine sediments along the project reach, and the stream bed consisted of fine gravel upstream of the project reach. It is probable that once the design condition becomes stable and the impacts of livestock intrusion is alleviated, that the channel bed may consist of fine gravels. However, for purposes of this analysis Clear Creek has been treated as a sand bed stream due to the current presence of fine sediments and the probability of sediment inflow from upstream development that will likely impact the design reach. Furthermore, samples of the fine gravels in the streambed showed that they were on the borderline between very coarse sand and very fine gravels (D_{50} approximately 3.0 mm).

The sediment transport capacity was checked for the Clear Creek design. Sediment transport capacity refers to the stream's ability to move a mass of sediment past a cross section per unit time; stream power is often used to describe capacity. For the purposes of this analysis the techniques described by Nanson and Cooke (1992) were used to calculate stream power (specific stream power in W/m^2). The stream power for selected existing cross-sections was compared to the stream power for the design condition cross-sections. Also, the Copeland Method used for stable channel design within HEC-RAS was used to assess whether the design cross-section dimension would aggrade or degrade. Stability curves comparing slope to base width and slope to channel depth were developed using the HEC-RAS design function.

5.2.2. Calculations and Discussion

Tables 11 and 12 display the sediment competency calculation results for McKee Creek, and Exhibits 1 and 2 display the sediment capacity calculation results for Clear Creek. The existing conditions cross-section numbers correspond with the Existing Site Condition plansheets (sheets B – G).

As stated previously in this report, since only certain pieces or sections of McKee Creek were restored, the design tie-in points of the upstream and downstream portions of the existing stream usually dictated the design profile, pattern, and some of the dimension parameters. This should be considered when reviewing the sediment transport data for McKee Creek; sometimes physical constraints allow the designer to only improve the existing condition, not necessarily correct it altogether.

A sediment transport assessment of the upstream portions of McKee Creek – Reach 1 shows that the existing stream is slightly degrading (the required bankfull mean depth and slope are less than the actual measured values; Table 11). A comparison of the design to the existing conditions shows that the design cross-section dimension and slope will probably lessen the stream degradation in this section. The same assessment of the downstream portions of the reach estimate that the existing stream is definitely aggrading or depositing sediment (the required bankfull mean depth and slope are much higher than the actual measured values; Table 11). A field assessment of McKee Creek – Reach 1 corroborates these findings. This is particularly true in the section from existing station 25+00 to 33+00 (XSC #6, 7, and 8) where the channel dimension has become overly wide with high width/depth ratios (see Table 8 between XSC #6 and 8). A comparison of the design to the existing conditions shows that the design cross-section dimension and slope will improve the streams competency in this aggrading section. This sediment transport analysis for the section from station 25+00 to 33+00 is an important component in justifying the need to redesign the dimension and profile through the section. The negative impacts caused by the excessive deposition in this area to the overall stream functionality must be considered when deciding on the design action.

A sediment transport assessment of McKee Creek – Reach 2 shows that the existing stream is aggrading (the required bankfull mean depth and slope are greater than the actual measured values; Table 11). This is mainly due to the high sinuosity, low channel slope, and cross-section widening caused by the livestock traffic along the banks. Also, the sediment data collected for McKee Creek – Reach 1 was used for Reach 2, this was necessary due to the excessive amount of fine sediment within the reach due to livestock access. Accurate and representative pavement and subpavement samples taken in Reach 2 would probably not demonstrate such a drastic level of aggradation within the reach; as a whole the reach is degrading more than it is aggrading. However, the sediment transport information and methodology was necessary in order to demonstrate the differences between the existing and design conditions. A comparison of the design to the existing conditions shows that the design cross-section dimension and increased slope will help improve the sediment transport competency throughout McKee Creek – Reach 2. The magnitude in which the required mean depth and slope is higher than the actual values is much lower for the design than the existing condition.

A sediment transport analysis was performed on Clear Creek to determine if the stream restoration design would create a stable sand-bed channel that does not excessively aggrade or degrade over time. The degradation potential of the existing stream was compared to the design stream through the use of stream power (W/m^2). As a check, the calculated stream power values for the existing and proposed conditions were compared with values for similar stream and valley types described by Nanson and Croke (1992). The calculated values for Clear Creek compared well with the similar B3b valley type; sands and minor gravel beds in wide alluvial valleys (in their study the range of stream powers were 10 to 60 W/m^2). Exhibit 1 demonstrates how the existing channel experiences higher sediment transport rates and specific stream power than the design channel. The design channel will allow flows greater than bankfull to spread out on the floodplain, thus dissipating the excess energy. The maximum stage that is plotted along the X-axis on Exhibit 1 is the stage that will be reached within the floodplain cross-section during the approximate 10-year storm event (Q = 340 cfs). It is evident from the comparison that the incised existing channel will be subject to much higher and erosive energies than the design channel during a given storm duration.

It is clear from the above assessment that the Clear Creek design channel will be subjected to much lower and less erosive stream power than the existing channel. However, this does not answer the question of whether or not the design channel will adequately transport sediment during the bankfull flow condition. A study to understand the design channel's sediment transport capacity, or ability to move a mass of sediment past a cross-section per unit time, is also necessary. Exhibit 2 shows stability curves for Clear Creek that were developed within the HEC-RAS stable channel design function (Copeland Method). The curves compare channel slope to bottom width and channel slope to depth. Theoretically, values plotted above the curve would produce degradation and values plotted below the curve would produce aggradation. The design channel's bottom width (5.9 ft) and depth (2.2) were plotted against the design slope (0.0039) on the curves. The data point plotted close to the curves, but slightly to the degradation side. Having the design channel slightly more erosive than depositional is preferred. This shows that the channel can adequately move its bed load, the potential for slight degradation will be controlled through the use of in-stream structures and established vegetation.

5.3. HEC-RAS Analysis

The output from the HEC-RAS analysis for the project flood study is shown in Appendix 7. The flood study for McKee Creek shows that the proposed design condition will produce a decrease to the 100-year water surface elevation when compared to the existing condition. Since the design condition proposes to remove a large portion of the deposited sediment within the existing channel, the proposed design will result in a substantial decrease to the 100-year water surface elevation. Since a large portion of the Clear Creek design will be priority I, the design condition will cause a slight increase in the 100-year water surface elevation when compared to the incised existing condition. However, the increase in 100-year water surface elevation limits will not exceed the upstream property limits.

A separate HEC-RAS analysis was done on all of the project reaches in order to model the bankfull flow condition. The bankfull model outputs are shown on Tables 8 – 10.

5.3.1. No-rise, LOMR, CLOMR

Clear Creek is impacted from the 100-year backwater elevation from McKee Creek, but it is not a mapped FEMA detailed floodplain. The section of McKee Creek within the project limits is located in a FEMA detailed floodplain. Stream enhancement (Level I) is proposed on sections of the project reach of McKee Creek. Some of the existing sections along McKee Creek project reaches have experienced channel deposition since the cross-sections were surveyed for the original FEMA flood model. Since our proposed design will remove some of the deposited sediment, the proposed 100-year water surface elevation is less than the corrected effective/ existing condition 100-year water surface elevation (decrease greater than 0.1 ft). As a result, it is anticipated that a FEMA Letter of Map Revision (LOMR) will be required at the conclusion of the project's construction; the LOMR will be submitted by the NC EEP. Due to the excessive deposition, the majority of the corrective effective/ existing conditions 100-year water surface elevations are higher than the duplicate effective elevations. The local floodplain administrator for Cabarrus County was contacted (Mike Byrd). Mr. Byrd stated that what he required for us to show compliance was verification that our design would not cause hydraulic trespass issues to the adjacent properties (comparing proposed condition to the existing condition). The proposed design condition meets Mr. Byrd's standards for compliance. However, the NC EEP is mandated by the State of North Carolina to comply with the FEMA rules and regulations which currently state that if the proposed condition causes more than a 0.1 ft decrease when compared to the corrected effective/existing condition then a LOMR is required.

5.3.2. Hydrologic Trespass

Hydraulic modeling with HEC-RAS has confirmed that hydraulic trespass will not be an issue on the McKee Creek Project. Hydraulic trespass was considered during the design of all the project stream reaches; the designs were altered in order to avoid trespass issues.

5.4. Natural Plant Community Restoration

5.4.1. Narrative & Plant Community Restoration

Plant selection is based on species native to the area and chosen to mimic existing plant material observed on the project and reference site. A mixture of bare root seedlings, live stakes, and a permanent seeding mixture of grasses and forbs will be used to revegatate the area. Refer to Table 7 for the proposed vegetation species, and the Design Sheets for the designated planting areas.

In general, hardwoods will consist of bare root vegetation planted at a target density of 680 stems per acre, spaced on an 8’ by 8’ grid. Selected species shall be planted according to their wetness tolerance and the anticipated wetness of the planting areas. Bare root trees should be planted during dormancy and installed within two days of being transported to the site. Soil within the target areas shall be disked and loosened prior to planting. Trees shall be planted manually using a planting or dibble bar, mattock, or other approved method for installation. Planting holes must be of sufficient depth to allow proper root development without “J-rooting,” and soil will be loosely compacted around the trees.

In areas prone to erosion, including steep banks, live stakes will be used. Stakes shall be installed randomly with respect to species, 2’ to 3’ apart using triangular spacing along the outside of bends and 4’ to 6’ apart using triangular spacing along the banks of straight riffle sections (maximum of 20% Black Willow). Stakes shall be selectively placed on existing vegetated stream banks. Live stake material should be dormant, but have the presence of young buds and green bark. Stakes should be 1” to 2” diameter, 2’ to 3’ in length, with angled bottoms and cut flush on the top with buds oriented upward. Stakes shall be installed either by hammering into the ground with a rubber mallet or by excavating a hole and slipping the stake into it. Stakes shall be tamped in perpendicular to the slope with 4/5 of the stake installed below ground surface. A minimum of two buds must be visible above ground surface. Once installed, soil shall be firmly compacted around the stake and a fresh cut be made on the live stake to promote end growth and vigor. No split stakes are to be used and stakes that split during installation should be replaced.

A permanent seed mixture of native grasses and forbs shall be applied to all disturbed areas of the site. Separate mixtures are provided for stream banks and for flood plain areas. The permanent seed mixture for stream banks shall be applied in order to provide rapid stabilization of constructed stream banks and steep slopes. The permanent seed mixture for floodplains shall be applied to all other disturbed areas, outside of existing tree lines, to provide rapid growth of herbaceous ground cover with a high biological habitat value.

5.4.2. *On-site invasive Species Management*

Non-native invasive plants can limit the native plant communities' ability to regenerate and be self-dependent. These non-native invasive plants (i.e. Multiflora rose) develop into a dense ground that prohibits the natural regeneration of natural trees, shrubs, and forbs.

The non-native specie, multiflora rose, is present along the banks of McKee Creek. As part of this restoration plan it is recommended that these areas be treated with an herbicide application. The following table indicates the specific herbicide, amount, and time of year it should be applied. The following herbicide applications are foliar sprays which should completely coat the foliage of the target plant. Repeated applications may be required to completely eradicate the target specie from the restoration site.

Herbicides		
Herbicide	**Amount per 3 gallons of water with surfactant**	**Time of Year**
Escort	0.2 dry ounces	April - June
Arsenal AC	4 ounces	Aug. – Oct.
**Glyphosate*	8 ounces	May – Oct.

** Herbicide is not soil active and will not negatively affect surrounding plant species. Multiple applications may be required.*

6.0 Performance Criteria

In order to determine if the design streams have successfully achieved the objectives of providing proper channel function and increased habitat quality, monitoring will be performed on the as-built conditions for 5-years. The success criteria for the restoration project will follow the rules as presented in the USACOE Stream Mitigation Guidelines (2003). It must be demonstrated that the design channel has been subjected to the channel forming discharge. Therefore, two bankfull events must be documented within the 5-year monitoring period, and the bankfull events must occur in separate years.

6.1. Streams

The success of the design streams overall stability will be monitored through cross-section and longitudinal surveys, pebble counts, and photo reference sites. The photo reference sites will be used to document success by visually verifying that no substantial aggradation, degradation, or bank erosion has occurred during the 5-year monitoring period. Some photo reference sites will also be developed prior to channel construction in order to provide a baseline when comparing before-and-after conditions of the streams. The stream parameters that are physically measured during the monitoring period, such as cross-section surveys, longitudinal surveys, and pebble counts, will be used to confirm the project's channel stability. A successfully designed channel that is stable will show minimal evidence of down-cutting, deposition, bank erosion, or an increase in naturally occurring sands or finer substrate materials. Changes to the physical cross-section and/or longitudinal measurements should be evaluated to determine if they represent a movement toward a more unstable condition.

If substantial aggradation, degradation, bank erosion, and/or evidence of other forms of instability occur, remedial actions will be planned, approved, and implemented.

All of the above measures will be monitored for the sections of McKee Creek that have been restored through stream enhancement (Level I) measures, and for all of the Clear Creek design reach. Only photo reference sites will be used for monitoring for the sections of McKee Creek that have been restored through stream enhancement (Level II), no physical measurements will be taken in these areas.

6.2. Vegetation

The success of the implemented vegetation plan will be monitored through the photo reference sites, plant survival plots, live stake counts, and tree counts. The location and number of vegetation monitoring plots will be determined during the as-built survey. In order for the photo reference sites to document success, they must show at least 75% coverage in the plots. A successful vegetation plot will verify survival and growth of at least 320 stems per acre through year 3, then 10% mortality allowed in year 4 (288 stems per acre), and an additional 10% mortality in year 5 for 260 stems per acre through year 5.

6.3. Schedule / Reporting

An as-built report will be prepared and used as a baseline for all subsequent monitoring. The monitoring and monitoring reports will begin 1 year following completion of the as-built report, and continue for years 2, 3, 4, and 5. A BEHI assessment will also be completed in year 5. The as-built and monitoring reports will include:

1. Executive Summary/ Project Abstract;

2. Project Background Section which will include project objectives, structure, location and setting, and history and background;

3. Project drawings that shall include vegetation and stream issue areas, plans include a Monitoring Plan View and Current Condition Plan View;

4. The Project Condition and Monitoring Results which will include details of the stream and vegetation assessment;

5. Methodology Section;

6. An Exhibit/ Tables Section that will include such tables as the Project Structure Table, Project Activity and Reporting History, Project Contact Table, Project Background Table, Hydrological (Bankfull) Verifications, BEHI and Sediment Export Estimates, Categorical Stream Feature Visual Stability Assessment, Baseline Morphology and Hydraulic Summary, and Morphology and Hydraulic Monitoring Summary;

7. An Appendix Section which will include Appendix A – Vegetation Raw Data and Appendix B – Geomorphologic Raw Data.

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8.0 Tables

Table 1. Project Restoration Structure and Objectives Project Number D07063S (McKee Creek)						
Restoration Reach ID	**Station Range**	**Restoration Type**	**Priority Approach**	**Existing Linear Footage**	**Designed Linear Footage**	**Comment**
McKee Reach 1	10+00 - 25+00	Enhancement II	P4	1500 lf	1500 lf	The is a mix of P2 and P4 as designated by the stationing.
McKee Reach 1	25+00 - 29+00	Enhancement I	P2	493 lf	400 lf	
McKee Reach 1	29+00 - 46+40	Enhancement II	P4	1740 lf	1740 lf	
			McKee Reach 1 Totals	3,733 lf	3,640 lf	
McKee Reach 2	10+00 - 22+86	Enhancement I	P2	847 lf	696 lf	The reach is a mix of P2 and P3, but is mostly dominated by P2. Includes 200 lf of channel relocation.
Clear Creek	10+69 - 27+76	Restoration	P1	1,513 lf	1,641 lf	Includes 1,351 lf of channel relocation
			Project Totals	**6,093 lf**	**5,977 lf**	

Table 2. Drainage Areas Project Number D07063S (McKee Creek)	
Reach	**Drainage Area (Acres)**
McKee Creek - Reach 1 (at Peach Orchard Rd.)	4,131
McKee Creek - Reach 2 (at downstream project limits)	4,214
Clear Creek (at confluence with McKee Creek)	635

Table 3. Land Use of Watersheds

Project Number D07063S (McKee Creek)

McKee Creek - Reach 1 (at Peach Orchard Rd.)		
Land Use	**Acreage**	**Percentage**
Single-Fam	2,150	52%
Woods	1,154	28%
Commercial	114	3%
Govt-Inst	73	2%
Warehouse	76	2%
Pasture	565	14%
McKee Creek - Reach 2 (at downstream project limits)		
Land Use	**Acreage**	**Percentage**
Single-Fam	2,147	51%
Woods	1,166	28%
Commercial	113	3%
Govt-Inst	73	2%
Warehouse	76	2%
Pasture	640	15%
Clear Creek (at confluence with McKee Creek)		
Land Use	**Acreage**	**Percentage**
Pasture	60	9%
Woods	469	74%
Single-Fam	106	17%

Table 4-a. Morphological Table - Project Number #D07063S (McKee Creek - Reach 1)						
	Existing Conditions McKee Creek - R1		**Design Conditions McKee Creek - R1**		**Other Reference ACOE Manual**	
Parameter	MIN	MAX	MIN	MAX	MIN	MAX
Drainage Area, DA (sq mi)	4131 ac - 6.45 sq. mi.		4131 ac - 6.45 sq. mi.			
Stream Type (Rosgen)	E4		C4			
Bankfull Discharge, Qbkf (cfs)	340		340			
Bankfull Riffle XSEC Area, Abkf (sq ft)	68.2	77.6	80.0			
Bankfull Mean Velocity, Vbkf (ft/s)	4.4	5.0	4.3			
Bankfull Riffle Width, Wbkf (ft)	27.5	31.8	31.0			
Bankfull Riffle Mean Depth, Dbkf (ft)	2.10	2.80	2.6			
Width to Depth Ratio, W/D (ft/ft)	10.2	14.9	12.0			
Width Floodprone Area, Wfpa (ft)	75	160	75	160		
Entrenchment Ratio, Wfpa/Wbkf (ft/ft)	2.6	5.5	2.4	5.2		
Riffle Max Depth @ bkf, Dmax (ft)	3.5	4.4	3.4	4.4		
Riffle Max Depth Ratio, Dmax/Dbkf	1.4	1.8	1.3	1.7		
Max Depth @ tob, Dmaxtob (ft)	3.5	8.1	3.4	4.4		
Bank Height Ratio, Dtob/Dmax (ft/ft)	1.0	2.1	1.0			
Meander Length, Lm (ft)	101	305	235	350		
Meander Length Ratio, Lm/Wbkf *	3.5	10.5	7.6	11.3	11.3	12.5
Radius of Curvature, Rc (ft)	48	195	62	108		
Rc Ratio, Rc/Wbkf *	1.6	6.7	2.0	3.5	1.5	4.5
Belt Width, Wblt (ft)	65	145	93	139		
Meander Width Ratio, Wblt/Wbkf *	2.2	5.0	3.0	4.5		
Sinuosity, K	1.28		1.16			
Valley Slope, Sval (ft/ft)	0.0037		0.0037			
Channel Slope, Schan (ft/ft)	0.0029		0.0032			
Slope Riffle, Srif (ft/ft)	0.0055	0.0131	0.0061	0.0106		
Riffle Slope Ratio, Srif/Schan	1.9	4.5	1.9	3.3		
Slope Pool, Spool (ft/ft)	0.0006	0.0009	0.0006	0.0013		
Pool Slope Ratio, Spool/Schan	0.20	0.30	0.20	0.40		
Pool Max Depth, Dmaxpool (ft)	3.1	6.4	5.2	7.7		
Pool Max Depth Ratio, Dmaxpool/Dbkf	1.3	2.6	2.0	3.0	2.5	4.5
Pool Width, Wpool (ft)	29.1	58.2	37.2	43.4		
Pool Width Ratio, Wpool/Wbkf	1.0	2.0	1.2	1.4	1.3	1.4
Pool-Pool Spacing, Lps (ft)	50.0	205.0	123.9	216.9		
Pool-Pool Spacing Ratio, Lps/Wbkf	1.7	7.0	4.0	7.0	5.0	7.0
d16 (mm)	0.7		0.7			
d35 (mm)	27.8		27.8			
d50 (mm)	49.4		49.4			
d84 (mm)	83.2		83.2			
d95 (mm)	109.5		109.5			

Table 4-b. Morphological Table - Project Number #D07063S (McKee Creek - Reach 2)						
	Existing Conditions McKee Creek - R2		Design Conditions McKee Creek - R2		Other Reference ACOE Manual	
Parameter	MIN	MAX	MIN	MAX	MIN	MAX
Drainage Area, DA (sq mi)	4214 ac - 6.58 sq. mi.		4214 ac - 6.58 sq. mi.			
Stream Type (Rosgen)	E4		C4			
Bankfull Discharge, Qbkf (cfs)	350		350			
Bankfull Riffle XSEC Area, Abkf (sq ft)	78.5	88.0	85.0			
Bankfull Mean Velocity, Vbkf (ft/s)	4.0	4.5	4.1			
Bankfull Riffle Width, Wbkf (ft)	25.5	26.8	31.9			
Bankfull Riffle Mean Depth, Dbkf (ft)	3.10	3.30	2.7			
Width to Depth Ratio, W/D (ft/ft)	8.1	8.3	12.0			
Width Floodprone Area, Wfpa (ft)	150	205	150	205		
Entrenchment Ratio, Wfpa/Wbkf (ft/ft)	5.7	7.9	4.7	6.4		
Riffle Max Depth @ bkf, Dmax (ft)	4.4	4.8	3.5	4.5		
Riffle Max Depth Ratio, Dmax/Dbkf	1.4	1.5	1.3	1.7		
Max Depth @ tob, Dmaxtob (ft)	4.5	5.6	3.5	4.5		
Bank Height Ratio, Dtob/Dmax (ft/ft)	1.0	1.2	1.0			
Meander Length, Lm (ft)	208	377	243	447		
Meander Length Ratio, Lm/Wbkf *	8.0	14.4	7.6	14.0	11.3	12.5
Radius of Curvature, Rc (ft)	95	240	64	144		
Rc Ratio, Rc/Wbkf *	3.6	9.2	2.0	4.5	1.5	4.5
Belt Width, Wblt (ft)	135	240	96	287		
Meander Width Ratio, Wblt/Wbkf *	5.0	9.2	3.0	9.0		
Sinuosity, K	1.50		1.17			
Valley Slope, Sval (ft/ft)	0.0027		0.0027			
Channel Slope, Schan (ft/ft)	0.0018		0.0023			
Slope Riffle, Srif (ft/ft)	0.0130	0.0200	0.0044	0.0076		
Riffle Slope Ratio, Srif/Schan	5.9	9.1	1.9	3.3		
Slope Pool, Spool (ft/ft)	0.0002	0.0004	0.0002	0.0005		
Pool Slope Ratio, Spool/Schan	0.10	0.20	0.10	0.20		
Pool Max Depth, Dmaxpool (ft)	6.5	6.5	5.3	8.0		
Pool Max Depth Ratio, Dmaxpool/Dbkf	2.0	2.0	2.0	3.0	2.5	4.5
Pool Width, Wpool (ft)	32.6	32.6	38.3	44.7		
Pool Width Ratio, Wpool/Wbkf	1.2	1.2	1.2	1.4	1.3	1.4
Pool-Pool Spacing, Lps (ft)	45.0	180.0	127.7	223.6		
Pool-Pool Spacing Ratio, Lps/Wbkf	1.7	6.9	4.0	7.0	5.0	7.0
d16 (mm)	0.7		0.7			
d35 (mm)	27.8		27.8			
d50 (mm)	49.4		49.4			
d84 (mm)	83.2		83.2			
d95 (mm)	109.5		109.5			

Table 4-c. Morphological Table - Project Number #D07063S (Clear Creek)								
	Existing Conditions Clear Creek		Design Conditions Clear Creek		Reference Reach Dixon Branch		Other Reference ACOE Manual	
Parameter	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX
Drainage Area, DA (sq mi)	635 ac - 0.99 sq. mi.		635 ac - 0.99 sq. mi.		350 ac - 0.55 sq. mi.			
Stream Type (Rosgen)	E/C5		C4		E4			
Bankfull Discharge, Qbkf (cfs)	89		89		41			
Bankfull Riffle XSEC Area, Abkf (sq ft)	21.8	24.8	25.0		11.3	13.2		
Bankfull Mean Velocity, Vbkf (ft/s)	3.3	3.9	3.6		3.6			
Bankfull Riffle Width, Wbkf (ft)	11.5	16.7	17.3		7.9	13.9		
Bankfull Riffle Mean Depth, Dbkf (ft)	1.30	2.00	1.4		0.80	1.40		
Width to Depth Ratio, W/D (ft/ft)	5.8	12.8	12.0		5.4	10.8		
Width Floodprone Area, Wfpa (ft)	50	150	90	190	35	100		
Entrenchment Ratio, Wfpa/Wbkf (ft/ft)	3.8	11.3	5.2	11.0	3.1	8.9		
Riffle Max Depth @ bkf, Dmax (ft)	2.6	3.1	2.2	2.5	1.8	2.0		
Riffle Max Depth Ratio, Dmax/Dbkf	1.5	1.7	1.5	1.7	1.7	1.9		
Max Depth @ tob, Dmaxtob (ft)	3.7	6.1	2.1	2.4	2.0	2.9		
Bank Height Ratio, Dtob/Dmax (ft/ft)	1.4	2.3	1.0		1.1	1.5		
Meander Length, Lm (ft)	45	75	132	196	48	85		
Meander Length Ratio, Lm/Wbkf *	3.4	5.6	7.6	11.3	4.3	7.6	11.3	12.5
Radius of Curvature, Rc (ft)	15	25	35	52	6	22		
Rc Ratio, Rc/Wbkf *	1.1	1.9	2.0	3.0	0.5	2.0	1.5	4.5
Belt Width, Wblt (ft)	35	47	52	78	29	50		
Meander Width Ratio, Wblt/Wbkf *	2.6	3.5	3.0	4.5	2.6	4.5		
Sinuosity, K	1.12		1.21		1.30			
Valley Slope, Sval (ft/ft)	0.0047		0.0047		0.0072			
Channel Slope, Schan (ft/ft)	0.0042		0.0039		0.0055			
Slope Riffle, Srif (ft/ft)	0.0059	0.0084	0.0055	0.0086	0.0120	0.0180		
Riffle Slope Ratio, Srif/Schan	1.4	2.0	1.4	2.2	2.2	3.3		
Slope Pool, Spool (ft/ft)	0.0008	0.0025	0.0008	0.0016	0.0019	0.0022		
Pool Slope Ratio, Spool/Schan	0.20	0.60	0.20	0.40	0.30	0.40		
Pool Max Depth, Dmaxpool (ft)	2.8	3.3	2.9	4.3	2.1	2.5		
Pool Max Depth Ratio, Dmaxpool/Dbkf	1.6	1.9	2.0	3.0	2.0	2.3	2.5	4.5
Pool Width, Wpool (ft)	21.9	23.4	20.8	24.2	10.3	13.8		
Pool Width Ratio, Wpool/Wbkf	1.6	1.8	1.2	1.4	0.9	1.2	1.3	1.4
Pool-Pool Spacing, Lps (ft)	57.5	116.9	69.3	121.2	10.0	45.0		
Pool-Pool Spacing Ratio, Lps/Wbkf	5.0	7.0	4.0	7.0	0.9	4.0	5.0	7.0
d16 (mm)	0.35		0.4		2.3			
d35 (mm)	0.7		1.3		5.0			
d50 (mm)	1.2		3.0		10.1			
d84 (mm)	3.2		14.0		80.3			
d95 (mm)	6.0		18.0		170.0			

Table 5. BEHI and Sediment Export Estimates for Project Site Streams
McKee Creek Stream Restoration/Project # D07063S

Time Point	Segment/Reach	Linear Footage or Acreage	Extreme		Very High		High		Moderate		Low		Very Low		Sediment Export
			ft	%	ft	%	ft	%	ft	%	ft	%	ft	%	Ton/y
Pre-Construction	McKee Creek Reach 1	3759			88	2.3	494	13.1	1175	31.3	533	14.2	1469	39.1	302.5
	McKee Creek Reach 2	1623					496	30.6	686	42.3			441	27.2	305.8
	Clear Creek	1566			68	4.3	231	14.8	97	6.2			1170	74.7	36.5
	Project Total	6948			156	2.2	1221	17.6	1958	28.2	533	7.7	3080	44.3	644.8

Table 6. BEHI and Sediment Export Estimates for Reference Stream McKee Creek Stream Restoration/Project # D07063S															
Time Point	**Segment/Reach**	**Linear Footage or Acreage**	**Extreme**		**Very High**		**High**		**Moderate**		**Low**		**Very Low**		**Sediment Export**
			ft	%	ft	%	ft	%	ft	%	ft	%	ft	%	Ton/y
Survey	Dixon Branch	352							157	44.6	112	31.8	14	4.0	1.9
	Project Total	352							157	44.6	112	31.8	14	4.0	1.9

Table 7. Designed Vegetative Communities

Bare Root Seedlings (Floodplain for Restoration and Enhancement Areas)		
Scientific Name	**Common Name**	**Tolerance**
Betula nigra	River Birch	FACW
Carya aquatica	Water Hickory	OBL
Celtis laevigata	Sugarberry	FACW
Fraxinus pennsylvanica	Green Ash	FACW
Juglans nigra	Black Walnut	FAC
Liriodendron tulipifera	Tulip Poplar	FAC
Platanus occidentalis	Sycamore	FAC-
Quercus michauxii	Swamp Chestnut Oak	FACW-

Live Stakes (Stream banks for Restoration Area and as needed for Enhancement Areas)		
Scientific Name	**Common Name**	**Tolerance**
Cephalanthus occidentalis	Buttonbush	OBL
Cornus amomum	Silky Dogwood	FACW+
Salix nigra	Black Willow	OBL
Sambucus canadensis	Elderberry	FACW-

Stream Banks Permanent Seed Mixture (Restoration Area and re-graded channel sections in Enhancement Areas)			
Scientific Name	**Common Name**	**% of Mixture**	**Seeding Density (lbs./ac.)**
Andropogon glomeratus	Bushy Beard Grass	20%	2
Bidens aristosa	Beggar Ticks	10%	2
Dichanthelium clandestinum	Deer Tongue	15%	3
Elymus virginicus	Virginia Wild Rye	25%	2
Juncus effusus	Soft Rush	15%	2
Panicum virgatum	Switch Grass	10%	3
Tripsacum dactyloides	Gamma Grass	5%	3

Flood Plain Permanent Seed Mixture (Restoration Area and Enhancement Area)			
Scientific Name	**Common Name**	**% of Mixture**	**Seeding Density (lbs./ac.)**
Andropogon gerardii	Big Blue Stem	15%	12-15
Bidens aristosa	Beggar Ticks	10%	12-15
Carex vulpinoidea	Fox Sedge	25%	12-15
Chamaecrista fasciulata	Partridge Pea	15%	12-15
Elymus virginicus	Virginia Wild Rye	15%	12-15
Schizachyrium scoparium	Little Blue Stem	20%	12-15

Table 8. McKee Creek - Reach #1 (HEC-RAS Bankfull Model Output)

River Sta	Profile	Q Total (cfs)	W.S. Elev (ft)	E.G. Slope (ft/ft)	Max Chl Dpth (ft)	Hydr Depth C (ft)	Flow Area Ch (sq ft)	W.P. Channel (ft)	Hydr Radius C (ft)	Top W Chnl (ft)	Vel Chnl (ft/s)	Shear Chan (lb/sq ft)	Power Chan (lb/ft s)	Power Chan (W/m^2)	W/D Ratio	Cross Section #
3048.3	BKFL	340	593.87	0.001114	4.56	3.52	124	37.7	3.29	35.25	2.74	0.23	0.63	9.2	10.0	
2996.3	BKFL	340	593.81	0.001203	5.47	3.18	127.05	42.45	2.99	39.93	2.68	0.22	0.6	8.7	12.6	
2930.8	BKFL	340	593.63	0.001864	4.74	3.51	97.88	30.71	3.19	27.87	3.47	0.37	1.29	18.8	7.9	
2842.0	BKFL	340	593.4	0.002451	4.42	3.37	88.14	29.02	3.04	26.15	3.86	0.46	1.79	26.1	7.8	#1
2760.1	BKFL	340	593.14	0.002987	5.24	3.18	83.09	29.03	2.86	26.09	4.09	0.53	2.18	31.7	8.2	
2688.4	BKFL	340	593.01	0.001964	4.9	3.8	94.92	29.57	3.21	25	3.58	0.39	1.41	20.5	6.6	
2621.5	BKFL	340	592.96	0.001309	6.55	3.5	119.83	39.06	3.07	34.28	2.84	0.25	0.71	10.3	9.8	
2538.8	BKFL	340	592.81	0.001516	6.44	3.71	107	32.86	3.26	28.87	3.18	0.31	0.98	14.3	7.8	
2491.5	BKFL	340	592.71	0.00175	6.32	3.61	100.39	31.2	3.22	27.84	3.39	0.35	1.19	17.3	7.7	
2424.0	BKFL	340	592.52	0.002276	5.87	3.62	89.08	28.19	3.16	24.62	3.82	0.45	1.71	24.9	6.8	#2
2352.3	BKFL	340	592.41	0.001834	5.25	3.44	100.12	32.11	3.12	29.14	3.4	0.36	1.21	17.6	8.5	
2288.5	BKFL	340	592.31	0.001772	6.02	3.17	107.32	37.22	2.88	33.8	3.17	0.32	1.01	14.7	10.7	
2197.5	BKFL	340	592.17	0.001477	5.93	3.81	108.66	33.48	3.25	28.54	3.13	0.3	0.94	13.7	7.5	
2122.0	BKFL	340	591.96	0.002232	5.14	3.48	91.79	29.93	3.07	26.39	3.7	0.43	1.58	23.0	7.6	
2044.7	BKFL	340	591.84	0.001689	5.04	3.67	101.09	30.91	3.27	27.54	3.36	0.34	1.16	16.9	7.5	
1968.1	BKFL	340	591.61	0.00285	4.14	2.97	86.86	31.32	2.77	29.26	3.91	0.49	1.93	28.1	9.9	
1912.4	BKFL	340	591.39	0.003163	4.69	3.25	79.32	26.98	2.94	24.41	4.29	0.58	2.49	36.3	7.5	
1848.9	BKFL	340	591.32	0.001759	4.85	3.49	100.77	31.62	3.19	28.89	3.37	0.35	1.18	17.2	8.3	
1769.5	BKFL	340	591.21	0.00138	5.09	3.94	107.8	31.2	3.45	27.36	3.15	0.3	0.94	13.7	6.9	
1701.4	BKFL	340	591.05	0.002016	5.93	3.56	95.32	30.48	3.13	26.8	3.57	0.39	1.4	20.4	7.5	
1631.9	BKFL	340	590.94	0.001598	5.47	3.7	102.69	30.85	3.33	27.74	3.31	0.33	1.1	16.0	7.5	
1558.3	BKFL	340	590.79	0.002043	5.71	3.2	98.52	33.44	2.95	30.79	3.45	0.38	1.3	18.9	9.6	
1515.7	BKFL	340	590.76	0.001275	6.17	3.74	114.28	34.03	3.36	30.59	2.98	0.27	0.8	11.6	8.2	
1471.1	BKFL	340	590.66	0.00174	5.93	3.6	102.41	32.65	3.14	28.41	3.32	0.34	1.13	16.5	7.9	
1381.7	BKFL	340	590.55	0.00131	5.59	3.27	120.06	39.28	3.06	36.77	2.83	0.25	0.71	10.3	11.2	
1334.2	BKFL	340	590.43	0.001631	5.32	3.73	101.45	30.39	3.34	27.22	3.35	0.34	1.14	16.6	7.3	
1284.9	BKFL	340	590.28	0.002239	5.14	3.71	88.88	27.68	3.21	23.98	3.83	0.45	1.72	25.0	6.5	#5
1209.4	BKFL	340	590.18	0.001545	5.17	3.96	102.59	30	3.42	25.89	3.31	0.33	1.09	15.9	6.5	
1135.3	BKFL	340	589.88	0.003464	5.57	3.05	78.91	28.52	2.77	25.86	4.31	0.6	2.58	37.6	8.5	
1069.8	BKFL	340	589.81	0.001735	5.76	3.54	100.45	31.05	3.24	28.39	3.38	0.35	1.19	17.3	8.0	
994.3	BKFL	340	589.63	0.002146	5.43	3.43	92.54	29.66	3.12	26.98	3.67	0.42	1.54	22.4	7.9	
923.8	BKFL	340	589.49	0.001997	5.14	3.35	96.63	31.31	3.09	28.84	3.52	0.38	1.35	19.7	8.6	
861.7	BKFL	340	589.45	0.001117	6.32	3.93	117.33	32.9	3.57	29.84	2.9	0.25	0.72	10.5	7.6	
808.3	BKFL	340	589.17	0.00356	4.72	3.01	77.9	28.19	2.76	25.92	4.36	0.61	2.68	39.0	8.6	
745.7	BKFL	340	588.96	0.003534	4.1	2.77	81.27	31.17	2.61	29.37	4.18	0.58	2.41	35.1	10.6	
680.1	BKFL	340	588.71	0.004073	4.57	2.44	81.49	34.9	2.33	33.43	4.17	0.59	2.48	36.1	13.7	#6
638.2	BKFL	340	587.9	0.018134	3.03	1.64	49.87	31.34	1.59	30.41	6.82	1.8	12.28	178.8	18.5	
613.3	BKFL	340	587.82	0.010622	2.09	1.41	70.99	50.74	1.4	50.2	4.79	0.93	4.44	64.6	35.6	
565.3	BKFL	340	587.59	0.005309	4.57	1.49	98	67.53	1.45	65.73	3.47	0.48	1.67	24.3	44.1	#7
519.4	BKFL	340	587.46	0.002298	3.51	2.24	112.58	50.97	2.21	50.15	3.02	0.32	0.96	14.0	22.4	
491.9	BKFL	340	587.42	0.002128	3.91	2.16	120.6	57.16	2.11	55.78	2.82	0.28	0.79	11.5	25.8	
425.6	BKFL	340	587.05	0.004355	4.04	2.36	80.83	35.97	2.25	34.24	4.21	0.61	2.57	37.4	14.5	
372.2	BKFL	340	586.76	0.004419	4.86	2.76	74.22	29.37	2.53	26.92	4.58	0.7	3.19	46.4	9.8	
314.5	BKFL	340	586.5	0.00443	4.48	2.72	73.7	28.91	2.55	27.11	4.61	0.7	3.25	47.3	10.0	
239.1	BKFL	340	586.29	0.003978	4.26	1.84	99.78	56.89	1.75	54.26	3.41	0.44	1.48	21.5	29.5	
213.6	BKFL	340.0	586.01	0.005721	3.6	1.7	76.39	46.82	1.63	45.06	4.45	0.58	2.59	37.7	26.5	#8
188.1	BKFL	340	585.35	0.018934	2.57	1.55	51.03	34.3	1.49	32.91	6.66	1.76	11.72	170.6	21.2	
130.3	BKFL	340	585.42	0.002197	4.83	3.06	97.08	34.02	2.85	31.75	3.5	0.39	1.37	19.9	10.4	
79.1	BKFL	340	585.08	0.004288	4.21	3.15	70.59	25.33	2.79	22.42	4.82	0.75	3.59	52.3	7.1	
20.8	BKFL	340	584.87	0.004003	4.23	3.04	74.92	27.92	2.68	24.64	4.54	0.67	3.04	44.3	8.1	

Table 9. McKee Creek - Reach #2 (HEC-RAS Bankfull Model Output)

River Sta	Profile	Q Total (cfs)	W.S. Elev (ft)	E.G. Slope (ft/ft)	Max Chl Dpth (ft)	Hydr Depth C (ft)	Flow Area Ch (sq ft)	W.P. Channel (ft)	Hydr Radius C (ft)	Top W Chnl (ft)	Vel Chnl (ft/s)	Shear Chan (lb/sq ft)	Power Chan (lb/ft s)	W/D Ratio	Cross Section #
1504.877	BKFL	350	580.98	0.000953	4.94	3.03	133.38	47.09	2.83	44.05	2.62	0.17	0.4	15.6	
1452.157	BKFL	350	580.87	0.001573	4.52	2.61	113.28	45.58	2.49	43.36	3.09	0.24	0.8	17.4	
1384.994	BKFL	350	580.81	0.000924	5.8	3.38	125.43	39.45	3.18	37.09	2.79	0.18	0.5	11.7	
1331.401	BKFL	350	580.76	0.000986	4.35	3.19	120.27	39.48	3.05	37.68	2.8	0.19	0.5	12.4	
1287.24	BKFL	350	580.77	0.000603	6.05	2.86	172.06	63.87	2.69	60.11	2.02	0.1	0.2	22.3	Check
1233.479	BKFL	350	580.55	0.001669	4.56	3.41	94.36	30.19	3.13	27.71	3.71	0.33	1.2	8.9	
1184.566	BKFL	350	580.56	0.000763	5.55	4.02	126.21	34.72	3.63	31.43	2.77	0.17	0.5	8.7	
1139.055	BKFL	350	580.49	0.001101	5.69	3.5	114.56	35.88	3.19	32.7	3.05	0.22	0.7	10.3	
1102.629	BKFL	350	580.39	0.00187	6.44	3.22	99.14	37.22	2.66	30.77	3.53	0.31	1.1	11.6	Check
1063.159	BKFL	350	580.29	0.001779	5.54	3.36	93.45	30.89	3.02	27.8	3.75	0.34	1.3	9.2	
983.344	BKFL	350	579.86	0.004409	3.96	2.76	67.96	27.52	2.47	24.59	5.15	0.68	3.5	10.0	#9
949.768	BKFL	350	579.88	0.002247	6.28	3.22	88.36	31.99	2.76	27.4	3.96	0.39	1.5	9.9	
905.854	BKFL	350	579.84	0.001439	5.45	3.57	99.83	31.09	3.21	27.94	3.51	0.29	1.0	8.7	
858.974	BKFL	350	579.68	0.002258	4.93	3.18	85.48	29.57	2.89	26.86	4.09	0.41	1.7	9.3	
803.61	BKFL	350	579.69	0.001089	3.84	2.83	125.85	45.7	2.75	44.42	2.75	0.19	0.5	16.2	
747.785	BKFL	350	579.51	0.002002	4.23	2.96	94.02	34.28	2.74	31.75	3.72	0.34	1.3	11.6	
686.937	BKFL	350	579.26	0.003024	4.16	2.79	79.37	30.57	2.6	28.44	4.41	0.49	2.2	10.9	
630.637	BKFL	350	579.18	0.002091	3.73	2.84	93.88	35.27	2.66	33.03	3.73	0.35	1.3	12.4	
586.045	BKFL	350	579.05	0.002362	4.32	2.82	87.58	32.57	2.69	31.07	3.99	0.4	1.6	11.6	
536.77	BKFL	350	579.04	0.001166	4.62	3.27	115.96	38.59	3	35.42	3.02	0.22	0.7	11.8	
486.744	BKFL	350	578.95	0.001299	5.47	3.48	105.14	32.77	3.21	30.24	3.33	0.26	0.9	9.4	
436.747	BKFL	350	578.77	0.002457	4.72	2.91	86.7	32.64	2.66	29.81	4.04	0.41	1.7	11.2	#11
390.268	BKFL	350	578.62	0.0028	4.29	2.86	82.27	31.57	2.61	28.77	4.25	0.46	1.9	11.0	
348.811	BKFL	350	578.48	0.002982	4.47	2.88	80.14	30.99	2.59	27.81	4.37	0.48	2.1	10.7	
293.013	BKFL	350	578.5	0.001038	4.26	3.43	118.57	37.39	3.17	34.53	2.95	0.21	0.6	10.9	
238.354	BKFL	350	578.24	0.002888	4.01	2.77	81.1	31.17	2.6	29.25	4.32	0.47	2.0	11.3	
183.705	BKFL	350	578.14	0.002329	5.33	3.04	88.2	32.72	2.7	29	3.97	0.39	1.6	10.7	
131.688	BKFL	350	578.05	0.001824	5.75	3.27	95.52	33.25	2.87	29.17	3.66	0.33	1.2	10.2	
87.574	BKFL	350	577.8	0.003649	3.63	2.63	75.37	30.93	2.44	28.67	4.64	0.56	2.6	11.8	
38.737	BKFL	350	577.67	0.003	4.29	2.88	79.32	30.34	2.61	27.58	4.41	0.49	2.2	10.6	

Table 10. Clear Creek (HEC-RAS Bankfull Model Output)

River Sta	Profile	Q Total (cfs)	W.S. Elev (ft)	E.G. Slope (ft/ft)	Max Chl Dpth (ft)	Hydr Depth C (ft)	Flow Area Ch (sq ft)	W.P. Channel (ft)	Hydr Radius C (ft)	Top W Chnl (ft)	Vel Chnl (ft/s)	Shear Chan (lb/sq ft)	Power Chan (lb/ft s)	W/D Ratio	Cross Section #
1543.267	BKFL	89	583.39	0.008295	2.6	1.32	19.01	15.58	1.22	14.44	4.68	0.63	3.0	11.8	#1
1487.218	BKFL	89	583.12	0.004623	2.56	1.64	22.51	15.34	1.47	13.69	3.95	0.42	1.7	9.3	#2
1444.336	BKFL	89	583.11	0.001609	2.99	1.89	34.29	19.9	1.72	18.16	2.6	0.17	0.5	10.6	
1364.241	BKFL	89	582.87	0.002999	2.34	1.61	27.52	18.32	1.5	17.11	3.23	0.28	0.9	11.4	
1293.322	BKFL	89	582.63	0.003283	2.63	1.7	25.89	16.83	1.54	15.23	3.44	0.32	1.1	9.9	
1214.657	BKFL	89	582.03	0.007299	3.03	1.87	17.71	11.85	1.49	9.45	5.03	0.68	3.4	6.3	
1140.916	BKFL	89	581.68	0.004818	2.59	1.84	21.03	13.35	1.58	11.4	4.23	0.47	2.0	7.2	#3
1069.104	BKFL	89	581.52	0.00267	2.26	1.55	29.7	20.33	1.46	19.17	3	0.24	0.7	13.1	#4
972.654	BKFL	89	581.1	0.004003	2.71	1.83	22.7	14.06	1.61	12.44	3.92	0.4	1.6	7.7	#5
885.923	BKFL	89	580.78	0.004538	2.62	1.21	27.3	24.49	1.11	22.59	3.26	0.32	1.0	20.4	
778.451	BKFL	89	580.62	0.001106	3.7	2.19	37.92	19.33	1.96	17.35	2.35	0.14	0.3	8.9	
680.988	BKFL	89	580.41	0.002038	3.29	2.32	28.28	14.87	1.9	12.17	3.12	0.24	0.8	6.4	
595.63	BKFL	89	580.4	0.000579	3.96	2.55	41.04	18.62	2.2	16.12	1.83	0.08	0.2	7.3	
536.342	BKFL	89	580.39	0.000195	5.25	3.26	58.68	21.08	2.78	18	1.24	0.03	0.0	6.5	
509.212	BKFL	89	578.3	0.002172	3.33	2.09	28.47	15.66	1.82	13.59	3.13	0.25	0.8	7.5	
443.705	BKFL	89	578.31	0.000325	3.76	2.52	63.63	28.15	2.26	25.24	1.4	0.05	0.1	11.2	
365.317	BKFL	89	578.13	0.002413	2.76	1.7	29.43	18.41	1.6	17.31	3.02	0.24	0.7	10.8	
285.48	BKFL	89	577.96	0.002125	2.82	1.81	30.64	18.52	1.65	16.93	2.9	0.22	0.6	10.3	#7
218.437	BKFL	89	577.98	0.000357	3.14	2.21	63.62	30.88	2.06	28.78	1.38	0.05	0.1	14.0	#8
121.043	BKFL	89	577.31	0.016844	1.64	1.07	14.99	14.64	1.02	13.97	5.94	1.08	6.4	13.7	
73.051	BKFL	89	577.18	0.004004	2	1.36	26.19	20.1	1.3	19.27	3.4	0.33	1.1	14.8	

Table 11 - **Sediment Transport Competency Analysis Using HEC-RAS Bankfull Model (McKee Creek - Reach #1)**

Shear Stress Analysis - Survey Data	**Existing Cross-sections**						**Proposed**
Feature	XSC#1	XSC#2	XSC#5	XSC#6	XSC#7	XSC#8	Design XSC
Bankfull Cross Sectional Area, Abkf (sq ft)	88.1	89.08	88.9	81.5	98	76.39	80
Bankfull Width, Wbkf (ft)	26.1	24.6	24.0	33.4	65.7	45.1	31.0
Bankfull Mean Depth, Dbkf (ft)	**3.4**	**3.6**	**3.7**	**2.4**	**1.5**	**1.7**	**2.6**
Wetted Perimeter, WP=W+2D (ft)	29.0	28.2	27.7	34.9	67.5	46.8	32.5
Hydraulic Radius, R=Abkf/WP (ft)	3.04	3.16	3.21	2.34	1.45	1.63	2.46
Average Channel Slope, Se (ft/ft)	**0.00290**	**0.00290**	**0.00290**	**0.00290**	**0.00290**	**0.00290**	**0.00320**
Boundary Shear Stress, τ (lb/sq ft)	0.61	0.66	0.67	0.44	0.27	0.31	0.52
Median Diameter of Pavement, D_{50} (mm)	57	57	57	57	57	57	57
Median Diameter of Sub-pavement, $D\hat{}_{50}$ (mm)	24	24	24	24	24	24	24
Critical Dimensionless Shear Stress, τ_{ci}	0.0392	0.0392	0.0392	0.0392	0.0392	0.0392	0.0392
Largest Particle from Sub-Pavement, D_i (mm)	45	45	45	45	45	45	45
Largest Particle from Sub-Pavement, D_i (ft)	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Required Mean Bankfull Depth, Dr (ft)	**3.3**	**3.3**	**3.3**	**3.3**	**3.3**	**3.3**	**3.0**
Required Mean Bankfull Slope, Sr (ft/ft)	**0.0028**	**0.0026**	**0.0026**	**0.0039**	**0.0064**	**0.0056**	**0.0037**

Table 12 - **Sediment Transport Competency Analysis Using HEC-RAS Bankfull Model (McKee Creek - Reach #2)**

Shear Stress Analysis - Survey Data	**Existing Cross-sections**				**Proposed**
Feature	XSC#9	XSC#11	Check (RS 1287.2)	Check (RS 1102.6)	Design XSC
Bankfull Cross Sectional Area, Abkf (sq ft)	67.96	86.7	172.06	99.4	85
Bankfull Width, Wbkf (ft)	24.59	29.81	60.1	30.8	31.9
Bankfull Mean Depth, Dbkf (ft)	**2.8**	**2.9**	**2.9**	**3.2**	**2.7**
Wetted Perimeter, WP=W+2D (ft)	27.5	32.6	63.9	37.2	27.4
Hydraulic Radius, R=Abkf/WP (ft)	2.47	2.66	2.69	2.67	3.10
Average Channel Slope, Se (ft/ft)	**0.00180**	**0.00180**	**0.00180**	**0.00180**	**0.00230**
Boundary Shear Stress, τ (lb/sq ft)	0.31	0.33	0.32	0.36	0.38
Median Diameter of Pavement, D_{50} (mm)	57	57	57	57	57
Median Diameter of Sub-pavement, $D\hat{}_{50}$ (mm)	24	24	24	24	24
Critical Dimensionless Shear Stress, τ_{ci}	0.0392	0.0392	0.0392	0.0392	0.0392
Largest Particle from Sub-Pavement, D_i (mm)	45	45	45	45	45
Largest Particle from Sub-Pavement, D_i (ft)	0.15	0.15	0.15	0.15	0.15
Required Mean Bankfull Depth, Dr (ft)	**5.3**	**5.3**	**5.3**	**5.3**	**4.2**
Required Mean Bankfull Slope, Sr (ft/ft)	**0.0035**	**0.0033**	**0.0033**	**0.0030**	**0.0036**

9.0 Figures

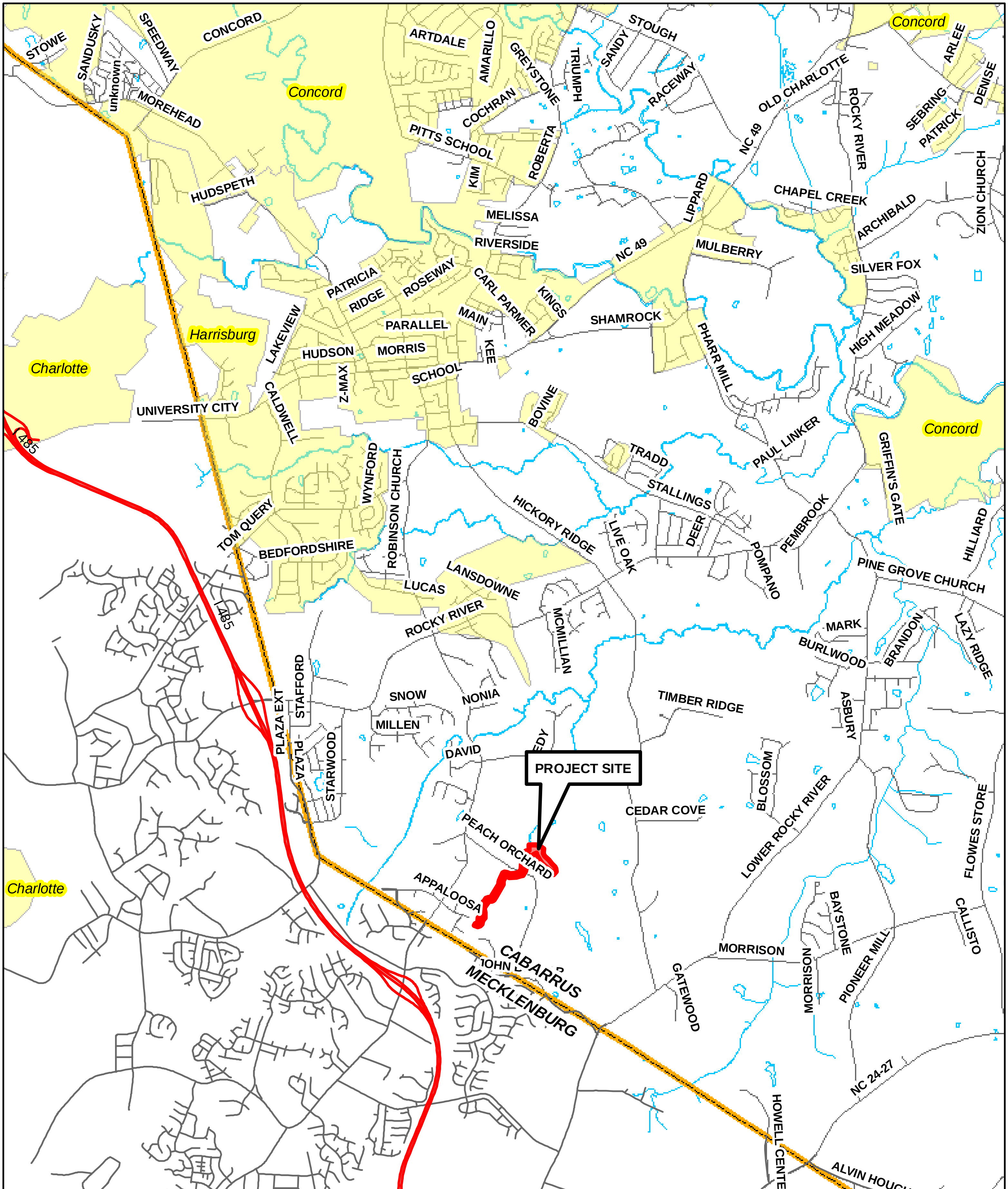

FIGURE #1 - VICINITY MAP
McKee Creek Project (D07063S)
Cabarrus County, NC
Date: 02/13/08

1 inch equals 5,000 feet

N

Ecosystem Enhancement PROGRAM

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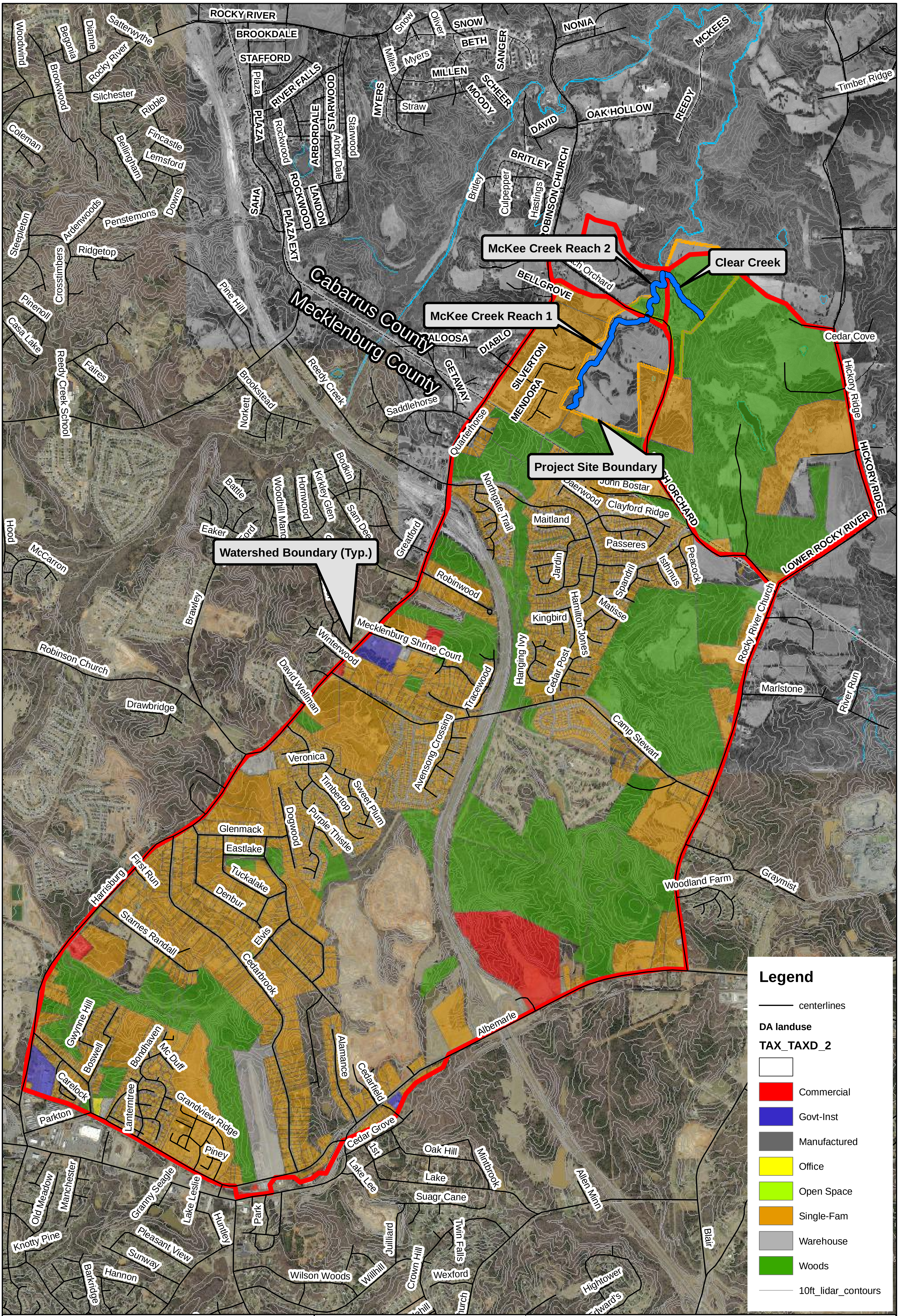

FIGURE #2 - Project Site Watershed Map
McKee Creek Project (D07063S)
Cabarrus County, NC
Date: 12/12/07
1 inch equals 2,000 feet

N

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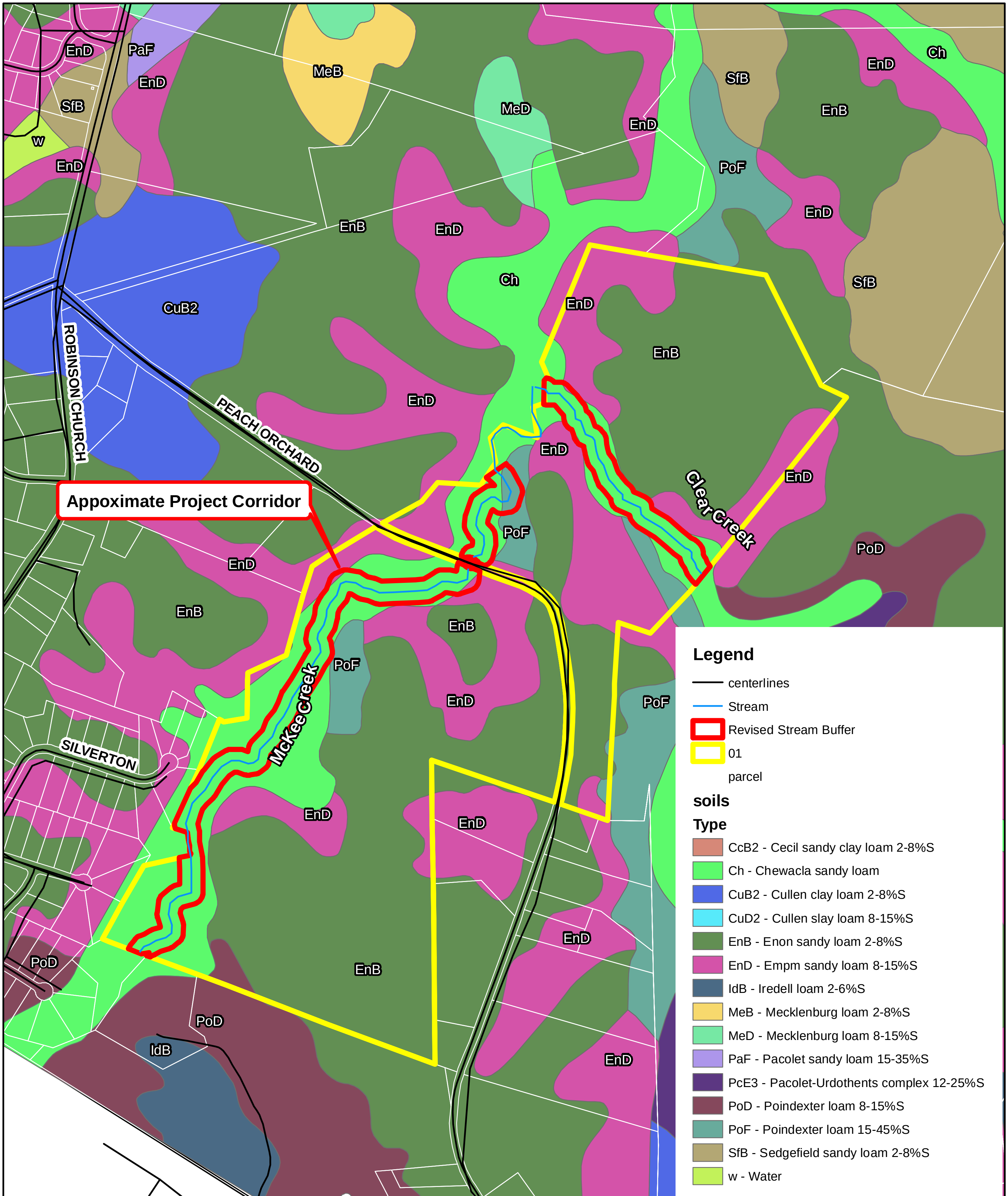

FIGURE #3 - Project Site NRCS Soil Survey Map

McKee Creek Project (D07063S)
Cabarrus County, NC
Date: 12/12/07

1 inch equals 700 feet

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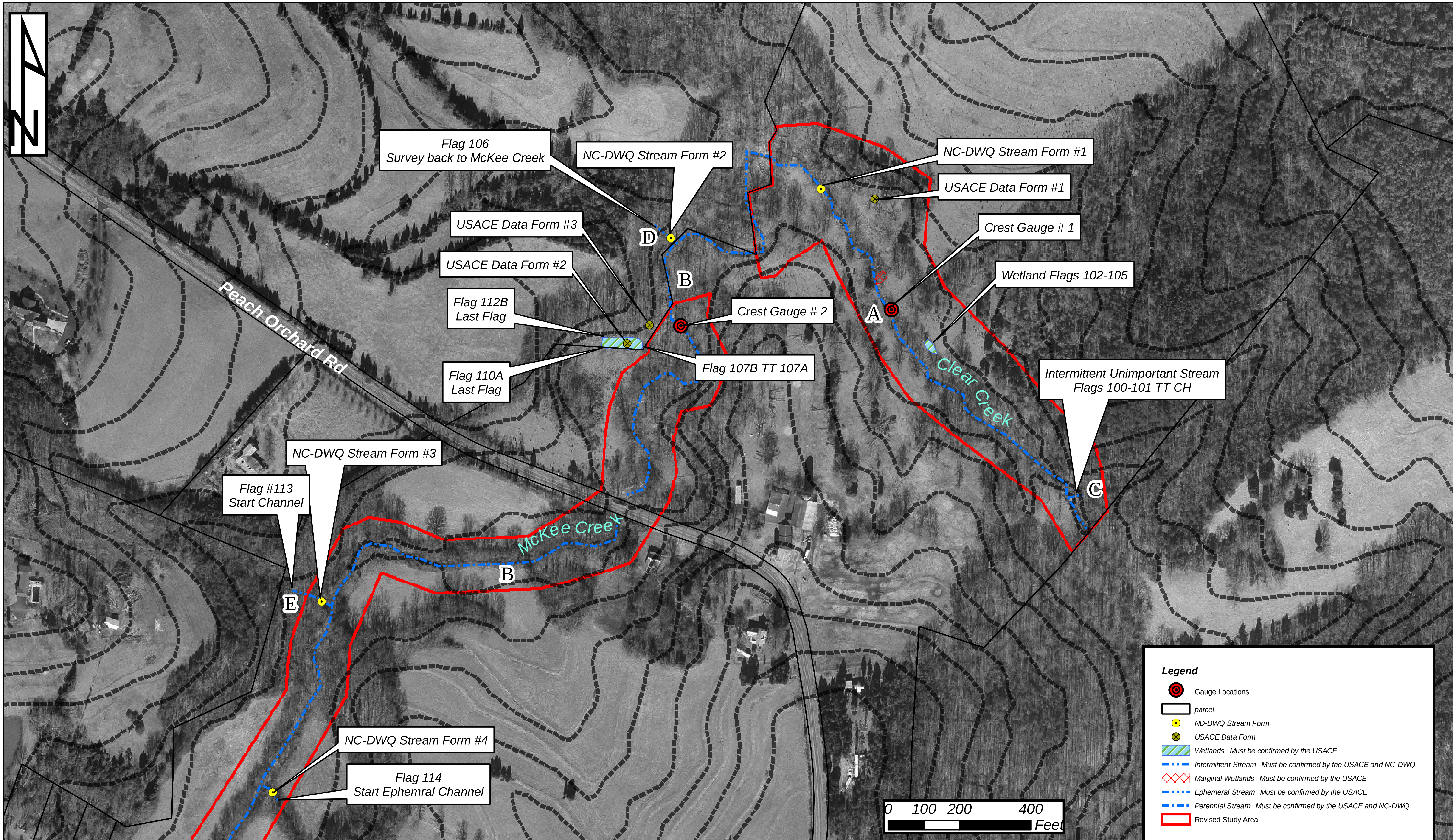

FIGURE #4A - Hydro. Features w/ Gauge Locations #1
McKee Creek Project (D07063S)
Cabarrus County, NC
Date: 01/04/2008
1 inch equals 248 feet

N

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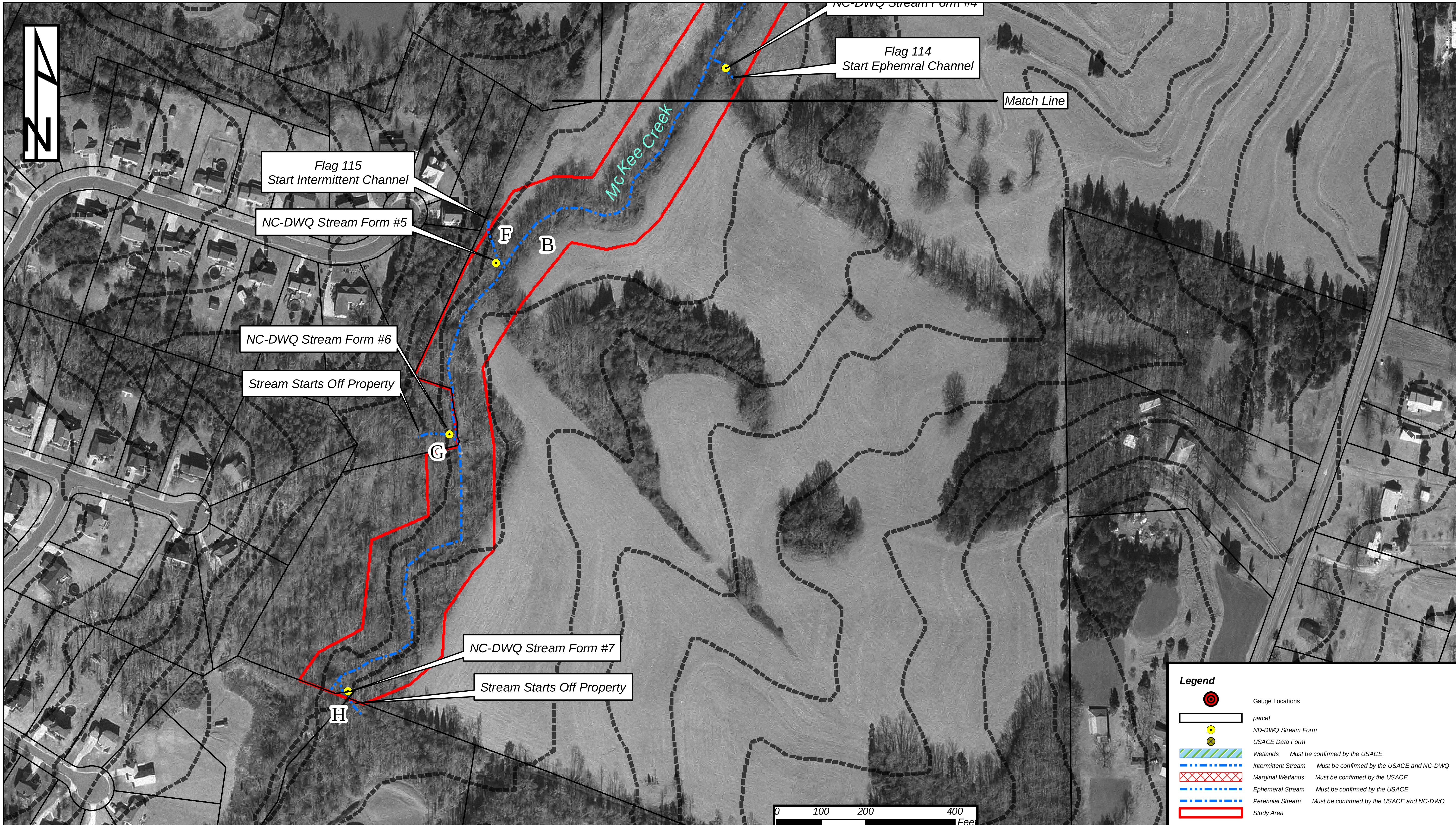

FIGURE #4B - Hydro. Features w/ Gauge Locations #2
McKee Creek Project (D07063S)
Cabarrus County, NC
Date: 01/04/08
1 inch equals 200 feet

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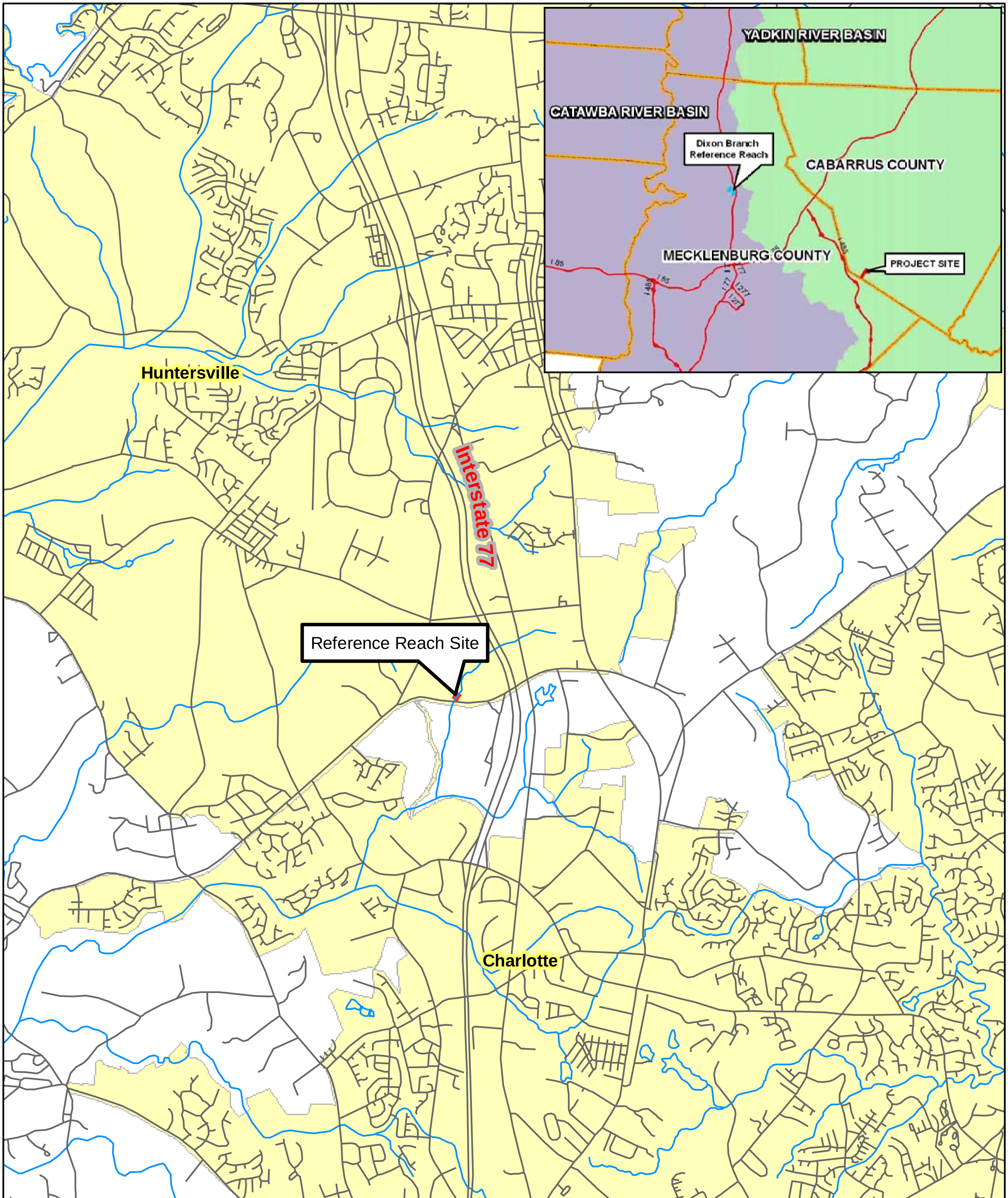

FIGURE #5 - Reference Site Vicinity Map

McKee Creek Project (D07063S)
Cabarrus County, NC
Date: 12/12/07
1 inch equals 5,000 feet

N

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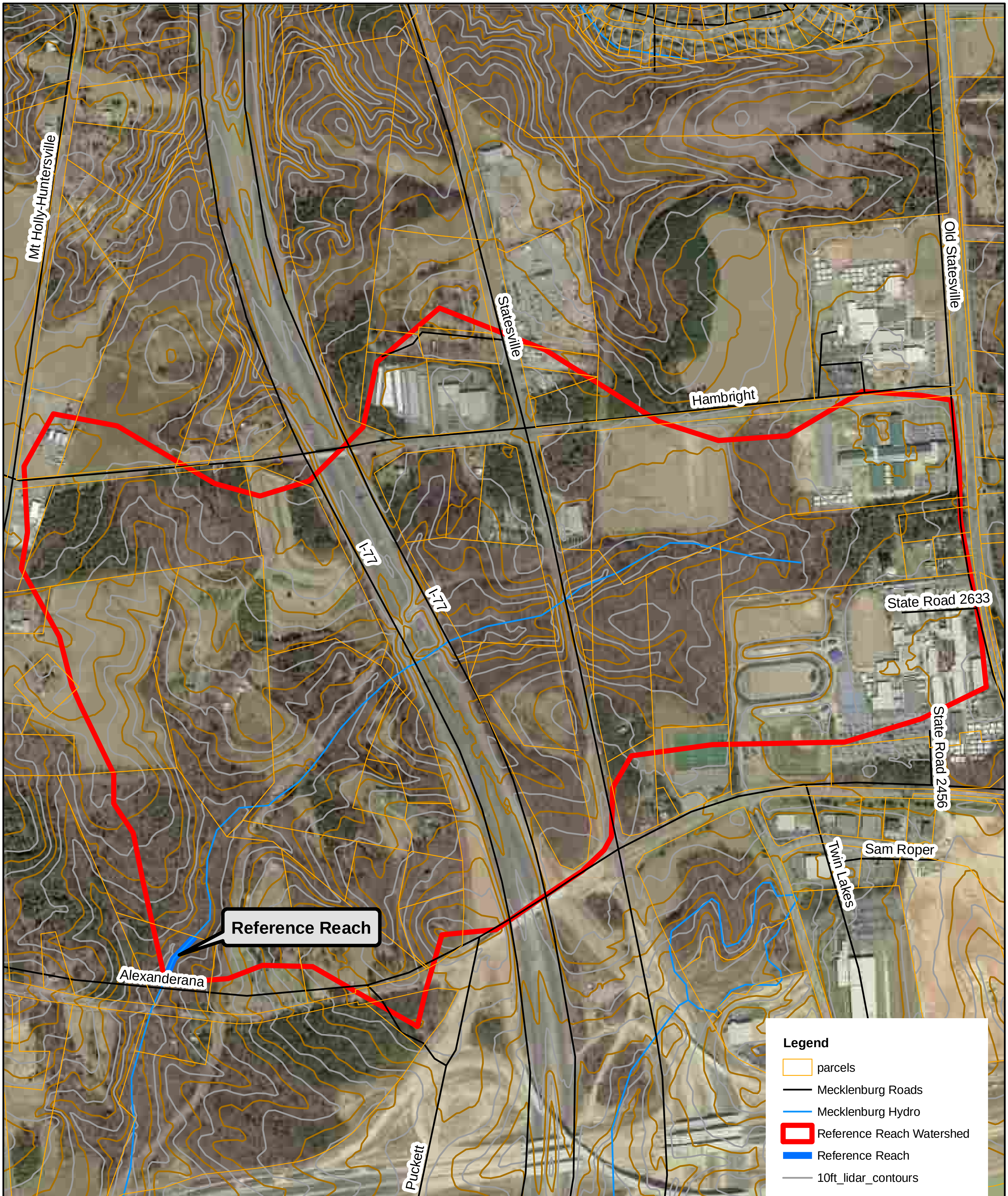

FIGURE #6 - Reference Site Watershed Map

McKee Creek Project (D07063S)
Cabarrus County, NC
Date: 12/12/07
1 inch equals 800 feet

N

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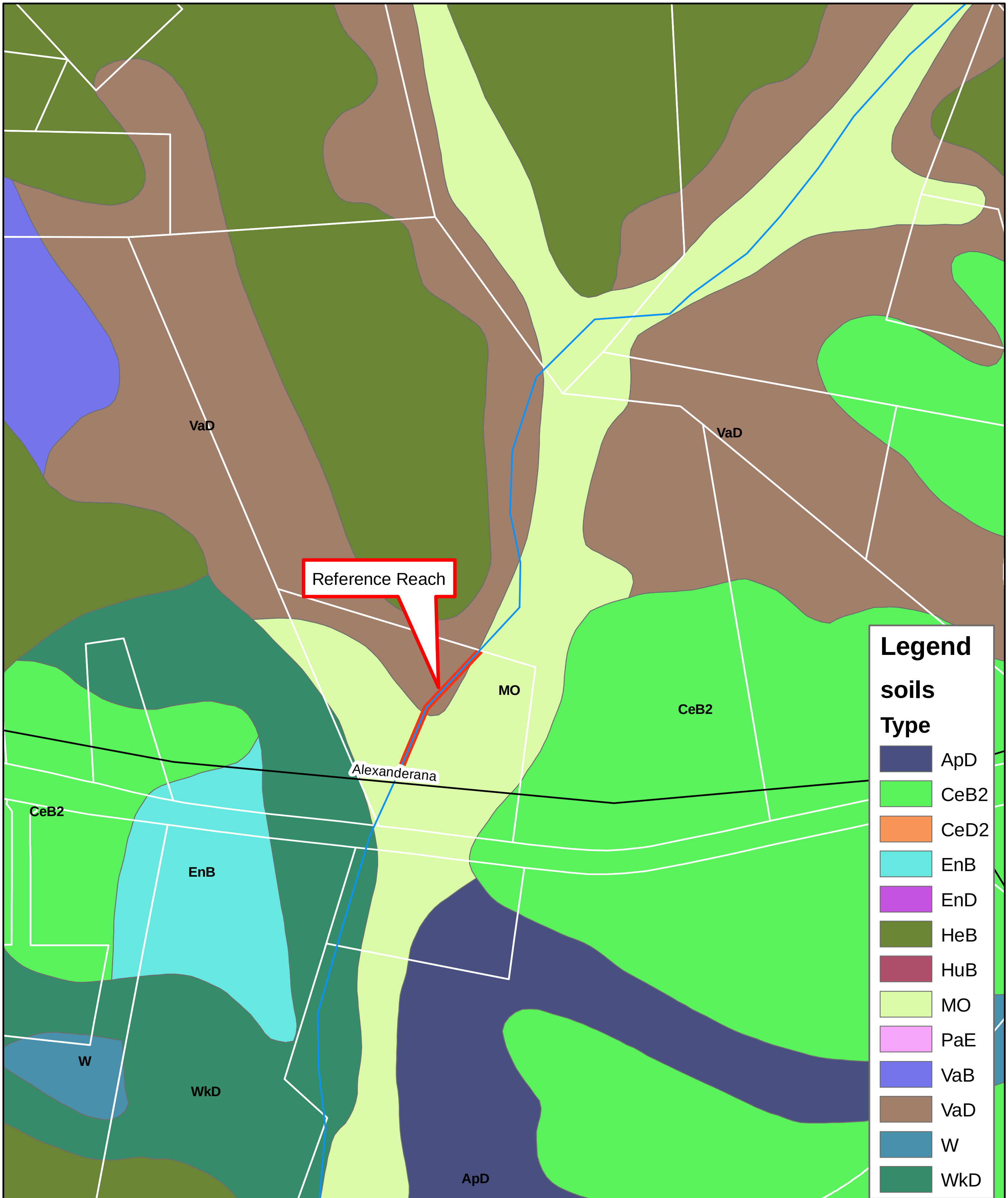

FIGURE #7 - Reference Site NRCS Soil Survey Map

McKee Creek Project (D07063S)
Cabarrus County, NC
Date: 12/12/07
1 inch equals 312 feet

N

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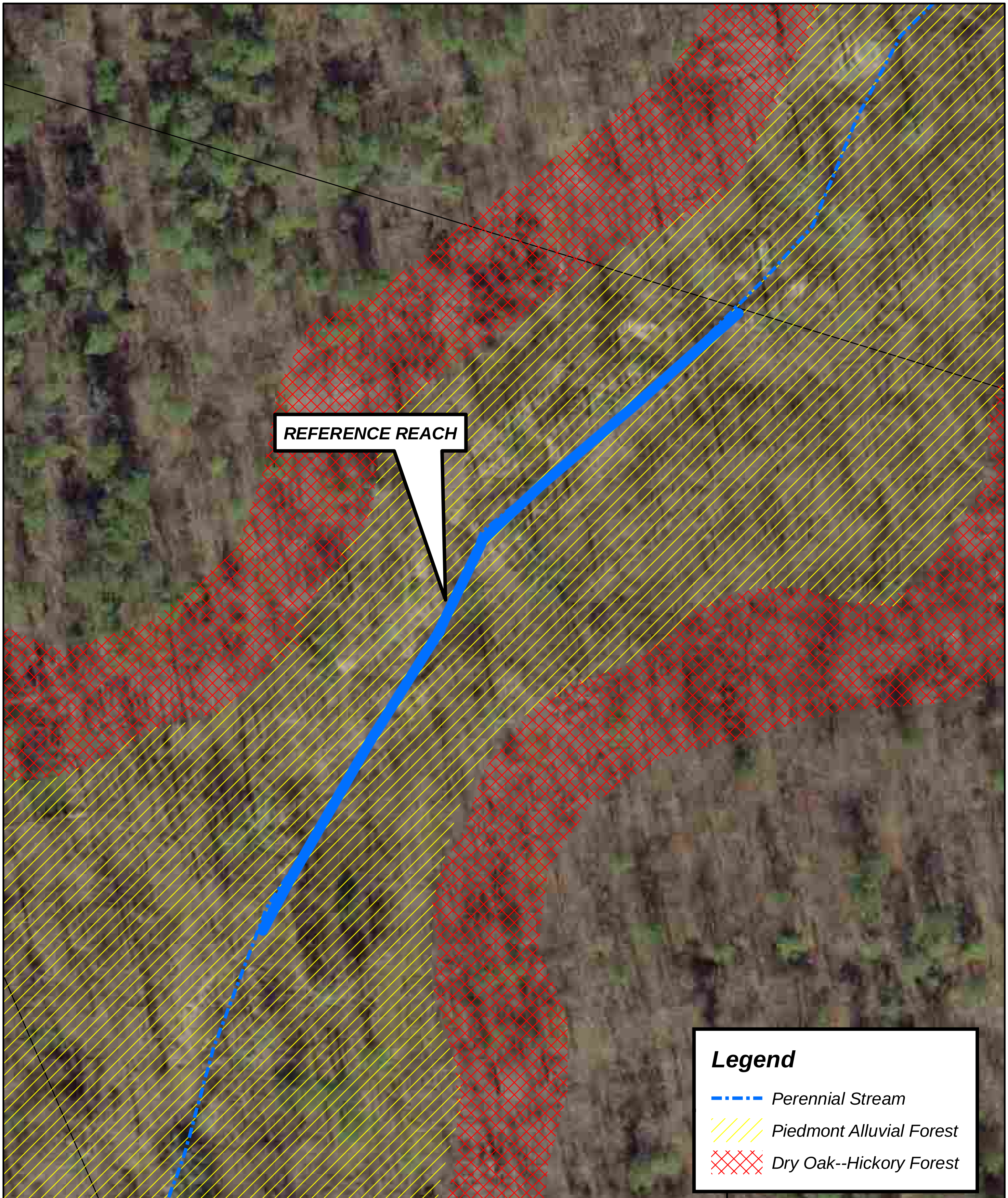

FIGURE #8 - Reference Reach Community Type Map

McKee Creek Project (D07063S)
Cabarrus County, NC
Date: 09/07/07
1 inch equals 50 feet

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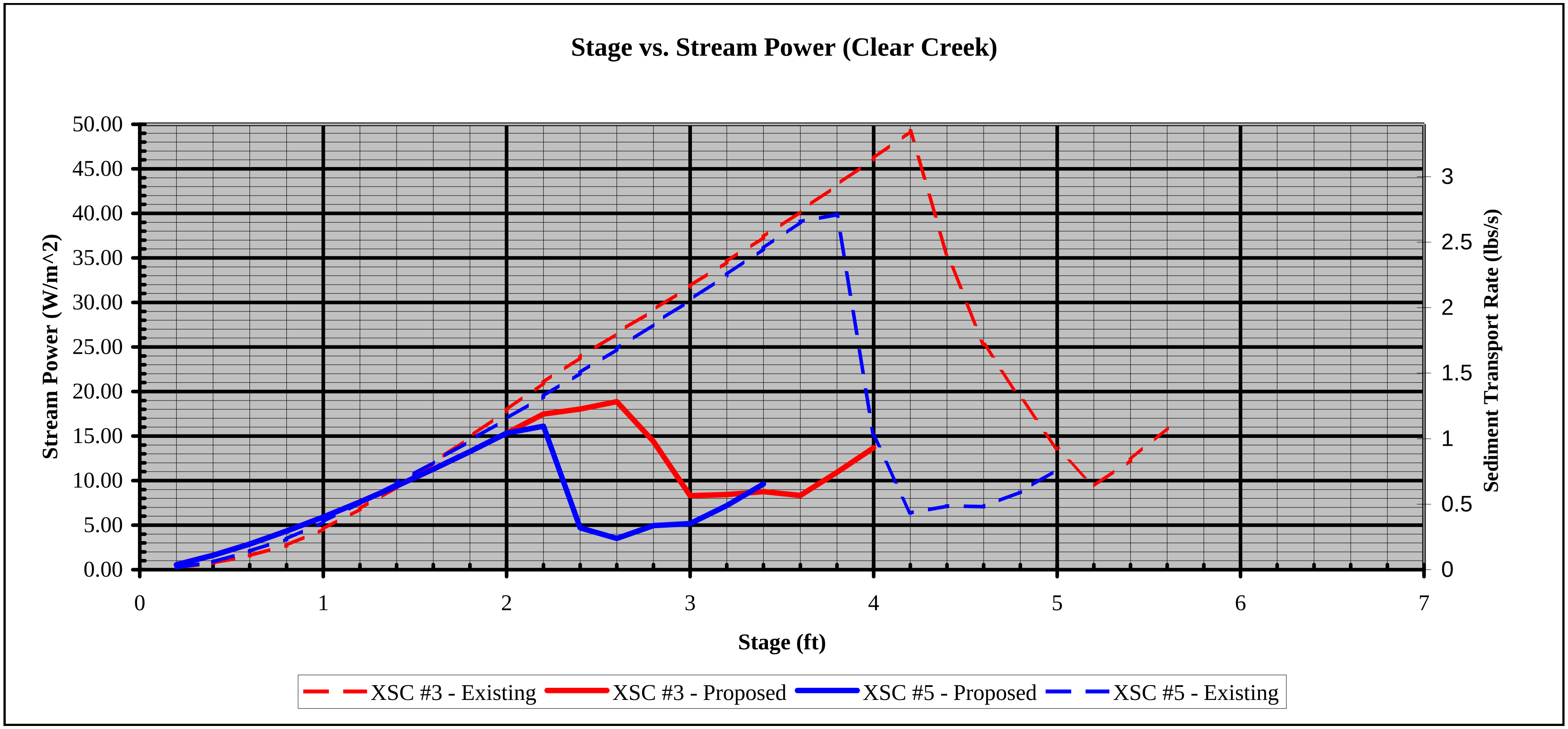
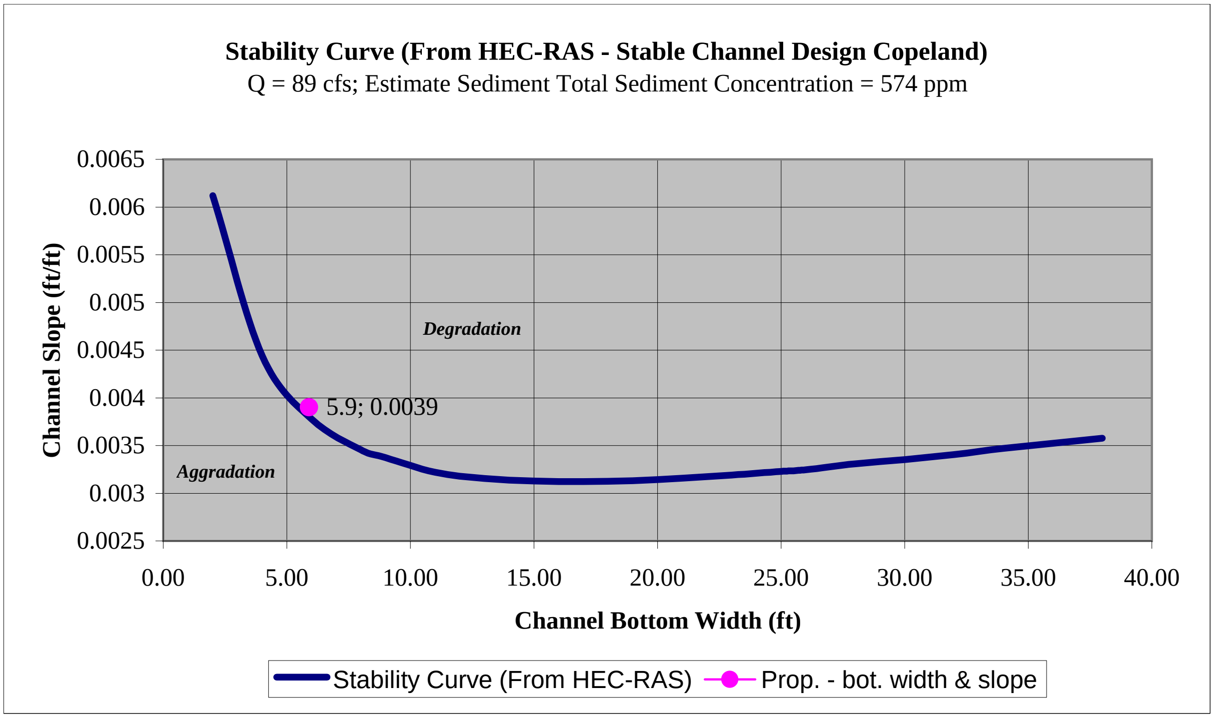
10.0 Exhibits



Maximum In-Channel Values	XSC #3	
	Ext.	Prop.
Q (cfs)	205	115
Stream Power (W/m^2)	49.2	18.9
Sed. Transport Rate (lbs/s)	3.4	1.3

Maximum In-Channel Values	XSC #5	
	Ext.	Prop.
Q (cfs)	163	82
Stream Power (W/m^2)	39.6	16.1
Sed. Transport Rate (lbs/s)	2.7	1.1

Exhibit 1 - Stage vs. Stream Power for Clear Creek (Existing compared to Design)



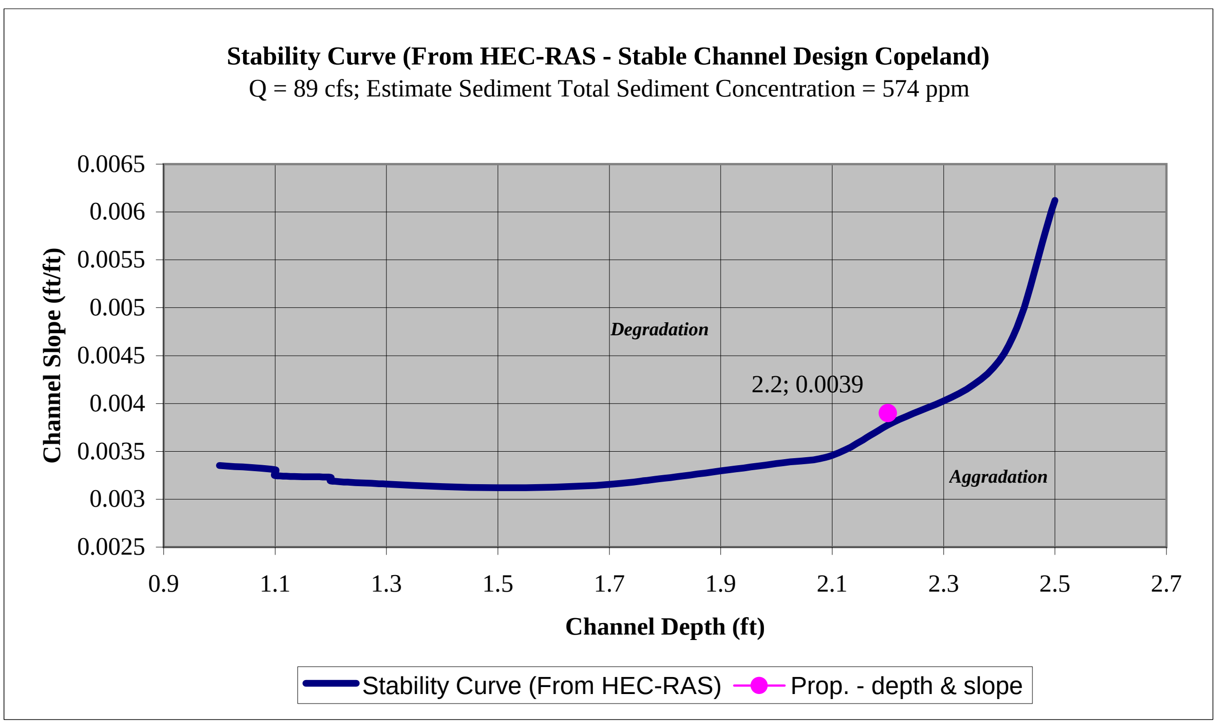


Exhibit 2 - Stability Curves From HEC-RAS (Clear Creek Design)

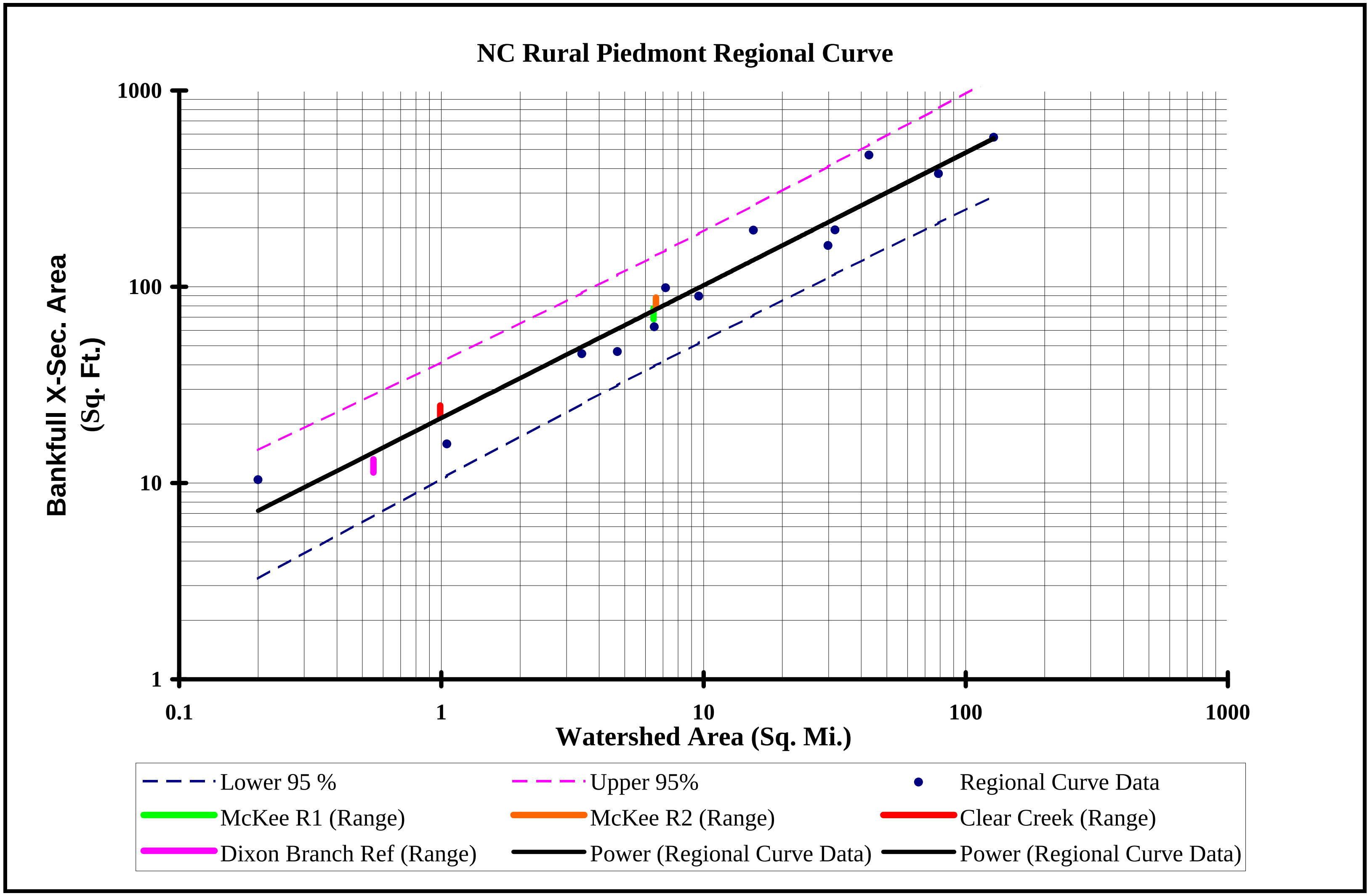
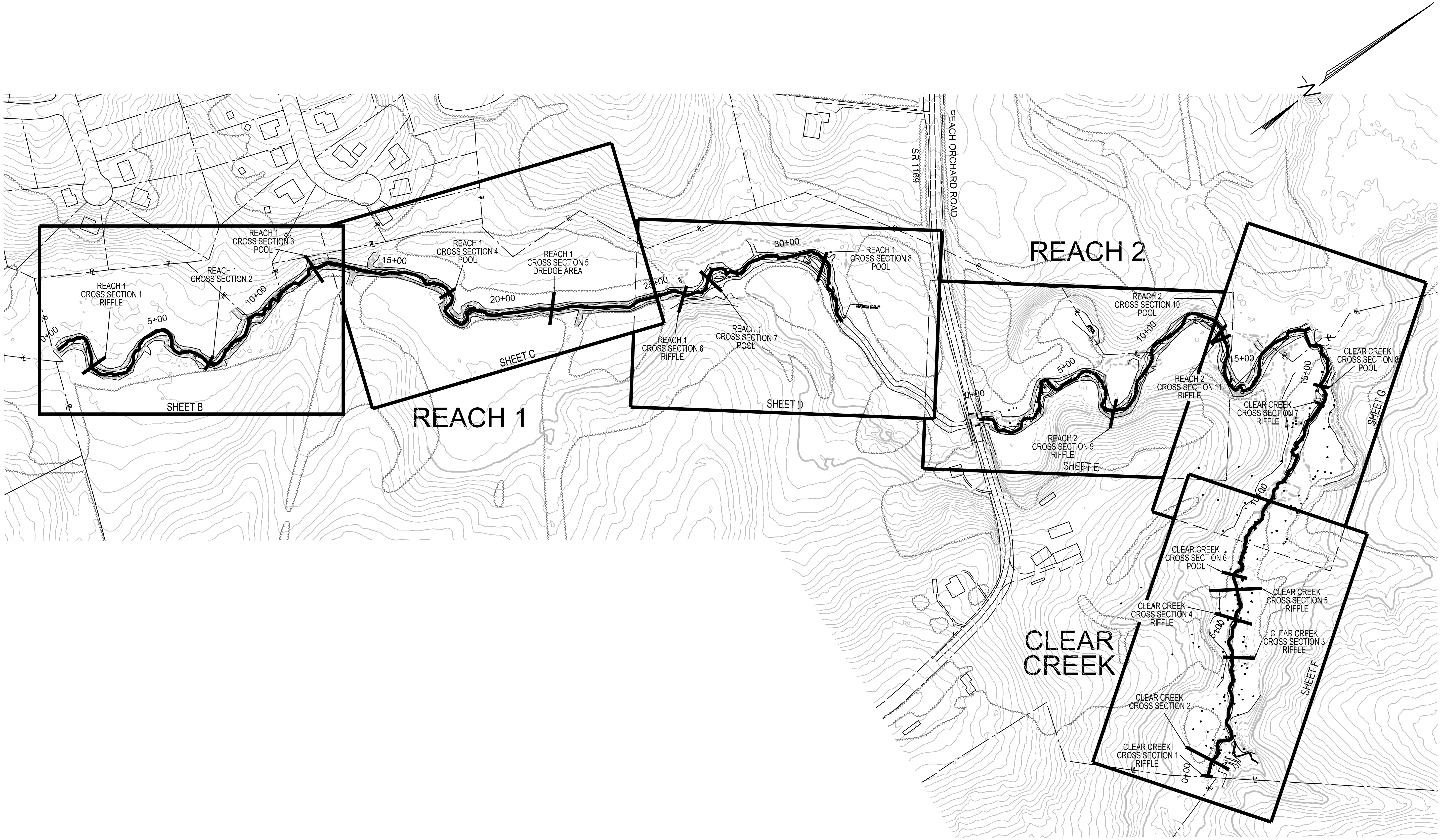


Exhibit 3 - NC Piedmont Rural Regional Curve, including project and reference reach surveyed data

11.0 Designed Sheets



No.	Revision	Date	By

Designer CHW	Scale 1" = 300'
Drawn By MFC	Date FEBRUARY 2008
Checked By CHW	Job No. 02070568.00

MCKEE CREEK RESTORATION PROJECT

CABARRUS COUNTY, NORTH CAROLINA

EXISTING SITE CONDITION
REACH 1, REACH 2 & CLEAR CREEK

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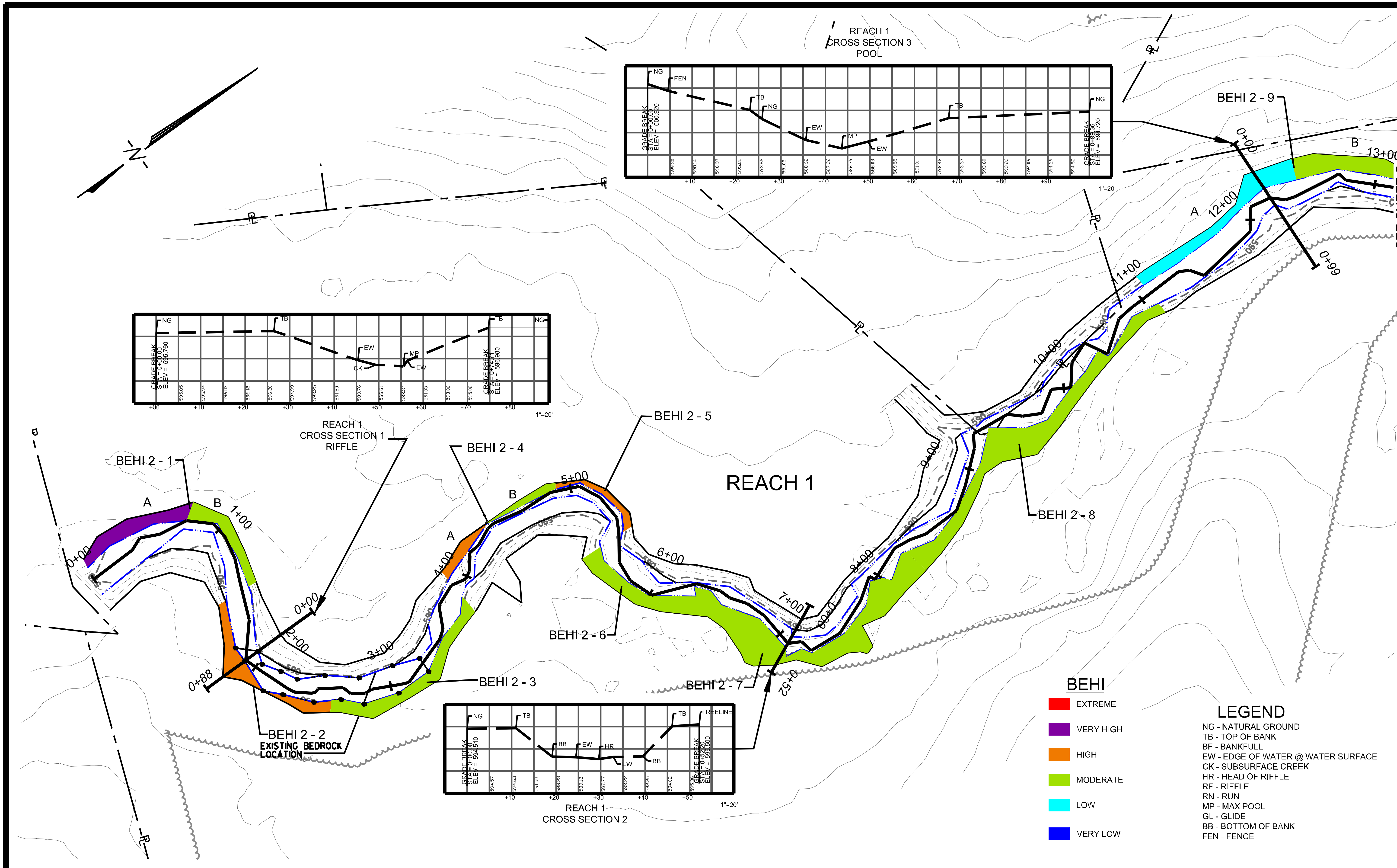
Sheet No.
A



No.	Revision	Date	By

Designer CHW	Scale 1" = 60'
Drawn By MFC	Date FEBRUARY 2008
Checked By CHW	Job No. 02070568.00

MCKEE CREEK RESTORATION PROJECT

CABARRUS COUNTY, NORTH CAROLINA

EXISTING SITE CONDITION
REACH 1

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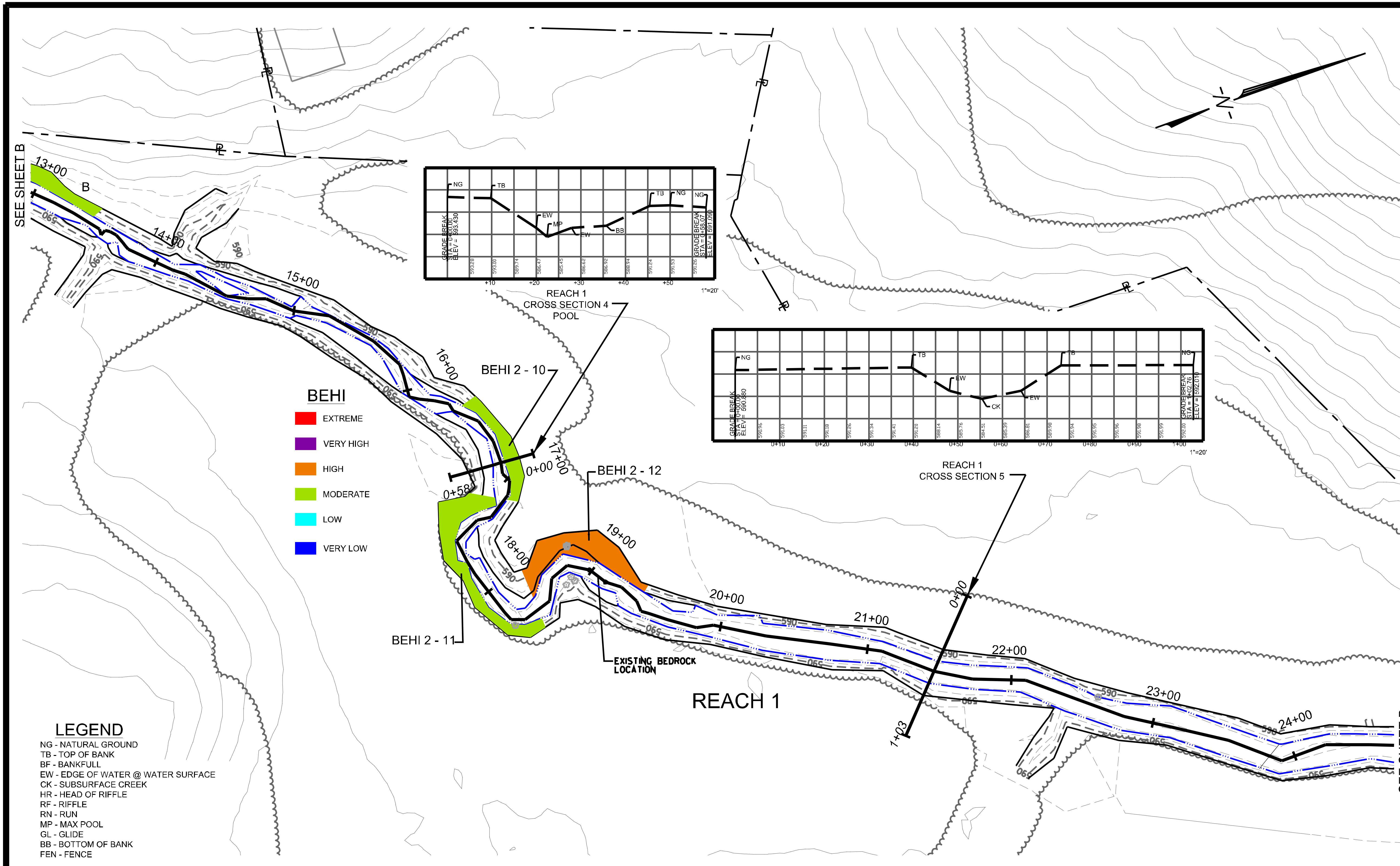
B



No.	Revision	Date	By

Designer CHW	Scale 1" = 60'
Drawn By MFC	Date FEBRUARY 2008
Checked By CHW	Job No. 02070568.00

MCKEE CREEK RESTORATION PROJECT

CABARRUS COUNTY, NORTH CAROLINA

EXISTING SITE CONDITION
REACH 1

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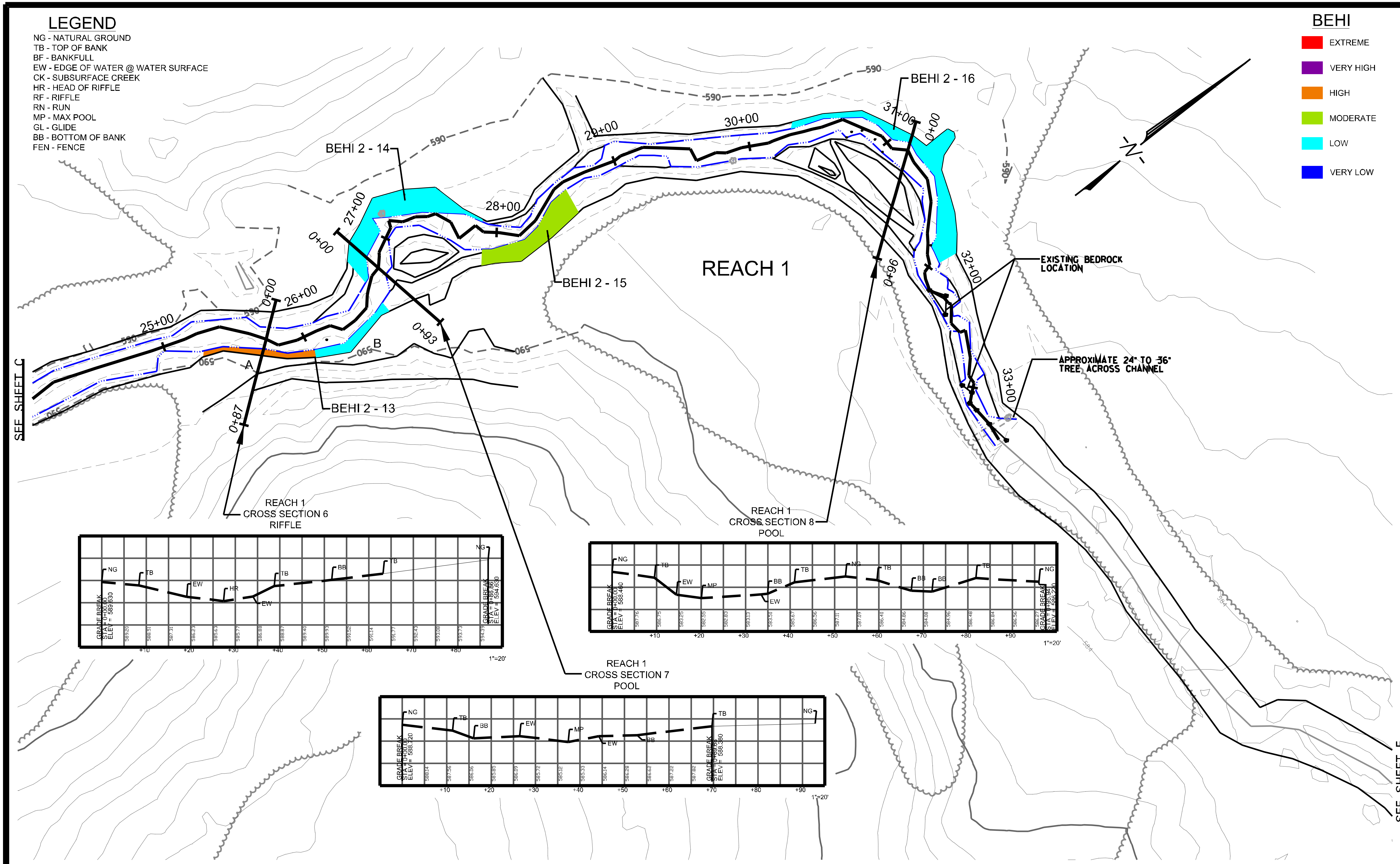
Sheet No. C



No.	Revision	Date	By

Designer CHW
Drawn By MFC
Checked By CHW
Scale 1" = 60'
Date FEBRUARY 2008
Job No. 02070568.00

MCKEE CREEK RESTORATION PROJECT

CABARRUS COUNTY, NORTH CAROLINA

EXISTING SITE CONDITION
REACH 1

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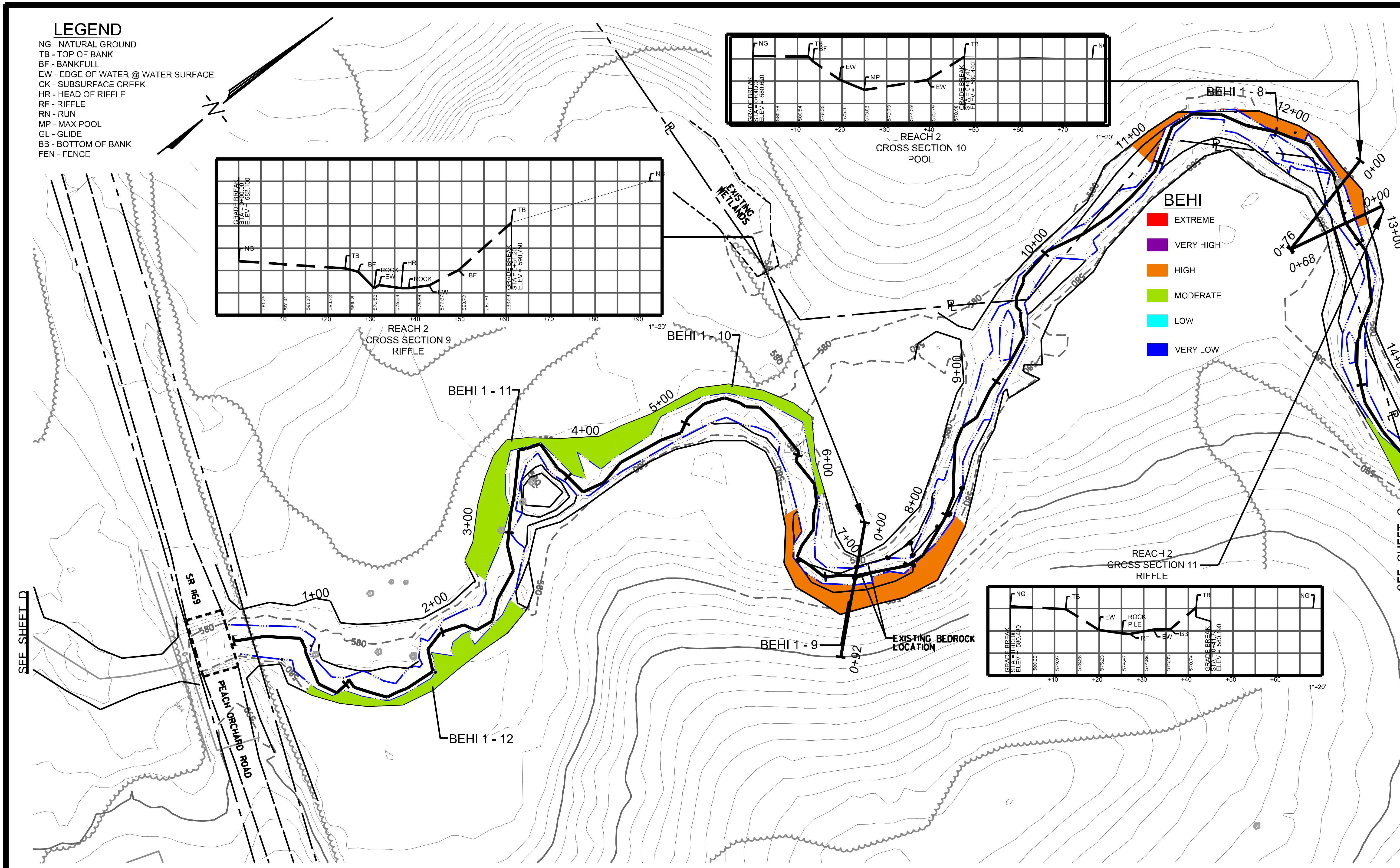

No.	Revision	Date	By

Designer CHW | Scale 1" = 60'
Drawn By MFC | Date FEBRUARY 2008
Checked By CHW | Job No. 02070568.00

MCKEE CREEK RESTORATION PROJECT
CABARRUS COUNTY, NORTH CAROLINA

EXISTING SITE CONDITION
REACH 2

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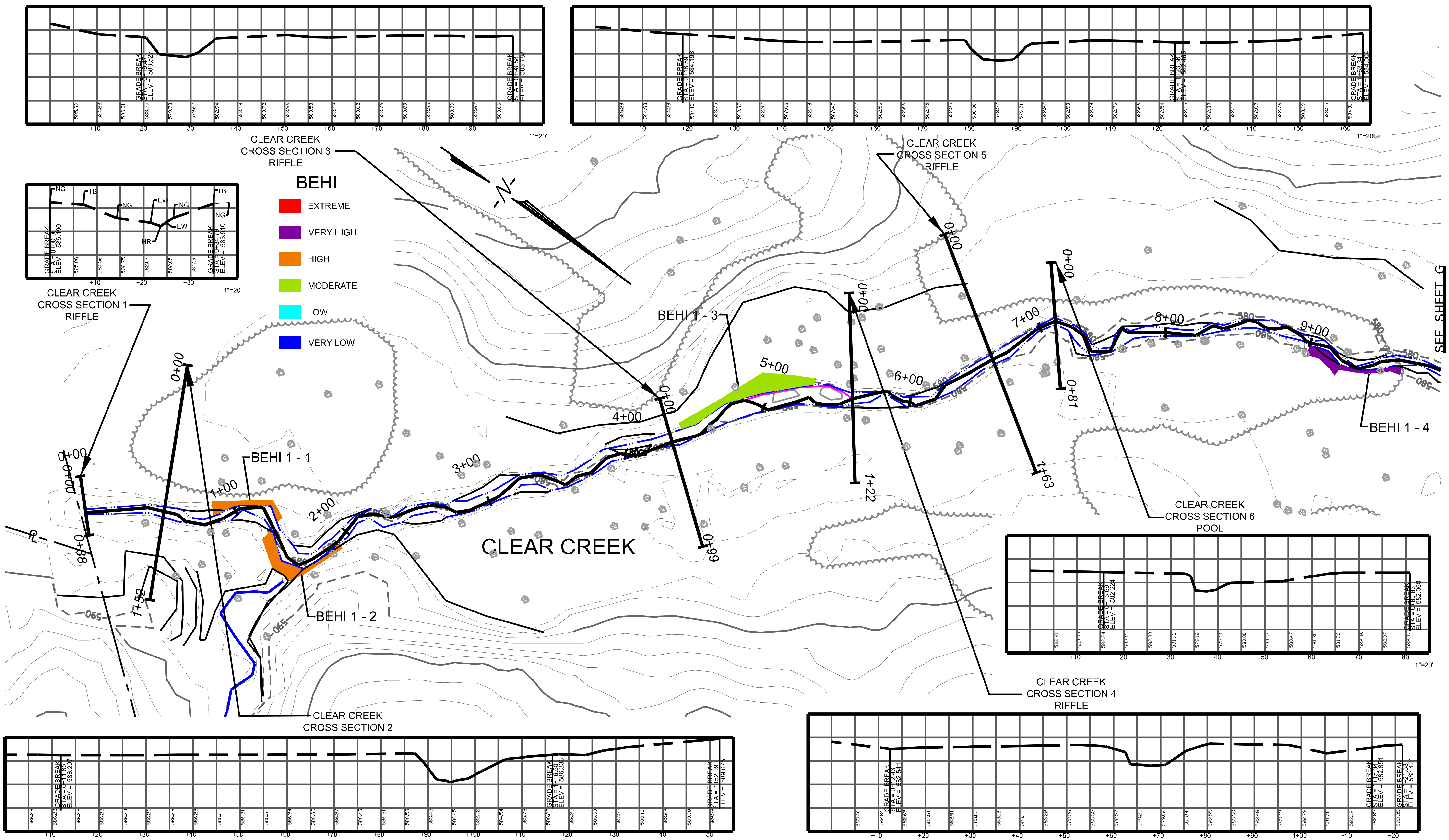

No.	Revision	Date	By

Designer CHW | Scale 1" = 60'
Drawn By MFC | Date FEBRUARY 2008
Checked By CHW | Job No. 02070568.00

MCKEE CREEK RESTORATION PROJECT
CABARRUS COUNTY, NORTH CAROLINA

EXISTING SITE CONDITION
CLEAR CREEK

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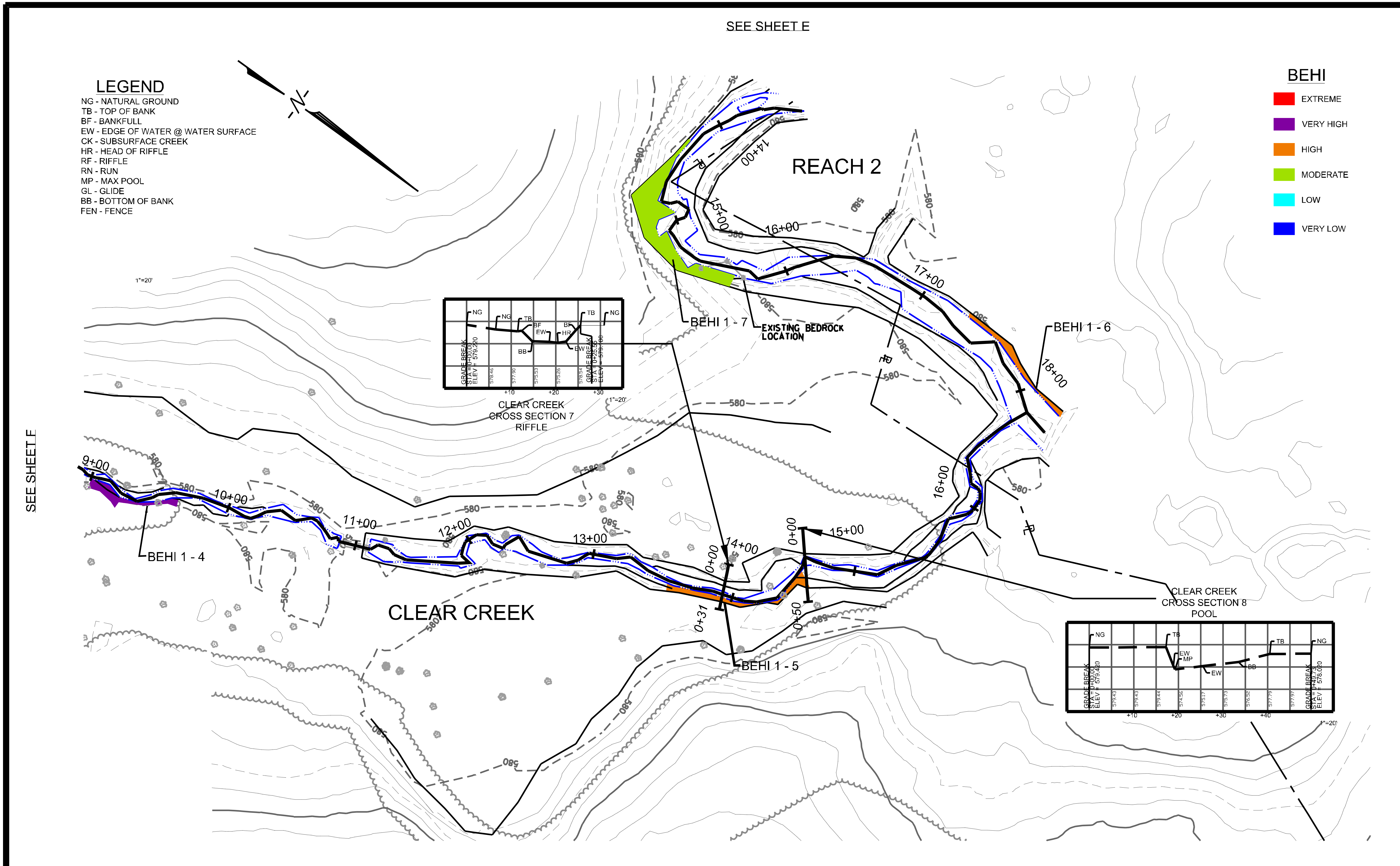
F



No.	Revision	Date	By

Designer CHW	Scale 1" = 60'
Drawn By MFC	Date FEBRUARY 2008
Checked By CHW	Job No. 02070568.00

MCKEE CREEK RESTORATION PROJECT

CABARRUS COUNTY, NORTH CAROLINA

EXISTING SITE CONDTION
REACH 1 & CLEAR CREEK

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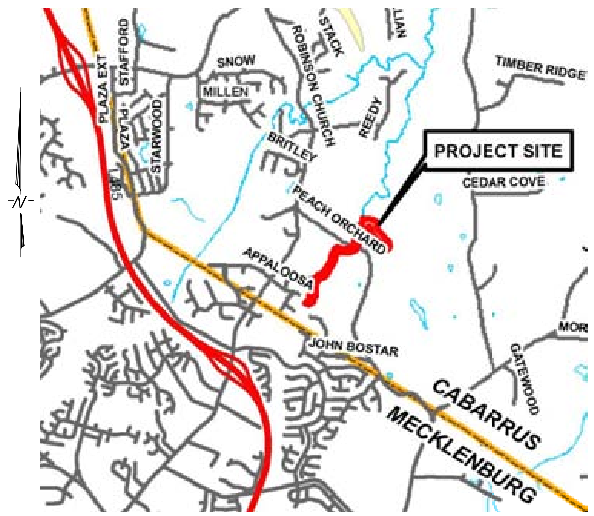
Sheet No. G

MCKEE CREEK RESTORATION PROJECT
ECOSYSTEM ENHANCEMENT PROGRAM

CABARRUS COUNTY

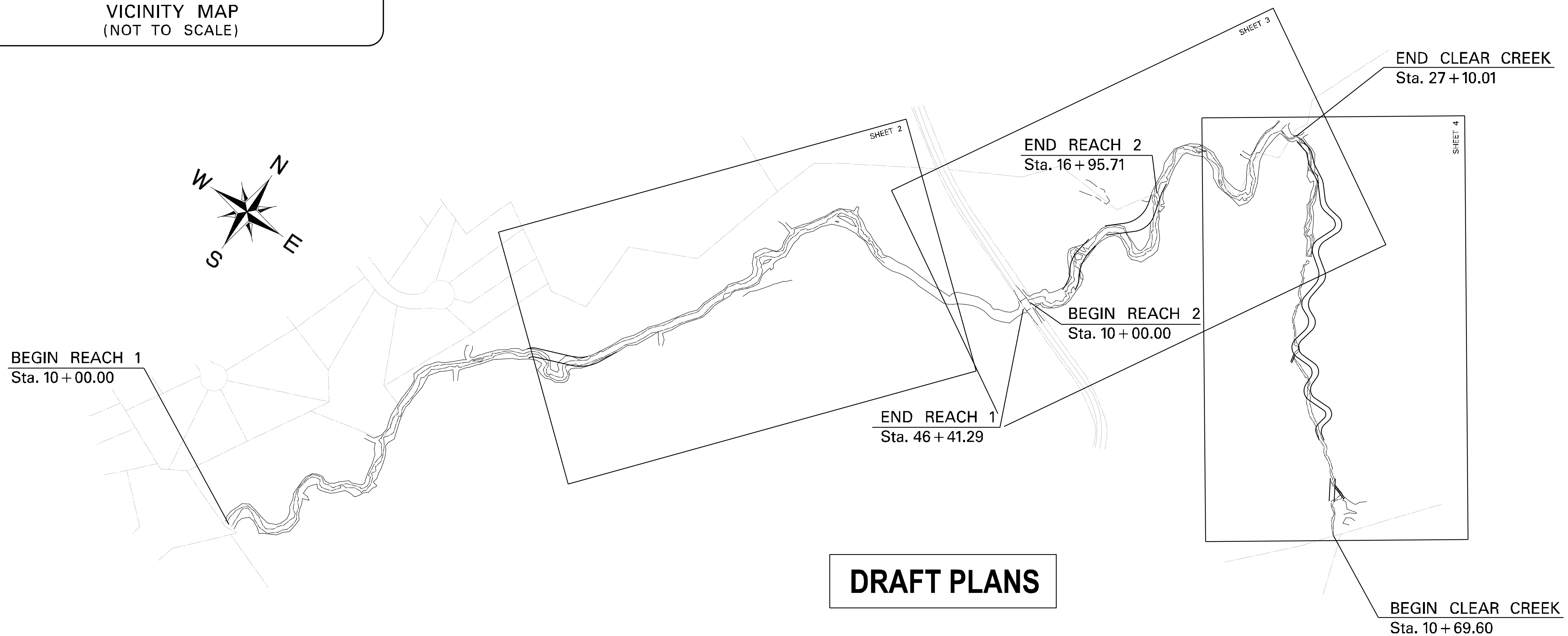
LOCATION: SOUTHEAST OF SR 1168 ROBINSON CHURCH RD. AND SR 1169 PEACH ORCHARD RD.

TYPE OF WORK: **STREAM RESTORATION AND ENHANCEMENT**



VICINITY MAP
(NOT TO SCALE)

INDEX OF SHEETS



Project Reach Beakdown			
	Begin sta	End sta	Totals
McKee Creek - Reach 1			
Stream Enhancement (Level II)			
	10+00	25+00	1500
	29+00	46+40	1740
			3240
Stream Enhancement (Level I)	25+00	29+00	**400**
McKee Creek - Reach 2			
Stream Enhancement (Level I)			
	10+00	16+96	**696**
Clear Creek			
Stream Restoration			
	10+69	27+10	**1641**

Project Totals		
Stream Restoration=	1641	feet
Stream Enhancement (Level I)=	1096	feet
Stream Enhancement (Level II)=	3240	feet
Total Amount of Stream=	5977	feet

DRAFT PLANS

PREPARED FOR THE OFFICE OF:

NORTH CAROLINA DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES
Ecosystem Enhancement Program
2728 CAPITAL BLVD., SUITE 1H 103
RALEIGH, NC 27604
CONTACT: ROBIN DOLIN
TEL: (919) 715 - 5836
FAX: (919) 715 - 2214

Prepared by:
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ENGINEERS | PLANNERS | SURVEYORS
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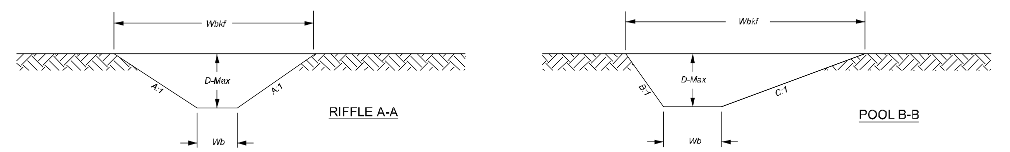
tel: 919-469-3340 fax: 919-467-6008 www.withersravenel.com

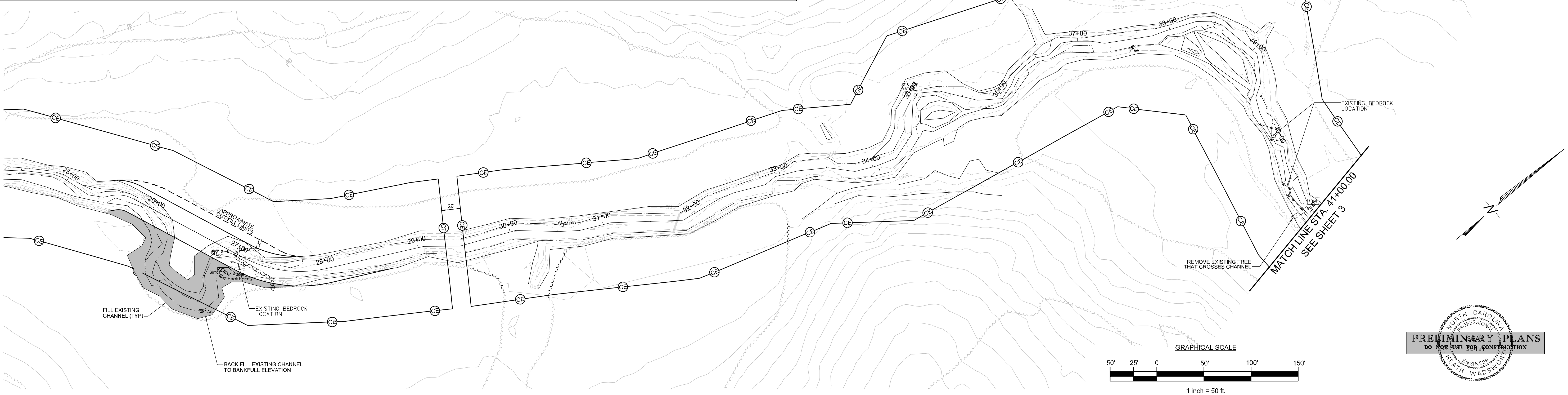
PROJECT ENGINEER

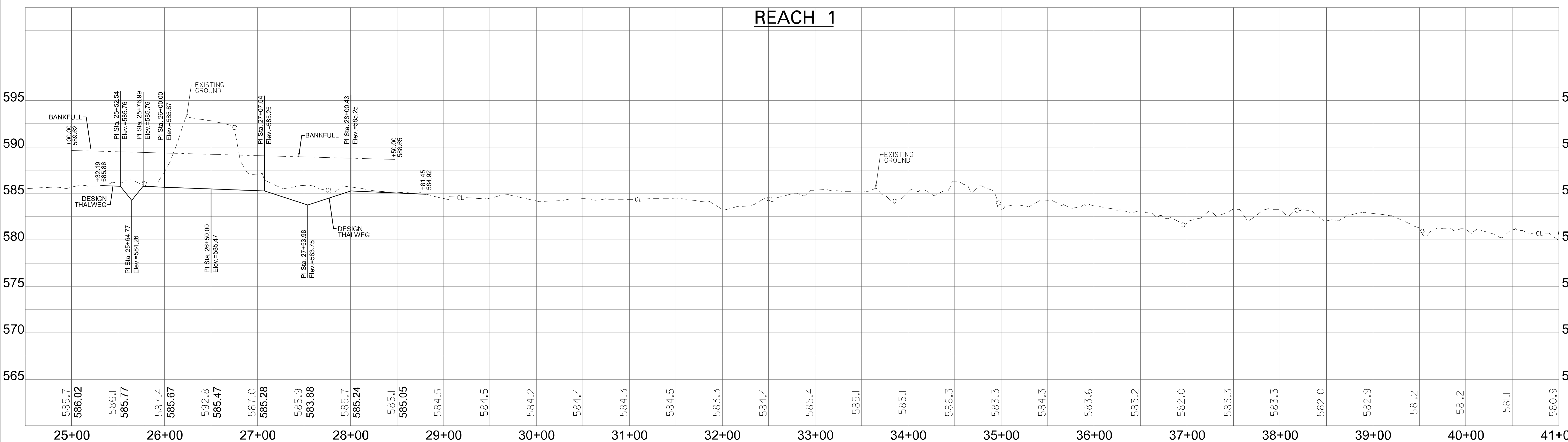
PRELIMINARY PLANS
DO NOT USE FOR CONSTRUCTION

TYPICAL RIFFLE AND POOL CROSS SECTIONS



REACH 1		REACH 2		CLEAR CREEK		
RIFFLE	POOL	RIFFLE	POOL	RIFFLE	POOL	
31.0	40.0	31.9	42.0	17.3	23.0	*WIDTH OF BANKFULL (Wbkf)*
2.6	3.3	2.7	3.5	1.4	1.8	*AVERAGE DEPTH (D)*
3.6	6.0	3.8	6.2	2.2	3.2	*MAXIMUM DEPTH (D-Max)*
12.1	12.0	11.9	12.2	12.4	12.7	*WIDTH TO DEPTH RATIO (Wbkf / D)*
79.7	133.3	85.4	145.1	25.0	41.6	*BANKFULL AREA (Abkf)*
13.8	4.4	13.6	4.8	5.9	3.0	*BOTTOM WIDTH (Wb)*
2.4	----	2.4	----	2.6	----	*SLOPE A*
—	2.0	----	2.0	—-	2.0	*SLOPE B*
—	3.9	----	4.0	—-	4.3	*SLOPE C*





8/20/2008
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No.	Revision	Date	By
1	DRAFT RESTORATION PLAN COMMENTS	05/08/08	CHW
1	FINAL RESTORATION PLAN COMMENTS	08/15/08	CHW

Designer W&R	Scale 1" = 50'
Drawn By MFC	Date AUGUST 2008
Checked By CHW	Job No. 2070568.00

McKEE CREEK

CABARRUS COUNTY, NORTH CAROLINA

PLAN & PROFILE – REACH 1
STA. 25+00.00 TO STA. 39+97.42

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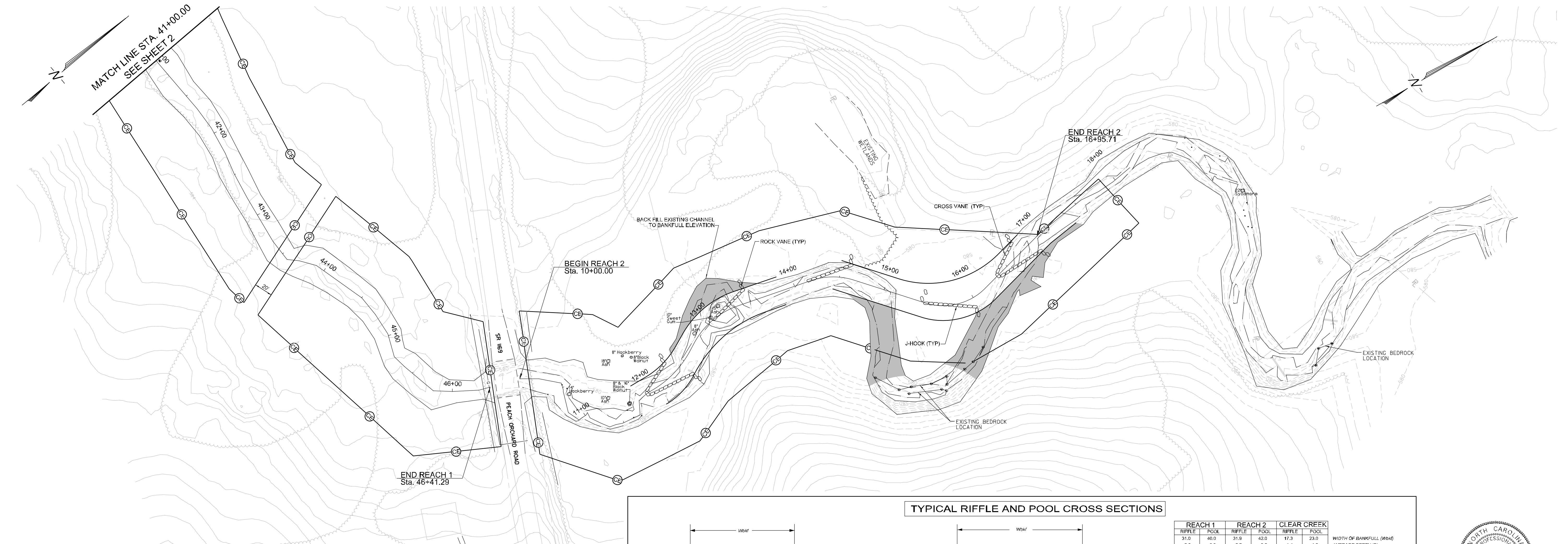
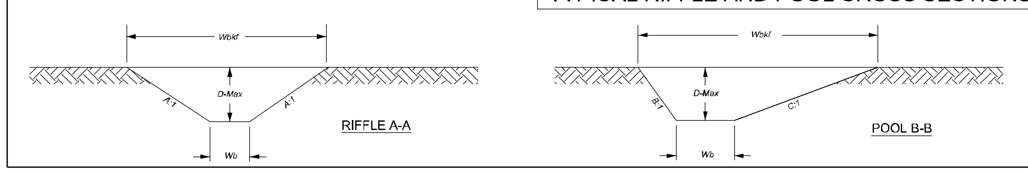
2



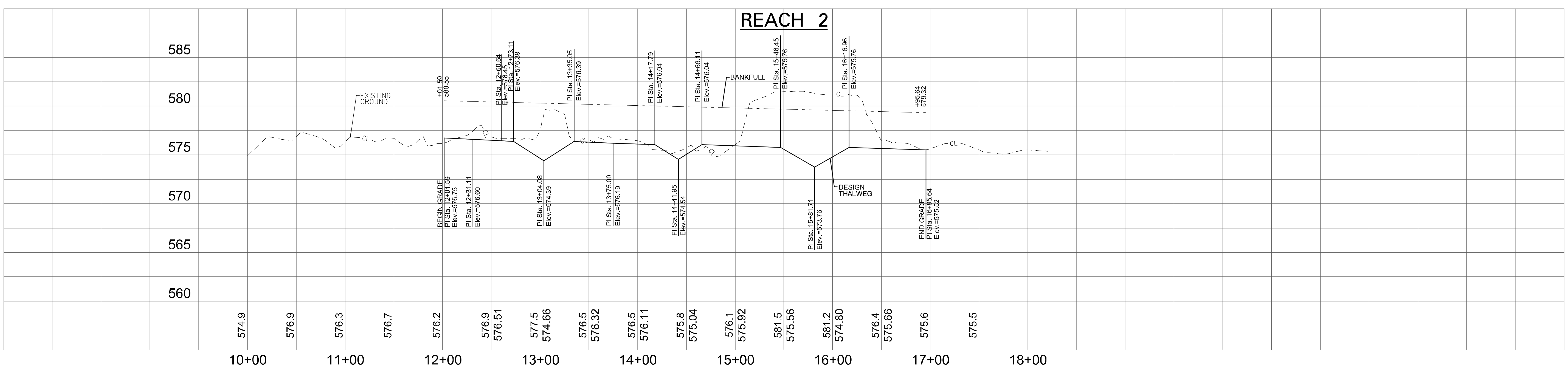
TYPICAL RIFFLE AND POOL CROSS SECTIONS



REACH 1		REACH 2		CLEAR CREEK		
RIFFLE	POOL	RIFFLE	POOL	RIFFLE	POOL	
31.0	40.0	31.9	42.0	17.3	23.0	*WIDTH OF BANKFULL (Wbkf)*
2.6	3.3	2.7	3.5	1.4	1.8	*AVERAGE DEPTH (D)*
3.6	6.0	3.8	6.2	2.2	3.2	*MAXIMUM DEPTH (D-Max)*
12.1	12.0	11.9	12.2	12.4	12.7	*WIDTH TO DEPTH RATIO (Wbkf / D)*
79.7	133.3	85.4	145.1	25.0	41.6	*BANKFULL AREA (Abkf)*
13.8	4.4	13.6	4.8	5.9	3.0	*BOTTOM WIDTH (Wb)*
2.4	---	2.4	---	2.6	---	*SLOPE A*
---	2.0	---	2.0	---	2.0	*SLOPE B*
---	3.9	---	4.0	---	4.3	*SLOPE C*

PRELIMINARY PLANS
DO NOT USE FOR CONSTRUCTION

REACH 2



No.	Revision	Date	By
1	DRAFT RESTORATION PLAN COMMENTS	05/08/08	CHW
1	FINAL RESTORATION PLAN COMMENTS	08/15/08	CHW

Designer	W&R	Scale	1" = 50'
Drawn By	MFC	Date	AUGUST 2008
Checked By	CHW	Job No.	2070568.00

McKEE CREEK

CABARRUS COUNTY, NORTH CAROLINA

PLAN & PROFILE – REACH 2
STA. 10+00.00 TO STA. 22+86.39

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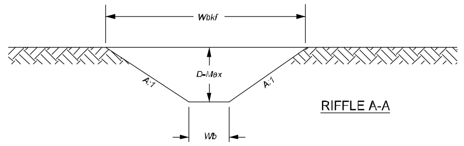
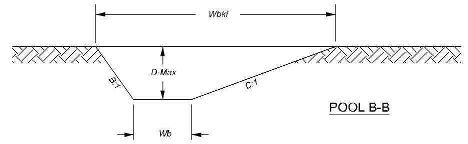
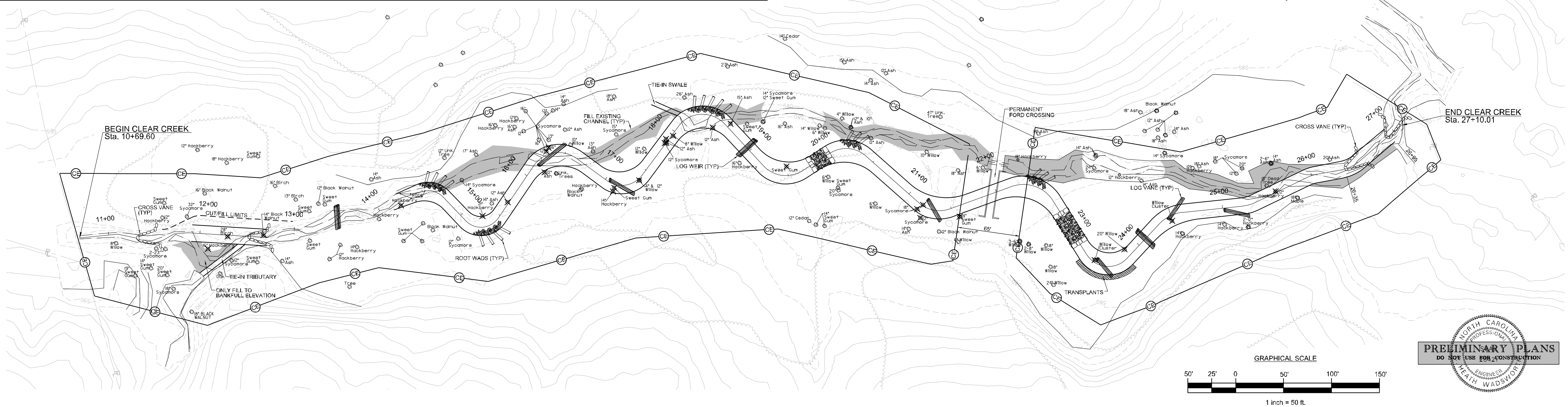
Sheet No. 3

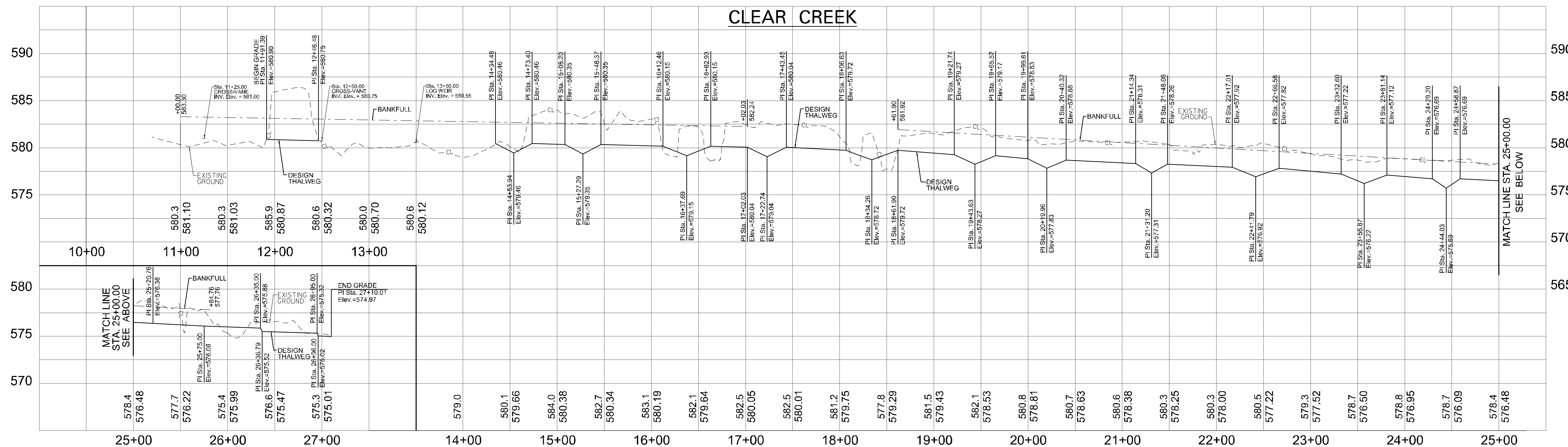
TYPICAL RIFFLE AND POOL CROSS SECTIONS





REACH 1		REACH 2		CLEAR CREEK		
RIFFLE	POOL	RIFFLE	POOL	RIFFLE	POOL	
31.0	40.0	31.9	42.0	17.3	23.0	*WIDTH OF BANKFULL (Wbkf)*
2.6	3.3	2.7	3.5	1.4	1.8	*AVERAGE DEPTH (D)*
3.6	6.0	3.8	6.2	2.2	3.2	*MAXIMUM DEPTH (D-Max)*
12.1	12.0	11.9	12.2	12.4	12.7	*WIDTH TO DEPTH RATIO (Wbkf / D)*
79.7	133.3	85.4	145.1	25.0	41.6	*BANKFULL AREA (Abkf)*
13.8	4.4	13.6	4.8	5.9	3.0	*BOTTOM WIDTH (Wb)*
2.4	----	2.4	----	2.6	----	*SLOPE A*
----	2.0	—	2.0	----	2.0	*SLOPE B*
----	3.9	—	4.0	----	4.3	*SLOPE C*





No.	Revision	Date	By
1	DRAFT RESTORATION PLAN COMMENTS	05/08/08	CHW
1	FINAL RESTORATION PLAN COMMENTS	08/15/08	CHW

Designer	W&R	Scale	1" = 50'
Drawn By	MFC	Date	AUGUST 2008
Checked By	CHW	Job No.	2070568.00

McKEE CREEK

CABARRUS COUNTY, NORTH CAROLINA

PLAN & PROFILE – CLEAR CREEK
STA. 10 + 00.00 TO STA. 27 + 76.41

WITHERS & RAVENEL
ENGINEERS | PLANNERS | SURVEYORS
111 MacKenan Drive Cary, North Carolina 27511 tel: 919-469-3340 fax: 919-467-6008 www.withersravenel.com

Sheet No. 4

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Bare Root Seedlings

Scientific Name	Common Name	Tolerance
Betula nigra	River Birch	FACW
Carya aquatica	Water Hickory	OBL
Celtis laevigata	Sugarberry	FACW
Fraxinus pennsylvanica	Green Ash	FACW
Juglans nigra	Black Walnut	FAC
Liriodendron tulipifera	Tulip Poplar	FAC
Platanus occidentalis	Sycamore	FAC-
Quercus michauxii	Swamp Chestnut Oak	FACW-

In general, hardwoods will consist of bare root vegetation planted at a target density of 680 stems per acre, spaced on an 8′ by 8′ grid. Selected species shall be planted according to their wetness tolerance and the anticipated wetness of the planting areas. Bare roots shall be planted in the designated hatched areas as shown on the plans; Non-hatched areas on the floodplain that are designated as invasive species removal areas will also require bare root plantings.

Live Stakes

Scientific Name	Common Name	Tolerance
Cephalanthus occidentalis	Buttonbush	OBL
Cornus amomum	Silky Dogwood	FACW+
Salix nigra	Black Willow	OBL
Sambucus canadensis	Elderberry	FACW-

Live stakes shall be installed on all the stream banks throughout the project area. Stakes shall be installed randomly with respect to species, 2′ to 3′ apart using triangular spacing along the outside of bends and 4′ to 6′ apart using triangular spacing along the banks of straight riffle sections (maximum of 20% Black Willow). Stakes shall be selectively placed on existing vegetated stream banks.

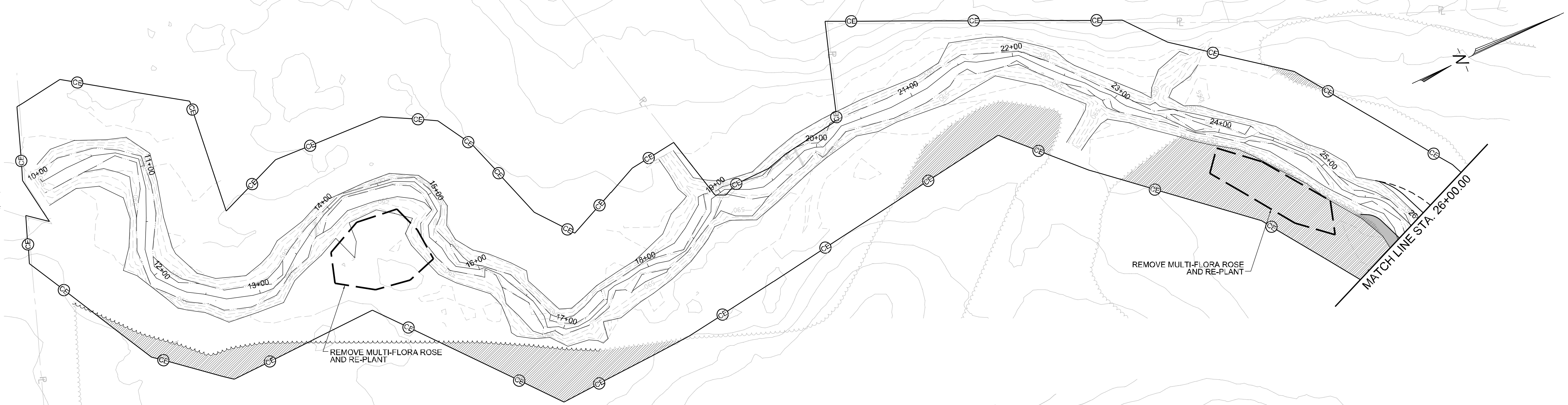
Stream Banks Permanent Seed Mixture

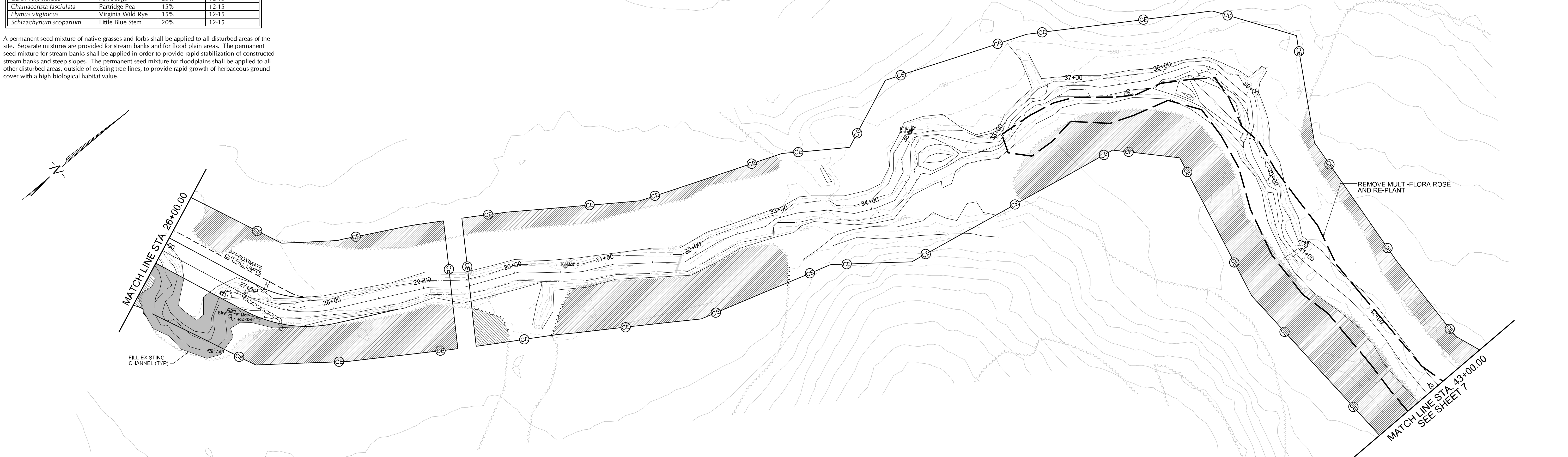
Scientific Name	Common Name	% of Mixture	Seeding Density (lbs/ac)
Andropogon glomeratus	Bushy Beard Grass	20%	2
Bidens aristosa	Beggar Ticks	10%	2
Dichanthelium clandestinum	Deer Tongue	15%	3
Elymus virginicus	Virginia Wild Rye	25%	2
Juncus effusus	Soft Rush	15%	2
Panicum virgatum	Switch Grass	10%	3
Tripsacum dactyloides	Gamma Grass	5%	3

Flood Plain Permanent Seed Mixture

Scientific Name	Common Name	% of Mixture	Seeding Density (lbs/ac)
Andropogon gerardii	Big Blue Stem	15%	12-15
Bidens aristosa	Beggar Ticks	10%	12-15
Carex vulpinoidea	Fox Sedge	25%	12-15
Chamaecrista fasciulata	Partridge Pea	15%	12-15
Elymus virginicus	Virginia Wild Rye	15%	12-15
Schizachyrium scoparium	Little Blue Stem	20%	12-15

A permanent seed mixture of native grasses and forbs shall be applied to all disturbed areas of the site. Separate mixtures are provided for stream banks and for flood plain areas. The permanent seed mixture for stream banks shall be applied in order to provide rapid stabilization of constructed stream banks and steep slopes. The permanent seed mixture for floodplains shall be applied to all other disturbed areas, outside of existing tree lines, to provide rapid growth of herbaceous ground cover with a high biological habitat value.





BARE ROOTS AND FLOOD PLAIN PERMANENT SEED MIXTURE SHALL BE INSTALLED IN THE HATCHED AREAS. REFERENCE THE NOTES BELOW THE PLANT TABLES FOR FURTHER PLANTING INSTRUCTIONS.

GRAPHICAL SCALE

50' 25' 0 50' 100' 150'

1 inch = 50 ft.

PRELIMINARY PLANS
DO NOT USE FOR CONSTRUCTION

NORTH CAROLINA PROFESSIONAL SEAL 28421 ENGINEER HEATH WADSWORTH

No.	Revision	Date	By
1	DRAFT RESTORATION PLAN COMMENTS	05/08/08	CHW
1	FINAL RESTORATION PLAN COMMENTS	08/15/08	CHW

Designer W&R	Scale 1″ = 50′
Drawn By MFC	Date AUGUST 2008
Checked By CHW	Job No. 2070568.00

McKEE CREEK

CABARRUS COUNTY, NORTH CAROLINA

VEGETATION PLANTING PLAN REACH 1

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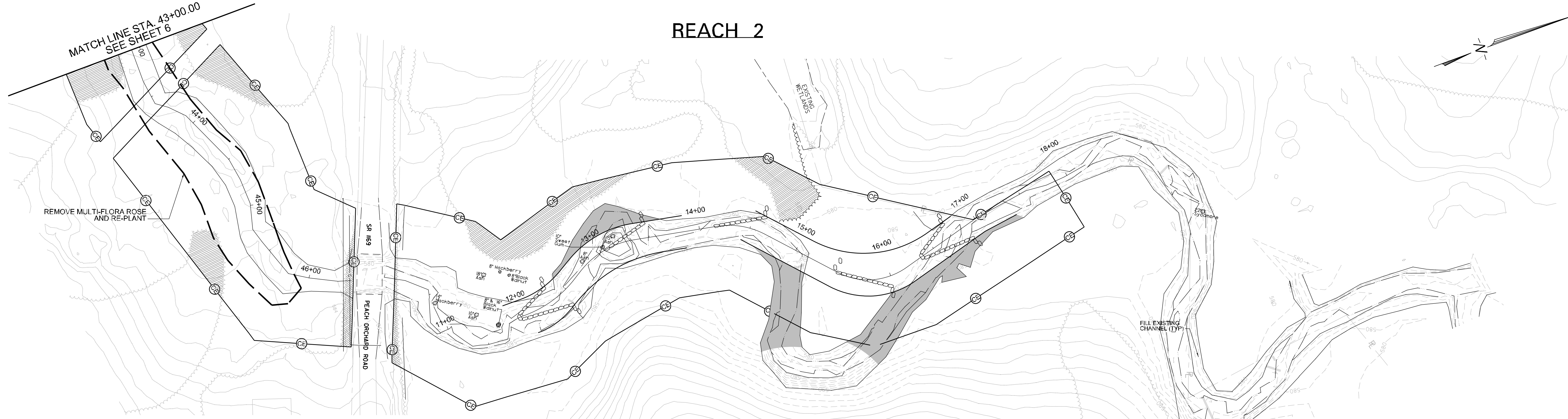
REACH 2



GRAPHICAL SCALE

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Celtis laevigata	Sugarberry	FACW
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Juglans nigra	Black Walnut	FAC
Liriodendron tulipifera	Tulip Poplar	FAC
Platanus occidentalis	Sycamore	FAC-
Quercus michauxii	Swamp Chestnut Oak	FACW-

In general, hardwoods will consist of bare root vegetation planted at a target density of 680 stems per acre, spaced on an 8′ by 8′ grid. Selected species shall be planted according to their wetness tolerance and the anticipated wetness of the planting areas. Bare roots shall be planted in the designated hatched areas as shown on the plans; Non-hatched areas on the floodplain that are designated as invasive species removal areas will also require bare root plantings.

Live Stakes

Scientific Name	Common Name	Tolerance
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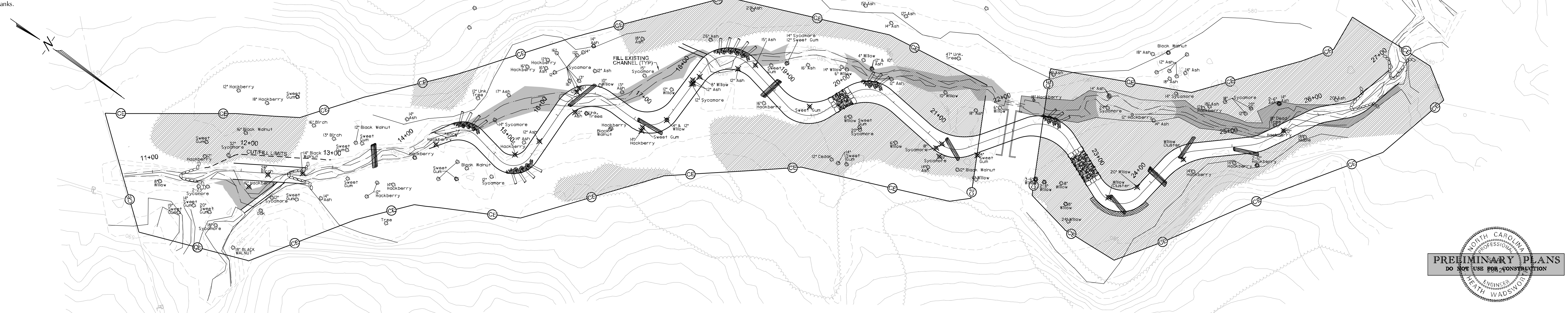
Juncus effusus	Soft Rush	15%	2
Panicum virgatum	Switch Grass	10%	3
Tripsacum dactyloides	Gamma Grass	5%	3

Flood Plain Permanent Seed Mixture

Scientific Name	Common Name	% of Mixture	Seeding Density (lbs/ac)
Andropogon gerardii	Big Blue Stem	15%	12-15
Bidens aristosa	Beggar Ticks	10%	12-15
Carex vulpinoidea	Fox Sedge	25%	12-15
Chamaecrista fasciulata	Partridge Pea	15%	12-15
Elymus virginicus	Virginia Wild Rye	15%	12-15
Schizachyrium scoparium	Little Blue Stem	20%	12-15

A permanent seed mixture of native grasses and forbs shall be applied to all disturbed areas of the site. Separate mixtures are provided for stream banks and for flood plain areas. The permanent seed mixture for stream banks shall be applied in order to provide rapid stabilization of constructed stream banks and steep slopes. The permanent seed mixture for floodplains shall be applied to all other disturbed areas, outside of existing tree lines, to provide rapid growth of herbaceous ground cover with a high biological habitat value.

CLEAR CREEK



PRELIMINARY PLANS
DO NOT USE FOR CONSTRUCTION

NORTH CAROLINA PROFESSIONAL ENGINEER HEATH WADSWORTH

No.	Revision	Date	By
1	DRAFT RESTORATION PLAN COMMENTS	05/08/08	CHW
1	FINAL RESTORATION PLAN COMMENTS	08/15/08	CHW

Designer	W&R	Scale	1" = 50'
Drawn By	MFC	Date	AUGUST 2008
Checked By	CHW	Job No.	2070568.00

McKEE CREEK

CABARRUS COUNTY, NORTH CAROLINA

VEGETATION PLANTING PLAN
REACH 2 & CLEAR CREEK

WITHERS & RAVENEL
ENGINEERS | PLANNERS | SURVEYORS
111 MacKenan Drive Cary, North Carolina 27511 tel: 919-469-3340 fax: 919-467-6008 www.withersravenel.com

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12.0 Appendices

Appendix 1 – Project Site Photographs

Photograph 1: View of feature A (Clear Creek) just upstream of its confluence with feature B (see Figure 4a and 4b).

Photograph 2: View of the floodplain of feature A (Clear Creek) (see Figure 4a and 4b).

Photograph 3: View of the pasture land adjacent to feature A (see Figure 4a and 4b).

Photograph 4: View of the section of stream channel that was evaluated in stream form #1 (see Figure 4a and 4b).

Photograph 5: View of the forested floodplain at the confluence of feature A (Clear Creek) and feature B (McKee Creek) (see Figure 4a and 4b).

Photograph 6: View of feature D as described by stream form #2 (see Figure 4a and 4b).

Photograph 7: View of the wetland just north of Peach Orchard Rd along feature B demarcated by wetland flags 107A&B through 110A & 112B (see Figure 4a and 4b).

Photograph 8: View of feature B (McKee Creek) south of Peach Orchard Rd (see Figure 4a and 4b).

Photograph 9: View of feature E just below flag #113 (start channel) (see Figure 4a and 4b).

Photograph 10: View of the ephemeral channel as described by stream form #4 (see Figure 4a and 4b).

Photograph 11: Clear Creek Cross-Section 1

Photograph 12: Clear Creek Cross-Section 2


Photograph 13: Clear Creek Cross-Section 3


Photograph 14: Clear Creek Cross-Section 4

Photograph 15: Clear Creek Cross-Section 5

Photograph 16: Clear Creek Cross-Section 6

Photograph 17: Clear Creek Cross-Section 7

Photograph 18: Clear Creek Cross-Section 8


Photograph 19: McKee Creek Cross-Section 1


Photograph 20: McKee Creek Cross-Section 2

Photograph 21: McKee Creek Cross-Section 3


Photograph 22: McKee Creek Cross-Section 4

Photograph 23: McKee Creek Cross-Section 5

Photograph 24: McKee Creek Cross-Section 6

Photograph 25: McKee Creek Cross-Section 7

Photograph 26: McKee Creek Cross-Section 8


Photograph 27: McKee Creek Cross-Section 9


Photograph 28: McKee Creek Cross-Section 10


Photograph 29: McKee Creek Cross-Section 11


Photograph 30: McKee Creek Bent to be Removed Vicinity of Cross-Section 4

Photograph 31: McKee Creek Log on Reach 1 at End of topographic mapping upstream from bridge on Peach Orchard Road

Photograph 32: McKee Creek Stagnate Water Area on Reach 1

Appendix 2 – Project Site USACE Routine Wetlands Determination Data Forms

DATA FORM #1
ROUTINE WETLAND DETERMINATION
(1987 COE Wetlands Determination Manual)

Project / Site: W&R Project # -02070568

Applicant / Owner: NC-EEP

Investigator: Luke Tuschak: Todd Preuninger

Date: 7-17-07
County: Cabarrus
State: NC

Do normal circumstances exist on the site? Yes ☒ No ☐
Is the site significantly disturbed (Atypical situation)? Yes ☐ No ☒
Is the area a potential problem area? Yes ☐ No ☒
(explain on reverse if needed)

Community ID Cow Pasture
Transect ID: --
PlotID:

VEGETATION

Dominant Plant Species	Stratum	Indicator	Dominant Plant Species	Stratum	Indicator
1. Impatiens capensis	Herb	FACW	9.		
2. Eulalia viminea	Herb	FAC	10.		
3. Verbesina alternifolia	Herb	FAC	11.		
4. Salix nigra	Tree	OBL	12.		
5. Fraxinus pennsylvanica	Tree	FACW	13.		
6. Gelditrsia tricanthos	Tree	FAC-	14.		
7. Celtis laevigata	Tree	FACW	15.		
8. Juniperus virgininia	Tree	FACU-	16.		

Percent of Dominant Species that are OBL, FACW, or FAC excluding FAC-). 75 %

Remarks:
Hydrophytic Vegetation Present

HYDROLOGY

☐ **Recorded Data (Describe In Remarks):**
- ☐ **Stream, Lake, or Tide Gauge**
- ☐ **Aerial Photographs**
- ☐ **Other**

☒ **No Recorded Data Available**

Field Observations:

Depth of Surface Water: --- (in.)

Depth to Free Water in Pit: --- (in.)

Depth to Saturated Soil: --- (in.)

Wetland Hydrology Indicators

Primary Indicators:
- ☐ **Inundated**
- ☐ **Saturated in Upper 12"**
- ☐ **Water Marks**
- ☐ **Drift Lines**
- ☐ **Sediment Deposits**
- ☐ **Drainage Patterns in Wetlands**

Secondary Indicators:
- ☐ **Oxidized Roots Channels in Upper 12"**
- ☐ **Water-Stained Leaves**
- ☐ **Local Soil Survey Data**
- ☒ **FAC-Neutral Test**
- ☐ **Other (Explain in Remarks)**

Remarks: Hydrology Indicators Absent

SOILS

Map Unit Name
(Series and Phase): Chewalca sandy Loam **Drainage Class:** Somewhat Poorly Drained

Taxonomy (Subgroup): Thermic Fluvaquentic Dystrochrepts **Confirm Mapped Type?** **Yes** ☐ **No** ☐

Profile Description:

Depth (inches)	Horizon	Matrix Colors (Munsell Moist)	Mottle Colors (Munsell Moist)	Mottle Abundance/Contrast	Texture, Concretions, Structure, etc.
0-10”		10YR 4/4			Clay Loam
11-12”		10YR 5/3			Clay Loam

Hydric Soil Indicators:

- ☐ Histosol
- ☐ Histic Epipedon
- ☐ Sulfidic Odor
- ☐ Aquic Moisture Regime
- ☐ Reducing Conditions
- ☐ Gleyed or Low-Chroma Colors
- ☐ Concretions
- ☐ High Organic Content in Surface Layer in Sandy Soils
- ☐ Organic Streaking in Sandy Soils
- ☐ Listed On Local Hydric Soils List
- ☐ Listed on National Hydric Soils List
- ☐ Other (Explain in Remarks)

Remarks:
Hydric Soils Absent

WETLAND DETERMINATION

Hydrophytic Vegetation Present?	**Yes** ☒	**No** ☐	**Is the Sampling Point**		
Wetland Hydrology Present?	**Yes** ☐	**No** ☒	**Within a Wetland?**	**Yes** ☐	**No** ☒
Hydric Soils Present?	**Yes** ☐	**No** ☒			

Remarks:

DATA FORM #2
ROUTINE WETLAND DETERMINATION
(1987 COE Wetlands Determination Manual)

Project / Site: W&R Project # -02070568	**Date:** 7-17-07
Applicant / Owner: NC-EEP	**County:** Cabarrus
Investigator: Luke Tuschak: Todd Preuninger	**State:** NC
Do normal circumstances exist on the site? Yes ☒ No ☐ **Is the site significantly disturbed (Atypical situation)?** Yes ☐ No ☒ **Is the area a potential problem area?** Yes ☐ No ☒ **(explain on reverse if needed)**	**Community ID:** Vernal Pool **Transect ID:** -- **PlotID:**

VEGETATION

Dominant Plant Species	Stratum	Indicator	Dominant Plant Species	Stratum	Indicator
1. Betula nigra	Tree	FACW	9.		
2. Sagittaria latifolia	Herb	OBL	10.		
3. Carex Sp.	Herb	FACW	11.		
4. Salix nigra	Tree	OBL	12.		
5. Fraxinus pennsylvanica	Tree	FACW	13.		
6.			14.		
7.			15.		
8.			16.		

Percent of Dominant Species that are OBL, FACW, or FAC excluding FAC-). 100 %

Remarks:
Hydrophytic Vegetation Present

HYDROLOGY

☐ **Recorded Data (Describe In Remarks):**
- ☐ **Stream, Lake, or Tide Gauge**
- ☐ **Aerial Photographs**
- ☐ **Other**

☒ **No Recorded Data Available**

Field Observations:

Depth of Surface Water: --- **(in.)**

Depth to Free Water in Pit: --- **(in.)**

Depth to Saturated Soil: --- **(in.)**

Wetland Hydrology Indicators

Primary Indicators:
- ☐ **Inundated**
- ☐ **Saturated in Upper 12"**
- ☒ **Water Marks**
- ☐ **Drift Lines**
- ☐ **Sediment Deposits**
- ☐ **Drainage Patterns in Wetlands**

Secondary Indicators:
- ☐ **Oxidized Roots Channels in Upper 12"**
- ☒ **Water-Stained Leaves**
- ☐ **Local Soil Survey Data**
- ☒ **FAC-Neutral Test**
- ☐ **Other (Explain in Remarks)**

Remarks: Hydrology Indicators Present

SOILS

Map Unit Name
(Series and Phase): Chewalca sandy Loam **Drainage Class:** Somewhat Poorly Drained

Taxonomy (Subgroup): Thermic Fluvaquentic Dystrochrepts **Confirm Mapped Type?** Yes☐ No☐

Profile Description:

Depth (inches)	Horizon	Matrix Colors (Munsell Moist)	Mottle Colors (Munsell Moist)	Mottle Abundance/Contrast	Texture, Concretions, Structure, etc.
0-5”		10YR 5/1			Clay Loam 50%
0-5”		10YR 4/4			Clay Loam 50%
6-12”		10YR 4/1			Clay 50%
		7.5YR 4/4			Clay 50%

Hydric Soil Indicators:

- ☐ Histosol
- ☐ Histic Epipedon
- ☐ Sulfidic Odor
- ☐ Aquic Moisture Regime
- ☒ Reducing Conditions
- ☒ Gleyed or Low-Chroma Colors
- ☐ Concretions
- ☐ High Organic Content in Surface Layer in Sandy Soils
- ☐ Organic Streaking in Sandy Soils
- ☐ Listed On Local Hydric Soils List
- ☐ Listed on National Hydric Soils List
- ☐ Other (Explain in Remarks)

Remarks:
Hydric Soils Present

WETLAND DETERMINATION

Hydrophytic Vegetation Present? Yes ☒ No ☐
Wetland Hydrology Present? Yes ☒ No ☐
Hydric Soils Present? Yes ☒ No ☐

Is the Sampling Point Within a Wetland? Yes☒ No☐

Remarks:

DATA FORM #3
ROUTINE WETLAND DETERMINATION
(1987 COE Wetlands Determination Manual)

Project / Site: W&R Project # -02070568

Applicant / Owner: NC-EEP

Investigator: Luke Tuschak: Todd Preuninger

Date: 7-17-07
County: Cabarrus
State: NC

Do normal circumstances exist on the site? Yes ☒ No ☐
Is the site significantly disturbed (Atypical situation)? Yes ☐ No ☒
Is the area a potential problem area? Yes ☐ No ☒
(explain on reverse if needed)

Community ID: Vernal Pool
Transect ID: --
PlotID:

VEGETATION

Dominant Plant Species	Stratum	Indicator	Dominant Plant Species	Stratum	Indicator
1. Quercus alba	Tree	FACU	9.		
2. Liriodendron tulipifera	Tree	FAC	10.		
3. Acer rubrum	Tree	FAC	11.		
4. Fagus grandifolia	Tree	NI	12.		
5. Carya ovalis	Tree	FACU	13.		
6.			14.		
7.			15.		
8.			16.		

Percent of Dominant Species that are OBL, FACW, or FAC excluding FAC-). 40 %

Remarks:
Hydrophytic Vegetation Absent

HYDROLOGY

☐ **Recorded Data (Describe In Remarks):**
- ☐ **Stream, Lake, or Tide Gauge**
- ☐ **Aerial Photographs**
- ☐ **Other**

☒ **No Recorded Data Available**

Field Observations:

Depth of Surface Water: --- (in.)

Depth to Free Water in Pit: --- (in.)

Depth to Saturated Soil: --- (in.)

Wetland Hydrology Indicators

Primary Indicators:
- ☐ Inundated
- ☐ Saturated in Upper 12”
- ☐ Water Marks
- ☐ Drift Lines
- ☐ Sediment Deposits
- ☐ Drainage Patterns in Wetlands

Secondary Indicators:
- ☐ Oxidized Roots Channels in Upper 12”
- ☐ Water-Stained Leaves
- ☐ Local Soil Survey Data
- ☐ FAC-Neutral Test
- ☐ Other (Explain in Remarks)

Remarks: Hydrology Indicators Absent

SOILS

Map Unit Name
(Series and Phase): Enon Sandy Loam **Drainage Class:** Well Drained

Taxonomy (Subgroup): Thermic Ultic Hapludalfs **Confirm Mapped Type?** Yes ☐ No ☐

Profile Description:

Depth (inches)	Horizon	Matrix Colors (Munsell Moist)	Mottle Colors (Munsell Moist)	Mottle Abundance/Contrast	Texture, Concretions, Structure, etc.
0-12”		10YR 5/6			Loam

Hydric Soil Indicators:

- ☐ Histosol
- ☐ Histic Epipedon
- ☐ Sulfidic Odor
- ☐ Aquic Moisture Regime
- ☐ Reducing Conditions
- ☐ Gleyed or Low-Chroma Colors
- ☐ Concretions
- ☐ High Organic Content in Surface Layer in Sandy Soils
- ☐ Organic Streaking in Sandy Soils
- ☐ Listed On Local Hydric Soils List
- ☐ Listed on National Hydric Soils List
- ☐ Other (Explain in Remarks)

Remarks:
Hydric Soils Absent

WETLAND DETERMINATION

Hydrophytic Vegetation Present? Yes ☐ No ☒
Wetland Hydrology Present? Yes ☐ No ☒
Hydric Soils Present? Yes ☐ No ☒

Is the Sampling Point Within a Wetland? Yes ☐ No ☒

Remarks:

Appendix 3 – Project Site NCDWQ Stream Classification Forms

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

Date: 7-17-07	Project: Mckee Creek	Latitude:
Evaluator: TP, LT	Site:	Longitude:
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30* 43.75	County: Cabarrus	Other *e.g. Quad Name:* #1

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 = 9.5)				
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 = 12.25)				
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: 7-17-07	Project: Mckee Creek	Latitude:
Evaluator:	Site:	Longitude:
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30* 15.5	County: Cabarrus	Other *e.g. Quad Name:* #2

A. Geomorphology (Subtotal = 7.5)	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 = 2.5)				
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 = 5.5)				
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.)

Picture # 124

Sketch:

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

Date: 7-17-07	Project: Mckee Creek	Latitude:
Evaluator: LT, TP	Site:	Longitude:
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30*	County: Cabarrus	Other *e.g. Quad Name:* #3

A. Geomorphology (Subtotal = 13)	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 = 3)				
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 =)				
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.)

Pic #121

Sketch:

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

Date: 7-17-07	Project: McKee Creek	Latitude:
Evaluator: LT, TP	Site:	Longitude:
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30*	County: Cabarrus	Other *e.g. Quad Name:* #4

A. Geomorphology (Subtotal = 6.5)	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 = 1.5)				
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 = 4)				
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.)

Ephemeral
Picture # 120

Sketch:

USACE AID#________ DWQ #________ Site #*#1* (indicate on attached map)

Clear Creek

STREAM QUALITY ASSESSMENT WORKSHEET

Provide the following information for the stream reach under assessment:

1. Applicant's name: ________ 2. Evaluator's name: *Todd P ; Luke T*
3. Date of evaluation: *7-17-07* 4. Time of evaluation: *Early Afternoon*
5. Name of stream: *Unamed Trib. to Makee Creek* 6. River basin: *Yadkin River Basin*
7. Approximate drainage area: ________ 8. Stream order: *3rd on Cabarrus Soil Survey*
9. Length of reach evaluated: *50 feet* 10. County: *Cabarrus*
11. Site coordinates (if known): prefer in decimal degrees. 12. Subdivision name (if any): ________

Latitude (ex. 34.872312): *35.2683 °N* Longitude (ex. –77.556611): *80.6372 °W*

Method location determined (circle): GPS Topo Sheet Ortho (Aerial) Photo/GIS Other GIS Other________

13. Location of reach under evaluation (note nearby roads and landmarks and attach map identifying stream(s) location): *approximately 300 feet upstream from its confluence with Makee Creek.*
14. Proposed channel work (if any): *Complete Stream restoration and vegetative Buffer restoration*
15. Recent weather conditions: *Hot with occasional Evening Storms*
16. Site conditions at time of visit: *Temperature was high 80'S and Sunny*
17. Identify any special waterway classifications known: ___Section 10 ___Tidal Waters ___Essential Fisheries Habitat ___Trout Waters ___Outstanding Resource Waters ___Nutrient Sensitive Waters ___Water Supply Watershed ___(I-IV)
18. Is there a pond or lake located upstream of the evaluation point? YES NO If yes, estimate the water surface area: ________
19. Does channel appear on USGS quad map? YES NO 20. Does channel appear on USDA Soil Survey? YES NO
21. Estimated watershed land use: ___% Residential ___% Commercial ___% Industrial *40* % Agricultural *60* % Forested ___% Cleared / Logged ___% Other (________)
22. Bankfull width: *6'* 23. Bank height (from bed to top of bank): *3'-4'*
24. Channel slope down center of stream: *X* Flat (0 to 2%) ___Gentle (2 to 4%) ___Moderate (4 to 10%) ___Steep (>10%)
25. Channel sinuosity: ___Straight *X* Occasional bends ___Frequent meander ___Very sinuous ___Braided channel

Instructions for completion of worksheet (located on page 2): Begin by determining the most appropriate ecoregion based on location, terrain, vegetation, stream classification, etc. Every characteristic must be scored using the same ecoregion. Assign points to each characteristic within the range shown for the ecoregion. Page 3 provides a brief description of how to review the characteristics identified in the worksheet. Scores should reflect an overall assessment of the stream reach under evaluation. If a characteristic cannot be evaluated due to site or weather conditions, enter 0 in the scoring box and provide an explanation in the comment section. Where there are obvious changes in the character of a stream under review (e.g., the stream flows from a pasture into a forest), the stream may be divided into smaller reaches that display more continuity, and a separate form used to evaluate each reach. The total score assigned to a stream reach must range between 0 and 100, with a score of 100 representing a stream of the highest quality.

Total Score (from reverse): *68* **Comments:** *The evaluated stretch is located within a cow pasture.*

Evaluator's Signature *[signature]* Date *7-17-07*

This channel evaluation form is intended to be used only as a guide to assist landowners and environmental professionals in gathering the data required by the United States Army Corps of Engineers to make a preliminary assessment of stream quality. The total score resulting from the completion of this form is subject to USACE approval and does not imply a particular mitigation ratio or requirement. Form subject to change – version 06/03. To Comment, please call 919-876-8441 x 26.

STREAM QUALITY ASSESSMENT WORKSHEET

	#	CHARACTERISTICS	ECOREGION POINT RANGE			SCORE
			Coastal	Piedmont	Mountain	
PHYSICAL	1	**Presence of flow / persistent pools in stream** (no flow or saturation = 0; strong flow = max points)	0 – 5	0 – 4	0 – 5	4
	2	**Evidence of past human alteration** (extensive alteration = 0; no alteration = max points)	0 – 6	0 – 5	0 – 5	3
	3	**Riparian zone** (no buffer = 0; contiguous, wide buffer = max points)	0 – 6	0 – 4	0 – 5	2
	4	**Evidence of nutrient or chemical discharges** (extensive discharges = 0; no discharges = max points)	0 – 5	0 – 4	0 – 4	3
	5	**Groundwater discharge** (no discharge = 0; springs, seeps, wetlands, etc. = max points)	0 – 3	0 – 4	0 – 4	3
	6	**Presence of adjacent floodplain** (no floodplain = 0; extensive floodplain = max points)	0 – 4	0 – 4	0 – 2	4
	7	**Entrenchment / floodplain access** (deeply entrenched = 0; frequent flooding = max points)	0 – 5	0 – 4	0 – 2	3
	8	**Presence of adjacent wetlands** (no wetlands = 0; large adjacent wetlands = max points)	0 – 6	0 – 4	0 – 2	2
	9	**Channel sinuosity** (extensive channelization = 0; natural meander = max points)	0 – 5	0 – 4	0 – 3	2
	10	**Sediment input** (extensive deposition = 0; little or no sediment = max points)	0 – 5	0 – 4	0 – 4	4
	11	**Size & diversity of channel bed substrate** (fine, homogenous = 0; large, diverse sizes = max points)	NA*	0 – 4	0 – 5	2
STABILITY	12	**Evidence of channel incision or widening** (deeply incised = 0; stable bed & banks = max points)	0 – 5	0 – 4	0 – 5	4
	13	**Presence of major bank failures** (severe erosion = 0; no erosion, stable banks = max points)	0 – 5	0 – 5	0 – 5	4
	14	**Root depth and density on banks** (no visible roots = 0; dense roots throughout = max points)	0 – 3	0 – 4	0 – 5	2
	15	**Impact by agriculture, livestock, or timber production** (substantial impact = 0; no evidence = max points)	0 – 5	0 – 4	0 – 5	1
HABITAT	16	**Presence of riffle-pool/ripple-pool complexes** (no riffles/ripples or pools = 0; well-developed = max points)	0 – 3	0 – 5	0 – 6	2
	17	**Habitat complexity** (little or no habitat = 0; frequent, varied habitats = max points)	0 – 6	0 – 6	0 – 6	4
	18	**Canopy coverage over streambed** (no shading vegetation = 0; continuous canopy = max points)	0 – 5	0 – 5	0 – 5	3
	19	**Substrate embeddedness** (deeply embedded = 0; loose structure = max)	NA*	0 – 4	0 – 4	3
BIOLOGY	20	**Presence of stream invertebrates** (see page 4) (no evidence = 0; common, numerous types = max points)	0 – 4	0 – 5	0 – 5	4
	21	**Presence of amphibians** (no evidence = 0; common, numerous types = max points)	0 – 4	0 – 4	0 – 4	3
	22	**Presence of fish** (no evidence = 0; common, numerous types = max points)	0 – 4	0 – 4	0 – 4	3
	23	**Evidence of wildlife use** (no evidence = 0; abundant evidence = max points)	0 – 6	0 – 5	0 – 5	3
		Total Points Possible	100	100	100	
		TOTAL SCORE (also enter on first page)				68

* These characteristics are not assessed in coastal streams.

USACE AID#________ DWQ #________ Site # #2 (indicate on attached map)

Mckee Creek

STREAM QUALITY ASSESSMENT WORKSHEET

Provide the following information for the stream reach under assessment:

1. Applicant's name: ________
2. Evaluator's name: Todd P, Luke T
3. Date of evaluation: 7-17-07
4. Time of evaluation: Early Afternoon
5. Name of stream: Mckee Creek
6. River basin: Yadkin River Basin
7. Approximate drainage area: ________
8. Stream order: ________
9. Length of reach evaluated: 50 feet
10. County: Cabarrus County
11. Site coordinates (if known): prefer in decimal degrees.
12. Subdivision name (if any): ________

Latitude (ex. 34.872312): 35.2681°N Longitude (ex. 77.556611): 80.6381°W

Method location determined (circle): GPS Topo Sheet Ortho (Aerial) Photo/GIS Other GIS Other________

13. Location of reach under evaluation (note nearby roads and landmarks and attach map identifying stream(s) location): upstream of the confluence of Clear Creek and Mckee Creek
14. Proposed channel work (if any): Restoration (Provide additional structure in channel)
15. Recent weather conditions: Hot with occasional evening Storms
16. Site conditions at time of visit: Temperature was high 80's and Sunny
17. Identify any special waterway classifications known: ___Section 10 ___Tidal Waters ___Essential Fisheries Habitat ___Trout Waters ___Outstanding Resource Waters ___Nutrient Sensitive Waters ___Water Supply Watershed ___(I-IV)
18. Is there a pond or lake located upstream of the evaluation point? YES NO If yes, estimate the water surface area:________
19. Does channel appear on USGS quad map? YES NO
20. Does channel appear on USDA Soil Survey? YES NO
21. Estimated watershed land use: 10 % Residential ___% Commercial ___% Industrial 10 % Agricultural 80 % Forested ___% Cleared / Logged ___% Other (________)
22. Bankfull width: 20-25'
23. Bank height (from bed to top of bank): 5-6'
24. Channel slope down center of stream: X Flat (0 to 2%) Gentle (2 to 4%) ___Moderate (4 to 10%) ___Steep (>10%)
25. Channel sinuosity: ___Straight ___Occasional bends X Frequent meander ___Very sinuous ___Braided channel

Instructions for completion of worksheet (located on page 2): Begin by determining the most appropriate ecoregion based on location, terrain, vegetation, stream classification, etc. Every characteristic must be scored using the same ecoregion. Assign points to each characteristic within the range shown for the ecoregion. Page 3 provides a brief description of how to review the characteristics identified in the worksheet. Scores should reflect an overall assessment of the stream reach under evaluation. If a characteristic cannot be evaluated due to site or weather conditions, enter 0 in the scoring box and provide an explanation in the comment section. Where there are obvious changes in the character of a stream under review (e.g., the stream flows from a pasture into a forest), the stream may be divided into smaller reaches that display more continuity, and a separate form used to evaluate each reach. The total score assigned to a stream reach must range between 0 and 100, with a score of 100 representing a stream of the highest quality.

Total Score (from reverse): 80 **Comments:**________

Evaluator's Signature [signature] Date 7-17-07

This channel evaluation form is intended to be used only as a guide to assist landowners and environmental professionals in gathering the data required by the United States Army Corps of Engineers to make a preliminary assessment of stream quality. The total score resulting from the completion of this form is subject to USACE approval and does not imply a particular mitigation ratio or requirement. Form subject to change – version 06/03. To Comment, please call 919-876-8441 x 26.

STREAM QUALITY ASSESSMENT WORKSHEET

	#	CHARACTERISTICS	ECOREGION POINT RANGE			SCORE
			Coastal	Piedmont	Mountain	
PHYSICAL	1	**Presence of flow / persistent pools in stream** (no flow or saturation = 0; strong flow = max points)	0 – 5	0 – 4	0 – 5	4
	2	**Evidence of past human alteration** (extensive alteration = 0; no alteration = max points)	0 – 6	0 – 5	0 – 5	4
	3	**Riparian zone** (no buffer = 0; contiguous, wide buffer = max points)	0 – 6	0 – 4	0 – 5	4
	4	**Evidence of nutrient or chemical discharges** (extensive discharges = 0; no discharges = max points)	0 – 5	0 – 4	0 – 4	3
	5	**Groundwater discharge** (no discharge = 0; springs, seeps, wetlands, etc. = max points)	0 – 3	0 – 4	0 – 4	4
	6	**Presence of adjacent floodplain** (no floodplain = 0; extensive floodplain = max points)	0 – 4	0 – 4	0 – 2	4
	7	**Entrenchment / floodplain access** (deeply entrenched = 0; frequent flooding = max points)	0 – 5	0 – 4	0 – 2	3
	8	**Presence of adjacent wetlands** (no wetlands = 0; large adjacent wetlands = max points)	0 – 6	0 – 4	0 – 2	3
	9	**Channel sinuosity** (extensive channelization = 0; natural meander = max points)	0 – 5	0 – 4	0 – 3	3
	10	**Sediment input** (extensive deposition= 0; little or no sediment = max points)	0 – 5	0 – 4	0 – 4	3
	11	**Size & diversity of channel bed substrate** (fine, homogenous = 0; large, diverse sizes = max points)	NA*	0 – 4	0 – 5	3
STABILITY	12	**Evidence of channel incision or widening** (deeply incised = 0; stable bed & banks = max points)	0 – 5	0 – 4	0 – 5	3
	13	**Presence of major bank failures** (severe erosion = 0; no erosion, stable banks = max points)	0 – 5	0 – 5	0 – 5	3
	14	**Root depth and density on banks** (no visible roots = 0; dense roots throughout = max points)	0 – 3	0 – 4	0 – 5	2
	15	**Impact by agriculture, livestock, or timber production** (substantial impact =0; no evidence = max points)	0 – 5	0 – 4	0 – 5	3
HABITAT	16	**Presence of riffle-pool/ripple-pool complexes** (no riffles/ripples or pools = 0; well-developed = max points)	0 – 3	0 – 5	0 – 6	3
	17	**Habitat complexity** (little or no habitat = 0; frequent, varied habitats = max points)	0 – 6	0 – 6	0 – 6	6
	18	**Canopy coverage over streambed** (no shading vegetation = 0; continuous canopy = max points)	0 – 5	0 – 5	0 – 5	4
	19	**Substrate embeddedness** (deeply embedded = 0; loose structure = max)	NA*	0 – 4	0 – 4	3
BIOLOGY	20	**Presence of stream invertebrates** (see page 4) (no evidence = 0; common, numerous types = max points)	0 – 4	0 – 5	0 – 5	4
	21	**Presence of amphibians** (no evidence = 0; common, numerous types = max points)	0 – 4	0 – 4	0 – 4	3
	22	**Presence of fish** (no evidence = 0; common, numerous types = max points)	0 – 4	0 – 4	0 – 4	3
	23	**Evidence of wildlife use** (no evidence = 0; abundant evidence = max points)	0 – 6	0 – 5	0 – 5	5
		Total Points Possible	100	100	100	
		TOTAL SCORE (also enter on first page)				80

* These characteristics are not assessed in coastal streams.

#5

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

Date: 7-24-07	Project: McKee Creek	Latitude:
Evaluator: LT	Site:	Longitude:
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30* 20	County: Cabarrus	Other *e.g. Quad Name:*

A. Geomorphology (Subtotal = 11)	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 = 3.5)				
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 = 5.5)				
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.)

Between #115 and McKee Crk

Eulalia Viminea in Stream Bed

Sketch:

USACE AID#__________ DWQ #__________ Site #5 (indicate on attached map)

STREAM QUALITY ASSESSMENT WORKSHEET

Provide the following information for the stream reach under assessment:

1. Applicant's name: EEP-NC
2. Evaluator's name: Luke T
3. Date of evaluation: 7-24-07
4. Time of evaluation: 12:30
5. Name of stream: UT to McKee
6. River basin: Yadkin
7. Approximate drainage area:
8. Stream order: 1st
9. Length of reach evaluated:
10. County: Cabarrus
11. Site coordinates (if known): prefer in decimal degrees.
12. Subdivision name (if any):

Latitude (ex. 34.872312): __________ Longitude (ex. -77.556611): __________

Method location determined (circle): GPS Topo Sheet Ortho (Aerial) Photo/GIS Other GIS Other__________

13. Location of reach under evaluation (note nearby roads and landmarks and attach map identifying stream(s) location):

14. Proposed channel work (if any): None
15. Recent weather conditions:
16. Site conditions at time of visit:
17. Identify any special waterway classifications known: ___Section 10 ___Tidal Waters ___Essential Fisheries Habitat ___Trout Waters ___Outstanding Resource Waters ___ Nutrient Sensitive Waters ___Water Supply Watershed ___(I-IV)
18. Is there a pond or lake located upstream of the evaluation point? YES NO If yes, estimate the water surface area:
19. Does channel appear on USGS quad map? YES NO
20. Does channel appear on USDA Soil Survey? YES NO
21. Estimated watershed land use: X % Residential ___% Commercial ___% Industrial ___% Agricultural ___% Forested ___% Cleared / Logged ___% Other (__________)
22. Bankfull width: 2-3'
23. Bank height (from bed to top of bank): 4-5'
24. Channel slope down center of stream: X Flat (0 to 2%) ___Gentle (2 to 4%) ___Moderate (4 to 10%) ___Steep (>10%)
25. Channel sinuosity: ___Straight X Occasional bends ___Frequent meander ___Very sinuous ___Braided channel

Instructions for completion of worksheet (located on page 2): Begin by determining the most appropriate ecoregion based on location, terrain, vegetation, stream classification, etc. Every characteristic must be scored using the same ecoregion. Assign points to each characteristic within the range shown for the ecoregion. Page 3 provides a brief description of how to review the characteristics identified in the worksheet. Scores should reflect an overall assessment of the stream reach under evaluation. If a characteristic cannot be evaluated due to site or weather conditions, enter 0 in the scoring box and provide an explanation in the comment section. Where there are obvious changes in the character of a stream under review (e.g., the stream flows from a pasture into a forest), the stream may be divided into smaller reaches that display more continuity, and a separate form used to evaluate each reach. The total score assigned to a stream reach must range between 0 and 100, with a score of 100 representing a stream of the highest quality.

Total Score (from reverse): 45 **Comments:**

Evaluator's Signature__________ **Date**__________

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STREAM QUALITY ASSESSMENT WORKSHEET

	#	CHARACTERISTICS	ECOREGION POINT RANGE			SCORE
			Coastal	Piedmont	Mountain	
PHYSICAL	1	Presence of flow / persistent pools in stream (no flow or saturation = 0; strong flow = max points)	0 – 5	0 – 4	0 – 5	0
	2	Evidence of past human alteration (extensive alteration = 0; no alteration = max points)	0 – 6	0 – 5	0 – 5	1
	3	Riparian zone (no buffer = 0; contiguous, wide buffer = max points)	0 – 6	0 – 4	0 – 5	3
	4	Evidence of nutrient or chemical discharges (extensive discharges = 0; no discharges = max points)	0 – 5	0 – 4	0 – 4	2
	5	Groundwater discharge (no discharge = 0; springs, seeps, wetlands, etc. = max points)	0 – 3	0 – 4	0 – 4	0
	6	Presence of adjacent floodplain (no floodplain = 0; extensive floodplain = max points)	0 – 4	0 – 4	0 – 2	0
	7	Entrenchment / floodplain access (deeply entrenched = 0; frequent flooding = max points)	0 – 5	0 – 4	0 – 2	2
	8	Presence of adjacent wetlands (no wetlands = 0; large adjacent wetlands = max points)	0 – 6	0 – 4	0 – 2	0
	9	Channel sinuosity (extensive channelization = 0; natural meander = max points)	0 – 5	0 – 4	0 – 3	2
	10	Sediment input (extensive deposition = 0; little or no sediment = max points)	0 – 5	0 – 4	0 – 4	3
STABILITY	11	Size & diversity of channel bed substrate (fine, homogenous = 0; large, diverse sizes = max points)	NA*	0 – 4	0 – 5	1
	12	Evidence of channel incision or widening (deeply incised = 0; stable bed & banks = max points)	0 – 5	0 – 4	0 – 5	3
	13	Presence of major bank failures (severe erosion = 0; no erosion, stable banks = max points)	0 – 5	0 – 5	0 – 5	3
	14	Root depth and density on banks (no visible roots = 0; dense roots throughout = max points)	0 – 3	0 – 4	0 – 5	3
	15	Impact by agriculture, livestock, or timber production (substantial impact = 0; no evidence = max points)	0 – 5	0 – 4	0 – 5	4
HABITAT	16	Presence of riffle-pool/ripple-pool complexes (no riffles/ripples or pools = 0; well-developed = max points)	0 – 3	0 – 5	0 – 6	2
	17	Habitat complexity (little or no habitat = 0; frequent, varied habitats = max points)	0 – 6	0 – 6	0 – 6	5
	18	Canopy coverage over streambed (no shading vegetation = 0; continuous canopy = max points)	0 – 5	0 – 5	0 – 5	4
	19	Substrate embeddedness (deeply embedded = 0; loose structure = max)	NA*	0 – 4	0 – 4	3
BIOLOGY	20	Presence of stream invertebrates (see page 4) (no evidence = 0; common, numerous types = max points)	0 – 4	0 – 5	0 – 5	0
	21	Presence of amphibians (no evidence = 0; common, numerous types = max points)	0 – 4	0 – 4	0 – 4	0
	22	Presence of fish (no evidence = 0; common, numerous types = max points)	0 – 4	0 – 4	0 – 4	0
	23	Evidence of wildlife use (no evidence = 0; abundant evidence = max points)	0 – 6	0 – 5	0 – 5	4
		Total Points Possible	100	100	100	
		TOTAL SCORE (also enter on first page)				45

* These characteristics are not assessed in coastal streams.

#6

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

Date: 7-24-07	Project:	Latitude:
Evaluator:	Site:	Longitude:
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30* 18.75	County:	Other *e.g. Quad Name:*

A. Geomorphology (Subtotal = 11)	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 = 2)	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 = 5.75)	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.)

30' from Confluence w/ McKee Crk

Sketch:

USACE AID#__________ DWQ #__________ Site # 6 (indicate on attached map)

STREAM QUALITY ASSESSMENT WORKSHEET

Provide the following information for the stream reach under assessment:

1. Applicant's name:__________ 2. Evaluator's name: Luke T

3. Date of evaluation: 7-24-07 4. Time of evaluation: 12:00

5. Name of stream: ut to Makee 6. River basin: Yadkin RB

7. Approximate drainage area:__________ 8. Stream order: 1st

9. Length of reach evaluated: 50' 10. County: Cabarrus

11. Site coordinates (if known): prefer in decimal degrees. 12. Subdivision name (if any):__________

Latitude (ex. 34.872312): __________ Longitude (ex. –77.556611):__________

Method location determined (circle): GPS Topo Sheet Ortho (Aerial) Photo/GIS Other GIS Other __________

13. Location of reach under evaluation (note nearby roads and landmarks and attach map identifying stream(s) location):__________

14. Proposed channel work (if any):__________

15. Recent weather conditions:__________

16. Site conditions at time of visit:__________

17. Identify any special waterway classifications known: ___Section 10 ___Tidal Waters ___Essential Fisheries Habitat

___Trout Waters ___Outstanding Resource Waters ___Nutrient Sensitive Waters ___Water Supply Watershed ___(I-IV)

18. Is there a pond or lake located upstream of the evaluation point? YES NO If yes, estimate the water surface area:__________

19. Does channel appear on USGS quad map? YES NO 20. Does channel appear on USDA Soil Survey? YES NO

21. Estimated watershed land use: ___% Residential ___% Commercial ___% Industrial ___% Agricultural

___% Forested ___% Cleared / Logged ___% Other (__________)

22. Bankfull width:__________ 23. Bank height (from bed to top of bank):__________

24. Channel slope down center of stream: ___Flat (0 to 2%) ___Gentle (2 to 4%) ___Moderate (4 to 10%) ___Steep (>10%)

25. Channel sinuosity: ___Straight ___Occasional bends ___Frequent meander ___Very sinuous ___Braided channel

Instructions for completion of worksheet (located on page 2): Begin by determining the most appropriate ecoregion based on location, terrain, vegetation, stream classification, etc. Every characteristic must be scored using the same ecoregion. Assign points to each characteristic within the range shown for the ecoregion. Page 3 provides a brief description of how to review the characteristics identified in the worksheet. Scores should reflect an overall assessment of the stream reach under evaluation. If a characteristic cannot be evaluated due to site or weather conditions, enter 0 in the scoring box and provide an explanation in the comment section. Where there are obvious changes in the character of a stream under review (e.g., the stream flows from a pasture into a forest), the stream may be divided into smaller reaches that display more continuity, and a separate form used to evaluate each reach. The total score assigned to a stream reach must range between 0 and 100, with a score of 100 representing a stream of the highest quality.

Total Score (from reverse): 57 **Comments:**__________

Evaluator's Signature__________ **Date**__________

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STREAM QUALITY ASSESSMENT WORKSHEET

	#	CHARACTERISTICS	ECOREGION POINT RANGE			SCORE
			Coastal	Piedmont	Mountain	
PHYSICAL	1	**Presence of flow / persistent pools in stream** (no flow or saturation = 0; strong flow = max points)	0 – 5	0 – 4	0 – 5	0
	2	**Evidence of past human alteration** (extensive alteration = 0; no alteration = max points)	0 – 6	0 – 5	0 – 5	4
	3	**Riparian zone** (no buffer = 0; contiguous, wide buffer = max points)	0 – 6	0 – 4	0 – 5	4
	4	**Evidence of nutrient or chemical discharges** (extensive discharges = 0; no discharges = max points)	0 – 5	0 – 4	0 – 4	4
	5	**Groundwater discharge** (no discharge = 0; springs, seeps, wetlands, etc. = max points)	0 – 3	0 – 4	0 – 4	0
	6	**Presence of adjacent floodplain** (no floodplain = 0; extensive floodplain = max points)	0 – 4	0 – 4	0 – 2	2
	7	**Entrenchment / floodplain access** (deeply entrenched = 0; frequent flooding = max points)	0 – 5	0 – 4	0 – 2	0
	8	**Presence of adjacent wetlands** (no wetlands = 0; large adjacent wetlands = max points)	0 – 6	0 – 4	0 – 2	0
STABILITY	9	**Channel sinuosity** (extensive channelization = 0; natural meander = max points)	0 – 5	0 – 4	0 – 3	1
	10	**Sediment input** (extensive deposition = 0; little or no sediment = max points)	0 – 5	0 – 4	0 – 4	3
	11	**Size & diversity of channel bed substrate** (fine, homogenous = 0; large, diverse sizes = max points)	NA*	0 – 4	0 – 5	4
	12	**Evidence of channel incision or widening** (deeply incised = 0; stable bed & banks = max points)	0 – 5	0 – 4	0 – 5	3
	13	**Presence of major bank failures** (severe erosion = 0; no erosion, stable banks = max points)	0 – 5	0 – 5	0 – 5	4
	14	**Root depth and density on banks** (no visible roots = 0; dense roots throughout = max points)	0 – 3	0 – 4	0 – 5	3
	15	**Impact by agriculture, livestock, or timber production** (substantial impact = 0; no evidence = max points)	0 – 5	0 – 4	0 – 5	4
HABITAT	16	**Presence of riffle-pool/ripple-pool complexes** (no riffles/ripples or pools = 0; well-developed = max points)	0 – 3	0 – 5	0 – 6	3
	17	**Habitat complexity** (little or no habitat = 0; frequent, varied habitats = max points)	0 – 6	0 – 6	0 – 6	6
	18	**Canopy coverage over streambed** (no shading vegetation = 0; continuous canopy = max points)	0 – 5	0 – 5	0 – 5	5
	19	**Substrate embeddedness** (deeply embedded = 0; loose structure = max)	NA*	0 – 4	0 – 4	3
BIOLOGY	20	**Presence of stream invertebrates** (see page 4) (no evidence = 0; common, numerous types = max points)	0 – 4	0 – 5	0 – 5	0
	21	**Presence of amphibians** (no evidence = 0; common, numerous types = max points)	0 – 4	0 – 4	0 – 4	0
	22	**Presence of fish** (no evidence = 0; common, numerous types = max points)	0 – 4	0 – 4	0 – 4	0
	23	**Evidence of wildlife use** (no evidence = 0; abundant evidence = max points)	0 – 6	0 – 5	0 – 5	4
		Total Points Possible	100	100	100	
		TOTAL SCORE (also enter on first page)				57

* These characteristics are not assessed in coastal streams.

#7

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

Date:	7-24-07	Project:	Mckee Creek	Latitude:	
Evaluator:	LT	Site:		Longitude:	
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30*	20.75	County:	Cabarrus	Other *e.g. Quad Name:*	

A. Geomorphology (Subtotal = 13)	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 = 2)				
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 = 5.75)				
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.)

Elm in Stream Bed
50' from Mckee

Sketch:

USACE AID#________ DWQ #________ Site #7 (indicate on attached map)

STREAM QUALITY ASSESSMENT WORKSHEET

Provide the following information for the stream reach under assessment:

1. Applicant's name: ________
2. Evaluator's name: Luke Tuschat
3. Date of evaluation: 7-24-07
4. Time of evaluation: 11:15
5. Name of stream: UT to Meker Creek
6. River basin: Yadkin River Basin
7. Approximate drainage area: ________
8. Stream order: ________
9. Length of reach evaluated: 50'
10. County: Cabarrus
11. Site coordinates (if known): prefer in decimal degrees.
12. Subdivision name (if any): ________

Latitude (ex. 34.872312): ________ Longitude (ex. -77.556611): ________

Method location determined (circle): GPS Topo Sheet Ortho (Aerial) Photo/GIS Other GIS Other________

13. Location of reach under evaluation (note nearby roads and landmarks and attach map identifying stream(s) location): ________

14. Proposed channel work (if any): ________
15. Recent weather conditions: Dry
16. Site conditions at time of visit: ________
17. Identify any special waterway classifications known: ___Section 10 ___Tidal Waters ___Essential Fisheries Habitat ___Trout Waters ___Outstanding Resource Waters ___ Nutrient Sensitive Waters ___Water Supply Watershed ___(I-IV)
18. Is there a pond or lake located upstream of the evaluation point? YES NO If yes, estimate the water surface area: ________
19. Does channel appear on USGS quad map? YES NO
20. Does channel appear on USDA Soil Survey? YES NO
21. Estimated watershed land use: ___% Residential 35% Commercial ___% Industrial 50% Agricultural 15% Forested ___% Cleared / Logged ___% Other (________)
22. Bankfull width: 7'-8'
23. Bank height (from bed to top of bank): 6'
24. Channel slope down center of stream: X Flat (0 to 2%) ___Gentle (2 to 4%) ___Moderate (4 to 10%) ___Steep (>10%)
25. Channel sinuosity: ___Straight X Occasional bends ___Frequent meander ___Very sinuous ___Braided channel

Instructions for completion of worksheet (located on page 2): Begin by determining the most appropriate ecoregion based on location, terrain, vegetation, stream classification, etc. Every characteristic must be scored using the same ecoregion. Assign points to each characteristic within the range shown for the ecoregion. Page 3 provides a brief description of how to review the characteristics identified in the worksheet. Scores should reflect an overall assessment of the stream reach under evaluation. If a characteristic cannot be evaluated due to site or weather conditions, enter 0 in the scoring box and provide an explanation in the comment section. Where there are obvious changes in the character of a stream under review (e.g., the stream flows from a pasture into a forest), the stream may be divided into smaller reaches that display more continuity, and a separate form used to evaluate each reach. The total score assigned to a stream reach must range between 0 and 100, with a score of 100 representing a stream of the highest quality.

Total Score (from reverse): 49 **Comments:** ________

Evaluator's Signature________ **Date**________

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STREAM QUALITY ASSESSMENT WORKSHEET

	#	CHARACTERISTICS	ECOREGION POINT RANGE			SCORE
			Coastal	Piedmont	Mountain	
PHYSICAL	1	**Presence of flow / persistent pools in stream** (no flow or saturation = 0; strong flow = max points)	0 – 5	0 – 4	0 – 5	0
	2	**Evidence of past human alteration** (extensive alteration = 0; no alteration = max points)	0 – 6	0 – 5	0 – 5	5
	3	**Riparian zone** (no buffer = 0; contiguous, wide buffer = max points)	0 – 6	0 – 4	0 – 5	3
	4	**Evidence of nutrient or chemical discharges** (extensive discharges = 0; no discharges = max points)	0 – 5	0 – 4	0 – 4	4
	5	**Groundwater discharge** (no discharge = 0; springs, seeps, wetlands, etc. = max points)	0 – 3	0 – 4	0 – 4	0
	6	**Presence of adjacent floodplain** (no floodplain = 0; extensive floodplain = max points)	0 – 4	0 – 4	0 – 2	1
	7	**Entrenchment / floodplain access** (deeply entrenched = 0; frequent flooding = max points)	0 – 5	0 – 4	0 – 2	2
	8	**Presence of adjacent wetlands** (no wetlands = 0; large adjacent wetlands = max points)	0 – 6	0 – 4	0 – 2	0
	9	**Channel sinuosity** (extensive channelization = 0; natural meander = max points)	0 – 5	0 – 4	0 – 3	1
	10	**Sediment input** (extensive deposition = 0; little or no sediment = max points)	0 – 5	0 – 4	0 – 4	1
	11	**Size & diversity of channel bed substrate** (fine, homogenous = 0; large, diverse sizes = max points)	NA*	0 – 4	0 – 5	4
STABILITY	12	**Evidence of channel incision or widening** (deeply incised = 0; stable bed & banks = max points)	0 – 5	0 – 4	0 – 5	1
	13	**Presence of major bank failures** (severe erosion = 0; no erosion, stable banks = max points)	0 – 5	0 – 5	0 – 5	3
	14	**Root depth and density on banks** (no visible roots = 0; dense roots throughout = max points)	0 – 3	0 – 4	0 – 5	2
	15	**Impact by agriculture, livestock, or timber production** (substantial impact = 0; no evidence = max points)	0 – 5	0 – 4	0 – 5	3
HABITAT	16	**Presence of riffle-pool/ripple-pool complexes** (no riffles/ripples or pools = 0; well-developed = max points)	0 – 3	0 – 5	0 – 6	3
	17	**Habitat complexity** (little or no habitat = 0; frequent, varied habitats = max points)	0 – 6	0 – 6	0 – 6	6
	18	**Canopy coverage over streambed** (no shading vegetation = 0; continuous canopy = max points)	0 – 5	0 – 5	0 – 5	4
	19	**Substrate embeddedness** (deeply embedded = 0; loose structure = max)	NA*	0 – 4	0 – 4	3
BIOLOGY	20	**Presence of stream invertebrates** (see page 4) (no evidence = 0; common, numerous types = max points)	0 – 4	0 – 5	0 – 5	0
	21	**Presence of amphibians** (no evidence = 0; common, numerous types = max points)	0 – 4	0 – 4	0 – 4	0
	22	**Presence of fish** (no evidence = 0; common, numerous types = max points)	0 – 4	0 – 4	0 – 4	0
	23	**Evidence of wildlife use** (no evidence = 0; abundant evidence = max points)	0 – 6	0 – 5	0 – 5	3
		Total Points Possible	100	100	100	
		TOTAL SCORE (also enter on first page)				49

* These characteristics are not assessed in coastal streams.

Appendix 4 – Reference Site Photographs

Cross-Section 1 Riffle

Cross-Section 2 Pool

Cross-Section 3 Pool

Cross-Section 4 Riffle

Cross-Section 5 Riffle

Cross-Section 6 Pool

Appendix 5 – Reference Site USACE Routine Wetland Determination Data Forms

USACE AID#________	DWQ #________	Site #____ (indicate on attached map)

STREAM QUALITY ASSESSMENT WORKSHEET

Provide the following information for the stream reach under assessment:

1. Applicant's name: NC-EED
2. Evaluator's name: Todd P. ; Luke T
3. Date of evaluation: 1-9-08
4. Time of evaluation: Early Afternoon
5. Name of stream: Dixon Branch
6. River basin: Catawba River Basin
7. Approximate drainage area:________
8. Stream order: unknown
9. Length of reach evaluated: 50'
10. County: Mecklenburg
11. Site coordinates (if known): prefer in decimal degrees
12. Subdivision name (if any):________

Latitude (ex. 34.872312):________ Longitude (ex. -77.556611):________

Method location determined (circle): GPS Topo Sheet Ortho (Aerial) Photo/GIS Other GIS Other________

13. Location of reach under evaluation (note nearby roads and landmarks and attach map identifying stream(s) location): The reach evaluated is ~ 300' upstream of the intersection of Dixon Branch and S.R. 2116.
14. Proposed channel work (if any): None
15. Recent weather conditions: Drought
16. Site conditions at time of visit: Dry
17. Identify any special waterway classifications known: ___Section 10 ___Tidal Waters ___Essential Fisheries Habitat ___Trout Waters ___Outstanding Resource Waters ___Nutrient Sensitive Waters ___Water Supply Watershed ___(I-IV)
18. Is there a pond or lake located upstream of the evaluation point? YES NO If yes, estimate the water surface area: < 1 Acre
19. Does channel appear on USGS quad map? YES NO
20. Does channel appear on USDA Soil Survey? YES NO
21. Estimated watershed land use: 30 % Residential 30 % Commercial 10 % Industrial ___% Agricultural 30 % Forested ___% Cleared / Logged ___% Other (________)
22. Bankfull width: 4-6'
23. Bank height (from bed to top of bank): 2'-3'
24. Channel slope down center of stream: ___Flat (0 to 2%) X Gentle (2 to 4%) ___Moderate (4 to 10%) ___Steep (>10%)
25. Channel sinuosity: ___Straight ___Occasional bends X Frequent meander ___Very sinuous ___Braided channel

Instructions for completion of worksheet (located on page 2): Begin by determining the most appropriate ecoregion based on location, terrain, vegetation, stream classification, etc. Every characteristic must be scored using the same ecoregion. Assign points to each characteristic within the range shown for the ecoregion. Page 3 provides a brief description of how to review the characteristics identified in the worksheet. Scores should reflect an overall assessment of the stream reach under evaluation. If a characteristic cannot be evaluated due to site or weather conditions, enter 0 in the scoring box and provide an explanation in the comment section. Where there are obvious changes in the character of a stream under review (e.g., the stream flows from a pasture into a forest), the stream may be divided into smaller reaches that display more continuity, and a separate form used to evaluate each reach. The total score assigned to a stream reach must range between 0 and 100, with a score of 100 representing a stream of the highest quality.

Total Score (from reverse):________ Comments: Reference Reach

Evaluator's Signature________ Date________

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STREAM QUALITY ASSESSMENT WORKSHEET

	#	CHARACTERISTICS	ECOREGION POINT RANGE Coastal	Piedmont	Mountain	SCORE
PHYSICAL	1	**Presence of flow / persistent pools in stream** (no flow or saturation = 0; strong flow = max points)	0 – 5	0 – 4	0 – 5	3
	2	**Evidence of past human alteration** (extensive alteration = 0; no alteration = max points)	0 – 6	0 – 5	0 – 5	3
	3	**Riparian zone** (no buffer = 0; contiguous, wide buffer = max points)	0 – 6	0 – 4	0 – 5	3
	4	**Evidence of nutrient or chemical discharges** (extensive discharges = 0; no discharges = max points)	0 – 5	0 – 4	0 – 4	4
	5	**Groundwater discharge** (no discharge = 0; springs, seeps, wetlands, etc. = max points)	0 – 3	0 – 4	0 – 4	3
	6	**Presence of adjacent floodplain** (no floodplain = 0; extensive floodplain = max points)	0 – 4	0 – 4	0 – 2	3
	7	**Entrenchment / floodplain access** (deeply entrenched = 0; frequent flooding = max points)	0 – 5	0 – 4	0 – 2	1
	8	**Presence of adjacent wetlands** (no wetlands = 0; large adjacent wetlands = max points)	0 – 6	0 – 4	0 – 2	0
	9	**Channel sinuosity** (extensive channelization = 0; natural meander = max points)	0 – 5	0 – 4	0 – 3	3
	10	**Sediment input** (extensive deposition = 0; little or no sediment = max points)	0 – 5	0 – 4	0 – 4	2
	11	**Size & diversity of channel bed substrate** (fine, homogenous = 0; large, diverse sizes = max points)	NA*	0 – 4	0 – 5	3
STABILITY	12	**Evidence of channel incision or widening** (deeply incised = 0; stable bed & banks = max points)	0 – 5	0 – 4	0 – 5	3
	13	**Presence of major bank failures** (severe erosion = 0; no erosion, stable banks = max points)	0 – 5	0 – 5	0 – 5	3
	14	**Root depth and density on banks** (no visible roots = 0; dense roots throughout = max points)	0 – 3	0 – 4	0 – 5	2
	15	**Impact by agriculture, livestock, or timber production** (substantial impact = 0; no evidence = max points)	0 – 5	0 – 4	0 – 5	2
HABITAT	16	**Presence of riffle-pool/ripple-pool complexes** (no riffles/ripples or pools = 0; well-developed = max points)	0 – 3	0 – 5	0 – 6	4
	17	**Habitat complexity** (little or no habitat = 0; frequent, varied habitats = max points)	0 – 6	0 – 6	0 – 6	5
	18	**Canopy coverage over streambed** (no shading vegetation = 0; continuous canopy = max points)	0 – 5	0 – 5	0 – 5	4
	19	**Substrate embeddedness** (deeply embedded = 0; loose structure = max)	NA*	0 – 4	0 – 4	3
BIOLOGY	20	**Presence of stream invertebrates** (see page 4) (no evidence = 0; common, numerous types = max points)	0 – 4	0 – 5	0 – 5	4
	21	**Presence of amphibians** (no evidence = 0; common, numerous types = max points)	0 – 4	0 – 4	0 – 4	1
	22	**Presence of fish** (no evidence = 0; common, numerous types = max points)	0 – 4	0 – 4	0 – 4	0
	23	**Evidence of wildlife use** (no evidence = 0; abundant evidence = max points)	0 – 6	0 – 5	0 – 5	3
		Total Points Possible	100	100	100	
		TOTAL SCORE (also enter on first page)				62

* These characteristics are not assessed in coastal streams.

Appendix 6 – Reference Site NCDWQ Stream Classification Forms

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

Date: 1-9-08	Project: Mckee Crk Rest.	Latitude:	
Evaluator: LT, TP	Site: Reference Reach (Dixon Branch)	Longitude:	
Total Points: Stream is at least intermittent if ≥ 19 or perennial if ≥ 30 45.5	County: Mecklenburg	Other e.g. Quad Name:	

A. Geomorphology (Subtotal = 24.5)	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 = 10.5)				
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 = 10.5)				
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 7 – HEC-RAS Analysis

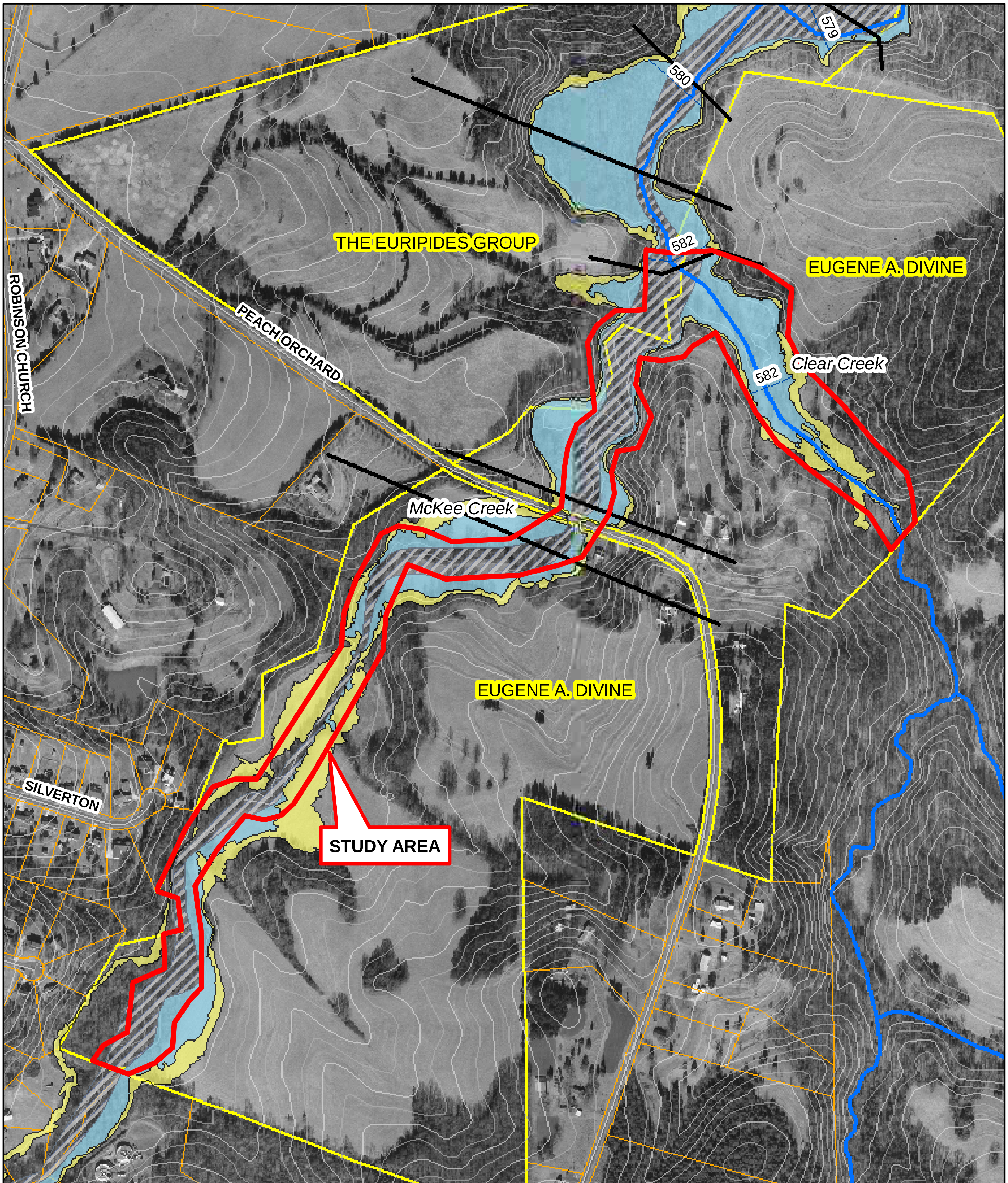


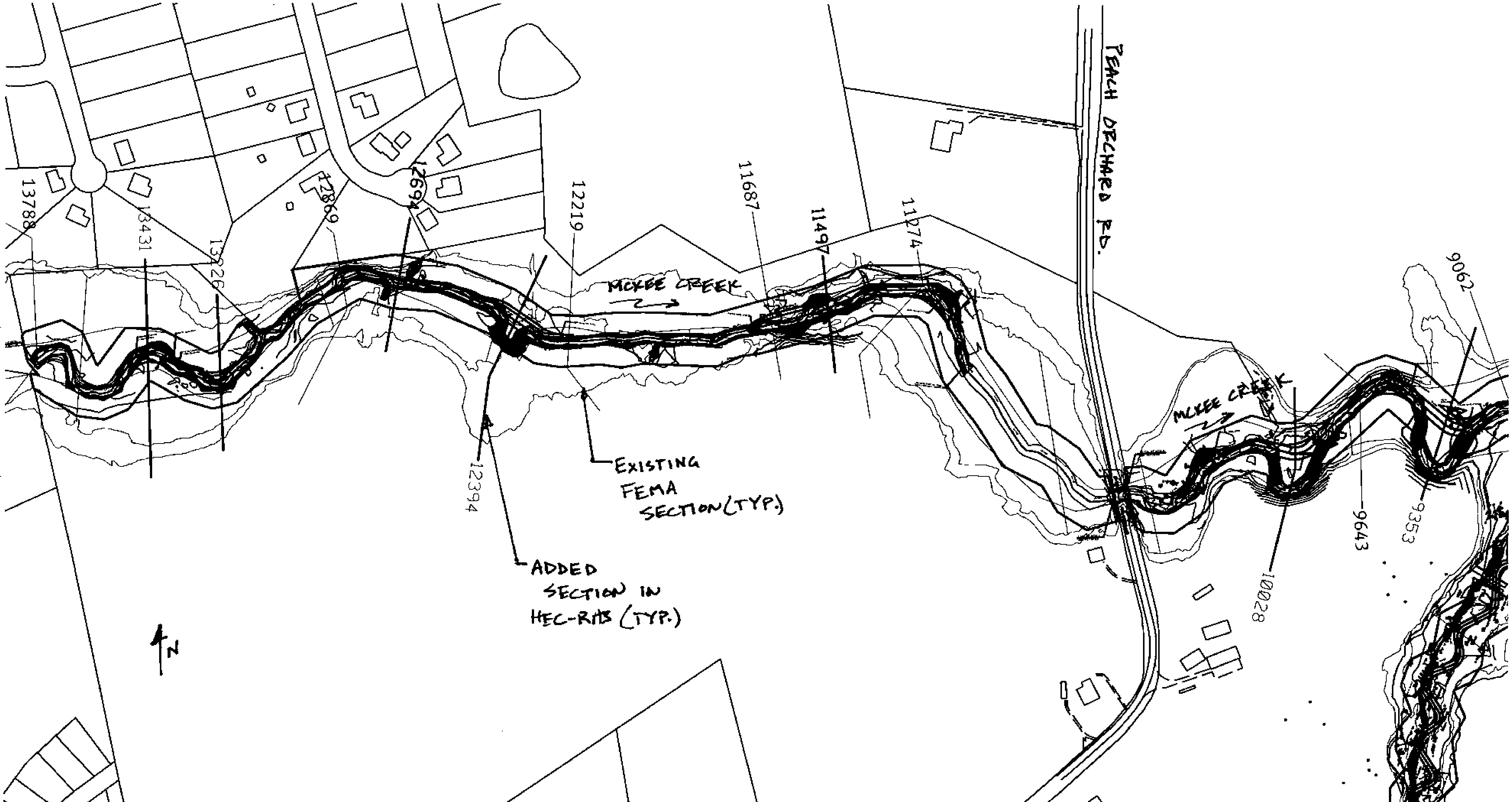
FIGURE - STUDY AREA MAP
McKee Creek Project (D07063S)
Cabarrus County, NC
Date: 10/04/07

1 inch equals 500 feet

N

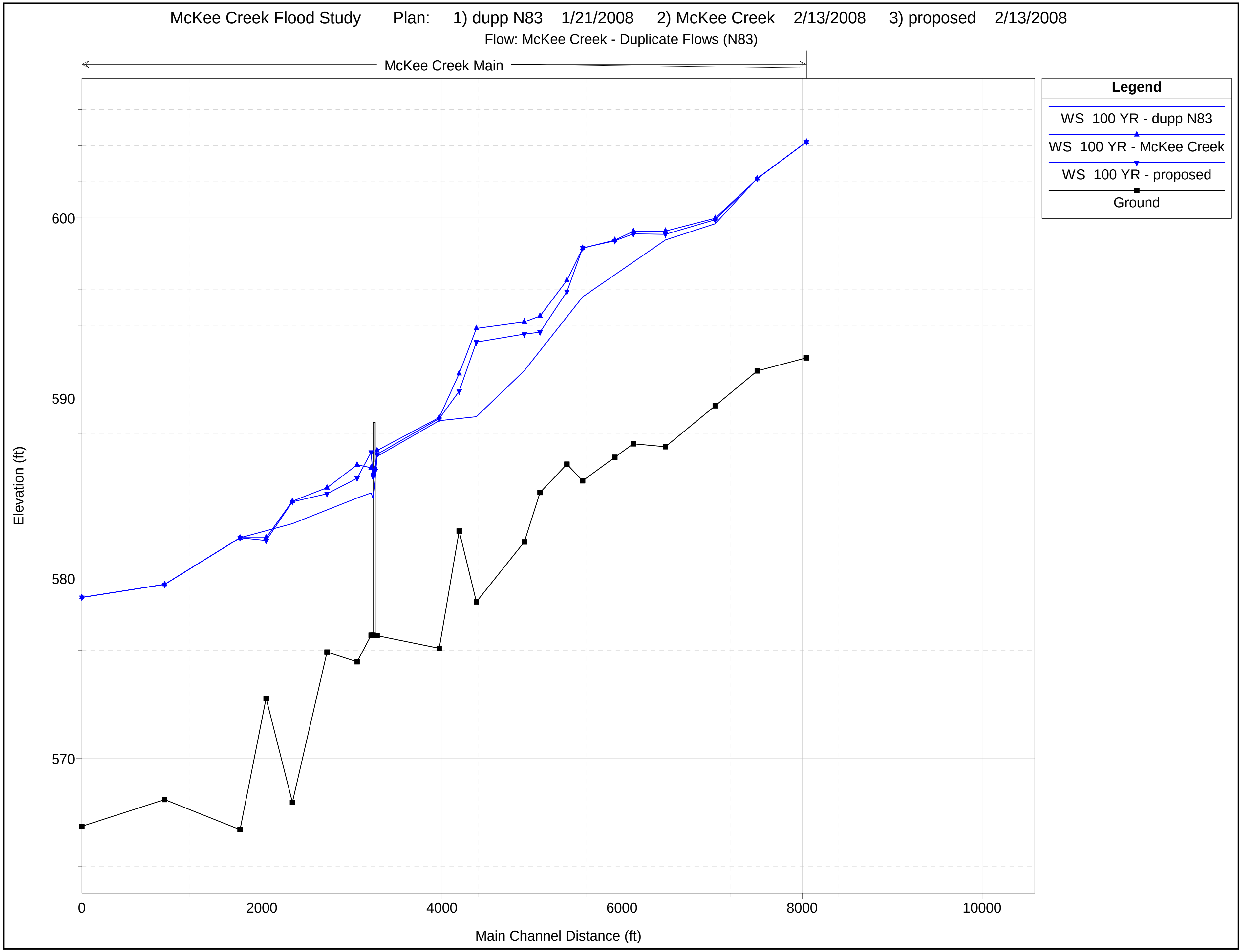
Ecosystem Enhancement PROGRAM

WITHERS & RAVENEL
ENGINEERS | PLANNERS | SURVEYORS
111 MacKenan Drive Cary, North Carolina
telephone: 919.469.3340 www.withersravenel.com



PEACH ORCHARD RD.
MCKEE CREEK
13788
13431
13226
12869
12694
12394
12219
11687
11497
11274
10028
9643
9353
9062
EXISTING FEMA SECTION (TYP.)
ADDED SECTION IN HEC-RAS (TYP.)
N

1" = 250'



1 in Horiz. = 1400 ft 1 in Vert. = 7 ft

FLOODSTUDY COMPARISON TABLE - McKee Creek

STREAM: McKee Creek

Cabarrus County, NC
Date: 2/13/2008

			WSEL from FIS	Duplicate WSEL from HEC-RAS		Existing Conditions Model		Proposed Conditions Model	
River Station	Profile	Discharge (cfs)	WSEL (ft.)	WSEL (ft.)	(FIS WSEL - Dup. WSEL)	WSEL (ft.)	(Ext. WSEL - Dup. WSEL)	WSEL (ft.)	(Prop.WSEL- Ext. WSEL)
15353	10 YR	1640		602.36		602.36	0	602.36	
15353	25 YR	2610		603.73		603.73	0	603.73	
15353	100 YR	3010		604.21		604.21	0	604.21	0
15353	500 YR	4170		605.45		605.45	0	605.45	
14808	10 YR	1640		600		600.02	0.02	600.01	
14808	25 YR	2610		601.62		601.61	-0.01	601.61	
14808	100 YR	3010	602.2	602.18	0.02	602.17	-0.01	602.17	0
14808	500 YR	4170		603.58		603.61	0.03	603.60	
14341	10 YR	1640		597.88		598.18	0.3	597.94	
14341	25 YR	2610		599.18		599.43	0.25	599.33	
14341	100 YR	3010	599.7	599.67	0.03	599.97	0.3	599.89	-0.08
14341	500 YR	4170		600.92		601.49	0.57	601.43	
13788	10 YR	1640		596.88		597.48	0.6	596.94	
13788	25 YR	2610		598.15		598.62	0.47	598.38	
13788	100 YR	3010	598.8	598.77	0.03	599.26	0.49	599.09	-0.17
13788	500 YR	4170		600.39		601.09	0.7	601.01	
13431	10 YR	1640				597.29		596.81	
13431	25 YR	2610				598.55		598.35	
13431	100 YR	3010				599.25		599.11	-0.14
13431	500 YR	4170				601.14		601.07	
13226	10 YR	1640				597.01		596.60	
13226	25 YR	2610				598.04		597.97	
13226	100 YR	3010				598.76		598.72	-0.04
13226	500 YR	4170				600.74		600.71	
12869	10 YR	1923		593.94		596.68	2.74	596.22	
12869	25 YR	2732		595.03		597.63	2.6	597.59	
12869	100 YR	3272	595.6	595.61	-0.01	598.32	2.71	598.32	0
12869	500 YR	4974		596.98		600.21	3.23	600.21	
12694	10 YR	1923				595.82		594.43	
12694	25 YR	2732				596.11		595.26	
12694	100 YR	3272				596.53		595.90	-0.63
12694	500 YR	4974				597.49		597.49	
12394	10 YR	1923				592.25		591.26	
12394	25 YR	2732				594.19		592.66	
12394	100 YR	3272				594.55		593.65	-0.9
12394	500 YR	4974				596.61		596.15	
12219	10 YR	1923		589.68		591.92	2.24	591.06	
12219	25 YR	2732		590.85		593.39	2.54	592.66	
12219	100 YR	3272	591.5	591.51	-0.01	594.22	2.71	593.55	-0.67
12219	500 YR	4974		593.41		596.42	3.01	595.87	
11687	10 YR	1923		586.77		591.69	4.92	590.70	
11687	25 YR	2732		588.10		593.08	4.98	592.25	
11687	100 YR	3272	589	588.96	0.04	593.86	4.9	593.10	-0.76
11687	500 YR	4974		591.35		595.93	4.58	595.31	
11497	10 YR	1923				589.54		588.24	
11497	25 YR	2732				590.70		589.58	
11497	100 YR	3272				591.35		590.37	-0.98
11497	500 YR	4974				592.98		592.15	

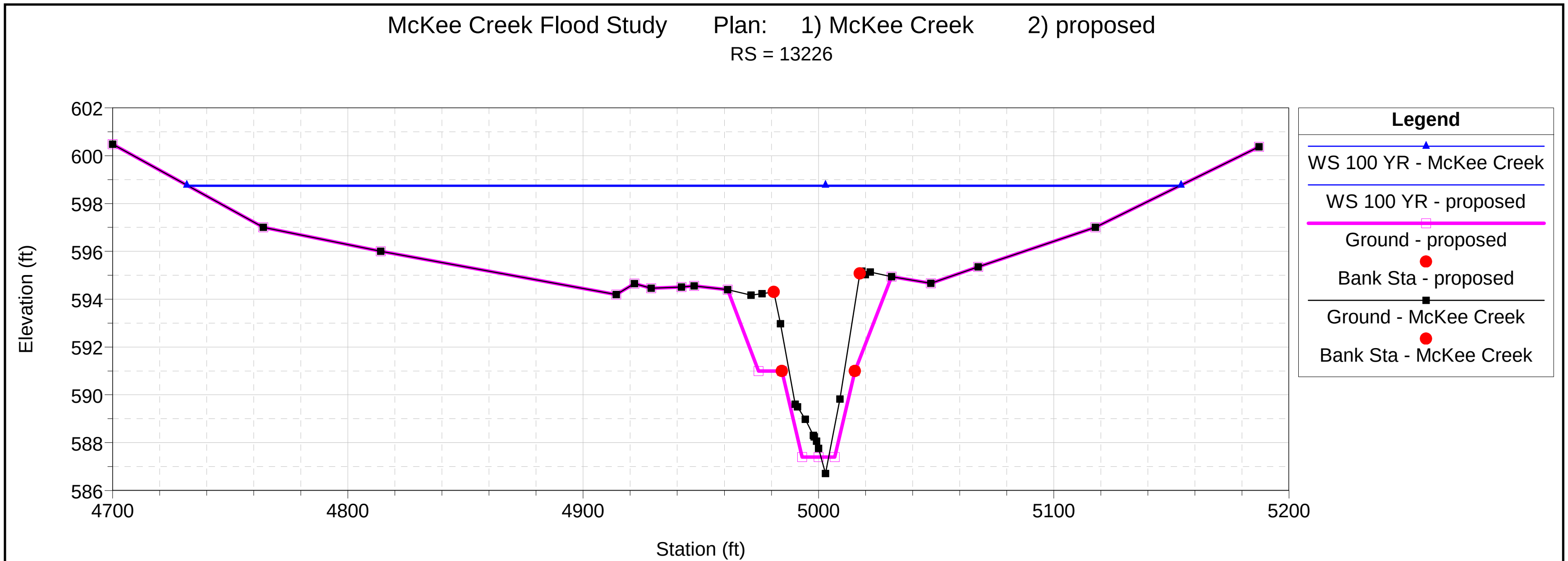
FLOODSTUDY COMPARISON TABLE - McKee Creek

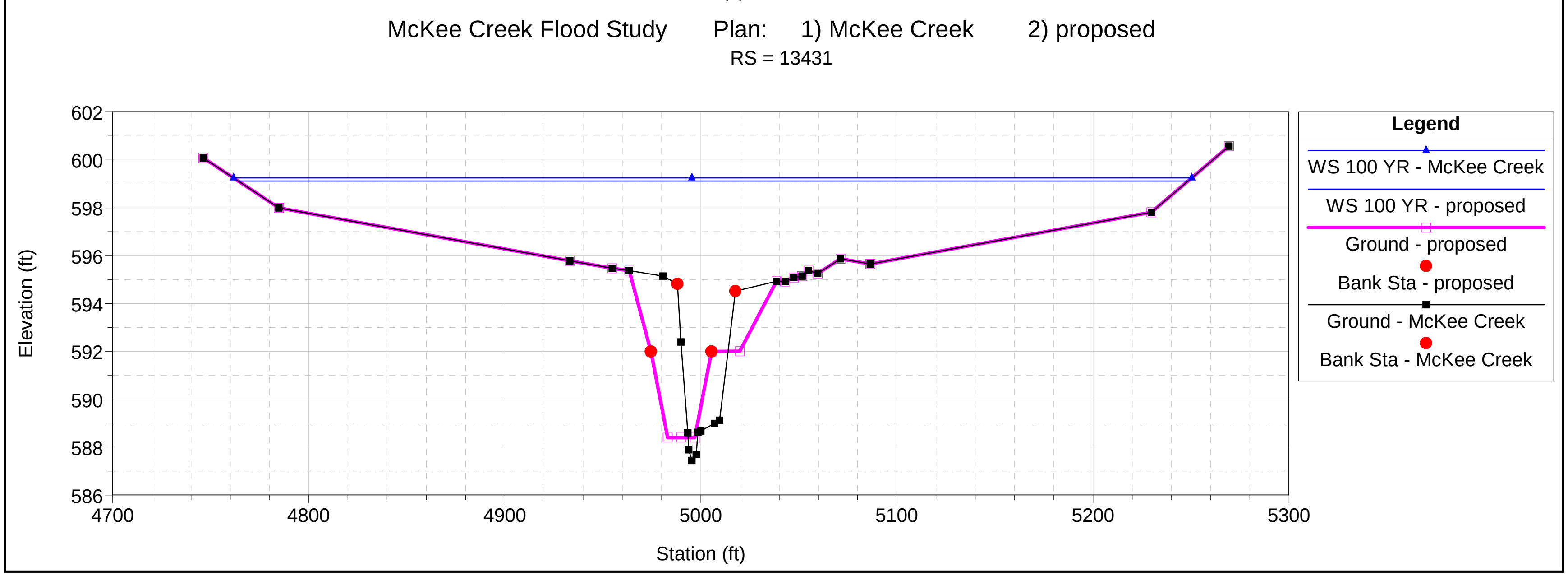
STREAM: McKee Creek

Cabarrus County, NC

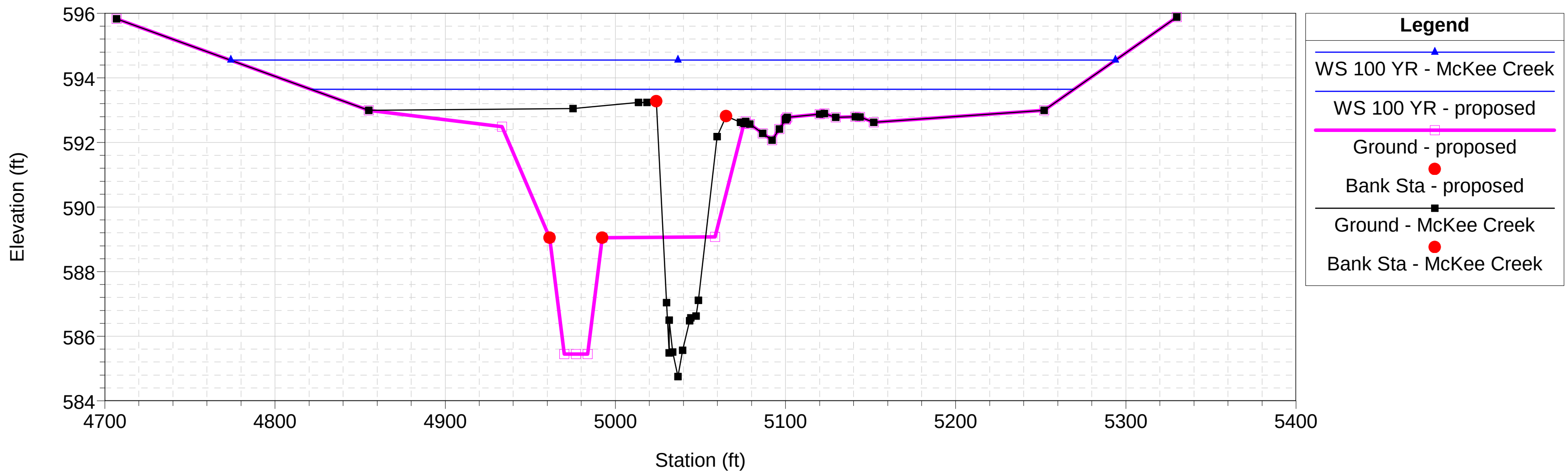
Date: 2/13/2008

			WSEL from FIS	Duplicate WSEL from HEC-RAS		Existing Conditions Model		Proposed Conditions Model	
River Station	Profile	Discharge (cfs)	WSEL (ft.)	WSEL (ft.)	(FIS WSEL - Dup. WSEL)	WSEL (ft.)	(Ext. WSEL - Dup. WSEL)	WSEL (ft.)	(Prop.WSEL- Ext. WSEL)
11274	10 YR	1923		586.36		586.62	0.26	586.43	
11274	25 YR	2732		587.79		588.12	0.33	587.94	
11274	100 YR	3272	588.7	588.74	-0.04	588.91	0.17	588.86	-0.05
11274	500 YR	4974		591.34		591.66	0.32	591.35	
10362	10 YR	1923		582.13		584.58	2.45	583.68	
10362	25 YR	2732		583.59		585.65	2.06	584.87	
10362	100 YR	3272		584.44		586.28	1.84	585.54	-0.74
10362	500 YR	4974		586.63		588.02	1.39	587.32	
10028	10 YR	1923				582.94		582.62	
10028	25 YR	2732				584.29		584.00	
10028	100 YR	3272				585.01		584.68	-0.33
10028	500 YR	4974				586.92		586.48	
9643	10 YR	1923		580.79		582.69	1.9	582.39	
9643	25 YR	2732		582.19		583.70	1.51	583.63	
9643	100 YR	3272	583	583.02	-0.02	584.27	1.25	584.24	-0.03
9643	500 YR	4974		585.09		585.82	0.73	585.83	
9353	10 YR	1923				580.86		579.71	
9353	25 YR	2732				581.80		581.56	
9353	100 YR	3272				582.23		582.08	-0.15
9353	500 YR	4974				584.55		584.43	
9062	10 YR	1954		580.06		580.06	0	580.06	
9062	25 YR	2748		581.43		581.43	0	581.43	
9062	100 YR	3296	582.2	582.24	-0.04	582.24	0	582.24	0
9062	500 YR	5027		584.26		584.26	0	584.26	
8226	10 YR	1954		577.36		577.36	0	577.36	
8226	25 YR	2748		578.78		578.78	0	578.78	
8226	100 YR	3296	579.6	579.65	-0.05	579.65	0	579.65	0
8226	500 YR	5027		581.16		581.16	0	581.16	
7306	10 YR	1954		576.58		576.58	0	576.58	
7306	25 YR	2748		578.04		578.04	0	578.04	
7306	100 YR	3296	578.9	578.92	-0.02	578.92	0	578.92	0
7306	500 YR	5027		580.00		580.00	0	580.00	

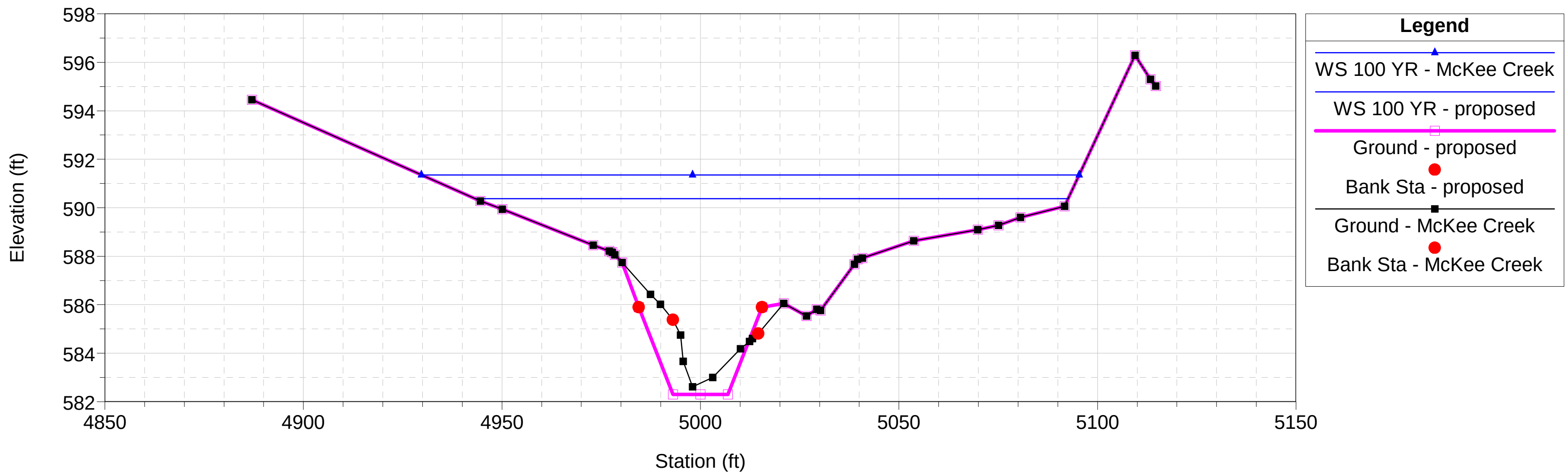

McKee Creek Flood Study Plan: 1) McKee Creek 2) proposed
RS = 13226
Elevation (ft)
Station (ft)
602
600
598
596
594
592
590
588
586
4700
4800
4900
5000
5100
5200
Legend
WS 100 YR - McKee Creek
WS 100 YR - proposed
Ground - proposed
Bank Sta - proposed
Ground - McKee Creek
Bank Sta - McKee Creek

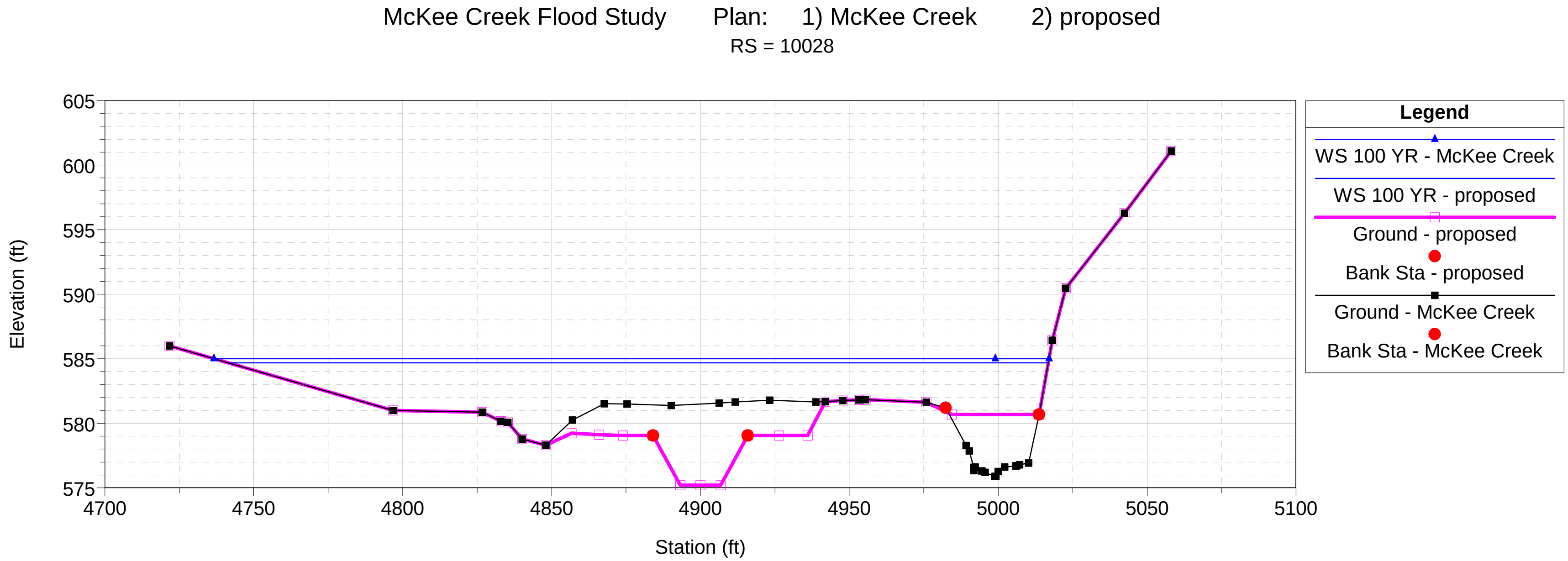

McKee Creek Flood Study Plan: 1) McKee Creek 2) proposed
RS = 13431
Elevation (ft)
Station (ft)
602
600
598
596
594
592
590
588
586
4700
4800
4900
5000
5100
5200
5300
Legend
WS 100 YR - McKee Creek
WS 100 YR - proposed
Ground - proposed
Bank Sta - proposed
Ground - McKee Creek
Bank Sta - McKee Creek

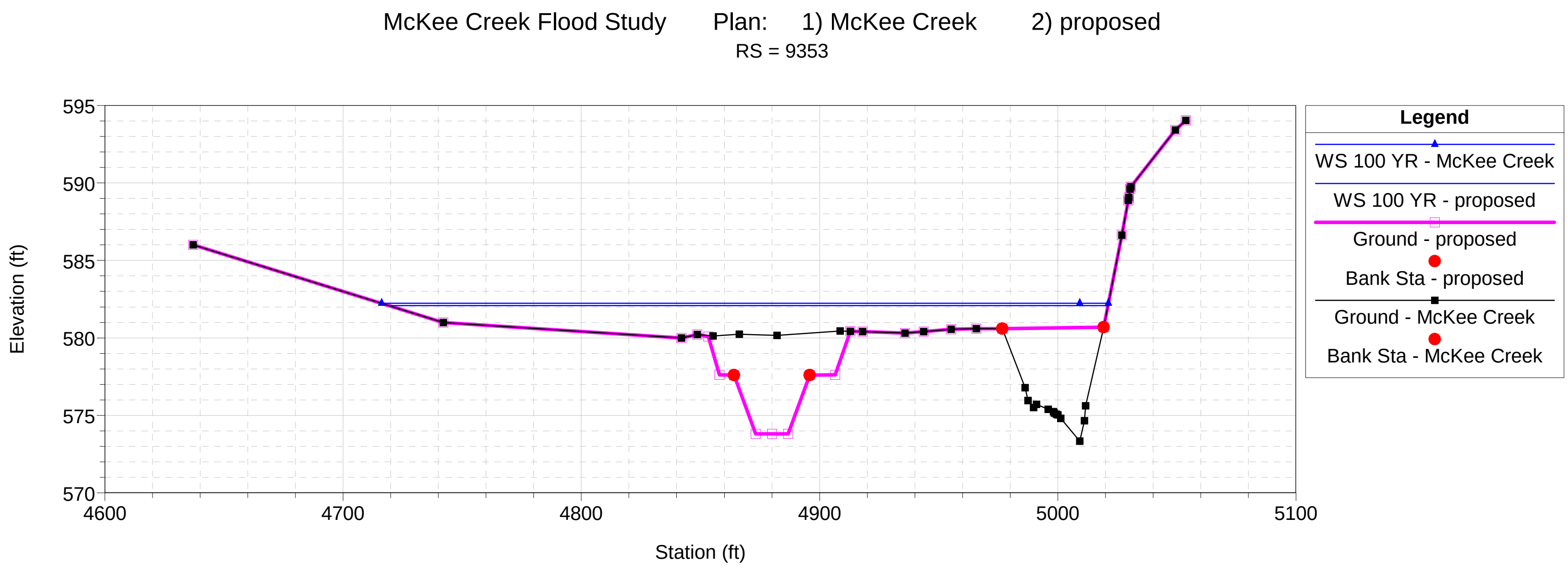
McKee Creek Flood Study Plan: 1) McKee Creek 2) proposed
RS = 12394

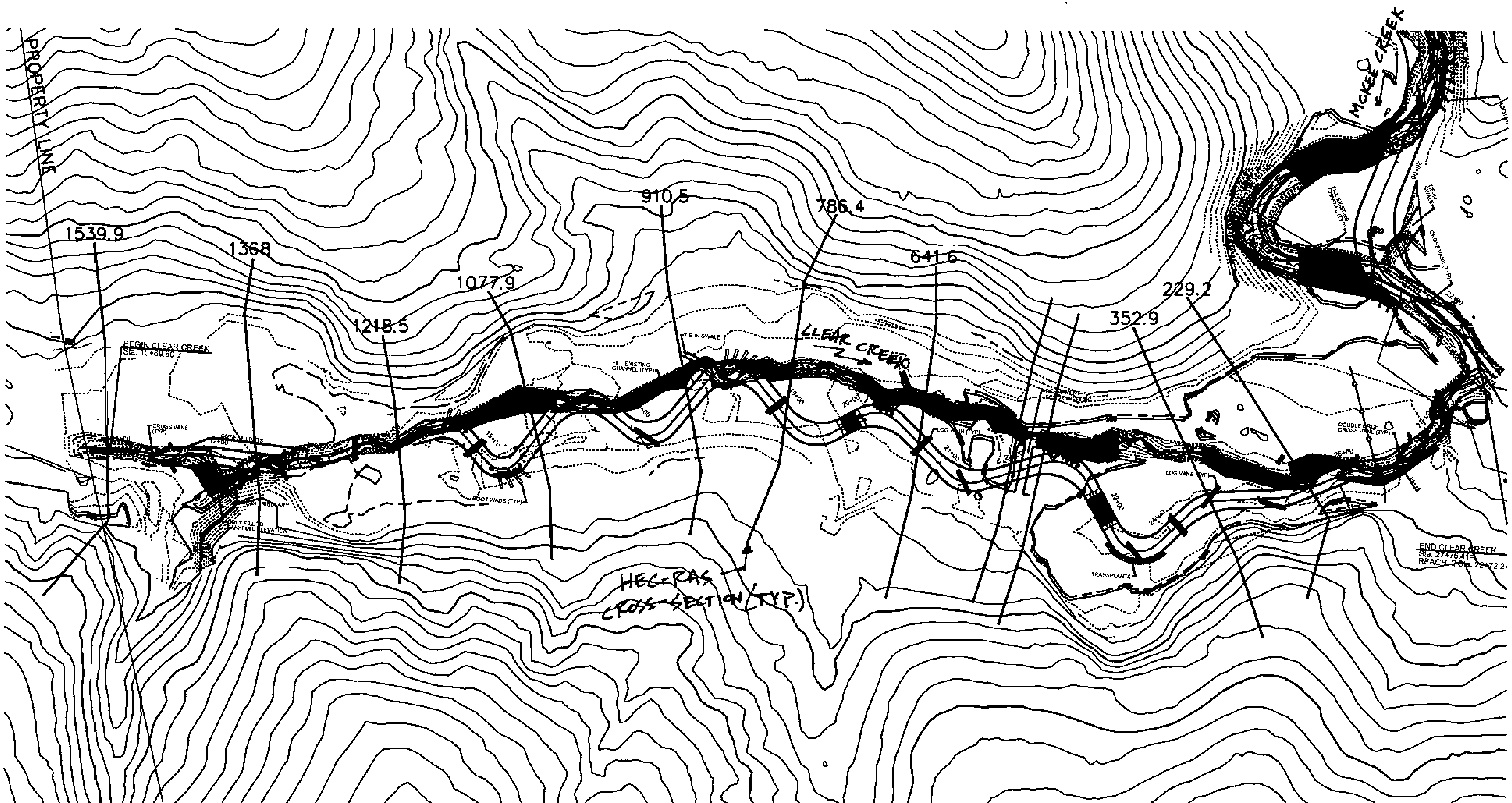


McKee Creek Flood Study Plan: 1) McKee Creek 2) proposed
RS = 11497

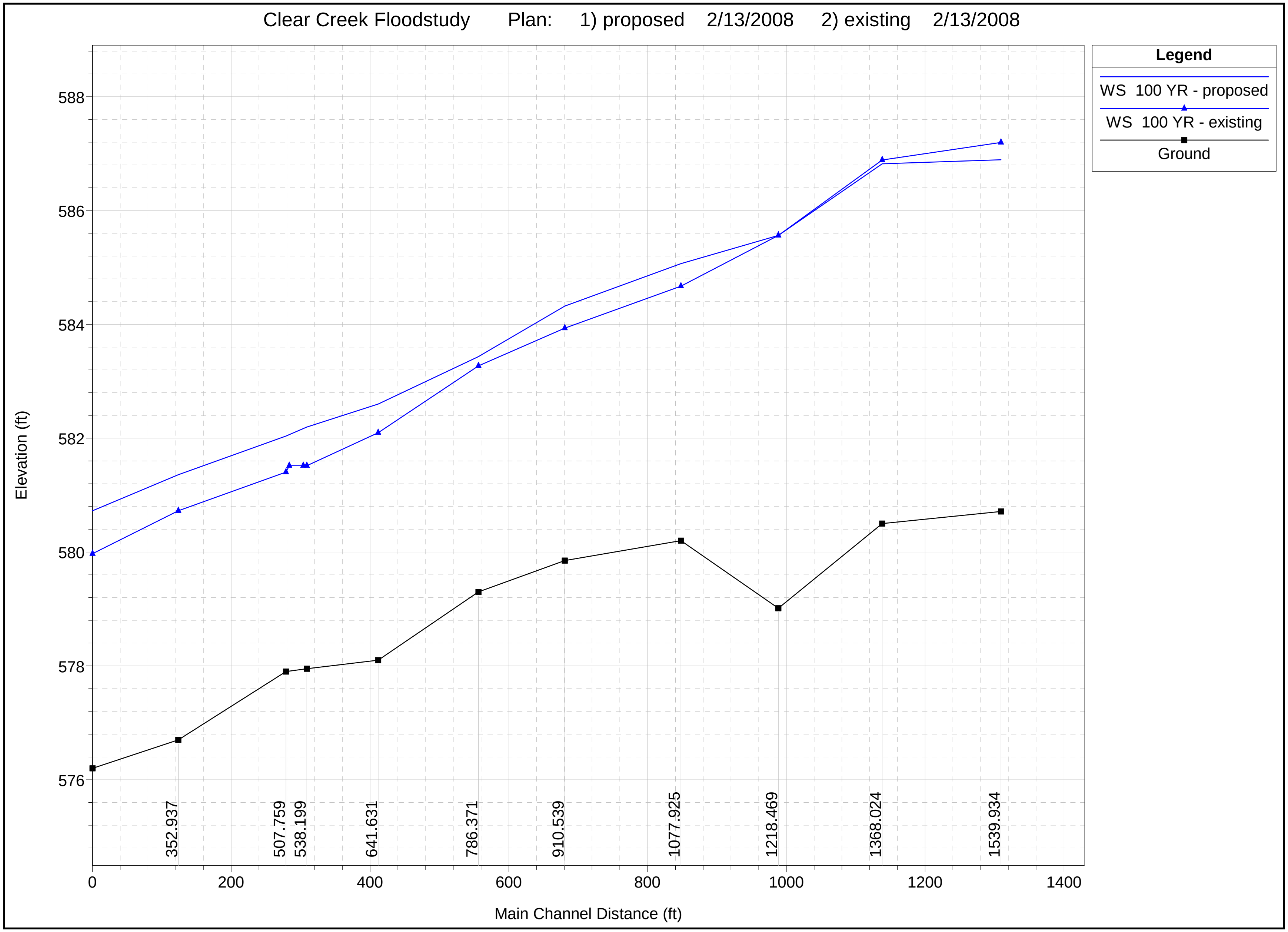



McKee Creek Flood Study Plan: 1) McKee Creek 2) proposed
RS = 10028
Elevation (ft)
605
600
595
590
585
580
575
4700
4750
4800
4850
4900
4950
5000
5050
5100
Station (ft)
Legend
WS 100 YR - McKee Creek
WS 100 YR - proposed
Ground - proposed
Bank Sta - proposed
Ground - McKee Creek
Bank Sta - McKee Creek


McKee Creek Flood Study Plan: 1) McKee Creek 2) proposed
RS = 9353
Elevation (ft)
595
590
585
580
575
570
4600
4700
4800
4900
5000
5100
Station (ft)
Legend
WS 100 YR - McKee Creek
WS 100 YR - proposed
Ground - proposed
Bank Sta - proposed
Ground - McKee Creek
Bank Sta - McKee Creek


PROPERTY LINE
1539.9
1368
1218.5
1077.9
910.5
786.4
641.6
352.9
229.2
BEGIN CLEAR CREEK
Sta. 10+89.60
CLEAR CREEK
McKEE CREEK
HEC-RAS
CROSS-SECTION (TYP.)
END CLEAR CREEK
ROOT WADS (TYP)
TRANSPLANTS
LOG VANE (TYP)
DOUBLE DROP CROSS VANE (TYP)

1" = 100'



1 in Horiz. = 205 ft 1 in Vert. = 2.5 ft

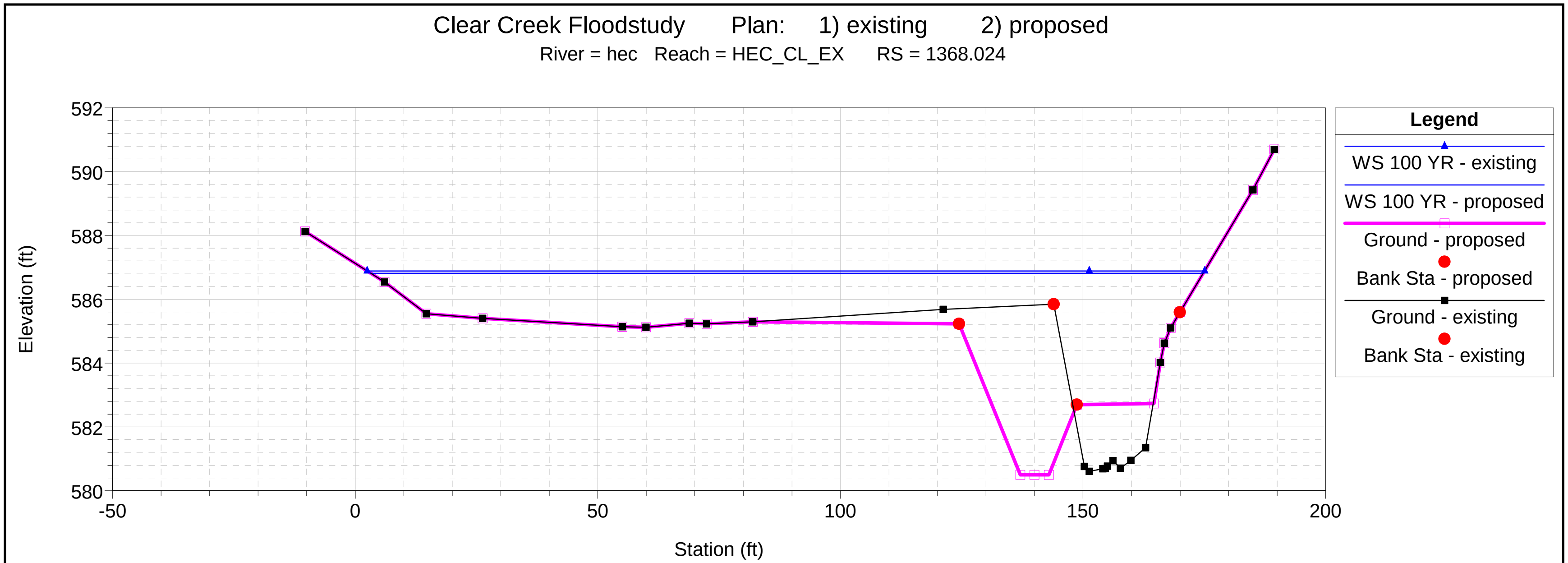
FLOODSTUDY COMPARISON TABLE - Clear Creek

STREAM: Clear Creek

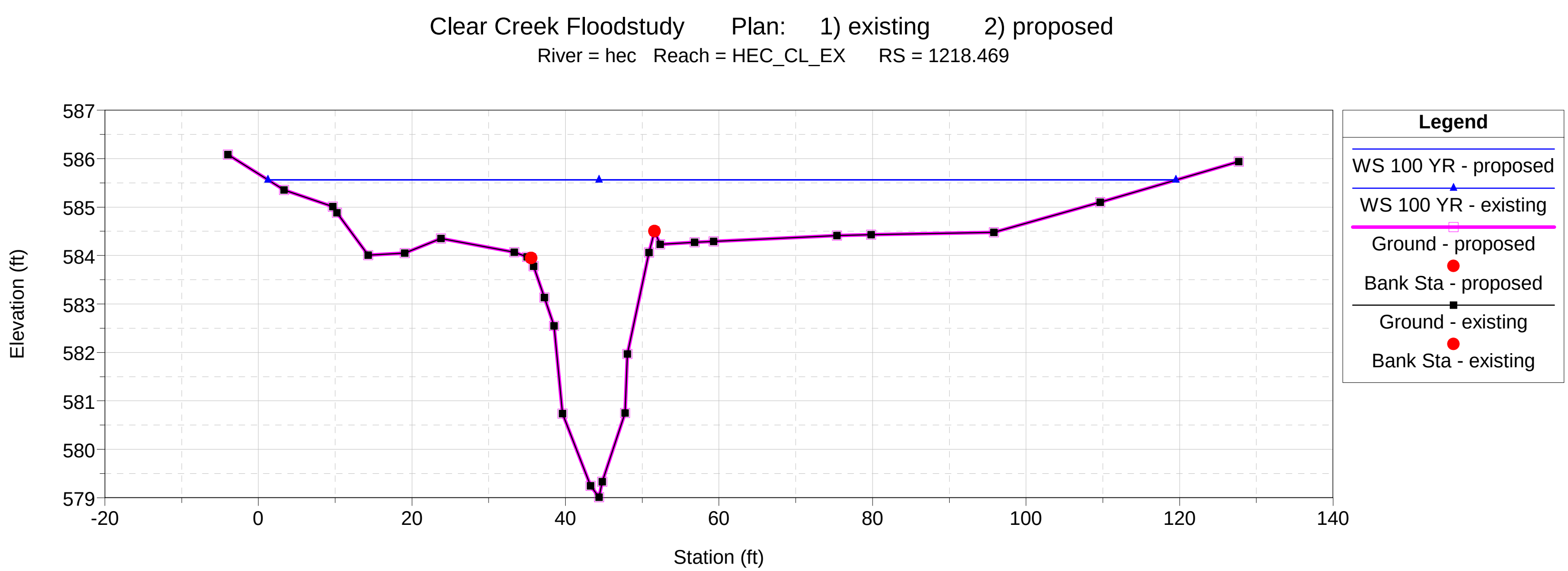
Cabarrus County, NC

Date: 2/13/2008

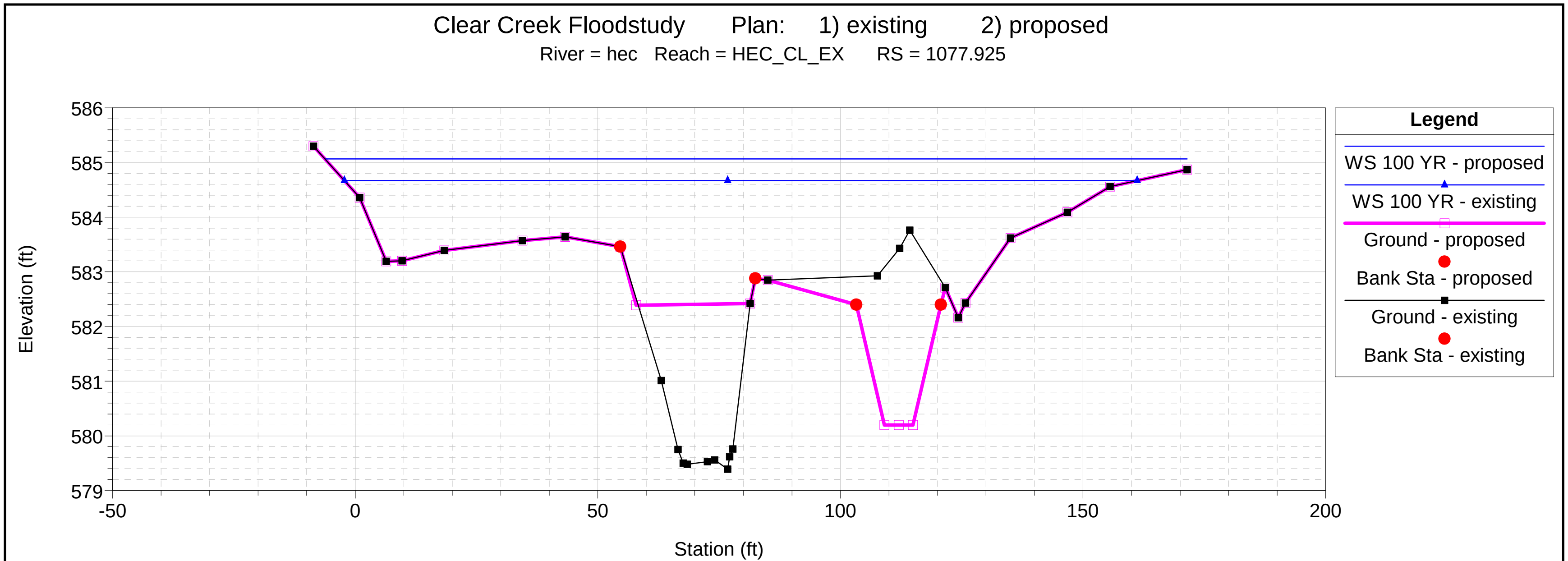
			WSEL from FIS	Duplicate WSEL from HEC-RAS		Existing Conditions Model		Proposed Conditions Model	
River Station	Profile	Discharge (cfs)	WSEL (ft.)	WSEL (ft.)	(FIS WSEL - Dup. WSEL)	WSEL (ft.)	(Ext. WSEL - Dup. WSEL)	WSEL (ft.)	(Prop.WSEL-Ext. WSEL)
1539.934	10 YR	340				586.08		585.8	-0.28
1539.934	100 YR	720				587.19		586.89	-0.3
1368.024	10 YR	340				585.63		585.54	-0.09
1368.024	100 YR	720				586.89		586.82	-0.07
1218.469	10 YR	340				583.90		584.44	0.54
1218.469	100 YR	720				585.56		585.56	0
1077.925	10 YR	340				583.56		584.07	0.51
1077.925	100 YR	720				584.67		585.06	0.39
910.539	10 YR	340				582.76		583.36	0.6
910.539	100 YR	720				583.93		584.32	0.39
786.371	10 YR	340				582.21		582.50	0.29
786.371	100 YR	720				583.27		583.43	0.16
641.631	10 YR	340				581.34		581.69	0.35
641.631	100 YR	720				582.09		582.60	0.51
538.199	10 YR	340				581.17		581.32	0.15
538.199	100 YR	720				581.51		582.19	0.68
507.759	10 YR	340				580.28		581.06	0.78
507.759	100 YR	720				581.40		582.04	0.64
352.937	10 YR	340				579.38		580.44	1.06
352.937	100 YR	720				580.72		581.36	0.64
229.236	10 YR	340				578.71		579.81	1.1
229.236	100 YR	720				579.97		580.72	0.75

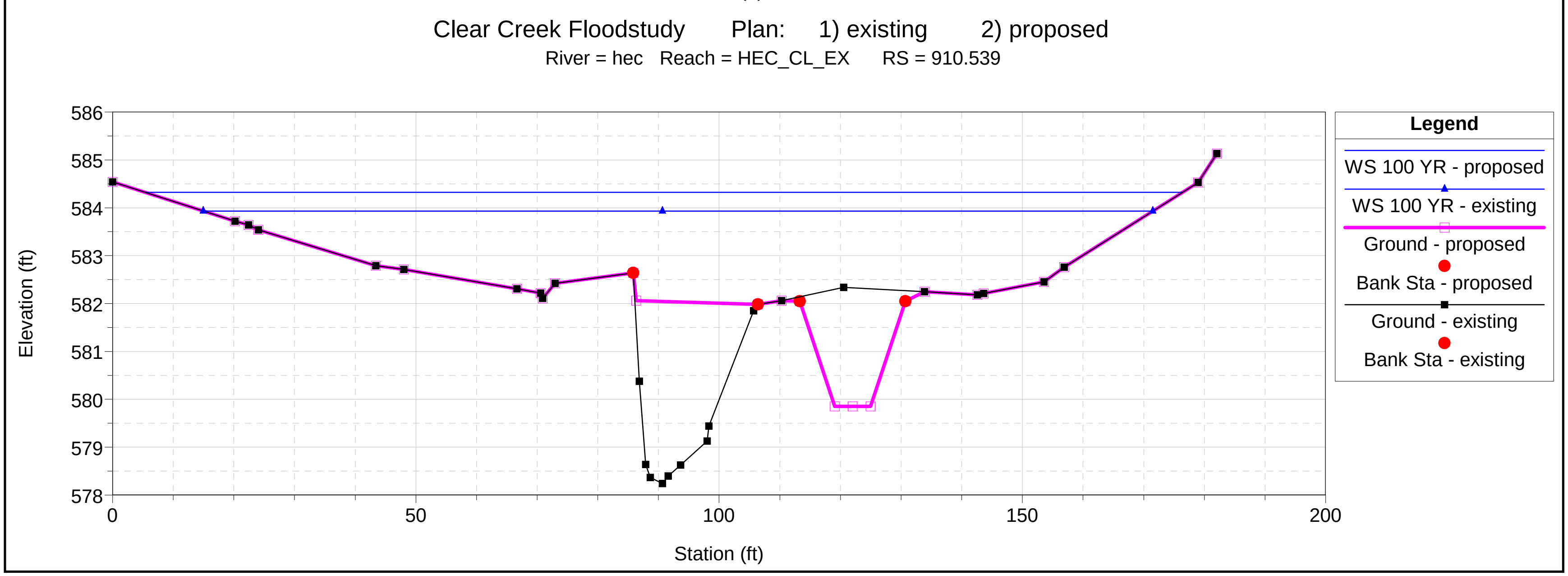


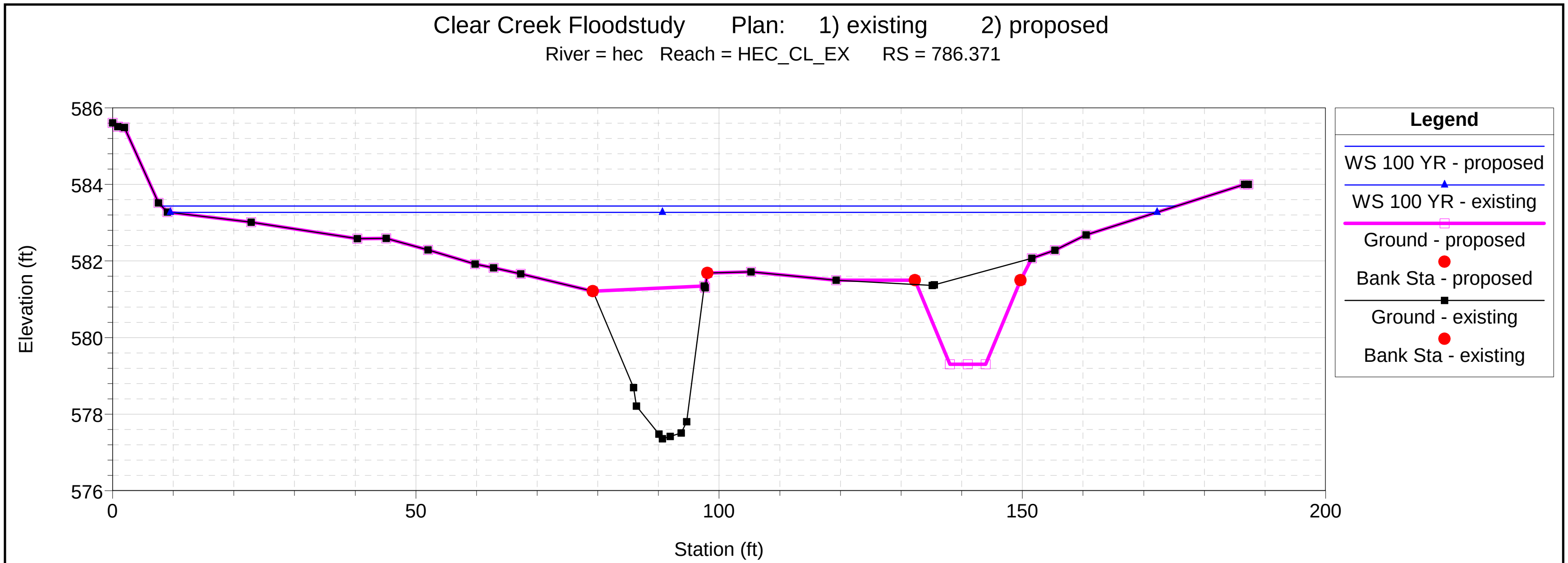
Clear Creek Floodstudy Plan: 1) existing 2) proposed
River = hec Reach = HEC_CL_EX RS = 1368.024
Elevation (ft)
Station (ft)
592
590
588
586
584
582
580
-50
0
50
100
150
200
Legend
WS 100 YR - existing
WS 100 YR - proposed
Ground - proposed
Bank Sta - proposed
Ground - existing
Bank Sta - existing



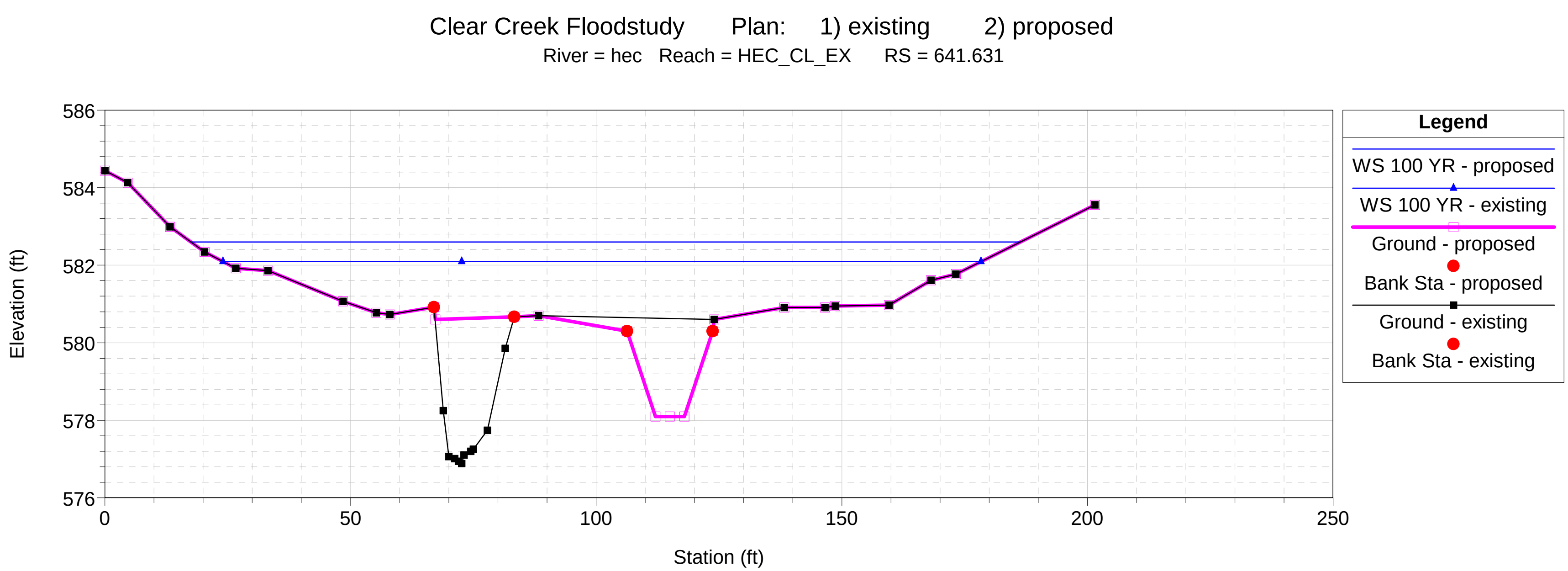
Clear Creek Floodstudy Plan: 1) existing 2) proposed
River = hec Reach = HEC_CL_EX RS = 1218.469
Elevation (ft)
Station (ft)
587
586
585
584
583
582
581
580
579
-20
0
20
40
60
80
100
120
140
Legend
WS 100 YR - proposed
WS 100 YR - existing
Ground - proposed
Bank Sta - proposed
Ground - existing
Bank Sta - existing


Clear Creek Floodstudy Plan: 1) existing 2) proposed
River = hec Reach = HEC_CL_EX RS = 1077.925
Elevation (ft)
Station (ft)
Legend
WS 100 YR - proposed
WS 100 YR - existing
Ground - proposed
Bank Sta - proposed
Ground - existing
Bank Sta - existing

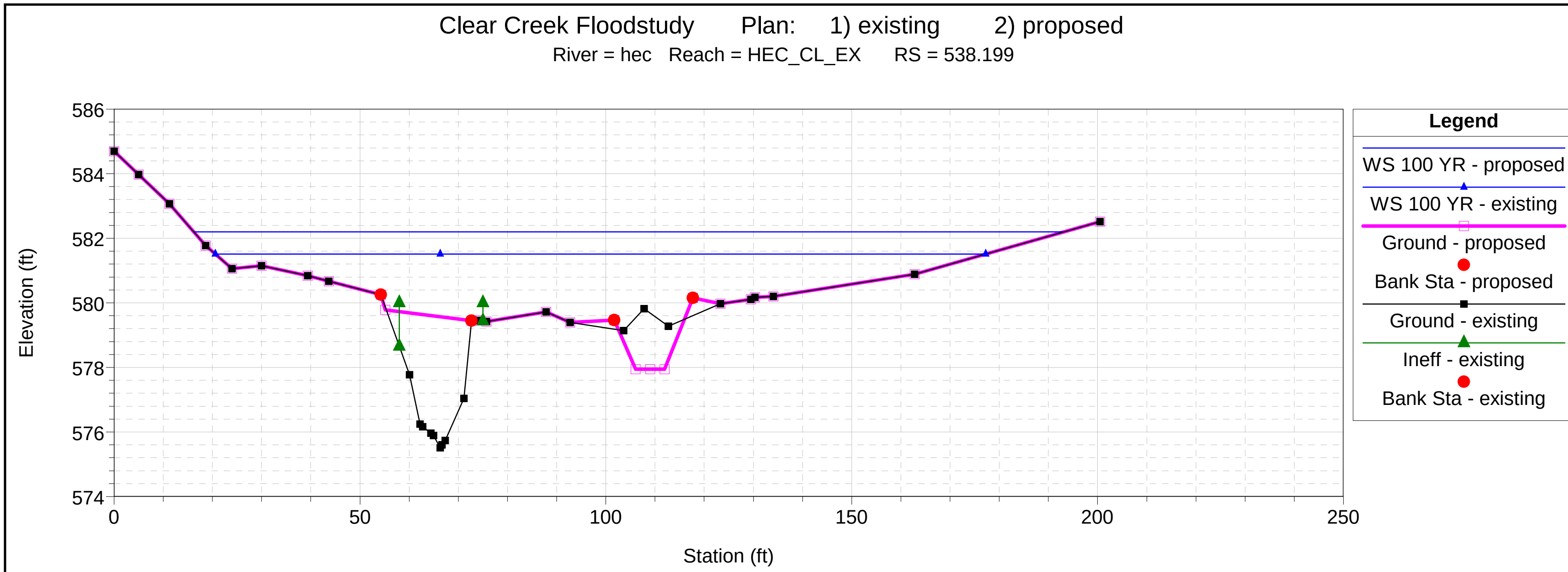

Clear Creek Floodstudy Plan: 1) existing 2) proposed
River = hec Reach = HEC_CL_EX RS = 910.539
Elevation (ft)
Station (ft)
Legend
WS 100 YR - proposed
WS 100 YR - existing
Ground - proposed
Bank Sta - proposed
Ground - existing
Bank Sta - existing

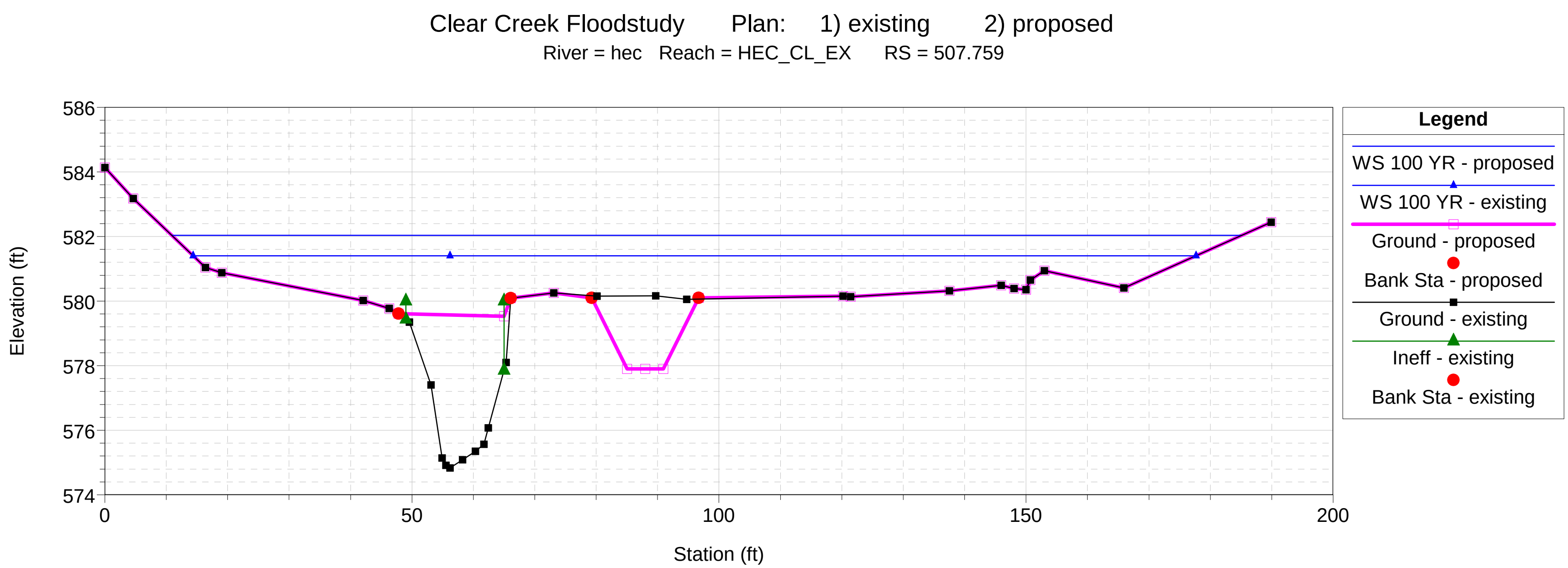


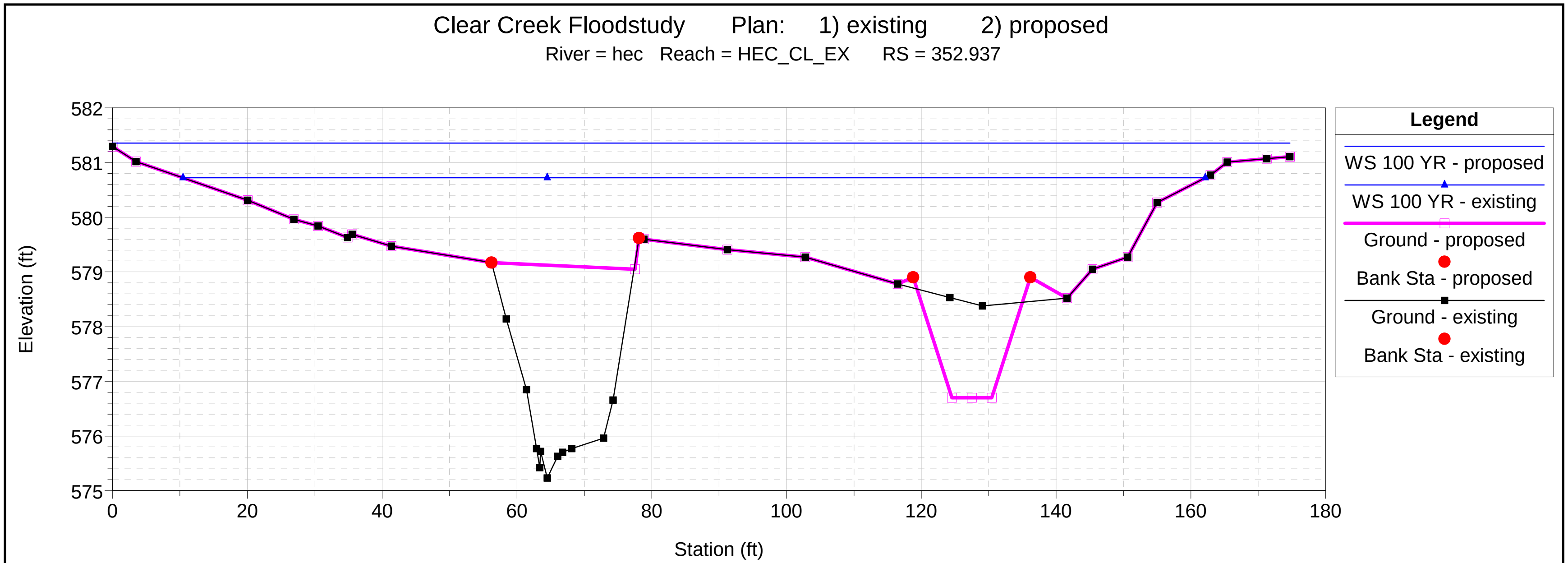
Clear Creek Floodstudy Plan: 1) existing 2) proposed
River = hec Reach = HEC_CL_EX RS = 786.371
Elevation (ft)
Station (ft)
586
584
582
580
578
576
0
50
100
150
200
Legend
WS 100 YR - proposed
WS 100 YR - existing
Ground - proposed
Bank Sta - proposed
Ground - existing
Bank Sta - existing

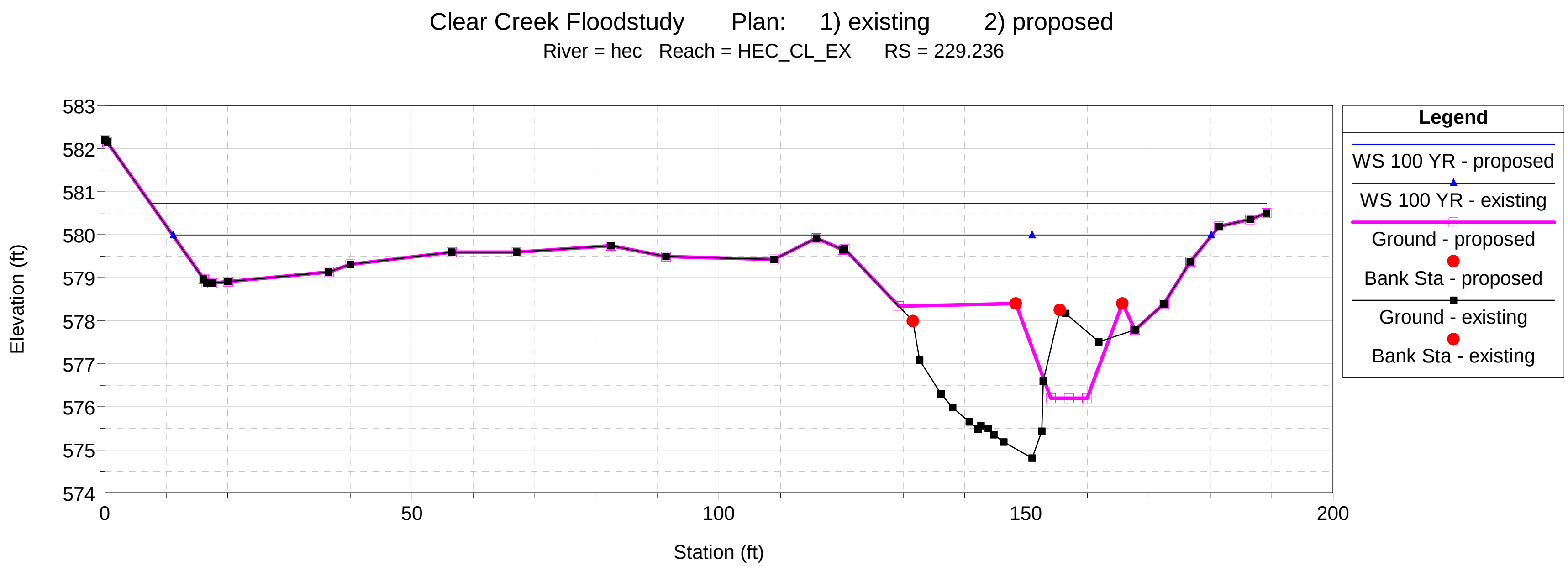


Clear Creek Floodstudy Plan: 1) existing 2) proposed
River = hec Reach = HEC_CL_EX RS = 641.631
Elevation (ft)
Station (ft)
586
584
582
580
578
576
0
50
100
150
200
250
Legend
WS 100 YR - proposed
WS 100 YR - existing
Ground - proposed
Bank Sta - proposed
Ground - existing
Bank Sta - existing


Clear Creek Floodstudy Plan: 1) existing 2) proposed
River = hec Reach = HEC_CL_EX RS = 538.199
Elevation (ft)
Station (ft)
Legend
WS 100 YR - proposed
WS 100 YR - existing
Ground - proposed
Bank Sta - proposed
Ground - existing
Ineff - existing
Bank Sta - existing


Clear Creek Floodstudy Plan: 1) existing 2) proposed
River = hec Reach = HEC_CL_EX RS = 507.759
Elevation (ft)
Station (ft)
Legend
WS 100 YR - proposed
WS 100 YR - existing
Ground - proposed
Bank Sta - proposed
Ground - existing
Ineff - existing
Bank Sta - existing


Clear Creek Floodstudy Plan: 1) existing 2) proposed
River = hec Reach = HEC_CL_EX RS = 352.937
Elevation (ft)
Station (ft)
Legend
WS 100 YR - proposed
WS 100 YR - existing
Ground - proposed
Bank Sta - proposed
Ground - existing
Bank Sta - existing


Clear Creek Floodstudy Plan: 1) existing 2) proposed
River = hec Reach = HEC_CL_EX RS = 229.236
Elevation (ft)
Station (ft)
Legend
WS 100 YR - proposed
WS 100 YR - existing
Ground - proposed
Bank Sta - proposed
Ground - existing
Bank Sta - existing

Appendix 8 – FHWA Categorical Exclusion Form

Appendix A

Categorical Exclusion Form for Ecosystem Enhancement Program Projects Version 1.4

Note: Only Appendix A should to be submitted (along with any supporting documentation) as the environmental document.

Part 1: General Project Information	
Project Name:	MCKEE CREEK STREAM RESTORATION
County Name:	CABARRUS
EEP Number:	D070603S
Project Sponsor:	
Project Contact Name:	HEATH WADSWORTH
Project Contact Address:	111 MACKENAN DRIVE, CARY NC 27511
Project Contact E-mail:	hwadsworth@withersravenel.com
EEP Project Manager:	ROBIN DOLAN

Project Description

For Official Use Only

Reviewed By:

12-11-07
Date

EEP Project Manager

Conditional Approved By:

Date

For Division Administrator FHWA

☐ **Check this box if there are outstanding issues**

Final Approval By:

12-10-07
Date

For Division Administrator FHWA