Mitigation Plan and As-built Baseline Report
9/25/09

Goose Creek Stream Restoration Project

EEP Project #147
SCO No. 04-06298-01
DENR No. D05035S
Durham County
Data Collection: September 15, 2008-May 27, 2009

Prepared for:

NORTH CAROLINA ECOSYSTEM ENHANCEMENT PROGRAM
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Executive Summary

The Goose Creek stream restoration project was constructed between May 12, 2008 and September 5, 2008. Grading and stream structure installation began on May 14, 2008 and was completed on August 20, 2008. Planting of the buffer was completed on February 18, 2009.

The goals of the project are:

- To improve aquatic habitat by removing the fabriform channel liner on the Eastway Elementary School reach and the stone retaining walls on the Longmeadow Park reach and reintroducing a more defined and natural riffle/pool channel geometry sequence
- To improve water quality by reducing nutrient loading from adjacent developed properties through restoration of a riparian buffer
- To improve terrestrial habitat by restoring a riparian buffer
- To decrease sediment and nutrient content of the stormwater flow originating in the Barnes Street Redevelopment project site, which flows through the site and into Goose Creek, through the means of a re-configured stormwater channel which slows stormwater flow, allowing sediment to settle and nutrients to be absorbed by planted vegetation.

These goals will be accomplished through the implementation of the following objectives:

- Removal of the fabriform channel liner on the Eastway Elementary School reach and the stone retaining walls on the Longmeadow Park reach and implementation of a channel geometry that more closely mimics nature
- Improvement of water quality (reduction of nutrient and sediment inputs) by creating a vegetated riparian buffer filter strip between the stream and the areas surrounding the reach
- Improvement of terrestrial habitat by creating a vegetated riparian buffer
- Treatment of stormwater originating in the housing complex east of the Eastway Elementary School reach in a reconfigured stormwater channel that decreases flow velocity and prolongs flow contact time with nutrient absorbing plants.

The Goose Creek stream restoration project is in the urban confines of the City of Durham, in a highly developed watershed. The project is within EEP's Ellerbe Creek Local Watershed Plan area, within the Ellerbe Creek watershed, extending from eastern downtown Durham northeast to Falls Lake. The pre-project stream was highly modified and artificially confined by concrete on the channel and banks upstream (reach behind Eastway Elementary School) and by rock walls downstream (reach located in Longmeadow City Park).

There were two reaches that were restored, the upstream reach begins as the stream exits a culvert just north of Taylor Street, behind Eastway Elementary School, and continues downstream to the point where the stream goes into a box culvert under Liberty Street (hereafter referred to as the Eastway reach). The second reach begins where the stream exits the box culvert under Liberty Street and continues downstream through Longmeadow Park, to Holloway Street (hereafter referred to as the Longmeadow reach). The upstream reach is bounded by Eastway Elementary School to the west and the Barnes Avenue Community Redevelopment Project to the east. The reach down stream of Liberty Street flows through and is contained in the City of Durham's Longmeadow Park.

The restoration design included reconfiguration of the planform, cross-sectional, and profile properties of the channel to a stable form under the existing hydrologic conditions and limited sediment supply regime. The design was a Priority II configuration, which provides the existing incised channel with a new, lower floodplain surface and reestablishes an adjacent native riparian buffer.

In the Eastway reach, the conservation easement width was constrained by existing school facilities and existing housing development, which limited the design belt-width. Given the flashy urban stormwater-driven hydrology of the watershed, single wing deflectors were used to create as much channel sinuosity as possible while also providing stability in the highly variable, and at times extreme, flow regime. These structures stabilize the floodplain laterally, while allowing the flow regime to form a stable profile after the deflectors are installed. A more conventional and probably familiar design and structures were used in the Longmeadow reach.

There were three notable changes made to the project that deviate from the original design. First, stormwater pipes that drain to the creek were left intact and the flow from them was accommodated by using riprap to stabilize the pipe's flow channel. The second deflector downstream on the left bank of the Eastway reach was modified to accommodate a stormwater pipe, the next to last boulder on the downstream arm was not installed to allow stormwater from the pipe to flow through the deflector to Goose Creek. Second, the second cross vane downstream on the Longmeadow reach was modified to an "A" vane configuration due to the erodible soil substrate encountered at that point in the channel. Third, coarse woody debris in the Longmeadow reach were omitted due to the excessive amount of trash that collected in them after high flow events.

Channel stability and vegetation survival will be monitored for a period of five years per the protocol contained in the document entitled "Stream Mitigation Guidelines" published in 2003 jointly by the U.S. Army Corps of Engineers, the Environmental Protection Agency, N.C. Wildlife Resources Commission and the Division of Water Quality.

1.0 Project Goals, Background and Attributes

The Goose Creek stream restoration project is in the urban confines of the City of Durham, in a highly developed watershed. The pre-project stream was highly modified and artificially confined by concrete on the channel and banks upstream (the reach behind Eastway Elementary School, hereafter referred to as the Eastway reach)and by rock walls downstream (the reach in Longmeadow Park, hereafter referred to as the Longmeadow reach). The goals of the project are to eradicate the artificial hardening structures, restore a more natural channel geometry and create a robust riparian buffer. The upstream Eastway reach is divided into two sections based on flow regimes. The downstream Longmeadow reach is not divided.

1.1 Location and Setting

The Goose Creek stream restoration project is located in the city of Durham, North Carolina (**Figure 1**, **located with all Figures and Tables in Appendix A**). There were two reaches that were restored, the upstream reach begins as the stream exits a culvert just north of Taylor Street, behind Eastway Elementary School, and continues downstream to the point where the stream goes into a box culvert under Liberty Street (hereafter referred to as the Eastway reach). The second reach begins where the stream exits the box culvert under Liberty Street and continues downstream to Holloway Street. The upstream reach is bounded by Eastway Elementary School to the west and the Barnes Avenue Community Redevelopment Project to the east. The reach down stream of Liberty Street flows through and is contained in the City of Durham's Longmeadow Park (hereafter referred to as the Longmeadow reach). An unnamed tributary to Cabin Creek, located in northern Durham, was used as a reference reach (**Figure 2**).

Goose Creek is part of the Neuse River Basin (Upper Neuse, Subbasin 03-04-01) and is a tributary to Ellerbe Creek, which flows into Falls Lake. Because Falls Lake is a water supply source, the Goose Creek watershed is considered a water supply watershed. The project area falls within the USGS Cataloging Unit 03020201. The North Carolina Division of Water Quality (DWQ) Stream Index Number for Goose Creek is 27-5-1. The project is located within EEP's Ellerbe Creek LWP area.

Goose Creek flows through a residential community subsidized by the City of Durham in Durham County. The Goose Creek watershed is in an old, well-established, low-income neighborhood with very limited direct opportunities for modifications to alter runoff quantity or quality.

Goose Creek is located in North Carolina's relatively narrow Triassic Basin geologic area, along the eastern edge of the more generalized Piedmont physiographic province. The Triassic Basin is filled with sedimentary rocks that formed about 200-190 million years ago when streams carried mud, silt, sand and gravel from adjacent highlands into rift valleys. Streams in the Triassic Basin tend to have finer bed material and lower summer flow conditions (due to quick infiltration into sandy soils).

2.0 Project Goals and Objectives

The Ellerbe Creek LWP goals include: addressing poor water quality, protecting water quality for Falls Lake water supply, and improving aquatic life.
The goals of the Goose Creek stream restoration project are:

- To improve aquatic habitat by removing the fabriform channel liner on the Eastway Elementary School reach and the stone retaining walls on the Longmeadow Park reach and reintroducing a more defined and natural riffle/pool channel geometry sequence
- To improve water quality by reducing nutrient loading from adjacent developed properties through restoration of a riparian buffer
- To improve terrestrial habitat by restoring a riparian buffer

- To decrease sediment and nutrient content of the stormwater flow originating in the Barnes Street Redevelopment project site, which flows through the site and into Goose Creek, through the means of a re-configured stormwater channel which slows stormwater flow, allowing sediment to settle and nutrients to be absorbed by planted vegetation.

These goals will be accomplished through the implementation of the following objectives:

- Removal of the fabriform channel liner on the Eastway Elementary School reach and the stone retaining walls on the Longmeadow Park reach and implementation of a channel geometry that more closely mimics nature
- Improvement of water quality (reduction of nutrient and sediment inputs) by creating a vegetated riparian buffer filter strip between the stream and the areas surrounding the reach
- Improvement of terrestrial habitat by creating a vegetated riparian buffer.
- Treatment of stormwater originating in the housing complex east of the Eastway Elementary School reach in a reconfigured stormwater channel that decreases flow velocity and prolongs flow contact time with nutrient absorbing plants.

The goals will be accomplished by the design and construction of a natural, stable profile and dimension for the stream channel and re-establishing continuous riparian buffers along the banks. Project implementation will greatly increase the prominence of riffles and pools in the reach, improving aquatic habitat.

3.0 Project Structure, Restoration Type and Approach

3.1 Project Structure

The project structure is summarized in **Figure 3** and **Table 1**, which along with the rest of the report tables, are located in the Appendix. The total restored stream length for the project is 1465 feet. Before restoration, there were 861 feet of stream in the Eastway reach and 659 feet of stream in the Longmeadow reach, for a total of 1,500 feet of existing stream.

The restoration design and construction did not change the existing stream length of the Eastway reach, because the easement for restoration was not wide enough to allow for more sinuosity. The Eastway reach is divided into two discrete reaches for the purposes of this report and future monitoring. The upstream section is 514 feet and the downstream section is 347 feet in length, for a total stream restoration length of 861 feet. The reach is divided at that point to account for the increase in flow created by the large stormwater outfall that joins Goose Creek from the west there.

The restoration design and construction of the Longmeadow reach resulted in 604 feet of restored channel. There are 55 feet of channel remaining in the reach which were not restored, just upstream of the Holloway Street culvert. The rock walls on both sides of the stream were allowed to remain in place in order to protect the upstream side of the Holloway Street culvert abutments.

As a part of the stream restoration, the design included revegetating the riparian buffer with native wetland and upland woody plants. Of the total buffer area that was replanted, about 1.4 acres is available for buffer restoration mitigation per Neuse Buffer Rule. The design also included converting a riprap stormwater channel from an adjacent housing development to a vegetated stormwater channel.

3.2 Restoration Type and Approach

This section contains a brief description of the pre-project condition and a description of the overall restoration strategy/approach.

Pre-Project Site Conditions

In the Eastway Elementary School reach, the channel bed and banks were armored with a grouted mattress lining (a “Fabriform” type lining). The grouted mattress lining covered the entire channel, extending from top-of-bank to top-of-bank. The lining was installed when the school was constructed in 1994, at which time the creek was also relocated approximately 100 feet east toward the property line, with a portion enclosed within a culvert under the school parking lot. It is likely that this reach meandered in the historical past, but was straightened and hardened to confine lateral movement and contain the stream away from adjacent infrastructure.

Limited improvements to the channel were made by the local Soil & Water Conservation District in 1998. The concrete-lined channel provided no flow attenuation, vegetation, or water quality protection. Log structures were placed within the concrete-lined channel in 1998 to provide habitat and increase dissolved oxygen. With time these structures forced the deposition of alternate bars and subsequent growth of vegetation along the upstream edge of each log structure. As a result, a slightly sinuous lower flow channel formed within the confines of the grouted mattress banks.

In the Longmeadow Park Reach, the channel was confined by vertical masonry walls. In the context of channel improvement, vane structures were placed within the channel in 1998. Locally, those structures led to the formation of lateral deposits upstream of the point of contact between the vane and rock wall. Although the vane structures helped create some variability in bed topography, the low flow channel was relatively straight, homogenous, and sluggish.

The pre-existing stream buffer was very limited in the Eastway reach and even more limited in the Longmeadow reach. In the Eastway Elementary Reach, the bankfull channel is bordered by mowed areas. A Natural Resource Conservation Service (NRCS) stream project installed log vanes in the channel in 1998, and herbaceous species and small woody saplings of black willow (*Salix nigra*), catalpa (*Catalpa speciosa*), and white mulberry (*Morus alba*) have occupied the alternate bar deposits. The natural (unmowed) buffer varies in width from 5-15 feet in width. In the Longmeadow Park reach, the existing stream is bracketed by stone walls, beyond which are mowed areas with scattered, planted, large (3-4 foot) diameter trees, mainly willow oaks (*Quercus phellos*). Except for the large oaks, there is no woody vegetative buffer on the Longmeadow Park Reach. Accordingly, the terrestrial and aquatic habitat that the existing buffers offer is very limited.

Bed material in both the Eastway and Longmeadow reaches was dominated by sand and silt. Because of the high degree of channel alteration and artificial hardening of the channel bed and banks, channel classification was not possible for either reach.

Restoration Design

The restoration design included reconfiguration of the planform, cross-sectional, and profile properties of the channel to a stable form under the existing hydrologic conditions and limited sediment supply regime. The design was a Priority II configuration, which provides the existing incised channel with a new, lower floodplain surface and reestablishes an adjacent native riparian buffer.

In the Eastway reach, the conservation easement width limited the design belt-width. Given the flashy urban stormwater driven hydrology of the watershed, single wing deflectors were used to create as much channel sinuosity as possible while also providing stability in the highly variable, and at times extreme, flow regime. More conventional and probably familiar structures were used in the Longmeadow reach.

The riparian buffers were planted with two different vegetation community types. A floodplain bench community type was planted that can tolerate more frequent flooding events, with woody species such as black willow and hydrophytic and facultative herbaceous species. A mesic hardwood community type was also planted with species adapted to better drained conditions such as sycamore, willow oak, switchgrass and purpletop.

An existing stormwater channel originating offsite to the east of the Eastway reach was also naturalized by adding sinuosity to the channel and hydrophytic wetland plants to the plant community there.

3.3 Project History, Contacts and Attribute Data

In early 2004 CDM and Biohabitats were tasked with production of a feasibility study for a Goose Creek stream restoration project. The original project area consisted of an upper reach of Goose Creek (~598'), beginning near the intersection of Morning Glory and North Hyde Park Avenues extending downstream to the culvert at the Holman Homes (formerly Few Gardens) property boundary in addition to the Eastway and Longmeadow reaches. The upper 590' reach was eventually eliminated from consideration by the property owners. Biohabitats produced the restoration design and construction on the remaining Eastway and Longmeadow Park reaches was completed in September 2008. **Table 2** contains data on the project history and **Table 3** lists contact information for important contributors to the project.

The project watershed is entirely within the Triassic Basin, which is characterized by low permeability soils and high runoff rates. The watershed is also entirely in the city limits of Durham, and is highly developed, which also contributes to a high runoff rate (**Table 4**). Land use land cover data from the watershed verify its developed nature. Over 80 percent of the watershed is classified as residential, urban low intensity or urban high intensity development.

4.0 Success Criteria

Project success criteria are detailed in this section for each of the relevant project elements (i.e. stream, vegetation, hydrology). The urban nature of the stream's watershed and the Priority II restoration design affect these criteria, as explained below.

4.1 Morphologic Parameters and Channel Stability

The conventional stream restoration design strategy involves reshaping a degraded, eroding channel, using the geometry and characteristics of a stable reference stream type as a template. Success in restoring a stable morphology is determined by periodic re-measurement of the built channel, analysis of the measurements, and confirmation that the built channel is performing as intended and stability persists. In a general sense, a restored channel's morphology should accommodate a watershed's hydrologic cycle and sediment supply regime such that higher stream flows are able to access the stream's floodplain and the stream's bedload is transported efficiently without excess shear forces eroding the bed and banks. Ecological functions associated with stable stream channels and their riparian floodplains include:

- good terrestrial and aquatic habitat,
- dissipation of flood flow energy through the release of higher flows into the adjacent riparian floodplain,
- water quality improvement from floodwater dropping its sediment load in the floodplain,
- groundwater recharge from infiltration of floodwaters that become trapped as flooding recedes,
- lower sediment loads due to higher bank and bad stability
- floodwater storage of excess flow in the floodplain

In highly urbanized watersheds such as Goose Creek, frequent release of higher flows into the adjacent floodplain can cause property damage or create a safety hazard. Therefore designed channel morphology must not increase risk associated with inevitable high stage events.

Restored or enhanced streams should demonstrate morphologic stability to be considered successful. Stability does not equate to an absence of change, but rather to sustainable rates of change or stable patterns of variation. Restored streams often demonstrate some level of initial adjustment in the several months that follow construction and some change/variation subsequent to that is also to be expected. However, the observed change should not be unidirectional such that it represents a robust trend. If some trend is evident, it should be very modest or indicate migration to another stable form. Annual variation is to be expected, but over time this should demonstrate maintenance around some acceptable baseline with maintenance of or even a reduction in the amplitude of variation. Lastly, all of this must be evaluated in the context of hydrologic events to which the system is exposed.

4.2 Dimension

General maintenance of a stable cross-section and hydrologic access to the floodplain features over the course of the monitoring period will generally represent success in dimensional stability. However, some change is natural and expected and can even indicate that the design was successful and appropriate for the hydrologic and sediment regime. The typical cross section designs for Goose Creek increased the cross-sectional area of the channel in both the Eastway and Longmeadow reaches substantially, so that a greater volume of floodwater could be accommodated by the channel. The additional cross-sectional area also creates space where smaller in-channel floodplain benches can form, restoring a portion of the lost floodplain function. In the Eastway reach single wing deflector structures were used to establish and maintain a stable, in-channel floodplain.

For stream dimension, cross-sectional overlays and key parameters such as cross-sectional area, and the channel’s width to depth ratios should demonstrate modest overall change and patterns of variation that are in keeping with the descriptions above. Significant widening of the channel cross-section or trends of increase in the cross-sectional area generally represent concern, although some adjustment in this direction is acceptable if the process is arrested after a period of modest adjustment. In the case of riffle cross sections, maintenance of depths that represent small changes to target competency would also reflect stability. Although a pool cross-section may experience periodic infilling due to watershed activity and the timing of events relative to monitoring, the majority of pools within a project stream reach/component should demonstrate maintenance of greater depths and low water surface slopes over time. The habitat aspect (depth) of the pool cross sections need to be maintained over time and the rates of lateral migration need to be moderate.

4.3 Pattern and Profile

The classic riffle-run-pool-glide channel sequence was altogether absent in the pre-project channel. Channel pattern was drastically limited in the pre-project channel by the concrete fabriform lining on the Eastway reach and by rock walls lining both sides of the channel in the Longmeadow reach.

The restoration design in the entire project reach was a Priority II restoration. Naturalization of the channel dictated removing the concrete fabriform in the Eastway reach and the stone walls in the Longmeadow reach. Meanders were created in the Eastway reach with single wing deflectors. Sinuosity was increased somewhat in the Longmeadow reach, where changing the channel alignment was feasible based on adjacent land uses.

The single wing deflector structures used in the Eastway reach stabilize the streams lateral planform with boulders. In general, single wing deflectors are used in shallow, widened channels that lack a well-defined thalweg. They redirect flows and induce sorting of channel materials, pool formation and habitat diversity. The alternating-bank pattern of the deflectors in the downstream direction also creates sinuosity. The design profile in the Eastway reach, between the deflectors, is not intended to remain static after construction. The deflectors, which protect the banks and help prevent lateral migration of the channel, also create their own unique hydraulic environments as water flows through the reach. Therefore the stream creates its own riffles and pools over time, based on the watershed's intrinsic flows. It follows that the profile will adjust based on the regime of flows through the system, which will stabilize over time, but will not necessarily reflect the design riffle and pool lengths and depths.

Channel slope on the entire restoration reach is set by culvert outlets and inlets at the beginning and end, and by a culvert under Liberty Street that roughly bisects the reach. Variation in channel depth was practically non-existent on the pre-project reach. However, riffle-pool variation was introduced to the channel profile with the design. The magnitude of variation in channel depth between riffle and pool sections is less pronounced in the Eastway reach than in the Longmeadow reach at the time of construction completion. Riffle-pool depth variation is greater in the Longmeadow reach. When single wing deflectors are installed, the riffle pool sequences form themselves based on the flow regime of the stream. That process is continuing to establish an equilibrium on the Eastway reach. There have been several (>5) high flow or bankfull events since construction. The long-term disposition of the longitudinal profile in the Eastway reach should become apparent relatively soon, unless an extended, unbroken drought occurs during the monitoring period.

4.4 Substrate and Sediment Transport

The substrate composition of the channel pre-project was silt/sand. That composition persists in the Eastway reach after construction. In the Longmeadow reach, there are 5 constructed riffles which increase the substrate size distribution to a D50 of 57 mm. See Table 5, Longmeadow Reach for additional substrate information.

Substrate measurements should indicate the progression towards, or the maintenance of the known distributions from the design phase. Also, no significant trend in aggradation or deposition in the channel should occur during the monitoring period.

4.5 Vegetation

Buffer protection for stream mitigation is intended to enhance the recovery and protection of stream mitigation projects. Survival of woody species planted at mitigation sites should be at least 320 stems/acre through year three. A ten percent mortality rate will be accepted in year four (288 stems/acre) and another ten percent in year five resulting in a required survival rate of 260 trees/acre through year five. This is consistent with Wilmington District (1993) guidance for wetland mitigation.

Applicable laws and guidelines include: USACOE (2003) Stream Mitigation Guidelines, Buffer Rules administered by the NC Division of Water Quality Nonpoint Source Management Program, and the NC Sedimentation Pollution Control Act of 1973 administered by the NC Division of Land Resources.

4.6 Stream Hydrology

A minimum of two bankfull events will be documented within the standard 5-year monitoring period, such that 2 verification events occur in separate monitoring years.

5.0 Monitoring Plan Guidelines

There will be annual data collection for the monitoring parameters below unless otherwise stated.

5.1 Stream Hydology

A crest gauge has been installed on the Longmeadow reach at approximate station 4+75.

Observations of wrack and deposition may serve to augment gauge observations when necessary. Each site visit by the monitoring performer will include documentation of the highest stage for the monitoring interval and a reset of the device or download of any data. The data related to bankfull verification will be summarized.

5.2 Stream Channel Stability and Geomorphology

Please refer to Tables 5 and 6 in Appendix A. They contain hydraulic and geomorphic data referred to in the following section. Since this project is in a very impacted urban watershed, the restoration design incorporates a mixture of Rosgen methodology, modeling and common sense. The profile and dimension of the existing channel were altered in a relatively substantial way from the pre-project condition, to restore stability. However, due to the inherent constraints of a highly urbanized project, the pattern of the stream was not changed dramatically. The as-built pattern is identical to the design pattern, thus the pattern morphology is not extensively described in the morphological tables.

5.2.1 Dimension

There are four permanent cross sections installed on both the Eastway and Longmeadow reaches, eight in total, as shown on the as-built drawings. This is actually three more cross sections than the number required by the Mitigation Plan guidance.

The hydraulics created by the single wing deflectors, along with the stream's hydrology on the Eastway reach will form a stable longitudinal profile over time, such that it is not possible to accurately predict at the present time what type of channel feature will evolve in those locations. On the Longmeadow reach, there are three riffle cross sections and one pool cross section. All cross sections are currently stable, based on the as-built drawings.

5.2.2 Profile

Pattern will be assessed in year five if there are any indications through profile and dimensional data generated during monitoring that significant geomorphical adjustments have occurred.

5.2.3 Pattern

The entire longitudinal profile of the project was surveyed and is presented in the as-built drawings.

5.2.4 Visual Assessment

The Eastway and Longmeadow reaches were visually assessed, per the latest monitoring plan guidance contained in Version 1.2-(11/16/06). The data are located in Table 4a and 4b in Appendix B. There are approximately 100 feet (6%) of moderate right bank erosion on the downstream end of the Eastway reach, near Liberty Street. This erosion should be stabilized if the established vegetation grows well in the current growing season. All other elements on this reach are stable. `

There are approximately 20 feet of light to moderate bank erosion on the right bank of the Longmeadow reach, just downstream of the crossvane at station 2+95 and also at station 3+40. All other elements on the reach are stable.

5.2.5 Bank Stability Assessments

No bank stability (BEHI) data is available from the pre-existing condition, as the entire reach was artificially hardened.

5.3 Vegetation

After site construction and planting, four plots (two 10-meters x 10-meters and two 5-meters x 20 meters in size) were randomly installed within the Site. An initial evaluation was performed in March 2009 to verify planting methods and to determine initial species compositions and densities using the *CVS-EEP Protocol for Recording Vegetation Level 1-2 Plot Sampling Only* (Version 4.0) (Lee et al. 2006). The taxonomic standard for vegetation used for this document was *Flora of the Carolinas, Virginia, Georgia, and Surrounding Areas* (Weakley 2007). Subsequently, quantitative sampling of vegetation will be performed each year in September of the first monitoring year and between June 1 and September 30 for each subsequent year until the vegetation success criteria are achieved. A photographic record of plant growth will be included in each annual monitoring report.

Success criteria dictate that an average density of 320 stems per acre must be surviving at the end of the third monitoring year. Subsequently, 290 stems per acre must be surviving at the end of year 4 and 260 stems per acre at the end of year 5. Stem counts will be based on an average of the evaluated vegetation plots.

5.3.1 Digital Photos

Photo stations of the channel and vegetation plots are included in Appendix C.

6.0 Maintenance and Contingency Plans

If the channel or banks are deemed to have become destabilized, based on visual inspection and comparison to the design/asbuilt condition, appropriate corrective action will be taken, which can include small repairs carried out with hand labor to larger mechanized efforts such as structure repair. If vegetation success criteria are not achieved, based on average density calculations from combined plots over the entire restoration area, supplemental planting may be performed with tree species approved by regulatory agencies. Supplemental planting will be performed as needed until achievement of vegetation success criteria.

7.0 Documenting the As-built Condition (Baseline)

7.1 Morphological State of the Channel

The detailed measurement of dimension, pattern and profile features in the as-built state provides the baseline to which future monitoring data can be compared and also permits an evaluation of any design deviations. Exhibit Tables 5 and 6 in the appendix are provided to capture useful data and organize and display it in such a way as to facilitate future database incorporation and graphical display. These tables will be carried through and updated in the monitoring reports under different table numbering. The tables are designed to capture all data of relevance for morphometric and hydraulic assessment. Some of these parameters for certain baseline categories may not apply or may not be available. There are no deviations in morphological parameters between the design and As-built state that are of concern or warrant attention.

7.2 Profile

A geomorphologically relevant survey of the projects entire channel length was performed as part of the As-built baseline. It was extracted into Excel and plotted in Appendix B. This is to make for easy overlay, ready examination and facilitate monitoring.

7.3 Dimension

Cross-sections monumented for permanence in were installed and surveyed. They are plotted in Appendix B.

7.4 Sediment Transport in the As-built State

Sediment transport data are included in Table A.

Table A. Summary of Pertinent Sediment Transport Data						
Reach	Pre-project Shear Stress (lb/ft$^{2)}$	Pre-project Particle Mobilized (mm)	Design Shear Stress (lb/ft$^{2)}$	Design Particle Mobilized (mm)	As-built Shear Stress (lb/ft$^{2)}$	As-built Particle Mobilized (mm)
Eastway Upstream	0.12	6	0.33	16	0.30	15
Eastway Downstream	0.12	6	0.33	16	0.30	15
Longmeadow Park	0.61	30	0.58	29	0.53	28

The pre-project shear stress in the Eastway upstream reach was 0.12 lb/ft^2, which mobilizes a maximum size particle of 6 mm at bankfull discharge. The design shear stress is 0.33 lb/ft^2, which mobilizes a maximum size particle of 16 mm at bankfull discharge. The as-built shear stress is 0.30 lb/ft^2, which mobilizes a maximum size particle of 15 mm at bankfull. The design stream power is 1.09 lb/ft/sec and the as-built stream power is 0.99 lb/ft/sec. The similarity between design and as-built stream competency is high.

The shear stress quantities for the Eastway downstream reach are the same as for the upstream.

The pre-project shear stress in the Longmeadow reach was 0.61 lb/ft^2, which mobilizes a maximum size particle of 30 mm at bankfull discharge. The design shear stress is 0.58 lb/ft^2, which mobilizes a maximum size particle of 29 mm at bankfull discharge. The as-built shear stress is 0.53 lb/ft^2, which mobilizes a maximum size particle of 28 mm at bankfull. The design stream power is 2.49 lb/ft/sec and the as-built stream power is 2.28 lb/ft/sec. The compatibility between design and as-built stream competency is high.

7.5 Verification of Plantings

Based on the number of stems counted, average densities were measured at 658 stems per acre immediately following planting during the as-built year 0 monitoring. The dominant species identified at the Site were planted stems of tulip poplar (*Liriodendron tulipifera*), buttonbush (*Cephalanthus occidentalis*), and river birch (*Betula nigra*). In addition, each individual vegetation plot met success criteria and no vegetation problem areas were present. Overall vigor of planted stems was excellent to good.

8.0 References

USACOE (2003) *Stream Mitigation Guidelines*. USACOE, NCDENR-DWQ, USEPA, NCWRC,

Lee, Michael T., R. K. Peet, S. D. Roberts, and T. R. Wentworth. 2006. CVS-EEP Protocol for Recording Vegetation, Version 4.0 (http://cvs.bio.unc.edu/methods.htm).

Weakley, A.S. 2007. *Flora of the Carolinas, Virginia, Georgia, and Surrounding Areas*. University of North Carolina Herbarium, N.C. Botanical Garden, UNC-Chapel Hill.

Appendix A: Figures 1-3 and Tables 1-4

Figure 1

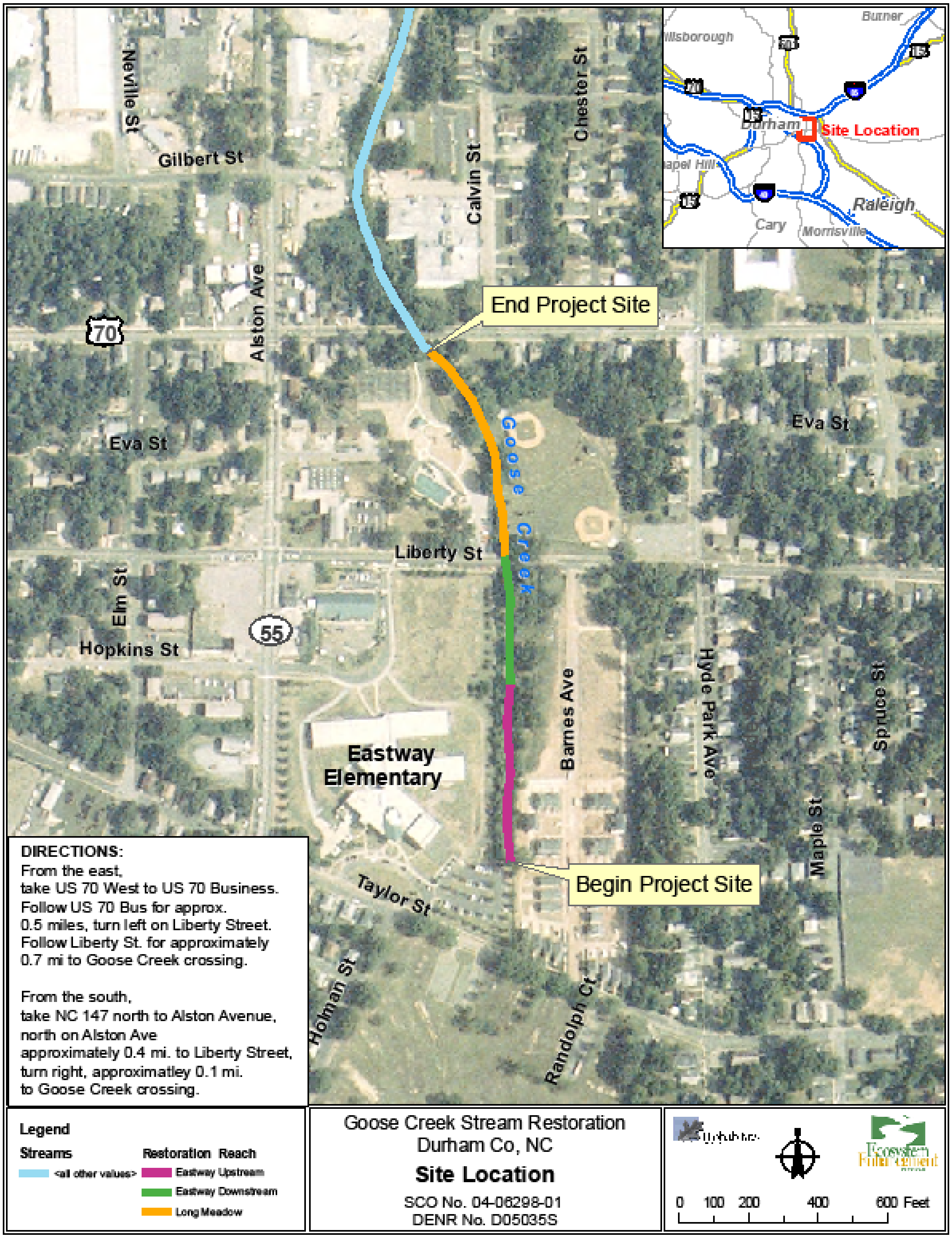

Neville St
Gilbert St
Calvin St
Chester St
Alston Ave
70
End Project Site
Eva St
Goose Creek
Liberty St
Elm St
55
Hopkins St
Barnes Ave
Hyde Park Ave
Spruce St
Eastway Elementary
Maple St
Begin Project Site
Taylor St
Holman St
Randolph Ct
Butner
Hillsborough
Durham
Site Location
Chapel Hill
Raleigh
Cary
Morrisville
DIRECTIONS:
From the east,
take US 70 West to US 70 Business.
Follow US 70 Bus for approx.
0.5 miles, turn left on Liberty Street.
Follow Liberty St. for approximately
0.7 mi to Goose Creek crossing.
From the south,
take NC 147 north to Alston Avenue,
north on Alston Ave
approximately 0.4 mi. to Liberty Street,
turn right, approximatley 0.1 mi.
to Goose Creek crossing.
Legend
Streams
Restoration Reach
<all other values>
Eastway Upstream
Eastway Downstream
Long Meadow
Goose Creek Stream Restoration
Durham Co, NC
Site Location
SCO No. 04-06298-01
DENR No. D05035S
0 100 200 400 600 Feet

Figure 2

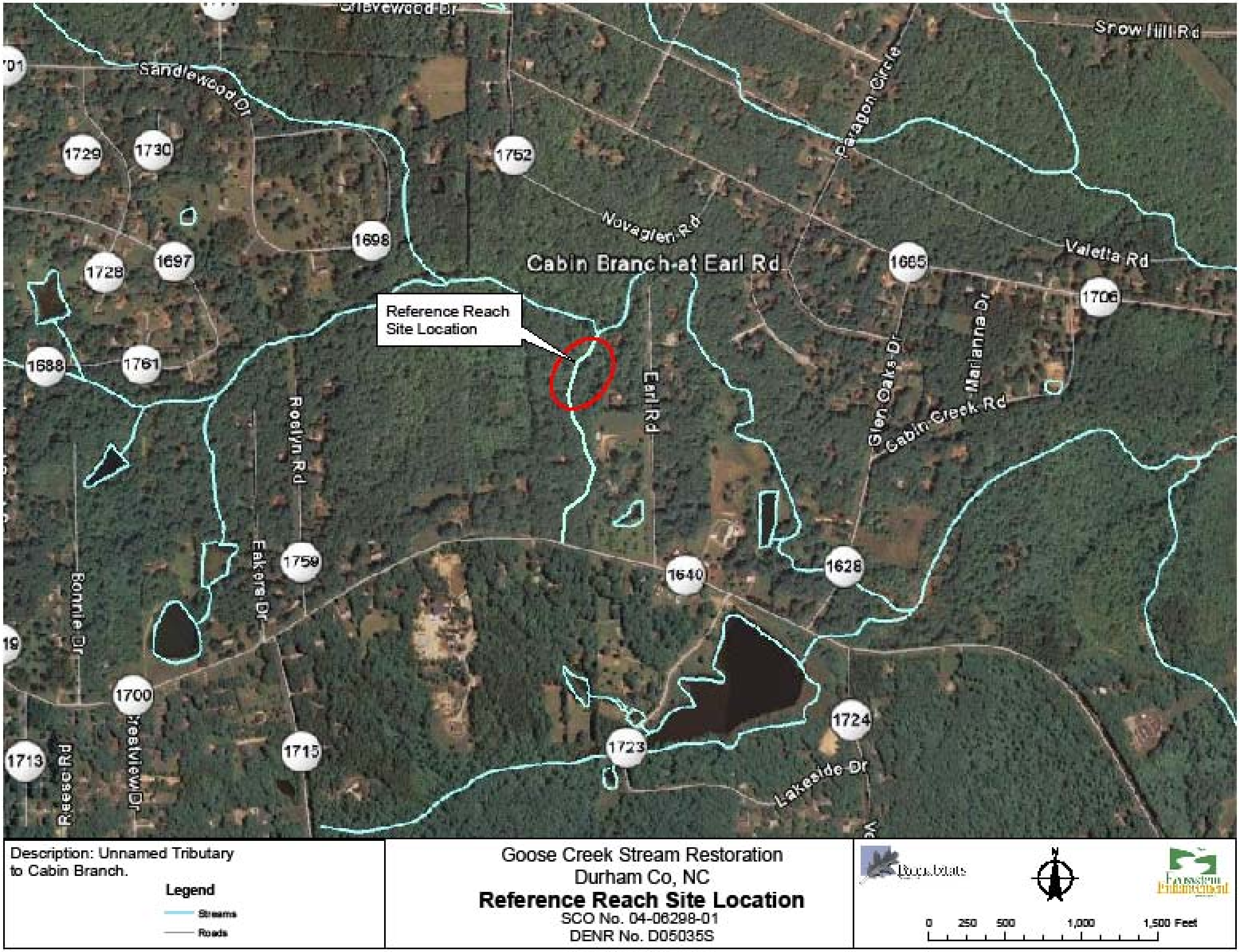

Sandlewood Dr
Snow Hill Rd
Paragon Circle
Novaglen Rd
Cabin Branch at Earl Rd
Valetta Rd
Reference Reach Site Location
Earl Rd
Glen Oaks Dr
Marianna Dr
Cabin Creek Rd
Roslyn Rd
Eakers Dr
Bonnie Dr
Reese Rd
Westview Dr
Lakeside Dr
1729
1730
1752
1698
1728
1697
1685
1706
1688
1761
1759
1640
1628
1700
1724
1713
1715
1723
Description: Unnamed Tributary to Cabin Branch.
Legend
Streams
Roads
Goose Creek Stream Restoration
Durham Co, NC
Reference Reach Site Location
SCO No. 04-06298-01
DENR No. D05035S
0
250
500
1,000
1,500 Feet

Figure 3

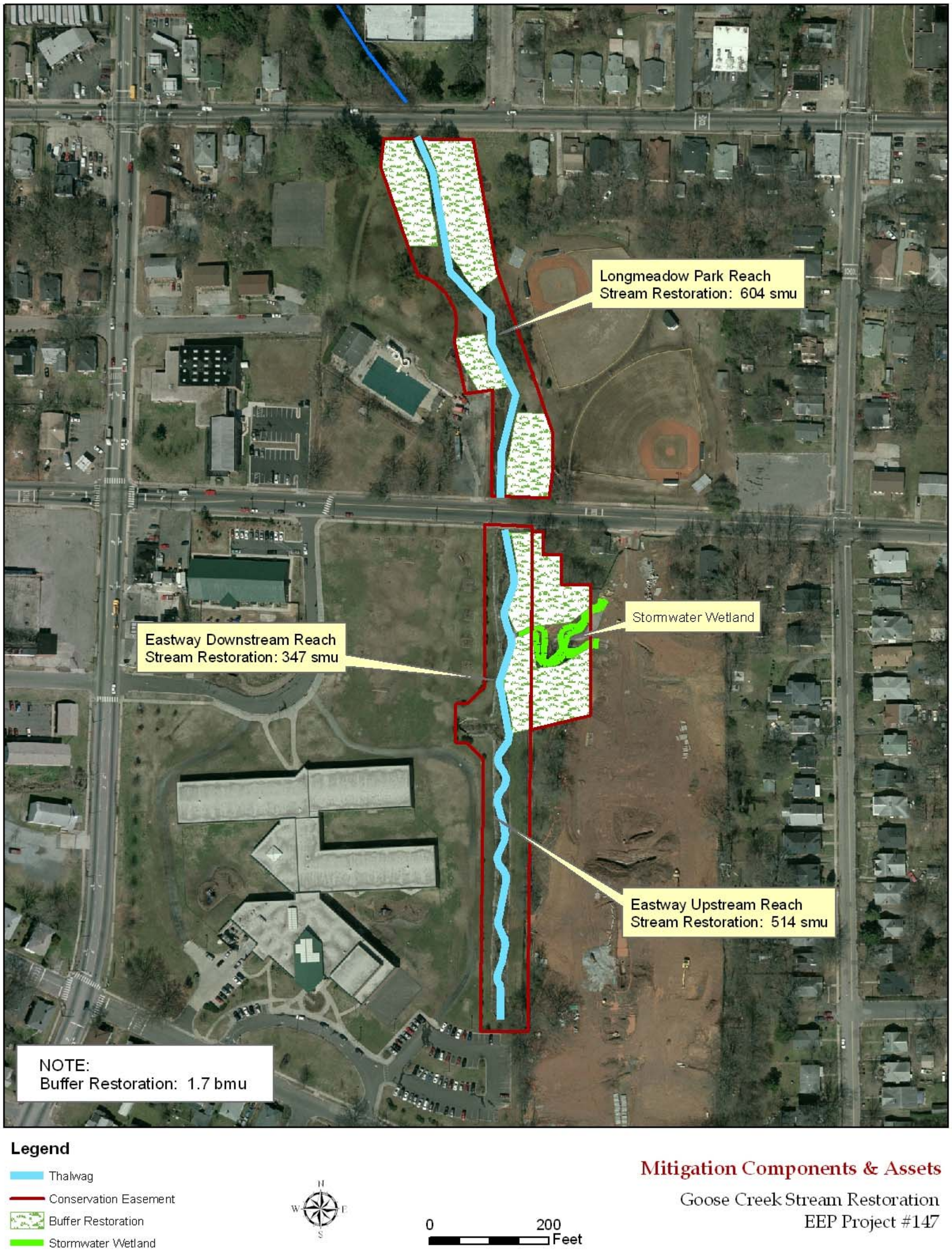

Longmeadow Park Reach
Stream Restoration: 604 smu
Stormwater Wetland
Eastway Downstream Reach
Stream Restoration: 347 smu
Eastway Upstream Reach
Stream Restoration: 514 smu
NOTE:
Buffer Restoration: 1.7 bmu
Legend
Thalweg
Conservation Easement
Buffer Restoration
Stormwater Wetland
0
200
Feet
Mitigation Components & Assets
Goose Creek Stream Restoration
EEP Project #147

Table 1A. Project Components- Goose Creek Stream Restoration DENR No. D05035S							
Reach	**Pre-Project Length (ft)**	**Stationing**	**Restoration Level**	**Approach**	**Planted Easement Acreage**	**Buffer Restoration (acres)***	**Restoration Length (ft)****
Eastway Upstream Section	514	3+48-8+61	R	P2	0.86		514
Eastway Downstream Section	347	0+00-3+47	R	P2	1.4	0.6	347
Longmeadow Park Section	659	0+55-6+59	R	P2	1.69	0.8	604
TOTALS	**1,500**				**3.95**	**1.4**	**1,465**

*Buffer restoration is to be used to mitigate for buffer impacts per the Neuse River Buffer Rules
**Restored length of Longmeadow reach does not include 55 feet of stream between the end of the project and the Holloway Street culvert that was not restored.

Table 1B. Components Summation- Goose Creek Stream Restoration DENR No. D05035S		
Restoration Level	**Stream (ft)**	**Restoration Buffer Acreage***
Restoration	1,465	1.4

*0.6 acres in Eastway downstream section and 0.8 acres in the Longmeadow Park Section

Table 2. Project History-Goose Creek Stream Restoration DENR No. D05035S		
Activity or Deliverable	**Data Collection Completed**	**Delivery or Completion**
Restoration Plan	July 2005	October 2005
Final Design-Construction Plans	November 2006	April 2008
Construction	N/A	September 2008
Permanent Seeding Completed		September 2008
As-Builts	October 2008	December 2008
Planting	N/A	February 2009
Mitigation Plan	March 2009	March 2009

Table 3. Project Contacts- Goose Creek Stream Restoration DENR No. D05035S	
Designer Biohabitats, Inc	8918 Creedmoor Road, Suite 200 Raleigh, NC 27613 **Kevin Nunnery** 919-518-0311
Construction Contractor Shamrock Environmental, Inc	6106 Corporate Park Dr. Browns Summit, NC 27214 **Dan Albert** 336-375-1989
Survey Contractor Level Cross Surveying, PLLC	668 Marsh Country Lane Randleman, NC 23717 **Sheri Willard** 336-495-1713
Planting Contractor Southern Garden, Inc	1932 Holt Rd Cary, NC 27519 **Todd Laakso** 919-362-1050
Seed Mix Suppliers Green-Resource	1218 Management Way, Garner, NC 27529 **Rodney Montgomery** 919-779-4727
Planting Stock Suppliers **Container Stock-Cure Nursery**	880 Buteo Ridge Road Pittsboro, NC 27312 **Bill Cure** 919-542-6186
Balled in Burlap-Taylor's Nursery	3705 New Bern Ave Raleigh, NC 27610 **Richard Taylor** 919 231-6161

Table 4. Project Attribute Table
Goose Creek Stream Restoration- SCO No. 04-06298-01 DENR No. D05035S

Project County	Durham		
Physiographic Region	Piedmont		
Ecoregion	Triassic Basin		
Project River Basin	Neuse		
USGS HUC for Project (14 digit)	3020201050010		
NCDWQ Sub-basin for Project	03-04-01		
Within extent of EEP Watershed Plan?	Ellerbe Creek Local Watershed Plan		
WRC Hab Class (Warm, Cool, Cold)	Warm		
% of project easement demarcated	~50		
Beaver activity observed?	No		
	Eastway upstream	Eastway downstream	Longmeadow
Drainage area (ac)	~350	404	481
Stream order	2	2	2
Restored length (feet)	514	347	604
Perennial or Intermittent	perennial	perennial	perennial
Watershed type (Rural, Urban, etc.)	urban	urban	urban
Watershed LULC Distribution (%)			
Urban-Low Intensity Developed		44	43
Urban-High Intensity Developed		22	22
Residential Urban		18	19
Forest, Herbaceous, Open Water		16	16
Watershed impervious cover (%)		~55	~54
NCDWQ AU/Index number	27-5-1	27-5-1	27-5-1
NCDWQ classification	WS-IV, NSW	WS-IV, NSW	WS-IV, NSW
303d listed?	no	no	no
Upstream of a 303d listed segment?	yes	yes	yes
Reasons for 303d listing or stressor	urban stormwater	urban stormwater	urban stormwater
Total acreage of easement	0.86	1.4	1.69
Rosgen classification of pre-existing	N/A	N/A	N/A
Rosgen classification of As-built	Bc5	Bc5	Bc5
Valley type	N/A	N/A	N/A
Valley slope	N/A	N/A	N/A
Valley side slope range (e.g. 2-3.%)	10-15%	10-15%	10-15%
Valley toe slope range (e.g. 2-3.%)	3-5%	3-5%	3-5%
Dominant soil series/characteristics			
Series	Whitestore-Urban	Whitestore-Urban	Whitestore-Urban
Depth	60"	60"	60"
Clay%	5-70	5-70	5-70

Table 4a. Categorical Stream Feature Visual Stability Assessment Goose Creek Stream Restoration Eastway Reach: (861 feet)						
Feature	**Initial**	**MY-01**	**MY-02**	**MY-03**	**MY-04**	**MY-05**
A. Riffles	100%					
B. Pools	100%					
C. Thalweg	100%					
D. Meanders	100%					
E. Bed General	100%					
F. Bank Condition	94%					
G. Deflectors	100%					

Table 4b. Categorical Stream Feature Visual Stability Assessment Goose Creek Stream Restoration Longmeadow Reach: (659 feet)						
Feature	**Initial**	**MY-01**	**MY-02**	**MY-03**	**MY-04**	**MY-05**
A. Riffles	100%					
B. Pools	100%					
C. Thalweg	100%					
D. Meanders	100%					
E. Bed General	100%					
F. Bank Condition	96%					
G. Crossvanes	100%					
H. Rock Toe Protection	100%					

Appendix B: Tables 5-7 and Permanent Cross Sections

Exhibit Table 5. Baseline Stream Data Summary
Goose Creek Stream Restoration/040629801 - Eastway Upstream (514 feet)

Parameter	Gauge[2]	Regional Curve			Pre-Existing Condition						Reference Reach(es) Data						Design			As-built / Baseline					
Dimension and Substrate - Riffle		LL	UL	Eq.	Min	Mean	Med	Max	SD	n	Min	Mean	Med	Max	SD	n	Min	Med	Max	Min	Mean	Med	Max	SD	n
Bankfull Width (ft)					16.7	24.6		29.7			15	16.8		20.1				36		30	40	40	50		3
Floodprone Width (ft)					19.5	29		38.5			67.8	79.1		85.4				72		72	117	100	180		3
Bankfull Mean Depth (ft)					1.6	2.3		3.1			1.6	1.7		1.8				2.3		1.4	2	2.1	2.5		3
[1]Bankfull Max Depth (ft)					2.1	3.5		4.3			2.5	2.6		2.8				4		3	3.7	4	4		3
Bankfull Cross Sectional Area (ft^2)					27.2	62.5		84.3			27.1	28.5		31.4				82.5		61.8	76.1	68.6	97.9		3
Width/Depth Ratio					9.1	12		16.7			8.3	9.9		12.9				15.7		14.3	20	16	35.7		3
Entrenchment Ratio					1.2	≥2.2		≥2.2			4.2	4.8		5.7				≥2.0		2.4	2.9	2.5	3.6		3
[1]Bank Height Ratio																									
Profile																									
Riffle Length (ft)																	23	42	68		NA				
Riffle Slope (ft/ft)																	0.0037	0.0053	0.0089		NA				
Pool Length (ft)																	21	47.8	70		NA				
Pool Max depth (ft)																	2	2.3	2.5		NA				
Pool Spacing (ft)																	58	79.3	107.5		NA				
Pattern																									
Channel Beltwidth (ft)						80						NA						NA			NA				
Radius of Curvature (ft)					23.2	33.6		41.6			11.3	33.4		63.5				NA			NA				
Rc:Bankfull width (ft/ft)					0.9	1.4		2.5			0.6	2		4.2				NA			NA				
Meander Wavelength (ft)					89	94		99				98						NA			NA				
Meander Width Ratio						3.3						NA						NA			NA				
Transport parameters																									
Reach Shear Stress (competency) lb/f^2					0.12												0.33			0.3					
Max part size (mm) mobilized at bankfull					6												16			15					
Stream Power (transport capacity) lb/ft/s					0.55												1.09			0.99					
Additional Reach Parameters																									
Rosgen Classification					F5						C4						Bc5			Bc5					
Bankfull Velocity (fps)					4.6												3.3			3.3					
Bankfull Discharge (cfs)					30 - 400																				
Valley length (ft)					1800						NA														
Channel Thalweg length (ft)					NA						NA						514			514					
Sinuosity (ft)					1.0 - 1.1						NA						1.0			1.0					
Water Surface Slope (Channel) (ft/ft)					NA						0.006									0.0018					
BF slope (ft/ft)					0.011						0.009						0.0023			0.0023					
[3]Bankfull Floodplain Area (acres)					NA						NA														
[4]Proportion over wide (%)					NA						NA														
Channel Stability or Habitat Metric					NA						NA														
Biological or Other					NA						NA														

Shaded cells indicate that these will typically not be filled in.

1 = The distributions for these parameters can include information from both the cross-section surveys and the longitudinal profile. 2 = For projects with a proximal USGS gauge in-line with the project reach (added bankfull verification - rare).

3. Utilizing survey data produce and estimate of the bankfull floodplain area in acres, which should be the area from the top of bank to the toe of the terrace riser/slope.

4 = Proportion of reach determined to be over-wide based on the visual survey using the regional curve UL for width

Exhibit Table 5. Baseline Stream Data Summary
Goose Creek Stream Restoration/040629801 - Eastway Downstream (347 feet)

Parameter	Gauge[2]	Regional Curve			Pre-Existing Condition						Reference Reach(es) Data						Design			As-built / Baseline					
Dimension and Substrate - Riffle		LL	UL	Eq.	Min	Mean	Med	Max	SD	n	Min	Mean	Med	Max	SD	n	Min	Med	Max	Min	Mean	Med	Max	SD	n
Bankfull Width (ft)					16.7	24.6		29.7			15	16.8		20.1				46		70	70	70	70		1
Floodprone Width (ft)					19.5	29		38.5			67.8	79.1		85.4				92		320	320	320	320		1
Bankfull Mean Depth (ft)					1.6	2.3		3.1			1.6	1.7		1.8				2.5		1.8	1.8	1.8	1.8		1
[1]Bankfull Max Depth (ft)					2.1	3.5		4.3			2.5	2.6		2.8				4		4	4	4	4		1
Bankfull Cross Sectional Area (ft^2)					27.2	62.5		84.3			27.1	28.5		31.4				113.8		126.1	126.1	126.1	126.1		1
Width/Depth Ratio					9.1	12		16.7			8.3	9.9		12.9				18.4		38.9	38.9	38.9	38.9		1
Entrenchment Ratio					1.2	≥2.2		≥2.2			4.2	4.8		5.7				≥2.0		4.6	4.6	4.6	4.6		1
[1]Bank Height Ratio																									
Profile																									
Riffle Length (ft)																	26	43	68		NA				
Riffle Slope (ft/ft)																	0.0023	0.0046	0.0076		NA				
Pool Length (ft)																	32	50	83		NA				
Pool Max depth (ft)																	2	2.2	2.5		NA				
Pool Spacing (ft)																	58	88.8	107.5		NA				
Pattern																									
Channel Beltwidth (ft)						80						NA						NA			NA				
Radius of Curvature (ft)					23.2	33.6		41.6			11.3	33.4		63.5				NA			NA				
Rc:Bankfull width (ft/ft)					0.9	1.4		2.5			0.6	2		4.2				NA			NA				
Meander Wavelength (ft)					89	94		99				98						NA			NA				
Meander Width Ratio						3.3						NA						NA			NA				
Transport parameters																									
Reach Shear Stress (competency) lb/f^2					0.12												0.33			0.3					
Max part size (mm) mobilized at bankfull					6												16			15					
Stream Power (transport capacity) lb/ft/s					0.55												1.09			0.99					
Additional Reach Parameters																									
Rosgen Classification					F5						C4						Bc5			Bc5					
Bankfull Velocity (fps)					4.6												3.4			3.4					
Bankfull Discharge (cfs)					30 - 400																				
Valley length (ft)					1800						NA														
Channel Thalweg length (ft)					NA						NA						347			347					
Sinuosity (ft)					1.0 - 1.1						NA						1.0			1.0					
Water Surface Slope (Channel) (ft/ft)					NA						0.006									0.0018					
BF slope (ft/ft)					0.011						0.009						0.0023			0.0023					
[3]Bankfull Floodplain Area (acres)					NA						NA						NA			NA					
[4]Proportion over wide (%)					NA						NA														
Channel Stability or Habitat Metric					NA						NA														
Biological or Other					NA						NA														

Shaded cells indicate that these will typically not be filled in.

1 = The distributions for these parameters can include information from both the cross-section surveys and the longitudinal profile. 2 = For projects with a proximal USGS gauge in-line with the project reach (added bankfull verification - rare).

3. Utilizing survey data produce and estimate of the bankfull floodplain area in acres, which should be the area from the top of bank to the toe of the terrace riser/slope.

4 = Proportion of reach determined to be over-wide based on the visual survey using the regional curve UL for width

Exhibit Table 5. Baseline Stream Data Summary
Goose Creek Stream Restoration/040629801 - Long Meadow Park (655 feet)

Parameter	Gauge[2]	Regional Curve			Pre-Existing Condition						Reference Reach(es) Data						Design			As-built / Baseline					
Dimension and Substrate - Riffle		LL	UL	Eq.	Min	Mean	Med	Max	SD	n	Min	Mean	Med	Max	SD	n	Min	Med	Max	Min	Mean	Med	Max	SD	n
Bankfull Width (ft)					16.7	24.6		29.7			15	16.8		20.1				38		33	41	40	50		3
Floodprone Width (ft)					19.5	29		38.5			67.8	79.1		85.4				72		72	184	230	250		3
Bankfull Mean Depth (ft)					1.6	2.3		3.1			1.6	1.7		1.8				2.4		2.3	2.5	2.4	2.9		3
[1]Bankfull Max Depth (ft)					2.1	3.5		4.3			2.5	2.6		2.8				3.5		3.3	3.4	3.4	3.5		3
Bankfull Cross Sectional Area (ft^2)					27.2	62.5		84.3			27.1	28.5		31.4				92.3		78.2	105.4	93.7	144.3		3
Width/Depth Ratio					9.1	12		16.7			8.3	9.9		12.9				15.8		13.8	16.1	17.2	17.4		3
Entrenchment Ratio					1.2	≥2.2		≥2.2			4.2	4.8		5.7				≥2.2		2.2	4.5	5	5.8		3
[1]Bank Height Ratio																									
Profile																									
Riffle Length (ft)																	32	56.2	106	40	57.5	55	80		6
Riffle Slope (ft/ft)																	0.0039	0.0076	0.0110	0.0033	0.0080	0.0073	0.0120		6
Pool Length (ft)																	39	53	61	50	62.6	60	75		5
Pool Max depth (ft)																		5.5		5.5	5.9	5.9	6.3		5
Pool Spacing (ft)																	41	99.5	163	40	52.5	50	60		4
Pattern																									
Channel Beltwidth (ft)						80						NA						NA			NA				
Radius of Curvature (ft)					23.2	33.6		41.6			11.3	33.4		63.5				NA			NA				
Rc:Bankfull width (ft/ft)					0.9	1.4		2.5			0.6	2		4.2				NA			NA				
Meander Wavelength (ft)					89	94		99				98						NA			NA				
Meander Width Ratio						3.3						NA						NA			NA				
Transport parameters																									
Reach Shear Stress (competency) lb/f[2]					0.61												0.58			0.53					
Max part size (mm) mobilized at bankfull					30												29			28					
Stream Power (transport capacity) lb/ft/s					2.81												2.49			2.28					
Additional Reach Parameters																									
Rosgen Classification					F5						C4						Bc5			Bc3					
Bankfull Velocity (fps)					4.6												4.3			4.3					
Bankfull Discharge (cfs)					30 - 400																				
Valley length (ft)					1800						NA														
Channel Thalweg length (ft)					NA						NA						604			604					
Sinuosity (ft)					1.0 - 1.1						NA						1			1					
Water Surface Slope (Channel) (ft/ft)					NA						0.006														
BF slope (ft/ft)					0.011						0.009						0.0039			0.0039					
[3]Bankfull Floodplain Area (acres)					NA						NA														
[4]Proportion over wide (%)					NA						NA														
Channel Stability or Habitat Metric					NA						NA														
Biological or Other					NA						NA														

Shaded cells indicate that these will typically not be filled in.

1 = The distributions for these parameters can include information from both the cross-section surveys and the longitudinal profile. 2 = For projects with a proximal USGS gauge in-line with the project reach (added bankfull verification - rare).

3. Utilizing survey data produce and estimate of the bankfull floodplain area in acres, which should be the area from the top of bank to the toe of the terrace riser/slope.

4 = Proportion of reach determined to be over-wide based on the visual survey using the regional curve UL for width

Exhibit Table 6. Dimensional Morphology Summary (Dimensional Parameters – Cross Sections)

Goose Creek Stream Restoration-DENR No.D05035S

	Cross Section 1 (Riffle)							Cross Section 2 (Riffle)							Cross Section 3 (Pool)							Cross Section 4 (Riffle)						
Based on fixed baseline bankfull elevation[1]	Base	MY1	MY2	MY3	MY4	MY5	MY+	Base	MY1	MY2	MY3	MY4	MY5	MY+	Base	MY1	MY2	MY3	MY4	MY5	MY+	Base	MY1	MY2	MY3	MY4	MY5	MY+
Bankfull Width (ft)	33							56							40							45						
Floodprone Width (ft)	170							~300							>225							>240						
Bankfull Mean Depth (ft)	3.4							2.6							4.3							2						
Bankfull Max Depth (ft)	3.5							3.5							5.5							3.5						
Bankfull Cross Sectional Area (ft^2)	111							144							172							94						
Bankfull Width/Depth Ratio	10							22							9							22						
Bankfull Entrenchment Ratio	5.2							5.3							>5.6							>5						
Bankfull Bank Height Ratio	1.7							1.7							1.4							~1.1						
Based on current/developing bankfull feature[2]																												
Bankfull Width (ft)																												
Floodprone Width (ft)																												
Bankfull Mean Depth (ft)																												
Bankfull Max Depth (ft)																												
Bankfull Cross Sectional Area (ft^2)																												
Bankfull Width/Depth Ratio																												
Bankfull Entrenchment Ratio																												
Bankfull Bank Height Ratio																												
Cross Sectional Area between end pins (ft^2)																												
d50 (mm)																												

	Cross Section 5 (Pool)							Cross Section 6 (Riffle)							Cross Section 7 (Pool)							Cross Section 8 (Riffle)						
Based on fixed baseline bankfull elevation[1]	Base	MY1	MY2	MY3	MY4	MY5	MY+	Base	MY1	MY2	MY3	MY4	MY5	MY+	Base	MY1	MY2	MY3	MY4	MY5	MY+	Base	MY1	MY2	MY3	MY4	MY5	MY+
Bankfull Width (ft)	68							45							40							37						
Floodprone Width (ft)	200							162							140							170						
Bankfull Mean Depth (ft)	1.8							1.5							2.4							2.5						
Bankfull Max Depth (ft)	5							4							4.5							4						
Bankfull Cross Sectional Area (ft^2)	126							69							98							92						
Bankfull Width/Depth Ratio	38							30							17							15						
Bankfull Entrenchment Ratio	2.9							3.6							3.5							4.6						
Bankfull Bank Height Ratio	1.3							1.1							1.8							1.5						
Based on current/developing bankfull feature[2]																												
Bankfull Width (ft)																												
Floodprone Width (ft)																												
Bankfull Mean Depth (ft)																												
Bankfull Max Depth (ft)																												
Bankfull Cross Sectional Area (ft^2)																												
Bankfull Width/Depth Ratio																												
Bankfull Entrenchment Ratio																												
Bankfull Bank Height Ratio																												
Cross Sectional Area between end pins (ft^2)																												
d50 (mm)																												

1 = Widths and depths for each resurvey will be based on the baseline bankfull datum regardless of dimensional/depositional development. 2 = Based on the elevation of any dominant depositional feature that develops and is observed at the time of survey. If the baseline datum remains the only significant depositional feature then these two sets of dimensional parameters will be equal, however, if another depositional feature of significance develops above or below the baseline bankfull datum then this should be tracked and quantified in these cells.

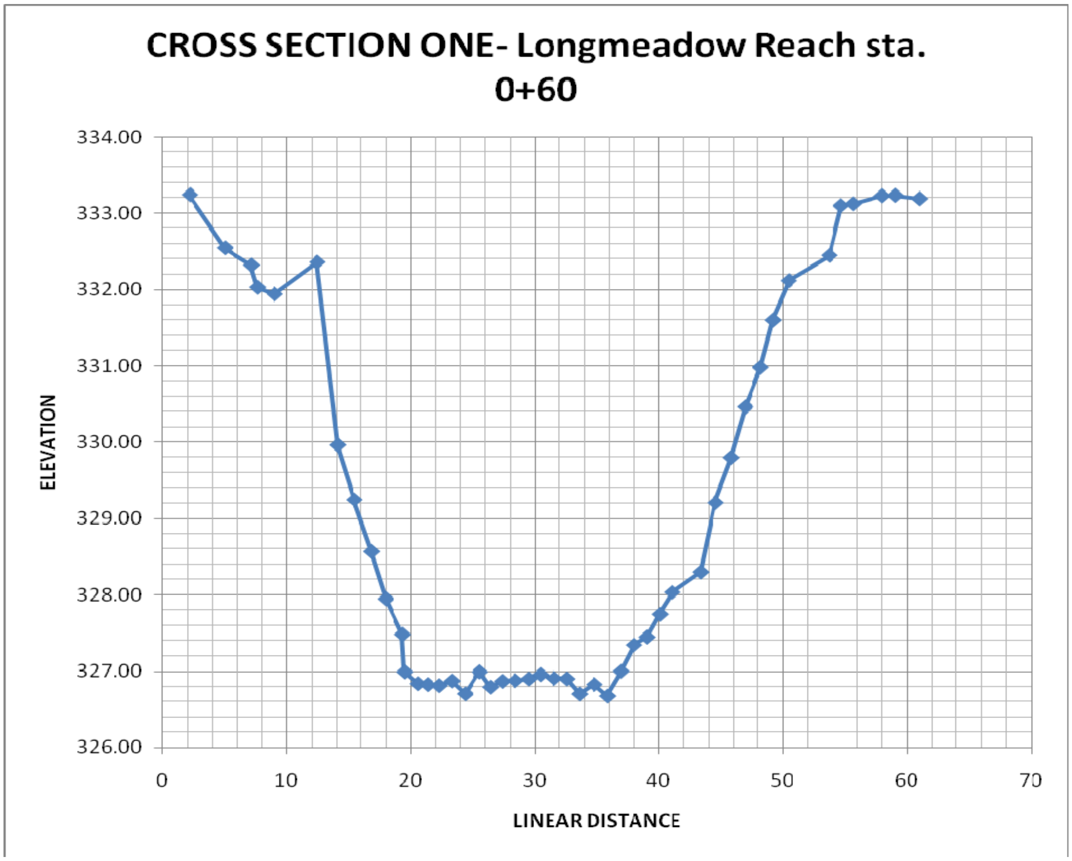
Exhibit Table 6. Dimensional Morphology Summary (Dimensional Parameters – Cross Sections)

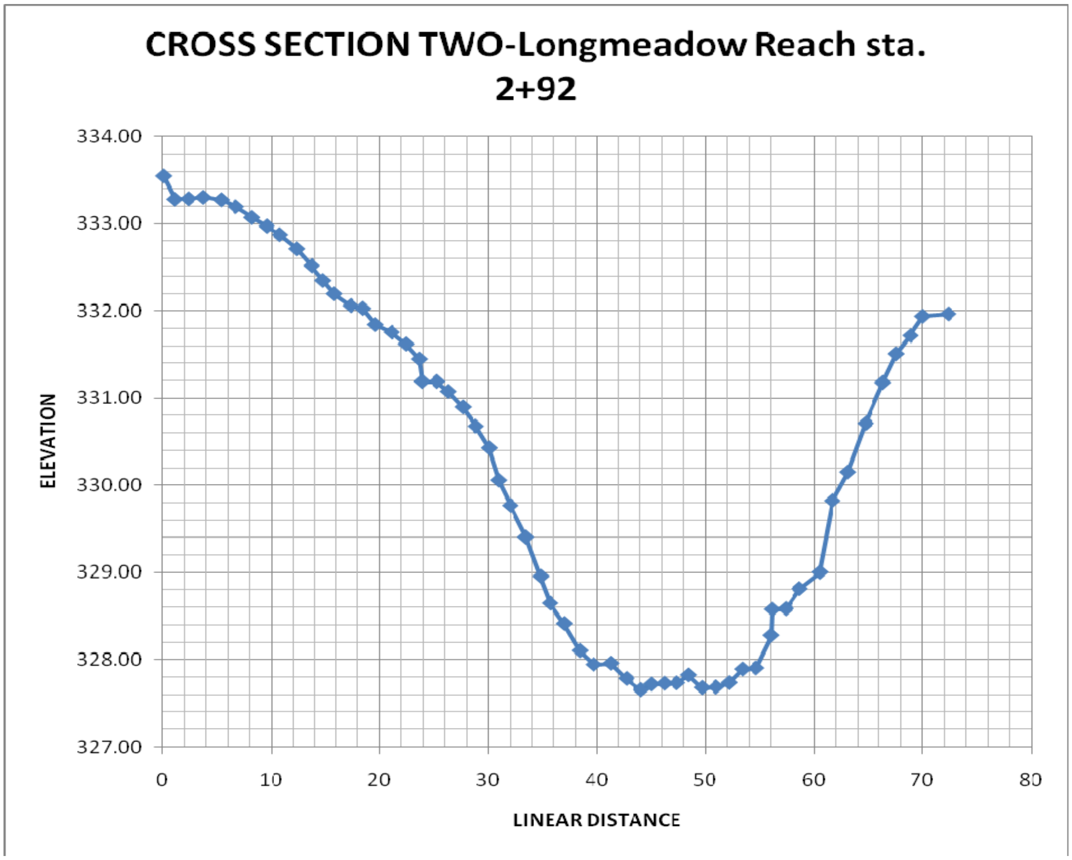
Goose Creek Stream Restoration-DENR No.D05035S

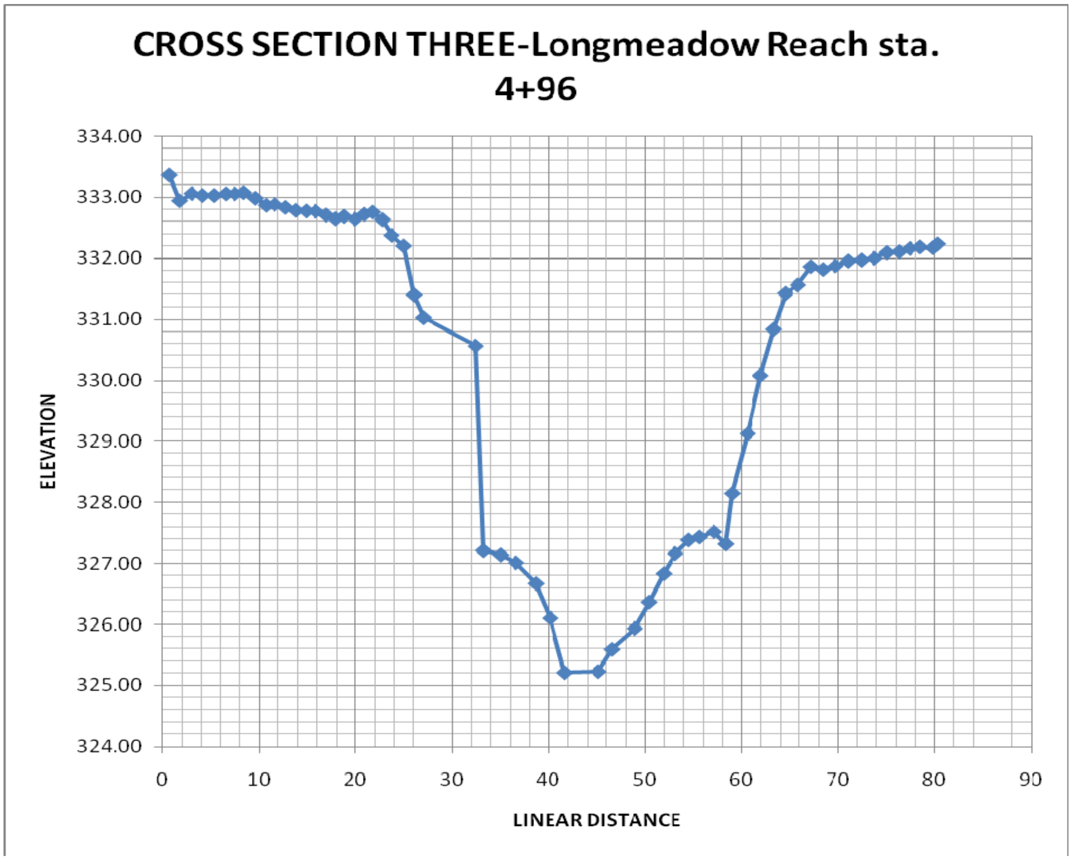
	Cross Section 1 (Riffle)							Cross Section 2 (Riffle)							Cross Section 3 (Pool)							Cross Section 4 (Riffle)						
Based on fixed baseline bankfull elevation[1]	Base	MY1	MY2	MY3	MY4	MY5	MY+	Base	MY1	MY2	MY3	MY4	MY5	MY+	Base	MY1	MY2	MY3	MY4	MY5	MY+	Base	MY1	MY2	MY3	MY4	MY5	MY+
Bankfull Width (ft)	33							56							40							45						
Floodprone Width (ft)	170							~300							>225							>240						
Bankfull Mean Depth (ft)	3.4							2.6							4.3							2						
Bankfull Max Depth (ft)	3.5							3.5							5.5							3.5						
Bankfull Cross Sectional Area (ft^2)	111							144							172							94						
Bankfull Width/Depth Ratio	10							22							9							22						
Bankfull Entrenchment Ratio	5.2							5.3							>5.6							>5						
Bankfull Bank Height Ratio	1.7							1.7							1.4							~1.1						
Based on current/developing bankfull feature[2]																												
Bankfull Width (ft)																												
Floodprone Width (ft)																												
Bankfull Mean Depth (ft)																												
Bankfull Max Depth (ft)																												
Bankfull Cross Sectional Area (ft^2)																												
Bankfull Width/Depth Ratio																												
Bankfull Entrenchment Ratio																												
Bankfull Bank Height Ratio																												
Cross Sectional Area between end pins (ft^2)																												
d50 (mm)																												

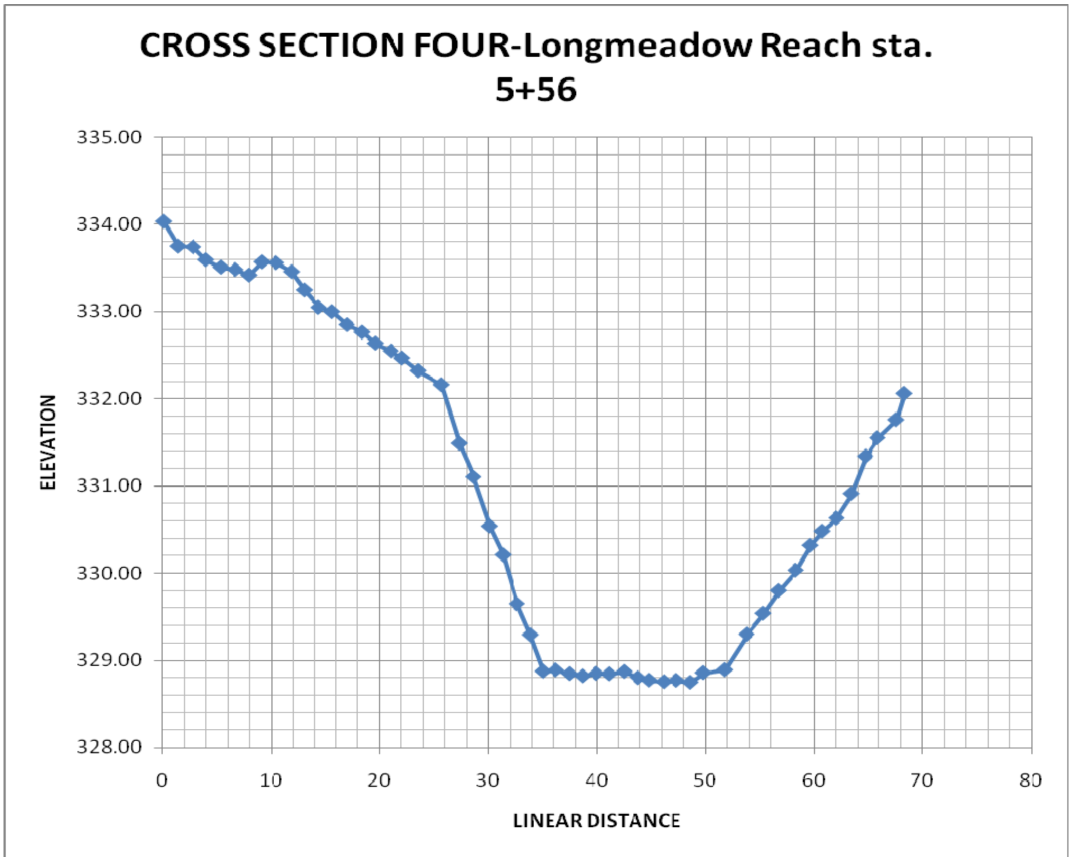
	Cross Section 5 (Pool)							Cross Section 6 (Riffle)							Cross Section 7 (Pool)							Cross Section 8 (Riffle)						
Based on fixed baseline bankfull elevation[1]	Base	MY1	MY2	MY3	MY4	MY5	MY+	Base	MY1	MY2	MY3	MY4	MY5	MY+	Base	MY1	MY2	MY3	MY4	MY5	MY+	Base	MY1	MY2	MY3	MY4	MY5	MY+
Bankfull Width (ft)	68							45							40							37						
Floodprone Width (ft)	200							162							140							170						
Bankfull Mean Depth (ft)	1.8							1.5							2.4							2.5						
Bankfull Max Depth (ft)	5							4							4.5							4						
Bankfull Cross Sectional Area (ft^2)	126							69							98							92						
Bankfull Width/Depth Ratio	38							30							17							15						
Bankfull Entrenchment Ratio	2.9							3.6							3.5							4.6						
Bankfull Bank Height Ratio	1.3							1.1							1.8							1.5						
Based on current/developing bankfull feature[2]																												
Bankfull Width (ft)																												
Floodprone Width (ft)																												
Bankfull Mean Depth (ft)																												
Bankfull Max Depth (ft)																												
Bankfull Cross Sectional Area (ft^2)																												
Bankfull Width/Depth Ratio																												
Bankfull Entrenchment Ratio																												
Bankfull Bank Height Ratio																												
Cross Sectional Area between end pins (ft^2)																												
d50 (mm)																												

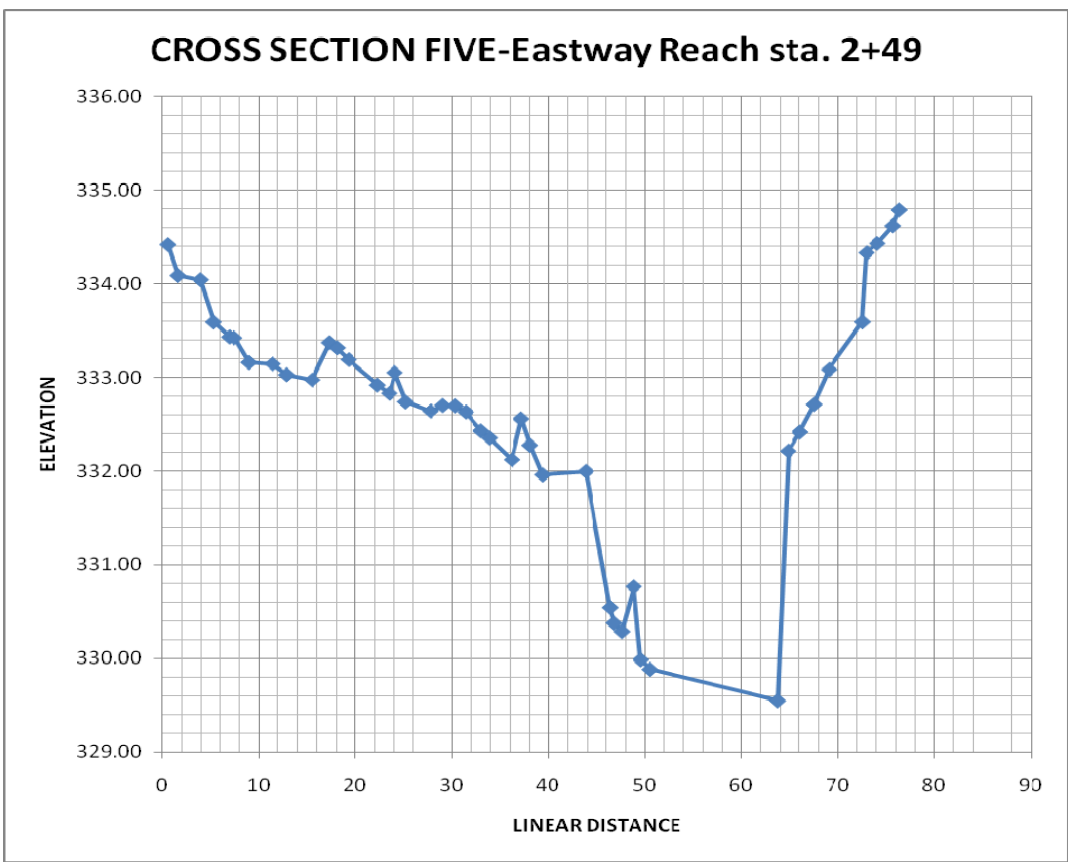
1 = Widths and depths for each resurvey will be based on the baseline bankfull datum regardless of dimensional/depositional development. 2 = Based on the elevation of any dominant depositional feature that develops and is observed at the time of survey. If the baseline datum remains the only significant depositional feature then these two sets of dimensional parameters will be equal, however, if another depositional feature of significance develops above or below the baseline bankfull datum then this should be tracked and quantified in these cells.

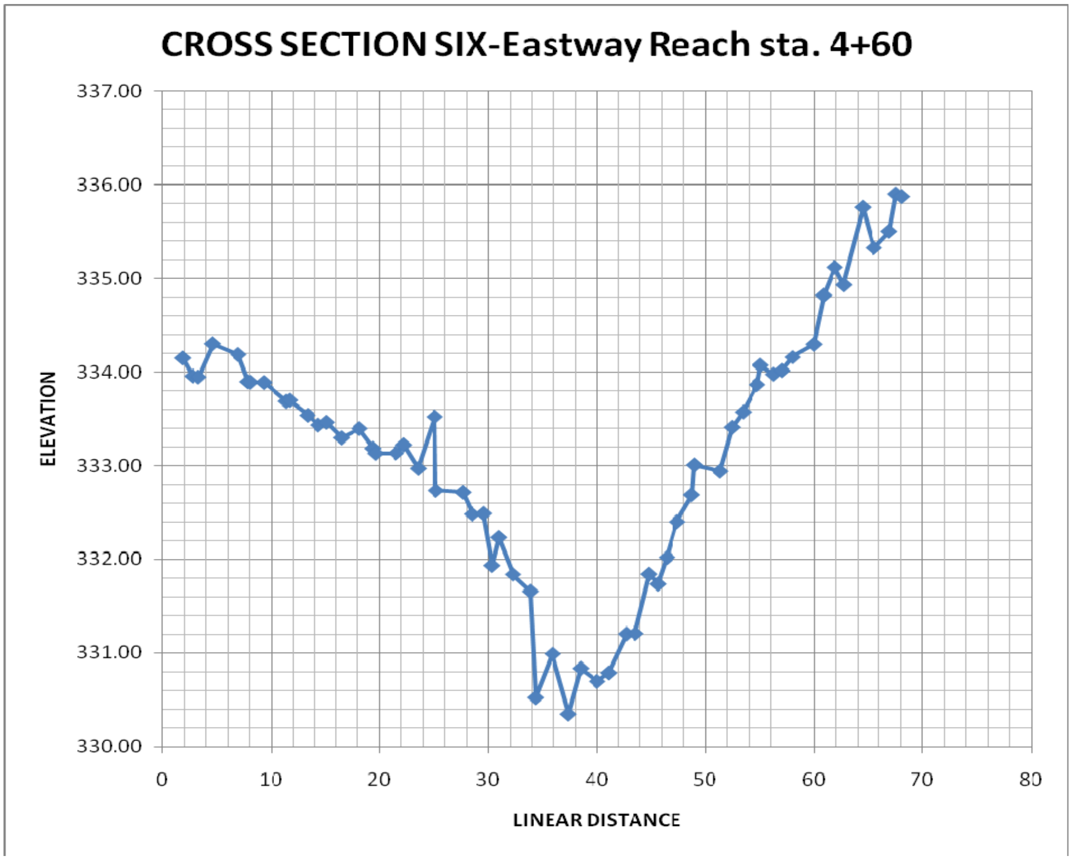

CROSS SECTION ONE- Longmeadow Reach sta. 0+60
ELEVATION
334.00
333.00
332.00
331.00
330.00
329.00
328.00
327.00
326.00
0
10
20
30
40
50
60
70
LINEAR DISTANCE

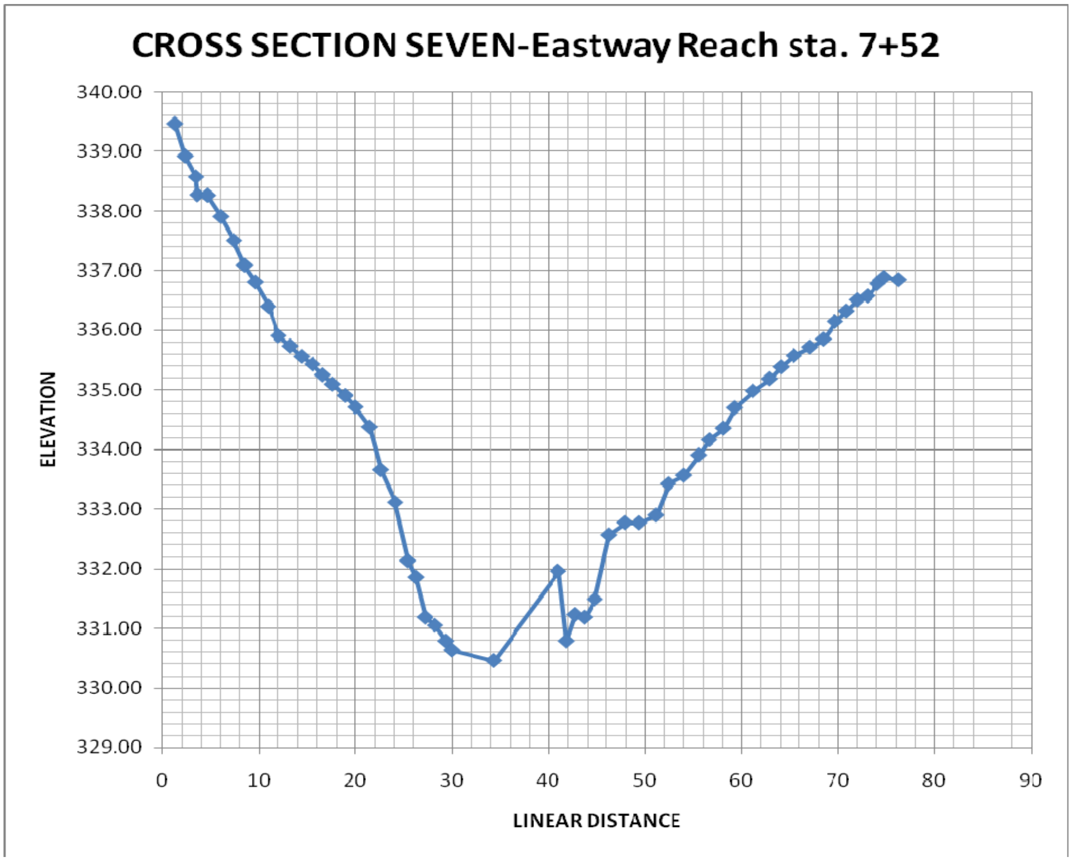

CROSS SECTION TWO-Longmeadow Reach sta. 2+92
ELEVATION
334.00
333.00
332.00
331.00
330.00
329.00
328.00
327.00
0
10
20
30
40
50
60
70
80
LINEAR DISTANCE

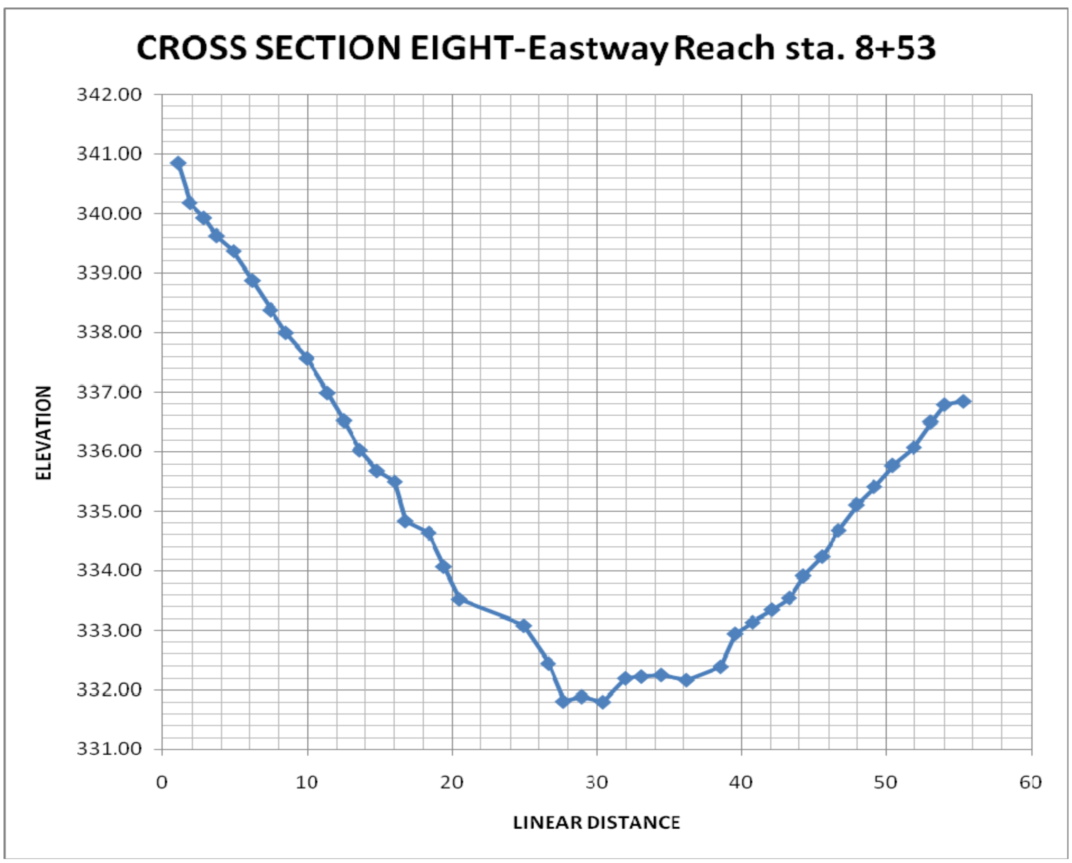

CROSS SECTION THREE-Longmeadow Reach sta. 4+96
ELEVATION
334.00
333.00
332.00
331.00
330.00
329.00
328.00
327.00
326.00
325.00
324.00
0
10
20
30
40
50
60
70
80
90
LINEAR DISTANCE

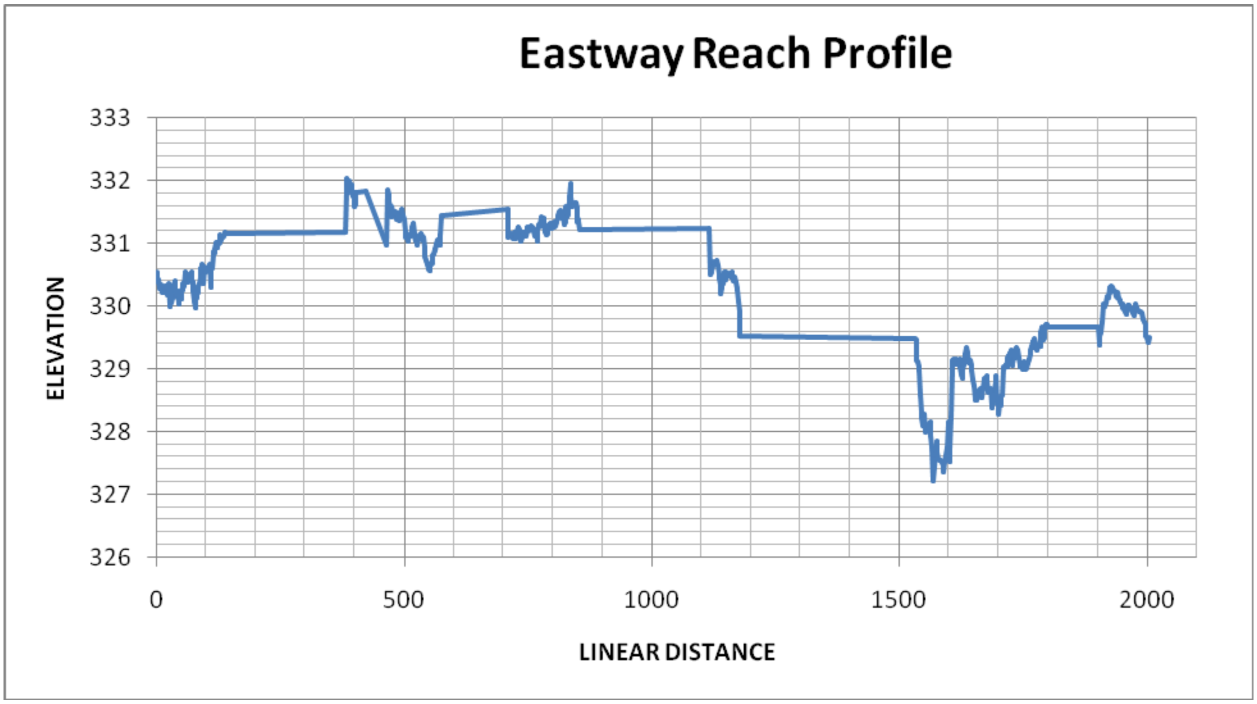

CROSS SECTION FOUR-Longmeadow Reach sta. 5+56
335.00
334.00
333.00
332.00
331.00
330.00
329.00
328.00
ELEVATION
0
10
20
30
40
50
60
70
80
LINEAR DISTANCE

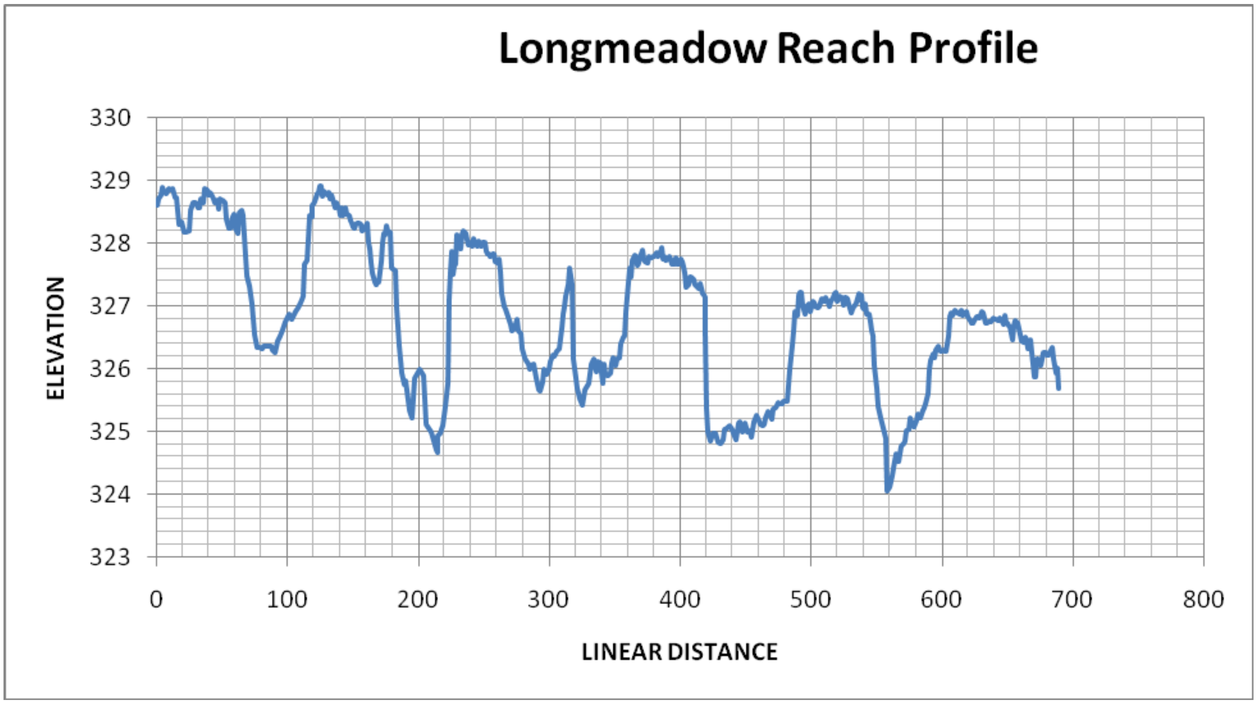

CROSS SECTION FIVE-Eastway Reach sta. 2+49
336.00
335.00
334.00
333.00
332.00
331.00
330.00
329.00
ELEVATION
0
10
20
30
40
50
60
70
80
90
LINEAR DISTANCE


CROSS SECTION SIX-Eastway Reach sta. 4+60
337.00
336.00
335.00
334.00
333.00
332.00
331.00
330.00
ELEVATION
0
10
20
30
40
50
60
70
80
LINEAR DISTANCE


CROSS SECTION SEVEN-Eastway Reach sta. 7+52
ELEVATION
340.00
339.00
338.00
337.00
336.00
335.00
334.00
333.00
332.00
331.00
330.00
329.00
0
10
20
30
40
50
60
70
80
90
LINEAR DISTANCE


CROSS SECTION EIGHT-Eastway Reach sta. 8+53
ELEVATION
342.00
341.00
340.00
339.00
338.00
337.00
336.00
335.00
334.00
333.00
332.00
331.00
0
10
20
30
40
50
60
LINEAR DISTANCE


Eastway Reach Profile
ELEVATION
LINEAR DISTANCE
333
332
331
330
329
328
327
326
0
500
1000
1500
2000


Longmeadow Reach Profile
ELEVATION
LINEAR DISTANCE
330
329
328
327
326
325
324
323
0
100
200
300
400
500
600
700
800

Appendix C: Vegetation

Plot 1, Longmeadow reach, downstream, left bank.

Plot 2, Longmeadow reach, downstream, right bank.

Plot 3, Eastway reach, downstreawm, right bank.

Plot 4, Eastway reach, upstream, right bank.

Eastway reach, upstream, right bank, looking downstream, ~ sta. 8+00.

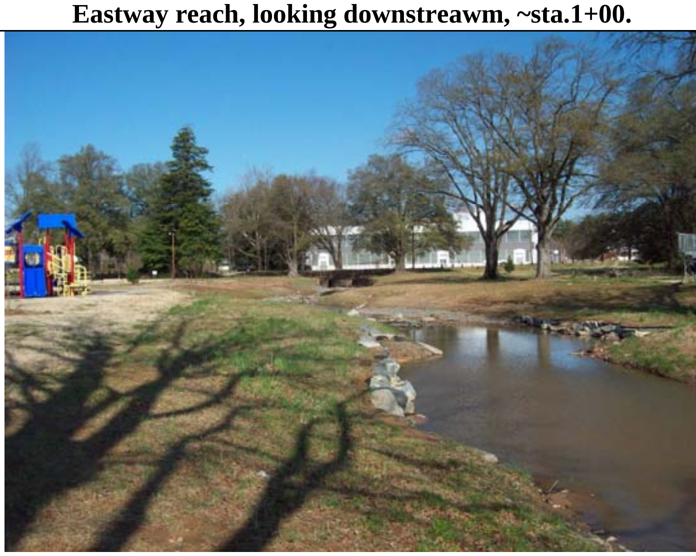
Eastway reach, right bank looking downstream, ~ sta. 6+00.

Eastway reach, looking downstream,~ sta. 3+00.

Eastway reach, stormwater channels, ~ sta. 2+00.

Eastway reach, looking downstreawm, ~sta.1+00.

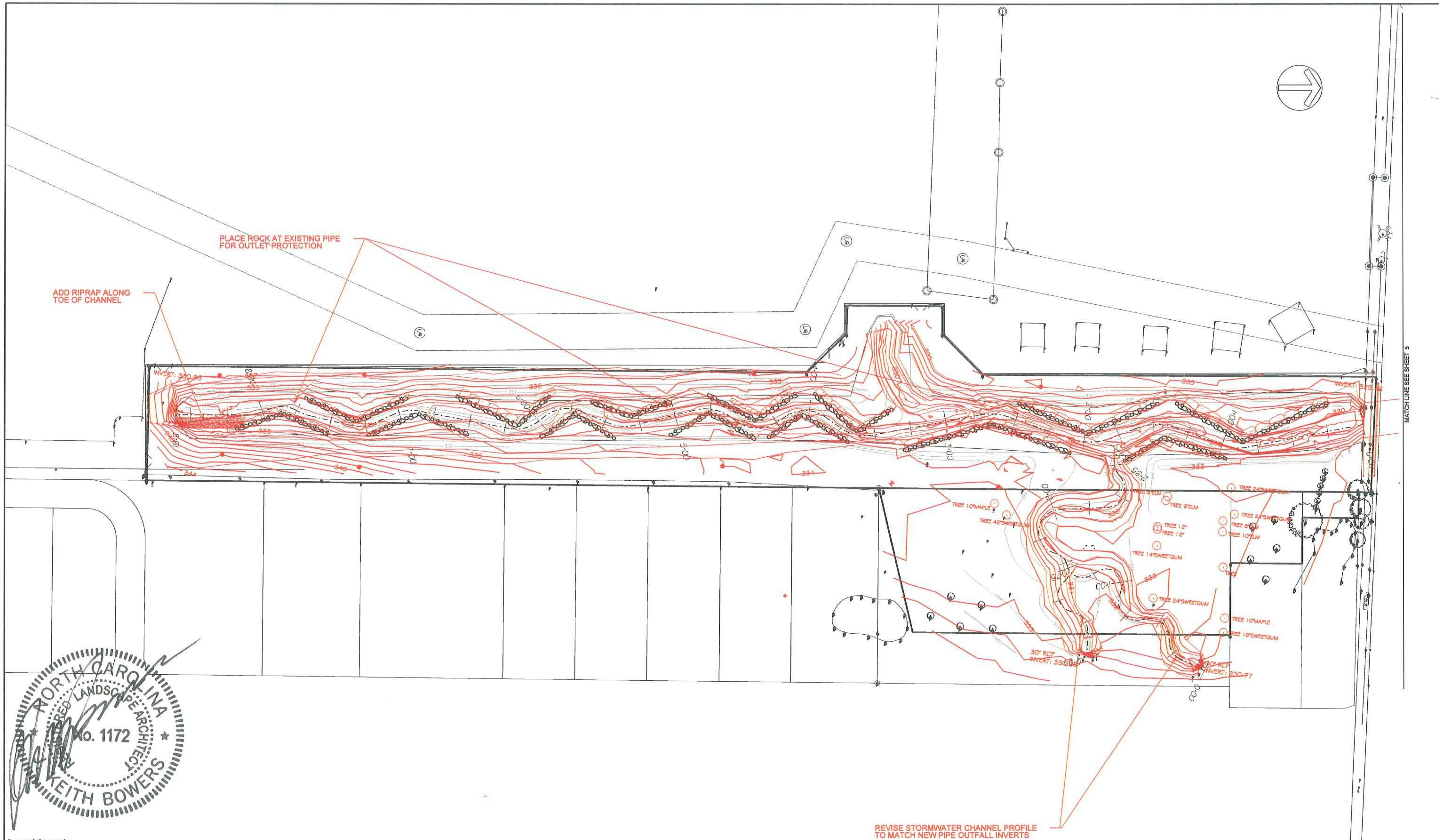
Longmeadow reach, from Liberty St., ~ sta. 0+00.



Longmeadow reach, looking downstream, ~ sta. 0+00.

Longmeadow reach, looking downstream, ~ sta. 2+50.

Appendix D: As-Built Plansheets



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REVISION		
DATE	BY	DESCRIPTION

SEAL

DATE: MARCH 2006
DESIGNED: EMM/VLS/KN
DRAWN: WC/AP
CHECKED: JKB
APPROVED:
Biohabitats Project No. 4802.02

Ecosystem Enhancement PROGRAM
EEP PROJECT MANAGER: PERRY SUGG
REVIEW COORDINATOR: SALAM MURTADA

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TECHNICAL CONTACTS: VINCE SORTMAN
ELLEN McCLURE

• Fostering Ecological Stewardship •

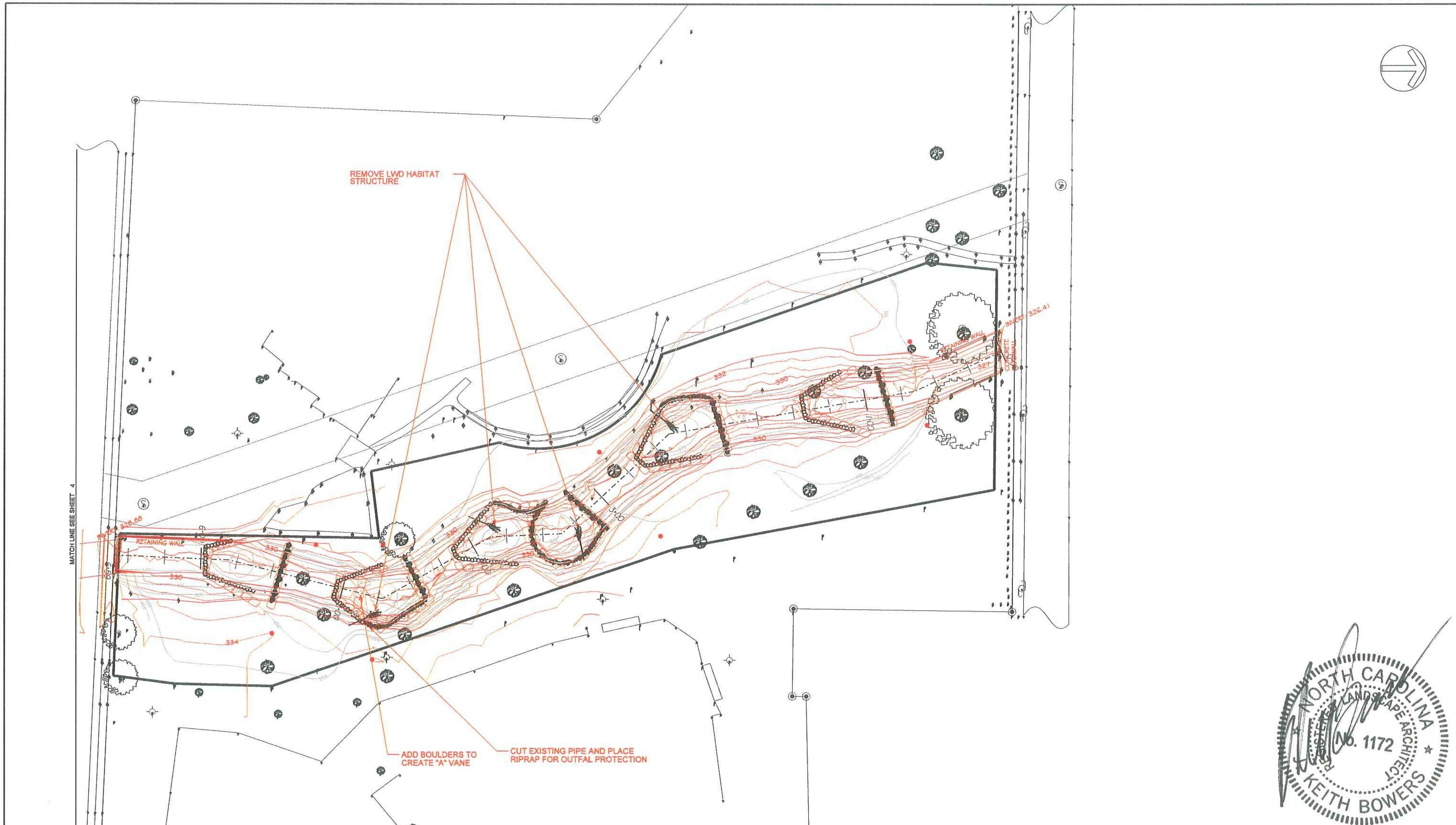
GOOSE CREEK STREAM RESTORATION

DURHAM, NORTH CAROLINA

GRADING AND EROSION & SEDIMENT CONTROL PLAN: EASTWAY ELEMENTARY SCHOOL REACH

SCALE: 1" = 30'
CONTRACT NO.
SHEET 4 OF 17

AS-BUILT



SEAL

REVISION		
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GOOSE CREEK STREAM RESTORATION

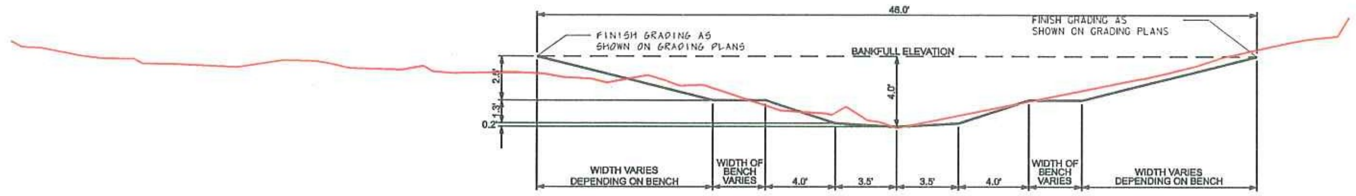
DURHAM, NORTH CAROLINA

GRADING AND EROSION & SEDIMENT PLAN: LONGMEADOW PARK REACH

SCALE: 1" = 30'

CONTRACT NO.

AS-BUILT

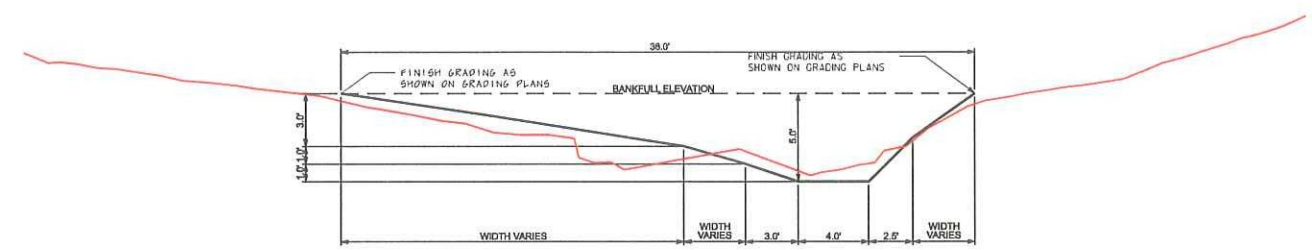


SECTION 5

TYPICAL CROSS SECTION - RIFFLE MIDPOINT

EASTWAY ELEMENTARY SCHOOL REACH
STA. - 0+00 - 3+47

NOT TO SCALE

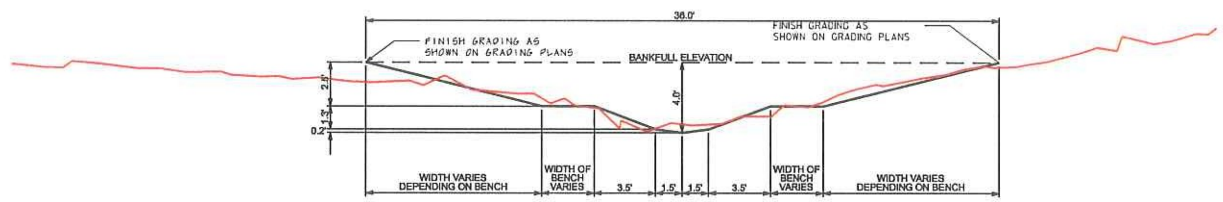


SECTION 7

TYPICAL CROSS SECTION - POOL

EASTWAY ELEMENTARY SCHOOL REACH
STA. - 3+47 - 4+17 5+73 - 8+60

NOT TO SCALE

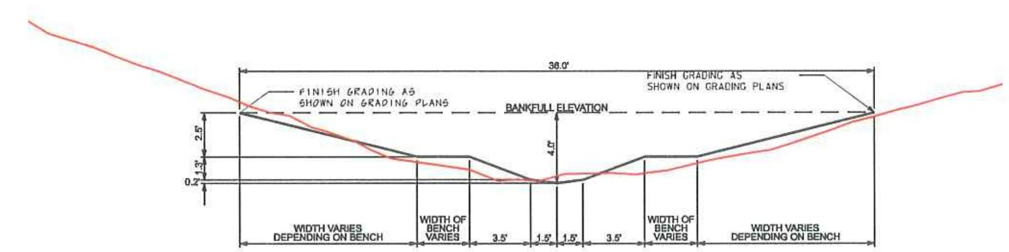


SECTION 6

TYPICAL CROSS SECTION - RIFFLE MIDPOINT

EASTWAY ELEMENTARY SCHOOL REACH
STA. - 3+47 - 8+60

NOT TO SCALE

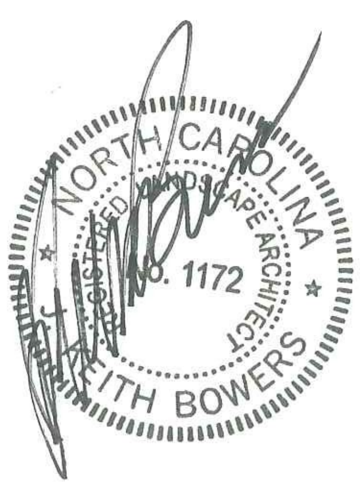


SECTION 8

TYPICAL CROSS SECTION - RIFFLE MIDPOINT

EASTWAY ELEMENTARY SCHOOL REACH
STA. - 3+47 - 8+60

NOT TO SCALE



LEGEND

PROPOSED GRADE

AS-BUILT GRADE

NOTE:
END OF LINES ON THE CROSS SECTIONS ARE WHERE THE PERMANENT PINS ARE.

REVISION		
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GOOSE CREEK STREAM RESTORATION

DURHAM, NORTH CAROLINA

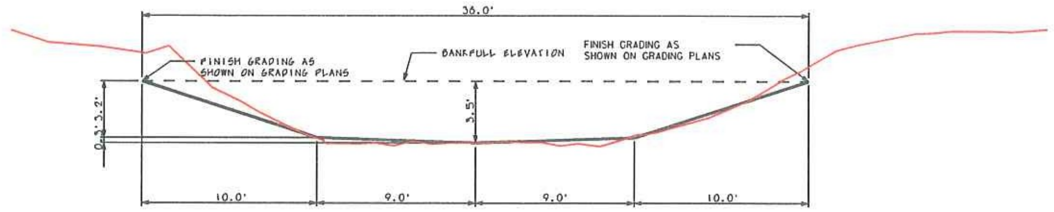
TYPICAL CROSS SECTIONS: EASTWAY ELEMENTARY SCHOOL REACH

SCALE: AS SHOWN

CONTRACT NO.

SHEET 10 OF 17

AS-BUILT

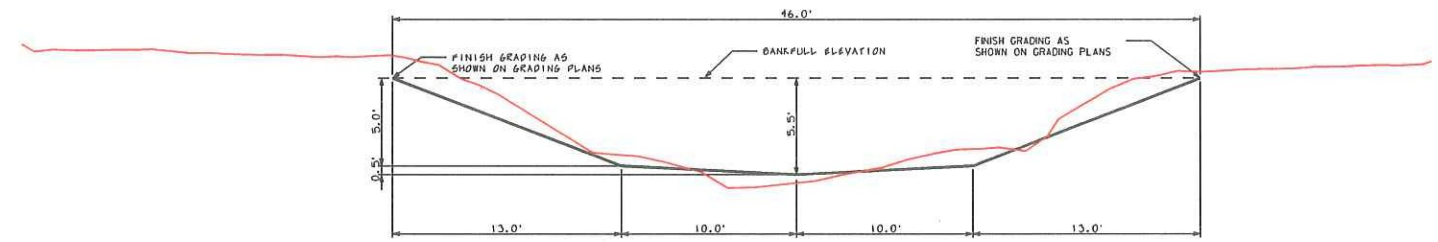


SECTION 1

TYPICAL CROSS SECTION - RIFFLE MIDPOINT

LONGMEADOW PARK REACH
STA 0+00 - 5+42

SCALE 1" = 3'

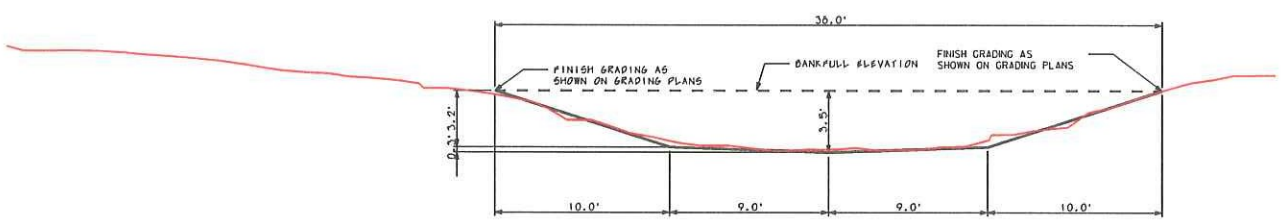


SECTION 3

TYPICAL CROSS SECTION - POOL

LONGMEADOW PARK REACH
STA 0+00 - 5+42

SCALE 1" = 3'

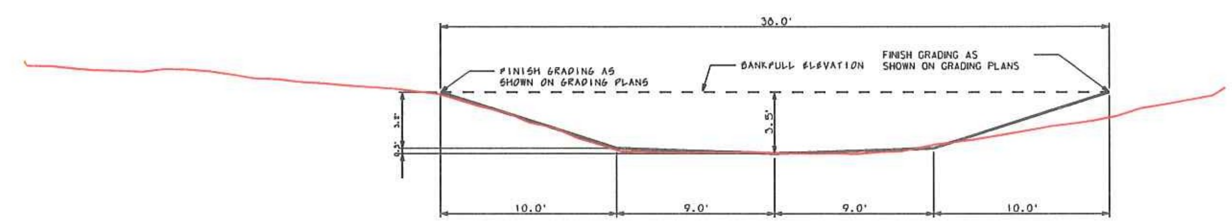


SECTION 2

TYPICAL CROSS SECTION - RIFFLE MIDPOINT

LONGMEADOW PARK REACH
STA 0+00 - 5+42

SCALE 1" = 3'



SECTION 4

TYPICAL CROSS SECTION - RIFFLE MIDPOINT

LONGMEADOW PARK REACH
STA 0+00 - 5+42

SCALE 1" = 3'

NORTH CAROLINA
LANDSCAPE ARCHITECT
NO. 1172
KEITH BOWERS

LEGEND

PROPOSED GRADE

AS-BUILT GRADE

NOTE:
END OF LINES ON THE CROSS SECTIONS ARE WHERE THE PERMANENT PINS ARE.

REVISION		
DATE	BY	DESCRIPTION

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CHECKED: JKB
APPROVED:
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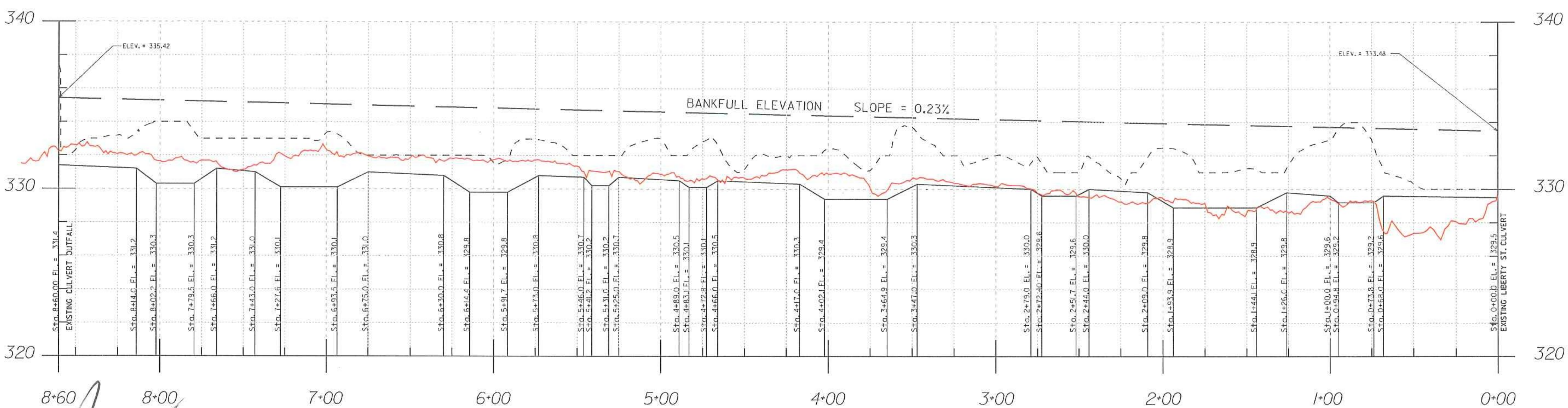
GOOSE CREEK STREAM RESTORATION

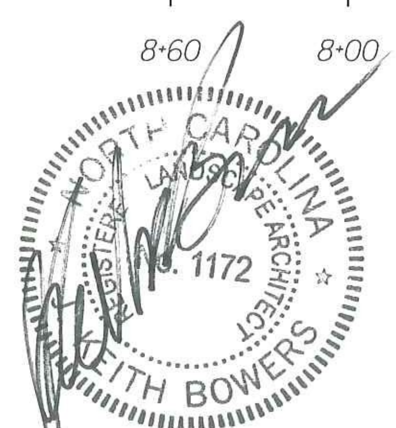
DURHAM, NORTH CAROLINA

TYPICAL CROSS SECTIONS:

LONGMEADOW PARK REACH

SCALE: AS SHOWN
CONTRACT NO.
SHEET 11 OF 17
AS-BUILT





LEGEND

(red solid line)	As-Built Grade
– – – –	Existing Ground at Thalweg
———	Proposed Grade at Thalweg
— —	Bankfull Elevation

SCALE:
HOR. 1" = 30'
VER. 1" = 3'

REVISION		
DATE	BY	DESCRIPTION

SEAL

DATE: MARCH 2006
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GOOSE CREEK STREAM RESTORATION

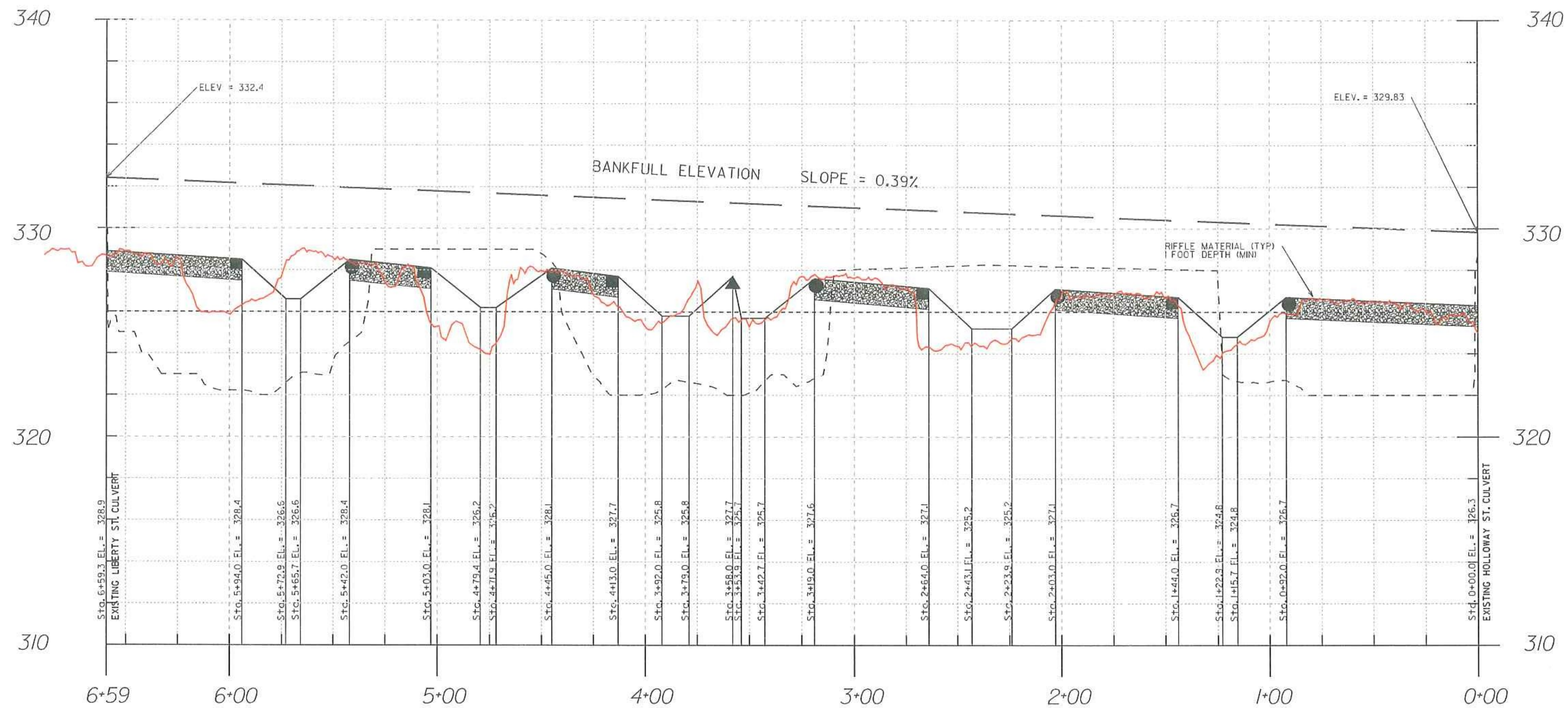
DURHAM, NORTH CAROLINA

PROFILE: EASTWAY ELEMENTARY SCHOOL REACH

SCALE: AS SHOWN

CONTRACT NO.

AS-BUILT



LEGEND

- As-Built Grade
- Existing Ground at Thalweg
- Proposed Grade at Thalweg
- Bankfull Elevation
- Rock Cross Vane
- Riffle Structure
- Rock Step
- Riffle Material

SCALE:
HOR. 1" = 30'
VER. 1" = 3'

REVISION		
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DATE: MARCH 2006
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GOOSE CREEK STREAM RESTORATION

DURHAM, NORTH CAROLINA

PROFILE: LONGMEADOW PARK REACH

SCALE: AS SHOWN
CONTRACT NO.
SHEET 13 OF 17

AS-BUILT

SEAL