UNDERWOOD MITIGATION SITE

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Baseline Monitoring Document and As-Built Baseline Report
FINAL
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APPENDICES

EXECUTIVE SUMMARY

The Underwood Mitigation Site consists of two separate areas (Harris Site and Lindley Site) located in western Chatham County within the Cape Fear River Basin (USGS Hydrologic Unit 03030002). The upstream area is located along Clyde Underwood Road just west of Planfield Church Road (Harris Site) and the downstream area is located southwest of Moon Lindley Road between Johnny Lindley Road and Bob Clark Road (Lindley Site) north of Siler City, North Carolina. The adjacent land to the stream and wetlands is mainly used for agricultural purposes. The project goals established were completed with careful consideration of goals and objectives that were described in the *Cape Fear River Basin Restoration Priorities* (CFRBRP) and to meet the North Carolina Ecosystem Enhancement Program's (NCEEP) mitigation needs while maximizing the ecological and water quality uplift within the watershed.

The following project specific goals established in the mitigation plan include:

- Restore and stabilize stream dimensions, pattern, and profile;
- Establish proper substrate distribution throughout restored and enhanced streams,
- Improve aquatic and benthic habitat;
- Reduce nutrient loads within the watershed and to downstream waters;
- Further improve water quality within the watershed through reductions of sediment, bacteria, and other pollutants;
- Decrease water temperature and increase dissolved oxygen concentrations
- Establish appropriate hydrology for wetland areas;
- Restore native vegetation to wetlands and riparian buffers/improve existing buffers; and
- Create appropriate terrestrial habitat.

These objectives were achieved through restoring and enhancing 9,155 linear feet (LF) of perennial and intermittent stream channel and restoring, enhancing, and creating 13.84 acres of riparian and non-riparian wetland. The stream and wetland areas were also planted with native vegetation to improve habitat and protect water quality.

Pre-Construction Site Conditions

The Underwood Mitigation Site is located in the Carolina Slate Belt of the Piedmont Physiographic Province (USGS, 1998). Approximately 60% of the land in the project watershed is forest, 39% is classified as managed herbaceous cover or agricultural, and the remaining 1% is split between unmanaged herbaceous and open water (MRLC, 2001). The drainage areas for the Harris Site and Lindley Site are 1,051 acres (1.64 square miles) and 3,362 acres (5.25 square miles) respectively.

Prior to construction activities, the streams and wetlands on the Harris Site were impacted by cattle grazing, which led to stream bank erosion and instability. The Lindley site was used for row crop agriculture and the streams were straightened and deepened and much of the riparian vegetation was removed. Related degradation includes declining aquatic habitat, loss

of forest, degraded riparian buffers, loss of wetlands, and water quality problems related to increased sediment and nutrient loadings. Tables 5a, 5b, and 5c in Appendix 2 present the pre-restoration conditions in detail.

Restoration Approach and Implementation

The mitigation project is intended to provide numerous ecological benefits within the Cape Fear River Basin. While many of these benefits are limited to the Underwood Site project area, others, such as pollutant removal and improved aquatic and terrestrial habitat, have more far-reaching effects. Expected improvements to water quality and ecological processes are outlined below in Section 1.2 as project goals and objectives.

The design streams and wetlands were restored to the appropriate type based on the surrounding landscape, climate, and natural vegetation communities but also with strong consideration to existing watershed conditions and trajectory. The designs were developed to correct incision and lack of pattern caused by channelization, bank instability caused by erosion and livestock access, lack of vegetation in riparian zones, lack of riparian and aquatic habitat, and depletion of hydrology for adjacent wetlands. The project includes stream restoration and enhancement as well as wetland restoration and creation. Based on a May 18th letter and subsequent conversation, the 0.42 acre portion of NRW1 that was previously a pond will be considered creation. However, the rest of NRW1 will be considered restoration. Figure 2 and Table 1 present the restoration, creation, and enhancement mitigation components for the Underwood Mitigation Site.

The final mitigation plan was submitted and accepted by the NCEEP in September of 2011. Construction activities were completed by Land Mechanics Designs, Inc. in November 2012. Planting and seeding activities were completed by Bruton Natural Systems, Inc. in January 2013. The baseline as-built survey was completed by Stewart-Proctor Engineering and Surveying, PLLC between December 2012 and February of 2013. There were no significant deviations reported in the project elements in comparison to the design plans. A few structures were either eliminated or adjusted slightly based on field conditions. Field adjustments made during construction are described in detail in section 5.1. Appendix 1 provides more detailed project activity, history, contact information, and watershed/site background information for this project.

Monitoring

Baseline monitoring (MY-0) was conducted between December 2012 and February of 2013. The first annual monitoring assessment (MY-1) will be completed in the fall of 2013. The streams and wetlands will be monitored for a total of five years, with the final monitoring activities conducted in 2017. The close-out for the Underwood Mitigation Site will be conducted in 2018 given the success criteria are met. As part of the closeout process, NCEEP will evaluate the site at the end of the fourth year monitoring period to determine whether or not the site is eligible to closeout following monitoring year five. If the site is meeting success criteria, NCEEP will propose to the interagency review team (IRT) to proceed with the closeout

process. If the site is not meeting success criteria, then NCEEP will close it out or amend the contract to cover an additional two years of monitoring.

Monitoring will consist of collecting morphological, vegetative, and hydrological data on an annual basis to assess the project success based on the restoration goals and objectives. The success of the project will be assessed using measurements of the stream channel's dimension, pattern, profile, substrate composition, permanent photographs, vegetation, surface water hydrology, and groundwater hydrology. Any areas with identified high priority problems, such as streambank instability, aggradation/degradation, insufficient groundwater hydroperiod, or lack of vegetation establishment will be evaluated on a case-by-case basis. The problem areas will be visually noted and remedial actions will be discussed with NCEEP staff to determine a plan of action. A remedial action plan will be submitted if maintenance is required.

1.0 Project Goals, Background and Attributes

1.1 Project Location and Setting

The Underwood Mitigation Site consists of two separate areas located in western Chatham County within the Cape Fear River Basin (USGS Hydrologic Unit 03030002) as shown in Figure 1. The upstream area is located along Clyde Underwood Road just west of Planfield Church Road (Harris Site) and the downstream area is located southwest of Moon Lindley Road between Johnny Lindley Road and Bob Clark Road (Lindley Site) north of Siler City, North Carolina. The adjacent land to the stream and wetlands is mainly used for agriculture purposes.

The Harris Site of the Underwood Mitigation Site is located within three tracts of land. The first is an 84 acre tract owned by Mary Jean Harris (Deed Book 05E, Page Number 0102). A conservation easement (Deed Book 1578, Page 495) was recorded on 7.68 acres of this tract. The second and third tracts include a 46.4 acre tract owned by William Darrel Harris (Deed Book 673, Page Number 532 and Deed Book 632, Page 796) and a 47.2-acre tract also owned by William Darrel Harris (Deed Book 972, Page Number 0977). A conservation easement (Deed Book 1578, Page 507) was recorded on 18.44 acres of these tracts. The Lindley Site of the project is located within two tracts of land. The first is a 150-acre tract owned by James Randall Lindley (Deed Book 06E, Page Number 0098). A conservation easement (Deed Book 1579, Page 1067) was recorded on the 5.34-acre project area within this tract. The second is an 82-acre tract owned by Jonathan Marshall Lindley (Deed Book 716, Page Number 0707). A conservation easement (Deed Book 716, Page 707) was recorded on the 6.29-acre project area within this tract.

The South Fork of Cane Creek (North Carolina Division of Water Quality (NCDWQ) AU No. 16-28-5) is the main stream of the project and has been classified as Class WS-V; NSW waters. Class WS-V waters are water supplies which are generally upstream and draining to Class WS-IV waters which include waters used by industry to supply their employees with drinking water or as waters formerly used as water supply. These waters are also protected for Class C uses. The Nutrient Sensitive Waters (NSW) classification is a supplemental classification for waters

needing additional nutrient management due to being subject to excessive growth of microscopic or macroscopic vegetation (NCDWQ, 2011).

A local watershed plan has not been developed at this time for the Cane Creek watershed, the 14-digit HUC in which the project is located. The goals for the Haw River watershed, which includes Cane Creek, discussed in the 2009 NCEEP planning document CFRBRP are focused on the Jordan Lake nutrient strategy which calls for reductions in nutrient loads to the lake. The lake was designated as nutrient sensitive waters (NSW) by the NC Environmental Management Commission (EMC) in 1983. The NCDWQ determined that the Haw River arm of the lake was failing to meet its designated uses in 2006 due to exceedences of chlorophyll-a (chl-a) and pH standards. The entire reservoir is now on North Carolina's list of impaired waters under Section 303(d) of the federal Clean Water Act. The specific goals for the watershed are continued restoration and preservation work, promotion of healthy riparian corridors, improvements to "aquatic conditions" and benthic habitats, and, because it is part of the Jordan Lake watershed, reductions in nitrogen and phosphorous loads to help meet established nutrient reductions for the lake. The 51 cattle, dairy, and poultry operations within the watershed are implied to be a major stressor to aquatic resources by the CFRBRP.

Directions and a map of the Underwood Mitigation Site are provided in Figure 1.

1.2 Project Goals and Objectives

The Underwood Mitigation Site was designed to meet the over-arching goals as described in the mitigation plan (2011). The project addresses multiple watershed stressors that have been documented for both Cane Creek and the Jordan Lake watersheds. The following project specific goals established in the mitigation plan include:

- Restore and stabilize stream dimensions, pattern, and profile;
- Establish proper substrate distribution throughout restored and enhanced streams,
- Improve aquatic and benthic habitat;
- Reduce nutrient loads within the watershed and to downstream waters;
- Further improve water quality within the watershed through reductions of sediment, bacteria, and other pollutants;
- Decrease water temperature and increase dissolved oxygen concentrations
- Establish appropriate hydrology for wetland areas;
- Restore native vegetation to wetlands and riparian buffers/improve existing buffers; and
- Create appropriate terrestrial habitat.

The design features of this project were developed to achieve multiple project objectives. The stream restoration elements were designed to frequently flood the reconnected floodplain and adjacent riparian wetlands. This design approach provides more frequent dissipation of energy from higher flows (bankfull and above) to improve channel stability; provide water quality treatment through detention, settling, and biological removal of pollutants; and restore a more natural hydrologic regime. Existing, restored, and created wetlands were key

components of the design incorporated to better meet goals described above. The project objectives defined in the mitigation plan (2011) are as follows:

- Construct stream channels that will remain relatively stable over time and adequately transport their sediment loads without significant erosion or aggradation;
- Construct stream channels that maintain riffles with coarse bed material and pools with finer bed material;
- Provide aquatic and benthic habitat diversity in the form of pools, riffles, woody debris, and in-stream structures;
- Add riffle features and structures and riparian vegetation to decrease water temperatures and increase dissolved oxygen to improve water quality;
- Construct stream reaches so that floodplains and wetlands are frequently flooded to provide energy dissipation, detain and treat flood flows, and create a more natural hydrologic regime;
- Construct fencing to keep livestock out of the streams;
- Raise local groundwater table through raising stream beds and removing agricultural drainage features;
- Grade wetland creation areas as necessary to promote wetland hydrology; and
- Plant native tree species to establish appropriate wetland and floodplain communities and retain existing, native trees were possible.

1.3 Project Structure, Restoration Type and Approach

1.3.1 Project Structure

Please refer to Figure 2 for the project component/asset map for the stream and wetland restoration feature exhibits and Table 1 for the project component and mitigation credit information for the Underwood Mitigation Site.

1.3.2 Restoration Type and Approach

The design streams and wetlands were restored to the appropriate type based on the surrounding landscape, climate, and natural vegetation communities but also with strong consideration to existing watershed conditions and trajectory. The designs were developed to correct incision and lack of pattern caused by channelization, bank instability caused by erosion and livestock access, lack of vegetation in riparian zones, lack of riparian and aquatic habitat, and depletion of hydrology for adjacent wetlands. The project includes stream restoration and enhancement as well as wetland restoration and creation.

Restoration of dimension, pattern, and profile was implemented for all or portions of SF1, SF3, SF4, SF4A, and UT1 as shown on Figures 2a – 2c. The project also includes stream enhancement on seven reaches classified as either Enhancement I (EI) or Enhancement II (EII). All stream restoration and EI reaches (all or portions of SF1, SF3, SF4, SF4A, and UT1) were constructed as C type streams according to the Rosgen classification system (Rosgen, 1996). The specific values for the design parameters were selected based on designer

experience and judgment and were verified with morphologic data form reference reach data sets. The design width to depth ratio for most of the reaches is approximately 12. The expectation is that the streams will narrow over time and classify as E stream types in some locations and, therefore, resemble the C/E morphology of the references. A design width to depth ratio of 14 was used for SF4 to raise the invert of the restored channel and improve adjacent wetland hydrology. The design channel slopes of the restoration and EI reaches range from 0.0034 to 0.0141. Each of the design reaches were reconnected with the existing floodplain (Priority 1). The restored channels were designed to have an entrenchment ratio of greater than 2. The sinuosity for the restored channels was designed to be near 1.2.

The proposed project also included restoration, enhancement, and creation within six distinct wetland zones; four riparian wetland zones (RW1, RW2, RW3, and RW4) and two non-riparian wetland zones (NRW1 and NRW2) as shown on Figures 2a – 2c. Within the riparian wetland zones, in-stream structures were used to raise the channel grade and any unstable banks were regraded, seeded, and matted. This approach was implemented to decrease the drainage effect on the surrounding historic wetlands and restore a natural flooding regime. Wetland areas were also disked to increase surface roughness and better capture rainfall to improve connection with the water table for groundwater recharge.

RW1 was restored by raising the bed elevation of UT2. RW2 was restored through a combination of grading in the creation zone and raising the bed elevations of SF1. RW3 was restored and created using a combination of grading in the creation zones and raising the bed elevation of SF3. RW4 was restored and created using a combination of grading in the creation zones, plugging and filling several floodplain ditches, and raising the bed elevation of SF4 and SF4A. NRW1 was restored and created by removing the dam creating the farm pond, which restored a natural hydrologic regime to the entire wetland area. NRW2 was enhanced by planting native vegetation. Based on the previously mentioned (Executive Summary page 2) May 18th letter and subsequent conversation, the 0.42 acre portion of NRW1 that was previously a pond will be considered creation. However, the rest of NRW1 will be considered restoration. All wetland areas were disked using agricultural disking equipment to increase surface roughness and better capture rainfall with the intention to improve connection with the water table for groundwater recharge.

1.4 Project History, Contacts and Attribute Data

The Underwood Mitigation Site was restored by Wildlands Engineering, Inc. (Wildlands) through a full-delivery contract with NCEEP. Tables 2, 3, and 4 in Appendix 1 provide detailed information regarding the Project Activity and Reporting History, Project Contacts, and Project Baseline Information and Attributes.

2.0 Success Criteria

The stream restoration success criteria for the Underwood Mitigation Site follow approved performance criteria presented in the NCEEP Mitigation Plan Template (version 1.0, 11/20/2009) and the Stream Mitigation Guidelines issued in April 2003 by the USACE and

NCDWQ. Annual monitoring and quarterly site visits will be conducted to assess the condition of the finished project for five years for the stream areas and wetland areas, or until success criteria are met. The stream restoration and EI reaches (SF1, SF3, SF4, SF4A, UT1, and UT2) of the project have been assigned specific performance criteria components for stream morphology, hydrology, and vegetation. The EII reaches (SF2, SF3, UT1, UT1A, and UT1B) will be documented through photographs and visual assessments to verify that no significant degradational changes are occurring in the stream channel or riparian corridor. The wetland restoration, enhancement, and creation sections will be assigned specific performance criteria for hydrology and vegetation. These success criteria are covered in detail in the following paragraphs.

2.1 Streams

2.1.1 Dimension

Riffle cross-sections on the restoration reaches should remain relatively stable; however, as sediment moves through the project reaches, fluctuations of the riffle bed elevation over time are expected. These fluctuations should be temporary and will likely correspond to storm events. Riffle cross-sectional ratios (width-to-depth ratio, depth ratio, and bank height ratio) should fall within the parameters defined for channels of the appropriate Rosgen stream type. If persistent changes are observed, these changes will be evaluated to assess whether the stream channel is showing signs of long term instability. Indicators of instability include a vertically incising or aggrading thalweg or eroding channel banks. Changes in the channel that indicate a movement toward stability or enhanced habitat include a decrease in the width-to-depth ratio in meandering channels or an increase in pool depth. Remedial action would not be taken if channel changes indicate a movement toward stability.

2.1.2 Pattern and Profile

Longitudinal profile data for the stream restoration reaches should show that the bedform features are remaining stable. The riffles should be steeper and shallower than the pools, while the pools should be deep with nearly flat water surface slopes. The relative percentage of riffles and pools should not change significantly from the design parameters. Adjustments in length and slope of run and glide features are expected and will not be considered a sign of instability. The longitudinal profile should show that the bank height ratio remains very near to 1.0 for the majority of the restoration reaches.

2.1.3 Substrate

Substrate materials in the restoration and EI reaches should indicate a progression towards or the maintenance of coarser materials in the riffle features and smaller particles in the pool features.

2.1.4 Photo Documentation

Photographs should illustrate the site's vegetation and morphological stability on an annual basis. Cross-section photos should demonstrate no excessive erosion or degradation of the banks. Longitudinal photos should indicate the absence of persistent

bars within the channel or vertical incision. Grade control structures should remain stable. Deposition of sediment on the bank side of vane arms is preferable. Maintenance of scour pools on the channel side of vane arms is expected. Reference photos will also be taken for each of the vegetation plots.

2.1.5 Bankfull Events

Two bankfull flow events in separate years must be documented on the project within the five-year monitoring period. Bankfull events will be documented using a crest gage, photographs, and visual assessments for physical evidence such as debris lines.

2.2 Vegetation

The final vegetative success criteria will be the survival of 260 planted stems per acre in the riparian corridor along restored and enhanced reaches and within the wetland restoration and creation areas at the end of the required monitoring year (MY-5). The interim measure of vegetative success for the site will be the survival of at least 320 planted stems per acre at the end of the third monitoring year. The extent of invasive species coverage will also be monitored and controlled as necessary throughout the required monitoring period (MY-5).

2.3 Wetlands

The final performance criteria for wetland hydrology will be a free groundwater surface within 12 inches of the ground surface for 7.5 percent of the growing season, which is measured on consecutive days under typical precipitation conditions. These success criteria were determined through model simulations of post-restoration conditions and comparison to an existing reference wetland system. If a particular well does not meet these criteria for a given monitoring year, rainfall patterns will be analyzed and the hydrograph will be compared to that of the reference well to assess whether atypical weather conditions occurred during the monitoring period.

2.4 Schedule and Reporting

Monitoring reports will be prepared in the fall of each year of monitoring and submitted to NCEEP. Based on the NCEEP Monitoring Report Template (version 1.2.1, 12/01/2009), the monitoring reports will include the following:

- Project background which includes project objectives, project structure, restoration type and approach, location and setting, history and background;
- As-built topographic plans of major project elements including such items as grade control structures, vegetation plots, permanent cross-sections, groundwater gages, and crest gages;
- Photographs showing views of the restored Stream Site taken from fixed point stations.
- Assessment of the stability of the Stream Site based on the cross-sections and longitudinal profile, where applicable;
- Assessment of the stability of the Wetland Site based on groundwater gages and vegetation plots;

- Vegetative data as described above including the identification of any invasion by undesirable plant species;
- A description of damage by animals or vandalism;
- Maintenance issues and recommended remediation measures will be detailed and documented; and
- Wildlife observations.

3.0 Monitoring Plan

Annual Monitoring will be conducted for the monitoring parameters as noted below for five years for stream and wetland assessments beyond completion of construction or until performance criteria have been met.

3.1 Stream

In order to ensure the streams on site meet regulatory stream success criteria, stream dimension, pattern, and profile will be monitored annually for five years for restoration and EI reaches (SF1, SF3, SF4, SF4A, UT1, and UT2). Geomorphic assessments should be performed following guidelines outlined in the Stream Channel Reference Sites: An Illustrated Guide to Field Techniques (Harrelson et al., 1994), methodologies utilized in the Rosgen stream assessment and classification document (Rosgen, 1994 and 1996), and in the Stream Restoration: A Natural Channel Design Handbook (Doll et al, 2003).

3.1.1 Dimension

In order to monitor the channel dimension, a total of two permanent cross-sections were installed along SF1, five on SF3, four on SF4, three on SF4A, two on UT1, and two on UT2. Cross-sections were located at representative riffle and pool sections on each monitored reach. Each cross-section was permanently marked with rebar pins to establish its location. Cross-section surveys will be performed annually and will include points measured at all breaks in slope including top of bank, bankfull, edge of water, and thalweg.

3.1.2 Pattern and Profile

During the as-built survey, six separate longitudinal profiles were conducted on project streams; 874 LF on SF1, 2,120 LF on SF3, 1,429 LF on SF4, 866 LF on SF4A, 515 LF on UT1, and 418 LF on UT2. The beginning and end of each longitudinal profile have been established such that they are able to be located either through field identification or with the use of a GPS unit. Each longitudinal profile survey following the initial as-built survey will include re-surveying the same profile. The location of bedform features, in-stream structures, water surface, bankfull, top of bank, and permanent benchmarks will be collected during each survey. Data will be processed in CAD and analyzed using RiverMorph and Microsoft Excel.

Stream pattern was assessed and ranges of pattern parameters were defined for SF1, SF3, SF4, SF4A, UT1, and UT2. Stream pattern assessment will not be conducted in subsequent monitoring years unless issues in the profile and dimension indicate that pattern might be changed.

3.1.3 Substrate

A reach-wide pebble count was conducted in each restoration and EI reaches (SF1, SF3, SF4, SF4A, UT1, and UT2) for classification purposes. A wetted perimeter pebble count was conducted at each permanent riffle cross-section to characterize the pavement. Subsequent sampling will be performed annually at the same locations for the duration of the monitoring.

3.1.4 Photo Reference Points

A total of 46 permanent photograph reference points were established within the project streams and wetland areas after construction. Photographs will be taken once a year to visually document stability for five years following construction. Permanent markers were established so that the same locations and view directions on the site are monitored each year. Photographs will be used to monitor stream restoration and enhancement reaches and and wetland creation, restoration, and enhancement areas as well as vegetation plots. The photographer will make every effort to maintain the same view in each photo over time. The representative digital photo(s) will be taken on the same day(s) the surveys are conducted.

3.1.5 Bankfull Events

Six crest gages were installed on the site; one on SF1, one on SF3, one on SF4, one on SF4A, one on UT1 and the other gage on UT2. The crest gages were installed onsite in a surveyed riffle cross-section of the restored channels at a central site location. The gages will be checked during each site visit to determine if a bankfull event has occurred since the last visit. Photographs will be used to document the occurrence of debris lines and sediment deposition as evidence of bankfull events.

3.1.6 Visual Assessment

Visual assessments will be conducted along all reaches each year to obtain qualitative geomorphic data. Each visual assessment evaluation after the baseline survey will include re-evaluation along the same profile.

3.2 Vegetation

Planted woody vegetation was monitored in accordance with the guidelines and procedures developed by the Carolina Vegetation Survey-NCEEP Level 2 Protocol (Lee et al., 2006) to monitor and assess the planted woody vegetation. A total of 42 vegetation plots were established within the project easement areas (29 at the Harris Site; 13 at the Lindley Site) using standard 10 meter by 10 meter vegetation monitoring plots.

Vegetation plots were randomly established within the planted corridor of the streams and wetland restoration areas to capture the heterogeneity of the designed vegetative communities. The vegetation plot corners have been marked and are recoverable either through field identification or with the use of a GPS unit. Reference photographs at the origin looking diagonally across the plot to the opposite corner were taken during the baseline monitoring. Subsequent assessments following baseline survey will capture the

same reference photograph locations. Species composition, density and survival rates will be evaluated on an annual basis by plot and for the entire site. Individual plot data will be provided and will include diameter, height, density, vigor, damage (if any), and percent survival. Planted woody stems will be marked annually as needed, based off of a known origin, so they can be found in succeeding monitoring years. Mortality will be determined from the difference between the baseline year's living planted stems and the current year's living planted stems.

3.3 Wetlands

Fifteen groundwater monitoring gages were established throughout the wetland restoration, creation, and enhancement zones. The gages were installed at appropriate locations so that the data collected will provide an indication of groundwater levels throughout the site. To provide data for the determination of the growing season for the wetland areas, two soil temperature loggers were installed in representative areas within RW3 and RW4. A barrotroll logger (to measure barometric pressure used in the calculations of groundwater levels with well transducer data) and a rain gage were also installed within the wetland areas on both the Harris and Lindley Site. All monitoring gages will be downloaded on a quarterly basis and will be maintained on an as needed basis. Refer to the as-built plans in Appendix 4 for the monitoring gage locations within the Underwood Mitigation Site.

4.0 Maintenance and Contingency Plans

Any identified high priority problem areas, such as streambank instability, aggradation/degradation, lack of vegetation establishment, or failure to meet groundwater hydrology success criteria will be evaluated on a case-by-case basis. The problem areas will be visually noted and remedial actions will be discussed with NCEEP staff to determine a plan of action. A remedial action plan will be submitted if maintenance is required.

4.1 Stream

Stream problem areas will be mapped and included in the Current Condition Plan View (CCPV) as part of the annual stream assessment. Stream problems areas may include bank erosion, structure failure, beaver dams, aggradation/degradation, etc. Appropriate remedial actions will be determined with NCEEP correspondence. A proposal of work will be submitted if remediation of an area is required.

4.2 Vegetation

Vegetative problem areas will be mapped and included in the CCPV as part of the annual vegetation assessment. Vegetation problems areas may include planted vegetation not meeting success criteria, persistent invasive species, barren areas with little to no herbaceous cover, or grass suffocation/crowding of planted stems. Appropriate remedial actions will be determined with NCEEP correspondence. A proposal of work will be submitted if remediation of an area is required.

4.3 Wetlands

Wetland problem areas will be mapped and included in the CCPV as part of the annual wetland assessment. Wetland problems areas may include planted vegetation not meeting success criteria, persistent invasive species, barren areas with little to no herbaceous cover, grass suffocation/crowding of planted stems, or wetland hydrology not meeting success criteria. Appropriate remedial actions will be determined with NCEEP correspondence. A proposal of work will be submitted if remediation of an area is required.

5.0 As-Built Condition (Baseline)

The Underwood Mitigation Site construction and as-built surveys were completed between December 2012 and February 2013. The survey included developing an as-built topographic surface on both the Stream and Wetland Sites. The survey also involved locating the channel boundaries, structures, cross-sections, and monitoring features such as photo points, vegetation plots, groundwater gages, and crest gages. For comparison purposes, the baseline monitoring divided the reach assessments in the same way they were established for design parameters: SF1, SF2, SF3, SF4, SF4A, UT1, and UT2.

5.1 As-Built/Record Drawings

A half size as-built plan is located in Appendix 4 with the post-construction locations and alignments for the project. A record drawing has also been provided to NCEEP as a separate document that indicates any significant field adjustments made during construction that were different from the design plans.

Minimal adjustments were made during construction, where needed, based on field evaluation. On SF1, there was a lack of wetland grasses on site that were planned to be used as sod. Therefore sod mats were not installed as designed along SF1. On certain locations along SF3 and SF4, pool depths were constructed shallower than designed due to existing bedrock found on site. Bedrock was also discovered within the banks along SF3. Sod mats were used as bank revetments in lieu of root wads and/or brush toe in these locations where shallow bedrock inhibited rootwad/brush toe installation along the streambanks. The original design along SF4A proposed using constructed riffles at the tail end of shallow tangent reaches. During construction, it was determined that additional grade control was needed. Therefore, constructed riffles were installed at the head and tail ends of each tangent reach to provide adequate grade control. On UT2, log sills were added at the downstream end of each constructed riffle to provide additional grade control to the bed which was raised in place. More specific changes include:

- On SF2 at station 301+50, a rock vane was installed instead of a log vane due to bedrock in the stream bed;
- On SF3 at station 420+00, a J-hook structure was originally designed, but was not built. A brush toe was constructed at that bend;
- At the downstream end of UT1A and UT1B, constructed riffles were not installed due to a lack of need for grade control in those locations;

- The drainage berm on the south side of SF1A was not installed. It determined to be unnecessary due to floodplain grading;
- Constructed riffle on SF3 at Station 420+80 was not installed due to the presence of coarse native bed material;
- Constructed riffle on UT1 at station 514+90 was not installed. Existing bedrock features were found to be providing adequate grade control; and
- Profiles, specifically on SF4 are slightly different than proposed profiles. During construction, the thalweg was over excavated to create a narrow, low flow zone for improved habitat during baseflow conditions.

The following sections further detail the as-built conditions in comparison to the design plans.

5.2 Baseline Data Assessment

5.2.1 Morphological State of the Channel

Morphological data for the as-built profile was collected in December 2012 and January of 2013. Please refer to Appendix 2 for summary data tables, morphological plots, and stream photographs.

Profile

The baseline (MY-0) profiles closely match the profile design parameters. The plotted longitudinal profile and related summary data can be found in Appendix 2.

On the design profiles, all riffles were depicted as straight lines with consistent slopes. However, at some locations (e.g. SF3 sta. 411+00 to 411+70) on the as-built survey riffle profiles are not consistent in slope due to rock and log riffle features installed during construction for habitat variability. The as-built profile reflects the installation of log and rock sills with micro-pools interspersed in the riffle. Some of the pools were not excavated as deeply as designed due to shallow bedrock preventing excavation to the design depth. In addition, the as-built survey includes only one maximum pool depth point rather than two deep pool points shown on the design profiles.

Dimension

The baseline (MY-0) dimension numbers are closely matched to the design parameters with the exception that UT2 was left wider than was originally planned during design. During construction of this E1 component stream, a decision was made to raise the bed as planned but to not fill in the channel to narrow it. Filling in the channel would have required placing fill around remaining mature trees on the top of one or both banks and adding fill to a live stream channel. The result was that the bed of the channel was raised so that the stream is connected to its floodplain, adjacent riparian wetlands are hydrated, mature trees remain along the tops of both banks but the channel is wider than designed and the cross sectional area is somewhat larger than designed. Summary data and cross-section plots of each project reach can be found in Appendix 2.

Pattern

The baseline (MY-0) pattern metrics fell within the design parameters for all six reaches. No design changes were made to any alignments during construction. Pattern data will be evaluated in monitoring year five if there are any indicators through the profile or dimensions that significant geomorphic adjustments have occurred.

Sediment Transport

As-built shear stresses and velocities are similar to design parameters and should reduce the risk of further erosion along all three restoration reaches. Prior to and following restoration, reaches SF1, UT2, and SF3, classified as gravel bed streams. Reaches UT1, SF4, and SF4A classified as sand bed channels prior to construction, but each had a significant gravel component to its substrate compositions as well. After construction these reaches also classified as gravel bed channels.

The as-built condition for each of these reaches indicates a significant increase in substrate particle size (Table 5a – 5c). The substrate data for each constructed reach were compared to the design shear stress parameters from the mitigation plan to assess the potential for bed degradation. The shear stress and calculated for the constructed channels are generally within the allowable range, which indicate that the channel is not at risk to trend toward channel degradation.

5.2.2 Vegetation

The baseline monitoring (MY-0) vegetative survey was completed in January of 2013. The baseline vegetation monitoring on the Site resulted in an average of 692 planted stems per acre, which is greater than the design density required. There was an average of 17 stems per plot. Please refer to Appendix 3 for vegetation summary tables, raw data tables, and vegetation plot photographs.

5.2.3 Photo Documentation

A total of 46 permanent photographs locations were installed and photographed by Wildlands. These photographs can be found in Appendix 2.

5.2.4 Hydrology

Bankfull events have been observed on UT1, SF2, SF3, SF4, and SF4A following completion of construction. The bankfull event occurred following the installation of crest gages, but was also evidenced by wrack lines. Crest gage data logs will be included in the Year one monitoring report.

6.0 References

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Harrelson, Cheryl C; Rawlins, C.L.; Potyondy, John P. 1994. *Stream Channel Reference Sites: An Illustrated Guide to Field Technique.* Gen. Tech. Rep. RM-245. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 61 p.

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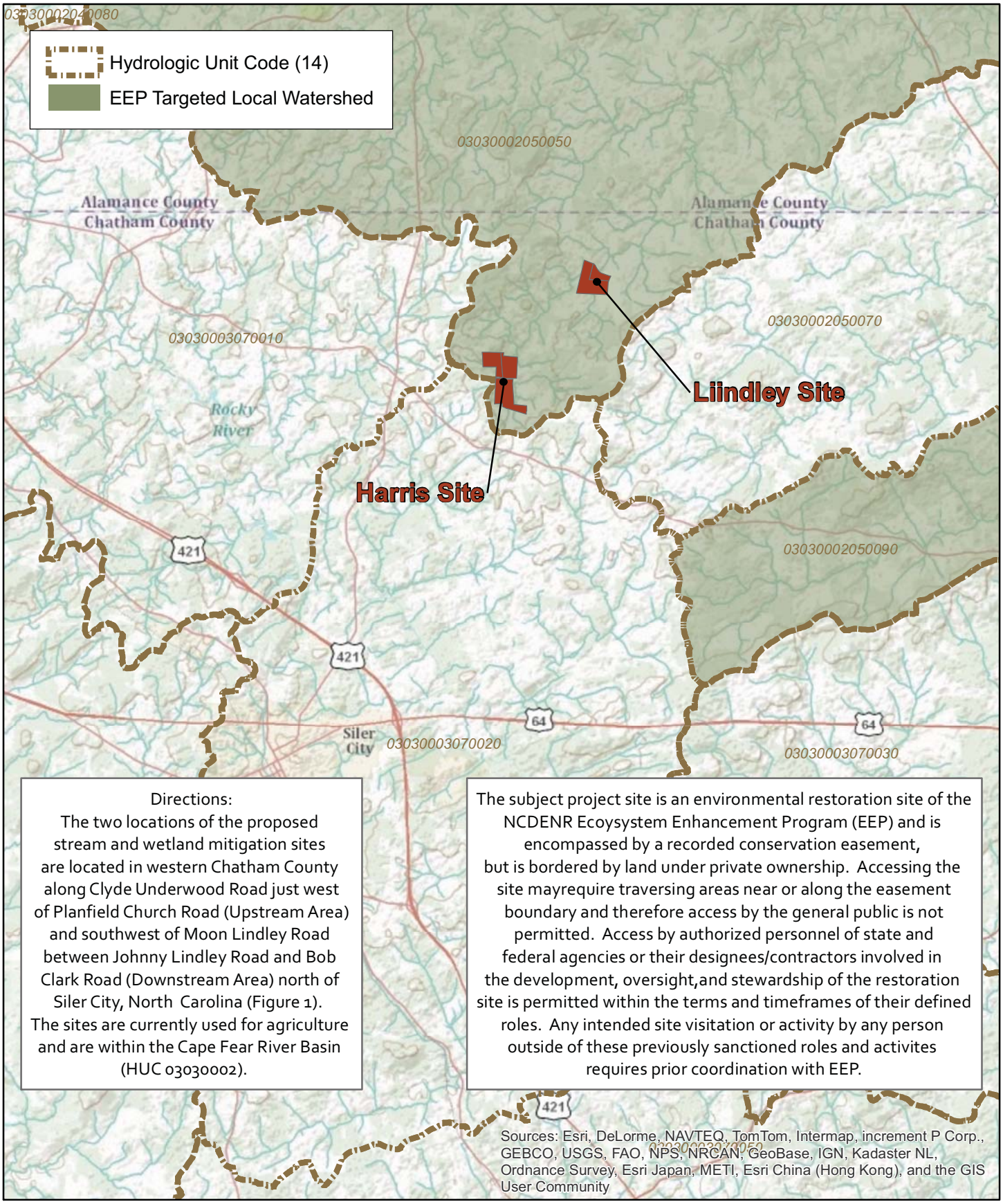
APPENDIX 1. General Tables and Figures



Directions:
The two locations of the proposed stream and wetland mitigation sites are located in western Chatham County along Clyde Underwood Road just west of Planfield Church Road (Upstream Area) and southwest of Moon Lindley Road between Johnny Lindley Road and Bob Clark Road (Downstream Area) north of Siler City, North Carolina (Figure 1). The sites are currently used for agriculture and are within the Cape Fear River Basin (HUC 03030002).

The subject project site is an environmental restoration site of the NCDENR Ecosystem Enhancement Program (EEP) and is encompassed by a recorded conservation easement, but is bordered by land under private ownership. Accessing the site mayrequire traversing areas near or along the easement boundary and therefore access by the general public is not permitted. Access by authorized personnel of state and federal agencies or their designees/contractors involved in the development, oversight,and stewardship of the restoration site is permitted within the terms and timeframes of their defined roles. Any intended site visitation or activity by any person outside of these previously sanctioned roles and activites requires prior coordination with EEP.

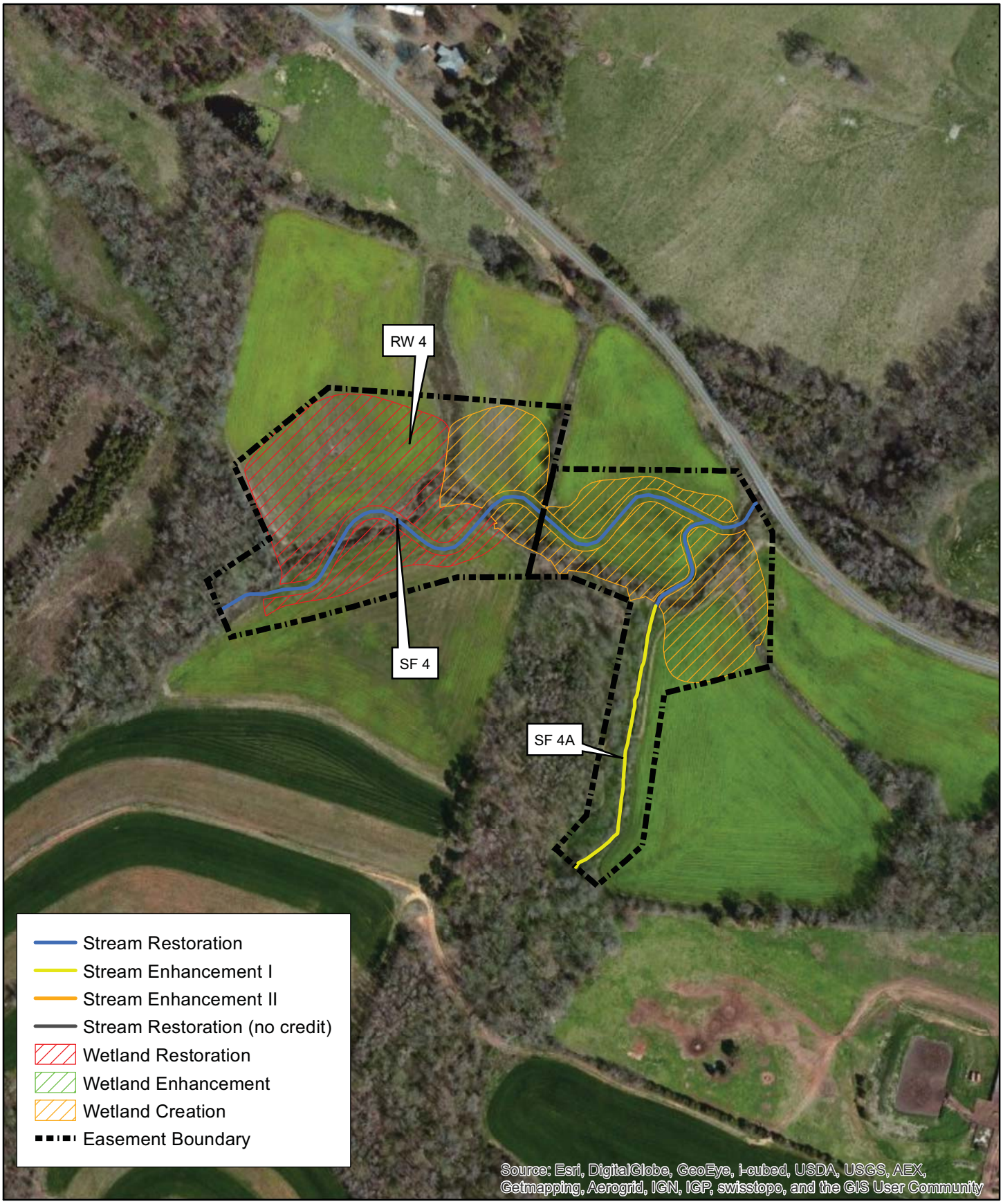
WILDLANDS ENGINEERING

0 0.625 1.25 Miles

N

Figure 1. Project Vicinity Map
Underwood Mitigation Site
NCEEP Project No. 94641
Monitoring Year 0

Chatham County, NC



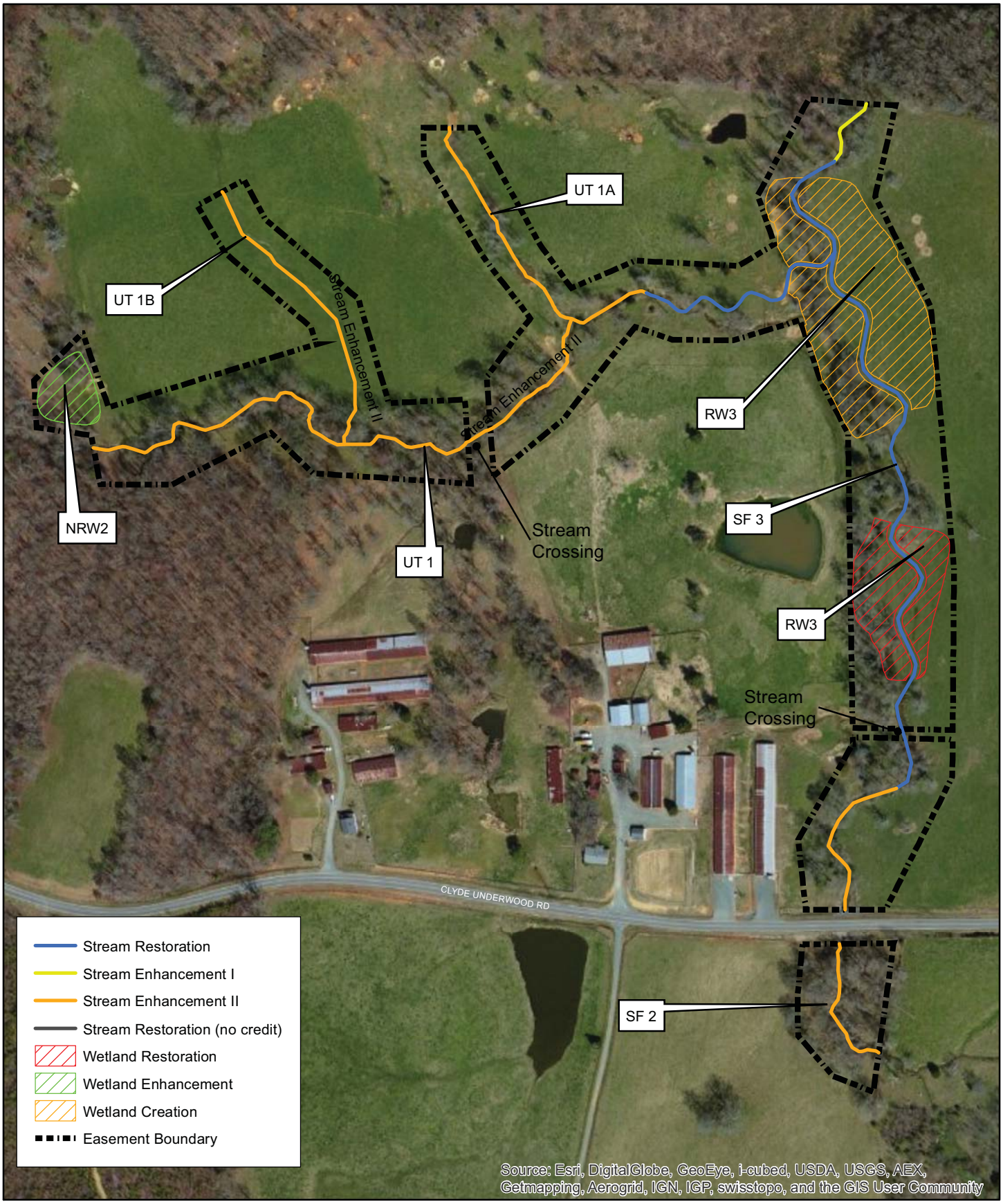
WILDLANDS ENGINEERING

0 175 350 Feet

N

Figure 2c. Project Component/Asset Map
Underwood Mitigation Site - Harris Site
NCEEP Project No. 94641
Monitoring Year 0

Chatham County, NC



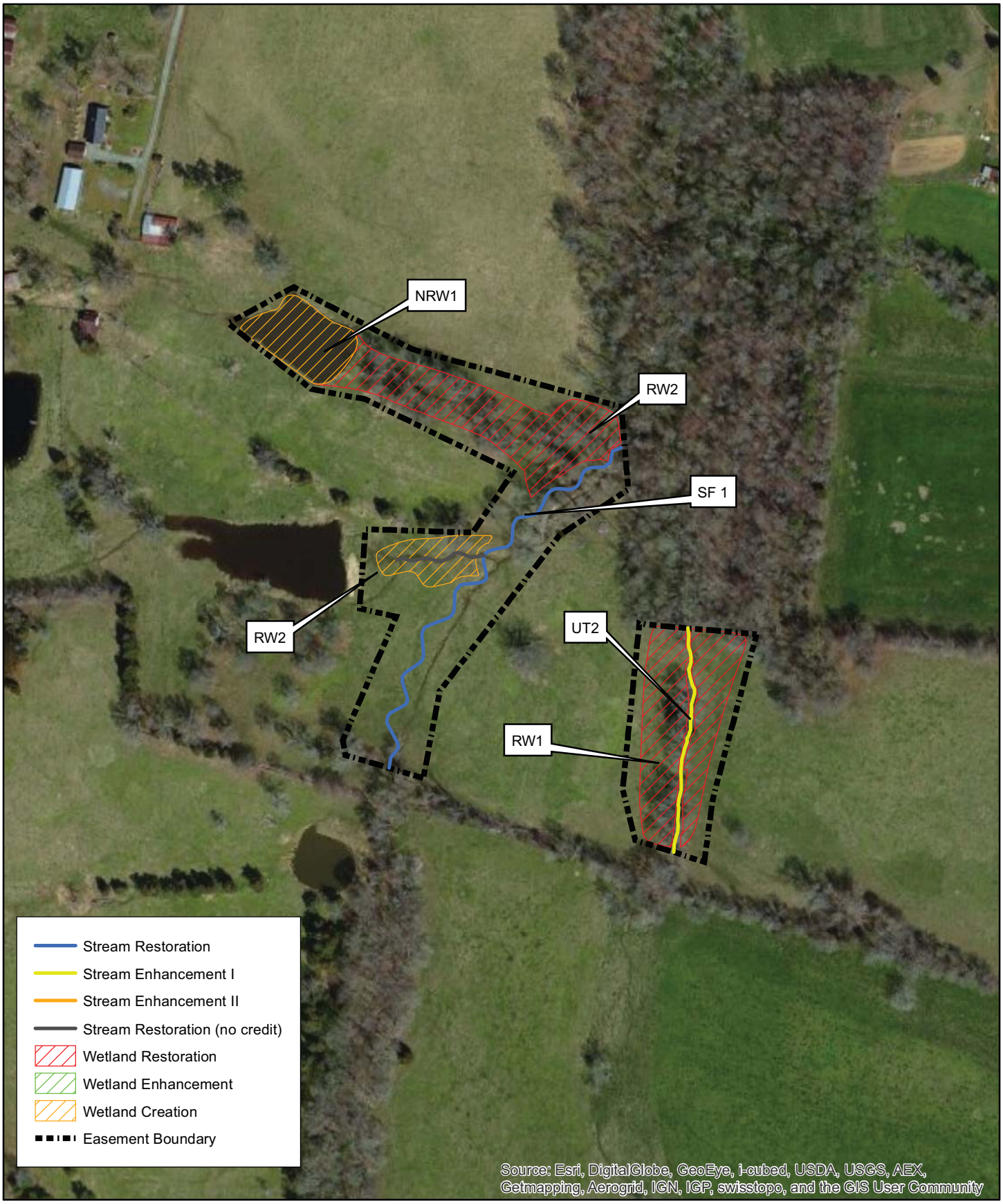
WILDLANDS ENGINEERING

0 175 350 Feet

N

Figure 2b. Project Component/Asset Map
Underwood Mitigation Site - Harris Site
NCEEP Project No. 94641
Monitoring Year 0

Chatham County, NC



WILDLANDS ENGINEERING

0 150 300 Feet

N

Figure 2a. Project Component/Asset Map
Underwood Mitigation Site - Harris Site
NCEEP Project No. 94641
Monitoring Year 0

Chatham County, NC

Appendix 1. General Tables and Figures
Table 1. Project Components and Mitigation Credits
Underwood Mitigation Site (NCEEP Project No.94641)
Monitoring Year 0

Mitigation Credits									
	Stream		Riparian Wetland		Non-Riparian Wetland		Buffer	Nitrogen Nutrient Offset	Phosphorous Nutrient Offset
Type	R	RE	R	RE	R	RE			
Totals	4,661	2104	9.2	N/A	1.1	0.2	N/A	N/A	N/A

Project Components						
Reach ID	As-Built Stationing/ Location (LF)	Existing Footage (LF) / Acreage (Ac)	Approach	Restoration or Restoration Equivalent	Restoration Footage (LF) / Acreage (Ac)*	Mitigation Ratio
Streams						
SF1	100+00-108+74	773	Priority 1	Restoration	874	1:1
SF2	300+00-303+02	302	N/A	Enhancement Level II	302	2.5:1
SF3	400+00-421+20	532	N/A	Enhancement Level II	359	2.5:1
		1,499	Priority 1	Restoration	1,586	1:1
		152	N/A	Enhancement Level I	153	1.5:1
SF4	800+00-	1,450	Priority 1	Restoration	1,429	1:1
SF4A	900+00-908+66	0	Priority 1	Restoration	257	1:1
		609	N/A	Enhancement Level I	609	1.5:1
UT1	500+00-520+38	1,463	N/A	Enhancement Level II	1,468	2.5:1
		452	Priority 1	Restoration	515	1:1
UT1A	700+00-705+11	524	N/A	Enhancement Level II	511	2.5:1
UT1B	600+00-606+52	660	N/A	Enhancement Level II	652	2.5:1
UT2	0+00-4+18	421	N/A	Enhancement Level I	418	1.5:1
Wetlands						
RW1	N/A	1.25	N/A	Restoration	1.25	1:1
RW2	N/A	0.45	N/A	Creation	0.45	3:1
		0.50		Restoration	0.50	1:1
RW3	N/A	2.63	N/A	Creation	2.63	3:1
		1.33		Restoration	1.33	1:1
RW4	N/A	3.95	N/A	Creation	3.95	3:1
		3.65		Restoration	3.65	1:1
NRW1	N/A	1.20	N/A	Restoration	0.75	1:1
				Creation	0.45	3:1
NRW2	N/A	0.34	N/A	Enhancement	0.34	2:1

Component Summation						
Restoration Level	Stream (linear feet)	Riparian Wetland (acres)		Non-Riparian Wetland (acres)	Buffer (square feet)	Upland (acres)
		Riverine	Non-Riverine			
Restoration	4,661	13.76	-	1.54	-	-
Enhancement			-	-	-	-
Enhancement I	1,180					
Enhancement II	3,292					
Creation			-	-		
Preservation	-	-	-	-		-
High Quality Preservation	-	-	-	-		-

BMP Elements									
Elements		Location		Purpose/Function		Notes			
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-

BR = Bioretention Cell; S F= Sand Filter; SW = Stormwater Wetland; WDP = Wet Detention Pond; DDP = Dry Detention Pond; FS = Filter Strip; S = Grassed Swale; LS = Level Spreader; NI = Natural Infiltration Area; FB = Forested Buffer

* Note that lengths do not match stationing because channel sections that do not generate credit have been removed from length calculations.

Appendix 1. General Tables and Figures
Table 2. Project Activity and Reporting History
Underwood Mitigation Site (NCEEP Project No.94641)
Monitoring Year 0

Activity or Report	Date Collection Complete	Completion or Scheduled Delivery
Mitigation Plan	September 2011	September 2011
Final Design - Construction Plans	July 2012	July 2012
Construction	November 2012	November 2012
Temporary S&E mix applied to entire project area[1]	November 2012	November 2012
Permanent seed mix applied to reach/segments	November 2012	November 2012
Bare root and live stake plantings for reach/segments	January 2013	January 2013
Baseline Monitoring Document (Year 0 Monitoring - baseline)	March 2013	March 2013
Year 1 Monitoring	2013	December 2013
Year 2 Monitoring	2014	December 2014
Year 3 Monitoring	2015	December 2015
Year 4 Monitoring	2016	December 2016
Year 5 Monitoring	2017	December 2017

[1]Seed and mulch is added as each section of construction is completed.

Appendix 1. General Tables and Figures
Table 3. Project Contact Table
Underwood Mitigation Site (NCEEP Project No.94641)
Monitoring Year 0

Designer	**Wildlands Engineering, Inc.**
Nicole Makaluso, PE	5605 Chapel Hill Road, Suite 122 Raleigh, NC 27604 919.851.9986
Construction Contractor	**Land Mechanic Designs, Inc.** 126 Circle G Lane Willow Spring, NC 27592
Planting Contractor	**Bruton Natural Systems, Inc** P.O. Box 1197 Fremont, NC 27830
Seeding Contractor	**Land Mechanic Designs, Inc.** 126 Circle G Lane Willow Spring, NC 27592
Seed Mix Sources	**Green Resource, LLC**
Nursery Stock Suppliers	
Bare Roots	**ArborGlen, Inc**
Live Stakes	**Foggy Mountain Nursery**
Monitoring Performers	**Wildlands Engineering, Inc.**
Stream, Vegetation, and Wetland Monitoring, POC	Kirsten Gimbert 704.332.7754, ext. 110

Appendix 1. General Tables and Figures
Table 4. Project Baseline Information and Attributes
Underwood Mitigation Site (NCEEP Project No.94641)
Monitoring Year 0

Project Information									
Project Name	Underwood Mitigation Site								
County	Chatham County								
Project Area (acres)	38 ac								
Project Coordinates (latitude and longitude)	35° 48' 05"N, 79° 24' 10"W (Harris Site), 35° 49' 51"N, 79° 22' 60"W (Lindley Site)								
Project Watershed Summary Information									
Physiographic Province	Carolina Slate Belt of the Piedmont Physiographic Province								
River Basin	Cape Fear								
USGS Hydrologic Unit 8-digit	03030002								
USGS Hydrologic Unit 14-digit	03030002050050								
DWQ Sub-basin	03-06-04								
Project Drainiage Area (acres)	1,504 ac (Harris Site) and 3,362 ac (Lindley Site)								
Project Drainage Area Percentage of Impervious Area	<1%								
CGIA Land Use Classification	60% Forest Land, 39% managed herbaceous cover/agricultural, 1% unmanaged herbaceous/open water								
Reach Summary Information									
Parameters	**SF1**	**SF2**	**SF3**	**UT1**	**UT1A**	**UT1B**	**UT2**	**SF4**	**SF4A**
Length of reach (linear feet) - Post-Restoration	874	302	2,098	1,983	511	652	418	1,429	866
Drainage area (acres)	134	781	1,056	230	11	11	78	3362	637
NCDWQ stream identification score	36/50.5/43.25			40	22.75	24.25	38	U	34.5
NCDWQ Water Quality Classification	WS-V, NSW	WS-V, NSW	WS-V, NSW	C	C	C	C	WS-V, NSW	C
Morphological Desription (stream type)	P	P	P	P	I	I	P	P	P
Evolutionary trend (Simon's Model) - Pre- Restoration	IV	IV	IV	IV	IV	IV	IV	IV	IV
Underlying mapped soils	Nanford-Baden Complex	Nanford-Baden Complex	Nanford-Baden Complex	Nanford-Baden Complex	Nanford-Baden Complex	Nanford-Baden Complex	Georgeville Silt Loam	Chewacla and Wehadkee	Chewacla and Wehadkee
Drainage class	---	---	---	---	---	---	---	---	---
Soil Hydric status	---	---	---	---	---	---	---	---	---
Slope	---	---	---	---	---	---	---	---	---
FEMA classification	---	---	---	---	---	---	---	AE	---
Native vegetation community	Piedmont bottomland forest								
Percent composition of exotic invasive vegetation - Post-Restoration	0%								
Regulatory Considerations									
Regulation	**Applicable?**	**Resolved?**	**Supporting Documentation**						
Waters of the United States - Section 404	X	X							
Waters of the United States - Section 401	X	X	USACE Nationwide Permit No.27 and DWQ 401 Water Quality Certification No. 3689						
Division of Land Quality (Dam Safety)	N/A	N/A	N/A						
Endangered Species Act	X	X	Underwood Mitigation Plan; no critical habitat for listed species exists within the project area (USFWS correspondence letter)						
Historic Preservation Act	X	X	No historic resources were found to be impacted (letter from SHPO)						
Coastal Zone Management Act (CZMA)/Coastal Area Management Act (CAMA)	N/A	N/A	N/A						
FEMA Floodplain Compliance	X	X	Approved CLOMR						
Essential Fisheries Habitat	N/A	N/A	N/A						

U: Unknown

APPENDIX 2. Morphological Summary and Data Plots

Appendix 2. Morphological Summary Data and Plots
Table 5a. Baseline Stream Data Summary
Underwood Mitigation Site (NCEEP Project No. 94641)
Harris Site
Monitoring Year 0

Parameter	Gage	Pre-Restoration Condition				Reference Reach Data				Design				As-Built/Baseline			
		SF1		UT2		Long Branch		UT to Cane Creek		SF1		UT2		SF1		UT2	
		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Dimension and Substrate - Riffle																	
Bankfull Width (ft)	n/a	7.6		7.0		14.8	18.6	8.2	11.8	8.8		7.1		8.4		16.6	
Floodprone Width (ft)		51.9		133.2		50+		40+		50+		200+		50+		200+	
Bankfull Mean Depth		1.2		1.4		1.3	2.1	0.9	1.0	0.7		0.6		0.7		0.8	
Bankfull Max Depth		2.2		1.8		1.9	2.9	1.5	1.7	1.0		0.7		1.0		1.1	
Bankfull Cross-sectional Area (ft^2)		9.5		9.6		25.0	34.6	8.5	10.7	6.5		4.2		5.6		13.6	
Width/Depth Ratio		6.2		5.2		7.9	13.8	7.9	13.1	12.0		12.0		12.8		20.4	
Entrenchment Ratio		6.8		18.9		3.4+		4.59+		2.2+		2.2+		2.2+		2.2+	
Bank Height Ratio		1.6		1.5		1.2	1.5	1.0	1.0	1.0		1.0		1.0		1.0	
D50 (mm)		4.7		6.1										23.3		34.3	
Profile																	
Riffle Length (ft)	n/a					---		---		---		---		11	36	7	25
Riffle Slope (ft/ft)[4]		0.011	0.0100	---		0.0130	0.0120	0.012		0.0143	0.0255	0.0197	0.0353	0.0053	0.0283	0.0040	0.1512
Pool Length (ft)						---		---		---		---		16	34	16	51
Pool Max Depth (ft)		---		---		---		---		---		---		1.67		2.69	
Pool Spacing (ft)^		---		---		---		---		35	62	29	50	37	61	23	59
Pool Volume (ft^3)																	
Pattern																	
Channel Beltwidth (ft)	n/a	N/A		N/A		60		50	77	26	44	N/A		26	44	N/A	
Radius of Curvature (ft)		N/A		N/A		16	87	11.3	27.1	15	25	N/A		15	25	N/A	
Rc:Bankfull Width (ft/ft)		---		---		1.1	4.7	1	2.5	2	3	N/A		2	3	N/A	
Meander Length (ft)		N/A		N/A		66	191	29	96	62	106	N/A		62	106	N/A	
Meander Width Ratio		---		---		3.2	4.1	50	77	3	5	N/A		3	5	N/A	
Substrate, Bed and Transport Parameters																	
Ri%/Ru%/P%/G%/S%	n/a																
SC%/Sa%/G%/C%/B%/Be%																	
d16/d35/d50/d84/d95/d100		N/A/0.9/4.7/20.9/87/362		N/A/N/A/6.1/62/128/256		---		---						SC/SC/SC/46.6/100/256		SC/SC/SC/58.6/111.2/180	
Reach Shear Stress (Competency) lb/ft^{2}[1]		---		---						0.42		---		0.37		N/A	
Max part size (mm) mobilized at bankfull																	
Stream Power (Capacity) W/m^2																	
Additional Reach Parameters																	
Drainage Area (SM)	n/a	0.21		0.12		1.49		0.28		0.21		0.12		0.21		0.12	
Watershed Impervious Cover Estimate (%)		<1%		<1%		---		---		<1%		<1%		<1%		<1%	
Rosgen Classification		E4		E4		C/E4		C/E4		C4		C4		C5		C5	
Bankfull Velocity (fps)		3.1		2.04						3.1		3.1		3.6		1.0	
Bankfull Discharge (cfs)		20		13.1		101	124	20.6	53.2	20		13.1		20		13.1	
Q-NFF regression		45.2		30.96													
Q-USGS extrapolation		---		---													
Q-Mannings		---		---													
Valley Length (ft)		---		---		---		---		---		---					
Channel Thalweg Length (ft)		773		421		---		---		878		421		874		418	
Sinuosity (ft)		1.1		1.0		1.30		1.20		1.2		1.0		1.2		1.0	
Water Surface Slope (ft/ft)[2]		0.011		0.015		0.004		0.005		0.0102		0.0141		0.0104		0.0143	
Bankfull Slope (ft/ft)		---		---		0.006		---		---		---		0.0104		0.0145	

(---): Data was not provided
N/A: Not Applicable

[1]Design Parameters based on revised Shields Diagram.

[2]Channel was dry at time of baseline survey. Slopes were calculated using the channel thalweg.

[3]As-Built pattern measuremeants fell within the design ranges, therefore the design parameters set are still applicable.

Appendix 2. Morphological Summary Data and Plots
Table 5b. Baseline Stream Data Summary
Underwood Mitigation Site (NCEEP Project No. 94641)
Harris Site
Monitoring Year 0

Parameter	Gage	Pre-Restoration Condition				Reference Reach Data				Design						As-Built/Baseline			
		SF3		UT1		Long Branch		UT to Cane Creek		SF3-u/s of UT1		SF3-d/s of UT1		UT1		SF3		UT1	
		Min	Max	Min	Max	Min	Max	Min	Max			Min	Max	Min	Max	Min	Max	Min	Max
Dimension and Substrate - Riffle																			
Bankfull Width (ft)	n/a	15.9		9.0		14.8	18.6	8.2	11.8	18.2		18.0		10.7		15.9	19.7	12.6	
Floodprone Width (ft)		48.6		14.2		50+		40+		50+		200+		>100		50+	200+	100+	
Bankfull Mean Depth		1.8		0.8		1.3	2.1	0.9	1.0	1.5		1.5		0.9		1.2	1.6	0.8	
Bankfull Max Depth		2.4		1.5		1.9	2.9	1.5	1.7	2.1		2.1		1.3		1.8	2.3	1.5	
Bankfull Cross-sectional Area (ft^2)		28.9		7.2		25.0	34.6	8.5	10.7	27.5		27.1		9.6		19.0	30.5	10.5	
Width/Depth Ratio		8.8		11.1		7.9	13.8	7.9	13.1	12.0		12.0		12.0		12.7	13.5	15.1	
Entrenchment Ratio		3.1		1.6		3.4+		4.59+		2.2+		2.2+		>2.2		2.2+	2.2+	2.2+	
Bank Height Ratio		1.6		1.9		1.2	1.5	1.0	1.0	1.0		1.0		1.0		1.0	1.0	1.0	
D50 (mm)		4.7		1.0												19.8	35.4	21.1	
Profile																			
Riffle Length (ft)	n/a					---		---		---		---		---		12	103	11	39
Riffle Slope (ft/ft)		0.030	0.0500			0.0130	0.0120	0.012		0.005	0.009	0.0078	0.0140	0.0118	0.0210	0.0003	0.0169	0.0023	0.0185
Pool Length (ft)						---		---		---		---		---		23	100	20	80
Pool Max Depth (ft)		---		---		---		---		---		---		---		1.8	2.3	2.6	
Pool Spacing (ft)^		---		---		---		---		---		---		---		53	166	58	76
Pool Volume (ft^3)																			
Pattern																			
Channel Beltwidth (ft)	n/a	51	106	31	59	60		50	77	54	91	54	90	32	54	54	91	32	54
Radius of Curvature (ft)		27	105	10	83	16	87	11.3	27.1	31	51	31	50	21	30	31	51	21	30
Rc:Bankfull Width (ft/ft)		7	16	1	9	1	5	1	3	2	3	2	3	2	3	2	3	2	3
Meander Length (ft)		46	272	80	161	66	191	29	96	127	218	126	216	75	129	126	218	75	129
Meander Width Ratio		26	70	3	7	3	4	50	77	3	5	3	5	3	5	3	5	3	5
Substrate, Bed and Transport Parameters																			
Ri%/Ru%/P%/G%/S%	n/a																		
SC%/Sa%/G%/C%/B%/Be%																			
d16/d35/d50/d84/d95/d100		7.53/16.66/40.82/74.02/97.42/180		N/A/N/A/1/16/107.3/256		---		---								0.08/0.21/11/67.2/256/>2048		0.07/0.16/0.3/26.9/71.7/256	
Reach Shear Stress (Competency) lb/ft^2 [1]		---		---						0.35		0.52		0.37		0.27		0.34	
Max part size (mm) mobilized at bankfull																			
Stream Power (Capacity) W/m^2																			
Additional Reach Parameters																			
Drainage Area (SM)	n/a	1.27		0.36		1.49		0.28		1.27				0.36		1.27		0.36	
Watershed Impervious Cover Estimate (%)		<1%		<1%		---		---		<1%		<1%		<1%		<1%		<1%	
Rosgen Classification		E4		E/G5		C/E4		C/E4		C4		C4		C5		C4		C5	
Bankfull Velocity (fps)		3.7		5.87						3.0		3.4		3.2		4.3	3.3	2.9	
Bankfull Discharge (cfs)		81.5		30.3		101	124	20.6	53.2	81.5		99.8		30.3		81.5	99.8	30.3	
Q-NFF regression		159.7		65.7															
Q-USGS extrapolation		---		---															
Q-Mannings		---		---															
Valley Length (ft)		---		---		---		---		---		---		---					
Channel Thalweg Length (ft)		2183		1915		---		---		2116				1997		2120		2038	
Sinuosity (ft)		1.2		1.2		1.3		1.2		1.2		1.2		1.2		1.2		1.2	
Water Surface Slope (ft/ft) [2]		0.004		0.01		0.004		0.005		0.0036		0.0056		0.0084		0.0041		0.0075	
Bankfull Slope (ft/ft)		---		---		0.006		---		---		---		---		0.0047		0.0083	

(---): Data was not provided
N/A: Not Applicable
[1]Design Parameters based on revised Shields Diagram.
[2]Channel was dry at time of baseline survey. Slopes were calculated using the channel thalweg.
[3]As-Built pattern measuremeants fell within the design ranges, therefore the design parameters set are still applicable.

Appendix 2. Morphological Summary Data and Plots
Table 5c. Baseline Stream Data Summary
Underwood Mitigation Site (NCEEP Project No. 94641)
Lindley Site
Monitoring Year 0

Parameter	Gage	Pre-Restoration Condition				Reference Reach Data				Design				As-Built/Baseline			
		SF4		SFA		Long Branch		UT to Cane Creek		SF4		SFA		SF4		SFA	
		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Dimension and Substrate - Riffle																	
Bankfull Width (ft)	n/a	18.6		10.3		14.8	18.6	8.2	11.8	14.0		12.0		27.3	27.6	13.9	23.7
Floodprone Width (ft)		157.3		29.4		50+		40+		50+		200+		200+	200+	200+	200+
Bankfull Mean Depth		2.7		1.6		1.3	2.1	0.9	1.0	1.9		1.2		1.8	1.9	0.9	1.3
Bankfull Max Depth		4.0		2.2		1.9	2.9	1.5	1.7	2.3		1.7		3.0	3.2	2.1	2.3
Bankfull Cross-sectional Area (ft^2)		49.7		16.9		25.0	34.6	8.5	10.7	53.0		18.0		49.5	51.2	17.5	20.4
Width/Depth Ratio		6.9		6.3		7.9	13.8	7.9	13.1	14.0		12.0		14.9	15.1	11.0	27.5
Entrenchment Ratio		3.5		2.9		3.4+		4.59+		2.2+		2.2+		2.2+	2.2+	2.2+	2.2+
Bank Height Ratio		1.4		1.8		1.2	1.5	1.0	1.0	1.0		1.0		1.0	1.0	1.0	1.0
D50 (mm)		0.3		0.8										29.1	35.6	12.7	9.4
Profile																	
Riffle Length (ft)	n/a					---		---		---		---		51	112	41	79
Riffle Slope (ft/ft)		---		---		0.0130	0.0120	0.012		0.0048	0.0085	0.0108	0.0193	0.0010	0.0098	0.0001	0.0210
Pool Length (ft)						---		---		---		---		54	123	28	79
Pool Max Depth (ft)		---		---		---		---		---		---		3.0	3.2	2.1	2.3
Pool Spacing (ft)^		---		---		---		---		---		---		146	210	71	110
Pool Volume (ft^3)																	
Pattern[3]																	
Channel Beltwidth (ft)	n/a	N/A		N/A		60		50	77	82	136	44	74	82	136	44	74
Radius of Curvature (ft)		N/A		N/A		16	87	11	27	46	76	25	41	46	76	25	41
Rc:Bankfull Width (ft/ft)		---		---		1	5	1	3	1.7	2.8	1.7	2.8	2	3	2	3
Meander Length (ft)		N/A		N/A		66	191	29	96	191	327	103	177	191	327	103	177
Meander Width Ratio		---		---		3	4	6	7	3	5	3	5	3	5	3	5
Substrate, Bed and Transport Parameters																	
Ri%/Ru%/P%/G%/S%	n/a																
SC%/Sa%/G%/C%/B%/Be%																	
d16/d35/d50/d84/d95/d100		N/A/N/A/0.3/17.9/45.8/90		N/A/0.1/0.8/204./62.9/362		---		---						0.13/0.36/5.3/102.5/320.7/>2048		SC/0.12/1.4/44/71.3/362	
Reach Shear Stress (Competency) $lb/ft^{2,1}$		---		---						0.32	0.63	---		0.33	0.34	0.49	0.34
Max part size (mm) mobilized at bankfull																	
Stream Power (Capacity) W/m^2																	
Additional Reach Parameters																	
Drainage Area (SM)	n/a	5.26		1.00		1.49		0.28		5.26		1.00		5.26		1.00	
Watershed Impervious Cover Estimate (%)		<1%		<1%		---		---		<1%		<1%		<1%		<1%	
Rosgen Classification		E5		E5		C/E4		C/E4		C5		C5		C4		C5	
Bankfull Velocity (fps)		5.9		5.26						3.9		3.7		4.1	4.0	3.9	3.3
Bankfull Discharge (cfs)		247.4		67.3		101	124	20.6	53.2	204		67.3		204		67.3	
Q-NFF regression		432.92		134.59													
Q-USGS extrapolation		---		---													
Q-Mannings		---		---													
Valley Length (ft)		---		---		---		---		---		---					
Channel Thalweg Length (ft)		1450.0		609.0		---		---		1,424		868		1429		866	
Sinuosity (ft)		1.3		1.1		1.3		1.2		1.2		1.0		1.2		1.1	
Water Surface Slope ($ft/ft)^2$		0.003		0.008		0.004		0.005		0.0034		0.0077		0.0033		0.0070	
Bankfull Slope (ft/ft)		---		---		0.006		---		0.0034		0.0077		0.0034		0.0067	

(---): Data was not provided
N/A: Not Applicable

[1]Design Parameters based on revised Shields Diagram.

[2]Channel was dry at time of baseline survey. Slopes were calculated using the channel thalweg.

[3]As-Built pattern measuremeants fell within the design ranges, therefore the design parameters set are still applicable.

Appendix 2. Morphological Summary Data and Plots
Table 6. Morphology and Hydraulic Summary (Dimensional Parameters - Cross-Section)
Underwood Mitigation Site (NCEEP Project No. 94641)
Harris and Lindley Site
Monitoring Year 0

	SF1												UT2											
	Cross-Section 1 (Riffle)						Cross-Section 2 (Pool)						Cross-Section 3 (Pool)						Cross-Section 4 (Riffle)					
Dimension and Substrate	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**
based on fixed bankfull elevation																								
Bankfull Width (ft)	8.4						11.7						15.0						16.6					
Floodprone Width (ft)	50+						N/A						N/A						200+					
Bankfull Mean Depth (ft)	0.7						0.9						1.6						0.8					
Bankfull Max Depth (ft)	1.0						1.7						2.7						1.1					
Bankfull Cross-Sectional Area (ft^2)	5.6						12.8						24.2						13.6					
Bankfull Width/Depth Ratio	12.8						12.8						9.3						20.4					
Bankfull Entrenchment Ratio	2.2+						N/A						N/A						2.2+					
Bankfull Bank Height Ratio	1.0						1.2						1.0						1.0					

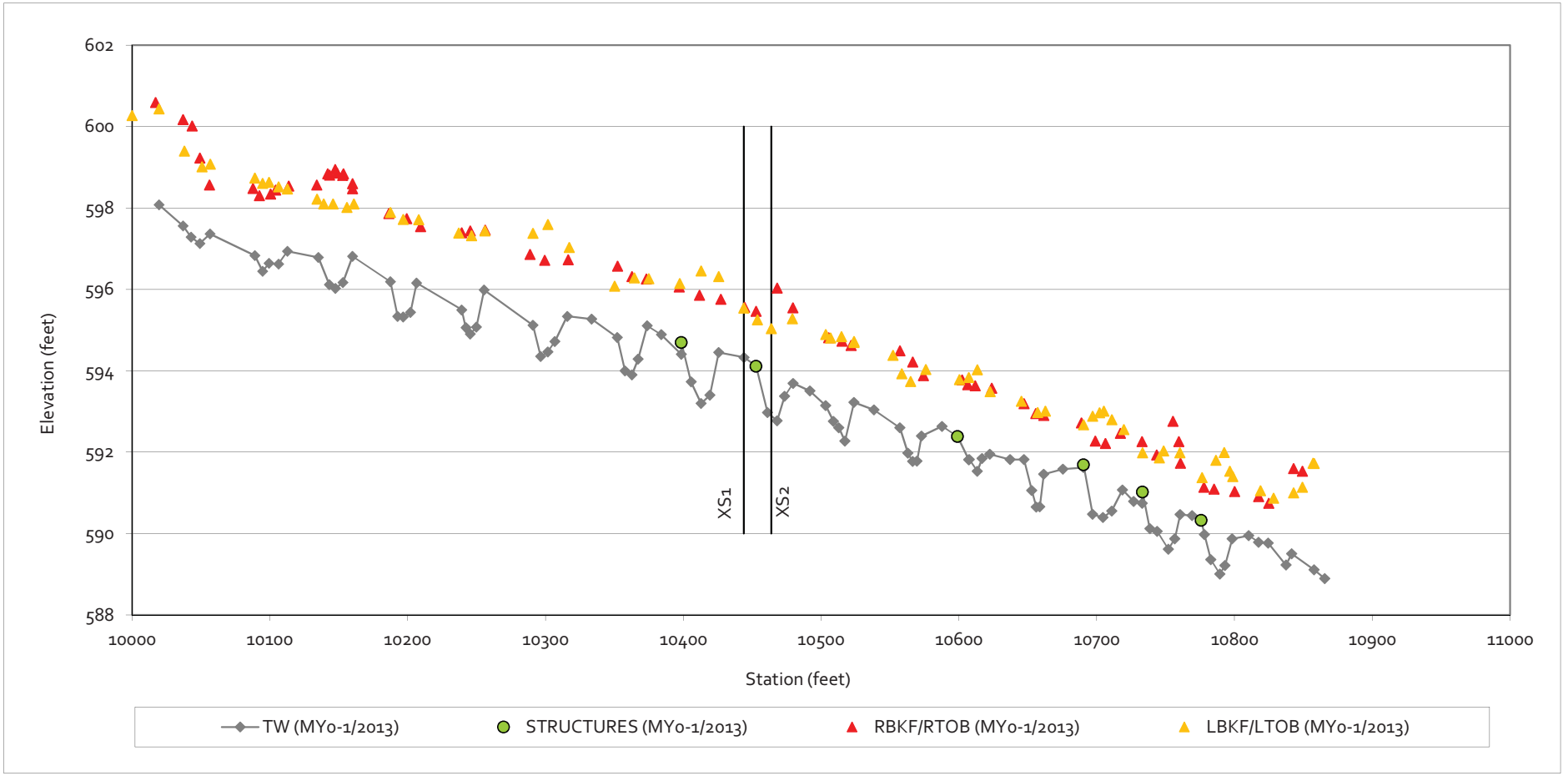
	SF3																							
	Cross-Section 5 (Riffle)						Cross-Section 6 (Pool)						Cross-Section 7 (Riffle)						Cross-Section 8 (Pool)					
based on fixed bankfull elevation	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**
Bankfull Width (ft)	19.7						19.7						16.7						19.7					
Floodprone Width (ft)	200+						N/A						200+						N/A					
Bankfull Mean Depth (ft)	1.6						1.6						1.2						1.4					
Bankfull Max Depth (ft)	2.3						2.3						2.2						3.0					
Bankfull Cross-Sectional Area (ft^2)	30.5						30.5						20.6						28.0					
Bankfull Width/Depth Ratio	12.7						12.7						13.5						13.9					
Bankfull Entrenchment Ratio	2.2+						N/A						2.2+						N/A					
Bankfull Bank Height Ratio	1.0						1.0						1.0						1.0					

	SF3						UT1												SF4					
	Cross-Section 9 (Riffle)						Cross-Section 10 (Riffle)						Cross-Section 11 (Pool)						Cross-Section 12 (Pool)					
Dimension and Substrate	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**
based on fixed bankfull elevation																								
Bankfull Width (ft)	15.9						12.6						14.2						33.3					
Floodprone Width (ft)	200+						100+						N/A						N/A					
Bankfull Mean Depth (ft)	1.2						0.8						1.3						2.2					
Bankfull Max Depth (ft)	1.8						1.5						2.6						4.9					
Bankfull Cross-Sectional Area (ft^2)	19.0						10.5						17.7						74.4					
Bankfull Width/Depth Ratio	13.3						15.1						11.3						14.9					
Bankfull Entrenchment Ratio	2.2+						2.2+						N/A						N/A					
Bankfull Bank Height Ratio	1.0						1.0						1.0						1.0					

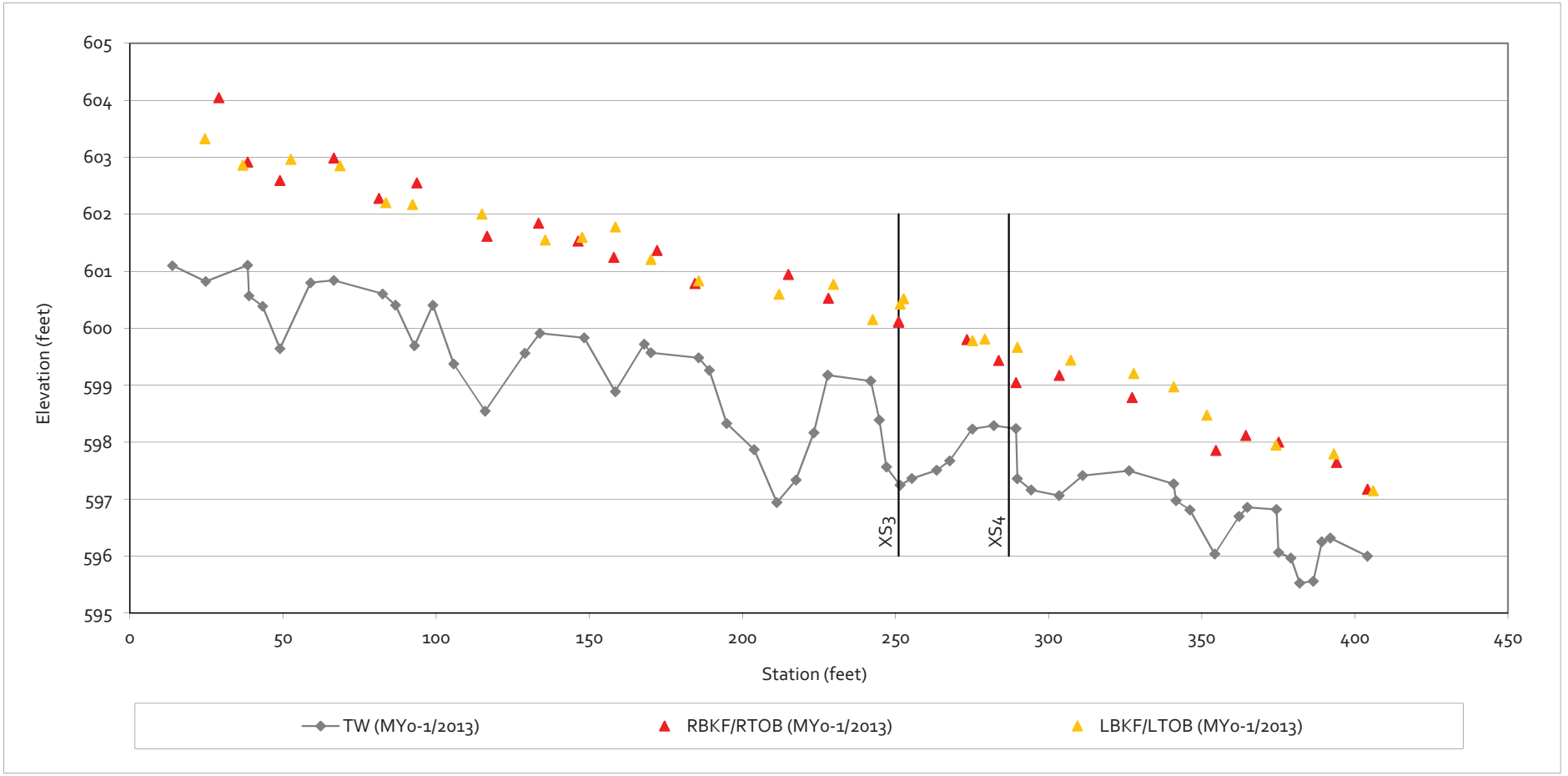
	SF4																		SF4A					
	Cross-Section 13 (Riffle)						Cross-Section 14 (Pool)						Cross-Section 15 (Riffle)						Cross-Section 16 (Riffle)					
Dimension and Substrate	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**
based on fixed bankfull elevation																								
Bankfull Width (ft)	27.3						38.7						27.6						23.7					
Floodprone Width (ft)	200+						N/A						200+						200+					
Bankfull Mean Depth (ft)	1.8						1.8						1.9						0.9					
Bankfull Max Depth (ft)	3.0						4.3						3.2						2.3					
Bankfull Cross-Sectional Area (ft^2)	49.5						70.6						51.2						20.4					
Bankfull Width/Depth Ratio	15.1						21.2						14.9						27.5					
Bankfull Entrenchment Ratio	2.2+						N/A						2.2+						2.2+					
Bankfull Bank Height Ratio	1.0						1.0						1.0						1.0					

	SF4A											
	Cross-Section 17 (Riffle)						Cross-Section 18 (Pool)					
Dimension and Substrate	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**
based on fixed bankfull elevation												
Bankfull Width (ft)	13.9						16.0					
Floodprone Width (ft)	200+						N/A					
Bankfull Mean Depth (ft)	1.3						1.4					
Bankfull Max Depth (ft)	2.1						2.8					
Bankfull Cross-Sectional Area (ft^2)	17.5						22.9					
Bankfull Width/Depth Ratio	11.0						11.1					
Bankfull Entrenchment Ratio	2.2+						N/A					
Bankfull Bank Height Ratio	1.0						1.0					

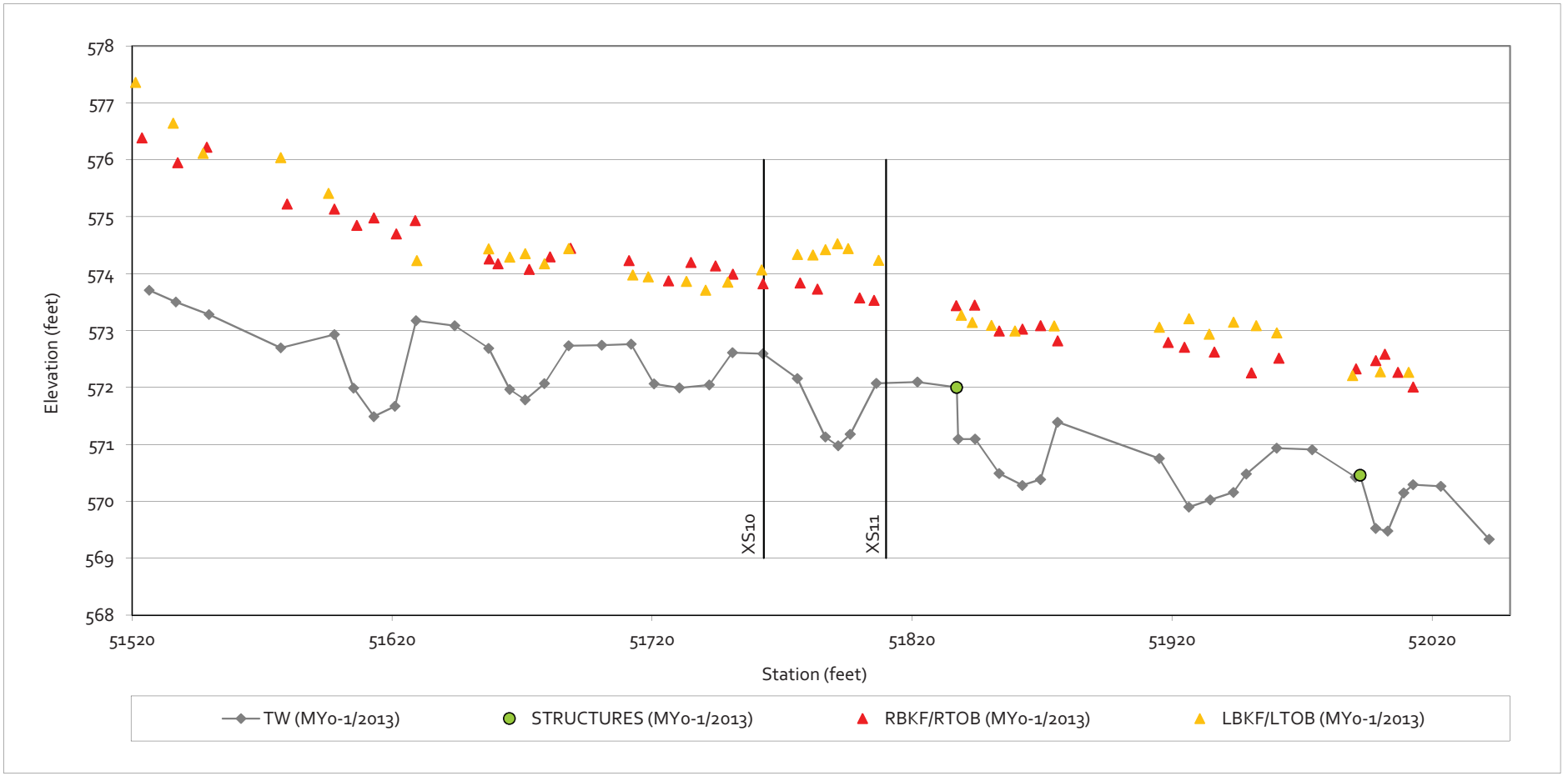
Appendix 2. Morphological Summary Data and Plots
Longitudinal Profile Plots
Underwood Mitigation Site (NCEEP Project No. 94641)
SF1
Monitoring Year 0



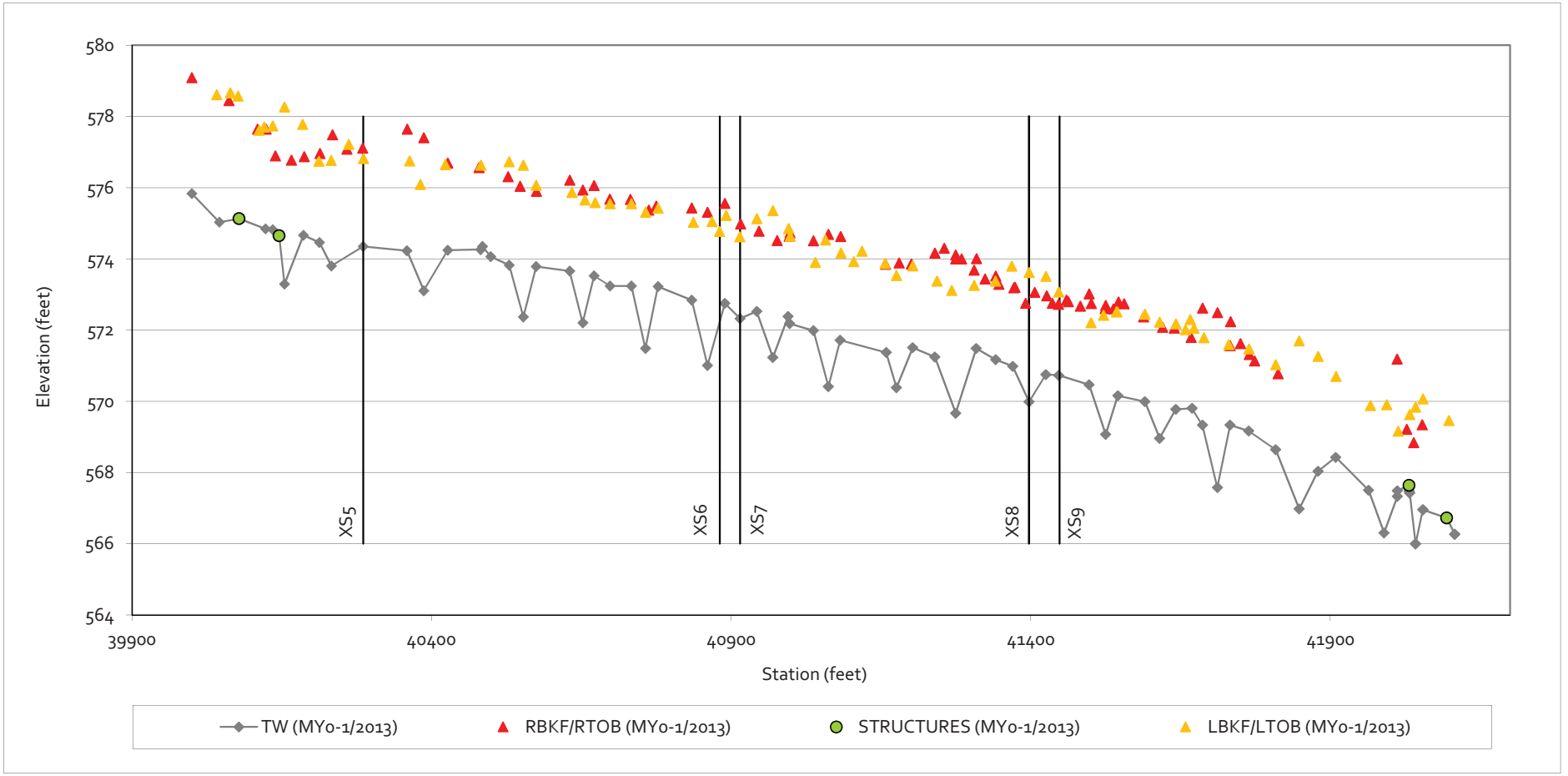
Appendix 2. Morphological Summary Data and Plots
Longitudinal Profile Plots
Underwood Mitigation Site (NCEEP Project No. 94641)
UT2
Monitoring Year 0



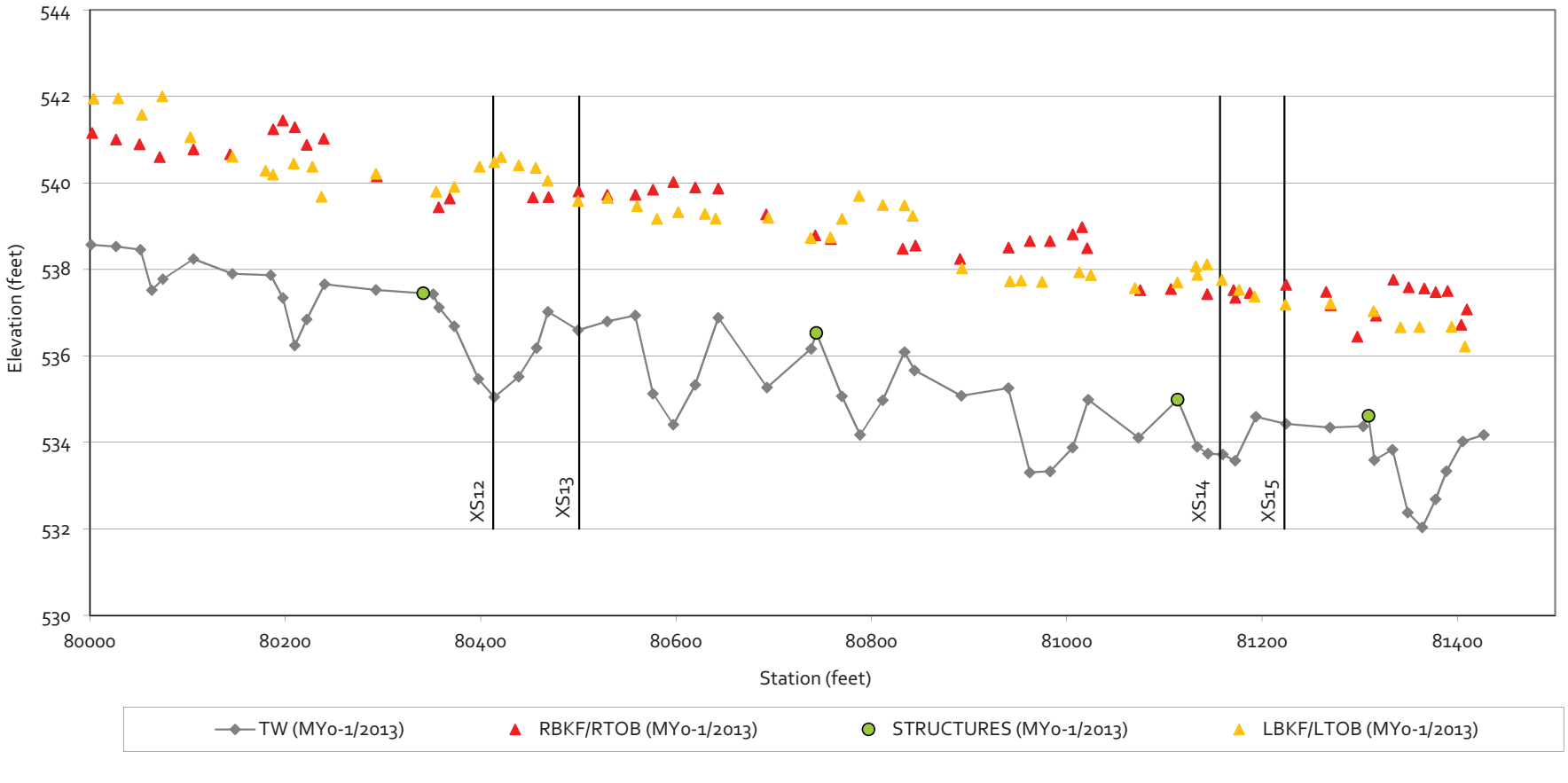
Appendix 2. Morphological Summary Data and Plots
Longitudinal Profile Plots
Underwood Mitigation Site (NCEEP Project No. 94641)
UT1
Monitoring Year 0



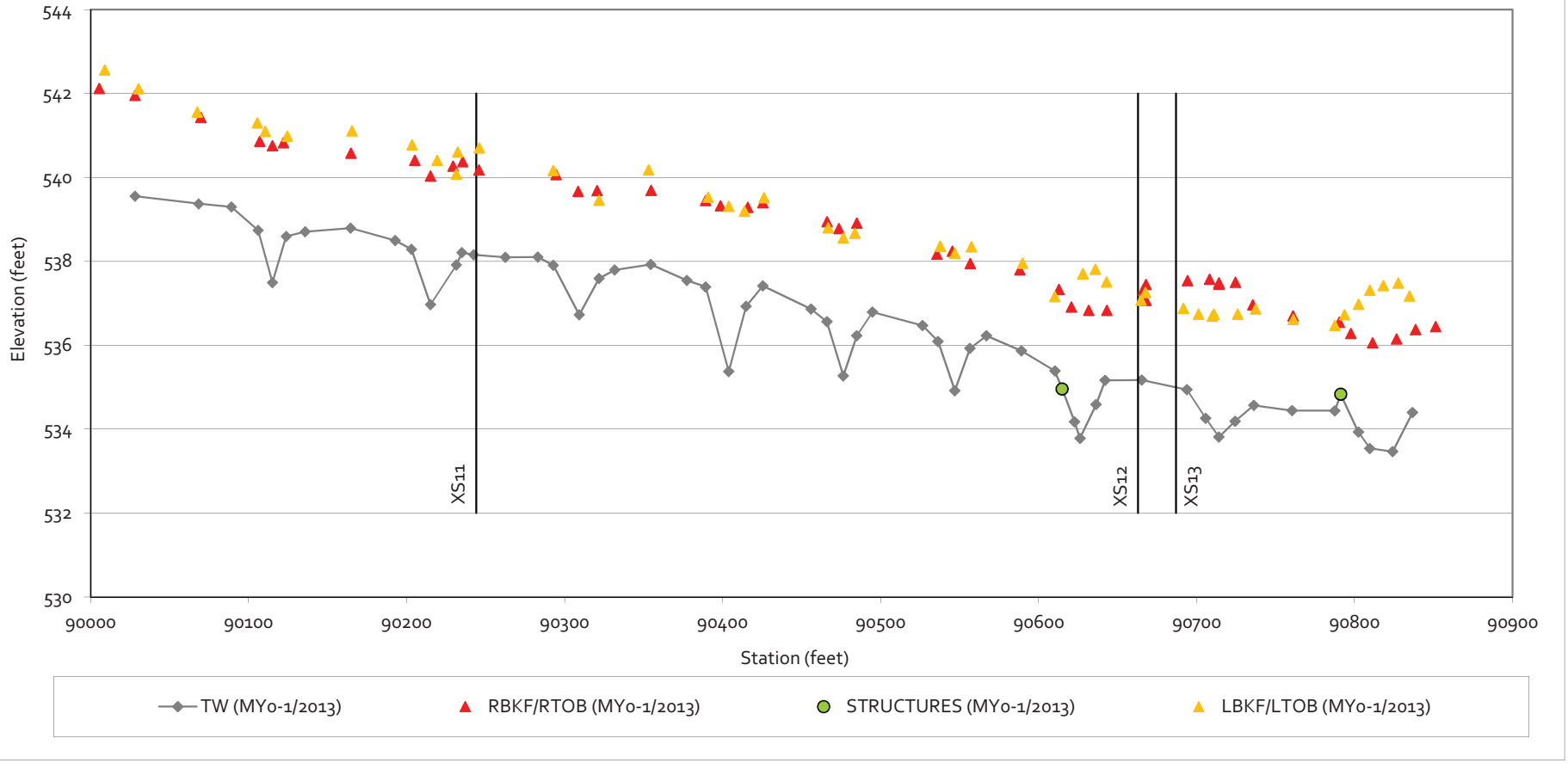
Appendix 2. Morphological Summary Data and Plots
Longitudinal Profile Plots
Underwood Mitigation Site (NCEEP Project No. 94641)
SF3
Monitoring Year 0



Appendix 2. Morphological Summary Data and Plots
Longitudinal Profile Plots
Underwood Mitigation Site (NCEEP Project No. 94641)
SF4
Monitoring Year 0



Appendix 2. Morphological Summary Data and Plots
Longitudinal Profile Plots
Underwood Mitigation Site (NCEEP Project No. 94641)
SF4A
Monitoring Year 0



Appendix 2. Morphological Summary Data and Plots
Cross-Section Plots
Underwood Mitigation Site (NCEEP Project No. 94641)
SF1, Cross-Section 1 (Riffle)
Monitoring Year 0

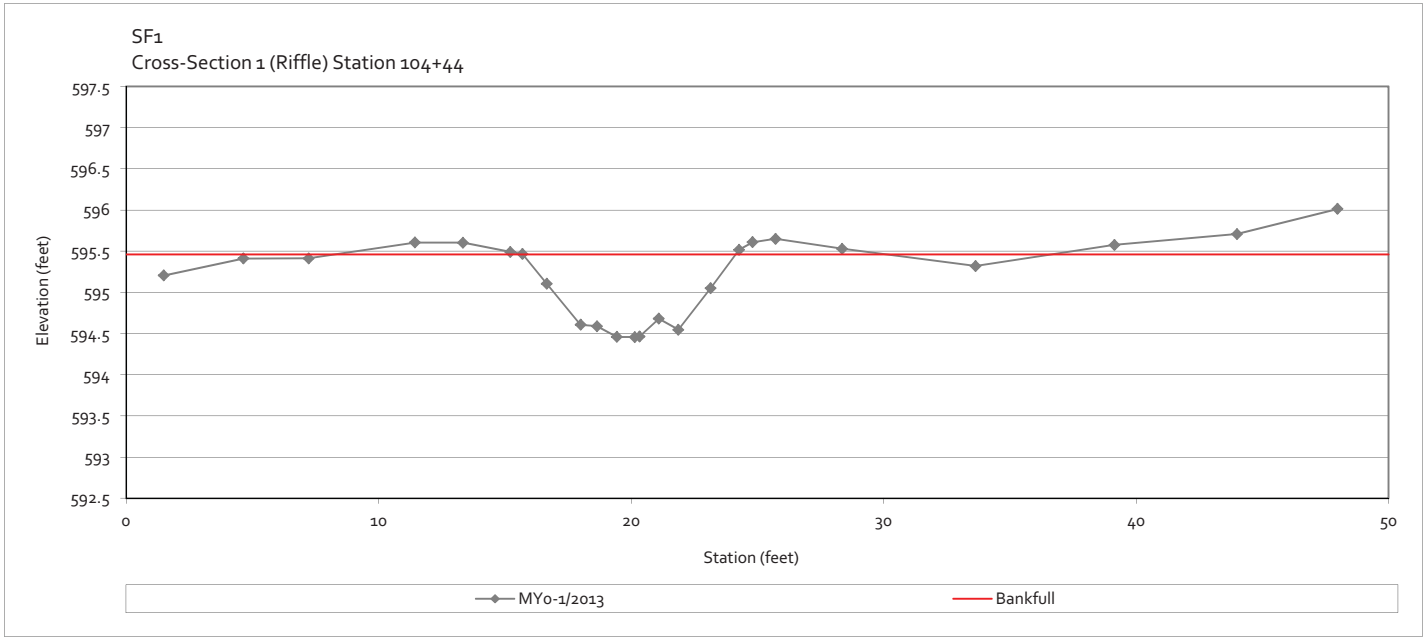
River Basin	Cape Fear
Watershed HUC	303002050050
XS ID	1
Drainage Area	132 acres
Date	1/22/2013
Field Crew	DT, AT

Summary Data	
Bankfull Elevation (ft)	595.5
Bankfull Cross-Sectional Area (ft2)	5.6
Bankfull Width (ft)	8.4
Flood Prone Area Elevation (ft)	596.5
Flood Prone Width (ft)	50+
Max Depth at Bankfull (ft)	1.0
Mean Depth at Bankfull (ft)	0.7
W/D Ratio	12.8
Entrenchment Ratio	2.2+
Bank Height Ratio	1.0
Stream Type	C

Cross-Section 1: View Upstream (1/22/2013)

Cross-Section 1: View Downstream (1/22/2013)

Station	Elevation	Station	Elevation
1.49	595.21		
4.64	595.41		
7.23	595.41		
11.44	595.61		
13.34	595.60		
15.22	595.49		
15.70	595.47		
16.66	595.11		
18.00	594.61		
18.65	594.59		
19.44	594.46		
20.14	594.46		
20.34	594.47		
21.10	594.68		
21.87	594.55		
23.15	595.05		
24.28	595.52		
24.81	595.61		
25.72	595.65		
28.36	595.53		
33.65	595.32		
39.14	595.58		
44.00	595.71		
47.98	596.01		



Appendix 2. Morphological Summary Data and Plots
Cross-Section Plots
Underwood Mitigation Site (NCEEP Project No. 94641)
SF1, Cross-Section 2 (Pool)
Monitoring Year 0

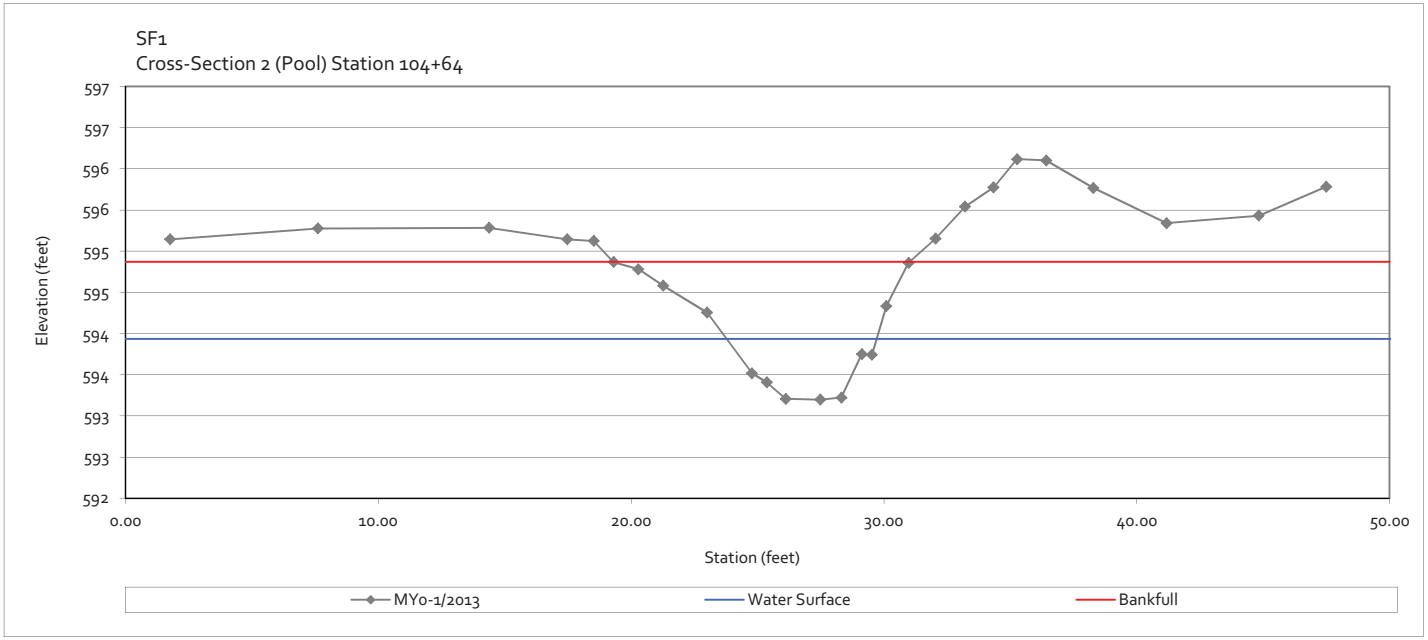
River Basin	Cape Fear
Watershed HUC	303002050050
XS ID	2
Drainage Area	132 acres
Date	1/22/2013
Field Crew	DT, AT

Summary Data	
Bankfull Elevation (ft)	594.9
Bankfull Cross-Sectional Area (ft2)	12.8
Bankfull Width (ft)	11.7
Flood Prone Area Elevation (ft)	N/A
Flood Prone Width (ft)	N/A
Max Depth at Bankfull (ft)	1.7
Mean Depth at Bankfull (ft)	0.9
W/D Ratio	12.8
Entrenchment Ratio	N/A
Bank Height Ratio	1.2
Stream Type	N/A

Cross-Section 2: View Upstream (1/22/2013)

Cross-Section 2: View Downstream (1/22/2013)

Station	Elevation	Station	Elevation
1.76	595.15	41.18	595.34
7.61	595.28	44.83	595.43
14.38	595.29	47.50	595.78
17.48	595.15		
18.52	595.13		
19.31	594.87		
20.29	594.78		
21.27	594.58		
23.01	594.26		
24.78	593.52		
25.37	593.41		
26.12	593.21		
27.49	593.20		
28.32	593.22		
29.13	593.75		
29.53	593.74		
30.10	594.34		
30.98	594.86		
32.04	595.15		
33.21	595.54		
34.34	595.77		
35.27	596.12		
36.42	596.10		
38.29	595.77		



Appendix 2. Morphological Summary Data and Plots
Cross-Section Plots
Underwood Mitigation Site (NCEEP Project No. 94641)
UT2, Cross-Section 3 (Pool)
Monitoring Year 0

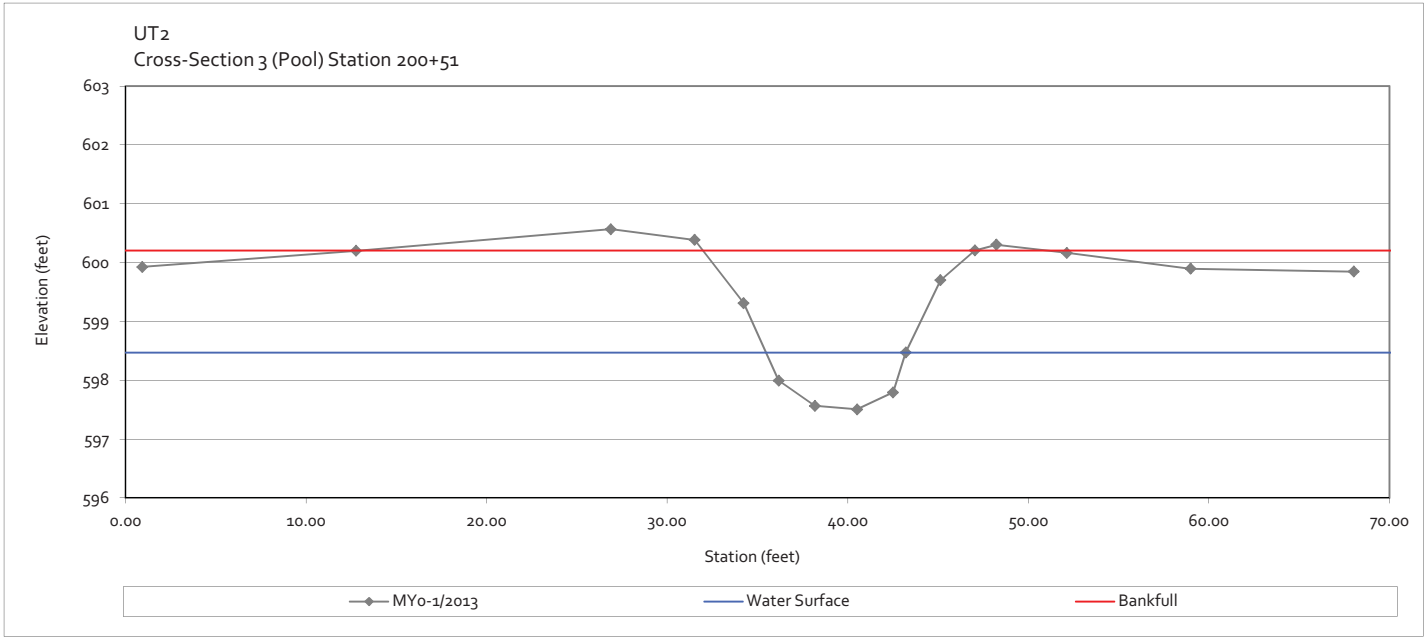
River Basin	Cape Fear
Watershed HUC	303002050050
XS ID	3
Drainage Area	78 acres
Date	1/22/2013
Field Crew	DT, AT

Summary Data	
Bankfull Elevation (ft)	600.2
Bankfull Cross-Sectional Area (ft2)	24.2
Bankfull Width (ft)	15.0
Flood Prone Area Elevation (ft)	N/A
Flood Prone Width (ft)	N/A
Max Depth at Bankfull (ft)	2.7
Mean Depth at Bankfull (ft)	1.6
W/D Ratio	9.3
Entrenchment Ratio	N/A
Bank Height Ratio	1.0
Stream Type	N/A

Cross-Section 3: View Upstream (1/22/2013)

Cross-Section 3: View Downstream (1/22/2013)

Station	Elevation	Station	Elevation
0.93	599.93		
12.77	600.20		
26.88	600.57		
31.52	600.39		
34.23	599.31		
36.17	598.00		
38.18	597.56		
40.52	597.51		
42.51	597.79		
43.21	598.47		
45.13	599.70		
47.04	600.21		
48.23	600.31		
52.13	600.17		
58.98	599.90		
68.02	599.85		



Appendix 2. Morphological Summary Data and Plots
Cross-Section Plots
Underwood Mitigation Site (NCEEP Project No. 94641)
UT2, Cross-Section 4 (Riffle)
Monitoring Year 0

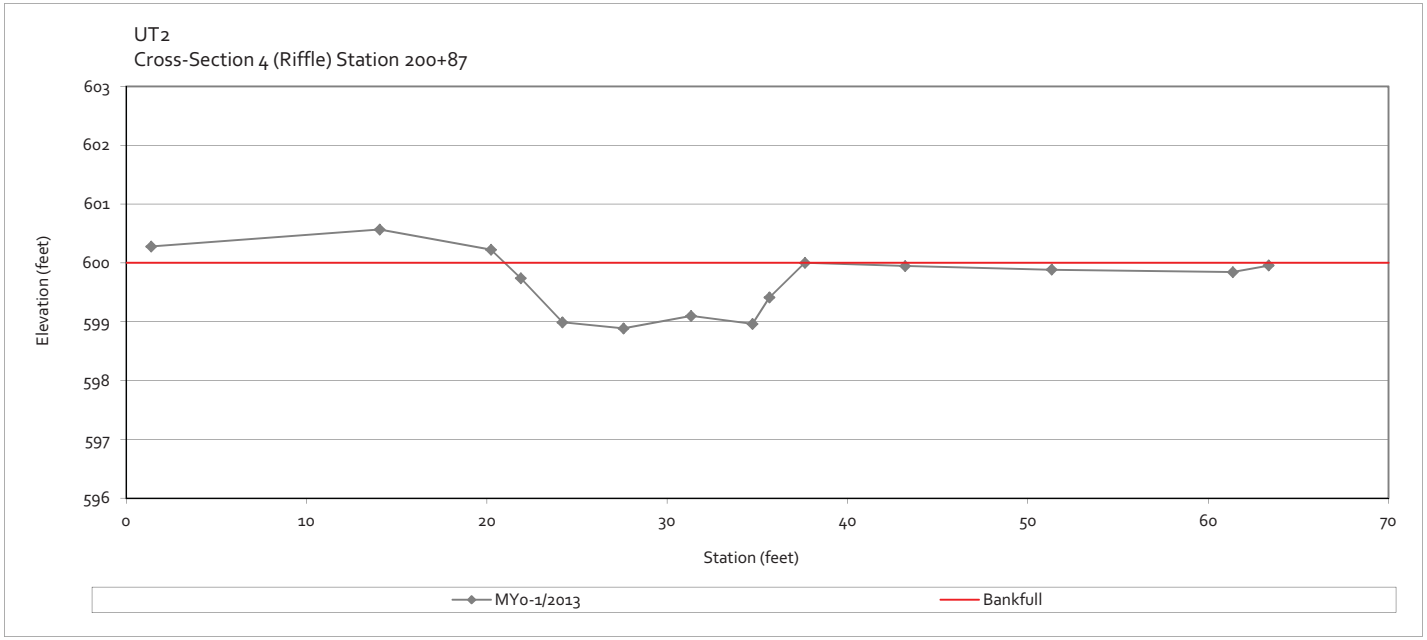
River Basin	Cape Fear
Watershed HUC	303002050050
XS ID	4
Drainage Area	78 acres
Date	1/22/2013
Field Crew	DT, AT

Summary Data	
Bankfull Elevation (ft)	599.5
Bankfull Cross-Sectional Area (ft2)	13.6
Bankfull Width (ft)	16.6
Flood Prone Area Elevation (ft)	611.6
Flood Prone Width (ft)	200+
Max Depth at Bankfull (ft)	1.1
Mean Depth at Bankfull (ft)	0.8
W/D Ratio	20.4
Entrenchment Ratio	2.2+
Bank Height Ratio	1.0
Stream Type	C

Cross-Section 4: View Upstream (1/22/2013)

Cross-Section 4: View Downstream (1/22/2013)

Station	Elevation	Station	Elevation
1.40	599.78		
14.06	600.07		
20.23	599.73		
21.89	599.24		
24.20	598.49		
27.58	598.39		
31.33	598.60		
34.74	598.46		
35.68	598.92		
37.64	599.50		
43.20	599.45		
51.33	599.39		
61.36	599.34		
63.36	599.46		



Appendix 2. Morphological Summary Data and Plots
Cross-Section Plots
Underwood Mitigation Site (NCEEP Project No. 94641)
SF3, Cross-Section 5 (Riffle)
Monitoring Year 0

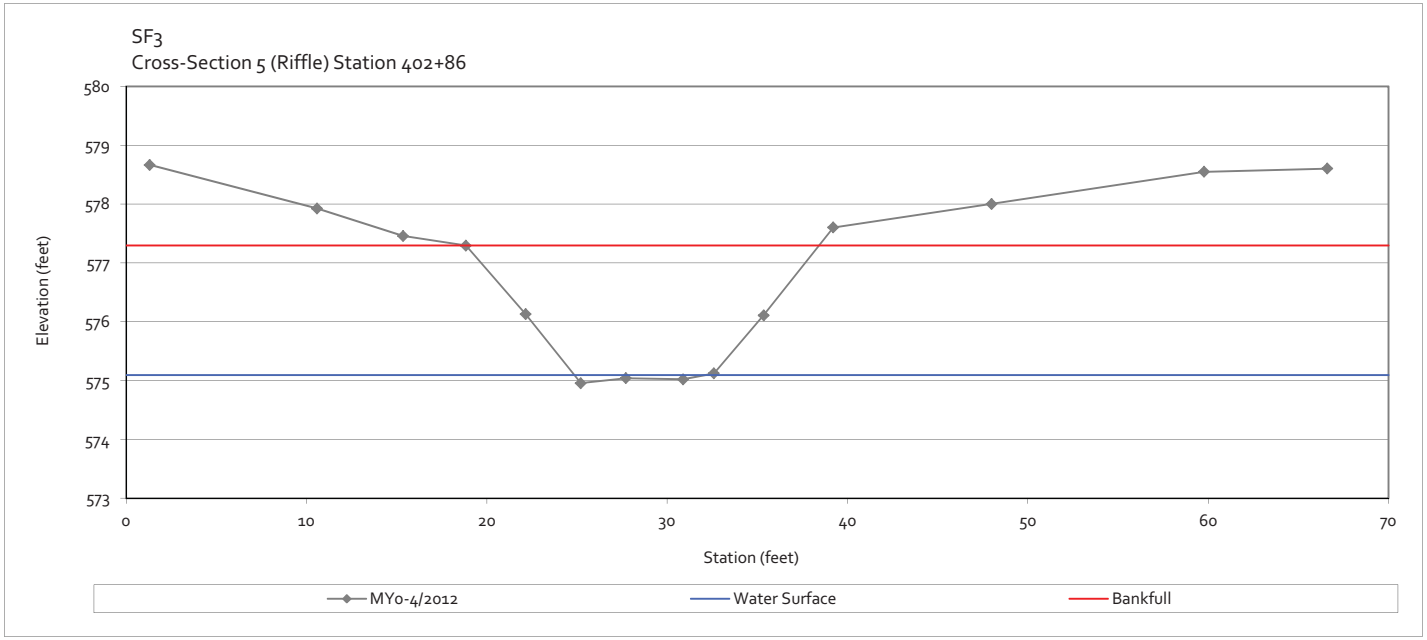
River Basin	Cape Fear
Watershed HUC	303002050050
XS ID	5
Drainage Area	1,056 acres
Date	1/22/2013
Field Crew	DT, AT

Summary Data	
Bankfull Elevation (ft)	576.8
Bankfull Cross-Sectional Area (ft2)	30.5
Bankfull Width (ft)	19.7
Flood Prone Area Elevation (ft)	579.1
Flood Prone Width (ft)	200+
Max Depth at Bankfull (ft)	2.3
Mean Depth at Bankfull (ft)	1.6
W/D Ratio	12.7
Entrenchment Ratio	2.2+
Bank Height Ratio	1.0
Stream Type	C

Cross-Section 5: View Upstream (1/22/2013)

Cross-Section 5: View Downstream (1/22/2013)

Station	Elevation	Station	Elevation
1.31	578.17		
10.58	577.43		
15.35	576.96		
18.84	576.80		
22.15	575.63		
25.21	574.46		
27.71	574.54		
30.89	574.52		
32.59	574.62		
35.35	575.61		
39.21	577.10		
47.98	577.50		
59.77	578.05		
66.60	578.10		
0.00	0.00		



Appendix 2. Morphological Summary Data and Plots
Cross-Section Plots
Underwood Mitigation Site (NCEEP Project No. 94641)
SF3, Cross-Section 6 (Pool)
Monitoring Year 0

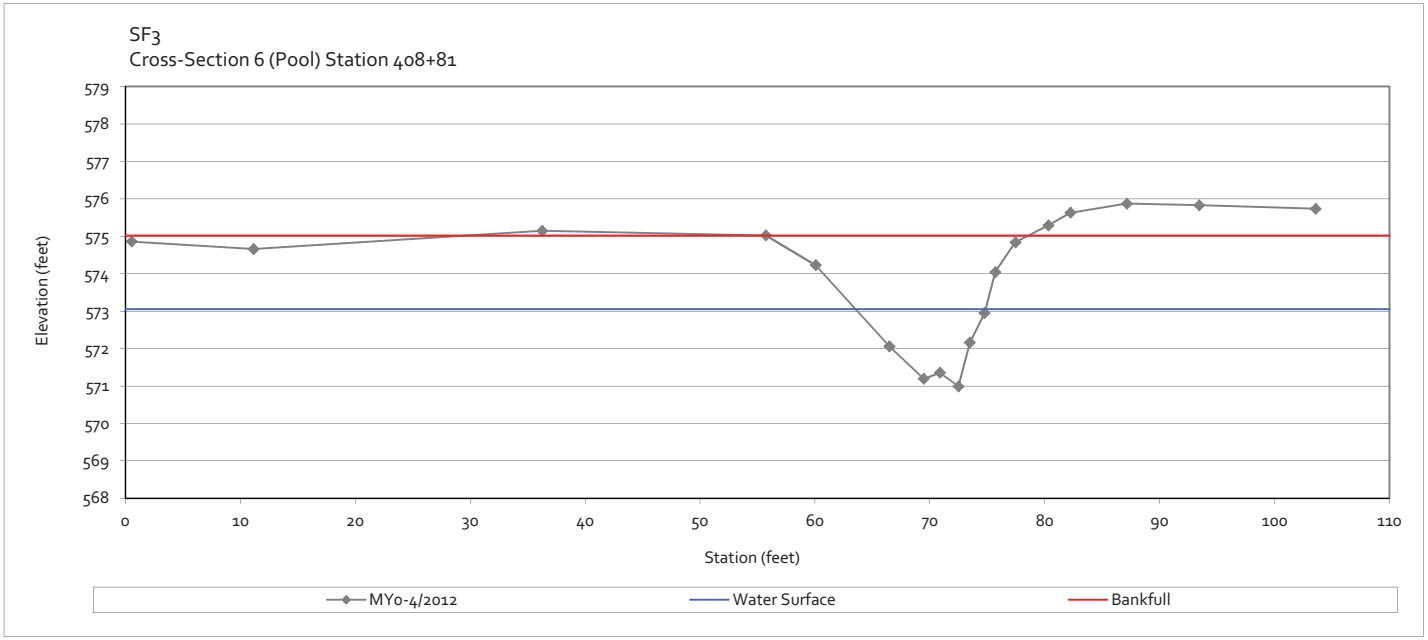
River Basin	Cape Fear
Watershed HUC	303002050050
XS ID	6
Drainage Area	1,056 acres
Date	1/22/2013
Field Crew	DT, AT

Summary Data	
Bankfull Elevation (ft)	575.0
Bankfull Cross-Sectional Area (ft2)	30.5
Bankfull Width (ft)	19.7
Flood Prone Area Elevation (ft)	N/A
Flood Prone Width (ft)	N/A
Max Depth at Bankfull (ft)	2.3
Mean Depth at Bankfull (ft)	1.6
W/D Ratio	12.7
Entrenchment Ratio	N/A
Bank Height Ratio	1.0
Stream Type	N/A

Cross-Section 6: View Upstream (1/22/2012)

Cross-Section 6: View Downstream (1/22/2012)

Station	Elevation	Station	Elevation
0.53	574.86		
11.16	574.66		
36.27	575.15		
55.74	575.02		
60.07	574.22		
66.49	572.05		
69.47	571.19		
70.88	571.35		
72.49	570.99		
73.48	572.16		
74.77	572.95		
75.70	574.04		
77.45	574.84		
80.32	575.29		
82.24	575.63		
87.14	575.87		
93.45	575.83		
103.58	575.73		



Appendix 2. Morphological Summary Data and Plots
Cross-Section Plots
Underwood Mitigation Site (NCEEP Project No. 94641)
SF3, Cross-Section 7 (Riffle)
Monitoring Year 0

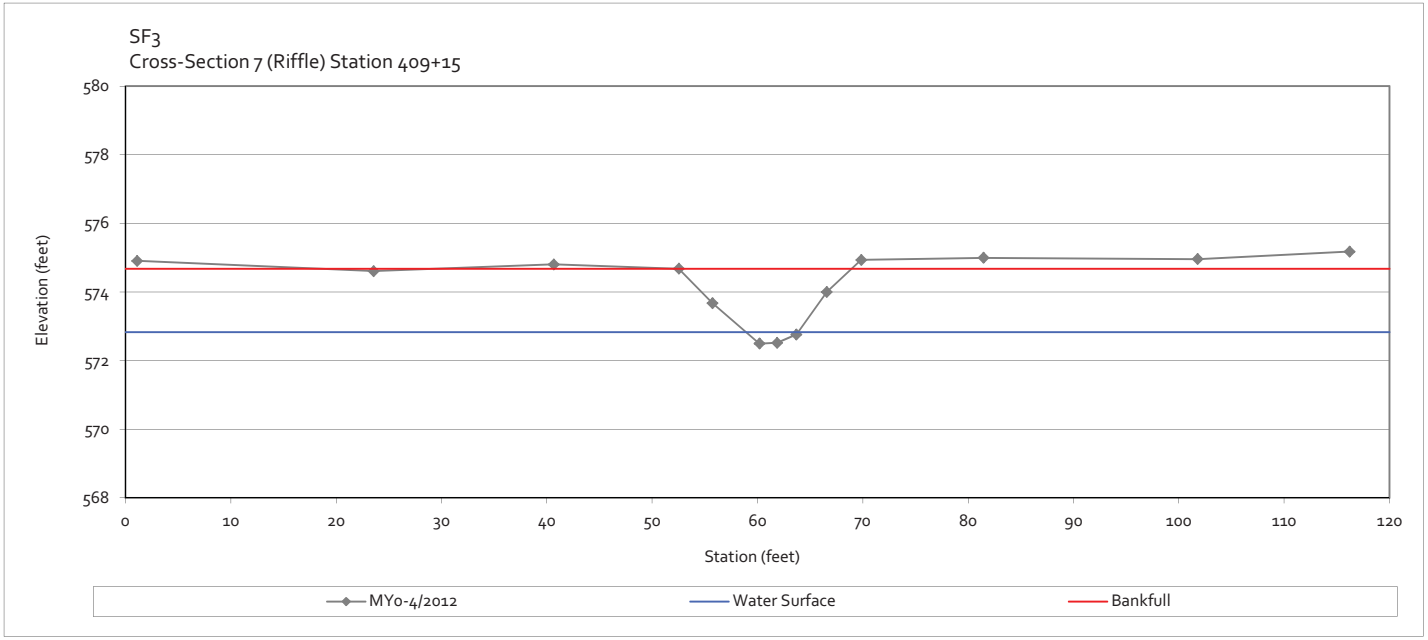
River Basin	Cape Fear
Watershed HUC	303002050050
XS ID	7
Drainage Area	1,056 acres
Date	1/22/2013
Field Crew	DT, AT

Summary Data	
Bankfull Elevation (ft)	574.7
Bankfull Cross-Sectional Area (ft2)	20.6
Bankfull Width (ft)	16.7
Flood Prone Area Elevation (ft)	576.9
Flood Prone Width (ft)	200+
Max Depth at Bankfull (ft)	2.2
Mean Depth at Bankfull (ft)	1.2
W/D Ratio	13.5
Entrenchment Ratio	2.2+
Bank Height Ratio	1.0
Stream Type	C

Cross-Section 7: View Upstream (1/22/2012)

Cross-Section 7: View Downstream (1/22/2012)

Station	Elevation	Station	Elevation
1.11	574.91		
23.57	574.61		
40.65	574.81		
52.53	574.68		
55.72	573.68		
60.19	572.50		
61.87	572.52		
63.70	572.76		
66.58	574.00		
69.85	574.93		
81.45	575.00		
101.79	574.96		
116.22	575.18		



Appendix 2. Morphological Summary Data and Plots
Cross-Section Plots
Underwood Mitigation Site (NCEEP Project No. 94641)
SF3, Cross-Section 8 (Pool)
Monitoring Year 0

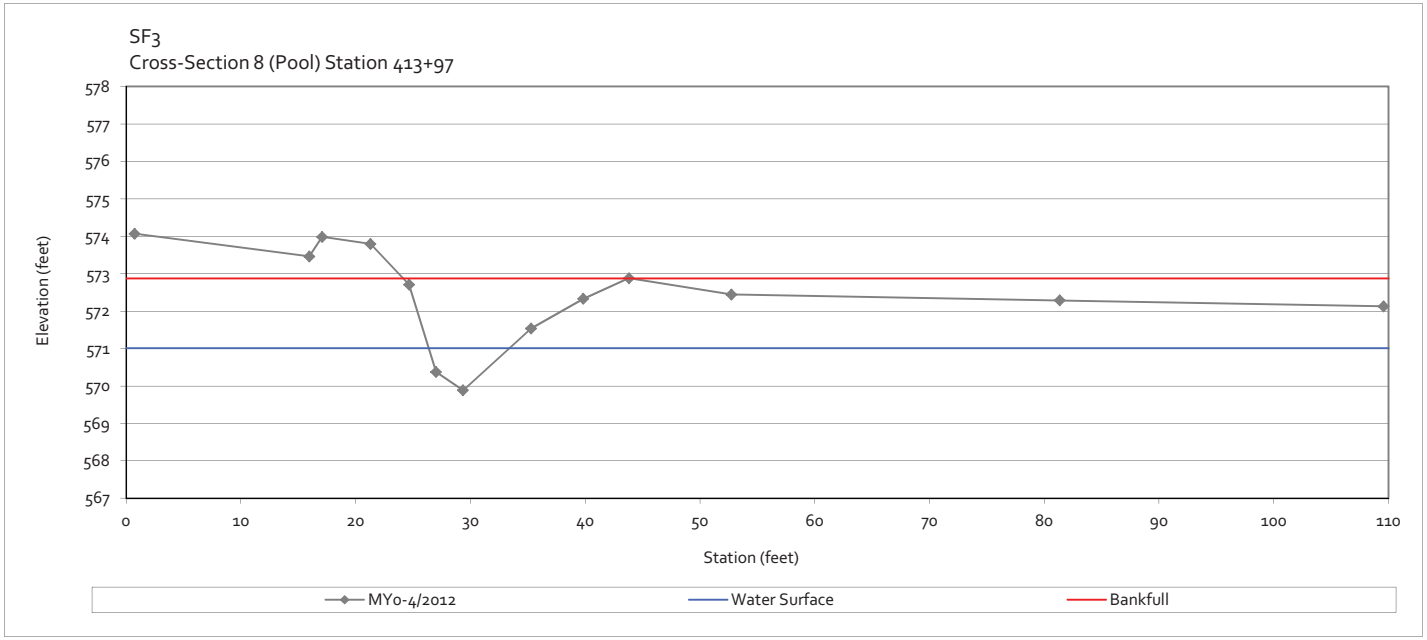
River Basin	Cape Fear
Watershed HUC	303002050050
XS ID	8
Drainage Area	1,056 acres
Date	1/22/2013
Field Crew	DT, AT

Summary Data	
Bankfull Elevation (ft)	572.9
Bankfull Cross-Sectional Area (ft2)	28.0
Bankfull Width (ft)	19.7
Flood Prone Area Elevation (ft)	N/A
Flood Prone Width (ft)	N/A
Max Depth at Bankfull (ft)	3.0
Mean Depth at Bankfull (ft)	1.4
W/D Ratio	13.9
Entrenchment Ratio	N/A
Bank Height Ratio	1.0
Stream Type	N/A

Cross-Section 8: View Upstream (1/22/2013)

Cross-Section 8: View Downstream (1/22/2013)

Station	Elevation	Station	Elevation
0.73	574.07		
15.97	573.46		
17.09	573.98		
21.30	573.80		
24.66	572.71		
27.01	570.37		
29.35	569.88		
35.28	571.53		
39.84	572.33		
43.81	572.88		
52.75	572.44		
81.34	572.29		
109.58	572.13		



Appendix 2. Morphological Summary Data and Plots
Cross-Section Plots
Underwood Mitigation Site (NCEEP Project No. 94641)
SF3, Cross-Section 9 (Riffle)
Monitoring Year 0

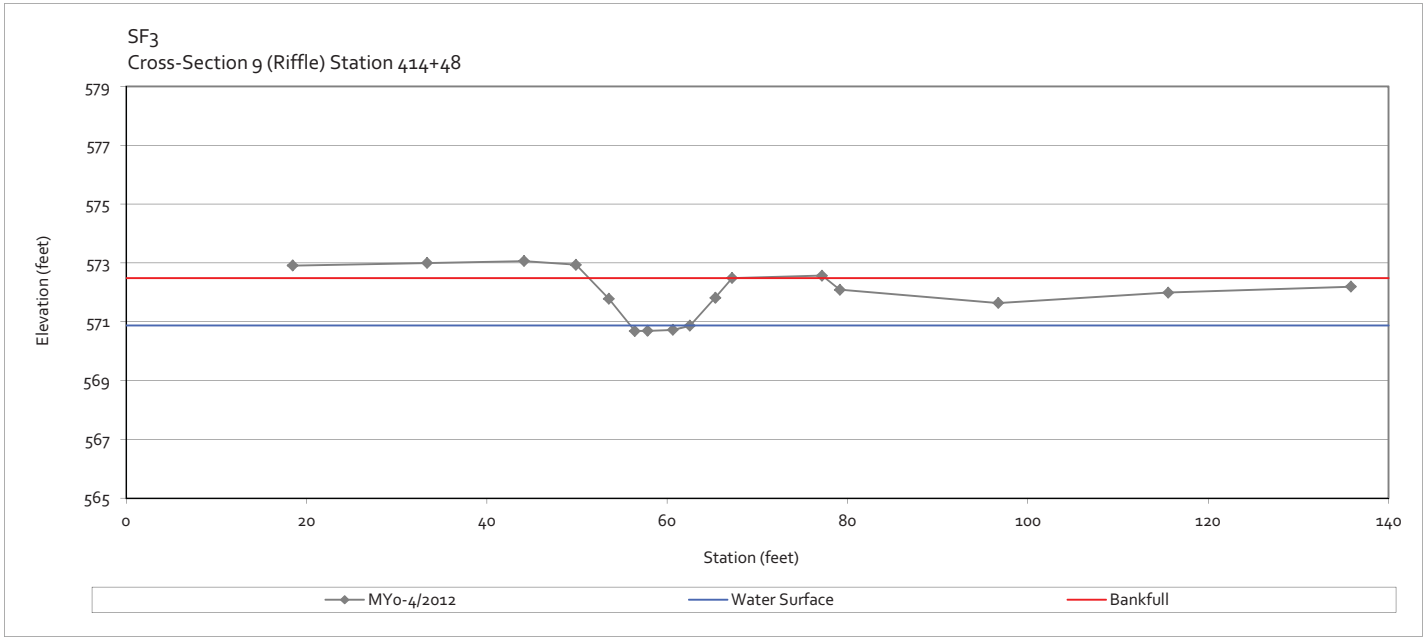
River Basin	Cape Fear
Watershed HUC	303002050050
XS ID	9
Drainage Area	1,056 acres
Date	1/22/2013
Field Crew	DT, AT

Summary Data	
Bankfull Elevation (ft)	572.5
Bankfull Cross-Sectional Area (ft2)	19.0
Bankfull Width (ft)	15.9
Flood Prone Area Elevation (ft)	574.3
Flood Prone Width (ft)	200+
Max Depth at Bankfull (ft)	1.8
Mean Depth at Bankfull (ft)	1.2
W/D Ratio	13.3
Entrenchment Ratio	2.2+
Bank Height Ratio	1.0
Stream Type	C

Cross-Section 9: View Upstream (1/22/2013)

Cross-Section 9: View Downstream (1/22/2013)

Station	Elevation	Station	Elevation
18.46	572.91		
33.36	573.00		
44.13	573.06		
49.88	572.94		
53.54	571.78		
56.41	570.69		
57.81	570.69		
60.64	570.72		
62.52	570.87		
65.35	571.82		
67.20	572.49		
77.17	572.57		
79.14	572.09		
96.72	571.64		
115.58	571.99		
135.83	572.20		



Appendix 2. Morphological Summary Data and Plots
Cross-Section Plots
Underwood Mitigation Site (NCEEP Project No. 94641)
UT1, Cross-Section 10 (Riffle)
Monitoring Year 0

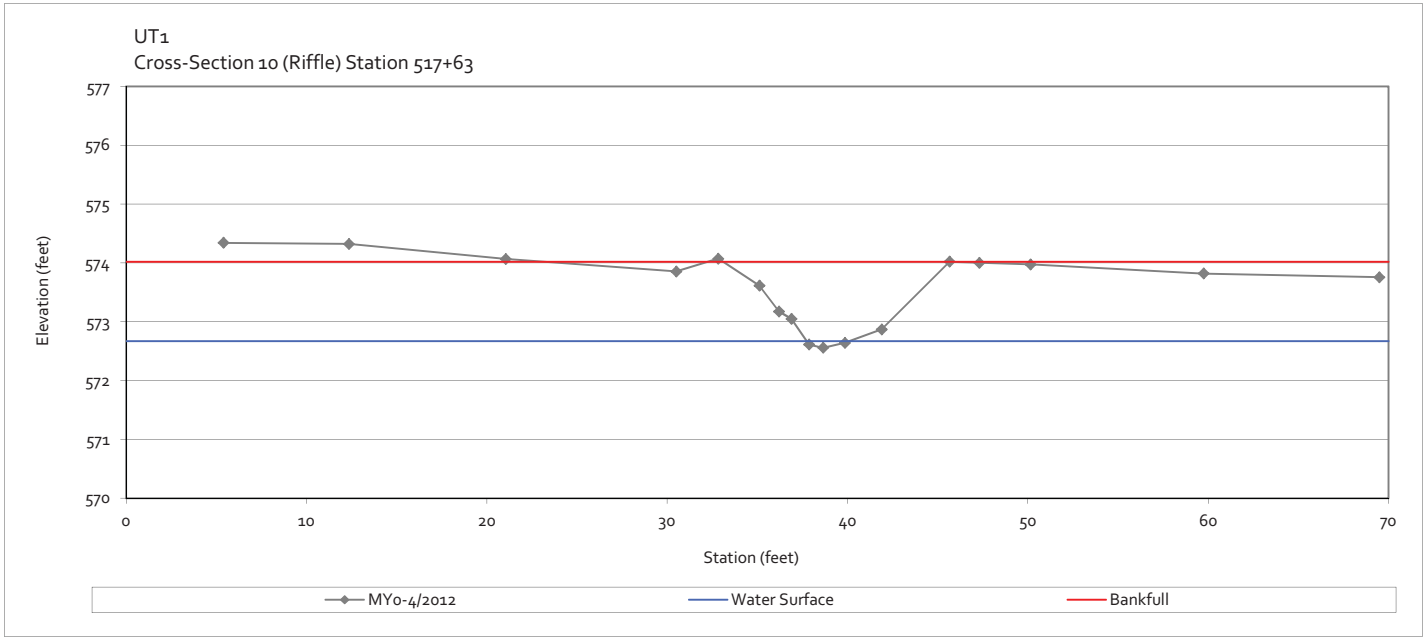
River Basin	Cape Fear
Watershed HUC	303002050050
XS ID	10
Drainage Area	230 acres
Date	1/22/2013
Field Crew	DT, AT

Summary Data	
Bankfull Elevation (ft)	574.0
Bankfull Cross-Sectional Area (ft2)	10.5
Bankfull Width (ft)	12.6
Flood Prone Area Elevation (ft)	575.5
Flood Prone Width (ft)	100+
Max Depth at Bankfull (ft)	1.5
Mean Depth at Bankfull (ft)	0.8
W/D Ratio	15.1
Entrenchment Ratio	2.2+
Bank Height Ratio	1.0
Stream Type	C

Cross-Section 10: View Upstream (1/22/2013)

Cross-Section 10: View Downstream (1/22/2013)

Station	Elevation	Station	Elevation
5.41	574.34		
12.35	574.32		
21.05	574.07		
30.51	573.86		
32.83	574.07		
35.12	573.61		
36.20	573.17		
36.90	573.05		
37.88	572.61		
38.65	572.56		
39.86	572.64		
41.90	572.87		
45.66	574.02		
47.32	574.00		
50.15	573.97		
59.75	573.82		
69.49	573.76		



Appendix 2. Morphological Summary Data and Plots
Cross-Section Plots
Underwood Mitigation Site (NCEEP Project No. 94641)
UT1, Cross-Section 11 (Pool)
Monitoring Year 0

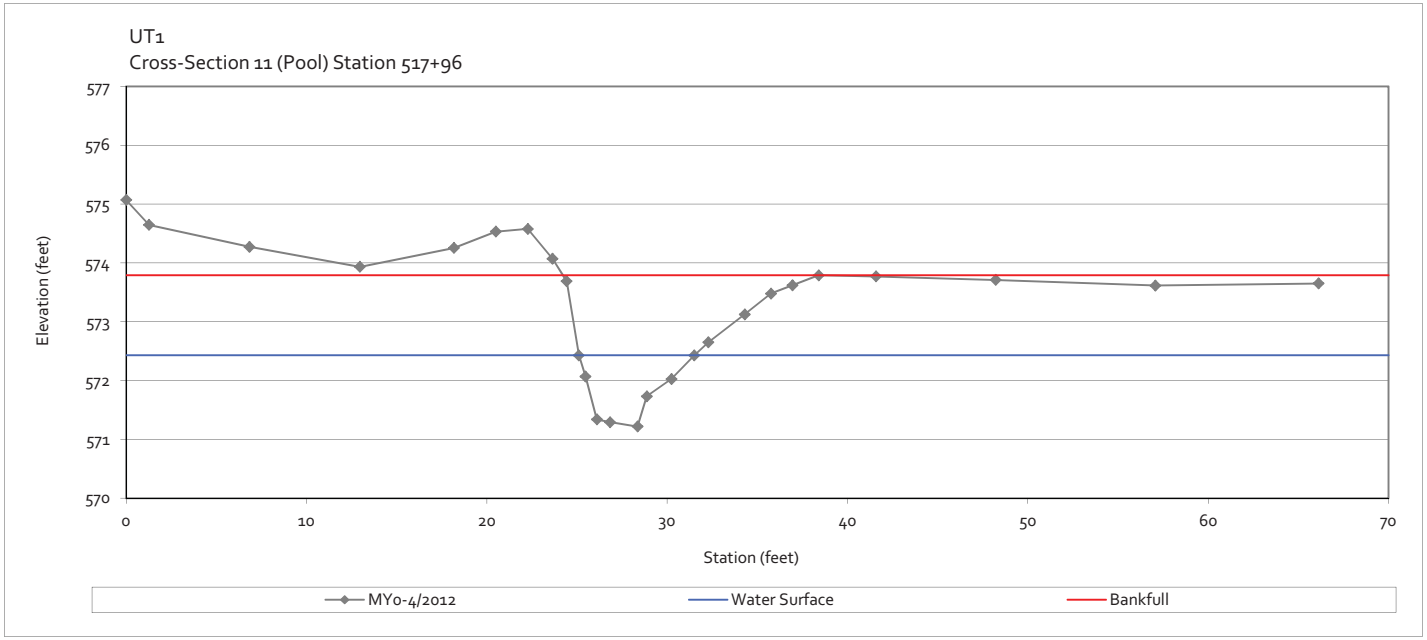
River Basin	Cape Fear
Watershed HUC	303002050050
XS ID	11
Drainage Area	230 acres
Date	1/22/2013
Field Crew	DT, AT

Summary Data	
Bankfull Elevation (ft)	573.8
Bankfull Cross-Sectional Area (ft2)	17.7
Bankfull Width (ft)	14.2
Flood Prone Area Elevation (ft)	N/A
Flood Prone Width (ft)	N/A
Max Depth at Bankfull (ft)	2.6
Mean Depth at Bankfull (ft)	1.3
W/D Ratio	11.3
Entrenchment Ratio	N/A
Bank Height Ratio	1.0
Stream Type	N/A

Cross-Section 11: View Upstream (1/22/2013)

Cross-Section 11: View Downstream (1/22/2013)

Station	Elevation	Station	Elevation
0.00	575.07	57.08	573.62
1.27	574.65	66.12	573.65
6.84	574.28		
12.97	573.93		
18.17	574.26		
20.50	574.53		
22.27	574.58		
23.65	574.07		
24.43	573.69		
25.10	572.43		
25.48	572.07		
26.11	571.34		
26.84	571.29		
28.36	571.22		
28.87	571.74		
30.24	572.03		
31.51	572.43		
32.28	572.65		
34.30	573.13		
35.76	573.48		
36.96	573.62		
38.40	573.79		
41.58	573.77		
48.22	573.71		



Appendix 2. Morphological Summary Data and Plots
Cross-Section Plots
Underwood Mitigation Site (NCEEP Project No. 94641)
SF4, Cross-Section 12 (Pool)
Monitoring Year 0

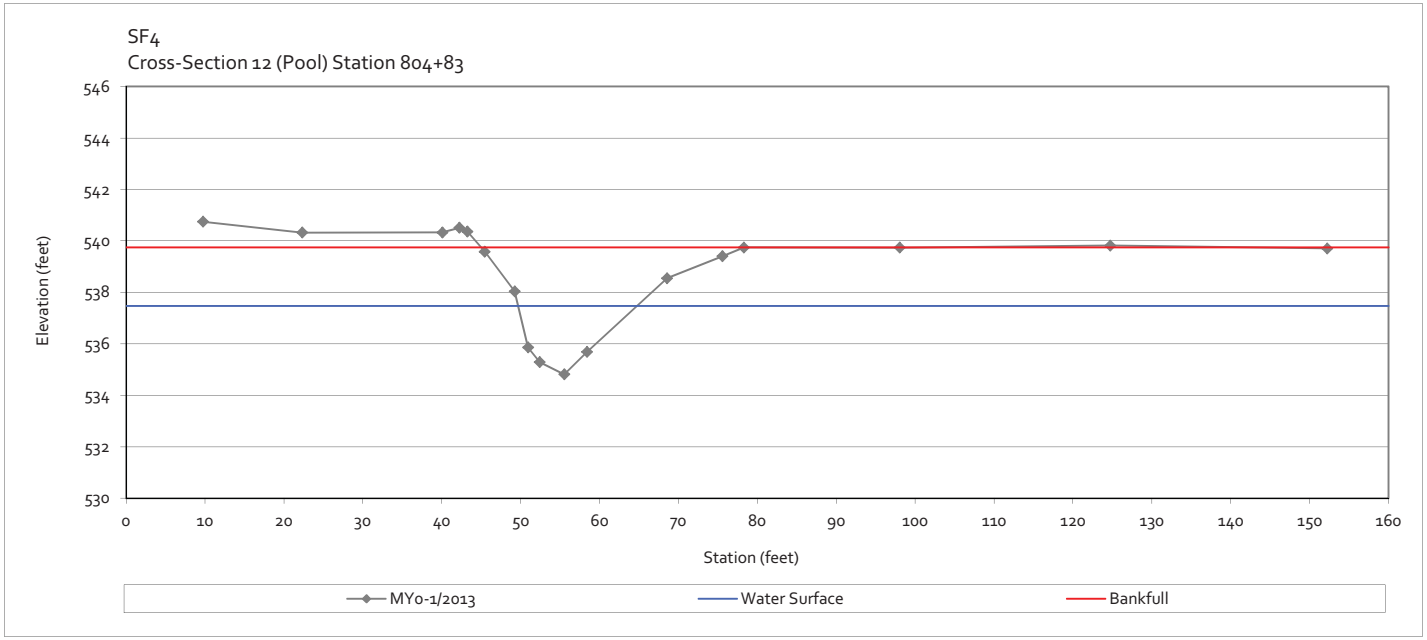
River Basin	Cape Fear
Watershed HUC	303002050050
XS ID	12
Drainage Area	3,362 acres
Date	1/22/2013
Field Crew	DT, AT

Summary Data	
Bankfull Elevation (ft)	539.7
Bankfull Cross-Sectional Area (ft2)	74.4
Bankfull Width (ft)	33.3
Flood Prone Area Elevation (ft)	N/A
Flood Prone Width (ft)	N/A
Max Depth at Bankfull (ft)	4.9
Mean Depth at Bankfull (ft)	2.2
W/D Ratio	14.9
Entrenchment Ratio	N/A
Bank Height Ratio	1.0
Stream Type	N/A

Cross-Section 12: View Upstream (1/22/2013)

Cross-Section 12: View Downstream (1/22/2013)

Station	Elevation	Station	Elevation
0.26	540.44		
9.76	540.75		
22.33	540.32		
40.08	540.33		
42.23	540.51		
43.27	540.36		
45.45	539.59		
49.24	538.04		
50.95	535.86		
52.43	535.29		
55.54	534.82		
58.42	535.69		
68.58	538.55		
75.57	539.40		
78.30	539.74		
98.06	539.74		
124.74	539.82		
152.25	539.71		



Appendix 2. Morphological Summary Data and Plots
Cross-Section Plots
Underwood Mitigation Site (NCEEP Project No. 94641)
SF4, Cross-Section 13 (Riffle)
Monitoring Year 0

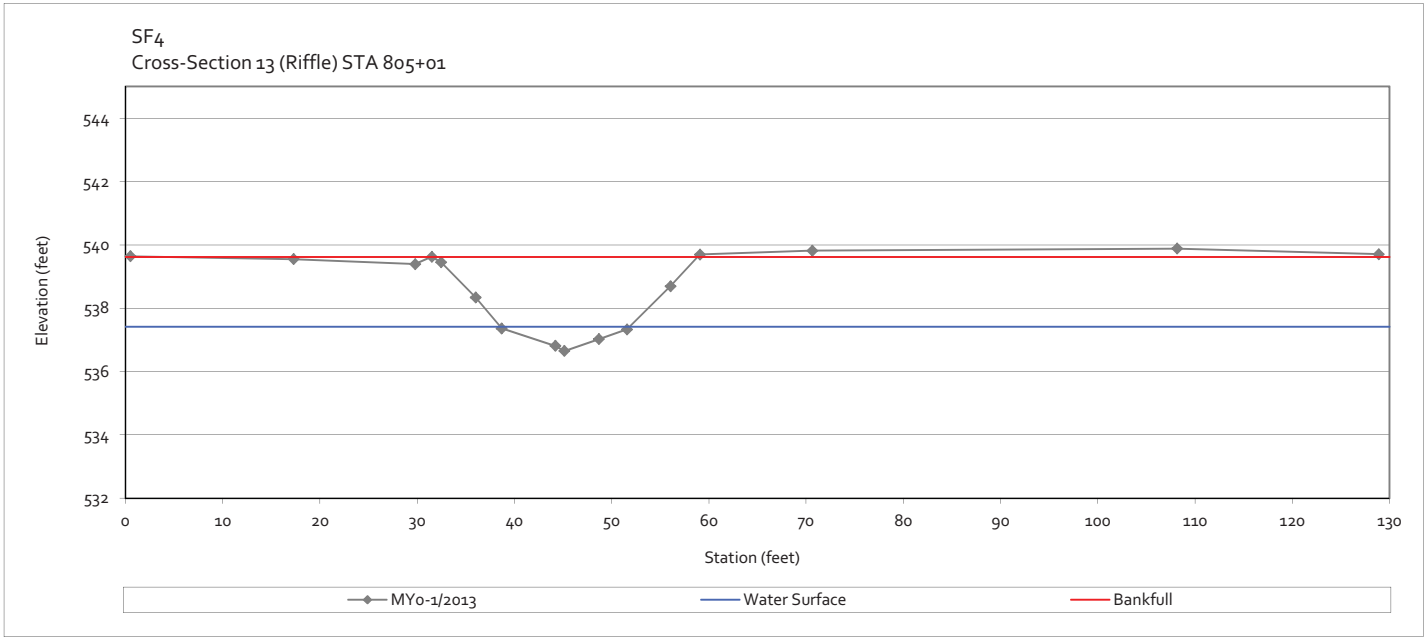
River Basin	Cape Fear
Watershed HUC	303002050050
XS ID	13
Drainage Area	3,362 acres
Date	1/22/2013
Field Crew	DT, AT

Summary Data	
Bankfull Elevation (ft)	539.6
Bankfull Cross-Sectional Area (ft2)	49.5
Bankfull Width (ft)	27.3
Flood Prone Area Elevation (ft)	542.6
Flood Prone Width (ft)	200+
Max Depth at Bankfull (ft)	2.97
Mean Depth at Bankfull (ft)	1.81
W/D Ratio	15.1
Entrenchment Ratio	2.2+
Bank Height Ratio	1.0
Stream Type	C

Cross-Section 13: View Upstream (1/22/2013)

Cross-Section 13: View Downstream (1/22/2013)

Station	Elevation	Station	Elevation
0.52	539.64		
17.30	539.55		
29.79	539.39		
31.50	539.62		
32.46	539.45		
36.01	538.34		
38.70	537.36		
44.21	536.81		
45.14	536.65		
48.69	537.02		
51.58	537.33		
56.05	538.69		
59.09	539.70		
70.63	539.82		
108.17	539.88		
128.90	539.71		



Appendix 2. Morphological Summary Data and Plots
Cross-Section Plots
Underwood Mitigation Site (NCEEP Project No. 94641)
SF4, Cross-Section 14 (Pool)
Monitoring Year 0

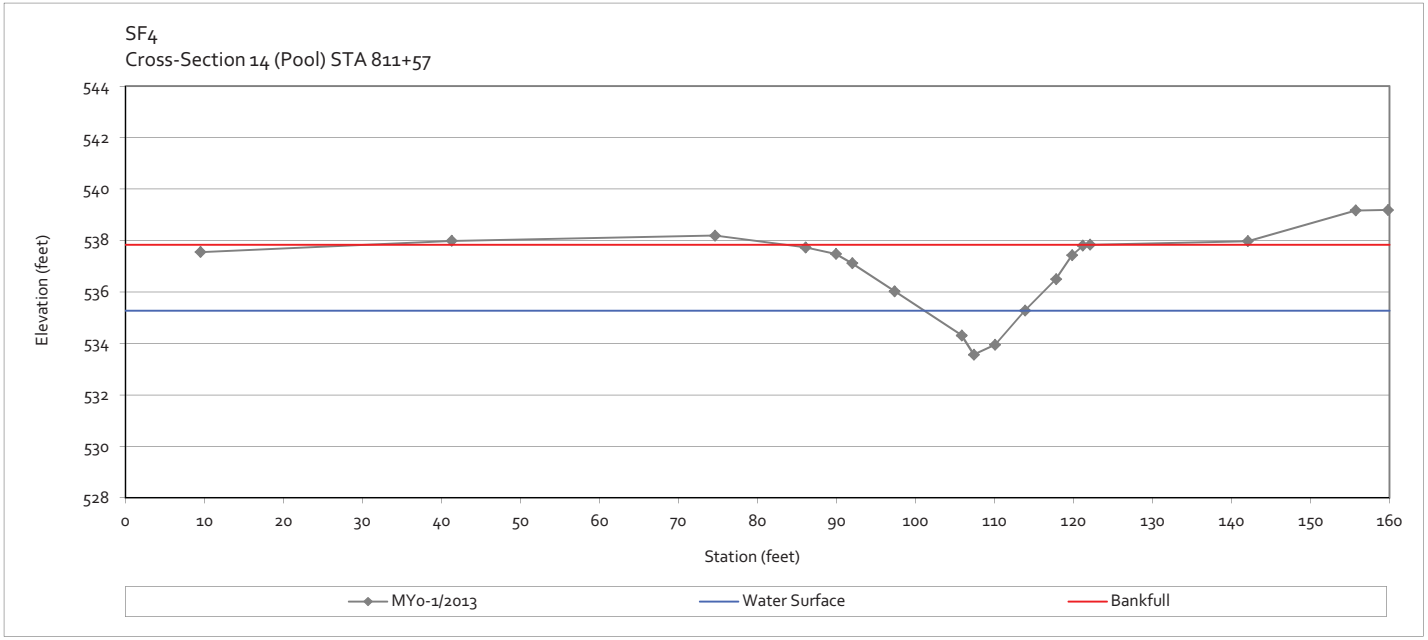
River Basin	Cape Fear
Watershed HUC	303002050050
XS ID	14
Drainage Area	3,362 acres
Date	1/22/2013
Field Crew	DT, AT

Summary Data	
Bankfull Elevation (ft)	537.8
Bankfull Cross-Sectional Area (ft2)	70.6
Bankfull Width (ft)	38.7
Flood Prone Area Elevation (ft)	N/A
Flood Prone Width (ft)	N/A
Max Depth at Bankfull (ft)	4.3
Mean Depth at Bankfull (ft)	1.8
W/D Ratio	21.2
Entrenchment Ratio	N/A
Bank Height Ratio	1.0
Stream Type	N/A

Cross-Section 14: View Upstream (1/22/2013)

Cross-Section 14: View Downstream (1/22/2013)

Station	Elevation	Station	Elevation
9.51	537.55		
41.30	537.99		
74.62	538.19		
86.08	537.73		
89.96	537.48		
92.01	537.12		
97.35	536.03		
105.86	534.31		
107.39	533.56		
110.09	533.95		
113.87	535.28		
117.80	536.50		
119.83	537.43		
121.19	537.80		
122.11	537.84		
142.06	537.98		
155.72	539.17		
159.81	539.18		



Appendix 2. Morphological Summary Data and Plots
Cross-Section Plots
Underwood Mitigation Site (NCEEP Project No. 94641)
SF4, Cross-Section 15 (Riffle)
Monitoring Year 0

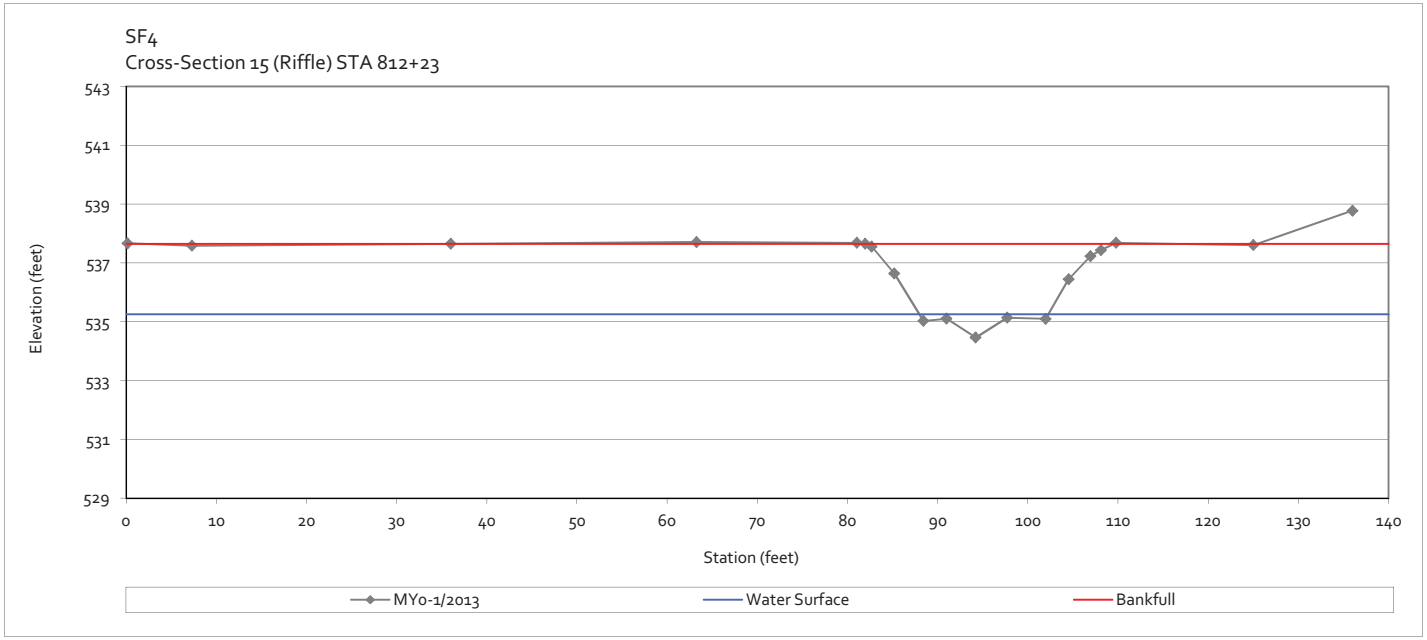
River Basin	Cape Fear
Watershed HUC	303002050050
XS ID	15
Drainage Area	3,362 acres
Date	1/22/2013
Field Crew	DT, AT

Summary Data	
Bankfull Elevation (ft)	537.7
Bankfull Cross-Sectional Area (ft2)	51.2
Bankfull Width (ft)	27.6
Flood Prone Area Elevation (ft)	540.8
Flood Prone Width (ft)	200+
Max Depth at Bankfull (ft)	3.2
Mean Depth at Bankfull (ft)	1.9
W/D Ratio	14.9
Entrenchment Ratio	2.2+
Bank Height Ratio	1.0
Stream Type	C

Cross-Section 15: View Upstream (1/22/2013)

Cross-Section 15: View Downstream (1/22/2013)

Station	Elevation	Station	Elevation
0.16	537.67		
7.30	537.58		
35.99	537.65		
63.25	537.71		
81.05	537.68		
81.97	537.65		
82.67	537.56		
85.19	536.64		
88.42	535.03		
90.99	535.10		
94.22	534.47		
97.70	535.14		
101.99	535.10		
104.52	536.44		
106.95	537.23		
108.12	537.44		
109.79	537.68		
125.01	537.61		
135.99	538.78		



Appendix 2. Morphological Summary Data and Plots
Cross-Section Plots
Underwood Mitigation Site (NCEEP Project No. 94641)
SF4A, Cross-Section 16 (Riffle)
Monitoring Year 0

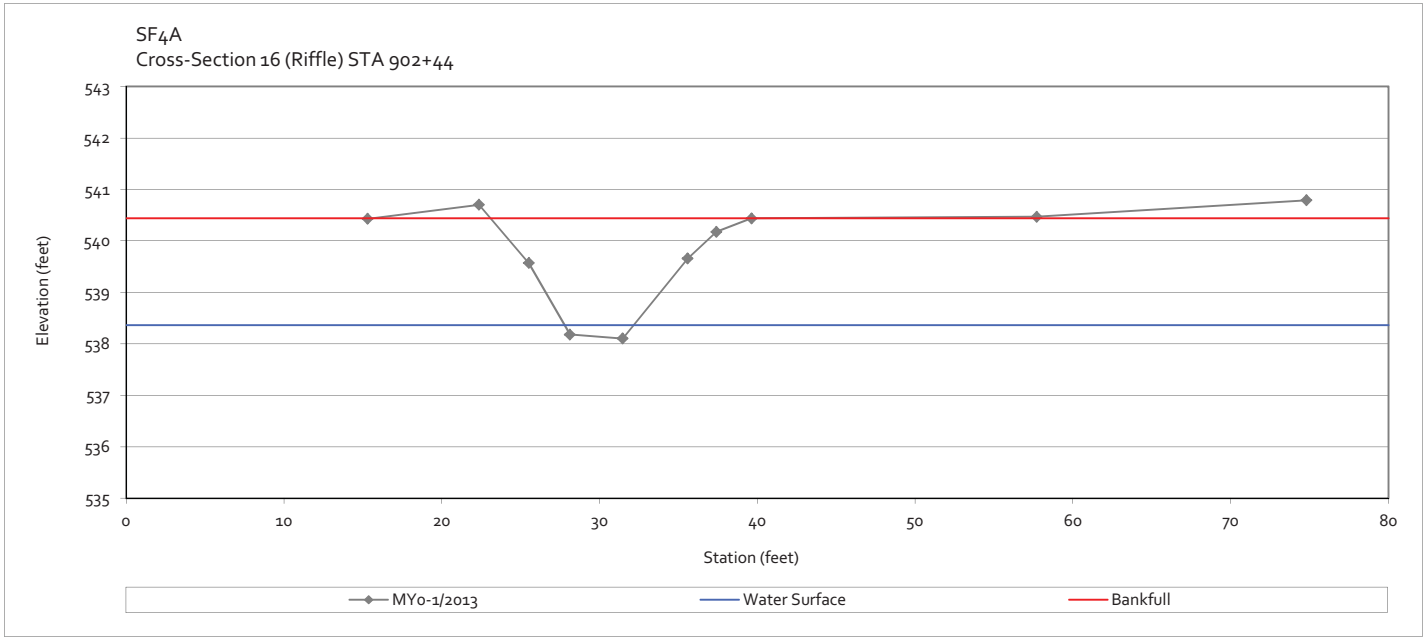
River Basin	Cape Fear
Watershed HUC	303002050050
XS ID	16
Drainage Area	637 acres
Date	1/22/2013
Field Crew	DT, AT

Summary Data	
Bankfull Elevation (ft)	540.4
Bankfull Cross-Sectional Area (ft2)	20.4
Bankfull Width (ft)	23.7
Flood Prone Area Elevation (ft)	542.8
Flood Prone Width (ft)	200+
Max Depth at Bankfull (ft)	2.3
Mean Depth at Bankfull (ft)	0.9
W/D Ratio	27.5
Entrenchment Ratio	2.2+
Bank Height Ratio	1.0
Stream Type	C

Cross-Section 16: View Upstream (1/22/2013)

Cross-Section 16: View Downstream (1/22/2013)

Station	Elevation	Station	Elevation
15.30	540.43		
22.36	540.70		
25.52	539.57		
28.12	538.18		
31.47	538.10		
35.58	539.66		
37.41	540.18		
39.63	540.44		
57.71	540.47		
74.79	540.79		



Appendix 2. Morphological Summary Data and Plots
Cross-Section Plots
Underwood Mitigation Site (NCEEP Project No. 94641)
SF4A, Cross-Section 17 (Riffle)
Monitoring Year 0

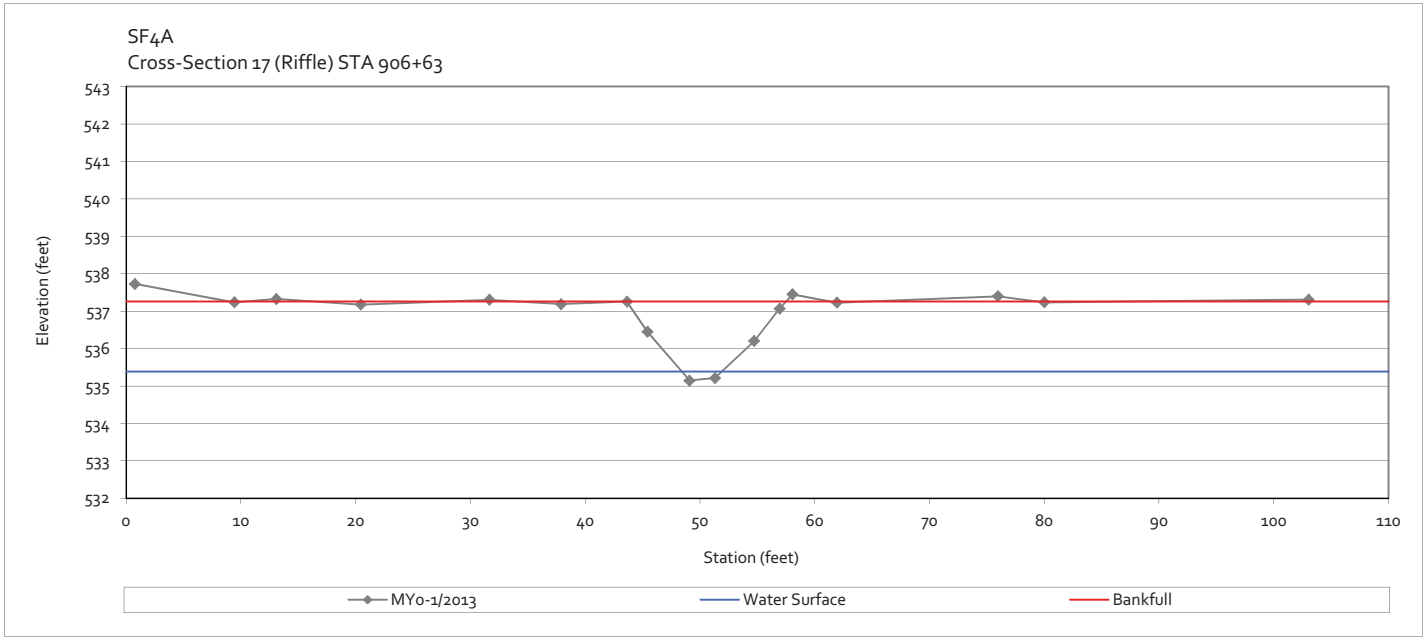
River Basin	Cape Fear
Watershed HUC	303002050050
XS ID	17
Drainage Area	637 acres
Date	1/22/2013
Field Crew	DT, AT

Summary Data	
Bankfull Elevation (ft)	537.3
Bankfull Cross-Sectional Area (ft2)	17.5
Bankfull Width (ft)	13.9
Flood Prone Area Elevation (ft)	539.4
Flood Prone Width (ft)	200+
Max Depth at Bankfull (ft)	2.1
Mean Depth at Bankfull (ft)	1.3
W/D Ratio	11.0
Entrenchment Ratio	2.2+
Bank Height Ratio	1.0
Stream Type	E

Cross-Section 17: View Upstream (1/22/2013)

Cross-Section 17: View Downstream (1/22/2013)

Station	Elevation	Station	Elevation
0.78	537.73		
9.43	537.23		
13.10	537.32		
20.45	537.18		
31.66	537.30		
37.92	537.19		
43.64	537.26		
45.43	536.45		
49.10	535.14		
51.31	535.21		
54.73	536.20		
56.94	537.07		
58.08	537.45		
61.94	537.22		
75.98	537.40		
80.01	537.23		
103.03	537.31		



Appendix 2. Morphological Summary Data and Plots
Cross-Section Plots
Underwood Mitigation Site (NCEEP Project No. 94641)
SF4A, Cross-Section 18 (Pool)
Monitoring Year 0

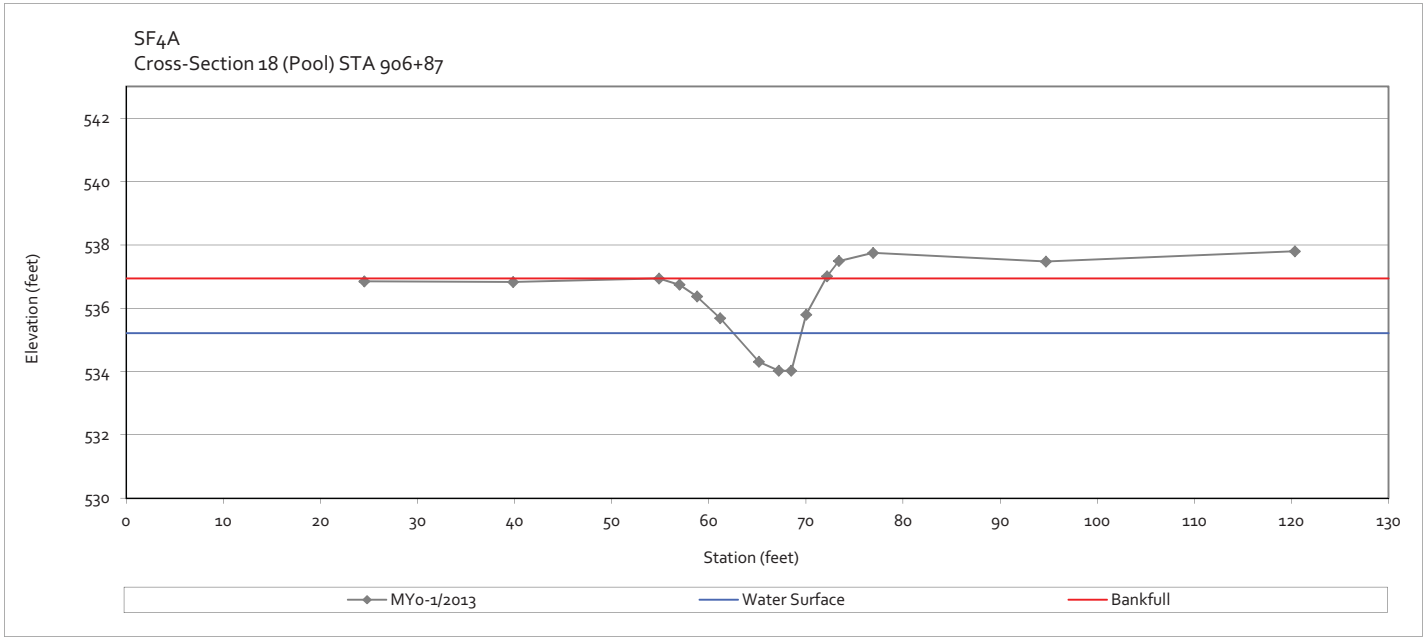
River Basin	Cape Fear
Watershed HUC	303002050050
XS ID	18
Drainage Area	637 acres
Date	1/22/2013
Field Crew	DT, AT

Summary Data	
Bankfull Elevation (ft)	536.9
Bankfull Cross-Sectional Area (ft2)	22.9
Bankfull Width (ft)	16.0
Flood Prone Area Elevation (ft)	N/A
Flood Prone Width (ft)	N/A
Max Depth at Bankfull (ft)	2.8
Mean Depth at Bankfull (ft)	1.4
W/D Ratio	11.1
Entrenchment Ratio	N/A
Bank Height Ratio	1.0
Stream Type	N/A

Cross-Section 18: View Upstream (1/22/2013)

Cross-Section 18: View Downstream (1/22/2013)

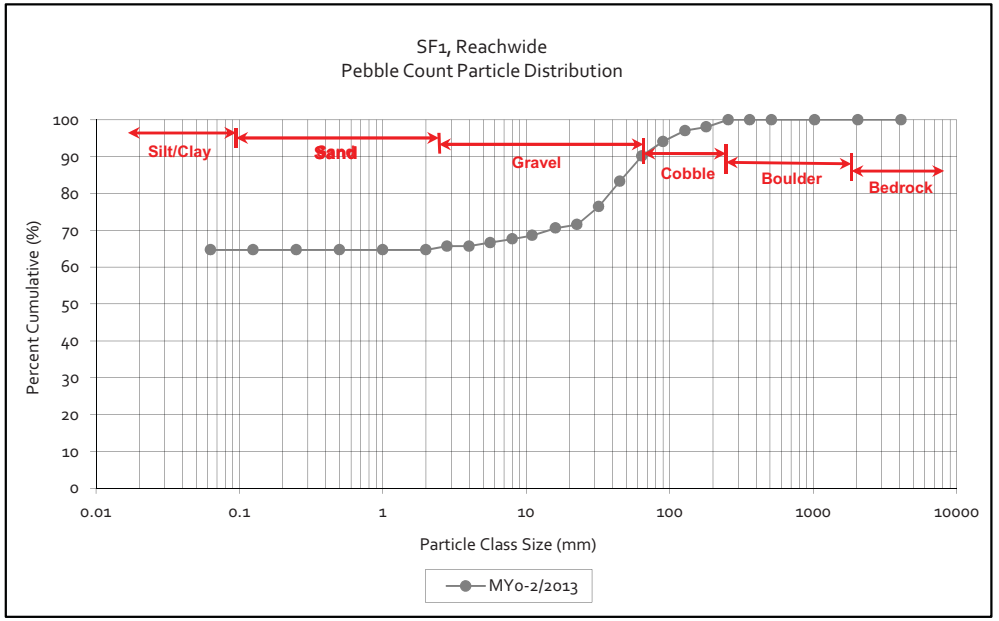
Station	Elevation	Station	Elevation
24.54	536.85		
39.86	536.83		
54.87	536.94		
56.98	536.74		
58.79	536.37		
61.19	535.68		
65.17	534.31		
67.20	534.03		
68.50	534.02		
70.04	535.79		
72.18	537.00		
73.39	537.49		
76.92	537.75		
94.74	537.48		
120.37	537.79		

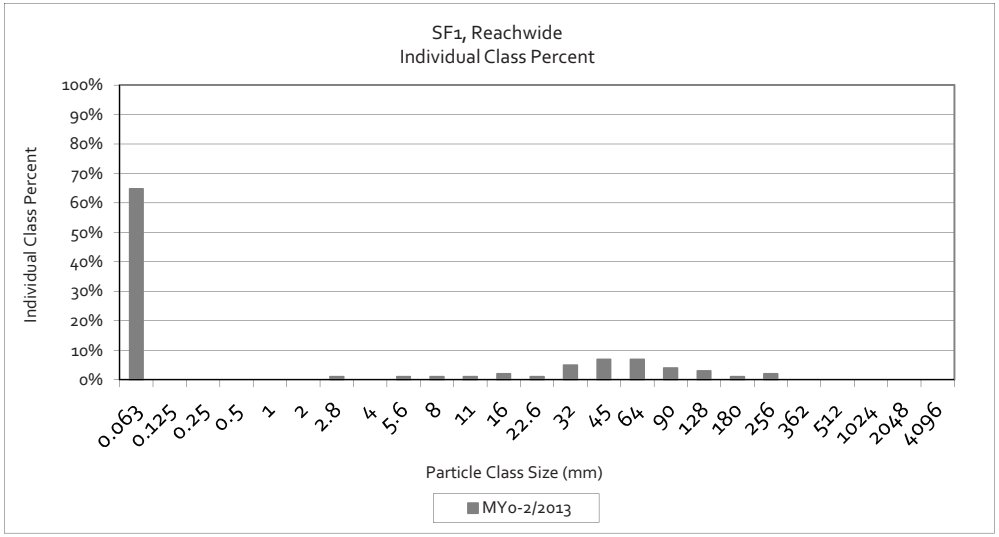


Appendix 2. Morphological Summary Data and Plots
Reachwide and Cross-Section Pebble Count Plots
Underwood Mitigation Site (NCEEP Project No. 94641)
SF1, Reachwide
Monitoring Year 0

Particle Class		Diameter (mm)		Particle Count			SF1 Reach Summary	
		min	max	Riffle	Pool	Total	Class Percentage	Percent Cumulative
SILT/CLAY	Silt/Clay	0.000	0.062	26	40	66	65	65
SAND	Very fine	0.062	0.125					65
	Fine	0.125	0.250					65
	Medium	0.250	0.500					65
	Coarse	0.5	1.0					65
	Very Coarse	1.0	2.0					65
GRAVEL	Very Fine	2.0	2.8	1		1	1	66
	Very Fine	2.8	4.0					66
	Fine	4.0	5.7	1		1	1	67
	Fine	5.7	8.0	1		1	1	68
	Medium	8.0	11.3	1		1	1	69
	Medium	11.3	16.0	2		2	2	71
	Coarse	16.0	22.6	1		1	1	72
	Coarse	22.6	32	5		5	5	76
	Very Coarse	32	45	7		7	7	83
	Very Coarse	45	64	7		7	7	90
COBBLE	Small	64	90	4		4	4	94
	Small	90	128	3		3	3	97
	Large	128	180	1		1	1	98
	Large	180	256	2		2	2	100
BOULDER	Small	256	362					100
	Small	362	512					100
	Medium	512	1024					100
	Large/Very Large	1024	2048					100
BEDROCK	Bedrock	2048	>2048					100
			Total	**62**	**40**	**102**	**100**	**100**

Reachwide	
Channel materials (mm)	
D_{16} =	silt/clay
D_{35} =	silt/clay
D_{50} =	silt/clay
D_{84} =	46.6
D_{95} =	100.0
D_{100} =	256.0

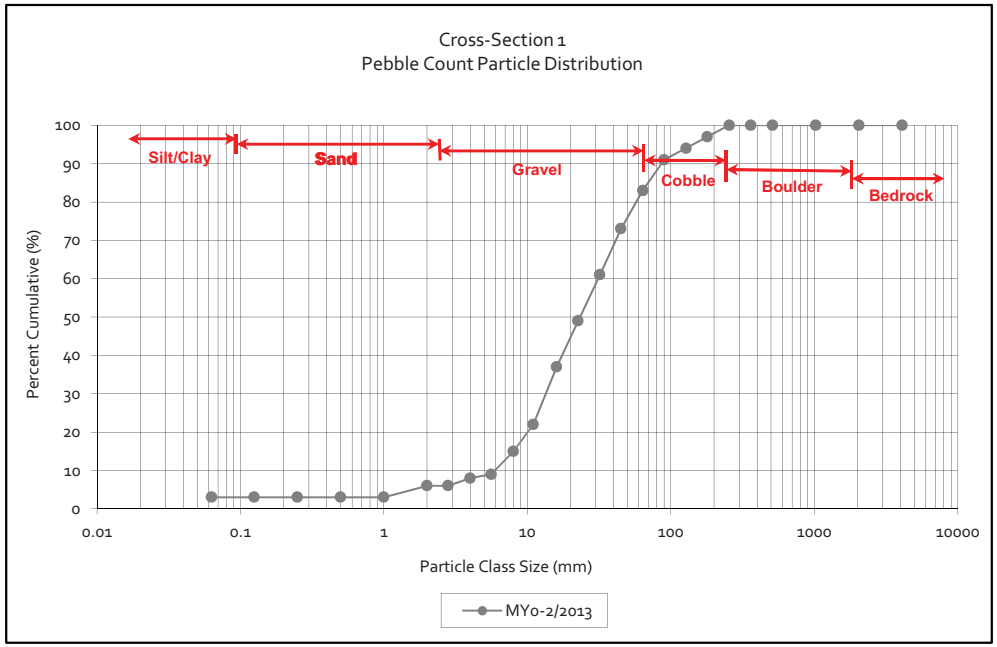


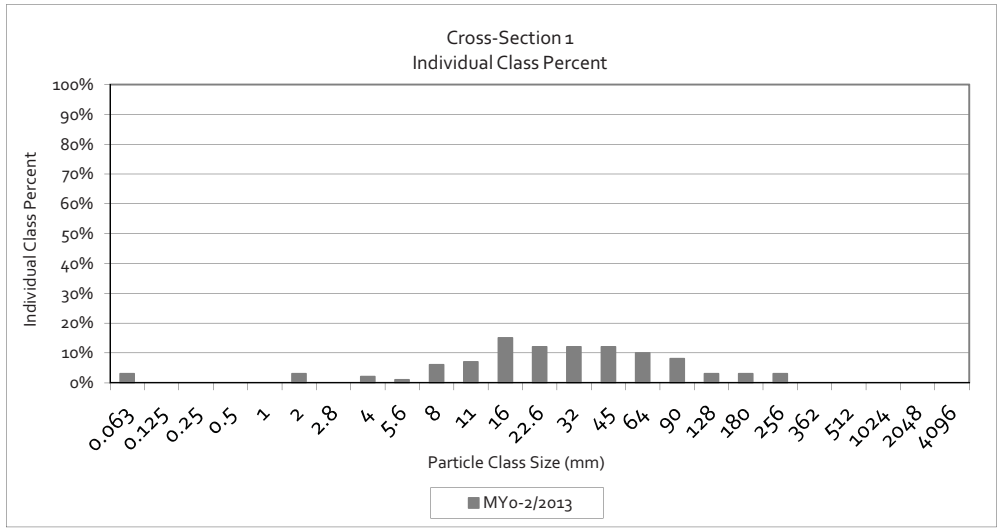


Appendix 2. Morphological Summary Data and Plots
Reachwide and Cross-Section Substrate Plots
Underwood Mitigation Site (NCEEP Project No. 94641)
SF1, Cross-Section 1
Monitoring Year 0

Particle Class		Diameter (mm)		Particle Count	Cross-Section 1 Summary	
		min	max	Total	Class Percentage	Percent Cumulative
SILT/CLAY	Silt/Clay	0.000	0.062	3	3	3
SAND	Very fine	0.062	0.125			3
	Fine	0.125	0.250			3
	Medium	0.250	0.500			3
	Coarse	0.5	1.0			3
	Very Coarse	1.0	2.0	3	3	6
GRAVEL	Very Fine	2.0	2.8			6
	Very Fine	2.8	4.0	2	2	8
	Fine	4.0	5.7	1	1	9
	Fine	5.7	8.0	6	6	15
	Medium	8.0	11.3	7	7	22
	Medium	11.3	16.0	15	15	37
	Coarse	16.0	22.6	12	12	49
	Coarse	22.6	32	12	12	61
	Very Coarse	32	45	12	12	73
	Very Coarse	45	64	10	10	83
COBBLE	Small	64	90	8	8	91
	Small	90	128	3	3	94
	Large	128	180	3	3	97
	Large	180	256	3	3	100
BOULDER	Small	256	362			100
	Small	362	512			100
	Medium	512	1024			100
	Large/Very Large	1024	2048			100
BEDROCK	Bedrock	2048	>2048			100
			Total	100	100	100

Cross-Section 1	
Channel materials (mm)	
D_{16} =	8.4
D_{35} =	15.2
D_{50} =	23.3
D_{84} =	66.8
D_{95} =	143.4
D_{100} =	256.0

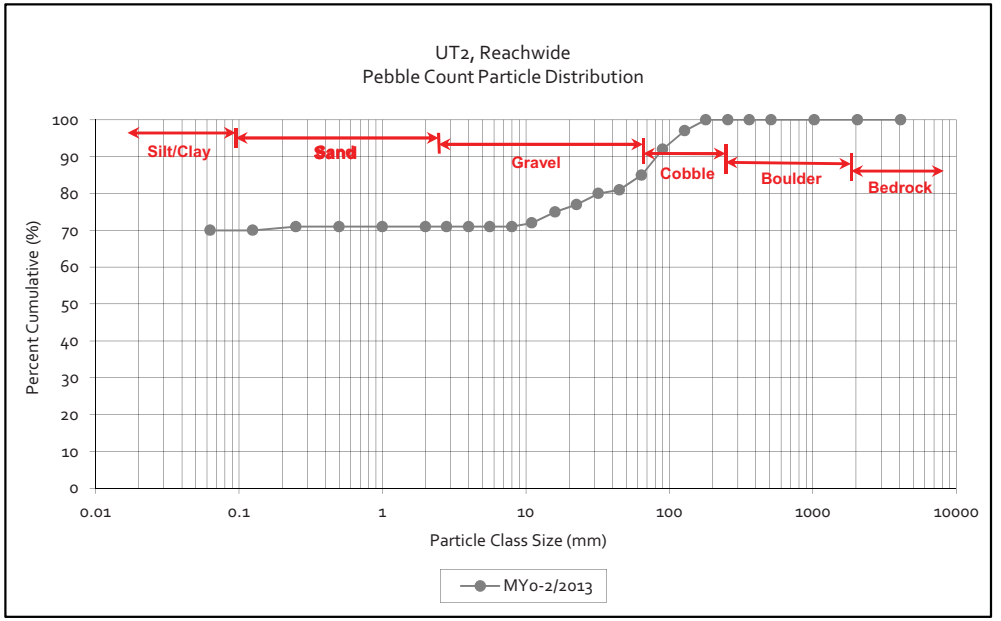


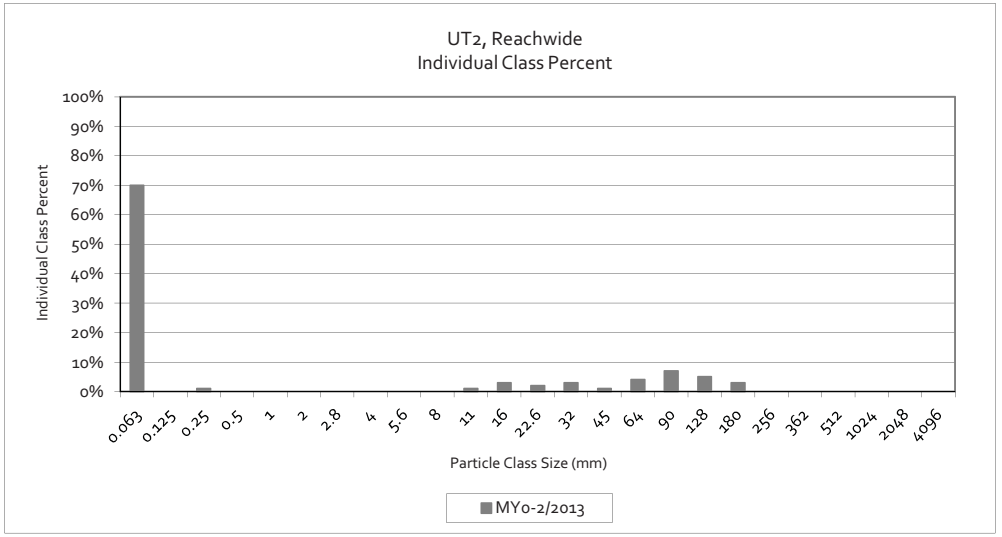


Appendix 2. Morphological Summary Data and Plots
Reachwide and Cross-Section Pebble Count Plots
Underwood Mitigation Site (NCEEP Project No. 94641)
UT2, Reachwide
Monitoring Year 0

Particle Class		Diameter (mm)		Particle Count			UT2 Reach Summary	
		min	max	Riffle	Pool	Total	Class Percentage	Percent Cumulative
SILT/CLAY	Silt/Clay	0.000	0.062	20	50	70	70	70
SAND	Very fine	0.062	0.125					70
	Fine	0.125	0.250	1		1	1	71
	Medium	0.250	0.500					71
	Coarse	0.5	1.0					71
	Very Coarse	1.0	2.0					71
GRAVEL	Very Fine	2.0	2.8					71
	Very Fine	2.8	4.0					71
	Fine	4.0	5.7					71
	Fine	5.7	8.0					71
	Medium	8.0	11.3	1		1	1	72
	Medium	11.3	16.0	3		3	3	75
	Coarse	16.0	22.6	2		2	2	77
	Coarse	22.6	32	3		3	3	80
	Very Coarse	32	45	1		1	1	81
	Very Coarse	45	64	4		4	4	85
COBBLE	Small	64	90	7		7	7	92
	Small	90	128	5		5	5	97
	Large	128	180	3		3	3	100
	Large	180	256					100
BOULDER	Small	256	362					100
	Small	362	512					100
	Medium	512	1024					100
	Large/Very Large	1024	2048					100
BEDROCK	Bedrock	2048	>2048					100
			Total	50	50	100	100	100

Reachwide	
Channel materials (mm)	
D_{16} =	silt/clay
D_{35} =	silt/clay
D_{50} =	silt/clay
D_{84} =	58.6
D_{95} =	111.2
D_{100} =	180.0

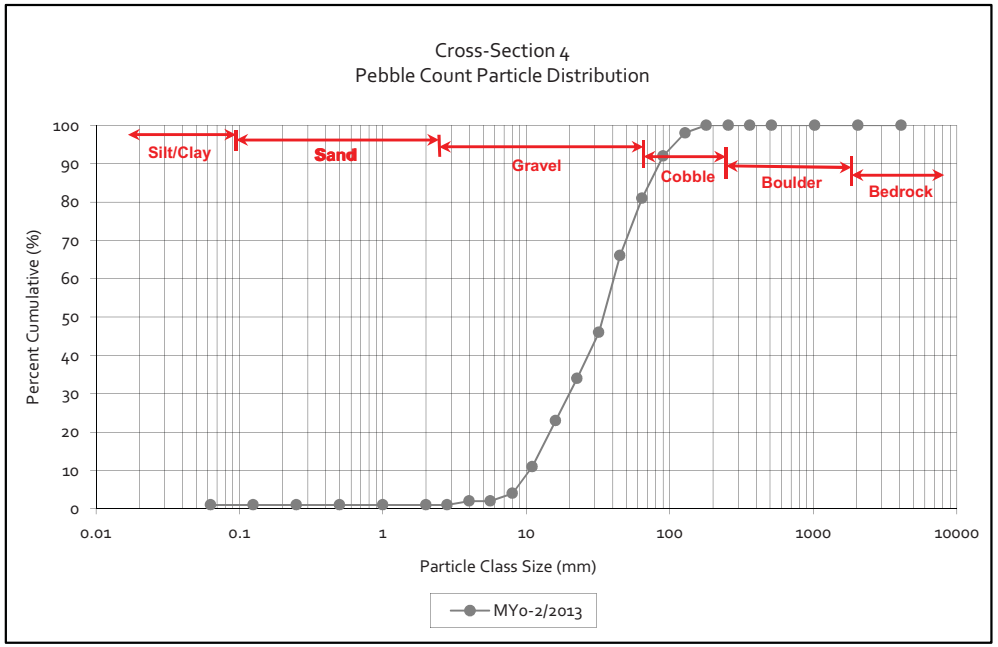


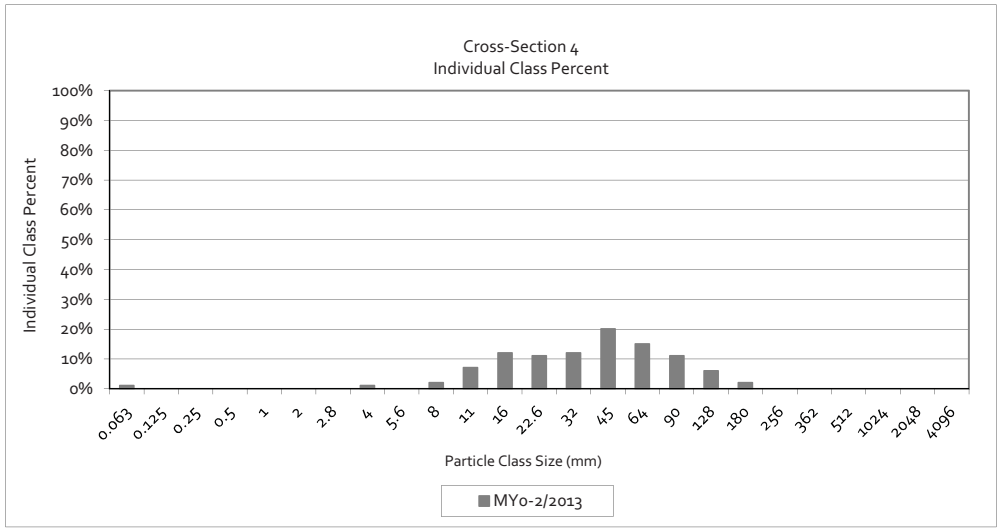


Appendix 2. Morphological Summary Data and Plots
Reachwide and Cross-Section Substrate Plots
Underwood Mitigation Site (NCEEP Project No. 94641)
UT2, Cross-Section 4
Monitoring Year 0

Particle Class		Diameter (mm) min	Diameter (mm) max	Particle Count Total	Cross-Section 4 Summary Class Percentage	Cross-Section 4 Summary Percent Cumulative
SILT/CLAY	Silt/Clay	0.000	0.062	1	1	1
SAND	Very fine	0.062	0.125			1
	Fine	0.125	0.250			1
	Medium	0.250	0.500			1
	Coarse	0.5	1.0			1
	Very Coarse	1.0	2.0			1
GRAVEL	Very Fine	2.0	2.8			1
	Very Fine	2.8	4.0	1	1	2
	Fine	4.0	5.7			2
	Fine	5.7	8.0	2	2	4
	Medium	8.0	11.3	7	7	11
	Medium	11.3	16.0	12	12	23
	Coarse	16.0	22.6	11	11	34
	Coarse	22.6	32	12	12	46
	Very Coarse	32	45	20	20	66
	Very Coarse	45	64	15	15	81
COBBLE	Small	64	90	11	11	92
	Small	90	128	6	6	98
	Large	128	180	2	2	100
	Large	180	256			100
BOULDER	Small	256	362			100
	Small	362	512			100
	Medium	512	1024			100
	Large/Very Large	1024	2048			100
BEDROCK	Bedrock	2048	>2048			100
			Total	100	100	100

Cross-Section 4 Channel materials (mm)	
D_{16} =	12.9
D_{35} =	23.3
D_{50} =	34.3
D_{84} =	70.2
D_{95} =	107.3
D_{100} =	180.0

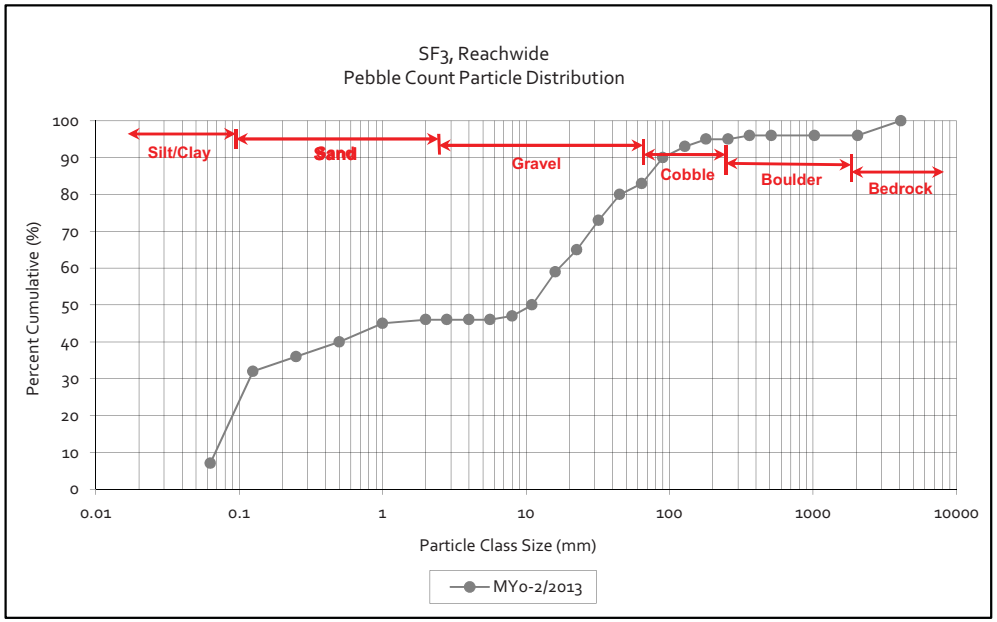


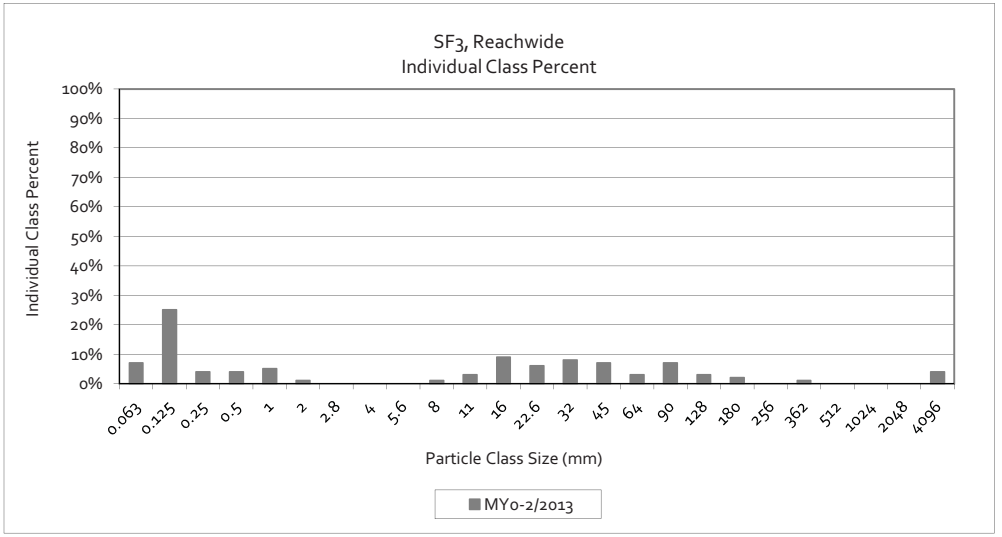


Appendix 2. Morphological Summary Data and Plots
Reachwide and Cross-Section Pebble Count Plots
Underwood Mitigation Site (NCEEP Project No. 94641)
SF3, Reachwide
Monitoring Year 0

Particle Class		Diameter (mm)		Particle Count			SF3 Reach Summary	
		min	max	Riffle	Pool	Total	Class Percentage	Percent Cumulative
SILT/CLAY	Silt/Clay	0.000	0.062		7	7	7	7
SAND	Very fine	0.062	0.125	18	7	25	25	32
	Fine	0.125	0.250	1	3	4	4	36
	Medium	0.250	0.500		4	4	4	40
	Coarse	0.5	1.0	2	3	5	5	45
	Very Coarse	1.0	2.0	1		1	1	46
GRAVEL	Very Fine	2.0	2.8					46
	Very Fine	2.8	4.0					46
	Fine	4.0	5.7					46
	Fine	5.7	8.0	1		1	1	47
	Medium	8.0	11.3	1	2	3	3	50
	Medium	11.3	16.0	4	5	9	9	59
	Coarse	16.0	22.6	4	2	6	6	65
	Coarse	22.6	32	8		8	8	73
	Very Coarse	32	45	4	3	7	7	80
	Very Coarse	45	64	3		3	3	83
COBBLE	Small	64	90	7		7	7	90
	Small	90	128	3		3	3	93
	Large	128	180	2		2	2	95
	Large	180	256					95
BOULDER	Small	256	362	1		1	1	96
	Small	362	512					96
	Medium	512	1024					96
	Large/Very Large	1024	2048					96
BEDROCK	Bedrock	2048	>2048		4	4	4	100
			Total	60	40	100	100	100

Reachwide	
Channel materials (mm)	
D_{16} =	0.08
D_{35} =	0.21
D_{50} =	11.0
D_{84} =	67.2
D_{95} =	256.0
D_{100} =	>2048

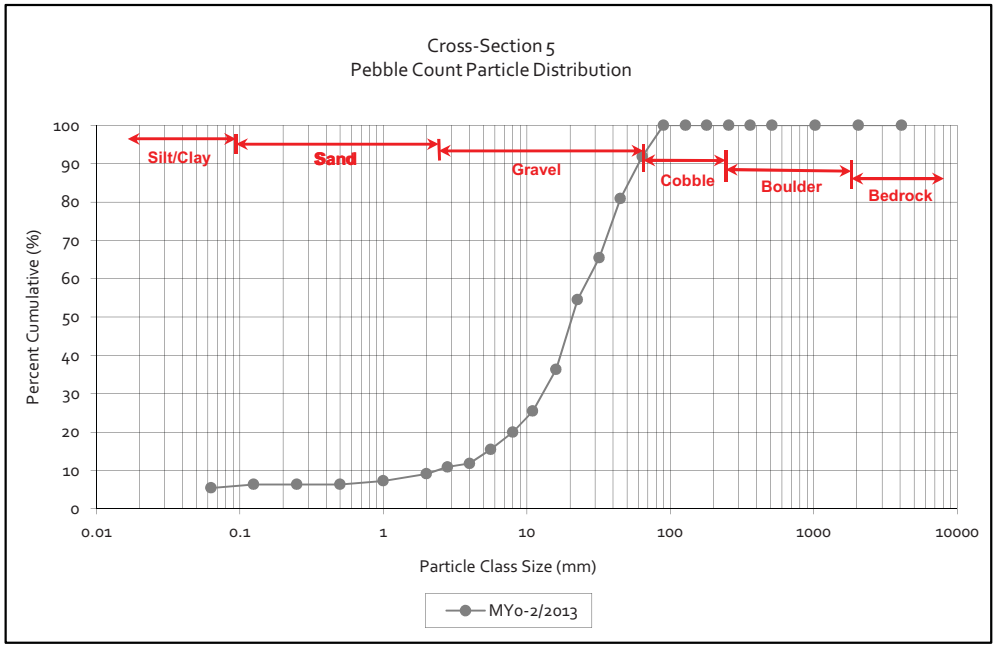


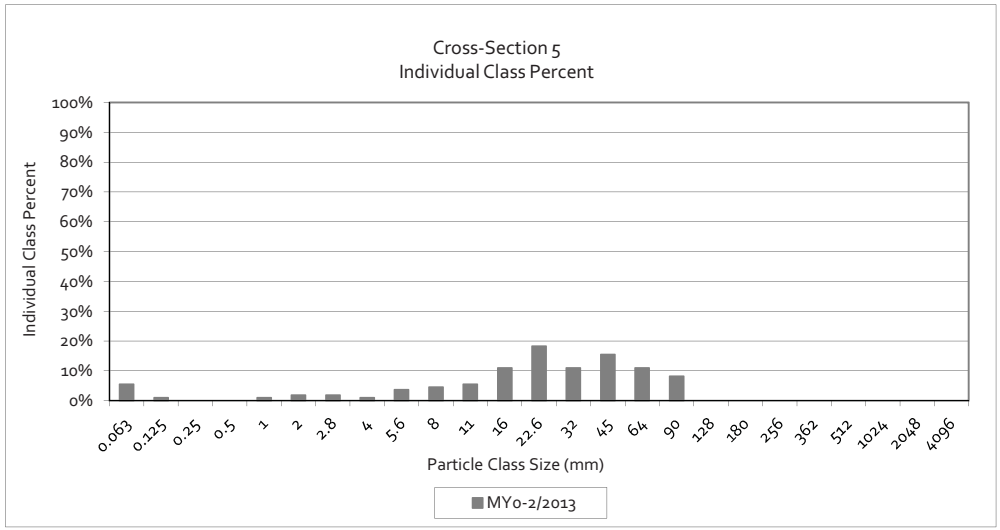


Appendix 2. Morphological Summary Data and Plots
Reachwide and Cross-Section Substrate Plots
Underwood Mitigation Site (NCEEP Project No. 94641)
SF3, Cross-Section 5
Monitoring Year 0

Particle Class		Diameter (mm)		Particle Count	Cross-Section 5 Summary	
		min	max	Total	Class Percentage	Percent Cumulative
SILT/CLAY	Silt/Clay	0.000	0.062	6	5	5
SAND	Very fine	0.062	0.125	1	1	6
	Fine	0.125	0.250			6
	Medium	0.250	0.500			6
	Coarse	0.5	1.0	1	1	7
	Very Coarse	1.0	2.0	2	2	9
GRAVEL	Very Fine	2.0	2.8	2	2	11
	Very Fine	2.8	4.0	1	1	12
	Fine	4.0	5.7	4	4	15
	Fine	5.7	8.0	5	5	20
	Medium	8.0	11.3	6	5	25
	Medium	11.3	16.0	12	11	36
	Coarse	16.0	22.6	20	18	55
	Coarse	22.6	32	12	11	65
	Very Coarse	32	45	17	15	81
	Very Coarse	45	64	12	11	92
COBBLE	Small	64	90	9	8	100
	Small	90	128			100
	Large	128	180			100
	Large	180	256			100
BOULDER	Small	256	362			100
	Small	362	512			100
	Medium	512	1024			100
	Large/Very Large	1024	2048			100
BEDROCK	Bedrock	2048	>2048			100
			Total	110	100	100

Cross-Section 5	
Channel materials (mm)	
D_{16} =	5.8
D_{35} =	15.3
D_{50} =	20.7
D_{84} =	49.7
D_{95} =	73.1
D_{100} =	90.0

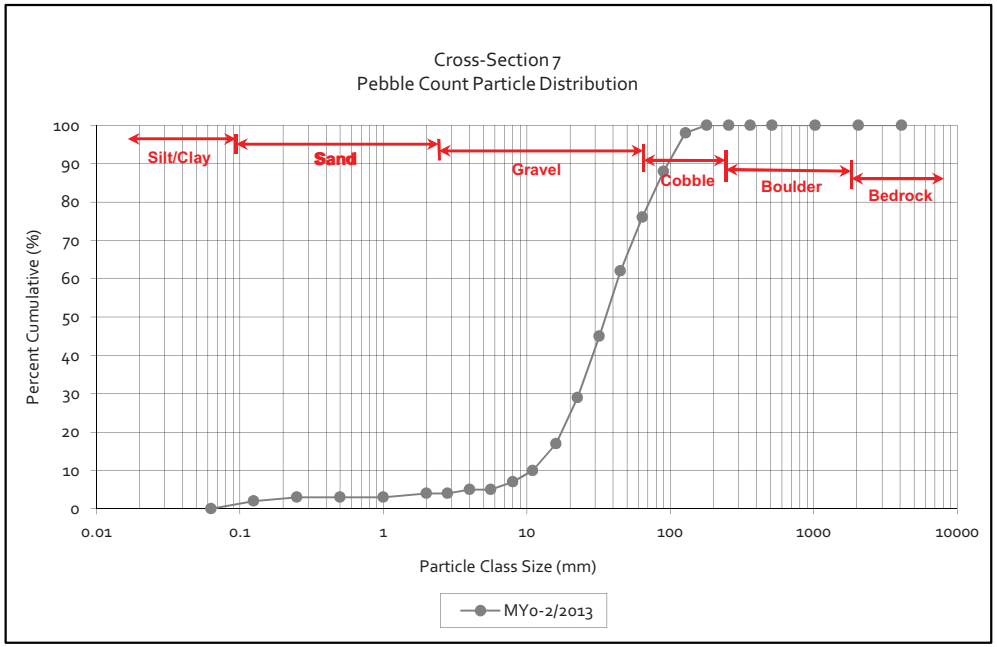


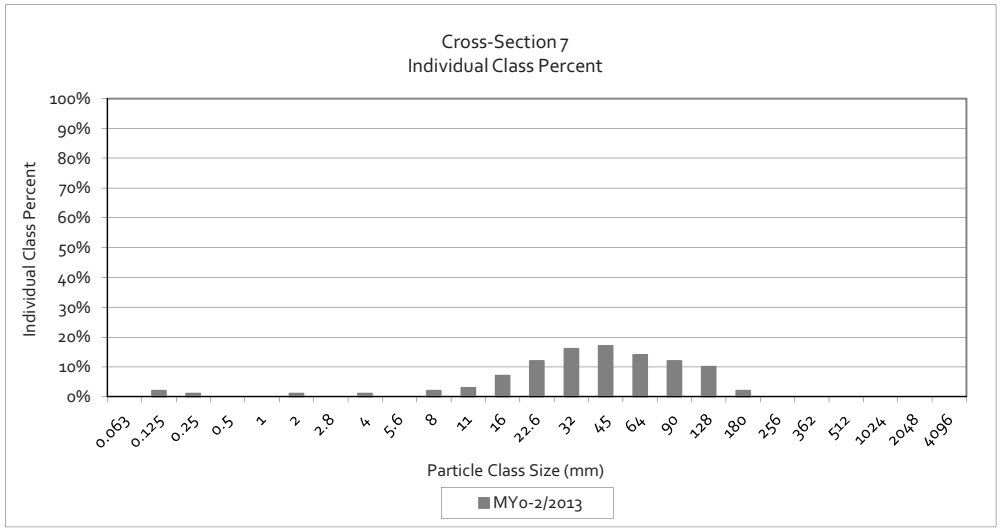


Appendix 2. Morphological Summary Data and Plots
Reachwide and Cross-Section Substrate Plots
Underwood Mitigation Site (NCEEP Project No. 94641)
SF3, Cross-Section 7
Monitoring Year 0

Particle Class		Diameter (mm)		Particle Count	Cross-Section 7 Summary	
		min	max	Total	Class Percentage	Percent Cumulative
SILT/CLAY	Silt/Clay	0.000	0.062			0
SAND	Very fine	0.062	0.125	2	2	2
	Fine	0.125	0.250	1	1	3
	Medium	0.250	0.500			3
	Coarse	0.5	1.0			3
	Very Coarse	1.0	2.0	1	1	4
GRAVEL	Very Fine	2.0	2.8			4
	Very Fine	2.8	4.0	1	1	5
	Fine	4.0	5.7			5
	Fine	5.7	8.0	2	2	7
	Medium	8.0	11.3	3	3	10
	Medium	11.3	16.0	7	7	17
	Coarse	16.0	22.6	12	12	29
	Coarse	22.6	32	16	16	45
	Very Coarse	32	45	17	17	62
	Very Coarse	45	64	14	14	76
COBBLE	Small	64	90	12	12	88
	Small	90	128	10	10	98
	Large	128	180	2	2	100
	Large	180	256			100
BOULDER	Small	256	362			100
	Small	362	512			100
	Medium	512	1024			100
	Large/Very Large	1024	2048			100
BEDROCK	Bedrock	2048	>2048			100
			Total	100	100	100

Cross-Section 7	
Channel materials (mm)	
D_{16} =	15.2
D_{35} =	25.7
D_{50} =	35.4
D_{84} =	80.3
D_{95} =	115.2
D_{100} =	180.0

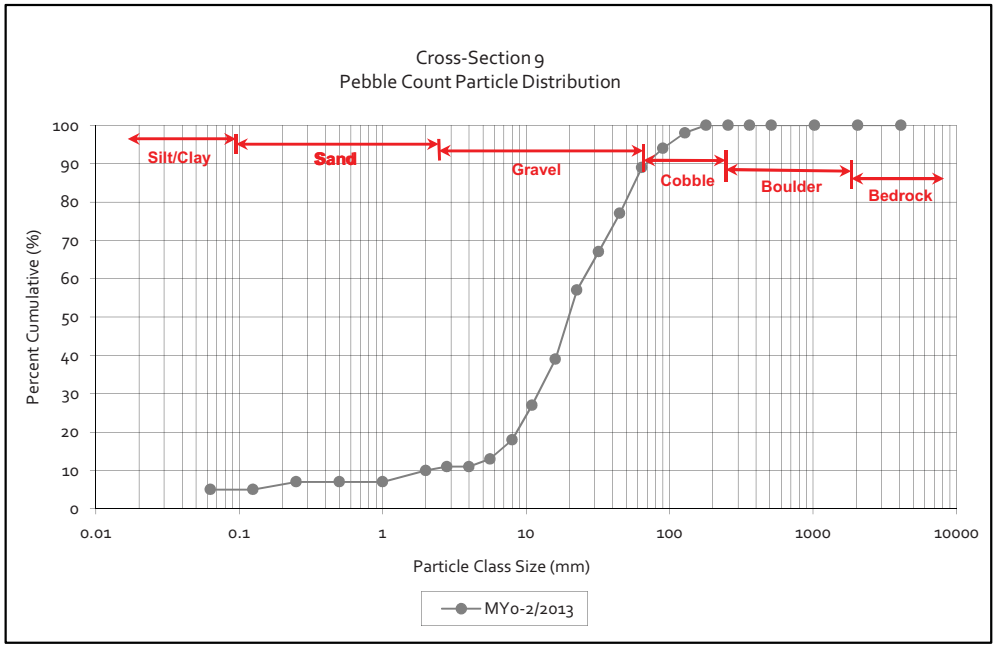


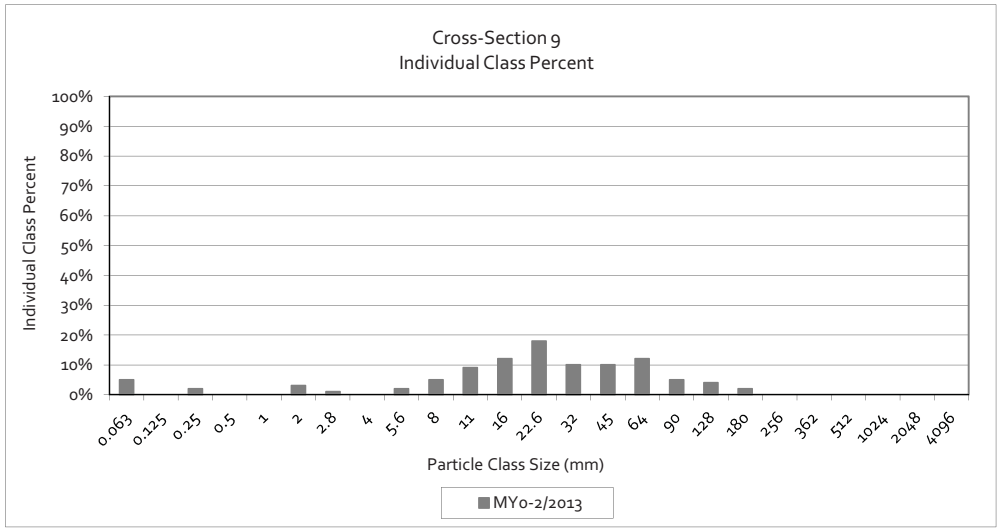


Appendix 2. Morphological Summary Data and Plots
Reachwide and Cross-Section Substrate Plots
Underwood Mitigation Site (NCEEP Project No. 94641)
SF3, Cross-Section 9
Monitoring Year 0

Particle Class		Diameter (mm)		Particle Count	Cross-Section 9 Summary	
		min	max	Total	Class Percentage	Percent Cumulative
SILT/CLAY	Silt/Clay	0.000	0.062	5	5	5
SAND	Very fine	0.062	0.125			5
	Fine	0.125	0.250	2	2	7
	Medium	0.250	0.500			7
	Coarse	0.5	1.0			7
	Very Coarse	1.0	2.0	3	3	10
GRAVEL	Very Fine	2.0	2.8	1	1	11
	Very Fine	2.8	4.0			11
	Fine	4.0	5.7	2	2	13
	Fine	5.7	8.0	5	5	18
	Medium	8.0	11.3	9	9	27
	Medium	11.3	16.0	12	12	39
	Coarse	16.0	22.6	18	18	57
	Coarse	22.6	32	10	10	67
	Very Coarse	32	45	10	10	77
	Very Coarse	45	64	12	12	89
COBBLE	Small	64	90	5	5	94
	Small	90	128	4	4	98
	Large	128	180	2	2	100
	Large	180	256			100
BOULDER	Small	256	362			100
	Small	362	512			100
	Medium	512	1024			100
	Large/Very Large	1024	2048			100
BEDROCK	Bedrock	2048	>2048			100
			Total	100	100	100

Cross-Section 9	
Channel materials (mm)	
D_{16} =	6.9
D_{35} =	14.1
D_{50} =	19.8
D_{84} =	55.3
D_{95} =	98.3
D_{100} =	180.0

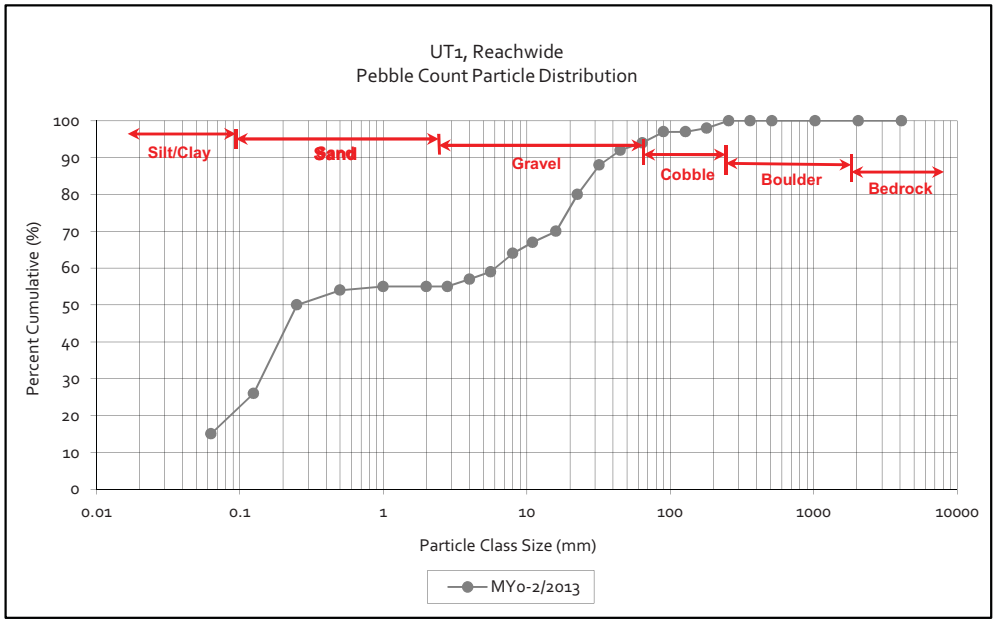


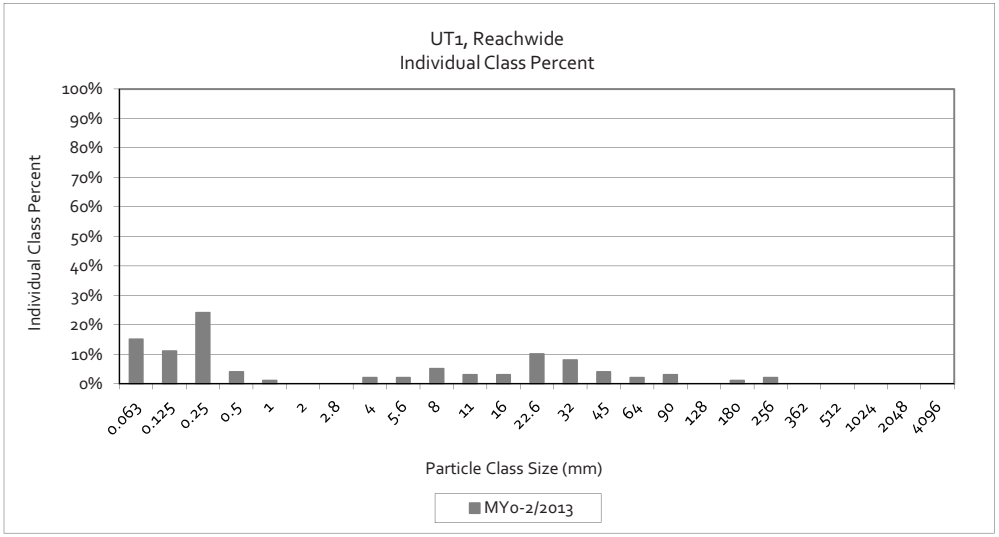


Appendix 2. Morphological Summary Data and Plots
Reachwide and Cross-Section Pebble Count Plots
Underwood Mitigation Site (NCEEP Project No. 94641)
UT1, Reachwide
Monitoring Year 0

Particle Class		Diameter (mm)		Particle Count			UT1 Reach Summary	
		min	max	Riffle	Pool	Total	Class Percentage	Percent Cumulative
SILT/CLAY	Silt/Clay	0.000	0.062	8	7	15	15	15
SAND	Very fine	0.062	0.125	5	6	11	11	26
	Fine	0.125	0.250	8	16	24	24	50
	Medium	0.250	0.500		4	4	4	54
	Coarse	0.5	1.0		1	1	1	55
	Very Coarse	1.0	2.0					55
GRAVEL	Very Fine	2.0	2.8					55
	Very Fine	2.8	4.0		2	2	2	57
	Fine	4.0	5.7	1	1	2	2	59
	Fine	5.7	8.0	3	2	5	5	64
	Medium	8.0	11.3	3		3	3	67
	Medium	11.3	16.0	2	1	3	3	70
	Coarse	16.0	22.6	10		10	10	80
	Coarse	22.6	32	13		8	8	88
	Very Coarse	32	45	4		4	4	92
	Very Coarse	45	64	2		2	2	94
COBBLE	Small	64	90	3		3	3	97
	Small	90	128					97
	Large	128	180	1		1	1	98
	Large	180	256	2		2	2	100
BOULDER	Small	256	362					100
	Small	362	512					100
	Medium	512	1024					100
	Large/Very Large	1024	2048					100
BEDROCK	Bedrock	2048	>2048					100
			Total	65	40	100	100	100

Reachwide	
Channel materials (mm)	
D_{16} =	0.07
D_{35} =	0.16
D_{50} =	0.3
D_{84} =	26.9
D_{95} =	71.7
D_{100} =	256.0

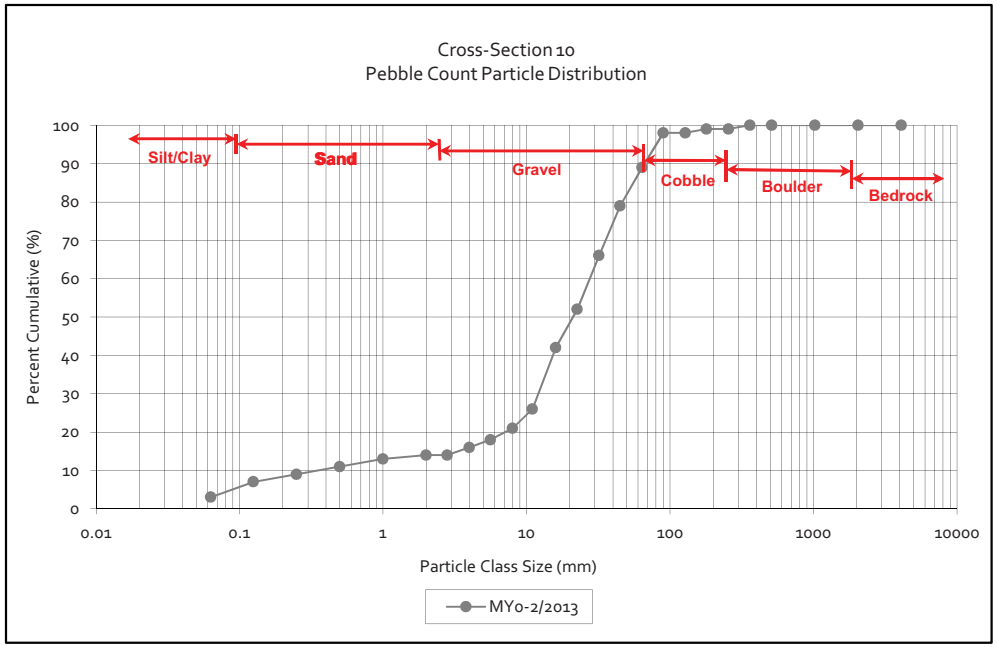


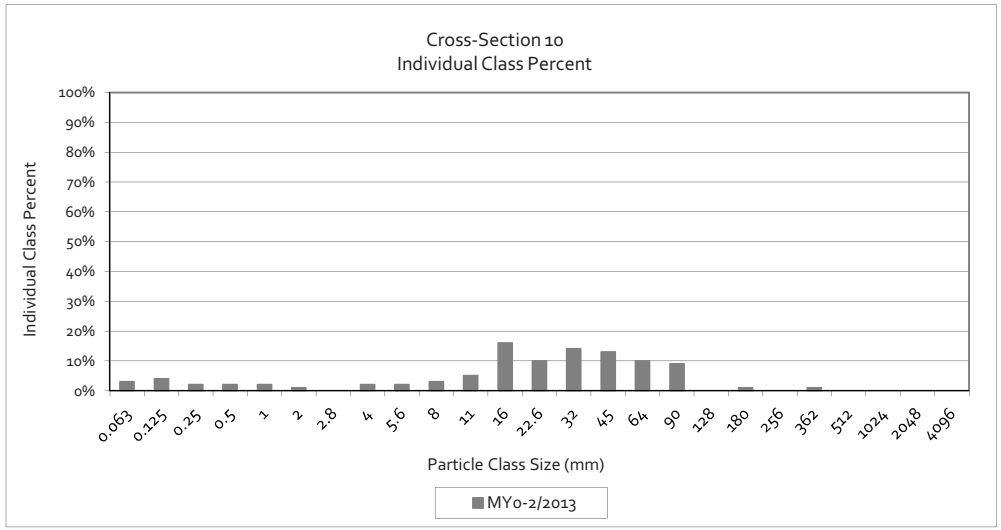


Appendix 2. Morphological Summary Data and Plots
Reachwide and Cross-Section Substrate Plots
Underwood Mitigation Site (NCEEP Project No. 94641)
UT1, Cross-Section 10
Monitoring Year 0

Particle Class		Diameter (mm)		Particle Count	Cross-Section 10 Summary	
		min	max	Total	Class Percentage	Percent Cumulative
SILT/CLAY	Silt/Clay	0.000	0.062	3	3	3
SAND	Very fine	0.062	0.125	4	4	7
	Fine	0.125	0.250	2	2	9
	Medium	0.250	0.500	2	2	11
	Coarse	0.5	1.0	2	2	13
	Very Coarse	1.0	2.0	1	1	14
GRAVEL	Very Fine	2.0	2.8			14
	Very Fine	2.8	4.0	2	2	16
	Fine	4.0	5.7	2	2	18
	Fine	5.7	8.0	3	3	21
	Medium	8.0	11.3	5	5	26
	Medium	11.3	16.0	16	16	42
	Coarse	16.0	22.6	10	10	52
	Coarse	22.6	32	14	14	66
	Very Coarse	32	45	13	13	79
	Very Coarse	45	64	10	10	89
COBBLE	Small	64	90	9	9	98
	Small	90	128			98
	Large	128	180	1	1	99
	Large	180	256			99
BOULDER	Small	256	362	1	1	100
	Small	362	512			100
	Medium	512	1024			100
	Large/Very Large	1024	2048			100
BEDROCK	Bedrock	2048	>2048			100
			Total	100	100	100

Cross-Section 10 Channel materials (mm)	
D_{16} =	4.0
D_{35} =	13.6
D_{50} =	21.1
D_{84} =	53.7
D_{95} =	80.3
D_{100} =	362.0

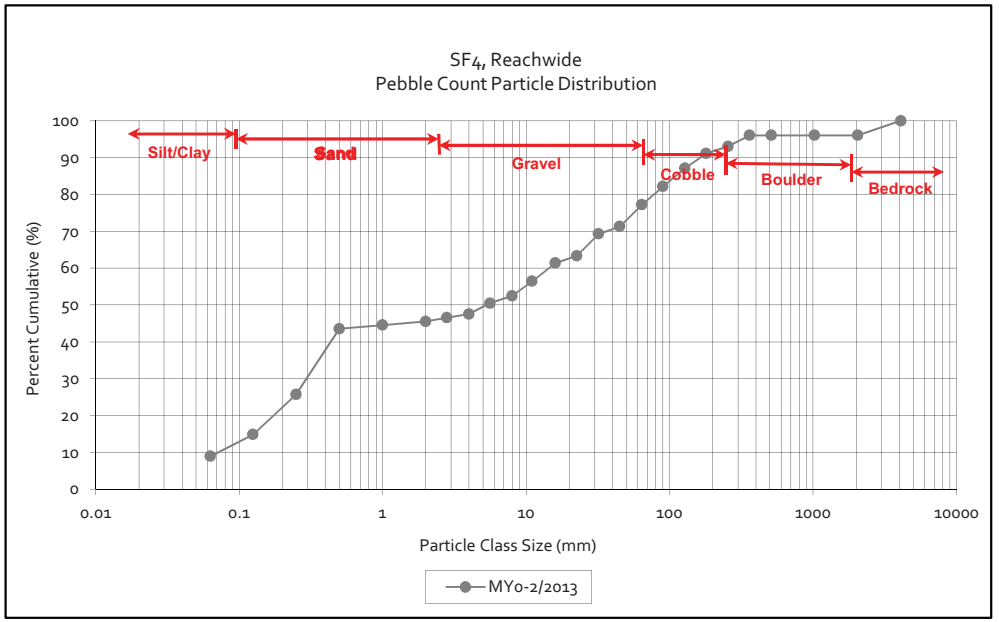


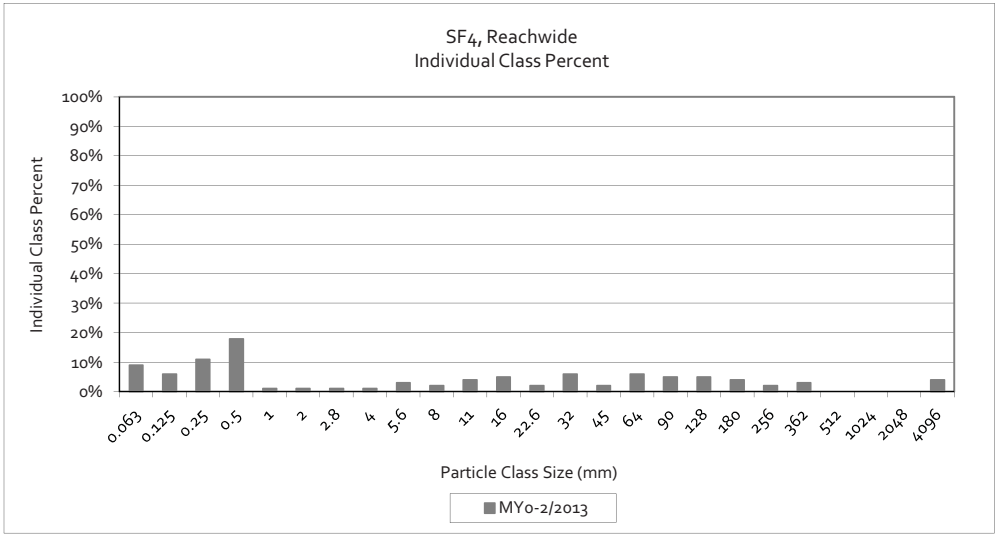


Appendix 2. Morphological Summary Data and Plots
Reachwide and Cross-Section Pebble Count Plots
Underwood Mitigation Site (NCEEP Project No. 94641)
SF4, Reachwide
Monitoring Year 0

Particle Class		Diameter (mm)		Particle Count			SF4 Reach Summary	
		min	max	Riffle	Pool	Total	Class Percentage	Percent Cumulative
SILT/CLAY	Silt/Clay	0.000	0.062	2	7	9	9	9
SAND	Very fine	0.062	0.125	3	3	6	6	15
	Fine	0.125	0.250	5	6	11	11	26
	Medium	0.250	0.500	2	16	18	18	44
	Coarse	0.5	1.0		1	1	1	45
	Very Coarse	1.0	2.0		1	1	1	46
GRAVEL	Very Fine	2.0	2.8	1		1	1	47
	Very Fine	2.8	4.0	1		1	1	48
	Fine	4.0	5.7	1	2	3	3	50
	Fine	5.7	8.0	1	1	2	2	52
	Medium	8.0	11.3	3	1	4	4	56
	Medium	11.3	16.0	3	2	5	5	61
	Coarse	16.0	22.6	2		2	2	63
	Coarse	22.6	32	4	2	6	6	69
	Very Coarse	32	45	1	1	2	2	71
	Very Coarse	45	64	5	1	6	6	77
COBBLE	Small	64	90	5		5	5	82
	Small	90	128	4	1	5	5	87
	Large	128	180	3	1	4	4	91
	Large	180	256	2		2	2	93
BOULDER	Small	256	362	3		3	3	96
	Small	362	512					96
	Medium	512	1024					96
	Large/Very Large	1024	2048					96
BEDROCK	Bedrock	2048	>2048		4	4	4	100
			Total	51	50	101	100	100

Reachwide	
Channel materials (mm)	
D_{16} =	0.13
D_{35} =	0.36
D_{50} =	5.3
D_{84} =	102.5
D_{95} =	320.7
D_{100} =	>2048

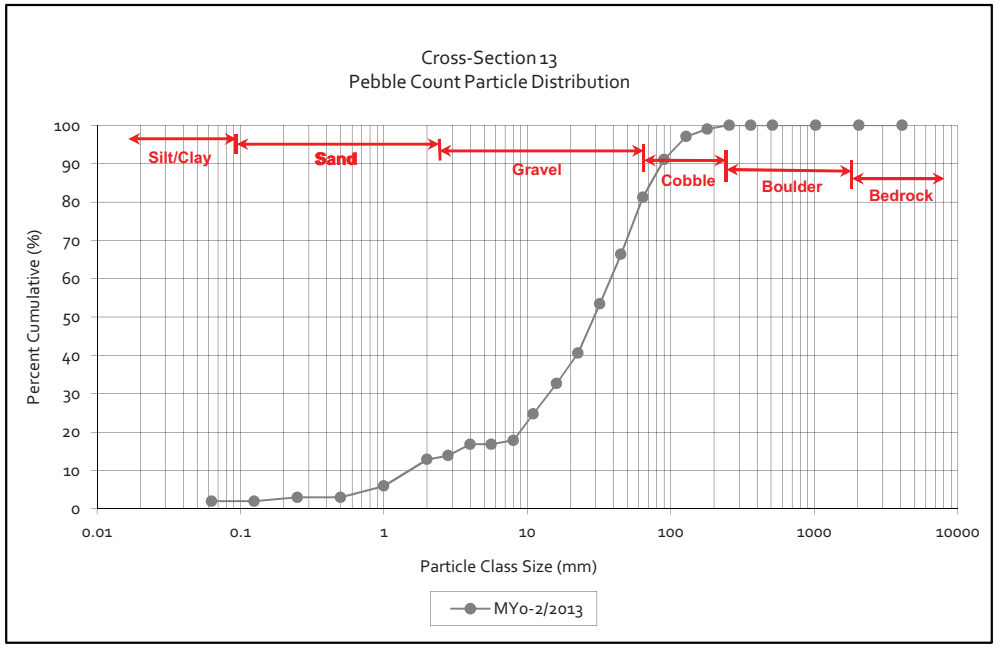


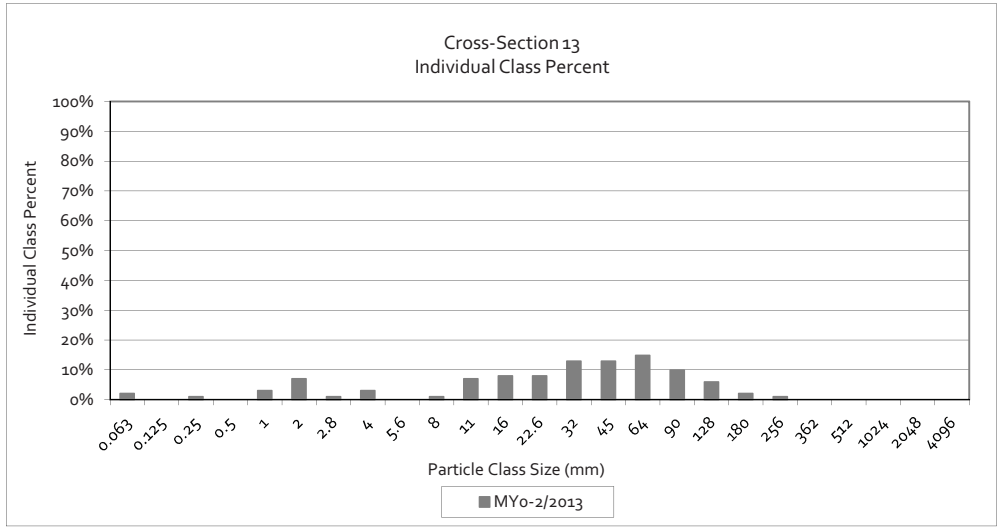


Appendix 2. Morphological Summary Data and Plots
Reachwide and Cross-Section Substrate Plots
Underwood Mitigation Site (NCEEP Project No. 94641)
SF4, Cross-Section 13
Monitoring Year 0

Particle Class		Diameter (mm)		Particle Count	Cross-Section 13 Summary	
		min	max	Total	Class Percentage	Percent Cumulative
SILT/CLAY	Silt/Clay	0.000	0.062	2	2	2
SAND	Very fine	0.062	0.125			2
	Fine	0.125	0.250	1	1	3
	Medium	0.250	0.500			3
	Coarse	0.5	1.0	3	3	6
	Very Coarse	1.0	2.0	7	7	13
GRAVEL	Very Fine	2.0	2.8	1	1	14
	Very Fine	2.8	4.0	3	3	17
	Fine	4.0	5.7			17
	Fine	5.7	8.0	1	1	18
	Medium	8.0	11.3	7	7	25
	Medium	11.3	16.0	8	8	33
	Coarse	16.0	22.6	8	8	41
	Coarse	22.6	32	13	13	53
	Very Coarse	32	45	13	13	66
	Very Coarse	45	64	15	15	81
COBBLE	Small	64	90	10	10	91
	Small	90	128	6	6	97
	Large	128	180	2	2	99
	Large	180	256	1	1	100
BOULDER	Small	256	362			100
	Small	362	512			100
	Medium	512	1024			100
	Large/Very Large	1024	2048			100
BEDROCK	Bedrock	2048	>2048			100
			Total	101	100	100

Cross-Section 13	
Channel materials (mm)	
D_{16} =	3.6
D_{35} =	17.7
D_{50} =	29.1
D_{84} =	70.5
D_{95} =	113.5
D_{100} =	256.0

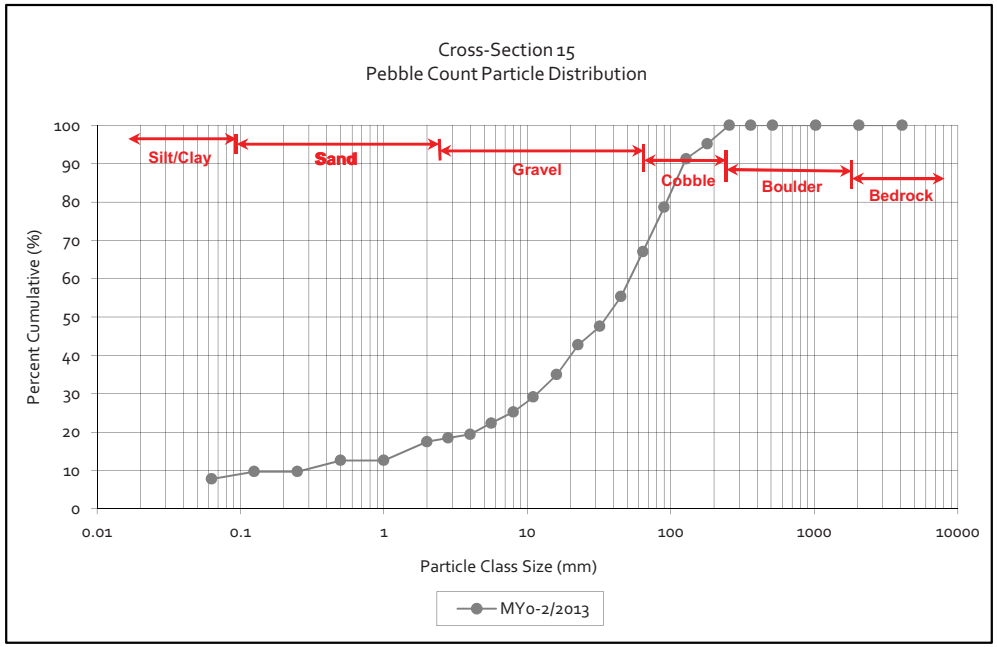


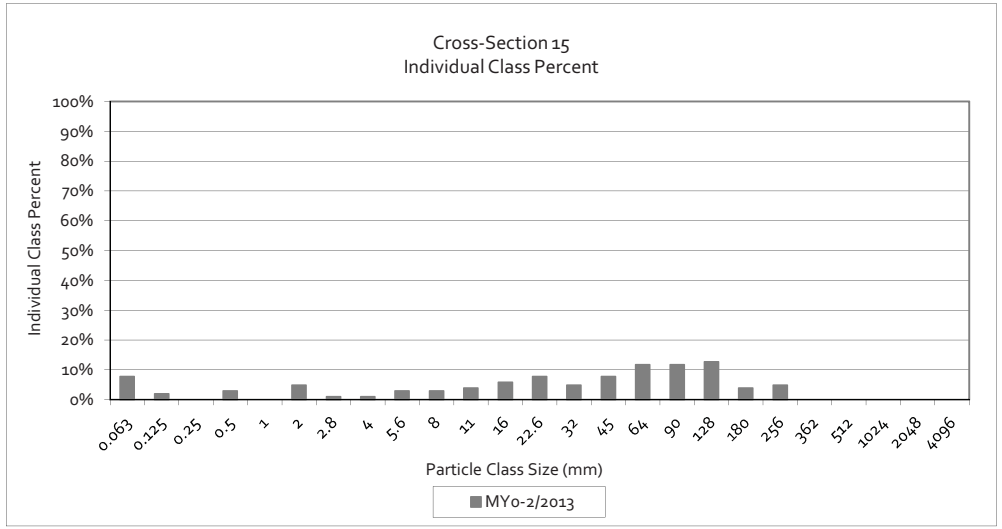


Appendix 2. Morphological Summary Data and Plots
Reachwide and Cross-Section Substrate Plots
Underwood Mitigation Site (NCEEP Project No. 94641)
SF4, Cross-Section 15
Monitoring Year 0

Particle Class		Diameter (mm)		Particle Count	Cross-Section 15 Summary	
		min	max	Total	Class Percentage	Percent Cumulative
SILT/CLAY	Silt/Clay	0.000	0.062	8	8	8
SAND	Very fine	0.062	0.125	2	2	10
	Fine	0.125	0.250			10
	Medium	0.250	0.500	3	3	13
	Coarse	0.5	1.0			13
	Very Coarse	1.0	2.0	5	5	17
GRAVEL	Very Fine	2.0	2.8	1	1	18
	Very Fine	2.8	4.0	1	1	19
	Fine	4.0	5.7	3	3	22
	Fine	5.7	8.0	3	3	25
	Medium	8.0	11.3	4	4	29
	Medium	11.3	16.0	6	6	35
	Coarse	16.0	22.6	8	8	43
	Coarse	22.6	32	5	5	48
	Very Coarse	32	45	8	8	55
	Very Coarse	45	64	12	12	67
COBBLE	Small	64	90	12	12	79
	Small	90	128	13	13	91
	Large	128	180	4	4	95
	Large	180	256	5	5	100
BOULDER	Small	256	362			100
	Small	362	512			100
	Medium	512	1024			100
	Large/Very Large	1024	2048			100
BEDROCK	Bedrock	2048	>2048			100
			Total	103	100	100

Cross-Section 15	
Channel materials (mm)	
D_{16} =	1.6
D_{35} =	16.0
D_{50} =	35.6
D_{84} =	104.5
D_{95} =	177.7
D_{100} =	256.0

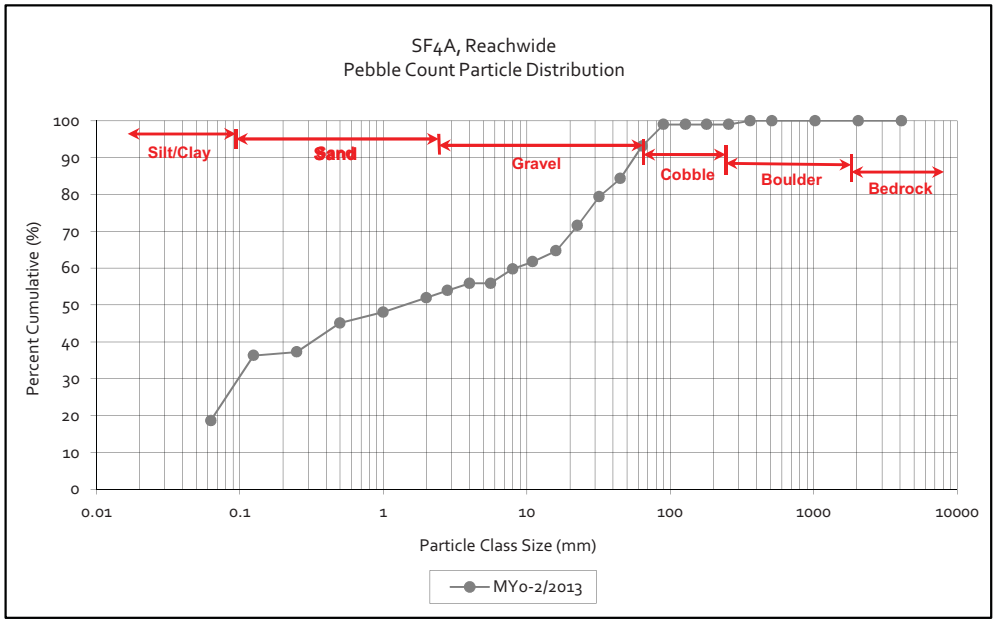


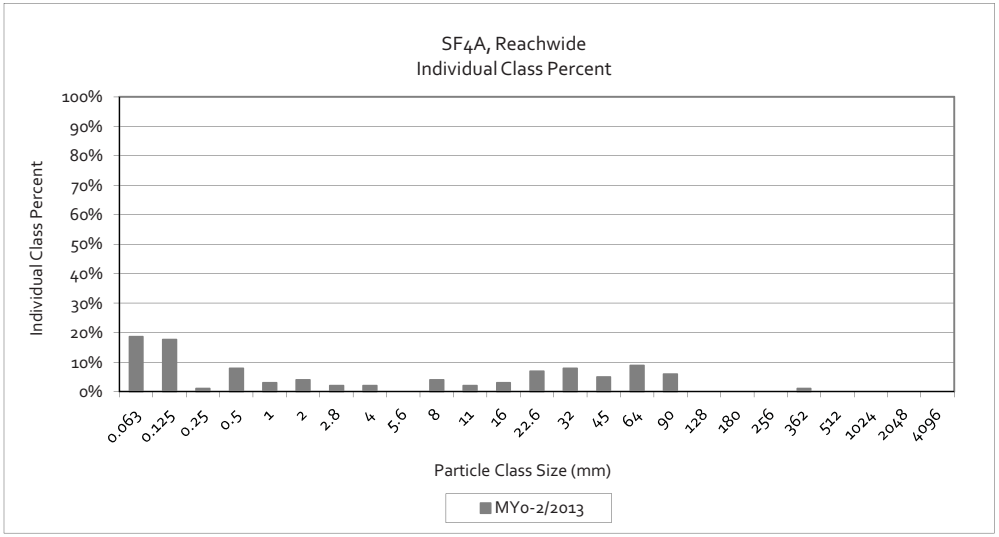


Appendix 2. Morphological Summary Data and Plots
Reachwide and Cross-Section Pebble Count Plots
Underwood Mitigation Site (NCEEP Project No. 94641)
SF4A, Reachwide
Monitoring Year 0

Particle Class		Diameter (mm)		Particle Count			SF4A Reach Summary	
		min	max	Riffle	Pool	Total	Class Percentage	Percent Cumulative
SILT/CLAY	Silt/Clay	0.000	0.062	4	15	19	19	19
SAND	Very fine	0.062	0.125	7	11	18	18	36
	Fine	0.125	0.250		1	1	1	37
	Medium	0.250	0.500	2	6	8	8	45
	Coarse	0.5	1.0		3	3	3	48
	Very Coarse	1.0	2.0	2	2	4	4	52
GRAVEL	Very Fine	2.0	2.8	1	1	2	2	54
	Very Fine	2.8	4.0	1	1	2	2	56
	Fine	4.0	5.7					56
	Fine	5.7	8.0	4		4	4	60
	Medium	8.0	11.3	2		2	2	62
	Medium	11.3	16.0	3		3	3	65
	Coarse	16.0	22.6	7		7	7	72
	Coarse	22.6	32	8		8	8	79
	Very Coarse	32	45	5		5	5	84
	Very Coarse	45	64	9		9	9	93
COBBLE	Small	64	90	6		6	6	99
	Small	90	128					99
	Large	128	180					99
	Large	180	256					99
BOULDER	Small	256	362	1		1	1	100
	Small	362	512					100
	Medium	512	1024					100
	Large/Very Large	1024	2048					100
BEDROCK	Bedrock	2048	>2048					100
			Total	62	40	102	100	100

Reachwide	
Channel materials (mm)	
D_{16} =	silt/clay
D_{35} =	0.12
D_{50} =	1.4
D_{84} =	44.0
D_{95} =	71.3
D_{100} =	362.0

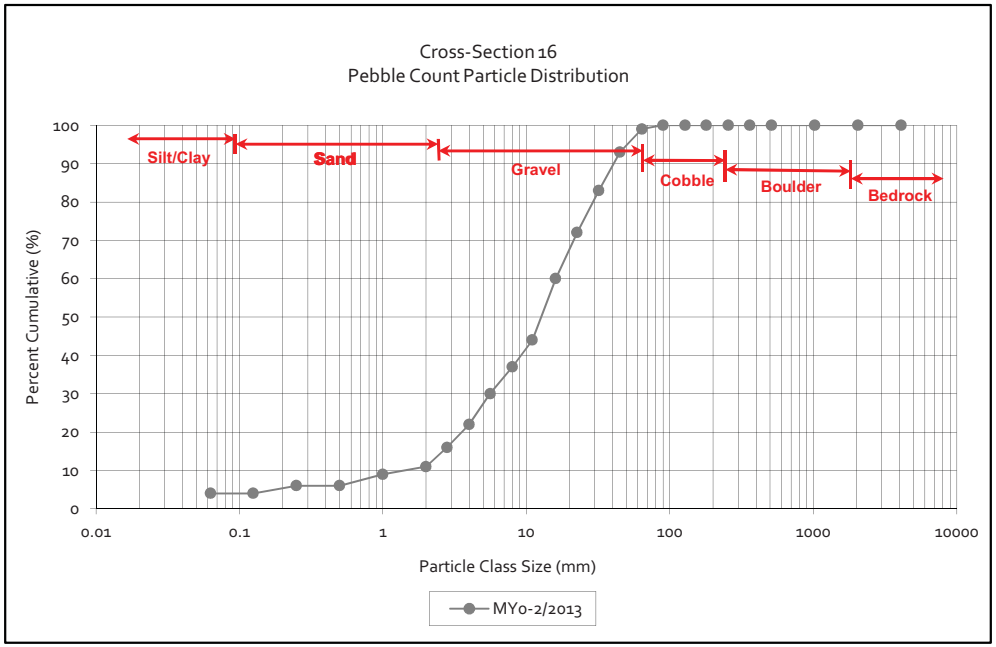


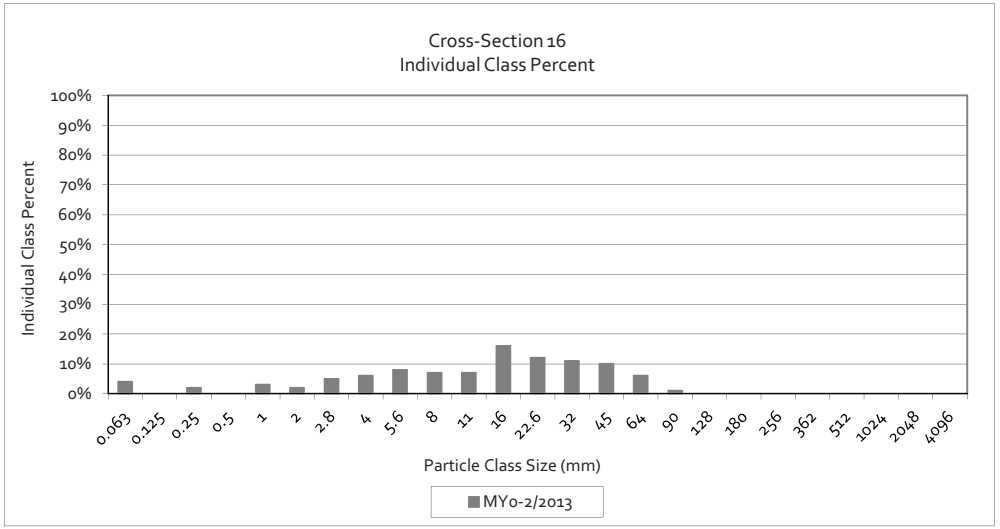


Appendix 2. Morphological Summary Data and Plots
Reachwide and Cross-Section Substrate Plots
Underwood Mitigation Site (NCEEP Project No. 94641)
SF4A, Cross-Section 16
Monitoring Year 0

Particle Class		Diameter (mm)		Particle Count	Cross-Section 16 Summary	
		min	max	Total	Class Percentage	Percent Cumulative
SILT/CLAY	Silt/Clay	0.000	0.062	4	4	4
SAND	Very fine	0.062	0.125			4
	Fine	0.125	0.250	2	2	6
	Medium	0.250	0.500			6
	Coarse	0.5	1.0	3	3	9
	Very Coarse	1.0	2.0	2	2	11
GRAVEL	Very Fine	2.0	2.8	5	5	16
	Very Fine	2.8	4.0	6	6	22
	Fine	4.0	5.7	8	8	30
	Fine	5.7	8.0	7	7	37
	Medium	8.0	11.3	7	7	44
	Medium	11.3	16.0	16	16	60
	Coarse	16.0	22.6	12	12	72
	Coarse	22.6	32	11	11	83
	Very Coarse	32	45	10	10	93
	Very Coarse	45	64	6	6	99
COBBLE	Small	64	90	1	1	100
	Small	90	128			100
	Large	128	180			100
	Large	180	256			100
BOULDER	Small	256	362			100
	Small	362	512			100
	Medium	512	1024			100
	Large/Very Large	1024	2048			100
BEDROCK	Bedrock	2048	>2048			100
			Total	100	100	100

Cross-Section 16	
Channel materials (mm)	
D_{16} =	2.8
D_{35} =	7.2
D_{50} =	12.7
D_{84} =	33.1
D_{95} =	50.6
D_{100} =	90.0

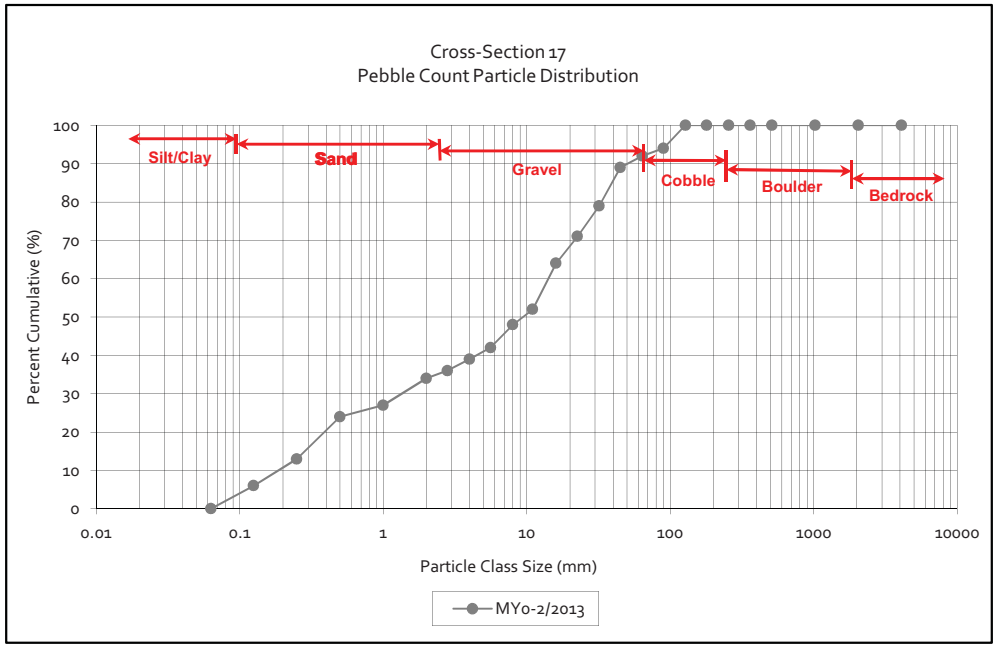


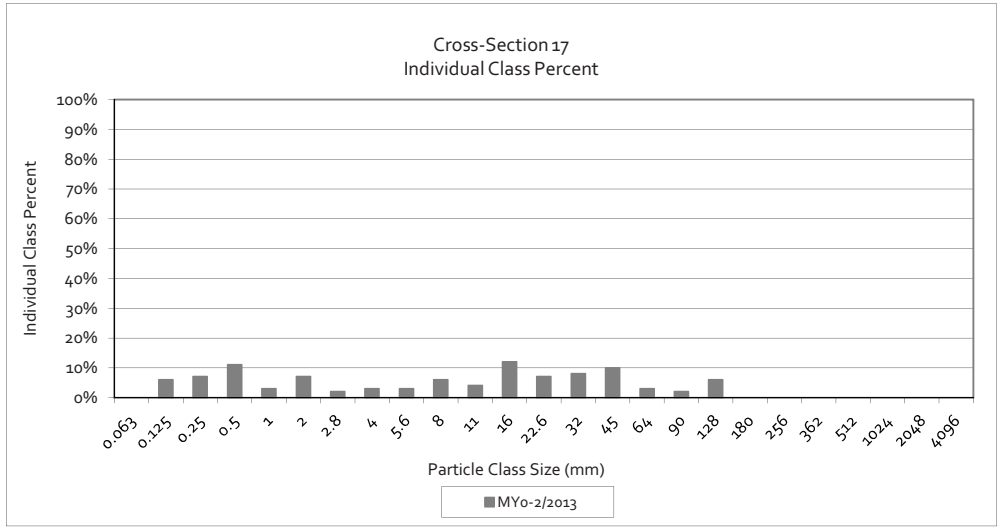


Appendix 2. Morphological Summary Data and Plots
Reachwide and Cross-Section Substrate Plots
Underwood Mitigation Site (NCEEP Project No. 94641)
SF4A, Cross-Section 17
Monitoring Year 0

Particle Class		Diameter (mm)		Particle Count	Cross-Section 17 Summary	
		min	max	Total	Class Percentage	Percent Cumulative
SILT/CLAY	Silt/Clay	0.000	0.062			0
SAND	Very fine	0.062	0.125	6	6	6
	Fine	0.125	0.250	7	7	13
	Medium	0.250	0.500	11	11	24
	Coarse	0.5	1.0	3	3	27
	Very Coarse	1.0	2.0	7	7	34
GRAVEL	Very Fine	2.0	2.8	2	2	36
	Very Fine	2.8	4.0	3	3	39
	Fine	4.0	5.7	3	3	42
	Fine	5.7	8.0	6	6	48
	Medium	8.0	11.3	4	4	52
	Medium	11.3	16.0	12	12	64
	Coarse	16.0	22.6	7	7	71
	Coarse	22.6	32	8	8	79
	Very Coarse	32	45	10	10	89
	Very Coarse	45	64	3	3	92
COBBLE	Small	64	90	2	2	94
	Small	90	128	6	6	100
	Large	128	180			100
	Large	180	256			100
BOULDER	Small	256	362			100
	Small	362	512			100
	Medium	512	1024			100
	Large/Very Large	1024	2048			100
BEDROCK	Bedrock	2048	>2048			100
			Total	100	100	100

Cross-Section 17	
Channel materials (mm)	
D_{16} =	0.3
D_{35} =	2.4
D_{50} =	9.4
D_{84} =	37.9
D_{95} =	95.4
D_{100} =	128.0





Stream Photographs (Harris Site)

Photo Point 1 – looking upstream (01/22/2013)

Photo Point 1 – looking downstream (01/22/2013)

Photo Point 2 – looking upstream (01/22/2013)

Photo Point 2 – looking downstream (01/22/2013)

Photo Point 3 – looking upstream (01/22/2013)

Photo Point 3 – looking downstream (01/22/2013)

Photo Point 4 – looking upstream (01/22/2013)

Photo Point 4 – looking downstream (01/22/2013)

Photo Point 5 – looking upstream (05/17/2012)

Photo Point 5 – looking downstream (05/17/2012)

Photo Point 6 – looking upstream (01/22/2013)

Photo Point 6 – looking downstream (01/22/2013)

	
Photo Point 7 – looking upstream (01/22/2013)	Photo Point 7 – looking downstream (01/22/2013)
	
Photo Point 8 – looking upstream (01/22/2013)	Photo Point 8 – looking downstream (01/22/2013)
	
Photo Point 9 – looking upstream (01/22/2013)	Photo Point 9 – looking downstream (01/22/2013)

	
Photo Point 10 – looking upstream (02/27/2013)	Photo Point 10 – looking downstream (02/27/2013)
	
Photo Point 11 – looking upstream (02/27/2013)	Photo Point 11 – looking downstream (02/27/2013)
	
Photo Point 12 – looking upstream (02/27/2013)	Photo Point 12 – looking downstream (02/27/2013)

Photo Point 13 – looking upstream (2/12/2013)

Photo Point 13 – looking downstream (2/12/2013)

Photo Point 14 – looking upstream (2/12/2013)

Photo Point 14 – looking downstream (2/12/2013)

Photo Point 15 – looking upstream (01/22/2013)

Photo Point 15 – looking downstream (01/22/2013)

Photo Point 16 – looking upstream (2/12/2013)

Photo Point 16 – looking downstream (2/12/2013)

Photo Point 17 – looking upstream (01/22/2013)

Photo Point 17 – looking downstream (01/22/2013)

Photo Point 18 – looking upstream (01/22/2013)

Photo Point 18 – looking downstream (01/22/2013)

Photo Point 19 – looking upstream (01/22/2013)

Photo Point 19 – looking upstream (01/22/2013)

Photo Point 20 – looking upstream (01/22/2013)

Photo Point 20 – looking upstream (01/22/2013)

Photo Point 21 – looking upstream (1/22/2013)

Photo Point 21 – looking downstream (1/22/2013)

	
Photo Point 22 – looking upstream (1/22/2013)	Photo Point 22 – looking downstream (1/22/2013)
	
Photo Point 23 – looking upstream (1/22/2013)	Photo Point 23 – looking downstream (1/22/2013)
	
Photo Point 24 – looking upstream (01/22/2013)	Photo Point 24 – looking downstream (01/22/2013)

Photo Point 25 – looking upstream (01/22/2013)

Photo Point 25 – looking downstream (01/22/2013)

Photo Point 26 – looking upstream (01/22/2013)

Photo Point 26 – looking downstream (01/22/2013)

Photo Point 27 – looking upstream (01/22/2013)

Photo Point 27 – looking downstream (01/22/2013)

Photo Point 28 – looking upstream (01/22/2013)

Photo Point 28 – looking downstream (01/22/2013)

Photo Point 29 – looking upstream (01/22/2013)

Photo Point 29 – looking downstream (01/22/2013)

Photo Point 30 – looking upstream (01/22/2013)

Photo Point 30 – looking downstream (01/22/2013)

Photo Point 31 – looking upstream (02/12/2013)

Photo Point 31 – looking downstream (02/12/2013)

Photo Point 34 – looking upstream (02/12/2013)

Photo Point 34 – looking downstream (02/12/2013)

Photo Point 35 – looking upstream (02/12/2013)

Photo Point 35 – looking downstream (02/12/2013)

Photo Point 36 – looking upstream (02/12/2013)

Photo Point 36 – looking downstream (02/12/2013)

Photo Point 37 – looking upstream (02/12/2013)

Photo Point 37 – looking downstream (02/12/2013)

Photo Point 38 – looking upstream (02/12/2013)

Photo Point 38 – looking downstream (02/12/2013)

	
Photo Point 39 – looking upstream (02/12/2013)	Photo Point 39 – looking downstream (02/12/2013)

Stream Photographs (Lindley Site)

Photo Point 40 – looking upstream (01/22/2013)

Photo Point 40 – looking downstream (01/22/2013)

Photo Point 41 – looking upstream (01/22/2013)

Photo Point 41 – looking downstream (01/22/2013)

Photo Point 42 – looking upstream (01/22/2013)

Photo Point 42 – looking downstream (01/22/2013)

Photo Point 43 – looking upstream (01/22/2013)

Photo Point 43 – looking downstream (01/22/2013)

Photo Point 44 – looking upstream (01/22/2013)

Photo Point 44 – looking downstream (01/22/2013)

Photo Point 45 – looking upstream (01/22/2013)

Photo Point 45 – looking downstream (01/22/2013)

Photo Point 46 – looking upstream (01/22/2013)

Photo Point 46 – looking downstream (01/22/2013)

Photo Point 47 – looking upstream (01/22/2013)

Photo Point 47 – looking downstream (01/22/2013)

Photo Point 48 – looking upstream (01/22/2013)

Photo Point 48 – looking downstream (01/22/2013)

APPENDIX 3. Vegetation Plot Data

Appendix 3. Vegetation Plot Data
Table 7a. Planted and Total Stem Counts (Species by Plot with Annual Means)
Underwood Mitigation Site (NCEEP Project No. 94641)
Harris Site
Monitoring Year 0

			Current Data (MY0-1/2013)																												Annual Means	
			Plot 1		Plot 2		Plot 3		Plot 4		Plot 5		Plot 6		Plot 7		Plot 8		Plot 9		Plot 10		Plot 11		Plot 12		Plot 13		Plot 14		Plot 15		Current Mean	
Species	Common Name	Type	P	T	3	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T
Betula nigra	river birch	Tree	2	2	3	3	2	2	2	2	3	3	1	1	7	7	9	9	3	3	3	3	3	3	5	5			3	3	6	6	**3**	**3**
Cornus amomum	silky dogwood	Shrub																			2	2											**3**	**3**
Fraxinus pennsylvanica	green ash	Tree	1	1	2	2	1	1	4	4	4	4			3	3	1	1			3	3	4	4	1	1			1	1	3	3	**3**	**3**
Liriodendron tulipifera	tuliptree	Tree	2	2	2	2	3	3																	3	3							**2**	**2**
Platanus occidentalis	American sycamore	Tree	4	4	5	5	3	3	4	4	8	8	6	6	3	3	4	4	1	1			4	4	5	5	17	17	4	4			**4**	**4**
Quercus michauxii	swamp chestnut oak	Tree	4	4			7	7	3	3									1	1	2	2	6	6	2	2			2	2			**3**	**3**
Quercus pagoda	cherrybark oak	Tree	4	4	5	5	1	1	1	1	1	1	3	3					5	5			2	2	3	3			3	3	5	5	**4**	**4**
Quercus phellos	willow oak	Tree	1	1	3	3			1	1	3	3	2	2					3	3									5	5	1	1	**2**	**2**
Salix sericea	silky willow	Tree																	2	2	4	4									1	1	**3**	**3**
	Plot Area (acres)		0.0247																															
	Species Count		7	7	6	6	6	6	6	6	5	5	4	4	3	3	3	3	6	6	5	5	5	5	6	6	1	1	6	6	5	5	6	6
	Stem Count		18	18	20	20	17	17	15	15	19	19	12	12	13	13	14	14	15	15	14	14	19	19	19	19	17	17	18	18	16	16	17	17
	Stems per Acre		729	729	810	810	688	688	607	607	769	769	486	486	526	526	567	567	607	607	567	567	769	769	769	769	688	688	729	729	648	648	698	698

Type=Shrub or Tree
P = Planted
T = Total

Appendix 3. Vegetation Plot Data
Table 7b. Planted and Total Stem Counts (Species by Plot with Annual Means)
Underwood Mitigation Site (NCEEP Project No. 94641)
Harris Site
Monitoring Year 0

			Current Data (MY0-1/2013)																												Annual Means	
			Plot 16		Plot 17		Plot 18		Plot 19		Plot 20		Plot 21		Plot 22		Plot 23		Plot 24		Plot 25		Plot 26		Plot 27		Plot 28		Plot 29		Current Mean	
Species	Common Name	Type	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T
Betula nigra	river birch	Tree	3	3	3	3	2	2	1	1	3	3	4	4	2	2	5	5	1	1	3	3	1	1	2	2	1	1	8	8	**3**	**3**
Cornus amomum	silky dogwood	Shrub	6	6															2	2											**3**	**3**
Fraxinus pennsylvanica	green ash	Tree					3	3	1	1			3	3	1	1	2	2	1	1			4	4	3	3	4	4	1	1	**3**	**3**
Liriodendron tulipifera	tuliptree	Tree			4	4	2	2	2	2	1	1	1	1	1	1	1	1					1	1	2	2	2	2			**2**	**2**
Platanus occidentalis	American sycamore	Tree			1	1	3	3	7	7	4	4	3	3	2	2	1	1	3	3	6	6	3	3			3	3	2	2	**4**	**4**
Quercus michauxii	swamp chestnut oak	Tree	3	3	2	2	6	6	3	3	5	5	2	2	8	8	2	2	1	1	2	2	5	5	4	4	2	2			**3**	**3**
Quercus pagoda	cherrybark oak	Tree			2	2			2	2	3	3	2	2	5	5	6	6	2	2	3	3	3	3	5	5	4	4	8	8	**4**	**4**
Quercus phellos	willow oak	Tree	2	2	6	6	1	1	1	1	1	1	1	1	2	2	1	1	3	3	3	3					2	2	3	3	**2**	**2**
Salix sericea	silky willow	Tree	5	5															2	2									2	2	**3**	**3**
		Plot Area (acres)	**0.0247**																													
		Species Count	**5**	**5**	**6**	**6**	**6**	**6**	**7**	**7**	**6**	**6**	**7**	**7**	**7**	**7**	**7**	**7**	**8**	**8**	**5**	**5**	**6**	**6**	**5**	**5**	**7**	**7**	**6**	**6**	**6**	**6**
		Stem Count	**19**	**19**	**18**	**18**	**17**	**17**	**17**	**17**	**17**	**17**	**16**	**16**	**21**	**21**	**18**	**18**	**15**	**15**	**17**	**17**	**17**	**17**	**16**	**16**	**18**	**18**	**24**	**24**	**17**	**17**
		Stems per Acre	**769**	**769**	**729**	**729**	**688**	**688**	**688**	**688**	**688**	**688**	**648**	**648**	**850**	**850**	**729**	**729**	**607**	**607**	**688**	**688**	**688**	**688**	**648**	**648**	**729**	**729**	**972**	**972**	**698**	**698**

Type=Shrub or Tree
P = Planted
T = Total

Appendix 3. Vegetation Plot Data
Table 7c. Planted and Total Stem Counts (Species by Plot with Annual Means)
Underwood Mitigation Site (NCEEP Project No. 94641)
Lindley Site
Monitoring Year 0

			Current Data (MY0-1/2013)																										Annual Means	
			Plot 30		Plot 31		Plot 32		Plot 33		Plot 34		Plot 35		Plot 36		Plot 37		Plot 38		Plot 39		Plot 40		Plot 41		Plot 42		Current Mean	
Species	Common Name	Type	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T
Betula nigra	river birch	Tree			3	3			2	2	3	3	1	1	2	2	3	3	5	5	5	5	1	1	4	4	4	4	**3**	**3**
Cornus amomum	silky dogwood	Shrub	2	2	2	2	1	1	2	2	4	4	1	1	2	2							1	1	4	4	1	1	**3**	**3**
Fraxinus pennsylvanica	green ash	Tree	3	3	3	3	4	4	4	4	4	4	1	1	10	10			4	4	1	1					1	1	**3**	**3**
Liriodendron tulipifera	tuliptree	Tree											1	1			2	2	1	1	4	4							**2**	**2**
Platanus occidentalis	American sycamore	Tree	1	1	1	1	5	5	6	6	4	4	8	8	1	1	1	1	1	1	3	3	3	3	2	2	3	3	**4**	**4**
Quercus michauxii	swamp chestnut oak	Tree							4	4							6	6	3	3	2	2							**3**	**3**
Quercus pagoda	cherrybark oak	Tree	4	4	6	6	3	3	1	1	2	2	2	2	3	3	6	6	5	5	5	5	7	7	7	7	2	2	**4**	**4**
Quercus phellos	willow oak	Tree	6	6	2	2	3	3	3	3			1	1	1	1	1	1					1	1			1	1	**2**	**2**
Salix sericea	silky willow	Tree	4	4	5	5	2	2			6	6			1	1									3	3	1	1	**3**	**3**
		Plot Area (acres)	**0.0247**																											
		Species Count	**6**	**6**	**7**	**7**	**6**	**6**	**7**	**7**	**6**	**6**	**7**	**7**	**7**	**7**	**6**	**6**	**6**	**6**	**6**	**6**	**5**	**5**	**5**	**5**	**7**	**7**	**6**	**6**
		Stem Count	**20**	**20**	**22**	**22**	**18**	**18**	**22**	**22**	**23**	**23**	**15**	**15**	**20**	**20**	**19**	**19**	**19**	**19**	**20**	**20**	**13**	**13**	**20**	**20**	**13**	**13**	**17**	**17**
		Stems per Acre	**810**	**810**	**891**	**891**	**729**	**729**	**891**	**891**	**931**	**931**	**607**	**607**	**810**	**810**	**769**	**769**	**769**	**769**	**810**	**810**	**526**	**526**	**810**	**810**	**526**	**526**	**698**	**698**

Type=Shrub or Tree
P = Planted
T = Total

Appendix 3. Vegetation Plot Data
Table 8a. CVS Vegetation Tables - Metadata
Underwood Mitigation Site (NCEEP Project No. 94641)
Harris Site
Monitoring Year 0

Report Prepared By	Alea Tuttle
Date Prepared	*2/11/2013 15:02*
database name	*Underwood MYo-cvs-eep-entrytool-v2.3.0.mdb*
database location	*\\WILDNCSVR\Projects\ActiveProjects\005-02125 Underwood Mitigation FDP\Monitoring\Baseline Monitoring\Vegetation Assessment*
DESCRIPTION OF WORKSHEETS IN THIS DOCUMENT----------	
Metadata	*This worksheet, which is a summary of the project and the project data.*
Plots	*List of plots surveyed.*
Vigor	*Frequency distribution of vigor classes.*
Vigor by Spp	*Frequency distribution of vigor classes listed by species.*
Damage	*List of most frequent damage classes with number of occurrences and percent of total stems impacted by each.*
Damage by Spp	*Damage values tallied by type for each species.*
Damage by Plot	*Damage values tallied by type for each plot.*
Stem Count by Plot and Spp	*Unknown*
PROJECT SUMMARY----------	
Project Code	94641
Project Name	Underwood Mitigation Site
Description	Stream and Wetland
length (ft)	n/a
stream-to-edge width (ft)	n/a
area (sq m)	
Required Plots (calculated)	
Sampled Plots	29

Appendix 3. Vegetation Plot Data
Table 8b. CVS Vegetation Tables - Metadata
Underwood Mitigation Site (NCEEP Project No. 94641)
Lindley Site
Monitoring Year 0

Report Prepared By	Alea Tuttle
Date Prepared	*2/11/2013 15:06*
database name	*Underwood MY0-cvs-eep-entrytool-v2.3.0.mdb*
database location	*\\WILDNCSVR\Projects\ActiveProjects\005-02125 Underwood Mitigation FDP\Monitoring\Baseline Monitoring\Vegetation Assessment*
DESCRIPTION OF WORKSHEETS IN THIS DOCUMENT----------	
Metadata	*This worksheet, which is a summary of the project and the project data.*
Plots	*List of plots surveyed.*
Vigor	*Frequency distribution of vigor classes.*
Vigor by Spp	*Frequency distribution of vigor classes listed by species.*
Damage	*List of most frequent damage classes with number of occurrences and percent of total stems impacted by each.*
Damage by Spp	*Damage values tallied by type for each species.*
Damage by Plot	*Damage values tallied by type for each plot.*
Stem Count by Plot and Spp	*Unknown*
PROJECT SUMMARY----------	
Project Code	94641
Project Name	Underwood Mitigation Site
Description	Stream and Wetland
length (ft)	n/a
stream-to-edge width (ft)	n/a
area (sq m)	
Required Plots (calculated)	
Sampled Plots	13

Appendix 3. Vegetation Plot Data
Table 9a. CVS Vegetation Tables - Vigor by Species
Underwood Mitigation Site (NCEEP Project No. 94641)
Harris Site
Monitoring Year 0

	Species	CommonName	4	3	2	1	0	Missing
	Betula nigra	river birch	91					
	Cornus amomum	silky dogwood	10					
	Fraxinus pennsylvanica	green ash	51					
	Quercus michauxii	swamp chestnut oak	72					
	Quercus pagoda	cherrybark oak	78					
	Quercus phellos	willow oak	45					
	Salix sericea	silky willow	16					
	Liriodendron tulipifera	tuliptree	27					
	Platanus occidentalis	American sycamore	106					
TOT:			**496**					

vigor	Count	Percent
0	0	0
1	0	0
2	0	0
3	0	0
4	496	100
TOT	**496**	**100**

Notes: Vigor Scores
4: Excellent
3: Good
2: Fair
1: Unlikely to survive year
2: Dead

Appendix 3. Vegetation Plot Data
Table 9b. CVS Vegetation Tables - Vigor by Species
Underwood Mitigation Site (NCEEP Project No. 94641)
Lindley Site
Monitoring Year 0

	Species	CommonName	4	3	2	1	0	Missing
	Betula nigra	river birch	33					
	Cornus amomum	silky dogwood	20					
	Fraxinus pennsylvanica	green ash	35					
	Quercus michauxii	swamp chestnut oak	15					
	Quercus pagoda	cherrybark oak	53					
	Quercus phellos	willow oak	19					
	Salix sericea	silky willow	22					
	Liriodendron tulipifera	tuliptree	8					
	Platanus occidentalis	American sycamore	39					
TOT:			**244**					

vigor	Count	Percent
0	0	0
1	0	0
2	0	0
3	0	0
4	244	100
TOT	**244**	**100**

Notes: Vigor Scores
4: Excellent
3: Good
2: Fair
1: Unlikely to survive year
2: Dead

Appendix 3. Vegetation Plot Data
Table 10a. CVS Vegetation Tables - Damage by Species
Underwood Mitigation Site (NCEEP Project No. 94641)
Harris Site
Monitoring Year 0

Species	Common Name	No Damage
Betula nigra	river birch	91
Cornus amomum	silky dogwood	10
Fraxinus pennsylvanica	green ash	51
Liriodendron tulipifera	tuliptree	27
Platanus occidentalis	American sycamore	106
Quercus michauxii	swamp chestnut oak	72
Quercus pagoda	cherrybark oak	78
Quercus phellos	willow oak	45
Salix sericea	silky willow	16
TOT:		**496**

Damage	Count	Percent Of Stems
No Damage	496	100
TOT:	**496**	**100**

Appendix 3. Vegetation Plot Data
Table 10b. CVS Vegetation Tables - Damage by Species
Underwood Mitigation Site (NCEEP Project No. 94641)
Lindley Site
Monitoring Year 0

Species	Common Name	No Damage
Betula nigra	river birch	33
Cornus amomum	silky dogwood	20
Fraxinus pennsylvanica	green ash	35
Liriodendron tulipifera	tuliptree	8
Platanus occidentalis	American sycamore	39
Quercus michauxii	swamp chestnut oak	15
Quercus pagoda	cherrybark oak	53
Quercus phellos	willow oak	19
Salix sericea	silky willow	22
TOT:		**244**

Damage	Count	Percent Of Stems
No Damage	244	100
TOT:	**244**	**100**

Appendix 3. Vegetation Plot Data
Table 11a. CVS Vegetation Tables - Stem Count by Plot and Species
Underwood Mitigation Site (NCEEP Project No. 94641)
Harris Site
Monitoring Year 0

	Species	CommonName	Total Stems	# plots	avg# stems	94640-WEI-0001	94640-WEI-0002	94640-WEI-0003	94640-WEI-0004	94640-WEI-0005	94640-WEI-0006	94640-WEI-0007	94640-WEI-0008	94640-WEI-0009	94640-WEI-0010	plot 94641-WEI-0011	plot 94641-WEI-0012	plot 94641-WEI-0013	plot 94641-WEI-0014	plot 94641-WEI-0015
	Betula nigra	river birch	35	10	4	2	3	2	2	3	1	7	9	3	3	3	5		3	6
	Cornus amomum	silky dogwood	2	1	2										2					
	Fraxinus pennsylvanica	green ash	19	8	2	1	2	1	4	4		3	1		3	4	1		1	3
	Liriodendron tulipifera	tuliptree	7	3	2	2	2	3									3			
	Platanus occidentalis	American sycamore	38	9	4	4	5	3	4	8	6	3	4	1		4	5	17	4	
	Quercus michauxii	swamp chestnut oak	17	5	3	4		7	3					1	2	6	2		2	
	Quercus pagoda	cherrybark oak	20	7	3	4	5	1	1	1	3			5		2	3		3	5
	Quercus phellos	willow oak	13	6	2	1	3		1	3	2			3					5	1
	Salix sericea	silky willow	6	2	3									2	4					1
TOT:			**157**	**9**	**3**	**18**	**20**	**17**	**15**	**19**	**12**	**13**	**14**	**15**	**14**	**19**	**19**	**17**	**18**	**16**

Appendix 3. Vegetation Plot Data
Table 11b. CVS Vegetation Tables - Stem Count by Plot and Species
Underwood Mitigation Site (NCEEP Project No. 94641)
Harris Site
Monitoring Year 0

	Species	CommonName	Total Stems	# plots	avg# stems	plot 94641-WEI-0016	plot 94641-WEI-0017	plot 94641-WEI-0018	plot 94641-WEI-0019	plot 94641-WEI-0020	plot 94641-WEI-0021	plot 94641-WEI-0022	plot 94641-WEI-0023	plot 94641-WEI-0024	plot 94641-WEI-0025	plot 94641-WEI-0026	plot 94641-WEI-0027	plot 94641-WEI-0028	plot 94641-WEI-0029
	Betula nigra	river birch	56	18	3	3	3	2	1	3	4	2	5	1	3	1	2	1	8
	Cornus amomum	silky dogwood	8	2	4	6								2					
	Fraxinus pennsylvanica	green ash	32	14	2			3	1		3	1	2	1		4	3	4	1
	Liriodendron tulipifera	tuliptree	20	11	2		4	2	2	1	1	1	1			1	2	2	
	Platanus occidentalis	American sycamore	68	16	4		1	3	7	4	3	2	1	3	6	3		3	2
	Quercus michauxii	swamp chestnut oak	55	16	3	3	2	6	3	5	2	8	2	1	2	5	4	2	
	Quercus pagoda	cherrybark oak	58	16	4		2		2	3	2	5	6	2	3	3	5	4	8
	Quercus phellos	willow oak	32	14	2	2	6	1	1	1	1	2	1	3	3			2	3
	Salix sericea	silky willow	10	4	3	5								2					2
TOT:			**339**	**9**	**3**	**19**	**18**	**17**	**17**	**17**	**16**	**21**	**18**	**15**	**17**	**17**	**16**	**18**	**24**

Appendix 3. Vegetation Plot Data
Table 11c. CVS Vegetation Tables - Stem Count by Plot and Species
Underwood Mitigation Site (NCEEP Project No. 94641)
Lindley Site
Monitoring Year 0

	Species	CommonName	Total Stems	# plots	avg# stems	plot 94641-WEI-0030	plot 94641-WEI-0031	plot 94641-WEI-0032	plot 94641-WEI-0033	plot 94641-WEI-0034	plot 94641-WEI-0035	plot 94641-WEI-0036	plot 94641-WEI-0037	plot 94641-WEI-0038	plot 94641-WEI-0039	plot 94641-WEI-0040	plot 94641-WEI-0041	plot 94641-WEI-0042
	Betula nigra	river birch	33	11	3		3		2	3	1	2	3	5	5	1	4	4
	Cornus amomum	silky dogwood	20	10	2	2	2	1	2	4	1	2				1	4	1
	Fraxinus pennsylvanica	green ash	35	10	4	3	3	4	4	4	1	10		4	1			1
	Liriodendron tulipifera	tuliptree	8	4	2						1		2	1	4			
	Platanus occidentalis	American sycamore	39	13	3	1	1	5	6	4	8	1	1	1	3	3	2	3
	Quercus michauxii	swamp chestnut oak	15	4	4				4				6	3	2			
	Quercus pagoda	cherrybark oak	53	13	4	4	6	3	1	2	2	3	6	5	5	7	7	2
	Quercus phellos	willow oak	19	9	2	6	2	3	3		1	1	1			1		1
	Salix sericea	silky willow	22	7	3	4	5	2		6		1					3	1
TOT:			**244**	**9**	**3**	**20**	**22**	**18**	**22**	**23**	**15**	**20**	**19**	**19**	**20**	**13**	**20**	**13**

Vegetation Photographs (Harris Site)

Vegetation Plot 1 (01/22/2013)

Vegetation Plot 2 (01/22/2013)

Vegetation Plot 3 (01/22/2013)

Vegetation Plot 4 (01/22/2013)

Vegetation Plot 5 (01/22/2013)

Vegetation Plot 6 (01/22/2013)

Vegetation Plot 7 (01/22/2013)

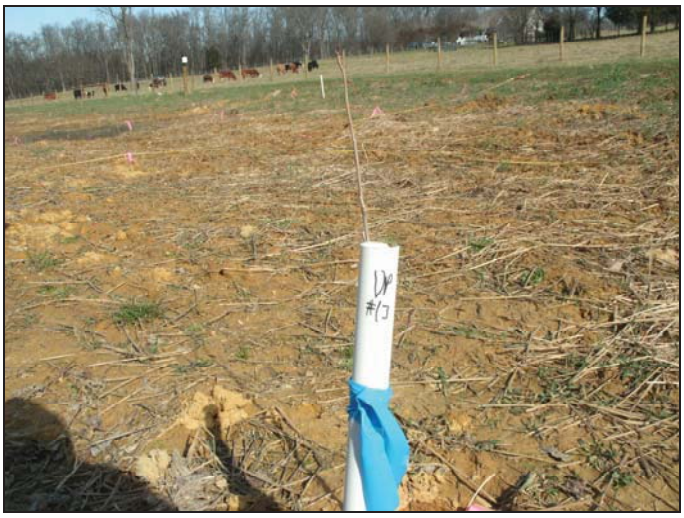
Vegetation Plot 8 (01/22/2013)

Vegetation Plot 9 (01/22/2013)

Vegetation Plot 10 (01/22/2013)

Vegetation Plot 11 (01/22/2013)

Vegetation Plot 12 (01/22/2013)



Vegetation Plot 13 (01/22/2013)

Vegetation Plot 14 (01/22/2013)

Vegetation Plot 15 (01/22/2013)

Vegetation Plot 16 (01/22/2013)

Vegetation Plot 17 (01/22/2013)

Vegetation Plot 18 (01/22/2013)

Vegetation Plot 19 (01/22/2013)

Vegetation Plot 20 (01/22/2013)

Vegetation Plot 21 (01/22/2013)

Vegetation Plot 22 (01/22/2013)

Vegetation Plot 23 (01/22/2013)

Vegetation Plot 24 (01/22/2013)

Vegetation Plot 25 (01/22/2013)

Vegetation Plot 26 (01/22/2013)

Vegetation Plot 27 (01/22/2013)

Vegetation Plot 28 (01/22/2013)

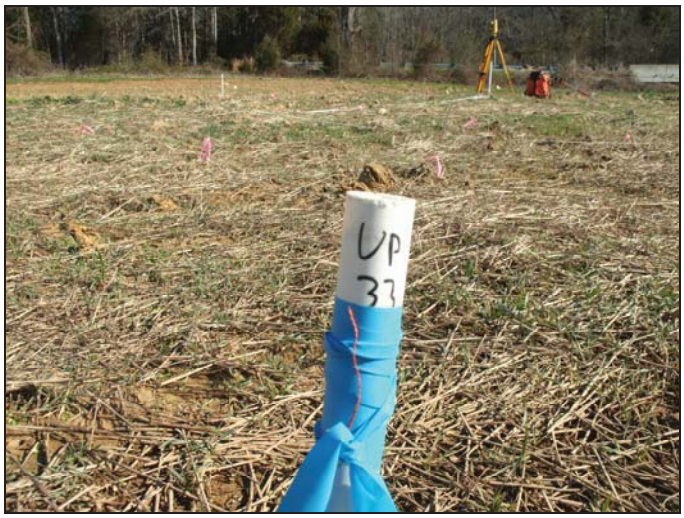
Vegetation Plot 29 (01/22/2013)

Vegetation Photographs (Lindley Site)

Vegetation Plot 30 (01/22/2013)

Vegetation Plot 31 (01/22/2013)

Vegetation Plot 32 (01/22/2013)



Vegetation Plot 33 (01/22/2013)

Vegetation Plot 34 (01/22/2013)

Vegetation Plot 35 (01/22/2013)

Vegetation Plot 36 (01/22/2013)

Vegetation Plot 37 (01/22/2013)

Vegetation Plot 38 (01/22/2013)

Vegetation Plot 39 (01/22/2013)

Vegetation Plot 40 (01/22/2013)

Vegetation Plot 41 (01/22/2013)

Vegetation Plot 42 (01/22/2013)

APPENDIX 4. As-Built Plan Sheets

Underwood Mitigation Site

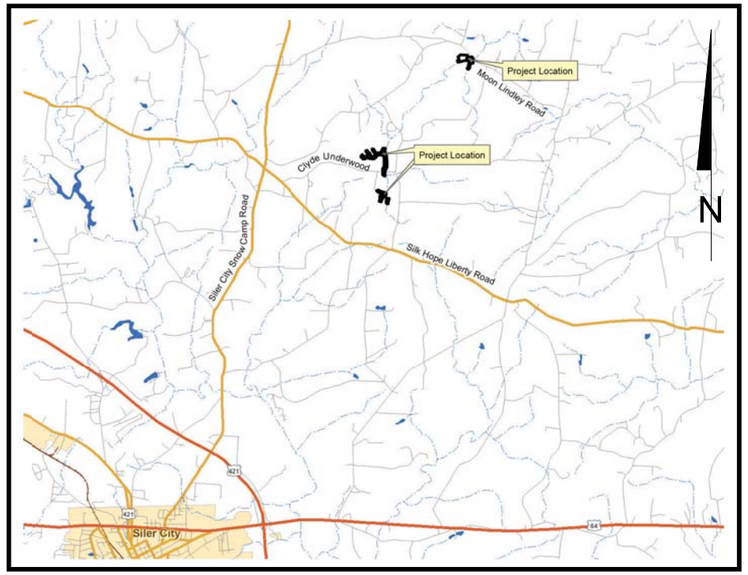
Chatham County, NC

Cape Fear River Basin Cataloging Unit

03030002050050

for

North Carolina Ecosystem Enhancement Program



Vicinity Map
Not to Scale

BEFORE YOU DIG!
CALL 1-800-632-4949
N.C. ONE-CALL CENTER
IT'S THE LAW!

To Clyde Underwood Road access:

From the intersection of US 64 and Arthur Teague Rd, travel north approximately 3.25 miles to the intersection of Silk Hope Rd. Turn right on Silk Hope Road. After going north approximately 0.3 miles, turn left onto Silk Hope Liberty Rd. Travel west approximately 1.8 miles and turn right on Plainfield Church Rd. Travel north approximately 1.1 miles and turn right onto Clyde Underwood Rd. The temporary construction entrances will be located approximately 0.15 miles on the right and 0.25 miles on the left of Clyde Underwood Road.

To Moon Lindley Road Access:

Leaving the intersection of Plainfield Church Rd and Clyde Underwood Rd, travel north on Plainfield Church Rd. approximately 0.5 miles and turn right on Johnny Lindley Rd. At the intersection of Johnny Lindley Rd and Moon Lindley Rd, turn left. The construction entrance will be on the left in approximately 0.25 miles.

BASELINE DRAWING
ISSUED MAY 6, 2013

REACH ORGINS

Reach	Latitude	Longitude
UT 2	N 35° 48' 03.53"	W 79° 24' 03.73"
SF 1	N 35° 48' 05.05"	W 79° 24' 10.08"
SF 1A	N 35° 48' 08.81"	W 79° 24' 09.90"
SF 2	N 35° 48' 24.94"	W 79° 24' 06.04"
SF 3	N 35° 48' 27.95"	W 79° 24' 06.91"
UT 1	N 35° 48' 37.68"	W 79° 24' 26.44"
UT 1A	N 35° 48' 44.41"	W 79° 24' 17.20"
UT 1B	N 35° 48' 43.07"	W 79° 24' 23.09"
SF 4	N 35° 49' 50.67"	W 79° 22' 59.63"
SF 4A	N 35° 49' 45.25"	W 79° 22' 50.37"

Sheet Index

Project Directory

Engineering:
Wildlands Engineering, Inc
License No. F-0831
5605 Chapel Hill Road
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Raleigh, NC 27607
Nicole Macaluso, PE
919-851-9986

Surveying:
Stewart Proctor Engineering and Surveying, PLLC
322 Chapanoke Road, Suite 100
Raleigh, NC 27603
Herbert Proctor Jr., PLS
919-779-1855

Owner:
Ecosystem Enhancement Program
NC Department of Environment and Natural Resources
1652 Mail Service Center
Raleigh, NC 27699-1652
Guy Pearce
919-715-1157

Contractor:
Land Mechanic Designs, Inc
126 Circle G Lane
Willow Springs, NC 27592
919-639-6132

DENR Contract No. 003268
EEP Project No. 94641

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Final Baseline Drawing
Underwood Mitigation Site
Chatham County, NC
Cover Sheet

Date:	May 6, 2013
Job Number:	005-02125
Project Engineer:	NMM
Drawn By:	JTL
Checked By:	JWH

Revisions

COVER SHEET

Sheet
0.1

LEGEND

P L — Existing Property Line

Existing Power Pole

Conservation Easement

10+00 — As-Built Channel Centerline (Restoration)

10+00 — As-Built Channel Centerline (Enhancement I)

10+00 — As-Built Channel Centerline (Enhancement II)

10+00 — As-Built Channel Centerline (No Credit)

As-Built Bankfull

715 — As-Built Contour

Permanent Cross Section (XS)

Monitoring Gage (CG, GWG)

PP #6 — Photo Point

VP # — Vegetation Plot

As-Built Constructed Riffle

As-Built Log Vane

As-Built Log Sill

As-Built Rock Vane

As-Built Root Wads

As-Built J-Hook

As-Built Brush Toe

As-Built Sod Mat

As-Built Rip Rap

As-Built Ford Crossing

Zone 1 - Streambank Planting Zone

Zone 2 - Floodplain Planting Zone

Zone 3 - Wetland Planting

Zone 4 - Permanent Seeding Outside Easement

Wetland Restoration

Wetland Enhancement

Wetland Creation

WILDLANDS ENGINEERING, INC.
Ecological Restoration Services

Underwood Mitigation Site
Chatham County, NC

Legend

Final Baseline Drawing

LEGEND

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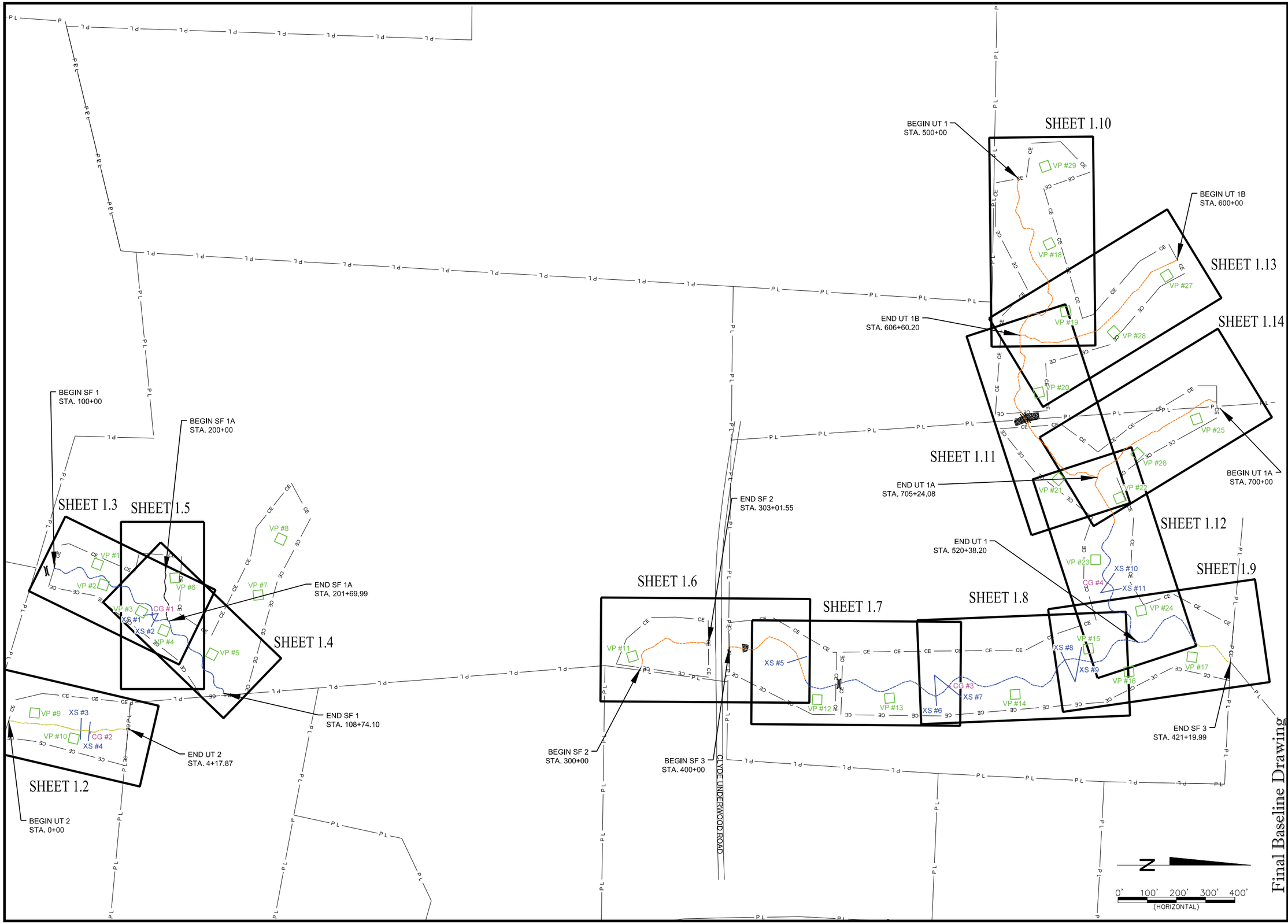

Final Baseline Drawing

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Underwood Mitigation Site
Chatham County, NC
Stream Baseline Overview

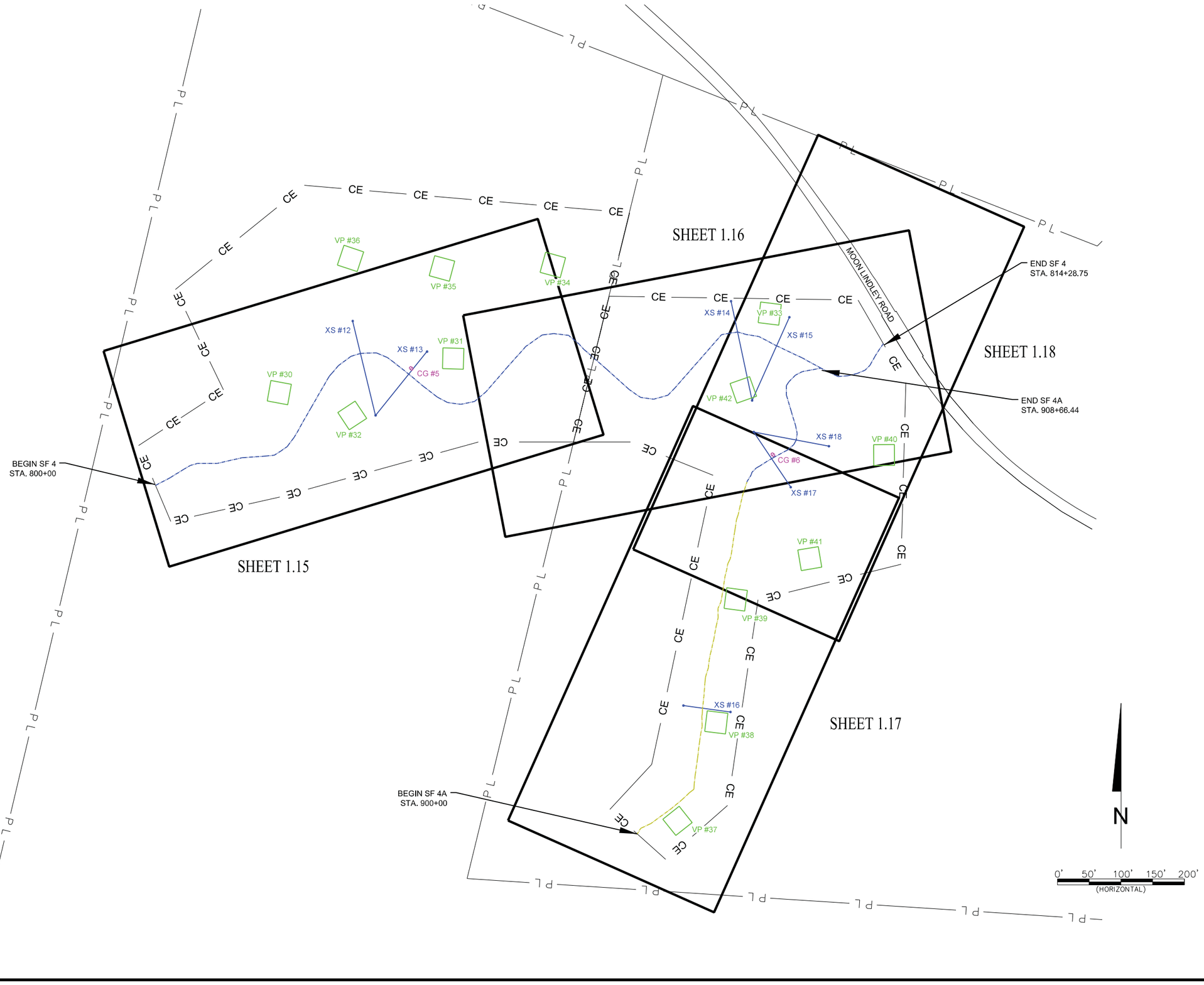
Date:	May 6, 2013
Job Number:	005-02125
Project Engineer:	NMM
Drawn By:	JTL
Checked By:	JWH

Revisions

STREAM BASELINE OVERVIEW

Sheet

1.0



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Underwood Mitigation Site
Chatham County, NC

Stream Baseline Overview

Final Baseline Drawing

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Checked By:	JWH

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STREAM BASELINE OVERVIEW

Sheet

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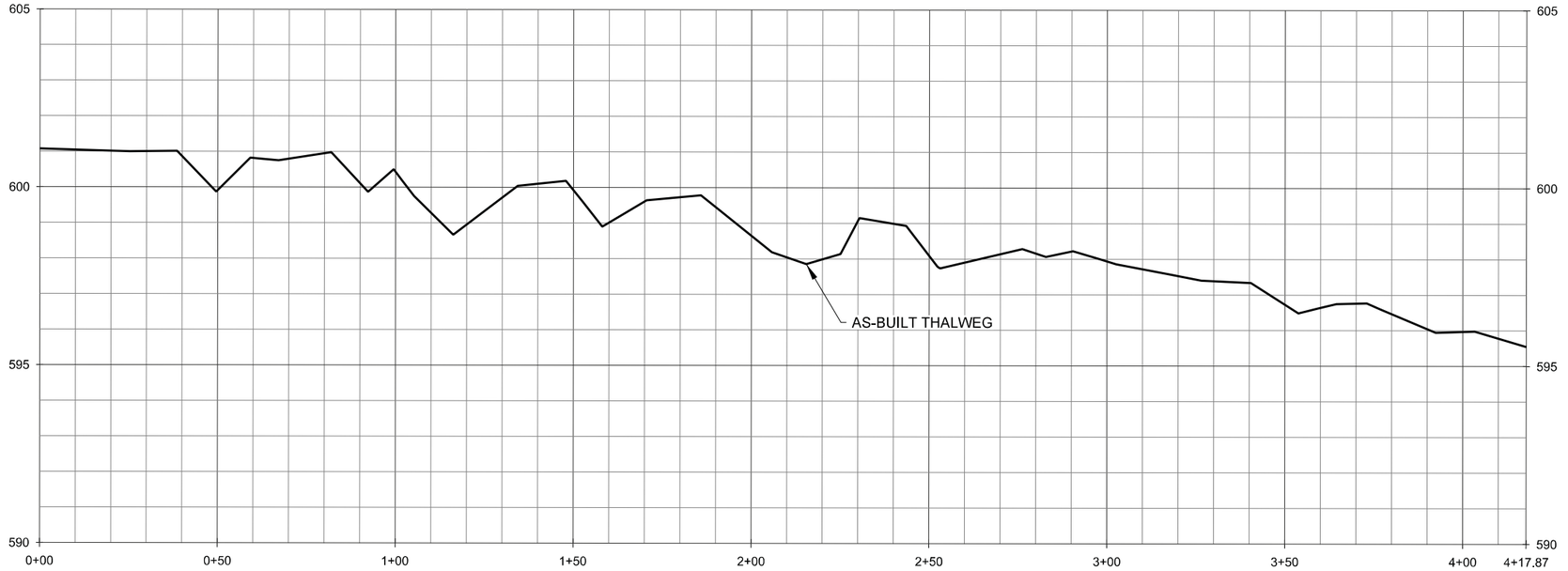

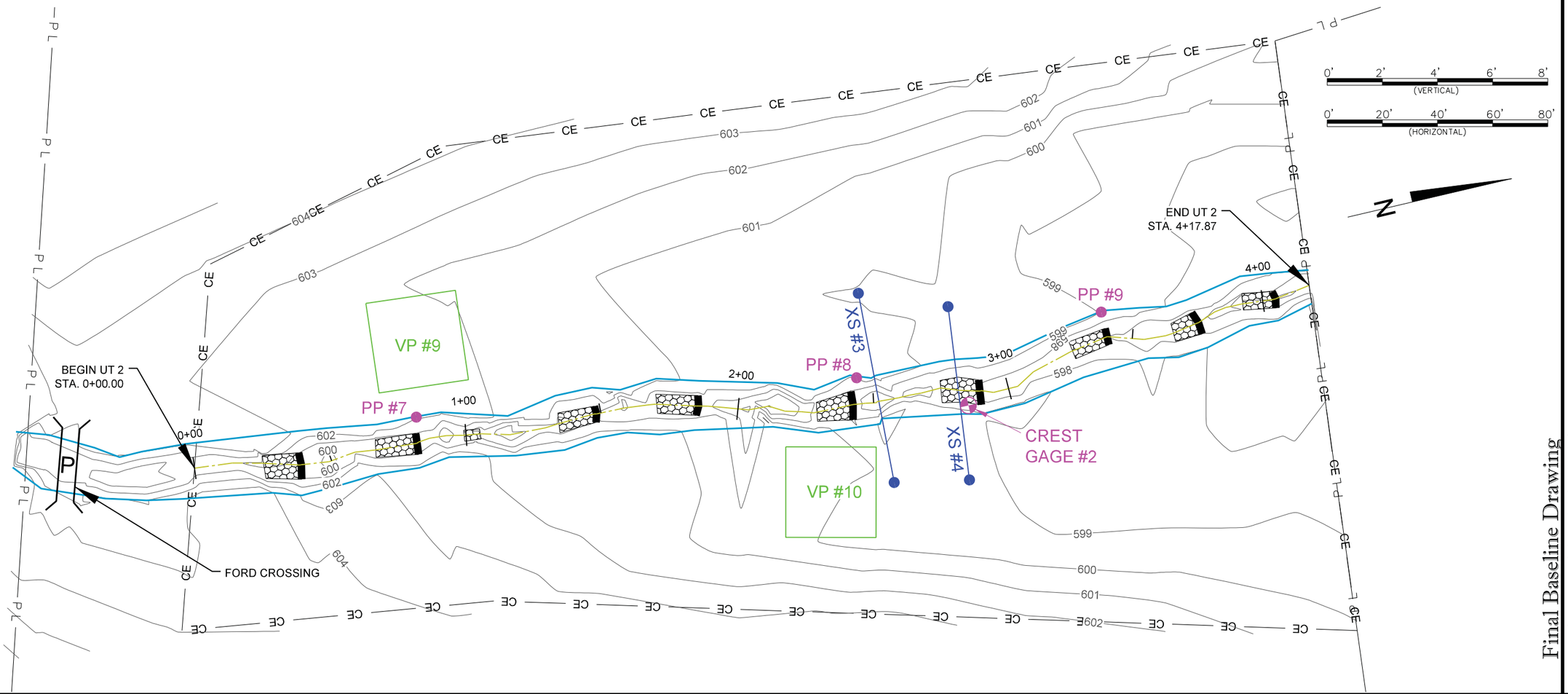

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Underwood Mitigation Site
Chatham County, NC

Stream Baseline Plans
UT 2 Plan and Profile

Final Baseline Drawing

Date:	May 6, 2013
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Drawn By:	JTL
Checked By:	JWH

Revisions

STREAM BASELINE PLANS

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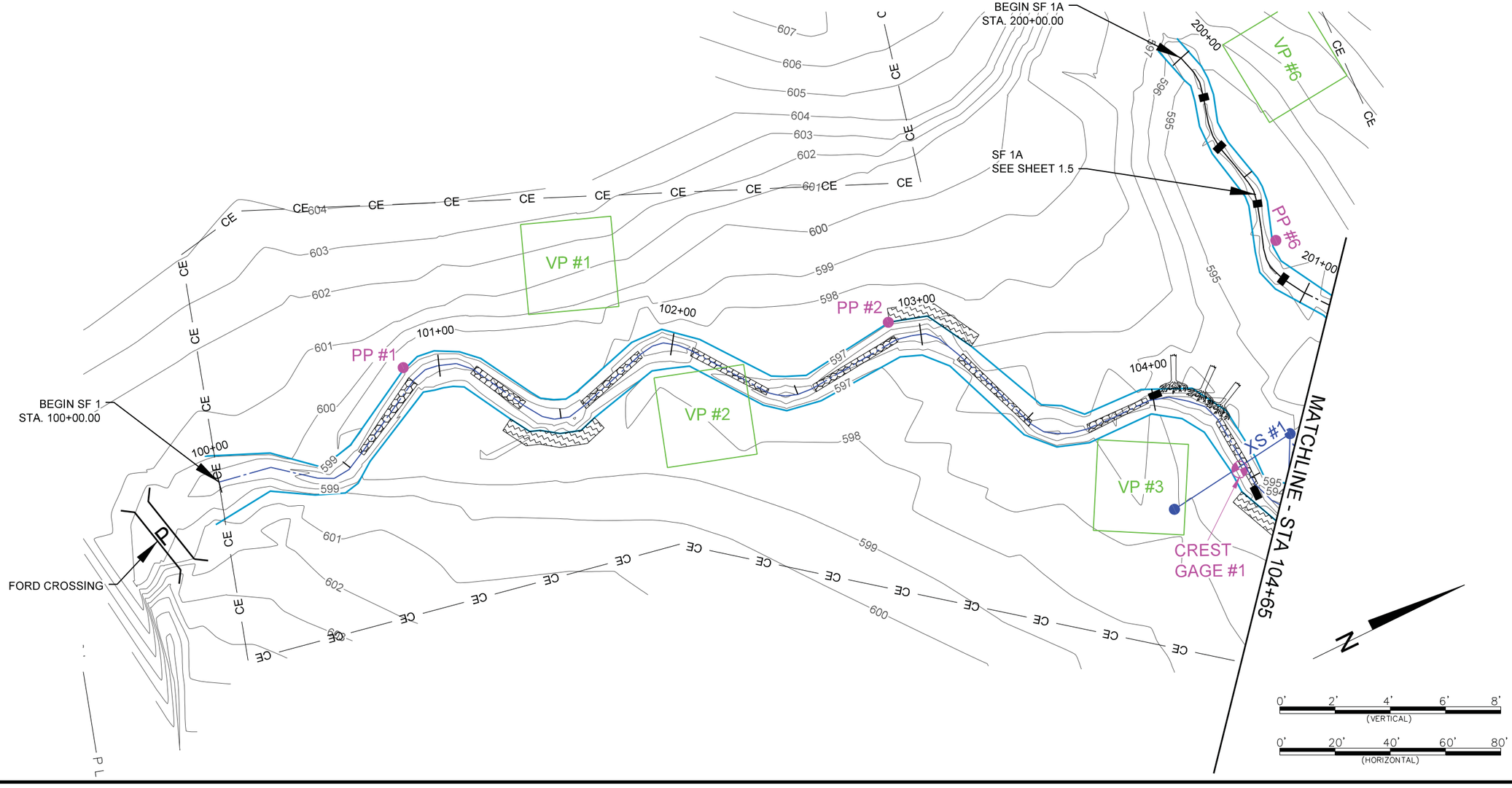

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Underwood Mitigation Site
Chatham County, NC

Stream Baseline Plans
SF 1 Plan and Profile

Final Baseline Drawing

Date:	May 6, 2013
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Drawn By:	JTL
Checked By:	JWH

Revisions

STREAM BASELINE PLANS

Sheet

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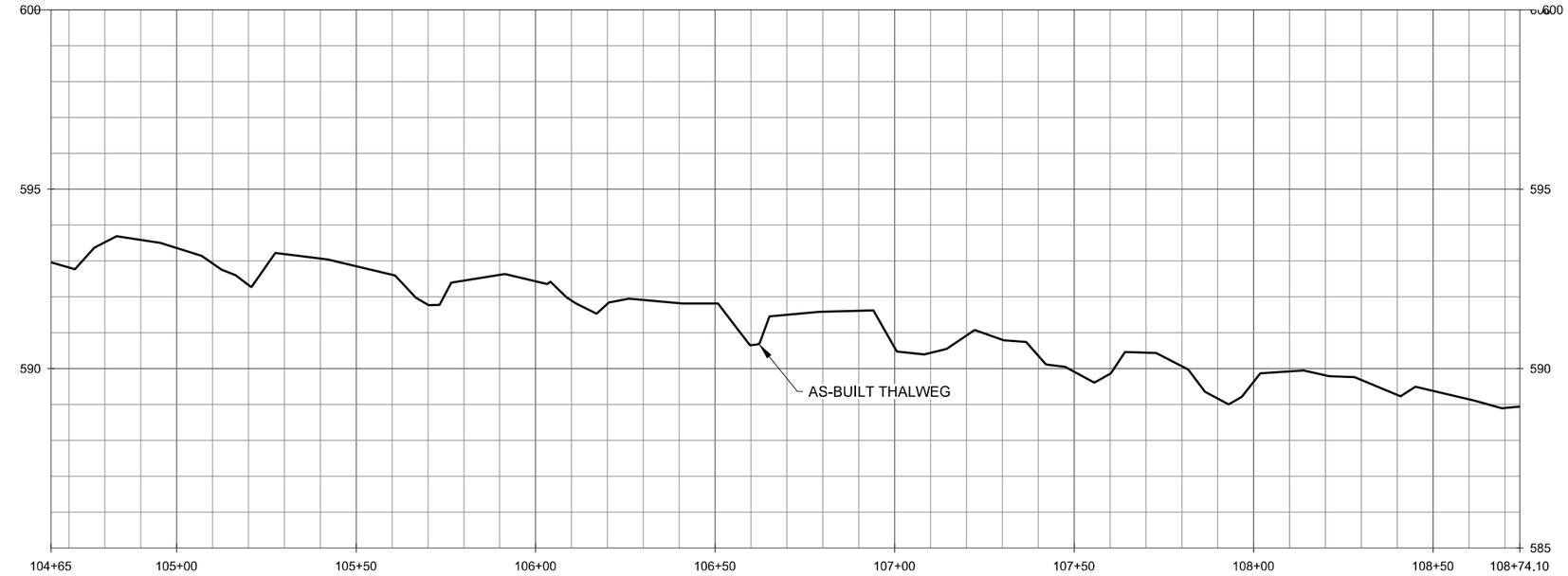

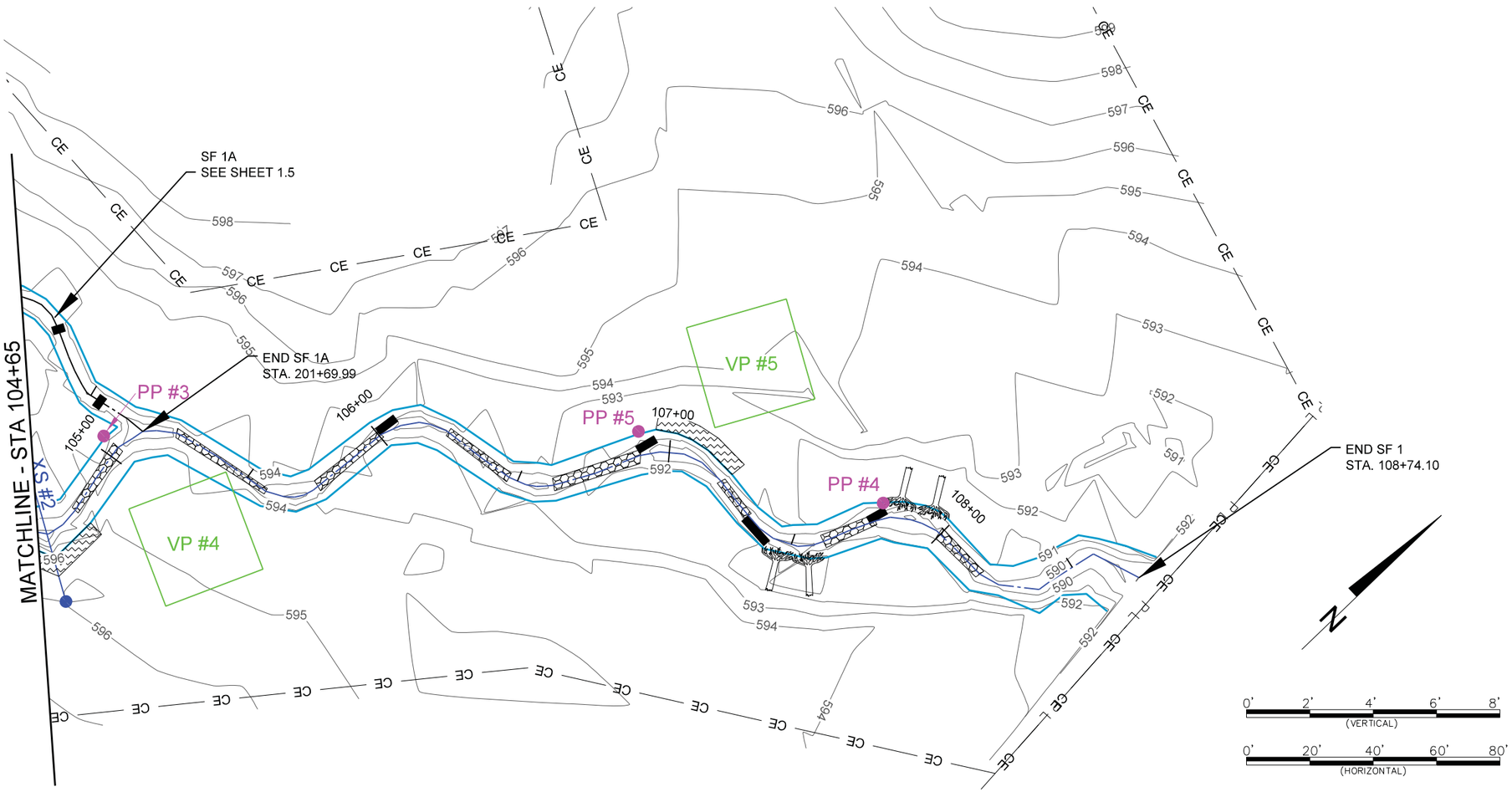

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Underwood Mitigation Site
Chatham County, NC

Stream Baseline Plans
SF 1 Plan and Profile

Final Baseline Drawing

Date:	May 6, 2013
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Revisions

STREAM BASELINE PLANS

Sheet

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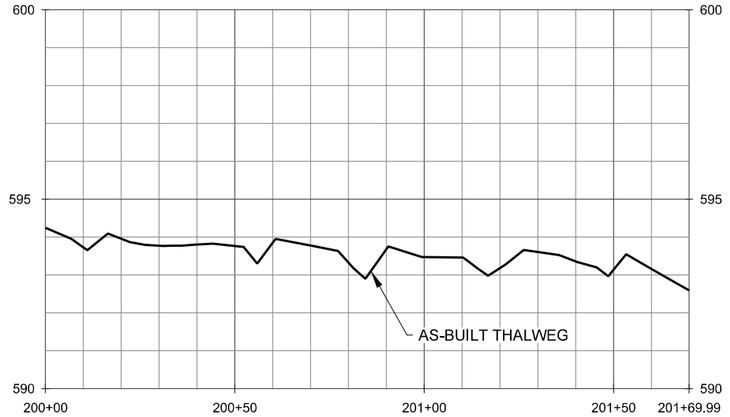

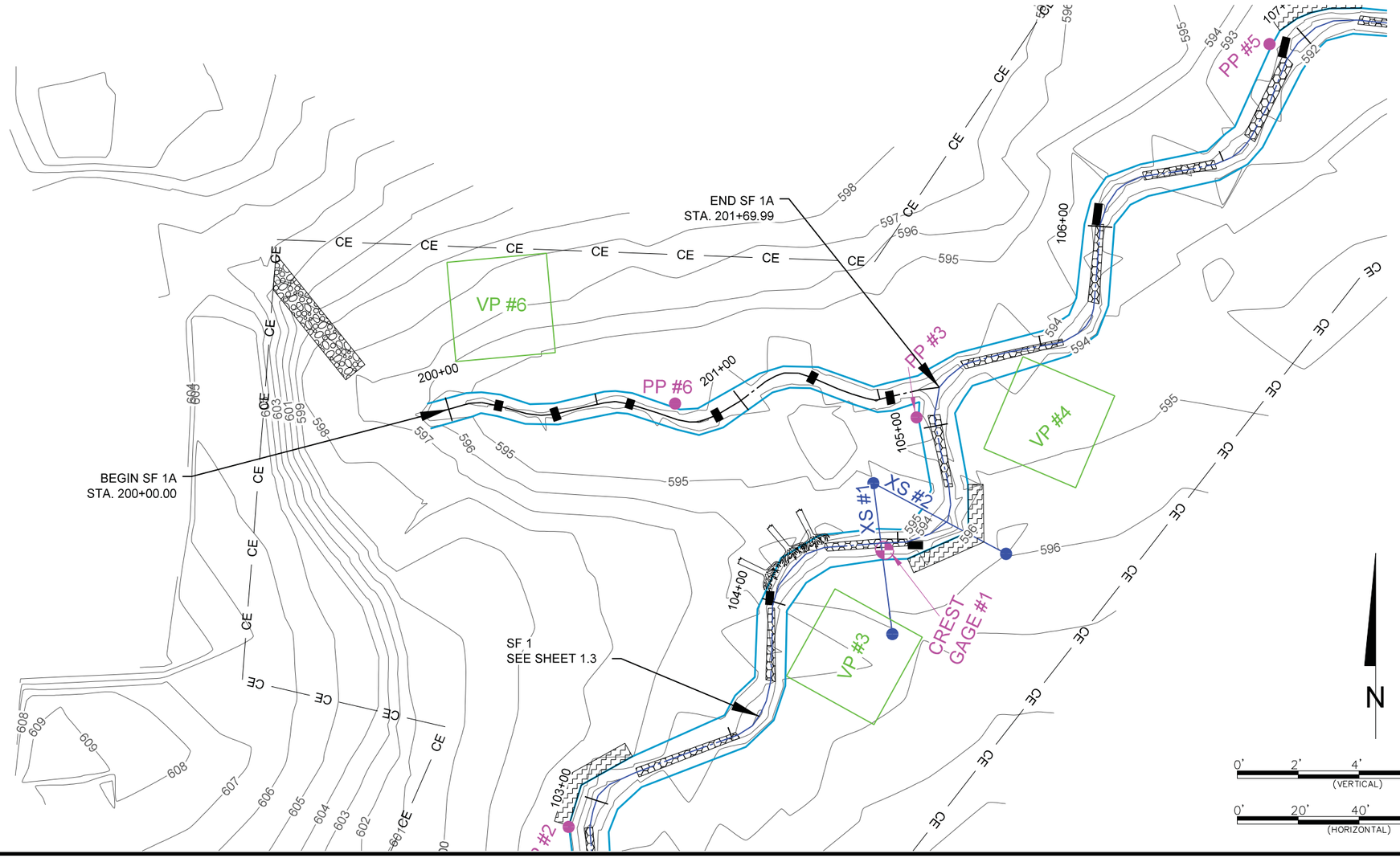

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Final Baseline Drawing

Underwood Mitigation Site
Chatham County, NC

Stream Baseline Plans
SF 1A Plan and Profile

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Job Number:	005-02125
Project Engineer:	NMM
Drawn By:	JTL
Checked By:	JWH

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STREAM BASELINE PLANS

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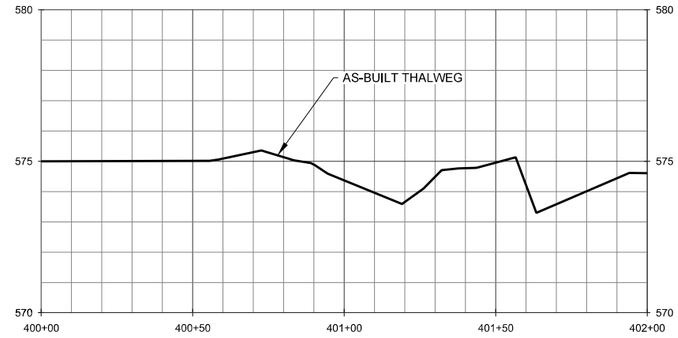

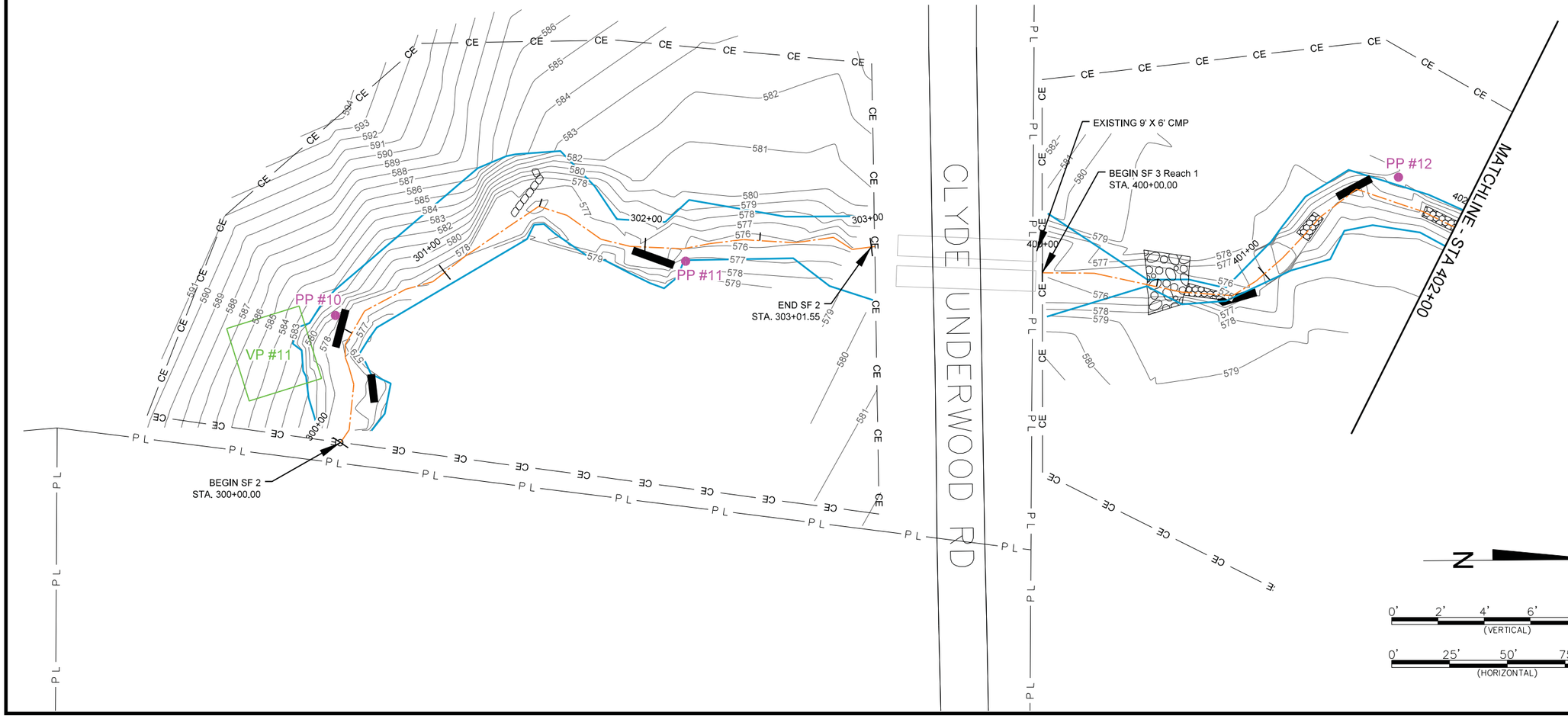

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Underwood Mitigation Site
Chatham County, NC

Stream Baseline Plans
SF 2 & SF 3 Reach 1 Plan and Profile

Final Baseline Drawing

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Drawn By:	JTL
Checked By:	JWH

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STREAM BASELINE PLANS

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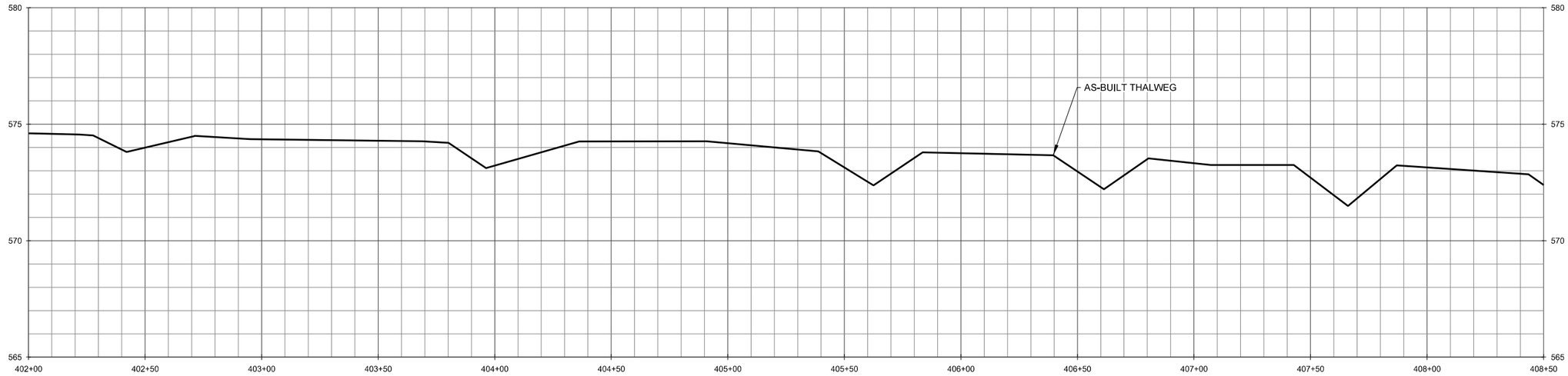

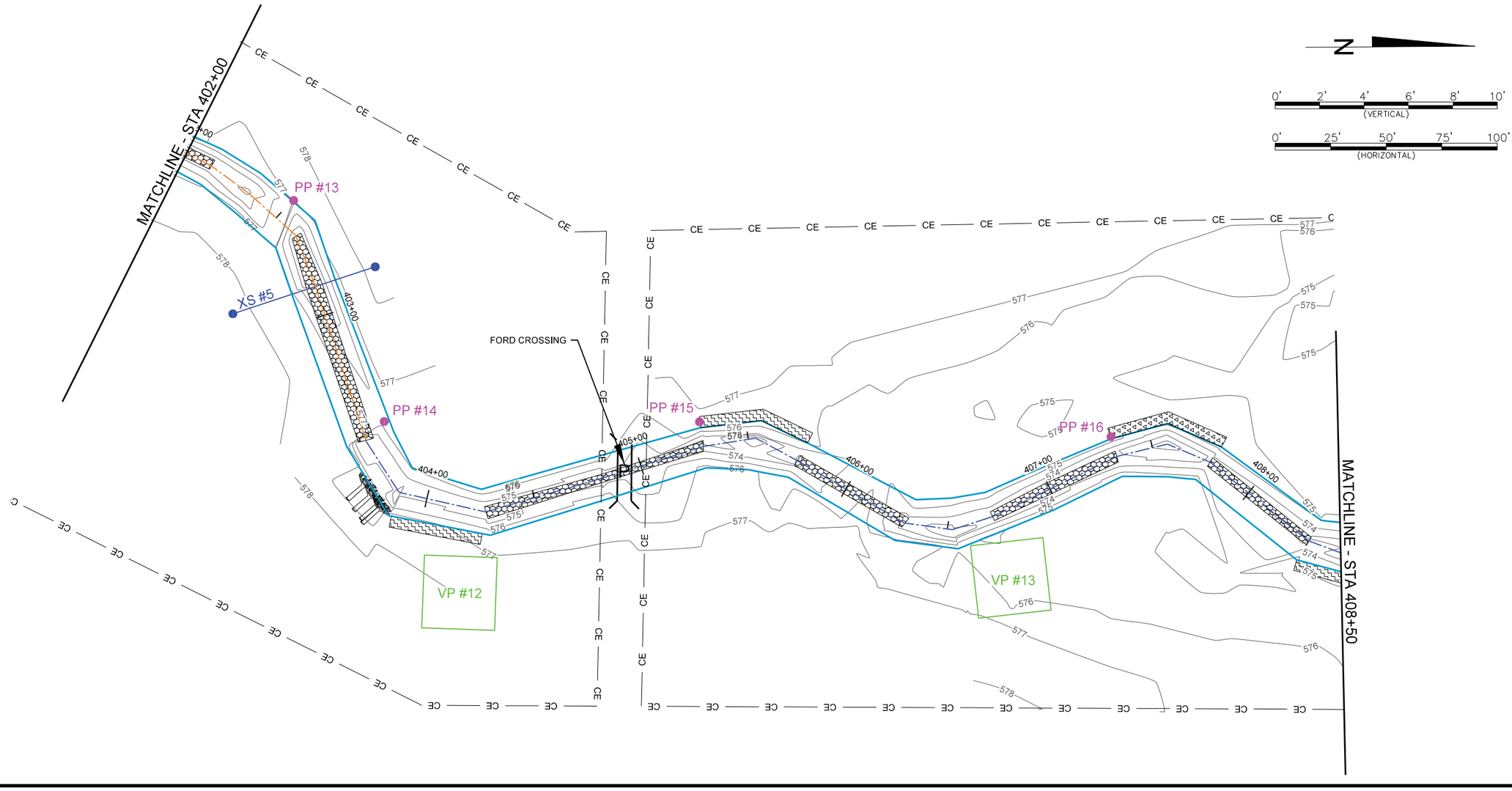

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Underwood Mitigation Site
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SF 3 Reach 1 Plan and Profile

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STREAM BASELINE PLANS

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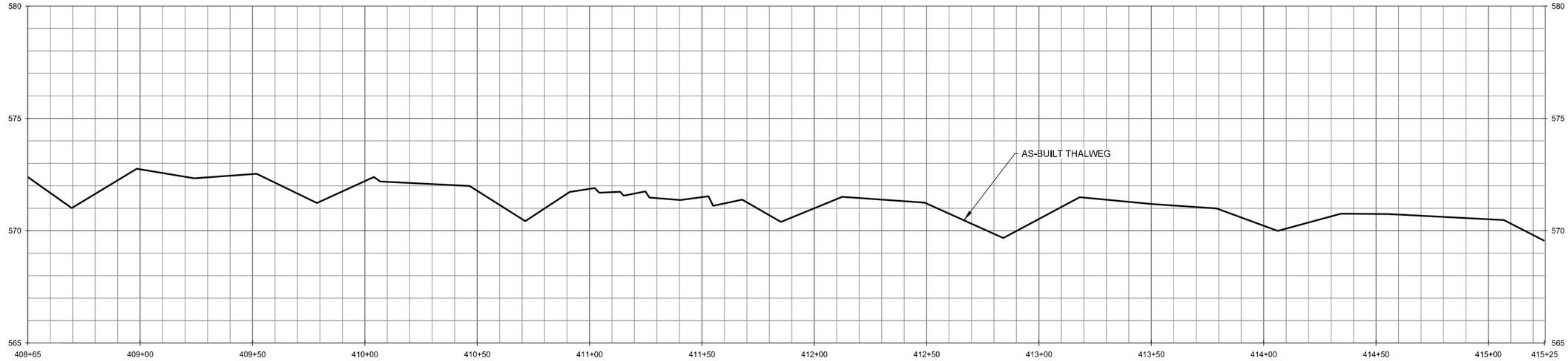

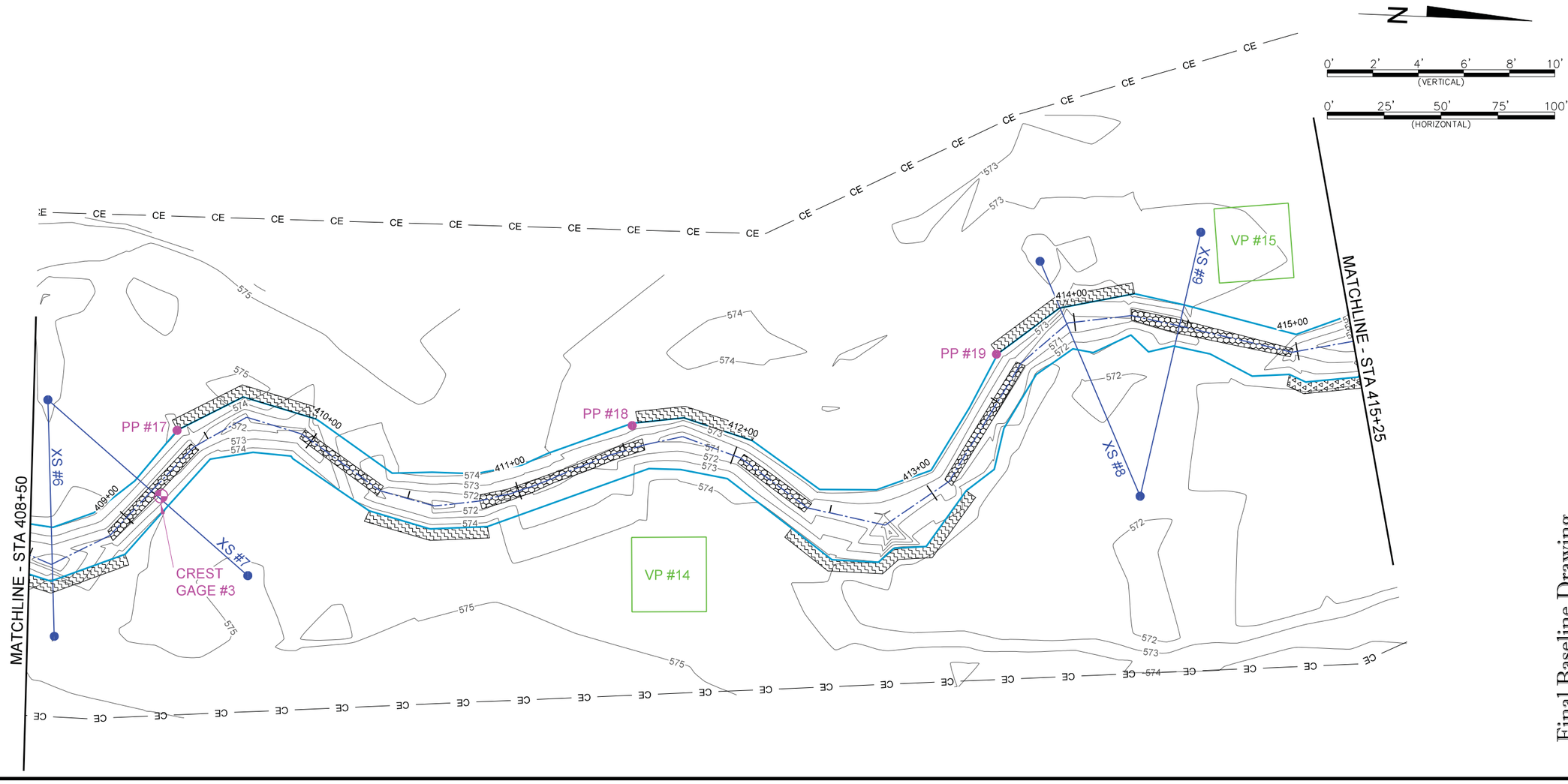

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Final Baseline Drawing

Underwood Mitigation Site
Chatham County, NC
Stream Baseline Plans
SF 3 Reach 1 Plan and Profile

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Checked By:	JWH

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STREAM BASELINE PLANS

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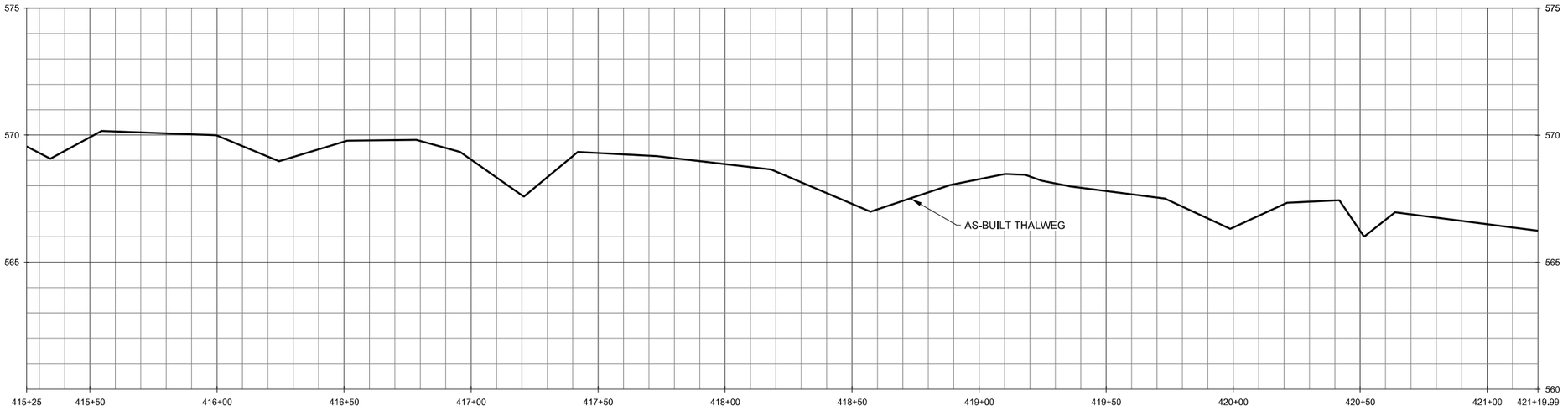

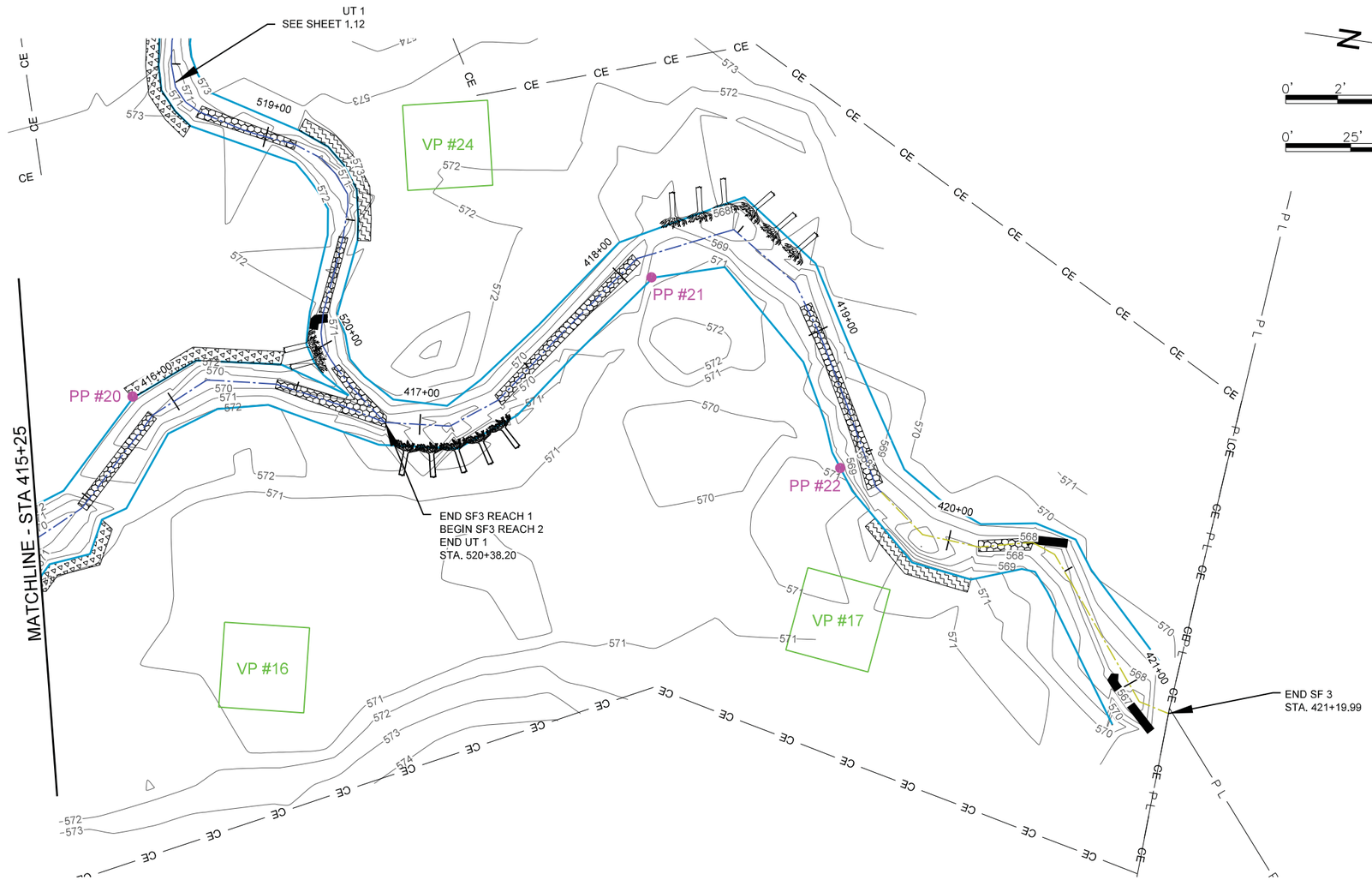

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Final Baseline Drawing

Underwood Mitigation Site
Chatham County, NC

Stream Baseline Plans
SF 3 Reachs 1 & 2 Plan and Profile

Date:	May 6, 2013
Job Number:	005-02125
Project Engineer:	NMM
Drawn By:	JTL
Checked By:	JWH

Revisions

STREAM BASELINE PLANS

Sheet
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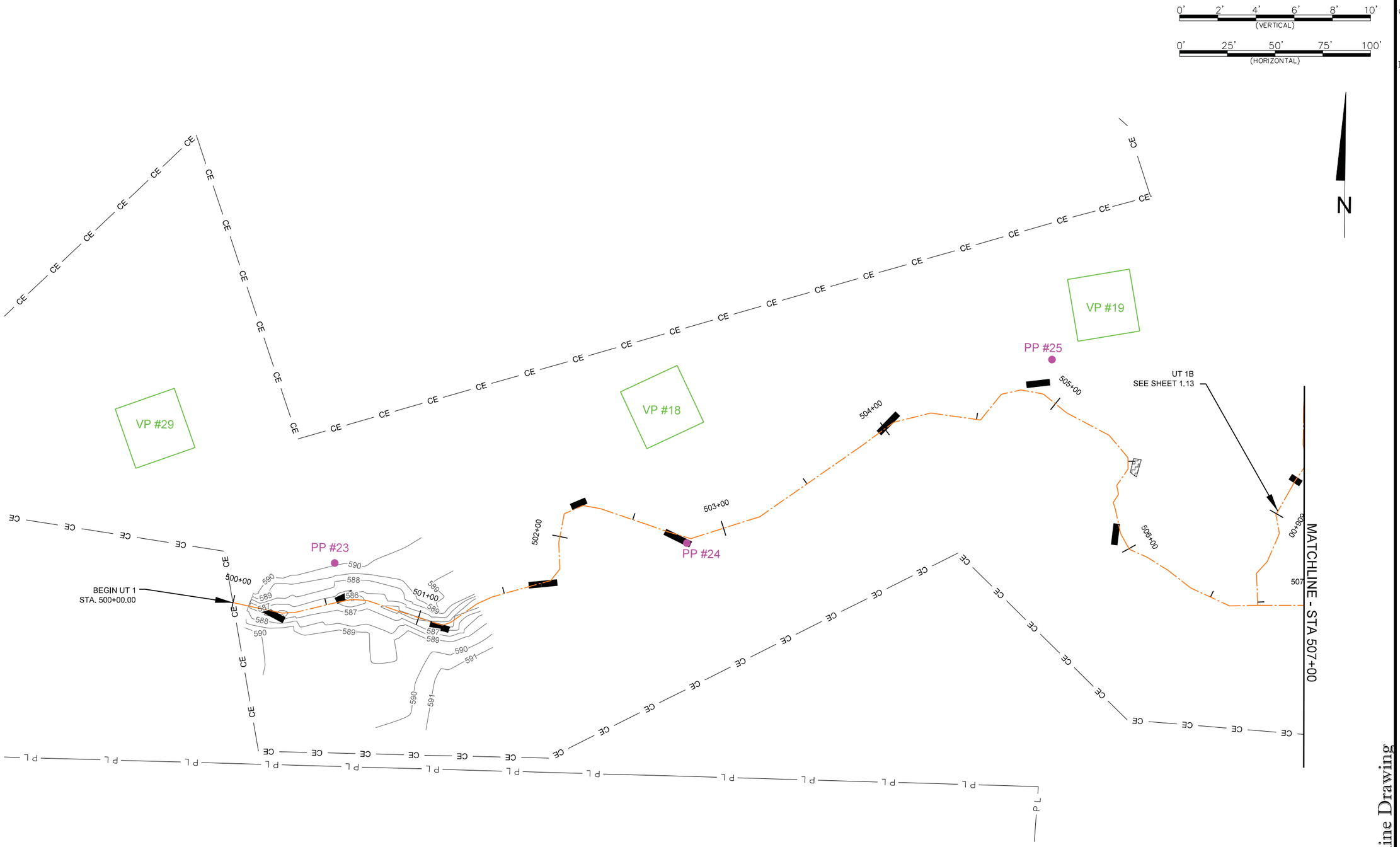

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Underwood Mitigation Site
Chatham County, NC

Stream Baseline Plans
UT 1 Plan and Profile

Final Baseline Drawing

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Checked By:	JWH

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STREAM BASELINE PLANS

Sheet

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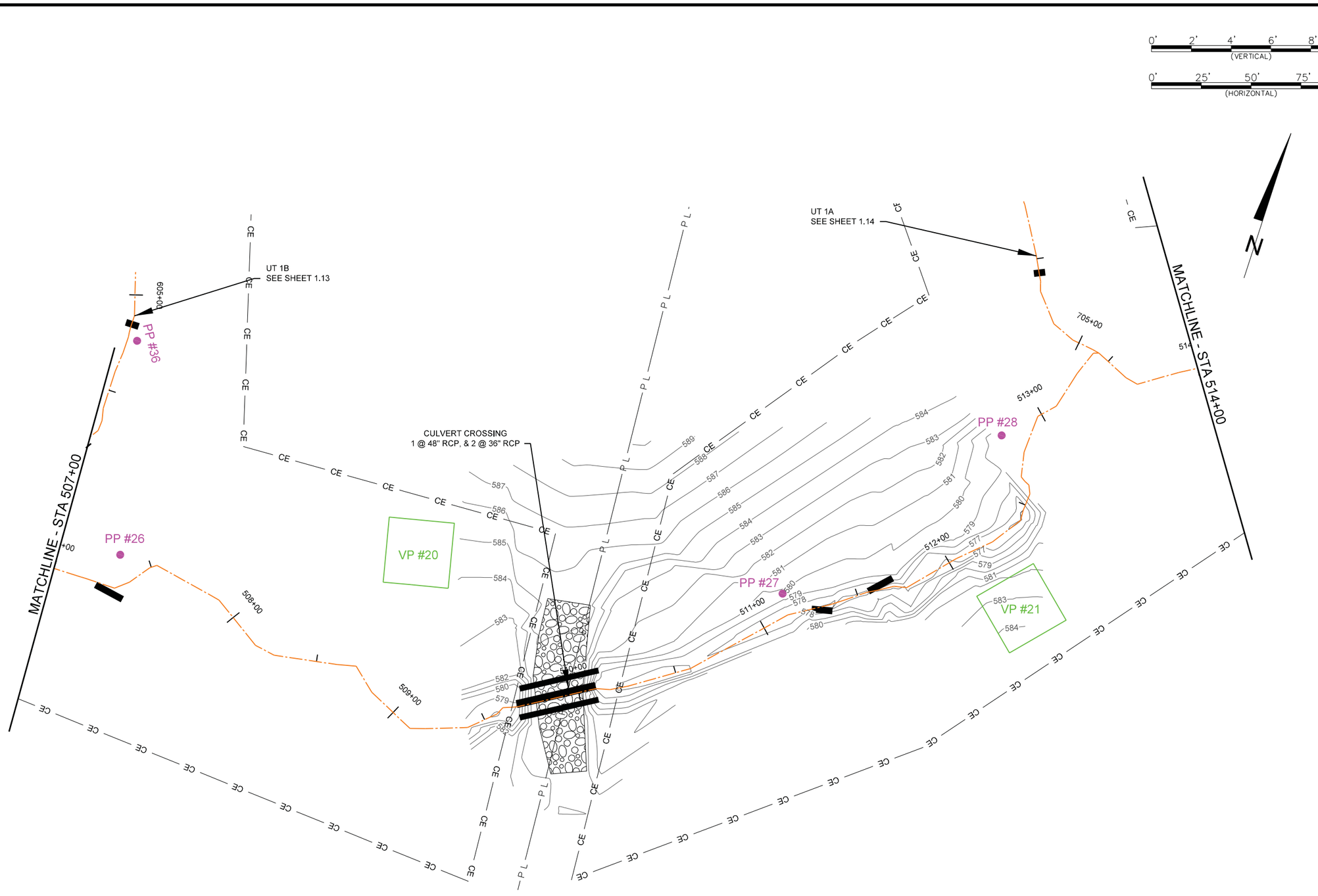

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Underwood Mitigation Site
Chatham County, NC

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UT 1 Plan and Profile

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STREAM BASELINE PLANS

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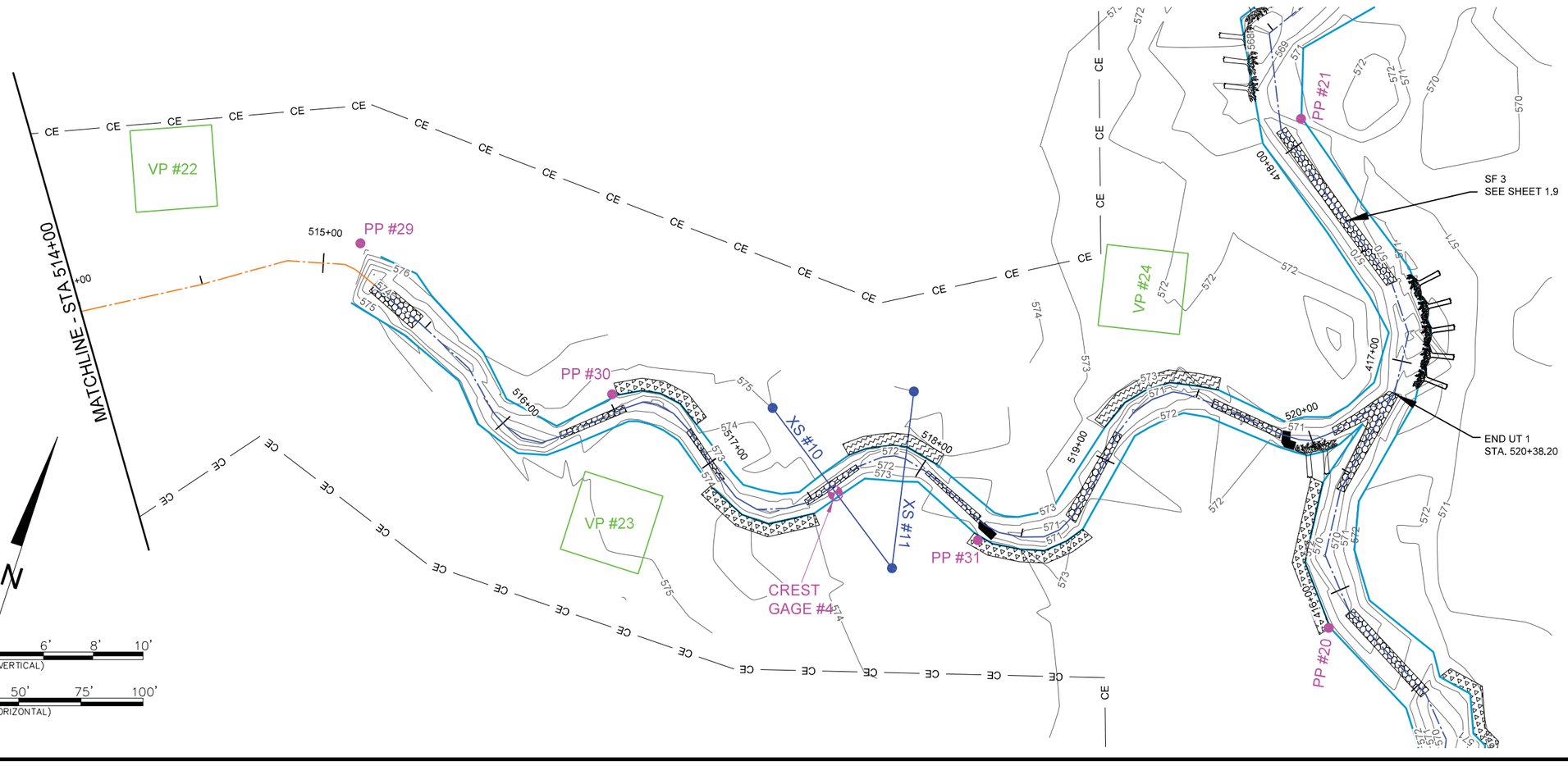

Final Baseline Drawing

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Underwood Mitigation Site
Chatham County, NC
Stream Baseline Plans
UT 1 Plan and Profile

Date:	May 6, 2013
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Project Engineer:	NMM
Drawn By:	JTL
Checked By:	JWH

Revisions

STREAM BASELINE PLANS

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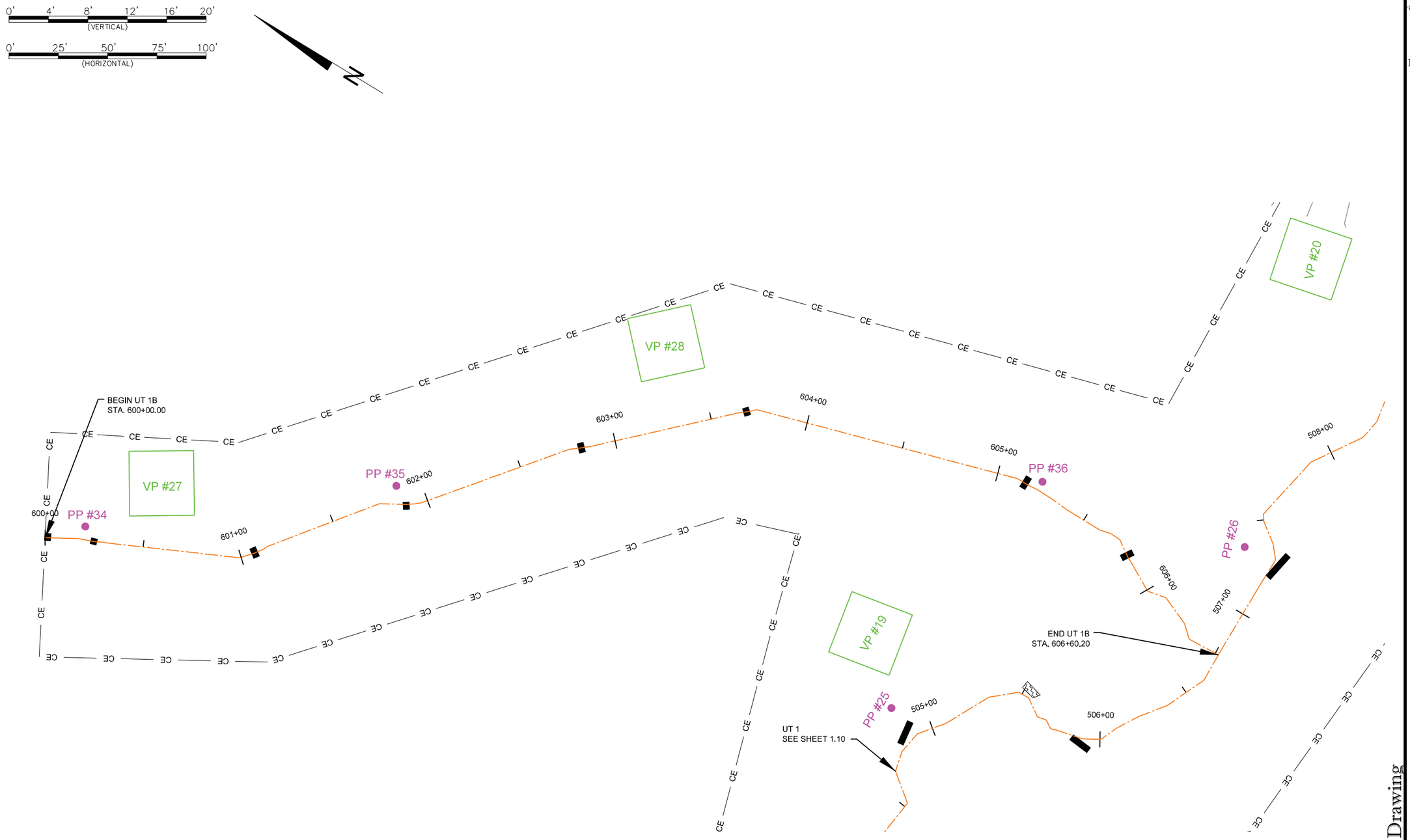

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Underwood Mitigation Site
Chatham County, NC

Stream Baseline Plans
UT 1B Plan and Profile

Final Baseline Drawing

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Drawn By:	JTL
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Revisions

STREAM BASELINE PLANS

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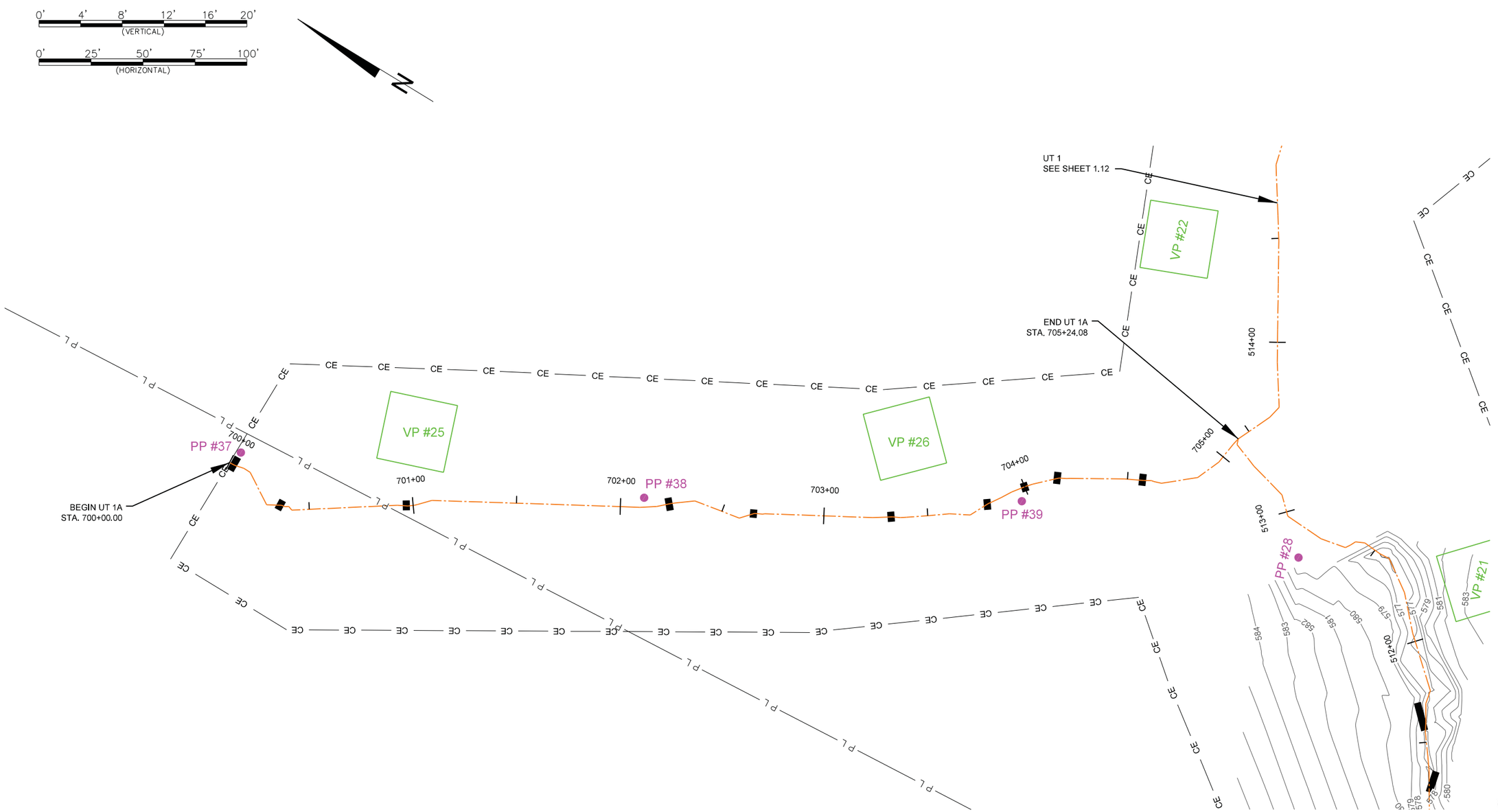

Final Baseline Drawing

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Underwood Mitigation Site
Chatham County, NC

Stream Baseline Plans
UT 1A Plan and Profile

Date:	May 6, 2013
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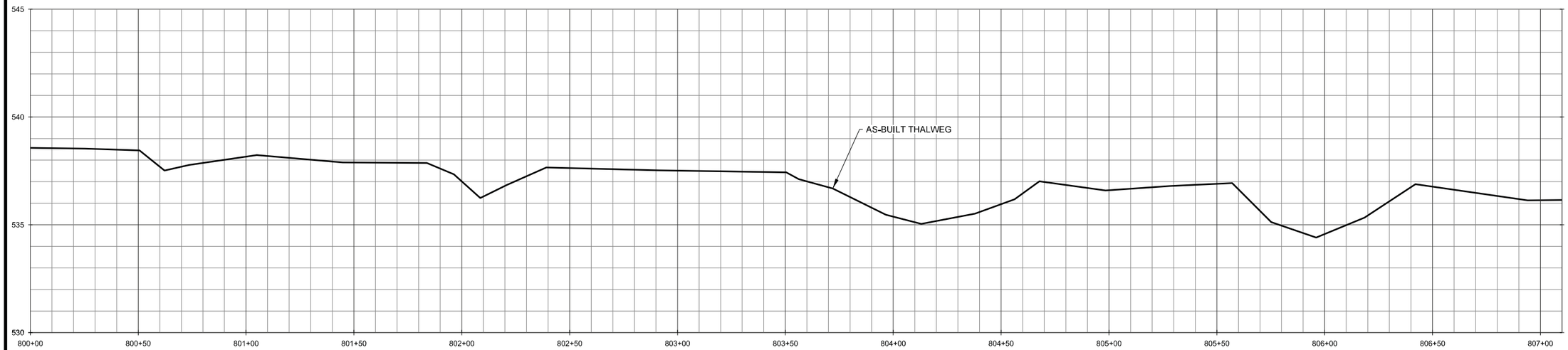
Checked By:	JWH

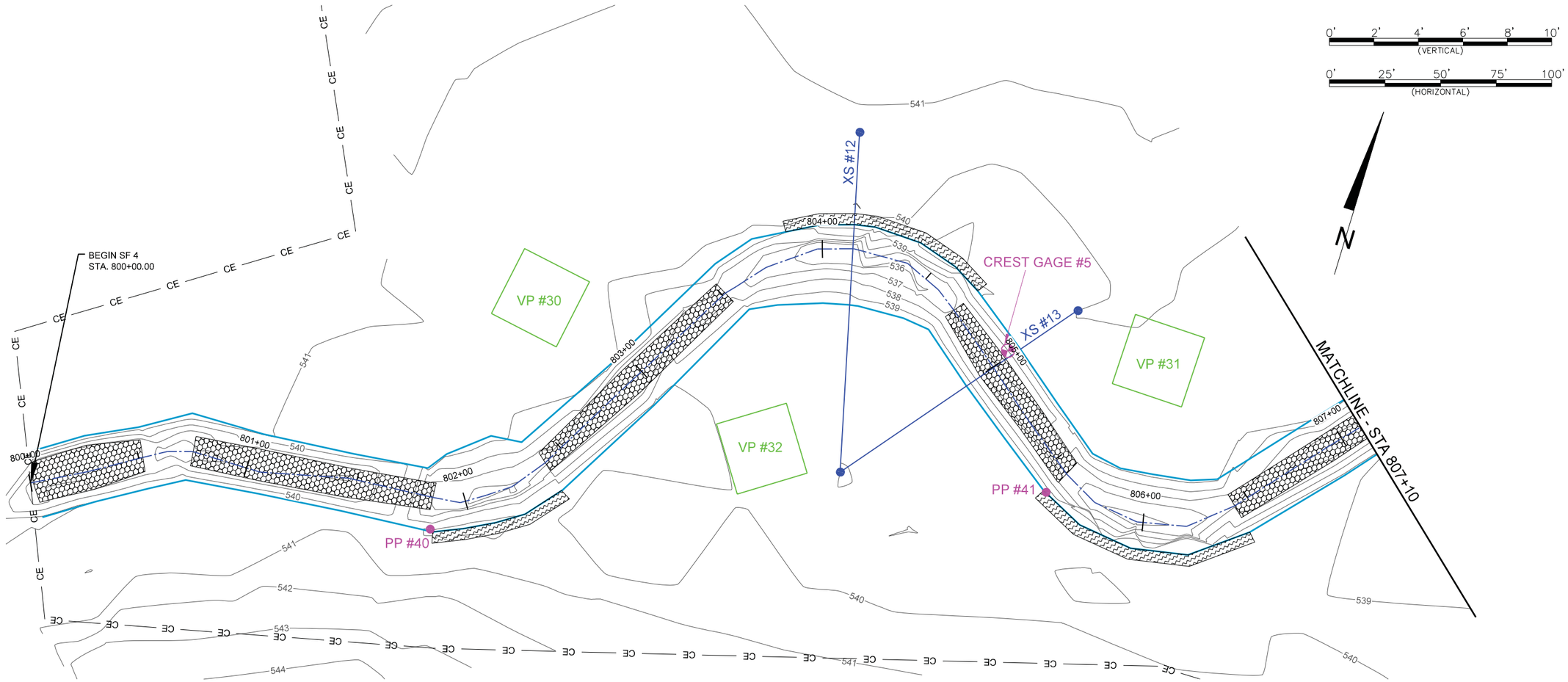
Revisions

STREAM BASELINE PLANS

Sheet

1.14





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Underwood Mitigation Site
Chatham County, NC

Stream Baseline Plans
SF 4 Plan and Profile

Final Baseline Drawing

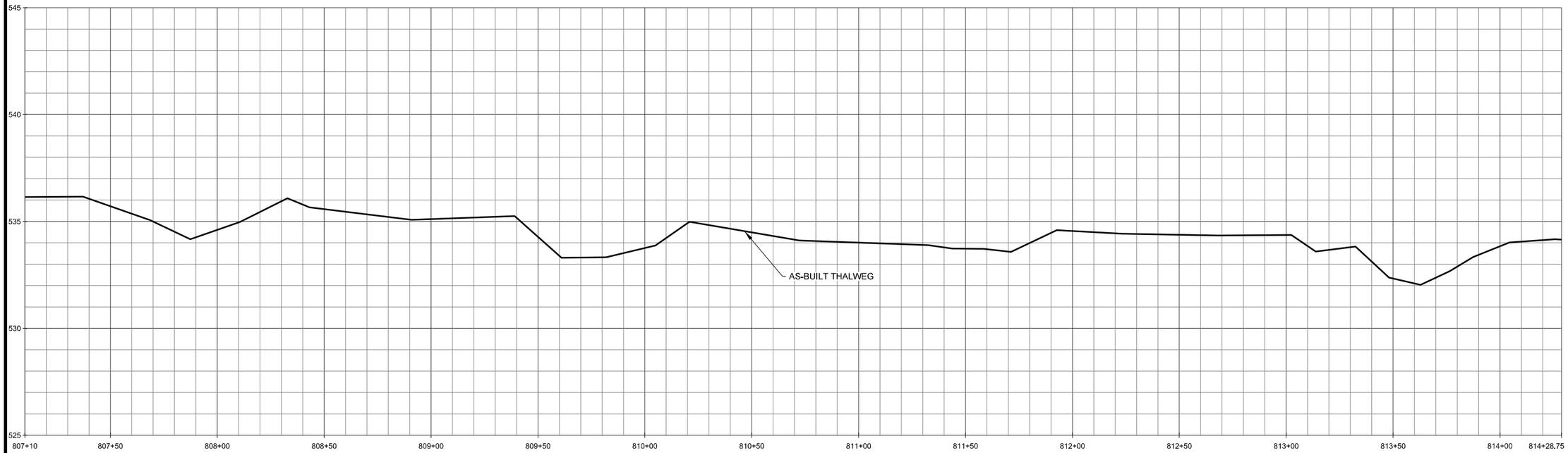
Date:	May 6, 2013
Job Number:	005-02125
Project Engineer:	NMM
Drawn By:	JTL
Checked By:	JWH

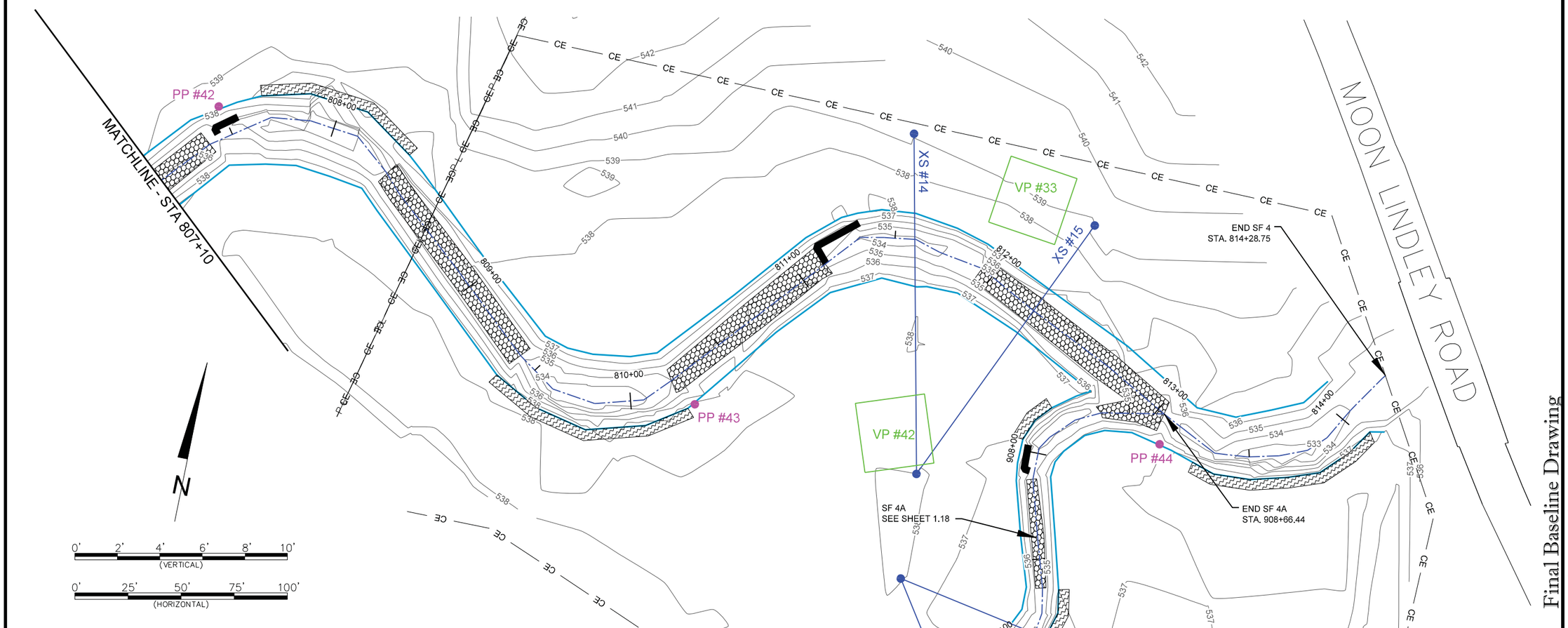
Revisions

STREAM BASELINE PLANS

Sheet

1.15





Final Baseline Drawing

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Stream Baseline Plans
SF 4 Plan and Profile

Date:	May 6, 2013
Job Number:	005-02125
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Drawn By:	JTL
Checked By:	JWH

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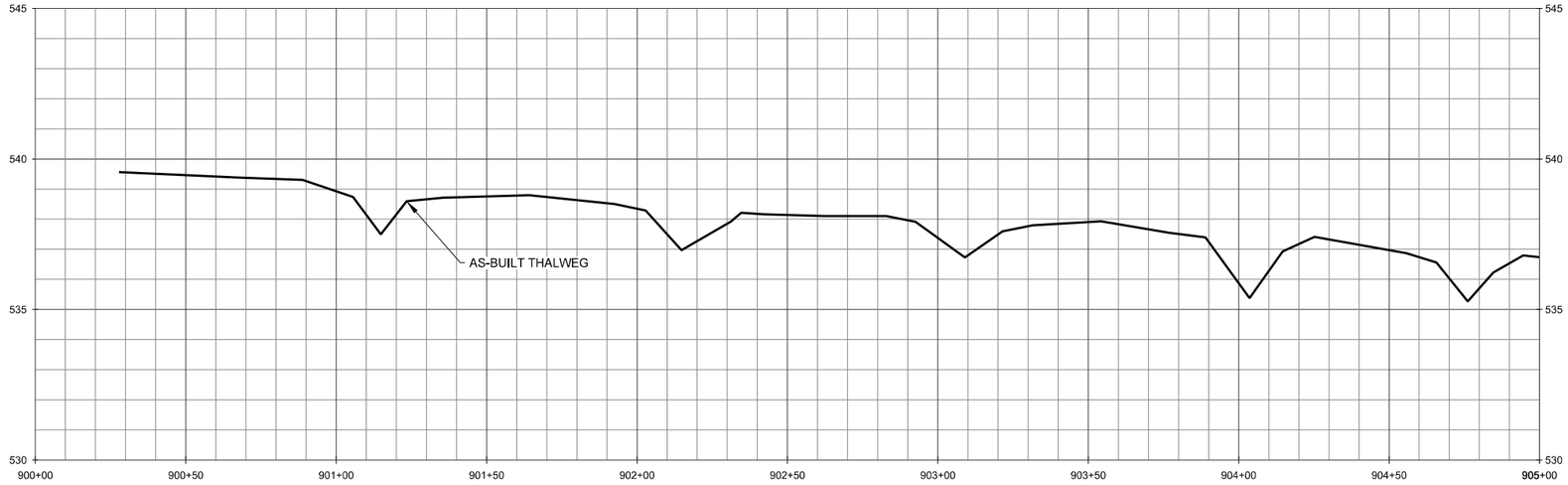
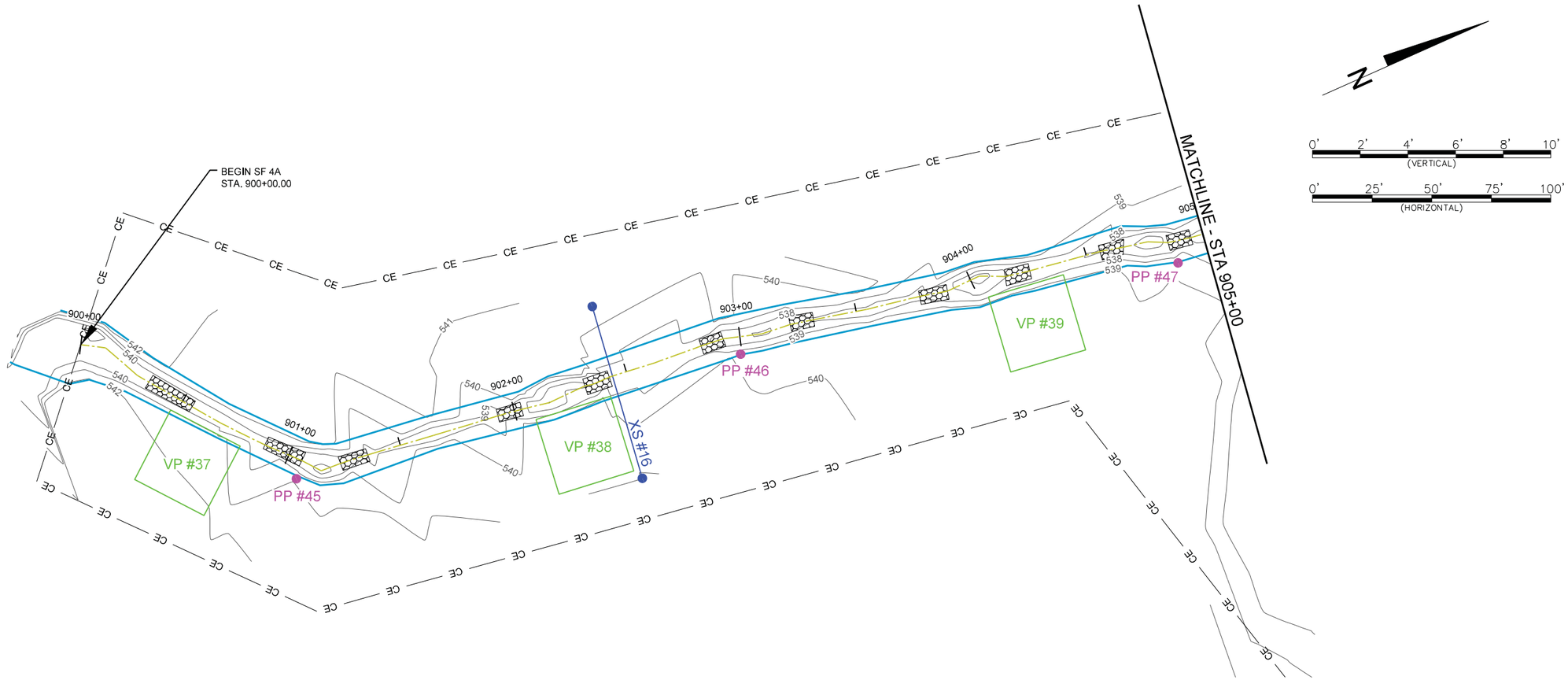
STREAM BASELINE PLANS

Sheet

1.16





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Firm License No. P-0831

Underwood Mitigation Site
Chatham County, NC

Stream Baseline Plans
SF 4A Plan and Profile

Final Baseline Drawing

Date:	May 6, 2013
Job Number:	005-02125
Project Engineer:	NMM
Drawn By:	JTL
Checked By:	JWH

Revisions

STREAM BASELINE PLANS

Sheet

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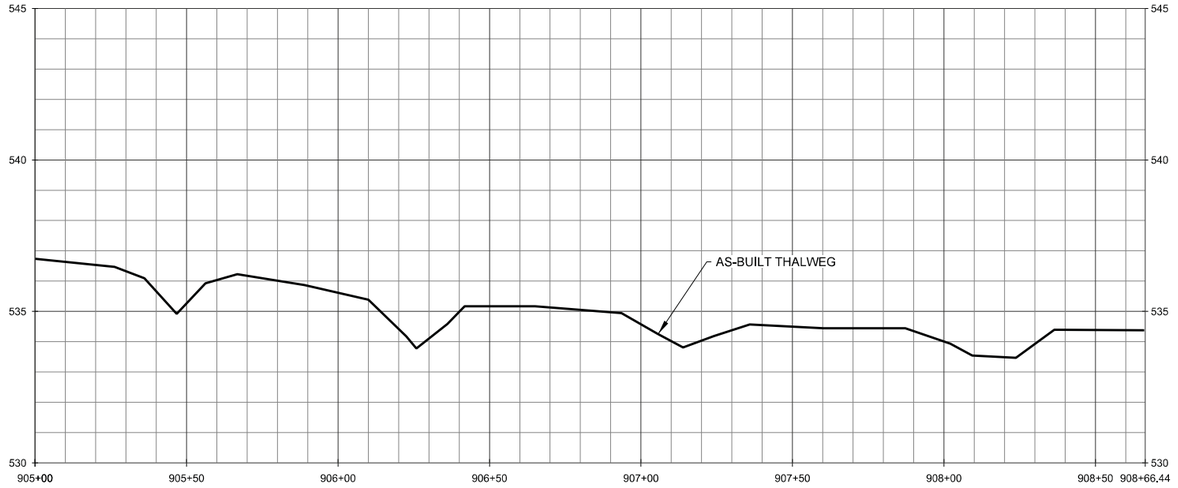

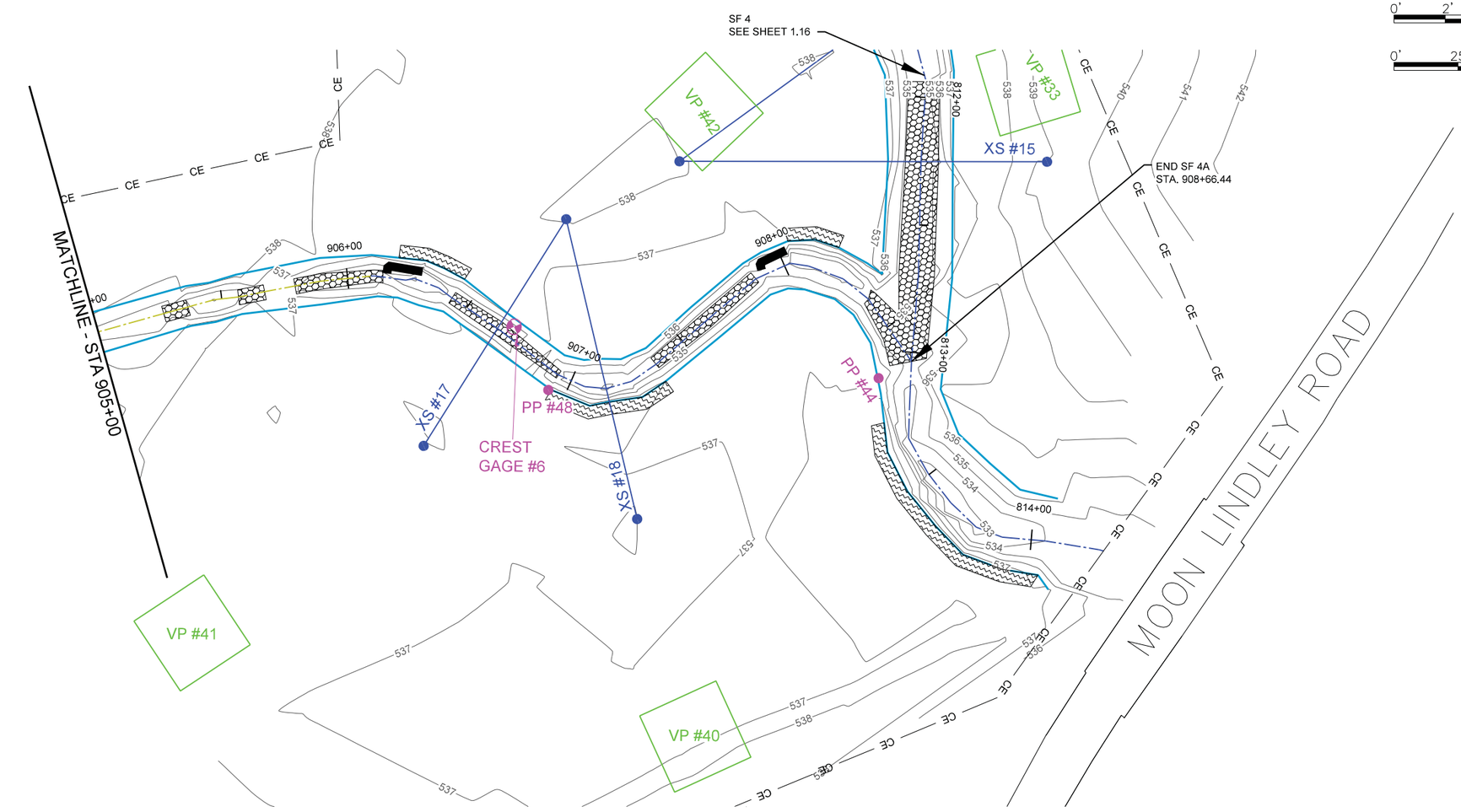

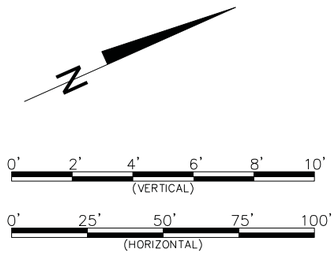

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Stream Baseline Plans
SF 4A Plan and Profile

Final Baseline Drawing

Date:	May 6, 2013
Job Number:	005-02125
Project Engineer:	NMM
Drawn By:	JTL
Checked By:	JWH

Revisions

STREAM BASELINE PLANS

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1.18

SHEET 2.6

SHEET 2.3

SHEET 2.2

SHEET 2.4

SHEET 2.5

NRW 2

GWG #9

VP #29

VP #18

VP #27

UT 1B

VP #19

VP #28

UT 1

VP #20

VP #25

UT 1A

VP #26

VP #21

VP #22

VP #23

VP #24

RW 2

SF 1A

GWG #3

VP #6

NRW 1

VP #1

VP #2

GWG #2

VP #5

VP #7

SF 1

VP #3

VP #4

GWG #4

VP #8

RW 2

UT 2

VP #9

GWG #1

TW #1

VP #10

RW 1

CLYDE UNDERWOOD ROAD

SF 2

VP #11

SF 3

RW 3

VP #12

VP #13

GWG #5

RG #1

VP #14

GWG #8

BARO #1

VP #15

VP #16

ST #1

GWG #7

VP #17

GWG #6

RW 3

N

0' 100' 200' 300' 400'

(HORIZONTAL)

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Underwood Mitigation Site
Chatham County, NC
Wetland Baseline Overview

Final Baseline Drawings

Date:	May 6, 2013
Job Number:	[redacted]
Project Engineer:	TDM
Drawn By:	DJL
Check By:	MRW
Revisions:	

WETLAND BASELINE OVERVIEW

Sheet

2.0

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Wetland Baseline Overview

Final Baseline Drawings

WETLAND BASELINE OVERVIEW

Sheet
2.1

0' 2' 4' 6' 8'
(VERTICAL)

0' 20' 40' 60' 80'
(HORIZONTAL)

N

RW 1

UT 2

GROUND WATER GAGE #1

VP #9

VP #10

FORD CROSSING

0+00 1+00 2+00 3+00 4+00

603 602 601 600 599 598

CE PL

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Underwood Mitigation Site
Chatham County, NC

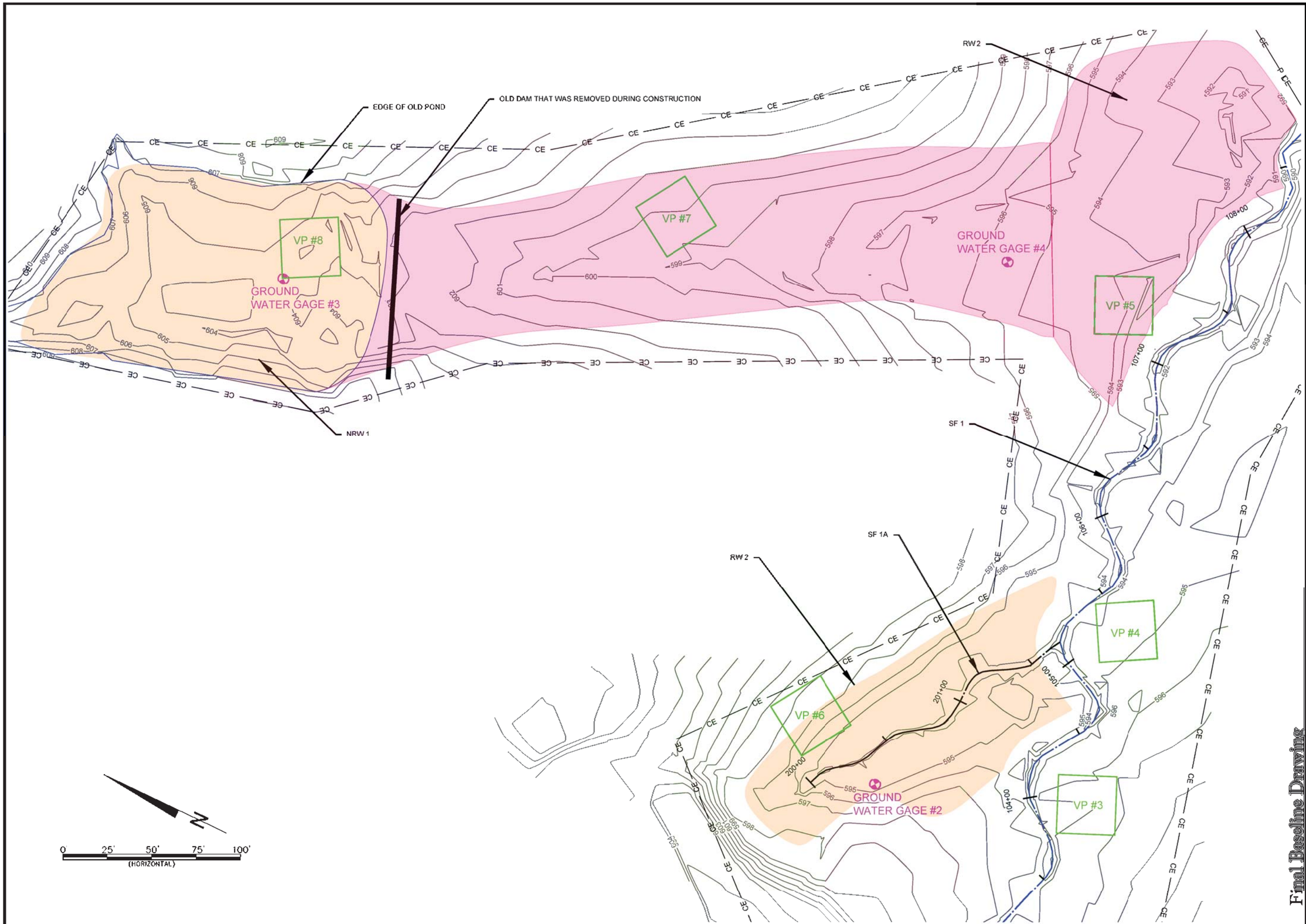
Wetland Baseline Plans
RW 1

Final Baseline Drawings

WETLAND BASELINE PLANS

Sheet

2.2



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Underwood Mitigation Site
Chatham County, NC

Wetland Baseline Plans
RW 2 & NRW 1

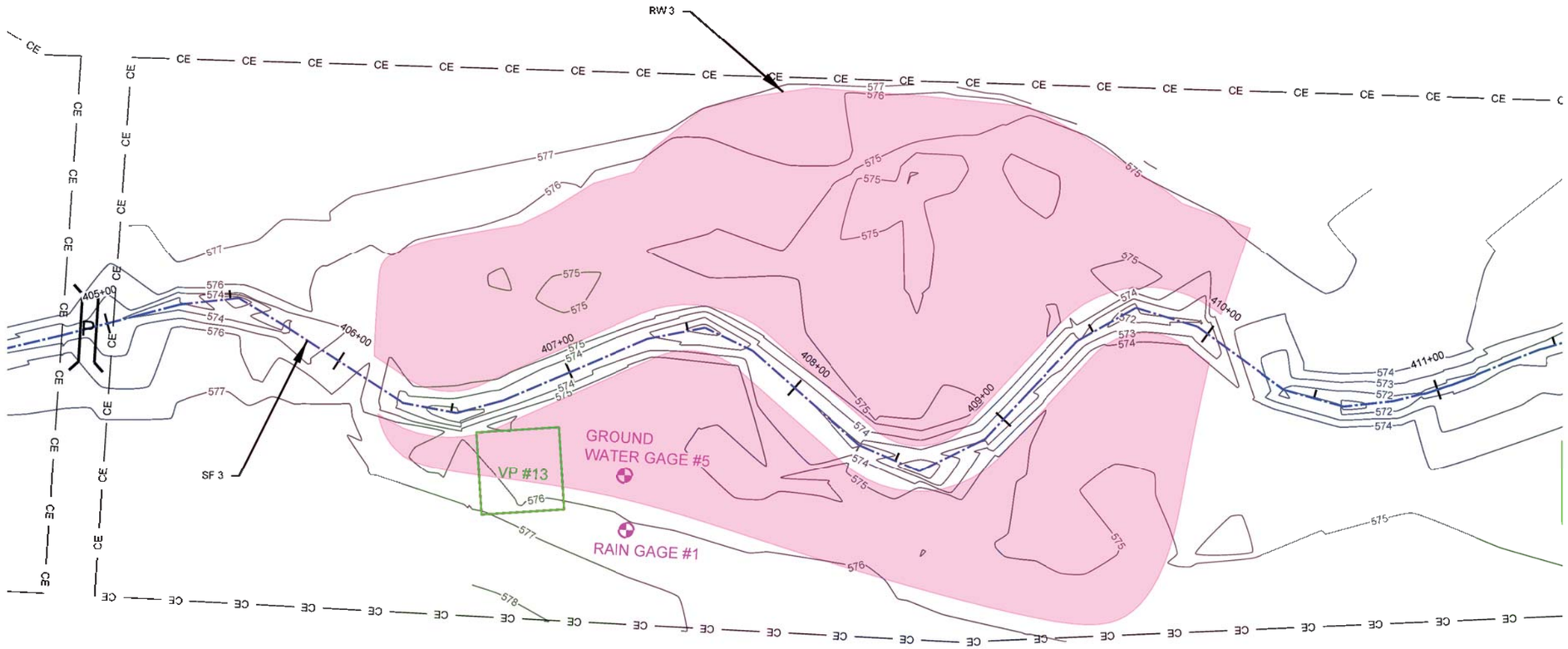
Final Baseline Drawings

Date:	May 6, 2009
Job Number:	404-00005
Project Engineer:	MBW
Drawn By:	BWL
Checked By:	BWL
Revisions:	

WETLAND BASELINE PLANS

Sheet:

2.3



0' 2' 4' 6' 8' 10'
(VERTICAL)

0' 25' 50' 75' 100'
(HORIZONTAL)

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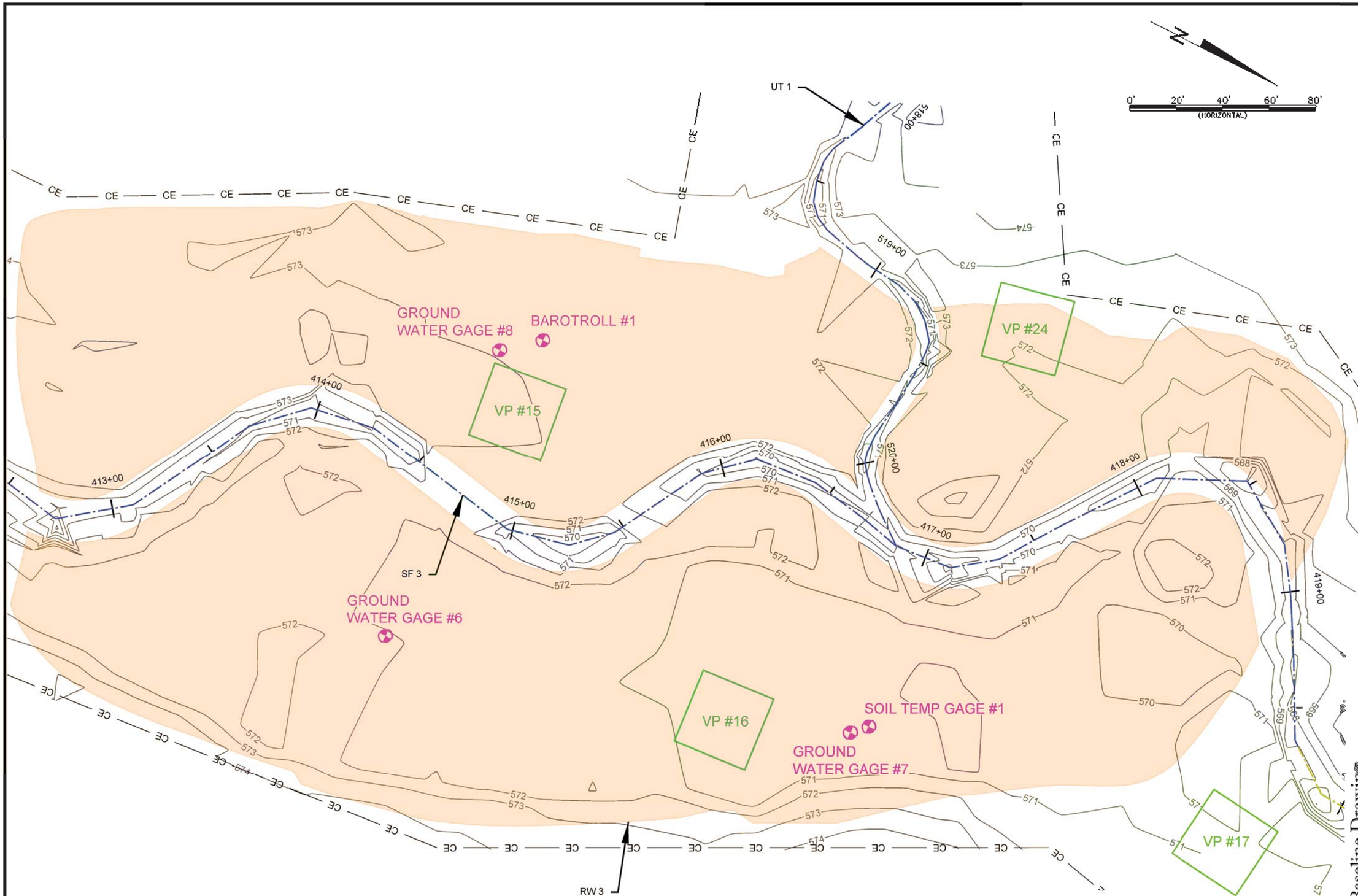
Underwood Mitigation Site
Chatham County, NC
Wetland Baseline Plans
RW 3

Final Baseline Drawings

WETLAND BASELINE PLANS

Sheet
2.4



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Underwood Mitigation Site
Chatham County, NC
Wetland Baseline Plans
RW 3

Final Baseline Drawings

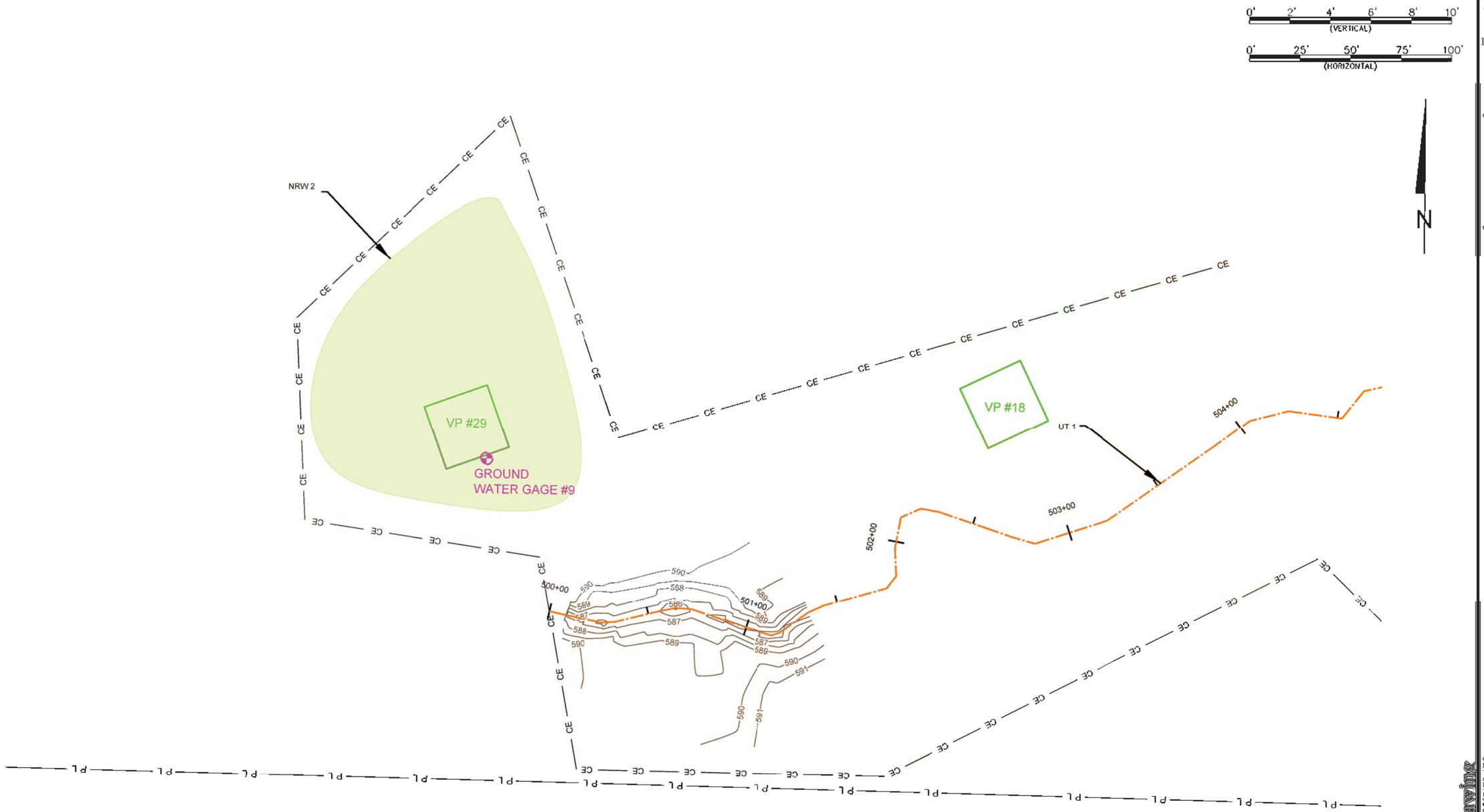
Date:	May 6, 2020
Job Number:	682-00005
Project Engineer:	NMM
Drawn By:	JTL
Checked By:	JWH

Revisions

WETLAND BASELINE PLANS

Sheet

2.5



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Underwood Mitigation Site
Chatham County, NC

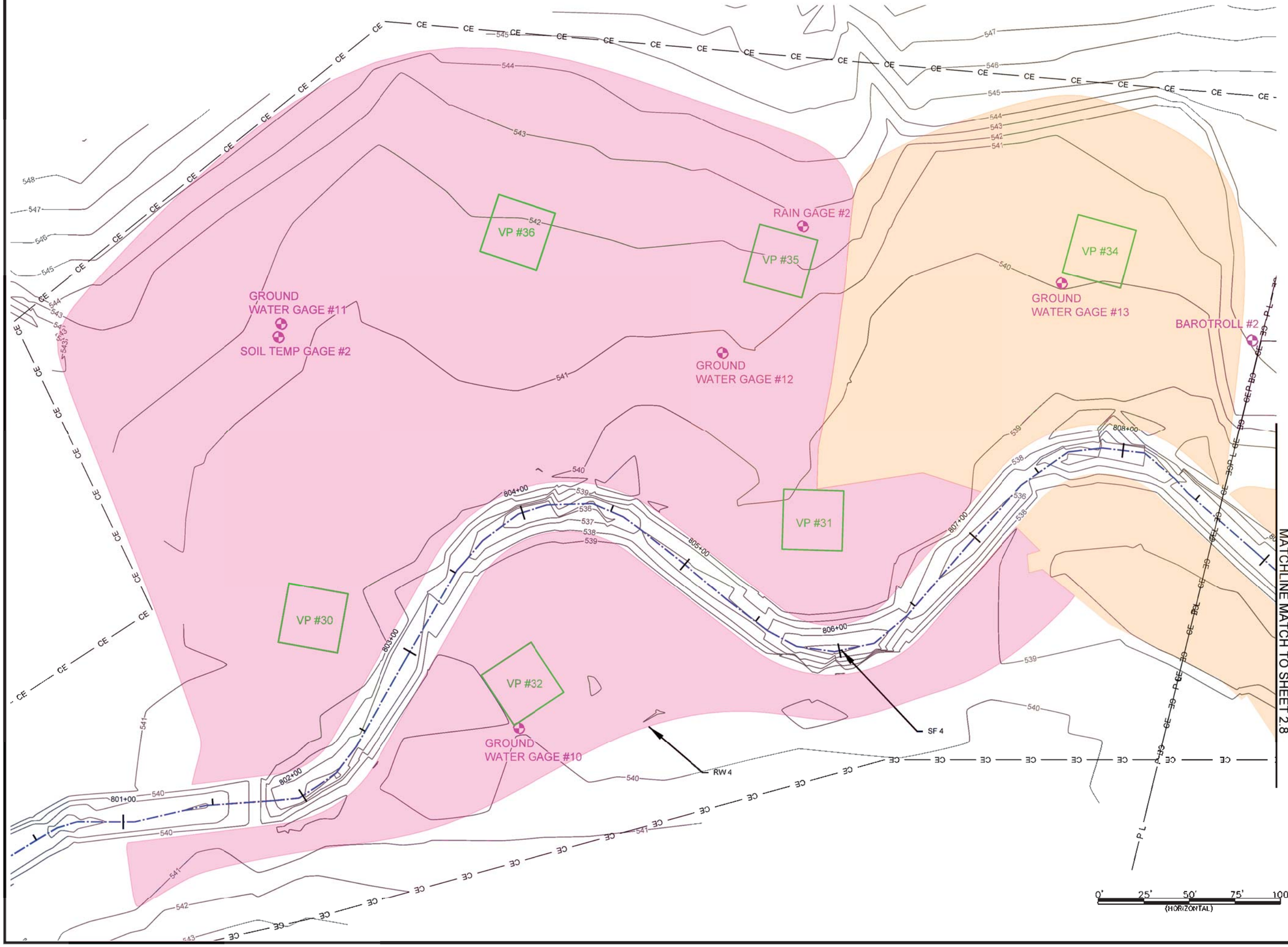
Wetland Baseline Plans
NRW 2

Final Baseline Drawing

Date	May 4, 2020
Job Number	684-0002
Project Engineer	MBH
Surveyor	JDL
Checked By	MBH
Revisions	

WETLAND BASELINE PLANS

Sheet
2.6



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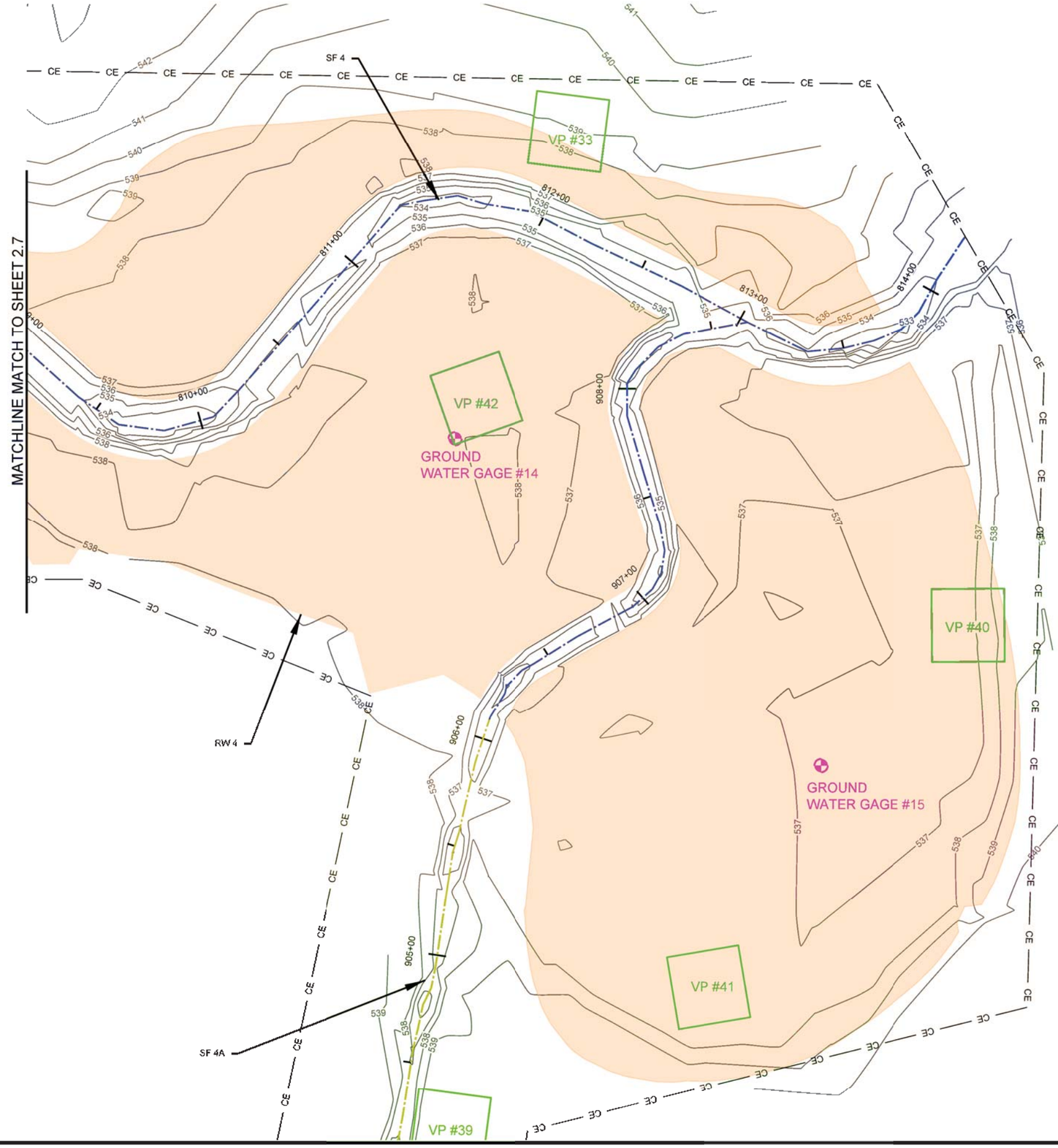
Underwood Mitigation Site
Chatham County, NC
Wetland Baseline Plans
RW 4

Final Baseline Drawing

WETLAND BASELINE PLANS

Sheet
2.7



N

0' 25' 50' 75' 100'
(HORIZONTAL)

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Underwood Mitigation Site
Chatham County, NC
Wetland Baseline Plans
RW 4

Final Baseline Drawing

Date	May 6, 2015
Job Number	682-00015
Project Engineer	MBH
Drawn By	BBL
Checked By	BWR
Revisions	

WETLAND BASELINE PLANS

Sheet
2.8

PLANTING ZONES:

Zone 1 - Streambank Planting Zone

Zone 2 - Floodplain Planting Zone

Zone 3 - Wetland Planting Zone

Zone 4 - Permanent Seeding Outside Easement

VEGETATION TABLES

Planting Summary Table

Streambank Planting - Zone 1 — Acres: 1.9

Species	Common Name	Max Spacing	Unit Type*	Min. Size	Stratum	Indiv. Spacing	# of Stems	Total lbs
Salix nigra	Black Willow	8 ft.	L	0.5"-1.0" cal.	Shrub	2-8 ft.	662	
Cornus amomum	Silky Dogwood	8 ft.	L	0.5"-1.0" cal.	Shrub	2-8 ft.	1324	
Salix sericea	Silky Willow	8 ft.	L	0.5"-1.0" cal.	Shrub	2-8 ft.	1324	
Juncus effusus	Soft Rush**	5 ft.	P	1.0"-2.0" cal.	Herb	5 ft.	2720	
						Subtotal	**6,030**	**0**

* *L = Live Stake; P = Herbaceous Plug; R = Bare Root*

** *Soft Rush shall be installed at the toe of streambank only on all restoration reaches*

Planting Summary Table

Floodplain Planting - Zone 2 — Acres: 15.8

Species	Common Name	Max Spacing	Unit Type*	Min. Caliper Size	Stratum	Indiv. Spacing	# of Stems	Total lbs
Quercus pagoda	Cherrybark Oak	12 ft.	R	0.25"-1.0"	Canopy	6-12 ft.	1700	
Liriodendron tulipifera	Tulip Poplar	12 ft.	R	0.25"-1.0"	Canopy	6-12 ft.	1300	
Quercus phellos	Willow Oak	12 ft.	R	0.25"-1.0"	Canopy	6-12 ft.	1300	
Plantus occidentalis	Sycamore	12 ft.	R	0.25"-1.0"	Canopy	6-12 ft.	2200	
Betula nigra	River Birch	12 ft.	R	0.25"-1.0"	Canopy	6-12 ft.	1600	
Quercus michauxii	Swamp Chestnut Oak	12 ft.	R	0.25"-1.0"	Canopy	6-12 ft.	1300	
Fraxinus pennsylvanica	Green Ash	12 ft.	R	0.25"-1.0"	Canopy	6-12 ft.	1400	
						Subtotal	**10,800**	**0**

* *L = Live Stake; P = Herbaceous Plug; R = Bare Root*

Planting Summary Table

Wetland Planting - Zone 3 — Acres: 20.1

Species	Common Name	Max Spacing	Unit Type*	Min. Caliper Size	Stratum	Indiv. Spacing	# of Stems	Total lbs
Salix sericea	Silky Willow	8 ft.	L	0.25"-1.0"	Canopy	6-8 ft.	1100	
Cornus ammomum	Silky Dogwood	8 ft.	L	0.25"-1.0"	Shrub	6-8 ft.	1100	
Quercus phellos	Willow Oak	8 ft.	R	0.25"-1.0"	Canopy	6-8 ft.	1200	
Plantus occidentalis	Sycamore	8 ft.	R	0.25"-1.0"	Canopy	6-8 ft.	1900	
Betula nigra	River Birch	8 ft.	R	0.25"-1.0"	Canopy	6-8 ft.	1500	
Quercus michauxii	Swamp Chestnut Oak	8 ft.	R	0.25"-1.0"	Canopy	6-8 ft.	1300	
Fraxinus pennsylvanica	Green Ash	8 ft.	R	0.25"-1.0"	Canopy	6-8 ft.	1500	
						Subtotal	**9,600**	**0**

* *L = Live Stake; P = Herbaceous Plug; R = Bare Root*

Permanent Seeding Outside Easement - Zone 4

Acres: 4.6

Approved Date	Species Name	Stratum	Common Name	Density (lbs/acre)
All Year	*Festuca arundinacea*	Herb	Tall Fescue	40

Permanent Seeding - Zone 1, 2, & 3

Acres: 37.8

Approved Date	Species Name	Stratum	Common Name	Density (lbs/acre)
All Year	Panicum virgatum	Herb	Swithgrass	7
All Year	Carex vulpinoidea	Herb	Fox sedge	6
All Year	Elymus virginicus	Herb	Virginia Wild Rye	4.5
All Year	Bidens aristosa	Herb	Showy Tickseed	4.5
			Subtotal	**22**

Temporary Seeding - Zone 1, 2, & 3

Acres: 37.8

Approved Date	Species Name	Stratum	Common Name	Density (lbs/acre)
Aug 15 - May 1	*Secale cereale*	Herb	Rye Grain	140
May 1 - Aug 15	*Setaria italica*	Herb	German Millet	50

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Underwood Mitigation Site
Chatham County, NC
Planting Tables

Final Baseline Drawing

Date: May 6, 2013
Job Number: 005-02125
Project Engineer: NMM
Drawn By: JTL
Checked By: JWH

Revisions

PLANTING TABLES

Sheet
3.0

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Underwood Mitigation Site
Chatham County, NC
UT 2, SF 1, SF 1A, RW 1, RW 2, & NRW 1
Planting

Final Baseline Drawing

Date:	May 6, 2013
Job Number:	005-02125
Project Engineer:	NMM
Drawn By:	JTL
Checked By:	JWH

Revisions

PLANTING

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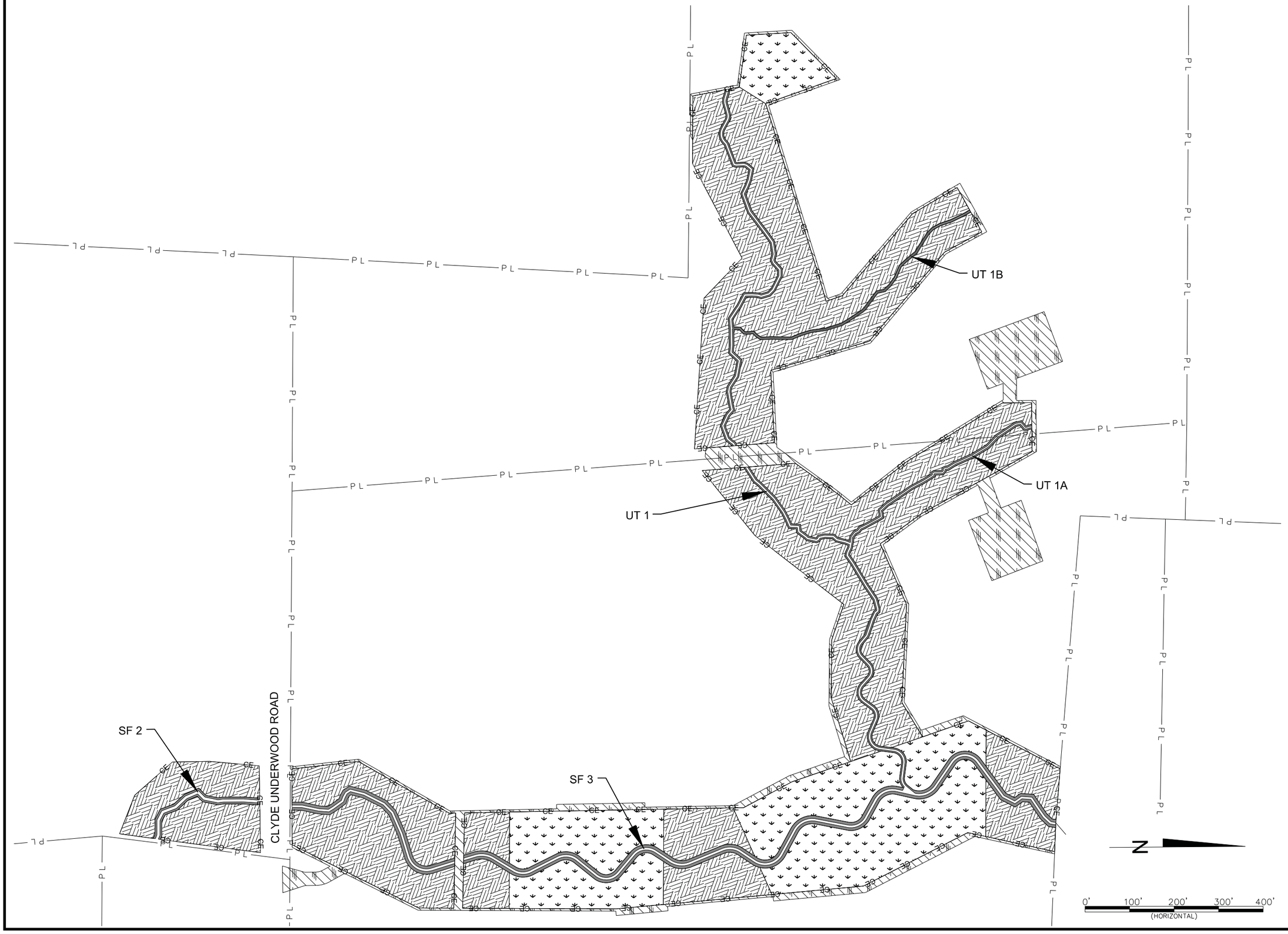

Final Baseline Drawing

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Underwood Mitigation Site
Chatham County, NC
SF 2, SF 3, UT 1, UT 1A, UT 1B, RW 3, & NRW 2
Planting

Date:	May 6, 2013
Job Number:	005-02125
Project Engineer:	NMM
Drawn By:	JTL
Checked By:	JWH

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PLANTING

Sheet
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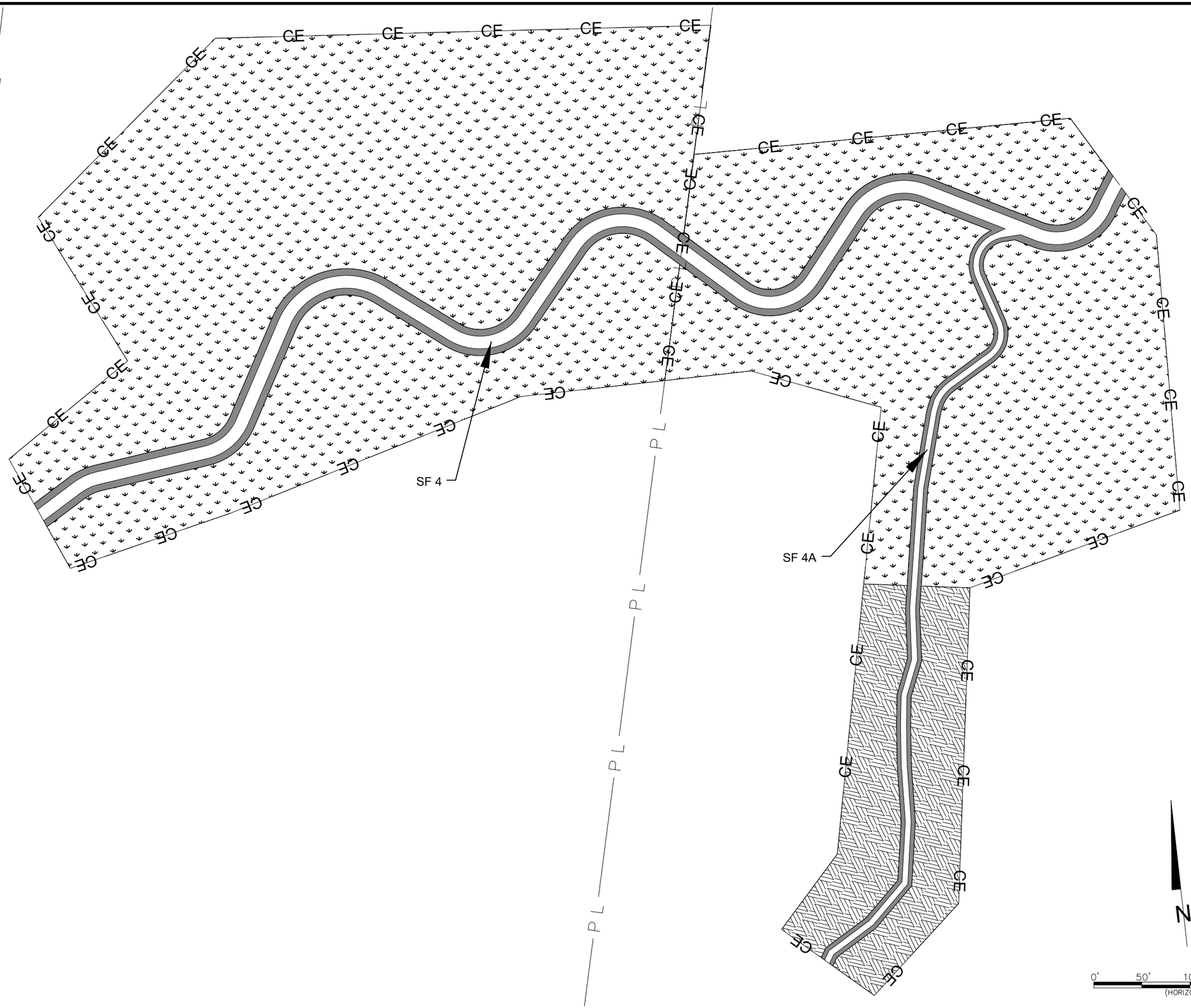

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Underwood Mitigation Site
Chatham County, NC

SF 4, SF 4A, & RW 4
Planting

Final Baseline Drawing

Date:	May 6, 2013
Job Number:	005-02125
Project Engineer:	NMM
Drawn By:	JTL
Checked By:	JWH

Revisions

PLANTING

Sheet
3.3