BEST STREAM AND WETLAND RESTORATION PROJECT
MONITORING REPORT
MONITORING YEAR 1

DUPLIN COUNTY, NORTH CAROLINA
CONTRACT NO. 004631 - PROJECT NO. 95353

Prepared for:

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Cape Fear River Basin
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EXECUTIVE SUMMARY

The Best Site Stream & Wetland Mitigation Project is located within an agricultural watershed in Duplin County, North Carolina, approximately two miles east of Beulaville. The project streams were significantly impacted by channelization and agricultural practices. The project involved the restoration and protection of streams and wetlands in the Muddy Creek watershed. The purpose of this restoration project is to restore and enhance a stream/wetland complex located within the Cape Fear River Basin.

The project lies within USGS Hydrologic Unit Code 03030007060010 (USGS, 1998) and within the North Carolina Division of Water Quality (NCDWQ) Cape Fear River Sub-basin 03-06-22 (NCDENR, 2005). The 2009 Cape Fear River Basin Plan identified HUC 03030007060010 as a Targeted Local Watershed. The watershed is characterized by 52 percent agricultural land use area with Muddy Creek identified as Impaired for aquatic life because of a Fair benthic community rating. The plan listed water quality and animal operations as major stressors within this TLW, and the planning goals include identifying restoration and stormwater BMP needs.

The Best stream and wetland mitigation project is located within the northern (upstream) portion of the TLW and includes sections of Muddy Creek (303d listed) and headwater streams that discharge into Muddy Creek. The stream and wetland restoration and enhancement activities on this project will provide numerous ecological and water quality benefits within the Cape Fear River Basin. These benefits will address the degraded water quality and nutrient inputs from agriculture that were identified as major watershed stressors in the 2009 Cape Fear River Basin Plan.

The Best Site consists of stream and wetland restoration on tributaries that located directly adjacent to Muddy Creek and includes 19,807 linear feet of Stream Preservation and Buffer Enhancement along Muddy Creek and its tributaries. Stream restoration has been completed for two tributaries, headwater valley restoration along a portion of one tributary, stream enhancement along three tributaries, and stream preservation and buffer enhancement for the remaining streams.

This Year 1 Annual Monitoring Report presents the data from 23 vegetation monitoring plots, six manual crest gauges, six auto crest gauges, an auto-logging rain gauge, nine wetland restoration groundwater gauges, three reference groundwater gauges, 31 stream cross sections, eight sets of bank pins, and photo reference locations, as required by the approved Mitigation Plan for the site.

The Best Year 1 Monitoring activities were completed in February 2016. All Year 1 monitoring data is presented below and in the appendices. Data presented shows the site has a few localized areas of bank erosion and unstable structures on UT1, UT2, and UT4. UT8 has a crossing culvert that needs to be repaired. Most vegetation plots (91%) are above the interim year 3 success criteria. The site is on track to meeting stream, wetland and vegetation interim success criteria.

Throughout the Year 1 monitoring season, the restoration and enhancement reaches remained mostly stable and continued to provide the intended habitat and hydrologic functions. Minimal changes were noted for Year 1 cross section surveys resulting from stable bed and bank conditions. Five of the six crest gauges recorded bankfull events during the Year 1 monitoring period. A total of seven stream problem areas were noted during the Year 1 monitoring period. These problem areas consists of bank erosion and scouring around log grade control structures on UT1 and UT2. UT4 exhibited bed and bank erosion on approximately 75 linear feet of stream. UT8 also has a culvert crossing that needs repairing. The problem areas are addressed below in the report detailing the severity and repair recommendations. Year 1 stream problems are likely the result of October 2015 Hurricane Joaquin which resulted in record amount of rainfall flowing through the newly constructed site.

Eight of the nine wetland gauges achieved the success criteria by remaining continuously within 12 inches of the soil surface for at least nine percent of the growing season. Since wetland hydrology was only monitored for a portion of the growing season, it is difficult to determine success of the remaining gauge. Groundwater gauge data indicate the hydroperiods being very responsive to rainfall events. Year 2 wetland hydrology monitoring data will represent the first full growing season.

The Year 1 vegetation monitoring observations are summarized in this report. Planted-stem survival for 21 out of 23 Vegetation Plots (VP) at the Best Site were above the interim success criterion of 320 trees per acre at the end of Monitoring Year 3. The average stem density (excluding live stakes) across all vegetation plots was 788 stems per acre. Sweetgum (*Liquidambar styraciflua*) and oak (*Quercus sp*.) volunteers were noted in a few vegetation plots on the site. Three vegetation problems were noted during the Year 1 monitoring period. These problems consist of sparse herbaceous cover along UT1 for approximately 150 feet and two low stems density areas on UT3 and UT8. The Best Site is on track to meet the Year 3 vegetation survival success criterion of 320 trees per acre as specified in the Mitigation Plan.

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1 PROJECT GOALS, BACKGROUND AND ATTRIBUTES

1.1 Location and Setting

The Best Stream and Wetland Site is located in Duplin County approximately two miles east of Beulaville, NC (**Figure 1**). To access the downstream end of the Site from the town of Beulaville, travel 0.6 miles east on NC HWY 24, take a right onto Lyman Road (SR 1801), and continue 1.6 miles southeast to the crossing with Muddy Creek. Reaches UT7, UT8, UT9, UT10 and the lower end of Muddy Creek may all be accessed from Lyman Road. Reaches UT5 and UT6 are located just south of NC HWY 24, approximately 1.9 miles east of Beulaville. The upstream portion of the site may be accessed from two locations. Reaches UT1, UT2 and Muddy Creek are located to the south of NC HWY 24, opposite of the intersection of NC HWY 24 and Penny Road (SR 1720), approximately 2.8 miles east of Beulaville. To access reaches UT3, UT4 and Muddy Creek, travel 3.2 miles east on NC HWY 24 from Beulaville to Edwards Road (SR 1835), continue south for approximately 1.0 mile, turn right onto Put Lane, and follow the road down to Reaches UT3 and UT4.

1.2 Project Goals and Objectives

The Best stream and wetland mitigation project will provide numerous ecological and water quality benefits within the Cape Fear River Basin. While many of these benefits are limited to the project area, others, such as pollutant removal and improved aquatic and terrestrial habitat, have more far-reaching effects. Expected improvements to water quality, hydrology, and habitat are outlined below.

Design Goals and Objectives

Benefits Related to Water Quality	
Nutrient removal	Benefit will be achieved through filtering of runoff from adjacent CAFOs through buffer areas, the conversion of active farm fields to forested buffers, improved denitrification and nutrient uptake through buffer zones, and installation of BMPs at the headwaters of selected reaches and ditch outlets.
Sediment removal	Benefit will be achieved through the stabilization of eroding stream banks and reduction of sediment loss from field areas due to lack of vegetative cover. Channel velocities will also be decreased through a reduction in slope, therefore decreasing erosive forces.
Increase dissolved oxygen concentration	Benefit will be achieved through the construction of instream structures to increase turbulence and dissolved oxygen concentrations and lower water temperature to increase dissolved oxygen capacity.
Runoff filtration	Benefit will be achieved through the restoration of buffer areas that will receive and filter runoff, thereby reducing nutrients and sediment concentrations reaching water bodies downstream.
Benefits to Flood Attenuation	
Water storage	Benefit will be achieved through the restoration of buffer areas which will infiltrate more water during precipitation events than under current site conditions.
Improved groundwater recharge	Benefit will be achieved through the increased storage of precipitation in buffer areas, ephemeral depressions, and reconnection of existing floodplain. Greater storage of water will lead to improved infiltration and groundwater recharge.
Improved/restored hydrologic connections	Benefit will be achieved by restoring the stream to a natural meandering pattern with an appropriately sized channel, such that the channel's floodplain will be flooded more frequently at flows greater than the bankfull stage.
Benefits Related to Ecological Processes	
Restoration of habitats	Benefit will be achieved by restoring riparian buffer habitat to appropriate bottomland hardwood ecosystem.

Improved substrate and instream cover	Benefit will be achieved through the construction of instream structures designed to improve bedform diversity and to trap detritus. Substrate will become coarser as a result of the stabilization of stream banks and an overall decrease in the amount of fine materials deposited in the stream.
Addition of large woody debris	Benefit will be achieved through the addition of wood structures as part of the restoration design. Such structures may include log vanes, root wads, and log weirs.
Reduced temperature of water due to shading	Benefit will be achieved through the restoration of canopy tree species to the stream buffer areas.
Restoration of terrestrial habitat	Benefit will be achieved through the restoration of riparian buffer bottomland hardwood habitats.

The North Carolina Division of Mitigation Services (NCDMS) develops River Basin Restoration Priorities (RBRP) to guide its restoration activities within each of the state's 54 cataloging units. RBRPs delineate specific watersheds that exhibit both the need and opportunity for wetland, stream and riparian buffer restoration. These TLWs receive priority for DMS planning and restoration project funds. Currently, no Local Watershed Plan (LWP) is available for the project area.

The 2009 Cape Fear River Basin River Basin Restoration Priorities (RPRP) identified HUC 03030007060010 as a Targeted Local Watershed (TLW). The watershed is characterized by 52 percent agricultural land use area with Muddy Creek identified as Impaired for aquatic life because of a Fair benthic community rating. The Best Stream and Wetland Restoration Project was identified as a stream and wetland opportunity to improve water quality, habitat, and hydrology within the TLW.

The project goals address stressors identified in the TLW and include the following:

- Nutrient removal,
- Sediment removal,
- Reducing runoff from animal operations,
- Filtration of runoff, and
- Improved aquatic and terrestrial habitat.

The project goals will be addressed through the following project objectives:

- Establishing riparian buffer areas adjacent to CAFOs,
- Converting active farm field to forested buffers,
- Stabilization of eroding stream banks,
- Improving and protecting portions of headwater systems that discharge to a 303d listed stream,
- Reduction in stream bank slope,
- Restoration of riparian buffer bottomland hardwood habitats, and
- Construction of in-stream structures designed to improve bedform diversity and trap detritus.

The proposed Best stream and wetland mitigation project is located within the northern (upstream) portion of the TLW and includes sections of Muddy Creek (303d listed) and headwater streams that discharge into Muddy Creek. Due to its location and proposed improvements, the project will provide numerous ecological and water quality benefits within the Cape Fear River Basin. While many of these benefits are limited to the project area, others, such as pollutant removal and improved aquatic and terrestrial habitat, have more far-reaching effects. Many of the project design goals and objectives, including restoration of riparian buffers to filter runoff from agricultural operations and improve terrestrial habitat, and construction of in-stream structures to improve habitat diversity, will address the degraded water quality and nutrient input from farming that were identified as major watershed stressors in the 2009 Cape Fear RBRP.

1.3 Project Structure

Table 1a. Best Site Project Components – Stream Mitigation

Reach	Mitigation Type*	As-Built Stationing (Existing)			Existing Length (LF)	As-Built Length (LF)	Mitigation Ratio	SMUs
UT1	P1 Restoration	0+46	to	18+63	1,551	1,757	1 : 1.0	1,757
UT1	SP & BE	18+63	to	21+42	303	279	1 : 5.0	56
UT2	P1 Restoration	2+30	to	30+64	2,552	2,772	1 : 1.0	2,772
UT2	SP & BE	30+64	to	33+95	331	331	1 : 5.0	66
UT3	Enhancement II	0+00	to	8+42	1,458	812	1 : 2.5	325
UT3	SP & BE	14+58	to	15+22	64	64	1 : 5.0	13
UT4	HV Restoration	5+63	to	11+19	534	494	1 : 1.0	494
UT4	SP & BE	11+19	to	17+65	655	646	1 : 5.0	129
UT5	SP & BE	0+00	to	40+86	4,086	4,043	1 : 5.0	809
UT6	Enhancement I	0+62	to	6+00	538	538	1 : 1.5	359
UT7	SP & BE	0+44	to	32+27	3,183	3,183	1 : 5.0	637
UT8	Enhancement I	0+75	to	9+00	825	765	1 : 1.5	510
UT8	SP & BE	9+00	to	12+13	313	313	1 : 5.0	63
UT9	SP & BE	0+64	to	11+71	1,107	1,107	1 : 5.0	221
UT10	SP & BE	3+37	to	11+05	768	768	1 : 5.0	154
Muddy Creek	SP & BE	0+35	to	92+49	9,214	9,073	1 : 5.0	1,815
		Total			**27,482**	**26,945**		**10,180**

*P1 = Priority 1, SP & BE= Stream Preservation and Buffer Enhancement, HV = Headwater Valley

Table 1b. Best Site Project Components – Wetland Mitigation

Wetland	Mitigation Type	Mitigation Area (ac)	Mitigation Ratio	WMUs
W1	Restoration	3.77	1:1	3.77
W2	Restoration	0.31	1:1	0.31
W3A	Restoration	0.58	1:1	0.58
W3B	Restoration	0.59	1:1	0.59
	Total	**5.25**		**5.25**

1.3.1 Restoration Type and Approach

UT1

Priority Level 1 restoration was completed for UT1 to address all existing impairments, particularly the greatly oversized channel and lack of bedform diversity. The design approach included meandering the channel within the natural valley and backfilling the existing stream. A minimum 50 foot buffer was established and planted with native riparian vegetation. Because the pre-existing buffer was devoid of significant woody vegetation, woody debris was installed along the bed to

improve in-stream habitat. Livestock was excluded with fencing installed along the easement boundary. An existing CMP culvert located along the middle of the reach was removed and replaced downstream at station 13+75 to allow the landowner access to both sides of the property. Stream Preservation and Buffer Enhancement was completed for the downstream section of the channel where it flows through a forested buffer down to the confluence with Muddy Creek. Buffer enhancement activities included the treatment of invasive exotic species by herbicide applications and/or mechanical control as well as planting bare root seedlings in sparsely vegetated areas. RES will continue to conduct invasive species treatments on an as needed basis. Additional treatments will be dependent on monitoring results and regulatory agency guidance. These treatments will be timed in accordance with specific invasive exotic plant phenology for the most effective control. Considering such factors as the influence of established invasive exotics on adjacent land, it is not feasible to expect complete eradication of the targeted invasive species. However, RES does expect to achieve significant reduction of targeted invasive exotic species through this control plan. The goal of the treatment program is control of invasive exotic species such that the target natural communities are present and on a positive trajectory at project closeout.

UT2

Similar to UT1, Priority 1 restoration was completed for UT2 to address historic straightening and channel enlargement. The existing channel was backfilled, and the restored channel was relocated such that it meanders within the existing valley. A diffuse flow structure was installed at the ditch adjacent to the proposed crossing. The structure was placed such that flows from the existing ditch will be attenuated to establish sheet flow as the water enters the restored channel. All areas within the minimum 50 foot buffer were planted with native riparian vegetation. An existing 60” CMP culvert located at station 20+25 of the reach was removed and replaced with a 48” HDPE culvert to allow the landowner access to the entire property. Additionally, the existing culvert at the upstream end of UT2 was upgraded to a 48” HDPE culvert and reset to more effectively transition the existing channel upstream into the project stream. Priority Level I restoration was appropriate for this channel because it was the only mitigation approach that would address bed and bank instability, establish a forested riparian buffer, and significantly enhance aquatic habitat. Stream Preservation and Buffer Enhancement was completed for the most downstream section, where the channel enters the existing forested buffer, down to its confluence with Muddy Creek. Buffer enhancement activities included the treatment of invasive exotic species by herbicide applications and/or mechanical control as well as planting bare root seedlings in sparsely vegetated areas. RES will continue to conduct invasive species treatments on an as needed basis. Additional treatments will be dependent on monitoring results and regulatory agency guidance. These treatments will be timed in accordance with specific invasive exotic plant phenology for the most effective control. Considering such factors as the influence of established invasive exotics on adjacent land, it is not feasible to expect complete eradication of the targeted invasive species. However, RES does expect to achieve significant reduction of targeted invasive exotic species through this control plan. The goal of the treatment program is control of invasive exotic species such that the target natural communities are present and on a positive trajectory at project closeout.

UT3

Enhancement Level II was completed on Reach UT3 due to the channel’s stability and appropriate size. The design approach on this reach focused on improving the riparian buffer. The existing hog lagoon located within buffer on the west side of the reach has remained in place, preventing the generation of stream credits for approximately 600 linear feet. Through this section, the left buffer was extended out to a minimum of 75 feet along the left bank, and the right buffer was extended just past top of bank. The existing crossing located at station 8+50 was replaced and upgraded with a 30” HDPE pipe, allowing the landowner continued access across his property. Additional bank grading and stabilization was included in the culvert replacement. The grading of pools and the installation of

woody debris structures was performed along the reach to improve aquatic habitat. Upstream of the crossing, a 75-foot buffer was restored along the east bank where the channel currently flowed through an active pasture. A 100-foot buffer was implemented for the headwater origin point to further protect water quality from cattle access. Cattle have been excluded with fencing. All areas within the buffer were planted with native riparian vegetation. Stream Preservation and Buffer Enhancement was implemented along the downstream end where the channel enters the Muddy Creek floodplain. Buffer enhancement activities included the treatment of invasive exotic species by herbicide applications and/or mechanical control as well as planting bare root seedlings in sparsely vegetated areas. RES will continue to conduct invasive species treatments on an as needed basis. Additional treatments will be dependent on monitoring results and regulatory agency guidance. These treatments will be timed in accordance with specific invasive exotic plant phenology for the most effective control. Considering such factors as the influence of established invasive exotics on adjacent land, it is not feasible to expect complete eradication of the targeted invasive species. However, RES does expect to achieve significant reduction of targeted invasive exotic species through this control plan. The goal of the treatment program is control of invasive exotic species such that the target natural communities are present and on a positive trajectory at project closeout.

UT4

Headwater valley restoration was completed for the upper section of UT4. The existing channel was backfilled, and flow was directed from its current position east back to the historic valley location. A minor amount of earthwork was completed in the headwater valley restoration apart from ditch plugging to tie the existing ditch back to the natural valley. Areas within the 100 foot buffer that were disturbed or lacked riparian vegetation were planted. Cattle were excluded from the buffer through the installation of fencing. An existing 15” CPP culvert crossing located at station 8+50 of the reach was removed and replaced with triple 18” HDPE culverts. This crossing was relocated to the low spot in the valley to allow the landowner continued access to an agricultural field west of the channel. Downstream of the crossing, a smaller low flow channel was constructed within the natural valley. This segment now connects the upstream headwater valley section to the existing channel approximately 230 feet below the crossing. Due to the stable nature of the buffer along the downstream reach of UT4, Stream Preservation and Buffer Enhancement was implemented from just downstream of the crossing to the confluence with Muddy Creek. Buffer enhancement activities included the treatment of invasive exotic species by herbicide applications and/or mechanical control as well as planting bare root seedlings in sparsely vegetated areas. RES will continue to conduct invasive species treatments on an as needed basis. Additional treatments will be dependent on monitoring results and regulatory agency guidance. These treatments will be timed in accordance with specific invasive exotic plant phenology for the most effective control. Considering such factors as the influence of established invasive exotics on adjacent land, it is not feasible to expect complete eradication of the targeted invasive species. However, RES does expect to achieve significant reduction of targeted invasive exotic species through this control plan. The goal of the treatment program is control of invasive exotic species such that the target natural communities are present and on a positive trajectory at project closeout.

UT5

Stream Preservation and Buffer Enhancement was completed on UT5. The channel is stable throughout the easement and provides a variety of aquatic habitats. The easement boundary extends a minimum of 50 feet outward from the stream channel, or the limit of adjacent riparian wetlands, whichever is wider. The riparian buffer is an intact hardwood forest with localized areas of privet. Buffer enhancement activities included the treatment of invasive exotic species by herbicide applications and/or mechanical control as well as planting bare root seedlings in sparsely vegetated areas. RES will continue to conduct invasive species treatments on an as needed basis. Additional treatments will be dependent on monitoring results and regulatory agency guidance. These treatments

will be timed in accordance with specific invasive exotic plant phenology for the most effective control. Considering such factors as the influence of established invasive exotics on adjacent land, it is not feasible to expect complete eradication of the targeted invasive species. However, RES does expect to achieve significant reduction of targeted invasive exotic species through this control plan. The goal of the treatment program is control of invasive exotic species such that the target natural communities are present and on a positive trajectory at project closeout.

UT6
Enhancement Level I was completed on UT6. The mitigation approach on this reach focused on bank stabilization, bedform diversity, and improving the riparian buffer. The existing channel was impaired by channelization, vertical un-vegetated banks, and a dense privet understory within the buffer. The grading of pools, grade control structures, and the installation of woody debris structures were implemented along the reach to improve aquatic habitat. All disturbed areas within the riparian buffer were planted with native riparian vegetation.

UT7
Stream Preservation and Buffer Enhancement was completed on UT7. The channel is stable throughout the easement and provides a variety of aquatic habitats. The easement boundary extends a minimum of 50 feet outward from the stream channel, or the limit of adjacent riparian wetlands, whichever is wider. The riparian buffer is an intact hardwood forest with localized areas of privet. Buffer enhancement activities included the treatment of invasive exotic species by herbicide applications and/or mechanical control as well as planting bare root seedlings in sparsely vegetated areas. RES will continue to conduct invasive species treatments on an as needed basis. Additional treatments will be dependent on monitoring results and regulatory agency guidance. These treatments will be timed in accordance with specific invasive exotic plant phenology for the most effective control. Considering such factors as the influence of established invasive exotics on adjacent land, it is not feasible to expect complete eradication of the targeted invasive species. However, RES does expect to achieve significant reduction of targeted invasive exotic species through this control plan. The goal of the treatment program is control of invasive exotic species such that the target natural communities are present and on a positive trajectory at project closeout.

UT8
Enhancement Level I was completed on UT8. The mitigation approach on this reach focused on bank stabilization, bedform diversity, and riparian buffer restoration. The existing channel was impaired by channelization, localized bank instability, and cleared agricultural land in the buffer. Stabilization activities included grading a floodplain bench, installing grade control structures, and installing woody debris structures to improve hydraulic efficiency and aquatic habitat. All disturbed areas within the riparian buffer were planted with native riparian vegetation. Stream Preservation and Buffer Enhancement was completed on 313 linear feet where the channel enters the existing forested buffer, down to its confluence with Muddy Creek. Buffer enhancement activities included the treatment of invasive exotic species by herbicide applications and/or mechanical control as well as planting bare root seedlings in sparsely vegetated areas. RES will continue to conduct invasive species treatments on an as needed basis. Additional treatments will be dependent on monitoring results and regulatory agency guidance. These treatments will be timed in accordance with specific invasive exotic plant phenology for the most effective control. Considering such factors as the influence of established invasive exotics on adjacent land, it is not feasible to expect complete eradication of the targeted invasive species. However, RES does expect to achieve significant reduction of targeted invasive exotic species through this control plan. The goal of the treatment program is control of invasive exotic species such that the target natural communities are present and on a positive trajectory at project closeout.

UT9
Stream Preservation and Buffer Enhancement was completed on UT9. The stream is channelized, but stable throughout the easement. The active channel is meandering within the larger excavated channel bottom. The riparian buffer is intact hardwood forest with localized areas of privet. The easement boundary extends a minimum of 50 feet outward from the stream channel, or to the limit of adjacent riparian wetlands, whichever is wider. Buffer enhancement activities included the treatment of invasive exotic species by herbicide applications and/or mechanical control as well as planting bare root seedlings in sparsely vegetated areas. RES will continue to conduct invasive species treatments on an as needed basis. Additional treatments will be dependent on monitoring results and regulatory agency guidance. These treatments will be timed in accordance with specific invasive exotic plant phenology for the most effective control. Considering such factors as the influence of established invasive exotics on adjacent land, it is not feasible to expect complete eradication of the targeted invasive species. However, RES does expect to achieve significant reduction of targeted invasive exotic species through this control plan. The goal of the treatment program is control of invasive exotic species such that the target natural communities are present and on a positive trajectory at project closeout.

UT10
Stream Preservation and Buffer Enhancement was completed on UT10. The channel is stable throughout the easement and provides a variety of aquatic habitats. The easement boundary extends a minimum of 50 feet outward from the stream channel, or the limit of adjacent riparian wetlands, whichever is wider. The riparian buffer is an intact hardwood forest with localized areas of privet. Buffer enhancement activities included the treatment of invasive exotic species by herbicide applications and/or mechanical control as well as planting bare root seedlings in sparsely vegetated areas. RES will continue to conduct invasive species treatments on an as needed basis. Additional treatments will be dependent on monitoring results and regulatory agency guidance. These treatments will be timed in accordance with specific invasive exotic plant phenology for the most effective control. Considering such factors as the influence of established invasive exotics on adjacent land, it is not feasible to expect complete eradication of the targeted invasive species. However, RES does expect to achieve significant reduction of targeted invasive exotic species through this control plan. The goal of the treatment program is control of invasive exotic species such that the target natural communities are present and on a positive trajectory at project closeout.

Muddy Creek
Stream Preservation and Buffer Enhancement was completed for the majority of Muddy Creek. The buffer was restored and increased to a width of 75 feet along the south side. Buffer enhancement activities included the treatment of invasive exotic species by herbicide applications and/or mechanical control as well as planting bare root seedlings in sparsely vegetated areas. RES will continue to conduct invasive species treatments on an as needed basis. Additional treatments will be dependent on monitoring results and regulatory agency guidance. These treatments will be timed in accordance with specific invasive exotic plant phenology for the most effective control. Considering such factors as the influence of established invasive exotics on adjacent land, it is not feasible to expect complete eradication of the targeted invasive species. However, RES does expect to achieve significant reduction of targeted invasive exotic species through this control plan. The goal of the treatment program is control of invasive exotic species such that the target natural communities are present and on a positive trajectory at project closeout.

Wetland W1
Wetland W1 is located at the headwater of UT1 and has a natural constriction at the outlet. The soil is a sandy loam/loamy sandy underlain by clayey textured subsoil that forms an effective restrictive

layer to groundwater loss. This area receives runoff from NC HWY 24. Based upon soil and landscape position, it is likely this area has a seasonal seepage along the upper boundary.

Site modifications included removal of dredged and excavated materials, plugging the ditch, and raising the streambed elevation to bring the water table closer to the ground surface. Additional temporal habitat was constructed to eliminate surface leveling and smoothing for agricultural use. The temporal habitat is variable to mimic sloughs, oxbows, root-tips and other shallow natural features. During monitoring, beaver activity will be controlled to allow the site to stabilize and vegetative community to establish. After the monitoring period, the site is designed to promote and tolerate beaver activity. No hydrologic trespass is anticipated due to beaver activity in this wetland. These modifications will increase storage and eliminate the rapid loss of surface water. This area may receive limited overbank flows due to location in the headwater of UT1. Subsoil ripping and roughing of the soil surface were performed to ameliorate soil compaction and create an uneven surface more conducive for surface water retention, infiltration, and increase storage that would be present in natural wetland systems.

Wetland W2
Wetland W2 is located at the toe slope along Muddy Creek and UT2. The soil is a sandy loam/loamy sandy underlain by sandy clay loam and sandy clay. This site is at a low elevation and is influenced by the water table on the floodplain of Muddy Creek. It is unlikely that groundwater loss is significant during most of the year. This area has a small watershed, but flooding from UT2 and Muddy Creek will increase hydrologic storage.

Hydrology was restored by removing dredge material along the channel and raising the streambed elevation, bringing the water table closer to the ground surface. Site modifications included subsoil ripping, crown removal, and surface roughing of the area. Additional temporal habitat was constructed to eliminate the surface leveling and smoothing for agricultural use. The temporal habitat is variable to mimic sloughs, root-tips and other shallow natural features. This ameliorates past soil leveling and compaction and creates an uneven surface more conducive of infiltration and storage that would be present in natural wetland systems.

Wetland W3
Wetland W3 is composed of two similar area (W3a and W3b) located at the toe slope along Muddy Creek. A low finger of soil separates them. The soil in these areas is a loamy sand/sandy loam. The surrounding upland is underlain by clayey subsoil that forms an effective restrictive layer that lateral flow rides provide additional hydrological input. A ditch is located upslope of these areas and alongside W3a that drains to Muddy Creek.

The soil is a sandy loam/loamy sand. The surrounding upland has a sandy clay loam and sandy clay that form an effective restrictive layer that lateral flow rides provide additional hydrological input. Both areas have small watersheds, but W3b receives groundwater seepage along the toe of slope diverted by the upslope ditch.

Hydrology was restored by filling ditches and enhancing the concave topography by removing soil material where cultivation had filled low features and leveled the surface to facilitate cultivation. Additional groundwater seepage diverted by the ditch was restored to these wetlands. Temporal habitat was constructed to eliminate the surface leveling and smoothing for agricultural use. Subsoil ripping and surface roughing of the area was performed to ameliorate soil compaction and create an uneven surface more conducive of infiltration and storage that would be present in natural wetland systems.

1.4 Project History, Contacts and Attribute Data

1.4.1 Project History

The Best Stream and Wetland Restoration Site was restored by Resource Environmental Solutions, LLC (RES) through a full-delivery contract awarded by NCDMS in 2012. Tables 2, 3, and 4 in **Appendix A** provide a time sequence and information pertaining to the project activities, history, contacts, and baseline information.

1.4.2 Project Watersheds

The easement totals 142.7 acres and the project streams include ten unnamed tributaries to Muddy Creek and a portion of Muddy Creek extending from approximately 0.3 miles west of Edwards Road to 0.4 miles past Lyman Road. The total drainage area at the downstream limits of the project is 2,928 acres (4.58 mi^2). The land use in the project watershed is approximately 47 percent cultivated cropland, 21 percent evergreen and deciduous forest, 13 percent shrub/scrub, ten percent bottomland forest/hardwood swamp, three percent developed, and six percent managed herbaceous cover and pasture.

UT1 has a drainage area of 0.06 square miles (41 acres), and flows in a southerly direction to the confluence with Muddy Creek. UT2 flows south to its confluence with Muddy Creek and has a drainage area of 0.23 square miles (146 acres). UT3 is located to the south of Muddy Creek, opposite of UT2, and flows to the north and into Muddy Creek. This reach has a drainage area of 0.09 square miles (56 acres). UT4 is located to the west of UT3 and discharges to Muddy Creek. This reach has a drainage area of 0.13 square miles (82 acres). UT5 flows in a southerly direction from NC HWY 24 to Muddy Creek and has a drainage area of 0.59 square miles (380 acres). UT6 flows southeast to its confluence with UT5 and has a drainage area of 0.12 square miles (79 acres). UT7 flows in a southerly direction east of Lyman Road down to its confluence with UT5 before discharging to Muddy Creek. UT7 has a drainage area of 0.60 square miles (387 acres). UT8 has a drainage area of 0.09 square miles (56 acres), and flows in an easterly direction through a cultivated field east of Lyman Road down to the confluence with UT7. UT9 flows southeast to its confluence with Muddy Creek and has a drainage area of 0.06 square miles (36 acres). UT10 is the downstream-most tributary within the Best Site and flows in a westerly direction from a farm crossing west of Lyman Road down to Muddy Creek. UT10 has a drainage area of 0.48 square miles (306 acres). Muddy Creek is a stable swamp stream system with intact hardwood forest floodplain, extending from approximately 0.3 miles west of Edwards Road to 0.5 miles south of Lyman Road. Muddy Creek has a drainage area of 4.6 square miles (2,930 acres) at the downstream limits and has an existing length of 9,214 linear feet.

2 Success Criteria

The success criteria for the Best Site will follow accepted and approved success criteria presented in the USACE Stream Mitigation Guidelines and subsequent NCDMS and agency guidance. Specific success criteria components are presented below.

2.1 Stream Restoration

2.1.1 Bankfull Events

Two bankfull flow events must be documented within the seven-year monitoring period. The two bankfull events must occur in separate years. Otherwise, the stream monitoring will continue until

two bankfull events have been documented in separate years. Bankfull events will be documented using crest gauges, auto-logging crest gauges, photographs, and visual assessments for evidence of debris rack lines.

2.1.2 Cross Sections

There should be little change in as-built cross-sections. If changes do take place, they should be evaluated to determine if they represent a movement toward a less stable condition (for example down-cutting or erosion), or are minor changes that represent an increase in stability (for example settling, vegetative changes, deposition along the banks, or decrease in width/depth ratio). Cross-sections are classified using the Rosgen stream classification method, and all monitored cross-sections should fall within the quantitative parameters defined for channels of the design stream type.

2.1.3 Bank Pin Arrays

Bank pin arrays will be used as a supplemental method to monitor erosion on selected meander bends where there is not a cross section. Bank pin arrays will be installed along the outer bend of the meander. Bank pins will be installed just above the water surface and every two feet above the lowest pin. Bank pin exposure will be recorded at each monitoring event, and the exposed pin will be driven flush with the bank.here should be little change in as-built cross-sections. If changes do take place, they should be evaluated to determine if they represent a movement toward a less stable condition (for example down-cutting or erosion), or are minor changes that represent an increase in stability (for example settling, vegetative changes, deposition along the banks, or decrease in width/depth ratio). Cross-sections shall be classified using the Rosgen stream classification method, and all monitored cross-sections should fall within the quantitative parameters defined for channels of the design stream type.

2.1.4 Digital Image Stations

Digital images are used to subjectively evaluate channel aggradation or degradation, bank erosion, success of riparian vegetation, and effectiveness of erosion control measures. Longitudinal images should not indicate the absence of developing bars within the channel or an excessive increase in channel depth. Lateral images should not indicate excessive erosion or continuing degradation of the banks over time. A series of images over time should indicate successional maturation of riparian vegetation.

2.2 Wetland Restoration

Success criteria and monitoring for wetland hydrology within the wetland restoration areas on the site follows NCDMS Guidance dated 7 November 2011. The target minimum wetland hydroperiod is 9 percent of the growing season. Stream hydrology and water balance calculations indicate the wetland area will meet jurisdictional criteria (5 percent hydroperiod). However, due to immature vegetation and reduced PET, a longer success criterion is appropriate. Auto recording gauges are used to measure daily groundwater elevations throughout the Sampson County growing season in all 7 years of monitoring.

If a hydrology gauge location fails to meet these success criteria in the seven year monitoring period then monitoring may be extended, remedial actions may be undertaken, or groundwater modeling may be used to demonstrate the limits of wetland restoration.

2.3 Vegetation Success Criteria

Specific and measurable success criteria for plant density within the wetland restoration and riparian buffers on the site will follow NCDMS Guidance dated 7 November 2011. Vegetation monitoring plots are a minimum of 0.02 acres in size, and cover a minimum of two percent of the planted area. The following data is recorded for all trees in the plots: species, height, planting date (or volunteer), and grid location. Monitoring occurs in the fall of Years 1, 2, 3, 5, and 7. The interim measures of vegetative success for the site is the survival of at least 320 three-year old planted trees per acre at the end of Year 3, and 260 planted trees per acre at the end of Year 5. The final vegetative success criteria is the survival of 210 planted trees per acre at the end of Year 7 of the monitoring period.

Invasive and noxious species will be monitored and controlled so that none become dominant or alter the desired community structure of the site. If necessary, RES will develop a species-specific control plan.

2.4 Scheduling/Reporting

The monitoring program will be implemented to document system development and progress toward achieving the success criteria. The restored stream morphology is assessed to determine the success of the mitigation. The monitoring program will be undertaken for seven years or until the final success criteria are achieved, whichever is longer.

Monitoring reports will be prepared in the fall of each year of monitoring and submitted to NCDMS. The monitoring reports will include all information, and be in the format required by NCDMS in Version 2.0 of the NCDMS Monitoring Report Template (Oct. 2010).

3 MONITORING PLAN

Annual monitoring data will be reported using the DMS monitoring template. Annual monitoring shall be conducted for stream, wetland, and vegetation monitoring parameters as noted below.

3.1 Stream Restoration

3.1.1 As-Built Survey

An as-built survey was conducted following construction to document channel size, condition, and location. The survey will include a complete profile of thalweg, water surface, bankfull, and top of bank to compare with future geomorphic data. Longitudinal profiles will not be required in annual monitoring reports unless requested by NCDMS or USACE.

3.1.2 Bankfull Events

Six sets of manual and auto-logging crest gauges were installed on the site, one along UT1, UT2, UT3, UT4, UT6, and one along UT8. The auto logging crest gauges were installed within the channel and will continuously record flow conditions at an hourly interval. Manual crest gauges were installed on the bank at bankfull elevation. Crest gauges will be checked during each site visit to determine if a bankfull event has occurred since the last site visit. Crest gauge readings and debris rack lines will be photographed to document evidence of bankfull events.

3.1.3 Cross Sections

A total of 31 permanent cross sections were installed to monitor channel dimensions and stability. Twelve cross sections were installed along UT1 where Priority 1 restoration was performed. Twelve cross sections (six pools and six shallows) were installed along UT2 also. UT4 has a total of two cross sections installed throughout its length. Stream segment UT6 has two cross sections installed along its length where enhancement activities was performed. On the UT8 side of the project, a total of three cross sections were installed. Cross sections were typically located at representative riffle and pool sections along each stream reach. Each cross section was permanently marked with 3/8 rebar pin to establish a monument location at each end. A marker pole was also installed at both ends of each cross section to allow ease locating during monitoring activities. Cross section surveys will be performed once a year during annual monitoring years 1, 2, 3, 5, and 7 and will include all breaks in slope including top of bank, bottom of bank, streambed, edge of water, and thalweg.

3.1.4 Digital Image Stations

Digital photographs will be taken at least once a year to visually document stream and vegetation conditions. This monitoring practice will continue for seven years following construction and planting. Permanent photo point locations at cross sections and vegetation plots have been established so that the same directional view and location may be repeated each monitoring year. Monitoring photographs will also be used to document any stream and vegetation problematic areas such as erosion, stream and bank instability, easement encroachment and vegetation damage.

3.1.5 Bank Pin Arrays

Eight bank pin array sets have been installed at pool cross sections located along UT1 and UT2. These bank pin arrays were installed along the upstream and downstream third of the meander. Bank pins are a minimum of three feet long, and have been installed just above the water surface and every two feet above the lowest pin. Bank pin exposure will be recorded at each monitoring event, and the exposed pin will be driven flush with the bank.

3.1.6 Visual Assessment Monitoring

Visual monitoring of all mitigation areas is conducted a minimum of twice per monitoring year by qualified individuals. The visual assessments include vegetation density, vigor, invasive species, and easement encroachments. Visual assessments of stream stability include a complete stream walk and structure inspection. Digital images are taken at fixed representative locations to record each monitoring event as well as any noted problem areas or areas of concern. Results of visual monitoring are presented in a plan view exhibit with a brief description of problem areas and digital images. Photographs will be used to subjectively evaluate channel aggradation or degradation, bank erosion, success of riparian vegetation, and effectiveness of erosion control measures. Longitudinal photos should indicate the absence of developing bars within the channel or an excessive increase in channel depth. Lateral photos should not indicate excessive erosion or continuing degradation of the banks over time. A series of photos over time should indicate successional maturation of riparian vegetation.

3.1.7 Surface Flow

The headwater valley restoration area on UT4 will be monitored to document intermittent or seasonal surface flow. This will be accomplished through direct observation, photo documentation of dye tests, and continuous flow monitoring devices (pressure transducers). An auto logging crest gauges has been installed within the headwater valley channel and will continuously record flow conditions at an

hourly interval. This gauge will be downloaded during each site visit to determine if intermittent or seasonal flows conditions are present.

3.2 Wetland Hydrology

Wetland hydrology will be monitored to document hydric conditions in the wetland restoration areas. This will be accomplished with automatic recording pressure transducer gauges installed in representative locations across the restoration areas and reference wetland areas. A total of twelve automatic recording pressure transducers (Auto-Wells) have been installed on the site. Nine auto-wells have been installed within the wetland restoration area and three within reference areas. The gauges will be downloaded quarterly and wetland hydroperiods will be calculated during the growing season. Gauge installation followed current regulatory and DMS guidance. Visual observations of primary and secondary wetland hydrology indicators will also be recorded during quarterly site visits.

3.3 Vegetation

A total of 23 vegetation plots were randomly established within the planted stream riparian buffer easement. Vegetation plots measure 10 meters by 10 meters or 5 meters by 20 meters (0.02 acres) and have all four corners marked with metal posts. Planted woody vegetation was assessed within each plot to establish a baseline dataset. Within each vegetation plot, each planted stem was identified for species, “X” and “Y” origin located, and measured for height. Reference digital photographs were also captured to document baseline conditions. Species composition, density, growth patterns, damaged stems, and survival ratios will be measured and reported on an annual basis. Vegetation plot data will be reported for each plot as well as an overall site average.

4 MAINTENANCE AND CONTINGENCY PLAN

All identified problematic areas or areas of concern such as stream bank erosion/instability, aggradation/degradation, lack of targeted vegetation, and invasive/exotic species which prevent the site from meeting performance success criteria will be evaluated on a case by case basis. These areas will be documented and remedial actions will be discussed amongst NCDMS staff to determine a plan of action. If it is determined remedial action is required, a plan will be provided.

4.1 Stream

Seven stream problems were identified during the Year 1 monitoring period and have been mapped on the Current Conditions Plan View (CCPV). Year 1 stream problems are likely the result of October 2015 Hurricane Joaquin which resulted in record amount of rainfall flowing through the newly constructed site. Stream problem 1 (SPA1) consists of minor bank erosion at station 14+90 on UT1 just below the crossing. This area can be repaired with livestakes and securing the matting back in place. Stream problems 2 and 3 (SPA2 and SPA3) are also located along UT1 and exhibit bank erosion and unstable log grade control structures. Remedial action activities will include repairing the bank erosion areas and re-installation of the log grade control structures. Stream problems 4 and 5 (SPA4 and SPA5) are similar to SPA2 and SPA3 but are located on UT2. These areas of bank erosion and log grade control failures are located from Sta. 25+50 - 26+25. Eroding stream banks and log structures will be repaired in this segment along UT2. Stream problem area 6 (SPA6) is located on UT4 and shows evidence of bed and bank erosion. Log structures within this 75 foot stream segment need repairing as well. Concentrated overland flow has created some gullies and rills. Structures and stream banks will be repaired on UT4 from Sta. 10+25 – 11+00. The last stream

problem area (SPA7) is located on UT8 stream crossing. This area is within the easement break; however, the stream culvert and banks have blown out. The existing culvert remains in place but likely needs to be upsized and re-installed. This stream crossing was an existing culvert and was not upgraded during initial constructions activities. Upon completion of all stream erosion and structure repairs, the areas will be matted and livestaked. All stream problem areas are localized and the overall stability of the project streams on site are stable. Remedial action repair work is planned for spring 2016.

4.2 Wetlands

No wetland problems areas were noted during the Year 1 monitoring period. Wetland hydrology and vegetation represent typical conditions of a site in Year 1 post construction monitoring. If any wetland problem areas are identified in the future, they will be documented and mapped on the CCPV as part of the annual monitoring report. Wetland hydrology gauges were installed late June, and documented hydrology conditions for approximately 62% of the total growing season. Eight of the nine wetland gauges achieved the success criteria by remaining continuously within the 12 inches of the soil surface for at least nine percent of the growing season. Since wetland construction occurred in the early growing season and wetland hydrology was only monitored for the last portion of the growing season, it is difficult to determine success of the remaining gauge. Year 2 wetland hydrology monitoring data will represent the first full growing season.

4.3 Vegetation

Three vegetation problems were identified during the Year 1 monitoring period. These vegetation problem areas are documented and mapped on the Current Conditions Plan View (CCPV) as part of the annual monitoring report. Vegetation problem area 1 (VPA1) is a bare area along UT1 with minimal herbaceous ground cover. The remaining two vegetation problem areas (VPA2 and VPA3) are areas with low stem densities. Vegetation plots within these areas exhibited high mortality rates; therefore, RES plans to perform a supplemental replant within low stem count areas in the spring 2016. It should be noted that these VPAs are minimal and the Best Site is on track to meet the Year 3 vegetation survival success criterion of 320 trees per acre as specified in the Mitigation Plan.

5 YEAR 1 MONITORING CONDITIONS (MY1)

The Best Year 1 Monitoring activities were completed from October 2015 to February 2016. All Year 1 monitoring data is present below and in the appendices. Data presented shows the site has seven stream problem areas and three vegetation problems areas. Stream problem areas consist of localized bank erosion and unstable grade control structures. The vegetation problem areas are minor and consist of two low stem density areas and one sparse herbaceous cover along UT1; however, the site is on track to meeting stream, wetland and vegetation interim success criteria.

5.1 Year 1 Monitoring Data Collection

5.1.1 Morphological State of the Channel

All morphological stream data for the as-built profile and dimensions were collected during the annual monitoring survey performed during October 2015. **Appendix D** includes summary data tables, morphological parameters, and stream photographs.

Profile

The baseline (MY-0) profiles closely matches the proposed design profiles. The plotted longitudinal profiles can be found on the As-Built Drawings. Longitudinal profiles will not be performed in annual monitoring reports unless requested by NCEEP or USACE. Morphological summary data tables can be found in **Appendix D**.

Dimension
The Year 1 (MY-1) cross sectional dimensions closely matches the baseline cross section parameters. Minimal changes were noticed for most Year 1 cross section surveys resulting from stable bed and bank conditions. All cross section plots and data tables can be found in **Appendix D**.

Sediment Transport
The Year 1 conditions show that shear stress and velocities have been reduced for all six restoration reaches. Pre-construction conditions documented all six reaches as sand bed channels and remain classified as sand bed channels post-construction. Visual assessments (**Appendix B**) show the channels are transporting sediment as designed and will continue to be monitored for aggradation and degradation.

Bank Pin Arrays
Eight pool cross section locations with bank pin arrays were observed and measured for bank erosion located on the outside meander bends. If bank pin exposure was noticeable, it was measured, recorded, photographed, and then driven flush with the bank at each monitoring location. One bank pin array recorded exposure during the Year 1 monitoring season. This bank pin array is located at the downstream portion of cross section 11. Both the top and bottom bank pins had readings and are documented in Table 12. The meander at cross section 11 is the upstream limits of SPA2 which is the result of some bank erosion. Bank pin array data tables can be found in Appendix D.

5.1.2 Vegetation

The Year 1 monitoring (MY-1) vegetation survey was completed in February 2016 and resulted in an average of 788 planted stems per acre, well above the interim survival density of 320 stems per acre at the end of Year 3 monitoring. The average stems per vegetation plot was 19.3 planted stems. The minimum planted stem per plot was 0 stems and the maximum was 33 stems per plot. Sweetgum (*Liquidambar styraciflua*) and oak (*Quercus sp*.) volunteers were noted throughout the site and were recorded within the CVS-EEP Data entry tool. Vegetation summary data tables can be found in **Appendix C** and vegetation plot photos in **Appendix B**.

5.1.3 Photo Documentation

Permanent photo point locations have been established at cross sections, vegetation plots, stream crossings, and stream structures by RES staff. Any additional problem areas or areas of concern will also be documented with a digital photograph during monitoring activities. Stream digital photographs can be found in Appendix B and Appendix C for vegetation photos.

5.1.4 Stream Hydrology

Six sets of manual and auto-logging crest gauges were installed on the site, one along UT1, UT2, UT3, UT4, UT6, and one along UT8. The auto logging crest gauges were installed within the channel and will continuously record flow conditions at an hourly interval. Five of the six crest gauges

recorded bankfull events during the Year 1 monitoring period. UT4 (Crest Gauge 4) did not record a bankfull event; however, the stream was noted to be flowing at each site visit throughout MY1.

5.1.5 Wetland Hydrology

A total of twelve wetland hydrology gauges were installed in late June 2015 and documented hydrology conditions for approximately 62 percent of the total growing season. Eight of the nine wetland gauges (only AW2 did not) achieved the success criteria by remaining continuously within 12 inches of the soil surface for at least nine percent of the growing season. Since wetland hydrology was only monitored for the last portion of the growing season, it is difficult to determine if the remaining gauge was successful. Groundwater gauge data indicate the hydroperiods being responsive to rainfall events. All three reference gauges met the nine percent success criteria with hydroperiods of 12 percent or greater. Year 2 wetland hydrology monitoring data will represent the first full growing season. Wetland gauge and rainfall data is presented in Appendix E.

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Appendix A

Project Background Data and Maps

Table 1. Project Components and Mitigation Credits
Table 2. Project Activity and Reporting History
Table 3. Project Contacts
Table 4. Project Information and Attributes
Figure 1. Project Vicinity Map
Figure 2. Project USGS Map

Appendix A. **General Tables and Figures**
Table 1 Project Components and Mitigation Credits
Monitoring Report Year 1

Table 1. Project Components and Mitigation Credits
Best Stream and Wetland Restoration Project/DMS Project # 95353

Mitigation Credits

	Stream		Riparian Wetland		Non-riparian Wetland		Buffer	Nitrogen Nutrient Offset	Phosphorous Nutrient Offset
Type	R	RE	R	RE	R	RE			
Totals	5,023	5,157	5.25	N/A	N/A	N/A	N/A	N/A	N/A

Project Components

Project Component -or- Reach ID	As-Built Stationing/Location (LF)	Existing Footage/Acreage	Approach (PI, PII etc.)	Restoration -or-Restoration Equivalent	Restoration Footage or Acreage	Mitigation Ratio	SMUs/ WMUs
UT1	0+46 to 18+63	1,551	PI	R	1,757	1 : 1.0	1,757
UT1	18+63 to 21+42	303	Preservation & BE	RE	279	1 : 5.0	56
UT2	2+30 to 30+64	2,552	PI	R	2,772	1 : 1.0	2,772
UT2	30+64 to 33+95	309	Preservation & BE	RE	331	1 : 5.0	66
UT3	0+00 to 8+42	1,458	EII	RE	812	1 : 2.5	325
UT3	14+58 to 15+22	64	Preservation & BE	RE	64	1 : 5.0	13
UT4	5+63 to 11+19	534	HV Restoration	R	494	1 : 1.0	494
UT4	11+19 to 17+65	655	Preservation & BE	RE	646	1 : 5.0	129
UT5	0+00 to 40+86	4,086	Preservation & BE	RE	4,043	1 : 5.0	809
UT6	0+62 to 6+00	538	EI	RE	538	1 : 1.5	359
UT7	0+44 to 32+27	3,183	Preservation & BE	RE	3,183	1 : 5.0	637
UT8	0+75 to 9+00	825	EI	RE	765	1 : 1.5	510
UT8	9+00 to 12+13	313	Preservation & BE	RE	313	1 : 5.0	63
UT9	0+64 to 11+71	1,171	Preservation & BE	RE	1,107	1 : 5.0	221
UT10	3+37 to 11+05	768	Preservation & BE	RE	768	1 : 5.0	154
Muddy Creek	0+35 to 92+49	9,214	Preservation & BE	RE	9,073	1 : 5.0	1,815
Wetland 1	---	3.66	Restoration	RE	3.77	1 : 1.0	3.77
Wetland 2	---	0.29	Restoration	RE	0.31	1 : 1.0	0.31
Wetland 3A	---	0.58	Restoration	RE	0.58	1 : 1.0	0.58
Wetland 3B	---	0.59	Restoration	RE	0.59	1 : 1.0	0.59

Component Summation

Restoration Level	Stream (linear feet)	Riparian Wetland (acres)		Non-riparian Wetland	Buffer (square feet)	Upland (acres)
		Riverine	Non-Riverine			
Restoration	4,529	5.25				
Headwater Valley	494					
Enhancement I	1,303					
Enhancement II	812					
Creation						
Preservation	19,807					
High Quality Preservation						

BMP Elements

Element	Location	Purpose/Function	Notes
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---	---	---	---
---	---	---	---

BMP Elements
BR = Bioretention Cell; SF = 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

Table 2. Project Activity and Reporting History

Project Activity and Reporting History Best Stream and Wetland Restoration Project / DMS Project #95353		
Activity or Report	**Data Collection Complete**	**Completion or Delivery**
Mitigation Plan	NA	October 2013
Final Design – Construction Plans	NA	November 2014
Construction Completed	April 2015	May 2015
Site Planting Completed	May 2015	May 2015
Baseline Monitoring Document (Year 0 Monitoring – baseline)	July 2015	October 2015
Year 1 Monitoring	December 2015	March 2016
Year 2 Monitoring		
Year 3 Monitoring		
Year 4 Monitoring		
Year 5 Monitoring		
Year 6 Monitoring		
Year 7 Monitoring		

Table 3. Project Contacts

Project Contacts Table Best Stream and Wetland Restoration Project /DMS Project # 95353	
Designer	WK Dickson and Co., Inc. 720 Corporate Center Drive Raleigh, NC 27607 (919) 782-0495 Frasier Mullen, PE
Construction Contractor	Wright Contracting PO Box 545 Siler City, NC 27344 (919) 663-0810 Joseph Wright
Planting Contractor	Resource Environmental Solutions, LLC 302 Jefferson Street, Suite 110 Raleigh, NC 27605 (919) 209-1061 David Godley
Seeding Contractor	Wright Contracting PO Box 545 Siler City, NC 27344 (919) 663-0810 Joseph Wright
Seed Mix Sources	Green Resource
Nursery Stock Suppliers	Arbogen, NC Forestry Services Nursery
Full Delivery Provider Project Manager:	Resource Environmental Solutions, LLC 302 Jefferson Street, Suite 110 Raleigh, NC 27605 (919) 209-1061 Daniel Ingram
Monitoring Performers Project Manager:	Resource Environmental Solutions, LLC 302 Jefferson Street, Suite 110 Raleigh, NC 27605 (919) 209-1061 Brian Hockett, PLS

Table 4. Project Information

Project Information

Project Name	Best Stream and Wetland Restoration Project
County	Duplin
Project Area (acres)	142.7
Project Coordinates (latitude and longitude)	34° 54' 44.011" N 77° 44' 57.344" W

Project Watershed Summary Information

Physiographic Province	Outer Coastal Plain
River Basin	Cape Fear
USGS Hydrologic Unit 8-digit	03030007
USGS Hydrologic Unit 14-digit	03030007060010
DWQ Sub-basin	03-06-22
Project Drainage Area (acres)	2,928 acres
Project Drainage Area Percentage of Impervious Area	6%
CGIA Land Use Classification	Woody wetlands, emergent herbaceous wetlands, cultivated crops, evergreen forest

Reach Summary Information (As-Built Conditions)

Parameters	UT1	UT2	UT3	UT4	UT5	UT6
Length of reach (linear feet)	2,036	3,103	876	1,140	4,043	538
Valley Classification	X	X	X	X	X	X
Drainage area (acres)	41	146	56	82	380	79
NCDWQ stream identification score	32.50	31.50	33.00	33.75	36.75	30.50
NCDWQ Water Quality Classification	N/A	C Sw	N/A	N/A	C Sw	N/A
Morphological Description (stream type)	G5c	G5c	E5	G5c/E5	C5	E5
Evolutionary trend	Stage II	Stage II	Stage VI	Stage II/VI	Stage I	Stage II
Underlying mapped soils	GoA MkA NbB RaA	AuB McC MkA NbA NbB	McC MkA NbB	McC MkA NbB	MkA NbB	NbA NbB
Drainage class	well; mod. well; poorly	well; poorly	well; poorly	well; poorly	well; poorly	well
Soil Hydric status	Hydric	Hydric	Hydric	Hydric	Hydric	Not hydric
Slope	0.66%	0.44%	0.93%	0.42%	0.40%	0.12%
FEMA classification	N/A	N/A	N/A	N/A	AE (high risk)	N/A
Native vegetation community	pasture, cultivated	cultivated	pasture	mixed hardwood forest	mixed hardwoo d forest	mixed hardwood forest
Percent composition of exotic invasive vegetation	0	0	5	5	<40	<25

Reach Summary Information (continued)

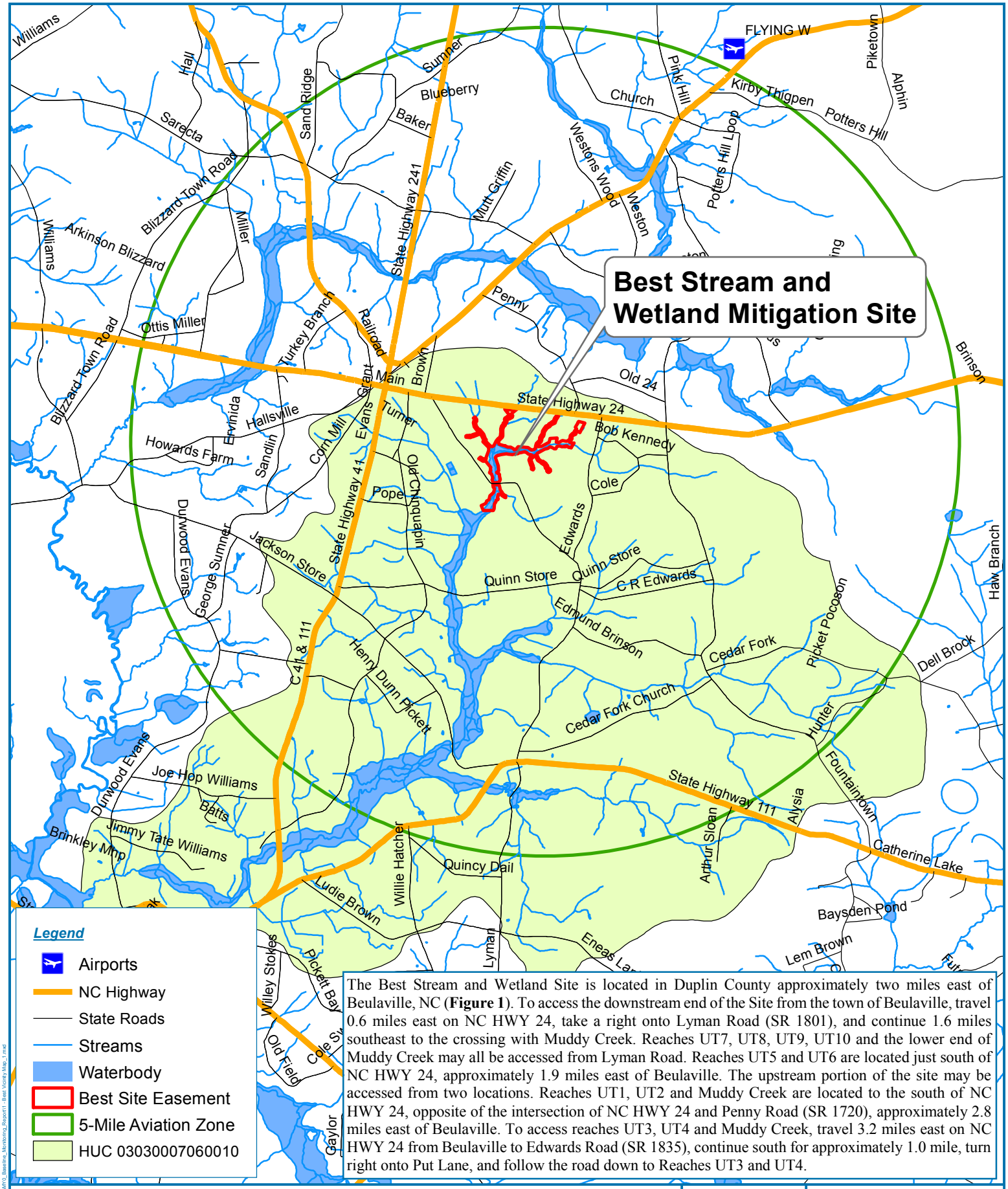
Parameters	UT7	UT8	UT9	UT10	Muddy Creek
Length of reach (linear feet)	3,183	1,078	1,107	768	9,214
Valley Classification	X	X	X	X	X
Drainage area (acres)	387	56	36	306	2930
NCDWQ stream identification score	38.50	30.50	32.00	34.00	43.25
NCDWQ Water Quality Classification	C Sw	N/A	N/A	C Sw	C Sw
Morphological Description (stream type)	C5	F5	E5	C5	E5
Evolutionary trend	Stage I	Stage II	Stage VI	Stage VI	Stage VI
Underlying mapped soils	McC MkA NbB	McC NbA NbB	McC MkA	McC MkA	McC MkA
Drainage class	well; poorly	well	well; poorly	well; poorly	well; poorly
Soil Hydric status	Hydric	Hydric	Hydric	Hydric	Hydric
Slope	0.40%	0.29%	0.80%	0.40%	0.11%
FEMA classification	AE (high risk)	N/A	AE (high risk)	AE (high risk)	AE (high risk)
Native vegetation community	mixed hardwood forest	cultivated	mixed hardwood forest	mixed hardwood forest	mixed hardwood forest
Percent composition of exotic invasive vegetation	<40	<5	<15	<20	<45

Wetland Summary Information

Parameters	Wetland 1	Wetland 2	Wetland 3A	Wetland 3B
Size of Wetland (acres)	3.77	0.31	0.58	0.59
Wetland Type (non-riparian, riparian	Riparian	Riparian	Riparian	Riparian
Mapped Soil Series	Rains, Goldston	Noboco, Autyville, Marvyn, Gritney	Marvyn, Gritney, Muckalee loam	Marvyn, Gritney, Muckalee loam
Drainage class	Poorly	Mod. Well, Poorly	Poorly, Well	Poorly, Well
Soil Hydric Status	Yes	Hydric with Hydric Inclusions	Hydric with Hydric Inclusions	Hydric with Hydric Inclusions
Source of Hydrology	Runoff/Groundwater Discharge	Runoff/Groundwater Discharge	Runoff, Flooding, Groundwater Discharge	Runoff, Flooding, Groundwater Discharge
Hydrologic Impairment	Grazing Cattle and Incised Channel	Incised Channel	Ditched	Ditched
Native vegetation community	Forested	Cultivated	Cultivated	Cultivated
Percent composition of exotic invasive	0	0	0	0

Regulatory Considerations

Regulation	Applicable	Resolved	Supporting Documentation
Waters of the United States - Section 404	Yes	Yes	SAW-2012-01384
Waters of the United States - Section 401	Yes	Yes	DWR # 13-0865
Endangered Species Act	Yes	Yes	USFWS (Corr. Letter)
Historic Preservation Act	Yes	Yes	SHPO (Corr. Letter)
Coastal Zone Management Act (CZMA)/Coastal Area Management Act (CAMA)	No	NA	N/A
FEMA Floodplain Compliance	Yes	Yes	EEP Floodplain Requirements Checklist
Essential Fisheries Habitat	No	NA	N/A



The Best Stream and Wetland Site is located in Duplin County approximately two miles east of Beulaville, NC (**Figure 1**). To access the downstream end of the Site from the town of Beulaville, travel 0.6 miles east on NC HWY 24, take a right onto Lyman Road (SR 1801), and continue 1.6 miles southeast to the crossing with Muddy Creek. Reaches UT7, UT8, UT9, UT10 and the lower end of Muddy Creek may all be accessed from Lyman Road. Reaches UT5 and UT6 are located just south of NC HWY 24, approximately 1.9 miles east of Beulaville. The upstream portion of the site may be accessed from two locations. Reaches UT1, UT2 and Muddy Creek are located to the south of NC HWY 24, opposite of the intersection of NC HWY 24 and Penny Road (SR 1720), approximately 2.8 miles east of Beulaville. To access reaches UT3, UT4 and Muddy Creek, travel 3.2 miles east on NC HWY 24 from Beulaville to Edwards Road (SR 1835), continue south for approximately 1.0 mile, turn right onto Put Lane, and follow the road down to Reaches UT3 and UT4.

Figure1
Project Vicinity Map
Best Stream and Wetland Restoration Site
Duplin County, North Carolina

Date: 9/15/2015

Drawn by: BSH

res

Document Path: E:\RES Files\Best\CADD\GIS\MXD\WYO_Baseline_Monitoring_Report\1 - Best Vicinity Map_1.mxd

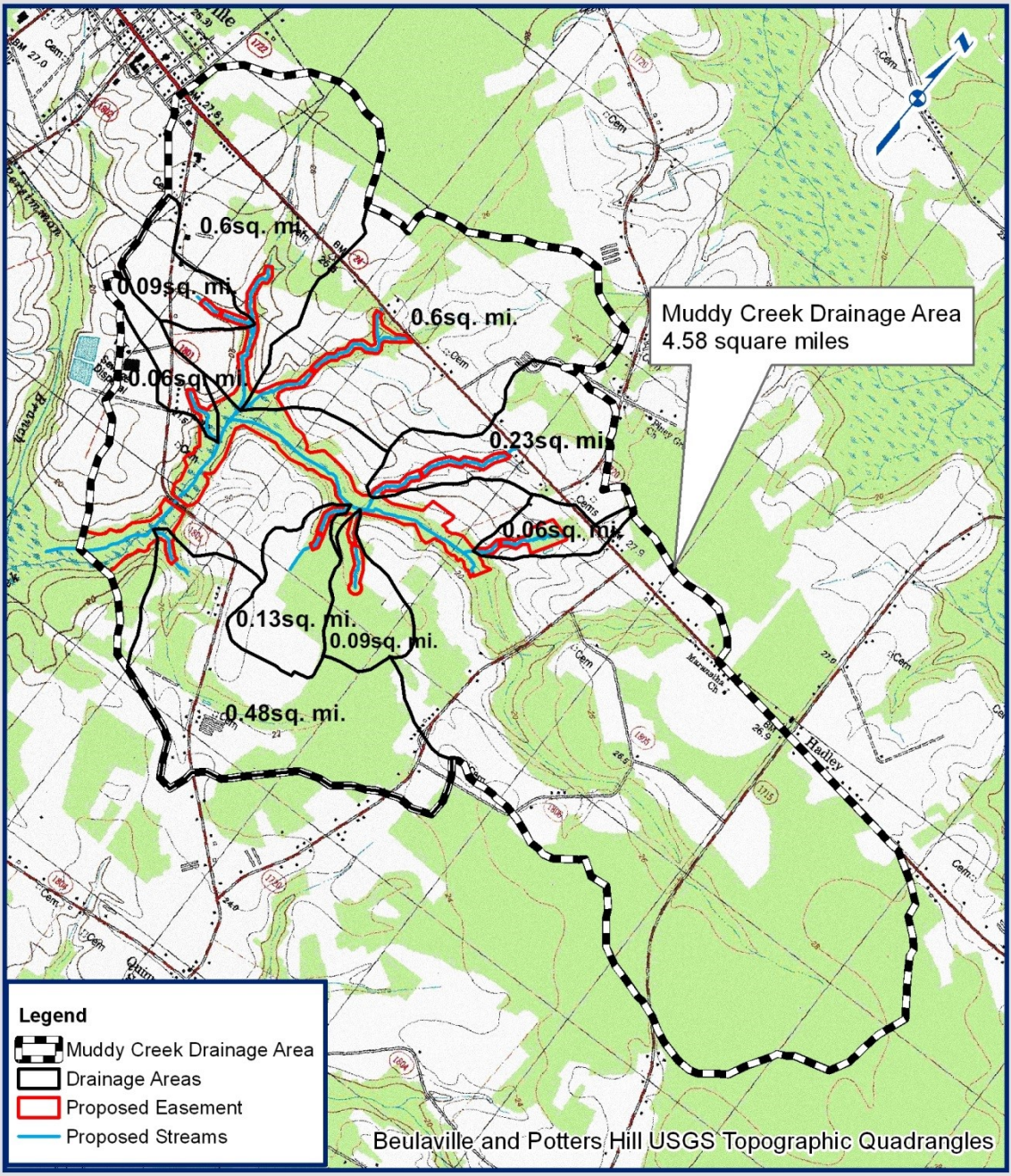


Figure 2.
USGS Map
Best Stream and Wetland Mitigation Site

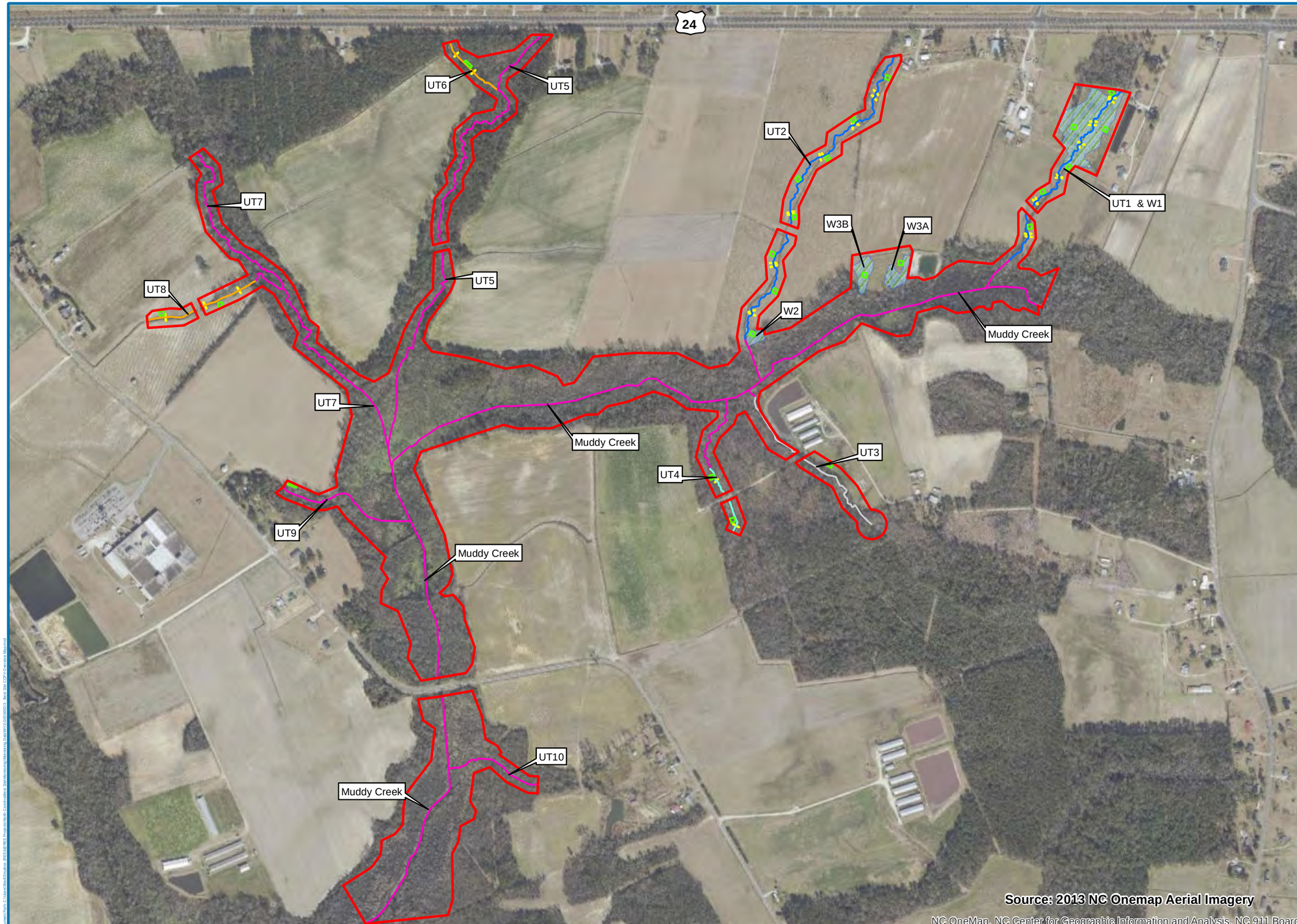
0 1,500 3,000 6,000 Feet

1 inch = 3,000 feet

Appendix B

Visual Assessment Data

Figure 3. Current Conditions Plan View Map (CCPV)
Table 5. Visual Stream Morphology Stability Assessment
Table 6. Vegetation Condition Assessment
Table 7. Stream Problem Areas
Table 8. Vegetation Problem Areas
Stream Photos
Vegetation Photos
Stream and Vegetation Problem Area Photos



res

N
W E
S

0 350 700
Feet

1 inch = 700 feet

Figure 3.

Best Stream and Wetland Restoration Project

Current Conditions Overview Map

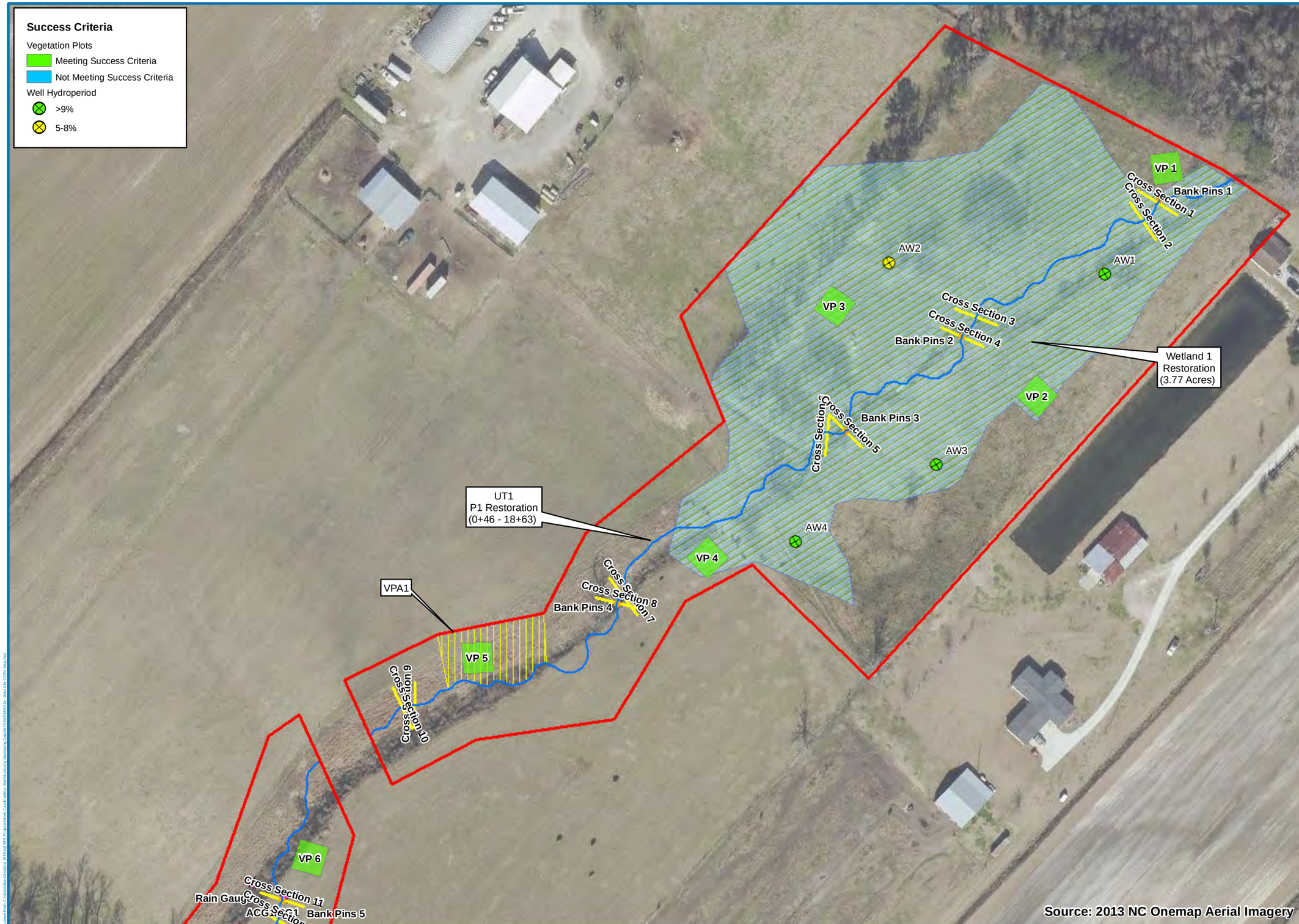
Date: 3/4/2016	Drawn by: BSH

LEGEND

- Conservation Easement
- Vegetation Plots
- NC Highway
- State Roads
- BE & Preservation
- Enhancement I
- Enhancement II
- Headwater Valley Rest.
- P1 Restoration
- Cross Sections
- Wetland Restoration Areas

Riparian Buffer Conditions

Invasive Species	Target Community: Present	Target Community: Marginal	Target Community: Absent
Absent	No Fill		
Present			
Common			



res

N
W
E
S

0 50 100
Feet

1 inch = 100 feet

Figure 3a.

Best Stream and Wetland Restoration Project

UT1 & W1 Current Conditions Plan View Map

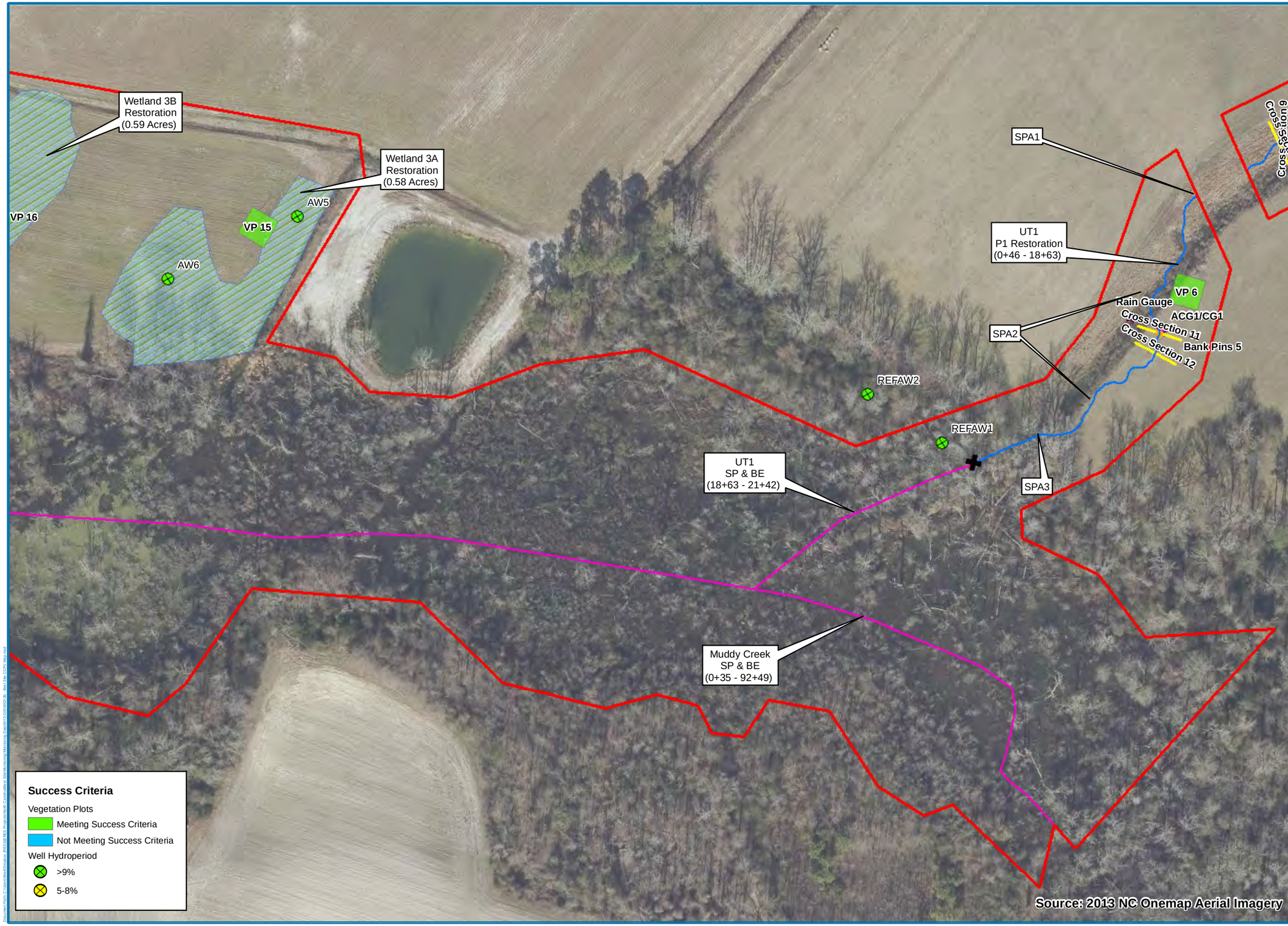
Date: 3/4/2016	Drawn by: BSH

LEGEND

- Conservation Easement
- Reach Breaks
- BE & Preservation
- Enhancement I
- Enhancement II
- Headwater Valley Rest.
- P1 Restoration
- Stream Structures
- Bankpin Locations
- Cross Sections
- Crest Gauge/RG Locations
- Wetland Restoration Areas

Riparian Buffer Conditions

Invasive Species	Target Community: Present	Target Community: Marginal	Target Community: Absent
Absent	No Fill		
Present			
Common			



res

N
W E
S

0 50 100
Feet

1 inch = 100 feet

Figure 3b.

Best Stream and Wetland Restoration Project

UT1 & Muddy Creek Current Conditions Plan View Map

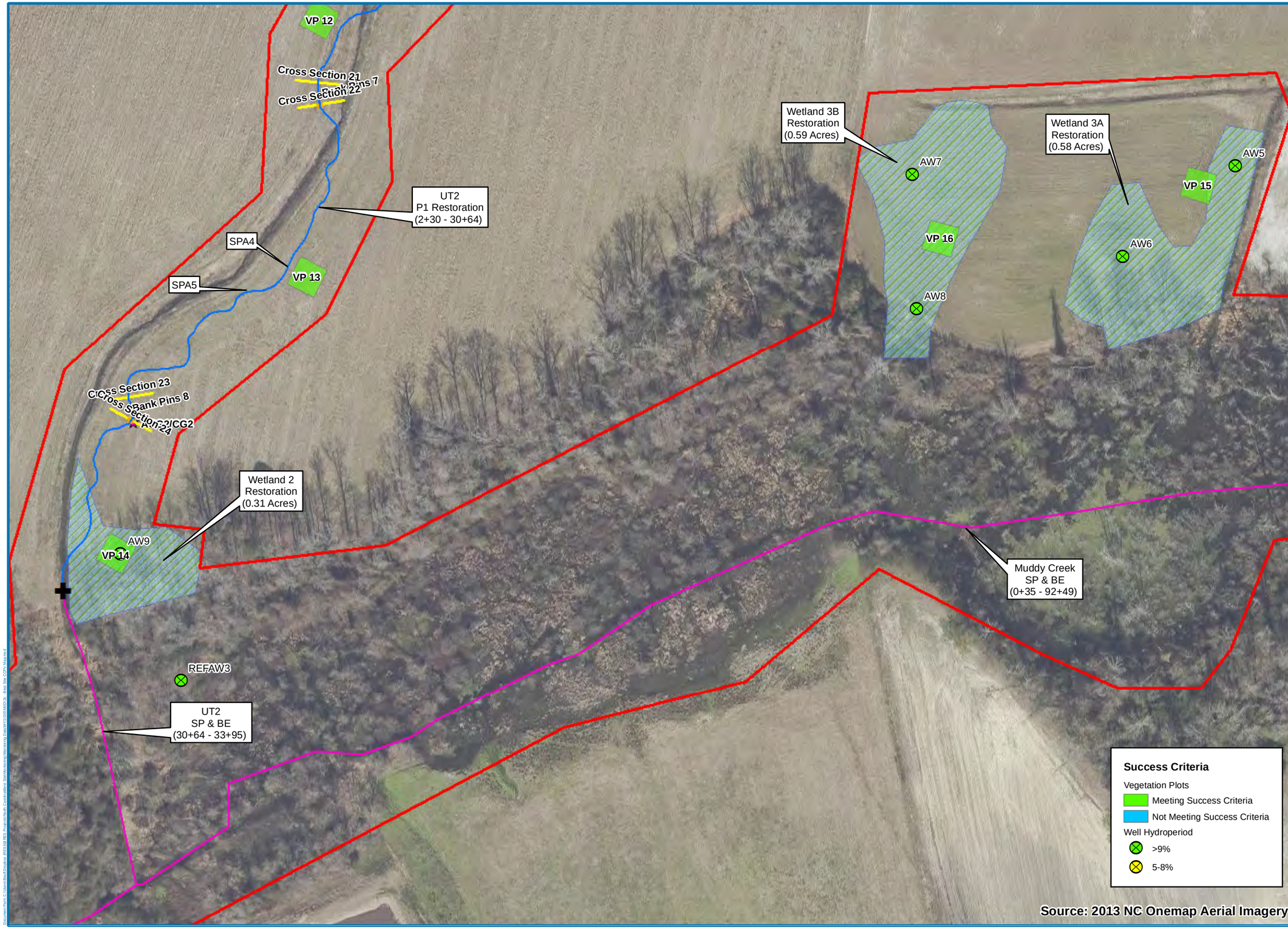
Date: 3/4/2016	Drawn by: BSH

LEGEND

- Conservation Easement
- Reach Breaks
- BE & Preservation
- Enhancement I
- Enhancement II
- Headwater Valley Rest.
- P1 Restoration
- Stream Structures
- Bankpin Locations
- Cross Sections
- Crest Gauge/RG Locations
- Wetland Restoration Areas

Riparian Buffer Conditions

Invasive Species	Target Community: Present	Target Community: Marginal	Target Community: Absent
Absent	No Fill		
Present			
Common			



N
W E
S

0 50 100
Feet

1 inch = 100 feet

Figure 3c.

Best Stream and Wetland Restoration Project

UT2 & Muddy Creek Current Conditions Plan View Map

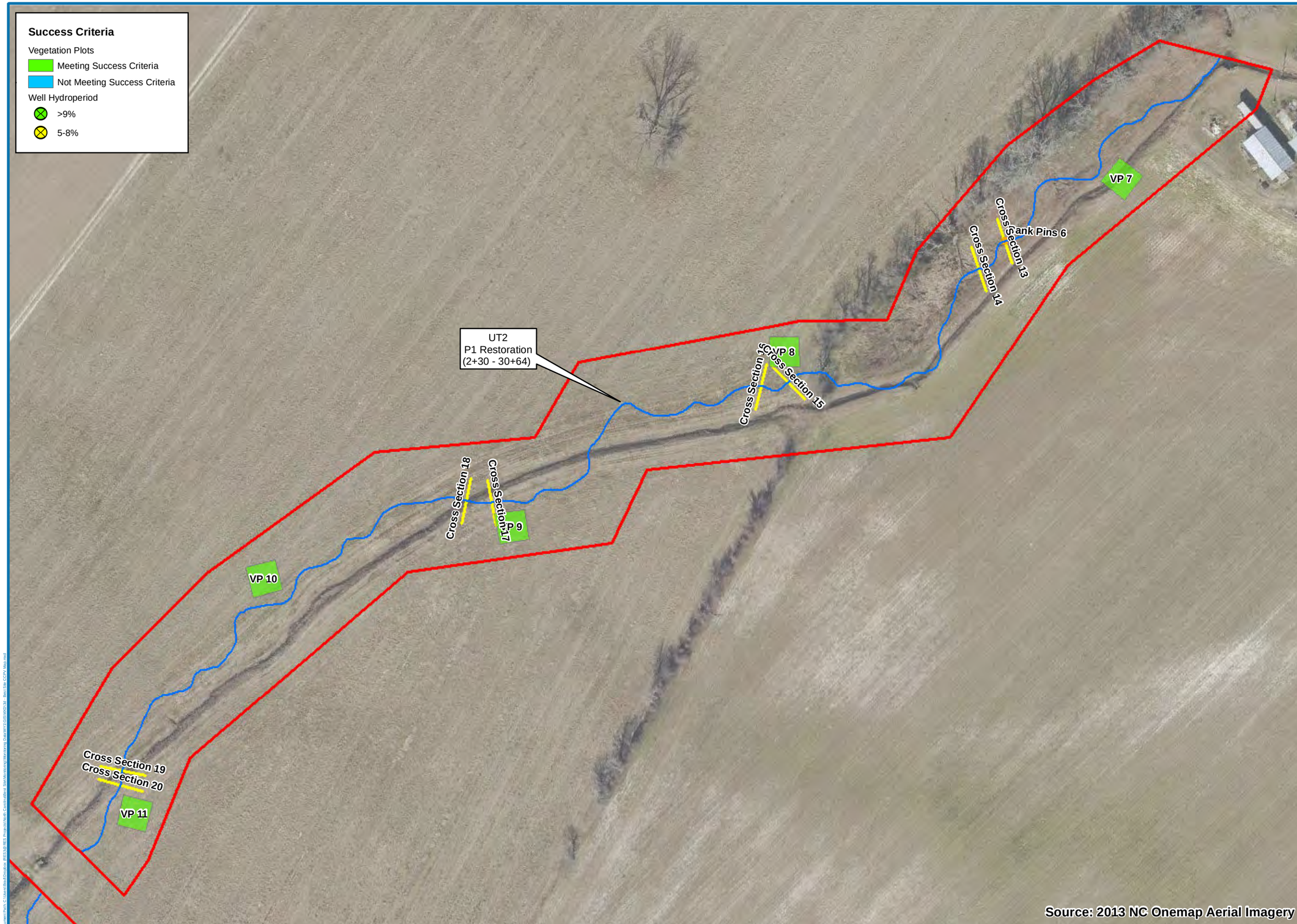
Date: 3/4/2016	Drawn by: BSH

LEGEND

- Conservation Easement
- Reach Breaks
- BE & Preservation
- Enhancement I
- Enhancement II
- Headwater Valley Rest.
- P1 Restoration
- Stream Structures
- Bankpin Locations
- Cross Sections
- Crest Gauge/RG Locations
- Wetland Restoration Areas

Riparian Buffer Conditions

Invasive Species	Target Community: Present	Target Community: Marginal	Target Community: Absent
Absent	No Fill		
Present			
Common			



res

N
W
E
S

0 50 100
Feet

1 inch = 100 feet

Figure 3d.

Best Stream and Wetland Restoration Project

UT2
Current Conditions
Plan View Map

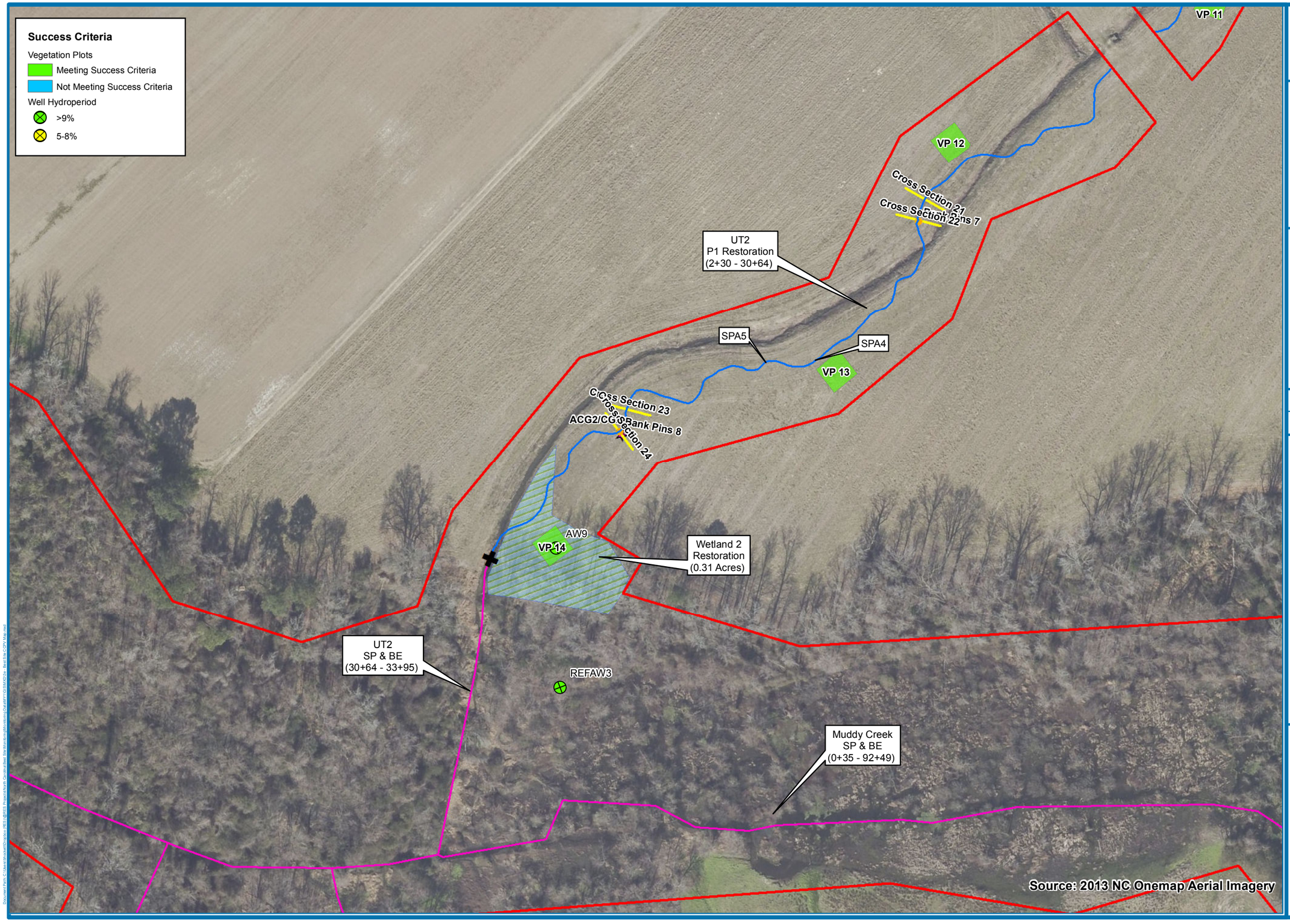
Date: 3/4/2016	Drawn by: BSH

LEGEND

- Conservation Easement
- Reach Breaks
- BE & Preservation
- Enhancement I
- Enhancement II
- Headwater Valley Rest.
- P1 Restoration
- Stream Structures
- Bankpin Locations
- Cross Sections
- Crest Gauge/RG Locations
- Wetland Restoration Areas

Riparian Buffer Conditions

Invasive Species	Target Community: Present	Target Community: Marginal	Target Community: Absent
Absent	No Fill		
Present			
Common			



res

0 50 100
Feet

1 inch = 100 feet

Figure 3e.

Best Stream and Wetland Restoration Project

UT2 & Muddy Creek Current Conditions Plan View Map

Date: 3/29/2016	Drawn by: BSH

LEGEND

- Conservation Easement
- Reach Breaks
- BE & Preservation
- Enhancement I
- Enhancement II
- Headwater Valley Rest.
- P1 Restoration
- Stream Structures
- Bankpin Locations
- Cross Sections
- Crest Gauge/RG Locations
- Wetland Restoration Areas

Riparian Buffer Conditions

Invasive Species	Target Community: Present	Target Community: Marginal	Target Community: Absent
Absent	No Fill		
Present			
Common			

Success Criteria

Vegetation Plots
- Meeting Success Criteria
- Not Meeting Success Criteria

Well Hydroperiod
- >9%
- 5-8%

0 50 100
Feet

1 inch = 100 feet

Figure 3f.

Best Stream and Wetland Restoration Project

UT3
Current Conditions
Plan View Map

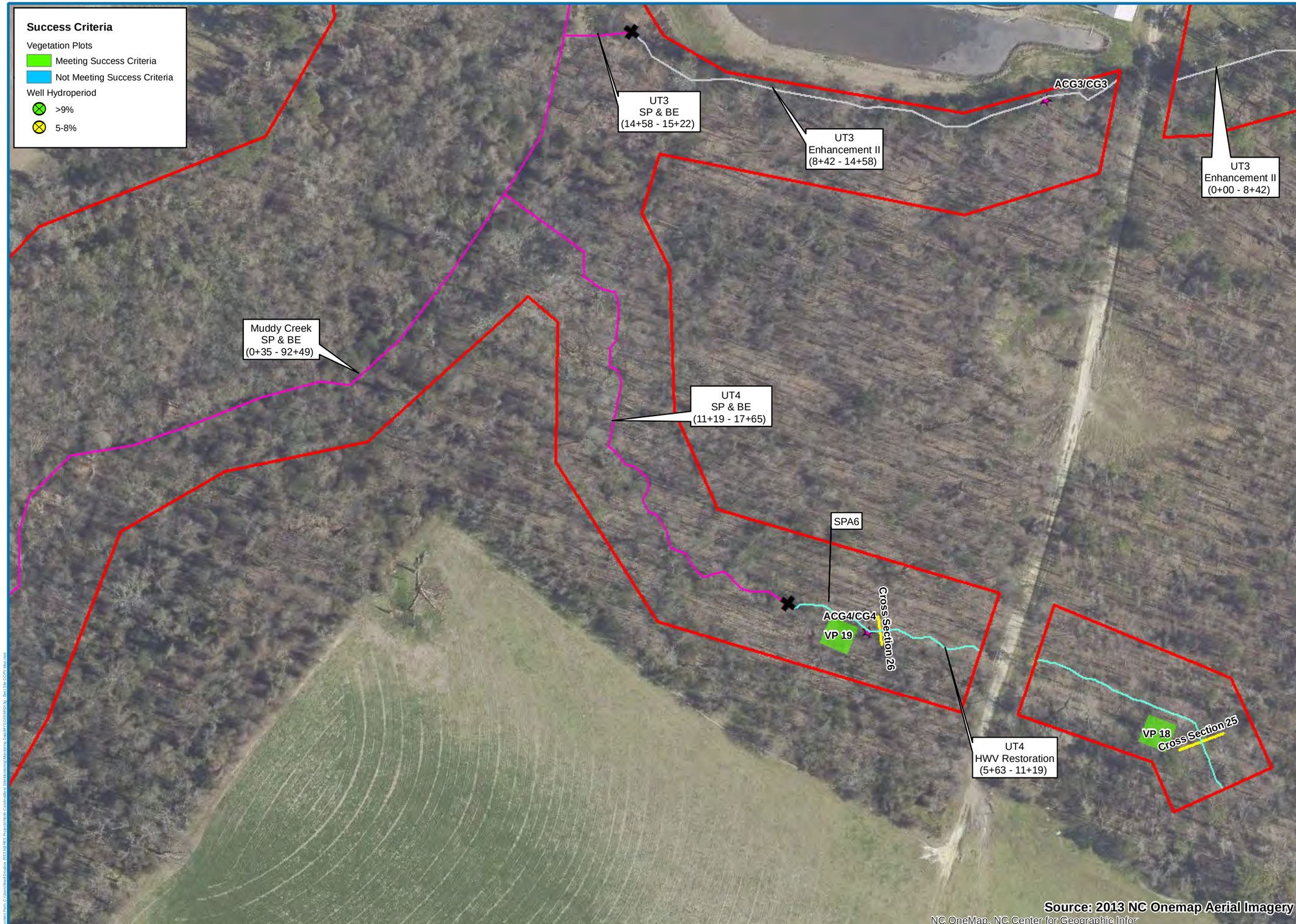
Date: 3/29/2016	Drawn by: BSH

LEGEND

- Conservation Easement
- Reach Breaks
- BE & Preservation
- Enhancement I
- Enhancement II
- Headwater Valley Rest.
- P1 Restoration
- Stream Structures
- Bankpin Locations
- Cross Sections
- Crest Gauge/RG Locations
- Wetland Restoration Areas

Riparian Buffer Conditions

Invasive Species	Target Community: Present	Target Community: Marginal	Target Community: Absent
Absent	No Fill		
Present			
Common			



res

0 50 100
Feet

1 inch = 100 feet

Figure 3g.

Best Stream and Wetland Restoration Project

UT4 & Muddy Creek Current Conditions Plan View Map

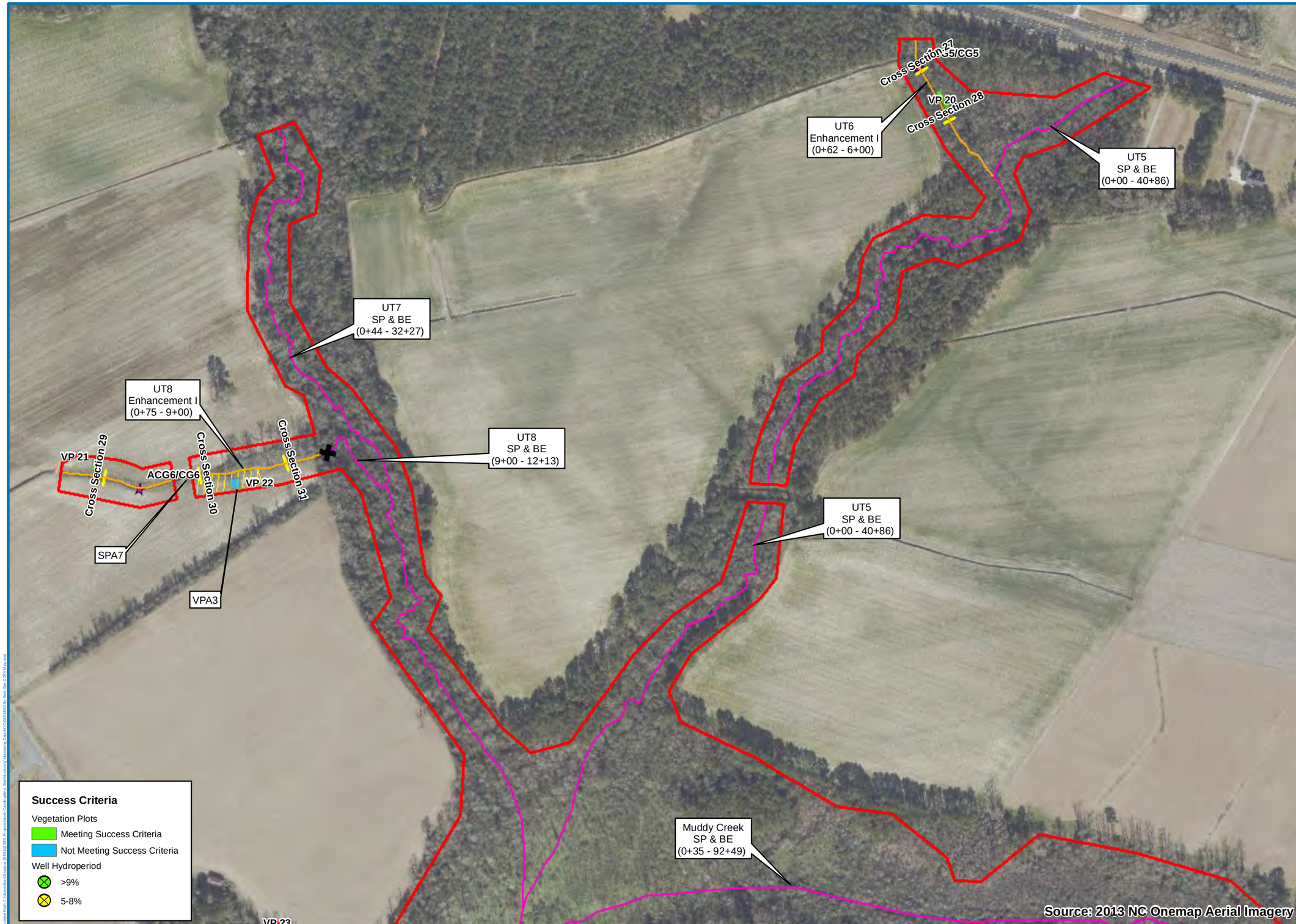
Date: 3/4/2016	Drawn by: BSH

LEGEND

- Conservation Easement
- Reach Breaks
- BE & Preservation
- Enhancement I
- Enhancement II
- Headwater Valley Rest.
- P1 Restoration
- Stream Structures
- Bankpin Locations
- Cross Sections
- Crest Gauge/RG Locations
- Wetland Restoration Areas

Riparian Buffer Conditions

Invasive Species	Target Community: Present	Target Community: Marginal	Target Community: Absent
Absent	No Fill		
Present			
Common			



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N
W
E
S
0 150 300
Feet

1 inch = 300 feet

Figure 3h.

Best Stream and Wetland Restoration Project

UT5, UT6, UT7, & UT8 Current Conditions Plan View Map

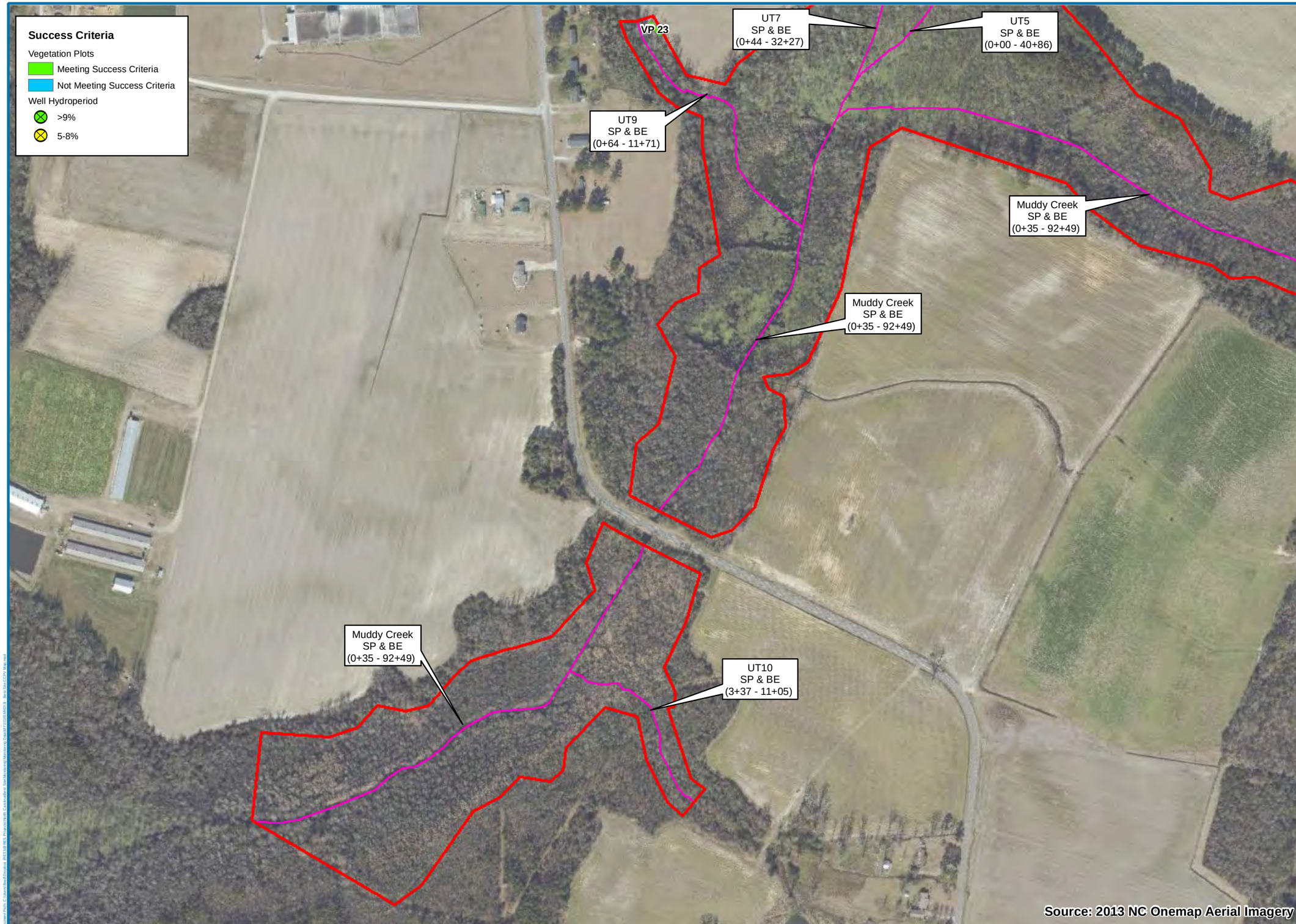
Date: 3/4/2016	Drawn by: BSH

LEGEND

- Conservation Easement
- Reach Breaks
- BE & Preservation
- Enhancement I
- Enhancement II
- Headwater Valley Rest.
- P1 Restoration
- Stream Structures
- Bankpin Locations
- Cross Sections
- Crest Gauge/RG Locations
- Wetland Restoration Areas

Riparian Buffer Conditions

Invasive Species	Target Community: Present	Target Community: Marginal	Target Community: Absent
Absent	No Fill		
Present			
Common			



0 150 300
Feet

1 inch = 350 feet

Figure 3i.

Best Stream and Wetland Restoration Project

UT9, UT10 & Muddy Creek Current Conditions Plan View Map

Date: 3/4/2016	Drawn by: BSH

LEGEND

- Conservation Easement
- Reach Breaks
- BE & Preservation
- Enhancement I
- Enhancement II
- Headwater Valley Rest.
- P1 Restoration
- Stream Structures
- Bankpin Locations
- Cross Sections
- Crest Gauge/RG Locations
- Wetland Restoration Areas

Riparian Buffer Conditions

Invasive Species	Target Community: Present	Target Community: Marginal	Target Community: Absent
Absent	No Fill		
Present			
Common			

Table 5 **Visual Stream Morphology Stability Assessment**
Reach ID **UT1**
Assessed Length **2036**

Major Channel Category	Channel Sub-Category	Metric	Number Stable, Performing as Intended	Total Number in As-built	Number of Unstable Segments	Amount of Unstable Footage	% Stable, Performing as Intended	Number with Stabilizing Woody Vegetation	Footage with Stabilizing Woody Vegetation	Adjusted % for Stabilizing Woody Vegetation
1. Bank	1. Scoured/Eroding	Bank lacking vegetative cover resulting simply from poor growth and/or scour and erosion			1	90	98%	0	0	98%
*	2. Undercut	Banks undercut/overhanging to the extent that mass wasting appears likely. Does NOT include undercuts that are modest, appear sustainable and are providing habitat.			0	0	100%	0	0	100%
	3. Mass Wasting	Bank slumping, calving, or collapse			0	0	100%	0	0	100%
				Totals	1	90	98%	0	0	98%
2. Engineered Structures	1. Overall Integrity	Structures physically intact with no dislodged boulders or logs.	15	19			79%			
	2. Grade Control	Grade control structures exhibiting maintenance of grade across the sill.	15	19			79%			
	2a. Piping	Structures lacking any substantial flow underneath sills or arms.	15	19			79%			
	3. Bank Protection	Bank erosion within the structures extent of influence does not exceed 15%. (See guidance for this table in EEP monitoring guidance document)	15	19			79%			
	4. Habitat	Pool forming structures maintaining ~ Max Pool Depth : Mean Bankfull Depth ratio ≥ 1.6 Rootwads/logs providing some cover at base-flow.	15	19			79%			

Table 5 **Visual Stream Morphology Stability Assessment**
Reach ID **UT2**
Assessed Length **3103**

Major Channel Category	Channel Sub-Category	Metric	Number Stable, Performing as Intended	Total Number in As-built	Number of Unstable Segments	Amount of Unstable Footage	% Stable, Performing as Intended	Number with Stabilizing Woody Vegetation	Footage with Stabilizing Woody Vegetation	Adjusted % for Stabilizing Woody Vegetation
1. Bank	1. Scoured/Eroding	Bank lacking vegetative cover resulting simply from poor growth and/or scour and erosion			0	0	100%	0	0	100%
*	2. Undercut	Banks undercut/overhanging to the extent that mass wasting appears likely. Does NOT include undercuts that are modest, appear sustainable and are providing habitat.			0	0	100%	0	0	100%
	3. Mass Wasting	Bank slumping, calving, or collapse			0	0	100%	0	0	100%
				Totals	0	0	100%	0	0	100%
2. Engineered Structures	1. Overall Integrity	Structures physically intact with no dislodged boulders or logs.	21	23			91%			
	2. Grade Control	Grade control structures exhibiting maintenance of grade across the sill.	21	23			91%			
	2a. Piping	Structures lacking any substantial flow underneath sills or arms.	21	23			91%			
	3. Bank Protection	Bank erosion within the structures extent of influence does not exceed 15%. (See guidance for this table in EEP monitoring guidance document)	21	23			91%			
	4. Habitat	Pool forming structures maintaining ~ Max Pool Depth : Mean Bankfull Depth ratio ≥ 1.6 Rootwads/logs providing some cover at base-flow.	21	23			91%			

Table 5 **Visual Stream Morphology Stability Assessment**
Reach ID **UT3**
Assessed Length **876**

Major Channel Category	Channel Sub-Category	Metric	Number Stable, Performing as Intended	Total Number in As-built	Number of Unstable Segments	Amount of Unstable Footage	% Stable, Performing as Intended	Number with Stabilizing Woody Vegetation	Footage with Stabilizing Woody Vegetation	Adjusted % for Stabilizing Woody Vegetation
1. Bank *	1. Scoured/Eroding	Bank lacking vegetative cover resulting simply from poor growth and/or scour and erosion			0	0	100%	0	0	100%
	2. Undercut	Banks undercut/overhanging to the extent that mass wasting appears likely. Does NOT include undercuts that are modest, appear sustainable and are providing habitat.			0	0	100%	0	0	100%
	3. Mass Wasting	Bank slumping, calving, or collapse			0	0	100%	0	0	100%
				Totals	0	0	100%	0	0	100%
2. Engineered Structures	1. Overall Integrity	Structures physically intact with no dislodged boulders or logs.	1	1			100%			
	2. Grade Control	Grade control structures exhibiting maintenance of grade across the sill.	1	1			100%			
	2a. Piping	Structures lacking any substantial flow underneath sills or arms.	1	1			100%			
	3. Bank Protection	Bank erosion within the structures extent of influence does not exceed 15%. (See guidance for this table in EEP monitoring guidance document)	1	1			100%			
	4. Habitat	Pool forming structures maintaining ~ Max Pool Depth : Mean Bankfull Depth ratio ≥ 1.6 Rootwads/logs providing some cover at base-flow.	1	1			100%			

Table 5 **Visual Stream Morphology Stability Assessment**
Reach ID **UT4**
Assessed Length **1140**

Major Channel Category	Channel Sub-Category	Metric	Number Stable, Performing as Intended	Total Number in As-built	Number of Unstable Segments	Amount of Unstable Footage	% Stable, Performing as Intended	Number with Stabilizing Woody Vegetation	Footage with Stabilizing Woody Vegetation	Adjusted % for Stabilizing Woody Vegetation
1. Bank	1. Scoured/Eroding	Bank lacking vegetative cover resulting simply from poor growth and/or scour and erosion			1	75	97%	1	25	98%
*	2. Undercut	Banks undercut/overhanging to the extent that mass wasting appears likely. Does NOT include undercuts that are modest, appear sustainable and are providing habitat.			0	0	100%	0	0	100%
	3. Mass Wasting	Bank slumping, calving, or collapse			0	0	100%	0	0	100%
				Totals	1	75	97%	1	25	98%
2. Engineered Structures	1. Overall Integrity	Structures physically intact with no dislodged boulders or logs.	4	6			67%			
	2. Grade Control	Grade control structures exhibiting maintenance of grade across the sill.	4	6			67%			
	2a. Piping	Structures lacking any substantial flow underneath sills or arms.	4	6			67%			
	3. Bank Protection	Bank erosion within the structures extent of influence does not exceed 15%. (See guidance for this table in EEP monitoring guidance document)	4	6			67%			
	4. Habitat	Pool forming structures maintaining ~ Max Pool Depth : Mean Bankfull Depth ratio ≥ 1.6 Rootwads/logs providing some cover at base-flow.	4	6			67%			

Table 5 **Visual Stream Morphology Stability Assessment**
Reach ID **UT6**
Assessed Length **538**

Major Channel Category	Channel Sub-Category	Metric	Number Stable, Performing as Intended	Total Number in As-built	Number of Unstable Segments	Amount of Unstable Footage	% Stable, Performing as Intended	Number with Stabilizing Woody Vegetation	Footage with Stabilizing Woody Vegetation	Adjusted % for Stabilizing Woody Vegetation
1. Bank *	1. Scoured/Eroding	Bank lacking vegetative cover resulting simply from poor growth and/or scour and erosion			0	0	100%	0	0	100%
	2. Undercut	Banks undercut/overhanging to the extent that mass wasting appears likely. Does NOT include undercuts that are modest, appear sustainable and are providing habitat.			0	0	100%	0	0	100%
	3. Mass Wasting	Bank slumping, calving, or collapse			0	0	100%	0	0	100%
				Totals	0	0	100%	0	0	100%
2. Engineered Structures	1. Overall Integrity	Structures physically intact with no dislodged boulders or logs.	3	3			100%			
	2. Grade Control	Grade control structures exhibiting maintenance of grade across the sill.	3	3			100%			
	2a. Piping	Structures lacking any substantial flow underneath sills or arms.	3	3			100%			
	3. Bank Protection	Bank erosion within the structures extent of influence does not exceed 15%. (See guidance for this table in EEP monitoring guidance document)	3	3			100%			
	4. Habitat	Pool forming structures maintaining ~ Max Pool Depth : Mean Bankfull Depth ratio ≥ 1.6 Rootwads/logs providing some cover at base-flow.	3	3			100%			

Table 5 **Visual Stream Morphology Stability Assessment**
Reach ID **UT6**
Assessed Length **765**

Major Channel Category	Channel Sub-Category	Metric	Number Stable, Performing as Intended	Total Number in As-built	Number of Unstable Segments	Amount of Unstable Footage	% Stable, Performing as Intended	Number with Stabilizing Woody Vegetation	Footage with Stabilizing Woody Vegetation	Adjusted % for Stabilizing Woody Vegetation
1. Bank	1. Scoured/Eroding	Bank lacking vegetative cover resulting simply from poor growth and/or scour and erosion			0	0	100%	0	0	100%
*	2. Undercut	Banks undercut/overhanging to the extent that mass wasting appears likely. Does NOT include undercuts that are modest, appear sustainable and are providing habitat.			0	0	100%	0	0	100%
	3. Mass Wasting	Bank slumping, calving, or collapse			1	60	96%	0	0	96%
				Totals	1	60	96%	0	0	96%
2. Engineered Structures	1. Overall Integrity	Structures physically intact with no dislodged boulders or logs.	3	3			100%			
	2. Grade Control	Grade control structures exhibiting maintenance of grade across the sill.	3	3			100%			
	2a. Piping	Structures lacking any substantial flow underneath sills or arms.	3	3			100%			
	3. Bank Protection	Bank erosion within the structures extent of influence does not exceed 15%. (See guidance for this table in EEP monitoring guidance document)	3	3			100%			
	4. Habitat	Pool forming structures maintaining ~ Max Pool Depth : Mean Bankfull Depth ratio ≥ 1.6 Rootwads/logs providing some cover at base-flow.	3	3			100%			

Table 6 — Vegetation Condition Assessment

Planted Acreage[1] **24.5**

Vegetation Category	Definitions	Mapping Threshold	CCPV Depiction	Number of Polygons	Combined Acreage	% of Planted Acreage
1. Bare Areas	Very limited cover of both woody and herbaceous material.	0.1 acres		1	0.15	0.6%
2. Low Stem Density Areas	Woody stem densities clearly below target levels based on MY3, 4, or 5 stem count criteria.	0.1 acres		2	0.69	2.8%
			Total	3	0.84	3.4%
3. Areas of Poor Growth Rates or Vigor	Areas with woody stems of a size class that are obviously small given the monitoring year.	0.25 acres		0	0.00	0.0%
			Cumulative Total	3	0.84	3.4%

Easement Acreage[2] **37.6**

Vegetation Category	Definitions	Mapping Threshold	CCPV Depiction	Number of Polygons	Combined Acreage	% of Easement Acreage
4. Invasive Areas of Concern[4]	Areas or points (if too small to render as polygons at map scale).	1000 SF		0	0.00	0.0%
5. Easement Encroachment Areas[3]	Areas or points (if too small to render as polygons at map scale).	none		0	0.00	0.0%

1 = Enter the planted acreage within the easement. This number is calculated as the easement acreage minus any existing mature tree stands that were not subject to supplemental planting of the understory, the channel acreage, crossings or any other elements not directly planted as part of the project effort.

2 = The acreage within the easement boundaries.

3 = Encroachment may occur within or outside of planted areas and will therefore be calculated against the overall easement acreage. In the event a polygon is cataloged into items 1, 2 or 3 in the table and is the result of encroachment, the associated acreage should be tallied in the relevant item (i.e., item 1,2 or 3) as well as a parallel tally in item 5.

4 = Invasives may occur in or out of planted areas, but still within the easement and will therefore be calculated against the overall easement acreage. Invasives of concern/interest are listed below. The list of high concern spcies are those with the potential to directly outcompete native, young, woody stems in the short-term (e.g. monitoring period or shortly thereafter) or affect the community structure for existing, more established tree/shrub stands over timeframes that are slightly longer (e.g. 1-2 decades). The low/moderate concern group are those species that generally do not have this capacity over the timeframes discussed and therefore are not expected to be mapped with regularity, but can be mapped, if in the judgement of the observer their coverage, density or distribution is suppressing the viability, density, or growth of planted woody stems. Decisions as to whether remediation will be needed are based on the integration of risk factors by EEP such as species present, their coverage, distribution relative to native biomass, and the practicality of treatment. For example, even modest amounts of Kudzu or Japanese Knotweed early in the projects history will warrant control, but potentially large coverages of Microstegium in the herb layer will not likley trigger control because of the limited capacities to impact tree/shrub layers within the timeframes discussed and the potential impacts of treating extensive amounts of ground cover. Those species with the "watch list" designator in gray shade are of interest as well, but have yet to be observed across the state with any frequency. Those in *red italics* are of particular interest given their extreme risk/threat level for mapping as points where isolated specimens are found, particularly ealry in a projects monitoring history. However, areas of discreet, dense patches will of course be mapped as polygons. The symbology scheme below was one that was found to be helpful for symbolzing invasives polygons, particularly for situations where the conditon for an area is somewhere between isolated specimens and dense, discreet patches. In any case, the point or polygon/area feature can be symbolized to describe things like high or low concern and species can be listed as a map inset, in legend items if the number of species are limited or in the narrative section of the executive summary.

Table 7. Stream Problem Areas Best Stream and Wetland Restoration Project - Project # 95353			
Feature Issue	**Station # / Range**	**Suspected Cause; Repair**	**Photo Number**
Bank Erosion	UT1- Sta 14+90	Lack of vegetation; regrade, plant livestakes and install matting	SPA1
Bank Erosion/Loose grade control structures	UT1- Sta. 15+90 to 16+80	Heavy rain event and sustained high flows; repair banks and repair/reinstall log structures, livestake and install matting after all work is complete	SPA2
Loose grade control structure	UT1- Sta. 17+60	Heavy rain event and sustained high flows; repair banks and repair/reinstall log structure	SPA3
Bank Erosion/Loose grade control structure	UT2- Sta. 25+50	Heavy rain event and sustained high flows; repair left bank and reinstall log structure, livestake and install matting after all work is complete	SPA4
Loose grade control structure	UT2- Sta. 26+25	Heavy rain event and sustained high flows; repair banks and repair/reinstall log structure	SPA5
Bank, Bed, and Floodplain Erosion	UT4- Sta. 10+25 to 11+00	Heavy rain event and sustained high flows; repair banks and repair/reinstall log structures, regrade floodplain to disperse concentrated overland flow	SPA6 (2 photos)
Bank Erosion/Failing Crossing	UT8- Sta. 4+07 to 4+67	Loose soil and heavy rain; repair/replace crossing, livestake and install matting on banks	SPA7 (2 photos)

Table 8. Vegetation Problem Areas Best Stream and Wetland Restoration Project - Project # 95353			
Feature Category	**Station Numbers**	**Suspected Cause; Repair**	**Photo Number**
Sparse Herbaceous Coverage	UT1- Sta. 11+00 to 12+50	Low Soil Fertility and compaction; Re-seed area	VPA1
Low Stem Density	UT3- Sta 6+50 to 8+42	Low Soil Fertility and compaction; Re-plant area with bare root stems	VPA2
Low Stem Density	UT8- Sta. 4+67 to 7+00	Low Soil Fertility and compaction; Re-plant area with bare root stems	VPA3

Appendix B.
Best Stream Photos

UT1/Wetland Area 1 Looking Upstream (2/9/2016)

UT1 STA 2+00 Looking Downstream (2/9/2016)

UT2 STA 8+00 Looking Upstream (2/9/2016)

UT2 STA 18+00 Looking Downstream (2/9/2016)

UT3 STA 5+50 at Looking Upstream (2/9/2016)

UT4 STA 6+75 Looking Downstream (2/9/2016)

Appendix B.
Best Stream Photos

UT6 STA 2+00 Looking Downstream (2/9/2016)

UT8 STA 3+25 Looking Downstream (2/9/2016)

UT8 STA 9+00 Looking Upstream (2/9/2016)

UT9 STA 3+50 Buffer Enhancement Area (2/9/2016)

Muddy Creek Wetland Area (6/25/2015)

Muddy Creek Wetland Area (6/18/2015)

Appendix B.
Best Stream and Wetland Photos

Wetland Restoration Area 1 (10/8/2015)

Wetland Restoration Area 3A (10/8/2015)

Crest Gauge 1 – UT1 (2/9/2016)

Crest Gauge 2 – UT2 (2/9/2016)

Crest Gauge 3 – UT3 (2/9/2016)

Crest Gauge 4 – UT4 (2/9/2016)

Appendix B.
Bank Pins

Bank Pin Array 1 UT1 STA 1+10 (2/9/2016)

Bank Pin Array 2 UT1 STA 4+25 (2/9/2016)

Bank Pin Array 3 UT1 STA 6+25 (2/9/2016)

Bank Pin Array 4 UT1 STA 9+90 (2/9/2016)

Best Site Bank Pin Array Photos

Bank Pin Array 5 UT1 STA 15+90 (2/9/2016)

Bank Pin Array 6 UT2 STA 5+75 (2/9/2016)

Bank Pin Array 8 UT2 STA 23+55 (2/9/2016)

Bank Pin Array 8 UT2 STA 28+45 (2/9/2016)

Appendix C.
Best Site Vegetation Plot Photos

Vegetation Plot 1 (2/9/2016)

Vegetation Plot 2 (2/9/2016)

Vegetation Plot 3 (2/9/2016)

Vegetation Plot 4 (2/9/2016)

Vegetation Plot 5 (2/9/2016)

Vegetation Plot 6 (2/9/2016)

Best Site Vegetation Plot Photos

Vegetation Plot 7 (2/9/2016)

Vegetation Plot 8 (2/9/2016)

Vegetation Plot 9 (2/9/2016)

Vegetation Plot 10 (2/9/2016)

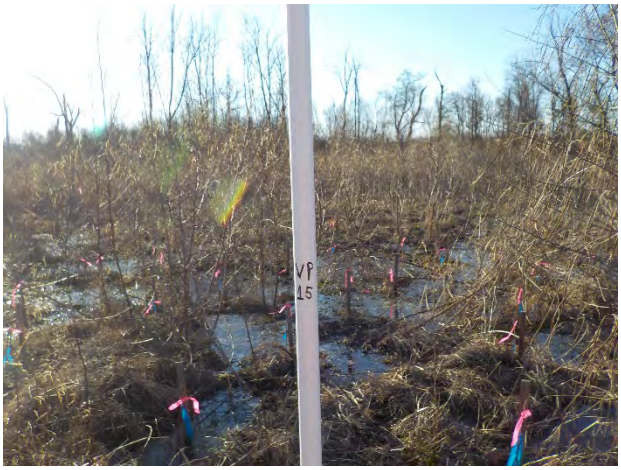
Vegetation Plot 11 (2/9/2016)

Vegetation Plot 12 (2/9/2016)

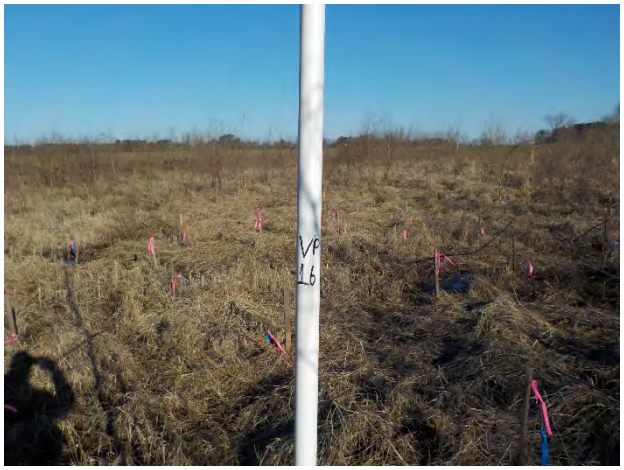
Best Site Vegetation Plot Photos

Vegetation Plot 13 (2/9/2016)

Vegetation Plot 14 (2/10/2016)



Vegetation Plot 15 (2/9/2016)



Vegetation Plot 16 (2/9/2016)

Vegetation Plot 17 (2/10/2016)

Vegetation Plot 18 (2/10/2016)

Best Site Vegetation Plot Photos

Vegetation Plot 19 (2/10/2016)

Vegetation Plot 20 (2/10/2016)

Vegetation Plot 21 (2/10/2016)

Vegetation Plot 22 (2/10/2016)

Vegetation Plot 23 (2/10/2016)

Appendix B - Stream Problem Area Photos

SPA1- Bank Erosion- UT1 @ Sta. 14+90

SPA2- Bank Erosion and Loose log structures- UT1 @ Sta. 15+90 to 16+80

SPA3- Loose log structure- UT1 @ Sta. 17+60

SPA4- Bank Erosion and Loose log structure- UT2 @ Sta. 25+50

SPA5- Loose grade control structure- UT2 @ Sta. 26+25

SPA6- Loose structure and bank erosion- UT4 @ Sta 10+25 to 11+00

SPA6- Floodplain erosion/concentrated flow- UT4 @ Sta 10+25 to 11+00

SPA7- Failing Crossing- UT8 @ Sta 4+07 to 4+67

SPA7- Failing Crossing- UT8 @ Sta 4+07 to 4+67

Appendix B - Vegetation Problem Area Photos

VPA1- Sparse Herbaceous Cover- UT1 @ Sta. 11+50 to 12+50

VPA2- Low Stem Density- UT3 @ Sta 6+50 to 8+00

VPA3- Low Stem Density- UT8 @ Sta 5+50 to 6+50

Appendix C

Vegetation Plot Data

Table 9a. Planted Stem Count Summary
Table 9b. Planted Species Totals
Table 9c. Planted and Total Stem Counts (Species by Plot)

Table 9a. Vegetation Plot Criteria Attainment Best Stream and Wetland Restoration Site		
Vegetation Plot ID	Vegetation Survival Threshold Met?	Tract Mean
1	Yes	91%
2	Yes	
3	Yes	
4	Yes	
5	Yes	
6	Yes	
7	Yes	
8	Yes	
9	Yes	
10	Yes	
11	Yes	
12	Yes	
13	Yes	
14	Yes	
15	Yes	
16	Yes	
17	No	
18	Yes	
19	Yes	
20	Yes	
21	Yes	
22	No	
23	Yes	

Table 9b. CVS Vegetation Plot Data Best Stream and Wetland Restoration Site	
Report Prepared By	Brad Breslow
Date Prepared	2/15/2016 11:13
database name	Best_MY1_CVS_Entrytool.mdb
database location	C:\Users\Brad\Dropbox (RES)\@RES Projects\North Carolina\Best Site\Monitoring\Monitoring Data\MY1\Vegetation Data
computer name	BRESLOW-PC
file size	75464704
DESCRIPTION OF WORKSHEETS IN THIS DOCUMENT	
Metadata	Description of database file, the report worksheets, and a summary of project(s) and project data.
Proj, planted	Each project is listed with its PLANTED stems per acre, for each year. This excludes live stakes.
Proj, total stems	Each project is listed with its TOTAL stems per acre, for each year. This includes live stakes, all planted stems, and all natural/volunteer stems.
Plots	List of plots surveyed with location and summary data (live stems, dead stems, missing, etc.).
Vigor	Frequency distribution of vigor classes for stems for all plots.
Vigor by Spp	Frequency distribution of vigor classes listed by species.
Damage	List of most frequent damage classes with number of occurrences and percent of total stems impacted by each.
Damage by Spp	Damage values tallied by type for each species.
Damage by Plot	Damage values tallied by type for each plot.
Planted Stems by Plot and Spp	A matrix of the count of PLANTED living stems of each species for each plot; dead and missing stems are excluded.
ALL Stems by Plot and spp	A matrix of the count of total living stems of each species (planted and natural volunteers combined) for each plot; dead and missing stems are excluded.
PROJECT SUMMARY	
Project Code	95353
project Name	Best Stream/Wetland Restoration Site
Description	
River Basin	Cape Fear
length(ft)	
stream-to-edge width (ft)	
area (sq m)	
Required Plots (calculated)	
Sampled Plots	23

Table 9c. Planted Total Stem Counts -- Project Name: Best Stream/Wetland Restoration Site

			Current Plot Data (MY1 2016)																																				
			95353-01-0001			95353-01-0002			95353-01-0003			95353-01-0004			95353-01-0005			95353-01-0006			95353-01-0007			95353-01-0008			95353-01-0009			95353-01-0010			95353-01-0011			95353-01-0012			95353-01-0013		
Scientific Name	**Common Name**	**Species Type**	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T
Betula nigra	river birch	Tree										2	2	2	1	1	1													1	1	1	1	1	1	4	4	4	2	2	2
Liquidambar styraciflua	sweetgum	Tree			1			1																																	
Liriodendron tulipifera	tuliptree	Tree	2	2	2										3	3	3													1	1	1				2	2	2			
Nyssa sylvatica	blackgum	Tree																																							
Platanus occidentalis	American sycamore	Tree	3	3	3	1	1	1				13	13	13				7	7	7	8	8	8	2	2	2	12	12	12	2	2	2	1	1	1	5	5	5	10	10	10
Quercus	oak	Tree	1	1	1																4	4	4							1	1	1	1	1	1				1	1	1
Quercus lyrata	overcup oak	Tree	3	3	3	4	4	4	1	1	1	5	5	5	5	5	5	10	10	10	2	2	2	1	1	1	3	3	3	7	7	7	1	1	1	6	6	6	6	6	6
Quercus michauxii	swamp chestnut oak	Tree	1	1	1	4	4	4	5	5	5	1	1	1	7	7	7				5	5	5	8	8	8	1	1	1	1	1	1	2	2	2	4	4	4	3	3	3
Quercus myrtifolia	myrtle oak	Shrub Tree																																							
Quercus nigra	water oak	Tree				2	2	2	1	1	1	1	1	1																											
Quercus phellos	willow oak	Tree			1							7	7	7	5	5	5	9	9	9	2	2	2	4	4	4	2	2	2	2	2	2				1	1	1	1	1	1
Taxodium distichum	bald cypress	Tree	1	1	1				4	4	4																4	4	4	5	5	5	27	27	27	3	3	3	3	3	3
Unknown		Shrub or Tree																																							
		Stem count	11	11	13	11	11	12	11	11	11	29	29	29	21	21	21	26	26	26	21	21	21	15	15	15	22	22	22	20	20	20	33	33	33	25	25	25	26	26	26
		size (ares)	1			1			1			1			1			1			1			1			1			1			1			1			1		
		size (ACRES)	0.02			0.02			0.02			0.02			0.02			0.02			0.02			0.02			0.02			0.02			0.02			0.02			0.02		
		Species count	6	6	8	4	4	5	4	4	4	6	6	6	5	5	5	3	3	3	5	5	5	4	4	4	5	5	5	8	8	8	6	6	6	7	7	7	7	7	7
		Stems per ACRE	445.2	445.2	526.1	445.2	445.2	485.6	445.2	445.2	445.2	1174	1174	1174	849.8	849.8	849.8	1052	1052	1052	849.8	849.8	849.8	607	607	607	890.3	890.3	890.3	809.4	809.4	809.4	1335	1335	1335	1012	1012	1012	1052	1052	1052

			Current Plot Data (MY1 2016)																														Annual Means					
			95353-01-0014			95353-01-0015			95353-01-0016			95353-01-0017			95353-01-0018			95353-01-0019			95353-01-0020			95353-01-0021			95353-01-0022			95353-01-0023			MY1 (2016)			MY0 (2015)		
Scientific Name	**Common Name**	**Species Type**	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T
Betula nigra	river birch	Tree	1	1	1																5	5	5	3	3	3							20	20	20	26	26	26
Liquidambar styraciflua	sweetgum	Tree																																	2			
Liriodendron tulipifera	tuliptree	Tree															7																8	8	15	25	25	25
Nyssa sylvatica	blackgum	Tree				5	5	5																									5	5	5	6	6	6
Platanus occidentalis	American sycamore	Tree	6	6	6	1	1	1	1	1	1										12	12	12										84	84	84	113	113	113
Quercus	oak	Tree	1	1	1										2	2	2																11	11	11	48	48	48
Quercus lyrata	overcup oak	Tree	6	6	6				8	8	8				7	7	7	4	4	4				4	4	4	1	1	1	4	4	4	88	88	88	119	119	119
Quercus michauxii	swamp chestnut oak	Tree	2	2	2	1	1	1	11	11	11										14	14	14	2	2	2							72	72	72	86	86	86
Quercus myrtifolia	myrtle oak	Shrub Tree																1	1	1													1	1	1			
Quercus nigra	water oak	Tree													2	2	3	1	1	1										5	5	5	12	12	13	15	15	15
Quercus phellos	willow oak	Tree	1	1	1				2	2	2				4	4	4	6	6	6				1	1	1	2	2	2	17	17	17	66	66	67	90	90	90
Taxodium distichum	bald cypress	Tree	8	8	8	21	21	21	1	1	1													2	2	2							79	79	79	98	98	98
Unknown		Shrub or Tree																			1	1	1	1	1	1							2	2	2	4	4	4
		Stem count	25	25	25	28	28	28	23	23	23	0	0	0	15	15	23	12	12	12	32	32	32	13	13	13	3	3	3	26	26	26	448	448	459	630	630	630
		size (ares)	1			1			1			1			1			1			1			1			1			1			23			23		
		size (ACRES)	0.02			0.02			0.02			0.02			0.02			0.02			0.02			0.02			0.02			0.02			0.57			0.57		
		Species count	7	7	7	4	4	4	5	5	5	0	0	0	4	4	5	4	4	4	4	4	4	6	6	6	2	2	2	3	3	3	12	12	13	11	11	11
		Stems per ACRE	1012	1012	1012	1133	1133	1133	930.8	930.8	930.8	0	0	0	607	607	930.8	485.6	485.6	485.6	1295	1295	1295	526.1	526.1	526.1	121.4	121.4	121.4	1052	1052	1052	788.3	788.3	807.6	1108	1108	1108

Color for Density
Exceeds requirements by 10%
Exceeds requirements, but by less than 10%
Fails to meet requirements, by less than 10%
Fails to meet requirements by more than 10%

Appendix D

Stream Geomorphology Data

Table 10. Morphological Parameters Summary Data
Table 11. Dimensional Morphology Summary – Cross Sections Data
Table 12. Bank Pin Array Summary Data
Cross Section Plots

Table 10. Best Site Morphological Parameters

	Reference Reach			Existing[1]												Design				As-Built/Baseline			
				UT1	UT2	UT3	UT4 (US)	UT4 (DS)	UT5	UT6	UT7	UT8	UT9	UT10	Muddy Creek	UT1		UT2		UT1		UT2	
Feature	Pool	Run	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow	Pool	Shallow	Pool	Shallow	Pool	Shallow	Pool
Drainage Area (ac)	286			41	146	59	82	82	380	79	387	56	36	306	2930	41		146		41		146	
Drainage Area (mi^2)	0.45			0.06	0.23	0.09	0.13	0.13	0.59	0.12	0.60	0.09	0.06	0.48	4.58	0.06		0		0.06		0	
NC Regional Curve Discharge (cfs)[2]	---	---	9.3	2.3	5.7	3.0	3.8	3.8	11.4	3.7	11.5	2.9	2.1	9.7	49.5	2.3		6		2.3		6	
NC Regional Curve Discharge (cfs)[3]	---	---	4.8	1.1	2.9	1.4	1.8	1.8	5.9	1.8	6.0	1.4	1.0	5.0	27.9	1.1		3		1.1		3	
Design/Calculated Discharge (cfs)	---	---	13	---	---	---	---	---	---	---	---	---	---	---	---	---		---		---		---	
Dimension																							
BF Width (ft)	10.9	8.9	7.0	5.1	4.8	9.8	6.4	7.5	11.0	5.1	10.1	9.5	6.5	13.7	15.7	6.2	7.1	9.4	10.8	6.6	7.8	10.0	11.9
Floodprone Width (ft)	100	100	100	9	9	22	10	>50	>100	>50	>50	12	>50	84	>50	>50	>50	>50	>50	>50	>50	>50	>50
BF Cross Sectional Area (ft^2)	11.4	8.4	5.0	3.2	4.6	8.1	6.4	6.2	6.0	4.3	6.1	4.9	3.6	7.8	21.2	3.9	6.1	8.9	14.2	3.0	5.1	10.2	15.0
BF Mean Depth (ft)	1.0	0.9	0.8	0.6	1.0	0.8	0.9	0.8	0.5	0.8	0.6	0.5	0.6	0.6	1.4	0.6	0.9	1.0	1.3	0.5	0.7	1.0	1.3
BF Max Depth (ft)	2.1	1.7	1.3	1.1	1.3	1.2	1.1	1.2	1.0	1.2	1.1	0.7	1.1	0.9	2.3	1.0	1.4	1.5	2.2	0.8	1.3	1.8	2.3
Width/Depth Ratio	10.4	9.5	8.8	8.1	5.0	11.8	8.4	9.1	20.2	6.2	16.7	18.2	11.8	24.0	11.6	9.9	8.3	9.9	8.2	14.8	12.3	9.9	9.5
Entrenchment Ratio	9.2	11.2	15.1	1.8	1.9	2.2	1.4	>2.2	>2.2	>2.2	>2.2	1.3	>2.2	6.1	>2.2	>2.2	>2.2	>2.2	>2.2	>2.2	>2.2	>2.2	>2.2
Wetted Perimeter (ft)	12.8	9.7	7.4	5.8	6.3	10.8	8.1	8.3	11.3	6.0	10.5	9.8	7.2	13.9	17.0	6.6	7.7	10.0	11.8	6.8	8.3	10.8	13.0
Hydraulic Radius (ft)	0.9	0.9	0.7	0.6	0.7	0.8	0.8	0.8	0.5	0.7	0.6	0.5	0.5	0.6	1.2	0.6	0.8	0.9	1.2	0.4	0.6	0.9	1.2
Substrate																							
	Fine Sand			Fine Sand												Fine Sand		Fine Sand		Fine Sand		Fine Sand	
Pattern																							
	Min	**Max**	**Med**	---	---	---	---	---	---	---	---	---	---	---	---	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**
Channel Beltwidth (ft)	13.6	31.8	23.1	---	---	---	---	---	---	---	---	---	---	---	---	11	28	20	41	13	33	21	48
Radius of Curvature (ft)	11.0	27.6	17.6	---	---	---	---	---	---	---	---	---	---	---	---	9	27	17	37	9	34	14	44
Radius of Curvature Ratio	1.5	3.7	2.3	---	---	---	---	---	---	---	---	---	---	---		1.5	4.4	1.8	3.9	1.4	5.1	1.4	4.4
Meander Wavelength (ft)	34.9	68.3	54.5	---	---	---	---	---	---	---	---	---	---	---	---	32	71	44	106	31	67	35	108
Meander Width Ratio	1.8	4.2	3.1	---	---	---	---	---	---	---	---	---	---	---	---	1.8	4.5	2.1	4.4	1.9	5.0	2.1	4.8
Profile																							
Shallow Length (ft)	3.1	30.7	12.6	---	---	---	---	---	---	---	---	---	---	---	---	4	23	6	41	5	26	8	45
Run Length (ft)	2.2	33.2	11.3	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Pool Length (ft)	4.2	9.5	5.8	---	---	---	---	---	---	---	---	---	---	---	---	3	10	7	12	5	14	8	15
Pool -to-Pool Spacing (ft)	17.5	59.8	36.3	---	---	---	---	---	---	---	---	---	---	---	---	16	49	25	68	18	55	30	74
Additional Reach Parameters																							
Valley Length (ft)	274			1826	2818	1417	253	686	2843	567	2192	942	725	1042	9021	1510		2529		1510		2529	
Channel Length (ft)	309			1905	2865	1522	255	772	3228	597	2629	994	769	1104	9808	1723		2770		1756		2771	
Sinuosity	1.13			1.04	1.02	1.07	1.01	1.13	1.14	1.05	1.20	1.06	1.06	1.06	1.09	1.14		1.10		1.16		1.10	
Water Surface Slope (ft/ft)	0.004			---	---	---	---	---	---	---	---	---	---	---	---	---		---		---		---	
Channel Slope (ft/ft)	0.003			0.0066	0.0044	0.0093	0.0042	0.0042	0.004	0.0012	0.004	0.0029	0.008	0.004	0.0011	0.0056		0.0027		0.0063		0.0045	
Rosgen Classification	E5			G5c	G5c	E5	G5c	E5	C5	E5	C5	F5	E5	C5	E5	E5		E5		E5		E5	

[1] Bankfull stage was estimated using NC Regional Curve equations and existing conditions data

[2] NC Regional Curve equations source: Doll et al. (2003)

[3] NC Regional Curve equations source: Sweet and Geratz (2003)

Appendix D. Table 11. - Monitoring Data - Dimensional Morphology Summary (Dimensional Parameters – Cross Sections)

Project Name/Number: Best Site/ NCDMS Project # 95353

	Cross Section 1 (Pool)							Cross Section 2 (Riffle)							Cross Section 3 (Riffle)							Cross Section 4 (Pool)							Cross Section 5 (Pool)						
Based on fixed baseline bankfull elevation[1]	Base	MY1	MY2	MY3	MY5	MY7	MY+	Base	MY1	MY2	MY3	MY5	MY7	MY+	Base	MY1	MY2	MY3	MY5	MY7	MY+	Base	MY1	MY2	MY3	MY5	MY7	MY+	Base	MY1	MY2	MY3	MY5	MY7	MY+
Record elevation (datum) used	74.7	74.7						74.8	74.8						73.1	73.1						72.8	72.8						71.9	71.9					
Bankfull Width (ft)	8.0	6.7						8.2	7.2						5.2	3.9						6.1	4.5						6.8	6.8					
Floodprone Width (ft)	50.0	50.0						50.0	50.0						50.0	50.0						50.0	50.0						50.0	50.0					
Bankfull Mean Depth (ft)	0.8	0.7						0.5	0.5						0.3	0.2						0.4	0.5						0.6	0.6					
Bankfull Max Depth (ft)	1.4	1.2						1.0	1.0						0.6	0.5						0.8	0.7						1.4	1.3					
Bankfull Cross Sectional Area (ft^2)	6.0	4.5						4.2	3.9						1.8	0.9						2.6	2.0						4.1	4.0					
Bankfull Width/Depth Ratio	10.5	10.0						15.9	13.5						15.1	16.2						14.5	9.9						11.4	11.7					
Bankfull Entrenchment Ratio	>2.2	>2.2						>2.2	>2.2						>2.2	>2.2						>2.2	>2.2						>2.2	>2.2					
Bankfull Bank Height Ratio	1.0	1.0						1.0	1.0						1.0	1.0						1.0	1.0						1.0	1.0					

	Cross Section 6 (Riffle)							Cross Section 7 (Riffle)							Cross Section 8 (Pool)							Cross Section 9 (Pool)							Cross Section 10 (Riffle)						
Based on fixed baseline bankfull elevation[1]	Base	MY1	MY2	MY3	MY5	MY7	MY+	Base	MY1	MY2	MY3	MY5	MY7	MY+	Base	MY1	MY2	MY3	MY5	MY7	MY+	Base	MY1	MY2	MY3	MY5	MY7	MY+	Base	MY1	MY2	MY3	MY5	MY7	MY+
Record elevation (datum) used	72.1	72.1						70.7	70.7						70.7	70.7						66.0	66.0						68.8	68.8					
Bankfull Width (ft)	7.1	6.1						6.4	7.1						7.7	10.1						7.7	7.1						6.1	5.7					
Floodprone Width (ft)	50.0	50.0						50.0	50.0						50.0	50.0						50.0	50.0						50.0	50.0					
Bankfull Mean Depth (ft)	0.4	0.4						0.5	0.5						0.7	0.6						0.8	0.7						0.6	0.5					
Bankfull Max Depth (ft)	0.7	0.6						0.8	0.8						1.2	1.4						1.4	1.2						0.9	0.9					
Bankfull Cross Sectional Area (ft^2)	2.8	2.4						3.0	3.3						5.2	5.6						6.1	5.0						3.5	2.9					
Bankfull Width/Depth Ratio	18.0	16.0						14.0	15.2						11.3	18.2						9.9	10.3						10.4	11.3					
Bankfull Entrenchment Ratio	>2.2	>2.2						>2.2	>2.2						>2.2	>2.2						>2.2	>2.2						>2.2	>2.2					
Bankfull Bank Height Ratio	1.0	1.0						1.0	1.0						1.0	1.0						1.0	1.0						1.0	1.0					

	Cross Section 11 (Pool)							Cross Section 12 (Riffle)							Cross Section 13 (Pool)							Cross Section 14 (Run/Riffle)							Cross Section 15 (Riffle)						
Based on fixed baseline bankfull elevation[1]	Base	MY1	MY2	MY3	MY5	MY7	MY+	Base	MY1	MY2	MY3	MY5	MY7	MY+	Base	MY1	MY2	MY3	MY5	MY7	MY+	Base	MY1	MY2	MY3	MY5	MY7	MY+	Base	MY1	MY2	MY3	MY5	MY7	MY+
Record elevation (datum) used	66.5	66.5						66.6	66.6						71.0	71.0						70.7	70.7						69.9	69.9					
Bankfull Width (ft)	10.4	10.0						6.5	5.5						13.7	13.1						10.0	10.0						9.0	9.4					
Floodprone Width (ft)	50.0	50.0						37.0	37.0						50.0	50.0						50.0	50.0						50.0	50.0					
Bankfull Mean Depth (ft)	0.6	0.8						0.4	0.5						1.4	1.3						1.1	1.1						0.9	0.8					
Bankfull Max Depth (ft)	1.3	1.8						0.9	0.8						2.6	2.3						1.7	1.7						1.5	1.4					
Bankfull Cross Sectional Area (ft^2)	6.7	7.6						2.8	2.9						18.6	17.6						10.7	10.6						7.8	7.3					
Bankfull Width/Depth Ratio	16.0	13.2						15.1	10.7						10.1	9.0						9.3	9.6						10.3	12.0					
Bankfull Entrenchment Ratio	>2.2	>2.2						>2.2	>2.2						>2.2	>2.2						>2.2	>2.2						>2.2	>2.2					
Bankfull Bank Height Ratio	1.0	1.0						1.0	1.0						1.0	1.0						1.0	1.0						1.0	1.0					

	Cross Section 16 (Pool)							Cross Section 17 (Riffle)							Cross Section 18 (Pool)							Cross Section 19 (Pool)							Cross Section 20 (Run/Riffle)						
Based on fixed baseline bankfull elevation[1]	Base	MY1	MY2	MY3	MY5	MY7	MY+	Base	MY1	MY2	MY3	MY5	MY7	MY+	Base	MY1	MY2	MY3	MY5	MY7	MY+	Base	MY1	MY2	MY3	MY5	MY7	MY+	Base	MY1	MY2	MY3	MY5	MY7	MY+
Record elevation (datum) used	69.4	69.4						68.7	68.7						68.1	68.1						66.7	66.7						67.1	67.1					
Bankfull Width (ft)	12.4	13.3						9.8	9.6						10.4	9.2						10.8	11.4						11.4	12.1					
Floodprone Width (ft)	50.0	50.0						50.0	50.0						50.0	50.0						50.0	50.0						50.0	50.0					
Bankfull Mean Depth (ft)	1.2	1.2						0.9	0.8						1.1	1.0						1.2	1.1						1.2	1.1					
Bankfull Max Depth (ft)	2.3	2.2						1.6	1.5						1.9	1.7						2.1	2.8						2.3	2.1					
Bankfull Cross Sectional Area (ft^2)	15.1	15.7						9.3	7.5						11.2	8.8						12.5	11.4						13.8	13.0					
Bankfull Width/Depth Ratio	10.2	11.3						10.3	12.3						9.7	9.6						9.4	10.0						9.4	11.2					
Bankfull Entrenchment Ratio	>2.2	>2.2						>2.2	>2.2						>2.2	>2.2						>2.2	>2.2						>2.2	>2.2					
Bankfull Bank Height Ratio	1.0	1.0						1.0	1.0						1.0	1.0						1.0	1.0						1.0	1.0					

1 = Widths and depths for annual measurements will be based on the baseline bankfull datum regardless of dimensional/depositional development. Input the elevation used as the datum, which should be consistent and based on the baseline datum established. If the performer has inherited the project and cannot acquire the datum used for prior years this must be discussed with EEP. If this cannot be resolved in time for a given years report submission a footnote in this should be included that states: "It is uncertain if the monitoring datum has been consistent over the monitoring history, which may influence calculated values. Additional data from a prior performer is being acquired to provide confirmation. Values will be recalculated in a future submission based on a consistent datum if determined to be necessary."

Appendix D. Table 11. - Monitoring Data - Dimensional Morphology Summary (Dimensional Parameters – Cross Sections)

Project Name/Number: Best Site/ NCDMS Project # 95353

	Cross Section 21 (Run)							Cross Section 22 (Pool)							Cross Section 23 (Run)							Cross Section 24 (Pool)							Cross Section 25 (Run)						
Based on fixed baseline bankfull elevation[1]	Base	MY1	MY2	MY3	MY5	MY7	MY+	Base	MY1	MY2	MY3	MY5	MY7	MY+	Base	MY1	MY2	MY3	MY5	MY7	MY+	Base	MY1	MY2	MY3	MY5	MY7	MY+	Base	MY1	MY2	MY3	MY5	MY7	MY+
Record elevation (datum) used	65.1	65.1						65.0	65.0						62.8	62.8						62.5	62.5						71.5	71.5					
Bankfull Width (ft)	10.9	10.0						10.7	10.5						9.1	10.3						13.2	13.8						12.2	11.5					
Floodprone Width (ft)	50.0	50.0						50.0	50.0						50.0	50.0						50.0	50.0						50.0	50.0					
Bankfull Mean Depth (ft)	1.0	1.0						1.3	1.2						1.0	0.8						1.4	1.0						0.3	0.3					
Bankfull Max Depth (ft)	1.9	1.9						2.4	2.3						1.8	1.4						2.6	2.1						0.8	0.7					
Bankfull Cross Sectional Area (ft^2)	11.1	10.0						14.2	12.4						8.7	8.1						18.3	14.4						4.2	3.6					
Bankfull Width/Depth Ratio	10.7	9.9						8.1	8.8						9.4	13.1						9.5	13.3						35.5	36.6					
Bankfull Entrenchment Ratio	>2.2	>2.2						>2.2	>2.2						>2.2	>2.2						>2.2	>2.2						>2.2	>2.2					
Bankfull Bank Height Ratio	1.0	1.0						1.0	1.0						1.0	1.0						1.0	1.0						1.0	1.0					

	Cross Section 26 (Run)							Cross Section 27 (Riffle)							Cross Section 28 (Run)							Cross Section 29 (Pool)							Cross Section 30 (Run)						
Based on fixed baseline bankfull elevation[1]	Base	MY1	MY2	MY3	MY5	MY7	MY+	Base	MY1	MY2	MY3	MY5	MY7	MY+	Base	MY1	MY2	MY3	MY5	MY7	MY+	Base	MY1	MY2	MY3	MY5	MY7	MY+	Base	MY1	MY2	MY3	MY5	MY7	MY+
Record elevation (datum) used	67.9	67.9						69.9	69.9						69.2	69.2						65.3	65.3						63.7	63.7					
Bankfull Width (ft)	5.6	5.3						7.2	6.7						5.7	5.3						8.7	3.3						6.4	6.7					
Floodprone Width (ft)	50.0	50.0						50.0	15.0						50.0	15.0						50.0	20.0						50.0	20.0					
Bankfull Mean Depth (ft)	0.6	0.5						0.7	0.6						0.5	0.5						0.4	0.4						0.9	0.8					
Bankfull Max Depth (ft)	1.0	0.9						1.1	1.0						0.9	0.8						0.9	0.8						1.3	1.5					
Bankfull Cross Sectional Area (ft^2)	3.1	2.7						4.7	4.1						3.1	2.4						3.8	3.3						5.7	5.6					
Bankfull Width/Depth Ratio	10.2	10.2						10.8	11.0						10.4	11.4						19.9	22.1						7.1	7.9					
Bankfull Entrenchment Ratio	>2.2	>2.2						>2.2	>2.2						>2.2	>2.2						>2.2	1.9						>2.2	>2.2					
Bankfull Bank Height Ratio	1.0	1.0						1.0	1.0						1.0	1.0						1.0	1.0						1.0	1.0					

	Cross Section 31 (Riffle)																																		
Based on fixed baseline bankfull elevation[1]	Base	MY1	MY2	MY3	MY5	MY7	MY+	Base	MY1	MY2	MY3	MY5	MY7	MY+	Base	MY1	MY2	MY3	MY5	MY7	MY+	Base	MY1	MY2	MY3	MY5	MY7	MY+	Base	MY1	MY2	MY3	MY5	MY7	MY+
Record elevation (datum) used	63.0	63.0																																	
Bankfull Width (ft)	7.7	8.5																																	
Floodprone Width (ft)	50.0	15.0																																	
Bankfull Mean Depth (ft)	0.4	0.2																																	
Bankfull Max Depth (ft)	0.7	0.5																																	
Bankfull Cross Sectional Area (ft^2)	3.0	2.1																																	
Bankfull Width/Depth Ratio	19.5	34.5																																	
Bankfull Entrenchment Ratio	>2.2	1.7																																	
Bankfull Bank Height Ratio	1.0	1.0																																	

Based on fixed baseline bankfull elevation[1]	Base	MY1	MY2	MY3	MY5	MY7	MY+	Base	MY1	MY2	MY3	MY5	MY7	MY+	Base	MY1	MY2	MY3	MY5	MY7	MY+	Base	MY1	MY2	MY3	MY5	MY7	MY+	Base	MY1	MY2	MY3	MY5	MY7	MY+
Record elevation (datum) used																																			
Bankfull Width (ft)																																			
Floodprone Width (ft)																																			
Bankfull Mean Depth (ft)																																			
Bankfull Max Depth (ft)																																			
Bankfull Cross Sectional Area (ft^2)																																			
Bankfull Width/Depth Ratio																																			
Bankfull Entrenchment Ratio																																			
Bankfull Bank Height Ratio																																			

1 = Widths and depths for annual measurements will be based on the baseline bankfull datum regardless of dimensional/depositional development. Input the elevation used as the datum, which should be consistent and based on the baseline datum established. If the performer has inherited the project and cannot acquire the datum used for prior years this must be discussed with EEP. If this cannot be resolved in time for a given years report submission a footnote in this should be included that states: "It is uncertain if the monitoring datum has been consistent over the monitoring history, which may influence calculated values. Additional data from a prior performer is being acquired to provide confirmation. Values will be recalculated in a future submission based on a consistent datum if determined to be necessary."

Table 12.Best Bank Pin Array Summary

Cross Section	Location	Position	Year 1 Reading
XS 1 @ Sta. 1+00 - UT1	US	Top	0.0
		Bottom	0.0
	DS	Top	0.0
		Bottom	0.0
XS 4 @ Sta. 4+25 - UT1	US	Top	0.0
	DS	Top	0.0
XS 5 @ Sta. 6+25 - UT1	US	Top	0.0
	DS	Top	0.0
XS 8 @ Sta. 9+90 - UT1	US	Top	0.0
		Bottom	0.0
	DS	Top	0.0
		Bottom	0.0
XS 11 @ Sta. 15+90 - UT1	US	Top	0.0
		Bottom	0.0
	DS	Top	6"
		Bottom	24"
XS 13 @ Sta. 5+75 - UT2	US	Top	0.0
		Bottom	0.0
	DS	Top	0.0
		Bottom	0.0
XS 22 @ Sta. 23+55 - UT2	US	Top	0.0
		Bottom	0.0
	DS	Top	0.0
		Bottom	0.0
XS 24 @ Sta. 28+45 - UT2	US	Top	0.0
		Bottom	0.0
	DS	Top	0.0
		Bottom	0.0

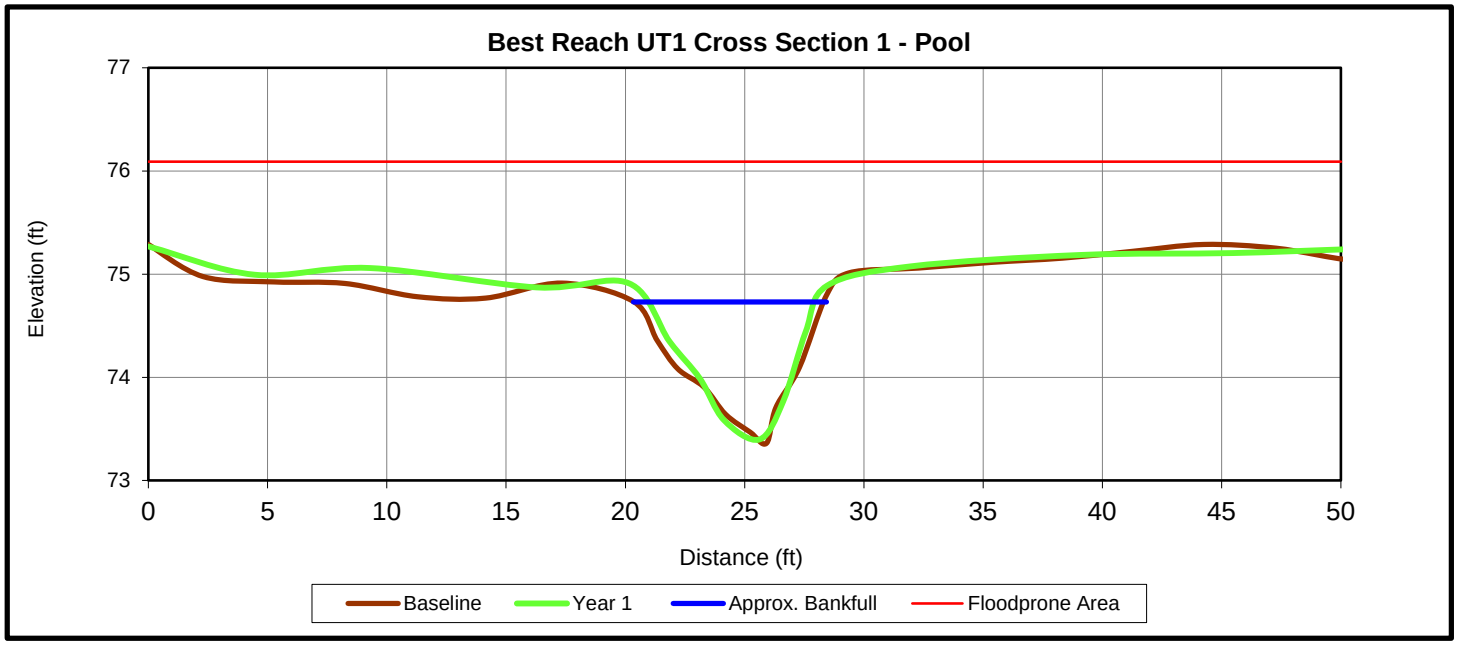
Notes:

US - Upstream from cross section

DS - Downstream from cross section

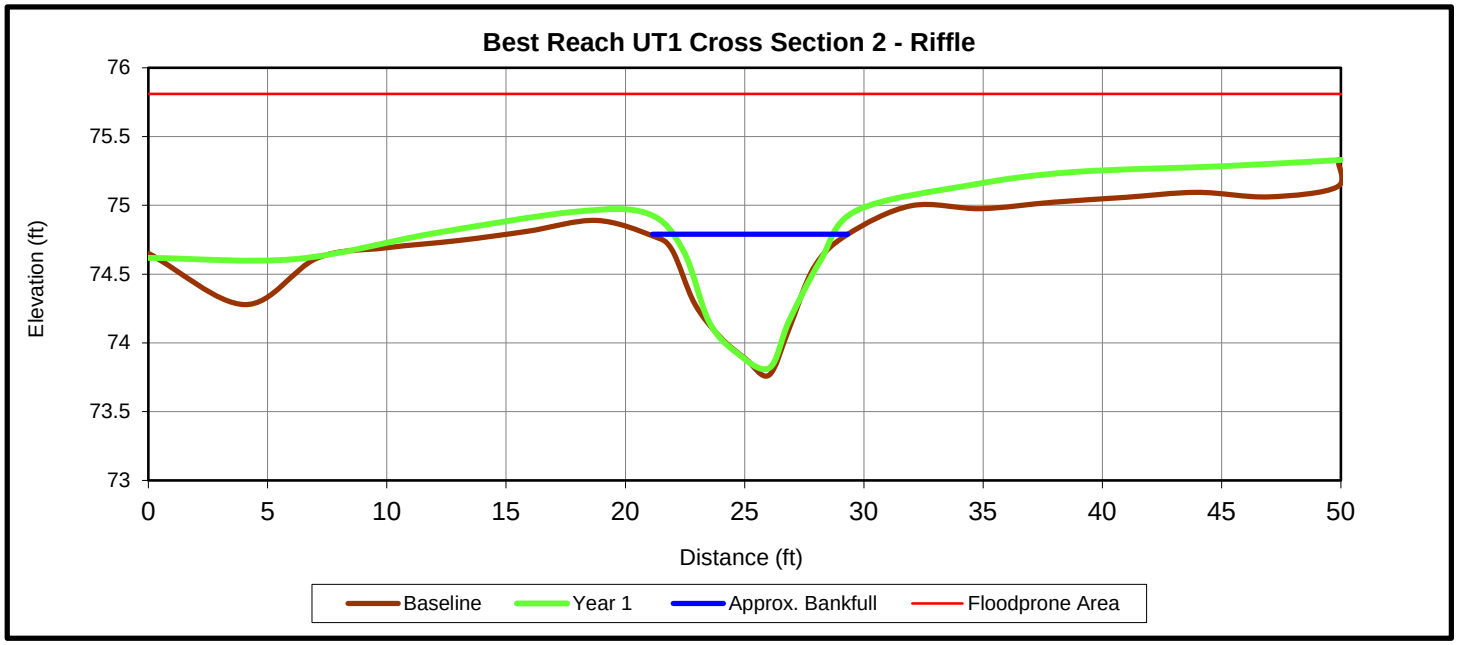
Upstream

Downstream



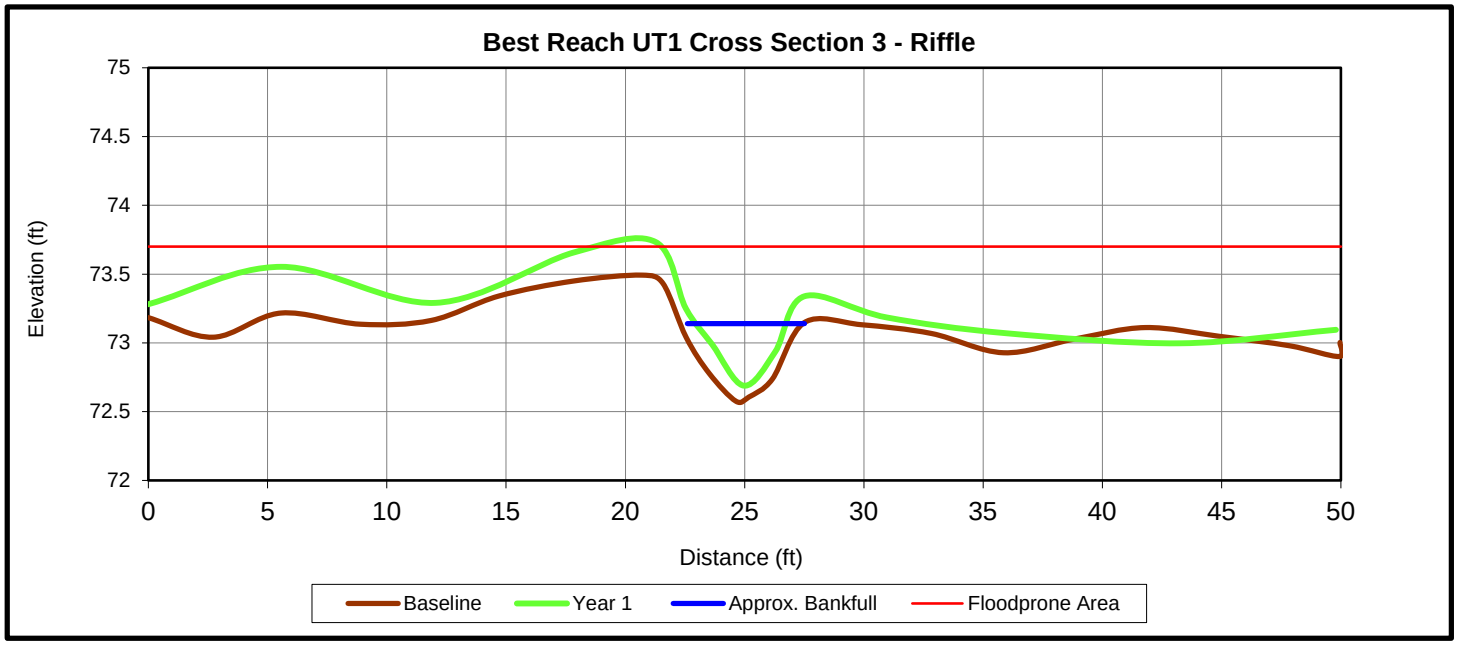
Upstream

Downstream



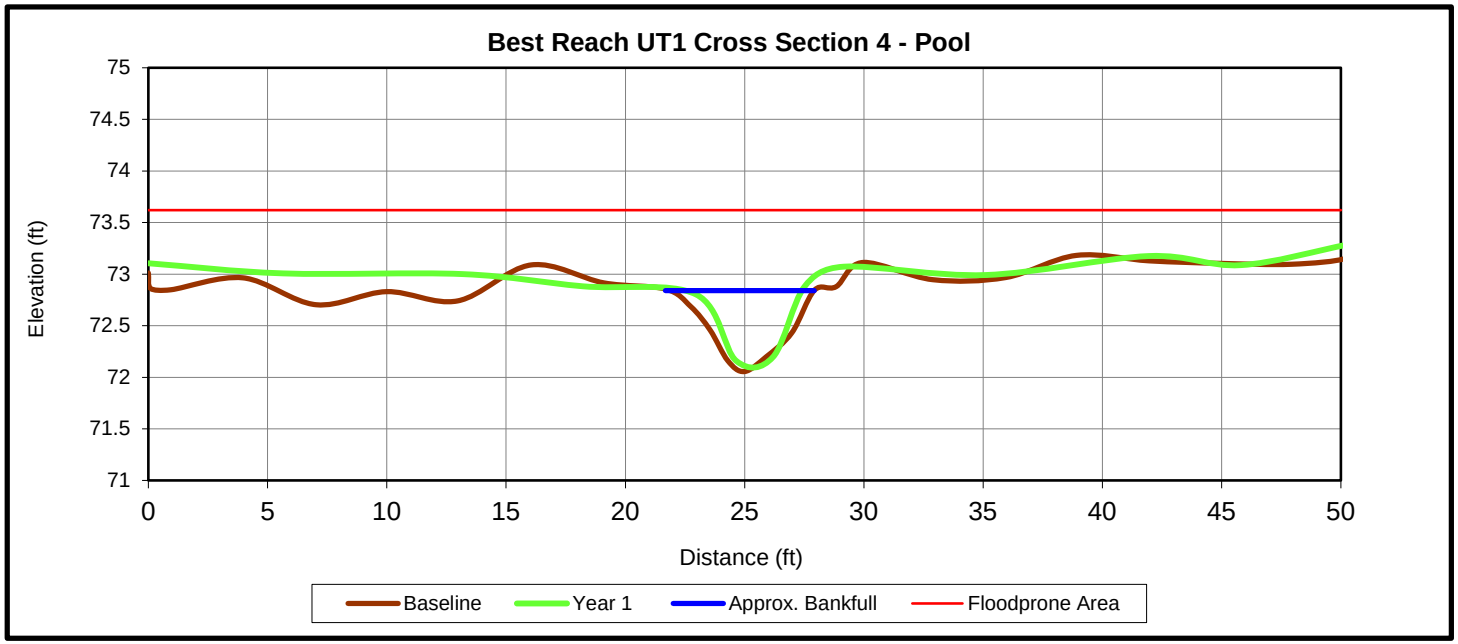
Upstream

Downstream



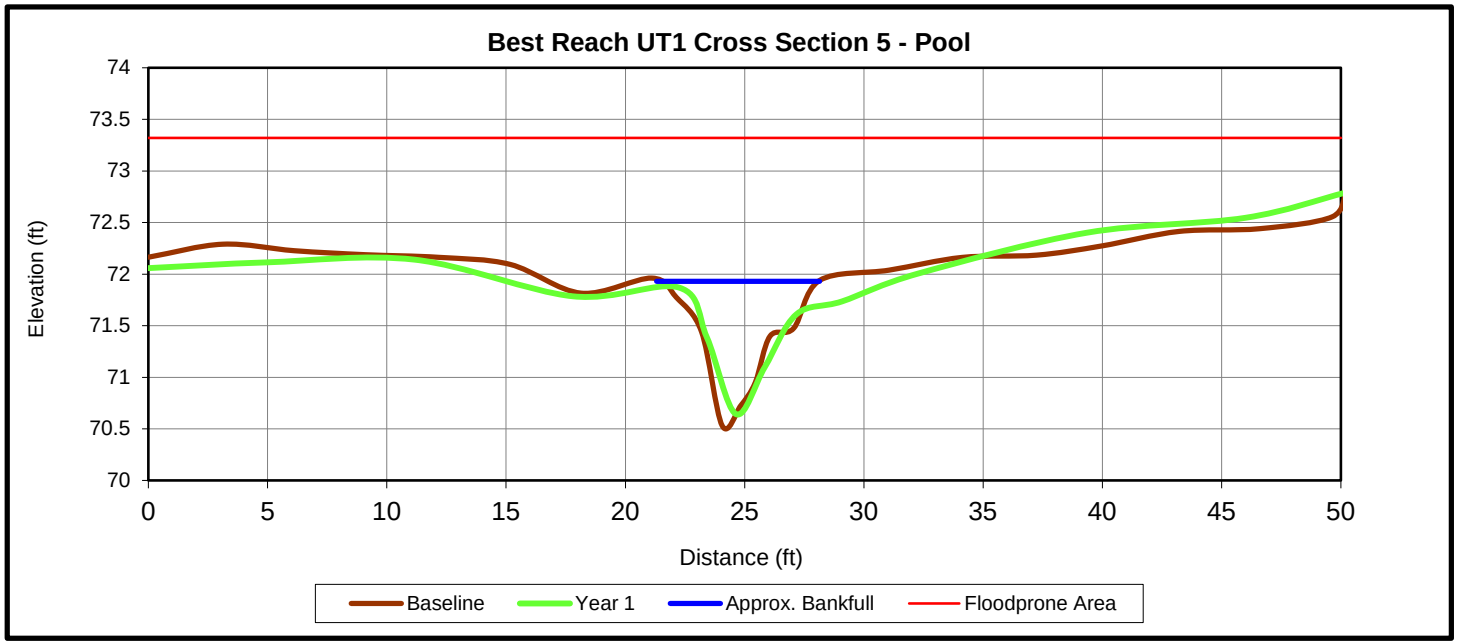
Upstream

Downstream



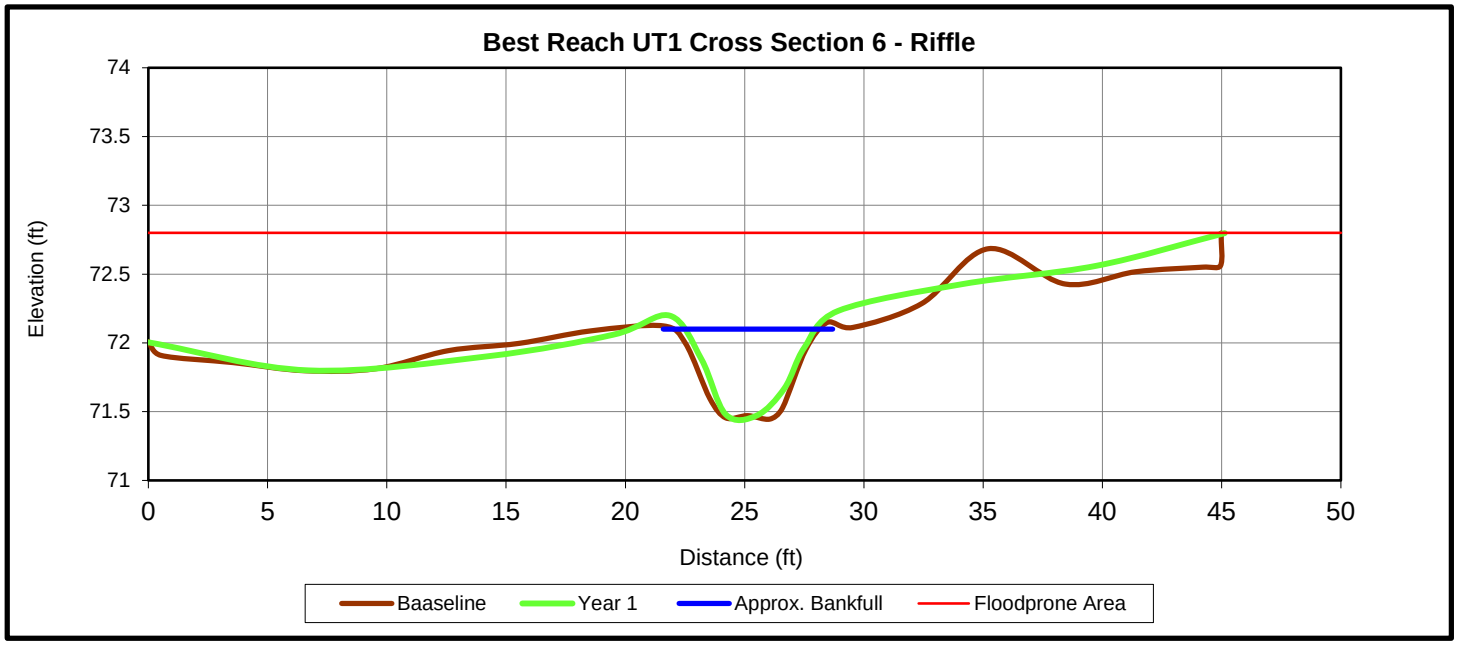
Upstream

Downstream



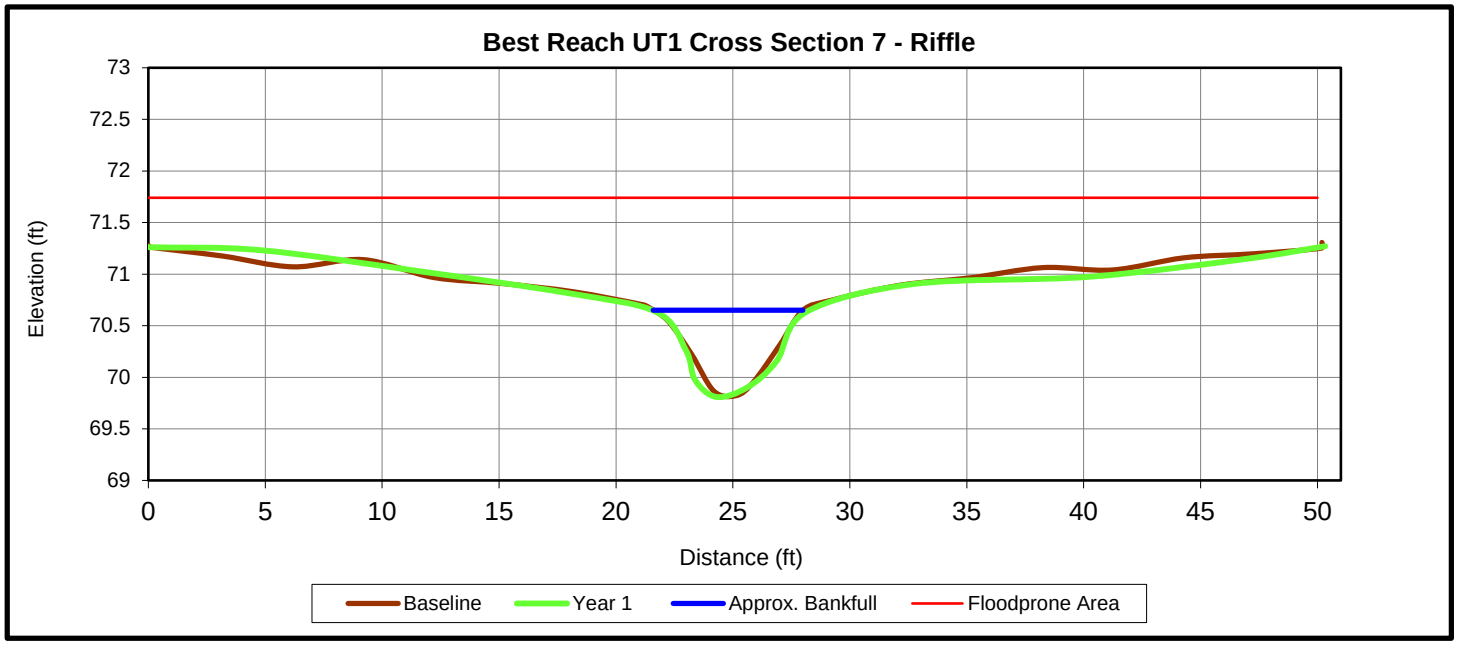
Upstream

Downstream



Upstream

Downstream



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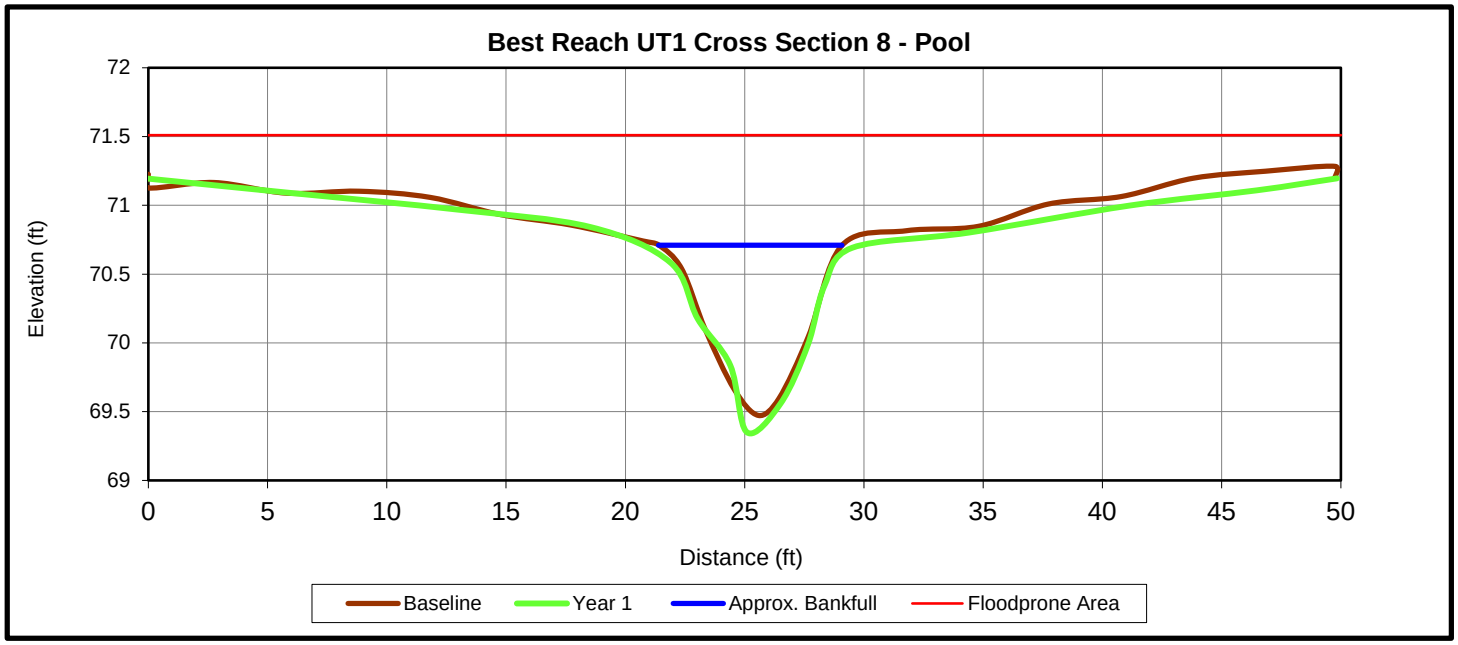
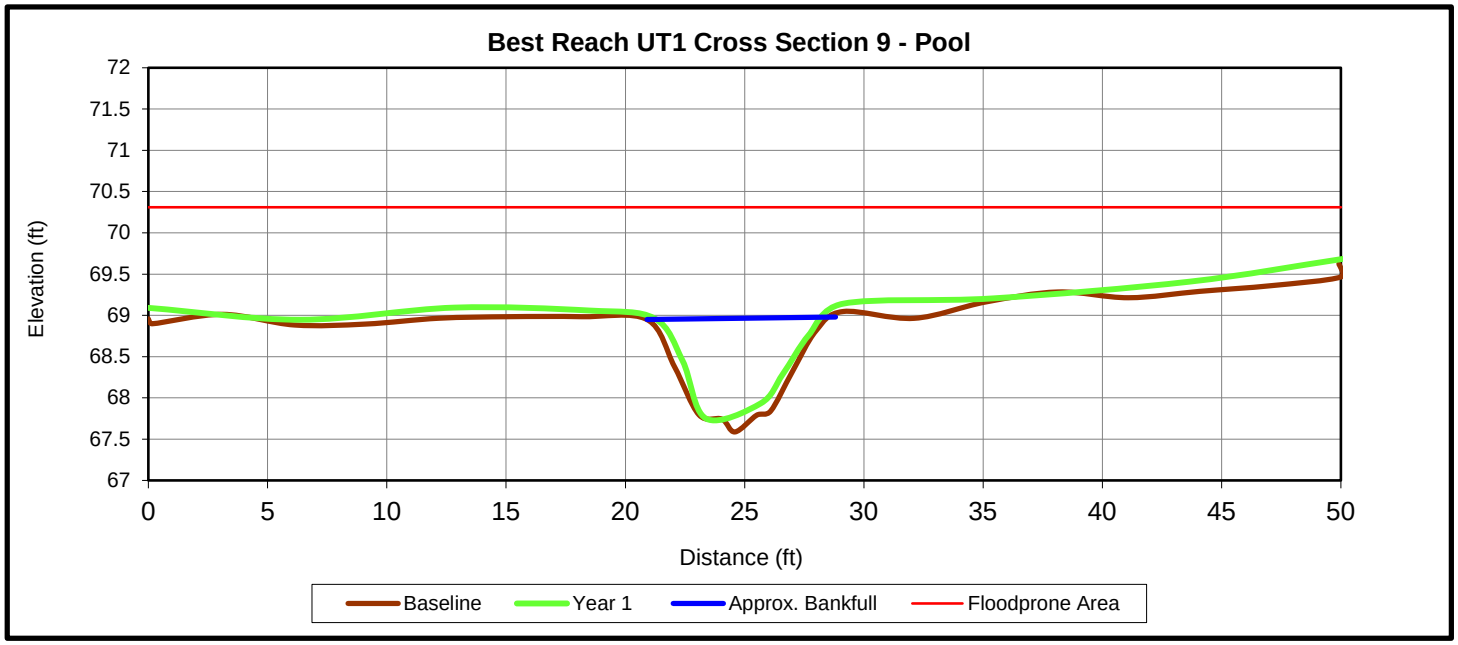
Downstream



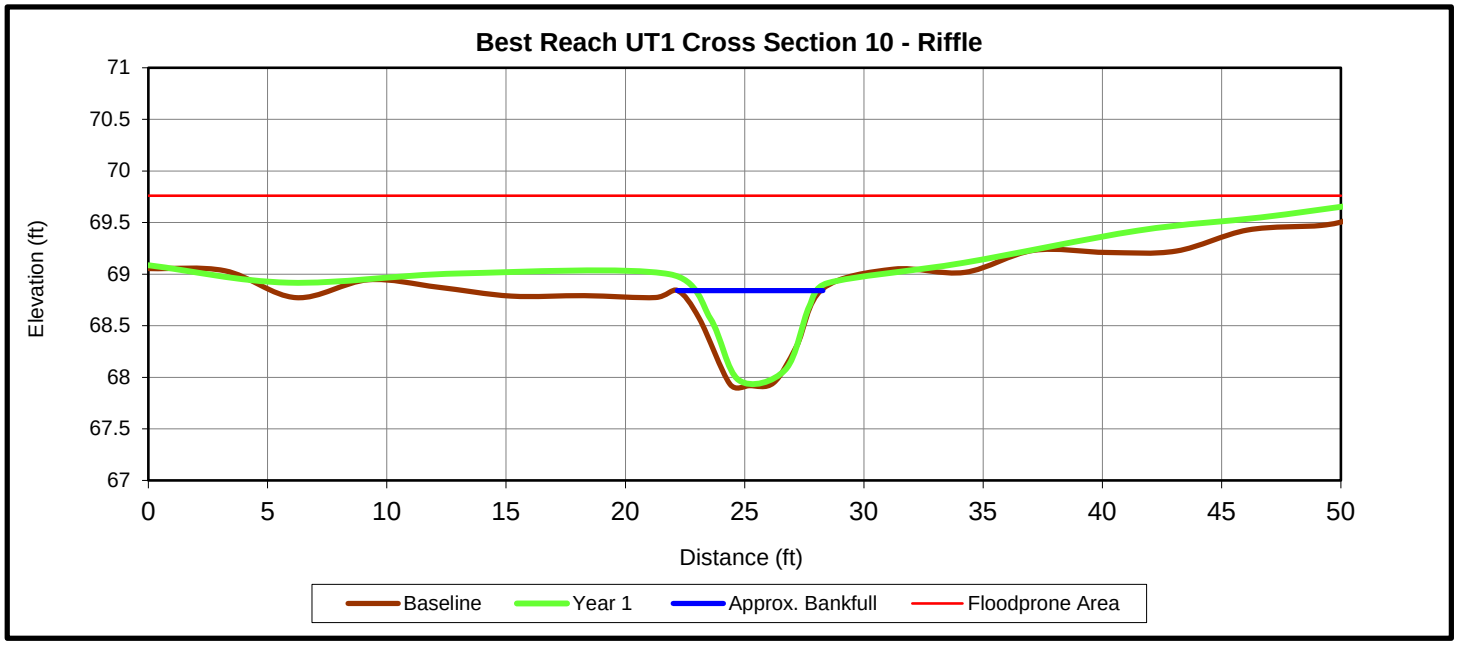
Upstream

Downstream



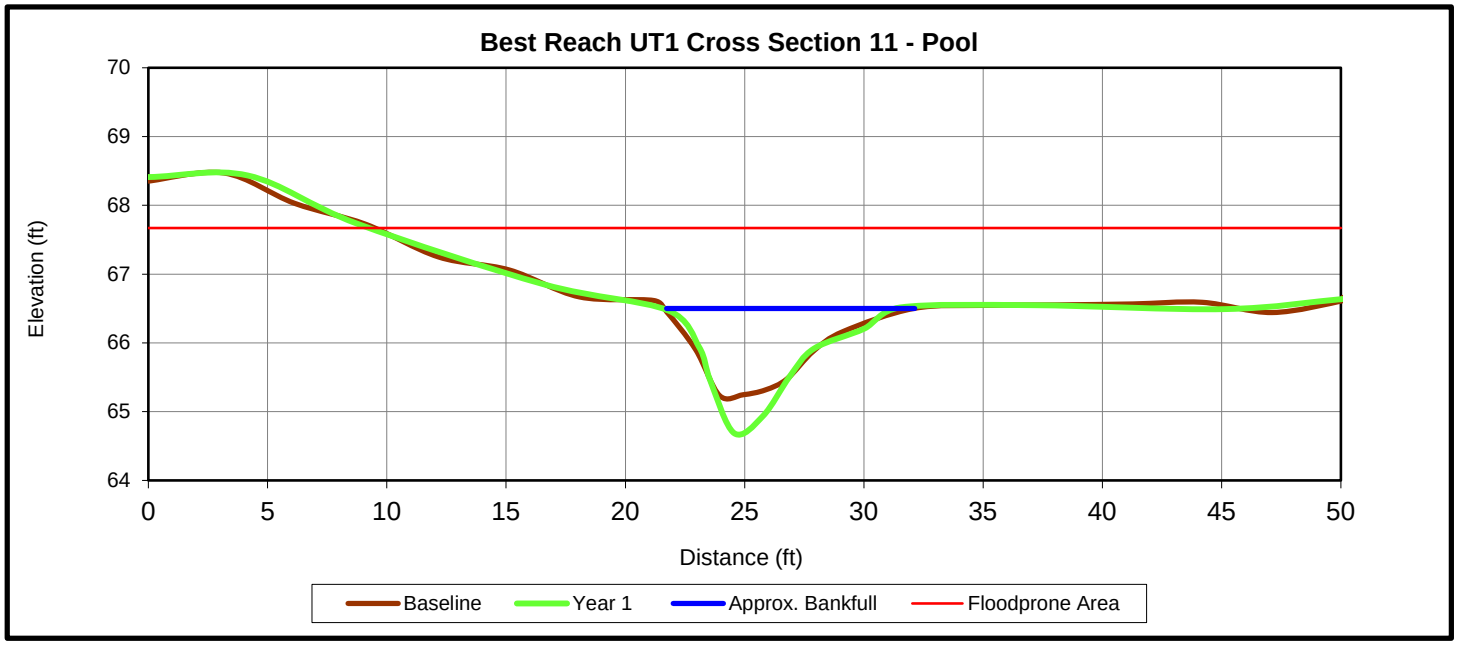
Upstream

Downstream



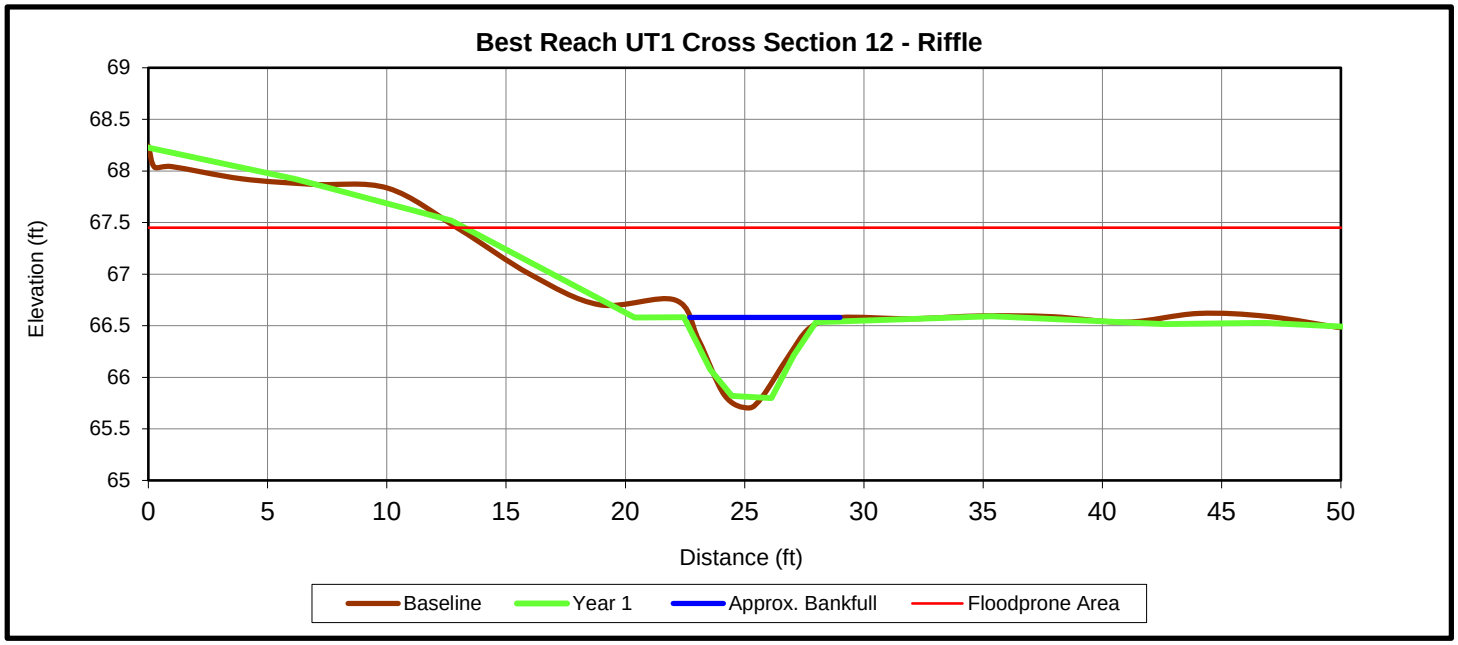
Upstream

Downstream



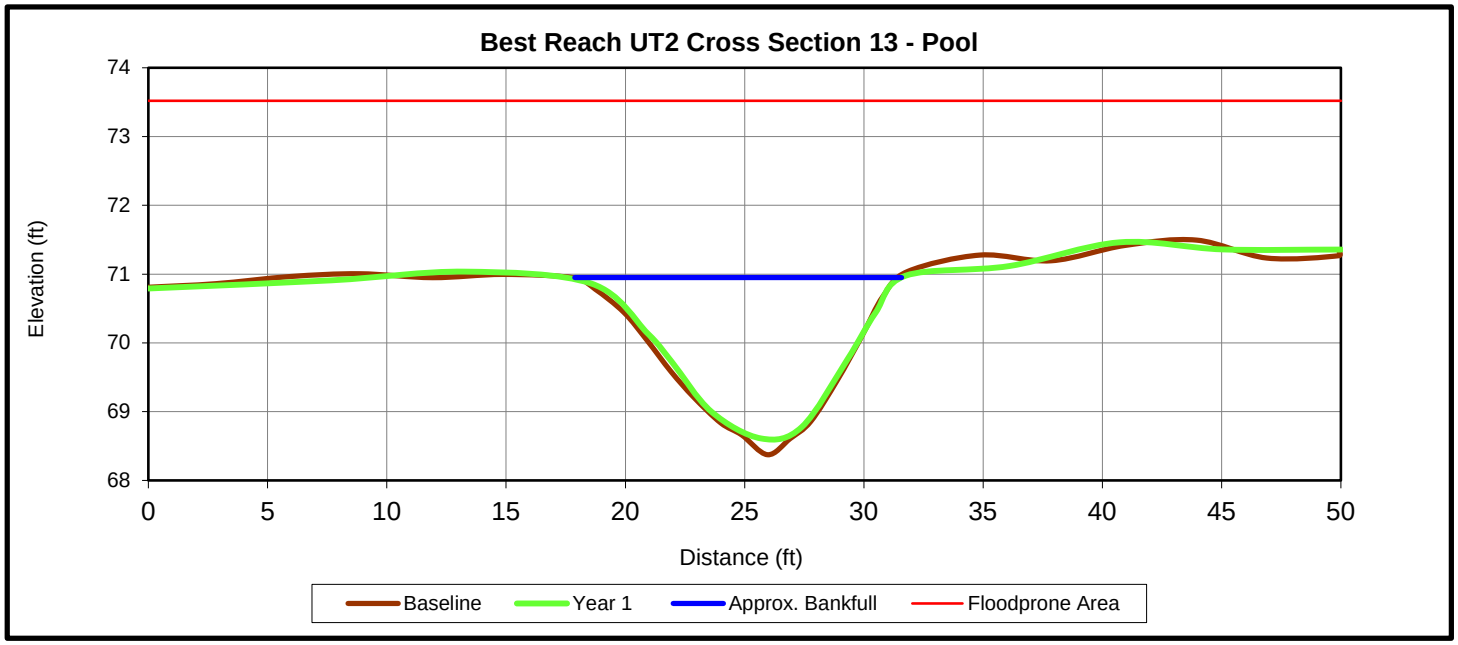
Upstream

Downstream



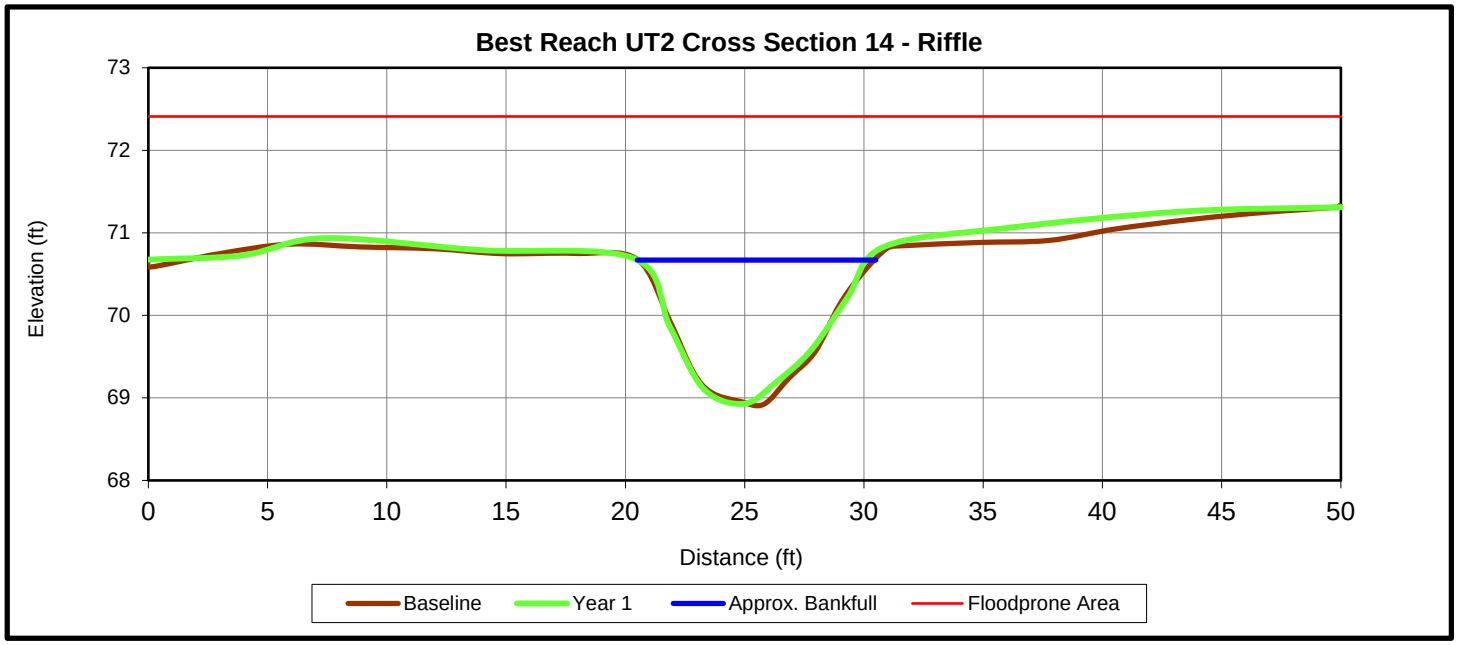
Upstream

Downstream



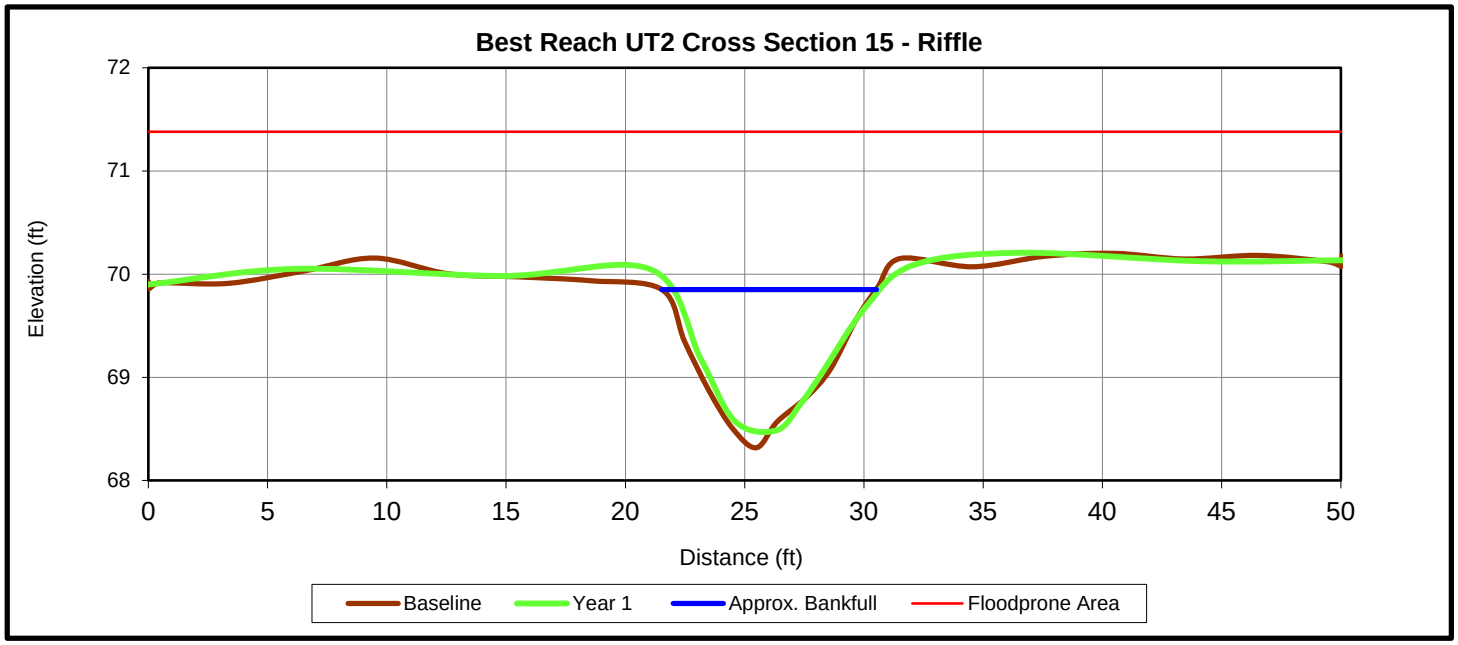
Upstream

Downstream



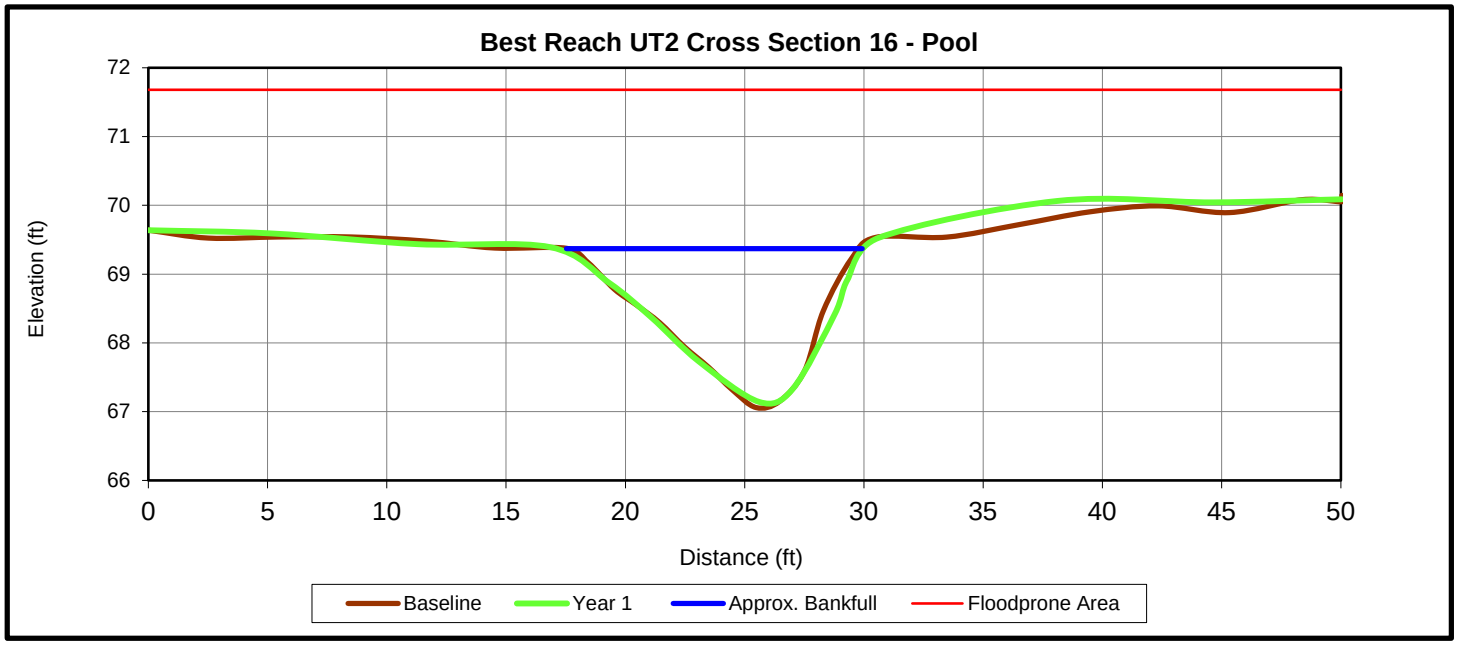
Upstream

Downstream



Upstream

Downstream



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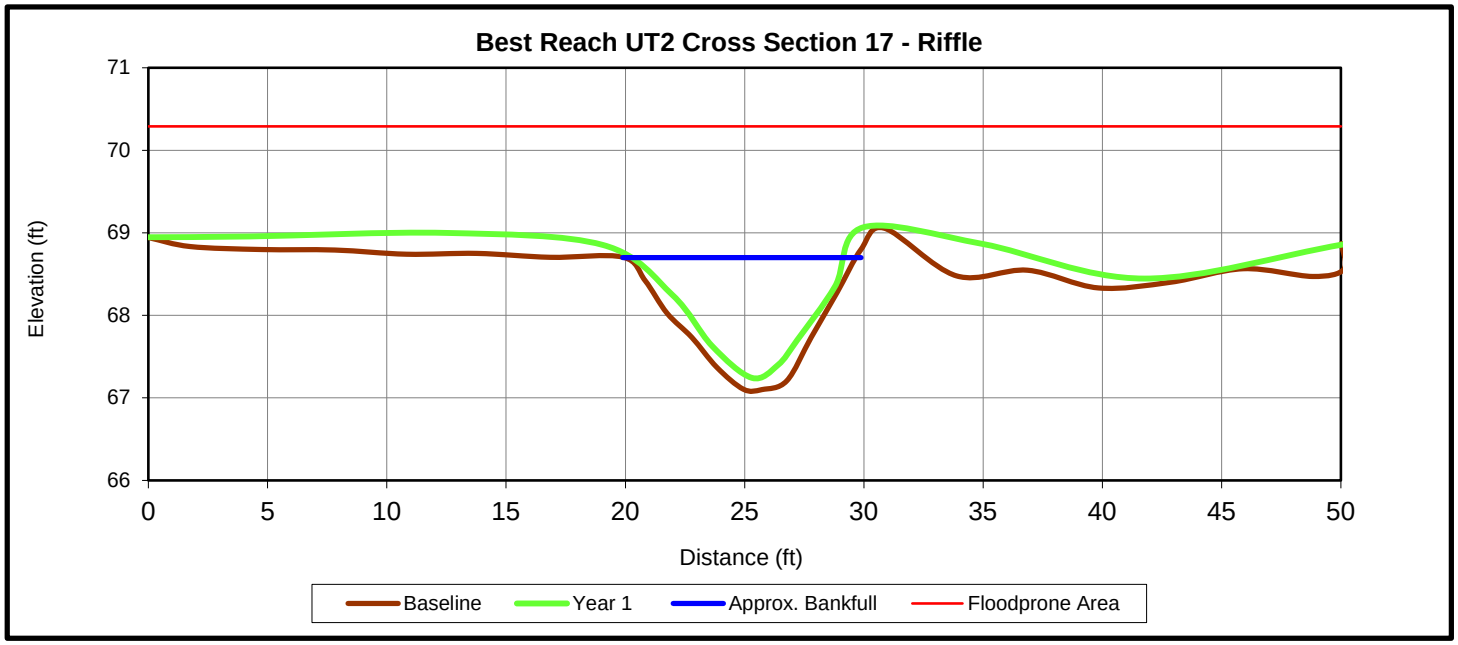

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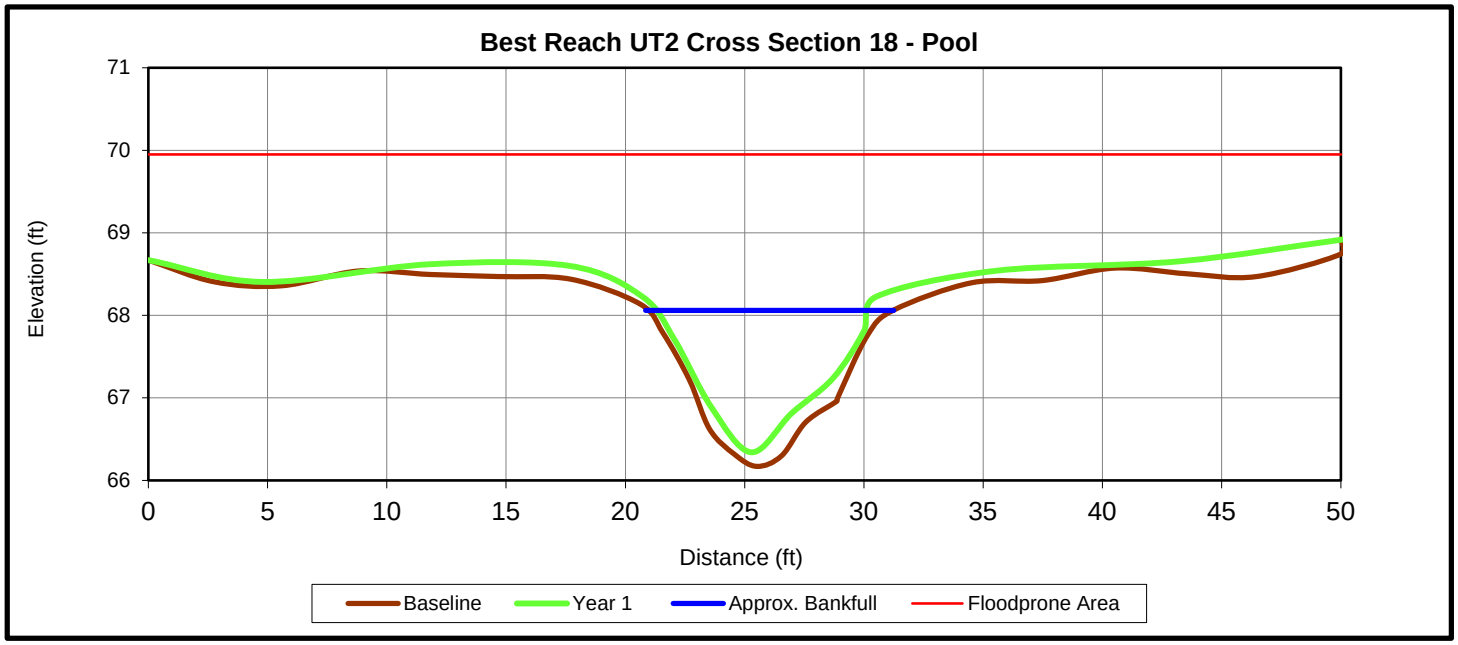

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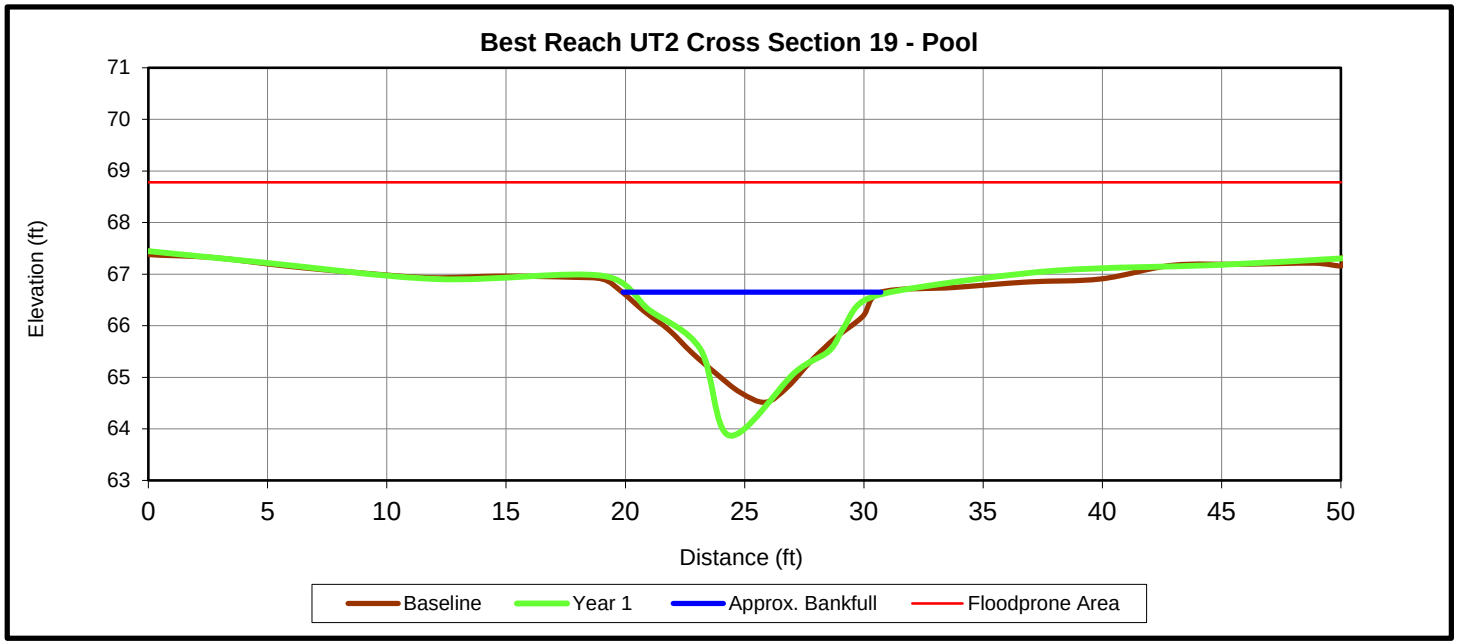

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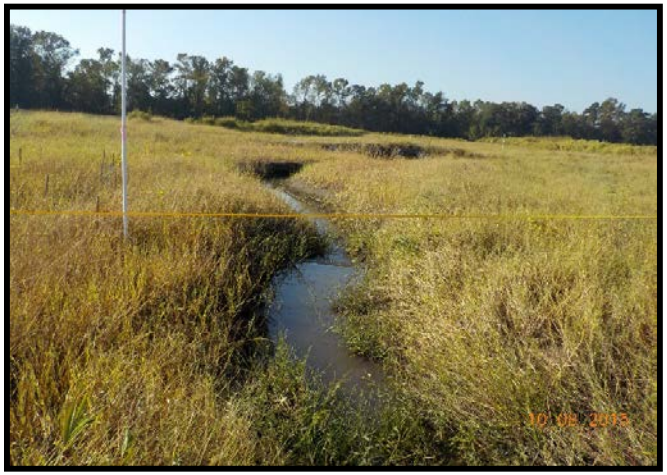

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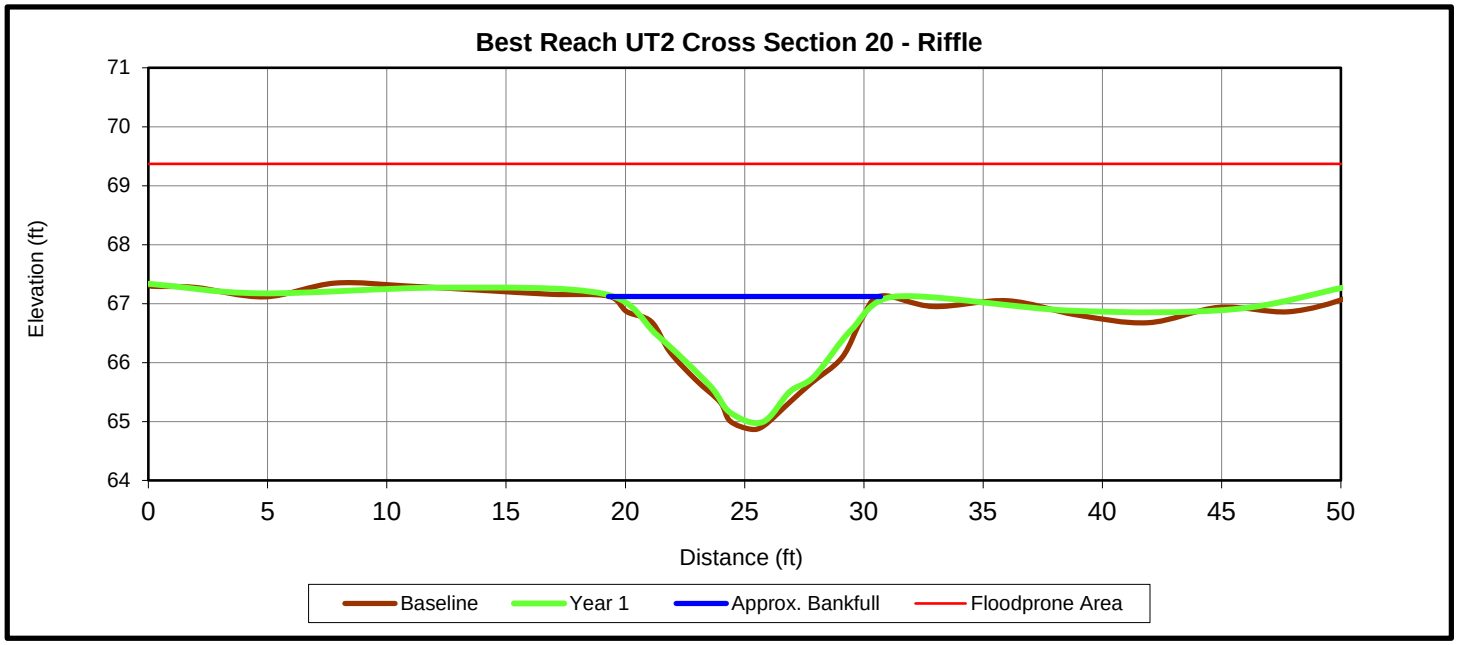

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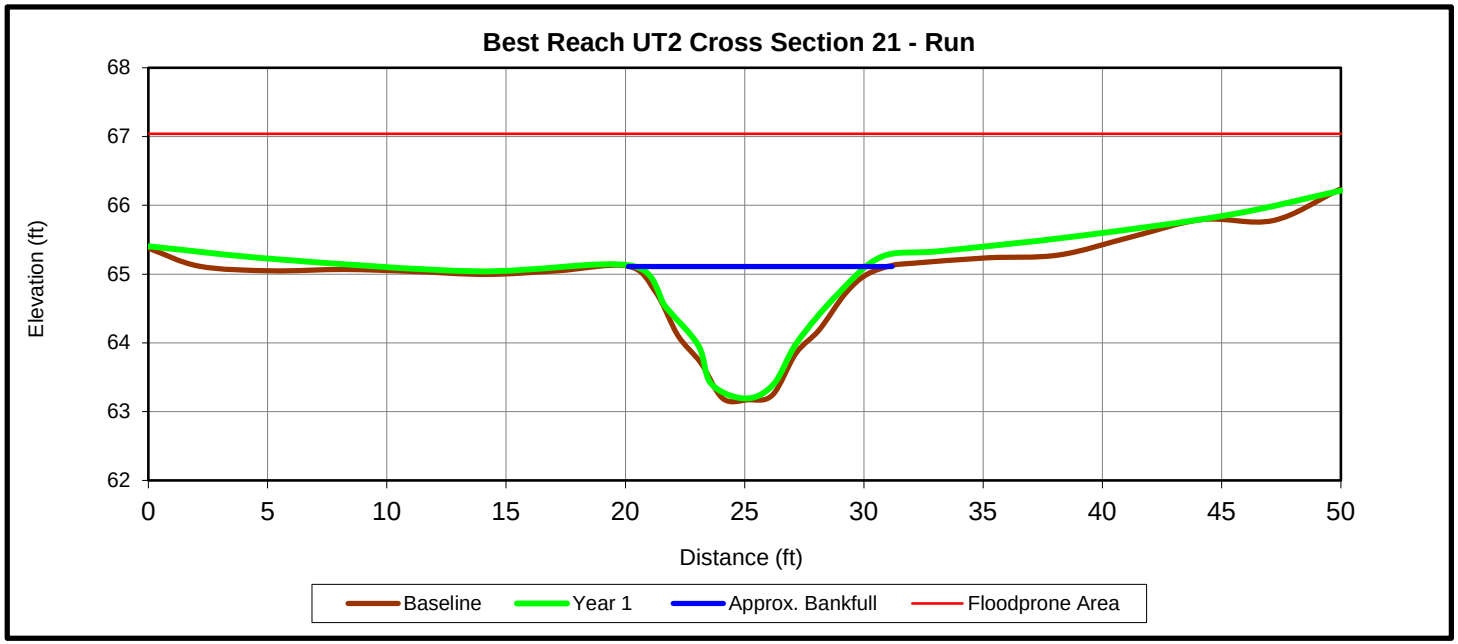

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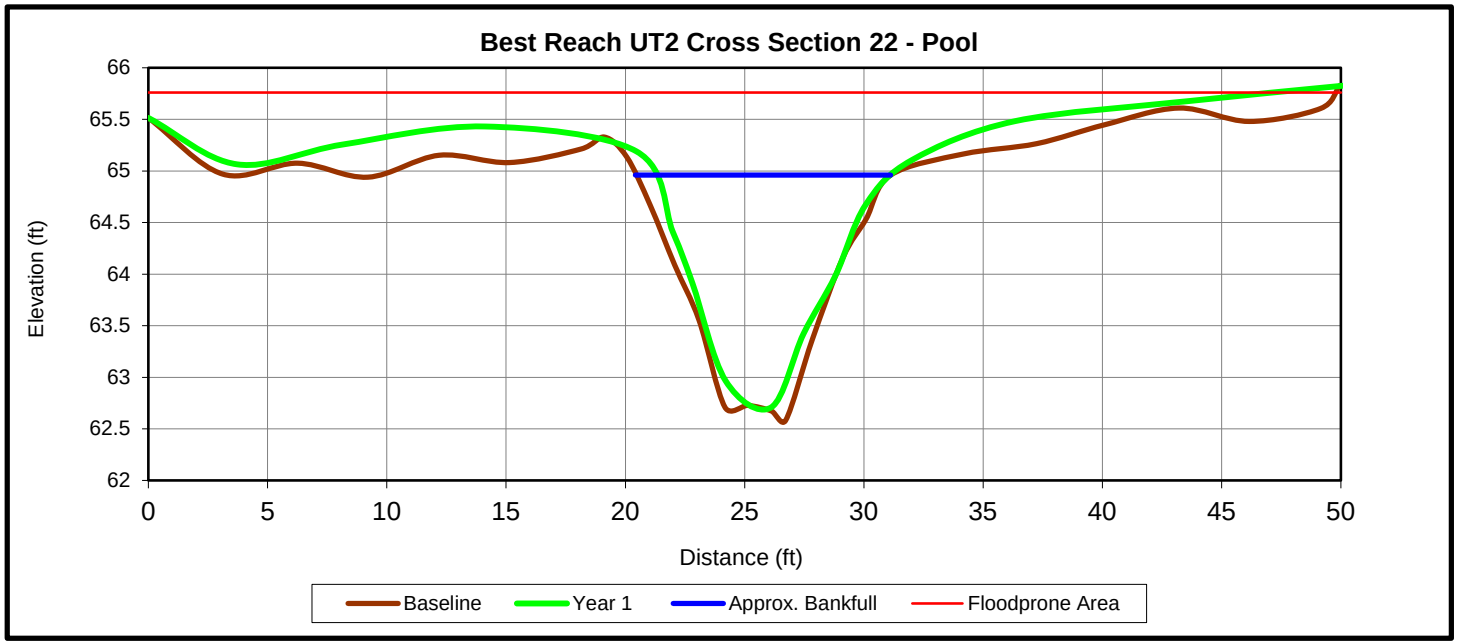

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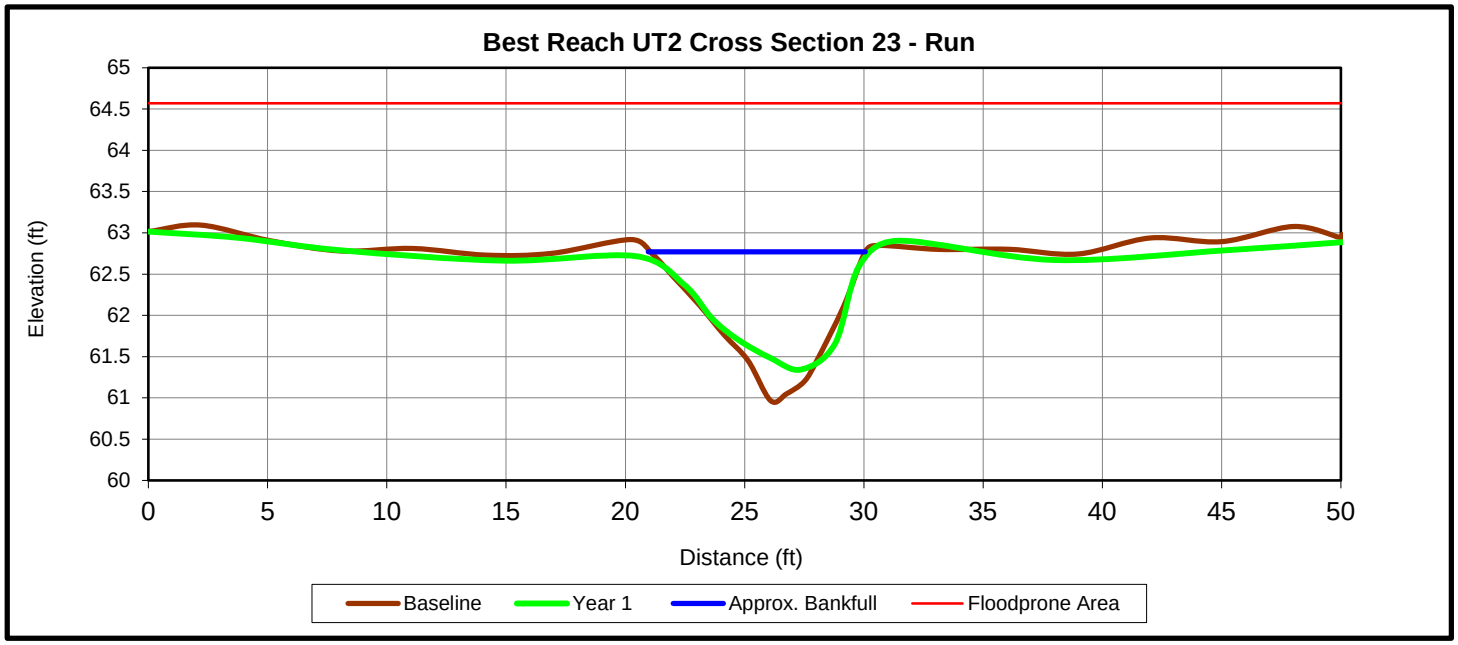

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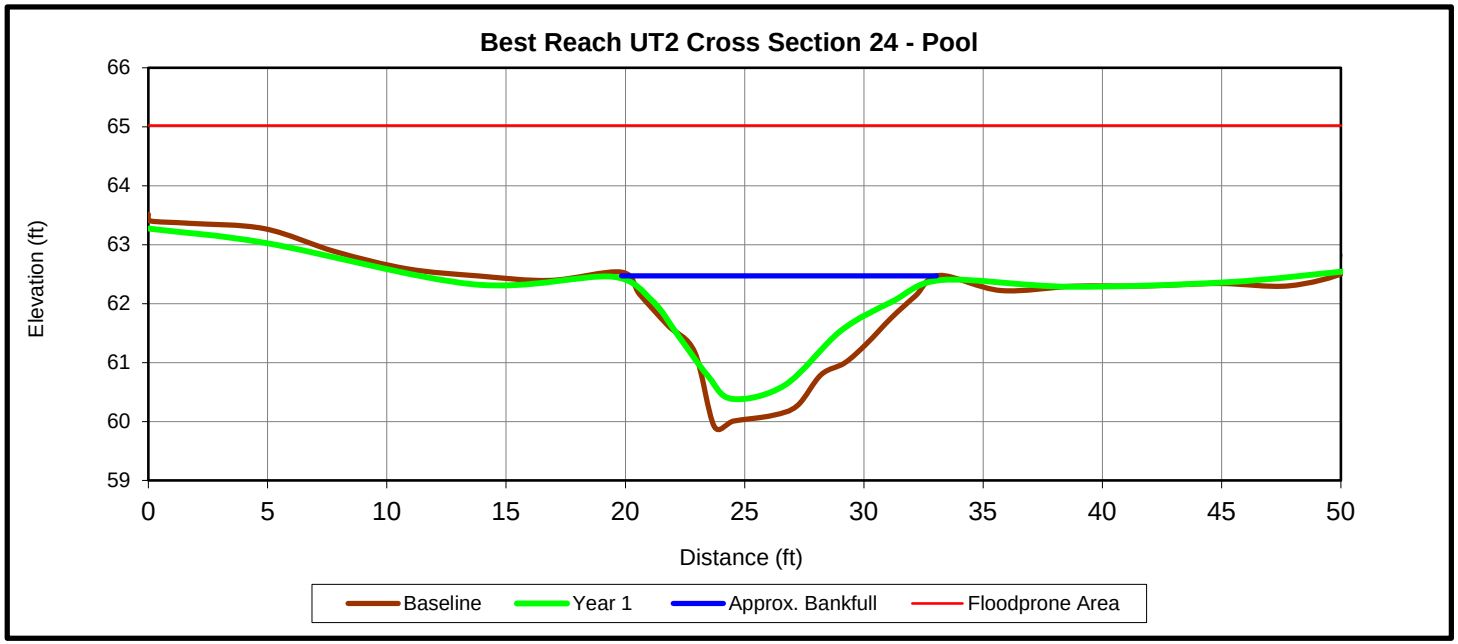

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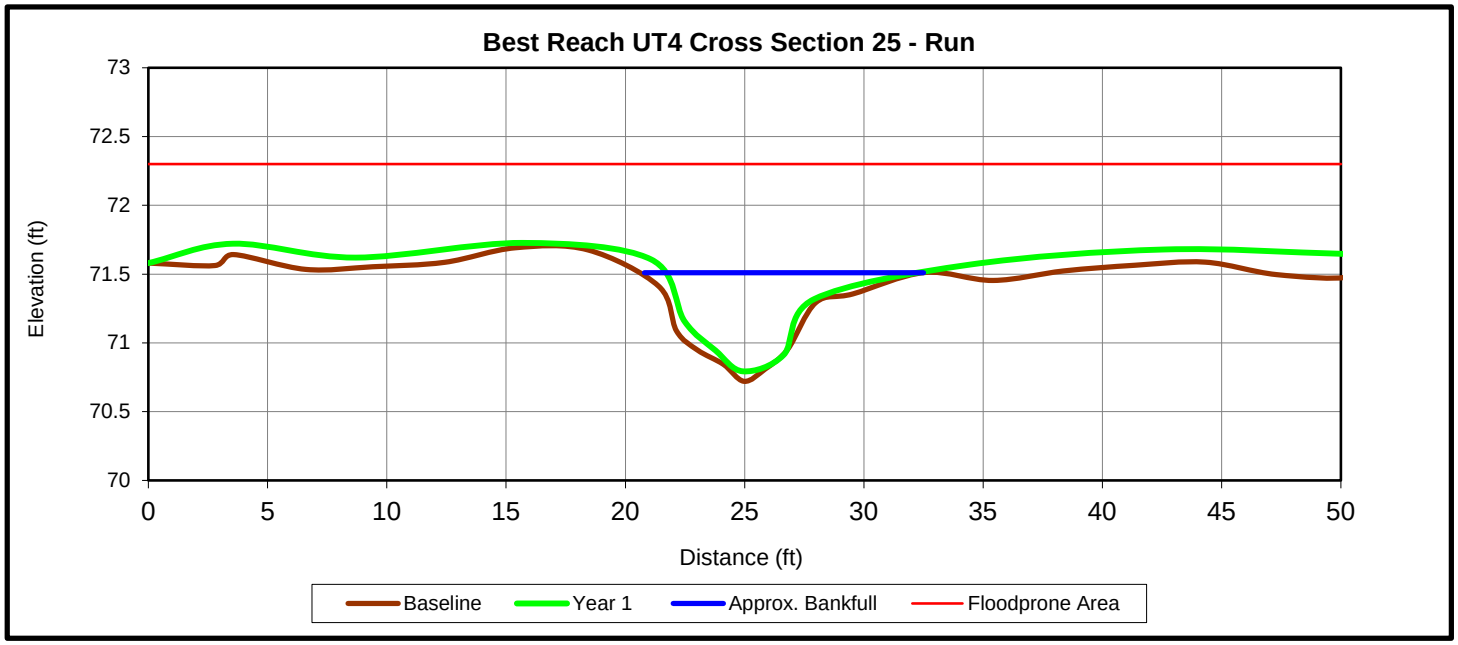

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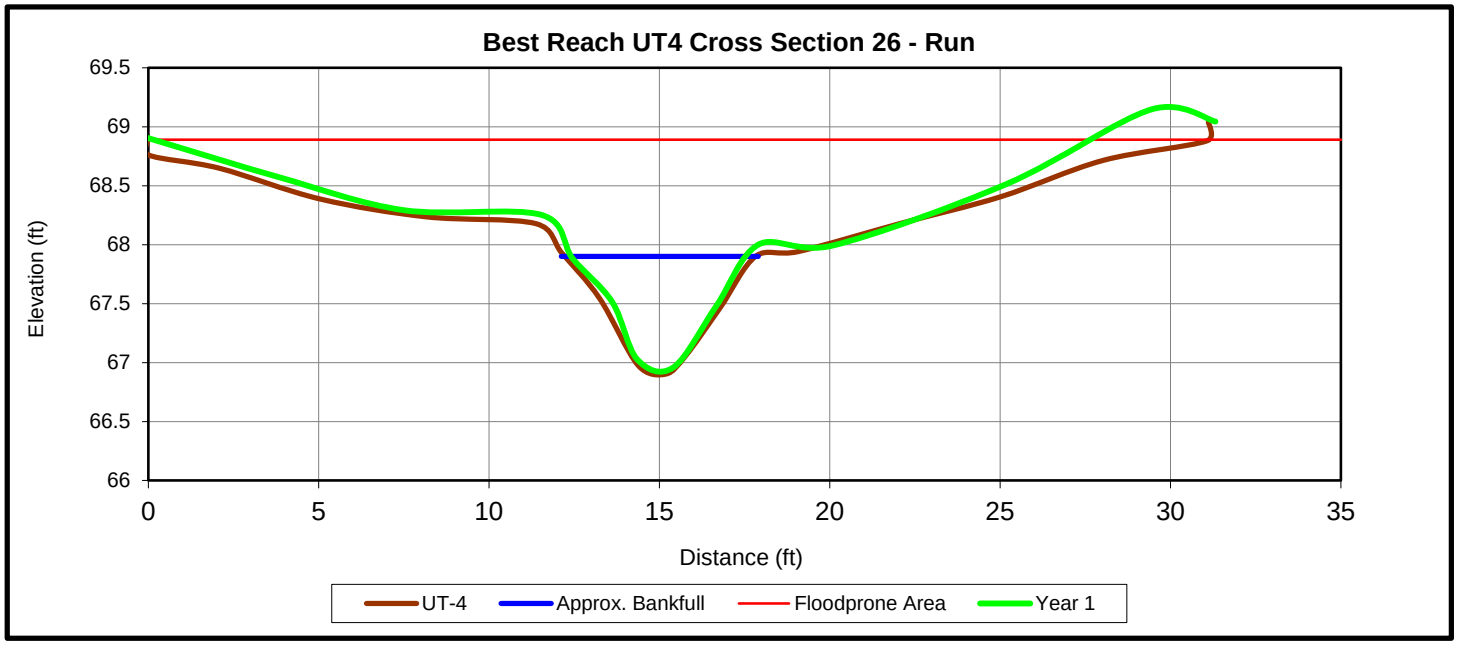

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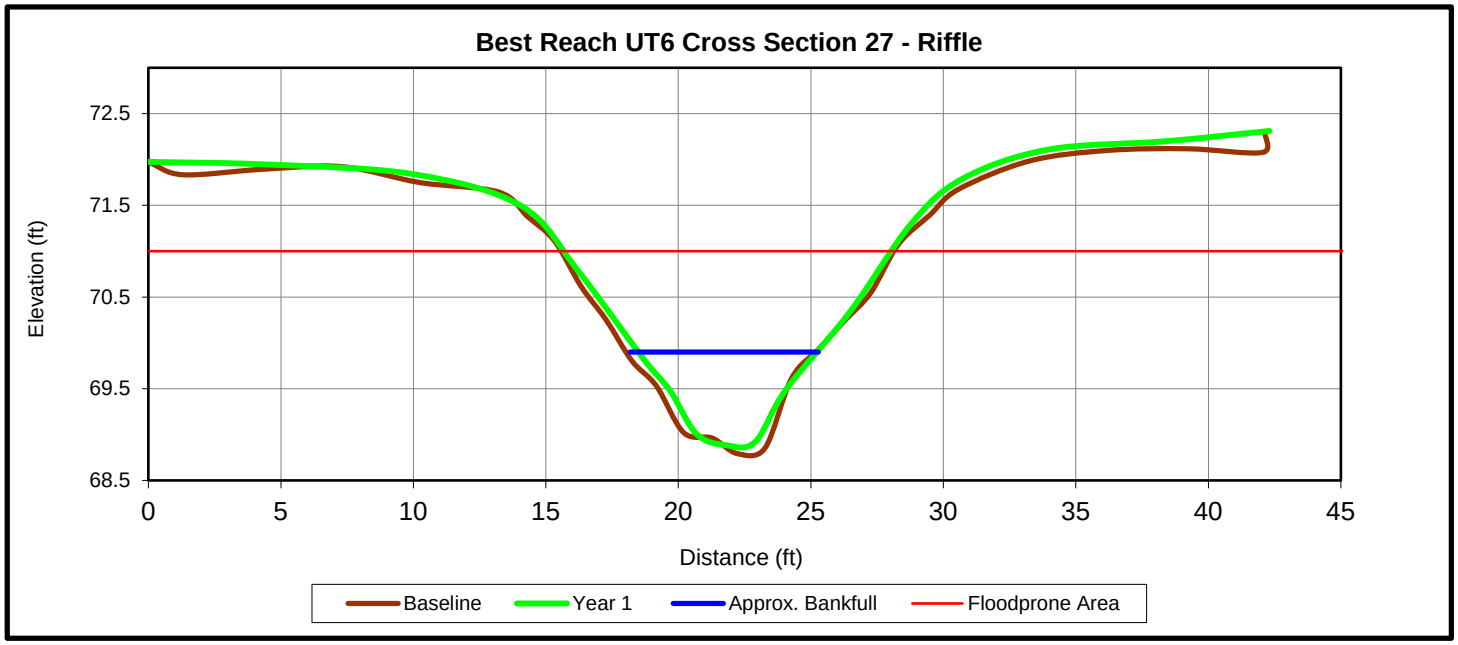

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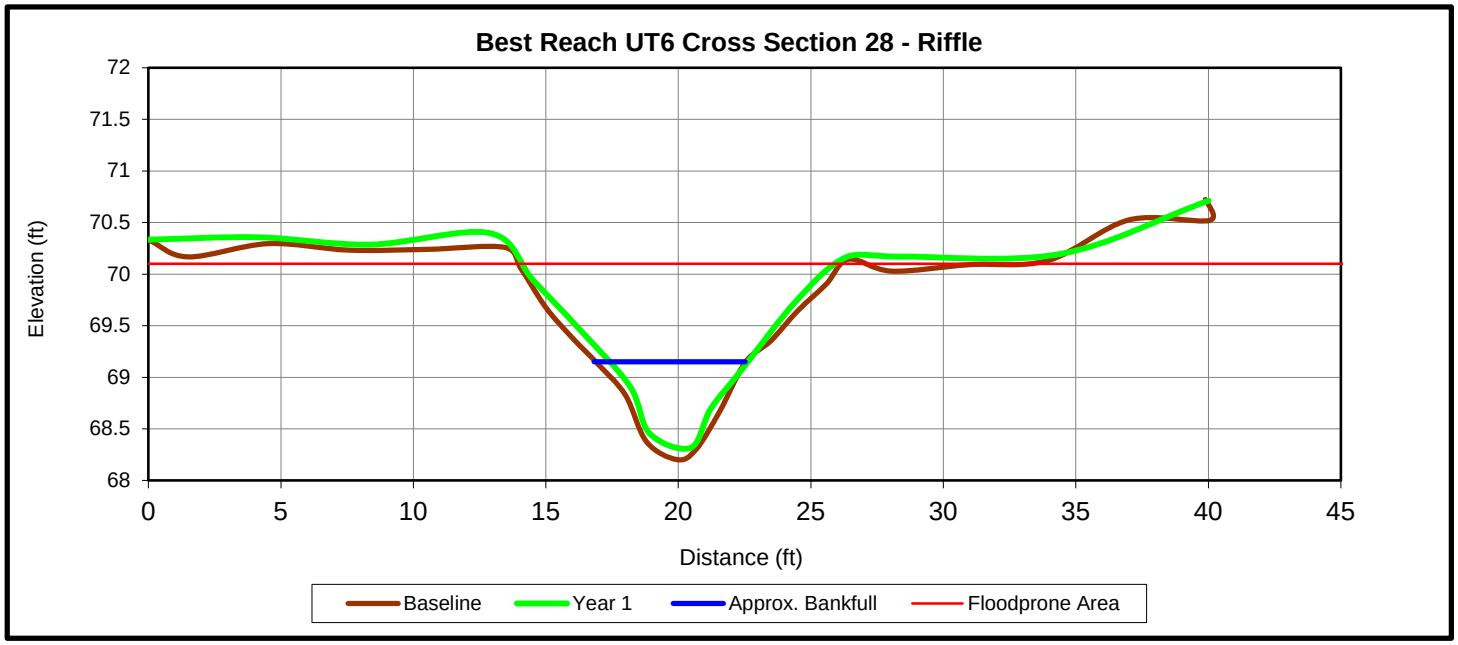

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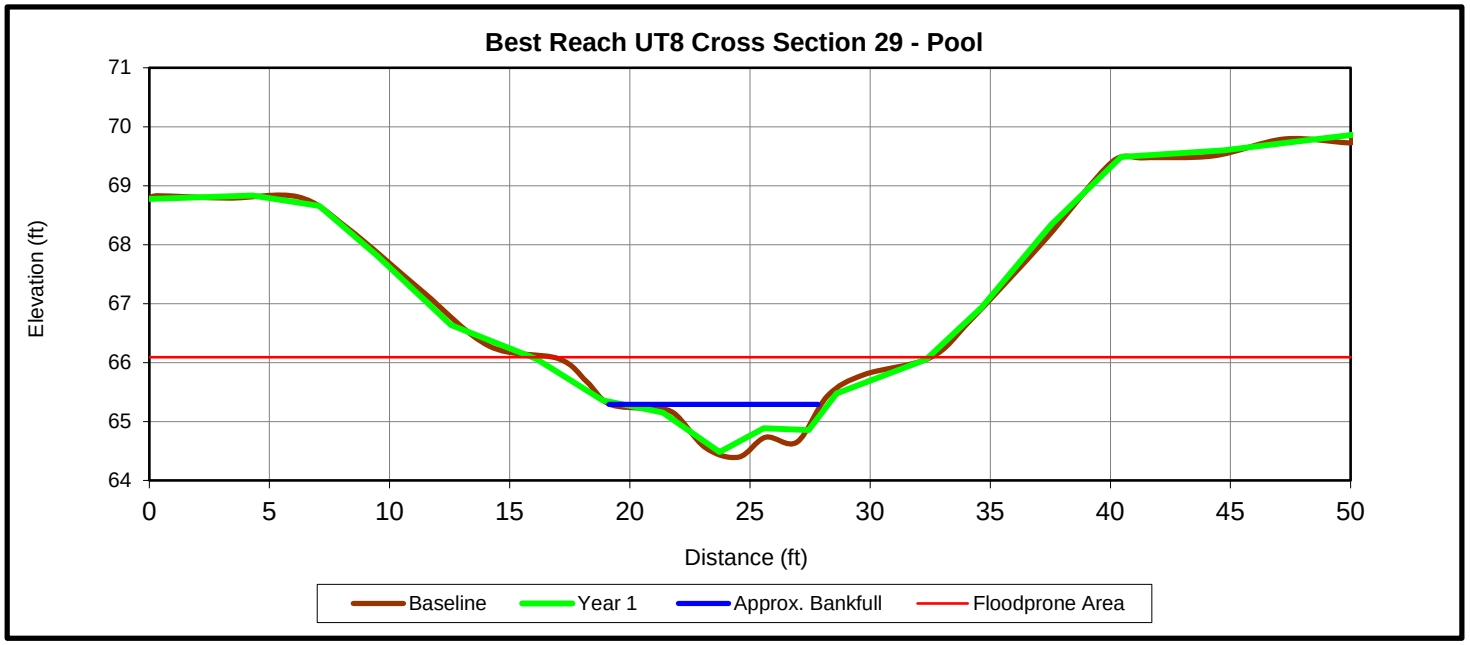
Downstream



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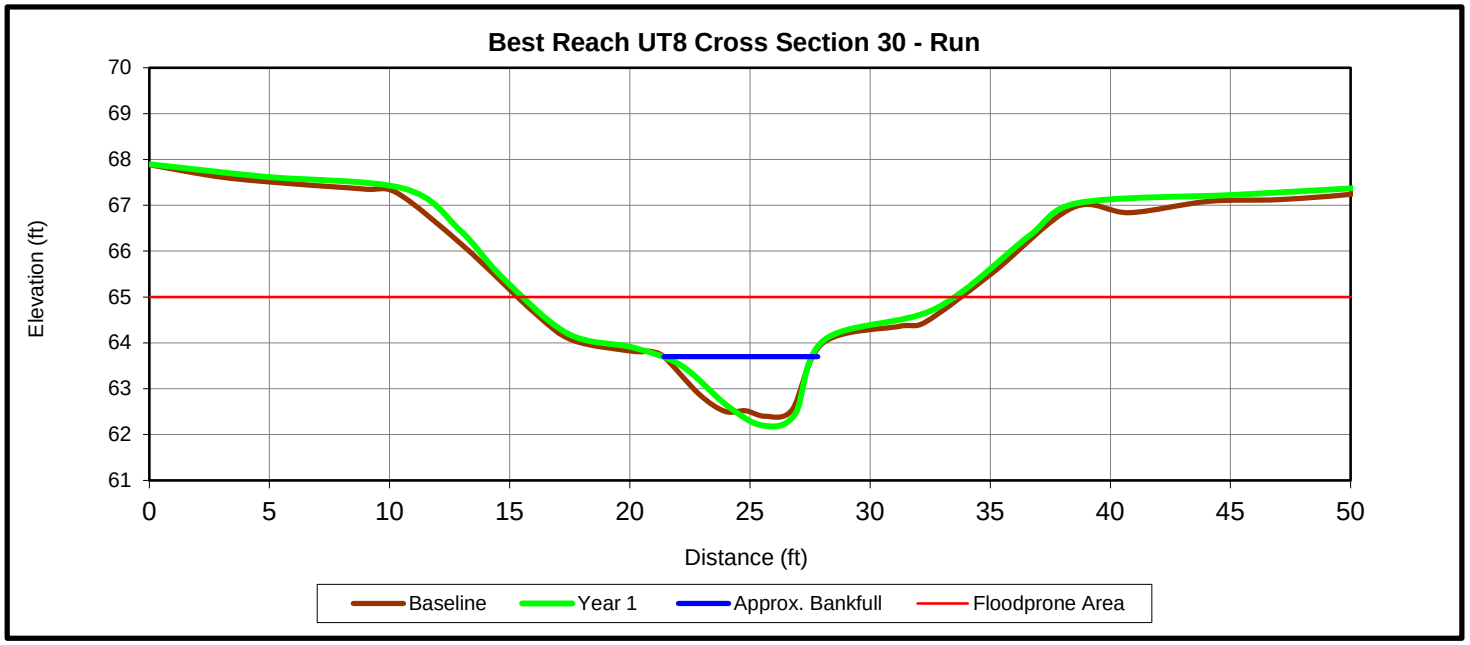

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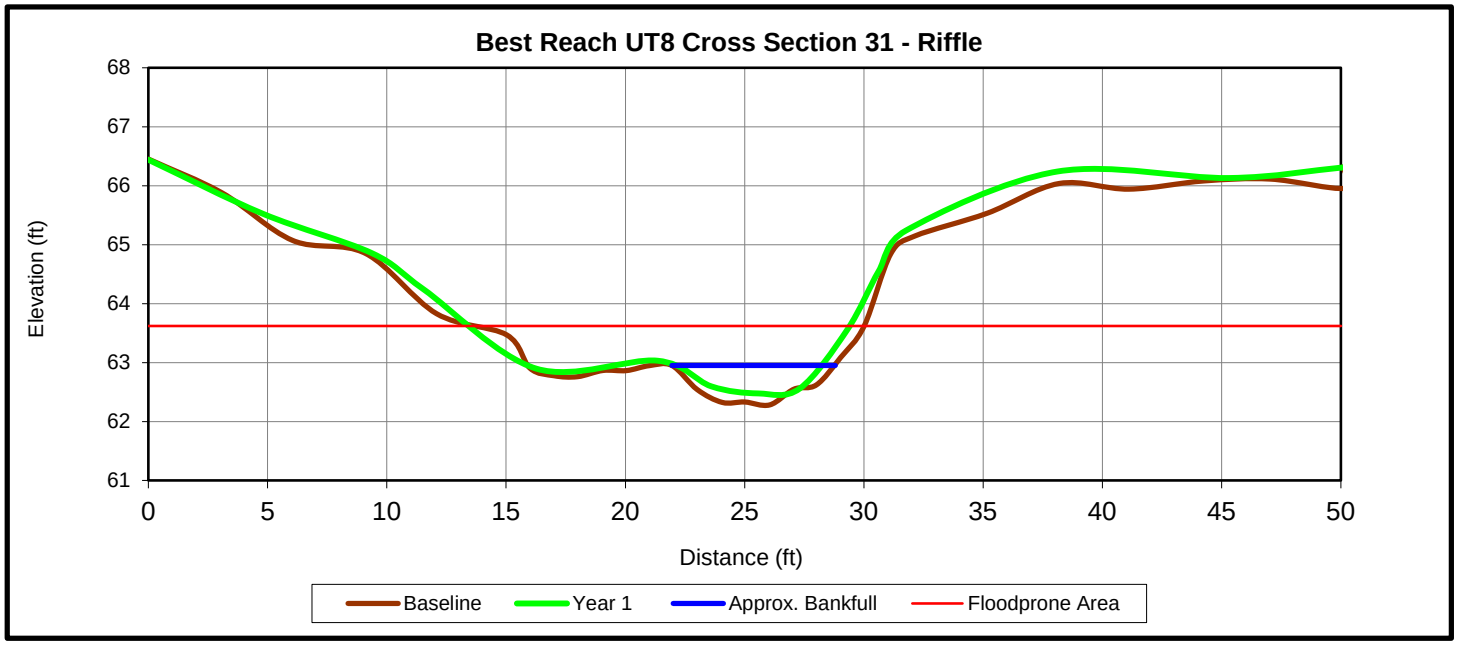


Appendix E

Hydrology Data

Table 13. Documentation of Geomorphologically Significant Flow Events
Table 14. Rainfall Summary
Table 15. Wetland Hydrology Criteria Attainment
Chart 1. 2015 Precipitation Data for Best Site
Chart 2. 2015 Groundwater Monitoring Gauge Hydrographs
Crest Gauge Verification Photos

Table 13. Documentation of Geomorphologically Significant Flow Events

Crest Gauge	Stream Reach	Number of Bankfull Events	Date of Highest Bankfull Event	Maximum Bankfull Height (ft.)	Photo Number
Crest Gauge 1	UT-1	2	10/2/2015	0.3	1
Crest Gauge 2	UT-2	11	10/2/2015	1.3	2
Crest Gauge 3	UT-3	2	10/2/2015	0.8	3
Crest Gauge 4	UT-4	0	NA	NA	NA
Crest Gauge 5	UT-6	3	10/2/2015	1.1	4
Crest Gauge 6	UT-8	8	10/2/2015	1.9	5

Table 14. 2015 Rainfall Summary

Month	Average	Normal Limits		Beulaville Station Precipitation	On-Site Auto Rain Gauge
		30 Percent	70 Percent		
January	4.33	3.32	5.03	4.08	---
February	3.23	2.14	3.87	5.83	---
March	4.50	3.23	5.32	4.64	---
April	3.16	1.70	3.85	2.71	---
May	3.68	2.69	4.34	5.69	---
June	4.49	3.11	5.34	3.04	1.17
July	6.06	4.16	7.22	3.77	5.45
August	5.40	3.12	6.56	3.43	6.48
September	5.00	2.04	6.07	5.40	6.53
October	3.21	1.62	3.92	1.17	6.04
November	2.89	1.83	3.49	7.62	10.08
December	3.24	2.14	3.88	5.19	8.31
Total	**49.19**	**31.10**	**58.89**	**47.38**	**44.06**

*June Rainfall is from June 20th - 30th 2015.

Table 15. Wetland Hydrology Criteria Attainment

2015 Max Hydroperiod (Growing Season 17-Mar through 14-Nov, 242 days) Well Data for 19-June through 14-November Success Criterion 9% = 22 Consecutive Days					
	Consecutive		Cumulative		
Gauge	Days	Percent of growing Season	Days	Percent of growing Season	Occurrences
AW1	49	20	62	26	9
AW2	18	7	41	17	9
AW3	88	36	107	44	5
AW4	88	36	98	40	3
AW5	51	21	115	48	10
AW6	28	12	96	40	12
AW7	22	9	54	22	9
AW8	24	10	68	28	11
AW9	24	10	72	30	10
RAW1	52	21	98	40	13
RAW2	46	19	56	23	5
RAW3	29	12	78	32	11

* Well data represents 149 days (~62%) during the total growing season from June 19th to November 14th.

Chart 1. 2015 Precipitation Data for Best Site

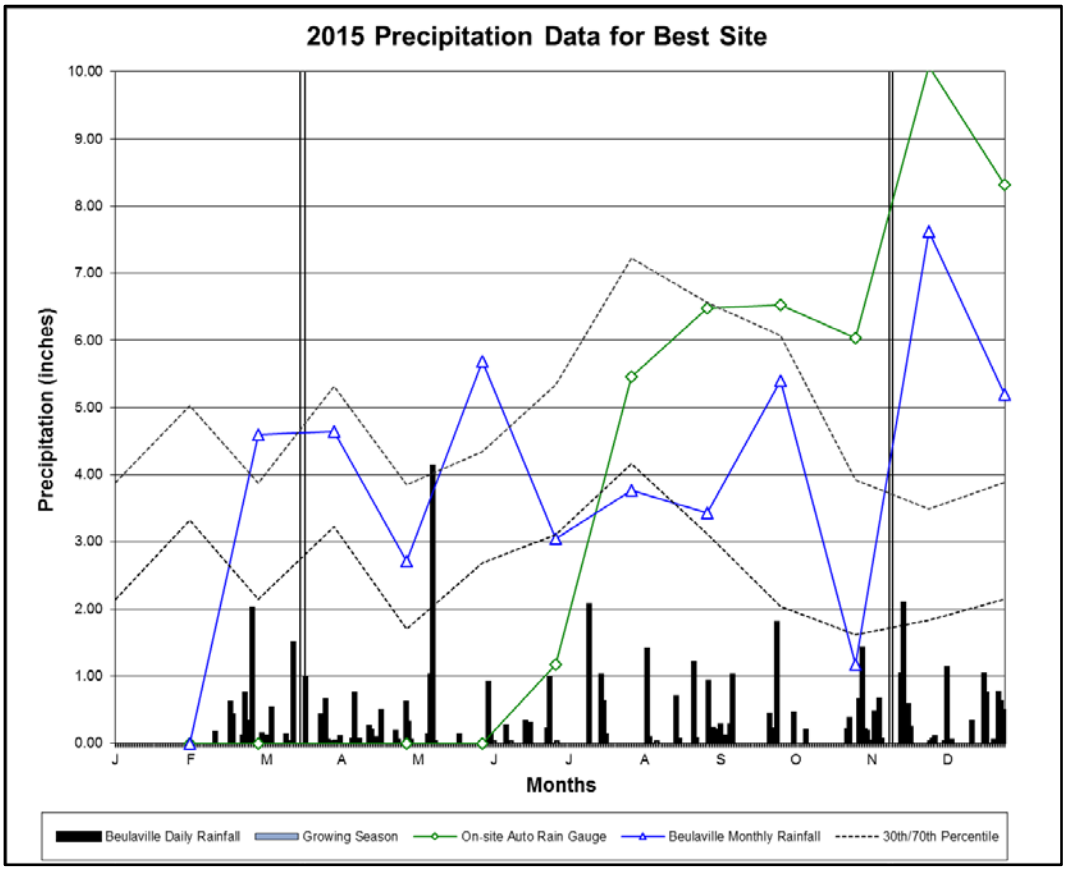
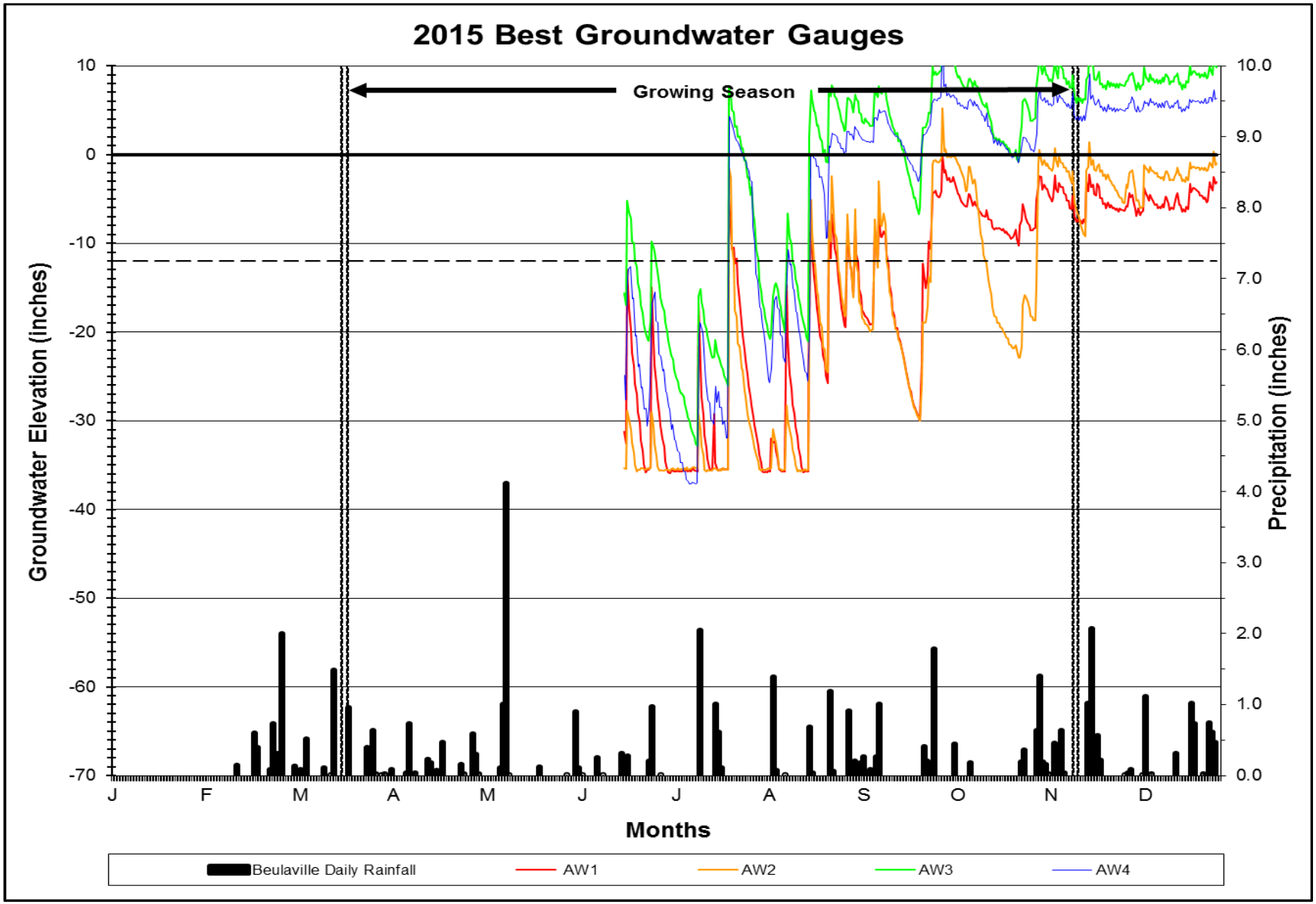
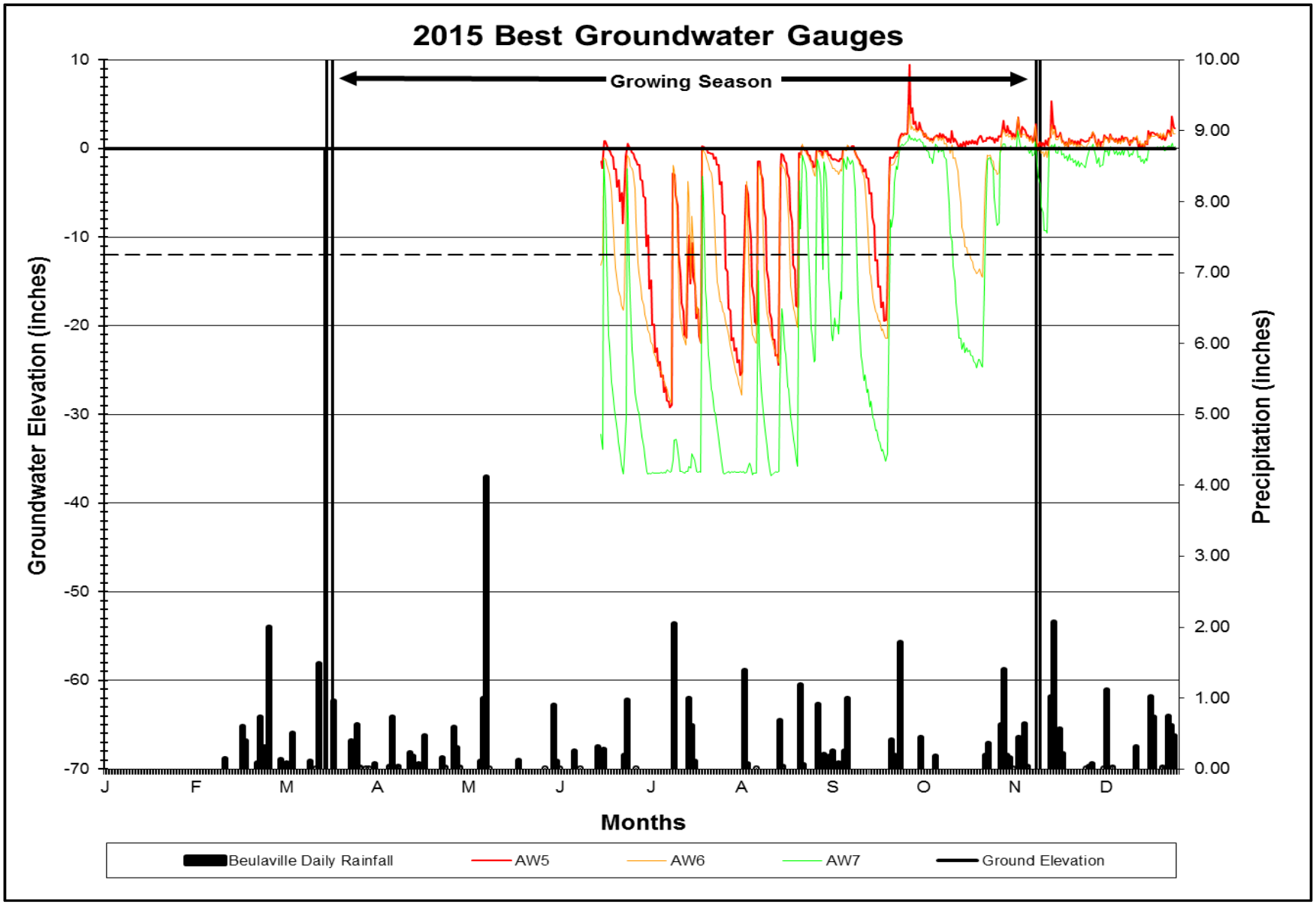
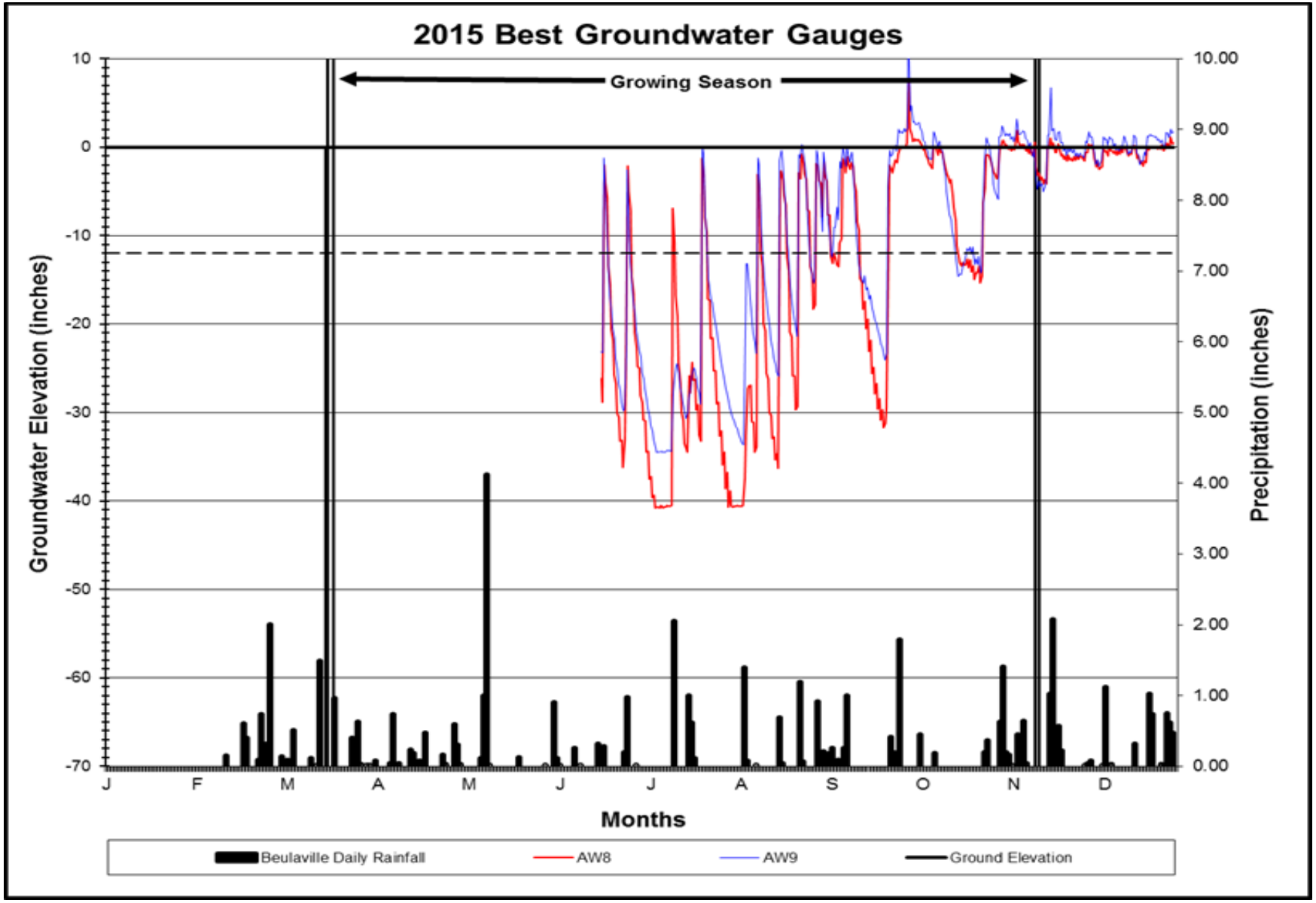
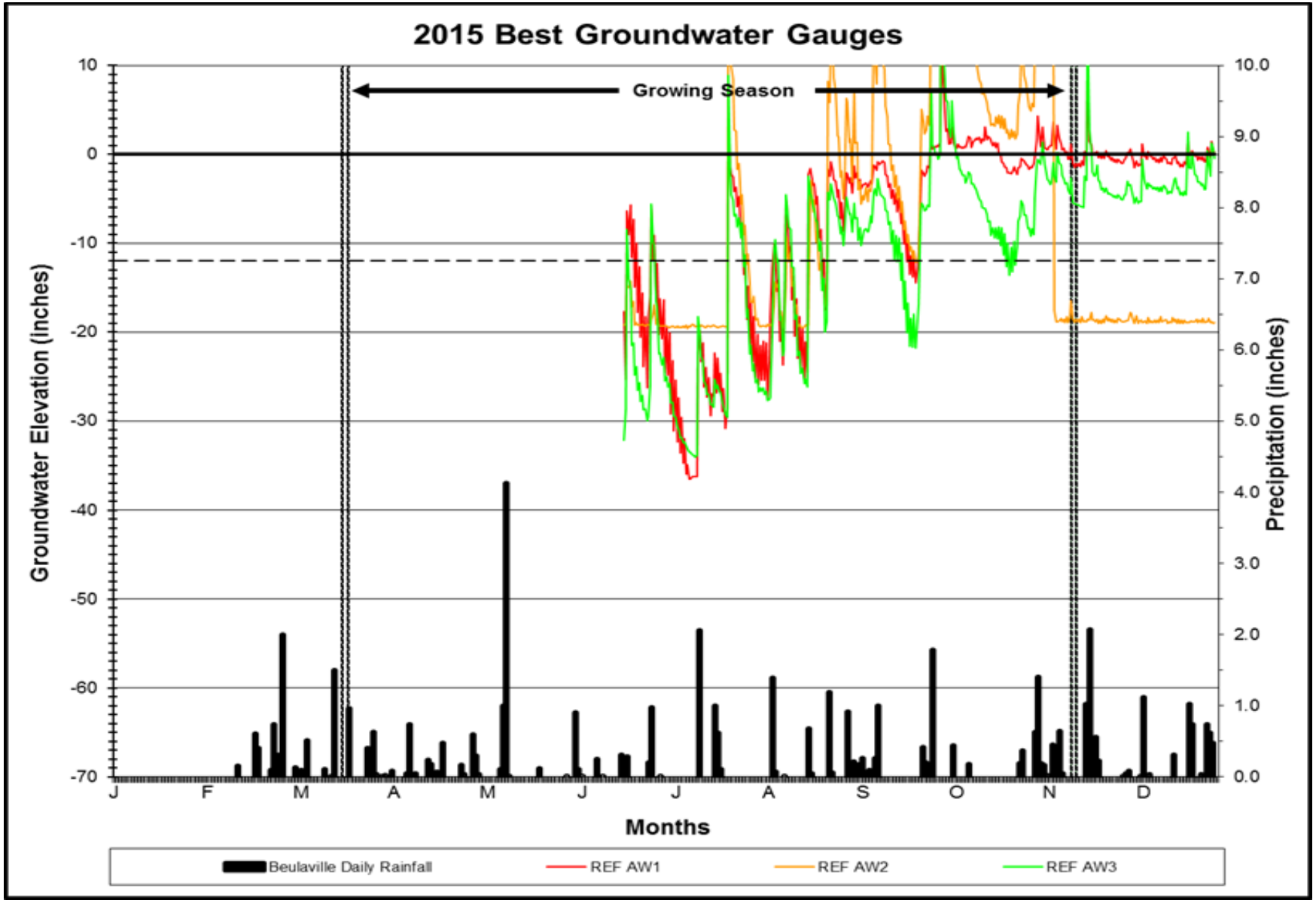


Chart 2. 2015 Best Site Groundwater Monitoring Gauge Hydrographs




2015 Best Groundwater Gauges
Growing Season
Groundwater Elevation (inches)
Precipitation (inches)
10
0
-10
-20
-30
-40
-50
-60
-70
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
J
F
M
A
M
J
J
A
S
O
N
D
Months
Beulaville Daily Rainfall
AW5
AW6
AW7
Ground Elevation


2015 Best Groundwater Gauges
Growing Season
Groundwater Elevation (inches)
Precipitation (inches)
10
0
-10
-20
-30
-40
-50
-60
-70
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
J
F
M
A
M
J
J
A
S
O
N
D
Months
Beulaville Daily Rainfall
AW8
AW9
Ground Elevation


2015 Best Groundwater Gauges
Growing Season
Groundwater Elevation (inches)
Precipitation (inches)
10
0
-10
-20
-30
-40
-50
-60
-70
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
J
F
M
A
M
J
J
A
S
O
N
D
Months
Beulaville Daily Rainfall
REF AW1
REF AW2
REF AW3

Appendix E – Crest Gauge Verification Photos

Crest Gauge 1 Reading 0.3’ (10/8/2015)

Crest Gauge 2 Reading 1.30’ (10/8/2015)

Crest Gauge 3 Reading 0.80’ (10/8/2015)

Crest Gauge 5 Reading 1.1’ (10/8/2015)

Crest Gauge 6 Reading 1.9’ (10/8/2015)