Holly Pond Restoration Alternatives Analysis

FINAL REPORT

June 2016

louisberger.com

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EXECUTIVE SUMMARY

Holly Pond is a shallow estuarine embayment at the mouth of the Noroton River in Stamford and Darien Connecticut with a tidal dam at its confluence with Long Island Sound. Two large shoals have formed near each other in the pond near the mouth of the River that are exposed above the water level at low tide (referred to together as "the shoal area"). Exposed sediment is an aesthetic concern for the local businesses and community. Sediment that is contaminated from urban runoff may present an exposure pathway to ecological receptors. On behalf of the Connecticut Department of Energy & Environmental Protection, Louis Berger evaluated existing and recently collected data and developed a hydrodynamic and watershed model to evaluate restoration alternatives for Holly Pond and the Noroton River eroding streambanks.

The results of the modeling and field studies, combined with existing information, seem to indicate that the sediment load from the Noroton River is currently not significantly contributing to the Holly Pond shoal area. The top six inches of shoal area is composed of approximately 90 percent coarse to medium material and only 10 percent fine grained material. The model indicates that the sediment flowing out of the Noroton River into Holly Pond during 100-year storms is comprised of fine grained material. Model results show that storm flows are capable of transporting medium to coarse materials within the upstream reaches of the river, but these would settle in low velocity areas upstream of Holly Pond. Also, while it is possible for larger sized material to be transported beyond the Noroton River outlet during storms larger than the 100-year storm, data suggests that there are currently no significant sources of medium to coarse grained material and that the sources that formed the Holly Pond shoal have significantly decreased over time.

The majority of the fine sediment load appears to originate in a residential and forested subwatershed near New Canaan (approximately 56 percent). Only an estimated 12 percent of Holly Pond sediment load comes from erosion of the Noroton River stream riverbed and banks according to the model. This load estimate from Noroton River stream riverbed and banks is significantly different from the estimate of 67 to 85 percent provided in the Holly Pond Sedimentation Study report (CH2M Hill, 2010). Nevertheless, visual inspection of the river banks confirmed that the bank soils are composed of fine grained material that does not match the shoal grain size distribution. While fine grained materials could potentially be settling on the sediment shoal areas, data suggests that these are likely being washed out with storm events since the 2015 bathymetric survey showed no significant changes in the bed and shoal elevations on the northern areas of Holly Pond since 2008.

Restoration of Shoal Areas

Louis Berger evaluated several alternatives for the proposed restoration of the Holly Pond sediment shoals. The alternatives range from complete removal of the shoal areas to profiling of the shoal areas to create marsh habitat. *Table 1* provides a comparison of the alternatives evaluated.

Noroton River Bank Stabilization

Louis Berger identified at least sixteen areas along the Noroton River streambanks that may benefit from stabilization measures south of Camp Avenue in Stamford. These areas are highly eroded and unstable, however, the sediment from the banks does not appear to be greatly contributing to the Holly Pond sediment shoal. The restoration of sixteen severely eroded stream banks in the Noroton River would involve the use of various soil bioengineering techniques, and would have of a cost of approximately $1.6M.

Table 1: Holly Pond Alternatives Comparison

HOLLY POND SEDIMENT SHOAL RESTORATION: ALTERNATIVES ANALYSIS			
	DREDGING ALTERNATIVE	**TIDAL MARSH ALTERNATIVE**	**LIVING SHORELINE ALTERNATIVE**
DESCRIPTION	Removal and disposal of sediment shoal area to 0.5 feet NAVD88 or 0.0 feet NAVD88	Clean soil placed on sediment shoal area for creation of low marsh habitat in Holly Pond	Relocation of sediment shoal material to create living shoreline of low marsh habitat on Holly Pond shoreline
SEDIMENT REMOVAL IN CUBIC YARDS: LOW CONTAMINATION CONCENTRATION	▪ **REMOVAL:** 6,300 or 16,400 ▪ **CLEAN SAND:** NONE ▪ **REUSE:** NONE ▪ **DISPOSE**: 6,300 or 16,400	▪ **REMOVAL:** NONE ▪ **CLEAN SOIL:** 5,800 ▪ **REUSE:** NONE ▪ **DISPOSE:** NONE	▪ **REMOVAL:** 1,900 ▪ **CLEAN SAND:** NONE ▪ **REUSE:** 1,400 ▪ **DISPOSE:** 500
SEDIMENT REMOVAL IN CUBIC YARDS: HIGH CONTAMINATION CONCENTRATION	▪ **REMOVAL:** 14,700 or 42,700 ▪ **CLEAN SAND:** 8,400 or 26,300 ▪ **REUSE:** NONE ▪ **DISPOSE**: 14,700 or 42,700	▪ **REMOVAL:** NONE ▪ **CLEAN SOIL:** 5,800 ▪ **REUSE:** NONE ▪ **DISPOSE:** NONE	▪ **REMOVAL:** 4,700 ▪ **CLEAN SAND:** 2,900 ▪ **REUSE:** NONE ▪ **DISPOSE:** 4,700
HABITAT MODIFICATION	Disturbance while dredging	Introduces and enhances habitat in Holly Pond	Introduces and enhances habitat in Holly Pond
WATER QUALITY IMPROVEMENT	May not improve water quality in Holly Pond	Slightly improves water quality in Holly Pond	Slightly improves water quality in Holly Pond
COSTS [a]	**0.5 feet NAVD88** ▪ LOW: $6.0M ▪ HIGH: $15.7M **0.0 feet NAVD88** ▪ LOW: $14.1M ▪ HIGH: $43.8M	▪ $1.9M	▪ LOW: $1.3M ▪ HIGH: $3.8M

a. Low cost range assumes that 20 percent of the sediment is contaminated and disposed at a higher cost. High cost range assumes that 100 percent of sediment is contaminated and disposed at a higher cost and that dredged areas require additional sediment removal to make room for a sand cover. Costs conservatively assume an additional 15 percent of sediment removal, clean, reuse, and disposal volumes. Costs were estimated in current 2016 dollars.

Watershed Management Practices

Louis Berger evaluated watershed management practices to reduce peak flows and resulting erosion within the riverbed along with the implementation of measures to reduce solids from watershed sources entering Noroton River. As noted above, the majority of the fine sediment solid load appears to originate in a residential and forested subwatershed nearer to the New Canaan border. Options to reduce the sediment load from Noroton River and its watershed to Holly Pond were also evaluated. The construction of two extended wet detention ponds may reduce the sediment load to Holly Pond by about 50 percent. However, it should be acknowledged that the option to reduce peak discharge rates and solids loads from the watershed is a potentially enormous undertaking that would require the widespread installation of green infrastructure and best management practices (BMPs). That said, any efforts to promote and support low-impact development processes in the watershed should be embraced. The approximate cost of both extended wet detention ponds is estimated at over $600,000. While these efforts along with targeted streambank stabilization measures can reduce the solids load into Holly Pond, the overall benefit to Noroton River and Holly Pond would require additional evaluation and data collection.

1 Introduction And Project Goals

Louis Berger is supporting the Connecticut Department of Energy and Environmental Protection (DEEP) to evaluate alternatives for the restoration of Holly Pond and Lower Noroton River in Stamford and Darien Connecticut. Holly Pond is a shallow estuarine embayment at the mouth of the Noroton River with a tidal dam at its confluence with Long Island Sound as shown in *Figure 1*. At the opposite end of Holly Pond, a large shoal (composed of two areas) has formed that is exposed above the water level at low tide as shown in *Figure 2*. The sediment in the shoal is believed to be contaminated as a result of non-point source pollution in the watershed. No specific sources of pollution have been identified by the DEEP. Exposed sediment that is contaminated may present an exposure pathway to ecological receptors and is a concern for DEEP. Furthermore, the exposed sediment (above the average low water elevation) is an aesthetic concern for the local businesses and community, thus, all proposed project alternatives presented in this report were guided by principals of restoration ecology, environmental engineering and landscape architecture.

As part of this feasibility level analysis, Louis Berger reviewed existing data and documents (refer to Section 2), collected additional field data (refer to Section 3) and developed hydrodynamic and watershed models in order to understand the sources of the sediments into the Noroton River and Holly Pond (refer to Section 4). Alternatives were evaluated in the following three main areas:

- **Restoration of Shoal Area:** Restoration of the shoal area may include sediment removal, re-profiling, and/or habitat creation (refer to Section 5).
- **Bank Stabilization:** Bank stabilization to reduce sediment load to the river from bank erosion (refer to Section 6).

- **Watershed Management Practices:** Watershed management practices to reduce peak flows and resulting erosion within the riverbed along with the implementation of measures to reduce solids from watershed sources entering Noroton River (refer to Section 7).

2 Background Documents

Louis Berger reviewed the available reports and studies that have been prepared to date to improve project understanding and aid in the development of this restoration analysis. The Holly Pond Sedimentation Study contributed significant information for the analysis (CH2M Hill, 2010).

2008 Sediment Investigation

Appendix F of the Holly Pond Sedimentation Study (CH2M Hill, 2010) summarizes the field activities and analytical results of the 2008 Holly Pond Sediment Investigation. Physical and chemical characteristics of the shoal materials were the focus of the investigation. *Appendix A* includes the sediment data from the Holly Pond Sedimentation Study report.

Each of the 11 sediment sampling locations in the shoal areas of Holly Pond near Route 1 was sampled at two depth intervals. The first depth interval was from 0.0-0.5 feet and the second depth interval was from 0.5-1.7 feet. The analytical results for grain size characterized gravel, sand, clay and silt in the 11 locations. The particle size distribution of the northern shoal (samples SD-01 to SD-05) is different than the southern shoal (SD-06 to SD-11). Although both areas are mostly made up of sand, the northern shoal consisted of coarser material than the southern shoal, which contained more fines. The northern locations contained stone fragments and gravel along with the sand, and the southern locations contained silty gravel along with the sand. When comparing the depth intervals, generally 0.5-1.7 feet contained more fine sediments than the top 6 inches.

Samples were chemically analyzed for polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), metals, pesticides and physical parameters such as grain size and organic carbon content. Results from the chemical analyses are summarized as follows.

PAHs: Sediment samples were analyzed for EPA 16 priority list and 2-methylnaphthalene. Of the 17 PAHs, only three compounds, benzo(a)anthracene, benzo (a)pyrene and indeno(1,2,3-cd)pyrene exceeded the State criteria for industrial soils of 1,000 ug/kg. Concentrations for these three compounds ranged from 300 to 2,100 ug/kg respectively. However, the average sediment concentrations were only marginally higher than the 1,000 mg/kg criteria. Summary statistics of these concentrations are listed in *Table 2*.

Table 2: Summary statistics for PAH compounds exceeding the State Industrial Soils Criteria

SUMMARY STATISTIC	BENZ(A)ANTHRACENE	BENZO(A)PYRENE	INDENO(1,2,3-CD)PYRENE
Minimum (ug/kg)	340	370	300
Maximum (ug/kg)	1,900	2,100	1,025
Average (ug/kg)	1,015	1,110	481
Median (ug/kg)	790	950	370

PCBs: Sediments were analyzed for Aroclor concentration to quantify PCB concentration in the sediments. Very low levels of PCBs were measured in the sediment samples. All, but one sample, were reported as non-detect; i.e. resulting concentration was below the lab reporting limit. Aroclor 1254 was detected only in one subsurface sample (SD-01, depth interval 0.5-1.7 feet.). Detected concentration was nine times lower than the State criteria for industrial soils.

Metals: Sediment samples were analyzed for arsenic, cadmium, chromium, copper, lead, mercury, nickel, and zinc. Results for all metals were well below the State criteria for industrial and residential soils.

Pesticides: Of the analyzed pesticides, chlordane was the only pesticide detected in the sediment samples. Chlordane values ranged from 100 to 260 ug/kg with average concentration of 168 ug/kg. Detected concentrations of chlordane are well below the State criteria for residential and industrial soils.

2008 Bathymetric Survey

The Holly Pond Sedimentation Study report (CH2M Hill, 2010) included bathymetry of the pond completed by CR Environmental, Inc (CR Environmental) in 2008. "The November 2008 bathymetry of Holly Pond indicated that sediment surface elevations range from about +2 to -14 feet (North American Vertical Datum of 1988 [NAVD88]). The bathymetry data were used to define the lateral and vertical extent of the shoal in the inlet, to approximate the volume of material comprising the shoal, and to guide the selection of sampling locations for the physical chemical characterization." (CH2M Hill 2010). The 2008 bathymetry was updated in 2015 by CR Environmental. Refer to *Section 3.1* for a discussion of the comparison between the two bathymetric surveys.

Box Model

The Holly Pond Sedimentation Study report (CH2M Hill, 2010) included development of a box model to evaluate the sources of sediment shoaling in Holly Pond as well as the fate of sediment within the system. Primary sources of sediment to Holly Pond were identified as follows:

- "Runoff and erosion from land in the watershed
- Erosion of stream and river banks and beds
- Biologically mediated generation of solids within Holly Pond
- Influx from Long Island Sound on the incoming tide" (CH2M Hill, 2010)

The fate of the solids was identified as two processes: sediment deposit into Holly Pond, and sediments flushing out into Long Island Sound. The erosion and runoff from the watershed was estimated at 430 tons/year. The erosion of streambanks and beds was estimated at 2,890 tons/year. Biologically mediated soils within Holly Pond was estimated to contribute 320 tons/year. The input and export to and from Long Island Sound balanced out at about 1,200 tons/year in and out. Therefore, total sediment deposited into Holly Pond was 3,610 tons/year. The conclusion of the box model indicated that it is likely that in-stream sources are the primary source of solids being transported into Holly Pond.

General Conclusions

The Holly Pond Sedimentation Study report (CH2M Hill, 2010) summarized design alternatives and management strategies for restoring Holly Pond as well as a basis of design. Alternatives were analyzed for Holly Pond, Noroton River and their watershed. The main alternatives proposed for restoring the shoal areas were sediment removal and tidal marsh restoration. Regarding the Noroton River and watershed, the alternatives included restoring streambanks and stormwater retrofits.

The Holly Pond Sedimentation Study report (CH2M Hill, 2010) recommended alternative for Holly Pond was tidal marsh restoration, which would restore approximately 8 acres of historical tidal marsh habitat. Benefits of this project include habitat improvement and minimized potential for adverse impacts. The recommended alternative for Noroton River watershed was the use of bioretention areas. The benefits of bioretention are cost effectiveness and flexibility with minimal maintenance required. Two potential sites were chosen to implement the design: the Connecticut Department of Transportation (ConnDOT) I-95 Southbound Rest Area in Darien and a local Stamford school.

3 Data Collection

3.1 Bathymetry And Tidal Data

In 2015, CR Environmental performed a single beam bathymetric survey and a tidal study of Holly Pond. The bathymetric survey was completed on April 21 and 22, 2015. Weather conditions on April 22 caused data to be outside of the quality control limits, therefore, additional bathymetric data were collected on June 17, 2015 in order to generate "cross-tie" data sufficient to assess data uncertainty.

Bathymetric data were statistically analysed to evaluate accuracy according to U.S. Army Corps of Engineers specifications (USACE, 2013). The USACE 95th percentile confidence interval (CI) recommendation for bias (repeatability) is +/- 0.3 feet in depths less than 15 feet, and "resultant elevation/depth accuracy" is +/- 0.8 feet for "Coastal (tidal) Shallow Draft Projects". Cross-tie statistics for the site bathymetric dataset yielded a bias of -0.071 feet and a 95% CI uncertainty of 0.40 feet (SD = 0.192 feet). All comparisons show compliance with USACE Performance Standards.

Bathymetric data were adjusted to both NAVD88 and to a site-specific estimated Mean Lower Low Water (MLLW) using a digitally recording in-situ tide gage installed adjacent to a control point established within the upstream portion of the survey area. The NAVD88 elevation of this benchmark (6.39 feet) was provided by Land Resource Consultants, Inc. CR Environmental maintained this in-situ tide gage between April 21 and May 28, 2015. Water surface elevations relative to the NAVD88 control point were recorded at 3-minute intervals.

Seventy low-water slack tides were recorded during the study period. The standard deviation amongst the slack low water elevations was 0.06 feet. The mean low water elevation was 1.13 feet NAVD88. Due to pooling effects behind the Holly Pond dam, no significant differences were observed in Holly Pond between the "lower low water" and "low water" tides in Long Island Sound (as measured by the NOAA tide gage in the Sound at Bridgeport). The timing and height of slack high tide agreed well with the nearest NOAA Tide Gage Station (Bridgeport #8467150) as shown in *Figure 3*.

Figure 4 shows the elevations obtained from the bathymetric survey in NAVD88. The results indicate that there are extensive areas within Holly Pond which are exposed at low water (i.e., 1.13 feet NAVD88). For more details on survey operations, data processing, and survey results refer to CR Environmental's Bathymetric Survey and Tidal Study report included as *Appendix B*.

The 2015 bathymetric surface was compared to the 2008 bathymetric surface, which was also performed by CR Environmental and presented in the Holly Pond Sedimentation Study (CH2M HILL, 2010). *Figure 5* shows the difference between the 2015 and 2008 elevations and indicates that most of the shoal area shows erosion of approximately 0.2 feet and small areas of deposition of approximately 0.2 feet. However, these magnitudes are within the 2015 survey uncertainty of 0.4 feet, indicating that the observed changes are not significant. Also, no difference in the areal extent of the shoal areas was observed from the survey data comparison.

3.2 Sediment Sampling

Sediment samples were collected from the Holly Pond shoal area by CH2M HILL and CR Environmental in December 2008 (refer to *Section 2* and *Appendix A)*. Surface sediment samples were collected from a total of 11 locations and subsurface sediment was collected from 5 locations. Louis Berger reviewed the sediment contaminant concentrations and found the following:

- Sediment is impacted with low level PAHs concentrations;
- Sediment concentrations seem to be consistent with depth so that it can be assumed that deeper sediment contains similar concentrations; and
- Contaminant concentrations appear to be consistent to urban background concentrations.

Moreover, since the shoal area appears to be in equilibrium (refer to Section 3.1 and 4.5), data is deemed sufficient for a feasibility level assessment of the potential restoration alternatives. No additional sediment samples were collected by Louis Berger. However, additional sampling should be performed during the design phase of the selected alternative. For this feasibility level analysis, Louis Berger will assume that sediment disturbed by restoration alternatives will be covered by a one foot layer of clean sand.

3.3 Bio-Benchmarks

Biological benchmarks (bio-benchmarks) are typically used as reference points, in conjunction with tidal data, to determine optimal elevation ranges for the establishment of plants in tidal wetlands. The long-term success of a restored or created marsh relies primarily on establishing, with a high degree of accuracy, the correct elevations for the different plant communities. To determine target elevation ranges, detailed observations of functioning habitats are made and survey data are collected. These observations illustrate the elevations and tidal regimes under which individual species thrive or struggle, and reveal the elevations at which undesirable non-native species begin to out-compete target native species. The bio-benchmarks are then compared with tidal analyses results to determine optimal elevations for plant establishment within tidal marsh habitats.
A bio-benchmark survey was conducted on October 17, 2014 and April 22, 2015 to determine elevations of key vegetative zones within the project area. Bio-benchmarks were established at nineteen locations within the project area and nearby reference marshes within Cove Island Park. Bio-benchmark locations are depicted on *Figure 6* and bio-benchmark data is presented in *Table 3*.

Table 3: Bio-Benchmark Data

LOCATION	DESCRIPTION	ELEVATION FEET NAVD88
BB-1	Previously restored area south of Giovanni's parking lot; low edge of stunted *Phragmites australis*	2.9
BB-2	Previously restored area south of Giovanni's parking lot; healthy *Spartina alterniflora* relative to the remainder of the restored area; *Spartina alterniflora, Ulva lactuca, Lemna*	2.4
BB-3	Previously restored area south of Giovanni's parking lot; unvegetated mudflat just below low edge of planted area	2.0
BB-4	Previously restored area south of Giovanni's parking lot; stunted *Spartina alterniflora* in middle of planted area	2.2
BB-5	South of previously restored area; upper edge of *Spartina alterniflora*	2.7
BB-6	South of previously restored area; upper edge of *Spartina alterniflora* and *Iva frutescens*	3.8
BB-10	Cove Island Park, marsh near boat ramp; upper edge of high marsh, *Distichlis spicata, Spartina patens, Limonium, Suaeda linearis, Atriplex patula, Iva frutescens; Spartina alterniflora*	3.7
BB-11	Cove Island Park, marsh near boat ramp; upper edge of low marsh, transition to high marsh; *Spartina alterniflora, Limonium, Salicornia virginica*	2.7

LOCATION	DESCRIPTION	ELEVATION FEET NAVD88
BB-12	Cove Island Park, marsh near boat ramp; middle of healthy stand of *Spartina alterniflora* at seed, ribbed mussels and fiddler crabs	1.8
BB-13	Cove Island Park, marsh near boat ramp; low-middle of healthy stand of *Spartina alterniflora* at seed, *Fucus*	0.4
BB-14	Cove Island Park, marsh near boat ramp; low edge of healthy stand of *Spartina alterniflora* at seed, *Ulva lactuca, Fucus*	-0.8
BB-15	Cove Island Park, south of dam; mid high marsh (predominantly *Spartina patens*)	3.3
BB-16	Cove Island Park, south of dam; transition between high and low marsh	3.1
BB-17	Cove Island Park, south of dam; mid dense stand of *Spartina alterniflora*	2.6
BB-18	Cove Island Park, south of dam; low edge of low marsh, *Spartina alterniflora* present in individual clumps	0.3
BB-20	Wetland fringe on west side of Holly Pond; unvegetated mudflat	2.0
BB-21	Wetland fringe on west side of Holly Pond; low edge of healthy stand of *Spartina alterniflora* at seed	2.8
BB-22	Wetland fringe on west side of Holly Pond; middle of healthy stand of *Spartina alterniflora* at seed	3.2
BB-23	Wetland fringe on west side of Holly Pond; upper edge of healthy stand of *Spartina alterniflora* at seed, limited by seawall, not necessarily elevation	3.4

Precise vertical elevations were coupled with observations of key vegetative, soil and hydrological characteristics to investigate (1) the lowest elevation at which *Spartina alterniflora* was observed; (2) the elevations for strong and vigorous *Spartina alterniflora*; (3) the elevations for strong and vigorous growth of native high marsh species (*Spartina patens, Distichlis spicata, Limonium nashi, and Iva frutescens*); and (4) the lower elevation of invasive, non-native *Phragmites australis* colonization. *Table 4* summarizes the elevations (or range of elevations) of key vegetative zones based on the bio-benchmark survey.

Table 4: Elevations of Key Vegetative Zones (NAVD88)

RANGE OF LOWEST ELEVATIONS OF SPARTINA ALTERNIFLORA	RANGE OF ELEVATION WITH MOST VIGOROUS GROWTH OF SPARTINA ALTERNIFLORA	NATIVE HIGH MARSH	PHRAGMITES AUSTRALIS LOWEST ELEVATION
-0.8 to 2.8	1.8 to 3.2	2.7 to 3.7	2.9

The previously restored area (conducted by others) near Giovanni's Restaurant was unvegetated below elevation 2.2 feet NAVD88. A large portion of this area was at elevation 2.0 feet NAVD88. Healthy *Spartina alterniflora* was present at elevation 2.4 feet NAVD88 in this area.

3.4 Proposed Wetland Design elevations

The tidal datums in Holly Pond were computed from an assessment of the 2015 Holly Pond tide gage data and data from the nearest NOAA Tide Gage Station (Bridgeport #8467150) in Long Island Sound (*Table 5*). Although, Mean Low Water (MLW) and Mean Lower Low Water (MLLW) do not exist at the shoal area due to the existing dam on Holly Pond, the Holly Pond 2015 tide gage provides the average low of each low tide in the pond and the lowest water level.

Table 5: Holly Pond Developed Tidal Datum

BRIDGEPORT DATUMS CONSIDERING TRUNCATION FOR HOLLY POND (WITH REFERENCE TO NAVD88)		
Mean Higher High Water	MHHW	3.48
Mean High Water	MHW	3.15
Mean Tide Level	MTL	None
Mean Low Water	MLW	None
Mean Lower Low Water	MLLW	None
Average Low Water	Ave Low	1.13
Min Low Water	Min Low	1.04

Based on the tidal data, the inundation time for the existing and proposed elevations were also calculated as shown in *Table 6*.

Table 6: Holly Pond Inundation Times

HOLLY POND TIDAL INUNDATION AT VARIOUS ELEVATIONS [a]						
Elevation (feet, NAVD88)	1.5	2.0	2.50	3.0	3.5	4.0
Percentage of Gage Time Above Elevation:	43%	27%	20%	13%	7%	2%
Inundation Time (24 Hours):	10.7	6.7	4.9	3.2	1.6	0.6

a. Data obtained from gage data at Holly Pond Site 4/21/15 to 5/28/15.

Based on the biobenchmark and tide gage analysis, the best design elevations for low marsh within Holly Pond are between 2.5 and 3.0 NAVD88. As the current elevation of the shoal area is 1.0 to 2.0 NAVD88, the shoal would need to be raised an average of two feet to provide suitable elevations to support native tidal marsh vegetation.

4 HYDROLOGIC AND HYDRAULIC ANALYSES

4.1 INTRODUCTION

Purpose

The objective of the Holly Pond modeling effort was to use established models that adequately represented the processes affecting stream hydraulics, sediment supply and transport. Sediment transport is important because hydrophobic contaminants, like PCBs, are preferentially transported in the particulate phase sorbed to fine-grained sediments. The model simulated results were used to assess the relative impacts of flow and sediments into Holly Pond under various remediation or restoration scenarios. The modeling effort is critical to evaluate project alternatives and inform the design of practical and effective sustainable solutions to the shoaling issues.

Modeling Approach

The hydraulics and sediment impact analysis modeling was conducted for the Noroton River Watershed from an area immediately north of the end of Country Club Road to its outlet into Holly Pond as shown in *Figure 7*. Because runoff and sediment yield from the watershed into Holly Pond are inputs into the hydraulics and sediment impact analysis modeling, it was necessary to include a watershed model with the in-river hydraulic and sediment impact analysis model. The modeling framework developed for the Noroton River consisted of the following:

- A watershed model that provided inputs of runoff and sediments into the in-stream model. The hydrologic model Soil Water Assessment Tool (SWAT; (Arnold et al., 1998) version 2009) was selected to perform the simulation of continuous water movements and sediment yield through various patterns of land uses in the watershed. SWAT is a continuous-time simulation, semi-distributed, quasi-process-based watershed model. The ArcSWAT interface was used to prepare the inputs to the SWAT model.
- An in-stream hydraulic and sediment impact analysis model. The Hydrologic Engineering Center-River Analysis System (HEC-RAS) hydraulic model was used for this component of the modeling framework. The one-dimensional model HEC-RAS is a physically-based modeling system to analyse river flow, sediment, and water quality dynamics. Within HEC-RAS, a sediment assessment model was constructed using the SIAM (Sediment Impact Assessment Model) feature. HEC-RAS was selected because it has been present in the public realm for more than 15 years and has been peer reviewed (USACE, 2010a, b). It is freely available for download from the HEC website and is supported by the US Army Corps of Engineers. It is also widely used by many government agencies and private firms. The SIAM tool was recommended by USACE for sediment assessment in this study because it is already part of the HEC-RAS modeling system.

The SWAT model and HEC-RAS were externally coupled[1], such that the results of the SWAT model were used as an input to the HEC-RAS model without changing the codes of the models.

4.2 WATERSHED MODELING

Watershed Modeling Methodology

The GIS interface for SWAT model (ArcSWAT) was used to develop the inputs for simulating the Noroton River watershed flows and sediment. As mentioned above, SWAT is a continuous-time simulation, semi-distributed, quasi-process-based watershed model. The model operates on a daily time step and was developed to evaluate the effects of alternative management decision on water resources and non-point-source pollution in ungauged watersheds.

Major model components include weather, hydrology, soil temperature and properties, plant growth, nutrients, pesticides, bacteria and pathogens, and land management. The ArcSWAT GIS Interface, Version 10.1 was used for model parameterization. Total years of study were from the period of 1996 to 2015, however continuous flow data was available from the USGS gauge near St John's Cemetery about 3 miles upstream from Holly Pond (USGS gauge ID: 01209785) for the years of 1963 to 1967. The years 1996 and 1997 were used as a warm-up period for the model while 1963 through 1967 were used for model calibration and 1998 through 2014 was used for model validation. This division into calibration and validation periods ensures that both periods have a similar number of wet and dry years.

SWAT-CUP version 4.3.7 (Abbaspour et al., 2007) was used for sensitivity analysis and model calibration. SWAT-CUP provides a decision making framework that incorporates a semi-automated approach (SUF12) using both manual and automated calibration and incorporates a sensitivity and uncertainty analysis. In SWAT-CUP, users can manually adjust parameters and ranges iteratively between autocalibration runs. Parameter sensitivity analysis helps focus the calibration and uncertainty analysis and is used to provide statistics for goodness-of-fit.

Watershed Study Area

The headwaters of the Noroton River originate in a residential area of New Canaan (see *Figure 7*). The Noroton River flows southerly connecting with tributaries through Darien and Stamford into Holly Pond, where the water flows into Cove Harbor and Long Island Sound. The Noroton River watershed area is approximately 12.7 square miles as shown in *Figure 7*.

Model Components and Input Data

The steps involved in creating and running SWAT model are provided in *Figure 8*. The major model inputs are topography, soil properties (such as texture, soil erodibility, hydraulic conductivity, hydrologic soil group,

[1] External coupling occurs when one program calls another program (executable file) explicitly, and there is a mechanism of external data exchange, either by a text file I/O or by more sophisticated interprocess communication (Yahiaoui et al., 2004).

soil depth, organic matter content, available water capacity), land use/cover type, weather/climate, and land management practices. Using the site topography, the SWAT ArcGIS interface delineates the stream and partitions the watershed into subwatersheds. Subwatersheds possess a geographic position in the watershed and are related to one another spatially. For example, outflow from upstream sub-watershed number 3 may enter downstream subwatershed number 6. The subwatersheds are further processed and divided into the Hydraulic Response Units (HRUs). SWAT then uses the input data from the user to create inputs files with different levels of detail for the watershed, subwatershed, or HRU. Watershed level inputs are used to model processes throughout the watershed, while subwatershed or HRU inputs files are used to identify unique processes to specific subwatershed or HRUs.

The National Elevation Dataset (NED) of 1/3 Arc Second *assembled* by the U.S. Geological Survey along with the surveyed bathymetry of Holly Pond performed by CR Environmental in 2015 were used in representing the elevation terrain of the watershed. The USGS National Land Cover Database (NLCD) 2011 (amended in 2014) Land Cover data was used to represent the land use in the watershed. Average land use characteristics of the Holly Pond watershed were as follows:

- 60% Residential;
- 30% Forested;
- 3% Industrial; and
- 7% Other.

The USGS Soil Survey Geographic (SSURGO) data, completed in September 2015, was used in classifying the soil characteristics of the watershed. The Soil Survey of the State of Connecticut gives a complete description of each soil map unit. The most prevalent soil type for the Holly Pond Watershed, at 30%, was fine sandy loam.

4.3 HYDRAULICS MODELING

Hydraulics Modeling Methodology

For stream hydraulics modeling, the HEC-RAS model was used. HEC-RAS is a one-dimensional model, intended for hydraulic analysis of river channels. The model is comprised of a graphical user interface, separate hydraulic analysis components, data storage and management capabilities, graphics and reporting facilities. The HEC-RAS system includes four river analysis components. Based on the laws on conversation of energy, the HEC-RAS model uses physical field measurements of the stream and floodplain cross sections to simulate flow related values including: flow rates, velocity, energy, and water surface elevation.

The main inputs to the model are:

- River geometric data: width, elevation, shape, location, length;
- River floodplain data: length, elevation;

- Manning roughness coefficient (Manning 'n' values) for the land use type covering the river and the floodplain area;
- Boundary conditions e.g. slope, critical depth; and,
- Stream discharge values from SWAT model runoff and stream routing result.

The outputs from the model include:

- Water surface elevations;
- Rating curves;
- Hydraulic properties, i.e., energy grade line slope and elevation, flow area, velocity; and,
- Visualization of stream flow, which shows the extent of flooding.

River geometric data used in the Holly Pond HEC-RAS model were obtained from field surveys conducted by Bolduc Land Consultants, LLC during the winter of 2009. A few of the surveyed cross sections did not extend far enough to the left and right stream bank stations to cover the entire floodplain to higher ground which is required for the HEC-RAS model to accurately model high flow conditions. Beyond the limits of the site survey, these few cross sections were supplemented with additional contours that were generated using the U.S. Geological Survey (USGS) National Elevation Dataset (NED) digital elevation models (DEM).

In HEC-RAS, boundary conditions are needed to establish the starting water surface at the Noroton River study limits (upstream and downstream ends) and for the model to begin the calculations. For the Holly Pond HEC-RAS model, a mixed flow regime was assumed and for this flow regime, normal depth boundary conditions were used at the upstream end and average tide level boundary condition was used at the downstream end to represent tidal effect in Holly Pond. The normal depths for upstream boundary conditions were approximated by using the slope of the upstream Noroton River bed. The average tide level was developed from the 30-day (4/21/2015 through 5/28/2015) tide data collected in Holly Pond.

HEC-RAS Model Runs for SIAM

The sediment budget model described in the next Section requires hydraulic results from HEC-RAS for its analysis. Before a SIAM model is developed and run in HEC-RAS, a steady-state HEC-RAS model must first be created and run. Since the HEC-RAS\SIAM model runs under quasi-steady-state condition, the 1998-2014 SWAT model-computed flows were transformed to annualized flow duration values. Each flow level required for SIAM is modeled in HEC-RAS and the steady state hydraulic results are passed onto SIAM. A HEC-RAS perspective plot of the Noroton River reach from Holly Pond to Camp Avenue in Stamford can be seen in *Figure 9*.

4.4 Sediment Transport Analysis

A sediment assessment model constructed using the SIAM feature in HEC-RAS was used to evaluate existing conditions aggradation (deposition) and degradation (erosion) and potential changes in sedimentation patterns that could occur due to sediment erosion management alternatives. SIAM compares the annual sediment transport capacity of a river reach to the annual sediment supply and provides an indication of whether aggradation, degradation, or equilibrium may occur.

The SIAM feature was applied for all reaches in the Noroton River from just below Camp Avenue down to Holly Pond for the following scenarios:

- Existing Conditions;
- Removal of Bank Erosion Source on Noroton River Streambanks; and
- Grain Size Analysis for 100-yr Storm Event.

SIAM Sediment Reaches

The first step in SIAM is to subdivide the stream in the HEC-RAS hydraulic model into sediment reaches, which represent the scale at which sediment transport calculations are performed. A sediment reach is defined as a grouping of cross-sections with relatively consistent hydraulic and sediment properties, recognizing any significant geomorphic changes, changes in channel gradient, planform and geometry, and shifts in sediment composition. Based on these parameters and field observations of sediment texture and grain size, the Noroton River was subdivided into fifteen sediment reaches.

SIAM Input Data

The input required for the SIAM module includes cross section data for the study reach, annualized discharge-duration data, bed material gradations, an appropriate sediment transport function, wash load criteria, and annualized sediment input volumes (broken down by grain size fractions). The SIAM modeling was conducted using the calibrated HEC-RAS bank full model that created the elevation-duration curves.

Sediment transport estimates developed by SIAM are based on annualized flow-duration curves created from mean daily discharges. The flow-duration curves used in the SIAM simulations were based on the results of the SWAT simulated stream flow for the period 1996 to 2014 presented in Section 4.2. Bed material gradations associated with each SIAM sediment reach were obtained from the instream pebble counts reported at several locations in the river bed in the Holly Pond River Assessment - Field and Analytical Data Report (CH2M HILL, 2009). The MPM sediment transport function was selected for the SIAM model based on its applicability to the range of silt to cobble that is found in the bed material. The wash material threshold diameter was evaluated for each sediment reach based on the approximate D10 diameter of the bed material for the reach. Annualized sediment input volumes were based on results of the sediment yield from the watershed SWAT model.

4.5 SUMMARY OF RESULTS

Watershed Model Results

The SWAT model simulated watershed flows and sediment yield per subwatershed. There were many note-worthy results from the SWAT model, as summarized in *Table 7*.

Table 7: Watershed Model Results

SWAT MODEL RESULTS
▪ Approximately **4,500 tons** of sediment per year flow through the outlet of the Noroton River into Holly Pond
▪ Sediment flowing into Holly Pond is **silt**
▪ Approximately **12%** of the sediment is coming from the Noroton River streambanks
▪ Approximately **56%** of the sediment is coming from subwatershed number 4, an area of 1.4 square miles (total watershed area is 12.7 square miles)
▪ Approximately **18%** of the sediment is coming from subwatershed number 9, an area of 1.8 square miles

A schematic of subwatersheds 4 and 9 is provided in *Figure 10*. Further analysis of subwatersheds 4 and 9 is provided in *Section 7*. Watershed modeling results pertaining to the proposed restoration alternatives are depicted in the subsequent sections of this report.

Hydraulics and Sediment Transport Model Results

The hydraulics HEC-RAS model was run with the SIAM module for existing conditions, proposed alternatives, and the 100-year storm event. Model results for the proposed alternatives are summarized in the subsequent sections. Results for existing conditions and the 100-year storm event, are provided in *Table 8* and *Figure 11*.

Table 8: Hydraulic Model and Sediment Transport Analysis Results for the 100 Year Storm Event

HEC-RAS SIAM MODEL RESULTS
▪ Sediment is *not* currently depositing into Holly Pond Shoal areas
▪ Holly Pond northern and southern shoals are in equilibrium
▪ Velocities at 100-yr storm event only allow fine soils to pass under Route 1 into Holly Pond

When computing SIAM results, the model indicated there is no bed degradation nor bed aggradation in the Holly Pond shoal areas. The model indicates that the shoals are in equilibrium. This result is complimented by the bathymetry data discussed in Section 3.1, which show no significant change in the shoal areas. In addition, a 100-year storm was modelled in order to compute the grain size movement in each reach during storm conditions. The results of the analysis indicated that during the high flow event, the velocities at the outlet of the Noroton River only allow fine soils into Holly Pond. Refer to *Figure 11* to see the different materials permissible through the end of each reach by the 100 year storm event velocities at each reach outlet. The results show that storm flows are capable of transporting medium to coarse materials within the upstream reaches of the river, but these would settle in low velocity areas upstream of Holly Pond.

As described in Section 2, available data as well as observations from field visits performed in 2015 indicate that the Holly Pond sediment shoals are mostly made up of medium to coarse grained materials. The model, bathymetry, and sediment analysis indicate that the shoal sediment is not currently coming from Noroton River streambanks nor the watershed because the sediment load is comprised of fine grained materials. While fine grained materials could potentially be settling on the sediment shoal areas, data suggests that these are likely being washed out with storm events since no significant changes in the bathymetry have been observed since 2008. These fine grained materials are likely being deposited in the deeper areas of Holly Pond or being transported to Long Island Sound. Also, while it is possible for larger sized material to be transported beyond the Noroton River outlet during storms larger than the 100-year storm, the medium to coarse grained material sources that formed the Holly Pond shoal seem to have significantly decreased over time. Possible sources of the shoal sediment are historic land uses, which were mentioned in the Holly Pond Sedimentation Study (CH2M Hill, 2010). The following is an excerpt from the report.

> *"Interviews conducted during the course of the study indicated that the following types of commercial/industrial users were in operation along the Noroton River throughout the 20th Century:*
>
> - *Landscaping companies*
> - *Heavy industrial and commercial*
> - *Plating*
> - *Rock crushing*
> - *Phillips Milk of Magnesia*
>
> *The interviews indicated that historical land uses may have been a source of contaminants discharged to the Noroton River."*

Other possible sources include historical soil erosion prior to the advent of sediment control plans, roadway sanding operations by ConnDOT which ceased approximately ten years ago, and the degradation of the Noroton River bed, though none of these were revealed in the model results because the model was run with existing surveys and data.

5 Task 2: Holly Pond Sediment Shoal

5.1 Alternatives Analysis

Introduction

Upon the completion of gathering data and establishing hydrologic and hydraulic models, the evaluation of alternatives was initiated. Updated bathymetry gave insight into the current state of the Holly Pond shoal areas, as well as compared the current elevations to previous studies. Tidal hydrology and bio-benchmarks were measured to determine correct elevations to restore tidal marsh habitat. The watershed model results summed the discharge through each subwatershed as well as sediment yield per year. The stream model computed bed aggradation and bed degradation, and analysed velocities and grain sizes through each reach. The collection of data provided insight into the existing conditions of the Holly Pond watershed. With this new insight, engineering solutions to the Holly Pond sediment shoal are possible.

Existing Conditions

The Holly Pond sediment is spread into two visible shoals at low tide. The northern shoal, across from Giovanni's Restaurant is about 0.6 acres in size. The shoal sits along the western shore of Holly Pond at the outlet of the Noroton River. The southern shoal is approximately 1.3 acres, behaving as a small island within Holly Pond. *Figure 12* shows the location of the shoal areas as well as the bathymetry elevations. The average low water elevation is 1.13 feet NAVD88 and the Mean High Water is 3.15 feet NAVD88. A cross section of the existing conditions of the northern shoal is depicted in *Figures 13 and 14*.

The grey vertical lines on *Figure 14* are the locations of the seawalls. The cross section view is left bank to right bank looking downstream. The white line in *Figure 14* depicts the existing bathymetry. Please note that the scale of the figure horizontally is not the same as the vertical scale. The Holly Pond sediment shoal is approximately 110 feet wide at the location of this cross section.

5.1.1 Sediment Removal Alternative

Introduction

This proposed restoration alternative involves sediment removal to eliminate the exposure of bare sediments above the surface of the water at low tide. Sediment removal may be accomplished by excavation or dredging. Dredging could be performed by mechanical or hydraulic means. Sediment that is removed will need to be beneficially used or properly disposed off-site. Sediment that meets applicable criteria for contaminant concentrations and structural properties could serve a beneficial purpose such as structural fill or lower permeability cover or cap for a brownfield or landfill without pre-treatment. In some instances, ex-situ treatment, such as ex-situ immobilization, is required prior to application of dredged sediment as fill or cover material. Sediment disposed at an off-site land facility may need to be processed to remove excess free liquids to allow for over-road transport and to reduce the cost of offsite disposal, while sediment disposed at an aquatic disposal facility must pass rigorous testing procedures and be transported over navigable waterways, which may be technically impractical due to the presence of the tidal dam at the southern boundary of Holly Pond.

Design Criteria and Restoration Analysis

Sediment removal requires the evaluation of removal, dewatering, and disposal options. The following key items were considered when evaluating the options:

- Access: The tidal dam is a major navigation constraint to alternatives that involve movement of vessels, equipment, materials, or waste to the project site.
- Targeted Area Conditions: The area targeted for sediment removal is influenced by tidal action from Long Island Sound. At low tide, water is not deep enough to support navigation and at high tide, water depth averages 2 to 3 feet. The tidal influence and available water depths will limit the type of equipment that can be used in the area.
- Sediment Characteristics: Sediment targeted for removal consists of mostly coarse and medium sized particles, which may allow for easy dewatering of material. Particle size also plays a role when selecting removal equipment as a small hydraulic dredged may not be handle the larger rocks that are in the area. The sediment also contains PAHs ranging from 300 - 2100 ug/kg. The sediment's chemical composition will influence equipment selection, since contaminated sediment would be more safely removed with a closed dredging bucket than an open excavator bucket. Also, contaminated sediment will have to be properly disposed of and may limit beneficial reuse options.
- Processing Area: There is available land in the vicinity of the sediment removal area that may be used for sediment processing. This includes small parcels of public and private land, Gerli Park and about half of the Giovanni's Restaurant parking lot, respectively. Each area is approximately 0.3 acres, which may be better suited for an operation of less than 5,000 cubic yards. The sediment removal rate will have to be adjusted based on the size of the processing area.
- Cost: The cost of each option was used to balance the options. A feasible option may be cost prohibitive and provide no benefits over a less costly option.

Proposed Condition Analysis

Bathymetric and tide data was reviewed to determine an appropriate sediment removal depth so that no sediment is visible at low water. Two scenarios were developed for evaluation:

- Dredging shoal to an elevation of 0 feet NAVD88: This alternative results in water depths of approximately 1-foot at low water and was also evaluated in the previous Holly Pond Sedimentation Study (CH2M Hill, 2010). Approximately 16,400 cubic yards will be dredged over a 16-acre area. *Figure 18* shows the extent of dredging and an example cross-section with the proposed dredging elevation. If sediment remaining in place requires capping, at least an additional foot of material would have to be removed from the area in order to create room for a sand cover. Assuming a 1-

foot sand thickness, removal quantities could increase to approximately 42.700 cubic yards over the same area.

- Dredging shoal to an elevation of 0.5 feet NAVD88: This alternative results in water depths of approximately 0.5-feet at low water. This elevation was selected because cross-sections from the Noroton River indicate a bed elevation of 0.5-feet just upstream of the Route 1/East Main Street Bridge. Approximately 6,300 cubic yards will be dredged over a 5-acre area. *Figure 16* shows the extent of dredging and an example cross-section with the proposed dredging elevation. If sediment remaining in place requires capping, at least an additional foot of material would have to be removed from the area in order to create room for a sand cover. Assuming a 1-foot sand cover thickness, removal quantities could increase to approximately 14,700 cubic yards over the same area.

Sediment removal options for these two alternatives were evaluated based on the criteria above. *Table 9* presents a summary of the options evaluated. Screening level costs per cubic yard are provided for all options. These costs can be added to obtain a rough estimate for a removal alternative. For example, for an alternative that uses hydraulic dredging, geotextile tube dewatering, and land disposal, cost would range between $670 to $830 per *in-situ* cubic yard. These screening level costs do not include pre-design investigation, design and permitting, construction management, or contingency, however these are included in the detailed cost estimates. Detailed cost estimates were focused on developing a plan for mechanical dredging, shore-side processing, and offsite disposal as presented in *Section 5.2*. *Figures 15, 16, 17,* and *18* depict the proposed sediment removal alternatives. *Figures 15* and *17* are depictions of the cross sectional proposed dredging depth on the shoal, respectively. *Figures 16* and *18* are aerial views of the proposed sediment removal alternatives, dredging to 0.5 feet NAVD88 and 0.0 feet NAVD88, respectively.

Summary of Results

Based on this preliminary assessment, sediment removal is a viable alternative for the Holly Pond sediment shoal. The implementation of either sediment removal alternative (i.e., 0 feet NADV88 or 0.5 feet NADV88) will result in an aesthetically pleasing open water pond. Model results showed little to no sediment deposition over several years in the shoal areas and therefore maintenance dredging may not be required. Additional modeling should be performed during the design phase of the selected alternative to verify these predictions. While removing sediment to an elevation of 0 feet NAVD88 will provide a deeper water column during low tide, the cost for this alternative is significantly higher than removing sediments to 0.5 feet NAVD88 and it does not provide any additional benefits. Neither alternative provides any ecological uplift because of the removal of mudflat habitat. Also, improvements to the water quality may not be measurable because these alternatives do not address any of the sediment or contaminant loads coming into the pond from the Noroton River. Disposal of the excavated material could be challenging and expensive.

Table 9: Summary of Sediment Removal, Dewatering, and Disposal Options

PROCESS OPTION	ACCESS	TARGETED AREA CONDITIONS	SEDIMENT CHARACTERISTICS	PROCESSING AREA	APPROXIMATE COST PER IN-SITU CUBIC YARD FOR EACH OPTION [a]	VIABLE OPTION FOR HOLLY POND?
Removal Options [b]						
Hydraulic Dredging	May require crane to deploy hydraulic dredge in the pond. Once dislodged dredged material can be pumped to processing area.	Shallow water depths will only support a 6-8” impeller diameter hydraulic dredge. Productivity will be really low because hydraulic dredging operations may only occur during high tide.	Northern shoal area has gravel and rocks that may make hydraulic dredging infeasible for a smaller hydraulic dredge.	Will require large processing area because of added water when dredging.	$450 - $500	No
Mechanical Dredging	Temporary ramp can be built to access site and move materials to and from site.	Shallow water depths are still a challenge but can be better managed with mechanical removal equipment.	Closed bucket is suitable for contaminated sediment – but production is slower than excavator.	Sediment removal rate may need to be adjusted depending on the size of the processing area.	$250 - $300	Yes
Mechanical Excavation	Temporary ramp can be built to access site and move materials to and from site.	Shallow water depths are still a challenge but can be better managed with mechanical removal equipment.	Open bucket may release some sediment into the water column during high tide periods.	Need to build ramp for access.	$200 - $250	Yes

PROCESS OPTION	ACCESS	TARGETED AREA CONDITIONS	SEDIMENT CHARACTERISTICS	PROCESSING AREA	APPROXIMATE COST PER IN-SITU CUBIC YARD FOR EACH OPTION [a]	VIABLE OPTION FOR HOLLY POND?
Dewatering Options [c]						
Free draining (mechanical removal only)	Temporary ramp can be constructed to move materials.	N/A	Sediment mostly consist of sand, which may freely drain.	Sediment removal rate may need to be adjusted to fit processing area.	\$25-\$50	Yes
Geotextile Container Dewatering (hydraulic removal only)	Material is pumped directly into geotextile containers.	N/A	Addition of polymers may not be necessary because sediment mostly consist of sand.	Not enough laydown area is available for geotextile tube dewatering.	\$100 -\$150	No
Mechanical Dewatering	Hydraulic dredging: material is pumped directly to processing site. Mechanical removal: need temporary access ramp.	N/A	Technology is capable of sorting material by grain size. May be able to beneficially use segregated material.	Requires small footprint. Power requirements and noise levels are much greater than other methods.	\$250 - \$300	No
Amendment/ Desiccation (mechanical removal only)	Temporary ramp can be constructed to move materials.	N/A	Portland cement may bind contaminants.	Sediment removal rate may need to be adjusted to fit processing area.	\$50 -\$100	Yes

PROCESS OPTION	ACCESS	TARGETED AREA CONDITIONS	SEDIMENT CHARACTERISTICS	PROCESSING AREA	APPROXIMATE COST PER IN-SITU CUBIC YARD FOR EACH OPTION [a]	VIABLE OPTION FOR HOLLY POND?
Disposal Options [d]						
Aquatic Disposal	Dam constraints navigation of vessels to and from Long Island Sound. Double handling material will be required either by mechanically transferring material over the dam to second barge or using a high solids pump.	Shallow water depths will require specialty shallow draft equipment for navigation from shoal areas to Long Island Sound confluence.	Material will require toxicological testing to make sure it can be safely disposed off-shore. PAH levels are above ecological screening levels and may be too high to allow for ocean disposal.	No processing area is required for sediment processing.	$200 - $250	No
Land Disposal	Temporary ramp can be constructed to move materials.	N/A	Higher tipping fees may apply for contaminated sediment.	See dewatering options above.	$120 - $180	Yes
Beneficial Use	Temporary ramp can be constructed to move materials.	N/A	Need to pair material with viable project. PAH levels may limit use of material.	See dewatering options above.	$50 - $180	Yes

a. Low range cost assumes that dredged material contains low level contamination below ecological benchmarks and high range cost assumes that dredged material contains contamination above ecological benchmarks that would require additional dredging and capping of disturbed material.
b. Costs include mobilization of dredging equipment, sediment removal, capping of contaminated material.
c. Costs include dredged material handling, equipment mobilization, and dewatering.
d. Costs include transport of material to disposal facility and disposal site tipping fee.

5.1.2 Tidal Marsh Restoration Alternative

Introduction

A viable alternative to reduce sediment disposal costs and achieve other ecological functions and aesthetic project goals is tidal marsh restoration of the two Holly Pond sediment shoals. This alternative includes raising the shoals to an elevation that will support tidal wetland vegetation. Bio-benchmark information, inundation duration analyses, and tide data analyses were used to determine the optimal inundation duration and the optimal drainage configuration. This data is critical to the establishment of native *Spartina* habitat. Introduction of tidal marsh in this area of Holly Pond would improve habitat diversity as well as improve water quality. As stated by the Connecticut DEEP:

> *"All tidal wetlands support a diverse ecosystem of vegetation and wildlife. Tidal wetlands provide habitat, nesting, feeding, and refuge areas for shorebirds; serve as a nursery ground for larval and juvenile forms of many of the organisms of Long Island Sound and of many estuarine-dependent oceanic species; and provide significant habitat for shellfish. These resource areas also improve water quality by trapping sediments, reducing turbidity, restricting the passage of toxics and heavy metals, decreasing biological oxygen demand (BOD), trapping nutrients, and buffering storm and wave energy. Tidal wetland vegetation stabilizes shorelines and buffers erosion."*
>
> \- *(CTDEEP, 2015)*

Design Criteria and Restoration Analysis

To restructure the Holly Pond shoal area to achieve a restored tidal marsh, the following design criteria were developed:

- Tidal marsh shall restore wetland ecological functions.
- Emergent tidal marsh should have an acceptable elevation based upon the bio-benchmark and tide gage analysis.
- Sediment shoals shall be replaced with vegetated wetlands and/or open water; contaminated soil shall be excavated or capped.
- Tidal marsh shall be aesthetically pleasing.

Tidal marsh configurations were developed based upon the design criteria. Data collection used included bathymetry, surveyed topography, bio-benchmarks, tidal datum analysis, and inundation tables. In order for the marsh to function properly, to allow high nutrient and biological productivity, suitable design elevations are essential.

Sea Level Rise Projections

To support design, Louis Berger incorporated a site specific calculation of sea level rise (SLR) following United States Army Corps of Engineers (USACE) methodologies. To simulate future impacts of SLR on Holly Pond, the most recent version of the USACE sea level change projection methodology summarized in USACE Regulation 1100-2-8162 (December 2013) was used in conjunction with the nearby NOAA Gage 8467150 at Bridgeport. NOAA's published SLR rate for the Bridgeport gage is 0.00840 feet per year. Sea level projections were calculated with three projections: a high rate projection, an intermediate projection, and a projection of the historically measured rate (or low rate). This methodology considers the entire range of possible future rates of sea-level change for planning studies and engineering designs. The upper rate projection assumes that in addition to the historic rate of sea level rise, there is a major acceleration in the rate over the 21st century. SLR will be accounted for during the final design phase of the restoration project. See *Table 10* for the calculated sea level rise projections for Holly Pond.

Table 10: Calculated SLR Projections for Holly Pond

HOLLY POND SEA LEVEL RISE PROJECTIONS (IN FEET NAVD88)			
YEAR	USACE LOW	USACE INT	USACE HIGH
2015	-0.03	0.02	0.17
2020	0.02	0.09	0.31
2025	0.06	0.15	0.46
2030	0.10	0.23	0.63
2035	0.14	0.31	0.83
2045	0.18	0.39	1.04
2050	0.23	0.48	1.27
2055	0.27	0.57	1.51
2060	0.35	0.76	2.07
2065	0.39	0.87	2.37

Proposed Condition Analysis

Hydrologic modeling was used to evaluate tidal marsh restoration alternatives. The SWAT model, previously developed for the Holly Pond watershed, was used to predict the influence of various dredging scenarios and marsh configurations. The purpose was to identify a preferred configuration which minimises sediment deposition within the upper reaches of the pond and associated future sediment removal. Any proposed changes to the bathymetry within the shoal area were designed in a fashion as to not impede the passage of diadromous species of fish. To design the proposed elevations in the shoal, a cut-fill analysis was performed using GIS and AutoCAD. The proposed low marsh alternative (tidal marsh restoration) includes the import and placement of clean sand/planting medium to raise the shoal by approximately 1.5 feet. The native salt marsh species, *Spartina alternifloria* will be planted 2 feet on center and protected by herbivory fencing for a year.

Tidal marsh restoration alternatives are shown as cross section and aerial views in *Figures 19* and *20,* respectively. The grey vertical bars shown on the cross section are the approximate location of the seawall. The proposed low marsh starts with a 3:1 (horizontal: vertical) slope from 0.5 feet NAVD88 to 2.5 feet NAVD88. From 2.5 to 3 feet NAVD88 there is a very gradual (almost flat) slope to the existing sea wall.

For the southern shoal, as shown in the aerial *Figure 20,* the center of the shoal would be raised to elevation 3 feet NAVD88 and gradually sloped to 2.5 feet NAVD88 on the edge of the restored marsh. The area would then be graded with a 3H:1V slope to 0.5 feet NAVD88.

Summary of Results

The proposed tidal marsh configurations would replace the sediment shoal areas with vegetated wetlands, thus improving ecological functions. Tidal marsh restoration is a viable alternative for the Holly Pond sediment shoal to encourage habitat as well as improve water quality in Holly Pond.

5.1.3 Retaining Wall Evaluation

The City of Stamford is currently evaluating repair options for collapsed portions of the retaining wall along Holly Pond. Louis Berger contacted the city of Stamford in the summer 2015. The City is planning repairs of large breaks in the vicinity of Birch Street intersection with Weed Avenue. No documents were available for review.

5.1.4 Living Shoreline Alternative

Introduction

The living shoreline alternative incorporates bank stabilization with the introduction of a tidal marsh. The sediment shoal would be moved to the bank and then shaped to appropriate low marsh elevations. A more natural approach to shore stabilization, living shorelines utilize a variety of structural and organic materials, such as tidal wetland plants, to provide shoreline protection and maintain or restore coastal resources and habitat. The Connecticut Coastal Management Act contains policies encouraging the protection of natural shoreline sedimentation and erosion processes, and discourages hard structure or shoreline armouring. Public Act 12-101 modified and explained several of these policies, including encouraging the '*feasible, less environmentally damaging alternative"* such as restoration or creation of a dune or vegetated slope or living shorelines techniques.

The benefits of living shorelines include stabilization of the shoreline, protection of surrounding riparian and intertidal environment, improvement of water quality via filtration of upland run-off, and creation of habitat for aquatic and terrestrial species. In some cases a continuous connection to the water can improve access for recreational opportunities.

Design criteria and restoration analysis

To develop potential living shoreline alternatives for the Holly Pond sediment shoal area, the following design criteria were developed:

- Living shoreline shall integrate erosion control and a functioning tidal marsh habitat.
- Tidal marsh as natural shore stabilization shall support storm surges and stream outlet velocities.
- Emergent tidal marsh should have an acceptable elevation based upon the tide gage and bio-benchmark data.
- Living shoreline shall be created from repositioned sediment shoal material.
- Living shoreline shall be aesthetically pleasing.

Living shoreline configurations were developed based upon the design criteria. Data collection included bathymetry, surveyed topography, bio-benchmarks, tidal datum analysis, and inundation tables. In order for the living shoreline to function properly as a marsh suitable design elevations are essential.

Proposed condition analysis

Hydrologic modeling was used to evaluate living shoreline alternatives. The SWAT model, previously developed for the Holly Pond watershed, was used to predict the influence of various dredging scenarios and shoreline marsh configurations. The purpose was to identify a preferred configuration which minimises sediment deposition within the upper reaches of the pond and associated future sediment removal. Any proposed changes to the bathymetry within the shoal were designed in a fashion as to not impede the passage of diadromous species of fish. To design the proposed elevations in the shoal, a cut-fill analysis was performed using GIS and AutoCAD. The proposed living shoreline alternative includes the dredging and movement of sediment shoals to shore areas. The sediment will then be covered with clean sand or planting medium. *Spartina alternifloria* plants will be planted 2 feet on center and protected by herbivory fencing for a year.

Living shoreline alternatives are shown as cross section and aerial view in *Figures 21* and *22*. The grey vertical bars shown on the cross section are the approximate location of the existing seawall. The proposed living shoreline alternative includes dredging portions of the sediment shoal to 0.5 feet NAVD88 and using the dredged material to raise areas within Holly Pond to an elevation that will support native tidal marsh plants. The living shoreline will start with a 3:1 slope from 0.5 feet NAVD88 to 2.5 feet NAVD88. From 2.5 to 3 feet there is a gradual slope to the sea wall. An aerial of the living shoreline alternative can be seen in *Figure 22*. Once the dredged material is placed, the low marsh vegetation will be planted from 2.5 to 3.0 feet NAVD88.

Summary of Results

The model results provided living shoreline configurations which would restore wetland ecological functions and relocate sediment shoals. If necessary, contaminated sediment will be covered with clean sand to prevent future contamination on-site. In addition, model results of proposed living shoreline showed an absence of sediment deposition over several years in the shoal areas and therefore maintenance by dredging would be unnecessary. Living shoreline is a viable alternative for the Holly Pond sediment shoal to encourage habitat as well as improve water quality in Holly Pond.

5.2 Cost Estimate

Louis Berger developed conceptual design cost estimates based on the information available for all the different alternatives as discussed with DEEP. Quantities for the items that were used in the cost estimates were generated from cut-fill surface volume calculations between the existing and proposed conditions based on the depth of excavation to proposed grades as per the proposed conceptual designs. Several key assumptions had to be made during the development of the conceptual costs. These included, but was not limited to, the amount of contamination in the excavated material, the reuse of material based on the findings from the sampling frequency, the cost of disposal of the material that may be deemed contaminated with respect to stringent requirements of disposal facilities accepting the material and also the transportation and tipping fees for the material that is assumed to be contaminated. The costs can vary significantly based on the location of the disposal facility.

The unit prices for items that were considered for developing the conceptual costs were obtained from various sources. The costs for the standard items were obtained from the ConnDOT 2015 Cost Estimate Guidelines reference document with specific item unit prices obtained from the General Price ranges for common items. The unit prices for the most common items were chosen median values for the price range provided and higher unit price values were chosen for items used in the projects that comply more or less close to standard item descriptions for a more conservative cost estimate. Other unit prices were obtained from similar representative projects that Louis Berger has worked on. The contingency percentages for all the alternatives were kept the same to evaluate the most cost economical alternative. *Table 11* displays the conceptual cost estimates for the Holly Pond shoal alternatives. The low cost range assumes that 20 percent of the sediment is contaminated and disposed at higher cost. The high cost range assumes that 100 percent of sediment is contaminated and disposed at a higher cost and that dredged areas require additional sediment removal to make room for a sand cover. Also, costs conservatively assume an additional 15 percent of sediment removal, clean, reuse, and disposal volumes of those presented in *Table 1*. Costs were estimated in current 2016 dollars. *Appendix C* shows the detailed conceptual cost estimates. In the future, these costs can be updated to the current year using the Engineering News Record (ENR) Construction Cost Index. The current year cost can be approximated by multiplying the 2016 cost by the ratio of current ENR to the February 2016 ENR. The current ENR Construction Cost Index can be obtained at www.enr.com.

Table 11: Conceptual Cost Estimates for Holly Pond Sediment Shoal Alternatives

	Northern Shoal	Southern Shoal	Total
DREDGING ALTERNATIVE 0.0 FEET NAVD88	Low $2.0M High $3.7M	Low $12.1M High $40.1M	Low $14.1M High $43.8M
DREDGING ALTERNATIVE 0.5 FEET NAVD88	Low $1.5M High $3.0M	Low $4.5M High $12.7M	Low $6.0M High $15.7M
TIDAL MARSH ALTERNATIVE	$0.7M	$1.2M	$1.9M
LIVING SHORELINE ALTERNATIVE	Low $0.6M High $1.4M	Low $0.7M High $2.4M	Low $1.3M High $3.8M

Shoal Dredging Alternative

This alternative was considered for both the northern and southern shoal areas and the volume of excavation was estimated for dredging to 0.0' NAVD88 and 0.5' NAVD88. The most critical assumption for this alternative is the amount of contaminated material that will be excavated during the execution of this alternative. It is assumed that 80% of the material excavated will be non-contaminated and 20% will be contaminated. The low and high range costs for these alternatives are provided considering all the material will not need to be disposed (no contamination) or will have to be disposed completely (all contamination).

Tidal Marsh Alternative

This alternative was also cost estimated for both the northern and southern shoal areas. The unit prices cost for the planting items in this particular alternative are obtained from similar representative projects that Louis Berger has vast experience and data available based on projects that we have been involved in for the past 20 years. Louis Berger also used the reference for the final report that summarizes the costs for wetland creation and restoration projects in the Glaciated northeast submitted to the United States Environmental Protection Agency (USEPA) New England Regional office for a prior work assignment.

Living Shoreline Alternative

This alternative was considered for both the northern and southern shoal areas and the volume of excavation was estimated for material to be either non contaminated or completely contaminated. The most critical assumption for contaminated alternative was the amount of contaminated material that will be excavated during the execution of this alternative. It is assumed that 80% of the material excavated will be non-contaminated and 20% will be contaminated. The low range costs was for non-contaminated material living shoreline and high range costs for these alternatives are provided considering all the material will have to be disposed completely (all contamination).

6 TASK 3: STABILIZATION OF NOROTON RIVER ERODING STREAMBANKS

6.1 ALTERNATIVES ANALYSIS

6.1.1 Introduction

For Task 3 of the Holly Pond Restoration Alternatives Analysis, recommended streambank stabilization measures were developed. Louis Berger integrated fluvial geomorphology, natural stream channel design, lotic ecology, hydrology, and hydraulics to address stream and habitat degradation with a sustainable stabilization design. Since there are many types of bank stabilization methods which can either be beneficial or detrimental to this system, research and preliminary sizing design has been conducted with proposed measures added to the stream model. The model was able to predict the probability of success of the stabilization measures, and determined future flows and velocities resulting from the stabilization measures will not cause adverse effects in other reaches of the Noroton River.

6.1.2 Initial Assessment

To begin this restoration design, the cause of the instability in the streambanks needed to be understood. There were three main researching platforms to identify the specific mechanisms of failure:

- Hydrologic and Hydraulic (H&H) model,
- 2015 field assessment of the Noroton River, and
- The previous Holly Pond Sedimentation Study (CH2M Hill, 2010).

6.1.2.1 The Model

The H&H modeling effort was critical to evaluate project alternatives and inform the design of effective and practical sustainable solutions. A watershed model allowed for more complete understanding of stormwater runoff and sediment transport within the Noroton River watershed. A stream model analysed sediment transport/mobility and downstream tidal boundary conditions within the river.

The existing conditions model is a HEC-RAS model developed by the United States Army Corps of Engineers. The SIAM module, or Sediment Impact Assessment Model, is used in conjunction with HEC-RAS to analyse sediment transport in the system. Several strategies were used in the analysis of the existing conditions model.

The 16 areas identified as highly eroded with a high or very high shear stress in the Holly Pond River Assessment - Field and Analytical Data Report (CH2M Hill, 2009) were identified in the model. The model contains a total of 235 cross sections along the 3.5 mile stretch surveyed. 46 cross sections are identified as unstable along the Noroton River from the inlet of Holly Pond to Camp Avenue. In addition, cross sections in the model were identified as mechanically stable based on the 2015 field visit and Holly Pond River Assessment - Field and Analytical Data Report (CH2M, 2009). *Figure 23* is one of the cross sections identified with unstable conditions in the model. *Figure 24* is one of the cross sections identified with stable conditions in the model.

To continue with the analysis, the model cross sections were categorized into 16 different SIAM sediment reaches based on ARC SWAT Noroton River watershed subbasins. Each sediment reach has different hydraulic characteristics defined by the SIAM module. The SIAM sediment properties of each reach, established in the Holly Pond River Assessment - Field and Analytical Data Report (CH2M Hill, 2009), were examined for each erosion area.

The following streambed characteristics were identified for each erosion area in the HEC RAS model:

- Bankfull Elevations
- 2-year Storm Flow
- Maximum Shear Stress
- Streambank Slope
- Sediment Bedload
- Sediment Accumulation at each Basin Output
- Sediment Transport

6.1.2.2 Site Visit

In order to select the most appropriate streambank protection technique, a site visit was conducted to determine and define the mechanism of failure causing the streambank erosion to occur. During the November 2015 site visit to the Noroton River and Holly Pond, reach based causes were identified by characterizing physical conditions of the channel in each erosion area, as well as stable areas and areas where stabilization techniques are currently in use. *Table 12* presents data gathered during the site visit.

Table 12: Data Gathered During Site Assessment

FEATURES	DATA COLLECTED/VERIFIED
Channel Cross-Section Geometry	Cross Section Widths, Bankfull Indicators, Max Bankfull Depths, Streambank Height
Plan Form/Flow Patterns	Low Flow and Bankfull Indicators, Geometry/Sinuosity, Floodplain Access and Obstructions
Scouring/Stability	Verification of Bank Soils, Bed Materials and Armoring, Depth of Scour Holes Identified In Model
Vegetation	Location on Streambank, Percent Coverage

FEATURES	DATA COLLECTED/VERIFIED
Sediment Transport Indicators	Bed Material Diversity, Quantity Excess/Scarce
Man-Made Features Impacting Flows	Bridges, Weirs, Armored Streambanks, Culverts

Photos taken onsite were taken at each erosion area from several perspectives. In *Figure 25* toe erosion has occurred causing mass failure of the streambank. In this particular reach of the Noroton River, seven erosion areas were identified. These seven areas have a reduced vegetative bank structure and weak streambank soils. The right bank of the river is composed of urban development thus contributing stormwater runoff as concentrated and sheetflow into the system.

Concentrated scour is most likely caused by Maple Tree Avenue as shown in *Figure 26*. Erosion Area 6 is immediately downstream from a bridge. In addition, there is a culvert outfall on the right bank of the Maple Tree Avenue bridge directing flow into the direction of the left bank just below the bridge, the eroded area shown in *Figure 27*. Immediately upstream of the failed bank the left bank is armoured with boulder rip-rap. Scour concentration points were identified by finding greater streambank erosional forces, as depicted in *Figure 27*. Mass failure on this erosion area were most likely triggered by excess runoff and drainage from stormwater outfalls on the slope (multiple pipes were identified in the failed section of bank, but with no flow observed) from the subdivision. In conjunction with the increased saturation of soils along steep channel banks caused by development, increased velocities from the rail line crossing immediately upstream (with rip-rap reinforced banks on the toe) would significantly increase shear stress along this bending bank area and lead to failure.

In this alluvial channel, the average channel slope at the 16 erosion areas is 1:1, and in non-hardened stable reaches average at 2:1, documented by analysis of cross sections and confirmed by site assessment. The average sediment load in the streambed visualized on site (D50) is medium gravel. The average sediment load on the streambanks visualized on site (D50) is medium sand. This site assessment is confirmed in the Holly Pond River Assessment - Field and Analytical Data Report (CH2M Hill, 2009). Fine streambank sediment can clearly be seen in *Figure 28*.

6.1.3 Design Criteria

The next task, desirable design criteria, introduced performance measures as preventing, reversing, and minimizing mechanisms of failure to achieve stable streambanks and enhance lotic ecology reducing downstream sediment deposits. This provides a comparison of channel characteristics between reaches with severely eroded banks to areas within reference reaches of the study limits that show a natural flow with stabilized banks. Design criteria was developed as follows:

- Bank toe stabilization measures taken shall resist high near bank shear stress.
- The bank protection above the water level that occurs at the two-year discharge shall resist maximum shear stresses. Maximum shear stresses were calculated by the SIAM sediment transport HEC-RAS model as feet per second (ft/s) per each sediment reach.
- Stabilization measure must be able to redirect flow and forces away from channel banks.
- Lotic ecology shall be enhanced and promoted. Fish passage shall not be impeded by introduction of stabilization measure.
- Stabilization structures shall be aesthetically pleasing.

6.1.4 Structure Alternatives Analysis

Refer to *Appendix D* for Bank Stabilization Techniques, which was used to evaluate design stabilization structure alternatives based on the design criteria. Categories were chosen based on design criteria from the work plan as well as general H&H engineering requirements and soil bioengineering guidelines. Recognizing that these restoration activities would likely occur on private property the alternatives have also been evaluated on the basis of aesthetics concerns. The thirty-five techniques were chosen for the analysis as they are currently in use by the CTDEEP and are appropriate for Noroton River channel geometry. The green shaded techniques are the chosen proposed measures for the Noroton River streambank stabilization as will be discussed in the section to follow. The yellow shaded techniques were chosen as alternatives to the stabilization measures proposed.

6.1.5 Proposed Condition Analysis

Hydraulic analyses were conducted to evaluate the alternatives. The HEC-RAS hydraulic model with SIAM extension was used to assess the suitability of each proposed bank stabilization measure chosen. To run the proposed alternatives in the HEC RAS model, each of the 46 cross sections identified as erosion areas needed to be manipulated to model proposed geometry and bank material. Each proposed stabilization measure was coded into the HEC RAS model geometry data using engineering design guidelines to produce new dimensions. The hydraulic design of each erosion areas was also manipulated in the SIAM counterpart of HEC RAS which included coding in the streambank sediment material. For example, the difference in wash load of re-established native plant community verses the existing non-vegetated bank area was incorporated into the bioengineering stabilization measures coded into the hydraulic model.

The model output predicted the impact of stabilized streambanks in comparison to existing conditions. Shear stress, slope, flow, velocity, sediment load, and sediment deposition were all factors aiding in the proposed verses existing model comparison. Three perspectives were analysed; watershed, SIAM sediment reach, and individual cross sections. The change in sediment deposition in the Holly Pond sediment shoal was evaluated for reduction in volume.

The following stabilization measures reached the design criteria and predicted suitable results during the proposed condition analysis. *Table 13* introduces a summary of the proposed stabilization measures, while

Table 14 introduces the specific measures for each erosion area. *Figure 29* and *Figure 30* introduce the location of each erosion area as well as the limit of impact for each measure.

Table 13: Proposed Stabilization Measures

PROPOSED STABILIZATION MEASURES	
BANK SHAPING & TOE STABILIZATION	Live Stakes
	Native Seeding/Planting
	Coir Fiber Matting
	Native Material Revetment (Boulder, Rootwad)
BANK RESTORATION & TOE STABILIZATION	Live Stakes
	Native Seeding/Planting
	Coir Fiber Matting
	Native Material Revetment (Boulder, Rootwad)
VEGETATED GEOGRID	Live Stakes
	Native Live Cuttings
	Wrapped Geotextile Fabric
	Rock Toe
HARD ARMORING	Boulder Wall
	Joint Planting
	Bank Revegetation
ADDITIONAL RESTORATION MEASURES	In-Stream Sediment Shoal Removal
	Boulder Placement for Habitat Enhancement

Table 14: Proposed Stabilization Measures per Erosion Area

PROPOSED STABILIZATION MEASURES PER EROSION AREA		
1	**ER 1A**	Hard Armoring - Boulder Rock Wall: Joint Planting, Restored Slope with Erosion Matting where Needed, Live Stakes, Native Planting
2	**ER 22**	Vegetated Geogrid; Live Stake Plantings, Native Cuttings, Erosion Control Matting, seeding, Boulder Toe
3	**ER 1**	Native Material Toe Revetment; Soil reinforcement and Herbaceous Cover; Live Stake Plantings, Erosion Ctrl Matting, Seeding, and Native Vegetation Planting
4	**ER 2**	Bank Shaping with Native Material Toe Revetment; Soil reinforcement and Herbaceous Cover; Live Stake Plantings, Erosion Ctrl Matting, Seeding, and Native Vegetation Planting
5	**ER 6**	Hard Armoring - Boulder Rock Wall: Joint Planting, Restored Slope with Erosion Matting where Needed, Live Stakes, Native Planting
6	**ER 25**	Bank Shaping with Native Material Toe Revetment; Soil reinforcement and Herbaceous Cover; Live Stake Plantings, Erosion Ctrl Matting, Seeding, and Native Vegetation Planting
7	**ER 27**	Bank Shaping with Native Material Toe Revetment; Soil reinforcement and Herbaceous Cover; Live Stake Plantings, Erosion Ctrl Matting, Seeding, and Native Vegetation Planting

PROPOSED STABILIZATION MEASURES PER EROSION AREA		
8	ER 29	Bank Shaping with Native Material Toe Revetment; Soil reinforcement and Herbaceous Cover; Live Stake Plantings, Erosion Ctrl Matting, Seeding, and Native Vegetation Planting
9	ER 31	Bank Shaping with Native Material Toe Revetment; Soil reinforcement and Herbaceous Cover; Live Stake Plantings, Erosion Ctrl Matting, Seeding, and Native Vegetation Planting. Remove in-stream Large Sediment Shoal, Place Boulders for Habitat Enhancement.
10	ER 34	Bank Shaping with Native Material Toe Revetment; Soil reinforcement and Herbaceous Cover; Live Stake Plantings, Erosion Ctrl Matting, Seeding, and Native Vegetation Planting. Rootwad Revetment on Toe of Bend. Boulder Revetment at Tennis Court Edge.
11	ER 35	Bank Shaping with Native Material Toe Revetment; Soil reinforcement and Herbaceous Cover; Live Stake Plantings, Erosion Ctrl Matting, Seeding, and Native Vegetation Planting.
12	ER 36	Bank Shaping with Native Material Toe Revetment; Soil reinforcement and Herbaceous Cover; Live Stake Plantings, Erosion Ctrl Matting, Seeding, and Native Vegetation Planting.
13	ER 12	Native Material Toe Revetment; Soil reinforcement and Herbaceous Cover; Live Stake Plantings, Erosion Ctrl Matting, Seeding, and Native Vegetation Planting.
14	ER 15	Native Material Toe Revetment; Soil reinforcement and Herbaceous Cover; Live Stake Plantings, Erosion Ctrl Matting, Seeding, and Native Vegetation Planting.
15	ER 17	Bank Shaping with Native Material Toe Revetment; Soil reinforcement and Herbaceous Cover; Live Stake Plantings, Erosion Ctrl Matting, Seeding, and Native Vegetation Planting.
16	ER 18	Native Material Toe Revetment; Soil reinforcement and Herbaceous Cover; Live Stake Plantings, Erosion Ctrl Matting, Seeding, and Native Vegetation Planting. Rootwad Revetment on Toe of Bend.

6.1.6 In-Stream Sediment Trap

An in-stream sediment trap (also known as a silt trap) is intended to create a low velocity region in which a large part of the suspended sediments will have a chance to settle out. One or several sediment traps could be constructed in the Noroton River to reduce the solid loads into Holly Pond. The size and shape of a sediment trap depends on the stream size, hydrology, and sediment load. For cost estimating purposes, a sediment trap that would physically fit immediately north of Route 1 was conceptualized at a maximum capacity of 1,000 cubic yards (if 100 percent effective at trapping solids). The cost to construct the sediment trap is approximately $1.6 million, which includes design and construction, but does not include maintenance. Since data and model results indicate that the shoals are mostly sand and are currently in equilibrium (refer to Section 4), this alternative was not evaluated further because it presents little value if the intent is to prevent further deposition in the Holly Pond shoal areas. Also, solid loads may be better managed with BMPs before they reach the river as presented in Section 7.

6.1.7 Summary of Results

Streambank stabilization measures are proposed to stabilize the severely eroded channel reaches in the Noroton River. The results of the HEC RAS model with SIAM module, field visit, Connecticut case studies, and the Holly Pond Sedimentation Study report (CH2M Hill, 2010) were integrated into the selection of streambank protection treatments. A matrix was used to evaluate design stabilization structure alternatives based on the design criteria. To assess the suitability of the proposed bank stabilization alternatives, a proposed conditions HEC-RAS model was developed. The HEC-RAS proposed conditions model predicted design performance, the impact of stabilized streambanks on the Holly Pond sediment shoal, and allowed for existing conditions versus proposed conditions comparison.

The draft proposed stabilization measures combine flow-redirection techniques, structural techniques, biotechnical techniques, bank reshaping, and habitat restoration. Each measure contains several techniques and remedies the mechanisms of failure through evaluating the design criteria for each individual erosion area.

6.2 Cost Estimate

The costs for this alternative is generated for the stabilization of the 16 erosion areas that were identified based on field visits conducted in 2015 and the Holly Pond River Assessment - Field and Analytical Data Report. (CH2M Hill, 2009). The quantities for the items needed to carry out the four different types of comprehensive stabilization methods were done during the conceptual design for this alternative. Bank Shaping and Toe Stabilization, Bank restoration and Toe Stabilization, Vegetated Geogrid with Bank Restoration and Boulder Rock Wall with Bank Restoration and Joint Planting were the stabilization measures considered. The unit prices for costs related to each stabilization measures items was obtained from previous Louis Berger experience with similar kind of projects that have been design-built. *Table 15* displays the conceptual cost estimates for the stabilization of the Noroton River streambanks. For more information regarding the cost estimate, please refer to Section 5.2 of this report and *Appendix C*.

Table 15: Conceptual Cost Estimate for Stabilization of Noroton River Streambanks

NOROTON RIVER STREAMBANK STABILIZATION MEASURES	
	TOTAL COST
STABILIZATION FOR 16 AREAS	$1,600,000

7 Task 4: Management of Peak Stormwater Discharge Volumes

7.1 Alternatives Analysis

7.1.1 Introduction

As part of Task 4, Louis Berger has been tasked to recommend an approach to manage peak stormwater discharge volumes in the Holly Pond watershed. This approach would improve stormwater management using a combination of pollution prevention and structural controls to reduce runoff volumes contributing to excessive erosion within the Noroton River as well as reduce the discharge of pollutants and sediment. The primary objective is to target groundwater recharge via low impact development best management practices (LID BMPs).

7.1.2 Watershed Reconnaissance

A conceptual screening analysis of the sub-subwatersheds contributing to targeted outfalls is necessary to select cost effective, technically feasible, and environmentally acceptable BMPs to meet stormwater flow and sediment reduction goals. GIS mapping of land use, available reports, soils data, and results of H&H modeling was used to identify major stormwater outfalls to the Noroton River system.

Use of the H&H modeling developed for previous tasks inspired the starting point for analysis. Results from watershed modeling concluded 56% of the total sediment yield (tons/year) emanates from subwatershed 4 of the Holly Pond watershed. Subwatershed 4, the northeastern watershed, contributes about 2,500 of the total 4,500 tons of silt per year to the outlet of the Noroton River into Holly Pond. Subwatershed 4 is shown in *Figure 31*.

After isolating subwatershed 4, the 1.4 square miles were modelled through the SWAT model interface to refine locations contributing to sediment discharge. SWAT model components and input data remained the same as discussed in Section 4 of this report. Upon analysis of SWAT results, two subwatersheds within subwatershed 4 are of major concern. *Figure 32* depicts the two subwatersheds contributing significant sediment yield into the watershed system.

The sub-subwatersheds were further studied to analyse sources of runoff. Both sub-subwatersheds are made up of residential and forested land. The soils ranged from fine sandy loam to very rocky soils. The USDA NRCS Custom Soil Resource Report for each sub-subwatershed are attached as *Appendix E*. The elevations in area 16 range from 174 feet to 376 feet NAVD88 and the elevations in area 19 range from 174 to 393 feet NAVD88. The change in slope in both sub-subwatersheds is maximum 1:1, not including streambank slope. Elevation change can be seen in *Figure 33*. Upon completion of the watershed reconnaissance, the chosen areas for BMPs are sub-subwatersheds 19 and 16 within Holly Pond subwatershed 4.

7.1.3 Design Criteria and Structure Alternatives

The next step in this task is to develop desirable design criteria, introduced performance measures as preventing, reversing, and minimizing discharge and sediment yield to achieve improved stormwater management watershed-wide. Design criteria was based upon recommendations from the 2004 Connecticut Stormwater Quality Manual (CTDEEP 2004). In addition, structure alternatives will be analysed for sub-subwatershed compatibility.

Design criteria was developed as follows:

- BMPs must reduce runoff volume and rate, increase groundwater recharge, and increase runoff water quality in selected sub-subwatershed.
- BMPs must remove at least 80% of the average annual total suspended solids (TSS) load.
- BMPs chosen must be capable of acceptable performance or operational longevity in the field.
- BMPs must be properly selected, sited, designed, constructed, and maintained in accordance with the guidelines contained in the 2004 Connecticut Stormwater Quality Manual.

The 2004 Connecticut Stormwater Quality Manual was used to evaluate design stabilization structure alternatives based on the design criteria. Alternatives were chosen based on the manual, design criteria above as well as general H&H engineering requirements and soil bioengineering guidelines. Land use, physical feasibility criteria, maintenance factors, winter conditions, as well as consideration to natural wetlands and vernal pools were taken into consideration through use of the manual. A summary of the Connecticut Statewide Stormwater Criteria for sizing the BMPs is provided in *Table 16*.

Table 16: Summary of the Connecticut Statewide Stormwater Criteria [a]

SIZING CRITERIA	DESCRIPTION OF STORMWATER SIZING CRITERIA
Water Quality Volume (WQ_v) (acre-feet)	$WQ_v = \frac{[(P)(Rv)(A)]}{12}$ *P* = rainfall depth in inches and is equal to 1.0” in the Eastern Rainfall Zone and 0.9 in the Western Rainfall Zone. R_v = volumetric runoff coefficient *A* = area in acres
Recharge volume (Re_v) (acre-feet)	Fraction of WQ_v, depending on predevelopment soil hydrologic group. $Re_v = \frac{[(S)(Rv)(A)]}{12}$ *S* = soil specific recharge factor in inches.
Channel protection storage volume (Cp_v)	$CP_v = 24\ hour$ (12 hour in USE II and IV watersheds) extended detention of post-developed one-year, 24-hour storm event. Not required for direct discharges to tidal waters and the Eastern Shore of Maryland.
Overbank flood protection volume (Q_v)	Controlling the peak discharge rate from the 10-year storm event to the predevelopment rate (Q_{p10}) is optional; consult the appropriate review authority. For Eastern Shore: provide peak discharge control for the 2-year storm event (Q_{p2}). Control of at the 10-year storm event is not required (Q_{p10}).
Extreme flood volume (Q_1)	Consult with the appropriate reviewing authority. Normally, no control is needed if development is excluded from 100-year floodplain and downstream conveyance is adequate.

a. *Source: The Bioretention Manual 2009*

The three BMPs listed in *Table 17* reached the design criteria and predicted suitable results during the proposed condition analysis. These three BMPs were chosen as alternatives for the two sub-subwatersheds. Conceptual designs of the selected alternatives are depicted in *Figure 34, Figure 35,* and *Figure 36*.

Table 17: Chosen BMPs for Sub-subwatersheds

PROPOSED BMPS	
1	EXTENDED WET DETENTION POND
2	INFILTRATION BASIN
3	BIORETENTION AREAS

The selection of suitable BMPs is conditional on the design criteria shown below for each BMP in *Table 18, Table 19,* and *Table 20*. Specifically, the contributing drainage area is the limiting factor. Sub-subwatershed 16 contributes a drainage area of 89 acres and sub-subwatershed 19 contributes a drainage area of 152 acres to subwatershed 4. The minimum contributing drainage area for an extended wet detention pond is 25 acres, which makes it a suitable BMP for sub-subwatersheds 16 and 19. The maximum contributing drainage area for an infiltration basin is 25 acres and for a bioretention area it is 2 acres. The contributing drainage areas for sub-subwatersheds 16 and 19 surpass the recommended limit for an infiltration basin or a bioretention area; however, further detailed studies could identify smaller drainage areas within the sub-subwatersheds that could benefit from these BMPs. Therefore, infiltration basins and bioretention areas should be considered in future evaluations.

Table 18: Design Criteria for Extended Wet Detention Pond [a]

PARAMETER	DESIGN CRITERIA
Setback requirements [b]	❍ 50 feet from on-site sewage disposal systems ❍ 50 feet from private wells ❍ 10 feet from a property line ❍ 20 feet from any structure ❍ 50 feet from any steep slope (greater than 15%) ❍ 750 feet from a vernal pool
Preferred Shape	Curvilinear
Side Slopes	3:1 maximum or flatter preferred
Length to Width Ratio	3:1 minimum along the flow path between the inlet and outlet; flow length is the length at mid-depth (avg. top width+avg. bottom width)/2
Pretreatment Volume	Forebays are highly recommended for wet ponds and sized to contain 10% of the WQV. For sites with potential for higher

PARAMETER	DESIGN CRITERIA
	pollutant loads (see Chapter Seven), 100% of the WQV must receive pretreatment.
Pond Volume	Minimum pond volume, including pretreatment volume, should be equal to or exceed the WQV.
Drainage Area	Minimum contributing drainage area is 25 acres for wet ponds, 10 acres for extended detention basins, and 1-5 acres for pocket ponds.
Underlying Soils	Low permeability soils are best (NRCS Hydrologic Soil Group A and B soils require modifications to maintain a permanent pool unless groundwater is intercepted).
Capacity	The minimum ratio of pool volume to runoff volume must be greater than 2:1 and preferably 4:1. A 4:1 ratio provides 85-90% sediment removal based on a residence time of two weeks.
Depth	❍ An average pool depth of 3 to 6 feet is recommended and varying depths in the pond are preferred. ❍ The aquatic bench should be 12-18 inches deep. ❍ Ponds should not be greater than 8 feet deep.

a. *Source: 2004 Connecticut Stormwater Quality Control Manual*
b. Minimum requirements. State and local requirements supersede.

Table 19: Design Criteria for Infiltration Basin [a]

PARAMETER	DESIGN CRITERIA
Design Volume	Entire water quality volume (WQV)
Pretreatment Volume	25% of WQV
Maximum Draining Time	48 to 72 hours after storm event (entire WQV)
Minimum Draining Time	12 hours (for adequate pollutant removal)
Maximum Contributing Drainage Area	Basin: 25 acres (10 recommended)
Minimum Infiltration Rate	0.3 in/hr (as measured in the field), lower infiltration rates may be acceptable provided sufficient basin floor area is provided to meet the required WQV and drain time
Maximum Infiltration Rate	5.0 in/hr (as measured in the field); pretreatment required for infiltration rates over 3.0 in/hr
Depth	Basin: 3 feet (ponding depth) recommended, unless used as combined infiltration and flood control facilities

a. *Source: 2004 Connecticut Stormwater Quality Control Manual*

Table 20: Design Criteria for Bioretention Areas [a]

CRITERIA	FILTRATION DESIGN	INFILTRATION DESIGN
General Feasibility		
Location	All locations okay with underdrain	*In situ* soils to be certified suitable
Drainage Area	2 acres maximum, 1 acre maximum impervious	1 acres maximum, ½ acre maximum impervious
Soils infiltration rate	See soil mixture specifications	*In situ* soils 1" /hour infiltration rate2
Clay Content	<5%	<5%
Hotspots	Yes w/liner	No without proper treatment
Water Table	> 2 vert. feet from facility invert	> 4 vert. feet from facility invert
Water Supply Well	Maintain > 100" distance	
Building Structures	Setback > 10-3 Downgradient	Setback > 25-3 Downgradient
Septic System	Maintain > 50' distance	
Sloped Areas	Okay with weep garden design	Not recommended greater than 20%
Property Line Setback	2' minimum	
Conveyance		
Entrance Flow	Surface sheetflow	
Entrance Treatment	Riprap gabion mattress.surge stone	
Surface Pool Dewater	3–4 hours	
System Dewater	< 48 hours	
Overflow Outlet	Safe overflow path or appropriate Outlet	Safe overflow path
Flow Path	Off-line is preferred; where not feasible, in-line is permissible	
Flow Regulator	Divert WQv	
Media Filter	Non-woven filter fabric or pea gravel diaphragm	None
Underdrain	4" diameter minimum	N/A
Pretreatment		
Pretreatment BMP	Surface	Required
Grass Filter Strip	Use where space permits. Not always feasible	
Surface Treatment	Allowable where impervious area > 75%	
Pretreatment Volume	25% of WQv	N/A
Treatment		
Volume	Entire WQv filtered – pretreatment volume	Entire WQv filtered – pretreatment volume
Porosity	n = .25 for soil mix; .40 for stone	n = .25 for soil mix

a. *Source: MDE 2000*

7.1.4 Proposed Condition Analysis

Hydraulic analyses were conducted to evaluate the three BMP alternatives. The SWAT model on the GIS interface was used to assess the effectiveness of each BMP alternative. It is important to note that this model is only a screening tool to determine the amount of sediment load that could potentially be removed in the selected area. The dimensions of the BMPs are not necessary for this evaluation nor does the model provide the dimensions of the BMPs. BMPs can be simulated with SWAT and parameterized using the ArcSWAT interface. To run the proposed alternatives in the SWAT model, each of the three alternatives were coded into the sub-subwatersheds. The model output predicted the impact of each BMP in comparison to existing conditions, the main factor in consideration being the change in sediment yield. Summary of model results can be seen in *Tables 21, 22,* and *23.*

Table 21: Proposed Conditions of Extended Wet Detention Pond BMP in Subwatershed 4 through H&H Model Results

	EXISTING CONDITIONS		EXTENDED WET DETENTION POND		
SUB-SUBWATERSHED	Existing Sediment Yield (tons/year)	Existing Sediment Yield (%)	Resulting Sediment Yield (tons/year)	Sediment Yield Reduction (%)	Proposed Sediment Yield (%)
16	1692	38%	406	86%	14%
19	785	18%	188	86%	14%

Table 22: Proposed Conditions of Infiltration Basin BMP in Subwatershed 4 through H&H Model Results

	EXISTING CONDITIONS		INFILTRATION BASIN		
SUB-SUBWATERSHED	Existing Sediment Yield (tons/year)	Existing Sediment Yield (%)	Resulting Sediment Yield (tons/year)	Sediment Yield Reduction (%)	Proposed Sediment Yield (%)
16	1692	38%	102	94%	6%
19	785	18%	47	94%	6%

Table 23: Proposed Conditions of Bioretention BMP in Subwatershed 4 through H&H Model Results

	EXISTING CONDITIONS		BIORETENTION AREAS		
SUB-SUBWATERSHED	Existing Sediment Yield (tons/year)	Resulting Sediment Yield (tons/year)	Resulting Sediment Yield (tons/year)	Sediment Yield Reduction (%)	Proposed Sediment Yield (%)
16	1692	38%	338	80%	20%
19	785	18%	157	80%	20%

7.1.5 Summary of Results

As shown in the SWAT model results, the alternative that reduces the greatest amount of sediment is the infiltration basin. However, as discussed in Section 7.1.3, the maximum contributing drainage area for an infiltration basin is 25 acres, which would not suitable for sub-subwatersheds 16 and 19, unless multiple basins are constructed or further analysis identifies a smaller area to be addressed. At this point of the analysis, the recommended alternative is constructing two extended wet detention ponds, one in each sub-subwatershed. In addition, there are existing ponds in each sub-subwatershed near the outlet which could each be restructured to incorporate extended wet detention pond design.

A draft conceptual design showing the potential locations of the proposed extended wet detention ponds can be viewed in *Figure 37*. Further studies are necessary to size the BMPs and decide on specific locations within the sub-subwatersheds.

7.2 Cost Estimate

Two extended wet detention ponds were selected as alternatives to reduce runoff volumes contributing to excessive erosion and sediment discharge through Noroton River. As further studies need to be done to quantify items needed to carry out the BMP alternatives, the cost estimates for the alternatives are approximate and vary depending on configuration, location, and site specific conditions. *Table 24* displays the conceptual cost estimates for both wet detention ponds. Costs were estimated assuming wet detentions ponds of approximately 2 acre-feet for sub-subwatershed 16 and 4 acre-feet for sub-subwatershed 19. For more information regarding the cost estimate, please refer to Section 5.2 of this report and *Appendix C*. For reference, the construction costs (not including design or contingency) for infiltration basins and bioretention areas are approximately $450 and $200 per square yard, respectively. These costs were obtained from previous Louis Berger experience with similar kind of projects that have been design-built.

Table 24: Conceptual Cost Estimate for Proposed BMPs

HOLLY POND WATERSHED LID BMP's	
	TOTAL COST
2 EXTENDED WET DETENTION PONDS	$640,000

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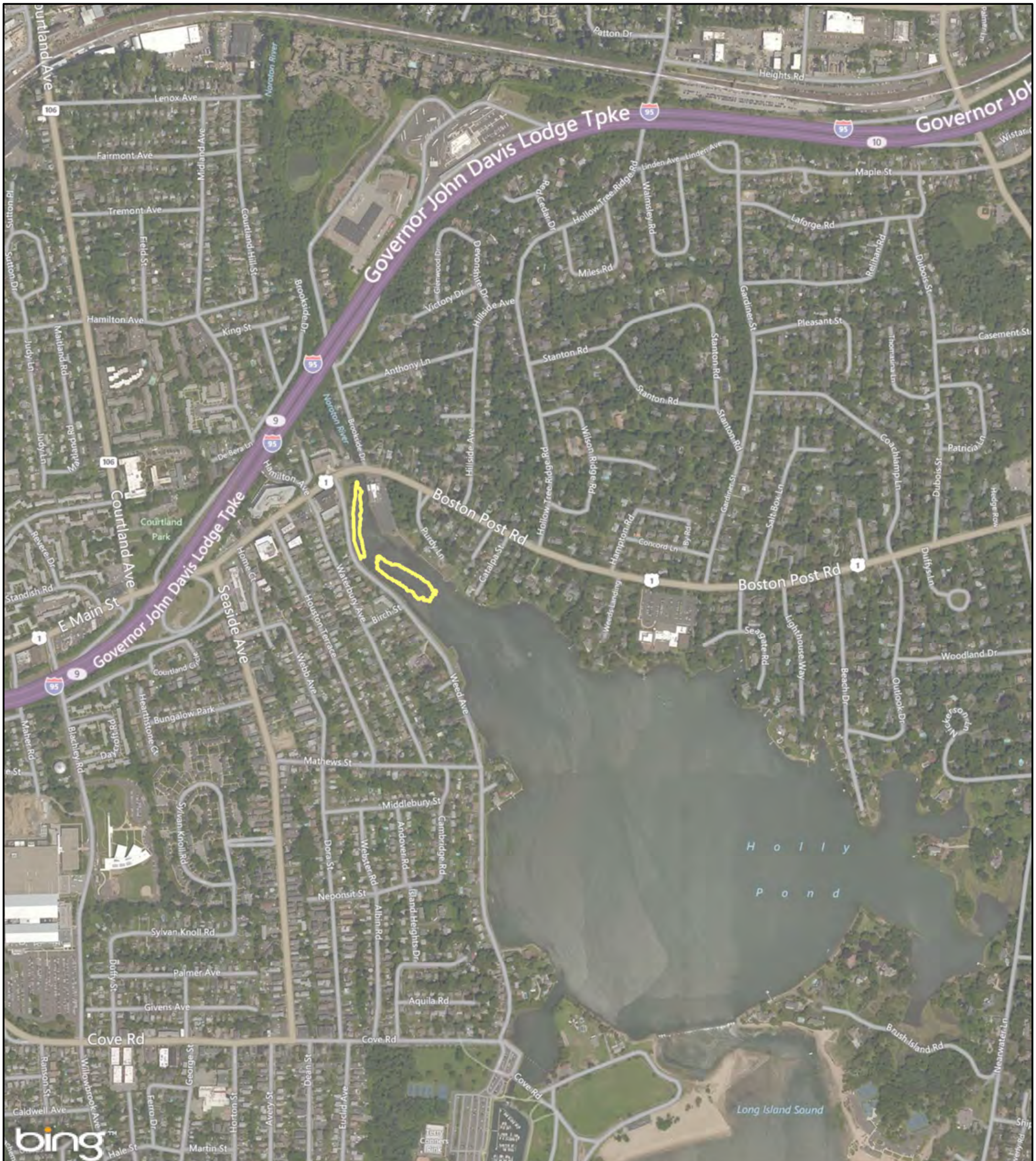
FIGURES

Figures 1 through 37



Projection:
NAD1983 State Plane Connecticut (Feet).
Sources:
ESRI BING Imagery Map Service, 2016;

June 2016

Legend

- Shoal Areas
- Project Area

Figure 1
Project Area
Fairfield County, Connecticut

Connecticut Department of Energy and Environmental Protection

Louis Berger

0 750 1,500 Feet

June 2016

Figure 2
Sediment Shoal in Holly Pond
Near Noroton River Mouth
Fairfield County, Connecticut

Louis Berger

Connecticut Department of Energy and Environmental Protection

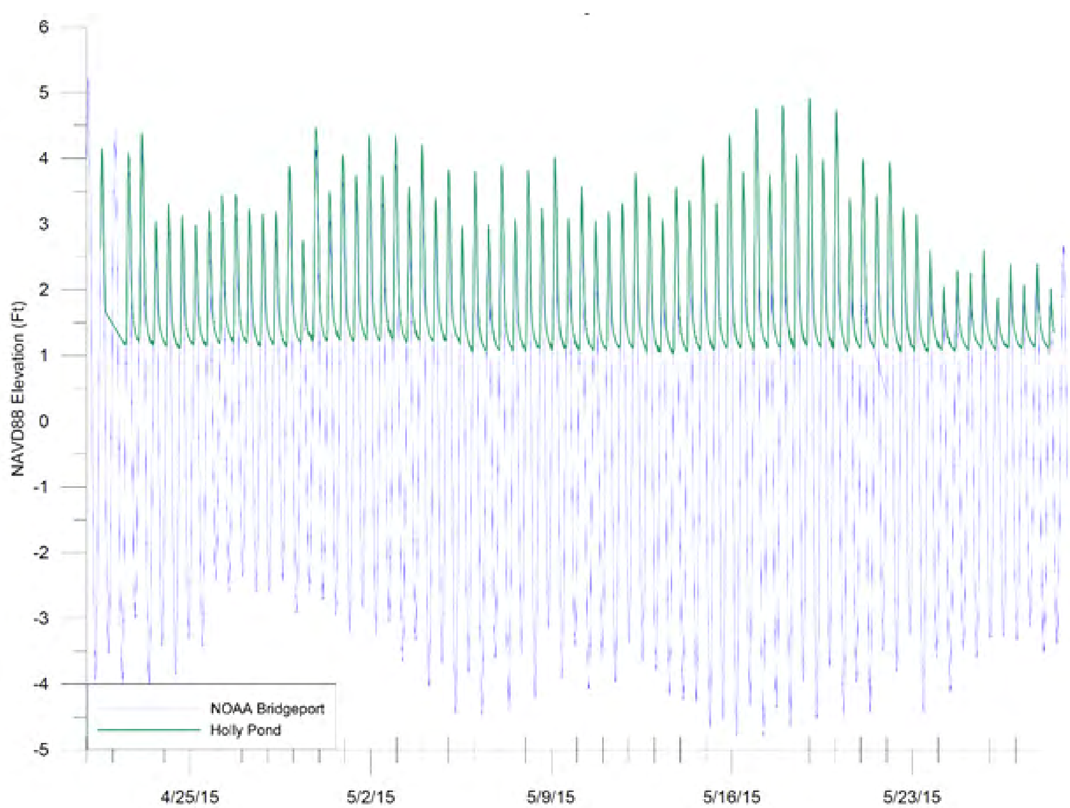


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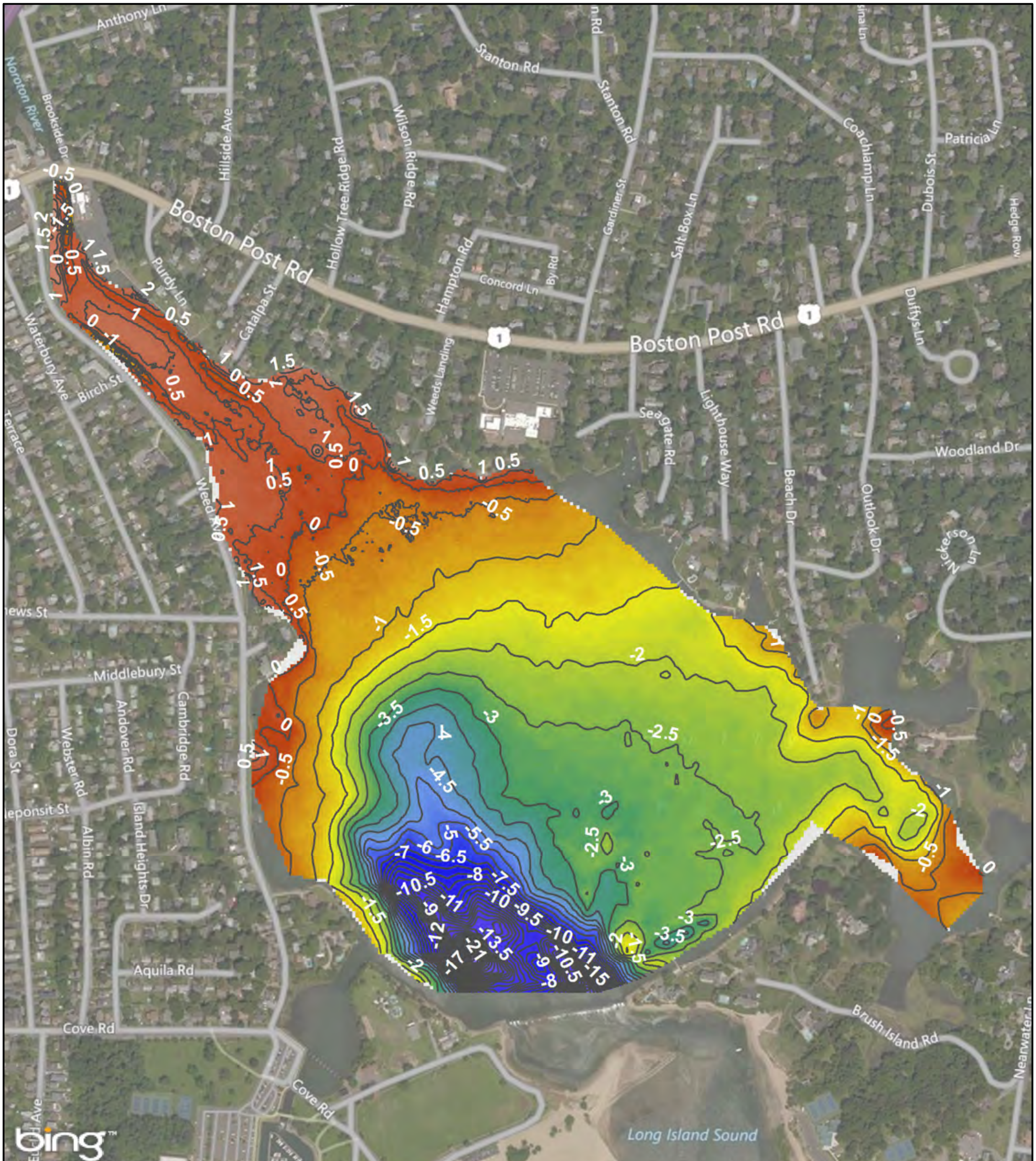
Figure 3
Holly Pond and NOAA Bridgeport #8467150 Tide Series Comparison
Fairfield County, Connecticut

Louis Berger

Connecticut Department of Energy and Environmental Protection



Projection:
NAD1983 State Plane Connecticut (Feet).
Sources:
ESRI BING Imagery Map Service, 2016;

June 2016

Legend

Bathymetric Contours

Project Area

NOTES:
1. Survey conducted 4/21/15 and 6/17/15.
2. Grid CT State Plane, NAVD88, US Foot.
3. Spectrum map uses 0.25-foot contour intervals.

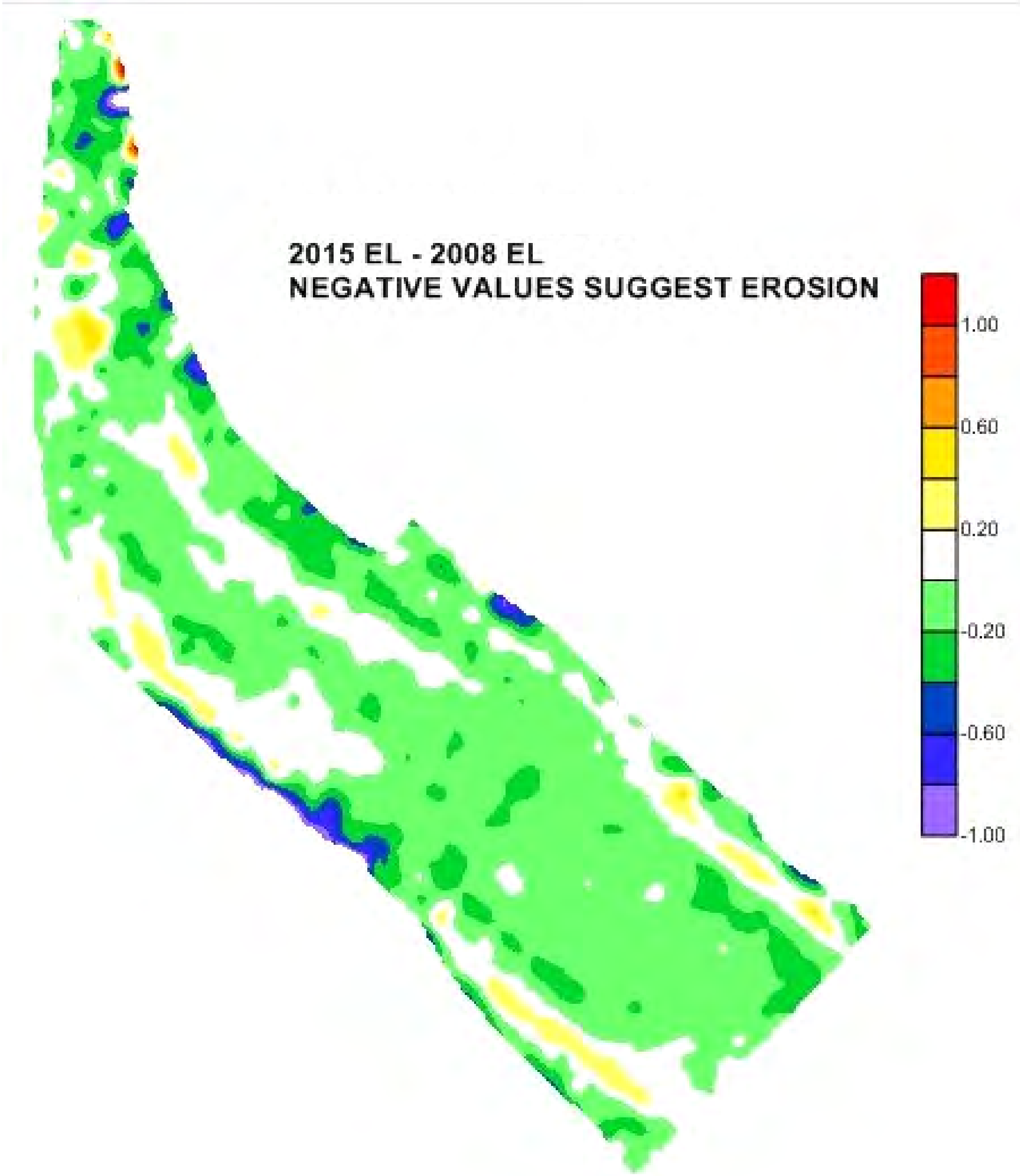
Figure 4
2015 Holly Pond Bathymetry

Fairfield County, Connecticut

Connecticut Department of Energy and Environmental Protection

Louis Berger

0 500 1,000 Feet



Projection:
NAD1983 State Plane Connecticut (Feet).
Sources:
ESRI BING Imagery Map Service, 2016;

June 2016

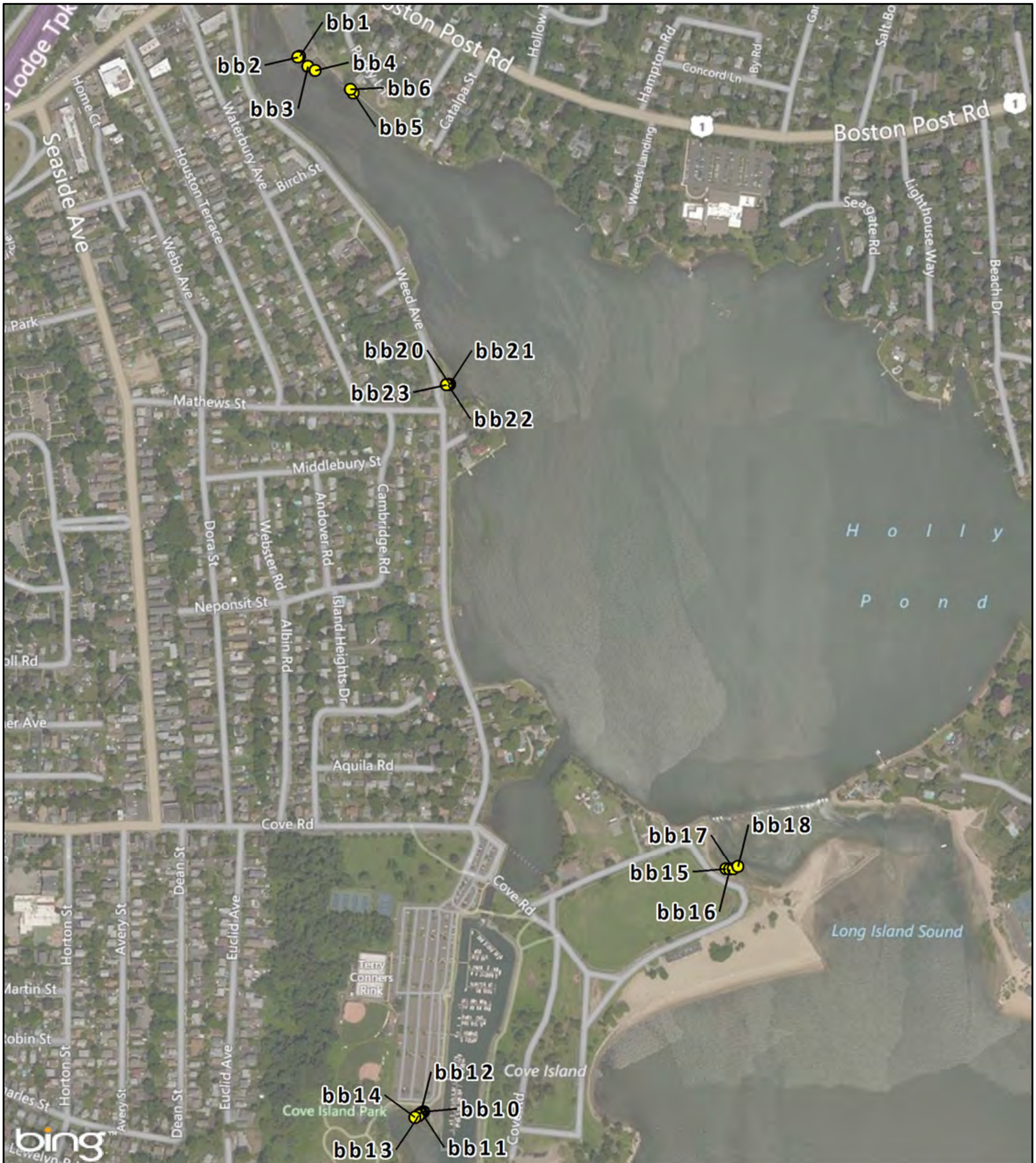
Figure 5
Comparison of 2015 and 2008 Holly Pond Bathymetry

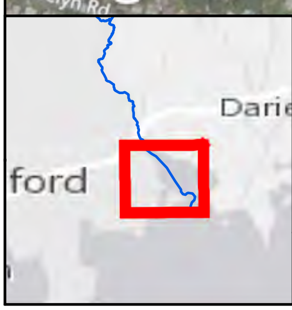
Fairfield County, Connecticut

Connecticut Department of Energy and Environmental Protection

Louis Berger

0 0.03 0.06 Miles





Projection:
NAD1983 State Plane Connecticut (Feet).
Sources:
ESRI BING Imagery Map Service, 2016;

June 2016

Legend

- Biobenchmark
- Project Area

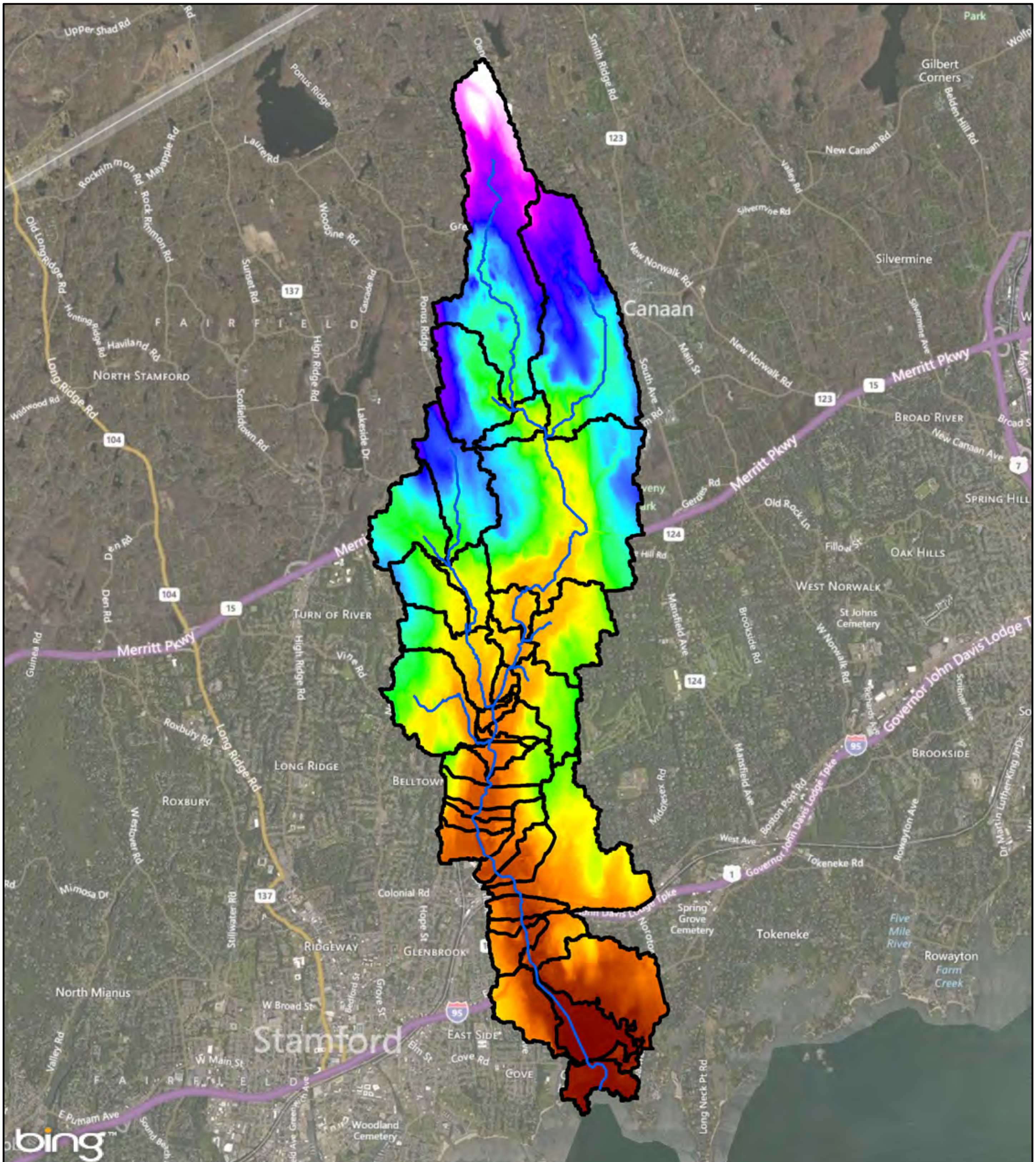
Figure 6
Holly Pond Bio-Benchmark Locations

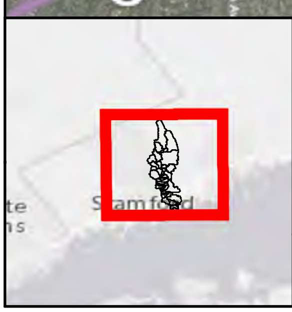
Fairfield County, Connecticut

Connecticut Department of Energy and Environmental Protection

Louis Berger

0 450 900 Feet





Projection:
NAD1983 State Plane
Connecticut (Feet).
Sources:
ESRI BING Imagery
Map Service, 2016;

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Legend

- Noroton River
- Noroton River Subbasins
- Project Area

National Elevation Dataset (NED)

Value

High : 571 feet

Low : -20 feet

Figure 7
ArcSWAT Holly Pond Watershed
Fairfield County, Connecticut

Connecticut Department of Energy and Environmental Protection

Louis Berger

0 0.8 1.6 Miles

June 2016

Figure 8
Components and Input/Output Data of SWAT Model (after Kharchaf et al., 2013)
Fairfield County, Connecticut

Louis Berger

Connecticut Department of Energy and Environmental Protection

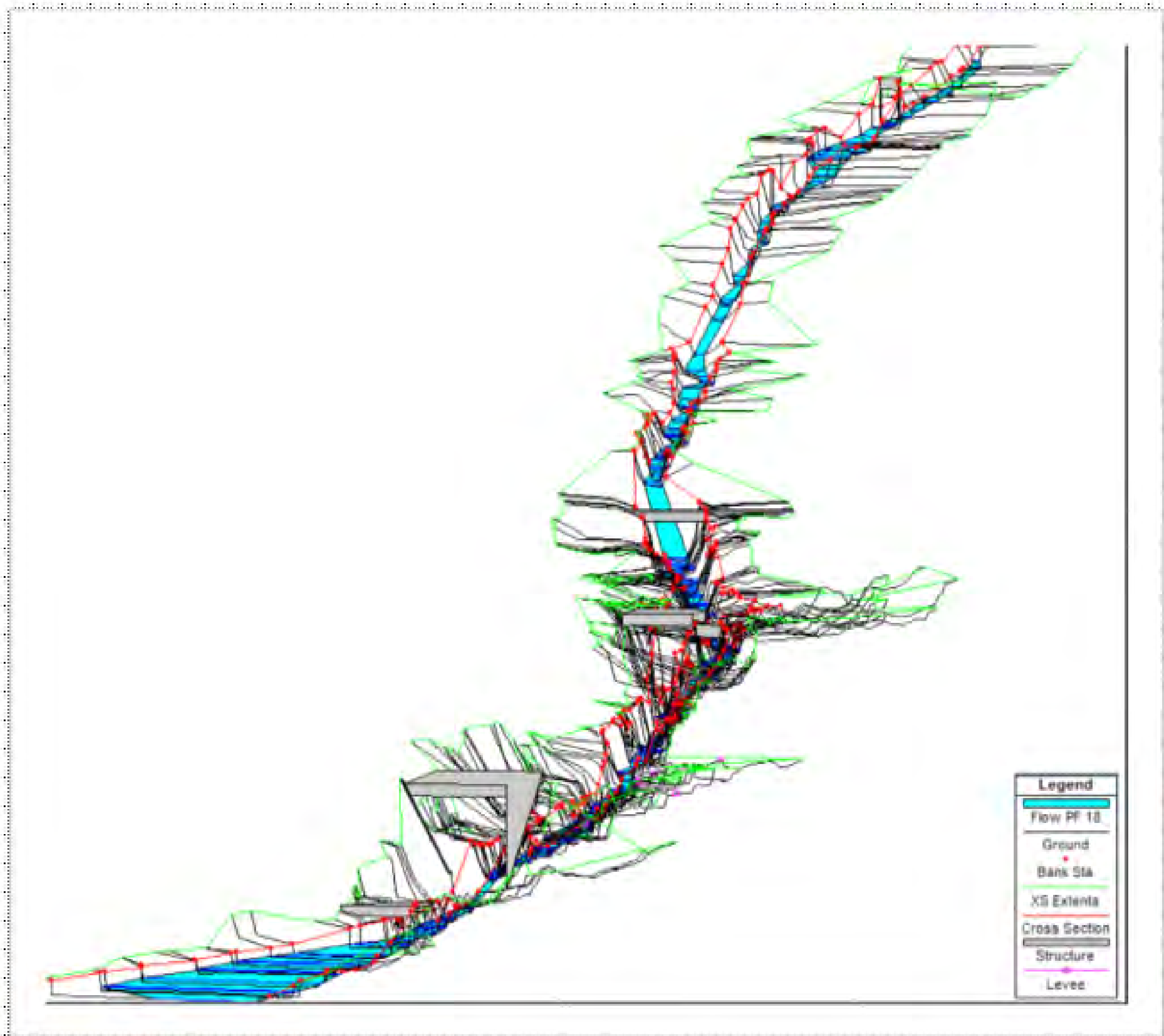

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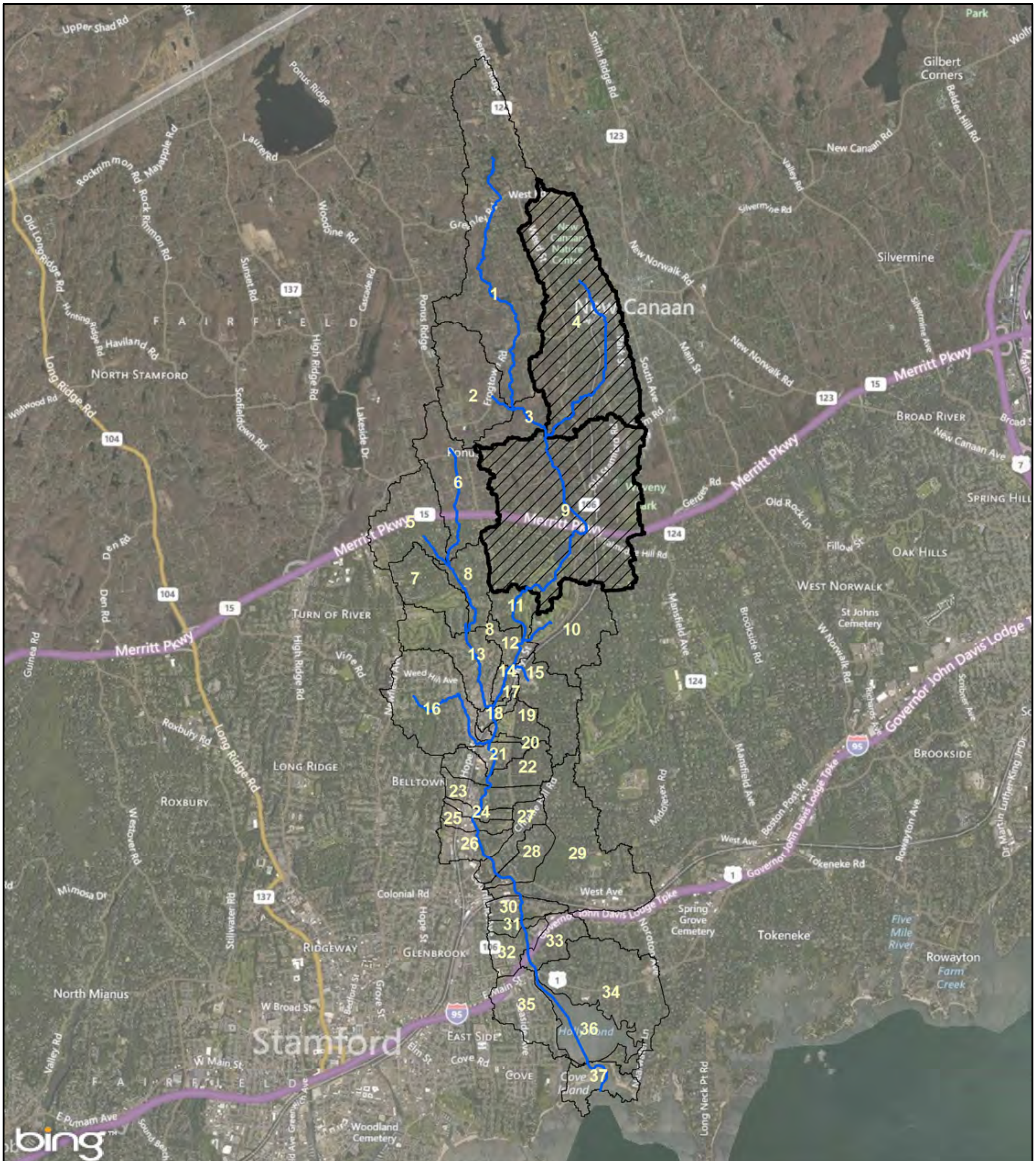
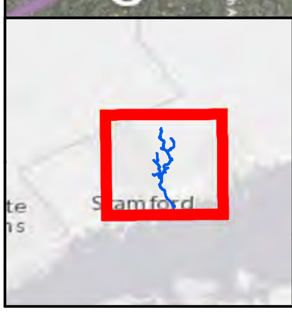
Figure 9
HEC-RAS Perspective Plot

Fairfield County, Connecticut

Louis Berger

Connecticut Department of Energy and Environmental Protection





Projection:
NAD1983 State Plane Connecticut (Feet).
Sources:
ESRI BING Imagery Map Service, 2016;

June 2016

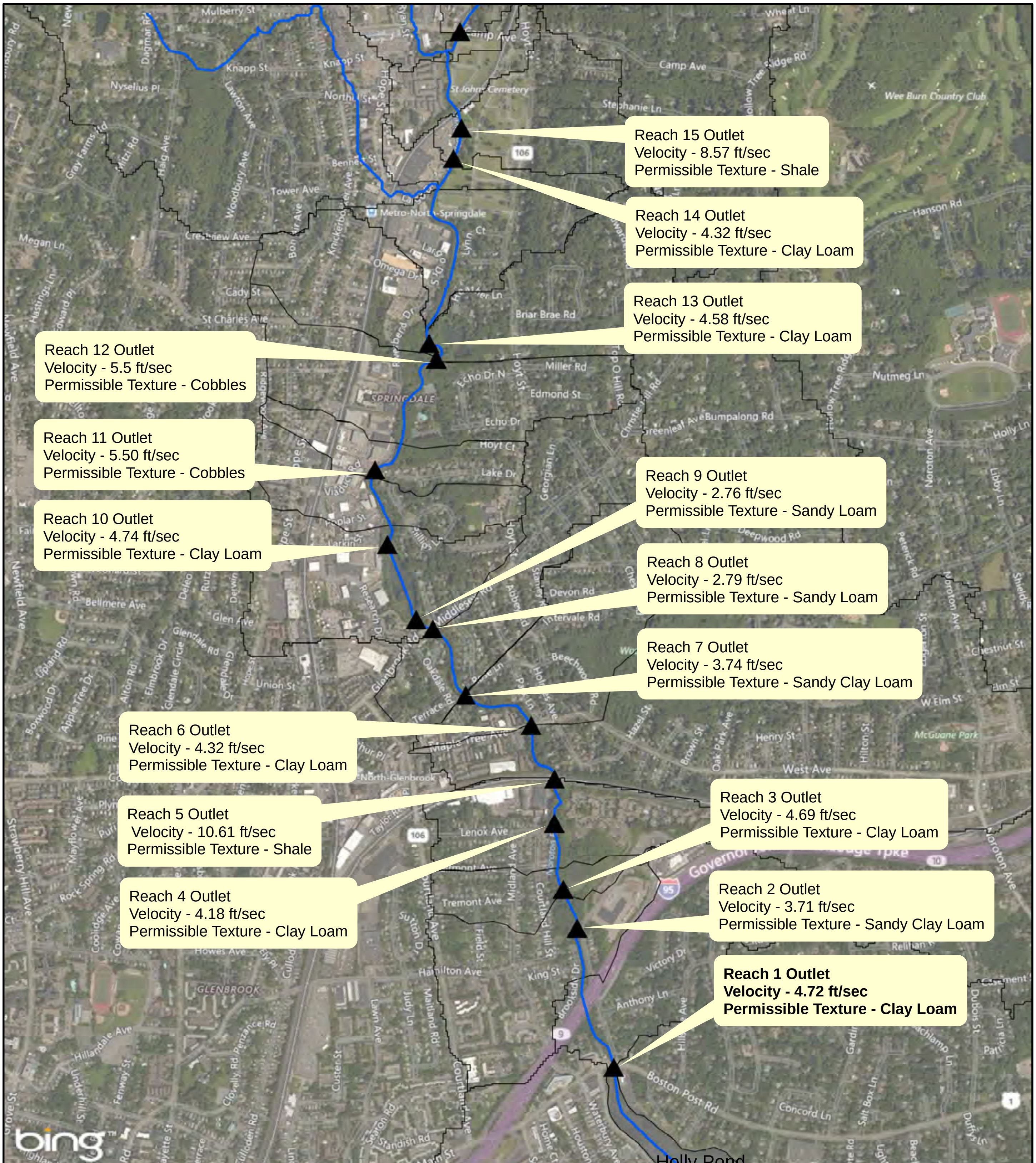
Legend

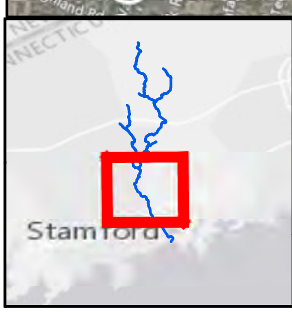
- Noroton River
- Subwatershed 4 - 55.6% Sediment Yield
- Subwatershed 9 - 17.6% Sediment Yield
- Noroton River Subbasins
- Project Area

Figure 10
SWAT Subwatersheds % Sediment Yield Per Year
Fairfield County, Connecticut

Connecticut Department of Energy and Environmental Protection
Louis Berger

0 0.75 1.5
Miles





Projection:
NAD1983 State Plane Connecticut (Feet).
Sources:
ESRI BING Imagery Map Service, 2016;

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Legend

- River Reaches
- Noroton River
- Noroton River Subbasins
- Project Area

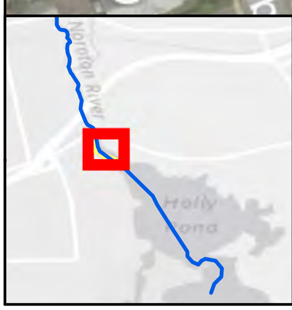
Permissible velocities for various soil textures gathered from the NJ State Soil Conservation Committee, Standards for soil erosion and sediment control in New Jersey, 2012.

Figure 11
HEC-RAS 100 Year Storm Event Max Soil Texture Passable During Outlet Storm Velocities
Fairfield County, Connecticut

Connecticut Department of Energy and Environmental Protection

Louis Berger

0 0.2 0.4
Miles



Projection:
NAD1983 State Plane Connecticut (Feet).
Sources:
ESRI BING Imagery Map Service, 2016;

June 2016

Legend

Shoal 1	
Shoal 2	

Bathymetry

All Other Values

FT NAVD88

-1.5	0
-1	0.5
-0.5	1
	1.5
	2
	2.5

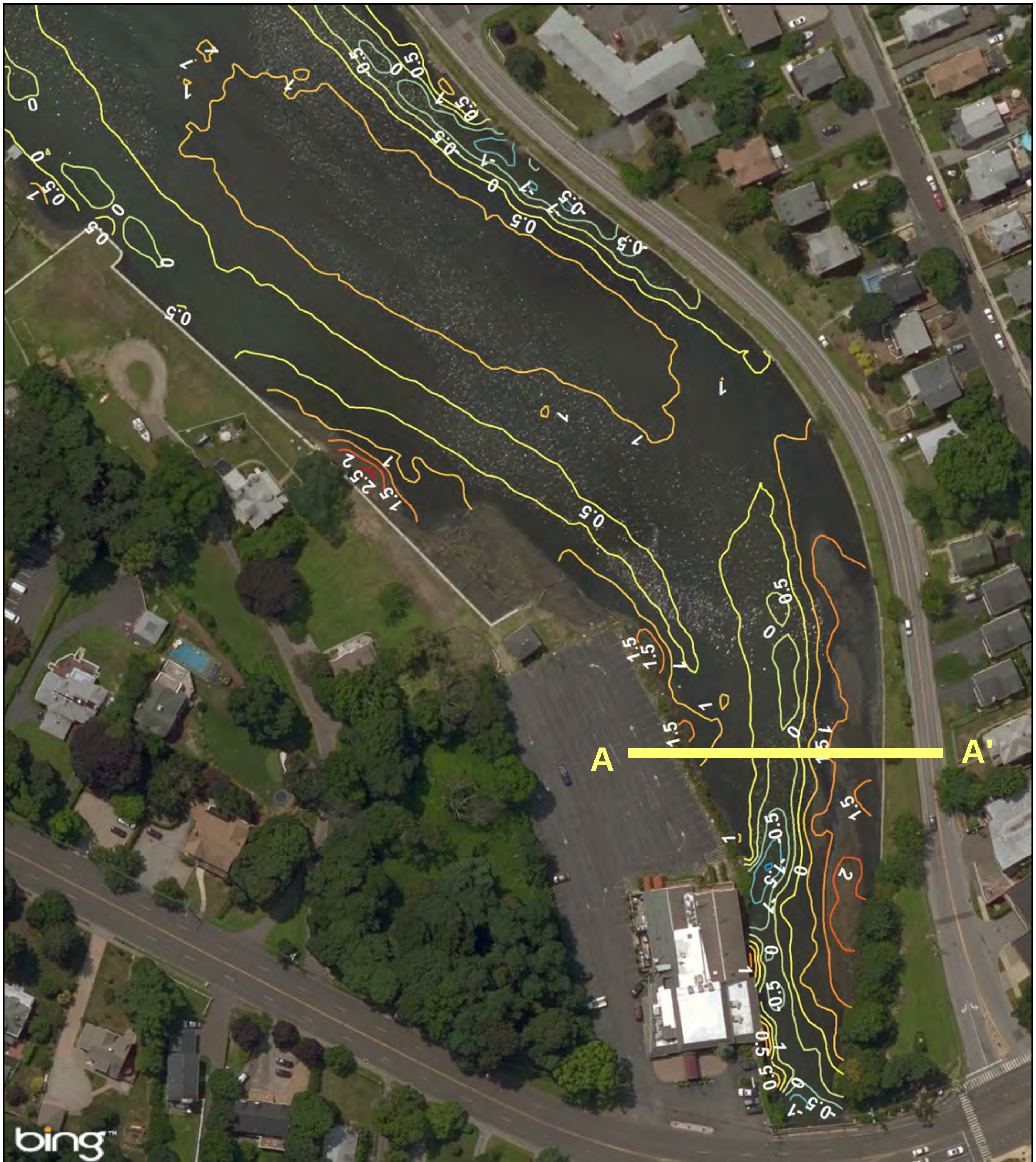
Figure 12
Holly Pond Existing Shoal Areas and Bathymetry

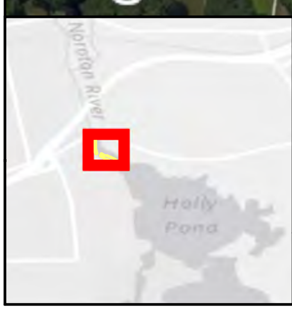
Fairfield County, Connecticut

Connecticut Department of Energy and Environmental Protection

Louis Berger

0 75 150
Feet





Projection:
NAD1983 State Plane Connecticutt (Feet).
Sources:
ESRI BING Imagery Map Service, 2016;

June 2016

Legend

Bathymetry

All Other Values

FT NAVD88

- -1.5
- -1
- -0.5
- 0
- 0.5
- 1
- 1.5
- 2
- 2.5

Figure 13

Cross Section Location

Fairfiled County, Connecticut

Connecticut Department of Energy and Environmental Protection

Louis Berger

0 75 150 Feet

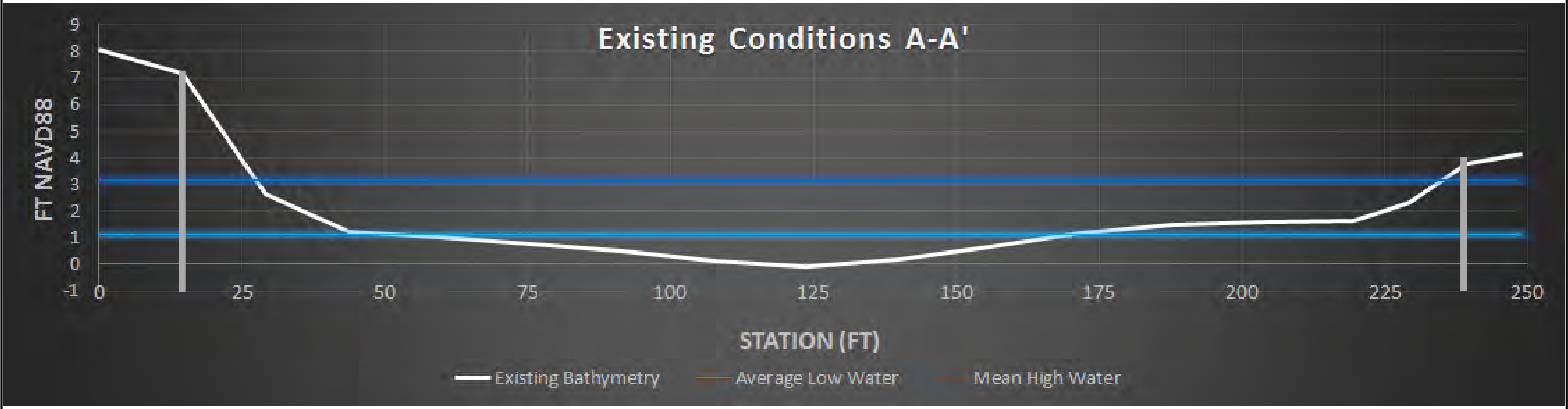


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Figure 14
Existing Conditions Cross Section

Fairfield County, Connecticut

Louis Berger

Connecticut Department of Energy and Environmental Protection

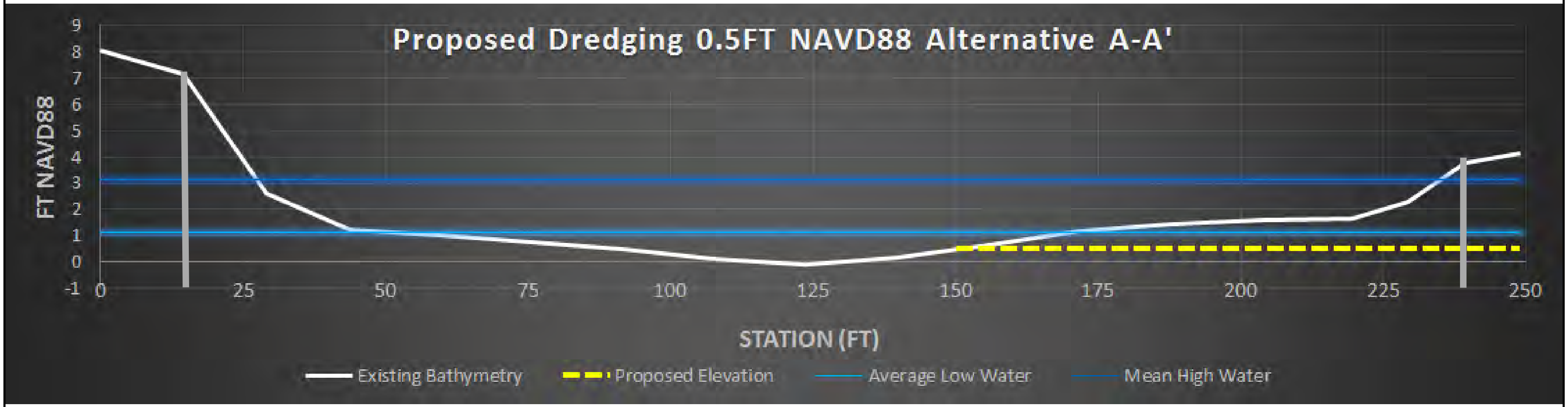

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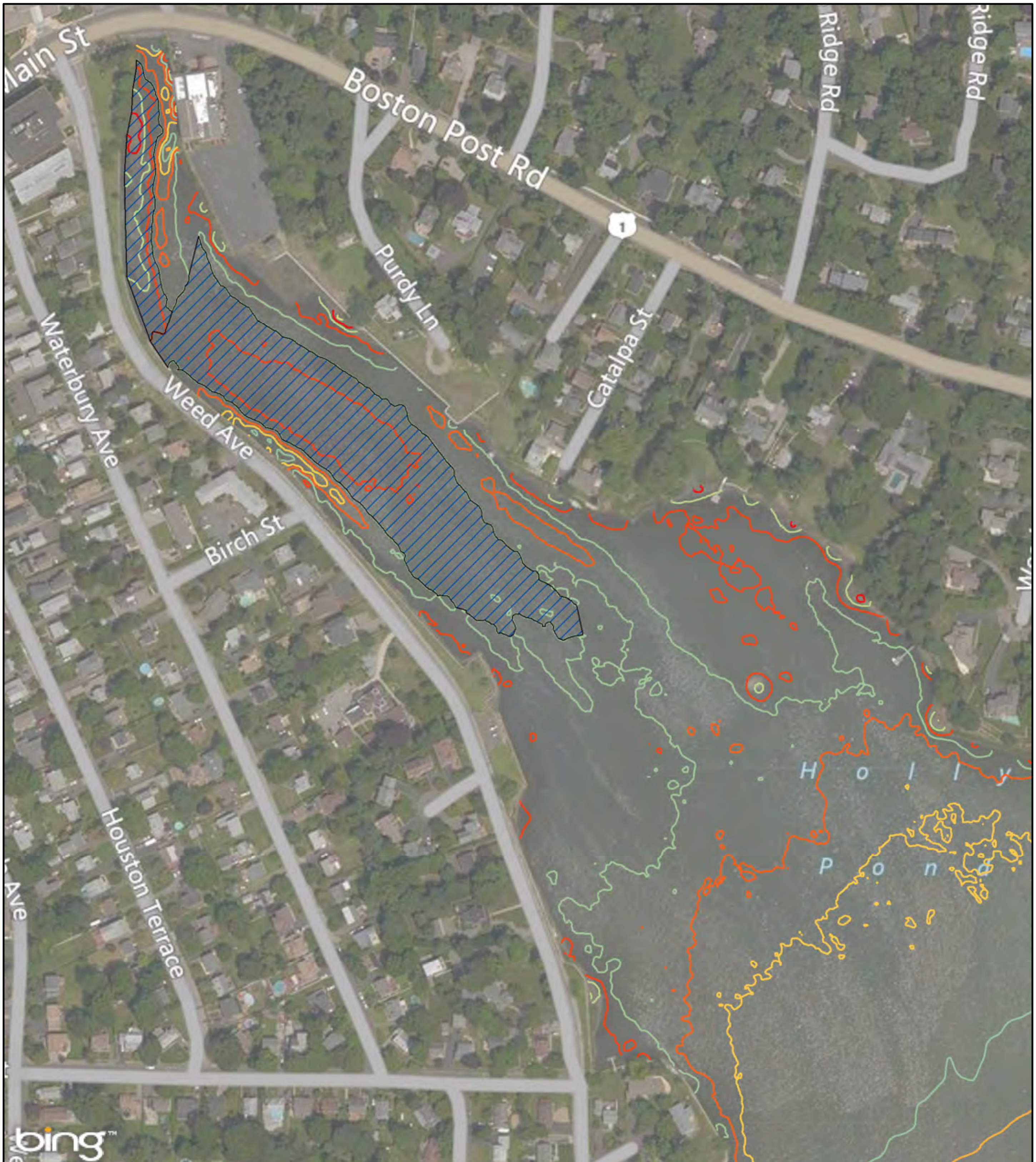
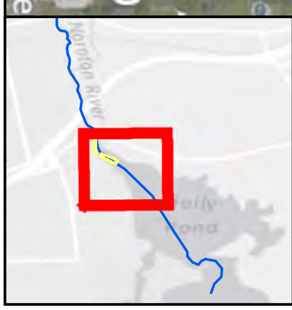
Figure 15
Proposed Dredging Alternative
to 0.5ft NAVD88
Cross Sectional View

Fairfield County, Connecticut

Louis Berger

Connecticut Department of Energy and Environmental Protection





Projection:
NAD1983 State Plane
Connecticut (Feet).
Sources:
ESRI BING Imagery
Map Service, 2016;

June 2016

Sediment Shoal Dredging Conceptual Design

Legend

- Dredge Area - 0.5ft NAVD88
- Project Area

Figure 16
Proposed Dredging Alternative
0.5ft NAVD88

Fairfield County, Connecticut

Connecticut Department of Energy and Environmental Protection

Louis Berger

0 175 350
Feet

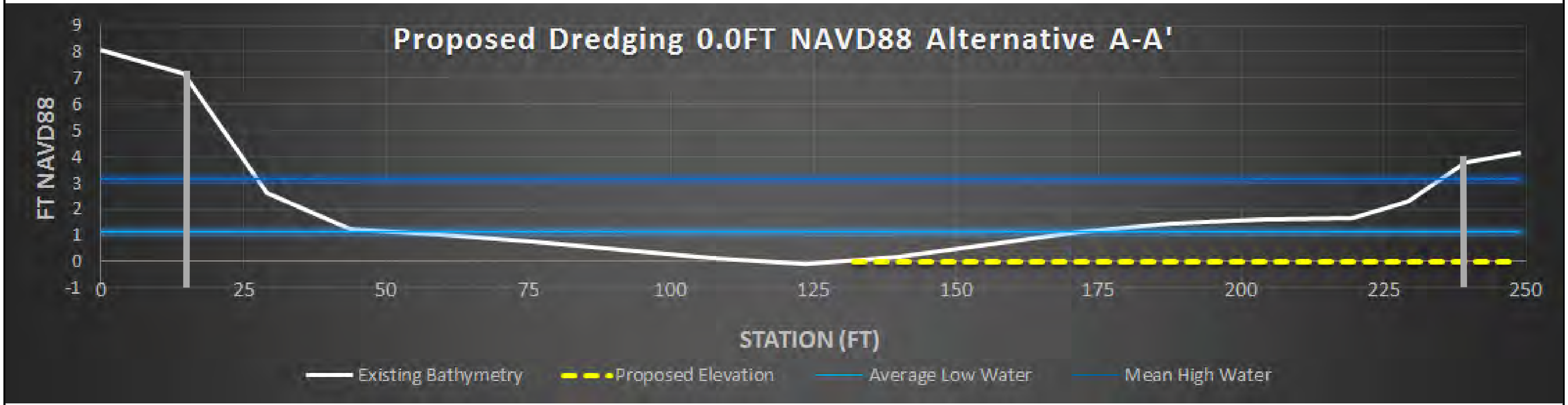


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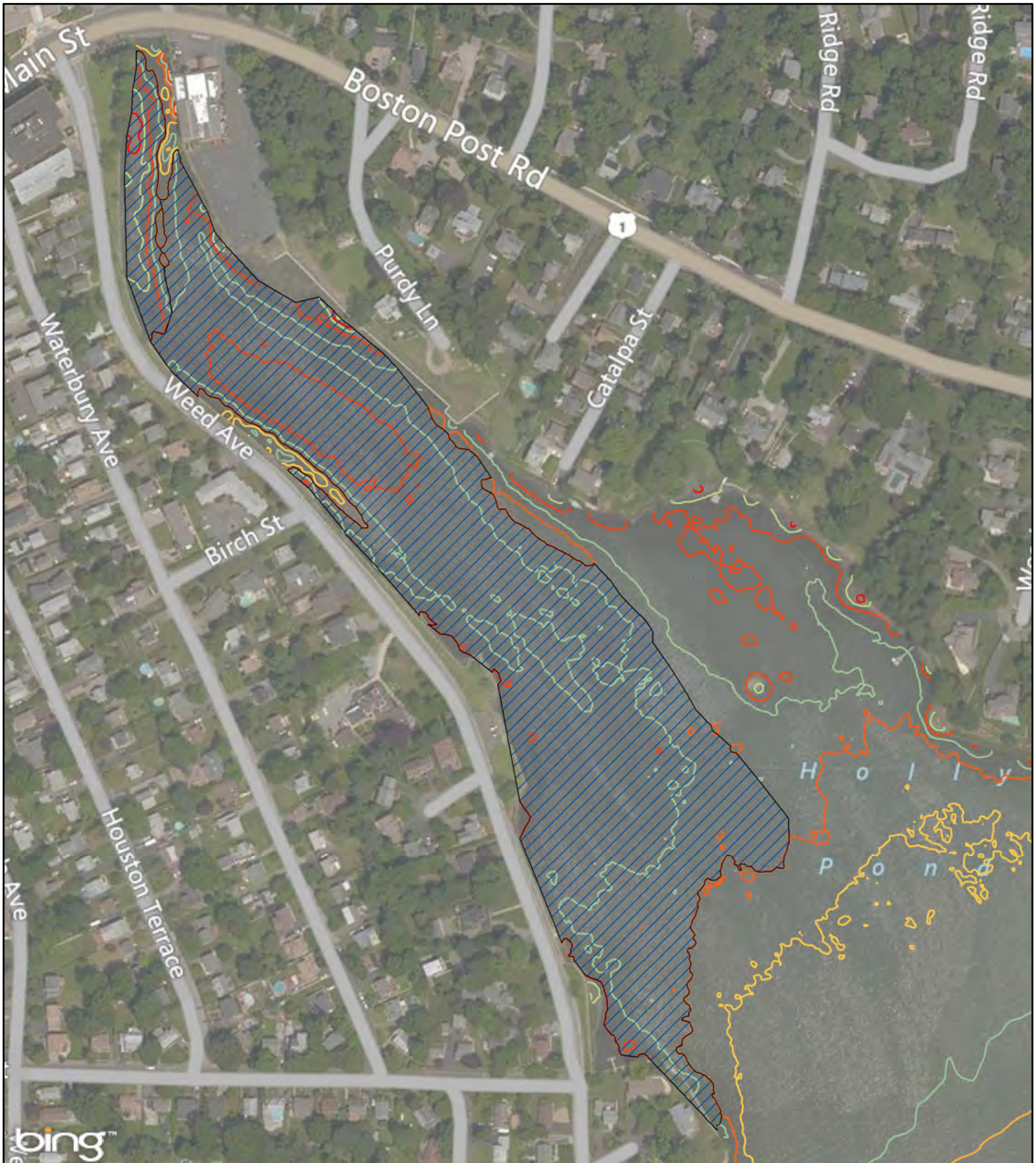
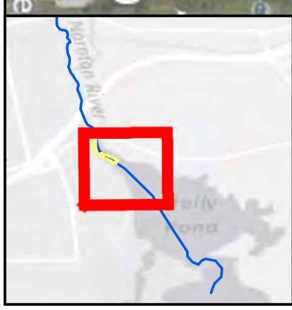
Figure 17
Proposed Dredging Alternative
to 0.0ft NAVD88
Cross Sectional View

Fairfield County, Connecticut

Louis Berger

Connecticut Department of Energy and Environmental Protection





Projection:
NAD1983 State Plane Connecticut (Feet).
Sources:
ESRI BING Imagery Map Service, 2016;

June 2016

Sediment Shoal Dredging Conceptual Design

Legend

Dredge Area - 0.0ft NAVD88

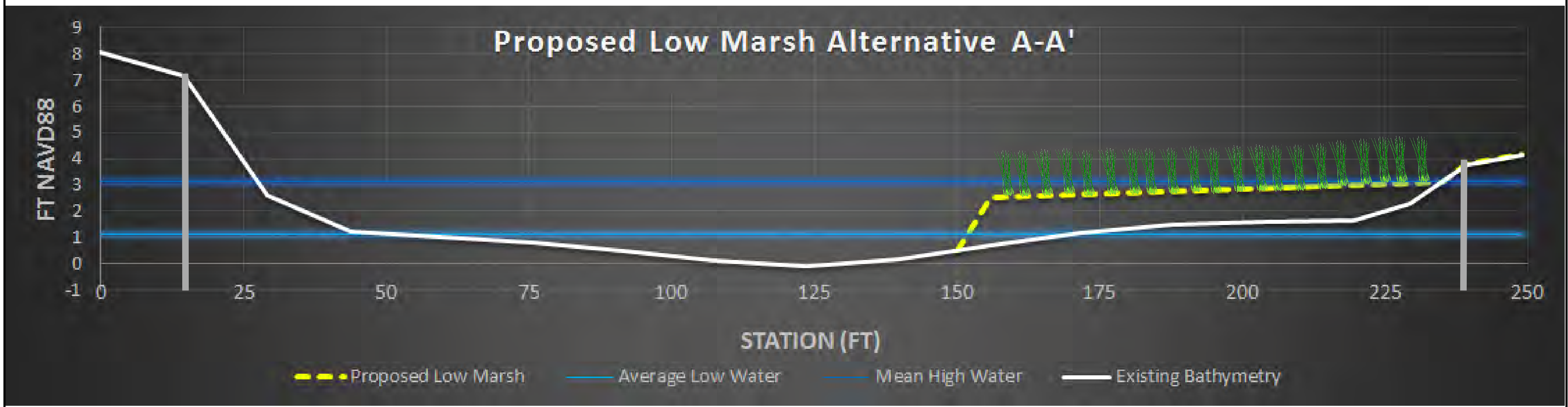
Project Area

Figure 18
Proposed Dredging Alternative
0.0ft NAVD88
Fairfield County, Connecticut

Connecticut Department of Energy and Environmental Protection

Louis Berger

0 175 350 Feet



June 2016

Figure 19
Tidal Marsh Restoration Alternative
Cross Sectional View

Fairfield County, Connecticut

Louis Berger

Connecticut Department of Energy and Environmental Protection

Projection:
NAD1983 State Plane Connecticut (Feet).
Sources:
ESRI BING Imagery Map Service, 2016;

June 2016

Tidal Marsh Restoration Conceptual Design

Legend

Low Marsh Alternative

Project Area

Figure 20
Proposed Low Marsh Alternative
Fairfield County, Connecticut

Connecticut Department of Energy and Environmental Protection

Louis Berger

0 75 150
Feet

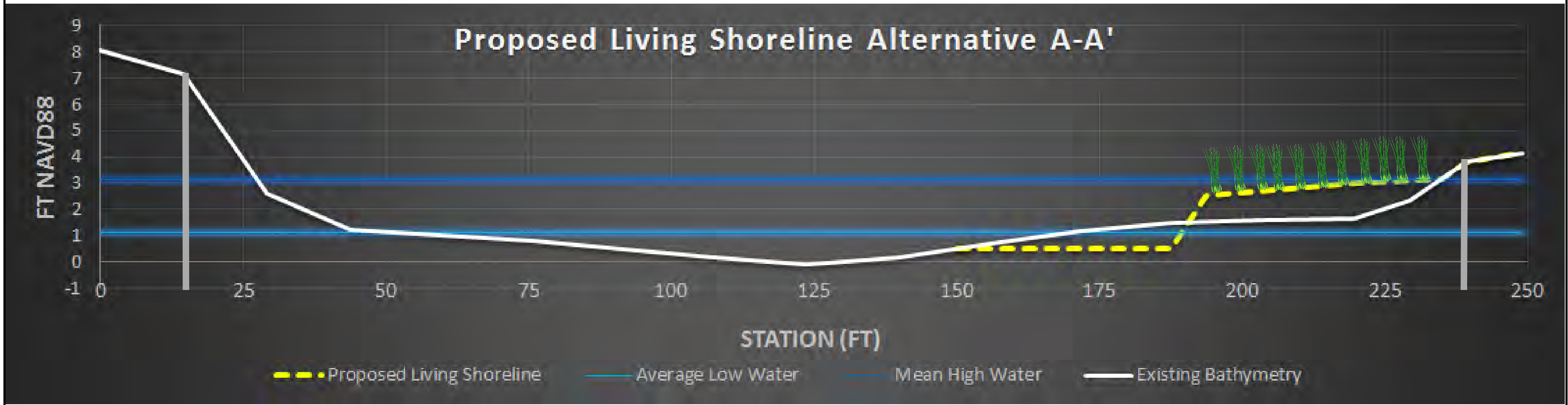


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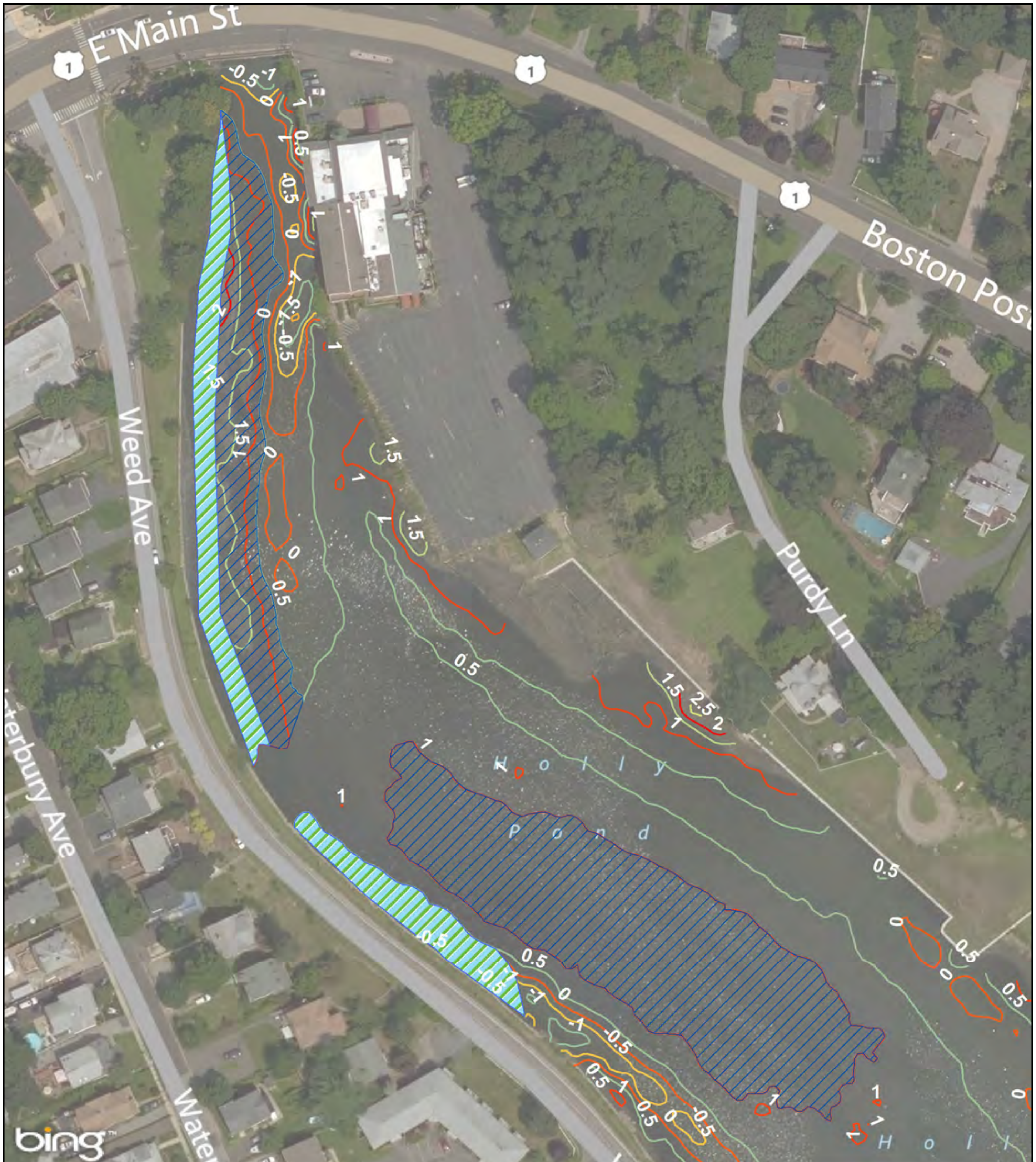
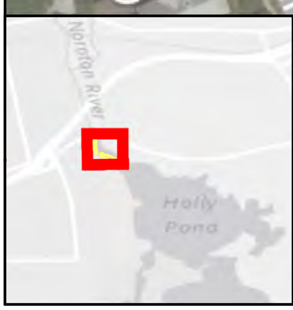
Figure 21
Living Shoreline Alternative
Cross Sectional View

Fairfield County, Connecticut

Louis Berger

Connecticut Department of Energy and Environmental Protection





Projection:
NAD1983 State Plane
Connectictt (Feet).
Sources:
ESRI BING Imagery
Map Service, 2016;

June 2016

Living Shoreline Conceptual Design

Legend

- Living Shoreline
- Dredged Material
- Project Area

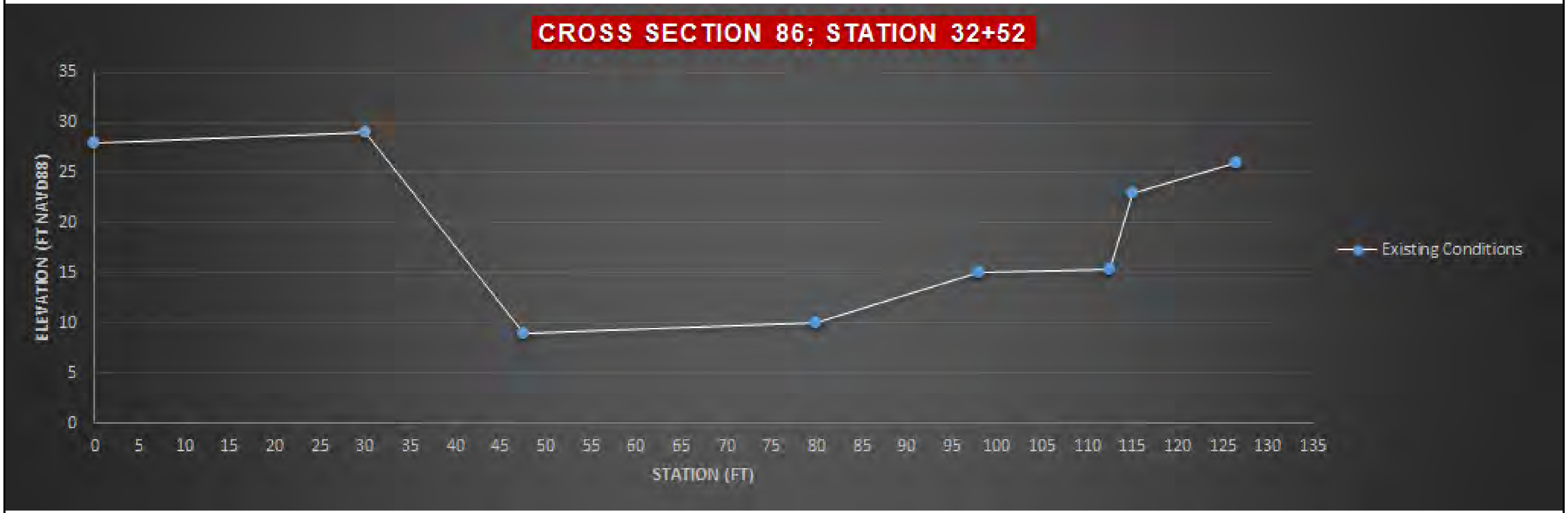
Figure 22
Proposed Living Shoreline Alternative

Fairfield County, Connecticut

Connecticut Department of Energy and Environmental Protection

Louis Berger

0 75 150 Feet



June 2016

Figure 23
Erosion Area 22 Unstable Bank Conditions
with Left Bank Slope of <1:1
Cross Sectional View

Fairfield County, Connecticut

Louis Berger

Connecticut Department of Energy and Environmental Protection

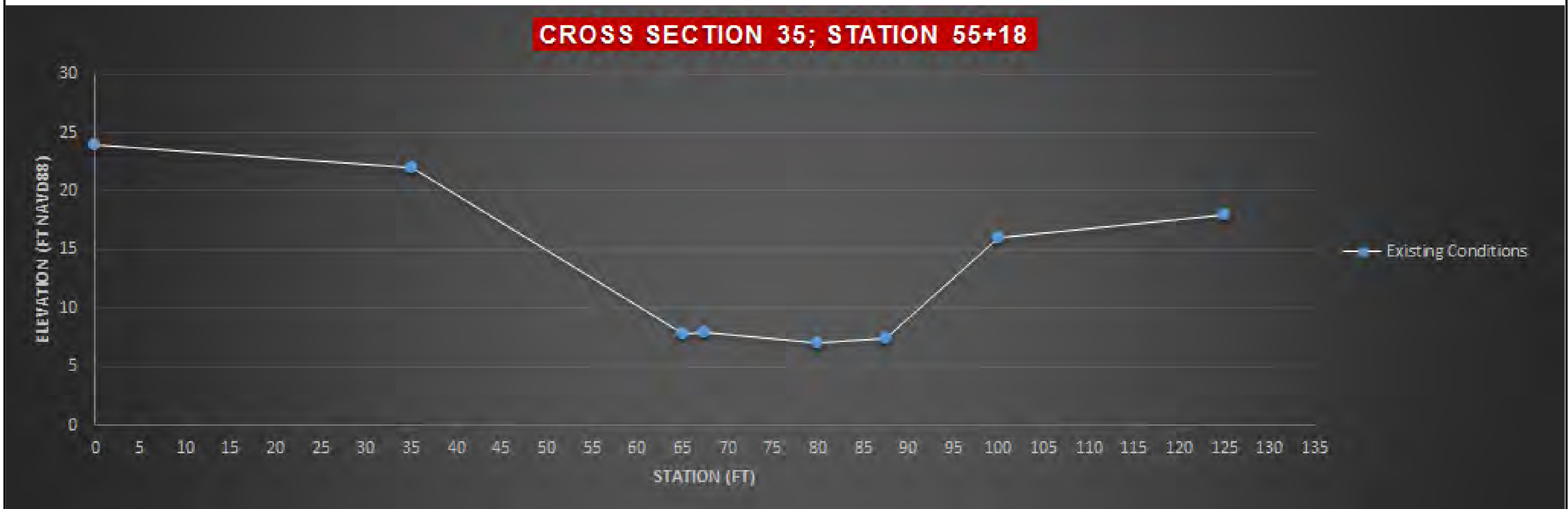


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Figure 24
Stable Bank Conditions with Left Bank Slope of 2:1
Cross Sectional View

Fairfield County, Connecticut

Louis Berger

Connecticut Department of Energy and Environmental Protection

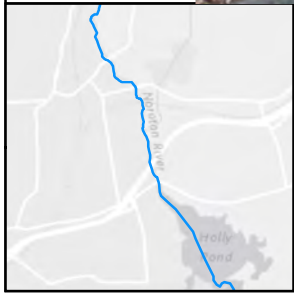

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Figure 25
Erosion Area 36 Bank Erosion
Taken November, 2015

Fairfield County, Connecticut

Louis Berger

Connecticut Department of Energy and Environmental Protection

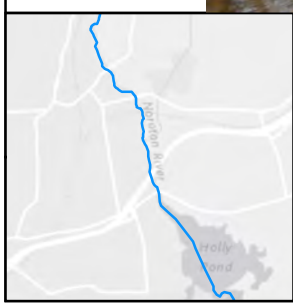

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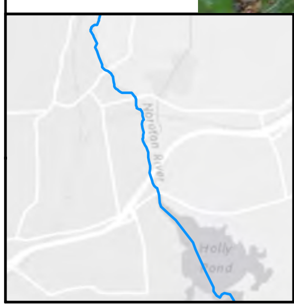
Figure 26
Erosion Area 6 Bank Erosion
Taken November, 2015

Fairfield County, Connecticut

Louis Berger

Connecticut Department of Energy and Environmental Protection



June 2016

Figure 27
Erosion Area 22 Mass Failure on Left Bank
(View is Upstream)
Taken November, 2015

Fairfield County, Connecticut

Louis Berger

Connecticut Department of Energy and Environmental Protection

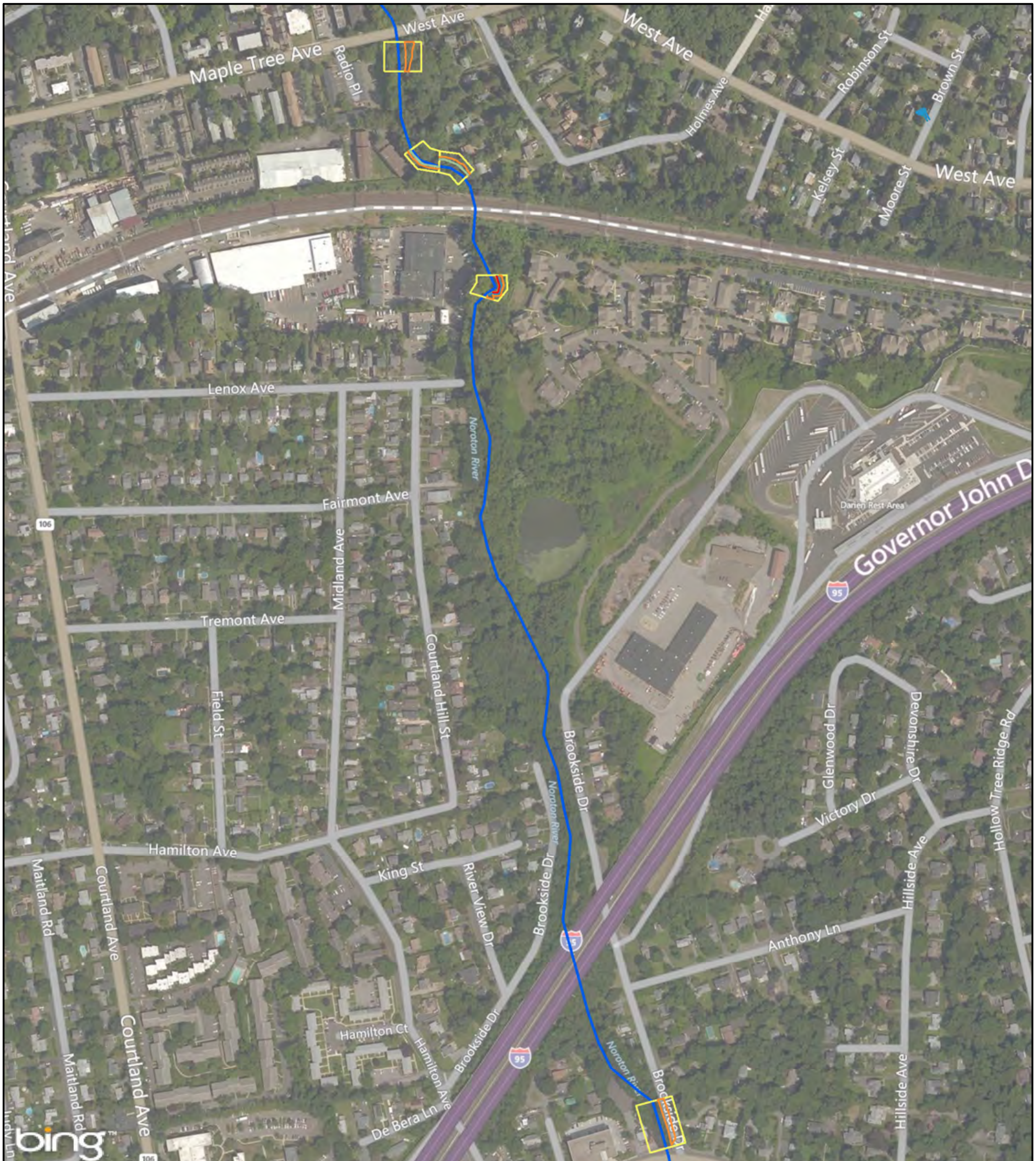
June 2016

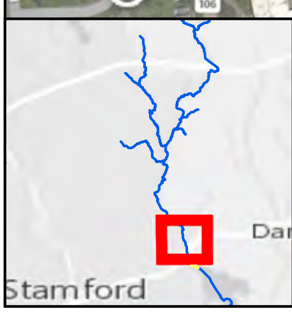
Figure 28
Erosion Area 27 Bank Erosion and Fine Sediment on Streambank
Taken November, 2015

Fairfield County, Connecticut

Louis Berger

Connecticut Department of Energy and Environmental Protection





Projection:
NAD1983 State Plane Connecticut (Feet).
Sources:
ESRI BING Imagery Map Service, 2016;

June 2016

Streambank Stabilization Conceptual Design

Legend

- Stabilization Measure Area
- Project Area

Figure 29

Proposed Stabilization Measures A

Fairfield County, Connecticut

Connecticut Department of Energy and Environmental Protection

Louis Berger

0 300 600 Feet

Projection:
NAD1983 State Plane Connecticut (Feet).
Sources:
ESRI BING Imagery Map Service, 2016;

June 2016

Streambank Stabilization Conceptual Design

Legend

Stabilization Measure Area

Project Area

Figure 30

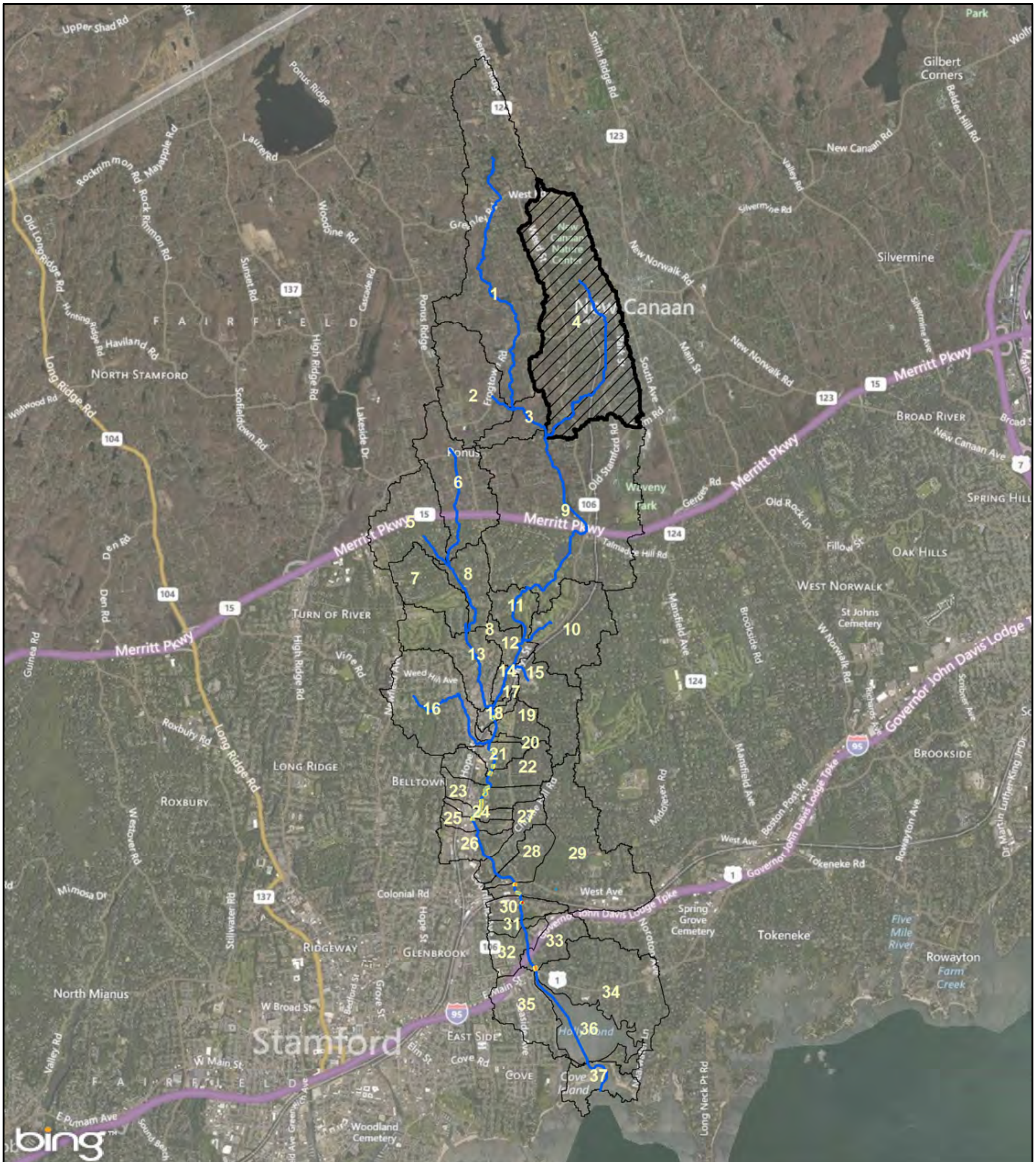
Proposed Stabilization Measures B

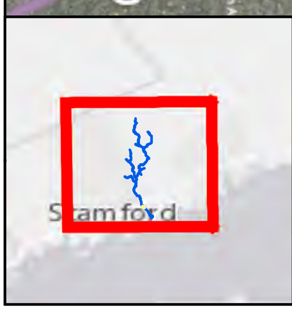
Fairfield County, Connecticut

Connecticut Department of Energy and Environmental Protection

Louis Berger

0 410 820 Feet





Projection:
NAD1983 State Plane
Connecticut (Feet).
Sources:
ESRI BING Imagery
Map Service, 2016;

June 2016

Legend

- Noroton River
- Noroton River Subbasins
- Subwatershed 4 - 55.6% Sediment Yield
- Project Area

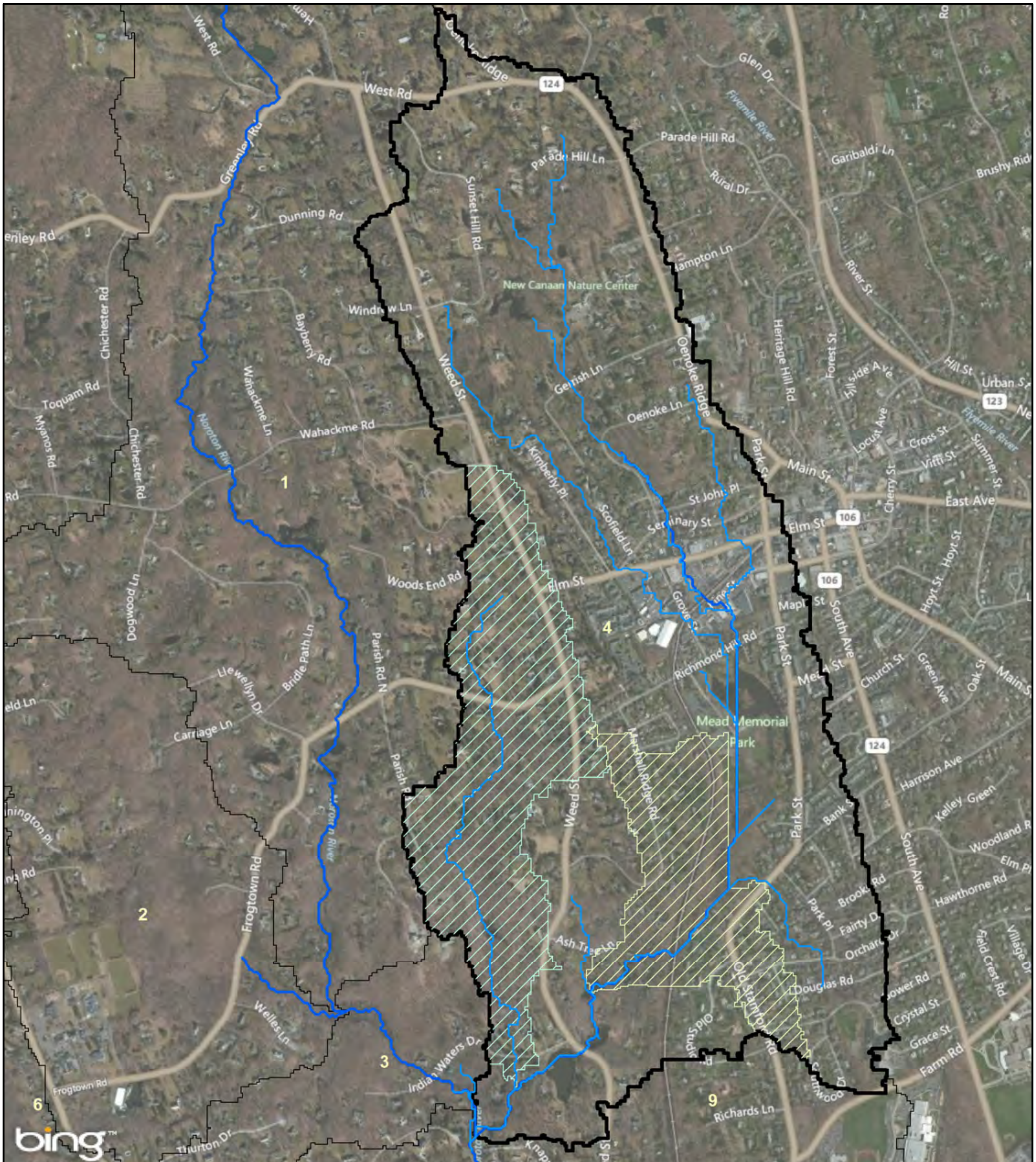
Figure 31
Subwatershed 4 of
Holly Pond Watershed

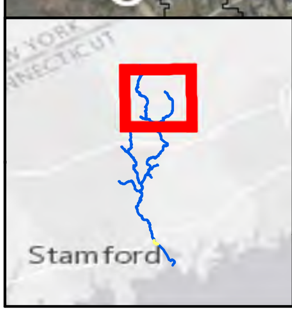
Fairfield County, Connecticut

Connecticut Department of Energy and Environmental Protection

Louis Berger

0 0.75 1.5 Miles





Projection:
NAD1983 State Plane Connecticut (Feet).
Sources:
ESRI BING Imagery Map Service, 2016;

June 2016

Legend

- Noroton River
- Noroton River Subbasins
- Sub-subwatershed 16: 38% of Total Sediment Yield
- Sub-subwatershed 19: 17% of Total Sediment Yiel
- Subwatershed 4
- Project

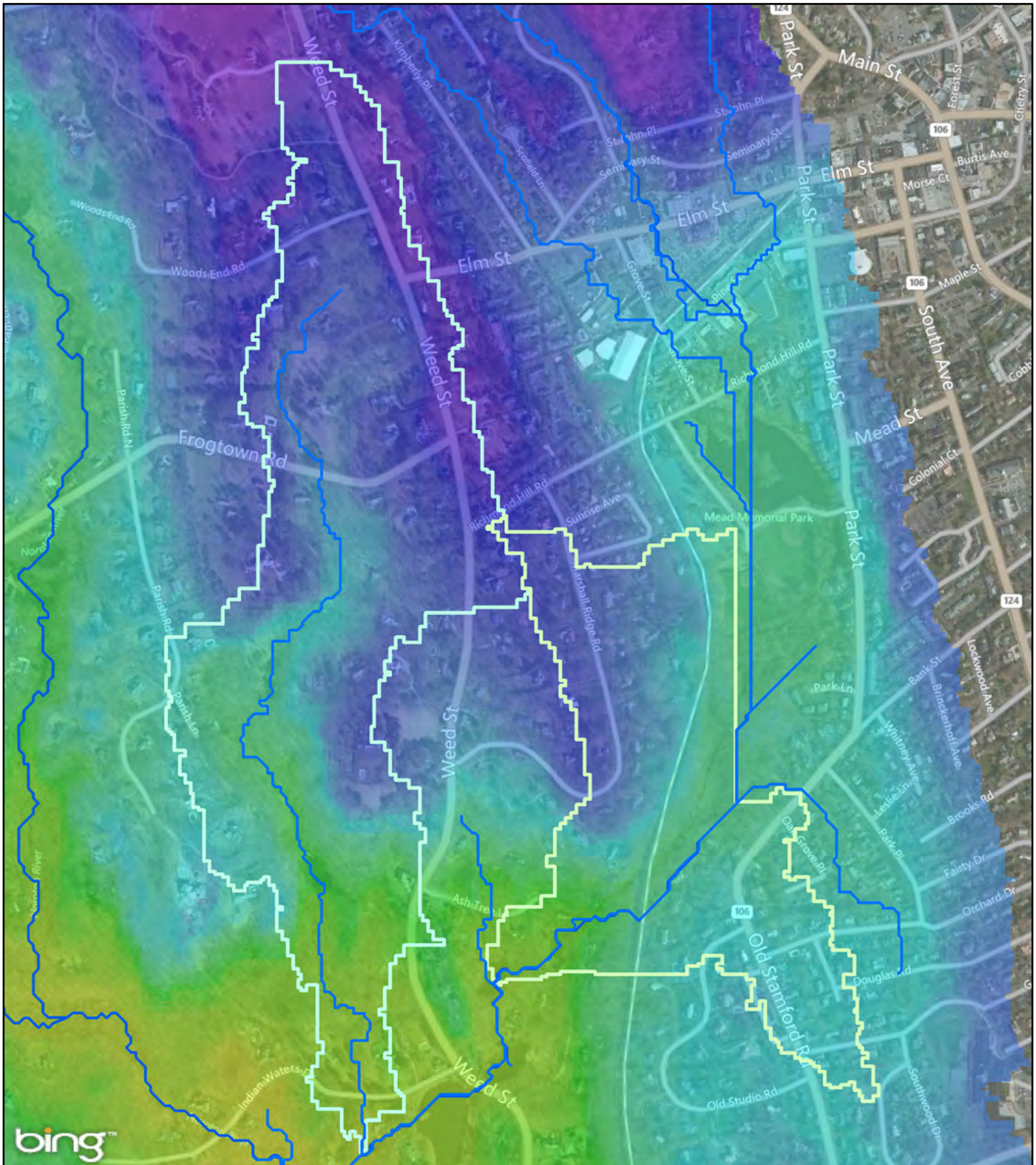
Figure 32
Sub-subwatersheds of Holly Pond 55% of Total Sediment Yield

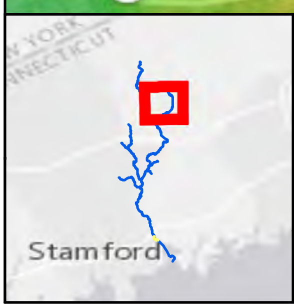
Fairfield County, Connecticut

Connecticut Department of Energy and Environmental Protection

Louis Berger

0 0.15 0.3 Miles





Projection:
NAD1983 State Plane Connecticut (Feet).
Sources:
ESRI BING Imagery Map Service, 2016;

June 2016

Legend

- Noroton River
- Sub-subwatershed 16: 38% of Total Sediment Yield
- Sub-subwatershed 19: 17% of Total Sediment Yiel
- Project Area

National Elevation Dataset (NED)

Value

High : 571 feet

Low : -20 feet

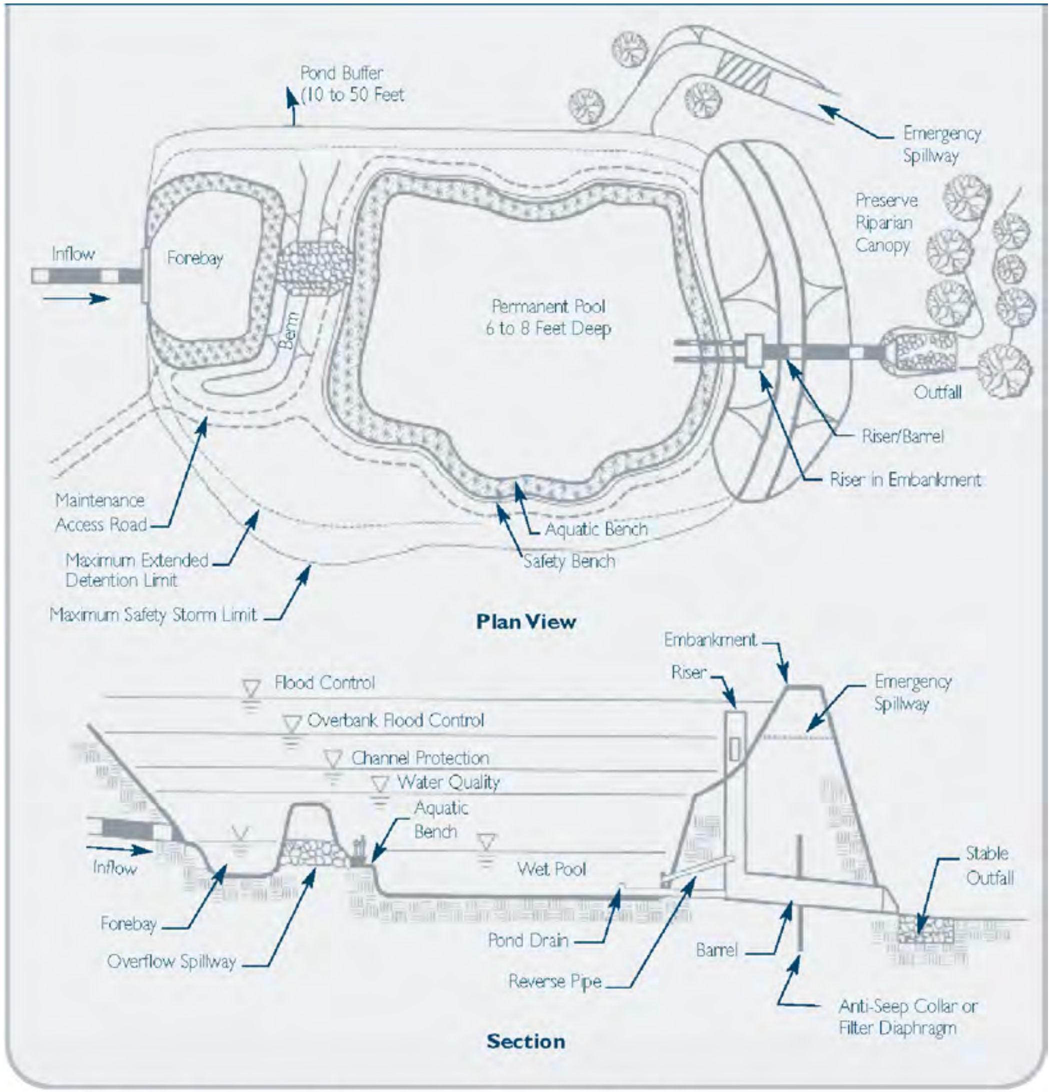
Figure 33
Elevation Range within Sub-subwatershed Areas

Fairfield County, Connecticut

Connecticut Department of Energy and Environmental Protection

Louis Berger

0 0.1 0.2 Miles



Source: Adapted from 2004 Connecticut Stormwater Quality Manual: NYDEC, 2001.

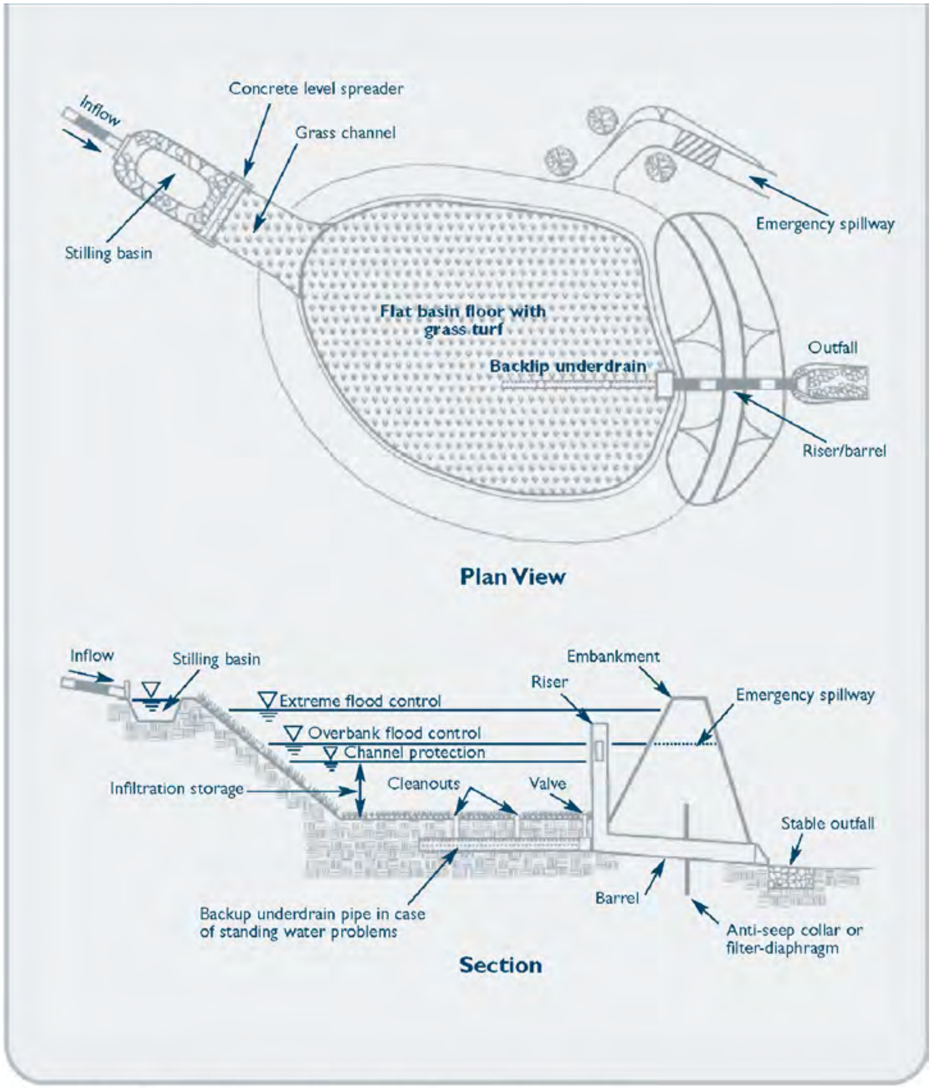
June 2016

Figure 34
Extended Wet Detention Pond
Conceptual Design

Fairfield County, Connecticut

Louis Berger

Connecticut Department of Energy and Environmental Protection



Source: Adapted from 2004 Connecticut StormwaterQuality Manual; NYDEC, 2001.

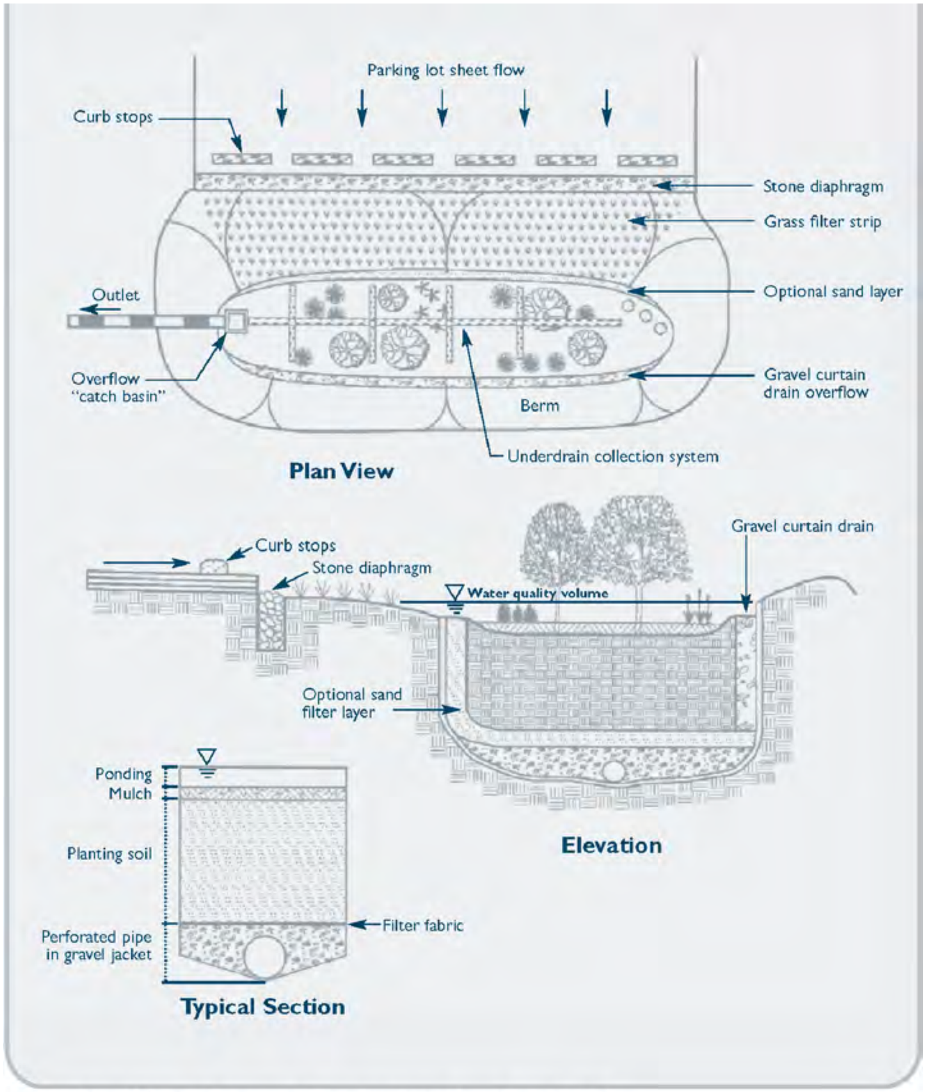
June 2016

Figure 35
Infiltration Basin
Conceptual Design

Fairfield County, Connecticut

Louis Berger

Connecticut Department of Energy and Environmental Protection



Source: Adapted from 2004 Connecticut StormwaterQuality Manual: NYDEC, 2001.

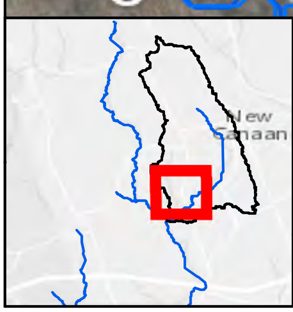
June 2016

Figure 36
Bioretention Areas
Conceptual Design

Fairfield County, Connecticut

Louis Berger

Connecticut Department of Energy and Environmental Protection



Projection:
NAD1983 State Plane Connecticut (Feet).
Sources:
ESRI BING Imagery Map Service, 2016;

June 2016

BMP Conceptual Design

Legend

- Proposed BMP Locations - Extended Wet Detention Ponds
- Noroton River
- Sub-subwatershed 16: 38% of Total Sediment Yield
- Sub-subwatershed 19: 17% of Total Sediment Yiel
- Project Area

Figure 37
Extended Wet Detention Pond Potential **Locations**

Fairfield County, Connecticut

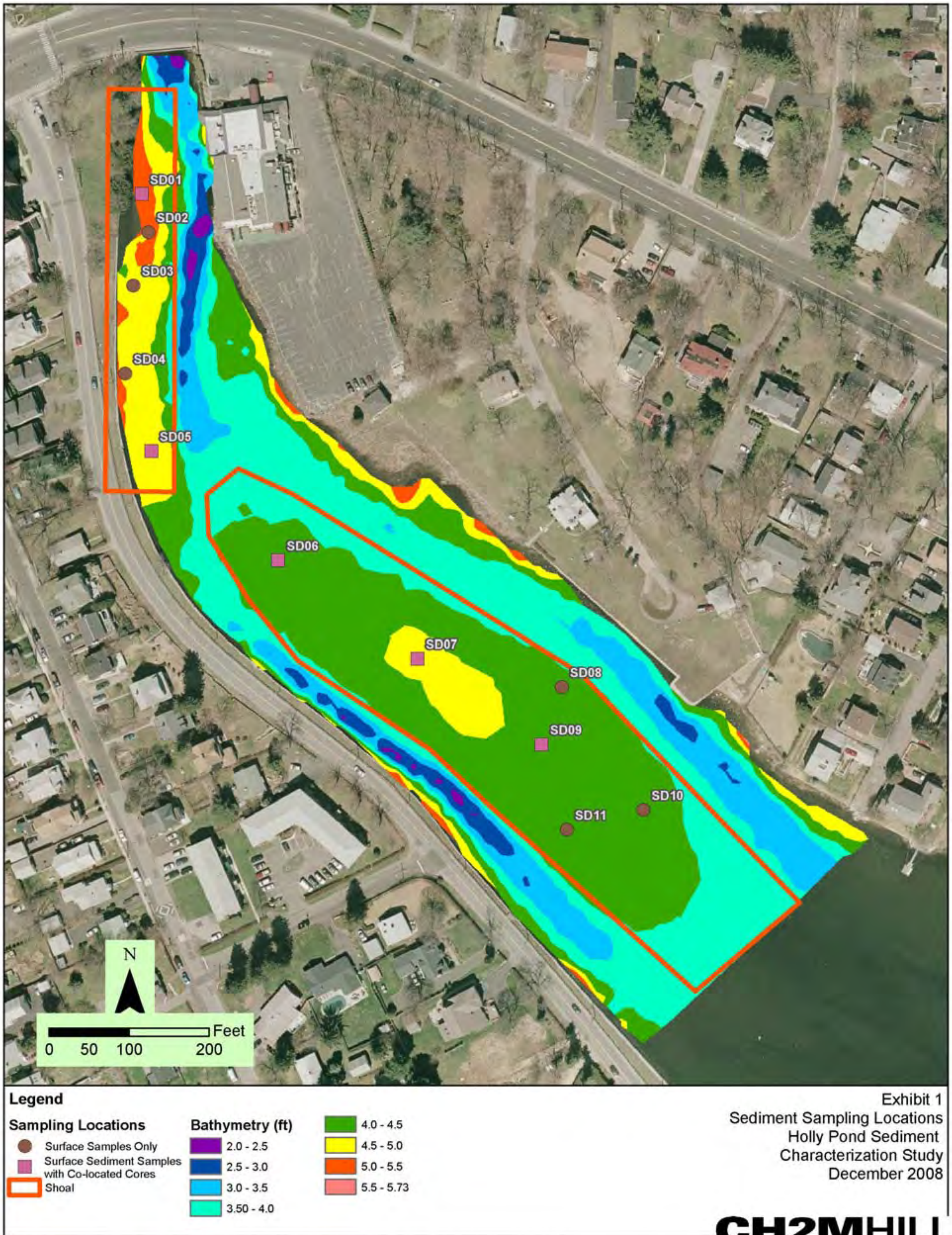
Connecticut Department of Energy and Environmental Protection

Louis Berger

0 250 500 Feet

APPENDIX A

2008 Sedimentation Investigation Results



PHL \\Andromeda\proj\Stamford\WPCA\373533\Phase_1\Task_1.2\1.2.2_GIS\New\Mapfiles\PropSampLoc.mxd jgould 12/15/08

EXHIBIT 2
Summary of Target and As-Sampled Station Coordinates
Holly Pond Sediment Investigation – December 2008

Location	Target Coordinates		As-Sampled Coordinates	
	Northing	Easting	Northing	Easting
SD-01	583612.8	791115.0	583613.2	791115.5
SD-02	583566.0	791121.4	583565.3	791123.5
SD-03	583498.2	791098.2	583498.3	791105.0
SD-04	583388.6	791095.0	583388.1	791094.7
SD-05	583291.2	791127.0	583290.8	791127.7
SD-06	583154.5	791286.5	583153.9	791286.2
SD-07	583031.9	791459.8	583031.1	791460.1
SD-08	582995.3	791639.4	582995.4	791640.4
SD-09	582922.9	791614.8	582923.8	791615.3
SD-10	582844.2	791743.0	582841.5	791742.4
SD-11	582814.3	791636.6	582816.9	791646.7

EXHIBIT 3
Summary of Sediment Sample Depths and Analyses
Holly Pond Sediment Investigation – December 2008

Location ID	Depth (ft)	Date Sampled	Analysis						
			SVOC	Pesticides	PCBs	Metals	Grain size	TOC	Moisture
SD-01	0.0-0.5	12/03/2008	X	X	X	X	X	X	X
	0.5-1.7	12/03/2008	X	X	X	X	X	X	X
SD-02	0.0-0.5	12/03/2008	X	X	X	X	X	X	X
SD-03	0.0-0.5	12/03/2008	X	X	X	X	X	X	X
SD-04	0.0-0.5	12/03/2008	X	X	X	X	X	X	X
SD-05	0.0-0.5	12/03/2008	X	X	X	X	X	X	X
	0.5-1.5	12/03/2008	X	X	X	X	X	X	X
SD-06	0.0-0.5	12/03/2008	X	X	X	X	X	X	X
	0.5-1.7	12/03/2008	X	X	X	X	X	X	X
SD-07	0.0-0.5	12/03/2008	X	X	X	X	X	X	X
	0.8-1.9	12/03/2008	X	X	X	X	X	X	X
SD-08	0.0- 0.5	12/03/2008	X	X	X	X	X	X	X
SD-09	0.0-0.5	12/03/2008	X	X	X	X	X	X	X
	0.5-2.5	12/03/2008	X	X	X	X	X	X	X
SD-10	0.0-0.5	12/02/2008	X	X	X	X	X	X	X
SD-11	0.0-0.5	12/02/2008	X	X	X	X	X	X	X

EXHIBIT 4
Analytical Results for Physical Characterization Parameters
Holly Pond Sediment Investigation – December 2008

Location	Depth Interval (ft)	Analytical Results							
		TOC (mg/kg)	Percent Moisture	Percent Solids	Percent Cobble	Percent Gravel	Percent Sand	Percent Clay & Silt	Classification
SD-01	0.0-0.5	6070	10	90	--	32.4	58.9	8.7	stone fragments, gravel, and sand
SD-01	0.5-1.7	11400	31	69	--	47.6	40.1	12.3	stone fragments, gravel, and sand
SD-02	0.0-0.5	13000	18	82	--	30.1	51.9	18	stone fragments, gravel, and sand
SD-03	0.0-0.5	1590	21	79	--	32.3	56	11.7	stone fragments, gravel, and sand
SD-04	0.0-0.5	18400	44	56	--	0.9	70.4	28.7	silty gravel and sand
SD-04 (FD)	0.0-0.5	18200	43	57	--	0.0	74.0	26.0	silty gravel and sand
SD-05	0.0-0.5	1240	19	81	--	7.9	90.3	1.8	stone fragments, gravel, and sand
SD-05	0.5-1.5	5280	28	72	--	3.5	74.9	21.6	silty gravel and sand
SD-06	0.0-0.5	14200	37	63	--	6.7	91.4	1.9	stone fragments, gravel, and sand
SD-06	0.5-1.7	1040	25	75	--	3.4	35.9	60.7	silty soils
SD-07	0.0-0.5	12900	32	68	--	--	92.7	7.3	fine sand
SD-07	0.8-1.9	1900	37	63	--	1.0	48.3	50.7	silty soils
SD-08	0.0-0.5	1060	25	75	--	0.2	95.3	4.5	stone fragments, gravel, and sand
SD-09	0.0-0.5	18500	38	62	--	0.1	94.8	5.1	fine sand
SD-09	0.5-2.5	2800	32	68	--	0.0	44.9	55.1	silty soils
SD-10	0.0-0.5	9250	36	64	--	0.0	86.0	14.0	silty gravel and sand
SD-11	0.0-0.5	20800	51	49	--	0.3	81.1	18.6	silty gravel and sand

Notes:
FD = field duplicate
-- parameter not measured
mg/kg = milligram/kilogram

EXHIBIT 5
Analytical Results for Metals
Holly Pond Sediment Investigation – December 2008

Location	Depth Interval (ft)	Analytical Results (mg/kg or ppm)							
		Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Zinc
SD-01	0.0-0.5	0.8	ND	16.2	40.7	30.8	ND	8.4	81.9
SD-01	0.5-1.7	3.3	1.16	47	527	152	0.18	31.8	677
SD-02	0.0-0.5	2.1	ND	15.8	41.2	745	ND	13.4	119
SD-03	0.0-0.5	1	ND	10.7	43.2	54.6	ND	10.3	90.7
SD-04	0.0-0.5	2.4	0.85	35.4	105	144	ND	16.9	226
SD-04 (FD)	0.0-0.5	2.8	0.8	32	90.6	79.6	ND	15.1	195
SD-05	0.0-0.5	1.8	ND	8.12	33.3	36	ND	8.42	59
SD-05	0.5-1.5	1.8	0.76	29.3	85.1	159	ND	16.3	159
SD-06	0.0-0.5	6.4	3.5	136	1060	422	0.19	42.3	1120
SD-06	0.5-1.7	ND	ND	9.47	25.5	26.9	ND	6.94	54.6
SD-07	0.0-0.5	4.4	1.53	64.1	422	287	0.15	27.5	455
SD-07	0.8-1.9	ND	0.5	14	50.3	36.5	ND	8.61	88.5
SD-08	0.0-0.5	ND	ND	5.25	17.8	16.5	ND	5.21	43.9
SD-09	0.0-0.5	6.1	1.74	116	719	195	0.21	24.8	571
SD-09	0.5-2.5	ND	ND	12.3	81.4	133	ND	6.69	67.5
SD-10	0.0-0.5	1.4	0.48	24.4	55.1	45.6	ND	11.4	123
SD-11	0.0-0.5	3.1	1.16	47.2	105	139	ND	19	258

Notes:
FD = field duplicate
ND = parameter not detected at concentrations greater than the reporting limit
ppm = part per million
mg/kg = milligram/kilogram

EXHIBIT 6
Analytical Results for SVOCs
Holly Pond Sediment Investigation – December 2008

Location	Depth Interval (ft)	Analytical Results (ug/kg or ppb)																
		Naphthalene	2-Methylnaphthalene	Acenaphthene	Acenaphthylene	Fluorene	Anthracene	Phenanthrene	Pyrene	Fluoranthene	Benz(a)anthracene	Chrysene	Benzo(a)pyrene	Benzo(b) fluoranthene	Benzo(k) fluoranthene	Benzo(ghi) perylene	Dibenz(a,h) anthracene	Indeno(1,2,3-cd)pyrene
SD-01	0.0-0.5	ND	ND	ND	ND	ND	140	480	1300	1600	790	800	740	1200	450	370	91	340
SD-01	0.5-1.7	ND	ND	ND	ND	ND	190	380	2400	2700	940	800	1100	2000	630	500	160	500
SD-02	0.0-0.5	ND	ND	ND	ND	ND	140	770	1300	1700	670	760	680	1200	380	380	100	370
SD-03	0.0-0.5	ND	ND	ND	ND	ND	180	710	1600	1700	780	840	780	1300	450	340	90	320
SD-04	0.0-0.5	ND	ND	ND	ND	ND	260	1200	3900	4800	2000	2200	2100	3700	1200	1200	300	1100
SD-04 (FD)	0.0-0.5	ND	ND	ND	ND	ND	230	1200	3400	4200	1700	2000	1900	3500	1100	940	240	950
SD-05	0.0-0.5	ND	ND	ND	ND	ND	ND	310	700	860	340	400	370	600	ND	ND	ND	ND
SD-05	0.5-1.5	ND	ND	ND	ND	ND	230	610	2700	3300	1300	1300	1400	2200	850	610	160	600
SD-06	0.0-0.5	ND	ND	ND	ND	ND	150	ND	1800	2000	700	730	820	1400	530	380	130	360
SD-06	0.5-1.7	ND	ND	ND	ND	ND	250	680	2600	2200	1400	1200	1800	2800	970	650	200	670
SD-07	0.0-0.5	ND	ND	ND	ND	ND	150	360	2100	1700	820	910	1000	1700	580	570	180	550
SD-07	0.8-1.9	ND	ND	ND	ND	ND	140	560	1300	1600	720	780	760	1400	450	350	ND	350
SD-08	0.0-0.5	ND	ND	ND	ND	ND	120	560	1200	1500	660	680	660	1100	370	320	ND	300
SD-09	0.0-0.5	ND	ND	ND	ND	ND	160	440	1700	1900	790	820	900	1500	590	400	130	390
SD-09	0.5-2.5	ND	ND	ND	ND	ND	270	1200	2300	3000	1200	1300	1300	2200	580	540	150	550
SD-10	0.0-0.5	ND	ND	ND	ND	ND	140	700	1800	2200	930	1100	1000	1700	590	620	150	580
SD-11	0.0-0.5	ND	ND	ND	ND	ND	300	1400	3900	5000	1900	2200	2100	3700	1300	1100	280	1100

Notes:
FD = field duplicate
ND = parameter not detected at concentrations greater than the reporting limit
ppb = part per billion
ug/kg = microgram/kilogram

EXHIBIT 7
Analytical Results for Chlorinated Pesticides
Holly Pond Sediment Investigation – December 2008

Location	Depth Interval (ft)	Analytical Results (ug/kg or ppb)																				
		4,4' -DDD	4,4' -DDE	4,4' -DDT	Alachlor	Aldrin	a-BHC	b-BHC	d-BHC	g-BHC	Chlordane	Dieldrin	Endosulfan I	Endosulfan II	Endosulfan sulfate	Endrin	Endrin aldehyde	Endrin ketone	Heptachlor	Heptachlor epoxide	Methoxy- chlor	Toxaphene
SD-01	0.0-0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	210	3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SD-01	0.5-1.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	260	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SD-02	0.0-0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	200	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SD-03	0.0-0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	160	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SD-04	0.0-0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	170	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SD-04 (FD)	0.0-0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	150	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SD-05	0.0-0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	120	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SD-05	0.5-1.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	260	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SD-06	0.0-0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	130	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SD-06	0.5-1.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	170	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SD-07	0.0-0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	170	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SD-07	0.8-1.9	ND	ND	ND	ND	ND	ND	ND	ND	ND	120	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SD-08	0.0-0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	100	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SD-09	0.0-0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	180	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SD-09	0.5-2.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	110	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SD-10	0.0-0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	150	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SD-11	0.0-0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	180	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Notes:
FD = field duplicate
ND = parameter not detected at concentrations greater than the reporting limit
ppb = part per billion
ug/kg = microgram/kilogram

EXHIBIT 8
Analytical Results for PCBs (quantified as Aroclors)
Holly Pond Sediment Investigation – December 2008

Location	Depth Interval (ft)	Analytical Result (ug/kg or ppb)								
		Aroclor 1016	Aroclor 1221	Aroclor 1232	Aroclor 1242	Aroclor 1248	Aroclor 1254	Aroclor 1260	Aroclor 1262	Aroclor 1268
SD-01	0.0-0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND
SD-01	0.5-1.7	ND	ND	ND	ND	ND	1100	ND	ND	ND
SD-02	0.0-0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND
SD-03	0.0-0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND
SD-04	0.0-0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND
SD-04 (FD)	0.0-0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND
SD-05	0.0-0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND
SD-05	0.5-1.5	ND	ND	ND	ND	ND	ND	ND	ND	ND
SD-06	0.0-0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND
SD-06	0.5-1.7	ND	ND	ND	ND	ND	ND	ND	ND	ND
SD-07	0.0-0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND
SD-07	0.8-1.9	ND	ND	ND	ND	ND	ND	ND	ND	ND
SD-08	0.0-0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND
SD-09	0.0-0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND
SD-09	0.5-2.5	ND	ND	ND	ND	ND	ND	ND	ND	ND
SD-10	0.0-0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND
SD-11	0.0-0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND

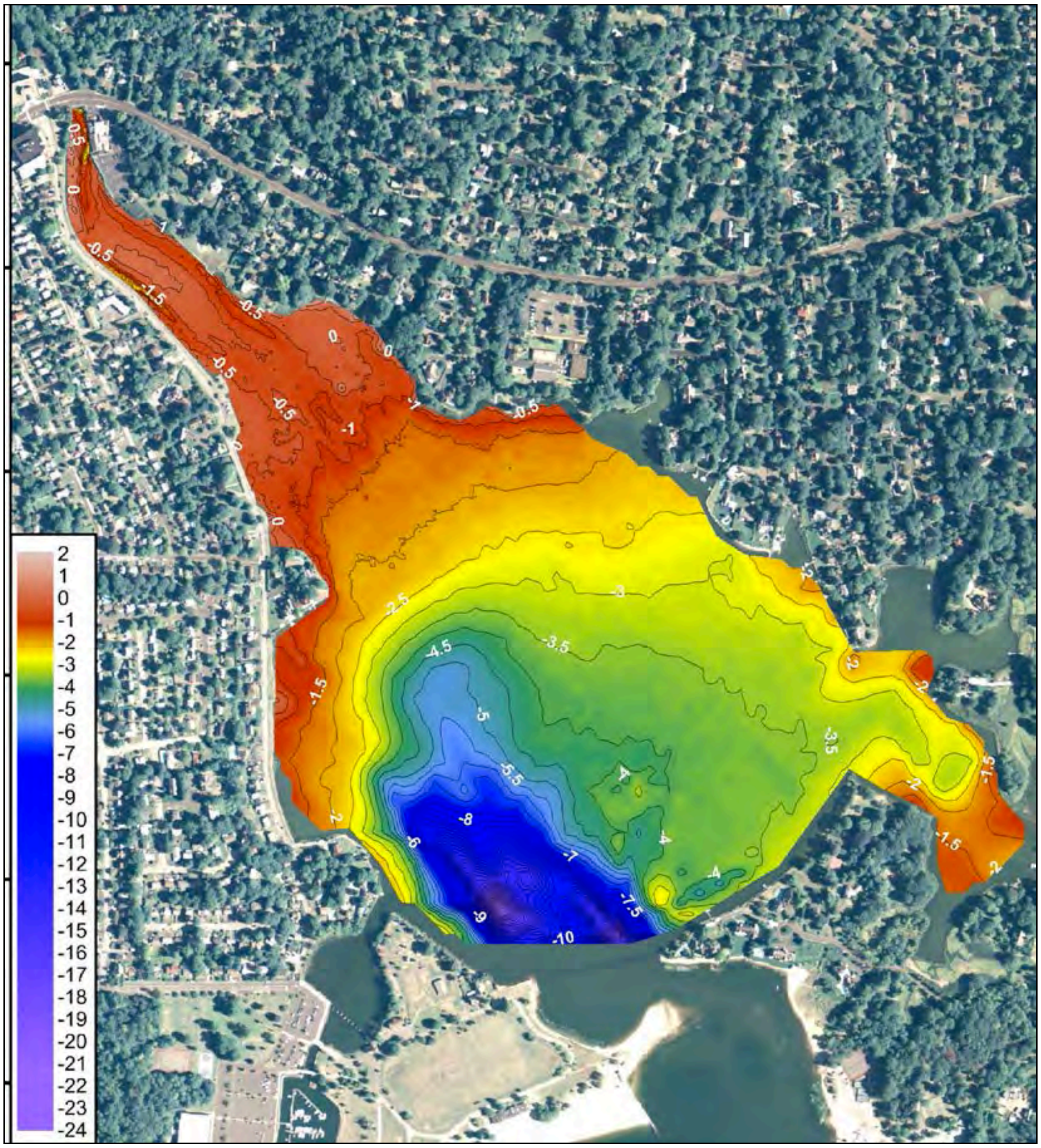
Notes:
FD = field duplicate
ND = parameter not detected at concentrations greater than the reporting limit
ppb = part per billion
ug/kg = microgram/kilogram

APPENDIX B

CR Environmental Bathymetric Survey and Tidal Study Report

HOLLY POND BATHYMETRIC SURVEY AND TIDAL STUDY

Stamford and Darien, CT



Holly Pond Low Water Bathymetry – April-June 2015

Prepared for:

Louis Berger
565 Taxter Road Suite 510
Elmsford, New York 10589

Prepared by:
CR Environmental, Inc.
639 Boxberry Hill Road
East Falmouth, MA 02536

July 2015

TABLE OF CONTENTS

1.0 INTRODUCTION

CR Environmental, Inc. (CR) performed single beam bathymetric surveys and a tidal study of Holly Pond in Stamford and Darien, Connecticut between April 21 and June 17, 2015. The surveys were conducted to provide data to support ongoing dredge feasibility assessments by Louis Berger.

2.0 SURVEY OPERATIONS AND NAVIGATION

Surveys were conducted using a 14 foot shallow draft foot jonboat with a custom designed aluminum helm, instrument enclosure, rugged over-the-side transducer mount, and 12 and 110 volt power supplies. Survey operations were directed by a National Society of Professional Surveyors (NSPS) certified hydrographer and a U.S. Coast Guard licensed captain/senior oceanographic technician. Operations were scheduled during periods of the highest amplitude tides due to the extremely shallow conditions in the northern portion of the pond.

2.1 Horizontal Positioning

Navigation for the survey(s) was accomplished using a Hemisphere VS330 Real-time Kinematic Global Positioning System (RTK GPS). The accuracy of the system is approximately 1.0 centimeter horizontally and 2 centimeters vertically (Root Mean Squared 1-sigma). Horizontal accuracy in differential or float mode is approximately 1 foot. RTK corrections were provided via NTRIP internet connection by Maine Technical Source, Inc.

The RTK GPS was serially interfaced to a shipboard computer running HYPACK 2014 hydrographic surveying software. During the survey, this system calculated X and Y positions in the desired grid system (CT State Plane, NAD83, US Foot), recorded the water depth and navigation data, and provided a steering display for the vessel captain. HYPACK using georeferenced imagery (e.g. orthophotos) as background files depicted the progress of the survey, ensuring that the entire survey area was adequately insonified.

2.2 Vertical (Tide) Corrections

Bathymetric data were adjusted to both NAVD88 and to a site-specific estimated Mean Lower Low Water (MLLW). CR installed a digitally recording InSitu tide gage adjacent to a control point established within the upstream (Northerly) portion of the survey area. The NAVD88 elevation of this benchmark (6.39 feet) was provided by Land Resource Consultants, Inc. CR maintained this InSitu tide gage between April 21 and May 28, 2015. Water surface elevations relative to the NAVD88 control point were recorded at 3-minute intervals.

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639 Boxberry Hill Road, East Falmouth, MA 02536
Phone/Fax (508) 563-7970 www.crenvironmental.com

3.0 ACQUISITION AND PROCESSING METHODS

3.1 Bathymetry

Bathymetric data were initially acquired on April 21 and 22, 2015. Adverse sea states prevented the inclusion of data collected on April 22 in the final processed data set. Data were augmented by an additional field effort on June 17 in order to generate "cross-tie" data sufficient to assess data uncertainty.

Figure 1 shows the bathymetric data distribution or trackline map for the 2015 bathymetric survey. In the upstream portion of the northerly cove, the bathymetric survey consisted of shore-perpendicular transects spaced 25 feet apart. Transects in the seaward portion of the cove were occupied using transects spaced 50 feet apart. As the tide/time allowed, "cross-tie" transects oriented perpendicular to the primary transects were occupied using a separation of 100 feet to allow statistical analysis of data quality and vertical uncertainty. Additional tracklines were occupied in the main body of the pond using transects spaced approximately 500 feet apart.

Soundings were acquired using a Teledyne Odom Hydrographic Echotrac CV-100 single (vertical) beam echo sounder (VBES) equipped with a 9-degree 200-kHz transducer. System accuracy and the measured transducer draft were checked at the start and end of the survey by comparing echo sounder water depth measurements to known water depths obtained using the "bar check" method, in which a metal plate is lowered beneath the echo sounder's transducer to a measured distance (5 feet) below the water surface. Additional calibrations were conducted *in situ* by collecting water column profiles of sound velocity using an Odom Digibar sound velocimeter. The water column was well mixed and no sound velocity adjustments to raw data were required.

Measured depths were converted to NAVD88 and estimated low water bottom elevations based on water level data recorded using an In-Situ, Inc. LevelTroll pressure transducer installed at the vertical control point described above. Bathymetric data were exported in ASCII delimited point format. Gridded surfaces for Holly Pond were created and used to create contour maps and GIS layers projected to CT State Plane, NAD83, US Ft. Corrected soundings at the intersections of primary and cross-tie transects were identified and differences were calculated and statistically analyzed to quantify potential biases and vertical uncertainty.

4.0 SURVEY RESULTS & DELIVERABLES

Survey deliverables were provided to Louis Berger on June 26 and June 30, 2015. Bathymetric data have been delivered as ASCII comma-delimited points without sorting. Contours were developed at 0.5 ft and 1.0 ft intervals using both NAVD88 and site-specific low water datums and have been delivered in DXF and SHP files suitable for

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639 Boxberry Hill Road, East Falmouth, MA 02536
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analysis using CAD or GIS software. Tidal data have been delivered in Microsoft Excel format.

4.1 Tide Conditions

Seventy low-water slack tides were recorded during the study period. The standard deviation amongst the slack low water NAVD88 elevations was 0.06 feet. The mean low tide elevation above NAVD88 was 1.13 feet. No significant differences were observed in Holly Pond between “lower low water” and “low water” tides as observed by NOAA in Long Island Sound due to pooling effects behind the Holly Pond dam. The timing and height of slack high tide agreed well with the nearest NOAA Tide Station (Bridgeport #8467150) (Figure 2).

4.2 Bathymetric Conditions

The combined length of transects occupied during the survey was 15.5 statute miles. Bathymetric data were statistically analyzed to evaluate accuracy according to U.S. Army Corps of Engineers specifications (US ACOE, 2013, Ch. 3). The ACOE 95th percentile confidence interval (CI) recommendation for bias (repeatability) is +/- 0.3 feet in depths less than 15 feet, and “resultant elevation/depth accuracy” is +/- 0.8 feet for "Coastal (tidal) Shallow Draft Projects". Cross-tie statistics for the site bathymetric dataset yielded a bias of -0.071 feet and a 95% CI uncertainty of 0.40 feet (SD = 0.192 ft). All comparisons show compliance with ACOE Performance Standards. Note that the presence of algae (e.g., *Ulva lactuca)* likely exaggerated cross-tie sounding differences.

Maps of NAVD88 and low water elevations for Holly Pond (Figures 3 and 4, respectively) indicate extensive areas within the cove which are exposed at low water (i.e., low water elevation $\geq$ 0 ft).

REFERENCES

U.S. Army Corps of Engineers. 2013. *Engineering and Design Hydrographic Surveying*. EM1110-2-1003.

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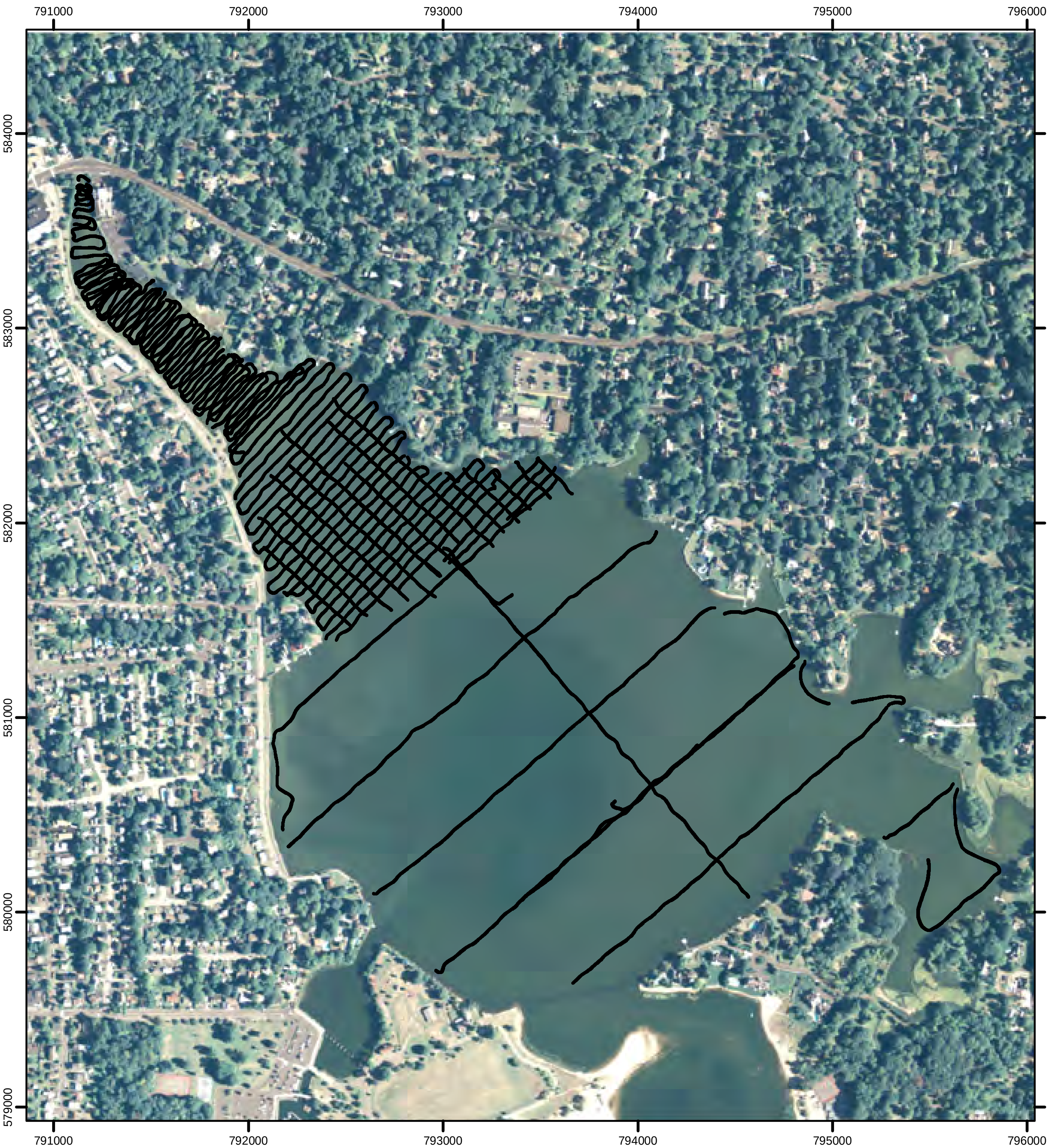
Phone/Fax (508) 563-7970 www.crenvironmental.com



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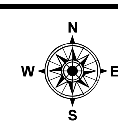
2015 Holly Pond Bathymetric Transects
Stamford and Darien, Connecticut



NOTES:

1) Survey conducted 4/21/15 and 6/17/15.
2) Grid CT State Plane, NAD 83, US Foot

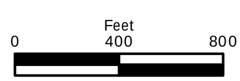
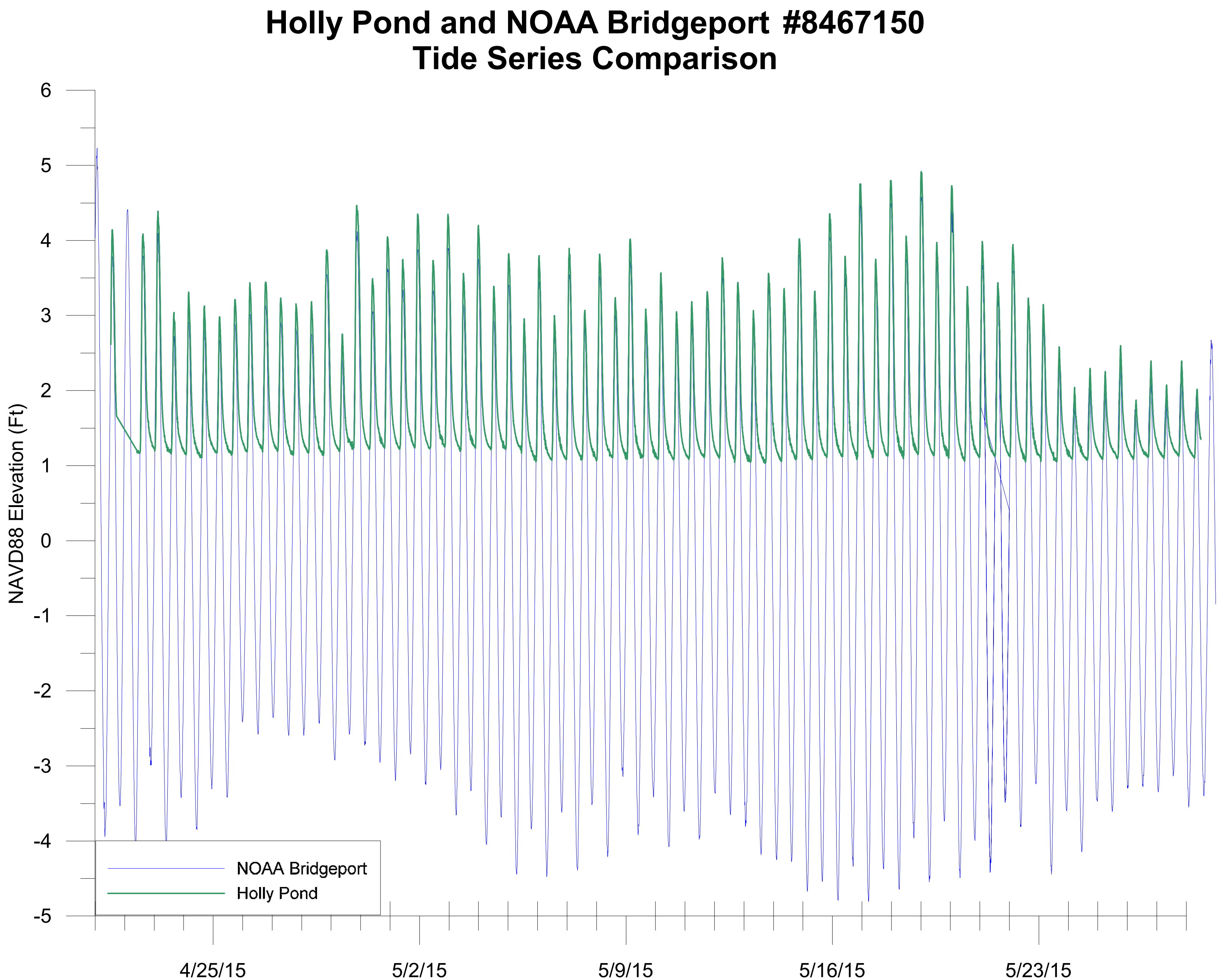
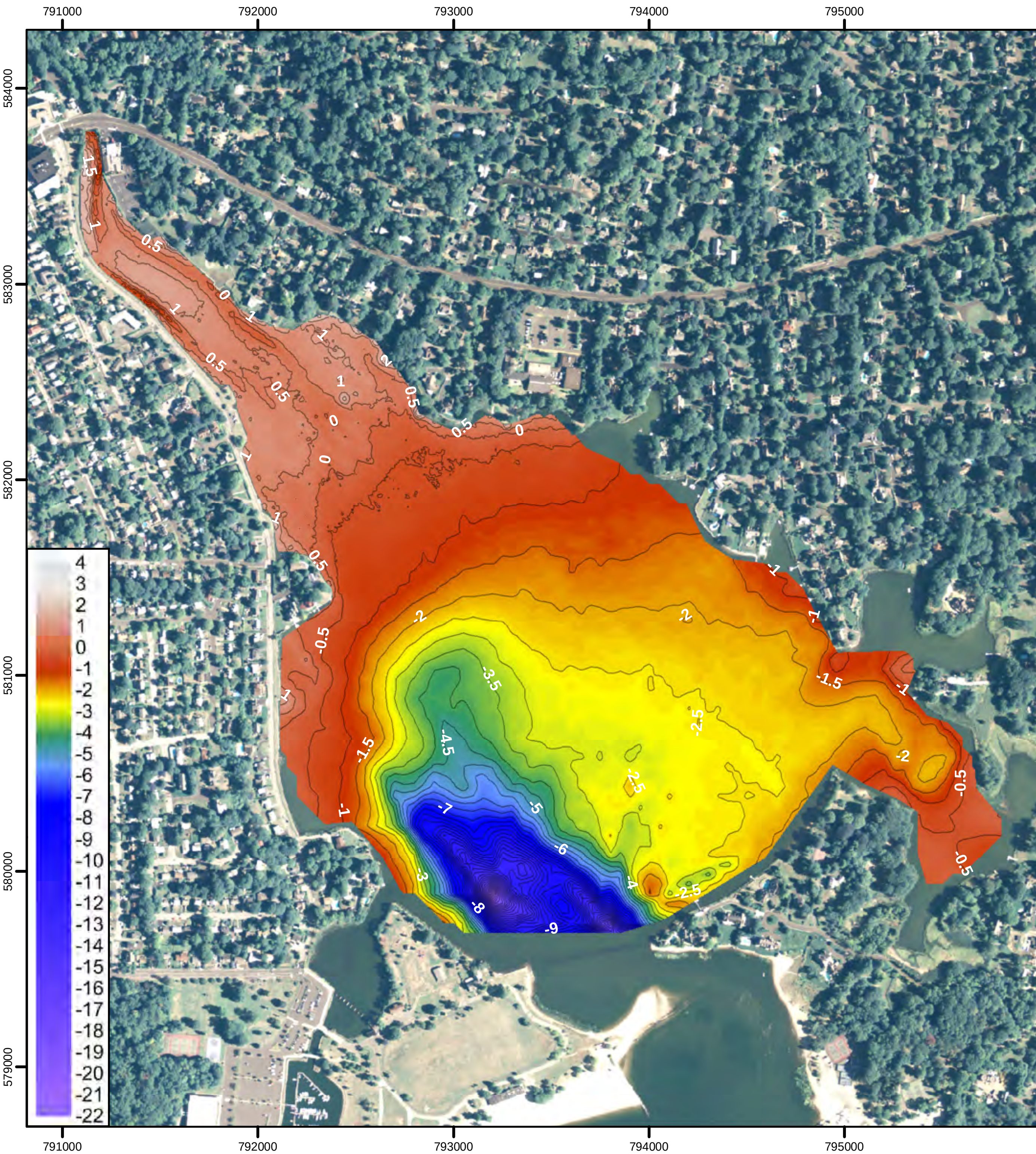


Figure 1

Figure 2


Holly Pond and NOAA Bridgeport #8467150
Tide Series Comparison
NAVD88 Elevation (Ft)
6
5
4
3
2
1
0
-1
-2
-3
-4
-5
4/25/15
5/2/15
5/9/15
5/16/15
5/23/15
NOAA Bridgeport
Holly Pond



2015 Holly Pond NAVD88 Bathymetry
0.5 Foot Contour Interval
Stamford and Darien, Connecticut

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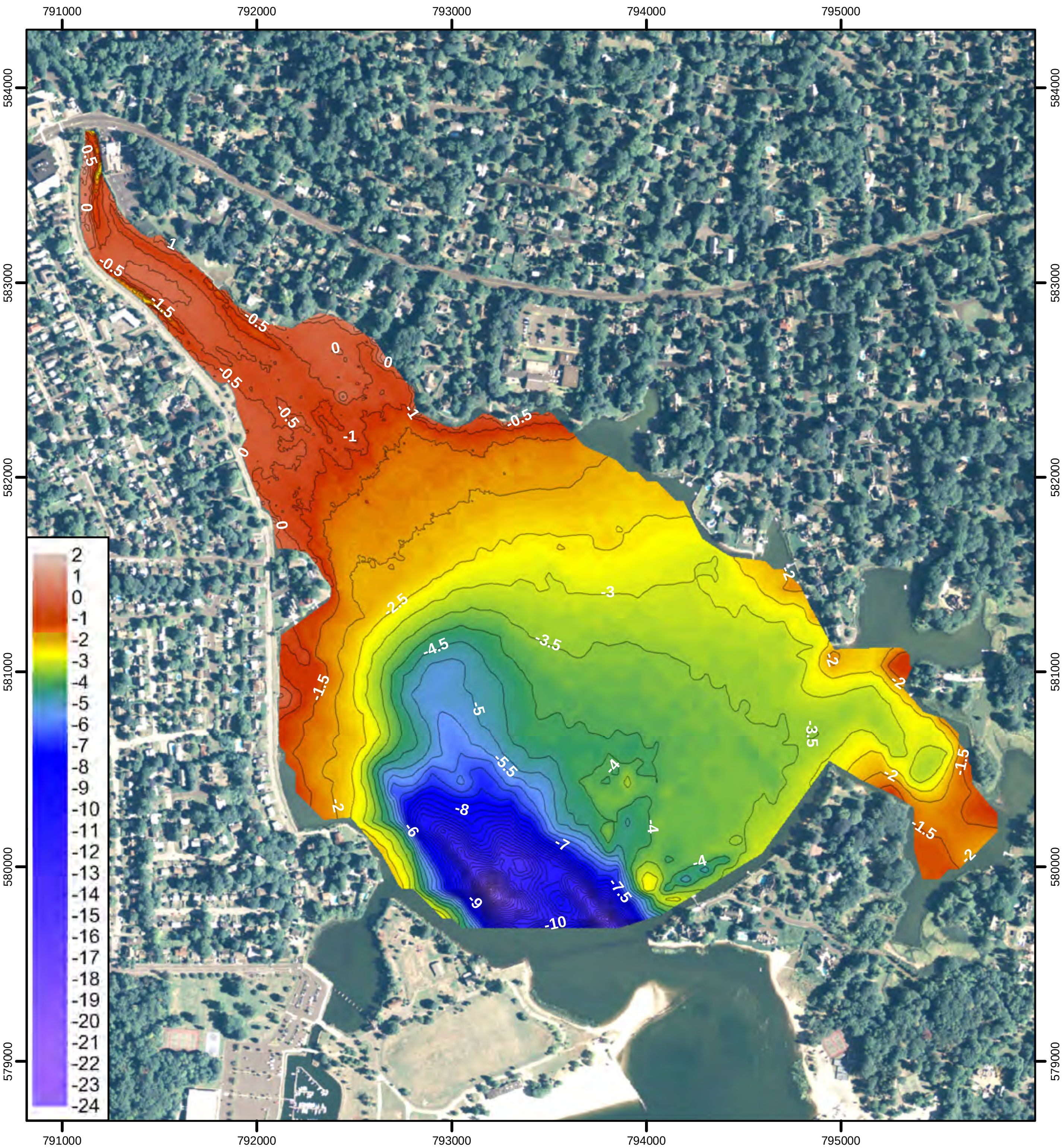
NOTES:
1) Survey conducted 4/21/15 and 6/17/15.
2) Grid CT State Plane, NAD 83, US Foot
3) Spectrum map uses 0.25-foot contour intervals

Feet
0 400 800

N W E S

Figure 3



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2015 Holly Pond Low Water Bathymetry
0.5 Foot Contour Interval
Stamford and Darien, Connecticut

N
W E
S

NOTES:
1) Survey conducted 4/21/15 and 6/17/15.
2) Grid CT State Plane, NAD 83, US Foot
3) Spectrum map uses 0.25-foot contour intervals

Feet
0 400 800

Figure 4

APPENDIX C

Detailed Conceptual Cost Estimates

UNIT PRICE SCHEDULE - NORTHERN SHOAL - DREDGING to 0 FEET NAVD88 ALTERNATIVE - LOW RANGE

ITEM	*DESCRIPTION*		*UNIT*	*ESTIMATED QUANTITY*	*UNIT PRICE*	*TOTAL ITEM PRICE*	*REFERENCE*
1	**Pre-Construction Activities**						
		Design	LS	1	$ 95,000	$ 95,000	
		Regulatory Requirement, Legal, and Community Outreach (2 % of construction activities)	%			$ 23,629	
		Pre-Design Investigation - Sediment Cores	EA	3	$ 6,000	$ 18,000	Assume minimum 1 sample per 4000 cy and minimum 3 cores per acre.
		Habitat/Cultural Surveys	LS	1	$ 10,000	$ 10,000	
		Borrow Material Screening and Characterization	EA	0	$ 5,000	$ -	
		Pre-Construction Meeting / Pre-Bid Meeting	LS	1	$ 3,000	$ 3,000	*PM and Engineer attending 1 meeting
2	**Site Preparation**						
		Site Preparation / Area Development					
		Pre Construction, Interim, Finalize Survey	D	10	$ 1,000	$ 10,000	Construction Staking is assumed at 2% of total costs as a standard (assuming approx 2 mil. Cost)
		Grading - Stabilize Construction Entrance	SY	667	$ 21	$ 14,000	2015 ConnDOT Cost estimating Guidelines unit price (assuming 3, 100'x20' construction entrances)
		Coarse Aggregate	CY	222	$ 80	$ 17,778	Assuming 3 100'x20' construction entrances
		Stabilization / fabric placement	SY	2,939	$ 3	$ 8,817	2015 ConnDOT Standard Cost items estimate
3	**Construction**						
		Site Construction Work					
		Erosion/Sediment control	LF	3000	$ 5	$ 15,000	SESC measures for Dredging Operations
		Turbidity Monitoring	LF	1500	$ 10	$ 15,000	2015 ConnDOT Sedimentation Control System Prices
		Site Dredging Quantity to 0.0 FT NAVD88	CY	2426	$ 295	$ 715,744	Relevant Projects worked by Louis Berger unit costs range based on previous experience. Estimated quantity includes an additional 15%.
		Site Dredged material Disposal (80% non contaminated)	CY	1941	$ 120	$ 232,920	Relevant Projects unit costs range based on previous experience (including testing before disposal)
		Site Dredged material Disposal (20% contaminated)	CY	485	$ 180	$ 87,345	Unit costs range based on previous experience (including tipping fees to landfill and material testing)
		Cofferdam/Dewatering / diversion channel (if required)	LS	1	$ 35,000	$ 35,000	Used for Setup of dewatering filter bags, operation and maintenance and disposal
4	**Restoration - Holly Pond**						
		Restoration of Dredged area Seeding	SY	24200	$ 1	$ 24,200	Higbee Beach Cost Estimate Pricing (assuming 3-5 acres of disturbed area to be restored)
		Miscellaneous planting for disturbed area during dredging	EA	75.0	$ 75	$ 5,625	Shrubs and trees planting at disturbed areas
5	**Other**						
		Construction Management (10% of Cost)	%			$ 133,106	
		Contingencies & Inflation (25% of cost)	%			$ 332,764	
		O&M Costs (5%)	%			$ 66,553	
		Mobilization/ Demobilization (10%)	%			$ 133,106	

Notes:

LS	Lump Sum
LF	Linear Foot
CY	Cubic Yard
SF	Square Foot
EA	Each
D	Days
SY	Square Yards

Sub-total	$ 1,331,057
Construction Management (10% of Cost)	$ 133,106
Contingencies & Inflation(15% of cost)	$ 332,764
O&M Costs (5%)	$ 66,553
Mobilization/ Demobilization (10%)	$ 133,106
NORTHERN SHOAL - 0 FEET NAVD88 LOW RANGE TOTAL	$ 1,996,585

UNIT PRICE SCHEDULE - SOUTHERN SHOAL - DREDGING to 0 FEET NAVD88 ALTERNATIVE - LOW RANGE

ITEM	DESCRIPTION		UNIT	ESTIMATED QUANTITY	UNIT PRICE	TOTAL ITEM PRICE	REFERENCE
1	**Pre-Construction Activities**						
		Design	LS	1	$ 580,000	$ 580,000	
		Regulatory Requirement, Legal, and Community Outreach (2 % of construction activities)	%			$ 145,025	
		Pre-Design Investigation - Sediment Cores	EA	15	$ 6,000	$ 90,000	Assume minimum 1 sample per 4000 cy and minimum 3 cores per acre.
		Habitat/Cultural Surveys	LS	1	$ 10,000	$ 10,000	
		Borrow Material Screening and Characterization	EA	0	$ 5,000	$ -	
		Pre-Construction Meeting / Pre-Bid Meeting	LS	1	$ 3,000	$ 3,000	*PM and Engineer attending 1 meeting
2	**Site Preparation**						
		Site Preparation / Area Development					
		Pre Construction, Interim, Finalize Survey	D	20	$ 1,000	$ 20,000	Construction Staking is assumed at 2% of total costs as a standard (assuming approx 2 mil. Cost)
		Grading - Stabilize Construction Entrance	SY	889	$ 21	$ 18,667	2015 ConnDOT Cost estimating Guidelines unit price (assuming 4, 100'x20' construction entrances)
		Coarse Aggregate	CY	296	$ 80	$ 23,704	Assuming 4 100'x20' construction entrances
		Stabilization / fabric placement	SY	3,833	$ 3	$ 11,500	2015 ConnDOT Standard Cost items estimate
3	**Construction**						
		Site Construction Work					
		Erosion/Sediment control	LF	5000	$ 5	$ 25,000	SESC measures for Dredging Operations
		Turbidity Monitoring	LF	2500	$ 10	$ 25,000	2015 ConnDOT Sedimentation Control System Prices
		Site Dredging Quantity to 0.0 FT NAVD88	CY	16435	$ 295	$ 4,848,310	Relevant Projects worked by Berger unit costs range based on previous experience. Estimated quantity includes an additional 15%.
		Site Dredged material Disposal (80% non contaminated)	CY	13148	$ 120	$ 1,577,755	Relevant Projects unit costs range based on previous experience (including testing before disposal)
		Site Dredged material Disposal (20% contaminated)	CY	3287	$ 180	$ 591,658	Unit costs range based on previous experience (including tipping fees to landfill and material testing)
		Cofferdam/Dewatering / diversion channel (if required)	LS	1	$ 50,000	$ 50,000	Used for Setup of dewatering filter bags, operation and maintenance and disposal
4	**Restoration - Holly Pond**						
		Restoration of Dredged area Seeding	SY	48400	$ 1	$ 48,400	Higbee Beach Cost Estimate Pricing (assuming 8-10 acres of disturbed area to be restored
		Miscellaneous planting for disturbed area during dredging	EA	150	$ 75	$ 11,250	Shrubs and trees planting at disturbed areas
5	**Other**						
		Construction Management (10% of Cost)	%			$ 807,927	
		Contingencies & Inflation (25% of cost)	%			$ 2,019,817	
		O&M Costs (5%)	%			$ 403,963	
		Mobilization/ Demobilization (10%)	%			$ 807,927	

Notes:

LS	Lump Sum
LF	Linear Foot
CY	Cubic Yard
SF	Square Foot
EA	Each
D	Days
SY	Square Yards

Sub-total	$ 8,079,268
Construction Management (10% of Cost)	$ 807,927
Contingencies & Inflation(25% of cost)	$ 2,019,817
O&M Costs (5%)	$ 403,963
Mobilization/ Demobilization (10%)	$ 807,927
SOUTHERN SHOAL - 0 FEET NAVD88 LOW RANGE TOTAL	$ 12,118,902

UNIT PRICE SCHEDULE - NORTHERN SHOAL - DREDGING to 0 FEET NAVD88 ALTERNATIVE - HIGH RANGE COST

ITEM	*DESCRIPTION*		*UNIT*	*ESTIMATED QUANTITY*	*UNIT PRICE*	*TOTAL ITEM PRICE*	*REFERENCE*
1	**Pre-Construction Activities**						
		Design	LS	1	$ 180,000	$ 180,000	
		Regulatory Requirement, Legal, and Community Outreach (2 % of construction activities)	%			$ 44,493	
		Pre-Design Investigation - Sediment Cores	EA	3	$ 6,000	$ 18,000	Assume minimum 1 sample per 4000 cy and minimum 3 cores per acre.
		Habitat/Cultural Surveys	LS	1	$ 10,000	$ 10,000	
		Borrow Material Screening and Characterization	EA	3	$ 5,000	$ 15,000	Assume screening of 3 borrow sources.
		Pre-Construction Meeting / Pre-Bid Meeting	LS	1	$ 3,000	$ 3,000	*PM and Engineer attending 1 meeting
2	**Site Preparation**						
		Site Preparation / Area Development					
		Pre Construction, Interim, Finalize Survey	D	10	$ 1,000	$ 10,000	Construction Staking is assumed at 2% of total costs as a standard (assuming approx 2 mil. Cost)
		Grading - Stabilize Construction Entrance	SY	667	$ 21	$ 14,000	2015 ConnDOT Cost estimating Guidelines unit price (assuming 3, 100'x20' construction entrances)
		Coarse Aggregate	CY	222	$ 80	$ 17,778	Assuming 3 100'x20' construction entrances
		Stabilization / fabric placement	SY	2,939	$ 3	$ 8,817	2015 ConnDOT Standard Cost items estimate
3	**Construction**						
		Site Construction Work					
		Erosion/Sediment control	LF	3000	$ 5	$ 15,000	SESC measures for Dredging Operations
		Turbidity Monitoring	LF	1500	$ 10	$ 15,000	2015 ConnDOT Sedimentation Control System Prices
		Site Dredging Quantity to 0.0 FT NAVD88	CY	4065	$ 295	$ 1,199,236	Relevant Projects worked by Berger unit costs range based on previous experience. Estimated quantity includes an additional 15%.
		Site Dredged material Disposal (0% non contaminated)	CY	0	$ 120	$ -	Relevant Projects unit costs range based on previous experience (including testing before disposal)
		Site Dredged material Disposal (100% contaminated)	CY	4065	$ 180	$ 731,737	Unit costs range based on previous experience (including tipping fees to landfill and material testing)
		Sand Cover Purchase, Delivery, and Placement	CY	1648	$ 90	$ 148,277	Estimated quantity includes an additional 15%.
		Cofferdam/Dewatering / diversion channel (if required)	LS	1	$ 35,000	$ 35,000	Used for Setup of dewatering filter bags, operation and maintenance and disposal
4	**Restoration - Holly Pond**						
		Restoration of Dredged area Seeding	SY	24200	$ 1	$ 24,200	Higbee Beach Cost Estimate Pricing (assuming 3-5 acres of disturbed area to be restored
		Miscellaneous planting for disturbed area during dredging	EA	75.0	$ 75	$ 5,625	Shrubs and trees planting at disturbed areas
5	**Other**						
		Construction Management (10% of Cost)	%			$ 249,516	
		Contingencies & Inflation (25% of cost)	%			$ 623,791	
		O&M Costs (5%)	%			$ 124,758	
		Mobilization/ Demobilization (10%)	%			$ 249,516	

Sub-total	$ 2,495,164
Construction Management (10% of Cost)	$ 249,516
Contingencies & Inflation(25% of cost)	$ 623,791
O&M Costs (5%)	$ 124,758
Mobilization/ Demobilization (10%)	$ 249,516
NORTHERN SHOAL - 0 FEET NAVD88 HIGH RANGE TOTAL	$ 3,742,745

Notes:

LS	Lump Sum
LF	Linear Foot
CY	Cubic Yard
SF	Square Foot
EA	Each
D	Days
SY	Square Yards

UNIT PRICE SCHEDULE - SOUTHERN SHOAL - DREDGING to 0 FEET NAVD88 ALTERNATIVE - HIGH RANGE

ITEM	*DESCRIPTION*		*UNIT*	*ESTIMATED QUANTITY*	*UNIT PRICE*	*TOTAL ITEM PRICE*	*REFERENCE*
1	**Pre-Construction Activities**						
		Design	LS	1	$ 1,940,000	$ 1,940,000	
		Regulatory Requirement, Legal, and Community Outreach (2 % of construction activities)	%			$ 484,081	
		Pre-Design Investigation - Sediment Cores	EA	15	$ 6,000	$ 90,000	Assume minimum 1 sample per 4000 cy and minimum 3 cores per acre.
		Habitat/Cultural Surveys	LS	1	$ 10,000	$ 10,000	
		Borrow Material Screening and Characterization	EA	3	$ 5,000	$ 15,000	Assume screening of 3 borrow sources.
		Pre-Construction Meeting / Pre-Bid Meeting	LS	1	$ 3,000	$ 3,000	*PM and Engineer attending 1 meeting
2	**Site Preparation**						
		Site Preparation / Area Development					
		Pre Construction, Interim, Finalize Survey	D	20	$ 1,000	$ 20,000	Construction Staking is assumed at 2% of total costs as a standard (assuming approx 2 mil. Cost)
		Grading - Stabilize Construction Entrance	SY	889	$ 21	$ 18,667	2015 ConnDOT Cost estimating Guidelines unit price (assuming 4, 100'x20' construction entrances)
		Coarse Aggregate	CY	296	$ 80	$ 23,704	Assuming 4 100'x20' construction entrances
		Stabilization / fabric placement	SY	3,833	$ 3	$ 11,500	2015 ConnDOT Standard Cost items estimate
3	**Construction**						
		Site Construction Work					
		Erosion/Sediment control	LF	5000	$ 5	$ 25,000	SESC measures for Dredging Operations
		Turbidity Monitoring	LF	2500	$ 10	$ 25,000	2015 ConnDOT Sedimentation Control System Prices
		Site Dredging Quantity to 0.0 FT NAVD88	CY	45044	$ 295	$ 13,287,895	Relevant Projects worked by Berger unit costs range based on previous experience. Estimated quantity includes an additional 15%.
		Site Dredged material Disposal (0% non contaminated)	CY	0	$ 120	$ -	Relevant Projects unit costs range based on previous experience (including testing before disposal)
		Site Dredged material Disposal (100% contaminated)	CY	45044	$ 180	$ 8,107,868	Unit costs range based on previous experience (including tipping fees to landfill and material testing)
		Sand Cover Purchase, Delivery, and Placement	CY	28609	$ 90	$ 2,574,789	Estimated quantity includes an additional 15%.
		Cofferdam/Dewatering / diversion channel (if required)	LS	1	$ 50,000	$ 50,000	Used for Setup of dewatering filter bags, operation and maintenance and disposal
4	**Restoration - Holly Pond**						
		Restoration of Dredged area Seeding	SY	48400	$ 1	$ 48,400	Higbee Beach Cost Estimate Pricing (assuming 8-10 acres of disturbed area to be restored
		Miscellaneous planting for disturbed area during dredging	EA	150	$ 75	$ 11,250	Shrubs and trees planting at disturbed areas
5	**Other**						
		Construction Management (10% of Cost)	%			$ 2,674,615	
		Contingencies & Inflation (25% of cost)	%			$ 6,686,538	
		O&M Costs (5%)	%			$ 1,337,308	
		Mobilization/ Demobilization (10%)	%			$ 2,674,615	

Notes:

LS	Lump Sum
LF	Linear Foot
CY	Cubic Yard
SF	Square Foot
EA	Each
D	Days
SY	Square Yards

Sub-total	$ 26,746,153
Construction Management (10% of Cost)	$ 2,674,615
Contingencies & Inflation(25% of cost)	$ 6,686,538
O&M Costs (5%)	$ 1,337,308
Mobilization/ Demobilization (10%)	$ 2,674,615
SOUTHERN SHOAL - 0 FEET NAVD88 HIGH RANGE TOTAL	$ 40,119,230

UNIT PRICE SCHEDULE - NORTHERN SHOAL - DREDGING to 0.5 FEET NAVD88 ALTERNATIVE - LOW RANGE

ITEM	DESCRIPTION		UNIT	ESTIMATED QUANTITY	UNIT PRICE	TOTAL ITEM PRICE	REFERENCE
1	**Meetings**						
		Design (8% of construction activities)	LS	1	$ 65,000	$ 65,000	
		Regulatory Requirement, Legal, and Community Outreach (2 % of construction activities)	%			$ 16,483	
		Pre-Design Investigation - Sediment Cores	EA	15	$ 6,000	$ 90,000	Assume minimum 1 sample per 4000 cy and minimum 3 cores per acre.
		Habitat/Cultural Surveys	LS	1	$ 10,000	$ 10,000	
		Borrow Material Screening and Characterization	EA	0	$ 5,000	$ -	
		Pre-Construction Meeting / Pre-Bid Meeting	LS	1	$ 3,000	$ 3,000	*PM and Engineers attending 1 meeting
2	**Site Preparation**						
		Site Preparation / Area Development					
		Pre Construction, Interim, Finalize Survey	D	10	$ 1,000	$ 10,000	Construction Staking is assumed at 2% of total costs as a standard (assuming approx 2 mil. Cost)
		Grading - Stabilize Construction Entrance	SY	667	$ 21	$ 14,000	2015 ConnDOT Cost estimating Guidelines unit price (assuming 3, 100'x20' construction entrances)
		Coarse Aggregate	CY	222	$ 80	$ 17,778	Assuming 3 100'x20' construction entrances
		Stabilization / fabric placement	SY	2,939	$ 3	$ 8,817	2015 ConnDOT Standard Cost items estimate
3	**Construction**						
		Site Construction Work					
		Erosion/Sediment control	LF	3000	$ 5	$ 15,000	SESC measures for Dredging Operations
		Turbidity Monitoring	LF	1500	$ 10	$ 15,000	2015 ConnDOT Sedimentation Control System Prices
		Site Dredging Quantity to 0.5' FT NAVD88	CY	1590	$ 295	$ 468,912	Relevant Projects worked by Berger unit costs range based on previous experience. Estimated quantity includes an additional 15%.
		Site Dredged material Disposal (80% non contaminated0	CY	1272	$ 120	$ 152,595	Relevant Projects unit costs range based on previous experience (including testing before disposal)
		Site Dredged material Disposal (20% contaminated0	CY	318	$ 180	$ 57,223	Unit costs range based on previous experience (including tipping fees to landfill and material testing)
		Cofferdam/Dewatering / diversion channel (if required)	LS	1	$ 35,000	$ 35,000	Used for Setup of dewatering filter bags, operation and maintenance and disposal
4	**Restoration - Holly Pond**						
		Restoration of Dredged area Seeding	SY	24200	$ 1	$ 24,200	Higbee Beach Cost Estimate Pricing (assuming 3-5 acres of disturbed area to be restored
		Miscellaneous planting for disturbed area during dredging	EA	75.0	$ 75	$ 5,625	Shrubs and trees planting at disturbed areas
5	**Other**						
		Construction Management (10% of Cost)	%			$ 100,863	
		Contingencies & Inflation (25% of cost)	%			$ 252,158	
		O&M Costs (5%)	%			$ 50,432	
		Mobilization/ Demobilization (10%)	%			$ 100,863	

Notes:

LS	Lump Sum
LF	Linear Foot
CY	Cubic Yard
SF	Square Foot
EA	Each
D	Days
SY	Square Yards

Sub-total	$ 1,008,632
Construction Management (10% of Cost)	$ 100,863
Contingencies & Inflation(25% of cost)	$ 252,158
O&M Costs (5%)	$ 50,432
Mobilization/ Demobilization (10%)	$ 100,863
NORTHERN SHOAL - 0.5 FEET NAVD88 LOW RANGE TOTAL	$ 1,512,948

UNIT PRICE SCHEDULE - SOUTHERN SHOAL - DREDGING to 0.5 FEET NAVD88 ALTERNATIVE - LOW RANGE

ITEM	DESCRIPTION		UNIT	ESTIMATED QUANTITY	UNIT PRICE	TOTAL ITEM PRICE	REFERENCE
1	**Meetings**						
		Design	LS	1	$ 210,000	$ 210,000	
		Regulatory Requirement, Legal, and Community Outreach (2 % of construction activities)	%			$ 53,196	
		Pre-Design Investigation - Sediment Cores	EA	15	$ 6,000	$ 90,000	Assume minimum 1 sample per 4000 cy and minimum 3 cores per acre.
		Habitat/Cultural Surveys	LS	1	$ 10,000	$ 10,000	
		Borrow Material Screening and Characterization	EA	0	$ 5,000	$ -	
		Pre-Construction Meeting / Pre-Bid Meeting	LS	1	$ 3,000	$ 3,000	*PM and Engineers attending 1 meeting
2	**Site Preparation**						
		Site Preparation / Area Development					
		Pre Construction, Interim, Finalize Survey	D	20	$ 1,000	$ 20,000	Construction Staking is assumed at 2% of total costs as a standard (assuming approx 2 mil. Cost)
		Grading - Stabilize Construction Entrance	SY	889	$ 21	$ 18,667	2015 ConnDOT Cost estimating Guidelines unit price (assuming 4, 100'x20' construction entrances)
		Coarse Aggregate	CY	296	$ 80	$ 23,704	Assuming 4 100'x20' construction entrances
		Stabilization / fabric placement	SY	3,833	$ 3	$ 11,500	2015 ConnDOT Standard Cost items estimate
3	**Construction**						
		Site Construction Work					
		Erosion/Sediment control	LF	5000	$ 5	$ 25,000	SESC measures for Dredging Operations
		Turbidity Monitoring	LF	2500	$ 10	$ 25,000	2015 ConnDOT Sedimentation Control System Prices
		Site Dredging Quantity to 0.0 FT NAVD88	CY	5682	$ 295	$ 1,676,234	Relevant Projects worked by Berger unit costs range based on previous experience. Estimated quantity includes an additional 15%.
		Site Dredged material Disposal (80% non contaminated0	CY	4546	$ 120	$ 545,486	Relevant Projects unit costs range based on previous experience (including testing before disposal)
		Site Dredged material Disposal (20% contaminated0	CY	1136	$ 180	$ 204,557	Unit costs range based on previous experience (including tipping fees to landfill and material testing)
		Cofferdam/Dewatering / diversion channel (if required)	LS	1	$ 50,000	$ 50,000	Used for Setup of dewatering filter bags, operation and maintenance and disposal
4	**Restoration - Holly Pond**						
		Restoration of Dredged area Seeding	SY	48400	$ 1	$ 48,400	Higbee Beach Cost Estimate Pricing (assuming 8-10 acres of disturbed area to be restored
		Miscellaneous planting for disturbed area during dredging	EA	150.0	$ 75	$ 11,250	Shrubs and trees planting at disturbed areas
5	**Other**						
		Construction Management (10% of Cost)	%			$ 302,599	
		Contingencies & Inflation (25% of cost)	%			$ 756,499	
		O&M Costs (5%)	%			$ 151,300	
		Mobilization/ Demobilization (10%)	%			$ 302,599	

Sub-total	$ 3,025,994
Construction Management (10% of Cost)	$ 302,599
Contingencies & Inflation(25% of cost)	$ 756,499
O&M Costs (5%)	$ 151,300
Mobilization/ Demobilization (10%)	$ 302,599
SOUTHERN SHOAL - 0.5 FEET NAVD88 LOW RANGE TOTAL	$ 4,538,992

Notes:

LS	Lump Sum
LF	Linear Foot
CY	Cubic Yard
SF	Square Foot
EA	Each
D	Days
SY	Square Yards

UNIT PRICE SCHEDULE - NORTHERN SHOAL - DREDGING to 0.5 FEET NAVD88 ALTERNATIVE - HIGH RANGE

ITEM	*DESCRIPTION*		*UNIT*	*ESTIMATED QUANTITY*	*UNIT PRICE*	*TOTAL ITEM PRICE*	*REFERENCE*
1	**Meetings**						
		Design	LS	1	$ 135,000	$ 135,000	
		Regulatory Requirement, Legal, and Community Outreach (2 % of construction activities)	%			$ 33,907	
		Pre-Design Investigation - Sediment Cores	EA	15	$ 6,000	$ 90,000	Assume minimum 1 sample per 4000 cy and minimum 3 cores per acre.
		Habitat/Cultural Surveys	LS	1	$ 10,000	$ 10,000	
		Borrow Material Screening and Characterization	EA	3	$ 5,000	$ 15,000	Assume screening of 3 borrow sources.
		Pre-Construction Meeting / Pre-Bid Meeting	LS	1	$ 3,000	$ 3,000	*PM and Engineers attending 1 meeting
2	**Site Preparation**						
		Site Preparation / Area Development					
		Pre Construction, Interim, Finalize Survey	D	10	$ 1,000	$ 10,000	Construction Staking is assumed at 2% of total costs as a standard (assuming approx 2 mil. Cost)
		Grading - Stabilize Construction Entrance	SY	667	$ 21	$ 14,000	2015 ConnDOT Cost estimating Guidelines unit price (assuming 3, 100'x20' construction entrances)
		Coarse Aggregate	CY	222	$ 80	$ 17,778	Assuming 3 100'x20' construction entrances
		Stabilization / fabric placement	SY	2,939	$ 3	$ 8,817	2015 ConnDOT Standard Cost items estimate
3	**Construction**						
		Site Construction Work					
		Erosion/Sediment control	LF	3000	$ 5	$ 15,000	SESC measures for Dredging Operations
		Turbidity Monitoring	LF	1500	$ 10	$ 15,000	2015 ConnDOT Sedimentation Control System Prices
		Site Dredging Quantity to 0.5' FT NAVD88	CY	2997	$ 295	$ 884,035	Relevant Projects worked by Berger unit costs range based on previous experience. Estimated quantity includes an additional 15%.
		Site Dredged material Disposal (0% non contaminated)	CY	0	$ 120	$ -	Relevant Projects unit costs range based on previous experience (including testing before disposal)
		Site Dredged material Disposal (100% contaminated)	CY	2997	$ 180	$ 539,411	Unit costs range based on previous experience (including tipping fees to landfill and material testing)
		Sand Cover Purchase, Delivery, and Placement	CY	1406	$ 90	$ 126,508	Estimated quantity includes an additional 15%.
		Cofferdam/Dewatering / diversion channel (if required)	LS	1	$ 35,000	$ 35,000	Used for Setup of dewatering filter bags, operation and maintenance and disposal
4	**Restoration - Holly Pond**						
		Restoration of Dredged area Seeding	SY	24200	$ 1	$ 24,200	Higbee Beach Cost Estimate Pricing (assuming 3-5 acres of disturbed area to be restored
		Miscellaneous planting for disturbed area during dredging	EA	75.0	$ 75	$ 5,625	Shrubs and trees planting at disturbed areas
5	**Other**						
		Construction Management (10% of Cost)	%			$ 198,228	
		Contingencies & Inflation (25% of cost)	%			$ 495,570	
		O&M Costs (5%)	%			$ 99,114	
		Mobilization/ Demobilization (10%)	%			$ 198,228	

Notes:

LS	Lump Sum
LF	Linear Foot
CY	Cubic Yard
SF	Square Foot
EA	Each
D	Days
SY	Square Yards

Sub-total	$ 1,982,281
Construction Management (10% of Cost)	$ 198,228
Contingencies & Inflation(25% of cost)	$ 495,570
O&M Costs (5%)	$ 99,114
Mobilization/ Demobilization (10%)	$ 198,228
NORTHERN SHOAL - 0.5 FEET NAVD88 HIGH RANGE TOTAL	$ 2,973,422

UNIT PRICE SCHEDULE - SOUTHERN SHOAL - DREDGING to 0.5 FEET NAVD88 ALTERNATIVE - HIGH RANGE

ITEM	*DESCRIPTION*		*UNIT*	*ESTIMATED QUANTITY*	*UNIT PRICE*	*TOTAL ITEM PRICE*	*REFERENCE*
1	**Meetings**						
		Design	LS	1	$ 610,000	$ 610,000	
		Regulatory Requirement, Legal, and Community Outreach (2 % of construction activities)	%			$ 152,297	
		Pre-Design Investigation - Sediment Cores	EA	15	$ 6,000	$ 90,000	Assume minimum 1 sample per 4000 cy and minimum 3 cores per acre.
		Habitat/Cultural Surveys	LS	1	$ 10,000	$ 10,000	
		Borrow Material Screening and Characterization	EA	3	$ 5,000	$ 15,000	Assume screening of 3 borrow sources.
		Pre-Construction Meeting / Pre-Bid Meeting	LS	1	$ 3,000	$ 3,000	*PM and Engineers attending 1 meeting
2	**Site Preparation**						
		Site Preparation / Area Development					
		Pre Construction, Interim, Finalize Survey	D	20	$ 1,000	$ 20,000	Construction Staking is assumed at 2% of total costs as a standard (assuming approx 2 mil. Cost)
		Grading - Stabilize Construction Entrance	SY	889	$ 21	$ 18,667	2015 ConnDOT Cost estimating Guidelines unit price (assuming 4, 100'x20' construction entrances)
		Coarse Aggregate	CY	296	$ 80	$ 23,704	Assuming 4 100'x20' construction entrances
		Stabilization / fabric placement	SY	3,833	$ 3	$ 11,500	2015 ConnDOT Standard Cost items estimate
3	**Construction**						
		Site Construction Work					
		Erosion/Sediment control	LF	5000	$ 5	$ 25,000	SESC measures for Dredging Operations
		Turbidity Monitoring	LF	2500	$ 10	$ 25,000	2015 ConnDOT Sedimentation Control System Prices
		Site Dredging Quantity to 0.5 FT NAVD88	CY	13969	$ 295	$ 4,120,983	Relevant Projects worked by Berger unit costs range based on previous experience. Estimated quantity includes an additional 15%.
		Site Dredged material Disposal (0% non contaminated)	CY	0	$ 120	$ -	Relevant Projects unit costs range based on previous experience (including testing before disposal)
		Site Dredged material Disposal (100% contaminated)	CY	13969	$ 180	$ 2,514,498	Unit costs range based on previous experience (including tipping fees to landfill and material testing)
		Sand Cover Purchase, Delivery, and Placement	CY	8287	$ 90	$ 745,852	Estimated quantity includes an additional 15%.
		Cofferdam/Dewatering / diversion channel (if required)	LS	1	$ 50,000	$ 50,000	Used for Setup of dewatering filter bags, operation and maintenance and disposal
4	**Restoration - Holly Pond**						
		Restoration of Dredged area Seeding	SY	48400	$ 1	$ 48,400	Higbee Beach Cost Estimate Pricing (assuming 8-10 acres of disturbed area to be restored
		Miscellaneous planting for disturbed area during dredging	EA	150	$ 75	$ 11,250	Shrubs and trees planting at disturbed areas
5	**Other**						
		Construction Management (10% of Cost)	%			$ 849,515	
		Contingencies & Inflation (25% of cost)	%			$ 2,123,787	
		O&M Costs (5%)	%			$ 424,757	
		Mobilization/ Demobilization (10%)	%			$ 849,515	

Notes:

LS	Lump Sum
LF	Linear Foot
CY	Cubic Yard
SF	Square Foot
EA	Each
D	Days
SY	Square Yards

Sub-total	$ 8,495,150
Construction Management (10% of Cost)	$ 849,515
Contingencies & Inflation(25% of cost)	$ 2,123,787
O&M Costs (5%)	$ 424,757
Mobilization/ Demobilization (10%)	$ 849,515
SOUTHERN SHOAL - 0.5 FEET NAVD88 HIGH RANGE TOTAL	$ 12,742,725

UNIT PRICE SCHEDULE - NORTHERN SHOAL - TIDAL MARSH ALTERNATIVE

ITEM	*DESCRIPTION*		*UNIT*	*ESTIMATED QUANTITY*	*UNIT PRICE*	*TOTAL ITEM PRICE*	*REFERENCE*
1	**Meetings**						
		Design	LS	1	$ 64,000	$ 64,000	
		Regulatory Requirement, Legal, and Community Outreach (5 % of construction activities)	%			$ 15,791	
		Pre-Design Investigation - Sediment Cores (Surface Grabs)	EA	15	$ 2,500	$ 37,500	Assume minimum 1 sample per 4000 cy and minimum 3 cores per acre.
		Habitat/Cultural Surveys	LS	1	$ 10,000	$ 10,000	
		Borrow Material Screening and Characterization	EA	3	$ 5,000	$ 15,000	Assume screening of 3 borrow sources.
		Pre-Construction Meeting / Pre-Bid Meeting	LS	1	$ 3,000	$ 3,000	*PM and Engineers attending 1 meeting
2	**Site Preparation**						
		Site Preparation / Area Development					
		Pre Construction, Interim, Finalize Survey	D	10	$ 1,000	$ 10,000	Construction Staking is assumed at 2% of total costs as a standard (assuming approx 2 mil. Cost)
		Grading - Stabilize Construction Entrance	SY	667	$ 21	$ 14,000	2015 ConnDOT Cost estimating Guidelines unit price (assuming 3, 100'x20' construction entrances)
		Coarse Aggregate	CY	222	$ 80	$ 17,778	Assuming 3 100'x20' construction entrances
		Stabilization / fabric placement	SY	2,939	$ 3	$ 8,817	2015 ConnDOT Standard Cost items estimate
3	**Construction**						
		Site Construction Work					
		Erosion/Sediment control	LF	3000	$ 5	$ 15,000	SESC measures for material placement
		Turbidity Monitoring	LF	1500	$ 10	$ 15,000	2015 ConnDOT Sedimentation Control System Prices
		Clean material placement for planting medium	CY	1978	$ 75	$ 148,385	2015 ConnDOT cost estimating Guideline Prices for granular Fill placement + material cost per cubic yd. Estimated quantity includes an additional 15%.
		Cofferdam/Dewatering / diversion channel (if required)	LS	1	$ 20,000	$ 20,000	Used for Setup of working in area of marsh restoration
4	**Restoration - Holly Pond**						
		LM planting for restored Shoal 1 area (Spartina Alterniflora)	EA	9500	$ 3.5	$ 33,250	MARSHES Construction Cost Estimate (planting at 2' center to center)
		Herbivory fencing and Control for marsh planting	LF	4800	$ 7	$ 33,600	4,500 to 5,500 LF per acre depening upon even and odd shaped planting area
5	**Other**						
		Construction Management (15% of Cost)	%			$ 69,168	
		Contingencies & Inflation (25% of cost)	%			$ 115,280	
		O&M Costs (5%)	%			$ 23,056	
		Mobilization/ Demobilization (10%)	%			$ 46,112	

Notes:

LS	Lump Sum
LF	Linear Foot
CY	Cubic Yard
SF	Square Foot
EA	Each
D	Days
SY	Square Yards

Sub-total	$ 461,121
Construction Management (15% of Cost)	$ 69,168
Contingencies & Inflation(25% of cost)	$ 115,280
O&M Costs (5%)	$ 23,056
Mobilization/ Demobilization (10%)	$ 46,112
NORTHERN SHOAL - TIDAL MARSH TOTAL	$ 714,738

UNIT PRICE SCHEDULE - SOUTHERN SHOAL - TIDAL MARSH ALTERNATIVE

ITEM	DESCRIPTION		UNIT	ESTIMATED QUANTITY	UNIT PRICE	TOTAL ITEM PRICE	REFERENCE
1	**Meetings**						
		Design	LS	1	$ 93,000	$ 93,000	
		Regulatory Requirement, Legal, and Community Outreach (3 % of construction activities)	%			$ 18,514	
		Pre-Design Investigation - Sediment Cores (Surface Grabs)	EA	15	$ 2,500	$ 37,500	Assume minimum 1 sample per 4000 cy and minimum 3 cores per acre.
		Habitat/Cultural Surveys	LS	1	$ 10,000	$ 10,000	
		Borrow Material Screening and Characterization	EA	3	$ 5,000	$ 15,000	Assume screening of 3 borrow sources.
		Pre-Construction Meeting / Pre-Bid Meeting	LS	1	$ 3,000	$ 3,000	*PM and Engineers attending 1 meeting
2	**Site Preparation**						
		Site Preparation / Area Development					
		Pre Construction, Interim, Finalize Survey	D	20	$ 1,000	$ 20,000	Construction Staking is assumed at 2% of total costs as a standard (assuming approx 2 mil. Cost)
		Grading - Stabilize Construction Entrance	SY	889	$ 21	$ 18,667	2015 ConnDOT Cost estimating Guidelines unit price (assuming 4, 100'x20' construction entrances)
		Coarse Aggregate	CY	296	$ 80	$ 23,704	Assuming 4 100'x20' construction entrances
		Stabilization / fabric placement	SY	3,833	$ 3	$ 11,500	2015 ConnDOT Standard Cost items estimate
3	**Construction**						
		Site Construction Work					
		Erosion/Sediment control	LF	5000	$ 5	$ 25,000	SESC measures for material placement
		Turbidity Monitoring	LF	2500	$ 10	$ 25,000	2015 ConnDOT Sedimentation Control System Prices
		Clean material placement for planting medium	CY	4735	$ 75	$ 355,094	2015 ConnDOT cost estimating Guideline Prices for granular Fill placement + material cost per cubic yd. Estimated quantity includes an additional 15%.
		Cofferdam/Dewatering / diversion channel (if required)	LS	1	$ 40,000	$ 40,000	Used for Setup of working in area of marsh restoration
4	**Restoration - Holly Pond**						
		LM planting for restored Shoal 2 area (Spartina Alterniflora)	EA	13750	$ 3.5	$ 48,125	MARSHES Construction Cost Estimate (planting at 2' center to center)
		Herbivory fencing and Control for marsh planting	LF	7150	$ 7	$ 50,050	4,500 to 5,500 LF per acre depening upon even and odd shaped planting area
5	**Other**						
		Construction Management (10% of Cost)	%			$ 79,415	
		Contingencies & Inflation (25% of cost)	%			$ 198,539	
		O&M Costs (5%)	%			$ 39,708	
		Mobilization/ Demobilization (10%)	%			$ 79,415	

Notes:

LS	Lump Sum
LF	Linear Foot
CY	Cubic Yard
SF	Square Foot
EA	Each
D	Days
SY	Square Yards

Sub-total	$ 794,154
Construction Management (10% of Cost)	$ 79,415
Contingencies & Inflation(25% of cost)	$ 198,539
O&M Costs (5%)	$ 39,708
Mobilization/ Demobilization (10%)	$ 79,415
SOUTHERN SHOAL -TIDAL MARSH TOTAL	$ 1,191,231

UNIT PRICE SCHEDULE - NORTHERN SHOAL - LIVING SHORELINE ALTERNATIVE - LOW RANGE

ITEM	DESCRIPTION		UNIT	ESTIMATED QUANTITY	UNIT PRICE	TOTAL ITEM PRICE	REFERENCE
1	**Meetings**						
		Design	LS	1	$ 48,000	$ 48,000	
		Regulatory Requirement, Legal, and Community Outreach (10 % of construction activities)	%			$ 22,975	
		Pre-Design Investigation - Sediment Cores	EA	15	$ 6,000	$ 90,000	Assume minimum 1 sample per 4000 cy and minimum 3 cores per acre.
		Habitat/Cultural Surveys	LS	1	$ 10,000	$ 10,000	
		Borrow Material Screening and Characterization	EA	0	$ 5,000	$ -	
		Pre-Construction Meeting / Pre-Bid Meeting	LS	1	$ 3,000	$ 3,000	*PM and Engineers attending 1 meeting
2	**Site Preparation**						
		Site Preparation / Area Development					
		Pre Construction, Interim, Finalize Survey	D	10	$ 1,000	$ 10,000	Construction Staking is assumed at 2% of total costs as a standard (assuming approx 2 mil. Cost)
		Grading - Stabilize Construction Entrance	SY	667	$ 21	$ 14,000	2015 ConnDOT Cost estimating Guidelines unit price (assuming 3, 100'x20' construction entrances)
		Coarse Aggregate	CY	222	$ 80	$ 17,778	Assuming 3 100'x20' construction entrances
		Stabilization / fabric placement	SY	2,939	$ 3	$ 8,817	2015 ConnDOT Standrd Cost items estimate
3	**Construction**						
		Site Construction Work					
		Erosion/Sediment control	LF	3000	$ 5	$ 15,000	SESC measures for material placement
		Turbidity Monitoring	LF	1500	$ 10	$ 15,000	2015 ConnDOT Sedimentation Control System Prices
		Site Exacavation/grading (80% non contaminated)	CY	729	$ 25	$ 18,225	2015 ConnDOT Cost estimating Guidelines unit costs range. Estimated quantity includes an additional 15%.
		Site Excavation/grading (20% contaminated material)	CY	182	$ 55	$ 10,024	Contaminated material not suitable for reuse
		Reused fill material placement for planting medium (non contaminated)	CY	725	$ 55	$ 39,878	2015 ConnDOT Cost estimating Guidelines unit costs range for Select Granular Fill Placement. Estimated quantity includes an additional 15%.
		Clean material placement for planting medium	CY	0	$ 75	$ -	2015 ConnDOT cost estimating Guideline Prices for granular Fill placement + material cost per cubic yd. Estimated quantity includes an additional 15%.
		Offsite material disposal (0% non contaminated)	CY	4	$ 120	$ 472	Material not reused
		Offsite material disposal (100% contaminated)	CY	182	$ 180	$ 32,804	
		Cofferdam/Dewatering / diversion channel (if required)	LS	1	$ 25,000	$ 25,000	Used for Setup of working in area of marsh restoration
4	**Restoration - Holly Pond**						
		LM planting for restored Marsh 1 area (Spartina Alterniflora)	EA	3200	$ 3.5	$ 11,200	MARSHES Construction Cost Estimate (planting at 2' center to center)
		Herbivory fencing and Control for marsh planting	LF	1650	$ 7	$ 11,550	4,500 to 5,500 LF per acre depening upon even and odd shaped planting area
5	**Other**						
		Construction Management (10% of Cost)	%			$ 40,372	
		Contingencies & Inflation (25% of cost)	%			$ 100,930	
		O&M Costs (5%)	%			$ 20,186	
		Mobilization/ Demobilization (10%)	%			$ 40,372	

Notes:

LS	Lump Sum
LF	Linear Foot
CY	Cubic Yard
SF	Square Foot
EA	Each
D	Days
SY	Square Yards

Sub-total	$ 403,722
Construction Management (10% of Cost)	$ 40,372
Contingencies & Inflation(25% of cost)	$ 100,930
O&M Costs (5%)	$ 20,186
Mobilization/ Demobilization (10%)	$ 40,372
NORTHERN SHOAL - LIVING SHORELINE - LOW RANGE TOTAL	$ 605,583

UNIT PRICE SCHEDULE - SOUTHERN SHOAL - LIVING SHORELINE ALTERNATIVE - LOW RANGE

ITEM	*DESCRIPTION*		*UNIT*	*ESTIMATED QUANTITY*	*UNIT PRICE*	*TOTAL ITEM PRICE*	*REFERENCE*
1	**Meetings**						
		Design	LS	1	$ 51,000	$ 51,000	
		Regulatory Requirement, Legal, and Community Outreach (5% of construction activities)	%			$ 15,688	
		Pre-Design Investigation - Sediment Cores	EA	15	$ 6,000	$ 90,000	Assume minimum 1 sample per 4000 cy and minimum 3 cores per acre.
		Habitat/Cultural Surveys	LS	1	$ 10,000	$ 10,000	
		Borrow Material Screening and Characterization	EA	0	$ 5,000	$ -	
		Pre-Construction Meeting / Pre-Bid Meeting	LS	1	$ 3,000	$ 3,000	*PM and Engineers attending 1 meeting
2	**Site Preparation**						
		Site Preparation / Area Development					
		Pre Construction, Interim, Finalize Survey	D	20	$ 1,000	$ 20,000	Construction Staking is assumed at 2% of total costs as a standard (assuming approx 2 mil. Cost)
		Grading - Stabilize Construction Entrance	SY	889	$ 21	$ 18,667	2015 ConnDOT Cost estimating Guidelines unit price (assuming 4, 100'x20' construction entrances)
		Coarse Aggregate	CY	296	$ 80	$ 23,704	Assuming 4 100'x20' construction entrances
		Stabilization / fabric placement	SY	3,833	$ 3	$ 11,500	2015 ConnDOT Standrd Cost items estimate
3	**Construction**						
		Site Construction Work					
		Erosion/Sediment control	LF	5000	$ 5	$ 25,000	SESC measures for material placement
		Turbidity Monitoring	LF	2500	$ 10	$ 25,000	2015 ConnDOT Sedimentation Control System Prices
		Site Exacavation/grading (80% non contaminated)	CY	947	$ 25	$ 23,673	2015 ConnDOT Cost estimating Guidelines unit costs range. Estimated quantity includes an additional 15%.
		Site Excavation/grading (20% contaminated material)	CY	237	$ 55	$ 13,020	Contaminated material not suitable for reuse
		Reused fill material placement for planting medium (non contaminated)	CY	875	$ 55	$ 48,122	2015 ConnDOT Cost estimating Guidelines unit costs range for Select Granular Fill Placement. Estimated quantity includes an additional 15%.
		Clean material placement for planting medium	CY	0	$ 75	$ -	2015 ConnDOT cost estimating Guideline Prices for granular Fill placement + material cost per cubic yd. Estimated quantity includes an additional 15%.
		Offsite material disposal (0% non contaminated)	CY	72	$ 120	$ 8,638	Material not reused
		Offsite material disposal (100% contaminated)	CY	237	$ 180	$ 42,611	
		Cofferdam/Dewatering / diversion channel (if required)	LS	1	$ 40,000	$ 40,000	Used for Setup of working in area of marsh restoration
4	**Restoration - Holly Pond**						
		LM planting for restored Marsh 1 area (Spartina Alterniflora)	EA	1750	$ 3.5	$ 6,125	MARSHES Construction Cost Estimate (planting at 2' center to center)
		Herbivory fencing and Control for marsh planting	LF	1100	$ 7	$ 7,700	4,500 to 5,500 LF per acre depening upon even and odd shaped planting area
5	**Other**						
		Construction Management (10% of Cost)	%			$ 48,345	
		Contingencies & Inflation (25% of cost)	%			$ 120,862	
		O&M Costs (5%)	%			$ 24,172	
		Mobilization/ Demobilization (10%)	%			$ 48,345	

Notes:

LS	Lump Sum
LF	Linear Foot
CY	Cubic Yard
SF	Square Foot
EA	Each
D	Days
SY	Square Yards

Sub-total	$ 483,447
Construction Management (10% of Cost)	$ 48,345
Contingencies & Inflation(25% of cost)	$ 120,862
O&M Costs (5%)	$ 24,172
Mobilization/ Demobilization (10%)	$ 48,345
SOUTHERN SHOAL - LIVING SHORELINE - LOW RANGE TOTAL	$ 725,171

UNIT PRICE SCHEDULE - NORTHERN SHOAL - LIVING SHORELINE ALTERNATIVE - HIGH RANGE

ITEM	DESCRIPTION		UNIT	ESTIMATED QUANTITY	UNIT PRICE	TOTAL ITEM PRICE	REFERENCE
1	**Meetings**						
		Design	LS	1	$ 80,000	$ 80,000	
		Regulatory Requirement, Legal, and Community Outreach (5% of construction activities)	%			$ 35,671	
		Pre-Design Investigation - Sediment Cores	EA	15	$ 6,000	$ 90,000	Assume minimum 1 sample per 4000 cy and minimum 3 cores per acre.
		Habitat/Cultural Surveys	LS	1	$ 10,000	$ 10,000	
		Borrow Material Screening and Characterization	EA	3	$ 5,000	$ 15,000	Assume screening of 3 borrow sources.
		Pre-Construction Meeting / Pre-Bid Meeting	LS	1	$ 3,000	$ 3,000	*PM and Engineers attending 1 meeting
2	**Site Preparation**						
		Site Preparation / Area Development					
		Pre Construction, Interim, Finalize Survey	D	10	$ 1,000	$ 10,000	Construction Staking is assumed at 2% of total costs as a standard (assuming approx 2 mil. Cost)
		Grading - Stabilize Construction Entrance	SY	667	$ 21	$ 14,000	2015 ConnDOT Cost estimating Guidelines unit price (assuming 3, 100'x20' construction entrances)
		Coarse Aggregate	CY	222	$ 80	$ 17,778	Assuming 3 100'x20' construction entrances
		Stabilization / fabric placement	SY	2,939	$ 3	$ 8,817	2015 ConnDOT Standrd Cost items estimate
3	**Construction**						
		Site Construction Work					
		Erosion/Sediment control	LF	3000	$ 5	$ 15,000	SESC measures for material placement
		Turbidity Monitoring	LF	1500	$ 10	$ 15,000	2015 ConnDOT Sedimentation Control System Prices
		Site Exacavation/grading (0% non contaminated)	CY	0	$ 25	$ -	2015 ConnDOT Cost estimating Guidelines unit costs range. Estimated quantity includes an additional 15%.
		Site Excavation/grading (100% contaminated material)	CY	1897	$ 55	$ 104,345	Contaminated material not suitable for reuse
		Reused fill material placement for planting medium (non contaminated)	CY	0	$ 55	$ -	2015 ConnDOT Cost estimating Guidelines unit costs range for Select Granular Fill Placement. Estimated quantity includes an additional 15%.
		Clean material placement for planting medium	CY	725	$ 75	$ 54,379	2015 ConnDOT cost estimating Guideline Prices for granular Fill placement + material cost per cubic yd. Estimated quantity includes an additional 15%.
		Offsite material disposal (0% non contaminated)	CY	0	$ 120	$ -	Material not reused
		Offsite material disposal (100% contaminated)	CY	1897	$ 180	$ 341,492	
		Sand Cover Purchase, Delivery, and Placement	CY	943	$ 90	$ 84,855	Sand cover over dredged areas
		Cofferdam/Dewatering / diversion channel (if required)	LS	1	$ 25,000	$ 25,000	Used for Setup of working in area of marsh restoration
4	**Restoration - Holly Pond**						
		LM planting for restored Marsh 1 area (Spartina Alterniflora)	EA	3200	$ 3.5	$ 11,200	MARSHES Construction Cost Estimate (planting at 2' center to center)
		Herbivory fencing and Control for marsh planting	LF	1650	$ 7	$ 11,550	4,500 to 5,500 LF per acre depening upon even and odd shaped planting area
5	**Other**						
		Construction Management (10% of Cost)	%			$ 94,709	
		Contingencies & Inflation (25% of cost)	%			$ 236,771	
		O&M Costs (5%)	%			$ 47,354	
		Mobilization/ Demobilization (10%)	%			$ 94,709	

Notes:

LS	Lump Sum
LF	Linear Foot
CY	Cubic Yard
SF	Square Foot
EA	Each
D	Days
SY	Square Yards

Sub-total	$ 947,086
Construction Management (10% of Cost)	$ 94,709
Contingencies & Inflation(25% of cost)	$ 236,771
O&M Costs (5%)	$ 47,354
Mobilization/ Demobilization (10%)	$ 94,709
NORTHERN SHOAL - LIVING SHORELINE - HIGH RANGE TOTAL	$ 1,420,629

UNIT PRICE SCHEDULE - SOUTHERN SHOAL - LIVING SHORELINE ALTERNATIVE - HIGH RANGE

ITEM	*DESCRIPTION*		*UNIT*	*ESTIMATED QUANTITY*	*UNIT PRICE*	*TOTAL ITEM PRICE*	*REFERENCE*
1	**Meetings**						
		Design	LS	1	$ 130,000	$ 130,000	
		Regulatory Requirement, Legal, and Community Outreach (5% of construction activities)	%			$ 64,541	
		Pre-Design Investigation - Sediment Cores	EA	15	$ 6,000	$ 90,000	Assume minimum 1 sample per 4000 cy and minimum 3 cores per acre.
		Habitat/Cultural Surveys	LS	1	$ 10,000	$ 10,000	
		Borrow Material Screening and Characterization	EA	3	$ 5,000	$ 15,000	Assume screening of 3 borrow sources.
		Pre-Construction Meeting / Pre-Bid Meeting	LS	1	$ 3,000	$ 3,000	*PM and Engineers attending 1 meeting
2	**Site Preparation**						
		Site Preparation / Area Development					
		Pre Construction, Interim, Finalize Survey	D	20	$ 1,000	$ 20,000	Construction Staking is assumed at 2% of total costs as a standard (assuming approx 2 mil. Cost)
		Grading - Stabilize Construction Entrance	SY	889	$ 21	$ 18,667	2015 ConnDOT Cost estimating Guidelines unit price (assuming 4, 100'x20' construction entrances)
		Coarse Aggregate	CY	296	$ 80	$ 23,704	Assuming 4 100'x20' construction entrances
		Stabilization / fabric placement	SY	3,833	$ 3	$ 11,500	2015 ConnDOT Standard Cost items estimate
3	**Construction**						
		Site Construction Work					
		Erosion/Sediment control	LF	5000	$ 5	$ 25,000	SESC measures for material placement
		Turbidity Monitoring	LF	2500	$ 10	$ 25,000	2015 ConnDOT Sedimentation Control System Prices
		Site Exacavation/grading (0% non contaminated)	CY	0	$ 25	$ -	2015 ConnDOT Cost estimating Guidelines unit costs range. Estimated quantity includes an additional 15%.
		Site Excavation/grading (100% contaminated material)	CY	3551	$ 55	$ 195,302	Contaminated material not suitable for reuse
		Reused fill material placement for planting medium (non contaminated)	CY	0	$ 55	$ -	2015 ConnDOT Cost estimating Guidelines unit costs range for Select Granular Fill Placement. Estimated quantity includes an additional 15%.
		Clean material placement for planting medium	CY	875	$ 75	$ 65,620	2015 ConnDOT cost estimating Guideline Prices for granular Fill placement + material cost per cubic yd. Estimated quantity includes an additional 15%.
		Offsite material disposal (0% non contaminated)	CY	0	$ 120	$ -	Material not reused
		Offsite material disposal (100% contaminated)	CY	3551	$ 180	$ 639,170	
		Sand Cover Purchase, Delivery, and Placement	CY	2367	$ 90	$ 213,030	Sand cover over dredged areas
		Cofferdam/Dewatering / diversion channel (if required)	LS	1	$ 40,000	$ 40,000	Used for Setup of working in area of marsh restoration
4	**Restoration - Holly Pond**						
		LM planting for restored Marsh 1 area (Spartina Alterniflora)	EA	1750	$ 3.5	$ 6,125	MARSHES Construction Cost Estimate (planting at 2' center to center)
		Herbivory fencing and Control for marsh planting	LF	1100	$ 7	$ 7,700	4,500 to 5,500 LF per acre depening upon even and odd shaped planting area
5	**Other**						
		Construction Management (10% of Cost)	%			$ 160,336	
		Contingencies & Inflation (25% of cost)	%			$ 400,840	
		O&M Costs (5%)	%			$ 80,168	
		Mobilization/ Demobilization (10%)	%			$ 160,336	

Sub-total	$ 1,603,358
Construction Management (10% of Cost)	$ 160,336
Contingencies & Inflation(25% of cost)	$ 400,840
O&M Costs (5%)	$ 80,168
Mobilization/ Demobilization (10%)	$ 160,336
SOUTHERN SHOAL - LIVING SHORELINE - HIGH RANGE TOTAL	$ 2,405,037

Notes:

LS	Lump Sum
LF	Linear Foot
CY	Cubic Yard
SF	Square Foot
EA	Each
D	Days
SY	Square Yards

UNIT PRICE SCHEDULE - NOROTON RIVER - STREAMBANK STABILIZATION ALTERNATIVE

ITEM	*DESCRIPTION*		*UNIT*	*ESTIMATED QUANTITY*	*UNIT PRICE*	*TOTAL ITEM PRICE*	*REFERENCE*
1	**Meetings**						
		Design	LS	1	$ 95,000	$ 95,000	
		Regulatory Requirement, Legal, and Community Outreach (2 % of construction activities)	%			$ 19,184	
		Habitat/Cultural Surveys	LS	1	$ 10,000	$ 10,000	
		Borrow Material Screening and Characterization	EA	0	$ 5,000	$ -	
		Pre-Construction Meeting / Pre-Bid Meeting	LS	1	$ 3,000	$ 3,000	*PM and Engineers attending 1 meeting
2	**Site Preparation**						
		Site Preparation / Area Development					
		Pre Construction, Interim, Finalize Survey	D	8	$ 1,000	$ 8,000	Construction Staking is assumed at 2% of total costs as a standard (assuming approx 2 mil. Cost)
		Grading - Stabilize Construction Entrance	SY	333	$ 21	$ 7,000	2015 ConnDOT Cost estimating Guidelines unit price (Assuming require 2 100'x15' Const entrances)
		Coarse Aggregate	CY	125	$ 80	$ 10,000	Assuming require 2 100'x15' Const entrances)
		Stabilization / fabric placement	SY	1,891	$ 3	$ 5,674	2015 ConnDOT Standard Cost items estimate
3	**Construction**						
		Site Construction Work					
		Erosion/Sediment control matting	SY	5588	$ 5	$ 27,942	Costs from recent Orange County wetland mitigation project.
		Turbidity Monitoring	LF	1000	$ 10	$ 10,000	2015 ConnDOT Sedimentation Control System Prices
		Site excavation/grading	CY	27605	$ 25	$ 690,130	2015 ConnDOT Cost estimating Gudielines unit costs range. Estimated quantity includes an additional 15%.
		Placement of clean material	CY	337	$ 55	$ 18,546	2015 ConnDOT Cost estimating Gudielines unit costs range for Select Granular Fill Placement. Estimated quantity includes an additional 15%.
		Cofferdam/Dewatering / diversion channel (if required)	LS	1	$ 4,000	$ 4,000	2015 ConnDOT Standard cost guidelines calculated at per linear feet range
4	**Restoration - Holly Pond**						
		Boulder Rock Wall	CY	118	$ 150	$ 17,697	Higbee Beach Cost Estimate Pricing
		Toe of Slope Rock Protection	CY	398	$ 113	$ 44,735	Sample ConnDOT Pricing from 2014 Example estimate
		Rip - Rap Channel Protection	CY	60	$ 100	$ 5,963	Sample 2014 ConnDOT Cost Estimate and Higbee Beach Cost Estimate Pricing
		Large Boulders for Habitat	EA	4	$ 750	$ 3,000	Estimated based on previous projects expereience like Hoffman park
5	**Restoration- Re-Planting**						
		Rock wall rooted plants	EA	332	$ 3	$ 830	Based on Pricing from Hoffman Park and Little Buffalo Creek Cost Estimates
		Root Wads	EA	6	$ 4,000	$ 24,000	Based on Hoffman Park and Little Buffalo Creek Cost Estimates
		Live Stakes/Cuttings	EA	15216.8	$ 5	$ 76,084	Little Buffalo Creek Cost Estimates
		Seeding mix	SY	5588.4	$ 1	$ 5,588	Based on ConnDOT 2015 Cost Estimating Guidelines for Turf Re establishement
6	**Other**						
		Construction Management (10% of Cost)	%			$ 108,637	
		Contingencies & Inflation (25% of cost)	%			$ 271,593	
		O&M Costs (5%)	%			$ 54,319	
		Mobilization/ Demobilization (10%)	%			$ 108,637	

Sub-total	$ 1,086,373
Construction Management (10% of Cost)	$ 108,637
Contingencies & Inflation(25% of cost)	$ 271,593
O&M Costs (5%)	$ 54,319
Mobilization/ Demobilization (10%)	$ 108,637
STREAMBANK STABILIZATION TOTAL	$ 1,629,560

Notes:

LS	Lump Sum
LF	Linear Foot
CY	Cubic Yard
SF	Square Foot
EA	Each
D	Days
SY	Square Yards

UNIT PRICE SCHEDULE - WATERSHED BMP - EXTENDED WET DETENTION POND ALTERNATIVE

ITEM	*DESCRIPTION*		*UNIT*	*ESTIMATED QUANTITY*	*UNIT PRICE*	*TOTAL ITEM PRICE*	*REFERENCE*
1	**Meetings**						
		Design	LS	1	$ 50,000	$ 50,000	
		Regulatory Requirement, Legal, and Community Outreach (5% of construction activities)	%			$ 16,534	
		Habitat/Cultural Surveys	LS	1	$ 10,000	$ 10,000	
		Borrow Material Screening and Characterization	EA	0	$ 5,000	$ -	
		Pre-Construction Meeting / Pre-Bid Meeting	LS	1	$ 3,000	$ 3,000	*PM and Engineers attending 1 meeting
2	**Site Preparation**						
		Site Preparation / Area Development					
		Pre Construction, Interim, Finalize Survey	D	8	$ 1,000	$ 8,000	Construction Staking is assumed at 2% of total costs as a standard (assuming approx 2 mil. Cost)
		Grading - Stabilize Construction Entrance	SY	333	$ 21	$ 7,000	2015 ConnDOT Cost estimating Guidelines unit price (Assuming require 2 100'x15' Const entrances)
		Coarse Aggregate	CY	125	$ 80	$ 10,000	Assuming require 2 100'x15' Const entrances)
		Stabilization / fabric placement	SY	1,891	$ 3	$ 5,674	2015 ConnDOT Standard Cost items estimate.
3	**Construction**						
		Site Construction Work					
		Extended Wet Detention pond	AF	6.0	$ 50,000	$ 300,000	Costs from Stormwater management fact Sheet Pricing per ac-ft Construction costs
6	**Other**						
		Construction Management (15% of Cost)	%			$ 61,531	
		Contingencies & Inflation (25% of cost)	%			$ 102,552	
		O&M Costs (5%)	%			$ 20,510	
		Mobilization/ Demobilization (10%)	%			$ 41,021	

Sub-total	$ 410,208
Construction Management (15% of Cost)	$ 61,531
Contingencies & Inflation(25% of cost)	$ 102,552
O&M Costs (5%)	$ 20,510
Mobilization/ Demobilization (10%)	$ 41,021
EXTENDED WET DETENTION POND TOTAL	$ 635,822

Notes:

LS	Lump Sum
LF	Linear Foot
CY	Cubic Yard
SF	Square Foot
EA	Each
D	Days
SY	Square Yards
AF	Acre-Feet

APPENDIX D

Bank Stabilization Techniques

BANK STABILIZATION TECHNIQUES

STABILIZATION TECHNIQUES	USED IN CONNECTICUT PROJECTS	COST[1]	EFFICACY TIMELINE	STABILIZATION TECHNIQUE LIFE SPAN	CONSTRUCTION DISTURBANCE LEVEL[2]	AESTHETICS[3]	REDIRECTS FORCES AWAY FROM CHANNEL BANKS	ABLE TO PROMOTE OR ENHANCE HABITAT	POTENTIALLY IMPEDES FISH PASSAGE	GRADING/ANGLE OF REPOSE NEEDED[4]	ALLOWABLE SHEAR STRESS	LONG-TERM MAINTENANCE	OTHER CONSIDERATIONS	OTHER ALTERNATIVES THAT WORK WELL IN CONJUNCTION
		SOIL BIOENGINEERING												
LIVE STAKES	Y	$	Long-term	Long-term	Minor-Moderate	+	N	Y	N	2	Low-Moderate	Requires continuing maintenance/replacement	Bank slopes should be moderate to shallow for success rate of stakes.	brush mattresses, joint plantings, branch packing, live fascines, root wad, tree revetment, coconut fiber rolls, geotextile fabric
LIVE FASCINES	N	$	Short-term	Long-term	Minor	+	N	Y	N	1	Moderate	Requires continuing maintenance/replacement	Not recommended below ordinary high water.	brush mattresses, joint plantings, branch packing, brush layering, live stakes, root wad, tree revetment, coconut fiber rolls, geotextile fabric
BRUSH LAYERING	Y	$	Long-term	Long-term	Minor	+	N	Y	N	1	Moderate	Requires continuing maintenance/replacement	Does not work on outside bends. Not recommended below ordinary high water.	brush mattresses, joint plantings, branch packing, live stakes, live fascines, root wad, tree revetment, coconut fiber rolls, geotextile fabric
BRANCH PACKING	Y	$	Long-term	Long-term	Minor	+	N	Y	N	1	Moderate	Requires continuing maintenance/replacement	Will not prevent future stream migration. Not recommended below ordinary high water	Live stakes, brush mattresses, brush layering, joint plantings, live fascines, live stakes, root wad, tree revetment, coconut fiber rolls, geotextile fabric
VEGETATED GEOGRIDS	N	$$	Immediate	Long-term	Moderate	+	N	Y	N	1	High	Requires continuing maintenance/replacement	Can be placed below ordinary high water.	Live stakes, geotextile fabric
LIVE CRIBWALL	N	$$	Immediate	Long-term	Moderate	+	N	Y	N	3	High	Requires continuing maintenance/replacement	More effective on outside bends. Limited height allowed for structure.	Live stakes, geotextile fabric
JOINT PLANTING	N	$	Long-term	Long-term	Moderate	+	N	Y	N	2	Low	Requires continuing maintenance/replacement	Can be used to disguise riprap.	Live stakes, live fascines, brush layering, branch packing, brush mattress, live posts, tree revetment, rood wad, geotextile fabric
BRUSH MATTRESS	Y	$$	Immediate	Long-term	Moderate	+	N	Y	N	2	Low-Moderate	Requires continuing maintenance/replacement	Not recommended below ordinary high water.	A brush mattress incorporates live stakes, live fascines, and branch cuttings to create one comprehensive protective cover over a stream bank.
LIVE POST	Y	$	Long-term	Long-term	Minor-Moderate	+	N	Y	N	2	Low-Moderate	Requires continuing maintenance/replacement	Bank slopes should be moderate to shallow for success rate of stakes.	Live stakes, tree revetment, root wad, coconut fiber rolls, rip rap, geotextile fabric
TREE REVETMENT	Y	$	Immediate	Short-term	Moderate	+	N	Y	N	0	Low	Requires continuing maintenance/replacement	Not recommended for heavy ice flows. Not recommended for banks taller than 12 feet high. Toe protection only.	Live stakes, live fascines, brush layering, branch packing, joint planting
ROOT WAD	Y	$	Immediate	Short-term	Moderate	+	Y	Y	N	0	Moderate	Requires continuing maintenance/replacement	Should be used in combination with other techniques. Toe protection only. Not used for high banks.	Live stakes, Live fascines, brush layering, joint planting, brush mattress, live posts
DORMANT POST-PLANTINGS	N	$	Long-term	Long-term	Minor	+	N	Y	N	2	Moderate	Requires continuing maintenance/replacement	Concern: water level, because the ends of the plantings need to have access to the water.	Live stakes, live fascines, brush layering, branch packing, joint planting, brush mattress
COCONUT FIBER ROLLS	Y	$$	Short-term	(6-10 years)	Minor	+	N	N	N	0	Low-Moderate	Requires continuing maintenance/replacement	Cannot be used at sites where flow velocities are high	Live stakes, live fascines, brush layering, brush packing, live post, geotextile fabric
		BANK ARMORING												

STABILIZATION TECHNIQUES	USED IN CONNECTICUT PROJECTS	COST [1]	EFFICACY TIMELINE	STABILIZATION TECHNIQUE LIFE SPAN	CONSTRUCTION DISTURBANCE LEVEL [2]	AESTHETICS [3]	REDIRECTS FORCES AWAY FROM CHANNEL BANKS	ABLE TO PROMOTE OR ENHANCE HABITAT	POTENTIALLY IMPEDES FISH PASSAGE	GRADING/ANGLE OF REPOSE NEEDED [4]	ALLOWABLE SHEAR STRESS	LONG-TERM MAINTENANCE	OTHER CONSIDERATIONS	OTHER ALTERNATIVES THAT WORK WELL IN CONJUNCTION
RIP-RAP	Y	$$	Immediate	Long-term	Major	-	N	N	N	2	Moderate	Minimal maintenance/upkeep	Overtopping and scour are important design considerations which may be exacerbated under sea level rise scenarios	Live posts, geotextile fabric
SOIL COVERED RIP-RAP	Y	$$	Immediate	Long-term	Major	+	N	Y	N	2	Moderate	Minimal maintenance/upkeep	Maintenance earthwork may be required to maintain aesthetic appearance.	Live posts, geotextile fabric
ARTICULATED BLOCKS	N	$$$	Immediate	Long-term	Major	-	N	N	N	2	Moderate	Minimal maintenance/upkeep		Geotextile fabric
GEOGRID	N	$	Immediate	Long-term	Minor	-	N	N	N	1	High	May require occasional repair	Prone to failure from debris and ice. Typically not used as a sole restoration technique	Live stakes, joint planting
GABIONS	N	$$	Immediate	(5-10 years)	Moderate	-	N	N	N	2	Moderate	May require occasional repair	Prone to failure from debris and ice.	Live stakes, live posts
GEOTEXTILE FABRICS	Y	$	Immediate	Long-term	Minor	+	N	Y	N	0	Low	May require occasional repair	Prone to failure from debris and ice. Typically not used as a sole restoration technique	Live stakes, live fascines, brush layering, brush mattress, joint planting, rip rap, soil covered rip rap
SOIL CEMENT	N	$	Immediate	Short-term	Moderate	-	N	N	N	1	Low	May require occasional repair	Prone to undermining and circumventing	
FLOW DIVERSION														
HARD POINTS AND JETTIES	Y	$$	Long-term	Long-term	Moderate	Depends on type	Y	Y	N	2	Moderate	May require occasional modification based on channel conditions	Fluctuating water levels can affect effectiveness. Streambed stabilization technique, not for stream banks	
CRIBS	N	$	Long-term	Short-term	Moderate	Depends on type	Y	Y	N	0	Low	May require occasional modification based on channel conditions	Fluctuating water levels can affect effectiveness. Can cause further bank erosion.	Live stakes, joint planting, geotextile fabric
DIKES	Y	$$	Long-term	Long term	Major	Depends on type	Y	NN	Y	0	Moderate	May require occasional modification based on channel conditions	Fluctuating water levels can affect effectiveness. Major reconstruction of banks that will can require further bank stabilizations techniques	Live stakes, joint plantings, dormant post plantings, rip rap, soil covered rip rap, geotextile fabric
FENCE DIKES	N	$	Long-term	Long-term	Moderate	-	Y	N	Y	0	Low	Requires continuing maintenance/replacement	Prone to ice damage, require greater maintenance	
FENCES	Y	$	Long-term	Long-term	Moderate	-	Y	N	Y	0	Low	Requires continuing maintenance/replacement	Prone to ice damage	
ENERGY REDUCTION														
VANES	Y	$$	Long-term	Long-term	Moderate	Depends on type	Y	Y	N	0	Moderate	May require occasional modification based on channel conditions	Fluctuating water levels can affect effectiveness.	Live stakes, joint planting
CHANNEL BLOCKS	UK	$$	Long-term	Long-term	Moderate	Depends on type	Y	Y	Y	2	High	May require occasional modification based on channel conditions	Fluctuating water levels can affect effectiveness. Ineffective on large streams with large side channels.	Rip-rap should be used on the downstream side to prevent scour.
FENCE REVETMENT	UK	$	Immediate	Long-term	Moderate	-	Y	N	Y	0	Moderate	Requires continuing maintenance/replacement	Prone to ice damage	

STABILIZATION TECHNIQUES	USED IN CONNECTICUT PROJECTS	COST[1]	EFFICACY TIMELINE	STABILIZATION TECHNIQUE LIFE SPAN	CONSTRUCTION DISTURBANCE LEVEL[2]	AESTHETICS[3]	REDIRECTS FORCES AWAY FROM CHANNEL BANKS	ABLE TO PROMOTE OR ENHANCE HABITAT	POTENTIALLY IMPEDES FISH PASSAGE	GRADING/ANGLE OF REPOSE NEEDED[4]	ALLOWABLE SHEAR STRESS	LONG-TERM MAINTENANCE	OTHER CONSIDERATIONS	OTHER ALTERNATIVES THAT WORK WELL IN CONJUNCTION
GRADE CONTROL STRUCTURES	Y	$$$	Short-term	Long-term	Major	-	Y	Y	Y	2	Moderate	Minimal maintenance/upkeep		
GEOTECHNICAL SLOPE STABILIZATION														
GRADING	Y	$	Immediate	Short-term	Moderate	+	N	N	N	3	Low	May require occasional modification based on channel conditions	Should be used in combination with other techniques. Grading is typically involved in most stabilization techniques	Live stakes, live fascines, brush layering, brush mattress, joint planting, tree revetments, root wad, rip rap, geotextile fabric
GEOGRIDS AND GEOTEXTILES	Y	$	Immediate	Long-term	Minor	+	N	N	N	1	Moderate	May require occasional repair	Prone to failure from debris and ice	
RETAINING WALLS	Y	$$$	Immediate	Long-term	Major	Depends on type	N	N	N	0	High	Minimal maintenance/upkeep		
DRAINS	Y	$$	Short-term		Moderate	Depends on type	N	N	N	1	Low-Moderate	Requires continuing maintenance/replacement	Should be used on unstable slopes and in combination with other techniques. Unlikely to be successful in the long-term. Used for stormwater drainage on slopes over bank stabilization technique	Rip rap, geotextile fabric, bank armoring techniques
CHANNEL DEVELOPMENT														
CHANNEL WIDENING	Y	$$$	Immediate	Long-term	Major	+	Y	N	N	2	Moderate-High	Minimal maintenance/upkeep	May not resolve issue of eroding banks. Ice jams could occur due to lowering velocity with channel expansion. Major engineering design required to resolve all issues	Live stakes, live fascines, brush layering, brush mattress, branch packing, joint planting, live cribwall, live post, tree revetment, rip rap, geo grids, vanes, channel blocks, grading, retaining walls, high flow diversion channels
HIGH FLOW DIVERSION CHANNELS	UK	$$$	Immediate	Long-term	Major	+	N	N	N	2	Moderate-High	May require occasional ice jam of log jam clearing	Ice and debris jams are likely to be reoccurring. Major engineering design required to insure stability.	Live stakes, live fascines, brush layering, brush mattress, branch packing, joint planting, live cribwall, live post, tree revetment, rip rap, geo grids, vanes, channel blocks, grading, retaining walls, channel widening

[1] $ = Low cost; $$ = moderate cost; $$$ = high cost

[2] Construction disturbance level can vary depending on current condition of banks and will be dependent on bank slope/angle of repose necessary for structure technique, as well as depth/footprint of grading needed for installation

[3] + = positive aesthetic features; - = negative aesthetic features

[4] 0 = No grading/angle of repose is not significant; 1 = minor grading needed/high angle of repose acceptable; 2 = major grading needed/low angle of repose necessary; 3 = major grading needed for structure but angle of repose not applicable or significant

APPENDIX E

USGS NRCS Soil Resource Report for Sub-Subwatersheds 16 & 19

United States Department of Agriculture

NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for

State of Connecticut

Sub-subwatershed 16 of Subwatershed 4 of Holly Pond Watershed

January 12, 2016

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (http://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

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Contents

How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

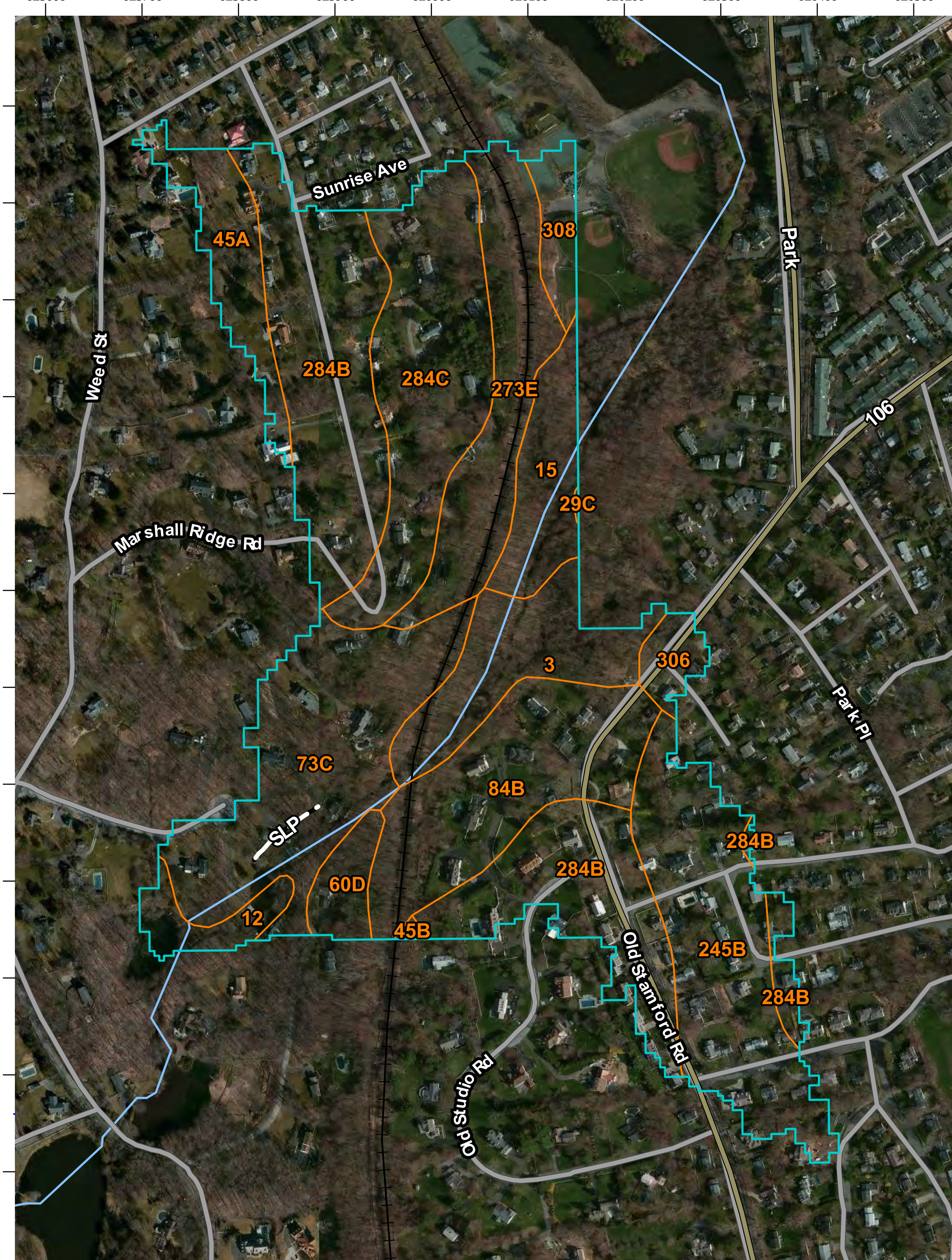
Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Soil Map



Map Scale: 1:6,300 if printed on A portrait (8.5" x 11") sheet.

Meters: 0, 50, 100, 200, 300

Feet: 0, 300, 600, 1200, 1800

N

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 18N WGS84

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Map Unit Polygons

Soil Map Unit Lines

Soil Map Unit Points

Special Point Features

Blowout

Borrow Pit

Clay Spot

Closed Depression

Gravel Pit

Gravelly Spot

Landfill

Lava Flow

Marsh or swamp

Mine or Quarry

Miscellaneous Water

Perennial Water

Rock Outcrop

Saline Spot

Sandy Spot

Severely Eroded Spot

Sinkhole

Slide or Slip

Sodic Spot

Spoil Area

Stony Spot

Very Stony Spot

Wet Spot

Other

Special Line Features

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:12,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: State of Connecticut
Survey Area Data: Version 14, Sep 22, 2015

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Mar 26, 2011—Apr 16, 2012

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

State of Connecticut (CT600)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
3	Ridgebury, Leicester, and Whitman soils, 0 to 8 percent slopes, extremely stony	5.7	6.4%
12	Raypol silt loam	1.7	1.9%
15	Scarboro muck, 0 to 3 percent slopes	3.7	4.2%
29C	Agawam fine sandy loam, 8 to 15 percent slopes	0.0	0.0%
45A	Woodbridge fine sandy loam, 0 to 3 percent slopes	3.8	4.3%
45B	Woodbridge fine sandy loam, 3 to 8 percent slopes	0.1	0.1%
60D	Canton and Charlton soils, 15 to 25 percent slopes	1.6	1.8%
73C	Charlton-Chatfield complex, 3 to 15 percent slopes, very rocky	12.1	13.7%
84B	Paxton and Montauk fine sandy loams, 3 to 8 percent slopes	9.6	10.8%
245B	Woodbridge-Urban land complex, 0 to 8 percent slopes	10.7	12.1%
273E	Urban land-Charlton-Chatfield complex, rocky, 15 to 45 percent slopes	7.4	8.4%
284B	Paxton-Urban land complex, 3 to 8 percent slopes	18.7	21.1%
284C	Paxton-Urban land complex, 8 to 15 percent slopes	10.5	11.9%
306	Udorthents-Urban land complex	1.2	1.4%
308	Udorthents, smoothed	1.6	1.8%
Totals for Area of Interest		**88.6**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

State of Connecticut

3—Ridgebury, Leicester, and Whitman soils, 0 to 8 percent slopes, extremely stony

Map Unit Setting

National map unit symbol: 2t2qt
Elevation: 0 to 1,480 feet
Mean annual precipitation: 36 to 71 inches
Mean annual air temperature: 39 to 55 degrees F
Frost-free period: 140 to 240 days
Farmland classification: Not prime farmland

Map Unit Composition

Ridgebury, extremely stony, and similar soils: 40 percent
Leicester, extremely stony, and similar soils: 35 percent
Whitman, extremely stony, and similar soils: 20 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Ridgebury, Extremely Stony

Setting

Landform: Depressions, drainageways, ground moraines, hills
Landform position (two-dimensional): Toeslope, backslope, footslope
Landform position (three-dimensional): Base slope, head slope, dip
Down-slope shape: Concave
Across-slope shape: Concave
Parent material: Coarse-loamy lodgment till derived from gneiss, granite, and/or schist

Typical profile

A - 0 to 5 inches: fine sandy loam
Bw - 5 to 9 inches: sandy loam
Bg - 9 to 18 inches: gravelly sandy loam
Cd - 18 to 65 inches: gravelly sandy loam

Properties and qualities

Slope: 0 to 8 percent
Percent of area covered with surface fragments: 9.0 percent
Depth to restrictive feature: 14 to 32 inches to densic material
Natural drainage class: Poorly drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.14 in/hr)
Depth to water table: About 0 to 6 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Very low (about 2.1 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: D

Description of Leicester, Extremely Stony

Setting

Landform: Depressions, drainageways
Landform position (two-dimensional): Toeslope, footslope, backslope
Landform position (three-dimensional): Base slope
Down-slope shape: Linear
Across-slope shape: Concave
Parent material: Coarse-loamy melt-out till derived from gneiss, granite, and/or schist

Typical profile

Oe - 0 to 1 inches: moderately decomposed plant material
A - 1 to 7 inches: fine sandy loam
Bg1 - 7 to 10 inches: fine sandy loam
Bg2 - 10 to 18 inches: fine sandy loam
BC - 18 to 24 inches: fine sandy loam
C1 - 24 to 43 inches: gravelly fine sandy loam
C2 - 43 to 65 inches: gravelly fine sandy loam

Properties and qualities

Slope: 0 to 8 percent
Percent of area covered with surface fragments: 9.0 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Poorly drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 5.95 in/hr)
Depth to water table: About 0 to 18 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 6.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: B/D

Description of Whitman, Extremely Stony

Setting

Landform: Depressions, drainageways
Landform position (two-dimensional): Toeslope, footslope, backslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave
Across-slope shape: Concave
Parent material: Coarse-loamy lodgment till derived from gneiss, granite, and/or schist

Typical profile

Oi - 0 to 1 inches: slightly decomposed plant material
A - 1 to 9 inches: fine sandy loam
Bg - 9 to 16 inches: fine sandy loam
Cdg1 - 16 to 22 inches: fine sandy loam
Cdg2 - 22 to 60 inches: fine sandy loam

Properties and qualities

Slope: 0 to 8 percent
Percent of area covered with surface fragments: 9.0 percent
Depth to restrictive feature: 12 to 20 inches to densic material
Natural drainage class: Very poorly drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately high (0.00 to 0.20 in/hr)
Depth to water table: About 0 to 12 inches
Frequency of flooding: None
Frequency of ponding: Occasional
Available water storage in profile: Very low (about 1.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: D

Minor Components

Woodbridge, extremely stony

Percent of map unit: 3 percent
Landform: Drumlins, ground moraines, hills
Landform position (two-dimensional): Backslope, footslope, summit
Landform position (three-dimensional): Side slope
Down-slope shape: Concave
Across-slope shape: Linear

Swansea

Percent of map unit: 2 percent
Landform: Bogs, swamps
Landform position (three-dimensional): Dip
Down-slope shape: Concave
Across-slope shape: Concave

12—Raypol silt loam

Map Unit Setting

National map unit symbol: 9ljx
Elevation: 0 to 1,200 feet
Mean annual precipitation: 43 to 54 inches
Mean annual air temperature: 45 to 55 degrees F
Frost-free period: 140 to 185 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Raypol and similar soils: 80 percent

Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Raypol

Setting

Landform: Depressions, drainageways
Down-slope shape: Concave
Across-slope shape: Concave
Parent material: Coarse-loamy eolian deposits over sandy and gravelly glaciofluvial deposits derived from granite and/or schist and/or gneiss

Typical profile

Ap - 0 to 8 inches: silt loam
Bg1 - 8 to 12 inches: very fine sandy loam
Bg2 - 12 to 20 inches: silt loam
Bw1 - 20 to 26 inches: silt loam
Bw2 - 26 to 29 inches: very fine sandy loam
2C1 - 29 to 52 inches: stratified very gravelly coarse sand to loamy fine sand
2C2 - 52 to 65 inches: stratified very gravelly coarse sand to loamy fine sand

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Poorly drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: About 0 to 12 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 7.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4w
Hydrologic Soil Group: C/D

Minor Components

Haven

Percent of map unit: 5 percent
Landform: Outwash plains, terraces
Down-slope shape: Convex
Across-slope shape: Linear

Enfield

Percent of map unit: 5 percent
Landform: Outwash plains, terraces
Down-slope shape: Convex
Across-slope shape: Linear

Ninigret

Percent of map unit: 3 percent
Landform: Outwash plains, terraces
Down-slope shape: Linear
Across-slope shape: Concave

Tisbury

Percent of map unit: 2 percent
Landform: Outwash plains, terraces
Down-slope shape: Concave
Across-slope shape: Linear

Walpole

Percent of map unit: 2 percent
Landform: Depressions on terraces, drainageways on terraces
Down-slope shape: Concave
Across-slope shape: Concave

Scarboro

Percent of map unit: 2 percent
Landform: Depressions, drainageways, terraces
Down-slope shape: Concave
Across-slope shape: Concave

Unnamed, loamy substratum

Percent of map unit: 1 percent

15—Scarboro muck, 0 to 3 percent slopes

Map Unit Setting

National map unit symbol: 2svkt
Elevation: 0 to 1,350 feet
Mean annual precipitation: 36 to 71 inches
Mean annual air temperature: 39 to 55 degrees F
Frost-free period: 140 to 240 days
Farmland classification: Not prime farmland

Map Unit Composition

Scarboro and similar soils: 80 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Scarboro

Setting

Landform: Depressions, drainageways, outwash terraces, outwash deltas
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Base slope, tread, dip
Down-slope shape: Concave
Across-slope shape: Concave, linear
Parent material: Sandy glaciofluvial deposits derived from schist and/or gneiss and/or granite

Typical profile

Oa - 0 to 8 inches: muck
A - 8 to 14 inches: mucky fine sandy loam
Cg1 - 14 to 22 inches: sand

Cg2 - 22 to 65 inches: gravelly sand

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Very poorly drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (1.42 to 14.17 in/hr)
Depth to water table: About 0 to 2 inches
Frequency of flooding: None
Frequency of ponding: Frequent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Moderate (about 6.1 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 5w
Hydrologic Soil Group: A/D

Minor Components

Timakwa

Percent of map unit: 10 percent
Landform: Swamps
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Base slope, tread, dip
Down-slope shape: Linear, concave
Across-slope shape: Linear, concave

Walpole

Percent of map unit: 8 percent
Landform: Deltas, depressions, depressions, outwash plains, outwash terraces
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Tread, talf, dip
Down-slope shape: Concave
Across-slope shape: Concave

Deerfield

Percent of map unit: 2 percent
Landform: Outwash plains, terraces
Landform position (three-dimensional): Tread, dip
Down-slope shape: Linear
Across-slope shape: Concave

29C—Agawam fine sandy loam, 8 to 15 percent slopes

Map Unit Setting

National map unit symbol: 2tyqy
Elevation: 0 to 360 feet
Mean annual precipitation: 36 to 71 inches

Mean annual air temperature: 39 to 55 degrees F
Frost-free period: 140 to 240 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Agawam and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Agawam

Setting

Landform: Kame terraces, outwash plains, kames, moraines, outwash terraces
Landform position (two-dimensional): Backslope, shoulder, footslope, summit
Landform position (three-dimensional): Side slope, crest, tread, riser, rise, dip
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Coarse-loamy eolian deposits over sandy and gravelly glaciofluvial deposits derived from gneiss, granite, schist, and/or phyllite

Typical profile

Ap - 0 to 11 inches: fine sandy loam
Bw1 - 11 to 16 inches: fine sandy loam
Bw2 - 16 to 26 inches: fine sandy loam
2C1 - 26 to 45 inches: loamy fine sand
2C2 - 45 to 55 inches: loamy fine sand
2C3 - 55 to 65 inches: loamy sand

Properties and qualities

Slope: 8 to 15 percent
Depth to restrictive feature: 15 to 35 inches to strongly contrasting textural stratification
Natural drainage class: Well drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to high (0.14 to 14.17 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Low (about 3.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: B

Minor Components

Ninigret

Percent of map unit: 5 percent
Landform: Terraces
Down-slope shape: Linear
Across-slope shape: Concave

Windsor

Percent of map unit: 5 percent

Landform: Deltas, dunes, outwash plains, outwash terraces
Landform position (three-dimensional): Riser, tread
Down-slope shape: Linear, convex
Across-slope shape: Linear, convex

Merrimac

Percent of map unit: 5 percent
Landform: Eskers, outwash plains, kames, moraines, outwash terraces
Landform position (two-dimensional): Backslope, footslope, shoulder, summit
Landform position (three-dimensional): Side slope, crest, riser, tread
Down-slope shape: Convex
Across-slope shape: Convex

45A—Woodbridge fine sandy loam, 0 to 3 percent slopes

Map Unit Setting

National map unit symbol: 2w686
Elevation: 0 to 1,420 feet
Mean annual precipitation: 36 to 71 inches
Mean annual air temperature: 39 to 55 degrees F
Frost-free period: 140 to 240 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Woodbridge and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Woodbridge

Setting

Landform: Drumlins, ground moraines, hills
Landform position (two-dimensional): Footslope, summit
Landform position (three-dimensional): Crest
Down-slope shape: Convex
Across-slope shape: Linear
Parent material: Coarse-loamy lodgment till derived from gneiss, granite, and/or schist

Typical profile

Ap - 0 to 7 inches: fine sandy loam
Bw1 - 7 to 18 inches: fine sandy loam
Bw2 - 18 to 30 inches: fine sandy loam
Cd - 30 to 65 inches: gravelly fine sandy loam

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: 20 to 39 inches to densic material
Natural drainage class: Moderately well drained
Runoff class: Very high

Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.14 in/hr)
Depth to water table: About 18 to 30 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Low (about 4.7 inches)

Interpretive groups
Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2w
Hydrologic Soil Group: C/D

Minor Components

Paxton
Percent of map unit: 7 percent
Landform: Drumlins, ground moraines, hills
Landform position (two-dimensional): Summit, shoulder
Landform position (three-dimensional): Crest
Down-slope shape: Linear, convex
Across-slope shape: Convex

Ridgebury
Percent of map unit: 6 percent
Landform: Depressions, drainageways, drumlins, ground moraines, hills
Landform position (two-dimensional): Toeslope, footslope
Landform position (three-dimensional): Base slope, head slope
Down-slope shape: Concave
Across-slope shape: Concave

Whitman, extremely stony
Percent of map unit: 1 percent
Landform: Depressions, drainageways
Down-slope shape: Concave
Across-slope shape: Concave

Sutton
Percent of map unit: 1 percent
Landform: Ground moraines, hills
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave
Across-slope shape: Linear

45B—Woodbridge fine sandy loam, 3 to 8 percent slopes

Map Unit Setting
National map unit symbol: 2t2ql
Elevation: 0 to 1,470 feet
Mean annual precipitation: 36 to 71 inches

Mean annual air temperature: 39 to 55 degrees F
Frost-free period: 140 to 240 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Woodbridge, fine sandy loam, and similar soils: 82 percent
Minor components: 18 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Woodbridge, Fine Sandy Loam

Setting

Landform: Drumlins, ground moraines, hills
Landform position (two-dimensional): Backslope, footslope, summit
Landform position (three-dimensional): Side slope
Down-slope shape: Concave
Across-slope shape: Linear
Parent material: Coarse-loamy lodgment till derived from gneiss, granite, and/or schist

Typical profile

Ap - 0 to 7 inches: fine sandy loam
Bw1 - 7 to 18 inches: fine sandy loam
Bw2 - 18 to 30 inches: fine sandy loam
Cd - 30 to 65 inches: gravelly fine sandy loam

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: 20 to 39 inches to densic material
Natural drainage class: Moderately well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.14 in/hr)
Depth to water table: About 18 to 30 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Low (about 3.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2w
Hydrologic Soil Group: C/D

Minor Components

Paxton

Percent of map unit: 10 percent
Landform: Drumlins, ground moraines, hills
Landform position (two-dimensional): Backslope, summit, shoulder
Landform position (three-dimensional): Side slope, crest, nose slope
Down-slope shape: Linear, convex
Across-slope shape: Convex

Ridgebury

Percent of map unit: 8 percent
Landform: Depressions, drainageways, ground moraines, hills

Landform position (two-dimensional): Toeslope, backslope, footslope
Landform position (three-dimensional): Base slope, head slope, dip
Down-slope shape: Concave
Across-slope shape: Concave

60D—Canton and Charlton soils, 15 to 25 percent slopes

Map Unit Setting

National map unit symbol: 9lpq
Elevation: 0 to 1,200 feet
Mean annual precipitation: 43 to 54 inches
Mean annual air temperature: 45 to 55 degrees F
Frost-free period: 140 to 185 days
Farmland classification: Not prime farmland

Map Unit Composition

Canton and similar soils: 45 percent
Charlton and similar soils: 35 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Canton

Setting

Landform: Hills
Down-slope shape: Linear
Across-slope shape: Convex
Parent material: Coarse-loamy over sandy and gravelly melt-out till derived from granite and/or schist and/or gneiss

Typical profile

Oe - 0 to 1 inches: moderately decomposed plant material
A - 1 to 3 inches: gravelly fine sandy loam
Bw1 - 3 to 15 inches: gravelly loam
Bw2 - 15 to 24 inches: gravelly loam
Bw3 - 24 to 30 inches: gravelly loam
2C - 30 to 60 inches: very gravelly loamy sand

Properties and qualities

Slope: 15 to 25 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 5.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: B

Description of Charlton

Setting

Landform: Hills
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Coarse-loamy melt-out till derived from granite and/or schist and/or gneiss

Typical profile

Ap - 0 to 4 inches: fine sandy loam
Bw1 - 4 to 7 inches: fine sandy loam
Bw2 - 7 to 19 inches: fine sandy loam
Bw3 - 19 to 27 inches: gravelly fine sandy loam
C - 27 to 65 inches: gravelly fine sandy loam

Properties and qualities

Slope: 15 to 25 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 5.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: B

Minor Components

Sutton

Percent of map unit: 5 percent
Landform: Depressions, drainageways
Down-slope shape: Concave
Across-slope shape: Linear

Leicester

Percent of map unit: 5 percent
Landform: Depressions, drainageways
Down-slope shape: Linear
Across-slope shape: Concave

Chatfield

Percent of map unit: 5 percent
Landform: Hills, ridges
Down-slope shape: Convex
Across-slope shape: Linear

Hollis

Percent of map unit: 5 percent
Landform: Hills, ridges
Down-slope shape: Convex
Across-slope shape: Convex

73C—Charlton-Chatfield complex, 3 to 15 percent slopes, very rocky

Map Unit Setting

National map unit symbol: 9lqk
Elevation: 0 to 1,200 feet
Mean annual precipitation: 43 to 56 inches
Mean annual air temperature: 45 to 55 degrees F
Frost-free period: 140 to 185 days
Farmland classification: Not prime farmland

Map Unit Composition

Charlton and similar soils: 45 percent
Chatfield and similar soils: 30 percent
Minor components: 25 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Charlton

Setting

Landform: Hills
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Coarse-loamy melt-out till derived from granite and/or schist and/or gneiss

Typical profile

Ap - 0 to 4 inches: fine sandy loam
Bw1 - 4 to 7 inches: fine sandy loam
Bw2 - 7 to 19 inches: fine sandy loam
Bw3 - 19 to 27 inches: gravelly fine sandy loam
C - 27 to 65 inches: gravelly fine sandy loam

Properties and qualities

Slope: 3 to 15 percent
Percent of area covered with surface fragments: 1.6 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None

Available water storage in profile: Low (about 5.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6s
Hydrologic Soil Group: B

Description of Chatfield

Setting

Landform: Hills, ridges
Down-slope shape: Convex
Across-slope shape: Linear
Parent material: Coarse-loamy melt-out till derived from granite and/or schist and/or gneiss

Typical profile

Oa - 0 to 1 inches: highly decomposed plant material
A - 1 to 6 inches: gravelly fine sandy loam
Bw1 - 6 to 15 inches: gravelly fine sandy loam
Bw2 - 15 to 29 inches: gravelly fine sandy loam
2R - 29 to 80 inches: unweathered bedrock

Properties and qualities

Slope: 3 to 15 percent
Percent of area covered with surface fragments: 1.6 percent
Depth to restrictive feature: 20 to 40 inches to lithic bedrock
Natural drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Low to high (0.01 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 3.3 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6s
Hydrologic Soil Group: B

Minor Components

Rock outcrop

Percent of map unit: 6 percent

Sutton

Percent of map unit: 5 percent
Landform: Depressions, drainageways
Down-slope shape: Concave
Across-slope shape: Linear

Leicester

Percent of map unit: 5 percent
Landform: Depressions, drainageways
Down-slope shape: Linear
Across-slope shape: Concave

Hollis

Percent of map unit: 5 percent
Landform: Hills, ridges
Down-slope shape: Convex
Across-slope shape: Convex

Unnamed, red parent material

Percent of map unit: 2 percent

Unnamed, sandy subsoil

Percent of map unit: 2 percent

84B—Paxton and Montauk fine sandy loams, 3 to 8 percent slopes

Map Unit Setting

National map unit symbol: 2t2qn
Elevation: 0 to 1,570 feet
Mean annual precipitation: 36 to 71 inches
Mean annual air temperature: 39 to 55 degrees F
Frost-free period: 140 to 240 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Paxton and similar soils: 55 percent
Montauk and similar soils: 30 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Paxton

Setting

Landform: Drumlins, ground moraines, hills
Landform position (two-dimensional): Backslope, summit, shoulder
Landform position (three-dimensional): Nose slope, side slope, crest
Down-slope shape: Linear, convex
Across-slope shape: Convex
Parent material: Coarse-loamy lodgment till derived from gneiss, granite, and/or schist

Typical profile

Ap - 0 to 8 inches: fine sandy loam
Bw1 - 8 to 15 inches: fine sandy loam
Bw2 - 15 to 26 inches: fine sandy loam
Cd - 26 to 65 inches: gravelly fine sandy loam

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: 18 to 39 inches to densic material
Natural drainage class: Well drained
Runoff class: Medium

Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.14 in/hr)
Depth to water table: About 18 to 37 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Low (about 3.1 inches)

Interpretive groups
Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2s
Hydrologic Soil Group: C

Description of Montauk

Setting
Landform: Drumlins, hills
Down-slope shape: Convex
Across-slope shape: Linear
Parent material: Coarse-loamy lodgment till derived from gneiss, granite, and/or schist

Typical profile
A - 0 to 4 inches: fine sandy loam
Bw1 - 4 to 14 inches: fine sandy loam
Bw2 - 14 to 25 inches: sandy loam
2Cd1 - 25 to 39 inches: gravelly loamy coarse sand
2Cd2 - 39 to 60 inches: gravelly sandy loam

Properties and qualities
Slope: 3 to 8 percent
Depth to restrictive feature: 20 to 38 inches to densic material
Natural drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately high (0.00 to 0.20 in/hr)
Depth to water table: About 24 to 30 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 3.3 inches)

Interpretive groups
Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: C

Minor Components

Woodbridge
Percent of map unit: 5 percent
Landform: Drumlins, ground moraines, hills
Landform position (two-dimensional): Footslope, backslope, summit
Landform position (three-dimensional): Side slope
Down-slope shape: Concave
Across-slope shape: Linear

Charlton
Percent of map unit: 5 percent

Landform: Hills
Down-slope shape: Linear
Across-slope shape: Linear

Ridgebury

Percent of map unit: 5 percent
Landform: Depressions, drainageways, ground moraines, hills
Landform position (two-dimensional): Toeslope, backslope, footslope
Landform position (three-dimensional): Base slope, head slope, dip
Down-slope shape: Concave
Across-slope shape: Concave

245B—Woodbridge-Urban land complex, 0 to 8 percent slopes

Map Unit Setting

National map unit symbol: 2w68d
Elevation: 0 to 970 feet
Mean annual precipitation: 36 to 71 inches
Mean annual air temperature: 39 to 55 degrees F
Frost-free period: 145 to 240 days
Farmland classification: Not prime farmland

Map Unit Composition

Woodbridge and similar soils: 43 percent
Urban land: 35 percent
Minor components: 22 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Woodbridge

Setting

Landform: Drumlins, ground moraines, hills
Landform position (two-dimensional): Backslope, footslope, summit
Landform position (three-dimensional): Side slope, crest
Down-slope shape: Convex
Across-slope shape: Linear
Parent material: Coarse-loamy lodgment till derived from gneiss, granite, and/or schist

Typical profile

Ap - 0 to 7 inches: fine sandy loam
Bw1 - 7 to 18 inches: fine sandy loam
Bw2 - 18 to 30 inches: fine sandy loam
Cd - 30 to 65 inches: gravelly fine sandy loam

Properties and qualities

Slope: 0 to 8 percent
Depth to restrictive feature: 20 to 39 inches to densic material
Natural drainage class: Moderately well drained
Runoff class: Very high

Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.14 in/hr)
Depth to water table: About 18 to 30 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Low (about 4.7 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2w
Hydrologic Soil Group: C/D

Description of Urban Land

Properties and qualities

Slope: 0 to 8 percent
Depth to restrictive feature: 0 inches to manufactured layer
Capacity of the most limiting layer to transmit water (Ksat): Very low (0.00 to 0.00 in/hr)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8
Hydrologic Soil Group: D

Minor Components

Paxton

Percent of map unit: 7 percent
Landform: Drumlins, ground moraines, hills
Landform position (two-dimensional): Backslope, shoulder, summit
Landform position (three-dimensional): Side slope, crest
Down-slope shape: Linear, convex
Across-slope shape: Convex

Ridgebury

Percent of map unit: 5 percent
Landform: Depressions, drainageways, drumlins, ground moraines, hills
Landform position (two-dimensional): Toeslope, footslope
Landform position (three-dimensional): Base slope, head slope
Down-slope shape: Concave, linear
Across-slope shape: Concave, linear

Udorthents

Percent of map unit: 5 percent
Down-slope shape: Linear
Across-slope shape: Linear

Sutton

Percent of map unit: 5 percent
Landform: Ground moraines, hills
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave
Across-slope shape: Linear

273E—Urban land-Charlton-Chatfield complex, rocky, 15 to 45 percent slopes

Map Unit Setting

National map unit symbol: 9lln
Elevation: 0 to 1,200 feet
Mean annual precipitation: 43 to 56 inches
Mean annual air temperature: 45 to 55 degrees F
Frost-free period: 140 to 185 days
Farmland classification: Not prime farmland

Map Unit Composition

Urban land: 35 percent
Charlton and similar soils: 25 percent
Chatfield and similar soils: 15 percent
Minor components: 25 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Urban Land

Setting

Landform: Hills, ridges

Typical profile

H - 0 to 6 inches: material

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8
Hydrologic Soil Group: D

Description of Charlton

Setting

Landform: Hills
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Coarse-loamy melt-out till derived from granite and/or schist and/or gneiss

Typical profile

Ap - 0 to 4 inches: fine sandy loam
Bw1 - 4 to 7 inches: fine sandy loam
Bw2 - 7 to 19 inches: fine sandy loam
Bw3 - 19 to 27 inches: gravelly fine sandy loam
C - 27 to 65 inches: gravelly fine sandy loam

Properties and qualities

Slope: 15 to 45 percent

Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 5.9 inches)

Interpretive groups
Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: B

Description of Chatfield

Setting
Landform: Hills, ridges
Down-slope shape: Convex
Across-slope shape: Linear
Parent material: Coarse-loamy melt-out till derived from granite and/or schist and/or gneiss

Typical profile
Oa - 0 to 1 inches: highly decomposed plant material
A - 1 to 6 inches: gravelly fine sandy loam
Bw1 - 6 to 15 inches: gravelly fine sandy loam
Bw2 - 15 to 29 inches: gravelly fine sandy loam
2R - 29 to 80 inches: unweathered bedrock

Properties and qualities
Slope: 15 to 45 percent
Percent of area covered with surface fragments: 1.6 percent
Depth to restrictive feature: 20 to 40 inches to lithic bedrock
Natural drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Low to high (0.01 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 3.3 inches)

Interpretive groups
Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: B

Minor Components

Hollis
Percent of map unit: 8 percent
Landform: Hills, ridges
Down-slope shape: Convex
Across-slope shape: Convex

Sutton

Percent of map unit: 5 percent
Landform: Depressions, drainageways
Down-slope shape: Concave
Across-slope shape: Linear

Leicester

Percent of map unit: 5 percent
Landform: Depressions, drainageways
Down-slope shape: Linear
Across-slope shape: Concave

Udorthents

Percent of map unit: 5 percent
Down-slope shape: Convex
Across-slope shape: Linear

Rock outcrop

Percent of map unit: 2 percent

284B—Paxton-Urban land complex, 3 to 8 percent slopes

Map Unit Setting

National map unit symbol: 2w67s
Elevation: 0 to 1,070 feet
Mean annual precipitation: 36 to 71 inches
Mean annual air temperature: 39 to 55 degrees F
Frost-free period: 145 to 240 days
Farmland classification: Not prime farmland

Map Unit Composition

Paxton and similar soils: 45 percent
Urban land: 35 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Paxton

Setting

Landform: Drumlins, ground moraines, hills
Landform position (two-dimensional): Backslope, shoulder, summit
Landform position (three-dimensional): Side slope, crest
Down-slope shape: Linear, convex
Across-slope shape: Convex
Parent material: Coarse-loamy lodgment till derived from gneiss, granite, and/or schist

Typical profile

Ap - 0 to 8 inches: fine sandy loam
Bw1 - 8 to 15 inches: fine sandy loam
Bw2 - 15 to 26 inches: fine sandy loam
Cd - 26 to 65 inches: gravelly fine sandy loam

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: 20 to 39 inches to densic material
Natural drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.14 in/hr)
Depth to water table: About 18 to 37 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Low (about 4.1 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: C

Description of Urban Land

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: 0 inches to manufactured layer
Capacity of the most limiting layer to transmit water (Ksat): Very low (0.00 to 0.00 in/hr)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8
Hydrologic Soil Group: D

Minor Components

Charlton

Percent of map unit: 7 percent
Landform: Hills
Landform position (two-dimensional): Shoulder, backslope, summit
Landform position (three-dimensional): Side slope, crest
Down-slope shape: Convex
Across-slope shape: Convex

Udorthents

Percent of map unit: 5 percent
Down-slope shape: Convex
Across-slope shape: Linear

Woodbridge

Percent of map unit: 5 percent
Landform: Drumlins, ground moraines, hills
Landform position (two-dimensional): Backslope, summit, footslope
Landform position (three-dimensional): Side slope, crest

Down-slope shape: Concave
Across-slope shape: Linear

Ridgebury

Percent of map unit: 3 percent
Landform: Depressions, drainageways, drumlins, ground moraines, hills
Landform position (two-dimensional): Toeslope, footslope
Landform position (three-dimensional): Base slope, head slope
Down-slope shape: Concave, linear
Across-slope shape: Concave, linear

284C—Paxton-Urban land complex, 8 to 15 percent slopes

Map Unit Setting

National map unit symbol: 2w67n
Elevation: 0 to 1,030 feet
Mean annual precipitation: 36 to 71 inches
Mean annual air temperature: 39 to 55 degrees F
Frost-free period: 140 to 240 days
Farmland classification: Not prime farmland

Map Unit Composition

Paxton and similar soils: 45 percent
Urban land: 35 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Paxton

Setting

Landform: Drumlins, ground moraines, hills
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear, convex
Across-slope shape: Convex
Parent material: Coarse-loamy lodgment till derived from gneiss, granite, and/or schist

Typical profile

Ap - 0 to 8 inches: fine sandy loam
Bw1 - 8 to 15 inches: fine sandy loam
Bw2 - 15 to 26 inches: fine sandy loam
Cd - 26 to 65 inches: gravelly fine sandy loam

Properties and qualities

Slope: 8 to 15 percent
Depth to restrictive feature: 20 to 39 inches to densic material
Natural drainage class: Well drained
Runoff class: Medium

Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.14 in/hr)
Depth to water table: About 18 to 37 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Low (about 4.1 inches)

Interpretive groups
Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: C

Description of Urban Land

Properties and qualities
Slope: 8 to 15 percent
Depth to restrictive feature: 0 inches to manufactured layer
Capacity of the most limiting layer to transmit water (Ksat): Very low (0.00 to 0.00 in/hr)

Interpretive groups
Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8
Hydrologic Soil Group: D

Minor Components

Udorthents
Percent of map unit: 9 percent
Down-slope shape: Linear
Across-slope shape: Linear

Canton
Percent of map unit: 7 percent
Landform: Hills
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex, linear
Across-slope shape: Convex

Woodbridge
Percent of map unit: 3 percent
Landform: Drumlins, ground moraines, hills
Landform position (two-dimensional): Backslope, footslope, summit
Landform position (three-dimensional): Side slope, crest
Down-slope shape: Concave
Across-slope shape: Linear

Ridgebury
Percent of map unit: 1 percent
Landform: Depressions, drainageways, drumlins, ground moraines, hills
Landform position (two-dimensional): Toeslope, footslope
Landform position (three-dimensional): Base slope, head slope
Down-slope shape: Concave, linear
Across-slope shape: Concave, linear

306—Udorthents-Urban land complex

Map Unit Setting

National map unit symbol: 9lmg
Elevation: 0 to 2,000 feet
Mean annual precipitation: 43 to 56 inches
Mean annual air temperature: 45 to 55 degrees F
Frost-free period: 120 to 185 days
Farmland classification: Not prime farmland

Map Unit Composition

Udorthents and similar soils: 50 percent
Urban land: 35 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Udorthents

Setting

Down-slope shape: Convex
Across-slope shape: Linear
Parent material: Drift

Typical profile

A - 0 to 5 inches: loam
C1 - 5 to 21 inches: gravelly loam
C2 - 21 to 80 inches: very gravelly sandy loam

Properties and qualities

Slope: 0 to 25 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Very low to high (0.00 to 1.98 in/hr)
Depth to water table: About 54 to 72 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 6.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: B

Description of Urban Land

Typical profile

H - 0 to 6 inches: material

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8
Hydrologic Soil Group: D

Minor Components

Unnamed, undisturbed soils

Percent of map unit: 8 percent

Udorthents, wet substratum

Percent of map unit: 5 percent
Down-slope shape: Convex
Across-slope shape: Linear

Rock outcrop

Percent of map unit: 2 percent

308—Udorthents, smoothed

Map Unit Setting

National map unit symbol: 9lmj
Elevation: 0 to 2,000 feet
Mean annual precipitation: 43 to 56 inches
Mean annual air temperature: 45 to 55 degrees F
Frost-free period: 120 to 185 days
Farmland classification: Not prime farmland

Map Unit Composition

Udorthents and similar soils: 80 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Udorthents

Setting

Down-slope shape: Convex
Across-slope shape: Linear

Typical profile

A - 0 to 5 inches: loam
C1 - 5 to 21 inches: gravelly loam
C2 - 21 to 80 inches: very gravelly sandy loam

Properties and qualities

Slope: 0 to 35 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Moderately well drained
Runoff class: Medium

Capacity of the most limiting layer to transmit water (Ksat): Very low to high (0.00 to 1.98 in/hr)
Depth to water table: About 24 to 54 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 6.8 inches)

Interpretive groups
Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: C

Minor Components

Udorthents, wet substratum
Percent of map unit: 7 percent

Unnamed, undisturbed soils
Percent of map unit: 7 percent

Urban land
Percent of map unit: 5 percent

Rock outcrop
Percent of map unit: 1 percent

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United States Department of Agriculture

NRCS

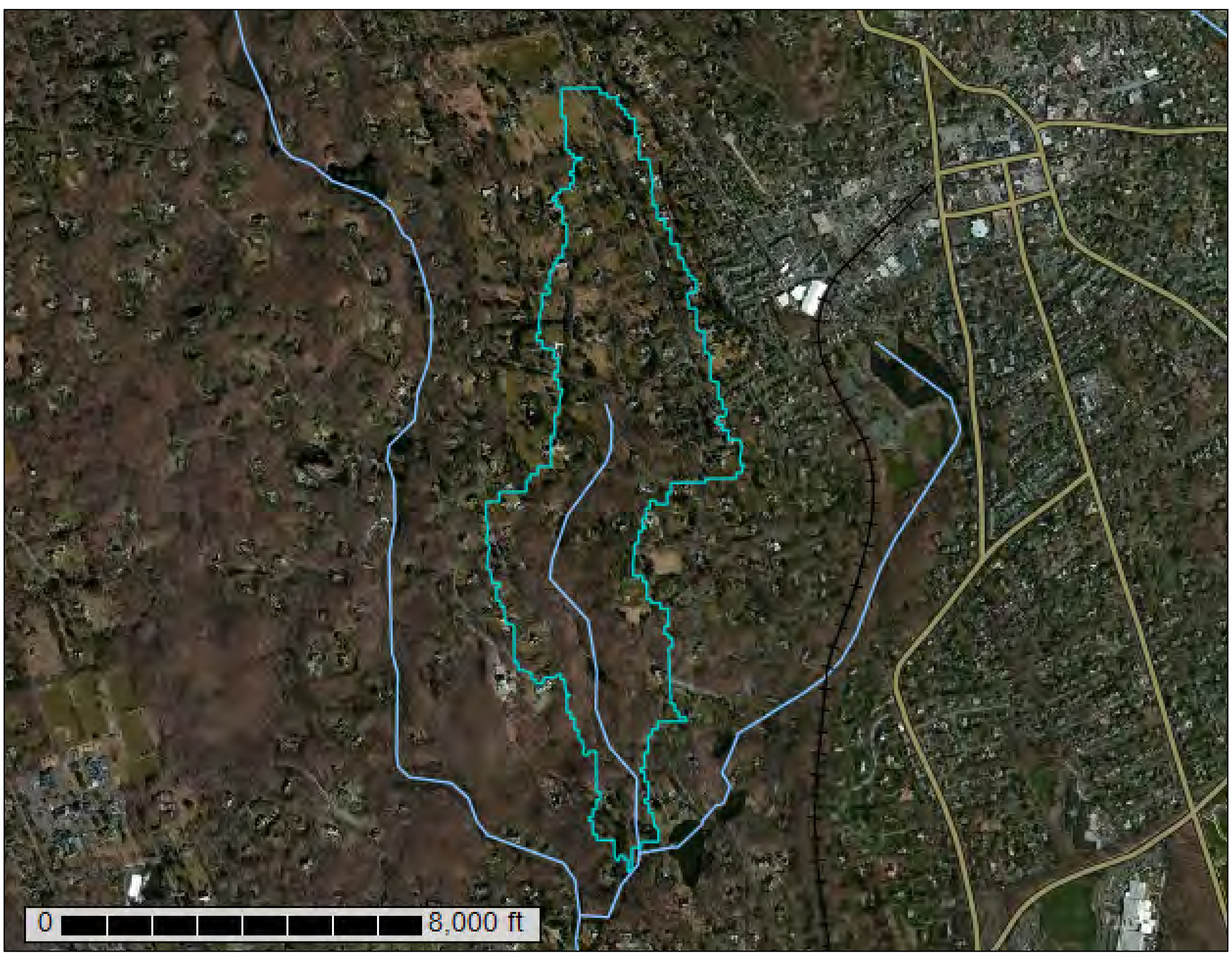
Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for

State of Connecticut

Sub-subwatershed 19 of Subwatershed 4 of Holly Pond Watershed



January 13, 2016

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (http://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

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Contents

How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

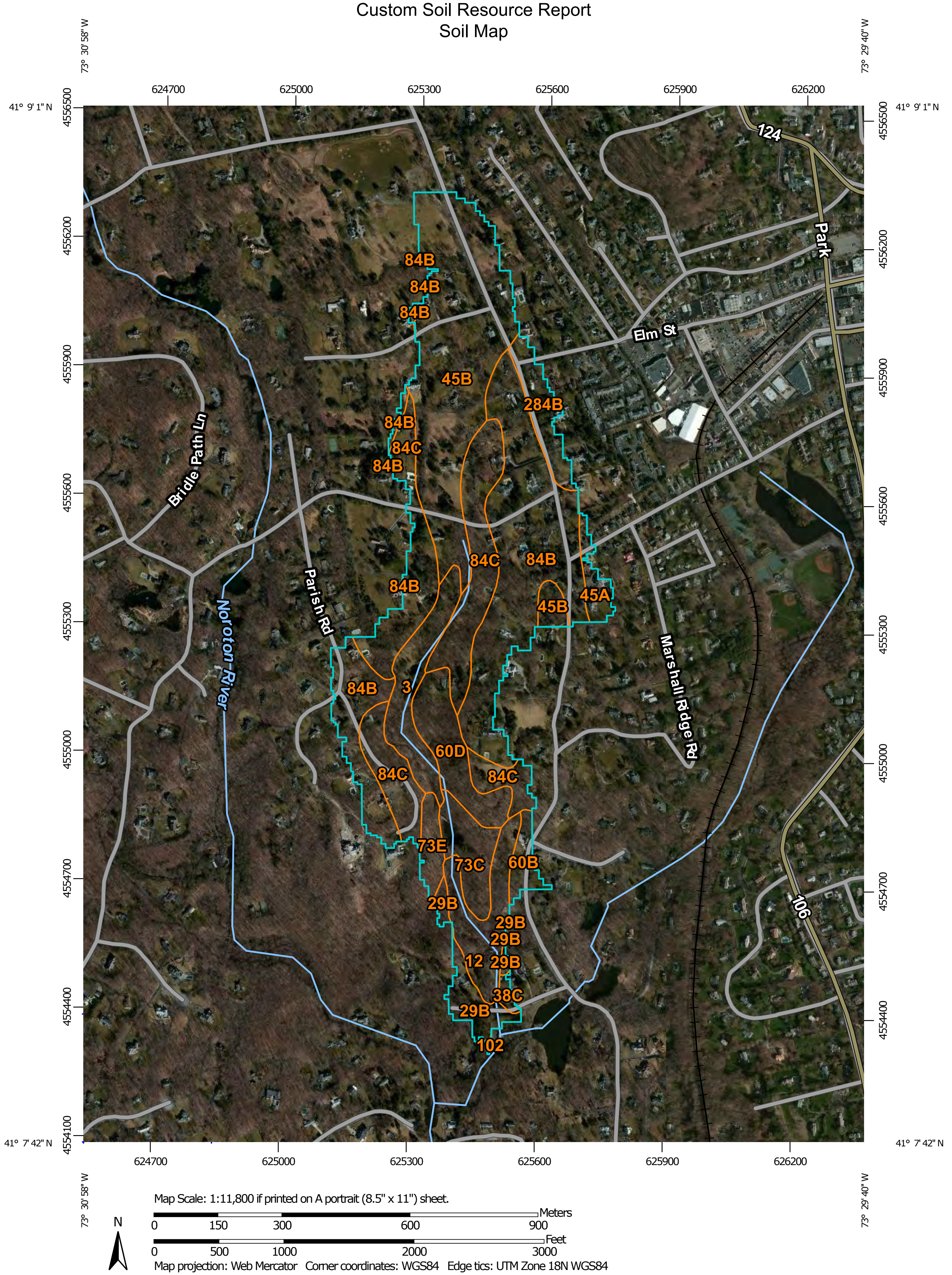
Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Soil Map


73° 30' 58" W
73° 29' 40" W
41° 9' 1" N
41° 7' 42" N
624700
625000
625300
625600
625900
626200
4556500
4556200
4555900
4555600
4555300
4555000
4554700
4554400
4554100
124
Park
Elm St
Bridle Path Ln
Parish Rd
Noroton River
Marshall Ridge Rd
106
84B
84C
45B
284B
45A
3
60D
73E
73C
60B
29B
12
38C
102
Map Scale: 1:11,800 if printed on A portrait (8.5" x 11") sheet.
Meters
0 150 300 600 900
Feet
0 500 1000 2000 3000
N
Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 18N WGS84

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features

- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features

- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:12,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: State of Connecticut
Survey Area Data: Version 14, Sep 22, 2015

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Mar 26, 2011—Apr 16, 2012

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

State of Connecticut (CT600)			
Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
3	Ridgebury, Leicester, and Whitman soils, 0 to 8 percent slopes, extremely stony	8.4	5.5%
12	Raypol silt loam	8.2	5.4%
29B	Agawam fine sandy loam, 3 to 8 percent slopes	4.7	3.1%
38C	Hinckley loamy sand, 3 to 15 percent slopes	0.7	0.4%
45A	Woodbridge fine sandy loam, 0 to 3 percent slopes	2.4	1.6%
45B	Woodbridge fine sandy loam, 3 to 8 percent slopes	35.7	23.4%
60B	Canton and Charlton soils, 3 to 8 percent slopes	2.4	1.6%
60D	Canton and Charlton soils, 15 to 25 percent slopes	8.1	5.3%
73C	Charlton-Chatfield complex, 3 to 15 percent slopes, very rocky	5.7	3.7%
73E	Charlton-Chatfield complex, 15 to 45 percent slopes, very rocky	2.6	1.7%
84B	Paxton and Montauk fine sandy loams, 3 to 8 percent slopes	38.7	25.4%
84C	Paxton and Montauk fine sandy loams, 8 to 15 percent slopes	29.8	19.6%
102	Pootatuck fine sandy loam	0.1	0.1%
284B	Paxton-Urban land complex, 3 to 8 percent slopes	4.9	3.2%
Totals for Area of Interest		**152.2**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

State of Connecticut

3—Ridgebury, Leicester, and Whitman soils, 0 to 8 percent slopes, extremely stony

Map Unit Setting

National map unit symbol: 2t2qt
Elevation: 0 to 1,480 feet
Mean annual precipitation: 36 to 71 inches
Mean annual air temperature: 39 to 55 degrees F
Frost-free period: 140 to 240 days
Farmland classification: Not prime farmland

Map Unit Composition

Ridgebury, extremely stony, and similar soils: 40 percent
Leicester, extremely stony, and similar soils: 35 percent
Whitman, extremely stony, and similar soils: 20 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Ridgebury, Extremely Stony

Setting

Landform: Depressions, drainageways, ground moraines, hills
Landform position (two-dimensional): Toeslope, backslope, footslope
Landform position (three-dimensional): Base slope, head slope, dip
Down-slope shape: Concave
Across-slope shape: Concave
Parent material: Coarse-loamy lodgment till derived from gneiss, granite, and/or schist

Typical profile

A - 0 to 5 inches: fine sandy loam
Bw - 5 to 9 inches: sandy loam
Bg - 9 to 18 inches: gravelly sandy loam
Cd - 18 to 65 inches: gravelly sandy loam

Properties and qualities

Slope: 0 to 8 percent
Percent of area covered with surface fragments: 9.0 percent
Depth to restrictive feature: 14 to 32 inches to densic material
Natural drainage class: Poorly drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.14 in/hr)
Depth to water table: About 0 to 6 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Very low (about 2.1 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: D

Description of Leicester, Extremely Stony

Setting

Landform: Depressions, drainageways
Landform position (two-dimensional): Toeslope, footslope, backslope
Landform position (three-dimensional): Base slope
Down-slope shape: Linear
Across-slope shape: Concave
Parent material: Coarse-loamy melt-out till derived from gneiss, granite, and/or schist

Typical profile

Oe - 0 to 1 inches: moderately decomposed plant material
A - 1 to 7 inches: fine sandy loam
Bg1 - 7 to 10 inches: fine sandy loam
Bg2 - 10 to 18 inches: fine sandy loam
BC - 18 to 24 inches: fine sandy loam
C1 - 24 to 43 inches: gravelly fine sandy loam
C2 - 43 to 65 inches: gravelly fine sandy loam

Properties and qualities

Slope: 0 to 8 percent
Percent of area covered with surface fragments: 9.0 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Poorly drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 5.95 in/hr)
Depth to water table: About 0 to 18 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 6.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: B/D

Description of Whitman, Extremely Stony

Setting

Landform: Depressions, drainageways
Landform position (two-dimensional): Toeslope, footslope, backslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave
Across-slope shape: Concave
Parent material: Coarse-loamy lodgment till derived from gneiss, granite, and/or schist

Typical profile

Oi - 0 to 1 inches: slightly decomposed plant material
A - 1 to 9 inches: fine sandy loam
Bg - 9 to 16 inches: fine sandy loam
Cdg1 - 16 to 22 inches: fine sandy loam
Cdg2 - 22 to 60 inches: fine sandy loam

Properties and qualities

Slope: 0 to 8 percent
Percent of area covered with surface fragments: 9.0 percent
Depth to restrictive feature: 12 to 20 inches to densic material
Natural drainage class: Very poorly drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately high (0.00 to 0.20 in/hr)
Depth to water table: About 0 to 12 inches
Frequency of flooding: None
Frequency of ponding: Occasional
Available water storage in profile: Very low (about 1.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: D

Minor Components

Woodbridge, extremely stony

Percent of map unit: 3 percent
Landform: Drumlins, ground moraines, hills
Landform position (two-dimensional): Backslope, footslope, summit
Landform position (three-dimensional): Side slope
Down-slope shape: Concave
Across-slope shape: Linear

Swansea

Percent of map unit: 2 percent
Landform: Bogs, swamps
Landform position (three-dimensional): Dip
Down-slope shape: Concave
Across-slope shape: Concave

12—Raypol silt loam

Map Unit Setting

National map unit symbol: 9ljx
Elevation: 0 to 1,200 feet
Mean annual precipitation: 43 to 54 inches
Mean annual air temperature: 45 to 55 degrees F
Frost-free period: 140 to 185 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Raypol and similar soils: 80 percent

Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Raypol

Setting

Landform: Depressions, drainageways
Down-slope shape: Concave
Across-slope shape: Concave
Parent material: Coarse-loamy eolian deposits over sandy and gravelly glaciofluvial deposits derived from granite and/or schist and/or gneiss

Typical profile

Ap - 0 to 8 inches: silt loam
Bg1 - 8 to 12 inches: very fine sandy loam
Bg2 - 12 to 20 inches: silt loam
Bw1 - 20 to 26 inches: silt loam
Bw2 - 26 to 29 inches: very fine sandy loam
2C1 - 29 to 52 inches: stratified very gravelly coarse sand to loamy fine sand
2C2 - 52 to 65 inches: stratified very gravelly coarse sand to loamy fine sand

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Poorly drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: About 0 to 12 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 7.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4w
Hydrologic Soil Group: C/D

Minor Components

Haven

Percent of map unit: 5 percent
Landform: Outwash plains, terraces
Down-slope shape: Convex
Across-slope shape: Linear

Enfield

Percent of map unit: 5 percent
Landform: Outwash plains, terraces
Down-slope shape: Convex
Across-slope shape: Linear

Ninigret

Percent of map unit: 3 percent
Landform: Outwash plains, terraces
Down-slope shape: Linear
Across-slope shape: Concave

Tisbury

Percent of map unit: 2 percent
Landform: Outwash plains, terraces
Down-slope shape: Concave
Across-slope shape: Linear

Walpole

Percent of map unit: 2 percent
Landform: Depressions on terraces, drainageways on terraces
Down-slope shape: Concave
Across-slope shape: Concave

Scarboro

Percent of map unit: 2 percent
Landform: Depressions, drainageways, terraces
Down-slope shape: Concave
Across-slope shape: Concave

Unnamed, loamy substratum

Percent of map unit: 1 percent

29B—Agawam fine sandy loam, 3 to 8 percent slopes

Map Unit Setting

National map unit symbol: 2tyqx
Elevation: 0 to 820 feet
Mean annual precipitation: 36 to 71 inches
Mean annual air temperature: 39 to 55 degrees F
Frost-free period: 140 to 250 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Agawam and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Agawam

Setting

Landform: Kame terraces, outwash plains, kames, moraines, outwash terraces
Landform position (two-dimensional): Backslope, shoulder, footslope, summit
Landform position (three-dimensional): Side slope, crest, riser, tread, rise, dip
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Coarse-loamy eolian deposits over sandy and gravelly glaciofluvial deposits derived from gneiss, granite, schist, and/or phyllite

Typical profile

Ap - 0 to 11 inches: fine sandy loam
Bw1 - 11 to 16 inches: fine sandy loam
Bw2 - 16 to 26 inches: fine sandy loam

2C1 - 26 to 45 inches: loamy fine sand
2C2 - 45 to 55 inches: loamy fine sand
2C3 - 55 to 65 inches: loamy sand

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: 15 to 35 inches to strongly contrasting textural stratification
Natural drainage class: Well drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to high (0.14 to 14.17 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Low (about 3.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2s
Hydrologic Soil Group: B

Minor Components

Hinckley

Percent of map unit: 5 percent
Landform: Deltas, eskers, outwash plains, kames
Landform position (two-dimensional): Summit, shoulder, backslope
Landform position (three-dimensional): Head slope, nose slope, side slope, crest, rise
Down-slope shape: Convex
Across-slope shape: Convex, linear

Sudbury

Percent of map unit: 5 percent
Landform: Deltas, outwash plains, terraces
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Tread, dip
Down-slope shape: Concave
Across-slope shape: Linear

Merrimac

Percent of map unit: 3 percent
Landform: Eskers, outwash plains, kames, moraines, outwash terraces
Landform position (two-dimensional): Backslope, footslope, shoulder, summit
Landform position (three-dimensional): Side slope, crest, riser, tread
Down-slope shape: Convex
Across-slope shape: Convex

Windsor

Percent of map unit: 2 percent
Landform: Deltas, dunes, outwash plains, outwash terraces
Landform position (three-dimensional): Riser, tread
Down-slope shape: Linear, convex
Across-slope shape: Linear, convex

38C—Hinckley loamy sand, 3 to 15 percent slopes

Map Unit Setting

National map unit symbol: 2svmb
Elevation: 0 to 1,290 feet
Mean annual precipitation: 36 to 71 inches
Mean annual air temperature: 39 to 55 degrees F
Frost-free period: 140 to 240 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Hinckley and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Hinckley

Setting

Landform: Eskers, kame terraces, outwash plains, kames, moraines, outwash terraces, outwash deltas
Landform position (two-dimensional): Footslope, toeslope, shoulder, backslope, summit
Landform position (three-dimensional): Nose slope, side slope, crest, head slope, riser, tread
Down-slope shape: Convex, concave, linear
Across-slope shape: Concave, linear, convex
Parent material: Sandy and gravelly glaciofluvial deposits derived from gneiss and/or granite and/or schist

Typical profile

Oe - 0 to 1 inches: moderately decomposed plant material
A - 1 to 8 inches: loamy sand
Bw1 - 8 to 11 inches: gravelly loamy sand
Bw2 - 11 to 16 inches: gravelly loamy sand
BC - 16 to 19 inches: very gravelly loamy sand
C - 19 to 65 inches: very gravelly sand

Properties and qualities

Slope: 3 to 15 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Excessively drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to very high (1.42 to 99.90 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Low (about 3.1 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: A

Minor Components

Windsor

Percent of map unit: 5 percent
Landform: Eskers, kame terraces, outwash plains, kames, moraines, outwash terraces, outwash deltas
Landform position (two-dimensional): Shoulder, backslope, footslope, toeslope, summit
Landform position (three-dimensional): Crest, head slope, nose slope, side slope, riser, tread
Down-slope shape: Convex, concave, linear
Across-slope shape: Concave, linear, convex

Merrimac

Percent of map unit: 5 percent
Landform: Eskers, outwash plains, kames, moraines, outwash terraces
Landform position (two-dimensional): Shoulder, toeslope, backslope, footslope, summit
Landform position (three-dimensional): Side slope, head slope, nose slope, crest, riser, tread
Down-slope shape: Convex
Across-slope shape: Convex

Agawam

Percent of map unit: 3 percent
Landform: Eskers, kame terraces, outwash plains, kames, moraines, outwash terraces, outwash deltas
Landform position (two-dimensional): Shoulder, backslope, toeslope, summit, footslope
Landform position (three-dimensional): Crest, head slope, nose slope, side slope, tread, riser
Down-slope shape: Linear, convex, concave
Across-slope shape: Convex, linear, concave

Sudbury

Percent of map unit: 2 percent
Landform: Kame terraces, outwash plains, moraines, outwash terraces, outwash deltas
Landform position (two-dimensional): Backslope, footslope
Landform position (three-dimensional): Base slope, tread
Down-slope shape: Concave, linear
Across-slope shape: Linear, concave

45A—Woodbridge fine sandy loam, 0 to 3 percent slopes

Map Unit Setting

National map unit symbol: 2w686
Elevation: 0 to 1,420 feet
Mean annual precipitation: 36 to 71 inches
Mean annual air temperature: 39 to 55 degrees F
Frost-free period: 140 to 240 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Woodbridge and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Woodbridge

Setting

Landform: Drumlins, ground moraines, hills
Landform position (two-dimensional): Footslope, summit
Landform position (three-dimensional): Crest
Down-slope shape: Convex
Across-slope shape: Linear
Parent material: Coarse-loamy lodgment till derived from gneiss, granite, and/or schist

Typical profile

Ap - 0 to 7 inches: fine sandy loam
Bw1 - 7 to 18 inches: fine sandy loam
Bw2 - 18 to 30 inches: fine sandy loam
Cd - 30 to 65 inches: gravelly fine sandy loam

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: 20 to 39 inches to densic material
Natural drainage class: Moderately well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.14 in/hr)
Depth to water table: About 18 to 30 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Low (about 4.7 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2w
Hydrologic Soil Group: C/D

Minor Components

Paxton

Percent of map unit: 7 percent
Landform: Drumlins, ground moraines, hills
Landform position (two-dimensional): Summit, shoulder
Landform position (three-dimensional): Crest
Down-slope shape: Linear, convex
Across-slope shape: Convex

Ridgebury

Percent of map unit: 6 percent
Landform: Depressions, drainageways, drumlins, ground moraines, hills
Landform position (two-dimensional): Toeslope, footslope
Landform position (three-dimensional): Base slope, head slope
Down-slope shape: Concave
Across-slope shape: Concave

Whitman, extremely stony

Percent of map unit: 1 percent
Landform: Depressions, drainageways
Down-slope shape: Concave
Across-slope shape: Concave

Sutton

Percent of map unit: 1 percent
Landform: Ground moraines, hills
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave
Across-slope shape: Linear

45B—Woodbridge fine sandy loam, 3 to 8 percent slopes

Map Unit Setting

National map unit symbol: 2t2ql
Elevation: 0 to 1,470 feet
Mean annual precipitation: 36 to 71 inches
Mean annual air temperature: 39 to 55 degrees F
Frost-free period: 140 to 240 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Woodbridge, fine sandy loam, and similar soils: 82 percent
Minor components: 18 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Woodbridge, Fine Sandy Loam

Setting

Landform: Drumlins, ground moraines, hills
Landform position (two-dimensional): Backslope, footslope, summit
Landform position (three-dimensional): Side slope
Down-slope shape: Concave
Across-slope shape: Linear
Parent material: Coarse-loamy lodgment till derived from gneiss, granite, and/or schist

Typical profile

Ap - 0 to 7 inches: fine sandy loam
Bw1 - 7 to 18 inches: fine sandy loam
Bw2 - 18 to 30 inches: fine sandy loam
Cd - 30 to 65 inches: gravelly fine sandy loam

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: 20 to 39 inches to densic material
Natural drainage class: Moderately well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.14 in/hr)
Depth to water table: About 18 to 30 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Low (about 3.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2w
Hydrologic Soil Group: C/D

Minor Components

Paxton

Percent of map unit: 10 percent
Landform: Drumlins, ground moraines, hills
Landform position (two-dimensional): Backslope, summit, shoulder
Landform position (three-dimensional): Side slope, crest, nose slope
Down-slope shape: Linear, convex
Across-slope shape: Convex

Ridgebury

Percent of map unit: 8 percent
Landform: Depressions, drainageways, ground moraines, hills
Landform position (two-dimensional): Toeslope, backslope, footslope
Landform position (three-dimensional): Base slope, head slope, dip
Down-slope shape: Concave
Across-slope shape: Concave

60B—Canton and Charlton soils, 3 to 8 percent slopes

Map Unit Setting

National map unit symbol: 9lpn
Elevation: 0 to 1,200 feet
Mean annual precipitation: 43 to 54 inches
Mean annual air temperature: 45 to 55 degrees F
Frost-free period: 140 to 185 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Canton and similar soils: 45 percent
Charlton and similar soils: 35 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Canton

Setting

Landform: Hills
Down-slope shape: Linear
Across-slope shape: Convex
Parent material: Coarse-loamy over sandy and gravelly melt-out till derived from granite and/or schist and/or gneiss

Typical profile

Oe - 0 to 1 inches: moderately decomposed plant material
A - 1 to 3 inches: gravelly fine sandy loam
Bw1 - 3 to 15 inches: gravelly loam
Bw2 - 15 to 24 inches: gravelly loam
Bw3 - 24 to 30 inches: gravelly loam
2C - 30 to 60 inches: very gravelly loamy sand

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 5.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: B

Description of Charlton

Setting

Landform: Hills
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Coarse-loamy melt-out till derived from granite and/or schist and/or gneiss

Typical profile

Ap - 0 to 4 inches: fine sandy loam
Bw1 - 4 to 7 inches: fine sandy loam
Bw2 - 7 to 19 inches: fine sandy loam
Bw3 - 19 to 27 inches: gravelly fine sandy loam
C - 27 to 65 inches: gravelly fine sandy loam

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 5.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: B

Minor Components

Sutton

Percent of map unit: 5 percent
Landform: Depressions, drainageways
Down-slope shape: Concave
Across-slope shape: Linear

Leicester

Percent of map unit: 5 percent
Landform: Depressions, drainageways
Down-slope shape: Linear
Across-slope shape: Concave

Chatfield

Percent of map unit: 5 percent
Landform: Hills, ridges
Down-slope shape: Convex
Across-slope shape: Linear

Hollis

Percent of map unit: 3 percent
Landform: Hills, ridges
Down-slope shape: Convex

Across-slope shape: Convex

Unnamed, silt loam surface

Percent of map unit: 2 percent

60D—Canton and Charlton soils, 15 to 25 percent slopes

Map Unit Setting

National map unit symbol: 9lpq
Elevation: 0 to 1,200 feet
Mean annual precipitation: 43 to 54 inches
Mean annual air temperature: 45 to 55 degrees F
Frost-free period: 140 to 185 days
Farmland classification: Not prime farmland

Map Unit Composition

Canton and similar soils: 45 percent
Charlton and similar soils: 35 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Canton

Setting

Landform: Hills
Down-slope shape: Linear
Across-slope shape: Convex
Parent material: Coarse-loamy over sandy and gravelly melt-out till derived from granite and/or schist and/or gneiss

Typical profile

Oe - 0 to 1 inches: moderately decomposed plant material
A - 1 to 3 inches: gravelly fine sandy loam
Bw1 - 3 to 15 inches: gravelly loam
Bw2 - 15 to 24 inches: gravelly loam
Bw3 - 24 to 30 inches: gravelly loam
2C - 30 to 60 inches: very gravelly loamy sand

Properties and qualities

Slope: 15 to 25 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 5.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: B

Description of Charlton

Setting

Landform: Hills
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Coarse-loamy melt-out till derived from granite and/or schist and/or gneiss

Typical profile

Ap - 0 to 4 inches: fine sandy loam
Bw1 - 4 to 7 inches: fine sandy loam
Bw2 - 7 to 19 inches: fine sandy loam
Bw3 - 19 to 27 inches: gravelly fine sandy loam
C - 27 to 65 inches: gravelly fine sandy loam

Properties and qualities

Slope: 15 to 25 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 5.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: B

Minor Components

Sutton

Percent of map unit: 5 percent
Landform: Depressions, drainageways
Down-slope shape: Concave
Across-slope shape: Linear

Leicester

Percent of map unit: 5 percent
Landform: Depressions, drainageways
Down-slope shape: Linear
Across-slope shape: Concave

Chatfield

Percent of map unit: 5 percent
Landform: Hills, ridges
Down-slope shape: Convex
Across-slope shape: Linear

Hollis

Percent of map unit: 5 percent
Landform: Hills, ridges
Down-slope shape: Convex
Across-slope shape: Convex

73C—Charlton-Chatfield complex, 3 to 15 percent slopes, very rocky

Map Unit Setting

National map unit symbol: 9lqk
Elevation: 0 to 1,200 feet
Mean annual precipitation: 43 to 56 inches
Mean annual air temperature: 45 to 55 degrees F
Frost-free period: 140 to 185 days
Farmland classification: Not prime farmland

Map Unit Composition

Charlton and similar soils: 45 percent
Chatfield and similar soils: 30 percent
Minor components: 25 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Charlton

Setting

Landform: Hills
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Coarse-loamy melt-out till derived from granite and/or schist and/or gneiss

Typical profile

Ap - 0 to 4 inches: fine sandy loam
Bw1 - 4 to 7 inches: fine sandy loam
Bw2 - 7 to 19 inches: fine sandy loam
Bw3 - 19 to 27 inches: gravelly fine sandy loam
C - 27 to 65 inches: gravelly fine sandy loam

Properties and qualities

Slope: 3 to 15 percent
Percent of area covered with surface fragments: 1.6 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None

Available water storage in profile: Low (about 5.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6s
Hydrologic Soil Group: B

Description of Chatfield

Setting

Landform: Hills, ridges
Down-slope shape: Convex
Across-slope shape: Linear
Parent material: Coarse-loamy melt-out till derived from granite and/or schist and/or gneiss

Typical profile

Oa - 0 to 1 inches: highly decomposed plant material
A - 1 to 6 inches: gravelly fine sandy loam
Bw1 - 6 to 15 inches: gravelly fine sandy loam
Bw2 - 15 to 29 inches: gravelly fine sandy loam
2R - 29 to 80 inches: unweathered bedrock

Properties and qualities

Slope: 3 to 15 percent
Percent of area covered with surface fragments: 1.6 percent
Depth to restrictive feature: 20 to 40 inches to lithic bedrock
Natural drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Low to high (0.01 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 3.3 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6s
Hydrologic Soil Group: B

Minor Components

Rock outcrop

Percent of map unit: 6 percent

Sutton

Percent of map unit: 5 percent
Landform: Depressions, drainageways
Down-slope shape: Concave
Across-slope shape: Linear

Leicester

Percent of map unit: 5 percent
Landform: Depressions, drainageways
Down-slope shape: Linear
Across-slope shape: Concave

Hollis

Percent of map unit: 5 percent
Landform: Hills, ridges
Down-slope shape: Convex
Across-slope shape: Convex

Unnamed, red parent material

Percent of map unit: 2 percent

Unnamed, sandy subsoil

Percent of map unit: 2 percent

73E—Charlton-Chatfield complex, 15 to 45 percent slopes, very rocky

Map Unit Setting

National map unit symbol: 9lql
Elevation: 0 to 1,200 feet
Mean annual precipitation: 43 to 56 inches
Mean annual air temperature: 45 to 55 degrees F
Frost-free period: 140 to 185 days
Farmland classification: Not prime farmland

Map Unit Composition

Charlton and similar soils: 45 percent
Chatfield and similar soils: 30 percent
Minor components: 25 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Charlton

Setting

Landform: Hills
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Coarse-loamy melt-out till derived from granite and/or schist and/or gneiss

Typical profile

Ap - 0 to 4 inches: fine sandy loam
Bw1 - 4 to 7 inches: fine sandy loam
Bw2 - 7 to 19 inches: fine sandy loam
Bw3 - 19 to 27 inches: gravelly fine sandy loam
C - 27 to 65 inches: gravelly fine sandy loam

Properties and qualities

Slope: 15 to 45 percent
Percent of area covered with surface fragments: 1.6 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: High

Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 5.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: B

Description of Chatfield

Setting

Landform: Hills, ridges
Down-slope shape: Convex
Across-slope shape: Linear
Parent material: Coarse-loamy melt-out till derived from granite and/or schist and/or gneiss

Typical profile

Oa - 0 to 1 inches: highly decomposed plant material
A - 1 to 6 inches: gravelly fine sandy loam
Bw1 - 6 to 15 inches: gravelly fine sandy loam
Bw2 - 15 to 29 inches: gravelly fine sandy loam
2R - 29 to 80 inches: unweathered bedrock

Properties and qualities

Slope: 15 to 45 percent
Percent of area covered with surface fragments: 1.6 percent
Depth to restrictive feature: 20 to 40 inches to lithic bedrock
Natural drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Low to high (0.01 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 3.3 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: B

Minor Components

Rock outcrop

Percent of map unit: 10 percent

Sutton

Percent of map unit: 5 percent
Landform: Depressions, drainageways
Down-slope shape: Concave
Across-slope shape: Linear

Leicester

Percent of map unit: 5 percent
Landform: Depressions, drainageways
Down-slope shape: Linear
Across-slope shape: Concave

Hollis

Percent of map unit: 3 percent
Landform: Hills, ridges
Down-slope shape: Convex
Across-slope shape: Convex

Unnamed, red parent material

Percent of map unit: 1 percent

Unnamed, sandy subsoil

Percent of map unit: 1 percent

84B—Paxton and Montauk fine sandy loams, 3 to 8 percent slopes

Map Unit Setting

National map unit symbol: 2t2qn
Elevation: 0 to 1,570 feet
Mean annual precipitation: 36 to 71 inches
Mean annual air temperature: 39 to 55 degrees F
Frost-free period: 140 to 240 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Paxton and similar soils: 55 percent
Montauk and similar soils: 30 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Paxton

Setting

Landform: Drumlins, ground moraines, hills
Landform position (two-dimensional): Backslope, summit, shoulder
Landform position (three-dimensional): Nose slope, side slope, crest
Down-slope shape: Linear, convex
Across-slope shape: Convex
Parent material: Coarse-loamy lodgment till derived from gneiss, granite, and/or schist

Typical profile

Ap - 0 to 8 inches: fine sandy loam
Bw1 - 8 to 15 inches: fine sandy loam
Bw2 - 15 to 26 inches: fine sandy loam
Cd - 26 to 65 inches: gravelly fine sandy loam

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: 18 to 39 inches to densic material
Natural drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.14 in/hr)
Depth to water table: About 18 to 37 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Low (about 3.1 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2s
Hydrologic Soil Group: C

Description of Montauk

Setting

Landform: Drumlins, hills
Down-slope shape: Convex
Across-slope shape: Linear
Parent material: Coarse-loamy lodgment till derived from gneiss, granite, and/or schist

Typical profile

A - 0 to 4 inches: fine sandy loam
Bw1 - 4 to 14 inches: fine sandy loam
Bw2 - 14 to 25 inches: sandy loam
2Cd1 - 25 to 39 inches: gravelly loamy coarse sand
2Cd2 - 39 to 60 inches: gravelly sandy loam

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: 20 to 38 inches to densic material
Natural drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately high (0.00 to 0.20 in/hr)
Depth to water table: About 24 to 30 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 3.3 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: C

Minor Components

Woodbridge

Percent of map unit: 5 percent
Landform: Drumlins, ground moraines, hills
Landform position (two-dimensional): Footslope, backslope, summit

Landform position (three-dimensional): Side slope
Down-slope shape: Concave
Across-slope shape: Linear

Charlton
Percent of map unit: 5 percent
Landform: Hills
Down-slope shape: Linear
Across-slope shape: Linear

Ridgebury
Percent of map unit: 5 percent
Landform: Depressions, drainageways, ground moraines, hills
Landform position (two-dimensional): Toeslope, backslope, footslope
Landform position (three-dimensional): Base slope, head slope, dip
Down-slope shape: Concave
Across-slope shape: Concave

84C—Paxton and Montauk fine sandy loams, 8 to 15 percent slopes

Map Unit Setting
National map unit symbol: 2w67b
Elevation: 0 to 1,550 feet
Mean annual precipitation: 36 to 71 inches
Mean annual air temperature: 39 to 55 degrees F
Frost-free period: 145 to 240 days
Farmland classification: Farmland of statewide importance

Map Unit Composition
Paxton and similar soils: 55 percent
Montauk and similar soils: 30 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Paxton

Setting
Landform: Drumlins, ground moraines, hills
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear, convex
Across-slope shape: Convex
Parent material: Coarse-loamy lodgment till derived from gneiss, granite, and/or schist

Typical profile
Ap - 0 to 8 inches: fine sandy loam
Bw1 - 8 to 15 inches: fine sandy loam
Bw2 - 15 to 26 inches: fine sandy loam
Cd - 26 to 65 inches: gravelly fine sandy loam

Properties and qualities

Slope: 8 to 15 percent
Depth to restrictive feature: 20 to 39 inches to densic material
Natural drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.14 in/hr)
Depth to water table: About 18 to 37 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Low (about 4.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: C

Description of Montauk

Setting

Landform: Drumlins, ground moraines, hills, recessionial moraines
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear, convex
Across-slope shape: Convex
Parent material: Coarse-loamy over sandy lodgment till derived from gneiss, granite, and/or schist

Typical profile

Ap - 0 to 4 inches: fine sandy loam
Bw1 - 4 to 26 inches: fine sandy loam
Bw2 - 26 to 34 inches: sandy loam
2Cd - 34 to 72 inches: gravelly loamy sand

Properties and qualities

Slope: 8 to 15 percent
Depth to restrictive feature: 20 to 39 inches to densic material
Natural drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately high (0.00 to 1.42 in/hr)
Depth to water table: About 18 to 37 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Low (about 5.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: C

Minor Components

Woodbridge

Percent of map unit: 6 percent

Landform: Drumlins, ground moraines, hills
Landform position (two-dimensional): Backslope, footslope
Landform position (three-dimensional): Side slope
Down-slope shape: Concave
Across-slope shape: Linear

Charlton
Percent of map unit: 5 percent
Landform: Hills
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear, convex
Across-slope shape: Convex

Ridgebury
Percent of map unit: 3 percent
Landform: Depressions, drainageways, drumlins, ground moraines, hills
Landform position (two-dimensional): Footslope, toeslope
Landform position (three-dimensional): Base slope, head slope
Down-slope shape: Concave
Across-slope shape: Concave

Stockbridge
Percent of map unit: 1 percent
Landform: Hills
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Concave
Across-slope shape: Linear

102—Pootatuck fine sandy loam

Map Unit Setting
National map unit symbol: 9ljn
Elevation: 0 to 1,200 feet
Mean annual precipitation: 43 to 54 inches
Mean annual air temperature: 45 to 55 degrees F
Frost-free period: 140 to 185 days
Farmland classification: All areas are prime farmland

Map Unit Composition
Pootatuck and similar soils: 80 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Pootatuck

Setting
Landform: Flood plains
Down-slope shape: Linear

Across-slope shape: Concave
Parent material: Coarse-loamy alluvium

Typical profile

Ap - 0 to 4 inches: fine sandy loam
Bw1 - 4 to 16 inches: fine sandy loam
Bw2 - 16 to 21 inches: fine sandy loam
Bw3 - 21 to 29 inches: sandy loam
C1 - 29 to 35 inches: stratified very gravelly coarse sand to loamy fine sand
C2 - 35 to 40 inches: stratified very gravelly coarse sand to loamy fine sand
C3 - 40 to 65 inches: stratified very gravelly coarse sand to loamy fine sand

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Moderately well drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 5.95 in/hr)
Depth to water table: About 18 to 30 inches
Frequency of flooding: Frequent
Frequency of ponding: None
Available water storage in profile: Low (about 5.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2w
Hydrologic Soil Group: B

Minor Components

Suncook

Percent of map unit: 5 percent
Landform: Flood plains
Down-slope shape: Linear
Across-slope shape: Convex

Occum

Percent of map unit: 5 percent
Landform: Flood plains
Down-slope shape: Linear
Across-slope shape: Linear

Lim

Percent of map unit: 3 percent
Landform: Flood plains
Down-slope shape: Concave
Across-slope shape: Concave

Rippowam

Percent of map unit: 3 percent
Landform: Flood plains
Down-slope shape: Linear
Across-slope shape: Concave

Saco

Percent of map unit: 2 percent
Landform: Flood plains

Down-slope shape: Concave
Across-slope shape: Concave

Limerick

Percent of map unit: 2 percent
Landform: Flood plains
Down-slope shape: Concave
Across-slope shape: Concave

284B—Paxton-Urban land complex, 3 to 8 percent slopes

Map Unit Setting

National map unit symbol: 2w67s
Elevation: 0 to 1,070 feet
Mean annual precipitation: 36 to 71 inches
Mean annual air temperature: 39 to 55 degrees F
Frost-free period: 145 to 240 days
Farmland classification: Not prime farmland

Map Unit Composition

Paxton and similar soils: 45 percent
Urban land: 35 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Paxton

Setting

Landform: Drumlins, ground moraines, hills
Landform position (two-dimensional): Backslope, shoulder, summit
Landform position (three-dimensional): Side slope, crest
Down-slope shape: Linear, convex
Across-slope shape: Convex
Parent material: Coarse-loamy lodgment till derived from gneiss, granite, and/or schist

Typical profile

Ap - 0 to 8 inches: fine sandy loam
Bw1 - 8 to 15 inches: fine sandy loam
Bw2 - 15 to 26 inches: fine sandy loam
Cd - 26 to 65 inches: gravelly fine sandy loam

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: 20 to 39 inches to densic material
Natural drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.14 in/hr)
Depth to water table: About 18 to 37 inches
Frequency of flooding: None

Frequency of ponding: None
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Low (about 4.1 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: C

Description of Urban Land

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: 0 inches to manufactured layer
Capacity of the most limiting layer to transmit water (Ksat): Very low (0.00 to 0.00 in/hr)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8
Hydrologic Soil Group: D

Minor Components

Charlton

Percent of map unit: 7 percent
Landform: Hills
Landform position (two-dimensional): Shoulder, backslope, summit
Landform position (three-dimensional): Side slope, crest
Down-slope shape: Convex
Across-slope shape: Convex

Udorthents

Percent of map unit: 5 percent
Down-slope shape: Convex
Across-slope shape: Linear

Woodbridge

Percent of map unit: 5 percent
Landform: Drumlins, ground moraines, hills
Landform position (two-dimensional): Backslope, summit, footslope
Landform position (three-dimensional): Side slope, crest
Down-slope shape: Concave
Across-slope shape: Linear

Ridgebury

Percent of map unit: 3 percent
Landform: Depressions, drainageways, drumlins, ground moraines, hills
Landform position (two-dimensional): Toeslope, footslope
Landform position (three-dimensional): Base slope, head slope
Down-slope shape: Concave, linear
Across-slope shape: Concave, linear

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