CASCADE BROOK SALT MARSH RESTORATION MONITORING PROJECT SUMMARY REPORT

CASCADE BROOK, SCARBOROUGH, MAINE

February 2009

Prepared for:

Friends of Scarborough Marsh

Prepared by:

451 Presumpscot Street
Portland, ME 04103

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P.O. Box 7049
Scarborough, Maine 04070

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1.0 INTRODUCTION

The Scarborough Marsh Planning Team (SMPT) has completed salt marsh restoration and monitoring activities along Cascade Brook between Old Blue Point Road and Pine Point Road, in the Scarborough Marsh Wildlife Management Area, in Scarborough, Maine (Figure 1). SMPT comprises Friends of Scarborough Marsh (FSM), United States Fish and Wildlife Service (USFWS), Maine Department of Inland Fisheries and Wildlife (MDIFW), United States Department of Agriculture – Natural Resources Conservation Service (NRCS), Conservation Law Foundation, and Ducks Unlimited, Inc.

The primary goals of SMPT's restoration efforts at the Cascade Brook Salt Marsh Restoration Monitoring Project (Project) site were to:

- Restore the native marsh surface elevation, allowing native salt marsh vegetation to repopulate the marsh;
- Reduce the constriction of tidal flow to the marsh, increasing salinities and reducing pooling of freshwater on the marsh; and,
- Eliminate populations of the invasive plant *Phragmites australis* (*Phragmites*) from the central sections of the marsh that were formerly dominated by salt meadow cordgrass (*Spartina patens*), and minimize the potential for *Phragmites* to repopulate the marsh.

To accomplish these goals, restoration activity at Cascade Brook included the following components:

- Removal of spoil material and peat piles deposited on the marsh when the Old Blue Point Road and culvert failed in a 1996 flood;
- Lowering of the 16-foot wide section of the water control structure located upstream of the Pine Point Road culvert;
- Removal of the first berm located upstream of the water control structures, and cutting of a 25-foot wide channel in the second berm; and,
- Control of *Phragmites* in four distinct areas of the marsh via the application of an herbicide (i.e., Rodeo).

To assist in this effort, Tetra Tech, Inc. (formerly Northern Ecological Associates, Inc.), was contracted by the FSM in 2002 to conduct pre- and post-restoration monitoring of an 88.0-acre portion of the Scarborough Marsh Wildlife Management Area along Cascade Brook. Monitoring activities were designed following the USFWS's *Salt Marsh Restoration Monitoring Plan for Ditch-Plugging Efforts in New England Marshes* (*Monitoring Plan*) (USFWS 2001). Although restoration activities did not directly involve ditch plugging, the Monitoring Plan provided a strong basis for designing restoration monitoring for the Cascade Brook site.

Restoring natural salt marsh conditions and improving hydrological conditions have allowed native salt marsh dependant species (*i.e.*, fish, invertebrates, waterbirds, shorebirds, wading birds, waterfowl) to be reestablished and/or to increase in number.

Pre-restoration monitoring activities were conducted from July through October 2002. Pre-restoration monitoring methods and data are presented in the Cascade Brook Salt Marsh Pre-Restoration Monitoring Data and Documentation Report (FSM and USFWS 2002). Construction occurred in the fall of 2003, and included removing the peat piles and excavating areas where spoil material was deposited on the original marsh surface, lowering the water control structure near Pine Point Road, and removing the berms, or sections of the berms, in the channel just upstream of the water control structure.. Post-restoration monitoring has taken place annually: Year 1 post restoration monitoring (August through October 2004), Year 2 (September 2005), Year 3 (August through September 2006), and Year 4 (September through November 2007). Data and summaries of post-restoration monitoring activities are presented in the Cascade Brook Salt Marsh Pre-Restoration Monitoring Data and Documentation Reports (FSM and USFWS 2004, 2005, 2006, and 2007, respectively). Year 5 post-restoration monitoring was conducted between August and October 2008.

This Project Summary Report presents a comprehensive analysis of data collected during pre- and post-restoration monitoring activities for the Project, and includes data gathered for Year 5 post-restoration monitoring. Also, this report includes a brief discussion of monitoring methodology (Section 2.0), results and discussion (Section 3.0), and management implications and recommendations (Section 4.0). In addition, this report also includes cover type maps of the Project area for pre- and Year 5 post-restoration (Appendix A), site assessment data forms (Appendix B), vegetation monitoring data (Appendix C), photographic documentation (Appendix D), water sampling data (Appendix E), field notes (Appendix F), and a list of wildlife species observed during monitoring activities (Appendix G). An electronic copy of data and information collected during all years of the monitoring effort are included on a CD located in the front cover of this report.

Source: USGS 7.5' Series Topographic Quadrangle,
Prouts Neck 1957 Photorevised 1978;
Old Orchard Beach 1956 Photorevised 1970.

Figure 1. Site Location Map for Cascade Brook Salt Marsh Restoration Monitoring Project Scarborough, Maine.

Client: U.S. Fish & Wildlife Service

Prepared By: NEA Northern Ecological Associates, Inc.

Date: 11/11/02

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2.0 METHODS

Year 5 post-restoration monitoring tasks included updating the Project cover type map, completing an annual site evaluation (site assessment and photo documentation), conducting vegetation monitoring, sampling of depth and duration of flooding on the marsh surface, measuring water quality and salinity, and noting incidental observations of wildlife using the Project area. The following sections provide a brief description of field monitoring techniques utilized to obtain the required data. Monitoring methods and sample locations were consistent with those used during the previous monitoring activities, and presented in the USFWS Cascade Brook Salt Marsh Pre-Restoration Monitoring Draft Data & Documentation Report (USFWS 2002).

2.1 COVER TYPE MAP

A cover type map was updated for the 88-acre Project area during the 2008 post-restoration monitoring effort. Updates to the cover type map created during the pre-restoration monitoring conducted in 2002 were based on observations made during an October 31, 2008, site visit. Cover type updates in 2008 included the addition of several new polygons and adjustments to the size and/or shape of a polygon boundary. Minor changes in cover type were noted during successive years of post-restoration monitoring conducted in 2004, 2005, 2006 and 2007, but the cover type map was not updated at those times, pending completion of the Year 5 cover type map update. The 2008 updated cover type map completed as part of Year 5 post-restoration monitoring is provided in Appendix A.

Changes to cover type classification and boundaries were approximated based on a visual assessment of the site conditions during low tide, as observed in the field. A minimum mapping unit of 10 m^2 (approximately 1,075 ft^2) was used. The updated field map was used to update polygon boundaries using a GIS, to create the updated final cover type map. The original 2002 Pre-Restoration, and updated 2008 Post-Restoration cover type maps are included in Appendix A.

Ten (10) dominant vegetated community types were differentiated and mapped, including one vegetated upland community and nine vegetated salt marsh communities. Three non-vegetated communities and one man-made structure also were identified. It should be noted that the community previous identified as big cordgrass (*Spartina cynosuroides*) has been changed to prairie cordgrass (*S. pectinata*) due to misidentification during pre-restoration cover type mapping. The following ten vegetated communities are included on the 2008 cover type map included in Appendix A, and are described below.

- Salt marsh bulrush (*Scirpus robustus*)
- Soft-stemmed bulrush (*Scirpus validus*)
- Smooth cordgrass (*Spartina alterniflora*)
- Prairie cordgrass (*Spartina pectinata*)
- Mixed salt marsh species (*S. alterniflora*, *S. robustus*, algal mats, *Distichlis spicata*, *Typha angustifolia*, *Phragmites australis*, and *Solidago* spp.)

- Smooth cordgrass and salt meadow cordgrass (*S. alterniflora* and *S. patens*)
- Cattail (*Typha* spp.)
- Upland
- Wetland forest
- Common reed (*Phragmites australis*)

Salt marsh bulrush (*Scirpus robustus*) – this emergent wetland salt marsh community contains greater than 60% cover of salt marsh bulrush. Other species associated with this community include various bulrush species, smooth cordgrass, salt meadow cordgrass, and various rushes (*Juncus* spp.). This community is uncommon on the marsh surface and is found in low-lying, semi-permanently-flooded areas, such as along the margins of pools.

Soft-stemmed bulrush (*Scirpus validus*) – two small communities of soft-stemmed bulrush are found along the eastern border of the Project area, in regularly or irregularly flooded areas where fresh water ponds. Other species associated with this community include dwarf spike-rush (*Eleocharis parvula*), other bulrush species, and cattail.

Smooth cordgrass (*Spartina alterniflora*) – a wetland community dominated by at least 50% cover of smooth cordgrass. Another herbaceous species commonly found in this community is salt meadow cordgrass. Less dominant species include, New York aster (*Aster novi-belgii*), seaside goldenrod (*Solidago sempervirens*), seaside arrow grass (*Triglochin maritimum*), and silverweed (*Potentilla anserina*). Smooth cordgrass is common in regularly flooded areas of the marsh. Specifically, at the Cascade Brook site, this community is found in low-lying areas of the marsh, along the edges of pools and channels, and within pannes throughout the marsh. Smooth cordgrass communities growing along channels, pools, and pannes may have been missed that were smaller than the minimum mapping unit.

Prairie cordgrass (*Spartina pectinata*) – formerly identified as big cordgrass, prairie cordgrass is found in several small patches in the irregularly flooded brackish or tidal fresh water sections of the marsh, near the upland border. These communities also include salt meadow cordgrass and various bulrush species.

Mixed salt marsh species – this community comprises a mixture of salt marsh species, including smooth cordgrass, salt meadow cordgrass, salt marsh bulrush, algal mats, spike grass (*Distichlis spicata*, also known as salt marsh grass, or saltgrass), narrow-leaved cattail (*Typha angustifolia*), *Phragmites*, and goldenrod species (*Solidago* spp.). There is no clear dominance by one particular species. The mixed salt marsh communities are found in the fill removal area and the *Phragmites* control area along the eastern boundary of the marsh.

Smooth cordgrass (*S. alterniflora*) and Salt meadow cordgrass (*S. patens*) – this community is dominated by smooth and salt meadow cordgrass, with the combination of these two species representing more than 75% cover. This is the dominant community type for the Project area. Other species found in this community include marsh orach (*Atriplex patula*), spike grass, common reed, common glasswort (*Salicornia europaea*), seaside goldenrod, and cattail.

Cattail (*Typha* spp.) – this community is dominated by narrow-leaved cattail and broad-leaved cattail (*T. latifolia*), both of which can grow and expand aggressively in wetland communities. Broad-leaved cattail is found primarily along the upper margins of the wetland, in areas where fresh water runoff and ponding may occur. Hedge false bindweed (*Calystegia sepium*) and New York aster are also associated with this community.

Upland – the upland community is dominated by a mixed cover of trees, shrubs, and herbaceous species. Dominant tree species include oak (*Quercus* spp.), pine (*Pinus* spp.), and maple (*Acer* spp.), and dominant shrub species include arrowwood (*Viburnum recognitum*), northern bayberry (*Myrica pennsylvanica*), and blackberry and raspberry species (*Rubus spp.*). This community also includes miscellaneous goldenrods (*Solidago* spp.), gramminoids, and salt marsh plant species, interspersed with upland plants along the upland/wetland transition zone.

Wetland forest – the wetland forest community is dominated by a mixed cover of trees and shrubs. Dominant tree species include red maple (*Acer rubrum*) and gray birch (*Betula populifolia*), and dominant shrub species include speckled alder (*Alnus rugosa*), winterberry (*Ilex verticillata*), and northern bayberry (*Myrica pensylvanica*). Common herbaceous species found in this community include halberd-leaved tearthumb (*Polygonum arifolium*), hedge bindweed, and numerous species of gramminoids.

Common reed (*Phragmites australis*) – common reed is an aggressive invasive wetland plant that may dominate wetland communities. Other species present in this community include salt meadow cordgrass, salt marsh bulrush, and narrow-leaved cattail. Minor components of creeping bentgrass (*Agrostis stolonifera*), New York aster, marsh orach, spike grass, dwarf spike-rush, bushy knotweed (*Polygonum* ramosissimum), glasswort, alkali bulrush (*Scirpus maritimus*), and seaside goldenrod are also present interspersed within the *Phragmites* community. At the Cascade Brook site this community is found primarily along the wetland edges of upland habitats and along open water and channel edges, although some populations persist within the interior areas of smooth cordgrass habitat. As an undesirable, invasive species, the location of this species is uniquely identified on the Project area cover type map regardless of the amount of cover.

The three non-vegetated communities included on the 2008 cover type map include mudflat, open water, and sandbar. The culvert located at the downstream end of Cascade Brook in the eastern-most corner of the Project area, and Pine Point Road have been added to the 2008 cover type map.

2.2 ANNUAL SITE EVALUATION

Annual site evaluations were performed to assess site conditions and changes following restoration activities, including completion of a site assessment data form (Appendix B), vegetation monitoring (Appendix C), and photographic documentation of post-restoration site conditions (Appendix D). Pre-restoration site conditions were established during site evaluations conducted in 2002 and used as a basis for comparison with site conditions observed following restoration activities. Post-restoration site evaluations were performed in Year 1 through Year 5 post-restoration (i.e., 2004 through 2008) to assess site conditions. The annual site evaluation

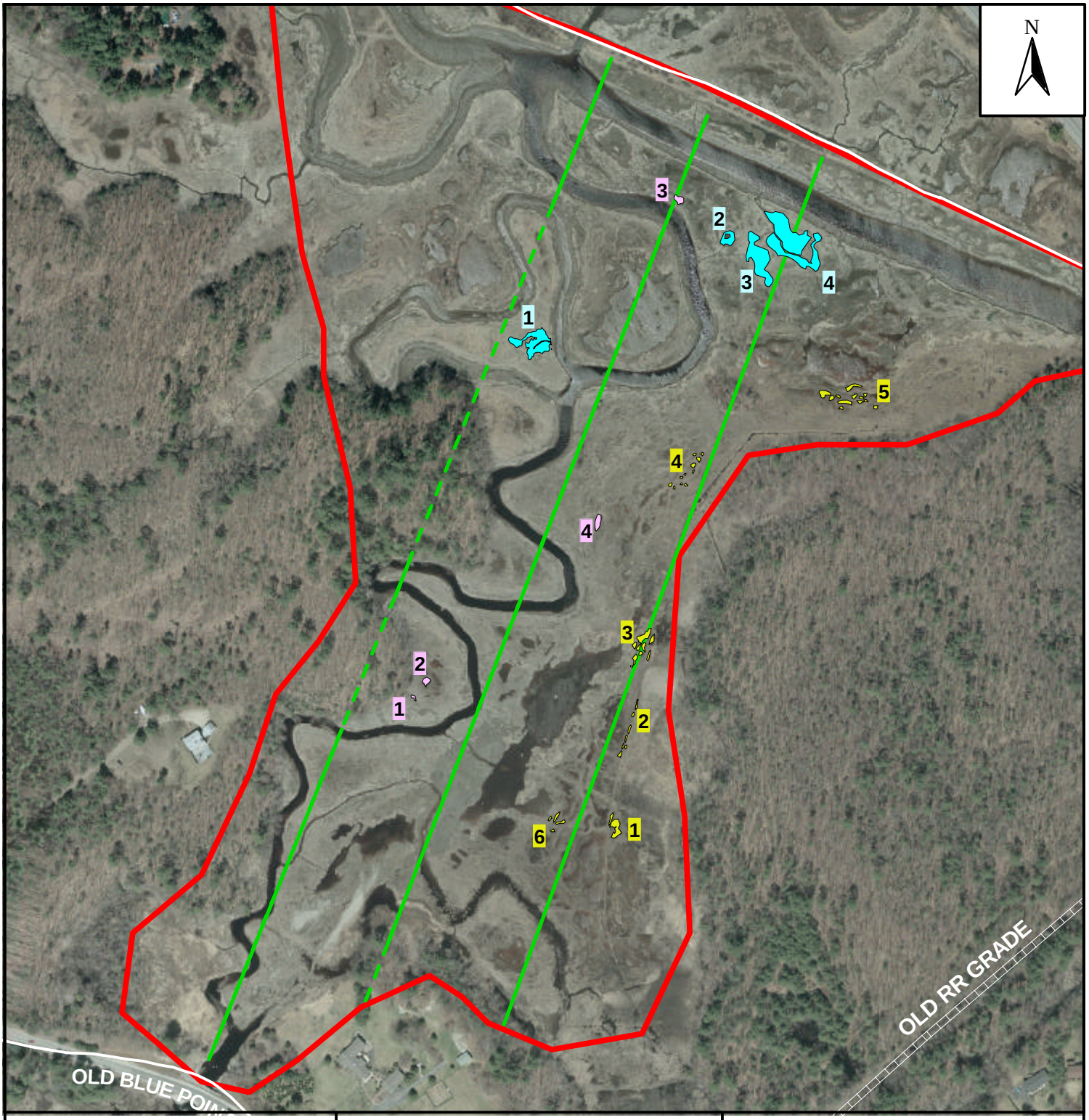
was based on the procedures presented in the *Monitoring Plan* (USFWS 2001), and modified according to specific site conditions.

2.2.1 Site Assessment

The site assessment was conducted on October 17, 2008, to qualitatively assess the overall post-restoration site conditions, 5 years after restoration. The assessment was conducted along three primary transects, spaced approximately 100 meters apart (Figure 2). The assessment included notation and/or observation of existing weather conditions and tidal cycle; condition of the Spoil Removal Area (SRA); condition of the altered tidal creek, natural pools and pannes; presence of undesirable and desirable species; presence of wildlife species; observation of recreational activities; and, evidence of site disturbance. See Appendix B for the completed site assessment form and the marked-up version of Figure 2.

The vegetative response in the SRA has been very positive. Desirable salt marsh species have repopulated the area and continue to thrive and increase in density 5 years after restoration was conducted. The species composition continues to evolve, and the low growing, mat-forming, early successional species, such as dwarf spike-rush have been replaced with alternative, native salt marsh grass species, such as spike grass, smooth cordgrass, salt marsh bulrush, and seaside goldenrod. *Phragmites* has been observed regrowing in several areas of the SRA, as noted on the site assessment in Appendix B. *Phragmites* coverage within the SRA has increased to approximately 25%, and it appears that populations have taken hold within areas that have a slightly higher elevation in comparison to areas dominated by native species, however, since a topographical survey was not conducted, this observation is subjective and not definitive. Notable increases in *Phragmites* coverage were observed in the southern end of the Project site, in the SRA located north of the main channel, and in the *Phragmites* control area located along the eastern boundary, and it is recommended that these areas be retreated and/or monitored for continued expansion or growth. Overall the SRA is predominately revegetated with desirable species that have become well established, and these restored areas are virtually indistinguishable from the undisturbed areas of the marsh.

Populations of cattail species are established within those areas depicted on the cover type map included in Appendix A. Aside from the significant expansion of the population of cattail within the southwest corner of the site, other cattail populations within the site do not appear to be increasing or decreasing in coverage. The restored channel areas are narrow (approximately 3 feet wide), contain a sandy substrate, and appear to be stable and are allowing unimpeded inflow of freshwater runoff. Channel banks appear to be stable and vegetated almost exclusively with smooth cordgrass. If vegetation continues to encroach within the channel area, this could become a potential concern in the future if encroachment and density of growth are great enough to impede water flow. Some of the natural pools observed during pre-restoration were reconnected to the main channel during restoration activities, and were observed to no longer retain significant volumes of water at low tide. As a result, channels are being carved into the mudflats of some of the former pools, and smooth cordgrass is becoming established in stands within the former pools. New pools have formed just north of water quality Station # 2. Pannes did hold some water at the time of the site assessment, which followed a spring high tide. These pannes appear to be stable, with typical species and conditions present.



Source: U.S. Fish & Wildlife Service Kodak Imagery Scarborough Marsh, April-May 2001.

200 0 200 400 Feet

LEGEND

- Project Area
- Poor Water Quality
- Insufficient Water Retained
- Mosquito Larvae Present or Expected
- Site Assessment Transect

Figure 2. Site Assessment Transect Locations for Cascade Brook Salt Marsh Restoration Monitoring Project Scarborough, Maine.

Client: U.S. Fish & Wildlife Service

Prepared By: NEA Northern Ecological Associates, Inc.

Date: 11/11/02

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2.2.2 Vegetation Monitoring

Year 5 post-restoration vegetation monitoring was conducted on September 22, 2007, to qualitatively characterize vegetation across the site using a variation of the Braun-Blanquet Relevé Method (Bonham 1989). The site was initially divided into five distinct plant associations: low marsh, high marsh, *Phragmites* control areas, spoil removal areas, and peat piles. As a result of restoration, the peat piles have been eliminated from the marsh surface; therefore this distinct group was no longer considered during vegetation monitoring. Within each plant association, a general reconnaissance was conducted to identify the plant species present in that community. A variable-sized quadrat was sampled at a representative location within each plant association; the quadrat was at least one square meter, and was increased in size until 90–95% of the plant species identified during the site reconnaissance were present in the quadrat. The species list and approximate percent cover were recorded for each plant association, and are included in Appendix C. A brief description of each of the four remaining plant associations is provided below.

Low Marsh – The low marsh community is limited in extent to areas that experience diurnal tidal flushing, particularly along the edges of tidal creeks and channels. The predominant cover in the low marsh community is smooth cordgrass. This community type has not changed substantially from pre-restoration, or Year 1, 2, 3 or 4 post-restoration monitoring.

High Marsh – The majority of the site is high marsh. Vegetated high marsh areas are interspersed with pools and pannes as topography changes across the marsh surface. The dominant species are salt meadow cordgrass, and smooth cordgrass. The vegetation monitoring focused on vegetated high marsh areas, and does not describe pool and panne communities. This community type has not changed substantially from pre-restoration or Year 1, 2, 3, or 4 post-restoration monitoring.

Phragmites Control Area – The *Phragmites* areas were treated with an herbicide and cut/mowed to create canopy openings for new growth. New and recurring growth was observed within the control areas, with this species representing the dominant cover class of 25–50% cover, particularly in *Phragmites* Control Site 4. Salt marsh bulrush and salt meadow cordgrass are also present in these areas at between 5 and 25% cover. It should be noted that this area had a higher occurrence of co-dominance in 2007, with marsh orach, and dwarf spike-rush declining in cover to the 1 to 5% cover class. The percent of bare ground also declined from the 5–25% cover class to the 1 to 5% cover class.

Spoil Removal Area (SRA) – The SRA has revegetated with a variety of native salt marsh species. This area exhibits a codominance by spike grass and smooth cordgrass, both of which were present in the 25 to 50% cover class. *Phragmites*, salt marsh bulrush, and seaside goldenrod are each present with 5 to 25% cover. Although the amount of *Phragmites* present in the SRA appears to have increased from 2007, the expansion was not great enough to move this species up to the next higher cover class category (i.e., class 3, 25–50%). The density and coverage of *Phragmites* should continue to be monitored to determine whether additional corrective action is necessary. Two large root masses populated with small stands of cattail species were observed to have washed onto the marsh near Blue Point Rd., likely during a storm

event that occurred during the late summer or fall. The debris line and vegetation caught within the reeds indicate that the stormwater was as high as 3.5 feet above the ground surface in the SRA near Blue Point Rd.

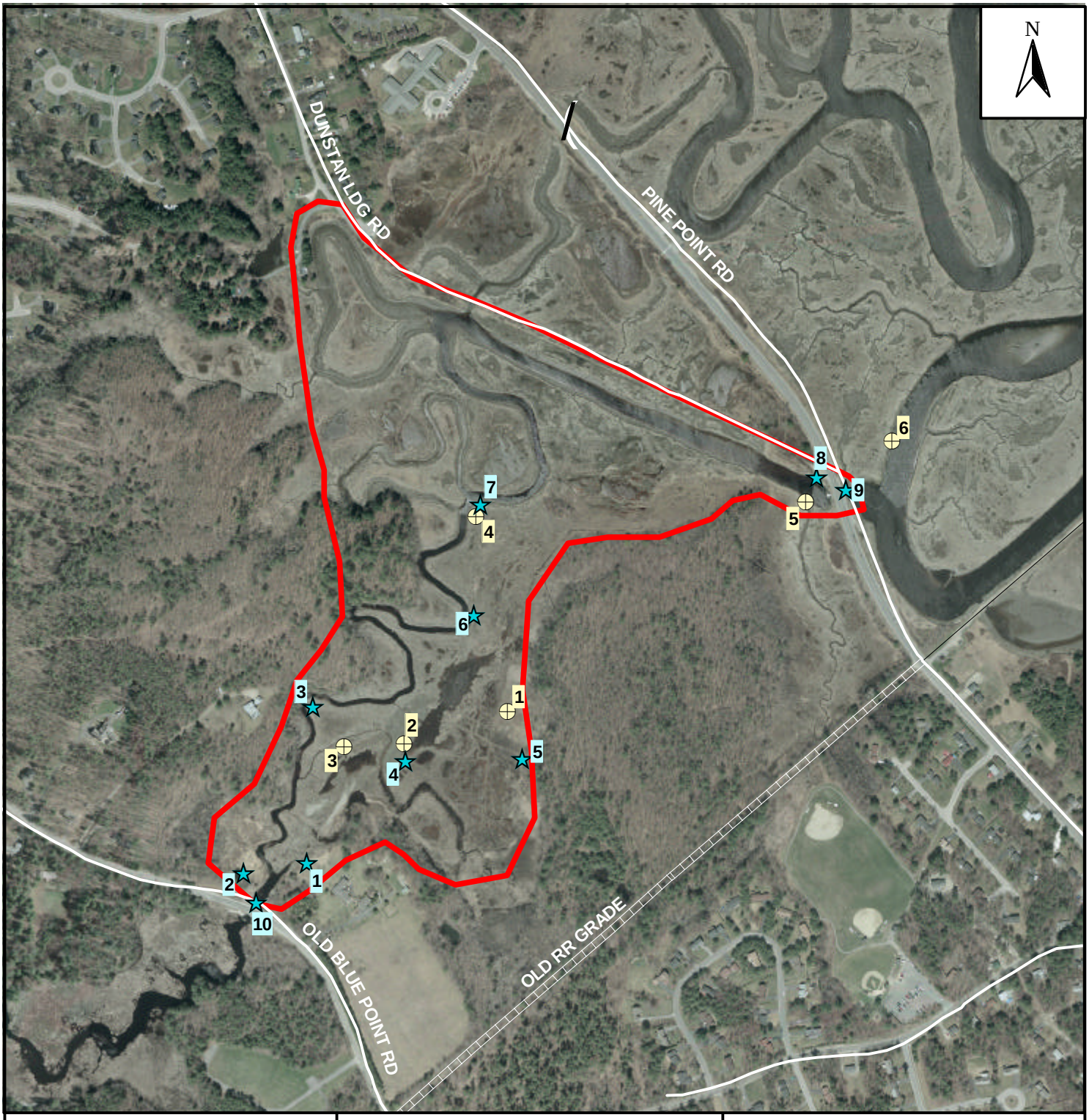
2.2.3 Photographic Documentation

Photographic stations were established to document pre-restoration marsh surface conditions and the location and size of existing undesirable communities (e.g., *Phragmites*) at the site. Panoramic photo series were taken during high and low neap tidal periods, at 10 locations across the site (Figure 3). Low tide and high tide photographs were taken on September 19, 2008 and September 22, 2008. Post-restoration monitoring photos were taken from approximately the same location as pre-restoration photos. The photographer noted the date, time, approximate compass direction of each photo, and a brief description of key features in the photograph. The Photo Station Photographic Records are presented in Appendix D.

When compared to pre-restoration photographs, the photos of the *Phragmites* control areas (i.e., Photo Stations #1A-C, 2A-E, 4A, 4E-F, 5A-D, and 10A-B) show that the homogenous *Phragmites* stands have been reduced significantly, however regrowth of *Phragmites* can be observed in some areas. Additionally, areas where *Phragmites* was excavated are repopulating with a combination of undesirable (i.e., *Phragmites*) and desirable salt marsh species. Photos of the SRA (i.e., Photo Stations #4B-D, 6E-G, and 10A-B) continue to show that the marsh is revegetating following the removal of the spoil material deposited following the road and culvert failure.

2.3 WATER LEVEL SAMPLING

Tidal signal (i.e., surface water depth) and groundwater level were assessed to determine the depth of flooding and duration of inundation of the marsh surface during the tidal cycle. Tidal signal and groundwater level were measured simultaneously using Global Water Model WL15 pressure transducer/data loggers (Global Water Instrumentation, Inc. 2001). To determine water level depth and duration of inundation on the marsh surface data were recorded at five minute intervals at each station for the six week period of August 7, 2008 through September 22, 2008, to record data within a full lunar cycle of two spring and two neap tides. One data gap is present within the collected data for Station 1, when no data was recorded due to battery failure for the 10-day period of August 19, 2008 through August 29, 2008. Figures summarizing the water level data are presented in Appendix E, and water monitoring station locations are shown on Figure 3.



Source: U.S. Fish & Wildlife Service Kodak Imagery Scarborough Marsh, April-May 2001.

400 0 400 Feet

LEGEND

- Project Area
- Water Monitoring Station
- Photo Station

Figure 3. Photographic and Sampling Station Locations for Cascade Brook Salt Marsh Restoration Monitoring Project Scarborough, Maine.

Client: U.S. Fish & Wildlife Service

Prepared By: NEA Northern Ecological Associates, Inc.

Date: 11/11/02

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2.3.1 Water Quality

Water quality sampling (i.e., dissolved oxygen, temperature, and salinity) was collected during six site visits, beginning August 12, 2008 through September 22, 2008 to correspond as much as possible with sampling data collected during pre-restoration monitoring. Water quality data collected from Stations 1, 2, 3, and 4 are presented in Appendix E, and water monitoring station locations are shown on Figure 3.

As with pre-restoration and Year 1 and Year 3 post-restoration monitoring water quality data, Year 5 post-restoration monitoring data for dissolved oxygen and salinity was highly variable between sites and sample events. No consistent patterns have been identified between pre and post-restoration water quality data. However, dissolved oxygen, salinity, and temperatures, remain within expected ranges for salt marsh communities.

2.4 ADDITIONAL PROJECT INFORMATION

A copy of all field notes collected during field sampling activities is provided in Appendix F. In addition, Appendix G contains a list of species observed during field sampling activities.

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3.0 RESULTS AND DISCUSSION

The final post-restoration monitoring was performed from August through October 2008, 5 years after restoration activities were completed in 2003. Restoration activities included: removal of spoil material and peat piles deposited on the marsh when the Old Blue Point Road and culvert failed in a 1996 flood; lowering of the 16-foot wide section of the water control structure located upstream of the Pine Point Road culvert; removal of the first berm located upstream of the water control structures, and cutting of a 25-foot wide channel in the second berm; and, control of *Phragmites* in four distinct areas of the marsh via the application of herbicide. Evaluation of the salt marsh response to restoration activities included completion of a site assessment, vegetation monitoring, photographic documentation of site conditions, as well as collection of groundwater level, and water quality data. This section provides a discussion of the Year 5 monitoring results in the context of the 6 years of monitoring data collected.

3.1 COVER TYPE MAP

The dominant vegetated and non-vegetated cover types or features identified in the Project area during pre-restoration monitoring included an emergent salt marsh community primarily composed of *Spartina patens* and *S. alterniflora*; open water areas, including pools and tidal channel; upland communities; and wetland *Phragmites* communities. The Year 5 post-restoration cover type mapping revealed minor changes in almost all cover types, and included the differentiation of one additional cover type: mixed salt marsh species (Appendix A). The culvert that extends under Pine Point Road, and the portion of Pine Point Road located within the boundaries of the eastern-most portion of the Project site were also added to the Year 5 post-restoration cover type map.

Substantial changes observed between the pre-restoration and post-restoration cover types, defined as a change of 1.0% or greater, were observed for five community types (Table 1). The greatest change was observed as a decrease in *Phragmites* coverage (-3.1%), which was reduced from 5.7% to 2.6% of the total area. Other substantial changes include an increase in *S. alterniflora* coverage (+2.8%), decrease in the coverage of *S. patens/S. alterniflora* (-2.7%), decrease in cover of open water areas (-1.5%), and increase in coverage of *Typha* species (+1.4%). Mixed salt marsh species, which was not included in the cover type communities described during pre-restoration monitoring, comprises 2.3% of the Project area as identified during the Year 5 post-restoration monitoring. The overall decrease in non-vegetated communities (-0.8%) was balanced by an increase in vegetated communities (+0.8%), resulting from restoration activities. Additional changes of less than 1.00% were observed in several other community types.

The changes observed in the aerial coverage of the community types support the observations that the extent and duration of inundation on the marsh surface has increased due to restoration activities. In areas where these hydrologic regime changes have occurred, the species composition has transitioned in response to these changes. In areas previously dominated by *Phragmites*, the predominant species composition comprises mixed salt marsh species, including a mixture of smooth cordgrass, salt meadow cordgrass, salt marsh bulrush, algal mats, spike

grass, narrow-leaved cattail, *Phragmites*, and goldenrod species. This is especially true for the area located along the wetland/upland transition zone located along the eastern project boundary. For control areas located within the southwestern portion of the Project area, cattail species dominate the areas previously dominated by *Phragmites*. It appears that some regrowth and expansion of *Phragmites* has occurred within the four control areas during the past 6 years of monitoring. However, the establishment and vigorous growth of native salt marsh species, including salt meadow cordgrass and salt marsh bulrush, have limited the expansion rate and dominance of *Phragmites* stands that were present during pre-restoration conditions. The increased extent and duration of flooding resulting from restoration activities may contribute to limiting the expansion rate of *Phragmites* within the salt marsh. Observations made during post-restoration suggest that the primary areas of *Phragmites* regrowth and expansion may be associated with areas of the marsh that have a slightly higher elevation, however, without a topographic survey, this observation is not definitive.

Increased occurrence of *S. alterniflora* is noted in much of the Project area, as noted on the 2008 cover type map, which may be a result of the hydrologic changes from restoration activities that have created conditions that are more conducive to the growth of *S. alterniflora*, which is more tolerant of wet conditions than *S. patens*. Additionally, although not large enough to be classified as a unique cover type, small areas dominated by golden rod (*Solidago* spp.) are present within the wetland/upland transition zone located along the eastern edge of the Project boundary. Goldenrod species and a variety of miscellaneous herbs are often found in irregularly flooded areas of salt marshes.

The reduction in the percentage of open water areas that is primarily associated with a replacement of pool habitat with vegetated communities, are balanced by the increase in aerial coverage of *S. alterniflora*, as well as an increase in the aerial coverage of mudflat observed during the Year 5 post-restoration monitoring. This is especially true for the large centrally-located open water pool that was present during pre-restoration monitoring, which now drains to reveal mudflat and *S. alterniflora* cover types at low tide (Appendix A). The restoration activities that were conducted in this area of the marsh, including reconnection of the pond with the tidal channel, have resulted in draining of the pond with the receding tides. As a result, the drying out periods have allowed establishment of salt marsh species, which have resulted in a cover type change of pool habitat from non-vegetated to vegetated.

Table 1. Approximate Percent Area Change of Community Types at the Cascade Brook Salt Marsh – Pre-Restoration Compared to Year 5 Post-Restoration Monitoring.

Community Type	Pre-Restoration (percent)	Post-Restoration (percent)	Change (percent)
Non-Vegetated			
Open Water (Pools and Tidal Channel)	16.7	15.2	-1.5
Mudflat, Sandbar, and Bare Ground	5.1	5.4	+0.3
Road and Culvert	0.0	0.4	+0.4
Total	**21.8**	**21.0**	**-0.8**
Vegetated			
Scirpus robustus	0.2	0.5	+0.3
Scirpus validus	0.0	0.1	+0.1
Spartina alterniflora	0.1	2.9	+2.8
*Spartina pectinata**	0.6	0.4	-0.2
Spartina patens/Spartina alterniflora	51.8	49.1	-2.7
Mixed salt marsh species	0.0	2.3	+2.3
Typha species	2.4	3.8	+1.4
Phragmites australis	5.7	2.6	-3.1
Upland	16.7	16.7	+0.0
Wetland Forest	0.5	0.5	+0.0
Peat Piles	0.2	0.0	-0.2
Total	**78.2**	**79.0**	**+0.8**
Total of All Cover Types	**100.0**	**100.0**	**n/a**

3.2 ANNUAL SITE EVALUATION

Site evaluations were used to subjectively compare observations of pre-restoration conditions with subsequent post-restoration conditions on the marsh surface. Site evaluations were documented in the form of a site assessment, vegetation monitoring, and photographic documentation.

3.2.1 Site Assessment

Site assessment observations, comparing pre-restoration and post-restoration conditions are summarized below.

- Based on visual observations, recovery of the SRA 5 years post-restoration is excellent. Predominantly mono-typic stands of *Phragmites* present pre-restoration have been replaced with more diverse cover types including mixed salt marsh species, *S. alterniflora*, soft stemmed bulrush, *S. patens/S. alterniflora* and *Typha* communities. Although *Phragmites* coverage immediately following restoration was minor and native species revegetating the

majority of the SRA, *Phragmites* coverage has increased within the SRA to less than 25% coverage. Existing native communities appear healthy and vigorous.

- Blocked channels that impeded water movement and dammed freshwater runoff pre-restoration have been restored, and appear stable, allowing freshwater runoff to flow unimpeded. Channel banks are vegetated with *S. alterniflora* almost exclusively. Encroachment of vegetation into the channel is identified as a concern, as this could result in impeded flows.
- Some of the natural pools noted during pre-restoration monitoring, no longer retain significant amounts of water at low tide. Reconnection of the channel leading to the main channel now drains the pools at low tide (see Site Assessment Figure, Appendix B), and this has resulted in carving of channels into the mudflat, and allowed growth and establishment of *S. alterniflora* in stands within former pools. New pools seem to have formed just north of Water Sampling Station 2, between it and the connector to the main channel. Some formerly natural pools are becoming vegetated and/or mudflat at low tide.
- Pannes appear to be stable, with typical conditions and species present. No major changes in pannes were noted from pre-restoration to 5 years post-restoration.
- *Phragmites* and *Typha* species are present on the site. Coverage of *Phragmites* has decreased overall on the site when compared to pre-restoration conditions; however, the aerial coverage of *Phragmites* has increased in the southern end of the Project area, in the SRA north of the main channel, and in the *Phragmites* control area along the eastern boundary of the site, compared to conditions immediately following restoration activities. *Typha* is present, and coverage increased following restoration activities in the *Phragmites* control area located at the southern end of the site when compared to pre-restoration conditions. However, the extent of *Typha* appears to have stabilized and is not clearly increasing or decreasing in coverage.
- Desirable species appear healthy and vigorous. The *Phragmites* control areas along the eastern boundary have revegetated with a combination of desirable and invasive species. The SRA is predominantly revegetated with desirable species, which have become well established and are in virtually indistinguishable from the areas adjacent to the SRA.

3.2.2 Vegetation Monitoring

Vegetation monitoring was conducted within four areas of the marsh, including: *Phragmites* control areas, SRAs, Low Marsh, and High Marsh Results of vegetation monitoring are included in Appendix C.

Low Marsh – Pre-restoration conditions of the vegetative community in the low marsh areas of the Project were dominated by smooth cordgrass (50–75%), with marsh orach, bare ground, and litter present at 5–25% cover. In Year 1 post-restoration, the dominance by smooth cordgrass had increased to 75–100% cover, with litter being the only community type included in the 5–25% cover class. For all remaining years of post-restoration monitoring (Year 2, Year 3, Year 4, and Year 5) smooth cordgrass remained as the dominant cover type at 75–100% cover, with salt meadow grass comprising the 5–25% cover class. Overall the low marsh was predominantly populated with smooth cordgrass, with minor changes to the secondary cover types observed in the first three years of the monitoring period. Over the last four years of monitoring, the vegetation within the low marsh areas of the Project has remained stable.

High Marsh – The high marsh was dominated by salt meadow cordgrass (25–50% cover) during the pre-restoration vegetation monitoring event, with smooth cordgrass and litter making up 5–25% of the cover. For Year 1 post-restoration, both vegetation types had increased one cover class, with salt meadow cordgrass representing 50–75% of the cover, and smooth cordgrass representing 25–50% of the cover. Litter remained 5–25% of the cover within the high marsh areas during Year 1 post-restoration. For Year 2 post-restoration salt meadow cordgrass again increased in cover class, representing 75–100% of the cover, with smooth cordgrass only making up 5–25% of the cover. During Year 3, Year 4 and Year 5 post-restoration the cover classes for salt meadow cordgrass and smooth cordgrass were similar to that observed during the Year 1 post-restoration monitoring, with spike grass included in the 5–25% cover class for Year 3 post-restoration results. Overall the high marsh community composition has consistently been dominated by salt meadow cordgrass and smooth cordgrass throughout the entire 6 year monitoring period, with minor changes in secondary cover class types observed.

Phragmites Control Area – During pre-restoration monitoring, the *Phragmites* control areas comprised essentially monotypic stands *of Phragmites* (50–75% cover), with *Phragmites* litter constituting the remaining ground cover (25–50% cover). Restoration activities conducted in 2003 removed large stands of *Phragmites* within the control areas, and the percent cover of *Phragmites* observed during Year 1 and Year 2 post-restoration was reduced to 5–25%. *Phragmites* litter comprised 75–100% of the *Phragmites* control areas during Year 1 and Year 2 post-restoration, particularly in the area along the eastern boundary of the site, with marsh orach covering 5–25% of the area. In Year 3 post-restoration, *Phragmites* coverage had increased to 25–50%, with litter still comprising 25–50% of the coverage area. Marsh orach, salt marsh bulrush, narrow-leaved cattail, and bare ground each represented 5–25% of the *Phragmites* control areas during Year 3 post-restoration. The coverage observed in Year 4 post-restoration was similar to the composition observed in Year 3 post-restoration, with the addition of spike grass, and dwarf spike-rush within the 5–25% cover class. For Year 5 post-restoration, *Phragmites* remained the dominant cover class, comprising 25–50% cover within the control areas. Dwarf spike-rush, and marsh orach decreased to the 1–5% cover class, with narrow-leaved cattail, salt marsh bulrush, and bare ground remaining within the 5–25% cover class.

These results indicate that *Phragmites* regrowth has occurred within the control areas overall; however, it appears that the establishment of native salt marsh species within the control areas, in addition to the hydrologic changes to the system, have slowed the regrowth and expansion of *Phragmites*, and may result in less *Phragmites* coverage and more diverse stands than existed pre-restoration. Additional monitoring of these sites would determine if the regrowth and expansion of *Phragmites* within the control areas is substantial enough to require additional herbicide treatment or removal to control further spread of *Phragmites* in the Project area.

Spoil Removal Area – The vegetative composition of the SRA has changed substantially since restoration activities removed spoil and peat piles, exposing the historic marsh surface, and increased hydrologic connectivity with the main tidal channel. The dominant vegetation type present during pre-restoration monitoring was creeping bentgrass (*Agrostis alba*), which made up 25–50% of the cover type within the SRA. Black grass (*Juncus gerardii*), *Phragmites*, seaside goldenrod (*Solidago sempervirens*), bare ground, purple loosestrife (*Lythrum salicaria*), and

pool/panne communities each comprised 5–25% of the pre-restoration SRA. After restoration activities were completed, the dominant vegetation observed in Year 1 post-restoration monitoring was dwarf spike-rush and soft-stemmed bulrush, both which represented 25–50% of the cover, with common three-square (*Scirpus pungens*) and pool/panne habitat covering 5–25% of the SRA. During Year 2 post-restoration dwarf spike-rush had increased to the 50–75% cover, with spike grass, salt marsh bulrush, soft-stemmed bulrush, smooth cordgrass, and pool/panne covering 5–25% of the SRA. In Year 3 post-restoration, a co-dominance of dwarf spike-rush, and salt marsh bulrush was observed (25–50% cover), followed by spike grass, common reed, soft-stemmed bulrush, smooth cordgrass, and pool/panne (5–25% cover). The Year 4 post-restoration results were similar to what was observed during Year 3 post-restoration, with the exception of spike grass, which increased two cover classes to 50–75% cover, and dwarf spike-rush, which decreased three cover classes to only a trace level of occurrence (<1%). A co-dominance of spike grass, and smooth cordgrass was present in Year 5 post-restoration, with each of these species making up 25–50% of the cover class. *Phragmites*, salt marsh bulrush, seaside goldenrod, and pool/panne communities all represented 5–25% of the cover within the SRA at Year 5 post-restoration.

The vegetative community structure within the SRA changed substantially after the restoration activities were completed. The removal of spoil and peat piles from the SRA, alteration of the downstream water control structures, and restoration of the tidal channel connecting the large pool area located adjacent to the SRA to the main tidal channel, have resulted in a change in community structure that was dominated by creeping bentgrass in pre-restoration conditions, to a more diverse community comprised primarily of native salt marsh species. Although *Phragmites* has repopulated some areas of the SRA (5–25% cover), overall the vegetative community within the SRA is more representative of a native salt marsh system than during pre-restoration conditions.

3.2.3 Photographic Documentation

Panoramic photo series were taken from 10 fixed photo stations each year, during an average neap low and neap high tide. The Photo Station Photographic Record taken to identify site conditions is presented in Appendix D. Based on comparisons of photographs from previous years monitoring activities, the marsh appears to be retaining more water on the marsh surface than during pre-restoration surveys. Additionally, the restoration of the hydrologic –connection between the large pool located in the center of the Project area and the main tidal channel, allows the former pool area to be flooded during high tide and drained during low tide conditions. This effect can be observed in the series of photographs taken from Photo Station #4 during low and high tide, and also shows the transition from pool habitat to a vegetated community in this area, due to reduced water ponding and lowered water levels during low tide conditions. Photographs associated with Photo Station #1, 2, 4, 5, 6 and 10 show the substantial decrease in *Phragmites* after restoration activities were completed.

- Photo Station #4: As a result of restoration activities that improved the hydrologic connectivity of the large pool located northeast of the SRA with the main tidal channel, the marsh in the vicinity of Photo Station #4 appears to be retaining less water at low tide, and more water at high tide. The reduced water ponding and lowered water levels that

occur during low tide have allowed native salt marsh species to become established in the former pool, and mudflat to be exposed during low tide. See high and low tide photographs for Photo Station #4, 4A through 4F.

- Photo Station #1, 2, 4, 5, 6, and 10: The marsh in the vicinity of Photo Stations 1, 2, 4, 5, 6, and 10 have changed dramatically from pre-restoration conditions as a direct result of herbicide treatment and removal of the large stands of *Phragmites.* Native salt marsh species have revegetated the *Phragmites* control areas, although small areas of *Phragmites* regrowth can be seen in the photographs. See low tide photograph for Photo Station #1, 1A; #2, 2C; #4, 4A and 4B; #5, 5A–5D; #6, 6D–6F; and #10, 10A and 10B.
- Photo Station #3, 7, 8, and 9: The differences in marsh surface conditions pre-restoration compared to post-restoration are not dramatic at these sites.

3.3 WATER LEVEL SAMPLING

Water level data were collected pre-restoration, and during Years 1, 3, and 5 post-restoration, to determine flooding depth and duration at the marsh surface, and evaluate the changes in water levels that may be attributed to restoration activities. Data collected at the Water Sampling Stations during pre- and post-restoration monitoring activities appear to indicate an increase in flooding depths and duration at two of the four monitoring stations, show an increase in magnitude of water level change at one of the monitoring stations, and show a decrease in water level at one of the monitoring stations (Appendix E). A major spike in water levels was recorded at Stations 1, 2, and 3 on September 7, 2008, which was likely associated with a storm surge

The overall trend of water level data for the three years of post-restoration data compared to pre-restoration, indicate an increase in both surface and ground water levels at Station 1 throughout the tidal cycle (Appendix E). Station 1 is located within the *Phragmites* control area along the eastern boundary of the Project area. The data for Station 1 indicate that more water is reaching this area of the marsh area post-restoration, with surface water levels that appear to be elevated during high tide events and groundwater levels that appear to be elevated throughout the duration of the tidal cycle when compared to pre-restoration conditions. This is especially clear during the neap tide portion of the tidal cycle when groundwater levels dropped substantially during pre-restoration monitoring.

Water level data at Station 2 suggest that the magnitude of water level change between high and low tides has increased at this station, as result of the changes in hydrologic conditions during the tidal cycle in the former pool located adjacent to the station (Appendix E). The reconnection of the channel connecting the former pool and the main tidal channel allows the former pool to drain during low tide, and appears to be resulting in higher high tide levels and lower low tide groundwater levels at this station, in comparison to the level of tidal change observed at this station during pre-restoration monitoring. It appears that changes in the hydrologic connection of the adjacent former pool to the main channel that have resulted in lowering of the groundwater levels between high tides, increasing the magnitude of the tides at this station. Groundwater levels appear to be lowest during the Year 5 monitoring period, however, high tide levels appear to be similar or higher post-restoration as compared with pre-restoration. Drainage of the former pool appears to be having a substantial effect of lowering groundwater levels at this station.

Data collected at Station 3 does not reveal a substantial change in groundwater levels between pre-restoration and post-restoration conditions. However, there appears to be a slight increase in groundwater level throughout the tidal cycle, and a slight increase in surface water levels at high tide post-restoration compared to pre-restoration conditions (Appendix E).

Station 4 represents the station located the furthest distance from the spoil removal and *Phragmites* control activities, and closest to the downstream water control structure. Similar to Station 3 it is difficult to determine the overall trend in water levels at Station 4 when comparing pre-restoration data to post-restoration data. It appears that groundwater level data collected during pre-restoration was the highest, Year 1 post-restoration was the lowest, and for Years 3 and 5groundwater levels were generally in between at this station (Appendix E). These results are difficult to explain; it is possible that the downstream changes to the water control structure are influencing the water levels at this station, or that the water monitoring structure itself has shifted, changing the elevation relative to the ground surface. The area around the water monitoring structure is very soft and mucky.

Water level data were collected at Station #5 and Station #6 during the pre-restoration and Year 1 post-restoration monitoring events only (Appendix E). These sites were added after Project initiation to evaluate the effects of the proposed changes to the water control structure and underwater berms located at the downstream end of Cascade Brook; because they were not part of the original scope of the Project, they were not continued after the first year of post-restoration monitoring. Following restoration activities, an increase in the magnitude of change in water levels between high and low tide was observed at Station #5. At Station #6 an increase in the water levels during high tide was observed Year 1 post-restoration compared to pre-restoration. These observations appear to indicate that changes to the water control structure are allowing additional water movement during both the incoming and outgoing tides, following restoration, resulting in higher high tide and lower low tide conditions upstream of the culvert post-restoration compared to pre-restoration.

The array of water level change from pre-restoration to post-restoration when comparing station to station reflects the response of the marsh in different areas, and zones of influence. Year to year, and month to month variability in the magnitude of the tides (i.e., how high the high tides are and how low the low tides are), and from the influences of evapotranspiration, precipitation, and storm surges, also affected groundwater levels during the monitoring periods. The station locations were selected to try to capture the effects of restoration activities at four distinct locations on the marsh; the microtopographic differences between sites may not be apparent when establishing the stations, and may result in slight differences in the expression of tidal signal at one location compared to another. Additionally, an attempt is made to collect water level monitoring data during similar tidal conditions between monitoring years; however this is not always possible, and may contribute to some of the variability in the data from year to year.

Overall, the water level data appear to indicate the desired responses to restoration activities resulting in increased duration and extent of flooding in many areas of the marsh following restoration activities, with some year to year and station to station variability depending on station location and tidal conditions. The changes to the hydrologic conditions are not clearly understood at all stations; however the overall hydrologic changes appear to be positive.

3.4 WATER QUALITY

Water quality data were collected to evaluate whether restoration activities resulted in a change in water quality at a gross level. Recognizing that water quality data can be highly variable, especially when few samples are collected, these data were collected primarily to determine whether water quality was within a suitable range for establishment and survival of nekton and desirable salt marsh vegetation, and to ensure that water quality remained within a suitable range following restoration activities.

Water quality data were collected on six separate field visits, pre-restoration, and during Years 1, 3, and 5 post-restoration, at all four monitoring stations. Although water quality data vary greatly between site locations and sampling events, recorded levels of dissolved oxygen, salinity, and temperatures remain within ranges suitable for nekton and salt marsh vegetation development and survival. These data are discussed in more detail in the sections below. Water quality data collected during Year 5 post-restoration monitoring were pooled and presented in figures, included in Appendix E and in Table 3 below.

3.4.1 Dissolved Oxygen

Table 3 presents the dissolved oxygen data collected during all years of the study. Minimum, maximum, and mean dissolved oxygen levels, are presented for pre-restoration, and Years 1, 3, and 5 post-restoration. Data for Year 5 post-restoration are also presented in more detail in figure format in Appendix E.

For the Year 5 post-restoration monitoring event dissolved oxygen levels were measured as both percent saturation and milligrams of oxygen per liter (mg/L) in the 18-inch and 6-inch monitoring wells and in the adjacent pools at each station. Pre-restoration and previous post-restoration monitoring events measured dissolved oxygen as percent saturation only. Mean dissolved oxygen levels measured as mg/L were very low at the 6-inch and 18-inch at all stations during the Year 5 post-restoration monitoring event, ranging from 0.08 mg/L (Station 4, 18-inch well) to 1.53 mg/L (Station 2, 6-inch well). The dissolved oxygen levels (mg/L) at the pool locations during Year 5 post-restoration were slightly higher, ranging from 1.22 mg/L (Station 1) to 7.65 mg/L (Station 2).

A comparison of the mean percent saturation levels of dissolved oxygen observed during pre- and post-restoration monitoring events show similar variability at each station and sampling locations, with much higher percent saturation levels observed in the pools. However, overall the range at each station tended to be lowest during pre-restoration and highest during the Year 1 post-restoration. For the three years of data collected at Station 5 and Station 6, the mean percent saturation levels of dissolved oxygen was much higher in comparison to the results observed for Stations 1–4. Water quality sampling data were collected in the channel for Stations 5 and 6, as opposed to in the pore water wells for Stations 1–4. At Station 5 percent saturation of dissolved oxygen ranged from 39.62–80.29%, and at Station 6 ranged from 57.16–75.08%. No pool data was collected for Station 5 or 6.

Fish and aquatic organisms, and virtually all algae and macrophytes (i.e., salt marsh vegetation), require varying amounts of dissolved oxygen to survive. Generally, levels of 5 mg/L are optimal for fish, although many fish species can survive for short periods at levels below 3 mg/L (WOW 2003). Mummichog, for example, requires low dissolved oxygen levels for hatching stimulus for their eggs (USFWS 1985). The relationship between the concentration of oxygen in mg/L and percent saturation is dependant on the temperature of the water. As temperature increases, the concentration of oxygen that water can hold decreases, therefore lower temperature water can potentially hold more dissolved oxygen then higher temperature water. At a temperature of 18^{o}C, 5 mg/L would be approximately 50% saturated, and 3 mg/L would be approximately 30% saturated (WOW 2003).

Based on this information, dissolved oxygen concentrations in the pools adjacent to monitoring stations were generally within the acceptable survival range for fish and aquatic organisms. Dissolved oxygen concentrations were much lower in water monitoring wells in comparison to pools, most likely as a result of oxidation-reduction (redox) reactions in the soils due to the flooded conditions. Comparable salt marsh studies have shown that similar variations in dissolved oxygen concentrations can occur daily and seasonally, with extreme fluctuations occurring diurnally in the late summer months (Portnoy 1991, Smith and Able 2003). In summary, post-restoration dissolved oxygen levels within the water monitoring wells were acceptable for growth and maintenance of salt marsh vegetation and pool dissolved oxygen levels were acceptable for fish and aquatic organism survival.

3.4.2 Salinity

Salinity levels were recorded in the 18-inch and 6-inch monitoring wells and in pools adjacent to wells at each station, and Table 3 presents the minimum, maximum, and mean salinity levels, measured in parts per trillion (ppt), for pre-restoration, and Years 1, 3, and 5 post-restoration monitoring events. Data for Year 5 post-restoration are also presented in more detail in figure format in Appendix E.

Mean salinity levels were variable among all stations and years of the study, ranging from a mean low of 7.95 ppt observed at Station 1 for pre-restoration, to a mean high of 26.19 ppt observed for the 6-inch well of Station 4 for Year 3 post-restoration (Table 3). Generally, the mean salinity was lowest at Station 1 and Station 3, and highest at Station 2 and Station 4 for all years of monitoring. For pools, mean salinity ranged from 7.56 ppt at Station 3 for Year 5 post-restoration to 27.64 ppt at Station 2 for Year 1 post-restoration. Mean salinity data for Station 5 and Station 6 during pre-restoration and Year 1 and Year 3 post-restoration monitoring was between 12.87 ppt and 25.31 ppt.

The station to station and year to year variability was likely influenced by local precipitation levels, with larger storm events resulting in lower average salinity levels, as well as the influence of recent tides. Overall the range in salinity levels observed for the study were within the normal range expected, and were well within the acceptable range necessary for survival of desirable species of nekton and salt marsh vegetation.

3.4.3 Temperature

Temperatures were recorded in the 18-inch and 6-inch monitoring wells and in pools adjacent to wells at each station, and Table 3 presents the minimum, maximum, and mean temperatures, measured in degrees Celsius (^{o}C), collected for pre-restoration, and Years 1, 3, and 5 post-restoration. Data for Year 5 post-restoration are also presented in more detail in figure format in Appendix E.

Temperature levels were variable for all years of the study and were generally higher in the pools. Mean temperature ranged from 13.06 ^{o}C for Year 1 post-restoration at Station 1, to 25.42 ^{o}C for pre-restoration at the Station 4 pool. For Station 5 and Station 6, mean water temperature ranged from 12.89 C for Year 1 post-restoration (Station 5) to 19.73 C for Year 3 post-restoration (Station 5). Water temperatures are expected to vary during the day, depending on the surrounding air and ground temperatures. Peak spawning for fish (i.e., mummichogs) typically found in salt marsh pools typically occurs in May and June, whereas fish are less active during the fall or winter months and tend to burrow into the mud until springtime (USFWS 1985, Smith and Able 2003). Despite noted temperature variability, all of the pre- and post-restoration temperatures were within an acceptable range for fish survival during the period of sampling.

Table 3-1. Mean Water Quality, Salinity and Ground Water Data Collected at Water Quality Station 1 at the Cascade Brook Salt Marsh.

Parameters	Pre-Restoration			Year 1 Post-Restoration			Year 3 Post-Restoration			Year 5 Post-Restoration		
Dissolved Oxygen (% saturation)												
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
18”	1.81	0.50	2.33	5.36	1.50	20.93	2.26	1.00	4.53	1.86	0.33	5.00
6”	4.01	0.37	17.03	2.16	1.23	3.90	3.09	0.93	10.50	1.31	0.43	2.03
Pool	20.01	0.63	49.67	50.05	19.70	99.10	40.61	7.63	116.03	14.22	1.33	26.43
Dissolved Oxygen (mg/L)												
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
18”	NR	NR	NR	NR	NR	NR	NR	NR	NR	0.17	0.03	0.43
6”	NR	NR	NR	NR	NR	NR	NR	NR	NR	0.12	0.04	0.20
Pool	NR	NR	NR	NR	NR	NR	NR	NR	NR	1.22	0.14	2.22
Salinity (ppt)												
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
18”	7.95	5.30	12.20	12.38	12.00	12.70	9.05	7.53	11.07	9.96	9.60	10.73
6”	11.49	4.17	17.90	14.98	13.10	20.80	13.41	10.47	16.83	8.07	7.43	8.93
Pool	26.21	15.83	31.70	11.87	10.17	12.90	14.46	6.13	24.57	8.85	6.33	10.87
Temperature (C)												
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
18”	17.03	16.00	18.10	13.06	11.60	14.70	16.22	11.60	18.60	15.93	14.73	16.97
6”	17.77	17.00	19.17	13.15	11.63	15.40	17.19	16.27	17.70	16.48	14.43	18.20
Pool	26.29	19.30	35.57	17.31	9.93	19.50	22.39	16.90	29.23	19.38	14.20	22.37
Pool Depth (inches)												
Pool	NR	NR	NR	NR	NR	NR	NR	NR	NR	2.75	2.00	3.50

Source: USFWS 2002, 2004, and 2006. NR = Not Recorded

Table 3-2. Mean Water Quality, Salinity and Ground Water Data Collected at Water Quality Station 2 at the Cascade Brook Salt Marsh.

Parameters	Pre-Restoration			Year 1 Post-Restoration			Year 3 Post-Restoration			Year 5 Post-Restoration		
Dissolved Oxygen (% saturation)												
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
18”	0.69	0.37	1.07	5.79	1.20	17.30	1.53	0.90	2.60	1.66	0.63	3.53
6”	0.62	0.37	0.90	31.16	4.43	68.10	7.61	1.17	25.47	18.54	3.67	52.33
Pool	31.05	3.17	110.63	76.03	6.27	142.47	76.48	8.03	176.60	93.77	55.83	113.23
Dissolved Oxygen (mg/L)												
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
18”	NR	NR	NR	NR	NR	NR	NR	NR	NR	0.15	0.05	0.31
6”	NR	NR	NR	NR	NR	NR	NR	NR	NR	1.53	0.29	4.23
Pool	NR	NR	NR	NR	NR	NR	NR	NR	NR	7.65	5.28	8.99
Salinity (ppt)												
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
18”	19.03	16.53	22.80	23.39	21.30	25.63	21.10	19.27	21.90	15.86	14.17	20.57
6”	18.68	0.10	27.93	26.16	24.37	29.03	26.17	24.07	27.33	25.73	25.03	27.37
Pool	27.64	22.97	30.17	20.07	14.63	23.43	19.99	18.10	22.90	12.89	6.17	18.13
Temperature (C)												
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
18”	20.66	18.13	23.23	15.59	13.10	17.93	17.96	17.17	18.63	16.81	15.50	17.90
6”	21.27	18.40	24.40	15.67	13.47	18.27	18.20	17.10	19.67	17.24	15.37	18.77
Pool	24.81	19.00	30.63	21.31	10.60	25.97	24.79	19.53	31.47	21.41	14.30	24.50
Pool Depth (inches)												
Pool	NR	NR	NR	NR	NR	NR	NR	NR	NR	2.75	2.00	3.50

Source: USFWS 2002, 2004, and 2006. NR = Not Recorded

Table 3-3. Mean Water Quality, Salinity and Ground Water Data Collected at Water Quality Station 3 at the Cascade Brook Salt Marsh.

Parameters	Pre-Restoration			Year 1 Post-Restoration			Year 3 Post-Restoration			Year 5 Post-Restoration		
Dissolved Oxygen (% saturation)												
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
18”	0.61	0.53	0.70	2.63	0.70	9.77	1.48	0.50	2.53	1.36	0.20	2.27
6”	0.62	0.43	0.90	1.97	0.90	4.60	1.85	1.03	4.37	2.03	0.90	3.23
Pool	40.04	3.77	95.73	93.28	12.10	161.37	75.19	0.27	197.07	64.84	33.67	89.30
Dissolved Oxygen (mg/L)												
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
18”	NR	NR	NR	NR	NR	NR	NR	NR	NR	0.12	0.01	0.21
6”	NR	NR	NR	NR	NR	NR	NR	NR	NR	0.19	0.08	0.31
Pool	NR	NR	NR	NR	NR	NR	NR	NR	NR	5.67	2.41	8.55
Salinity (ppt)												
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
18”	7.96	7.53	8.20	12.62	11.40	13.70	10.37	9.33	11.80	11.74	11.10	12.63
6”	12.93	0.00	18.60	15.63	12.90	19.47	16.73	13.40	19.60	12.17	10.53	14.57
Pool	25.07	16.33	31.27	12.07	5.33	18.37	20.14	12.27	25.53	7.56	0.63	16.17
Temperature (C)												
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
18”	19.54	18.23	21.23	15.06	12.20	17.13	16.93	15.70	18.13	16.15	14.90	16.93
6”	20.50	18.37	23.33	15.27	13.27	17.40	17.07	16.17	18.30	16.43	14.63	17.93
Pool	25.42	21.10	31.83	20.72	9.53	29.97	20.38	13.67	26.87	19.59	13.90	23.37
Pool Depth (inches)												
Pool	NR	NR	NR	NR	NR	NR	NR	NR	NR	7.17	6.00	8.50

Source: USFWS 2002, 2004, and 2006. NR = Not Recorded

Table 3-4. Mean Water Quality, Salinity and Ground Water Data Collected at Water Quality Station 4 at the Cascade Brook Salt Marsh.

Parameters	Pre-Restoration			Year 1 Post-Restoration			Year 3 Post-Restoration			Year 5 Post-Restoration		
Dissolved Oxygen (% saturation)												
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
18”	0.73	0.40	1.00	4.58	1.60	13.27	2.62	0.67	7.73	0.91	0.43	1.50
6”	0.51	0.30	0.67	4.94	2.37	7.17	1.78	1.10	3.23	2.13	0.37	4.30
Pool	16.52	1.60	41.30	68.99	18.43	134.63	48.99	15.53	110.23	48.64	18.57	72.50
Dissolved Oxygen (mg/L)												
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
18”	NR	NR	NR	NR	NR	NR	NR	NR	NR	0.08	0.04	0.13
6”	NR	NR	NR	NR	NR	NR	NR	NR	NR	0.18	0.03	0.37
Pool	NR	NR	NR	NR	NR	NR	NR	NR	NR	4.02	1.66	5.43
Salinity (ppt)												
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
18”	26.27	24.70	28.30	23.44	19.37	26.33	25.27	23.30	28.10	21.03	13.27	25.90
6”	30.65	26.97	32.33	25.92	20.10	34.37	26.19	24.57	27.43	22.38	19.67	25.93
Pool	30.95	29.00	32.47	24.46	18.43	28.67	25.89	24.03	28.47	18.55	6.40	28.40
Temperature (C)												
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
18”	19.11	17.87	20.70	14.36	9.70	18.60	17.51	16.07	18.93	17.26	15.33	18.83
6”	19.92	17.67	22.33	14.78	12.90	17.40	17.46	16.07	19.00	17.26	15.10	18.87
Pool	21.88	15.93	28.13	16.38	7.87	22.67	19.04	14.67	23.13	19.32	15.60	22.60
Pool Depth (inches)												
Pool	NR	NR	NR	NR	NR	NR	NR	NR	NR	10.42	8.50	12.00

Source: USFWS 2002, 2004 and 2006. NR = Not Recorded

Table 3-5. Mean Water Quality, Salinity and Ground Water Data Collected at Water Quality Station 5 at the Cascade Brook Salt Marsh.

Parameters	Pre-Restoration			Year 1 Post-Restoration			Year 3 Post-Restoration		
Dissolved Oxygen (% saturation)									
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
	39.62	16.87	50.97	69.04	0.00	99.07	80.29	54.60	104.73
Salinity (ppt)									
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
	23.47	14.50	29.37	12.87	0.00	26.57	19.14	10.63	21.97
Temperature (C)									
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
	17.49	10.53	21.90	12.89	0.00	20.67	19.73	15.10	22.40

Source: USFWS 2002, 2004 and 2006.

Table 3-6. Mean Water Quality, Salinity and Ground Water Data Collected at Water Quality Station 6 at the Cascade Brook Salt Marsh.

Parameters	Pre-Restoration			Year 1 Post-Restoration			Year 3 Post-Restoration		
Dissolved Oxygen (% saturation)									
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
	57.16	47.83	63.70	75.08	63.60	91.50	66.84	55.63	78.43
Salinity (ppt)									
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
	25.31	20.10	30.03	21.47	15.27	27.03	22.09	18.13	25.40
Temperature (C)									
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
	16.92	11.67	20.00	14.71	9.93	18.70	19.11	15.90	21.63

Source: USFWS 2002, 2004 and 2006.

4.0 MANAGEMENT IMPLICATIONS AND RECOMMENDATIONS

4.1 MANAGEMENT IMPLICATIONS

The results of pre- and post-restoration monitoring activities at Cascade Brook Salt Marsh indicate the following:

- There was a net decrease in the coverage of *Phragmites* (-3.1%) and *S. patens/S. alterniflora* (-2.7%), and open water (-1.5%), and a net increase in coverage of *S. alterniflora* (+2.7%) and *Typha* (+1.4%). Mixed salt marsh species replaced much of the former *Phragmites* control area post-restoration, covering 2.3% of the Project area.
- Some of the natural pools noted during pre-restoration monitoring, no longer retain significant amounts of water at low tide, including the pool located in the center of the Project area. The reduction in the percentage of open water area is primarily associated with a replacement of pool habitat with vegetated communities, and is balanced by the increase in aerial coverage of *S. alterniflora* and mudflat.
- Vegetation in the low marsh and high marsh communities has remained stable.
- *Phragmites* regrowth has occurred within the four control areas overall; however, it appears that the establishment of native salt marsh species within the control areas, in addition to the hydrologic changes to the system, have slowed the regrowth and expansion of *Phragmites*, and may result in less *Phragmites* coverage and more diverse stands than existed pre-restoration.
- The removal of spoil and peat piles from the SRA, alteration of the downstream water control structures, and restoration of the tidal channel connecting the large pool area located adjacent to the SRA to the main tidal channel, have resulted in a change in community structure that was dominated by creeping bentgrass in pre-restoration conditions, to a more diverse community comprised primarily of native salt marsh species. Although *Phragmites* has repopulated some areas of the SRA (5–25% cover), overall the vegetative community within the SRA is more representative of a native salt marsh system than during pre-restoration conditions.
- Photographic documentation indicates that the marsh appears to be retaining more water on the marsh surface than during pre-restoration surveys, and support the observations of changes in the vegetative community.
- Water monitoring data appear to indicate an increase in flooding depths and duration at two of the four monitoring stations, an increase in magnitude of water level change at one of the monitoring stations, and a decrease in water level at one of the monitoring stations. The changes to the hydrologic conditions are not clearly understood at all stations; however, the overall hydrologic changes appear to be positive.
- Post-restoration water quality parameters, dissolved oxygen, salinity, and temperature, were within the acceptable range necessary for survival of desirable species of nekton and salt marsh vegetation.

4.2 MANAGEMENT RECOMMENDATIONS

Recommendations for continued management of the Cascade Brook Salt Marsh, based on site assessments, data collection, and other incidental observations, include the following:

- Monitor areas where growth of *Phragmites australis* is occurring. If communities of *Phragmites* continue to expand out onto the marsh, treatment could be considered to control further spread of *Phragmites* in the Project area.

Overall, the salt marsh restoration appears to have successfully restored the historic marsh surface that had been buried by spoil material deposited with the 1996 road failure. Additionally, changes to the water control structure and underwater berms appears to have resulted in an increased magnitude of water flow through the main channel and culvert, and an increase in the duration and extent of flooding on the marsh surface post-restoration compared to pre-restoration in many areas of the Project area. However, *Phragmites* growth on the marsh persists, and continued monitoring of the *Phragmites* community is advised.

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APPENDIX A

Cover Type Map

- **Pre-Restoration**
- **Year 5 Post-Restoration**

N

Project Location

150 0 150 300 Feet

50 0 50 100 Meters

LEGEND

- Mudflat
- Open Water
- Peat Piles *
- Scirpus robustus
- Scirpus validus
- Spartina alterniflora
- Bare Ground
- Spartina cynosuroides
- Spartina patens/ Spartina alterniflora
- Typha species
- Upland
- Wetland Forest
- Phragmites australis
- Spoil Removal Area

* Triangle indicated Peat Piles smaller than the minimun mapping unit.

Pre-Restoration Cover Type Map for the Cascade Brook Salt Marsh Restoration Monitoring Project Scarborough, Maine.

Client: U.S. Fish & Wildlife Service

Prepared By: TETRA TECH, INC.

Date: 01/09

z:/projects/ep-2200/aprs/figure1.apr

N
W E
S

Project Location

150 75 0 150 300 450
Feet
50 25 0 50 100 150
Meters

LEGEND

- Culvert
- Mudflat
- Mixed Salt Marsh Species
- Open Water
- Road
- Sand Bar
- Scirpus robustus
- Scirpus validus
- Spartina alterniflora
- Spartina pectinata
- Spartina patens/Spartina alterniflora
- Typha species
- Upland
- Wetland Forest
- Phragmites australis
- Former Spoil Removal Area

Year 5 Post-Restoration Cover Type Map for the Cascade Brook Salt Marsh Restoration Monitoring Project Scarborough, Maine.

Client: U.S. Fish & Wildlife Service

Prepared By: TETRA TECH, INC.

Date: 02/09

z:/projects/Cascade/2008Maps/CTfigure.mxd

APPENDIX B

Completed Site Assessment Data Forms

Cascade Brook Restoration Monitoring Site Assessment

Site Name: Cascade	**Date:** 10-17-08	**Time:** 0730	**Time of last high tide:** 1014M
Evaluator(s): SW etc	**Tide:** High Mid (Low) and incoming (outgoing)		
Cloud Cover(%): (0,) 1 – 25, 25–50, 50–57, > 75%	**Precipitation:** (none,) drizzle, steady rain		
Temperature (°F): 45	**Wind:** calm (intermittent breeze) steady breeze gusting		
Rain events within past 3-days (avg. over 72 hours): none (<25 %,) 25-50%, 51-75%, >75			

REF #	ACCEPTABLE CONDITIONS	UN-ACCEPTABLE CONDITIONS
1) Spoil Removal Area (SRA)		
X	Desirable species present	X Desirable species absent; (undesirable species present)
X	Plant health/vigor good	____ Plants in poor health, showing signs of stress
X	No obvious loss of aerial coverage or density	____ Obvious loss of aerial coverage, plant density
X	No evidence of erosion at SRA	____ Evidence of erosion at SRA
2) Altered/Restored Tidal Creek:		
X	Natural tidal flow	____ Tidal flow blocked/restricted
X	Natural flow of freshwater runoff	____ Freshwater runoff blocked/restricted
X	Water quality adequate	____ Water quality poor (*i.e.*, anerobic conditions)
X	Banks stable	____ Banks sloughing, undercutting, or unstable
X	Typical vegetation species present	____ Devoid of vegetation or invasive species present
3) Natural Pools:		
X	Pools retaining adequate water	X In-sufficient water retained in pools
X	Water quality adequate	____ Water quality poor (*i.e.*, anerobic conditions)
X	Presence of nekton	____ Evidence of nekton die-off
X	Presence of macro-invertebrates	____ Evidence of macro-invertebrate die-off
X	Mosquito larvae none - few	____ Mosquito larvae common – many
* Note the pool number beside the appropriate unacceptable condition if encountered, and describe the problem on back		
4) Pannes: X	Size, aerial coverage not increasing	____ Size, aerial coverage increasing
X	Typical veg. species present	____ Presence of invasive species
* Note the panne number beside the appropriate unacceptable condition if encountered, and describe the problem on back		
5) Undesirable Species: (*Phragmites, Typha, Lythrum, Polygonum cuspidatum, and shrubs on high marsh surface)*		
____	No undesirable species present	X Undesirable species found on site
____	Undesirable species coverage not increasing	X Undesirable species coverage increasing
* Identify the location of undesirable species on the cover type map		
6) Desirable Species: (*Spartina, Juncus, Distichlis, Salicacia, Scirpus, Solidago, Ruppia) note others when encountered*		
X	Plant health, vigor good	____ Plants in poor health, showing signs of stress
X	No obvious loss of aerial coverage or density	____ Obvious loss of aerial coverage, plant density
N/A	Shrubs, if present, are ~~declining~~ in health	____ Shrubs, if present, are healthy or increasing in % cover

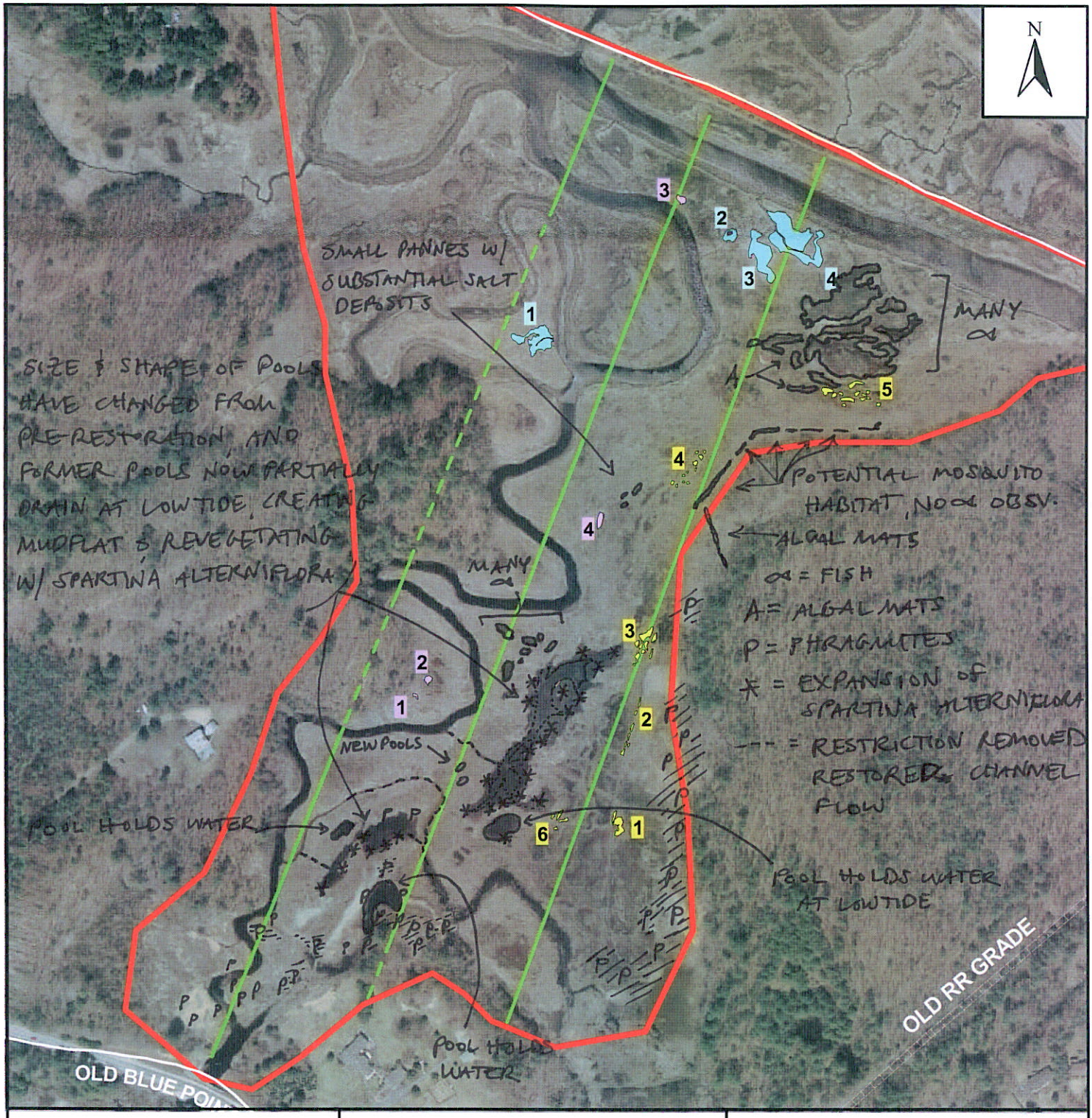
Observations (identify if any of the following observations are made)

Ref. #	Species Group	√ if None	Note Species, Activity, Number, Habitat Use, etc. (identify approximate location on cover type map)
7	Passerines or passerine nests		See species list
8	Wading birds or wading bird nests		"
9	Water birds or water bird nests		"
10	Raptors or raptor nests		"
11	Small mammals	✓	None observed
12	Large mammals		Deer tracks
13	Amphibians		Green frog
14	Reptiles		N/A
15	Recreational activities		Bird watching, hunting
16	Site disturbance	✓	None observed
17	Mosquito adult/larvae in pools	✓	None observed
18	Macro-invertebrates in pools	NA	
19	Fish in pools		Abundant in pools

Site Assessment (additional comments)

Be sure to record the location of features exhibiting un-acceptable conditions on the cover type map

Ref. #	Comments
1	Recovery of SRA 5yrs post-restoration is excellent. Phragmites has increased it's coverage to ~25% of SRA, and may continue to encroach and expand its aerial cover. However, native species have revegetated and the majority of the SRA and communities appear to be healthy & vigorous. It is possible that Phrag has taken hold on areas w/ slightly higher elevation than those populated w/ native species, but w/out a topo survey, this is not definitive. There are several "root masses" of Typha that were transported into SRA - probably during summer or early fall storms.
2	Restored channel is stable and is allowing freshwater run-off to flow unimpeded. Banks are stable and vegetated w/ S. alterniflora almost exclusively. Channel is narrow, ~3' wide, w/ a sandy substrate. Only concern is that encroachment of vegetation could eventually impede flow.
3.	Some natural pools have changed w/ post restoration and no longer hold significant water at low tide. Reconnection to channel leading to main channel now drains pools (see figure), and this connection and drainage has resulted in carving of channels into mudflat and allowed growth and establishment of S. alterniflora in stable w/in former pool. New pools seem to have formed just north of Station #2 between it and the connector to main channel. Some formerly natural pools are becoming vegetated and/or mudflat at low tide.
4.	Pannes holding some water at time of survey, which follows the high spring high tides. Pannes appear to be stable, with typical conditions and species present.
5	Phragmites and Typha are present on the site, and coverage of Phragmites has increased. In particular, Phragmites has increased coverage in the southern end of the project area, in the SRA north of the main channel, and in the Phrag Control area along the eastern boundary of the site. Typha is present but not clearly increasing or decreasing in coverage.
6	Desirable species appear healthy and vigorous. The Phragmites Control Areas along the eastern boundary have revegetated with a combination of desirable and invasive species (between 25-50% cover). The SRA is predominantly revegetated w/ desirable species, which have become well established and are virtually indistinguishable from the untouched areas.



Source: U.S. Fish & Wildlife Service Kodak Imagery Scarborough Marsh, April-May 2001.

200 0 200 400 Feet

LEGEND

- Project Area
- Poor Water Quality
- Insufficient Water Retained
- Mosquito Larvae Present or Expected
- Site Assessment Transect

Figure 2. Site Assessment Transect Locations for Cascade Brook Salt Marsh Restoration Monitoring Project Scarborough, Maine.

Client: U.S. Fish & Wildlife Service

Prepared By: NEA

Date: 11/11/02

z:/projects/ep-2200/aprs/figure1.apr

APPENDIX C

Vegetation Monitoring Data

Vegetation Monitoring - Fall 2008

Low Marsh

Scientific Name	Common Name	Strata of Vegetation	Cover Class
Atriplex patula	Marsh orach	H	1
Distichlis spicata	Spike grass	H	t
Phragmites australis	Common reed	H	t
Polygonum ramosissimum	Bushy knotweed	H	t
Scirpus robustus	Salt marsh bulrush	H	1
Spartina alterniflora	Smooth cordgrass	H	5
Spartina pectinata	Prairie cordgrass	H	1
Spartina patens	Salt meadow cordgrass	H	2
Typhia angustifolia	Narrow-leaved cattail	H	t
--	Bare ground	--	1
--	Litter	--	t

Percent Cover Class	
Class	Percent
t	<1
1	1 to 5
2	5 to 25
3	25 to 50
4	50 to 75
5	75 to 100

High Marsh

Scientific Name	Common Name	Strata of Vegetation	Cover Class
Aster novi-belgii	New York aster	H	t
Atriplex patula	Marsh orach	H	1
Calystegia sepium	Hedge bindweed	H	t
Distichlis spicata	Spike grass	H	1
Juncus gerardi	Black-grass rush	H	t
Limonium nashii	Sea lavender	H	t
Phragmites australis	Common reed	H	1
Plantago major	Common plantain	H	t
Polygonum ramosissimum	Bushy knotweed	H	t
Salicornia europaea	Common glasswort	H	1
Scirpus robustus	Salt marsh bulrush	H	t
Scirpus validus	Soft-stemmed bulrush	H	t
Solidago sempervirens	Seaside goldenrod	H	1
Spartina alterniflora	Smooth cordgrass	H	3
Spartina patens	Salt meadow cordgrass	H	4
Triglochin maritinum	Seaside arrowgrass	H	t
Typha angustifolia	Narrow-leaved cattail	H	1
--	Bare ground	--	t
--	Litter	--	t

Vegetation Monitoring - Fall 2008

Phragmites Areas

Scientific Name	Common Name	Strata of Vegetation	Cover Class
Alnus rugosa	Speckled alder	H	t
Agrostis stolonifera	Creeping bentgrass	H	1
Aster novi-belgii	New York aster	H	1
Atriplex patula	Marsh orach	H	1
Distichlis spicata	Saltgrass	H	1
Eleocharis parvula	Dwarf spike-rush	H	1
Phragmites australis	Common reed	H	3
Polygonum ramosissimum	Bushy knotweed	H	1
Salicornia europaea	Common glasswort	H	1
Scirpus maritimus	Alkali bulrush	H	1
Scirpus robustus	Salt marsh bulrush	H	2
Scirpus validus	Soft-stemmed bulrush	H	t
Solidago sempervirens	Seaside goldenrod	H	1
Spartina patens	Salt meadow cordgrass	H	2
Triglochin maritinum	Seaside arrowgrass	H	t
Typha angustifolia	Narrow-leaved cattail	H	2
--	Bare ground	--	1
--	Litter	--	t

Percent Cover Class	
Class	Percent
t	<1
1	1 to 5
2	5 to 25
3	25 to 50
4	50 to 75
5	75 to 100

Spoil Removal / Fill Areas

Scientific Name	Common Name	Strata of Vegetation	Cover Class
Agrostis stolonifera	Creeping bentgrass	H	1
Aster novi-belgii	New York aster	H	1
Atriplex patula	Marsh orach	H	t
Distichlis spicata	Spike grass	H	3
Eleocharis parvula	Dwarf spike-rush	H	1
Juncus gerardii	Black grass	H	1
Limonium nashii	Sea lavender	H	1
Phragmites australis	Common reed	H	2
Plantago major	Common plantain	H	t
Polygonum ramosissimum	Bushy knotweed	H	t
Scirpus robustus	Salt marsh bulrush	H	2
Scirpus pungens	Common threesquare	H	t
Scirpus validus	Soft-stemmed bulrush	H	1
Solidago sempervirens	Seaside goldenrod	H	2
Spartina alterniflora	Smooth cordgrass	H	3
Spartina patens	Salt meadow cordgrass	H	1
Typhia angustifolia	Narrow-leaved cattail	H	1
--	Bare ground	--	t
--	Litter	--	t
--	Pool/panne	--	2

APPENDIX D

Photographic Documentation

NORTHERN ECOLOGICAL ASSOCIATES, INC.

CASCADE BROOK SALT MARSH RESTORATION MONITORING
PHOTO STATION PHOTOGRAPHIC RECORD

Client: U.S. Fish & Wildlife Service; Friends of Scarborough Marsh
Project: Cascade Brook Salt Marsh Restoration Monitoring

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 1A
Direction: 250

Comments:
Photo Station #1, low tide.
Phragmites Control Site 1 can be seen in the distance.

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 1B
Direction: 310

Comments:
Photo Station #1, low tide.
Phragmites Control Site 1 can be seen in the distance.

NORTHERN ECOLOGICAL ASSOCIATES, INC.

CASCADE BROOK SALT MARSH RESTORATION MONITORING
PHOTO STATION PHOTOGRAPHIC RECORD

Client: U.S. Fish & Wildlife Service; Friends of Scarborough Marsh
Project: Cascade Brook Salt Marsh Restoration Monitoring

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 1C
Direction: 355

Comments:
Photo Station #1, low tide.

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 1D
Direction: 35

Comments:
Photo Station #1, low tide.

NORTHERN ECOLOGICAL ASSOCIATES, INC.

CASCADE BROOK SALT MARSH RESTORATION MONITORING
PHOTO STATION PHOTOGRAPHIC RECORD

Client: U.S. Fish & Wildlife Service; Friends of Scarborough Marsh
Project: Cascade Brook Salt Marsh Restoration Monitoring

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 2A
Direction: 330

Comments:
Photo Station #2, low tide.
Phragmites Control Site 1; forested wetland can be seen in the distance.

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 2B
Direction: 15

Comments:
Photo Station #2, low tide.
Phragmites Control Site 1.

NORTHERN ECOLOGICAL ASSOCIATES, INC.

CASCADE BROOK SALT MARSH RESTORATION MONITORING
PHOTO STATION PHOTOGRAPHIC RECORD

Client: U.S. Fish & Wildlife Service; Friends of Scarborough Marsh
Project: Cascade Brook Salt Marsh Restoration Monitoring

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 2C
Direction: 55

Comments:
Photo Station #2, low tide.
Phragmites Control Site 1.

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 2D
Direction: 95

Comments:
Photo Station #2, low tide.
Phragmites Control Site 1.

NORTHERN ECOLOGICAL ASSOCIATES, INC.

CASCADE BROOK SALT MARSH RESTORATION MONITORING
PHOTO STATION PHOTOGRAPHIC RECORD

Client: U.S. Fish & Wildlife Service; Friends of Scarborough Marsh
Project: Cascade Brook Salt Marsh Restoration Monitoring

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 2E
Direction: 140

Comments:
Photo Station #2, low tide.
Phragmites Control Site 1, and Old Blue Point Road bridge.

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 3A
Direction: 192

Comments:
Photo Station #3, low tide.
Main tidal creek.

NORTHERN ECOLOGICAL ASSOCIATES, INC.

CASCADE BROOK SALT MARSH RESTORATION MONITORING
PHOTO STATION PHOTOGRAPHIC RECORD

Client: U.S. Fish & Wildlife Service; Friends of Scarborough Marsh
Project: Cascade Brook Salt Marsh Restoration Monitoring

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 3B
Direction: 224

Comments:
Photo Station #3, low tide.
Main tidal creek.

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 3C
Direction: 313

Comments:
Photo Station #3, low tide.
Main tidal creek.

NORTHERN ECOLOGICAL ASSOCIATES, INC.

CASCADE BROOK SALT MARSH RESTORATION MONITORING
PHOTO STATION PHOTOGRAPHIC RECORD

Client: U.S. Fish & Wildlife Service; Friends of Scarborough Marsh
Project: Cascade Brook Salt Marsh Restoration Monitoring

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 3D
Direction: 340

Comments:
Photo Station #3, low tide.
Main tidal creek.

Photographer: S. Watts
Date: 9/21/07
Photo No.: 3E
Direction: 68

Comments:
Photo Station #3, low tide.
Main tidal creek.

NORTHERN ECOLOGICAL ASSOCIATES, INC.

CASCADE BROOK SALT MARSH RESTORATION MONITORING
PHOTO STATION PHOTOGRAPHIC RECORD

Client: U.S. Fish & Wildlife Service; Friends of Scarborough Marsh
Project: Cascade Brook Salt Marsh Restoration Monitoring

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 3F
Direction: 105

Comments:
Photo Station #3, low tide.

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 3G
Direction: 150

Comments:
Photo Station #3, low tide.

NORTHERN ECOLOGICAL ASSOCIATES, INC.

CASCADE BROOK SALT MARSH RESTORATION MONITORING
PHOTO STATION PHOTOGRAPHIC RECORD

Client: U.S. Fish & Wildlife Service; Friends of Scarborough Marsh
Project: Cascade Brook Salt Marsh Restoration Monitoring

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 4A
Direction: 230

Comments:
Photo Station #4, low tide.
Phragmites Control Site 2 and Old Blue Point Road bridge can be seen in the distance.

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 4B
Direction: 265

Comments:
Photo Station #4, low tide.

NORTHERN ECOLOGICAL ASSOCIATES, INC.

CASCADE BROOK SALT MARSH RESTORATION MONITORING
PHOTO STATION PHOTOGRAPHIC RECORD

Client: U.S. Fish & Wildlife Service; Friends of Scarborough Marsh
Project: Cascade Brook Salt Marsh Restoration Monitoring

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 4C
Direction: 335

Comments:
Photo Station #4, low tide.

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 4D
Direction: 25

Comments:
Photo Station #4, low tide.
Station #2 can be seen in center. The largest tidal pond in the Project area can be seen at right, with *Spartina* growth the light green color.

NORTHERN ECOLOGICAL ASSOCIATES, INC.

CASCADE BROOK SALT MARSH RESTORATION MONITORING
PHOTO STATION PHOTOGRAPHIC RECORD

Client: U.S. Fish & Wildlife Service; Friends of Scarborough Marsh
Project: Cascade Brook Salt Marsh Restoration Monitoring

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 4E
Direction: 58

Comments:
Photo Station #4, low tide.
The largest tidal pond in the Project area can be seen at left, with *Spartina* growth the light green color. Phragmites Control Site 4 can be seen in the distance.

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 4F
Direction: 120

Comments:
Photo Station #4, low tide.
Phragmites Control Site 4 can be seen in the distance.

NORTHERN ECOLOGICAL ASSOCIATES, INC.

CASCADE BROOK SALT MARSH RESTORATION MONITORING
PHOTO STATION PHOTOGRAPHIC RECORD

Client: U.S. Fish & Wildlife Service; Friends of Scarborough Marsh
Project: Cascade Brook Salt Marsh Restoration Monitoring

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 5A
Direction: 200

Comments:
Photo Station #5, low tide.
Phragmites Control Site 4.

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 5B
Direction: 245

Comments:
Photo Station #5, low tide.
Phragmites Control Site 4.

NORTHERN ECOLOGICAL ASSOCIATES, INC.

CASCADE BROOK SALT MARSH RESTORATION MONITORING
PHOTO STATION PHOTOGRAPHIC RECORD

Client: U.S. Fish & Wildlife Service; Friends of Scarborough Marsh
Project: Cascade Brook Salt Marsh Restoration Monitoring

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 5C
Direction: 290

Comments:
Photo Station #5, low tide.
Phragmites Control Site 4.

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 5D
Direction: 340

Comments:
Photo Station #5, low tide.
Phragmites Control Site 4.

NORTHERN ECOLOGICAL ASSOCIATES, INC.

CASCADE BROOK SALT MARSH RESTORATION MONITORING
PHOTO STATION PHOTOGRAPHIC RECORD

Client: U.S. Fish & Wildlife Service; Friends of Scarborough Marsh
Project: Cascade Brook Salt Marsh Restoration Monitoring

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 6A
Direction: 250

Comments:
Photo Station #6, low tide.
Main tidal creek.

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 6B
Direction: 295

Comments:
Photo Station #6, low tide.
Main tidal creek.

NORTHERN ECOLOGICAL ASSOCIATES, INC.

CASCADE BROOK SALT MARSH RESTORATION MONITORING
PHOTO STATION PHOTOGRAPHIC RECORD

Client: U.S. Fish & Wildlife Service; Friends of Scarborough Marsh
Project: Cascade Brook Salt Marsh Restoration Monitoring

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 6C
Direction: 10

Comments:
Photo Station #6, low tide.

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 6D
Direction: 50

Comments:
Photo Station #6, low tide.

NORTHERN ECOLOGICAL ASSOCIATES, INC.

CASCADE BROOK SALT MARSH RESTORATION MONITORING
PHOTO STATION PHOTOGRAPHIC RECORD

Client: U.S. Fish & Wildlife Service; Friends of Scarborough Marsh
Project: Cascade Brook Salt Marsh Restoration Monitoring

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 6E
Direction: 125

Comments:
Photo Station #6, low tide.

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 6F
Direction: 160

Comments:
Photo Station #6, low tide.
Phragmites Control Site 4 can be seen in the distance.

NORTHERN ECOLOGICAL ASSOCIATES, INC.

CASCADE BROOK SALT MARSH RESTORATION MONITORING
PHOTO STATION PHOTOGRAPHIC RECORD

Client: U.S. Fish & Wildlife Service; Friends of Scarborough Marsh
Project: Cascade Brook Salt Marsh Restoration Monitoring

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 6G
Direction: 224

Comments:
Photo Station #6, low tide.

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 7A
Direction: 230

Comments:
Photo Station #7, low tide.
Station #4 can be seen in the center. Main tidal creek.

NORTHERN ECOLOGICAL ASSOCIATES, INC.

CASCADE BROOK SALT MARSH RESTORATION MONITORING
PHOTO STATION PHOTOGRAPHIC RECORD

Client: U.S. Fish & Wildlife Service; Friends of Scarborough Marsh
Project: Cascade Brook Salt Marsh Restoration Monitoring

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 7B
Direction: 280

Comments:
Photo Station #7, low tide.
Main tidal creek.

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 7C
Direction: 335

Comments:
Photo Station #7, low tide.
Main tidal creek.

NORTHERN ECOLOGICAL ASSOCIATES, INC.

CASCADE BROOK SALT MARSH RESTORATION MONITORING
PHOTO STATION PHOTOGRAPHIC RECORD

Client: U.S. Fish & Wildlife Service; Friends of Scarborough Marsh
Project: Cascade Brook Salt Marsh Restoration Monitoring

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 7D
Direction: 15

Comments:
Photo Station #7, low tide.
Main tidal creek.

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 7E
Direction: 85

Comments:
Photo Station #7, low tide.
Main tidal creek and pools.

NORTHERN ECOLOGICAL ASSOCIATES, INC.

CASCADE BROOK SALT MARSH RESTORATION MONITORING
PHOTO STATION PHOTOGRAPHIC RECORD

Client: U.S. Fish & Wildlife Service; Friends of Scarborough Marsh
Project: Cascade Brook Salt Marsh Restoration Monitoring

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 7F
Direction: 127

Comments:
Photo Station #7, low tide.

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 7G
Direction: 178

Comments:
Photo Station #7, low tide.

NORTHERN ECOLOGICAL ASSOCIATES, INC.

CASCADE BROOK SALT MARSH RESTORATION MONITORING
PHOTO STATION PHOTOGRAPHIC RECORD

Client: U.S. Fish & Wildlife Service; Friends of Scarborough Marsh
Project: Cascade Brook Salt Marsh Restoration Monitoring

Photographer: L. Rivard
Date: 9/22/08
Photo No.: 8A
Direction: 170

Comments:
Photo Station #8, low tide.
Pine Point Road culvert, upstream, and water control structures. Dunstan Canal/ main tidal creek.

Photographer: L. Rivard
Date: 9/22/08
Photo No.: 8B
Direction: 215

Comments:
Photo Station #8, low tide.
Dunstan Canal.

NORTHERN ECOLOGICAL ASSOCIATES, INC.

CASCADE BROOK SALT MARSH RESTORATION MONITORING
PHOTO STATION PHOTOGRAPHIC RECORD

Client: U.S. Fish & Wildlife Service; Friends of Scarborough Marsh
Project: Cascade Brook Salt Marsh Restoration Monitoring

Photographer: L. Rivard
Date: 9/22/08
Photo No.: 8C
Direction: 245

Comments:
Photo Station #8, low tide.
Dunstan Canal.

Photographer: L. Rivard
Date: 9/22/08
Photo No.: 8D
Direction: 275

Comments:
Photo Station #8, low tide.
Dunstan Canal.

NORTHERN ECOLOGICAL ASSOCIATES, INC.

CASCADE BROOK SALT MARSH RESTORATION MONITORING
PHOTO STATION PHOTOGRAPHIC RECORD

Client: U.S. Fish & Wildlife Service; Friends of Scarborough Marsh
Project: Cascade Brook Salt Marsh Restoration Monitoring

Photographer: L. Rivard
Date: 9/22/08
Photo No.: 9A
Direction: 180

Comments:
Photo Station #9, low tide.
Pine Point Road culvert, downstream. Dunstan River.

Photographer: L. Rivard
Date: 9/22/08
Photo No.: 9B
Direction: 135

Comments:
Photo Station #9, low tide.
Dunstan River.

NORTHERN ECOLOGICAL ASSOCIATES, INC.

CASCADE BROOK SALT MARSH RESTORATION MONITORING
PHOTO STATION PHOTOGRAPHIC RECORD

Client: U.S. Fish & Wildlife Service; Friends of Scarborough Marsh
Project: Cascade Brook Salt Marsh Restoration Monitoring

Photographer: L. Rivard
Date: 9/22/08
Photo No.: 9C
Direction: 90

Comments:
Photo Station #9, low tide.
Dunstan River.

Photographer: L. Rivard
Date: 9/22/08
Photo No.: 9D
Direction: 45

Comments:
Photo Station #9, low tide.

NORTHERN ECOLOGICAL ASSOCIATES, INC.

CASCADE BROOK SALT MARSH RESTORATION MONITORING
PHOTO STATION PHOTOGRAPHIC RECORD

Client: U.S. Fish & Wildlife Service; Friends of Scarborough Marsh
Project: Cascade Brook Salt Marsh Restoration Monitoring

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 10A
Direction: 340

Comments:
Photo Station #10, low tide.
Phragmites Control Site 1. Riprap rock and silt fence stabilize the banks.

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 10B
Direction: 35

Comments:
Photo Station #10, low tide.
Phragmites Control Site 1. Main tidal creek.

NORTHERN ECOLOGICAL ASSOCIATES, INC.

CASCADE BROOK SALT MARSH RESTORATION MONITORING
PHOTO STATION PHOTOGRAPHIC RECORD

Client: U.S. Fish & Wildlife Service; Friends of Scarborough Marsh
Project: Cascade Brook Salt Marsh Restoration Monitoring

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 10C

Direction: 72

Comments:
Photo Station #10, low tide.
Riprap rock stabilizes the banks.

NORTHERN ECOLOGICAL ASSOCIATES, INC.

CASCADE BROOK SALT MARSH RESTORATION MONITORING
PHOTO STATION PHOTOGRAPHIC RECORD

Client: U.S. Fish & Wildlife Service; Friends of Scarborough Marsh
Project: Cascade Brook Salt Marsh Restoration Monitoring

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 1A
Direction: 250

Comments:
Photo Station #1, high tide.
Phragmites Control Site 1 can be seen in the distance.

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 1B
Direction: 310

Comments:
Photo Station #1, high tide.
Phragmites Control Site 1 can be seen in the distance.

NORTHERN ECOLOGICAL ASSOCIATES, INC.

CASCADE BROOK SALT MARSH RESTORATION MONITORING
PHOTO STATION PHOTOGRAPHIC RECORD

Client: U.S. Fish & Wildlife Service; Friends of Scarborough Marsh
Project: Cascade Brook Salt Marsh Restoration Monitoring

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 1C
Direction: 355

Comments:
Photo Station #1, high tide.

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 1D
Direction: 35

Comments:
Photo Station #1, high tide.

NORTHERN ECOLOGICAL ASSOCIATES, INC.

CASCADE BROOK SALT MARSH RESTORATION MONITORING
PHOTO STATION PHOTOGRAPHIC RECORD

Client: U.S. Fish & Wildlife Service; Friends of Scarborough Marsh
Project: Cascade Brook Salt Marsh Restoration Monitoring

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 2A
Direction: 330

Comments:
Photo Station #2, high tide.
Phragmites Control Site 1; forested wetland can be seen in the distance.

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 2B
Direction: 15

Comments:
Photo Station #2, high tide.
Phragmites Control Site 1.

NORTHERN ECOLOGICAL ASSOCIATES, INC.

CASCADE BROOK SALT MARSH RESTORATION MONITORING
PHOTO STATION PHOTOGRAPHIC RECORD

Client: U.S. Fish & Wildlife Service; Friends of Scarborough Marsh
Project: Cascade Brook Salt Marsh Restoration Monitoring

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 2C
Direction: 55

Comments:
Photo Station #2, high tide.
Phragmites Control Site 1.

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 2D
Direction: 95

Comments:
Photo Station #2, high tide.
Phragmites Control Site 1.

NORTHERN ECOLOGICAL ASSOCIATES, INC.

CASCADE BROOK SALT MARSH RESTORATION MONITORING
PHOTO STATION PHOTOGRAPHIC RECORD

Client: U.S. Fish & Wildlife Service; Friends of Scarborough Marsh
Project: Cascade Brook Salt Marsh Restoration Monitoring

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 2E
Direction: 140

Comments:
Photo Station #2, high tide.
Phragmites Control Site 1, and Old Blue Point Road bridge.

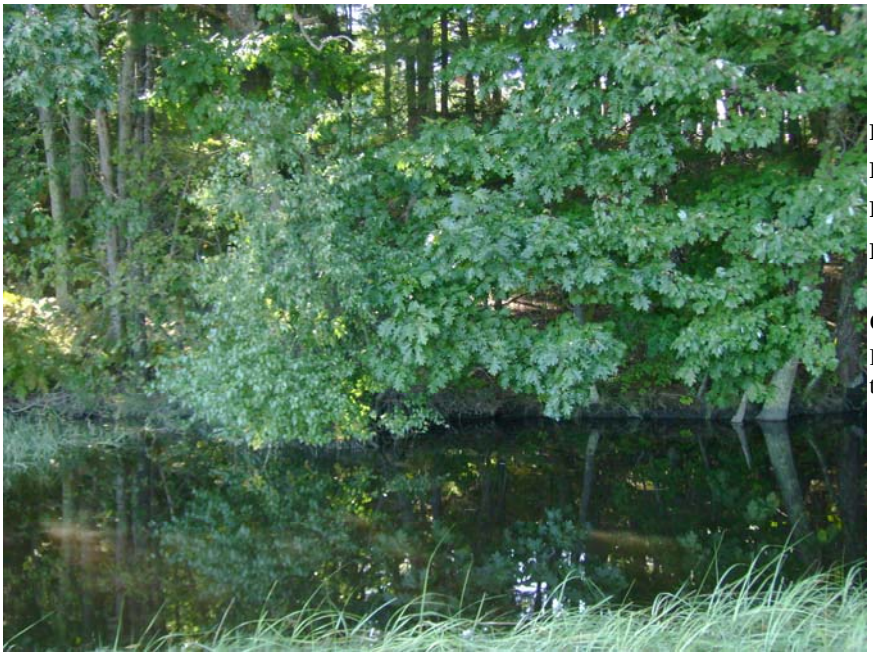
Photographer: L. Rivard
Date: 9/19/08
Photo No.: 3A
Direction: 192

Comments:
Photo Station #3, high tide.
Main tidal creek.

NORTHERN ECOLOGICAL ASSOCIATES, INC.

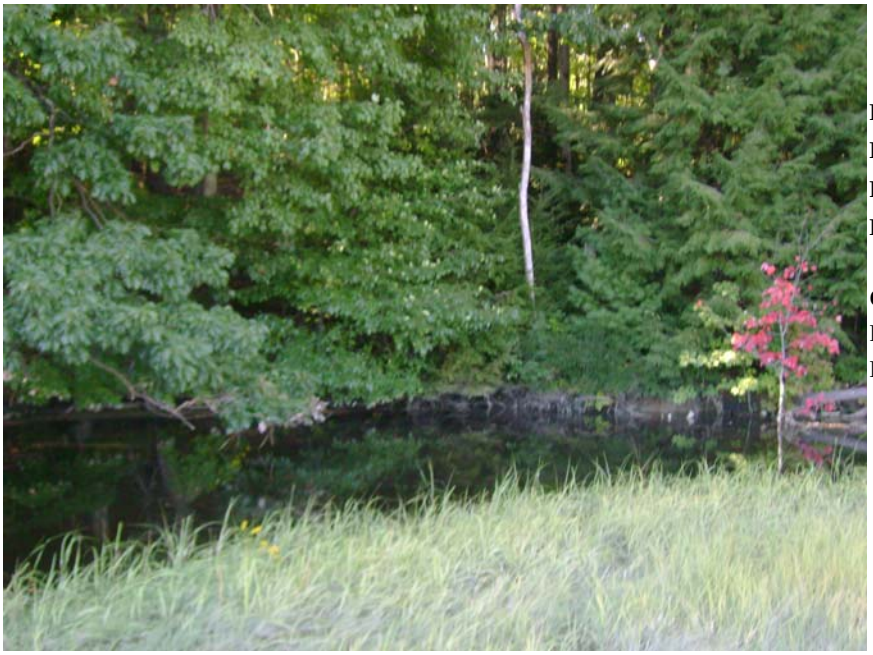
CASCADE BROOK SALT MARSH RESTORATION MONITORING
PHOTO STATION PHOTOGRAPHIC RECORD

Client: U.S. Fish & Wildlife Service; Friends of Scarborough Marsh
Project: Cascade Brook Salt Marsh Restoration Monitoring



Photographer: L. Rivard
Date: 9/19/08
Photo No.: 3B
Direction: 299

Comments:
Photo Station #3, high tide. Main tidal creek.



Photographer: L. Rivard
Date: 9/19/08
Photo No.: 3C
Direction: 313

Comments:
Photo Station #3, high tide.
Main tidal creek.

NORTHERN ECOLOGICAL ASSOCIATES, INC.

CASCADE BROOK SALT MARSH RESTORATION MONITORING
PHOTO STATION PHOTOGRAPHIC RECORD

Client: U.S. Fish & Wildlife Service; Friends of Scarborough Marsh
Project: Cascade Brook Salt Marsh Restoration Monitoring

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 3D
Direction: 340

Comments:
Photo Station #3, high tide. Main tidal creek.

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 3E
Direction: 58

Comments:
Photo Station #3, high tide.
Main tidal creek.

NORTHERN ECOLOGICAL ASSOCIATES, INC.

CASCADE BROOK SALT MARSH RESTORATION MONITORING
PHOTO STATION PHOTOGRAPHIC RECORD

Client: U.S. Fish & Wildlife Service; Friends of Scarborough Marsh
Project: Cascade Brook Salt Marsh Restoration Monitoring

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 3F
Direction: 95

Comments:
Photo Station #3, high tide.

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 3G
Direction: 150

Comments:
Photo Station #3, high tide.

NORTHERN ECOLOGICAL ASSOCIATES, INC.

CASCADE BROOK SALT MARSH RESTORATION MONITORING
PHOTO STATION PHOTOGRAPHIC RECORD

Client: U.S. Fish & Wildlife Service; Friends of Scarborough Marsh
Project: Cascade Brook Salt Marsh Restoration Monitoring

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 4A
Direction: 230

Comments:
Photo Station #4, high tide.
Phragmites Control Site 2 and Old Blue Point Road bridge can be seen in the distance.

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 4B
Direction: 265

Comments:
Photo Station #4, high tide.

NORTHERN ECOLOGICAL ASSOCIATES, INC.

CASCADE BROOK SALT MARSH RESTORATION MONITORING
PHOTO STATION PHOTOGRAPHIC RECORD

Client: U.S. Fish & Wildlife Service; Friends of Scarborough Marsh
Project: Cascade Brook Salt Marsh Restoration Monitoring

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 4C
Direction: 335

Comments:
Photo Station #4, high tide.

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 4D
Direction: 30

Comments:
Photo Station #4, high tide. Station #2 can be seen in center. The largest tidal pond in the Project area can be seen at right, with *Spartina* growth the light green color.

NORTHERN ECOLOGICAL ASSOCIATES, INC.

CASCADE BROOK SALT MARSH RESTORATION MONITORING
PHOTO STATION PHOTOGRAPHIC RECORD

Client: U.S. Fish & Wildlife Service; Friends of Scarborough Marsh
Project: Cascade Brook Salt Marsh Restoration Monitoring

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 4E
Direction: 88

Comments:

Photo Station #4, high tide.

The largest tidal pond in the Project area can be seen at left, with *Spartina* growth the light green color. Phragmites Control Site 4 can be seen in the distance.

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 4F
Direction: 125

Comments:

Photo Station #4, high tide.

Phragmites Control Site 4 can be seen in the distance.

NORTHERN ECOLOGICAL ASSOCIATES, INC.

CASCADE BROOK SALT MARSH RESTORATION MONITORING
PHOTO STATION PHOTOGRAPHIC RECORD

Client: U.S. Fish & Wildlife Service; Friends of Scarborough Marsh
Project: Cascade Brook Salt Marsh Restoration Monitoring

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 5A
Direction: 200

Comments:
Photo Station #5, high tide.
Phragmites Control Site 4.

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 5B
Direction: 245

Comments:
Photo Station #5, high tide.
Phragmites Control Site 4.

NORTHERN ECOLOGICAL ASSOCIATES, INC.

CASCADE BROOK SALT MARSH RESTORATION MONITORING
PHOTO STATION PHOTOGRAPHIC RECORD

Client: U.S. Fish & Wildlife Service; Friends of Scarborough Marsh
Project: Cascade Brook Salt Marsh Restoration Monitoring

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 5C
Direction: 290

Comments:
Photo Station #5, high tide.
Phragmites Control Site 4.

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 5D
Direction: 340

Comments:
Photo Station #5, high tide.
Phragmites Control Site 4.

NORTHERN ECOLOGICAL ASSOCIATES, INC.

CASCADE BROOK SALT MARSH RESTORATION MONITORING
PHOTO STATION PHOTOGRAPHIC RECORD

Client: U.S. Fish & Wildlife Service; Friends of Scarborough Marsh
Project: Cascade Brook Salt Marsh Restoration Monitoring

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 6A
Direction: 240

Comments:
Photo Station #6, high tide.
Main tidal creek.

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 6B
Direction: 280

Comments:
Photo Station #6, high tide.
Main tidal creek.

NORTHERN ECOLOGICAL ASSOCIATES, INC.

CASCADE BROOK SALT MARSH RESTORATION MONITORING
PHOTO STATION PHOTOGRAPHIC RECORD

Client: U.S. Fish & Wildlife Service; Friends of Scarborough Marsh
Project: Cascade Brook Salt Marsh Restoration Monitoring

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 6C
Direction: 20

Comments:
Photo Station #6, high tide.

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 6D
Direction: 68

Comments:
Photo Station #6, high tide.

NORTHERN ECOLOGICAL ASSOCIATES, INC.

CASCADE BROOK SALT MARSH RESTORATION MONITORING
PHOTO STATION PHOTOGRAPHIC RECORD

Client: U.S. Fish & Wildlife Service; Friends of Scarborough Marsh
Project: Cascade Brook Salt Marsh Restoration Monitoring

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 6E
Direction: 135

Comments:
Photo Station #6, high tide.

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 6F
Direction: 175

Comments:
Photo Station #6, high tide. Phragmites Control Site 4 can be seen in the distance.

NORTHERN ECOLOGICAL ASSOCIATES, INC.

CASCADE BROOK SALT MARSH RESTORATION MONITORING
PHOTO STATION PHOTOGRAPHIC RECORD

Client: U.S. Fish & Wildlife Service; Friends of Scarborough Marsh
Project: Cascade Brook Salt Marsh Restoration Monitoring

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 6G
Direction: 224

Comments:
Photo Station #6, high tide.

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 7A
Direction: 230

Comments:
Photo Station #7, high tide.
Station #4 can be seen in the center. Main tidal creek.

NORTHERN ECOLOGICAL ASSOCIATES, INC.

CASCADE BROOK SALT MARSH RESTORATION MONITORING
PHOTO STATION PHOTOGRAPHIC RECORD

Client: U.S. Fish & Wildlife Service; Friends of Scarborough Marsh
Project: Cascade Brook Salt Marsh Restoration Monitoring

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 7B
Direction: 270

Comments:
Photo Station #7, high tide.
Main tidal creek.

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 7C
Direction: 315

Comments:
Photo Station #7, high tide.
Main tidal creek.

NORTHERN ECOLOGICAL ASSOCIATES, INC.

CASCADE BROOK SALT MARSH RESTORATION MONITORING
PHOTO STATION PHOTOGRAPHIC RECORD

Client: U.S. Fish & Wildlife Service; Friends of Scarborough Marsh
Project: Cascade Brook Salt Marsh Restoration Monitoring

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 7D
Direction: 15

Comments:
Photo Station #7, high tide.
Main tidal creek.

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 7E
Direction: 85

Comments:
Photo Station #7, high tide.
Main tidal creek and pools. Old structure, possibly a duck blind, can be seen right of center

NORTHERN ECOLOGICAL ASSOCIATES, INC.

CASCADE BROOK SALT MARSH RESTORATION MONITORING
PHOTO STATION PHOTOGRAPHIC RECORD

Client: U.S. Fish & Wildlife Service; Friends of Scarborough Marsh
Project: Cascade Brook Salt Marsh Restoration Monitoring

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 7F
Direction: 127

Comments:
Photo Station #7, high tide.

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 7G
Direction: 178

Comments:
Photo Station #7, high tide.

NORTHERN ECOLOGICAL ASSOCIATES, INC.

CASCADE BROOK SALT MARSH RESTORATION MONITORING
PHOTO STATION PHOTOGRAPHIC RECORD

Client: U.S. Fish & Wildlife Service; Friends of Scarborough Marsh
Project: Cascade Brook Salt Marsh Restoration Monitoring

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 8A
Direction: 170

Comments:
Photo Station #8, high tide.
Pine Point Road culvert, upstream, and water control structures. Dunstan Canal/ main tidal creek.

Photographer: 9/19/08
Date: L. Rivard
Photo No.: 8B
Direction: 215

Comments:
Photo Station #8, high tide.
Dunstan Canal.

NORTHERN ECOLOGICAL ASSOCIATES, INC.

CASCADE BROOK SALT MARSH RESTORATION MONITORING
PHOTO STATION PHOTOGRAPHIC RECORD

Client: U.S. Fish & Wildlife Service; Friends of Scarborough Marsh
Project: Cascade Brook Salt Marsh Restoration Monitoring

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 8C
Direction: 245

Comments:
Photo Station #8, high tide. Dunstan Canal.

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 8D
Direction: 275

Comments:
Photo Station #8, high tide. Dunstan Canal.

NORTHERN ECOLOGICAL ASSOCIATES, INC.

CASCADE BROOK SALT MARSH RESTORATION MONITORING
PHOTO STATION PHOTOGRAPHIC RECORD

Client: U.S. Fish & Wildlife Service; Friends of Scarborough Marsh
Project: Cascade Brook Salt Marsh Restoration Monitoring

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 9A
Direction: 180

Comments:
Photo Station #9, high tide.
Pine Point Road culvert, downstream. Dunstan River.

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 9B
Direction: 135

Comments:
Photo Station #9, high tide.
Dunstan River.

NORTHERN ECOLOGICAL ASSOCIATES, INC.

CASCADE BROOK SALT MARSH RESTORATION MONITORING
PHOTO STATION PHOTOGRAPHIC RECORD

Client: U.S. Fish & Wildlife Service; Friends of Scarborough Marsh
Project: Cascade Brook Salt Marsh Restoration Monitoring

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 9C
Direction: 90

Comments:
Photo Station #9, high tide.
Dunstan River.

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 9D
Direction: 45

Comments:
Photo Station #9, high tide.

NORTHERN ECOLOGICAL ASSOCIATES, INC.

CASCADE BROOK SALT MARSH RESTORATION MONITORING
PHOTO STATION PHOTOGRAPHIC RECORD

Client: U.S. Fish & Wildlife Service; Friends of Scarborough Marsh
Project: Cascade Brook Salt Marsh Restoration Monitoring

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 10A
Direction: 340

Comments:
Photo Station #10, high tide.
Phragmites Control Site 1. Riprap rock and silt fence stabilize the banks.

Photographer: L. Rivard
Date: 9/19/08
Photo No.: 10B
Direction: 35

Comments:
Photo Station #10, high tide.
Phragmites Control Site 1. Main tidal creek.

NORTHERN ECOLOGICAL ASSOCIATES, INC.

CASCADE BROOK SALT MARSH RESTORATION MONITORING
PHOTO STATION PHOTOGRAPHIC RECORD

Client: U.S. Fish & Wildlife Service; Friends of Scarborough Marsh
Project: Cascade Brook Salt Marsh Restoration Monitoring

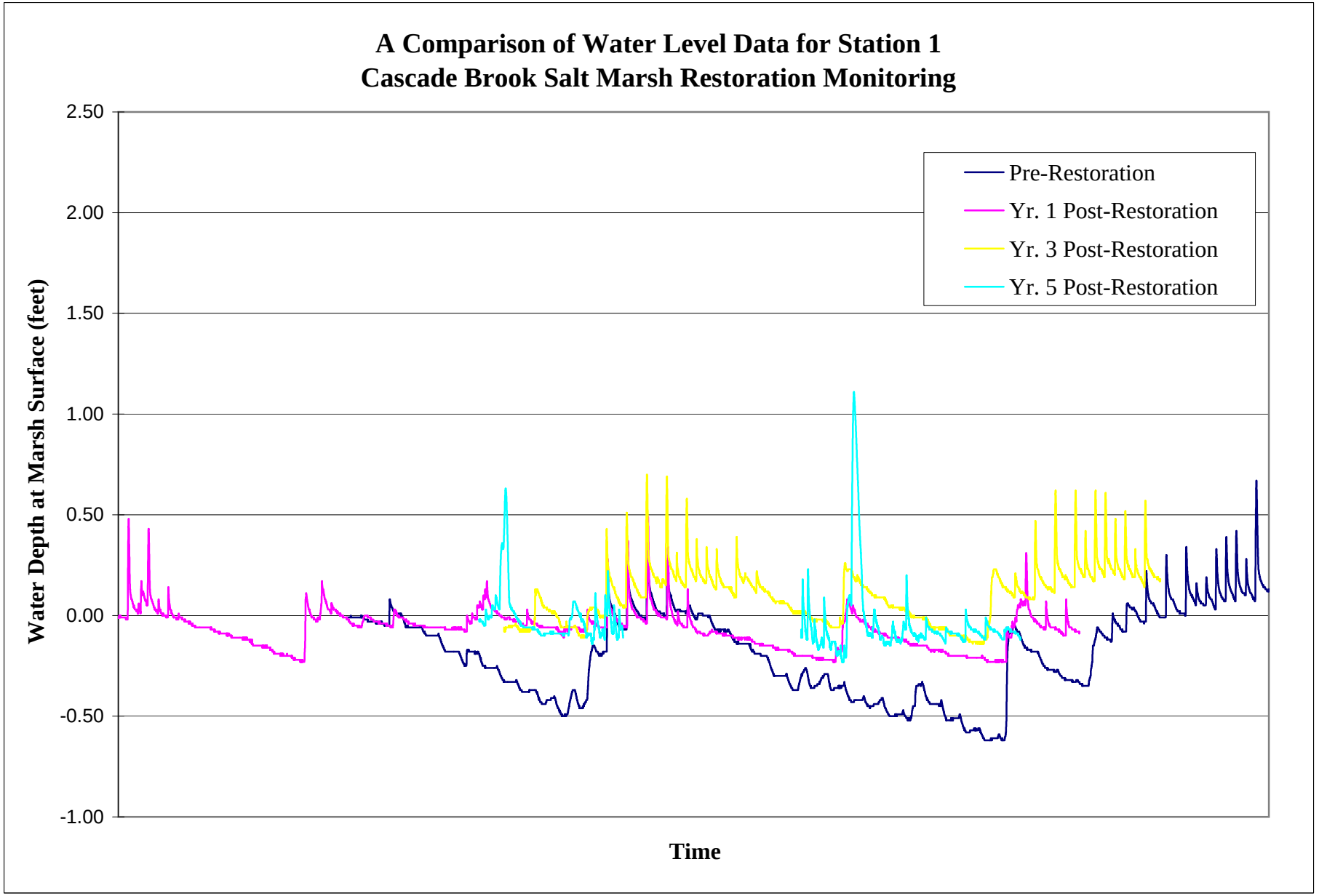
Photographer: L. Rivard
Date: 9/19/08
Photo No.: 10C
Direction: 72

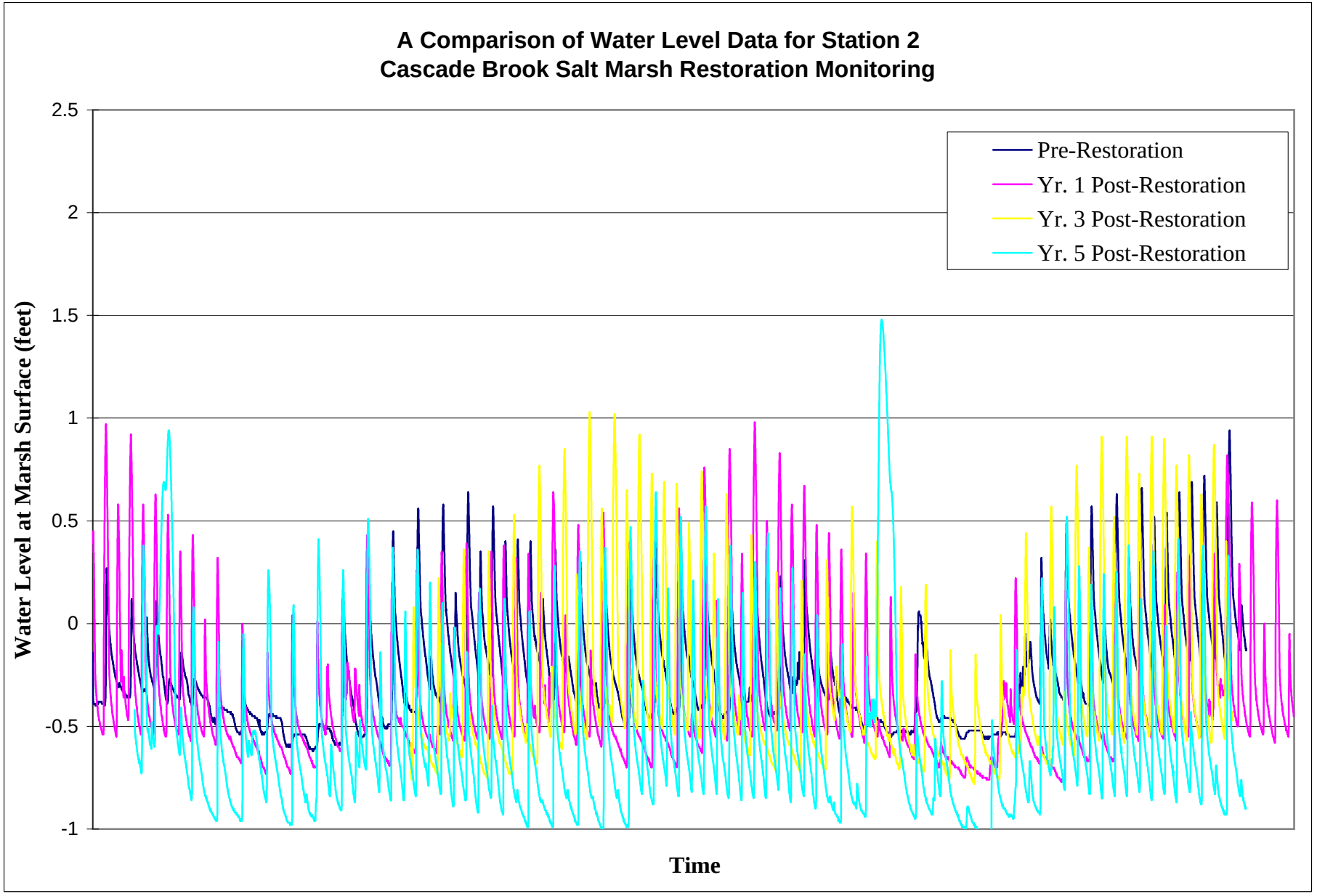
Comments:
Photo Station #10, high tide.
Riprap rock stabilizes the banks.

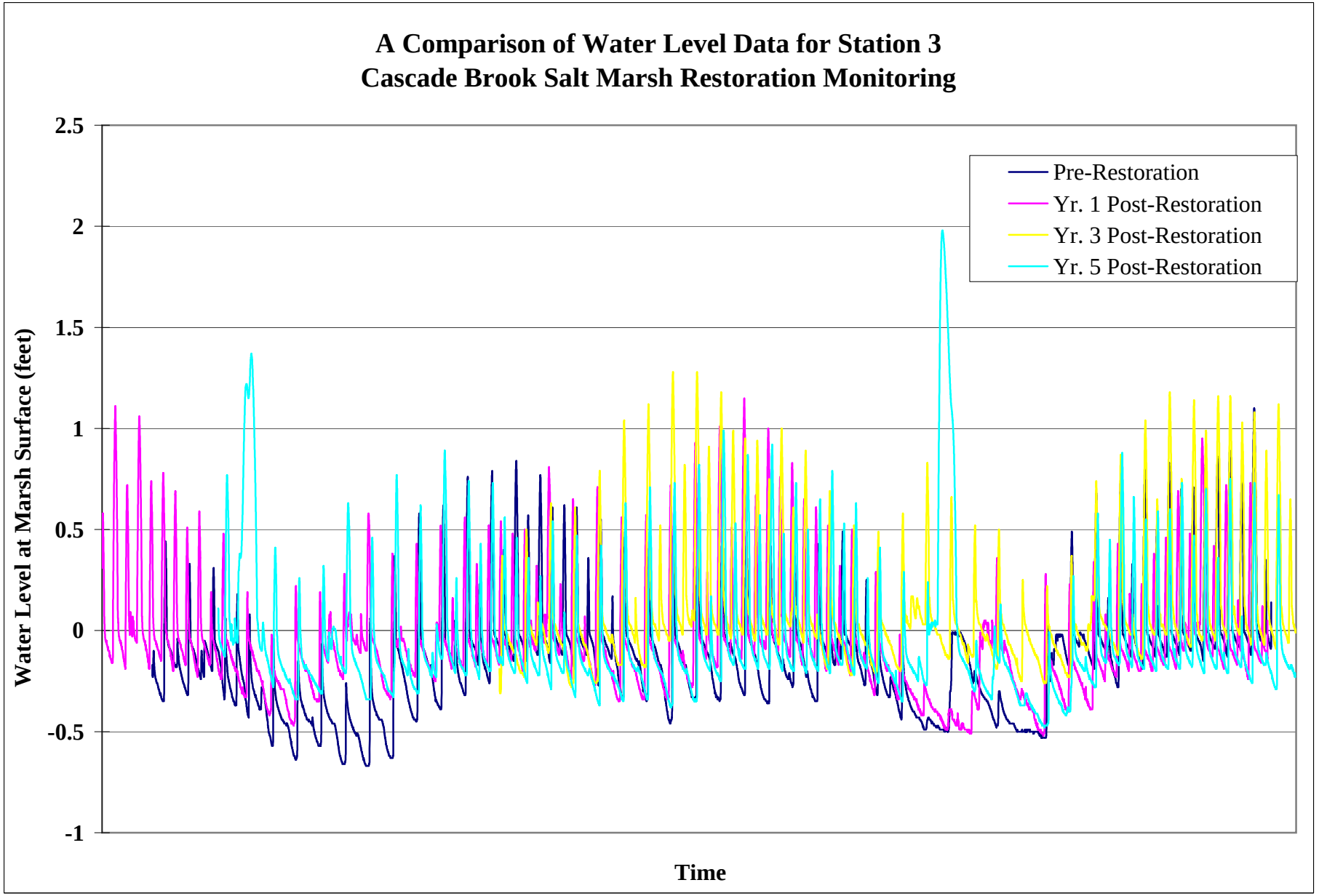
APPENDIX E

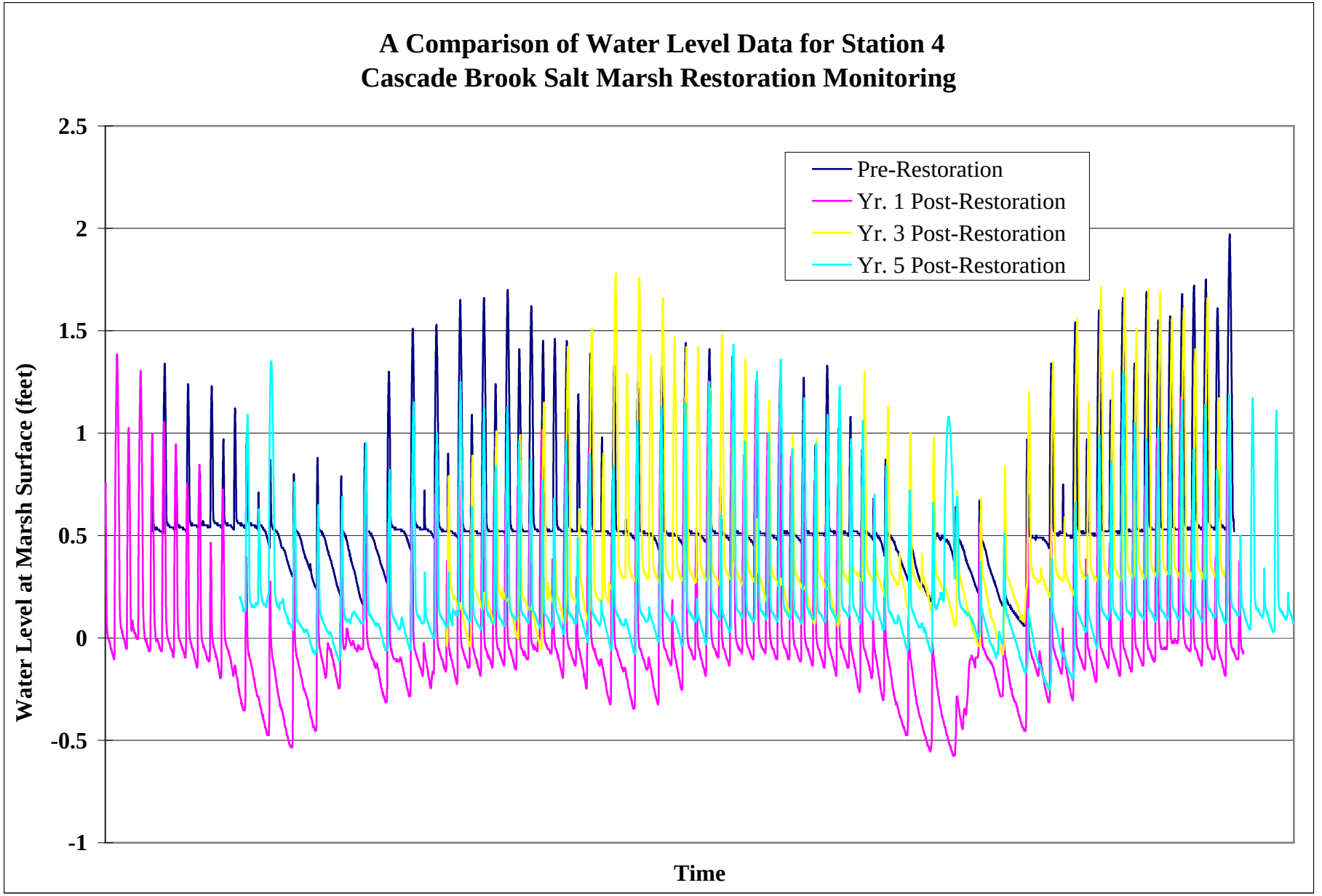
Water Sampling Data

- **Tidal Signal Data**
- **Water Quality Data**

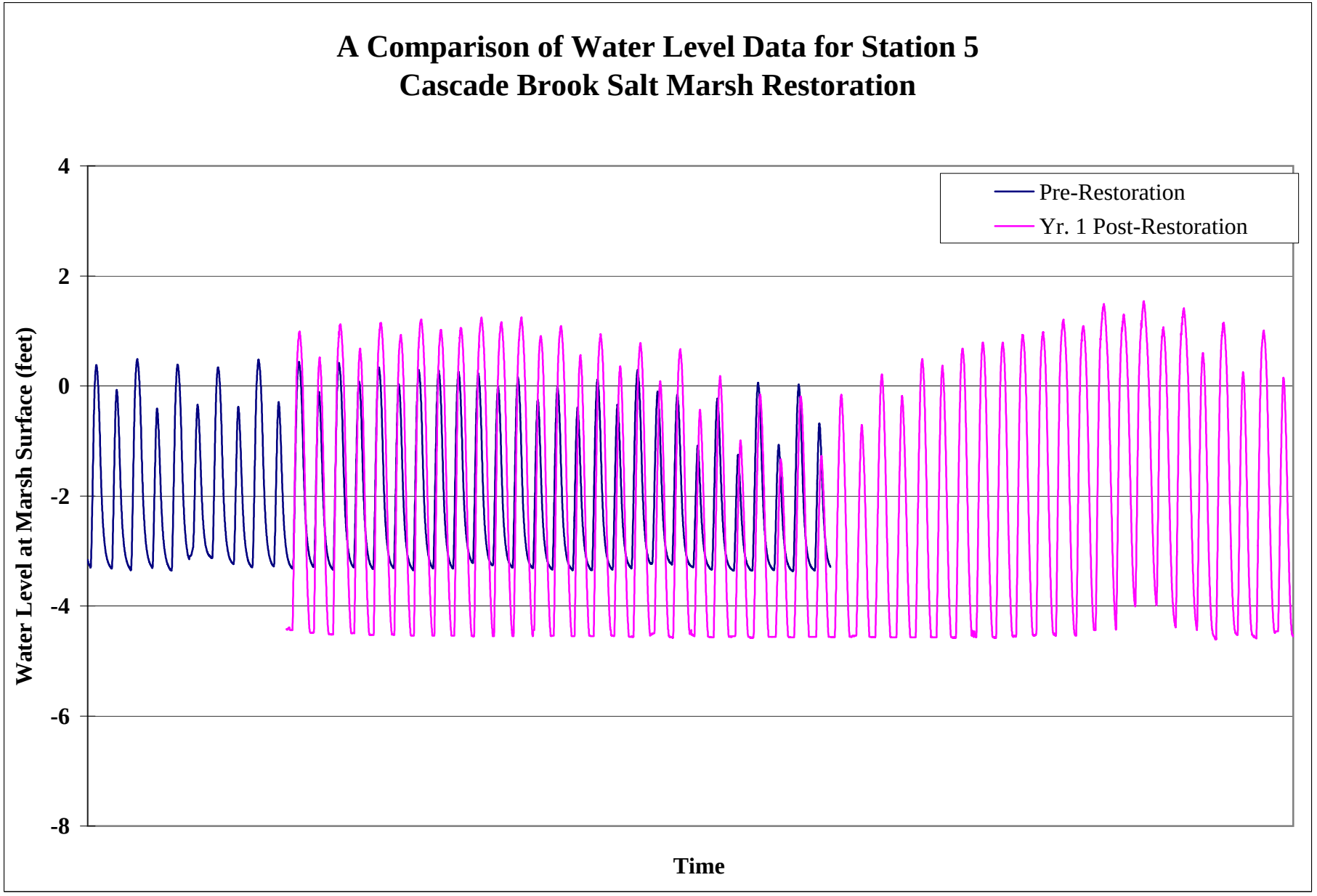

A Comparison of Water Level Data for Station 1
Cascade Brook Salt Marsh Restoration Monitoring
Water Depth at Marsh Surface (feet)
2.50
2.00
1.50
1.00
0.50
0.00
-0.50
-1.00
Time
Pre-Restoration
Yr. 1 Post-Restoration
Yr. 3 Post-Restoration
Yr. 5 Post-Restoration


A Comparison of Water Level Data for Station 2
Cascade Brook Salt Marsh Restoration Monitoring
Water Level at Marsh Surface (feet)
2.5
2
1.5
1
0.5
0
-0.5
-1
Time
Pre-Restoration
Yr. 1 Post-Restoration
Yr. 3 Post-Restoration
Yr. 5 Post-Restoration

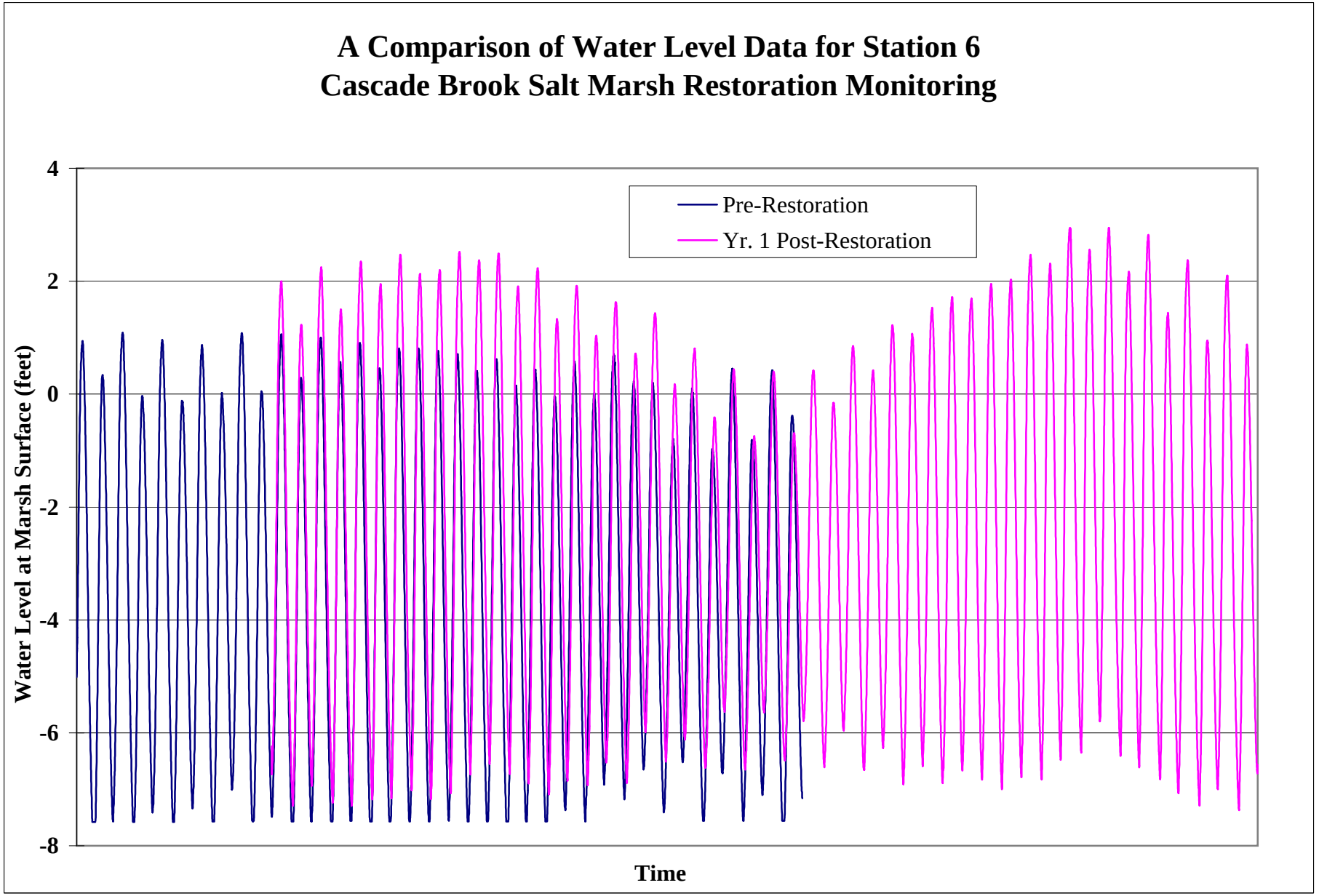

A Comparison of Water Level Data for Station 3
Cascade Brook Salt Marsh Restoration Monitoring
Water Level at Marsh Surface (feet)
2.5
2
1.5
1
0.5
0
-0.5
-1
Time
Pre-Restoration
Yr. 1 Post-Restoration
Yr. 3 Post-Restoration
Yr. 5 Post-Restoration


A Comparison of Water Level Data for Station 4
Cascade Brook Salt Marsh Restoration Monitoring
Water Level at Marsh Surface (feet)
2.5
2
1.5
1
0.5
0
-0.5
-1
Time
Pre-Restoration
Yr. 1 Post-Restoration
Yr. 3 Post-Restoration
Yr. 5 Post-Restoration

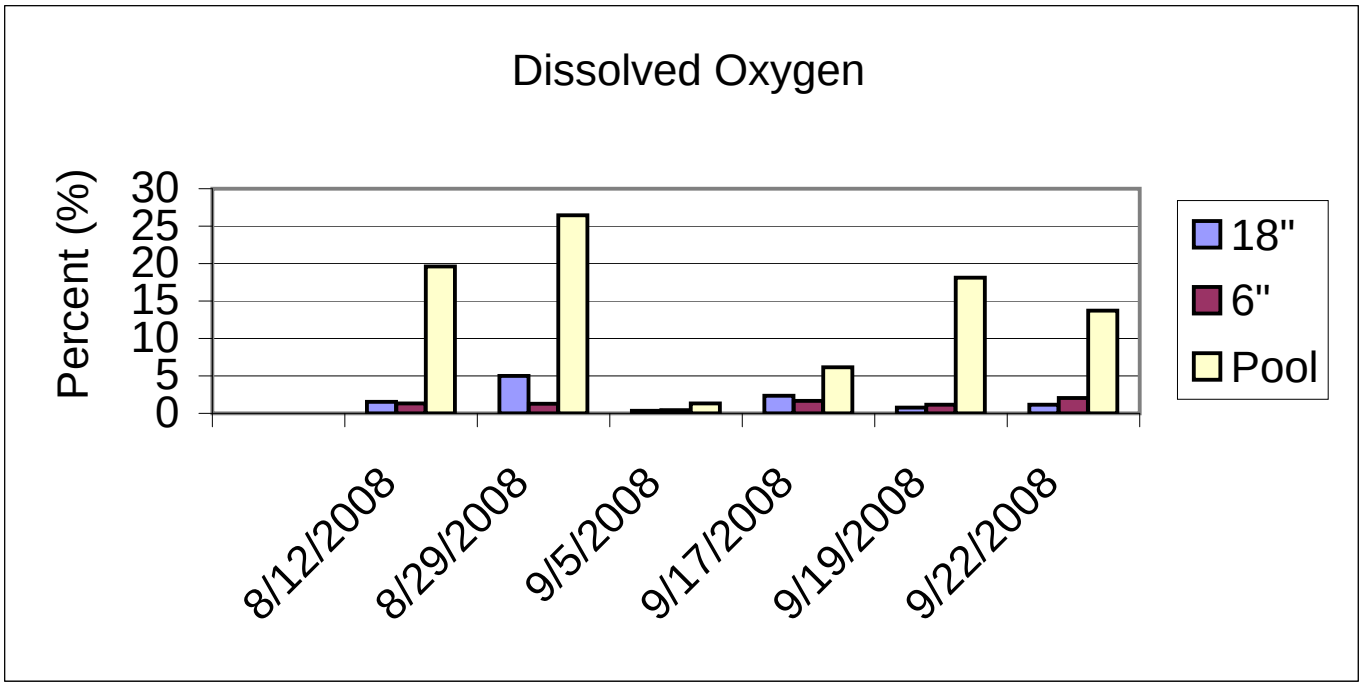
A Comparison of Water Level Data for Station 5
Cascade Brook Salt Marsh Restoration

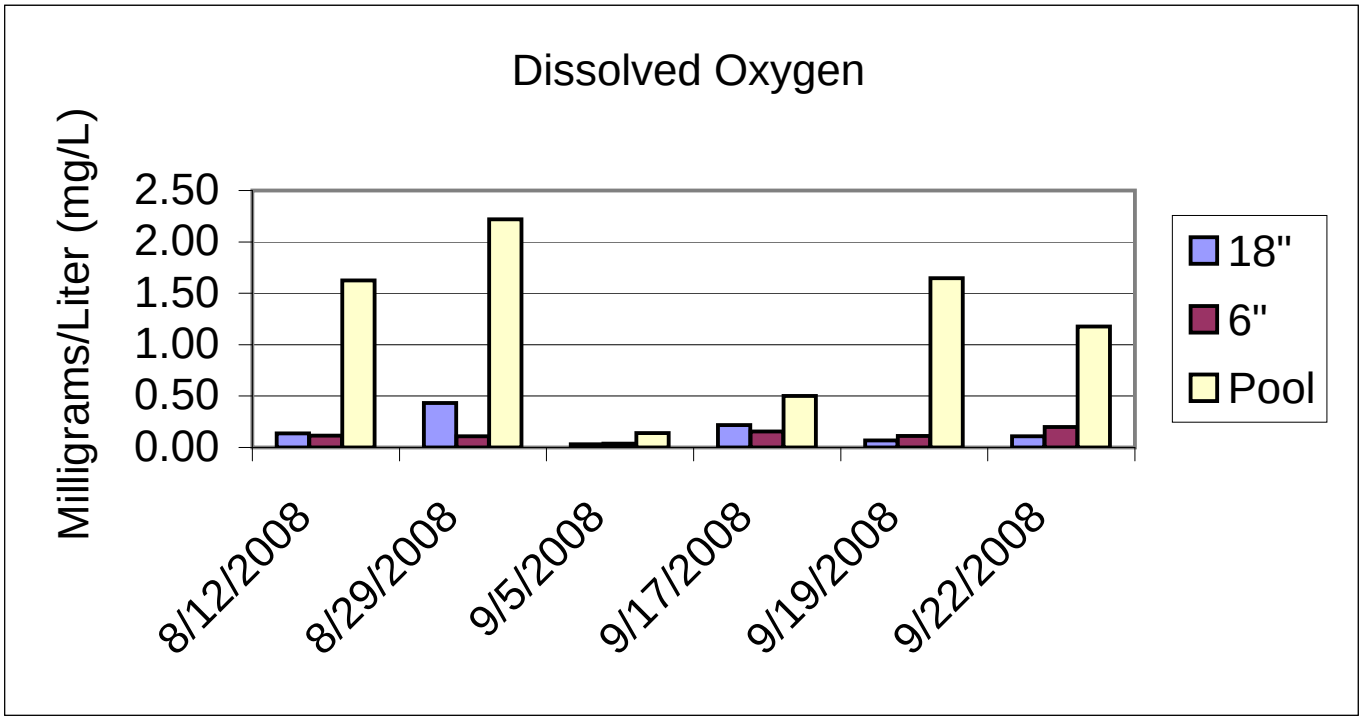


A Comparison of Water Level Data for Station 6
Cascade Brook Salt Marsh Restoration Monitoring

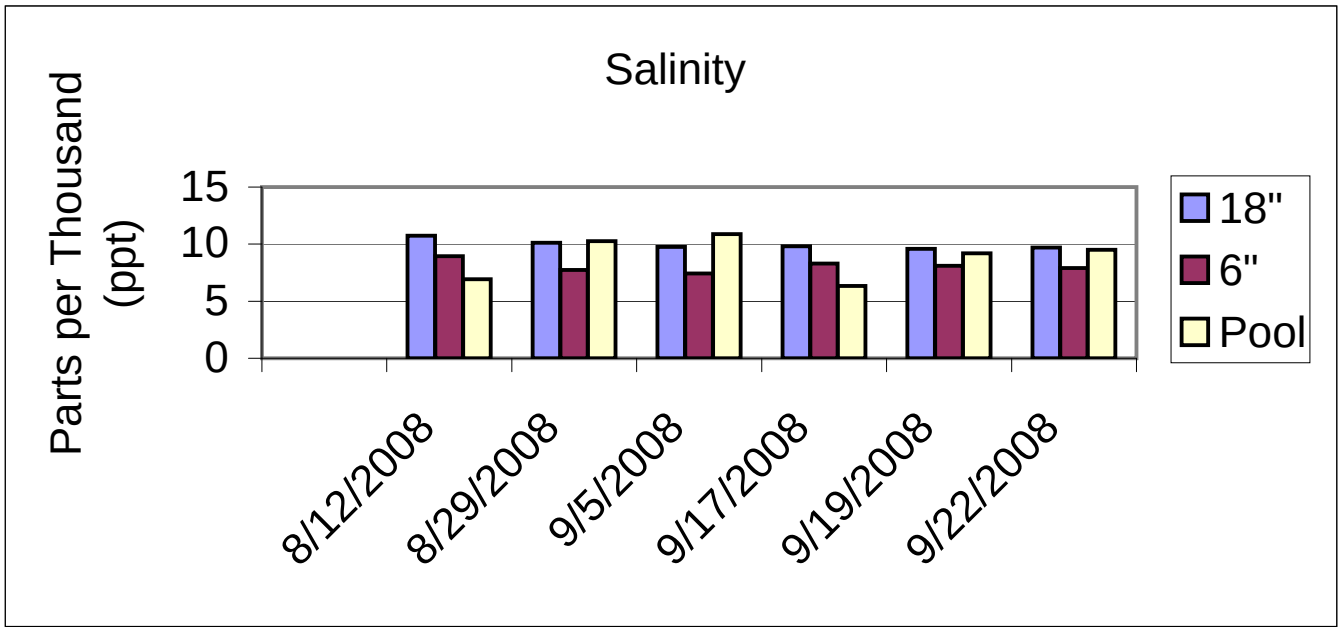


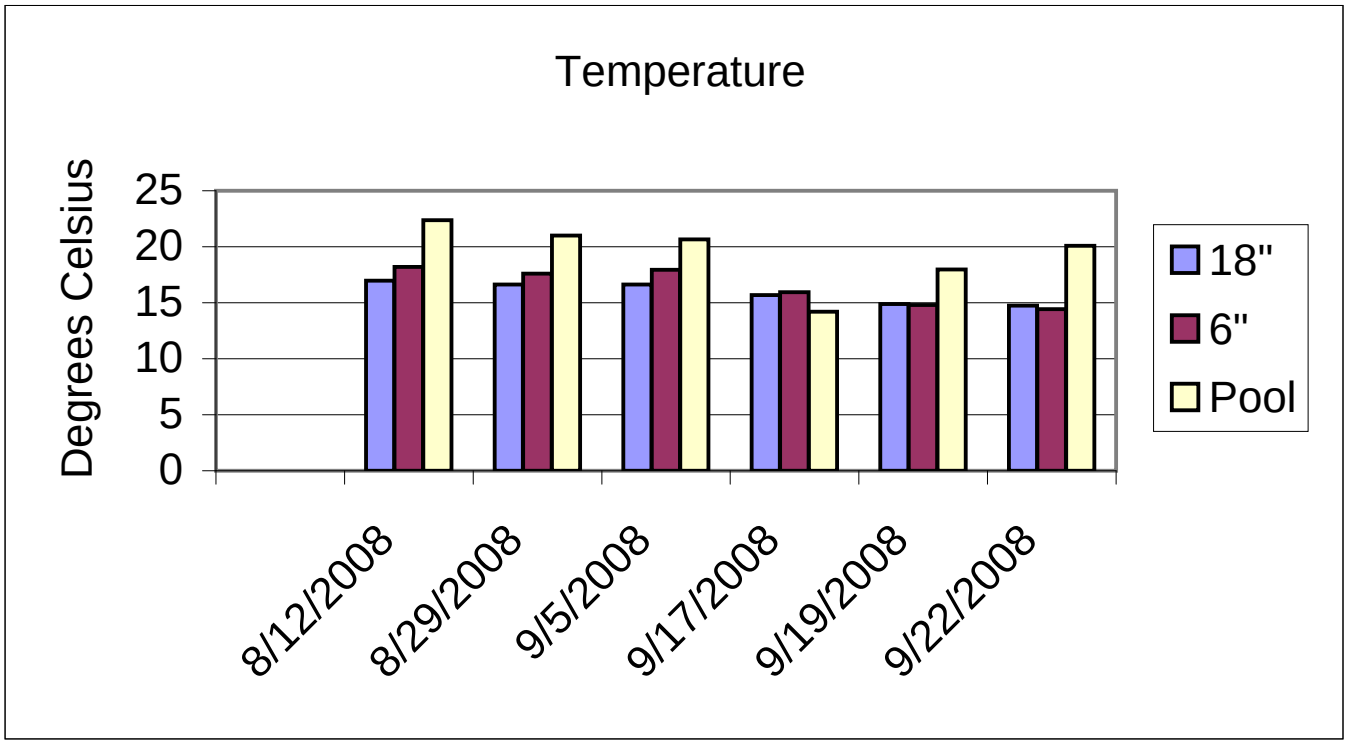
Water Sampling Station 1



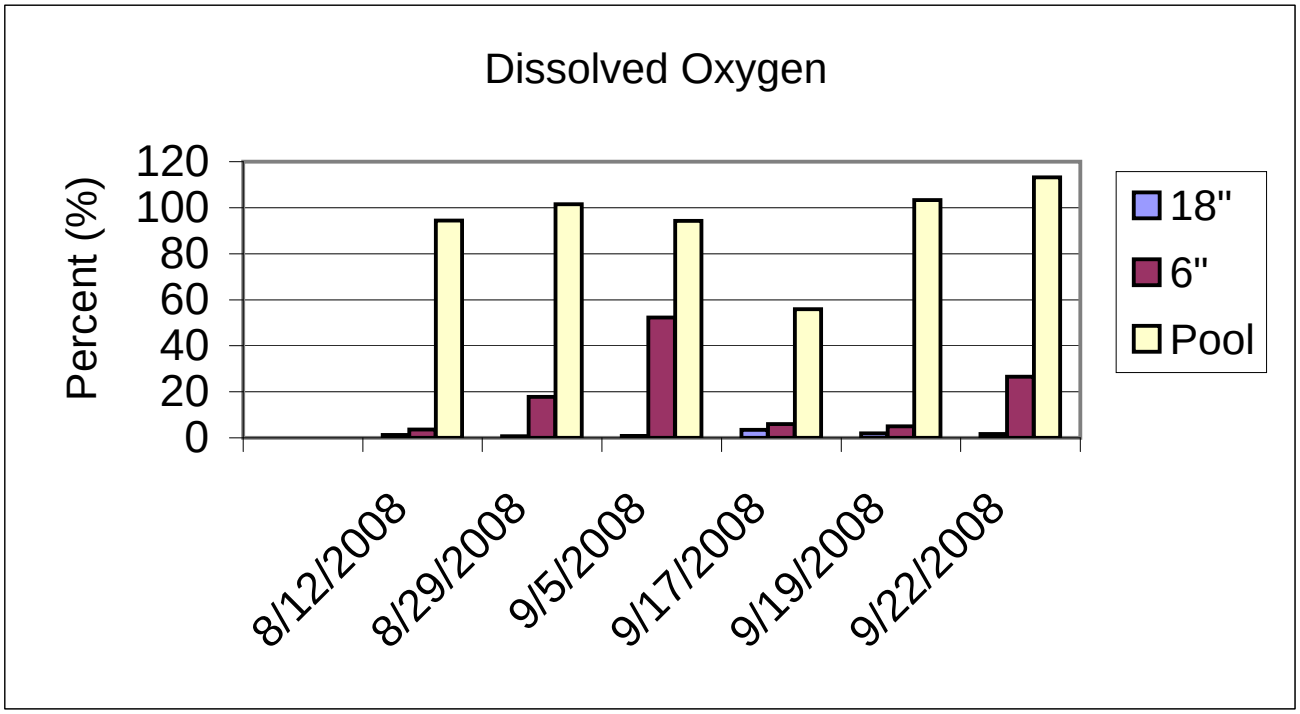


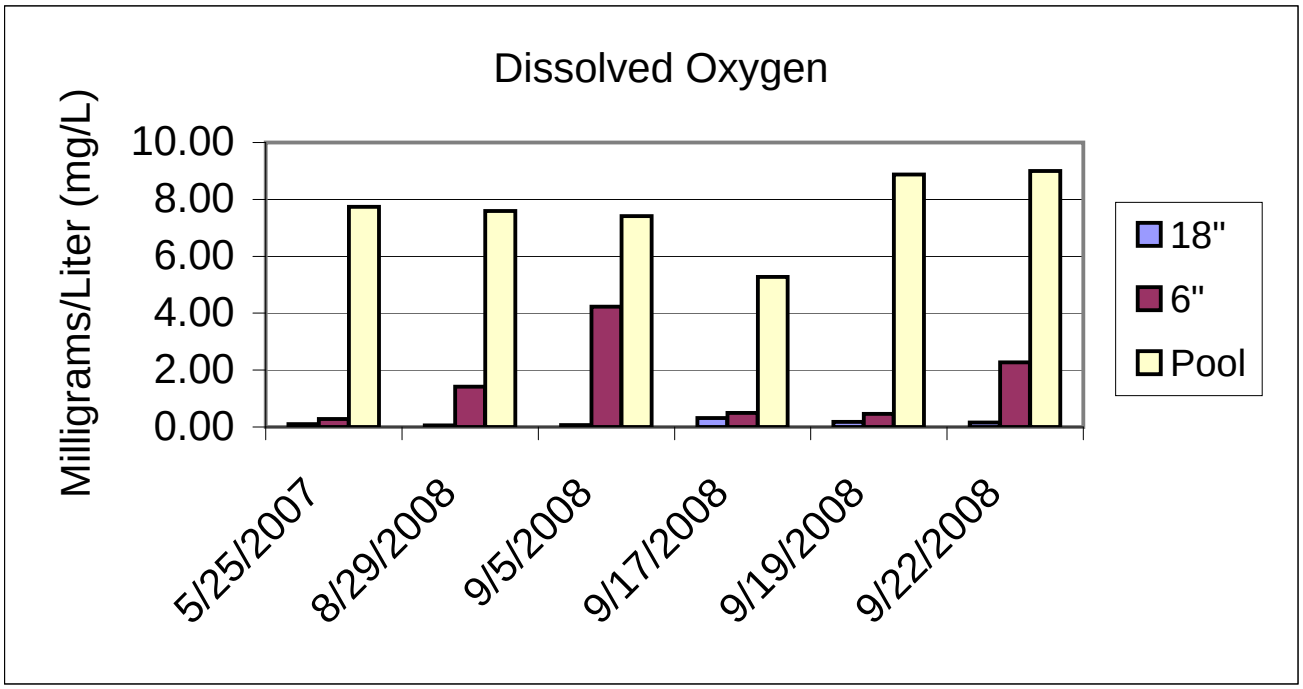
Water Sampling Station 1



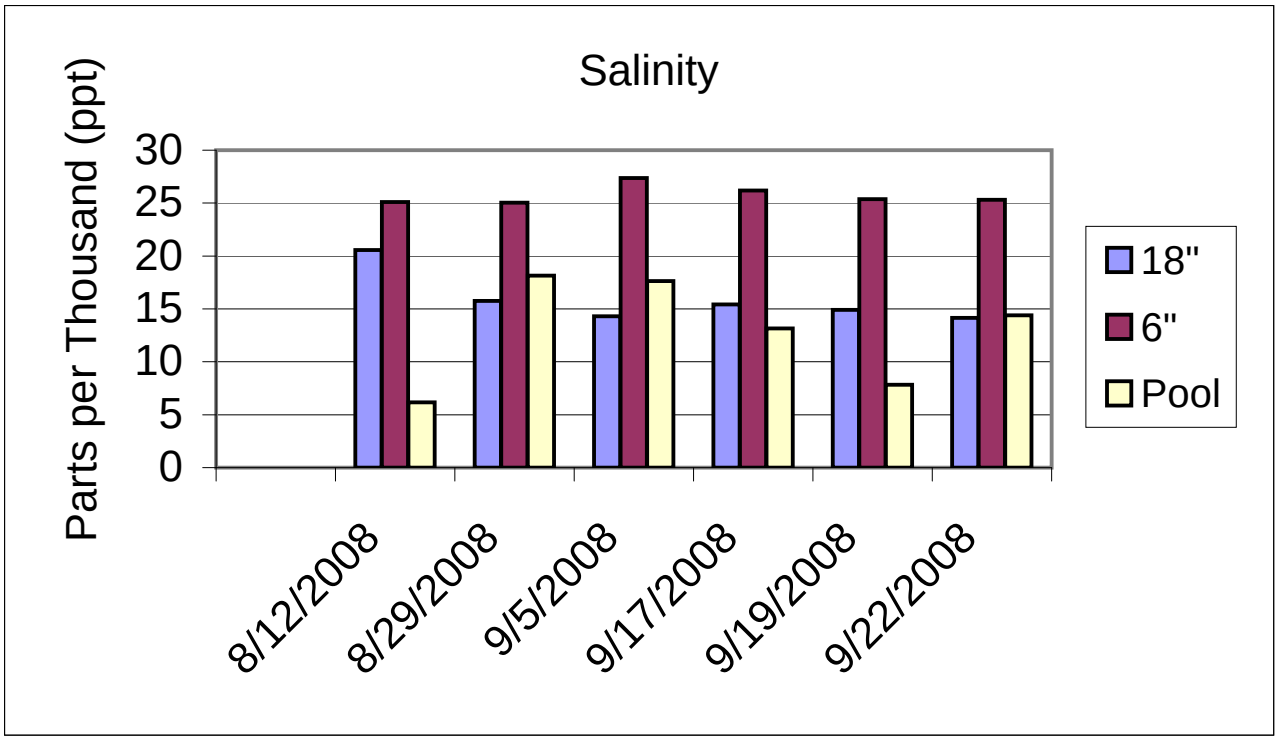


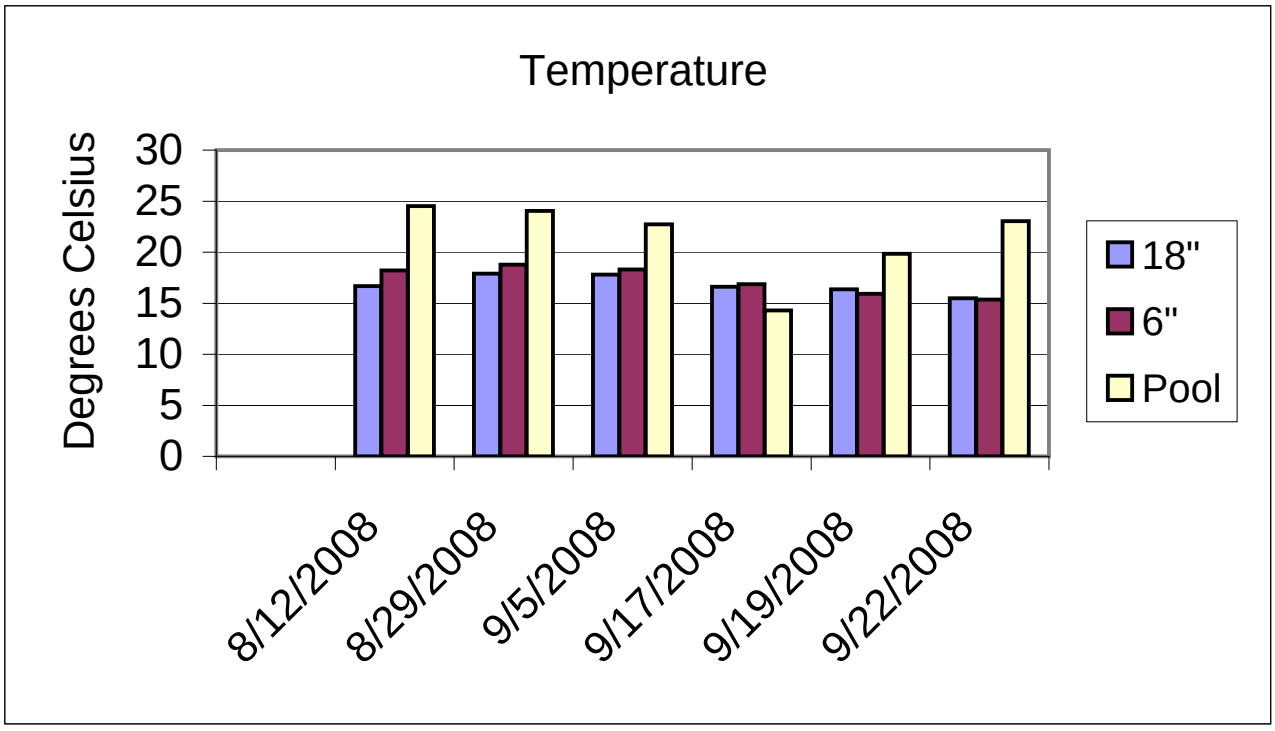
Water Sampling Station 2



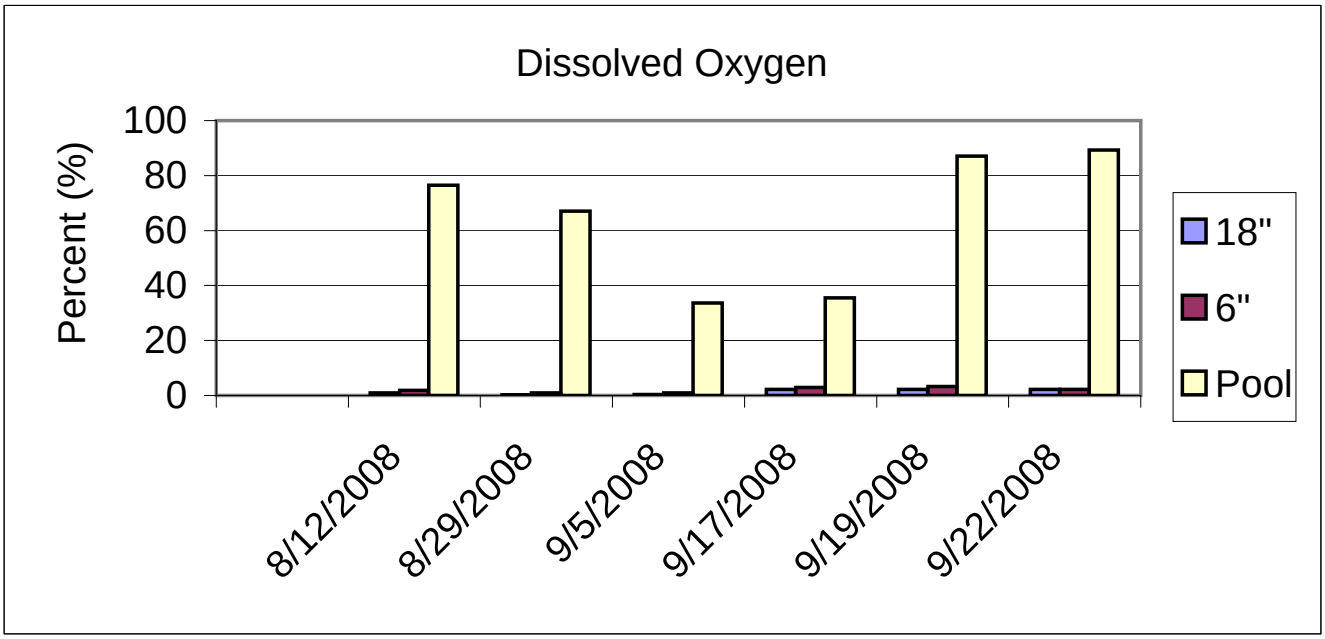


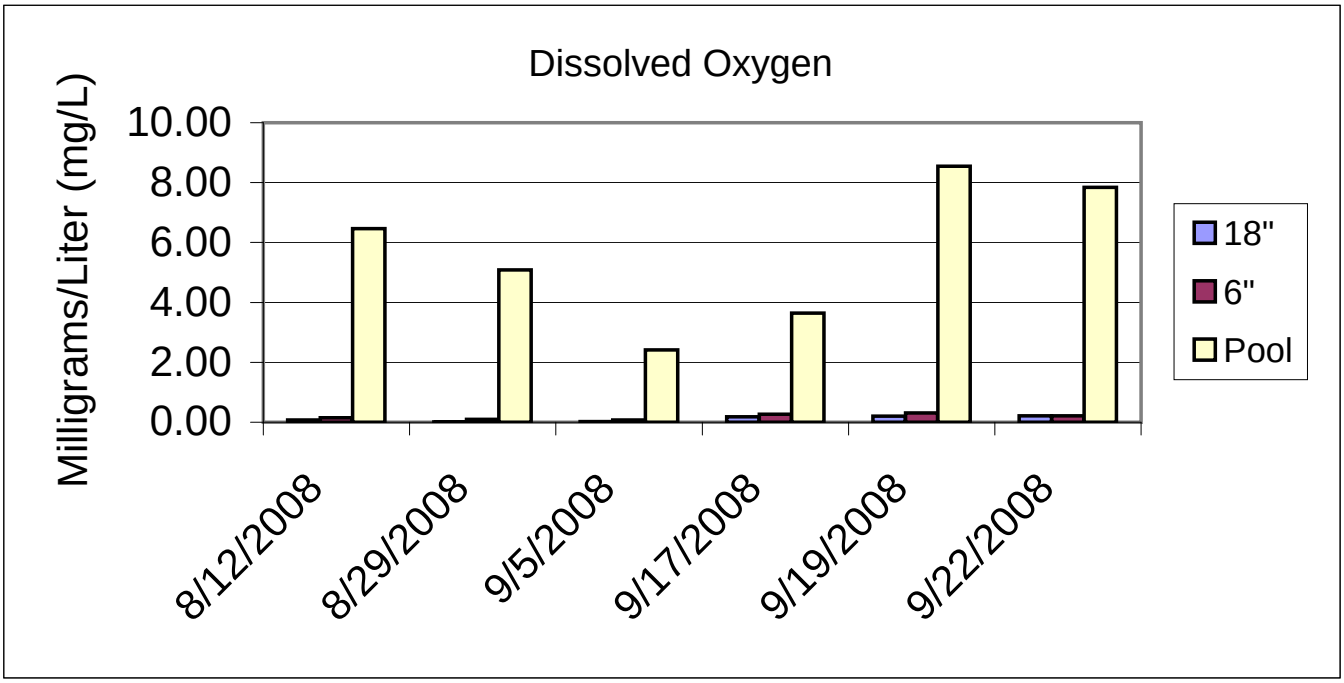
Water Sampling Station 2



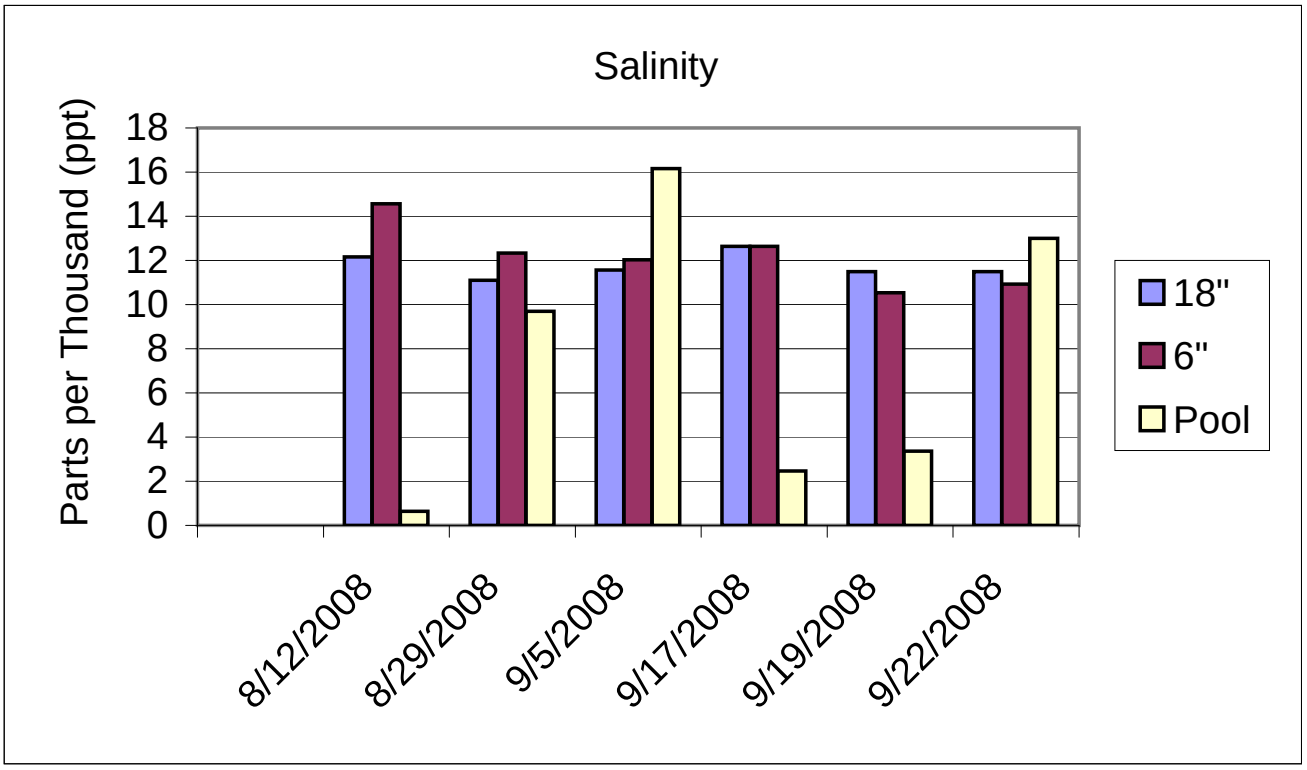


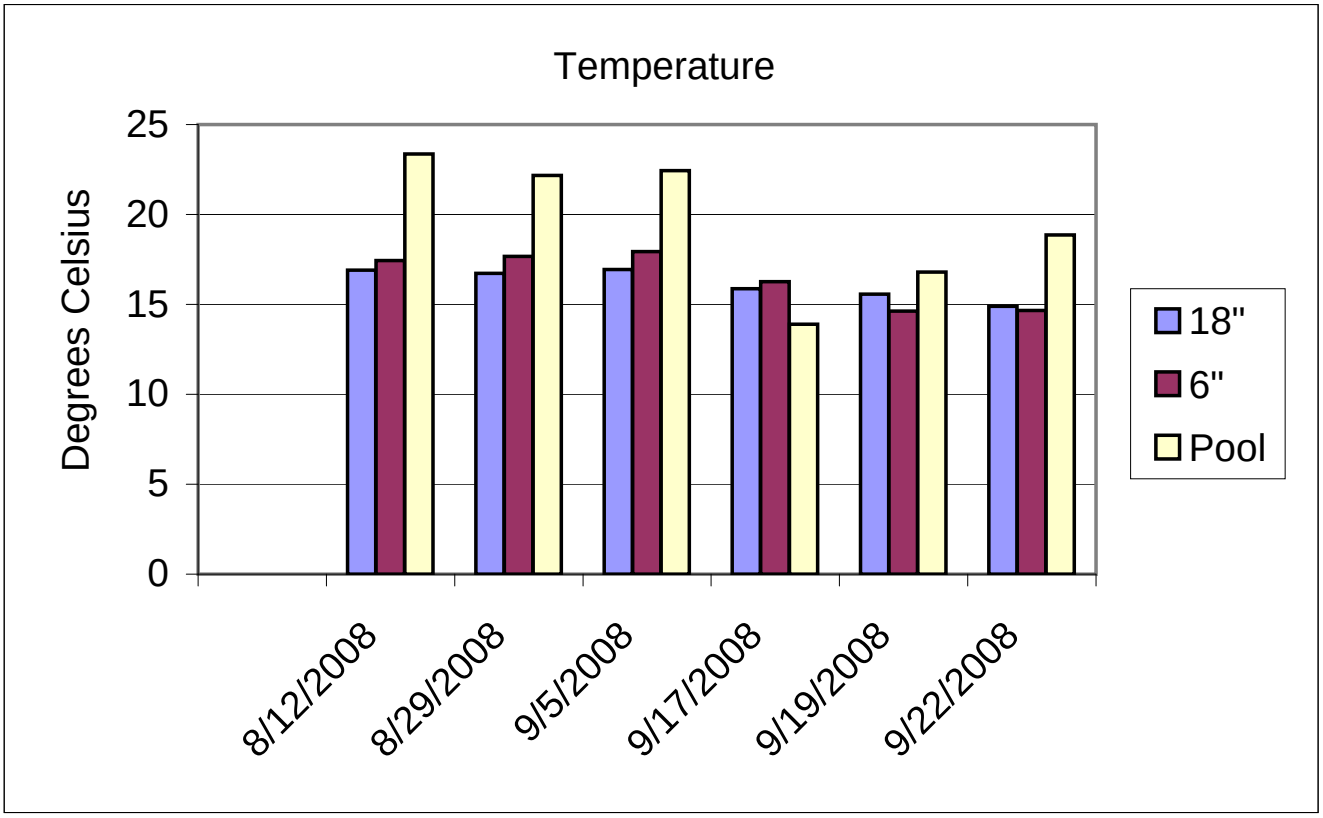
Water Sampling Station 3



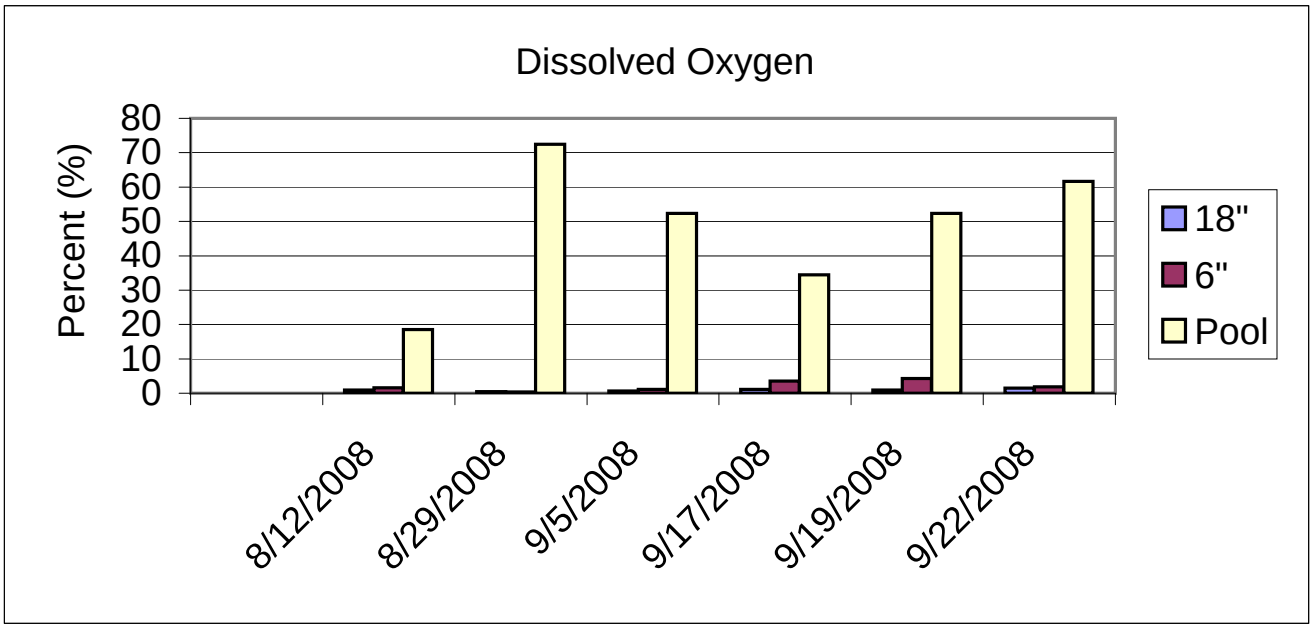


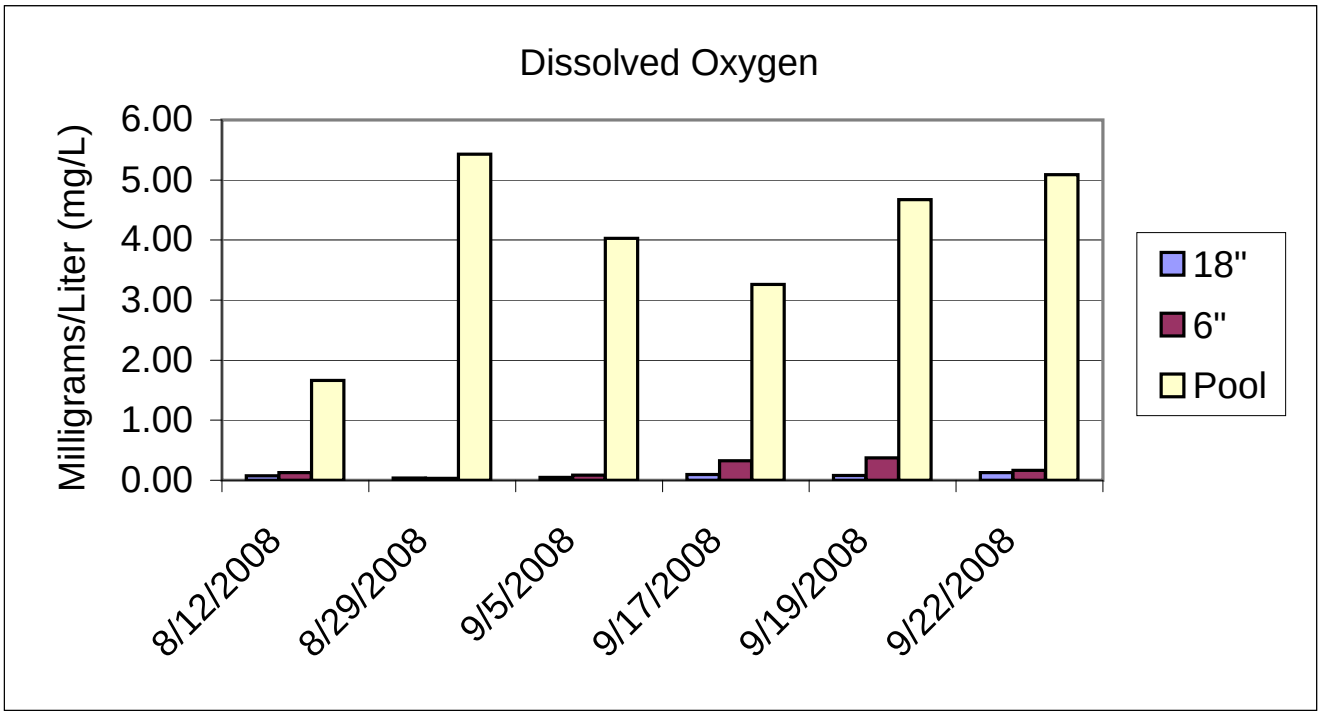
Water Sampling Station 3



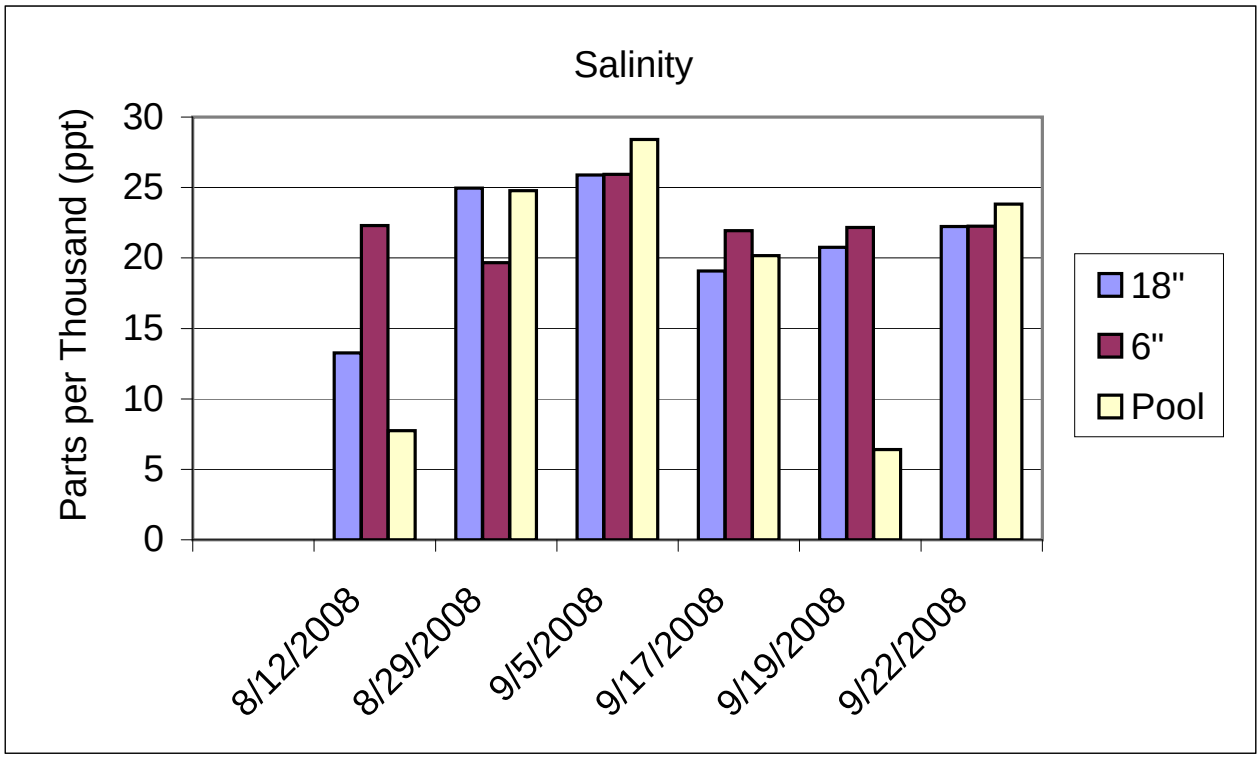


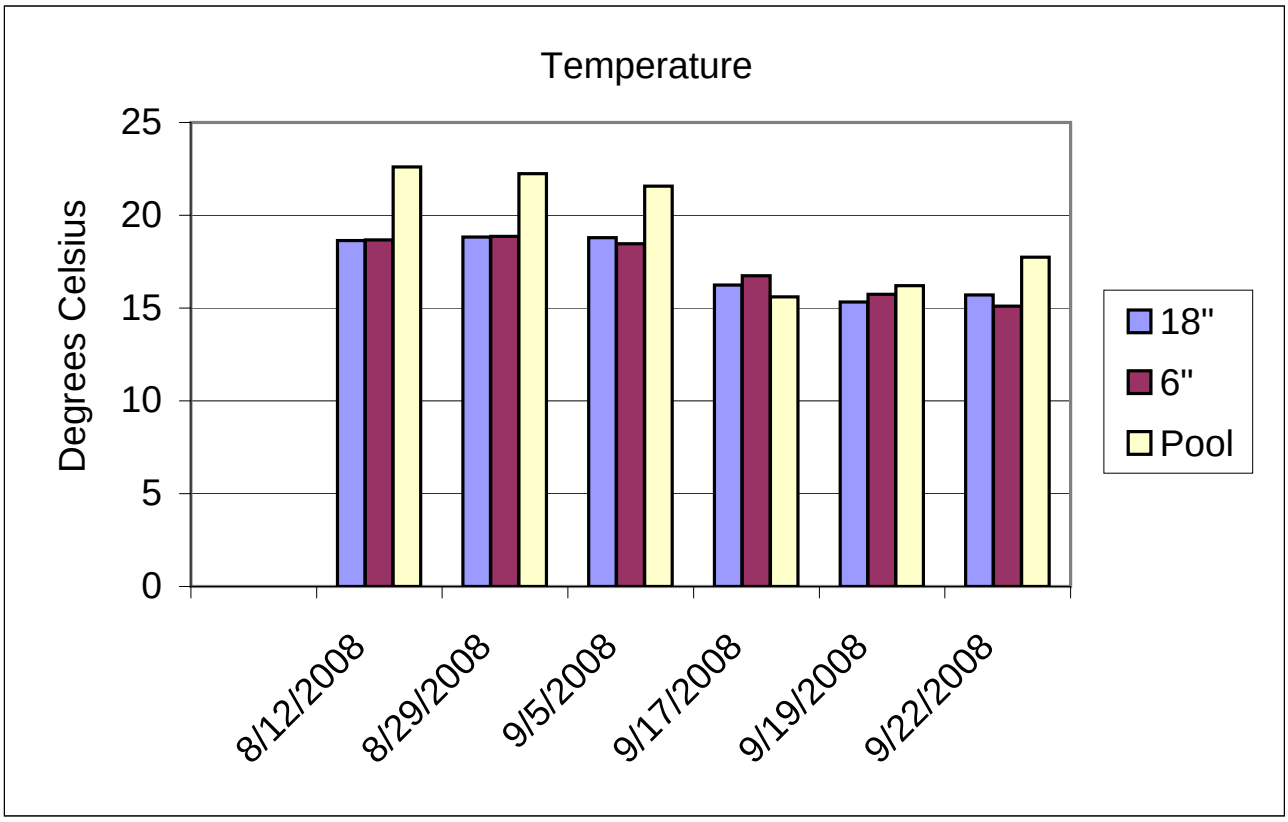
Water Sampling Station 4





Water Sampling Station 4





APPENDIX F

Field Notes

8/7/08 S. Watts & L. Rivard
8 AM on site

Field visit to deploy WLRs, mark photo stations w/ flags, + become familiar w/ site (LR)

Decision to reschedule Low Tide photos due to rainy weather. Reschedule for sunnier day.

Note - upon retrieval of WLRs - Measure actual depth + compare to depths in previous yrs - (mark w/ elec tape or w/ sharpie, bring tape)

Photo Station #3 - Not flagged
Calibrations w/ WLR station #3

Note: Plan on arriving close to low tide for site visits

WQ station #3 logger 49901 (check)
Pool is South - good size

WQ station #2 loggr 49904 pool to east linear in shape

Took photo of high-fresh water flow. Had to access site from east side of brook across bridge.

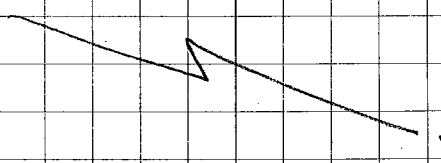
Birds 8/7/08

Great Blue Heron GRBH
salt marsh sharp Tailed Sparrows (SMST)
Blue Jay
Sparrow (Barn?)
↳ Baltimore
NKINGFSHR
Red Wing Blk Bird
Sand Piper sp.

CWQ #4 49906 logger
pool is north

WQ #1 44902 logger
small pool toward ~~fifth~~ marsh area

Field visit complete 10:30 AM



8/12/08 WQ + WLR download
L. Rivard onsite: 2 PM

2.22 Station #3 - WLR download OK.
Renamed Logger Sta# 3 (49901)

surface water depth @ station = 0

	DO%	DO mg/L	SAL	T
18"	1.1	0.09	12.3	16.9
	1.0	0.08	12.2	16.9
	0.8	0.06	12.0	16.9
6"	1.5	0.12	14.6	17.4
	2.0	0.17	14.3	17.5
	2.0	0.17	14.8	17.4
Pool	79.6	6.72	0.6	23.4
	78.8	6.66	0.7	23.3
	71.2	6.00	0.6	23.4

Pool depth = 6" +

Wildlife - Large tree frog. Brown w/ Black spots
Dragonfly 1 @ 3" inches long

Station # 2 3:07 PM
WLR download OK
Renamed Logger Station #2 (49904)

surface water depth @ station = 0

	DO%	DO mg/L	Sal (ppt)	T (C)
18"	1.0	0.09	20.9	16.7
	1.4	0.11	20.8	16.6
	1.4	0.12	20.0	16.7
6"	1.3	0.10	26.8	18.2
	3.5	0.27	25.0	18.2
	6.2	0.49	23.5	18.2
Pool	90.0	7.56	6.2	24.5
	95.5	7.75	6.2	24.5
	97.7	7.90	6.1	24.5

Pool depth = 3"

Wildlife - seagulls + white egret
. Blackbeak + feet

Station #4 3:48 PM

WLR download OK

Renamed logger to Station #4 (499906)

	DO%	DO mg/L	Sal (ppt)	T (C)
18"	0.8	0.07	12.6	18.7
	1.0	0.09	13.7	18.6
	0.9	0.07	13.5	18.6
6"	1.2	0.10	26.3	18.6
	1.6	0.12	21.0	18.7
	1.9	0.16	19.6	18.7
Pool	9.2	0.79	14.8	23.1
	20.0	1.84	3.9	22.4
	26.5	2.36	4.5	22.3

Depth of surface water @ station 1"

Depth of pool = 12"

Station #1 4:23 PM

WLR download OK

Renamed logger Station #1 (499902)

* Next time dk batteries (11.92 volts)

T is in Celsius

History not cleared

	DO%	DO mg/L	Sal (ppt)	T (C)
18"	1.1	0.10	10.9	16.7
	1.5	0.13	10.8	17.0
	2.0	0.18	10.5	17.2
6"	1.2	0.11	8.5	18.3
	1.5	0.13	9.0	18.2
	1.3	0.11	9.3	18.1
	16.8	1.39	7.1	22.1
Pool	21.3	1.79	6.3	22.5
	20.8	1.70	7.4	22.5

Depth of surface water at station = 0

Depth of Pool = 3.5"

Wildlife: Mourning Dove - Butterfly - Brown w/ orange spots (2) Grasshoppers

Back @ on 5:15

8/29/08 Onsite 3:10 PM LR
pt cloudy w/ sunshine
Lt. Breeze

Blue jays heard Crow
Prof Black Ducks

Station 3 3:30 PM
- 4:03 PM

WLR download - OK Volts - 16.6
surface water depth = 0

	DO%	DO mg/L	Sal	T
18"	0.4	0.03	10.8	16.8
	0.1	0.00	11.2	16.7
	0.1	0.01	11.3	16.7
6"	0.7	0.05	12.6	17.6
	0.9	0.12	12.1	17.6
	1.3	0.11	12.3	17.8
Pool	75.0	4.96	11.3	22.1
	69.3	5.69	9.8	22.3
	56.8	4.61	8.0	22.1

Rod depth = 8.5"

Station 2 4:10 PM
- 4.40

WLR download = OK
Volts = 16.57

Surface water depth = 0"

	DO%	DO mg/L	Sal	T
18"	0.5	0.04	11.0	17.8
	0.5	0.04	15.6	17.9
	0.9	0.08	14.7	18.0
6"	18.0	1.40	24.9	18.8
	16.1	1.30	25.1	18.7
	19.1	1.54	25.1	18.8
Pool	99.0	7.52	18.5	24.0
	102.4	7.50	18.1	24.0
	103.3	7.75	17.8	24.1

Pool depth = 3.5"

Station #4 great egret
dead Bittern on way
WLR download - OK
Volts - 16.42
Surface water depth - 0, ground saturated
large hole near logger pipe ~ 3+ ft deep.

	DO%	DO mg/L	Sal	T
18"	0.4	0.04	25.0	18.8
	0.4	0.03	25.0	18.8
	0.5	0.04	24.9	18.9
6"	0.2	0.02	20.1	18.7
	0.2	0.02	19.4	18.9
	0.7	0.06	19.5	19.0
Pool	72.6	5.41	26.4	22.2
	73.0	5.46	25.2	22.4
	71.9	5.42	22.7	22.1

Pool depth - 1ft (12")

PM 4:50 - 5:30

Station #1 - PM 5:35 + 6:07
WLR download - original connection w/ logger failed
Installed 2 new batteries - connection successful

Volts - 18.79

* data missing for 8/19/2008 16:47 - 8/29/2008 17:38

	DO%	DO mg/l	Sal	T
18"	0.8	0.08	10.5	16.4
	4.5	0.40	10.1	16.6
	9.7	0.82	9.8	16.9
16"	1.0	0.08	7.6	17.6
	1.4	0.13	7.8	17.6
	1.4	0.12	7.8	17.6
Pool	24.3	2.01	10.3	21.0
	29.8	2.69	9.9	20.7
	25.2	1.96	10.6	21.3

surface water depth @ station = 0
Pool depth = 2"

Back at car - 6:30
end

9/5/08 LR & (JR) ON Site 8:05
Breezy & overcast 70's
station 3 - 8:30 - 9:00

WLR Download - OK 16.3 volts

	DO%	DO mg/L	Sal	T
18"	0.3	0.02	11.8	16.7
	0.3	0.03	11.6	17.0
	0.3	0.03	11.3	17.1
6"	0.6	0.05	12.1	17.9
	0.7	0.06	12.0	18.0
	1.4	0.12	12.0	17.9
Pool	34.2	2.71	19.8	22.0
	34.1	2.10	18.5	22.5
	32.5	2.42	10.2	22.8

surface water depth = 0
Pool depth = 7.5"

Note Low Tide Was @ ~7:30

Station 2 9:02 - 9:25
WLR download - OK
volts 16.6

	DO%	DO mg/L	Sal	T
18"	.9	0.08	14.3	17.9
	.8	0.07	14.3	17.7
	.6	0.05	14.3	17.8
6"	50.9	4.07	27.4	18.0
	48.5	4.05	27.4	18.4
	57.6	4.58	27.3	18.5
Pool	0.2	7.39	18.6	22.6
	96.9	7.43	17.7	22.8
	95.8	7.42	16.6	22.8

surface water depth = 0
Pool depth = 2"

heard woodpecker

Station 4 -
9:35 - 10:10
WLR download
Volts - 16.15

	DO%	DO mg/L	Sal	T
18"	0.5	0.04	25.9	18.7
	0.8	0.06	25.9	18.8
	0.6	0.04	25.9	18.9
6"	1.2	0.09	25.8	18.8
	1.2	0.10	25.7	18.5
	0.9	0.07	26.3	18.1
Pool	53.0	4.00	28.3	21.5
	49.3	3.98	28.9	21.5
	54.8	4.11	28.0	21.7

surface depth @ station = 0 but saturated
Pool depth = 9"

Station #1 10:20 - 11:05
Volts 17.69
WLR download - trouble connecting to logger. Changed batteries, again but connection failed. Rebooted computer. Reinstalled original batteries. Download OK.

	DO%	DO mg/L	Sal	T
18"	.2	0.02	9.9	16.3
	0.4	0.04	9.8	16.5
	0.4	0.03	9.6	17.1
6"	0.3	0.03	7.6	17.7
	0.3	0.02	7.4	18.0
	0.7	0.06	7.3	18.1
Pool	1.10	0.90	11.1	20.4
	2.0	0.18	10.5	20.7
	1.0	0.14	11.0	20.9

Pool depth = 2" pool very small barely enough to take sample
Surface water depth @ Station = 0

Back @ vehicle - 11:30 AM

end.

LR/vard

Wed Sept. 17 2008 Low tide ~5:30
On site @ 5:45. Too dark waited until ~6:10 to head out into marsh.

Heard catbird in woods next to car,

on the way to Station 3 flushed 3 brown ducks w/ white patches on either side of tail. (2 mallard or similar) + sm brown marsh bird that flew back into vegetation. (willet?)

WIND CALM Dense fog ~ 65°

Station #3 6:35 AM - 7:20 AM

	DO%	DO mg/L	Sal	T
18"	1.9	0.17	11.3	15.9
	2.2	0.19	11.2	15.9
	2.5	0.20	11.2	15.8
6"	2.7	0.25	12.6	16.3
	3.2	0.29	12.6	16.3
	3.0	0.27	12.7	16.2
Pool	34.0	3.48	3.2	14.0
	35.0	3.57	2.8	14.1
	37.5	3.88	1.4	13.6

WLR download OK Volts 15.7
Surface water = 0 - saturated Pool depth = 7"

Station # 2 7:23 - 8:00 AM

WLR download OK volts 15.97

	DO%	DO mg/L	Sal	T
18"	3.7	0.33	15.3	16.7
	3.7	0.33	15.1	16.6
	3.2	0.28	15.9	16.5
6"	3.4	0.29	26.4	17.0
	7.2	0.59	20.1	16.8
	7.2	0.60	26.1	16.8
Pool	56.1	5.33	13.3	14.3
	56.2	5.29	13.3	14.3
	55.2	5.22	12.9	14.3

Surface water depth = 0 but saturated
Pool depth = 2.5"

Station #4 8:10AM - 9:00AM

WLR download OK volts 15.58

Canada geese, deer tracks

	DO%	DO mg/L	Sal	T
18"	1.3	0.11	18.9	16.3
	0.8	0.07	19.2	16.2
	1.2	0.10	19.1	16.2
6"	2.0	0.20	23.1	17.0
	4.8	0.43	21.8	16.7
	3.8	0.34	20.9	16.5
Pool	34.9	3.14	18.9	16.0
	34.2	3.23	20.5	15.8
	34.3	3.41	21.1	15.0

surface water <0.5"

Pool depth - 10"

med bird black wings w/ white belly
purple sandpiper ~~or sooty tern?~~
* (solitary sandpiper (in ag Poup)?
long beak - call is close to
peet weet weet stated in book

Station #1 9:10AM - 9:42AM

WLR download OK volts 16.99

buffy kestrel? mourning doves

reset settings (uncheck mly log + Δ by)

	DO%	DO mg/L	Sal	T
18"	3.6	0.32	9.8	15.7
	1.8	0.17	9.8	15.7
	1.7	0.15	9.8	15.7
6"	2.0	0.19	8.1	15.9
	1.6	0.15	8.4	16.0
	1.4	0.13	8.4	15.9
Pool	7.1	0.73	4.1	14.1
	6.3	0.64	5.9	14.2
	5.0	0.49	9.0	14.3

surface water depth = 0, saturated

pool depth = 3"

Back @ truck - ~10:05AM

end

9/19/08 LR onsite 9:00AM
sunny - light breeze ~65°
Photos LOW Tide + WLR + WQ

station # 2 pics # 5 - 12

Station # 10 pics 13, 14, 15
(forgot 10C - taken on way back to car)

station # 1 # 16 - 21

station # 3 22 - 34

station # 4 - # 35 - 40

Station # 6 41 - 49

station # 7 - 50 - 57

station # 5 58 - 61
62

Station # 8 63 - 66

station # 9 67 - 70

Station # 10C -

• Station # 3 9:30 - 10:23
(after pics # 3)

WLR download - OK volts 15.6
surface water = 0

	DO%	DO mg/L	Sal	T
18"	3.0	0.28	11.5	15.7
	2.1	0.19	11.5	15.5
	1.6	0.14	11.5	15.5
6"	2.7	0.27	10.2	14.3
	2.8	0.27	10.7	14.8
	4.2	0.40	10.7	14.8
	~~4.66~~	~~9.34~~	6.1	16.9
Pool	96.6	9.34	6.1	16.9
	89.2	8.75	3.7	17.4
	75.3	7.55	0.3	16.1

Pool depth = 7"

Station #2 10:25 - 11:05
WLR download - OK volts - 15.92

	DO%	DO mg/L	Sal	T
18"	3.8	0.34	15.2	16.5
	0.9	0.08	14.8	16.3
	1.3	0.11	14.7	16.3
6"	1.7	0.17	25.5	16.0
	4.5	0.41	25.4	16.0
	9.0	0.79	25.2	15.8
Pool	103.6	8.99	8.4	19.7
	104.1	9.02	8.4	19.8
	102.2	8.63	6.7	20.0

surface water depth = 0

Pool depth - 3"

station # 4 - 11:20 -
WLR download ok volts 15.49
surface water depth = ~ 1"

	DO%	DO mg/L	Sal	T
18"	0.8	0.08	20.8	15.3
	1.2	0.10	20.8	15.3
	0.7	0.06	20.7	15.4
6"	4.0	0.35	22.0	15.7
	4.3	0.37	22.3	15.8
	4.6	0.40	22.2	15.7
Pool	51.6	4.51	6.2	16.2
	52.5	4.83	9.6	16.2
	52.8	4.68	3.4	16.2

Pool depth = 8.5"

Station #1 12:10 —
WLR download - OK Volts = 16.88

	DO%	DO mg/L	Sal	T
18"	0.8	0.07	9.2	14.9
	0.8	0.07	9.8	14.9
	0.7	0.07	9.8	14.9
6"	1.0	0.09	8.1	14.8
	0.6	0.07	8.1	14.8
	1.8	0.18	8.1	14.8
Pool	21.1	1.94	9.4	18.1
	18.7	1.69	9.1	18.1
	14.5	1.31	9.1	17.7

surface water depth = 0

Pool depth = 3"
Pool is v. small
~ .5 ft × 3 ft

backe car —
end Low tide session
12:50
after pics 8/4 1:10 pm

9/19/08 LR 2:15 PM
High Tide Photos

Stat #8 71 - 74
Stat #9 75 - 78
Stat #2 79 - 83
Stat #10 84 - 86
Stat #1 87 - 90
Stat #3 91 - 97
Stat #4 ~~98~~ - 120 - ?
Stat #6 106 - 112
Stat #7 - 113 - 119
Stat #5 - 102 - 105
98 - 19 spider

end 4:45 PM

9/22/08 LR 10:00 AM
Revisit PinePt photo locations
#8 ? 126 - 130 5 photos
#9 ? 131 - 135 5 photos
10:10 end

9/22/08 LR + (SWATTS veg mon) pull
Stat. #3 WLRs + WQ ? start site assessment
10:45 - 11:11 AM

	DO%	DO mg/L	Sal	T
18"	2.4	0.23	11.5	14.9
	2.3	0.21	11.5	14.9
	2.1	0.19	11.5	14.9
6"	2.2	0.20	11.0	14.7
	2.2	0.21	10.9	14.7
	2.4	0.23	10.9	14.6
Pool	97.0	8.53	9.5	18.9
	90.6	7.70	15.0	19.0
	80.3	7.30	14.5	18.7

surface water depth @ station = 0
Pool depth - 7"

Cormorant (all black)
hawk - ~~red tailed~~ or 10 bycall (SW)
~~red shouldered~~

Stat #2 11:13 - 11:43

	DO%	DO mg/L	Sal	T
18"	2.4	0.22	14.2	15.5
	1.5	0.13	14.2	15.5
	1.3	0.11	14.1	15.5
6"	27.2	2.33	25.2	15.3
	25.8	2.23	25.3	15.4
	26.6	2.26	25.4	15.4
Pool	108.5	8.67	14.4	23.3
	114.8	9.10	14.5	22.9
	116.4	9.21	14.3	22.9

surface water depth @ station = 0

Pool depth = 2.5"

Stat #4 — AM 11:50 - 12:28 PM

	DO %	DO mg/L	Sal	T
18"	2.2	0.19	22.4	15.6
	1.5	0.13	21.9	15.7
	0.8	0.07	22.4	15.8
6"	1.5	0.13	22.5	15.1
	2.3	0.19	22.1	15.1
	1.9	0.17	22.2	15.1
Pool	62.1	5.08	26.1	17.7
	59.3	5.09	20.2	17.7
	63.5	5.10	25.2	17.8

surface water depth @ station = 1"

Pool depth = ~11"

Station #1 12:35 PM -

	DO %	DO mg/L	Sal	T
18"	1.1	0.11	9.7	14.7
	1.2	0.11	9.7	14.7
	1.1	0.11	9.7	14.8
6"	1.6	0.16	7.9	14.4
	1.9	0.19	7.9	14.4
	2.6	0.25	7.9	14.5
Pool	16.4	1.41	7.6	19.8
	12.3	1.05	9.5	20.3
	12.4	1.07	9.4	20.2

surface water @ station = 0

pool depth = 3"

DCCO green frog Downy Woodpecker

RTHA bl. capped chickadee

0 ——— 2 ——— 0 end of day @ car

10/17/08 Cascade Brook 0730

S. WATTS
Site Assessment
outgoing low tide
cool 45-50°F
intermittent wind

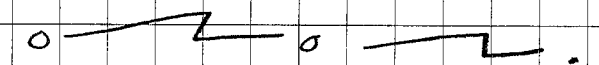
See data form for completed site assessment.

BEKI
AMGO
BLJA
DCCO
Sparrow
AMCR

END 0930 SW

10/31/08 7:15AM S. Watts + L. Rivard

Cover Type mapping update
730-1030



APPENDIX G

Species List

Species Observed in the vicinity of the Cascade Brook Project Area[1].

Common Name	Scientific Name	Visual Categories	Pre-Monitoring	Year 1 Post-Monitoring	Year 2 Post-Monitoring	Year 4 Post Monitoring	Year 5 Post Monitoring
Birds							
Alder flycatcher	*Empidonax alnorum*	Passerine	x				
American black duck	*Anas rubripes*	Water bird		x		x	x
American crow	*Corvus brachyrhynchos*	Passerine	x	x	x	x	x
American goldfinch	*Carduelis tristis*	Passerine	x	x	x		
Barn swallow	*Hirundo rustica*	Passerine					x
Belted kingfisher	*Ceryle alcyon*	Non-passerine	x	x	x	x	x
Black capped chickadee	*Parus atricapillus*	Passerine	x			x	x
Blue jay	*Cyanocitta cristata*	Passerine	x	x		x	x
Blue-winged teal	*Anas discors*	Water bird		x			
Canada goose	*Branta canadensis*	Water bird					x
Common grackle	*Quiscalus quiscula*	Passerine	x	x			
Common snipe	*Gallinago gallinago*	Water bird		x	x	x	x
Common yellowthroat	*Geothlypis trichas*	Passerine	x				
Double-crested cormorant	*Phalacrocorax auritus*	Water bird	x	x	x	x	x
Downy woodpecker	*Picoides pubescens*	Non-passerine	x	x	x		x
Eastern kingbird	*Tyrannus tyrannus*	Passerine	x				

Common Name	Scientific Name	Visual Categories	Pre-Monitoring	Year 1 Post-Monitoring	Year 2 Post-Monitoring	Year 4 Post Monitoring	Year 5 Post Monitoring
Birds (continued)							
Eastern phoebe	*Sayornis phoebe*	Passerine	x				
Eastern wood-pewee	*Contopus virens*	Passerine	x				
European starling	*Sturnus vulgaris*	Passerine	x				
Glossy ibis	*Plegadis falcinellus*	Wading bird	x	x		x	
Gray catbird	*Dumetella carolinensis*	Passerine	x				x
Great black-backed gull	*Larus marinus*	Seabird	x				
Great blue heron	*Ardea heroides*	Wading bird	x	x		x	x
Great egret	*Ardea alba*	Wading bird	x	x	x	x	x
Greater yellowlegs	*Tringa melanoleuca*	Wading bird	x	x	x	x	
Green-winged teal	*Anas crecca*	Water bird		x			
Green heron	*Butorides virescens*	Wading bird	x	x			
Herring gull	*Larus argentatus*	Seabird	x	x	x	x	x
Killdeer	*Charadrius vociferous*	Wading bird	x	x			
Kinglet species	*Regulus* species	Passerine	x				
Least sandpiper	*Calidris minutilla*	Wading bird	x		x	x	x
Lesser yellowlegs	*Tringa flavipes*	Wading bird	x	x	x		
Mallard duck	*Anas platyrhynchos*	Water bird	x	x	x	x	x

Common Name	Scientific Name	Visual Categories	Pre-Monitoring	Year 1 Post-Monitoring	Year 2 Post-Monitoring	Year 4 Post Monitoring	Year 5 Post Monitoring
Birds (continued)							
Marsh wren	*Cistothorus palustris*	Passerine	x			x	
Mourning dove	*Zenaida macroura*	Non-passerine	x	x			x
Northern cardinal	*Cardinalis cardinalis*	Passerine	x				
Northern harrier	*Circus cyaneus*	Bird of prey	x	x	x	x	
Purple sandpiper	*Calidris maritima*	Passerine		x			
Red-eyed vireo	*Vireo olivaceus*	Passerine	x				
Red-tailed hawk	*Buteo jamaicensis*	Bird of prey	x	x	x	x	x
Red-winged black bird	*Agelaius phoeniceus*	Passerine	x				x
Sanderling	*Calidris alba*	Wading bird				x	
Saltmarsh sharp-tailed sparrow	*Ammodramus caudacutus*	Passerine	x	x	x	x	x
Sharp-shined hawk	*Accipiter striatus*	Bird of prey	x				
Snowy egret	*Egretta thula*	Wading bird	x	x	x	x	x
Solitary sandpiper	*Tringa solitaria*	Wading bird					x
Solitary vireo	*Vireo solitarius*	Passerine	x				
Song sparrow	*Melospiza melodia*	Passerine	x				
Swamp sparrow	*Melospiza georgiana*	Passerine	x				
Tufted titmouse	*Baeolophus bicolor*	Passerine	x				

Common Name	Scientific Name	Visual Categories	Pre-Monitoring	Year 1 Post-Monitoring	Year 2 Post-Monitoring	Year 4 Post Monitoring	Year 5 Post Monitoring
Birds (continued)							
Willet	*Catoptrophorus semipalmatus*	Wading bird	x				x
Wood duck	*Aix sponsa*	Water bird	x				
Yellow-rumped warbler	*Dendroica coronata*	Passerine	x				
Mammals							
Deer tracks	*Odocoileus virginianus*	Large mammal	x	x	x	x	x
Eastern chipmunk	*Tamias striatus*	Small mammal	x				x
Raccoon track/scat	*Procyon lotor*	Large mammal	x	x	x	x	x
Seal (Harbor seal?)	*Phoca vitulina*	Large mammal	x	x			
Vole species		Small mammal	x				
Amphibians							
Eastern garter snake	*Thamnophis sirtalis*			x			
Green frog	*Rana clamitans*		x			x	x
Northern Leopard Frog	*Rana papiens*						x

[1] **Note:** Data collected on bird and wildlife observed using the project area are anecdotal observations collected during field sampling activities onsite, and are intended to provide additional information, and do not represent qualitative data collection. Additionally, these data are collected by individuals with a range of expertise in the identification of birds and wildlife, and therefore represent only a partial list of the species that may actually be using the project area.