SEAVEY LANDING SALT MARSH
YEAR 5 POST-RESTORATION MONITORING
PROJECT SUMMARY REPORT

SEAVEY LANDING, SCARBOROUGH, MAINE

January 2007

Prepared for:
Friends of Scarborough Marsh

Prepared by:

451 Presumpscot Street
Portland, ME 04103

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1.0 INTRODUCTION

The Scarborough Marsh Planning Team (SMPT) has initiated salt marsh restoration activities at Seavey Landing, in the Scarborough Marsh Wildlife Management Area, in Scarborough, Maine (Figure 1). SMPT comprises of 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 Resource Conservation Service (NRCS), Conservation Law Foundation, and Ducks Unlimited, Inc.

The primary goals of SMPT's restoration efforts at the Seavey Landing Salt Marsh Restoration Monitoring Project (Project) site are to:

- Increase the duration of flooding in temporary panes;
- Restore hydrologic functions as close as practicable to a pre-ditched condition, thereby increasing the elevation of groundwater; and,
- Increase the number of permanent pools on the marsh surface.

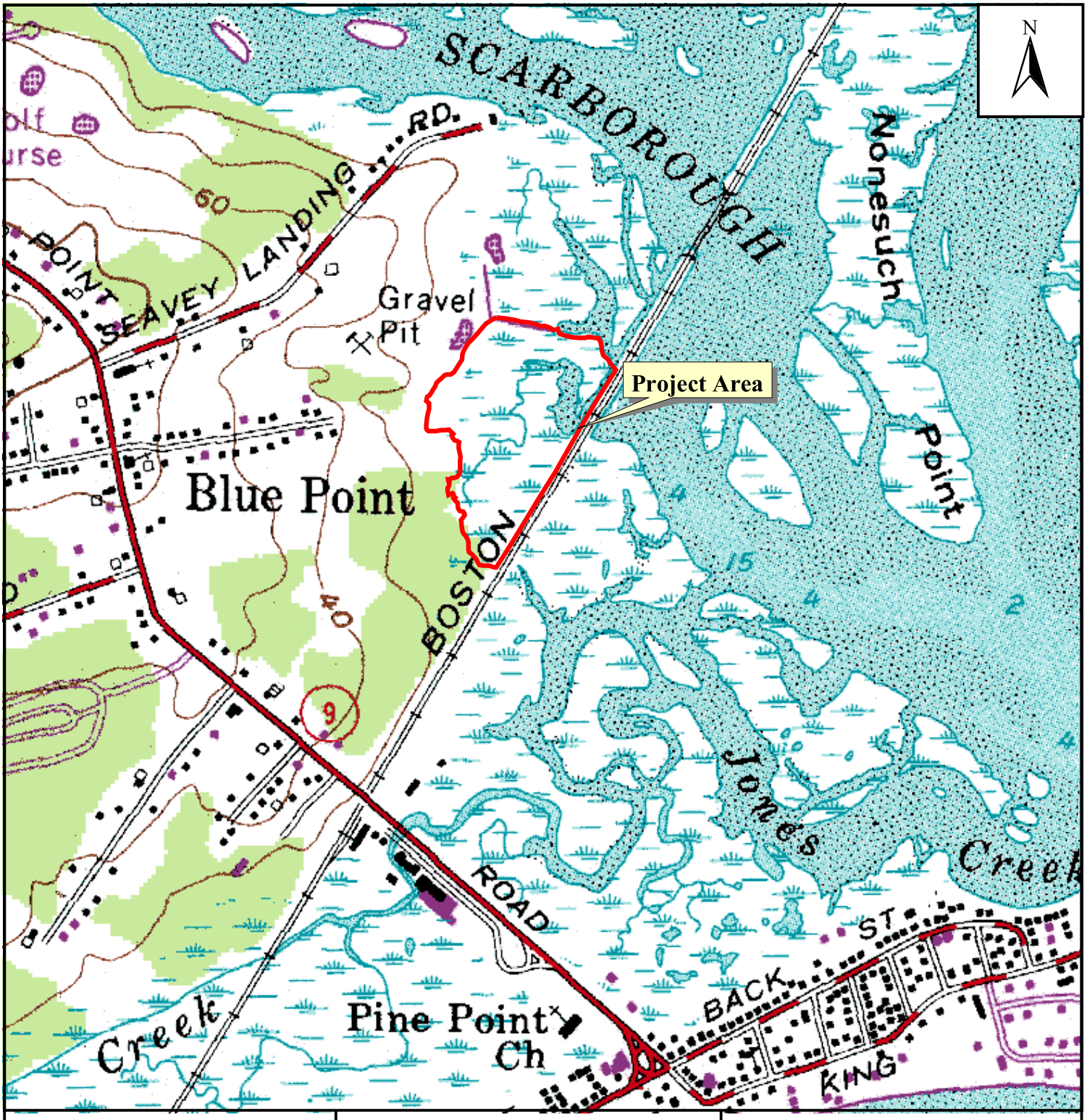
To accomplish these goals, restoration activity at Seavey Landing includes the following components:

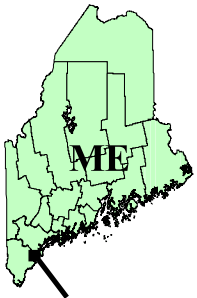
- Plugging man made ditches to restore hydrology to the marsh surface; and,
- Shallow excavation of panne areas on the marsh surface in order to promote permanent pool habitat.

Restoring natural salt marsh conditions and improving hydrological conditions will allow native salt marsh dependent species (i.e., fish, invertebrates, waterbirds, shorebirds, wading birds, waterfowl) to reestablish and/or to increase in number.

To assist in this effort, Northern Ecological Associates, Inc. (NEA) was contracted by the SMPT in 2001 to conduct pre- and post-restoration monitoring of a 38-acre portion of the Seavey Landing site. 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). The monitoring activities focused on an approximately 25-acre section of the marsh (Figure 1).

Ditch-plug construction was conducted by Swamp, Inc., in the winter of 2002. Ditch plugs were created by pounding a plywood board, or multiple plywood boards if the ditch being plugged was very large, into the marsh surface, perpendicular to the ditch. The plugs were back-filled, both upstream and downstream of the installed plywood board, with marsh material excavated from small pannes or created pools near the plug, or from the sloping ditch edges behind the plug.





Project Location

500 0 500 1000 Feet

100 0 100 200 Meters

Source: USGS 7.5' Series Topographic Quadrangle, Prouts Neck, 1957 Photorevised 1978

Figure 1. Location of Seavey Landing Salt Marsh Restoration Project, Scarborough, Maine.

Client: U.S. Fish & Wildlife Service & Friends of Scarborough Marsh

Prepared By: NEA Northern Ecological Associates, Inc.

Date: 11/10/03

e:/projects/seavey/aprs/figure1.apr

Pre-restoration monitoring activities were conducted in September and October 2001. Data gathered during 2001 monitoring activities were presented in the USFWS Seavey Landing Salt Marsh Pre-Restoration Monitoring Data and Documentation Report (USFWS 2002). Post-restoration monitoring activities were planned for the five years following completion of restoration. Year 1 through Year 4 post-restoration monitoring activities were performed in September, October and November 2002–2005. NEA conducted the Year 5 post-restoration monitoring activities during September and October 2006.

This Project Summary Report presents a comprehensive analysis of data collected during pre- and post-restoration monitoring activities for the Project. This report includes a brief discussion of monitoring methodology (Section 2.0), presentation of results and discussion (Section 3.0), and management implications and recommendations (Section 4.0). In addition, an updated cover type map of the Project area (Appendix A), site assessment data forms (Appendix B), photo documentation (Appendix C), water quality and water level data (Appendix D), field notes (Appendix E), and a list of wildlife species observed during monitoring activities (Appendix F) are also included with this report.

2.0 METHODS

Year 5 post-restoration monitoring tasks included documenting cover type changes in the Project area over the Project life, completing an annual site evaluation (site assessment, mosquito dip count, and photo documentation), collecting tidal signal data, measuring water quality, pore-water salinity, and ground water level, and incidental observations of any wildlife species usage of the area. The following sections provide a brief description and rationale for the sampling methodology, including the 2006 field monitoring effort. Comparisons to previous years monitoring activities are discussed in Section 3.0 Results and Discussion. Unless otherwise noted, monitoring methods and sample locations were consistent throughout the monitoring activities, as presented in the USFWS Seavey Landing Salt Marsh Restoration Pre-Restoration Monitoring Data and Documentation Report (USFWS 2002).

2.1 COVER TYPE MAP

A pre-restoration cover type map was generated for the approximately 25-acre Project area based on a review of digital ortho-quads, aerial photographs, and observations made during pre-restoration site visits in September through December 2002. The aerial extent and composition of vegetation communities was re-assessed during the fall and winter of 2006, and a 5-year post-restoration cover type map was prepared, for use in comparison with the pre-restoration cover type map (Appendix A).

Six dominant vegetated communities were differentiated and mapped. Unique wetland communities included:

- Salt marsh cordgrass (*Spartina alterniflora*)-dominated herbaceous salt marsh;
- Salt meadow cordgrass (*Spartina patens*)/salt meadow rush (*Juncus gerardii*)-dominated herbaceous salt marsh;
- *Scirpus*/*Juncus*-dominated herbaceous salt marsh;
- Salt marsh bulrush (*Scirpus robustus*)-dominated herbaceous salt marsh;
- Miscellaneous herbaceous/scrub-shrub wetlands; and,
- An invasive plant community, specifically broad-leaf cattail (*Typha latifolia*).

In addition, significant site features were recorded using a Trimble Pro-Mark IV Global Positioning System (GPS), and included as additional layers on the cover type map (Appendix A). These features included: pools, pannes, and tidal channels; restoration monitoring sampling stations; ditch plugs; photo stations; and, any other features considered to be noteworthy by the monitoring team. Community descriptions are provided below.

***Spartina alterniflora* (SPAL)** – An emergent salt-marsh community dominated by $\geq$ 50% cover of saltwater cordgrass. The other herbaceous species commonly found in this community is salt meadow cordgrass. Less dominant species in this community include salt marsh aster (*Aster subulatus*), seaside goldenrod (*Solidago sempervirens*), seaside arrow grass (*Triglochin maritimum*), and silverweed (*Potentilla anserina*). Saltwater cordgrass is commonly found in low-lying areas of the marsh that receive regular tidal inundation (i.e., intertidal marsh), such as

along the edges of pools and tidal channels, and in small clumps within lower elevation areas of pannes.

***Spartina patens/Juncus gerardii (*SPPA/JUGE)** – An emergent salt-marsh community dominated by a mixed cover of salt meadow cordgrass and blackgrass, with each representing ≥ 35% of the total cover within the community. Other less dominant species found in this community include silverweed, seaside arrow grass, seaside goldenrod, marsh orach (*Atriplex patula*), seaside gerardia (*Agalinis maritime*), and scattered clumps of saltwater cordgrass. This community is found in throughout irregularly flooded areas of the marsh (i.e., high marsh). This is the most common wetland community at the Seavey Landing site.

***Scirpus/Juncus* (SC/JU)** – This emergent salt-marsh community contains a diversity of salt marsh plant species including three-square (*Scirpus pungens*), salt marsh bulrush, saltwater cordgrass, salt meadow cordgrass, Canada rush (*Juncus canadensis*). Other species commonly found in this community include salt marsh aster, panic grass (*Panicum virgatum*), saltmarsh goldenrod, sedges (*Carex stricta* and *C. crinita*), and scattered big cordgrass (*Spartina cynosuroides*). The community occurs primarily along the transition from the SPPA/JUGE community into the wetland herbaceous/scrub-shrub community along the site perimeter.

***Scirpus robustus* (SCRO)** – An emergent salt-marsh community dominated by ≥ 60% cover of salt marsh bulrush. Associated species in this community include saltwater cordgrass, salt meadow cordgrass, and various rushes. This community is uncommon on the marsh surface and is found in low-lying, semi-permanently-flooded areas within the larger *Scirpus/Juncus* community.

Wetland herbaceous/scrub-shrub (WHSS) – A wetland community dominated by a mixed cover of shrubs and herbaceous vegetation, with hydric plant species representing ≥ 75% total cover within the community. Dominant shrub species include speckled alder (*Alnus rugosa*), winterberry (*Ilex verticillata*), raspberries and blackberries (*Rubus* spp.), and northern bayberry (*Myrica pensylvanica*). Common herbaceous species found in this community include halberd-leaved tearthumb (*Polygonum arifolium*) and numerous species of graminoids. In some areas of the marsh, the WHSS community also contains scattered red maple (*Acer rubrum*) trees. This community occurs primarily along the western and southern border of the Project area, in the transition zone from salt marsh communities to upland areas.

***Typha latifolia* (TYLA)** – An emergent wetland community dominated by broad-leaf cattail, which is an invasive wetland plant found in brackish marsh conditions. This species typically occurs along salt marsh edges where freshwater input from upland areas has reduced the salinity of tidal systems. This species is currently found in the southernmost portion of the Project area adjacent to the railroad bed.

Upland (UPL) – Upland communities in the Project area are dominated by a mixed cover of trees, shrubs, and herbs, with non-hydric plant species representing ≥ 75% total cover within the community. Dominant tree species include oak species (*Quercus sp.*) and quaking aspen (*Populus tremuloides*), and dominant shrub species include arrowood (*Viburnum recognitum*), blueberry (*Vaccinium corymbosum*), northern bayberry, blackberry and raspberry species, and

staghorn sumac (*Rhus typhina*). This community also includes miscellaneous goldenrods (*Solidago* spp.), graminoids, and salt marsh plant species, interspersed with upland plants along the upland/wetland transition zone. This community occurs primarily along the western border of the Project area, adjacent to residential properties, and along the railroad bed that parallels the easternmost border of the Project area. The UPL community along the railroad bed is maintained as part of the rail maintenance, and is therefore dominated by shrubs and herbs, and contains only a few scattered trees.

Channel (OW) – Generally linear, unvegetated, features that receive daily input of salt water. Water level in these features fluctuates in direct relation to daily tidal flow. Banks of channels are steep and in many areas of the marsh, the banks are unstable and slumping.

Pool (PO) – Generally circular, unvegetated, features that may receive salt water input on an irregular or regular basis, and typically will retain water throughout a normal lunar cycle. During average conditions, pool habitats have a water depth > 6 inches, lack rooted vascular plants within the pool, have a deep mucky substrate, have steep sides, and contain fish and occasionally crabs and shrimp.

Panne (PA) – A generally shallow, circular features that may receive salt water input on an irregular or regular basis, but do not retain water throughout a normal lunar cycle. During average conditions, panne habitats have a non-permanent water depth < 6 inches, stunted saltwater cordgrass growing within the panne, gradually sloping sides, and often a cracked and/or salt-coated substrate when the area dries out.

All pre- and post-restoration cover type mapping was conducted during low tide conditions. Each unique community greater than 10 m^2 was delineated and mapped using ARCView/ARC/INFO® GIS software (Environmental Systems Research Institute, Inc. [ESRI] 1982, 1996). To assist in cover type mapping, where necessary, the boundaries of cover types were recorded using a GPS.

2.2 ANNUAL SITE EVALUATION

Annual site evaluations were performed to assess site conditions and changes following restoration activities. Pre-restoration site conditions were established during site evaluations conducted in 2001 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., 2002 through 2006) to assess site conditions. All site evaluations included completion of a site assessment data form and mosquito dip net counts (Appendix B), and photographic documentation of site conditions (Appendix C).

2.2.1 Site Assessment

A site assessment was conducted to qualitatively assess the overall site conditions. The Year 5 post-restoration site assessment was conducted on October 3, 2006. Specifically, the assessment included notation and/or observation of existing weather conditions and tidal cycle, condition of

natural pools and pannes, presence of desirable and undesirable species, presence of wildlife species, presence of mosquito larvae, observations of recreational activities, and evidence of site disturbance. Data collected during assessments were used to document changes occurring as a result of restoration activities and were also used as a management tool to identify problems such as erosion around ditch plugs and initiate ameliorative action. See Appendix B for the completed Year 5 site assessment form. A comparison of pre-restoration and post-restoration site assessments are presented in Section 3.2.1.

2.2.2 Mosquito Dip Counts

Mosquito dip counts were conducted to evaluate whether salt marsh restoration activities may have contributed to an increase in the amount of breeding habitat for mosquitoes. The Year 5 post-restoration mosquito dip counts were conducted during low tide conditions of a neap tide cycle on October 3, 2006. Due to the relatively small Project area, and detail of the cover type map, observers were able to sample all pools identified on the cover type map (Appendix A). Observers used a standard-sized dip cup to collect three dip samples from all pannes/pools containing some water at the time of sampling. Mosquito dip count data forms are presented in Appendix B. A comparison of pre-restoration and post-restoration mosquito dip count data are presented in Section 3.2.2.

2.2.3 Photographic Documentation

Photographic stations were established to document the marsh surface conditions, and the location and size of any existing undesirable communities (e.g., *Typha latifolia*) at the site. Panoramic photo series were taken from six fixed photo stations pre-restoration in 2001 and at the same time of year in Year 1 through Year 5 post-restoration (i.e. 2002 thru 2006). During Year 5 monitoring activities, photographs were taken on October 3, 2006 during average neap low tide conditions to document conditions at the water monitoring stations. Additional photos were taken on October 24, 2006, to document water sampling stations and other features in the Project area. The photographer noted the date, time, compass direction, and a brief description of key features in the photograph. The Photo Station and Sampling Station Photographic Record for Year 5 post-restoration monitoring are presented in Appendix C. A comparison of pre- and post-restoration photographs is presented in Section 3.2.3.

2.3 TIDAL SIGNAL

Tidal signal data were collected to assess the depth of flooding and duration of inundation of the marsh surface during the tidal cycle. Based on site conditions and proposed restoration activities, four water level stations were established in the Project area. Water level data were collected using Global Water Model WL15 pressure transducer/data loggers (Global 2001). Data loggers recorded data for at least the 2-week tidal cycle, and whenever possible were left in place longer in order to capture a full lunar cycle of two spring and two neap tides. Sampling station locations were established pre-restoration and the locations were recorded using a GPS unit and transferred into GIS for overlay onto the cover type map (Appendix A). Figures summarizing the water level data for Year 5 post-restoration monitoring are included in

Appendix D. Appendix D also contains figures presenting data from pre-restoration, and Year 1, Year 3, and Year 5 post-restoration water level data, standardized by the approximate time in the lunar cycle when data were collected. These data are discussed in more detail in Section 3.3.

2.4 WATER QUALITY & PORE-WATER SALINITY

Water quality and pore-water salinity data were collected to assess changes in water quality conditions resulting from ditch plugging activities, and ensure that water quality conditions are within the range of desirable conditions for salt marsh following restoration activities. Samples were collected during pre-restoration, and Year 1, Year 3, and Year 5 post-restoration, over a 2-month sampling period. Samples were collected from piezometer wells at each of the four sampling stations during a 6-hour period surrounding low tide (i.e., 3 hours before and 3 hours after), for two spring and two neap tide cycles. Ideally, water quality sampling should occur during the growing season (May through August). However, due to the Project schedule, sampling took place in the fall of each monitoring year (i.e., 2001 through 2006).

Water quality and pore water salinity sampling stations were located within a 5-meter radius of the water level recording stations discussed in Section 2.3. A YSI Model 85 handheld oxygen, conductivity, salinity, and temperature system (YSI Incorporated 1996) was used to collect readings at the established sampling locations. For each station, dissolved oxygen, temperature, and salinity readings were measured from a 6-inch and an 18-inch deep piezometer wells, and from a nearby pool. To ensure data quality, three replicates were taken from each piezometer and pool at the four sampling station locations, and these data were averaged by parameter to obtain an average value per event. Water quality sampling data for Year 5 post-restoration monitoring are presented in figures in Appendix D. Summaries of pre-restoration and post-restoration data are presented in tabular format and discussed in more detail in Section 3.4.

2.5 GROUND WATER LEVEL

Groundwater data were collected from permanent ground water monitoring locations to assess the depth and duration of water at the marsh surface, to evaluate whether groundwater levels (i.e., water table) have increased following restoration activities. Groundwater level was measured manually using PVC groundwater wells that intersect the water table located within a 5-meter radius of the water level recording stations discussed in Section 2.3. During pre-restoration, and Year 1, Year 3, and Year 5 post-restoration monitoring activities, groundwater level was measured during a slack tide, at each of the four sampling stations. Groundwater level data for Year 5 post-restoration monitoring are presented in Appendix D. A comparison of pre-restoration and post-restoration ground water levels is presented in Section 3.5.

2.6 ADDITIONAL PROJECT INFORMATION

Field notes collected during field sampling activities are provided in Appendix E. In addition, Appendix F contains a list of species observed during field sampling activities.

3.0 RESULTS AND DISCUSSION

All annual monitoring activities from pre- to 5-year post restostoration were conducted between the months of September and December. Post-restoration monitoring activities were conducted during the same time of year in the 5 years following completion of restoration. Specifically, Year 1 post-restoration monitoring activities were performed in September through December 2002, and Years 2 through 5 post-restoration monitoring activities were performed in September through November 2003 through 2006. This section provides the results and discussion of monitoring activities performed throughout the duration of the Project.

3.1 COVER TYPE MAP

Any changes to the extent of pools, pannes, and other cover types observed during annual site assessments were noted on the original hard copy 2001 cover type map, and polygon boundaries were edited, as needed using ARCView/ARC/INFO® GIS software. Cover type boundaries were approximated based on a visual assessment of the site conditions during low tide pre- and post-restoration. The original (i.e., pre-restoration) and updated (i.e., post-restoration) cover type maps are included in Appendix A.

Vegetated and non-vegetated cover types/features identified in the Project area include upland, wetland herbaceous/scrub-shrub, five emergent salt marsh communities (i.e., *Spartina alterniflora, Spartina patens/Juncus gerardii, Scirpus/Juncus, Scirpus robustus, Typha latifolia*), pool and panne habitat, and tidal channels. Community descriptions are provided in Section 2.1.

Five years after restoration, minor changes were observed in all cover types, and no change was observed in the tidal channels (Table 1). The overall coverage of herbaceous vegetation has decreased by 0.24%, corresponding with an equivalent increase in pool/panne habitat, since the pre-restoration cover typing. Five herbaceous communities showed minor decreases in percent coverage, *Spartina patens/Juncus gerardii*-mix, *Scirpus/Juncus* mix, *Scirpus robustus*-dominated, herbaceous/scrub-shrub, and upland; two herbaceous communities showed minor increases in percent coverage, *Spartina alterniflora*-dominated, and *Typha* species. The most notable change was an apparent increase (+0.28%) in the undesirable species *Typha latifolia* on the marsh surface. This may be a result of a decrease in salinity levels as explained in Section 3.4.2. Overall, the changes observed in the Project area have been relatively minor, indicating a minor increase in the extent of pool/panne area, and a minor decrease in the extent of the vegetative cover types, over the 5 years post-restoration. This change from vegetation to pool/panne is attributable to a combination of factors, including the installation and function of ditch plugs to retain water and the excavation of panne areas to create permanent pool habitat, and suggests that water is remaining on the marsh surface for longer periods. See Table 1 for percent area by cover type observed pre- and post-restoration.

During the 2006 monitoring effort, vegetative conditions were compared to the 2001 cover type map to identify any gross changes in species composition and/or extent of coverage. In some areas, where duration and depth of inundation has increased as a result of restoration activities, the vegetation communities appear to be undergoing a change in species composition. In these

areas, *Spartina patens* and/or *Spartina alterniflora* communities appear to be stressed and the communities appear to be transitioning toward pool or panne habitats (depending on the hydroperiod in each area). See photographs 2(2), 3(3), and 4(2) to 4(4) in Appendix C for examples. In other areas, the inundation appears to be less in the pool and panne habitats and the communities appear to be transitioning toward *Spartina patens* and/or *Spartina alterniflora* communities. See photographs 5(3) to 5(4) in Appendix C for examples. Additionally, an increase in *Typha* communities was observed during Year 4 and 5 (see photographs 4(1), 11, and 22 in Appendix C).

Table 1. Percent Area Change by Community Type at Seavey Landing Salt Marsh.

Community Type	Pre-Restoration (percent)	Post-Restoration (percent)	Percent Change
Water			
Channel	9.73	9.73	0.00
Pool/Panne	4.60	4.84	+0.24
Total	**14.33**	**14.57**	**+0.24**
Herbaceous Vegetation			
Spartina alterniflora - dominated	2.46	2.50	+0.04
Spartina patens/*Juncus gerardii*-mix	40.25	40.15	-0.10
Scirpus/*Juncus*-mix	24.71	24.54	-0.17
Scirpus robustus-dominated	0.48	0.40	-0.08
Herbaceous/Scrub-Shrub	5.57	5.41	-0.16
Typha species	0.24	0.52	+0.28
Upland	11.95	11.90	-0.05
Total	**85.66**	**85.42**	**-0.24**
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, mosquito dip counts, and photographic documentation.

3.2.1 Site Assessment

Pre- and post-restoration site assessments were conducted to document conditions on the marsh surface, including observations regarding ditch plugs, excavated/created pools, natural pools, pannes, undesirable and desirable plant species, and various wildlife observations.

Construction of seven ditch plugs and associated excavated pools was completed in the winter of 2002. Since construction, observable changes have occurred to the areas surrounding these ditch

plugs as presented in Table 2 below. During the five years of post-restoration monitoring, evidence of erosion was observed around three ditch plugs (DP #1, 3, and 7) and the plywood was exposed at two ditch plugs (DP #5 and 6). Five of the seven ditch plugs were noted to be 6–12 inches higher in elevation than their surrounding areas (DP #1, 3, 5, 6, and 7). In these areas, the spoil material used to create the ditch plug was piled higher than the surrounding marsh surface, most likely to allow for settling and decomposition of the placed material. However, at these locations, the ditch plugs remained elevated above the surrounding marsh surface after 5 years, and should be monitored in the future to insure that undesirable species do not propagate on the earth mounds. Overall, all seven of ditch plugs have remained stable and structurally sound since completion of restoration activities in 2002.

All seven of the ditch plugs have revegetated with 95% cover or more (Table 2) (see photos 7–12 in Appendix C). Vegetation coverage has increased from Year 1 post restoration monitoring up to nearly complete vegetative coverage during Year 5 monitoring. The spoil material used to create the ditch plugs was excavated from the adjacent marsh, panne, and channel areas, and contained some viable roots and rhizomes that were able to reestablish quickly. The ditch plugs have revegetated with desirable salt marsh species, including black grass, salt meadow cordgrass, salt marsh bulrush, and spreading bentgrass (*Agrostis stolonifera*). Additionally, there were occasional individuals, or small patches, of saltwater cordgrass, marsh orach, spike grass, big cordgrass, *Aster* species, soft-stemmed bulrush (*Scirpus validus*), and *Salicornia* species. The only undesirable species observed growing on the ditch plugs was broad-leaf cattail. Broad-leaf cattails tend to be halo-intolerant and have ability to form monocultures and out-compete other native plants. Conversely, cattails can provide important habitat for many species of wildlife and birds.

After restoration, many of the pools on the marsh surface appeared to be more expansive than during pre-restoration activities. Six pools were found that had been excavated in the creation of ditch plugs. All of these pools were inundated throughout the post-restoration monitoring activities (see Appendix C). All six of the excavated pools appear to be deep enough to accommodate fish, e.g. mummichog (*Fundulus heteroclitus*), although fish were observed in only five of these pools.

During site assessments and field data collection, a variety of water birds, wading birds, passerines, one raptor, and large and small mammals were observed using the marsh, but no obvious increases or decreases in numbers or number of species were noted. Throughout the Project, the osprey nesting platform, placed along the marsh perimeter in 2002, has not been observed being used by any bird species during monitoring activities. The completed site assessment data form for Year 5 post-restoration monitoring activities is included in Appendix B.

Table 2. Condition of Ditch Plugs at Seavey Landing Salt Marsh throughout Post-Restoration Monitoring.

Ditch Plug ID	Vegetation Cover	Condition of ditch plug			Notable problems
		Stable	Erosion	Leaks	
DP 1	95%	Y	N	Y	Heard water leaks form DP; elevated spoil material.
DP 2	100%	Y	N	N	None observed.
DP 3	99%	Y	N	Y	Observed leaks from DP; slightly exposed; elevated spoil material.
DP 4	100%	Y	N	N	None observed.
DP 5	95%	Y	N	N	DP board is slightly exposed; elevated spoil material.
DP 6	100%	Y	N	N	DP board is slightly exposed; elevated spoil material.
DP 7	99%	Y	N	Y	Heard water leaks from DP; elevated spoil material.

3.2.2 Mosquito Dip Counts

Mosquito dip counts were conducted on October 3, 2006, during low tide conditions of a neap tide cycle. Similar tide conditions were targeted for mosquito sampling in pre-restoration, and Year 1 through Year 5 post-restoration, in order to conduct the assessment under relatively standardized conditions from year to year. Fish abundance was also noted for each of the 65 pools surveyed for mosquito larvae.

Three (3) of the 65 pools sampled within the Project area contained mosquito larvae at the time of sampling activities. Each of these three pools contained few (i.e. 1–20 individuals) mosquito larvae at the time of the sampling. The timing of the sample event may be a factor in that it was not closely tied to a significant marsh-flooding event. However, mosquito larvae were observed in pools/pannes on the northeastern portion of the marsh, outside of the Project area. Data forms are presented in Appendix D. Overall, restoration activities do not appear to have influenced the amount or concentration of mosquito larvae within the study area.

3.2.3 Photographic Documentation

One of the main objectives of restoration was to restore the hydrology to the marsh surface by retaining water in pools and pannes for longer periods throughout the tidal cycle. To visually document conditions on the marsh, a panoramic photo series was taken at each of the six established photo stations each year during monitoring activities. Photographic documentation for pre-restoration, and Year 1 through Year 5 post-restoration monitoring occurred in the fall, in the same general timeframe. Photographic documentation for Year 5 post-restoration monitoring occurred on October 3, 2006 and is located in Appendix C.

Representative photos taken at photo and sampling stations were compiled into a photographic record for comparison between pre- and post-restoration. During Year 1 post-restoration

monitoring activities, water levels on the marsh surface appear to be higher than those observed during pre-restoration activities, as depicted in photos taken from photo stations #2, 4, 5 and 6, and sampling stations #2, 3, and 4 (see Appendix C in USFWS 2003a). During Year 2 post-restoration activities, water levels remained on the marsh surface within many of the formerly dry panne areas during low-tide events. During Year 3 and 4, pools and pannes increased in size and aerial coverage. The marsh surface during Year 5 post-restoration monitoring activities was inundated or saturated in much of the study area. Photo #4 (1-6), 5(2), 9, 16, and 23 in Appendix C shows the high water levels during an average neap low-tide event. Photo documentation and visual assessments were supplemented with water level depth data, which was collected continuously over a 2-week period and is discussed in Section 3.3 and displayed in Appendix D.

3.3 TIDAL SIGNAL

Water level data were collected at each of the four water level stations using Global Water Model WL15 pressure transducer/data loggers (Global 2001). For all four water level stations, data loggers were left in place to record data beyond the originally proposed 2-week tidal cycle, in order to capture a full lunar cycle of two spring and two neap tides. Data logger at station #3 did experience a malfunction and recorded erratic readings. Despite the malfunction, the logger was functional for a full lunar cycle of two spring and two neap tides. Collection dates for each station are presented below. Figures summarizing the pre- and post-restoration monitoring water level data, standardized by the approximate time in the lunar cycle when data were collected, and an electronic copy of the water level data on compact disc, are included in Appendix D.

Station	Collection Dates
1	9/15/06-11/1/06
2	9/15/06-11/1/006
3	9/15/06-10/9/06[1]
4	9/15/06-11/1/06

[1] Collection dates truncated due to probe malfunction.

Water level data were collected to determine flooding depth and duration in pools and pannes on the marsh surface. When compared to pre-restoration conditions, the depth and duration of water on the marsh surface increased at three of the four sampling stations following restoration.

Data collected at Water Sampling Stations indicate increased hydrological period and flooding depths and durations at three of the four stations during Year 5 post-restoration monitoring activities (Appendix D). Data collected during Year 1 post-restoration activities at Sampling Stations #1 and 4 also indicate increased flooding depths and durations compared to pre-restoration conditions. Year 3 water levels were slightly higher at Station #2, 3, and 4, than pre-restoration or Year 1 post-restoration water levels. There was a decrease in water level and duration at Station #1 from Year 1 to Year 3, however the water levels remained higher than pre-restoration conditions.

The difference in water depth and duration may be a result of excessive water draining off the marsh surface, near the ditch plugs. Year 5 results indicated an increase in water levels at two of the four stations (Sampling Station #1 and 3) and a decrease in water level at Station #2 and 4

when compared to Year 3 water levels. However, when compared to pre-restoration conditions, Year 5 water levels increased at three of the four Sampling Stations. Station #2 was the only station that recorded lower level than that of pre-restoration conditions, although Year 1 and Year 3 post-restoration water levels were higher than pre-restoration water levels.

The array of water level change from pre-restoration to post-restoration may be due to the location of the stations in relation to ditch plugs and flood channels or to differences in precipitation and evapotranspiration levels during the monitoring periods. According to National Oceanic and Atmospheric Administration (NOAA) precipitation data for the region, the average precipitation for the months of August through October is 10.38 inches (NOAA 2006). Approximately 4.74 inches of precipitation fell during the pre-restoration monitoring period, which is substantially lower than the average expected rainfall for the time period. During Year 1, Year 3, and Year 5 post-restoration, near average precipitation levels were observed, with approximately 9.38, 8.78, and 11.28 inches, respectively, of precipitation falling between August and October (NOAA 2006). Annual variability in precipitation levels during the four sampling periods may have influenced the water level data during the precipitation event, or following the event as surface water runoff drained onto the marsh. Heavy precipitation events, in particular, also may have occurred during sampling periods, possibly skewing water level data on a short-term basis.

Overall, the water level data appear to indicate a net increase in water levels across the marsh surface following restoration, with some year to year and station to station variability depending on tidal conditions, and potentially precipitation levels.

3.4 WATER QUALITY AND PORE-WATER SALINITY

Water quality and pore-water salinity 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 and pore water salinity data were collected on six separate field visits over a six-week sampling period from August 19, 2006, through November 1, 2006, at all four monitoring stations. Overall, 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 and pore-water salinity sampling data collected during Year 5 monitoring were pooled and presented in figures, included in Appendix D and in Table 3 below.

3.4.1 Dissolved Oxygen

Dissolved oxygen levels were measured in the 18-inch and 6-inch piezometer wells and in the adjacent pools at each station. Pre-restoration dissolved oxygen levels were similar to those of post-restoration in the piezometers, and were generally higher in the pools (Table 3). Minimum, maximum, and mean dissolved oxygen levels, measured in percent saturation, are presented for pre-restoration, and Years 1, 3, and 5 post-restoration, in Table 3. Data for Year 5 post-restoration are also presented in more detail in figure format in Appendix D.

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 milligrams per liter (mg Oxygen/L) are optimal for fish, although many fish species can survive for short periods of time at levels below 3 mg Oxygen/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 Oxygen/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 Oxygen/L would be approximately 50% saturated, and 3 mg Oxygen/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 lower in pore-water samples, 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 pore-water dissolved oxygen levels 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 piezometer wells and in pools adjacent to wells at each station (Table 3). Minimum, maximum, and mean salinity levels, measured in percent saturation, are presented for pre-restoration, and Years 1, 3, and 5 post-restoration, in Table 3. Data for Year 5 post-restoration are also presented in more detail in figure format in Appendix D.

Salinity levels were notably lower in post-restoration monitoring, for all three years, than during pre-restoration (Table 3). This may be due to differences in precipitation levels during the pre-restoration sampling period compared to post-restoration precipitation levels. Precipitation was below normal pre-restoration, with approximately 4.74 inches falling in August through October 2001 (National Oceanic and Atmospheric Administration [NOAA] 2006). Precipitation for the Year 1 post-restoration sampling period averaged slightly above normal, with an estimated 9.38 inches falling in August and October 2002. During Year 3 post-restoration monitoring, salinity

and precipitation levels were similar to those collected in 2002, with an estimated 8.78 inches of precipitation falling between August and October 2004. During Year 5 post-restoration monitoring, precipitation levels averaged slightly above normal, with an estimated 11.28 inches falling in August and October 2006 (NOAA 2003). These differences in precipitation levels may have led to higher than average salinity levels on the marsh during pre-restoration monitoring, and lower than average salinity levels during post-restoration monitoring.

Salinity levels are highly variable on salt marsh, depending on recent tides and precipitation levels. Marsh restoration activities, specifically ditch plugging, may be trapping more freshwater runoff behind ditch plugs than pre-restoration conditions, in addition to holding saline tidal water. Despite these salinity differences pre- and post-restoration, for all years, these salinity levels were within acceptable limits for desirable species of nekton and salt marsh vegetation.

3.4.3 Temperature

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

Temperature levels recorded during the Year 3 and Year 5 post-restoration monitoring were slightly higher than those of the pre-restoration or Year 1 post-restoration monitoring period. 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.

3.5 GROUND WATER LEVEL

Data for groundwater depths provide further evidence that the overall depth and duration of standing water on the marsh surface has increased as a result of ditch plugging activities. Groundwater level data for Year 5 post-restoration monitoring are presented in Appendix D.

Groundwater levels were at the marsh surface as evidence by the inundated marsh surface at all monitoring stations throughout the entire year 5 post-restoration sampling event. The inundated marsh surface confirmed that groundwater level has increased as a result of ditch plugging activities.

Table 3. Mean Water Quality, Pore Water Salinity and Ground Water Data Collected at Water Quality Stations at the Seavey Landing 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”	7.65	1.10	126.63	1.55	0.63	3.13	8.39	2.43	41.60	2.25	0.60	7.30
6”	22.49	1.20	176.97	1.39	0.33	4.70	4.04	0.05	9.61	7.21	0.50	27.50
Pool	84.06	19.93	153.67	37.40	5.17	61.53	51.24	25.93	86.67	47.90	4.10	122.50
Salinity (ppt)												
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
18”	27.9	6.60	36.95	21.67	11.87	30.83	18.62	11.40	25.63	18.76	3.37	29.46
6”	30.57	21.50	44.04	15.94	4.64	28.33	19.56	4.13	31.90	16.53	4.06	29.00
Pool	25.90	13.99	33.55	18.05	0.30	30.99	14.91	0.67	31.87	13.54	0.55	33.83
Temperature (C)												
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
18”	11.80	9.27	16.60	11.41	5.90	15.53	15.00	9.77	22.77	14.52	10.10	23.93
6”	10.95	7.40	15.20	10.28	2.73	16.87	14.12	9.83	21.97	14.32	10.43	23.50
Pool	13.32	6.17	18.73	12.09	3.80	25.03	17.34	8.13	28.30	16.47	11.37	27.34
Groundwater (inches)												
Pool	1.41			7.33			6.12			8.03		

Source: USFWS 2002, 2003a, 2004.

4.0 MANAGEMENT IMPLICATIONS AND RECOMMENDATIONS

4.1 MANAGEMENT IMPLICATIONS

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

- There was an overall increase in the amount and duration of water on the marsh surface following ditch plugging.
- There was an overall increase in the extent of permanent pools.
- There was an overall increase in groundwater elevation.
- Water quality remained within acceptable ranges for fish, invertebrates, and macrophytes.
- Minor changes in vegetation have occurred since project inception.
- The majority of excavated/created pools appeared to have the capacity to sustain fish.

4.2 MANAGEMENT RECOMMENDATIONS

There are several recommendations for continued management of the Seavey Landing Salt Marsh, based on site assessments, data collection, and other incidental observations. These management recommendations include the following:

- Continue monitoring vegetation for long-term changes that could be attributed to ditch plugging activities.
- Continue periodic monitoring of ditch plugs for erosion, stability, revegetation of desirable species, and/or growth of undesirable species. In particular, ditch plugs that remained 6–12 inches higher than the surrounding marsh surface 5 years after restoration should be monitored.
- Monitor areas where growth of *Typha latifolia* is occurring. If communities of *Typha* continue to spread, treatment should be considered.
- Additional studies should be conducted to monitor the impacts of ditch plugging on the biological communities (i.e., fish, wildlife, macroinvertebrates).

Overall, ongoing quantitative monitoring of the marsh in the vicinity of the ditch plugs is recommended. In general, if the ditch plugs remain intact and functional (i.e., holding water at low tide), then ongoing success in the original goals of restoration could be reasonably inferred.

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APPENDIX A

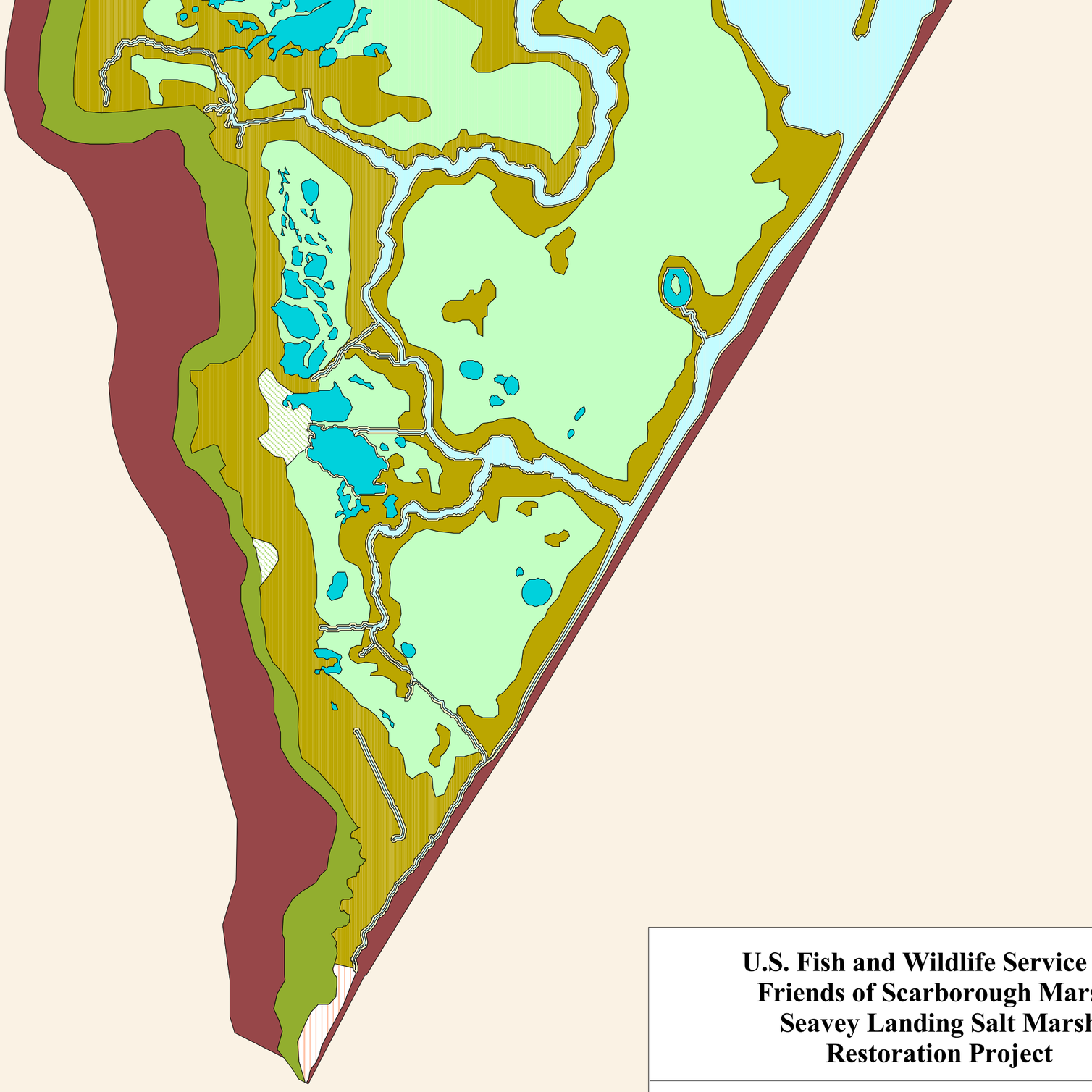
Cover Type Map

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

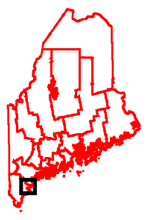
Cover Type Map

Pre-Restoration

COVER TYPES	ACRES
CHANNEL	2.41
POOL/PANNE	1.14
SCIRPUS/JUNCUS	6.12
SCIRPUS ROBUSTUS	0.12
SPARTINA PATENS/JUNCUS GERARDII	9.97
SPARTINA ALTERNIFLORA	0.61
TYPHA LATIFOLIA	0.06
WETLAND HERBACEOUS/SCRUB-SHRUB	2.96
UPLAND	1.38
TOTAL	24.78



PROJECT AREA



100 0 100 200 300 400 500 Feet

100 0 100 Meters

U.S. Fish and Wildlife Service and Friends of Scarborough Marsh Seavey Landing Salt Marsh Restoration Project

DRAFT COVER TYPE MAP

NEA
NORTHERN ECOLOGICAL ASSOCIATES, INC.

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Draft: February, 2003

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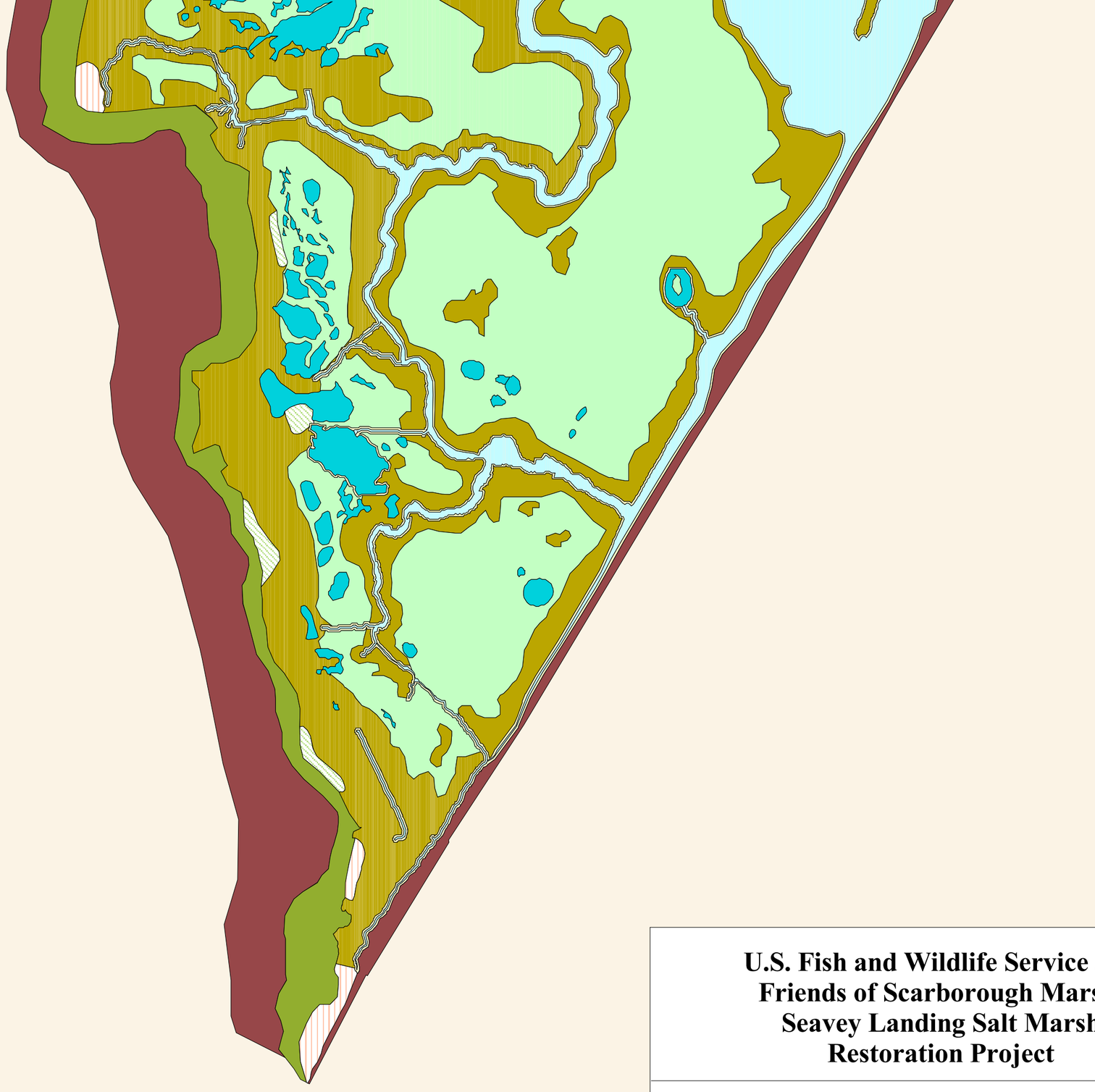
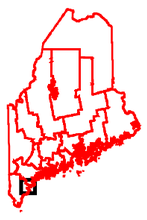
Cover Type Map

Year 5 Post-Restoration

COVER TYPES	ACRES
CHANNEL	2.41
POOL/PANNE	1.20
SCIRPUS/JUNCUS	6.08
SCIRPUS ROBUSTUS	0.10
SPARTINA PATENS/JUNCUS GERARDII	9.95
SPARTINA ALTERNIFLORA	0.62
TYPHA LATIFOLIA	0.13
WETLAND HERBACEOUS/SCRUB-SHRUB	1.34
UPLAND	2.95
TOTAL	24.78



PROJECT AREA



100 0 100 200 300 400 500 Feet

100 0 100 Meters

U.S. Fish and Wildlife Service and Friends of Scarborough Marsh Seavey Landing Salt Marsh Restoration Project

COVER TYPE MAP

NEA
NORTHERN ECOLOGICAL ASSOCIATES, INC.

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January, 2007

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APPENDIX B

Site Assessment Data Forms

Seavey Landing Restoration Monitoring Site Assessment

Site Name: Seavey Landing	**Date:** 10-3-06	**Time:** 1300	**Time of last high tide:** ~7:45 AM
Evaluator(s): S. Casto		**Tide:** High Mid Low **and** incoming outgoing	
Cloud Cover (%): 0, 1 – 25, 25–50, (50–75), > 75%		**Precipitation:** (none), drizzle, steady rain	
Temperature (°F):	**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) Ditch Plugs:	_____ Plug structure sound	_____	Plug structure failing, integrity is questionable
SEE NEXT PAGE	_____ Plug securely in place	_____	Plug not secure in ditch walls, unstable
	_____ No evidence of erosion at plug	_____	Evidence of erosion at plug
	_____ No evidence of water flow, leaks	_____	Evidence of water flow, leaks
* Note the ditch plug number beside the appropriate unacceptable condition if encountered, and describe the problem on back			
2) Excavated pools:			
SEE NEXT PAGE	_____ Pools retaining adequate water	_____	In-sufficient water retained in pools
	_____ Water quality adequate	_____	Water quality poor (*i.e.*, anerobic conditions)
	_____ Presence of nekton	_____	Evidence of nekton die-off
	_____ Presence of macro-invertebrates	_____	Evidence of macro-invertebrate die-off
	_____ Mosquito larvae none - few	_____	Mosquito larvae common - many
	_____ Pool edges intact, stable	_____	Pool edges sloughing, undercut, unstable
	_____ Typical aquatic veg. species present	_____	Devoid of aquatic veg. or invasive species present
* Note the excavated pool number beside the appropriate unacceptable condition if encountered, and describe the problem on back			
3) Natural pools:			
SEE NEXT PAGE	_____ Pools retaining adequate water	_____	In-sufficient water retained in pools
	_____ Water quality adequate	_____	Water quality poor (*i.e.*, anerobic conditions)
	_____ Presence of nekton	_____	Evidence of nekton die-off
	_____ Presence of macro-invertebrates	_____	Evidence of macro-invertebrate die-off
	_____ 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:	_____ Size, aerial coverage not increasing	_____	Size, aerial coverage increasing
SEE NEXT PAGE	_____ 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, and shrubs on high marsh surface)*			
SEE NEXT PAGE	_____ No undesirable species present	_____	Undesirable species found on site
	_____ Undesirable species coverage not increasing	_____	Undesirable species coverage increasing
* Identify the location of undesirable species on the cover type map			
6) Desirable Species: (*Spartina, Juncus, Distichlis, Salicacia, Scirpus, Solidago) note others when encountered*			
SEE NEXT PAGE	_____ Plant health, vigor good	_____	Plants in poor health, showing signs of stress
	_____ No obvious loss of aerial coverage or density	_____	Obvious loss of aerial coverage, plant density
	_____ 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 IN APPENDIX F
8	Wading birds or wading bird nests		
9	Water birds or water bird nests		
10	Raptors or raptor nests		
11	Small mammals		
12	Large mammals		
13	Amphibians		
14	Reptiles		
15	Recreational activities		Bird watching, fishing
16	Site disturbance	✓	
17	Mosquito adult/larvae in pools		
18	Macro-invertebrates in pools		
19	Fish in pools		SEE Field Notes in Appendix E

Site Assessment (additional comments)

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

Ref. #	Comments
	Ditch Plug #1 ⇒ DP is structurally sound with no evidence of erosion. Adjacent pannes are dry during time of survey. DP showed no evidence of water leaks and had no undesirable species present.
	Ditch Plug #2 ⇒ DP is structurally sound w/ no evidence of erosion or water leaks. No invasive/undesirable species were present. DP is slightly higher in elevation than the adjacent topography. Adjacent natural pools and pannes were inundated.
	Ditch Plug #3 ⇒ DP is structurally sound with no evidence of erosion, or water leaks. Pools adjacent are holding more water than previous years. DP is slightly higher in elevation than the adjacent topography. No unwanted / undesirable species present. Abundant nekton species in pool.
	Ditch Plug #4 ⇒ DP is structurally sound w/ no evidence of erosion no evidence of unwanted vegetation on DP. Adjacent Pool is full of fish species and pools have been inundated throughout this year's study.
	Ditch Plug #5 ⇒ DP is structurally sound w/ no evidence of erosion or water leaks. Evidence of a Typha sp. growing on the DP material. Small stems that may increase in size. Adjacent pools + pannes have been inundated throughout this years survey.
	Ditch Plug #6 = DP is structurally sound w/ no evidence of erosion or water leaks. Adjacent pools + pannes are inundated and have been for this years survey. Small Typha stems growing on DP material. DP is slightly higher than the adjacent topography. Additionally, large Typha stems growing near corner (southwest) of marsh.
	Ditch Plug #7 ⇒ DP is structurally sound with no evidence of erosion. Adjacent channel has some water in it with lots of fish and crabs. No evidence of unwanted/undesirable species of vegetation on DP. DP is slightly higher in elevation compare to adjacent topography.

Seavey Landing Salt Marsh Restoration Project
Mosquito Dip Count Survey Data Form

Date: 10-3-06	**Observer:** S. CASTO	**Temp (°F):** 55°
Start Time: 1429	**End Time:** 1637	**Tide:** low - incoming
Comments:		

Pool/Panne ID	Larvae Present (Yes or No)	Average of 3 Dips (Few 1 - 20, Common 21 - 40, Many >40)
1	N	—
2	N	—
3	N	—
4	N	—
5	N	—
6	N	—
7	N	—
8	N	—
9	N	—
10	N	—
11	N	—
12	N	—
13	Y	F
14	N	— * shrimp
15	Y	F
16	N	—
17	N	—
18	N	—
19	N	—
20	N	—
21	N	—
22	N	—
23	N	— * shrimp
24	N	—
25	N	—
26	N	—
27	N	—
28	N	—
29	N	—
30	N	— * shrimp
31	N	—
32	N	—
33	N	—
34	N	—
35	N	—
36	Y	F

37	N	—
38	N	— + shrimp
39	N	— + shrimp
40	N	—
41	N	—
42	N	—
43	N	—
44	N	—
45	N	—
46	N	—
47	N	—
48	N	—
49	N	—
50	N	—
51	N	—
52	N	—
53	N	—
54	N	—
55	N	—
56	N	—
57	N	—
58	N	—
59	N	—
60	N	—
61	N	—
62	N	—
63	N	—
64	N	—
65	N	—

Additional Comments/Sketch:

APPENDIX C

Photographic Documentation

NORTHERN ECOLOGICAL ASSOCIATES, INC.

PHOTOGRAPHIC RECORD
Year 5 Post-Restoration Monitoring

Company: U.S. Fish and Wildlife Service & Friends of Scarborough Marsh
Project: Seavey Landing Salt Marsh Restoration

PHOTO STATION 1

Photographer: S. Casto
Date: 10-03-06
Photo No.: 1(1)
Direction: 240

Comments:
Photo station # 1, looking southwest. Start of panoramic series. Photo shows the transition from marsh to upland along the eastern perimeter of project area. The railroad bed that runs parallel to the eastern perimeter of the marsh is visible in the upper left part of the photo.

Photographer: S. Casto
Date: 10-03-06
Photo No.: 1(2)
Direction: 270

Comments:
Photo station # 1, looking west. Photo of marsh surface during average low tide condition.

Company: U.S. Fish and Wildlife Service & Friends of Scarborough Marsh
Project: Seavey Landing Salt Marsh Restoration

PHOTO STATION 1

Photographer: S. Casto
Date: 10-03-06
Photo No.: 1(3)
Direction: 310

Comments:
Photo station # 1. Photo shows marsh surface with small drainage ditch in foreground during average low tide condition. Water Sampling Station is visible in far right of photo.

Photographer: S. Casto
Date: 10-03-06
Photo No.: 1(4)
Direction: 5

Comments:
Photo station # 1, looking north. Photo shows marsh surface during average low tide condition. Water Sampling Station 2 is visible on the far left.

Company: U.S. Fish and Wildlife Service & Friends of Scarborough Marsh
Project: Seavey Landing Salt Marsh Restoration

PHOTO STATION 1

Photographer: S. Casto
Date: 10-03-06
Photo No.: 1(5)
Direction: 10

Comments:
Photo station # 1, looking north. Photo shows flourishing shrub next to railroad tracks at Photo Station 1.

Photographer: S. Casto
Date: 10-03-06
Photo No.: 1(6)
Direction: 115

Comments:
Photo station # 1, looking northeast. Photo shows marsh transition to upland of the adjacent railroad bed during average low tide condition. End of panoramic photo series # 1.

Company: U.S. Fish and Wildlife Service & Friends of Scarborough Marsh
Project: Seavey Landing Salt Marsh Restoration

PHOTO STATION 2

Photographer: S. Casto
Date: 10-03-06
Photo No.: 2(1)
Direction: 160

Comments:
Photo station # 2, looking south/southeast. Start of panoramic series. Photo shows marsh surface during average low tide condition. Pipe setup is water sample station # 1.

Photographer: S. Casto
Date: 10-03-06
Photo No.: 2(2)
Direction: 130

Comments:
Photo station # 2, looking east. Photo shows marsh surface during average low tide condition. Ditch plug # 3 and associated pool is in the photo.

Company: U.S. Fish and Wildlife Service & Friends of Scarborough Marsh
Project: Seavey Landing Salt Marsh Restoration

PHOTO STATION 2

Photographer: S. Casto
Date: 10-03-06
Photo No.: 2(3)
Direction: 100

Comments:
Photo station # 2, looking east. Photo shows marsh surface during average low tide condition.

Photographer: S. Casto
Date: 10-03-06
Photo No.: 2(4)
Direction: 70

Comments:
Photo station # 2, looking east/northeast. Photo shows marsh surface during average low tide condition.

NORTHERN ECOLOGICAL ASSOCIATES, INC.

PHOTOGRAPHIC RECORD
Year 5 Post-Restoration Monitoring

Company: U.S. Fish and Wildlife Service & Friends of Scarborough Marsh
Project: Seavey Landing Salt Marsh Restoration

PHOTO STATION 2

Photographer: S. Casto
Date: 10-03-06
Photo No.: 2(5)
Direction: 40

Comments:

Photo station # 2, looking northeast. Photo shows marsh surface/ forest ecotone during average low tide condition. Water Sampling Station 2. End of panoramic photo series # 2

NORTHERN ECOLOGICAL ASSOCIATES, INC.

PHOTOGRAPHIC RECORD
Year 5 Post-Restoration Monitoring

Company: U.S. Fish and Wildlife Service & Friends of Scarborough Marsh
Project: Seavey Landing Salt Marsh Restoration

PHOTO STATION 3

Photographer: S. Casto
Date: 10-03-06
Photo No.: 3(1)
Direction: 180

Comments:
Photo station # 3, looking south. Start of panoramic series. Photo shows flooded marsh surface near water sampling station # 2 during average low tide condition.

Photographer: S. Casto
Date: 10-03-06
Photo No.: 3(2)
Direction: 150

Comments:
Photo station # 3, looking southeast. Photo shows flooded marsh surface during average low tide condition.

NORTHERN ECOLOGICAL ASSOCIATES, INC.

PHOTOGRAPHIC RECORD
Year 5 Post-Restoration Monitoring

Company: U.S. Fish and Wildlife Service & Friends of Scarborough Marsh
Project: Seavey Landing Salt Marsh Restoration

PHOTO STATION 3

Photographer: S. Casto
Date: 10-03-06
Photo No.: 3(3)
Direction: 140

Comments:
Photo station # 3, looking southeast. Photo shows flooded marsh surface during average low tide condition.

Photographer: S. Casto
Date: 10-03-06
Photo No.: 3(4)
Direction: 95

Comments:
Photo station # 3, looking east. Photo shows flooded marsh surface during average low tide condition.

NORTHERN ECOLOGICAL ASSOCIATES, INC.

PHOTOGRAPHIC RECORD
Year 5 Post-Restoration Monitoring

Company: U.S. Fish and Wildlife Service & Friends of Scarborough Marsh
Project: Seavey Landing Salt Marsh Restoration

PHOTO STATION 3

Photographer: S. Casto
Date: 10-03-06
Photo No.: 3(5)
Direction: 50

Comments:
Photo station # 3, looking northeast. Photo shows flooded marsh surface during average low tide condition.

Photographer: S. Casto
Date: 10-03-06
Photo No.: 3(6)
Direction: 15

Comments:
Photo station # 3, looking north. Photo shows flooded marsh surface during average low tide condition.

NORTHERN ECOLOGICAL ASSOCIATES, INC.

PHOTOGRAPHIC RECORD
Year 5 Post-Restoration Monitoring

Company: U.S. Fish and Wildlife Service & Friends of Scarborough Marsh
Project: Seavey Landing Salt Marsh Restoration

PHOTO STATION 3

Photographer: S. Casto
Date: 10-03-06
Photo No.: 3(7)
Direction: 330

Comments:
Photo station # 3, looking northwest. Photo shows flooded marsh surface during average low tide condition. End of panoramic photo series # 3.

NORTHERN ECOLOGICAL ASSOCIATES, INC.

PHOTOGRAPHIC RECORD
Year 5 Post-Restoration Monitoring

Company: U.S. Fish and Wildlife Service & Friends of Scarborough Marsh
Project: Seavey Landing Salt Marsh Restoration

PHOTO STATION 4

Photographer: S. Casto
Date: 10-03-06
Photo No.: 4(1)
Direction: 240

Comments:
Photo station # 4, looking southwest. Start of panoramic series. Photo shows flooded marsh surface during average low tide condition. Ditch plug # 6 is in the left of this photo. Note the large *Typha* stand in photo (right).

Photographer: S. Casto
Date: 10-03-06
Photo No.: 4(2)
Direction: 205

Comments:
Photo station # 4, looking southeast. Photo shows flooded marsh surface during average low tide condition.

NORTHERN ECOLOGICAL ASSOCIATES, INC.

PHOTOGRAPHIC RECORD
Year 5 Post-Restoration Monitoring

Company: U.S. Fish and Wildlife Service & Friends of Scarborough Marsh
Project: Seavey Landing Salt Marsh Restoration

PHOTO STATION 4

Photographer: S. Casto
Date: 10-03-06
Photo No.: 4(3)
Direction: 165

Comments:
Photo station # 4, looking south/southeast. Photo shows flooded marsh surface during average low tide condition.

Photographer: S. Casto
Date: 10-03-06
Photo No.: 4(4)
Direction: 140

Comments:
Photo station # 4, looking southeast. Photo shows flooded marsh surface during average low tide condition.

NORTHERN ECOLOGICAL ASSOCIATES, INC.

PHOTOGRAPHIC RECORD
Year 5 Post-Restoration Monitoring

Company: U.S. Fish and Wildlife Service & Friends of Scarborough Marsh
Project: Seavey Landing Salt Marsh Restoration

PHOTO STATION 4

Photographer: S. Casto
Date: 10-03-06
Photo No.: 4(5)
Direction: 115

Comments:
Photo station # 4, looking east/southeast. Photo shows flooded marsh surface during average low tide condition. Water sampling station # 3 is to the left of the photo.

Photographer: S. Casto
Date: 10-03-06
Photo No.: 4(6)
Direction: 82

Comments:
Photo station # 4, looking east. Photo shows flooded marsh surface near water sampling station # 3 during average low tide condition.

NORTHERN ECOLOGICAL ASSOCIATES, INC.

PHOTOGRAPHIC RECORD
Year 5 Post-Restoration Monitoring

Company: U.S. Fish and Wildlife Service & Friends of Scarborough Marsh
Project: Seavey Landing Salt Marsh Restoration

PHOTO STATION 4

Photographer: S. Casto
Date: 10-03-06
Photo No.: 4(7)
Direction: 58

Comments:
Photo station # 4, looking northeast. Photo shows flooded marsh surface during average low tide condition.

Photographer: S. Casto
Date: 10-03-06
Photo No.: 4(8)
Direction: 35

Comments:
Photo station # 4, looking northeast. Photo shows marsh surface during average low tide condition.

NORTHERN ECOLOGICAL ASSOCIATES, INC.

PHOTOGRAPHIC RECORD
Year 5 Post-Restoration Monitoring

Company: U.S. Fish and Wildlife Service & Friends of Scarborough Marsh
Project: Seavey Landing Salt Marsh Restoration

PHOTO STATION 4

Photographer: S. Casto
Date: 10-03-06
Photo No.: 4(9)
Direction: 5

Comments:
Photo station # 4, looking north. Photo shows marsh surface during average low tide condition. End of panoramic series # 4.

Company: U.S. Fish and Wildlife Service & Friends of Scarborough Marsh
Project: Seavey Landing Salt Marsh Restoration

PHOTO STATION 5

Photographer: S. Casto
Date: 10-03-06
Photo No.: 5(1)
Direction: 210

Comments:
Photo station # 5, looking southwest. Start of panoramic series. Photo shows flooded marsh surface during average low tide condition.

Photographer: S. Casto
Date: 10-03-06
Photo No.: 5(2)
Direction: 160

Comments:
Photo station # 5, looking south. Photo shows flooded marsh surface during average low tide condition. Pools and pannes are present.

Company: U.S. Fish and Wildlife Service & Friends of Scarborough Marsh
Project: Seavey Landing Salt Marsh Restoration

PHOTO STATION 5

Photographer: S. Casto
Date: 10-03-06
Photo No.: 5(3)
Direction: 135

Comments:
Photo station # 5, looking southeast during average low tide conditions. Photo shows panne habitat in photo foreground.

Photographer: S. Casto
Date: 10-03-06
Photo No.: 5(4)
Direction: 105

Comments:
Photo station # 5, looking east. Photo shows marsh surface during average low tide condition. The repaired Water Sampling Station # 4 is visible in rear of photo.

Company: U.S. Fish and Wildlife Service & Friends of Scarborough Marsh
Project: Seavey Landing Salt Marsh Restoration

PHOTO STATION 5

Photographer: S. Casto
Date: 10-03-06
Photo No.: 5(5)
Direction: 65

Comments:
Photo station # 5, looking northeast. Photo shows marsh surface/upland ecotone during average low tide condition.

Photographer: S. Casto
Date: 10-03-06
Photo No.: 5(6)
Direction: 30

Comments:
Photo station # 5, looking north. Photo shows marsh/riparian ecotone during average low tide condition.

NORTHERN ECOLOGICAL ASSOCIATES, INC.

PHOTOGRAPHIC RECORD
Year 5 Post-Restoration Monitoring

Company: U.S. Fish and Wildlife Service & Friends of Scarborough Marsh
Project: Seavey Landing Salt Marsh Restoration

PHOTO STATION 5

Photographer: S. Casto
Date: 10-03-06
Photo No.: 5(7)
Direction: 65

Comments:

Photo station # 5, looking northeast. Photo shows marsh surface/upland ecotone during average low tide condition. End of panoramic photo series # 5.

NORTHERN ECOLOGICAL ASSOCIATES, INC.

PHOTOGRAPHIC RECORD
Year 5 Post-Restoration Monitoring

Company: U.S. Fish and Wildlife Service & Friends of Scarborough Marsh
Project: Seavey Landing Salt Marsh Restoration

PHOTO STATION 6

Photographer: S. Casto
Date: 10-03-06
Photo No.: 6(1)
Direction: 150

Comments:
Photo station # 6, looking southeast. Start of the photo series. Photo shows marsh surface during average low tide condition. Channel associated with Ditch Plug # 7 is on the right of the photo.

Photographer: S. Casto
Date: 10-03-06
Photo No.: 6(2)
Direction: 180

Comments:
Photo station # 6, looking south. Photo shows marsh surface during average low tide condition.

NORTHERN ECOLOGICAL ASSOCIATES, INC.

PHOTOGRAPHIC RECORD
Year 5 Post-Restoration Monitoring

Company: U.S. Fish and Wildlife Service & Friends of Scarborough Marsh
Project: Seavey Landing Salt Marsh Restoration

PHOTO STATION 6

Photographer: S. Casto
Date: 10-03-06
Photo No.: 6(3)
Direction: 220

Comments:
Photo station # 6, looking south. Photo shows marsh surface during average low tide condition.

Photographer: S. Casto
Date: 10-03-06
Photo No.: 6(4)
Direction: 260

Comments:
Photo station # 6, looking west. Photo shows marsh surface during average low tide condition. Ditch plug # 7 is at the bottom left of the photo.

NORTHERN ECOLOGICAL ASSOCIATES, INC.

PHOTOGRAPHIC RECORD
Year 5 Post-Restoration Monitoring

Company: U.S. Fish and Wildlife Service & Friends of Scarborough Marsh
Project: Seavey Landing Salt Marsh Restoration

PHOTO STATION 6

Photographer: S. Casto
Date: 10-03-06
Photo No.: 6(5)
Direction: 300

Comments:
Photo station # 6, looking northwest. Photo shows marsh surface during average low tide condition.

Photographer: S. Casto
Date: 10-03-06
Photo No.: 6(6)
Direction: 340

Comments:
Photo station # 6, looking at Water Sample Station 4.

NORTHERN ECOLOGICAL ASSOCIATES, INC.

PHOTOGRAPHIC RECORD
Year 5 Post-Restoration Monitoring

Company: U.S. Fish and Wildlife Service & Friends of Scarborough Marsh
Project: Seavey Landing Salt Marsh Restoration

PHOTO STATION 6

Photographer: S. Casto
Date: 10-03-06
Photo No.: 6(7)
Direction: 300

Comments:
Photo station # 6, looking northwest. Photo shows marsh surface during average low tide condition.

Photographer: S. Casto
Date: 10-03-06
Photo No.: 6(8)
Direction: 340

Comments:
Photo station # 6. Photo shows marsh surface during average low tide condition. End of panoramic photo series # 6.

NORTHERN ECOLOGICAL ASSOCIATES, INC.

PHOTOGRAPHIC RECORD
Year 5 Post-Restoration Monitoring

Company: U.S. Fish and Wildlife Service & Friends of Scarborough Marsh
Project: Seavey Landing Salt Marsh Restoration

DITCH PLUGS

Photographer: S. Casto
Date: 10-03-06
Photo No.: 7
Direction: 100

Comments:
Ditch plug # 1 and associated pools. Photo shows ditch plug at a slightly higher elevation. Ditch plug has desirable vegetation growing and shows no evidence of erosion.

Photographer: S. Casto
Date: 10-03-06
Photo No.: 8
Direction: 280

Comments:
Ditch Plug # 2. Photo shows ditch plug has desirable vegetation growing and shows no evidence of erosion.

NORTHERN ECOLOGICAL ASSOCIATES, INC.

PHOTOGRAPHIC RECORD
Year 5 Post-Restoration Monitoring

Company: U.S. Fish and Wildlife Service & Friends of Scarborough Marsh
Project: Seavey Landing Salt Marsh Restoration

DITCH PLUGS

Photographer: S. Casto
Date: 10-03-06
Photo No.: 9
Direction: 200

Comments:
Ditch plug # 3 and associated pool. Water is pooling (approx. 6 in deep) behind the ditch plug. No evidence of erosion

Photographer: S. Casto
Date: 10-03-06
Photo No.: 10
Direction: 20

Comments:
Ditch plug # 4 and associated ditch. New vegetation is growing where pool was in previous years.

NORTHERN ECOLOGICAL ASSOCIATES, INC.

PHOTOGRAPHIC RECORD
Year 5 Post-Restoration Monitoring

Company: U.S. Fish and Wildlife Service & Friends of Scarborough Marsh
Project: Seavey Landing Salt Marsh Restoration

DITCH PLUGS

Photographer: S. Casto
Date: 10-03-06
Photo No.: 11
Direction: 260

Comments:
Ditch plug # 5 showing no evidence of erosion or leaks. Small stand of undesirable species (*Typha*) present.

Photographer: S. Casto
Date: 10-03-06
Photo No.: 12
Direction: 170

Comments:
Ditch plug # 7 in functional condition showing no evidence of erosion or water leaks.

NORTHERN ECOLOGICAL ASSOCIATES, INC.

PHOTOGRAPHIC RECORD
Year 5 Post-Restoration Monitoring

Company: U.S. Fish and Wildlife Service & Friends of Scarborough Marsh
Project: Seavey Landing Salt Marsh Restoration

WATER SAMPLING STATIONS

Photographer: S. Casto
Date: 10-03-06
Photo No.: 15
Direction: 5

Comments:
Water Quality Station # 1, looking north/northeast at average low tide conditions. Pool is about 6 to 12 inches deep with various nekton species. Note the water level recorder in place.

Photographer: S. Casto
Date: 10-03-06
Photo No.: 16
Direction: 15

Comments:
Water Quality Station # 2, looking northeast at average low tide conditions. Pool is about 6 inches deep with various nekton species. Note the water level recorder in place.

NORTHERN ECOLOGICAL ASSOCIATES, INC.

PHOTOGRAPHIC RECORD
Year 5 Post-Restoration Monitoring

Company: U.S. Fish and Wildlife Service & Friends of Scarborough Marsh
Project: Seavey Landing Salt Marsh Restoration

WATER SAMPLING STATIONS

Photographer: S. Casto
Date: 10-03-06
Photo No.: 17
Direction: 35

Comments:

Water Quality Station # 3, looking east/northeast at average low tide conditions. Pool is about 6 inches deep with various nekton species. Note the water level recorder in place.

Photographer: S. Casto
Date: 10-03-06
Photo No.: 18
Direction: 65

Comments:

Water Quality Station # 4, looking east at average low tide conditions. Pool is about 36 inches deep with various nekton species. This Water Quality Station was repaired on 9-19-06. Note the water level recorder in place.

NORTHERN ECOLOGICAL ASSOCIATES, INC.

PHOTOGRAPHIC RECORD
Year 5 Post-Restoration Monitoring

Company: U.S. Fish and Wildlife Service & Friends of Scarborough Marsh
Project: Seavey Landing Salt Marsh Restoration

MISCELLANEOUS

Photographer: S. Casto
Date: 10-03-06
Photo No.: 19
Direction: na

Comments:
Photo shows a native Salicornia spp. An increase in Salicornia coverage on the marsh surface was observed in 2006.

Photographer: S. Casto
Date: 10-03-06
Photo No.: 20
Direction: na

Comments:
Photo shows evidence of wildlife. Mammal scat near water quality station # 1

NORTHERN ECOLOGICAL ASSOCIATES, INC.

PHOTOGRAPHIC RECORD
Year 5 Post-Restoration Monitoring

Company: U.S. Fish and Wildlife Service & Friends of Scarborough Marsh
Project: Seavey Landing Salt Marsh Restoration

MISCELLANEOUS

Photographer: S. Casto
Date: 10-03-06
Photo No.: 21
Direction: na

Comments:
Photo shows deer tracks through a panne surface near Photo Station # 3.

Photographer: S. Casto
Date: 10-03-06
Photo No.: 22
Direction: 205

Comments:
Photo shows *Typha latifolia* stand on the southwest corner of the study area near Water Quality Station # 3.

NORTHERN ECOLOGICAL ASSOCIATES, INC.

PHOTOGRAPHIC RECORD
Year 5 Post-Restoration Monitoring

Company: U.S. Fish and Wildlife Service & Friends of Scarborough Marsh
Project: Seavey Landing Salt Marsh Restoration

MISCELLANEOUS

Photographer: S. Casto
Date: 10-03-06
Photo No.: 23
Direction: 154

Comments:
Overall marsh surface during average low tide conditions. Photo taken from northwestern area of marsh study area. Notice water levels of pools and pannes are generally high.

APPENDIX D

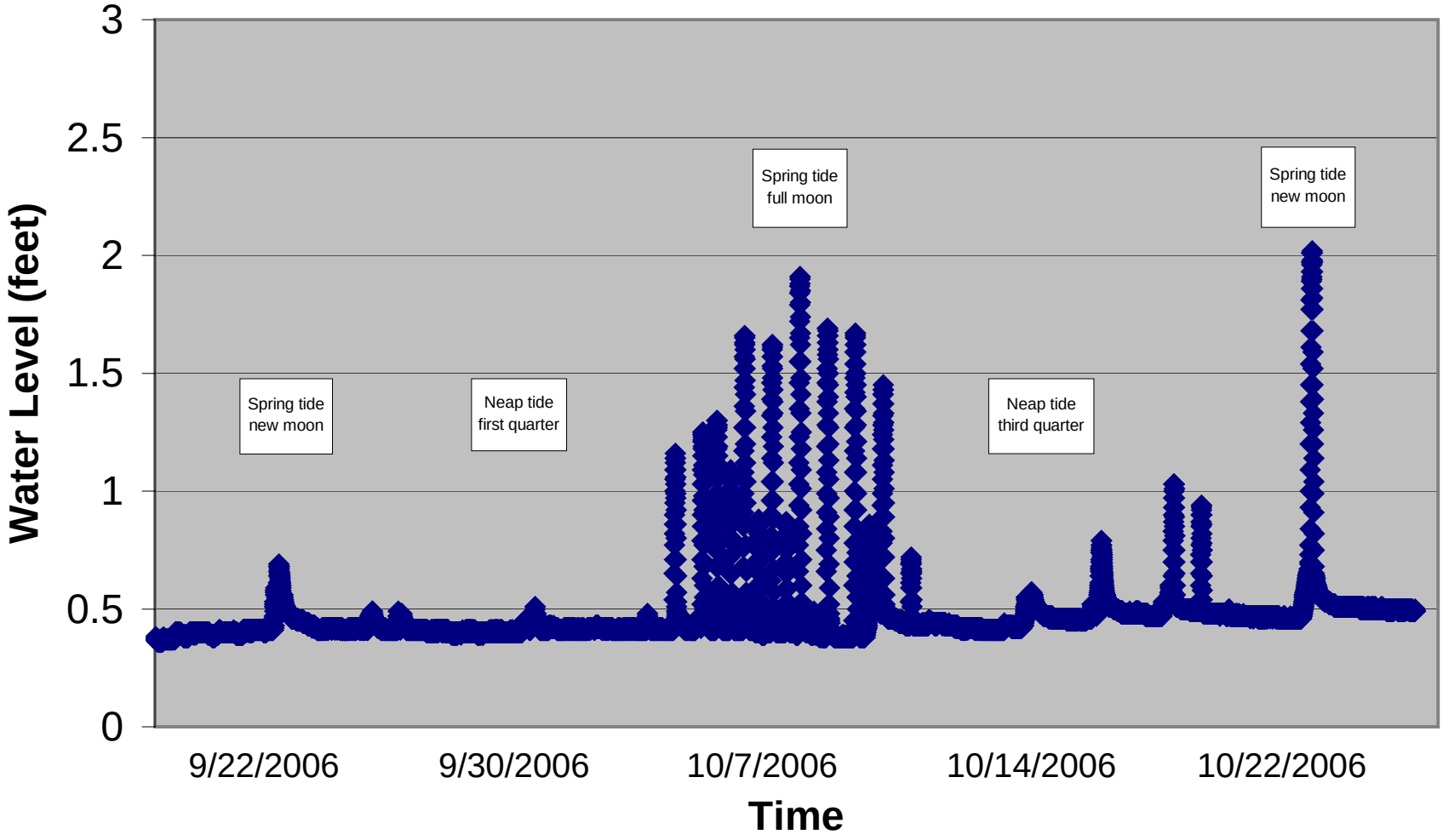
Water Sampling Data

- **Tidal Signal Data (water level recorder data)**
- **Water Quality Data**

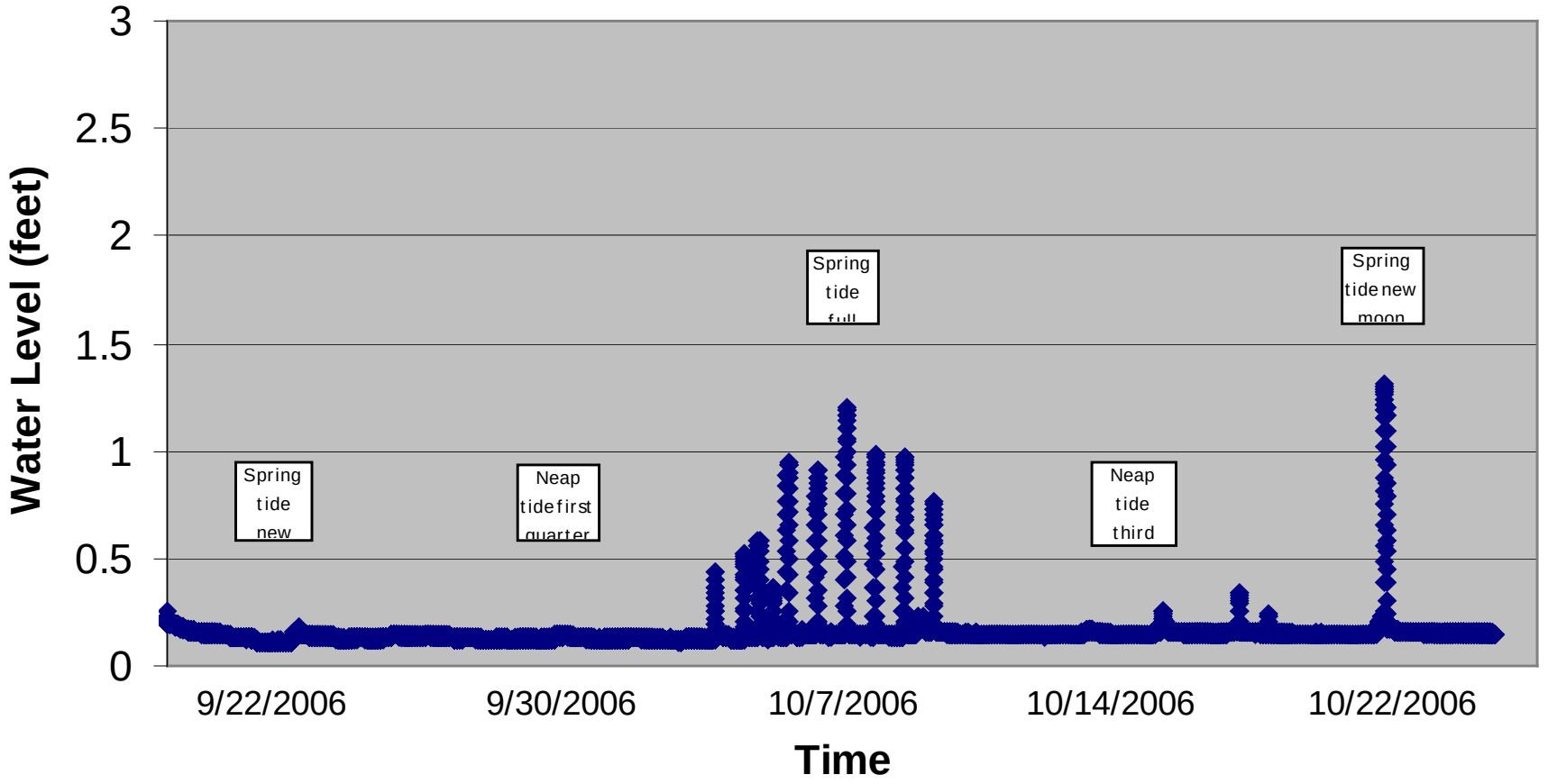
Tidal Signal Data

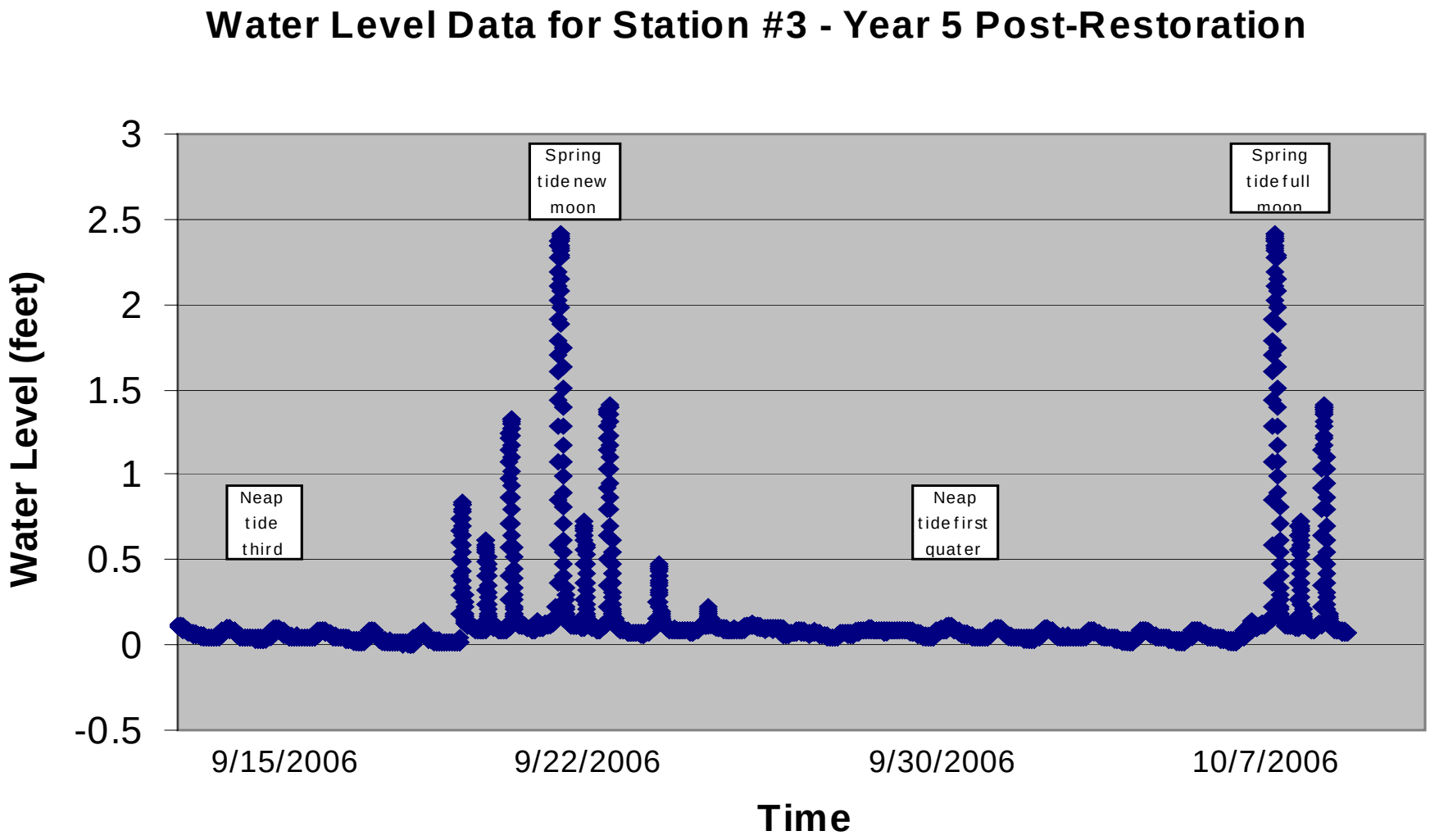
(water level recorder data)

Water Level Data for Station #1 - Year 5 Post-Restoration

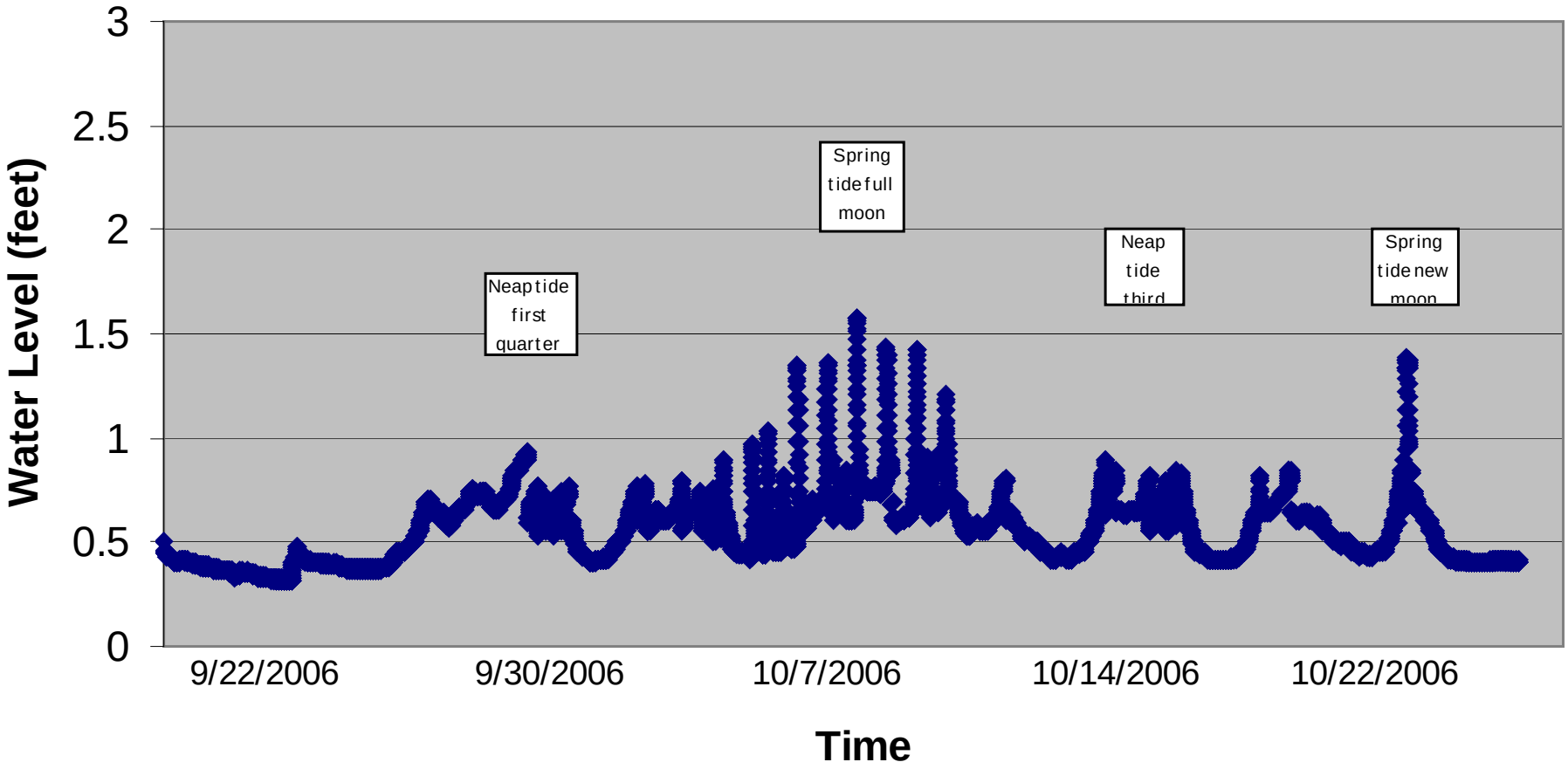


Water Level Data for Station #2 - Year 5 Post-Restoration

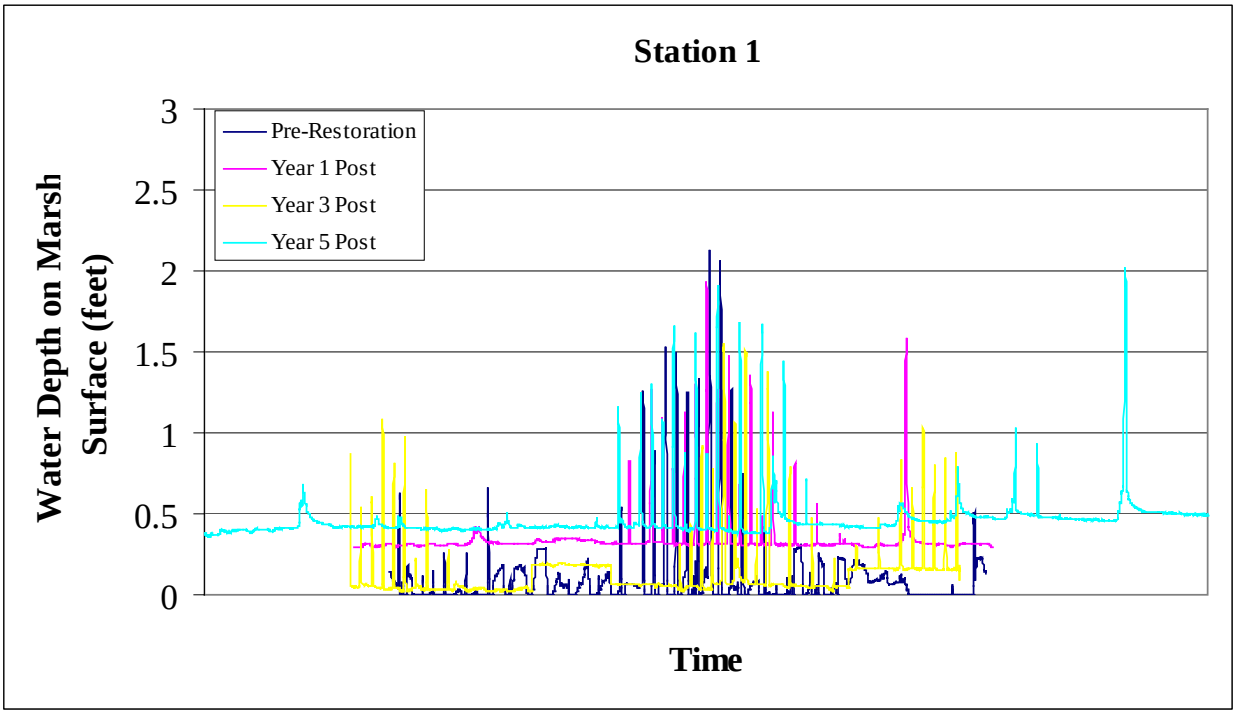


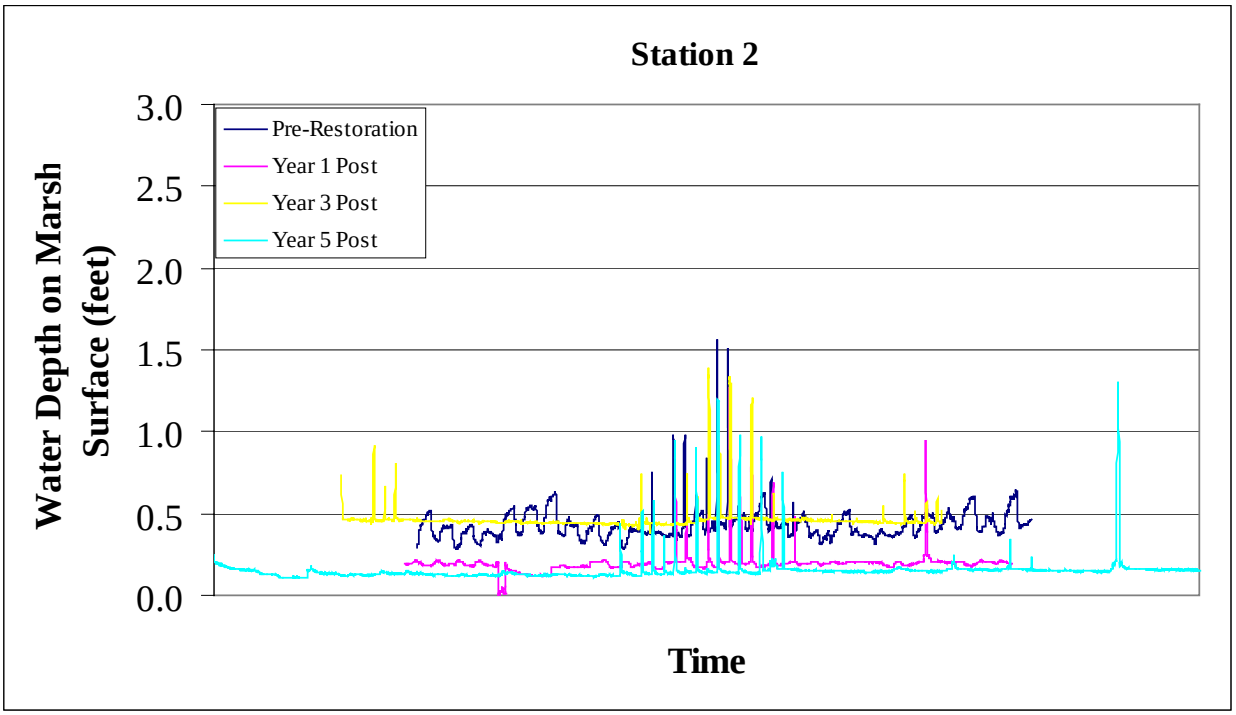

Water Level Data for Station #3 - Year 5 Post-Restoration
Water Level (feet)
3
2.5
2
1.5
1
0.5
0
-0.5
Spring tide new moon
Spring tide full moon
Neap tide third
Neap tide first quater
9/15/2006
9/22/2006
9/30/2006
10/7/2006
Time

Water Level Data for Station #4 - Year 5 Post-Restoration

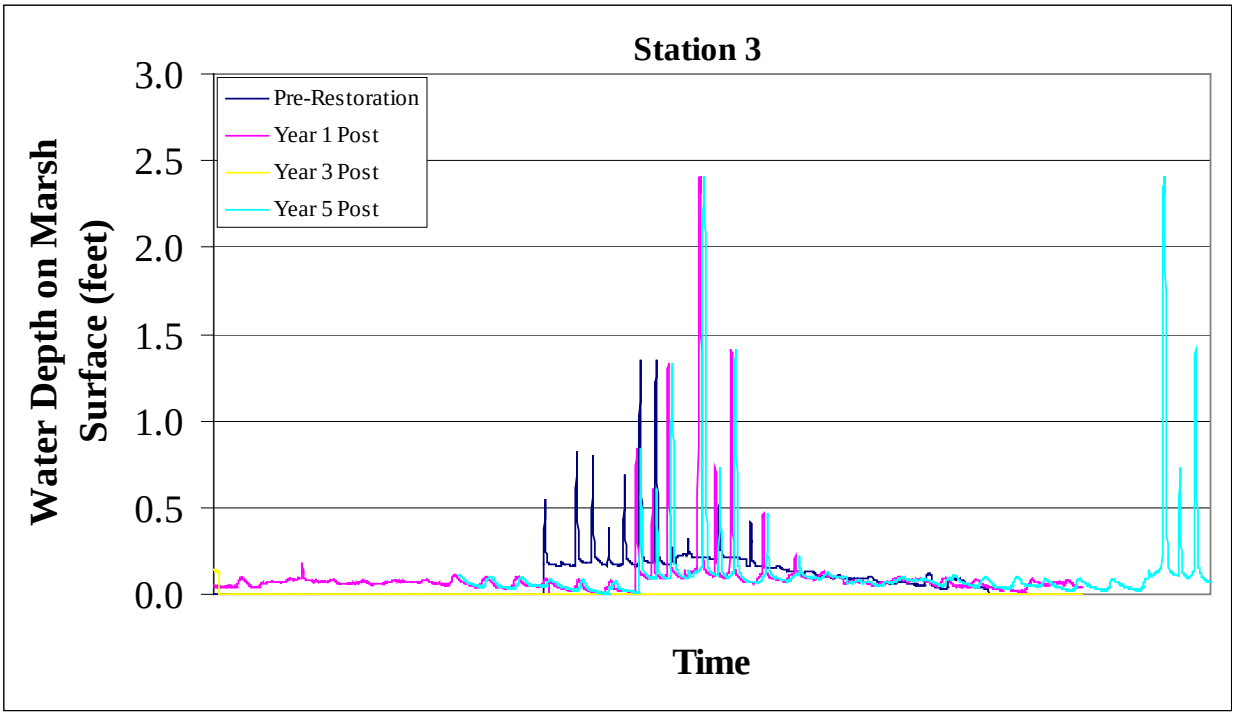


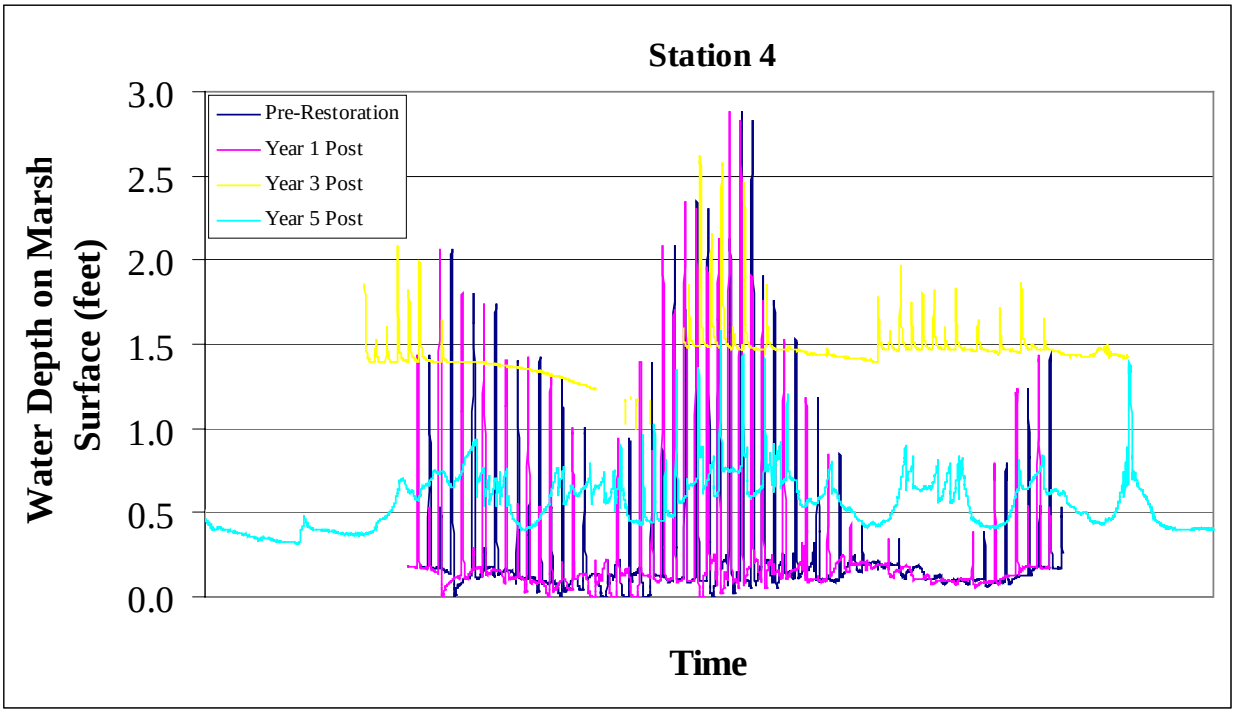
A Comparison of Pre-Restoration and Year 1, and 5 Post-Restoration Water Level on Marsh Surface at Seavey Landing





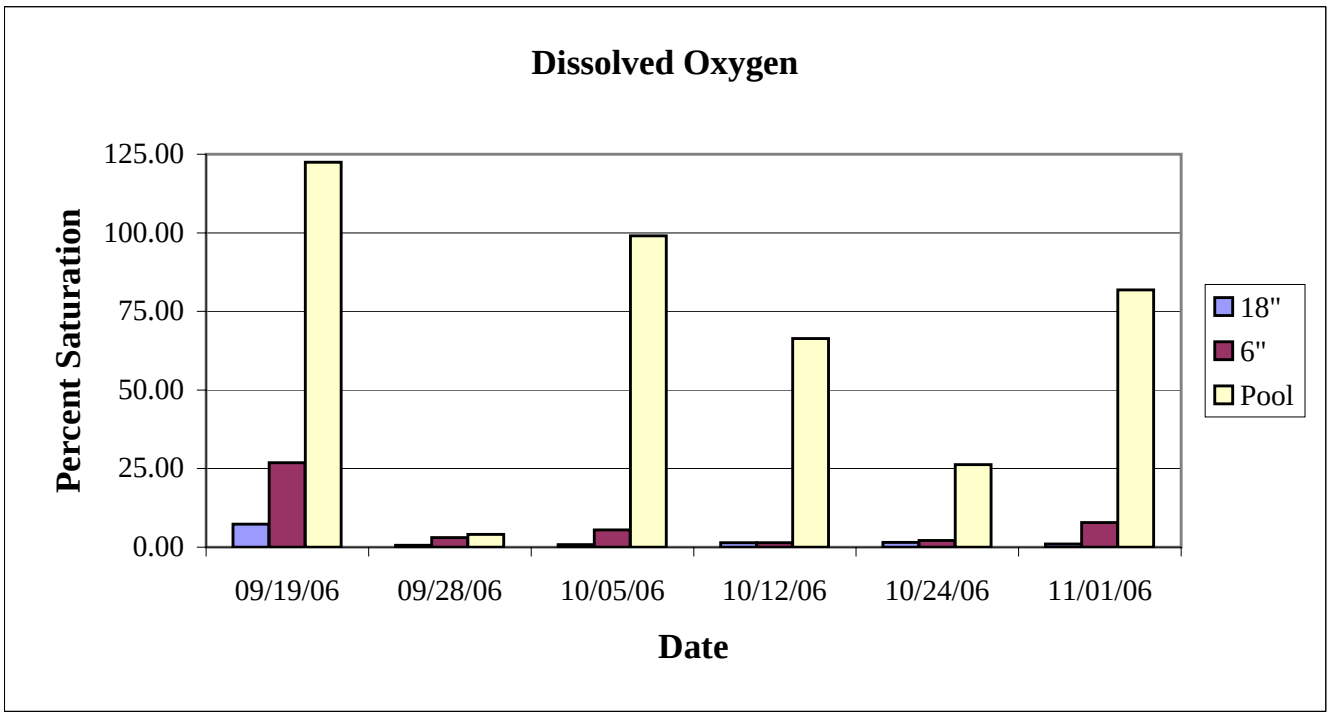
A Comparison of Pre-Restoration and Year 1 and 3 Post-Restoration Water Level on Marsh Surface at Seavey Landing (continued)

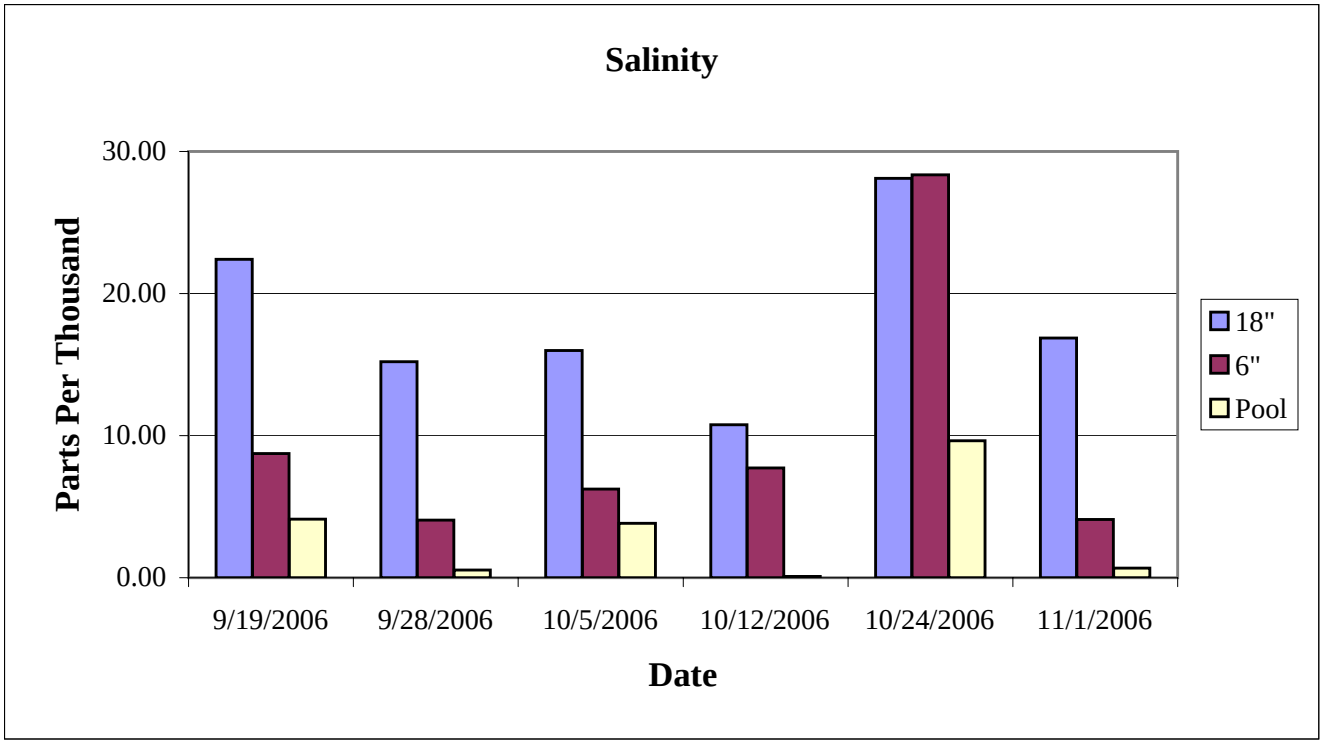




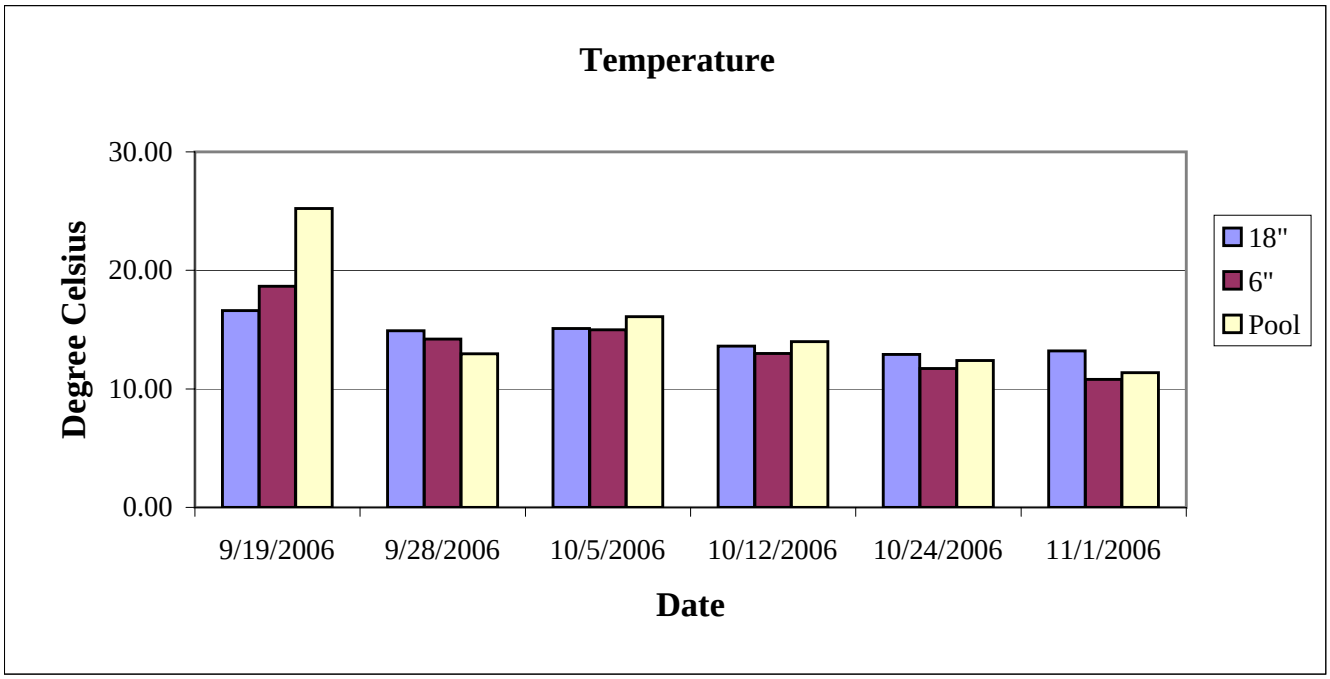
Water Quality Data

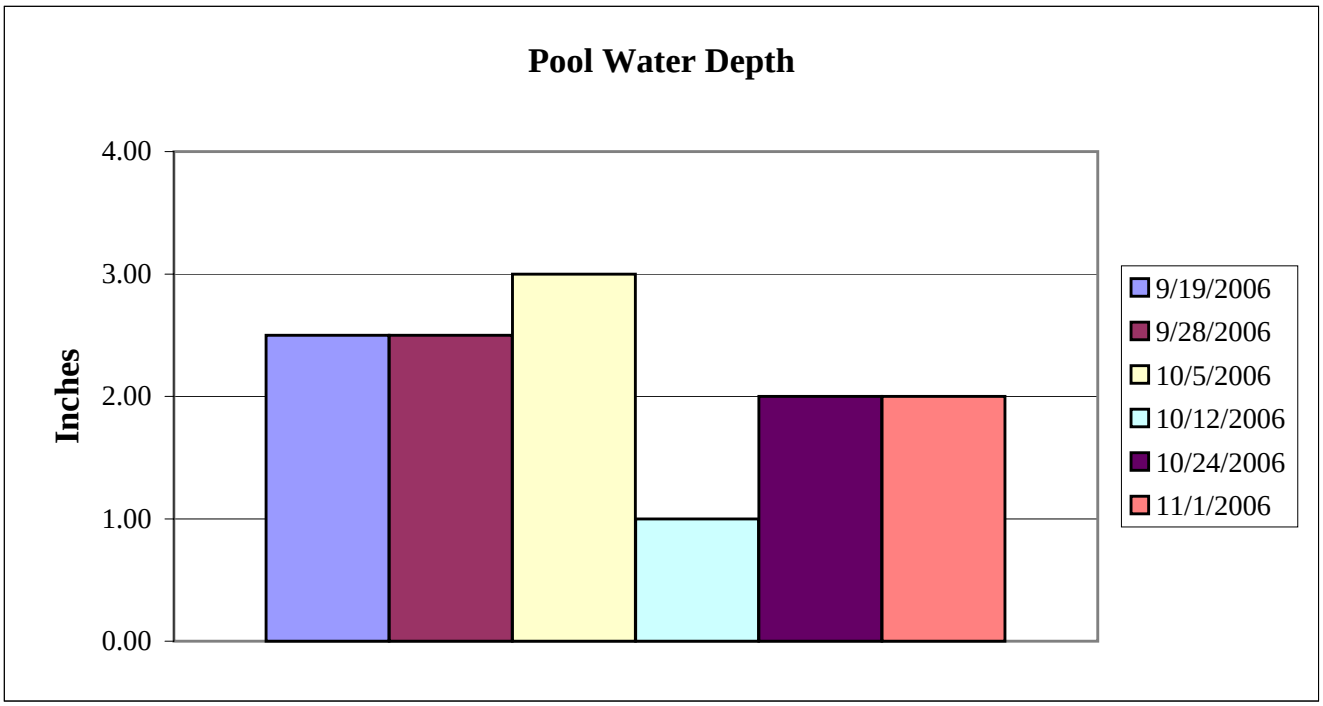
Station 1


Dissolved Oxygen
Percent Saturation
125.00
100.00
75.00
50.00
25.00
0.00
09/19/06
09/28/06
10/05/06
10/12/06
10/24/06
11/01/06
Date
18"
6"
Pool

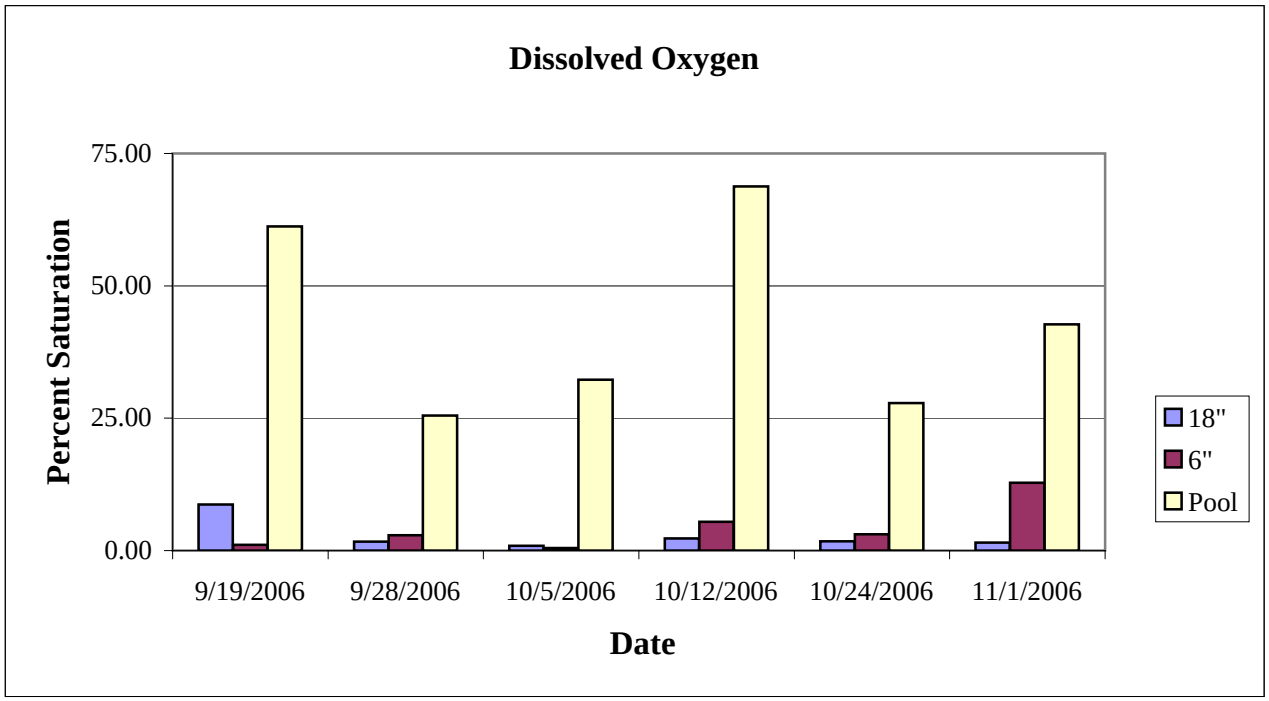

Salinity
Parts Per Thousand
30.00
20.00
10.00
0.00
9/19/2006
9/28/2006
10/5/2006
10/12/2006
10/24/2006
11/1/2006
Date
18"
6"
Pool

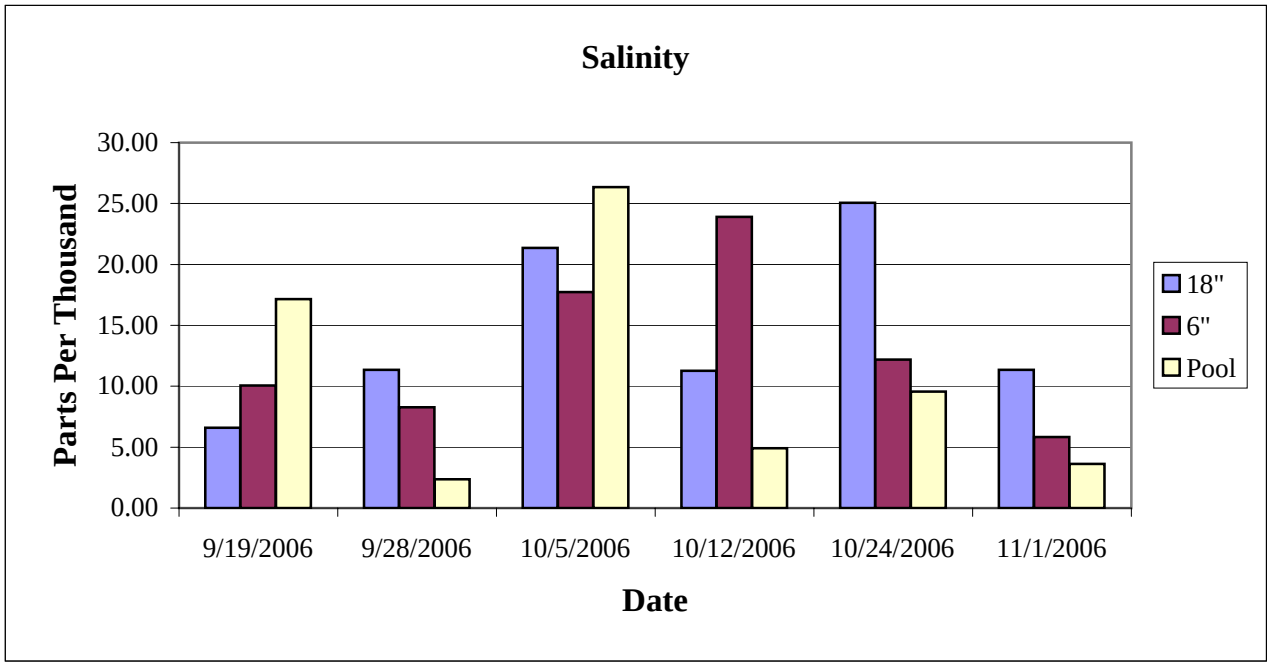
Station 1


Temperature
30.00
20.00
10.00
0.00
Degree Celsius
9/19/2006
9/28/2006
10/5/2006
10/12/2006
10/24/2006
11/1/2006
Date
18"
6"
Pool

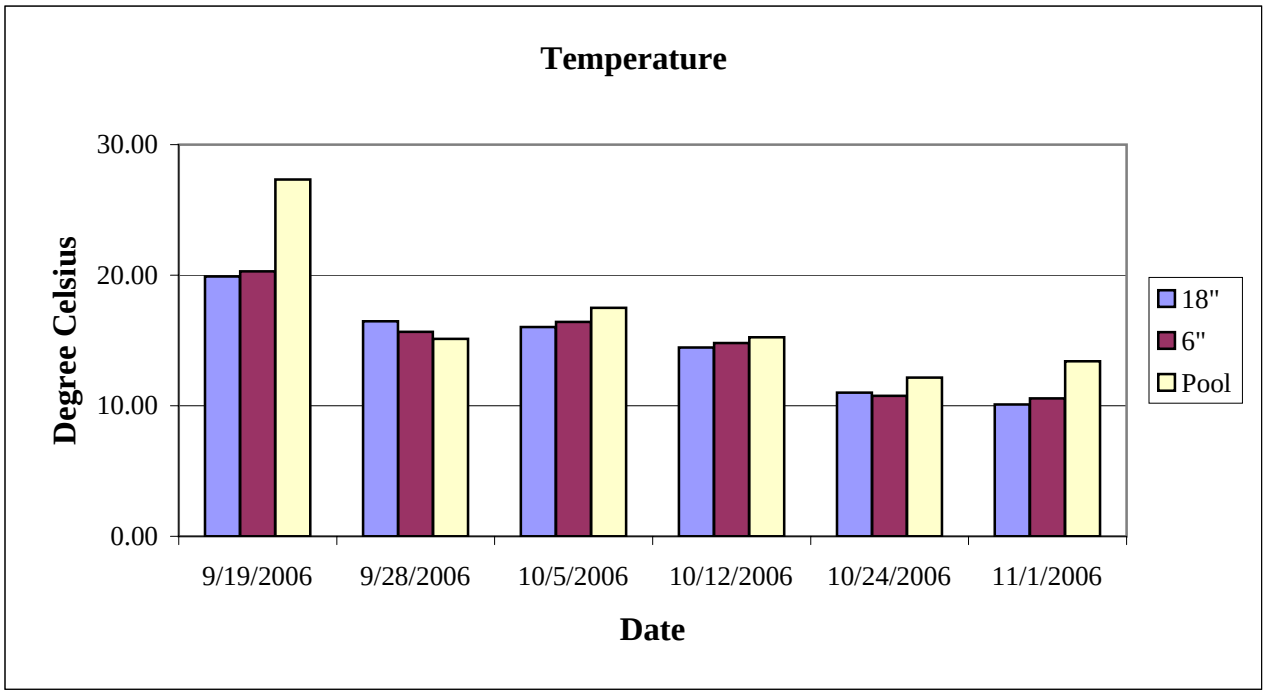

Pool Water Depth
4.00
3.00
2.00
1.00
0.00
Inches
9/19/2006
9/28/2006
10/5/2006
10/12/2006
10/24/2006
11/1/2006

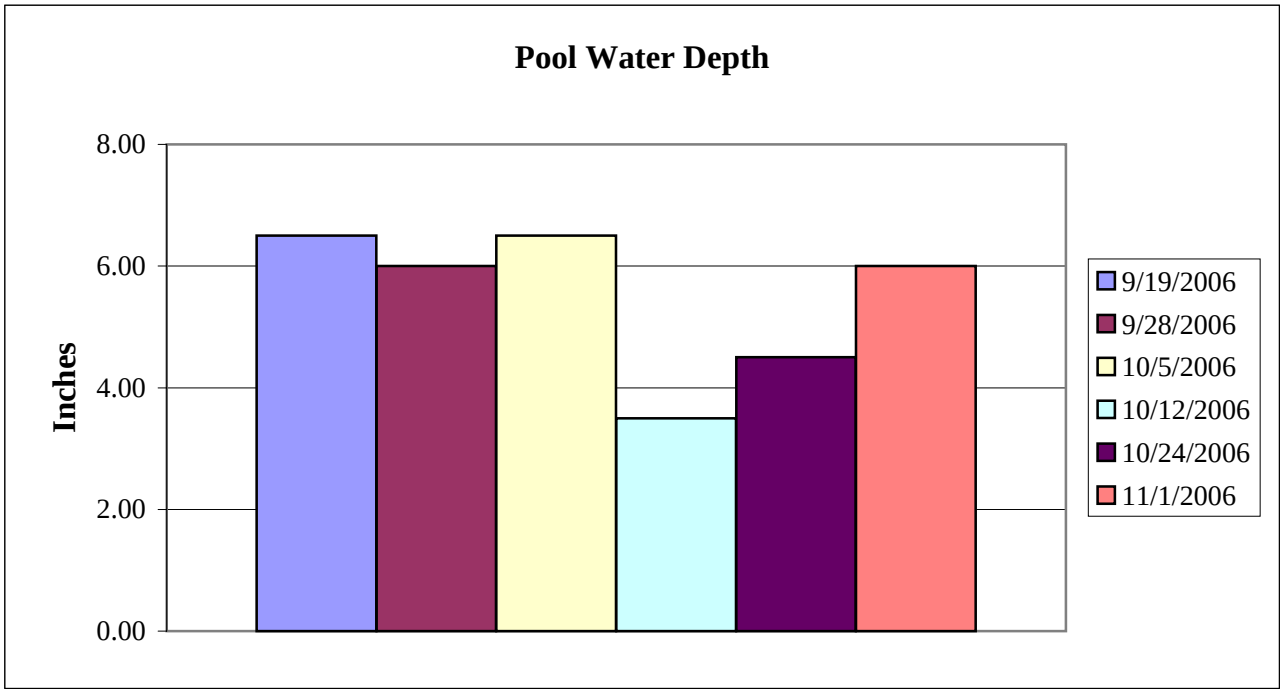
Station 2


Dissolved Oxygen
Percent Saturation
75.00
50.00
25.00
0.00
9/19/2006
9/28/2006
10/5/2006
10/12/2006
10/24/2006
11/1/2006
Date
18"
6"
Pool

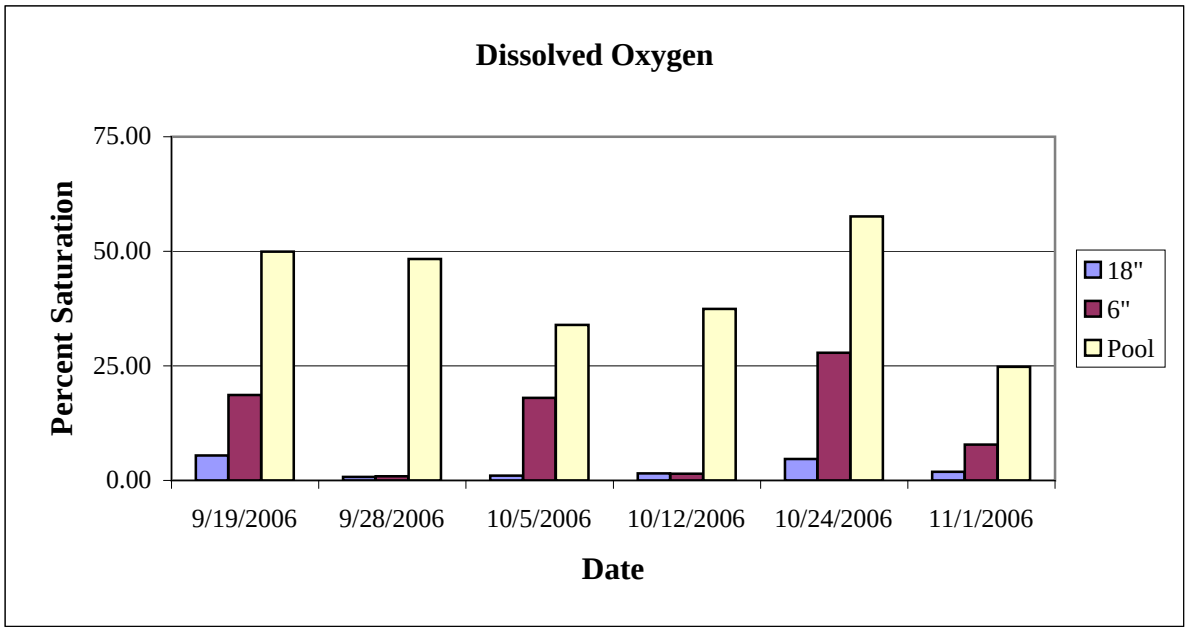

Salinity
Parts Per Thousand
30.00
25.00
20.00
15.00
10.00
5.00
0.00
9/19/2006
9/28/2006
10/5/2006
10/12/2006
10/24/2006
11/1/2006
Date
18"
6"
Pool

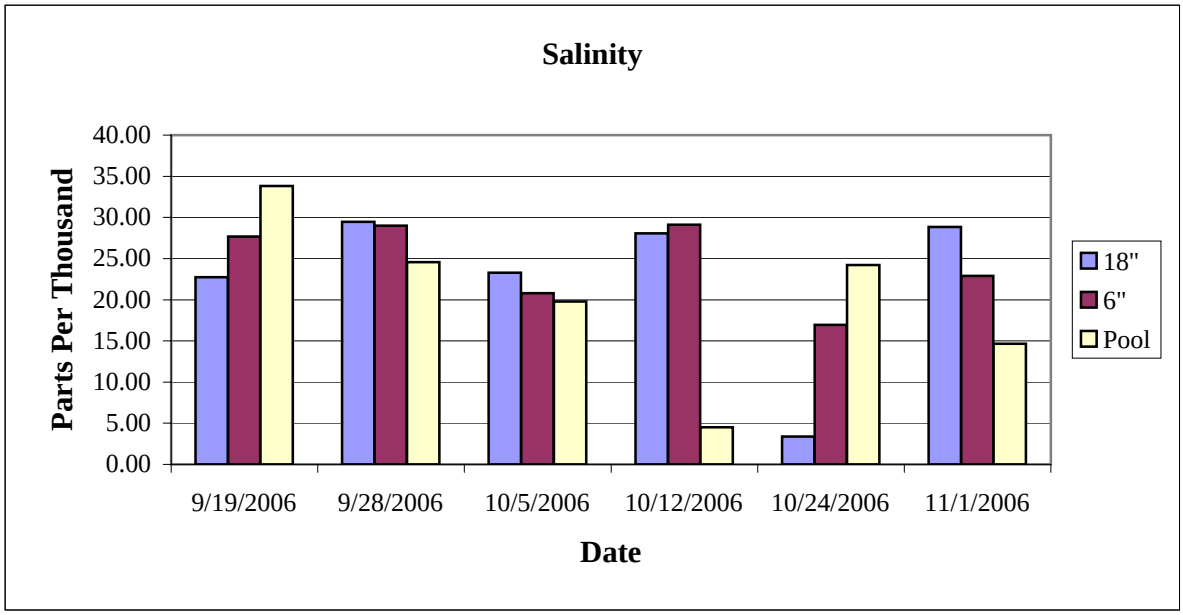
Station 2


Temperature
30.00
20.00
10.00
0.00
Degree Celsius
9/19/2006
9/28/2006
10/5/2006
10/12/2006
10/24/2006
11/1/2006
Date
18"
6"
Pool

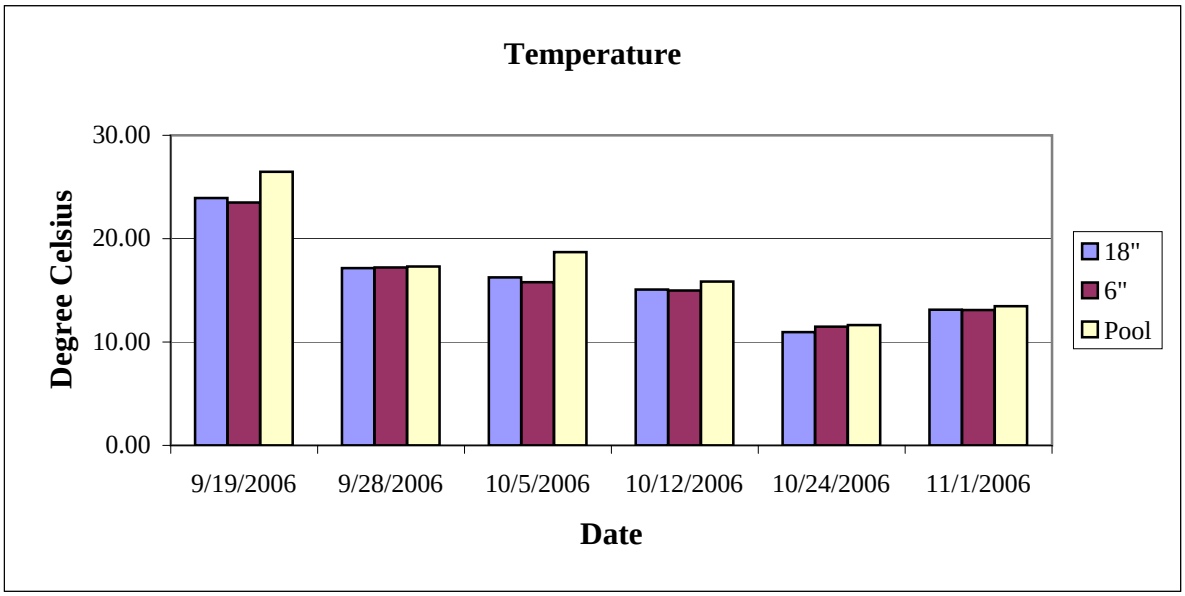

Pool Water Depth
8.00
6.00
4.00
2.00
0.00
Inches
9/19/2006
9/28/2006
10/5/2006
10/12/2006
10/24/2006
11/1/2006

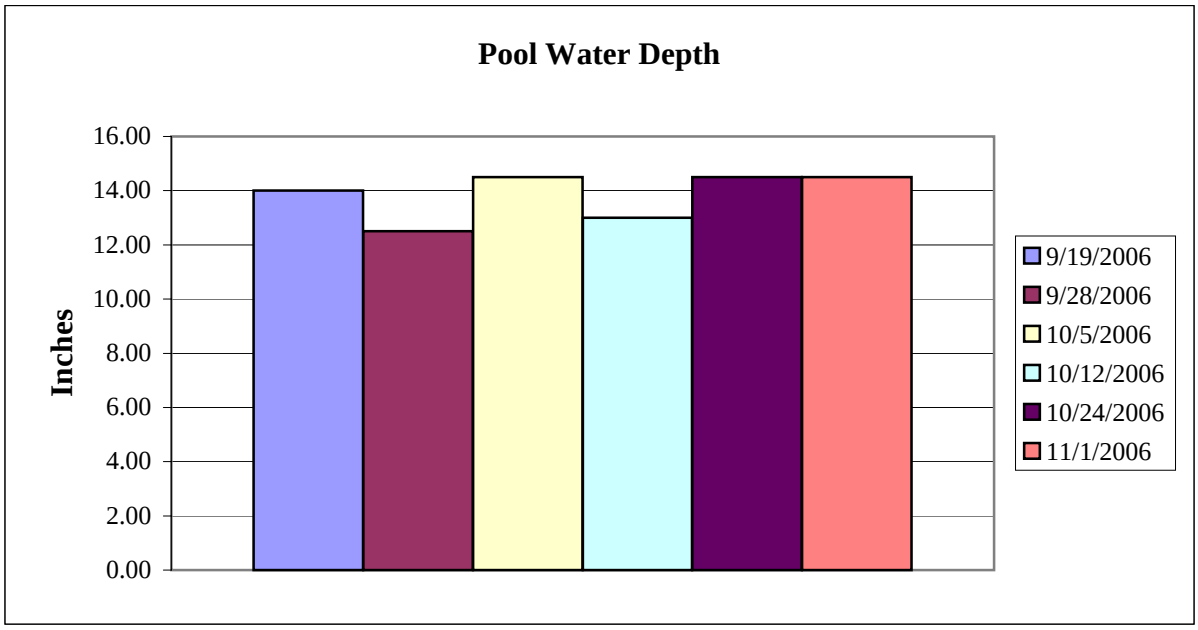
Station 3


Dissolved Oxygen
Percent Saturation
75.00
50.00
25.00
0.00
9/19/2006
9/28/2006
10/5/2006
10/12/2006
10/24/2006
11/1/2006
Date
18"
6"
Pool

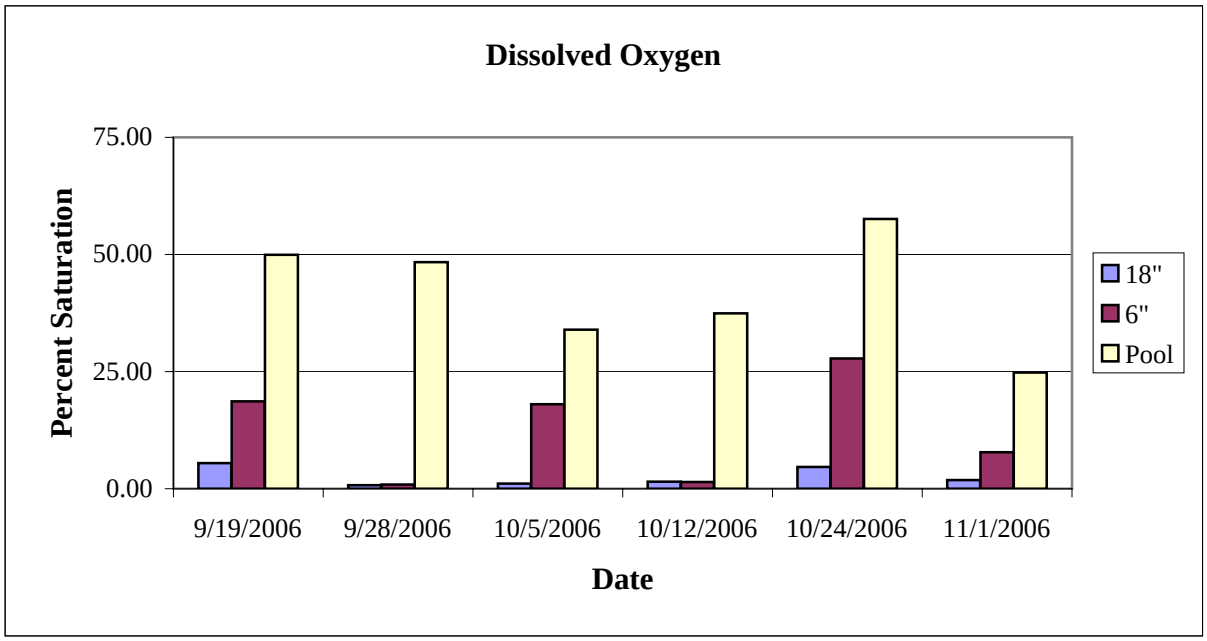

Salinity
Parts Per Thousand
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
9/19/2006
9/28/2006
10/5/2006
10/12/2006
10/24/2006
11/1/2006
Date
18"
6"
Pool

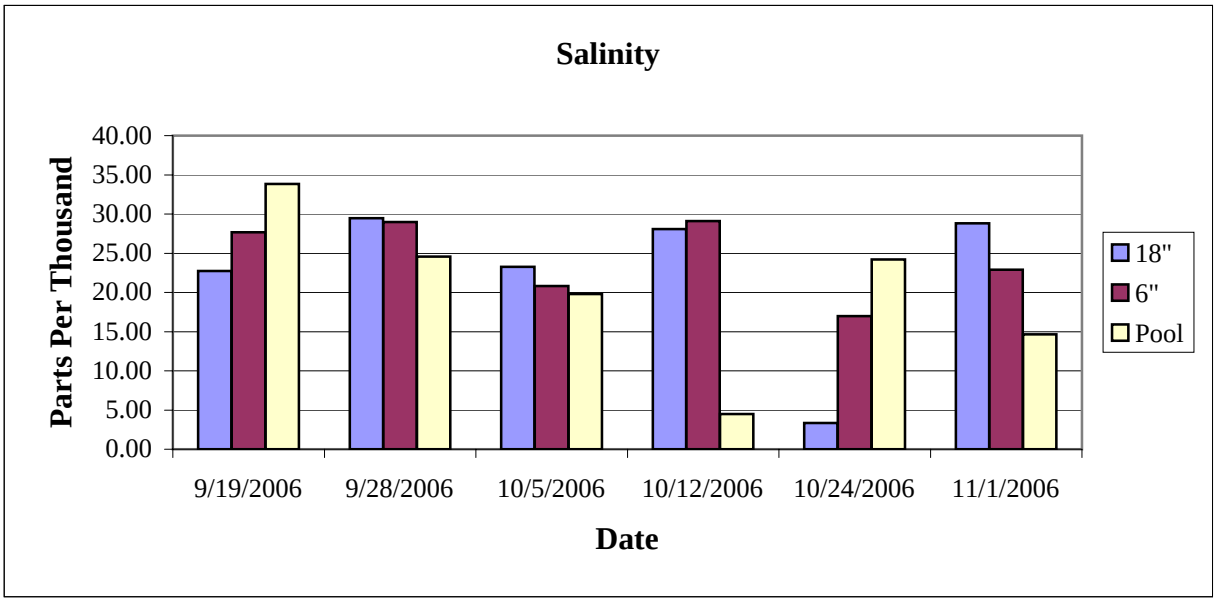
Station 3


Temperature
30.00
20.00
10.00
0.00
Degree Celsius
9/19/2006
9/28/2006
10/5/2006
10/12/2006
10/24/2006
11/1/2006
Date
18"
6"
Pool

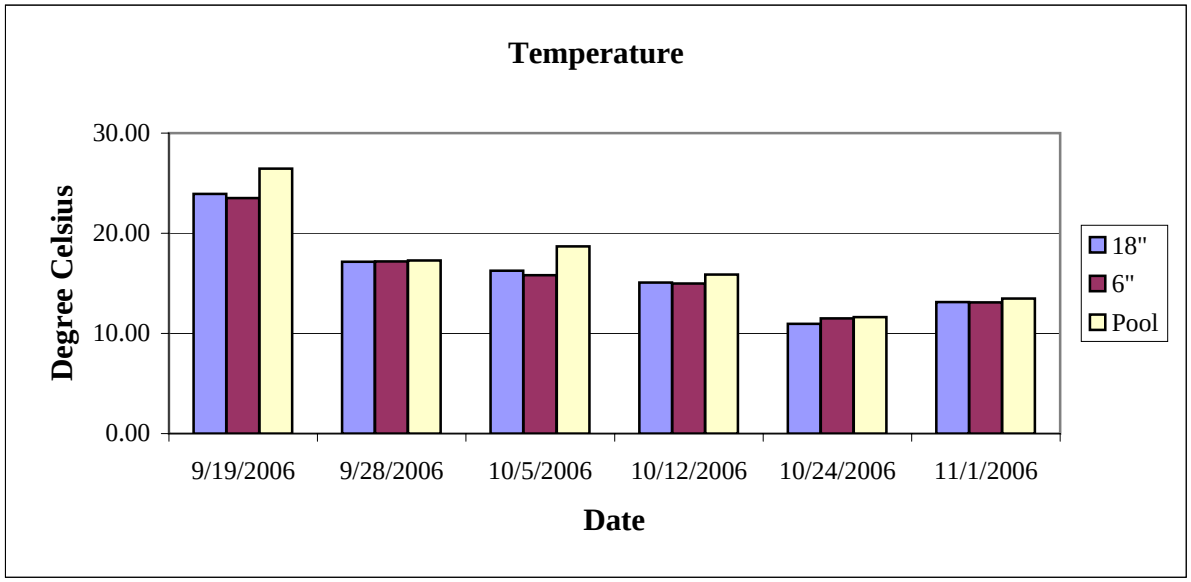

Pool Water Depth
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
Inches
9/19/2006
9/28/2006
10/5/2006
10/12/2006
10/24/2006
11/1/2006

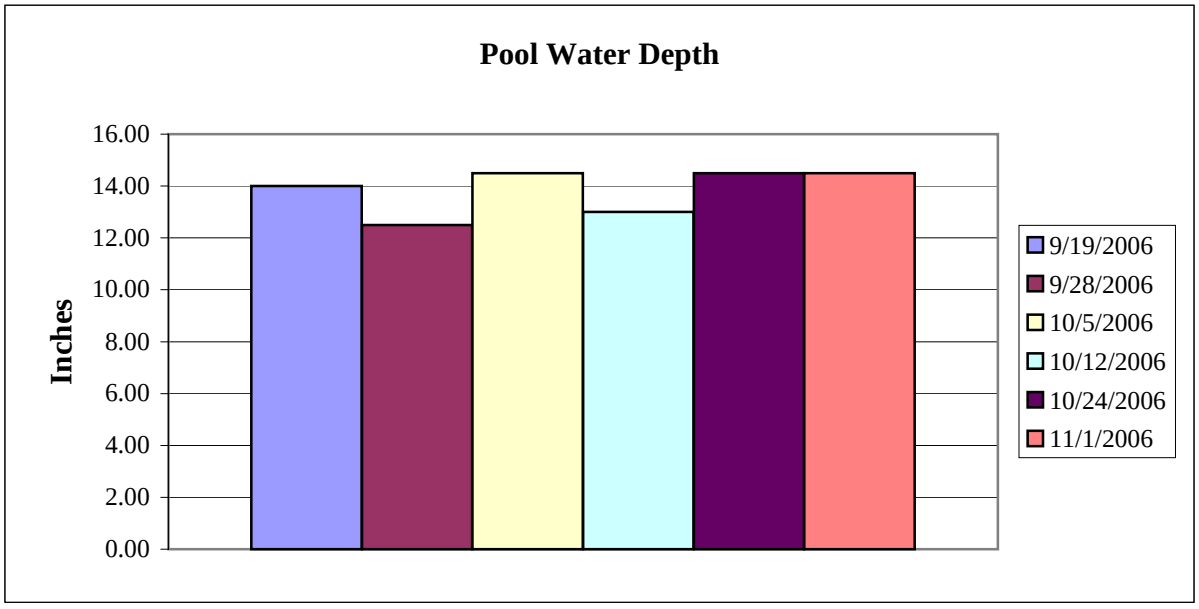
Station 4


Dissolved Oxygen
Percent Saturation
75.00
50.00
25.00
0.00
9/19/2006
9/28/2006
10/5/2006
10/12/2006
10/24/2006
11/1/2006
Date
18"
6"
Pool


Salinity
Parts Per Thousand
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
9/19/2006
9/28/2006
10/5/2006
10/12/2006
10/24/2006
11/1/2006
Date
18"
6"
Pool

Station 4


Temperature
30.00
20.00
10.00
0.00
Degree Celsius
9/19/2006
9/28/2006
10/5/2006
10/12/2006
10/24/2006
11/1/2006
Date
18"
6"
Pool


Pool Water Depth
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
Inches
9/19/2006
9/28/2006
10/5/2006
10/12/2006
10/24/2006
11/1/2006

APPENDIX E

Field Notes

9-15-06

Programmed loggers for deployment
SL #4 SL #2
SL #3 SL #1
-Synchronized time @ 9:45 am

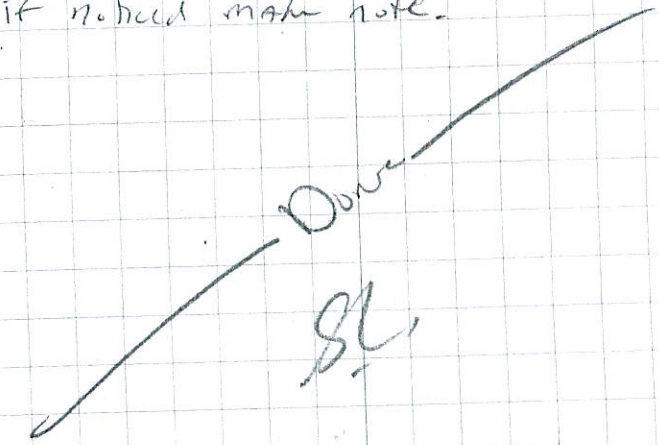
1100 - Water Quality station #4
pipe broken lying in pool (~2½ ft) deep lots of fish, crabs, large American eel (~16" long).
brought both for repair

1115 - Deployed WLR @ WQS #3
-Observation: typha lot. straw in pipe plug associated with WQS #3
* - Installed WQS #3 w/ WLR #4 *
MAKE NOTE WHEN DOWNLOADING

1125 - Deployed WLR @ WQS #2
-big osprey w/ ~12" fish flyover

1130 - Deployed WLR @ WQS #1

1145 - SW + SL washbucket to WQS #4 and fixed WQS.
Deployed WLR #3.
18" + 6" were non-recoverable. (i.e. broken past repair).
Salvaged piece from marsh pool.
Observation: siltation may have occured in both WQS due pipe. ~~#~~ on raising marsh surface readings. if noticed make note.



9-19-06 Sequoy Landing

Weather is partly cloudy, ~62°, no precip in ~2 weeks. Low tide is 1530.

Brought 2 pvc pipe sets for WQS #4 6" + 18". - Installed

Checked WQ at WQS #3

	T(c)	DO(%)	Sal (ppt)
18"	21.8	2.1	27.5
↓	21.7	2.4	27.6
↓	21.8	2.7	24.2
6"	21.9	3.4	20.6
↓	21.3	3.8	21.3
↓	20.7	2.1	22.1
pool	24.6	60.2	27.5
	23.9	65.1	27.5
	24.0	59.7	27.5

* put cap (w/ tape) over 6" w/ pvc pipe

Water Quality Station #2

	T	DO	Sal (ppt)
18"	19.8	8.7	6.6
↓	19.9	8.7	6.6
↓	20.1	8.7	6.6
6"	20.3	15.3	10.0
↓	20.3	15.2	10.3
↓	20.3	13.9	9.9
pool	27.4	22.5	17.1
↓	27.3	22.5	17.1
↳	27.4	26.1	17.3

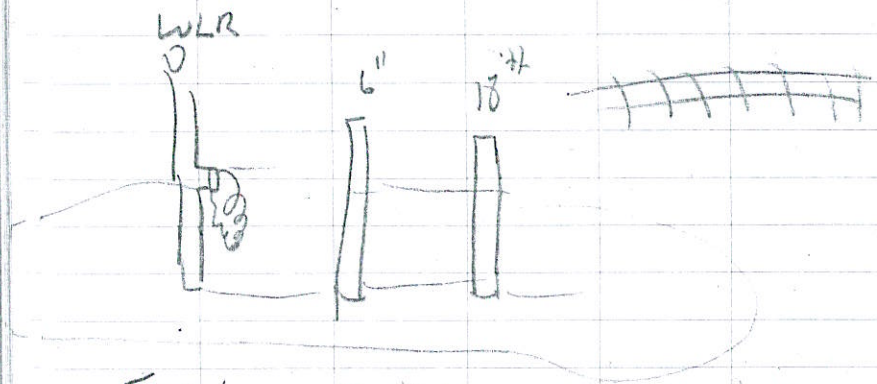
Water Quality Station #1

	T (c)	DO (%)	Sal (ppt)
18"	16.5	10.2	31.2
↓	16.5	6.4	33.5
↓	16.8	5.3	32.5
6"	16.7	23.4	4.7
↓	16.6	27.4	18.4
↓	16.7	30.0	3.1
pool	25.6	121.6	3.2
↓	25.2	132.0	3.1
↳	24.9	114.1	6.1

Water Quality Station #1

	T	DO	SAL
Pool	27.1	93.1	34.2
↓	26.7	93.6	33.1
	25.6	87.2	34.2
6"	24.1	16.7	27.5
↓	22.9	19.2	28.1
	23.5	20.1	27.4
18"	26.1	4.2	30.1
↓	22.1	6.7	19.2
↳	23.6	5.5	18.9

→ Installed 6" + 18" water quality



Duct tape over the top of the two

ODNB SC - 1725pm

9-28-06

COOL, 50s, OVERCAST, FOGGY.
S. WATTS

ONSITE 745

STATION #1 – furthest from Landing Rd. seaways near RR

	T(C)	DO(%)	SAL (ppt)
18"	14.9	0.8	16.1
↓	14.9	0.4	15.2
↓	14.9	0.6	14.3
6"	14.1	1.2	4.0
↓	14.2	4.4	4.2
↓	14.2	3.7	4.0
POOL	12.9	5.0	0.5
↓	13.0	4.1	0.6
↓	12.9	3.3	0.5

~4" deep

DO @ 6" decreased to 1.4 then steadily increased to 4.4 when collecting replicate #2

Download WLR & clear history Station #1

GW @ surface.

Station #2

Download WLR, data ok, clear history. Battery in computer is dying after only being on for ~15-20 minutes.

	T(°C)	DO(%)	sal(ppt)	
18"	16.5	0.2	12.0	
↓	16.4	0.6	10.9	
↓	16.5	4.3	11.2	
6"	15.7	2.9	8.7	
↓	15.6	3.0	7.8	
↓	15.6	2.8	8.3	
pool	15.5	15.0	2.8	
↓	15.1	32.9	2.1	*
↓	14.8	28.7	2.2	*

~4" deep to muck surface.

Ground Water (GW) at surface, o

* position of probe tip was slightly different in replicate 1 than in 2+3.

Station #3

	T(°C)	DO(%)	Sal(ppt)	
18"	16.9	1.8	21.2	
↓	17.0	1.6	21.2	
↓	16.9	0.9	21.2	
6"	16.6	0.8	21.5	
↓	16.4	0.7	21.6	
↓	16.4	0.8	21.6	
pool	17.7	~~37.3~~ 35.0	24.3	
↓	17.8	35.5	16.6	← varies w/ wind
↓	17.7	31.0	26.6	

~8" deep

Computer battery died in the middle of downloading / saving. Not successful. Data still retained on WLR. (at station 3)

Unable to download Station 4.

Station #4

	T (°C)	DO (%)	sal (ppt)
15"	17.1	0.6	29.4
↓	17.2	0.6	29.5
	17.2	1.0	29.5
6"	17.4	0.9	29.6
↓	17.1	1.0	29.0
	17.1	0.8	29.1
Pool	~~17.8~~ 17.3	48.8	24.5
↓	17.3	47.1	24.6
	17.3	~~49.~~ 49.1	24.6

END 9/28/06
10:57
JL

10-3-06

Cloudy, ~55°, wind 2-7mph

On site 1300 / Low tide: 1204

Site Assessment:
- Mosquito Dip count ✓
- photo log ✓
- Ditch plug inspection ✓

Photos:
- marsh surface
- marsh surface
- Photo series 1
- seal (mammal)
- photo series 2
- water quality pt. 1 w/ lots of water in pool ~16" deep (much more than last year (2 photos)

DP II 3 (water in QS = 1)
DP is structurally sound, no increase erosion or leak. It is holding more H_2O than in previous years.
- D. stricta / goldenrods / Juncus / Spartina

DP is slightly higher, firm, and moss.

JL

10-3-06

2 photos of DP#3

- Photo series #3
- Typha stand on edge of south west marsh between WQ#1 + WQ#2 near houses.
- Water Quality station #2 w/ WLR's in place

2 photos of DP #5.

- Structurally sound w/ no evidence of erosion leaks, or water flow. No invasive sp. present. Scirpus + Juncus abound. little bit of goldenrod (in flower). Would showing of DP. still in really good condition, pools retaining lots of water at average low tide.
- Photo station # 4
- Water Quality station # 3

SC.

10-3-06

DP#6 - near edge of marsh. St. sound w/ no evidence of erosion or water flow. Cannot see DP covered in thick vegetation Typha lat. stand growing, large stand near edge of marsh. Same place + size as last year.

- Dunlin, or avocet photos (2) White tail, Head sub, curled beak White belly, Plover(!)
- WQ St. #3. lots of Black flies in water
- Photo station #5

DP#5

- str. sound w/ no evidence of erosion or water flow, Drains of water from wet channel above. No invasive spp. * small Typha
- Photo station #6
  + 2 extra in series.

SC.

10-3-06

Wake Qual. #4

- Rec and Fractional compared to last year. WLR in place. deep pool ~3ft deep no obvious fish. eel.

- Vegetation Map
  - Not much change.
  - small spots of Salvinia on western ½ of marsh.
  - increased typha on dp #5. and small stand behind (southwest) of dp #5

Bird list.
- Cow / Raven
- Gull
- Cormorant
- spoonbill sp.
- plover

SL.

Mosquito Dip Count. -1429

1	⊘	21	⊘	41	⊘	61	⊘	
2	⊘	22	⊘	42		62	⊘	
3		23	sh.	43		63	⊘	
4		24		44		64	⊘	
5		25		45		65	⊘	
6		26		46		66	⊘	
7		27		47		67	⊘	
8		28		48	⊘	68	⊘	
9		29		49	⊘	69	⊘	
10		30	sh.	50	⊘	70	⊘	
11		31		51	⊘	→ Pulse ...		
12	⊘	32		52	⊘	Thermal		
13	1	33		53				
14	⊘ shrimp	34	6	54		out.		
15	2	35	⊘	55				
16	⊘	36	3	56				
17	⊘	37	⊘	57				
18	⊘	38	sh.	58				
19	⊘	39	sh.	59				
20	⊘	40		60				

Finish survey: 1637 S.C.

10-5-06

SC. sunny, windy.
low tide = 340

Downloaded WLR, okay! WL
4. saved to PC Laptop. need
to file. Battery was failing after
~10 min of operation. * Need new Battery.

WQS #4

	T	DO %	Sal. (ppt)
18"	16.7	0.7	32.1
↓	15.9	0.8	17.5
↓	16.2	1.7	19.9
6"	15.1	19.1	21.6
↓	15.2	18.2	20.2
↓	17.1	16.1	20.6
Pool	19.4	35.1	19.7
↓	17.6	35.6	19.6
↓	18.9	31.1	20.1

WQS #3

	T (c)	DO (%)	Sal (ppt)
18	16.7	0.3	22.7
↓	16.5	0.2	23.5
↓	16.7	0.7	22.9
6"	15.6	5.7	21.7
↓	15.2	5.9	21.7
↓	15.2	6.5	21.3
Pool	16.7	42.6	21.6
↓	15.8	46.2	20.9
↓	15.2	58.1	24.7

WQS #2

	T (c)	DO (%)	SAL (ppt)
18"	15.9	0.9	21.2
↓	15.9	1.3	21.5
↓	16.3	0.6	21.2
6"	16.7	0.5	21.0
↓	16.9	0.5	12.5
↓	15.8	0.5	19.7
Pool	17.6	28.7	26.2
↓	17.2	32.6	26.2
↓	17.7	35.6	26.7

WQS #1

	T(C)	DO (%)	SAL (PPT)
10"	15.5	0.9	16.1
↓	14.9	0.7	16.2
	14.9	0.8	15.7
6"	14.9	4.7	6.0
↓	15.1	6.3	7.1
	15.0	5.5	5.6
pool	16.1	*101.6	0.7
↓	16.2	*95.0	5.2
	16.0	*101.1	5.6

↖ very windy + would bounce w/ gusts!

- Pine Env.
  YSI-85 - long cord.

end 1632

and 10/5/06

SC

10/12/06 Seavey Landing Marsh
J. Wu

- Light drizzle + temp in the high 50's

- Rained all night and very heavy at times. According to radio, we received over an inch of rain during this period.

- Due to the drizzle condition, loggers will not be downloaded (hard to conceal laptop) and only H_2O quality will be taken.

- Wildlife Species observed: Egret, crow, gulls, black duck, deer (?), great blue heron

Water Quality at Station #1

	Temp (°C)	DO (%)	Sal (ppt)
18"	13.8	1.3	12.1
↓	13.5	1.7	9.2
↓	13.6	1.3	11.0
6"	12.9	1.4	8.0
↓	13.0	1.4	7.8
↓	13.1	1.4	7.4
pool	14.0	59.8	0.1
↓	14.0	69.6	0.1
↓	14.0	69.9	0.1

- Due to rain, marsh surface at Pool #1 is well inundated with constant "flow" / draining of the pool.

- Heard gun shots, but didn't think it's duck season yet.

Water Quality at Station #2

	Temp (°C)	DO (%)	Sal (ppt)
18"	14.5	1.5	11.9
↓	14.4	1.3	11.3
↓	14.3	4.2	10.6
6"	14.8	4.6	23.9
↓	14.9	6.0	23.9
↓	14.9	5.7	23.5
pool	15.2	31.8	1.1
↓	15.3	14.6	1.1
↓	15.3	22.4	2.7

- Pool at station #2 is also well inundated. However, water is stagnant and none flowing.

Water Quality at Station #3

	Temp (°C)	DO (%)	Sal (ppt)
18"	15.4	1.9	20.6
↓	15.3	2.6	20.6
	15.4	2.1	20.6
6"	15.8	2.0	25.7
↓	15.8	3.2	25.4
	15.8	5.9	25.1
pool	17.1	27.1	6.2
↓	17.3	38.6	6.1
	17.4	15.0	7.4

Water Quality at Station #4

	Temp (°C)	DO (%)	Sal (ppt)
18"	15.2	1.9	28.0
↓	15.0	1.4	28.1
6"	15.00	1.3	28.1
↓	15.00	1.4	29.1
	15.0	1.3	29.1
	15.0	1.6	29.1
pool	15.80	41.6	4.7
↓	15.80	34.8	4.4
	16.0	25.8	4.4

10/24/06 - Seavey landing

JC - Sunny ~45°-55° NO wind

No rain in ~4 days. getting cold ~35° last night

Water Quality station #1

18"	T (C)	DO (%)	Sal (ppt)
↓	12.1	1.2	28.1
	13.5	1.6	28.1
	13.2	1.8	28.2
6"	12.1	1.9	28.5
↓	11.5	2.1	28.3
	11.6	2.2	28.2
pool	12.3°	28.1	10.2
↓	12.4	25.2	10.2
	12.5	25.2	8.5

Downloaded DWLR to Laptop - one more sampling 5959 units.

10/24

Water Quality Station #2

	T	DO	SAL
18"	10.9	1.6	25.1
↓	11.1	1.5	25.1
↓	10.8	2.1	24.9
6"	10.8	3.0	12.2
↓	10.6	3.1	12.2
↓	10.8	3.1	12.1
pool	12.1	27.1	9.8
↓	12.2	27.8	9.8
	12.1	28.7	9.1

Downloaded WLR

WATER Quality Station #3

	T (C)	DO (%)	SAL (ppt)
18"	10.9	1.8	21.8
↓	10.9	1.2	9.5
↓	11.1	1.6	9.1
6"	10.9	5.3	12.3
↓	10.6	1.8	12.1
↓	10.8	5.5	12.1
pool	12.1	51.4	24.8
↓	12.5	50.3	24.5
	12.5	55.2	24.8

Downloaded WLR

10/24

Water Quality Station #4

18"	T (C)	DO (%)	Sal (ppt)
↓	11.0	1.2	1.8
↓	11.1	6.0	0.2
	10.8	6.8	8.1
6"	11.4	27.1	16.3
↓	11.6	28.2	20.1
↓	11.5	26.1	12.5
Pool	11.8	56.1	24.4
↓	11.6	58.2	24.1
↓	11.5	58.5	24.1

Downloaded WLR – 8575 units

Done
SC

11/1/06

WQS #1

pool	T (c)	DO %	Sal (ppt)
↓	13.2	68.1	0.3
	13.2	73.2	0.3
↓	13.2	84.1	1.4
6"	10.6	9.0	3.9
↓	11.1	8.2	4.2
↓	10.7	6.3	4.2
18"	11.1	1.2	15.8
↓	12.2	0.1	17.3
↓	10.8	0.7	17.5

took out WLR → back to office to download @ 1215
left PVC in field

Today is sunny wind 2.5mph.
Heavy rain this weekend. 2-4-5"
of rain winds ~30-50mph

WQS #2

pool	T (c)	DO (%)	Sal (ppt)
↓	12.9	65.1	6.1
↓	14.1	59.8	2.7
	13.2	62.3	2.1
6"	10.7	24.1	4.9
↓	9.9	6.3	7.1
↓	11.1	8.1	5.5
17"	10.2	1.3	11.5
↓	10.1	2.0	11.0
↓	10.1	1.2	11.5

Took out WLR @ 12:32 back to office to download.

WQS #3 I

pool	T (c)	DO	Sal (ppt)
	18.1	37.7	6.5
↓	17.4	27.3	6.2
↓	12.8	16.2	6.5
6"	10.9	8.1	11.1
↓	9.8	9.2	12.2
↓	10.6	6.3	9.8
18	10.2	1.2	11.0
↓	10.1	1.6	15.5
↓	9.7	1.3	13.8

WQS #4

	T	DO(%)	Sal
Pool	13.1	23.1	14.1
↓	14.1	25.1	14.2
	13.2	26.1	15.6
6"	13.7	7.4	23.9
↓	12.1	9.4	23.2
	13.5	7.0	21.6
18"	12.1	1.9	29.7
↓	13.1	1.8	27.5
	14.2	1.9	29.3

Pulled all WLRs

END 1:41pm.

APPENDIX F

Species List

Incidental Species Observations in the Vicinity of the Seavey Landing Project Area During Pre-Restoration and Year 1, Year 2, Year 3, Year 4, and Year 5 Post-Restoration Monitoring.

Common Name	Scientific Name	Observed Pre-Restoration	Observed Year 1 Post-Restoration	Observed Year 2 Post-Restoration*	Observed Year 3 Post-Restoration*	Observed Year 4 Post-Restoration	Observed Year 5 Post-Restoration
Birds							
American bittern	*Botarus lentiginosus*	*X*				*X*	
American black duck	*Anas rubripes*	*X*	*X*	*X*	*X*		
American crow	*Corvus brachyrhynchos*	*X*	*X*	*X*	*X*	*X*	*X*
American goldfinch	*Carduelis tristis*	*X*	*X*				*X*
American robin	*Turdus migratorius*	*X*	*X*				
American woodcock	*Scolopax minor*		*X*				
Belted kingfisher	*Ceryle alcyon*	*X*	*X*				
Black capped chickadee	*Parus atricapillus*	*X*	*X*				*X*
Black-crowned night heron	*Nycticorax nycticorax*	*X*					
Blue jay	*Cyanocitta cristata*	*X*	*X*			*X*	
Canada goose	*Branta canadensis*	*X*		*X*			*X*
Cedar waxwing	*Bombycilla cedrorum*		*X*				
Common grackle	*Quiscalus quiscula*		*X*				
Great blue heron	*Ardea heroides*	*X*	*X*	*X*	*X*		
Gray catbird	*Dumetella carolinensis*	*X*	*X*				
Double Crested Cormorant	*Phalacrocorax auritus*					*X*	*X*
Downy woodpecker	*Picoides pubescens*	*X*	*X*				
Eastern phoebe	*Sayornis phoebe*	*X*					

Common Name	Scientific Name	Observed Pre-Restoration	Observed Year 1 Post-Restoration	Observed Year 2 Post-Restoration*	Observed Year 3 Post-Restoration*	Observed Year 4 Post-Restoration	Observed Year 5 Post-Restoration
Great Egret	*Ardea alba*					*X*	*X*
Greater black-backed gull	*Larus marinus*	*X*	*X*				*X*
Greater yellowlegs	*Tringa melanoleuca*		*X*				*X*
Gull species	*Larus* sp.	*X*	*X*	*X*	*X*	*X*	*X*
Herring gull	*Larus argentatus*	*X*	*X*		*X*		
Killdeer	*Charadrius vociferous*	*X*					*X*
Mallard	*Anas platyrhynchos*	*X*				*X*	
Northern cardinal	*Cardinalis cardinalis*		*X*				
Northern flicker	*Colaptes auratus*	*X*	*X*				
Osprey	*Pandion haliaetus*		*X*			*X*	*X*
Pileated woodpecker	*Dryocopus pileatus*		*X*				
Red-tailed hawk	*Buteo jamaicensis*		*X*				
Ring-billed gull	*Larus delawarensis*	*X*					
Sandpiper species	*Actitis or Calidris*	*X*	*X*	*X*	*X*		*X*
Snowy egret	*Egretta thula*	*X*			*X*	*X*	*X*
Song sparrow	*Melospiza melodia*		*X*		*X*	*X*	
Swamp sparrow	*Melospiza georgiana*	*X*					
Tufted titmouse	*Baeolphus bicolor*		*X*				
Willet	*Catoptrophorus semipalmatus*		*X*				
Yellow-rumped warbler	*Dendroica coronata*	*X*	*X*				

Common Name	Scientific Name	Observed Pre-Restoration	Observed Year 1 Post-Restoration	Observed Year 2 Post-Restoration*	Observed Year 3 Post-Restoration*	Observed Year 4 Post-Restoration	Observed Year 5 Post-Restoration
Mammals							
Gray squirrel	*Sciurus carolinensis*	*X*	*X*	*X*			*X*
Red squirrel	*Tamiasciurus hudsonicus*		*X*				
River otter (tracks only – not confirmed)	*Lutra canadensis*	*X*					
Red fox	*Vulpes vulpes*	*X*	*X*				
Vole species	*Microtus* sp.	*X*					
White-tailed deer	*Odocoileus virginiana*	*X*	*X*	*X*	*X*	*X*	*X*
Common house cat	*Felis catus*			*X*			*X*
Raccoon (tracks only)	*Procyon lotor*				*X*		*X*
Amphibians							
Spring peeper	*Hyla cruicfer*	*X*	*X*				
Other							
Fiddler crab	*Uca* sp.	*X*	*X*		*X*	*X*	*X*
Striped killifish	*Fundulus majalis*	*X*	*X*				*X*
Killifish species	*Fundulus* sp.	*X*	*X*	*X*	*X*	*X*	*X*
Stickleback species	*Gasterosteus* sp.				*X*		*X*
Shore shrimp	*Palaemonetes* sp.	*X*	*X*				*X*

Note:* = Year 2 and 3 post-restoration survey was conducted during a 2-day survey period. The site assessment and photographic documentation were not conducted by an ornithologist, and therefore the extent of the usage of the marsh surface by bird species could not be determined.