2015 Post-Project Monitoring Report: Long Reach Lane at Long Marsh, Harpswell

Year 2 of 5

Compensation for the Martin's Point Bridge Project, Falmouth-Portland (PIN 16731.00)

March 2016

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. OVERVIEW

In 2012, the Maine Department of Transportation (MDOT) proposed a mitigation project at Long Reach Lane in Harpswell (Figure 1) to compensate for the functional impacts to marine wetlands associated with the construction of the Martin's Point Bridge between Falmouth and Portland. The mitigation project took place in January and February 2014, and resulted in the successful replacement of a 36" (7.1 ft^2 flow area) round concrete pipe beneath Long Reach Lane with a larger 6' x 12' concrete box culvert (72 ft^2 flow area) in February 2014 (photo MDOT, below).

This report primarily presents the results of pre-project monitoring, which occurred during the 2013 growing season, and Year 2 of post-project monitoring, which occurred during the 2015 growing season, at the Long Marsh mitigation site. Year 1 post-project data from 2014 are included in some instances for context.

1.1 Project Monitoring

The Casco Bay Estuary Partnership (CBEP), which is hosted by the University of Southern Maine, was contracted by MDOT to conduct monitoring within the Project Area for one year pre-project, and five years post-project. CBEP, one of 28 National Estuary Programs nationwide, has focused on assessment, restoration, and monitoring at tidal marshes since 2009.

The *Martin's Point Bridge Wetland Mitigation Plan* (*Plan;* MDOT 2012) describes the mitigation site Project Area as the marsh area upstream (south) of Long Reach Lane, and north of a bedrock feature locally known as "the narrows" (Figure 1). The *Plan* also states:

> In "*…the Marsh area south of the narrows … there are three large established patches of Phragmites that makes up approximately 7% of this portion of the marsh surface area. This area is outside of the project area."* (MDOT, Section J)

To monitor ecosystem change in response to the mitigation project, CBEP established 10 monitoring Stations at Long Marsh, spaced so that they were evenly distributed. Station 1 was located outside the Project Area, immediately to the north of Long Reach Lane, and Stations 2-10 were located within the Project Area, south of Long Reach Lane and north of the narrows (Figure 2). CBEP also established two monitoring Stations south of the Project Area, Stations 11 and 12.

The *Plan* specifies parameters for pre- and post-project monitoring:

- Hydrology signal – using continuous water level recorders deployed upstream and downstream of Long Reach Lane.
- Pore water and surface water salinity.
- Vegetation – abundance (percent cover) of halophytic, brackish, freshwater, and invasive plant species.
- Channel morphology – cross sectional area.
- Erosion – post-project visual surveys within the construction area.
- Photo stations.

1.2 Summary of Mitigation Goals and Performance Standards

The stated objective of the mitigation project was to eliminate the tidal restriction created by Long Reach Lane in Harpswell (MaineDOT 2012). The following performance standards were established for this objective:

1) *Tide curve data upstream of the crossing will be 80% or greater than that of the downstream area after crossing construction…The intention is that 80% (as opposed to 100%) removal will give us a comfortable operating margin, accounting for potential uncertainty in the model. If this standard is not met, the opening size will be enlarged to meet this standard. There may be a phase delay associated with this site after construction which will not be remediated.*
2) *All the constructed features such as slopes, soils, substrates within the mitigation site will be stabilized and free from erosion.* (MDOT 2012, Section I)

In addition, the *Plan* laid out a set of mitigation goals:

1) *Vegetation in the upstream marsh will transition from a salt marsh – brackish – freshwater system to predominately salt tolerant species. After the culvert replacement it is expected that a salinity gradient will limit freshwater species establishment. These species will be confined to the marsh edge fringe where overtopping does not occur and will include at a minimum the southernmost 30 acres of the marsh.*
2) *Invasive species, namely* Phragmites australis *(Common Reed) and* Lythrum salicaria *(Purple Loosestrife) will be monitored and controlled using integrated pest management techniques. The goal will be to eliminate the establishment of Common Reed and Loosestrife in the marsh*

restoration area. The project enhancement and restoration area does not support any Common Reed or Purple Loosestrife. (MDOT 2012, Section J)

Monitoring efforts to date indicate that site conditions within the Project Area continue to adjust in response to the new culvert, in ways that are consistent with the mitigation project objective, performance standards, and goals. Table 1 summarizes the status of tidal hydrology, erosion, and other monitored parameters in the second growing season post-project (2015), based on a comparison with pre-project monitoring data collected in 2013, and describes whether the status is consistent with pre-defined standards and goals for the mitigation site.

The performance standard for hydrology was met in 2014 as reported in Section 3.1 of the Year 1 post-project report (CBEP 2015). The performance standard for erosion control was met 2015, with the slopes, soils, and substrates within at the project site stable.

For the remaining monitoring parameters, response to the modified hydrology beneath Long Reach Lane is presumed to be ongoing, with Year 2 post-project data indicating that changes in site conditions are 'on-track' in that they are consistent with the objective and goals for the mitigation site over the 5-year post-project monitoring period.

Table 1. Summary of Performance Standards and Monitoring Parameters

Performance Standard/ Monitoring Parameters	2015 Findings	Meet Standard?*
Hydrology signal	*N/A*	Yes[1]
Erosion control	*Slopes, soils, substrates at the Project Site are stable*	On-track
Pore water salinity	*Pore water salinity levels generally remained higher throughout the Project Area over 2013*	On-track
Vegetation community	*Halophytic vegetation abundance increased in the Project Area; brackish and freshwater vegetation abundance decreased, with extensive dead cat tail stands*	On-track
Channel morphology	*Channel cross sectional area continued to increase throughout Project Area*	On-track
Invasive species	*No invasives species observed in the Project Area*	On-track

* *Hydrology signal and erosion control are the only two performance standards. Assessment of other monitoring parameters provided for context.*
[1] *Summarized in Year 1 post-project report.*

1.3 Remedial actions

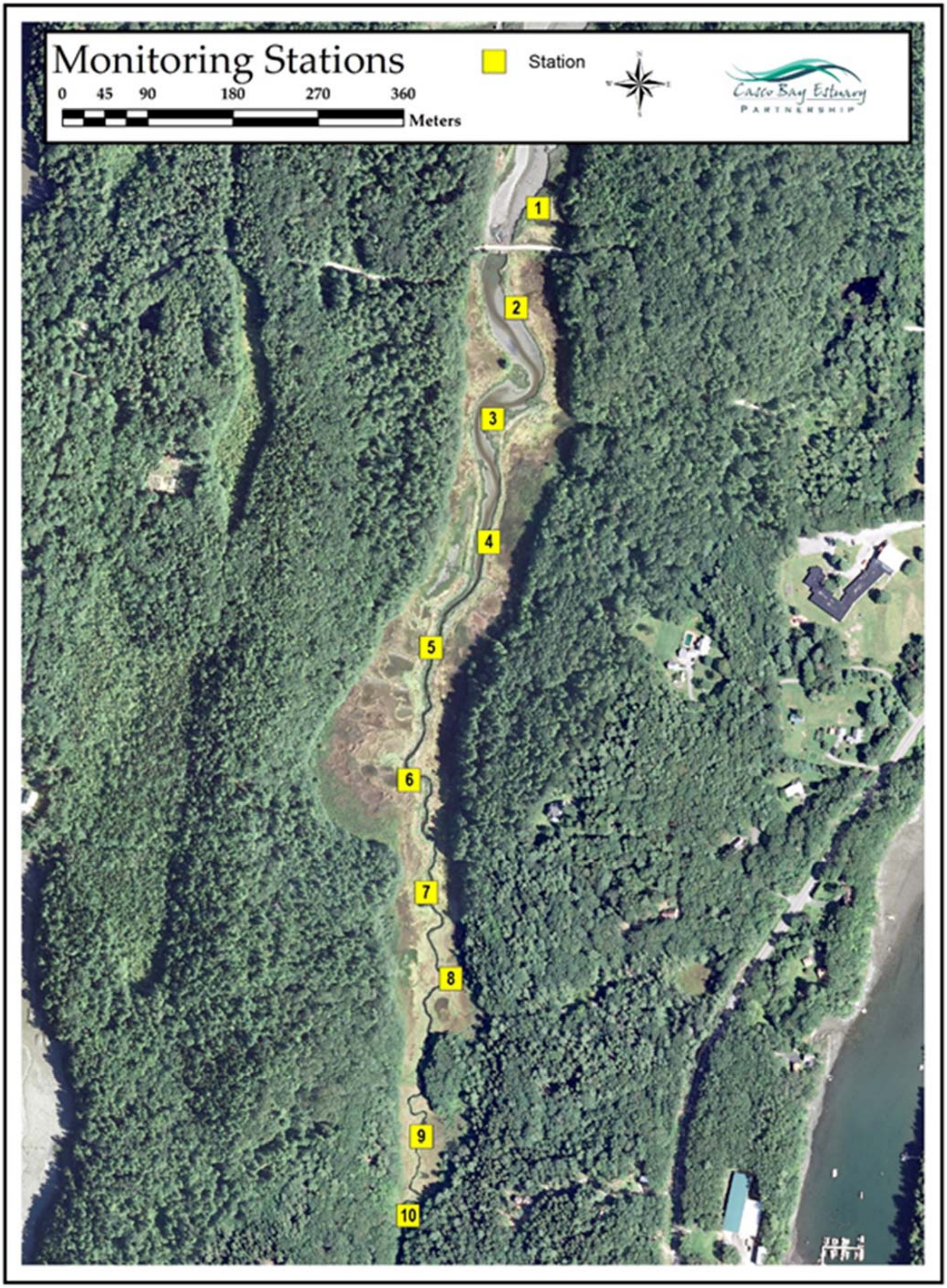
During cross section surveys on 6/25/15, CBEP staff observed a narrow band of rocks placed in a line across the culvert inlet, presumably in an effort to raise water levels upstream (photo, below). The rocks appeared to have been moved from the adjacent armored road bank and a black sled, standard equipment for shellfish harvesters, was observed next to the inlet. CBEP staff hand-removed the rocks from the culvert and placed them back on the road bank.

1.4 Erosion

The mitigation site is stable. As expected, the creek channel continues to widen and deepen within the Project Area in response to the changed hydrology resulting from the new culvert beneath Long Reach Lane. Other than this morphological response of the channel to the increased tidal exchange, and the associated sediment movement within and out of the system, the slopes, soils, and substrates adjacent within the construction area at Long Reach Lane were stable and no remedial actions were deemed to be necessary. CBEP will continue to closely monitor the stability of soil conditions at the Long Reach Lane construction site in years 3-5.

Figure 1. Project Area map.

Figure 2. Monitoring Station location map. Long Reach Lane is visible between Station 1 and Station 2. Stations 2-10 lie within the Project Area.



2. METHODS

Monitoring methods are based on protocols and methods laid out in Sections K and L of the *Mitigation Plan*, and which generally align with protocols set forth in the *Regional Standards to Identify and Evaluate Tidal Wetland Restoration in the Gulf of Maine* for the selected parameters (Neckles & Dionne 1999). Parameters were monitored in association with designated Stations unless otherwise noted (Table 2).

Table 2. Monitoring parameters by Station.

Station	Hydrology Signal**	Pore Water Salinity	Surface Water Salinity**	Vegetation	Channel Morphology	Plant Species of Concern
1	X	X		X	X	X
2	X	X	X	X	X	X
3				X	X	X
4		X		X	X	X
5				X	X	X
6		X*		X	X	X
7				X	X	X
8		X	X	X	X	X
9			X	X	X	X
10		X	X	X	X	X

* At Station 6, two pore water wells were monitored.
** Continuous monitoring of surface water hydrology and salinity limited to pre-project and Year 1 post-project.

2.1 Hydrology signal

Surface water hydrology was not monitored in 2015.

2.2 Pore water salinity

CBEP constructed wells from 2" PVC consistent with established protocols for monitoring pore water salinity (Neckles and Dionne 1999). Pore water wells were installed at Stations 1, 2, 4, 6, 8, and 10 approximately 10 meters from the tidal creek channel edge. A map is provided in Appendix A. An additional pore water well (6a) was installed approximately 10 m from the upland edge at Station 6 (s). Two wells are located beyond the Project Area (St. 11 & 12). Simultaneous surface water samples are taken from the tidal creek where vegetation transects intersect with the marsh channel. Water samples are collected using a syringe with a tube for extension into wells and the tidal creek, and sampled within two hours of predicted low tide. Salinity readings are read from a handheld refractometer that is calibrated with de-ionized water. Observations are recorded on a site-specific data sheet.

2.3 Surface Water Salinity

Surface water salinity was not monitored in 2015.

2.4 Vegetation

CBEP established vegetation transects at each Station in the Project Area. And additional two vegetation transects were established at Stations to the south of the Project Area (St. 11 & 12). Transects were set to allow for representative sampling of established marsh areas and adequate sampling intensity. Vegetation data are collected in meter-square plots located every 10-15 meters along the length of each transect. The number of plots collected along each transect varies from 10 to 12, with most transects having 11 plots. Observers replicate transect locations year over year by extending a tape measure from a PVC stake marking the channel edge (e.g., 1C) to another PVC stake located at the upland edge (e.g., 1U; see map, Appendix A). Transects run perpendicular to the tidal creek toward the upland edge, with 0' (zero) starting at the channel. Data collected in each plot includes: (1) a list of the well represented (>10% coverage) species in the plot; (2) percent coverage by those species; (3) overall percent coverage for the plot; and, (4) general hydrologic conditions. Data for each plot was recorded on a separate data sheet. All project vegetation data are entered into a Microsoft Access database.

2.5 Channel Morphology

CBEP established channel cross section transects at each Station (map, Appendix A). An additional cross section transect was established beyond the Project Area at Station 11. In addition, CBEP surveyed a longitudinal profile of the channel bottom from Station 1 to Station 3 (approximate). Cross sectional areas are surveyed in identical locations from stakes on the east and west side of the channel (e.g., XS1E, and XS1W; Figure 5) proximate to where vegetation transects originate at the marsh channel. Elevations are surveyed at regular increments or where elevation grade changes are evident, using an auto level on a tripod and a stadia rod, and tied to local benchmarks with known elevations relative to NAVD 88. Cross section and longitudinal profile data are recorded onto project-specific data sheets and entered into the *Reference Reach Spreadsheet* (Mecklenburg 2006) to standardize and quantify survey data. The spreadsheet is used broadly in among natural resource managers as a tool for quantifying channel morphology (Alex Abbott, personal communication).

2.6 Plant species of concern

Once per field season, an intensive meander survey for invasive plant species is conducted throughout the Project Area. Incidental observations of invasive plants during other monitoring activities are also documented. During the meander survey, invasive plant species are identified, photographed, described in field notebooks, geo-referenced, and flagged if possible. Any indication that invasive plant species of concern are establishing or expanding within the Project Area would be immediately communicated to MDOT, with recommendations for control measures, if needed.

2.7 Erosion

CBEP conducts regular visual surveys within the construction area to check for signs of erosion along the road bank, or structural failure within or adjacent to the culvert. Observations of erosion would be recorded and findings would be photographed, georeferenced, flagged, and immediately reported to MDOT if needed.

2.8 Photographic documentation

CBEP established a series of photo stations associated with the construction area, channel cross sections, and vegetation transects in order to provide a visual record of changes at and adjacent to the mitigation site and the Project Area during the monitoring period. Photos are taken annually at a minimum at each photo station.

2.9 Wildlife use

CBEP records incidental observations or signs of wildlife within or adjacent to the Project Area during each site visit.

2.10 Additional data

Additional data are being collected at Long Marsh by CBEP and other researchers:

- Additional field observational data, such as dead vegetation, etc., was periodically collected during the course of field sampling activities, recorded in field notebooks, and photographed, by CBEP staff.
- As part of broader CBEP monitoring of tidal marshes in Casco Bay, two additional Stations were established outside of the Project Area, to the south of "the narrows," and as time allowed, CBEP collected data on the core parameters at these Stations. Parameters monitored included vegetation transects, pore water and surface water salinity, surface water hydrology, and channel cross sections. These data were collected at no cost to DOT, but are available separately from this report upon request.
- Dr. Beverly Johnson, working with undergraduate students from Bates College, is collecting methane measurements as part of an ongoing research study. These data were not included in this report.

- Project SHARP (Saltmarsh Habitat & Avian Research Program), of which the University of Maine's School of Biology and Ecology is a collaborator, has a long-term bird monitoring station on Long Marsh, located within the Project Area.

3. RESULTS & DISCUSSION

This section presents monitoring results from monitoring of pore water salinity, vegetation, channel morphology, plant species of concern, wildlife use, erosion, and photo documentation. The Year 2 report draws primarily from 2013 and 2015 monitoring results, but data from 2014 monitoring is provided for context in some areas.

The winter of 2014–15, and associated ice formation and movement, resulted in extensive sediment deposits on the marsh surface. To document the extent of sediment deposits, CBEP hired a consultant to obtain aerial video footage of the project using a drone on 5/1/15, just as vegetation was starting to emerge. Ice movement affected the location of markers and wells at some Stations. (Video footage is available upon request).

Peat, sediment and shell deposited on the marsh surface resulting from ice scour, at Station 2 (left, 5/1/2015), and Station 4 (right, 4/28/2015).

3.1 Hydrology Signal

Not monitored in 2015. Refer to the 2014 monitoring report for hydrology data and analysis.

3.2 Pore Water Salinity

During the 2015 field season, CBEP staff collected seven sets of pore water salinity samples at Stations 1, 2, 4, 6, 6a, 8, 10, and 11 (Table 3). Prior to monitoring, pore water wells were relocated and their condition assessed following a winter with heavy ice buildup and ice movement on the marsh surface.

Table 3. Pore water salinity sampling dates.

Year	April	May	June	July	August	September	October
2013		5/21		7/1, 7/25	8/29	9/25	10/21
2014	4/23, 4/25	5/21	6/6, 6/24	7/8	8/28	9/17	10/28
2015	4/28	5/8	6/12	7/9	8/13	9/18	10/23

Pore water salinity levels in the marsh are influenced by a number of factors, including tide height, precipitation, local soil conditions and runoff from adjacent uplands. Although more salt is being delivered via tidal exchange into the Project Area following replacement of the Long Reach Lane culvert, it is useful to consider pore water data in the context of seasonal precipitation trends since rainfall appears to impact pore water salinity levels at Stations with groundwater seeps from the adjacent upland.

The West Bath Town Hall hosts a weather station that collects and records precipitation totals for the Maine Department of Marine Resources' use in determining rainfall closures for local shellfish beds. These data are posted online at The Weather Underground and can be downloaded into Excel. Graphical display of daily precipitation data over the 2013, 2014, and 2015 monitoring seasons illustrates variations in rainfall patterns from year to year (Fig. 3). 2013 was relatively dry in comparison to 2014, while 2015 was closer to normal. Heavy rains in 2014 (3.13" on 6/13; 3.89" 7/2-7/5), and 2015 (4.86" on 9/30) affected subsequent pore water salinity readings.

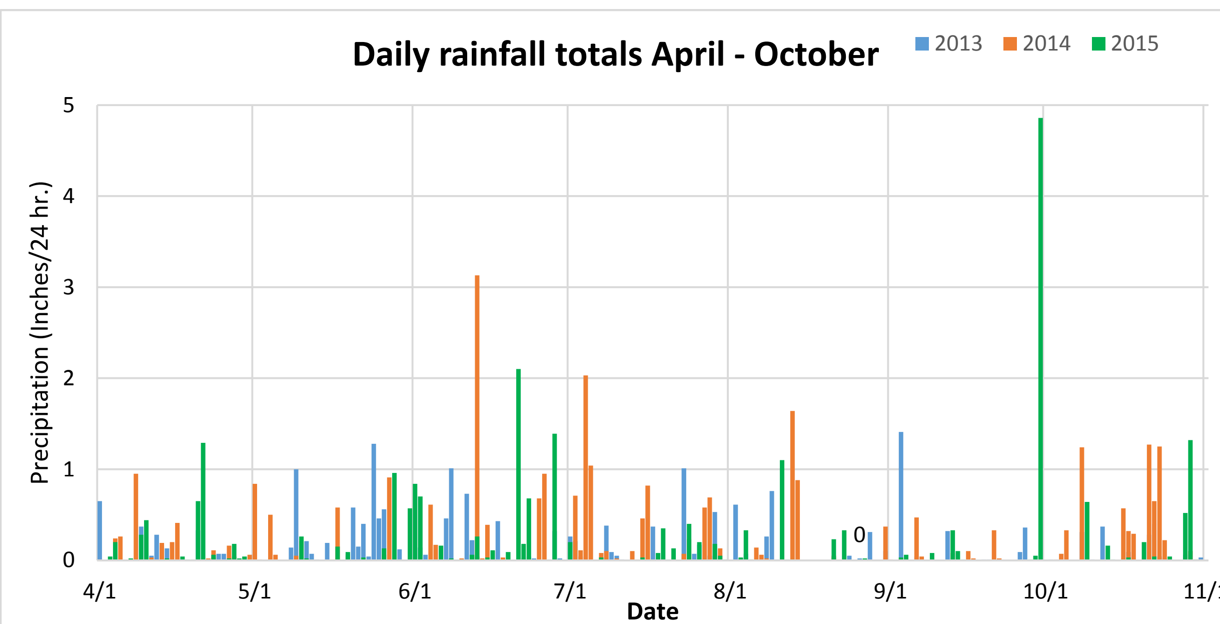


Figure 3. Daily rainfall totals (inches) at West Bath Town Hall. SOURCE: West Bath Town Hall via WeatherUnderground.

In both 2014 and 2015, precipitation for June was higher than normal, but about average in 2013 (Table 4). September rainfall was higher than normal in 2015, but because most of the rain fell at the end of the month, this spike did not affect the September pore water sample.

Table 4. Comparison of monthly precipitation with historic levels. Shown are monthly rainfall totals (inches) at West Bath Town Hall weather station.

Year	March	April	May	June	July	August	Sept.	Oct.	Cum.
2013	1.9	2.4	5.3	3.6	3.3	2.0	3.7	1.5	23.7
2014	4.2	2.7	3.4	6.0	7.2	2.9	1.3	4.5	32.1
2015	1.3	3.3	2.2	6.7	1.7	2.1	6.1	3.0	26.4
Normal*	*3.7*	*4.1*	*3.6*	*3.4*	*3.1*	*2.9*	*3.1*	*3.9*	*27.8*

*Historic 'normal' monthly rainfall at Portland Jetport (1961-1990).

Although recent studies incorporating more recent data than the "normal" rainfall totals shown in Table 4 suggest that precipitation totals may be increasing in spring, summer, and fall seasons (Wake *et. al.*, 2009), the Portland Jetport data still provides a useful baseline to show that 2014 rainfall totals were higher than normal, particularly in June and July, and that rainfall in September 2015 was nearly double normal levels. Looking only at freshwater inputs during the monitoring season (and excluding precipitation from the preceding winters), the 2014 monitoring season was generally a wetter one at Long Marsh than either 2013 or 2015, particularly during the typically hottest and driest summer months.

Despite above normal rainfall in 2014, pore water salinity levels were generally higher throughout the Project Area in 2014 than in 2013, consistent with what we would expect to find resulting from improved tidal exchange (Table 5). At Station 1, which can be considered a reference site, pore water salinity decreased from 22.7 ‰ to 14.5 ‰ from 2013 to 2014 even though measurements in the Project Area increased, consistent with the wetter conditions in 2014. In 2015, salinity at St. 1 remained lower than measured in 2013.

Table 5. Mean, minimum and maximum pore water salinity (‰) for the 2013 – 2015 monitoring seasons.

Station	Mean			Minimum			Maximum		
	2013	2014	2015	2013	2014	2015	2013	2014	2015
1	22.7	14.5	15.4	9	4	5	29	25	29
2	23.0	30.6	27.0	13	25	14	30	35	33
4	19.8	25.7	26.4	5	16	20	30	30	33
6	21.6	29.2	28.1	10	25	22	33	33	32
6a	8.6	24.7	23.7	2	10	20	15	29	28
8	27.2	28.4	23.5	20	23	14	33	32	31
10	25.4	27.0	24.6	17	24	20	30	32	30
11	8.6	18.0	22.5	2	12	15	14	25	28

Figure 4 plots pore water salinity levels at Stations 1-11 per visit per year. Each point represents the mean of three readings taken per a given sample. Pre-project samples are shown in blue, and post-project samples in orange, differentiated by symbols. Station 11 is outside the Project Area but included for context.

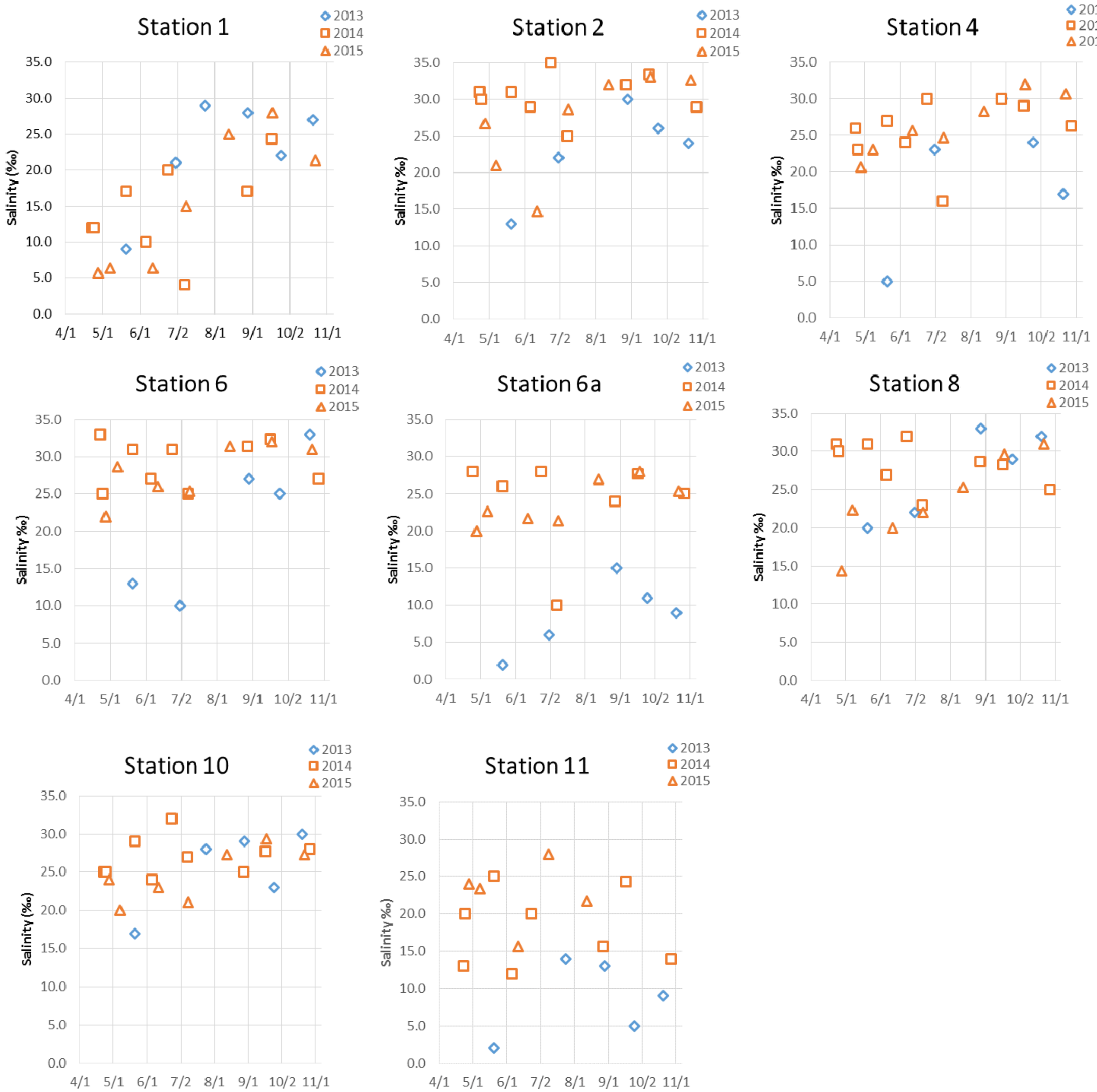


Figure 4. Plotted pore water salinity Stations 1, 2, 4, 6, 6a, 8, 10 and 11.

For most Stations in the Project Area, mean pore water salinity increased in 2014 and 2015 from pre-project levels, with the exception of Stations 8 and 10, which decreased slightly in 2015 from 2013 levels. In 2015, pore water salinity at Stations within the Project Area were generally slightly lower than in 2014, with the exception of Station 4, which was slightly higher (Table 5, Figure 5). The relatively cold and late winter of 2014-2015, compared with the previous winter, could provide a possible explanation for this decrease.

Figure 5 graphically illustrates mean, minimum, and maximum pore water salinity levels per Station. So far, post-project readings have yet to fall below 10 ‰ in the Project Area. The largest increases from pre-project levels are at Station 6a, located approximately 5m from the upland edge, and at Station 11, which is south of the narrows and outside the Project Area. The abrupt increase at Station 6a is consistent with the results of vegetation monitoring, which documented that freshwater species present in 2013 were dead in 2014 and 2015, with the vegetation community in transition. The increase at Station 11, which is adjacent to stands of invasive *Phragmites australis*, documents that the effect of the improved tidal exchange extends well south of the Project Area and the Narrows, into the southern reach of the marsh.

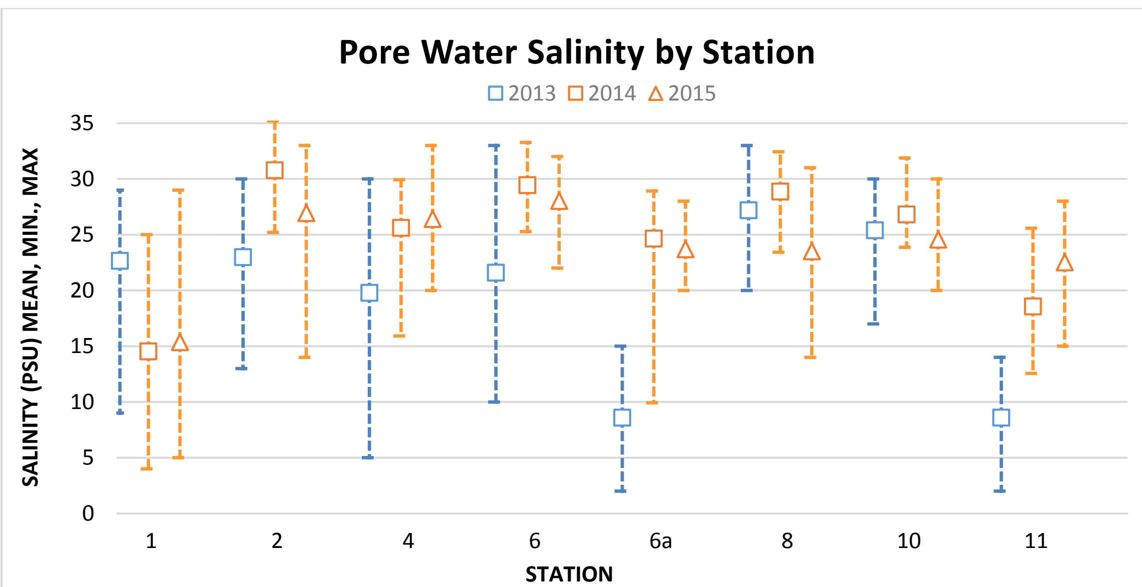


Figure 5. Mean (symbol), minimum (low bar), and maximum (high bar) pore water salinity (‰) for 2013-15.

Even with higher than normal precipitation in 2014, mean pore water salinity, including all observations within the Project Area (excluding Station 1 and Station 11), were higher in 2014 (mean = 27.4‰) and in 2015 (mean = 25.5‰) than in 2013 (mean = 20.3‰). Combined, mean pore water salinity is 26.6‰ post-project.

Figure 6 plots salinity measurements in the Project Area with linear trendlines for each year of data points. Based on trendlines, pore water salinity may be higher post-project earlier in the growing season than pre-project due to the increased tidal exchange and freshwater drainage out of the marsh. In 2013, pore water salinity at Stations 2-10 trended upward over the course of the summer into fall, whereas in 2014, pore water salinity at Stations 2-10 was consistent, other than the July samples, across the season. In 2015, pore water was lower than in 2014 early in the season, possibly reflecting the influence of snow and ice melt, but increased to higher levels later in the season. The similarity in slope of the lines in 2013 and 2015 is interesting as an illustration of the effect of tidal restoration, which in this visualization, has increased pore water salinity throughout the Project Area by at least 5‰.

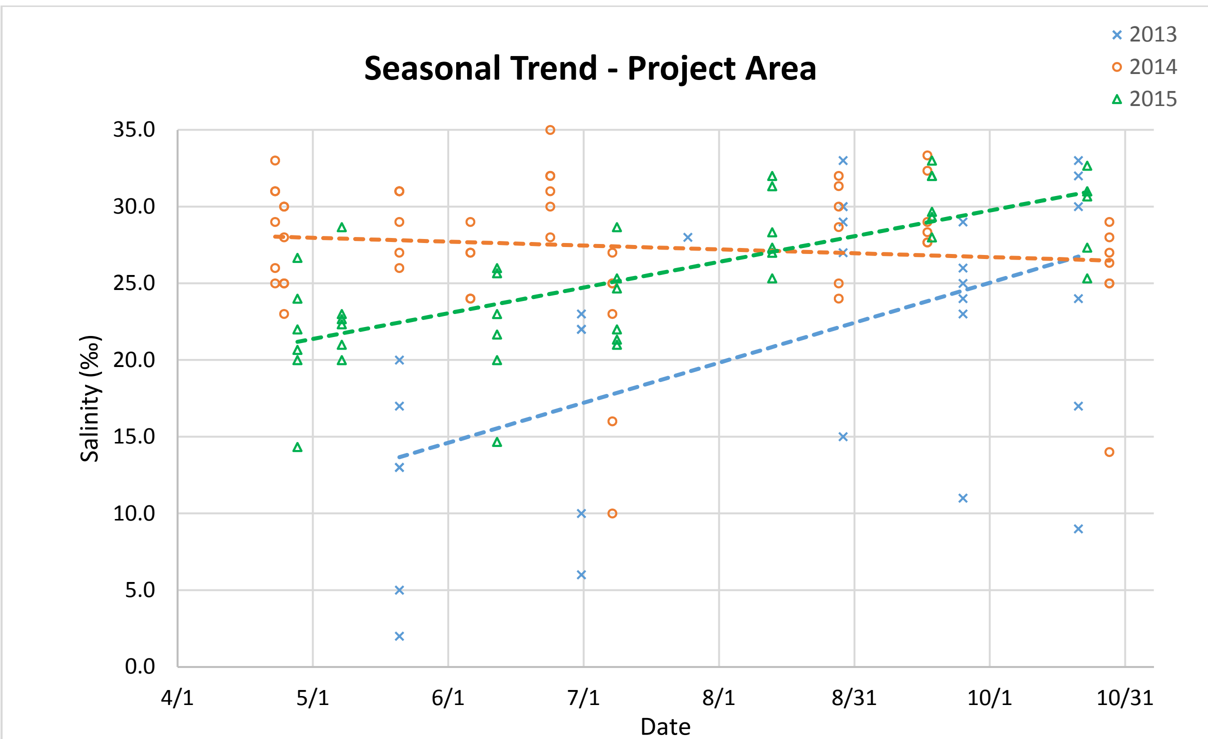


Figure 6. Year over year plot with trend lines of pore water salinity levels in the Project Area (excluding Station 1 & Station 11).

Overall, pore water salinity was observed to be higher within the Project Area in year 1 and year 2 post-project. Pore water salinity was also observed to be higher earlier in the growing season in 2014 and in 2015 than in 2013, consistent with expectations that the marsh is draining more quickly through the new culvert. This is illustrated by the dip and recovery of pore water salinity levels following heavy rain events in late June and early July 2014 and October 2015, following a 5" rain event on 9/30/15.

These data indicate that the change in tidal hydrology is delivering more salt water onto the high marsh, and that freshwater drains from pore water more quickly, resulting in higher salt content in the root zone, which influences the vegetation community. Pore water salinity levels appeared to be higher throughout the spring and summer in 2014 and 2015 than in 2013, which, over time, we expect to gradually influence the vegetation community. These data suggest that the vegetation community in the Project Area is likely to continue shifting toward more salt tolerant plant communities and salt marsh, from brackish and freshwater communities, in the years to come.

3.3 Surface Water Salinity

Continuous surface water salinity monitoring was not conducted in 2015. See Year 1 Post-Construction report for results.

3.4 Vegetation

CBEP monitored vegetation on July 15-16, 2013, July 8-9, 2014, and July 16 and 21-22, 2015. A total of 110 plots were sampled in 2013 (12 plots along Station 1, and 98 plots along transects at Stations 2-10). A total of 113 plots were monitored in 2014 (14 at Station 1, and 99 at Stations 2-10). A total of 112 plots were monitored in 2015 (13 at Station 1, and 99 at Stations 2-10). An additional 23 plots were monitored at Stations 11 and 12, which are south of the Project Area, in all years. Plot locations were at identical distances along each transect for most stations, but at Station 1, the transect markers were lost and the transect location was different in 2013 than in 2014 and 2015.

A total of 72 plant species were identified across all Stations over the three monitoring seasons. Of those, 67 were observed during the 2013 vegetation surveys, 49 in 2014, and 53 in 2015. Of the 21 species observed in 2013 but not in 2015, 16 are grouped as freshwater community species, and 5 are brackish community species. Of the 3 species that were observed in 2015 but not in 2013, 2 were glycophytes and 1 was a halophyte (Table 11, App. B).

Figures 7 and 8 plot salinity scores of monitored vegetation plots, with freshwater plants = 1, brackish plants = 2, and halophytic plants = 3, based on an index created by USM Biology graduate student Shri Verrill (unpublished thesis, 2014). The graphs illustrates transitions throughout the Project Area toward salt tolerant (brackish and halophytic) species. Closer to the project site (St. 2 & 3), a rapid transition to salt marsh is evident, with similarities to the reference site (St. 1), and similar distribution shifts are occurring at Stations 5-8. At the furthest end of the Project Area, St. 10, a similar immediate shift is evident closer to the channel, but less so away from the channel. The effects of the mitigation project clearly extend beyond the Project Area, as a marked shift toward halophytic plants is evident at Station 11, adjacent to invasive *Phragmites australis* stands, in the first several plots away from the channel. Station 12 appears to not yet have been affected by the change in hydrology.

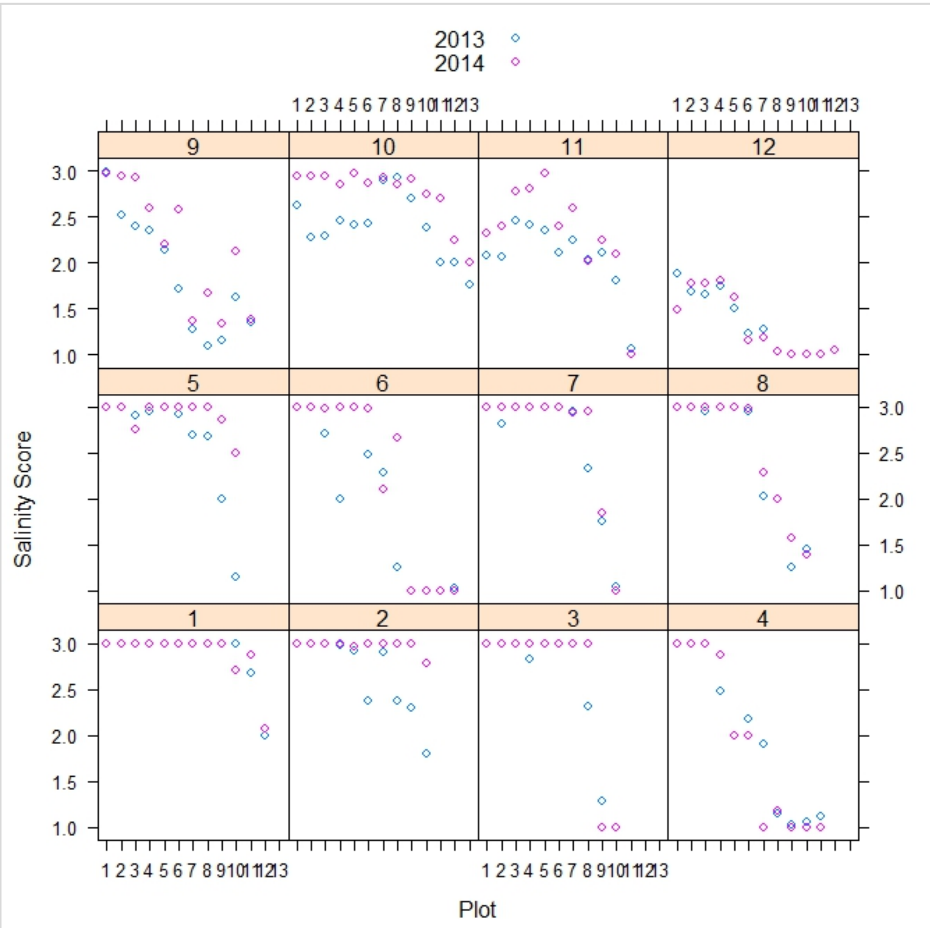


Figure 7. Salinity index scores of vegetation plots, 2013 to 2014.

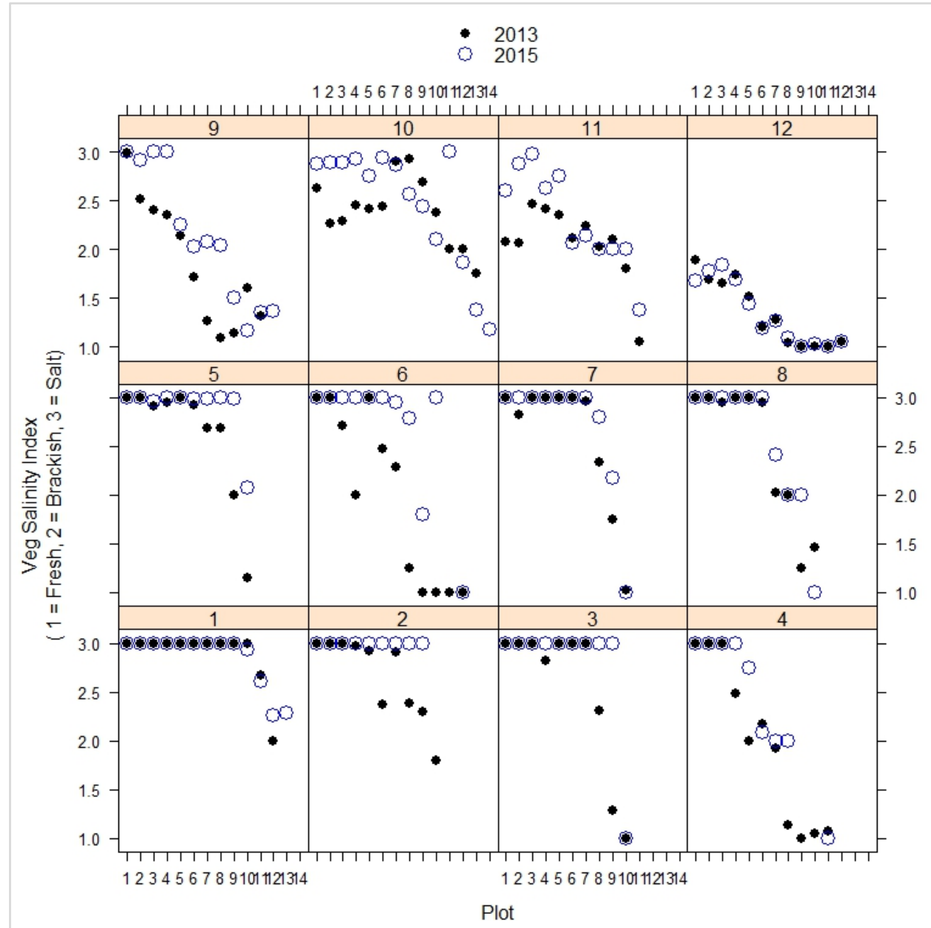
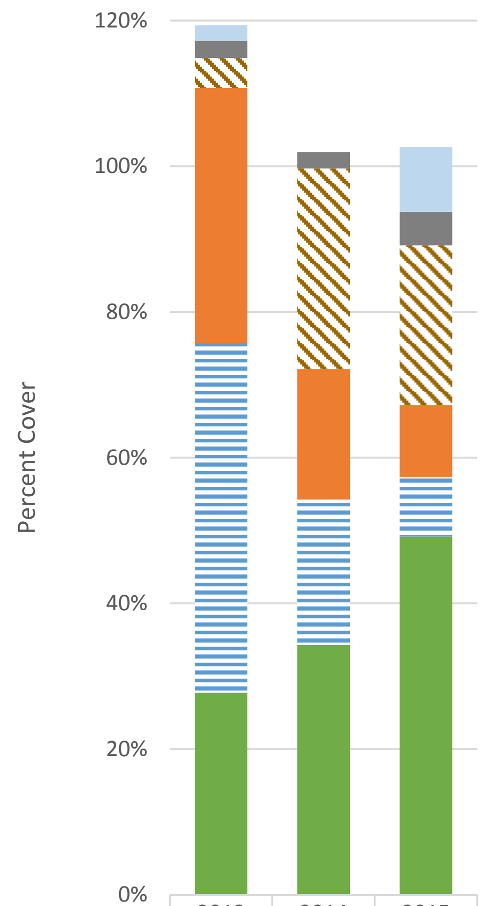
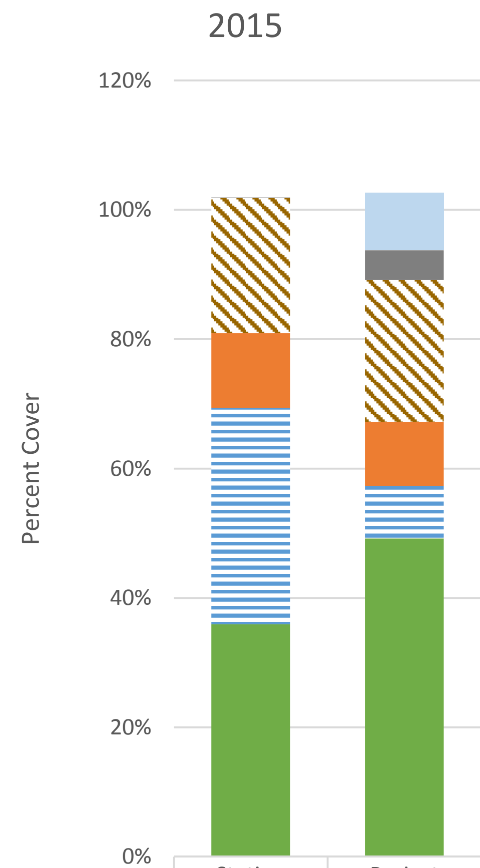


Figure 8. Salinity index scores of vegetation plots, 2013 to 2015.



	2013	2014	2015
Water	2.1%		9%
Bare	2.4%	2.3%	5%
Litter	4.1%	27.5%	22%
Glycophytic	35.1%	17.9%	10%
Brackish	48.0%	20.0%	8%
Halophytic	27.7%	34.3%	49%

Figure 10. Comparison of mean percent cover of plots in the Project Area, 2013 – 2015.



	Station 1	Project Area
Water		9%
Bare	0%	5%
Litter	21%	22%
Glycophytic	12%	10%
Brackish	33%	8%
Halophytic	36%	49%

Figure 9. Comparison of mean percent cover of plots within the Project Area and Station 1, 2015.

Figure 9 compares yearly mean percent cover types of plots within the Project Area (Stations 2-10). Halophytic species cover increased from pre-project levels of 27.7% in 2013 to 49% during the second growing season post-project. Glycophytes declined from 35.1% in 2013 to 10% in 2015, and brackish plants decreased from 48% in 2013 to 8% in 2015. The loss of freshwater and brackish species was accompanied by an increase in litter (standing dead plant matter) in 2014 and 2015 over pre-project levels.

Figure 10 compares mean percent cover of plots in the Project Area with plots at Station 1, which can be considered a reference site due its proximity downstream from the project site.

While there is a similar proportion of glycophytes in both the Project Area and Station 1 in 2015, the percent of brackish species was just 8% in the Project Area compared with 33% at Station 1. This difference can be at least partially explained by the ongoing vegetation community transition underway in the Project Area.

Table 12 (Appendix B) shows graphed percent cover for each community type against distance from the creek channel, by Station, in 2013, 2014, and 2015. Proximity to the creek channel appears to be associated with community type as shown by the prevalence of salt marsh community assemblages in proximity to the creek channel, even near the “narrows” at Station 10, in all years. The 2013 vegetation data show that community type shifted markedly moving toward the upland edge, so that brackish and freshwater assemblages were increasingly abundant at distances of 100 feet or more from the creek edge, particularly at the higher Stations. In 2014 and 2015, a change in this pattern is evident, with salt tolerant plants increasing in abundance in plots further away from the creek channel, and brackish and freshwater-grouped plants showing a marked decrease in area covered. This decrease is often associated with an increase in litter, which includes standing dead vegetation. The percent of plots covered by litter is particularly high at transects 4 and 6, which pass through large cattail stands. This illustrates a trend in evidence around the perimeter of much of the Project Area, where cattail stands died off in response to the higher tidal inundation, with mostly dead stands remaining (Table 9, vegetation transect photo stations). This trend is likely to continue as the energy stores of individual plants are depleted. Over the next few years, as light availability increases on the marsh surface within former cattail stands, salt tolerant and brackish plant community cover is anticipated to increase.

As with pore water salinity, Long Marsh’s vegetative community year-2 post-project shows a marked change consistent with what we would expect in response to the new culvert, which increased tidal exchange. Together, the salinity and vegetation data indicate that the vegetation community within the Project Area is shifting in response to the new tidal hydrology. Effects of increased tidal elevation and duration of inundation are evident in the plant community shifts at Stations furthest from the construction site, in plant community shifts mid-way through the transects and at approaching the upland edge, and widespread increase in litter as a result of dead freshwater loving and brackish plants. Viewed at the scale of the Project Area, the shift in community type is particularly evident in looking at living cattail plants (Figure 11), which declined from 8.34 acres in 2013 to .64 acres in 2015. Standing dead cattails covered much of the remaining 7.7 acres in 2015. Remaining cattail stands appear to be associated with freshwater seeps from adjacent uplands.

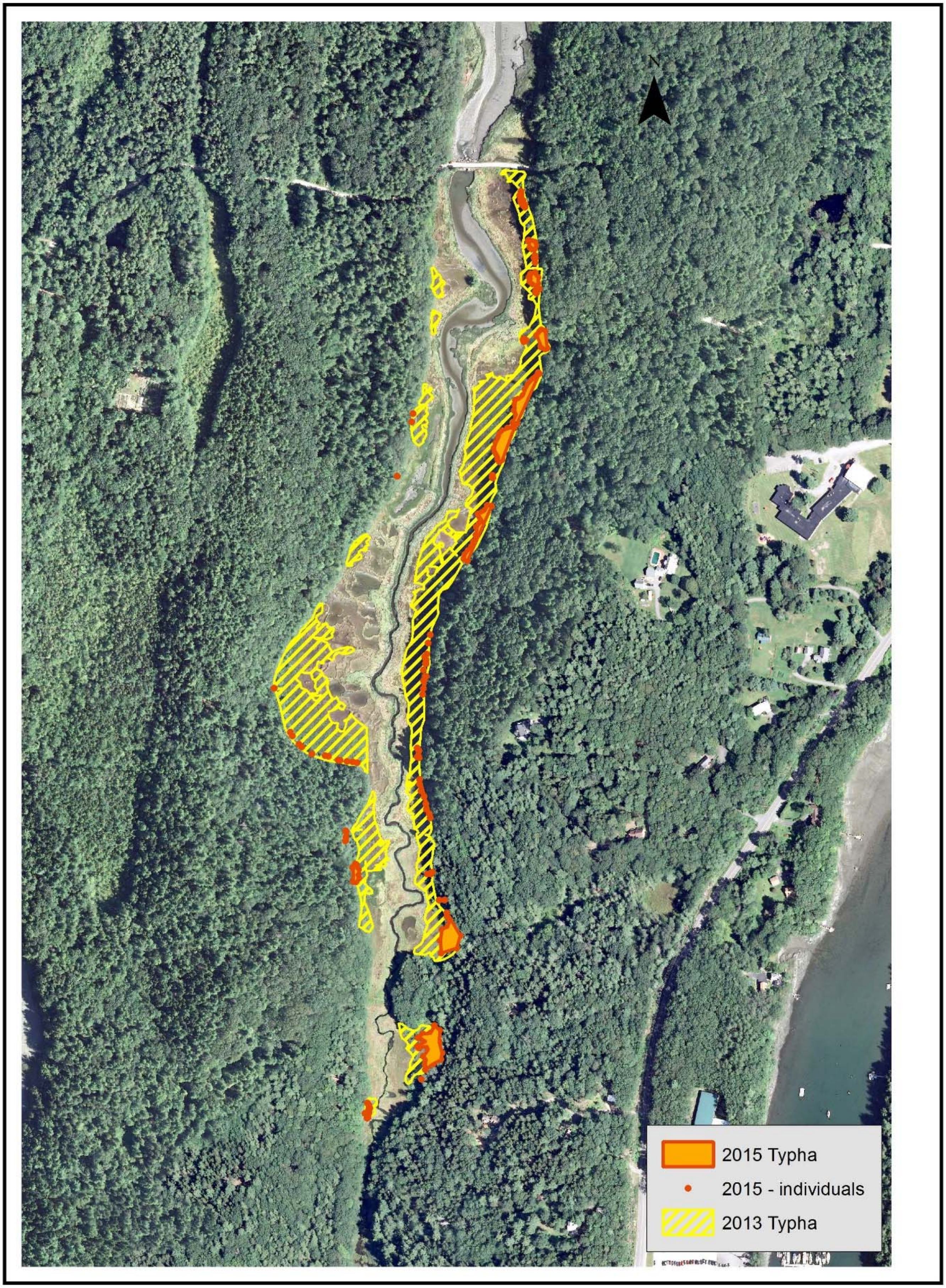


Figure 11. Map of Typha spp. stand extent in 2013 and 2015 (CBEP).

3.5 Channel Morphology

CBEP surveyed channel cross sections at each Station, as well as a longitudinal profile through the project site, in 2013, 2014, and 2015 (Table 6).

Table 6. Channel morphology survey dates.

Location	2013	2014	2015
Station 1	7/25	6/17	7/23
Station 2	7/31	6/17	7/23
Station 3	8/5	6/18	6/25
Station 4	8/5	6/18	6/25
Station 5	8/5	6/18	6/25
Station 6	8/5	6/18	6/25
Station 7	8/5	6/18	6/25
Station 8	8/5	6/18	6/25
Station 9	7/25	7/8	6/25
Station 10	7/25	7/8	6/25
Longitudinal Profile	8/30; 12/10	8/5	7/23

Longtidinal profiles for 2013 and 2015 are graphed in Figures 12 and 13, with elevations in feet relative to NAVD 88. Mean high water (MHW, 4.12' NAVD) at the Portland Tide Station is shown for context. Although transect lengths and the location of start and end points differed (the 2013 transect is longer), the location of channel cross sections at Stations 1 – 3 are shown for context, allowing for comparison year to year. The 2013 profile illustrates mudflat downstream of the road, rip-rap at the base of the outlet, the invert of the original round pipe, a deep scour pool hidden beneath water impounded upstream, and acculated sediment upstream of the scour pool. Upstream of the scour pool, sediment elevations level off consistent with the invert of the culvert.

The upstream head cut moved toward the center of the channel, possibly toward the location of the original channel (CBEP; 7/23/15).

The 2015 profile shows mudflat downstream of the road, with elevations comparable to 2013. Rip-rap at the base of the outlet remains, but the new culvert invert is lower. A series of sediment deposits are evident upstream of the culvert inlet, resulting in a series of shallow ripples and pools in the former upstream scour pool. A head cut is migrating up the channel, which is being tracked using stakes at the channel edge. Upstream of the head cut, the channel bottom levels off, but at an elevation over a foot deeper than prior to the project, indicating significant movement of fine sediments.

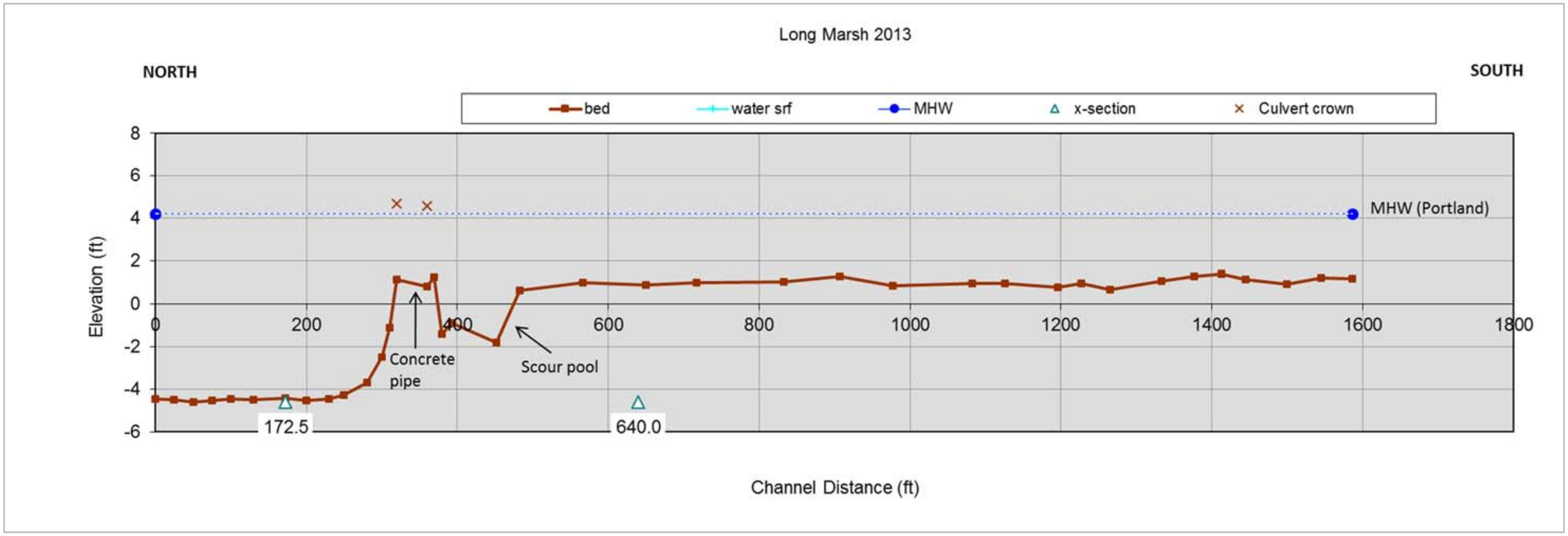


Figure 12. Longitudinal channel profile, 2013. Elevations shown in NAVD 88. (Mecklenburg 2006).

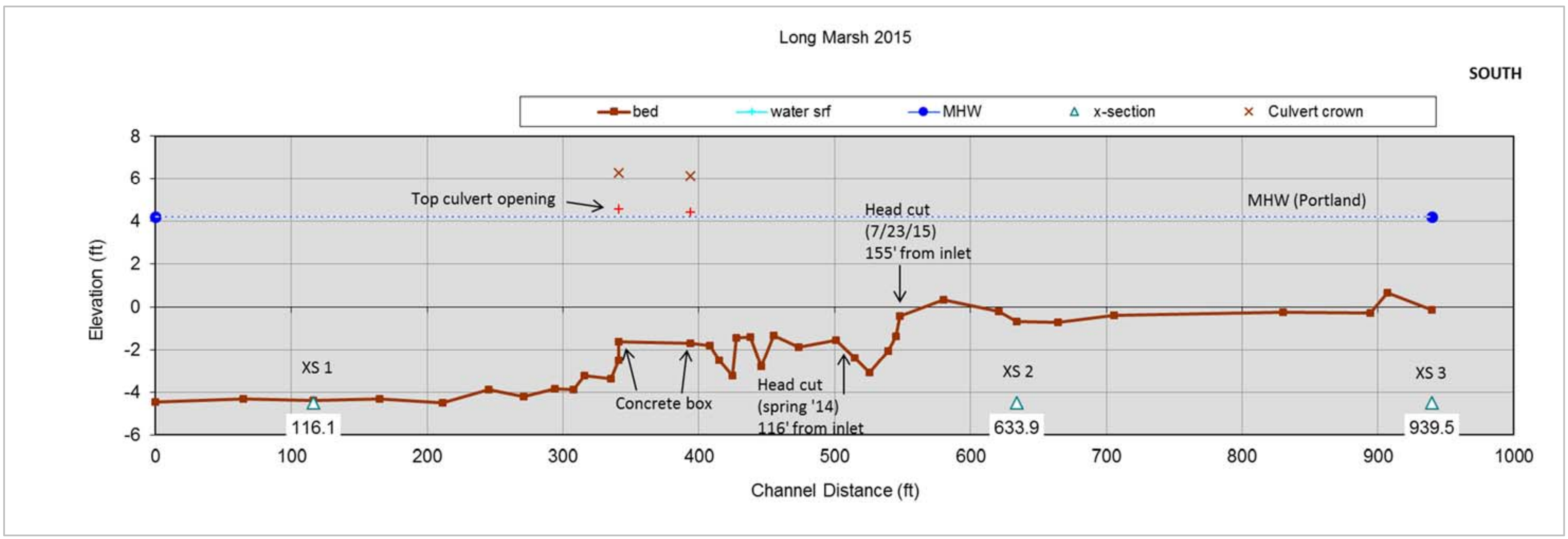


Figure 13. Longitudinal channel profile, 2015. Elevations shown in NAVD 88. (Mecklenburg 2006).

Figures 14 and 15 plot channel cross sections at Stations 1-10, with MHW (4.12' NAVD) at the Portland Tide Station for context. MHW was used in the Reference Reach Spreadsheet (Mecklenburg 2006) to calculate channel dimensions and cross sectional area, allowing for a standardized comparison of change in channel characteristics from one year to the next, which is particularly useful for looking at channel evolution in relation to increased inundation of the marsh surface. At each Station, the west side of the marsh is shown on the left side (0') of the transect. Elevations are in feet relative to NAVD 88. At most Stations, transects begin and end at fixed points that are higher than MHW, with the exception of Station 7. The location of cross section transects was identical each year, but slight differences in transect length were unavoidable at a couple locations because of conditions in the field. This was due to a breeze pulling the tape, which hangs above the channel, so that it is not as taut, and therefore a bit longer.

Channel response to increased tidal exchange was not always captured in surveys. A new and expanding rill along the east side of the channel at Station 4 (left, view N) could indicate future dimensions under the new hydrologic regime. Similarly, at the culvert inlet (right, view N), large chunks of peat continue to slump off, collapsing into the creek channel, following culvert replacement.

Channel cross section transect comparisons between 2013 and 2015:

- At Station 1, surveys continue to show slumping banks on each channel bank downstream of Long Reach Lane, at approximately 50 feet and 175 feet along the transect. This is consistent with anecdotal observations of local residents, who have commented that it appeared the downstream channel was widening.
- At Station 2, the channel scour continued downward in the center, but less so in the adjacent flat channel bed, resulting in a sharp V-shaped channel formation at the thalweg. In 2015, maximum channel depth dropped by about two feet from pre-project levels, but

has not yet reached the elevation of the culvert inlet. Unconsolidated sediment appears to have moved out of the channel outside the thalweg as well.

Station 2 cross section. Most of the channel remains mudflat, with a narrow thalweg in the center. Peat from winter ice movement in foreground.

- At Station 3, a U-shaped channel profile is evident and on the eastern channel edge (left side of the profile), a rill is forming.
- At Station 4, a distinctly angular, V-shaped channel profile has a maximum depth about three feet lower than in 2013, indicative that fine sediments were mobilized. The photo on the preceding page also shows that a rill is forming along the eastern bank. During the 2015 field season this crack in the peat often pooled water between tides.
- At Station 5, the channel depth has dropped by about two feet since 2013. Angular features seen in 2014 are becoming more rounded into a U-shape.
- At Station 6, the thalweg is about two feet lower than in 2013. The channel is incising at the base of the western bank, but not yet along the eastern bank.

Station 8 cross section. Remnant peat exposed on west bank (r).

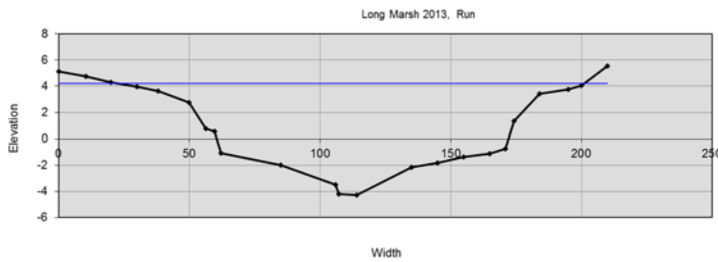
- At Station 7, the thalweg has dropped by over a foot from 2013, but the channel has maintained a U-shaped profile, but with vertical and slightly overhanging banks.
- At Station 8, the thalweg is over a foot lower than in 2013, scouring the eastern side of the channel with slightly overhanging banks. On the western edge, remnant peat is exposed.

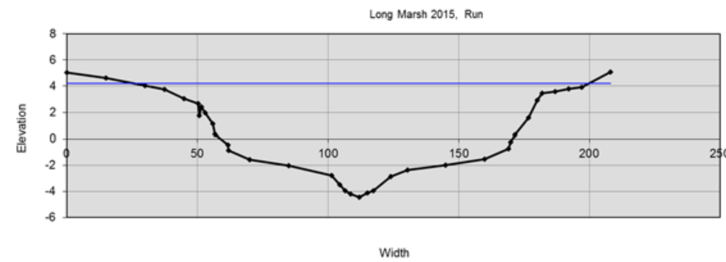
Scour downstream of the old road bed between Stations 8 and 9.

- At Station 9, which is upstream of the “old road bed” crossing described in last year’s report, the channel thalweg is about a foot lower. A secondary channel-like feature appears to be forming parallel to the western edge.
- At Station 10, which is located close to “the narrows” and also upstream of the old road bed, less scour is evident, although the base of the channel bank appears more angular than in 2013.

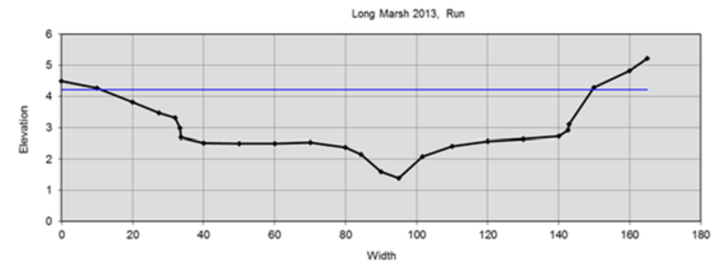
Pre-Project (2013)	**Post-Project (2015)**

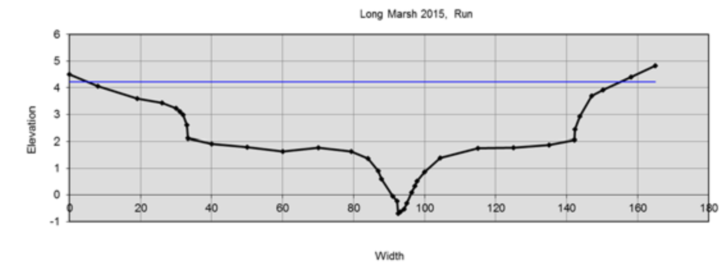
Station 1



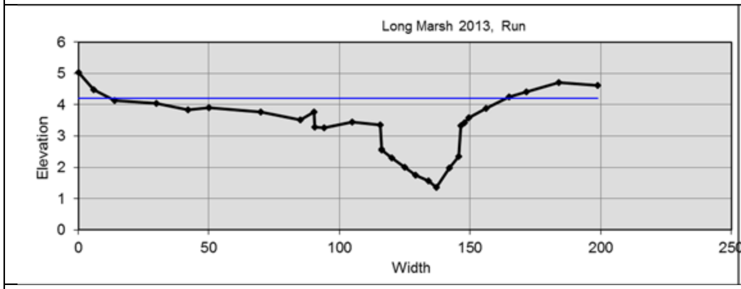


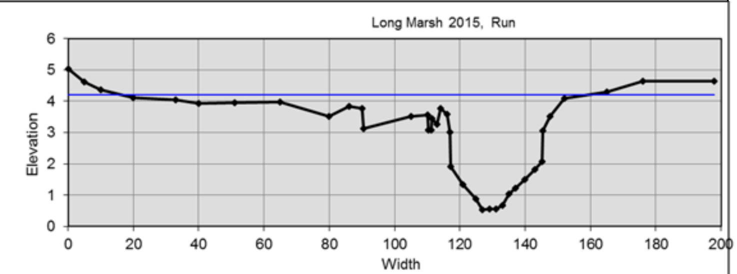
Station 2



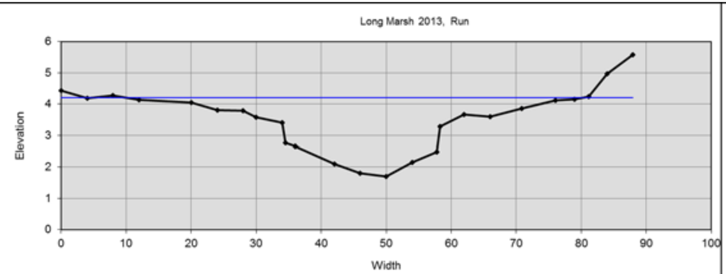


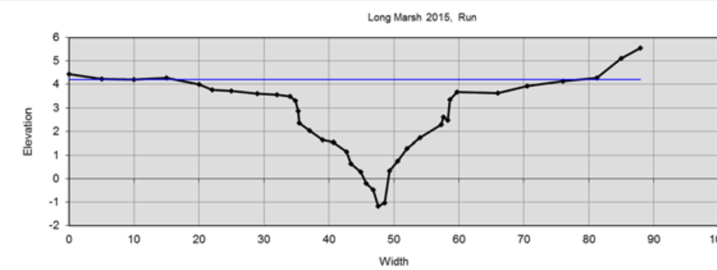
Station 3



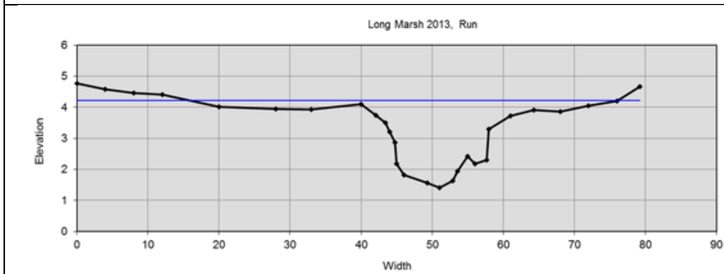


Station 4





Station 5



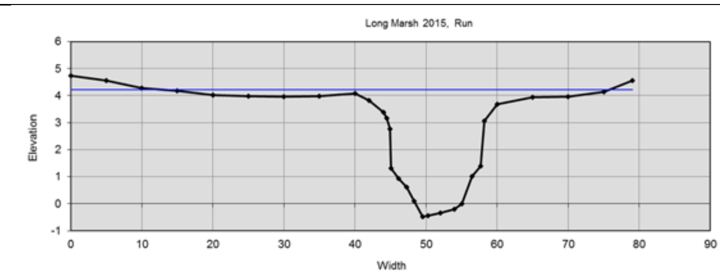


Figure 14. Plotted channel cross sections (Stations 1-5).

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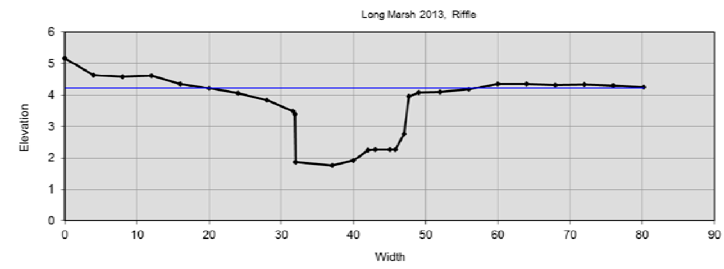
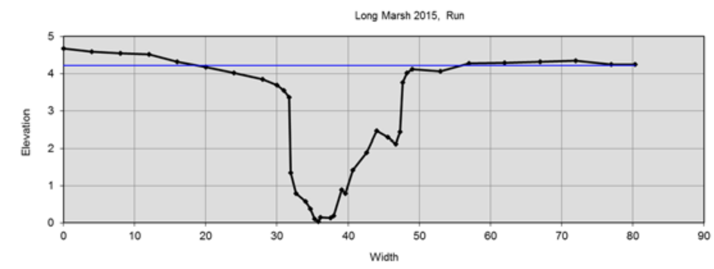
<tr><td>
</td><td>
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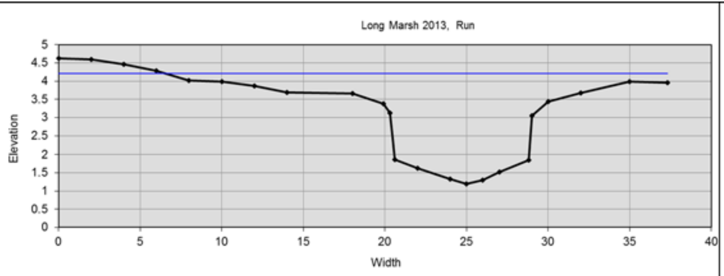
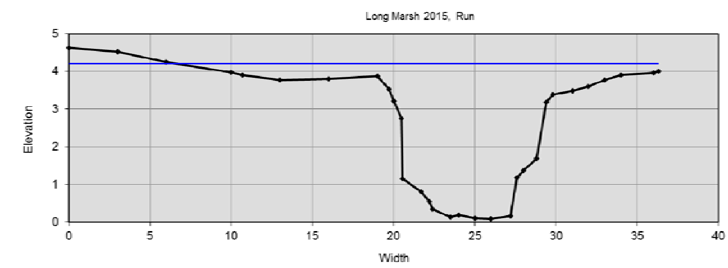
<tr><td>
</td><td>
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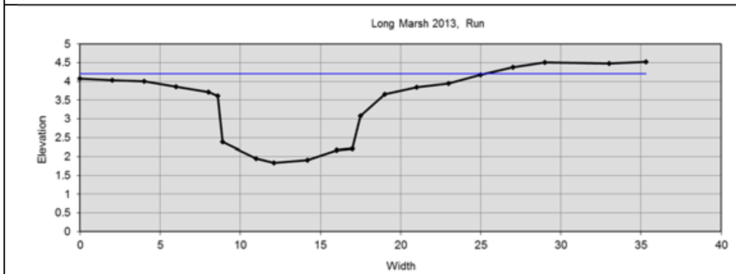
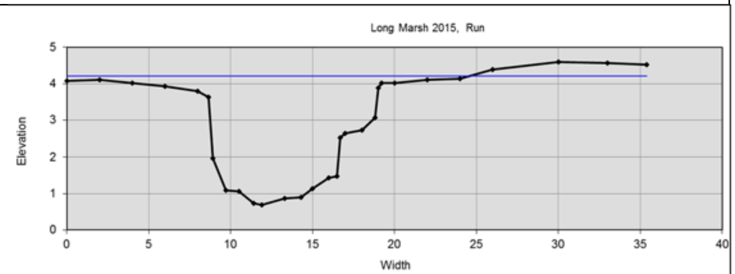
<tr><td>
</td><td>
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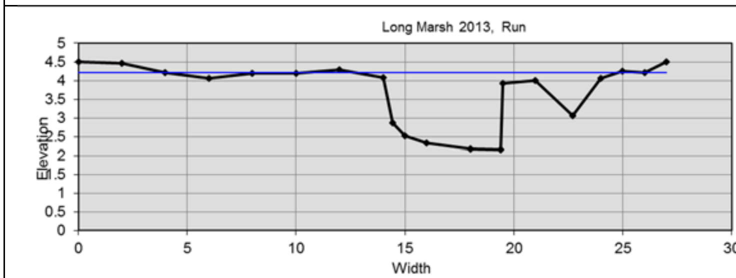
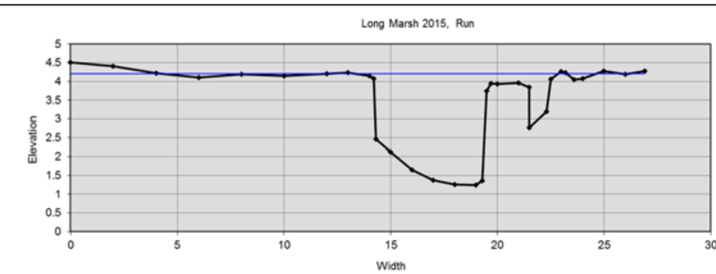
<tr><td>
</td><td>
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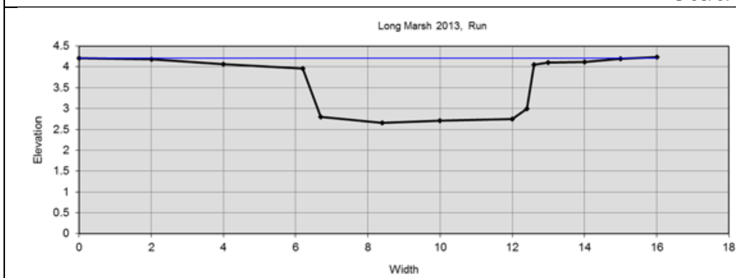
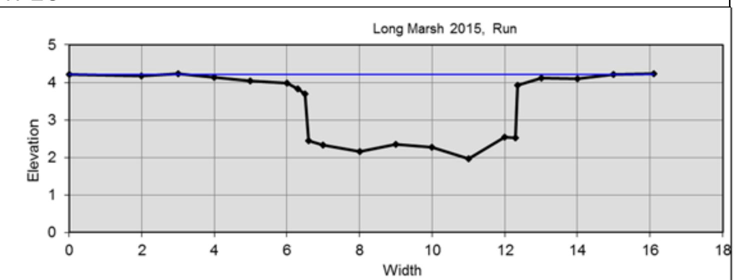
<tr><td colspan="2">Station 10</td></tr>
<tr><td>
</td><td>
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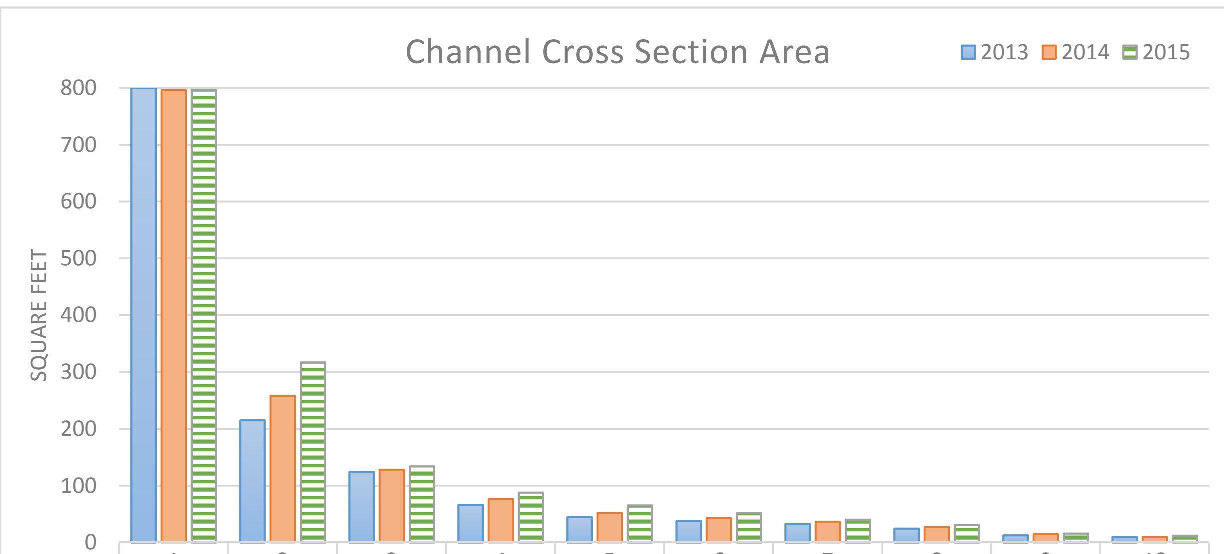
Figure 15. Plotted channel cross sections (Stations 6-10).

Addition photographs from the cross section surveys are included in Section 3.7 of this report, Photo Stations. At most Stations, photographs were taken looking upstream, downstream, and from each channel bank, providing a visual record of change. At some Stations, additional photos were taken showing views to the upland edge. These visual indicators the channel is actively evolving in response to increased tidal exchange are reflected in the quantitative metrics of the cross sections (Figures 16-17). Percent change in cross sectional area is also an indicator of the rate of erosion and sediment transport.

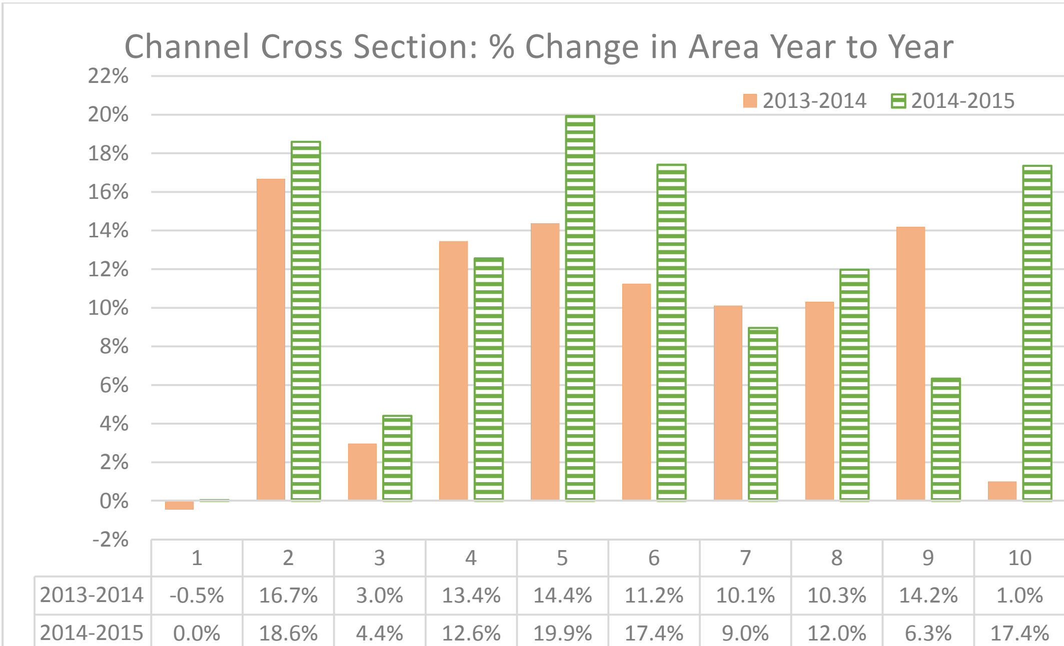
Cross section area remained constant at the reference station downstream of Long Reach Lane, but increased at every Station within the Project Area from 2013 to 2014, and again from 2014-2015. In 2015, the greatest increase in area (58.9 ft.^{2}) occurred at Station 2. By percentage change, the greatest increase (19.9%) was observed at Station 5, which also had one of the highest rates of change from 2013-2014 (14.4%). Generally, the rate of change of cross sections in the Project Area was greater in 2015 than in 2014, suggesting that the rate of change, and associated sediment movement, was still increasing 18 months after the culvert was replaced in January 2014. Cross section area of Stations 9 and 10 remain the smallest (about ½ that of Station 8), likely due to the presence of the historic ford across the creek channel upstream of Station 8, which acts as a grade control for the upstream channel depth.

The maximum channel depth increased at every Station in the Project Area in both 2014 and 2015, with all stations at least 1 foot lower in 2015 than in 2013 except for Station 10 (Fig. 18). The biggest change in maximum depth has been at Station 4, which is 2.9' deeper than in 2013.



	1	2	3	4	5	6	7	8	9	10
2013	800.0	214.9	124.3	66.3	44.7	37.9	32.9	24.4	12.7	9.9
2014	796.4	257.9	128.1	76.6	52.2	42.7	36.6	27.2	14.8	10.0
2015	796.7	316.8	134	87.6	65.2	51.7	40.2	30.9	15.8	12.1

Figure 16. Graphed cross sectional area by Station, 2013 and 2014. (Derived from Mecklenburg 2006).



	1	2	3	4	5	6	7	8	9	10
2013-2014	-0.5%	16.7%	3.0%	13.4%	14.4%	11.2%	10.1%	10.3%	14.2%	1.0%
2014-2015	0.0%	18.6%	4.4%	12.6%	19.9%	17.4%	9.0%	12.0%	6.3%	17.4%

Figure 17. Percent change in cross sectional area by Station, 2013 and 2014. (Derived from Mecklenburg 2006).

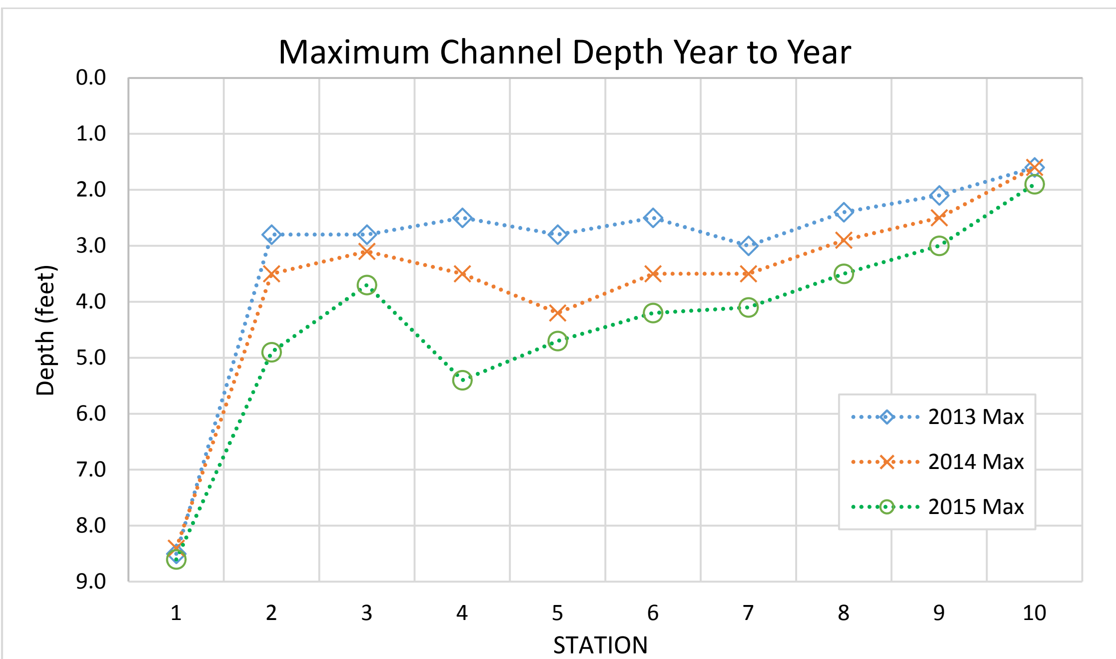


Figure 18. Comparison of mean and maximum channel depths by Station, 2013 and 2014 (derived from Mecklenburg 2006).

3.6 Plant Species of Concern

Incidence of invasive plant species were documented during vegetation transect surveys, meander surveys of the high marsh and marsh perimeter, and incidental observations during the course of monitoring in 2013, 2014, and 2015. The meander surveys did not cover the forested area upslope of the upland edge, an area which is determined to be outside of the Project Area, which is notable due to the fact that invasive plants and shrubs appear to be abundant in the adjacent forest based on incidental anecdotal observations traveling through the woods.

Within the Project Area, the only invasive plant species observed the Project Area in each of the three monitoring seasons was Purple Loosestrife (*Lythrum salicaria*). Although invasive Common Reed (*Phragmites australis*) continues to grow in three distinct patches downstream (south) of Station 10 (visible on Figure 1), and there is anecdotal visual evidence that these stands may be stressed by increased salt water delivery south of the "narrows", there continue to be no observations of *Phragmites* within the Project Area.

In 2015, just a single Purple Loosestrife plant was observed at the upland edge of Station 9 during vegetation surveys, in the middle of a cattail stand with a freshwater seep from the adjacent uplands. An exhaustive meander survey of other transitional areas confirms that the increased tidal exchange has eliminated virtually all of the Loosestrife in the Project Area by the second growing season post-project.

3.7 Photo Stations

Photographic documentation is being used to visually record conditions at fixed locations at the road crossing, and at each Station. Table 7 shows photo stations associated with the road crossing, before and after construction.

At most Stations, photographs were taken during cross section surveys looking upstream, downstream, and from each channel bank, providing a visual record of each Station (Table 8). At some Stations, additional photos were taken showing views to the upland edge.

During vegetation surveys, photographs were taken from the 0' (creek channel) looking to the end of the transect (upland edge), and from the upland edge looking back at the creek channel. Many of the 2015 photographs clearly show standing dead vegetation, particularly cattails (Table 9).

Table 7. Photo stations at the construction site, 2013 and 2015.

Pre-Project (2013)	**2015**
View Downstream (North)	
	
View to Outlet (South)	
	
View to Inlet (North)	
	
View Upstream (South)	
	

Table 8. Photos stations at channel cross section transects, 2013 and 2015.

Pre-Project (2013)	**2015**
Station 1 Cross Section (view north)	
	
Station 2 Cross Section (view upstream)	
	
Station 3 Cross Section (view west)	
	

Pre-Project (2013)	**2015**
Station 4 Cross Section (view north)	
	
Station 5 Cross Section (view south)	
	
Station 6 Cross Section (view east/upstream)	
	

<table>
<tr><th>PRE-PROJECT (2013)</th><th>2015</th></tr>
<tr><td colspan="2">Station 7 Cross Section (view south)</td></tr>
<tr><td></td><td></td></tr>
<tr><td colspan="2">Station 8 Cross Section (view east/upstream)</td></tr>
<tr><td></td><td></td></tr>
<tr><td colspan="2">Station 9 Cross Section (view south)</td></tr>
<tr><td></td><td></td></tr>
</table>

Pre-Project (2013)	2015
Station 10 Cross Section (view south)	
	

Table 9. Photo stations at vegetation transects, 2013 and 2015.

Pre-Project (2013)	**2015**
Station 1 Vegetation Transect (view from channel)	
	
Station 2 Vegetation Transect (view from channel)	
	
Station 2 Vegetation Transect (view from upland)	
	

Pre-Project (2013)	2015
Station 3 Vegetation Transect (view from channel)	
	
Station 3 Vegetation Transect (view from upland)	
	
Station 4 Vegetation Transect (view from channel)	
	

<table>
<tr><th>Pre-Project (2013)</th><th>2015</th></tr>
<tr><td colspan="2">Station 5 Vegetation Transect (view from channel)</td></tr>
<tr><td></td><td></td></tr>
<tr><td colspan="2">Station 6 Vegetation Transect (view from channel)</td></tr>
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<tr><td colspan="2">Station 7 Vegetation Transect (view from channel)</td></tr>
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<table>
<tr><th>Pre-Project (2013)</th><th>2015</th></tr>
<tr><td colspan="2">Station 7 Vegetation Transect (view from upland)</td></tr>
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<tr><td colspan="2">Station 8 Vegetation Transect (view from channel)</td></tr>
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<tr><td colspan="2">Station 9 Vegetation Transect (view from channel)</td></tr>
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2014	2015
Station 10 Vegetation Transect (view from channel)	
	

3.8 Wildlife use

CBEP continued to incidentally document use of the Project Area and the immediate upland edge by fish and wildlife but generally, time and energy was focused on monitoring core parameters. Observations are listed in Table 10.

Table 10. Incidental observations of fish and wildlife during monitoring (2013 – 2015).

Common name	Scientific name	Notes
Great blue heron	*Ardea herodias*	Pannes; outlet
Snowy egret	*Egretta thula*	Pannes; outlet
Bald eagle	*Haliaeetus leucocephalus*	2013 nest in pine
Glossy ibis	*Plegadis falcinellus*	Pools St. 1 & 2 (2015)
Osprey	*Pandion haliaetus*	
Greater yellowlegs	*Tringa melanoleuca*	Pannes; outlet
Sandpipers	*Scolopacidae spp.*	Pannes
Black duck	*Anas rubripes*	Creek channel
Mallard	*Anas platyrhynchos*	Creek channel
Canada goose	*Branta canadensis*	Creek channel
Belted Kingfisher	*Megaceryle alcyon*	
Black-crowned night heron	*Nycticorax nycticorax*	Pannes
Mink	*Neovison vison*	
Fisher	*Martes pennanti*	Found dead in spring trap
White-tailed deer	*Odocoileus virginianus*	
Coyote	*Canis latrans*	
Black bear	*Ursus americanus*	
Moose	*Alces alces*	
Raccoon	*Procyon lotor*	Tracks in channel flats
Soft shell clam	*Mya arenaria*	Upstream flats
Quahog	*Mercenaria mercenaria*	Upstream flats
Ribbed mussel	*Geukensia demissa*	
Mud snail	*Hydrobiidae sp.*	
Macoma clams	*Macoma sp.*	
Horseshoe crab	*Limulus polyphemus*	
Silverside	*Menidia menidia*	
Mummichog	*Fundulus heteroclitus*	
Green crab	*Carcinus maenas*	
American eel	*Anguilla rostrate*	
Moon jelly	*Aurelia spp.*	High marsh, 2014

4. MANAGEMENT RECOMMENDATIONS

Year 2 post-project monitoring data for all parameters show that conditions in the Project Area are on track to meet the mitigation goals and objectives. Aside from suggested options in the Year 1 report, there are no further management recommendations at this time.

5. REFERENCES

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APPENDIX A – MONITORING STATION MAPS


Vegetation
0
45
90
180
270
360
Meters
Transect Location
C = channel; U = upland
1C
1U
2C
2U
3C
3U
4C
4U
5U
5C
6C
6U
7C
7U
8U
8C
9C
9U
10C
10U

Channel Cross Sections
0
45
90
180
270
360
Meters
Stake
Casco Bay Estuary
PARTNERSHIP
XS1W
XS1E
XS2E
XS2W
XS3W
XS3E
XS4W
XS4E
XS5W
XS5E
XS6E
XS6W
XS7W
XS7E
XS8E
XS8W
XS9W
XS9E
XS10E
XS10W


Pore Water Salinity
0 45 90 180 270 360
Meters
Well
Casco Bay Estuary
PARTNERSHIP
1S
2S
4S
6S
6aS
8S
10S

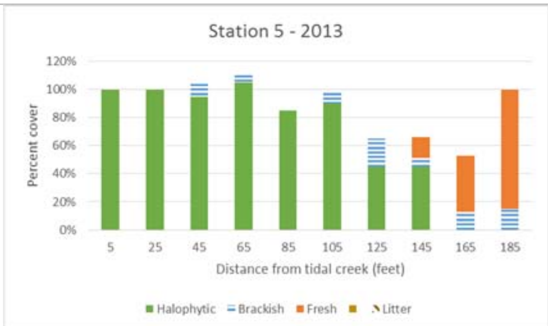
APPENDIX B – VEGETATION

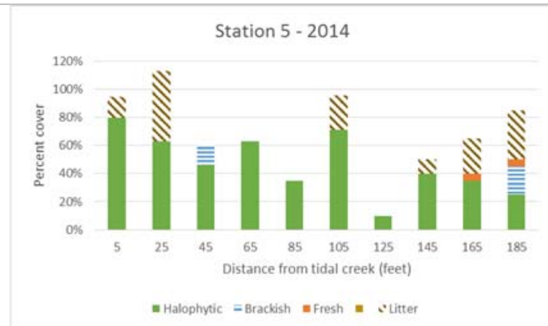
Table 11. List of observed plant species and associated community types. Groupings based on classifications in Verrill 2014.

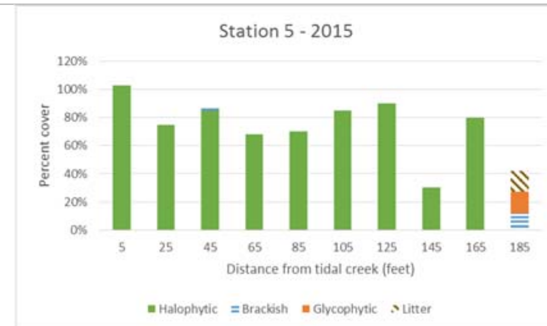
Latin Name	Common Name	Community Group	2013	2014	2015
Abies balsamea	Balsam Fir	Fresh	X		
Acer rubrum	Red Maple	Fresh		X	X
Agrostis stolonifera	Creeping Bent Grass	Brackish	X	X	X
Alnus incana	Speckled Alder	Fresh	X	X	X
Atriplex prostrata	Orach	Brackish	X	X	X
Bolboschoenus maritimus	Alkali Bulrush	Brackish	X	X	X
Calamagrostis Canadensis	Bluejoint Grass	Fresh	X	X	X
Calystegia sepium	Hedge Bindweed	Brackish	X		
Carex crinata	Fringed Sedge	Fresh	X		
Carex hystericina	Bottlebrush Sedge	Fresh	X	X	X
Carex lacustris	Lake Sedge	Fresh	X	X	
Carex lurida	Shallow Sedge	Fresh	X		
Carex paleacea	Chaffy Sedge	Fresh	X		
Carex scoparia	Broom Sedge	Fresh	X	X	X
Carex stipata	Stalk-Grain Sedge	Fresh	X		X
Carex utriculata	Common Beaked Sedge	Fresh		X	X
Cladium mariscoides	Smooth Sawgrass	Fresh	X	X	X
Distichlis spicata	Salt Grass	Halophyte		X	X
Dryopteris cristata	Crested Wood Fern	Fresh	X		
Dulichium arundinaceum	Three Way Sedge	Fresh	X		X
Eleocharis sp.	Sedge	Brackish	X		X
Elymus pycnanthus	Tick Quackgrass	Fresh	X		X
Elymus repens	Creeping Wild Rye	Fresh	X	X	
Equistem pratense	Horsetail	Fresh	X	X	
Euthamia graminifolia	Flat-Top Goldentop	Fresh	X		
Festuca rubra	Red Fescue	Brackish	X	X	X
Galium asprellum	Rough Bedstraw	Fresh		X	
Galium trifidum	Threepetal Bedstraw	Fresh	X	X	X
Glaux maritima	Milkwort	Brackish		X	
Glyceria canadensis	Rattlesnake Mannagrass	Fresh	X		
Hordeum jubatum	Foxtail Barley	Brackish	X	X	
Hypericum mutilum	St. John's Wort	Fresh	X	X	X
Ilex verticillata	Winterberry	Fresh	X	X	X
Impatens capensis	Jewelweed	Fresh	X	X	X
Juncus arcticus	Arctic Rush	Brackish	X	X	X
Juncus gerardii	Black Grass	Halophyte	X	X	X
Lycopus americanus	Cut-Leaf Water Horehound	Fresh	X		
Lycopus uniflorus	Northern Bugleweed	Fresh	X	X	X
Lysimachia terrestris	Swamp Candle	Fresh	X	X	X
Lythrum salicaria	Purple Loosestrife	Brackish	X	X	X
Onoclea sensibilius	Sensitive Fern	Fresh	X	X	X
Osmunda regalis	Royal Fern	Fresh	X		
Panicum dichotomiflorum	Panic Grass	Fresh	X		
Persicaria sagittata	Tearthumb	Fresh	X		X
Proserpinaca palustris	Marsh Mermaidweed	Fresh	X	X	X
Puccinellia tenella	Alkali Grass	Brackish	X		
Quercus rubra	Northern Red Oak	Fresh	X	X	X
Ribes sp.	Currant	Fresh	X		
Rosa palustris	Swamp Rose	Fresh	X		
Rubus sp.	Blackberry	Fresh	X	X	
Ruppia maritima	Widgeon Grass	Halophyte	X	X	X
Salicornia depressa	Common Glaswort	Halophyte	X	X	X
Schoenoplectus acutus	Hardstem Bulrush	Fresh	X	X	X
Schoenoplectus pungens	Three-Square Bulrush	Fresh	X	X	X
Scirpus sp.	Sedge	Brackish	X		
Scutellaria galericulata	Hooded Skullcap	Fresh	X	X	X

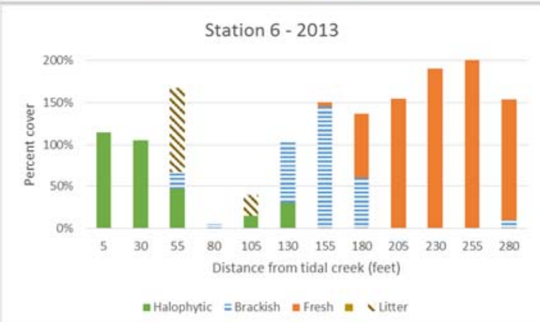
Solidago altissima	Tall Goldenrod	Fresh	X	X	X
Solidago sempervirens	Seaside Goldenrod	Halophyte	X	X	X
Spartina alterniflora	Smooth Cordgrass	Halophyte	X	X	X
Spartina patens	Salt Hay	Halophyte	X	X	X
Spartina pectinata	Freshwater Cordgrass	Brackish	X	X	X
Spirea alba	White Meadowsweet	Fresh	X	X	X
Spirea tomentosa	Steeplebush	Fresh	X		X
Symphyotricum novi-belgii	Aster	Brackish	X		X
Thelypteris palustris	Eastern Marsh fern	Brackish	X	X	X
Toxicodendron radicans	Poison Ivy	Brackish	X	X	X
Triglochin maritimum	Seaside Arrowgrass	Halophyte	X	X	X
Typha angustifolia	Narrow-Leaf Cattail	Brackish	X	X	X
Typha latifolia	Broad-Leaf Cattail	Fresh	X	X	X
Typha x glauca	hybrid cattail	Brackish	X	X	X
Vaccinium macrocarpon	Large Cranberry	Brackish	X	X	X
Viola sp.	violet	Fresh	X		X

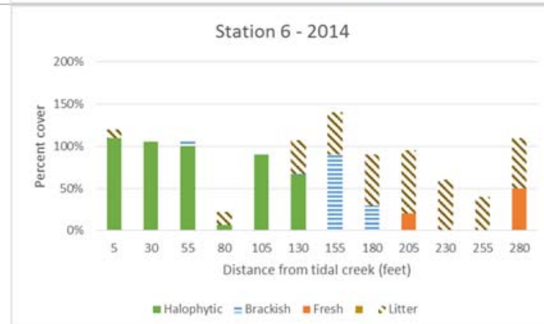
Table 12. Bar graphs of community type (% cover) for Stations 1-10, by transect distance, 2013 - 2015.

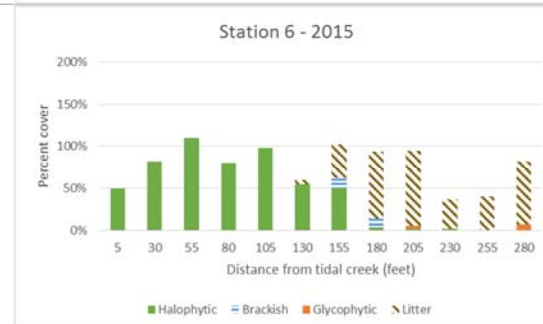

Station 5 - 2013
Percent cover
5 25 45 65 85 105 125 145 165 185
Distance from tidal creek (feet)
Halophytic Brackish Fresh Litter

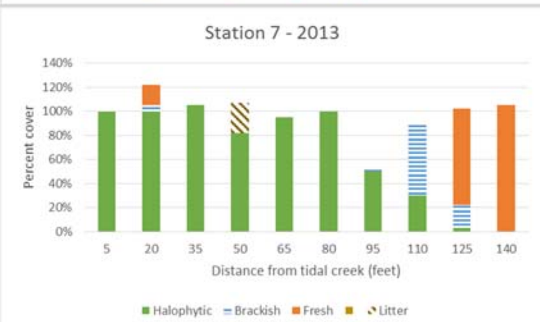

Station 5 - 2014
Percent cover
5 25 45 65 85 105 125 145 165 185
Distance from tidal creek (feet)
Halophytic Brackish Fresh Litter

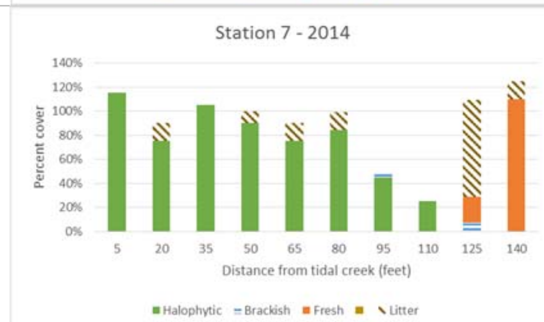

Station 5 - 2015
Percent cover
5 25 45 65 85 105 125 145 165 185
Distance from tidal creek (feet)
Halophytic Brackish Glycophytic Litter

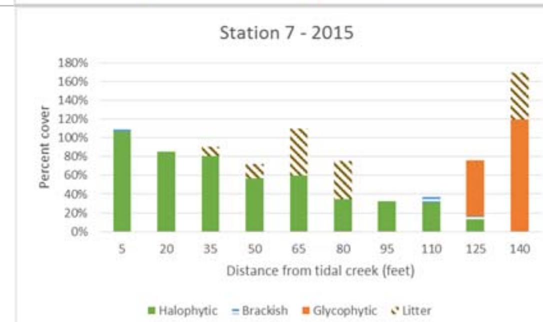

Station 6 - 2013
Percent cover
5 30 55 80 105 130 155 180 205 230 255 280
Distance from tidal creek (feet)
Halophytic Brackish Fresh Litter

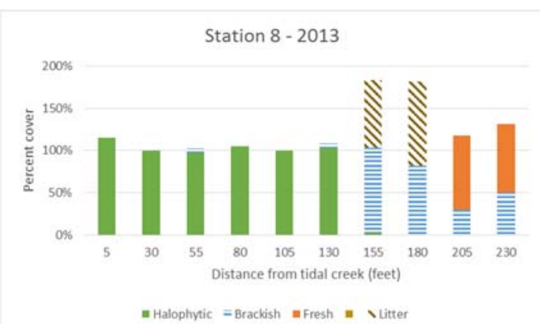

Station 6 - 2014
Percent cover
5 30 55 80 105 130 155 180 205 230 255 280
Distance from tidal creek (feet)
Halophytic Brackish Fresh Litter

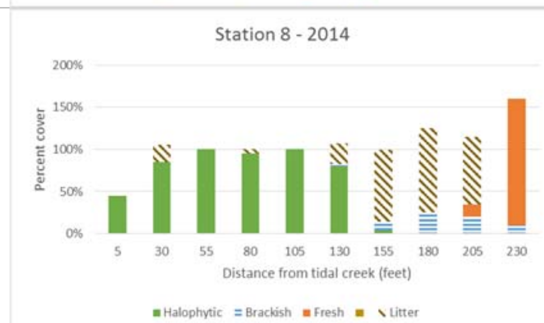

Station 6 - 2015
Percent cover
5 30 55 80 105 130 155 180 205 230 255 280
Distance from tidal creek (feet)
Halophytic Brackish Glycophytic Litter

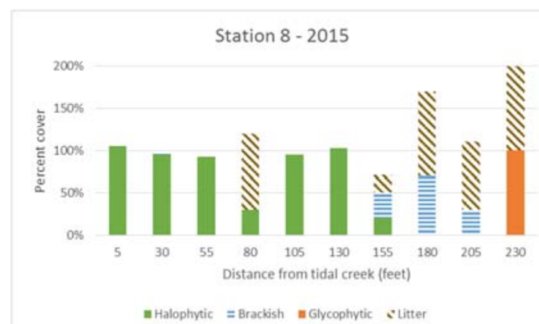

Station 7 - 2013
Percent cover
5 20 35 50 65 80 95 110 125 140
Distance from tidal creek (feet)
Halophytic Brackish Fresh Litter

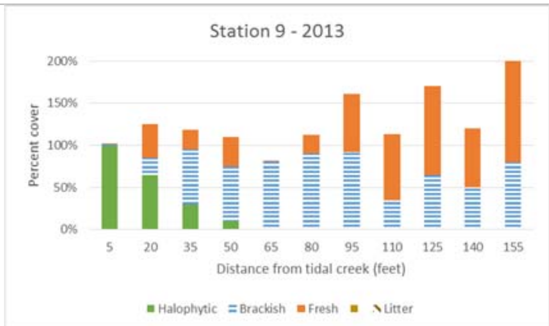

Station 7 - 2014
Percent cover
5 20 35 50 65 80 95 110 125 140
Distance from tidal creek (feet)
Halophytic Brackish Fresh Litter

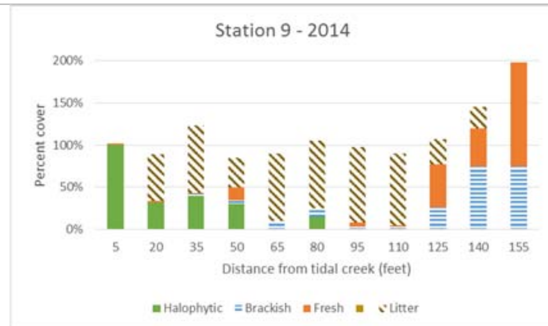

Station 7 - 2015
Percent cover
5 20 35 50 65 80 95 110 125 140
Distance from tidal creek (feet)
Halophytic Brackish Glycophytic Litter

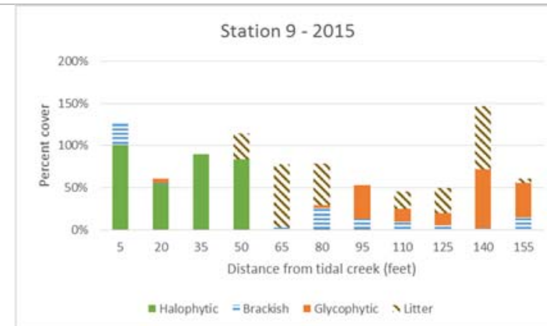

Station 8 - 2013
Percent cover
5 30 55 80 105 130 155 180 205 230
Distance from tidal creek (feet)
Halophytic Brackish Fresh Litter

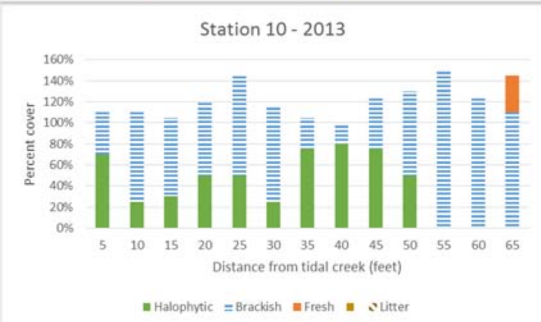

Station 8 - 2014
Percent cover
5 30 55 80 105 130 155 180 205 230
Distance from tidal creek (feet)
Halophytic Brackish Fresh Litter

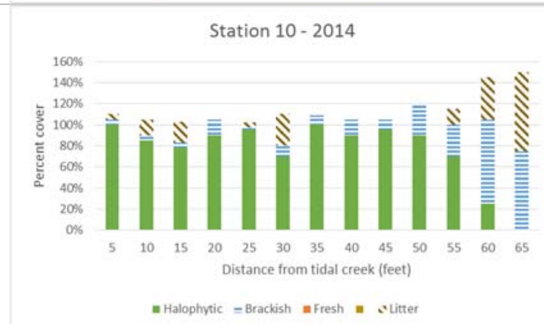

Station 8 - 2015
Percent cover
5 30 55 80 105 130 155 180 205 230
Distance from tidal creek (feet)
Halophytic Brackish Glycophytic Litter

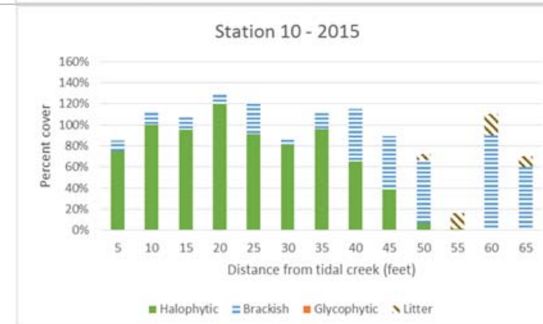

Station 9 - 2013
Percent cover
Distance from tidal creek (feet)
Halophytic
Brackish
Fresh
Litter


Station 9 - 2014
Percent cover
Distance from tidal creek (feet)
Halophytic
Brackish
Fresh
Litter


Station 9 - 2015
Percent cover
Distance from tidal creek (feet)
Halophytic
Brackish
Glycophytic
Litter


Station 10 - 2013
Percent cover
Distance from tidal creek (feet)
Halophytic
Brackish
Fresh
Litter


Station 10 - 2014
Percent cover
Distance from tidal creek (feet)
Halophytic
Brackish
Fresh
Litter


Station 10 - 2015
Percent cover
Distance from tidal creek (feet)
Halophytic
Brackish
Glycophytic
Litter