5.3 Physical Parameters

Four general sets of data were collected to characterize physical changes to the marsh. These had to do with water flows, the marsh water table height, sedimentation, and changes to the amount of open water (and the kinds of open water) found across the marsh.

5.3.1. Water Flow Measures

5.3.1.1.Ditch and Channel Conditions

Prior to marsh alterations, there were 43 delineated mosquito ditches within the study area. The ditches varied in width, but were constructed uniformly parallel east to west in all Areas 1, 2, and 3. Area 4 had a grid ditch network. In the late 1980s and early 1990s a fairly comprehensive ditch plug effort was made in Wertheim. This was an attempt to restore the hydrology thought to have been altered by ditching by blocking the mouths of the ditches. The plugs were generally two to three feet in thickness, and often had plywood framing at either end. The material for the plugs was found by digging deeper or wider sections of the ditch immediately in the vicinity of the plug (C. Kessler, Ducks Unlimited, personal communications 2004, 2005). No monitoring was done of the effect or impact of the plugs, and they were not maintained. Storm tides and muskrat undermining undid much of the plugs within several years of the effort.

A visual inspection of all the mosquito ditches was performed in January 2004 (pre-alterations) and May 2006 (post alterations), and general characteristics of the ditches were documented. These included accounts of the plugs, which were classified as "working" (retaining water), "moderate," or "failed." Major features were recorded by GPS coordinates. It should be noted that the January 2004 inspection found that most of the plugs in Area 4 were determined to have failed; most of the plugs in Area 1 were characterized as moderate; and most of the plugs in Area 3 were listed as working. Of some special interest is that Ditches 4 and 5 in Area 2 contained an additional plug in the mid-portion of the ditch, and Ditch 6 contained two additional mid-section plugs.

The main tidal channels installed in Area 1 and Area 2 were also inspected in May 2006. Natural erosion was observed along the banks of curves in Area 1. *Phragmites* was found to be stunted in growth and vigor along the tidal channel in the northern portion of Area 1. Several natural sills were noted draining water from the marsh surface into tidal channels. Some pooling and undercutting were observed along the tidal channels; however, most of the banks appeared to be gently sloping, water flow was visible, and fish were frequently observed. The banks of the newly constructed tidal channels in Area 2 appeared to be conforming to a gentler slope from the steeper slopes installed by the machines.

5.3.1.2.Water Flows Analyses

Two efforts were made to determine flow rates in the ditches. Due to the generally slow flows in the ditches, it was determined that current meters and stream flow gauges of various kinds would be unlikely to work well. The first effort used drift cards. These mostly became entangled in vegetation growing in and alongside the ditches. The second effort, following a published report that clementines floated immediately below the water surface at ambient Long Island marsh salinities, tried to follow these citrus fruit as they drifted. An advantage to using clementines is that they do not create as noxious a pollution problem as paper or other drift materials. However, the fruit did not float as expected, and still needed to be collected from the ditches.

5.3.1.3.Marsh Inundation Studies

In July 2004 and June 2006, a study was conducted to measure the magnitude of tidal inundation on the marsh surface. The data collected from the 2004 study aided in the development of the project design, and therefore was only conducted in the proposed treatment areas. The study was conducted again in 2006 to evaluate whether the newly constructed ponds and tidal channels increased inundation in the surrounding areas. Tidal inundation measurements in the control areas were measured in 2006 only.

Figure 67 is an estimated contour of the depths recorded across Areas 1 and 2 in 2004. Figure 68 is a similar diagram for Areas 1, 2 and 3 in 2006, and Figure 69 is a diagram for Area 4 for 2006. Comparisons for Areas 1 and 2 seem to find there was less area inundated across the marsh in 2006 than in 2004; however the depth of the water was greater in 2006 than 2004. The tide in 2006 was approximately 0.25 feet higher than that recorded in 2004, according to the USGS tide gage in Lindenhurst. This, coupled with the marsh alterations, may have increased the depth of water measured across Areas 1 and 2. Inundation across Area 3 in 2006 appears to be a result of the western tidal channel feeding into the ditches. Area 4 appears to receive inundation as a result of the river washing over the low-lying western shoreline across the mid and eastern portions of the marsh.

The tide at Wertheim may have been different than at Lindenhurst, especially given the higher flow rates in the river in 2006 as compared to 2004. Therefore, it is not clear if any good conclusion can be drawn from these two events regarding the amount of inundation that results following the changes to the marsh. The original purpose of the inundation study (in 2004) was to aid design by determining if spring tides would reach the potential pond areas. The methodology used could be altered to better determine the extent and depth of tidal flow across the marsh generally.

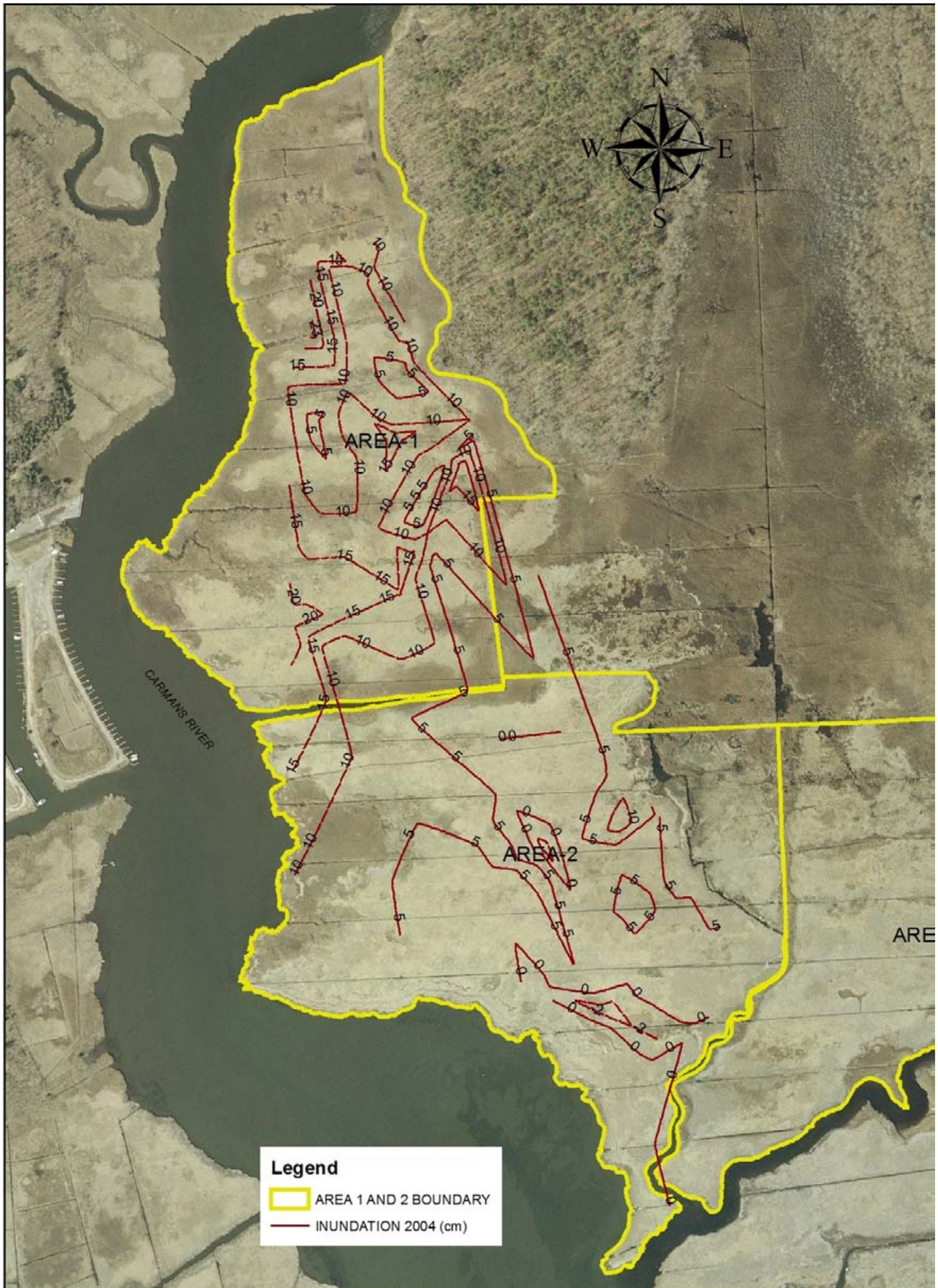

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FIGURE 67
WERTHEIM NATIONAL WILDLIFE REFUGE
WATER MANAGEMENT DEMONSTRATION PROJECT
AREA 1 AND 2 INUNDATION 2004

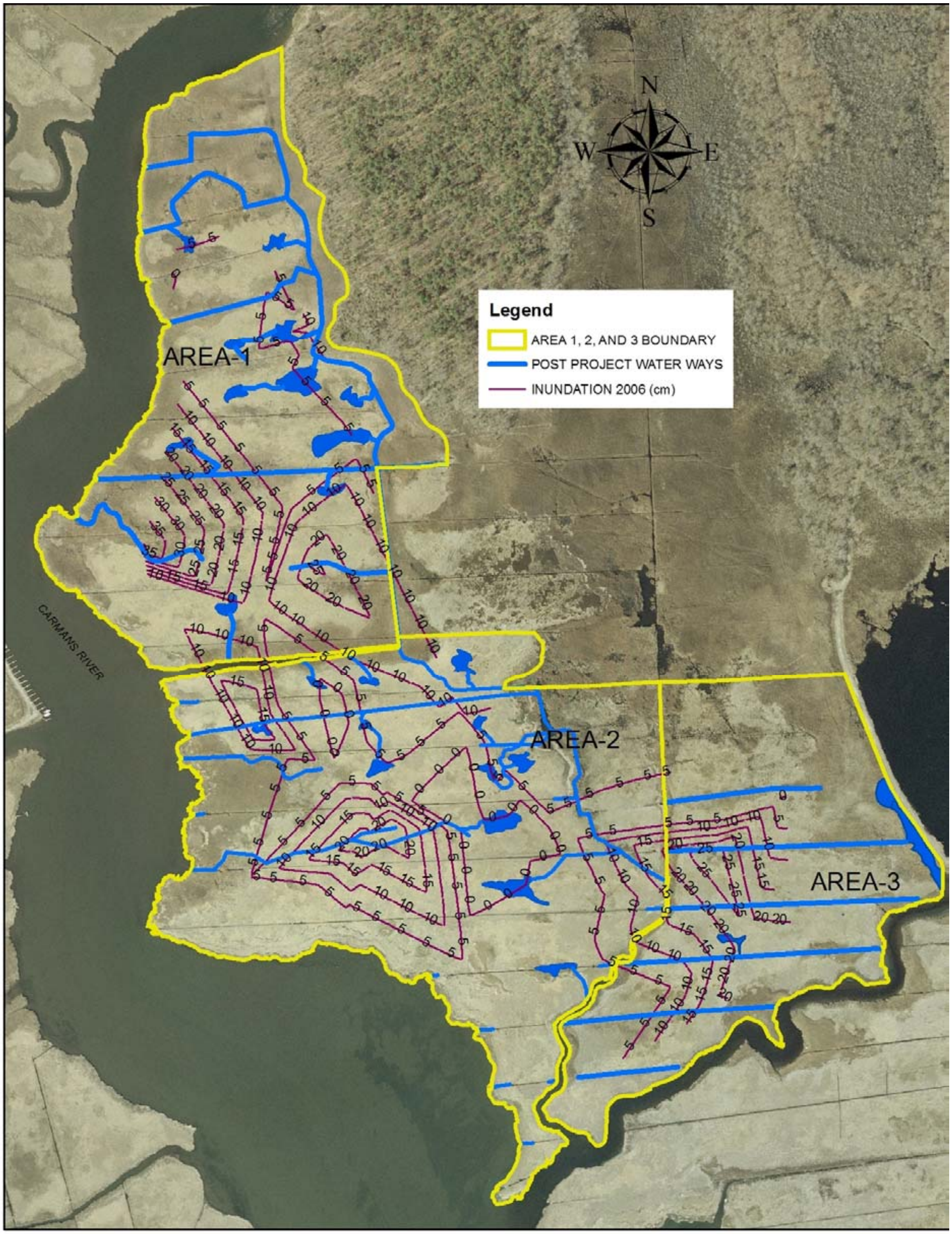

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FIGURE 68
WERTHEIM NATIONAL WILDLIFE REFUGE
WATER MANAGEMENT DEMONSTRATION PROJECT
AREA 1, 2, AND 3 INUNDATION 2006

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FIGURE 69
WERTHEIM NATIONAL WILDLIFE REFUGE
WATER MANAGEMENT DEMONSTRATION PROJECT
AREA 4 INUNDATION 2006

5.3.2. Water Table Heights

Water table elevations were measured relative to the marsh surface. The data have a great deal of scatter, both for individual stations, comparing stations across Areas on particular dates, or in comparing Area-wide measures. Figure 70 shows the pattern of Area-wide means per sampling event. Figure 71 shows the annual means for each Area (taking the mean of each station's mean over the course of the year).

Figure 70. Area-wide Water Table Height Means per Sampling Event

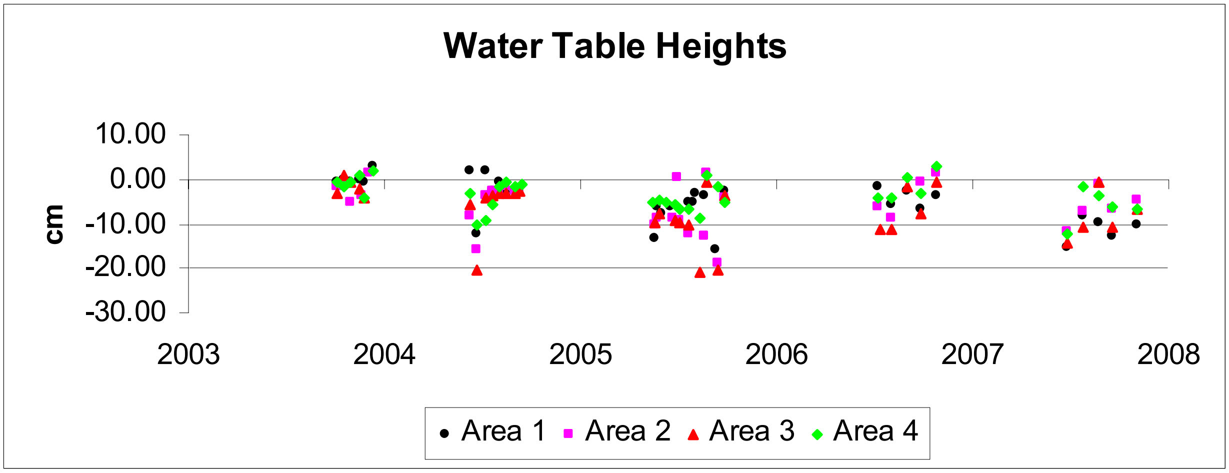
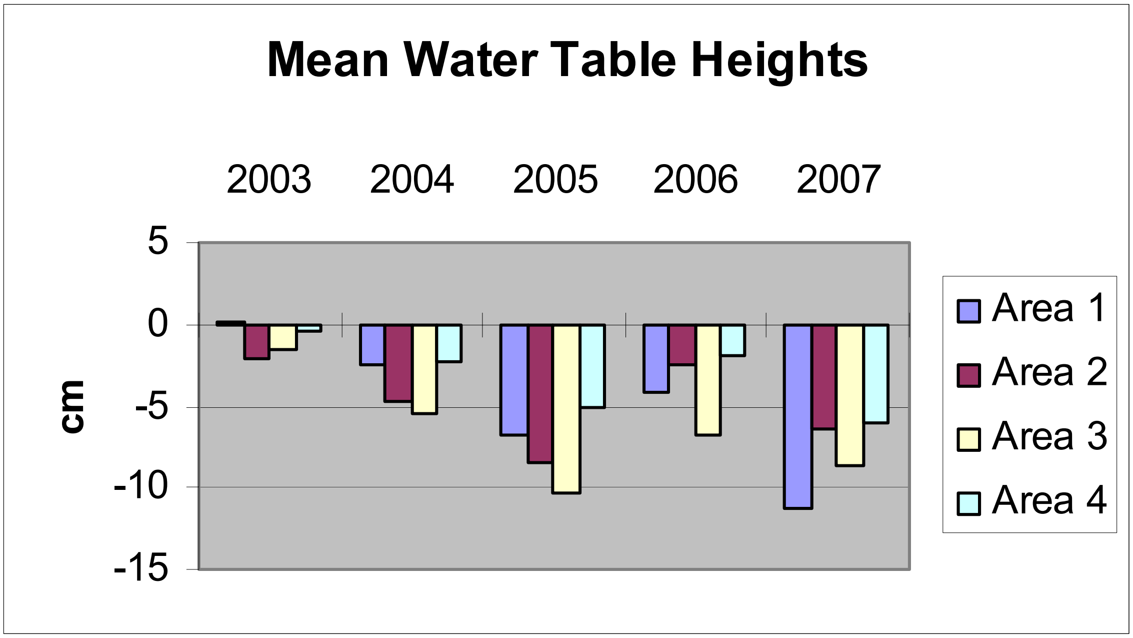


Figure 71. Annual Means, Water Table Heights, for All Measurements



These data imply that 2003 was the wettest time for the marsh, and 2005 and 2007 were the driest. However, those annual determinations probably do not exactly represent the widely varying data associated with individual stations, or for the Areas as a whole at any one particular time. The summary data necessarily simplify a very complicated data set.

The water tables are a function of river flow, since the flow rate of the river determines flooding frequency and the stage of the river provides resistance to discharge for the water table. Tidal inputs clearly affect the amount of water in the water table, by defining flooding events. Precipitation is another input of water; the amount of precipitation may not be as important, however, as is the related process of evaporation, which is associated with a lack of rain (and the presence of sun and heat). Transpiration by marsh plants as they grow and metabolize is also an important element in the determination of water levels in the water table, as would be changes in the location of ditches, channels, and ponds. The weighting and resultant sum of all these signals are the reason for the complicated patterns of the data sets.

It is difficult to determine appropriate comparisons for these water table measurements. They should vary over time, and from year-to-year. A determination of correlations among the important contributing to the overall water table might be informative. However, comparisons of annual means, or changes from (say) spring water table heights to the next year's spring-time heights, do not seem especially valuable. However, in relative, only semi-quantitative terms, Area 1 pre-treatment tended to be approximately as wet as Area 4; post-treatment, Area 1 was significantly drier (on the whole) than Area 4. Pre-treatment, Area 2 tended to be drier than Area 1; post-treatment (for both Areas), Area 1 has tended to be much drier than Area 2. Area 3 has tended to be drier than Area 4 (which, on the whole, has tended to be the wettest Area). It is possible that these data show a treatment effect for Area 1 (where the water table may have dropped, relatively) and for Area 2 (where the water table may have relatively risen).

5.3.3. Sedimentation

Marker horizons were established in 2003. A subset of the marker horizons were sampled in 2004 (one year of deposition). The marker horizons were reset in 2006, and resampled in 2007 (another one-year deposition time frame). The sampling in 2004 was also intended to establish a pre-treatment baseline, although it turned it out that Area 2 was not modified until 2006.

Sea level rise for the Long Island area, based on long-term data collections, is between 2.4 and 2.8 mm/yr (Cashin Associates, 2006b). The sediment accumulations exceeded this by considerable margins (Tables 69 and 70). Three of the four areas had lower accumulation rates post-treatment; the change for Area 1 was statistically significant. Area 2 had a slightly greater accumulation rate post-treatment; the difference, pre-treatment to post-treatment, was not significant. Note that there are high variations in accumulations, although the range found in 2007 tended to be smaller than that measured in 2004. Please note that this is a biased data set; failure to relocate a marker horizon was assumed to be a sampling failure, not erosion of the marker horizon. It is possible that some of the marker horizons were completely eroded away, and the station therefore should have been credited with a loss of sediment over the sampling time period.

Table 69. Average one year sedimentation rate, as determined in 2004 (pre-treatment)

Area	Samples	Accumulation Rate (mm/yr)	Range (mm)
Area 1	9	11.0	4-21
Area 2	7	5.7	0-15
Area 3	8	7.5	1-15
Area 4	8	6.1	0-13

Table 70. Average one year sedimentation rate, as determined in 2007 (post-treatment)

Area	Samples	Accumulation Rate (mm/yr)	Range (mm)
Area 1	10	3.6	1-5
Area 2	11	6.8	1-17
Area 3	10	4.0	2-8
Area 4	9	5.6	1-10

It was suggested that marsh sedimentation probably needs to be augmented by storm events in order to meet or exceed sea level rise rates. There were only two especially notable storm events over the 2003-2007 time period that might bring sediments onto the marsh. One was the massive rains in the fall of 2005, which might have brought upland sediments via river flooding (the summer thunder storms of July 2007 might have caused some flooding, as well). The only extended estuarine-oriented storm was a nor'easter in March 2007. There did not seem to have been an especially notable flooding-tide amplitude event in late 2003 through 2004 to provide excess sediments to account for the robust rates recorded over that time period.

It should be noted that marker horizons do not account for any subsurface compaction or decay, nor do they account for any relative uplift/downward coastal processes.

5.3.4. Open Water Areas

This project changed the amount and kind of open water across Area 1 and Area 2. Table 71 lists the changes in open water for the Areas.

Table 71. Open Water by Area

Area	Ditches, (Linear Feet)	Modified Ditches and Sills (ha)	Tidal Channels (ha)	Number of Ponds	Area of Ponds (ha)	Total Open Water (ha)
Area 1, pre-project	9,077	0	0	0	0	0.25
Area 1, post-project	0	0.15	0.09	11	0.45	0.69
Area 2, pre-project	10,992	0	0	0	0	0.36
Area 2, post-project	0	0.14	0.08	12	0.52	0.74
Area 3	4,913	0	0	1 (existing pre-project)	0.02	0.25
Area 4	12,790	0	0	0	0	0.36

Table 71 shows that more than three miles of ditches were filled as part of this project. Approximately half a hectare of open water, including 23 ponds, were added to the marsh. The percentage of open water in Area 1 was increased from 1.6 percent to 4.3 percent, and the open water area increased in Area 2 from 1.9 percent to 3.9 percent. The amount of open water in Area 3 is 2.5 percent, and in Area 4 it is 1.7 percent. Areas 1 and 2 therefore have more open water than Areas 3 and 4 do, post-construction. However, Adamowicz and Roman (2005) found that, on average, unditched marshes across New England (albeit mostly in northern Massachusetts and Maine) average approximately 10 percent open water (ditched marshes have less open water, presumably because the ditches drained some of the water from the marshes).