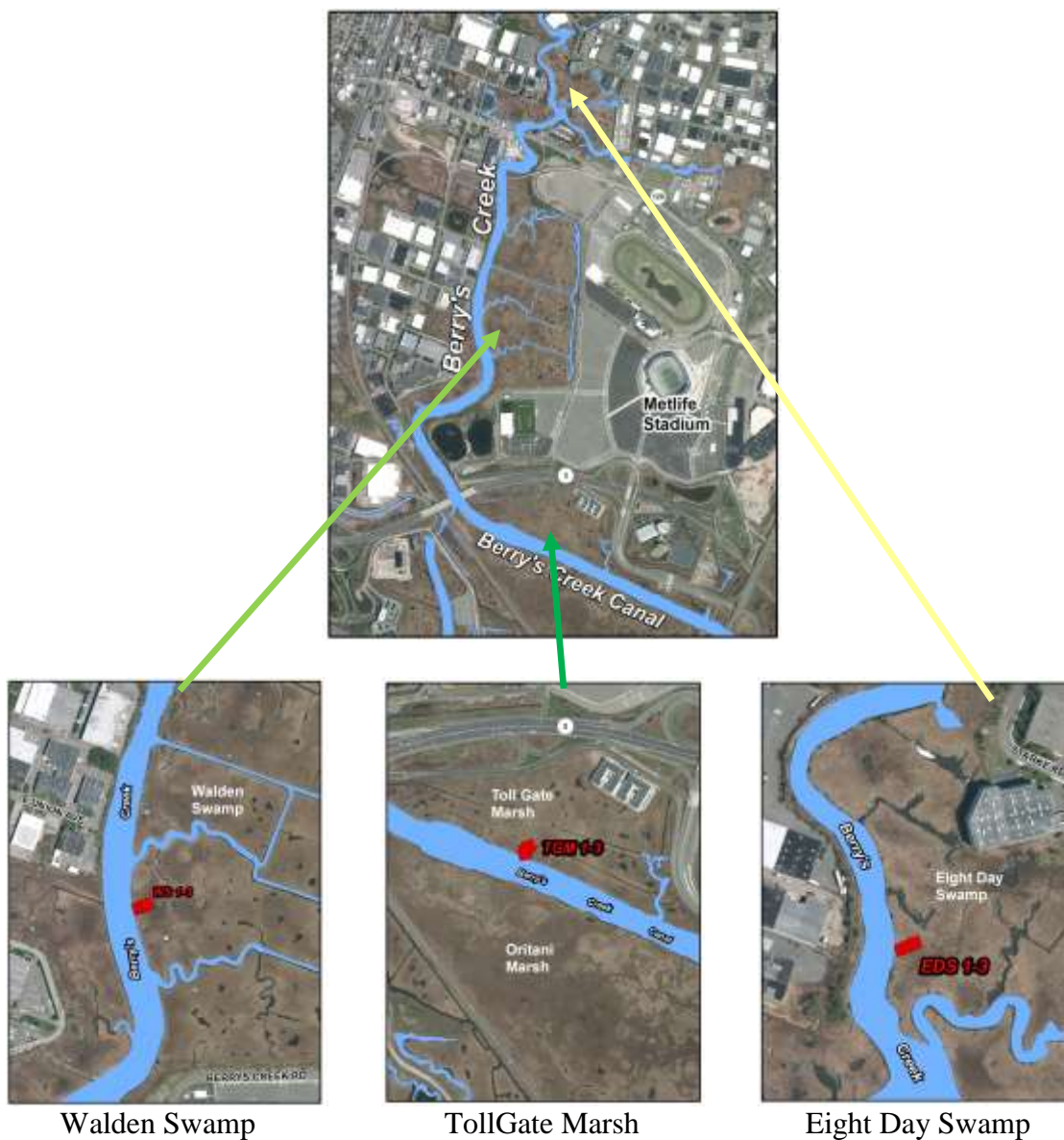


Measuring Elevation Change in Berry's Creek Marshes Using Surface Elevation Tables (SETs) and Marker Horizons Meadowlands Environmental Research Institute (Fall 2019)

The SET (Sediment Elevation Table) provides a constant plane in space from which the distance to the sediment surface can be measured by means of pins lowered to the marsh surface (USGS 2010). Benchmark rods were established, marker horizons of feldspar were emplaced, and baseline readings were taken at two locations in the Berry's Creek watershed, Eight Day Swamp and Walden Swamp, during the spring of 2009. Another site was added in the Tollgate Marsh area of Berry's Creek in the Fall of 2018 and measurements were taken in the following year the Fall of 2019. Each site will be revisited annually, and this report is a summary of those measurements.

Figure 1: Study Area



At each site, three replicate plots have been installed. At each plot, nine pins are lowered to the marsh surface. Readings are taken in each of four orientations resulting in a total of 108 measurements. At the time of each subsequent reading, results obtained from each pin are compared. The average of the resulting differences becomes one data point that represents the level of the marsh surface. To obtain a yearly rate, this value is divided by the number of days that have elapsed between establishment of the benchmark and the subsequent reading. Time elapsed between readings is summarized in this report (Table 1).

Table 1: Time Elapsed Between Readings

Location	Initial Date	Subsequent Date	Days	Years
EDS -1, 2, 3	4/30/2009	10/22/2019	3827	10.5
WS -1, 2, 3	4/30/2009	10/2/2019	3807	10.4
TM -1, 2, 3	11/30/2018	10/1/2019	305	0.84

Table 1 provides the dates for each reading and the time elapsed in days and years.

Table 2: Average Elevation Change (mm) – Fall 2019 Sampling

Table 2a: SETs Measurements – Fall 2019 sampling

Walden Swamp		Eight Day Swamp		Tollgate Marsh	
All Platforms	122.56	All Platforms	85.60	All Platforms	-7.21
Std Error	18.68	Std Error	6.58	Std Error	7.33
Platform 1	116.8	Platform 1	93.2	Platform 1	-20.7
SE	6.06	SE	12.65	SE	8.78
Platform 2	157.39	Platform 2	72.50	Platform 2	-5.44
SE	2.95	SE	4.56	SE	5.69
Platform 3	93.4	Platform 3	91.1	Platform 3	4.5
SE	4.5	SE	7.4	SE	5.9
Avg Corners	122.6	Avg Corners	85.6	Avg Corners	-28.8
SE	8.3	SE	5.4	SE	-27.2
WS-1 pos 2	122.7	WS-1 pos 2	86.8	WS-1 pos 2	5.4
WS-1 pos 4	130.6	WS-1 pos 4	130.6	WS-1 pos 4	-32.22
WS-1 pos 6	103.3	WS-1 pos 6	78.3	WS-1 pos 6	-14.11
WS-1 pos 8	110.78	WS-1 pos 8	77.00	WS-1 pos 8	-16.2
WS-2 pos 2	150.22	WS-2 pos 2	72.44	WS-2 pos 2	2.33
WS-2 pos 4	164.4	WS-2 pos 4	64.8	WS-2 pos 4	6.22
WS-2 pos 6	156.11	WS-2 pos 6	85.33	WS-2 pos 6	-7.8
WS-2 pos 8	158.78	WS-2 pos 8	67.44	WS-2 pos 8	-1.3
WS-3 pos 2	95.4	WS-3 pos 2	85.7	WS-3 pos 2	7.4
WS-3 pos 4	86.8	WS-3 pos 4	113.1	WS-3 pos 4	19.67
WS-3 pos 6	86.2	WS-3 pos 6	82.6	WS-3 pos 6	-7.21
WS-3 pos 8	105.33	WS-3 pos 8	83.22	WS-3 pos 8	7.33

Site	Marsh Type	Dominant Vegetation	Rate of Elevation Change (mm/yr)
Eight Day Swamp	High	Phragmites	8.17
Walden Swamp	High	Phragmites	11.75
Tollgate Marsh	High	Phragmites	-8.63

Tables 2 and 2a are summaries of the changes in elevation measured at each location.

Table 2 contains the averages of elevation changes obtained at each of the three plots (EDS-1, EDS-2, EDS-3 for Eight Day Swamp and WS-1, WS-2, WS-3 for Walden Swamp) as well as at each of the 4 orientation positions. The averages of measurements from all 108 platforms at each site are also included in Table 2. The average of all the platforms is then divided by the time elapsed since the initial date (Table 1) to derive the rate of elevation change in mm/yr (Table 2a). For the complete data set, please refer to Appendices at the end of this report.

Table 3: Average Accretion (mm) – Fall 2019 sampling

Walden Swamp		Eight Day Swamp		Tollgate Marsh	
All Platforms	56.89	All Platforms	52.44	All Platforms	1.67
Std Error	8.78	Std Error	2.12	Std Error	1.67
SM-1	65.67	SM-1	50.67	SM-1	0.00
Std Error	7.50	Std Error	1.50	Std Error	0.00
SM-2	65.67	SM-2	50.00	SM-2	0.00
Std Error	4.70	Std Error	2.89	Std Error	0.00
SM-3	39.33	SM-3	56.67	SM-3	5.00
Std Error	5.00	Std Error	2.50	Std Error	0.00
WS-1		EDS-1		TM-1	
A	72.0	A	55.0	A	0.0
B	70.0	B	50.0	B	0.0
C	55.0	C	47.0	C	0.0
WS-2		EDS-2		TM-2	
A	62.0	A	45.0	A	0.0
B	60.0	B	55.0	B	0.0
C	75.0	C	50.0	C	0.0
WS-3		EDS-3		TM-3	
A	40.0	A	55.0	A	5.0
B	50.0	B	50.0	B	5.0
C	28.0	C	65.0	C	5.0

Table 3a: Feldspar Horizon Measurements – Fall 2019 sampling

Site	Positive Accretion (Percent)	Accretion Rate (mm/yr)
Eight Day Swamp	100	6.45
Walden Swamp	100	5.45
Tollgate Marsh	33.3	2.0

Tables 3 and 3a are summaries of the accretion measured by use of feldspar horizons emplaced at each benchmark location

Feldspar horizons were emplaced inside three corners of each benchmark plot. The sediment between the white feldspar marker and the horizon is measured. One reading is taken at each of the three corners resulting in a total of nine values associated with each marsh; the average of all readings produces a summary value (Table 3a). Not all horizons produced recognizable accretion; it is possible that the feldspar cannot be found and will need to be replaced and a new data set generated. Where negligible material accumulated above the horizon, “NA accretion” is designated. All recoverable values are included in the calculation for accretion rate.

To obtain a yearly rate, this value is divided by the number of days that have elapsed between establishment of the benchmark and the subsequent reading. Approximately six years elapsed between the readings summarized in this report. Table 1 provides the dates for each reading and the time elapsed in days and years.

Table 4: Elevation Rate and Accretion Rate – Fall 2019

Eight Day Swamp									
Days	0	378	736	1322	1819	2188	3115	3515	3827
Sample Date	4/30/2009	5/13/2010	5/6/2011	12/12/2012	4/23/2014	4/27/2015	11/9/2017	12/14/2018	10/22/2019
Elevation Rate mm/yr	0	19.07	18.67	14.40	11.64	8.99	7.30	7.33	8.16
Accretion Rate mm/yr	0	5.92	5.68	5.74	6.05	7.23	3.93	5.45	6.45

Walden Swamp									
Days	0	378	736	1310	1824	2198	3120	3501	3807
Sample Date	4/30/2009	5/13/2010	5/6/2011	11/30/2012	4/28/2014	5/7/2015	11/14/2017	11/30/2018	10/2/2019
Elevation Rate mm/yr	0	40.27	32.82	22.40	18.37	12.93	11.55	12.35	11.75
Accretion Rate mm/yr	0	3.77	8.40	9.38	7.92	8.16	5.91	5.93	5.45

Tollgate Marsh		
Days	0	305
Sample Date	11/30/2018	10/1/2019
Elevation Rate mm/yr	0	-8.63
Accretion Rate mm/yr	0	2.00

Table 4 shows the yearly accretion and elevation rate for every sampling event.

Table 5: Marsh Processes (USGS 2010)

SURFACE PROCESSES:
1) Sediment deposition
2) Sediment erosion
SUBSURFACE PROCESSES:
3) Root Growth
4) Decomposition
5) Porewater Flux
6) Compaction

Table 5 explains both surface and subsurface interactions (USGS, 2010).

Discussion

While it is tempting to draw conclusions from this data set, one must acknowledge that marsh sediment processes take place slowly over long periods of time; to quote Jim Lynch, USGS SETs

methodology expert, "...It will take a long time to get enough data to see what's going on."(2010, personal communication)

Table 5 shows both surface and subsurface processes that can affect both the elevation and accretion rates. Elevation is affected by the surface and subsurface processes while the accretion is only affected by the surface processes.

Table 3a, Tollgate Marsh only had 1 plot to show positive accretion while the other plots still had the horizons at the surface. The horizons at Eight Day and Walden Swamp had 100 percent positive accretions.

According to table 4, the elevation rates for both Eight Day Swamp and Walden Swamp are keeping steady between 7 and 8 mm/yr and 11 and 12 mm/yr. The accretion rates remain constant between 5 and 6 mm/yr.

Conclusion

Tollgate Marsh was installed in 2018 and only has 1 year of measurements, which makes it hard to draw any long-term conclusions. After 10 years of data from Eight Day and Walden Swamp we can start to draw conclusions about the increasing elevation rates and accretions rates. After 2015, the data levels out around 7.5 - 8 mm.yr for Eight Day and 11.5 - 12 mm/yr for Walden.

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Appendix 1: Eight Day Swamp Surface Elevation Table Readings (mm)

Plot		EDS-1			Plot		EDS-2			Plot		EDS-3		
Position	Ptn	4/30/2009	10/22/2019	Difference	Position	Ptn	4/30/2009	10/22/2019	Difference	Position	Ptn	5/1/2009	10/22/2019	Difference
1	1	91	142	51	2	1	56	143	87	1	1	64	179	115
	2	45	179	134		2	68	135	67		2	64	188	124
	3	42	167	125		3	71	149	78		3	111	195	84
	4	40	154	114		4	67	132	65		4	102	185	83
	5	83	140	57		5	85	135	50		5	107	178	71
	6	65	142	77		6	65	139	74		6	113	168	55
	7	70	151	81		7	61	135	74		7	103	176	73
	8	65	127	62		8	70	140	70		8	101	164	63
	9	50	130	80		9	53	140	87		9	81	184	103
3	1	21	154	133	4	1	43	152	109	3	1	54	189	135
	2	21	168	147		2	65	136	71		2	90	181	91
	3	38	201	163		3	67	137	70		3	80	188	108
	4	50	182	132		4	65	130	65		4	56	214	158
	5	58	173	115		5	60	137	77		5	80	185	105
	6	48	214	166		6	75	108	33		6	75	209	134
	7	13	160	147		7	75	131	56		7	86	192	106
	8	60	161	101		8	68	114	46		8	76	165	89
	9	60	131	71		9	64	120	56		9	80	172	92
5	1	60	155	95	6	1	30	128	98	5	1	82	190	108
	2	118	171	53		2	24	137	113		2	79	153	74
	3	134	208	74		3	20	155	135		3	87	165	78
	4	105	182	77		4	37	117	80		4	89	193	104
	5	123	161	38		5	48	130	82		5	89	172	83
	6	123	203	80		6	42	127	85		6	95	155	60
	7	52	183	131		7	49	115	66		7	97	152	55
	8	55	164	109		8	46	110	64		8	92	168	76
	9	112	160	48		9	62	107	45		9	60	165	105
7	1	55	165	110	8	1	74	130	56	7	1	100	170	70
	2	60	130	70		2	62	122	60		2	98	177	79
	3	65	142	77		3	64	150	86		3	93	165	72
	4	64	120	56		4	51	140	89		4	78	144	66
	5	66	141	75		5	74	135	61		5	80	164	84
	6	62	150	88		6	76	132	56		6	80	168	88
	7	60	134	74		7	63	122	59		7	97	181	84
	8	58	145	87		8	62	127	65		8	80	184	104
	9	63	119	56		9	50	125	75		9	77	179	102

Appendix 2: Walden Swamp Surface Elevation Table Readings (mm)

Plot	WS-1				Plot	WS-2				Plot	WS-3			
Position	Pn	4/30/2009	10/2/2019	Difference	Position	Pn	4/30/2009	10/2/2019	Difference	Position	Pn	4/30/2009	10/2/2019	Difference
2	1	42	189	147	2	1	179	292	113	1	1	110	210	100
	2	53	180	127		2	156	297	141		2	96	205	109
	3	61	191	130		3	150	264	114		3	112	196	84
	4	121	184	63		4	69	293	224		4	109	182	73
	5	25	174	149		5	223	300	77		5	94	205	111
	6	45	178	133		6	155	296	141		6	112	196	84
	7	50	176	126		7	123	291	168		7	90	202	112
	8	40	186	146		8	83	302	219		8	112	203	91
	9	100	183	83		9	117	272	155		9	97	192	95
4	1	51	190	139	4	1	176	330	154	3	1	112	190	78
	2	71	195	124		2	156	310	154		2	118	176	58
	3	87	180	93		3	172	310	138		3	115	193	78
	4	52	182	130		4	82	325	243		4	127	173	46
	5	63	183	120		5	192	308	116		5	101	197	96
	6	67	170	103		6	127	345	218		6	88	177	89
	7	41	172	131		7	175	286	111		7	98	194	96
	8	33	192	159		8	144	322	178		8	75	193	118
	9	12	188	176		9	157	325	168		9	80	202	122
6	1	43	207	164	6	1	230	307	77	5	1	106	182	76
	2	80	185	105		2	200	310	110		2	106	172	66
	3	87	184	97		3	155	317	162		3	98	194	96
	4	78	193	115		4	195	325	130		4	96	181	85
	5	95	172	77		5	115	327	212		5	96	175	79
	6	92	185	93		6	140	338	198		6	85	147	62
	7	80	172	92		7	118	323	205		7	96	197	101
	8	90	175	85		8	170	325	155		8	65	181	116
	9	70	172	102		9	150	306	156		9	71	166	95
8	1	73	177	104	8	1	172	325	153	7	1	68	199	131
	2	73	170	97		2	230	281	51		2	69	200	131
	3	81	184	103		3	170	306	136		3	78	201	123
	4	70	173	103		4	94	312	218		4	116	204	88
	5	80	175	95		5	120	285	165		5	52	172	120
	6	45	176	131		6	110	322	212		6	93	207	114
	7	50	184	134		7	136	322	186		7	164	195	31
	8	80	183	103		8	100	325	225		8	75	185	110
	9	55	182	127		9	195	278	83		9	95	195	100

Appendix 3: Tollgate Marsh Surface Elevation Table Readings (mm)

TM-1					TM-2					TM-3				
Position	Pn	11/30/2018	10/1/2019	Difference	Position	Pn	11/30/2018	10/1/2019	Difference	Position	Pn	11/30/2018	10/1/2019	Difference
1	1	111	62	-49	1	1	130	84	-46	2	1	135	115	-20
	2	114	71	-43		2	162	100	-62		2	130	108	-22
	3	108	72	-36		3	106	92	-14		3	102	107	5
	4	92	69	-23		4	90	90	0		4	98	102	4
	5	82	100	18		5	92	85	-7		5	148	82	-66
	6	98	108	10		6	108	106	-2		6	90	100	10
	7	128	95	-33		7	101	95	-6		7	89	82	-7
	8	157	101	-56		8	105	95	-10		8	84	84	0
	9	145	98	-47		9	75	95	20		9	75	101	26
3	1	88	98	10	3	1	144	82	-62	4	1	93	100	7
	2	140	85	-55		2	85	87	2		2	121	87	-34
	3	125	85	-40		3	56	88	32		3	109	122	13
	4	62	87	25		4	71	98	27		4	96	95	-1
	5	115	72	-43		5	117	81	-36		5	85	85	0
	6	119	91	-28		6	114	91	-23		6	89	100	11
	7	118	65	-53		7	131	85	-46		7	106	88	-18
	8	120	57	-63		8	124	75	-49		8	77	72	-5
	9	76	78	2		9	74	83	9		9	72	87	15
5	1	82	92	10	5	1	69	87	18	6	1	94	96	2
	2	92	72	-20		2	86	84	-2		2	125	122	-3
	3	58	110	52		3	43	74	31		3	83	119	36
	4	100	105	5		4	126	86	-40		4	123	136	13
	5	74	105	31		5	90	80	-10		5	105	107	2
	6	121	86	-35		6	73	82	9		6	93	99	6
	7	60	61	1		7	82	87	5		7	96	122	26
	8	66	76	10		8	100	87	-13		8	120	114	-6
	9	88	83	-5		9	67	90	23		9	118	109	-9
7	1	128	80	-48	7	1	92	96	4	8	1	72	113	41
	2	164	86	-78		2	97	98	1		2	100	124	24
	3	155	79	-76		3	105	95	-10		3	94	115	21
	4	111	135	24		4	99	105	6		4	92	119	27
	5	136	96	-40		5	93	110	17		5	141	132	-9
	6	131	137	6		6	121	91	-30		6	89	121	32
	7	105	80	-25		7	101	90	-11		7	90	110	20
	8	109	76	-33		8	42	87	45		8	76	87	11
	9	88	68	-20		9	66	100	34		9	78	88	10