

Measuring Elevation Change in Meadowlands Marshes Using Surface Elevation Tables (SETs) and Marker Horizons

Meadowlands Environmental Research Institute (June, 2018)

The surface elevation table (SET) provides a constant plane in space from which the distance to a marsh surface can be measured by means of pins lowered to the surface (USGS 2010). During August of 2008, at five locations in the lower Hackensack River Meadowlands, benchmark rods were established, marker horizons of feldspar were emplaced and baseline readings were taken. Periodic monitoring will determine rates of accretion in marsh areas as well as track and compare both shallow and deep subsidence. Each site was revisited and readings taken annually, except in the year 2009. This report is a summary of those measurements taken up to the spring of 2018.

Figure 1: Study Area



Locations were chosen to span several miles of tidal wetlands and represent different vegetation and marsh regimes. The five sites selected include a restored *Spartina alterniflora* low marsh (Secaucus High School, SHS), a *Spartina alterniflora* low marsh (Saw Mill, SM), a *Spartina patens* dominated high marsh (Riverbend-Patens, RBP), a mixed *Spartina patens* and *Phragmites australis* high marsh (Riverbend Mixed, RBM) and a *Phragmites australis* dominated high marsh (Lyndhurst Riverside, LR). At each site, three replicate plots were installed. At each plot, nine pins are lowered to the marsh surface. Readings are taken in each of four directions resulting in a total of 108 measurements for each of the 5 sites. 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 elevation.

Table 1: Time Elapsed Between Readings

Location	Initial Date	Most Recent Date	Days	Years
RBP and RBM	8/26/2008	6/20/2018	3137	9.82
SM	8/28/2008	6/21/2018	3136	9.82
LR	8/29/2008	6/21/2018	3135	9.82
SHS	8/28/2008	6/22/2018	3169	9.82

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

Table 2: Average Elevation Change (mm) – Spring 2018

Riverbend Patens		Riverbend Mixed		Sawmill	
All Platforms	39.30	All Platforms	30.80	All Platforms	38.68
Std Error	3.76	Std Error	15.61	Std Error	1.95
RB-1	45.64	RB-4	0.83	SM-1	39.58
Std Error	4.90	Std Error	7.74	Std Error	16.95
RB-2	32.64	RB-5	38.17	SM-2	34.94
Std Error	2.02	Std Error	5.73	Std Error	14.82
RB-3	39.61	RB-6	53.39	SM-3	41.50
Std Error	3.62	Std Error	9.00	Std Error	7.12
RB-1 pos 1	39.30	RB-4 pos 1	30.80	SM-1 pos 2	38.68
RB-1 pos 3	2.51	RB-4 pos 3	7.75	SM-1 pos 4	7.17
RB-1 pos 5	39.33	RB-4 pos 5	18.56	SM-1 pos 6	-6.78
RB-1 pos 7	47.56	RB-4 pos 7	-15.11	SM-1 pos 8	58.00
RB-2 pos 1	58.67	RB-5 pos 2	8.56	SM-2 pos 1	70.44
RB-2 pos 3	37.00	RB-5 pos 4	-8.67	SM-2 pos 3	36.67
RB-2 pos 5	27.22	RB-5 pos 6	37.11	SM-2 pos 5	59.56
RB-2 pos 7	35.78	RB-5 pos 8	40.11	SM-2 pos 7	37.78
RB-3 pos 1	31.89	RB-6 pos 2	23.78	SM-3 pos 1	-7.44
RB-3 pos 3	35.67	RB-6 pos 4	51.67	SM-3 pos 3	49.89
RB-3 pos 5	50.44	RB-6 pos 6	56.78	SM-3 pos 5	47.44
RB-3 pos 7	35.22	RB-6 pos 8	28.33	SM-3 pos 7	57.89

Lyndhurst Riverside	
All Platforms	23.94
Std Error	8.61
LR-1	14.58
Std Error	10.39
LR-2	16.08
Std Error	4.52
LR-3	41.14
Std Error	18.72
LR-1 pos 1	23.94
LR-1 pos 3	7.55
LR-1 pos 5	5.00
LR-1 pos 7	-7.33
LR-2 pos 1	41.00
LR-2 pos 3	19.67
LR-2 pos 5	23.78
LR-2 pos 7	5.00
LR-3 pos 1	23.11
LR-3 pos 3	12.44
LR-3 pos 5	-0.89
LR-3 pos 7	69.56

Secaucus HS	
All Platforms	38.61
Std Error	16.45
SHS-1	57.1
Std Error	5.53
SHS-2	5.81
Std Error	5.67
SHS-3	52.9
Std Error	4.6
SHS-1 pos 2	38.6
SHS-1 pos 4	7.5
SHS-1 pos 6	59.0
SHS-1 pos 8	66.3
SHS-2 pos 1	61.9
SHS-2 pos 3	41.11
SHS-2 pos 5	18.44
SHS-2 pos 7	6.2
SHS-3 pos 2	-9.11
SHS-3 pos 4	7.67
SHS-3 pos 6	51.9
SHS-3 pos 8	43.7

Table 2a: SETs Locations and Measurements – Spring 2018 sampling

Location		Marsh Type	Dominant Vegetation	Rate of Elevation Change from 2008 to 2018(mm/yr.)
RBP	Riverbend Patens	High Marsh	<i>Spartina patens</i>	4.00
RBM	Riverbend Mixed	High Marsh	<i>Phragmites australis</i> / <i>Spartina patens</i>	3.67
SM	Sawmill	High Marsh	<i>Spartina alterniflora</i>	3.94
LR	Lyndhurst Riverside	High Marsh	<i>Phragmites australis</i>	2.44
SHS	Secaucus HS	Low Marsh	<i>Spartina alterniflora</i>	3.93

The above two tables, 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 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 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). The complete data set for elevation can be found in appendices at the end of the report. As shown in table 2a, values ranged from a subsidence rate of 2.44 mm/yr. at the Lyndhurst Riverside site to a maximum rise in elevation of 4.00 mm/yr. at the Riverbend Patens site.

Table 3: Average Accretion (mm) – Spring 2018 sampling

Riverbend Patens	
All Platforms	5.64
Std Error	0.42
RB-1	5.50
Std Error	0.25
RB-2	5.00
Std Error	0.29
RB-3	6.43
Std Error	0.15
RB-1	
A	6.0
B	5.0
C	5.5
RB-2	
A	5.5
B	4.5
C	5.0
RB-3	
A	6.8
B	6.5
C	6.0

Riverbend Mixed	
All Platforms	5.78
Std Error	0.39
RB-4	5.17
Std Error	0.25
RB-5	6.50
Std Error	0.29
RB-6	5.67
Std Error	0.25
RB-4	
A	5.0
B	5.0
C	5.5
RB-5	
A	6.5
B	6.0
C	7.0
RB-6	
A	6.0
B	5.5
C	5.5

Sawmill	
All Platforms	8.33
Std Error	0.17
SM-1	8.00
Std Error	NA
SM-2	8.50
Std Error	NA
SM-3	8.50
Std Error	NA
SM-1	
A	NA
B	8.0
C	NA
SM-2	
A	NA
B	NA
C	8.5
SM-3	
A	8.5
B	NA
C	NA

Lyndhurst Riverside	
All Platforms	3.20
Std Error	0.13
LR-1	3.43
Std Error	0.40
LR-2	3.00
Std Error	0.29
LR-3	3.17
Std Error	0.75
LR-1	
A	3.5
B	3.8
C	3.0
LR-2	
A	3.0
B	2.5
C	3.5
LR-3	
A	3.5
B	2.0
C	4.0

Secaucus HS	
All Platforms	5.72
Std Error	0.89
SHS-1	7.50
Std Error	0.29
SHS-2	4.67
Std Error	1.92
SHS-3	5.00
Std Error	1.04
SHS-1	
A	7.0
B	8.0
C	7.5
SHS-2	
A	2.5
B	3.0
C	8.5
SHS-3	
A	4.5
B	3.5
C	7.0

Table 3a: Feldspar Horizon Measurements 2008/2018

Site	Positive Accretion (Percent)	Accretion Rate (mm/yr.)
Riverbend Patens	100	5.75
Riverbend Mixed	100	5.88
Sawmill	33	8.50
Lyndhurst Riverside	100	3.30
Secaucus HS	100	5.80

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

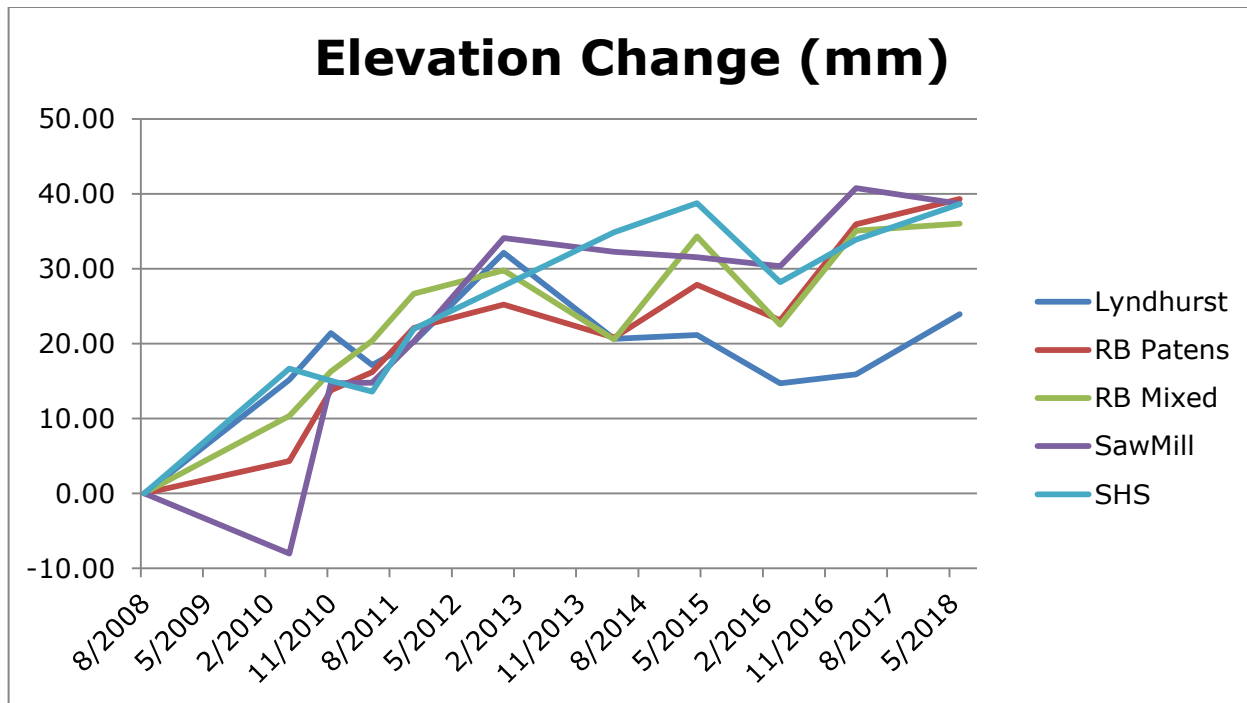
Feldspar horizons were emplaced inside three corners of each benchmark plot. The sediment between the white feldspar marker and the horizon is measured. One reading is taken at each of the three corners resulting in a total of nine values associated with each marsh; the average of all readings produces 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, “0.0 accretion” is designated. All recoverable values are included in the calculation for accretion rate. New horizons were added to the Secaucus HS site on 4-15-15. Six new feldspar horizons will be added at the Sawmill Creek site between 2018 and 2019.

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 and two-third 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.

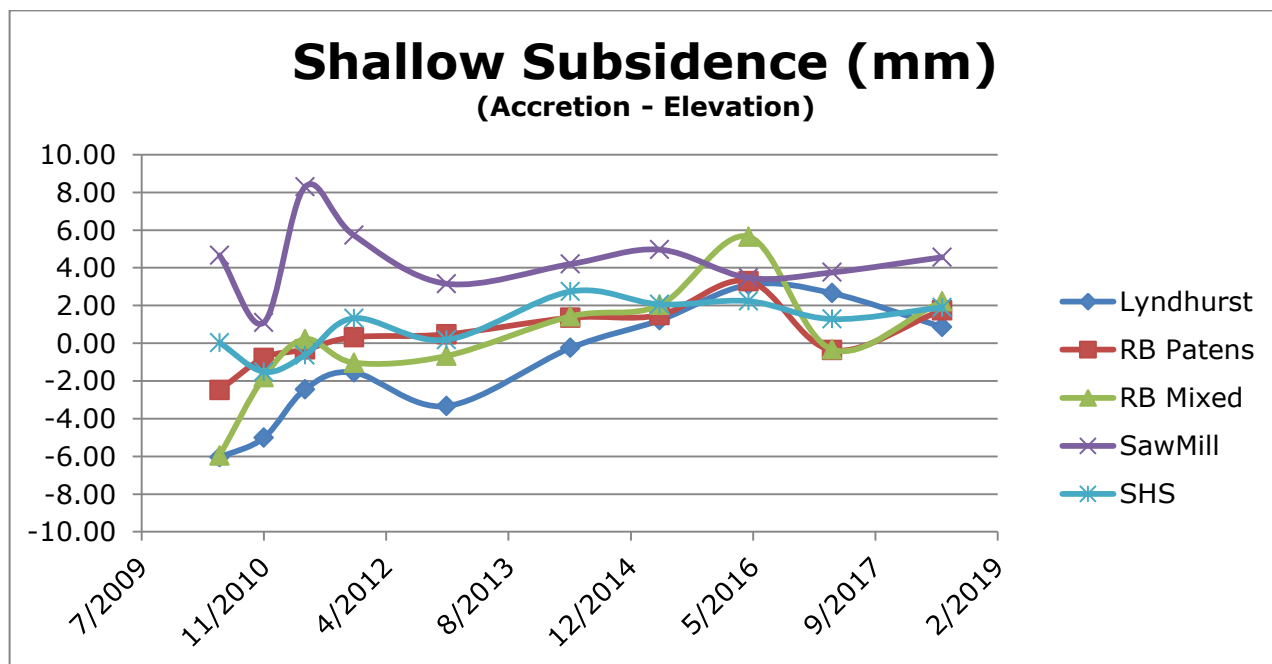
Table 4: Elevation Rate and Accretion Rate values – Fall 2008 to Spring 2018

Riverbend Patens									
Days	0	632	980	1555	2065	2430	2795	3137	3585
Sample Date	8/26/2008	5/20/2010	5/3/2011	11/28/2012	4/22/2014	4/22/2015	4/21/2016	3/29/2017	6/20/2018
Elevation Rate mm/yr	0.00	2.48	6.02	5.92	3.68	4.18	3.02	4.18	4.00
Accretion Rate mm/yr	0.00	0.00	5.69	6.39	5.03	5.67	6.31	3.81	5.75
Riverbend Mixed									
Days	0	632	980	1555	2065	2430	2795	3137	3585
Sample Date	8/26/2008	5/20/2010	5/3/2011	11/28/2012	4/22/2014	4/22/2015	4/21/2016	3/29/2017	6/20/2018
Elevation Rate mm/yr	0.00	5.96	7.58	6.99	3.63	5.15	2.94	4.08	3.67
Accretion Rate mm/yr	0.00	0.00	7.80	6.31	5.05	7.18	8.59	3.75	5.88
Sawmill									
Days	0	631	980	1566	2065	2430	2814	3136	3584
Sample Date	8/28/2008	5/21/2010	5/5/2011	12/11/2012	4/24/2014	4/24/2015	5/12/2016	3/30/2017	6/21/2018
Elevation Rate mm/yr	0.00	-4.66	5.51	7.94	5.70	4.74	3.93	4.75	3.94
Accretion Rate mm/yr	0.00	0.00	13.80	11.10	9.90	9.70	7.40	8.50	8.50
Lyndhurst Reserve									
Days	0	630	979	1557	2064	2429	2813	3135	3583
Sample Date	8/29/2008	5/21/2010	5/5/2011	12/3/2012	4/24/2014	4/24/2015	5/12/2016	3/30/2017	6/21/2018
Elevation Rate mm/yr	0	8.79	6.38	7.53	3.65	3.18	1.91	1.85	2.44
Accretion Rate mm/yr	0	2.74	3.94	4.20	3.40	4.40	5.00	4.50	3.26
Secaucus HS									
Days	0	609	984	1553	2066	2421	2801	3169	3585
Sample Date	8/28/2008	4/29/2010	5/9/2011	11/28/2012	4/25/2014	4/15/2015	4/29/2016	5/2/2017	6/22/2018
Elevation Rate mm/yr	0.00	9.97	5.03	6.52	6.16	5.84	3.67	3.90	3.93
Accretion Rate mm/yr	0.00	10.00	4.40	6.70	8.90	7.90	5.90	6.90	5.83

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



The graph shows the elevation change for every sampling event.



The graph shows the shallow subsidence for every sampling event.

“When used simultaneously, the SET and Marker Horizon techniques can provide information on below ground processes that influence elevation change. Differences between the rates of Vertical Accretion and Elevation Change can be attributed to processes occurring below the feldspar layer and above the bottom of the SET pipe. This area is called the Zone of Shallow Subsidence.” (USGS, 2010).

For example, if the rate of Vertical Accretion measured from the marker horizon is calculated to be 3 mm per year. While the rate of Elevation Change measured from the SET is 2 mm per year. Based on these numbers one would say that the rate of Shallow Subsidence is 1 mm per year (3 mm/yr - 2 mm/yr = 1 mm/yr). In other words, the difference between the two measurements is due to processes occurring in the Zone of Shallow Subsidence. (USGS, 2010).

Table 5: Marsh Processes (USGS 2010)

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

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

Discussion

Elevation change measured by the SET is influenced by both surface and subsurface processes occurring within the soil profile (USGS 2010). The marker horizons reveal surface processes only. One can surmise the relative contribution of these processes by looking at the difference between the rates obtained by each process.

On 4-15-15, new horizons were added at the Secaucus HS site so there can be better accretion rate results. Half of the horizons were eroded away or are just not visible anymore. New feldspar plots will be added to Sawmill in 6 different locations between 2018 and 2019.

The shallow subsidence graph shows that all the sites except Lyndhurst Riverside have a positive subsidence, which means that the accretion rates are the main contributor to the elevation increases.

Based on visual observations, the Lyndhurst Riverside site has lost vegetation in the plot areas, which does not promote steady accretion rates.

With ten years of data from 2008 – 2018, elevation and accretions rates are beginning to level out. All sites elevation rates are between 2.44 and 4.00 mm/yr. Sea level rise in New Jersey is about 3.30 mm/yr, so the elevation rates are well within the range to keep up with the rising sea levels.

Conclusions

The installation of the surface elevation tables and feldspar horizons provides an accurate method for determining changes in the marshes of the Hackensack River estuary. As more time passes, the accretion and elevation rates will become stable and there will not be large fluctuations in the measurements unless there is a large weather event or human impact on the sites.

References

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Appendix 1: Riverbend Patens Surface Elevation Table Readings (mm)

		RB-1			RB-2			RB-3						
Position	Pin	8/26/2008	6/20/2018	Difference	Position	Pin	8/26/2008	6/20/2018	Difference	Position	Pin	8/26/2008	6/20/2018	Difference
1	1	197	257	60	1	1	145	178	33	1	1	192	214	22
	2	227	248	21		2	150	175	25		2	179	242	63
	3	213	254	41		3	157	169	12		3	180	225	45
	4	230	261	31		4	159	171	12		4	188	235	47
	5	228	268	40		5	160	181	21		5	174	218	44
	6	222	272	50		6	160	199	39		6	177	214	37
	7	208	260	52		7	163	187	24		7	164	228	64
	8	226	261	35		8	161	200	39		8	158	236	78
	9	232	256	24		9	150	190	40		9	161	215	54
3	1	201	252	51	3	1	158	185	27	3	1	167	195	28
	2	203	260	57		2	155	214	59		2	196	222	26
	3	211	265	54		3	157	195	38		3	175	202	27
	4	218	266	48		4	143	197	54		4	182	226	44
	5	202	255	53		5	160	205	45		5	180	245	65
	6	220	266	46		6	162	204	42		6	192	214	22
	7	221	256	35		7	160	187	27		7	173	214	41
	8	223	257	34		8	165	175	10		8	191	240	49
	9	214	264	50		9	166	186	20		9	191	206	15
5	1	215	278	63	5	1	162	182	20	5	1	187	264	77
	2	208	285	77		2	165	194	29		2	195	242	47
	3	214	273	59		3	157	204	47		3	195	214	19
	4	208	270	62		4	158	180	22		4	204	211	7
	5	216	276	60		5	155	200	45		5	193	220	27
	6	221	283	62		6	161	185	24		6	199	230	31
	7	219	270	51		7	143	187	44		7	200	213	13
	8	216	264	48		8	161	187	26		8	185	222	37
	9	227	273	46		9	165	195	30		9	152	219	67
7	1	216	234	18	7	1	160	190	30	7	1	130	195	65
	2	213	260	47		2	154	188	34		2	178	197	19
	3	215	239	24		3	156	192	36		3	179	205	26
	4	216	244	28		4	155	182	27		4	195	227	32
	5	221	263	42		5	156	193	37		5	176	224	48
	6	216	268	52		6	155	190	35		6	193	229	36
	7	212	251	39		7	154	189	35		7	195	223	28
	8	217	255	38		8	153	204	51		8	192	224	32
	9	212	257	45		9	151	187	36		9	191	235	44

Appendix 2: Riverbend Mixed Surface Elevation Table Readings (mm)

RB-4					RB-5					RB-6				
Position	Pin	8/26/2008	6/20/2018	Difference	Position	Pin	8/26/2008	6/20/2018	Difference	Position	Pin	8/26/2008	6/20/2018	Difference
1	1	196	185	-11	2	1	148	190	42	1	1	180	231	51
	2	196	217	21		2	136	172	36		2	189	242	53
	3	100	205	105		3	146	204	58		3	186	241	55
	4	196	210	14		4	164	196	32		4	177	242	65
	5	186	200	14		5	161	189	28		5	185	239	54
	6	206	205	-1		6	106	173	67		6	181	235	54
	7	212	206	-6		7	136	172	36		7	189	240	51
	8	190	194	4		8	155	160	5		8	178	236	58
	9	180	207	27		9	149	179	30		9	149	219	70
3	1	223	215	-8	4	1	153	178	25	3	1	173	200	27
	2	225	203	-22		2	137	185	48		2	182	226	44
	3	223	206	-17		3	134	201	67		3	168	196	28
	4	204	200	-4		4	140	181	41		4	177	227	50
	5	222	207	-15		5	141	180	39		5	176	204	28
	6	204	203	-1		6	160	184	24		6	185	207	22
	7	203	199	-4		7	159	182	23		7	181	216	35
	8	199	180	-19		8	144	185	41		8	192	200	8
	9	223	177	-46		9	149	202	53		9	187	200	13
5	1	220	236	16	6	1	141	169	28	5	1	178	218	40
	2	240	243	3		2	164	165	1		2	176	217	41
	3	235	232	-3		3	149	176	27		3	149	202	53
	4	215	216	1		4	163	200	37		4	154	245	91
	5	212	229	17		5	162	175	13		5	151	237	86
	6	213	223	10		6	160	203	43		6	161	251	90
	7	227	235	8		7	162	194	32		7	168	246	78
	8	228	238	10		8	176	195	19		8	178	240	62
	9	223	238	15		9	170	184	14		9	148	248	100
7	1	225	200	-25	8	1	138	170	32	7	1	134	230	96
	2	208	228	20		2	142	172	30		2	161	225	64
	3	233	207	-26		3	145	167	22		3	163	247	84
	4	221	224	3		4	68	159	91		4	178	238	60
	5	196	197	1		5	126	163	37		5	175	235	60
	6	190	174	-16		6	141	203	62		6	191	217	26
	7	220	197	-23		7	139	194	55		7	192	239	47
	8	191	189	-2		8	120	192	72		8	193	221	28
	9	206	196	-10		9	124	188	64		9	188	238	50

Appendix 3: Sawmill Surface Elevation Table Readings (mm)

SM-1					SM-2					SM-3				
Position	Pin	8/28/2008	6/21/2018	Difference	Position	Pin	8/28/2008	6/21/2018	Difference	Position	Pin	8/28/2008	6/21/2018	Difference
2	1	171	164	-7	1	1	205	280	75	1	1	119	186	67
	2	178	122	-56		2	176	261	85		2	114	175	61
	3	170	141	-29		3	196	272	76		3	145	138	-7
	4	172	190	18		4	175	233	58		4	162	190	28
	5	144	195	51		5	206	256	50		5	152	196	44
	6	234	205	-29		6	219	250	31		6	152	182	30
	7	169	145	-24		7	205	274	69		7	117	197	80
	8	182	195	13		8	207	261	54		8	144	199	55
	9	202	204	2		9	238	276	38		9	135	204	69
4	1	70	190	120	3	1	218	242	24	3	1	149	197	48
	2	127	207	80		2	203	257	54		2	135	190	55
	3	127	194	67		3	200	260	60		3	85	186	101
	4	155	194	39		4	213	272	59		4	111	98	-13
	5	160	214	54		5	240	242	2		5	91	181	90
	6	156	169	13		6	226	253	27		6	140	216	76
	7	161	188	27		7	203	246	43		7	150	225	75
	8	166	210	44		8	222	247	25		8	153	217	64
	9	167	245	78		9	203	249	46		9	140	165	25
6	1	164	204	40	5	1	230	180	-50	5	1	156	192	36
	2	35	205	170		2	215	160	-55		2	150	170	20
	3	149	210	61		3	215	174	-41		3	145	166	21
	4	146	202	56		4	218	241	23		4	156	184	28
	5	109	180	71		5	225	211	-14		5	143	186	43
	6	134	185	51		6	225	265	40		6	157	210	53
	7	151	187	36		7	215	266	51		7	175	182	7
	8	121	196	75		8	216	210	-6		8	176	189	13
	9	130	204	74		9	228	213	-15		9	160	165	5
8	1	155	143	-12	7	1	232	255	23	7	1	115	200	85
	2	172	185	13		2	226	260	34		2	92	183	91
	3	153	204	51		3	205	241	36		3	100	150	50
	4	122	160	38		4	167	221	54		4	132	125	-7
	5	57	113	56		5	210	255	45		5	107	144	37
	6	129	185	56		6	185	249	64		6	116	105	-11
	7	50	200	150		7	200	235	35		7	164	192	28
	8	146	176	30		8	206	255	49		8	144	168	24
	9	187	135	-52		9	147	256	109		9	155	178	23

Appendix 4: Lyndhurst Riverside Surface Elevation Table Readings (mm)

LR-1					LR-2					LR-3				
Position	Pin	8/29/2008	6/21/2018	Difference	Position	Pin	8/29/2008	6/21/2018	Difference	Position	Pin	8/29/2008	6/21/2018	Difference
1	1	218	238	20	1	1	116	141	25	1	1	226	220	-6
	2	241	235	-6		2	90	135	45		2	219	219	0
	3	244	237	-7		3	55	130	75		3	219	225	6
	4	248	239	-9		4	64	130	66		4	215	216	1
	5	231	247	16		5	103	129	26		5	183	215	32
	6	223	219	-4		6	114	140	26		6	234	205	-29
	7	239	235	-4		7	113	140	27		7	208	200	-8
	8	228	236	8		8	188	140	-48		8	225	220	-5
	9	217	248	31		9	168	140	-28		9	215	216	1
3	1	234	237	3	3	1	175	157	-18	3	1	162	220	58
	2	210	205	-5		2	179	167	-12		2	193	209	16
	3	237	231	-6		3	102	154	52		3	184	225	41
	4	233	235	2		4	137	150	13		4	118	245	127
	5	242	237	-5		5	150	144	-6		5	153	210	57
	6	236	210	-26		6	82	145	63		6	137	227	90
	7	258	212	-46		7	125	144	19		7	138	205	67
	8	230	227	-3		8	185	151	-34		8	145	204	59
	9	225	245	20		9	207	175	-32		9	95	206	111
5	1	122	239	117	5	1	190	174	-16	5	1	195	198	3
	2	182	220	38		2	150	176	26		2	174	195	21
	3	210	237	27		3	166	176	10		3	134	204	70
	4	151	240	89		4	135	167	32		4	145	202	57
	5	210	216	6		5	137	161	24		5	72	235	163
	6	224	236	12		6	148	151	3		6	120	206	86
	7	208	227	19		7	145	194	49		7	97	202	105
	8	206	236	30		8	122	180	58		8	131	214	83
	9	197	228	31		9	130	152	22		9	114	207	93
7	1	212	244	32	7	1	135	131	-4	7	1	165	219	54
	2	219	235	16		2	123	141	18		2	175	214	39
	3	213	217	4		3	135	135	0		3	222	228	6
	4	211	220	9		4	116	126	10		4	216	220	4
	5	200	226	26		5	100	109	9		5	205	221	16
	6	205	231	26		6	98	118	20		6	220	222	2
	7	207	230	23		7	110	125	15		7	169	204	35
	8	227	226	-1		8	115	139	24		8	199	214	15
	9	190	232	42		9	115	135	20		9	196	207	11

Appendix 5: Secaucus HS Surface Elevation Table Readings (mm)

Position	SHS-1				SHS-2				SHS-3					
	Pin	8/28/2008	6/22/2018	Difference	Position	Pin	8/28/2008	6/22/2018	Difference	Position	Pin	8/21/2008	6/22/2018	Difference
2	1	154	243	89	1	1	122	147	25	1	1	177	190	13
	2	158	237	79		2	90	161	71		2	165	215	50
	3	172	275	103		3	174	134	-40		3	160	216	56
	4	160	245	85		4	164	167	3		4	168	225	57
	5	183	210	27		5	127	138	11		5	160	208	48
	6	172	215	43		6	155	146	-9		6	170	183	13
	7	178	199	21		7	147	169	22		7	165	225	60
	8	170	209	39		8	90	158	68		8	170	235	65
	9	150	195	45		9	136	151	15		9	130	235	105
4	1	142	198	56	3	1	141	157	16	3	1	182	229	47
	2	127	198	71		2	144	152	8		2	175	220	45
	3	134	204	70		3	156	147	-9		3	174	198	24
	4	165	213	48		4	132	150	18		4	165	192	27
	5	176	237	61		5	130	141	11		5	175	209	34
	6	156	246	90		6	135	132	-3		6	174	233	59
	7	148	218	70		7	116	128	12		7	175	245	70
	8	167	226	59		8	118	120	2		8	177	218	41
	9	163	235	72		9	120	121	1		9	175	221	46
6	1	170	231	61	5	1	146	133	-13	5	1	180	215	35
	2	173	241	68		2	145	135	-10		2	149	234	85
	3	171	218	47		3	152	160	8		3	155	254	99
	4	178	214	36		4	150	151	1		4	174	232	58
	5	181	226	45		5	156	150	-6		5	160	232	72
	6	165	255	90		6	155	131	-24		6	135	220	85
	7	182	254	72		7	140	125	-15		7	135	227	92
	8	185	259	74		8	120	115	-5		8	148	195	47
	9	180	244	64		9	114	96	-18		9	170	189	19
8	1	187	232	45	7	1	129	170	41	7	1	191	245	54
	2	183	240	57		2	187	143	-44		2	175	247	72
	3	184	218	34		3	232	152	-80		3	175	257	82
	4	178	204	26		4	180	187	7		4	188	225	37
	5	185	239	54		5	174	207	33		5	183	230	47
	6	199	236	37		6	158	195	37		6	190	220	30
	7	182	215	33		7	190	195	5		7	185	217	32
	8	186	230	44		8	186	210	24		8	200	234	34
	9	197	237	40		9	175	221	46		9	175	241	66

