Table 3-1: Climatic Normal Conditions at Tillamook and Cloverdale

Sitka Sedge Natural Area

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Tillamook Mean Max. Temperature (F)	52.1	54.1	55.8	58.3	62.0	65.0	68.0	69.1	69.2	63.1	55.6	51.2	60.3
Tillamook Mean Temperature (F)	44.7	45.4	46.8	48.8	52.8	56.4	59.1	59.5	57.8	52.8	47.6	43.7	51.3
Tillamook Mean Min. Temperature (F)	37.3	36.7	37.8	39.4	43.5	47.7	50.2	49.9	46.4	42.5	39.5	36.3	42.3
Tillamook Mean Precipitation (in.)	13.52	9.68	9.74	7.07	4.72	3.58	1.38	1.31	3.00	6.93	13.84	13.24	88.01
Cloverdale Mean Max. Temperature (F)	51.7	53.9	55.2	57.5	61.7	65.3	69.3	70.4	69.4	63.2	55.3	50.7	60.3
Cloverdale Mean Temperature (F)	46.1	47.2	48.3	50.1	54.1	57.6	60.6	61.3	59.7	54.7	49.2	45.1	52.9
Cloverdale Mean Min. Temperature (F)	40.6	40.5	41.4	42.8	46.5	50.0	52.0	52.3	50.0	46.1	43.0	39.6	45.4
Cloverdale Mean Precipitation (in.)	11.72	8.45	8.88	6.42	4.58	3.38	1.12	1.20	2.96	6.23	13.02	12.00	79.96

Note: *This table illustrates how monthly average climate differs between the Tillamook and Cloverdale weather stations over a 30-year record (1981-2010). Tillamook is wetter than Cloverdale.*

Table 5-1. Monitoring Point Construction and Survey Summary

Sitka Sedge Natural Area, Oregon

Well / Location Name	Transducer Serial Number	Oregon Well Tag	Northing	Easting	Measuring Point Elevation	Depth to Screen Top	Depth to Screen Bottom	Total Depth	Location Description
Miller Field	0112084949	L119971	598476	7310830	13.48	15	20	20	Roma and Sand Lake Rd (older, east)
PGG-1i	0112084850	**L106639**	598479	7310830	13.36	6.2	8.2	8.2	Roma and Sand Lake Rd (new, west)
PGG-2s	---	L106645	598064	7310495	16.75	3	5	5	East end Jasmine (west)
PGG-2i	27077	L106644	598063	7310498	16.79	10	12	12	East end Jasmine (middle)
PGG-2d	106693	L106643	598061	7310501	16.97	15.5	17.5	17.5	East end Jasmine (east)
PGG-3s	0112084955	L106641	598474	7310056	17.48	3	5	5	West end Pollock (east)
PGG-3i	--	L106642	598475	7310054	17.42	8.3	10.3	10.5	West end Pollock (middle)
PGG-3d	0112084843	**L106640**	598475	7310050	17.27	15.6	17.6	17.6	West end Pollock (west)
PGG-4i	29469	L106647	598062	7309921	18.56	9	11	11	West end Pier (west)
PGG-4d	011054222	L106646	598061	7309923	18.47	15	17	17	West end Pier (east)
TDM Pollock Ditch	--	--	598497	7309997	16.80	--	--	--	Metal Stake in ditch, west end Pollock
South Marsh #13	--	--	597803	7310719	13.67	--	--	--	Marsh/Wetland East of Pier Stake
Tide Gate Inner	'0032040119	--	601255	7312494	8.29	--	--	--	Concrete corner west end
Tide Gate Outer	27086	--	601296	7312500	8.41	--	--	--	Metal plate corner top west end
TDM-1s	*	--	595932	7309518	22.70	2.2	3.35	3.35	Irish Ave near foredune
TDM-2s	*	--	596286	7309829	21.18	2.13	3.35	3.35	Sand Lake Road between Floyd and Gage
TDM-3s	*	--	596666	7309624	22.72	2.2	3.35	3.35	West end Eloise Ave
TDM-4s	*	--	597164	7310016	20.90	2.2	3.35	3.35	Community Center on Bilyeu

Notes:

All measurements and units in feet

* Water level measurements provided by Pacific Hydro-Geology Inc.

Location description parentheses indicate location of well within well cluster.

Datum: Oregon North Zone Grid NAD 83; NAVD 88

-- indicates not applicable.

Measuring point elevations are approximately 0.3 ft below ground surface.

Well Logs are included in Appendx A.

Table 5-2. Manual Water Level Measurements
Sitka Sedge Natural Area, Oregon

Well	Date	Time	MP Elev (feet)	Depth To Water (feet)	Water Level Elevation (feet)
Miller Field	2/14/2018	8:20:00 AM	13.48	2.63	10.85
Miller Field	2/14/2018	10:05:00 AM	13.48	2.60	10.88
Miller Field	2/23/2018	12:35:00 PM	13.48	2.74	10.74
Miller Field	3/2/2018	11:39:00 PM	13.48	2.33	11.15
Miller Field	3/9/2018	3:25:00 PM	13.48	2.44	11.04
Miller Field	3/26/2018	3:51:00 PM	13.48	2.81	10.67
PGG-1i	2/15/2018	1:30:00 PM	13.36	1.08	12.28
PGG-1i	2/23/2018	12:38:00 PM	13.36	1.27	12.09
PGG-1i	3/2/2018	11:36:00 PM	13.36	0.07	13.29
PGG-1i	3/9/2018	3:23:00 PM	13.36	0.90	12.46
PGG-1i	3/26/2018	3:48:00 PM	13.36	0.81	12.55
PGG-2d	2/16/2018	8:35:00 AM	16.97	5.93	11.04
PGG-2d	2/23/2018	10:10:00 AM	16.97	5.92	11.05
PGG-2d	3/2/2018	10:35:00 AM	16.97	5.32	11.65
PGG-2d	3/9/2018	4:18:00 PM	16.97	5.63	11.34
PGG-2d	3/26/2018	4:40:00 PM	16.97	5.99	10.98
PGG-2i	2/16/2018	8:40:00 AM	16.79	nr	--
PGG-2i	2/23/2018	10:06:00 AM	16.79	1.98	14.81
PGG-2i	3/2/2018	10:40:00 AM	16.79	0.69	16.10
PGG-2i	3/9/2018	4:15:00 PM	16.79	1.57	15.22
PGG-2i	3/26/2018	4:38:00 PM	16.79	1.56	15.23
PGG-2s	2/16/2018	8:45:00 AM	16.75	1.82	14.93
PGG-2s	2/23/2018	10:54:00 AM	16.75	1.91	14.84
PGG-2s	3/2/2018	10:46:00 AM	16.75	0.61	16.14
PGG-2s	3/9/2018	4:11:00 PM	16.75	1.49	15.26
PGG-2s	3/26/2018	4:30:00 PM	16.75	1.51	15.24
PGG-3D	2/15/2018	2:15:00 PM	17.27	3.94	13.33
PGG-3d	2/23/2018	11:56:00 AM	17.27	4.23	13.04
PGG-3d	3/2/2018	5:05:00 PM	17.27	4.23	13.04
PGG-3d	3/9/2018	3:40:00 PM	17.27	4.02	13.25
PGG-3d	3/26/2018	4:14:00 PM	17.27	4.40	12.87
PGG-3i	2/15/2018	2:08:00 PM	17.42	2.00	15.42
PGG-3i	2/23/2018	12:05:00 PM	17.42	2.17	15.25
PGG-3i	3/2/2018	4:21:00 PM	17.42	3.48	13.94
PGG-3i	3/9/2018	3:46:00 PM	17.42	1.77	15.65
PGG-3i	3/26/2018	4:11:00 PM	17.42	1.95	15.47
PGG-3s	2/15/2018	2:05:00 PM	17.48	2.05	15.43
PGG-3s	2/23/2018	12:09:00 PM	17.48	2.19	15.29
PGG-3s	3/2/2018	4:08:00 PM	17.48	1.05	16.43
PGG-3s	3/9/2018	3:51:00 PM	17.48	1.83	15.65
PGG-3s	3/26/2018	4:07:00 PM	17.48	2.02	15.46

Table 5-2. Manual Water Level Measurements

Sitka Sedge Natural Area, Oregon

Well	Date	Time	MP Elev (feet)	Depth To Water (feet)	Water Level Elevation (feet)
PGG-4d	2/16/2018	1:41:00 PM	18.47	4.90	13.57
PGG-4d	2/23/2018	10:18:00 AM	18.47	5.06	13.41
PGG-4d	3/2/2018	10:07:00 AM	18.47	4.95	13.52
PGG-4d	3/9/2018	4:41:00 PM	18.47	4.68	13.79
PGG-4d	3/26/2018	2:46:00 PM	18.47	5.18	13.29
PGG-4i	2/16/2018	1:17:00 PM	18.56	2.36	16.20
PGG-4i	2/16/2018	1:34:00 PM	18.56	2.39	16.17
PGG-4i	2/23/2018	10:14:00 AM	18.56	2.68	15.88
PGG-4i	3/2/2018	10:05:00 AM	18.56	1.70	16.86
PGG-4i	3/9/2018	4:42:00 PM	18.56	2.21	16.35
PGG-4i	3/26/2018	2:48:00 PM	18.56	2.60	15.96
South Marsh #13	3/26/2018	5:56:00 PM	13.67	0.75	12.92
South Marsh #13	2/23/2018	11:20:00 AM	13.67	0.76	12.91
South Marsh #13	3/2/2018	11:06:00 AM	13.67	0.65	13.02
South Marsh #13	3/9/2018	3:25:00 PM	13.67	0.76	12.91
TDM Pollock Ditch	2/15/2018	10:00:00 AM	16.80	dry	dry
TDM Pollock Ditch	2/23/2018	11:41:00 AM	16.80	dry	dry
TDM Pollock Ditch	3/2/2018	11:18:00 AM	16.80	1.01	15.79
TDM Pollock Ditch	3/9/2018	3:57:00 PM	16.80	dry	dry
TDM Pollock Ditch	3/26/2018	5:05:00 PM	16.80	--	dry
Tide Gate Inner	2/15/2018	5:40:00 PM	8.29	2.53	5.76
Tide Gate Inner	2/23/2018	1:07:00 PM	8.29	2.79	5.50
Tide Gate Inner	3/2/2018	12:11:00 PM	8.29	1.18	7.11
Tide Gate Inner	3/2/2018	4:39:00 PM	8.29	0.65	7.64
Tide Gate Inner	3/9/2018	3:09:00 PM	8.29	2.80	5.49
Tide Gate Inner	3/26/2018	3:22:00 PM	8.29	2.73	5.56
Tide Gate Outer	2/14/2018	5:45:00 PM	8.41	2.77	5.64
Tide Gate Outer	2/23/2018	1:05:00 PM	8.41	2.86	5.55
Tide Gate Outer	3/2/2018	12:09:00 PM	8.41	nr	nr
Tide Gate Outer	3/2/2018	4:37:00 PM	8.41	1.87	6.54
Tide Gate Outer	3/9/2018	3:07:00 PM	8.41	2.97	5.44
Tide Gate Outer	3/26/2018	3:18:00 PM	8.41	2.94	5.47

All times in Pacifc Standard Time (PST)

Measuring point elevations as surveyed by OPRD.

The Miller well is co-located with PGG-1i.

Table 5-3. Average Water Levels and Vertical Differences

Sitka Sedge Natural Area, Oregon

	Average Water Levels								Vertical Differences Between Deep and Shallow Aquifers			
Data Interval	**Miller** *(PGG-1d)*	**PGG-1i**	**PGG-2d**	**PGG-2i**	**PGG-3d**	**PGG-3s**	**PGG-4d**	**PGG-4i**	***PGG-1 Vertical Difference***	***PGG-2 Vertical Difference***	***PGG-3 Vertical Difference***	***PGG-4 Vertical Difference***
Full Record Average	10.89	12.73	11.34	15.27	13.12	15.59	13.60	16.17	*1.85*	*3.92*	*2.47*	*2.56*
Minimum	10.60	12.20	10.95	14.75	12.53	15.01	12.99	15.47				
Maximum	11.35	13.64	11.99	16.34	13.80	16.71	14.24	17.18				
Standard Deviation	0.15	0.32	0.21	0.34	0.28	0.34	0.31	0.37	*0.39*	*0.25*	*0.51*	*0.21*
3-Day Average Rain Event *	11.21	13.19	11.79	16.01	13.59	16.29	14.07	16.87	*2.06*	*4.19*	*2.80*	*2.78*
Minimum	11.05	12.82	11.50	15.71	13.35	16.06	13.78	16.71				
Maximum	11.35	13.61	11.99	16.34	13.80	16.71	14.24	17.18				
Standard Deviation	0.07	0.18	0.10	0.15	0.10	0.15	0.12	0.13	*0.98*	*0.38*	*1.16*	*0.26*
Later 3-day Average **	10.70	12.29	11.06	14.79	12.68	15.07	13.15	15.58	*1.59*	*3.73*	*2.39*	*2.43*
Minimum	10.60	12.20	10.95	14.75	12.61	15.01	13.08	15.49				
Maximum	10.81	12.53	11.20	14.87	12.77	15.15	13.24	15.71				
Standard Deviation	0.06	0.10	0.06	0.03	0.04	0.04	0.04	0.06	*0.11*	*0.08*	*0.04*	*0.04*

All values in feet NAVD88.

Water levels from pressure transducers

Vertical gradient calculated as shallow/intermediate minus deep completion water interval.

* Includes data from 2/28 through 3/2/18.

** Includes data from 3/19 through 3/21/18.

Table 5-4. Average Groundwater Flow Direction and Gradient
Sitka Sedge Natural Area, Oregon

Well Set	PGG-1i : PGG-2i : PGG-3s		Miller : PGG-2d : PGG-3d		PGG-4d : PGG-2d : PGG-3d		PGG-4d : Miller : PGG-3d		PGG-4i : PGG-2i : PGG-3s		PGG-4i : PGG-1i : PGG-3s	
Data Interval	**Direction**	**Gradient**	**Direction**	**Gradient**	**Direction**	**Gradient**	**Direction**	**Gradient**	**Direction**	**Gradient**	**Direction**	**Gradient**
	Shallow Aquifer Unit		*Deep Aquifer Unit*		*Deep Aquifer Unit*		*Deep Aquifer Unit*		*Shallow Aquifer Unit*		*Shallow Aquifer Unit*	
Generalized Direction	*NE*		*E*		*E*		*E*		*NE*		*E*	
Feb. 16 through March 26	49.1	0.0049	112.4	0.0031	90.5	0.0039	84.1	0.0029	59.6	0.0018	87.0	0.0037
Standard Deviation	*1.7*	*0.0004*	*1.9*	*0.0003*	*2.8*	*0.0003*	*4.6*	*0.0002*	*3.7*	*0.0003*	*2.1*	*0.0003*
March 1 through 3	47.8	0.0054	108.4	0.0032	90.8	0.0039	85.8	0.0031	58.2	0.0017	88.8	0.0040
Standard Deviation	*0.6*	*0.0002*	*1.5*	*0.0001*	*1.6*	*0.0002*	*2.5*	*0.0001*	*2.0*	*0.0002*	*1.6*	*0.0002*
Mach 19 through 21	48.5	0.0048	114.2	0.0028	89.6	0.0036	82.0	0.0026	60.1	0.0016	89.2	0.0036
Standard Deviation	*0.3*	*0.0001*	*0.8*	*0.0001*	*0.4*	*0.0001*	*0.9*	*0.0001*	*0.8*	*0.0001*	*1.0*	*0.0001*

Direction is shown in aziumth degrees (0-360)
Direction is calculated from the three wells at top of each box.
The well set is the three wells used to triangulate the groundwater flow direction and gradient.
See Figures 5-2a and 5-2b for the March 1 and March 19 WL plots.

Table 5-5. Grain Size Analyses

Sitka Sedge Natural Area, Oregon

Grain Size Measurements

Sieve Size		PGG-2 17-19 ft bgs	PGG-2 7-8 ft bgs	PGG-4 12 ft bgs	PGG-4 5 ft bgs
mesh	**mm**	% Finer	% Finer	% Finer	% Finer
0.625	16	--	--	--	100.0
0.5	12.7	--	--	--	98.3
#4	4.76	100.0	--	100.0	98.3
#10	2	100.0	--	91.8	98.3
#20	0.841	99.9	100.0	73.3	98.3
#40	0.42	99.6	99.8	62.4	98.1
#60	0.25	75.2	61.4	46.5	74.6
#100	0.149	13.8	11.8	18.7	28.5
#200	0.074	2.7	0.2	7.7	0.6
USCS Soil Type		SP	SP	NP	SP
Soil Description		Gray poorly graded fine sand	Light brown poorly graded fine sand	Light gray to dark gray poorly graded sand with silt and organics (sandy peat)	Light brown poorly graded fine sand

Hydraulic Conductivity by Calculation Method * (m/day)

Alyamani	5.8	5.8	5.8	5.8
Beyer	9.2	9.2	8.7	8.7
Harleman	9.3	9.3	9.3	8.8
Hazen	7.3	7.2	7.2	6.9
Hazen (C_h)	10.2	10.2	10.2	9.6
Kozeny-Carman	7.2	7.2	7.2	7.0

Hydraulic Conductivity Statistics (m/day)

Median	8.2	8.2	7.9	7.8
Mean	8.2	8.1	8.0	7.8
Std Deviation	1.7	1.7	1.6	1.5

Hydraulic Conductivity Statistics (cm/s)

Median	9.5E-03	9.5E-03	9.2E-03	9.1E-03
Mean	9.4E-03	9.4E-03	9.3E-03	9.0E-03
Std Deviation	1.9E-03	1.9E-03	1.9E-03	1.7E-03

Capillary Rise (hc) Estimate

D_{10}		0.1183	0.1349	0.1086	0.1065
hc	mm	573	443	658	677
	m	0.6	0.4	0.7	0.7
	ft	1.9	1.5	2.2	2.2

Notes:

Laboratory grain size analyses in Appendix C.

* See Rosas et al. (2014) for discussion of calculation methods.

Capillary height (hc) estimated by method in Lane (1946).

$$h_c(\text{mm}) = -990 \ln D_{10} - 1540$$

D_{10} is the 10th percentile grain size.

Table 6-1: Surface Water Model Output to Groundwater Model Boundary Conditions

Sitka Sedge Natural Area

Simulation Period	Total 38 days. The first 28 days will provide an average winter water level baseline. The last 10 days will provide predicted response to a high tide event combined with an extreme storm event.
Tides	**Days 1-28:** Use measured tides outboard of the levee from January 7th to Febru-ary 4th, 2017 **Days 29-38:** Use a 10-day period from the Garibaldi gauge that includes a king tide event, and combine this with the wind setup observed at the site from Feb-ruary 5th to February 13th, to create combined king tide and wind setup storm event. **NOTE:** For storm conditions (Days 29-38), measured tide levels in Sand Lake from February 5th to 13th include the effects of persistent wind-driven setup. An approximate measure of the wind setup was estimated by subtracting the con-current Garibaldi tides. This setup was then added onto a 10-day period from the Garibaldi gauge that included a king tide event.
Precipitation	**Days 1-28:** Use average precipitation conditions for January 7th to February 4th, based on multi-year precipitation records **Days 29-38:** Start with actual precipitation measured in the 10-day period span-ning the February 2018 flood event, and scale these to 50-year levels
Streamflow	**Days 1-28:** Wet season average flow for January 7th to February 4th, based on multi-year Tucca Creek flow records **Days 29-38:** Scale February 5th – 14th flows from Tucca Creek gauge to match 50-year event level **NOTE:** Inputs for surface water model at Beltz and Reneke Creeks will be based on watershed scaling to Tucca Creek
Climate Change	Climate change would be modeled as a shift in mean sea level. We recommend using estimates for 50 years into the future under a “medium” greenhouse emis-sions scenario, corresponding to approximately a 1-foot increase in mean sea lev-el. **Note, sea level rise will not be incorporated in the initial ‘bookend’ scenarios.**

Note: *This table describes the assumptions and parameters applied to the calibrated surface-water model to generate stage data for Beltz Marsh and the Pacific Ocean to be used as input for predictive groundwater model simulations.*

Table 6-2: Recharge / Water Balance Using Long-Term Average Monthly Precipitation

Sitka Sedge Natural Area

General Station and Area Inputs

Vegetation Data

Type of Land Cover	mature conifers
Rooting Depth	36 in
Priestly Taylor "Alpha"	N/A
Average Annual Fractional Foliar Cover	N/A
Average Annual Foliar Interception Capacity	N/A
Net Surface Albedo Value	N/A

Tillamook Weather Station Data

Weather Station ID	Tillamook, OR 358494
Average Precipitati	88.0 in/yr
Avg Annual	60.3 ^{o}F
Latitude	45.45 ^{o}N
Longitude	-123.85 ^{o}W
Elevation	12 feet msl

Model Realization v12

Cloverdale Weather Station Data

Weather Station ID	Cloverdale, OR 351682-1
Average Precipitati	80.0 in/yr
Avg Annual	60.3 ^{o}F
Latitude	45.20 ^{o}N
Longitude	-123.07 ^{o}W
Elevation	1 feet msl

Model Realization v21

Soil and Water Data

Avg. Soil Available Water Capacity (AWC)	0.04	inch/inch within root zone, per NRCS soil descriptions.
Ratio of Site:Weather-Station Precipitation	100%	of official station
Portion of "P" going to immediate runoff*	0%	of effective precipitation, per high permeability of soils..

Recharge Calculator

Recharge Parameter	January	February	March	April	May	June	July	August	September	October	November	December	Total
Evaporation Estimates													
Monthly Temp (T, ^{o}F)	44.7	45.4	46.8	48.9	52.8	56.4	59.1	59.5	57.8	52.8	47.6	43.8	51.3
Monthly Temp (T, ^{o}C)	7.1	7.4	8.2	9.4	11.5	13.5	15.1	15.3	14.3	11.6	8.6	6.5	10.7
Blaney Criddle Crop Factor (k)	0.63	0.73	0.86	0.85	0.52	0.53	0.53	0.53	0.50	0.80	0.78	0.64	0.66
Blaney Criddle % of Annual Light (d)	0.064	0.065	0.082	0.091	0.103	0.105	0.106	0.097	0.084	0.076	0.064	0.061	1.00
Priestly Taylor Net Radiation (RN)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Potential Evapotranspiration (PET)	0.83	1.01	1.64	1.99	1.67	2.04	2.31	2.17	1.66	1.92	1.21	0.76	19.23
Water Balance (Tillamook); *Model Realization v12*													
Effective Precipitation (P)	13.52	9.68	9.74	7.07	4.72	3.58	1.38	1.31	3.00	6.93	13.84	13.24	88.01
Interception Loss (IL)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Average Snowpack Storage (SS)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	- - -
Snowpack Ablation (SA)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Snowmelt (SM)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
AvailableThroughfall (ATF)	13.52	9.68	9.74	7.07	4.72	3.58	1.38	1.31	3.00	6.93	13.84	13.24	88.01
Runoff (RO)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Infiltration (I)	13.52	9.68	9.74	7.07	4.72	3.58	1.38	1.31	3.00	6.93	13.84	13.24	88.01
Average Soil Moisture in Soil Profile (SW)	1.41	1.40	1.39	1.37	1.39	1.37	0.99	0.80	1.29	1.38	1.40	1.42	1.30
Soil Moistue Deficit (PET-P)	0.00	0.00	0.00	0.00	0.00	0.00	0.93	0.86	0.00	0.00	0.00	0.00	1.79
Actual Evapotranspiration (AET)	0.83	1.01	1.64	1.99	1.67	2.04	1.93	1.35	1.56	1.92	1.21	0.76	17.93
Shallow Recharge (RS)**	12.69	8.68	8.12	5.09	3.03	1.55	0.00	0.00	0.83	5.02	12.61	12.46	70.08
Perched Subflow (PS)***	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Deep Recharge (RD)***	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Water Balance (Cloverdale); *Model Realization v21*													
Effective Precipitation (P)	11.72	8.45	8.88	6.42	4.58	3.38	1.12	1.20	2.96	6.23	13.02	12.00	79.96
Interception Loss (IL)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Average Snowpack Storage (SS)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	- - -
Snowpack Ablation (SA)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Snowmelt (SM)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
AvailableThroughfall (ATF)	11.72	8.45	8.88	6.42	4.58	3.38	1.12	1.20	2.96	6.23	13.02	12.00	79.96
Runoff (RO)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Infiltration (I)	11.72	8.45	8.88	6.42	4.58	3.38	1.12	1.20	2.96	6.23	13.02	12.00	79.96
Average Soil Moisture in Soil Profile (SW)	1.41	1.40	1.38	1.37	1.38	1.37	0.87	0.66	1.23	1.37	1.40	1.41	1.27
Soil Moistue Deficit (PET-P)	0.00	0.00	0.00	0.00	0.00	0.00	1.34	1.14	0.00	0.00	0.00	0.00	2.48
Actual Evapotranspiration (AET)	0.91	1.12	1.78	2.13	1.78	2.16	1.81	1.22	1.63	2.09	1.32	0.83	18.79
Shallow Recharge (RS)**	10.82	7.34	7.11	4.30	2.78	1.24	0.00	0.00	0.61	4.15	11.68	11.15	61.17
Perched Subflow (PS)***	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Deep Recharge (RD)***	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

	STATION	P	IL	SM	ATF	RO	I	PET	AET	RS	PS	RD
ANNUAL SUMMARY	**- Tillamook**	**88.01**	**N/A**	**N/A**	**88.01**	**0.00**	**88.01**	**19.23**	**17.93**	**70.08**	**N/A**	**N/A**
	- Cloverdale	**79.96**	**N/A**	**N/A**	**79.96**	**0.00**	**79.96**	**20.72**	**18.79**	**61.17**	**N/A**	**N/A**

Notes:

All values used in the Evaporation Estimates, Water Balance, and Annual Summary are in inches unless otherwise noted.

Abbreviations used in the annual summary are defined in the Evaporation Estimates and Water Balance.

* Modeled runoff consists of the sum of the fixed percentage of effective precipitation going to runoff and any infiltration rejected when saturation reaches the land surface.

** Shallow recharge is the water that exits the bottom of the root zone.

*** Deep recharge is not applicable to this analysis, and is associated with water that flows through a perching layer.

***Note:** this table presents the parameters used to estimate groundwater recharge estimated based on climate, soils and vegetation. Groundwater recharge is a key driver behind groundwater level variations. Estimates of daily recharge were also developed.*

Table 6-3: Summary of Modeled Aquifer Property Values

Sitka Sedge Natural Area

Model Version 12 (Tillamook Precipitation)

Hydraulic Property Zone	Zone / Reach	Kh Range	Calibrated Kh	Kv Range	Calibrated Kv	S Range	Calibrated S	Comments
K & S of L1 Hydraulic Property	Z1	3 - 60	27	0.1*Kh	2.7	0.1 - 0.4	0.34	Sandy materials, shallow aquifer. S = Sy
K & S of L2 Western Hydraulic Property	Z2	N/A	1	>Z5	0.0034	1E-6 - 1E-4	2E-5	Aquitard materials, more peaty. S = Ss
K & S of L3 Hydraulic Property	Z3	3 - 60	32	0.1*Kh	3	1E-6 - 1E-4	2E-5	Sandy materials, deep aquifer. S = Ss
K & S of Connective Hydraulic Property	Z4	2 - 200	20	2-200	20	see note	see note	Higher energy sediments along bedrock upland
K & S of L2 Eastern Hydraulic Property	Z5	N/A	1	1E-7 - 2E-4	3.4E-4	1E-6 - 1E-4	2E-5	Aquitard materials, more clayey. S = Ss
Ks of Beltz Marsh River Cells	R1, R3	N/A	N/A	0.4 - 4	0.4	N/A	N/A	Finer-graned "skin" materials
Ks of Beach River Cells	R2,R4	N/A	N/A	12 - 40	12	N/A	N/A	Beach sand
Ks of Beach Drain Cells	D-1	N/A	N/A	12 - 40	12	N/A	N/A	Beach sand
Ks of All Other Land-Surface Drains	D-0	N/A	N/A	1.2 - 4	2	N/A	N/A	Surficial Soils
Ks of East Ditch	S-1	N/A	N/A	0.6 - 60	40	N/A	N/A	Maintained periodically
Ks of North Ditch	S-2	N/A	N/A	0.6 - 60	3	N/A	N/A	Maintained rarely

Model Version 21 (Cloverdale Precipitation)

Hydraulic Property Zone	Zone / Reach	Kh Range	Calibrated Kh	Kv Range	Calibrated Kv	S Range	Calibrated S	Comments
K & S of L1 Hydraulic Property	1	3 - 60	15	0.1*Kh	1.5	0.1 - 0.4	0.12	Sandy materials, shallow aquifer. S = Sy
K & S of L2 Western Hydraulic Property	2	N/A	1	>Z5	0.0034	1E-6 - 1E-4	2E-5	Aquitard materials, more peaty. S = Ss
K & S of L3 Hydraulic Property	3	3 - 60	30	0.1*Kh	3	1E-6 - 1E-4	2E-5	Sandy materials, deep aquifer. S = Ss
K & S of Connective Hydraulic Property	4	2 - 200	20	2-200	20	see note	see note	Higher energy sediments along bedrock upland
K & S of L2 Eastern Hydraulic Property	5	N/A	1	1E-7 - 2E-4	0.00034	1E-6 - 1E-4	2E-5	Aquitard materials, more clayey. S = Ss
Ks of Beltz Marsh River Cells	R1, R3	N/A	N/A	0.4 - 4	0.4	N/A	N/A	Finer-graned "skin" materials
Ks of Beach River Cells	R2,R4	N/A	N/A	12 - 40	12	N/A	N/A	Beach sand
Ks of Beach Drain Cells	D-1	N/A	N/A	12 - 40	12	N/A	N/A	Beach sand
Ks of All Other Land-Surface Drains	D-0	N/A	N/A	1.2 - 4	2	N/A	N/A	Surficial Soils
Ks of East Ditch	S-1	N/A	N/A	0.6 - 60	40	N/A	N/A	Maintained periodically
Ks of North Ditch	S-2	N/A	N/A	0.6 - 60	3	N/A	N/A	Maintained rarely

N/A = not applicable, either because it is not included in calculating flow (e.g. Kh of "skin" sediments) or has no effect on model results (e.g. Kh of an aquitard)
S = storativity. Sy = specific yield. Ss = specific storage. Storage properties for connective zone range from 0.34 (Sy) to 2E-5 (Ss)
K = Hydraulic conductivity. Kh = Horizontal hydraulic conductivity. Kv = Vertical hydraulic conductivity. All K values in ft/d.

Note: *This table summarizes the hydraulic property ranges for sediments employed during calibration of the groundwater flow model, along with final calibrated model values used for the purpose of predicting groundwater responses to various configurations of the Beltz Dike.*

Table 6-4: Key Calibration Statitstics

Sitka Sedge Natural Area

Name	Observed	v12 Steady State		v21 Steady State		Transient ΔH		v12 Transient Tidal Response		v21 Transient Tidal Response	
		Computed	Residual	Computed	Residual	v12	v21	Observed	Computed	Observed	Computed
PGG-1d	10.89	11.41	-0.52	11.37	-0.48	-0.9	-0.5	0.20	0.13	0.20	0.08
PGG-1i	12.73	12.24	0.49	12.35	0.38	0.5	0.5	~0	~0	~0	~0
PGG-2d	11.34	12.84	-1.50	12.82	-1.48	-2.2	-1.6	0.30	0.20	0.30	0.12
PGG-2i	15.27	16.01	-0.74	16.33	-1.06	-1.3	-0.8	~0	~0	~0	~0
PGG-3d	13.12	12.24	0.88	12.16	0.96	0.2	0.7	0.20	0.40	0.20	0.30
PGG-3s	15.59	15.83	-0.24	15.41	0.18	-1.0	0.4	~0	~0	~0	~0
PGG-4d	13.6	12.18	1.42	12.10	1.50	0.6	1.3	0.10	0.50	0.10	0.40
PGG-4i	16.17	15.86	0.31	15.38	0.79	-0.8	0.7	~0	~0	~0	~0
TDM-2s	18.19	18.08	0.11	18.27	-0.08	0.1	0.1	~0	~0	~0	~0
TDM-4s	17.41	16.75	0.66	16.77	0.64	0.2	0.8	~0	~0	~0	~0
East Ditch GW Flux (cfs)		0.15		0.12		range: 0.06 - 0.65	range: 0.02 - 0.34				
North Ditch GW Flux (cfs)		0.04		0.03		range: 0.02 - 0.13	range: 0.01 - 0.05				

Steady-State Statistics:	v12 Steady State	v21 Steady State
Residual Mean	0.09	0.14
Absolute Residual Mean	0.69	0.76
Residual Std. Deviation	0.81	0.88
RMS Error	0.82	0.89
Min. Residual	-1.50	-1.48
Max. Residual	1.42	1.50
Number of Observations	10	10
Range in Observations	7.3	7.3
Scaled Residual Std. Deviation	11.2%	12.1%
Scaled Absolute Residual Mean	9.4%	10.3%
Scaled RMS Error	11.2%	12.2%
Scaled RMS Error (L1 Only)	*8.8%*	*11.4%*
Scaled Residual Mean	1.2%	1.9%

All elevation values are in feet NAVD88, all residuals are in feet, and all flow rates are in cubic feet per second (cfs).

"Tidal Response": Diurnal groundwater level variation resulting from tidal influence.

v21: Input precipitation based on Cloverdate records

v12: Input precipitation based on Tillamook records

ΔH: Head difference between the observed hydrograph and the predicted hydrograph.

Note: *This table summarizes groundwater modeling predictions assessed against observed values ("calibration targets") along with statistical assessment of calibration accuracy.*

Table 6-5: Steady State Model Water Budgets

Sitka Sedge Natural Area

Description	v12 - Tillamook (cfs)	v21 - Cloverdale (cfs)
Recharge	4.71	3.69
- Recharge to TDM	*0.64*	*0.50*
Constant Head (Sear Lake)	-0.03	-0.03
Rivers (Beach and Marsh)	-3.62	-2.90
- Discharge to Beltz Marsh	*-0.71*	*-0.56*
- Discharge to Ocean	*-2.91*	*-2.34*
Land Surface Drains	-0.87	-0.62
Streams (East and North Ditches)	-0.19	-0.14
- Discharge to East Ditch	*-0.15*	*-0.12*
- Discharge to North Ditch	*-0.04*	*-0.03*
Total	*0.00*	*0.00*

Positive values indicate model inflows, negative values indicate outflows.
A total of zero indicates that inflows and outflows are balanced.

Note: *This table summarizes the hydrologic inflows and outflows for calibrated realizations of the groundwater model (steady-state calibration) representing average conditions over the 38-day monitoring period (February 16, 2018 thru March 26, 2016).*

PgG

Table 7-1: Differences in Predicted Shallow-Aqufer Groundwater Elevations

Sitka Sedge Natural Area

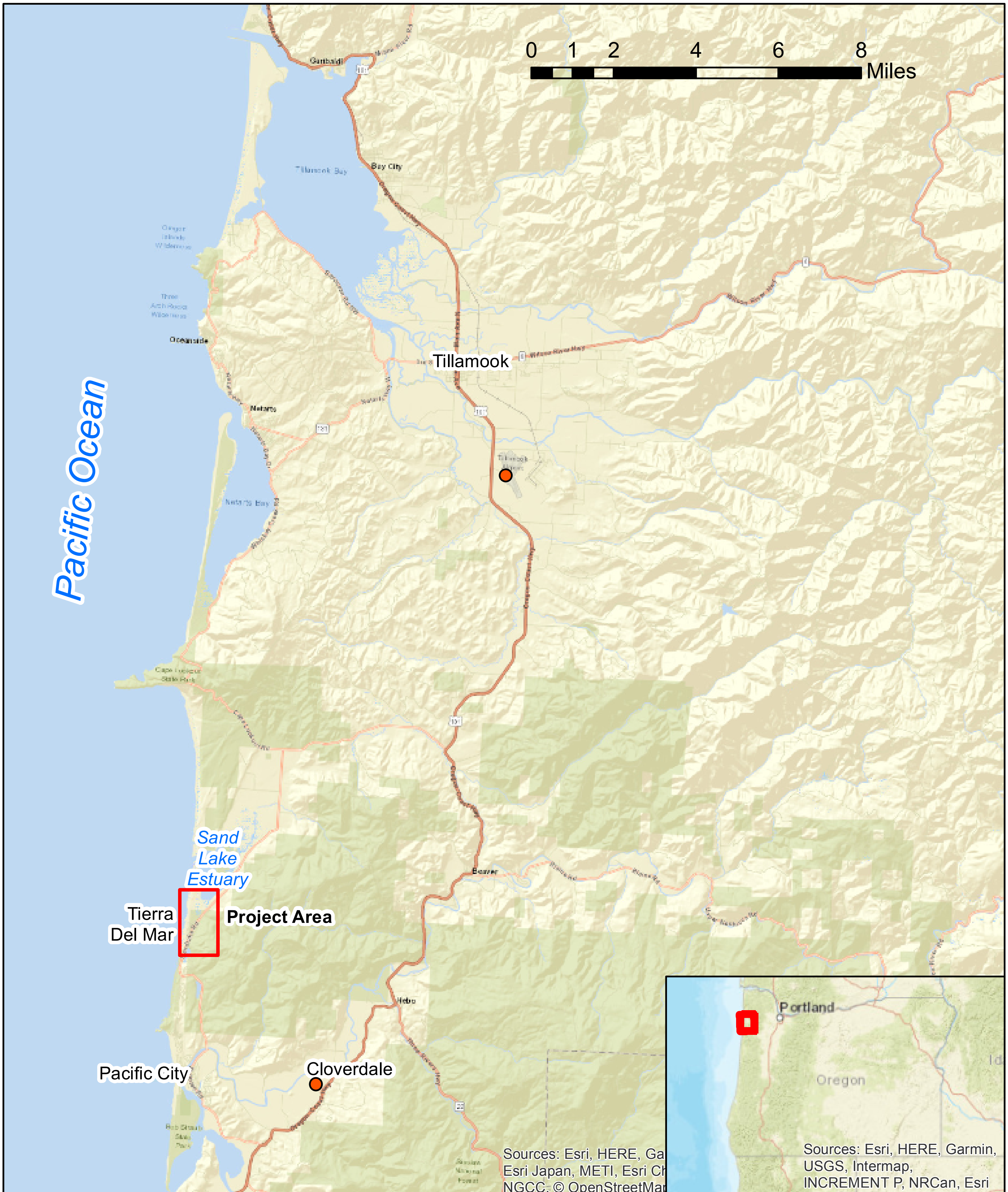
Dike Configuration	Model	Statistic	PGG-1i	PGG-2i	PGG-3s	PGG-4i	TDM-2	TDM-4
Dike Breach	v12 Tillamook	28d Max	0.02	0.00	0.00	0.00	0.00	0.00
		28d Avg	0.01	0.00	0.00	0.00	0.00	0.00
		28d Min	0.00	0.00	0.00	0.00	0.00	0.00
		10d Max	0.01	0.00	0.00	0.00	0.00	0.00
		10d Avg	-0.02	0.00	0.00	0.00	0.00	0.00
		10d Min	-0.10	0.00	0.00	0.00	0.00	0.00
	v21 Cloverdale	28d Max	0.02	0.00	0.00	0.00	0.00	0.00
		28d Avg	0.01	0.00	0.00	0.00	0.00	0.00
		28d Min	0.00	0.00	0.00	0.00	0.00	0.00
		10d Max	0.00	0.00	0.00	0.00	0.00	0.00
		10d Avg	-0.04	0.00	0.00	0.00	0.00	0.00
		10d Min	-0.14	0.00	0.00	0.00	0.00	0.00
Modern Tide Gate	v12 Tillamook	28d Max	0.00	0.00	0.00	0.00	0.00	0.00
		28d Avg	0.00	0.00	0.00	0.00	0.00	0.00
		28d Min	-0.01	0.00	0.00	0.00	0.00	0.00
		10d Max	0.00	0.00	0.00	0.00	0.00	0.00
		10d Avg	-0.03	0.00	0.00	0.00	0.00	0.00
		10d Min	-0.11	0.00	-0.01	0.00	0.00	0.00
	v21 Cloverdale	28d Max	0.00	0.00	0.00	0.00	0.00	0.00
		28d Avg	0.00	0.00	0.00	0.00	0.00	0.00
		28d Min	-0.01	0.00	0.00	0.00	0.00	0.00
		10d Max	0.00	0.00	0.00	0.00	0.00	0.00
		10d Avg	-0.05	0.00	0.00	0.00	0.00	0.00
		10d Min	-0.17	0.00	0.00	0.00	0.00	0.00

Difference = alternative configuration minus current conditions simulation
28d = 28-day winter average condition, 10d = 10d high tide/precipitation condition ("storm event")
All values in feet

Note: *This table summarizes the predicted changes in Shallow Aquifer water-table elevations derived from the predictive model scenarios. Changes are expressed (in feet) relative to the current tide gate for both the "dike breach" and "modern tide gage" dike configurations.* All values in feet

For the dike breach configuration, no effects are predicted in wells other than PGG1i. Maximum increase in groundwater level (1/50 inch) occurs during average conditions. Maximum decrease (~1/7 inch) occurs during flood conditions. This observation is representative for the shallow water table beneath TDM near Beltz Marsh. Higher water levels during average conditions reflects more tidal inflow thru the dike breach, whereas lower water levels during the storm event represents more efficient drainage out thru the breach gap.

For the modern tide gate configuration, predicted changes are all limited to Well PGG-1i and are all water-level declines. Declines occur because (relative to the current tide gate) the modern tide gate does a better job limiting inundation during high tide and allowing drainage during low tide.



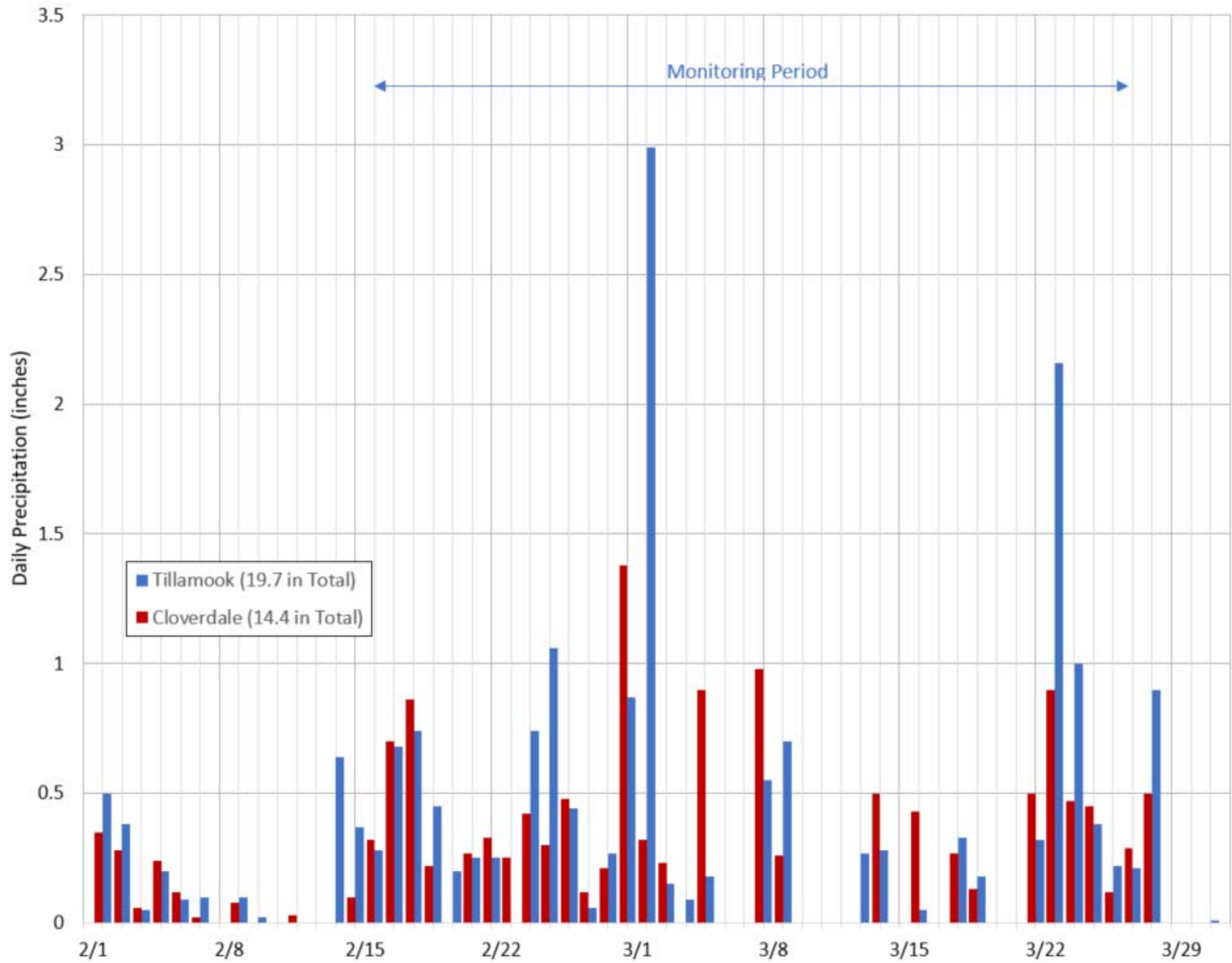
This figure shows the location of the study site (red square) relative to regional geography. Precipitation data discussed in the report was collected from stations located in Tillamook and Cloverdale; weather stations are shown by red dots.

Figure 1-1

Project Location Map

Sitka Sedge Natural Area

PGG

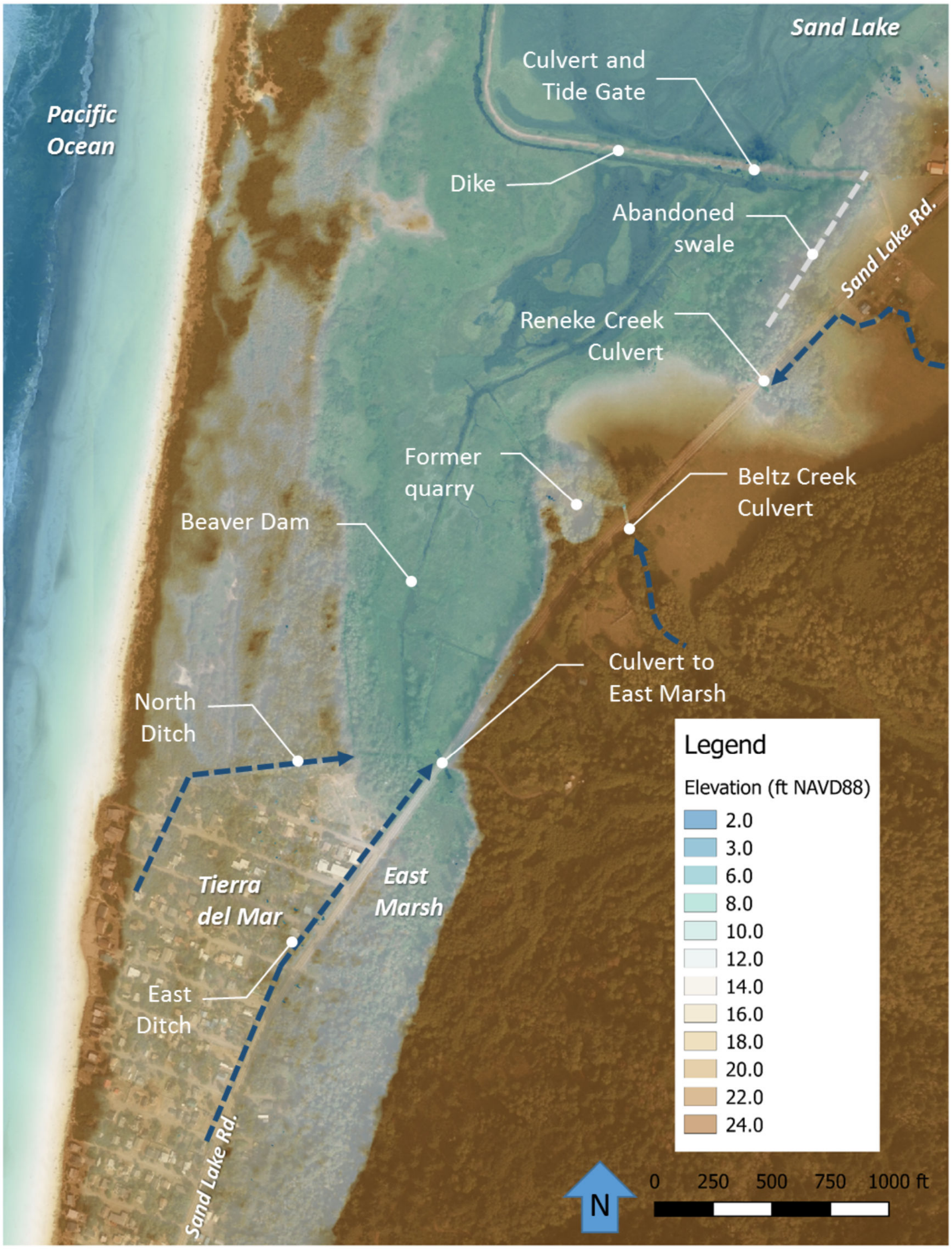


Note: *This figure compares daily precipitation at the Tillamook and Cloverdale weather stations for the 2-month period starting 2/1/18. Total 2-month precipitation at Tillamook is 37% higher than at Cloverdale.*

Figure 3-1
Daily Precipitation at Tillamook and Cloverdale (Feb-Mar 2018)

Sitka Sedge Natural Area

PGG

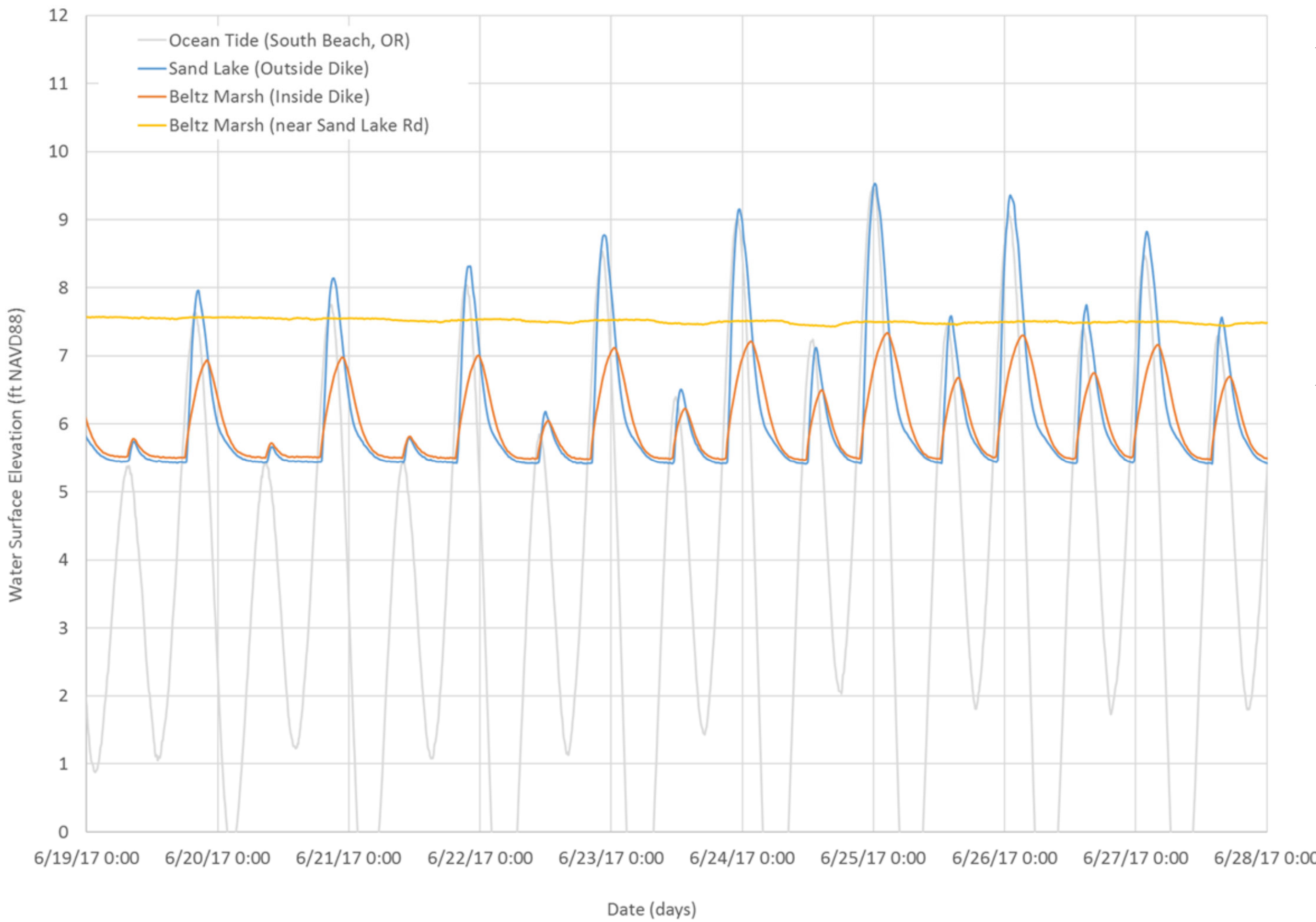


Note: *This figure is an aerial photo with a LiDAR elevation data overlay. Key site features are labeled for reference.*

Figure 4-1
Annotated Site Topographic and Hydrologic Map

ESA

Sitka Sedge Natural Area



Note: *This figure shows water level data collected during a typical period during the dry season..*

Ocean tides fluctuate between 0' and 9.5'. Sand Lake water levels are typically slightly higher than the ocean at high tide. Low tides in Sand Lake never fall below 5.5' due to controlling bed elevations.

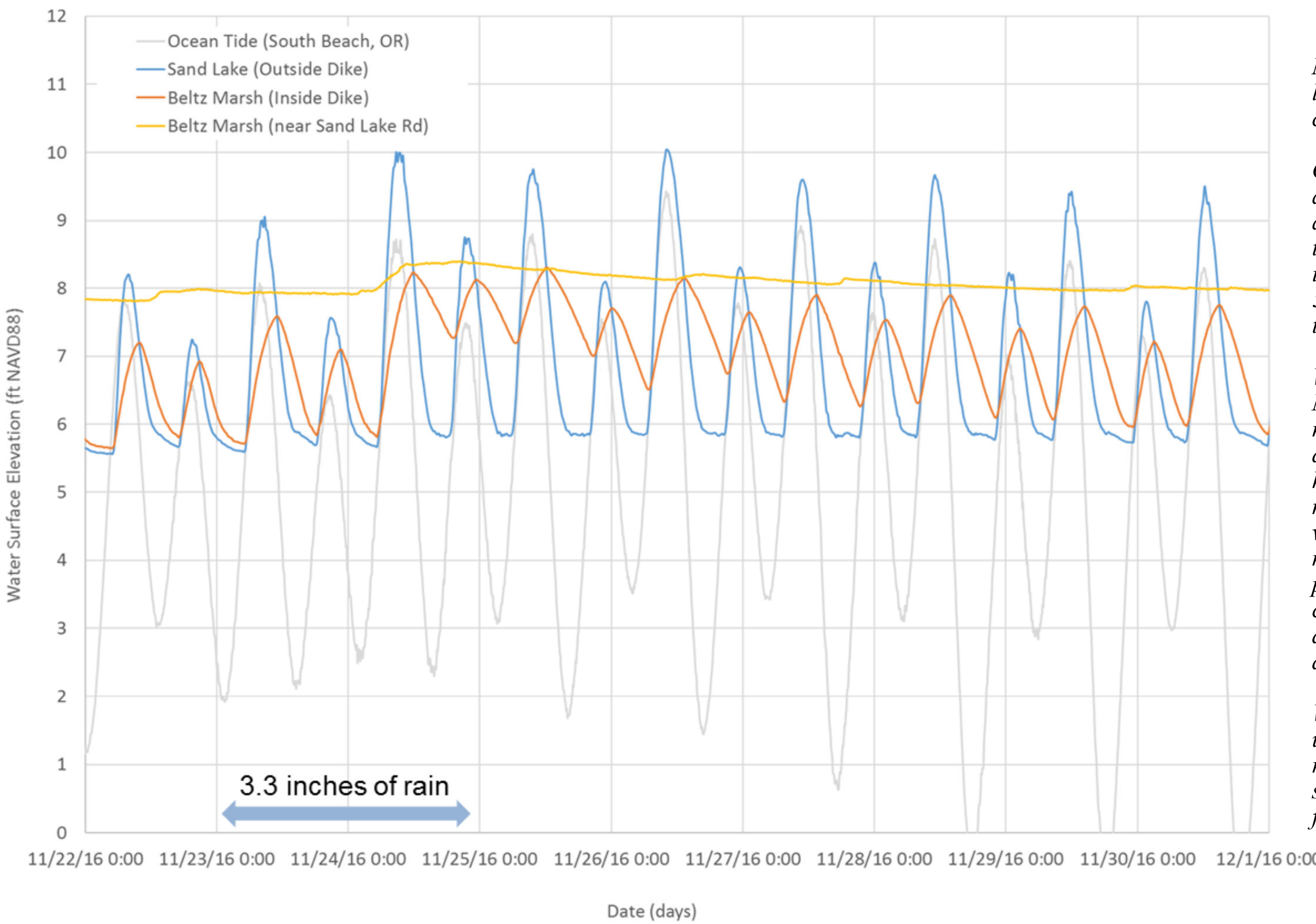
Water levels inside the dike/ Marsh show a muted tidal connection. The restriction of flow through the leaky tide gate prevents high tides in the marsh from reaching the maximum high tide elevation observed outside of the dike. Water drains out of the marsh as tides recede, slightly delayed due to limited capacity of the culvert.

Water levels at Sand Lake Road upstream of the beaver dam are relatively constant at 7.5'.

Figure 4-2
Typical Water Level Fluctuations in Beltz Marsh During the Dry Season

ESA

Sitka Sedge Natural Area



Note: *This figure shows water level data collected during a typical period during the wet season..*

Ocean tides fluctuate between 0' and 9.5'. Sand Lake water levels are typically slightly higher than the ocean at high tide. Low tides in Sand Lake never fall below 5.5' due to controlling bed elevations.

Water levels inside the dike/ Marsh show a muted tidal connection and low capacity for drainage. The tide gate prevents high tides from entering the marsh. After a rainfall event, water accumulates within the marsh, and the undersized culvert prevents efficient drainage. Accumulated water takes several days, and several low tides, to drain.

Water levels at Sand Lake Road upstream of the beaver dam are relatively constant at 8', with a slight increase following a rainfall event.

Figure 4-3
Typical Water Level Fluctuations in Beltz Marsh During the Wet Season

Sitka Sedge Natural Area

Recent Events	48-Hr Rainfall (inches)
Dec. 18, 2015	4.1
Nov. 24, 2016	3.3
Dec. 20, 2016	2.3
Feb. 9, 2017	3.1
Feb. 16-19, 2017	2.4 + 1.6
Mar. 7, 2017	1.3
Mar. 15, 2017	2.9

Note: *This figure shows areas of surface-water ponding observed following rainfall events.*

These ponded areas generally correspond to depression areas without positive drainage.

Figure 4-4
Areas of Surface-Water Ponding in Tierra Del Mar

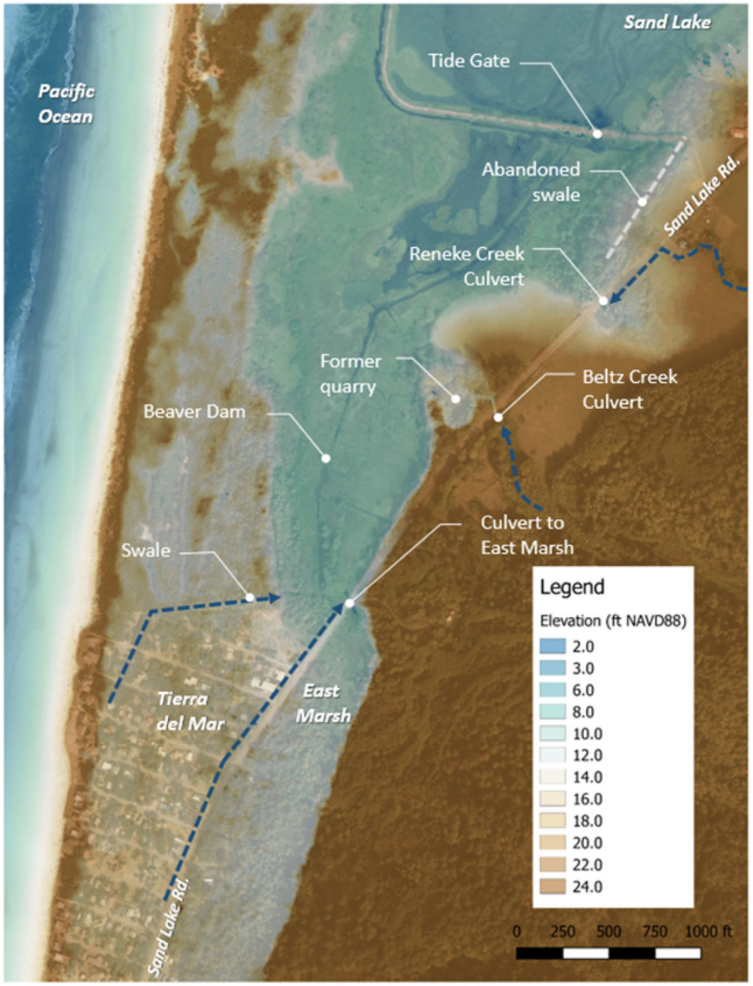
ESA

- Beltz Dike and tide gate
  - Limited tidal flux in/out of marsh
  - High tides behind dike are 1-2’ lower than Sand Lake
  - Water still flowing into marsh when tides begin to fall
  - Culvert limits draining of marsh
  - Heavy rainfall events can take several tide cycles for freshwater to drain out of marsh

- Beaver Dam within marsh
  - About 3 feet tall
  - Limits tidal fluctuation at south end of marsh
  - Steady water levels 7 to 8’ NAVD88
  - Backwater at culvert and east marsh
- Multiple Culverts (not shown)

Note: *This figure provides summary information on the primary features that control surface-water movement into, out of, and within Beltz Marsh.*

Figure 4-5
Hydraulic Control Features Affecting Surface-Water Movement



FEMA Base Flood EL. +11.8 ft

Low top of Dike EL. +12.1 ft
Bottom of Tide Gate EL. +1.3 ft
Scour hole EL. -4.5 ft

Low tide in Sand Lake EL. +5.5 ft
MSL in Ocean EL. +3.8 ft

Reneke Ck. Culvert Invert. EL. +9.6 ft

Beltz Ck. Culvert Invert. EL. +20.7 ft

Top of Beaver Dam EL. ~8.0 ft

Culvert to East Marsh Invert EL. 5.15 ft
Low Point in Sand Lk. Rd EL. ~11.6 ft

Culvert Invert at Roma Ave = +11.7 ft
Land in Tierra del Mar EL. +14 to 22 ft

Note: *This figure summarizes the elevations of key features within the project area. All elevations are referenced to North American Vertical Datum 1988 (NAVD88).*

Figure 4-6
Elevations of Key Site Features and Water Levels (NAVD88)

Sitka Sedge Natural Area

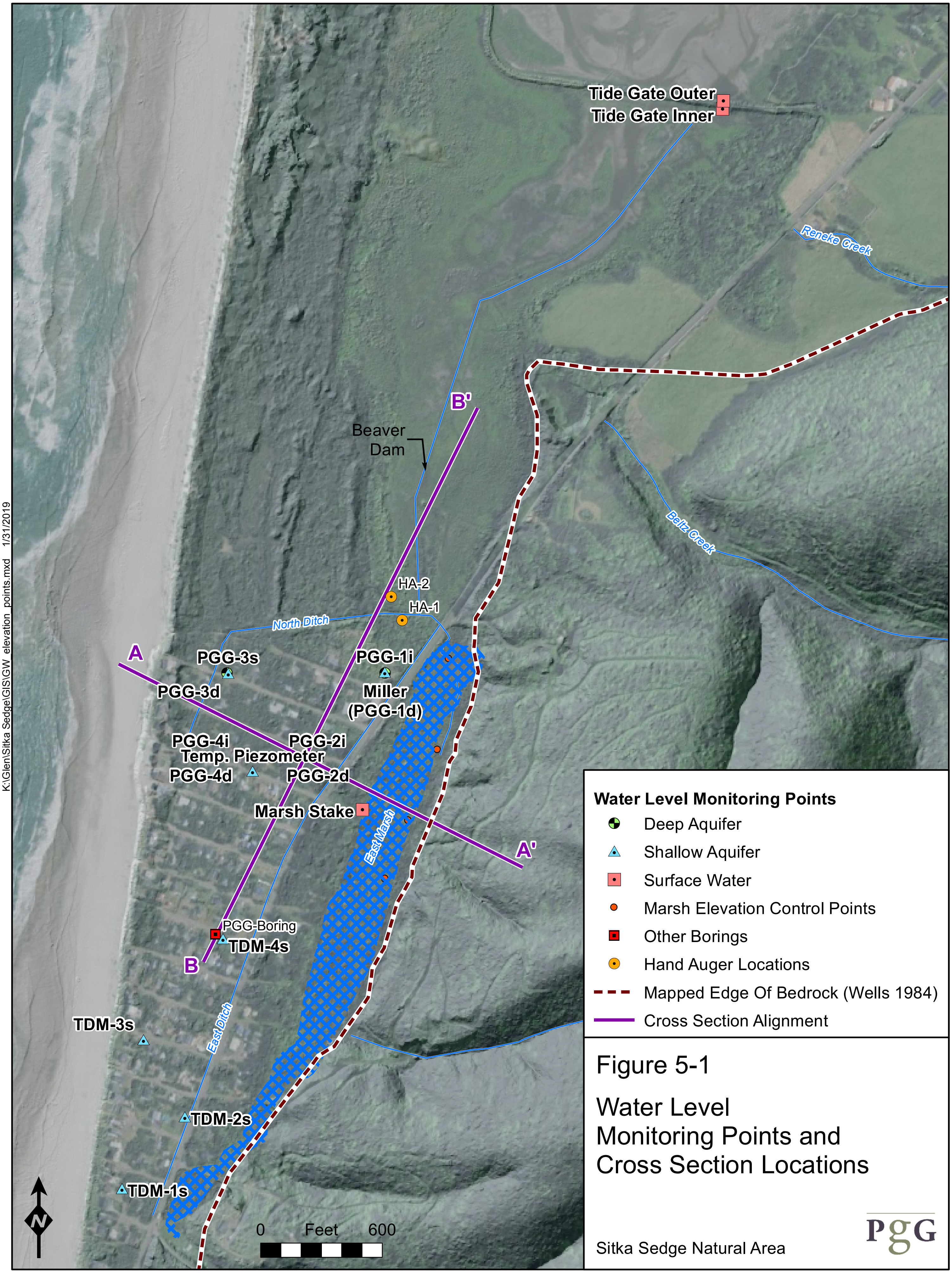
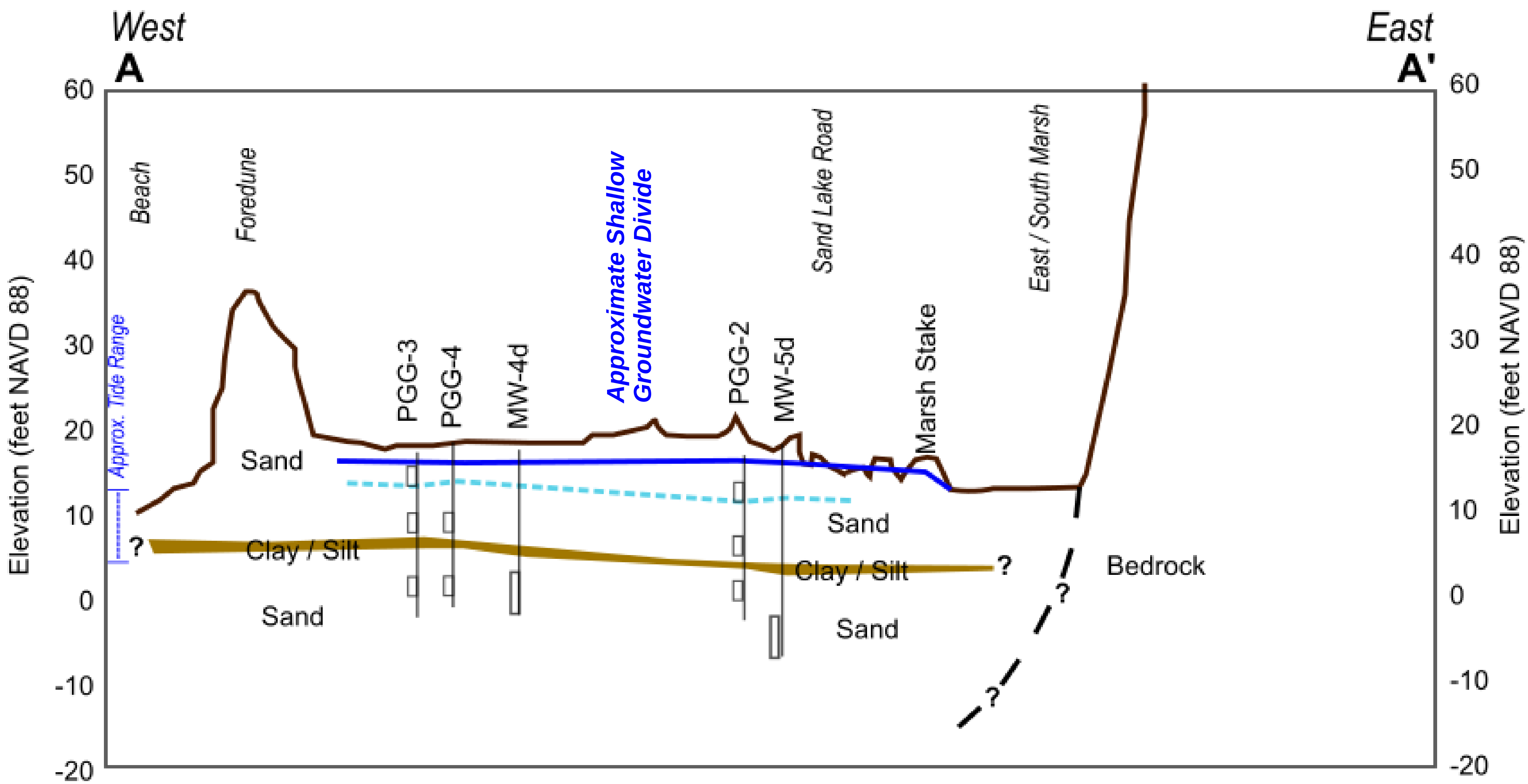


Figure 5-1

Water Level Monitoring Points and Cross Section Locations

Sitka Sedge Natural Area

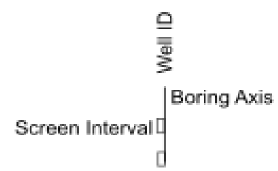
K:\Glen\Sitka Sedge\GIS\GW_elevation_points.mxd 1/31/2019



Notes:

- Shallow Potentiometric Surface
- Deep Potentiometric Surface

15x Vertical Exaggeration

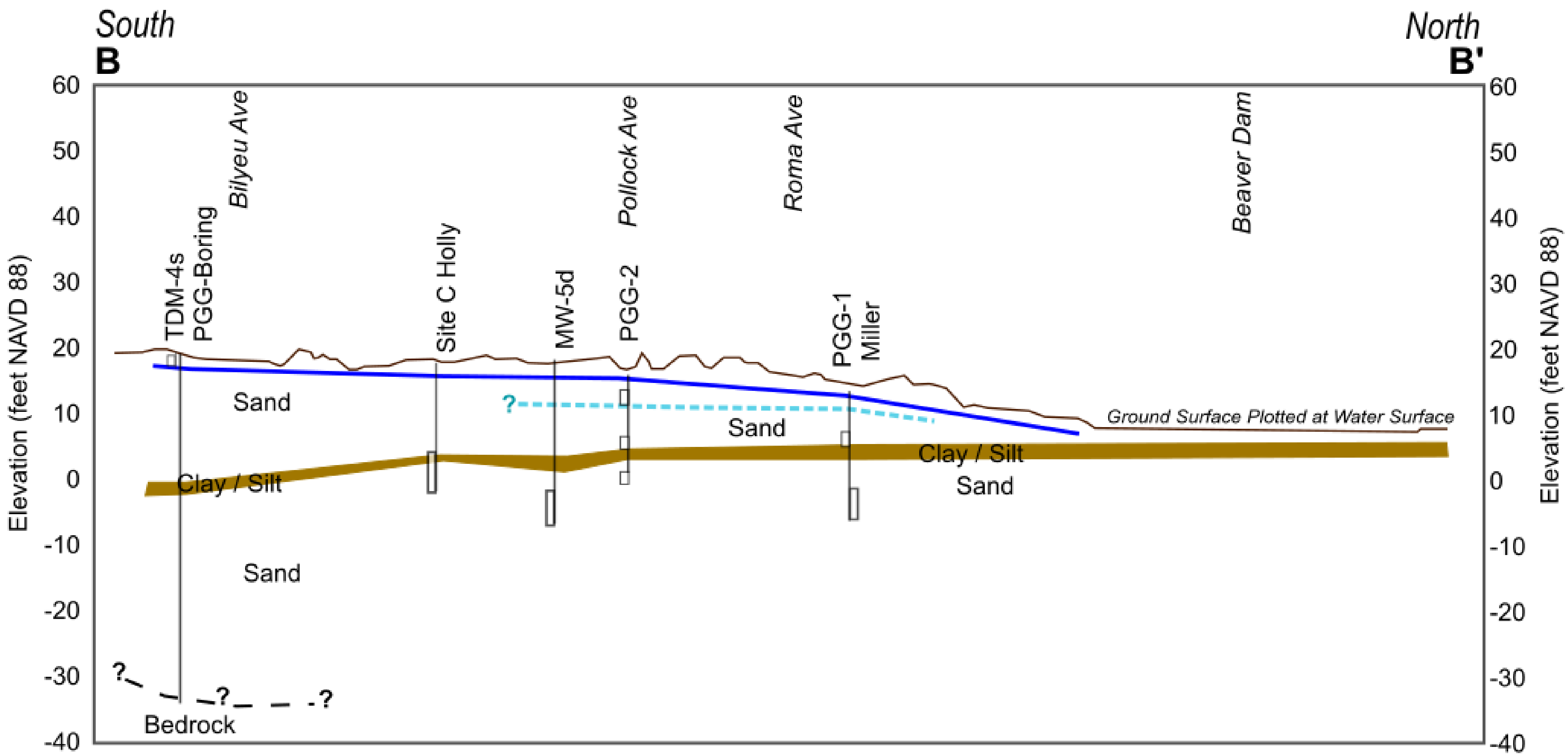


This figure shows a cross section through the study area from the beach (west) to bedrock in the hills east of TDM. There are no borings at or west of the foredune, and the clay layer is expected to pinch out west of the foredune, though the location of that transition is uncertain. It is common for water levels (reflecting pressure head) in semi-confined or confined aquifers to rise above the elevation overlying confining layer, as observed for the deep potentiometric surface, above.

Figure 5-2a
Geologic Cross Section A-A'

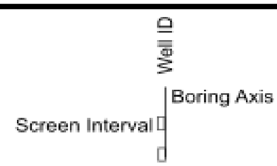
Sitka Sedge Natural Area

PgG



Notes:
- Shallow Potentiometric Surface
- Deep Potentiometric Surface

15x Vertical Exaggeration

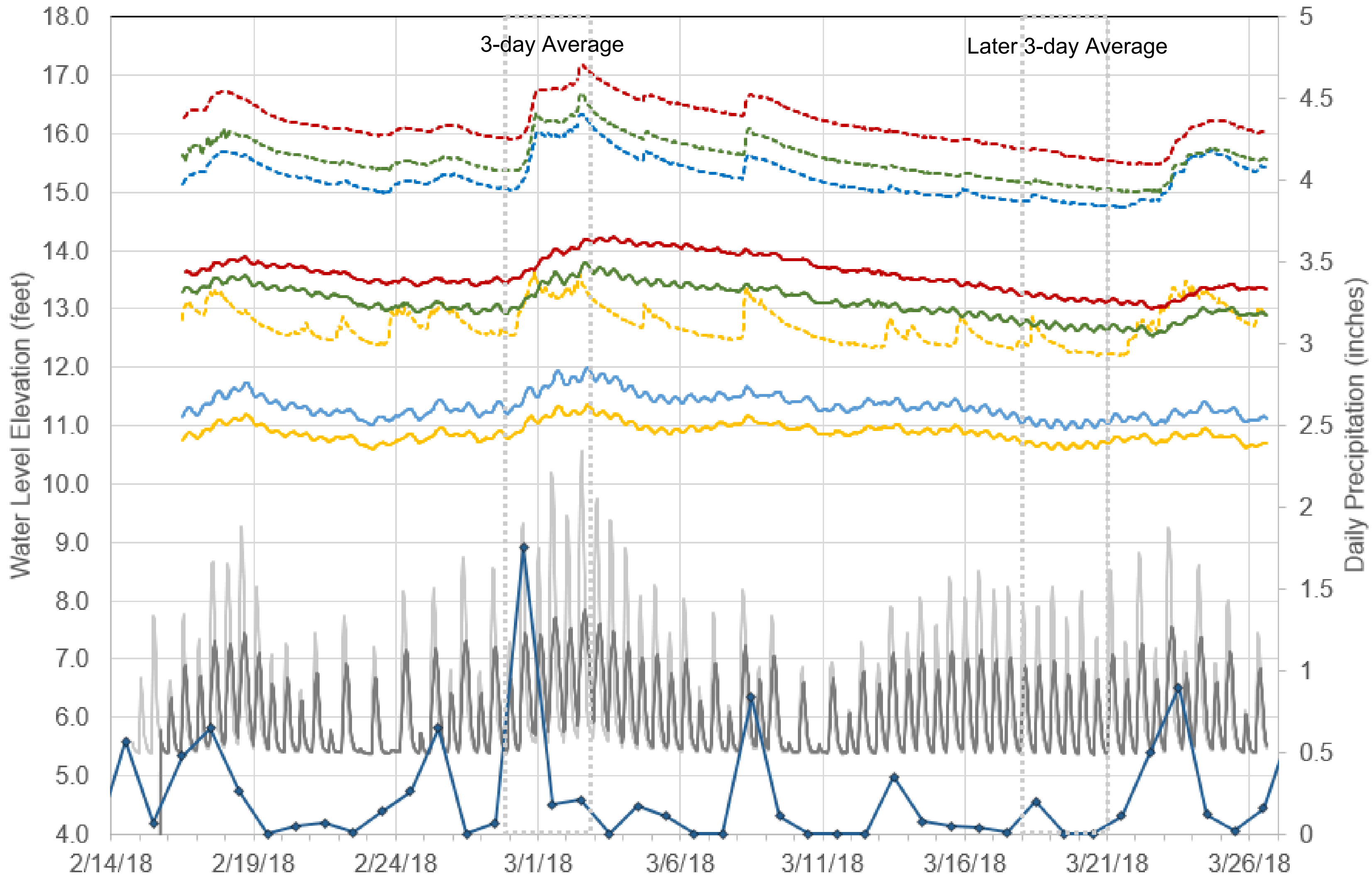


This figure shows a south to north cross section through the study area from near the TDM Community Center into Beltz Marsh. The boring log from a well on Whalen Island on the north part of Sand Lake Estuary suggests that the clay layer is present throughout the estuary. The shallow potentiometric surface (water table) dips to the north reflecting groundwater discharge towards surface water features (some of which are out of the plane of the cross section). It is common for water levels in semi-confined or confined aquifers to rise above the overlying confining layer, as observed for the deep potentiometric surface, above.

Figure 5-2b
Geologic Cross Section B-B'

Sitka Sedge Natural Area

PGG

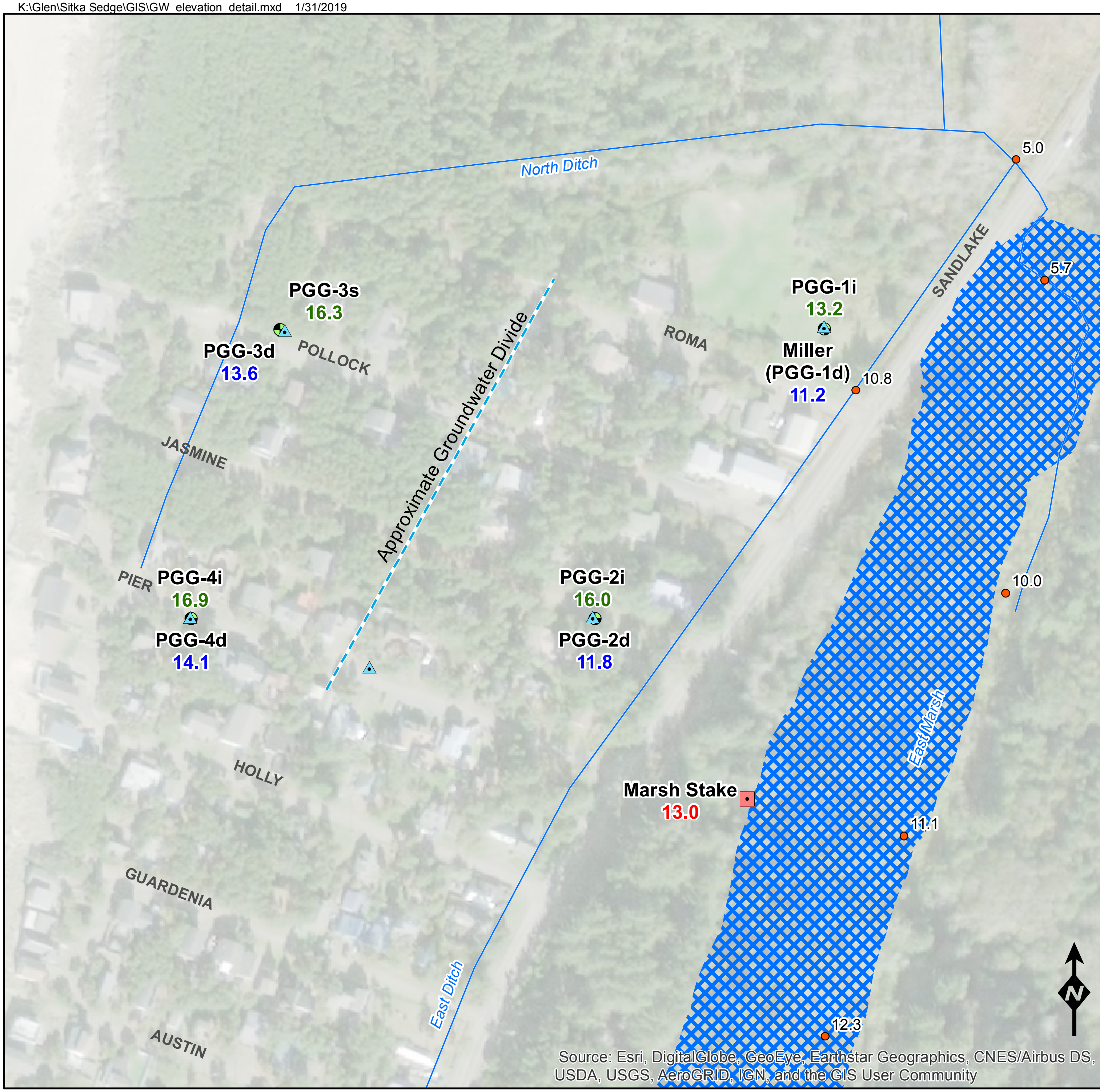


This figure shows the variation in water level elevations measured in each of the study wells and at the surface water monitoring points at the tide gate. This figure also shows the daily precipitation record from Tillamook, Oregon. Water levels measured in wells can be seen to rise following precipitation events as recharge reaches the water table. KTMK is the Tillamook weather station.

Figure 5-3
Water-Level Hydrographs

Sitka Sedge Natural Area

PgG



This figure shows the elecation of water levels at selected groundwater and surface water monitoring points. Groundwater will flow from areas of higher water levels to lower water levels. The water levels shown here were measured shortly after a storm event at the end of February 2018. The groundwater divide is inferred from observations shown on Figure 5-4c. The groundwater divide depicted represents the approximate location of a groundwater ridge which implies westward flow to the west of the line and eastward flow to the east of the line.

Water Level Elevation 3/1/2018

- Deep Aquifer
- Shallow Aquifer
- Surface Water
- Marsh Survey Elevations (4/2018)

0 Feet 200

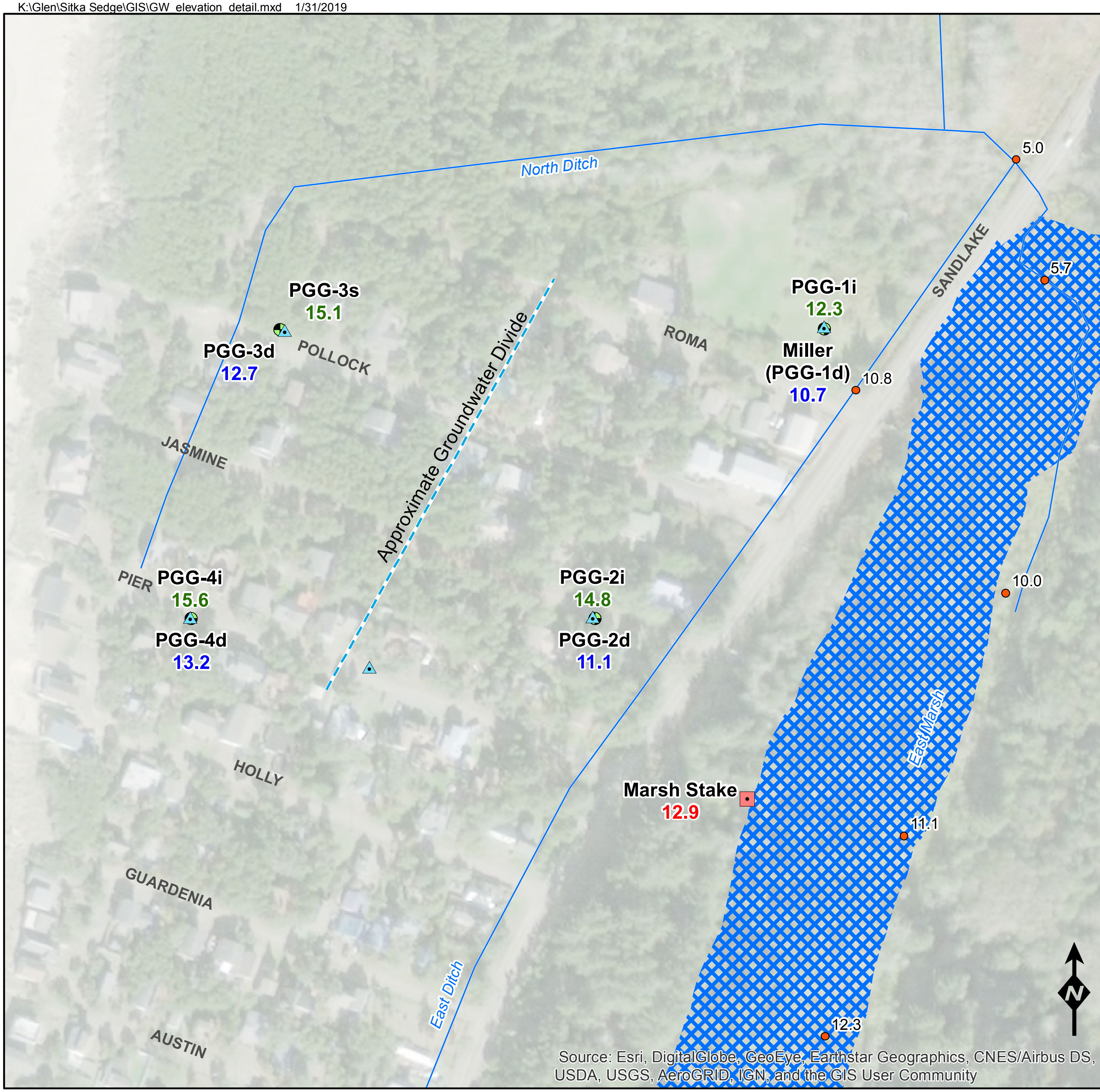
Figure 5-4a

Water-Level Elevations 3/1/2018

Recent Significant Precipitation

Sitka Sedge Natural Area

PGG



This figure shows the elecation of water levels at selected groundwater and surface water monitoring points. Groundwater will flow from areas of higher water levels to lower water levels. The water levels shown here were measured in winter conditions (seasonally high water table), but with little recent precipitation. The groundwater divide is inferred from observations shown on Figure 5-4c. The groundwater divide depicted represents the approximate location of a groundwater ridge which implies westward flow to the west of the line and eastward flow to the east of the line.

Water Level Elevation 3/20/2018

- Deep Aquifer
- Shallow Aquifer
- Surface Water
- Marsh Survey Elevations (4/2018)

0 Feet 200

Figure 5-4b

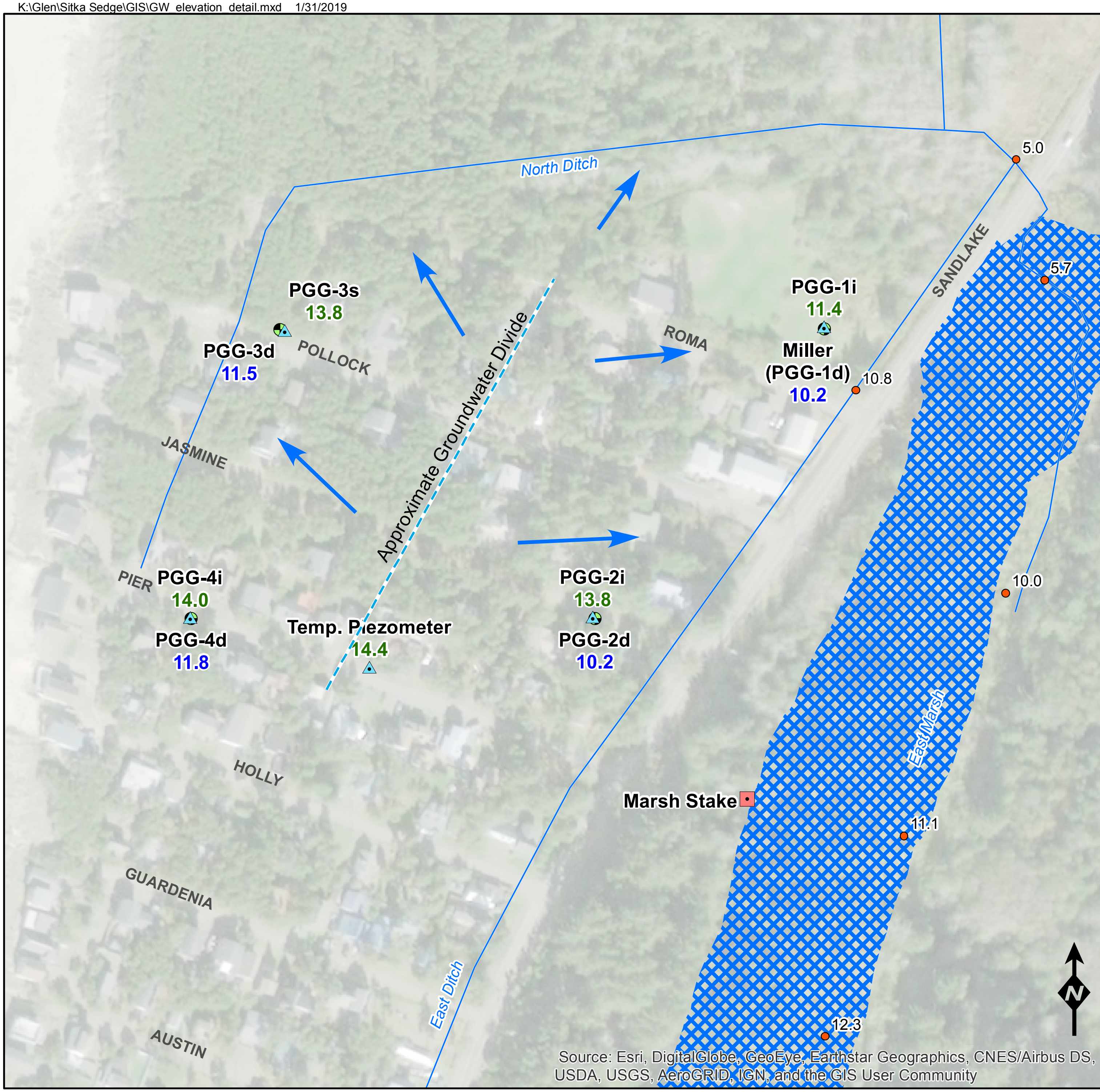
Water-Level Elevations 3/20/2018

Without Recent Significant Precipitation

Sitka Sedge Natural Area

PGG

K:\Glen\Sitka Sedge\GIS\GW_elevation_detail.mxd 1/31/2019



This figure shows the elecation of water levels at selected groundwater and surface water monitoring points. Groundwater will flow from areas of higher water levels to lower water levels. The water levels shown here were measured concurrent with the measurement of water levels at a termporary piezometer on Pier Avenue. This water level snapshot documented the presence of a groundwater divide in the shallow aquifer. The groundwater divide depicted represents the approximate location of a groundwater ridge which implies westward flow to the west of the line and eastward flow to the east of the line.

Water Level Elevation
5/21/2018

- Deep Aquifer
- Shallow Aquifer
- Surface Water
- Marsh Survey Elevations (4/2018)
- Expected Directions of Shallow Aquifer Groundwater Flow (Approximate)

0 Feet 200

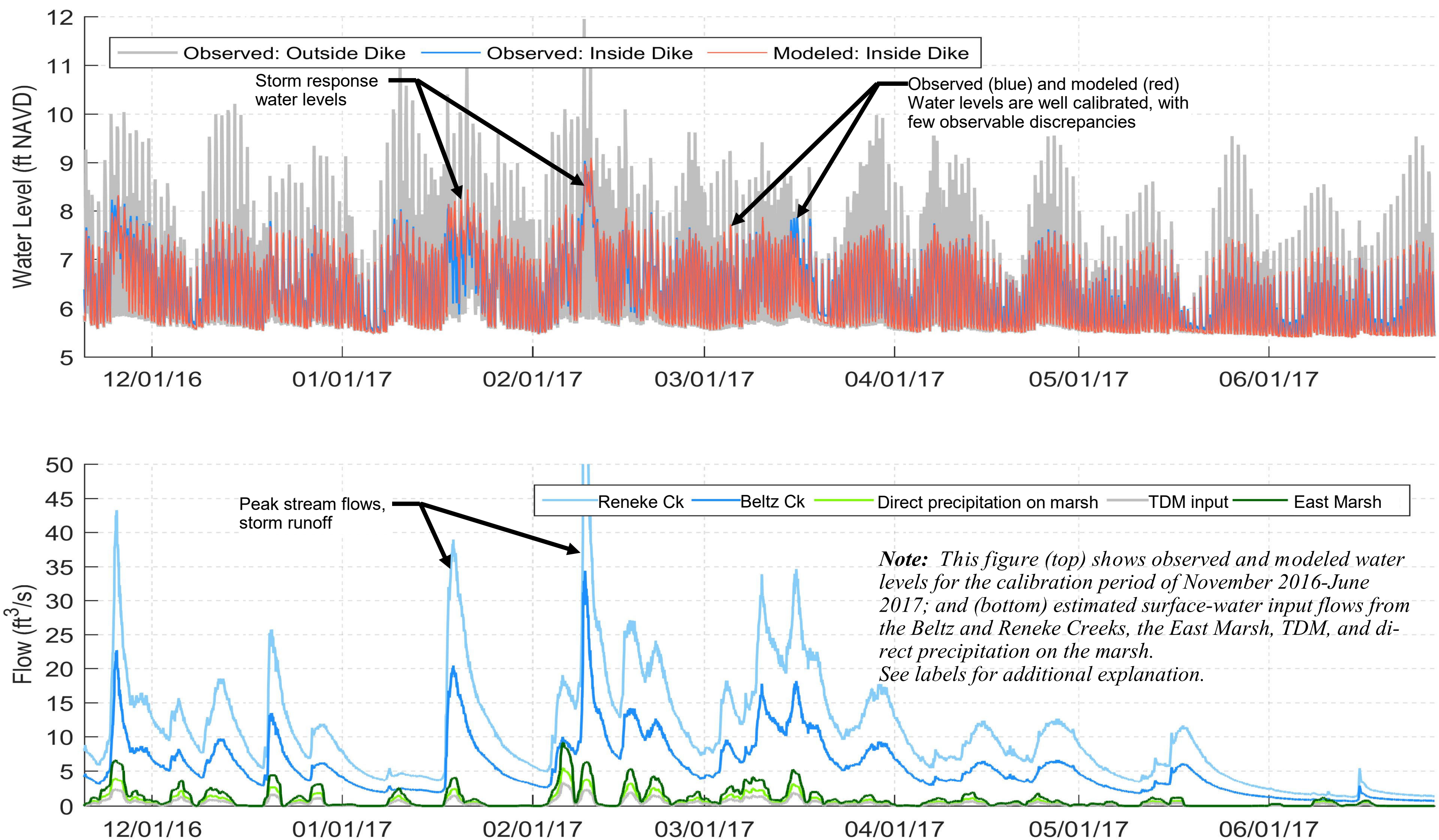
Figure 5-4c

Water-Level Elevations 5/21/2018

Demonstrates Presence of Groundwater Divide

Sitka Sedge
Natural Area

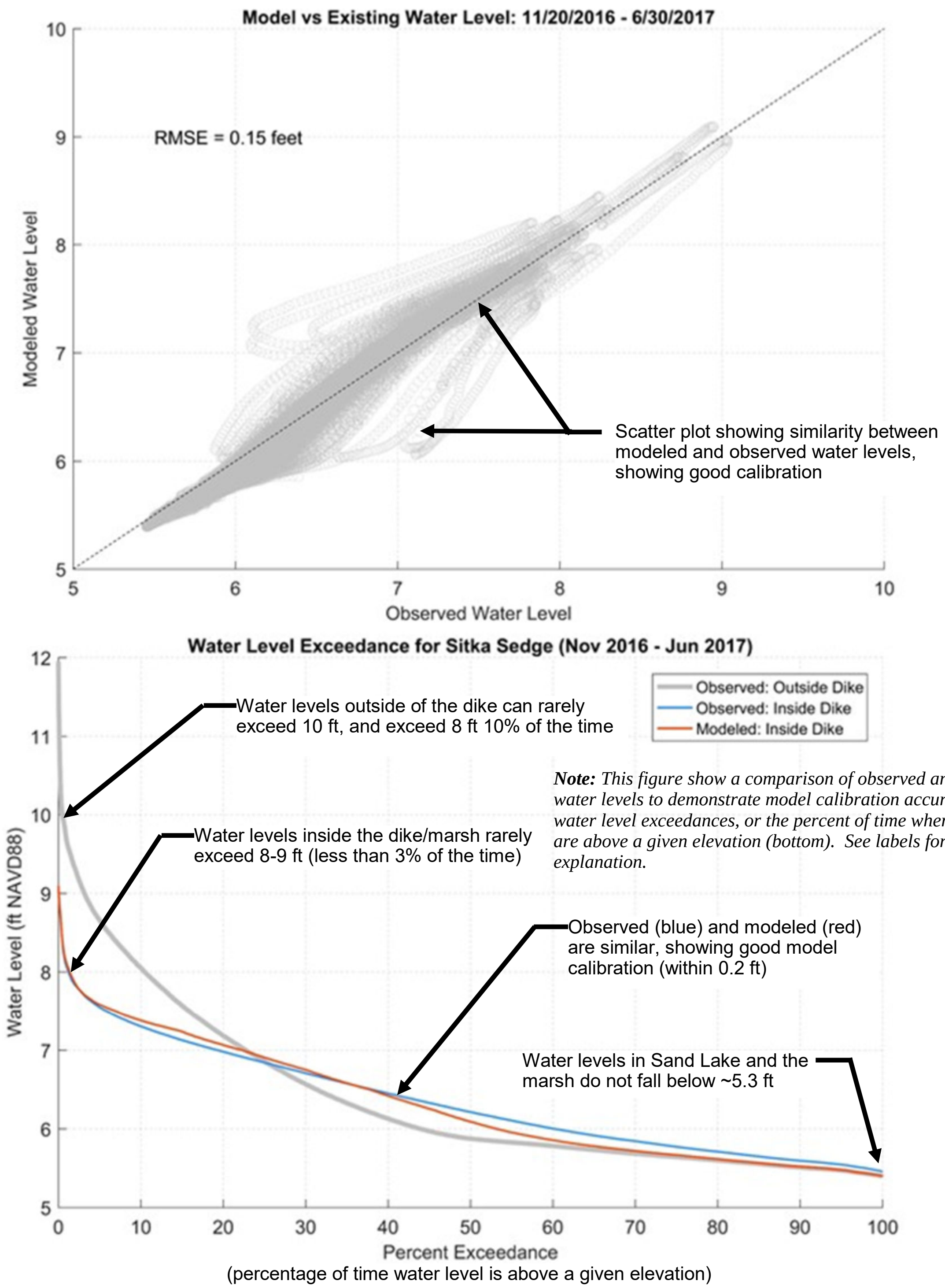
PGG



SOURCE: ESA surface water model. Runoff values were scaled based on precipitation measured at Tillamook and runoff measured at the USGS Tucca Creek

Figure 6-1
Comparison of Observed and Modeled Water Levels and Estimated Surface-water Input Flows for the 2016-2017 Model Calibration Period

Sitka Sedge Natural Area



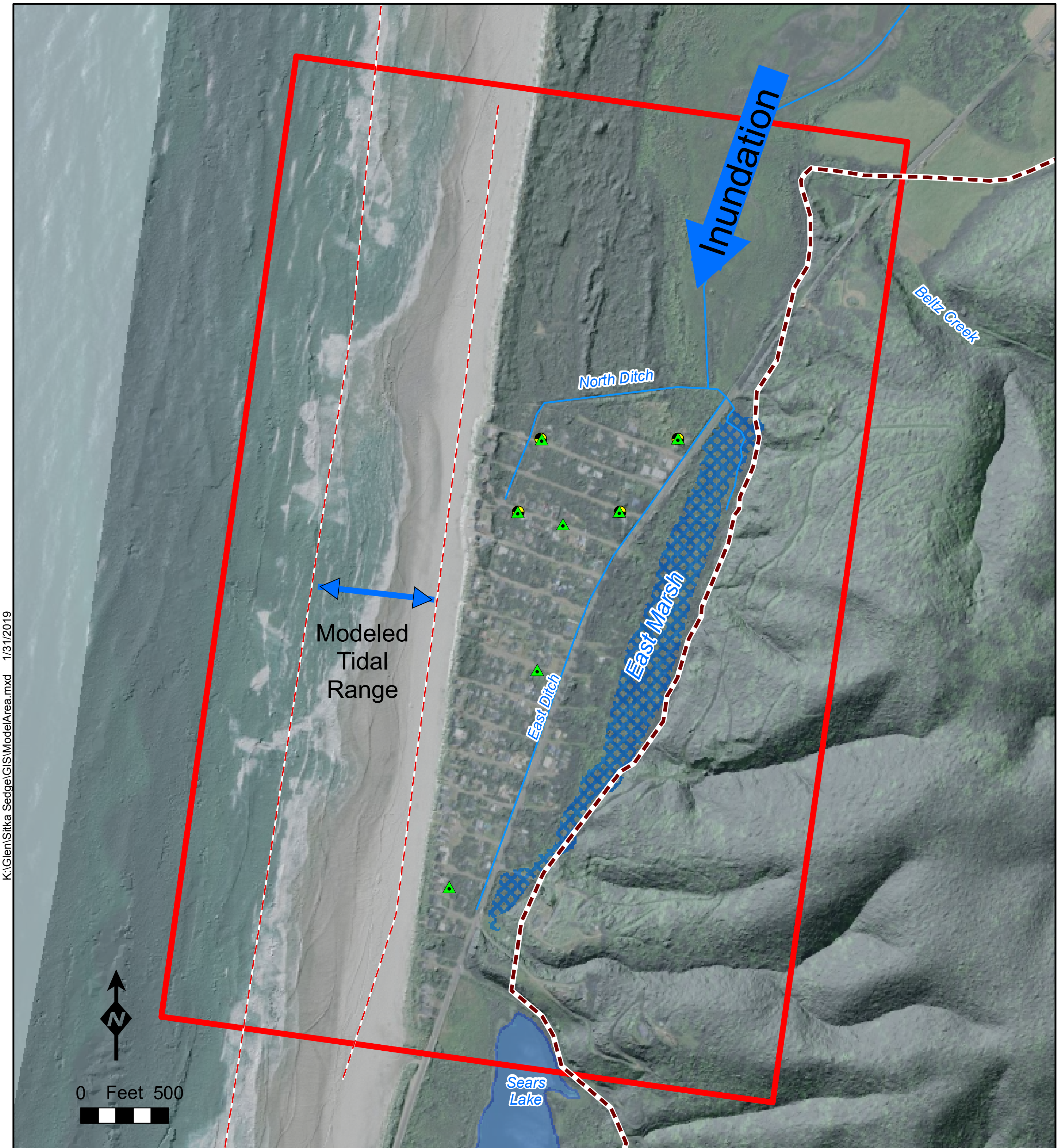
Note: *This figure show a comparison of observed and modeled water levels to demonstrate model calibration accuracy (top) and water level exceedances, or the percent of time when water levels are above a given elevation (bottom). See labels for additional explanation.*

Source: ESA Surface-water Model. Observed water level data provided by PgG.

Figure 6-2 Comparison of Observed and Modeled Water Levels and Water-Level Exceedance Percentages

Sitka Sedge Natural Area

ESA



Calibration Targets

Deep Aquifer Well

Shallow Aquifer Well

Model Domain

Mapped Edge Of Bedrock

Figure 6-3

Groundwater Model Features

Sitka Sedge Natural Area

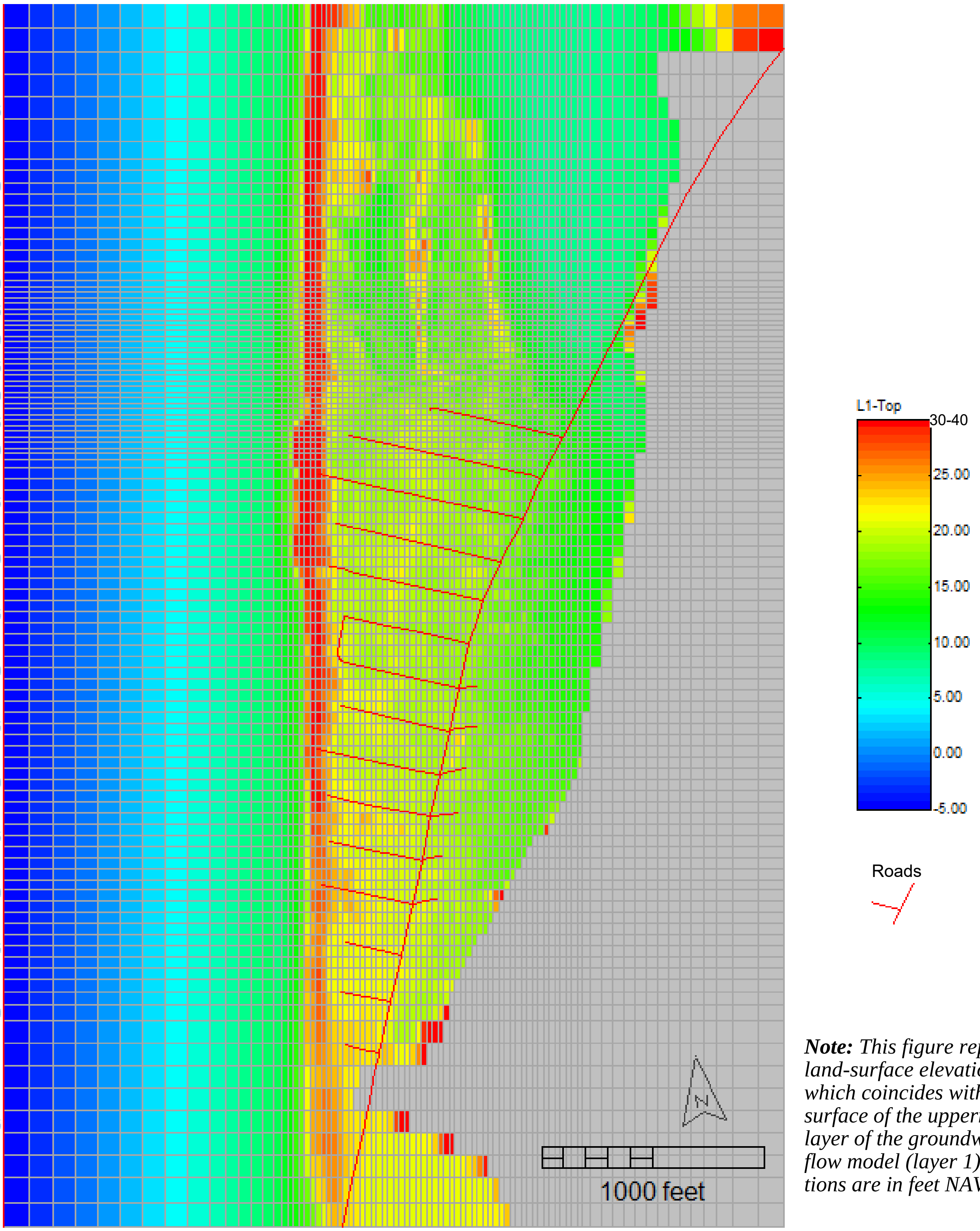
PGG

Note: *Groundwater modeling requires segmenting the modeling area into a "grid" of "cells". Cell size and dimensions are selected based on required resolution and expected areas of maximum hydrologic change. The grid depicted in this figure was designed to represent the groundwater flow system at a resolution appropriate for efficient numerical computation and adequate accuracy.*

Figure 6-4
Model Grid

Sitka Sedge Natural Area

PgG

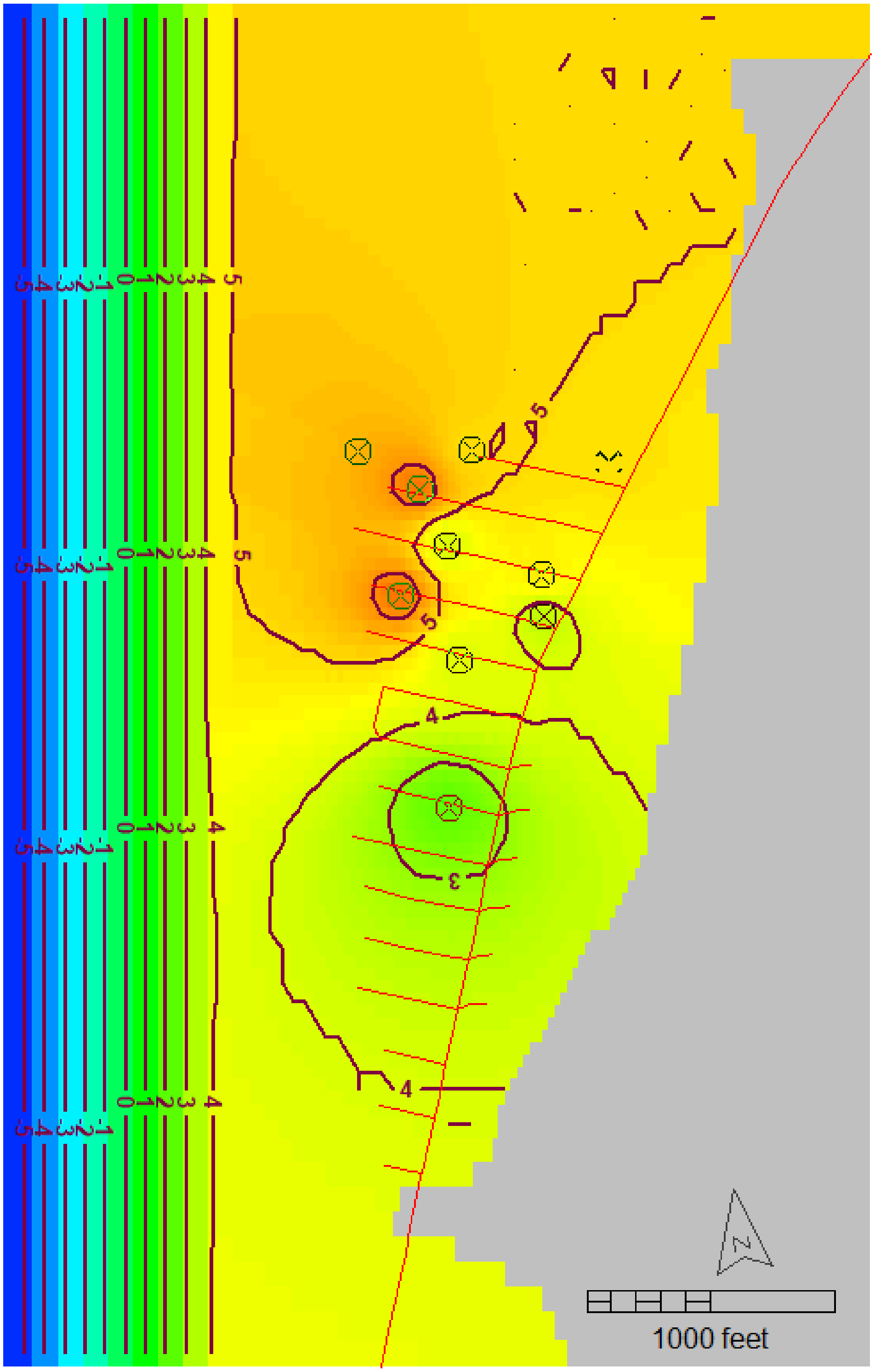


Note: *This figure represents land-surface elevation, which coincides with the top surface of the uppermost layer of the groundwater flow model (layer 1). Elevations are in feet NAVD88.*

Figure 6-5
Model Top Elevation

Sitka Sedge Natural Area

PgG



Note: This figure depicts the elevation of the top of the clay layer (aquitard) separating the shallow aquifer from the deep aquifer. Elevations are in feet NAVD88. The clay layer surface was interpolated from the data collected in the course of drilling 11 groundwater monitoring wells.

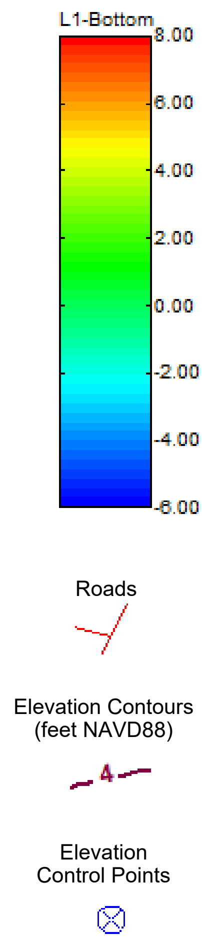
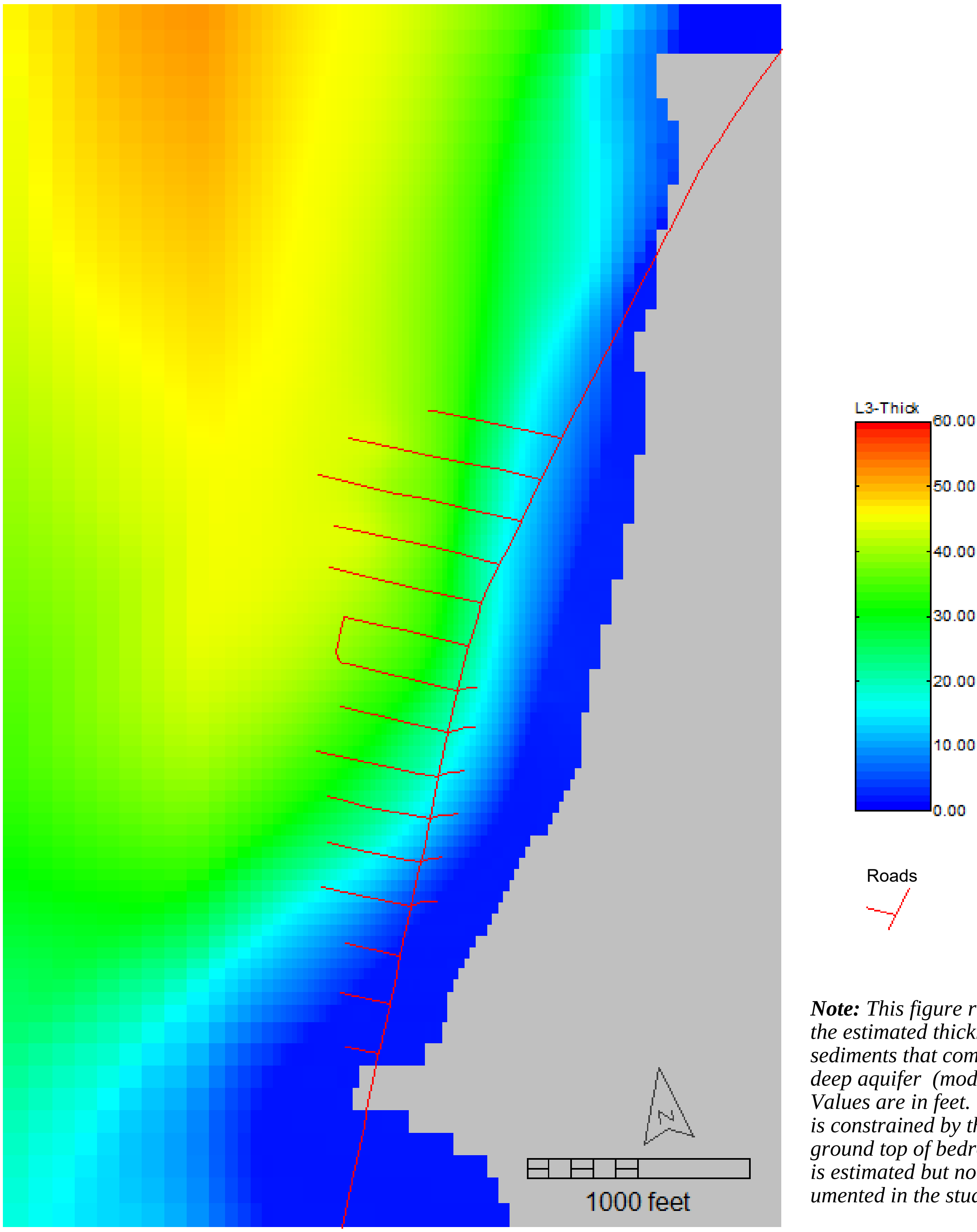


Figure 6-6
Layer 1 Bottom Elevation

Sitka Sedge Natural Area

PGG

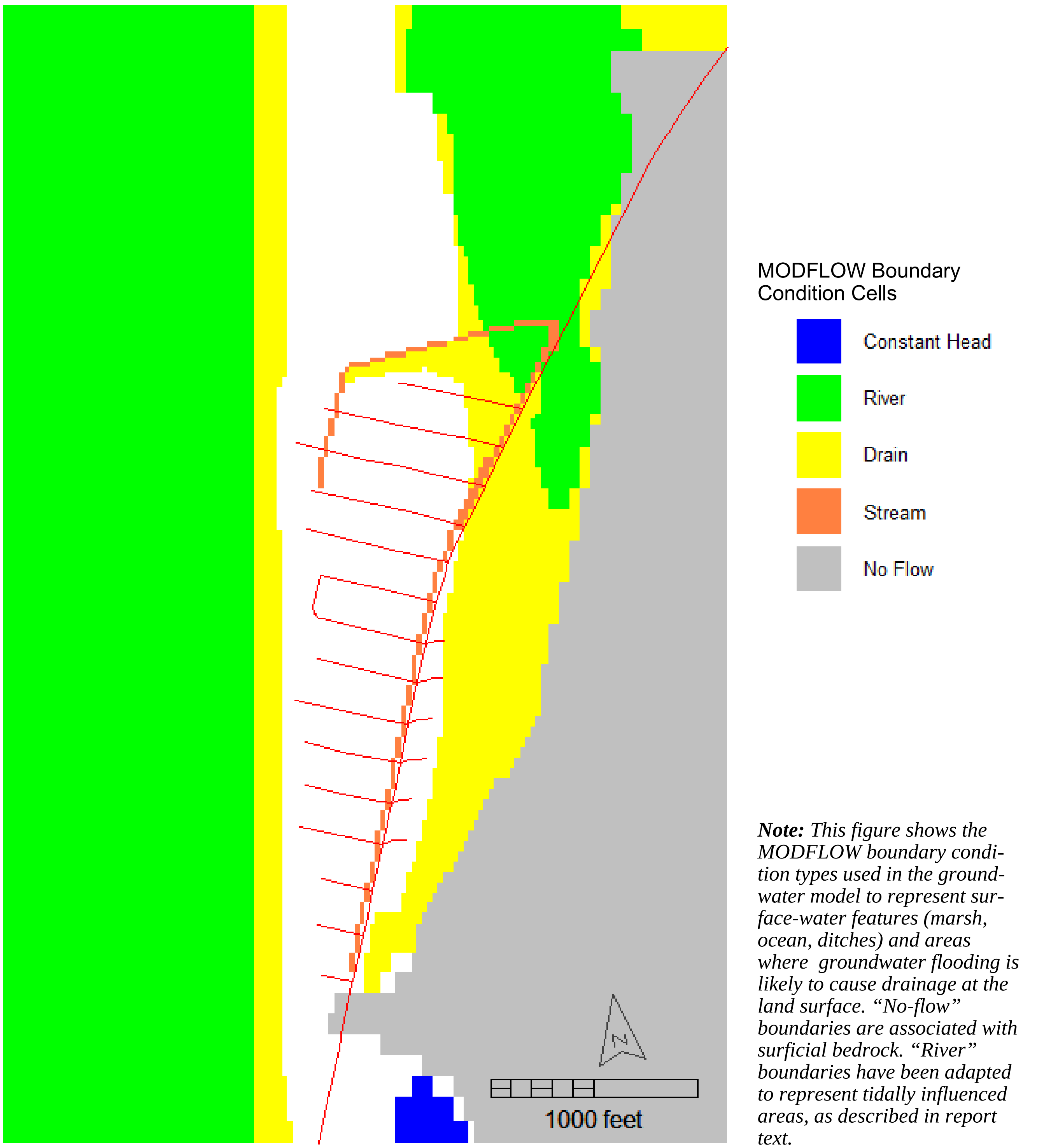


Note: *This figure represents the estimated thickness of the sediments that comprise the deep aquifer (model layer 3). Values are in feet. Thickness is constrained by the underground top of bedrock, which is estimated but not well documented in the study area.*

Figure 6-7
Layer 3 Thickness

Sitka Sedge Natural Area

PGG

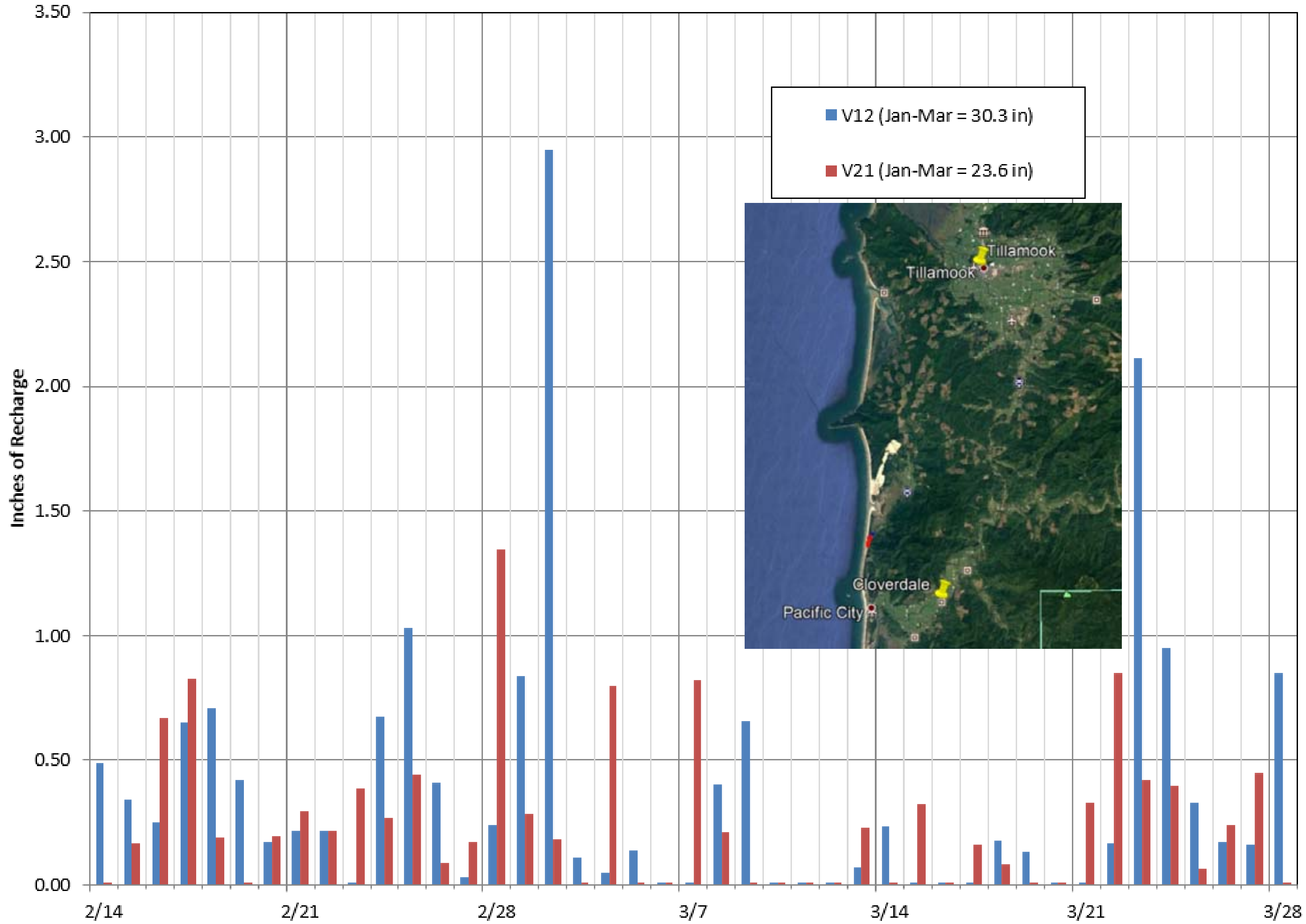


Note: *This figure shows the MODFLOW boundary condition types used in the groundwater model to represent surface-water features (marsh, ocean, ditches) and areas where groundwater flooding is likely to cause drainage at the land surface. "No-flow" boundaries are associated with surficial bedrock. "River" boundaries have been adapted to represent tidally influenced areas, as described in report text.*

Figure 6-8
Boundary Conditions in Layer 1

Sitka Sedge Natural Area

PGG

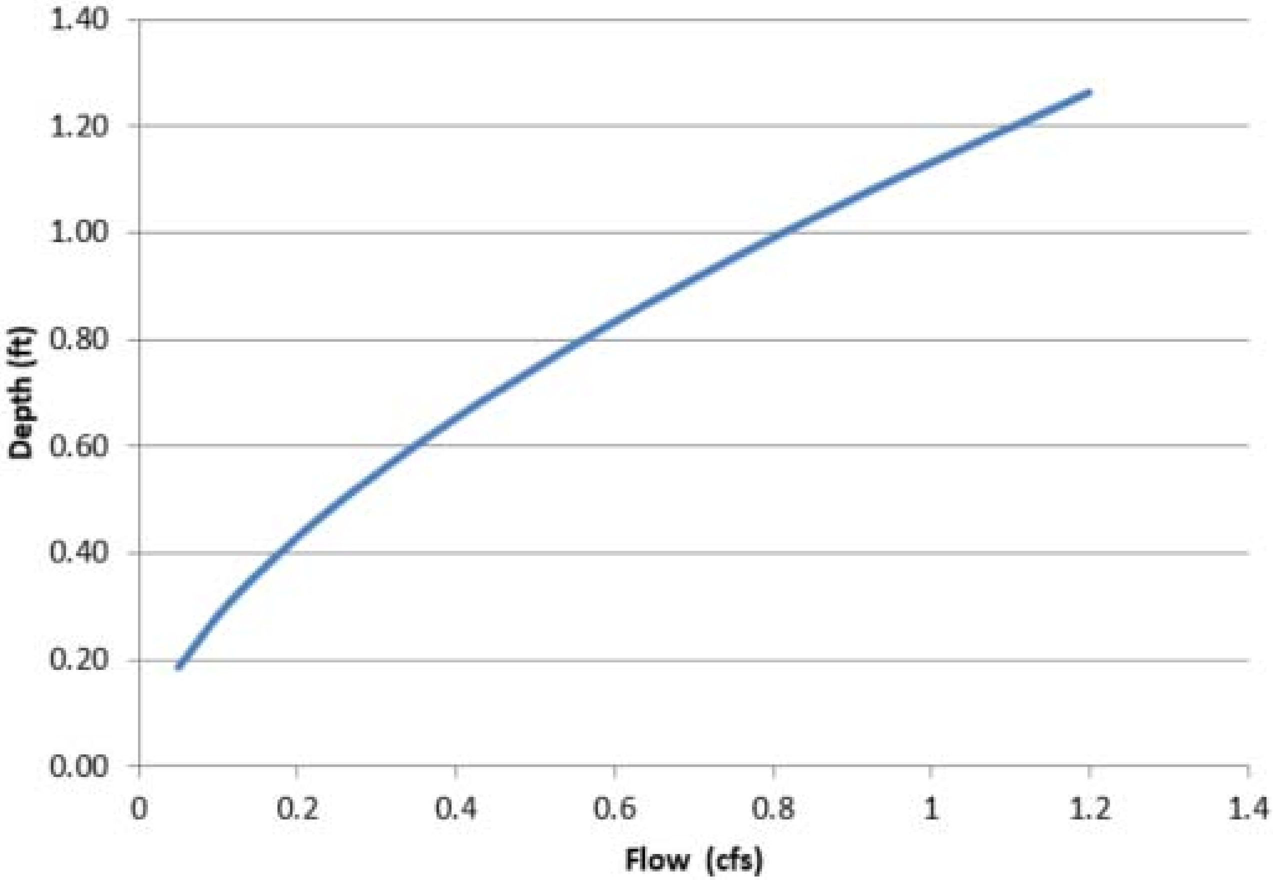


Note: *This figure shows the results of PGG recharge calculations using a proprietary version of the Deep Percolation Model (DPM). The values are based on precipitation at Tillamook (v12) and Cloverdale (v21). These two weather stations are assumed to provide a range of values for application to TDM. It is worth noting that for the 3-month period from January to March 2018, the DPM predicts 28% more recharge at Tillamook than at Cloverdale.*

Figure 6-9
Predicted 2018 Recharge Using Precipitation Data from Tillamook & Cloverdale

Sitka Sedge Natural Area

PGG

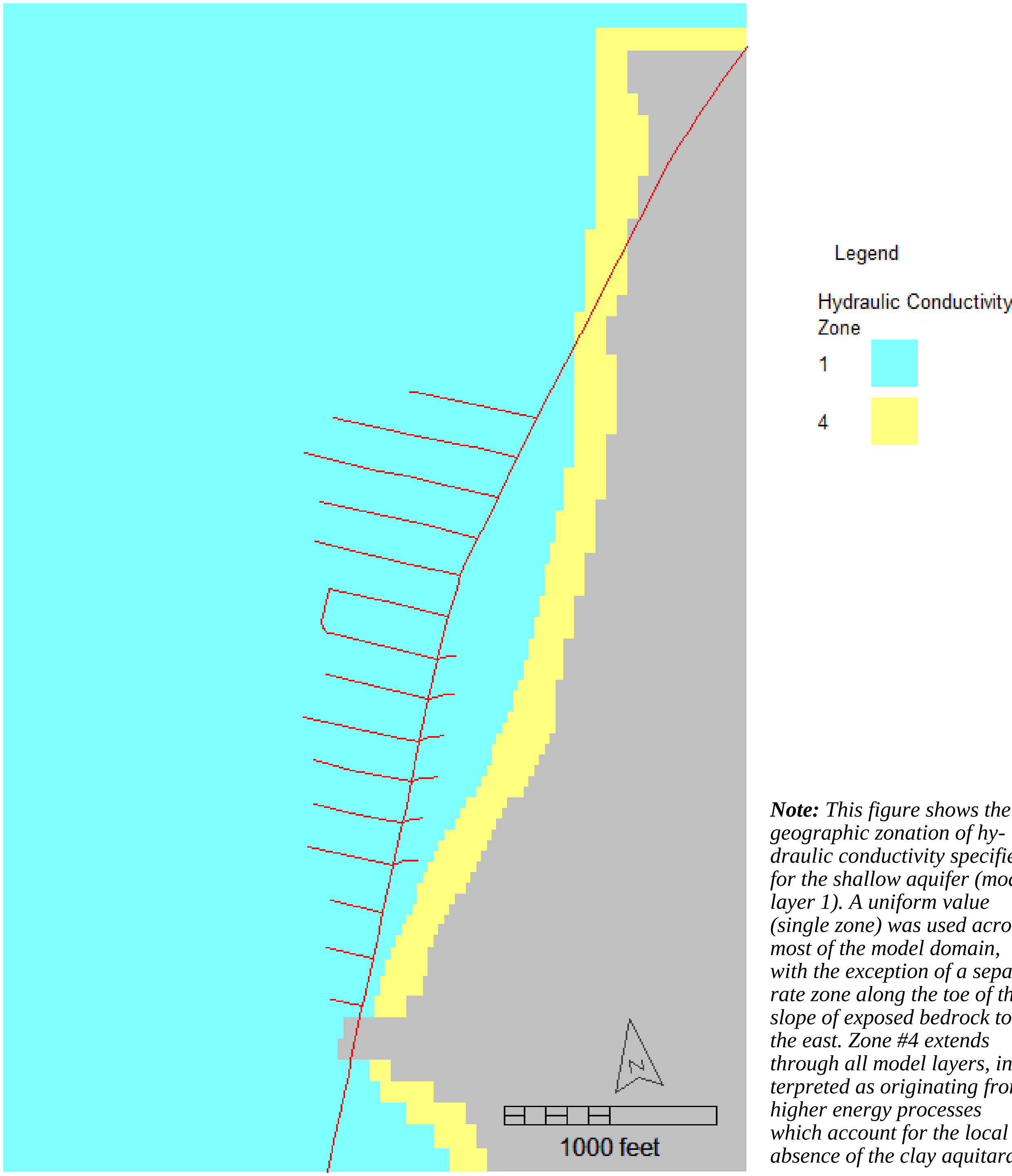


Note: *MODFLOW stream package assumptions for simplified stage/ discharge relationships used to represent TDM's East Ditch and North Ditch. This assumed relationship allows modeled water level in the ditches to vary with groundwater inflows (including going "dry" over portions of the ditch, if relevant). This approach is more realistic than other MODFLOW packages, which specify fixed water-level elevations for the ditches.*

Figure 6-10
Stream Package Relationship Between Flow and Depth

Sitka Sedge Natural Area

PgG

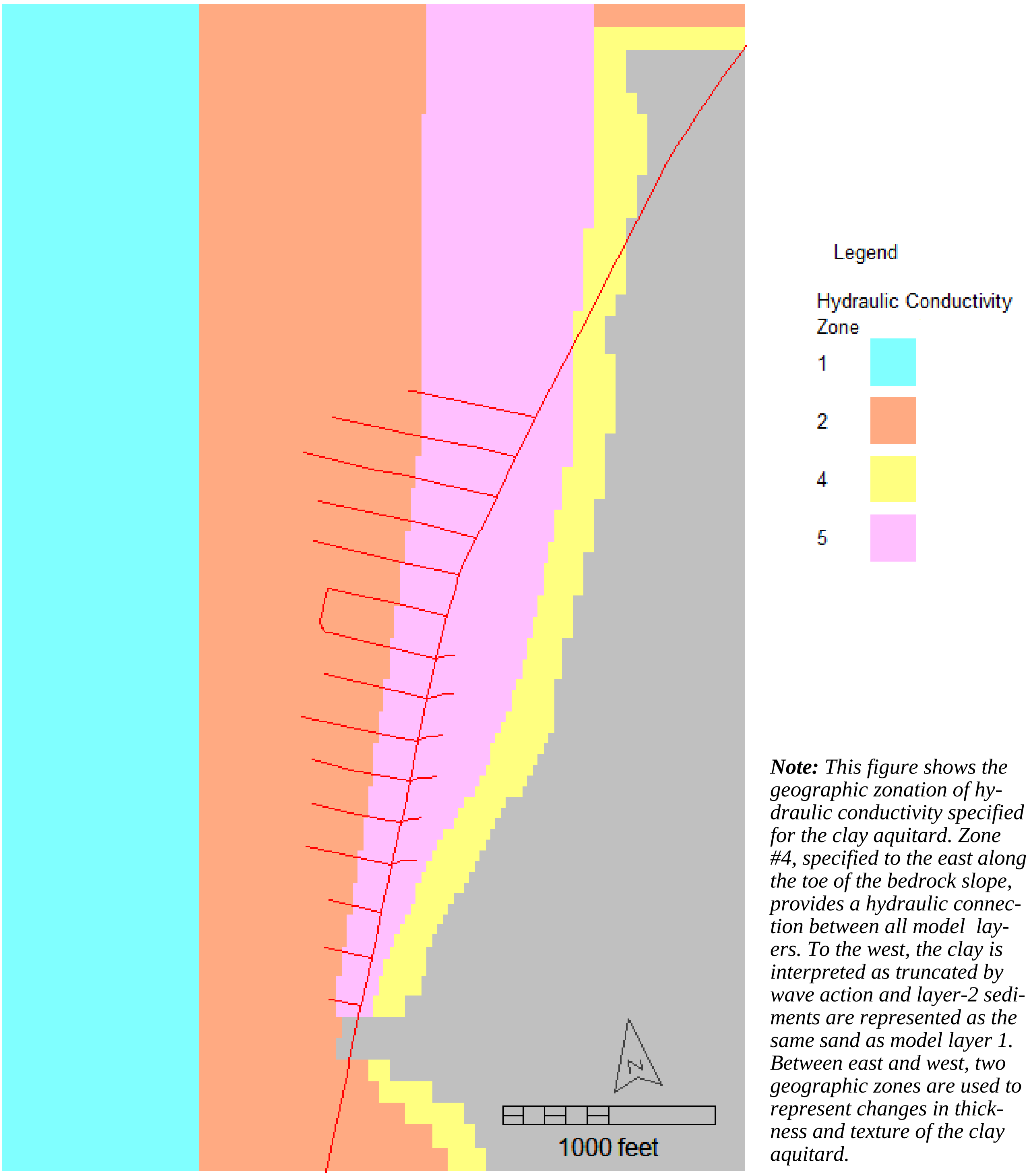


Note: *This figure shows the geographic zonation of hydraulic conductivity specified for the shallow aquifer (model layer 1). A uniform value (single zone) was used across most of the model domain, with the exception of a separate zone along the toe of the slope of exposed bedrock to the east. Zone #4 extends through all model layers, interpreted as originating from higher energy processes which account for the local absence of the clay aquitard.*

Figure 6-11
Hydraulic Conductivity Zones in Layer 1

Sitka Sedge Natural Area

PgG

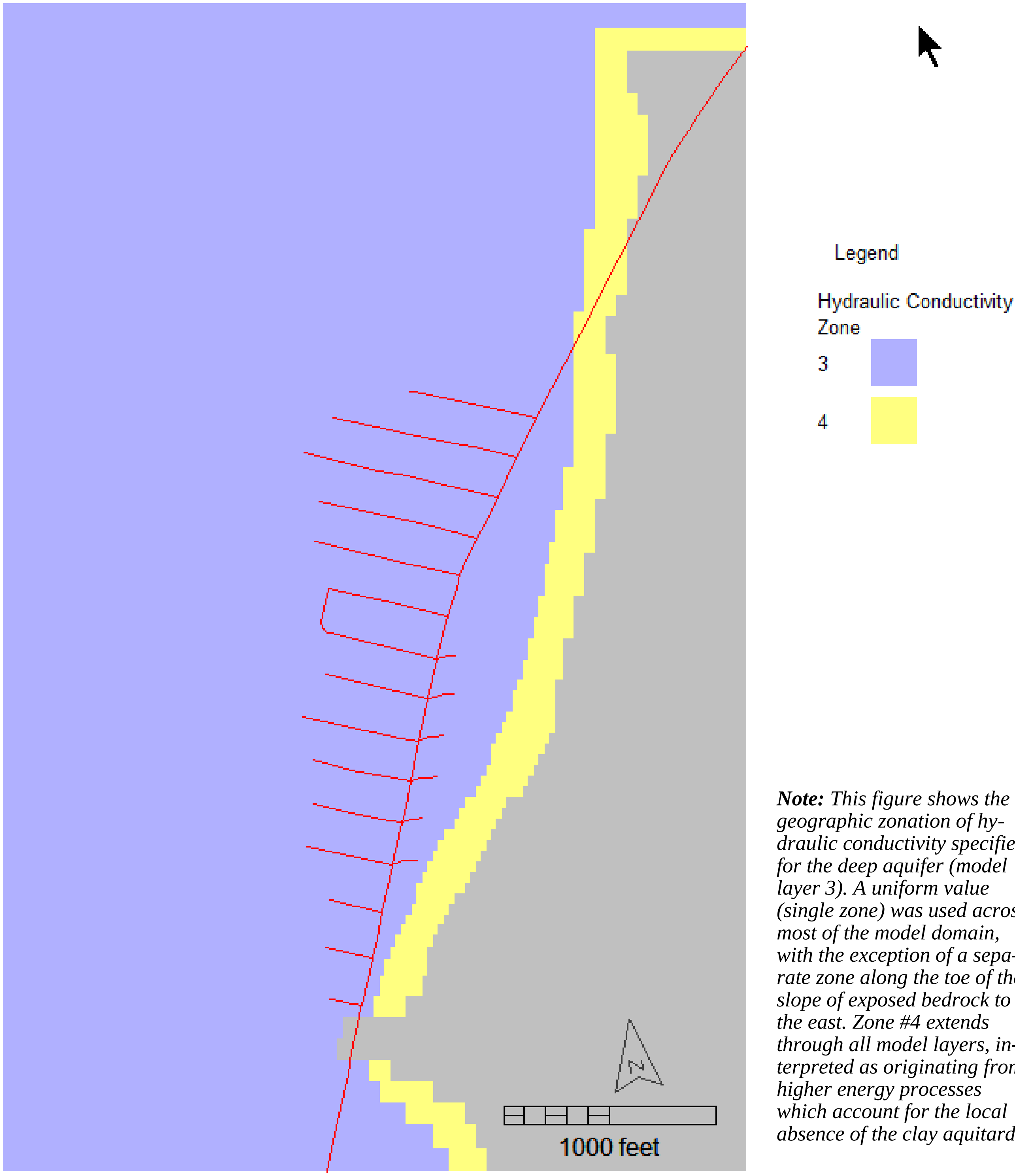


Note: *This figure shows the geographic zonation of hydraulic conductivity specified for the clay aquitard. Zone #4, specified to the east along the toe of the bedrock slope, provides a hydraulic connection between all model layers. To the west, the clay is interpreted as truncated by wave action and layer-2 sediments are represented as the same sand as model layer 1. Between east and west, two geographic zones are used to represent changes in thickness and texture of the clay aquitard.*

Figure 6-12
Hydraulic Conductivity Zones in Layer 2

Sitka Sedge Natural Area

PGG

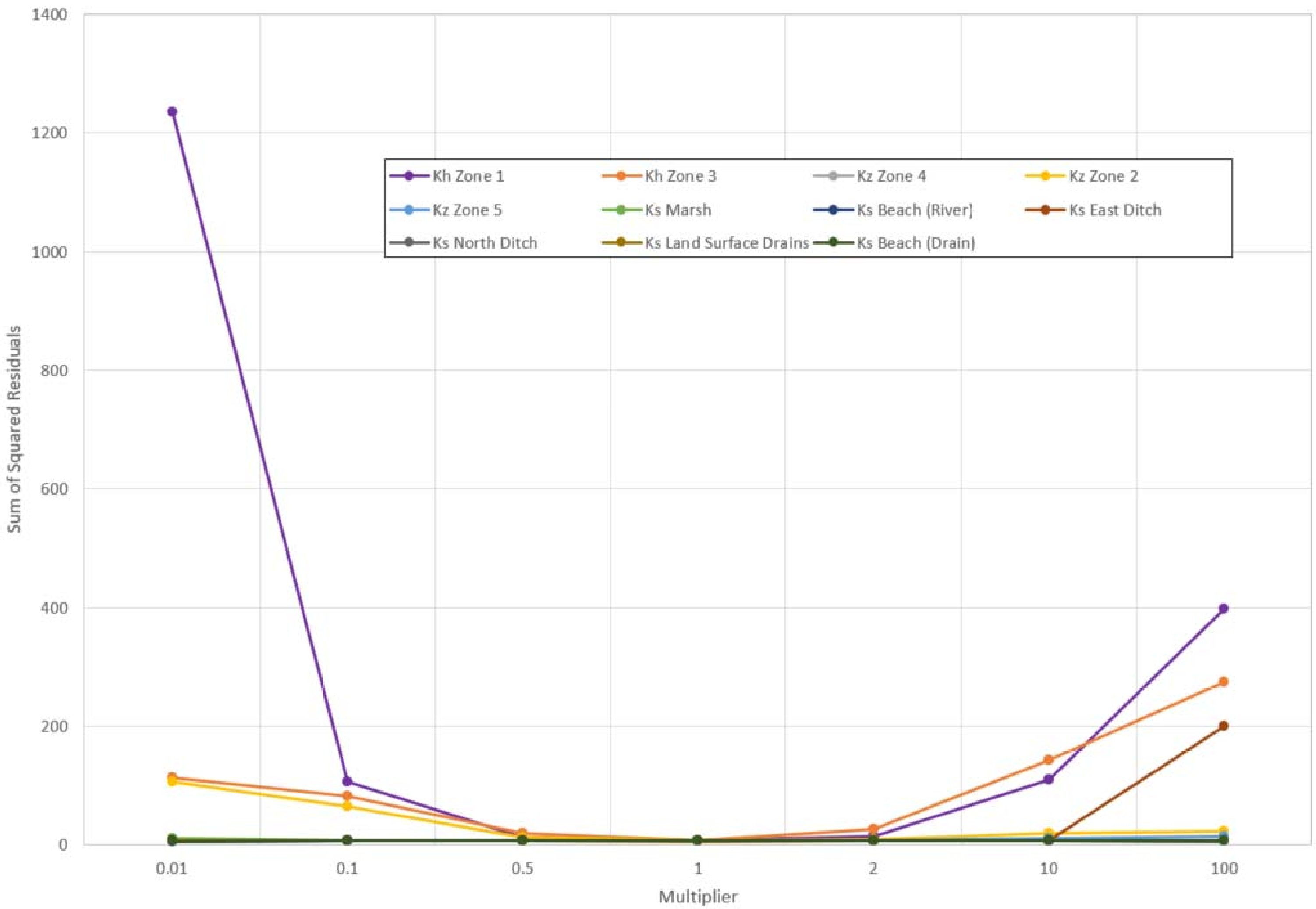


Note: *This figure shows the geographic zonation of hydraulic conductivity specified for the deep aquifer (model layer 3). A uniform value (single zone) was used across most of the model domain, with the exception of a separate zone along the toe of the slope of exposed bedrock to the east. Zone #4 extends through all model layers, interpreted as originating from higher energy processes which account for the local absence of the clay aquitard.*

Figure 6-13
Hydraulic Conductivity Zones in Layer 3

Sitka Sedge Natural Area

PgG

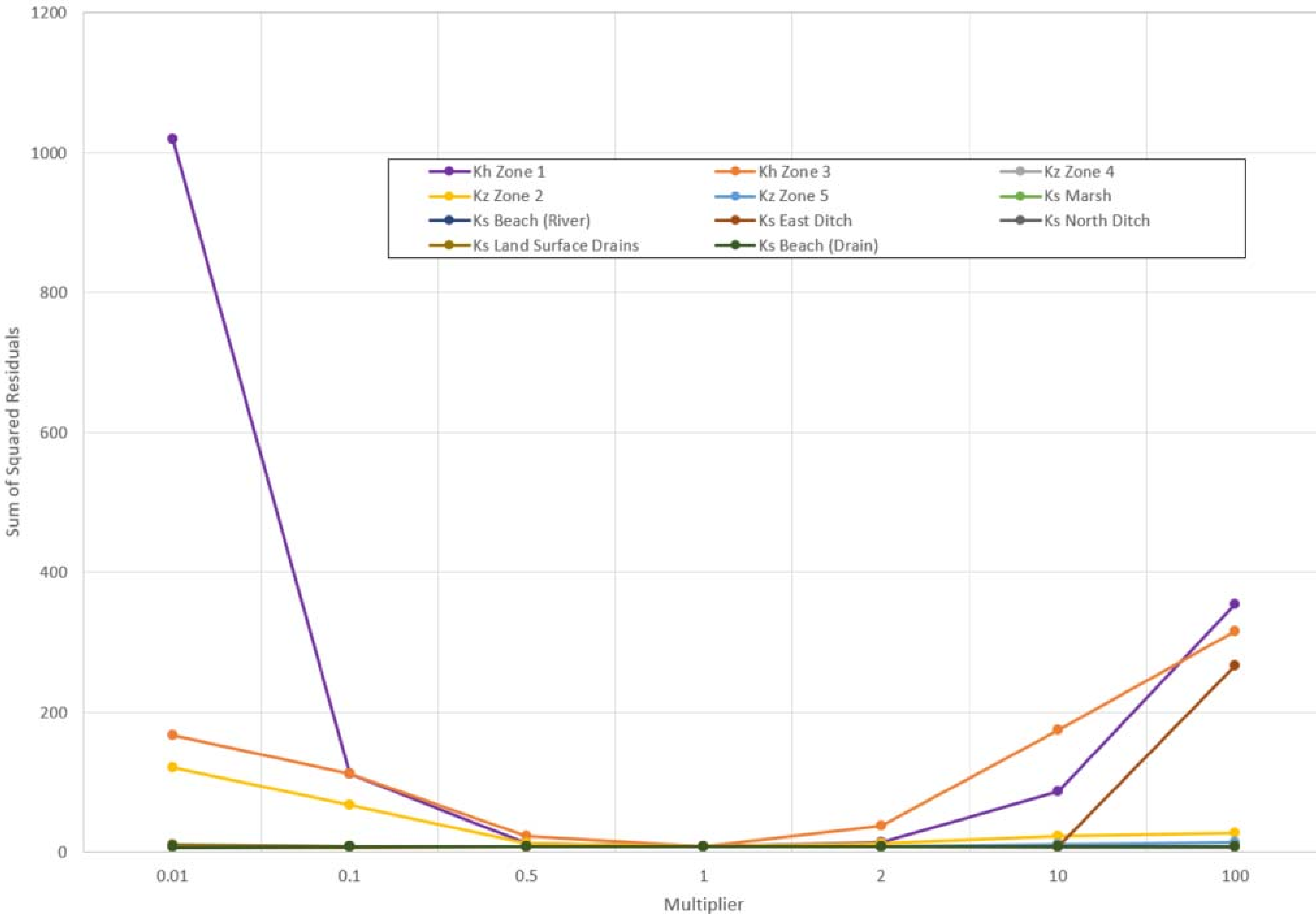


Note: *Sensitivity analysis was performed on key model parameters by varying values a range (0.01x thru 100x) and noting the effect on the sum of squared target water-level elevation residuals (SSR). A model is "sensitive" to parameters that substantially effect the SSR, and insensitive to parameters that have little effect on SSR. Along with the horizontal hydraulic conductivity (Kh) of Zones 1 & 3, the vertical hydraulic conductivity (Kz) of Zone 2, and the skin conductivity (Ks) of the East Ditch, the model proved highly sensitive to variation in groundwater recharge (not shown).*

Figure 6-14
Sensitivity Analysis for Sitka Steady-State Calibration to Tillamook Recharge (v12)

Sitka Sedge Natural Area

PgG



Note: *Sensitivity analysis was performed on key model parameters by varying values a range (0.01x thru 100x) and noting the effect on the sum of squared target water-level elevation residuals (SSR). A model is "sensitive" to parameters that substantially effect the SSR, and insensitive to parameters that have little effect on SSR. Along with the horizontal hydraulic conductivity (Kh) of Zones 1 & 3, the vertical hydraulic conductivity (Kz) of Zone 2, and the skin conductivity (Ks) of the East Ditch, the model proved highly sensitive to variation in groundwater recharge (not shown).*

Figure 6-15
Sensitivity Analysis for Sitka Steady-State Calibration to Cloverdale Recharge (v21)

PgG

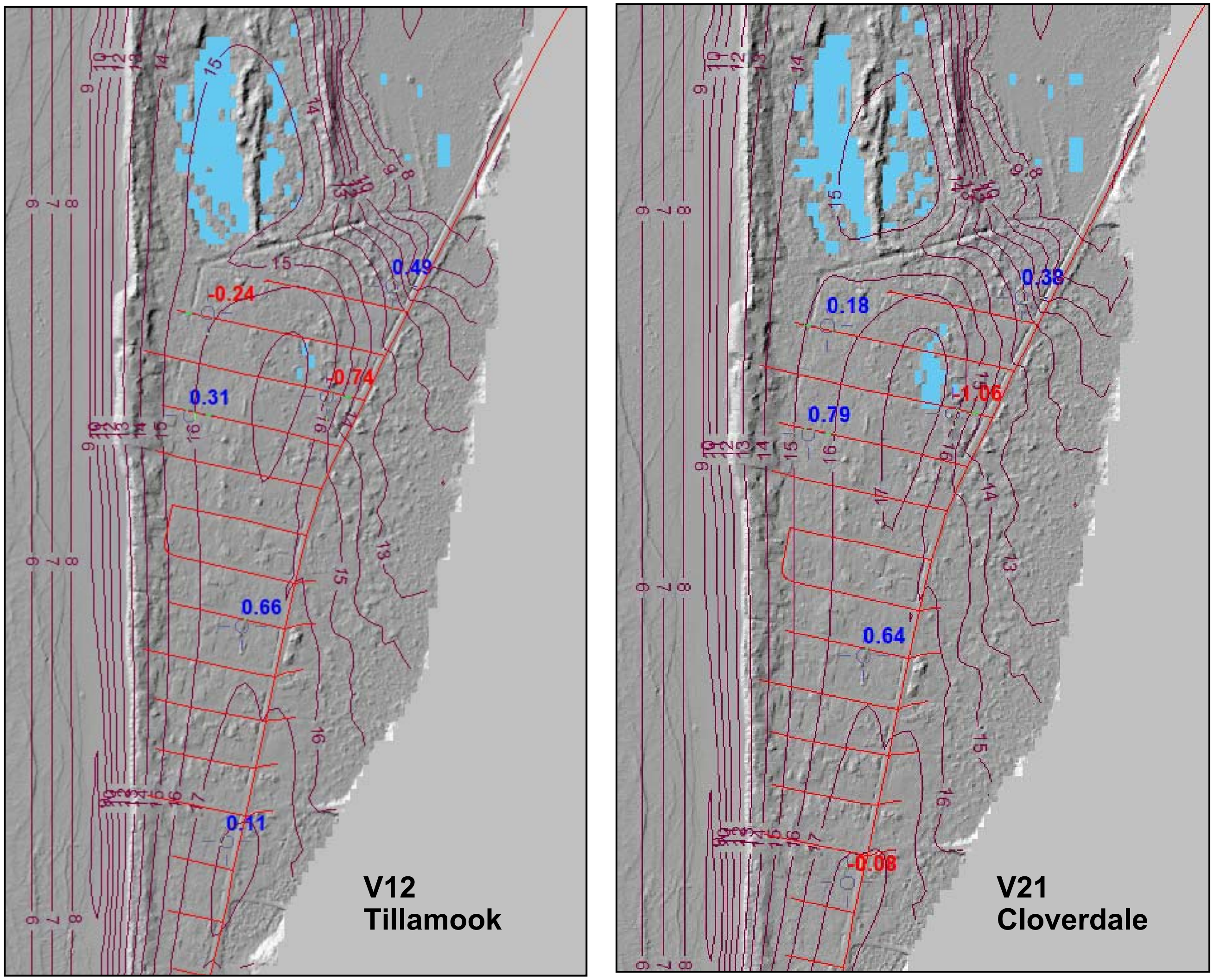
Sitka Sedge Natural Area

Note: *Using model v12 (Tillamook), PGG compared water levels in the shallow aquifer with inundation behind the beaver dam at 8.0 feet NAVD88.vs. an average Beltz Marsh tide of 6.07 feet NAVD88. Predicted changes in water-table elevation were < 0.01 feet below TDM.*

Figure 6-16
Predicted Steady-State Water-Level Rise Associated with Inundation Behind Beaver Dam

PGG

Sitka Sedge Natural Area

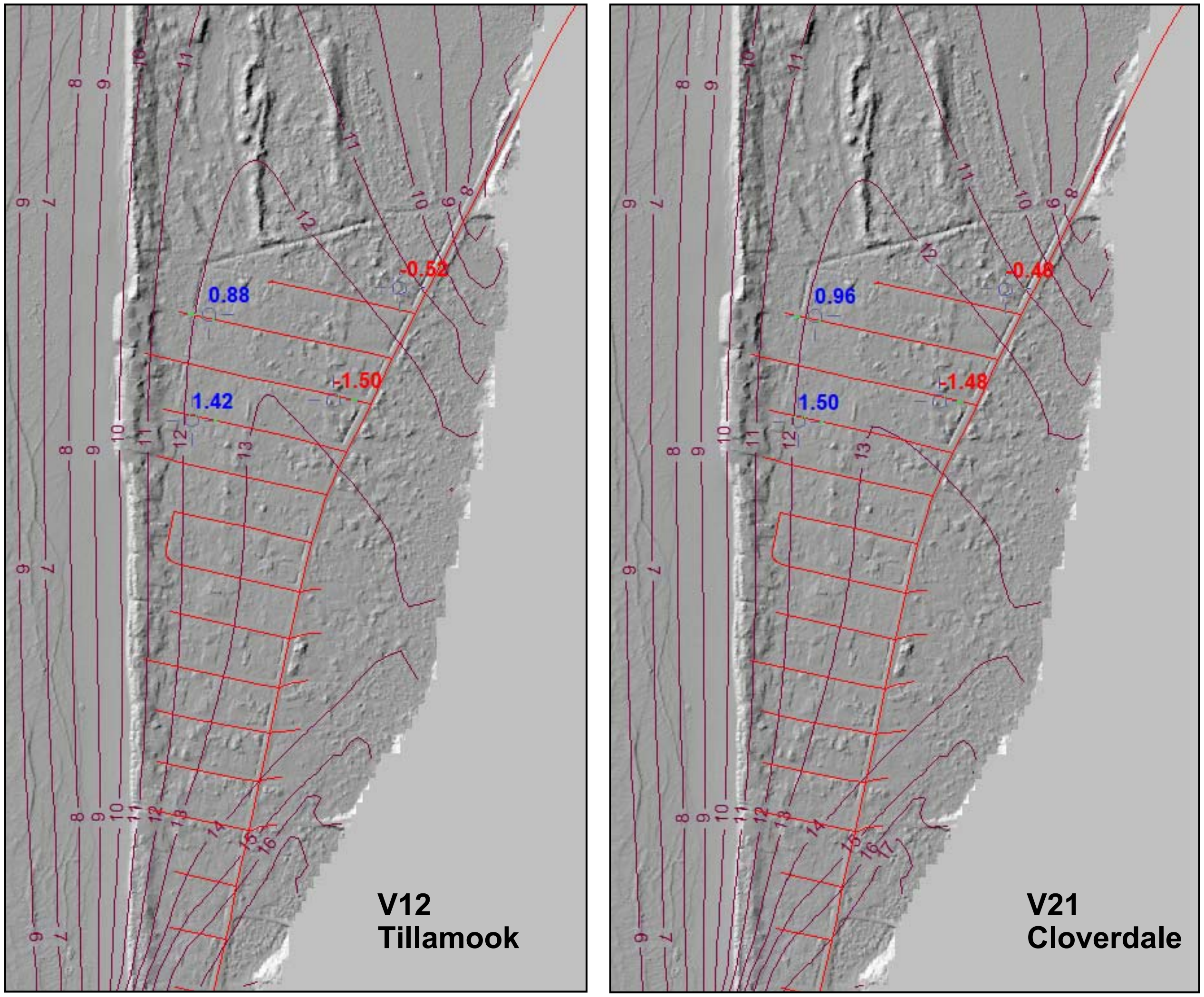


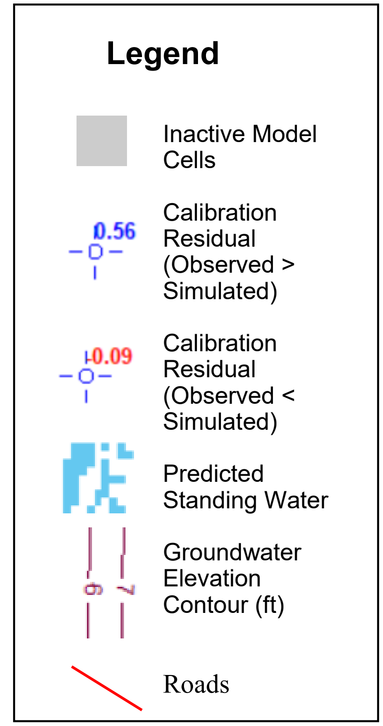
***Note**: Steady-state calibration predictions of Shallow Aquifer groundwater level contours and calibration target residuals (observed minus simulated water-level elevations). Calibration also predicted areas of groundwater flooding (standing water). The calibrated model adequately predicted groundwater elevations measured during the data-collection period and reasonably predicted the occurrence of standing water. The calibrated model was later used to perform predictive simulations.*

Figure 6-17
Shallow Aquifer Head Residuals from Steady-State Calibrations

PgG

Sitka Sedge Natural Area



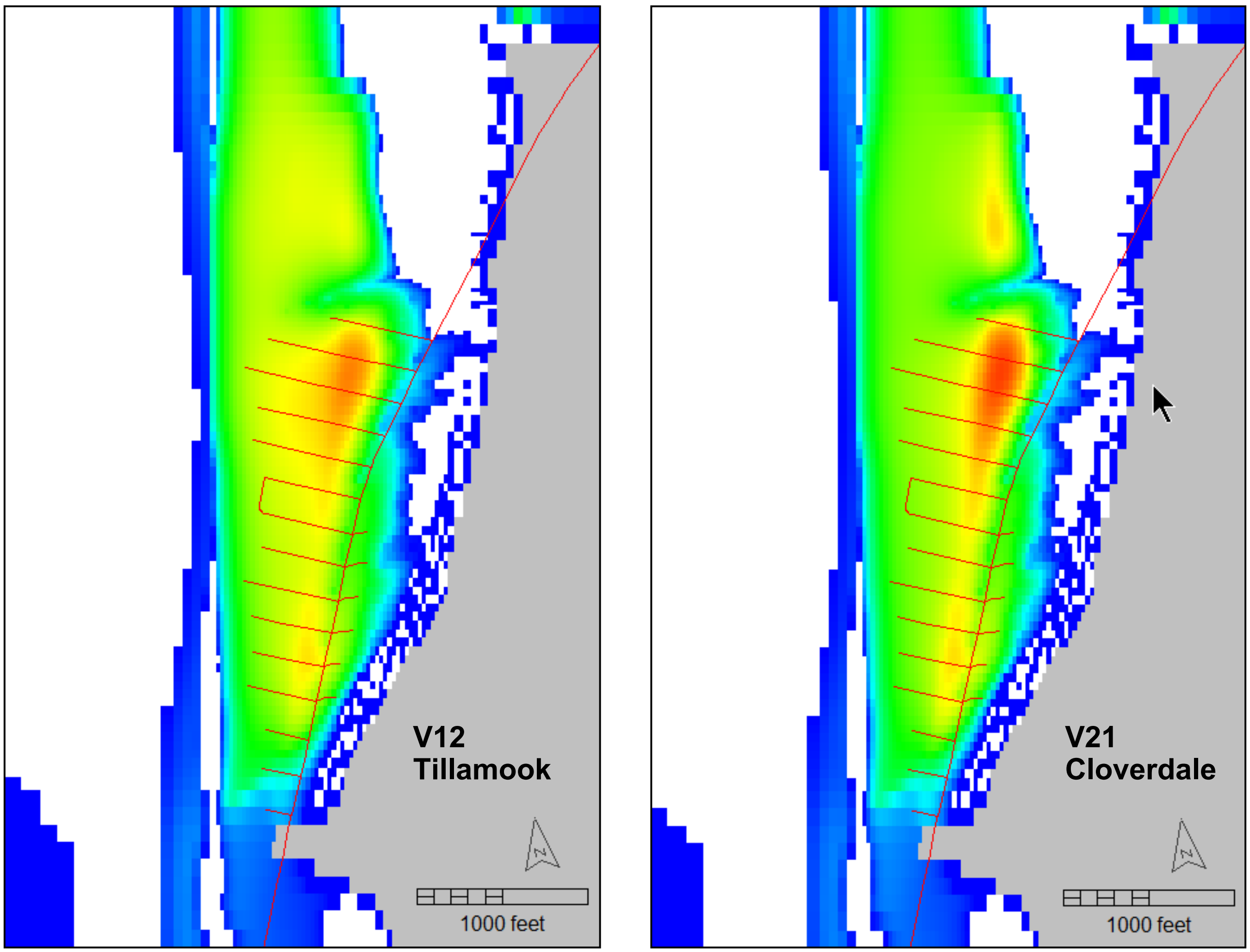


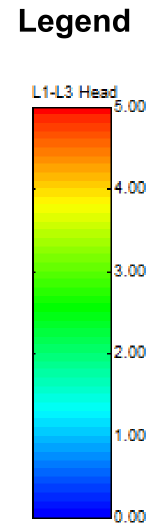
Note*: Steady-state calibration predictions of Shallow Aquifer groundwater level contours and calibration target residuals (observed minus simulated water-level elevations). Calibration also predicted areas of ground-water flooding (standing water). The cali-brated model adequately predicted ground-water elevations measured during the data-collection period. The calibrated model was later used to perform predictive simulations.*

Figure 6-18
Deep Aquifer Head Residuals from Steady-State Calibrations

Sitka Sedge Natural Area

PGG

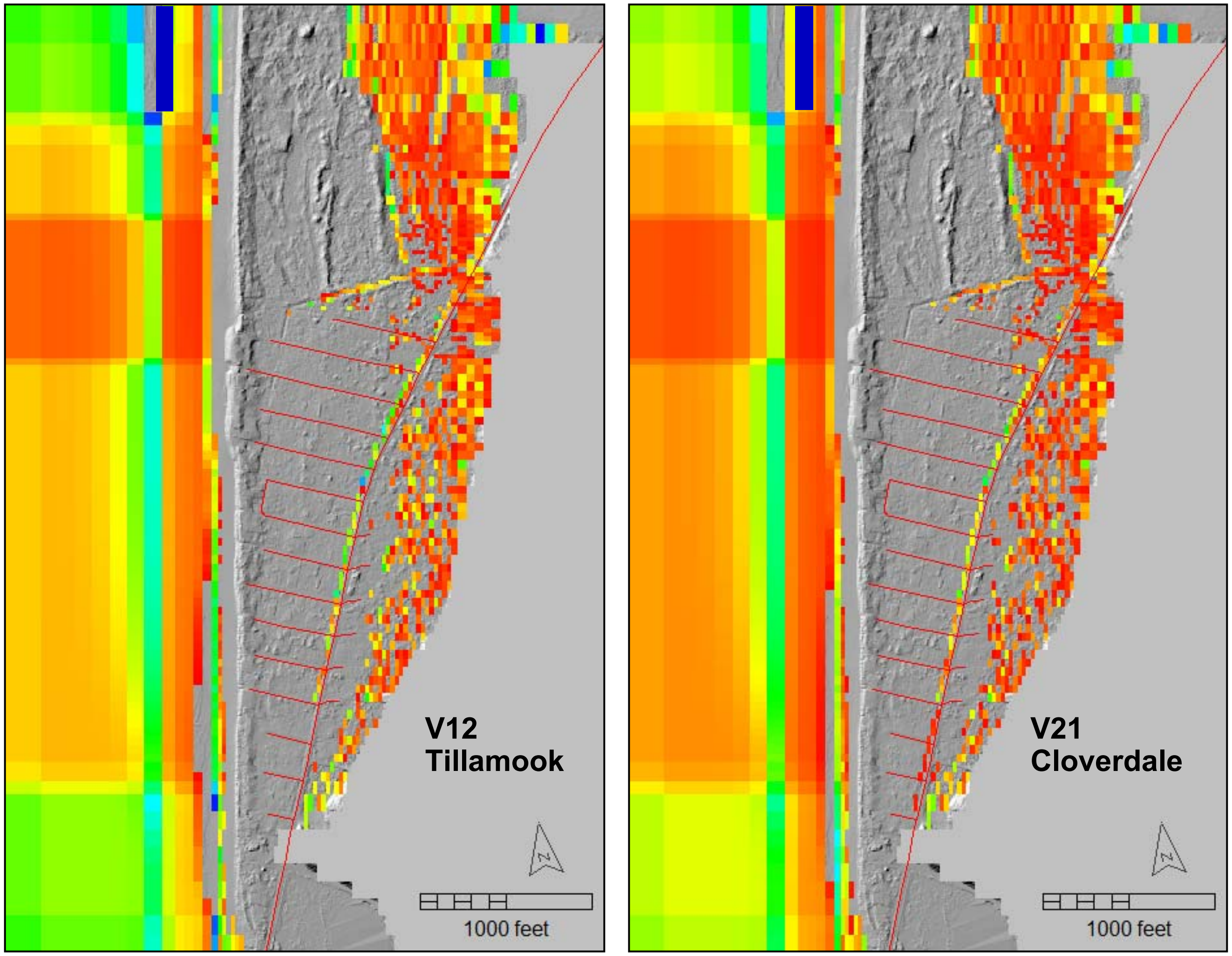


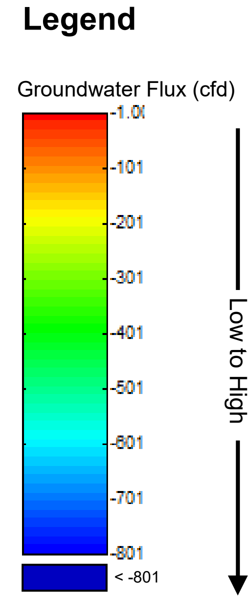


Note: *This figure shows the water-level elevation difference between the shallow and deep aquifers predicted during steady-state calibrations. Predicted values show overall good agreement with water-level differences measured in paired monitoring wells during the data collection period (2/16/18 thru 3/26/18). Color flood represents areas of downward vertical gradient whereas white model cells represent areas of upward vertical gradient (typical where groundwater discharges to surface-water features).*

Figure 6-19
Predicted Steady-State Water-Level Difference b/t Shallow and Deep Aquifers

Sitka Sedge Natural Area



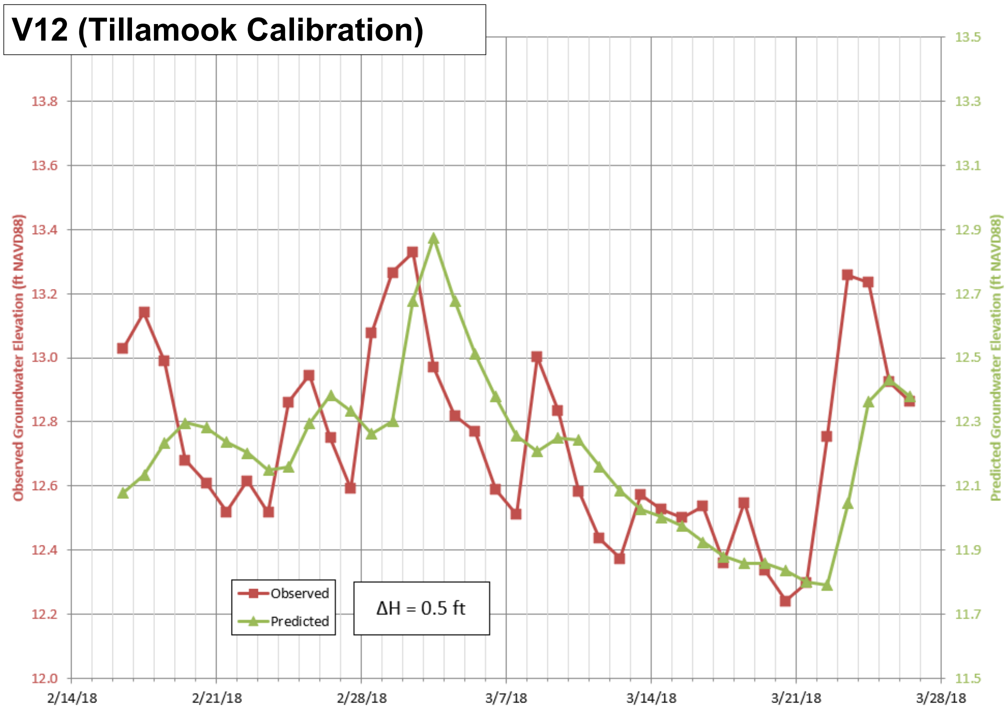


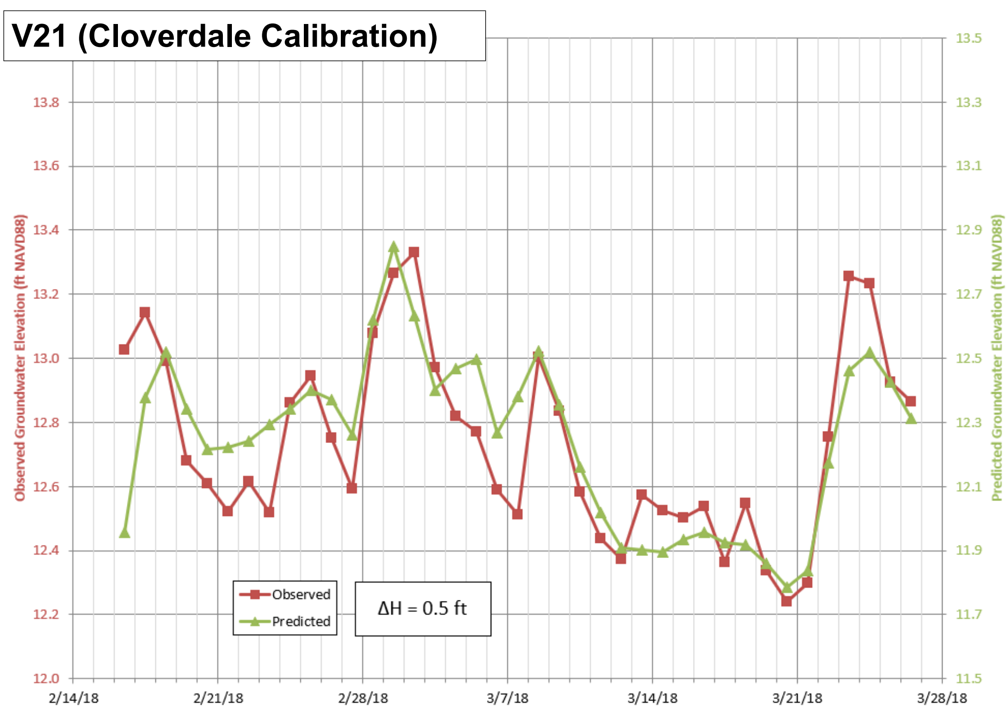
Note: *This figure shows the amount of groundwater discharge to model cells associated with surface-water boundary conditions as estimated by the calibrated steady-state models. MODFLOW uses negative values of groundwater flux to indicate groundwater discharge to surface-water features. Cells without color indicate no surface-water feature or seepage loss from surface-water feature. Values are in cubic feet per day (cfd). See Table 6-5 for summary water budgets.*

Figure 6-20
Predicted Steady-State Groundwater Flux to Surface-Water Features

Sitka Sedge Natural Area

PgG





Note:
This figure compares observed to model-predicted groundwater elevation hydrographs in Monitoring Well PGG-1i over the 38-day calibration period.

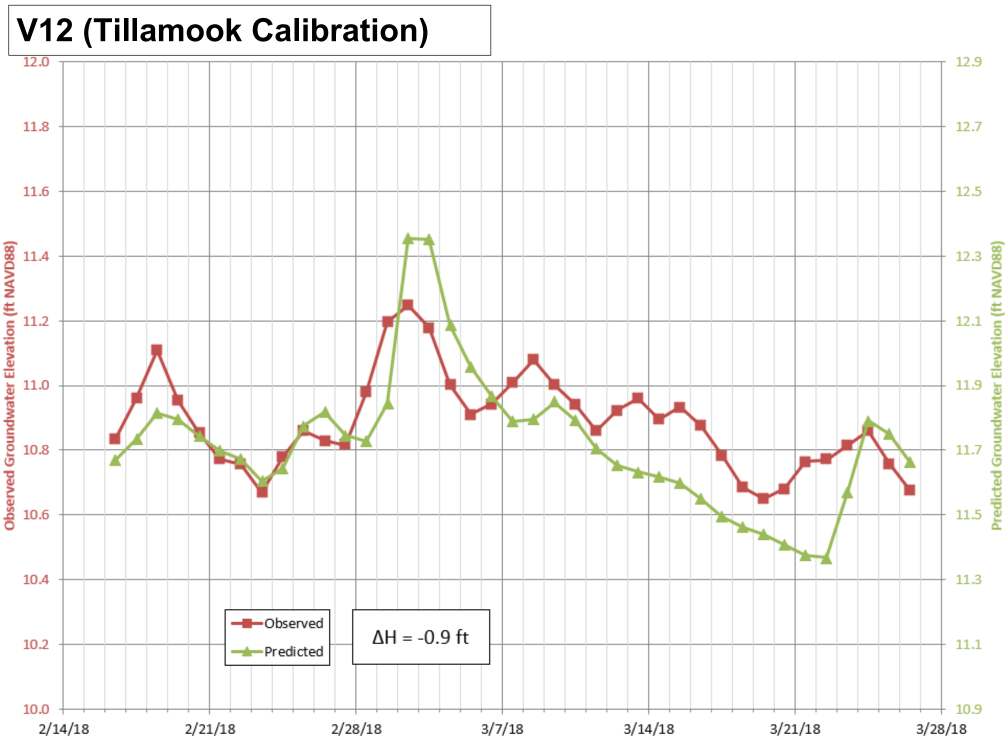
Differences in precipitation data between Tillamook and Cloverdale account for some of the differences in model predictions of groundwater level trends.

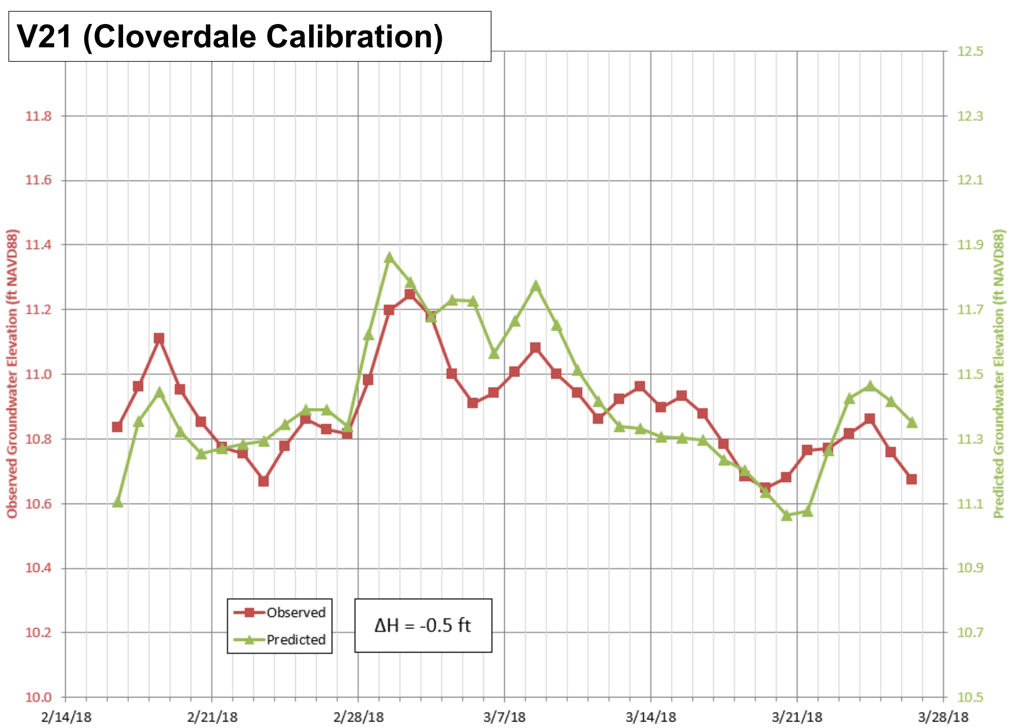
In contrast to steady-state calibration, transient calibration adjusts model parameters so that time-varying stresses (precipitation recharge or fluctuating tidal inundation) and corresponding groundwater level responses are well represented in the model. Transient calibration followed initial steady-state calibration.

Well locations are mapped on Figure 5-1.

Figure 6-21
Transient Calibration Results for Well PGG-1i (Shallow Aquifer)

Sitka Sedge Natural Area





Note:
This figure compares observed to model-predicted groundwater elevation hydrographs in Monitoring Well PGG-1d over the 38-day calibration period.

Differences in precipitation data between Tillamook and Cloverdale account for some of the differences in model predictions of groundwater level trends.

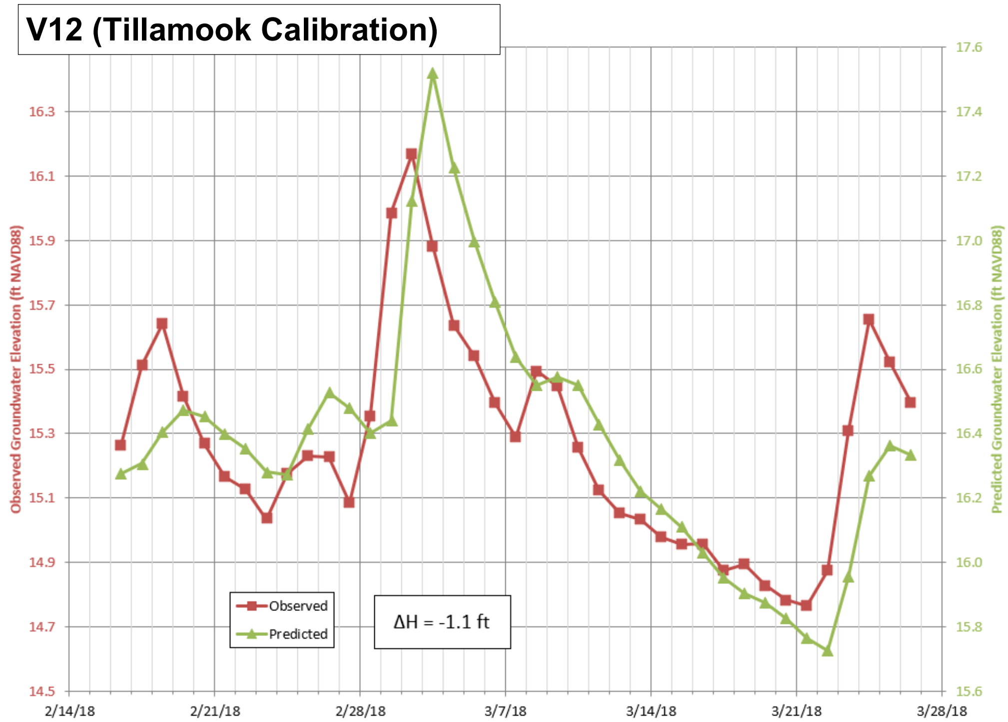
In contrast to steady-state calibration, transient calibration adjusts model parameters so that time-varying stresses (precipitation recharge or fluctuating tidal inundation) and corresponding groundwater level responses are well represented in the model. Transient calibration followed initial steady-state calibration.

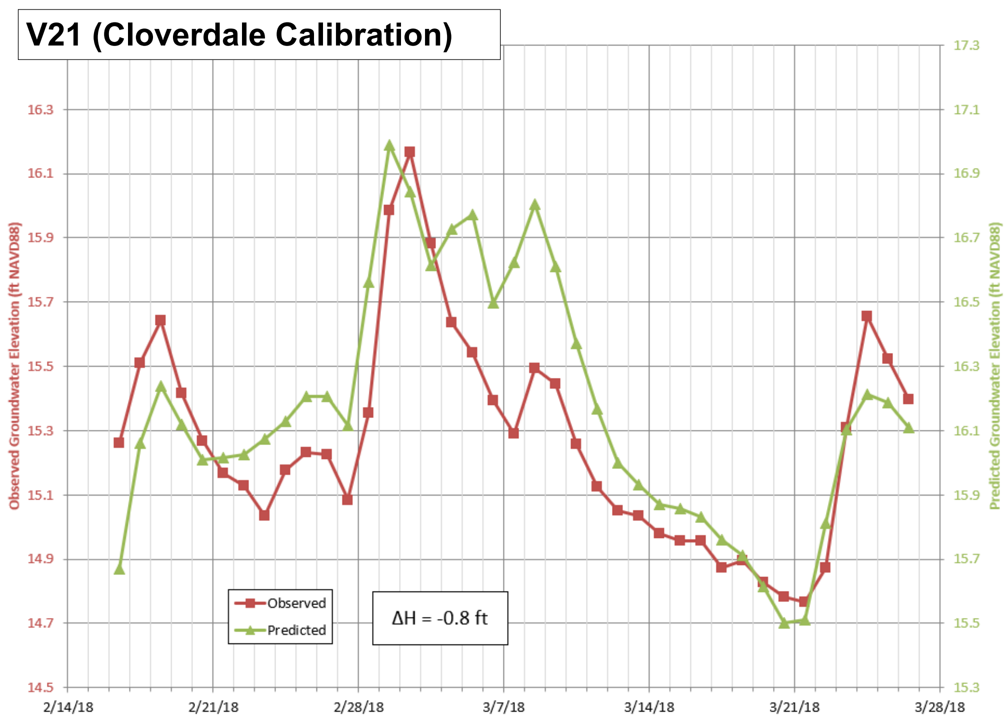
Well locations are mapped on Figure 5-1.

Figure 6-22
Transient Calibration Results for Well PGG-1d (Deep Aquifer)

Sitka Sedge Natural Area

PGG





Note:
This figure compares observed to model-predicted groundwater elevation hydrographs in Monitoring Well PGG-2i over the 38-day calibration period.

Differences in precipitation data between Tillamook and Cloverdale account for some of the differences in model predictions of groundwater level trends.

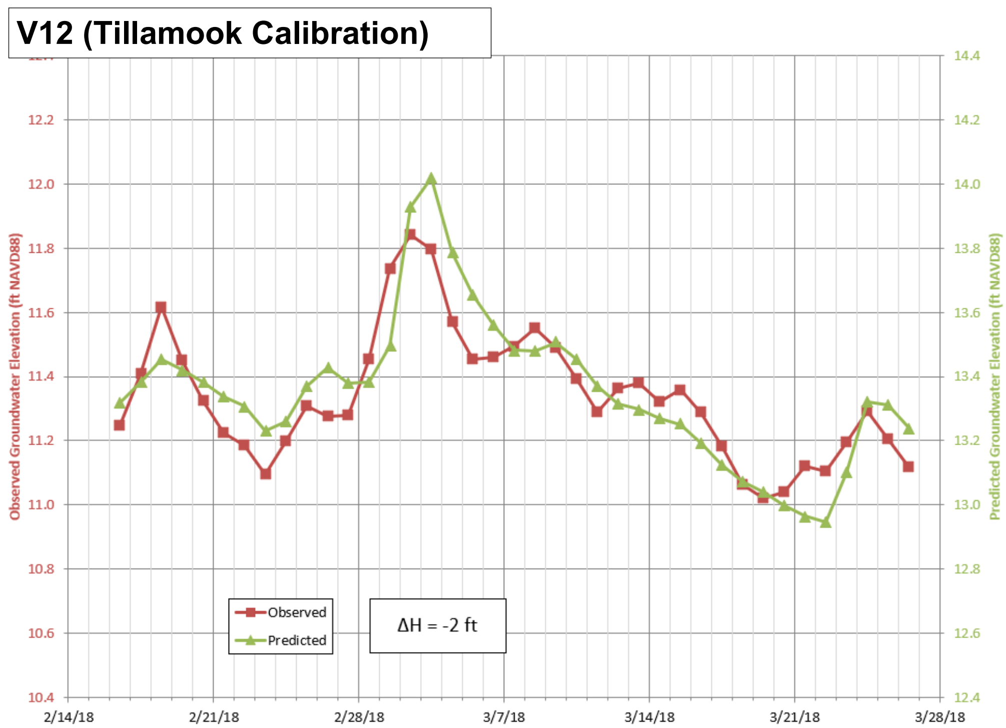
In contrast to steady-state calibration, transient calibration adjusts model parameters so that time-varying stresses (precipitation recharge or fluctuating tidal inundation) and corresponding groundwater level responses are well represented in the model. Transient calibration followed initial steady-state calibration.

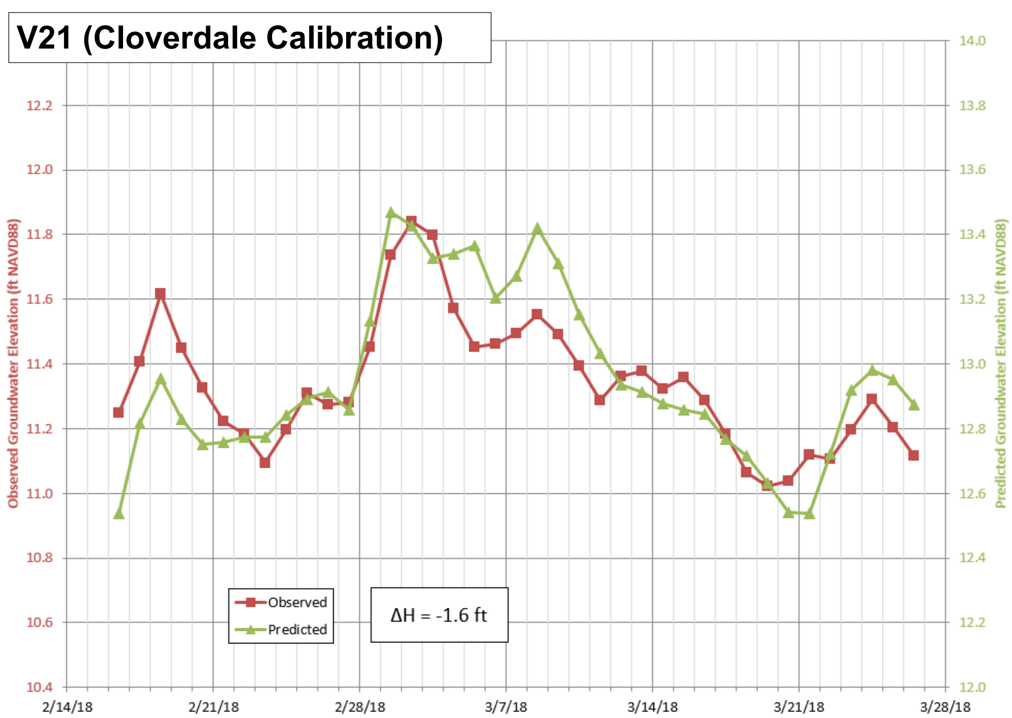
Well locations are mapped on Figure 5-1.

Figure 6-23
Transient Calibration Results for Well PGG-2i (Shallow Aquifer)

Sitka Sedge Natural Area

PGG





Note:
This figure compares observed to model-predicted groundwater elevation hydrographs in Monitoring Well PGG-2d over the 38-day calibration period.

Differences in precipitation data between Tillamook and Cloverdale account for some of the differences in model predictions of groundwater level trends.

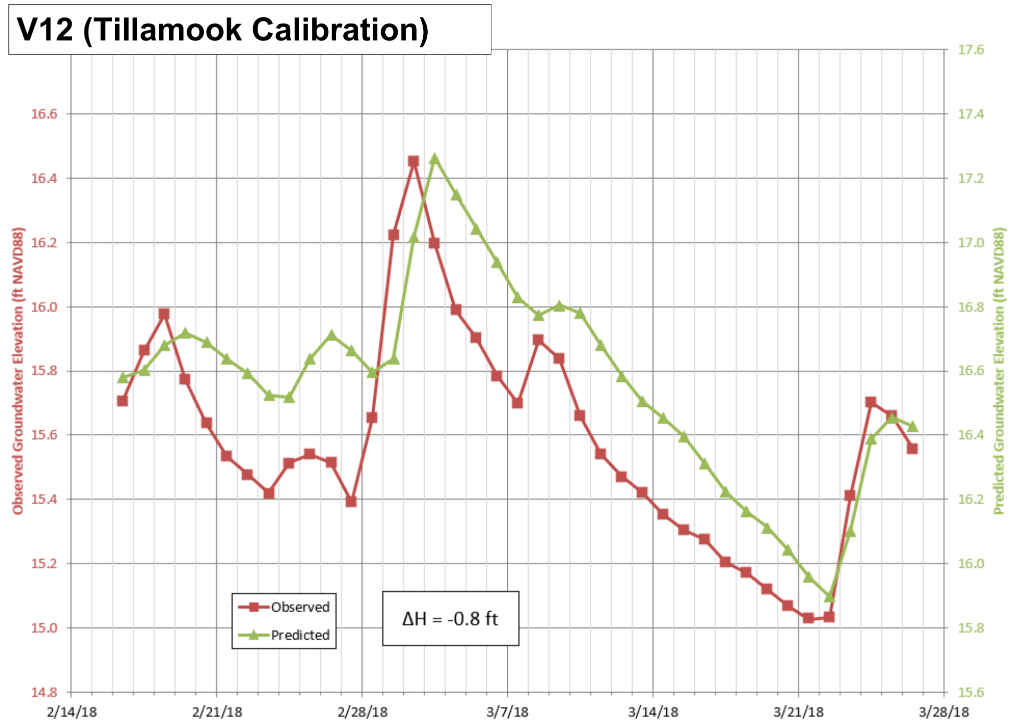
In contrast to steady-state calibration, transient calibration adjusts model parameters so that time-varying stresses (precipitation recharge or fluctuating tidal inundation) and corresponding groundwater level responses are well represented in the model. Transient calibration followed initial steady-state calibration.

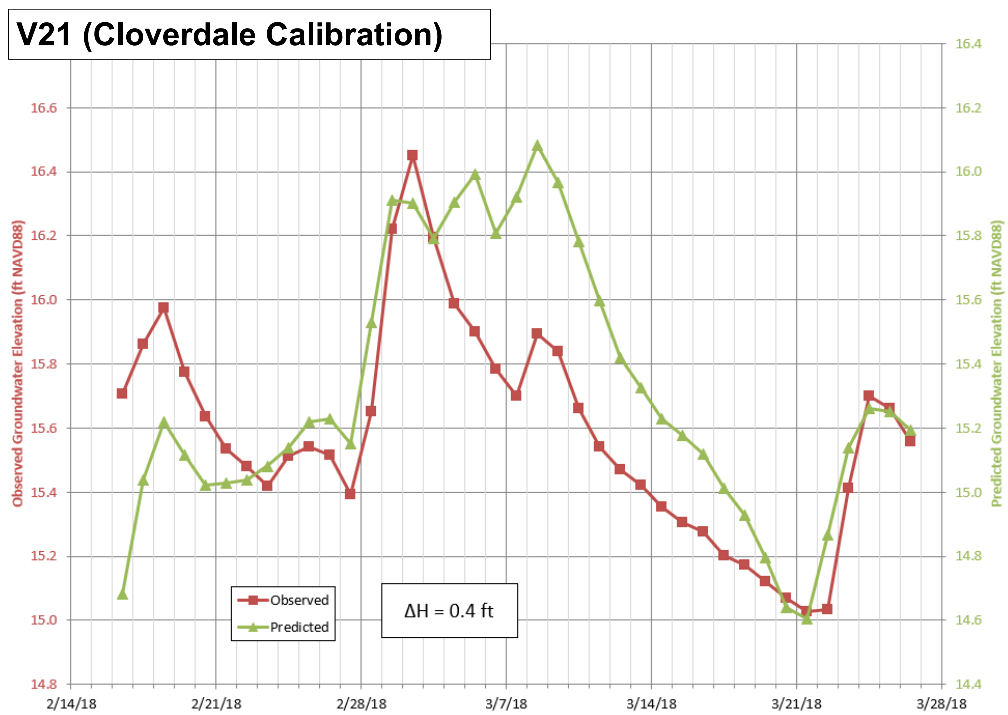
Well locations are mapped on Figure 5-1.

Figure 6-24
Transient Calibration Results for Well PGG-2d (Deep Aquifer)

Sitka Sedge Natural Area

PgG





Note:
This figure compares observed to model-predicted groundwater elevation hydrographs in Monitoring Well PGG-3s over the 38-day calibration period.

Differences in precipitation data between Tillamook and Cloverdale account for some of the differences in model predictions of groundwater level trends.

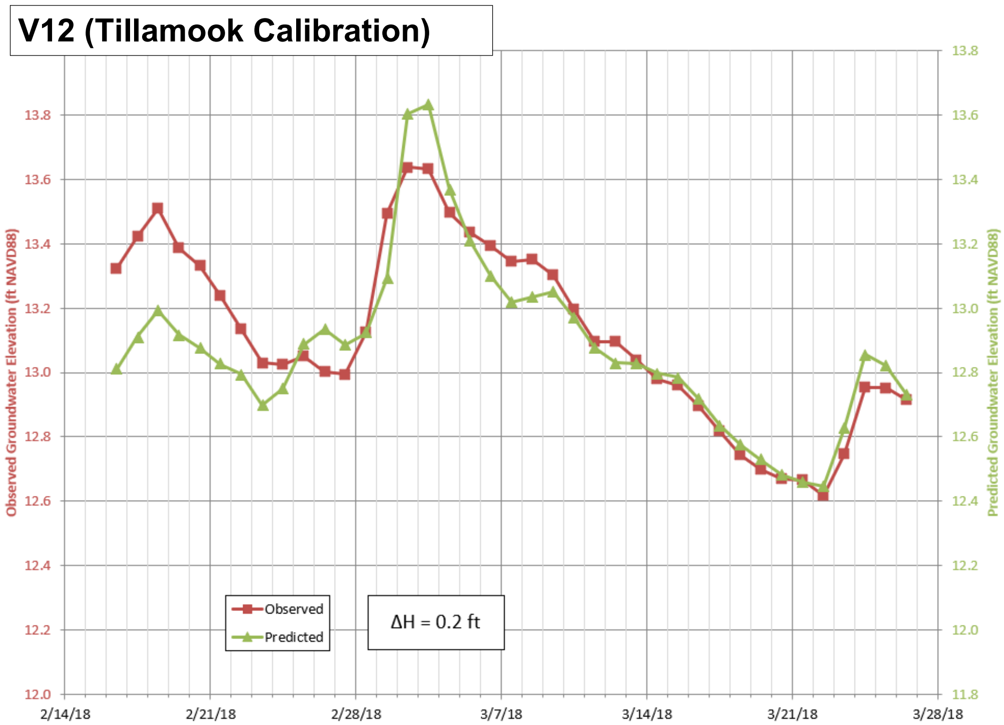
In contrast to steady-state calibration, transient calibration adjusts model parameters so that time-varying stresses (precipitation recharge or fluctuating tidal inundation) and corresponding groundwater level responses are well represented in the model. Transient calibration followed initial steady-state calibration.

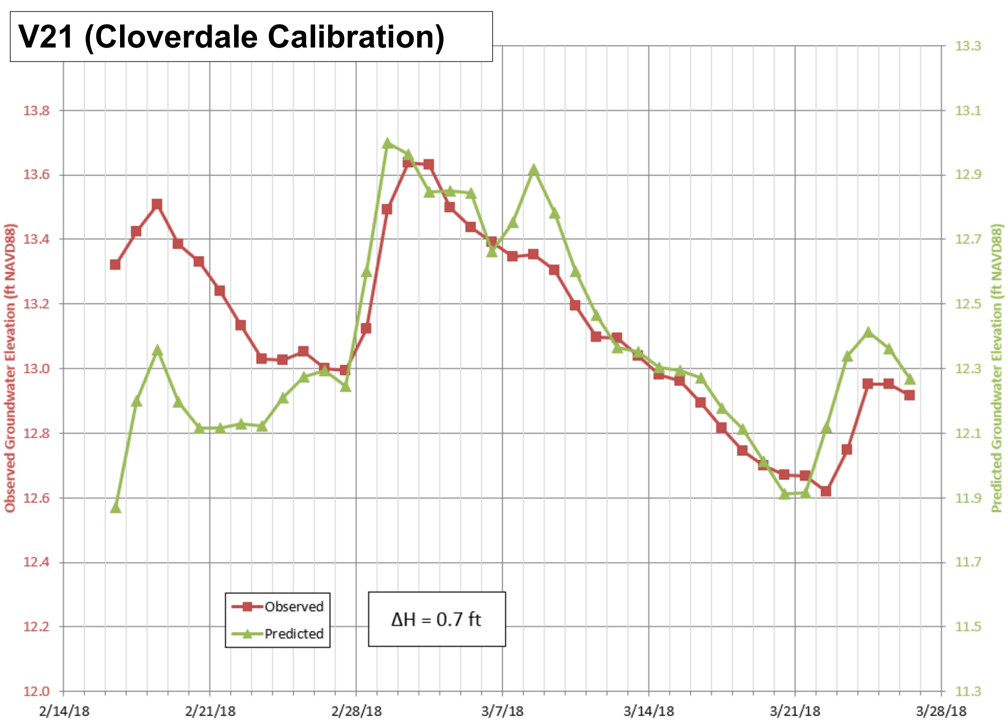
Well locations are mapped on Figure 5-1.

Figure 6-25
Transient Calibration Results for Well PGG-3s (Shallow Aquifer)

Sitka Sedge Natural Area

PGG





Note:
This figure compares observed to model-predicted groundwater elevation hydrographs in Monitoring Well PGG-3d over the 38-day calibration period.

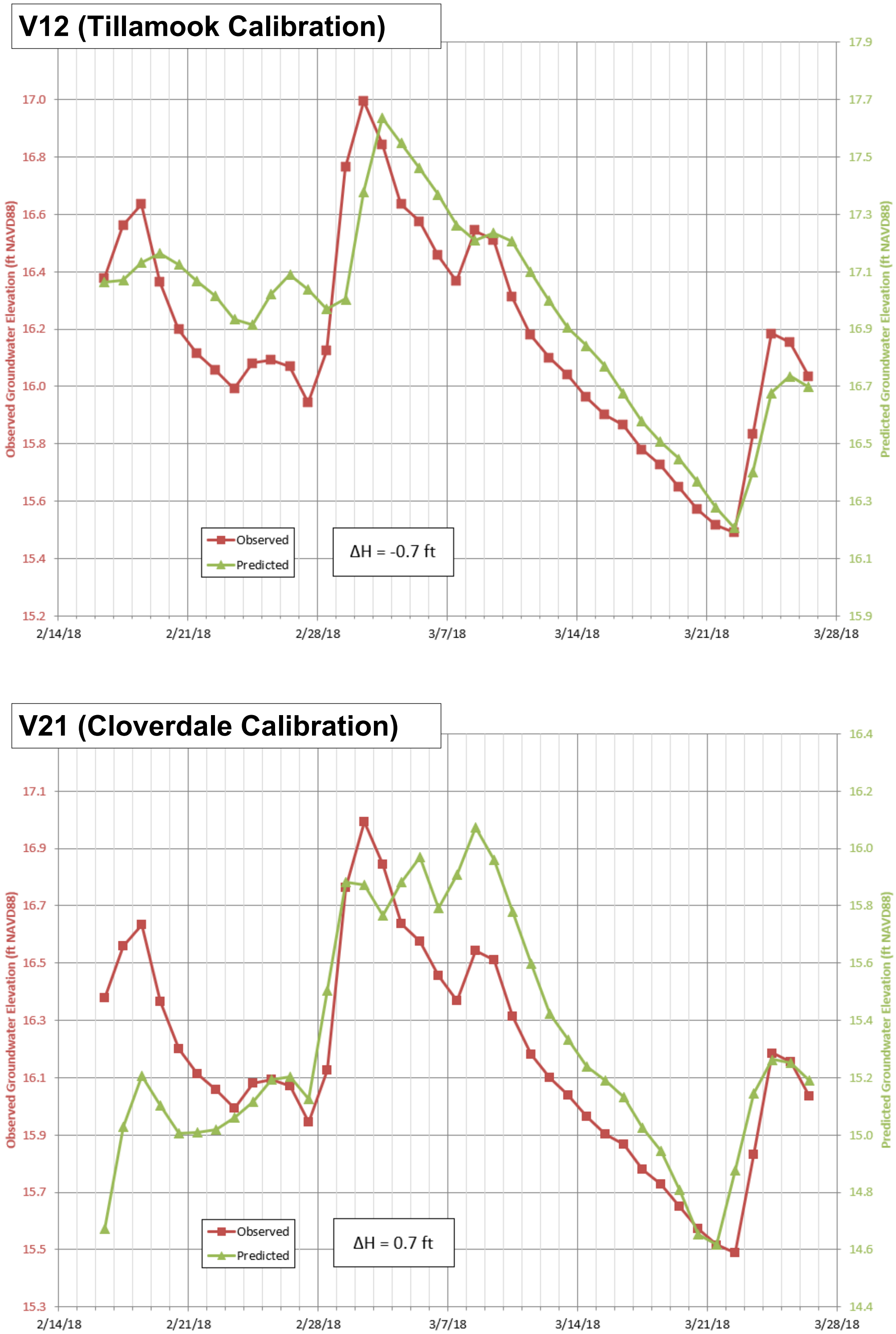
Differences in precipitation data between Tillamook and Cloverdale account for some of the differences in model predictions of groundwater level trends.

In contrast to steady-state calibration, transient calibration adjusts model parameters so that time-varying stresses (precipitation recharge or fluctuating tidal inundation) and corresponding groundwater level responses are well represented in the model. Transient calibration followed initial steady-state calibration.

Well locations are mapped on Figure 5-1.

Figure 6-26
Transient Calibration Results for Well PGG-3d (Deep Aquifer)

Sitka Sedge Natural Area



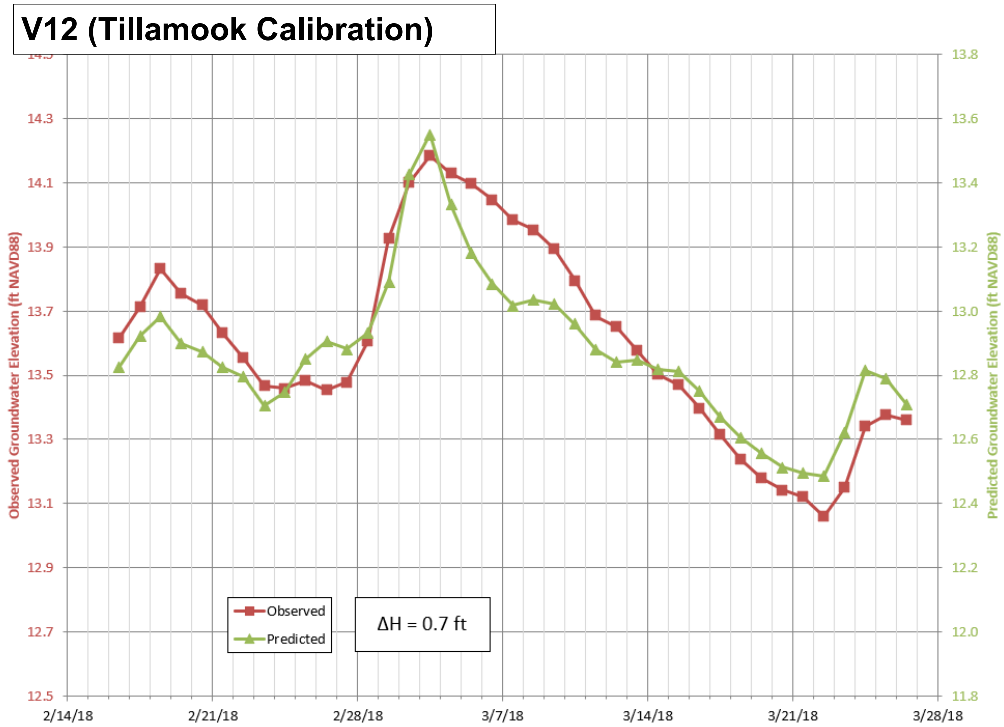
Note:
This figure compares observed to model-predicted groundwater elevation hydrographs in Monitoring Well PGG-4i over the 38-day calibration period.

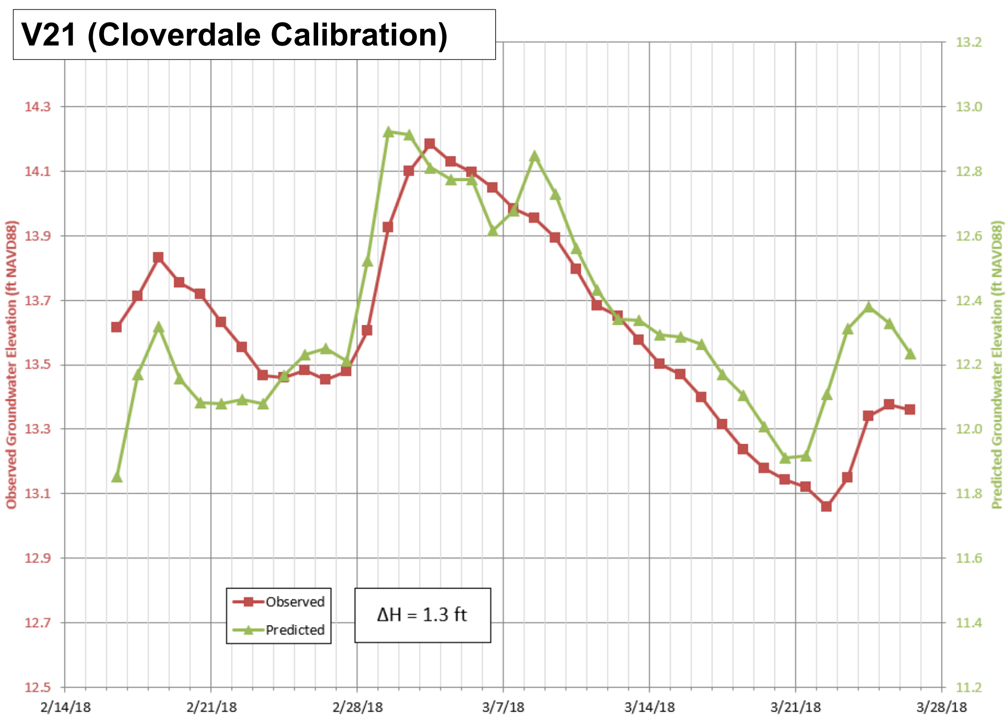
Differences in precipitation data between Tillamook and Cloverdale account for some of the differences in model predictions of groundwater level trends.

In contrast to steady-state calibration, transient calibration adjusts model parameters so that time-varying stresses (precipitation recharge or fluctuating tidal inundation) and corresponding groundwater level responses are well represented in the model. Transient calibration followed initial steady-state calibration.

Well locations are mapped on Figure 5-1.

Figure 6-27
Transient Calibration Results for Well PGG-4i (Shallow Aquifer)





Note:
This figure compares observed to model-predicted groundwater elevation hydrographs in Monitoring Well PGG-4d over the 38-day calibration period.

Differences in precipitation data between Tillamook and Cloverdale account for some of the differences in model predictions of groundwater level trends.

In contrast to steady-state calibration, transient calibration adjusts model parameters so that time-varying stresses (precipitation recharge or fluctuating tidal inundation) and corresponding groundwater level responses are well represented in the model. Transient calibration followed initial steady-state calibration.

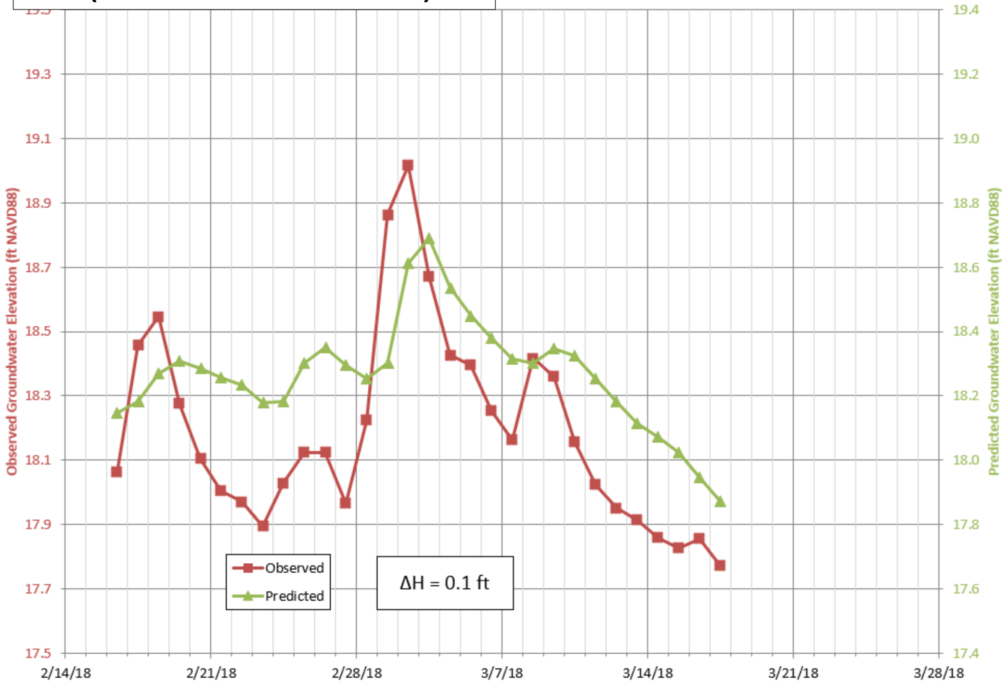
Well locations are mapped on Figure 5-1.

Figure 6-28
Transient Calibration Results for Well PGG-4d (Deep Aquifer)

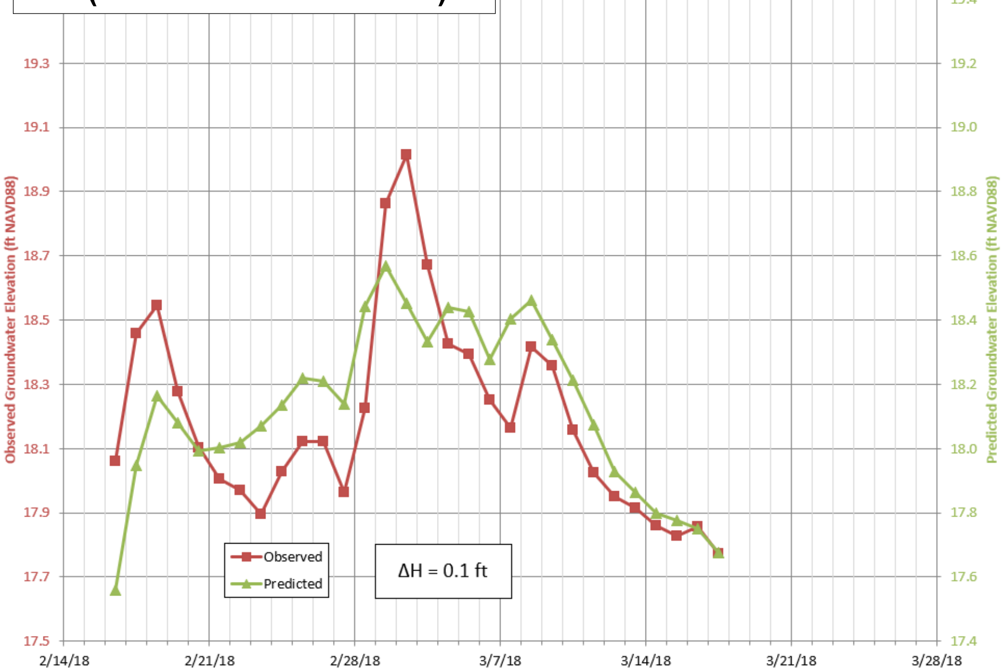
Sitka Sedge Natural Area

PGG

V12 (Tillamook Calibration)



V21 (Cloverdale Calibration)



Note:
This figure compares observed to model-predicted groundwater elevation hydrographs in Monitoring Well TDM-2 over the 38-day calibration period.

Differences in precipitation data between Tillamook and Cloverdale account for some of the differences in model predictions of groundwater level trends.

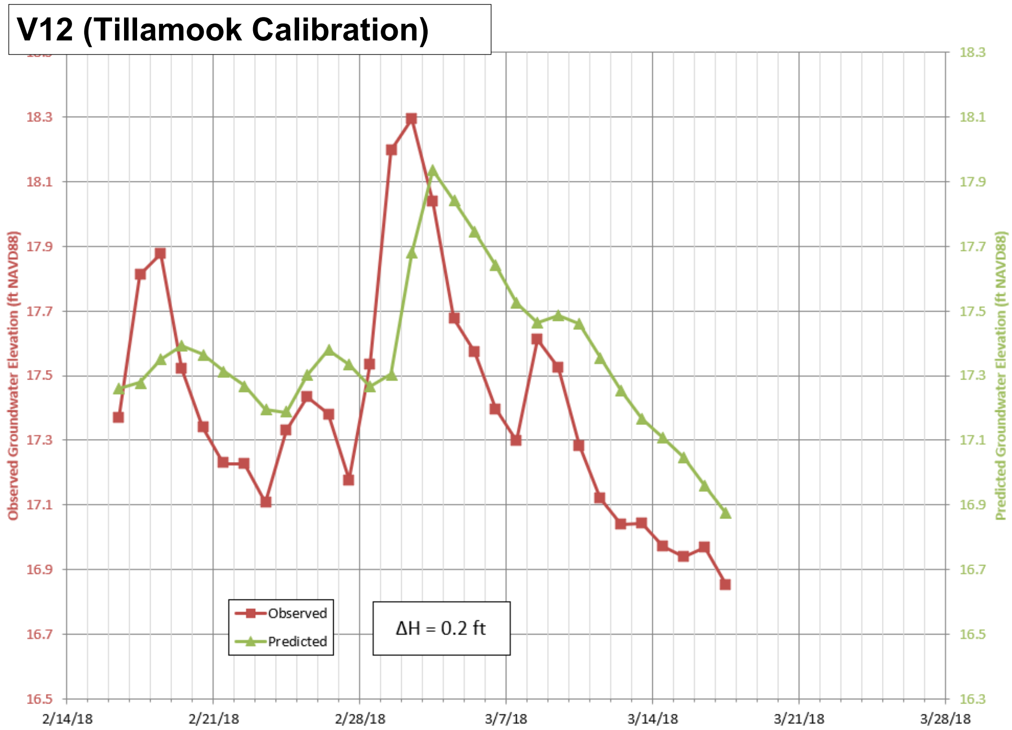
In contrast to steady-state calibration, transient calibration adjusts model parameters so that time-varying stresses (precipitation recharge or fluctuating tidal inundation) and corresponding groundwater level responses are well represented in the model. Transient calibration followed initial steady-state calibration.

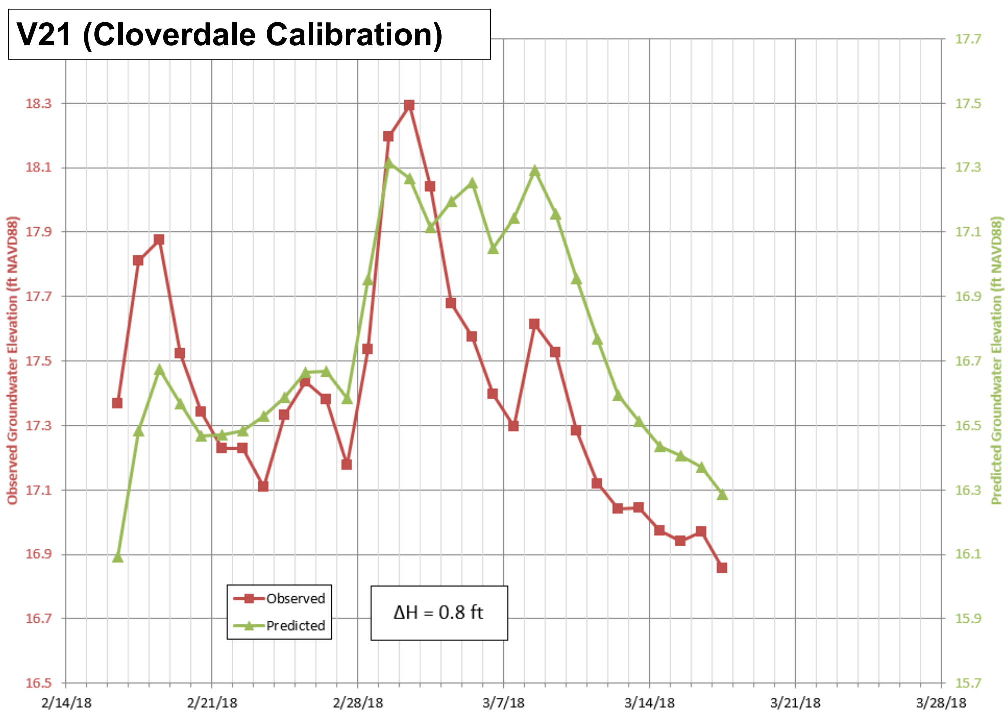
Well locations are mapped on Figure 5-1.

Figure 6-29
Transient Calibration Results for Well TDM-2 (Shallow Aquifer)

Sitka Sedge Natural Area

PGG





Note:
This figure compares observed to model-predicted groundwater elevation hydrographs in Monitoring Well TDM-4 over the 38-day calibration period.

Differences in precipitation data between Tillamook and Cloverdale account for some of the differences in model predictions of groundwater level trends.

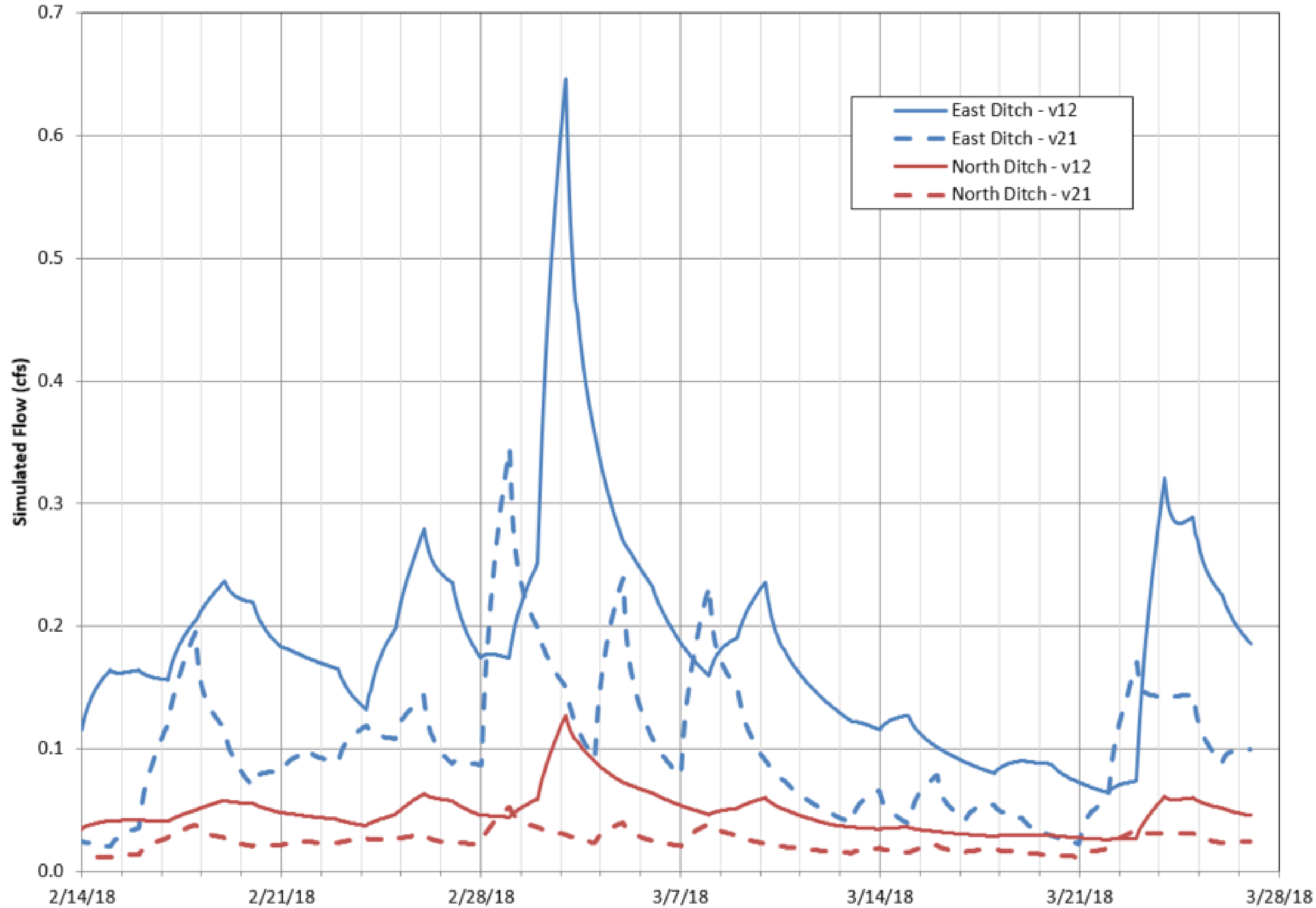
In contrast to steady-state calibration, transient calibration adjusts model parameters so that time-varying stresses (precipitation recharge or fluctuating tidal inundation) and corresponding groundwater level responses are well represented in the model. Transient calibration followed initial steady-state calibration.

Well locations are mapped on Figure 5-1.

Figure 6-30
Transient Calibration Results for Well TDM-4 (Shallow Aquifer)

Sitka Sedge Natural Area

PgG

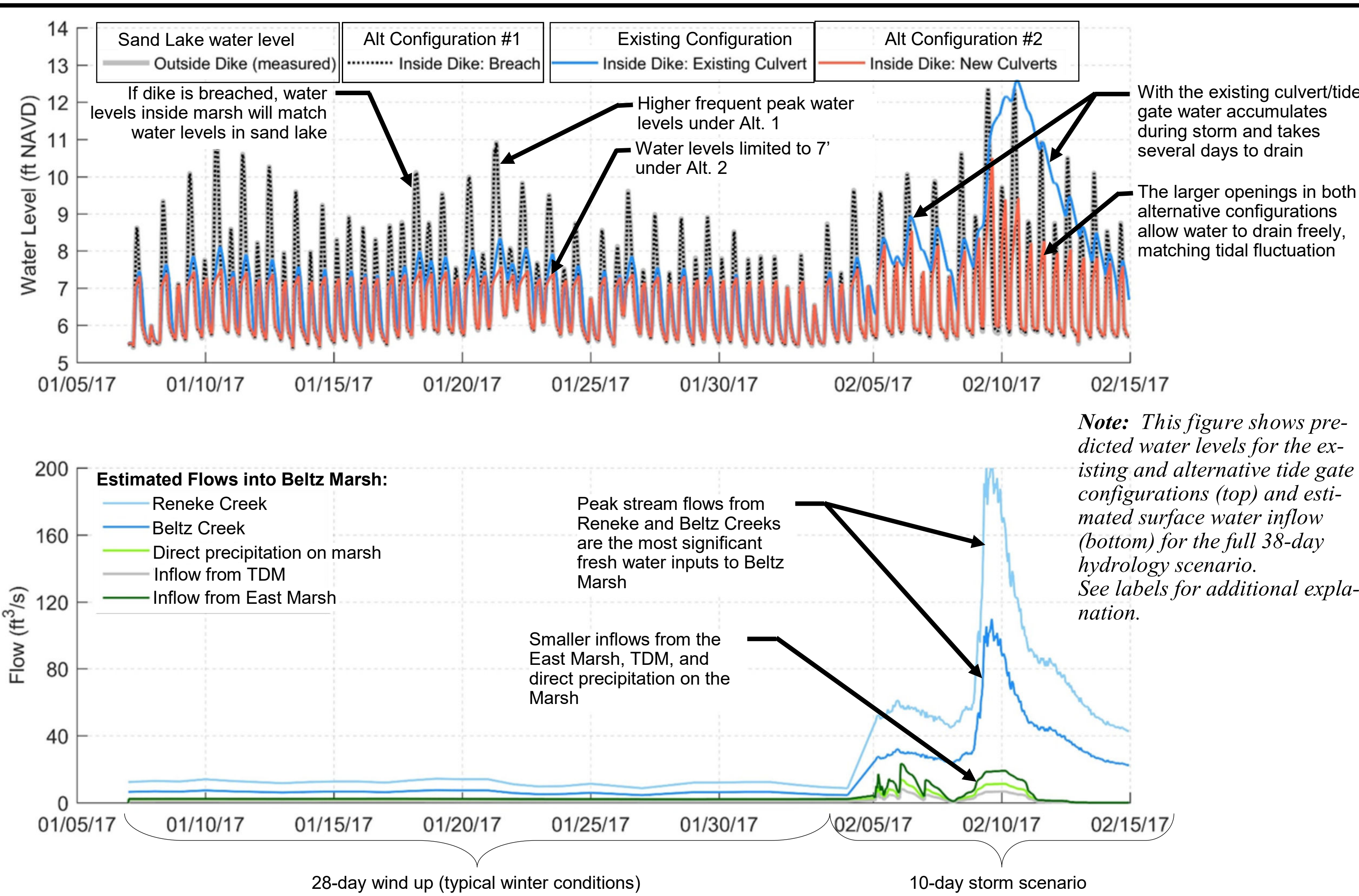


Note: *This figure shows model predictions of flow in the TDM ditches during the data collection period used for calibration*

Figure 6-31
Modeled Ditch Flow in Transient Calibrations

Sitka Sedge Natural Area

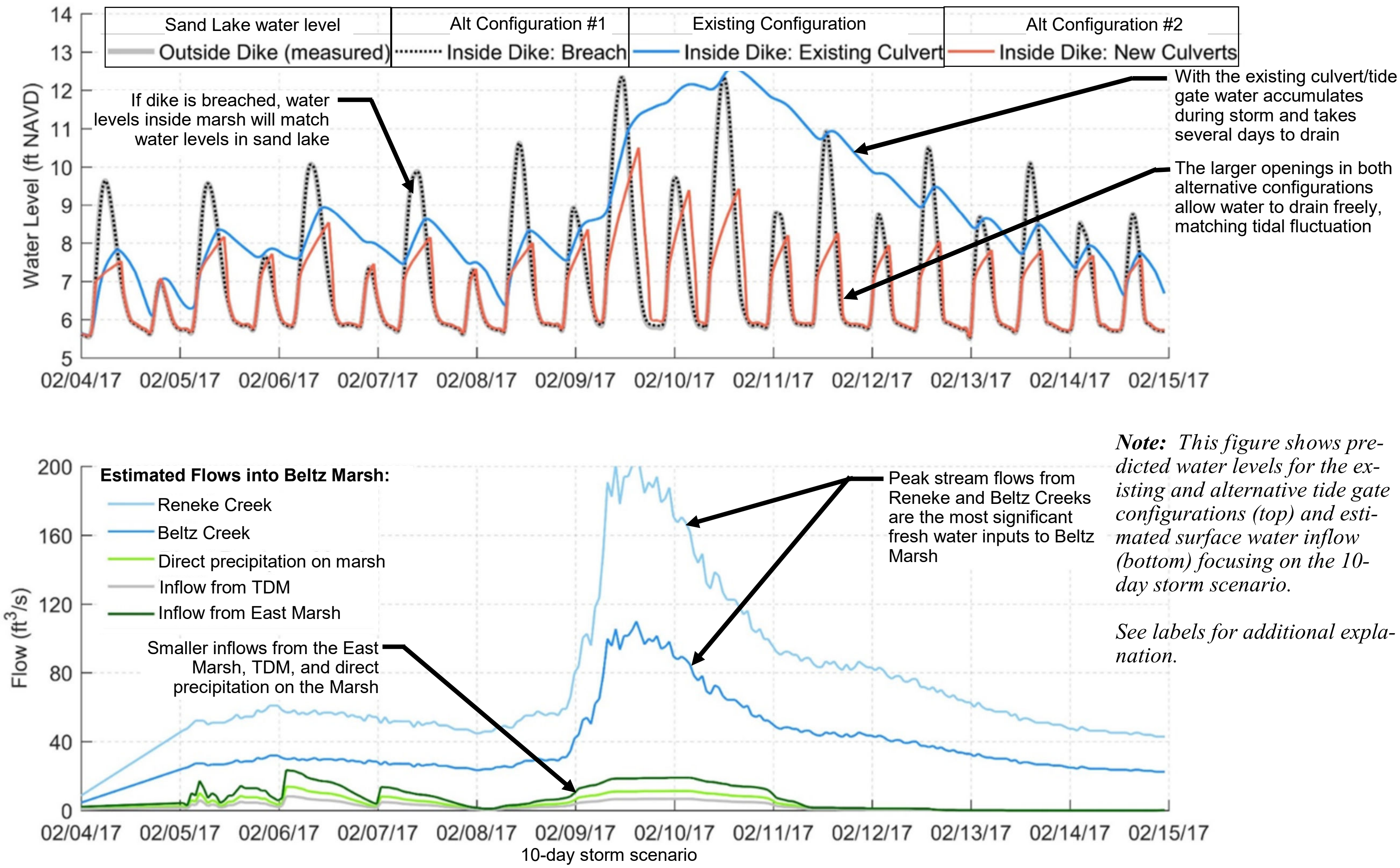
PgG



SOURCE: ESA surface water model. Runoff values were scaled to 50-year values based on precipitation measured at Tillamook and runoff measured at the USGS Tucca gauge

Figure 7-1
Predicted Water Levels in Beltz Marsh for the Existing and Alternative Tide Gate Configurations for the Full 38-day Hydrology Scenario

Sitka Sedge Natural Area



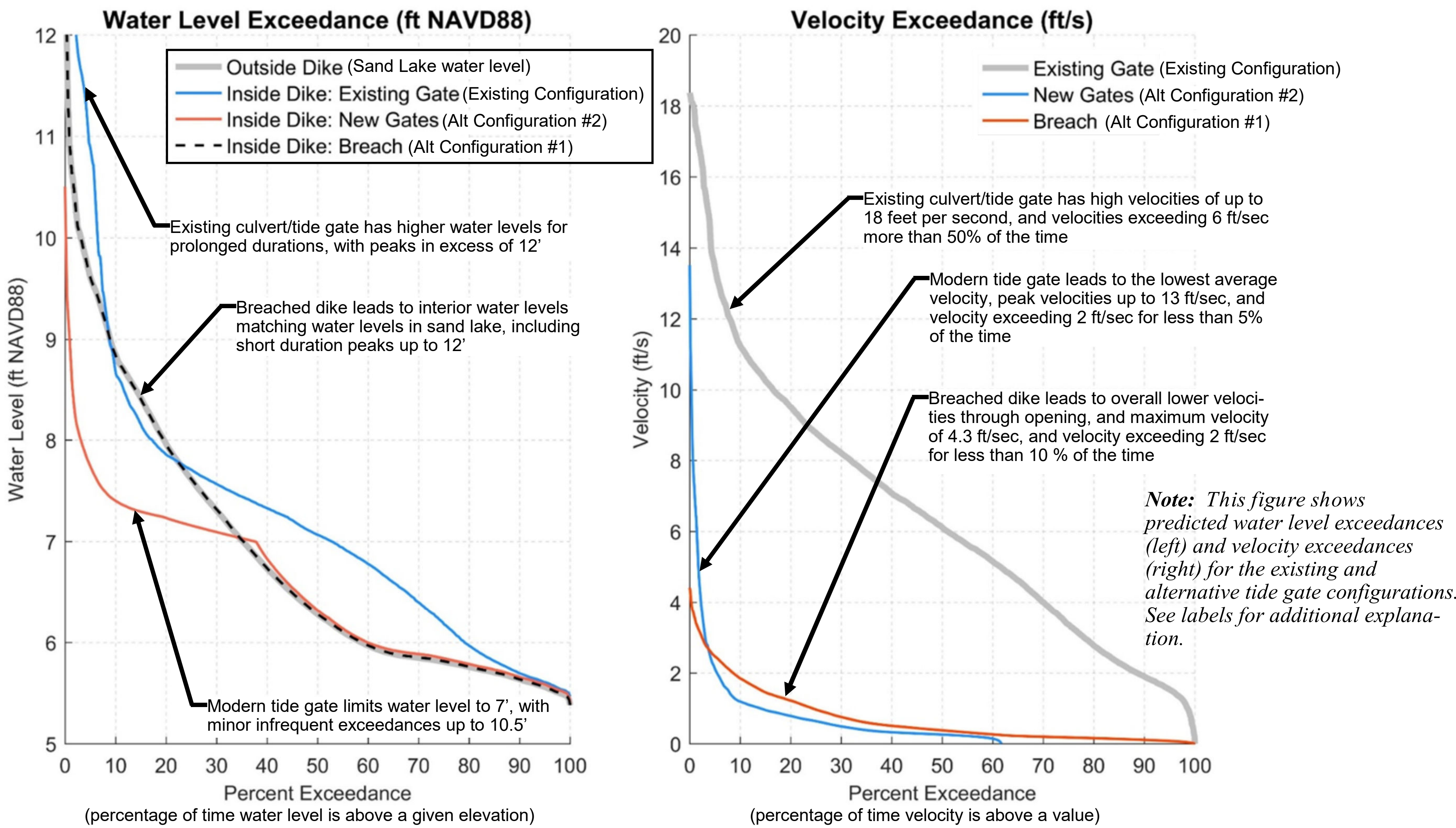
Note: *This figure shows predicted water levels for the existing and alternative tide gate configurations (top) and estimated surface water inflow (bottom) focusing on the 10-day storm scenario.*

See labels for additional explanation.

SOURCE: ESA surface water model. Runoff values were scaled to 50-year values based on precipitation measured at Tillamook and runoff measured at the USGS Tucca gauge

Figure 7-2
Predicted Water Levels in Beltz Marsh for the Existing and Alternative Tide Gate Configurations for the 10-day Storm Scenario

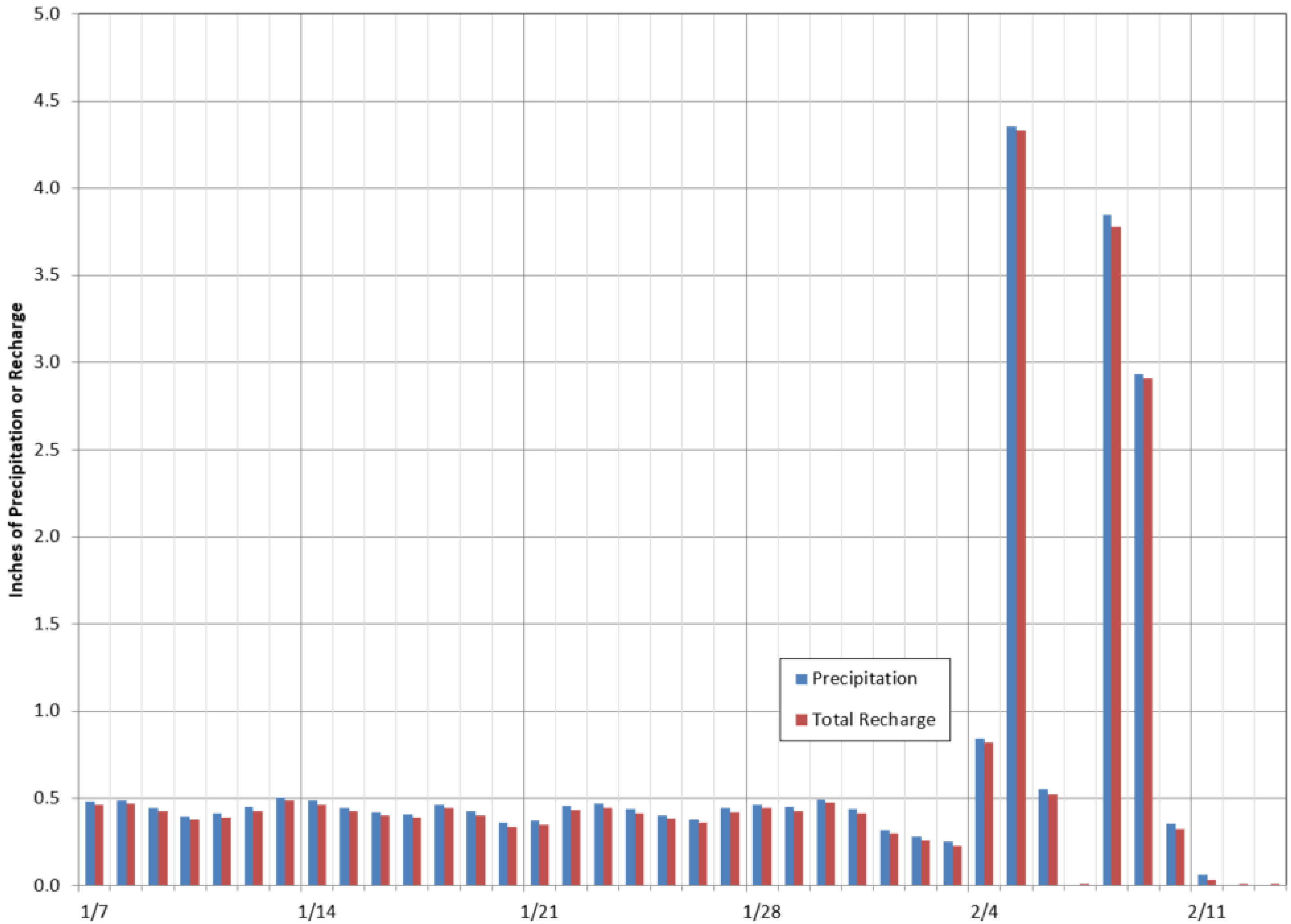
Sitka Sedge Natural Area



SOURCE: ESA surface water model. gauge

Figure 7-3
Comparison of Water-Level Exceedances and Velocity Exceedances for Existing and Alternative Tide Gate Configurations

Sitka Sedge Natural Area

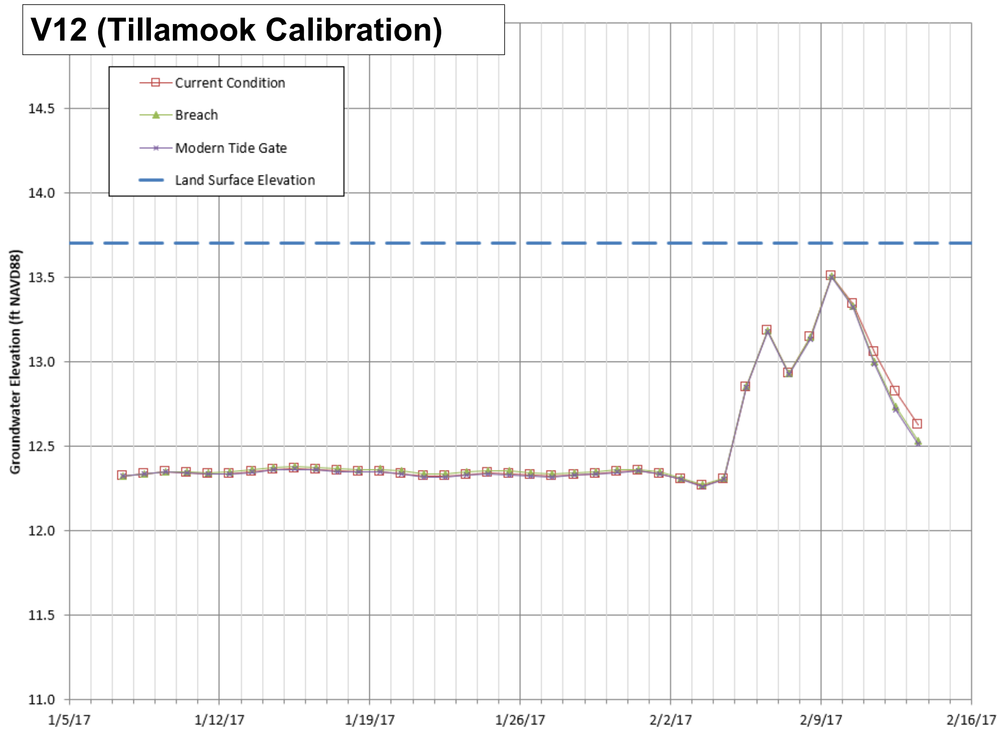


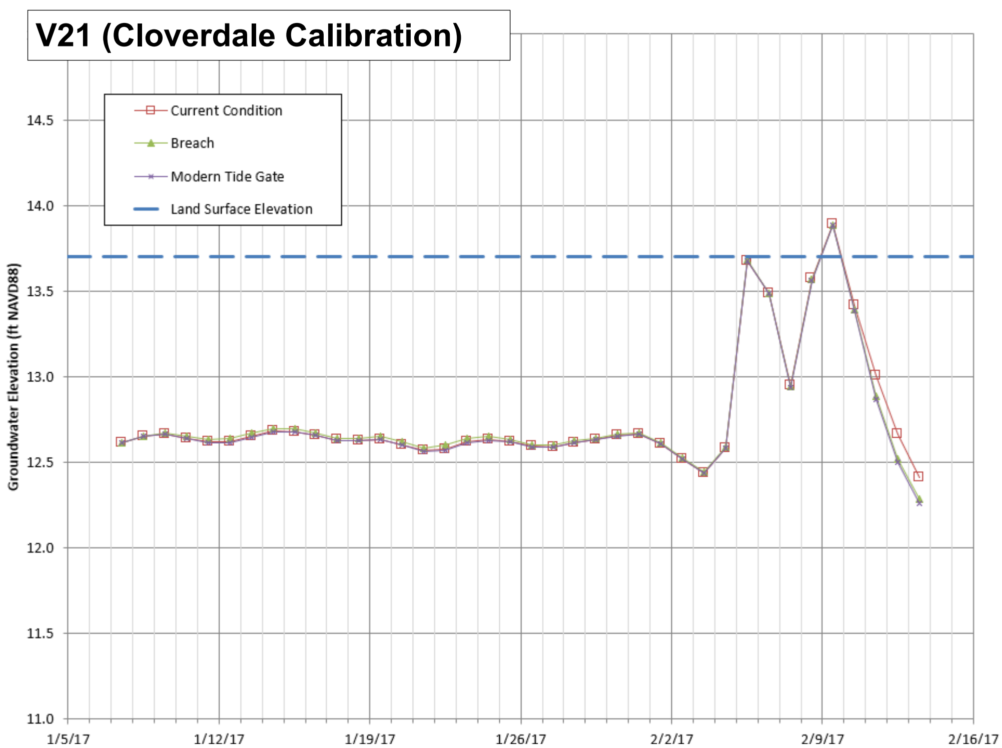
Note: *This figure shows Tillamook precipitation and the resulting groundwater recharge used for the predictive model simulations. Recharge was estimated with PGG's proprietary version of the Deep Percolation Model (DPM). During the wet season, little water is lost to evapotranspiration and recharge is close to precipitation. Two large storm events occur during the final 10 days of the prediction period.*

Figure 7-4
Predictive Simulation Precipitation and Recharge

PGG

Sitka Sedge Natural Area





Note:
This figure compares groundwater model predictions of water-level hydrographs in Monitoring Well PGG-1i for a hypothetical 28 days of average winter conditions (1/7—2/3) followed by 10 days of “flood” conditions (2/4—2/13).

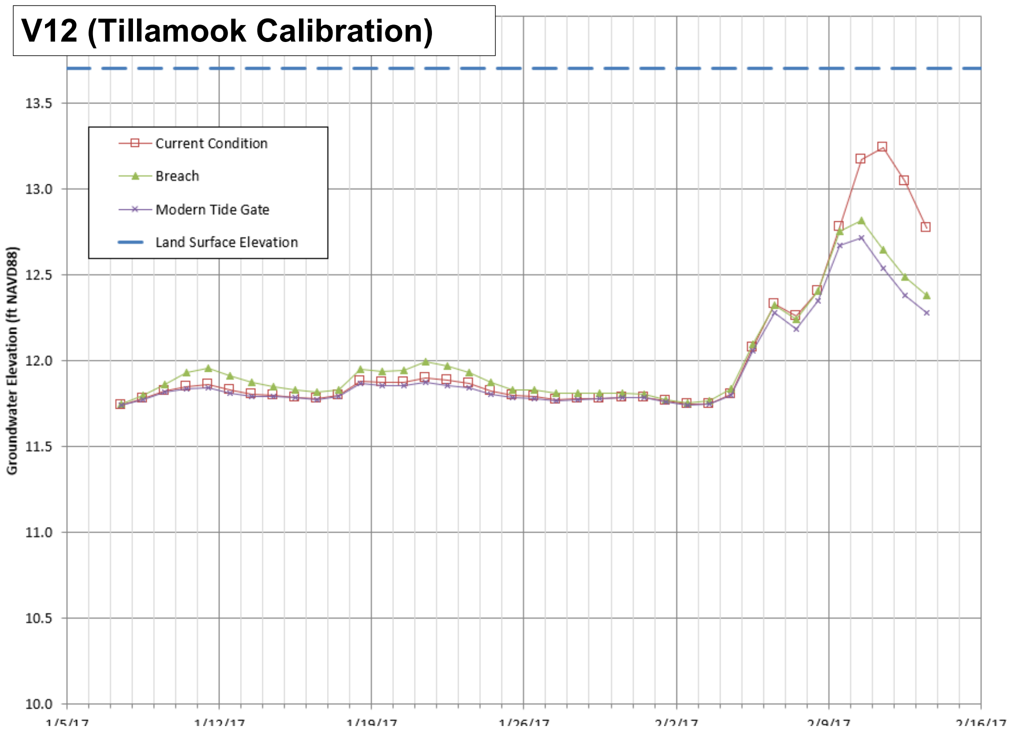
Predicted differences between the 3 dike configurations are negligible with the exception of slightly higher water levels during the “flood” condition with the current tide gate. This occurs because Beltz Marsh remains inundated for longer periods under the current condition due to limited drainage through the existing tide gate.

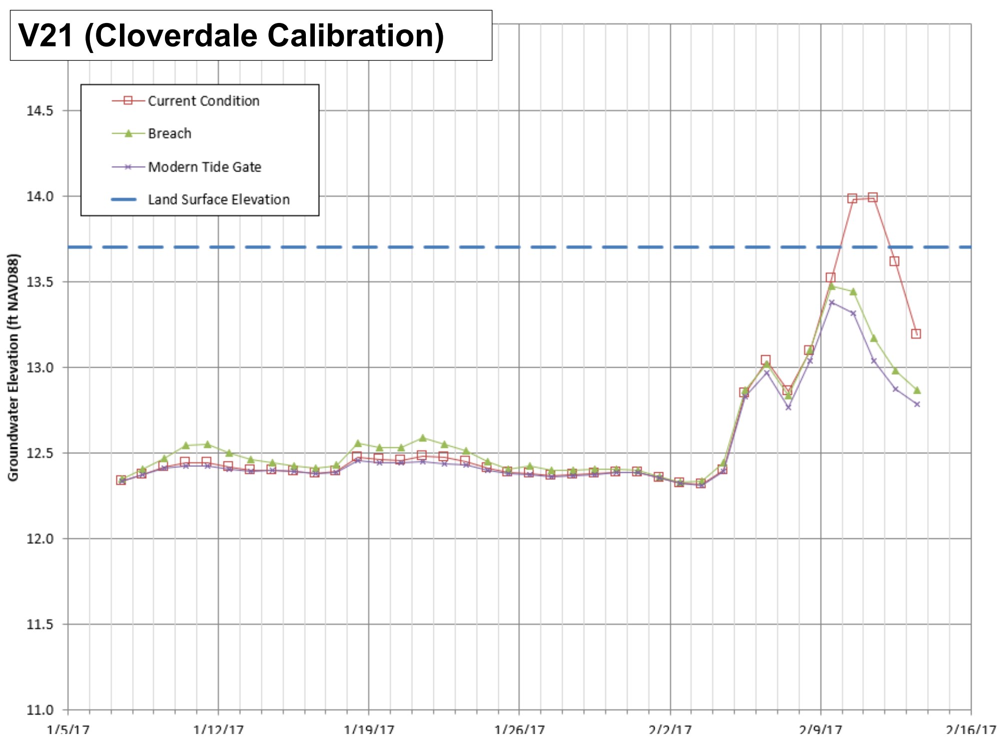
Well locations are mapped on Figure 5-1.

Figure 7-5
Predicted Effect of Dike Configuration on Groundwater Levels in PGG-1i (Shallow Aquifer)

Sitka Sedge Natural Area

PGG





Note:
This figure compares groundwater model predictions of water-level hydrographs in Monitoring Well PGG-1d for a hypothetical 28 days of average winter conditions (1/7—2/3) followed by 10 days of "flood" conditions (2/4—2/13).

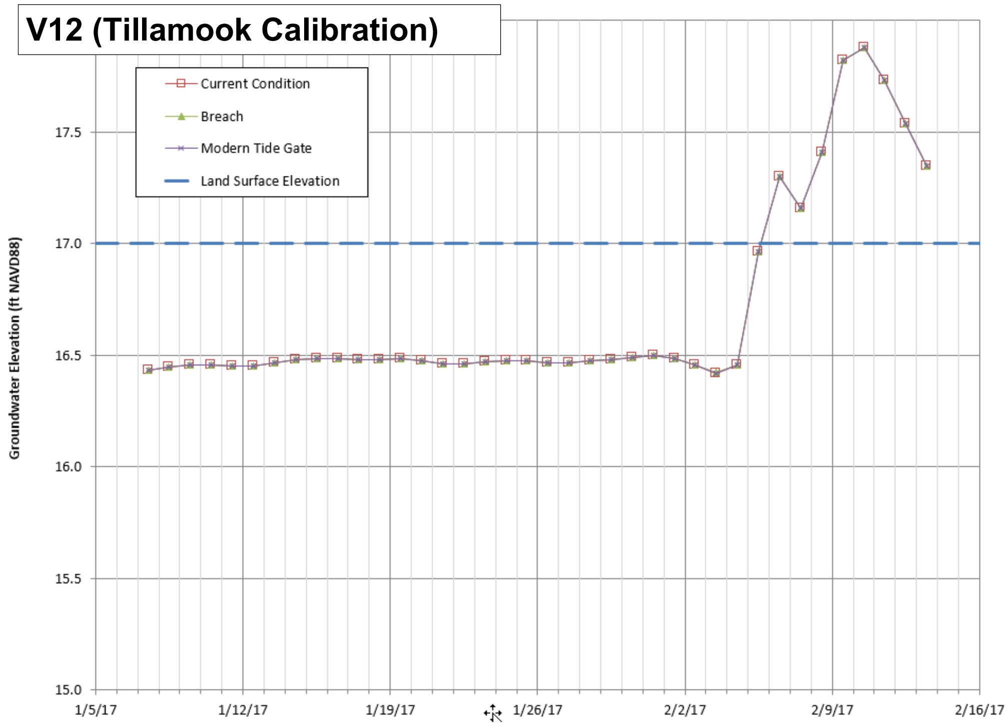
Predicted differences between the 3 dike configurations are negligible with the exception of higher water levels during the "flood" condition with the current tide gate. This occurs because Beltz Marsh remains inundated for longer periods under the current condition due to limited drainage through the existing tide gate.

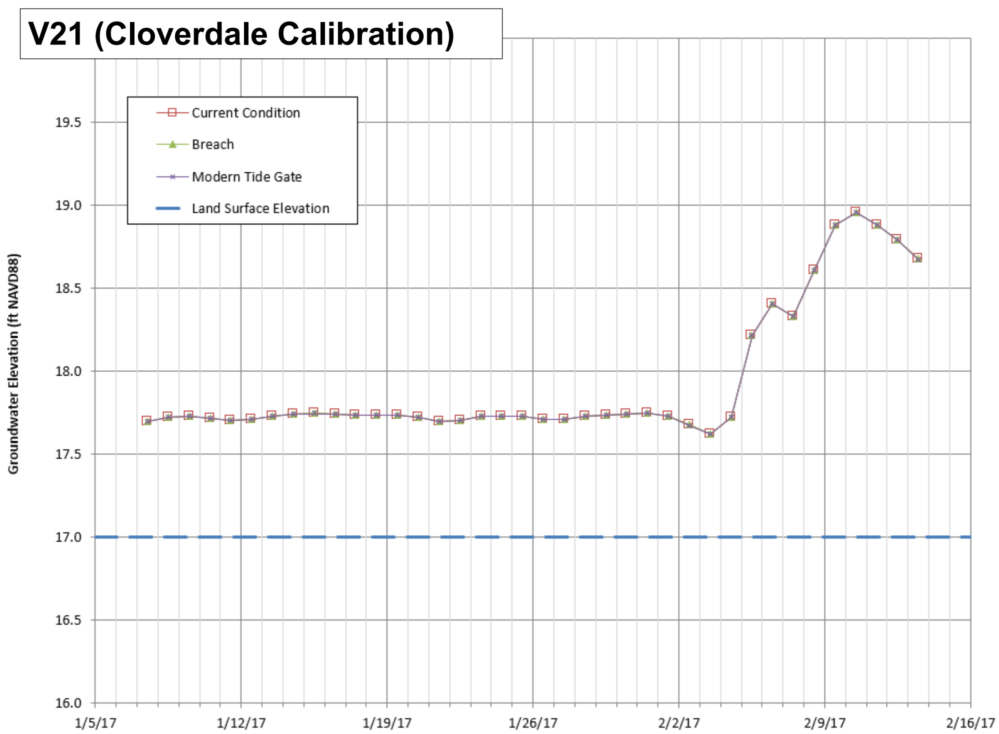
Well locations are mapped on Figure 5-1.

Figure 7-6
Predicted Effect of Dike Configuration on Groundwater Levels in PGG-1d (Deep Aquifer)

Sitka Sedge Natural Area

PGG





Note:
This figure compares groundwater model predictions of water-level hydrographs in Monitoring Well PGG-2i for a hypothetical 28 days of average winter conditions (1/7—2/3) followed by 10 days of "flood" conditions (2/4—2/13).

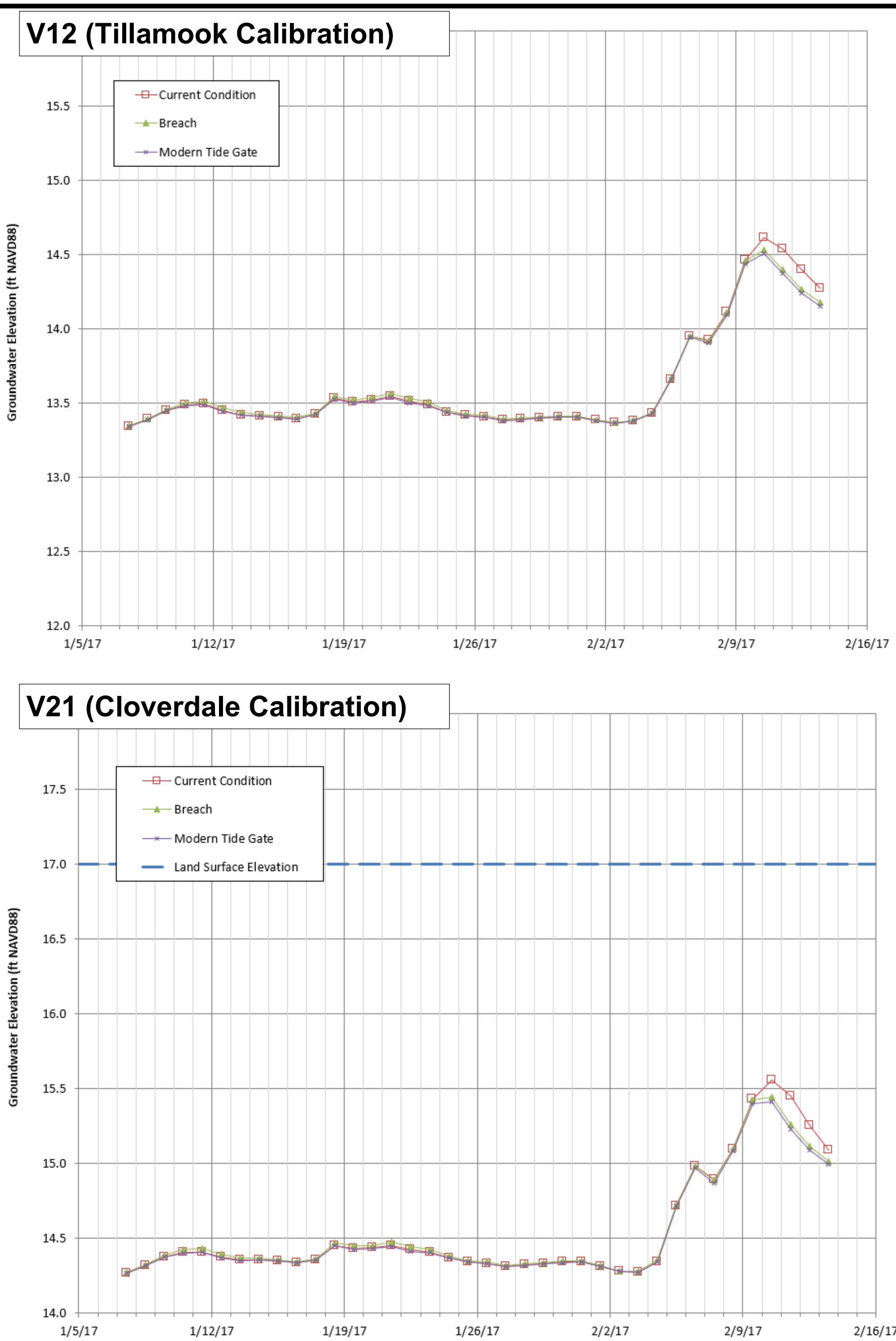
Predicted differences between the 3 dike configurations are negligible.

Well locations are mapped on Figure 5-1.

Figure 7-7
Predicted Effect of Dike Configuration on Groundwater Levels in PGG-2i (Shallow Aquifer)

Sitka Sedge Natural Area

PGG



Note:
This figure compares groundwater model predictions of water-level hydrographs in Monitoring Well PGG-2d for a hypothetical 28 days of average winter conditions (1/7—2/3) followed by 10 days of "flood" conditions (2/4—2/13).

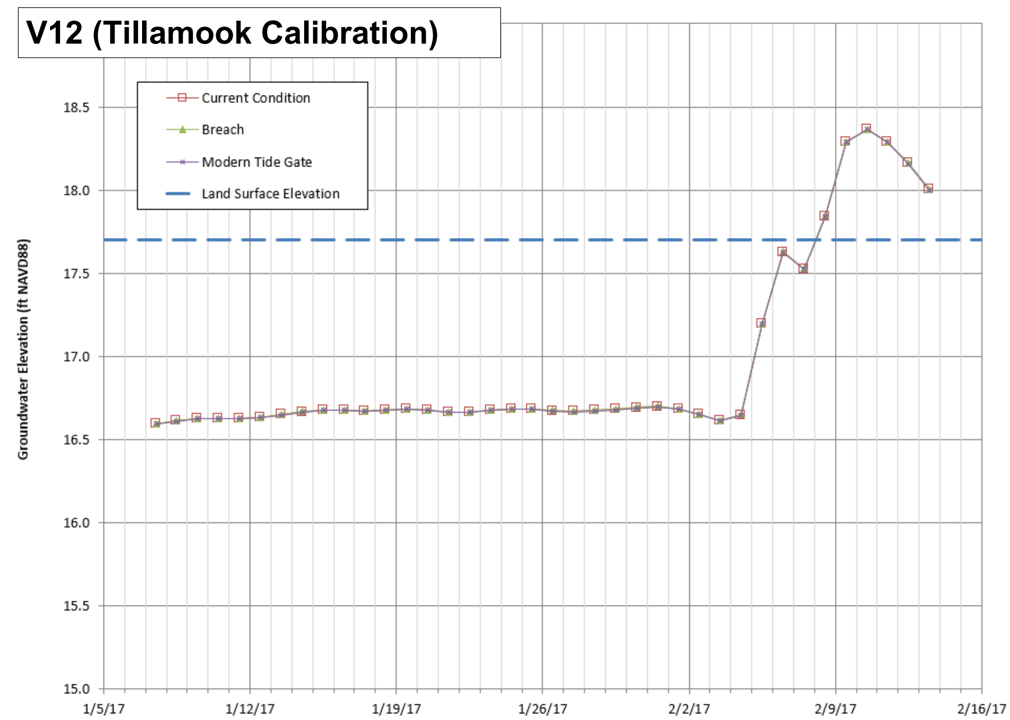
Predicted differences between the 3 dike configurations are negligible with the exception of slightly higher water levels during the "flood" condition with the current tide gate. This occurs because Beltz Marsh remains inundated for longer periods under the current condition due to limited drainage through the existing tide gate.

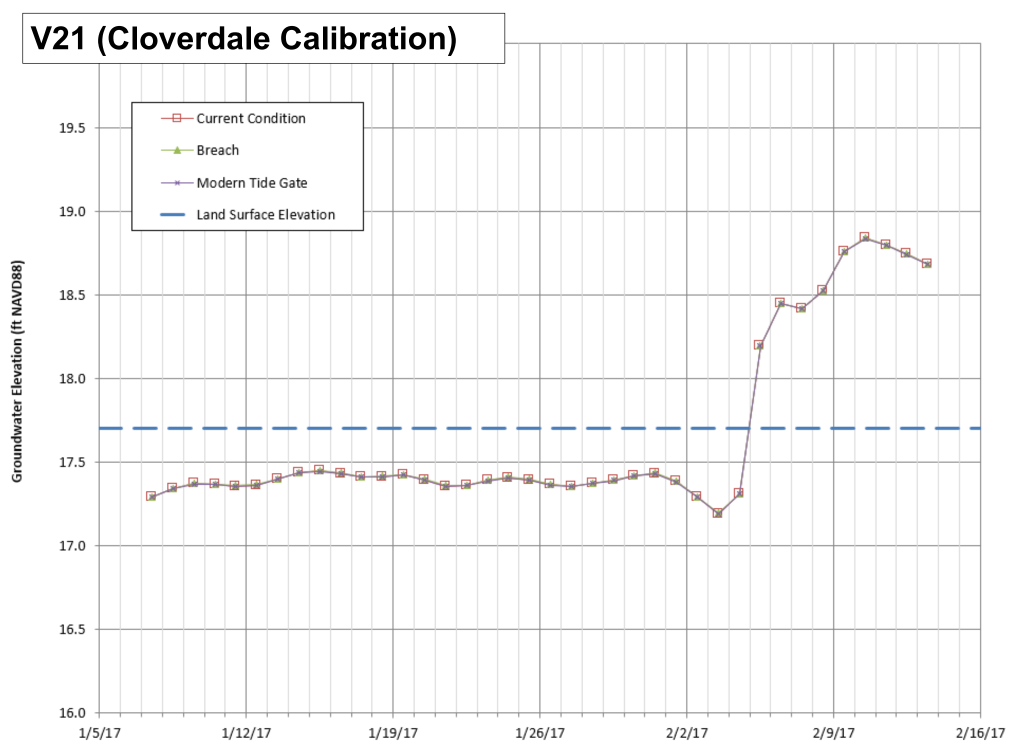
Well locations are mapped on Figure 5-1.

Figure 7-8
Predicted Effect of Dike Configuration on Groundwater Levels in PGG-2d (Deep Aquifer)

Sitka Sedge Natural Area

PGG





Note:
This figure compares groundwater model predictions of water-level hydrographs in Monitoring Well PGG-3s for a hypothetical 28 days of average winter conditions (1/7—2/3) followed by 10 days of "flood" conditions (2/4—2/13).

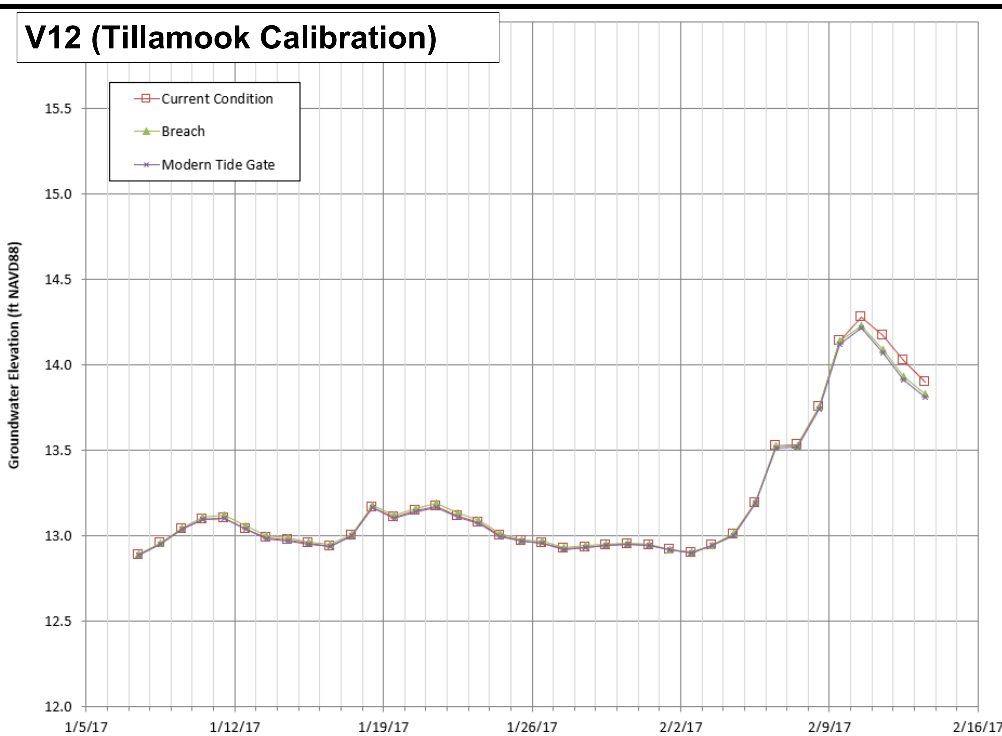
Predicted differences between the 3 dike configurations are negligible.

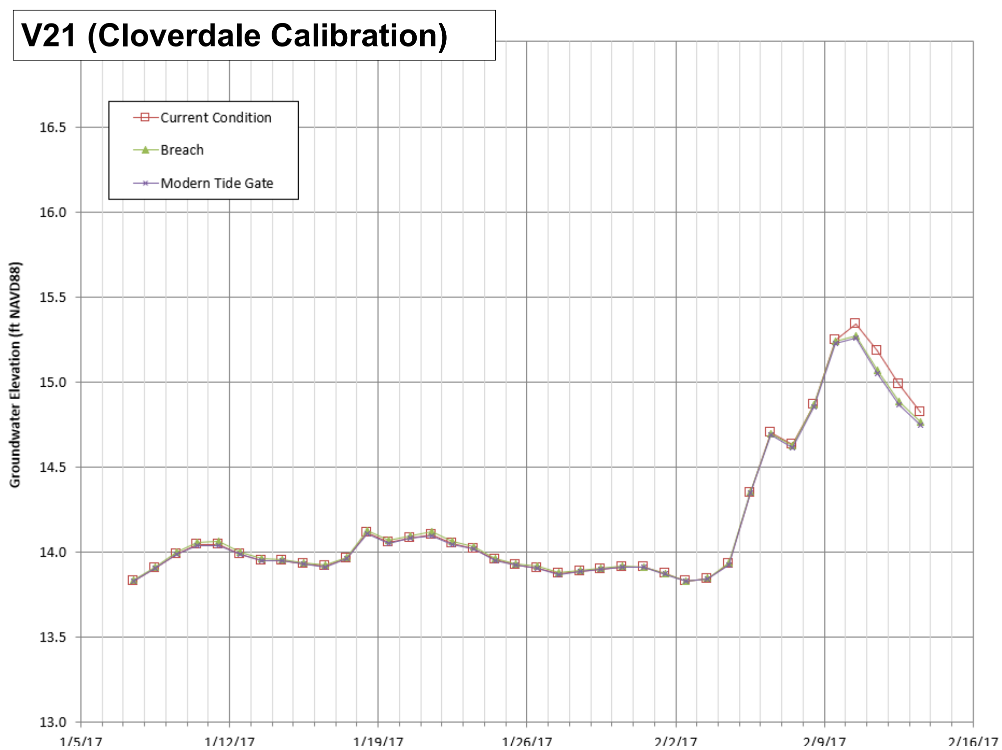
Well locations are mapped on Figure 5-1.

Figure 7-9
Predicted Effect of Dike Configuration on Groundwater Levels in PGG-3s (Shallow Aquifer)

Sitka Sedge Natural Area

PGG





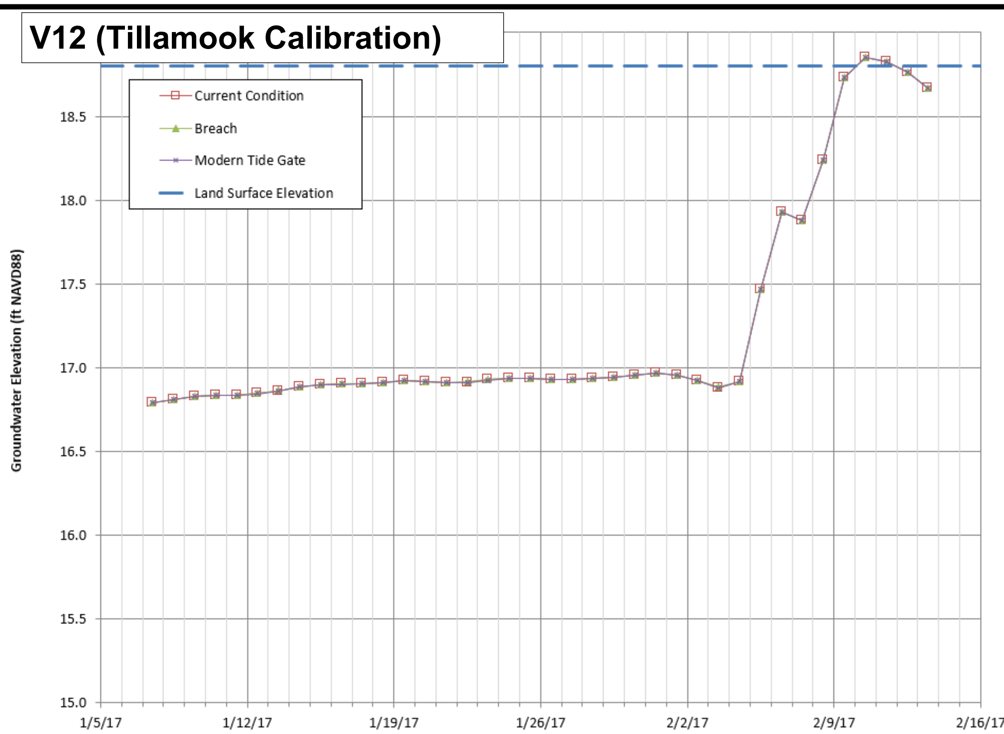
Note:
This figure compares groundwater model predictions of water-level hydrographs in Monitoring Well PGG-3d for a hypothetical 28 days of average winter conditions (1/7—2/3) followed by 10 days of "flood" conditions (2/4—2/13).

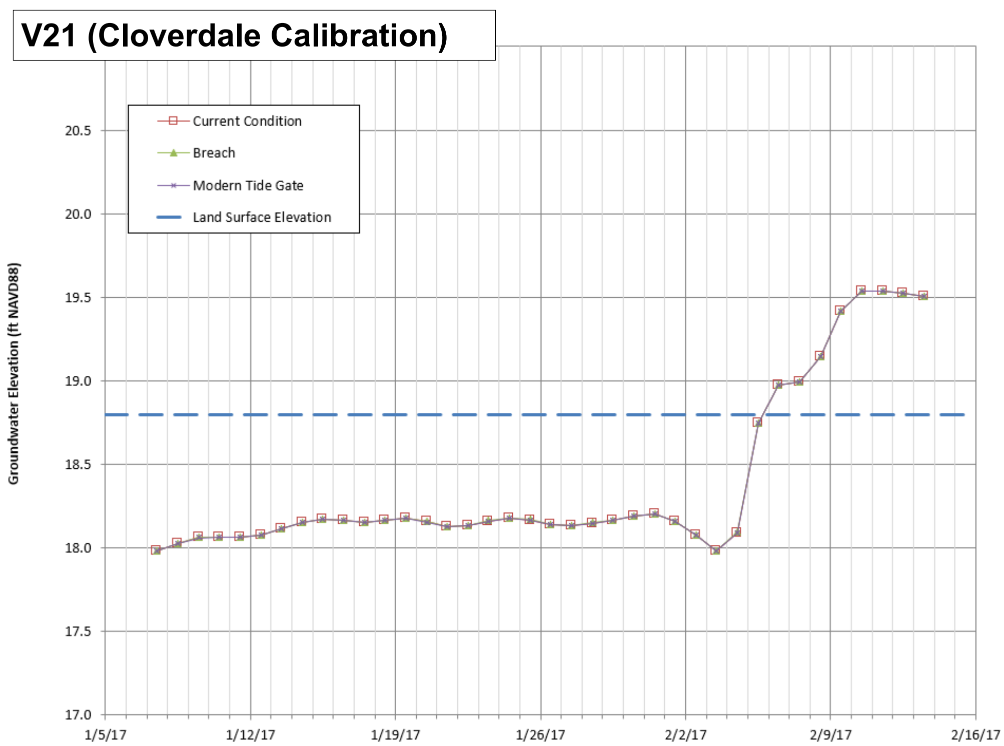
Predicted differences between the 3 dike configurations are negligible with the exception of slightly higher water levels during the "flood" condition with the current tide gate. This occurs because Beltz Marsh remains inundated for longer periods under the current condition due to limited drainage through the existing tide gate.

Well locations are mapped on Figure 5-1.

Figure 7-10
Predicted Effect of Dike Configuration on Groundwater Levels in PGG-3d (Deep Aquifer)

Sitka Sedge Natural Area





Note:
This figure compares groundwater model predictions of water-level hydrographs in Monitoring Well PGG-4i for a hypothetical 28 days of average winter conditions (1/7—2/3) followed by 10 days of "flood" conditions (2/4—2/13).

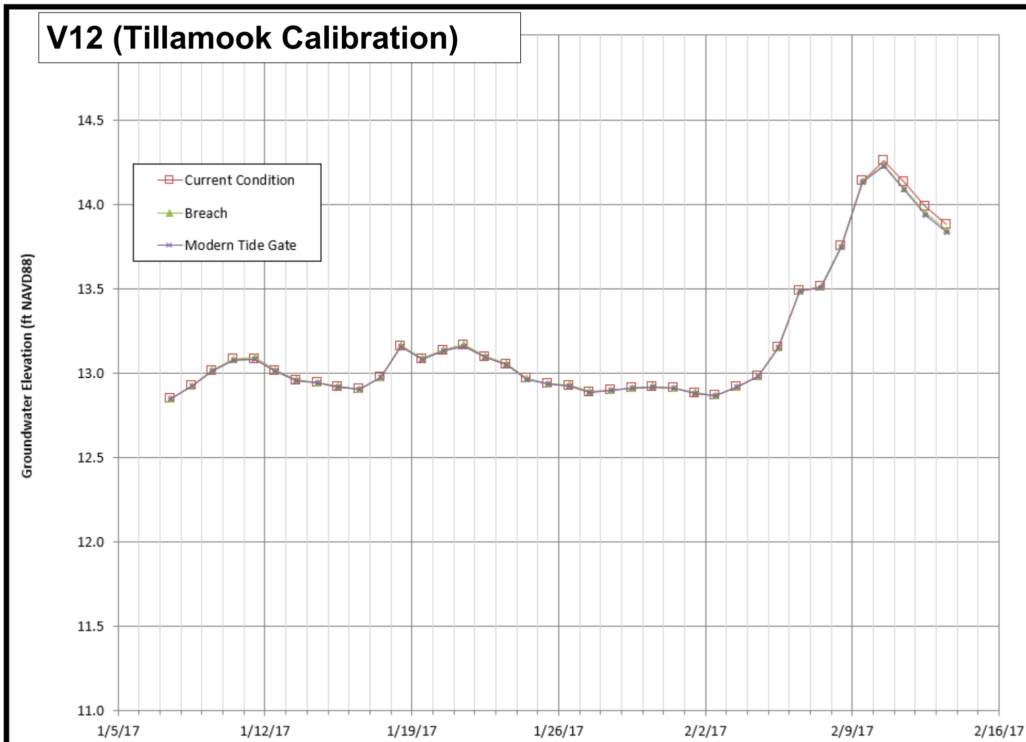
Predicted differences between the 3 dike configurations are negligible.

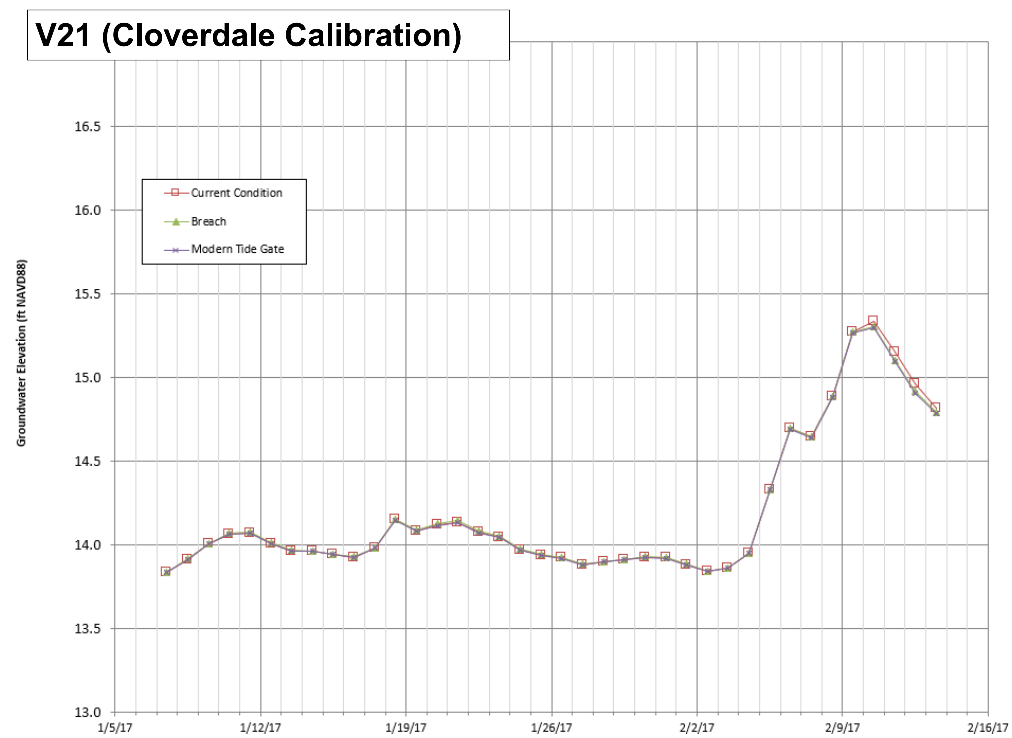
Well locations are mapped on Figure 5-1.

Figure 7-11
Predicted Effect of Dike Configuration on Groundwater Levels in PGG-4i (Shallow Aquifer)

Sitka Sedge Natural Area

PgG





Note:
This figure compares groundwater model predictions of water-level hydrographs in Monitoring Well PGG-4d for a hypothetical 28 days of average winter conditions (1/7—2/3) followed by 10 days of "flood" conditions (2/4—2/13).

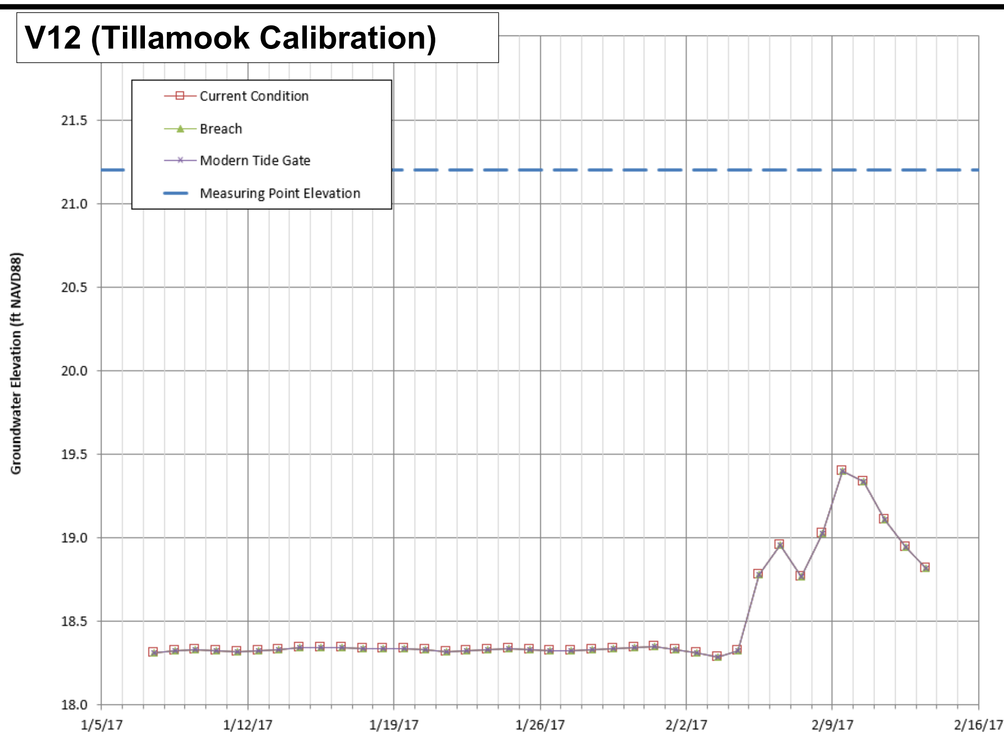
Predicted differences between the 3 dike configurations are negligible with the exception of slightly higher water levels during the "flood" condition with the current tide gate. This occurs because Beltz Marsh remains inundated for longer periods under the current condition due to limited drainage through the existing tide gate.

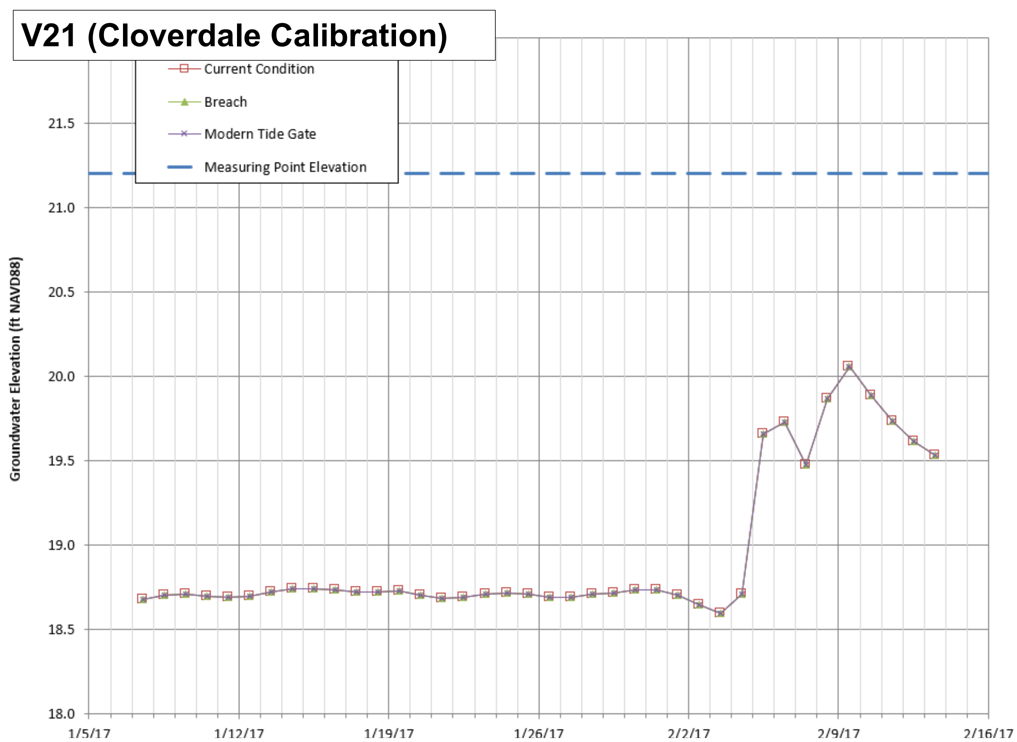
Well locations are mapped on Figure 5-1.

Figure 7-12
Predicted Effect of Dike Configuration on Groundwater Levels in PGG-4d (Deep Aquifer)

Sitka Sedge Natural Area

PGG





Note:
This figure compares groundwater model predictions of water-level hydrographs in Monitoring Well TDM-2 for a hypothetical 28 days of average winter conditions (1/7—2/3) followed by 10 days of "flood" conditions (2/4—2/13).

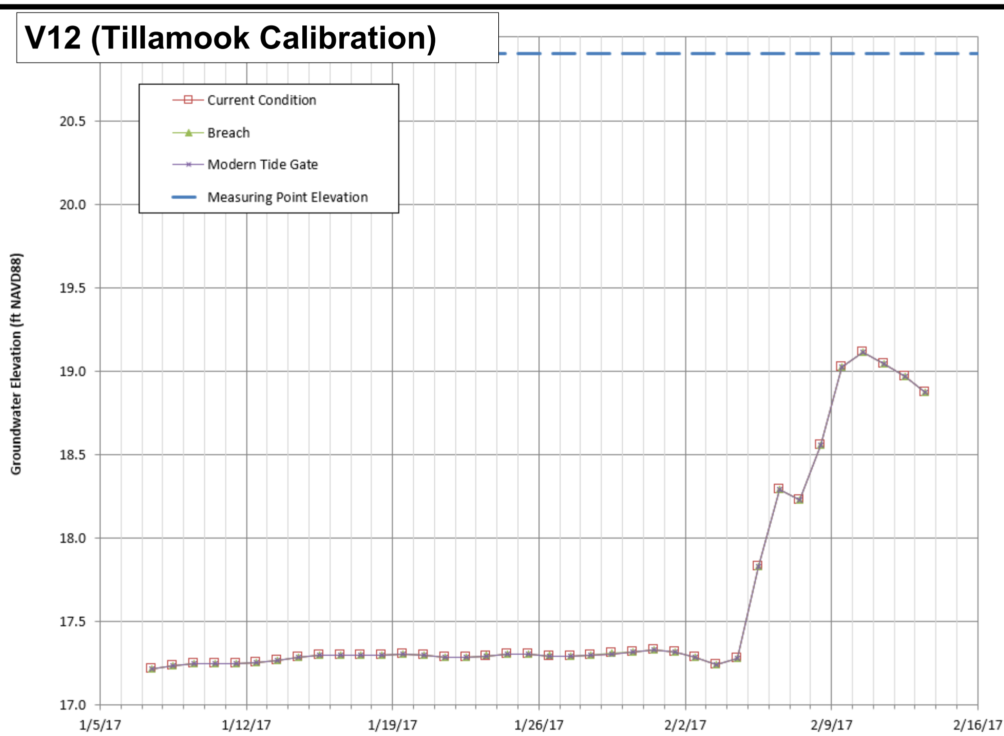
Predicted differences between the 3 dike configurations are negligible.

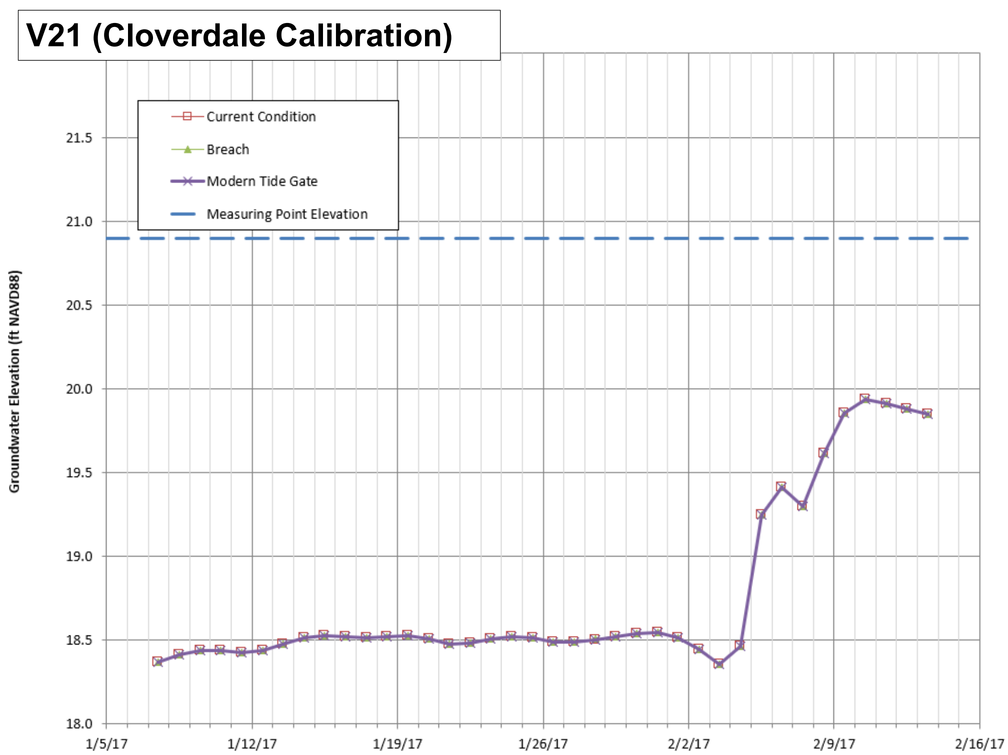
Well locations are mapped on Figure 5-1.

Figure 7-13
Predicted Effect of Dike Configuration on Groundwater Levels in TDM-2 (Shallow Aquifer)

Sitka Sedge Natural Area

PgG





Note:
This figure compares groundwater model predictions of water-level hydrographs in Monitoring Well TDM-4 for a hypothetical 28 days of average winter conditions (1/7—2/3) followed by 10 days of "flood" conditions (2/4—2/13).

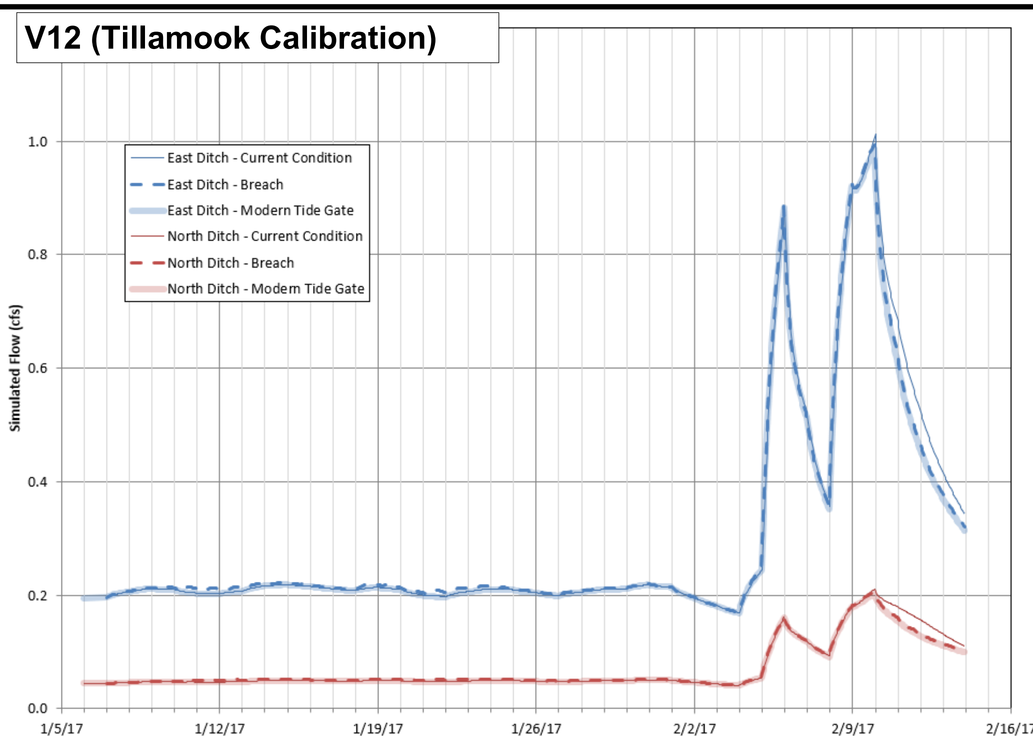
Predicted differences between the 3 dike configurations are negligible.

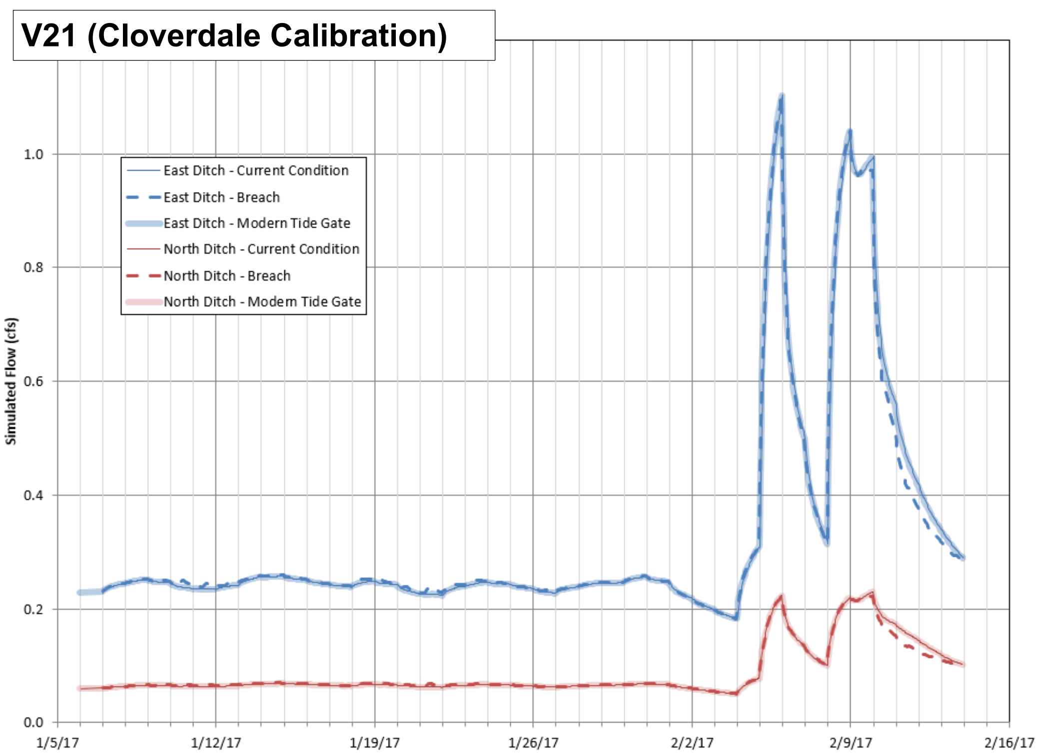
Well locations are mapped on Figure 5-1.

Figure 7-14
Predicted Effect of Dike Configuration on Groundwater Levels: TDM-4 (Shallow Aquifer)

Sitka Sedge Natural Area

PGG





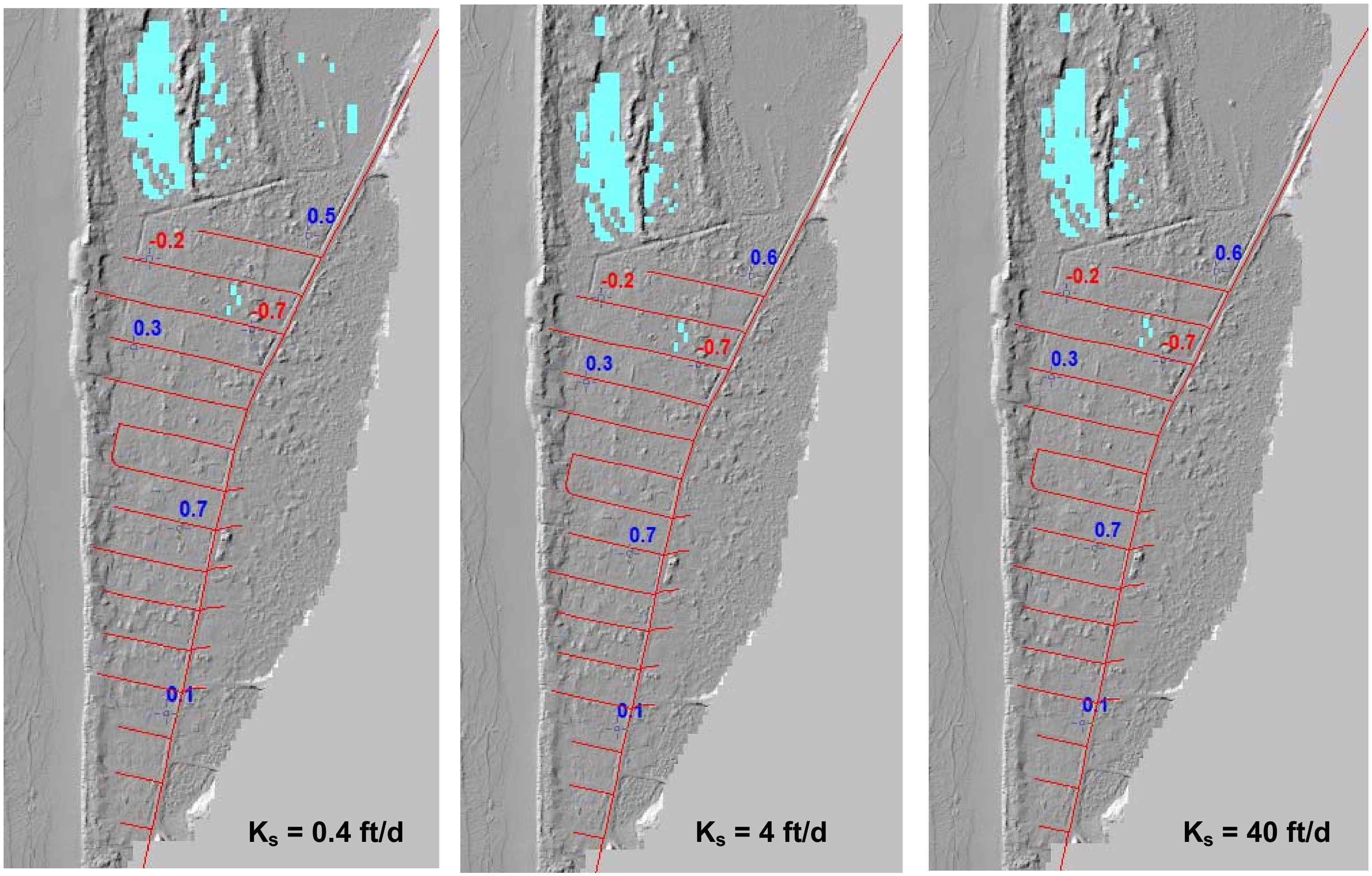
Note:
This figure compares groundwater model predictions of flow hydrographs for the East Ditch and the North Ditch over a hypothetical 28 days of average winter conditions (1/7—2/3) followed by 10 days of "flood" conditions (2/4—2/13).

Predicted differences between the 3 dike configurations are negligible with the exception of slightly higher ditch flows during the "flood" condition with the current tide gate. This occurs because Beltz Marsh remains inundated for longer periods under the current condition due to limited drainage through the existing tide gate. Longer inundation results in higher associated groundwater elevations.

Figure 7-15
Predicted Effect of Dike Configuration on Ditch Flows

Sitka Sedge Natural Area

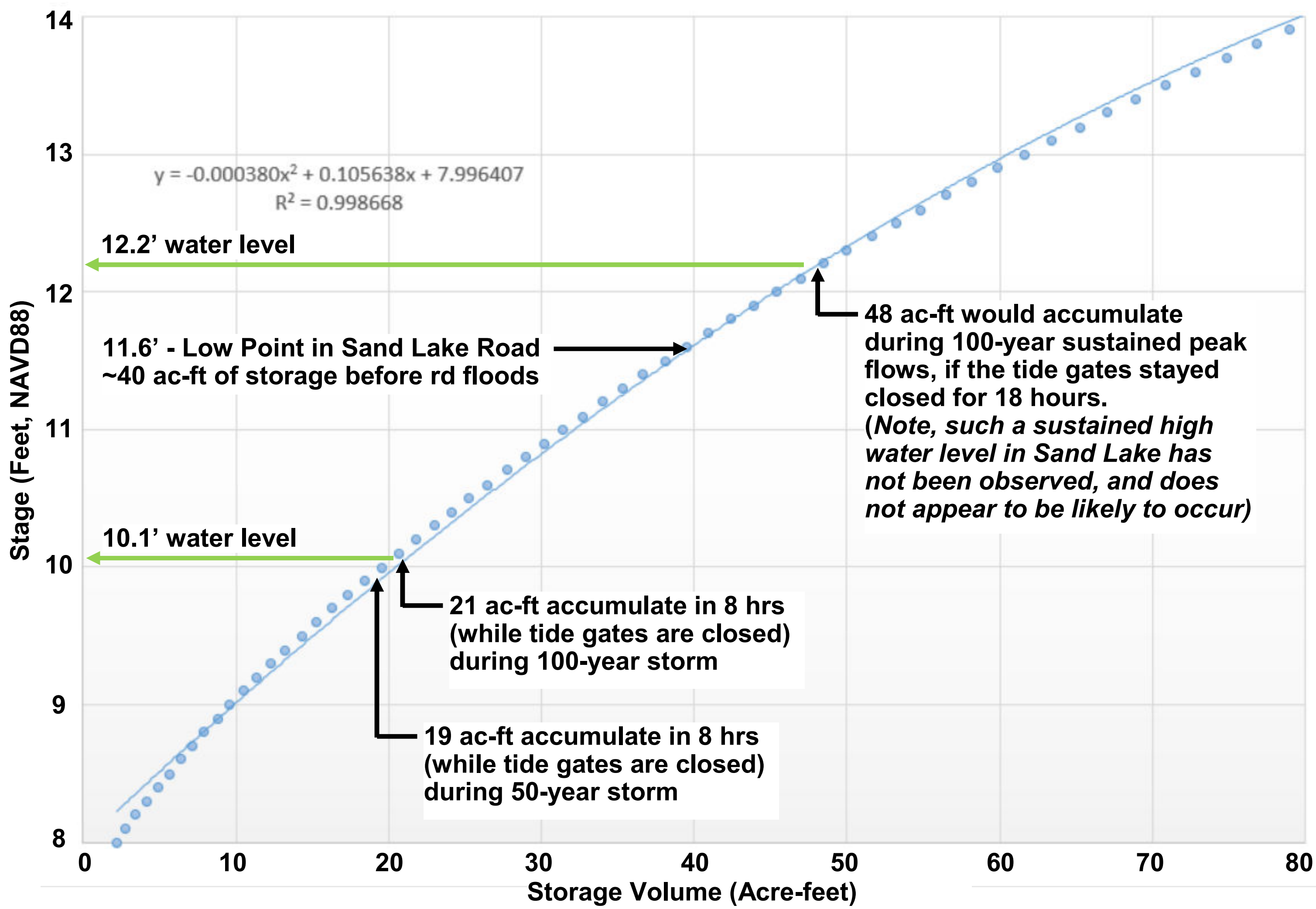
PGG



Note: *This figure illustrates how changes in the hydraulic conductivity of the basal ("skin") sediments in Beltz Marsh (Ks) has no significant impact on calibration residuals for the Shallow Aquifer. Ks was not identified as a highly sensitive parameter during calibration sensitivity analysis.*

Figure 7-16
Shallow Aquifer Residuals as a Function of Beltz Marsh K_s (Steady-State Model v12– Tillamook)

Sitka Sedge Natural Area



Note: This figure shows the stage-storage volume relationship for a theoretical setback dike constructed near the existing beaver dam, oriented east-to-west, across the south end of Beltz Marsh. The blue dots correspond to storage volume measurements at each 0.1-foot elevation increment. The solid blue line is the best-fit trend line for these data points.

The setback dike would be intended to allow the Beltz Dike to be fully breached while preventing tidal flooding from occurring at the south end of the marsh and at Tierra del Mar.

Based on preliminary conceptual analysis, it appears that a setback dike in this location would have adequate flood storage capacity to contain the combined 100-year storm surface-water inputs from TDM, the East Marsh, and direct precipitation.

See labels for additional explanation

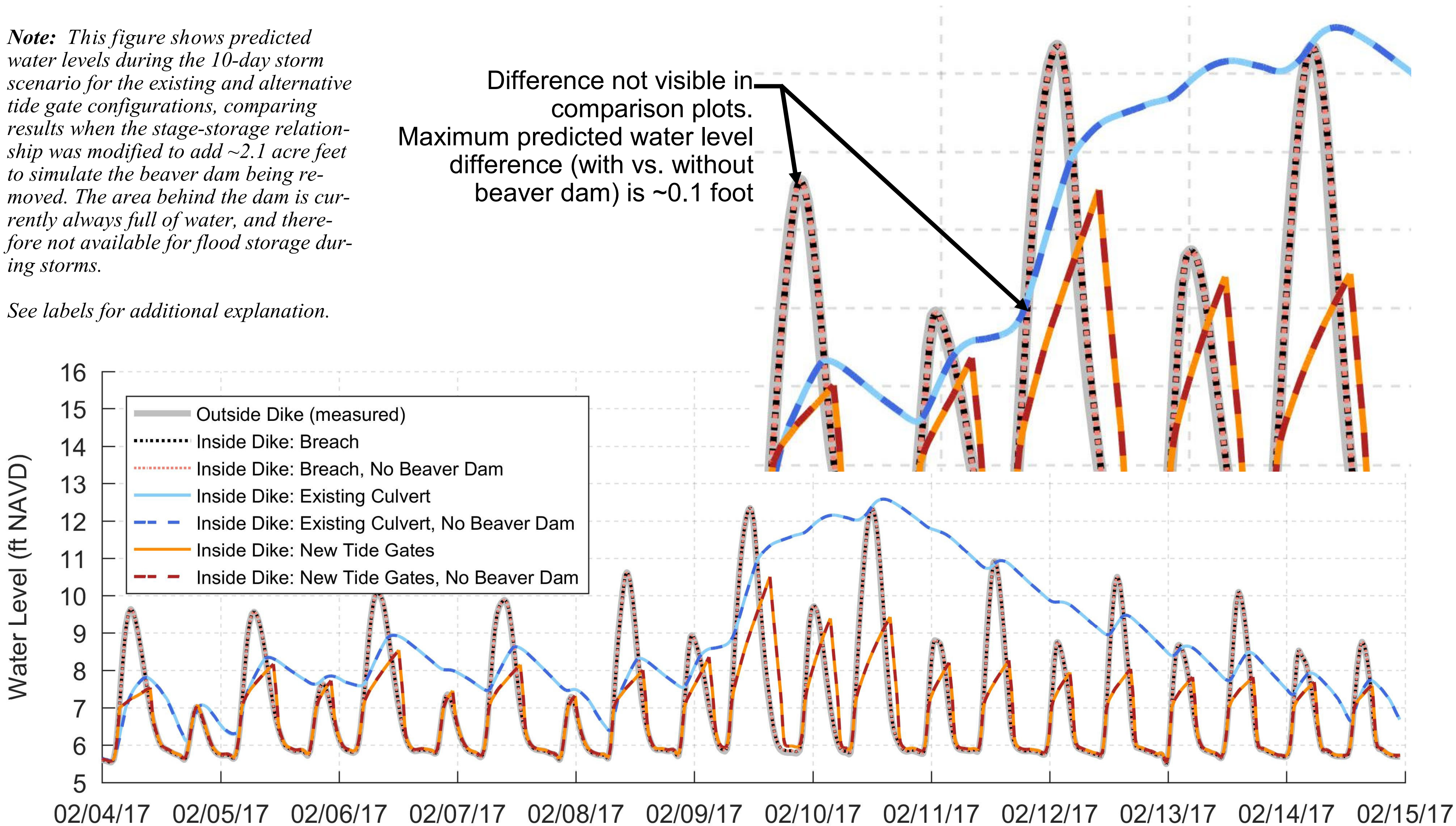
SOURCE: ESA derived stage-storage relationship based on PhoDAR terrain surface provided by OPRD.

Figure 8-1
Annotated Stage-Storage Relationship for the Area Behind a Proposed Setback Dike

Sitka Sedge Natural Area

Note: *This figure shows predicted water levels during the 10-day storm scenario for the existing and alternative tide gate configurations, comparing results when the stage-storage relationship was modified to add ~2.1 acre feet to simulate the beaver dam being removed. The area behind the dam is currently always full of water, and therefore not available for flood storage during storms.*

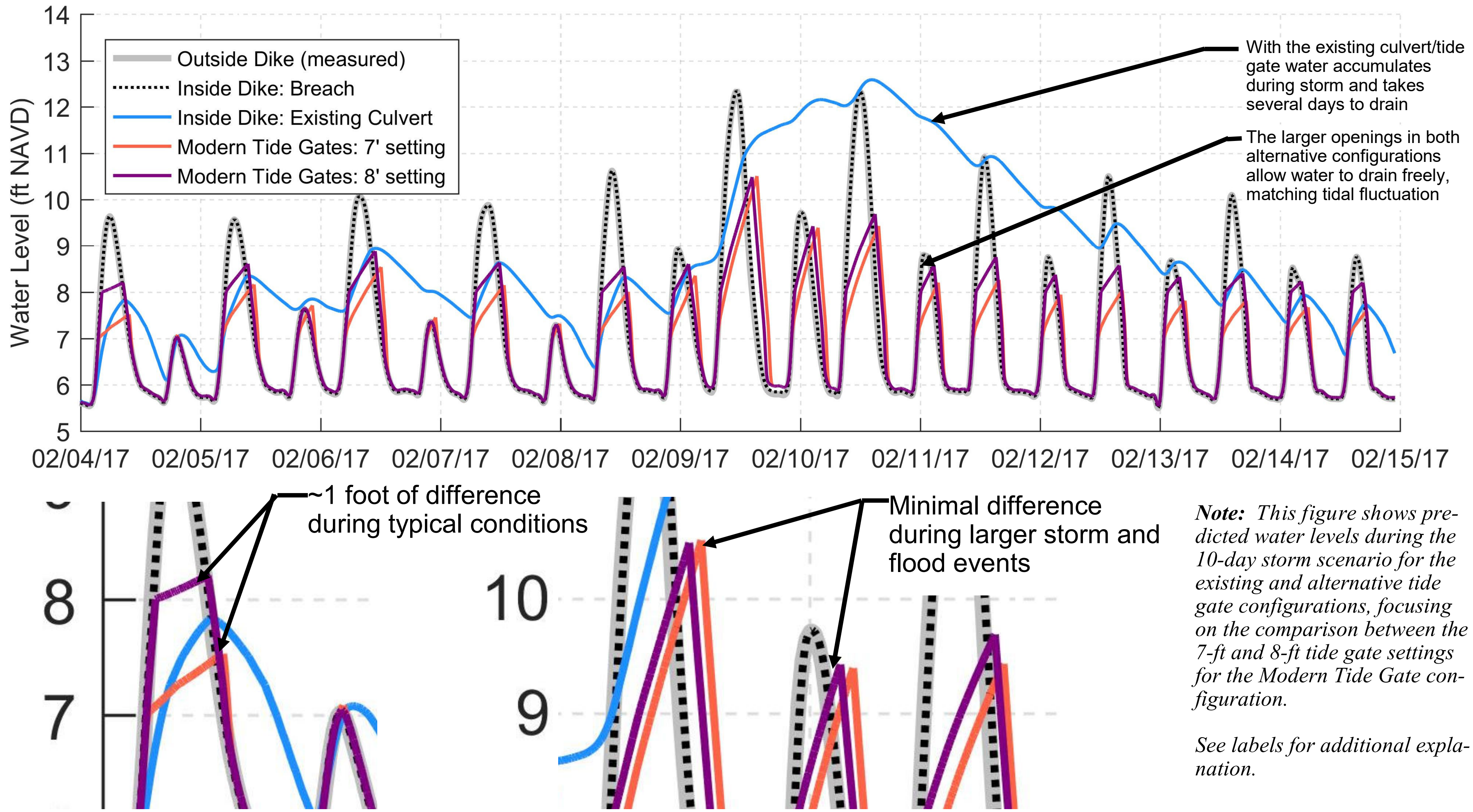
See labels for additional explanation.



SOURCE: ESA surface water model. gauge

Figure 8-2
Comparison of Predicted Water Levels for the Alternative Configurations, with and without the Beaver Dam

Sitka Sedge Natural Area



Note: This figure shows predicted water levels during the 10-day storm scenario for the existing and alternative tide gate configurations, focusing on the comparison between the 7-ft and 8-ft tide gate settings for the Modern Tide Gate configuration.

See labels for additional explanation.

SOURCE: ESA surface water model. Runoff values were scaled to 50-year values based on precipitation measured at Tillamook and runoff measured at the USGS Tucca gauge

Figure 8-3
Comparison of Predicted Water Levels for Modern Tide Gate Using 7-foot Vs. 8-foot Closure Settings

Sitka Sedge Natural Area