

Summary of study design and data collected at Fire Island National Seashore, NY

The health of maritime forests in three Mid-Atlantic National Seashores, U.S. Geological Survey. Summary Presentation of Approved Data Associated with The National Resource Protection Program

Introduction

Data used for this study were compiled from multiple U.S Geological Survey (USGS) and National Oceanographic and Atmospheric Administration (NOAA) sources. Tide-elevation data were compiled from USGS published records for the Great South Bay at Watch Hill on Fire Island, NY tidal gage (USGS station ID 01305575), which is located on the Fire Island barrier island about 6 miles east of the study area at the Watch Hill marina (fig. 1). Tides at this station are estimated to be about 40 to 45 minutes later than those at the Sunken Forest, as determined from the NOAA Center for Operational Oceanographic Products and Services (CO-OPS) Seaview Ferry Dock tidal prediction station (NOAA station ID 8514779), located just to the west of the study area near Ocean Beach. For part of the study period, the USGS also collected meteorological data (precipitation and wind speed and direction) at USGS station 01305575. Meteorological data from this station are provisional and unpublished; however, they compare well to nearby NOAA National Centers for Environmental Information (NCEI) climatological records from Long Island-Isip MacArthur Airport (about 10 miles to the north of the study area), are the closest continuous-recording dataset available, and were collected at the same location as the published tide data, so the USGS provisional data were used as a guide to select and compare storm events for this study.



Figure 1. Location of Sunken Forest study area, U.S. Geological Survey tidal gage on Great South Bay at Watch Hill on Fire Island, NY (USGS station ID 01305575), the National Oceanographic and Atmospheric Administration (NOAA) Climatic station at Long Island-Isip MacArthur Airport, and the NOAA Center for Operational Oceanographic Products and Services (CO-OPS) Seaview Ferry Dock tidal prediction station (NOAA station ID 8514779).

Groundwater-level and specific conductance data were compiled from published USGS records for five monitoring wells installed by the USGS for this study in the Sunken Forest on Fire Island National Seashore (hereafter referred to as FIIS). Marsh Well (USGS station ID 403922073064401) and Deep Well (USGS station ID 403922073064402) are both installed approximately 80 feet (ft) from the shoreline of the Great South Bay and are 60 ft away from each other; Middle Well (USGS station ID 403921073070401) is installed 180 ft from the shoreline; Inland Well 1 (USGS station ID 403921073070401) is installed approximately 300 ft from the shoreline; and Inland Well 2 (USGS station ID 403919073064801) is installed approximately 380 ft from the shoreline. Depth to water table in the Sunken Forest is generally less than 10 ft. Four of the five wells installed (Marsh Well, Middle Well, Inland Well 1, and Inland Well 2) were installed 1 to 3 ft below the water table. The fifth well (Deep Well) was installed 4 to 8 ft below the water table. The location of wells in the Sunken Forest are shown in figure 2.

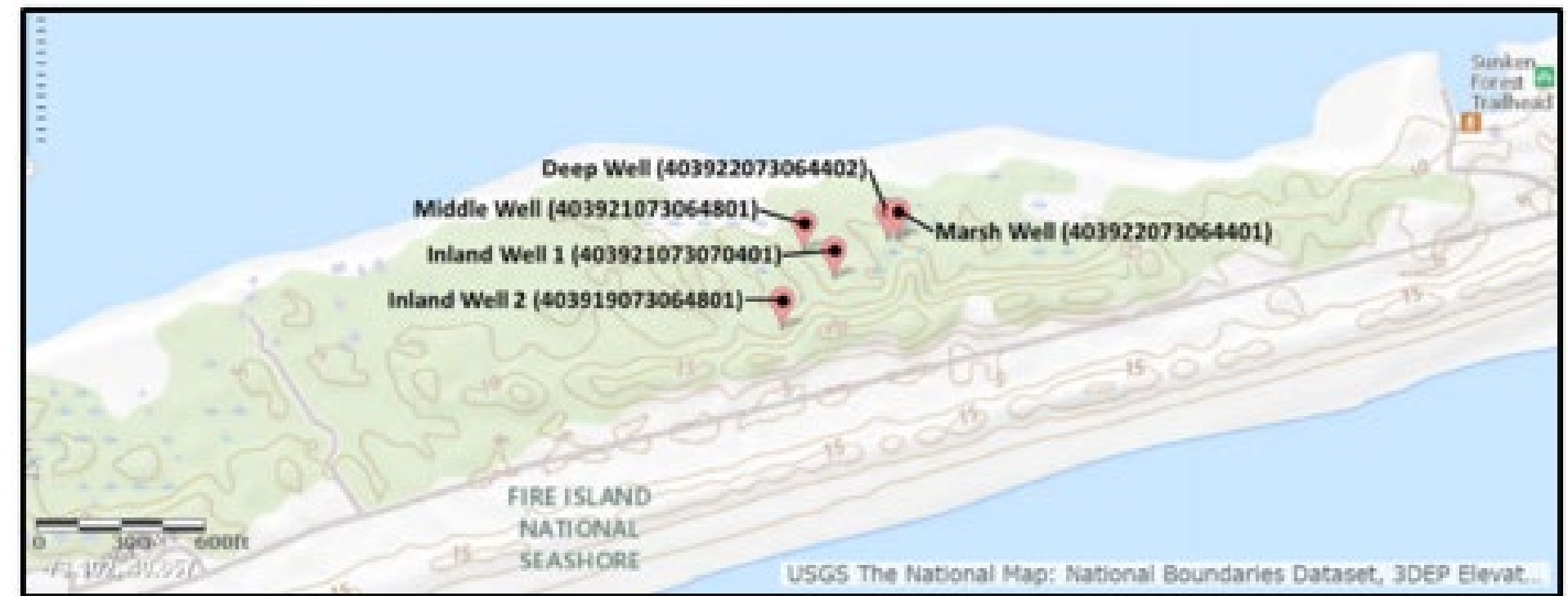


Figure 2. Location of wells in the Sunken Forest.

Water-level data at 15-minute intervals using a submersible water-level sensor was collected for the Marsh Well from September 13, 2017 to June 15, 2018 and September 13, 2018 to February 14, 2019; for the Deep Well from September 18, 2017 to April 18, 2018; for the Middle Well from September 13, 2017 to December 13, 2017 and September 13, 2018 to February 14, 2019; for Inland Well 1 from September 13, 2017 to November 22, 2017, December 13, 2017 to December 28, 2017, and January 24, 2018 to June 15, 2018; and Inland Well 2 from September 13, 2017 to January 24, 2018, March 30, 2018 to June 15, 2018, and September 13, 2018 to February 14, 2019.

Specific conductance data at 15-minute intervals using a submersible specific-conductance sensor was collected for the Marsh Well from September 13, 2017 to June 15, 2018; for the Deep Well from September 18, 2017 to April 8, 2018; for the Middle Well from September 13, 2017 to December 13, 2017 and September 14, 2018 to February 14, 2019; and Inland Well 1 from September 13, 2017 to November 22, 2017, December 13, 2017 to December 28, 2017, and January 24, 2018 to June 15, 2018. No specific conductance data was collected at Inland Well 2.

Water levels at the Marsh Well and Deep Well respond closely to astronomical tides in Great South Bay, with semidiurnal water-level fluctuations of about 0.25 to 0.5 ft recorded at these wells during non-storm conditions. At the more inland wells (Middle Well, Inland Well 1, and Inland Well 2) water levels generally show a more dampened response during normal astronomical tides, most likely due to their further distance from the Bay. For specific conductance, the Marsh Well and Deep Well had the highest maximum values of 10,800 microsiemens per centimeter (µS/cm) and 5,080 µS/cm respectively.

The more inland wells (Middle Well and Inland Well 1) generally show a lower maximum specific conductance of 3,400 µS/cm and 630 µS/cm respectively, most likely due to their further distance from the Bay. Semidiurnal fluctuations in specific conductance related to astronomical tides were recorded at the Marsh Well during some non-storm periods; these semidiurnal fluctuations were not evident at the Deep Well, Middle Well, or Inland Well 1.

Storm events for this study were selected when the maximum storm-tide elevation reached 2.0 ft (NAVD88) or greater or single-day precipitation total was 1.25 inches or greater as recorded at USGS station 01305575. Using these criteria, 18 events were selected during the study period (table 1). Of the 18 events, 3 unique events were selected for more in-depth analysis to determine the magnitude and timing of water-level and specific-conductance changes at the wells (tables 2 and 3). The three events selected were a precipitation-only event (storm event 2) that occurred on September 30, 2017; a relatively short duration high wind, coastal flooding, and heavy precipitation event (storm event 3) with a primary wind direction from the south and west that occurred on October 29 to 30, 2017; and a long duration high wind, coastal flooding, and heavy precipitation event (storm event 6) with a primary wind direction from the east to northeast that occurred on March 2 to 8, 2018. These events are discussed in more detail below.

Table 1. List of major precipitation and coastal-flooding events during the study period. Precipitation and maximum sustained-wind speed from published records of NOAA Long Island-Isip MacArthur Airport climatological data. Unpublished precipitation and maximum sustained wind speed data (shown in parentheses) from USGS Great South Bay at Watch Hill on Fire Island, NY tidal gage (USGS station ID 01305575). Maximum tide-elevation data from published records of USGS Great South Bay at Watch Hill on Fire Island, NY tidal gage (USGS station ID 01305575). *, occurred on multiple times or days; †, include period of high tides and precipitation from two consecutive storms; NA, data not available.

Storm Event Number	Storm Event Type	Event Start Date	Event End Date	Event Precipitation (in.)	Maximum Tide Elevation (ft)	Maximum Sustained Wind Speed (mph)	Maximum Sustained Wind Direction	Maximum Tide Elevation (ft)	Maximum Tide Date
1	Wind	09-18-2017	09-24-2017	0.71 (0.83)	0.71 (0.83)	26 (25)	09-19-2017	2.17	09-19-2017
2	Heavy Rain	09-30-2017	09-30-2017	0.70 (1.29)	0.70 (1.29)	28 (26)	09-30-2017	0.94	09-30-2017
3	Wind/Heavy Rain	10-29-2017	10-30-2017	4.02 (3.80)	4.02 (3.80)	41 (40)*	10-29-2017	3.32	10-30-2017
4	Wind	11-19-2017	11-19-2017	0.54 (0.28)	0.42 (0.28)	33 (29)	11-19-2017	2.39	11-19-2017
5	Heavy Rain	02-16-2018	02-13-2018	1.92 (1.69)	1.39 (1.34)	33* (30)	02-11-2018	0.65	02-13-2018
6	Wind/Heavy Rain†	03-02-2018	03-08-2018	4.62 (3.76)	3.11 (2.75)	38 (47)	03-02-2018	3.17	03-02-2018
7	Wind/Heavy Storm	03-20-2018	03-23-2018	1.96 (NA)	1.70 (NA)	26 (41)	03-21-2018	2.34	03-22-2018
8	Wind/Heavy Rain	04-16-2018	04-18-2018	1.58 (NA)	1.58 (NA)	36 (NA)	04-16-2018	2.37	04-16-2018
9	Heavy Rain	08-11-2018	08-11-2018	1.00 (1.49)	1.00 (1.49)	14 (18)	08-11-2018	1.42	08-11-2018
10	Heavy Rain	08-13-2018	08-13-2018	0.82 (1.33)	0.82 (1.33)	16 (19)	08-13-2018	1.27	08-13-2018
11	Wind/Heavy Rain	09-09-2018	09-11-2018	1.25 (1.29)	1.10 (1.16)	23 (26)	09-10-2018	2.25	09-10-2018
12	Wind/Heavy Rain	10-11-2018	10-13-2018	3.05 (2.88)	1.84 (1.95)	32 (40)	10-12-2018	2.04	10-12-2018
13	Wind/Heavy Rain	10-27-2018	10-29-2018	1.54 (1.96)	1.30 (1.83)	30 (NA)	10-27-2018	2.46	10-28-2018
14	Wind/Heavy Rain	11-15-2018	11-16-2018	1.31 (1.75)	1.09 (1.13)	36 (NA)	11-16-2018	2.01	11-16-2018
15	Wind/Heavy Rain	11-24-2018	11-28-2018	2.90 (2.21)	1.21 (1.10)	35 (NA)	11-26-2018	2.53	11-27-2018
16	Wind/Heavy Rain	12-20-2018	12-23-2018	1.75 (1.43)	1.65 (0.96)	31 (NA)	12-22-2018	2.72	12-22-2018
17	Wind/Heavy Rain	12-28-2018	12-29-2018	1.24 (1.59)	1.34 (1.59)	22* (NA)	12-28-2018	1.44	12-28-2018
18	Rain/Snow	12-31-2018	01-01-2019	1.51 (1.37)	1.26 (1.32)	30 (NA)	01-01-2019	1.73	01-01-2019

Table 2. Maximum daily precipitation, tide elevation, and groundwater-level elevations at 5 wells in the study area. Precipitation from published records of NOAA Long Island-Isip MacArthur Airport climatological data. Unpublished precipitation data (shown in parentheses) from USGS Great South Bay at Watch Hill on Fire Island, NY tidal gage (USGS station ID 01305575). Maximum tide-elevation data from published records of USGS Great South Bay at Watch Hill on Fire Island, NY tidal gage (USGS station ID 01305575). Groundwater-level data from USGS published records for each of the 5 monitoring wells; NA, data not available.

Event Number	Maximum Daily Precipitation (in.) and Date	Maximum Tide Elevation (NAVD88, ft) and Date for Well 403922073064401 (Marsh Well)	Maximum Water-Level Elevation (NAVD88, ft) and Date for Well 403922073064402 (Deep Well)	Maximum Water-Level Elevation (NAVD88, ft) and Date for Well 403921073064801 (Middle Well)	Maximum Water-Level Elevation (NAVD88, ft) and Date for Well 403919073064801 (Inland Well 1)	Maximum Water-Level Elevation (NAVD88, ft) and Date for Well 403921073070401 (Inland Well 2)
2	0.70 (1.29) 09-30	0.94 09-30	1.28 09-30	1.34 09-30	1.32 09-30	2.02 09-30
3	4.02 (3.80) 10-29	3.52 10-30	3.07 10-30	3.02 10-30	2.25 10-30	2.48 10-30
6	3.11 (2.75) 03-02	3.17 03-04	2.70 03-04	3.10 03-04	NA	2.77 03-02

Table 3. Maximum daily precipitation, tide elevation, and specific conductance at 4 wells in the study area. Precipitation from published records of NOAA Long Island-Isip MacArthur Airport climatological data. Precipitation (shown in parentheses) from USGS Great South Bay at Watch Hill on Fire Island, NY tidal gage (USGS station ID 01305575). Maximum tide-elevation from published records of USGS Great South Bay at Watch Hill on Fire Island, NY tidal gage (USGS station ID 01305575). Specific-conductance data from USGS published records for each of the 4 monitoring wells.

Event Number	Maximum Daily Precipitation (in.) and Date	Maximum Tide Elevation (NAVD88, ft) and Date	Maximum Specific Conductance (µS/cm) and Date for Well 403922073064401 (Marsh Well)	Maximum Specific Conductance (µS/cm) and Date for Well 403922073064402 (Deep Well)	Maximum Specific Conductance (µS/cm) and Date for Well 403921073064801 (Middle Well)	Maximum Specific Conductance (µS/cm) and Date for Well 403919073064801 (Inland Well 1)
2	0.70 (1.29) 09-30	0.94 09-30	4,740 9-30	5,78 9-30	1,702 10-5	357 9-30
3	4.02 (3.80) 10-29	3.52 10-30	6,040 11-5	20,60 11-7	1,642 11-04	450 11-7
6	3.11 (2.75) 03-02	3.17 03-04	7,770 3-4	783 3-2	NA	398 3-2

Fire Island Storm Events

Event #2 – Heavy Precipitation Event – September 30, 2017

The storm that affected the study area on September 30, 2017, was characterized by heavy rain, but no substantial high tide or strong wind (fig. 3). Storm-total precipitation of 0.70 inches (in.) at Long Island-Isip MacArthur Airport occurred as rainfall on a single day (September 30th). Winds were generally from a north to northeasterly direction throughout the event, reaching a maximum sustained wind speed of 28 miles per hour (mph) at Long Island-Isip MacArthur Airport during the early afternoon of September 30th. This event occurred during a period of low astronomical tide as determined from NOAA station 8514779, with a maximum tide elevation of 0.94 ft (NAVD 88) at USGS station 01305575 recorded during the mid-afternoon normal high-tide cycle.

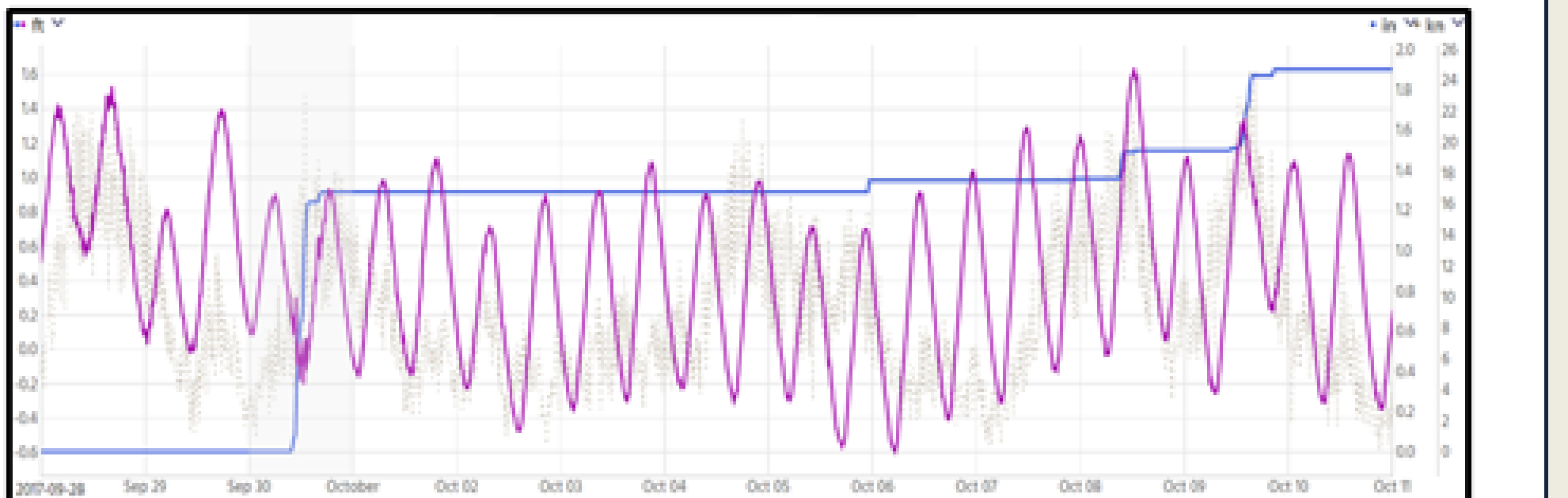


Figure 3. Precipitation (solid blue), tide elevation (solid magenta), and maximum sustained wind speed (dotted grey), at USGS Great South Bay at Watch Hill on Fire Island, NY tidal gage (USGS station ID 01305575) for the period September 28, 2017, to October 10, 2017 (2 days before and 10 days after the storm). Storm period shaded in grey.

Ground-Water Levels: During the event, only two of the wells experienced immediate increases in groundwater elevation (fig. 4) – Inland Well 1 and Inland Well 2. Water levels at Inland Well 1 rose 0.08 ft in 30 minutes, from 1.62 to 1.70 ft (NAVD 88). Similarly, water levels at Inland Well 2 rose 0.06 ft in 30 minutes, from 1.96 to 2.02 ft (NAVD 88). Another well experienced a slightly delayed increase in water levels, Marsh Well rose 0.07 ft in 1.25 hours, from 1.06 to 1.13 ft (NAVD 88). The other two wells, Middle Well and Deep Well, experienced no discernable water-level increase until the afternoon high tide

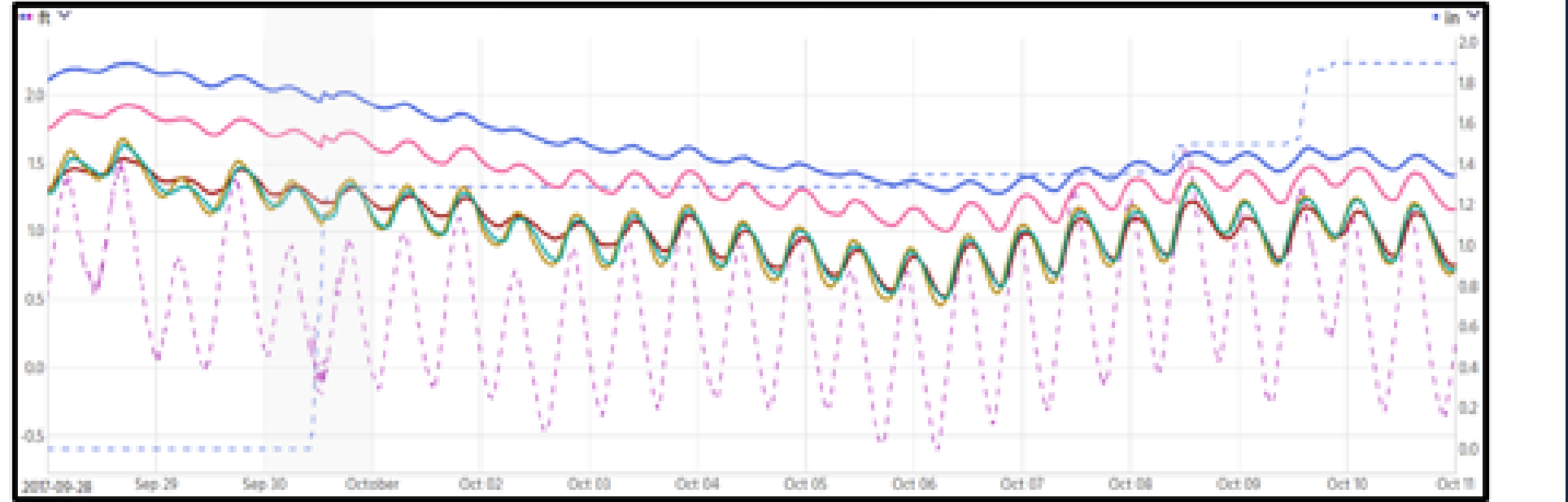


Figure 4. Precipitation (dashed blue) and tide elevation (dashed magenta) at USGS Great South Bay at Watch Hill on Fire Island, NY tidal gage (USGS station ID 01305575) and water-level elevations at USGS wells 403922073064401 (Marsh Well – solid brown), 403922073064402 (Deep Well – solid teal), 403921073064801 (Middle Well – solid dark red), 403921073070401 (Inland Well 1 – solid pink), and 403919073064801 (Inland Well 2 – solid blue) for the period September 28, 2017, to October 10, 2017 (2 days before and 10 days after the storm). Storm period shaded in grey.

Specific Conductance: None of the wells experienced a specific conductance increase or decrease from this heavy rain event besides those attributed to background variations (fig. 5).

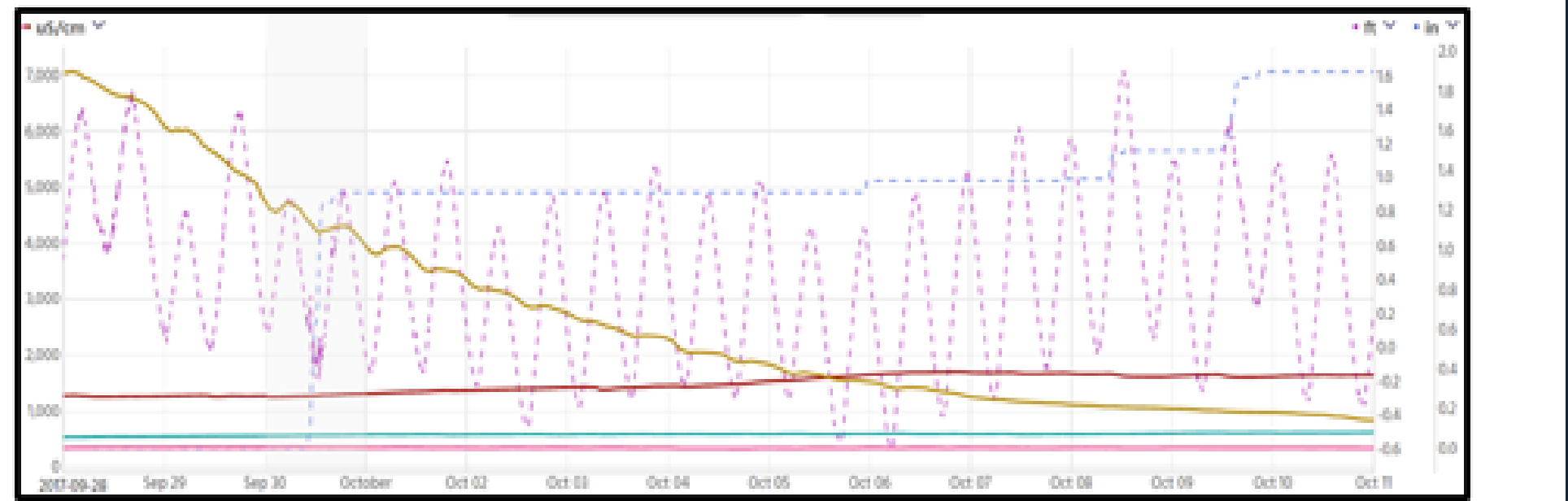


Figure 5. Precipitation (dashed blue) and tide elevation (dashed magenta) at USGS Great South Bay at Watch Hill on Fire Island, NY tidal gage (USGS station ID 01305575) and specific conductance at USGS wells 403922073064401 (Marsh Well – solid brown), 403922073064402 (Deep Well – solid teal), 403921073064801 (Middle Well – solid dark red), and 403921073070401 (Inland Well 1 – solid pink) for the period September 28, 2017, to October 10, 2017 (2 days before and 10 days after the storm). Storm period shaded in grey.

Event #3 – High Wind and Heavy Rain Event – October 29-30, 2017

The storm that affected the study area from October 29-30, 2017, was characterized by heavy rain and strong winds (fig. 6). Storm-total precipitation of 4.02 in. at Long Island-Isip MacArthur Airport occurred as rainfall on a single day (October 29th). Winds were generally from the south to southeast at the beginning of the event, reaching a maximum sustained wind speed of 41 mph at Long Island-Isip MacArthur Airport on October 29th, then shifted to a more westerly direction on the following day. This event occurred during a period of relatively low astronomical tide as determined from NOAA station 8514779. However, the strong winds associated with this event produced coastal flooding that reached a maximum elevation of 3.53 ft (NAVD 88) at USGS station 01305575 on the morning of October 30th. This maximum coincided with a period of strong westerly winds. This maximum tide elevation was also the highest recorded during the study period.

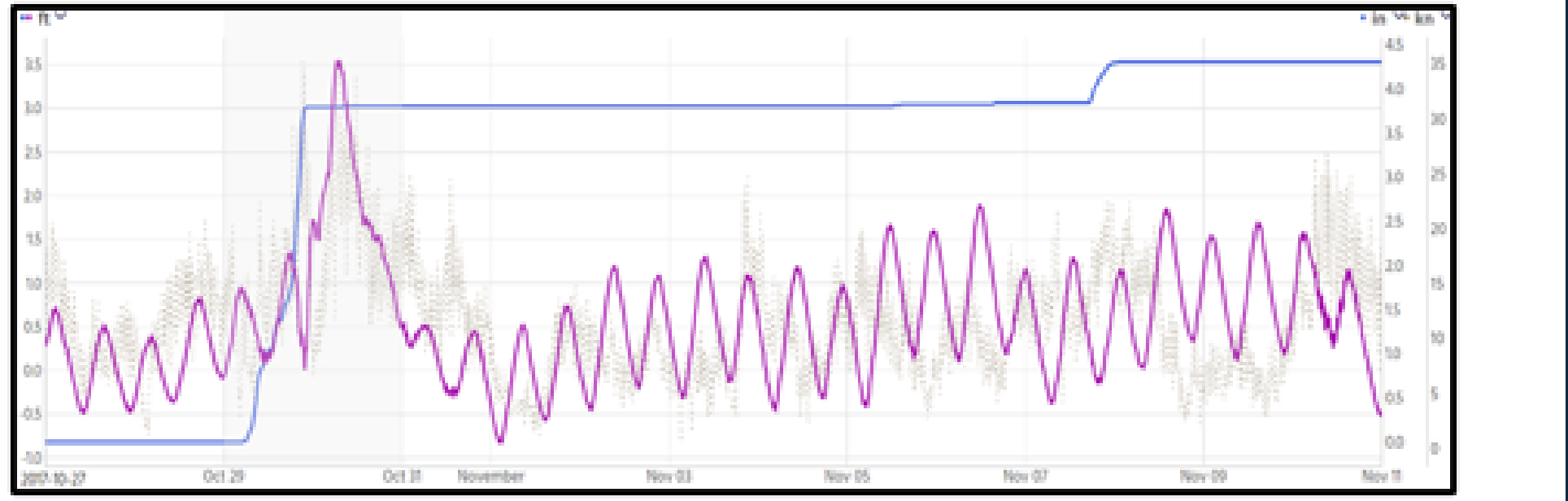


Figure 6. Precipitation (solid blue), tide elevation (solid magenta), and maximum sustained wind speed (dotted grey), at USGS Great South Bay at Watch Hill on Fire Island, NY tidal gage (USGS station ID 01305575) for the period October 27, 2017, to November 10, 2017 (2 days before and 10 days after the storm). Storm period shaded in grey.

Ground-Water Levels: During the event, all near-shore wells experienced significant increases in groundwater elevations (fig. 7). Water levels in the Marsh Well and Deep Well increased by about 2.5 ft during the event, with peak water levels of 3.07 ft (NAVD 88) and 3.02 ft (NAVD 88), respectively. Both wells reached their peaks about 45 minutes after the recorded peak storm tide at station 01305575. Water levels in the Middle Well, Inland Well 1 and Inland Well 2 showed smaller increases of about 1 ft, with peak water levels of 1.99 ft (NAVD 88), 2.25 ft (NAVD 88), and 2.48 ft (NAVD 88), respectively. Water levels reached their peak at these wells about 4 hours, 5 ½ hours, and 12 hours, respectively, after the recorded storm tide peak at USGS station 01305575. Water levels returned to pre-storm levels for the Marsh Well, Deep Well, and Middle Well by around November 2nd, while Inland Well 1 and Inland Well 2 remained elevated longer and did not return to pre-storm levels until around November 4th.

Parts of the shoreline above higher-high water were inundated during this event. However, none of the wells were believed to be overtopped by storm tide. Water levels did not peak above land-surface elevation during this event for any of the wells in the study area.

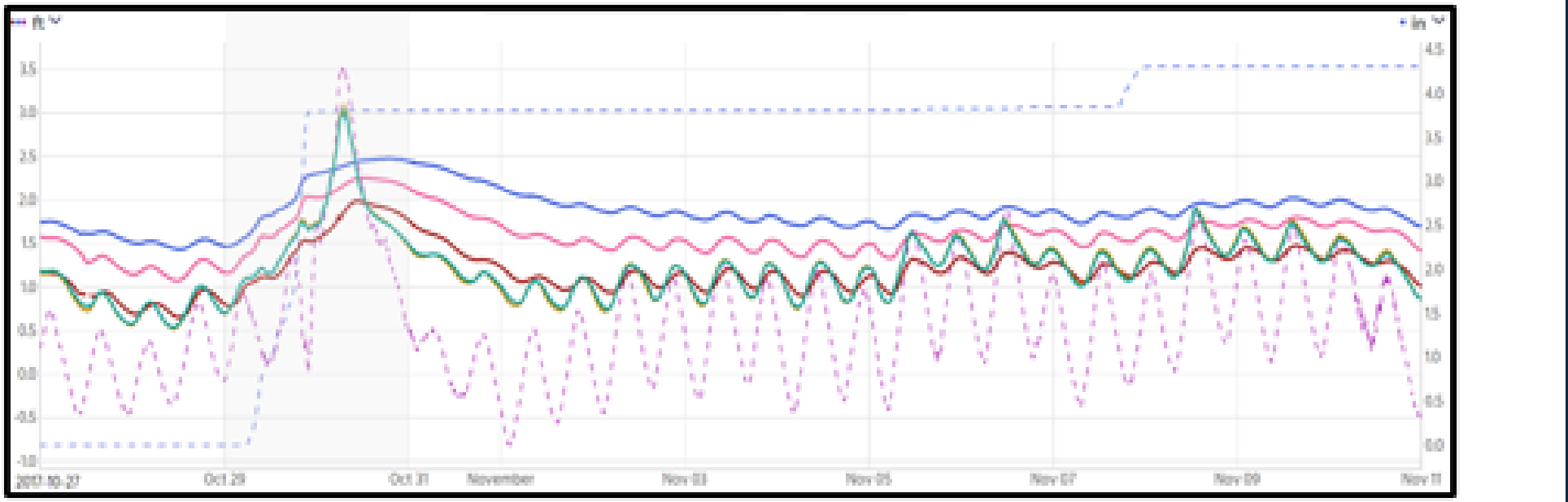


Figure 7. Precipitation (dashed blue) and tide elevation (dashed magenta) at USGS Great South Bay at Watch Hill on Fire Island, NY tidal gage (station USGS station ID) and water-level elevations at USGS wells 403922073064401 (Marsh Well – solid brown), 403922073064402 (Deep Well – solid teal), 403921073064801 (Middle Well – solid dark red), 403921073070401 (Inland Well 1 – solid pink), and 403919073064801 (Inland Well 2 – solid blue) for the period October 27, 2017, to November 10, 2017 (2 days before and 10 days after the storm). Storm period shaded in grey.

Specific Conductance: Specific conductance at the shallow marsh well (Marsh Well) increased from about 1,300 µS/cm to 4,200 µS/cm on October 30th, generally coinciding with the recorded peak storm tide at USGS station 01305575 (fig. 8) presumably from aquifer infiltration of seawater from the storm-tide inundation of the marsh. Specific conductance after the event slowly declined to about 2,500 µS/cm by November 2nd, then began increasing again and peaked at slightly above 6,000 µS/cm on November 5th. Specific conductance at the Marsh Well then slowly declined, returning to near pre-storm levels by November 16th (not shown on hydrograph). Specific conductance at the deeper marsh well (Deep Well) showed a delayed response to the coastal-flooding event. Specific conductance at this well began a gradual increase from about 600 µS/cm on November 4th to a peak of about 5,000 µS/cm on November 14th (not shown on hydrograph). Specific conductance at the Deep Well then slowly declined, returning to near pre-storm levels by the middle of December (not shown on hydrograph).

Two of the wells located further inland were also monitored for specific conductance during this event (Middle Well and Inland Well 1), with both wells showing significantly less response to the event than the two marsh wells. Specific conductance at the Middle Well showed a rapid decline from about 1,750 µS/cm to 1,450 µS/cm on October 30th near the recorded peak storm tide at station 01305575; however, the decrease in specific conductance began right around the time of heavy precipitation for this event and may be related to dilution of the aquifer from the rainfall. Specific conductance at this well then began a gradual rise and peaked on November 5th at about 1,650 µS/cm, then gradually declined to below 1,400 µS/cm by November 24th (not shown on hydrograph). Specific conductance at Inland Well 1 was the least responsive showing only a very gradual increase from about 380 µS/cm at the start of the event to around 550 µS/cm by November 22nd (not show on hydrograph) when the sensor stopped recording.

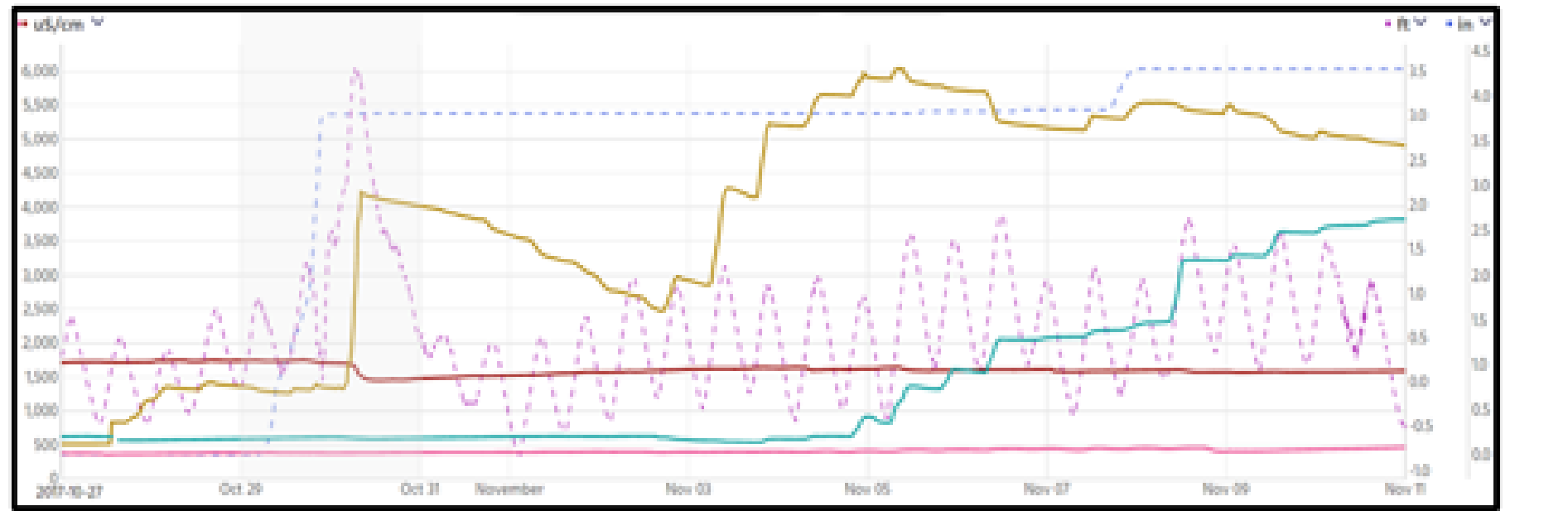


Figure 8. Precipitation (dashed blue) and tide elevation (dashed magenta) at USGS Great South Bay at Watch Hill on Fire Island, NY tidal gage (USGS station ID 01305575) and specific conductance at USGS wells 403922073064401 (Marsh Well – solid brown), 403922073064402 (Deep Well – solid teal), 403921073064801 (Middle Well – solid dark red), and 403921073070401 (Inland Well 1 – solid pink) for the period October 27, 2017, to November 10, 2017 (2 days before and 10 days after the storm). Storm period shaded in grey.

Event #6 – Nor'easter with High Winds and Heavy Rain – March 2-8, 2018

Two distinct storms affected the study area from March 2-8, 2018, that were characterized by heavy rain and strong winds (fig. 9). The more intense of these two events was a Nor'easter that affected the area from March 2nd to March 4th, the second storm affected the area from March 7th to March 8th. Storm-total precipitation for the combined event was 4.62 in. at Long Island-Isip MacArthur Airport over the six days, with a maximum daily total of 3.11 in. at Long Island-Isip MacArthur Airport recorded as rainfall on March 2nd. An additional 1.35 in. at Long Island-Isip MacArthur Airport (0.79 in. at USGS station 01305575, unpublished) was recorded as rain and snow on March 7th during the second storm.

Winds were generally from the east to northeast at the beginning of the first storm, reaching a maximum sustained wind speed of 38 mph at Long Island-Isip MacArthur Airport (47 mph at USGS station 01305575, unpublished) on the afternoon of March 2nd, then shifting to a more north-northeasterly direction later that same day. Winds remained generally from this north-northeasterly direction until the morning of March 6th. As the second storm approached, winds shifted to the south by the afternoon of March 6th and then to a more easterly to north-easterly direction later that day and during most of the following day. A second sustained wind peak of 30 mph at Long Island-Isip MacArthur Airport (42 mph at USGS station 01305575, unpublished) was reached on the evening of March 7th. Winds then shifted to a north-westerly direction by the morning of March 8th.

This event began during a period of relatively high astronomical tides and ended during a period of relatively low astronomical tides as determined from NOAA station 8514779. The strong winds associated with the first storm produced coastal flooding that reached a maximum elevation of 3.17 ft (NAVD 88) at USGS station 01305575 in the early morning of March 4th. This maximum occurred well after the peak of the east to northeasterly winds from this event and coincided with an extended period of moderate north-northeasterly winds with high astronomical tides. As second peak in storm tide of 2.71 ft (NAVD 88) at USGS station 01305575 occurred in the early morning of March 8th as winds from the departing second storm shifted to a northwest direction. Tides throughout the duration of this 7-day event remained elevated, with peaks during each of the diurnal high tides reaching above 2.0 ft (NGVD 88).

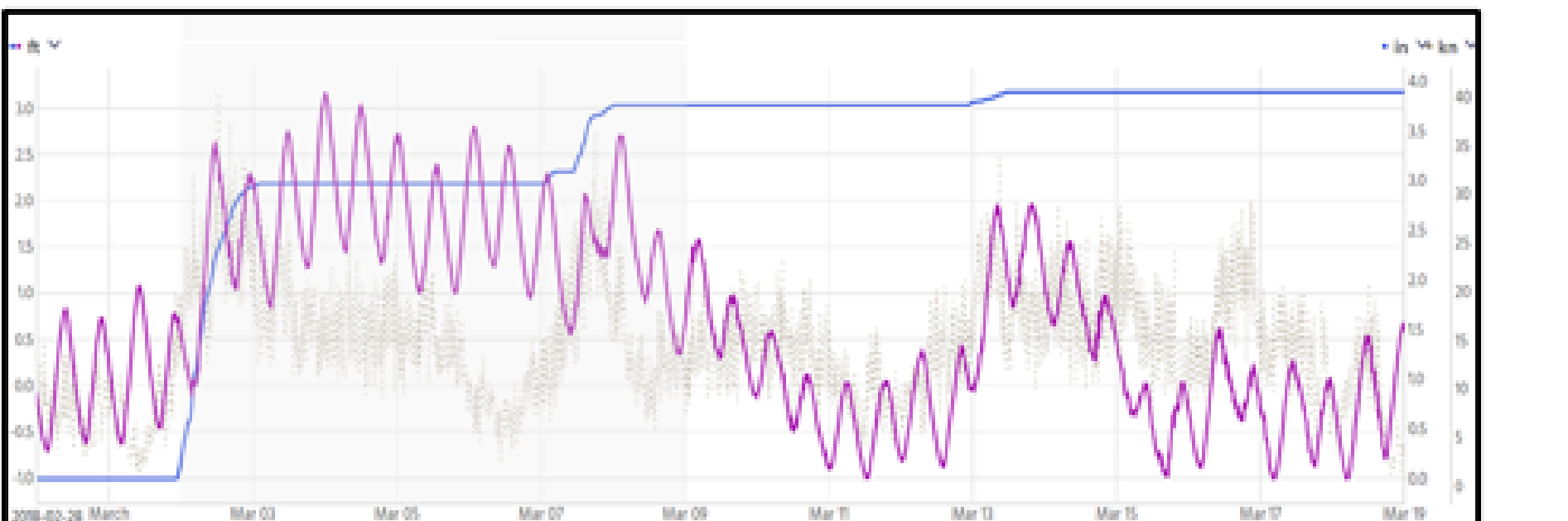


Figure 9. Precipitation (solid blue), tide elevation (solid magenta), and maximum sustained wind speed (dotted grey), at USGS Great South Bay at Watch Hill on Fire Island, NY tidal gage (USGS station ID 01305575) for the period February 28, 2018, to March 18, 2018 (2 days before and 10 days after the storm). Storm period shaded in grey.

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Fire Island Storm Events continued

Ground-Water Levels: During the event, all wells experienced significant increases in groundwater elevations (fig. 10). Water levels in the Marsh Well and Deep Well increased by about 2.5 ft during the event, with peak water levels of 2.79 ft (NAVD 88) and 3.19 ft (NAVD 88), respectively. The Deep Well reached a peak on the morning of March 4th at around the time of peak storm tide as recorded at USGS station 01305575, while the shallower Marsh Well reached a peak two days later in the early morning of March 6th at the time of high tide. This Marsh Well peak was only 0.01 ft above the peak water level reached at this well on March 4th at around the time of peak storm tide for the event. Only one of the three other inland wells (Inland Well 1) was monitored during this event. Inland Well 1 reached a peak water level of 2.77 ft (NAVD88) during the morning of March 8th, about 4 days after the storm-tide peak from the first storm and about 4 hours after the storm-tide peak of the second storm. Water levels returned to pre-storm levels for both the Marsh Well and Deep Well by around March 11th, while the Inland Well 1 remained elevated longer and did not return to pre-storm levels until around March 17th.

Parts of the shoreline above higher-high water were inundated during this event. However, none of the wells were believed to be overtopped by storm tide. Water levels did not peak above land-surface elevation during this event for any of the wells in the study area.

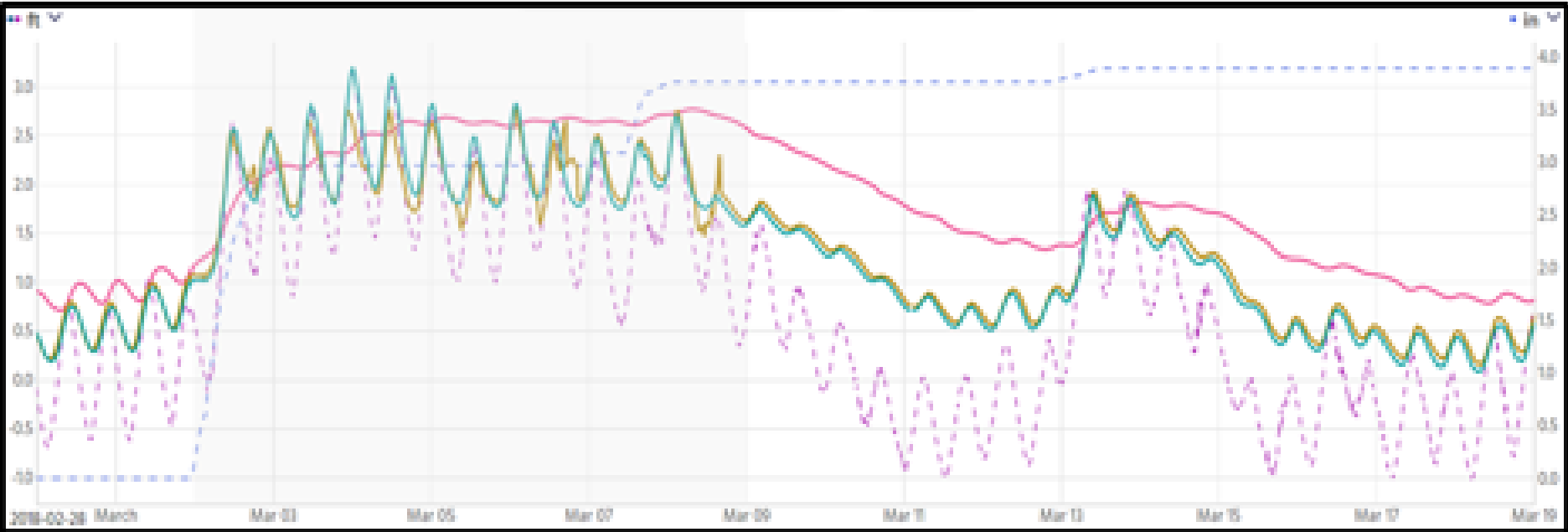


Figure 10. Precipitation (dashed blue) and tide elevation (dashed magenta) at USGS Great South Bay at Watch Hill on Fire Island, NY tidal gage (USGS station ID 01305575) and water-level elevations at USGS wells 403922073064401 (Marsh Well – solid brown), 403922073064402 (Deep Well – solid teal), and 403921073070401 (Inland Well 1 – solid pink) for the period February 28, 2018, to March 18, 2018 (2 days before and 10 days after the storm). Storm period shaded in grey.

Specific Conductance:

The specific conductance at the shallow marsh well (Marsh Well) increased from about 500 $\mu\text{S}/\text{cm}$ on March 2nd to almost 7,800 $\mu\text{S}/\text{cm}$ on March 4th, generally coinciding with the recorded peak storm tide at USGS station 01305575 (fig. 8) presumably from aquifer infiltration of seawater from the storm-tide inundation of the marsh. Specific conductance after the event slowly declined to about 700 $\mu\text{S}/\text{cm}$ by March 10th, then increased moderately during the second storm peaking at slightly above 2,300 $\mu\text{S}/\text{cm}$ on March 13th. Specific conductance at the Marsh Well was then variable until around March 25th when another sharp rise occurred peaking at about 7,800 $\mu\text{S}/\text{cm}$ on March 26th (not shown on hydrograph). It is not known if this March 26th peak is related to the effects of the two storms from this analysis period or are due to some other factors. It is also interesting to note that there was a semi-diurnal rise and fall of specific conductance at the Marsh Well during most of this event that closely coincides with the semi-diurnal (astronomical) tidal cycle. Specific conductance at the deeper marsh well (Deep Well) showed a delayed response to the coastal-flooding event. Specific conductance at this well began a gradual decline from about 800 $\mu\text{S}/\text{cm}$ on March 2nd to about 520 $\mu\text{S}/\text{cm}$ on March 12th. Specific conductance then increased sharply reaching a peak of about 4,600 $\mu\text{S}/\text{cm}$ on March 20th, then declined until April 8th, which was the end of the period of data collection at this well.

One of the wells located further inland was also monitored for specific conductance during this event (Inland Well 1) with this well showing significantly less response to the event than the two marsh wells. Specific conductance at Inland Well 1 showed a sharp decrease from 400 $\mu\text{S}/\text{cm}$ to 370 $\mu\text{S}/\text{cm}$ on March 2nd around the time of the heavy precipitation event, then gradually increased to about 480 $\mu\text{S}/\text{cm}$ on March 21st, and gradually declined to about 270 $\mu\text{S}/\text{cm}$ by the end of April.

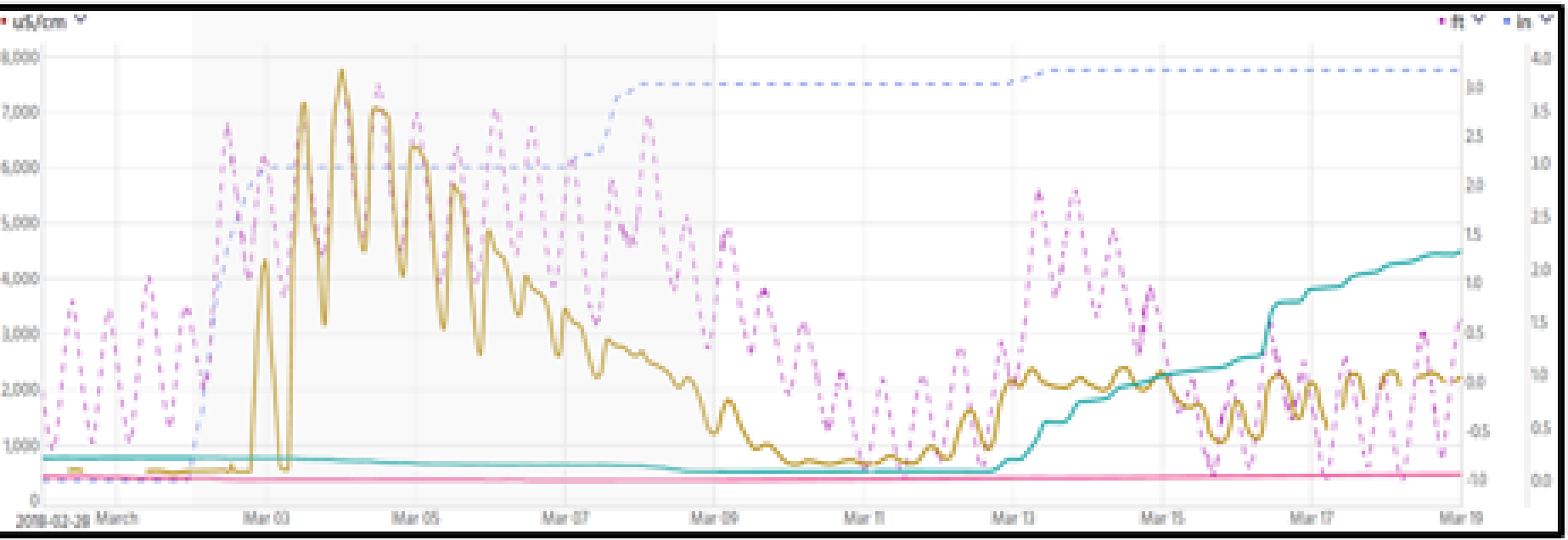


Figure 11. Precipitation (dashed blue) and tide elevation (dashed magenta) at USGS Great South Bay at Watch Hill on Fire Island, NY tidal gage (USGS station ID 01305575) and specific conductance at USGS wells 403922073064401 (Marsh Well – solid brown), 403922073064402 (Deep Well – solid teal), and 403921073070401 (Inland Well 1 – solid pink) for the period February 28, 2018, to March 18, 2018 (2 days before and 10 days after the storm). Storm period shaded in grey.

Summary

Fire Island National Seashore (hereafter referred to as FIIS) in New York is approximately 31 miles long and varies from about 500 to 1,300 ft wide. The study area for this project was located on the Great South Bay side of the barrier island at the Sunken Forest (fig. 12). The U.S. Geological Survey (USGS) installed a set of shallow wells in low-lying forest and near-forest areas likely to experience saltwater inundation during a coastal storm-tide flooding event, and a single well in a low-lying inland forest area likely to experience fresh groundwater flooding of the tree roots. Wells were installed at various distances from the shoreline to help assess the influence of tidal forcing, coastal flooding, and precipitation.

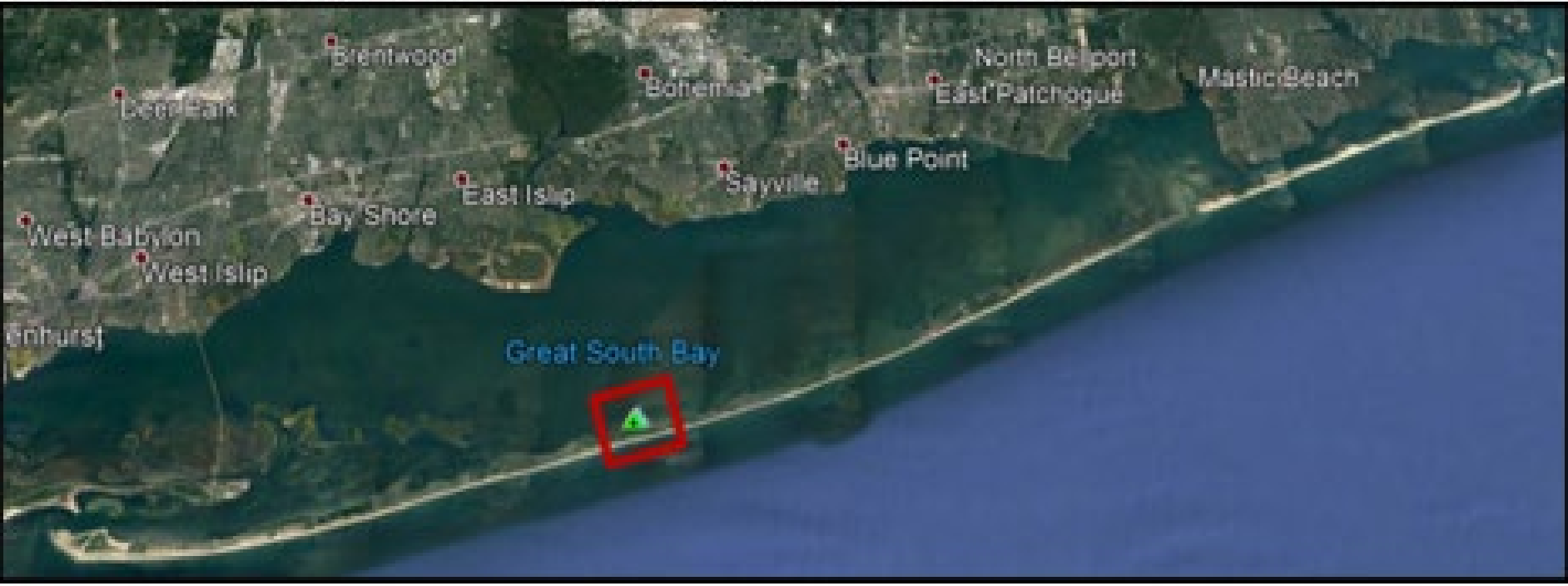


Figure 12. Location of the study area on Fire Island National Seashore.

Five wells were monitored for this project in the Sunken Forest: Marsh Well (USGS station ID 403922073064401) and Deep Well (USGS station ID 403922073064402) are both approximately 80 ft from the shoreline of the Great South Bay and are 60 ft away from each other; Middle Well (USGS station ID 403921073064801) is 180 ft from the shoreline; Inland Well #1 (USGS station ID 403921073070401) is approximately 300 ft from the shoreline; and Inland Well #2 (USGS station ID 403919073064801) is approximately 380 ft from the shoreline. The location of wells in the Sunken Forest is shown in figure 13.

Depth to the water table in the Sunken Forest area is generally less than 10 ft. Four of the five wells (Marsh Well, Middle Well, Inland Well 1, and Inland Well 2) were installed 1 to 3 ft below the water table. The fifth well (Deep Well) was installed 4 to 8 ft below the water table.

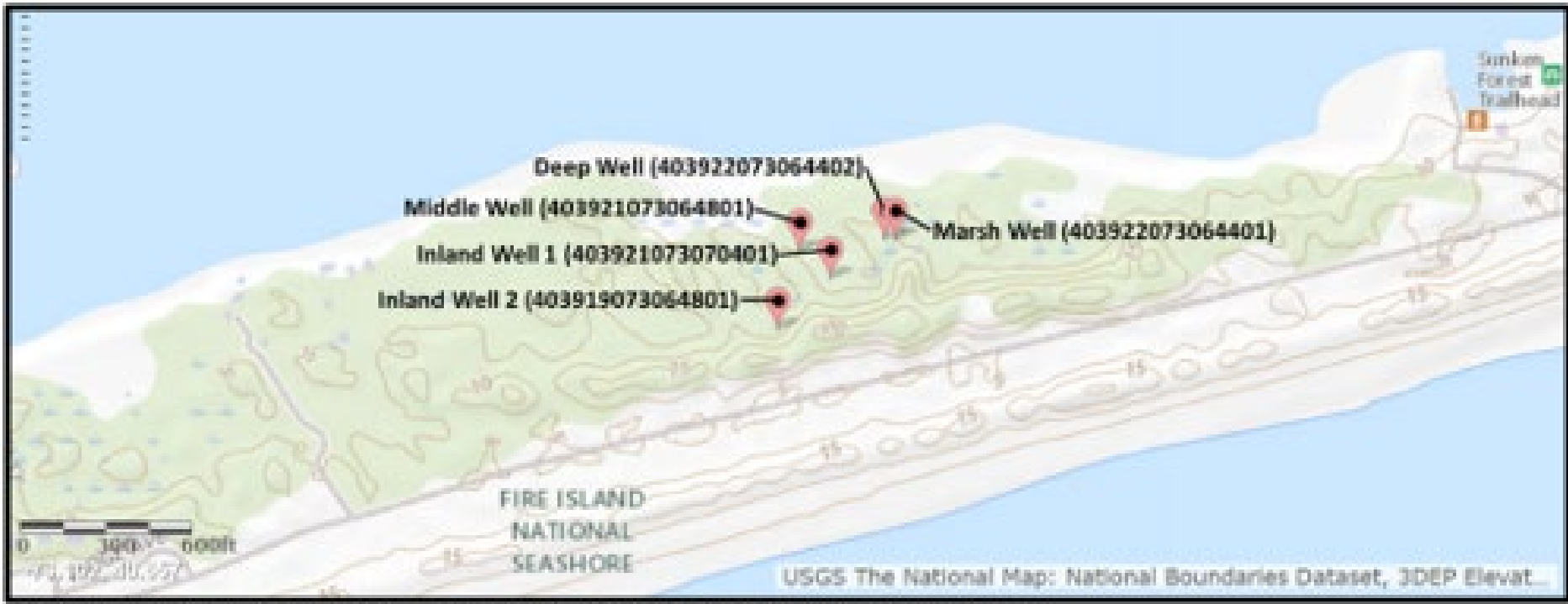


Figure 13. Location of wells in the Sunken Forest, Fire Island National Seashore, N.Y.

A sensor measuring water-levels and (or) specific-conductance was installed at the wells in September 2017. Data were measured every 15 minutes at most wells from September 2017 to February 2019 to record water-level and specific-conductance changes in the shallow aquifer caused by non-storm (astronomical) semidiurnal tidal forcing, coastal flooding, and (or) precipitation events. Fluctuations in water levels and specific conductance were highly dependent on a variety of factors such as precipitation, wind speed and direction, storm intensity, astronomical and storm-tide levels, wave climate, and proximity to the coast.

Responses to tidal forcing, coastal flooding, and precipitation were examined using the timeseries of water-level and specific-conductance data collected at the wells, along with precipitation, maximum sustained wind speed and direction, and tidal elevation data compiled from nearby USGS and National Oceanographic and Atmospheric Administration stations. During the monitoring period, two primary types of storms were observed: coastal flooding and precipitation-only events. Three events – one heavy rain, one short duration high wind and heavy rain, and one long-duration high wind and heavy rain (Nor’easter) – were reviewed in more detail in the data summary section of this webpage.

For the duration of the study, significant water-level responses to tidal forcing were observed in both marsh wells (shallow and deep). Water levels at these wells responded to semidiurnal and storm tides with little or no lag as shown in figure 14 below for the October 29-30, 2017, short duration heavy precipitation and coastal-flooding event. Water levels at wells located further inland responded much less to tidal forcing throughout the study period but did show minor responses to some of the heavy precipitation events.

Data References

National Oceanographic and Atmospheric Administration, Center for Operational Oceanographic Products and Services (CO-OPS). Tides and Currents website, <https://tidesandcurrents.noaa.gov/stationhome.html?id=8514779>, accessed on 2/11/22.

National Oceanographic and Atmospheric Administration, National Centers for Environmental Information (NCEI). Climate Data Online (CDO) website, <https://www.ndbc.noaa.gov/cdo-web/datasets/LCD/stations/WBAN:04781/detail>, accessed on 2/15/22.

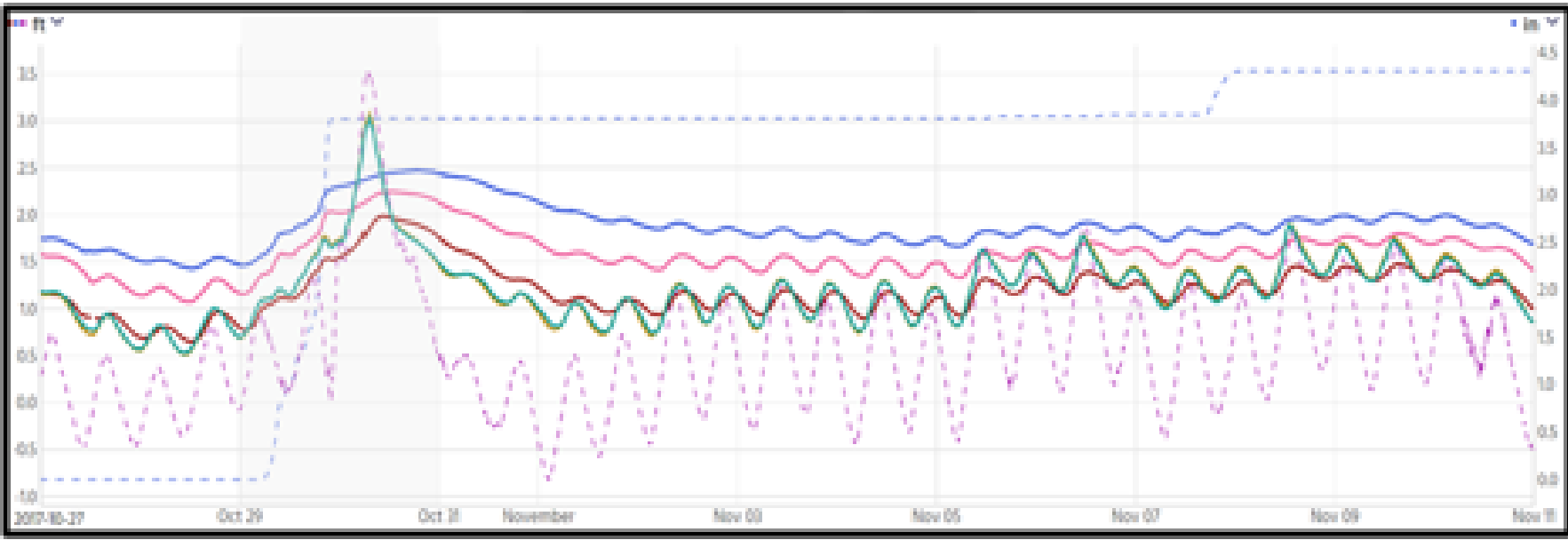


Figure 14. Precipitation (dashed blue) and tide elevation (dashed magenta) at USGS Great South Bay at Watch Hill on Fire Island, NY, tidal gage (USGS station ID 01305575) and water-level elevations at USGS wells 403922073064401 (Marsh Well – solid brown), 403922073064402 (Deep Well – solid teal), 403921073064801 (Middle Well – solid dark red), 403921073070401 (Inland Well 1 – solid pink), and 403919073064801 (Inland Well 2 – solid blue) for the period October 27, 2017, to November 10, 2017 (2 days before and 10 days after the storm). Storm period shaded in grey.

Significant increases in specific conductance during or shortly after the storm tide were recorded at both marsh wells as shown in figure 15 below for the October 29-30, 2017, short duration heavy precipitation and coastal-flooding event. The shallow marsh well showed the greatest increases in specific conductance throughout the period of study, generally occurring during or just after the peak storm tide. The deep marsh well showed less of a response with a much greater time lag than that of the shallow well. Wells located further inland from the Bay showed more modest or no specific conductance response to storms during the study period.

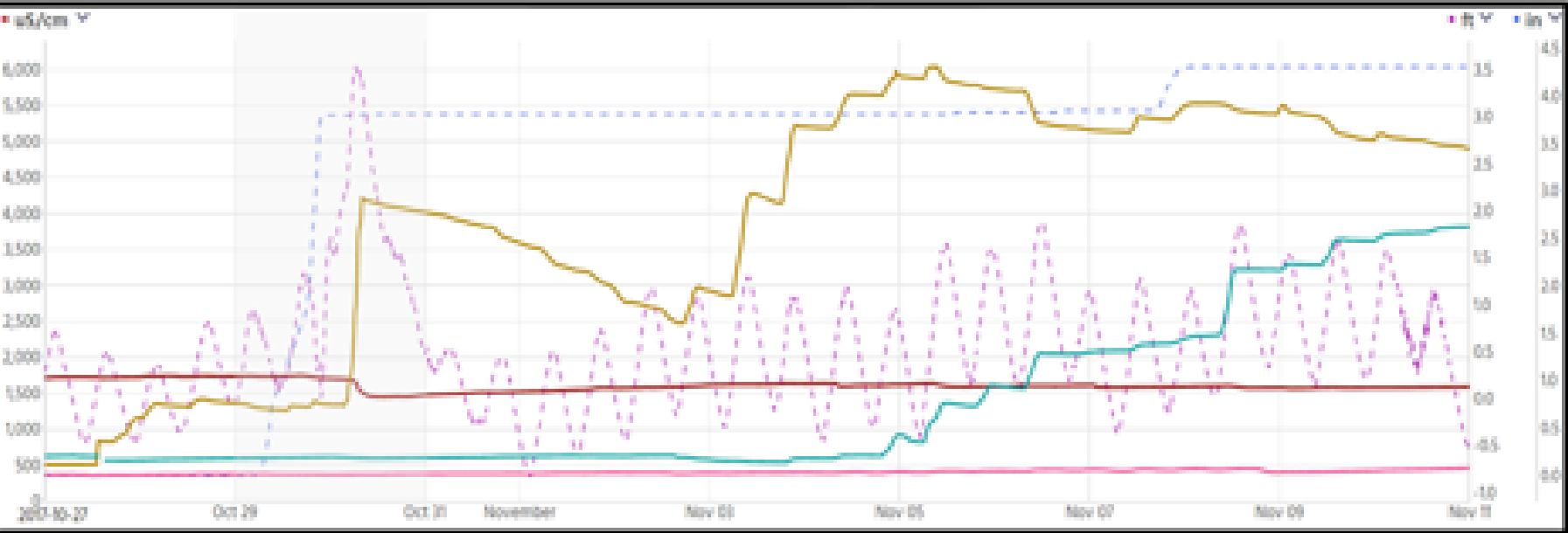


Figure 15. Precipitation (dashed blue) and tide elevation (dashed magenta) at USGS Great South Bay at Watch Hill on Fire Island, NY, tidal gage (USGS station ID 01305575) and specific conductance at USGS wells 403922073064401 (Marsh Well – solid brown), 403922073064402 (Deep Well – solid teal), 403921073064801 (Middle Well – solid dark red), and 403921073070401 (Inland Well 1 – solid pink) for the period October 27, 2017, to November 10, 2017 (2 days before and 10 days after the storm). Storm period shaded in grey.