Martin Slough Enhancement Project
2019 Physical Monitoring Report

Phase 2 – Year 1 Monitoring

Eureka, California

December 2019

Prepared for:

Redwood Community Action Agency

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1 INTRODUCTION

1.1 Background

Martin Slough is part of the Elk River watershed, which is part of the larger Humboldt Bay ecosystem. Martin Slough has been identified by the California Department of Fish and Wildlife as playing a key role in the life cycle of coho salmon, providing ideal rearing habitat for juvenile coho. In 2006 the Elk River watershed, including Martin Slough, was listed under the Clean Water Act as impaired for sediment and siltation, citing impaired water quality, impaired spawning habitat, and increased depth of flooding due to sediment. In response to these stressors, the Martin Slough Enhancement Project was developed with the goal of enhancing fish habitat for endangered coho salmon and reducing the extent and duration of flooding.

The project area encompasses two properties – 40 acres of pasture owned by the Northcoast Regional Land Trust (NRLT) and 120 acres upstream of the NRLT property owned by the City of Eureka and operated as the Eureka Municipal Golf Course. The project was initiated in 2001 when RCAA and partners began preparing a feasibility study, which was completed in 2006. Between 2007 and 2014, MLA and GHD developed designs for a new tide gates, enhanced slough channel, new tidal marshes, and off-channel brackish and freshwater ponds.

1.2 Project Purpose

While not much is known relative to the historical composition of the lower portions of Martin Slough prior to construction of the existing dikes, it is apparent from its elevation relative to tidewater and its geomorphic features that the lower portions of Martin Slough consisted of estuarine habitat, likely composed of some salt marsh and slough channels along with other more brackish and freshwater habitats. Existing limiting factors that have been identified in Martin Slough include obstructed fish access, poor fish habitat, poor sediment routing, lack of riparian habitat, and frequent prolonged flooding that has a negative economic impact on current land uses.

The purpose of the Martin Slough Enhancement Project is to improve aquatic and riparian habitat and reduce flooding of pasture and golf course greens throughout the project area. Specific goals of the project include the following:

1. Improve fish access from Swain Slough into Martin Slough,
2. Reduce flood impacts to current land use,
3. Improve sediment transport,
4. Increase the amount of riparian corridor and riparian canopy,
5. Improve water quality (increased circulation, decrease nutrient inputs, decrease sedimentation),
6. Increase the extent of the estuarine ecotone in Martin Slough, providing a gradual transition from brackish water to freshwater habitats, and
7. Enhance and create low-velocity off-channel/backwater habitats.

1.3 Project Phasing

Following completion of the project planning elements, implementation of the project occurring in phases due to funding constraints and the logistics associated with implementing the entire project. The project components and phases are shown in Figure 1.

1.3.1 Phase 1 – Tide Gate Replacement

Replacement of the Martin Slough tide gates was accelerated due to the dilapidated state of the existing gates. In 2014, the dilapidated tide gates at the confluence at Swain Sloughs were replaced with a new tide gate system that includes two Muted Tide Regulators (MTRs) designed to allow a limited amount of tidal water into the project area. This is considered **Phase 1** of the project. Since construction, only the smaller MTR gate (auxiliary door) has been in operation, and only during limited portions of the year. The MTR system cannot be fully operational until all project phases are complete.

1.3.2 Phase 2- NRLT Property

Over the summer and fall of 2018 channel and off-channel enhancements were constructed on the NRLT property (**Phase 2**). The as-built plan sheets are provided in Appendix A. The work included: enlarging approximately 3,000 feet of the Martin Slough channel to accommodate the design muted tidal prism (volume), constructing 3.05 acres of tidal marsh plains (Marsh Plain A and B), 1.7 acres of brackish marsh (Pond C), a new Southeast Tributary channel and terminal freshwater pond, replacing two undersized culverts to improve fish passage through the historical channel meander, installation of log weirs on the Southeast Tributary and woody instream habitat structures, and installation of an access bridge over the mainstem Martin Slough. Revegetation of native wetland and salt marsh plants in restored areas occurred over the winter/spring of 2019.

1.3.3 Phase 3 – Downstream of Fairway Drive

Phase 3 of the project was constructed during the summer and fall of 2019 on the Eureka Municipal Golf Course downstream of Fairway Drive. Phase 3 consisted of enlarging approximately 1,000 feet of Martin Slough mainstem channel, enlarging an existing tributary pond (Pond D), installation of log weirs on the tributary downstream of Pond D, installation of woody instream habitat structures in Pond D, and construction of one vehicle bridges across Martin Slough.

1.3.4 Future Phasing

The remaining project elements are anticipated to be constructed in 2020, with the potential of extending into 2021. Currently the golf course pumps water from the North Fork of Martin Slough upstream of Fairway Drive for irrigation of the greens. A separate project has been initiated to provide the golf course with an alternative water supply to avoid drawing brackish water into the upper extents of the project. Once this alternative water supply project is implemented, the MTRs on the tide gates can be adjusted to permit the full design muted tidal prism and intended project hydrology.

1.4 Physical Monitoring Goals

The goal of project monitoring is to ensure the project is functioning as intended and to provide a means of identifying any shortcomings in project performance to allow for adaptive management as needed.

Description of Phasing and Restoration Activities

Phase 1 (2014): Installed new tide gate to restore estuarine ecosystem function, increase conveyance and partially restore muted tidal influence.

Phase 2 (2018): Construction of mainstem Reaches 1, 2, and 3, Marsh Plains A, B1 and B2, Pond C and Southeast Tributary and Pond.

Phase 3 (2019): Construction of mainstem Reach 4 and partial Reach 5, and Pond D.

Future Phases: Construction of mainstem Reach 5, 6 and 7, and Ponds E, F, and G.

Project Elements

A & B (2.75 acres) - salt marsh plain 50 ft wide paralleling slough channel and 70 ft wide along abandoned meander.

C (1.72 acres) - Salt marsh with low elevation pond connected to springs.

D & E (0.64 acres & 1.17 acres) - Expanded brackish wetlands, containing deep open water, littoral benches and elevated outlet sill that minimizes salinity intrusion during wet season.

F (1.04 acres) - Backwater slough with island and deep open water and littoral bench on inside of bend.

G (0.5 acres) - Predominantly freshwater alcove pond. Deep open water with emergent vegetation along banks.

North Fork (0.74 acres) - Restored channel with marsh plan and side channel.

South East Tributary (0.3 acres) - Restored channel with small freshwater pond connected to existing tributary.

New channel dimensions - Trapezoidal shape with 1.5:1 (H:V) side slopes and bottom elevation ranges from -1.0 to 2.8 ft. Stable tidal channel geometry based on published relationships of diurnal tidal prism and slough channel dimensions.

MARTIN SLOUGH ENHANCEMENT PROJECT

Figure 1. Overview of Martin Slough Enhancement Project. Phase 1 (2014) comprised of tide gate replacement, Phase 2 (2018) comprised of Reach 1, 2, 3, Marsh plain A, B, Pond C, and the Southeast tributary, and Phase 3 (2019) included Reach 4 and Pond D.

2 MATERIALS AND METHODS

The following Parameters as defined by NOAA Restoration Center (NOAA, 2003) are being monitored as part of the Martin Slough Enhancement Project: Hydrology, Water Quality, and Topography. Vegetation and fisheries use are also parameters being monitored for the project, and are reported on in separate reports.

The Martin Slough Enhancement Project Monitoring Plan (RCAA 2018) provides performance and success criteria to evaluate whether the project is performing as intended. Once the project is fully completed, allowing for the intended tidal amplitude, hydrologic circulation, and water quality conditions, the monitoring results will be compared to the project performance and success criteria. Prior to project completion, monitoring of the three parameters (Topography, Hydrology, and Water Quality) will be used to manage interim water quality conditions, evaluate inundation of revegetated wetland areas, and identify areas experiencing topographic changes and the causes of those changes.

2.1 Topographical Parameter

The objectives of the Topography Parameter are to monitor persistence of, and identify changes in post-construction topographic conditions. Changes in topography include potential scour and aggradation within the slough channel, marsh plains, and ponds.

Topographic features were measured using standard survey methods conducted with a total station. Horizontal datum was State Plane Zone 1 feet and the vertical datum was NAVD88 using benchmarks established during construction. Channel change including channel width will be quantified using 10 cross sections established in the Phase 2 reach of the mainstem, meander, and ponds. Cross sections were monumented for future relocation using rebar with aluminum caps that read "RCAA MONITORING" and a unique ID stamped into each cap. Rebar and caps were set at both ends of each cross section and placed flush with the ground. Appendix B contains coordinate data and location descriptions for each pair of cross section monuments. To evaluate reach-wide channel adjustment, including scour and aggradation, a longitudinal thalweg profile of the mainstem Martin Slough channel bottom was surveyed. The thalweg survey and wetted portions of the cross-section survey were conducted using a sit on top kayak.

Cross section and profile survey data was processed and compared to the "Year 0" condition. Year 0 topographic data is based on the As-Built and design surfaces provided by GHD in AutoCAD Civil 3D. This data was supplemented with survey data collected by MLA while conducting grade checks during construction; specifically, the mainstem channel between stations 2+25 and 9+00, including Marsh plain A, and the Marsh plain B1 and B2 areas along the meander.

In addition to topographic surveying, large wood features placed in Phase 2 were visually inspected at the conclusion of Year 1. These included large wood cover structures throughout the constructed project and log weirs installed on the Southeast Tributary to maintain channel grade. The inspection focused on determining if any of the wood had moved, if any steel anchors were loose or corroded, and if any undesirable scour induced by the structure had occurred.

2.2 Hydrology Parameter

The objectives of monitoring hydrology of the project are to measure water level fluctuations relative to tidal influence within the project area to:

- Evaluate the extent to which the project muted tides match the design muted tidal ranges
- Assess flow conveyance (in both directions) through the project reaches, and
- Assess that the higher muted tides (spring tides) during the dry season are remaining within acceptable ranges and not inundating adjacent pasture (NRLT) and greens (Eureka Municipal Golf Course).

Results from the monitoring can be used to guide adjustments to the tide gate MTRs and identify if any flow constrictions are affecting project performance.

2.2.1 Water Level Monitoring

The methods used to monitor project hydrology consisted of installation of submersible water level loggers in four locations within the Phase 1, 2, and 3 project areas. The loggers measure the hydrostatic pressure above the sensor and is corrected using atmospheric pressure to calculate the stage, or water level, in 15-minute intervals. Each monitoring station consists of a perforated PVC stand pipe secured to a T-post or other stable feature. The data logger is placed at the bottom of the stand pipe and connected with a cable or cord to the cap for retrieval. A reference benchmark was established at each site and surveyed to determine elevation in NAVD88. The data loggers were downloaded approximately every two months and serviced or repaired as needed. At least one water level observation was made during each download period to calibrate the recoded data to the reference benchmark, placing all water level data into the NAVD88 vertical datum.

Stage data was recorded after Phase 1 completion starting in March 2017, and expanded after Phase 2 completion. The following monitoring stations/locations were established following Phase 1 and Phase 2 (Figure 2):

Phase 1

Property Line: On NRLT property, near the property line with the Eureka Municipal Golf Course, a water level gage was installed in Martin Slough on March 14, 2017 and was in operation through July 11, 2018, when it was removed for construction of Phase 2.

Swain Slough: In Swain Slough near the tide gate a water level logger was installed on February 11, 2018 and remains operational.

Phase 2

MS-Pond C: A water level logger was installed in Martin Slough, upstream of the confluence with Pond C on December 17, 2018 and remains operational.

MS-18: A water level logger was installed in Martin Slough between Hole 17 and 18 on the golf course on November 19, 2018 and removed on October 22, 2019 for Phase 3 construction. Following Phase 3 construction this water level logger was reinstalled on November 5, 2019 to the newly constructed vehicle bridge.

2.2.2 Tidal Datums

Humboldt Bay experiences semidiurnal tides: two high tides and two low tides per day. The tidal datums of Mean Higher High Water (MHHW), Mean Lower High Water (MLHW), Mean Higher Low Water (MHLW), Mean Lower Low Water (MLLW), and sometimes Mean Tide Level (MTL) are used for designing tidal restoration projects. A key metric in sizing and maintaining tidal channel geometry is the average tidal prism, which is defined as the volume of water that drains between MHHW and MLLW.

The North Spit, on Humboldt Bay, tidal datums (converted to NAVD88) were used as a reference for full tidal conditions. Tidal datums for each monitoring station were calculated on a per month basis and seasonally using the measured water levels. A spreadsheet algorithm was used to identify the daily MHHW, MLHW, MLLW, and MHLW and calculate the monthly averages.

2.2.3 Tidal Prism

The volume of tidal water exchanged between MHHW and MLLW defines the tidal prism. It is a key parameter in the design and self-sustainability of the project. Though Martin Slough receives freshwater inflows, the hydraulic geometry of the tidal channel of Martin Slough will be governed by the daily tidal flux created by the muted tide rather than less frequent high flow events from upstream. The daily tidal prism is a governing factor in the dimensions of the channel, and a significant reduction in the tidal prism could cause sedimentation and a decrease in the channel cross-sectional area.

The tidal prism provided by the constructed Phase 2 project was calculated using the as-built plans and the design tidal datums for the muted tide. As the future project phases are completed and the full muted tide is introduced, the actual tidal prism will be calculated from the tidal datums of the project water level data and measured changes in the area below MHHW for each monitored cross section. The actual tidal prism will be compared to design conditions to determine if the prism is changing and the trajectory of the change.

2.3 Water Quality Parameter

The objectives of monitoring water quality parameters are to measure salinity, dissolved oxygen and water temperature to assess sufficiency of water quality for target habitat and species and ensure that salinity does not extend upstream to the golf course pump intake used for irrigation. The methods used to measure water quality parameters consisted of installation of temperature and salinity data loggers at the same locations as the water level loggers (with the exception Swain Slough, no salinity loggers were installed at that gage station).

Two salinity data loggers, which also record water temperature, were installed in each perforated stand pipe; one at the bottom coupled to the water level logger, and one attached to a float that travels the height of the stand pipe and measures the surface conditions. The salinity data loggers' period of record matches the water level loggers. Salinity and temperature were recorded continuously on the same 15-minute interval as the stage data loggers. Salinity data loggers were not installed at the Swain Slough station. Spot measurements of salinity, temperature and dissolved oxygen were also taken using a YSI handheld meter and recorded on data sheets at the time of downloading the data.

Figure 2. Overview of Phase 1 and 2, and location of stage and water quality monitoring stations (image from Google Earth, April 2019).

3 RESULTS AND DISCUSSION

3.1 Topography

To quantify any changes to the channel shape and assess potential sedimentation or scour, annual surveys are planned for years 3 and 5 of each phase of construction. These surveys will be overlaid with the Year 1 survey for comparison. Year 0 data was derived from the As-Built plans provided by GHD and supplemented with construction surveys as described above, and the Phase 2-Year 1 data was derived from a total station survey as described above.

3.1.1 Thalweg Profile

Surveyed points along the channel bottom were referenced to the design alignment, where stationing represents distance upstream of Swain Slough (see As-Built Drawings in Appendix A). The recent survey data is shown with the Year 0 profile derived from the As-built survey as described above. The profile plot is shown in Figure 3 and also in Appendix B.

With the exception of two locations, the existing thalweg is at or slightly lower than design elevations. For the channel reach between Station 15+00 and 25+00 the surveyed thalweg is about 0.3 feet lower than the design grade. It is uncertain if this is from the original grading of the channel or due to scour over the course of Year 1. Future surveys will be used to identify any trends regarding the overall thalweg elevation.

Two notable areas of sedimentation warrant further investigation: Station 14+00 and 27+50. The high spot along the profile at Station 14+00 is approximately 1.8 feet above the design grade. This is located immediately upstream of the new bridge and sheet pile retaining wall at the NRLT barn. A section of the right bank appears to be slumping into the channel when observed at low tide (Figure 4). High groundwater along the base of the adjoining hillslope appears to be driving the instability. During construction this area was recognized as unstable, and some short pieces of sheet pile were driven into the bank at the slump. However, the Year 1 thalweg survey suggests that these sheet piles are not retaining the bank material, and the slump has extended across the entire channel width. Future monitoring will be used to evaluate changes in the channel condition and if any action is warranted.

The second area of note is at Station 27+50, located just downstream of the property line with the golf course. At this location there appears to be approximately 1.5 feet of sedimentation along 50 feet of the channel and then a deep section of channel upstream of the sedimentation. This location coincides with the Phase 2 temporary grade control. This grade control was constructed of rock, and was removed as part of Phase 3 construction in summer of 2019. The over deepened channel section around Station 30+00 was where the rock and sedimentation were removed. The area of sedimentation around Station 27+50 appears to be the tailout from the scour pool downstream of the Phase 2 grade control. This area was beyond the reach of the excavator during the removal of the grade control, and therefore the sediment was left in place. It is uncertain if high flows and tidal action will transport this material downstream. Future monitoring will be used to evaluate changes in the channel condition and if any action is warranted.

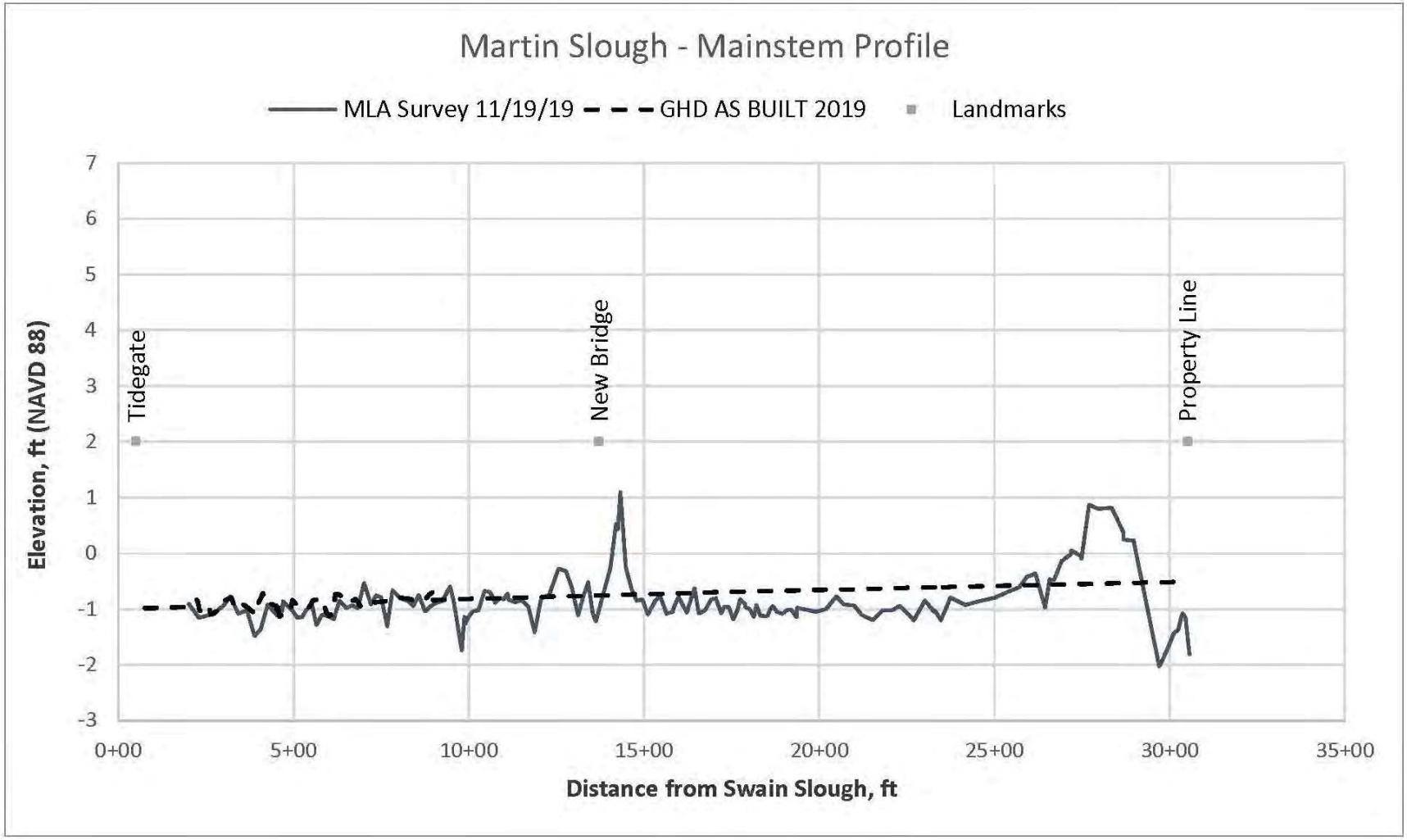


Figure 3. Channel profile of Martin Slough along the design alignment. Year 0 is represented by the dashed line as derived from the As-Built plans and the 2019 survey is shown as a solid line and represents the year 1 of Phase 2.

Figure 4. Slumping bank along the right side of the channel immediately upstream of the new bridge and sheet pile retaining wall at Station 14+00 on the profile.

3.1.2 Cross Sections

Cross section locations, descriptions of the benchmarks for each section, and plots of Year 1 surveyed sections are provided in Appendix B. There were no noteworthy changes to the channel shape at these locations in the first year after implementation.

The cross-sectional area below the design MHHW of 5.5 feet (NAVD88) was calculated for each cross section and is provided in Table 1. These areas will be used as a baseline for comparison following resurvey of the sections during subsequent monitoring years. A 10-percent increase or decrease in area will warrant further evaluation.

Table 1. Phase 2-Year 1 area below design MHHW of 5.5 feet (NAVD88) for surveyed cross sections.

Cross Section	Area Below Design MHHW (square feet)
MS 1	179.0
MS 2	144.5
MS 3	160.6
MS 4	156.7
MS 5	118.5
C1	84.8
C2	427.4
M1	71.7
M2	65.4
SE1	52.7

3.1.3 Culvert Placement

Three 4-foot diameter reinforced concrete culverts were installed during the Phase 2 implementation. The invert elevations were surveyed to confirm that they were installed according to the design intent, and are listed in Table 1. The culvert at the downstream meander was embedded with gravel approximately 0.4 feet thick. This gravel appears to have originated from gravel placed during construction.

Table 2. Culvert invert elevations in NAVD88 from 2019 Monitoring Survey (MLA)

Culvert Location	Inlet Elevation	Outlet Elevation
Downstream Meander	1.25 ft (concrete) 1.67 ft (gravel)	1.55ft (concrete) 1.89 ft (gravel)
Upstream Meander	2.46 ft (concrete)	2.45 ft (concrete)
Southeast Tributary	2.54 (concrete)	2.57 (concrete)

The culverts were placed effectively flat, and within design vertical tolerances. The two culverts in the meander were placed based on the invert elevation of the pre-project culvert to protect against channel downcutting within the meander due to the two gas line crossings. The culvert at the downstream end of the meander is lower than upstream to promote positive drainage during outgoing tides. The downstream culvert invert is also placed close to MLLW, such that it is backwatered and provides good fish passage conditions at all but the lowest tides. This is consistent with tributary tidal channels, which can become perched above the mainstem channel at low tides.

The Southeast Tributary culvert is placed level with the adjacent thalweg elevation in the meander and backwatered year-round, providing for good fish passage conditions.

3.1.4 Inspection of Large Wood Structures

Large wood structures were inspected on December 30, 2019 to ensure they were stable and functioning as intended. All structures (Log Cover Structures, Rood Wad Deflectors, and Root Wad Habitat Structures, Log Constrictors, Log Weirs) appeared stable and show no signs of shifting since constructed. No adverse scour to the bed or banks of the channel caused by the structures were noted. All anchor points looked sound. On structures that relied on cables and soil anchors, all cables were taught and looked to be in good condition. The only item of note was that some of the u-clamps attached to the cables had rusted more extensively than all of the other hardware. It is likely due to differences in galvanized coating. The rust is minimal and no action is warranted.

3.2 Hydrology

3.2.1 Water Level Observations

Water level data, combined with salinity and water temperature data, was plotted for each month during the period following Phase 1 and Phase 2 implementation. Water level plots for the year prior to Phase 2 implementation, starting on March 14, 2017 are provided in Appendix C for reference. Water level plots for Phase 2, Year-1 starting January 1, 2019 are provided in Appendix D.

Swain Slough Water Levels
Swain Slough water levels fluctuated similar to those recorded at the NOAA North Spit tidal station (No. 9418767), except that the water level never dropped below 1.0 feet. This is due to two reasons. One is that the gage is located in an outlet scour pool below a drainage flap gate, and the pool becomes disconnected from Swain Slough at lower tide levels. Also, through observations at low tide, Swain Slough drops less than 0.5 feet below elevation 1.0 feet at the lowest tides. This is due to a tidal sill located on Elk River downstream of the confluence with Swain Slough. This tidal sill was noted in NOAA's historical Elk River tidal station.

Martin Slough near Pond C Water Levels
The water levels in Martin Slough just upstream of the confluence with Pond C show the water levels fluctuating from January through late May, with a muted high tide that peaked around elevation 5.0 feet (except higher during rainfall-runoff events). Beginning around May 25th, 2019 the high tides become more muted, only rising to elevation 4.0 feet, and a little higher. At this time, the MTR float switch may have been lowered to close the MTR auxiliary gate at a lower water level in conjunction with the beginning of upstream pumping from Martin Slough for irrigation on the golf course.

At the beginning of Phase 3 construction, on June 21st, it appears the MTR auxiliary gate was closed, resulting in the only saline water entering Phase 1 coming from gate leakage. The result was a muted tide with a maximum high tide level of elevation 3.0 feet. Then, the MTR auxiliary gate appears to have been reengaged on two occasions during the summer for a duration of 7 to 10 days, increasing the muted tidal range. The reasons for this are unknown.

The MTR float switch appears to have been reengaged on October 9th, 2019. However, the muted high tides through the rest of the period of record remain at or slightly above elevation 4.0 feet, rather than the design muted MHHW of 5.5 feet. Subsequent to the end of this monitoring period, the MTR float switch for the auxiliary gate was raised in November 2019 to increase the tidal amplitude.

Martin Slough near Hole 18 Water Levels
The Hole 18 monitoring station is located in Martin Slough upstream of Phase 2 construction and the Phase 2 grade control. The Hole 18 water level logger stopped working for approximately 2 weeks during early January 2019. During Phase 3 construction the Hole 18 station was upstream of the temporary coffer dam, which was installed on June 21st, 2019 and removed on October 9th, 2019. During periods when the Phase 3 coffer dam was not in-place, the water level at the Hole 18 monitoring station was only tidally influenced during muted tides greater than 4.0 feet. At lower tides, this location in Martin Slough is fluvially dominated.

3.2.2 Tidal Datums

Stage data for the Phase 2 monitoring was analyzed and tidal datums were calculated relative to the NAVD88 vertical datum. Monthly values are provided at the end of Appendix D and averages for the dry season of July through October, when freshwater inputs were minimal, are provided in Table 3, below. For reference the yearly tidal datums calculated at the North Spit for the Epoch encompassing 1983 to 2001 and the design muted tidal datums are also included in Table 3.

With the exception of MLLW, which is influenced by a tidal sill in the Elk River Slough that limits draining of the tide, the Swain slough data collected during this first monitoring period appears similar to North Spit. As noted in the Section 3.2.1, the closing of the MTR auxiliary door during the irrigation season and the construction of Phase 3 from June into October resulted in minimal muted tidal ranges at the Pond C and Hole 18 monitoring stations. As such, the tidal datums for MHHW are much lower than design values.

The design tidal range will be provided once the project is completed and the golf course establishes an alternative water supply for irrigation. In the interim, the tidal datums can be used to determine the inundation frequency of different areas that have been revegetated with brackish-tolerant plant species. For example, much of Marsh plain A and B are at elevations ranging from 4.8 feet to 5.8 feet. Establishing brackish marsh vegetation on these surfaces will require increasing the muted tidal amplitude during the growing season.

Table 3. Tidal Datums for dry period of July through October, 2019 at each gage station.

	Water Level (NAVD88)			
Location	**MLLW**	**MTL**	**MHHW**	**Ave. Diurnal Range**
North Spit (for epoch 1983-2001)	-0.34 ft	3.36 ft	6.51 ft	6.85 ft
Swain Slough	1.47 ft	4.04 ft	6.82 ft	5.35 ft
Martin Slough				
MS Design	1.5 ft	Not Provided	5.5 ft	4.0 ft
MS at Pond C	1.29 ft	2.22 ft	3.04 ft	1.75 ft
MS at Hole 18*	4.42 ft	4.55 ft	4.72 ft	0.30 ft

**Minimal tidal influence at Hole 18 during July through October due to Phase 3 construction.*

3.2.3 Tidal Prism

The tidal prism for the constructed channel is defined as the volume of tidal water exchanged between the MHHW and MLLW, or the channel bed, whichever is higher. The design tidal prism serves as a baseline to evaluate future monitoring results, such as sedimentation or channel widening. For the Phase 2, Year-1 baseline, approximately 11.1-acre feet of tidal prism has been constructed based on the design tidal amplitude (Table 4).

Table 4. Summary of tidal prism (in acre-feet) for each reach of the constructed Phase 2 portion of the project. The prism is based on the design MHHW and MLLW of 5.5 ft and 1.5 ft, respectively.

Reach (Phase)	Reach Stationing (Length)	Contributing Tidal Prism (MHHW - MLLW)[1]
1 (Phase 2)	0+50 to 11+00 (1,050 ft)	2.8 Ac-Ft Channel 0.5 Ac-Ft Marsh Plain A and B 1.8 Ac-Ft Historical Meander
2 (Phase 2)	11+00 to 17+00 (600 ft)	1.4 Ac-Ft Channel 1.6 Ac-Ft Pond C
3 (Phase 2)	17+00 to 31+00 (1,400 ft)	3.0 Ac-Ft Channel
PHASE 2 Tidal Prism		**11.1** Ac-Ft

[1] *Measured at Downstream end of Reach.*

3.3 Water Quality

Surface and bottom salinity concentrations at the two post-Phase 1 monitoring stations are plotted with water level, and provided in Appendix C. The post-Phase 2 salinity and temperature plots, combined with water level, are provided in Appendix D. The plots also include daily rainfall totals measured at the NWS office on Woodley Island for reference. Also included near the end of Appendix D is a table of water quality spot measurements taken during each data download. These include salinity, temperature, and dissolved oxygen concentrations.

3.3.1 Salinity and Temperature

The project, when completed, is intended to create a longitudinal gradient of salinity, with highest salinity near the tide gate transitioning to freshwater conditions at the upstream end, with each pond having different concentrations of brackish water. Additionally, stratification is expected to provide a vertical gradient from more saline waters at the bottom to less brackish water near the surface. During runoff events the entire project channel length and all the ponds are anticipated to be predominately freshwater. The Phase 2, Year-1 salinity data show these conditions are partially provided, as expected. With completion of future project phases, the longitudinal salinity gradient will extend further upstream.

Water temperatures within the project area are dependent on air temperature, temperature of freshwater inflow from upstream, and temperatures of inflow from Swain Slough. During winter months temperatures are anticipated to be similar to freshwater streams around Humboldt Bay. During the dry season, areas with brackish water should experience higher water temperatures due to influences from water temperatures in Humboldt Bay and Swain Slough. These can well exceed 20 degrees Celsius due to shallow inundation of mudflats during rising tides in the day time. Water temperature data from Phase 2, Year-1 show these expected trends.

Swain Slough Salinity and Temperature

Salinity was not recorded in Swain Slough. Water temperatures in Swain Slough during the winter were similar to those measured in the freshwater reach of Martin Slough near Hole 18, with small

diurnal temperature fluctuations. By mid-April, water temperatures in Swain Slough become more elevated compared to near Hole 18 and both diurnal and tide-related temperature fluctuations become more apparent.

Martin Slough near Pond C Salinity and Temperature

In Martin Slough, near Pond C, the salinity was highly correlated to precipitation, and stratification was present during periods not dominated by freshwater inflows. During periods with no rainfall the bottom salinity would fluctuate dramatically with incoming verses outgoing tides, often changing by 12 ppt within one tide cycle. The peak of the bottom salinity concentration occurred right before the ebb of the muted tide in Martin Slough. The surface salinity fluctuated much less than the bottom salinity, often with a range of 3 ppt during a dry period. The peak of the surface salinity is during the early portion of the muted ebb tide. This is evident that on the flood tide the more saline tidal inflow was moving upstream along the channel bottom, maintaining stratification. As the tide turned in Martin Slough there was more mixing with the surface becoming more brackish and bottom becoming fresher.

During periods with precipitation, salinity concentrations become close to zero for days at a time. Several days following the cessation of rainfall, the bottom salinity would increase relatively rapidly, while the surface salinity slowly increased with each tide cycle.

Water temperatures in Martin Slough near Pond C remained low throughout the winter months. Surface and bottom temperatures were nearly identical much of the time, with periods where the surface water temperature was colder and fluctuated much more with tidal cycles than along the bottom. This is assumed to be associated with stratification during flood tide and then mixing during ebb tide. During the late spring and summer water temperatures at this location closely followed those measured in Swain Slough, with some temperature stratification that fluctuated with the tides similar to salinity.

Martin Slough near Hole 18 Salinity and Temperature

Salinity measurements in Martin Slough near Hole 18 show that for nearly the entire monitoring period the bottom and surface remained fresh, with salinity concentrations close to zero. There were two periods when salinity at this site was notable. During early January salinity in the bottom of the channel reached 9 ppt, with surface salinity above 6 ppt. This was following a dry fall and early winter, and ended at the onset of winter rains. The station's water level logger failed to collected data during this period, but water levels at Pond C station were resulting in a muted high tide of approximately 5.4 feet. This is close to the design MHHW, and therefore during dry periods this section of Martin Slough is likely to become brackish once the project muted tide is introduced.

The other period when brackish water reached the Hole 18 monitoring station was upon the opening of the MTR auxiliary gate at the end of construction and removal of the coffer dam on October 9, 2019. During this period the Phase 3 channel had been constructed, which more efficiently conveys brackish water to this location. It is also likely that this occurred when the golf course was regularly pumping from Martin Slough for irrigation from upstream of this location, thus "pulling" saltwater upstream. For unknown reasons, the bottom salinity rose to about 8 ppt and did not fluctuate with tidal fluctuations, while the surface salinity fluctuated between 0.5 ppt and 11 ppt. Going forward, these conditions will be monitored as part of the ongoing Phase 3, Year-1 monitoring program.

Water temperatures in Martin Slough near Hole 18 did not show signs of fluctuation associated with tides, but rather showed diurnal fluctuation with changes associated with precipitation and ambient air temperature. This is due to the minimal tidal influence at this site during Phase 2, Year-1.

3.3.2 Dissolved Oxygen Spot Measurements

Spot measurements of dissolved oxygen (DO) by RCAA staff during each download are provided at the end of Appendix D. The measured DO levels at the three sites were always above 5 mg/s, and were often substantially higher. These DO levels are considered acceptable for rearing salmonids and other aquatic organisms.

4 RECOMMENDATIONS

The Martin Slough Enhancement Project is being implemented in phases. The intended project hydrology, including the introduction of the design muted tidal prism, will not be fully functional until all of the project phases are completed. As such, the findings from the first year of monitoring following completion of Phase 2 show that the tidal amplitude and prism is less than the design range. However, the estuary environment created in the Phase 2 project area is already present, with brackish water extending up the mainstem, and salinity concentrations fluctuating with rainfall events and with tidal fluctuations.

The water level data and associated tidal datums show that Marsh plains A and B are receiving only minimal tidal inundation. Since these areas have been revegetated with brackish plant species, it is recommended that the MTR float switch for the auxiliary door be adjusted to cause inundation of these marsh plains during spring tides in Swain Slough. The muted tidal amplitude may need to be reduced in late spring, once pumping resumes for irrigation of the golf course.

An area of potential concern arising out of the Phase 2, Year-1 monitoring is associated with the two high points identified along the thalweg profile (Figure 3). The high points around Station 14+00 are due to a slumping bank associated with high groundwater and saturated soils close to the base of the adjoining hillslope. Continued slumping at this location could cause a substantial constriction of the channel. A constriction could cause upstream flooding and channel sedimentation, and would limit upstream tidal influences. It is unclear if the channel has the capacity to scour and transport this material downstream to Swain Slough. The project manager and project engineer should inspect this site after extended wet periods and following high flows to detect if any additional slumping occurs, and the site should be resurveyed as part of next year's monitoring activities.

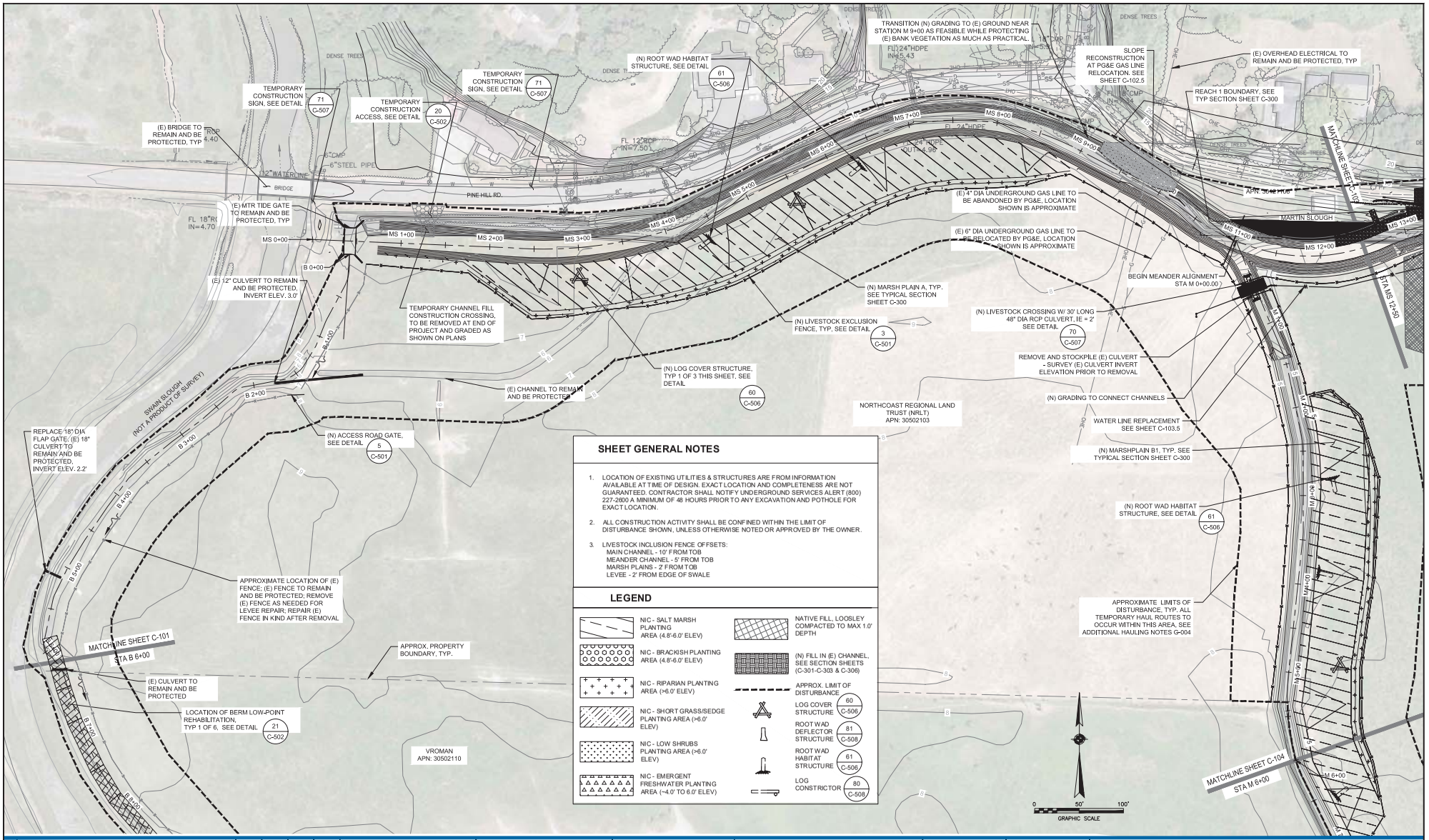
Near Station 27+50, the thalweg is approximately 1.5 feet above finished grade. This is likely a remnant deposition created by the rock grade control structure that was present just upstream and removed in the summer of 2019. This material may likely be mobilized by high flows during this upcoming water year. As such, this area should be resurveyed as part of the Phase 3, Year-1 thalweg monitoring in 2020 to characterize channel changes.

5 REFERENCES

NOAA, 2003. Science-based restoration monitoring of coastal habitats, Volume 1: A framework for monitoring plans under the Estuaries and Clean Water Act of 2000.

RCAA, 2018. Martin Sough Enhancement Project Monitoring Plan. August 2013, Revised July 2018. By Redwood Community Action Agency Natural Resources Services Division.

Appendix A
Phase 2 (2018) As-Built Drawings - Plan Sheets



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LEGEND

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- APPROX. LIMIT OF DISTURBANCE
- LOG COVER STRUCTURE 60 C-506
- ROOT WAD DEFLECTOR STRUCTURE 81 C-508
- ROOT WAD HABITAT STRUCTURE 61 C-506
- LOG CONSTRICTOR 80 C-508

No	Revision	Drawn	Job Manager	Project Director	Date
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Drafting Check	JS/DS/ML	Design Check	SA/ML
Approved (Project Director)	STEVE ALLEN		
Date	3/27/18		
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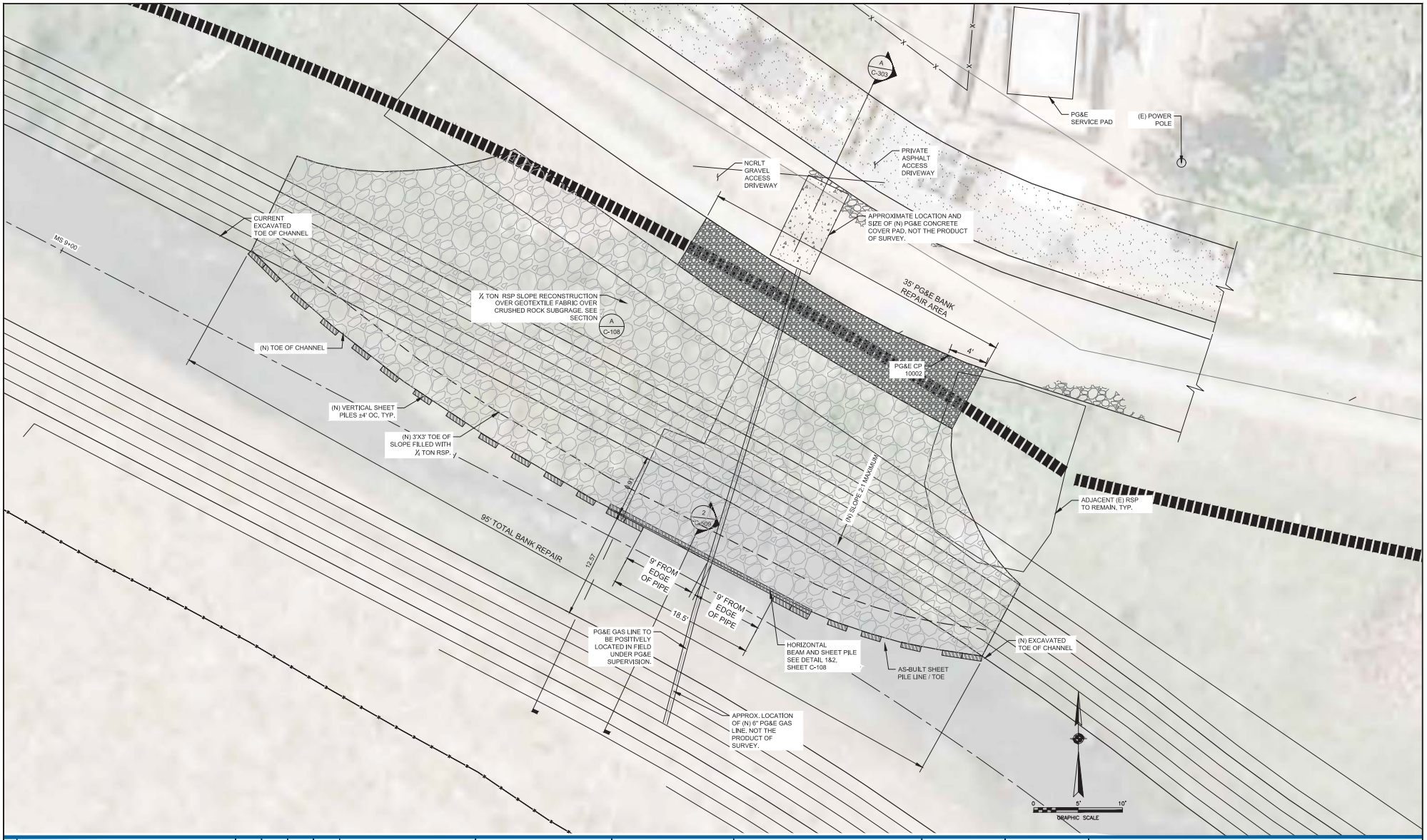
Client: RCAA/CITY OF EUREKA
Project: MARTIN SLOUGH HABITAT ENHANCEMENT PROJECT
Title: SITE PLAN SHEET 2 OF 7
Contract No. 11145257
Original Size: Ansi D
Drawing No: C-102
Sht. 8 of 41
Rev: 1

Plot Date: 12 February 2019 - 6:11 PM Plotted by: Tim Windbigler Cad File No: G:\111\11145257 Martin Slough-2017 Const Phase\06-CAD\Sheets\AS-BUILT\11145257 C101-C106_SitePlans.dwg



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SHEET 3 OF 7
Contract No. 11145257
Original Size: Ansi D
Drawing No: C-102.5
Sht. 8 of 41
Rev: 1

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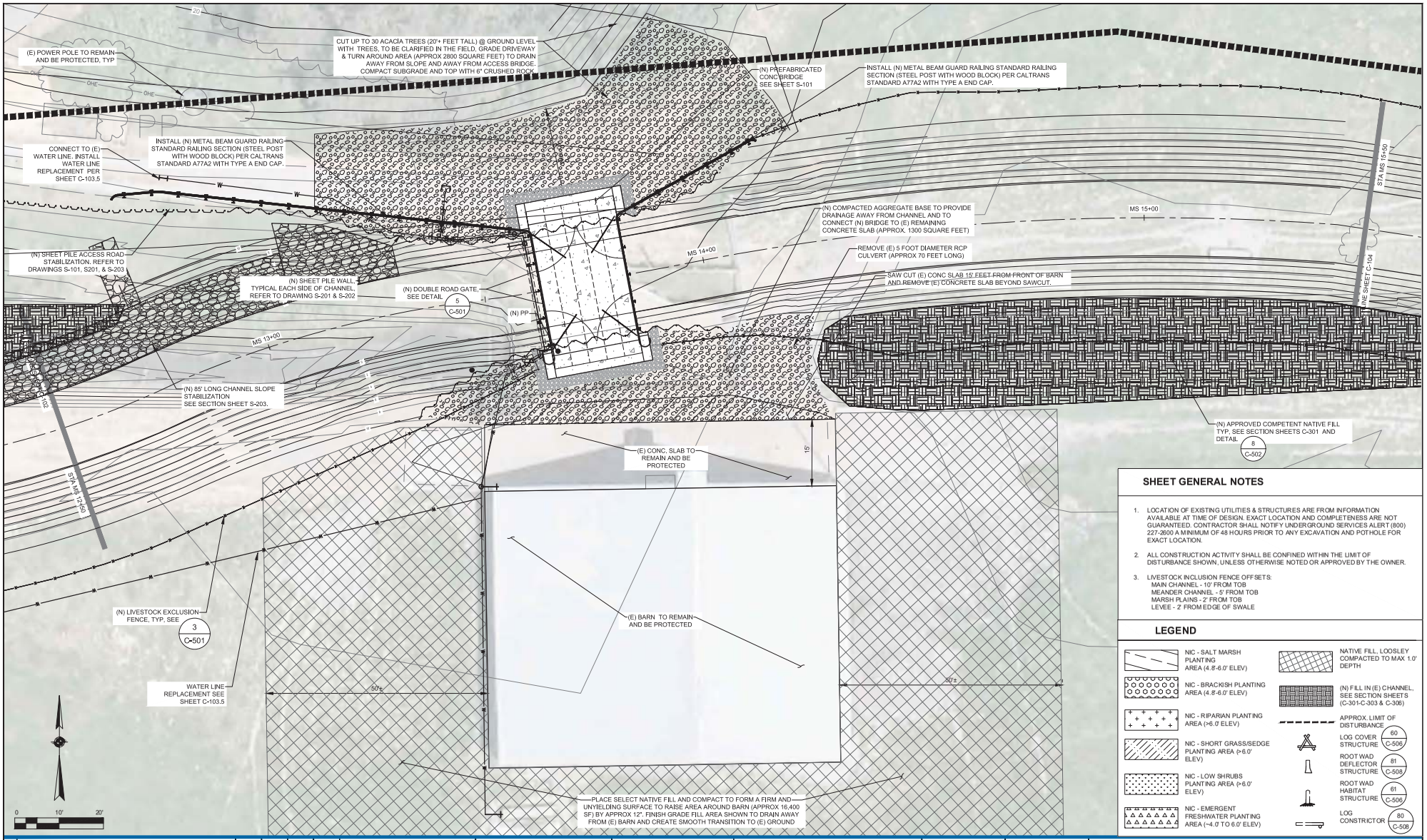

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Project MARTIN SLOUGH HABITAT ENHANCEMENT PROJECT
Title SITE PLAN SHEET 4 OF 7
BARN AREA
Contract No. 11145257
Original Size Ansi D
Drawing No: C-103
Sht 9 of 41
Rev: 1

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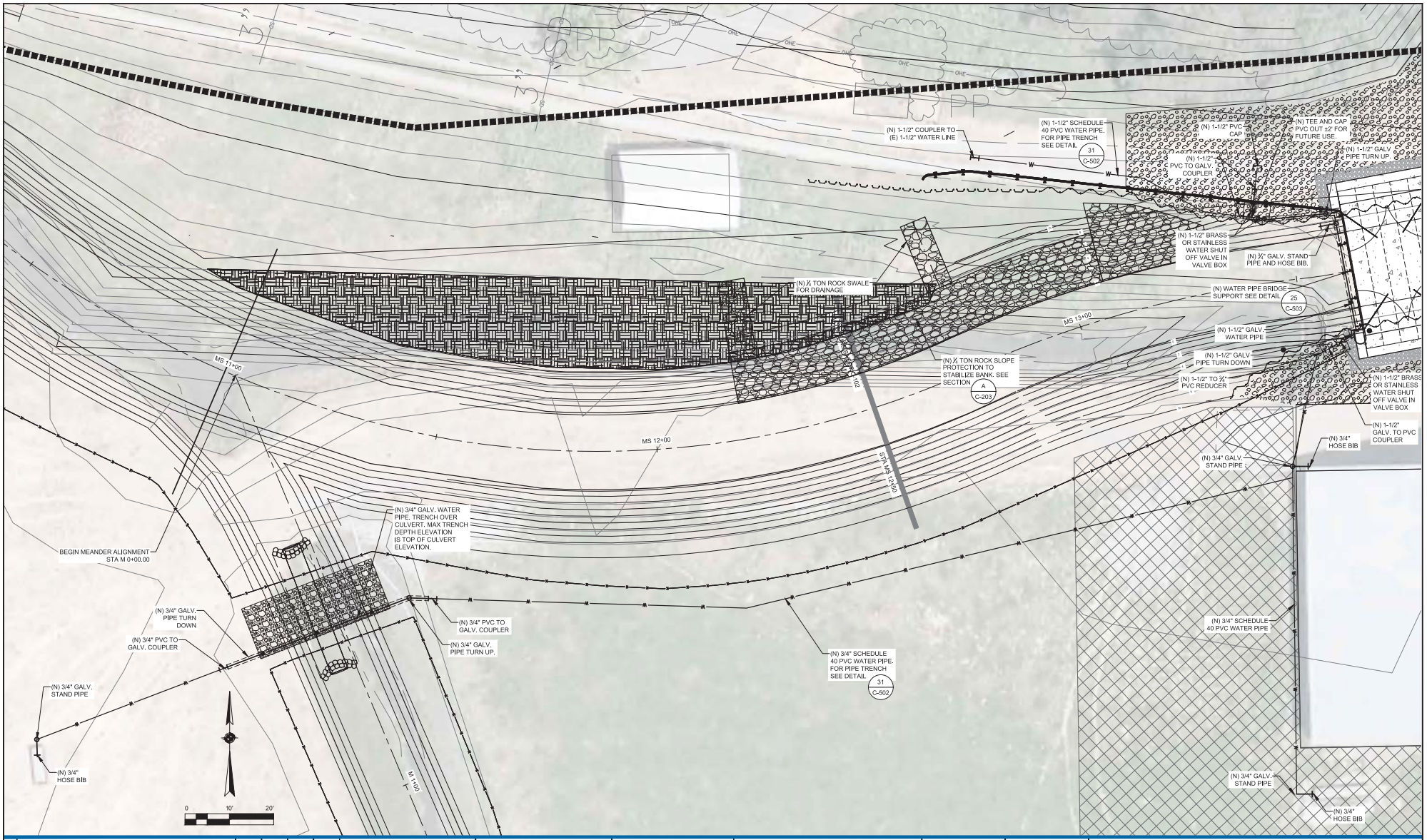

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BARN AREA
Contract No. 11145257
Original Size: Ansi D
Drawing No: C-103.5
Sht. 9 of 41
Rev: 1

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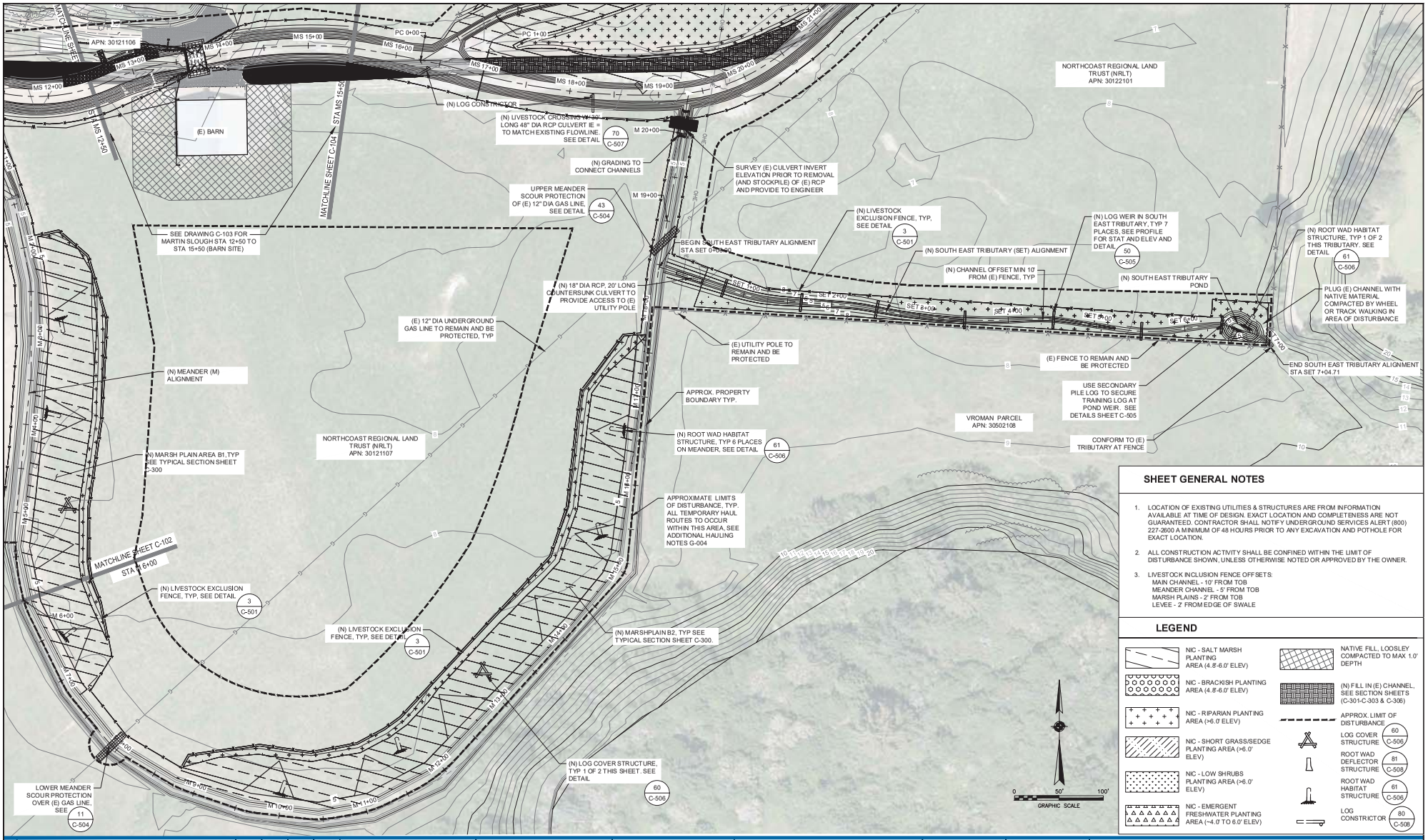

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Contract No. 11145257
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Drawing No: C-104
Sht 10 of 41
Rev: 1

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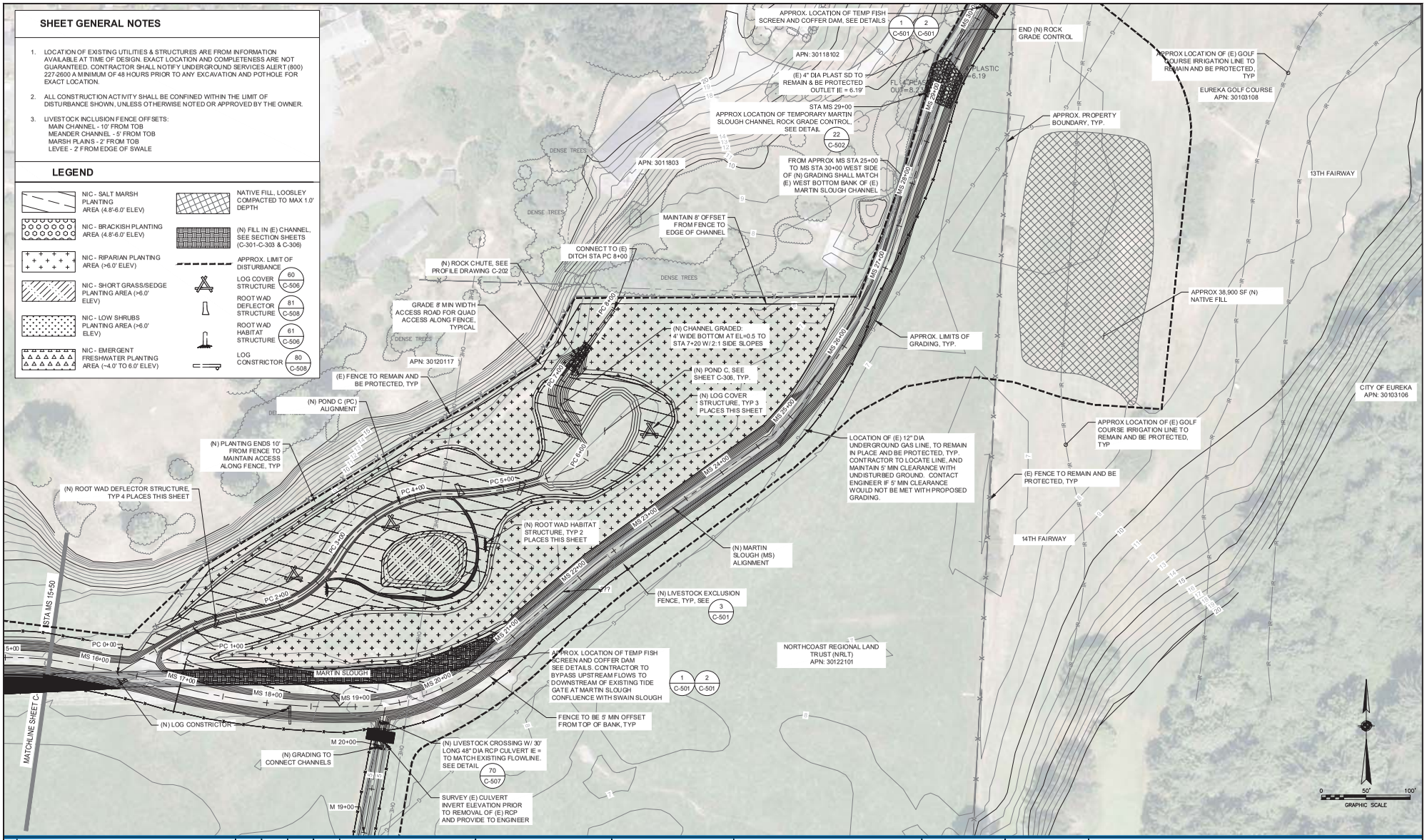

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Contract No. 11145257
Original Size: Ansi D
Drawing No: C-105
Sht. 11 of 41
Rev: 1

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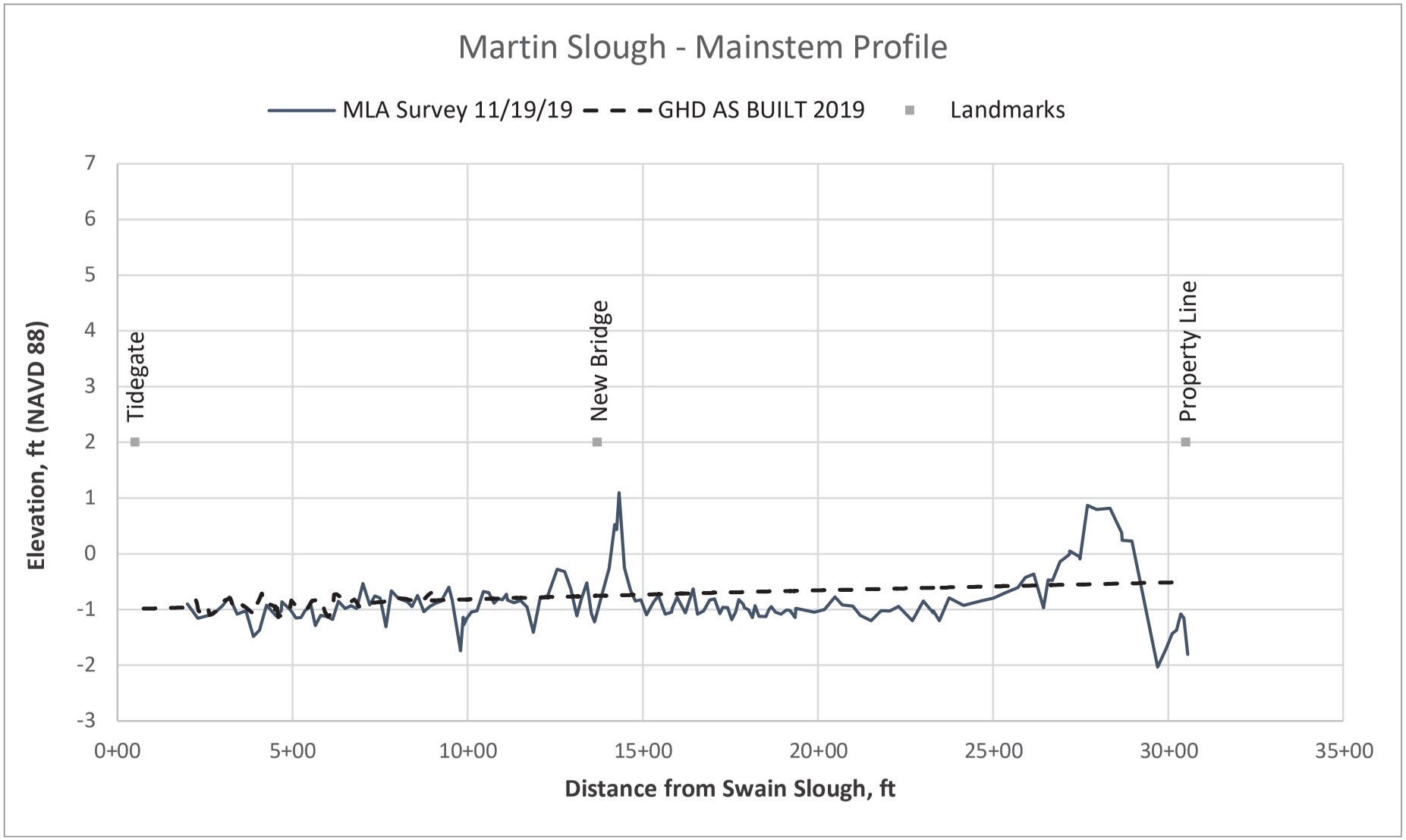
Appendix B
Topographic Monitoring for Phase 2, Year-1


Martin Slough - Mainstem Profile
MLA Survey 11/19/19
GHD AS BUILT 2019
Landmarks
Tidegate
New Bridge
Property Line
Elevation, ft (NAVD 88)
7
6
5
4
3
2
1
0
-1
-2
-3
0+00
5+00
10+00
15+00
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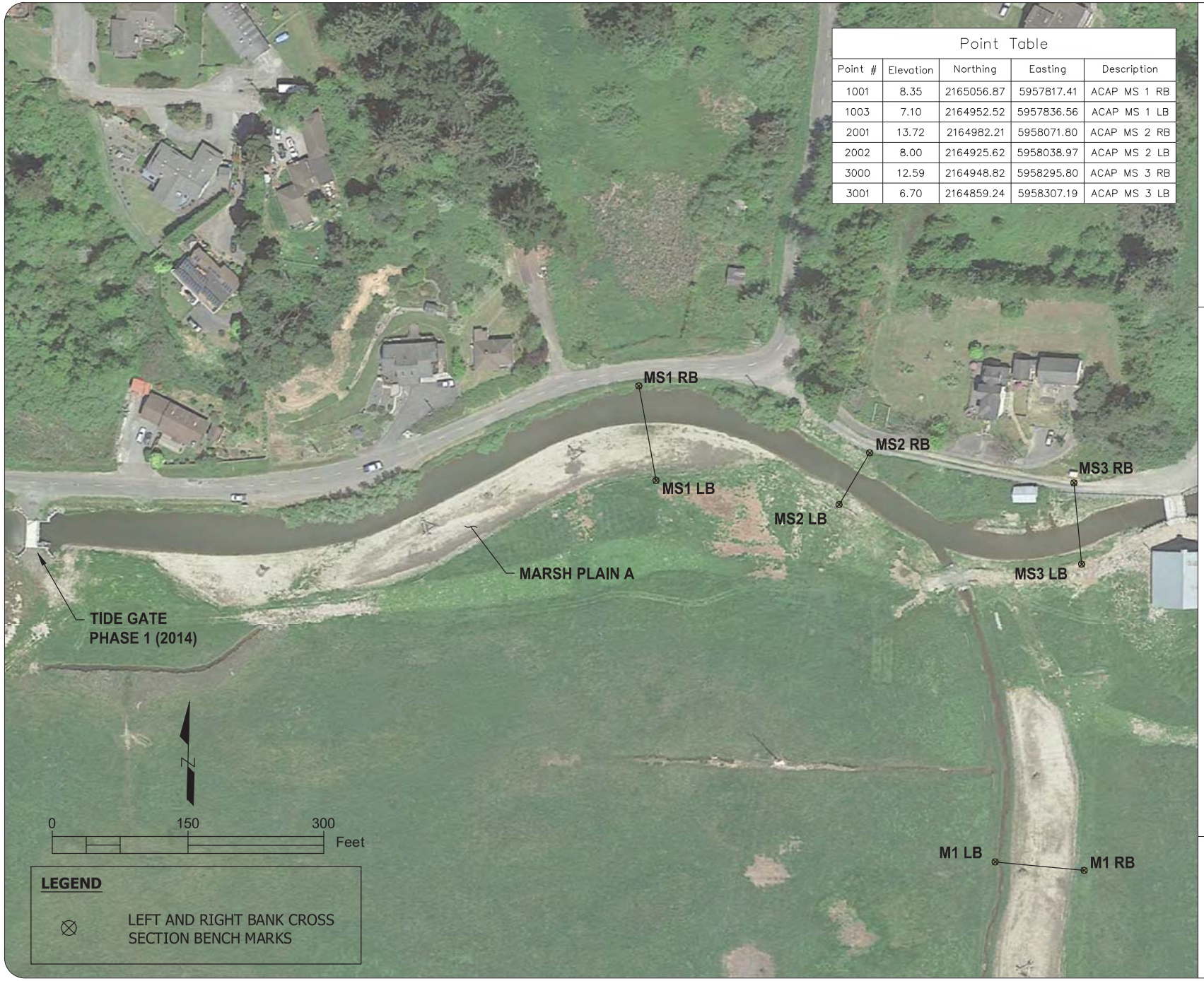
30+00
35+00
Distance from Swain Slough, ft



Point Table

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1003	7.10	2164952.52	5957836.56	ACAP MS 1 LB
2001	13.72	2164982.21	5958071.80	ACAP MS 2 RB
2002	8.00	2164925.62	5958038.97	ACAP MS 2 LB
3000	12.59	2164948.82	5958295.80	ACAP MS 3 RB
3001	6.70	2164859.24	5958307.19	ACAP MS 3 LB

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MARTIN SLOUGH ENHANCEMENT PROJECT

LOCATION OF MONITORING CROSS SECTIONS

FIGURE

1

12/20/19 Q:\Martin Slough Design\5_DWG\MONITORING.dwg

Point Table

Point #	Elevation	Northing	Easting	Description
4000	6.34	2164853.86	5958999.09	ACAP MS 4 LB
4001	7.94	2164935.42	5958979.77	ACAP MS 4 RB
5000	6.83	2165307.01	5959527.29	ACAP MS 5 LB
5001	7.03	2165341.91	5959479.28	ACAP MS 5 RB
6000	6.63	2165157.54	5958965.13	ACAP C1 RB
6001	8.02	2164968.93	5959036.41	ACAP C1 LB
7001	6.78	2165157.68	5959281.77	ACAP C2 LB
7002	8.62	2165265.44	5959139.46	ACAP C2 RB
10000	7.50	2164642.74	5959593.90	ACAP SE TRIB 1 RB
10001	7.60	2164596.02	5959590.62	ACAP SE TRIB 1 LB

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MARTIN SLOUGH ENHANCEMENT PROJECT

LOCATION OF MONITORING CROSS SECTIONS

FIGURE

2

12/20/19 Q:\Martin Slough Design\5_DWG\MONITORING.dwg

Point Table

Point #	Elevation	Northing	Easting	Description
8000	7.16	2164521.53	5958309.66	ACAP MEANDER 1 RB
8001	6.30	2164530.71	5958211.39	ACAP MEANDER 1 LB
9000	7.90	2164452.55	5958834.85	ACAP MEANDER 2 RB
9001	5.75	2164441.06	5958931.78	ACAP MEANDER 2 LB

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Natural Resources Services
A Division of Redwood Community Action Agency
(707) 269-2065 • 904 G St. Eureka, CA 95501

MARTIN SLOUGH ENHANCEMENT PROJECT

LOCATION OF MONITORING CROSS SECTIONS

FIGURE

3

12/20/19 Q:\Martin Slough Design\5_DWG\MONITORING.dwg

Martin Slough Channel Cross Sections

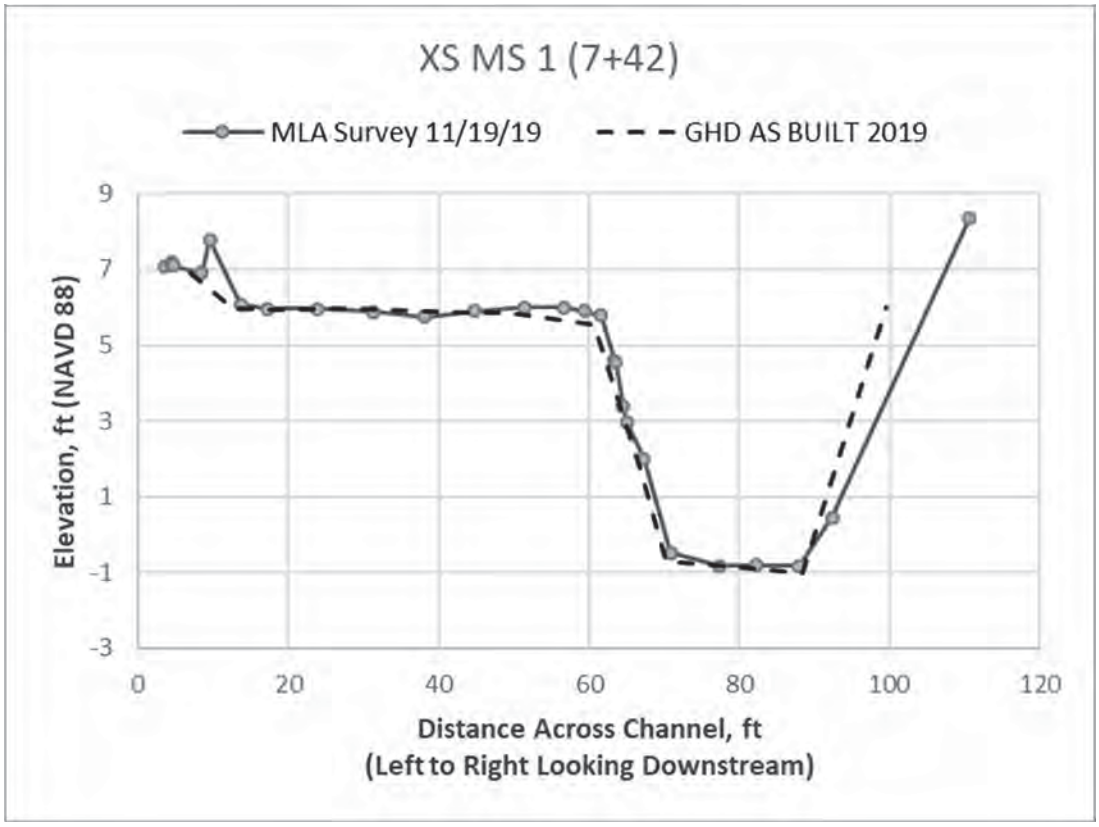
Phase 2 Project Area

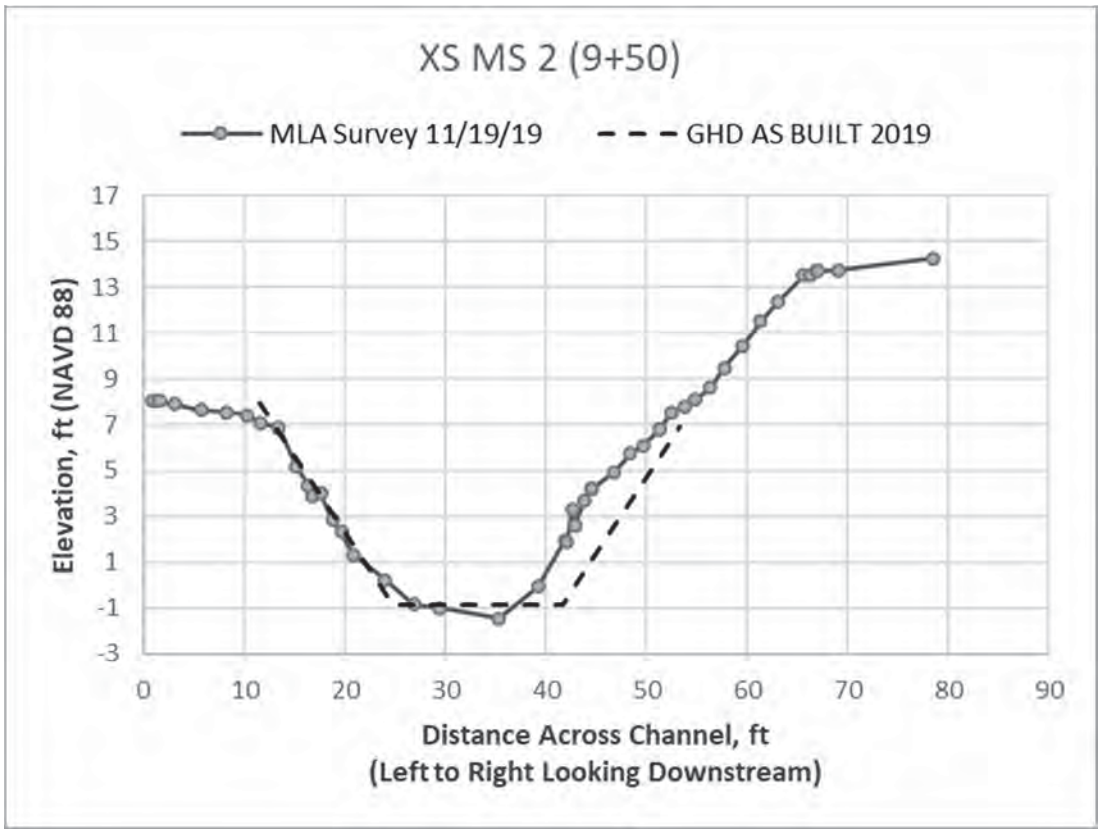
Monument Coordinates:

Aluminum Caps on rebar set at ground level, indicated with “RCAA MONITORING”
Horizontal Datum: NAD83 California State Planes, Zone I, US Foot
Vertical Datum: NAVD 88

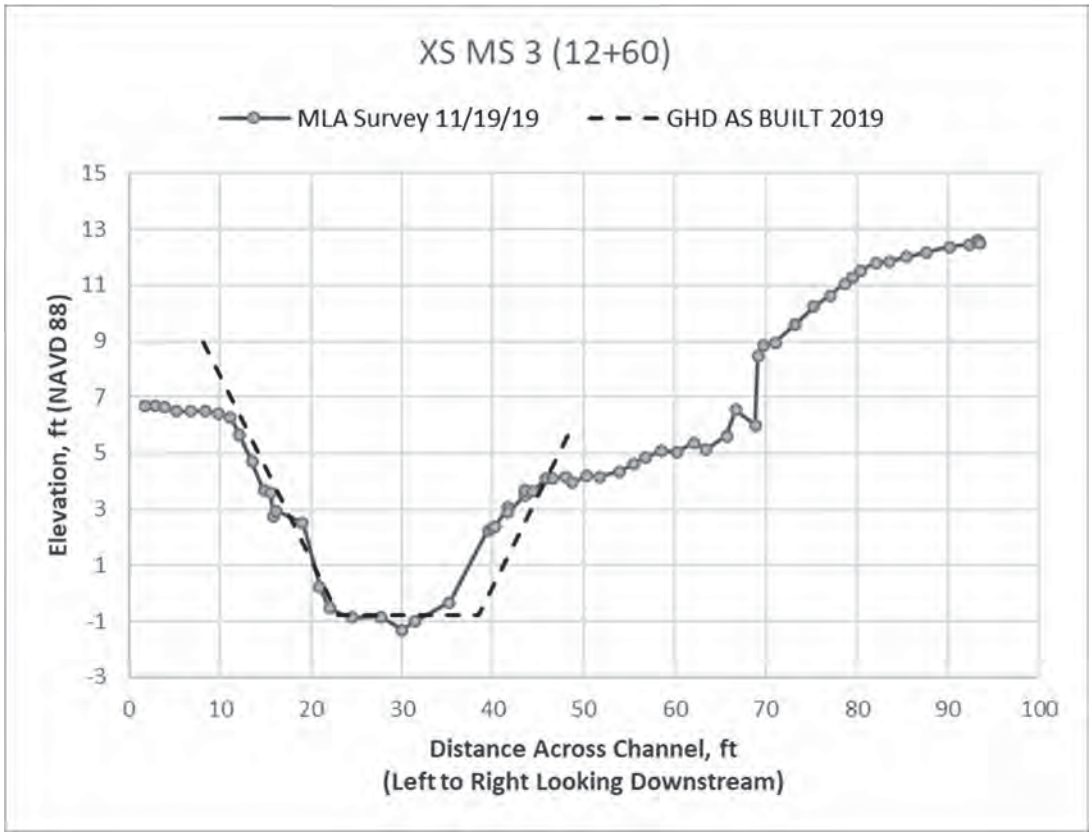
Point #	Description	Elevation (feet)	Northing (feet)	Easting (feet)
1,001	ACAP MS 1 RB	8.35	2,165,056.871	5,957,817.412
1,003	ACAP MS 1 LB	7.10	2,164,952.524	5,957,836.559
2,001	ACAP MS 2 RB	13.72	2,164,982.208	5,958,071.795
2,002	ACAP MS 2 LB	8.00	2,164,925.615	5,958,038.971
3,000	ACAP MS 3 RB	12.59	2,164,948.819	5,958,295.800
3,001	ACAP MS 3 LB	6.70	2,164,859.235	5,958,307.188
4,000	ACAP MS 4 LB	6.34	2,164,853.859	5,958,999.086
4,001	ACAP MS 4 LB	7.94	2,164,935.416	5,958,979.772
5,000	ACAP MS 5 LB	6.83	2,165,307.009	5,959,527.293
5,001	ACAP MS 5 RB	7.03	2,165,341.907	5,959,479.276
6,000	ACAP C1 RB	6.63	2,165,157.541	5,958,965.134
6,001	ACAP C1 LB	8.02	2,164,968.928	5,959,036.410
7,001	ACAP C2 LB	6.78	2,165,157.683	5,959,281.769
7,002	ACAP C2 RB	8.62	2,165,265.443	5,959,139.459
8,000	ACAP MEANDER 1 RB	7.16	2,164,521.532	5,958,309.662
8,001	ACAP MEANDER 1 LB	6.30	2,164,530.713	5,958,211.387
9,000	ACAP MEANDER 2 RB	7.90	2,164,452.548	5,958,834.845
9,001	ACAP MEANDER 2 LB	5.75	2,164,441.061	5,958,931.775
10,000	ACAP SE TRIB 1 RB	7.50	2,164,642.735	5,959,593.897
10,001	ACAP SE TRIB 1 LB	7.60	2,164,596.018	5,959,590.624

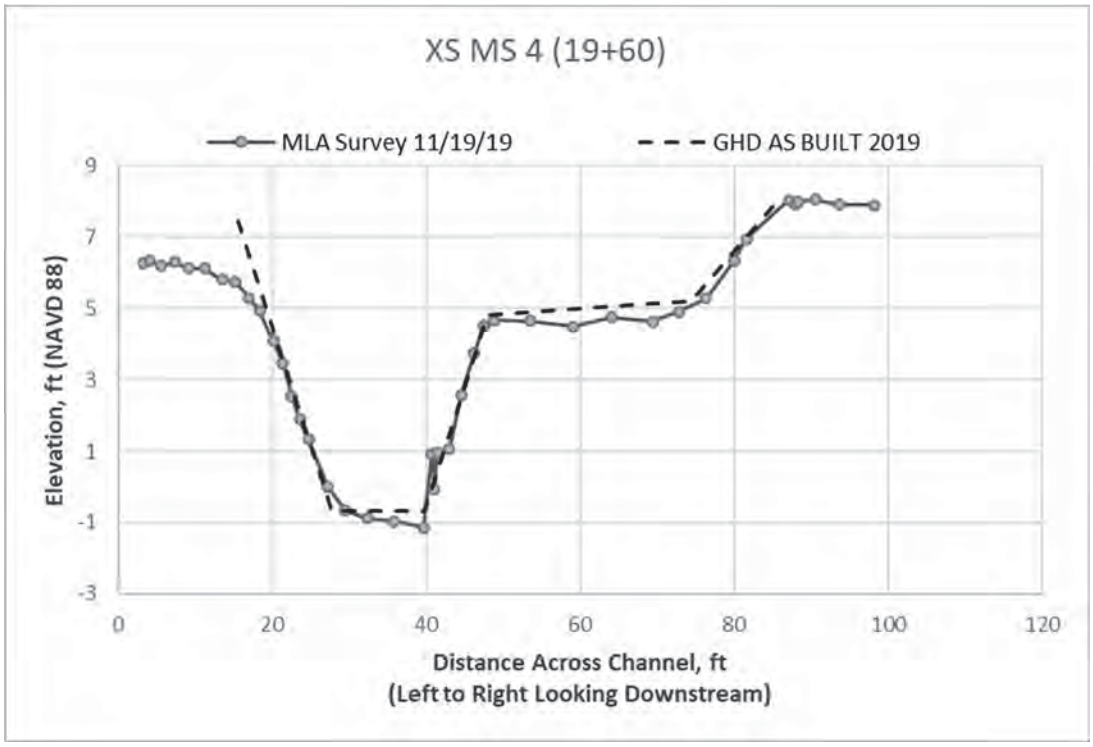
Martin Slough Monitoring Cross Sections



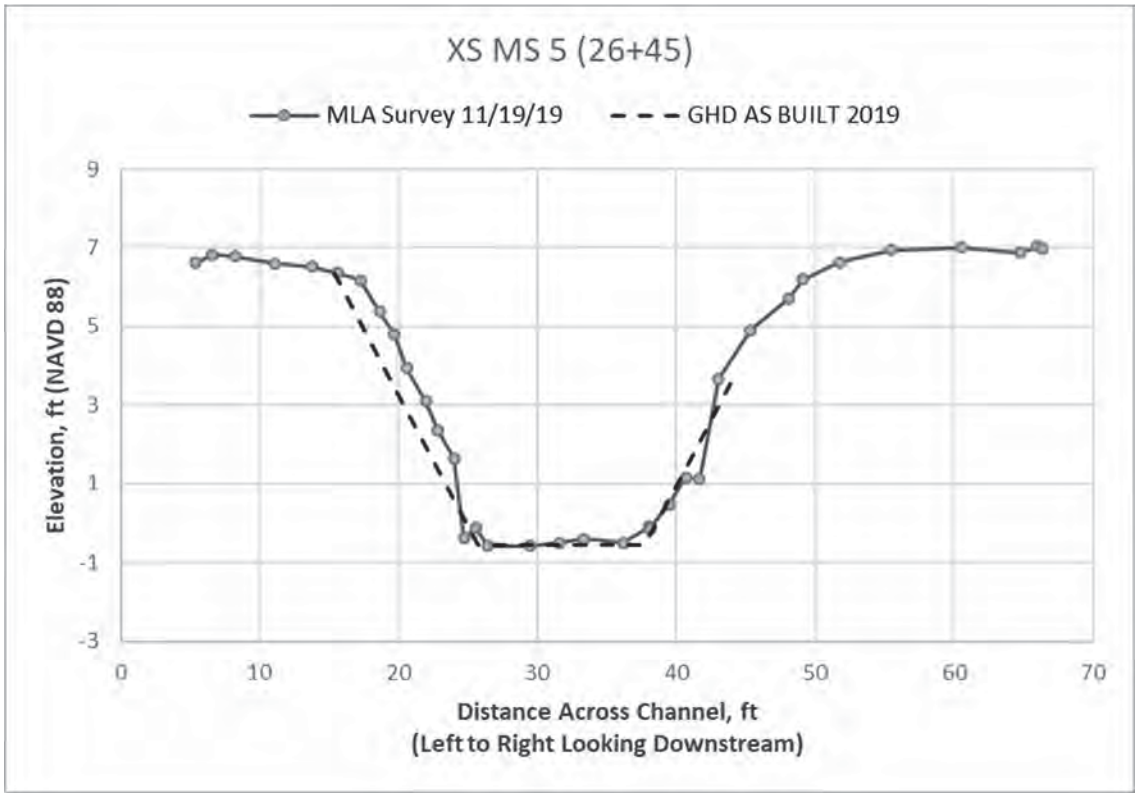


Martin Slough Monitoring Cross Sections

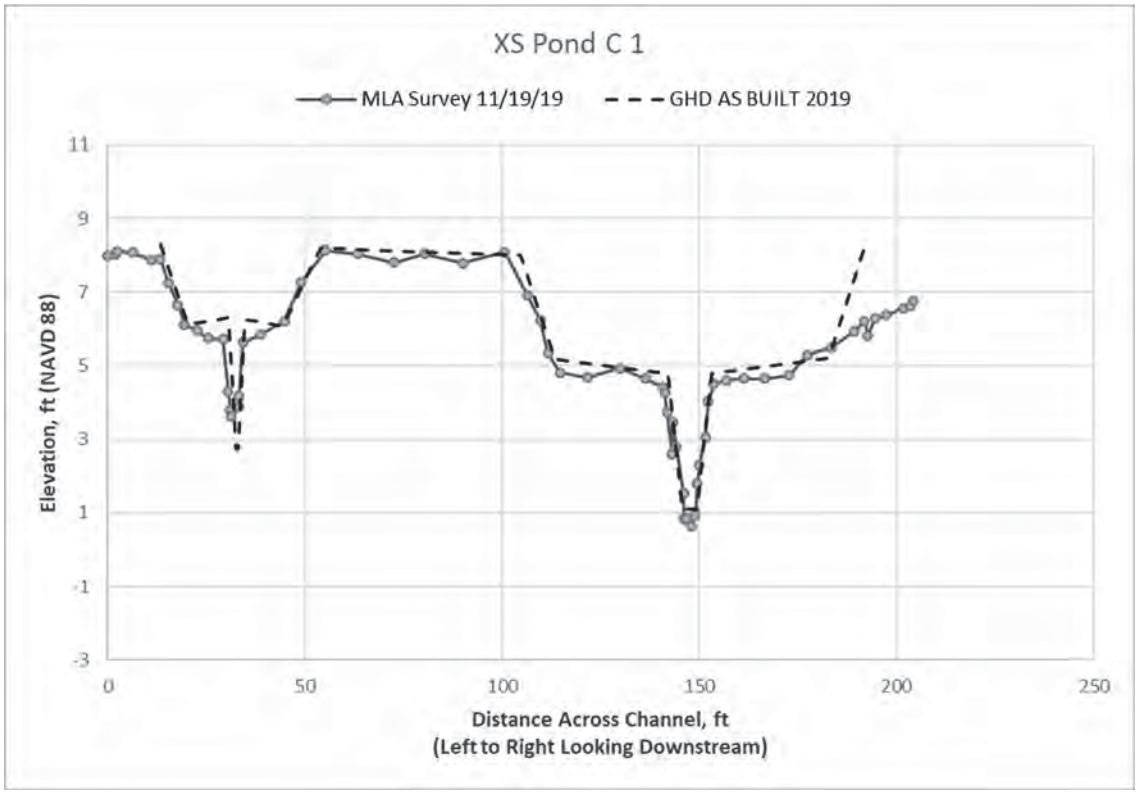


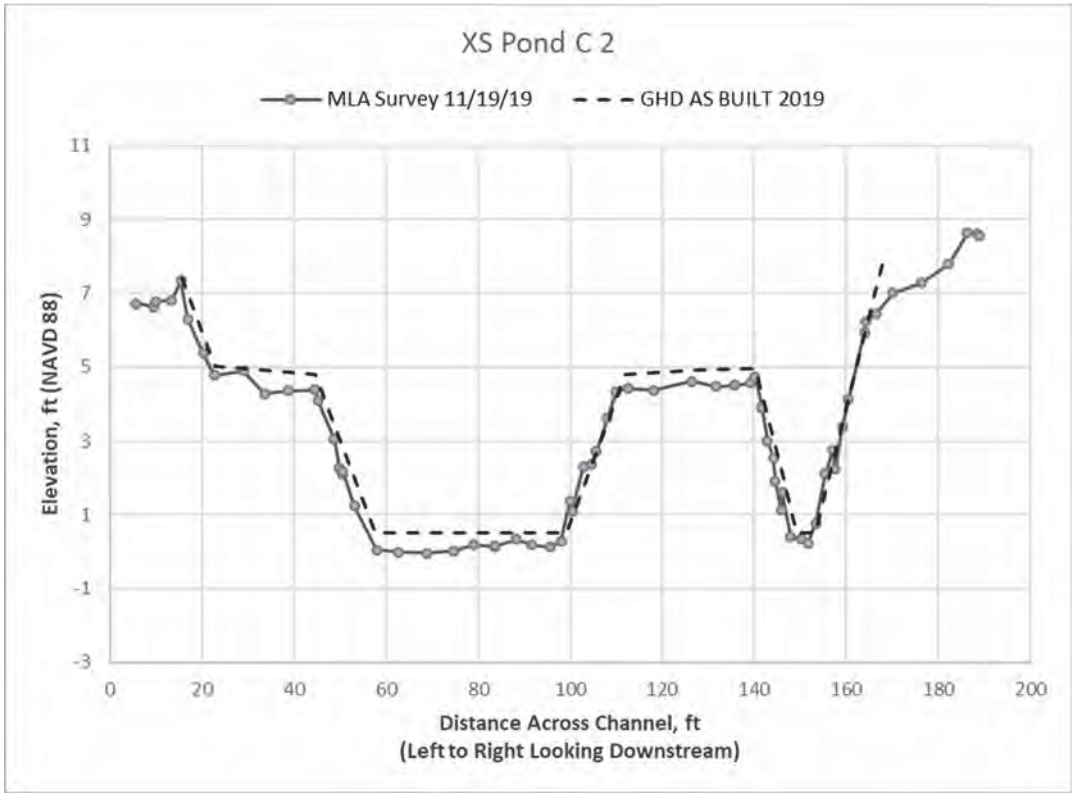


Martin Slough Monitoring Cross Sections

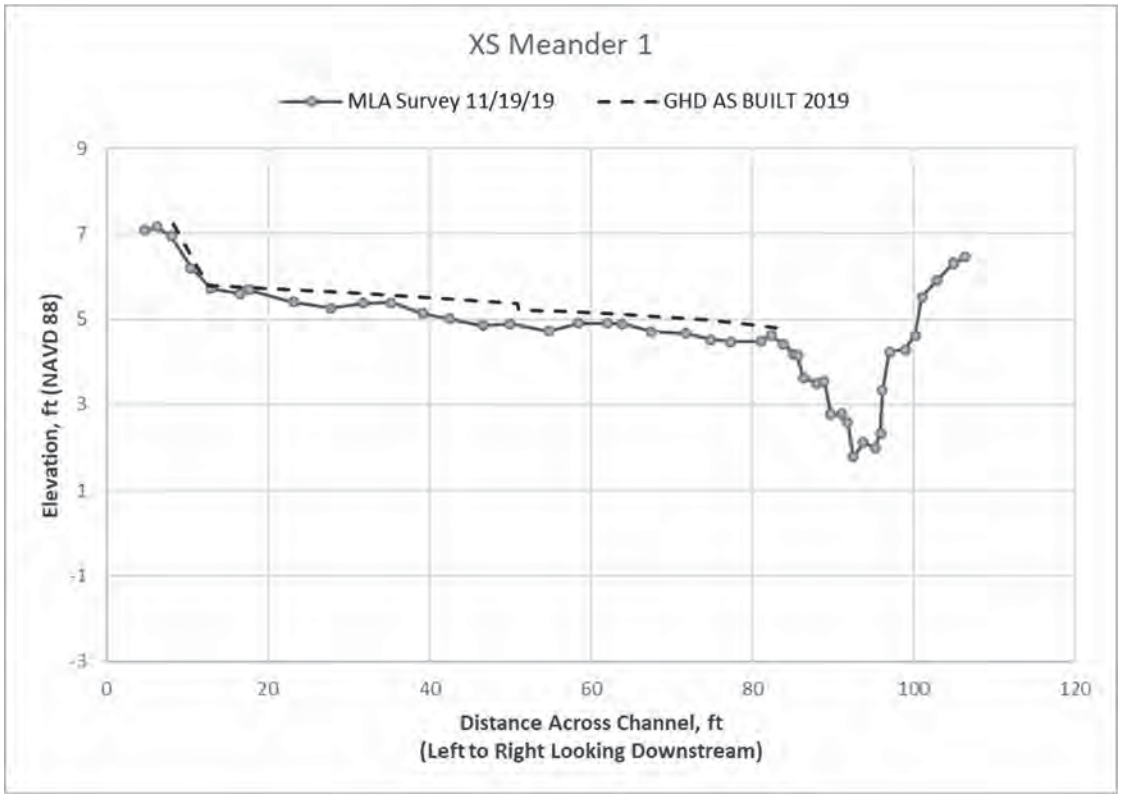


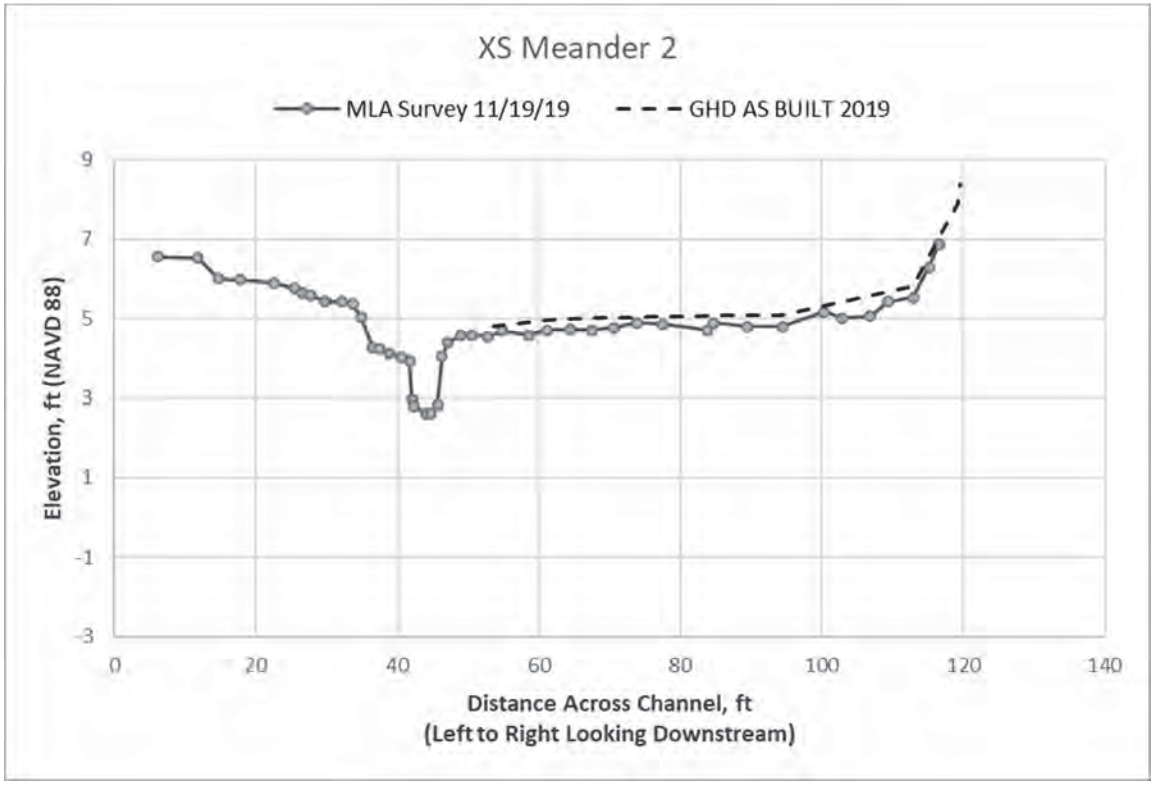
Martin Slough Monitoring Cross Sections





Martin Slough Monitoring Cross Sections





Martin Slough Monitoring Cross Section Benchmark Locations

MS1-LB: Rebar and aluminum cap labeled MS1. Set ~1 ft toward channel from wood fence post. Approximately 45 ft from active channel.

MS1-RB: Rebar and aluminum cap. 21 ft east of road culvert. 3.5 ft from PK Nail in shoulder of road, 2 ft from asphalt

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MS2-LB: Rebar and aluminum cap labeled MS2. Set ~1 ft toward channel from fence, between two aluminum fence posts. Approximately 15 ft from active channel.

MS2-RB: Rebar and aluminum cap. 5.5 ft upstream of gas marker on road shoulder.

MS3-LB: Rebar and aluminum cap labeled MS3. Set ~1 ft toward channel from fence, about 75 ft downstream from bridge.

MS3-RB: Rebar and aluminum cap labeled MS3 at base of third wooden post along neighbors' fence.

MS4-LB: Rebar and aluminum cap labeled MS4. 1 ft from 1st T-Post upstream of wood posts at culvert.

MS4-RB: Rebar and aluminum cap labeled MS4. Set ~30 ft from channel, ~2' from top of bank, ~12' east from trough, monument and SE corner of trough are equidistant from channel.

MS5-LB: Rebar and aluminum cap labeled MS5. Set ~1 ft toward channel from wood fence post (middle post in group of three wood posts).

MS5-RB: Rebar and aluminum cap labeled MS5. 1 ft off left gate wood post.

M1-LB: Rebar and aluminum cap labeled M1. Set 1 ft channel side of fence, about 8 ft from active channel.

M1-RB: Rebar and aluminum cap labeled M1. Inside fence, 7 ft from wood post.

M2-LB: Rebar and aluminum cap labeled M2. . Set on east side of channel, ~6' east from single old fence post. Directly under eastern powerline.

M2-RB: Rebar and aluminum cap labeled M2. 1 ft inside of t-post upstream of wood post at corner.

SE1-LB: Rebar and aluminum cap labeled SE1. Set on south side of pond, ~1' toward pond from aluminum fence post (4th post from corner, 2nd aluminum post from corner), ~4 ft from pond.

SE1-RB: 8-inches off middle T-post between wood posts.

C1-LB: Rebar and aluminum cap labeled C1. 3 ft north from spruce seedling. Approx 40 ft west and 10 ft north of MS4.

C1-RB: Rebar and aluminum cap labeled C1. 2 ft inside single wood post, northwest of T-post.

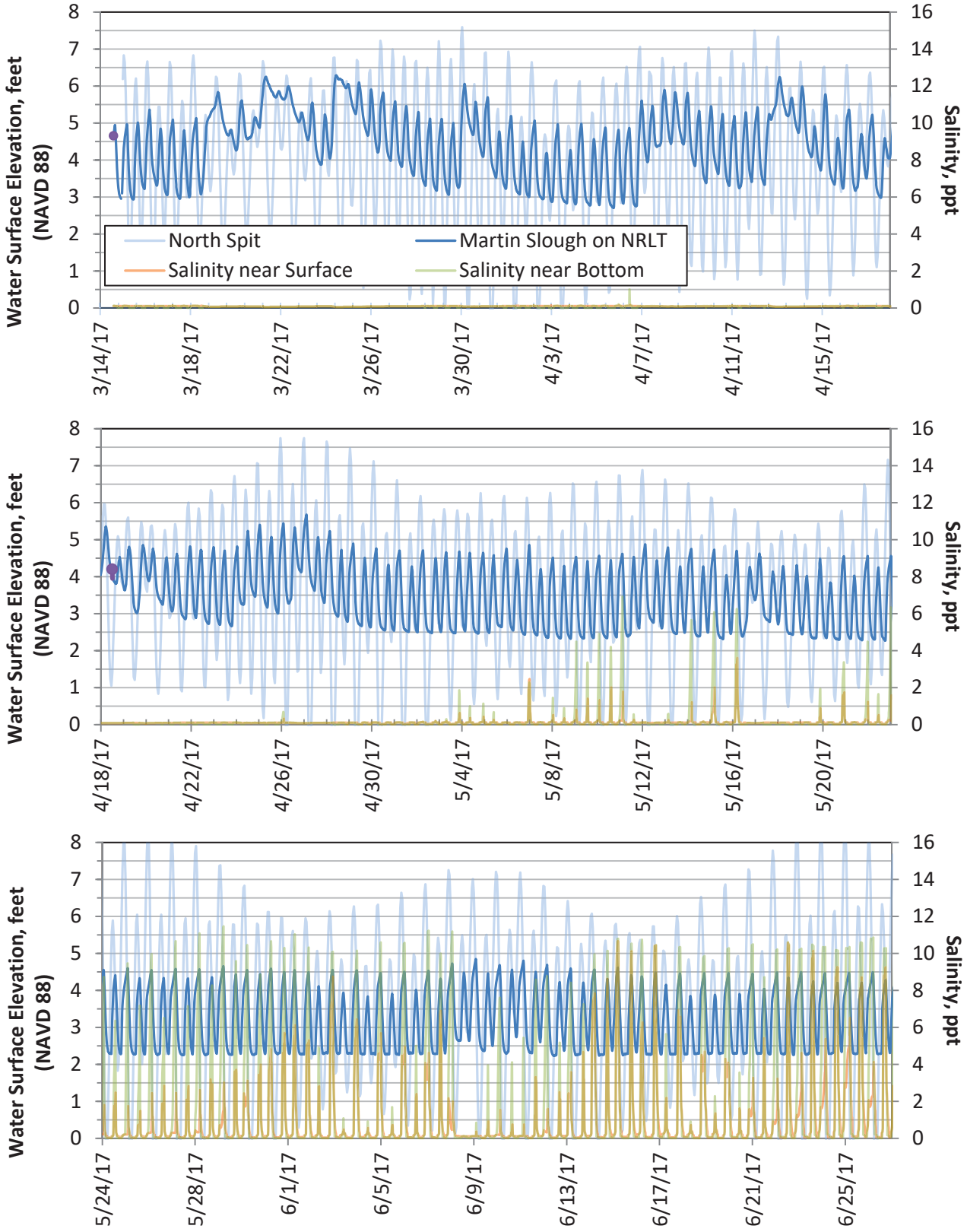
C2-LB: Rebar and aluminum cap labeled C2. Set approx 4 ft away from top of bank of pond, 30 ft ~west from a spruce seedling. If looking at Martin Slough mainstem, inline with middle of 3 wood posts.

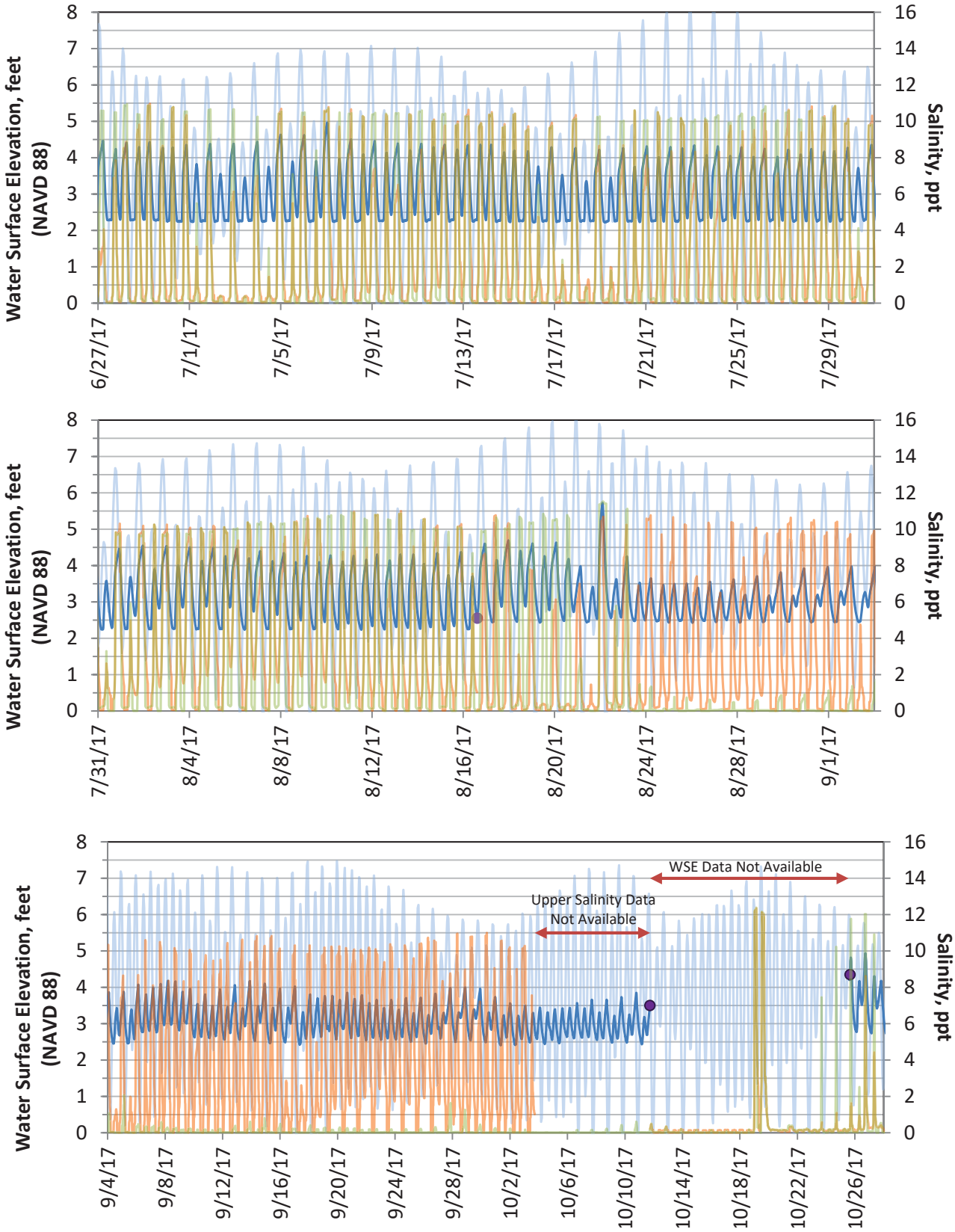
C2-RB: Rebar and aluminum cap labeled C2. 1 ft from fence corner next to Omsberg survey cap.

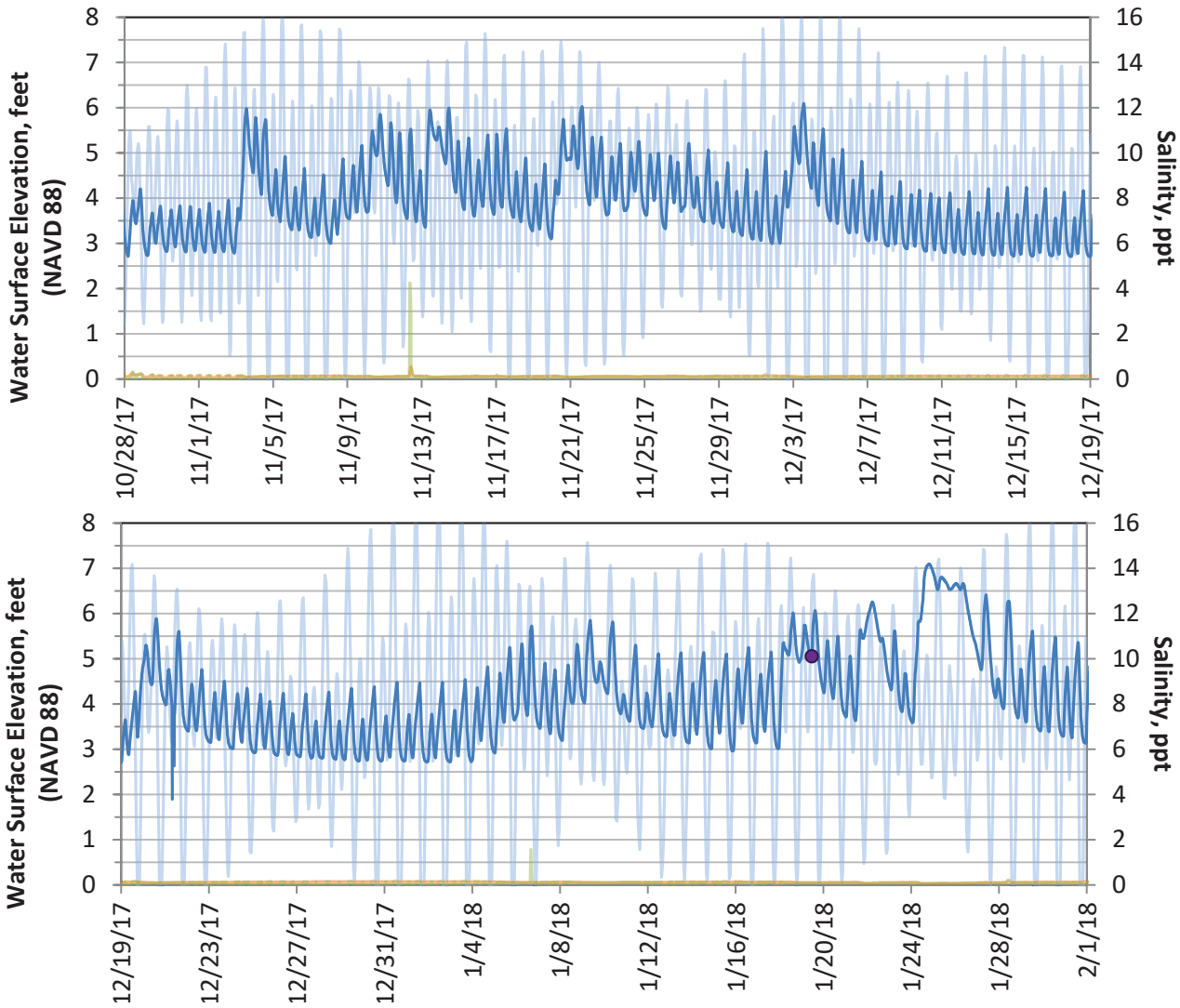

MS4
MS4
RCA

Appendix C
Hydrology and Water Quality Monitoring Following Phase 1 Completion

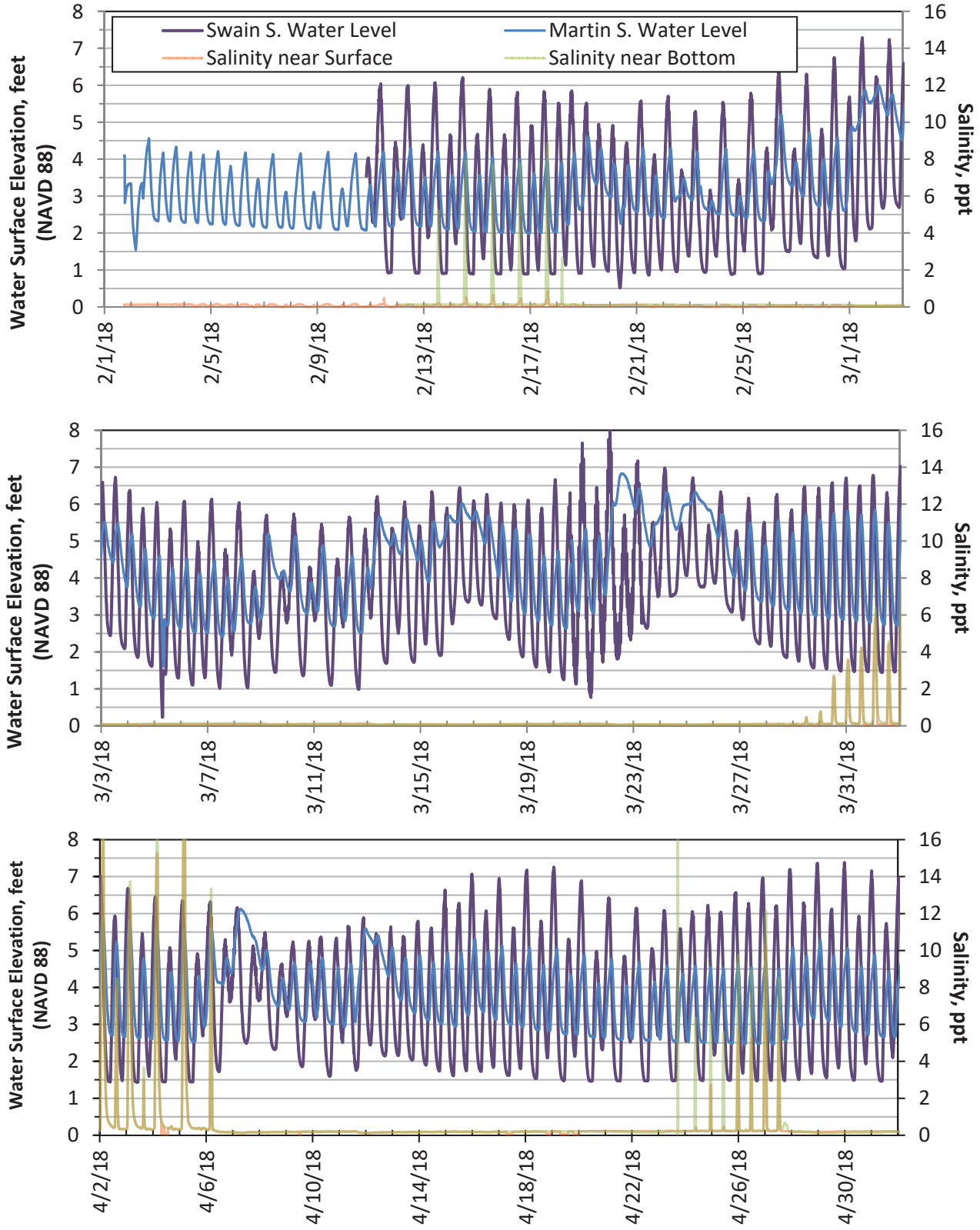
Recorded Water Levels and Salinity in Martin Slough on NRLT near Property Line



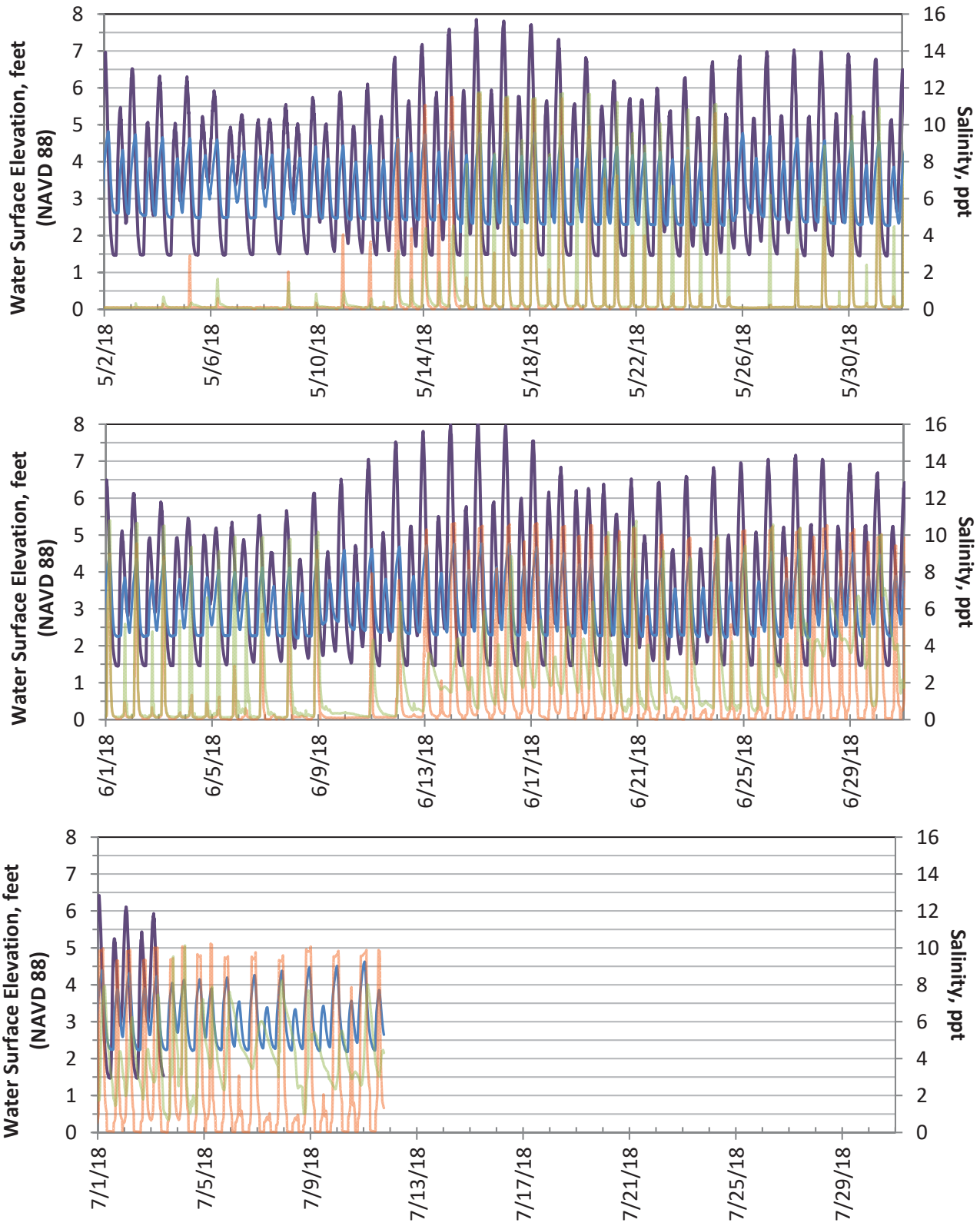

Water Surface Elevation, feet (NAVD 88)
Salinity, ppt
6/27/17
7/1/17
7/5/17
7/9/17
7/13/17
7/17/17
7/21/17
7/25/17
7/29/17
7/31/17
8/4/17
8/8/17
8/12/17
8/16/17
8/20/17
8/24/17
8/28/17
9/1/17
9/4/17
9/8/17
9/12/17
9/16/17
9/20/17
9/24/17
9/28/17
10/2/17
10/6/17
10/10/17
10/14/17
10/18/17
10/22/17
10/26/17
WSE Data Not Available
Upper Salinity Data Not Available


Water Surface Elevation, feet (NAVD 88)
Salinity, ppt
8
7
6
5
4
3
2
1
0
16
14
12
10
8
6
4
2
0
10/28/17
11/1/17
11/5/17
11/9/17
11/13/17
11/17/17
11/21/17
11/25/17
11/29/17
12/3/17
12/7/17
12/11/17
12/15/17
12/19/17
Water Surface Elevation, feet (NAVD 88)
Salinity, ppt
12/19/17
12/23/17
12/27/17
12/31/17
1/4/18
1/8/18
1/12/18
1/16/18
1/20/18
1/24/18
1/28/18
2/1/18

Recorded Water Levels and Salinity in Martin Slough on NRLT near Property Line



Recorded Water Levels and Salinity in Martin Slough on NRLT near Property Line

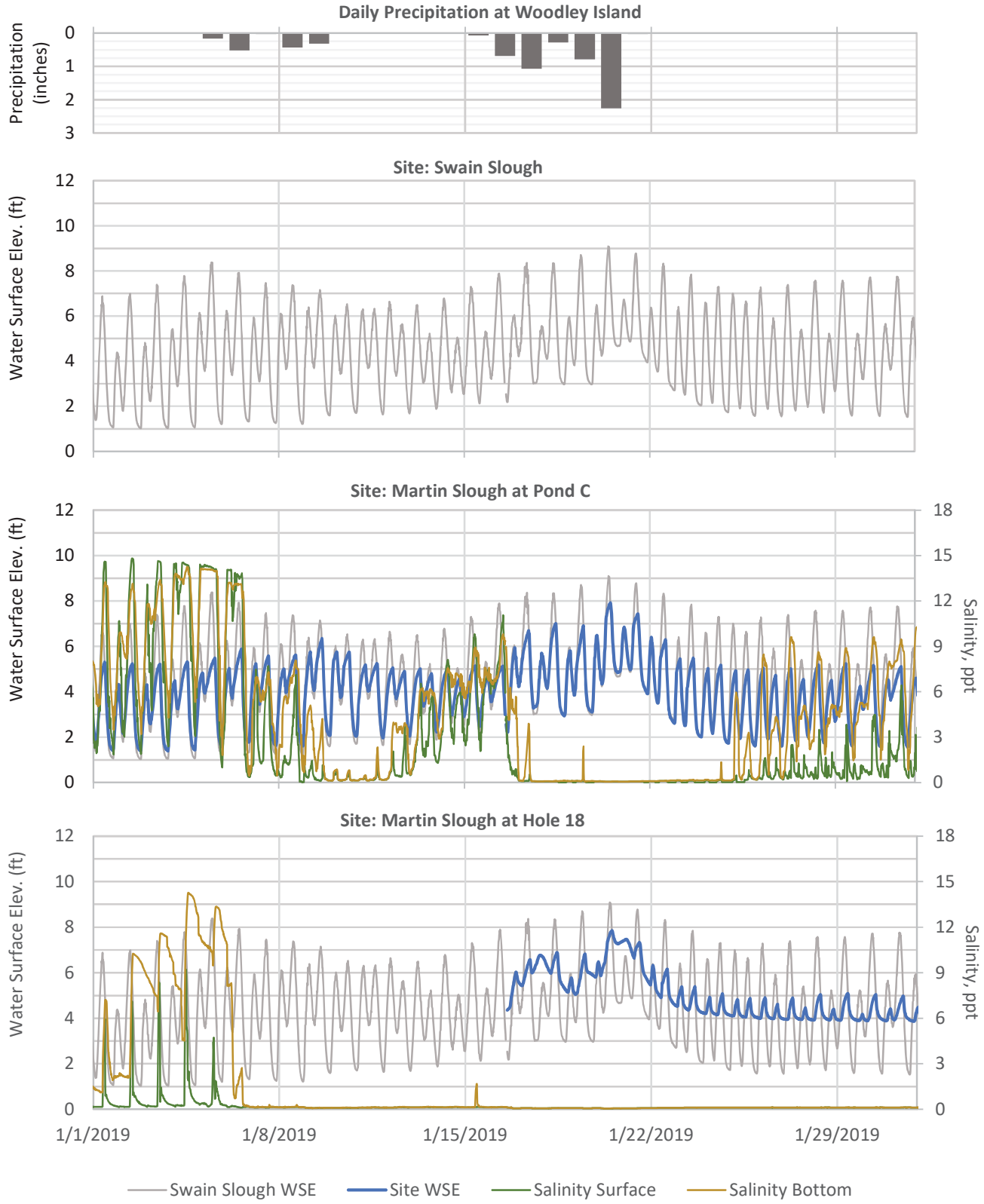


Appendix D
Hydrology and Water Quality Monitoring for Phase 2, Year-1

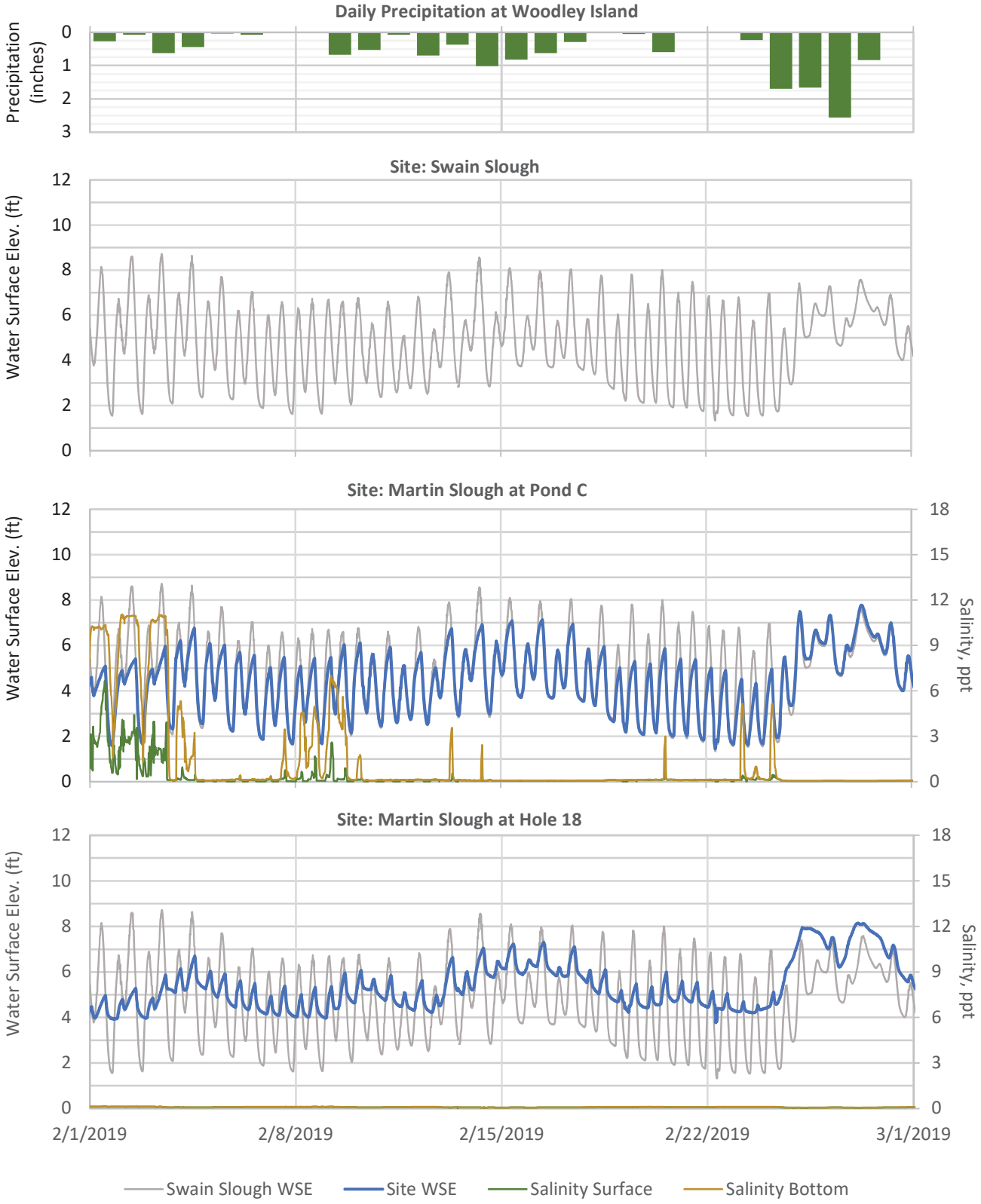
Martin Slough Water Level and Water Quality Data:

Stage and Salinity Plots

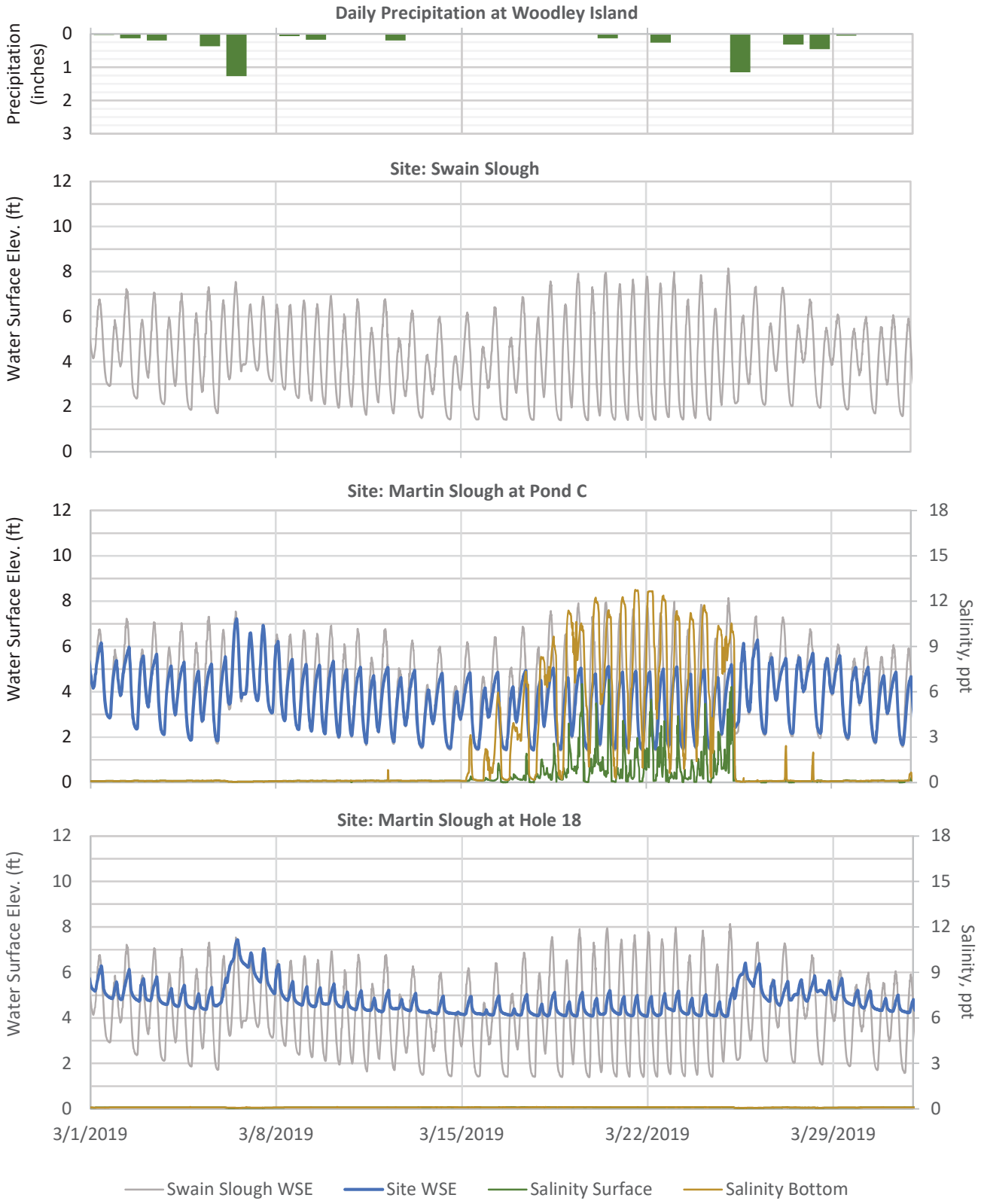
Martin Slough **January 2019**



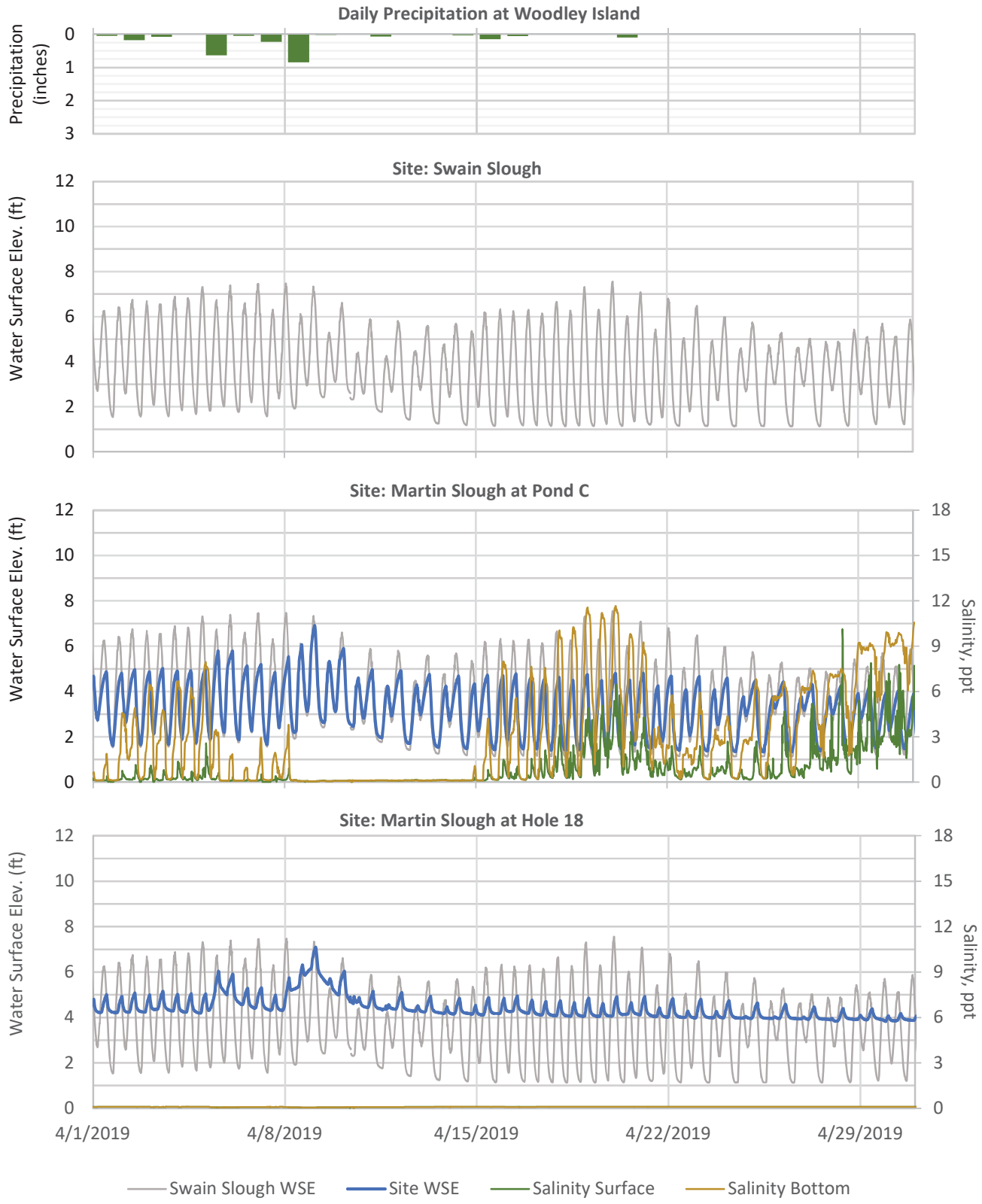
Martin Slough **February 2019**



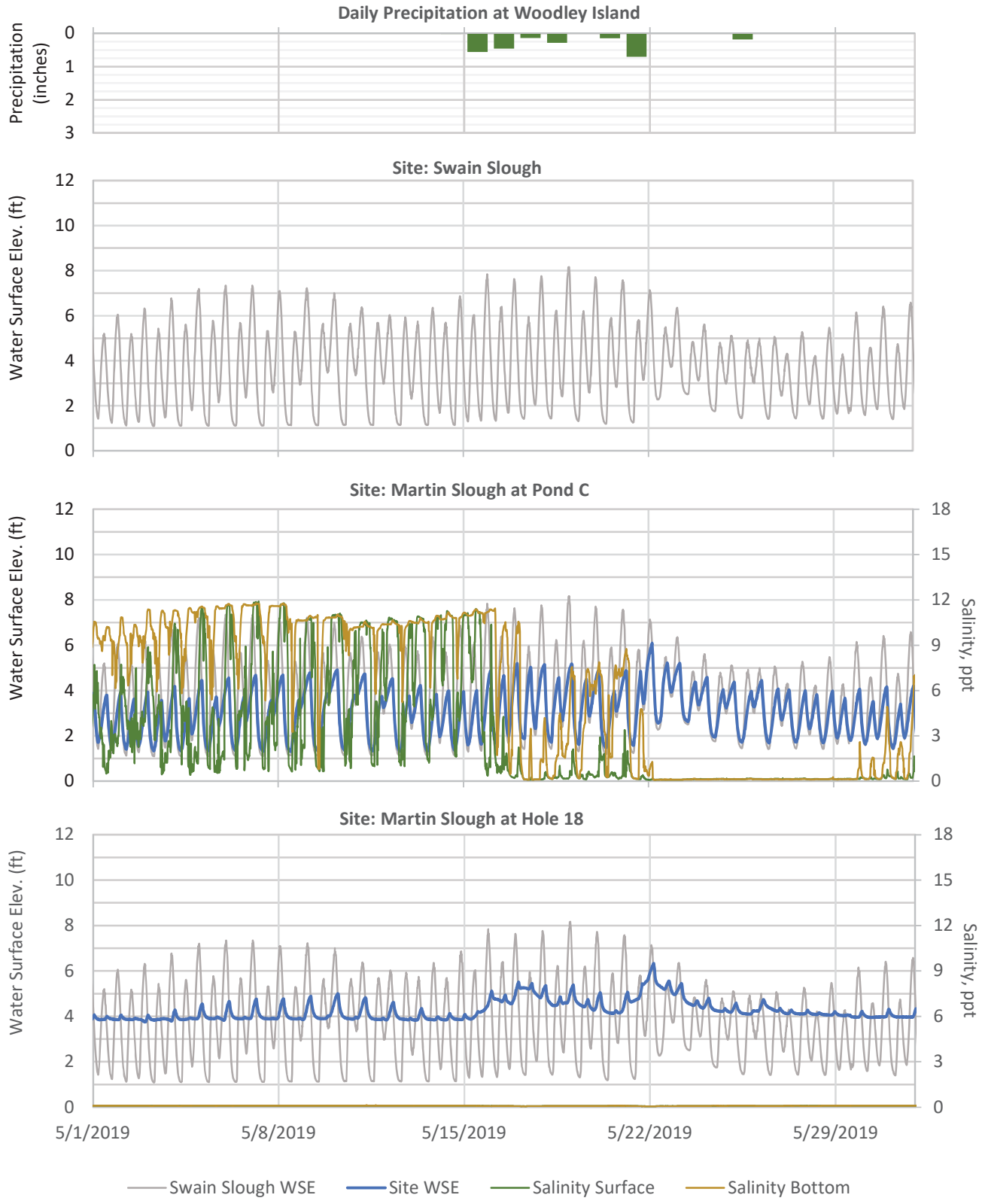
Martin Slough **March 2019**



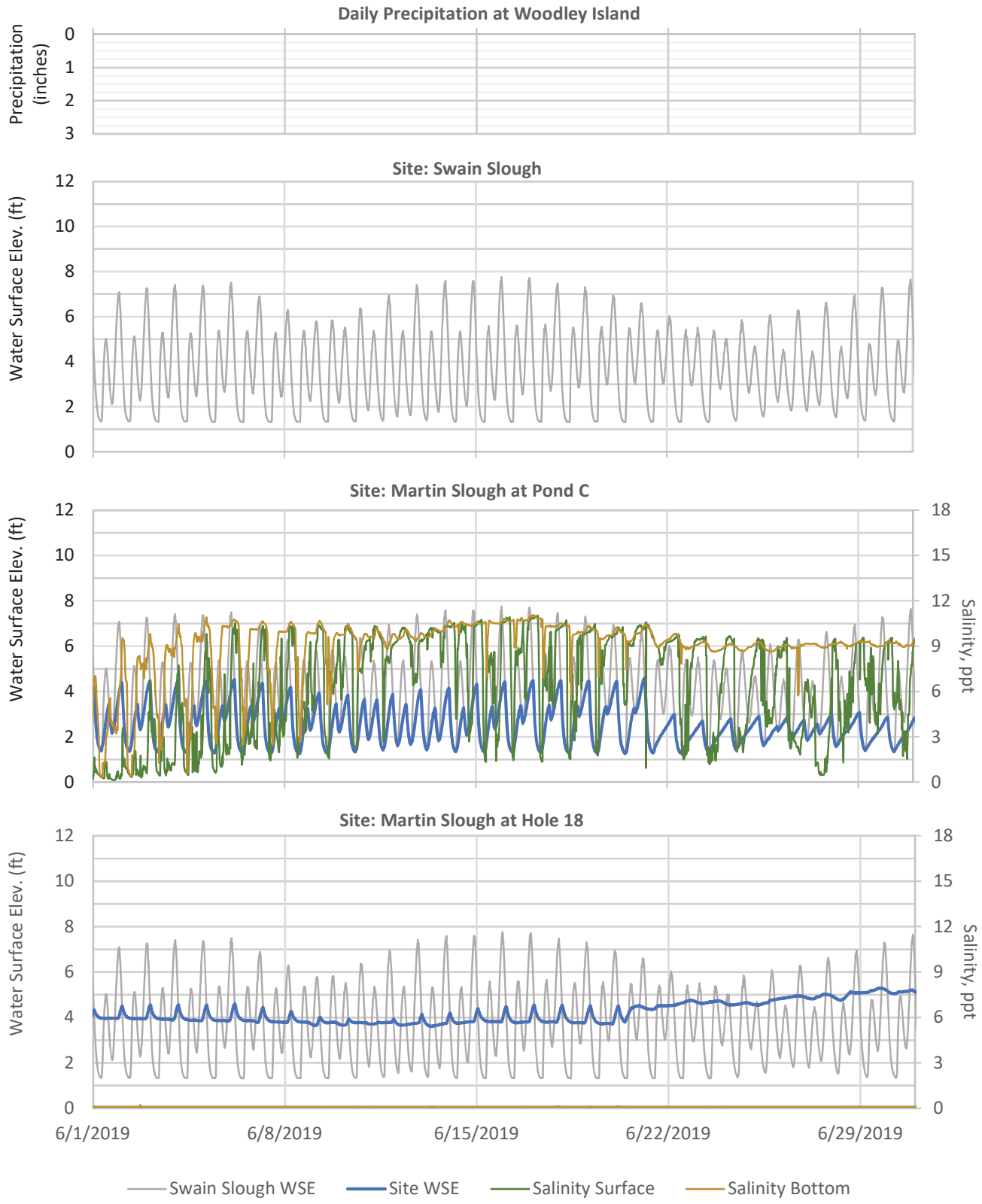
Martin Slough **April 2019**



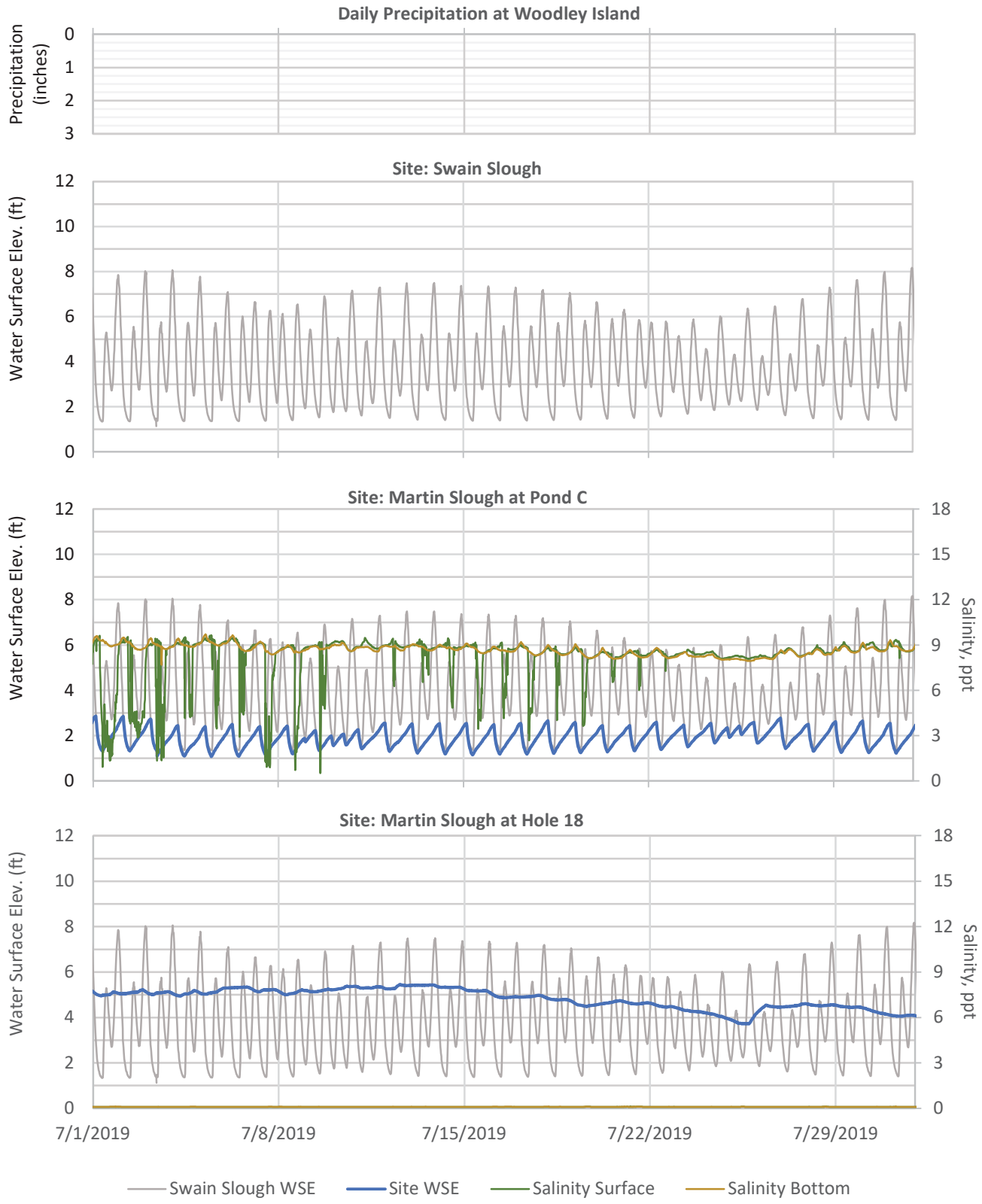
Martin Slough **May 2019**



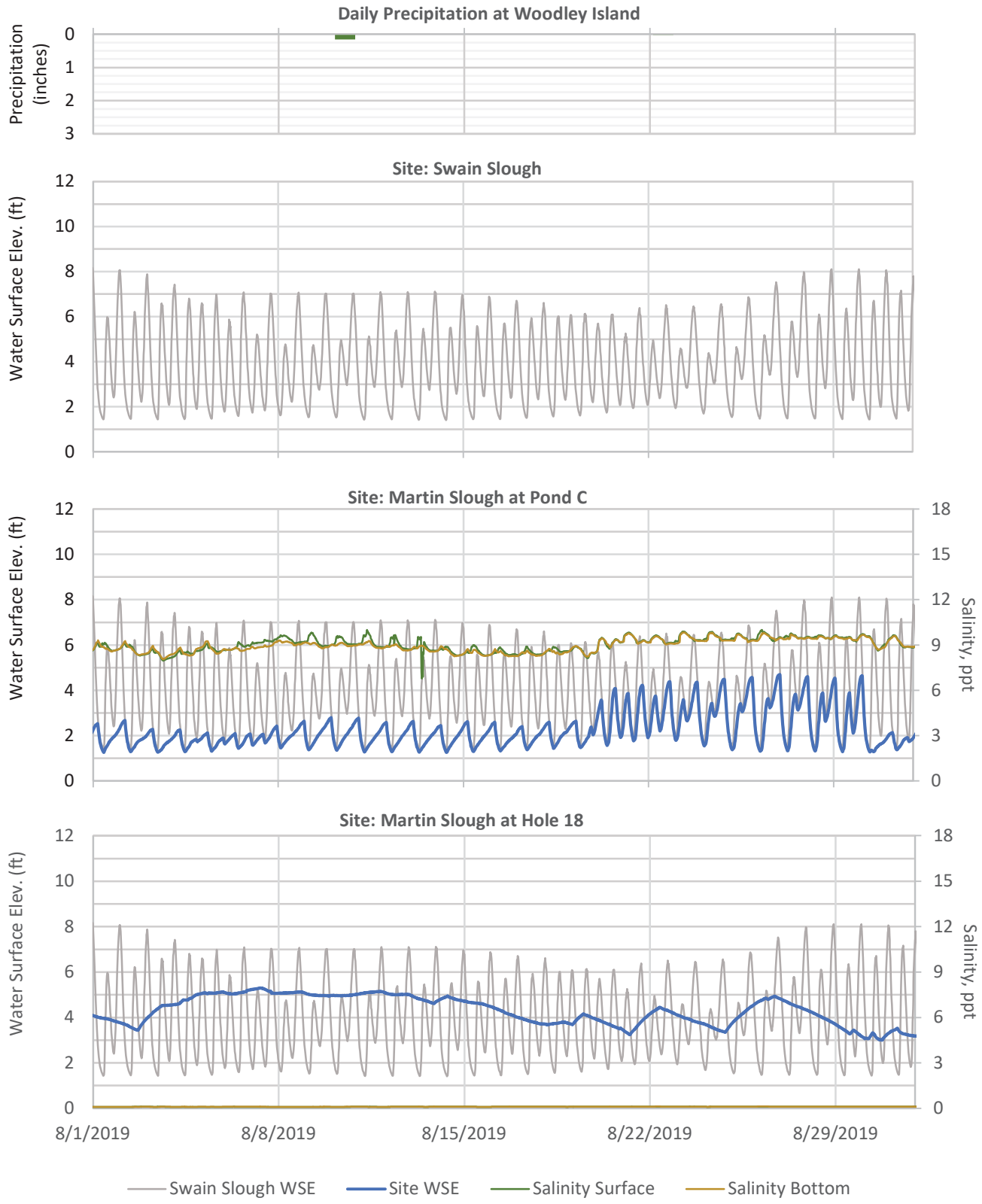
Martin Slough **June 2019**



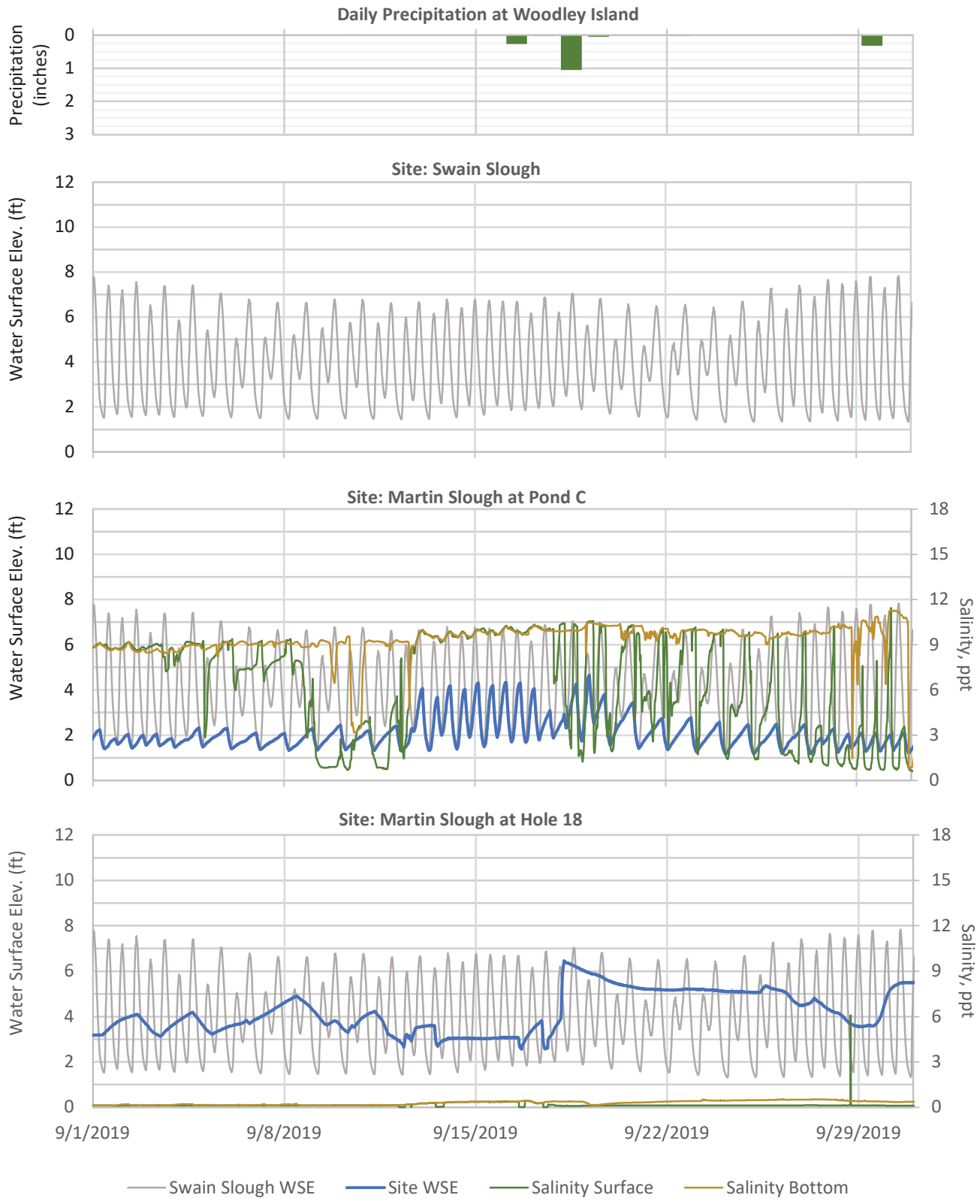
Martin Slough **July 2019**



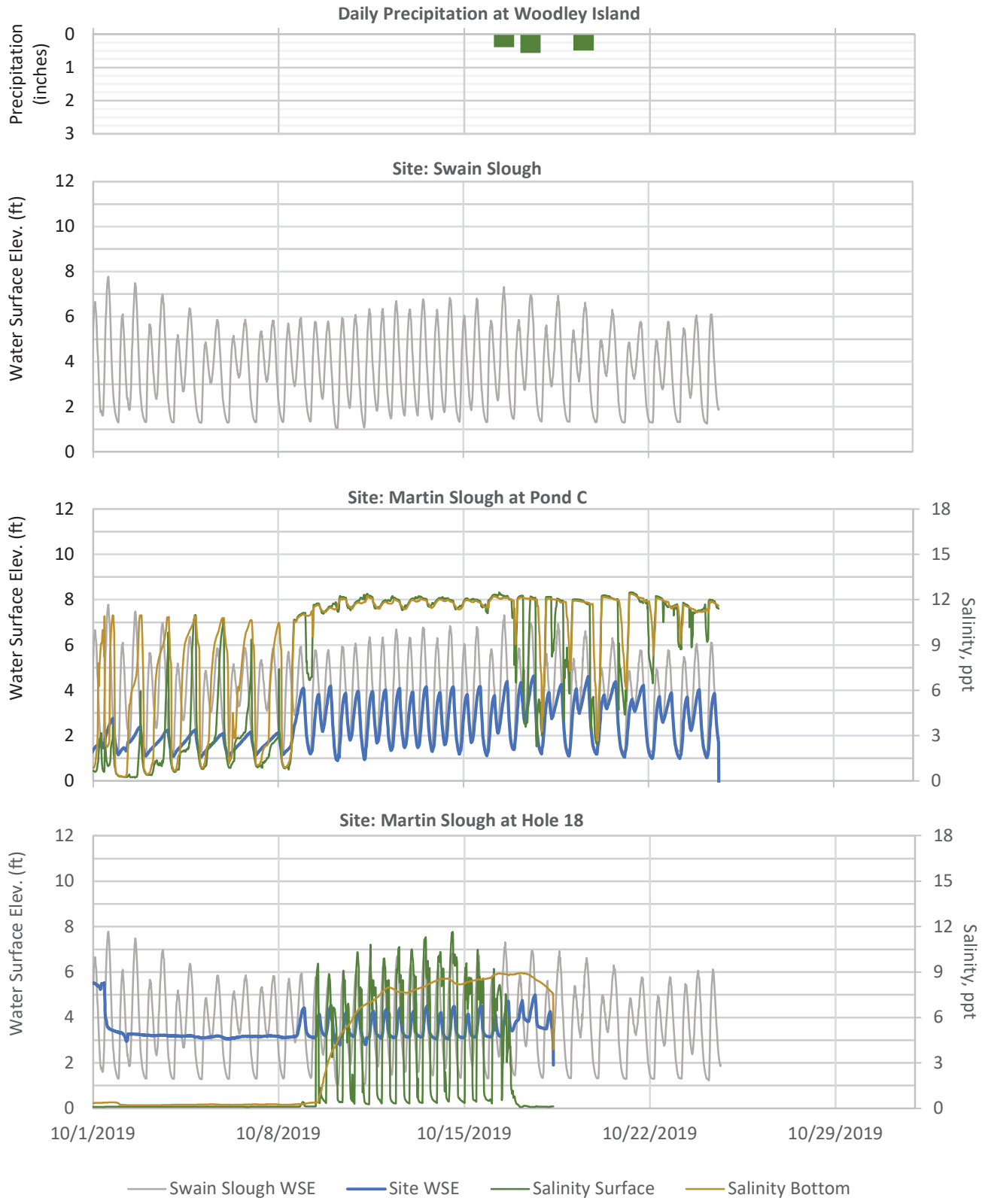
Martin Slough **August 2019**



Martin Slough **September 2019**



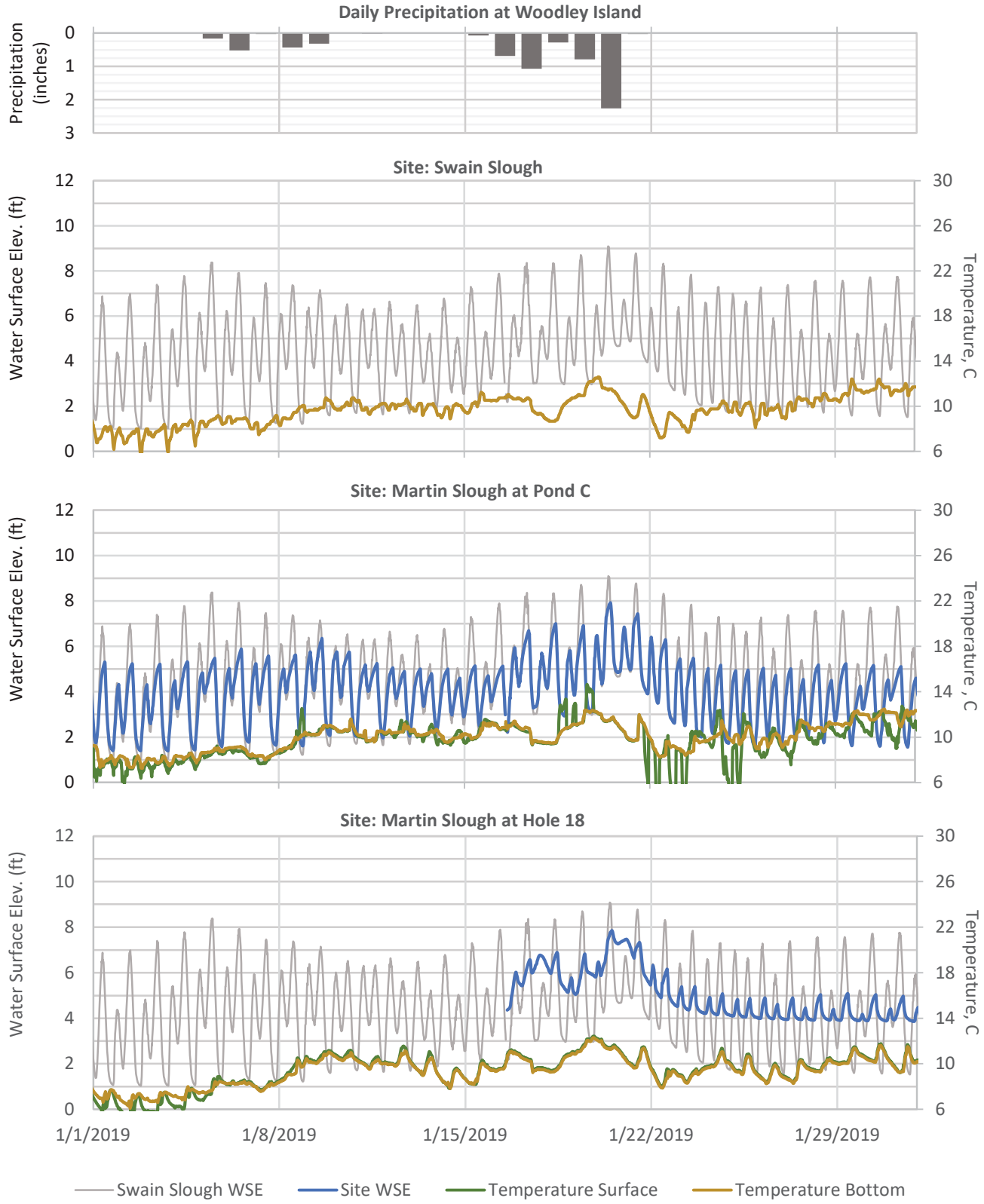
Martin Slough **October 2019**



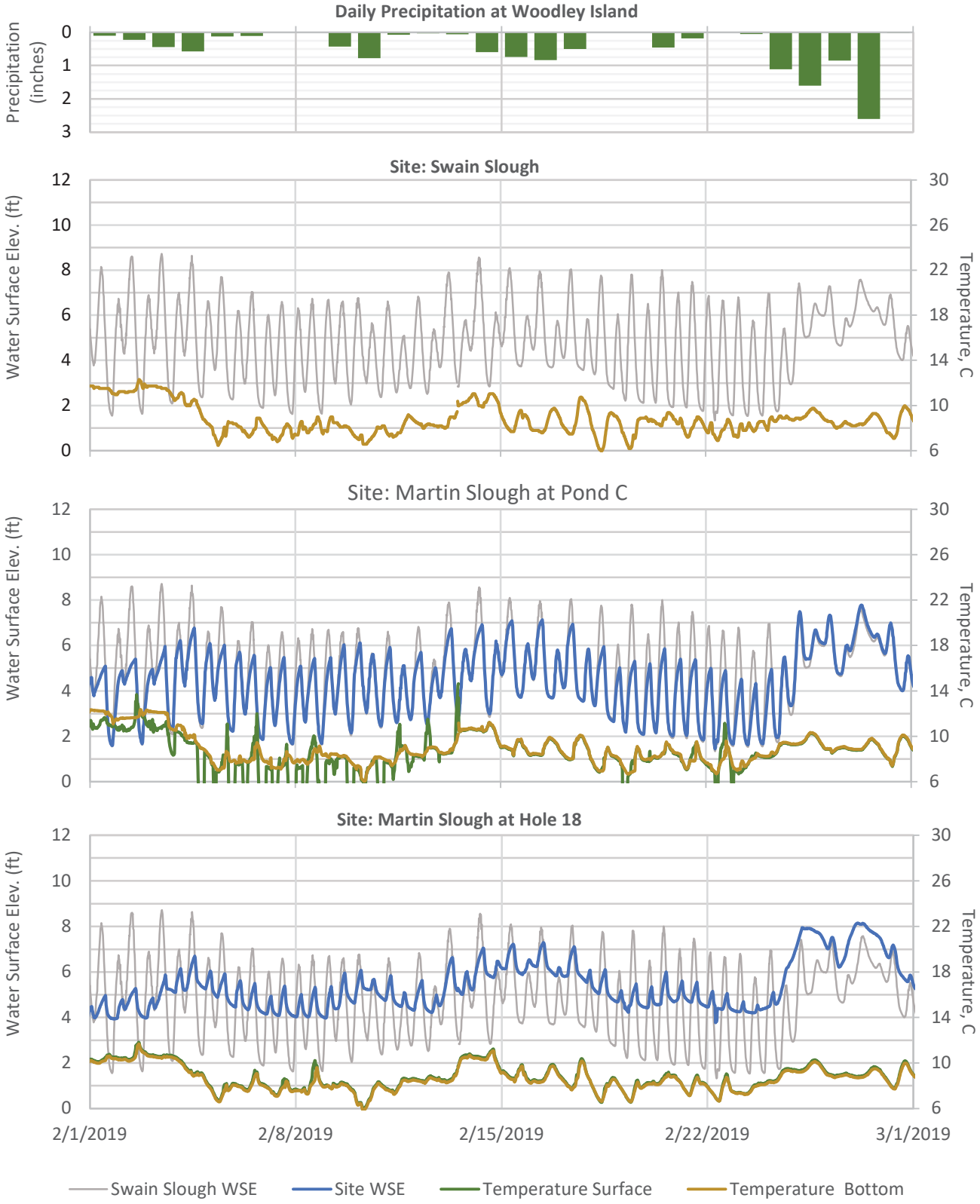
Martin Slough Water Level and Water Quality Data:

Stage and Temperature Plots

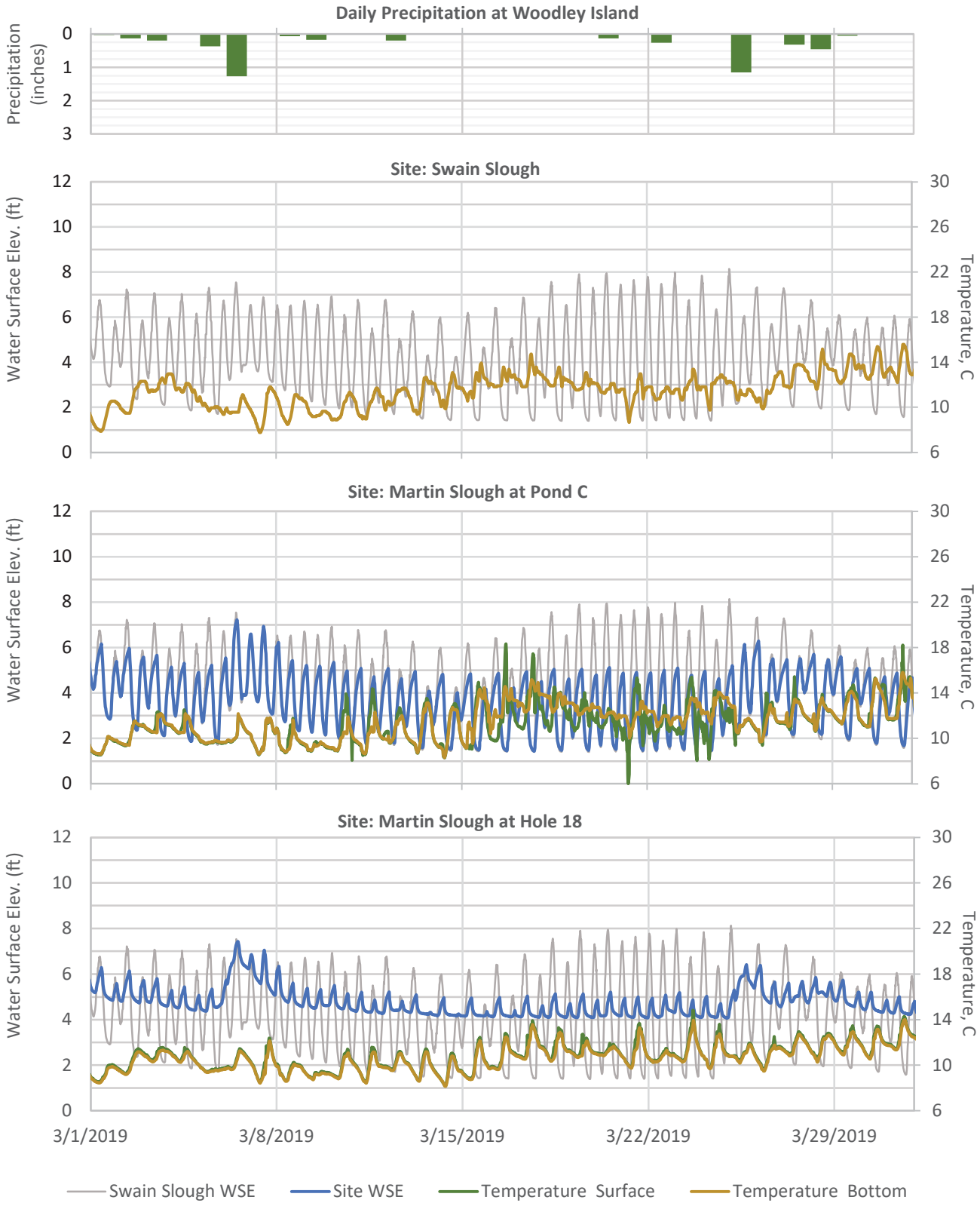
Martin Slough **January 2019**



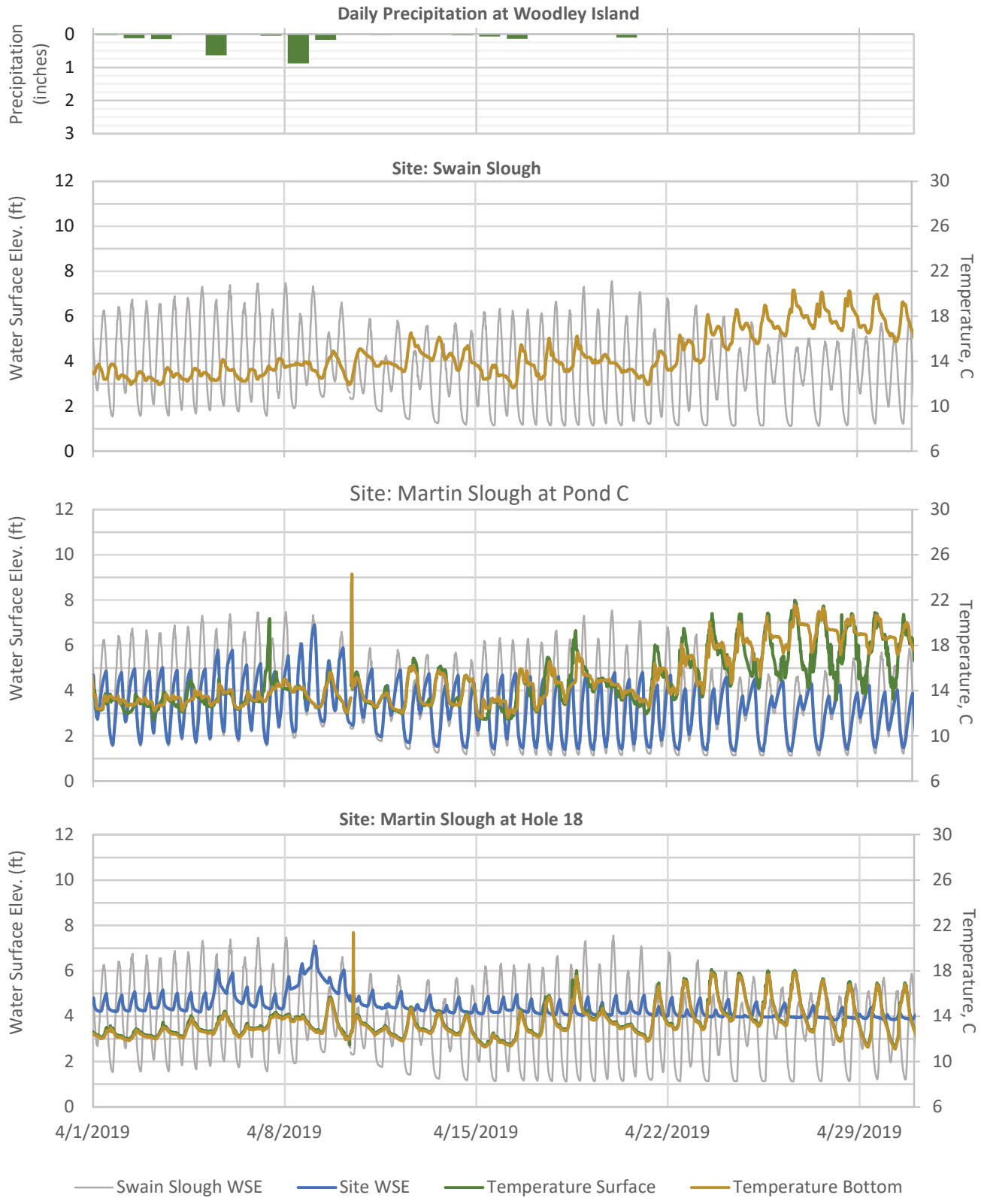
Martin Slough **February 2019**



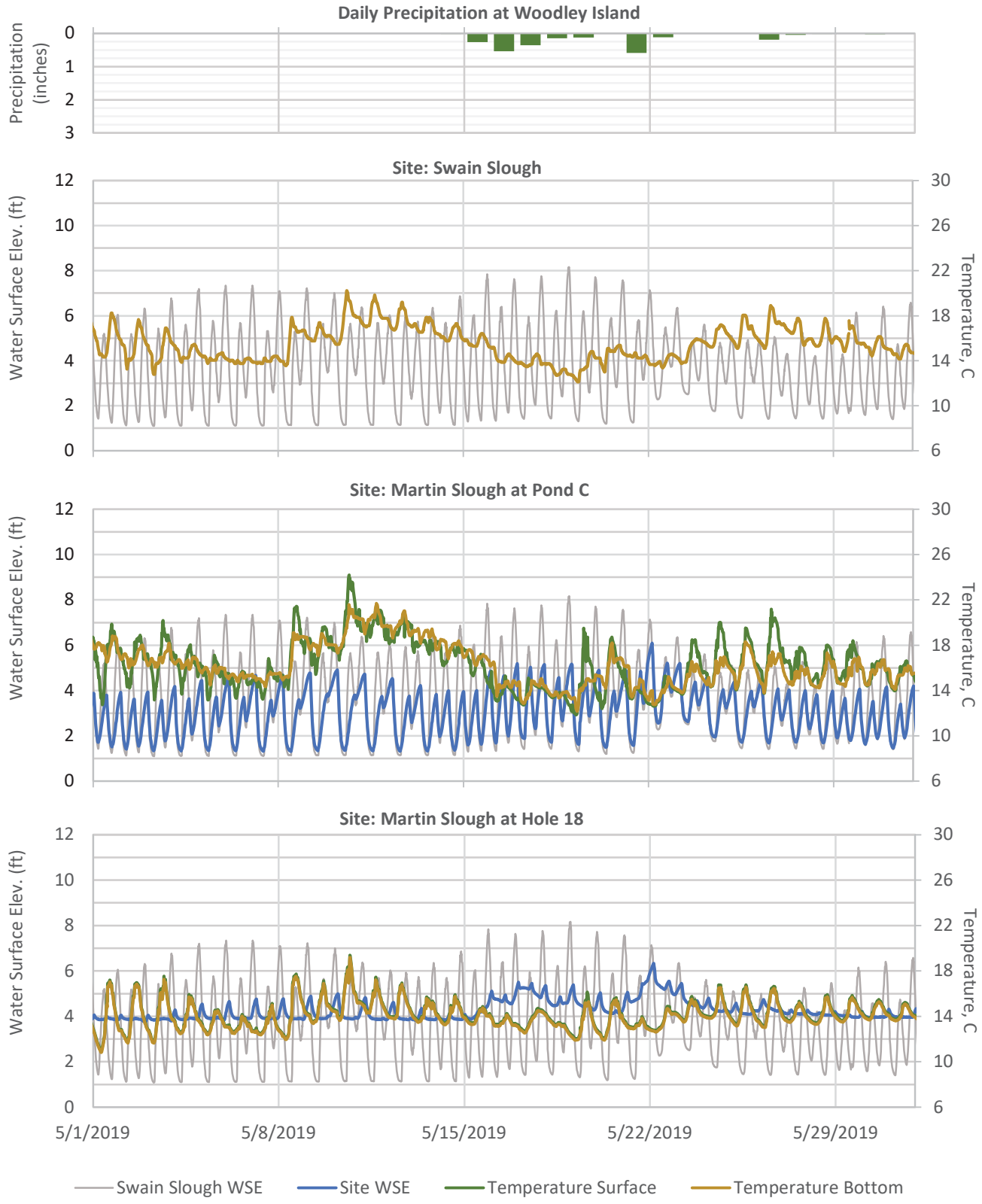
Martin Slough **March 2019**



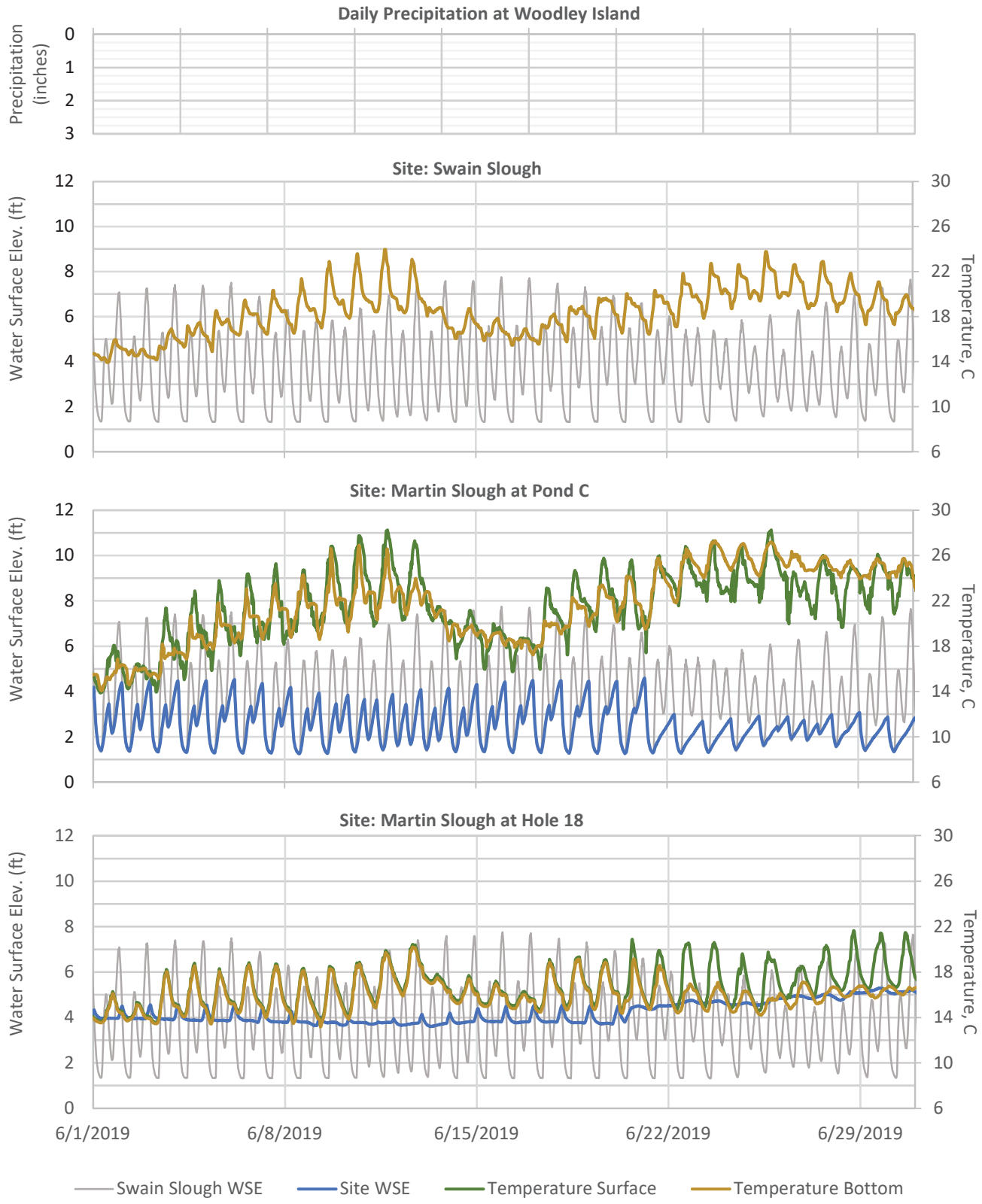
Martin Slough **April 2019**



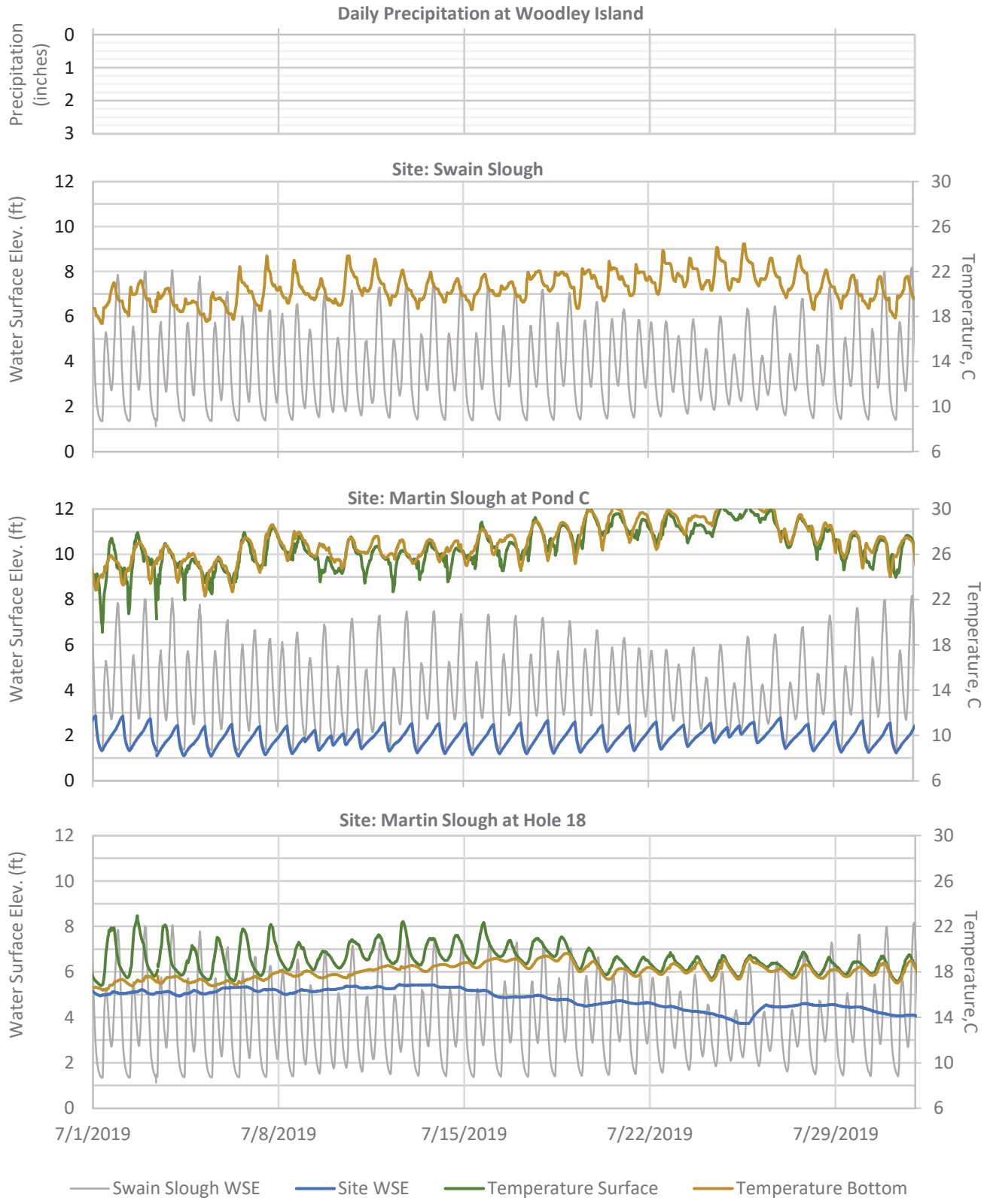
Martin Slough **May 2019**



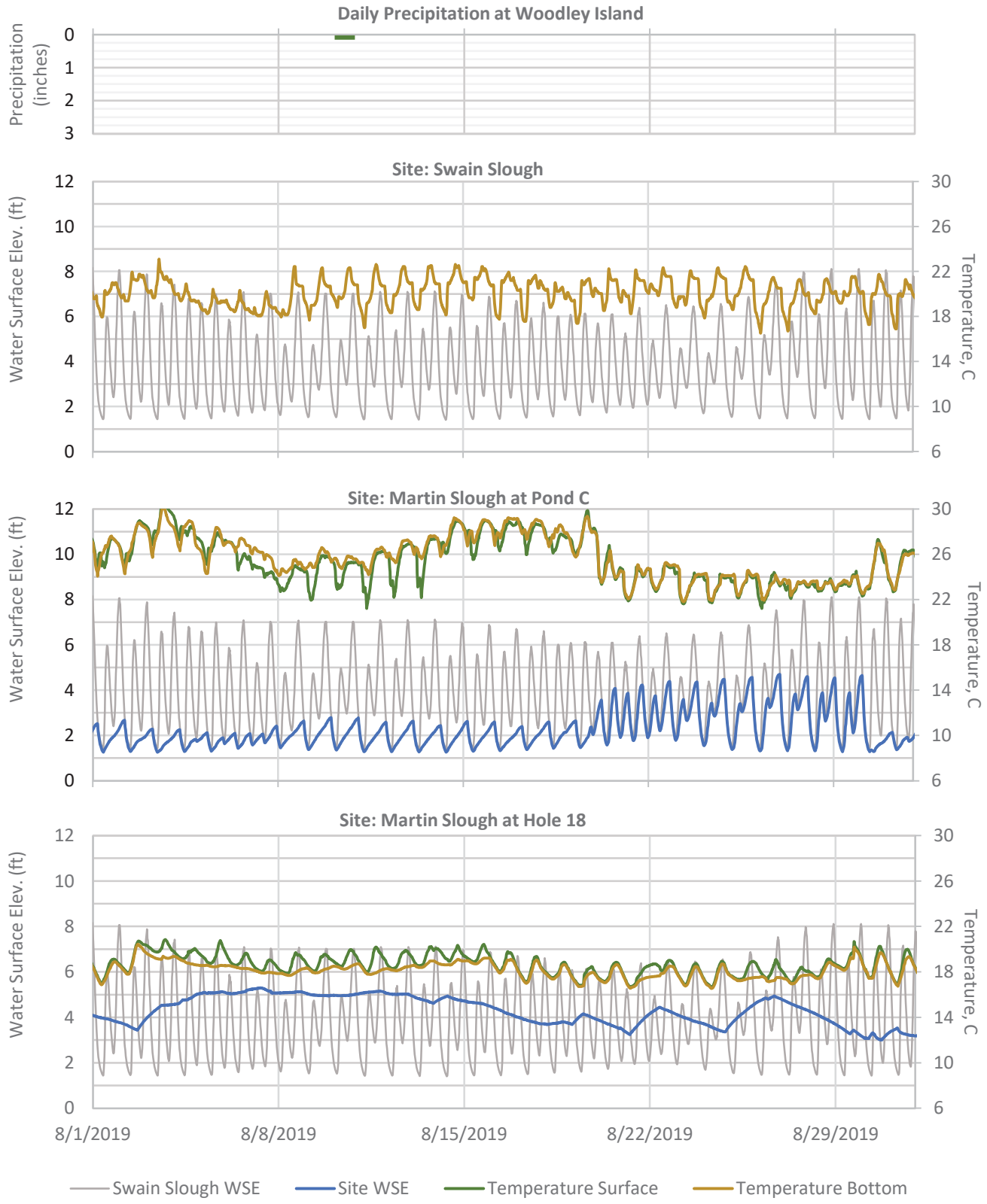
Martin Slough **June 2019**



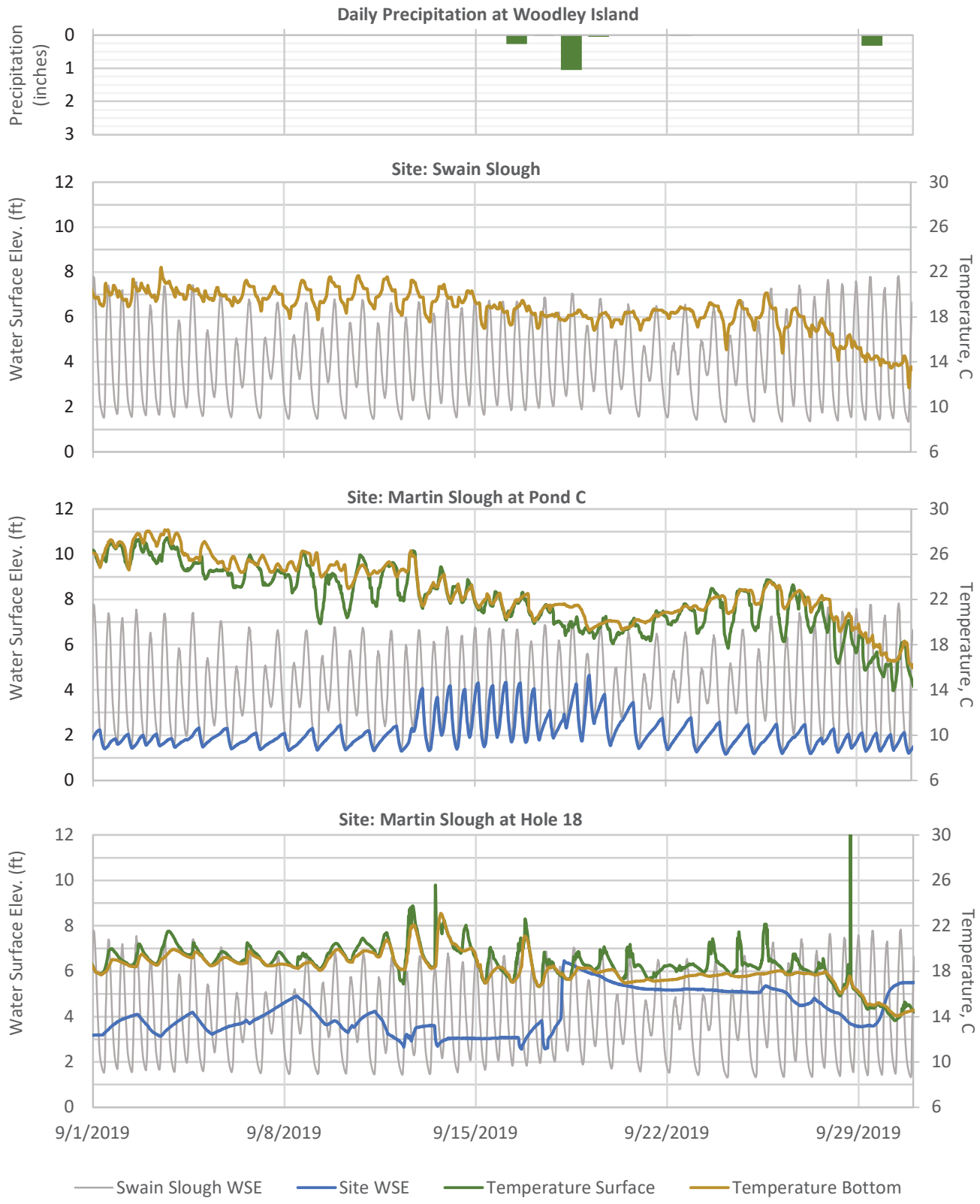
Martin Slough **July 2019**



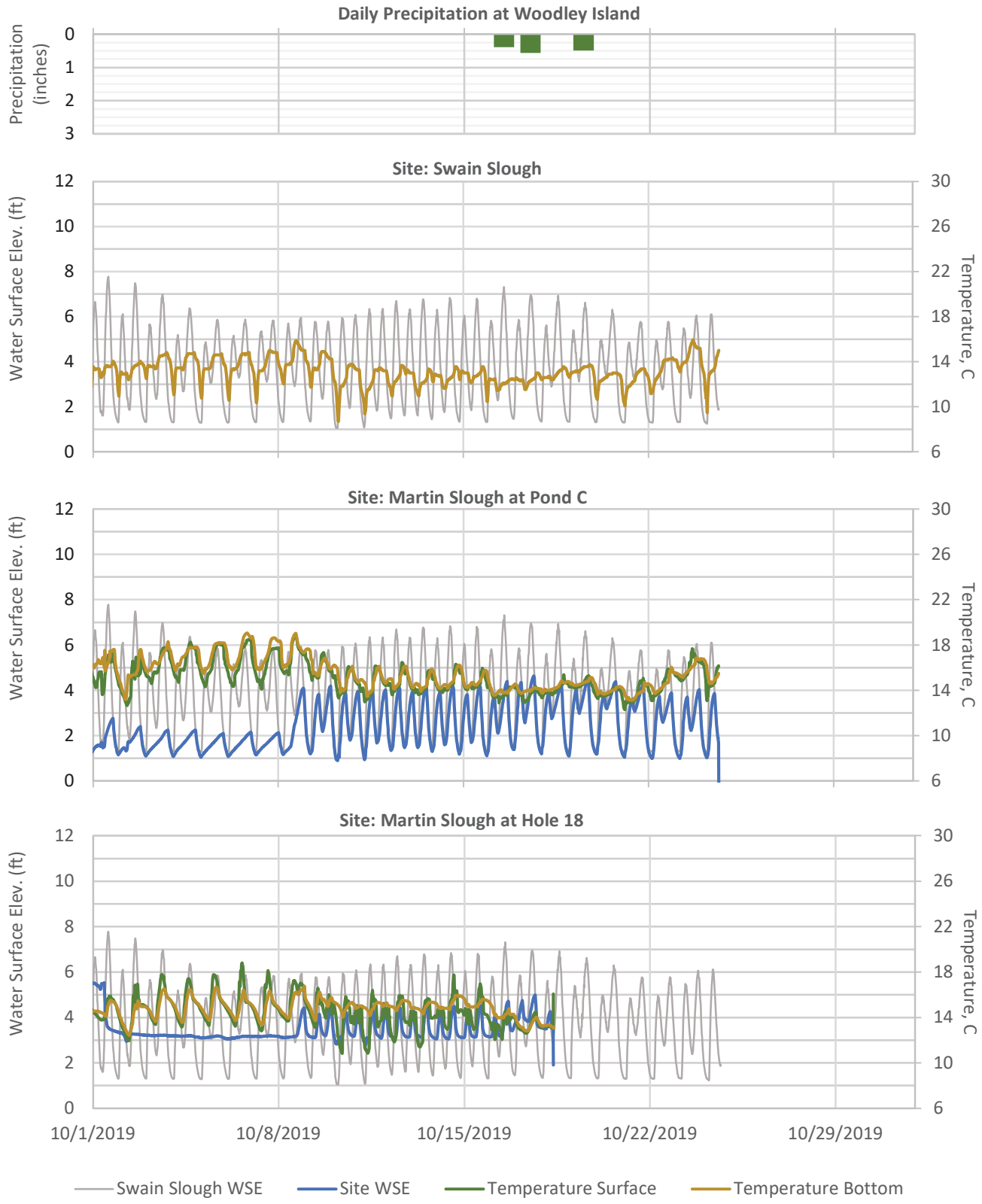
Martin Slough **August 2019**



Martin Slough **September 2019**



Martin Slough **October 2019**



Martin Slough Water Quality Spot Measurements

Martin Slough Channel Enhancement

Discrete Measurements of Water Surface Elevations (WSE) and Water Quality Parameters

Date: January 16, 2019			Period: Post Project						
		WSE	Surface			Bottom			
Gage Location	Time (PST)	NAVD88 (ft)	D.O. (mg/L)	Salinity (ppt)	Temp (°C)	D.O. (mg/L)	Salinity (ppt)	Temp (°C)	Tide at Gage
Swain Slough	12:45 PM	3.05	8.1	19.5	10.8	7.6	19.8	10.8	Ebb
MS POND C	1:11 PM	2.86	8.0	4.0	10.0	8.2	13.3	10.2	Ebb
MS-18	12:15 PM	4.51	6.8	0.1	9.5	6.3	0.1	9.5	Ebb

Date: February 13, 2019			Period: Post Project						
		WSE	Surface			Bottom			
Gage Location	Time (PST)	NAVD88 (ft)	D.O. (mg/L)	Salinity (ppt)	Temp (°C)	D.O. (mg/L)	Salinity (ppt)	Temp (°C)	Tide at Gage
Swain Slough	1:00 PM	2.75	8.3	0.6	9.8	9.5	0.9	9.6	Ebb
MS POND C	1:45 PM	2.92	10.5	0.1	9.5	9.4	0.1	9.5	Ebb
MS-18	12:15 PM	5.25	11.9	0.1	8.9	9.3	0.1	8.9	

Date: April 10, 2019			Period: Post Project						
		WSE	Surface			Bottom			
Gage Location	Time (PST)	NAVD88 (ft)	D.O. (mg/L)	Salinity (ppt)	Temp (°C)	D.O. (mg/L)	Salinity (ppt)	Temp (°C)	Tide at Gage
Swain Slough	9:45 AM	2.60	9.5	0.1	11.5	10.5	0.1	11.5	Ebb
MS POND C	10:30 AM	2.54	9.5	0.1	12.7	8.4	0.1	12.7	
MS-18	8:45 AM	4.76	7.1	0.1	11.5	6.9	0.1	11.5	

Date: July 3, 2019			Period: Post Project						
		WSE	Surface			Bottom			
Gage Location	Time (PST)	NAVD88 (ft)	D.O. (mg/L)	Salinity (ppt)	Temp (°C)	D.O. (mg/L)	Salinity (ppt)	Temp (°C)	Tide at Gage
Swain Slough	10:00 AM	1.37				8.3	29.2	19.9	
MS POND C	10:45 AM	1.16	6.7	18.0	22.8	5.5	14.8	22.3	
MS-18	11:30 AM	5.09	5.7	0.1	17.0	4.0	0.1	16.3	

Date: October 24, 2019			Period: Post Project						
		WSE	Surface			Bottom			
Gage Location	Time (PST)	NAVD88 (ft)	D.O. (mg/L)	Salinity (ppt)	Temp (°C)	D.O. (mg/L)	Salinity (ppt)	Temp (°C)	Tide at Gage
Swain Slough	3:15 PM	2.30	6.0	20.0	15.2	6.0	12.7	14.4	
MS POND C	4:45 PM	1.78	7.3	16.0	14.7	10.5	26.4	14.1	

Martin Slough Calculated Tidal Datums

Martin Slough Tidal Datums

Gage: Swain Slough

Year	Month	MLLW	MLW	MW	MHW	MHHW	MTL	DIURNAL RANGE	MINIMUM STAGE	MAXIMUM STAGE
2018	10	1.14	1.74	3.90	6.43	6.85	4.03	5.71	0.98	7.62
2018	11	1.16	1.76	3.85	6.36	6.91	3.99	5.75	0.99	8.32
2018	12	1.37	1.94	3.93	6.35	7.14	4.07	5.77	1.01	8.76
2019	1	1.88	2.49	4.41	6.72	7.53	4.54	5.64	1.03	9.09
2019	2	2.43	3.09	4.76	6.87	7.42	4.91	4.98	1.33	8.72
2019	3	1.78	2.26	4.16	6.51	6.97	4.31	5.19	1.40	8.14
2019	4	1.39	1.79	3.67	5.99	6.31	3.82	4.92	1.13	7.56
2019	5	1.32	1.79	3.70	6.02	6.55	3.83	5.23	1.10	8.16
2019	6	1.39	1.88	3.71	6.06	6.74	3.88	5.35	1.32	7.75
2019	7	1.49	1.99	3.84	6.23	7.02	4.02	5.54	1.13	8.17
2019	8	1.55	2.00	3.93	6.34	6.98	4.09	5.43	1.41	8.11
2019	9	1.53	1.94	3.99	6.49	6.94	4.14	5.41	1.32	7.84
2019	10	1.32	1.90	3.76	6.07	6.34	3.91	5.02	1.05	7.78
	Yearly	1.51	2.04	3.97	6.34	6.90	4.12	5.39	0.98	9.09
	July to Oct	1.47	1.96	3.88	6.28	6.82	4.04	5.35	1.23	7.97

Martin Slough Tidal Datums

Gage: MS-Pond C

Year	Month	MLLW	MLW	MW	MHW	MHHW	MTL	DIURNAL RANGE	MINIMUM STAGE	MAXIMUM STAGE
2018	12	1.80	2.22	3.64	5.26	5.50	3.70	3.70	1.42	6.53
2019	1	2.06	2.63	3.99	5.41	5.65	4.01	3.59	1.38	7.92
2019	2	2.51	2.93	4.41	5.87	6.19	4.40	3.67	1.44	7.78
2019	3	1.83	2.35	3.69	5.20	5.37	3.75	3.54	1.43	7.22
2019	4	1.59	1.90	3.23	4.70	4.84	3.28	3.25	1.33	6.92
2019	5	1.59	1.92	3.02	4.29	4.53	3.08	2.93	1.31	6.09
2019	6	1.38	1.57	2.51	3.63	3.80	2.57	2.42	1.25	4.59
2019	7	1.28	1.34	1.88	2.50	2.53	1.91	1.25	1.08	2.87
2019	8	1.37	1.52	2.24	3.21	3.20	2.33	1.82	1.26	4.70
2019	9	1.39	1.50	2.08	2.82	2.82	2.13	1.43	1.15	4.66
2019	10	1.12	1.48	2.39	3.69	3.64	2.52	2.51	-0.28	4.64
	Yearly	1.62	2.00	2.98	4.33	4.29	3.10	2.67	-0.28	7.92
	July to Oct	1.29	1.46	2.15	3.06	3.04	2.22	1.75	0.80	4.22

Martin Slough Tidal Datums

Gage: MS-18

Year	Month	MLLW	MLW	MW	MHW	MHHW	MTL	DIURNAL RANGE	MINIMUM STAGE	MAXIMUM STAGE
2018	7	4.64	4.44	4.84	4.96	4.93	4.75	0.29	3.88	5.76
2018	8	4.16	4.20	4.38	4.48	4.49	4.35	0.33	3.83	5.02
2018	9	4.08	4.11	4.31	4.38	4.41	4.27	0.33	3.74	5.41
2018	10	4.79	4.78	4.82	4.84	5.05	4.82	0.26	4.03	5.47
2018	11	3.95	3.95	4.00	4.05	4.05	4.00	0.11	3.89	4.91
2018	12	--	--	--	--	--	--	--	--	--
2019	1	4.22	4.51	5.04	5.68	5.58	5.08	1.36	3.87	7.86
2019	2	4.64	4.89	5.40	5.85	6.10	5.38	1.46	3.78	8.14
2019	3	4.30	4.46	4.78	5.34	5.48	4.86	1.19	4.06	7.44
2019	4	4.08	4.16	4.42	4.85	4.97	4.48	0.89	3.83	7.09
2019	5	3.95	4.08	4.26	4.50	4.72	4.28	0.78	3.75	6.33
2019	6	4.10	4.02	4.22	4.40	4.53	4.21	0.43	3.61	5.30
2019	7	4.80	4.90	4.83	4.97	5.01	4.90	0.22	3.72	5.45
2019	8	4.09	4.24	4.31	4.61	4.64	4.39	0.55	3.00	5.30
2019	9	3.38	3.63	4.20	4.19	4.36	4.01	0.98	2.55	6.47
2019	10	2.99	3.11	3.48	4.15	4.19	3.58	1.20	1.91	5.54
	Average	4.14	4.25	4.50	4.83	4.89	4.53	0.75	1.91	8.14
2018	**Average of July to Oct**	4.42	4.38	4.59	4.67	4.72	4.55	0.30	3.87	5.42
2019	**Average of July to Oct**	3.81	4.38	4.59	4.67	4.72	4.55	0.30	3.87	5.42