Cambria Community Services District
Water Reclamation Facility
Adaptive Management Plan
Annual Report
2021

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January 31, 2022

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1.0 INTRODUCTION

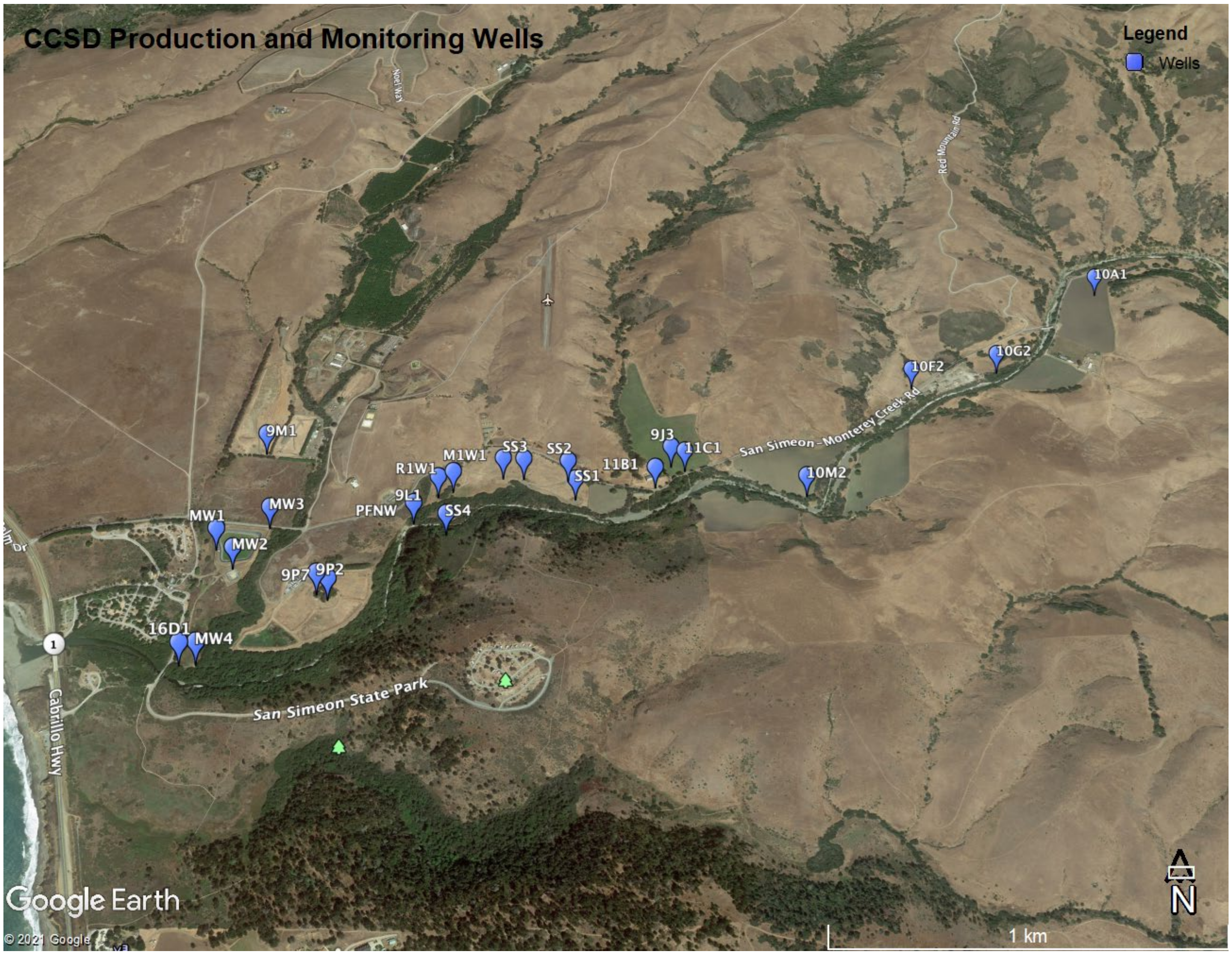
This annual report is per requirements contained within the Cambria Sustainable Water Facility Project (SWF), now called the Water Reclamation Facility (WRF), Adaptive Management Plan (AMP) for the Cambria Community Services District (CCSD, Michael Baker International 2017). The AMP requires annual reporting of completed surveys to analyze potential impacts to sensitive biological resources from the operation of the WRF. The WRF is currently not in operation. Therefore data collected for this annual report will form baseline conditions for possible future WRF operations. The annual report covers the period from January 2021 to December 2021.

AMP monitoring requires hydrological and biological monitoring, including California Rapid Assessment Method (CRAM) surveys, special status species surveys, and instream and riparian habitat monitoring. This report provides the methods, results, and discussion of the AMP monitoring per AMP requirements and the results of a hydrological modeling effort that provided information to update AMP thresholds, monitoring measures, and performance standards. The WRF has not been in operation, so the AMP water budget for the WRF is not discussed in this monitoring report.

2.0 METHODS

2.1 Groundwater Monitoring

CCSD employees take well readings either bimonthly or monthly from: 16D1, MW4, MW1, MW2, MW3, 9M1, 9P2, 9P7, 9L1, RIW1, SS4, MIW, SS3, SS2, SS1, 11B1, 11C1, PFNW, 10A1, 10G2, 10G1, 10F2, 10M2, 9J3, and the lagoon (Figure 1).



SS1, SS2, and SS3 are CCSD production wells and 16D1, MW4, MW1, MW2, MW3, SS4, M1W1, 11B1, 11C1, 10A1, 10G2, 10G1, 10F are monitoring wells. 9P2 and 9P7 are currently monitoring wells but can provide gradient controls. 9L1 was an irrigation well but is currently a monitoring well. R1W1 and 10M2 were built for the WRF and are currently monitoring wells. Additional monitoring wells include SS4 and Lagoon, both located on State Park's property, and 9M1 which is located on private property. PFNW (Palmer Flats New Well) is a USGS monitoring well, and 9J3 is a domestic use well. In April of 2021, CCSD installed four piezometers (SWMFW 1, SWMFW2, SWMFW3, SWFMW4) between well 9P7 and 16D1 for a proposed hydrological pump test.

2.2 Groundwater Quality Monitoring

Semiannually, CCSD performs water quality analysis at wells SS3, SS4, 9P7, 16Dl, and 9N2 for nitrate/nitrogen, total dissolved solids, sodium, chloride, sulfate, boron, and pH. Additional water quality monitoring is required for WRF mitigation water per the Regional Water Quality Control Board's Permit for low threat discharges. Due to the non-operation of the WRF, no analysis has been performed. Once the WRF is in operation, this water quality data will be included in future reports.

2.3 Biological Monitoring

CRAM Surveys

The California Rapid Assessment Method was completed at Van Gordon Creek and San Simeon Creek. CRAM surveys evaluate wetland conditions based on landscape setting, hydrology, physical structure, and biological structure. CRAM surveys were completed on San Simeon Creek in 2005, 2007, 2015, and 2020. Each annual survey was compared with previous surveys to evaluate habitat conditions.

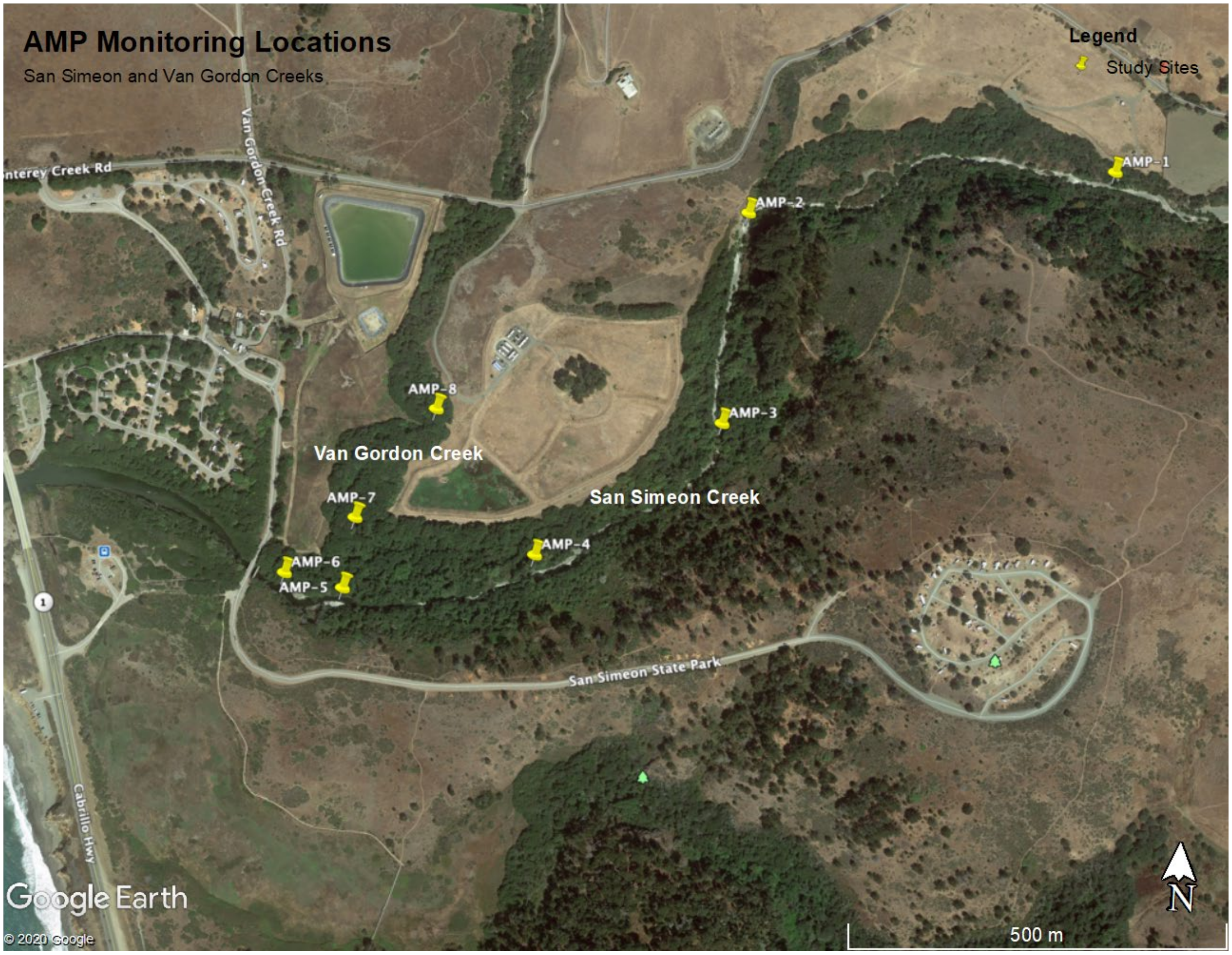
Special Status Species Surveys

Per AMP guidelines, non-protocol level, visual surveys for California red-legged frogs (*Rana draytonii*), tidewater gobies (*Eucyclogobius newberryi*), and south-central California coast steelhead Distinct Population Segment (DPS) were completed. Species surveys for this report were for baseline species data and include a discussion of the species distribution and habitat requirements.

California red-legged frog surveys followed the protocol contained in the “Revised Guidance on Site Assessments and Field Surveys for the California Red-legged Frog” (USFWS, 2005b). Prior to the fieldwork, a review of documents concerning the project site study area and the surrounding areas, including a search of the California Natural Diversity Database was completed. The daytime survey consisted of walking around the project site study area to characterize the habitat, assess site conditions, and prepare for the nighttime survey. The night survey consisted of walking upstream, using 400-800 lumen adjustable flashlights and 8 X 40 binoculars while scanning for eyeshine and identifying all amphibians observed. Approximately 0.60 acres were surveyed for each survey day.

Instream and Riparian Habitat Monitoring

Per methods described in the AMP, biological surveys were conducted at 7 survey sites twice a month to collect habitat, hydrological, water quality, and species information (Figure 2).



As identified in the AMP, survey sites are located on San Simeon Creek and Van Gordon Creek within CCSD property. The survey sites are described below by survey site number, creek, access description, site description, and GPS coordinates.

Survey Site Number	Creek	Access Description	Site Description	GPS Coordinates
Site 1	San Simeon	Well field	Trail by SS-1	35°36'0.23"N 121° 6'33.42"W
Site 2	San Simeon	Trail behind MW-4 behind Van Gordon Reservoir	Below rock pool, approx. 0.4 miles upstream of Van Gordon confluence	35°35'57.55"N 121° 6'53.39"W
Site 3	San Simeon	Trail behind MW-4 behind Van Gordon Reservoir	Draw a line from 9P7 along road to the creek	35°35'48.09"N 121° 6'54.29"W

Site 4	San Simeon	Trail behind MW-4 behind Van Gordon Reservoir	Low flow channel in summer	35°35'41.88"N 121° 7'4.04"W
Site 5	San Simeon	Trail behind MW-4 behind Van Gordon Reservoir	Upstream of Van Gordon confluence	35°35'40.00"N 121° 7'14.25"W
Site 6	San Simeon	No Access on State Parks property	Downstream of Van Gordon confluence	
Site 7	Van Gordon	Trail behind MW-4 behind Van Gordon Reservoir	Upstream from trail before debris jam	35°35'43.10"N 121° 7'13.85"W
Site 8	Van Gordon	Inside locked gate of the AWTP	Down trail through riparian	35°35'48.06"N 35°35'48.06"N

Survey Conditions

Survey condition data includes survey times, weather, time, and stage of high and low tides, if the sandbar is breached, and water levels for the San Simeon Creek County of San Luis Obispo Sensor 718, that records stage data near the well field.

Habitat

At each survey site, instream habitat data was collected for stream type (run, riffle, pool), instream cover type (large woody debris, small woody debris, bedrock, rootwad), substrate type (cobble, gravel, silt), percentage of substrate embeddedness, and estimated percentage of algae on the surface and the subsurface.

Vegetation

At each survey site, vegetation was measured with percentage estimates of instream and overhead cover and soil moisture levels within riparian forests on both banks were taken with a General soil moisture meter. For both stream banks, riparian widths were measured with aerial photographs and verified during site surveys.

Hydrology

At each survey site, maximum wetted width and depth were measured with a stadia rod, and average depth was calculated from 4 depth readings across the wetted width. Stream water rate was measured with a Global Water Flow Probe. Flow is a calculation of the wetted area times the rate. The area is determined by averaging four depth measurements times the wetted width.

Surface Water Quality

At each survey site, water quality was assessed using a YSI ProSolo ODO/CT optical meter to measure temperature in Fahrenheit, dissolved oxygen in parts per million (ppm), total dissolved solids in milligrams per liter (mg/L), and salinity in parts per trillion (ppt).

9P7 Soil Moisture

9P7 soil moisture was measured using a General soil moisture meter at cardinal points N, S, E, W of the 9P7 concrete pad. A photo of 9P7 and the surrounding trees were taken.

Species

Species observed during data collection were documented at each survey site. Types and abundance of non-native species were documented.

Photo Points

At each survey site, photos were taken with an iPhone 11 Pro Max using the 0.5 lens. The photos were taken from the center of the stream in four directions: upstream, right bank, downstream, left bank. Aerial photographs were taken with a Mavic 2 Pro using Litchi Waypoint to GPS points. These photos were used to determine any changes in vegetation composition or health. There were two additional video and still photo locations for stream flow analysis: PS-1, the San Simeon Creek bridge on Van Gordon Creek Road and PS-2, the San Simeon Creek bridge on Highway 1.

3.0 RESULTS

3.1 Groundwater Monitoring

CCSD production well data is presented below for average depth (in feet) for 2020. Well levels will be used for baseline data (Figure 3).

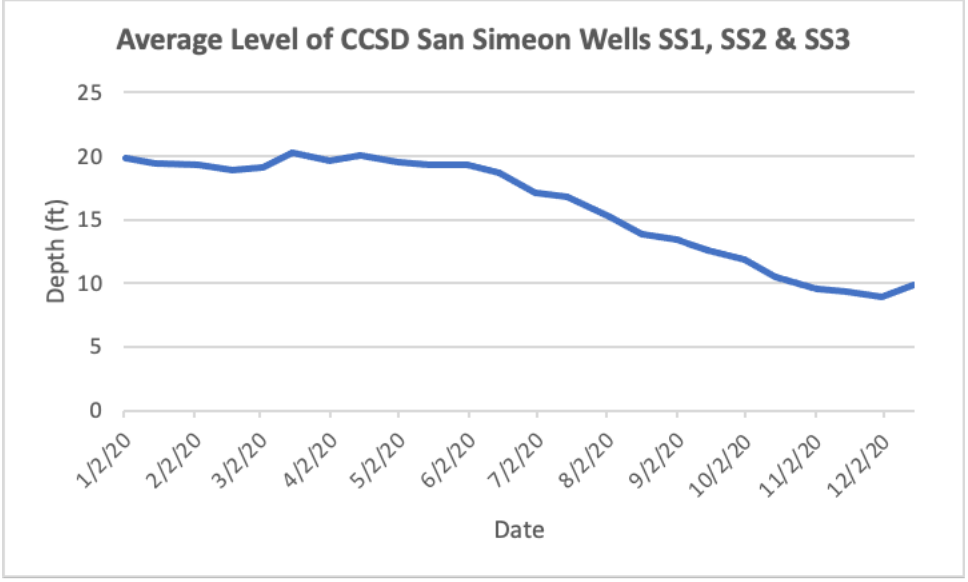


Figure 3. Graph showing average depth levels of wells SS1, SS2, and SS3.

3.2 CRAM Surveys

A Van Gordon Creek CRAM survey was completed on July 31, 2021. Van Gordon Creek is a riverine non-confined system that had an Index Score of 68. A 2015 CRAM survey on Van

Gordon Creek had an Index Score of 66 and our 2020 CRAM survey had an Index Score of 69. A comparison of the three CRAM surveys shows minor variations in the scoring of the attributes which contributed to the different scores. There do not appear to be any significant changes on Van Gordon Creek between the 2015 to 2021 surveys.

A San Simeon Creek CRAM survey was completed, approximately one mile upstream from the creek mouth, on August 1, 2021. San Simeon Creek is a riverine non-confined system which had an Index Score of 74. A 2015 CRAM survey on lower San Simeon Creek had an Index Score of 81 and our 2020 CRAM survey had an Index Score of 78. A comparison of the three CRAM surveys shows a slight decrease in structural patch richness and number of co-dominant species from 2015 to 2021 even though these variations are minor they could be due to an increase in invasive plant species.

3.3 Special Status Species Surveys

Non-protocol level visual surveys for California red-legged frogs, tidewater gobies, and steelhead trout were completed. The California red-legged frog surveys were completed under Cindy Cleveland's U.S. Fish and Wildlife California red-legged frog 10(a)(1)(a) Recovery Permit TE71222B-1 that expires on 08.03.2025. All three species were observed during the surveys.

The study area is located at 35°35'44"N/121°07'27"W, with agricultural uses to the north, San Simeon State Park to the south and west, and onsite CCSD percolations ponds and wells on the northeast and east. Beyond San Simeon State Park and CCSD properties are rolling hills that support livestock, agricultural crops, and native habitats. San Simeon Creek is mostly unconsolidated alluvium underlain by bedrock (USGS 1998). The banks of San Simeon Creek are lined with Central Coast Arroyo Willow Riparian Forest dominated by dense stands of arroyo willow. San Simeon Creek is approximately 35 square miles with two main forks, the north fork, and the south fork.

California Red-Legged Frog

Federally listed California red-legged frogs are the largest native frog in the western United States (USFSW 2010). Historically, California red-legged frogs occurred in California and Baja California from sea level to approximately 5,000 feet (USFWS 2010). The lower abdomen and underside of the hind legs are usually red or pink in color, and they have prominent dorsal folds (USFWS 2000).

Over their range, breeding for the California red-legged frog takes place from late November to late April, however, timing can vary depending on rainfall as it influences breeding behaviors (USFWS 2000, Ford et al. 2013). Males usually show up at breeding pools two to four weeks ahead of females and commence vocalizations (USFWS 2010). Egg masses are laid in areas in areas of still water among emergent vegetation, twigs, or other structures (USFWS 2010, Ford et al. 2013). Eggs hatch in 6-14 days and tadpoles metamorphose in 3.5-7 months (USFWS 2010). Juveniles usually move to shallow portions of the breeding area or nearby areas with water (Ford et al. 2013). Adult California red-legged frogs may disperse from breeding sites at any time of the year and some move to dry season refuges after breeding (USFWS 2010, Ford et al. 2013).

California red-legged frogs occur in both aquatic and terrestrial habitats within 1 to 2 miles of breeding sites. Habitat for the California red-legged frog includes still or slow-moving water in ponds, reservoirs, marshes, streams, and other permanent bodies of water and the surrounding upland habitats (USFWS 2000). California red-legged frogs can forage, shelter, and use cover in almost any moist and cool habitats during the summer; this includes upland habitats containing mammal burrows, logs, and manmade structures such as culverts (USFWS 2010).
California red-legged frog water quality requirements can widely vary (Ford et al. 2013). Water temperatures for egg-laying are usually less than 60.8° Fahrenheit (Cook 1997). Embryos tolerate stream water temperatures between 48 and 70° Fahrenheit (USFWS 2000). Adult frogs prefer water temperature above 60° Fahrenheit but are common at 50° Fahrenheit (Ford et al. 2013). The authors have seen high numbers of CRLFs in estuarine and streams when surface water temperatures are approaching 80° Fahrenheit, although there were likely nearby refuge areas with cooler water temperatures. California red-legged frogs are sensitive to high salinity. Salinity over 4.5 ppt has been shown to kill frog eggs and levels at 7.0 ppt cause larvae to die (USFWS 2000). The maximum salinity tolerance is 9 ppt for adults (Cook 1997). Turbidity ranges for California red-legged frogs are 0.9 NTU to 326 NTU, dissolved oxygen ranges are 0-24.5 mg/L, nitrate ranges from 0-4.0 mg/L (Ford et al. 2013). Water depth influences water temperatures and predator avoidance. California red-legged frogs need deep water areas (usually deeper than one yard) for predator avoidance.

Species Status and Distribution

California red-legged frogs are listed as federally threatened species and a California Department of Fish and Wildlife California species of special concern. The entire study area is in California red-legged frog critical habitat (USFWS 2020). According to the California Natural Diversity Database (CNDDB), there are multiple occurrences of the California red-legged frog in and around the study area (CDFW 2020a, CDFW 202b). In 1992 and 1993, federal researchers completed 26 California red-legged frog surveys in San Simeon Creek and Lagoon (Rathbun et al., 1993). They observed 379 California red-legged frogs with 125 frogs under <60 mm and 254 frogs >60 mm. During the 1992 and 1993 surveys, adult California red-legged frogs and tadpoles were also observed in Van Gordon Creek (Rathbun et al. 1993).

In 1997, Cindy Cleveland observed adult California red-legged frogs in San Simeon Lagoon. In 2014, RBF Consulting, A Michael Baker International Company, completed two mark-recapture night surveys in San Simeon Lagoon and Creek with a total of 53 observed California red-legged frogs (RBF Consulting 2015). In 2015, Cleveland Biological, LLC found 15 juvenile and adult California red-legged frogs in lower San Simeon Creek (Cleveland Biological, LLC 2015). California red-legged frogs are also known to occur in watersheds within two miles of the study area: Pico Creek (Cindy Cleveland pers. ob.), Leffingwell Creek, and Santa Rosa Creek (RBF 2015).

Survey Results

The study area is located at 35°35'44"N/121°07'27"W, with agricultural uses to the north, San Simeon State Park to the south and west, and the onsite CCSD percolations ponds and wells on the northeast and east. Beyond San Simeon State Park and CCSD property are rolling hills that support livestock, agricultural crops, and native habitats. San Simeon Creek is mostly unconsolidated alluvium underlain by bedrock (USGS 1998). The banks of San Simeon Creek are lined with Central Coast Arroyo Willow Riparian Forest dominated by dense stands of arroyo willow (*Salix lasiolepis*).

San Simeon Creek is mostly arroyo willow and red willow, with an understory of common nettle, California blackberry, mugwort, western poison oak, some American black nightshade, red osier dogwood, and abundant hemlock and non-native Cape ivy or German ivy. There is also a healthy population of Western sycamores. The survey area has good habitat quality for California red-legged frogs, with some naturally formed deep pools. The pool habitat is created from willow tree rootwads and the creek allowed to meander. There is not an abundance of emergent vegetation, however, this is not because the system is out of balance.

On February 21, 2021, June 10, 2021, and September 12, 2021, daytime and nighttime California red-legged frog surveys were performed by Cindy Cleveland and Paul Cleveland within the study area that extended from the mouth of Van Gordon Creek upstream for approximately 900 feet.

The February 21, 2021, survey was from 10:00 to 13:00 and 18:30 to 20:00. The moon phase was 30%, the air temperature was 58 degrees Fahrenheit, the water temperature was 56 degrees Fahrenheit, the humidity was 80%, and the wind was from the west at 1-2 mph. The survey conditions were clear and cool. The average depth was 1 foot, and the maximum depth was approximately 3.1 feet. The survey conditions were calm. Stream flow was 0.2 cfs, and the water was clear. Ten California red-legged frogs, all adults, were observed, and two frogs were heard jumping into the creek (Figure 4).

Figure 4. CRLF survey February 2, 2021.

The June 10, 2021, survey was from 9:00 to 13:00 and 21:00 to 23:30. The moon phase was 0%, the air temperature was 63 degrees Fahrenheit, the water temperature was 62 degrees Fahrenheit, the humidity was 70%, and the wind was from the west at 1 mph. The survey conditions were clear and cool. The average depth was 1 foot, and maximum depth was approximately 3 feet. Stream flow was 0.1 cfs, and the water was clear. The survey conditions were calm. Fourteen small adult and subadult and approximately 40 tadpole CRLFs were observed (Figure 5).

Figure 5. CRLF survey June 10, 2021

The September 12, 2021 survey was from 21:00 to 23:30. The moon phase was 41%, the air temperature was 65 degrees Fahrenheit, the water temperature was 65 degrees Fahrenheit, the humidity was 79%, and the wind was from the west at 1 mph. The survey conditions were clear and calm. The average depth was 1 foot, and maximum depth was approximately 3 feet. Stream flow was 0.1 cfs, and the water was clear. Sixteen small adult and subadult and one metamorph CRLFs were observed (Figure 6).

Figure 6. CRLF survey September 12, 2021.

Steelhead Trout and Tidewater Gobies

Steelhead trout

Steelhead trout are silvery-white on the underside with a heavily speckled body and a pink to red stripe along their sides (NOAA 2015). Adult female steelhead trout prepare a redd (or nest) in a stream and deposit eggs in 4 to 5 'nesting pockets' within a single redd. Steelhead trout are hatched in cool, fast-running streams, some stay in freshwater while others move to marine habitats (NOAA 2015). The fish that stay in freshwater are called rainbow trout; the fish that migrate to the ocean are steelhead trout. Juvenile steelhead may spend up to 7 years in freshwater before migrating to the ocean for up to 3 years before migrating back to freshwater to spawn (NOAA 2015). Young trout feed primarily on zooplankton, and adults feed on aquatic and terrestrial insects, mollusks, crustaceans, fish eggs, and other small fishes (NOAA 2015).

Optimal conditions for steelhead trout in San Simeon Creek are believed to be salinity of less than 10 parts per thousand (ppt), water temperatures below 72 degrees Fahrenheit, and dissolved oxygen of greater than 5 parts per million (ppm) (CCSD 2017). Steelhead trout can live in dissolved oxygens habitats with 1-2 ppm however, this is usually for only short periods as described in the AMP, "typically only in the morning when the temperature is low and DO is at its lowest due to overnight algal respiration. Algae conduct photosynthesis during the day when the sun is out, consuming carbon dioxide and producing high amounts of oxygen. At night the opposite trend occurs with photorespiration: algae consume and can nearly deplete oxygen while simultaneously producing high levels of carbon dioxide, thus leading to substantially lower DO levels overnight and into the early morning. Steelhead ecology is such that these temporary nightly drops in DO are tolerable because the temperature is generally cooler and metabolic rate is reduced; as water temperature increases over the course of the day, fish metabolic rates increase (generally doubling with each 10°C increase in water temperature) and they require more oxygen. It is estimated that steelhead would be able to survive for only 15-30 minutes with 1-2 ppm DO" (CCSD 2017 pg. 26).

Species Status and Distribution

Steelhead Trout is listed as a Federally threatened species under the Endangered Species Act. Steelhead trout were originally listed on January 5, 2006, and the listing was updated on April 14, 2014 (NOAA 2015). The study area is in steelhead trout critical habitat, and San Simeon Creek steelhead trout are within the south-central California coast steelhead DPS (NOAA 2015).

Titus provides a detailed history of steelhead trout in San Simeon Creek, which is summarized below (Titus et al. 2010). California Department of Fish and Game (CDFG, now Fish and Wildlife) surveyed San Simeon Creek in the 1930s and found that spawning grounds for steelhead were common except in the upper areas [upper area not defined]. The middle and lower portions of San Simeon dried up in late summer over several years, which resulted in a loss of rearing habitat. In 1932 the creek was stocked with 10,000 juvenile steelhead trout and in 1933 with 8,000 juvenile steelhead trout. During 1948 CDFG surveys, they found abundant spawning substrates and juveniles (approximately 160-250 trout/100 meters) and a bedrock barrier approximately 5.3 miles from the mouth. San Simeon Creek was planted with hatchery trout again from 1947 to1950. Surveys in the 1960-1970s showed high-quality spawning gravels but had limited steelhead trout populations. They theorize that upstream gravel mining operations and a historic mercury mine could have impacted steelhead trout populations. Surveys in the 1980-1990s found lower numbers of steelhead and noted the impacts to steelhead from upstream gravel mining and diminished creek flows.

From 1990 to 2002, scientists and volunteers rescued steelhead trout held in a pond on Van Gordon Creek for the summer (Alley 2004, CEMAR 2020). In1992 and 1993 researchers surveyed San Simeon Creek for steelhead trout and found one juvenile steelhead trout in San Simeon Lagoon and one juvenile in lower San Simeon Creek (Rathbun et al. 1993). They speculate that the low number of steelhead trout in the lagoon may have been related to dissolved oxygen levels that were below 5.0 ppm (Rathbun et al. 1993). They also observed exotic brown bullhead catfish that may have washed down from a stock pond located on an upstream side drainage. In a 2004 Alley and Associates summarized fish surveys they completed from 1994 to 2003 for San Simeon Creek and found an increase in steelhead trout population in relation to streamflows (Alley 2004).

Tidewater Goby

The tidewater goby is a small, elongate fish with large pectoral fins that rarely exceed 2 inches in length with differences in color between male and female gobies; the males are nearly transparent, and the females are darker (USFWS 2015). The tidewater goby is an endemic fish found in year-round California coastal lagoons, estuaries, and marshes (USFWS 2015). Sandbars influence tidewater goby populations by providing a barrier, and lower salinities, between marine and freshwater habitats (USFWS 2013). Artificial breaching of a sandbar limits tidewater goby habitats by increasing the salinity and decreasing ponded areas. Natural breaching of the sandbar usually occurs during the winter when tidewater goby breeding is at a low point in the lifecycle (USFWS 2013). Tidewater gobies can be flushed into marine habitats during seasonal breaching of sandbars, but may not survive for long periods in the marine environment (USFWS 2015).

They are most often found at the bottom of estuarine slow water habitats less than 6 feet in depth, but they often move upstream into freshwater streams (USFWS 2013). They have been documented in slack freshwater habitats 5 miles upstream from the San Antonio lagoon in Santa Barbara County but are mostly found in tidally influenced habitats (USFWS 2015).

Tidewater gobies prefer a sandy substrate for breeding and may have a wide tolerance for salinity, oxygenation, and temperature, especially over short periods or seasonally (USFWS 2015). Population sizes vary from a few fish to thousands of individuals. Reproduction peaks in spring but may occur year-round. Reproduction begins with a male goby digging a 10 to 20 centimeters nesting burrow in the substrate, while the female goby lays 300 to 500 eggs (USFWS 2015). The eggs, which stick to the walls of the burrow, are guarded by the males until they hatch approximately 9 to 11 days later. They have been documented in waters with salinities of 0 to 42 parts per thousand, temperatures of 46 to 77 degrees Fahrenheit, and depths of 10 to 79 inches (USFWS 2005a). Spawning water temperatures range between 48 and 77 degrees Fahrenheit and salinity ranges between 1 and 30 ppt, but gobies can live with higher salinities (USFWS 2013).

Species Status and Distribution

Tidewater gobies are listed as a Federally threatened species under the Endangered Species Act. The study area is in tidewater goby critical habitat (USFWS 2013, USFWS 2020).

Surveys completed in 1993 by a federal researcher found tidewater gobies in the San Simeon lagoon and 500 meters upstream (Rathbun et al. 1993). During the surveys, tidewater goby numbers peaked during the summer months after reproducing in the lagoon. Twelve monthly surveys found 7,962 juvenile (< 31 mm) and 3,573 adult gobies (>31 mm). In 2014, San Simeon Lagoon was seined to monitor tidewater goby populations and nine seine hauls resulted in 1,002 tidewater gobies (Alley 2015).

Survey Results

On July 5, 2021, and September 12, 2021, Cindy Cleveland and Paul Cleveland conducted steelhead trout and tidewater goby surveys were conducted within the study area located on Van Gordon Creek and San Simeon Creek. The visual surveys consisted of walking around the study area to characterize the habitat, assess site conditions, and record visually observed fish species.

The July 5, 2021, survey was from 10:00 to 13:45. The high tide of 3.20 feet was at 09:13; the sandbar was not breached. The air temperature was 65 degrees Fahrenheit at the beginning of the survey and 74 degrees Fahrenheit at the end of the survey. The skies were foggy at the beginning of the survey but quickly cleared. The water temperature was 65.5 degrees Fahrenheit at the Van Gordon and San Simeon Creek confluence. The surveyed habitats were a mix of pools and runs with mostly cobble and gravel substrates. The substrate embeddedness was on average 75%, there was no surface algae at any survey site and almost 100% subsurface algae near the Van Gordon and San Simeon Creek confluence; there was filamentous algae in between survey sites. The instream cover on average was 15%, and overhead cover on average was 15%. The maximum depth was 4.5 feet, the average depth was 1.0 feet, and the flow was 0.1 to ft/sec. Dissolved oxygen was 9.02 ppm, total dissolved solids was 349 mg/L, and salinity at the top of the water column was 0.4 ppt, and at the bottom of the water column was 0.46.

Hundreds of three-spined stickleback (*Gasterosteus aculeatus*) ranging in size from 0.75 to 2.5 inches in length were observed throughout the study area. Also observed were prickly sculpin (*Cottus asper*), approximately 2-3 inches in length. During the survey no steelhead trout were observed but were documented during monitoring surveys on April 25, 2021, when a 24-inch trout was seen in a pool above site 2; in the same location, one was observed the year before. In April, the pool was approximately 10 feet by 60 feet in size with a maximum depth of 3.5 feet, a water temperature of 57.2 degrees Fahrenheit, and 3.37 ppm dissolved oxygen. Possible steelhead trout fry were seen near Site 5 on May 9, 2021. On June 5, 2021, a dead female steelhead trout, 18 inches in length was seen on the ground next to the above-referenced pool. No tidewater gobies were observed during this survey, however, tidewater gobies have been observed within the survey area during monitoring surveys.

The September 12, 2021, survey was from 15:00 to 18:30. The high tide of 3.64 feet was at 03:14; the sandbar was not breached. The air temperature was 62 degrees Fahrenheit at the beginning of the survey and 64 degrees Fahrenheit at the end of the survey. The skies were clear during the survey. The water temperature was 65 degrees Fahrenheit at the Van Gordon and San Simeon Creek confluence. The surveyed habitats were a mix of pools and runs with mostly cobble and gravel substrates. The substrate embeddedness was on average 75%, there was 50% surface algae, almost 100% subsurface algae, and filamentous algae in between survey sites. The instream cover on average was 15%, and overhead cover on average was 15%. The maximum depth was 2.5 feet, the average depth was 1.0 feet, and the flow was 0.1 to ft/sec. Dissolved oxygen was 9.02 ppm, total dissolved solids was 349 mg/L, salinity at the top of the water column was 0.58 ppt, and at the bottom of the water column was 0.84. Observed fish include three-spined stickleback and prickly sculpin.

3.4 Instream and Riparian Habitat Monitoring

Survey Conditions

The sandbar was first breached for the January 31 survey but was closed for the February 28 survey and stayed so for the remainder of the year. This was a very short time for the sandbar to be open compared to 2020, when the sandbar was open when the surveys began in March and remained open until the middle of May.

San Simeon Creek County of San Luis Obispo Sensor 718 water level is presented in the graph below. This water level sensor is located just upstream of Site 2 (Figure 7).

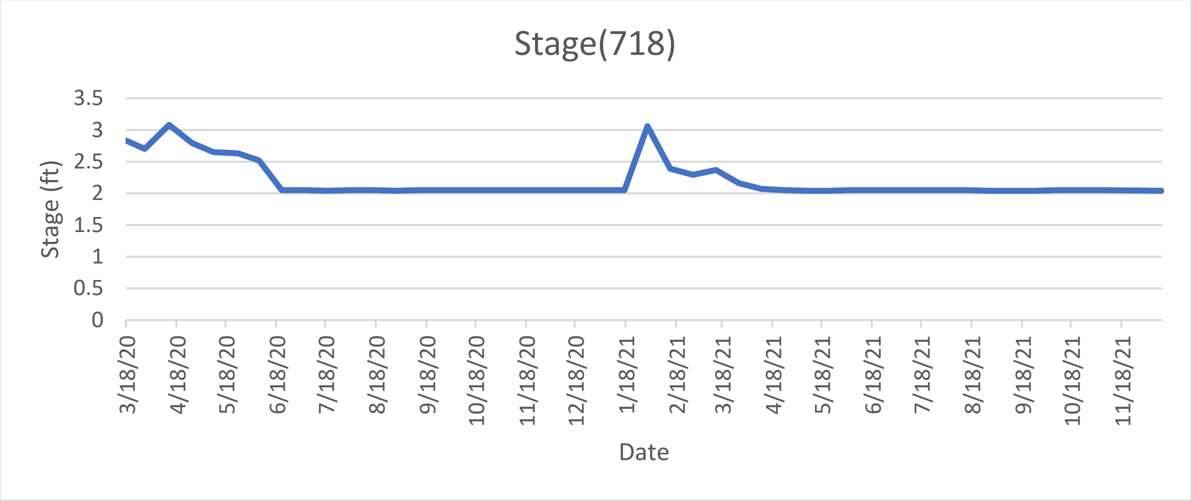


Figure 7. County of San Luis Obispo Water Sensor 718.

Habitat

For each survey site, there were minor instream habitat changes throughout the year. Below is a summary of what typically occurred at each site.

	Stream Type	Instream Cover Type	Substrate Type	Substrate Embeddedness (%)
Site 1	Pool	Small woody debris	Cobble, silt	85
Site 2	Riffle	Riparian vegetation	Cobble, gravel	25
Site 3	Pool	Large woody debris	Cobble, gravel	50 - 100
Site 4	Run	Large & small woody debris	Cobble, gravel	25 - 75
Site 5	Run	Riparian vegetation	Cobble, silt	50 - 90
Site 7	Riffle	None	Gravel, silt	75
Site 8	Run	None	Cobble, gravel	75

Surface and Subsurface Algae

Surface and subsurface algae percentages for each survey site are also presented. Surface algae appears correlated with daylight hours and low flows. Subsurface algae follows a similar correlation but is more persistent in the winter months (Figures 8 and 9).

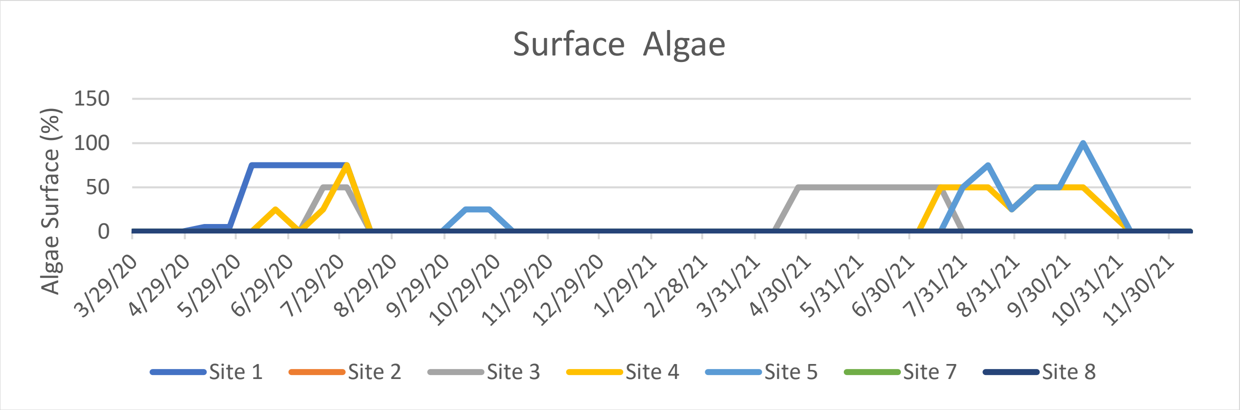


Figure 8. Surface algae.

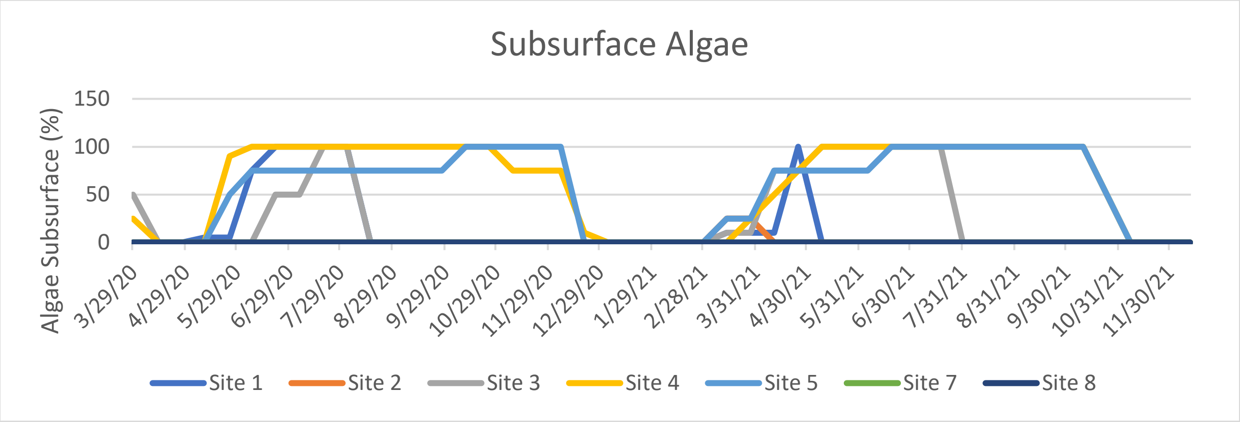


Figure 9. Subsurface algae.

Vegetation

The graphs below present data on instream and overhead cover, riparian width, and riparian moisture (Figures 10 through 13). Instream and overhead cover and riparian width did not change during the year. Riparian moisture changed often – sometimes the change was due to weather, but the readings would also vary if measurements were taken within inches of each other; the usefulness of this data is in question. Aerial photos of riparian vegetation were analyzed with no observed significant changes.

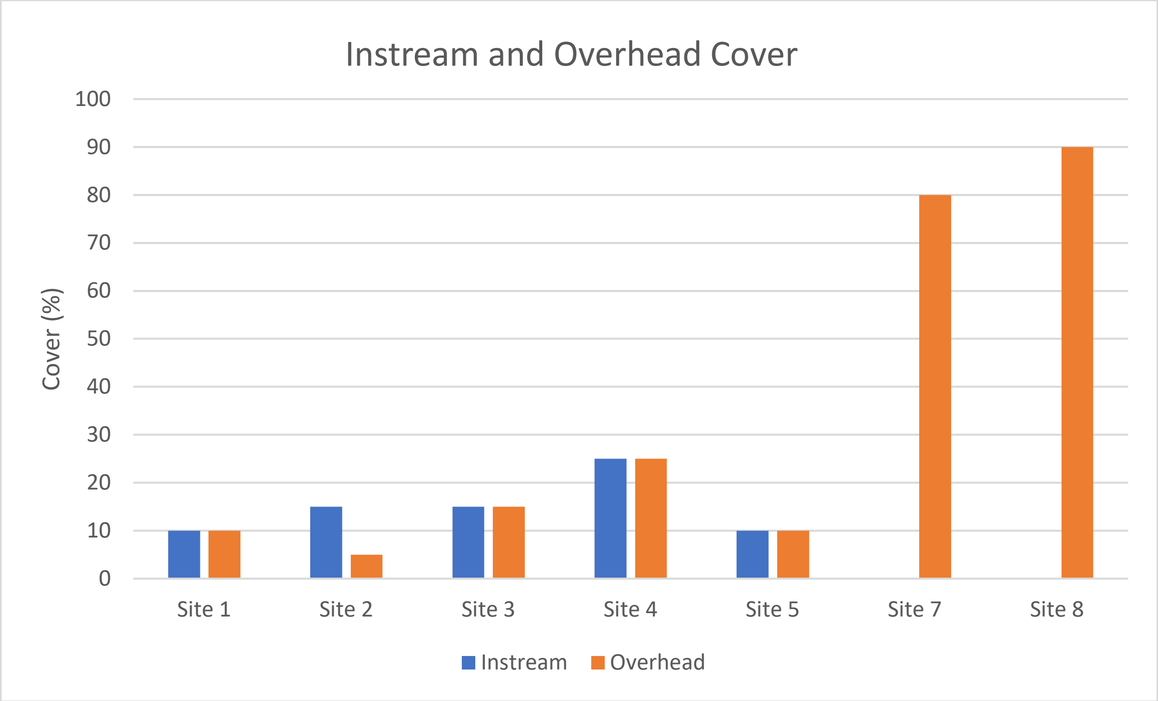


Figure 10. Instream and overhead cover

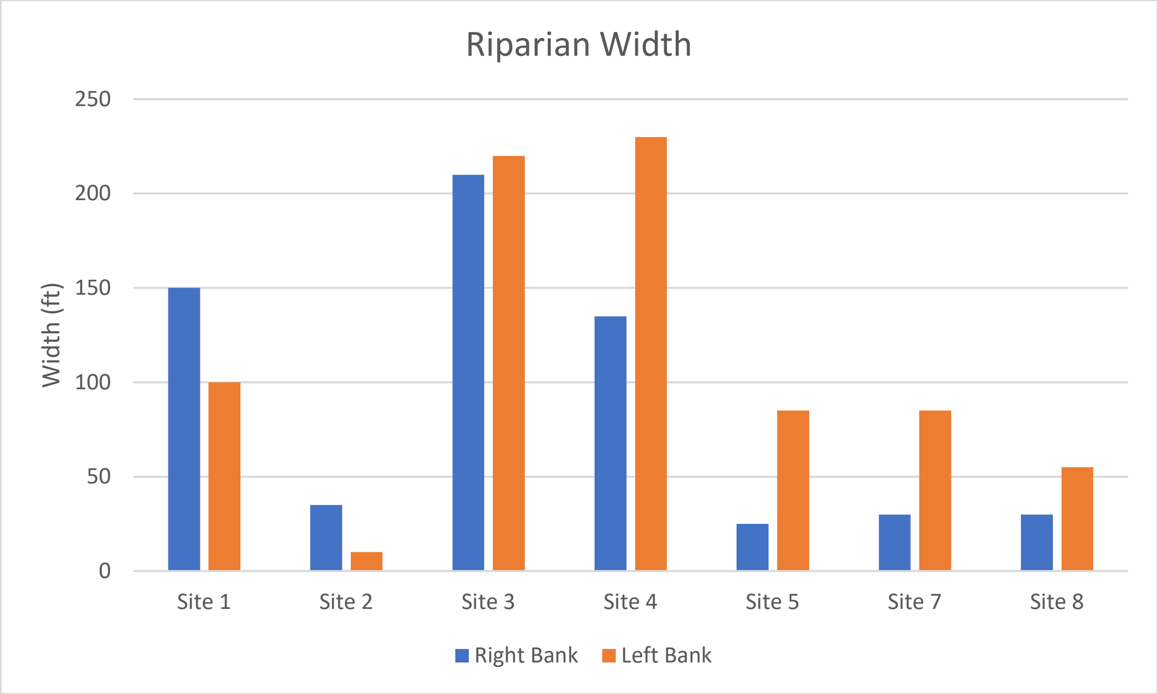


Figure 11. Riparian width.

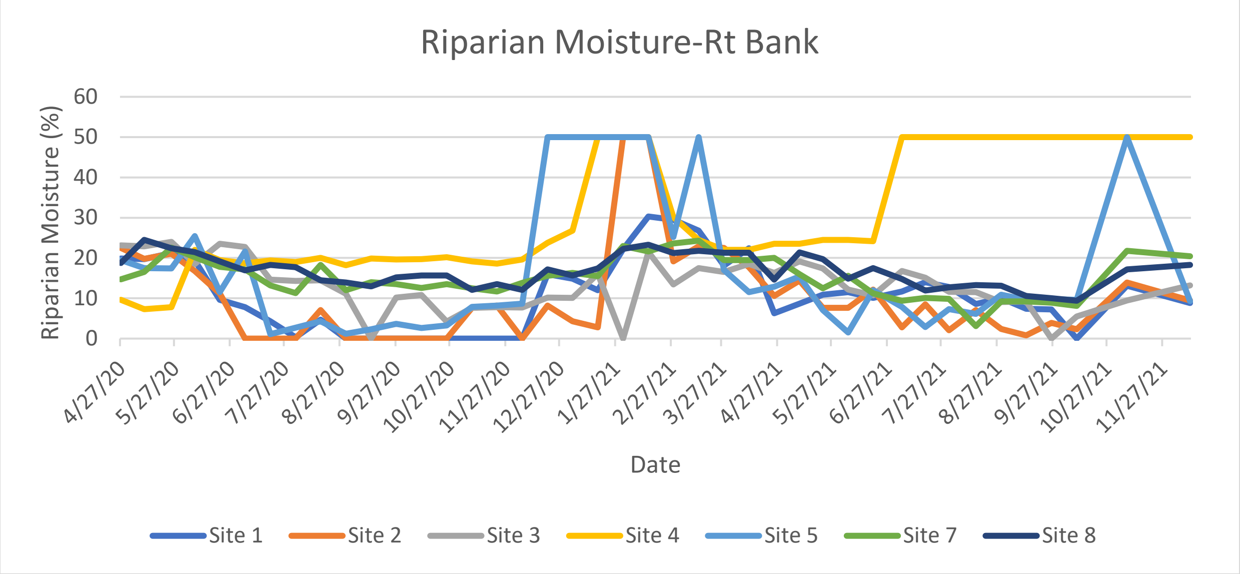


Figure 12. Riparian moisture on the right bank.

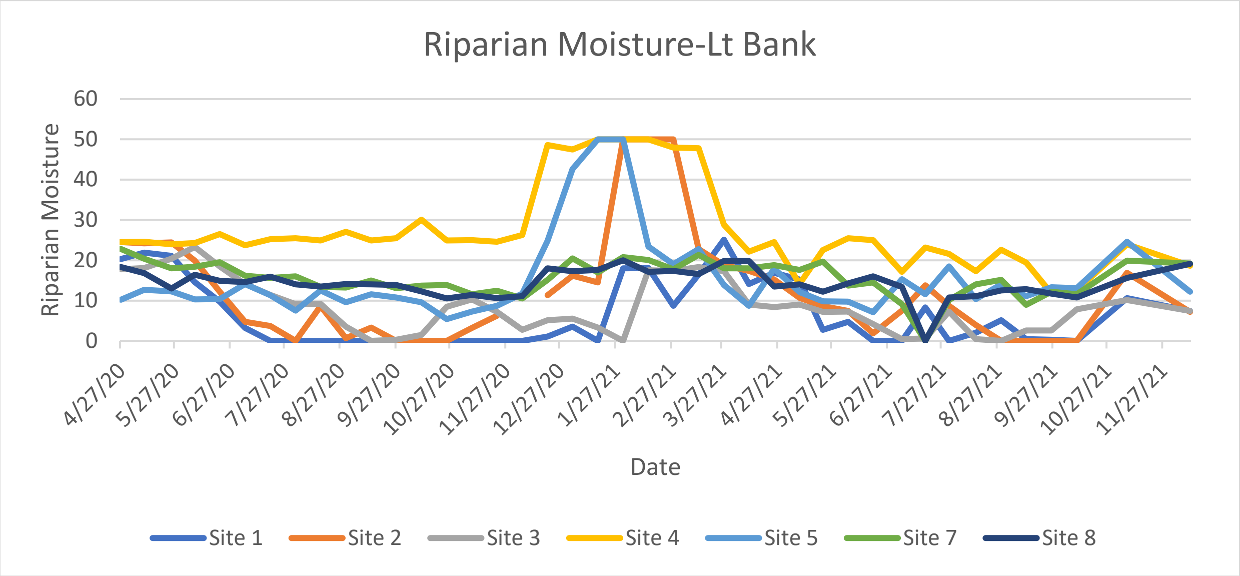


Figure 13. Riparian moisture on the left bank.

Hydrology

In 2020, Van Gordon Creek had water until May, but in 2021 it had water only into February. Similarly, San Simeon sites other than 4 & 5 had water in 2020 until July, but in 2021 had water only into May.

Wetted width, maximum depth, and average depth were measured year-round at Sites 4 and 5; other survey sites went dry in the following order from first to last: Site 7, 8, 2, 1, 3. The graphs below show seasonal variation. They also show that there were more months of flow in 2020 than in 2021. And even though 2021 had fewer wetted months, the width, depth, and flow were greater than the previous year, most likely attributed to a change in stream morphology.

All of these graphs, especially the flow data, show the rapid rise and fall of a typical coastal creek. Further discussion of Sites 4 and 5 follows (Figures 14 through 17).

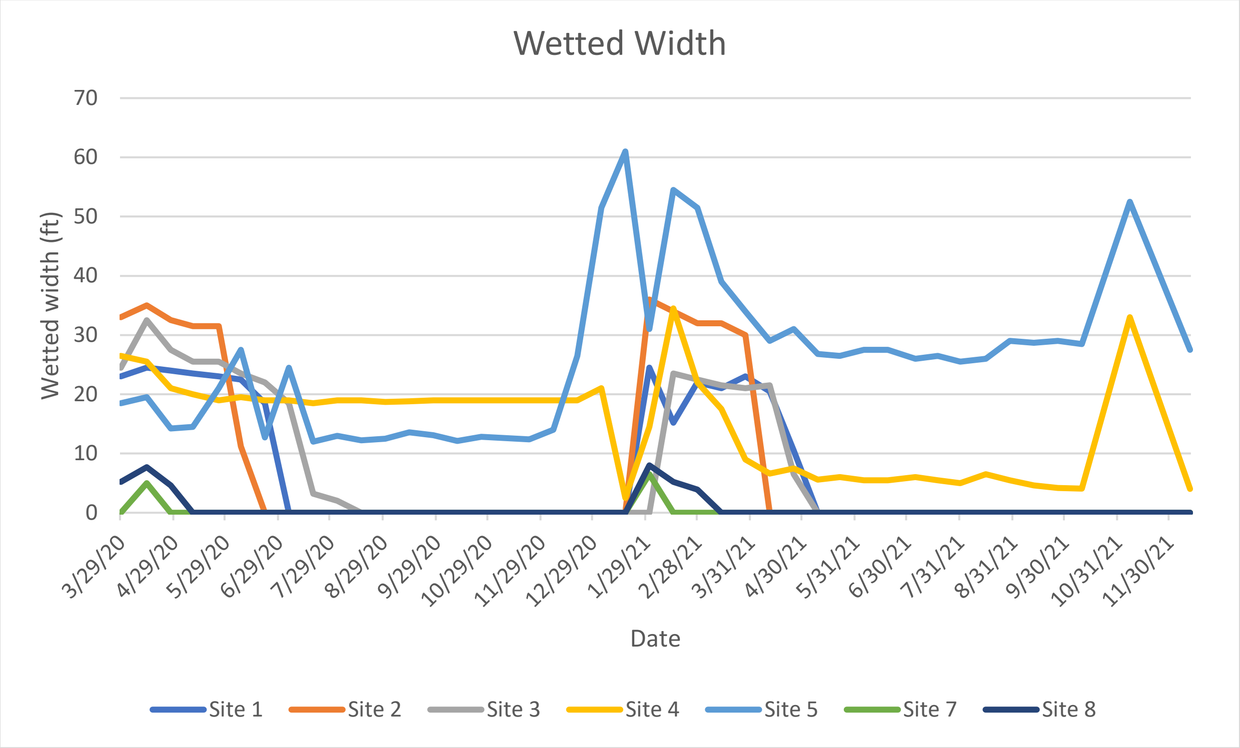


Figure 14. Wetted width.

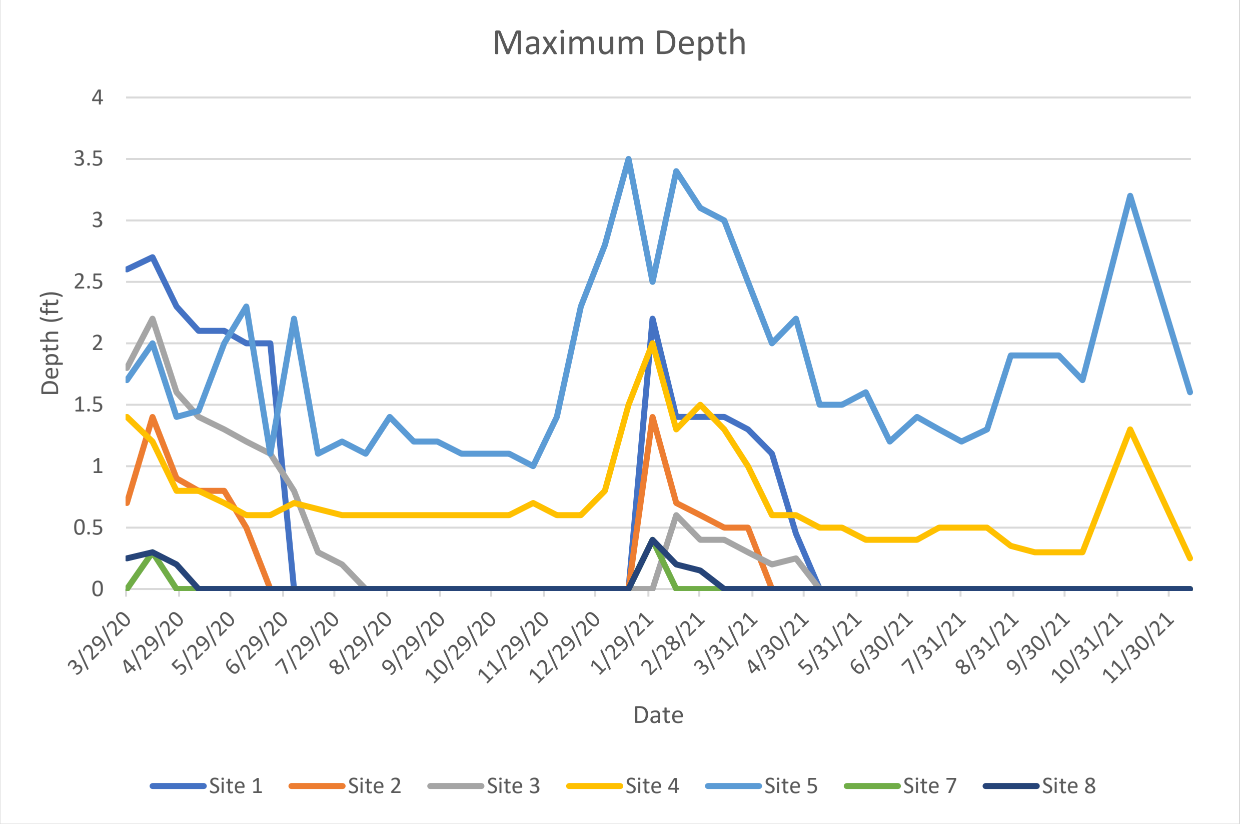


Figure 15. Maximum depth.

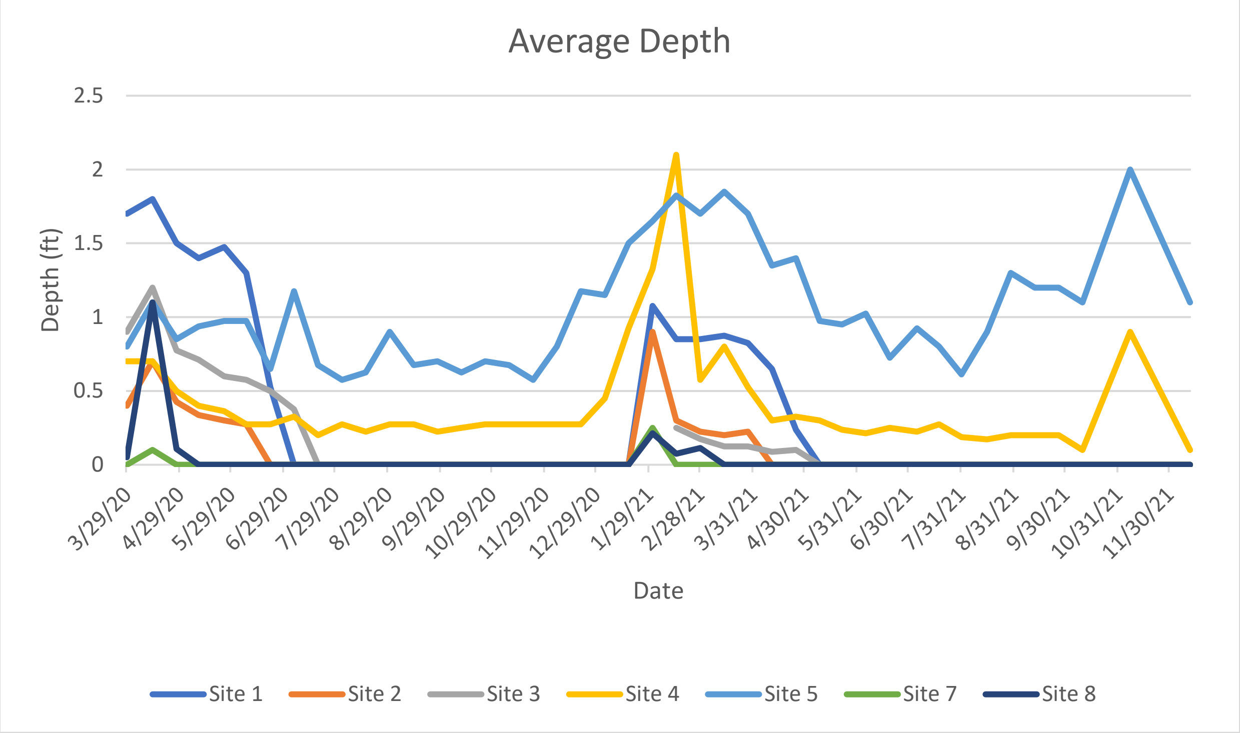


Figure 16. Average depth.

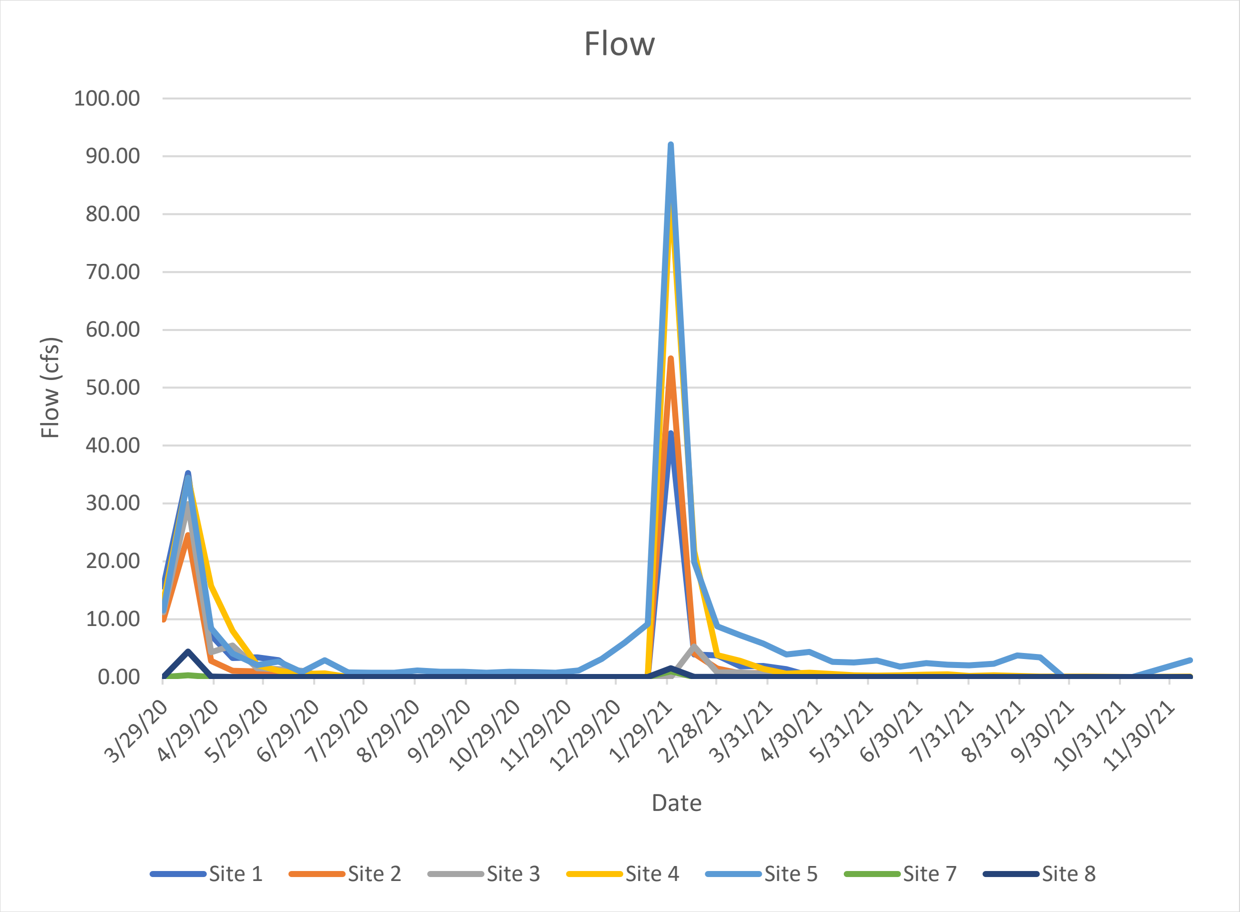


Figure 17. Flow.

Hydrology at Sites 4 and 5

These two sites have year-round water providing habitat for aquatic species. Comparing two years of data shows more annual variation in wetted width than in wetted depth. Site 4 was wider in 2020 which may be due to a shorter high flow season in 2021 or the change in habitat due to a tree falling directly on the site. Site 5 showed just the opposite, with a greater width in 2021. This may be due to the sandbar opening to the ocean for only one month and causing water to back up. This theory is supported by higher salinity levels in 2021, indicating more of a tidal effect further upstream than in 2020. Wetted depth was similar during both years at Site 4. At Site 5, the depth increased during higher tides in the winter months.

Flow data is presented for low flow months of May through November. Site 4 showed a steady decline inflow. Site 5 had more fluctuation because of tidal influence which, due to a greater wetted area, calculated a greater flow. Flow is a measurement of stream rate times wetted area.

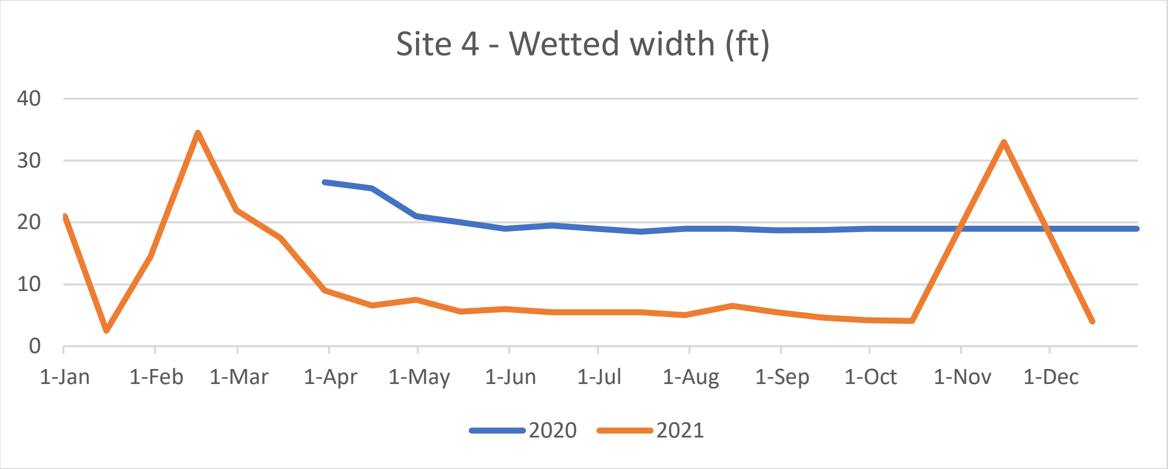


Figure 18. Site 4 Wetted width.

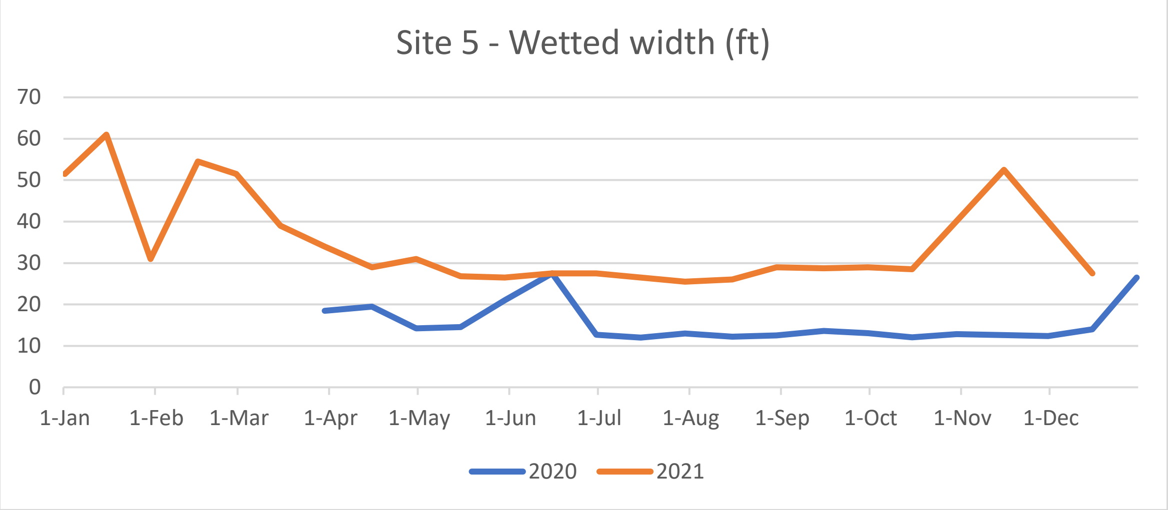


Figure 19. Site 5 Wetted width.

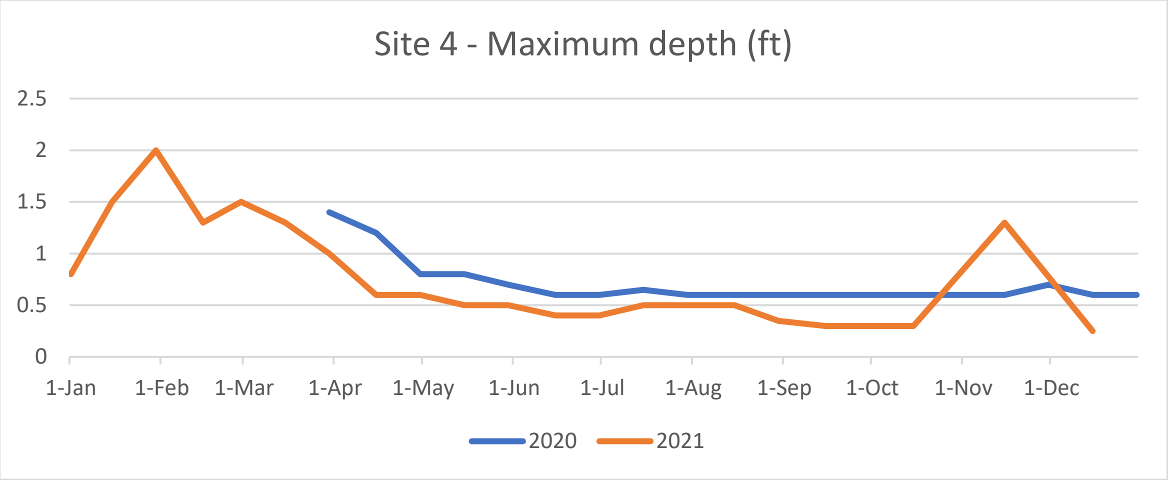


Figure 20. Site 4 Maximum depth.

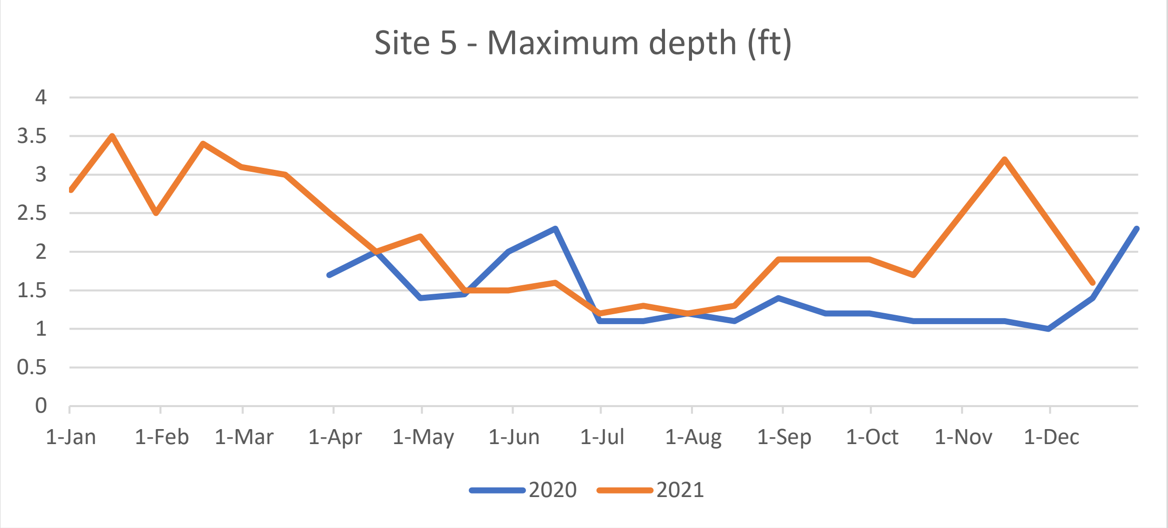


Figure 21. Site 5 Maximum depth.

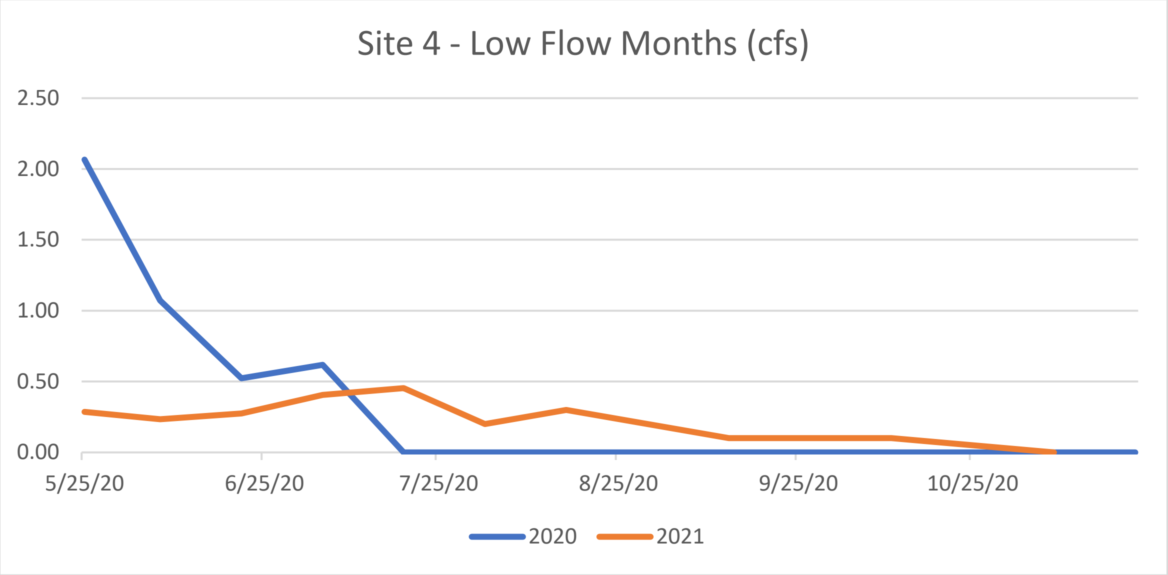


Figure 22. Site 4 Low flow months.

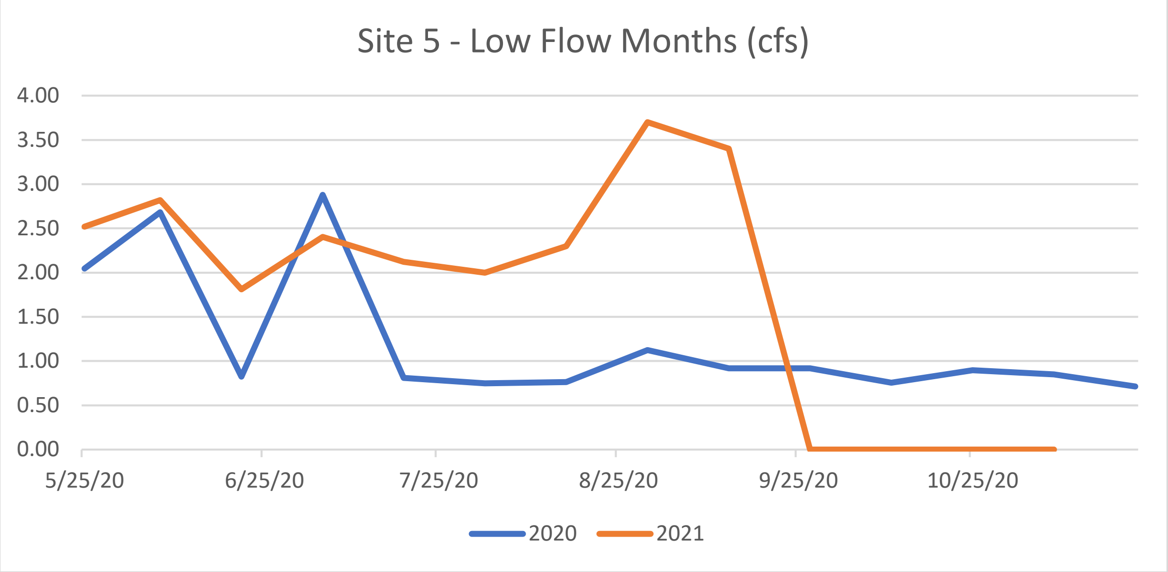


Figure 23. Site 5 Low flow months.

Surface Water Quality

Over the two years of monitoring, water temperatures and oxygen levels followed a similar pattern (Figures 24 and 25). Water temperature at Sites 4 and 5 had a low of 50.2 °F at the end of January. Site 4 peaked at 65.6 °F in July 2021, while Site 5 peaked at the same temperature in September 2021. Other sites had similar temperatures.

Dissolved oxygen at Sites 4 and 5 typically ranged between 2.5 and 10.5 ppm. Dissolved oxygen tends to decrease when temperature or salinity increase. It can also decrease with a reduction inflow. This relationship of dissolved oxygen and salinity was observed in November 2021 when dissolved oxygen dropped in one sample to 0.25 ppm and salinity increased to 20.7 ppt. On this sample date, it appears that salinity had more of a lowering effect on dissolved oxygen than did temperature, as shown in the charts below.

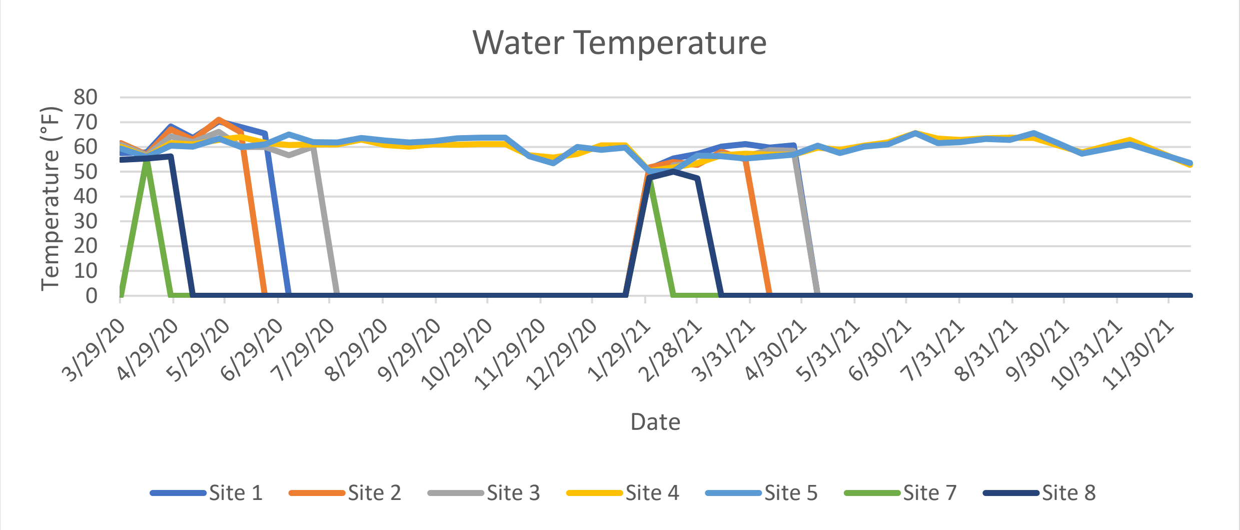


Figure 24. Water temperature.

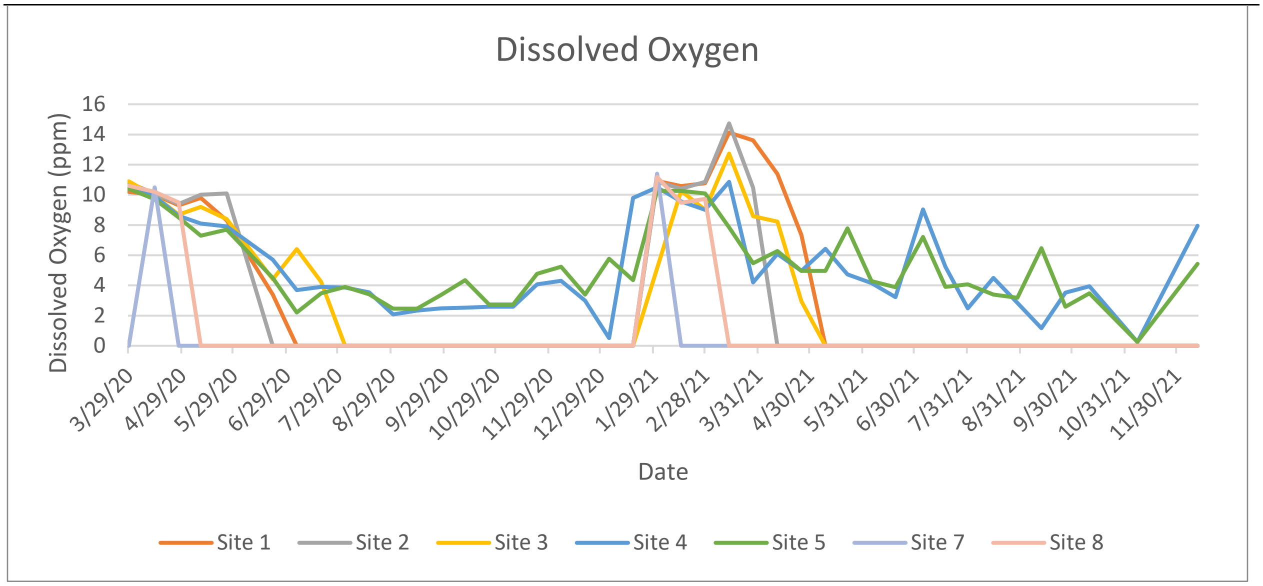


Figure 25. Dissolved oxygen.

Salinity usually ranged from 0.2 to 0.6 ppt (Figure 26). Towards the end of the year at Site 5, it began to increase and reached a level of 20.7 ppt in November, probably a result of tidal influence and a closed sandbar. Site 4 had high salinity readings in January 2021, indicating that tidal influence reached this far upstream (Figures 27 and 28).

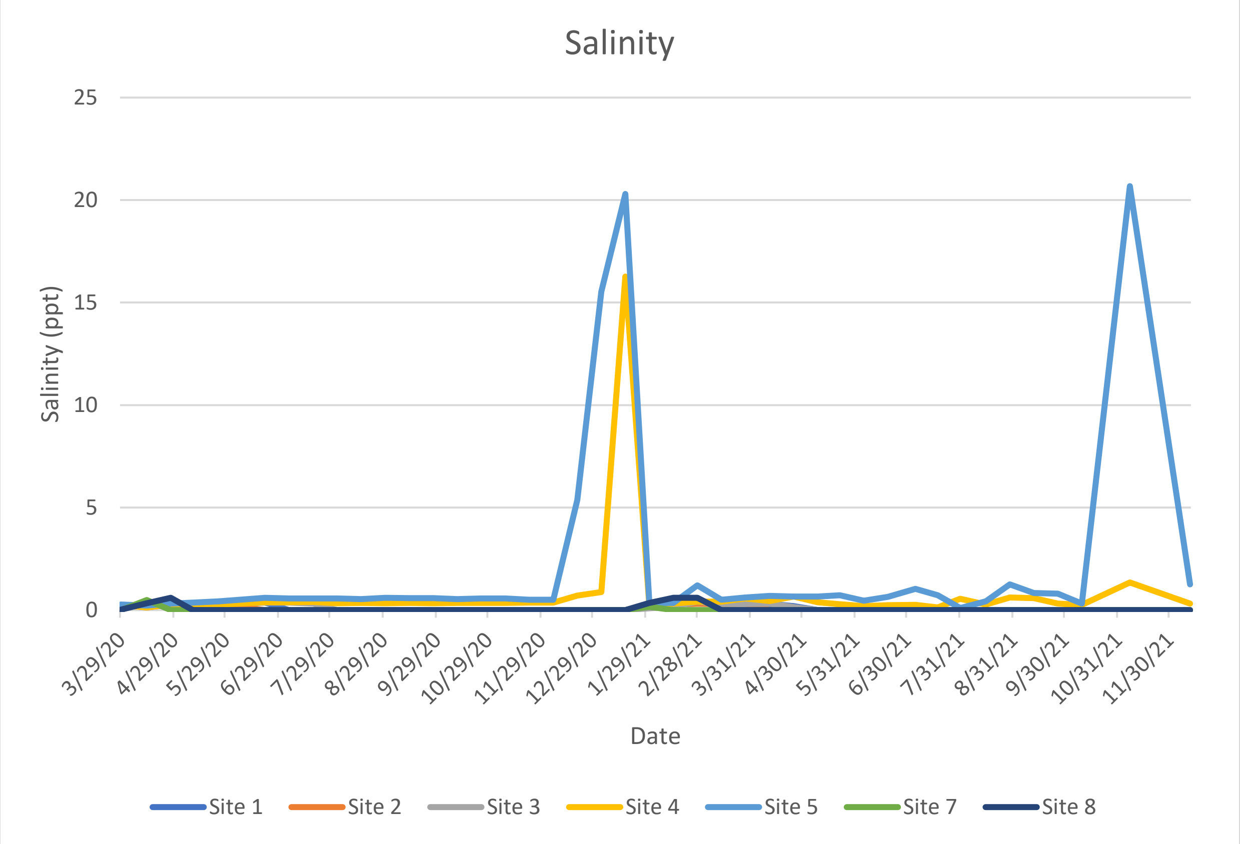


Figure 26. Salinity.

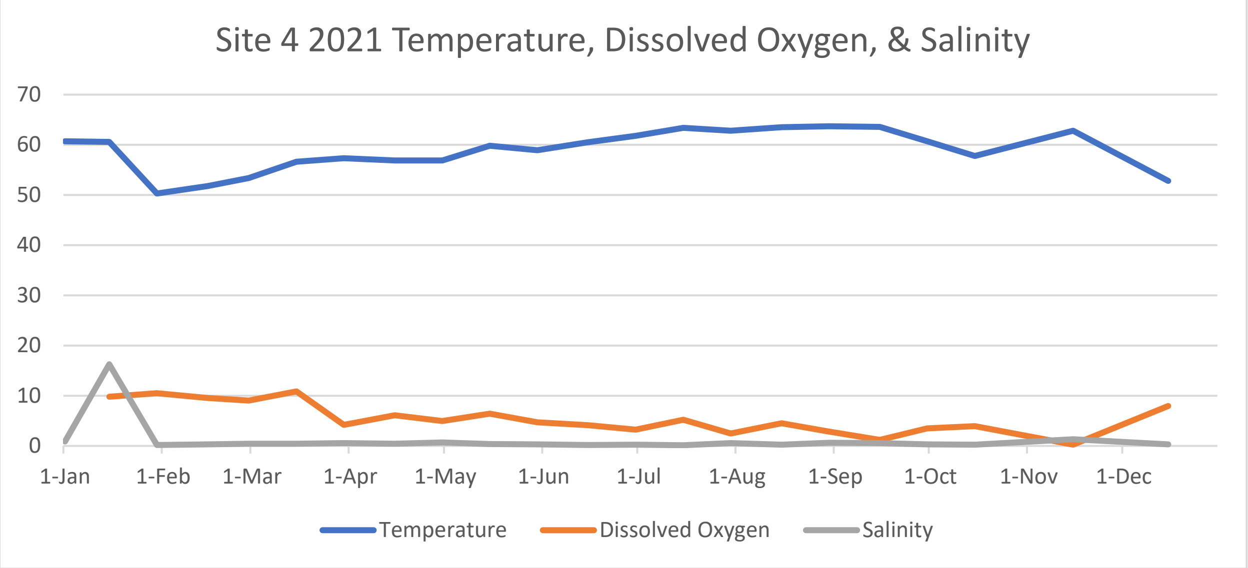


Figure 27. Site 4 2021 Temperature, Dissolved Oxygen, & Salinity.

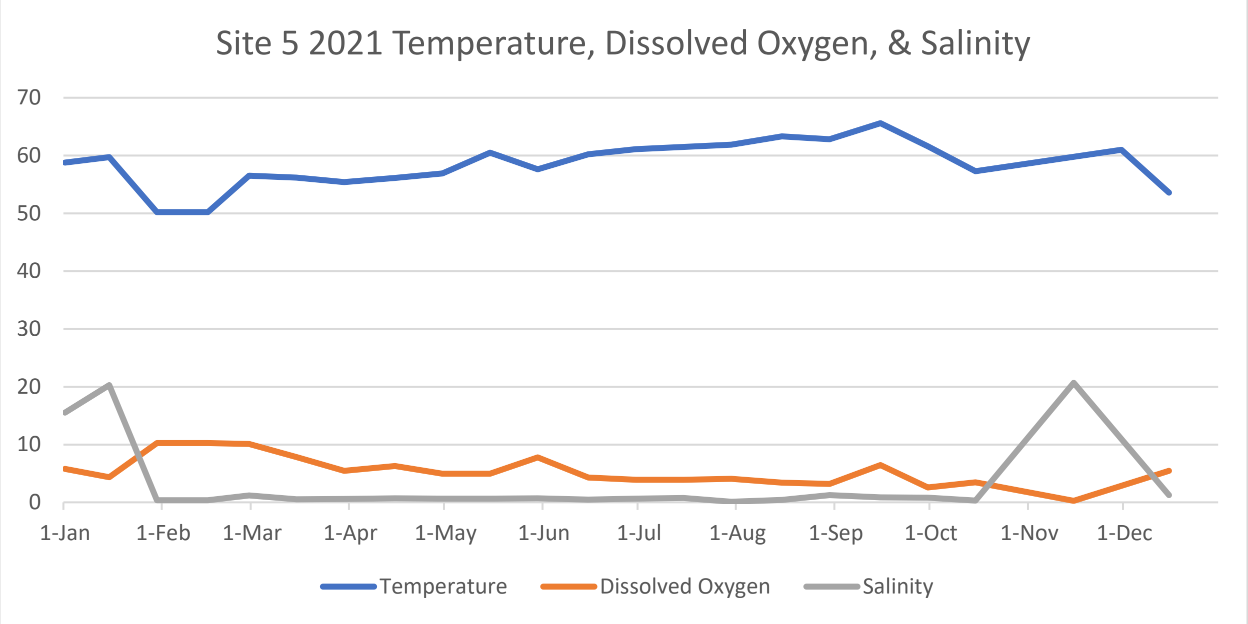


Figure 28. Site 5 2021 Temperature, Dissolved Oxygen, & Salinity.

Water temperatures were within range for the listed species. Dissolved oxygen levels dipped below optimal habitat requirements during the summer for steelhead trout. Salinity was also within range for the listed species, except for Site 5 on the last reading that was influenced by tides and the closed sandbar.

9P7 Soil Moisture

Soil moisture at the 9P7 well is presented in the graph below (Figure 29). As with other soil moisture measurements, the usefulness of this data is in question. The maximum moisture reading is 50%.

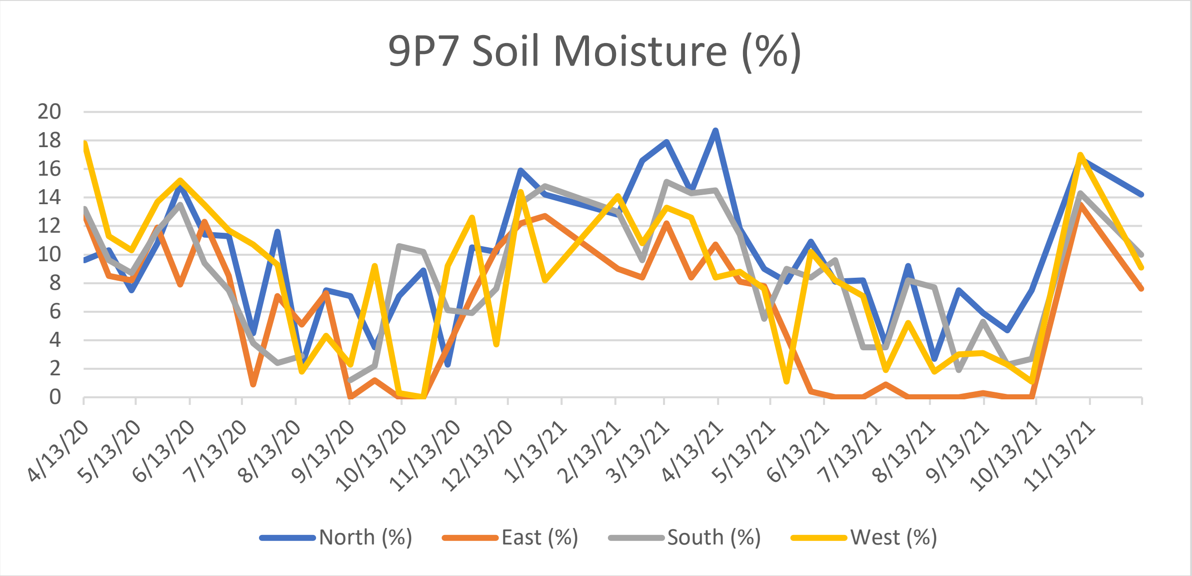


Figure 29. 9P7 Soil moisture.

Sensitive Species

Observed sensitive species include Monterey pine (*Pinus radiata*) at the percolation ponds. Photographs of this stand show there has been no change. Monarch butterflies (*Danaus plexippus*) have been observed in small numbers throughout the survey area; no change in the population size has been noted. Adult southwestern pond turtles (*Actinemys pallida*) were observed at the confluence of San Simeon and Van Gordon Creeks; no change in the population size has been noted.

Observed non-native plant species within the survey area includes: sweetclover (*Melilotus albus*), rumex (*rumex* sp.), common mustard (*Brassica rapa*), tree tobacco (*Nicotina glauca*), thistle (*carduus* sp.), fennel (*Foeniculum vulgare*), cape ivy (*Delairea odorata*), garden nasturtium (*Tropaeolum majus*), arrowweed (*Pluchea sericea*), canarygrass (*Phalaris canariensis*), bromus, poison hemlock (*Conium maculatum*), vinca (*Vinca major*), minor amounts of castor bean (*Ricinus communis*). Non-native vegetation at each survey site includes cape ivy. There has been no change in the amount of non-native plants at each survey site.

Photo Points

Ground and aerial photographs were reviewed to show any changes to riparian health and composition, and there were no observed changes. The two additional videos for stream flow analysis, taken at San Simeon Creek bridge on Van Gordon Creek Road and San Simeon Creek bridge on Highway 1, did not allow for a determination of stream flow from the video. Due to this, we propose that these two videos be eliminated from monitoring.

Thresholds to Trigger Additional Investigation and/or Adaptive Management Measures

Based upon initial results from the CCSD's hydrological modeling efforts, decreased lagoon elevation and inflow appear to be the most logical indicators of change in habitat quality (Todd Groundwater 2022). To monitor for and prevent any possible environmental impacts related to project activities, CCSD consultants and staff are analyzing data from two wells, 16D1 and MW4, both of which are located near the confluence of Van Gordon and San Simeon Creeks. Well levels below monthly historical averages would trigger an immediate investigation and, if needed, additional adaptive management measures such as increasing the volume of lagoon discharge. Existing piezometers installed in an array leading out from the WRF's extraction well (9P7) toward the lagoon and creek can be used to assist in determining if the decrease in lagoon elevation is related to project operations. These piezometers provide a profile of the extent of drawdown near 9P7 during project operations.

All adaptive management measures recommended for this project are subject to review and evaluation by permitting agencies. Baseline and monitoring data obtained through the AMP will inform the biological assessment being prepared for the Section 7 consultation with federal resource agencies.

4.0 CONCLUSION

AMP monitoring requires hydrological and biological monitoring, including California Rapid Assessment Method surveys, special status species surveys, and instream and riparian habitat monitoring at seven survey site locations to establish baseline conditions. CRAM surveys showed slight variation in Van Gordon Creek and San Simeon Creek. California red-legged frog and steelhead trout surveys showed that all life stages occur within the study area. Tidewater gobies were observed, but population dynamics are unknown. The baseline monitoring data shows stable habitats for sensitive species.

There were consistent annual fluctuations of in-stream habitat, vegetation, and water quality. Hydrology is mainly stable, with some annual variations due to morphological changes, mostly in measurements of wetted width. Flow data showed the rapid rise and fall of a typical coastal creek. Water quality shows expected seasonal fluctuations that maintain parameters for sensitive species. Baseline data will continue to be collected and analyzed at least four times a year to capture annual variations.

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TODD GROUNDWATER

March 8, 2022

MEMORANDUM

To: Ray Dienzo, Cambria Community Services District
Melissa Bland, Cambria Community Services District

From: Gus Yates, Senior Hydrologist

Re: Simulated Effects of Sustainable Water Facility Operation

BACKGROUND

The Sustainable Water Facility (SWF) purifies brackish groundwater extracted from the coastal part of the San Simeon Creek groundwater basin and processes it through microfiltration and reverse osmosis. After treatment, the water is injected back into the basin at a well farther up the San Simeon Creek Valley, where it augments groundwater available to three municipal wells that comprise the primary water supply for the community of Cambria. Cambria Community Services District (CCSD) constructed the SWF in 2014 under severe drought conditions, pursuant to an expedited emergency permitting procedure. At that time, the facility was called the Emergency Water Facility. The locations of the SWF, extraction well, injection well, municipal wells and other hydrologic features are shown in **Figure 1**.

The SWF operated intermittently for 4 months in early 2015, 4 months at the end of 2015, and briefly at the end of 2016, injecting a total of approximately 89 AF of purified water into the basin. Health regulations required that the subsurface travel time from the injection wells to the nearest municipal supply well be at least two months. Groundwater modeling was done to identify an injection well location and injection rate that would meet that requirement.

The SWF has been idle since 2016, but CCSD is seeking to convert the emergency permit to a regular Coastal Development Permit. Although lagoon impact issues were discussed in previous environmental compliance documents (CCSD, 2016; CDM Smith, 2015), some regulatory agencies have lingering concerns that SWF operation could adversely impact habitat for several sensitive species that inhabit the lagoon and perennial pools along San Simeon Creek upstream of the lagoon (California Coastal Commission, 2016; California Department of Fish and Wildlife, 2016).

CCSD plans to operate the SWF in drought years. The 2020 urban water management plan (WSC, 2021) includes a water shortage contingency plan that defines six stages of increasing drought severity and describes associated management actions that would be taken to reduce demand and augment supply. Assuming the District obtains the regular permit to operate outside of emergencies, SWF operation is contemplated for the three most severe water shortage stages (Stages 4, 5 and 6).

The San Simeon Creek groundwater basin extends along San Simeon Creek valley from the Pacific Ocean about 5 miles upstream to Palmer Flats. The width of the alluvial deposits that comprise the basin is generally 800-1,500 feet, and the depth to bedrock along the center of the valley decreases from slightly over 100 feet at the coast to about 80 feet at Palmer Flats (Yates and Van Konynenburg, 1998). A thick sequence of fine-grained estuarine deposits separates the basin fill into upper and lower aquifers downstream of Van Gordon Creek, which enters the San Simeon Creek valley about 0.5 mile upstream of the ocean.

San Simeon Creek drains a watershed of 26 square miles. In normal years, base flow is continuously present during the winter wet season, gradually receding to zero in late spring or early summer. The dry season is defined as starting on the day flow at the upstream end of the basin (Palmer Flats) recedes to 0 cfs, and it continues until stream flow resumes the following winter (typically around December). Because percolation from San Simeon Creek supplies most of the recharge to the basin, water shortage conditions can result from an unusually long dry season or from a winter with so little stream flow that the basin is not completely refilled prior to the next dry season. Both of these conditions were incorporated into the scenario simulations.

MODEL ACTIVATION AND VERIFICATION

In 2014, CDM Smith developed a numerical groundwater flow model of the San Simeon Creek groundwater basin for the purpose of simulating subsurface travel time of water from the SWF injection well to the nearest potable supply well (CDM Smith, 2014). The investigators modified an existing model for that purpose, decreasing the grid spacing and increasing the number of layers from three to eighteen. The model was recalibrated to measured water levels for 2002-2003. A groundwater tracer study was subsequently completed (CDM Smith, 2017). It confirmed the accuracy of the modeling and recommended a maximum injection rate of 400 gallons per minute (gpm). The modeling study presented some results related to simulated lagoon water levels and ocean boundary outflow, but the primary focus was on subsurface travel time.

For the present effort, the model was shifted from one proprietary modeling software platform (GMS) to another (Groundwater Vistas). Model layering was modified slightly, and inputs were changed to simulate March 2013 through December 2014 using semi-monthly stress periods. That two-year period was a drought and was selected to ensure that the model was calibrated to be accurate for dry-year scenarios, which are the focus of CCSD water supply planning. Model calibration involved adjustments to several variables. Layer thicknesses were adjusted to prevent excessive numbers of cells from going dry during the simulations. The CDM Smith model had eighteen 5-foot-thick layers, and the upper layers tend to become unsaturated when simulated water levels decline. The MODFLOW-NWT solver simulates unsaturated flow but becomes unstable if large numbers of cells convert from saturated to unsaturated. This was particularly problematic near the upper end of the basin, which experiences large fluctuations in water levels as groundwater drains down-valley during the dry season then refills as soon as stream flow resumes. Most of the basin thickness in that region was assigned to model layer 1 to minimize unsaturation. Other variables adjusted during calibration included hydraulic conductivity, storativity and stream bed elevations.

Figure 2 shows hydrographs comparing measured and simulated groundwater levels at nine wells used for calibration. The figure also shows a hydrograph of the simulated groundwater gradient between well SS-4 and well 9P2. The generally good fit between the simulated and measured hydrographs at the nine wells was confirmed by statistical analysis of pairs of simulated and measured data points. **Figure 3** shows a scatterplot of measured versus simulated water levels for the 362 available water level measurements. The plot is clustered tightly around the 1:1 line, which represents a perfect match. The scaled root-mean-squared error was 3.6 percent, which is low and indicates acceptable model calibration.

SWF OPERATIONAL SCENARIOS

The primary objective of the modeling was to determine whether SWF operation would substantially diminish surface or groundwater inflow to the lagoon and/or lower reach of San Simeon Creek, which might have adverse biological impacts. A secondary objective was to identify the amounts of SWF operation needed under various drought conditions to meet water supply needs.

The overall SWF-groundwater system is complex, with many variables that interact. The diagram in **Figure 4** shows the components of the system. These include well 9P7 (the SWF supply well), the microfiltration component of the SWF, a lagoon discharge to San Simeon Creek that occurs while 9P7 is pumping, percolation of microfiltration backflush water at the percolation ponds, treatment of the remaining microfiltration water by reverse osmosis followed by injection at well RIW1, pumping of groundwater at CCSD’s municipal wells (SS-1, SS-2 and SS-3), and percolation of treated wastewater at the ponds. Within the natural part of the system, seepage can occur in either direction between San Simeon Creek and groundwater and between the lagoon and groundwater. During the dry season, lagoon water seeps through the beach berm to reach the ocean. The basin extends offshore, and deeper layers are presumed to be in hydraulic connection with the ocean at some unknown offshore distance. Consequently, groundwater flow at the coastline can be seaward or landward, depending on the difference between onshore and offshore water levels. A change in any of the flows in this system affects all other flows.

The SWF is expensive to operate and would only be turned on in dry years when the supply of native groundwater might not be sufficient to meet CCSD water demand. CCSD plans to operate the SWF in water shortage Stages 5 and 6 and possibly in Stage 4. Those are the three most severe water shortage stages. To represent hydrologic conditions likely to be associated with those stages, the two years of the simulation period for scenario analysis represented two types of drought: a long dry season and a winter with incomplete basin recharge. These were implemented by adjusting the amount of San Simeon Creek inflow at the upstream end of the basin. **Figure 5** shows the assumed semi-monthly inflows for normal, Stage 4 and Stage 6 scenarios.

Some aspects of the model were held constant for all scenarios. These global assumptions included:

- Annual CCSD water demand in normal years is 700 AFY.
- Water shortage stages are associated with increasing amounts of water conservation. For Stage 4, conservation is assumed to decrease annual water demand by 40 percent, and for Stage 6 by 50 percent, per the water shortage contingency plan documented in the District's 2020 urban water management plan (WSC, 2021).
- The monthly distribution of water demand follows the average for 2013-2019. Monthly amounts range from 6.8 percent of the annual total in February to 10 percent in July. This reflects customer water use behavior during a drought.
- Pumping from the Santa Rosa Creek basin (located south of the San Simeon Creek basin) equals 20 percent of the CCSD water demand (after conservation) on an annual basis. The Santa Rosa pumping quota is distributed uniformly during June through October.
- Municipal wastewater percolation equals 92 percent of total CCSD water use on an annual basis and is uniform throughout the year. This was the percentage during 2014-2015, and it reflects customer water use patterns under drought conditions.
- All wastewater percolation is at Pond A (the most westerly pond).
- All water produced by SWF supply well 9P7 is processed through microfiltration.
- Microfiltration is 94.1 percent efficient. That is, 5.9 percent of the inflow is used to backflush the filters and is sent to the wastewater ponds for percolation.
- A constant flow of microfiltration product water is discharged to San Simeon Creek just upstream of the lagoon whenever well 9P7 is actively pumping. This flow can be adjusted independently of the reverse osmosis and RIW1 injection rates to prevent lagoon elevations and inflow from declining while the SWF is operating. Rates of 100-140 gpm were used in the simulations. These were assumed to be constant for each simulation, although in practice the lagoon discharge could be adjusted monthly as needed.
- Well 9P7 is assumed to have a pumping rate of 581 gpm, which was the measured discharge rate. Because the volume of SWF product water injected at well RIW1 varies by month and by scenario, the monthly hours of operation of well 9P7 also vary, and hence so does the monthly volume of lagoon discharge.

- Water produced by well 9P7 that is not used for backflushing the microfiltration filters or for lagoon discharge is processed through reverse osmosis. The reverse osmosis process has an efficiency of 92.1 percent (the remaining 7.9 percent is a brine that is trucked out of the basin for disposal). The reverse osmosis and advanced oxidation product water is injected at well RIW1.
- For a target amount of injection at well RIW1 in any semi-monthly stress period, the fraction of total time that 9P7 is pumping is imputed based on the recovery efficiencies of microfiltration and reverse osmosis. This is also the fraction of time the lagoon discharge is occurring. It is calculated based on the capacity of well 9P7 and the instantaneous lagoon discharge according to the following formula:
- $X = \frac{\left\{\frac{RIW}{RO\text{eff} \cdot MF\text{eff}}\right\}}{\left\{9P7\text{cap} - \left(\frac{Lag}{MF\text{eff}}\right)\right\}}$
- Where,
- X is the fraction of time 9P7 and the discharge are occurring
- RIW is the target SWF product water injection volume for the stress period (AF)
- RO_{eff} is the recovery efficiency of the reverse osmosis process (fraction)
- MF_{eff} is the recovery efficiency of the microfiltration process (fraction)
- $9P7_{cap}$ is the pumping capacity of well 9P7 if it operated continuously for the entire stress period (AF)
- Lag is the volume of lagoon discharge that would result if the discharge occurred continuously for the entire stress period (AF)
- Given a pumping capacity of 581 gpm for well 9P7, a lagoon discharge rate of 100 gpm, and the aforementioned efficiencies, the equation can be solved for X. The actual stress period volumes of 9P7 and lagoon discharge water equal their stress period capacities multiplied by X.
- 60 percent of water injected at RIW1 is available for extraction by municipal wells SS-1 and SS-2, and pumping of native groundwater is decreased by that amount. The remaining 40 percent of injected water flows joins native groundwater and flows west toward well 9P7 and the percolation pond area. This proportion was determined by prior modeling (CDM Smith, 2014).
- The lagoon discharge is to San Simeon Creek at the next-to-last stream cell before entering the lagoon (about 80 feet upstream of the lagoon).
- The lagoon has a fixed footprint.
- The “equivalent freshwater head” model assigns a constant head of 3.33 feet above the NAVD88 datum for all offshore cells in model layer 1. Lower model layers are assigned higher constant heads reflecting the greater density of seawater relative to fresh groundwater. Cells along the offshore end of the model grid in layers 10-12 are assigned a head of 3.84 feet, and cells along the offshore end of layers 14-18 are assigned a head of 5.40 feet. The density difference between seawater and fresh water can cause seawater to intrude a short distance into the onshore part of the aquifer, although in practice low onshore water levels due to pumping typically have a much larger effect.

- The principal management variable in the scenarios is the timing and amount of SWF operation. Other flexible input variables that were tested over a range of values were year type (water shortage stage) and the amounts of groundwater pumping for irrigation by neighboring well owners Pedotti and Warren. **Table 1** shows the combinations of assumptions regarding these variables for each of the scenarios.

SIMULATED EFFECTS OF SWF OPERATION

Hydrologic Conditions for Two Successive Dry Years

Each simulation covered a period of 22 months using semi-monthly stress periods. The simulations start in March with a full basin condition and continued through December of the following year. For model calibration, this period corresponded to March 2013-December 2014. Thus, the simulations covered two dry seasons. To simulate operational scenarios, different drought conditions were assumed for each dry season. The first one was long, with stream flow at Palmer Flats ceasing April 1 (for Stage 4 water shortage scenarios) or March 1 (for Stage 6) and not resuming until mid-January of the following year (see **Figure 5**). The second dry season was only moderately long (April 1 through December 15), but groundwater levels did not fully recover during the wet season between the two dry seasons. By trial and error, it was found that four semi-monthly stress periods with 5 cfs of San Simeon Creek inflow at Palmer Flats achieved partial basin refilling. These low flows mostly percolated out of the creek at the upstream end of the basin, with little surface flow reaching as far as the municipal well field. Water levels at the upstream end of the basin (represented by well 11B1) completely refilled for 2 weeks in late March before beginning the usual dry-season decline. Refilling decreased to about 40 percent of normal (based on water levels) at irrigation well 10M2, to about 35 percent of normal at the well field and roughly 10 percent of normal at well 9P7.

Operational Constraints

Constraints on SWF operation include infrastructure capacity, conditions in permits, and environmental impacts. None of the scenarios exceeded the capacity of well 9P7 or the microfiltration and reverse osmosis units. All of those operated less than full time in the scenarios. The dry season and annual groundwater production limits in CCSD's water rights permit were never exceeded. The limitation that most commonly constrained operation was the water-level gradient between well SS-4 and well 9P2 (see locations in **Figure 1**). To prevent the subsurface flow of percolated wastewater toward the well field, the water level in SS-4 should always be higher than the water level in 9P2. The existing permit for operating the percolation ponds allows temporary excursions to a reverse gradient, with SS-4 as much as -0.79 foot below 9P2. In practice, CCSD operates the system to avoid a water level difference less than +0.75 foot, and this was the criterion used in the scenarios.

The Coastal Commission has expressed concern regarding potential impacts of decreased inflow to the lagoon, although no quantitative threshold of significance has been defined.

The lagoon receives surface and subsurface inflow during the dry season. For the scenario analysis, the sum of the two inflows was tabulated for each stress period, and the minimum inflow during each dry season was identified. Lagoon inflow is affected by several variables including drought severity, irrigation pumping, municipal pumping and SWF operation. With regard to SWF operation, the effects of pumping at well 9P7 are partially or entirely offset by the lagoon discharge, a slight increase in percolation at the ponds, and injection at well RIW1.

Seawater intrusion is another potential constraint on system operation. If pumping and drought conditions cause groundwater levels near the coast to drop below 3.33 ft NAVD88 in upper model layers or 5.40 ft NAVD88 in lower model layers, groundwater flow across the coastline will shift from seaward to landward. The salinity of groundwater in the offshore part of the basin is not known, but eventually saline groundwater would begin arriving at onshore parts of the basin. Small amounts of landward groundwater flow during the dry season are not necessarily a concern if the water is flushed by large amounts of seaward flow during the wet season. Accordingly, scenario results were evaluated based on the ratio of seaward to landward flow on an annual basis and on the occurrence of relatively high amounts of landward flow.

Simulation of Normal Year Conditions

Under normal year conditions, CCSD water use was assumed to equal the full 700 AFY of demand, with no reduction by conservation. The dry season for San Simeon Creek flow was from June 1 to December 15 in both years of the simulation, and the basin refilled completely over the intervening wet season. The SWF was assumed not to operate.

This scenario was acceptable with respect to lagoon inflow and seawater intrusion but not with respect to the SS-4/9P2 gradient. Simulated water levels at key wells are shown in **Figure 6**, where they are compared with measured and simulated historical water levels for 2013-2014. The simulated CCSD water demand was greater than the demand during 2013-2014, but water levels declined more gradually during the start of the dry seasons due to generally wetter conditions. By December, however, the SS-4/9P2 gradient had dropped below the minimum target of +0.75 foot, reaching +0.17 foot in both years. The basin refilled abruptly when stream flow resumed and remained full throughout the wet season.

The brief downward spike in the the SS-4/9P2 gradient visible in December 2014 is present in the results for all scenarios. It is an artifact of model gridding, which causes the rapid rise in water levels at the onset of the winter flow season to reach well 9P7 before well SS-4 in the first time step of the final semi-weekly stress period. It is not meaningful from a water management standpoint.

Hydrographs of simulated lagoon water levels are shown in **Figure 7**, where they are compared with the results for other scenarios. For the normal year scenario, simulated lagoon levels were about 0.2-0.3 ft higher than for any other scenario during the first dry season. During the second dry season normal year water levels were very similar to those during the first dry season and 0.4-1.4 ft higher than those under the other scenarios. The other scenarios all included incomplete basin recharge over the winter, which lowers lagoon water levels substantially during the following dry season.

Water budgets for the scenarios were tabulated for two periods: March of year 1 through March of year 2, and April through December of year 2. The 13-month period for the first dry season was necessary because low stream recharge during winter caused water levels and gradients to continue declining through March of the second year. In other words, the winter months were functionally an extension of the year 1 dry season. The second budget analysis period covers a more normal April-December dry season for year 2. Key water budget inputs and results for all scenarios are listed in **Table 2**, with results for the first dry season shown in the upper table and results for the second dry season in the lower table. Scenarios may be compared within each dry season. Because of their different durations, results for the first dry season may not be directly comparable to results for the second dry season.

The minimum simulated lagoon inflow during the first and second dry seasons is shown in **Figure 8**, along with results for other scenarios. Minimum inflow during the first dry season under normal year conditions was slightly less than for historical 2013-2014 conditions, probably because the greater amount of CCSD pumping in the normal year scenario more than balanced the drier hydrologic conditions during 2013-2014. The opposite was true during the second year, when the larger amount of stream flow under normal year conditions more than offset the higher pumping.

Annual groundwater flow across the coastline is shown for all scenarios in **Figure 9**. All of the scenarios show a small amount of groundwater flow from offshore to onshore. This small, constant amount is probably an artifact of the equivalent freshwater head boundary condition in the model, which tends to create some vertical “short-circuiting” of groundwater flow from deep layers (where constant head = 5.40 ft) to shallow layers (where constant head = 3.33 ft). This effect could affect water levels and flow as far inland as the coastline. In any case, groundwater outflow in normal years exceeded groundwater inflow across the coastline by a factor of 24 to 29 in the two dry seasons, indicating an absence of significant intrusion.

Simulation of Stage 4 Water Shortage Conditions

Stage 4 water shortage conditions were simulated with and without SWF operation to test the specific effects of the SWF. Annual CCSD water demand was assumed to be reduced by 10 percent through conservation efforts. Simulated water levels at key wells with and without SWF operation are shown in **Figure 10**. Water levels under the stage 4 scenario without SWF operation were similar to historical 2013-2014 water levels during the first dry season but much lower during the second year due to the assumption of incomplete basin recovery in winter. The effect of SWF operation was to raise water levels from well 10M2 down to well 9P2 by 0.5-1 foot from the summer of year 1 through the end of year 2. The effect on the SS-4/9P2 gradient was more pronounced. SWF operation raises water levels at both wells, but it raises them more at SS-4, which is near injection well RIW1. The gradient responds immediately to SWF operation. In this scenario, operation at 10 acre-feet per month (AF/mo) increased the gradient by about 0.5 ft as long as the SWF was operating. Conversely, the gradient quickly drops by the same amount when the SWF is turned off.

Without SWF operation, the gradient declined below the minimum target in both years (to -0.60 and -0.45 ft, respectively). As described earlier, the brief downward spike in the gradient in December of year 2 is an artifact of modeling and not meaningful for water management. With SWF operation at 10-30 AF/mo, the minimums were close to the target in both years (+0.70 and +0.60 ft, respectively). Larger amounts of SWF operation would have increased the gradient even further. Because of the speed at which the gradient responds to SWF operation, SWF operation can be adjusted in real time to prevent the gradient from falling below the target.

An instantaneous lagoon discharge rate of 140 gpm was found to be necessary to prevent reductions in the minimum dry-season lagoon elevation and inflow. For example, with a discharge rate of 100 gpm, the minimum dry-season elevation was 0.01 to 0.05 ft lower than without SWF operation, and the minimum dry-season inflow was 0.05 to 0.09 AF/mo lower. With the 140 gpm discharge rate, minimum elevations were only 0.03 ft lower and minimum inflows were 0.02-0.03 cfs higher than without SWF operation (see **Figures 7 and 8**). The effect of SWF operation on the lagoon can be controlled by adjusting the lagoon discharge rate. The discharge has a larger effect on lagoon inflow than lagoon elevation. In practice, the width of the beach berm at the ocean end of the lagoon generally exerts the greatest influence on lagoon elevation.

Groundwater flow across the coastline under Stage 4 conditions was essentially the same with and without SWF operation. In both cases, the ratio of groundwater outflow to groundwater inflow was slightly smaller than in normal years, but the ratios remained above 20 (see **Figure 9**). Thus, seawater intrusion was not a concern for either scenario.

Simulation of Stage 6 Water Shortage Conditions

The difference between Stage 4 and Stage 6 hydrologic conditions is most apparent at the start of year 1, when San Simeon Creek inflow ceased a month earlier under Stage 6. This can be seen in the hydrographs for wells 10M2 and SS-2 in **Figure 11**. For both water shortage stages, stream flows in winter 2014 were assumed to be identical and insufficient to completely replenish groundwater storage. Thus, the simulations were very similar during year 2.

The amount of SWF operation was adjusted for the Stage 6 scenario so that the SS-4/9P2 gradient remained almost continuously above the target minimum of +0.75 foot. To avoid excessive SWF operation, the amounts of water injected at RIW1 were varied from month to month, as they could be under real-time operation. By trial and error, it was found that SWF operation at 15-30 AF/mo was needed from August of year 1 through April of year 2, with the highest rates occurring in December-January. SWF operation at 15-40 AF/mo was also needed in year 2, with the highest rates occurring in November-December. Over the course of the two years, SWF injection for Stage 6 was less than 10 percent greater than for Stage 4 because of greater assumed water conservation and because the principal hydrologic difference was one additional month of dry season in year 1.

Stage 6 drought conditions were slightly worse than Stage 4 conditions with respect to the lagoon and ocean boundary flow. Assuming SWF operation in both cases, the minimum simulated lagoon elevation was 0.05-0.06 ft lower for Stage 6 (see **Table 2**). The minimum simulated lagoon inflow was 0.04-0.06 cfs lower and annual groundwater outflow across the coastline was 10-102 AF (2-10 percent) lower. However, simulated groundwater inflow was the same.

Simulations of Increased Irrigation Pumping

Two farming operations use groundwater from the San Simeon Creek basin, and in both cases potential future groundwater use is greater than recent historical use. Jon Pedotti farms numerous fields along the basin from just upstream of the well field to Palmer Flats. His supply wells include several of the wells used for water level monitoring: 11B1, 10A1, 10M2 and others (see **Figure 1** for locations). In the late 1980s, all of his fields were planted every year and were irrigated primarily by sprinkler or furrow methods, resulting in estimated groundwater pumping of 264 AFY (Yates and Van Konynenburg, 1998). Irrigation was converted almost entirely to drip by the early 2000s, and Mr. Pedotti presently plants only about half of his total acreage each year (Pedotti, 2021). His annual groundwater pumping in recent years is estimated to be approximately 130 AFY. At full production, it would be about 260 AFY.

Clyde Warren irrigates land in and near Van Gordon Creek from well 9P4, which is located 86 feet north of well 9P7 in the percolation pond area. Pumping from well 9P4 is metered and recorded by CCSD. His cropping has been small in recent years, and pumping averaged only 14.5 AFY during 2012-2018. However, pursuant to an agreement with CCSD reached in 2006, he is entitled to pump 183.5 AFY.

Because of the well locations, increased groundwater pumping by the two farming operations was expected to have different effects on water levels, the SS-4/9P7 gradient, lagoon inflow and ocean boundary flow. Accordingly, increased pumping was simulated separately for each farming operation.

Increased Pedotti Pumping

For this scenario, the Stage 4 + SWF scenario was modified by increasing Pedotti pumping from 130 to 260 AFY in year 1 and year 2. The irrigation season was assumed to remain the same (June through October). The timing of irrigation pumping does not substantially affect simulation results as long as it all occurs during the dry season. SWF operation was adjusted iteratively to maintain the SS-4/9P2 gradient above +0.75 foot.

Simulated water levels at key wells are shown in **Figure 12**, where they are compared with the earlier Stage 4 + SWF scenario results. The largest effect shown is at well 10M2, which is a Pedotti irrigation well. Water levels were 4-5 ft lower due to the increased irrigation pumping. The effect extended all the way down the basin but decreased in magnitude to about 1 foot at well 16D1 near the lagoon. SWF operation had to be increased substantially above the amount needed for the Stage 4 + SWF scenario to prevent the SS-4/9P2 gradient from dropping below +0.75. SWF operation was required continuously from April of year 1 through December of year 2 at rates 5-15 AF/mo greater than the rates for corresponding months of the Stage 4 + SWF scenario. Over the course of the two years, SWF production was 1.4 times greater than for the Stage 4 + SWF scenario without the increased Pedotti pumping (see **Table 2**).

This simulation included a lagoon discharge of 100 gpm, and the minimum simulated lagoon elevations were 0.13-0.17 foot lower than for the scenario without increased Pedotti pumping (see **Figure 7**). Minimum simulated lagoon inflow was reduced by 0.08-0.16 cfs. A higher rate of lagoon discharge could potentially eliminate the decreased inflow but might not fully offset the decrease in lagoon elevation. Seaward flow of groundwater across the ocean boundary in year 1 was similar to the flows for the Stage 4 + SWF and Stage 6 + SWF scenarios, but outflow was lower in inflow was higher in year 2 (see **Figure 9** and **Table 2**). Groundwater outflow was 12-17 times greater than inflow, compared to 18-29 times greater for the earlier scenarios. Seawater intrusion is a potential concern with increased Pedotti pumping.

Increased Warren Pumping

To simulate increased irrigation pumping by Clyde Warren, the Stage 4 + SWF scenario was modified to increase irrigation pumping at well 9P4 from 15 AFY to 183.5 AFY during both dry seasons. The timing of irrigation pumping was assumed to remain the same. This scenario was simulated with and without SWF operation, to determine the extent to which SWF operation compounds or counteracts the effects of Warren pumping. The assumed lagoon discharge rate was 100 gpm whenever 9P7 was operating. SWF operation was increased only as much as was needed to maintain the SS-4/9P2 gradient at or above the target minimum of +0.75 foot. Total SWF injection over the two years was similar to the total for the Stage 4 + SWF scenario.

Simulated groundwater levels for increased Warren pumping with and without SWF operation are shown in **Figure 13**. SWF operation was able to increase the minimum SS-4/9P2 gradient from +0.09 to +0.62 foot in year 1 and from +0.12 to +0.88 foot in year 2. Additional SWF operation could have achieved even larger increases. Simulated lagoon levels were the lowest of any of the simulations, continuously 0.5-1.0 ft below the Stage 4 + SWF and Stage 6 + SWF levels (see **Figure 7**). The lower lagoon elevations were caused by the large amount of irrigation pumping at well 9P4 and its location relatively close to the lagoon. In this pair of simulations, adding SWF operation did not change the minimum lagoon water level during year 1 but lowered it by 0.04 ft in year 2. This could be largely or completely offset by increasing the rate of lagoon discharge during August-September of year 2.

With Warren pumping, the minimum lagoon elevations and inflows occurred in August of both years, during the peak of the irrigation season. Minimum lagoon inflow in year 1 (with or without SWF operation) was about the same as for the Stage 4 + SWF scenario. In year 2, however, it was only about half as much (again, with or without SWF operation). The potential for seawater intrusion was also the highest of any of the scenarios. Without SWF operation, groundwater outflow at the coastline was only about 16 times greater than groundwater inflow in year 1 and about 10 times greater in year 2. The ratios were slightly smaller with SWF operation (see **Table 2** and **Figure 9**).

Figure 14 compares water levels and groundwater flow directions in shallow and deep parts of the basin in November of year 2 with SWF operation and maximum Warren irrigation pumping. The upper plot shows contours of groundwater elevation in model layer 1 (top layer) using a contour interval of 0.2 foot. The pumping depression around wells 9P2 and 9P7 due to Warren and SWF pumping is visible as closed contours. The water table mound beneath Pond A also appears as a closed contour, about midway between the wells and the lagoon. The contours bend toward the lagoon and lower end of San Simeon Creek, indicating groundwater discharge into those water bodies even at the end of the dry season in year 2. Note that the base map in the figure overstates the length of the lagoon; it does not extend above the road crossing. Farther upstream, injection at well RIW1 produces a water-level plateau in the upstream direction (toward the municipal wells) and a steep gradient in the downstream direction, toward well 9P7.

In contrast, the water level gradient in model layer 16 near the bottom of the basin is landward from the offshore ocean boundary (lower plot in **Figure 14**). Groundwater elevation decreases from 5.0 ft NAVD88 offshore (the freshwater equivalent of sea level) to 4.6 ft at well 9P7, which is the low point for water levels in that model layer. The landward gradient is very small, but it produces the small increase in landward groundwater flow evident in the water balance.

SWF is capable of achieving an acceptable SS-4/9P7 gradient in the presence of maximum Warren pumping, but it cannot prevent lagoon impacts and increased risk of seawater intrusion associated with that pumping.

CONCLUSIONS

Conclusions that can be drawn from model calibration and the scenario simulations include the following:

- The reactivated model is calibrated to measured water levels during 2013-2014 with reasonable accuracy.
- Eight weeks of 5 cfs of San Simeon Creek inflow at Palmer Flats during the wet season only partially refills the basin. Increasing 2-4 of those weeks to 10 cfs refills it.
- The occurrence of two successive years as dry as the two years in the simulation is very unlikely. Although the two dry seasons were intended to be evaluated independently, the limited stream recharge between them had the effect of

prolonging some effects of the first dry season until March of year 2. Thus, the simulations represent extreme drought conditions with respect to stream flow.

- The amount of SWF injection can be adjusted to exactly meet the target minimum SS-4/9P7 gradient. The gradient responds very quickly to starting or stopping SWF operation. This would allow the amount of SWF injection to be adjusted in real time during a dry season to keep the gradient above the minimum.
- The lagoon discharge can similarly be adjusted independently of the reverse osmosis and RIW1 injection volumes to achieve target lagoon elevations and inflows. Simulation results demonstrated that a lagoon discharge rate of 100 gpm proved to be too small to prevent slight declines in minimum dry season lagoon elevation and inflow for the Stage 4 and Stage 6 simulations, relative to the corresponding simulations without SWF operation. This is probably because the original estimate of 100 gpm assumed a continuous discharge at that rate, whereas the simulations indicated that the SWF supply well (9P7) would need to operate much less than full time to supply the necessary injection at well RIW1. When the simulations were repeated with lagoon discharge rates of 120-140 gpm, simulated minimum dry-season lagoon levels and inflow were approximately the same as in the simulations without SWF operation. The discharge has a stronger effect on lagoon inflow than lagoon elevation.
- SWF operation can compensate for failure to achieve water conservation goals at each water shortage stage. It would supply the needed make-up water and keep groundwater conditions within constraints related to the SS-4/9P2 gradient, lagoon inflow and seawater intrusion. This could offer CCSD customers a choice between cutting back even further on water use or paying for expensive SWF water.
- In the Stage 4 + SWF and Stage 6 + SWF scenarios, it was possible to meet all three criteria for acceptability by adjusting the SWF injection volumes and lagoon discharge volumes on a semi-monthly basis. The SS-4/9P2 gradient remained above +0.75 foot almost continuously, lagoon levels and inflow were not reduced, and seawater intrusion did not occur.
- Groundwater flow in upper model layers near the coast was consistently toward the lagoon and ocean in all scenarios, even at the end of the dry season. In scenarios with maximum irrigation pumping (Pedotti or Warren), groundwater flow in deep model layers became landward in the summer of year 1 and remained landward until December of year 2. The gradients were small, but the condition persisted for 16 months. That condition could potentially cause seawater intrusion.
- The amounts of SWF injection required to prevent the SS-4/9P2 gradient from dropping below +0.75 ft ranged from 145 to 220 AF for the first dry season, and 145 to 235 AF for the second dry season, depending on the scenario. The highest amounts were in the scenario with increased Pedotti irrigation pumping.

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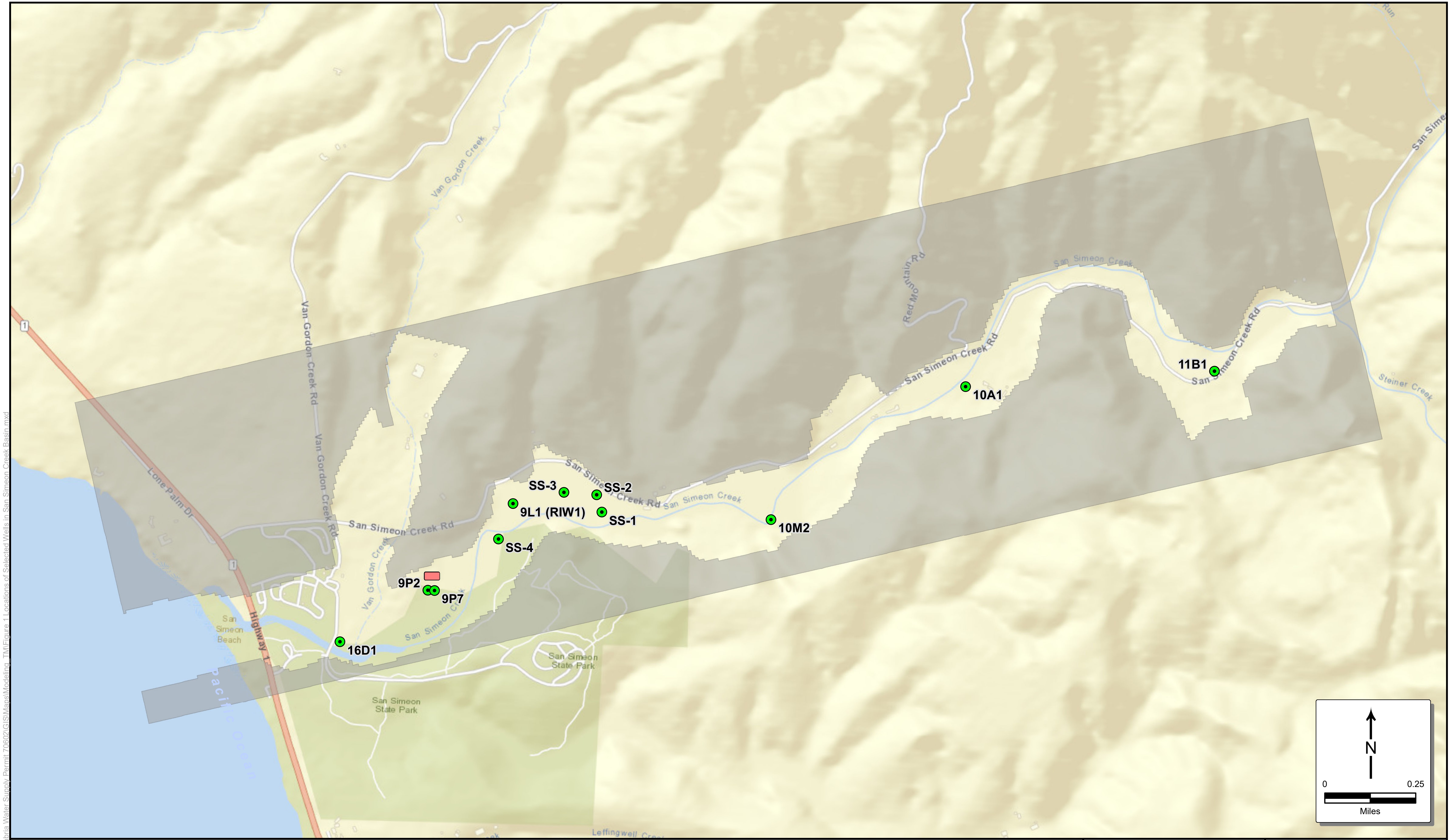
Table 1. Summary of Scenario Input Values

Scenario Description	Water Shortage Stage	SWF Activated	Pedotti Irrigation	Warren Irrigation	Mitigation Discharge (gpm)
Normal Year	None		Recent historical	Recent historical	0
Stage 4	4		Recent historical	Recent historical	0
Stage 4 + SWF	4	✓	Recent historical	Recent historical	120
Stage 6 + SWF	6	✓	Recent historical	Recent historical	120
Stage 4 + SWF + Full Pedotti Irrigation	4	✓	Full	Recent historical	100
Stage 4 + Maximum Warren Irrigation	4		Recent historical	Maximum	0
Stage 4 + SWF + Maximum Warren Irrigation	4	✓	Recent historical	Maximum	100

Table 2. Water Balance Results for Scenarios

Scenario Description	Year Type	March of Year 1 through March of Year 2																		
		CCSD Water Demand after Conservation (AFY)	Date Flow Ceases at Palmer Flats	Date Flow Resumes at Palmer Flats	San Simeon Well Field Groundwater Pumping (AF)	Pond Percolation (AF)		SWF Supply Well 9P7 Pumping (AF)	RIW1 Injection (AF)	Lagoon Discharge (AF)	Pedotti Irrigation Pumping (AF)	Warren Irrigation Pumping (AF)	Minimum SS-4 to 9P2 Water Level Difference (feet)	Minimum Lagoon Elevation		Minimum Dry-Season Inflow to Lagoon (cfs)				Groundwater Flow Across Coastline (AF)	
						Municipal Wastewater	Microfiltra-tion Backflush							Month	Elevation (feet NAVD88)	Month	Creek	Ground-water	Total	To Offshore	From Offshore
Historical 2013-2014	2013-2014	753	May 29	Feb 28	740	563	0	0	0	0	99	15	+0.23	OCT 2013	4.35	MAR 2014	0.58	0.34	0.92	1,157	48
Normal	Normal	753	Jun 1	Dec 16	613	697	0	0	0	0	130	15	+0.17	DEC 2013	4.6	DEC 2013	0.45	0.38	0.83	1,497	51
Stage 4, no SWF	Stage 4	678	Apr 1	Jan 1	552	628	0	0	0	0	130	15	-0.60	MAR 2014	4.17	FEB 2014	0.21	0.29	0.50	1,040	47
Stage 4 + SWF	Stage 4	678	Apr 1	Jan 1	552	628	14	229	150	52	130	15	+.79	MAR 2014	4.14	MAR 2014	0.31	0.22	0.53	1,023	51
Stage 6 + SWF	Stage 6	602	Mar 1	Jan 16	490	558	17	276	188	56	130	15	+0.81	MAR 2014	4.08	FEB 2014	0.27	0.22	0.49	921	51
Stage 4 + SWF + Pedotti	Stage 4	678	Apr 1	Jan 1	552	628	18	312	220	55	260	15	+0.72	MAR 2014	4.01	FEB 2014	0.25	0.2	0.45	942	55
Stage 4 + Warren	Stage 4	678	Apr 1	Jan 1	552	628	0	0	0	0	130	183	-0.68	AUG 2013	4.12	AUG 2013	0.17	0.35	0.52	855	52
Stage 4 + SWF + Warren	Stage 4	678	Apr 1	Jan 1	552	628	12	206	145	36	130	183	+0.63	AUG 2013	4.12	AUG 2013	0.17	0.35	0.52	845	58

Scenario Description	Year Type	April 2014 through December of Year 2																		
		CCSD Water Demand after Conservation (AFY)	Date Flow Ceases at Palmer Flats	Date Flow Resumes at Palmer Flats	San Simeon Well Field Groundwater Pumping (AF)	Pond Percolation (AF)		SWF Supply Well 9P7 Pumping (AF)	RIW1 Injection (AF)	Lagoon Discharge (AF)	Pedotti Irrigation Pumping (AF)	Warren Irrigation Pumping (AF)	Minimum SS-4 to 9P2 Water Level Difference (feet)	Minimum Lagoon Elevation		Minimum Dry-Season Inflow to Lagoon (cfs)				Groundwater Flow Across Coastline (AF)	
						Municipal Wastewater	Microfiltra-tion Backflush							Month	Elevation (feet NAVD88)	Month	Creek	Ground-water	Total	To Offshore	From Offshore
Historical 2013-2014	2013-2014	543	April 27	Dec 5	541	317	0	0	0	0	112	27	+0.52	NOV 2014	4.43	SEP 2014	0.3	0.4	0.7	838	36
Normal	Normal	543	Jun 1	Dec 16	403	483	0	0	0	0	130	15	+0.17	DEC 2014	4.64	DEC 2014	0.44	0.38	0.82	947	40
Stage 4, no SWF	Stage 4	489	Apr 1	Dec 16	363	435	0	0	0	0	130	15	-0.45	DEC 2014	4.26	DEC 2014	0.21	0.36	0.57	522	21
Stage 4 + SWF	Stage 4	489	Apr 1	Dec 16	363	435	15	252	165	58	130	15	+0.93	DEC 2014	4.23	DEC 2014	0.33	0.26	0.59	511	24
Stage 6 + SWF	Stage 6	435	Apr 1	Dec 16	323	386	12	214	145	44	130	15	+0.61	DEC 2014	4.18	DEC 2014	0.32	0.21	0.53	491	25
Stage 4 + SWF + Pedotti	Stage 4	489	Apr 1	Dec 16	363	435	20	336	235	59	260	15	+0.81	DEC 2014	4.06	DEC 2014	0.25	0.18	0.43	421	34
Stage 4 + Warren	Stage 4	489	Apr 1	Dec 16	363	435	0	0	0	0	130	183	-0.62	SEP 2014	3.86	AUG 2014	0.05	0.23	0.28	380	40
Stage 4 + SWF + Warren	Stage 4	489	Apr 1	Dec 16	363	435	14	241	170	43	130	183	+0.92	SEP 2014	3.82	AUG 2014	0.10	0.19	0.29	361	46



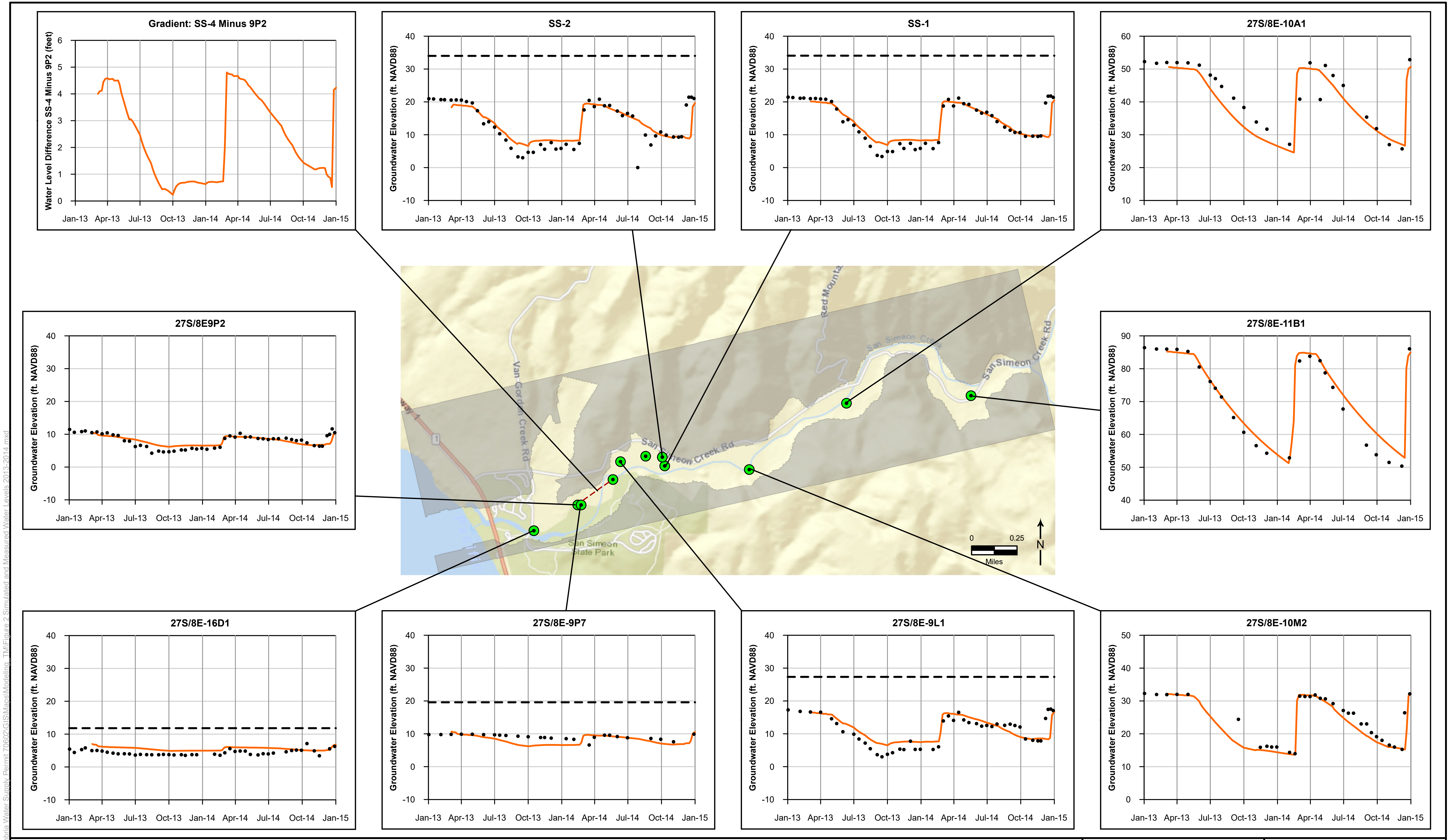
● Hydrograph Wells
🟥 Sustainable Water Facility
▨ Inactive Flow Cells

March 2022

TODD GROUNDWATER

Figure 1
Locations of Selected Wells in San Simeon Creek Basin

Path: T:\Projects\Cambria Water Supply Permit 70602\GIS\Maps\Modeling_TM\Figure 1 Locations of Selected Wells in San Simeon Creek Basin.mxd

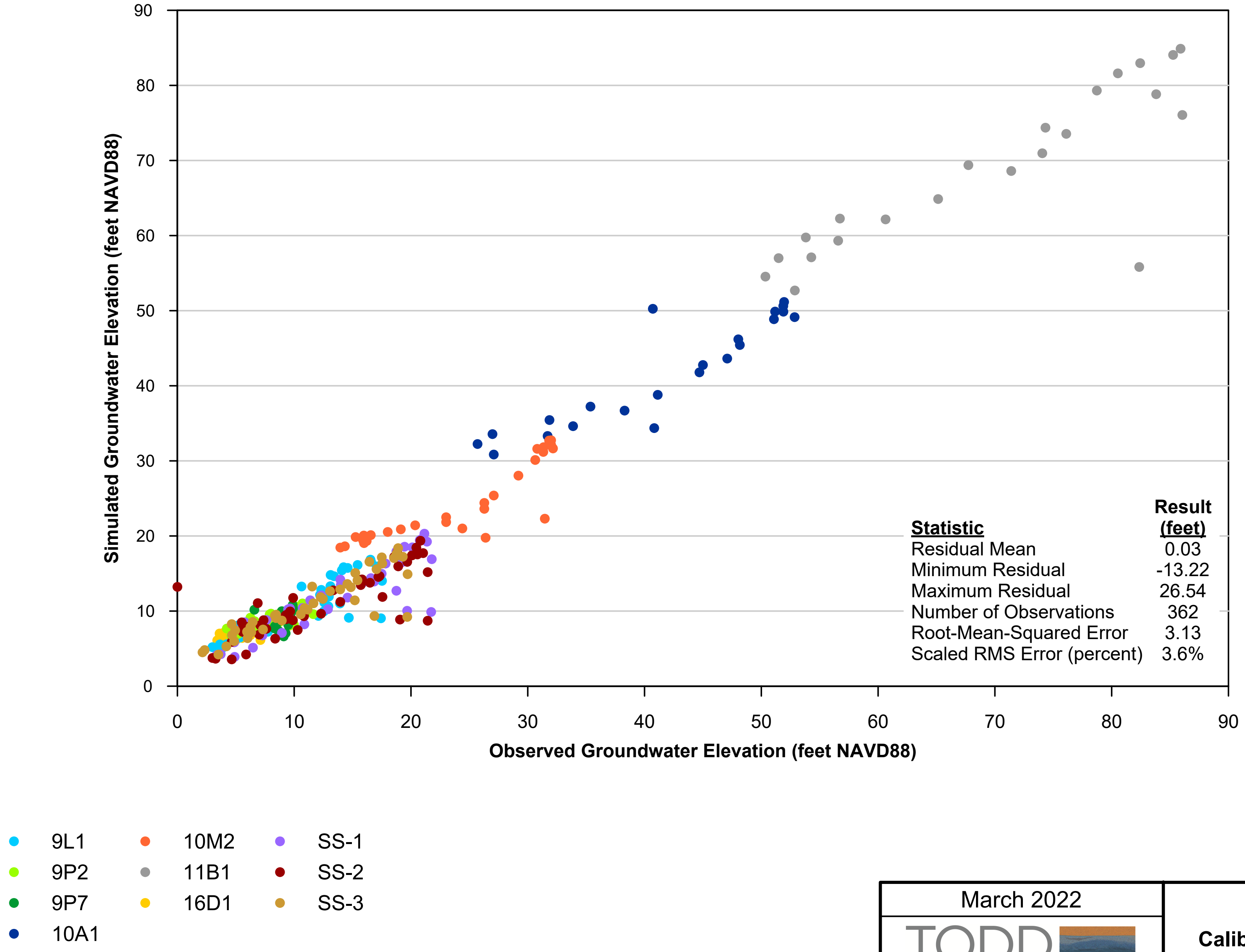


March 2022

TODD GROUNDWATER

Figure 2
Simulated and Measured Water Levels 2013-2014

Path: T:\Projects\Cambria Water Supply Permit 70602\GIS\Maps\Modeling_TM\Figure 2 Simulated and Measured Water Levels 2013-2014.mxd



Statistic	Result (feet)
Residual Mean	0.03
Minimum Residual	-13.22
Maximum Residual	26.54
Number of Observations	362
Root-Mean-Squared Error	3.13
Scaled RMS Error (percent)	3.6%

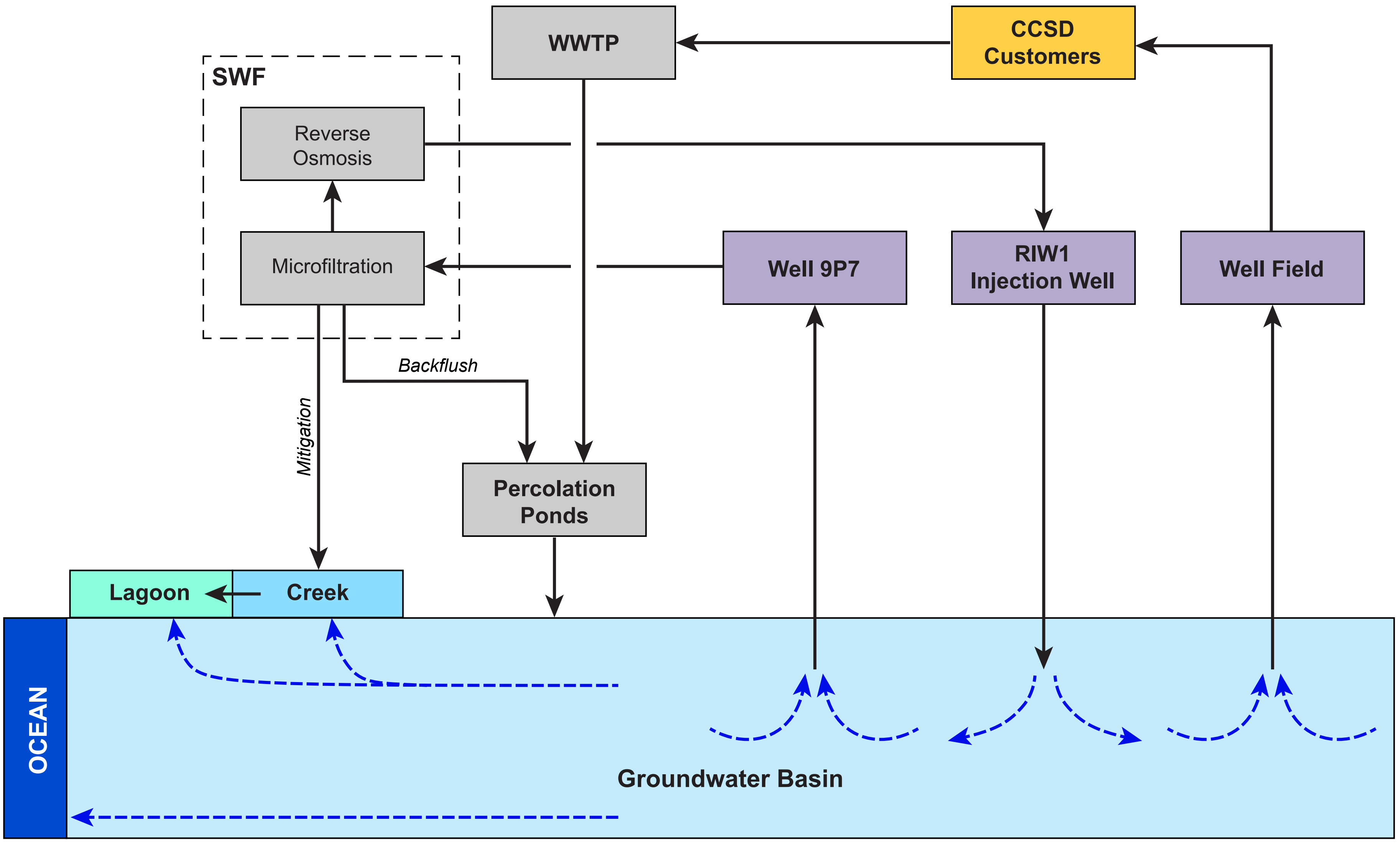
Data Source: T:\Projects\Cambria Water Supply Permit 70602\Model\Water_Levels\Target_results_Run017.xlsx Target_results_Run017

Path: T:\Projects\Cambria Water Supply Permit 70602\GRAPHICS\Figure 3 Calibration Residuals Plot and Statistics.gpj

March 2022

TODD GROUNDWATER

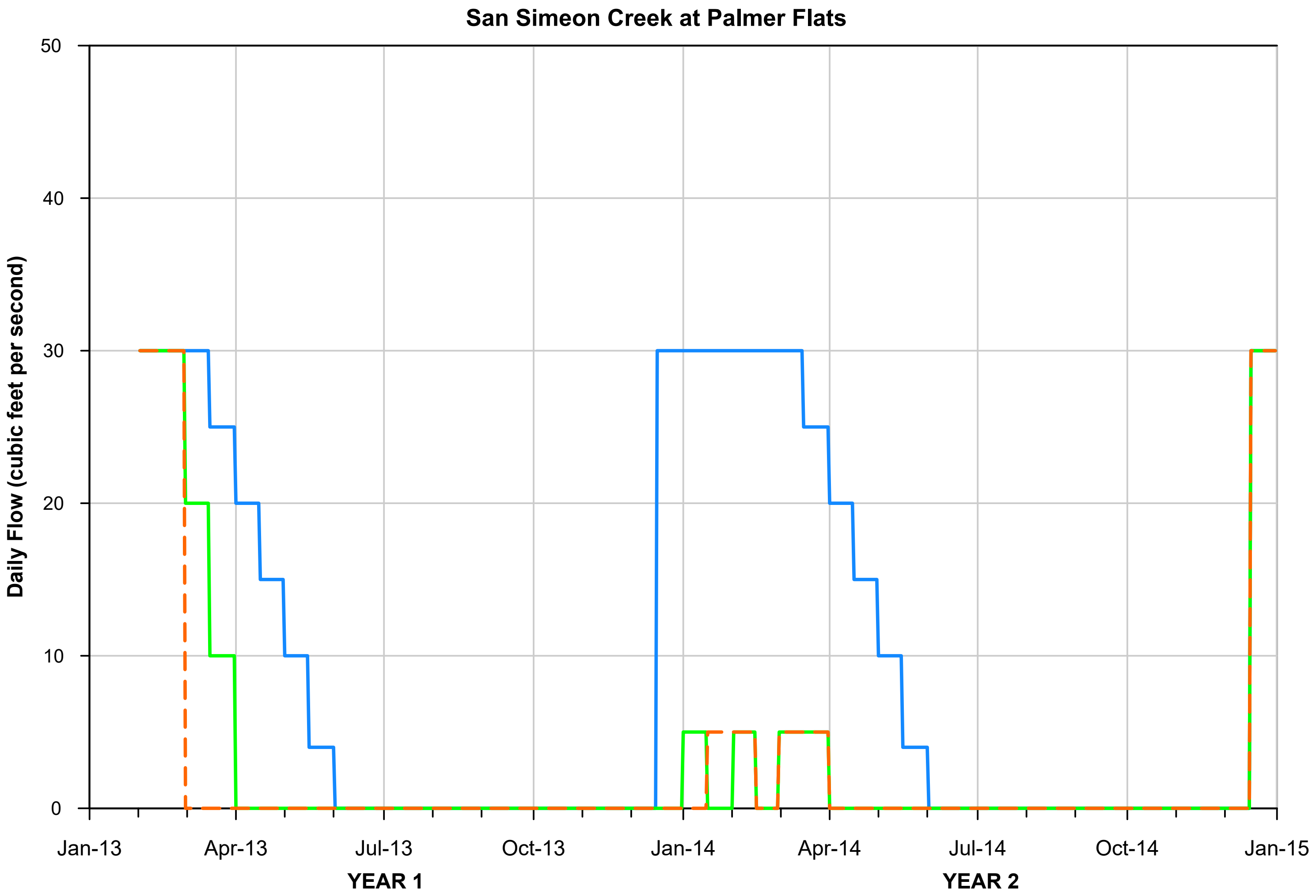
Figure 3
Calibration Residuals
Plot and Statistics



March 2022

TODD GROUNDWATER

Figure 4
Diagram of SWF and Groundwater System



- Normal
- Stage 4
- Stage 6

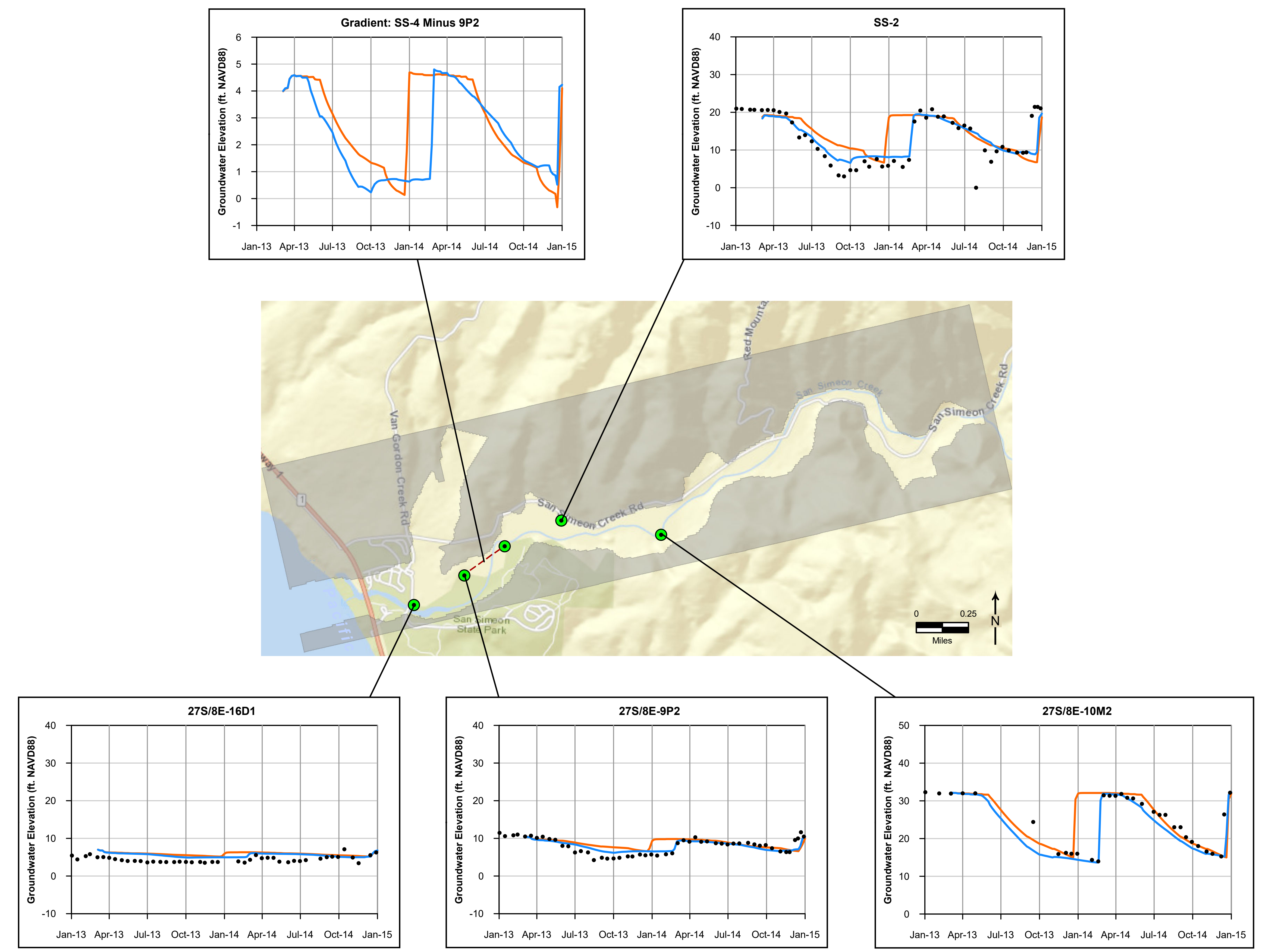
Data Source: T:\Projects\Cambria Water Supply Permit 70602\Model\SFR2\SFRprepIn_flow.xlsx SFRprepIn_flow

Path: T:\Projects\Cambria Water Supply Permit 70602\GRAPHICS\Figure 5 San Simeon Creek Inflow for Scenarios.gpj

March 2022

TODD GROUNDWATER

Figure 5
San Simeon Creek
Inflow for Scenarios



● Hydrograph Wells
▨ Inactive Flow Cells

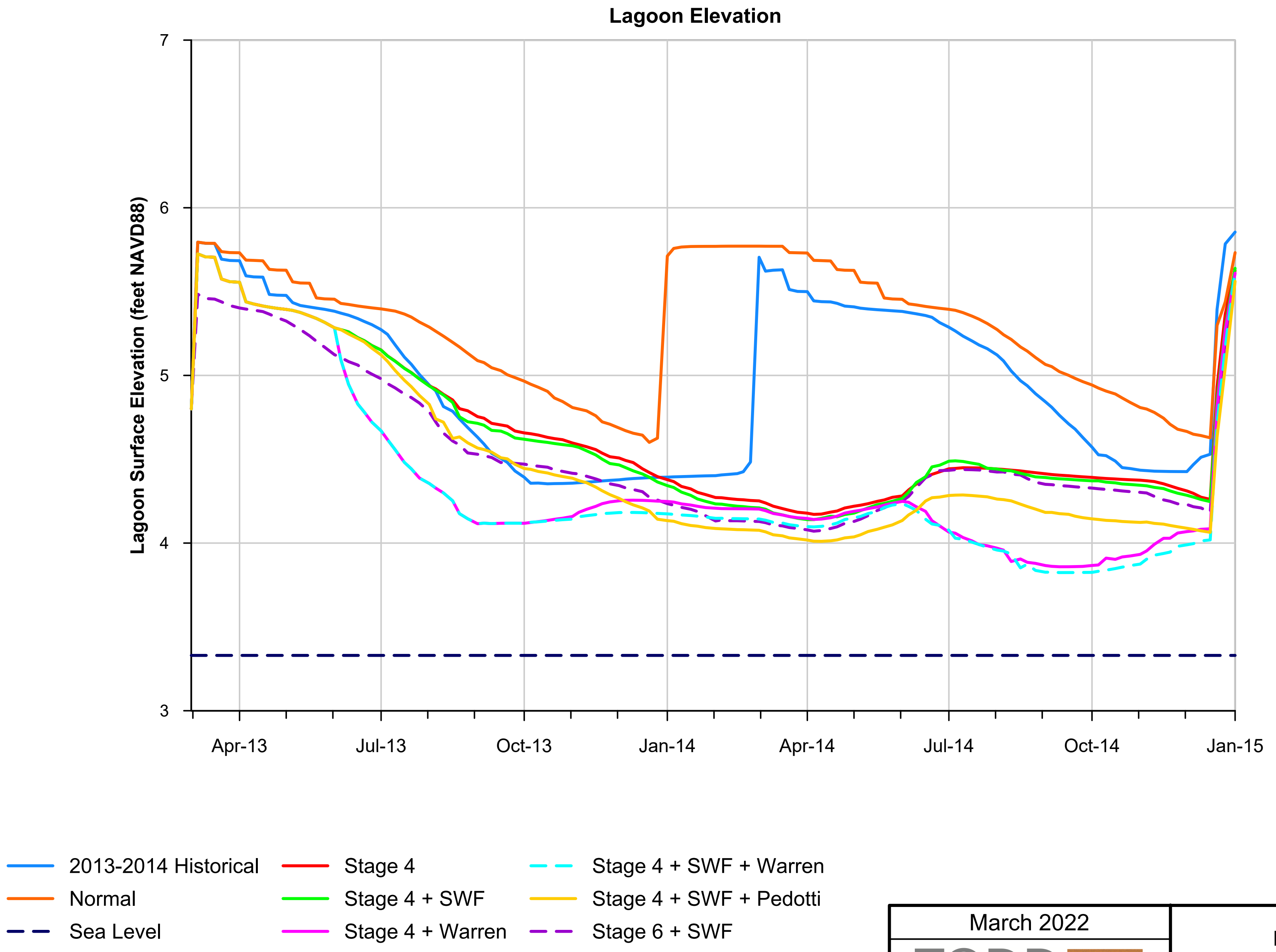
• Measured 2013-2014
— Simulated 2013-2014
— Normal Year

March 2022

TODD GROUNDWATER

Figure 6
Simulated Well Hydrographs - Historical and Normal Year

Path: T:\Projects\Cambria Water Supply Permit 70602\GIS\Maps\Modeling_TM\Figure 6 Simulated Well Hydrographs Historical and Normal Year.mxd



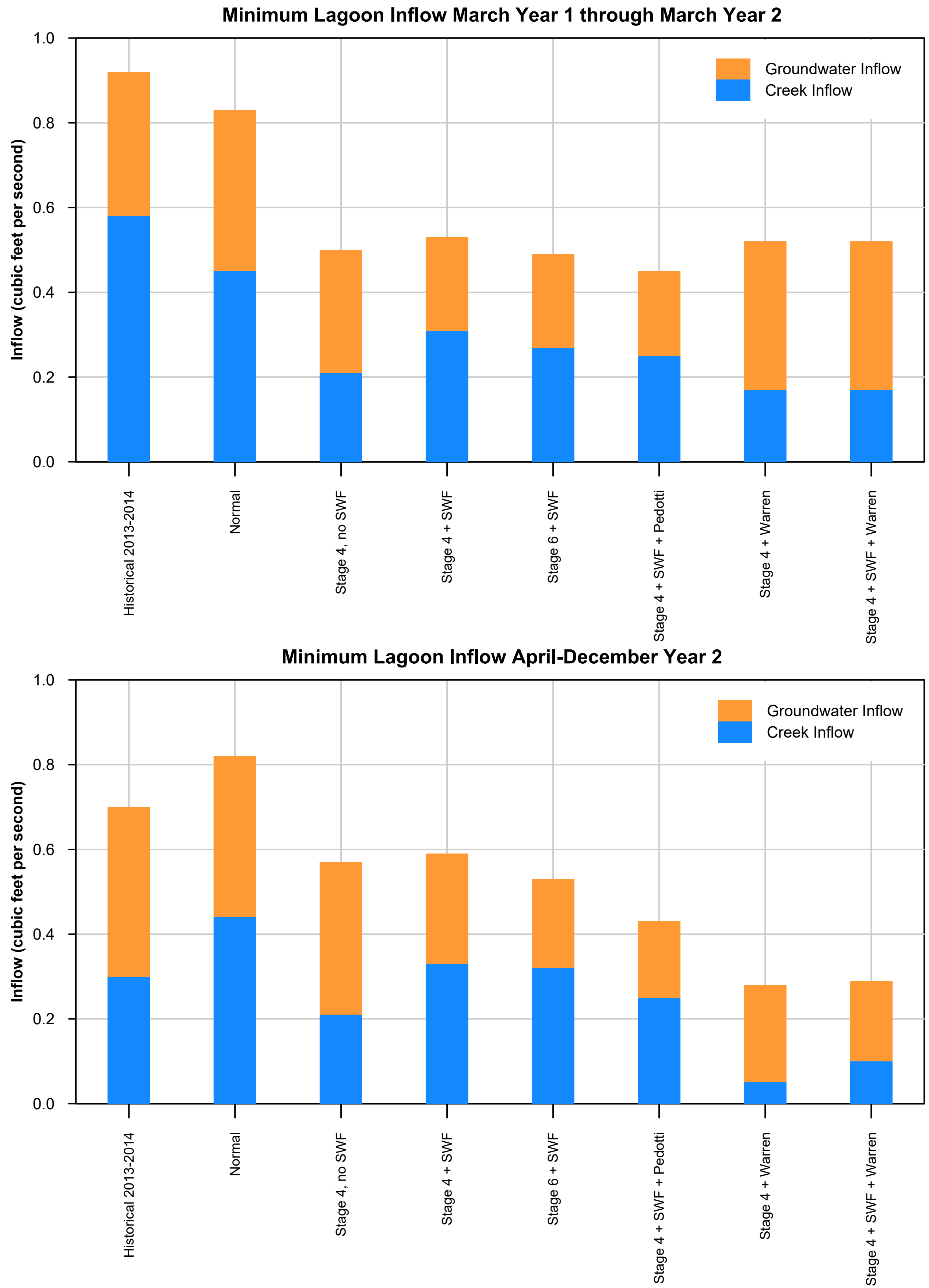
Data Source: T:\Projects\Cambria Water Supply Permit 70602\Model\GWV\SSCR2_gage_lak.xlsx Graph - all

March 2022

TODD GROUNDWATER

Figure 7
Simulated Lagoon Elevation

Path: T:\Projects\Cambria Water Supply Permit 70602\GRAPHICS\Figure 7 Simulated Lagoon Elevation.gpj



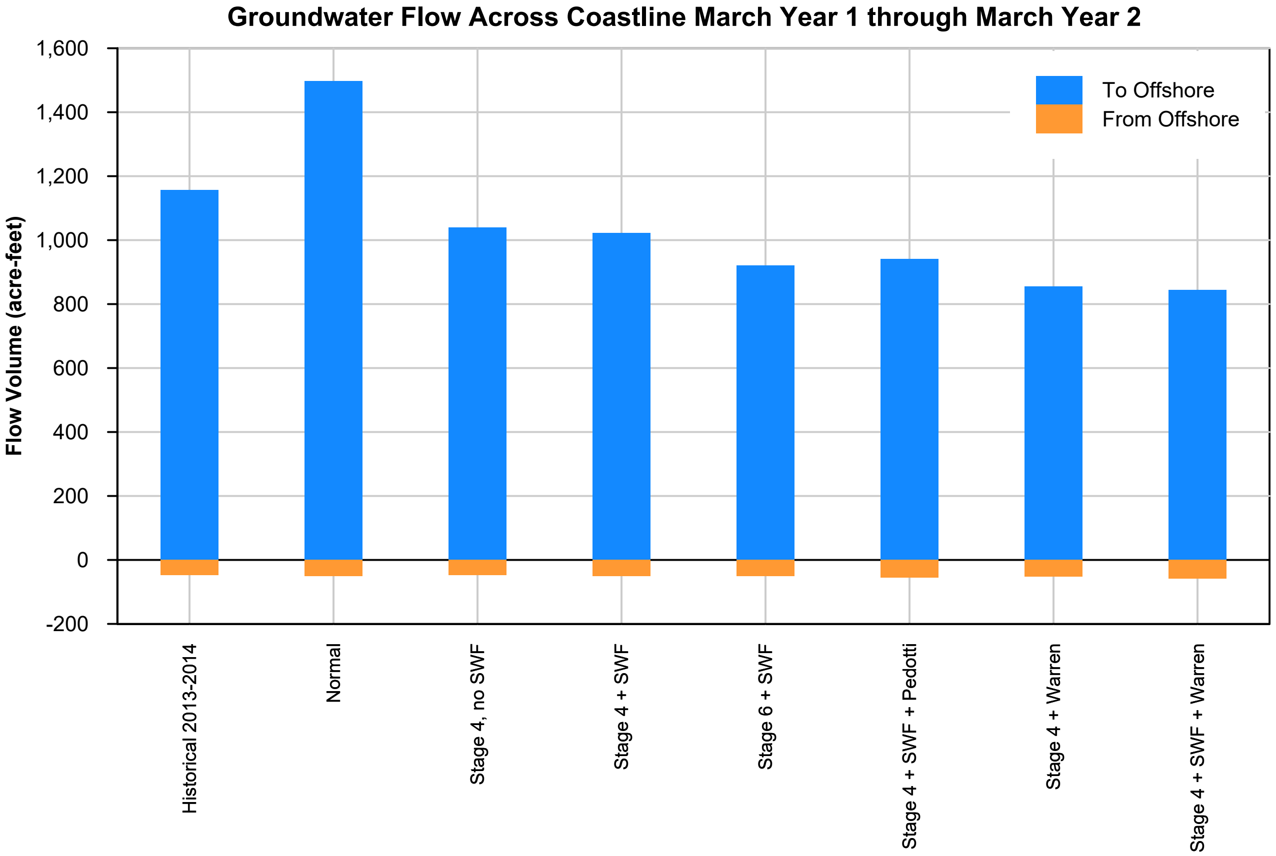
Data:
T:\Projects\Cambria Water Supply Permit 70602\Model_Modeling_log_CCSD.xlsx Scenarios

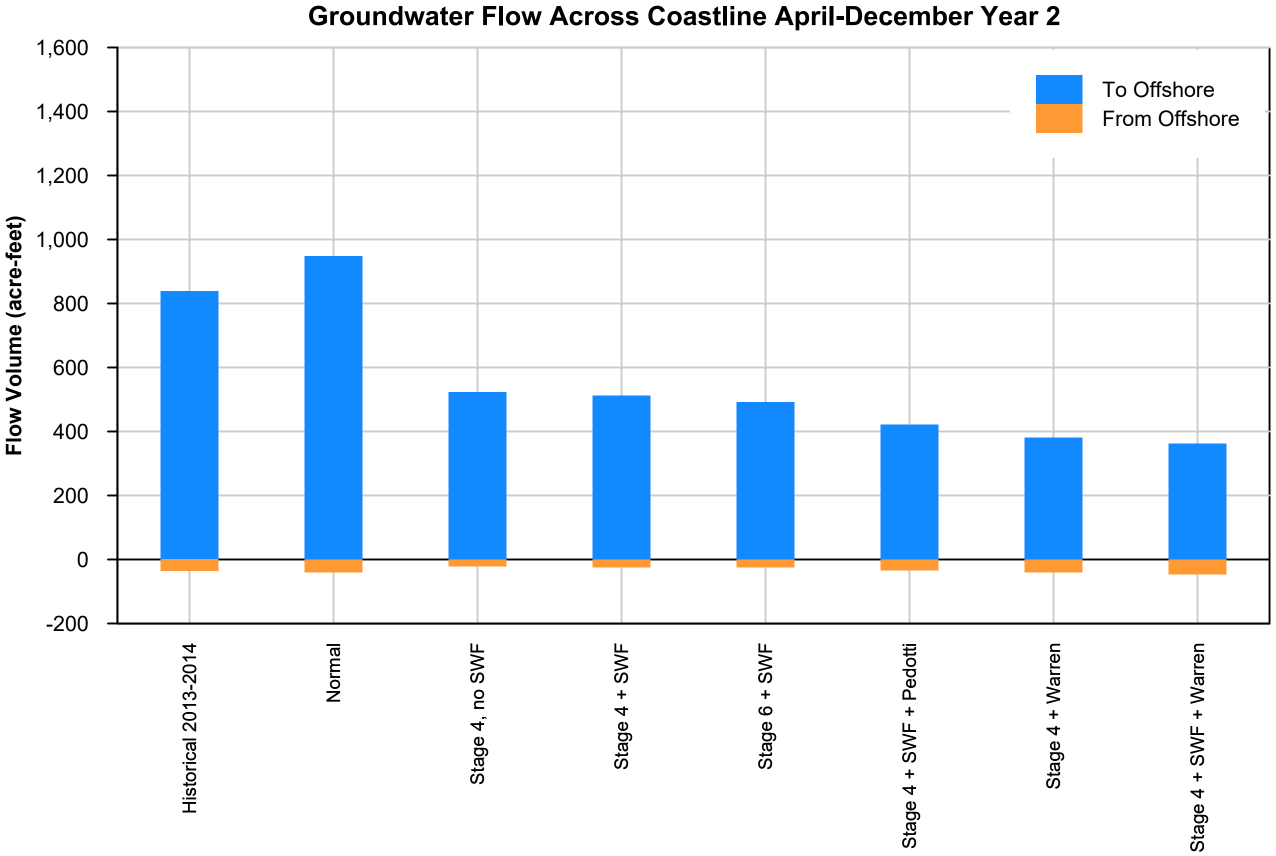
Path: T:\Projects\Cambria Water Supply Permit 70602\GRAPHICS\Figure 8 Minimum Dry Season Lagoon Inflow.gpj

March 2022

TODD GROUNDWATER

Figure 8
Minimum Dry Season
Lagoon Inflow





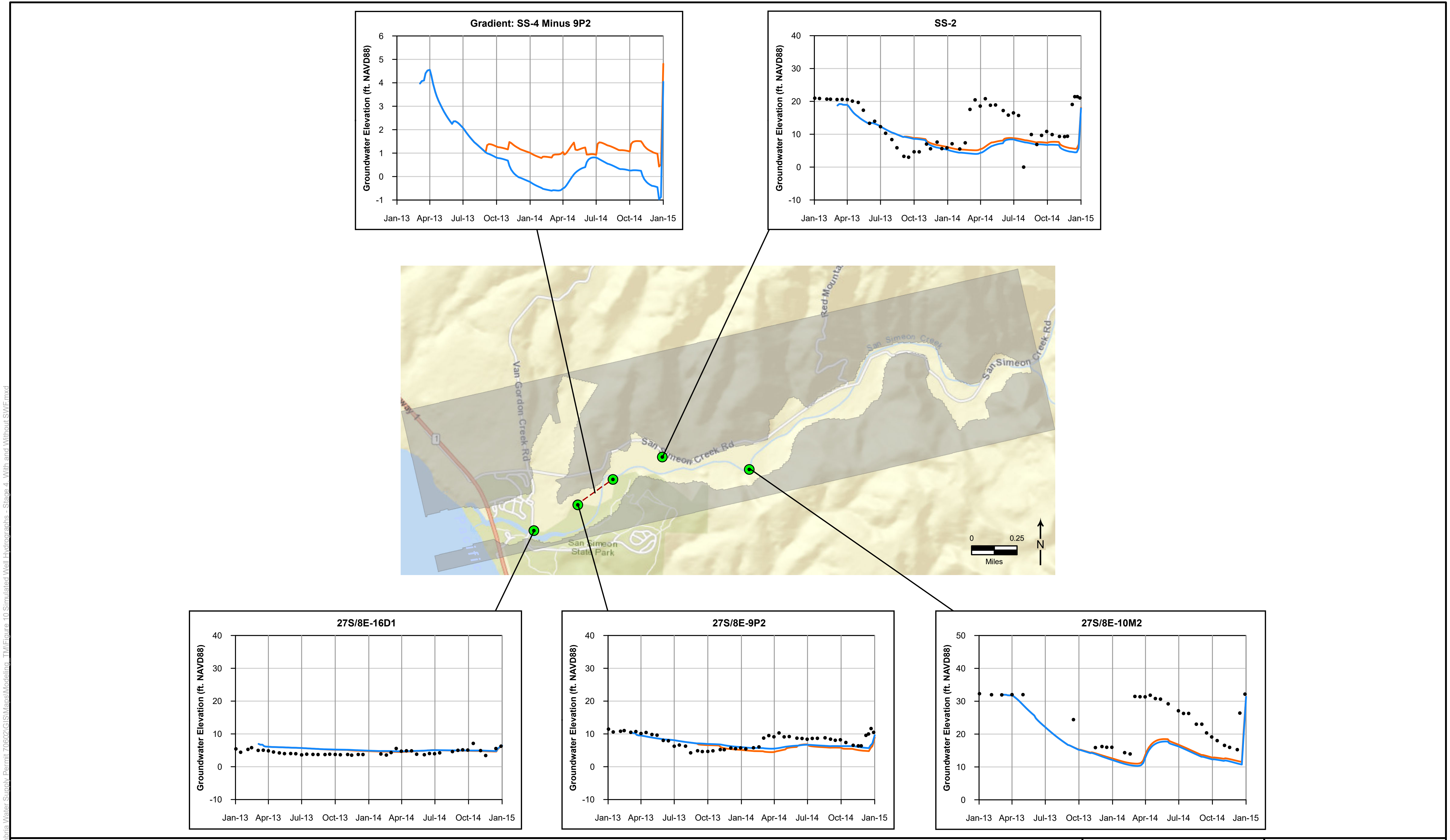
Path: T:\Projects\Cambria Water Supply Permit 70602\GRAPHICS\Figure 8 Minimum Dry Season Lagoon Inflow.gpj

Data:
T:\Projects\Cambria Water Supply Permit 70602\Model_Modeling_log_CCSD.xlsx Scenarios

March 2022

TODD GROUNDWATER

Figure 9
Groundwater Flow Across Coastline



● Hydrograph Wells

▨ Inactive Flow Cells

• Measured 2013-2014

Stage 4

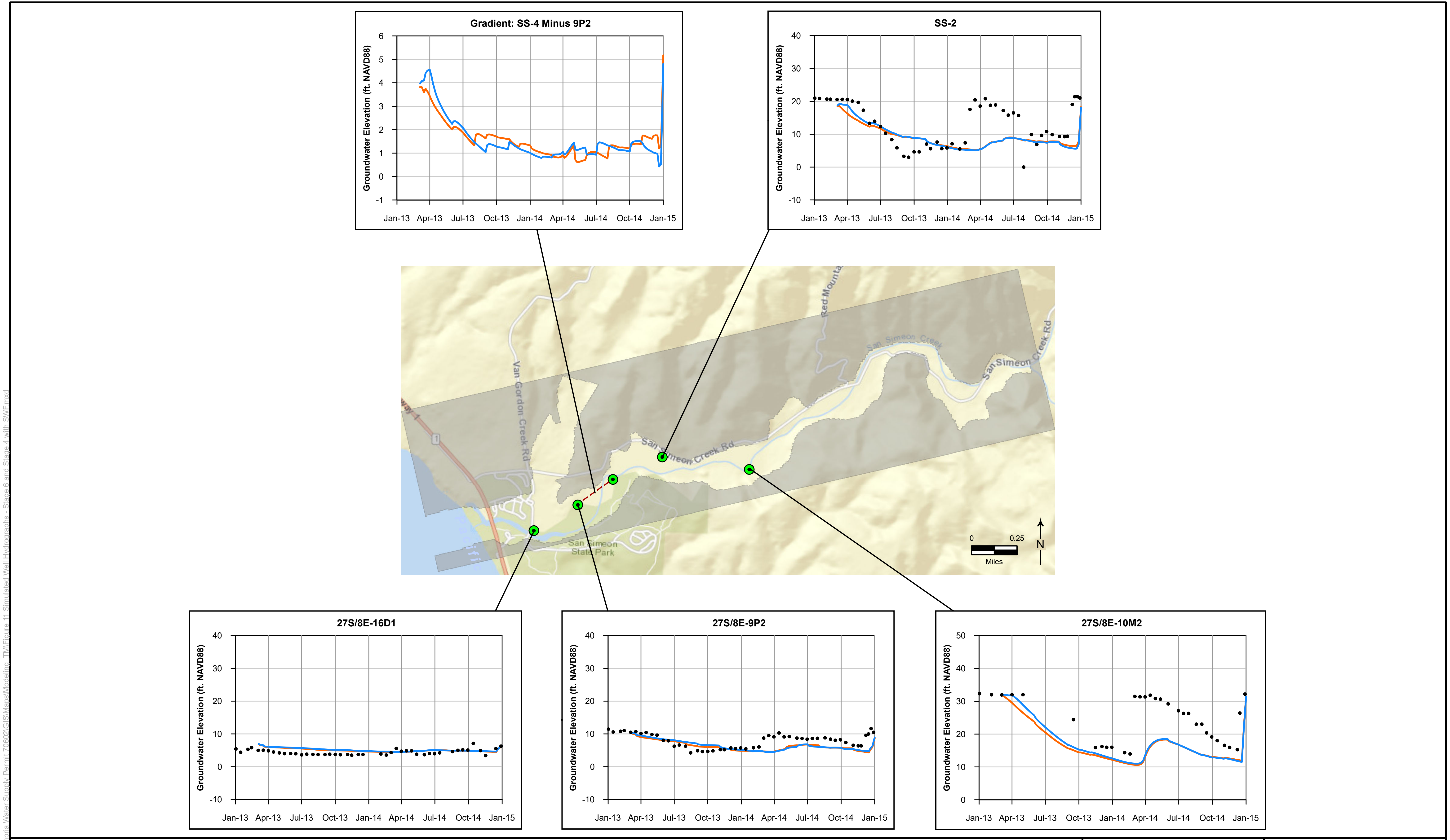
Stage 4 + SWF

March 2022

TODD GROUNDWATER

Figure 10
Simulated Well Hydrographs - Stage 4 With and Without SWF

Path: T:\Projects\Cambria Water Supply Permit 70602\GIS\Maps\Modeling_TM\Figure 10 Simulated Well Hydrographs - Stage 4_With and Without SWF.mxd



● Hydrograph Wells
▨ Inactive Flow Cells

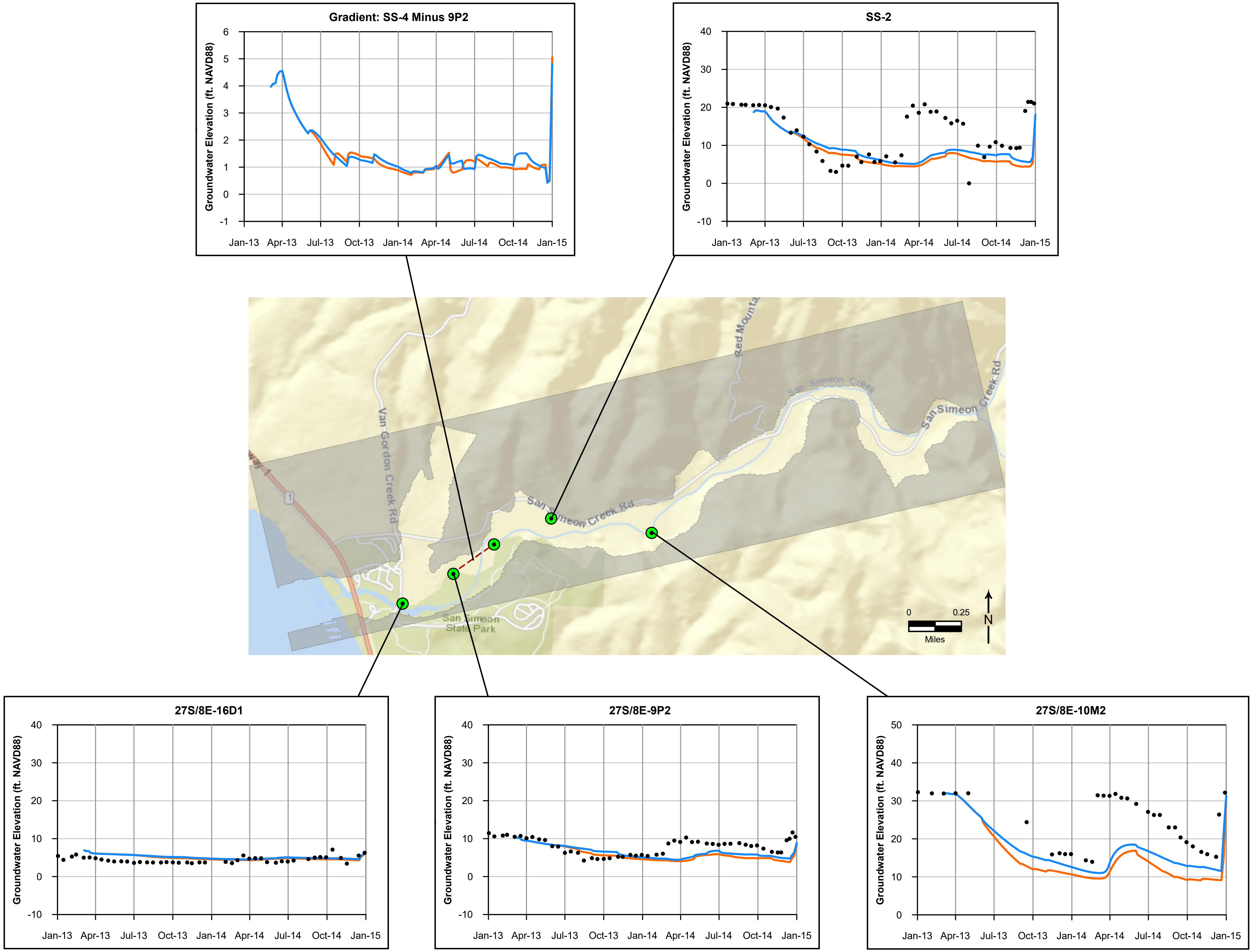
• Measured 2013-2014
— Stage 4 + SWF
— Stage 6 + SWF

March 2022

TODD GROUNDWATER

Figure 11
Simulated Well Hydrographs - Stage 6 and Stage 4 with SWF

Path: T:\Projects\Cambria Water Supply Permit 70602\GIS\Maps\Modeling_TM\Figure 11 Simulated Well Hydrographs - Stage 6 and Stage 4 with SWF.mxd



● Hydrograph Wells
▨ Inactive Flow Cells

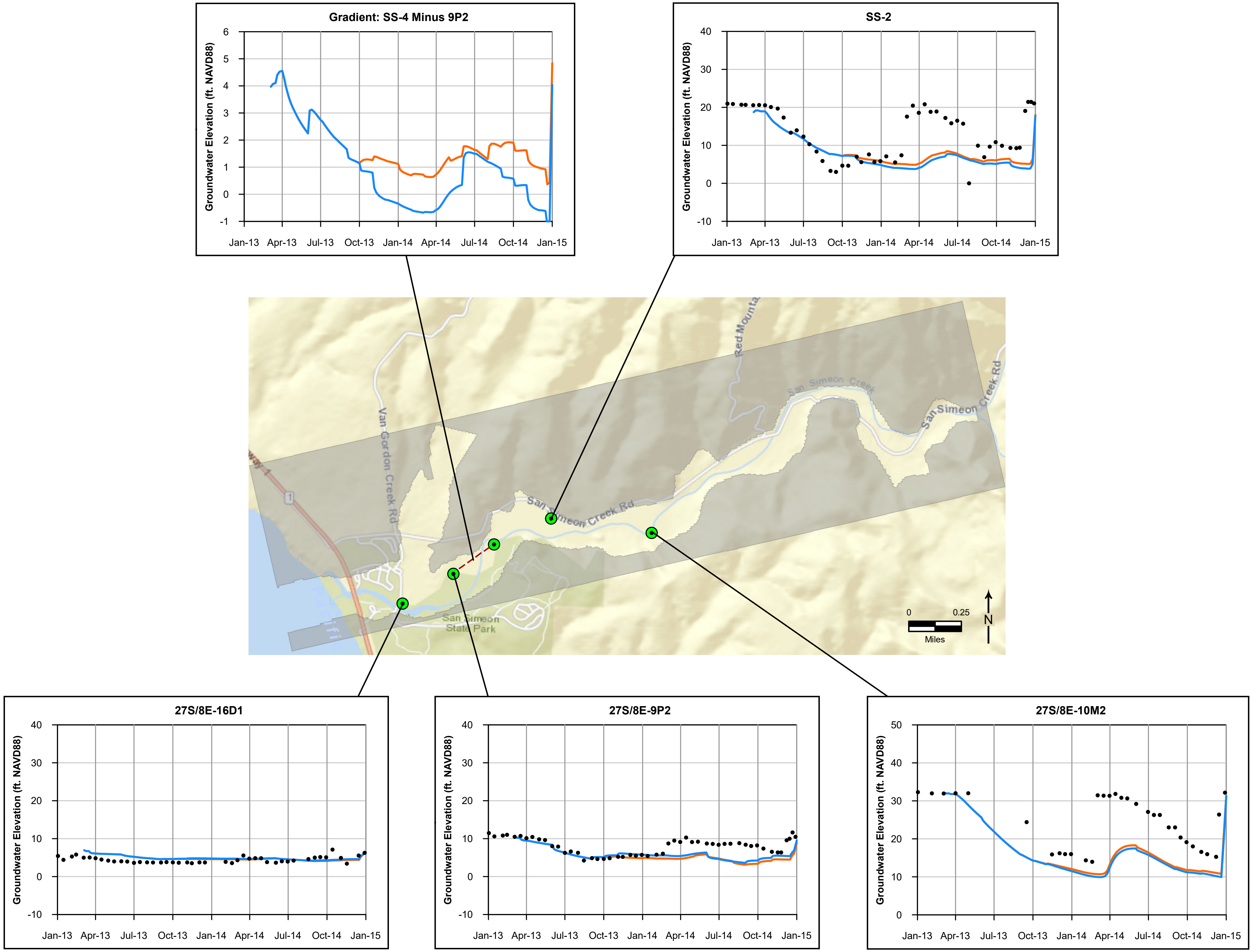
• Measured 2013-2014
— Stage 4 + SWF
— Stage 4 + SWF + Pedotti

March 2022

TODD GROUNDWATER

Figure 12
Simulated Well Hydrographs - Stage 4 with Increased Pedotti Pumping

Path: T:\Projects\Cambria Water Supply Permit 70602\GIS\Maps\Modeling_TM\Figure 12 Simulated Well Hydrographs - Stage 4 with Increased Pedotti Pumping.mxd



● Hydrograph Wells
▨ Inactive Flow Cells

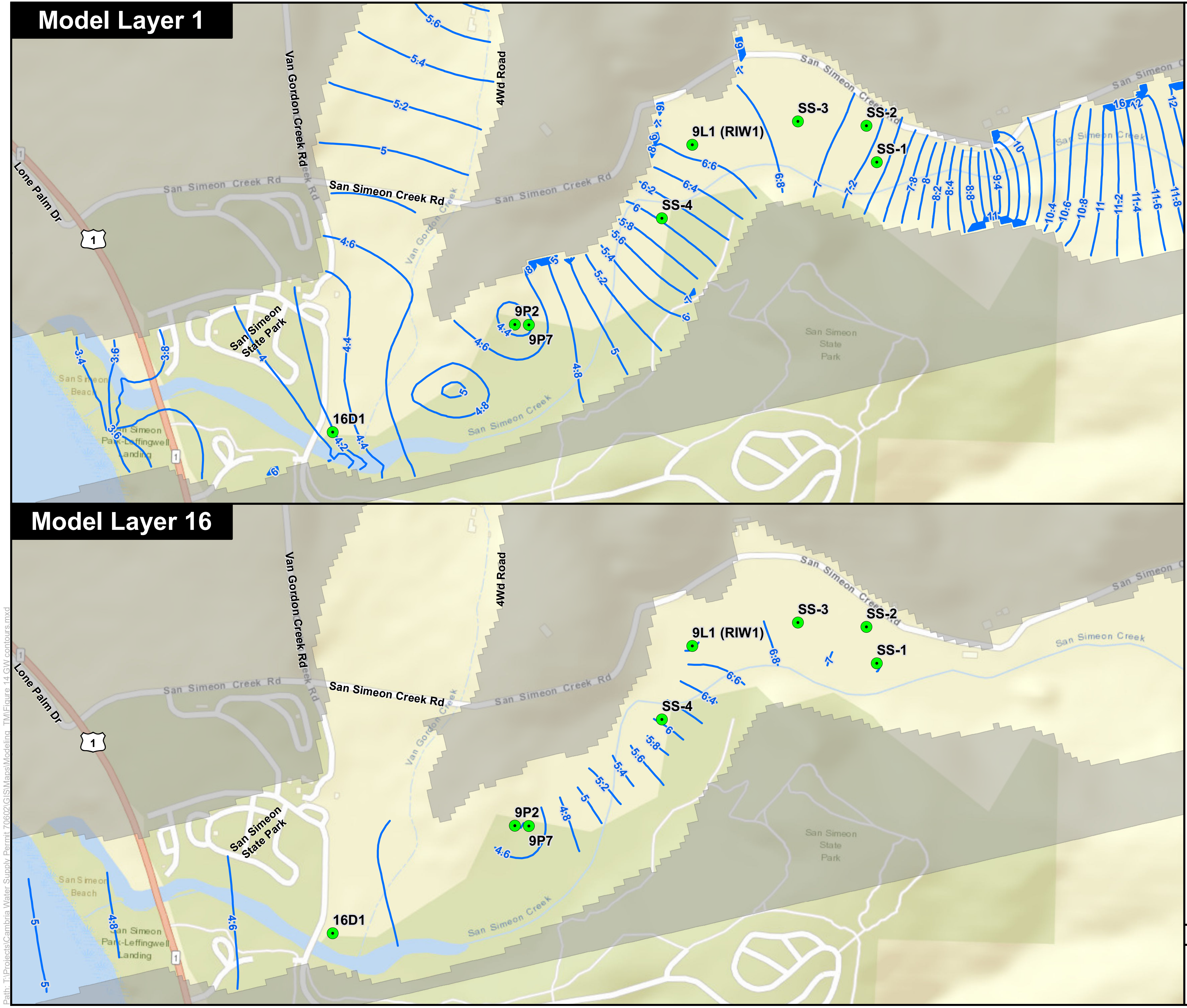
• Measured 2013-2014
— Stage 4 + Warren
— Stage 4 + SWF + Warren

March 2022

TODD GROUNDWATER

Figure 13
Simulated Well Hydrographs - Stage 4 with Increased Warren Pumping

Path: T:\Projects\Cambria Water Supply Permit 70602\GIS\Maps\Modeling_TM\Figure 13 Simulated Well Hydrographs - Stage 4 with Increased Warren Pumping.mxd



Scenario: Stage 4 + SWF + Warren
November of Year 2

● Hydrograph Wells
— Groundwater Elevation (feet NAVD88)
▨ Inactive Flow Cells

March 2022

TODD GROUNDWATER

Figure 14
Simulated Groundwater Elevations in Shallow and Deep Layers