TECHNICAL MEMO

WOOD RODGERS
BUILDING RELATIONSHIPS ONE PROJECT AT A TIME

Title:	ABSL Complex and Nave Gardens Flood Drainage Improvements Feasibility Study (8563016)		
Prepared For:	Roger Leventhal, PE Hannah Lee, PE	**Prepared By:**	Andrew Augustine, PE
Reviewed By:	Dan Matthies, PE		
Date:	August 26, 2024		
Purpose:	Hydrologic and Hydraulic Modeling and Alternatives Analysis (Task 4 & 5)		

1 INTRODUCTION

The Novato Creek watershed is located in Marin County, California, north of San Francisco Bay. The watershed is approximately 45 square miles in area, flows easterly from Stafford Dam in the upper portions of the watershed to San Francisco Bay, and has two major tributaries. The Arroyo Avichi Creek tributary flows from the southwest to the northeast with a drainage area of approximately 1.6 square miles, and flows into Novato Creek south of Downtown Novato. There is a flow diversion weir structure on Arroyo Avichi Creek just upstream of the South Novato Boulevard crossing that diverts higher flows from the creek through the Baccaglio Basin, the Scottsdale Marsh, the Scottsdale Pond, and Lynwood Basin (ABSL) Complex – all low-lying open spaces adjacent to Novato Creek. Lynwood Basin then discharges to Novato Creek via the Lynwood Pump Station and Cheda Pump Station further downstream in the Novato Baylands. The lower flows in Arroyo Avichi Creek that is not diverted drains directly to Novato Creek. Warner Creek is the second major tributary to Novato Creek and is approximately 5.2 square miles in area. Similar to Novato Creek, it flows easterly from the upper portions of the watershed and connects to Novato Creek south of Downtown Novato. See **Figure 1**.

Figure 1 – ABSL Complex

The Marin County Flood Control and Water Conservation District (District) has been aware of flooding when there is high water surface elevations in the creeks adjacent to the Novato Downtown area. Specifically, at the confluences of Arroyo Avichi Creek and Warner Creek with Novato Creek, there is a small single-family residential development named Nave Gardens that has been the subject of multiple complaints by local citizens due to the frequent flooding experienced by the community. Nave Gardens is bounded to the north and east by Novato Creek, to the south by the Arroyo Avichi Creek, and to the west by South Novato Boulevard. See **Figure 2**. Downtown Novato, Nave Gardens, and the ABSL complex are located within a Federal Emergency Management Agency (FEMA) designated Flood Hazard Zone, as displayed in **Figure 3**. The District has also documented historical flooding in Nave Gardens, as displayed in **Figure 4**.

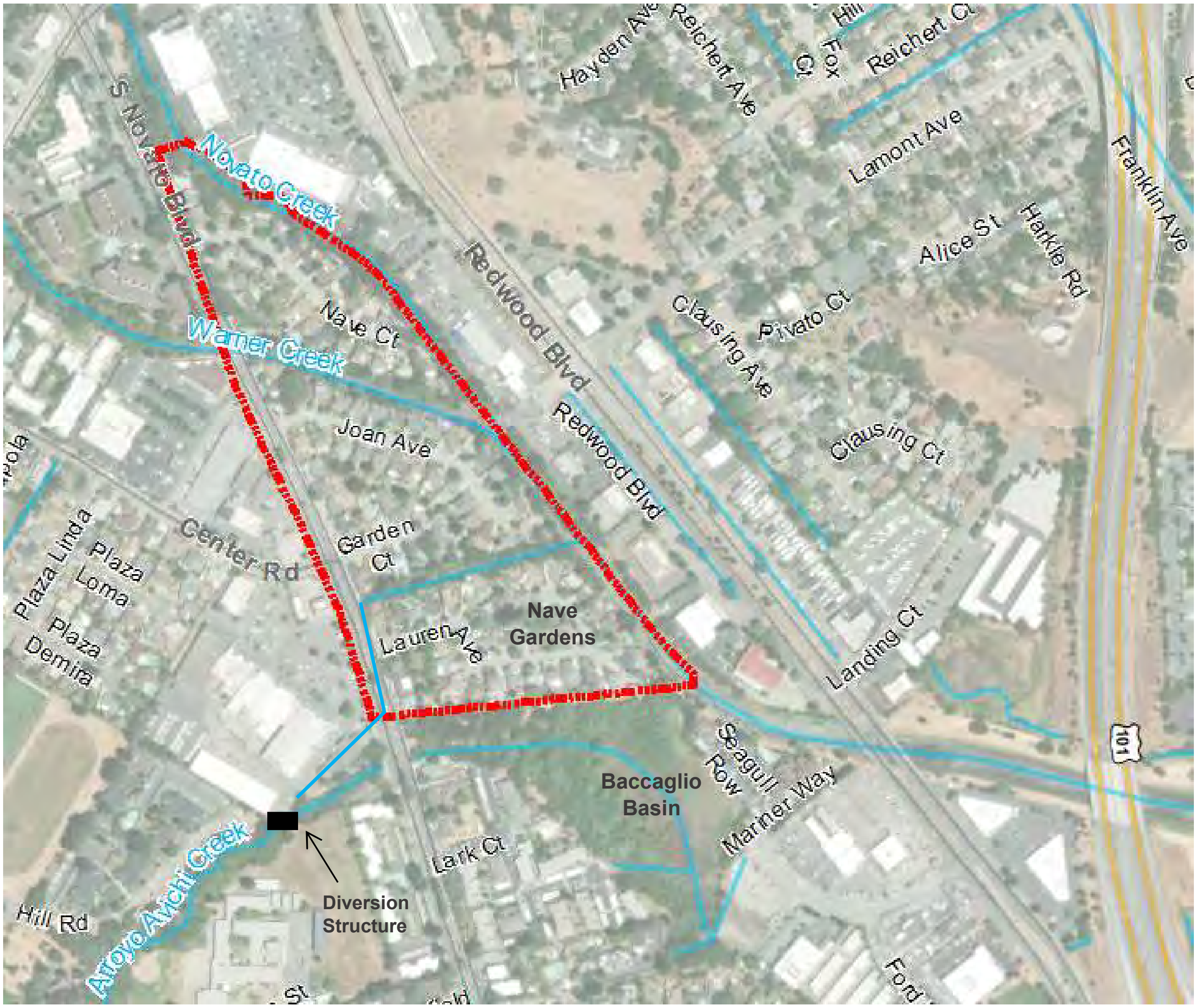


Figure 2 – Vicinity Map of Nave Gardens Outlined in Red

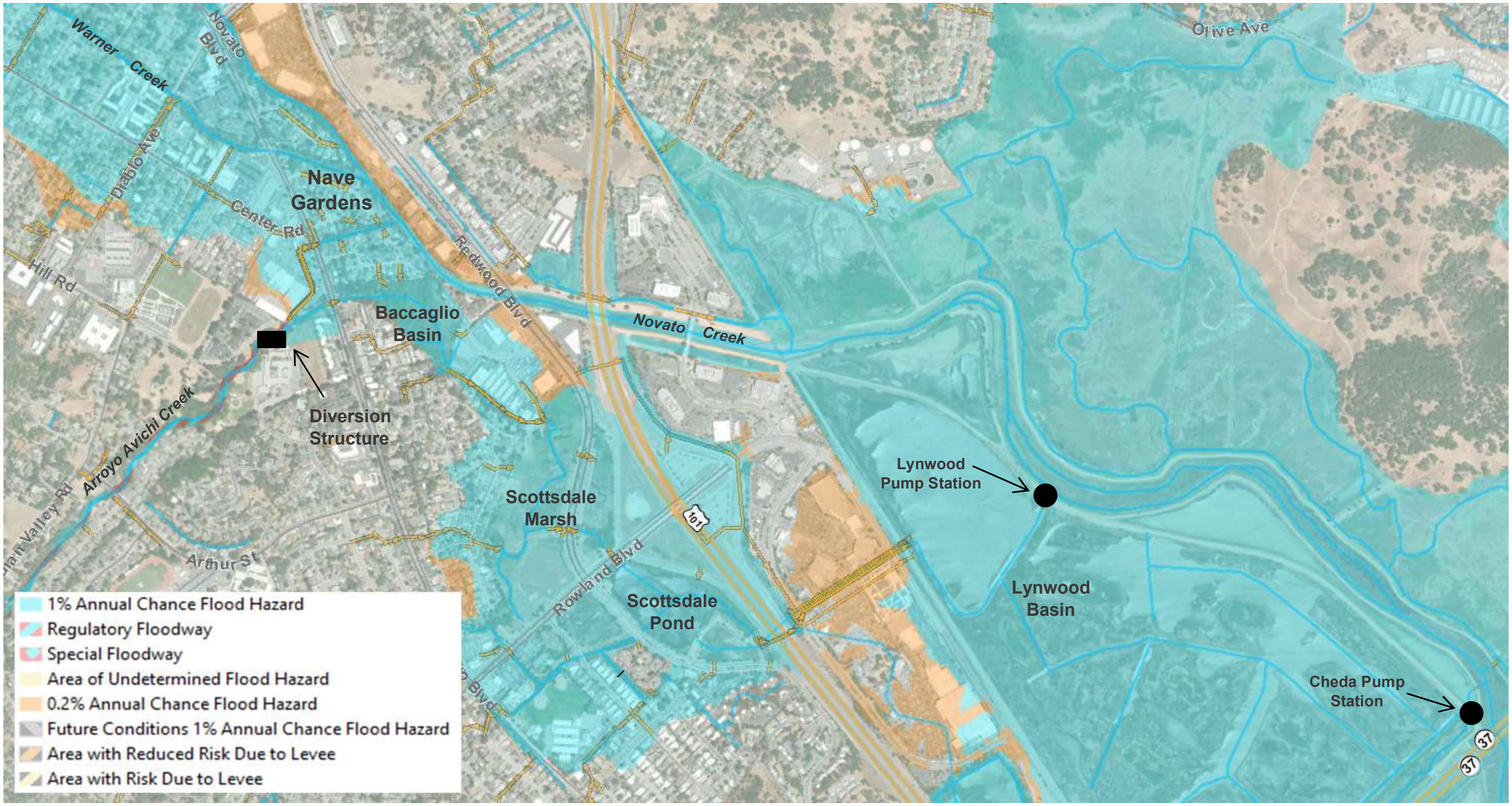


Figure 3 – FEMA Flood Hazard Zones

Figure 4 – January 31, 2024 Flooding of Nave Gardens on Joan Avenue (Left) and at the Joan Avenue cul-de-sac (Right)

To alleviate the flooding of Nave Gardens and downtown Novato, the District wanted to evaluate if the high flow diversion structure on Arroyo Avichi Creek could be modified to increase flows into the ABSL wetlands complex where the water has ecological benefits and achieve some flood reduction benefits to downtown Novato and Nave Gardens. The District also wanted to determine if other improvements can be proposed to alleviate the flooding of Nave Gardens and downtown Novato.

In addition to the downtown Novato and Nave Gardens flooding, the District required an evaluation of the benefits and costs for repairing, reoperating or relocating the Lynwood Pump Station located on the northern edge of Lynwood Basin adjacent to the south bank of Novato Creek. Combined with the Cheda Pump Station, it provides the only means of removing runoff from Lynwood Basin by pumping into Novato Creek. The pump station has an approximate capacity of 165 cubic feet per second (cfs), consisting of a 36” pump with an 80 cfs capacity, a 30” pump with a 55 cfs capacity, a 24” pump with a 25 cfs capacity, and a 10” pump with a 4.4 cfs capacity. The pump station was built in 1968. In 2005 the District designed a rehabilitation project for the Lynwood Pump Station, but the advisory board at the time asked not to implement it due to the high estimated cost. These rehabilitation design plans were refreshed for the purposes of applying for FEMA grant funds in 2017. The estimated construction cost to rehabilitate the pump station is $3 million. The grant application was not successful due to the perception that the project is primarily a major maintenance project rather than a flood mitigation project. Due to the high cost associated with rehabilitating the pump station, and lack of funding sources, the District would like to determine if any cost-saving alternatives exist.

In response, Wood Rodgers, Inc. is providing flood control planning services to the District for the ABSL Complex and Nave Gardens Flood Drainage Improvements Feasibility Study Project and recommending cost saving alternatives for the operation of the Lynwood Pump Station.

2 PROJECT OBJECTIVES

The project objectives are listed below:

1. Evaluate the costs and benefits of increasing the high flow diversion from Arroyo Avichi Creek into Baccaglio Basin and through the ABSL complex.
2. Evaluate the costs and benefits of additional improvement projects that reduce or eliminate flooding in downtown Novato and Nave Gardens.
3. Evaluate the costs and benefits of repairing, reoperating or relocating the Lynwood Pump Station.

3 DATA COLLECTION

Wood Rodgers provided the existing 2016 City of Novato Drainage Master Plan InfoWorks ICM hydrologic and hydraulic model (Novato DMP ICM) performed for the City of Novato under a separate contract as the basis for the project. Additional data was then collected to facilitate the unique modeling requirements of the project:

1. Bathymetric Survey of Lynwood Basin and Scottsdale Pond.
2. Detailed storm sewer network definition from Marin Map[1].
3. Field Inspection and survey of hydraulic infrastructure along the ABSL complex.
4. Rain and tide data from Marin OneRain[2].
5. Historic flow data of Novato Creek at the Novato Library from the USGS[3].
6. HEC-RAS hydraulic model of Novato Creek and its tributaries from the District. Constructed by Stetson Engineers Inc. in May 2020.
7. As-builts of hydraulic structures from the District.
8. Lynwood and Cheda Pump Station as-builts, pump curves, and operation documentation from the District
9. ADS level sensors installed at five locations in the ABSL complex to collect calibration data of the 2022 – 2023 wet season. Wood Rodgers provided a memorandum to the District in September 2022 describing the ADS gage installation in detail, which is provided in this document as **Appendix A**. The specific location of the ADS gages is summarized below.
    a. Location 1: Arroyo Avichi Diversion Weir
    b. Location 2: Arroyo Avichi Creek at South Novato Boulevard
    c. Location 3: Baccaglio Creek at South Novato Boulevard
    d. Location 4: Scottsdale Pond
    e. Location 5: Lynwood Basin

Exhibit A displays additional detail of collected data.

[1] https://www.marinmap.org/dnn/
[2] https://marin.onerain.com/map/?view=www_marincounty
[3] https://waterdata.usgs.gov/monitoring-location/11459500/#parameterCode=00065&period=P7D&showMedian=false

4 MODEL REFINEMENT AND ASSUMPTIONS

The Novato DMP ICM model (Ref. 6) was available for use in this project and was reviewed for opportunities to improve the model's geometry, hydrology, and hydraulics for the purposes of this project. Several aspects of the model were identified for improvement, as described in the following sections.

The refined Novato DMP ICM model after the collective improvements described below is hereby referred to as the ABSL ICM Model.

4.1 Geometry Refinement

The Novato DMP ICM model represented the geometry of the ABSL complex rather simply, and further refinement was required to accurately represent its unique characteristics. Using survey and inspection data collected in **Section 3**, several hydraulic structures were updated and/or verified with the survey.

The Arroyo Avichi diversion weir, which plays a critical role in diverting higher flows to the ABSL complex, was updated with field survey data. The survey included the diversion weir elevation and length, as well as the open channel cross sections just upstream and downstream of the diversion.

Additional locations updated with survey data included the box culverts on Arroyo Avichi Creek and Baccaglio Creek under South Novato Boulevard, the 48" CMP storm sewer connecting the Baccaglio Basin and western Scottsdale Marsh, the 42" RCP and 31" x 50" arch storm sewers connecting the western Scottsdale Marsh to the eastern Scottsdale Marsh, and the twin 48" RCP connecting the eastern Scottsdale Marsh to the Scottsdale Pond. Scottsdale pond and Lynwood Basin were updated with bathymetric surveys.

For difficult to access hydraulic structures that cannot be inspected or surveyed, geometry verification and updates were accomplished with as-builts. The Lynwood Pump Station[4] and Cheda Pump Station[5] were both updated in the model using several plan and profile details contained in their respective as-built drawings. Because the Lynwood Pump Station and the Cheda Pump Station operate on an as-needed basis, Wood Rodgers requested pump station logs for both pump stations, and used them to program the ICM model to turn on and off as reported in the pump logs during calibration. In addition, the complex system of storm sewers, culverts, and open channel between Scottsdale Pond and Lynwood Basin was verified and updated with an as-built[6] plan.

The Novato DMP ICM Model had no storm sewer infrastructure defined within the Nave Gardens development. Therefore, additional storm sewers were built into the model using data from MarinMap[1].

See **Exhibit A.**

4.2 Hydrologic Refinement

Watershed boundaries were redeveloped in areas where additional storm sewers were built into the model (for example, in Nave Gardens). These new watersheds were necessary to ensure the newly modeled storm sewers have proper runoff flowing to them so the hydraulic effects can be reflected. These watersheds and all remaining watersheds in the Novato DMP ICM Model were updated with hydrologic parameters consistent with Wood

[4] Improvement Plan – Lynwood Slough Storm Drainage Facilities. Storm Pumping Station – Structural Details. April 19, 1968

[5] Plans for Construction of Cheda Creek Pump Station Repair Novato, CA Project No. LUFX-11. June 2011

[6] Improvement Plans for the Construction of the Lynwood Box Culvert, March 13, 1992

Rodgers' latest modeling methodologies for Marin County. This included assigning the Horton SWMM infiltration model[7], the Snyder Unit Hydrograph[8], and assigning watershed imperviousness based on land use data[8].

4.3 Hydraulic Refinement

The 1D cross sections in Novato Creek used in the Novato DMP ICM Model were collected in 2017, which represented a post dredged condition in the creeks. Conversations with the District indicated after Novato Creek is dredged, sediment quickly settled back into the channel, and it returned to a pre-dredged condition within several months to a couple of years depending on flow conditions that move sediment. Therefore, a pre-dredged condition in Novato Creek was determined to be a more appropriate representation of normal channel conditions in Novato Creek. The District provided Wood Rodgers with a HEC-RAS model of the Novato Creek watershed (constructed in 2020) that was constructed using pre-dredge cross sections. In addition, the HEC-RAS model represented a more up-to-date definition of the geometries of Novato Creek, Warner Creek, and Arroyo Avichi Creek. Therefore, these channels' 1D cross sections in the Novato DMP ICM Model were replaced with cross sections from the HEC-RAS model. Sections of Warner Creek and other smaller open channels that were not included in the HEC-RAS model were updated with a DEM.

Finally, Manning's roughness along Novato Creek and Warner Creek between Diablo Avenue and Highway 101, and Arroyo Avichi Creek between Arthur Street and Novato Creek were updated based on aerial photography.

See **Exhibit A.**

[7] https://help.autodesk.com/view/IWICMS/2024/ENU/?guid=GUID-3AD0EFBA-92CC-481E-8C3B-7502D51C0F19
[8] https://acfloodcontrol.org/the-work-we-do/the-work-we-do-hydrology-manual/

4.4 Model Assumptions and Limitations

The following model assumptions and limitations are stated below:

1. The District operates the Lynwood and Cheda pump stations on an as-needed basis, and therefore does not have automatic on-off settings. For all model simulations (except calibration), an assumed pumping schedule was used to turn the pumps on and off. The pump schedule was assigned using guidance from District documentation[9] and is displayed in **Table 1**.

Table 1 – Assumed Lynwood and Cheda Pumping Schedules

Pump	On Elevation (feet, NAVD88)	Off Elevation (feet, NAVD88)
Lynwood 10"	2.7	1.7
Lynwood 24"	3.0	1.7
Lynwood 30"	3.3	1.7
Lynwood 36"	3.5	1.7
Cheda 20"	3.7	2.7
Cheda 20"	3.7	2.7

2. For all simulations (except calibration), the starting water surface elevation of Lynwood Basin was assumed to be approximately 1.5 feet NAVD88. This elevation was set based on District documentation[9].

3. The extent of the 2D built for the Novato DMP ICM Model was assumed to be sufficient for the purposes of this project. The Novato DMP ICM Model 2D extents covered most of the Novato Creek watershed including the ABSL Complex; however, a limited 2D area was defined outside of the watershed. This limits the ability to observe 2D flooding outside of the current 2D extent. **Figure 5** displays the 2D extents from the Novato DMP ICM Model which was used in this project.

[9] Pump Operation Guidelines (Updated August 12, 2010)

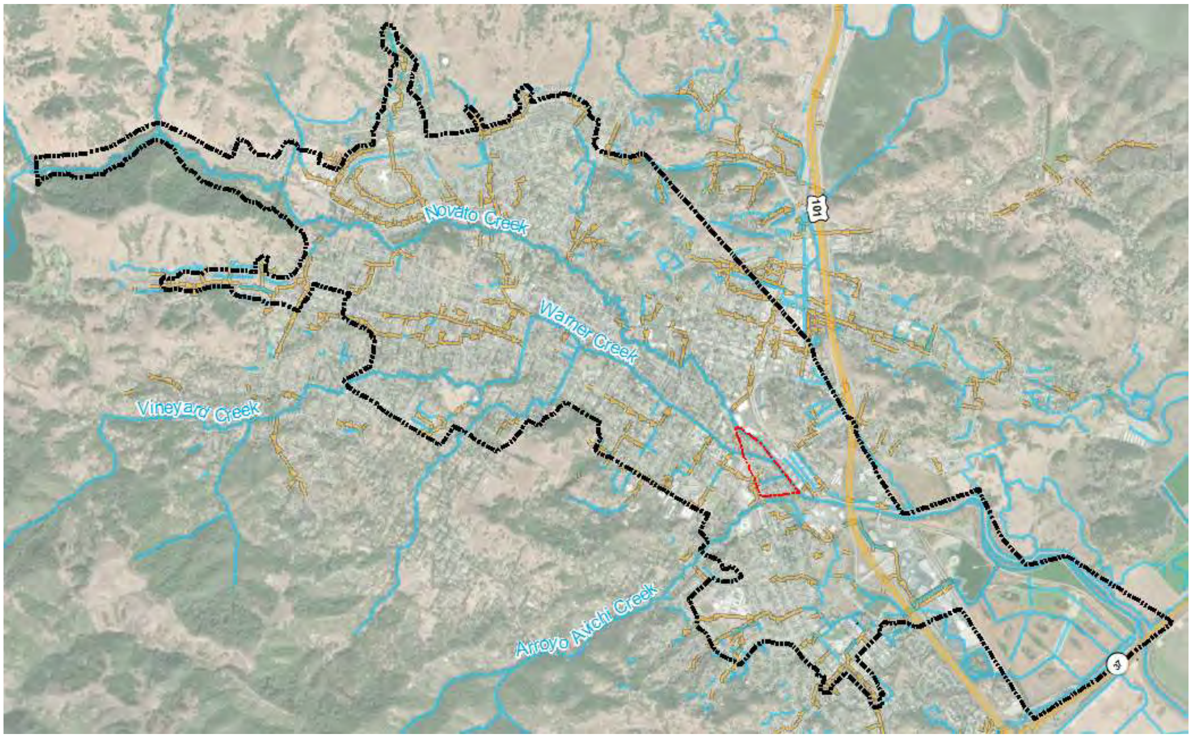


Figure 5 – Extents of the ABSL ICM Model's 2D Zone (Dashed Black Line) with Nave Gardens Extents (Red Dashed Line) as Reference

4. During design storm simulations, the ABSL ICM Model required a warm-up period to pre-fill the Lynwood Basin to an elevation of 1.5 feet NAVD88. See **Figure 6** as an example.

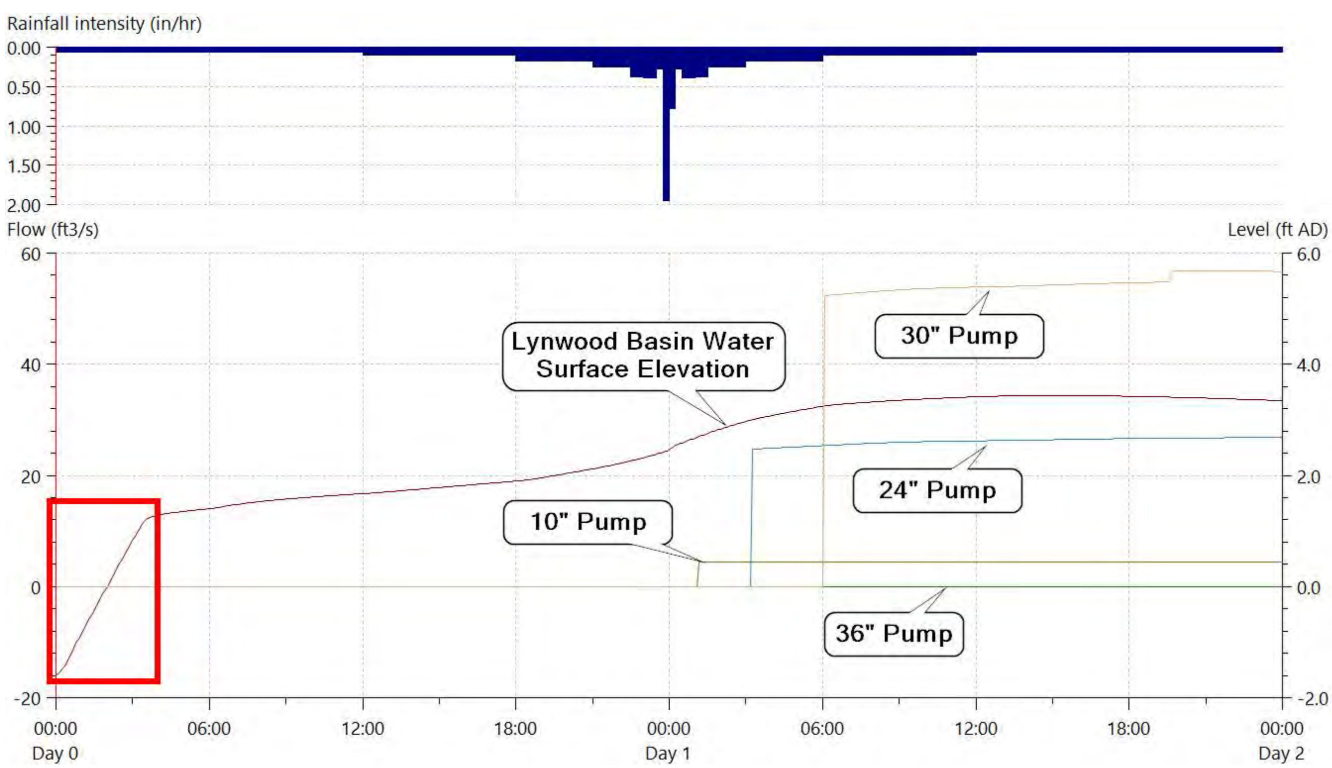


Figure 6 – Example of Lynwood Basin Filling to 1.5 feet NAVD88, as Shown Inside the Red Box

5. For model stability purposes, the ABSL ICM model requires all channels to have a constant artificial flow throughout all simulations. This flow was minimized in each channel (< 1 cfs); however, the combined artificial flow from all channels results in an 8 cfs constant flow into Lynwood Basin, even during periods of no precipitation.

5 CALIBRATION

To confirm that the model will reflect actual flood conditions with rainfall input, a calibration was performed. Rainfall and tide gage levels were used as boundary conditions for the ABSL ICM model calibration. The model was judged on its ability to replicate observed data measured by the level gages installed throughout the ABSL complex and the USGS flow gage on Novato Creek. See **Exhibit A** for location of the various gages used for calibration. Because of vandalism and malfunctioning level gages, the window to calibrate the model was isolated from January 6 to January 15 of 2023.

The ABSL ICM model was run using measured and standard Bay Area hydrologic and hydraulic parameters. After the initial run, Wood Rodgers' methodology to calibrate the model was to adjust the Horton SWMM and groundwater parameters in such a fashion as to see agreement between observed and modeled data, remaining well within the reasonable theoretical range for those parameters.

In general, calibration was successful, and produced modeled results that closely mimicked the observed data recorded at the gages. **Figure 7** shows model results versus observed data at the Arroyo Avichi diversion weir. See **Appendix B** for the complete modeled versus observed results and final Horton SWMM and groundwater parameters.

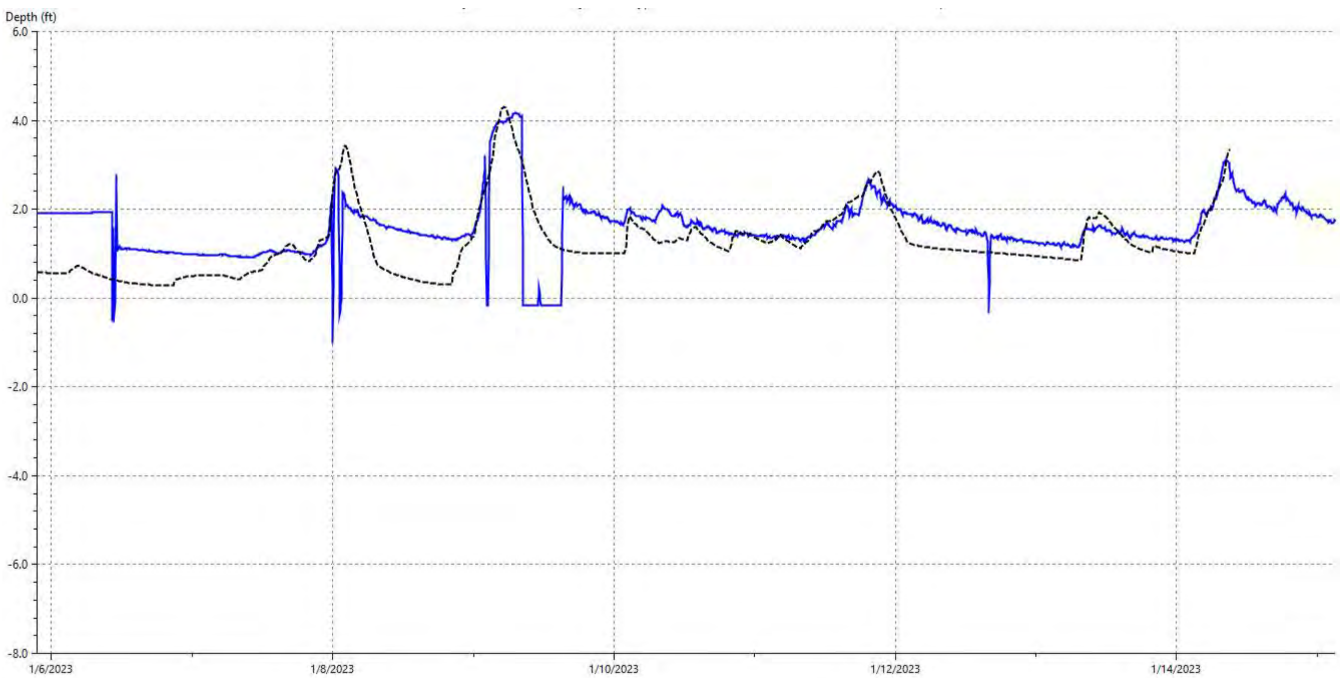


Figure 7 – Modeled Depth (Dashed Black Line) vs. Observed Depth (Solid Blue Line) - Arroyo Avichi Diversion Weir

The peak depths matched relatively well (noting the observed data discontinuity after the 1/9 peak). The difference evident in the post-peak depths can be explained by the fact that the model does not fully account for the interflow or drying of the soils between rainfall events – a limitation that will not substantially affect the results of this analysis because flooding is the primary focus.

6 DESIGN STORM HYETOGRAPHS, HISTORICAL STORMS, & TIDAL BOUNDARY CONDITIONS

The precipitation and tidal boundary conditions used in this report are described in the following sections.

6.1 Design Storms

Hypothetical design storm hyetographs were constructed and used for this project including 2-, 10-, and 50-year, 48-hour storms. The 2-year storm provided a hydraulic analysis of the watershed's ability to drain and convey frequent storms, while the 50-year storm is the District's level of service storm.

Design storm depths are typically collected from the National Oceanic and Atmospheric Administration (NOAA) Atlas 14[10] because of its ease of use and availability throughout the United States. However, design storm depths for this project were obtained from MetStat[11]. MetStat depths were developed in collaboration with Valley Water, and are spatially dependent gridded depth rasters for a given frequency and duration for the entire San Francisco Bay Area, including Marin County. MetStat was chosen because hydrologic studies[12] by Valley Water have concluded Atlas 14 depths produce unrealistically high design flows. In many cases, the design flows were almost double the stream's calculated flow frequency. In contrast, MetStat depths were shown to perform well in multiple validation studies and were thus chosen for this project. An example of MetStat's 2-year, 24-hour depth raster is shown in **Figure 8**.

For each of the three frequencies, the 15-min, 30-min, 1-hour, 2-hour, 3-hour, 6-hour, 12-hour, 24-hour, and 48-hour depths were extracted from the appropriate MetStat raster and used to create alternating block design storm hyetographs nested around hour 24. Examples of the 2-, 10-, and 50-year, 48-hour design storm hyetographs at the Lynwood Basin are shown in **Figure 9**.

[10] https://hdsc.nws.noaa.gov/pfds/?bkmrk=ca
[11] MetStat Inc. Regional All-Season Precipitation-Frequency Analysis and Mapping in Santa Clara, Alameda and San Mateo Counties, California, and comparison to NOAA Atlas 14. October 2016.
[12] https://archive.org/details/csjvwd_000205/mode/2up

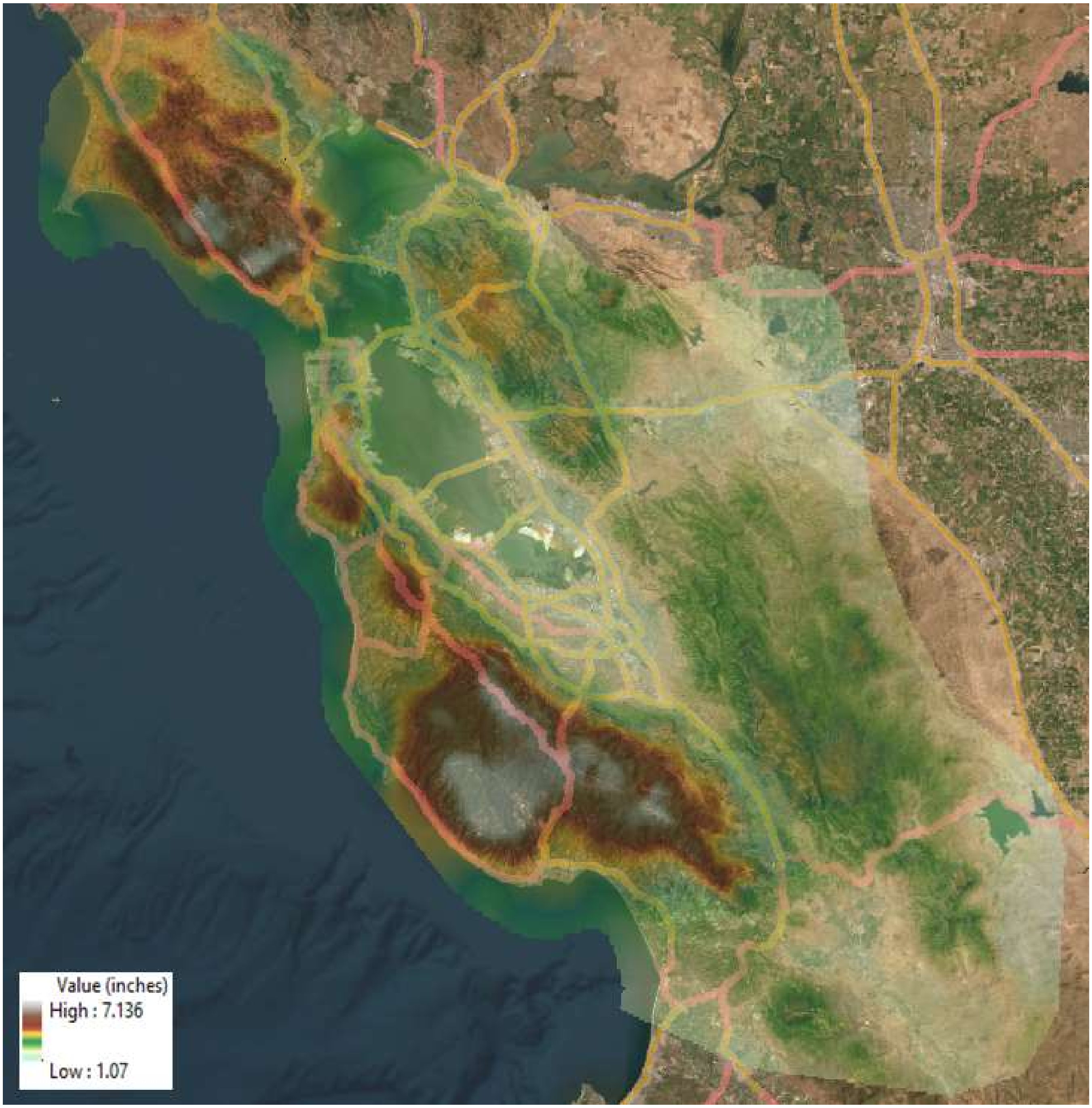


Figure 8 – MetStat 2-Year, 24-Hour Depths

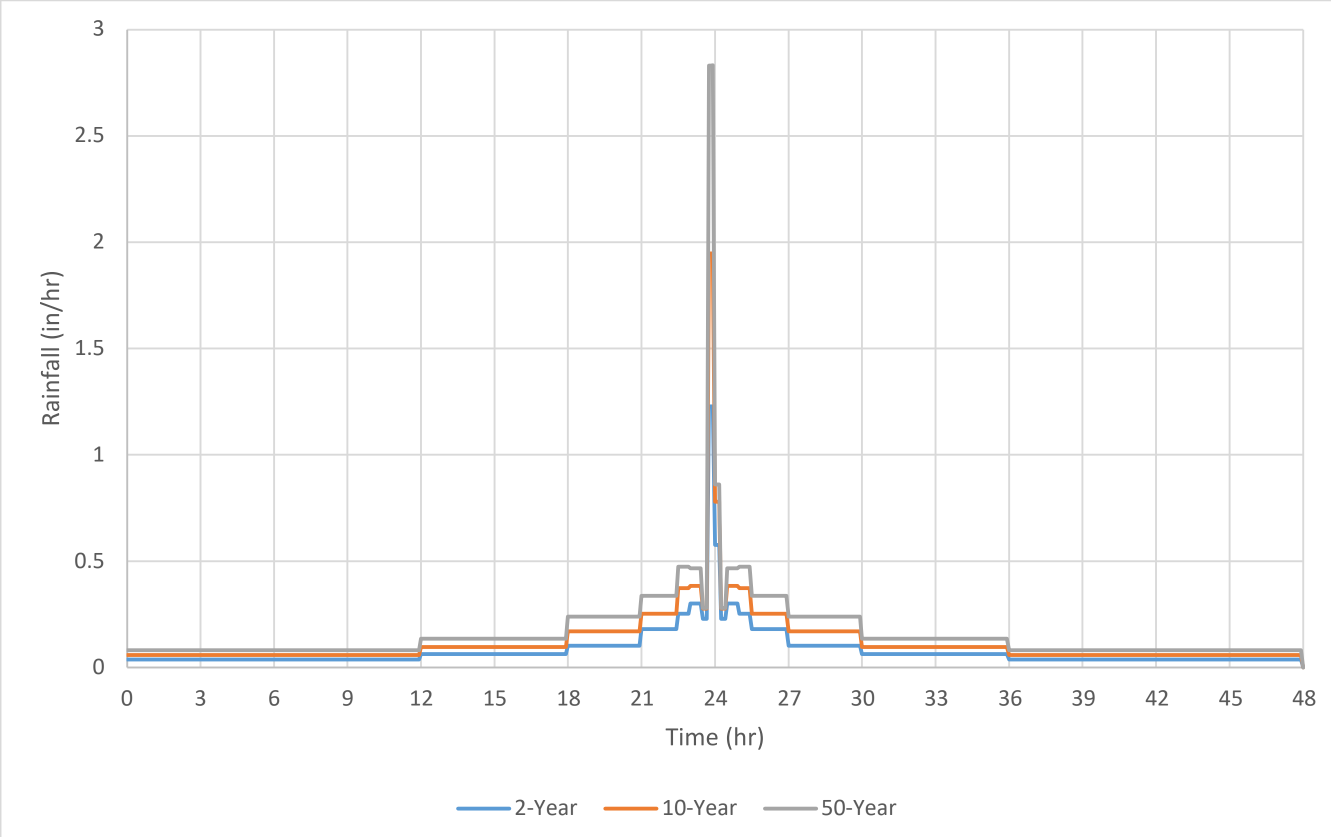


Figure 9 – 2-, 10-, and 50-Year, 48-Hour Design Storm Hyetographs at Lynwood Basin

6.2 Historical Storm

In addition to single event design storms, historical storms were used to evaluate the Lynwood Basin and Lynwood Pump Station in both the existing and proposed conditions. There are three rain gages in the Novato Creek Watershed available to extract historical rainfall data[2]: Pacheco & San Jose Creeks, Novato Library, Center Road Tank. Because the Pacheco & San Jose Creeks and Center Road Tank were installed in 2018, only wet seasons including and after 2018 were considered for the historical simulations. The Novato Library gage was observed to have faulty readings between January 11 and 14, 2023, and was therefore removed as a candidate for historical rainfall data. See **Figure 10**.

The 2022-2023 wet season was chosen because between late December 2022 and mid-January 2023, approximately 19 inches of rain fell near Lynwood Basin. See **Figure 11**. The large volume of rainfall in a relatively short period of time would test the ability of the Lynwood Pump Station to drain Lynwood Basin. **Table 2** summarizes the return intervals for peak rainfall depths at different durations (ranging from 1 to 25 years).

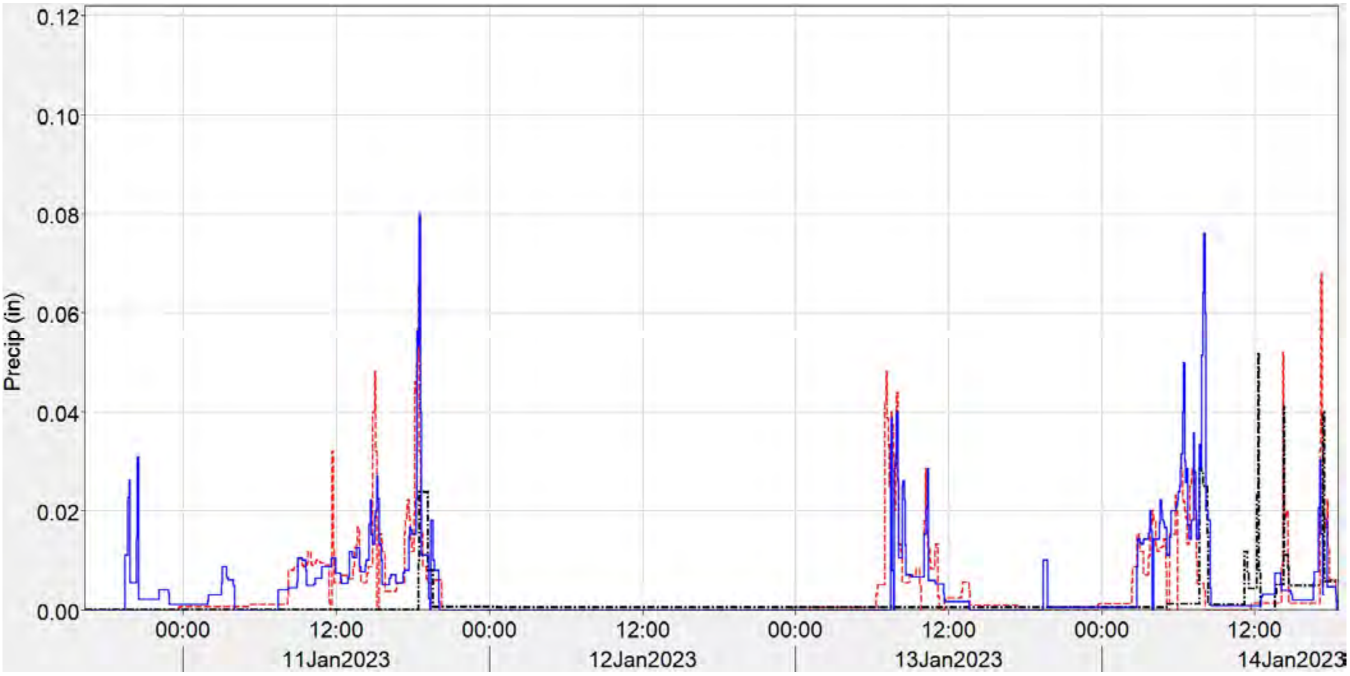


Figure 10 – Pacheco, & San Jose Creeks (Red Dashed Line), Novato Center Road Tank (Solid Blue Line) and Novato Library (Dashed Black) Incremental Rainfall (inches)

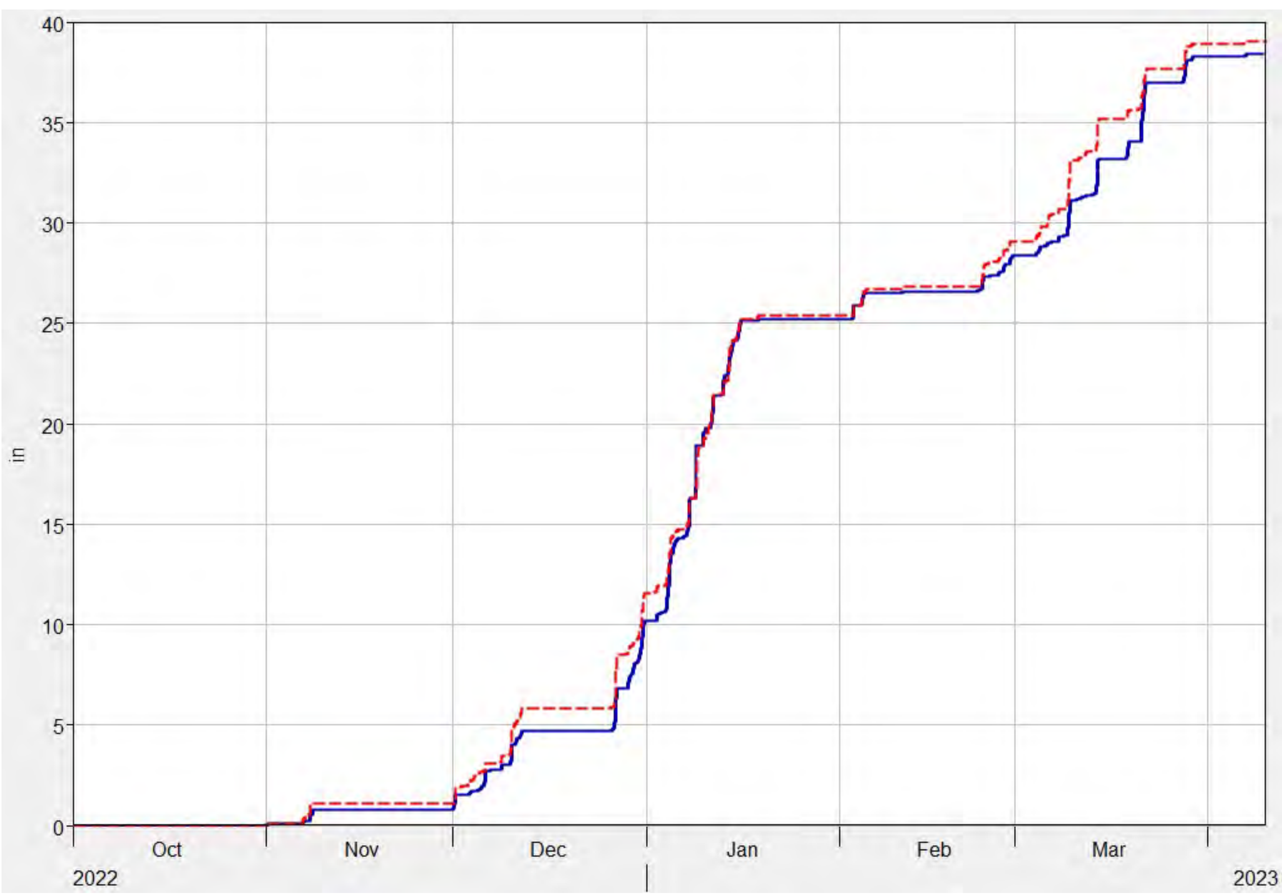


Figure 11 – 2022-2023 Novato, Pacheco, & San Jose Creeks (Red Dashed Line) and Novato Center Road Tank (Solid Blue Line) Cumulative Rainfall (inches)

Table 2 – 2022-2023 Wet Season Statistics

Rain Gage	15 Minutes		1 Hour		24 Hours		48 Hours	
	Depth (in)	Recurrence Interval (Yrs)	Depth (in)	Recurrence Interval (Yrs)	Depth (in)	Recurrence Interval (Yrs)	Depth (in)	Recurrence Interval (Yrs)
Center Road Tank	0.28	2	0.77	5	2.92	1	4.46	2 - 5
Novato, Pacheco & San Jose Creeks	0.49	10	0.86	10 - 25	2.67	2	4.03	2

6.3 Tidal Boundary Conditions

For use in the design storm simulations, synthetic tidal boundary conditions were developed based on known tidal peaks. The mean-high-high water (MHHW) level and king tide elevations were used as the highest tidal elevations and were oriented such that they occur during the peak of the 48-hour design storm. The MHHW was set to an elevation of 6.23 feet NAVD88[13], and the king tide was set to an elevation of 7.53 feet NAVD88[13]. See **Figure 12**.

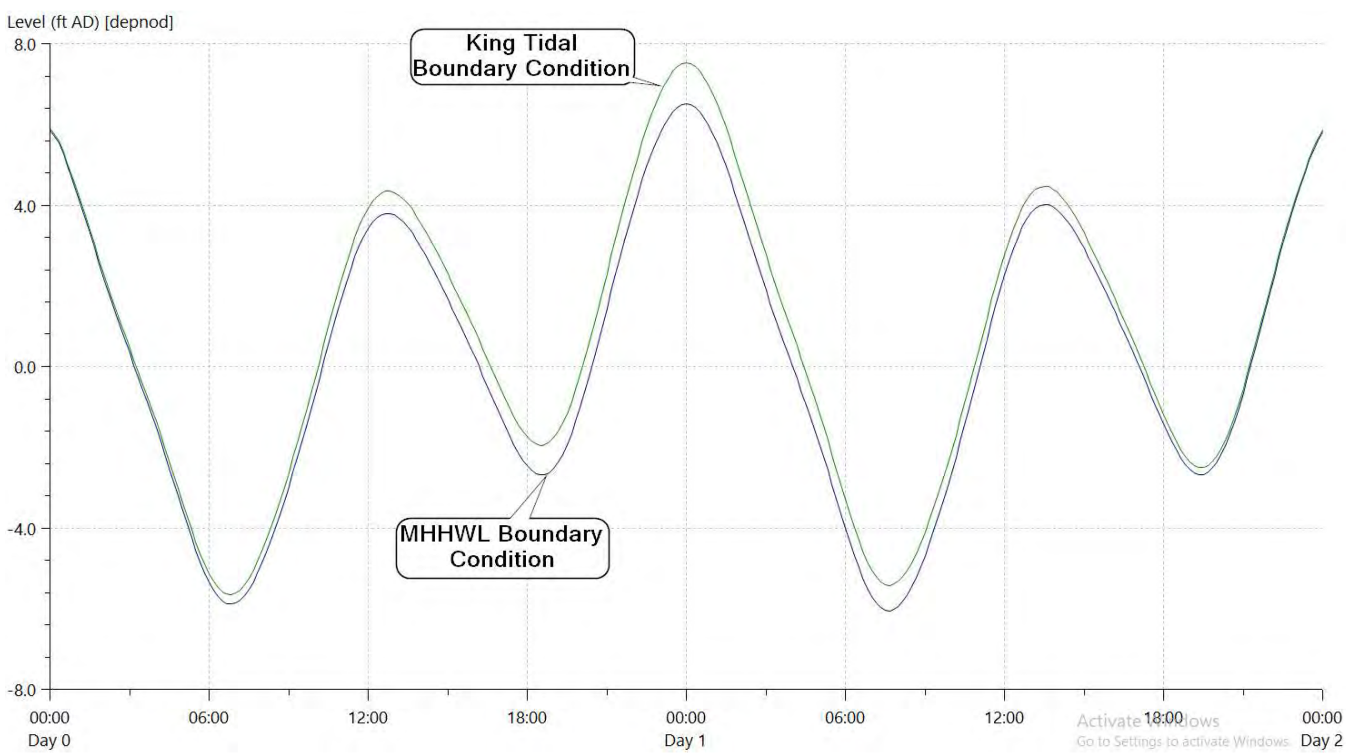


Figure 12 – MHHW (Blue) and King Tide (Green) Design Storm Synthetic Tidal Boundary Conditions

[13] San Francisco Bay Tidal Datums and Extreme Tides Study, Final Report, February 2016. AECOM

Historical simulations used tidal elevations recorded from Marin OneRain at the confluence of Novato Creek and San Pablo Bay. See **Figure 13**. Marin OneRain does not state the datum of the gage recordings, but it is assumed to be NAVD88. To confirm this assumption, gage recordings from OneRain were compared against an adjacent tidal gage operated by NOAA in Richmond, California[14], the gage readings of which are in NAVD88. In general, the elevations differed by approximately 0.3 feet, which makes it reasonable to assume the OneRain gage elevations were recorded in the NAVD88 datum.

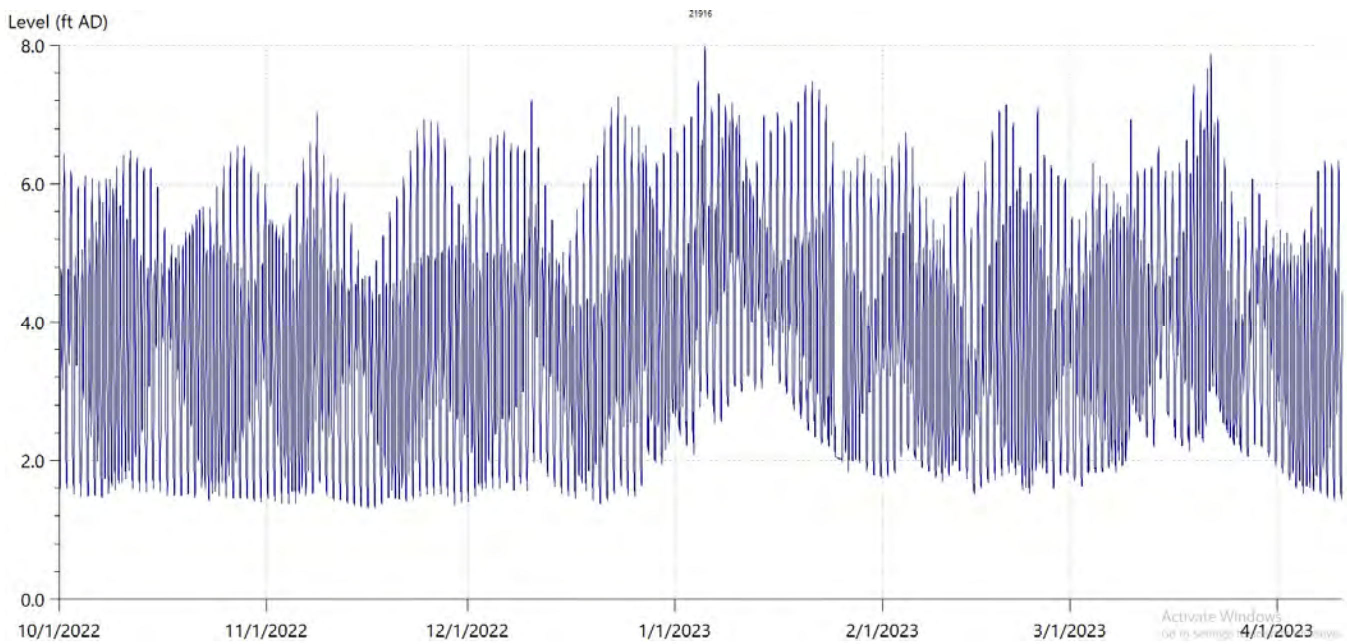


Figure 13 – Marin OneRain Tidal Gage Data at the Novato Creek and San Pablo Bay Confluence During the 2022-2023 Wet Season

[14] https://tidesandcurrents.noaa.gov/waterlevels.html?id=9414863

7 VALIDATION

The ability of the ABSL ICM model to produce design flows comparable to those statistically derived from a flow gage was investigated. The USGS flow gage at the Novato Library was installed in 1947 and has 78 years of flow data. These data were used to create a flow-frequency curve to compare to design storm model results. Annual maximum flows were extracted from the USGS website[3], and HEC-SSP was used to conduct a Bulletin 17C flow-frequency analysis. Wood Rodgers followed recommended guidelines for constructing the flow-frequency curves as outlined in the HEC-SSP Manual[15] and the USGS[16]. See **Figure 14**. The design storm model results compare favorably in the lower frequencies, and slightly low in the higher frequencies with the observed flow-frequency relationship.

[15] https://www.hec.usace.army.mil/confluence/sspdocs/sspum/latest
[16] chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://pubs.usgs.gov/sir/2010/5260/pdf/sir20105260.pdf

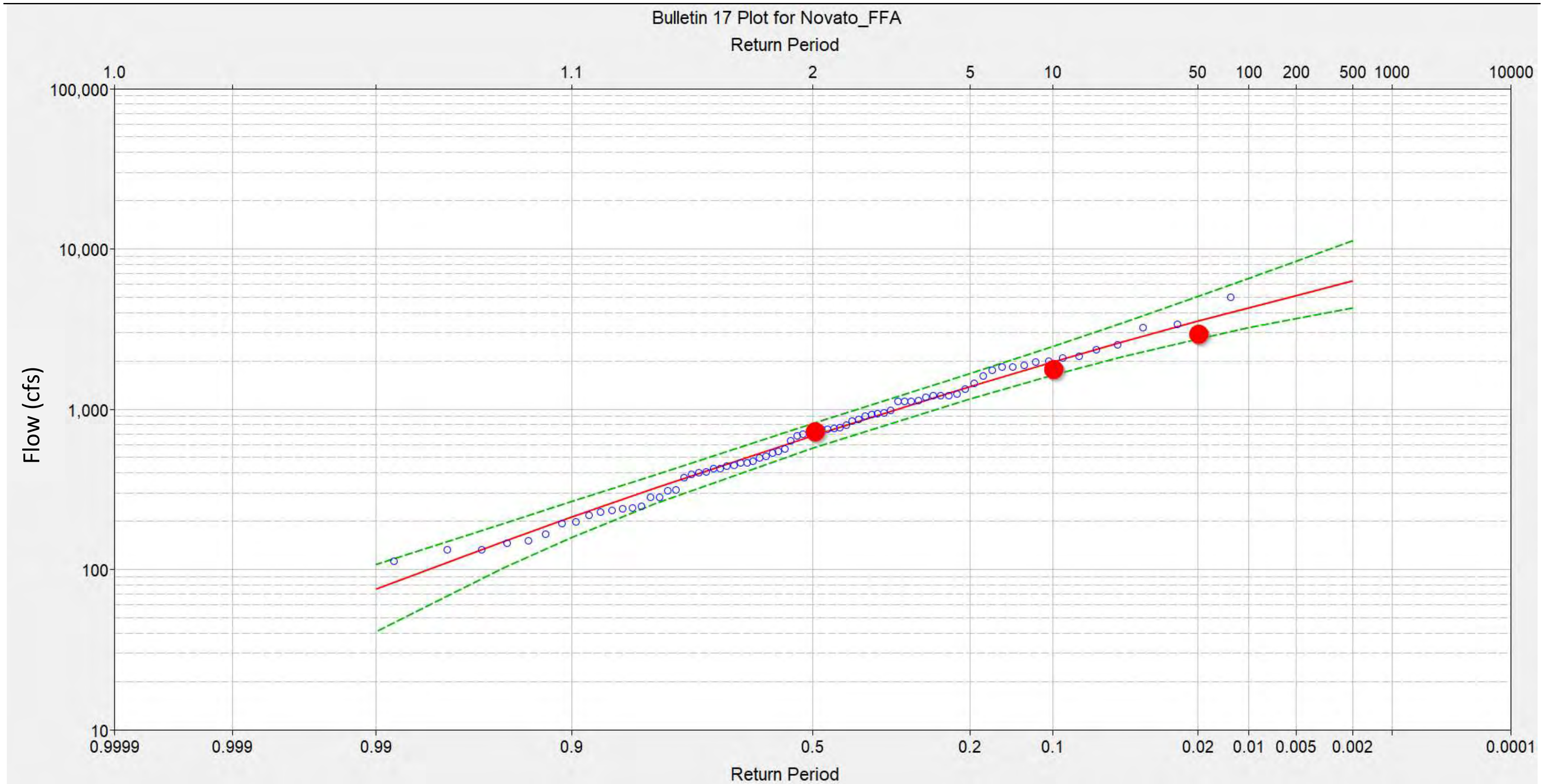


Figure 14 – Bulletin 17C Flow Frequency Curve of USGS Gage on Novato Creek at the Novato Library. Red Circles Indicate Design Storm Model Results

8 EXISTING CONDITIONS RESULTS

The calibrated ABSL ICM model was used to provide a basic assessment of existing conditions. Below describes the existing conditions hydraulic results for Nave Gardens and Lynwood Pump Station. For a detailed explanation of interpreting the hydraulic results below, see **Appendix C**.

8.1 Existing Conditions with MHHW Tide - Nave Gardens

Exhibits B, **C**, and **D** display existing condition floodplain results of the 2-, 10-, and 50-year design storms, respectively. Model results indicate the Nave Gardens development may experience no flooding in the 2-year storm, but may have extensive flooding in the 10- and 50-year storms. The primary mechanism for Nave Gardens flooding in the 10- and 50-year events was high stages in Novato Creek, Warner Creek and the Arroyo Avichi Creek flowing back into the storm sewer system and overtopping the banks. See **Figure 15**, **Figure 16**, **Figure 17**, and **Figure 18**. Results also show spilling of Novato, Warner, and Arroyo Avichi Creeks into Nave Gardens in the 10- and 50-year events as well. See **Figure 19**, **Figure 20**, and **Figure 21**. **Table 3** summarizes the floodplain extent and average flood depth within Nave Gardens for each of the three design storm simulations.

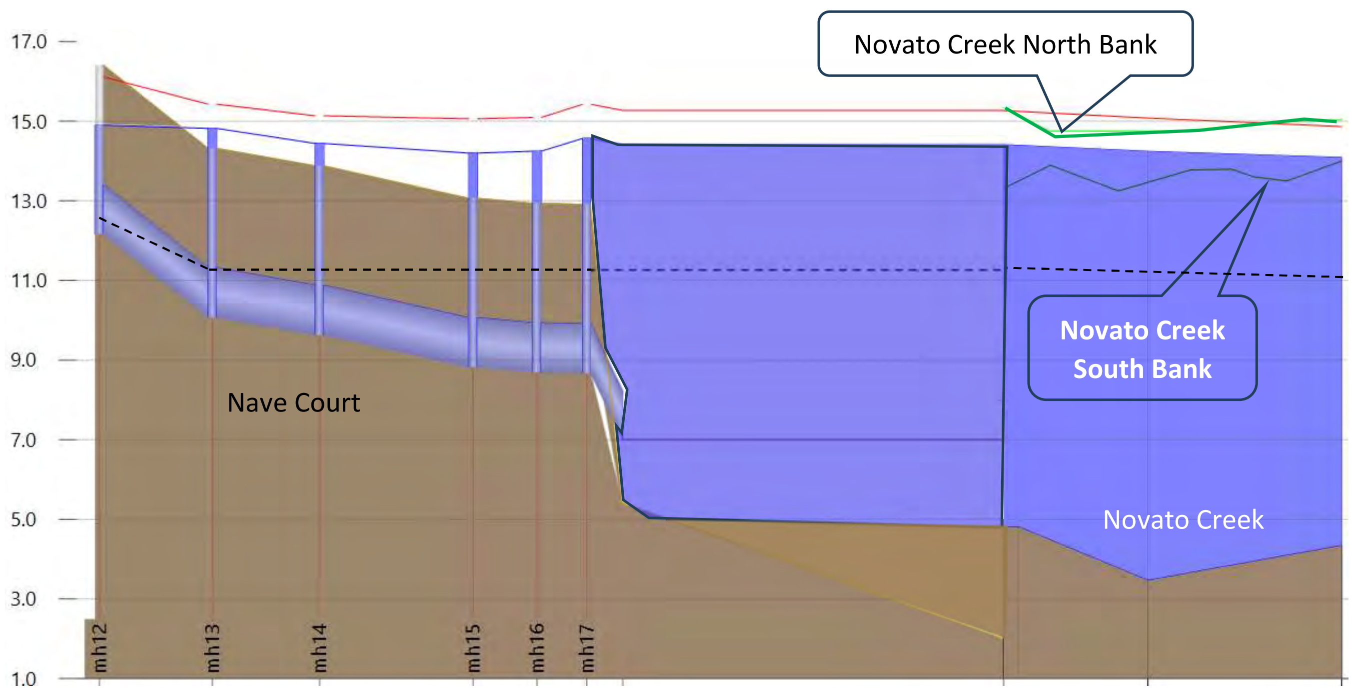


Figure 15 – Existing Conditions 2-, 10- and 50-Year Water Surface Elevations for Nave Court Storm Sewers Shown in Dashed Black, Solid Blue, and Solid Red, Respectively

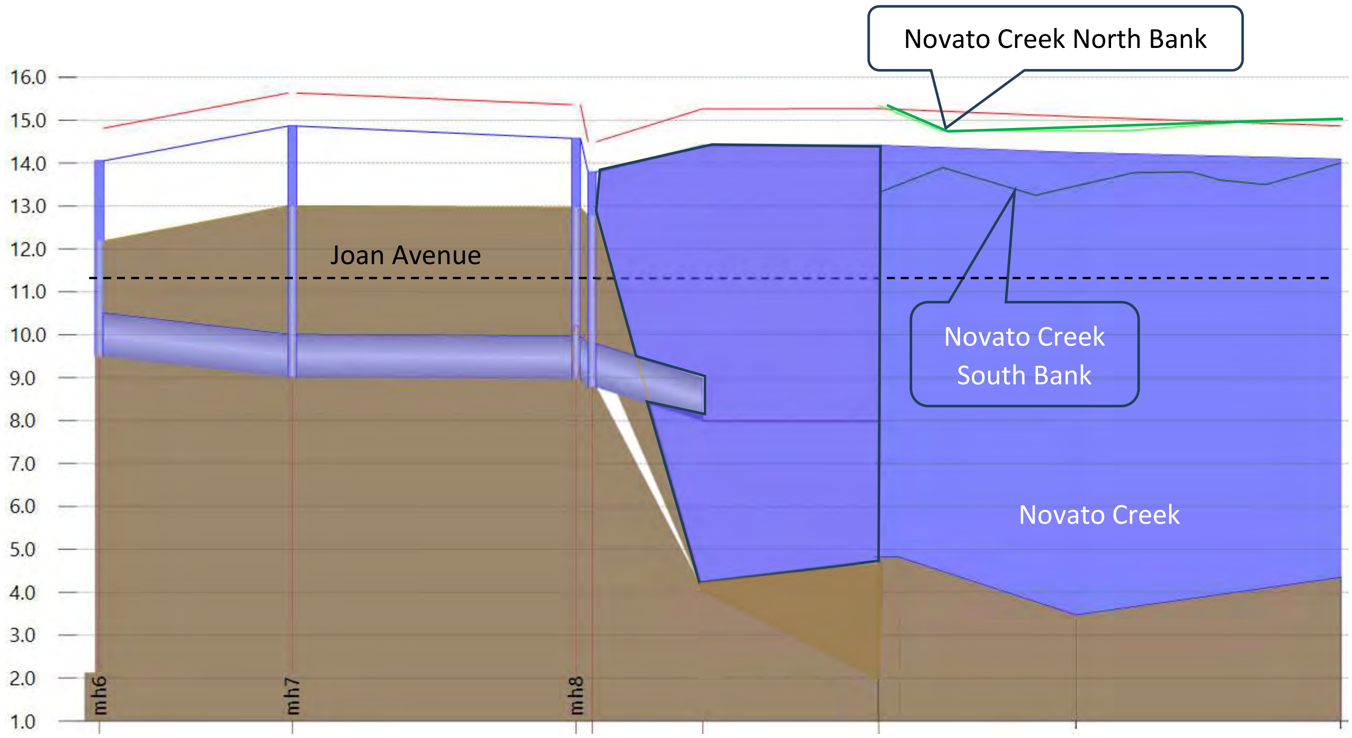


Figure 16 – Existing Conditions 2-, 10-, and 50-Year Water Surface Elevations for Joan Avenue Storm Sewers in Dashed Black, Solid Blue, and Solid Red, Respectively

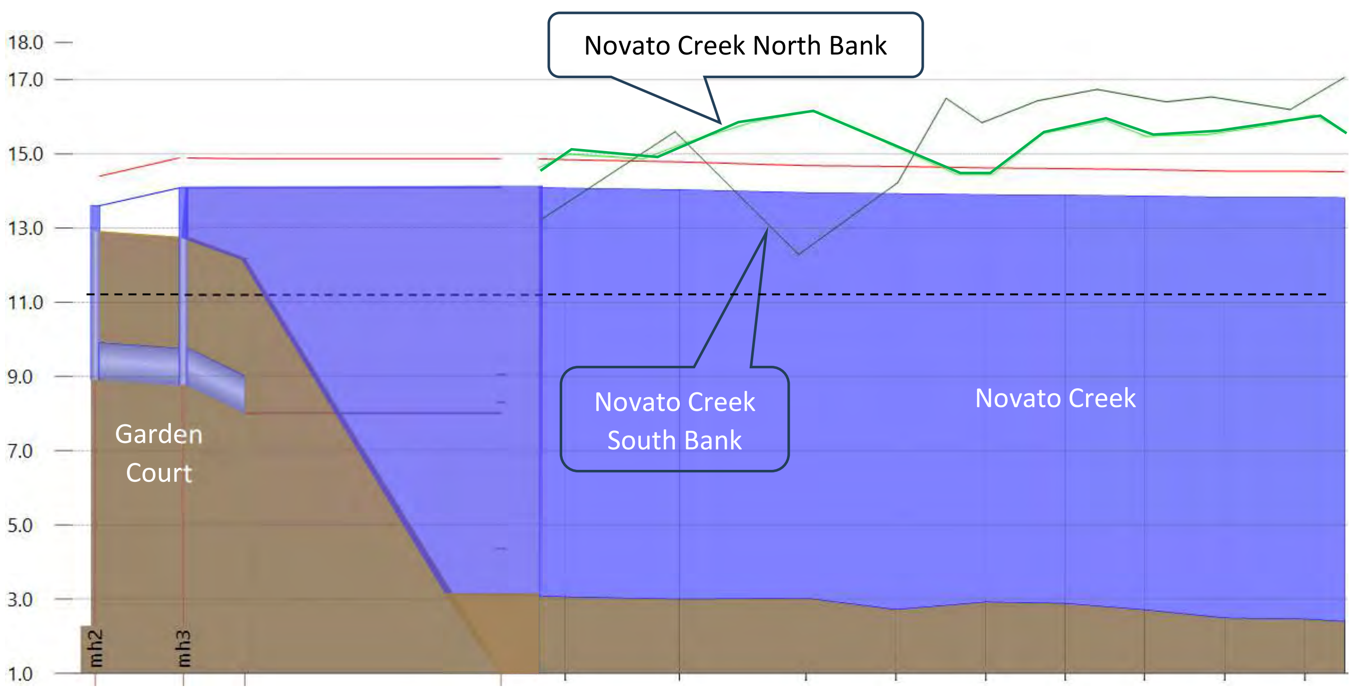


Figure 17 – Existing Conditions 2-, 10-, and 50-Year Water Surface Elevations for Garden Court Storm Sewers in Dashed Black, Solid Blue, and Solid Red, Respectively

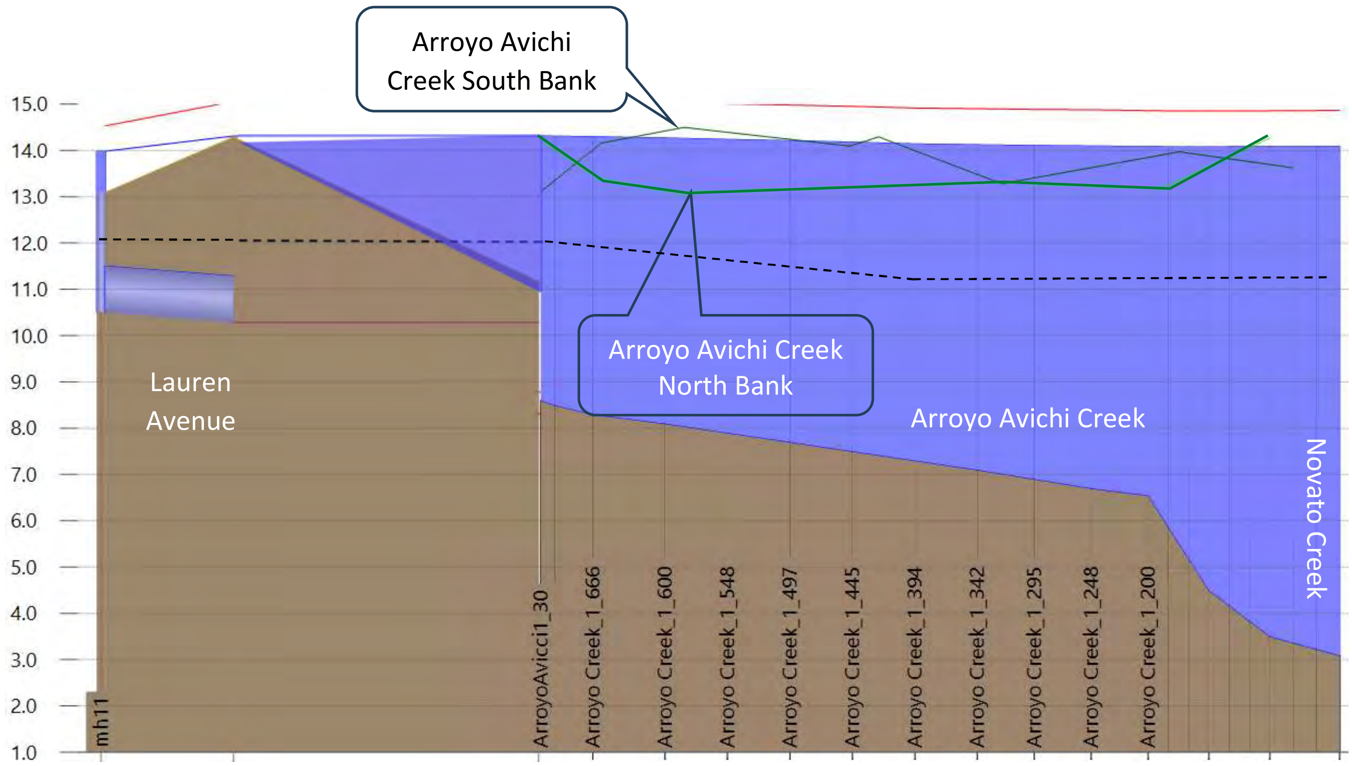


Figure 18 – Existing Conditions 2-, 10-, and 50-Year Water Surface Elevations for Lauren Avenue Storm Sewers in Dashed Black, Solid Blue, and Solid Red, Respectively

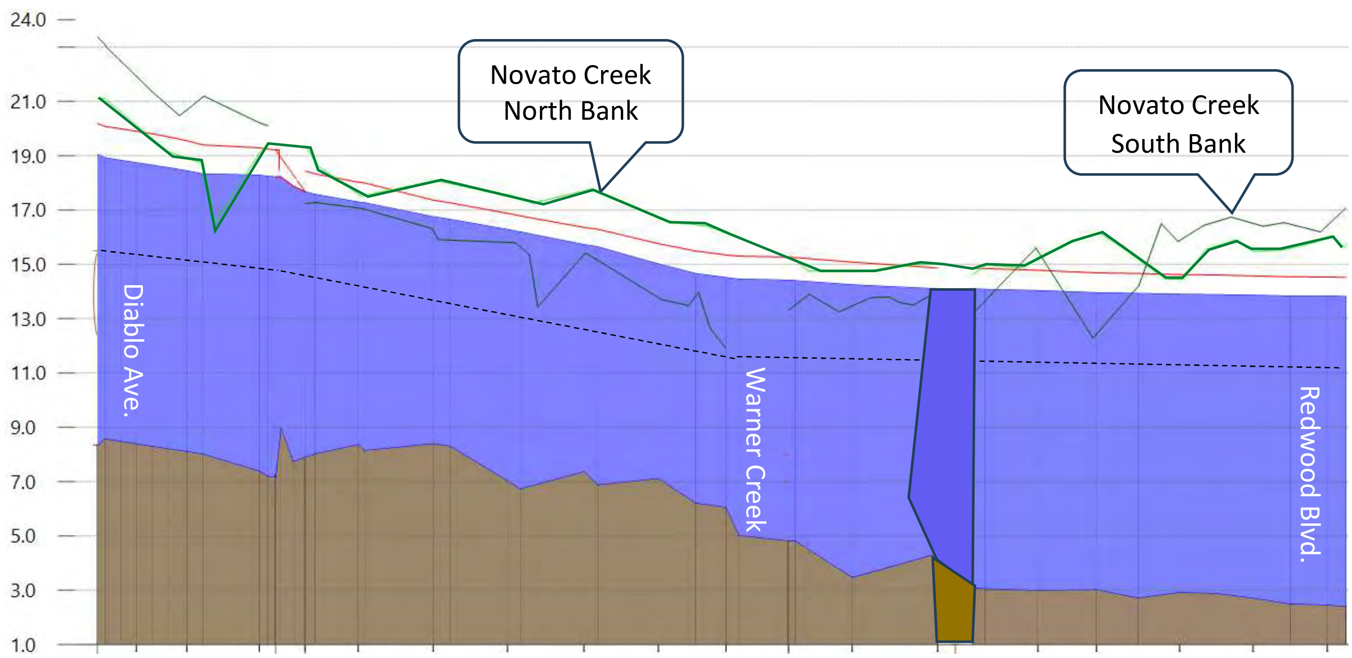


Figure 19 – Existing Conditions 2-, 10-, and 50-Year Water Surface Elevations Profile for Novato Creek Between Diablo Avenue and Redwood Boulevard in Dashed Black, Solid Blue, and Solid Red, Respectively

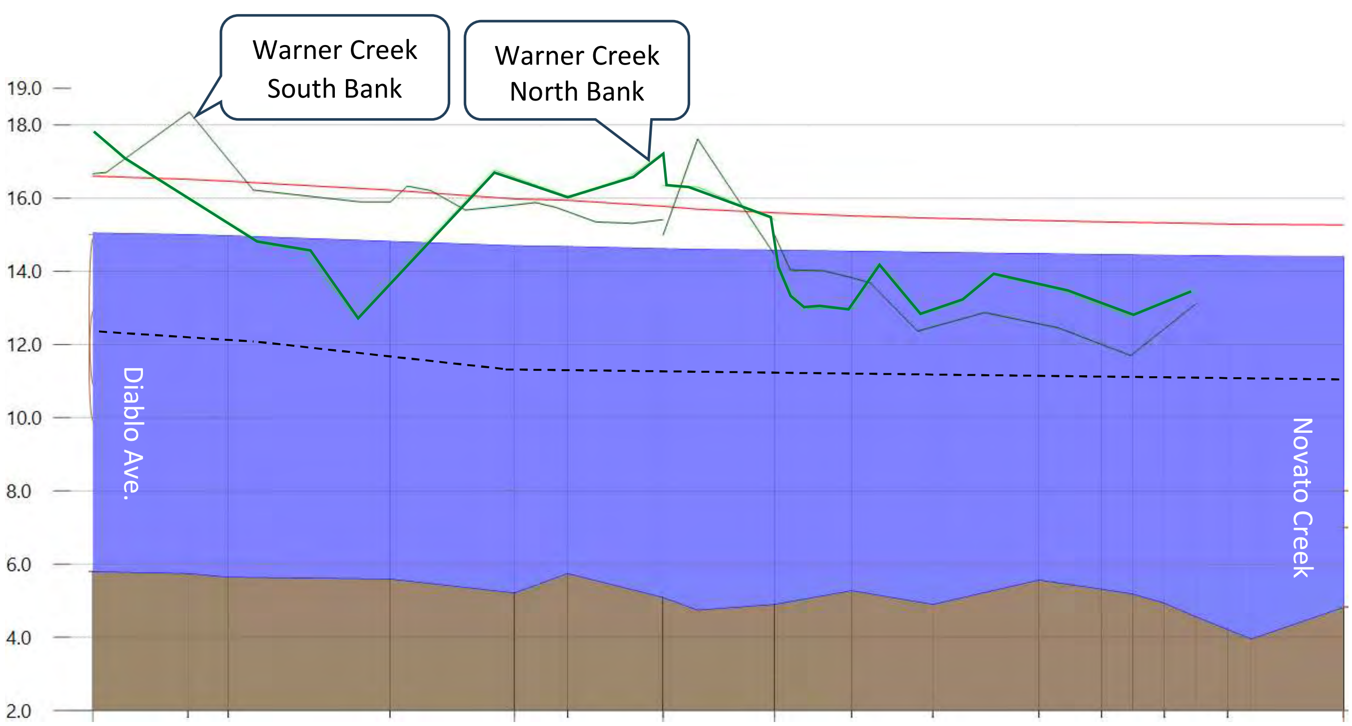


Figure 20 – Existing Conditions 2-, 10-, and 50-Year Water Surface Elevations Profile for Warner Creek Between Diablo Avenue and Novato Creek in Dashed Black, Solid Blue, and Solid Red, Respectively

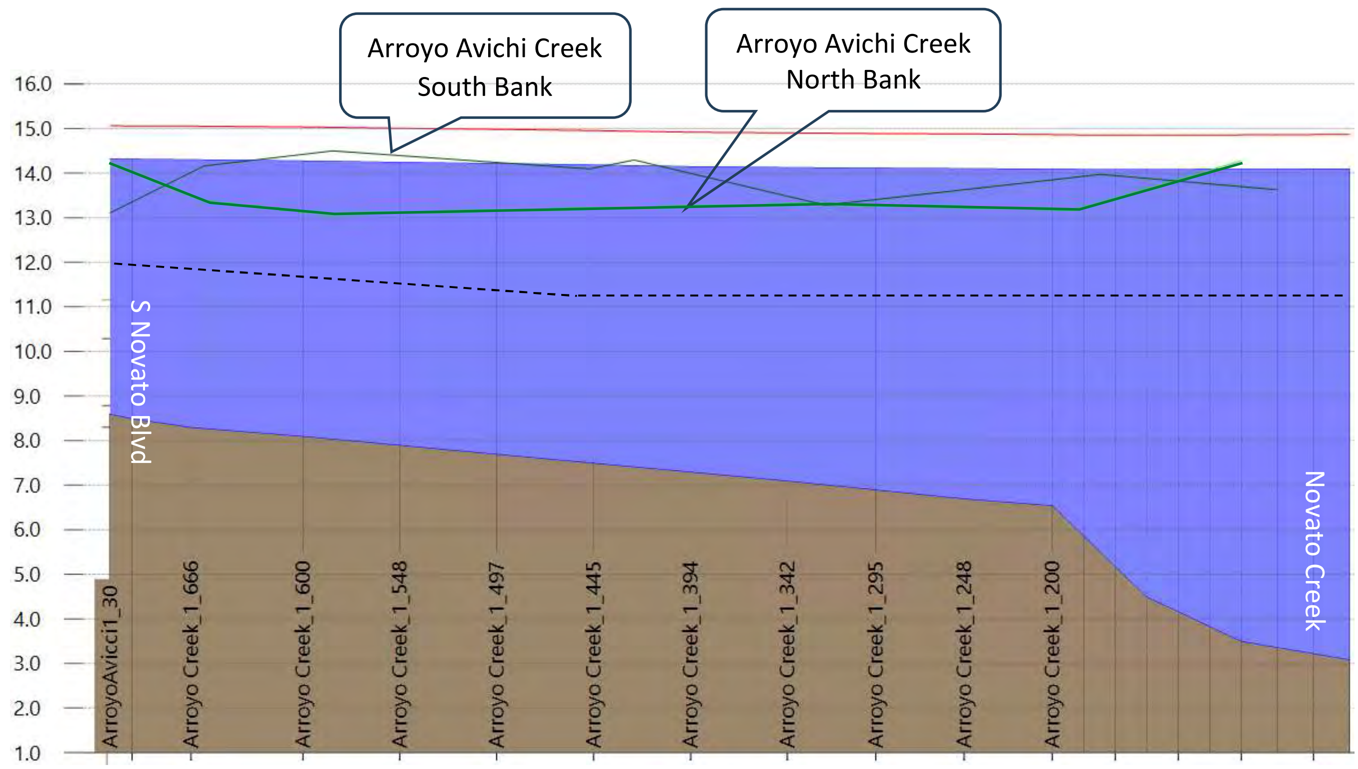


Figure 21 – Existing Conditions 2-, 10-, and 50-Year Water Surface Elevations Profile for Arroyo Avichi Creek Between South Novato Boulevard and Novato Creek

Table 3 – Existing Conditions Floodplain Extent and Average Depth Summary within Nave Gardens

	Floodplain Extent (ac)	Average Depth (ft)
2-Year	0.0	0.0
10-Year	17.7	0.7
50-Year	21.7	1.1

8.2 Existing Conditions with King Tide – Nave Gardens

Figure 22, **Figure 23**, and **Figure 24** show a comparison of the 2-, 10-, and 50-year water surface elevation on Novato Creek between Diablo Boulevard and San Pablo Bay using the MHHW and king tide boundary conditions, respectively. Water surface elevations only differed near the confluence with San Pablo Bay, which is downstream of the project's area of interest. Therefore, the MHHW was the only tidal boundary condition used for the remainder of the project.

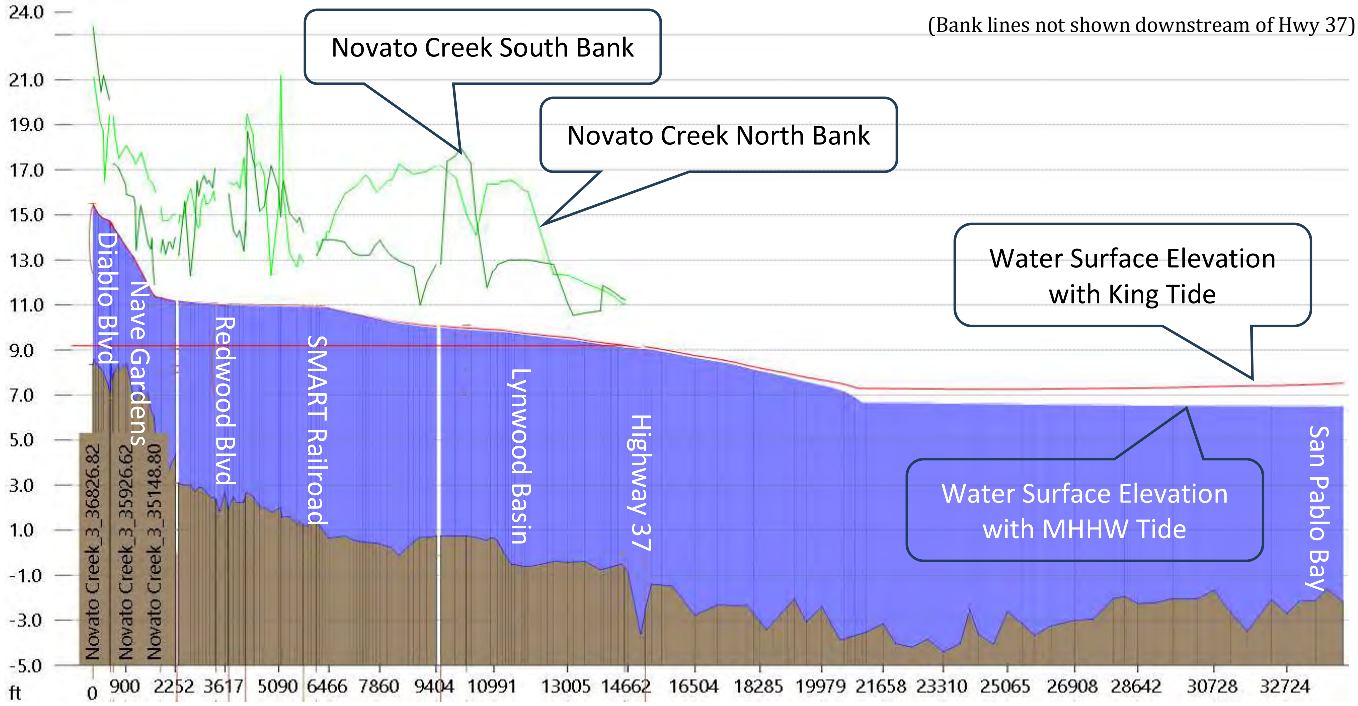


Figure 22 – Novato Creek 2-Year Maximum Water Surface Elevation with MHHW and King Tide Boundary Conditions

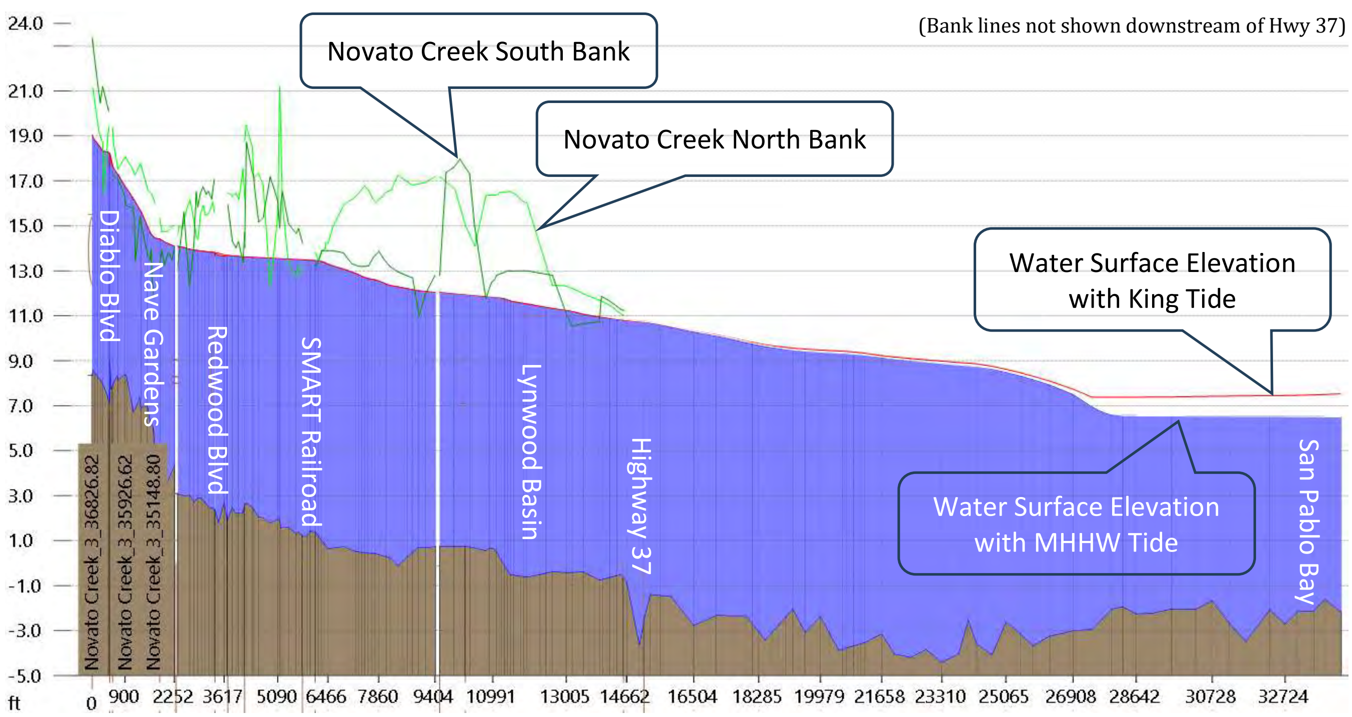


Figure 23 – Novato Creek 10-Year Maximum Water Surface Elevation with MHHW and King Tide Boundary Conditions

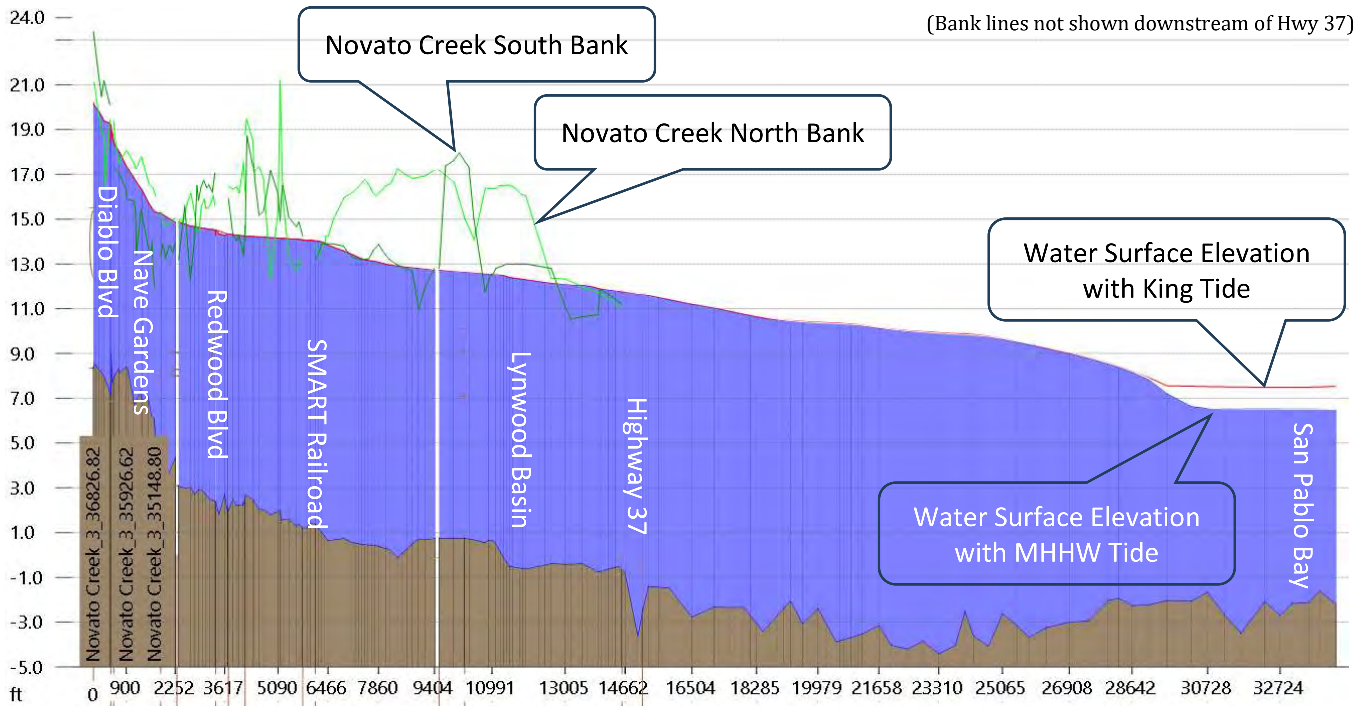


Figure 24 – Novato Creek 50-Year Maximum Water Surface Elevation with MHHW and King Tide Boundary Conditions

8.3 Lynwood Pump Station

Results show that the two smallest pumps (10” and 24”) turned on in the 2-year simulation, with an elevation in Lynwood Basin peaking at 3.0 feet NAVD88. See **Figure 25**. During the 10-year design storm, three pumps (10”, 24” and 30”) turned on. The Lynwood Basin peaked at an elevation of 3.4 feet NAVD88. See **Figure 26**. During the 50-year design storm, all four pumps turned on, and Lynwood Basin peaked at an elevation of 4.6 feet NAVD88. See **Figure 27**. In all three design storm simulations, model results showed flooding was not caused by high tailwater in Lynwood Basin.

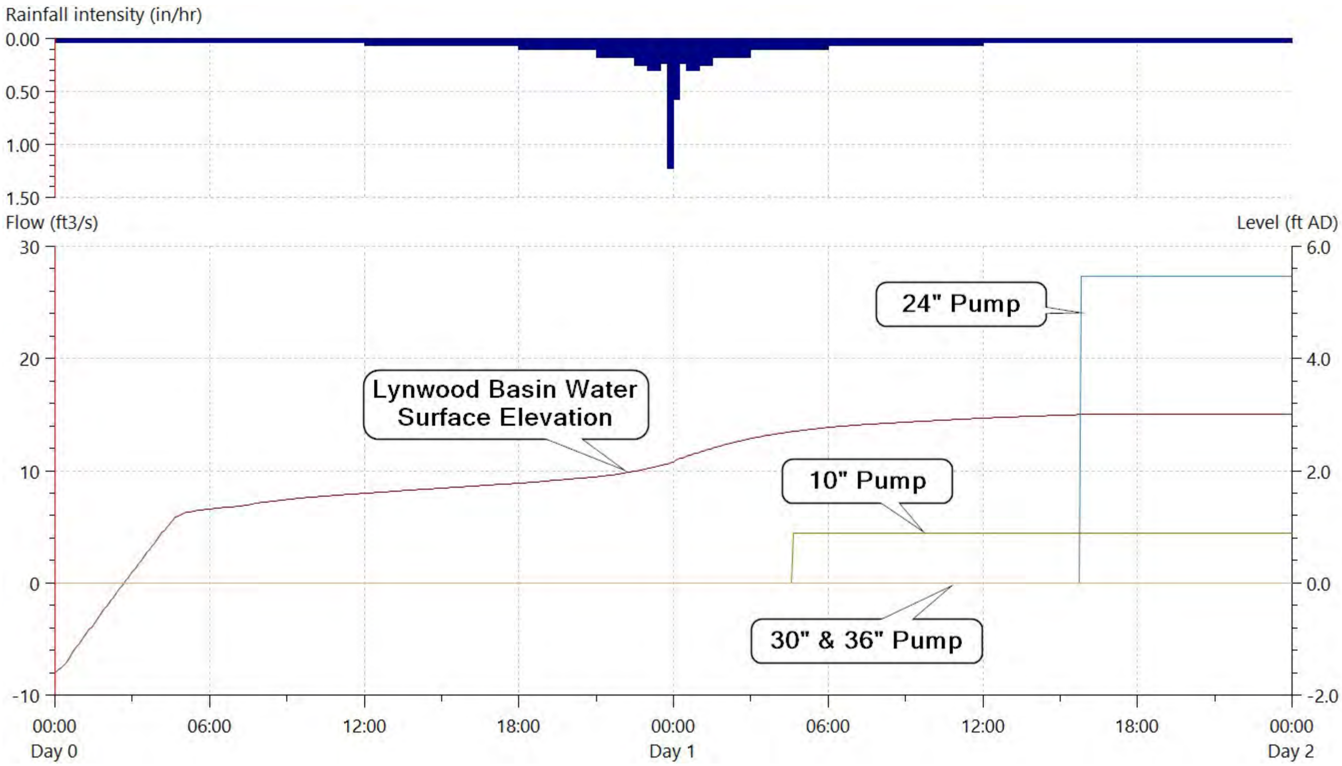


Figure 25 – Lynwood Pump Station and Lynwood Basin Model Results for the 2-Year Model Simulation

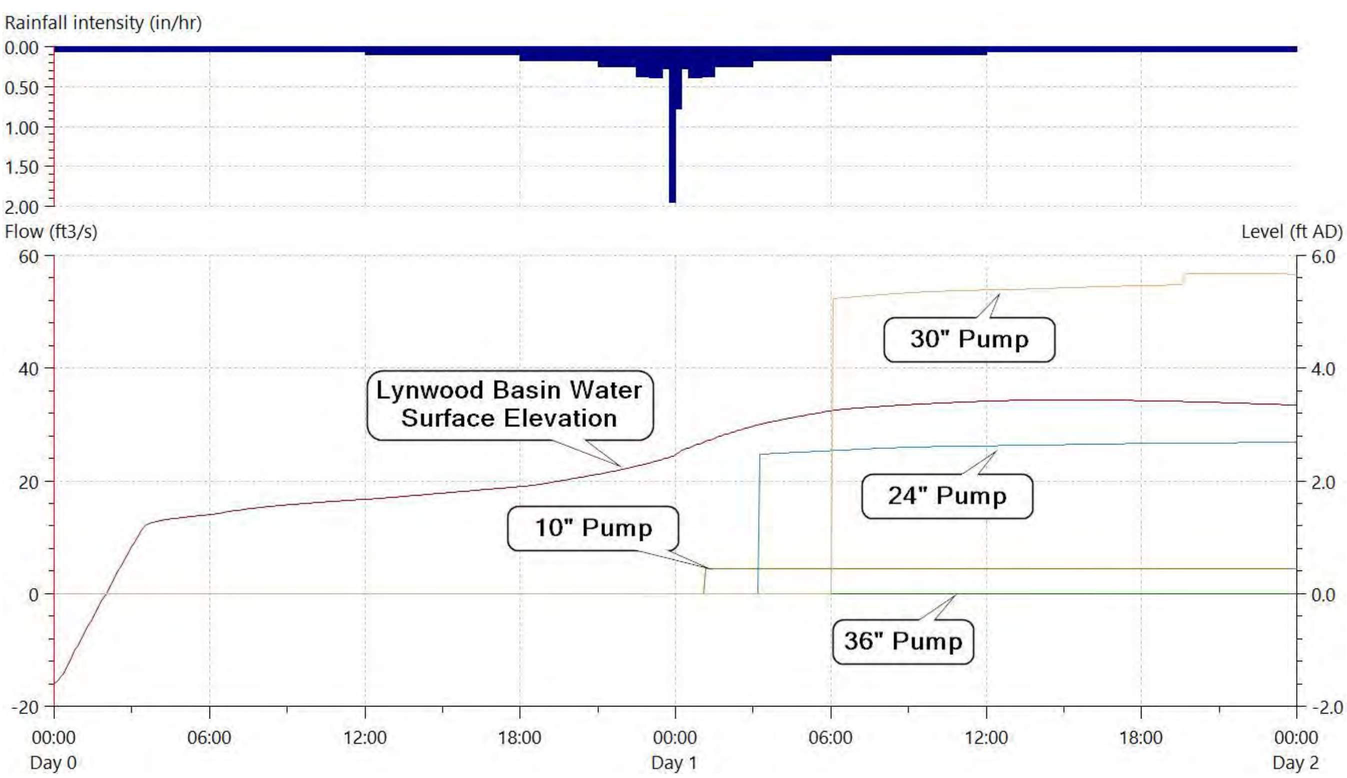


Figure 26 – Lynwood Pump Station and Lynwood Basin Model Results for the 10-Year Model Simulation

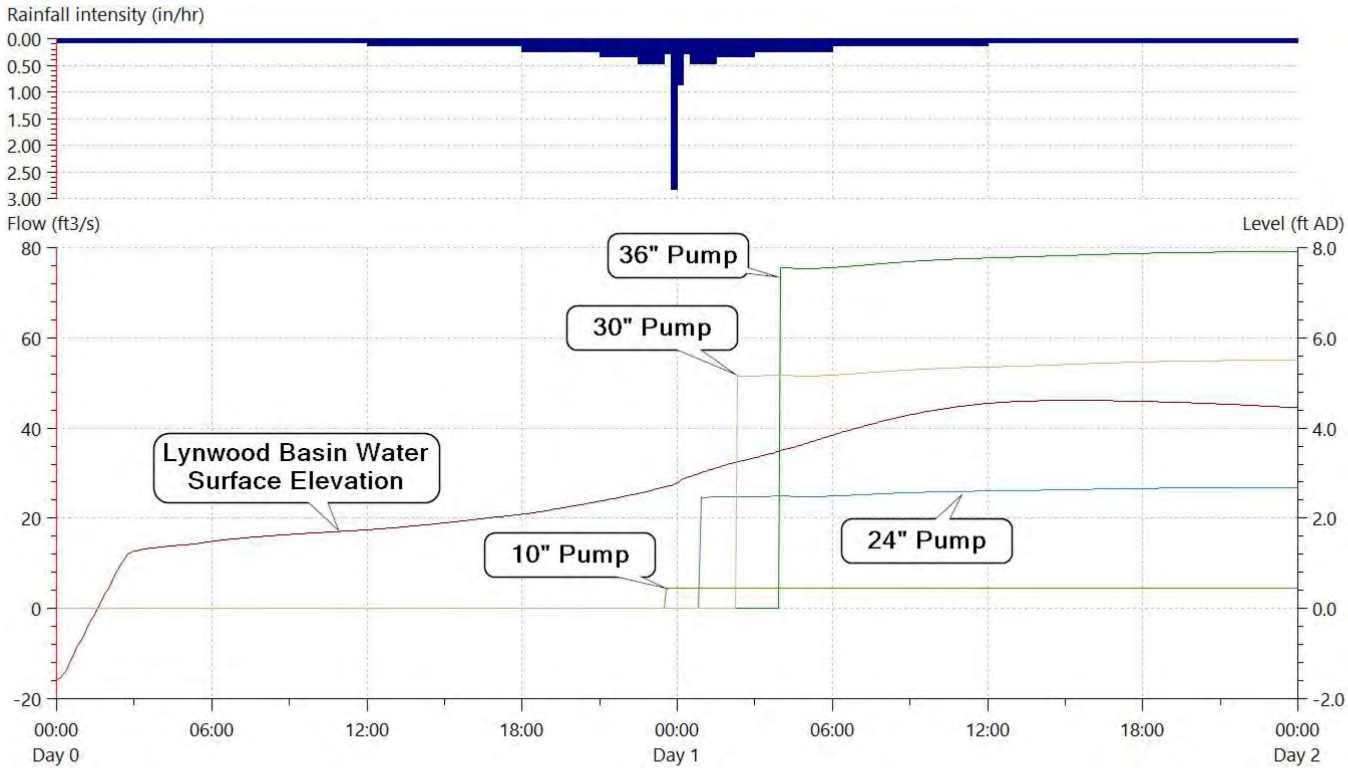


Figure 27 – Lynwood Pump Station and Lynwood Basin Model Results for the 50-Year Model Simulation

Results of the 2022-2023 wet season showed the 10”, 24”, and 30” pumps turned on, with Lynwood Basin peaking at an elevation of 3.4 feet NAVD88. See **Figure 28**.

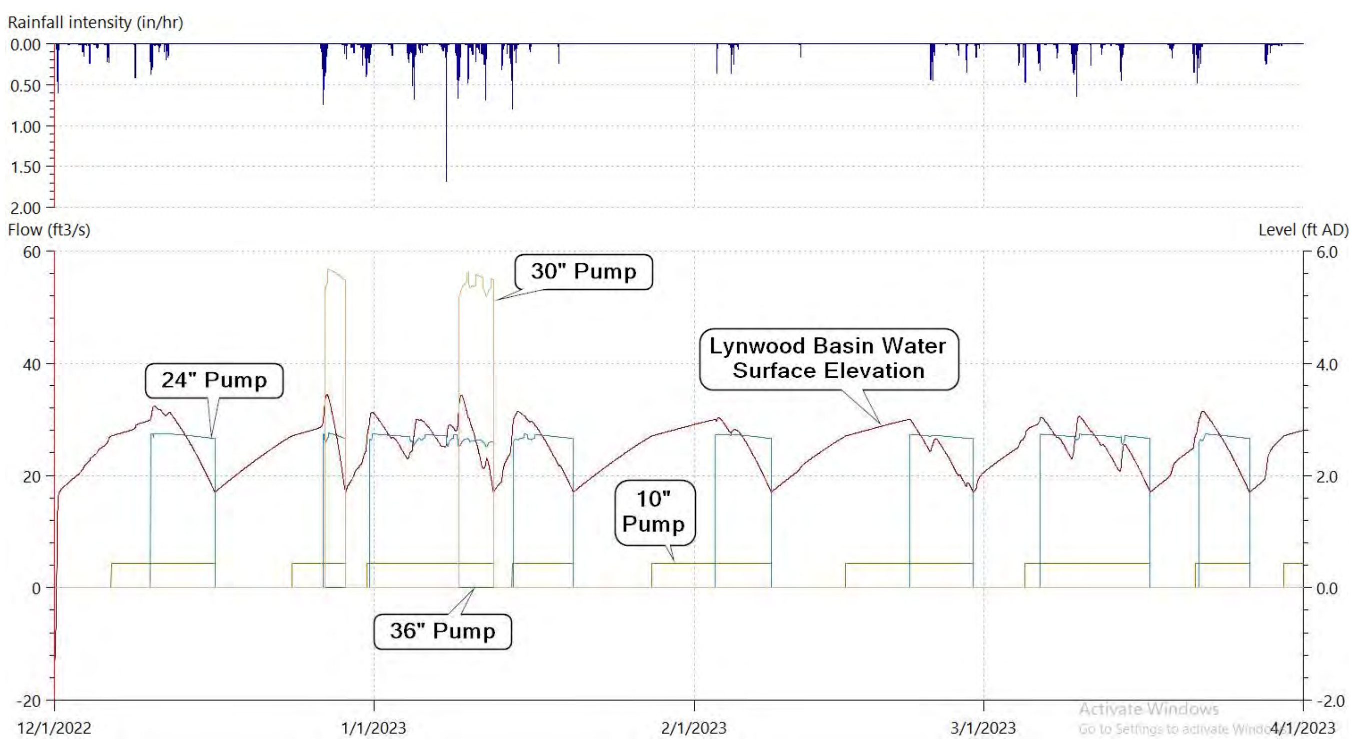


Figure 28 – Lynwood Pump Station and Lynwood Basin Model Results for the 2022-2023 Wet Season

9 DESCRIPTION OF IMPROVEMENT ALTERNATIVES & RESULTS

9.1 Nave Gardens

Several improvement alternatives were developed to reduce or eliminate the flooding in Nave Gardens. The alternatives aimed to eliminate backwater from Novato, Warner, and Arroyo Avichi Creeks from entering the storm drain systems and eliminate bank overflows. The 10- and 50-year design storm results are shown in the following sections for each alternative only, as there is no 2-year flooding.

9.1.1 Flap Gates

For this alternative, flap gates were installed on the downstream end of all storm drains discharging into Novato, Warner, Arroyo Avichi Creeks, and Baccaglio Basin. **Exhibits E** and **F** show the 10- and 50-year floodplain results, as well as the locations of the proposed flap gates.

Results show no significant difference in floodplains between the existing and proposed conditions. However, this is expected due to the timing of peak flows in Novato, Warner, and Arroyo Avichi Creeks during the design storm simulations. Results show when the peak flows arrive at Nave Gardens, it is still raining. Therefore, runoff will collect in the storm drain system until the water level exceeds the water surface in the creeks.

The benefits of flap gates will only occur when there is high tailwater in Novato, Warner, and Arroyo Avichi Creeks, and no rainfall. These benefits are deemed likely to be worthwhile, however, and flap gates were thus included in the remaining proposed improvements.

9.1.2 ABSL Bypass+ Flap Gates

Results from **Section 8.1** demonstrated when storms equivalent to the 10-year or greater occur, flow will breach the banks of Novato, Warner, and Arroyo Avichi Creeks and flood Nave Gardens. As discussed in **Section 1** and **2**, the District hypothesizes if more flow is diverted away from the Arroyo Avichi Creek via the diversion weir, flooding in Nave Gardens will be reduced.

To assess the maximum benefit possible for this alternative, the Arroyo Avichi diversion weir was completely removed, and the triple 42” RCP culverts directing runoff to Novato Creek were plugged. This resulted in all runoff in the Arroyo Avichi Creek being diverted to the ABSL Complex. This alternative scenario represented an analysis of the maximum flood reduction benefit one could achieve in Nave Gardens. Flap gates were installed at the same locations as those stated in **Section 9.1.1**.

Exhibits G and **H** show the 10- and 50-year floodplain results, respectively, as well as the improvement scenario layout.

The results show no significant difference in floodplains between existing and proposed conditions. This is because Arroyo Avichi Creek, in comparison to Novato and Warner Creeks, contributes far less flow into the Nave Gardens development. See **Figure 29**. Diverting Arroyo Avichi Creek flow to the ABSL Complex does not lower the tailwater in Novato or Warner Creeks sufficiently (if at all) to eliminate flooding in Nave Gardens. See **Figure 30** and **Figure 31**. Therefore, modification to the existing weir to increase flows into the ABSL complex was deemed not cost-effective and was removed from further consideration given the permitting and construction costs that would be required for little to no flood reduction benefits

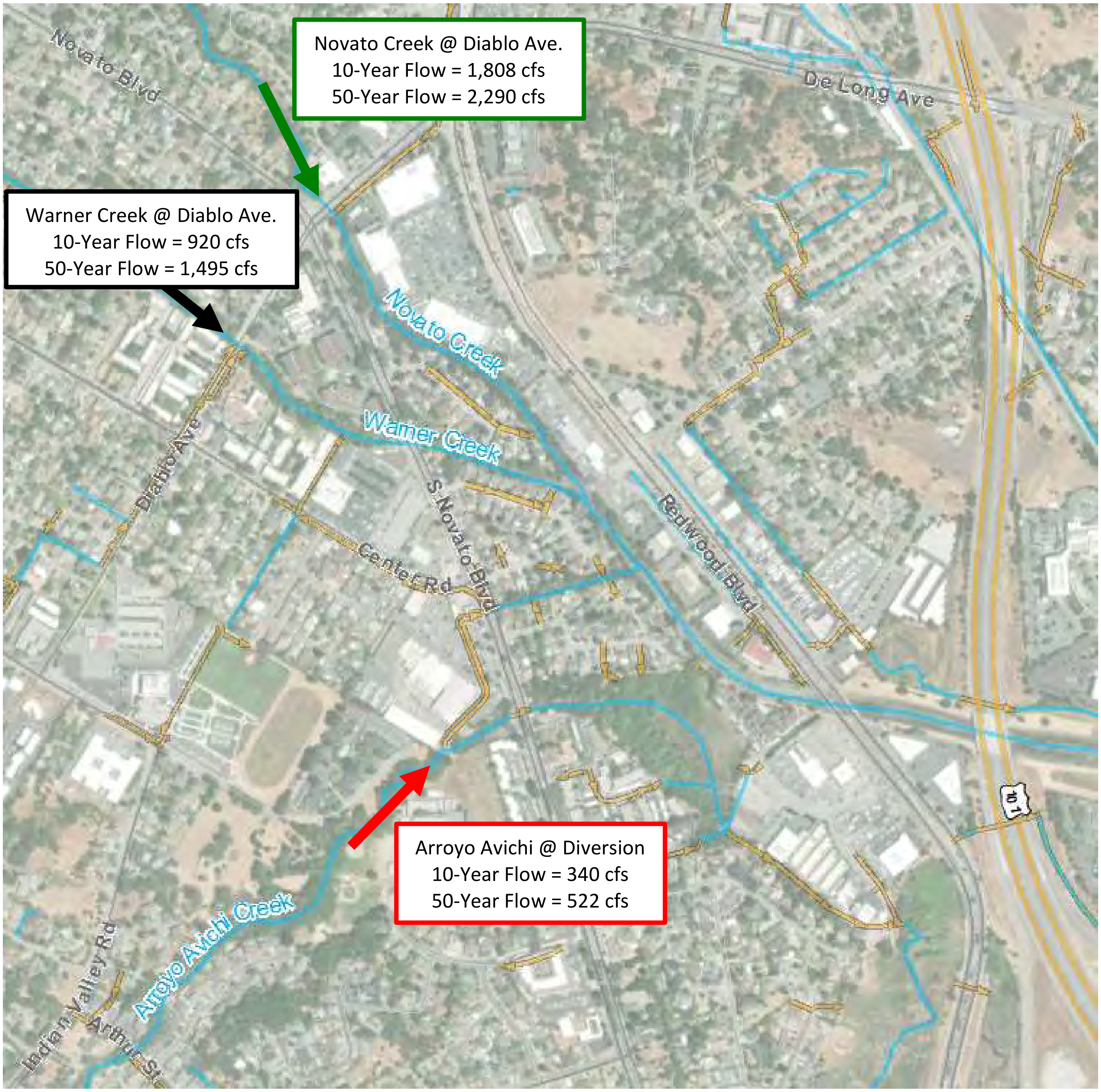


Figure 29 – Design Storm Peak Flows of Warner Creek and Novato Creek at Diablo Avenue, and Arroyo Avichi Creek at the Diversion Weir

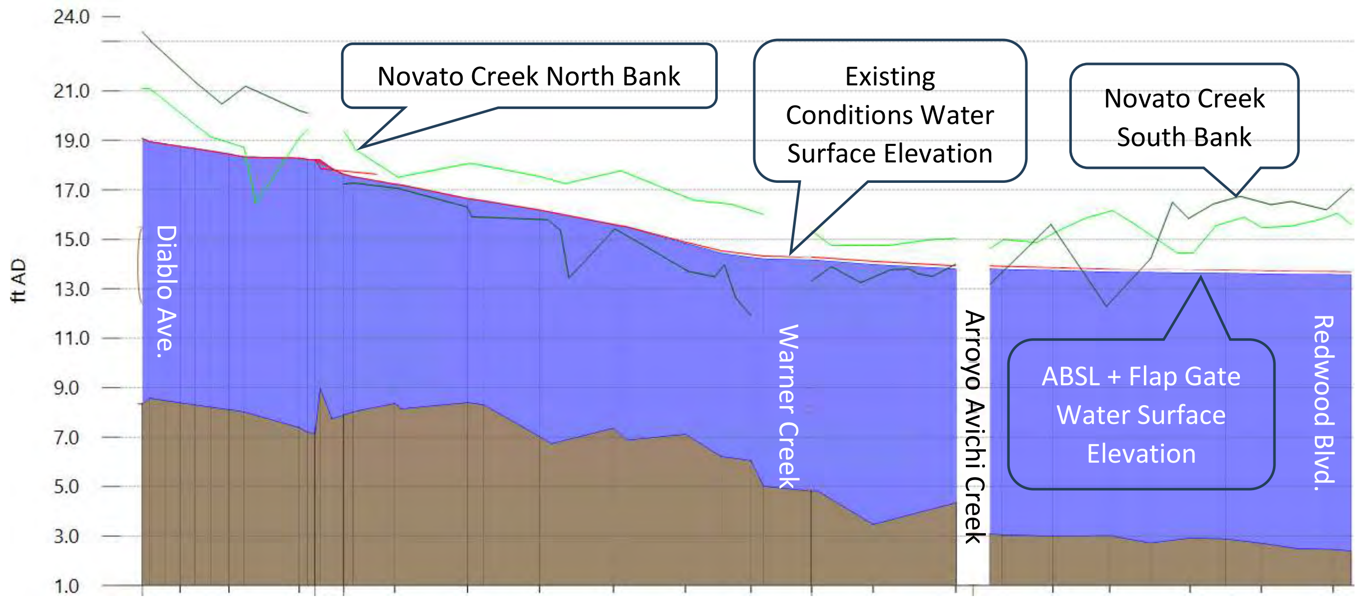


Figure 30 – Novato Creek Existing and ABSL + Flap Gate 10-Year Water Surface Elevation Profile Between Diablo Avenue and Redwood Boulevard

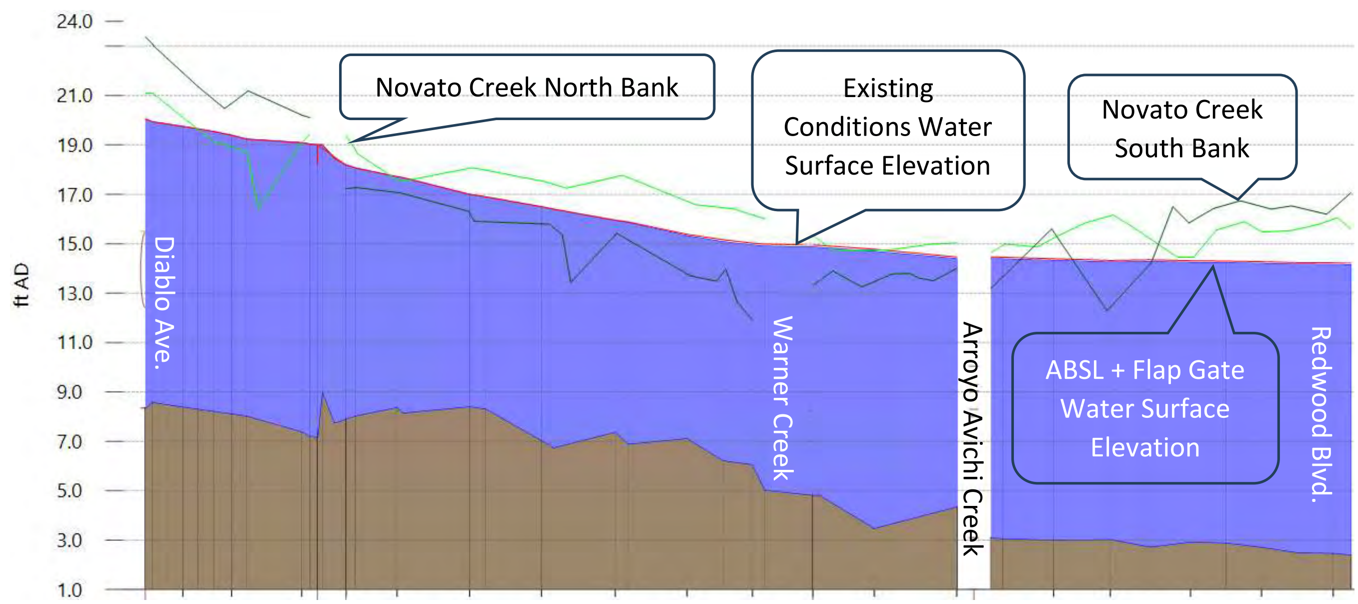


Figure 31 – Novato Creek Existing and ABSL + Flap Gate 50-Year Water Surface Elevation Profile Between Diablo Avenue and Redwood Boulevard

9.1.3 Floodwalls + Flap Gates

For this alternative, floodwalls were simulated on Novato Creek beginning at a private street 300 ft north of Nave Court off South Novato Boulevard to approximately 500 feet upstream of Redwood Boulevard, on Warner Creek between Diablo Avenue and Novato Creek, and on Arroyo Avichi Creek from South Novato Boulevard to Novato Creek. The floodwalls were modeled with an infinite height to assure no overtopping. Several parcels were affected by the floodwall installation including 58 residential, 6 commercial, 4 City of Novato, and 1 multi-family.

Flap gates were installed at the same locations as those stated in **Section 9.1.1**. **Exhibits I** and **J** show the 10- and 50-year floodplain results, respectively, as well as the proposed floodwall layout.

Model results showed a dramatic decrease in the Nave Gardens flooding extent and depth in the 10-year simulation. The 50-year results showed similar flood extents and depth between Warner Creek and Arroyo Avichi Creek, but a dramatic reduction of both flood depth and extent in the remaining areas of Nave Gardens. The floodwalls were effective at preventing spill from Novato, Warner, and Arroyo Avichi Creeks entering the Nave Gardens development. However, the high tailwater conditions in the creeks forced runoff to pool inside Nave Gardens until it was at a higher elevation than the creek tailwater. This is why part of Nave Gardens would still flood with this alternative. Flood waters were shown to be between 1 and 3 feet above the creek banks in the 50-year storm. Assuming 3 feet of freeboard, this would require the floodwalls to be between 4 and 6 feet tall to contain the District's 50-year level of service storm.

On average, the tailwater in Novato Creek within the extents of the floodwalls rose 0.4 feet in the 10-year simulation, and 1.0 foot in the 50-year simulation. If the District chooses to move forward with this alternative, FEMA would have to approve any increases in the base flood elevation and may require mitigation of negative effects caused by the water surface increase in areas outside the project extents. See **Figure 32** and **Figure 33**.

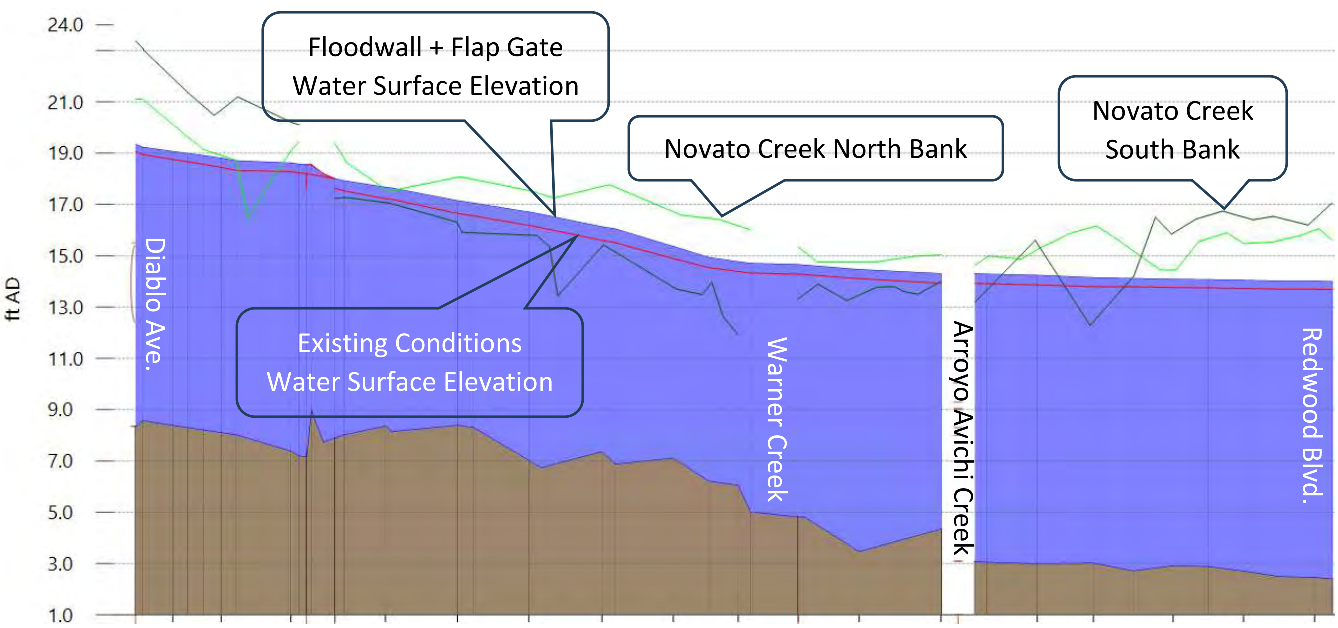


Figure 32 – Novato Creek Existing and Floodwall + Flap Gate 10-Year Water Surface Elevation Profile Between Diablo Avenue and Redwood Boulevard

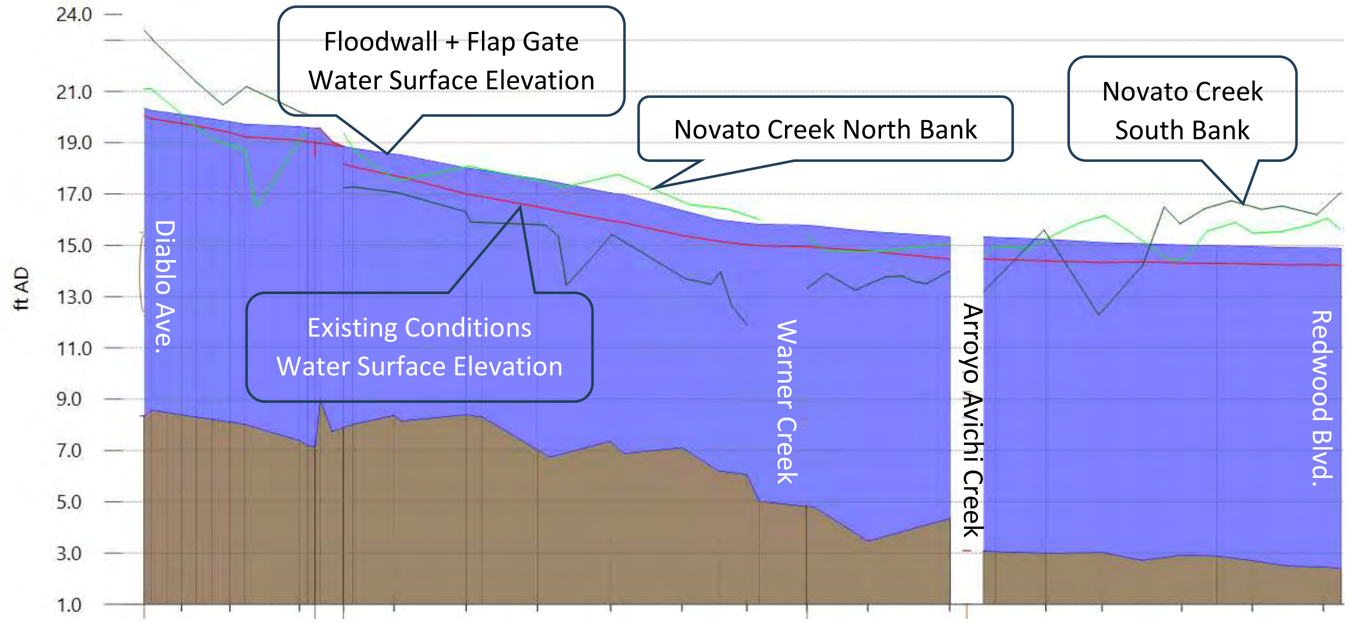


Figure 33 – Novato Creek Existing and Floodwall + Flap Gate 50-Year Water Surface Elevation Profile Between Diablo Avenue and Redwood Boulevard

9.1.4 North Deer Island Levee Lowering + Flap Gates

The District owns an area in the Novato Baylands that has been used in the past for flood storage during high flooding events. In past events, District staff would have to manually breach the North Deer Island levee as water levels rise to lessen flooding in Nave Gardens and Downtown. See **Figure 34**.

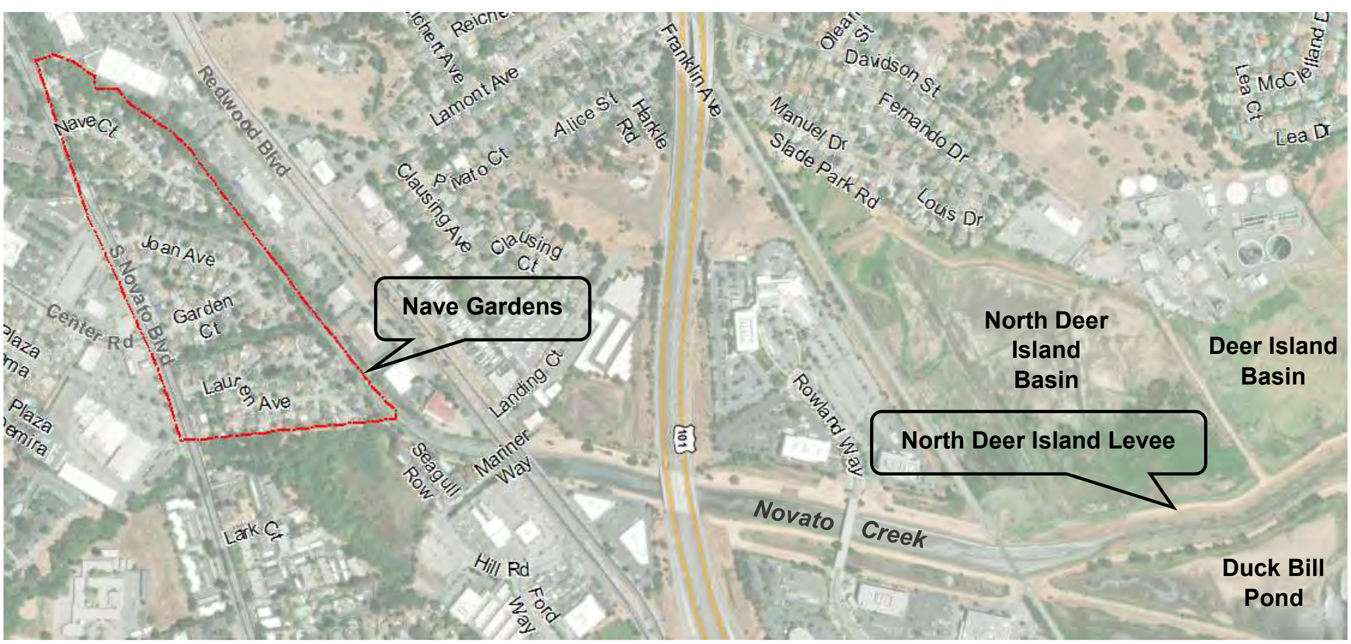


Figure 34 – North Deer Island Basin and the North Deer Island Levee

For this alternative, approximately 1,300 feet of the existing North Deer Island Levee was lowered by an average of 5.0 feet between the SMART railroad tracks and the cross berm separating North Deer Island Basin and Deer

Island Basin to an elevation of 10.0 feet NAVD88. Water spilling from Novato Creek over the lowered levee would flow into the North Deer Island Basin. Flap gates were installed at the same locations as those stated in **Section 9.1.1**. **Exhibits K** and **L** show the 10- and 50-year floodplain results, respectively, as well as the proposed improvement layout.

Model results showed a dramatic decrease in the Nave Gardens flooding extent and depth in the 10-year simulation. Water surface elevations in Novato Creek, Warner Creek, and Arroyo Avichi Creek were lowered enough to practically eliminate channel spilling into Nave Gardens. However, the tailwater was not lowered enough to eliminate runoff from ponding due to the closed flap gates, primarily on Nave Court. The 50-year results showed similar flood extents when compared to existing conditions, but a fair amount of flood depth reduction. Creek tailwater was still high enough to spill over the channel banks and prevent runoff from draining through the flap gates. See **Figure 35** and **Figure 36**.

The spilled water from Novato Creek into North Deer Island Basin resulted in a maximum water surface elevation of approximately 7.6 and 8.7 feet NAVD88 for the 10- and 50-year design storms, respectively. Because the cross berm separating North Deer Island Basin and Deer Island Basin has an average elevation of 5.5 feet NAVD88, large amounts of water spilled from North Deer Island Basin into Deer Island Basin. See **Figure 37**.

The District has expressed concerns with the proposed North Deer Island levee lowering. Precipitation events large enough to spill into North Deer Island Basin may result in stranding of fish. With no means of escaping back into Novato Creek, they would be trapped. Fish passage would need to be addressed in the levee-lowering design.

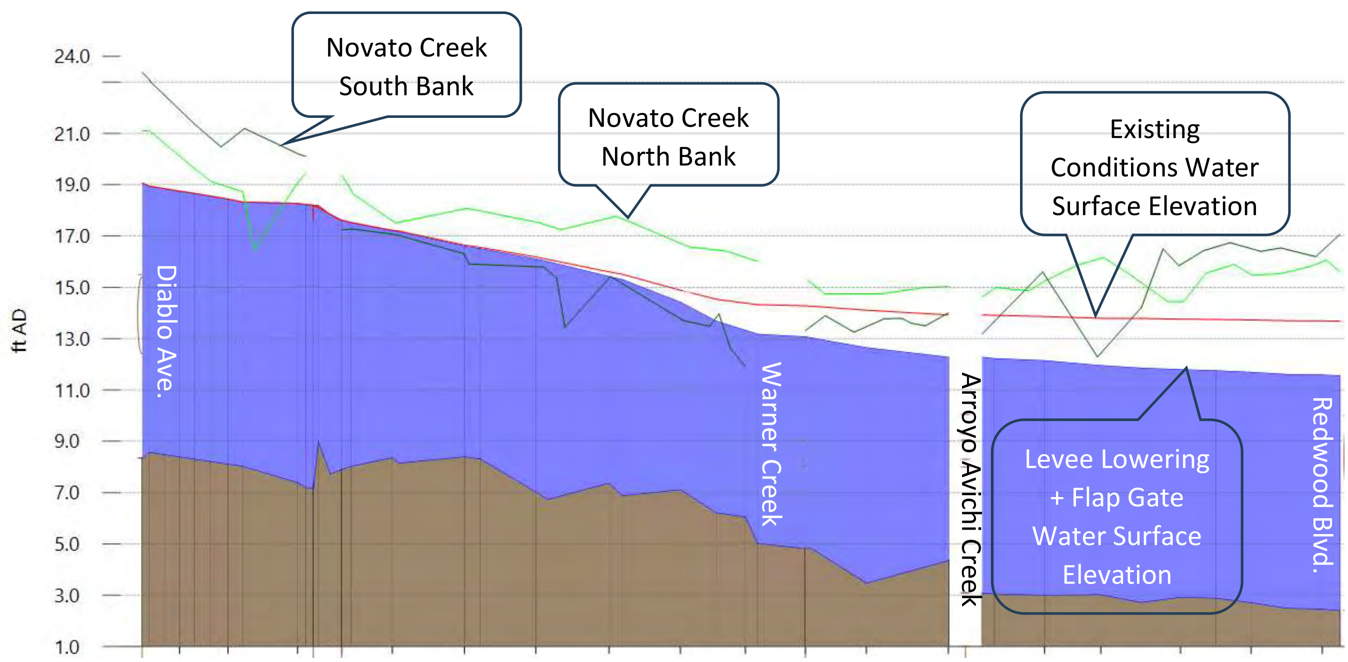


Figure 35 – Novato Creek Existing and Levee Lowering + Flap Gate 10-Year Water Surface Elevation Profile Between Diablo Avenue and Redwood Boulevard

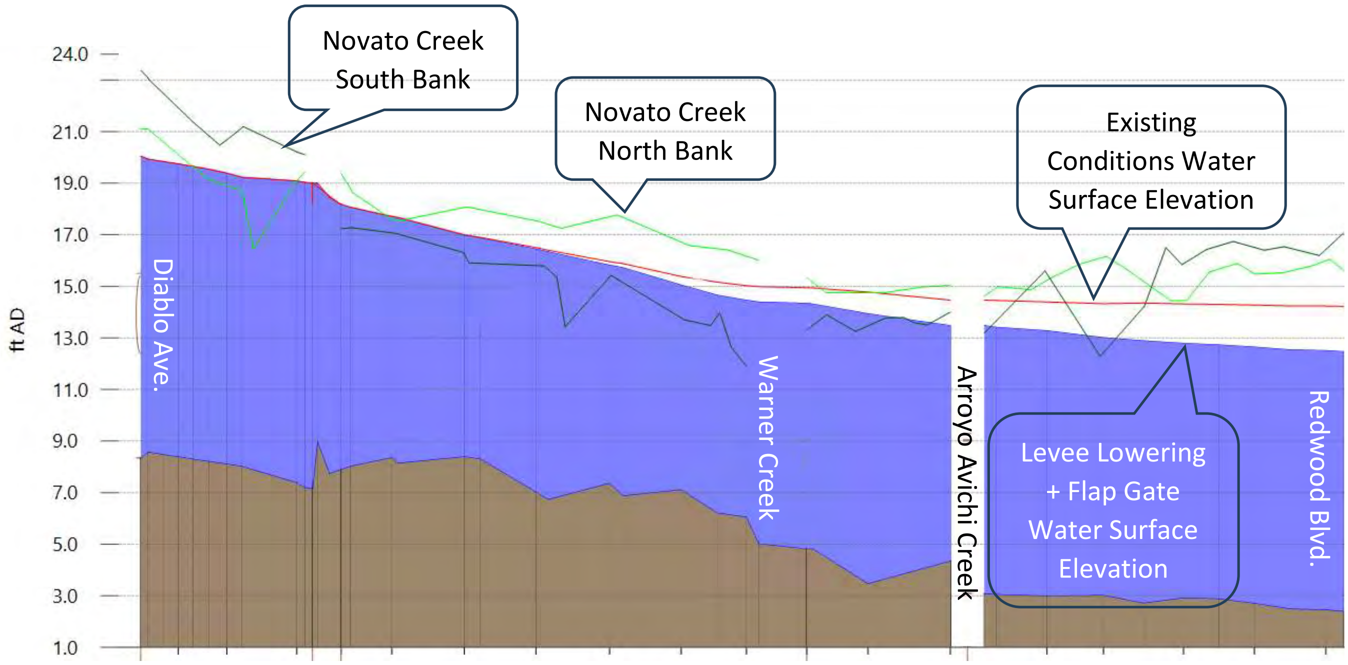


Figure 36 - Novato Creek Existing and Levee Lowering + Flap Gate 50-Year Water Surface Elevation Profile Between Diablo Avenue and Redwood Boulevard

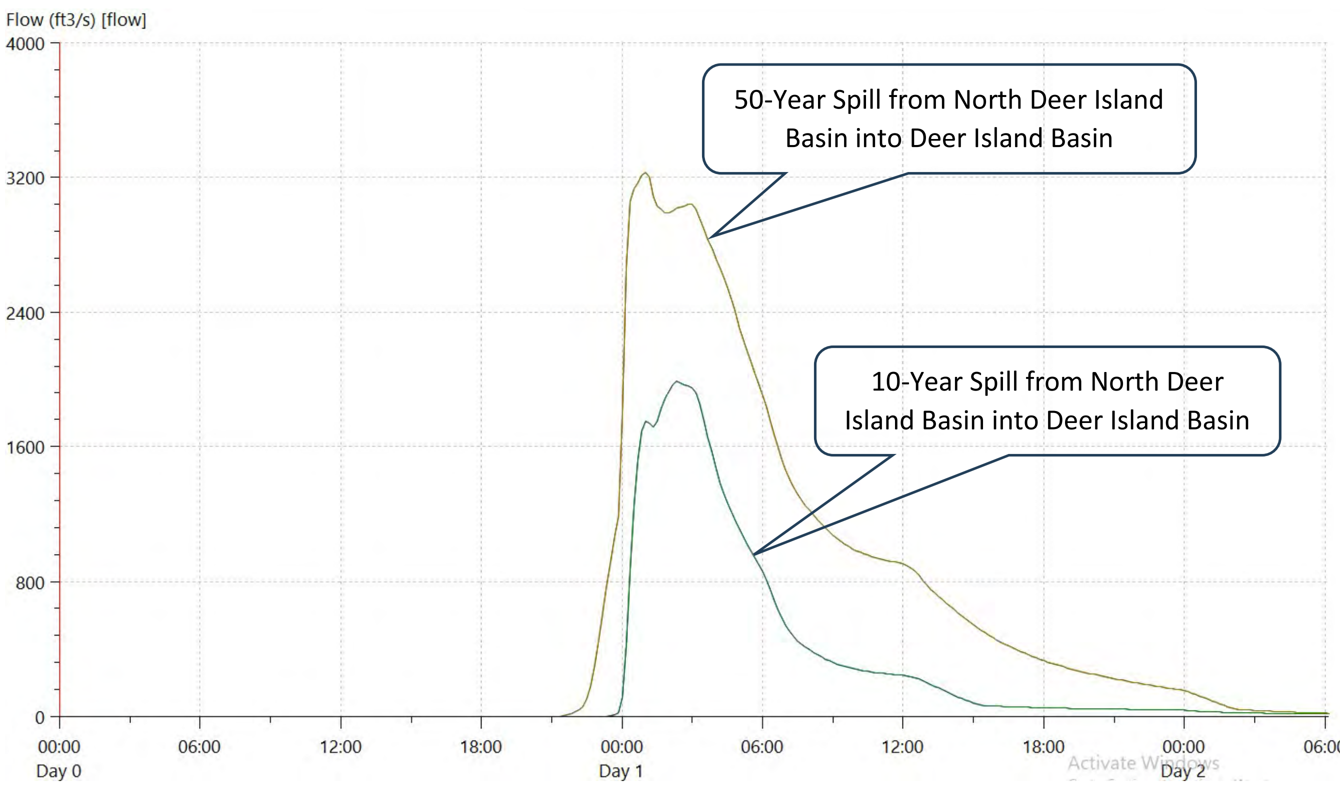


Figure 37 – Hydrograph of 10- and 50-Year Spill from North Deer Island Basin Into Deer Island Basin with North Deer Island Levee Lowering

9.1.5 Channel Dredging + Flap Gates

For this alternative, Novato Creek and Warner Creek cross sections were updated to a post-dredge condition. Novato Creek was dredged between the confluence of Arroyo Avichi Creek and a private bridge over Novato Creek approximately 300 feet north of Nave Court. Warner Creek was dredged between the confluence with Novato Creek and a location 350 feet upstream of the South Novato Boulevard crossing. Cross section geometry for the post-dredge condition was obtained from the Novato DMP ICM Model. Arroyo Avichi's cross sections were not modeled as dredged because its water surface elevations are heavily impacted by the tailwater of Novato Creek. Novato Creek and Warner Creek's thalwegs were, on average, lowered by 4.0 feet and 2.0 feet, respectively. Flap gates were installed at the same locations as those stated in **Section 9.1.1**. **Exhibits M** and **N** show the 10- and 50-year floodplain results, respectively, as well as the proposed improvement layout.

Model results show a slight reduction of floodplain extent and depth in both the 10-, and 50-year simulation when compared to existing conditions. Dredging did help prevent water spilling from Novato Creek into Nave Garden upstream of Warner Creek; however, the high tailwater conditions downstream of Warner Creek remained, and prevented runoff from draining through the flap gates. See **Figure 38** and **Figure 39**. The effects of channel dredging on Warner Creek's water surface elevations were less drastic than those observed on Novato Creek. As shown in **Figure 40** and **Figure 41**, the water surface elevations in Warner Creek were reduced by approximately 0.5 feet. Novato Creek's tailwater prevented a more drastic reduction in Warner Creek's water surface elevation.

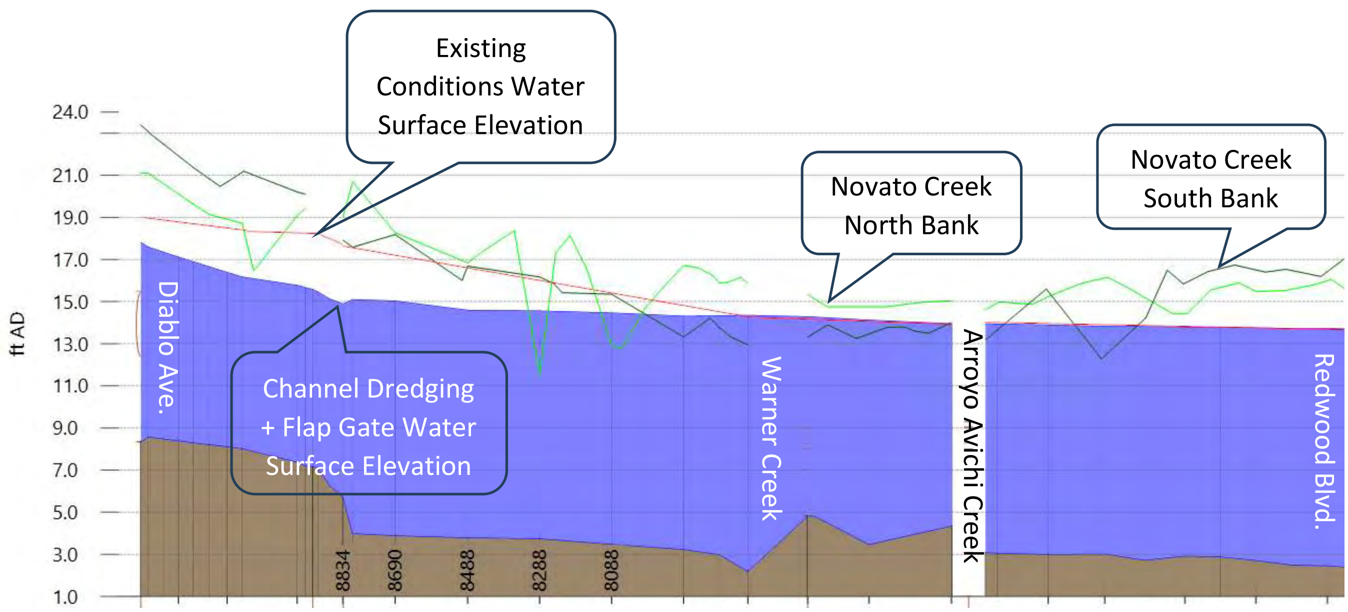


Figure 38 – Novato Creek Existing and Channel Dredging + Flap Gate 10-Year Water Surface Elevation Profile Between Diablo Avenue and Redwood Boulevard

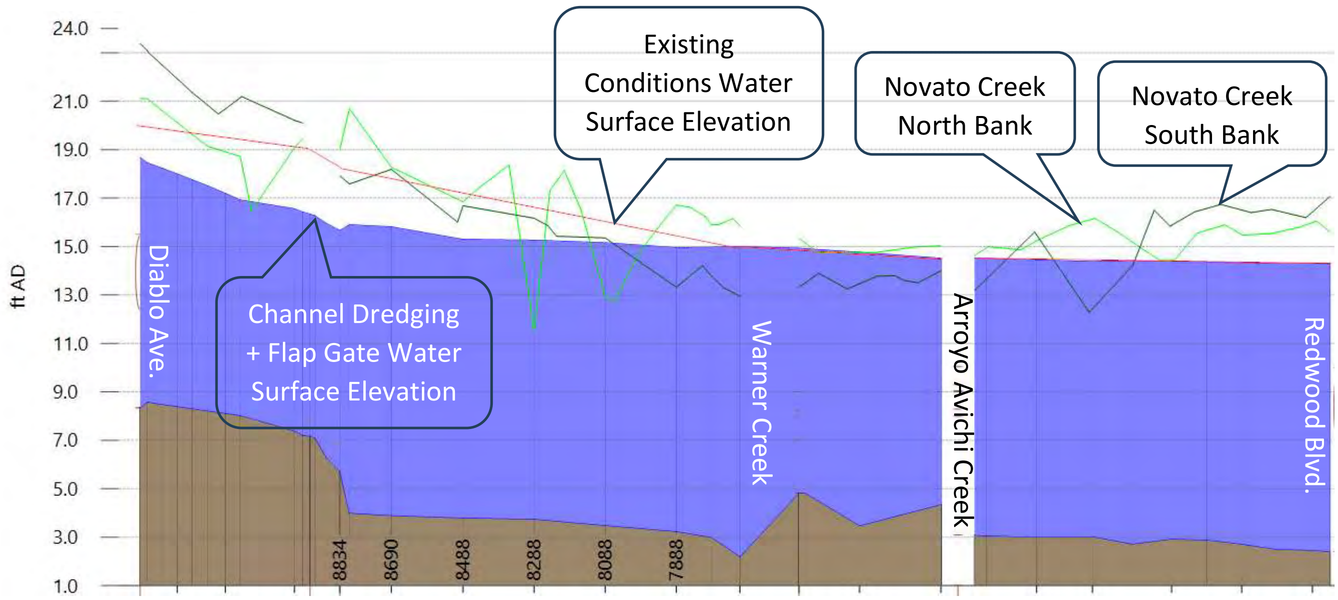


Figure 39 – Novato Creek Existing and Channel Dredging + Flap Gate 50-Year Water Surface Elevation Profile Between Diablo Avenue and Redwood Boulevard

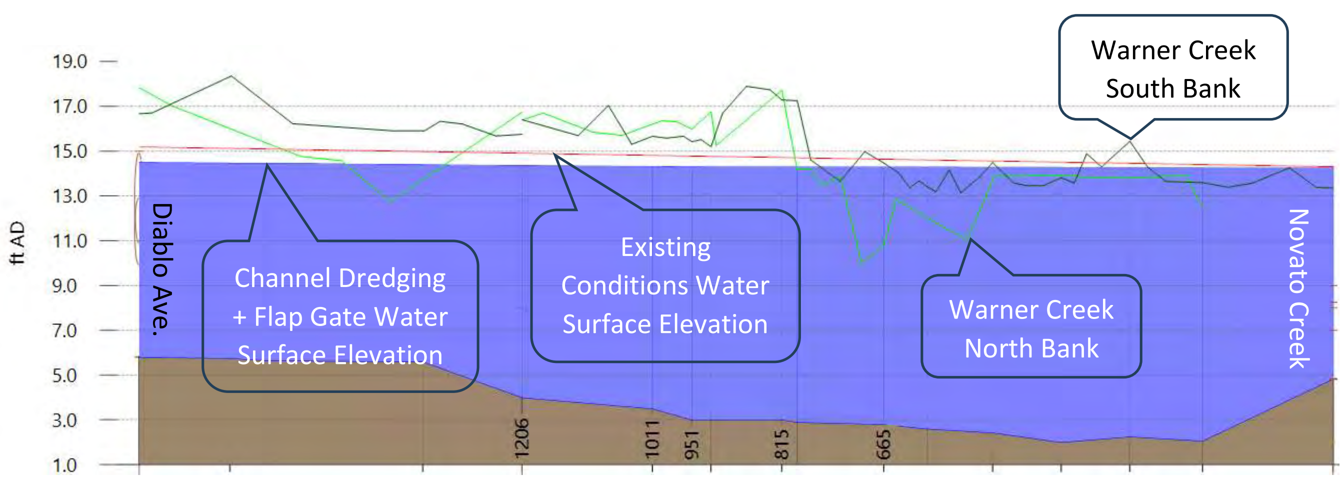


Figure 40 – Warner Creek Existing and Channel Dredging + Flap Gate 10-Year Water Surface Elevation Profile Between Diablo Avenue and Novato Creek

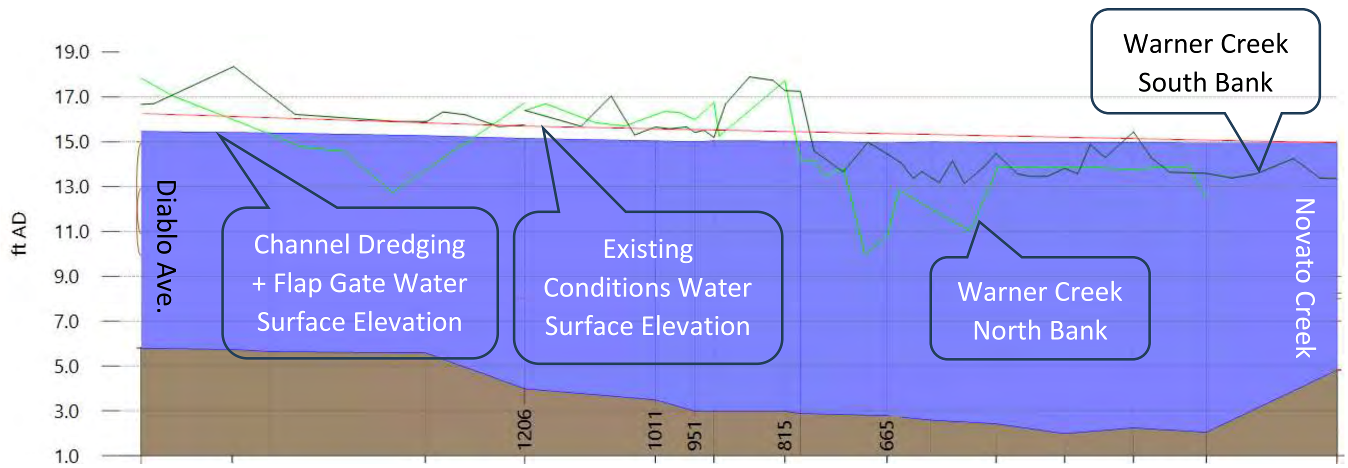


Figure 41 – Warner Creek Existing and Channel Dredging + Flap Gate 50-Year Water Surface Elevation Profile Between Diablo Avenue and Novato Creek

9.1.6 Floodwalls + Flap Gates + North Deer Island Levee Lowering

For this alternative, the improvements described in **Sections 9.1.1, 9.1.3,** and **9.1.4** were combined into one modeling scenario. **Exhibits O** and **P** show the 10- and 50-year floodplain results, respectively, as well as the proposed improvement layout. Modeling results showed a dramatic reduction in extent and depth for the 10-year simulation. The 50-year simulation showed a dramatic reduction in depth and extent between Novato and Warner Creeks and Arroyo Avichi Creek and Baccaglio Basin, while a mediocre reduction of extent and depth was observed between Warner Creek and Arroyo Avichi Creek. The floodwalls were effective at eliminating spill from the channels, and the Deer Island levee lowering reduced the tailwater in the channels, allowing runoff to exit the flap gates at a lower elevation. Similar to **Section 9.1.4**, the runoff spilling from Novato Creek into North Deer Island Basin also spilled into Deer Island Basin from North Deer Island Basin. Similar flows were observed from North Deer Island Basin into Deer Island Basin as those displayed in **Figure 37**.

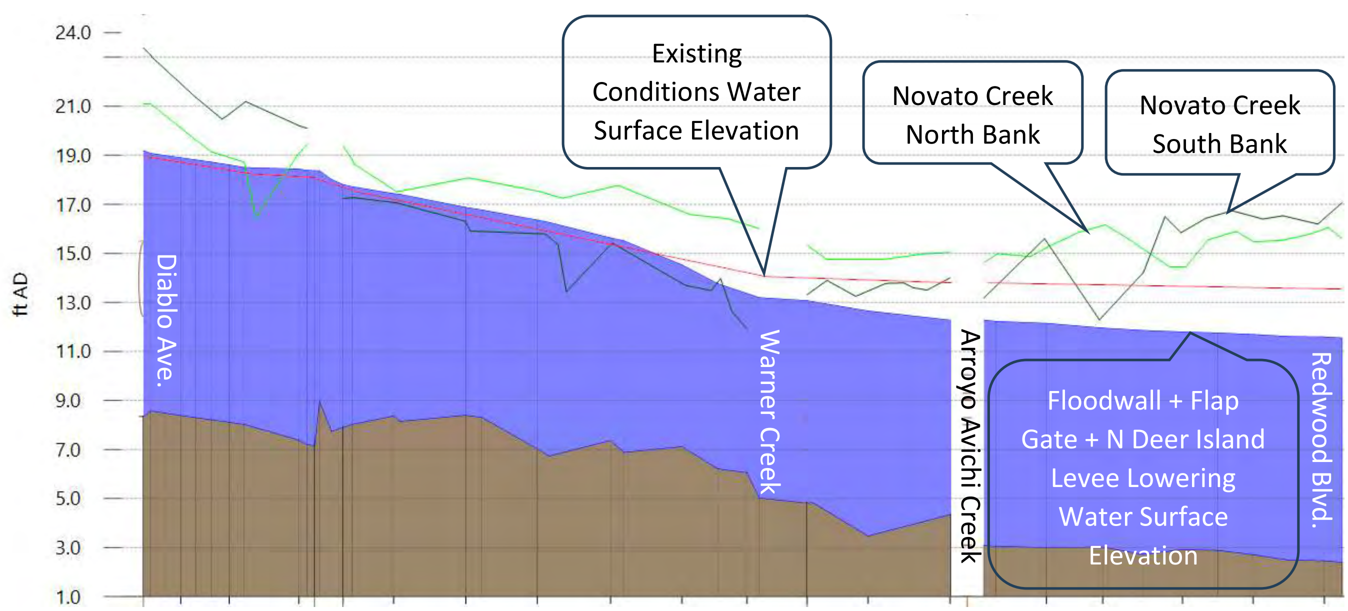


Figure 42 – Novato Creek Existing and Floodwall + Flap Gate + N Deer Island Levee Lowering 10-Year Water Surface Elevation Profile Between Diablo Avenue and Redwood Boulevard

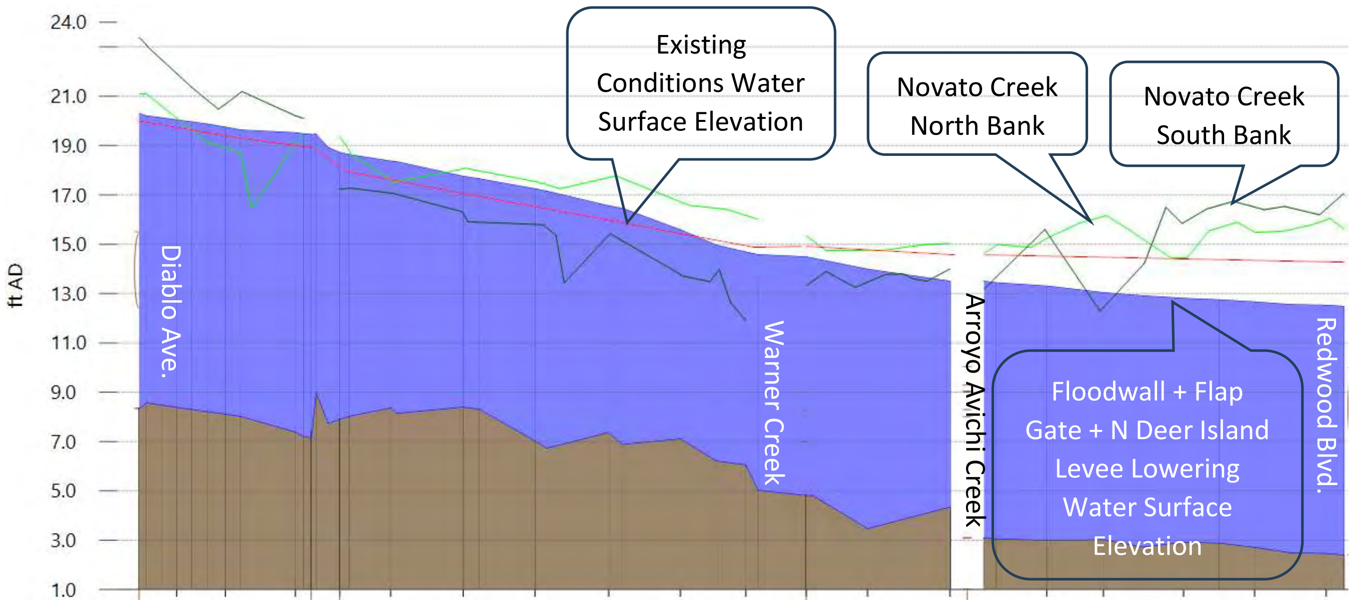


Figure 43 – Novato Creek Existing and Floodwall + Flap Gate + North Deer Island Levee Lowering 50-Year Water Surface Elevation Profile Between Diablo Avenue and Redwood Boulevard

9.1.7 Channel Dredging + Flap Gates + North Deer Island Levee Lowering

For this alternative, the improvements described in **Sections 9.1.1, 9.1.4, and 9.1.5** were combined into one modeling scenario. **Exhibits Q** and **R** show the 10- and 50-year floodplain results, respectively, as well as the proposed improvement layout. Modeling results showed an almost complete elimination of the 10-year floodplain. The 50-year simulation showed a dramatic reduction in depth and extent between Novato and Warner Creeks and Arroyo Avichi Creek and Baccaglio Basin, while a mediocre reduction of extent and depth was observed between Warner Creek and Arroyo Avichi Creek. The Deer Island levee lowering and the channel dredging lowered the water surface elevation in the channels such that there was no channel spill in the 10-year event, and limited spill in the 50-year event. In addition, the lower tailwater in the channels allowed runoff to drain through the flap gates at a lower elevation. See **Figure 44** and **Figure 45**. Similar flows were observed from North Deer Island Basin into Deer Island Basin as those displayed in **Figure 37**.

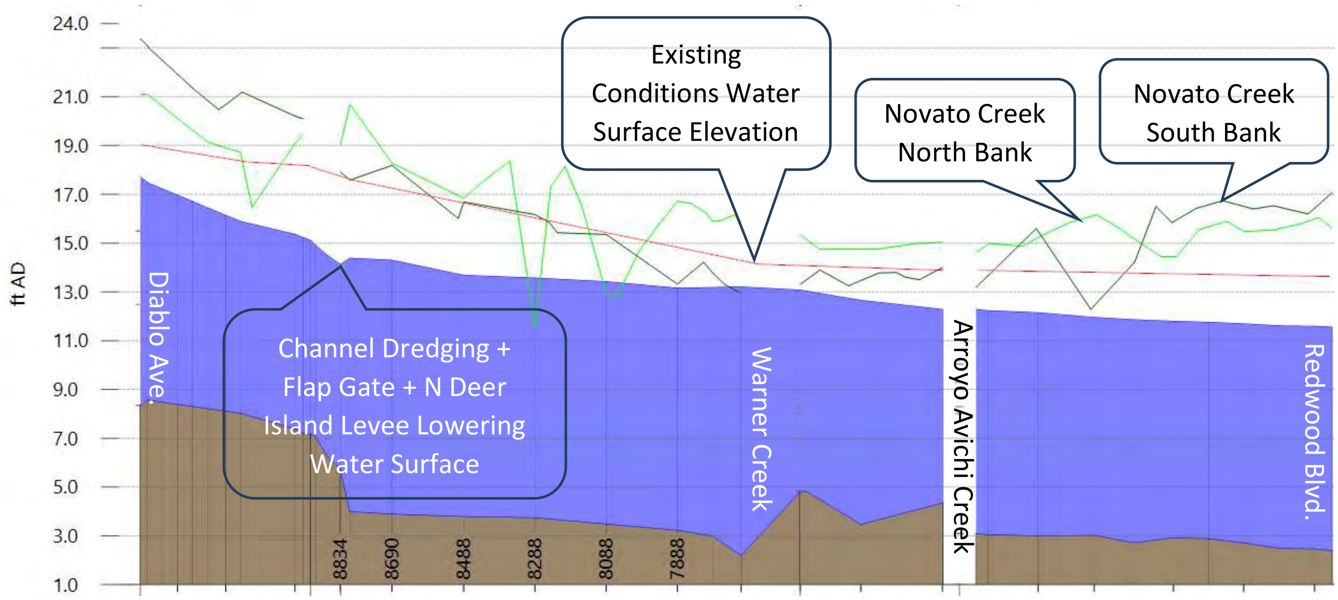


Figure 44 – Novato Creek Existing and Channel Dredging + Flap Gate + North Deer Island Levee Lowering 10-Year Water Surface Elevation Profile Between Diablo Avenue and Redwood Boulevard

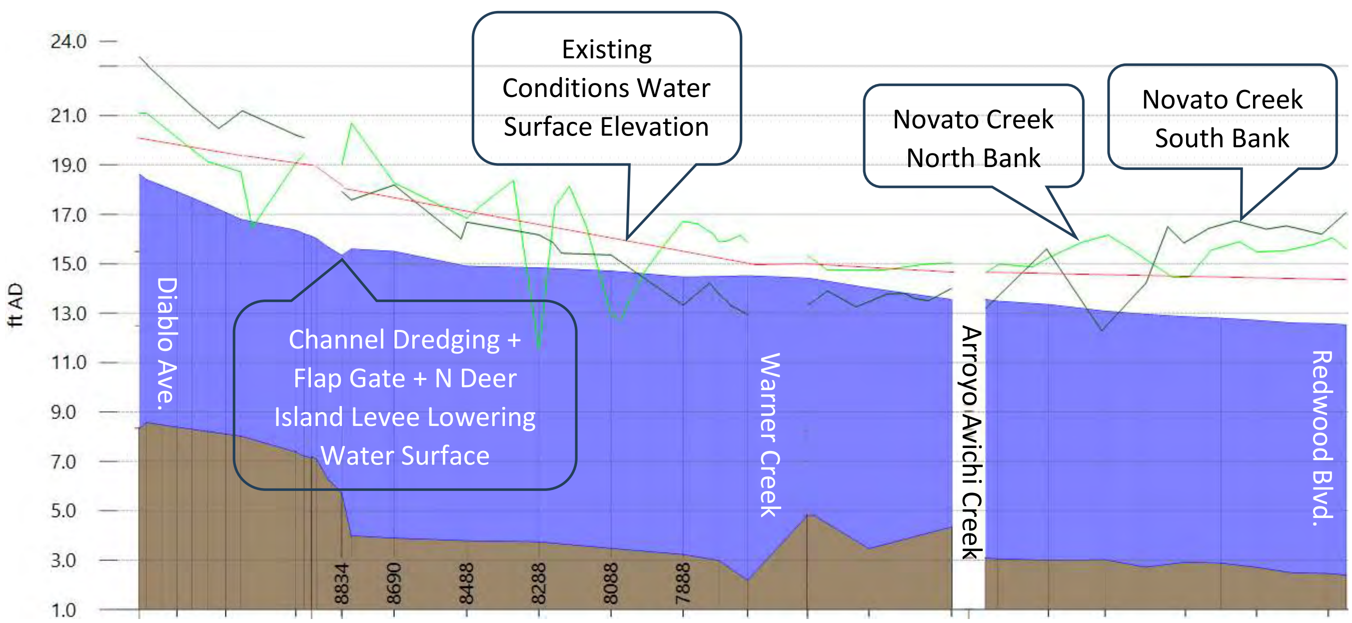


Figure 45 – Novato Creek Existing and Channel Dredging + Flap Gate + North Deer Island Levee Lowering 50-Year Water Surface Elevation Profile Between Diablo Avenue and Redwood Boulevard

9.1.8 Other Improvement Alternatives

Additional improvement alternatives were investigated but not presented in detail in this report. These improvement alternatives showed little to no difference when compared to existing conditions, or they were not practical. Less expensive scenarios were just as effective, and in some cases, more effective. These modeling scenarios are listed in **Table 4**.

Table 4 – Summary of Other Improvement Alternatives

Improvement Alternative	Reason not Feasible
ABSL Bypass + Flap Gates + N Deer Island Levee Lowering	Similar results to N Deer Island Levee Lowering + Flap Gates
ABSL Bypass + Flap Gates + Floodwalls	Similar results to Floodwalls + Flap Gates
Lu Sutton Elementary Temporary Seasonal Storage + Flap Gates	Little Change in Floodplain Extent & Depth
Lu Sutton Elementary Temporary Seasonal Storage + Flap Gates + N Deer Island Levee Lowering	Similar results to N Deer Island Levee Lowering + Flap Gates
Lu Sutton Elementary Temporary Seasonal Storage + Flap Gates + ABSL Bypass	Little Change in Floodplain Extent & Depth

9.1.9 Effects of Nave Gardens Improvements on Downtown Novato

The proposed improvements described **in Sections 9.1.1– 9.1.8** had little to no effect on the existing flooding in Downtown Novato. The changes in Novato Creek's hydraulic grade line were too far downstream to have any significant impact on Downtown Novato's flooding.

9.2 Lynwood Pump Station

The benefits and costs for repairing, reoperating or relocating the Lynwood Pump Station were investigated. These alternatives are described in detail below.

9.2.1 Move Lynwood Pump Station

The District has expressed their desire to move the Lynwood Pump Station from its current location to a location adjacent to the Cheda Pump Station. The current location of the Lynwood Pump Station makes access difficult for District staff when high flood waters are present in Novato Creek or the Lynwood Basin, birds frequently collide with overhead power lines and disrupt power to the pump station, and PG&E have expressed their desire the pump station be moved because it is within their easement. See **Figure 46**.

Because this alternative has no impact on the hydraulics of the pump stations or the Lynwood Basin, modeling results would be identical to those shown in **Section 8.3**.

Figure 46 – Proposed New Location of Lynwood Pump Station

9.2.2 Remove Lynwood Pump Station

For this alternative, a modeling scenario of removing the Lynwood Pump Station was created to determine if the Lynwood Basin can successfully detain runoff while gravity draining into Novato Creek. A triple 48" RCP culvert with flap gates was modeled between the Lynwood Basin and Novato Creek to allow it to drain when hydraulic conditions allow (i.e., tailwater in Novato Creek is lower than Lynwood Basin's water surface elevation). See **Figure 47**. Cheda Pump Station remained under normal operating conditions.

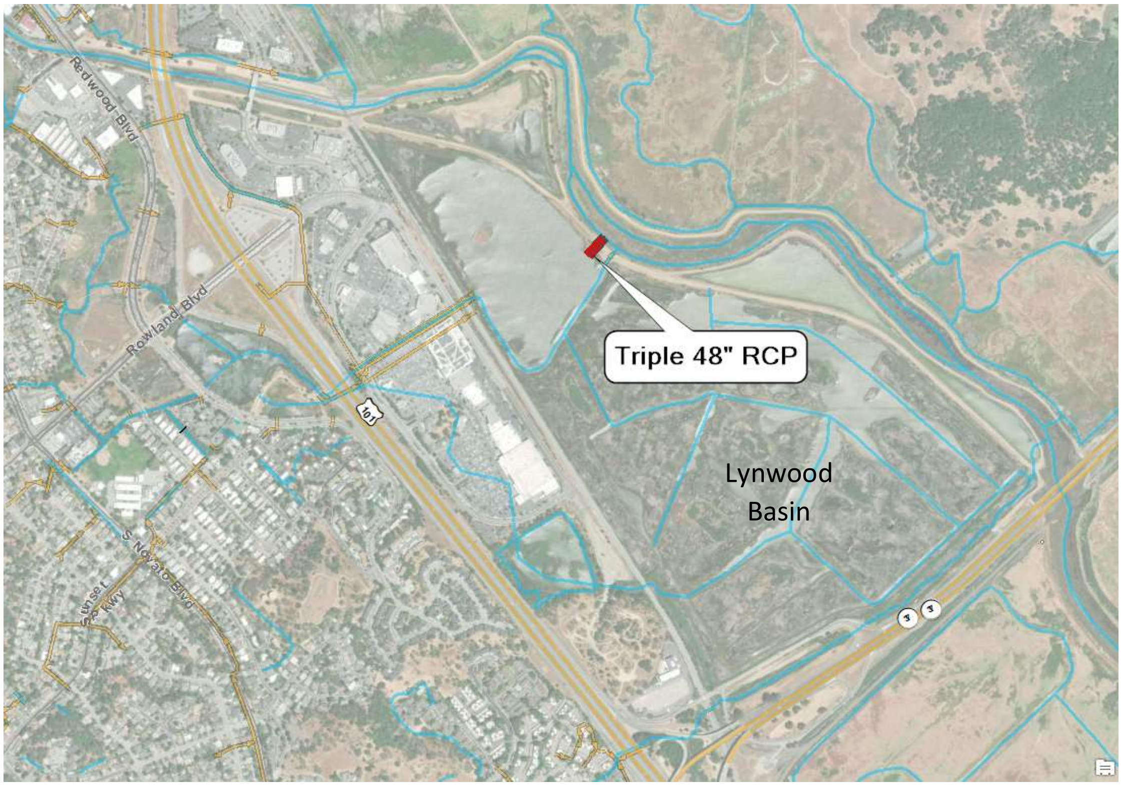


Figure 47 – Triple 48" RCP Culverts Location

9.2.2.1 Design Storms

Water surface elevations of the Lynwood Basin, Novato Creek, and flow through the triple 48" RCP pipes during the 2-, 10-, and 50-year design storms are displayed in **Figure 48**, **Figure 49**, and **Figure 50**, respectively. The maximum water surface elevations in Lynwood Basin were 3.1 feet, 3.9 feet, and 5.4 feet NAVD88 during the 2-, 10-, and 50-year storms, respectively. During the simulation, there was no opportunity for Lynwood Basin to drain because of the high tailwater in Novato Creek. No increase in flooding was observed when compared to the existing conditions in the 2- and 10-year simulations. However, in the 50-year simulation, a small portion of Hanna Ranch Road and Highway 37 was flooded. See **Figure 51**. Design storm results show the water surface elevation in Lynwood Basin will increase when compared to existing conditions.

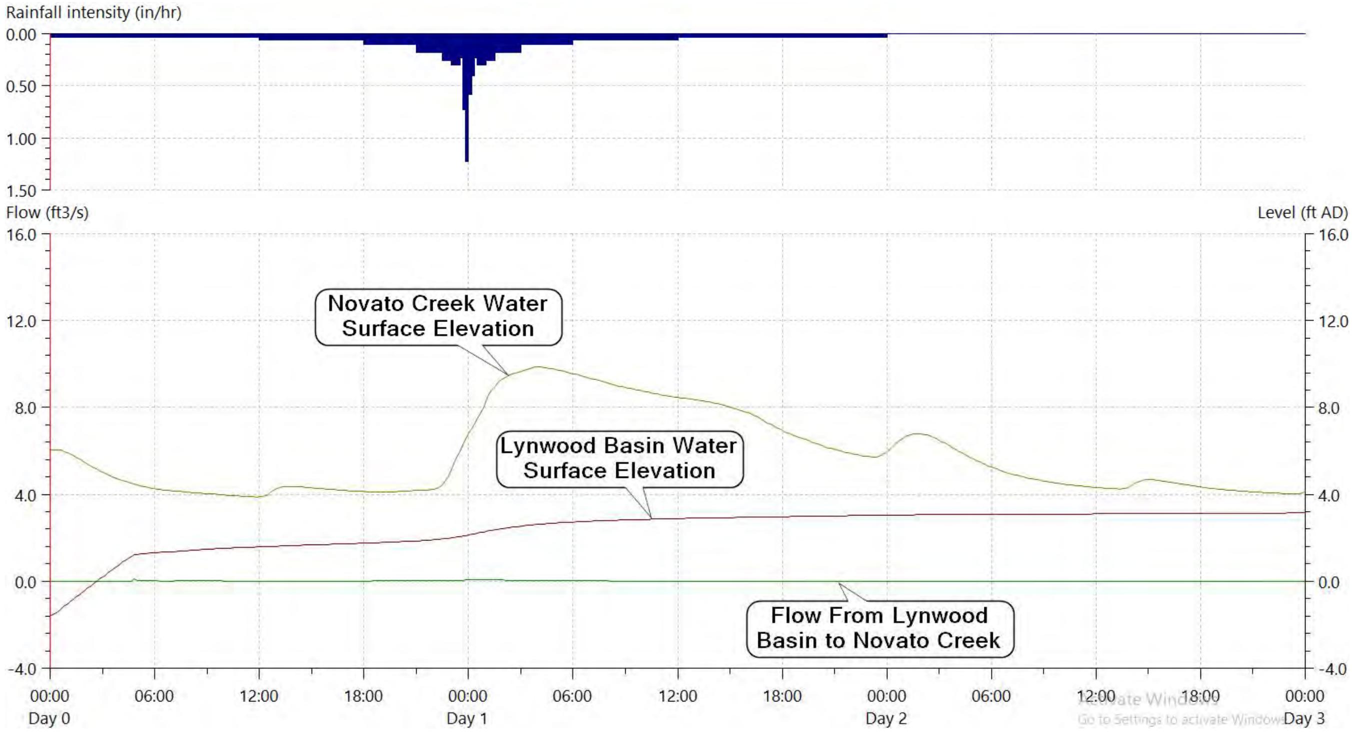


Figure 48 – Comparison of Novato Creek Water Surface Elevation, Lynwood Basin Water Surface Elevation, and Flow from Lynwood Basin to Novato Creek During the 2-Year Design Storm with no Lynwood Pump Station

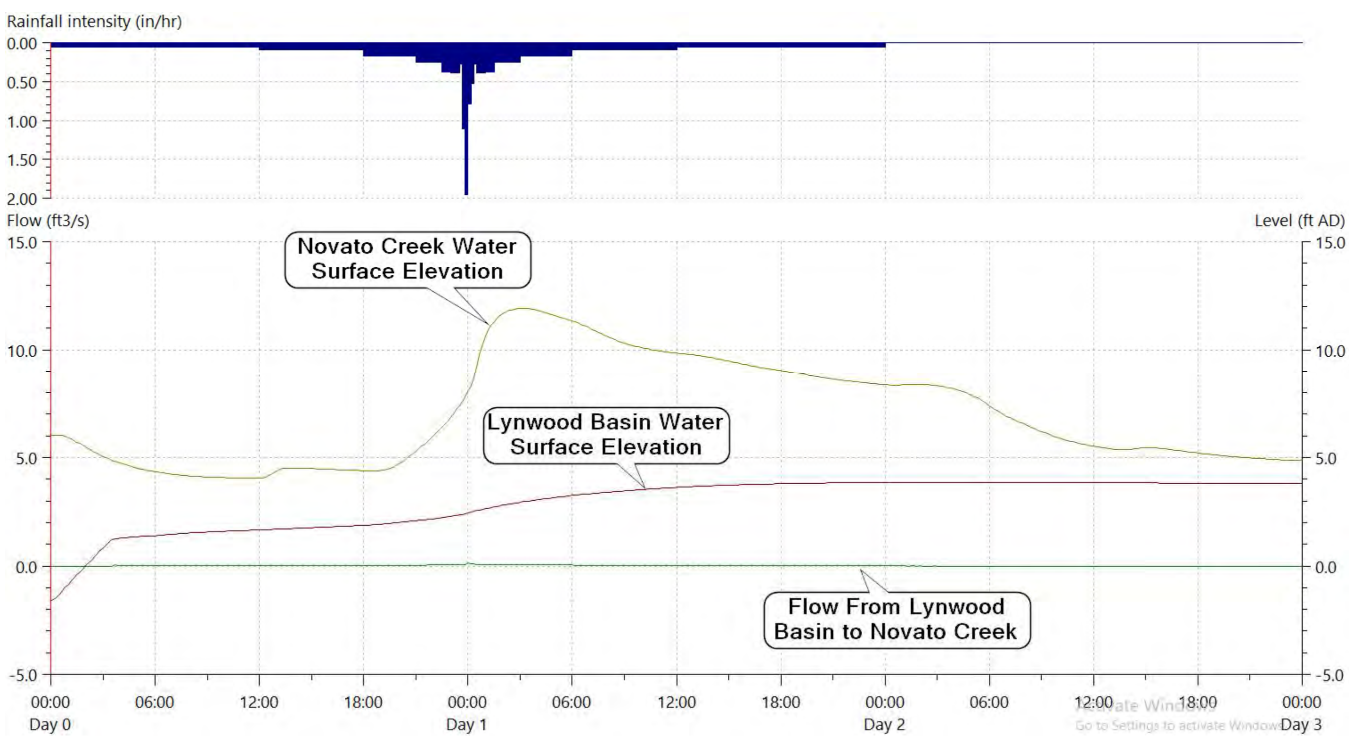


Figure 49 – Comparison of Novato Creek Water Surface Elevation, Lynwood Basin Water Surface Elevation, and Flow from Lynwood Basin to Novato Creek During the 10-Year Design Storm with no Lynwood Pump Station

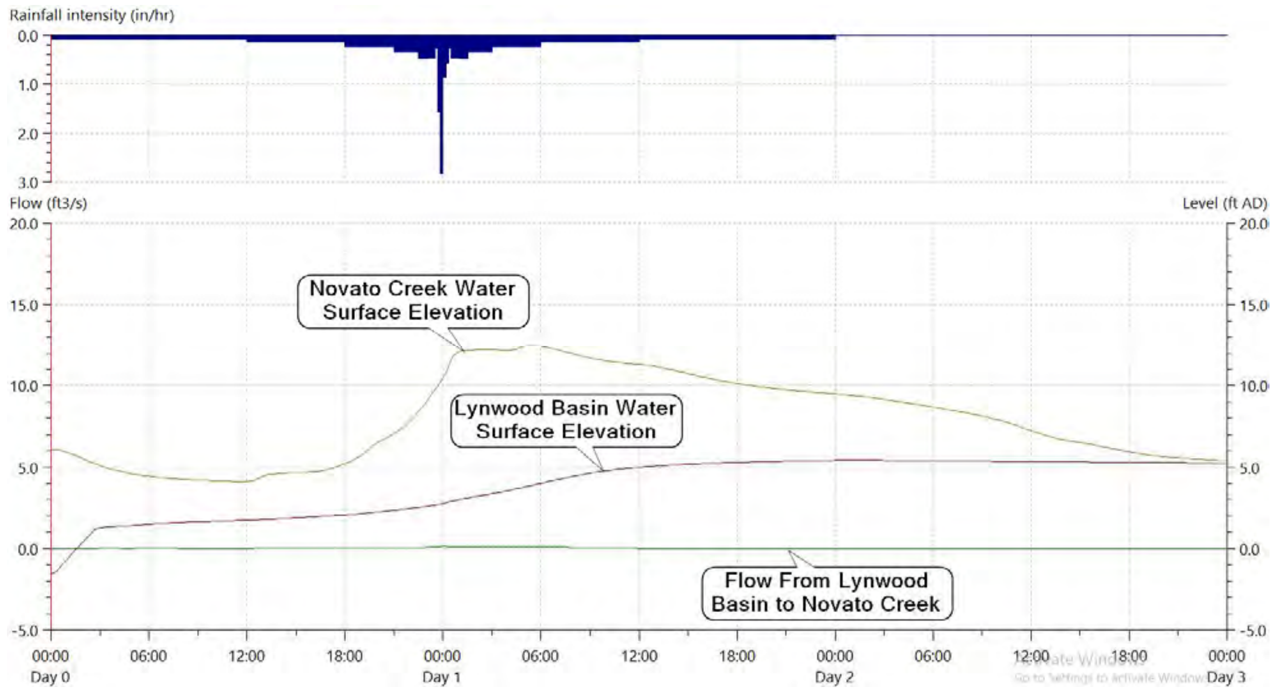


Figure 50 – Comparison of Novato Creek Water Surface Elevation, Lynwood Basin Water Surface Elevation, and Flow from Lynwood Basin to Novato Creek During the 50-Year Design Storm with no Lynwood Pump Station

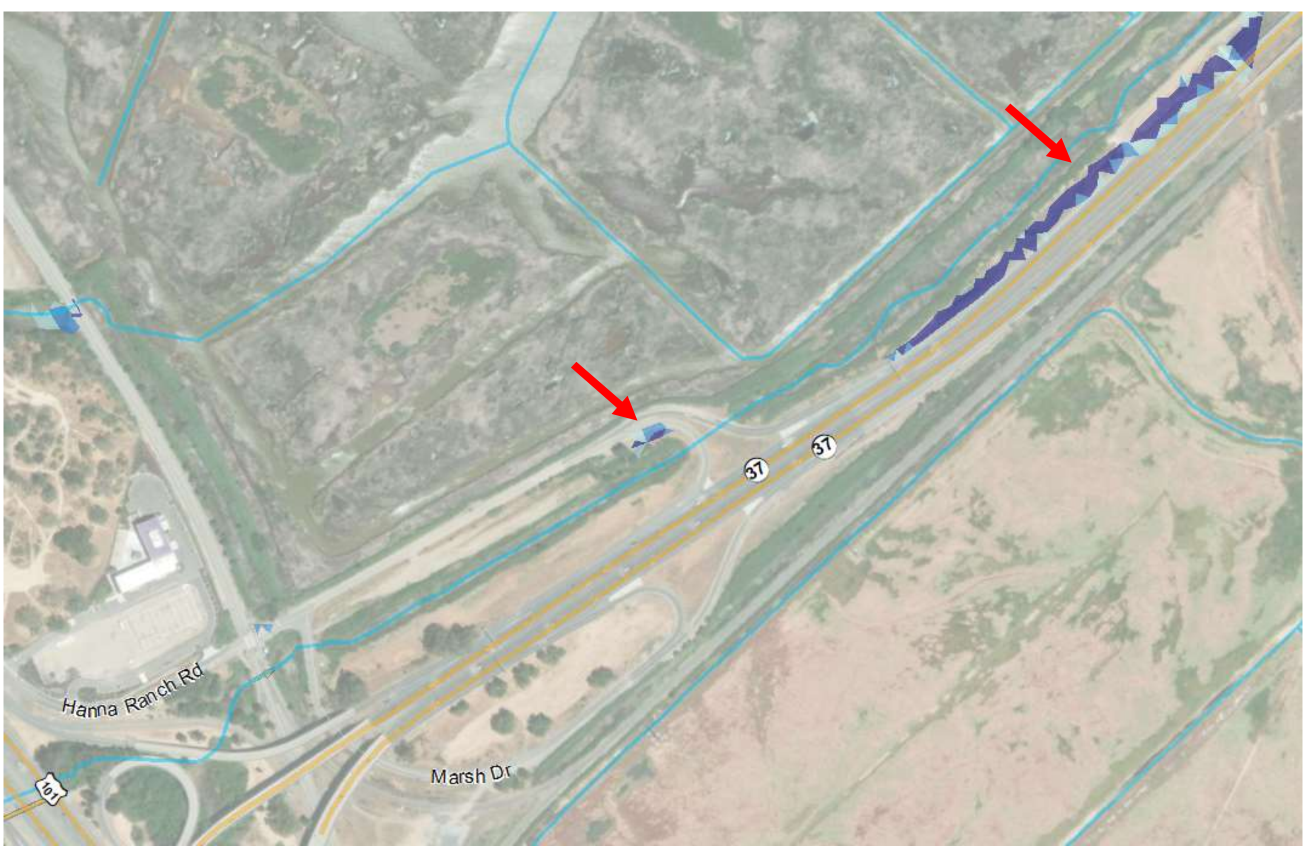


Figure 51 – 50-Year Flooding Resulting from No Lynwood Pump Station Near Hannah Ranch Road and Highway 37

9.2.2.2 2022-2023 Wet Season

The model simulation showed a peak elevation of 5.6 feet NAVD88 in the Lynwood Basin. See **Figure 52**. At that elevation, Hanna Ranch Road near the southern boundary of the basin flooded, and there is less than a foot of freeboard at the SMART railroad tracks. These results indicate there weren't enough opportunities for Lynwood Basin to drain during the 2022-2023 wet season to keep the water surface elevations similar to those simulated in the existing conditions simulation.

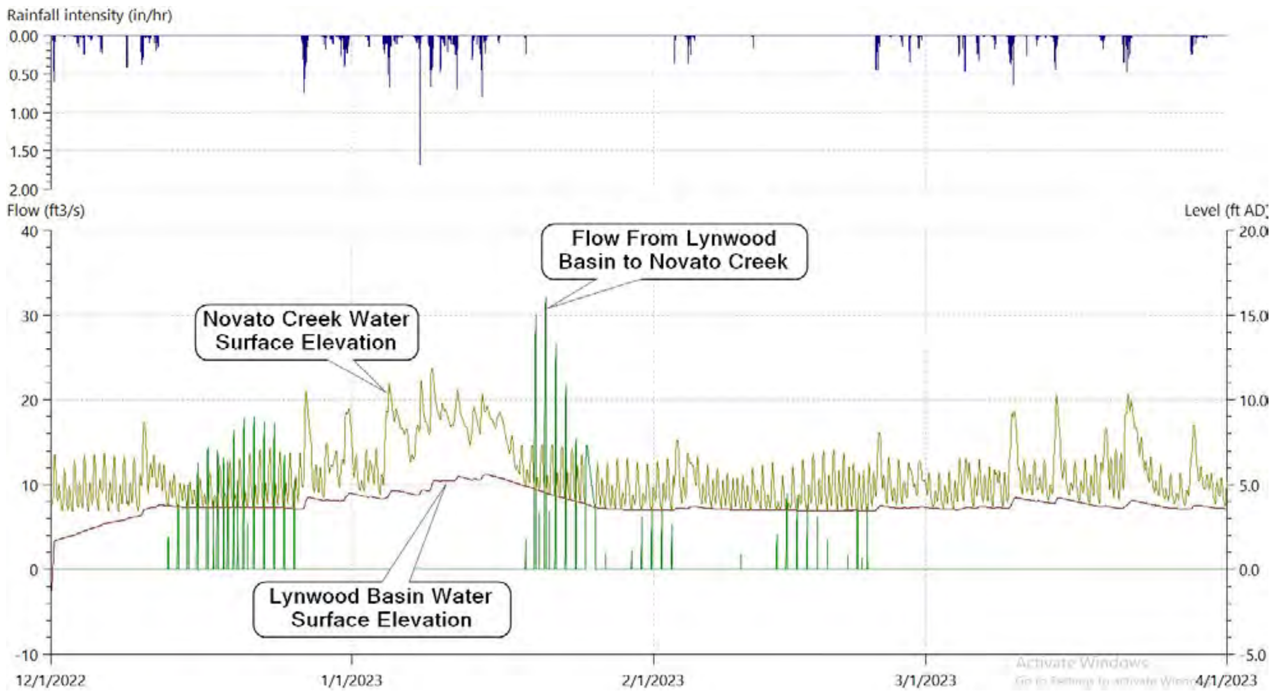


Figure 52 – Lynwood Basin Water Surface Elevation with Lynwood Pump Station Replaced with Triple 48" RCP During the 2022 – 2023 Wet Season

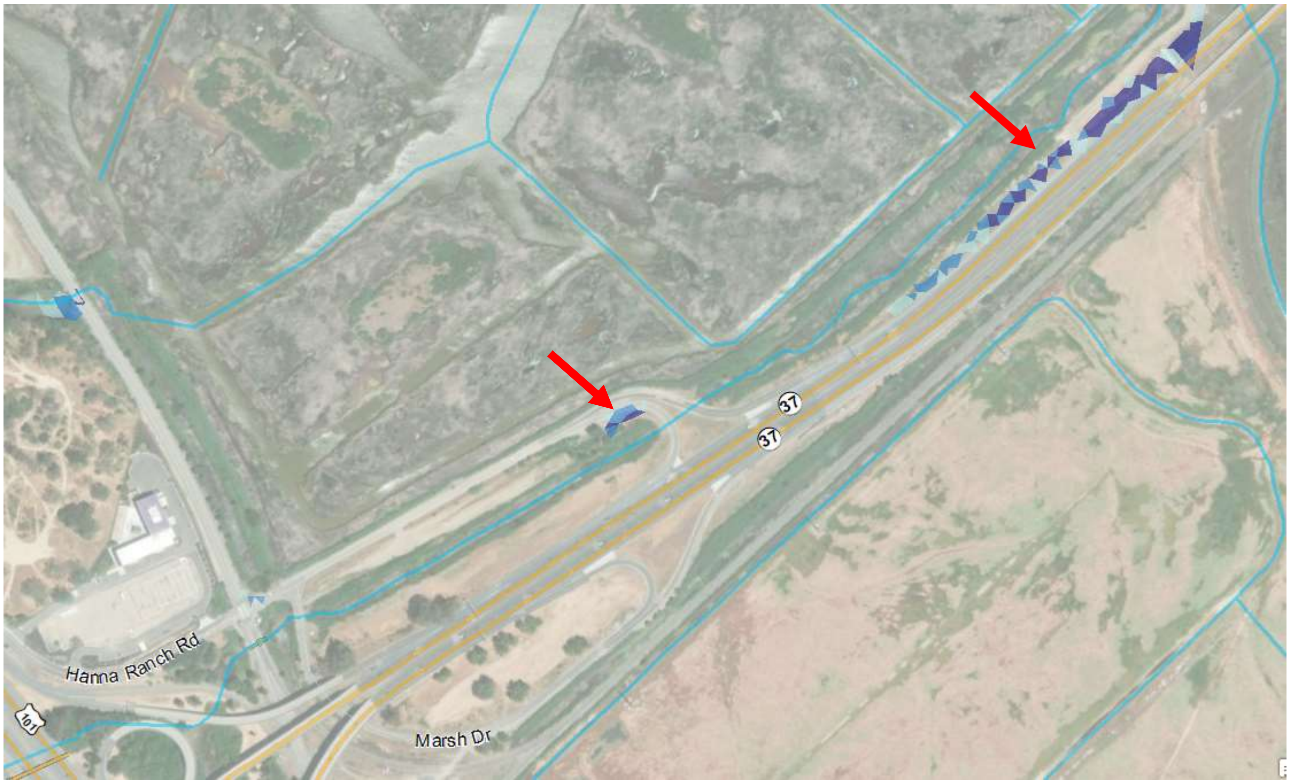


Figure 53 – 2022-2023 Wet Season Flooding Resulting from No Lynwood Pump Station Near Hannah Ranch Road and Highway 37

Results also showed a large strain on the Cheda Pump Station. With limited availability for water to escape Lynwood Basin, Cheda Pump Station was pumping for the majority of the wet season. See **Figure 54**.

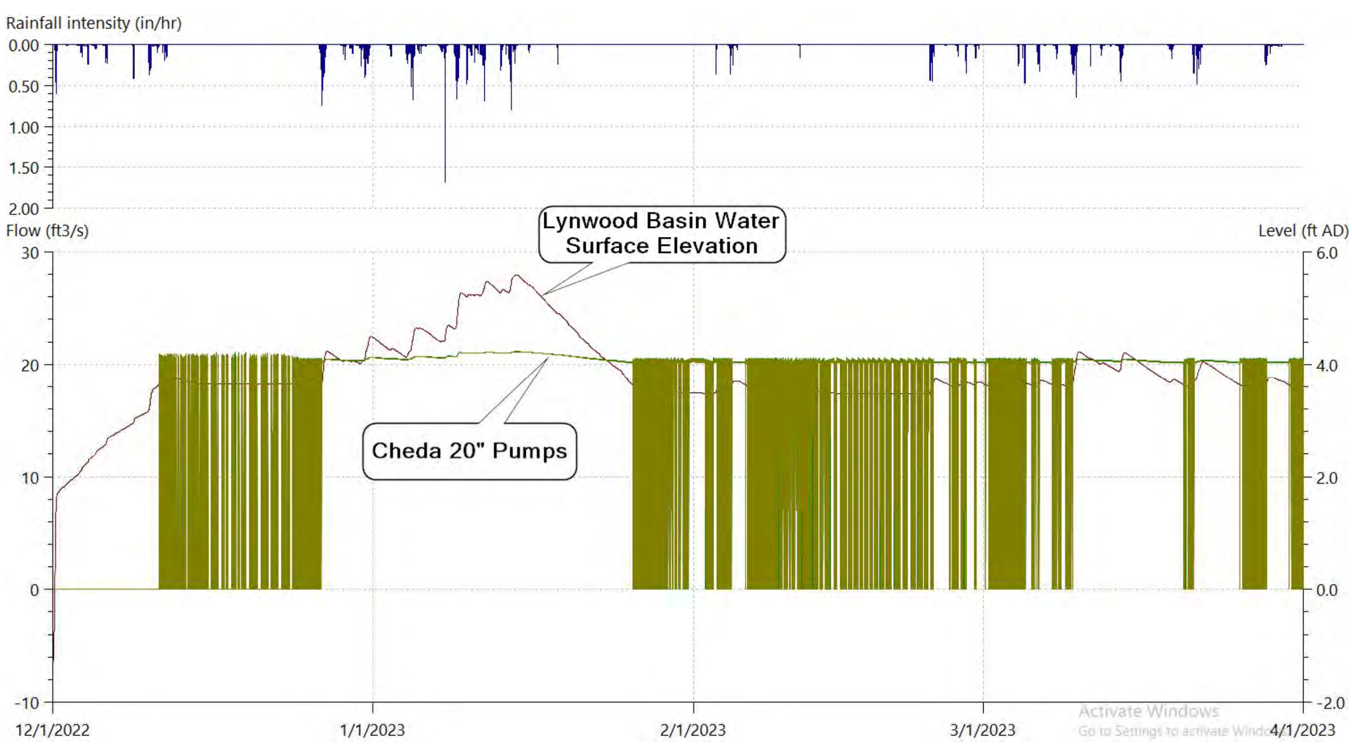


Figure 54 – Lynwood Basin Water Surface Elevation and Flow from Cheda Pump Station's Twin 20" Pumps

9.2.3 Remove Individual Pumps from the Lynwood Pump Station

The ability of the Lynwood Pump Station to remove runoff from the Lynwood Basin with the 24" pump, and the 24" and 30" pumps removed was simulated. In each scenario, the pumps were turned on at a lower elevation to maintain the recommended water surface elevations in Lynwood Basin per District recommendations[9]. Cheda Pump Station was not altered.

9.2.3.1 24" Pump Removed

The 24" pump was removed from the Lynwood Pump Station simulation.

Table 5 displays the pump schedule used in this scenario. Model results showed that during the 2-year simulation, the 10" and 30" pumps turned on, while Lynwood Basin peaked at elevation 3.0 feet NAVD88. See **Figure 55**. In the 10-year simulation, all three pumps turned on, while Lynwood Basin peaked at an elevation of 3.3 feet NAVD88. See **Figure 56**. In the 50-year simulation, all three pumps turned on, while the Lynwood Basin peaked at an elevation of 4.6 feet NAVD88. See **Figure 57**.

During the 2022-2023 wet season, model results showed all three pumps turned on during various periods of the simulation. Lynwood Basin had a peak water surface elevation of 3.3 feet NAVD88. See **Figure 58**. Results of the simulations indicate Lynwood Basin's peak water surface elevation can be maintained at elevations similar to those in the existing conditions simulations. However, the remaining pumps were forced to turn on more frequently. **Table 6** displays the frequency of each pump turning on compared to exiting conditions. Even though the frequency of turning on increased for the 10", 30" and 36" pumps, the time between pump cycles was still measured in days. This is well below the recommended limit of pumps turning on 4 – 5 times per hour.

Table 5 – Assumed Lynwood Pump Station Pumping Schedule with 24" Pump Removed

Pump	On Elevation (feet, NAVD88)	Off Elevation (feet, NAVD88)
Lynwood 10"	2.7	1.7
Lynwood 24"	-	-
Lynwood 30"	3.0	1.7
Lynwood 36"	3.3	1.7
Cheda 20"	3.7	2.7
Cheda 20"	3.7	2.7

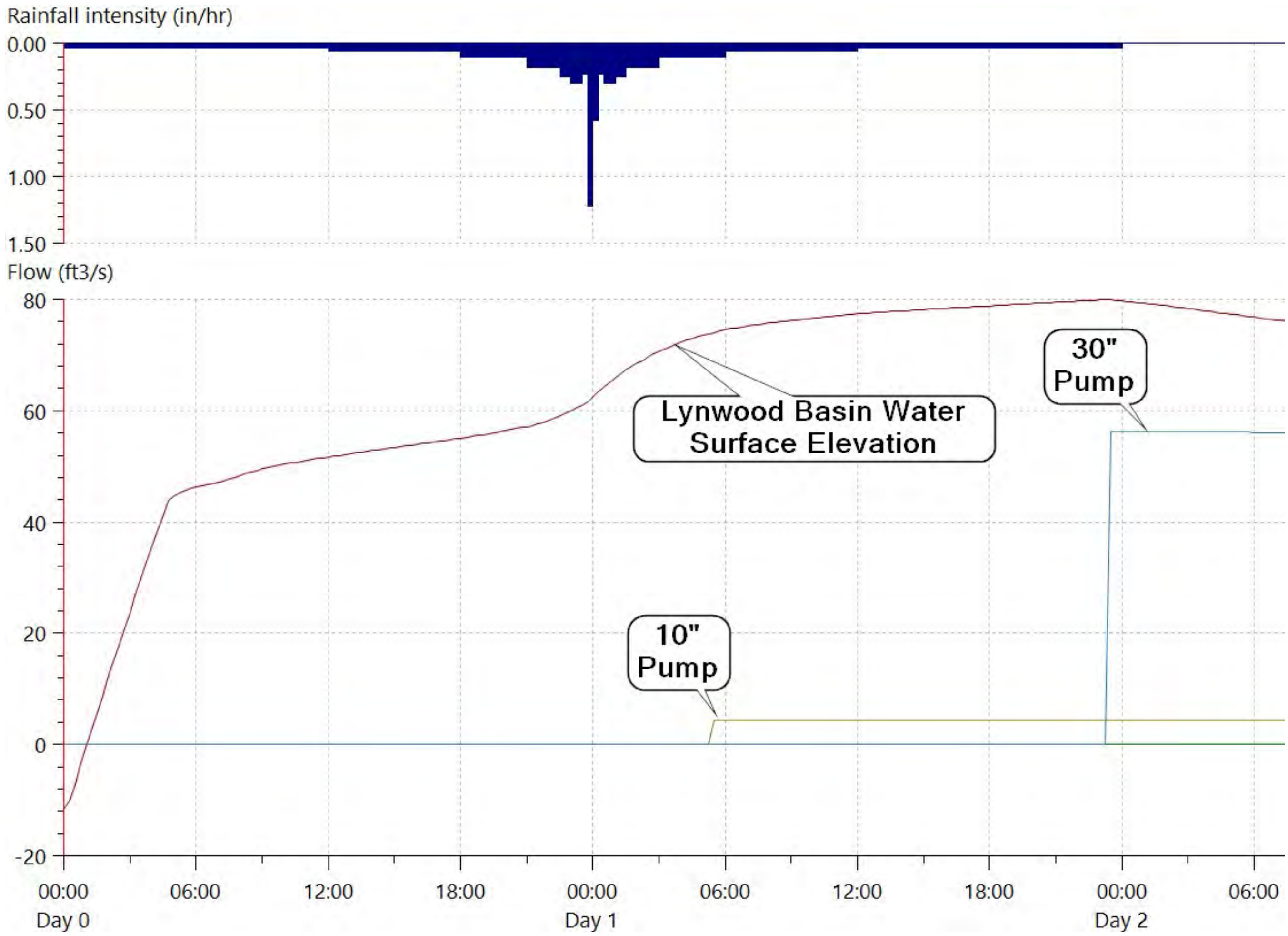


Figure 55 – Lynwood Pump Station with no 24" Pump and Lynwood Basin Model Results for the 2-Year Storm Simulation

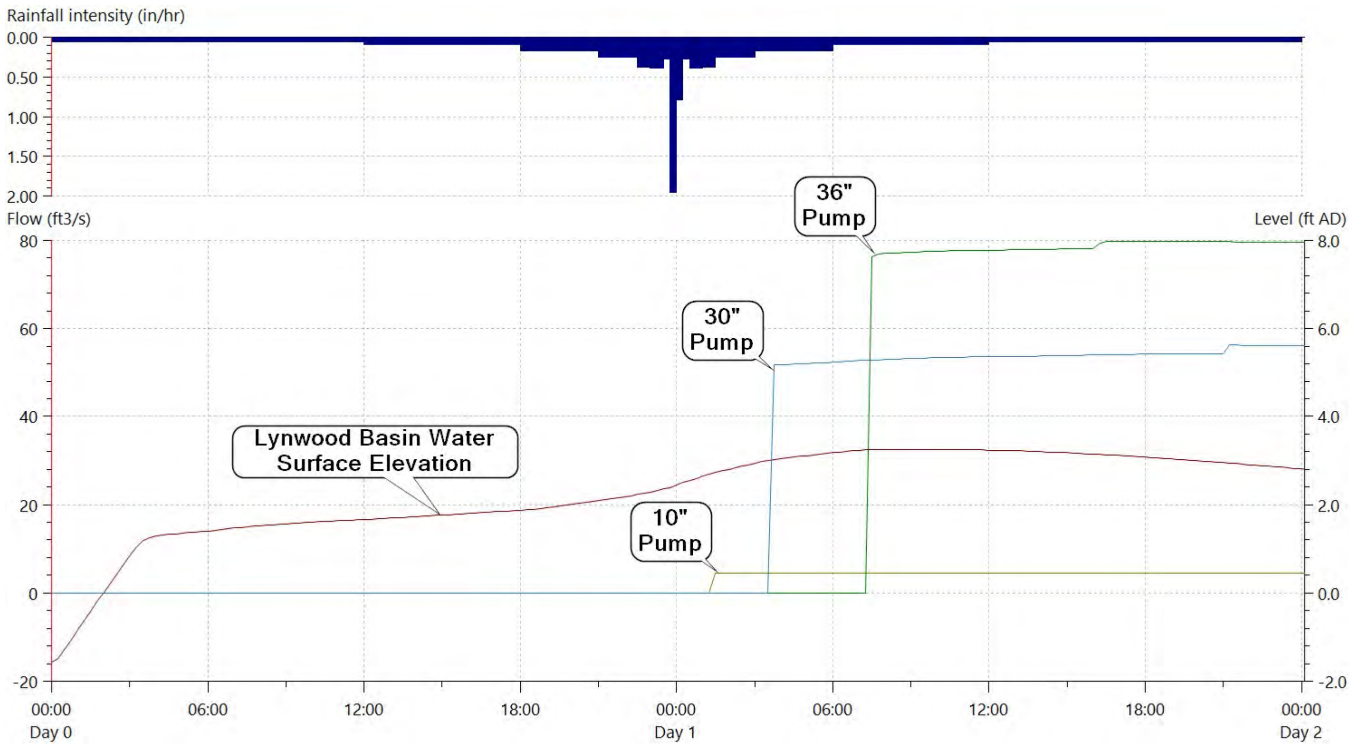


Figure 56 – Lynwood Pump Station with no 24" Pump and Lynwood Basin Model Results for the 10-Year Storm Simulation

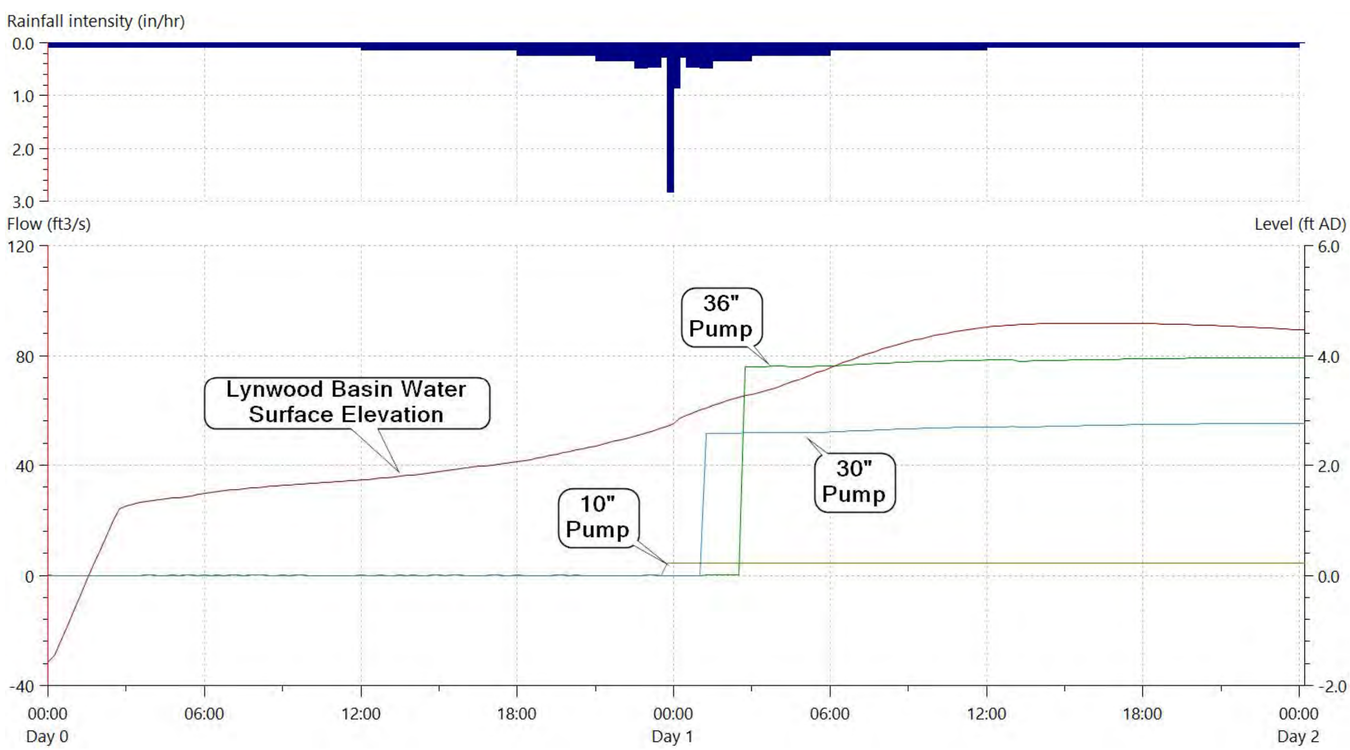


Figure 57 – Lynwood Pump Station with no 24" Pump and Lynwood Basin Model Results for the 50-Year Storm Simulation

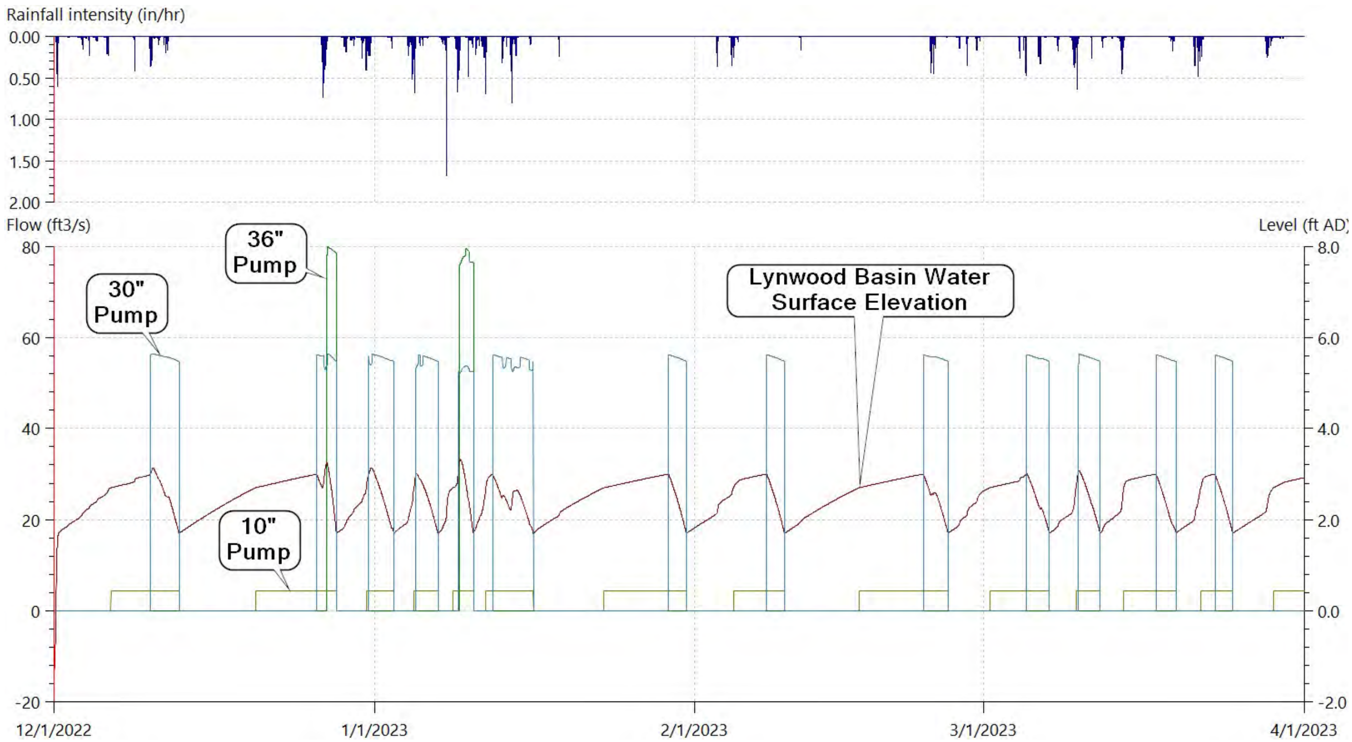


Figure 58 – Lynwood Basin Water Surface Elevation with 24" Pump from Lynwood Pump Station Removed During the 2022 – 2023 Wet Season

Table 6 – Lynwood Pump Station Pumping Frequency with the 24" Pump Removed Compared to Existing Conditions During the 2022-2023 Wet Season

Pump	On Frequency – Existing Conditions	On Frequency – Remove 24" Pump
Lynwood 10"	9	14
Lynwood 24"	8	-
Lynwood 30"	2	13
Lynwood 36"	0	2

9.2.3.2 24" and 30" Pumps Removed

The 24" and 30" pumps were removed from the Lynwood Pump Station. All other pumps remained. **Table 7** displays the pump schedule used in this modeling scenario. Model results showed that during the 2-year simulation, the 10" and 36" pumps turned on, while Lynwood Basin peaked at elevation 3.0 feet NAVD88. See **Figure 59**. In the 10-year simulation, the 10" and 36" pumps turned on, while Lynwood Basin peaked at an elevation of 3.3 feet NAVD88. See **Figure 60**. In the 50-year simulation, the 10" and 36" pumps turned on, while the Lynwood Basin peaked at an elevation of 4.9 feet NAVD88. See **Figure 61**. During the 2022-2023 wet season, model results showed the 10" and 36" pumps turned on during various periods of the simulation. Lynwood Basin had a peak water surface elevation of 3.4 feet NAVD88. See **Figure 62**. Results of the simulations indicate Lynwood Basin's peak water surface elevation can be maintained at elevations similar to those in the existing conditions simulations. However, the remaining pumps will be turned on more frequently. **Table 8** displays the frequency of each pump turning on compared to exiting conditions. Even though the frequency of turning on increased for the

10" and 36" pumps, the time between pump cycles was still measured in days. This is well below the recommended limit of pumps turning on 4 – 5 times per hour.

Table 7 – Assumed Lynwood Pump Station Pumping Schedule with the 24" and 30" Pumps Removed

Pump	On Elevation (feet, NAVD88)	Off Elevation (feet, NAVD88)
Lynwood 10"	2.7	1.7
Lynwood 24"	-	-
Lynwood 30"	-	-
Lynwood 36"	3.0	1.7
Cheda 20"	3.7	2.7
Cheda 20"	3.7	2.7

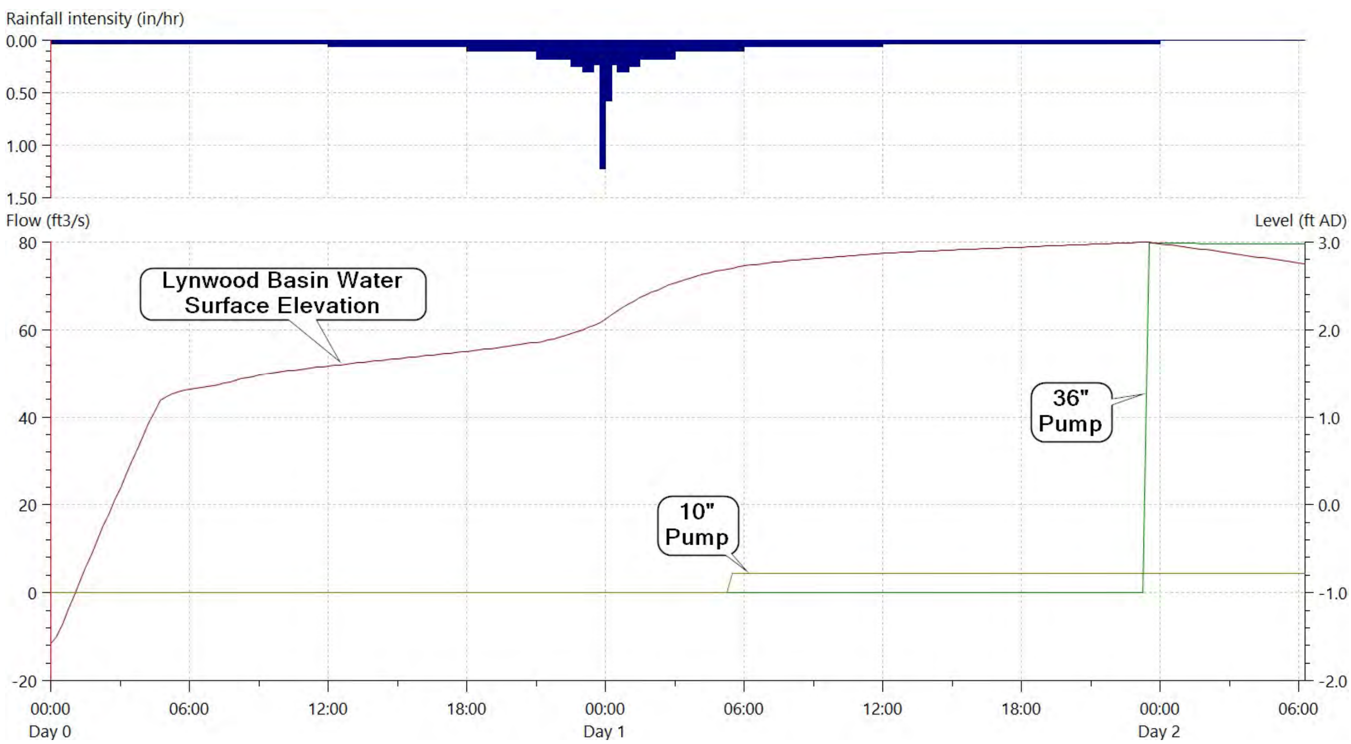


Figure 59 – Lynwood Pump Station with no 24" and 30" Pumps and Lynwood Basin Model Results for the 2-Year Storm Simulation

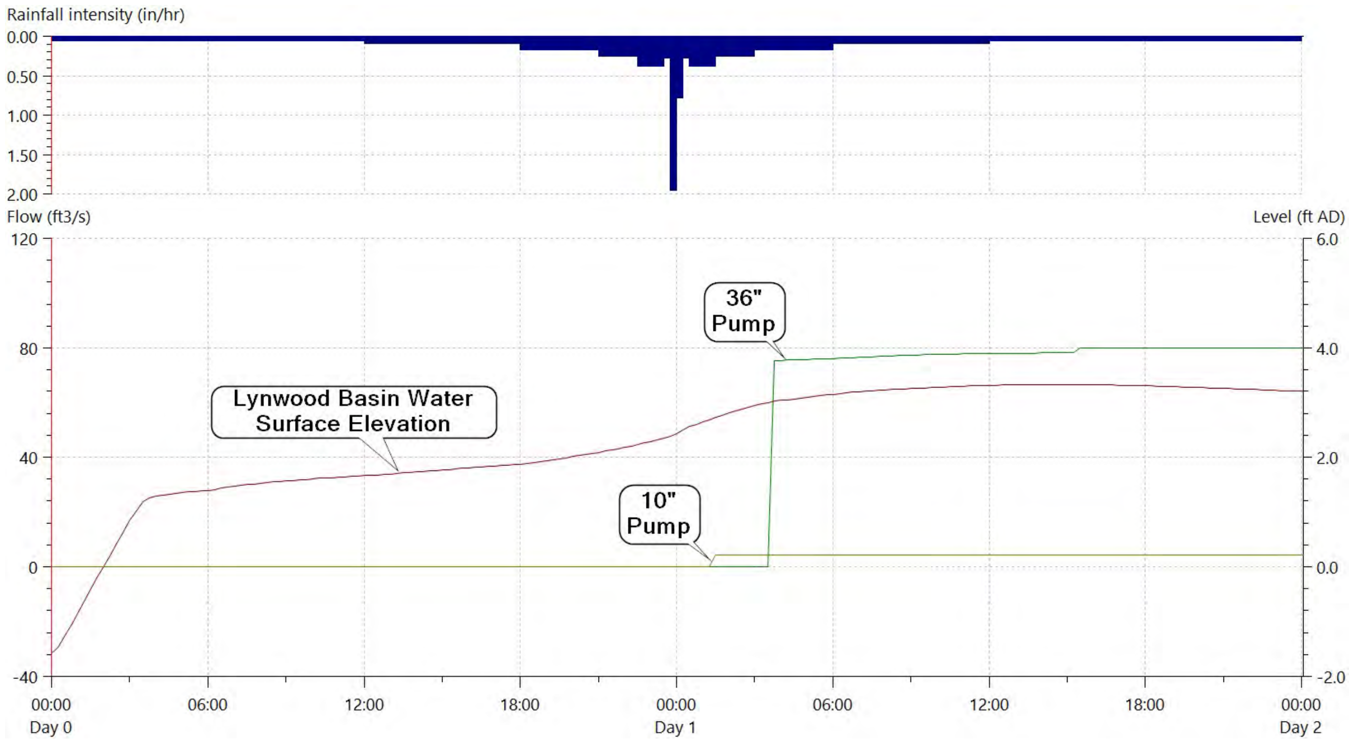


Figure 60 – Lynwood Pump Station with no 24" and 30" Pumps and Lynwood Basin Model Results for the 10-Year Storm Simulation

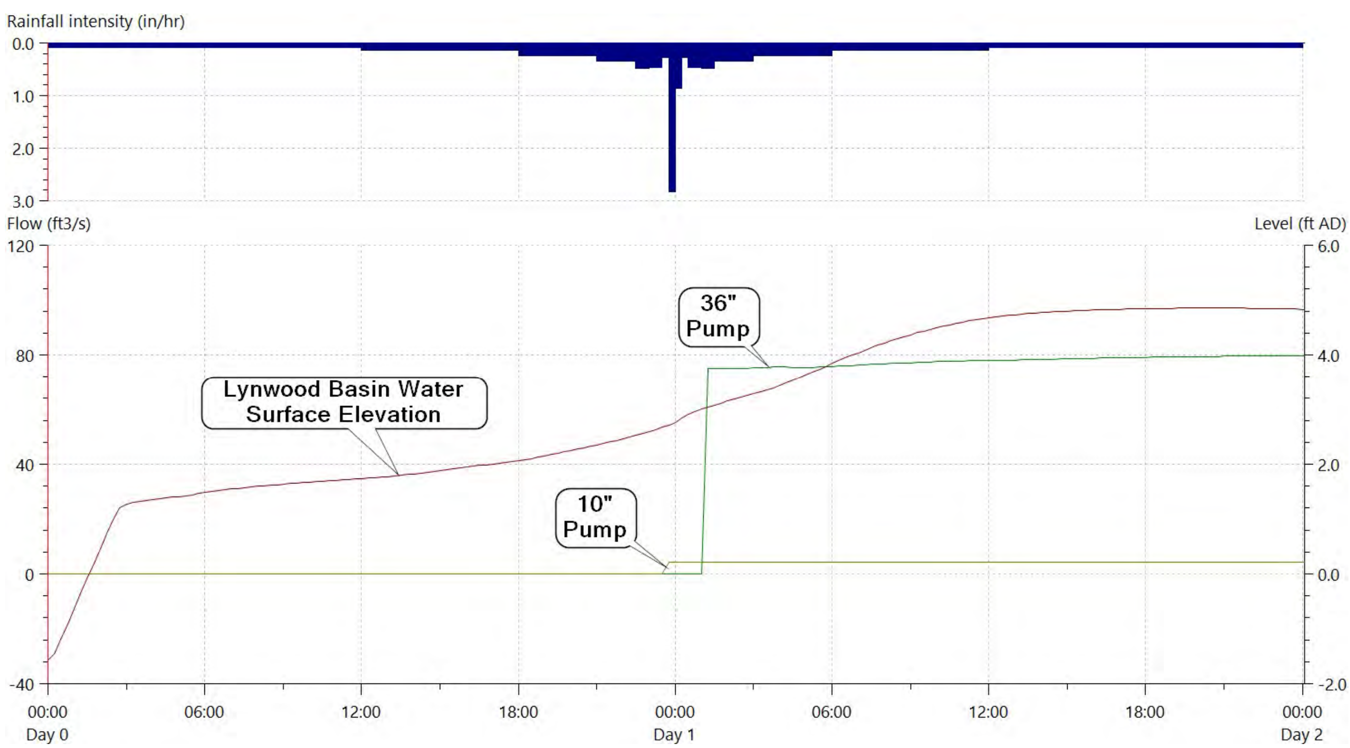


Figure 61 – Lynwood Pump Station with no 24" and 30" Pumps and Lynwood Basin Model Results for the 50-Year Storm Simulation

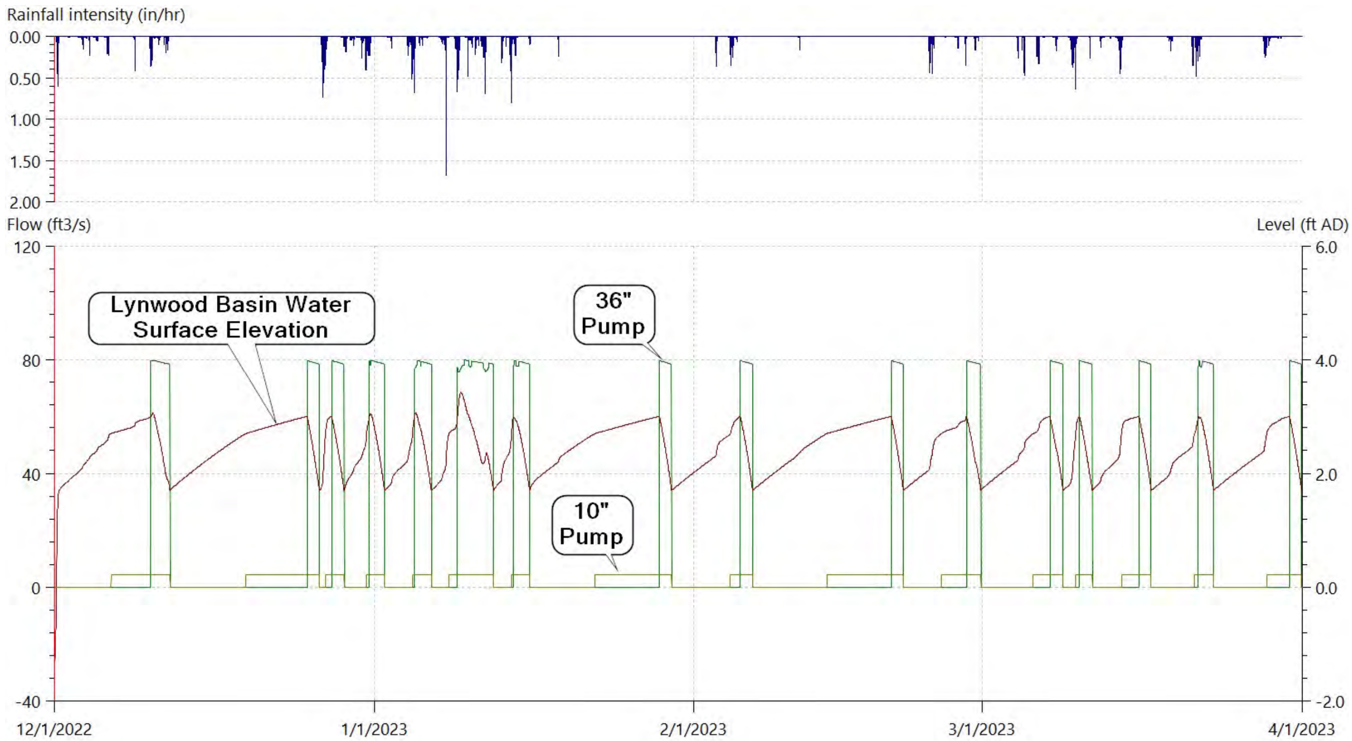


Figure 62 – Lynwood Basin Water Surface Elevation with 24" and 30" Pump from Lynwood Pump Station Removed During the 2022 – 2023 Wet Season

Table 8 - Lynwood Pump Station Pumping Frequency with the 24" and 30" Pumps Removed Compared to Existing Conditions During the 2022-2023 Wet Season

Pump	On Frequency – Existing Conditions	On Frequency – Remove 24" & 30" Pump
Lynwood 10"	9	16
Lynwood 24"	8	-
Lynwood 30"	2	-
Lynwood 36"	0	16

9.2.4 Lynwood Basin Analysis

For this alternative, the Lynwood Basin was split into two separate storage areas to determine the feasibility of transforming portions of the existing basin into a tidally influenced wetland. Two Lynwood Basin separation scenarios were tested. The first dedicated approximately 20% of the existing basin to flood control, while 80% was dedicated to a tidally influenced wetland. See **Figure 63**. The second assigned approximately 60% of the existing basin to flood control, while 40% was dedicated to a tidally influenced wetland. See **Figure 64**. Existing low-lying areas adjacent to the proposed wetland were assumed to be elevated and would not flood during high tides: for example, Hanna Ranch Road.

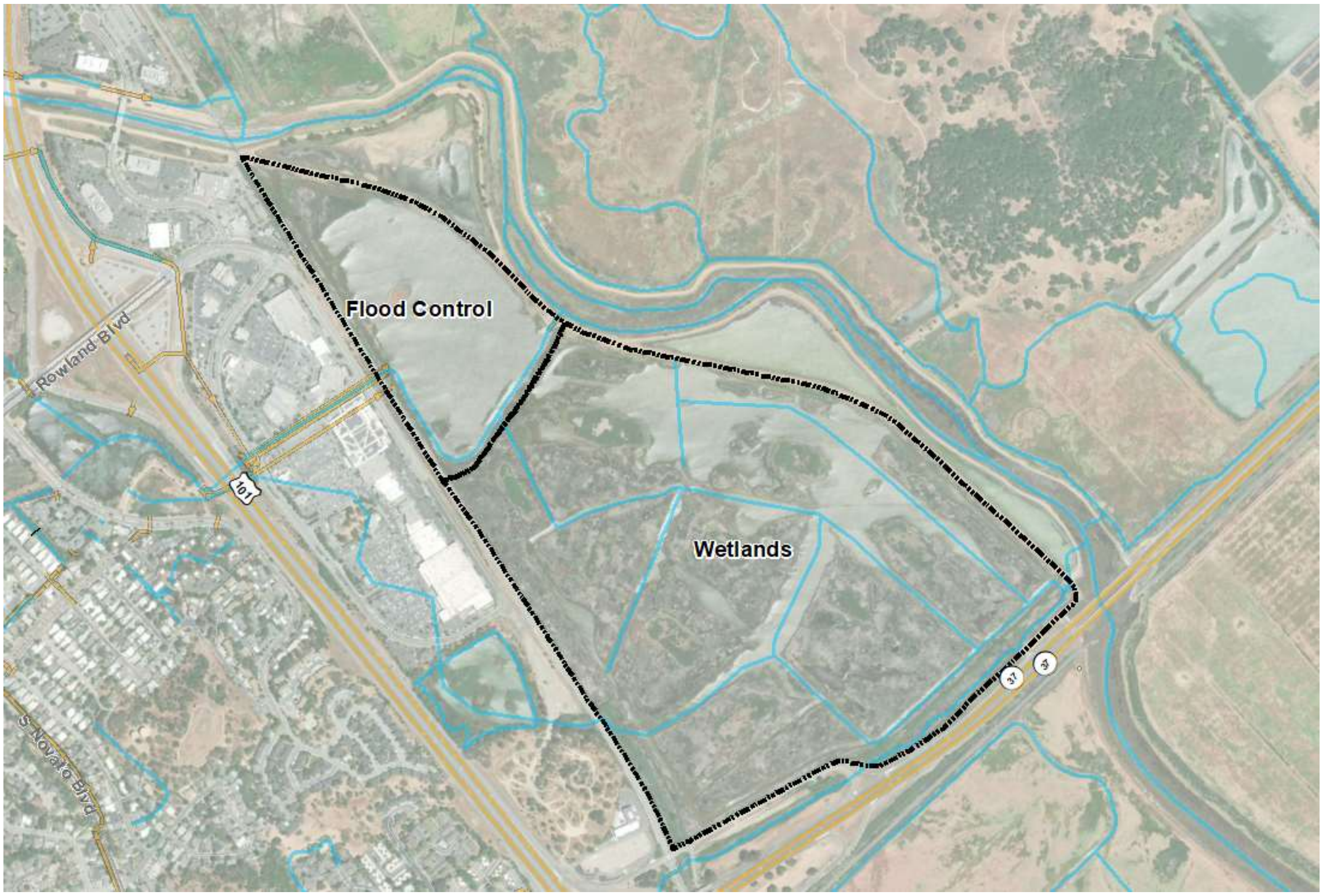


Figure 63 – Lynwood Basin with 20% Dedicated to Flood Control and 80% to Tidal Wetlands

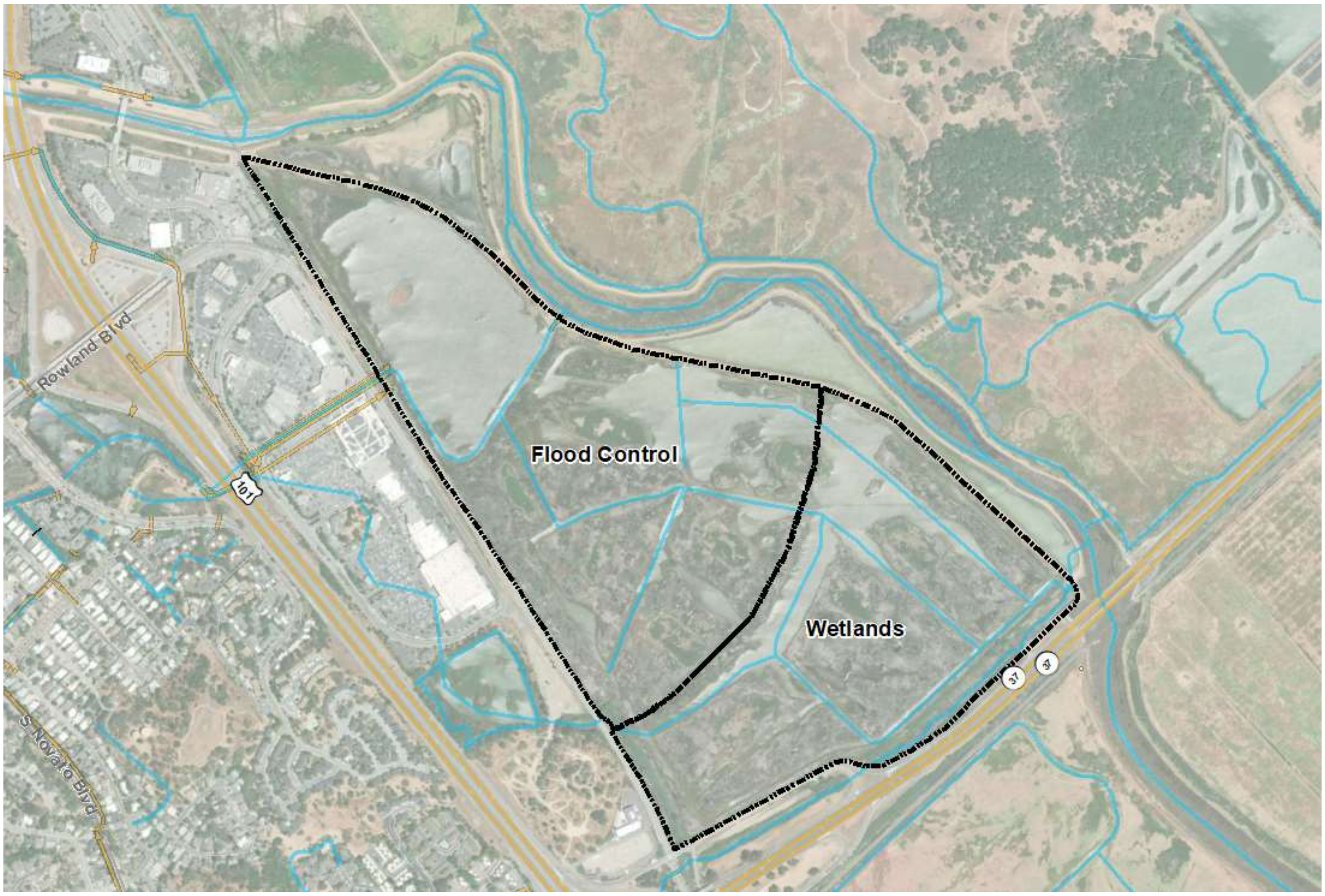


Figure 64 – Lynwood Basin with 60% Dedicated to Flood Control and 40% to Tidal Wetlands

9.2.4.1 Lynwood Basin: 20% Flood Control, 80% Tidal Wetlands

Model results showed that during the 2-year simulation, all pumps turned on, while Lynwood Basin peaked at elevation 3.5 feet NAVD88. See **Figure 65**. The 10-year simulation showed all pumps turned on, and the Lynwood Basin peaked at elevation 4.2 feet NAVD88. See **Figure 66**. The 50-year simulation showed all pumps turned on, and the Lynwood Basin peaked at elevation 7.1 feet NAVD88. See **Figure 67**. In each design storm simulation, all four pumps turned on, and the peak water surface elevation in Lynwood Basin increased when compared to existing conditions. This indicates the existing pumps' capacity cannot maintain water surface elevations in Lynwood Basin comparable to existing conditions. In addition, flooding was observed on the SMART railroad tracks during the 50-year simulation. See **Figure 68**.

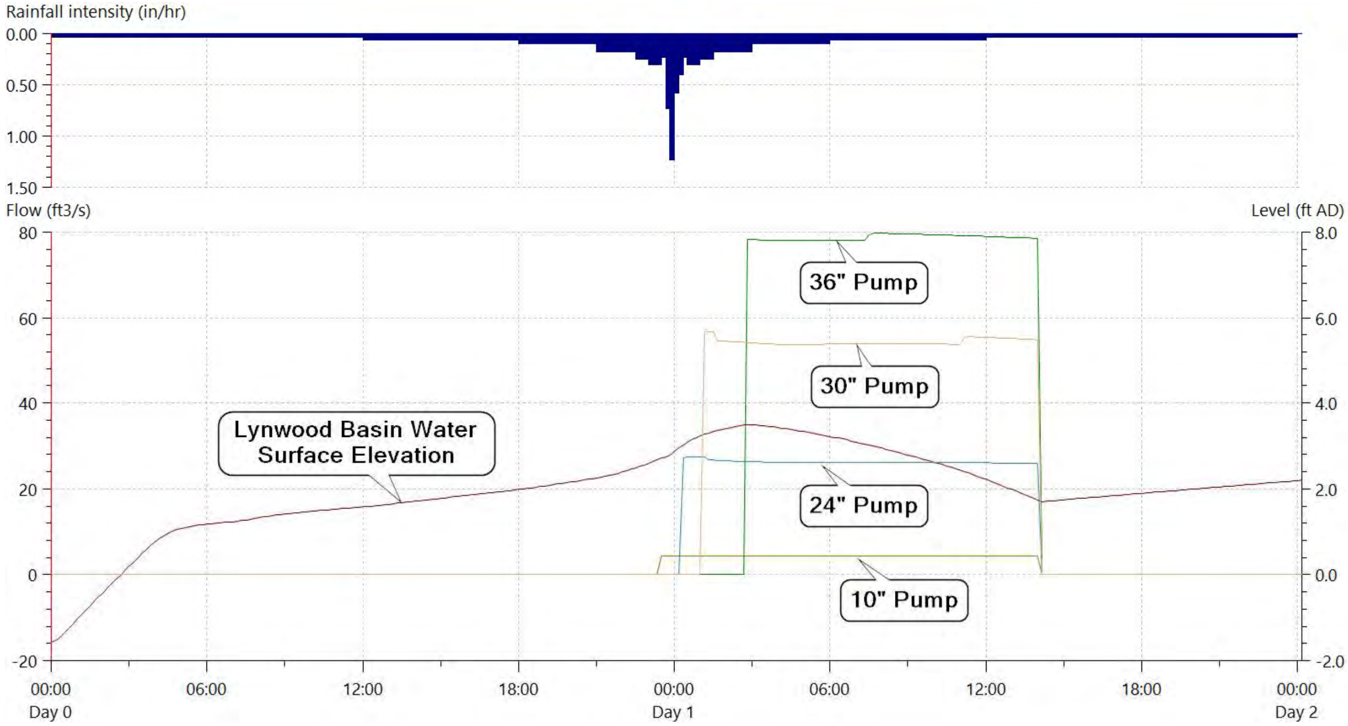


Figure 65 – Lynwood Pump Station and Lynwood Basin Model Results: the 2-Year Storm with 20% of Lynwood Basin Dedicated to Flood Control

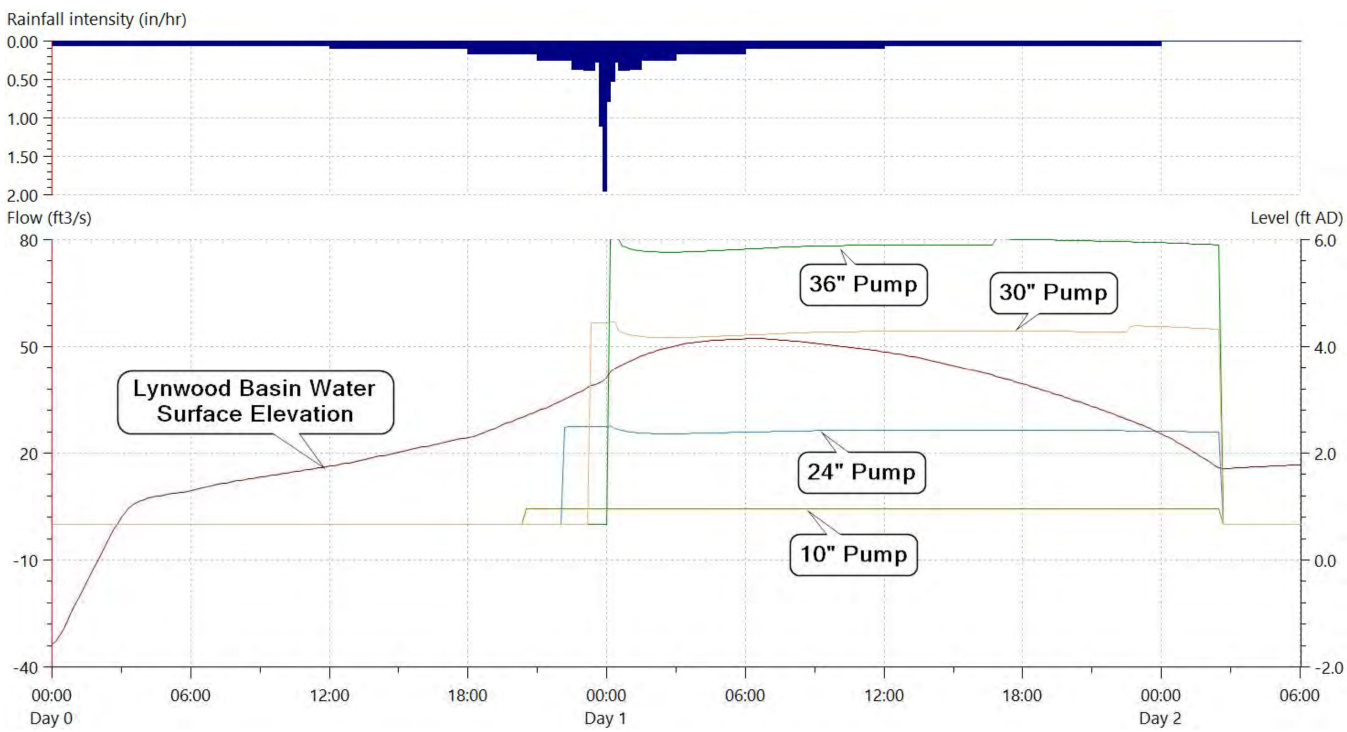


Figure 66 – Lynwood Pump Station and Lynwood Basin Model Results: the 10-Year Storm with 20% of Lynwood Basin Dedicated to Flood Control

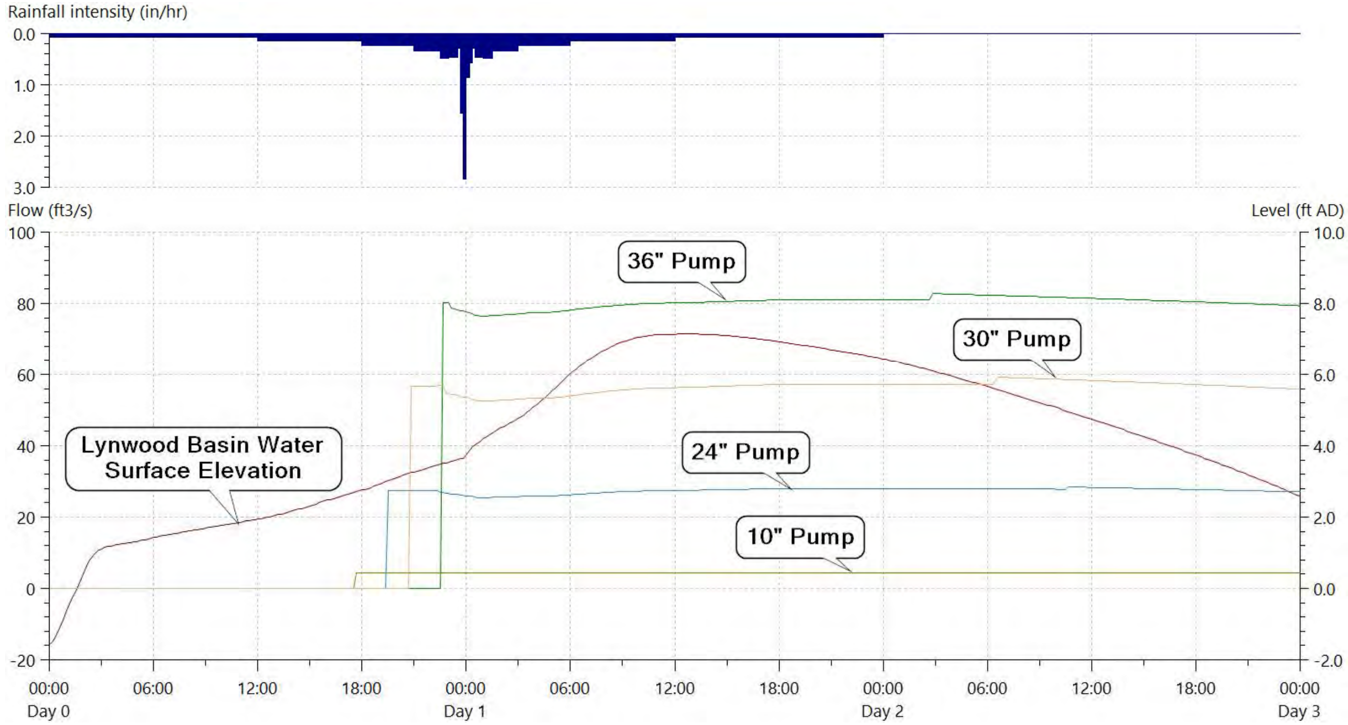


Figure 67 – Lynwood Pump Station and Lynwood Basin Model Results: the 50-Year Storm with 20% of Lynwood Basin Dedicated to Flood Control

Figure 68 – 50-Year Flooding of the SMART Railroad Tracks with 20% of Lynwood Basin Dedicated to Flood Control

Model results for the 2022-2023 wet season showed all four pumps turned on during various portions of the simulation, and Lynwood Basin's peak water surface elevation was 3.6 feet NAVD88. See **Figure 69**. The reduced volume of Lynwood Basin resulted in more frequent pumping by all four pumps, including the 36" pump, which did not turn on in the existing conditions simulation. However, the increased frequency of pumping resulted in a similar maximum water surface elevation in Lynwood Basin (3.4 feet NAVD in existing conditions). **Table 9** displays the frequency of each pump turning on compared to exiting conditions. Even though the frequency of turning on increased for all pumps, the time between pump cycles was still measured in days. This is well below the recommended limit of pumps turning on 4 – 5 times per hour.

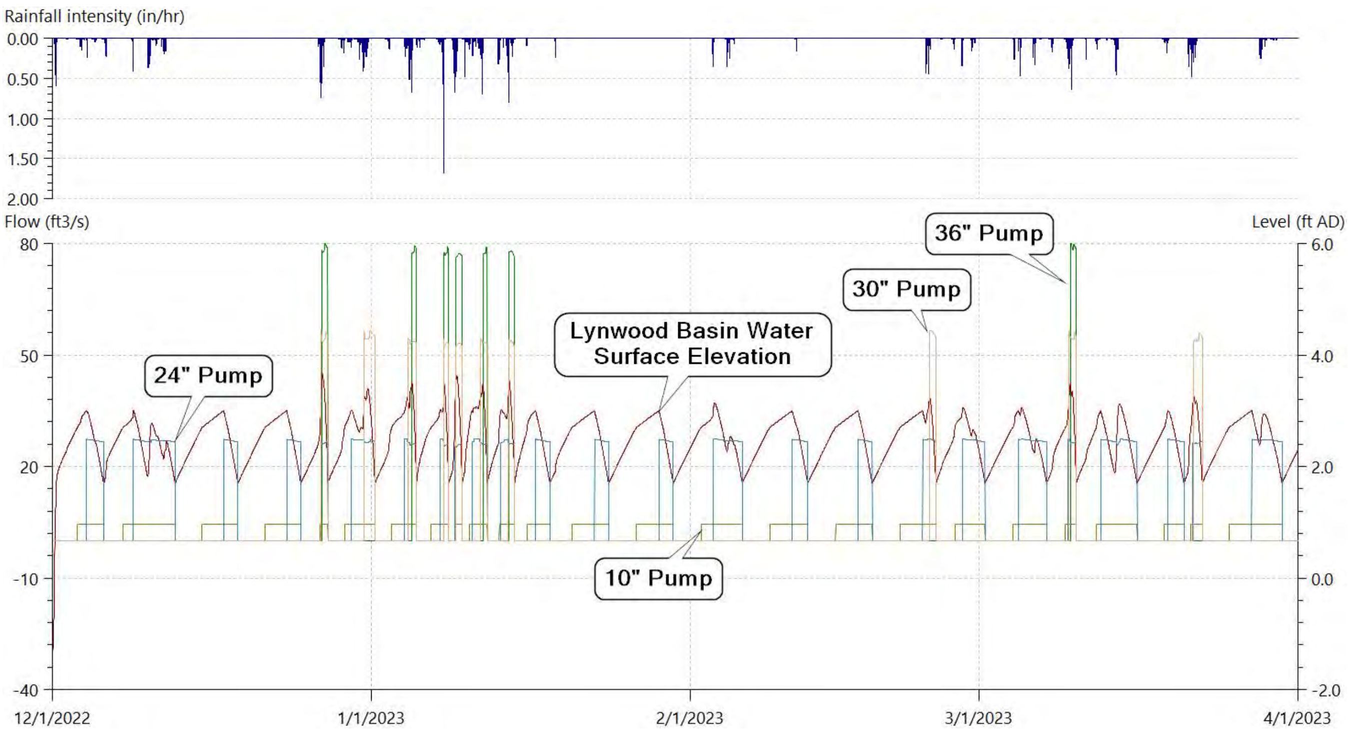


Figure 69 – Lynwood Pump Station and Lynwood Basin Model Results: the 2022-2023 Wet Season with 20% of Lynwood Basin Dedicated to Flood Control

Table 9 - Lynwood Pump Station Pumping Frequency with 20% of Lynwood Basin Dedicated to Flood Control Compared to Existing Conditions During the 2022-2023 Wet Season

Pump	On Frequency – Existing Conditions	On Frequency – 20% Lynwood Basin Flood Control
Lynwood 10"	9	25
Lynwood 24"	8	25
Lynwood 30"	2	10
Lynwood 36"	0	7

9.2.4.2 Lynwood Basin: 60% Flood Control 40% Tidal Wetlands

Model results showed that during the 2-year simulation, the 10” and 24” pumps turned on, while Lynwood Basin peaked at elevation 3.1 feet NAVD88. See **Figure 70**. The 10-year simulation showed all pumps turned on, and the Lynwood Basin peaked at elevation 3.5 feet NAVD88. See **Figure 71**. The 50-year simulation showed all pumps turned on, and the Lynwood Basin peaked at elevation 5.1 feet NAVD88. See **Figure 72**. The design storm results showed when 60% of Lynwood Basin is dedicated to flood control, similar peak water surface elevations can be expected. However, this comes at the expense of more pumps turning on and more frequently when compared to existing conditions.

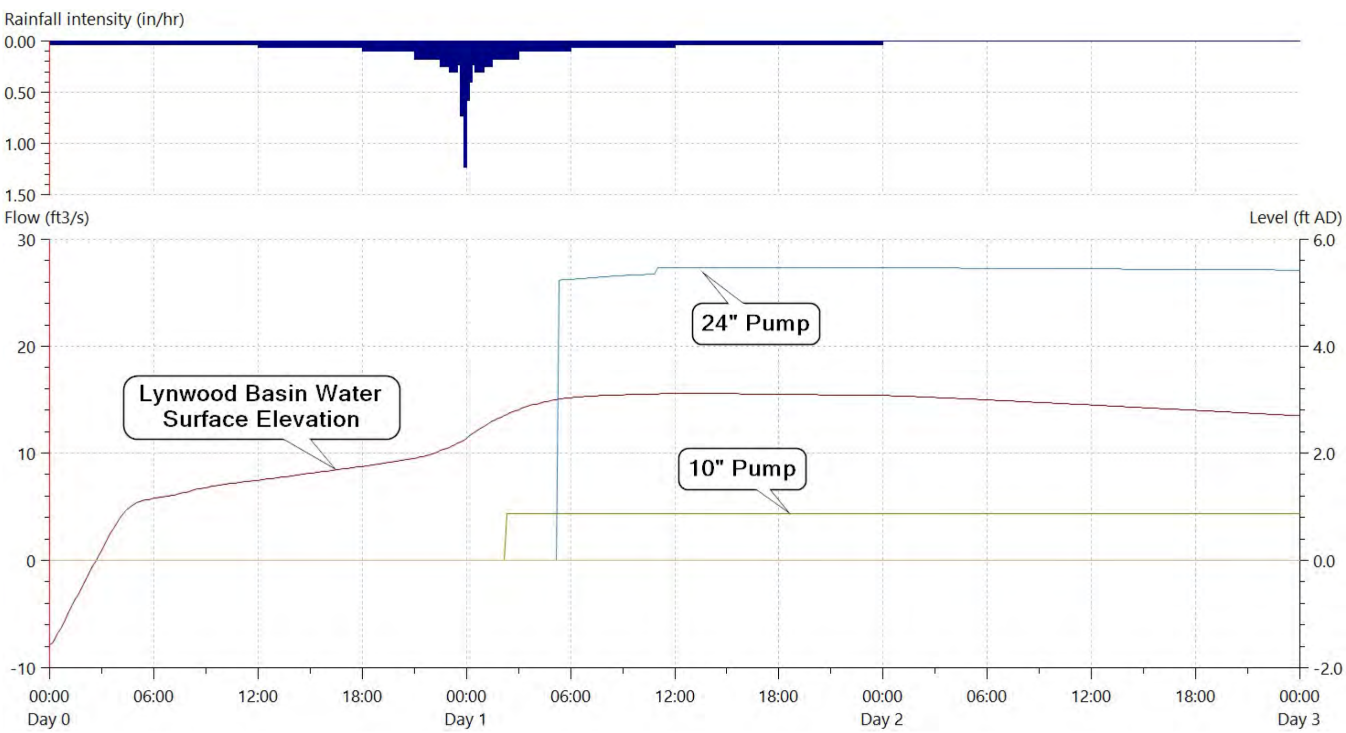


Figure 70 – Lynwood Pump Station and Lynwood Basin Model Results: the 2-Year Storm with 60% of Lynwood Basin Dedicated to Flood Control

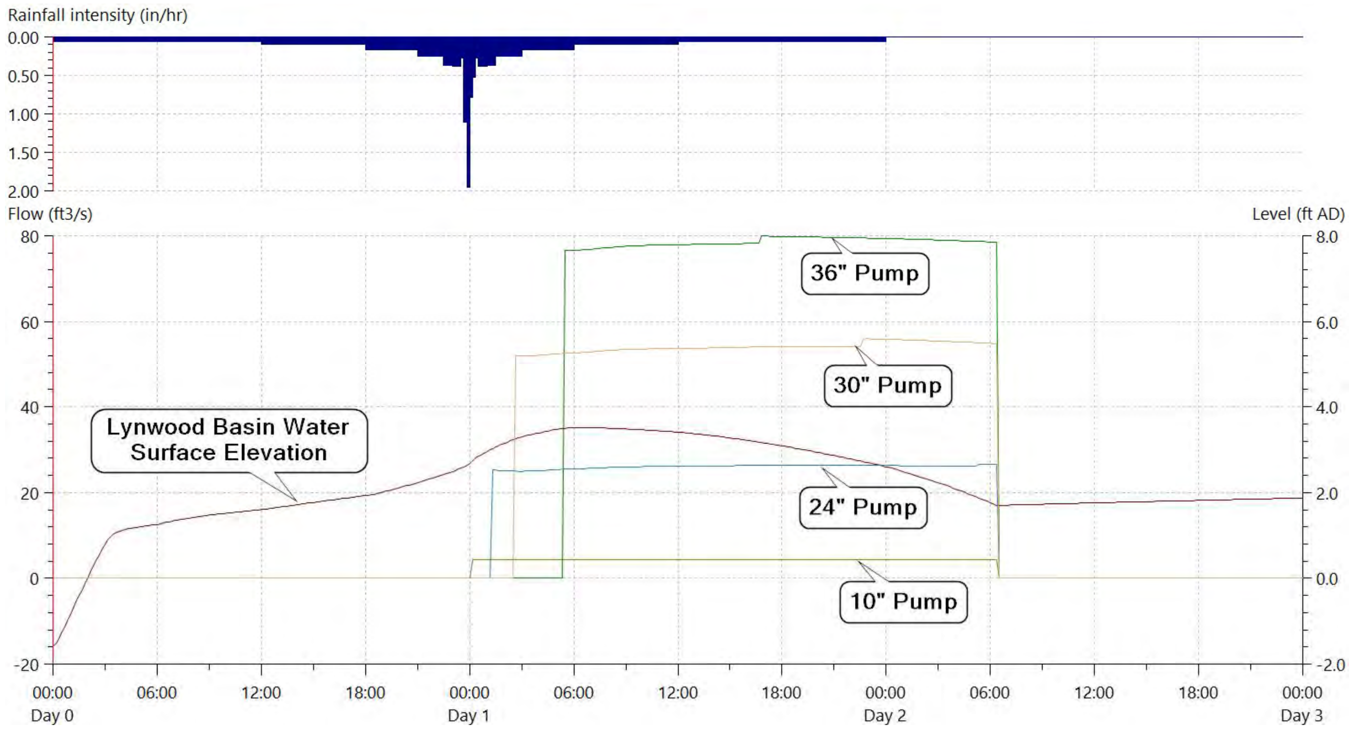


Figure 71 – Lynwood Pump Station and Lynwood Basin Model Results: the 10-Year Storm with 60% of Lynwood Basin Dedicated to Flood Control

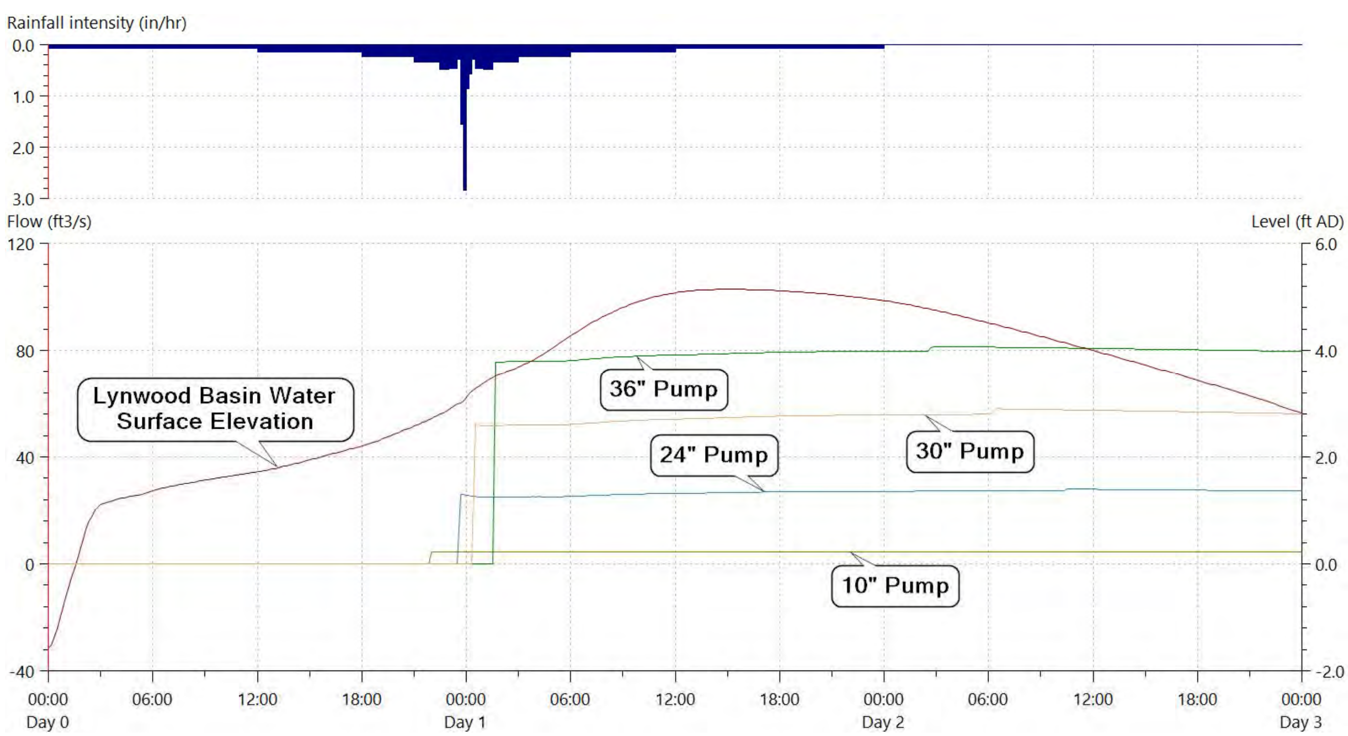


Figure 72 – Lynwood Pump Station and Lynwood Basin Model Results: the 50-Year Storm with 60% of Lynwood Basin Dedicated to Flood Control

Model results for the 2022-2023 wet season showed all four pumps turned on during various portions of the simulation, and Lynwood Basin's peak water surface elevation was 3.5 feet NAVD88. See **Figure 73**. The reduced volume of Lynwood Basin resulted in more frequent pumping by all four pumps, including the 36" pump, which did not turn on in the existing conditions simulation. However, the increased pumping frequency resulted in a similar maximum water surface elevation in Lynwood Basin (3.4 feet NAVD in existing conditions). **Table 10** displays the frequency of each pump turning on compared to exiting conditions. Even though the frequency of turning on increased for all pumps, the time between pump cycles was still measured in days. This is well below the recommended limit of pumps turning on 4 – 5 times per hour.

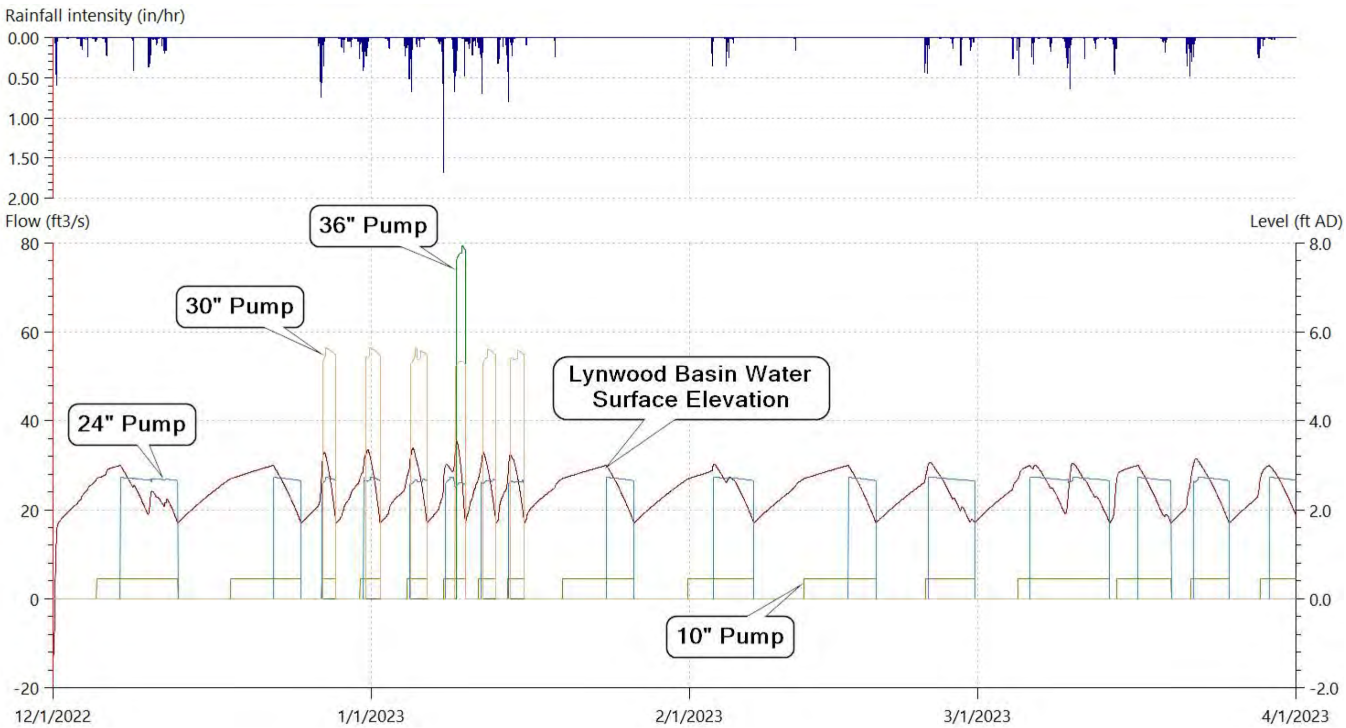


Figure 73 – Lynwood Pump Station and Lynwood Basin Model Results: the 2022-2023 Wet Season with 60% of Lynwood Basin Dedicated to Flood Control

Table 10 - Lynwood Pump Station Pumping Frequency with 60% of Lynwood Basin Dedicated to Flood Control Compared to Existing Conditions During the 2022-2023 Wet Season

Pump	On Frequency – Existing Conditions	On Frequency – 60% Lynwood Basin Flood Control
Lynwood 10"	9	16
Lynwood 24"	8	16
Lynwood 30"	2	6
Lynwood 36"	0	1

9.2.5 Summary

Table 11 summarizes the results of **Sections 9.2.1, 9.2.2, 9.2.3,** and **9.2.4**. An existing conditions table is also provided as a reference. The tables include the peak water surface elevation of Lynwood Basin, which pumps in the Lynwood Pump Station turned on during the design storm simulations, and how often the pumps turned on in the 2022-2023 wet season simulation.

Table 11 – Summary of Lynwood Basin and Lynwood Pump Station Alternatives with Existing Conditions

	Existing Conditions				
	Lynwood Basin Peak Elevation (ft, NAVD88)	10"	24"	30"	36"
2-Year	3.0	X	X		
10-Year	3.4	X	X	X	
50-Year	4.6	X	X	X	X
2022-2023 Wet Season Frequency	3.4	9	8	2	0

	Move Lynwood Pump Station				
	Lynwood Basin Peak Elevation (ft, NAVD88)	10"	24"	30"	36"
2-Year	3.0	X	X		
10-Year	3.4	X	X	X	
50-Year	4.6	X	X	X	X
2022-2023 Wet Season Frequency	3.4	9	8	2	0

	Remove Lynwood Pump Station				
	Lynwood Basin Peak Elevation (ft, NAVD88)	10"	24"	30"	36"
2-Year	3.1	n/a	n/a	n/a	n/a
10-Year	3.9	n/a	n/a	n/a	n/a
50-Year	5.4	n/a	n/a	n/a	n/a
2022-2023 Wet Season Frequency	5.6	n/a	n/a	n/a	n/a

	Remove 24" Pump From Lynwood Pump Station				
	Lynwood Basin Peak Elevation (ft, NAVD88)	10"	24"	30"	36"
2-Year	3.0	X	n/a	X	
10-Year	3.3	X	n/a	X	X
50-Year	4.6	X	n/a	X	X
2022-2023 Wet Season Frequency	3.3	14	n/a	13	2

	Remove 24" & 30" Pumps From Lynwood Pump Station				
	Lynwood Basin Peak Elevation (ft, NAVD88)	10"	24"	30"	36"
2-Year	3.0	X	n/a	n/a	X
10-Year	3.3	X	n/a	n/a	X
50-Year	4.9	X	n/a	n/a	X
2022-2023 Wet Season Frequency	3.4	16	n/a	n/a	16

	Lynwood Basin: 20% Flood Control, 80% Tidal Wetlands				
	Lynwood Basin Peak Elevation (ft, NAVD88)	10"	24"	30"	36"
2-Year	3.5	X	X	X	X
10-Year	4.2	X	X	X	X
50-Year	7.1	X	X	X	X
2022-2023 Wet Season Frequency	3.6	25	25	10	7

	Lynwood Basin: 60% Flood Control, 40% Tidal Wetlands				
	Lynwood Basin Peak Elevation (ft, NAVD88)	10"	24"	30"	36"
2-Year	3.1	X	X		
10-Year	3.5	X	X	X	X
50-Year	5.1	X	X	X	X
2022-2023 Wet Season Frequency	3.5	16	16	6	1

10 NAVE GARDENS ALTERNATIVE RISK ANALYSIS

The resultant floodplain extent and average depth of each alternative are summarized in **Table 12**. Floodplain reduction calculations were based on **Table 3**, which is shown again below as a reference.

Table 3 – Existing Conditions Floodplain Extent and Average Depth Summary

	Floodplain Extent (ac)	Average Depth (ft)
2-Year	0.0	0.0
10-Year	18.9	0.6
50-Year	21.9	1.1

Table 12 – Alternative Floodplain Extent and Average Depth Summary

	Flap Gates	ABSL Bypass + Flap Gates	Floodwalls + Flap Gates	N Deer Island Levee Lowering + Flap Gates	Novato Channel Dredging + Flap Gates	Floodwalls + Flap Gates + N Deer Island Levee Lowering	Novato Channel Dredging + Flap Gates + N Deer Island Levee Lowering
Proposed 10-Year Flooding (ac)	18.1	16.1	6.6	4.7	14.9	0.8	0.6
10-Year Floodplain Reduction (%)	4%	15%	65%	75%	21%	96%	97%
Average 10-Year Flooding Depth (ft)	0.6	0.6	0.4	0.4	0.6	0.2	0.6
Average 10-Year Flooding Depth Reduction (%)	2%	3%	33%	41%	8%	65%	12%
Proposed 50-Year Flooding (ac)	21.9	21.7	15.5	18.7	19.4	8.8	14.1
50-Year Floodplain Reduction (%)	0%	1%	29%	15%	12%	60%	35%
Average 50-Year Flooding Depth (ft)	1.1	1.0	0.8	0.7	1.0	0.5	0.6
Average 50-Year Flooding Depth Reduction (%)	0%	9%	29%	35%	12%	55%	48%

11 ENGINEER'S COST ESTIMATES

Table 13 displays the engineer's cost estimate for the improvement alternatives listed in **Section 9.1** while **Table 14** displays the cost estimate for improvement alternatives listed in **Section 9.2.**

Costing information was primarily derived from two sources, CalTrans[17] and EBidBoard[18]. Recent Bay Area bids from the two sources were used to construct average unit costs in the engineer's cost estimate. Wood Rodgers also obtained bids directly from Alameda County and Marin County of projects having similar scope as those proposed in **Section 9.1**, specifically for North Deer Island Basin levee lowering and Novato Creek channel dredging. Fixed percentage costs were included, which consisted of mobilization (10% of total, $30k minimum), water pollution control (1% of total, $30k minimum), traffic control (2% of total, $20k minimum), trench and excavation protection (1% of total, $10k minimum), dewatering (2% of total, $20k minimum, increased to 10% of total for projects with heavy construction in channels), engineering design (10% of total), permitting (10% of total), construction support (10% of total), and project management (10% of total). These percentages are based on the two sources above and from conversations with local municipalities. In addition, a 30% contingency was included to account for incidental items based on contractor bids for similar projects. The first four alternatives for the Lynwood Basin improvements (move Lynwood Pump Station, remove Lynwood Pump Station, remove 24" pump, remove 24" and 30" pumps) were estimated using previous project experience.

A more detailed breakdown of costs for each alternative is shown in **Appendix D**.

Table 13 – Nave Gardens Improvement Alternative Engineer's Cost Estimate

Improvement Alternative	Engineer's Cost Estimate
Flap Gates	$200,000
ABSL Bypass + Flap Gates	$700,000
Floodwalls + Flap Gates	$33,500,000
N Deer Island Basin Levee Lowering + Flap Gates	$10,900,000
Channel Dredging + Flap Gates	$800,000
Floodwalls + Flap Gates + N Deer Island Basin Levee Lowering	$44,200,000
Channel Dredging + Flap Gates + N Deer Island Basin Levee Lowering	$12,300,000

[17] https://sv08data.dot.ca.gov/contractcost/
[18] https://constructioncontracts.ebidboard.com/we-are-now-part-of-bidnet-direct/

Table 14 – Lynwood Pump Station Improvement Alternative Engineer's Cost Estimate

Improvement Alternative	Engineer's Cost Estimate
Move Lynwood Pump Station	$2,500,000
Remove Lynwood Pump Station	$750,000
Remove 24" Pump	$50,000
Remove 24" and 30" Pumps	$75,000
Lynwood Basin – 20% Flood Control, 80% Tidal Wetlands	$3,900,000
Lynwood Basin – 60% Flood Control, 40% Tidal Wetlands	$7,700,000

12 RECOMMENDATIONS

12.1 Nave Gardens

Table 15 summarizes the recommended improvement alternatives.

Table 15 – Improvement Alternatives Recommendations

Improvement Alternative	Advantages	Disadvantages	Recommended for further Analysis?
Flap Gates	• Under certain hydraulic conditions, the flap gates will prevent Nave Gardens from flooding. • Low cost.	• Will not prevent Nave Gardens flooding when tailwater is high and it is still raining. • Does not prevent Novato Creek from spilling into Nave Gardens. • Grants not likely available.	Yes; however, it is recommended flap gates are used in combination with other improvements.
ABSL Bypass + Flap Gates	• Low Cost. •	• Not effective at lowering the Novato or Warner Creek tailwater. • Little to no change in flooding extent or depth for the 10-, and 50-year design storm. • Grants not likely available.	No. The ABSL Bypass provides little to no benefit.
Floodwalls + Flap Gates	• Effective at reducing the 10-year floodplain extent and depth. • Reduces the 50-year floodplain depth and extent in the north and southern portions of Nave Gardens.	• High Cost. • Right-of-way procurement from 69 parcels is difficult. • Water surface elevations within the floodwalls, and slightly upstream and downstream, are higher when compared to existing conditions. • Grants not likely available.	Yes; however there are other improvement alternatives more effective at reducing floodplain extent and depths.
N Deerk Island Levee Lowering + Flap Gates	• Effective at reducing the 10-year floodplain extent and depth. • Potentially grant eligible.	• Little impact to 50-year floodplain extent and depth. • High Cost. • Environmental concerns (fish from Novato Creek spilling into North Deer Island Basin). • Insufficient storage in North Deer Island Basin resulting in runoff spilling into Deer Island Basin in 10-year and 50-year simulations. • Ability to lower water surface elevations reduces upstream of Warner and Novato Creek confluence.	Yes; however there are other improvement alternatives more effective at reducing floodplain extent and depths.

Channel Dredging + Flap Gates	• Effective at lowering Novato Creek's water surface elevations upstream of Warner Creek. • Eliminated 10-year Novato Creek spilling into Nave Gardens.	• Dredging costs are high and temporary benefits as channel fills in requiring regular dredging • Because of Novato Creek's tailwater, channel dredging was not effective in Warner Creek. • Novato Creek channel dredging is not effective downstream of Warner Creek. • Environmental permitting for dredging. • Grants not likely available.	Yes; however there are other improvement alternatives more effective at reducing floodplain extent and depths.
Floodwalls + Flap Gates + N Deer Island Levee Lowering	• Highly effective at reducing the 10-year floodplain extent and depth. • Effective at reducing the 50-year floodplain extent and depth.	• Same disadvantages as those listed in Floodwalls + Flap Gates and N Deer Island Levee Lowering + Flap Gates. • Grants not likely available.	This alternative is recommended for further analysis
Channel Dredging + Flap Gates + N Deer Island Levee Lowering	• Highly effective at reducing the 10-year floodplain extent and depth. • Effective at reducing the 50-year floodplain extent and depth. • Potentially grant eligible.	• Same disadvantages as those listed in Channel Dredging + Flap Gates and N Deer Island Levee Lowering + Flap Gates.	This alternative is recommended for further analysis

In summary, each improvement alternative had advantages and disadvantages. The District must understand these advantages and disadvantages and decide which improvement alternative is appropriate for further study. Wood Rodgers recommends the following improvement alternatives:

- Floodwalls + Flap Gates + North Deer Island Levee Lowering
- Channel Dredging + Flap Gates + North Deer Island Levee Lowering

These improvement alternatives were selected because they were the most successful at removing flooding extent and depth within Nave Gardens. If the District chooses to proceed with one of the above alternatives, a feasibility study, detailed design documents and additional modeling with the final project design would be the recommended next steps.

12.2 Lynwood Pump Station

Table 16 summarizes the recommended improvement alternatives.

Table 16 – Lynwood Pump Station Recommendations

Improvement Alternative	Advantages	Disadvantages	Recommended for Further Analysis?
Move Lynwood Pump Station	• Easy access for District Staff • Reduced power outages • Out of PG&E's easement	• Hydraulic results are identical to those in existing conditions	This alternative is recommended for further analysis
Remove Lynwood Pump Station	• No Lynwood Pump Station • 2- and 10-year design storms result in similar water surface elevations in Lynwood Basin compared to existing conditions	• Lynwood Basin's water surface elevation is no longer controlled by the District. • Model results showed Lynwood Basin's water surface elevation rose in all design storms and the 2022-2023 wet season. • Larger single event and consecutive historical storms result in a significant increase in water surface elevations and result in minor flooding on Hanna Ranch Road. • Tailwater elevations in Novato Creek limit the ability of the Lynwood Basin to drain during storm events. • When storm runoff is not influencing the tailwater in Novato Creek, the ability of Lynwood Basin to drain is dictated by the tide. • Grants not likely available.	This alternative is not recommended for further analysis. Minor flooding was observed in several scenarios, and the District would lose the ability to control Lynwood Basin's water surface elevation.
Remove the 24" Pump from Lynwood Pump Station	• No 24" pump • Model results showed similar water surface elevations in Lynwood Basin when compared to existing conditions for all design storms and the 2022-2023 wet season. • There is adequate redundancy. With the 24" pump removed, and if the 30" pump fails, results from the "Remove the 24" and 30" pumps from the Lynwood Pump Station" scenario show the 36" pump alone can keep water surface elevations similar to	• Longer, more frequent pumping of the remaining pumps. • Grants not likely available.	This alternative is recommended for further analysis

	those in existing conditions.		
Remove the 24” and 30” pumps from Lynwood Pump Station	• No 24” pump • No 30” pump • Model results showed similar water surface elevations in Lynwood Basin when compared to existing conditions for all design storms and the 2022-2023 wet season.	• Longer, more frequent pumping of the remaining pumps. • No redundancy if the 36” pump malfunctions. • Grants not likely available.	This alternative is not recommended for further analysis. Although the scenario showed similar results to existing conditions, the District loses redundancy if the 36” pump malfunctions.
Lynwood Basin: 20% Flood Control, 80% Tidal Wetlands	• Opportunity for the District to return land to a tidally influenced wetland.	• As shown in Section 9.2.5, simulations showed Lynwood Basin’s water surface elevation would increase during single event and muti-event storms. • Flooding would result from a 50-year event adjacent to Hannah Ranch Road and highway 37. • Increased frequency of pumping for all pumps. • Opportunity for the District to limit Lynwood Pump Station’s renovations would be eliminated.	This alternative is not recommended for further analysis.
Lynwood Basin: 60% flood Control, 40% Tidal Wetlands	• Opportunity for the District to return land to a tidally influenced wetland. • Lynwood Basin’s peak water surface elevations were shown to be similar to single event and multi-event storms when compared to existing conditions. • Potentially grant eligible.	• Increased frequency of pumping for all pumps. • Opportunity for the District to limit Lynwood Pump Station’s renovations would be eliminated.	This alternative is recommended for further analysis.

In summary, each alternative has advantages and disadvantages. The District must understand these advantages and disadvantages and decide which alternative is appropriate for further study. Wood Rodgers recommends the following alternative:

- 24” pump removal from the Lynwood Pump Station, and
- Lynwood Basin: 60% flood control, 40% tidal wetlands

These scenarios were chosen because model results showed similar Lynwood Basin water surface elevations for all design storms and the 2022-2023 wet season when compared to existing conditions.

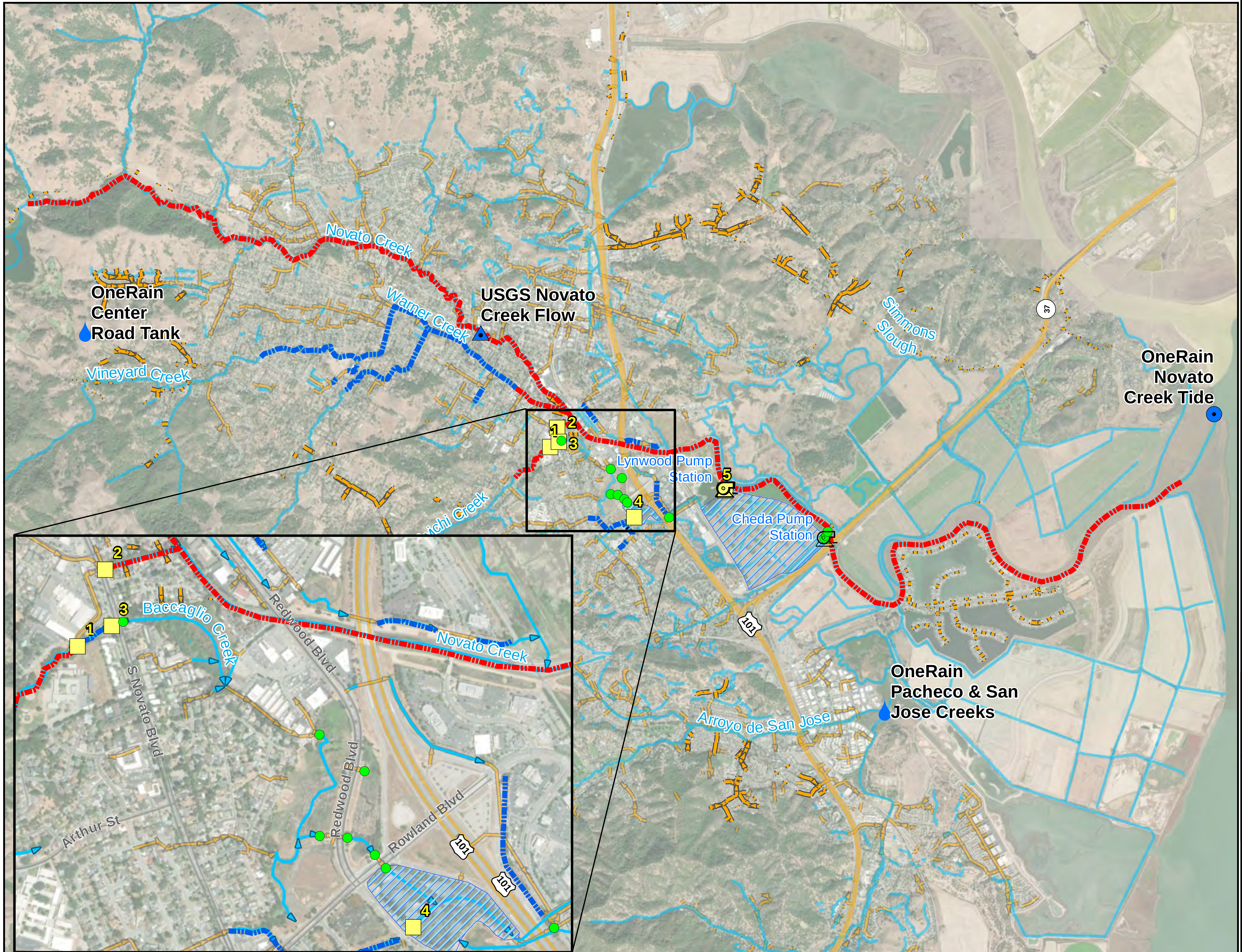
13 REFERENCES

1. *Hydraulic Assessment of Existing Conditions Novato Creek Watershed Project*, Kamman Hydrology & Engineering, Inc, June 2014.
2. *Novato Creek Hydraulic Study Analysis Of Alternatives*, Kamman Hydrology & Engineering, Inc., June 2016.
3. *Novato Creek Deer Island Basin Restoration Hydraulic Results*, PowerPoint Presentation, Schaaf & Wheeler, February 14, 2018.
4. *Evaluation of Tidal Restoration Alternatives*, Novato Creek Baylands Complex, Schaaf & Wheeler, January 28, 2019.
5. *ABSL Complex and Nave Gardens Flood Drainage Improvements Feasibility Study (8563016), Proposed Locations for Five Temporary Water Level Sensors (Task 3.1),* Wood Rodgers, September 12, 2023.
6. *City of Novato InfoWorks ICM Hydrology and Hydraulics Drainage Master Plan Model. Developed by Wood Rodgers in 2017.*

Marin County
ABSL

Data Collection

Marin County, California
February 2024



Legend

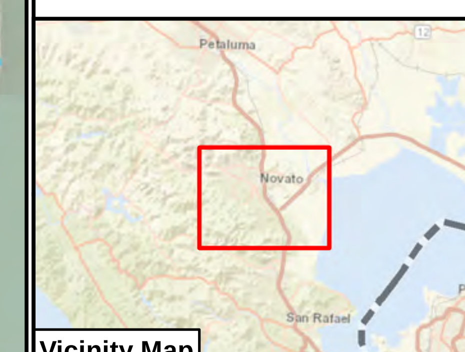
- ABSL Level Sensor
- Inspection & Survey
- Pump Station Data Collection
- Rain Gage
- Flow Gage
- Tide Gage
- Bathymetry
- Channel
- Marin Map Storm Sewers

XS Source

- DEM
- HEC-RAS
- Survey

NORTH

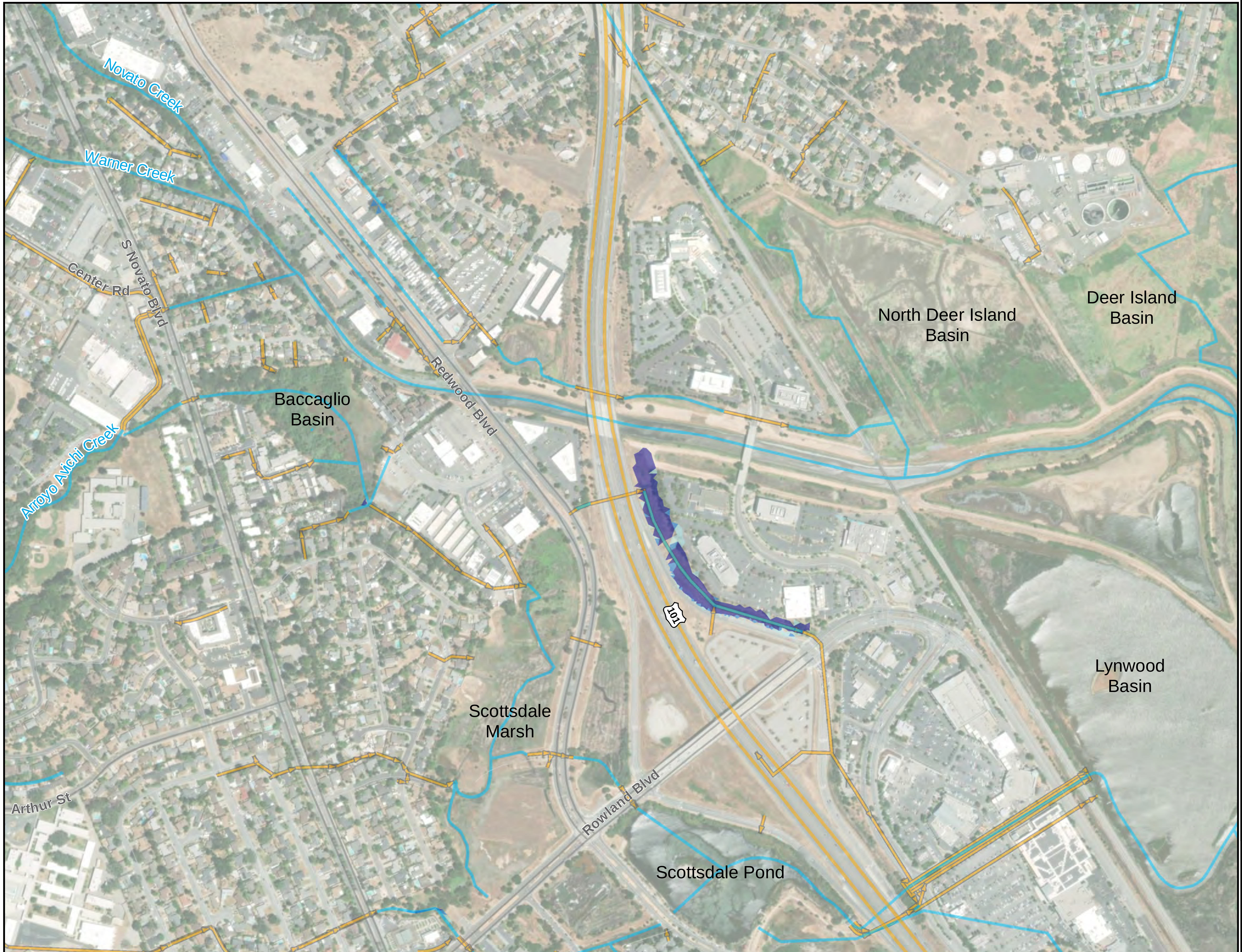
0 1,000 2,000
Feet



Vicinity Map

EXHIBIT A

WOOD RODGERS



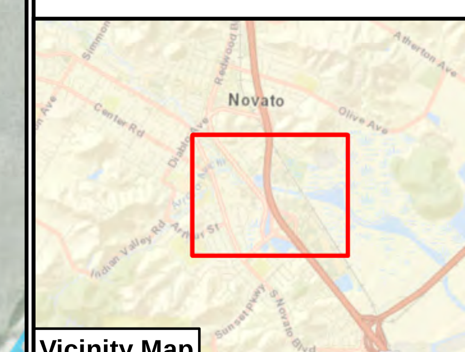
Marin County
ABSL

Existing Conditions
2-Year 48-Hour
Marin County, California
February 2024

Legend
Channel
Marin Map Storm Sewers
Depth
< 0.5'
0.5' - 1'
> 1'

NORTH

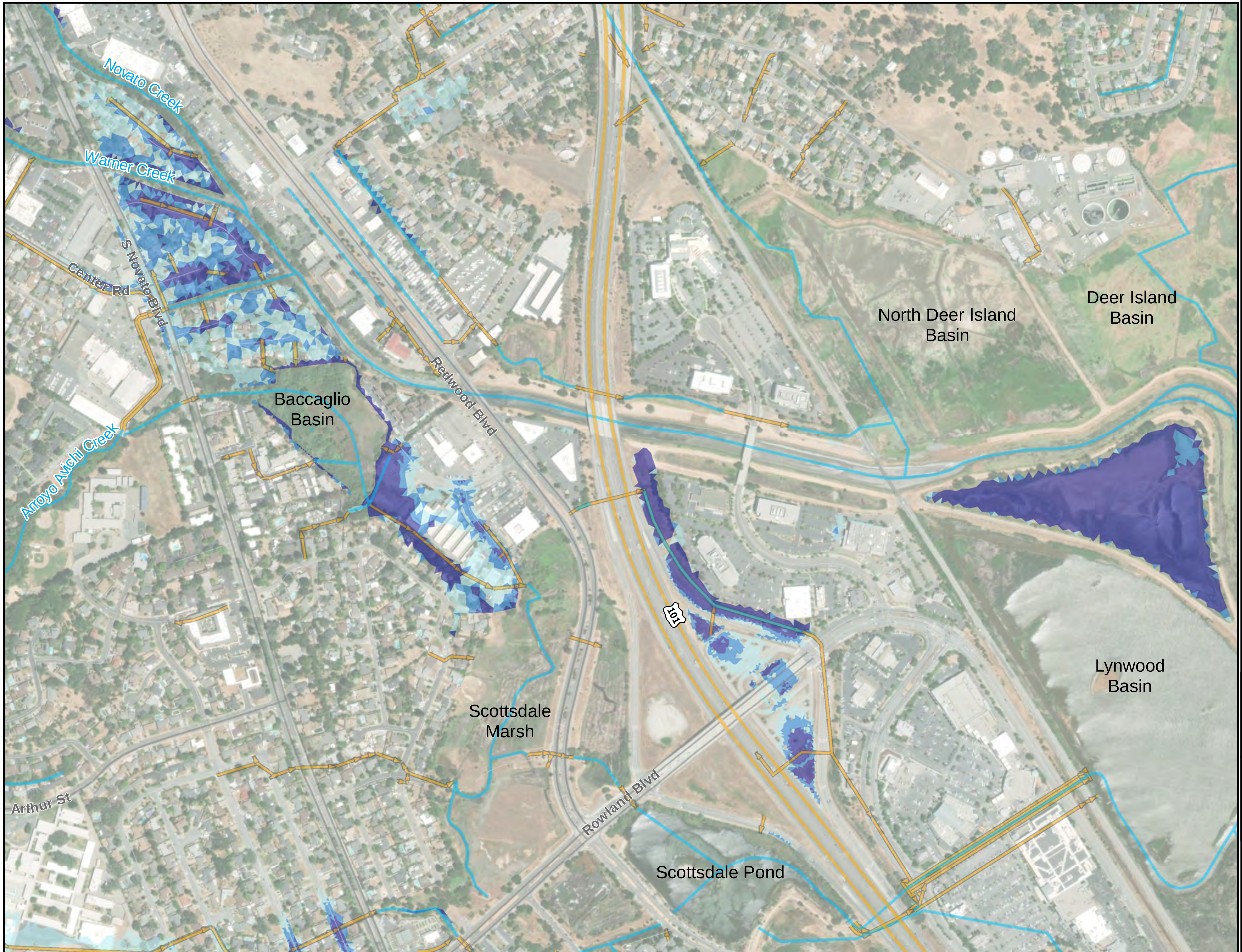
0 200 400
Feet



Vicinity Map

EXHIBIT B

WOOD RODGERS



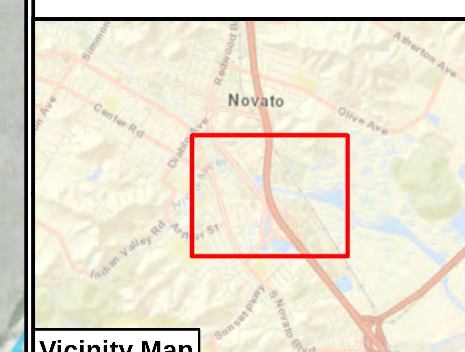
Marin County
ABSL

Existing Conditions
10-Year 48-Hour
Marin County, California
February 2024

Legend
Channel
Marin Map Storm Sewers
Depth
< 0.5'
0.5' - 1'
> 1'

NORTH

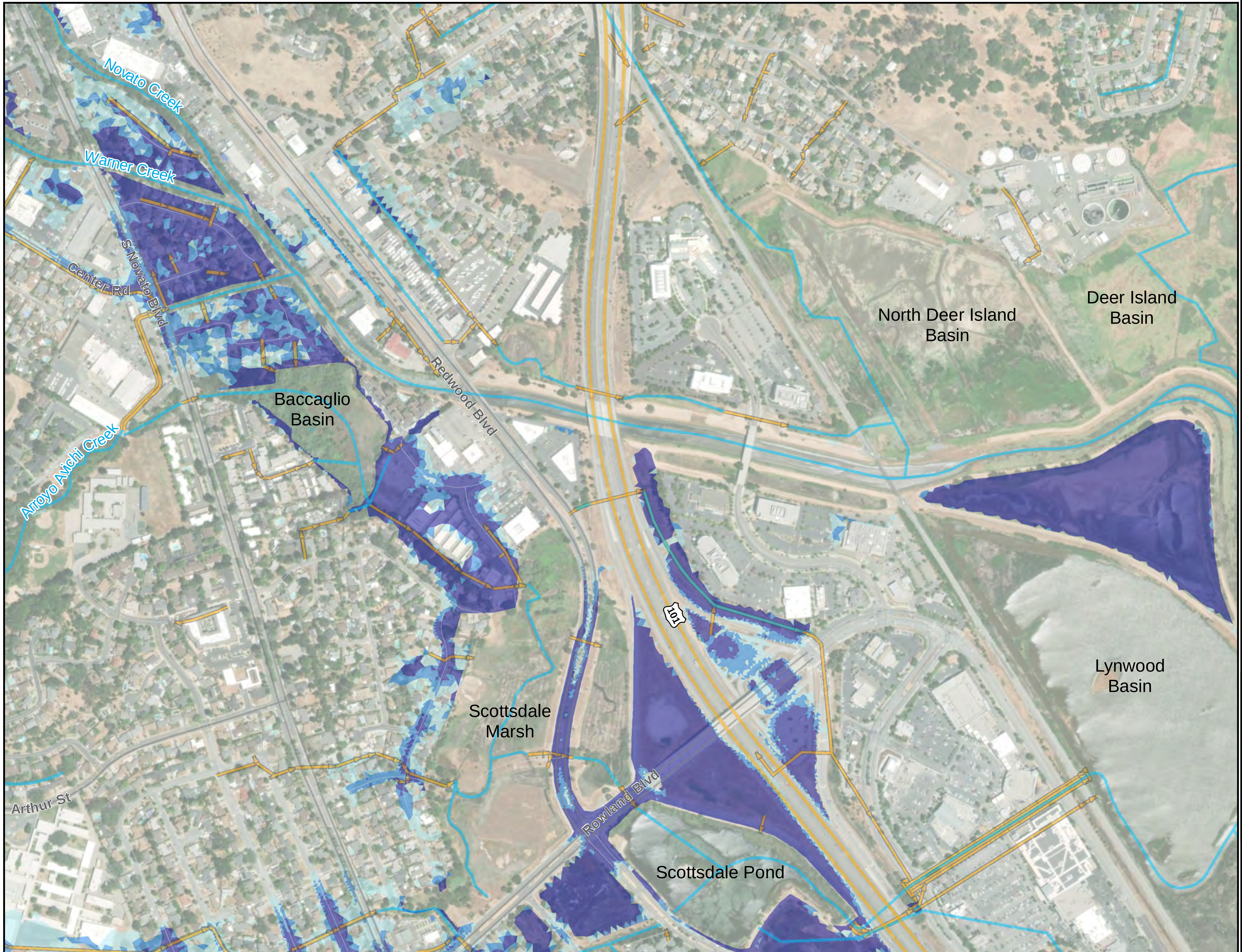
0 200 400
Feet



Vicinity Map

EXHIBIT C

WOOD RODGERS



Marin County
ABSL

Existing Conditions
50-Year 48-Hour
Marin County, California
February 2024

Legend

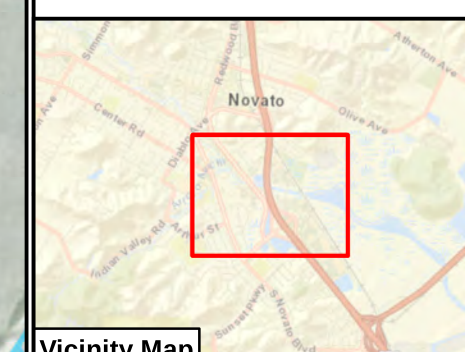
Channel
Marin Map Storm Sewers

Depth

< 0.5'
0.5' - 1'
> 1'

NORTH

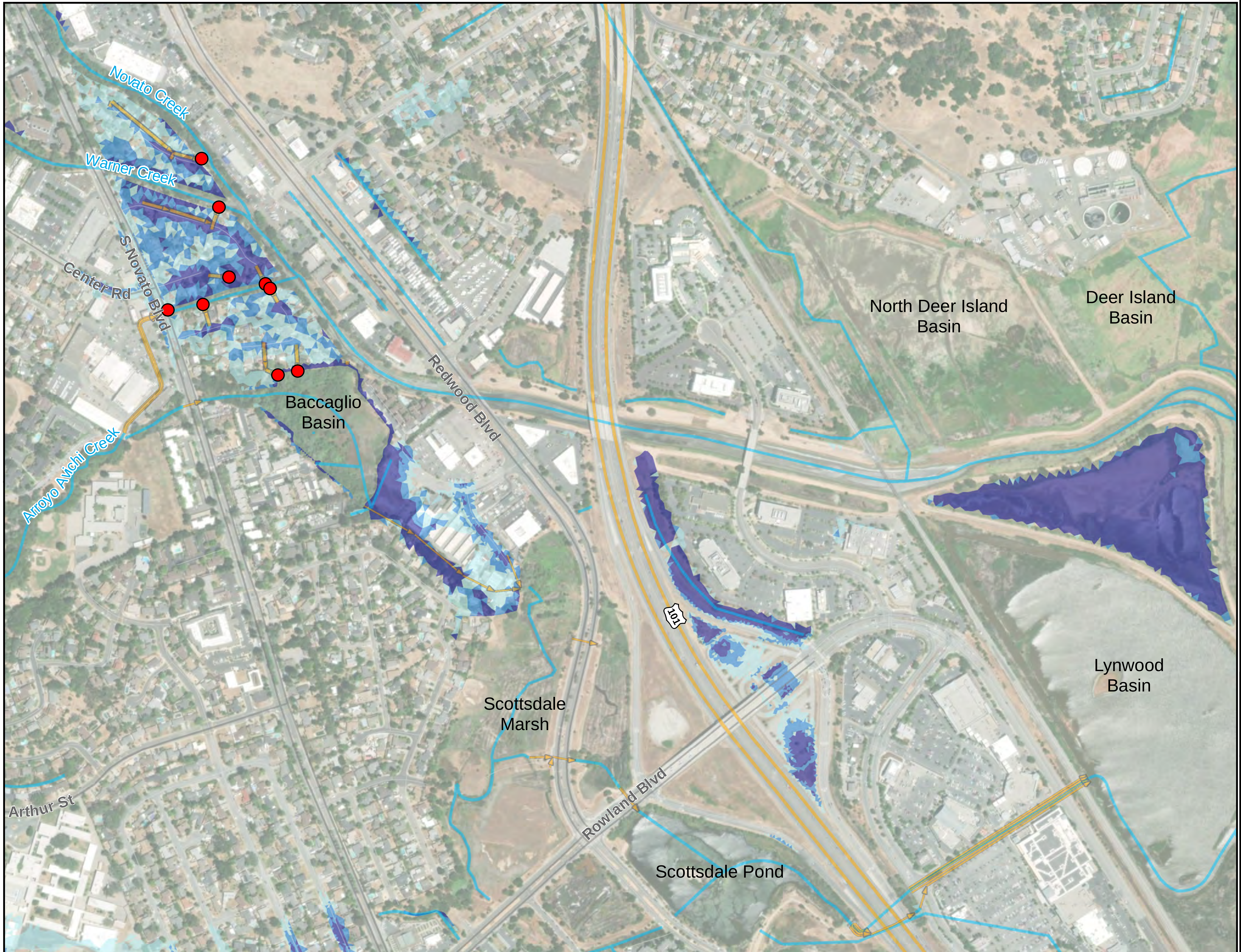
0 200 400
Feet



Vicinity Map

EXHIBIT D

WOOD RODGERS



Marin County
ABSL

Proposed Conditions
Flap Gates
10-Year 48-Hour
Marin County, California
February 2024

Legend

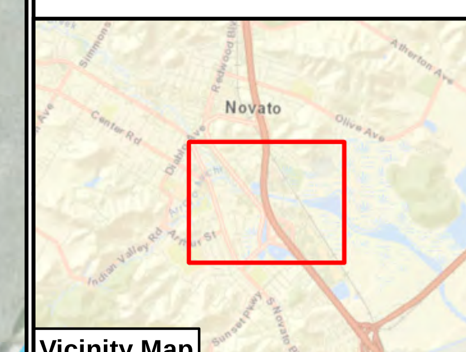
Channel
Marin Map Storm Sewers
Flapgates

Depth

< 0.5'
0.5' - 1'
> 1'

NORTH

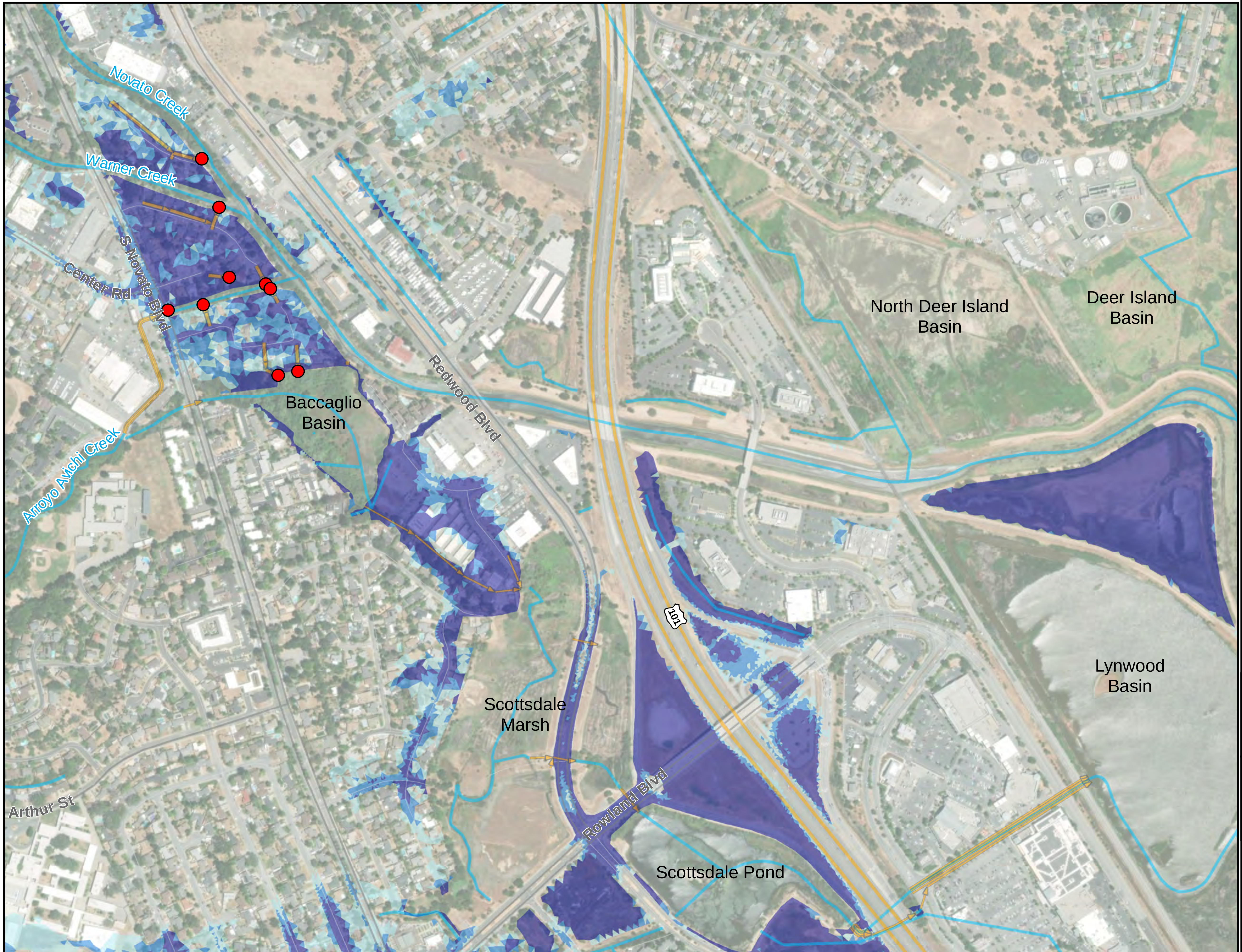
0 200 400
Feet



Vicinity Map

EXHIBIT E

WOOD RODGERS



Marin County
ABSL

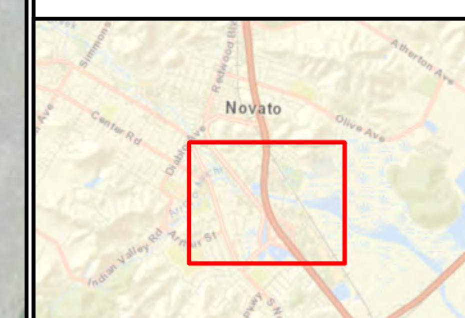
Proposed Conditions
Flap Gates
50-Year 48-Hour
Marin County, California
February 2024

Legend
- Channel
- Marin Map Storm Sewers
- Flapgates

Depth
- < 0.5'
- 0.5' - 1'
- > 1'

NORTH

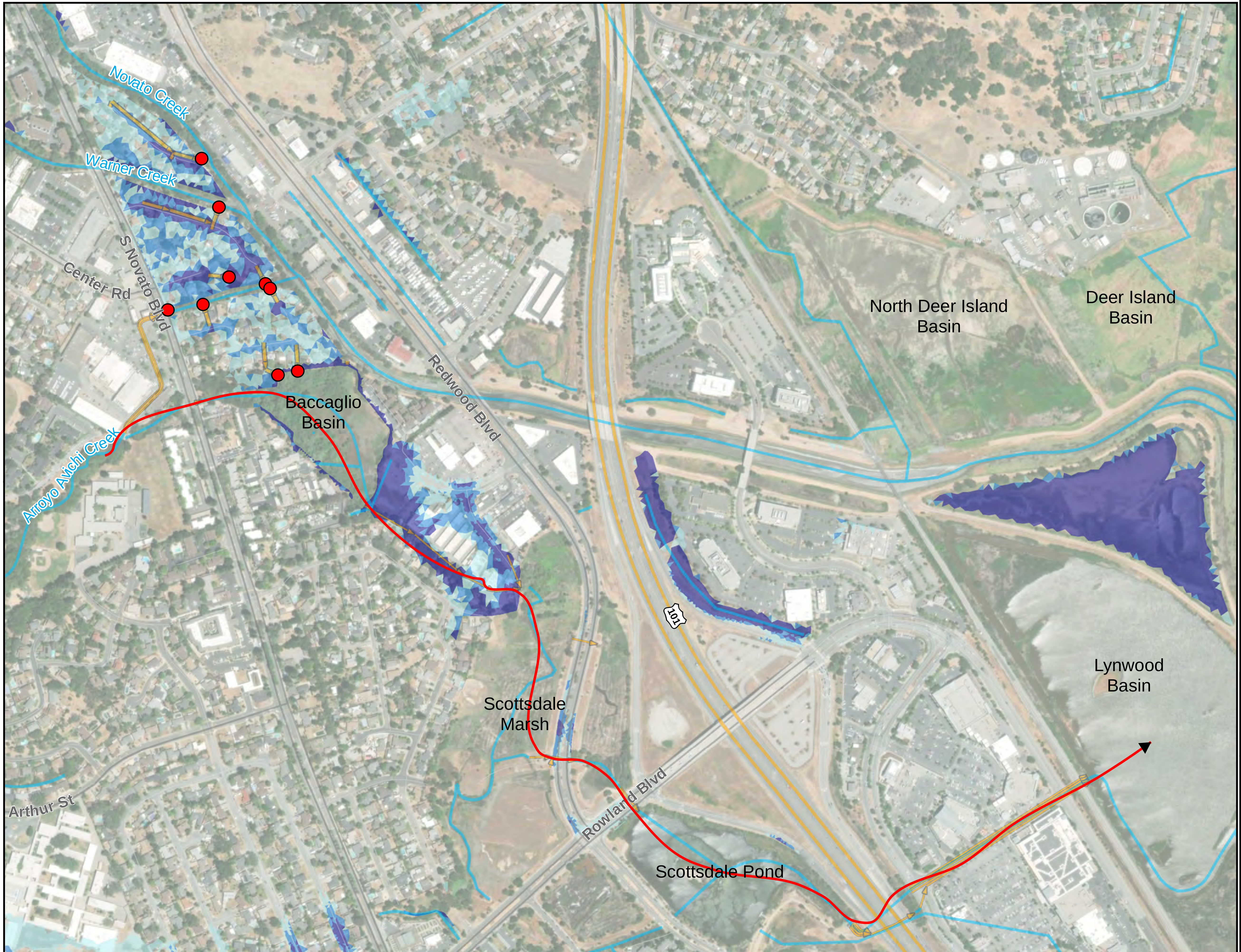
0 200 400
Feet



Vicinity Map

EXHIBIT F

WOOD RODGERS



Marin County
ABSL

Proposed Conditions
ABSL + Flap Gates
10-Year 48-Hour
Marin County, California
February 2024

Legend

- Channel
- Marin Map Storm Sewers
- Flapgates

Depth

- < 0.5'
- 0.5' - 1'
- > 1'
- ABSL Complex

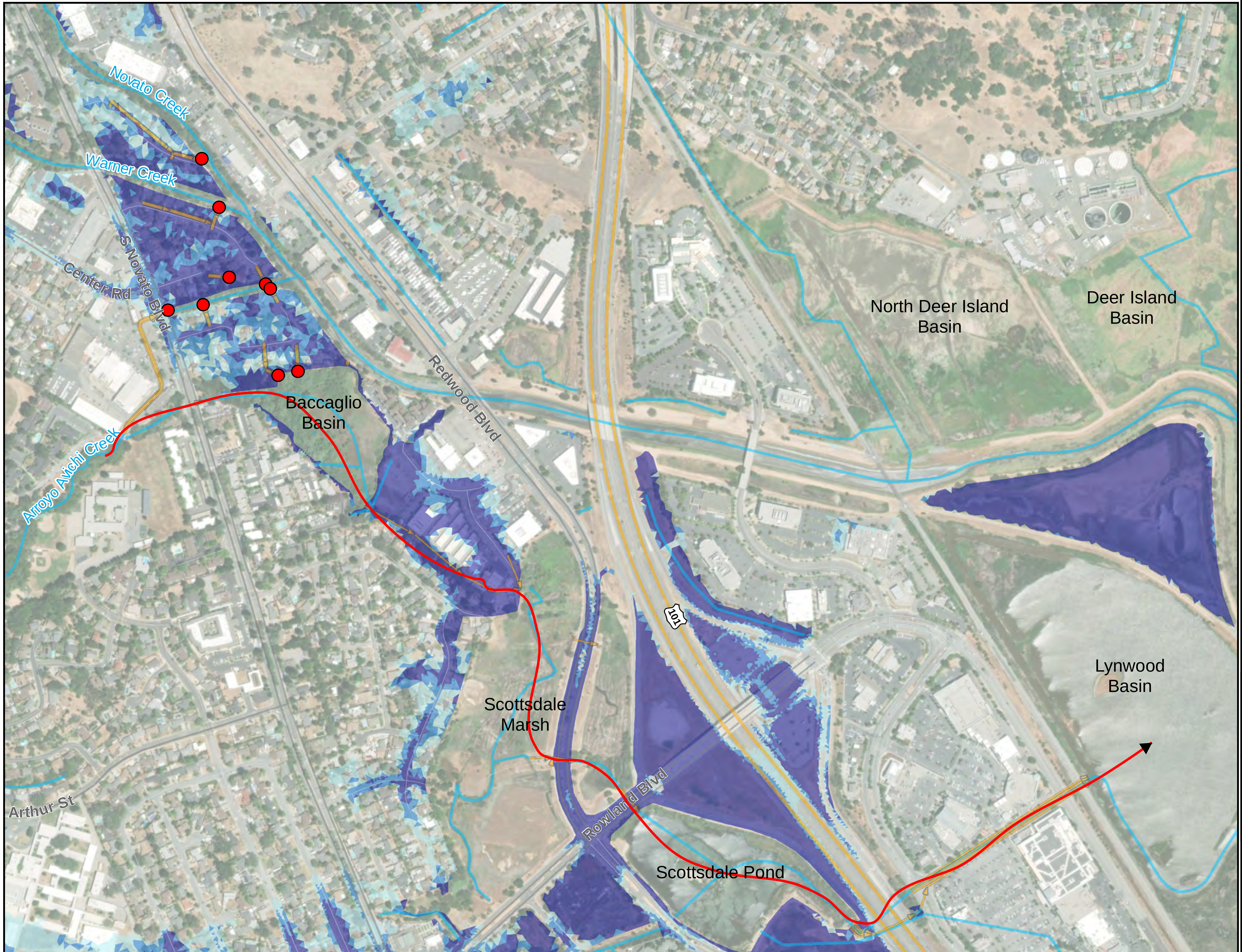
NORTH

0 200 400
Feet

Vicinity Map

EXHIBIT G

WOOD RODGERS

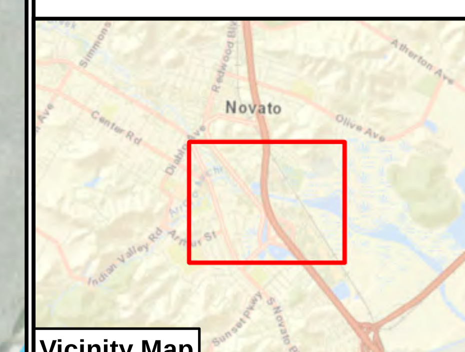


Marin County
ABSL

Proposed Conditions
ABSL + Flap Gates
50-Year 48-Hour
Marin County, California
February 2024

Legend
Channel
Marin Map Storm Sewers
Flapgates
Depth
< 0.5'
0.5' - 1'
>1'
ABSL Complex

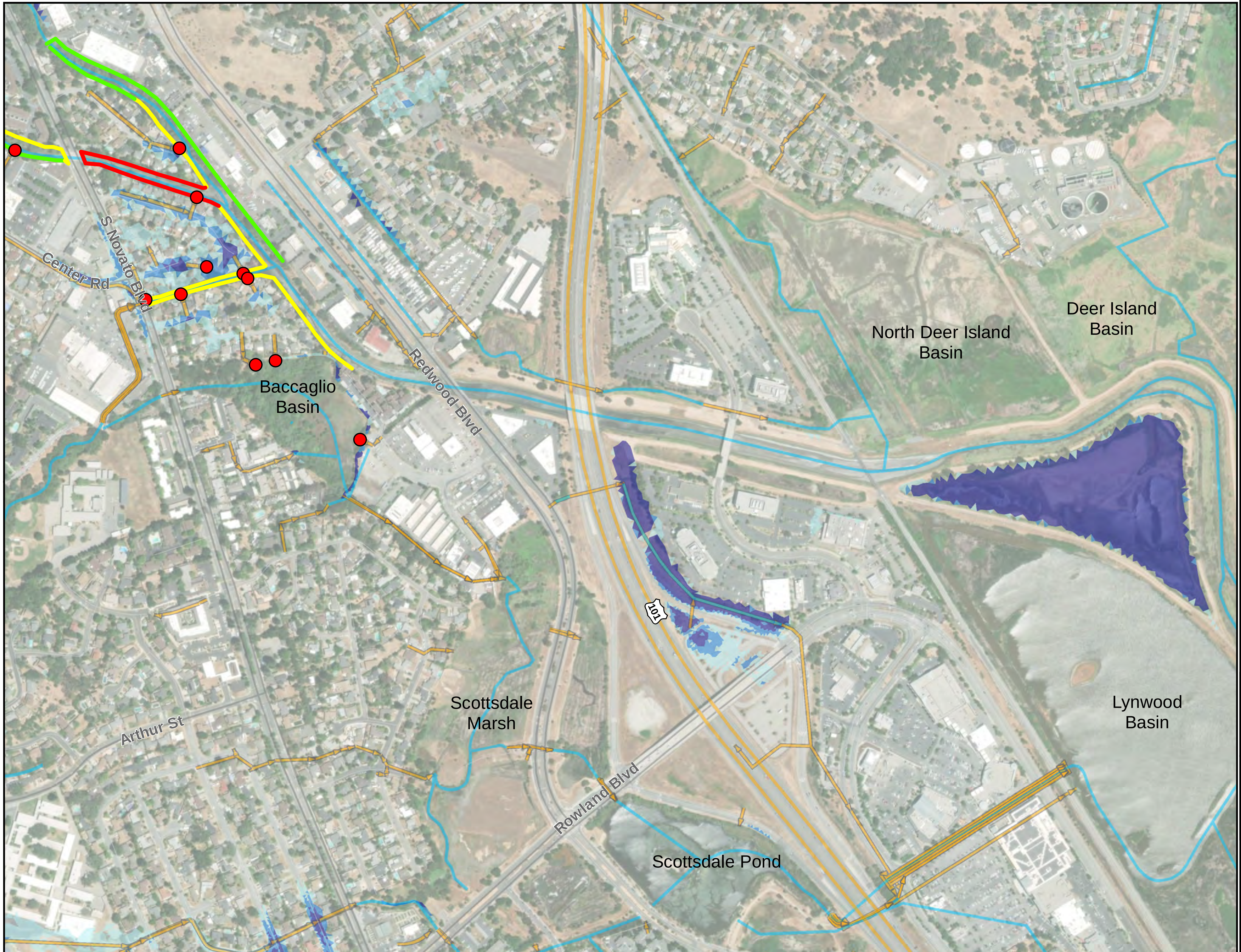
NORTH
0 200 400
Feet



Vicinity Map

EXHIBIT H

WOOD RODGERS



Marin County
ABSL

Proposed Conditions
Floodwalls + Flap Gates
10-Year 48-Hour
Marin County, California
August 2024

Legend

- Channel
- Marin Map Storm Sewers
- Flapgates

Floodwall Height

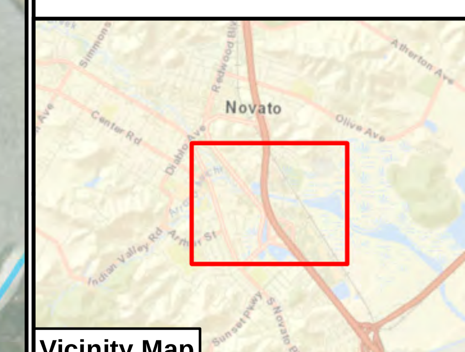
- 1 ft + 3 ft Freeboard = 4 ft
- 2 ft + 3 ft Freeboard = 5 ft
- 3 ft + 3 ft Freeboard = 6 ft

Depth

- < 0.5'
- 0.5' - 1'
- > 1'

NORTH

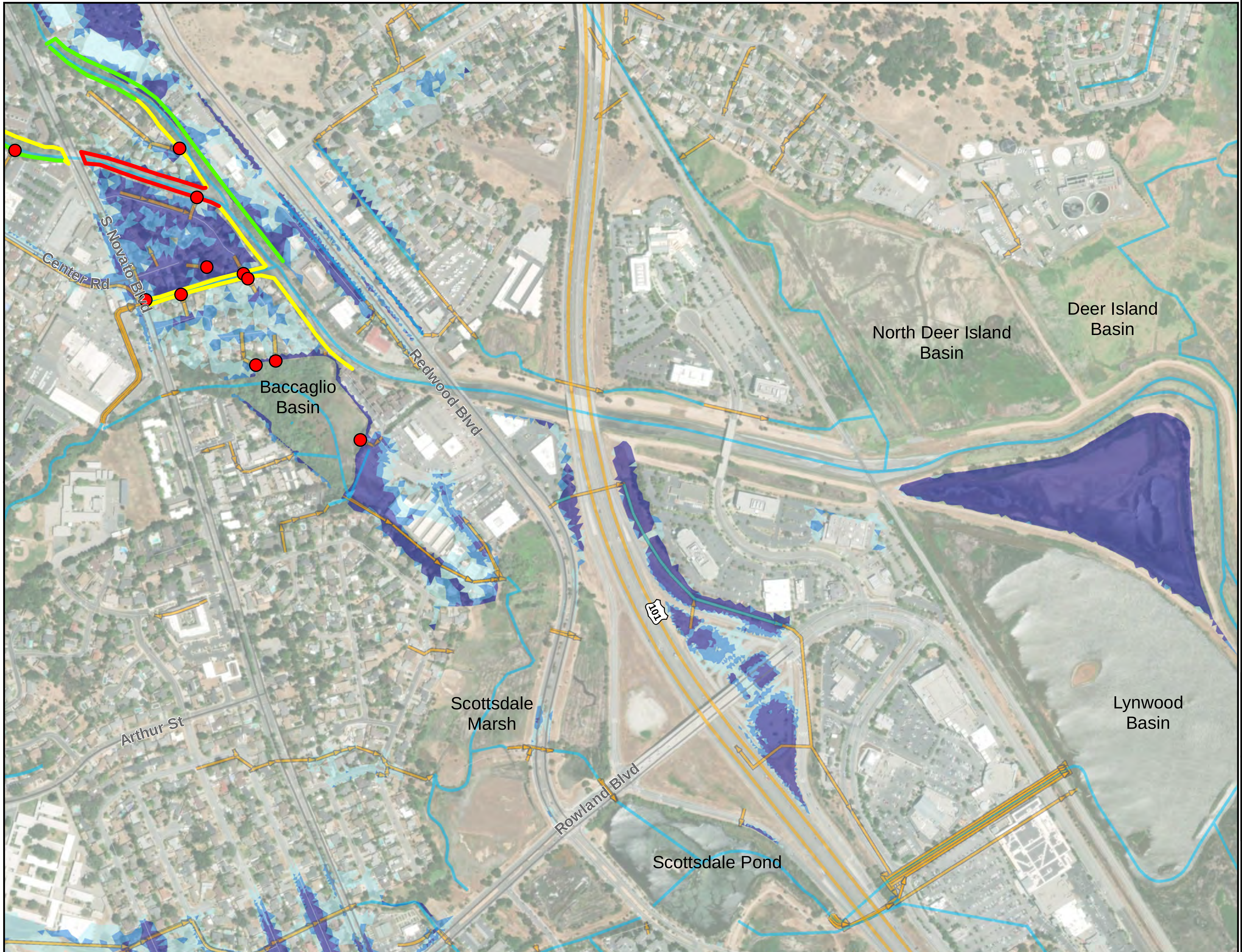
0 200 400
Feet



Vicinity Map

EXHIBIT I

WOOD RODGERS



Marin County
ABSL

Proposed Conditions
Floodwalls + Flap Gates
50-Year 48-Hour
Marin County, California
August 2024

Legend

- Channel
- Marin Map Storm Sewers
- Flapgates

Floodwall Height

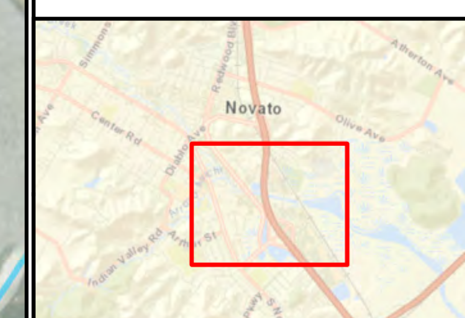
- 1 ft + 3 ft Freeboard = 4 ft
- 2 ft + 3 ft Freeboard = 5 ft
- 3 ft + 3 ft Freeboard = 6 ft

Depth

- < 0.5'
- 0.5' - 1'
- > 1'

NORTH

0 200 400
Feet



Vicinity Map

EXHIBIT J

WOOD RODGERS

Marin County
ABSL
Proposed Conditions North Deer Island Levee Lowering + Flap Gates 10-Year 48-Hour
Marin County, California
August 2024

Legend

- Channel
- Marin Map Storm Sewers
- Flapgates
- N Deer Island Levee Lowering

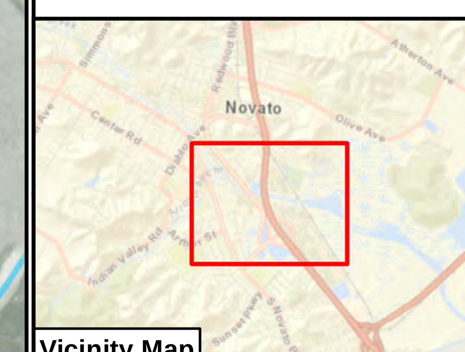
PR_10YR48HR

Depth

- < 0.5'
- 0.5' - 1'
- > 1'

NORTH

0 200 400
Feet



Vicinity Map

EXHIBIT K

WOOD RODGERS

Marin County
ABSL
Proposed Conditions
North Deer Island
Levee Lowering
+ Flap Gates
50-Year 48-Hour
Marin County, California
August 2024
Legend
Channel
Marin Map Storm Sewers
Flapgates
N Deer Island Levee Lowering
Depth
< 0.5'
0.5' - 1'
> 1'
NORTH
0
200
400
Feet
Vicinity Map
Novato
EXHIBIT L
WOOD RODGERS
North Deer Island Basin
Deer Island Basin
Baccaglio Basin
Scottsdale Marsh
Scottsdale Pond
Lynwood Basin
S Novato Blvd
Center Rd
Redwood Blvd
Arthur St
Rowland Blvd
101

Marin County
ABSL
Proposed Conditions
Channel Dredging
+ Flap Gates
10-Year 48-Hour
Marin County, California
April 2024

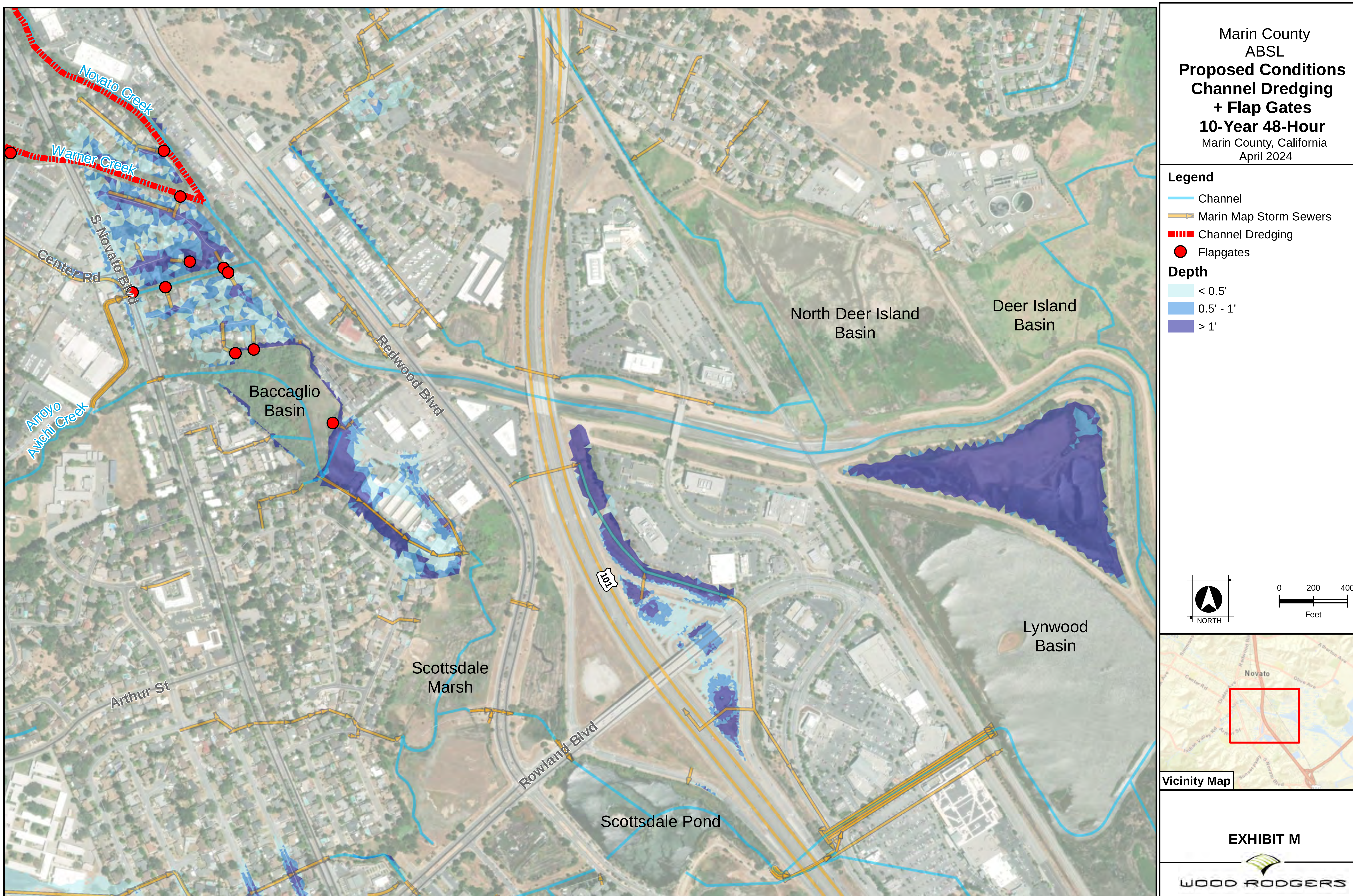
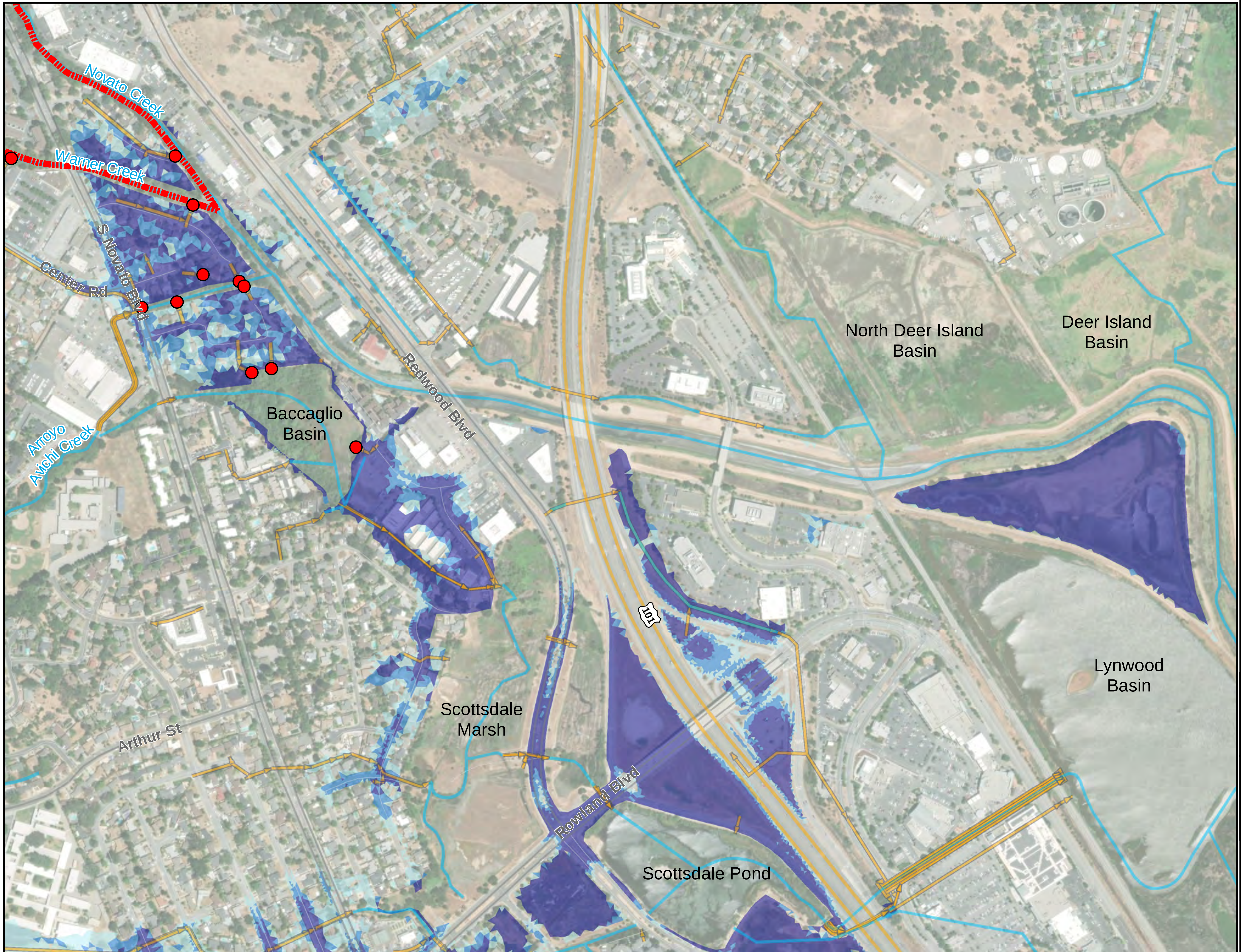


EXHIBIT M

WOOD RODGERS



Marin County
ABSL
Proposed Conditions
Channel Dredging
+ Flap Gates
50-Year 48-Hour
Marin County, California
April 2024

Legend

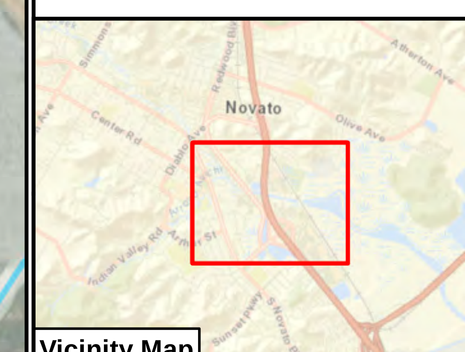
- Channel
- Marin Map Storm Sewers
- Channel Dredging
- Flapgates

Depth

- < 0.5'
- 0.5' - 1'
- > 1'

NORTH

0 200 400
Feet



Vicinity Map

EXHIBIT N

WOOD RODGERS

Marin County
ABSL
Proposed Conditions Floodwalls + North Deer Island Levee Lowering + Flap Gates 10-Year 48-Hour
Marin County, California
August 2024

Legend

- Channel
- Marin Map Storm Sewers
- Flapgates
- N Deer Island Levee Lowering

Floodwall Height

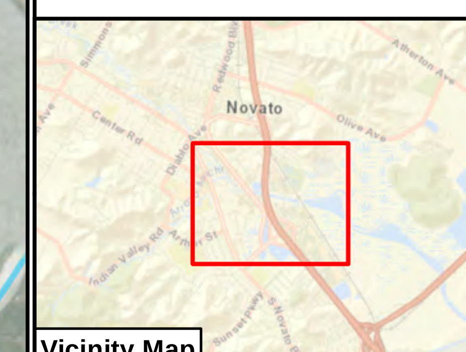
- 1 ft + 3 ft Freeboard = 4 ft
- 2 ft + 3 ft Freeboard = 5 ft
- 3 ft + 3 ft Freeboard = 6 ft

Depth

- < 0.5'
- 0.5' - 1'
- > 1'

NORTH

0 200 400
Feet



Vicinity Map

EXHIBIT O

WOOD RODGERS

Marin County
ABSL
Proposed Conditions
Floodwalls +
North Deer Island Levee
Lowering + Flap Gates
50-Year 48-Hour
Marin County, California
August 2024

Legend

- Channel
- Marin Map Storm Sewers
- Flapgates
- N Deer Island Levee Lowering

Floodwall Height

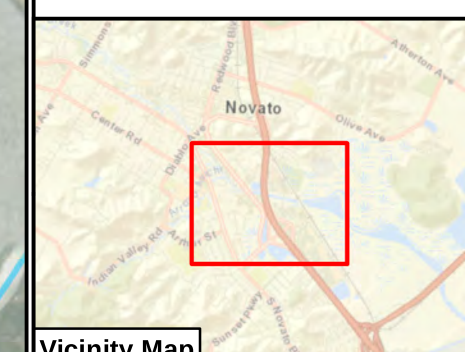
- 1 ft + 3 ft Freeboard = 4 ft
- 2 ft + 3 ft Freeboard = 5 ft
- 3 ft + 3 ft Freeboard = 6 ft

Depth

- < 0.5'
- 0.5' - 1'
- > 1'

NORTH

0 200 400
Feet



Vicinity Map

EXHIBIT P

WOOD RODGERS

Marin County
ABSL
Proposed Conditions
Channel Dredging +
North Deer Island Levee
Lowering + Flap Gates
10-Year 48-Hour
Marin County, California
August 2024

Legend

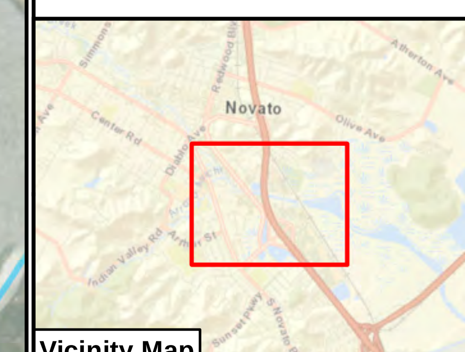
- Channel
- Marin Map Storm Sewers
- Channel Dredging
- Flapgates
- N Deer Island Levee Lowering

Depth

- < 0.5'
- 0.5' - 1'
- > 1'

NORTH

0 200 400
Feet



Vicinity Map

EXHIBIT Q

WOOD RODGERS

Marin County
ABSL
Proposed Conditions
Channel Dredging +
North Deer Island Levee
Lowering + Flap Gates
50-Year 48-Hour
Marin County, California
August 2024
Legend
Channel
Marin Map Storm Sewers
Channel Dredging
Flapgates
N Deer Island Levee Lowering
Depth
< 0.5'
0.5' - 1'
> 1'
NORTH
0
200
400
Feet
Novato Creek
Warner Creek
Center Rd
S Novato Blvd
Arroyo Avichi Creek
Baccaglio Basin
Redwood Blvd
North Deer Island Basin
Deer Island Basin
101
Scottsdale Marsh
Arthur St
Rowland Blvd
Scottsdale Pond
Lynwood Basin
Novato
Vicinity Map
EXHIBIT R
WOOD RODGERS

APPENDIX A – ADS Gage Installation

Technical Memorandum

Title:	ABSL Complex and Nave Gardens Flood Drainage Improvements Feasibility Study (8563016)
Prepared For:	Roger Leventhal, PE
Prepared By:	Alexis Robertson, PE
Reviewed By:	Judd Goodman, PE and Jeremiah McMahon, PE
Date:	September 12, 2022
Purpose:	Proposed Locations for Five Temporary Water Level Sensors (Task 3.1)

INTRODUCTION

Wood Rodgers, Inc. (Wood Rodgers) is providing flood control planning services to the Marin County Flood Control and Water Conservation District (District) for the Arroyo Avichi - Baccaglio Basin - Scottsdale Marsh and Pond - Lynwood Basin (ABSL) Complex and Nave Gardens Flood Drainage Improvements Feasibility Study Project. The purpose of this project is to evaluate the most feasible improvements to the ABSL complex of open spaces to assist with control of flooding in downtown Novato and the surrounding low elevation neighborhoods (e.g., Nave Gardens).

PURPOSE

As part of this study, Wood Rodgers will perform water level monitoring (Task 3.1) at five locations within the ABSL Complex system for one wet season. This will allow for calibration of the existing condition hydrology and hydraulic model. Wood Rodgers will collect the monitoring data with ADS ECHO water level gages, planned for installation in January 2022. The purpose of this technical memorandum is to provide the five planned locations for gage installation.

ATTACHMENTS

1. ADS ECHO Data Sheet by ADS, 2020
   www.adsenv.com/sites/default/files/datasheets/ADS-ECHO-DataSheet.pdf

2. Exhibit, “Proposed Locations for Water Level Sensors”, shows the mapped location where each photo was taken for each of the five temporary water level sensors.

CITY ASSISTANCE

Wood Rodgers will need coordination, assistance and approval from Novato City in order to complete the installation of the temporary water level sensors, as follows:

1. Review and approve the proposed **five** locations for the temporary water level sensors (see red circles marking installation surfaces on Photos 1-5). The proposed sensor locations will be mounted on City owned infrastructure. The temporary sensors wil remain in place for one wet season.
2. Review and approve the installation method for the temporary water level sensors. At each sensor location, four anchor bolts and one eye bolt will be **permanantly** installed as shown in *Figure 1* and *Figure*

3, respectively. Please note at Location 4, the anchorage will be installed into the architectural stone facia of the Bridge/Culverts Entering Scottsdale Pond on Northeast Side of Redwood Blvd.

3. City assistance will be needed to **lock-out tag-out** the pumps at the Lynwood Pump Station for one day during installation for safety of persons performing the sensor installation.

INSTALLATION METHOD

Wood Rodgers selected the ADS ECHO as the water level monitoring system for this project due to its advanced performance and simple installation. The ADS ECHO monitors water level when situated above the water surface or if submerged at high stages. These sensors have previosly been utilized to monitor water level at locations elsewhere in Marin County. The ADS ECHO Data Sheet (Attachment 1) is attached to this technical memorandum for further details on the sytem and its capabilites.

Each ADS ECHO system includes an ADS ECHO Level Monitor, Wireless Modem Antenna, Wall Mounting Bar, Hex Key, Setup/Activation Magnet, Bluetooth Dongle, Qstart Startup Application, Communications Provider (AT&T), and PRISM Software subscription. Each component of the ADS ECHO sytem will be temporarily installed, with the exception of the anchor bolts, which will remain on the installed surface after the system is removed.

For each of the proposed locations, an ADS ECHO system will be installed per the following method, summarized from ADS ECHO Manual (Installation, Operation, and Maintenance) #QR 775031 A5 by ADS, May 2018. First, the Wall Mount Bar bracket will be placed at each selected location (see red circles marking installation surfaces on *Photos 1-5)*. Once the Wall Mount Bar is leveled, points for drilling or screwing in the anchor bolts will be marked. Then, the Wall Mount Bar bracket will be secured to the installation surface with four (4) anchor bolts as demonstrated in *Figure 1* . The anchor bolts are permanent and will remain in place. The wall mount bracket, wall mount bar, and ADS ECHO Monitor are temporary installations that can be removed after the 1-year monitoring period.

Figure 1: Secured Wall Mount Bar bracket with four (4) anchor bolts (Ref. Attachment 1)

Next, the Wall Mount bar will be screwed into the bracket secured to the wall, as shown in *Figure 2*.

Figure 2: Installed Wall Mount Bar (Ref. Attachment 1)

The ADS ECHO Monitor will then be attached to the Wall Mount Bar. The eye bolt will be drilled and epoxied into the concrete sidewall, see red circle shown in *Figure 3*. The steel cable tether line will be installed to secure the ADS ECHO to the eye bolt. Finally, the antenna will be attached to the top of the ADS ECHO Monitor.

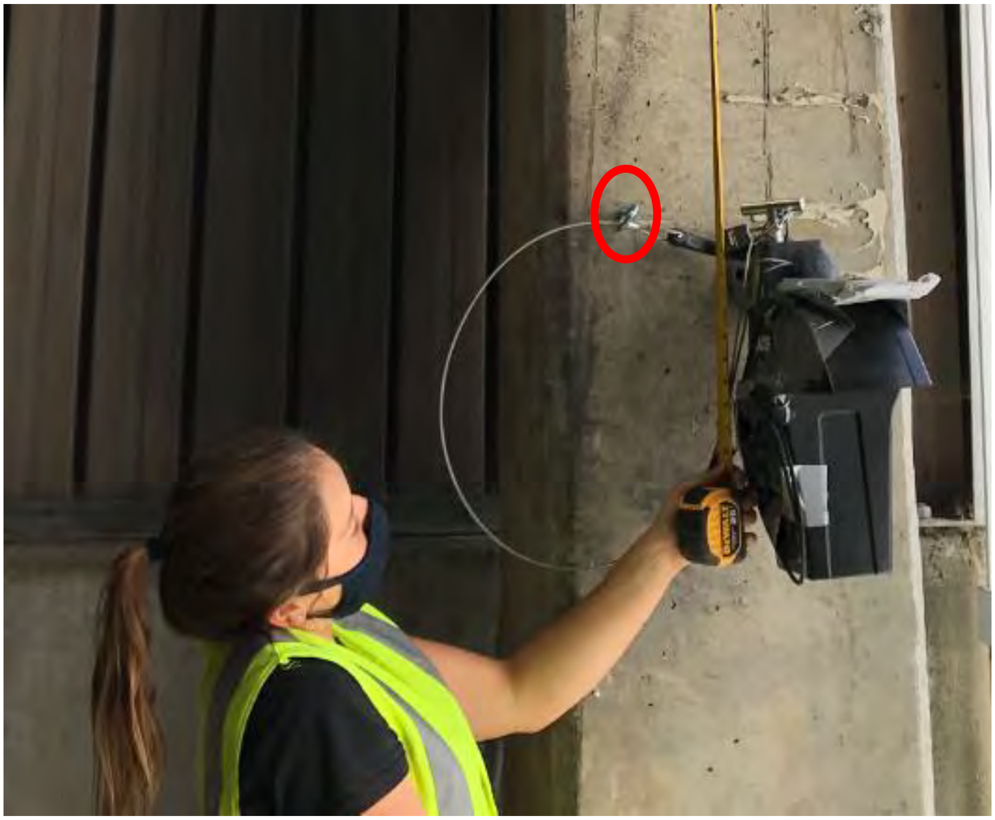


Figure 3: ADS ECHO Example Side Wall Installation

PROPOSED WATER LEVEL GAGE LOCATIONS

Based on site visits by Wood Rodgers engineers on December 13, 2021 and January 3, 2022, Wood Rodgers proposes the following water level sensor locations:

1. Upstream Side of Arroyo Avichi Creek Diversion Weir
2. Outlet of Arroyo Avichi Box Culvert on East Side of Novato Blvd at Nave Gardens
3. Inlet of Box Culvert for Diversion Channel on West Side of Novato Blvd
4. Outlet of Stone Bridge/Culverts Entering Scottsdale Pond
5. Fence Post on South Side of Lynwood Basin Pump Station

This section includes a site description with photographs from the site visits of the proposed locations. The attached exhibit, “Proposed Locations for Water Level Sensors”, shows the mapped location where each photo was taken.

Location 1: Upstream Side of Arroyo Avichi Creek Diversion Weir

The first proposed location is on Arroyo Avichi Creek just upstream of the trash rack inlet which services the inlet of three (3) 42" storm drains. As shown in *Photo 1*, the upstream side of the diversion weir is proposed for water level gage installation. The installation is proposed to be on the vertical face of the weir wall (approximately 3' tall) as shown by the red circle in *Photo 1.*

Photo 1: Proposed Installation Location on Upstream Side of Arroyo Avichi Creek Diversion Weir (facing upstream

Location 2: Outlet of Arroyo Avichi Box Culvert on East Side of Novato Blvd at Nave Gardens

The second proposed water level gage location is at the outlet of the Arroyo Avichi storm drain system. The outlet is a box culvert located on the East Side of Novato Blvd at Nave Gardens, between Lauren Ave. and Garden Ct. The installation is proposed to be on the top of the box culvert as shown by the red circle in *Photo 2**.***

Photo 2: Proposed Installation Location at the Outlet of Arroyo Avichi Box Culvert on East Side of Novato Blvd at Nave Gardens (facing upstream)

Location 3: Inlet of Box Culvert for Diversion Channel on West Side of Novato Blvd

This location is at the inlet of the box culvert for the diversion channel on the West side of Novato Blvd. The diversion channel currently conveys overflow from the Arroyo Avichi diversion structure to Baccaglio Basin. The box culvert is between Lark Ct. and Lauren Ave., as shown in the attached Exhibit. *Photo 3a* provides context of the surrounding area and *Photo 3b* shows the proposed installation location on the top of the wall (see red circle).

Photo 3a: Surrounding Vicinity of Diversion Channel (facing south [right] bank)

Photo 3b: Proposed Installation Location at Inlet of Box Culvert for Diversion Channel on West Side of Novato Blvd. (facing north [left] bank)

Location 4: Outlet of Stone Bridge/Culverts Entering Scottsdale Pond on Northeast Side of Redwood Blvd.

The fourth proposed location is at the outlet of the stone bridge/culverts entering Scottsdale Pond. The culverts are three semicircle structures on the northeast side of Redwood Blvd, just north of Cutlass Drive. The proposed level sensor installation is shown with the red circle. Since this location is visible to the public it is not recommend anchoring the level sensor to the stone wall. Wood Rodgers is proposing to install a temporary fence post and mount the level sensor to the top of the post.

Photo 4: Outlet of Stone Bridge/Culverts Entering Scottsdale Pond on Northeast Side of Redwood Blvd. (facing south)

Location 5: Fence Post on South Side of Lynwood Basin Pump Station

The fifth and final proposed location is at the Lynwood Basin Pump Station (PS). The proposed installation location is on the fence post on the south side of the PS, facing the open water. The PS would need to be turned off, with lock-out tag-out procedures, during installation for safety. Photo 5a shows the entire PS, while Photo 5b shows the proposed installation location on the back of the PS (see red circle).

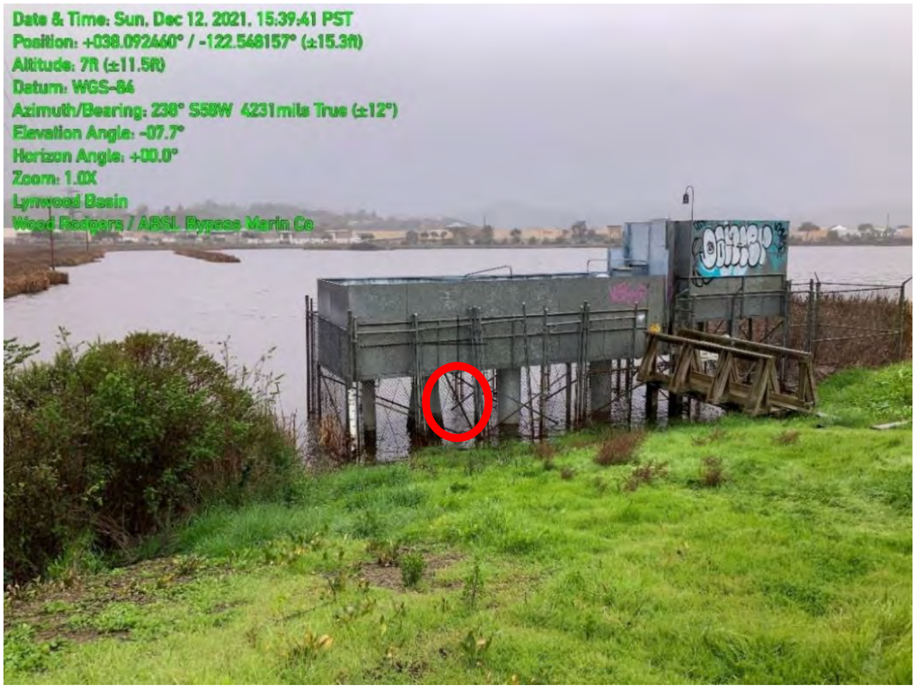


Photo 5a: Surrounding Vicinity of Lynwood Basin PS (facing southwest)

Photo 5b: Proposed Installation Location on Fence Post on South Side of Lynwood Basin Pump Station (facing east)

APPENDIX B – Calibration

The following figures display the results of calibration. Figure 1 through Figure 5 are model results versus observed data collected at the five locations throughout the ABSL complex Wood Rodgers installed ADS depth sensors during the 2022-2023 wet season. Because of depth sensor malfunctions and vandalism, the time frame all gages were recording data was between late December 2022 and mid January 2023. Figure 6 displays the model results versus observed results for flow at the USGS gage on Novato Creek at the Novato Creek Library.

In general, the calibration was successful at replicating the observed data during the 2022-2023 wet season. To accomplish this, Wood Rodgers changed Horton SWMM infiltration and groundwater parameters. Horton SWMM parameters such as initial infiltration and decay were adjusted to match storm runoff peaks, while groundwater parameters were adjusted to match hydrograph recession limbs. Table 1, Table 2 and Table 3 present the final root mean square error statistics, calibrated hydrologic parameters for Horton SWMM infiltration and groundwater, respectively.

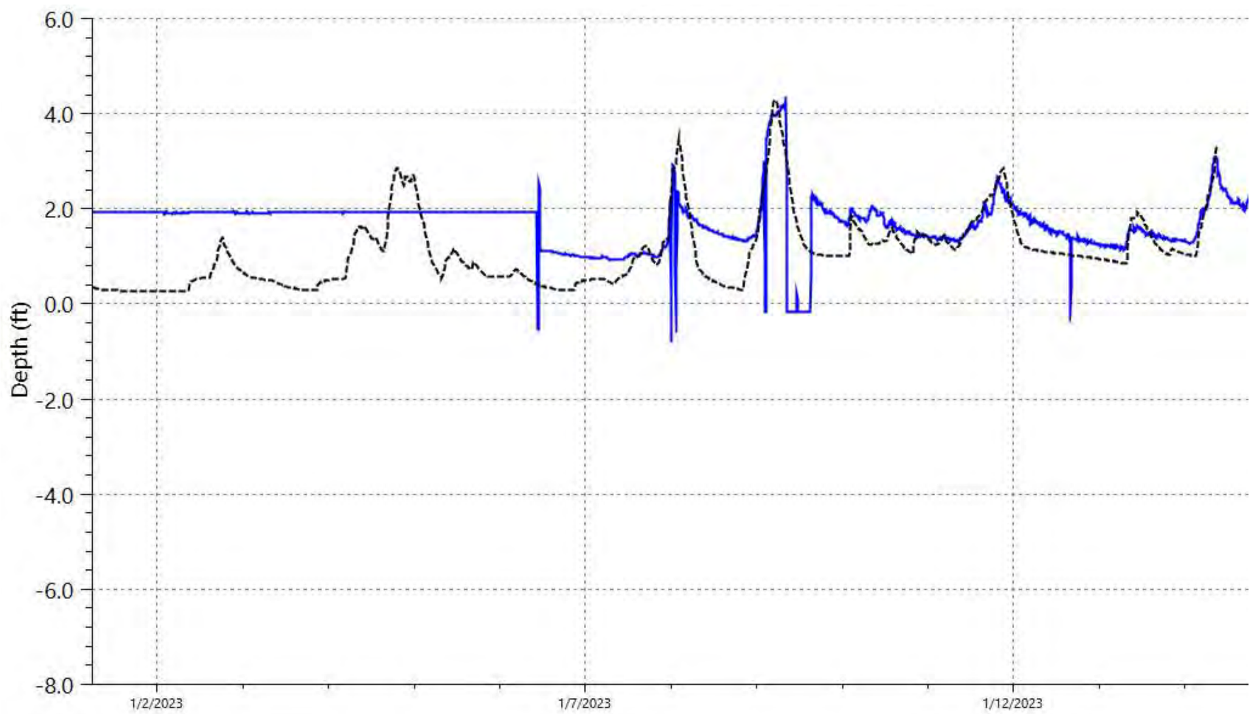


Figure 1 - Predicted Depth (Dashed Back Line) vs Observed Depth (Solid Blue Line) at the Arroyo Avichi Diversion Weir

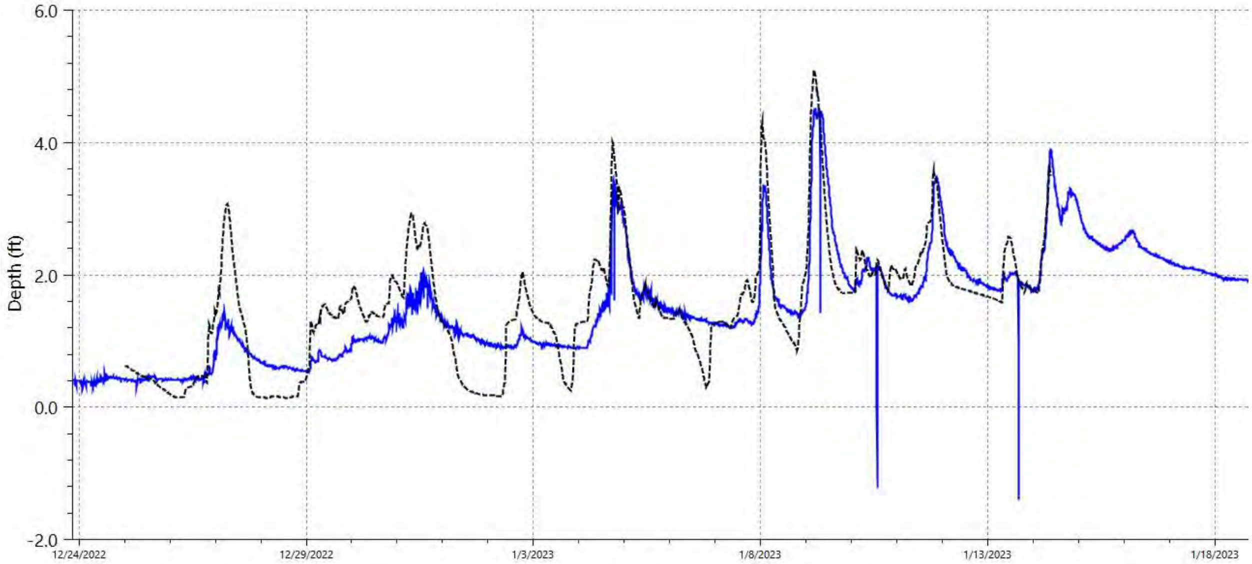


Figure 2 - Predicted Depth (Dashed Back Line) vs Observed Depth (Solid Blue Line) at Arroyo Avichi Creek at Novato Boulevard

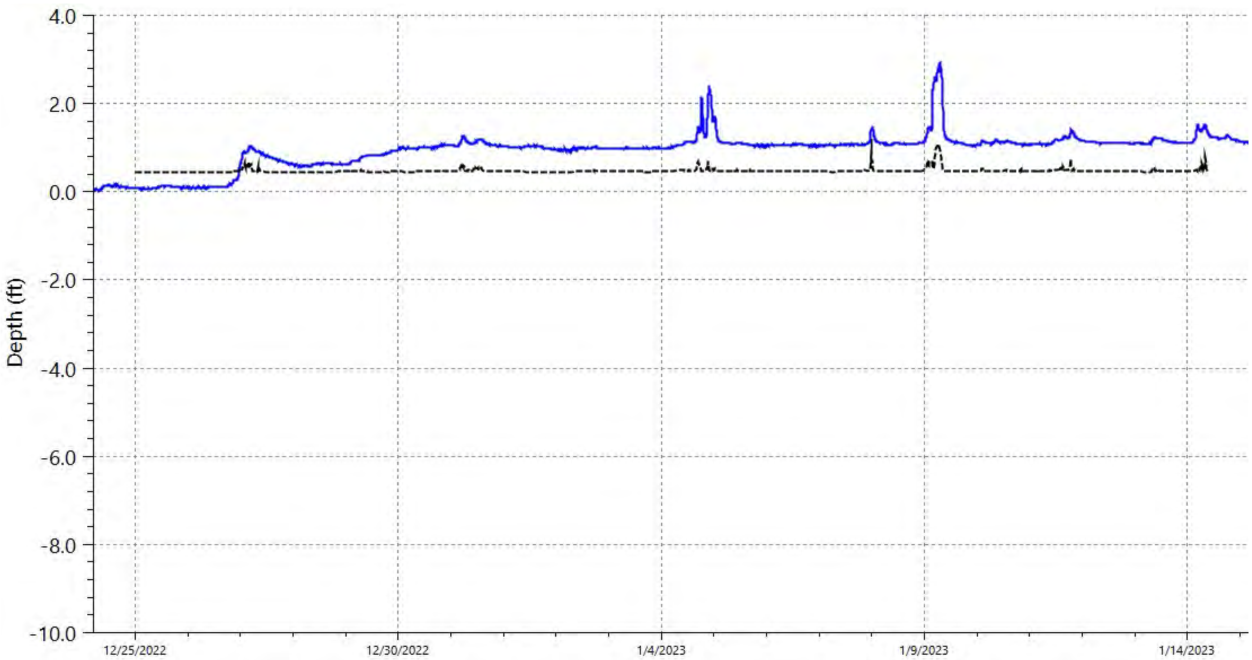


Figure 3 - Predicted Depth (Dashed Back Line) vs Observed Depth (Solid Blue Line) at Arroyo Avichi Creek Bypass at Novato Boulevard

The ADS gage at Scottsdale Pond malfunctioned the entire 2022-2023 wet season because it was under water. Wood Rodgers attempted to elevate the gage, but accessing the gage's location was determined to be unsafe. Figure 4 shows the observed data recorded by the malfunctioning gage, as well as the predicted water levels in Scottsdale Pond.

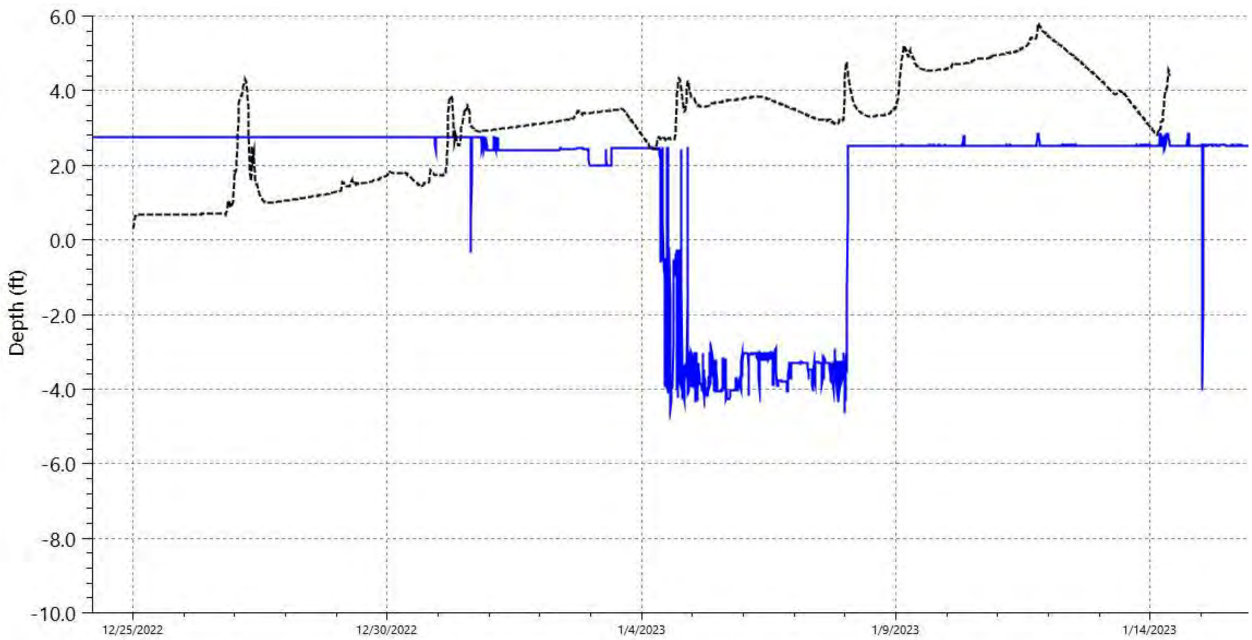


Figure 4 - Predicted Depth (Dashed Back Line) vs Observed Depth (Solid Blue Line) at Scottsdale Pond

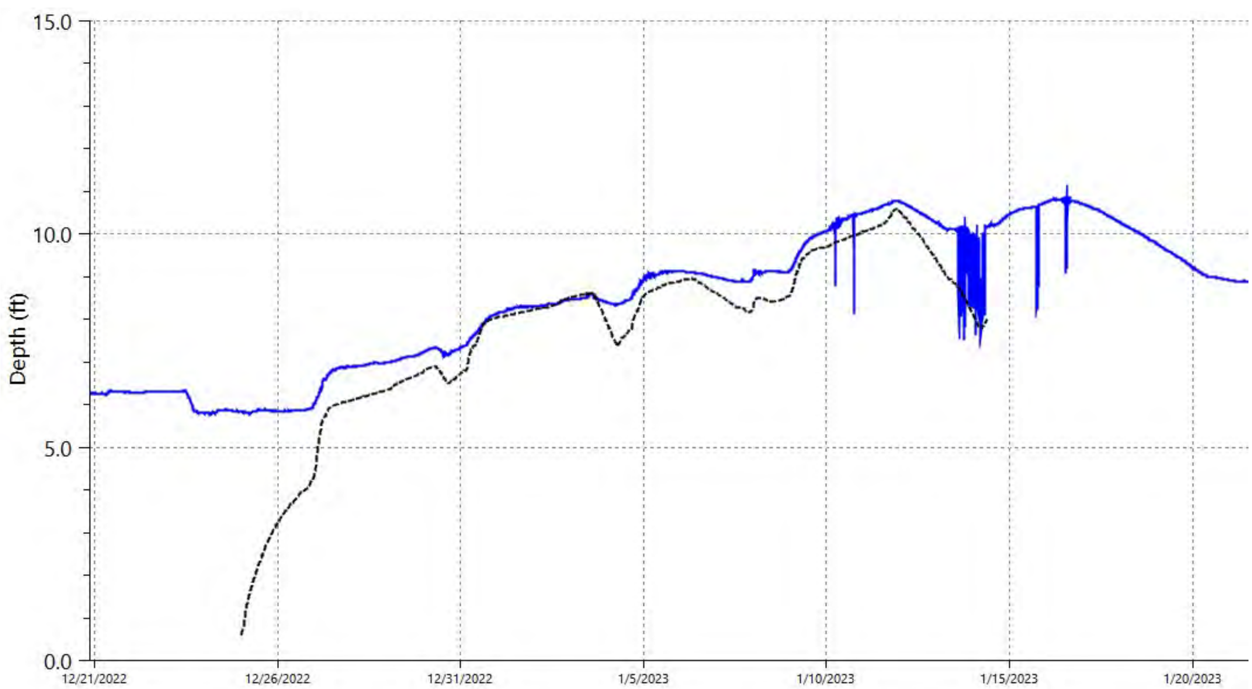


Figure 5 - Predicted Depth (Dashed Back Line) vs Observed Depth (Solid Blue Line) at Lynwood Basin

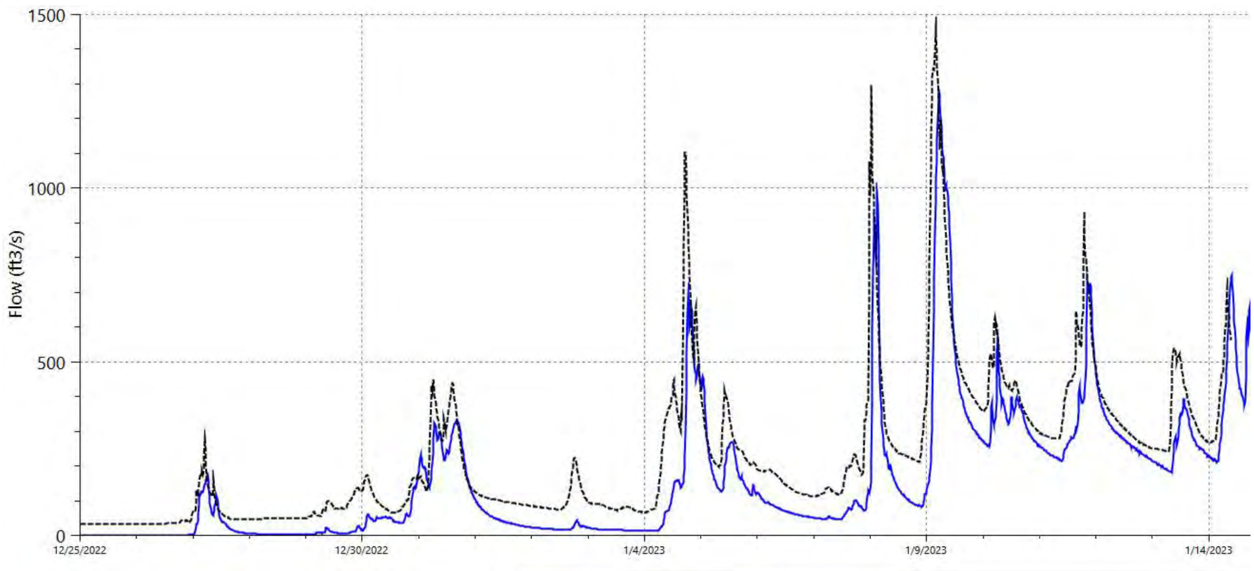


Figure 6 - Predicted Flow (Dashed Back Line) vs Observed Flow (Solid Blue Line) on Novato Creek at the Novato Creek Library

Table 1 – Root Mean Square Error Statistics

	RMSE (ft)	RMSE (ft3/s)
Arroyo Avichi Diversion Weir	0.52	
Arroyo Avichi Creek @ Novato Blvd	0.54	
Arroyo Avichi Bypass @ Novato Blvd	0.60	
Scottsdale Pond	-	-
Lynwood Basin	0.60	
Novato Creek Library		129.1

Table 2 – Calibrated Horton SWMM Parameters

	Initial Infiltration (in/hr)	Limiting Infiltration (in/hr)	Decay Factor (1/hr)	Horton Drying Time (Days)
Hydrologic Soils A	6.0	0.45	2.0	2.0
Hydrologic Soils B	4.5	0.30	2.0	2.0
Hydrologic Soils C	3.0	0.25	2.0	2.0
Hydrologic Soils D	2.0	0.09	2.0	2.0

Table 3 – Calibrated Groundwater Parameters

Soil Depth (ft)	Percolation Coefficient	Baseflow Coefficient	Infiltration Coefficient	Percolation Threshold	Percolation Percentage Infiltrating
4.0	0.10	20.0	10.0	10.0	35.0

Porosity of Soil	Porosity of Ground	Baseflow Threshold Level (ft)	Baseflow Threshold Type	Infiltration Threshold Level (ft)	Evaporation Depth (ft)
50.0	50.0	0.0	Absolute	0.6	4.0

APPENDIX C – ICM PROFILE EXPLANATION

This documentation provides a brief explanation of how to interpret ICM profiles. **Figure 1** shows the Nave Court storm drains schematized in the InfoWorks ICM model. A profile of the same system is shown in **Figure 2**. Notice in **Figure 2** the large white space between the Nave Court storm drain discharging into Novato Creek and the first cross section in Novato Creek. ICM is representing the feature hydraulicly connecting the storm drain to Novato Creek. Hydraulically, this feature has zero length, but graphically ICM is showing a length between the storm drain and Novato Creek. **Figure 2** also shows an approximate 2-foot drop from the downstream end of the hydraulic connection to the beginning of Novato Creek. The bottom represents the elevation assigned to the creek's junction node (the confluence between Warner Creek and Novato Creek, with an elevation of 2.0 ft), while the beginning of Novato Creek represents the thalweg elevation of the creek at that location. Elevations assigned to junction nodes *have no hydraulic impact, and are populated in ICM for profile aesthetic purposes only*. To improve the aesthetics of the profile in **Figure 2**, the junction node elevation should have been assigned the same elevation as the Novato Creek cross section thalweg (4.83 ft).

In addition, ICM profiles display the left and right banks of the channel (when looking downstream). These are represented by light green and dark green lines, respectively. Resultant water surface elevation profiles are displayed in dashed black lines, solid blue lines, and solid red lines for the 2-, 10-, and 50-year results, respectively. For example, in **Figure 2**, the reader should understand the 2-year storm backs up into the Nave Court storm drains, but does not surcharge the manholes. The 10-year event breaches the right bank of Novato Creek, and surcharges most manholes on Nave Court. And the 50-year event breaches both banks of Novato Creek, and surcharges most manholes on Nave Court.

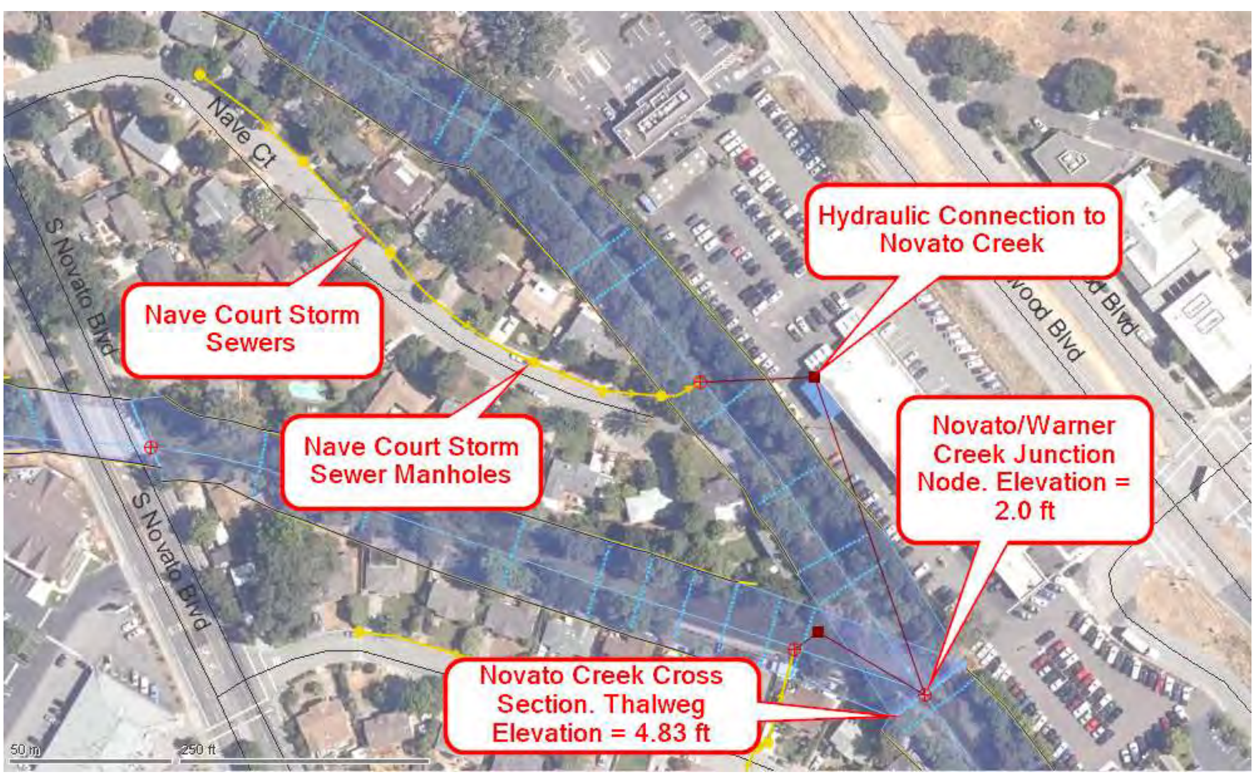


Figure 1 – Nave Court Storm Drain InfoWorks ICM Model Schematization

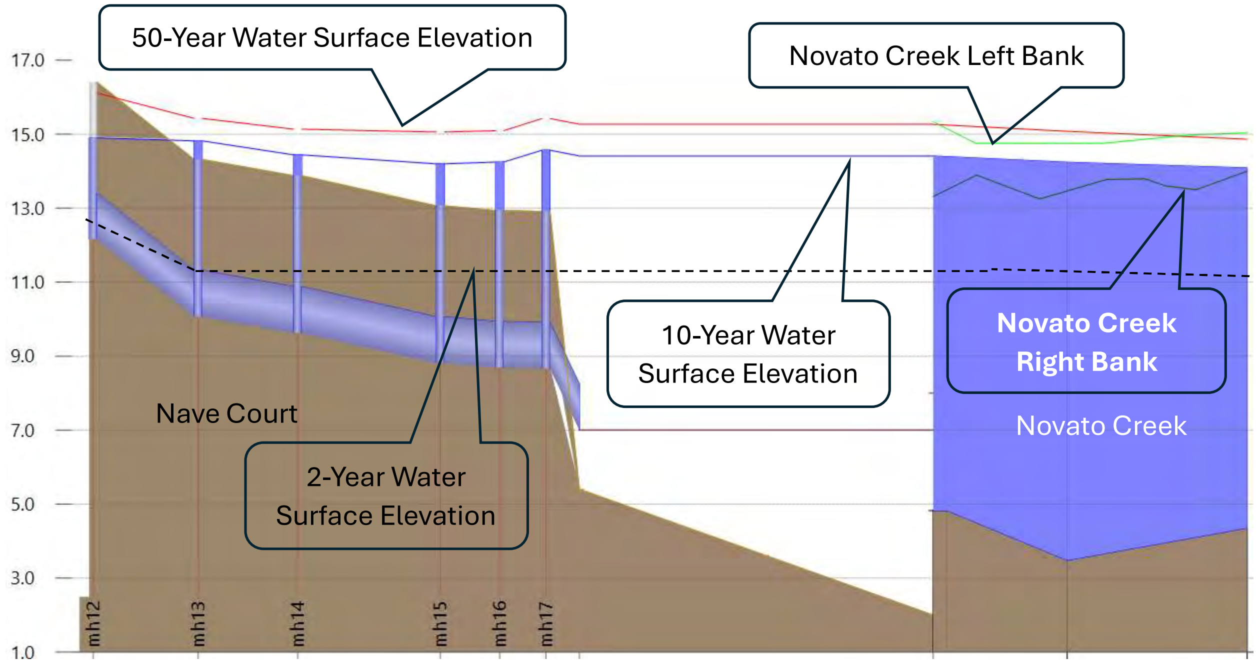


Figure 2 – Profile of Nave Court Storm Sewers and Novato Creek

To simplify the understanding of ICM profiles, Wood Rodgers recommends ignoring any white space in the profiles caused by hydraulic connection features or any mismatch of channel junction nodes and channel cross sections. An idealize representation of the Nave Court storm sewer system profile is show in **Figure 3**.

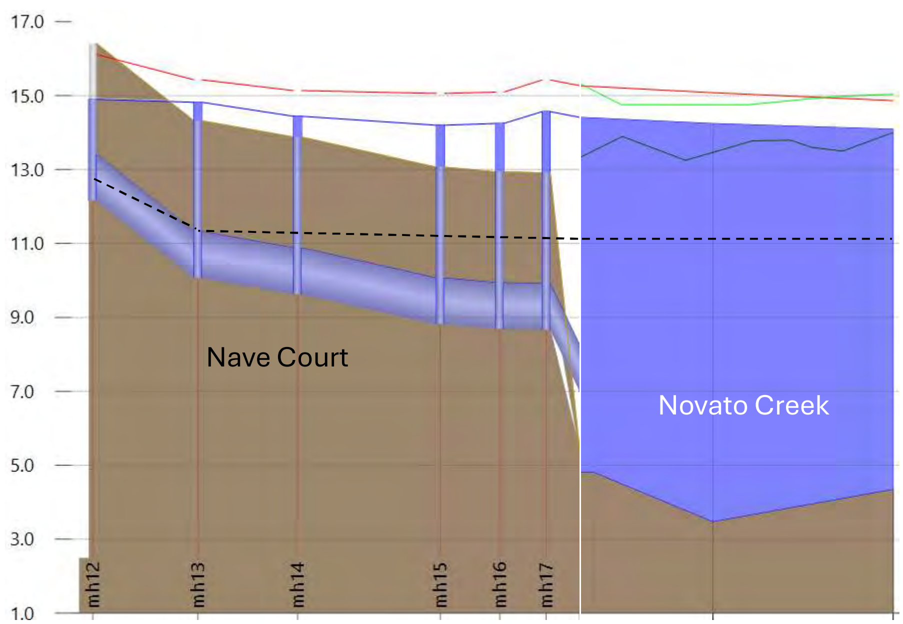


Figure 3 – Idealized Representation of the Nave Court Storm Sewers and Novato Creek

APPENDIX D – Engineer’s Cost Estimate

DATE	PROJECT	IMPROVEMENT
8/5/2024	ABSL	Flap Gates

#	Item Name	Unit Quantity	Unit of Measure	Unit Cost	Cost Estimate Total	Assumption
1	MOBILIZATION	1	LS	$ 30,000	$ 30,000	10% of total, min $30k
2	WATER POLLUTION CONTROL WORK	1	LS	$ 30,000	$ 30,000	1% of total, min $30k
3	TRAFFIC CONTROL	-	LS	$ -	$ -	Assume not needed
4	TRENCH AND EXCAVATION PROTECTION	-	LS	$ -	$ -	Assume not needed
5	DEWATERING	-	LS	$ -	$ -	Assume not needed
6	ENGINEERING DESIGN	1	LS	$ 6,420	$ 6,420	10% of total
7	PERMITTING	1	LS	$ 6,420	$ 6,420	10% of total
8	CONSTRUCTION SUPPORT	1	LS	$ 6,420	$ 6,420	10% of total
9	MANAGEMENT	1	LS	$ 6,420	$ 6,420	10% of total
10	12" FLAP GATE	5	EA	$ 4,500	$ 22,500	Includes Installation
11	15" FLAP GATE	3	EA	$ 5,900	$ 17,700	Includes Installation
12	30" FLAP GATE	1	EA	$ 24,000	$ 24,000	Includes Installation
				30% Contingency:	**$ 44,964**	
				Total Project Cost Estimate:	**$ 194,844**	

Note: Contingency developed to account for incidental items based on contractor bids for similar projects

DATE	PROJECT	IMPROVEMENT
8/5/2024	ABSL	ABSL Bypass + Flap Gates

#	Item Name	Unit Quantity	Unit of Measure	Unit Cost	Cost Estimate Total	Assumption
1	MOBILIZATION	1	LS	$ 30,000	$ 30,000	10% of total, min $30k
2	WATER POLLUTION CONTROL WORK	1	LS	$ 30,000	$ 30,000	1% of total, min $30k
3	TRAFFIC CONTROL	1	LS	$ 20,000	$ 20,000	2% of total, min $20k
4	TRENCH AND EXCAVATION PROTECTION	1	LS	$ 10,000	$ 10,000	1% of total, min $10k
5	DEWATERING	1	LS	$ 28,163	$ 28,163	10% of total
6	ENGINEERING DESIGN	1	LS	$ 28,163	$ 28,163	10% of total
7	PERMITTING	1	LS	$ 28,163	$ 28,163	10% of total
8	CONSTRUCTION SUPPORT	1	LS	$ 28,163	$ 28,163	10% of total
9	MANAGEMENT	1	LS	$ 28,163	$ 28,163	10% of total
10	CHANNEL RESTORATION[1]					
	CONCRETE REMOVAL & DISPOSAL	93	CY	$ 850	$ 78,880	
	BANK STABILIZATION	75	LF	$ 34	$ 2,550	
	CLEARING AND GRUBBING	2,800	SF	$ 20	$ 56,000	
	HYDROSEEDING	0.1	AC	$ 10,000	$ 1,000	
	SITE RESTORATION	1	LS	$ 20,000	$ 20,000	3% of total, min $20k
	SETTLEMENT MONITORING	1	LS	$ 35,000	$ 35,000	
11	PLUG 42" RCP	3	EA	$ 8,000	$ 24,000	
12	12" FLAP GATE	5	EA	$ 4,500	$ 22,500	Includes Installation
13	15" FLAP GATE	3	EA	$ 5,900	$ 17,700	Includes Installation
14	30" FLAP GATE	1	EA	$ 24,000	$ 24,000	Includes Installation
				30% Contingency:	**$ 153,734**	
				Total Project Cost Estimate:	**$ 666,179**	

Note: Contingency developed to account for incidental items based on contractor bids for similar projects

[1]Channel restoration costs based on Wood Rodgers engineer's cost estimate for similar project to the City of Oakland. See Figure 1.

DATE	PROJECT	IMPROVEMENT
8/5/2024	ABSL	Floodwalls + Flap Gates

#	Item Name	Unit Quantity	Unit of Measure	Unit Cost	Cost Estimate Total	Assumption
1	MOBILIZATION	1	LS	$ 1,650,040	$ 1,650,040	10% of total, min $30k
2	WATER POLLUTION CONTROL WORK	1	LS	$ 165,004	$ 165,004	1% of total, min $30k
3	TRAFFIC CONTROL	1	LS	$ 330,008	$ 330,008	2% of total, min $20k
4	TRENCH AND EXCAVATION PROTECTION	1	LS	$ 165,004	$ 165,004	1% of total, min $10k
5	DEWATERING	1	LS	$ 330,008	$ 330,008	2% of total, min $20k
6	ENGINEERING DESIGN	1	LS	$ 1,650,040	$ 1,650,040	10% of total
7	PERMITTING	1	LS	$ 1,650,040	$ 1,650,040	10% of total
8	CONSTRUCTION SUPPORT	1	LS	$ 1,650,040	$ 1,650,040	10% of total
9	MANAGEMENT	1	LS	$ 1,650,040	$ 1,650,040	10% of total
10	4' Floodwall	3,311	LF	$ 1,000	$ 3,311,000	Includes 3 ft Freeboard
11	5' Floodwall	4,150	LF	$ 1,250	$ 5,187,500	Includes 3 ft Freeboard
12	6' Floodwall	1,546	LF	$ 1,500	$ 2,319,000	Includes 3 ft Freeboard
13	12" FLAP GATE	5	EA	$ 4,500	$ 22,500	Includes Installation
14	15" FLAP GATE	3	EA	$ 5,900	$ 17,700	Includes Installation
15	30" FLAP GATE	1	EA	$ 24,000	$ 24,000	Includes Installation
16	ROW ACQUISITION[1]	69	EA	$ 61,850	$ 4,267,650	
17	ACCESS ROAD	135,105	SF	$ 10	$ 1,351,050	Assume 15' Road w/ 12" Aggregate Base
	30% Contingency:				**$ 7,722,187**	
	Total Project Cost Estimate:				**$ 33,462,811**	

Note: Contingency developed to account for incidental items based on contractor bids for similar projects

[1]Per SVLUP2.0 Real Estate Project Budget Estimate, March 15, 2022.

DATE	PROJECT	IMPROVEMENT
8/5/2024	ABSL	North Deer Island Basin Levee Lowering + Flap Gates

#	Item Name	Unit Quantity	Unit of Measure	Unit Cost	Cost Estimate Total	Assumption
1	MOBILIZATION	1	LS	$ 535,192	$ 535,192	10% of total, min $30k
2	WATER POLLUTION CONTROL WORK	1	LS	$ 53,519	$ 53,519	1% of total, min $30k
3	TRAFFIC CONTROL	1	LS	$ 107,038	$ 107,038	2% of total, min $20k
4	TRENCH AND EXCAVATION PROTECTION	1	LS	$ 53,519	$ 53,519	1% of total, min $10k
5	DEWATERING	1	LS	$ 107,038	$ 107,038	2% of total, min $20k
6	ENGINEERING DESIGN	1	LS	$ 535,192	$ 535,192	10% of total
7	PERMITTING	1	LS	$ 535,192	$ 535,192	10% of total
8	CONSTRUCTION SUPPORT	1	LS	$ 535,192	$ 535,192	10% of total
9	MANAGEMENT	1	LS	$ 535,192	$ 535,192	10% of total
10	12" FLAP GATE	5	EA	$ 4,500	$ 22,500	Includes Installation
11	15" FLAP GATE	3	EA	$ 5,900	$ 17,700	Includes Installation
12	30" FLAP GATE	1	EA	$ 24,000	$ 24,000	Includes Installation
13	LEVEE LOWERING[1]	1,300	LF	$ 4,067	$ 5,287,721	See Figure 2
	30% Contingency:				**$ 2,504,699**	
	Total Project Cost Estimate:				**$ 10,853,695**	

Note: Contingency developed to account for incidental items based on contractor bids for similar projects

[1]Unit price obtained from bid to lower levee in Zone 2 on Line A of Alameda County. See Figure 2.

DATE	PROJECT	IMPROVEMENT
8/5/2024	ABSL	Novato & Warner Creek Channel Dredge + Flap Gates

#	Item Name	Unit Quantity	Unit of Measure	Unit Cost	Cost Estimate Total	Assumption
1	MOBILIZATION	1	LS	$ 47,196	$ 47,196	10% of total, min $30k
2	WATER POLLUTION CONTROL WORK	1	LS	$ 30,000	$ 30,000	1% of total, min $30k
3	TRAFFIC CONTROL	1	LS	$ 20,000	$ 20,000	2% of total, min $20k
4	TRENCH AND EXCAVATION PROTECTION	1	LS	$ 10,000	$ 10,000	1% of total, min $10k
5	DEWATERING	1	LS	$ 47,196	$ 47,196	10% of total, min $20k
6	ENGINEERING DESIGN	1	LS	$ 47,196	$ 47,196	10% of total
7	PERMITTING	1	LS	$ 47,196	$ 47,196	10% of total
8	CONSTRUCTION SUPPORT	1	LS	$ 47,196	$ 47,196	10% of total
9	MANAGEMENT	1	LS	$ 47,196	$ 47,196	10% of total
10	CHANNEL DREDGING[1]	3,662	LF	$ 111	$ 407,760	See Figure 3
	Clearing and Grubbing					
	Sediment Removal & Trasport for Reuse					
	Ecotone Levee					
	Heron's Beak Pond					
	Erosion Control					
	Final Survey					
11	12" FLAP GATE	5	EA	$ 4,500	$ 22,500	Includes Installation
12	15" FLAP GATE	3	EA	$ 5,900	$ 17,700	Includes Installation
13	30" FLAP GATE	1	EA	$ 24,000	$ 24,000	Includes Installation
	30% Contingency:				**$ 244,541**	
	Total Project Cost Estimate:				**$ 815,137**	

Note: Contingency developed to account for incidental items based on contractor bids for similar projects

[1]Unit price obtained from Novato Creek Maintenance Sediment Removal & Wetlad Enhncement Project-Summary of Proposlas, Project #2020-002, Plan #Z1-55. See Figure 3.

DATE	PROJECT	IMPROVEMENT
8/5/2024	ABSL	Floodwalls + Flap Gates + North Deer Island Basin Levee Lowering

#	Item Name	Unit Quantity	Unit of Measure	Unit Cost	Cost Estimate Total	Assumption
1	MOBILIZATION	1	LS	$ 2,178,812	$ 2,178,812	10% of total, min $30k
2	WATER POLLUTION CONTROL WORK	1	LS	$ 217,881	$ 217,881	1% of total, min $30k
3	TRAFFIC CONTROL	1	LS	$ 435,762	$ 435,762	2% of total, min $20k
4	TRENCH AND EXCAVATION PROTECTION	1	LS	$ 217,881	$ 217,881	1% of total, min $10k
5	DEWATERING	1	LS	$ 435,762	$ 435,762	2% of total, min $20k
6	ENGINEERING DESIGN	1	LS	$ 2,178,812	$ 2,178,812	10% of total
7	PERMITTING	1	LS	$ 2,178,812	$ 2,178,812	10% of total
8	CONSTRUCTION SUPPORT	1	LS	$ 2,178,812	$ 2,178,812	10% of total
9	MANAGEMENT	1	LS	$ 2,178,812	$ 2,178,812	10% of total
10	LEVEE LOWERING[1]	1,300	LF	$ 4,067	$ 5,287,721	See Figure 2
11	4' FLOODWALL	3,311	LF	$ 1,000	$ 3,311,000	Includes 3 ft Freeboard
12	5' FLOODWALL	4,150	LF	$ 1,250	$ 5,187,500	Includes 3 ft Freeboard
13	6' FLOODWALL	1,546	LF	$ 1,500	$ 2,319,000	Includes 3 ft Freeboard
14	ROW ACQUISITION[2]	69	EA	$ 61,850	$ 4,267,650	
15	ACCESS ROAD	135,105	SF	$ 10	$ 1,351,050	Assume 15' Road w/ 12" Aggregate Base
16	12" FLAP GATE	5	EA	$ 4,500	$ 22,500	Includes Installation
17	15" FLAP GATE	3	EA	$ 5,900	$ 17,700	Includes Installation
18	30" FLAP GATE	1	EA	$ 24,000	$ 24,000	Includes Installation
	30% Contingency:				**$ 10,196,840**	
	Total Project Cost Estimate:				**$ 44,186,308**	

Note: Contingency developed to account for incidental items based on contractor bids for similar projects

[1]Unit price obtained from bid to lower levee in Zone 2 on Line A of Alameda County. See Figure 2

[2]Per SVLUP2.0 Real Estate Project Budget Estimate, March 15, 2022.

DATE	PROJECT	IMPROVEMENT
8/5/2024	ABSL	Novato Creek Channel Dredge + Flap Gates + Levee Lowering

#	Item Name	Unit Quantity	Unit of Measure	Unit Cost	Cost Estimate Total	Assumption
1	MOBILIZATION	1	LS	$ 575,968	$ 575,968	10% of total, min $30k
2	WATER POLLUTION CONTROL WORK	1	LS	$ 57,597	$ 57,597	1% of total, min $30k
3	TRAFFIC CONTROL	1	LS	$ 115,194	$ 115,194	2% of total, min $20k
4	TRENCH AND EXCAVATION PROTECTION	1	LS	$ 57,597	$ 57,597	1% of total, min $10k
5	DEWATERING	1	LS	$ 575,968	$ 575,968	10% of total, min $20k
6	ENGINEERING DESIGN	1	LS	$ 575,968	$ 575,968	10% of total
7	PERMITTING	1	LS	$ 575,968	$ 575,968	10% of total
8	CONSTRUCTION SUPPORT	1	LS	$ 575,968	$ 575,968	10% of total
9	MANAGEMENT	1	LS	$ 575,968	$ 575,968	10% of total
32	LEVEE LOWERING[1]	1,300	LF	$ 4,067	$ 5,287,721	See Figure 2
33	CHANNEL DREDGING[2]	3,662	LF	$ 111	$ 407,760	See Figuer 3
	Clearing and Grubbing					
	Sediment Removal & Trasport for Reuse					
	Ecotone Levee					
	Heron's Beak Pond					
	Erosion Control					
	Final Survey					
34	12" FLAP GATE	5	EA	$ 4,500	$ 22,500	Includes Installation
35	15" FLAP GATE	3	EA	$ 5,900	$ 17,700	Includes Installation
36	30" FLAP GATE	1	EA	$ 24,000	$ 24,000	Includes Installation
				30% Contingency:	**$ 2,833,763**	
				Total Project Cost Estimate:	**$ 12,279,640**	

Note: Contingency developed to account for incidental items based on contractor bids for similar projects

[1]Unit price obtained from bid to lower levee in Zone 2 on Line A of Alameda County. See Figure 2

[2]Unit price obtained from Novato Creek Maintenance Sediment Removal & Wetlad Enhncement Project-Summary of Proposlas, Project #2020-002, Plan #Z1-55. See Figure 3

DATE	PROJECT	IMPROVEMENT
8/13/2024	ABSL	Lynwood Basin: 20% Flood Control, 80% Tidal Wetlands

#	Item Name	Unit Quantity	Unit of Measure	Unit Cost	Cost Estimate Total	Assumption
1	MOBILIZATION	1	LS	$ 189,889	$ 189,889	10% of total, min $30k
2	WATER POLLUTION CONTROL WORK	1	LS	$ 30,000	$ 30,000	1% of total, min $30k
3	TRAFFIC CONTROL	1	LS	$ 37,978	$ 37,978	2% of total, min $20k
4	TRENCH AND EXCAVATION PROTECTION	1	LS	$ 18,989	$ 18,989	1% of total, min $10k
5	DEWATERING	1	LS	$ 37,978	$ 37,978	2% of total, min $20k
6	ENGINEERING DESIGN	1	LS	$ 189,889	$ 189,889	10% of total
7	PERMITTING	1	LS	$ 189,889	$ 189,889	10% of total
8	CONSTRUCTION SUPPORT	1	LS	$ 189,889	$ 189,889	10% of total
9	MANAGEMENT	1	LS	$ 189,889	$ 189,889	10% of total
10	LEVEE CONSTRUCTION[1]	1,500	LF	$ 1,126	$ 1,688,889	
11	ACCESS ROAD	21,000	SF	$ 10	$ 210,000	Assume 14' Road w/ 12" Aggregate Base
	30% Contingency:				**$ 891,983**	
	Total Project Cost Estimate:				**$ 3,865,261**	

Note: Contingency developed to account for incidental items based on contractor bids for similar projects

[1]Unit price obtained from bid to construct embankment Lower Pen Creek Milpitas 2020.

DATE	PROJECT	IMPROVEMENT
8/13/2024	ABSL	Lynwood Basin: 60% Flood Control, 40% Tidal Wetlands

#	Item Name	Unit Quantity	Unit of Measure	Unit Cost	Cost Estimate Total	Assumption
1	MOBILIZATION	1	LS	$ 379,778	$ 379,778	10% of total, min $30k
2	WATER POLLUTION CONTROL WORK	1	LS	$ 37,978	$ 37,978	1% of total, min $30k
3	TRAFFIC CONTROL	1	LS	$ 75,956	$ 75,956	2% of total, min $20k
4	TRENCH AND EXCAVATION PROTECTION	1	LS	$ 37,978	$ 37,978	1% of total, min $10k
5	DEWATERING	1	LS	$ 75,956	$ 75,956	2% of total, min $20k
6	ENGINEERING DESIGN	1	LS	$ 379,778	$ 379,778	10% of total
7	PERMITTING	1	LS	$ 379,778	$ 379,778	10% of total
8	CONSTRUCTION SUPPORT	1	LS	$ 379,778	$ 379,778	10% of total
9	MANAGEMENT	1	LS	$ 379,778	$ 379,778	10% of total
10	LEVEE CONSTRUCTION[1]	3,000	LF	$ 1,126	$ 3,377,778	
11	ACCESS ROAD	42,000	SF	$ 10	$ 420,000	Assume 14' Road w/ 12" Aggregate Base
	30% Contingency:				**$ 1,777,360**	
	Total Project Cost Estimate:				**$ 7,701,893**	

Note: Contingency developed to account for incidental items based on contractor bids for similar projects

[1]Unit price obtained from bid to construct embankment Lower Pen Creek Milpitas 2020.

Figure 1

DATE	PROJECT	DRAINAGE AREA	IMPROVEMENT PROJECT
5/1/2022	City of Oakland Drainage Master Plan	Empire Road	Alt 1- Trapezoidal Channel

#	Item Name	Unit Quantity	Unit of Measure	Unit Cost	Cost Estimate Total	Assumption
1	MOBILIZATION	1	LS	$ 60,000	$ 60,000	10% of total
2	WATER POLLUTION CONTROL WORK	1	LS	$ 6,000	$ 6,000	1% of total
3	TRAFFIC CONTROL	1	LS	$ 12,000	$ 12,000	2% of total
4	DEWATERING	1	LS	$ 178,000	$ 178,000	10% of total
5	REMOVE AND DISPOSE OF CHAIN LINK FENCE	1,400	LF	$ 40	$ 56,000	
6	SOIL EXCAVATION	750	CY	$ 120	$ 90,000	
7	HYDROSEEDING	1	AC	$ 10,000	$ 7,231	
8	INSTALL NEW CHAIN LINK FENCE	1,400	LF	$ 65	$ 91,000	
9	SITE RESTORATION	1	LS	$ 17,000	$ 17,000	3% of total
10	SETTLEMENT MONITORING	1	LS	$ 35,000	$ 35,000	
				30% Contingency:	**$ 165,669**	
				Total Project Cost Estimate:	**$ 717,901**	

Note: Contingency developed to account for incidental items based on contractor bids for similar projects

Figure 2

1	Water Pollution Control Work			100%	Lump Sum	$ -	$ -
2	Job Site Management			100%	Lump Sum	$ -	$ -
3	Trench and Excavation Shoring			100%	Lump Sum	$ -	$ -
4	Temporary Steel Sheetpile Cofferdam			100%	Lump Sum	$ 317,417.41	$ 317,417.41
5	De-watering			100%	Lump Sum	$ -	$ -
6	Reinforced Concrete Maintenance Road	147.0	110%	162	Cubic Yard	$ 1,566.65	$ 253,797.70
7	Earthwork	2,950	110%	3,245	Cubic Yard	$ 105.58	$ 342,603.05
8	Class 2 Aggregate Base	161.36	110%	180	Ton	$ 102.17	$ 18,391.14
9	Bedding Material (3/4" Crushed Rock)	100.0	110%	110	Cubic Yard	$ 187.32	$ 20,604.89
10	Controlled Low Strength Material	25.0	110%	28	Cubic Yard	$ 466.59	$ 13,064.52
11	Articulated Concrete Block Mat	9,500		10,450	Square Foot	$ 29.29	$ 306,076.21
12	Subgrade Enhancement Fabric	445.00	110%	490	Square Yard	$ 12.26	$ 6,007.77
13	Guardrail	44		48	Linear Foot	$ 333.77	$ 16,020.72
14	Hydroseeding			100%	Lump Sum	$ 11,579.61	$ 11,579.61
15	Cleaning Site			100%	Lump Sum	$ 20,434.60	$ 20,434.60

Notes Exclude items 1, 2, 3, and 5 because already acconted for in cost estimate

Sum of Quantities **$ 1,325,997.62**

Length of Zone 2 Levee (FT) 326

Cost Levee Lowering/FT $ 4,067.48

Figure 3

MARIN COUNTY FLOOD CONTROL - SUMMARY OF PROPOSALS OPENED

For Construction of: Novato Creek Maintenance Sediment Removal & Wetland Enhancement Project
Project Number 2020-002, Plan Number Z1-55

Date: 6/12/20 Time: 2:00 P.M. Room No.: 40

ITEM No.	DESCRIPTION	Estimated Quantity	Unit Measure	Team Ghilotti Petaluma, CA xx Unit Bid	Team Ghilotti Amount	Dixon Marine Inverness, CA xx Unit Bid	Dixon Marine Amount
1.	Signs & Traffic Control	1	LS	$44,002.00	$44,002.00	$6,058.62	$6,058.62
2.	Dewatering & Pollution Prevention (Includes Novato Creek, Warner Creek, and Heron's Beak Pond)*	1	LS	$114,416.00	$114,416.00	$162,051.14	$162,051.14
3.	Clearing and Grubbing	1	LS	$64,180.00	$64,180.00	$62,649.06	$62,649.06
4.	Earthwork						
4.A	*Sediment Removal & Trasnport for Reuse***	*14,905*	*CY*	*$22.44*	*$334,468.20*	*$30.26*	*$451,025.30*
4.B	*Ecotone Levee*	*1*	*LS*	*$27,430.00*	*$27,430.00*	*$35,798.11*	*$35,798.11*
4.C	*Heron's Beak Pond*	*1*	*LS*	*$35,200.00*	*$35,200.00*	*$53,988.22*	*$53,988.22*
5.	Erosion Control	1	LS	$22,850.00	$22,850.00	$14,563.08	$14,563.08
6.	Final Survey	1	LS	$8,755.00	$8,755.00	$19,918.00	$19,918.00
			Total Base Bid		**$651,301.20**		**$806,051.53**

Remove items 1 and 2 because already accounted for in the cost estimate

Bid 1:	$	492,883.20
Bid 2:	$	637,941.77

Total length of dredged channel 6071 ft

Cost per foot:

Bid 1:	$ 81.19	per ft
Bid 2:	$ 105.08	per ft
AVG	$ 93.13	per ft
AVG in 2024 Dollars	**$ 111.34**	https://www.bls.gov/data/inflation_calculator.htm