

Memo, DRAFT

Date: Tuesday, January 09, 2018

Project: Bay Area Clean Water Agencies, Nutrient Optimization and Upgrade Project

To: Holly Kennedy, Project Manager

From: Libby Mesbah, PE

Subject: Sea Level Rise Assessment

Purpose and Scope

HDR has evaluated each of the participating municipal discharge outfall locations to determine the flood impacts associated with sea level rise (SLR) over the next 100 years. The purpose of this memorandum is to summarize the assessment performed. This analysis utilized publically available data from the United States Army Corps of Engineers (USACE), the Federal Emergency Management Agency (FEMA), and publically available topography data to make an assessment of the current and future impacts associated with sea level rise.

The SLR flood risk assessment included the following steps:

1. Identify a point ground elevation representative of each municipal discharge location to compare against water surface elevations.
2. Evaluate FEMA's Flood Insurance Rate Maps (FIRMs) to determine if the municipal discharge site is already within the 1-percent annual chance (100-year) floodplain.
3. Utilize the USACE's Sea Level Change Curve Calculator (2017.55), <http://www.corpsclimate.us/ccaceslcurves.cfm>, to determine the projected SLR depths over the next 30, 50, and 100 years.
4. Generate tabular and graphical map to display the results.

The following sections provide additional detail for each of the assessment steps.

Topographic Data

The United States Geological Survey (USGS) National Elevation Dataset (NED), dated 2013, was utilized to determine a point ground elevation to represent each municipal discharge location. Elevations are provided in the North American Vertical Datum of 1988 (NAVD88) with 1/3 arc-second (approximately 10 meters) resolution. This elevation data was utilized to compare water surface elevations and SLR depths against to determine the time period in which the municipal discharge location may or may not experience flooding.

FEMA's Flood Insurance Rate Maps

FEMA's FIRMs were utilized to determine if each municipal discharge location is mapped with the 1-percent annual chance (100-year) floodplain. The term "100-year flood" is used to simplify the definition of a flood that statistically has a 1-percent chance of occurring in any given year.

The SLR depth is added on top of the 100-year water surface elevation. The 100-year floodplain is typically designated on the FEMA FIRM as a Zone VE or AE. If the location is identified as already being mapped within the floodplain, sea level rise will only worsen the flooding at the particular location in the future.

USACE's Sea Level Change Curve Calculator

Projected sea level rise (SLR) estimates over the next 100 years were identified using the U.S. Army Corps of Engineers (USACE) Sea Level Change Curve Calculator (2017.55), <http://www.corpsclimate.us/ccaceslcurves.cfm>. The USACE's calculator tool was selected for this analysis since the USACE is a highly recognized agency currently designing flood control structures throughout the San Francisco Bay.

The USACE Sea Level Change Curve Calculator computes three curves: USACE Low Curve¹, USACE Intermediate Curve², and the USACE High Curve³. For this flood risk assessment, the USACE High Curve was used to determine projected SLR values since it is the recommended curve for planning and design efforts of critical infrastructure with extended design life.

Figure 1 below provides an example of the projected sea level change curves generated at an existing gauge utilized for this analysis. This particular gauge is located in Suisun Bay.

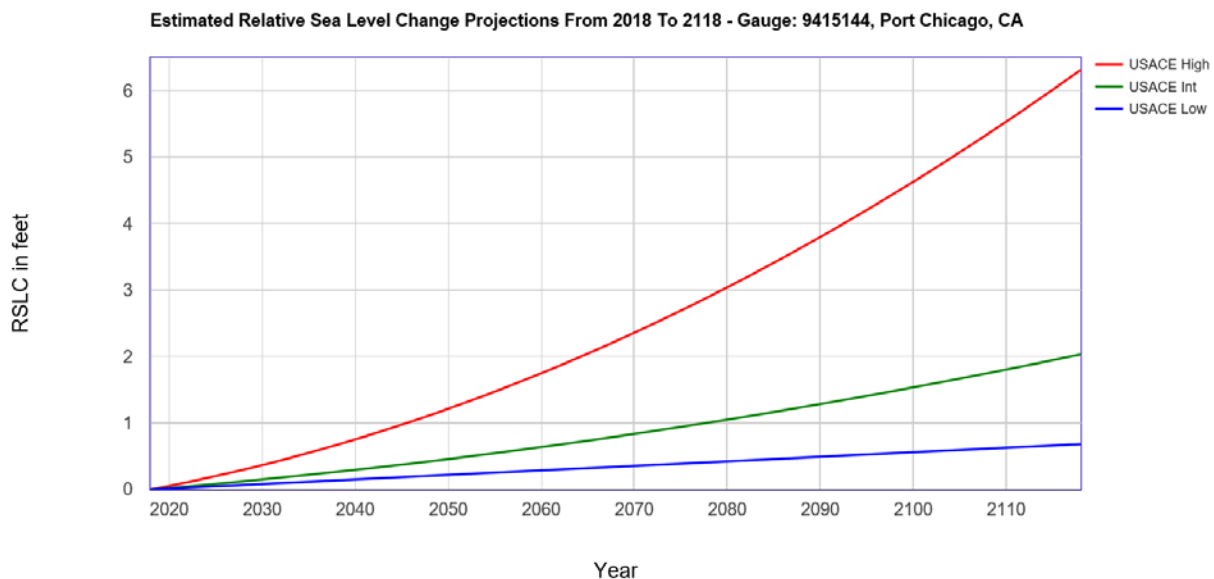


Figure 1 - USACE's Estimated Relative Sea Level Change Projections from 2018 to 2118 - Gauge: 9415144, Port Chicago, CA

¹ The rate for the USACE Low Curve is the historical rate of sea level change.

² The rate for the USACE Intermediate Curve is computed from the modified National Research Council (NRC) Curve I considering both the most recent Intergovernmental Panel on Climate Change (IPCC) projections and modified NRC projections with the local rate of vertical land movement added.

³ The rate for the USACE High Curve is computed from the modified NRC Curve III considering both the most recent IPCC projections and modified NRC projections with the local rate of vertical land movement added.

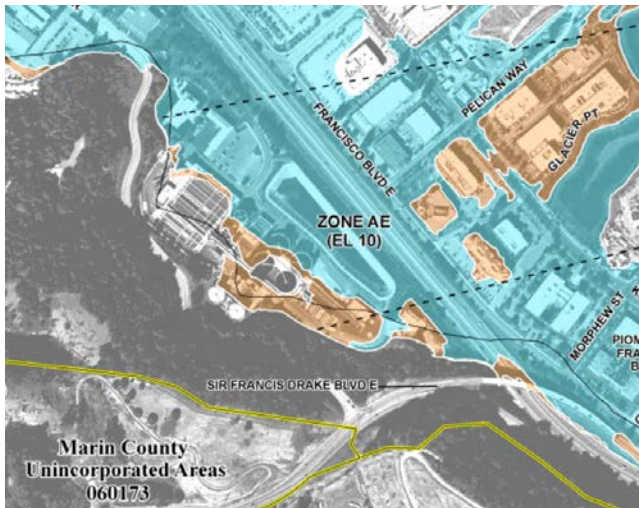
Evaluation and Results

The impact of sea level rise at each site was then evaluated.

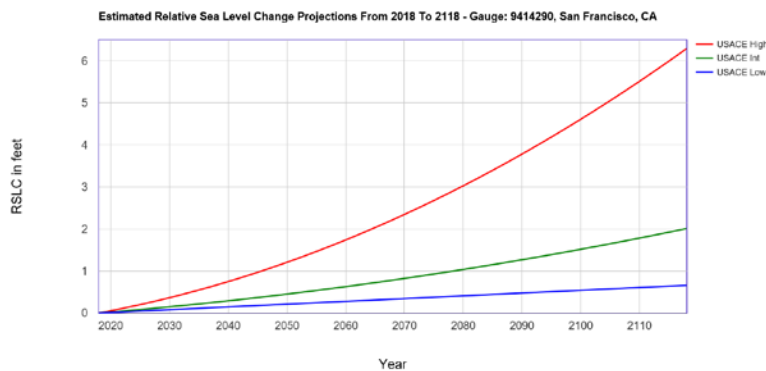
An example of the analysis performed at each location is provided below for the Central Marin Sanitation Agency (CMSA):

Step 1: A point elevation of 7.6 ft NAVD88 was selected to represent CMSA site.

Step 2: The FEMA FIRM 06041C0478E was evaluated to determine if portions or all the site are currently in the 1-percent annual chance floodplain. The map below shows that the majority of the site is within the floodplain with a Zone AE base flood elevation of 10 ft NAVD88. Thus, portions of the site are $10 \text{ ft} - 7.6 \text{ ft} = 2.4 \text{ ft}$ under water during a 1-percent annual chance storm event even before SLR occurs.



Step 3: The USACE Sea Level Change Curve Calculator (2017.55), is then used to generate the high curve. The San Francisco gauge is the closest gauge to CMSA. SLR predictions were extracted from the curve and are listed below.



Year 2047 (30 years) = +1.1 ft

Year 2067 (50 years) = +2.2 ft

Year 2117 (100 years) = +6.2 ft

These SLR predictions are then added to the 1-percent annual chance floodplain elevation to determine the future water surface elevation including SLR for planning and design efforts. For CMSA, the results for the 30-, 50, and 100-year planning horizon are:

Predicted Water Surface Elevation in Year 2047 (30 years) = +1.1 ft + 10 ft = 11.1 ft

Predicted Water Surface Elevation in Year 2067 (50 years) = +2.2 ft + 10 ft = 12.2 ft

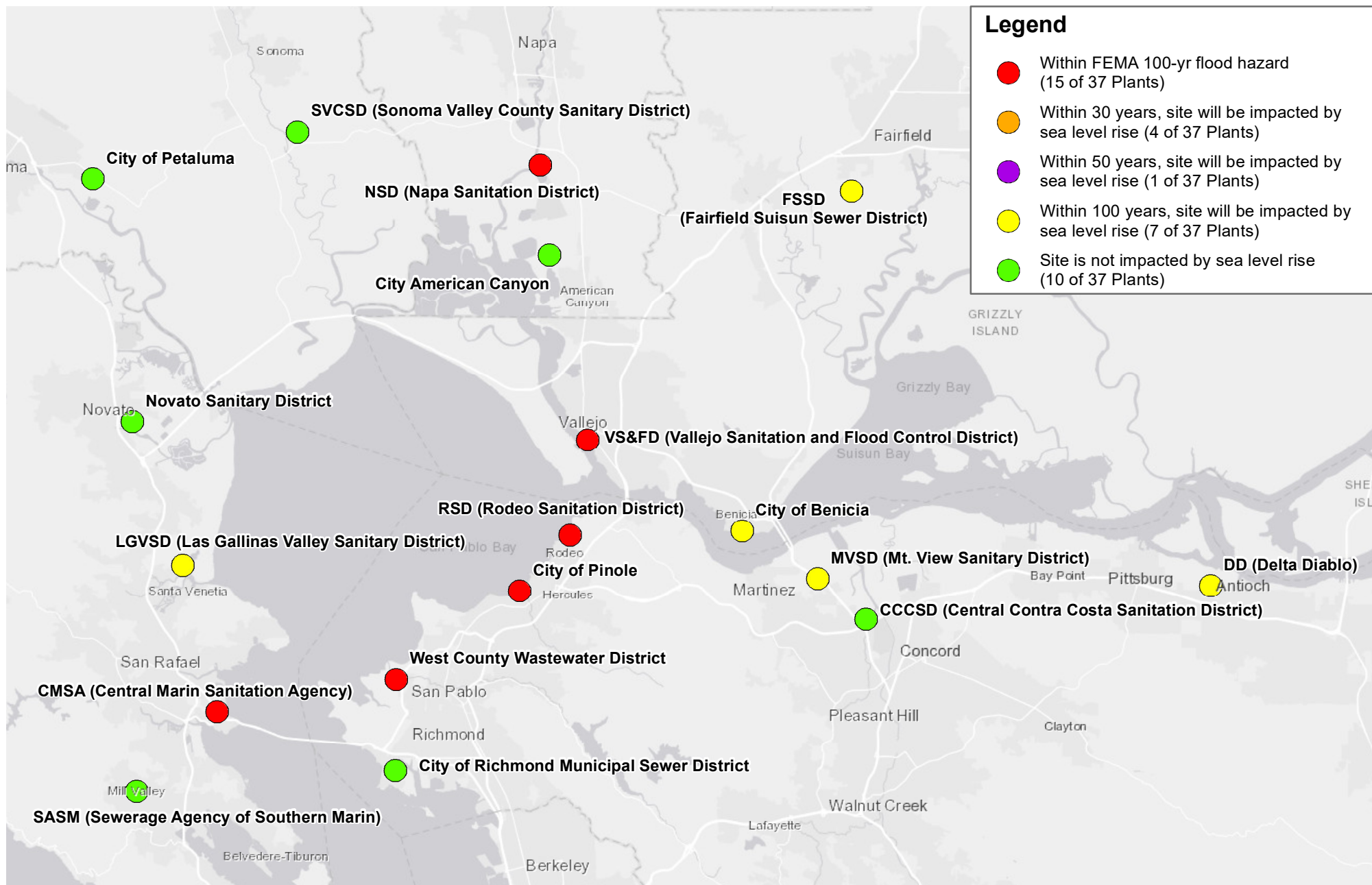
Predicted Water Surface Elevation in Year 2117 (100 years) = +6.2 ft + 10 ft = 16.2 ft

Attachment A presents a table of results for all locations included in the study. Attachment B presents figures illustrating the status of flooding for each of the facilities.

Name	Address	GageName	Year 2047 (30yr) USACE High Curve ² (ft)	Year 2067 (50yr) USACE High Curve ² (ft)	Year 2117 (100yr) USACE High Curve ² (ft)	Facility Type	FEMA_Zone	Current FEMA WSE ¹ (ft)	FEMA WSE + 30yr SLR (ft)	FEMA WSE + 50yr SLR (ft)	FEMA WSE + 100yr SLR (ft)	Average Ground Elev (ft)	SLR Impact
SFPUC SEP (San Francisco Public Utilities Commission Southeast Plant)	750 Phelps St, San Francisco, California, 94124	Alameda Creek	0.97	2.0	5.8	Plant	VE	10.0	11.0	12.0	15.8	15.9	Site is not impacted by sea level rise 10 of 37 Plants
EBMUD (East Bay Municipal Utilities District)	2020 Wake Ave, Oakland, California, 94607	Alameda Creek	0.97	2.0	5.8	Plant	VE	9.0	10.0	11.0	14.8	13.0	Within 100 years, site will be impacted by sea level rise 7 of 37 Plants
SFO (San Francisco International Airport)	Clearwater Dr, San Francisco, California, 94128	Alameda Creek	0.97	2.0	5.8	Plant	VE	10.0	11.0	12.0	15.8	11.0	Within 30 years, site will be impacted by sea level rise 4 of 37 Plants
Cities of South San Francisco and San Bruno	195 Belle Air Rd, South San Francisco, California, 94080	Alameda Creek	0.97	2.0	5.8	Plant	AE	10.0	11.0	12.0	15.8	11.7	Within 50 years, site will be impacted by sea level rise 1 of 37 Plants
City of Millbrae	651 Magnolia Ave, Millbrae, California, 94030	Alameda Creek	0.97	2.0	5.8	Outfalls	VE	10.0	11.0	12.0	15.8	6.2	Within FEMA 100-yr flood hazard 15 of 37 Plants
City of Palo Alto	2501 Embarcadero Way, Palo Alto, California, 94303	Coyote Creek	1.1	2.2	6.2	Plant	AE	11.0	12.1	13.2	17.2	11.5	Within 30 years, site will be impacted by sea level rise 4 of 37 Plants
Cities of San Jose and Santa Clara	700 Los Esteros Rd, San Jose, California, 95134	Coyote Creek	1.1	2.2	6.2	Plant	AE	12.0	13.1	14.2	18.2	9.6	Within FEMA 100-yr flood hazard 15 of 37 Plants
City of Sunnyvale	1444 Borregas Ave, Sunnyvale, California, 94089	Coyote Creek	1.1	2.2	6.2	Plant	AE	11.0	12.1	13.2	17.2	9.9	Within FEMA 100-yr flood hazard 15 of 37 Plants
City of Livermore	101 W Jack London Blvd, Livermore, CA 94551	N/A	N/A	N/A	N/A	Plant	N/A	0.0	0.0	0.0	0.0	410.0	Site is not impacted by sea level rise 10 of 37 Plants
Dublin San Ramon Services District	7399 Johnson Dr, Pleasanton, CA 94588	N/A	N/A	N/A	N/A	Plant	N/A	0.0	0.0	0.0	0.0	327.0	Site is not impacted by sea level rise 10 of 37 Plants
City American Canyon	205 Wetlands Edge Rd, American Canyon, California, 94503	Port Chicago	1.1	2.2	6.2	Outfalls	AE	11.0	12.1	13.2	17.2	18.0	Site is not impacted by sea level rise 10 of 37 Plants
CCCSO (Central Contra Costa Sanitation District)	5019 Imhoff Dr, Martinez, California, 94553	Port Chicago	1.1	2.2	6.2	Plant	AE	10.0	11.1	12.2	16.2	25.6	Site is not impacted by sea level rise 10 of 37 Plants
FSSD (Fairfield Suisun Sewer District)	1010 Chadbourne Rd, Fairfield, California, 94534	Port Chicago	1.1	2.2	6.2	Plant	AE	10.0	11.1	12.2	16.2	15.1	Within 100 years, site will be impacted by sea level rise 7 of 37 Plants
City of Benicia	614 E 5th St, Benicia, California, 94510	Port Chicago	1.1	2.2	6.2	Plant	AE	10.0	11.1	12.2	16.2	12.5	Within 100 years, site will be impacted by sea level rise 7 of 37 Plants
MVSD (Mt. View Sanitary District)	Arthur Rd, Martinez, California, 94553	Port Chicago	1.1	2.2	6.2	Outfalls	AE	10.0	11.1	12.2	16.2	13.3	Within 100 years, site will be impacted by sea level rise 7 of 37 Plants
DD (Delta Diablo)	2500 Pittsburg Antioch Hwy, Antioch, California, 94509	Port Chicago	1.1	2.2	6.2	Plant	AE	11.0	12.1	13.2	17.2	16.7	Within 100 years, site will be impacted by sea level rise 7 of 37 Plants
NSD (Napa Sanitation District)	Soscol Ferry Rd, Napa, California, 94558	Port Chicago	1.1	2.2	6.2	Outfalls	AE	11.0	12.1	13.2	17.2	6.1	Within FEMA 100-yr flood hazard 15 of 37 Plants
VS&FD (Vallejo Sanitation and Flood Control District)	450 Ryder St, Vallejo, California, 94590	Port Chicago	1.1	2.2	6.2	Plant	AE	10.0	11.1	12.2	16.2	7.5	Within FEMA 100-yr flood hazard 15 of 37 Plants
RSD (Rodeo Sanitation District)	800 San Pablo Ave, Rodeo, California, 94572	Port Chicago	1.1	2.2	6.2	Plant	VE	13.0	14.1	15.2	19.2	9.4	Within FEMA 100-yr flood hazard 15 of 37 Plants
City of Hayward	3700 Enterprise Ave, Hayward, CA 94545	Redwood City	1.1	2.2	6.2	Plant	VE	10.0	11.1	12.2	16.2	14.8	Within 100 years, site will be impacted by sea level rise 7 of 37 Plants
City of Burlingame	1103 Airport Blvd, Burlingame, California, 94010	Redwood City	1.1	2.2	6.2	Plant	AE	10.0	11.1	12.2	16.2	11.2	Within 30 years, site will be impacted by sea level rise 4 of 37 Plants
City of San Leandro	3000 Davis St, San Leandro, CA 94577	Redwood City	1.1	2.2	6.2	Plant	VE	10.0	11.1	12.2	16.2	8.3	Within FEMA 100-yr flood hazard 15 of 37 Plants
Oro Loma/Castro Valley Sanitary District	2655 Grant Ave, San Lorenzo, CA 94580	Redwood City	1.1	2.2	6.2	Plant	VE	10.0	11.1	12.2	16.2	7.2	Within FEMA 100-yr flood hazard 15 of 37 Plants
Union Sanitary District	5072 Benson Rd, Union City, CA 94587	Redwood City	1.1	2.2	6.2	Plant	VE	10.0	11.1	12.2	16.2	9.0	Within FEMA 100-yr flood hazard 15 of 37 Plants
City of San Mateo	2050 Detroit Dr, San Mateo, California, 94404	Redwood City	1.1	2.2	6.2	Plant	VE	10.0	11.1	12.2	16.2	6.3	Within FEMA 100-yr flood hazard 15 of 37 Plants
SVCW (Silicon Valley Clean Water)	1400 Radio Rd, Redwood City, California, 94065	Redwood City	1.1	2.2	6.2	Plant	VE	10.0	11.1	12.2	16.2	6.6	Within FEMA 100-yr flood hazard 15 of 37 Plants
SVCSO (Sonoma Valley County Sanitary District)	22675 8th St E, Sonoma, California, 95476	San Francisco	1.1	2.2	6.2	Plant	AE	11.0	12.1	13.2	17.2	24.8	Site is not impacted by sea level rise 10 of 37 Plants
City of Petaluma	3890 Cypress Dr, Petaluma, California, 94954	San Francisco	1.1	2.2	6.2	Plant	AE	10.0	11.1	12.2	16.2	16.8	Site is not impacted by sea level rise 10 of 37 Plants
Novato Sanitary District	500 Davidson St, Novato, California, 94945	San Francisco	1.1	2.2	6.2	Plant	AE	10.0	11.1	12.2	16.2	18.5	Site is not impacted by sea level rise 10 of 37 Plants
City of Richmond Municipal Sewer District	601 Canal Blvd, Richmond, California, 94804	San Francisco	1.1	2.2	6.2	Plant	AE	10.0	11.1	12.2	16.2	26.3	Site is not impacted by sea level rise 10 of 37 Plants
SASM (Sewerage Agency of Southern Marin)	26 Corte Madera Ave, Mill Valley, California, 94941	San Francisco	1.1	2.2	6.2	Outfalls	AE	10.0	11.1	12.2	16.2	74.7	Site is not impacted by sea level rise 10 of 37 Plants
LGVSD (Las Gallinas Valley Sanitary District)	300 Smith Ranch Rd, San Rafael, California, 94903	San Francisco	1.1	2.2	6.2	Plant	AE	10.0	11.1	12.2	16.2	15.2	Within 100 years, site will be impacted by sea level rise 7 of 37 Plants
Treasure Island	1220 Avenue M, San Francisco, California, 94130	San Francisco	1.1	2.2	6.2	Plant	VE	9.0	10.1	11.2	15.2	9.8	Within 30 years, site will be impacted by sea level rise 4 of 37 Plants
City of Pinole	2131 Pear St, Pinole, California, 94564	San Francisco	1.1	2.2	6.2	Outfalls	AE	11.0	12.1	13.2	17.2	6.2	Within FEMA 100-yr flood hazard 15 of 37 Plants
West County Wastewater District	2377 Garden Tract Road, Richmond, CA 94801	San Francisco	1.1	2.2	6.2	Plant	AE	10.0	11.1	12.2	16.2	7.7	Within FEMA 100-yr flood hazard 15 of 37 Plants
CMSA (Central Marin Sanitation Agency)	1301 Andersen Dr, San Rafael, California, 94901	San Francisco	1.1	2.2	6.2	Plant	AE	10.0	11.1	12.2	16.2	7.6	Within FEMA 100-yr flood hazard 15 of 37 Plants
SMCSD (Sausalito-Marín City Sanitary District)	East Rd, Sausalito, California, 94965	San Francisco	1.1	2.2	6.2	Outfalls	VE	14.0	15.1	16.2	20.2	12.9	Within FEMA 100-yr flood hazard 15 of 37 Plants

¹ Data from FEMA's National Flood Hazard Layer Website

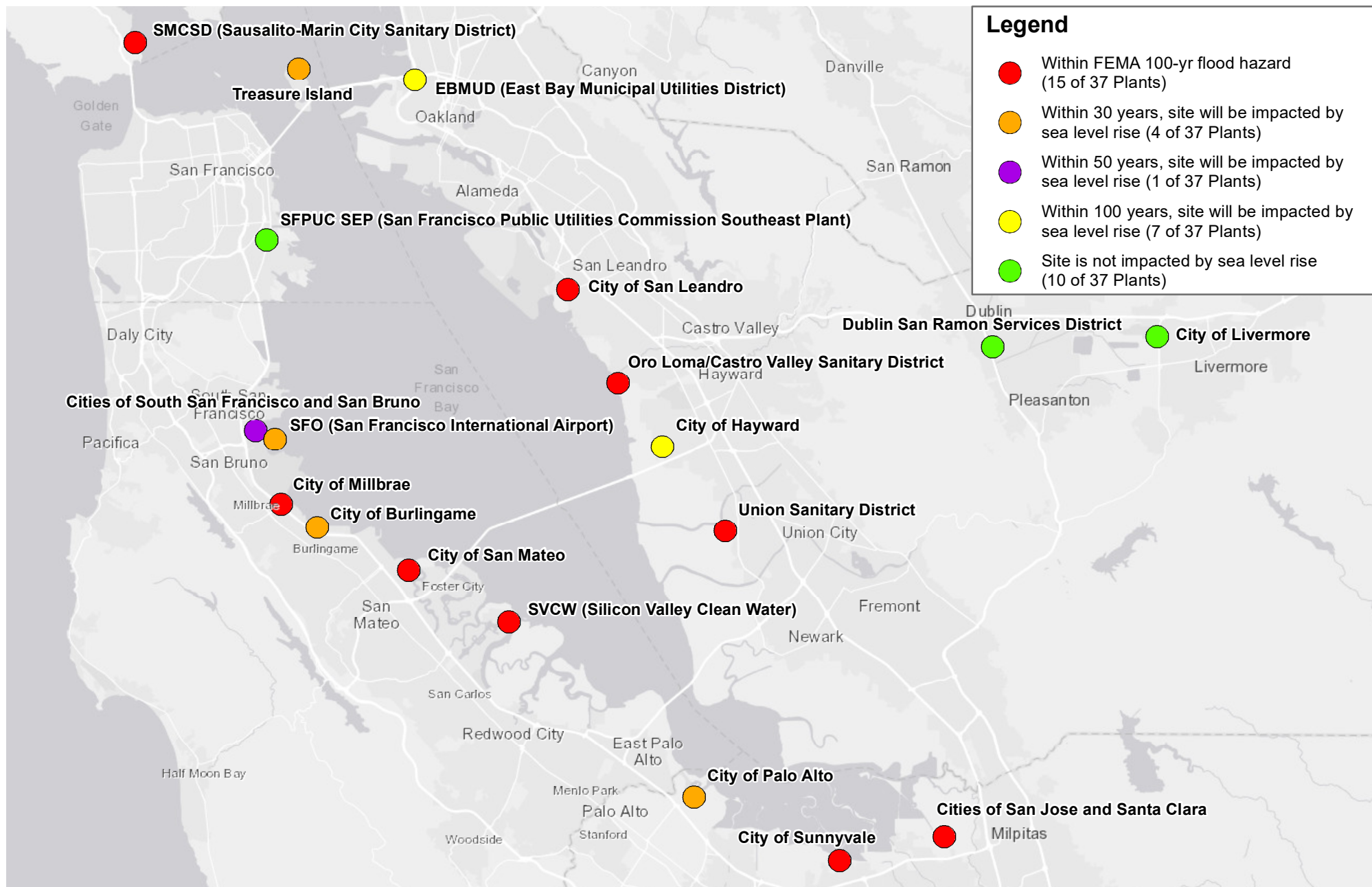
² Data from Sea-Level Change Curve Calculator (2017.55) with Project Start Date of 2017



0 2 4 8 Miles



BACWA-FLOOD HAZARD ASSESSMENT NORTH BAY
SAN FRANCISCO BAY NUTRIENTS WATERSHED PERMIT



0 2 4 8 Miles



BACWA-FLOOD HAZARD ASSESSMENT SOUTH BAY
SAN FRANCISCO BAY NUTRIENTS WATERSHED PERMIT