City of San Leandro, CA
DRAFT Storm Drain Master Plan Study
January 2024

PREPARED FOR:
City of San Leandro
14200 Chapman Road
San Leandro, CA 94578

PREPARED BY:
Schaaf & Wheeler
870 Market Street, Suite 1278
San Francisco, CA 94102

Schaaf & Wheeler
CONSULTING CIVIL ENGINEERS

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List of Abbreviations

Ac	Acres
BMP	Best Management Practices
CIP	Capital Improvement Program
CFS	Cubic Feet per Second
CMP	Corrugated Metal Pipe
CTP	Cooperating Technical Partnership
D/S	Downstream
EPA	Environmental Protection Agency
GIS	Geographic Information System
GPM	Gallons Per Minute
HDPE	High-Density Polyethylene
IDF	Intensity-Duration-Frequency
KW	Kinematic Wave
LiDAR	Light Detection and Ranging
MAP	Mean Annual Precipitation
MSL	Mean Sea Level
NAVD 88	North American Vertical Datum of 1988
NGVD	National Geodetic Vertical Datum of 1929
NPDES	National Pollutant Discharge Elimination System
NRCS	National Resource Conservation Service
OPC	California Ocean Protection Council
RWQCB	San Francisco Regional Water Quality Control Board
SDMP	Storm Drain Master Plan
UH	Unit Hydrograph
U/S	Upstream

1 Executive Summary

This is the first Storm Drain Master Plan (SDMP) for the City of San Leandro (City). This plan presents options for the City to update their storm drain infrastructure to better serve the community and meet capacity requirements to prevent or minimize flooding. This report seeks to aid the City in selecting and implementing storm drain system improvements, including developing funding strategies.

The City was originally the county seat of Alameda County and has been incorporated for more than 150 years. It is experiencing the effects of aging storm drainage infrastructure, including the need to maintain and replace expensive equipment and facilities. This is complicated by the intertwining of City and Alameda County Flood Control District (ACFCD) storm drain components; the City may only update portions of the system under their ownership. Due to this, there are areas within the City where upsizing only the City piping will not alleviate flooding as those City pipes flow directly into ones owned by ACFCD. ACFCD owns seven of the nine pump stations in the City, which further complicates the planning and implementation of Capital Improvement Programs (CIPs).

This SDMP identifies the capital projects needed to maintain acceptable levels of protection against local flooding and compares that to capital projects that are feasible based on ownership. The study incorporates the costs of mandated compliance measures, such as implementation and maintenance of trash capture devices. It also identifies the need for a revenue stream that will allow the improvements to be built and to keep the storm drain system maintained.

1.1 Study Objective

The basic objective of this study is to provide an examination of City-wide flood risks and recommend actions necessary to accomplish an appropriate level-of-service for the City's storm drainage systems.

Several steps were completed as part of this study:

- Examination of existing City storm drain system GIS for data gaps and evaluation of system ownership;
- Review of as-built drawings, supporting verification or revision of existing GIS data and addition of missing system elements;
- Collection of field data to supplement GIS data for building an existing conditions model of the storm drainage network;
- Delineation of drainage areas tributary to the City storm drain network;
- Assessment of the performance of existing storm drainage systems;
- Identification of capital improvement alternatives to reduce flood risk;
- Identification of projects to reduce maintenance;
- Review and incorporation of trash capture planning and projects;
- Establishment of a prioritized CIP for storm drainage;
- Development of unit costs based on the current construction environment and ENR indices; and
- Estimation of project costs for individual projects and the prioritized CIP.

The adoption of this document is exempt from the requirements to prepare Environmental Impact Reports (EIR) or Negative Declarations (ND). However, CEQA must be satisfied for any capital improvement project described in this report that may be implemented by the City in the future through the preparation of an appropriate EIR, ND, or determined to be categorically excluded.

1.2 Storm Drainage and Flooding in San Leandro

Once primarily agricultural with an economy dominated by fruit and vegetable growers, the City has evolved into an urban community. Storm runoff in the City is collected through a system of underground pipes and a network of street gutters. Local runoff flows into creeks and channels that run through the City and into the San Francisco Bay. Drainage in the City is generally from the east to the west. The City currently owns and operates two stormwater pumping stations. Urbanization tends to increase the rate of runoff generated from precipitation. Therefore, it is essential that stormwater systems are sized properly to convey runoff and prevent hazardous flooding in streets, homes, and businesses.

Flooding within San Leandro is caused by two basic interrelated factors: 1) major creeks and channels that overflow due to limited capacity with flood flow and 2) inadequate local drainage infrastructure. The operation and maintenance of major creeks and channels are, for the most part, outside of the City's control. Therefore, this document focuses on local storm drainage collection facilities owned and operated by the City of San Leandro.

1.3 Regional Stormwater Coordination

The Alameda County Flood Control District (ACFCD) is the City’s primary partner in managing local flood control issues. Coordination with ACFCD is integral to the SDMP’s success since many of the City’s storm drainage systems discharge into ACFCD-owned/managed facilities. ACFCD is keenly interested in any of the City’s storm drain projects that might impact one of their receiving creeks. In turn, the City has a vested interest in how ACFCD manages its legislated flood protection facilities, including County-owned and operated pump stations.

1.4 Evaluation

Criteria used to design storm drain systems and evaluate their performance must be defensible yet simple to understand and apply. Ideally, the same criteria used to analyze system performance will continue for future infrastructure design. Storm drain design criteria set forth by the Alameda County Hydrology and Hydraulic Manual (2018) prepared by the ACFCD are used in this SDMP.

Schaaf & Wheeler used data provided by the City and ACFCD along with data gathered in the field to construct a hydrologic and hydraulic Danish Hydraulic Institute (DHI) MIKE+ model. The model represents storm drain systems throughout the City. Aside from specific areas where the City identified specific flooding issues, only pipes 18 inches and larger were included in the analysis. This model uses a design storm and land-use-based runoff coefficients to generate runoff to each collection system.

The hydraulic capacity of each drainage system component is calculated. Flows that exceed the system capacity are represented by elevation above manholes; the model idealizes flooding in the vertical direction. These flooded regions are reviewed to confirm whether City systems offer appropriate capacities to carry storm flows. If the existing storm drainage system does not meet specific criteria, the model is then used to establish capital improvements. Multiple scenarios were created to model both the complete, necessary upsizing of storm drainpipes, and scenarios where only those pipes owned by the City are upsized.

The recommended improvements are preliminary in nature and based on currently available information. Detailed project designs will ultimately require more data, including utility locations, which remain to be obtained.

1.5 Climate Change

Climate change impacts on sea-levels and precipitation are addressed to a limited extent by this effort to ensure that proposed projects remain resilient in the context of adaptability.

This document does not consider coastal protection needs (e.g., erosion protection, armoring, flood walls, or levees). With a focus on interior drainage systems, the implications of sea level rise (SLR) are contemplated. However, a regional scale solution may be required for coastal protection as well to develop greater resilience against a broader array of climate hazards. This is beyond the scope of this analysis.

The analysis of climate change presented in this document provides a coastal vulnerability assessment in support of developing adaptable, resilient storm drain system improvement projects. This includes running increased precipitation to evaluate the impacts of greater expected runoff due to extreme precipitation events and identifying tidally influenced storm drainage systems that will require new pump systems necessary to continue meeting level of service standards against rising sea levels. Climate adaptation and resiliency should be further incorporated into each project as they are funded and designed.

The California Ocean Protection Council (OPC) produced and adopted a report in 2018 that cites potential SLR of up to 1.9 feet by 2050 and 6.9 feet by 2100 for a “high emissions” scenario.

1.6 Capital Improvement Recommendations

A prioritized CIP is established based on the analytical evaluation of the storm drainage system using the MIKE+ model. Table 1-1 summarizes CIP costs, Table 1-2 summarizes annual operations and maintenance costs, and Figure 1-1 displays potential CIP locations and priority labels. A requirement of the trash capture design is to ensure no adverse impacts to the hydraulic grade of the system; therefore, installation of trash capture devices is not expected to increase flooding in the system.

Recommended improvements are intended for public rights-of-way and other City-owned property or easements, not privately owned facilities.

Table 1-1: Approximate Cost Ranges by Project Type

Priority	Description	No. of Projects	Approximate Cost
Very High	Mitigate the most frequent, recurring flooding issues and the most severe system deficiencies with the greatest impact to properties. Includes installation of 177 small and 6 large trash capture devices to meet MRP requirements by June 2025.	4	$8,240,000
High	Mitigate areas of frequent, but less damaging flooding and areas where extensive deficiencies are identified by the model.	15	$24,010,000
Medium	Mitigate areas where moderate and/or isolated capacity deficiency is identified by the model or known to occur.	21	$24,590,000
Low	Mitigate isolated capacity deficiencies identified by the model that have the least potential impact on properties, or areas where the benefit of City projects is limited by the capacity of ACFCD facilities. Includes $10,000,000 cost for new pump station on Neptune Ave.	13	$22,750,000
		Total Cost	**$79,590,000**

Table 1-2: 2024-2025 Projected Operations and Maintenance Costs

Priority	Description	Approximate Annual Cost
Trash Capture	Planned trash capture device costs based on Full Trash Capture report from June 2023. Total includes maintenance for 902 small and 6 large devices.	$200,000
Operations & Maintenance	Annual stormwater budget.	$1,225,000
	Annual cost to clean-out dual county pipes with outfalls to Oyster Bay.	$100,000
	Total Cost	**$1,525,000**

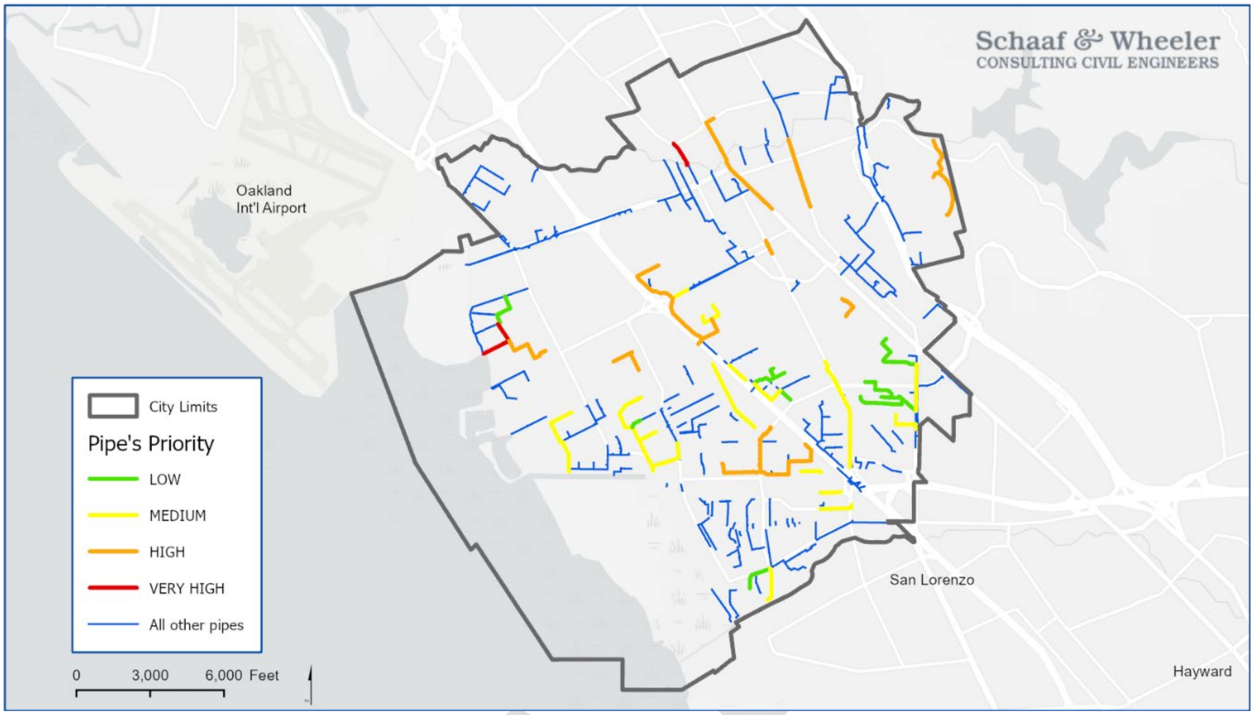

Figure 1-1: 2023 Master Plan CIP Priority Overview

1.7 Conclusion

This storm drain system analysis provides a tool for the City to use in their efforts to reduce both nuisance flooding and the likelihood of more serious storm water related hazards to private and/or public property in the community. This study and capital improvement alternatives are merely the conceptual starting point.

We anticipate that the City and/or their consultants will perform more detailed studies and alternatives analyses to identify the most affordable and effective capacity and condition improvement projects with information gathered as part of the design process, including more detailed topography, utility conflicts, available easements and rights-of-way, construction impacts, permitting needs, and long-term operation and maintenance. This report ventures to consider these factors in developing an alternatives analysis for various improvement strategies. However, more detailed information will always provide the best tool in making informed decisions.

2 Introduction

This SDMP is the first report of its kind for the City of San Leandro and provides an evaluation of the City's storm drain system capacity. It incorporates seven pump stations owned by the ACFCD. This 2023 report focuses on storm drainage infrastructure and acknowledges that the City's storm drain system is inexorably linked to pipes owned by ACFCD, over which the City exerts no responsibility.

This document is a guide for the City to implement a prioritized CIP. Key objectives of this SDMP update include:

- Updating the geographical information systems (GIS) to include pipelines 18 inches and greater in diameter throughout the entire City;
- Utilizing the MIKE+ modeling package to create an integrated hydrologic and hydraulic model that identifies capacity deficiencies during a design storm event;
- Preparing an updated CIP that remediates identified system deficiencies; and
- Updating projected capital improvement and costs.

This chapter provides a general discussion of drainage and flood management systems and issues currently affecting the community. It also describes the objectives of this analysis, explains the criteria used to evaluate storm drain system performance, and presents a summary of the data collected to support this effort. Each following chapter of this report is intended to help the City identify problems, manage resources, and provide cost-effective and comprehensive solutions.

2.1 Authorization

Schaaf & Wheeler Consulting Civil Engineers, Inc. prepared this SDMP for the City of San Leandro in accordance with the provisions of an agreement executed by the City in August 2023.

2.2 Study Area

The City of San Leandro is in Alameda County, in the East Bay of the San Francisco Bay Area. The bounding municipalities are the City of Oakland to the northwest, and Ashland, Castro Valley, and Hayward to the southeast, with the San Francisco Bay to the west. The City encompasses 15.52 square miles. There are several watersheds within the City:

- The Oyster Point Watershed drains a small, primarily industrial region to the east of Oakland Airport and into the San Francisco Bay;
- The San Leandro Marina Watershed drains urban neighborhoods and industrial areas near the marina through an engineered channel and two underground storm drains. It discharges to the San Francisco Bay; and
- The Estudillo Canal Watershed collects urban runoff from a wide area of urban San Leandro, ultimately discharging to the San Francisco Bay utilizing a network of canals and underground storm drains and a small creek along Fairmont.

The City and its vicinity are shown in Figure 2-1.

Figure 2-1: City of San Leandro Vicinity

2.2.1 Climate

The City has a mild Mediterranean climate with average winter low temperatures of 43°F and average summer high temperatures of 72°F. From May to September, there is minimal chance of precipitation within the area. However, winters can be cool and moist. Rainfall is the only significant cause of stormwater runoff (significant snowfall is extremely rare), averaging 21 inches per year within the City.

Most precipitation events in the City area fall under one of two categories. They are either orographic, when moist air is lifted over the hills and then cools and condenses, or cyclonic, when rain is caused by air mass movement from higher barometric pressure regions to lower pressure. Cyclonic events can also be caused by frontal activity. Warm fronts are generally associated with broad bands of low-intensity rainfall, while higher rainfall intensities are typical of cold fronts. Convective precipitation (e.g., thunderstorms) caused by air heating at the ground often leads to intense localized storms. However, this is not common in the City's vicinity.

2.2.2 Physiography

The San Leandro Hills run northeast of the City. The City generally slopes gradually from the east to the west, toward the San Francisco Bay. Elevations range from 680 feet North American Vertical Datum 1988 (NAVD 88) to -4 feet within the SDMP study area and has an overall minimum of -23 feet (in the Bay) within City limits. The soil is primarily deep, poorly drained, fine-grained soils.

2.2.3 Land Development and Drainage Characteristics

The City has developed as a mix of residential, commercial, and industrial development, with parks, schools, and greenbelts woven into the urban fabric. Future growth in the City will tend to be infill development, becoming denser as property values escalate.

Drainage in the City is generally from east to west, first via storm drain gravity pipes and pump stations, then in flood control channels and creeks. A system of underground pipes and culverts and a network of street gutters collect storm runoff in the City. Creeks and channels are generally owned by ACFCD and drain into the San Francisco Bay.

2.2.4 Flooding Sources

ACFCD manages a network of channels, levees, storm drains, pump stations, culverts, and dikes intended to reduce flood hazards throughout the county, including the City of San Leandro. However, certain low-lying areas of the City are still susceptible to tidal flooding. FEMA's effective Special Flood Hazard Areas (SFHA) identify 100-year flood risk for certain mapped water bodies, including the San Francisco Bay (Figure 22-2).

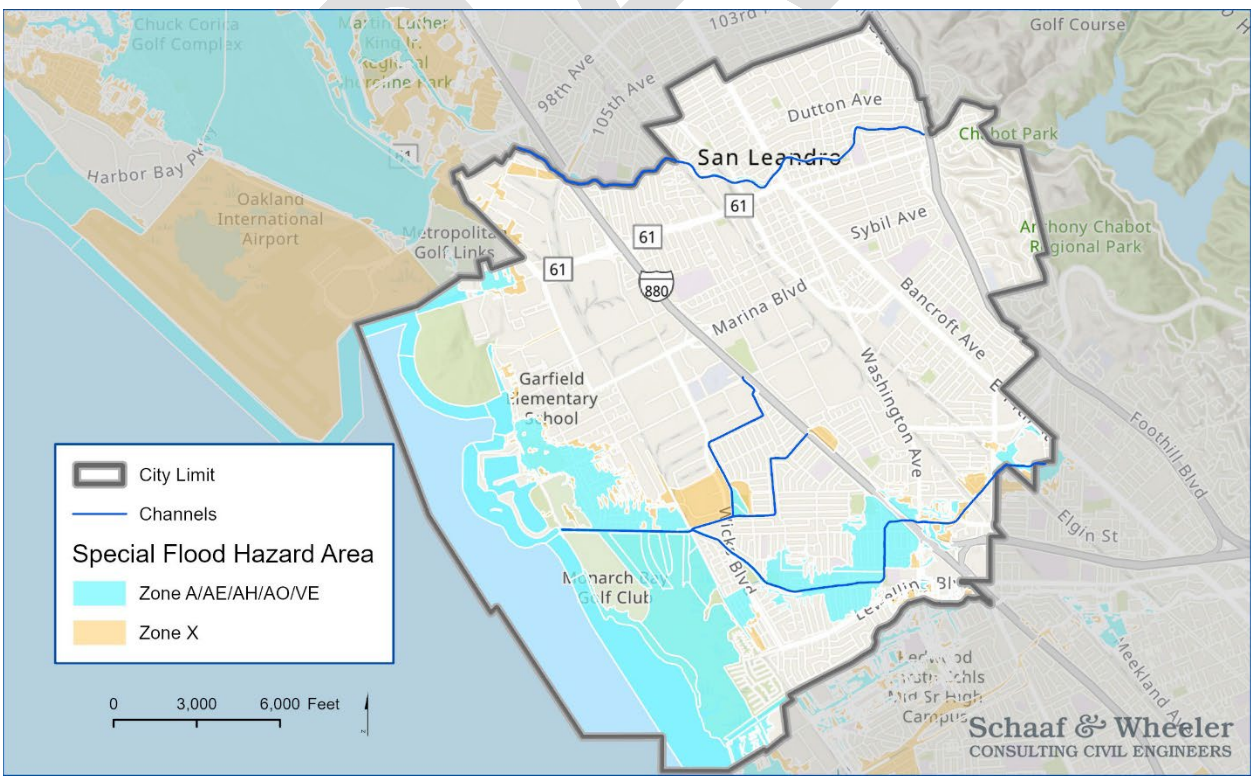

Figure 2-2: Effective FEMA Special Flood Hazard Areas (SFHA)

FEMA Flood Insurance Rate Maps (FIRM) indicate that a 100-year storm (e.g., a storm that has a 1% chance of occurring in any given year) could cause shallow flooding in parts of western San Leandro. Areas within the 100-year flood zones (shown in Figure 2-2) include land adjacent to San Leandro Creek, San Lorenzo Creek, and the Estudillo Canal; land along flood control channels in the vicinity of Bayfair Center and Bonaire Park; and coastal areas surrounding Oyster Bay Regional Shoreline, the San Leandro Shoreline Park, and Heron Bay.

ACFCD is studying options to provide greater flood protection to properties in the San Lorenzo Creek watershed, including increasing the capacity of Don Castro Reservoir, constructing flood walls, and removing bottlenecks along the San Lorenzo Creek channel[1].

It is important to understand the limitations of FEMA SFHA mapping. These maps generally do not consider localized storm drain system flooding, which this study seeks to understand and address in greater detail. City staff have identified several areas where it is known that local flooding occurs even in events more frequent than a 1% chance event. The models developed for this effort also identify capacity deficiencies for a 10-year design event.

2.3 Existing System

Runoff generated by precipitation within the City is drained through various, disconnected closed conduit pipe systems, which are owned by the City and ACFCD. A map of the area is shown in Figure 22-3.

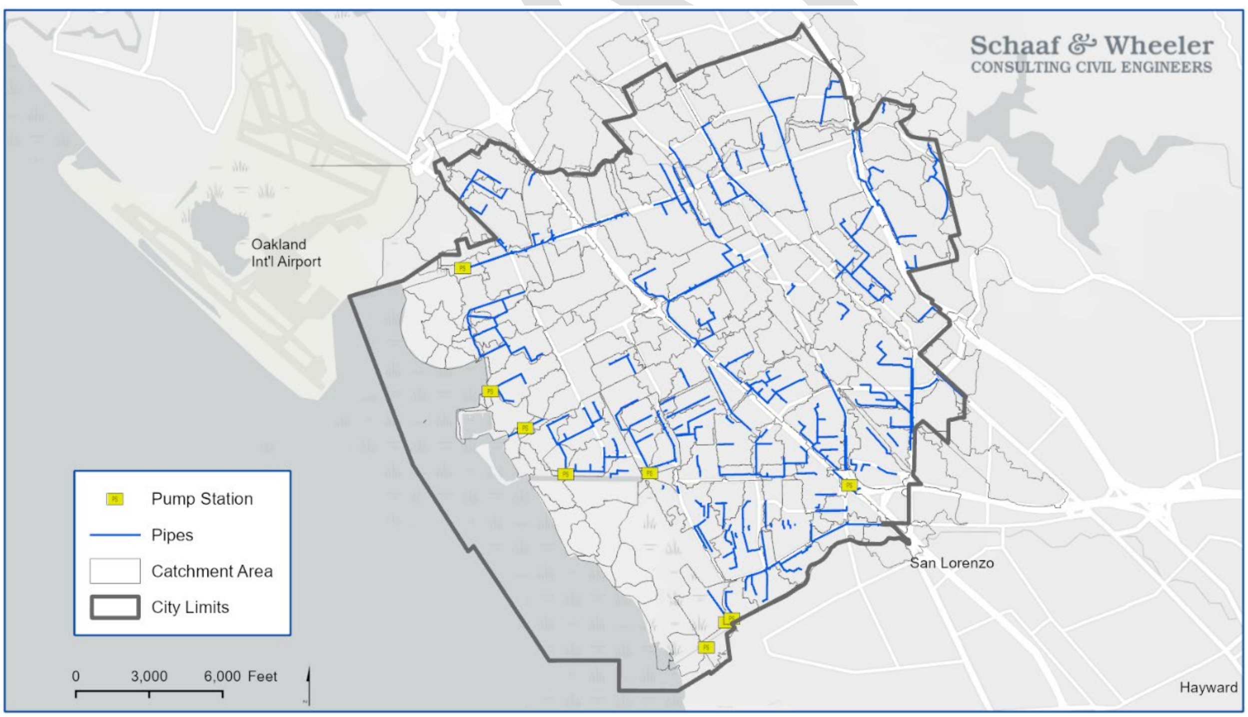

Figure 2-3: Approximate Study Area and Existing Storm Drainage System

City staff identified some known, recurring problems or deficiencies. These areas are shown in Figure 2-4 and summarized in Table 2-1.

[1] From City General Plan

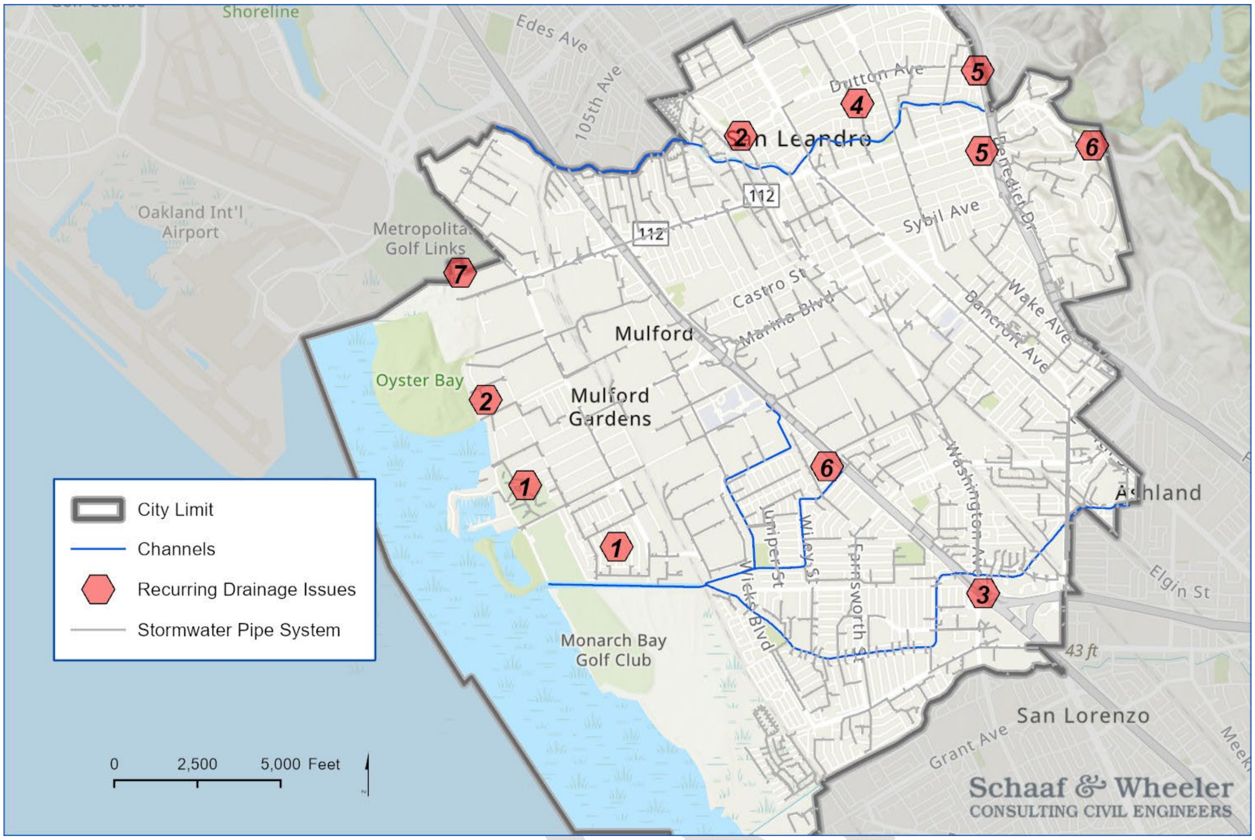

Figure 2-4: Map of Approximate Locations of Known Drainage Issues.

Table 2-1: Descriptions of Known Issues Shown in Figure 2-4

Identifier	Description
1	Flooding upstream of pump stations at Flagship, Marina, and Fairway
2	Recurring flooding at gravity systems near Neptune and at Best
3	Frequent dry weather pumping (groundwater management)
4	Disconnected French drain
5	Bubble up with no connections to SD mains at Oakes Blvd and Juana Ave near I-580
6	Potential historical flooding complaints near Corvallis St and along Lake Chabot Road
7	Pipe along Eden Road near Wastewater Treatment Plant - Unknown drainage area, filled with sediment

2.4 Local Planning Context

The City's 2035 General Plan, adopted in 2015, identified a variety of policies relevant to management of the storm drainage system. This document is an integral tool in advancing the policies and goals set by the City's General Plan.

A selection of these policies is summarized below:

Policy EH-4.1 Urban Runoff Control. Continue to implement water pollution control measures aimed at reducing pollution from urban runoff. These measures should emphasize best management practices by residents, businesses, contractors, and public agencies to ensure that surface water quality is maintained at levels that meet state and federal standards.

Action EH-4.1.A: Trash Capture Devices. Develop a funding plan for the installation and maintenance of trash capture devices on City storm drains, in order to comply with the unfunded State mandate for 100 percent trash capture in local storm drain systems.

Action EH-4.1.B: Municipal Regional Permit Implementation. As required by Section C3 of the Stormwater Municipal Regional Permit (also known as "C3" requirements), ensure that the City's development review procedures continue to include water quality protection measures. These include measures related to water supply, flood control, habitat protection, groundwater recharge, Bay-friendly landscaping, and sustainable development. In addition, the City will continue to require Stormwater Pollution Prevention Plans for qualifying projects and will ensure that such projects include appropriate measures to minimize the potential for water pollution.

Policy EH-1.7 Reducing Flood Hazards. Work collaboratively with County, State, and federal agencies to develop shorthand long-term programs that reduce flood hazards in the City. At the local level, the City will regularly maintain its storm drainage system and ensure that those portions of San Leandro Creek under its jurisdiction remain clear of obstructions.

Action EH-1.7.A: Coordination With ACFCWCD. Improve coordination with the Alameda County Flood Control and Water Conservation District to ensure that flood channels are regularly cleaned and maintained. This should include coordination of tree removal projects on ACFCWD land.

Action EH-1.7.B: Increase Flood Channel Capacity. Work with Alameda County, State and federal agencies, and elected officials to improve flood control channel Line A Zone 2 (the Estudillo Canal) to reduce flood hazards, including reconstruction of golf course bridges to improve channel capacity. As appropriate and necessary, pursue measures to increase the capacity of other flood control facilities to reduce the number of adjacent San Leandro properties subject to flooding.

Policy EH-1.8 Sea Level Rise. Consider the effects of projected sea level rise in the design and planning of all development, recreational improvements, and infrastructure along the San Leandro shoreline.

Action EH-1.8.A: Adaptation Plans. Develop long-term adaptation plans which minimize the potential for coastal flooding on public and private properties near the San Leandro shoreline. Periodically evaluate the risk to homes, businesses, parks, and other features and take steps to protect or fortify these areas to reduce damage potential.

Policy EH-4.3 Interagency Coordination. Coordinate water quality planning, regulation, and monitoring with other public agencies that are involved in water resource management. Establish partnerships and task forces with these agencies and with nearby cities as needed to develop programs addressing issues that cross jurisdictional lines.

Action EH-4.3.A: Municipal Regional Permit Revisions. Remain an active participant in discussions of possible revisions to state and federal clean water legislation, including revisions to the Municipal Regional Permit for stormwater.

Policy EH-4.5 Public Works Maintenance. Continue, and if feasible expand, City Public Works maintenance activities, including scheduled street sweeping and cleaning of storm drains and culverts, to minimize pollution from surface runoff.

Action EH-4.5.B: Street Sweeping Improvements. Improve the effectiveness of the City's street sweeping program through measures such as: (a) ticketing or towing of illegally parked cars; (b) increased public education about the program and the water quality benefits it provides; and (c) notification to property owners via information-sharing websites and social media.

Policy EH-6.11 Climate Change. Prepare for the weather-related impacts of climate change, such as more frequent extreme weather events, temperature extremes, and prolonged drought. Street rights-of-way, parks, and other public spaces, including such features as street trees and landscaping, should be designed to be more resilient to such events.

3 Data and Methodology

Criteria used to design and evaluate storm drain systems were devised to be both defensible and easy to understand and apply. Ideally, future infrastructure design would utilize the same criteria that were used to analyze system performance. As discussed in this chapter and the next, the City's storm drain design criteria, as laid out in its Design Standards and Guidelines (2015), were employed in this SDMP. Some additional provisions, as discussed herein, were also taken into account.

An integrated hydrologic and hydraulic MIKE+ model representing storm drain systems, creeks, and channels throughout the City was constructed using existing data from the City and the ACFCD, along with new data gathered in the field and from as-built plans. This model used a design storm event and land-use-based runoff coefficients to generate runoff from the surface area tributary to each collection system.

The hydraulic capacity of each drainage system component was calculated, and the resulting flood maps were reviewed to confirm whether City drainage system performance criteria were met. If the existing storm drainage system did not meet specific criteria, the model was then used to establish the capital improvement(s) needed. These criteria were met to the greatest extent practicable with the completion of the CIP presented in the next chapter.

However, given the level of interconnectedness with ACFCD facilities, it was not possible to meet the criteria system-wide without improvements to facilities owned and operated by others. Projects were therefore prioritized based on several factors, including system ownership, the severity of identified deficiencies, and the presence of known, documented flooding issues.

These criteria were completed based on the capital improvement priority system described in the next chapter.

3.1 Data Sources

The comprehensive SDMP model was built upon an integrated hydrologic and hydraulic MIKE+ storm drain system model. This model was constructed using City GIS data, as-built plans, LiDAR and aerial surveys, photos, improvement plans, other data documents, and field investigations.

For the comprehensive SDMP, Schaaf & Wheeler utilized GIS shapefiles of the storm drain network provided by the City in August 2023. These shapefiles were then updated using as-built and field investigation data. All elevations were converted to NAVD88.

The most common data transformation involved the conversion of the National Geodetic Vertical Datum of 1929 (NGVD):

$$\text{NGVD} + 2.72 \text{ feet} = \text{NAVD 88}$$

Sub catchment parameters of the model were based on the Existing Zoning land use data provided by the City in the form of GIS shapefiles. This was the most current available data for land use to characterize existing land surfaces. Aerial maps were used to assign land use of areas not defined by the City data or for recent development.

Information regarding pump station operation was obtained from record drawings wherever possible. Where as-builts were not available or complete, other information was acquired from City operations and maintenance staff.

3.1.1 City-wide Topography and Aerial Imagery

All project data and results are in vertical datum NAVD 88 (feet) and the State Plane California Zone III coordinate system.

A City-wide digital elevation model (DEM) was obtained from the nationwide NOAA Continuously Updated DEM (CUDEM) dataset, shown in Figure 3-1, to aid in developing the hydrologic and hydraulic models for the system analysis. This dataset represents a compilation of the most recently obtained LiDAR datasets obtained by the USGS and other agencies. Available aerial imagery in ArcGIS was also utilized to obtain related data such as road networks, land use, and water bodies.

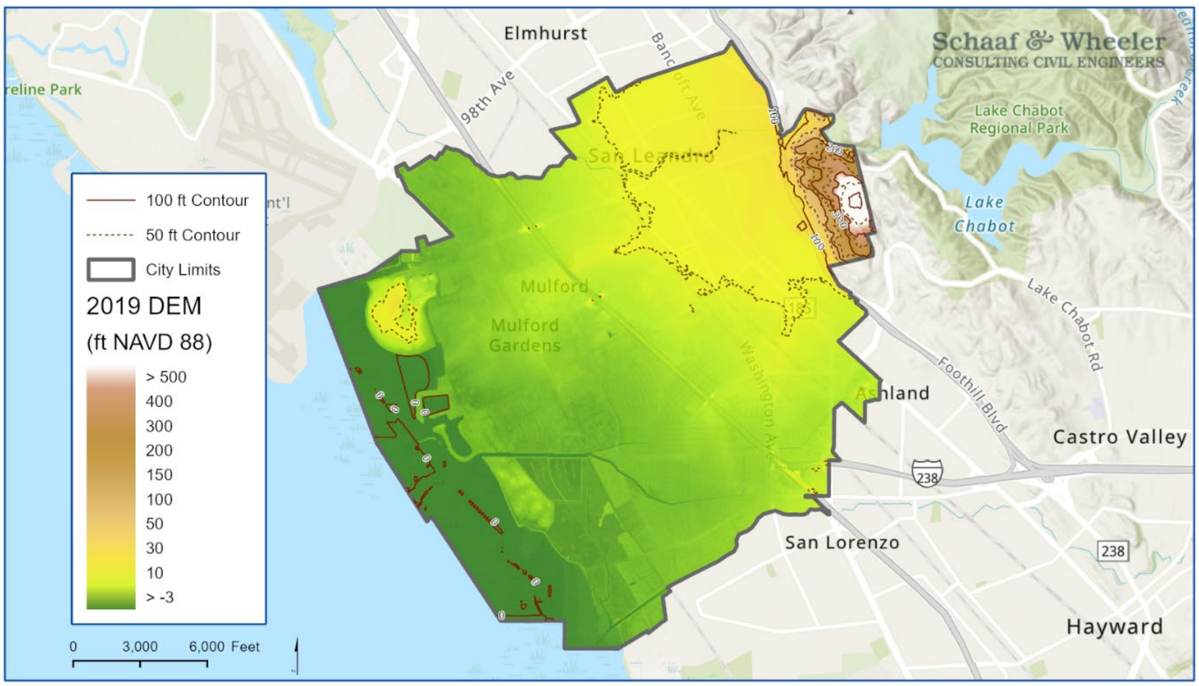

Figure 3-1: City of San Leandro NOAA CUDEM Topographic Data

3.1.2 Storm Drain System Data

City staff provided available GIS data representing storm drain nodes (e.g., inlets and outfalls) and storm drain pipes and/or open channels to Schaaf & Wheeler in shapefile formats. Initial data included:

- Pipe locations and lengths;
- Node types (inlet – grated combination, drop, or curb face, manhole, outfall, junction box, pump station, or confluence);
- Ownership (private, City, ACFCD, others);
- Invert elevation of 43% of modeled nodes;

- Invert elevation of connected pipes at an additional 32% of modeled nodes where node inverts were not recorded; and
- Shape and size for 100% of modeled closed conduit elements.

A map of the entire storm drain system GIS within the City is shown in Figure 3-2.

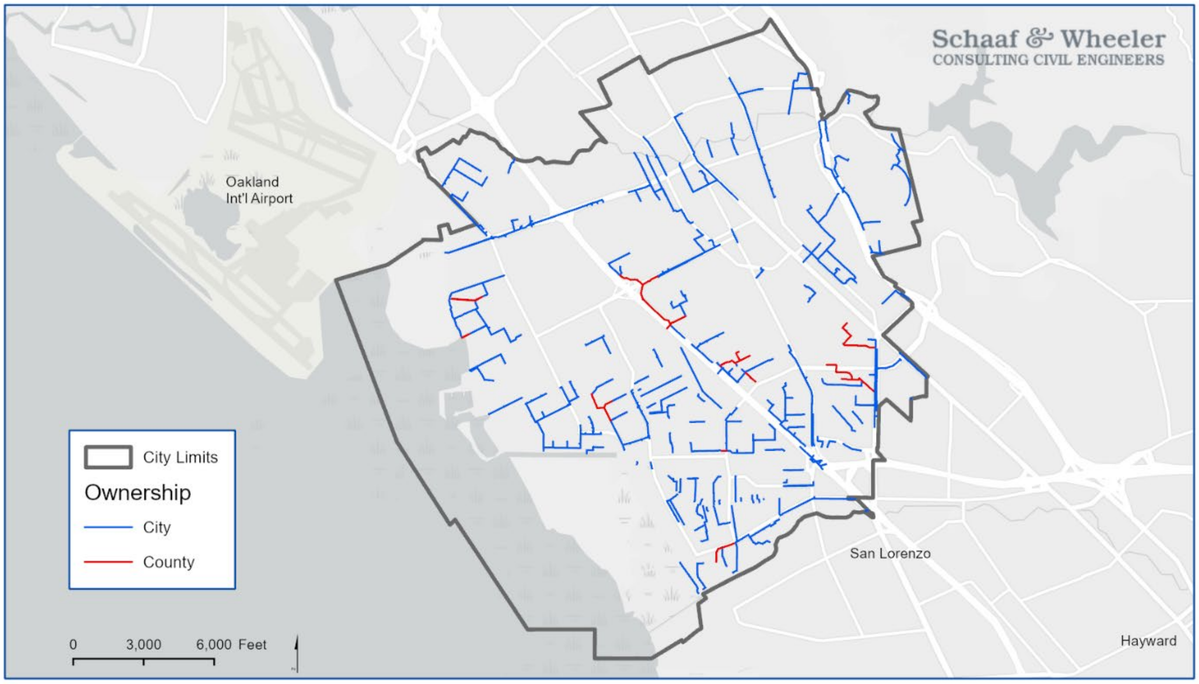

Figure 3-2: City Modeled Storm Drainage Network Map (Including Certain County Elements)

The modeled system consists of approximately 1,361 nodes and over 46 miles of closed conduit systems.

Schaaf & Wheeler identified missing data as well as items in need of verification. Information needed to create the model needed for analysis included:

- Verification of pipe diameters and
- Node depth and rim elevations.

The storm network elements were placed in GIS. Certain private systems and most pipes smaller than 18 inches were removed. Typically, when these smaller pipes surcharge, runoff is contained in the street gutters until it reaches the next inlet. This analysis aims to determine where the pipes responsible for more severe flooding issues lack the proper capacity to contain runoff. An exception was made for certain areas that the City identified as recurring problems. In those areas, it is considered likely that elements beneath the 18-inch threshold need to be upsized to 18 inches or greater.

Nodes were assigned ground elevations based on as-builts and LiDAR topography. Node inverts were assigned based on depths in the GIS except for the 555 nodes where that information already existed in the GIS. As-builts were used to fill in additional invert elevations. Because datums varied and/or were not listed in many of the as-built drawings, depths were calculated for various structures and used to assign the invert in the model based on the LiDAR ground elevation. This ensured that a uniform datum is applied to the entire model.

It is not practical or necessary to obtain measurements for every bit of remaining missing data. For information still missing after exhausting available data sources, system ends were initially assigned a depth of 4 feet from rim to invert. This assumes that the upstream end of modeled pipe is constructed with 3 feet of cover, a common design practice, unless deviation is required to work around various constraints.

The DHI model (discussed in detail in Section 3.8 and 3.9) was then used to interpolate missing invert elevations throughout the entire model. Where practical, missing pipe diameters were filled in based on the size of surrounding pipes in a conservative manner, using the smallest diameter of connecting pipe in the middle of a continuous run, or using the diameter of the next pipe downstream where a junction of multiple systems occurs upstream.

Upon examination of system profiles in the model, it became apparent that some areas of the system are likely shallower than the 3-foot cover assumption. This was confirmed in some areas with as-built drawings. In these locations, inverts were corrected and re-interpolated as necessary to create sensible profiles to complete the hydraulic model. There were also notable irregularities in the existing GIS data, including pipes that appeared to be missing or assigned incorrect diameters.

3.2 Watershed Characteristics

To model the storm drain system and include all pipes that are 18-inches in diameter and larger, relatively small sub-watersheds were developed for representation in the models.

The area that contributes runoff to a drainage line within these watersheds is referred to as a "Drainage Area." The smaller sub-watersheds within the Drainage Areas are noted as "Sub-Basins." Therefore, the hierarchy terminology for watersheds includes:

1. Watersheds – delineating the basin for each major creek system
2. Drainage Areas – delineating the basin for each named drainage line
3. Sub-Basins – delineating the smallest sub-basin for each drainage line

3.2.1 Sub-Basin Delineation

Sub-Basins were delineated based on the Digital Elevation Model (DEM) topographic mapping obtained from NOAA, City of San Leandro collector system locations, and overland release flow paths. The Sub-Basin size ranges from 0.05 acres in densely developed urban areas with shorter reaches of conveyance systems to approximately 320 acres in areas with more lengthy pipe systems or long reaches of ACFCD-owned infrastructure not included in the hydraulic model.

Sub-Basins were delineated first and foremost based on City-owned storm drain networks. However, delineations were also based on those ACFCD facilities that impact the function of City-owned systems directly. In some areas, ACFCD systems drain into City-owned systems and vice versa. In other locations, City and ACFCD systems appear parallel to one another, and capacity of both systems must be considered. Where the overland flow path and the storm drain network flow path conflict, the storm drain flow path governs since it generally conveys the most flow.

3.2.1.1 Sub-Basin Soils

The National Resource Conservation Service (NRCS) soil survey and map information identify soils in hydrologic soil groups based on their infiltration properties.

Hydrologic soil groups “A,” “B,” “C,” “C/D,” and “D” are present within the drainage system. Group “A” has a higher infiltration rate than Group “D.” “C/D” soils indicate a duality of hydrologic soil conditions. When the groundwater table is seasonably high (less than 24” from the surface), the soil has a “D” type response. When the water table is well-drained (greater than 24” from the surface), the soil has a “C” type response. The open space areas in the eastern portion of the study area have more groups “C” and “D.” Figure 3-2 presents the NRCS Soils Map.

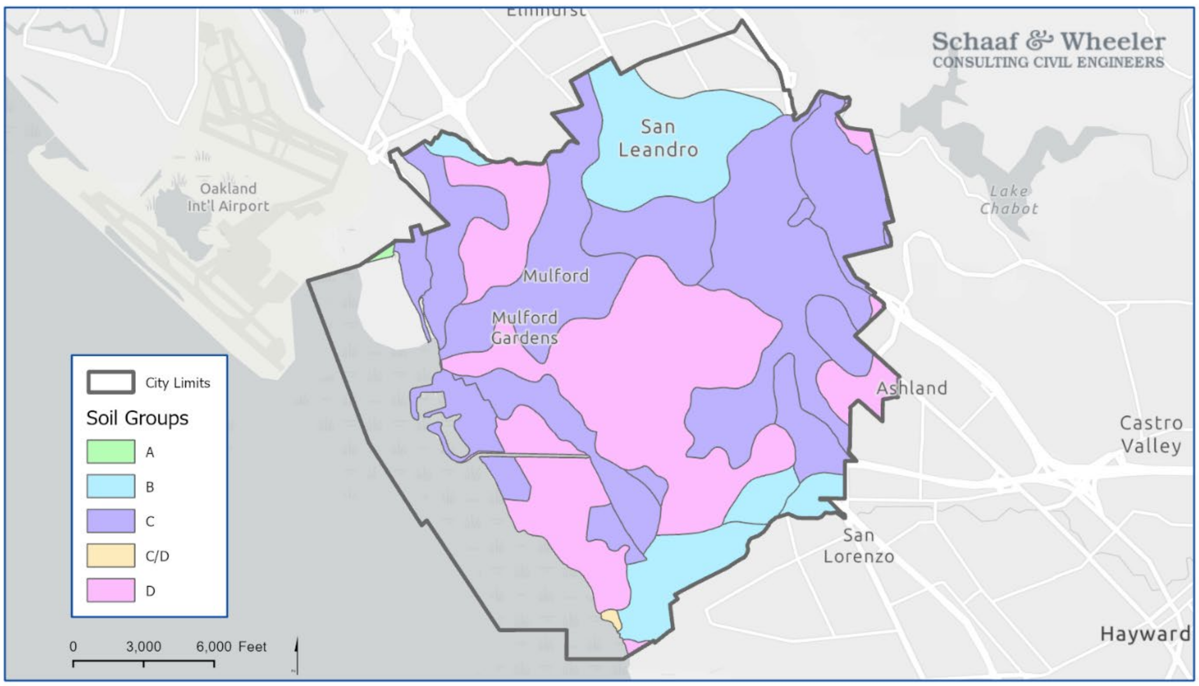

Figure 3-3: NRCS Soil Classification Map for the San Leandro Watershed

Each soil type consists of a combination of seven soil groups: A, A/B, B, B/C, C, C/D, D. The NRCS assigns the dominant hydrologic soil group in the soil survey publication. In the event of an even split of percentages between two soil groups, the soil group with a lower infiltration rate is assigned.

3.2.1.2 Sub-Basin Land Use

The City provided a land-use GIS shapefile reflecting the level of development within the City boundary. Each land use category was assigned a value of relative imperviousness based upon

Table 3-3. To develop Sub-Basin-specific hydrology parameters for the Snyder UHM, a combination of percent imperviousness and underlying soil infiltration regime are used.

Figure 3-3 shows the land use. Areas with no defined land use in the City's GIS are assigned sub-basin-specific hydrology parameters based on the Esri World Imagery Map.

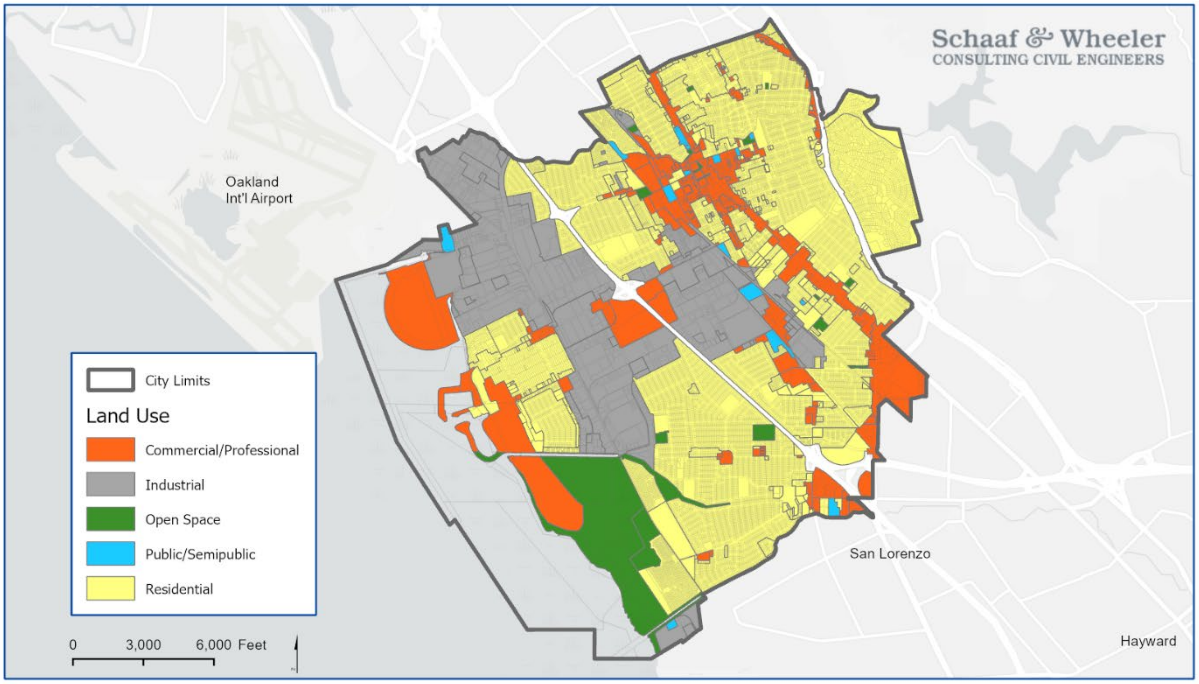

Figure 3-4: San Leandro Land Use

Table 3-1: City of San Leandro Land Use and Zoning Areas (Acres)

	Hydrologic Soil Group				Total Area
Description	**A**	**B**	**C**	**D**	
Community Open Space	--	14.5	53.4	7.2	***75.1***
General Commercial	--	213.8	200.5	145.2	***559.5***
Light/Heavy Industrial	--	72.4	955.7	1,018.9	***2,047.0***
Public/Semipublic	--	25.5	11.3	39.1	***75.9***
Road	--	21.0	134.3	76.7	***231.9***
Single-Family Residential	--	1,366.8	3,820.2	2,417.2	***7,604.2***
Multi-Family Residential	--	523.6	192.5	6.7	***722.9***
Grand Total	--	***2,237.6***	***5,367.9***	***3,711.0***	***11,316.5***

3.3 Hydrology

3.3.1 Design Storm Frequency

Flood frequency analyses are used to design facilities that control storm runoff since it is impossible to anticipate every conceivable storm's effect. Constructing a design storm is a common practice that both the City and ACFCD standards follow. A rainfall pattern is used in hydrologic models to estimate surface runoff and compare the surface runoff to the capacity of drainage systems designed to convey this runoff.

Precipitation-runoff frequency analyses are based on concepts of probability and statistics. Engineers generally assume that a rainfall event's frequency (probability) coincides with direct stormwater runoff frequency. However, the runoff generation depends on several factors not necessarily dependent upon the precipitation event, such as antecedent moisture conditions in the drainage basin.

The 10-year storm recurrence interval is used as the design storm to evaluate the flood control systems (i.e., storm drainpipes) for this SDMP. It is worth noting that over the typical 30-year life of a home mortgage, the chance of experiencing at least one 10-year event is about 96%.

3.3.2 Design Storm Duration

The ACFCD adopted a 6-hour storm duration for peak discharge calculations for drainage areas less than 25 square miles. The 6-hour design storm temporal distribution from the ACFCD Drainage Manual is displayed as Figure 3-5 below. The temporal rainfall distribution is for a 6-hour design storm with 15-minute intervals with a total depth of 1.92 inches.

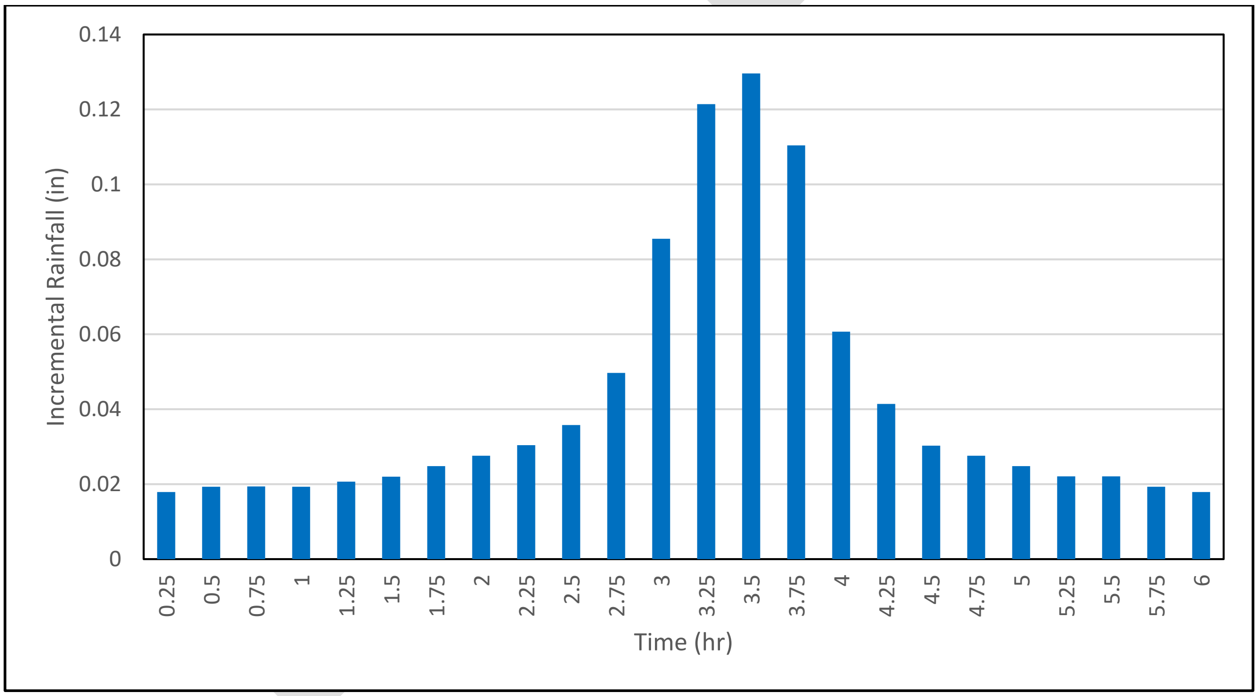

Figure 3-5: ACFCD 6-hour, 10-year Storm Distribution

3.4 Rainfall/Runoff Transformation Method

The methodology for the transformation of the precipitation into stormwater runoff is described in this section. The general steps to transform rainfall into runoff are:

1. Apply a loss method to convert rainfall distributions into excess rainfall. This is done by accounting for the portion of rainfall lost to surface depressions, evaporation, and soil

infiltration. The amount of precipitation that is lost will not result in direct runoff. Losses also vary over time during a storm. For example, as wetted soil becomes more saturated, losses decrease, and more rainfall becomes surface runoff. Losses are a function of land use and soil conditions.

2. Transform the excess rainfall into surface runoff using the hydrograph methods subsequently described.

3. Route surface runoff hydrographs through the storm drain and creek systems. When stormwater flows exceed a storm drain or creek's hydraulic capacity, some portion of the runoff hydrograph will be carried over the ground surface. The timing and depth of this overland flow produce flood hazard mapping.

3.4.1 Hydrograph Method

The transformation of rainfall into runoff can be calculated in a model using various methods. ACFCD has adopted the Snyder unit hydrograph transformation method (UHM or UH method), which utilizes basin lag time and basin peaking factor input parameters.

3.4.2 Loss Method

The initial and constant loss rate method was utilized per ACFCD methodology. Loss rates are a function of soil conditions and land use. Losses are only applicable to the pervious portion of the drainage areas. The initial loss for all soil conditions and land uses for a 6-hour design storm is 0.8 inches. The uniform loss rates based on hydraulic soil group and land use type are shown in Table 3-2.

Table 3-2: Uniform Loss Rates[2]

Hydrologic Soil Group	Rural Coverage (in/hr)	New Urban Coverage (in/hr)	Existing Urban Coverage (in/hr)
A	0.45	0.45	0.45
B	0.35	0.37	0.40
C	0.14	0.19	0.25
D	0.05	0.07	0.09

[4] Alameda County Hydrology and Hydraulics Manual, ACFCD, 2018

3.4.3 Imperviousness

Table 3-3 shows the percentages of directly connecting impervious surface, non-directly touching impervious surface, and porous surface for each land-use. The percentages are taken from the ACFCD drainage manual.

Directly connected impervious surfaces (such as driveways, street pavements, and sidewalks) drain to the City storm drain system with limited surface attenuation. Non-directly connected impervious surfaces within a sub-basin experience greater peak-flow attenuation by flowing across pervious surfaces before entering the storm drain. These surfaces are generally roofs that drain to roof gutters which discharge to pervious lawns or landscaping.

Table 3-3: Land Use Percent Impervious

LAND USE TYPE	Impervious (%)		Pervious (%)
	Directly Connecting	Non-Directly Connecting	Area
Undeveloped Land, parks, open space, golf	0	0	100
Rural Residential (larger than 1 ac lot)	4	6	90
Residential 10,000 sf – 1 ac lot	15	12	73
Residential ¼ ac (8,000 – 10,000 sf lot)	22	18	60
Residential 1/8 ac (5,000 – 8,000 sf lot)	24	26	50
Residential (3,600 – 5,000 sf lot)	26	28	46
Residential (2,700 – 3,600 sf lot)	28	32	40
Zero Lot Line Residential & Less than 2,700 sf	35	0	65
Townhouse	50	30	20
Condominium	60	25	15
Industrial	70	20	10
Apartment	80	10	10
Commercial	85	5	10
Freeway	90	0	10
Mobile Home Park	17	37	46
Schools (large open space)	15-20	0	80-85
Schools (small open space)	40-50	0	50-60

3.4.4 Hydrograph Method Parameters

3.4.4.1 Snyder Unit Hydrograph Method

The two major input parameters of the method are Basin Lag Time and Basin Peaking Factor. The Basin Lag Time is a measure of the time elapsed between the occurrence of unit rainfall and the occurrence of unit runoff. It is based on the longest flow path length, slope, and basin roughness.

Basin Lag Time is calculated using the following relationship (from ACFCD):

$$t_L = K * N \left(\frac{L * L_c}{\sqrt{S}}\right)^{0.38}$$ **(Equation 2)**

Where:

- t_L Lag time (hr)
- K Distance factor
  - for L > 1.7 mi, K = 24
  - for L ≤ 1.7 mi, K = 15.22 + 2.15L + 8.7/L
- N Basin roughness factor (from Table 3-4 or Equation 3)
- L Length of longest flow path
- L_c Length of longest flow path measured from the point opposite the watershed centroid
- S Average stream slope (ft/mi)

Table 3-4: Basin Roughness Factors for Rural Watersheds

Basin Type	Basin Roughness Factor (N)
Rural watersheds with generally clear stream bed and minimal vegetation growth in the drainage reaches	0.05
Rural watersheds with moderate to high levels of vegetation growth, or rock and boulder deposits within the main drainage reaches	0.07
Rural watersheds with dense vegetation or high levels of boulder deposits within the main drainage reaches	0.08

The basin roughness factor can be calculated using the following relationship:

$$N = 0.52n^{0.79}$$ **(Equation 3)**

Where:

N Basin roughness factor

n Manning's roughness coefficient (from Table 3-5)

Table 3-5: Manning's Roughness Coefficient

Type of Facility	n
Reinforced Concrete Pipe	
Conduit > 36" diameter	0.012
Conduit ≤ 36" diameter	0.14
Corrugated Metal Pipe	
Annular	0.021
Helical	0.018
Concrete-Lined Channels	
Smooth-troweled	0.015
District Simulated Stone	0.017
Reinforced Concrete Box	
Cast-in-Place	0.015
Pre-Cast	0.014
Earth Channels	
Smooth Geometric	0.030-0.035
Irregular or Natural	0.045-0.050

The Peaking Factor is a function of overland basin storage. Large areas with flat slopes are associated with relatively high amounts of overland basin storage. Conversely, water that falls on steeply sloped areas will run off quickly with little overland basin storage. The lower the basin storage, the higher the corresponding peaking factor.

$$C_p = 0.6e^{0.06(S_o/A)}$$ **(Equation 4)**

Where:

C_p Basin peaking factor ($C_p \leq 0.85$)

S_o Average watershed slope (%)

A Drainage area (mi^2)

3.5 Hydraulics

A detailed representation of the close conduit system properties is required in the model to evaluate the City's level of service goals. This representation accounts primarily for the conveyance capacity of the pipes, with some consideration of storage in the streets, and the effects of the water levels in receiving water bodies (open channels and San Francisco Bay). The DHI MIKE+ software performed the hydraulic analysis.

3.5.1 Conduit and Street Systems

The conduit and street systems are modeled using parameters as discussed in the following sections.

3.5.2 Conduit and Manhole Invert Elevations

The City's GIS file of the storm drain network provides inverts of conduits and manholes. If inverts are missing from these two data sources, as-builts have been referenced to fill in any data gaps. If data is still not found from these two data sources, an appropriate assumption is made by referencing upstream and downstream inverts and storm drainpipe cover.

3.5.3 Conduit Manning's n Roughness

Manning's n-values for conduit and street systems are estimated based on values specified in Table 3-5. All conduits of unknown material are assumed to be reinforced concrete pipe.

All conduit material descriptions by pipe segment were obtained from the City.

3.5.4 Conduit Manhole Losses

Manhole losses are calculated in MIKE+ using the Normal Headloss Method. This method does not account for bend, drop, contraction, and expansion losses. It does account for simple junction losses. However, storm drains are generally built on straight alignments of the same diameter from manhole to manhole without significant bends, drops, contractions, or expansions. Particularly for the larger pipe diameters, manholes provide periodic access to the top of continuous pipelines.

3.5.5 Boundary Conditions

The storm drain network's downstream boundary conditions have been estimated based on the characteristics of receiving channels and known tidal statistics for the San Francisco Bay.

For systems draining to the San Francisco Bay tidally influenced areas, the Mean Higher High Water (MHHW) elevation at the Alameda NOAA station is used as a boundary condition. MHHW at this location is approximately 6.4 feet NAVD 88.

3.5.6 Capacity Assumptions

In general, this analysis assumes that all conduits have their full conveyance capacity available. However, field investigation revealed certain elements where this is not the case.

Two County-owned pipes with outfalls to Oyster Bay are heavily affected by silt and/or debris as verified by field visits. The clogged pipes consist of a 66-inch corrugated metal pipe approximately 50% full of sediment and a 48-inch concrete pipe approximately 75% full of sediment. Images taken in the field are shown in Figure 3-6 and represent the state of the pipes at low tide.

Figure 3-6: Heavy Blockage in 66-inch (top) and 48-inch (bottom) Pipes at Low Tide

3.5.7 Pump Stations

The City and ACFCD own and operate several pump stations throughout the City to ensure that drainage of interior stormwater runoff is possible into channels and the Bay, regardless of the water levels in those receiving facilities. Pump stations are primarily concentrated in the low-lying areas, most susceptible to tidal influence and are generally located near outfalls. The Washington pump station is the exception since its purpose is to provide positive drainage for the depressed I-880 underpass at Washington Ave. ACFCD owns and operates 22 pump stations in all. Seven pump stations serve the City of San Leandro:

- Line D-1 (Farallon Drive)
- Line F (Fairway Drive)
- Line H (Monarch Bay Drive)
- Davis Street
- Line B (Anchorage Drive)
- San Lorenzo Creek Trail near Grant Avenue
- Flagship Street near Belvedere Avenue

The City owns and maintains two other pump stations, located at Wicks Boulevard discharging to San Lorenzo Creek and at I-880 near the Washington Street overpass discharging to the Alameda County Flood Control Canal to the north.

The pump stations are input into the MIKE+ model based on data obtained from as-builts and pump curves. Where possible, pumps have been modeled with discharge curves and recent performance testing integrated to ensure that the model predicts hydraulic grade lines in connecting systems as accurately as possible. Where such information is not available, as-built drawings have been examined to determine pump type and size and a reasonable constant flow pumping capacity has been assigned to the pumps. Design characteristics acquired for the pump stations are summarized in Table 3-6.

Table 36: Pump Station Data

Pump Station/Location	Capacity	Design Event	No. of Pumps
Line D-1 (Farallon Drive)*	85 cfs	15-year	3
Line F (Fairway Drive)*	87 cfs	100-year**	3
Line H (Monarch Bay Drive)*	15.5 cfs	< 15-year	2
Davis Street*	169 cfs	5-year	4
Line B (Anchorage Drive)	--[†]	--[†]	--[†]
San Lorenzo Creek Trail near Grant Ave	--[†]	--[†]	--[†]
I-880 at Washington Avenue Overpass	~5.5 cfs	--[†]	2
Flagship Street near Belvedere Ave	--[†]	--[†]	3
WICKS	~13.4 cfs	--[†]	2

**Study provided by ACFCD*
***Study indicated that 100-year capacity is provided without any redundancy*
[†]Information not available (San Lorenzo Cr Trail and Flagship stations not modeled)

The nine pump stations that drain systems within the City are shown in Figure 33-7.

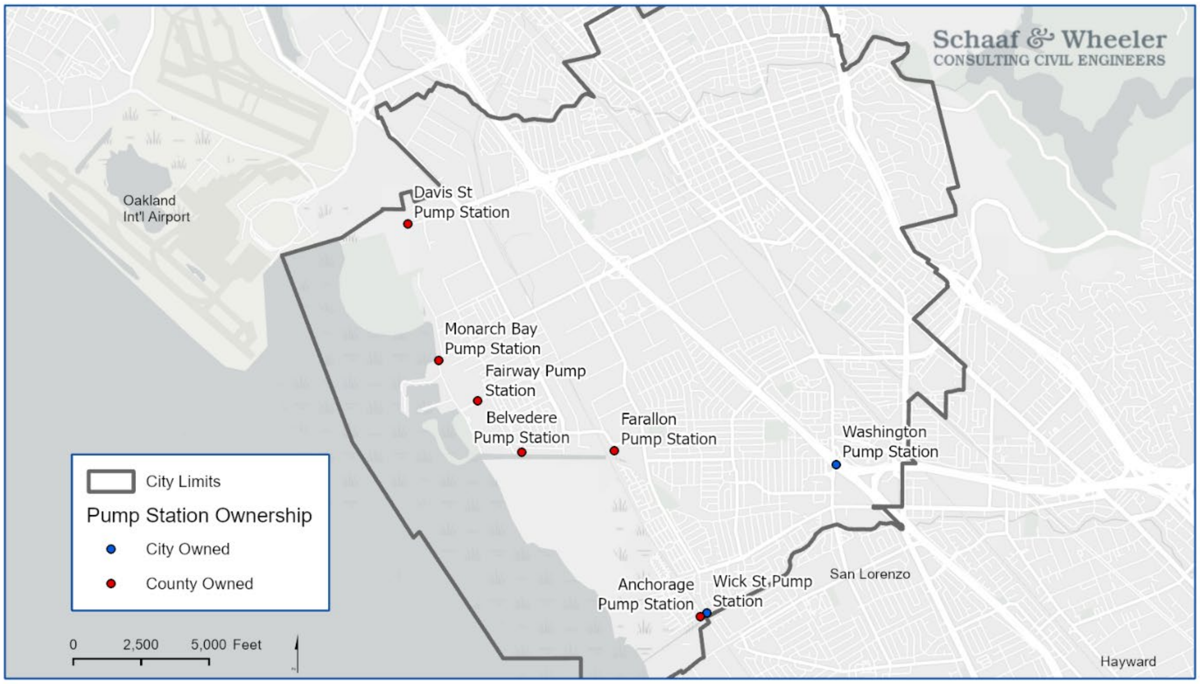

Figure 3-7: Modeled Pump Station Locations

3.6 Climate Change Considerations

Various tools exist to evaluate the impacts of climate change. Climate change and global SLR can be extremely impactful factors in planning a resilient surface water management system. Sea levels have risen in San Francisco area by approximately 8 inches over the past century[3], and the rate of rise is predicted to increase.

SLR predictions are based on complex climate models with several variables and uncertainties. However, the California Ocean Protection Council (OPC) provides probabilistic projections of SLR intended to guide policy decisions and local project design efforts. The agency's 2018 "State of California Sea-Level Rise Guidance" report cites a predicted rise of 1.9 feet by 2050 and 6.9 feet by 2100 for high flood risk aversion.

This poses risks to low-lying coastal areas of the City in particular, including increased incidences of flooding from King Tides, storm surges, and runoff from creeks and flood control channels. These projections should guide several activities in the City, including adaptation planning, coastal resilience projects, and development ordinances. Those efforts are beyond the scope of this SDMP.

However, in the context of this effort, the impacts of SLR must be considered in the development of a prioritized capital improvement plan. In addition to evaluating stormwater facilities needed to meet drainage standards under current conditions, this plan must anticipate

[3] OEHHA. https://oehha.ca.gov/climate-change/epic-2022/impacts-physical-systems/sea-level-rise#:~:text=Sea%20levels%20have%20increased%20over,mm%20or%200.03%E2%80%B3%20each%20year.

the need for new pipe systems and pump stations to provide functional systems well into the future.

3.6.1 Sea Level Rise

Without considering existing or future flood control projects, the topography of low-lying areas can be used to evaluate susceptibility to SLR. Both MHHW and 100-year Tide levels have been mapped for existing conditions, then with 1.9 feet and 6.9 feet of SLR to represent vulnerability in 2050 and 2100 for the OPC document high emissions scenario. These areas are shown in Figure 3-8 and Figure 3-9.

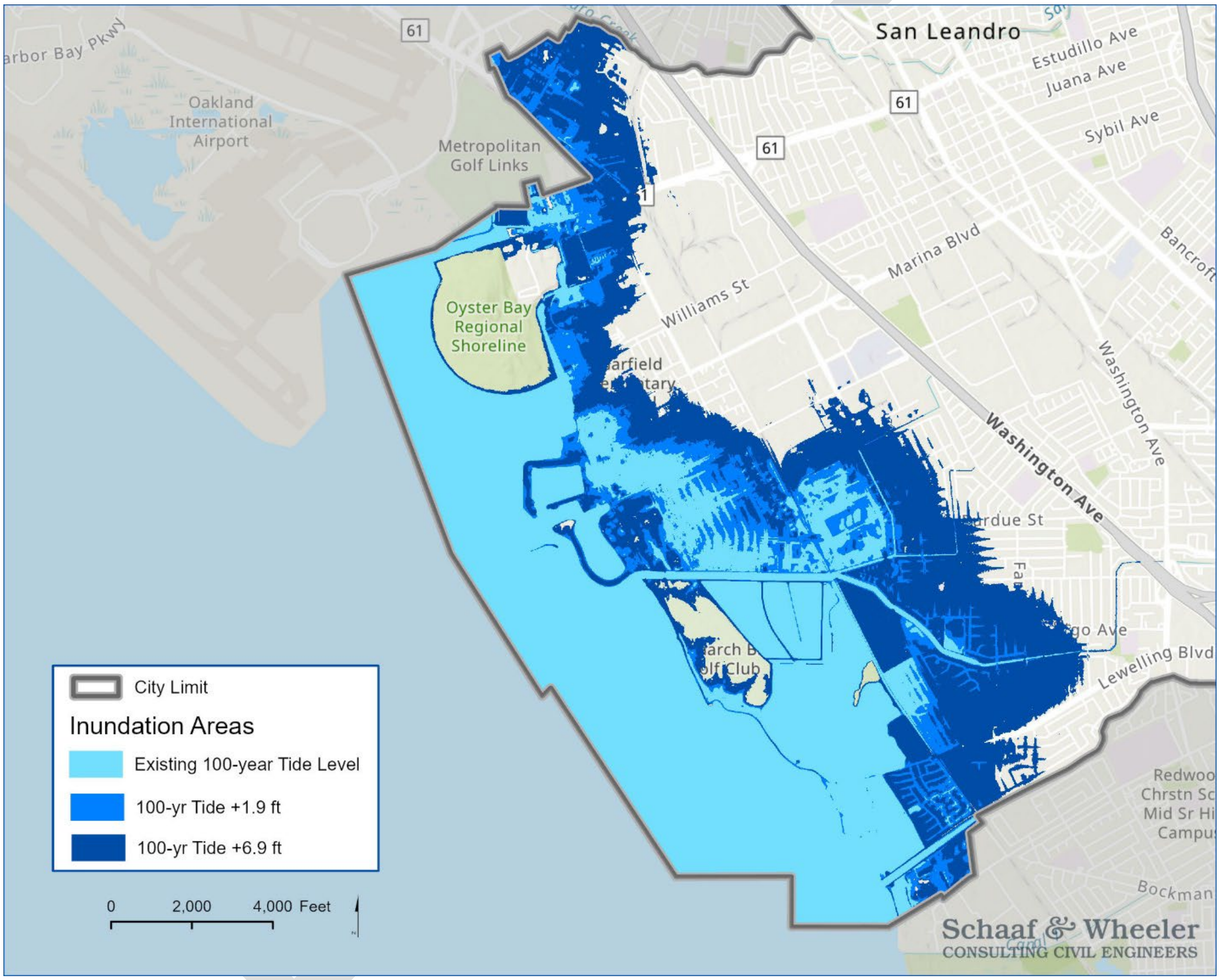

Figure 3-8: Areas Below 100-year Tide Level (Existing, 2050 High Emissions SLR, and 2100 High Emissions SLR)

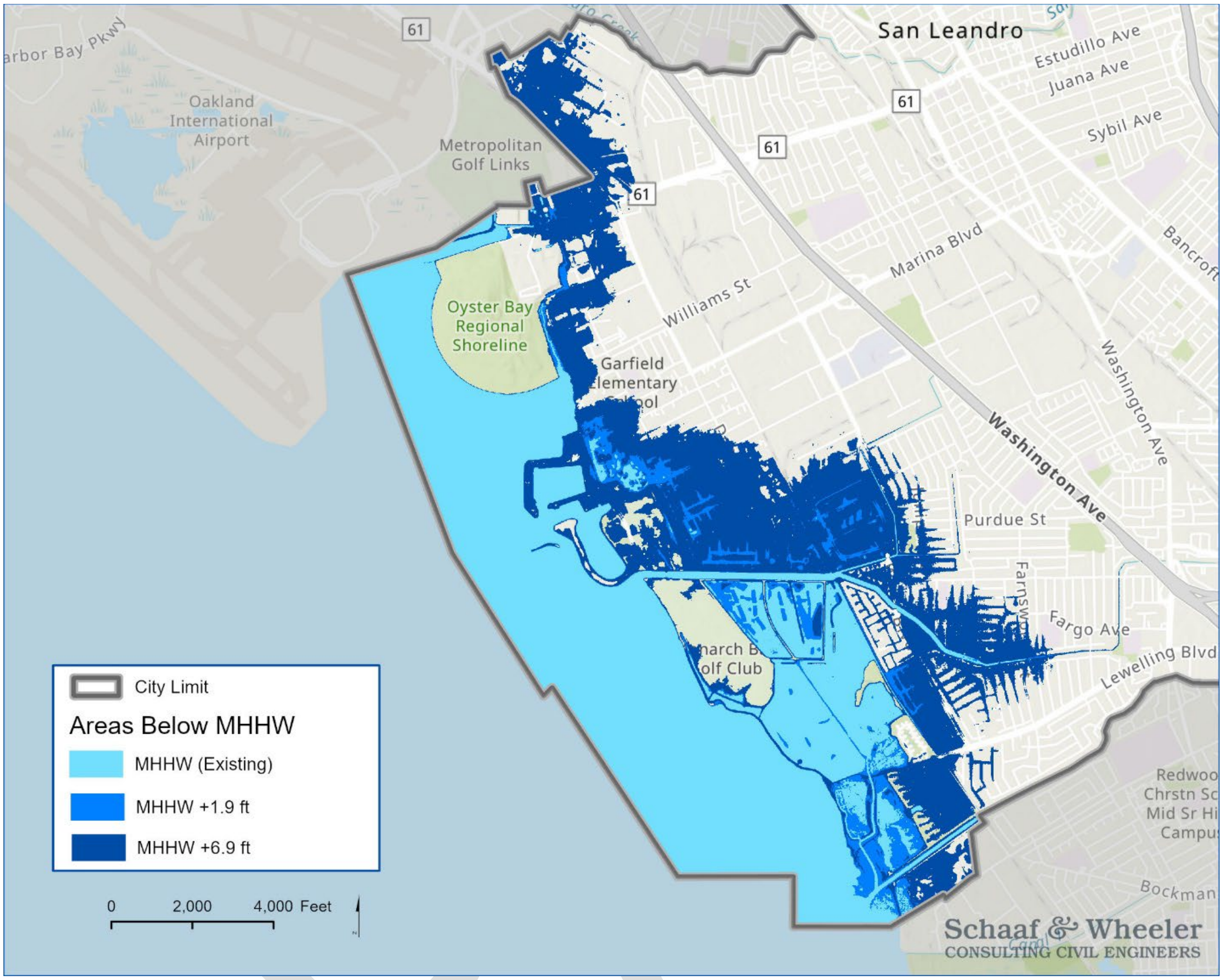

Figure 3-9: Areas Below Mean Higher High Water (Existing, 2050 High Emissions SLR, and 2100 High Emissions SLR)

3.6.2 Precipitation

The models also consider the potential impacts of climate change. This is accomplished by using EPA SWMM Climate Adjustment Tool (SWMM-CAT). The tool provides location-specific adjustment factors for Near-Term (2035) and Far-Term (2060) projects derived from global climate change model developed by the World Climate Research Program. The tool generates adjustment factors for several climate parameters. However, this analysis is primarily concerned with future changes in precipitation. Predictions generated by the tool are shown in Figure 3-10 and Figure 33-11. The EPA tool predicts near-term and far-term increases of approximately 11% and 22%, respectively, for a 10-year Design Storm.

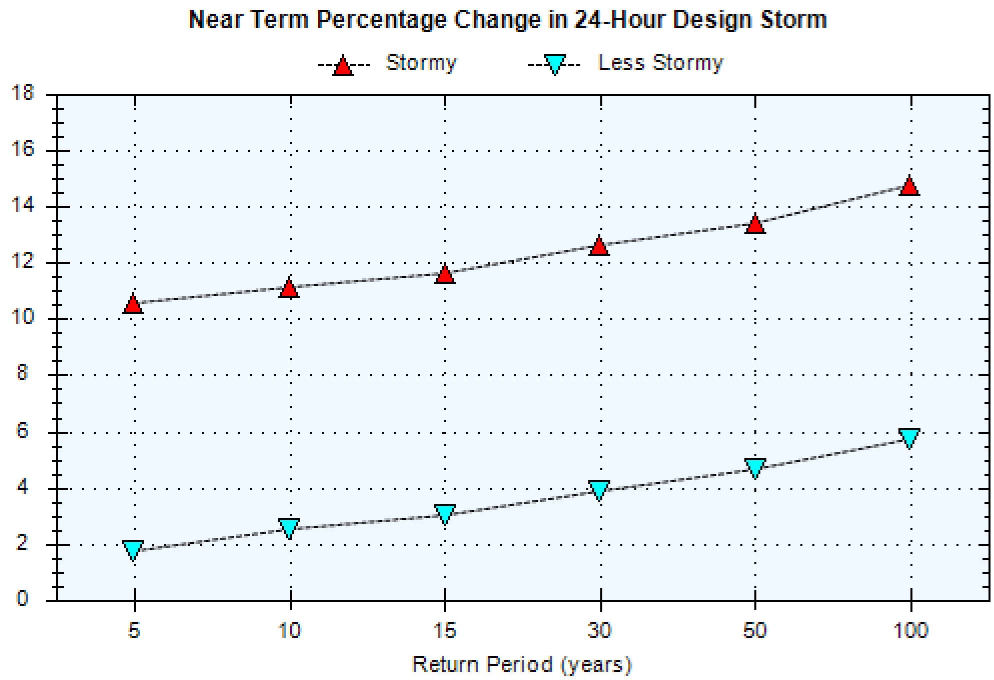

Figure 3-10: Near-Term 24-Hour Design Storm SWMM-CAT Predictions (San Leandro)

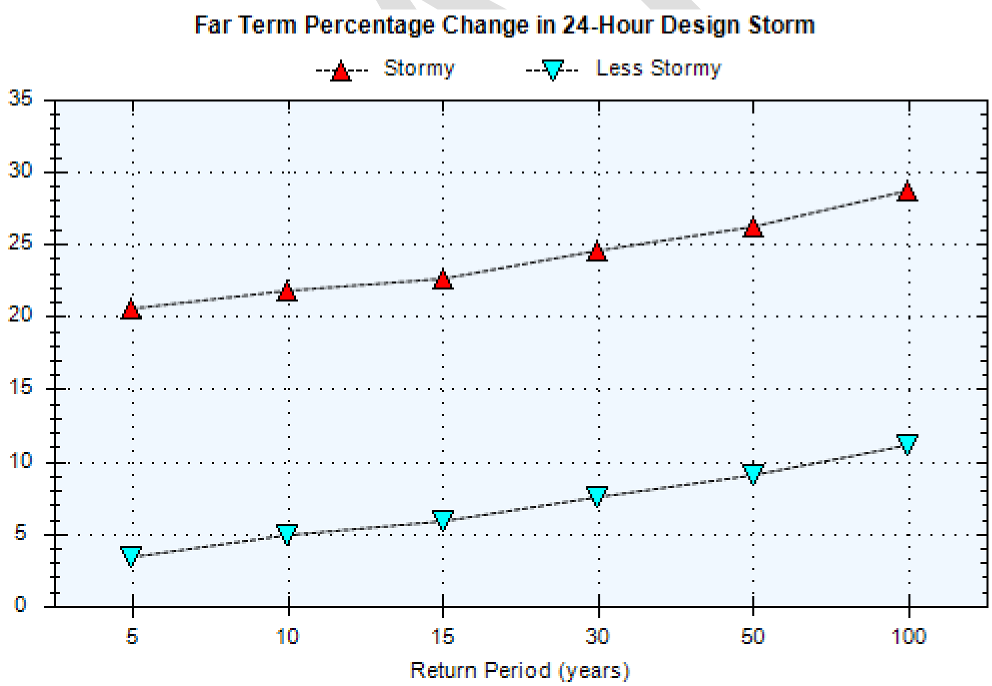

Figure 3-11: Far-Term 24-Hour Design Storm SWMM-CAT Predictions (San Leandro)

Cal Adapt provides another source of climate change predictions. For San Leandro, Cal Adapt predicts 10-year extreme precipitation event intensity to increase by approximately 30% under the high emissions model scenarios in their long-term modeling (End-Century, 2070-2099). The 95% confidence interval in the models predicts increases in End-Century extreme storm intensity in the range of 15 to 55%.

The models use single storms to evaluate system capacity and identify projects. The predictions from EPA and Cal Adapt forecast similar climate change impacts for these individual extreme storm events. For conservatism, the climate change model scenario used the design 10-year storm with depths increased uniformly by a factor of 0.15 for the 2050 modeling scenario, giving weight to the longer-term predictions provided by the models referenced in the Cal Adapt tool.

3.7 Evaluation Criteria

Schaaf & Wheeler created hydrologic analysis and one-dimensional hydraulic models for the 10-year event. We used the 10-year storm event as the design event for the storm drain system evaluation since the 10-year level-of-service standard was agreed upon as the governing criteria for general storm drain system conveyance.

This document recommends improvements to reduce the 10-year hydraulic grade to no higher than one foot above the rim elevation at any location in the pipe network. Given the degree of urbanization, most pipe systems are in streets where curbs are at least six inches above inlet rims. This standard contains most flow within gutters, minimizing hazardous conditions in roadways and risk of property damage. Typically, flows at curb height will be short-lived during storm peaks.

3.8 Modeling Software

The DHI MIKE+ software was selected to model the City's storm drain system. MIKE+ is a package of software programs designed by Danish Hydraulic Institute (DHI) for the analysis, design, and management of urban drainage systems, including storm water sewers and sanitary sewers. The model can simulate runoff, open channel flow, pipe flow, water quality, sediment transport, and two-dimensional surface flow.

The City of San Leandro modeling package consists of two interrelated products:

1. MIKE-1D is a group of hydrologic, hydraulic, water quality and sediment transport modeling modules that can be used together or independently.

   The modules used in the City storm drain model include the Surface Runoff Module, which computes surface runoff using one of five computational methods, and the Hydrodynamic Pipe Flow Module, which calculates an implicit finite-difference numerical solution of the St. Venant flow equations for the modeled pipe network.

2. MIKE+ is a GIS-based program that includes tools specifically designed to develop urban drainage models. MIKE+ provides a graphical user interface for data input and editing. It serves as a bridge between GIS data inputs and the hydrology and 1-D pipe flow module.

   Capabilities of the software include import and export of model data, network editing and gap-filling, catchment delineation, and network simplification. MIKE+ can also be used to present results including plan, longitudinal, and cross-section views; animation of results; presentation of flooding including water depth and pressure; and overlay of results on background graphics such as maps or aerial photos.

The software is also capable of two-dimensional surface flow analysis with proper software licenses and can be readily built upon for future modeling efforts.

3.9 Model Operation

MIKE+ performs two separate calculations for the model. First, a runoff calculation (hydrologic analysis) estimates the amount of water entering the storm drain system during a design rainfall event. Second, a network flow calculation (hydraulic modeling) replicates how the storm drain system will convey flows to outlet locations. Flows resulting from the runoff calculation are used as inflows for the subsequent network flow calculation.

The MIKE+ runoff model offers a choice of infiltration methods. The City storm drain models use the Soil Conservation Service (SCS) Unit Hydrograph Method (UHM) to estimate surface runoff from the delineated catchment areas. A simulation can be started at any point during the chosen design storm to assess surface runoff for any period of the design storm, with computations made based on a user-specified time step.

3.9.1 Input and Output

Surface runoff calculations require two types of input data: boundary and catchment. Boundary data for the run-off computation consists of an input rainfall time series representing the design storm event for the model.

Catchment data includes the pipe network and boundaries of each drainage catchment, along with relevant physical and hydrologic parameters including surface area and factors used to calculate basin lag time. Drainage catchments for the study area are shown in Figure 3-12. Catchments were delineated for the entire drainage system. Runoff from some catchments was not used in the hydraulic modeling.

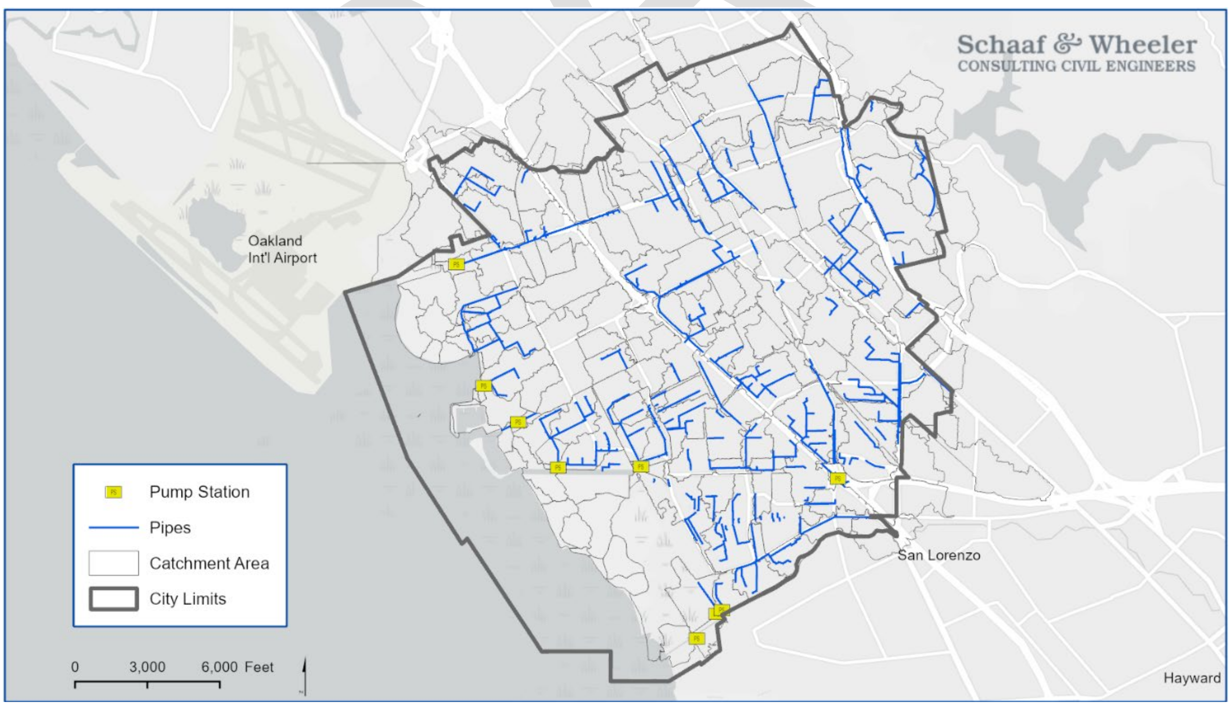

Figure 3-12: City of San Leandro Storm Drain System Catchments and Modeled System Elements

A summary of additional operation details is listed in Table 3-6.

Table 3-6: Summary of Model Input and Output

Model	Inputs	Outputs
Runoff	*Boundary Data* • Rainfall time series *Urban Catchment Data* • Drainage catchments • Lag time • Curve number	Runoff hydrographs for each individual catchment
Pipe Flow	*Storm Drain Network* • Nodes (catch basins, manholes, outlets, etc.) • Links (pipes, culverts, open channels) • Operational data (pump curves, basin elevation-volume curves, etc.) • Catchment connections • Junction losses • Boundary data (e.g., water surfaces at outfalls) • Catchment runoff hydrographs • Water surface elevation time series	Water level at each node Water level in network links Velocity in network links Water volume in the system Discharges at each link or structure (pump, weir, orifice)

4 Evaluation of Storm Drain Systems

4.1 Overview

This chapter describes deficiencies in the piped collection system, historical problem areas, and other known flood hazards. Detailed descriptions of necessary capital improvement projects and their prioritization are provided in this chapter.

4.2 Existing Conditions Flooding

The SDMP evaluates the existing storm drain system performance for the 10-year design storm. The maximum flood depths that occur during the 10-year storm is shown in Figure 4-1 and in greater detail in Appendix A. In this flood study, the SDMP proposes CIP projects that can eliminate or ameliorate the identified system surcharge beyond the design standard.

This analysis uses the MIKE "Node Flood" result, which does not necessarily represent a true to life flooding depth. It represents a level of hydraulic grade surcharge above the defined ground surface elevation at each node. Higher node flood values are considered a good analog for greater surface flow or ponding depths, depending on local conditions at each node in the system.

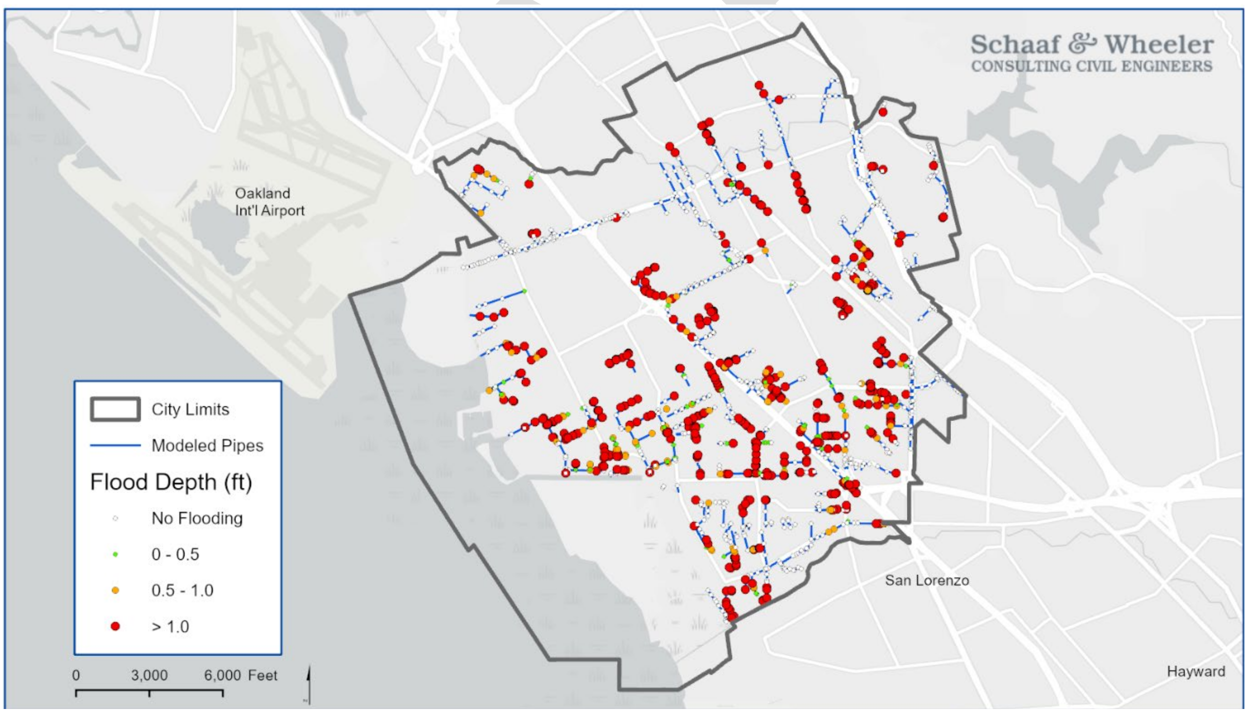

Figure 4-1: Node Flood Result from Existing Condition Model

4.3 Improvement Projects

Improvements have been developed that reduce 10-year flooding to a maximum depth of 1 foot. Recommended CIP projects are identified graphically, and general project routes are given. CIP priorities are assigned based on the consequence of flooding in the existing 10-year storm condition and on ownership of the pipes in the area.

- Very-High Priority CIP projects:
  - Mitigate the most severe 10-year flooding on residential or commercial properties that spreads across several streets and can widely disrupt traffic, residential, and commercial activities. Flooding is likely to spread across a large number of surrounding parcels.
  - Are located downstream of projects of all other priorities
  - Mandated trash capture projects

- High-priority CIP projects:
  - Mitigate extensive 10-year flooding on residential or commercial properties that spreads across several streets and can widely disrupt traffic, residential, and commercial activities. Flooding is likely to spread across a large number of surrounding parcels.
  - Are located downstream of moderate and/or low priority CIP projects.
  - Are entirely City-owned

- Medium-priority CIP projects:
  - Mitigate moderate flooding on residential or commercial properties and are likely to remove a moderate number of parcels from the 10-year floodplain.
  - Are located downstream of low priority CIP projects.
  - Are primarily defined on dominantly City-owned pipe systems with little interconnectivity or reliance on ACFCD facilities.

- Low-priority CIP projects:
  - Mitigate 10-year flooding that is beyond the maximum depth of one foot but is unlikely to cause extensive property damage or disruption to traffic.
  - Are at the most upstream end of pipe systems.
  - Are aimed solely at providing long-term resilience against climate change impacts.
  - May be defined where flooding is primarily due to capacity-deficient ACFCD facilities downstream.

City-owned storm drainpipes 18 inches and larger in diameter are evaluated. Pipes that act as laterals are not included in the mainline analysis but are treated to be part of the system that delivers flow into the main drainage lines. County pipes are included in the model only in areas where the City pipes connect to them prior to the outfall. Pipes smaller than 18 inches in diameter are included in the model in locations where the City has indicated known flooding issues.

4.3.1 ACFCD Facilities

In some areas, the capacity of existing ACFCD-owned facilities limits the effectiveness of projects focused on City-owned systems. To develop City projects, capacity deficiencies have been identified in downstream ACFCD facilities and remedied in the model to determine the properties of projects on City-owned systems that would be required to meet the 10-year level of service standard.

Subsequently, the ACFCD facilities have been reverted back to existing conditions in the model to determine the effectiveness of the City CIP projects in isolation. Maps of “node flood” results and the difference between results with and without ACFCD system capacity restrictions are shown in Figure 4-1 and Figure 4-2.

ACFCD has completed several pump station evaluations as well and has provided those documents for review. Their consultants constructed detailed models of systems upstream of certain pump stations. These documents provide an evaluation of 15-year system and pump station capacity and in some cases provide two-dimensional model results. Existing ACFCD pump stations were not improved in the models.

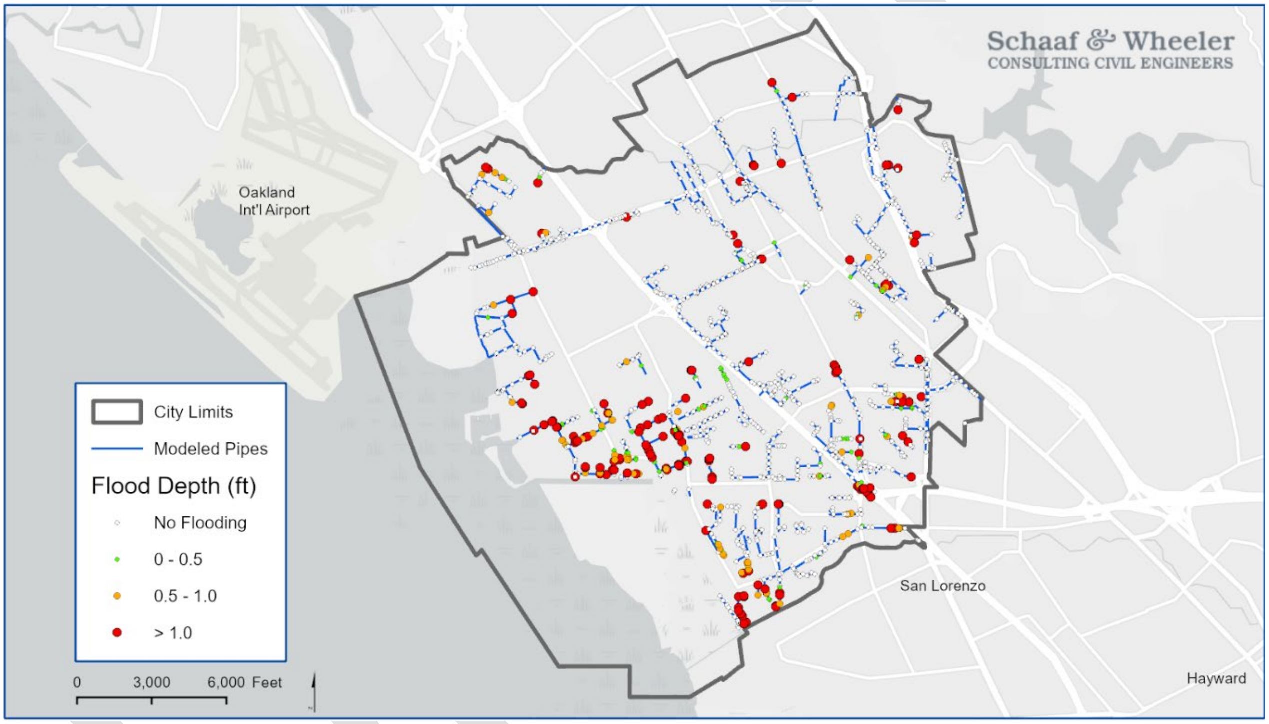

Figure 4-2: Node Flood Results Including ACFCD Gravity System CIP Projects

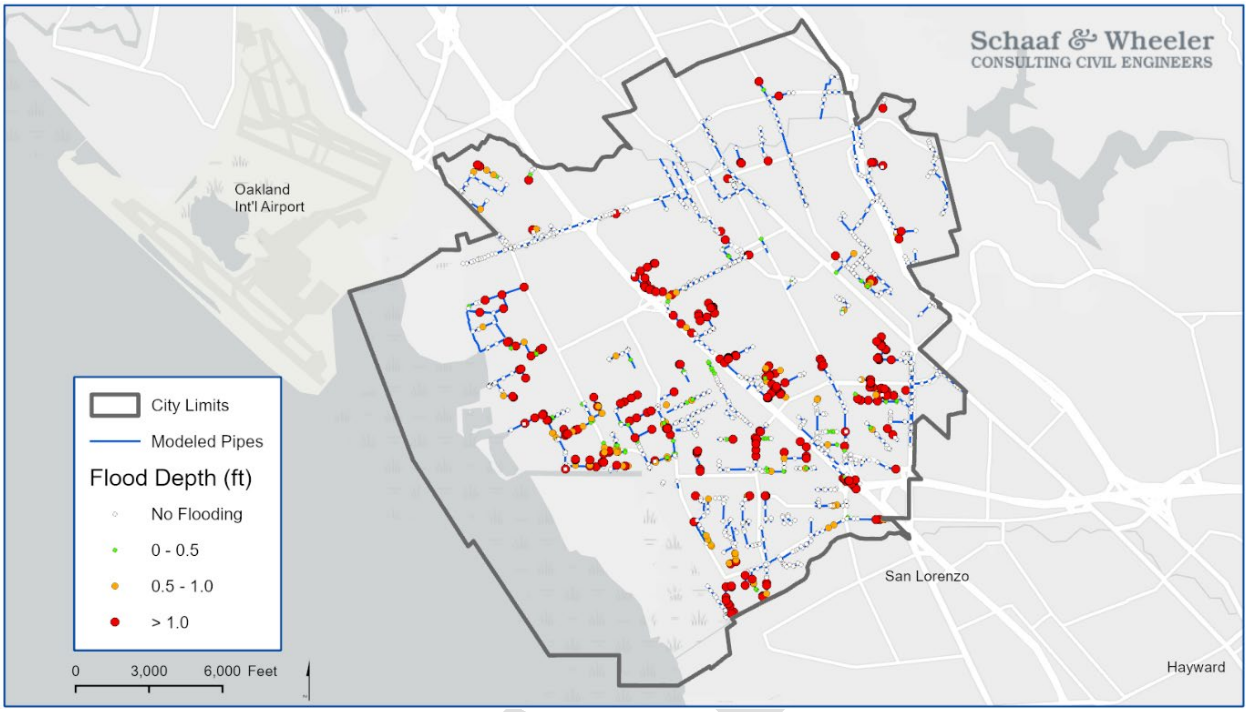

Figure 4-3: Node Flood Results Not Including ACFCD CIP Projects

Recommended capacity improvements on City systems are shown in Figure 4-4

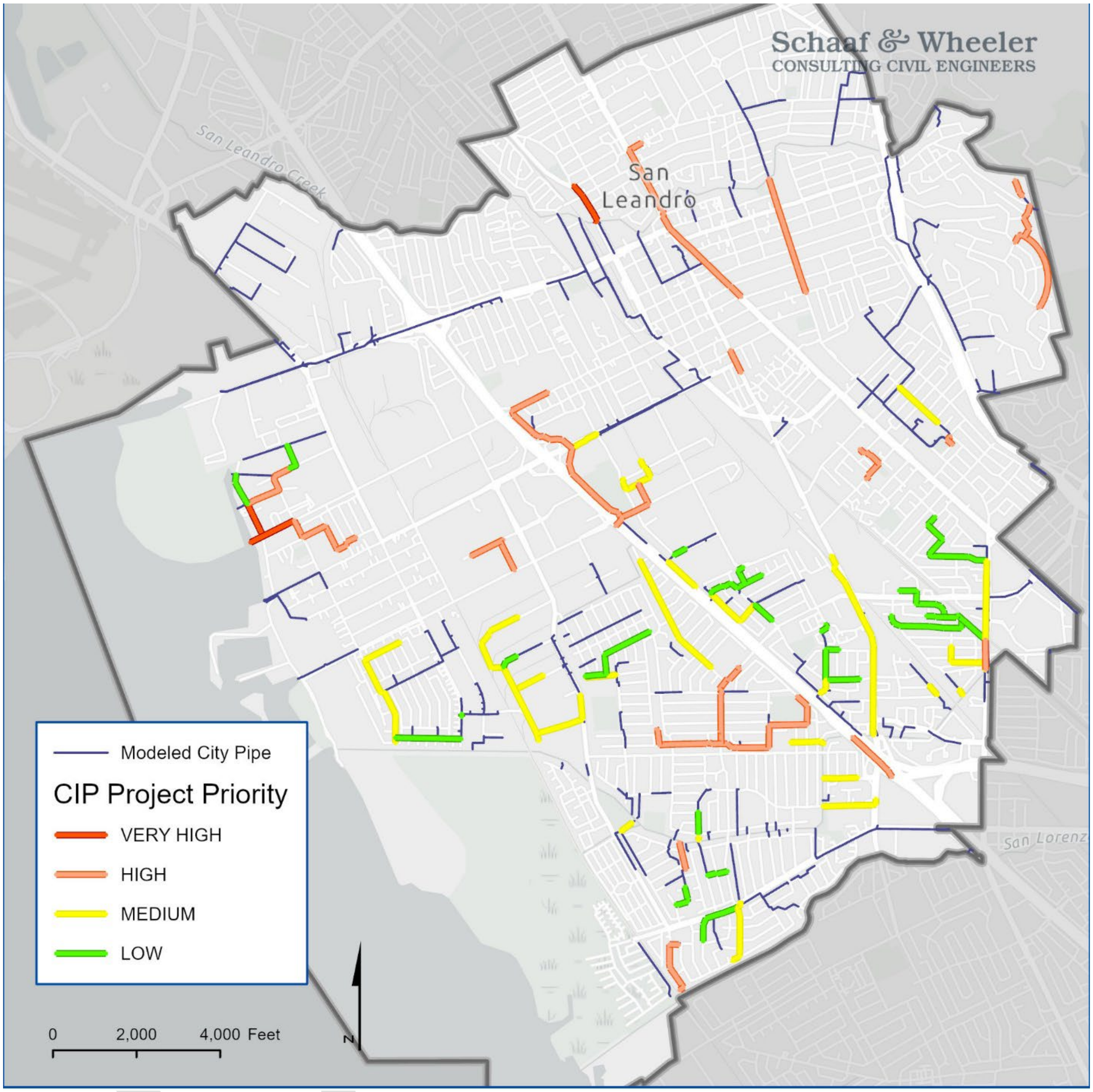

Figure 4-4: Prioritized CIP Project Map

4.4 Alternative Improvement Projects

To increase storm drain system capacity, two types of projects are available. One option is installation of a new relief storm drain parallel to the system lacking capacity, or the overloaded pipe can be replaced with a larger diameter pipe in the same alignment.

The two alternatives can be made equivalent to one another using the following formula, assuming that pipe material and length are equal:

$$D_R = \left(D_e^{2.63} + D_p^{2.63} \right)^{0.38}$$

Where D_R = Diameter of replacement pipe

D_e = Diameter of overloaded pipe

D_p = Diameter of parallel relief drain

The City's selection of a capacity improvement strategy will vary from project to project. It will be governed by construction constraints, including available rights-of-way and existing utilities. Most likely, the storm drain CIP for the City will utilize parallel relief drains unless right-of-way and utility constraints appear to favor the pipe's actual replacement, which is more costly.

Installing new parallel drains should be more cost-effective than replacing pipes in most cases since the required pipe size is smaller, and the existing pipe can stay in place. To be conservative on the cost estimate, pipe replacement, which is the more expensive method, is used as the default project.

4.5 Climate Change Impact

The model includes adjustment of the precipitation timeseries to reflect higher intensities expected during extreme precipitation events. This model has been run to evaluate the proposed CIP project set's resilience against greater levels of rainfall and higher tidal boundary conditions.

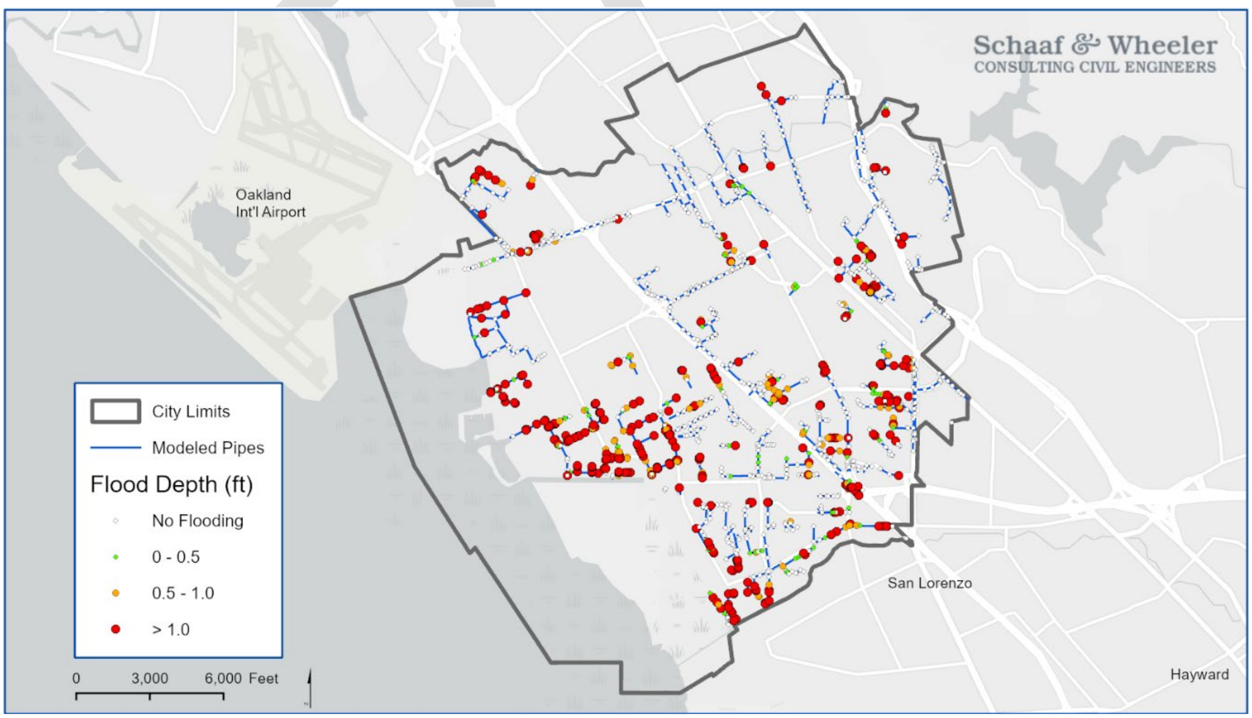

Figure 4-5: 2050 SLR Flood Results

The size of capital improvements has not been adjusted. This merely provides a tool for evaluating which projects will require further climate change resilience considerations during the design of these projects. Furthermore, since it is difficult to predict how coastal protection measures will be developed, this analysis assumes that appropriate protection is present to prevent tidal flooding propagating inland from the shoreline.

While many areas of the City are drained by existing pump stations, a 460-acre area of primarily industrial properties north of Williams and south of Davis Street rely solely on gravity drainage systems discharging to coastal outfalls near Oyster Bay. This area is likely to become more affected by high tide conditions with sea level rise by 2050. Other areas that rely only on gravity drainage systems will become increasingly susceptible to tidal flooding by 2100. Drainage areas to those systems include a 220-acre area near the northern City boundary that drains to the Metropolitan Golf Links, as well as 550 acres surrounding the Flood Control Canal east of the railroad. These drainage areas are highlighted in Figure 4-6.

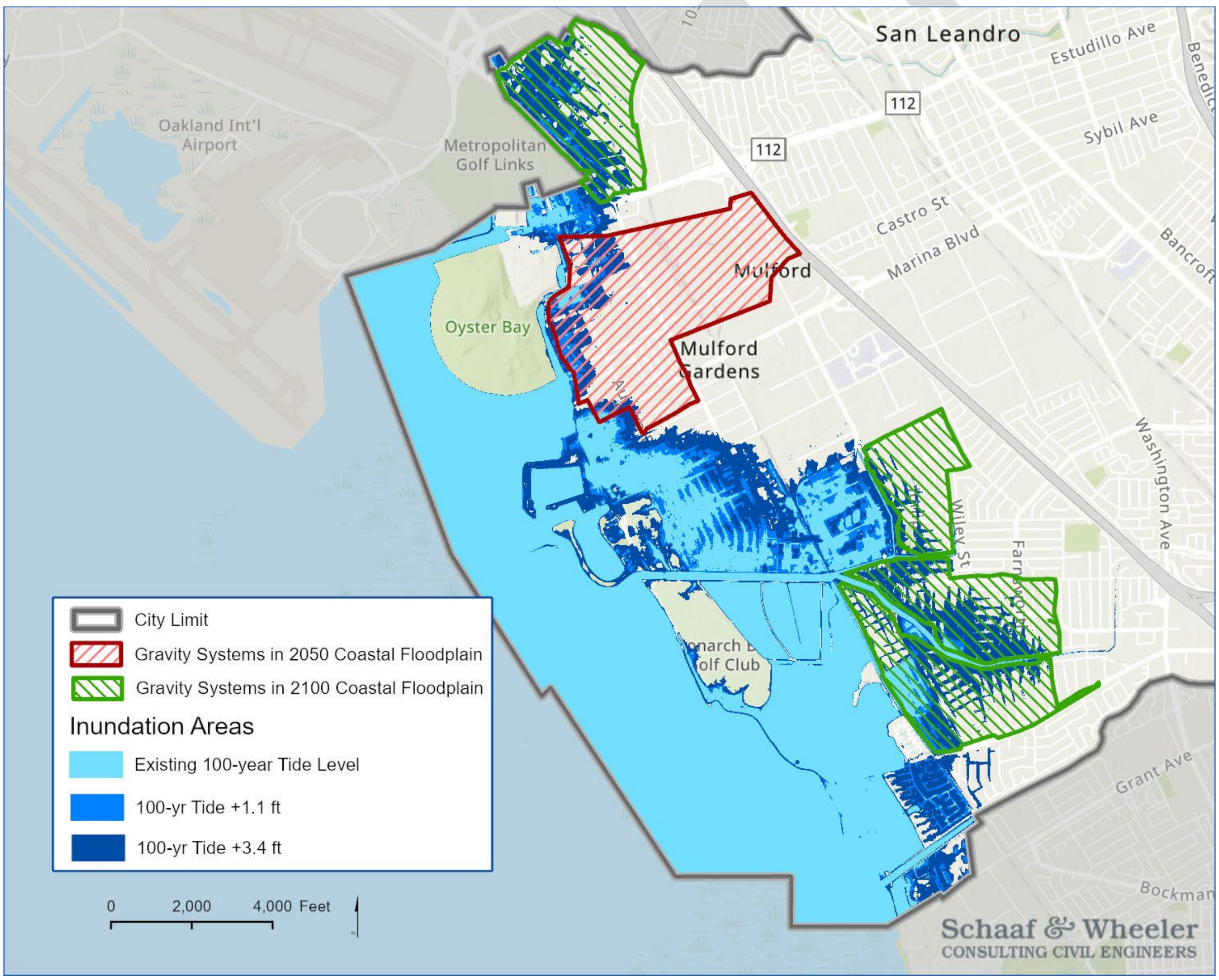

Figure 4-6: Areas with High Susceptibility to Future Tidal Flooding with Only Gravity Systems

It is assumed that this will not continue to be viable as mean high tides increase and the coastal floodplain expands. The area around Neptune Avenue will become susceptible to 100-year tidal flooding by 2050. The addition of a new pump station on Neptune Drive with connections to the gravity drainage systems from Williams Street to north of Polvorosa Avenue will alleviate current flooding in the area and protect against future SLR flooding.

A pump station project has been defined for the areas around Neptune Avenue that are most susceptible to increased coastal flooding by 2050 and documented impacts of Bay sediments. For the purposes of this SDMP, it is assumed that the pump station will be designed to discharge a 10-year peak flow from the tributary systems. Projects are defined in the area to connect the existing gravity systems together so that only one pump station must be built and maintained.

Gravity improvements and new system interconnects should be constructed first in the area. Trash capture projects in the area should contemplate the impacts of connecting the systems together and eventually relying on a pump station for discharge against high tides. Figure 4-6 shows the results of adding a pump station on Neptune Avenue in a 2050 SLR scenario in a 10-year storm occurring coincident with 100-year tides. The remaining flooded nodes in the area all experience short duration flooding just over one foot of depth in a depressed, vegetated area. The HGL is not high enough to reach the surrounding building pads.

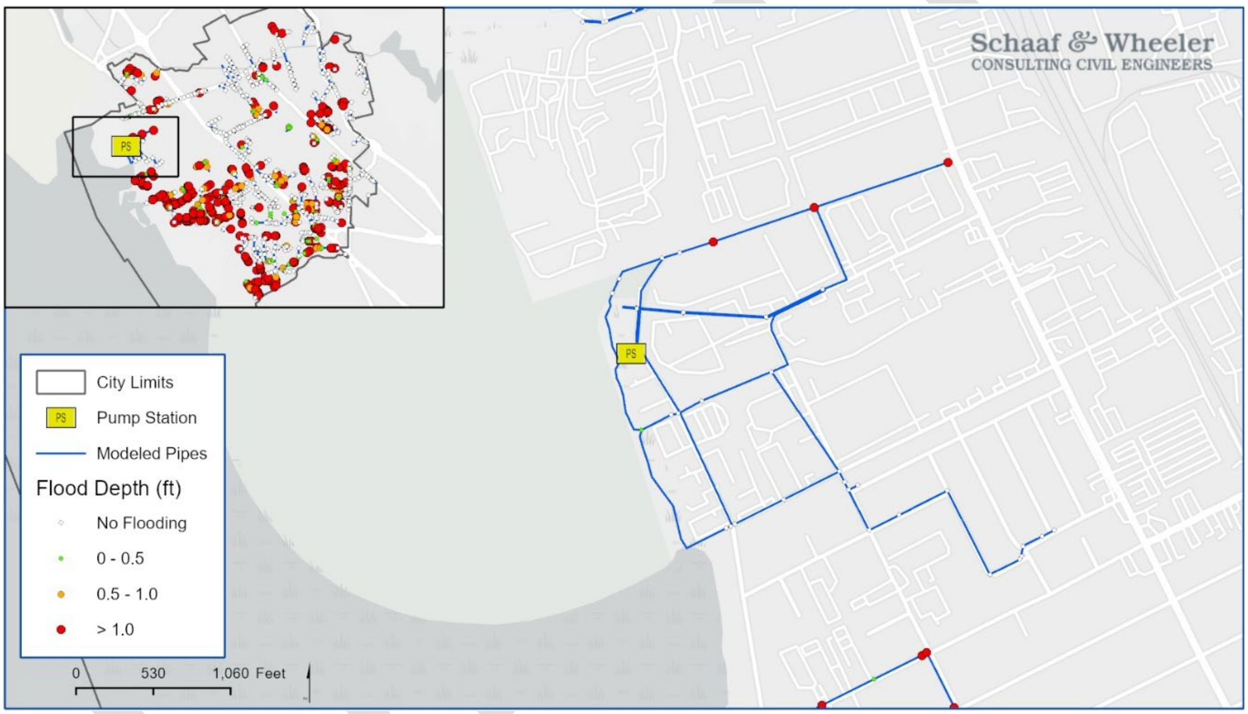

Figure 4-7: 2050 SLR Scenario with Installation of New Pump Station

Changes to existing pump stations may also be required with climate change to handle greater runoff from precipitation events and higher tidal boundaries that impact pump hydraulics. ACFCD owns most of these pump stations, but the City’s Wicks station will likely require new pumps and electrical systems at a minimum. If the pump capacity need becomes greater, the wetwell may also need modifications or replacement.

Some information on Wicks station’s motors is available. However, information on the axial flow pump models installed in the wetwell is not. Reasonable assumptions have been applied to the station to model an approximate capacity. Motors are 240 Volt, 20 HP operating at 1,175 rpm, based on nameplate information. Literature has been referenced from various axial flow pump manufacturers to estimate that each pump has a capacity of approximately 11 cfs each.

4.6 Collection System Capital Improvement Program

CIP projects for the piped collection system are identified in Table 4-1 and are shown in greater detail in Appendix B. Detailed figures, descriptions, and cost estimates for each very high priority CIP project are included in Appendix C.

Table 4-1: Capital Improvement Projects

Project No.	Priority	Description
1, 37	Very High/High	Williams Street from Aurora Drive to Marina outfall, connecting pipe on Aurora
2	High	Nicholson and Republic
3, 38	High/Medium	System from Williams/Sundberg and Marina Boulevard, adjacent to east side of Nimitz Freeway
4	Medium	West of Upton Avenue
5, 39, 40	High/Medium/Low	Hesperian Blvd and branching systems to the west
6	High	Bancroft Avenue
7	High	East 14th Street north of channel
8	High	East 14th Street south of channel
9	High	Lakeview Drive system in northeast of City
10, 41	Medium/Low	Belvedere Avenue and Flagship Street
11, 42	Medium/Low	Area northeast of the intersection of Farallon Drive and Wicks Boulevard
12	Medium	Willow Avenue South
13	Low	Willow Avenue North
14	Medium	Corvallis Street north of channel
15	Medium	Corvallis Street south of channel
16, 43	Medium/Low	Portola Drive, Figeroa Drive, Arguelo Drive
17, 44	High/Low	Hubbard Avenue to Washington Manor Park
18	Medium	Washington Avenue
19, 45	Medium/Low	Carmel Way and Monterey Boulevard to Serra Drive
20	Very High	San Leandro Boulevard from Best Avenue to San Leandro Creek
21	High	Estabrook Street
22	High	Reed and 143rd
23, 46	High/Medium	Lark Street
24	Medium	Central Avenue
25	Medium	Martell Avenue
26	High	Washington Pump Station Piping
27	Medium	Beatrice Street
28	Medium	Fargo Avenue
29	Medium	North of Manor Boulevard (west)
30, 47	Medium/Low	Off Lewelling Boulevard and Farnsworth
31	Medium	South of Stenzel Park
32, 48	High/Low	West of Mendocino/Laverne Drive
33, 49	Medium/Low	Inverness Street
34	Low	Teagarden Street to east side of Nimitz Freeway
35, 50	Medium/Low	Nimitz Freeway near Teagarden Street
51	Very High	Pipe on Aurora Drive from south of Polvorosa Avenue to Williams Street to redirect flooding from Neptune Avenue
52	High	Pipes connecting to Wicks Pump Station from north of Toronto Ave

5 Operations, Maintenance, and Replacement

The intent of this SDMP is not to focus on storm drain system operations and maintenance requirements or techniques. Rather, some foresight is provided into anticipated ongoing maintenance schedules, including periodic replacement of major storm drain system components. The City needs to set aside sufficient funds for annual facility maintenance and a systematic, long-term replacement program as some of its older storm drainage infrastructure is reaching the end of its useful life.

5.1 General Maintenance Regimen

Table 5-1 presents general criteria that can be useful in establishing a routine maintenance regimen. City staff will have the best experience with the necessary frequency and extent of ongoing maintenance on a system-by-system basis. Also, maintenance needs will fluctuate depending on seasonal and annual factors, particularly the amount of precipitation and, to a lesser extent, the general climate.

It is vitally important that all collection, storage, and pumping systems be in working order prior to the start of the wet season, which is near the end of October. Due to limited staff resources, certain items will have higher priority than others.

Table 5-1: Storm System Maintenance Guidelines

Category	Schedule
Inlet Inspection	annually (summer-fall)
Inlet Cleaning	as required (ongoing)
Storm Drainpipe Cleaning	continuous if possible (ongoing)
Channel Cleaning/Desilting	annually (fall)
Culvert Cleaning/Desilting	annually (fall)
Detention Basin Dredging	every 10 years
Pump Exercising	monthly (year-round)
Engine Exercising	monthly at full load (year-round)
Equipment Lubrication	per manufacturers' recommendations
Drain and Fill Diesel Fuel Tank	every six months
Motor/Engine Control Testing	annually (fall)

The storm drain and channel system cannot function if one of its components is plugged. Even though hydraulic analyses show criteria are met, blocked inlets, pipes, or channels will cause flooding. Lagoons and pumping forebays need to be monitored and periodically dredged to preserve design capacities.

It is important to maintain the more natural drainage features, such as non-creek open channels and basins. This will prevent them from becoming jurisdictional. Extensive regulatory permits will not be required to perform what should be routine maintenance.

Based on system history, the most significant problems occur at the base of the foothills, where sediment- and debris-laden runoffs are easily carried within the steeper pipes and streets. The sediment and debris are deposited as the topography flattens out within the City limit. Some of this sediment and debris originate outside of the City limits in unincorporated Alameda County.

5.2 Regulatory Background

Stormwater pollution control requirements in the City are rooted in the passage of the 1969 Porter Cologne Water Quality Act in California and the 1972 Federal Clean Water Act. The U.S. Environmental Protection Agency (EPA) is charged with implementing water quality regulations and setting standards for all surface waters federally. Since 1987, the U.S. EPA has required National Pollution Discharge Elimination System (NPDES) permits for surface water discharges from Municipal Separate Stormwater Systems (MS4). These permits specify allowable concentrations of pollutants, prohibit certain discharges, and sometimes identify stormwater best management practice (BMP) requirements for new development and redevelopment.

States with EPA authorization, including California, administer NPDES permits that have molded the adoption of local pollution control ordinances, development of stormwater management manuals, and other local programmatic activities. The Porter Cologne Act established the California State Water Resources Control Board, responsible for administering NPDES permits in California, and a system of nine Regional Water Quality Control Boards (RWQCB).

The California Regional Water Quality Control Board San Francisco Bay Region (Water Board) has found that stormwater runoff from urban and developing areas within the San Francisco Bay region contains significant sources of pollutants that contribute to water quality impairment in the waters of the region. In the City, these could include creeks, streams, and San Francisco Bay. In conformance with the Clean Water Act, the Water Board has established total maximum daily loading limits (TMDLs) for various pollutants to gradually eliminate the water bodies' impairment and attain water quality standards.

As a co-permittee, the City is required to effectively prohibit the discharge of anything other than stormwater into storm drain systems and watercourses. It is specifically prohibited from discharging rubbish, refuse, sediment, or other solid wastes into surface waters or anywhere such trash will eventually transport to surface waters, including floodplain areas.

5.2.1 Routine Practices

The City shall implement BMP to control and reduce polluted stormwater and non-stormwater discharges to storm drains and watercourses. BMP shall be implemented during operation, inspection, and routine repair and maintenance activities of municipal facilities and infrastructure. These practices apply to:

- Road repair and maintenance
- Sidewalk and other hardscape repairs, maintenance, and cleaning
- Structural maintenance (e.g., bridge repair) and graffiti removal
- Stormwater pump station operation and maintenance
- Corporation yard activities
- Construction sites
- Pesticide toxicity control

The City must implement an industrial and commercial site control program at all sites that could reasonably be considered to cause storm water runoff pollution. Routine inspections and enforcement to abate actual or potential pollution sources need to be consistent with an Enforcement Response Plan (Plan). The Plan is prepared to confirm the implementation of appropriate and effective pollutant controls by industrial and commercial site operators.

In addition, the City is responsible for detecting and eliminating illicit discharges by any parties within its jurisdiction. An illicit discharge program shall be developed and implemented to include active surveillance, a centralized point of contact for complaints, a tracking system, and reporting. Public outreach and water quality monitoring, which can be collaborative with other co-permittees, such as Alameda County, are also permit requirements.

5.2.2 New Development and Redevelopment

The City administers the implementation of new development and redevelopment projects to comply with the Municipal Regional Stormwater Permit requirements. Project administration includes project review and permitting in the areas of: site design, onsite stormwater treatment, hydro-modification management, landscaping, trash enclosures, plumbing, swimming pool water disposal, and fire test water disposal.

The MS4 Permit allows the City to consider the construction of regional stormwater treatment facilities in lieu of treatment on individual building sites. Such regional stormwater treatment facilities are not factored into capital planning for the stormwater system described in this SDMP.

5.2.3 Green Infrastructure

Development of green infrastructure aims to gradually transform the urban landscape and storm drainage systems from “gray” to “green.” It involves shifting from having stormwater flow directly off impervious surfaces into the storm drainage system to having runoff flow into a local, sustainable system.

Options include draining into vegetated areas for infiltration and evaporation, collecting runoff for non-potable uses, using permeable pavements, and treating runoff with biotreatment. This green infrastructure will help limit the transport of pollutants in stormwater by reducing runoff. Coordinating the proposed CIP projects with street greening can lower the marginal cost of stormwater management.

5.2.4 Trash Capture

As part of the MRP, the City is tasked with removing trash, which can make its way to Creeks and ultimately to San Francisco Bay via the City’s Municipal Separate Storm Sewer System (MS4). The City’s June 2023 Revised Trash Load Reduction Plan forms the City’s current guide to attaining 100% trash capture by 2025. The City is currently pursuing the design of six large-scale trash capture devices that will constitute a total trash load reduction of 10%.

Models produced for this SDMP effort are useful in evaluating the function and impact of proposed and future trash capture devices. This provides a useful tool for more efficiently developing trash capture projects that meet the requirements of the MRP.

5.3 Municipal Regional Stormwater Permit Requirements

San Leandro participates in the Alameda County Clean Water Program as a co-permittee under the California Regional Water Quality Control Board San Francisco Bay Region (Water Board) Municipal Regional Stormwater NPDES Permit (Order No. R2-2015-0049). Also referred to as the “MS4 Permit” or “MRP”, it became effective on November 19, 2015. Requirements outlined in the City’s MS4 Permit are subject to change.

This SDMP does not intend to document specific NPDES requirements or their implementation. Rather, it intends to provide a brief background regarding the requirements likely to affect system-wide operation and maintenance. An allowance is made in the next chapter for typical annual costs to satisfy system-wide permit requirements. A permit update (MRP3.0) was adopted in 2022.

5.4 Clean Water Program

The creeks and channels that flow through the City are prone to pollution from a variety of sources. Historically, the primary sources of pollution in the City have been heavy industries, landfills, and sewage plants, many of which discharged directly into San Francisco Bay with little or no treatment.[4]

The Clean Water Program includes several components aimed at meeting the requirements of the MRP, including:

- Regulatory compliance and illicit discharge control
- Trash capture programming and implementation
- Watershed planning
- Stormwater monitoring
- Public outreach and education
- Public works maintenance
- Development and construction controls

The Clean Water Program has been responsible for the implementation of numerous improvements to the storm drainage system to remove trash and pollution.

The City also administers a Storm Water Management and Discharge Ordinance. The intent of the Ordinance is to eliminate non-storm water discharge to City storm sewers and reduce pollutants in storm water discharge to the maximum extent practical. The Ordinance provides a mandate for preventive measures, such as street sweeping and regular cleaning of storm drain inlets. It also establishes a local inspection and enforcement program, with fines and penalties for violations. The Ordinance prohibits development within 30 feet of the centerline of any creek or 20 feet from the top of bank without written authorization from the City.

Water quality monitoring is another key part of the City's Clean Water Program. Monitoring is regularly conducted in San Leandro Creek and in San Francisco Bay near the San Leandro shoreline. The purpose of the monitoring is to assess water quality conditions and trends and identify potential sources of contamination. No specific "hot spots" have been identified in the City. However, the urban character of the watershed continues to present a challenge to restoring water quality.

5.5 Staffing and Budget

The City receives $1,073,000 in annual revenue from a Storm Water Fee that was adopted in 1993. The revenue has been flat since 1993. However, costs have been escalating due to increasing regulations and inflation. The City's annual expenditures exceed revenue, and the Storm Water Fund operates at an increasing deficit. There are currently 3.8 full-time equivalent staff, excluding consultants, who handle system operations and maintenance, street cleaning,

[4] General Plan

and monitoring and reporting.

The 2024 – 2025 stormwater management expenditure budget is $1,225,000 (Table 5-2). The estimated annualized replacement, maintenance and insurance costs for the major equipment used for stormwater maintenance is included in the operations and maintenance budget and street cleaning annual costs. Analysis of the storm drain system’s annual O&M needs identifies additional expenditures for compliance with NPDES, trash capture maintenance, pipe cleaning and green infrastructure as outlined in the $1,860,000 O&M Need below.

Table 5-2: 2024-2025 Stormwater Budget

Item	2024-25 Budget Amount
Monitoring & Reporting	$458,000
Operations & Maintenance	$140,000
Street & Trash Cleaning	$627,000
Trash Capture Device Maintenance	$200,000
Pipe Cleaning	$100,000
Green Infrastructure	$100,000
TOTAL EXPENDITURES	**$1,325,000**

6 Storm Drainage CIP Funding Requirements

6.1 Overview

Chapter 5 discusses the City's storm drainage system capacity and known and/or modeled deficiencies. It further lays out a strategy for addressing various issues and bringing City systems into compliance with performance criteria to the greatest possible extent.

This is an SDMP-level effort. Hence, many of the practical constraints that will govern the detailed design and construction of actual infrastructure improvements are unknown at this time, such as:

- Utility interference and relocation
- Right-of-way and/or easement availability
- Traffic control requirements
- Geotechnical and hazardous waste conditions
- Archaeological discoveries and environmental impacts
- Regulatory and permitting requirements

This chapter provides an analysis of cost for the proposed projects.

6.2 Cost Basis

Table 6-1 and Table 6-2 provide unit cost information for storm drain collection systems. Costs have been estimated based on a variety of available information, including:

- Cost estimation guides (e.g. RSMeans)
- Inflation indices, published by the Engineering News Record (ENR)
- Actual cost and bid data from recent projects
- Engineering judgement

Table 6-1: Direct Unit Cost of Storm Drain Pipes in September 2023 Dollars (Per Linear Ft)

Item	New Conduit Unit Cost	Removal/Disposal Unit Cost
12" Pipe	--	$30
15" Pipe	--	$35
18" Pipe	$260	$40
21" Pipe	$290	$45
24" Pipe	$320	$50
27" Pipe	$370	$55
30" Pipe	$410	$60
36" Pipe	$490	$70

Item	New Conduit	Removal/Disposal Unit Cost
42" Pipe	$570	$75
48" Pipe	$670	$80
54" Pipe	$780	$85
60" Pipe	$880	$95
66" Pipe	$1,010	$100
72" Pipe	$1,190	$120
84" Pipe	$1,670	$150
96" Pipe	$2,010	$200
120" Pipe or 72" x 96" box	$2,510	$225

Unit costs have also been estimated for storm drain structures, including connection of new and existing pipe. These are summarized in Table 6-2.

Table 6-2: Storm Drain Structure Unit Costs in 2023 Dollars

Connecting Conduit	Unit Cost
30" Pipe	$17,500
36" Pipe	$17,700
42" Pipe	$18,300
48" Pipe	$18,600
54" Pipe	$20,200
60" Pipe	$20,600
66" Pipe	$22,400
72" Pipe	$22,900
84" Pipe	$26,100
96" Pipe	$28,700
120" Pipe or 72" x 96" box	$33,900

The ENR Construction Cost Index (CCI) for San Francisco as of September 2023 is 15,490, compared with a 20-city average of 13,000. Schaaf & Wheeler performed a detailed unit cost analysis for storm drainpipe and structures. This information has also been used with adjustment based on the ENR CCI to establish unit costs in 2023 dollars.

6.3 Capital Improvement Program Costs

The cost of the recommended projects (both capacity and repair/replacement) are summarized by priority in Table 6-3. More detailed estimates for each project are provided in Appendix A. In addition to capacity improvements, the City will be installing several large and small trash capture devices to meet the MRP trash capture requirements.

In June 2023, Schaaf & Wheeler analyzed the stormwater system and reported feasible locations for both small and large trash capture devices to the City. The estimated total cost for trash capture installation as well as 50-year operations and maintenance from that report was $15.5 million. Of that amount, approximately $5.5 million is for capital costs. Three of the large devices planned for installation capture some amount of Caltrans drainage. As a result, funding from Caltrans potentially up to $2.7 million may be available to fund the trash capture installation projects. The MRP requires full trash capture installation by June 2025.

Table 6-3: Baseline Project Cost Estimate Summary

Priority	Project	Pipe Length (ft)	Estimated Cost
Very High	**1** Williams St, Aurora Drive to Marina outfall	1,170	$ 1,631,000
	20 San Leandro Boulevard / Best Avenue	1,083	$ 671,000
	51 Aurora Dr connecting pipe	827	$ 440,000
	52 Trash Capture installation by June 2025	--	$ 5,500,000
High	**37** Williams St from ACFCD pipes	2,267	$ 1,842,000
	2 Nicholson and Republic	1,627	$ 1,319,000
	3 Williams / Sundberg / Marina Blvd	1,678	$ 1,014,000
	5 Hesperian Blvd and branching systems	717	$ 666,000
	6 Bancroft Ave	2,877	$ 2,867,000
	7 East 14th St north of channel	1,978	$ 1,354,000
	8 East 14th St south of Channel	1,159	$ 899,000
	9 Lakeview Dr system in northeast of City	3,598	$ 2,330,000
	17 Hubbard Ave to Washington Manor Park	7,430	$ 6,759,000
	21 Estabrook St	594	$ 350,000
	22 Reed and 143rd	1,141	$ 974,000
	23 Lark St	283	$ 246,000
	26 Washington Pump Station Piping	1,344	$ 827,000
	32 West of Mendocino/Laverne Dr	675	$ 940,000
	52 Wicks Blvd	1,510	$1,620,000
Medium	**38** Williams / Sundberg / Marina Blvd	2,254	$ 1,942,000
	4 West of Upton Ave	1,400	$ 914,000
	39 Hesperian Blvd and branching systems to the	1,901	$ 1,228,000
	10 Belvedere Ave and Flagship St	3,201	$ 2,648,000
	11 Farallon Dr and Wicks Blvd	4,633	$ 3,864,000
	12 Willow Ave South	746	$ 434,000
	14 Corvallis St North	2,054	$ 1,346,000
	15 Corvallis St South	1,090	$ 729,000
	16 Portola Dr, Figuroa Dr, Arguelo Dr	1,502	$ 1,233,000
	18 Washington Ave	4,607	$ 2,770,000
	19 Carmel Way and Monterey Blvd to Serra Dr	400	$ 370,000
	46 Lark St	1,290	$ 819,000
	24 Central Ave	177	$ 131,000
	25 Martell Ave	311	$ 130,000
	27 Beatrice St	843	$ 567,000
	28 Fargo Ave	1,408	$ 914,000
	29 North of Manor Blvd (west)	838	$ 418,000
	30 Off Lewelling Blvd and Farnsworth	3,475	$ 2,941,000
	31 South of Stenzel Park	347	$ 275,000
	33 Inverness St	87	$ 65,000
	35 Nimitz Fwy near Teagarden St	825	$ 851,000
Low	**40** Hesperian Blvd and branching systems to the	7,996	$ 4,983,000
	41 Belvedere Ave and Flagship St	1,645	$ 1,336,000
	42 Farallon Dr and Wicks Blvd	444	$ 276,000
	13 Willow Ave North	2,210	$ 1,422,000

Priority	Project	Pipe Length (ft)	Estimated Cost
	43 Portola Dr, Figuroa Dr, Arguelo Dr	1,927	$ 1,140,000
	44 Hubbard Ave to Washington Manor Park	560	$ 235,000
	45 Carmel Way and Monterey Blvd to Serra Dr	2,050	$ 1,280,000
	47 Off Lewelling Blvd and Farnsworth	1,368	$ 882,000
	48 West of Mendocino/Laverne Dr	683	$ 349,000
	49 Inverness St	538	$ 325,000
	34 Teagarden St to east side of Nimitz Fwy	503	$ 292,000
	50 Nimitz Fwy near Teagarden St	324	$ 225,000
	36 Neptune PS (195 cfs)	--	$ 10,000,000
TOTAL:		**85,595**	**$ 79,538,000**

Appendix A

Model Result Maps

Appendix B

CIP Project Map

Appendix C

Detailed CIP Project Tables and Sheets