SANITARY DISTRICT NO. 5 OF MARIN COUNTY
2001 Paradise Drive
Tiburon, California 94920

AGENDA
Capital Improvement Program Committee Meeting
Tuesday, April 13th, 2021, 2:00 p.m.

CORONA VIRUS (COVID-19) ADVISORY NOTICE

Consistent with Executive Orders No. N-25-20 and No. N-29-20 from the Executive Department of the State of California, the Meeting will not be physically open to the public and all Board Members and Staff will be teleconferencing into the meeting.

How to Submit Public Comments:
Comments submitted prior to the commencement of the meeting will be presented to the Committee and included in the public record for the meeting.

Public Comments are to be submitted via email to rdohrmann@sani5.org.

In addition, members of the public who are calling-in will have the opportunity to provide public comments by following the steps below:

How to Participate in the Meeting:
Join Zoom Meeting by clicking on the following link:

https://us02web.zoom.us/j/6230620778

Meeting ID: 623 062 0778

or join by phone:

Call in number: (669) 900-9128 **Participant Code: 623 062 0778**

I. Roll Call

II. Public Comments

III. New Business

1. **Review HDR's draft presentation re SD5's renewable energy study**
2. **Review of SD5's upcoming capital improvement projects for FY2021-2022**
3. **Review SD5's Collection System Master Plan Report (final), prepared by HDR**
4. **Discussion regarding future procurement of District vehicles in reference to The Ark newspaper article "Tiburon declares climate emergency, echoing state emissions, energy goals."**
5. **Review of the 2020 Cove Rd Force Main Project Completion data:**
   - Total Project Cost and break down per zone
   - Total project time and breakdown of added time due to changed conditions, owner requests and Caltrans' right-of-way delays.
   - Summary of project and final testing and operation of the newly installed 14" HDPE Force Main Sewer Line for the City of Belvedere and the 6" HDPE Force Main Sewer-Tiburon By-pass line.

IV. Adjournment

This Committee may be attended by Board Members who do not serve on this committee. In the event that a quorum of the entire Board is present, this Committee shall act as a Committee of the Whole. In either case, any item acted upon by the Committee or the Committee of the Whole will require consideration and action by the full Board of Directors as a prerequisite to its legal enactment.
Accessible public meetings: *Any member of the public who needs accommodations should email the Office Manager, at rdohrmann@sani5.org, who will use her best efforts to provide as much accessibility as possible while also maintaining public safety.*

Renewable Energy Study

Sanitation District No. 5 of Marin County

DRAFT Version 1, April 15, 2021

This page is left intentionally blank.

Contents

List of Figures

List of Tables

Executive Summary

Introduction

XXXX

Approach and Workflow

XXXX

Findings and Next Steps

XXXX

1.0 Introduction

1.1 Project Background

Sanitation District No. 5 of Marin County (SD5) is considering on-site renewable generation to reduce its carbon footprint. This study is intended to outline the feasibility of on-site renewable energy opportunities across SD5's facilities and to provide SD5 with cost and payback information related to the systems.

The study aligns with SD5's mission to protect public health and the environment through effective and economical wastewater treatment. The District's mission is outlined below, as stated on the SD5 website:

> *Sanitary District No.5 of Marin County is a special District, which while meeting or exceeding all applicable local, state and federal laws and regulations, is dedicated to the protection of public health and the environment through effective and economical collection, conveyance, treatment and disposal of wastewater*

1.2 Goals and Objectives

The primary goal for this study is to determine whether renewable energy systems are feasible for SD5 and whether they are a cost-effective investment for the District.

The individual objectives for this study are to:

- Benchmark current annual energy use for the District
- Review potential renewable energy systems and determine those that are considered feasible for the District to pursue.
- Assess each of the districts wastewater treatment plants (WWTP) and pump stations to determine those that viable for an on-site renewable energy installation.
- Calculate the potential renewable energy generation for each of the sites where renewable energy is determined to be viable.
- Determine anticipated system costs and identify the likely payback duration.
- Prioritize the locations for which SD5 should consider installing renewable energy systems.

1.3 Report Purpose and Organization

SD5 will use this Renewable Energy Study as a reference and baseline for assessing renewable energy opportunities across its network of WWTPs and pump stations in Belvedere and Tiburon.

The following sections are included in the study:

1. SD5 Facilities and Energy Use
2. Renewable Energy Opportunities
3. System Interconnection
4. SD5 Renewable Energy Potential
5. Cost and Ownership Options
6. Implementation

1.4 Assumptions and Dependencies

The analyses and recommendations in this Study are based on the following assumptions and dependencies:

- The information, data and interpretations obtained from the data sources and reports provided are assumed to be accurate and correct. No attempt has been made to verify these sources of information.
- SD5's annual energy use data for the referenced 12-month period is an accurate interpretation of average annual energy use for the District.

1.5 Abbreviations and Definitions

The following abbreviations and definitions are used in this report:

HDR	HDR Engineering
MCE	Marin Clean Energy
NEM	Net-Energy Metering
NREL	National Renewable Energy Laboratory
PG&E	Pacific Gas and Electric
PV	Solar photovoltaic
REC	Renewable Energy Credit
SD5	Sanitation District No. 5 of Marin County
WWTP	Wastewater treatment plant

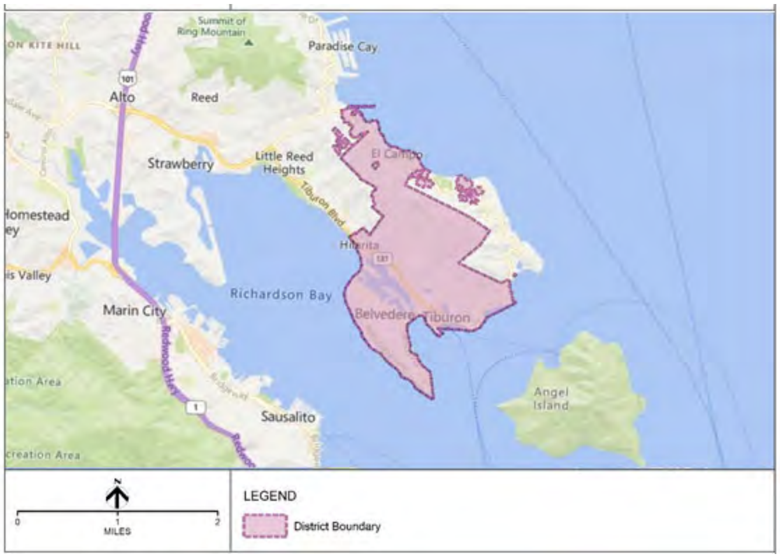
2.0 SD5 Facilities and Energy Use

SD5 is a special district established in 1922 that has been providing wastewater collection and treatment services to parts of the Tiburon Peninsula and the City of Belvedere since the early 1940s (SD5, 2020c). It currently provides services to more than 3,500 households and covers approximately 2,550 acres.

2.1 Service Area and Population Served

Located on the Tiburon Peninsula north of the city of San Francisco and on the San Francisco Bay, SD5 serves a population of approximately 8,400 people in the town of Tiburon, the city of Belvedere, and the surrounding, unincorporated areas (Figure 1). SD5's Main Treatment Plant collection system consists of 28.8 miles of gravity sewer line, 2.6 miles of force main, and 22 pump stations. The treatment plant provides secondary treatment of residential and commercial wastewater. The Paradise Cove collection system has an additional 1.5 miles of gravity sewer line, 2.3 miles of force mains and two pump stations that direct wastewater flow to the Paradise Cove treatment plant.

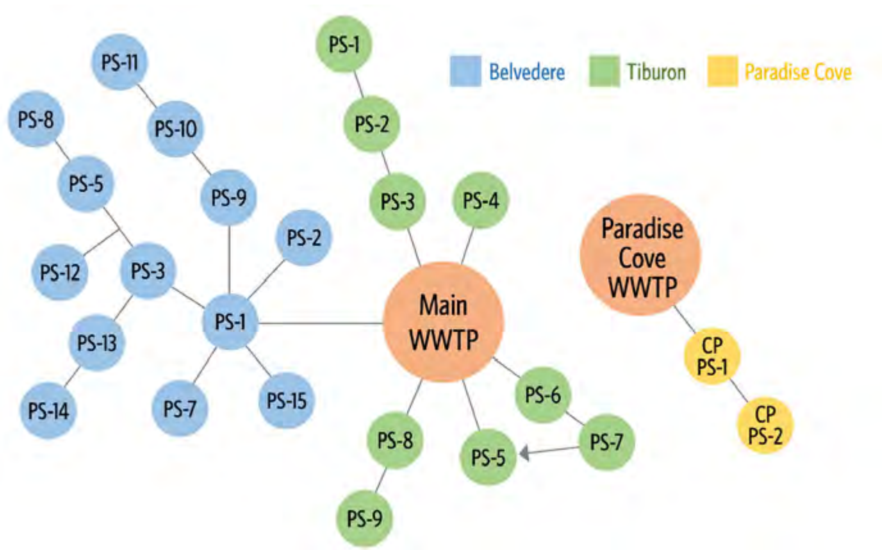
Figure 1 – SD5 Service Area



Source: SD5

SD5 collection system infrastructure is divided into two systems as shown in Figure 2: (1) the Main Treatment Plant collection system, which services all of the City of Belvedere and the southeastern and central portion of the Tiburon peninsula and (2) the Paradise Cove collection system, which services the northern portion of the Tiburon peninsula along the coast. Where gravity flow is not viable, SD5 pumps wastewater to its treatment plants through 24 pump stations and about 4.5 miles of force mains.

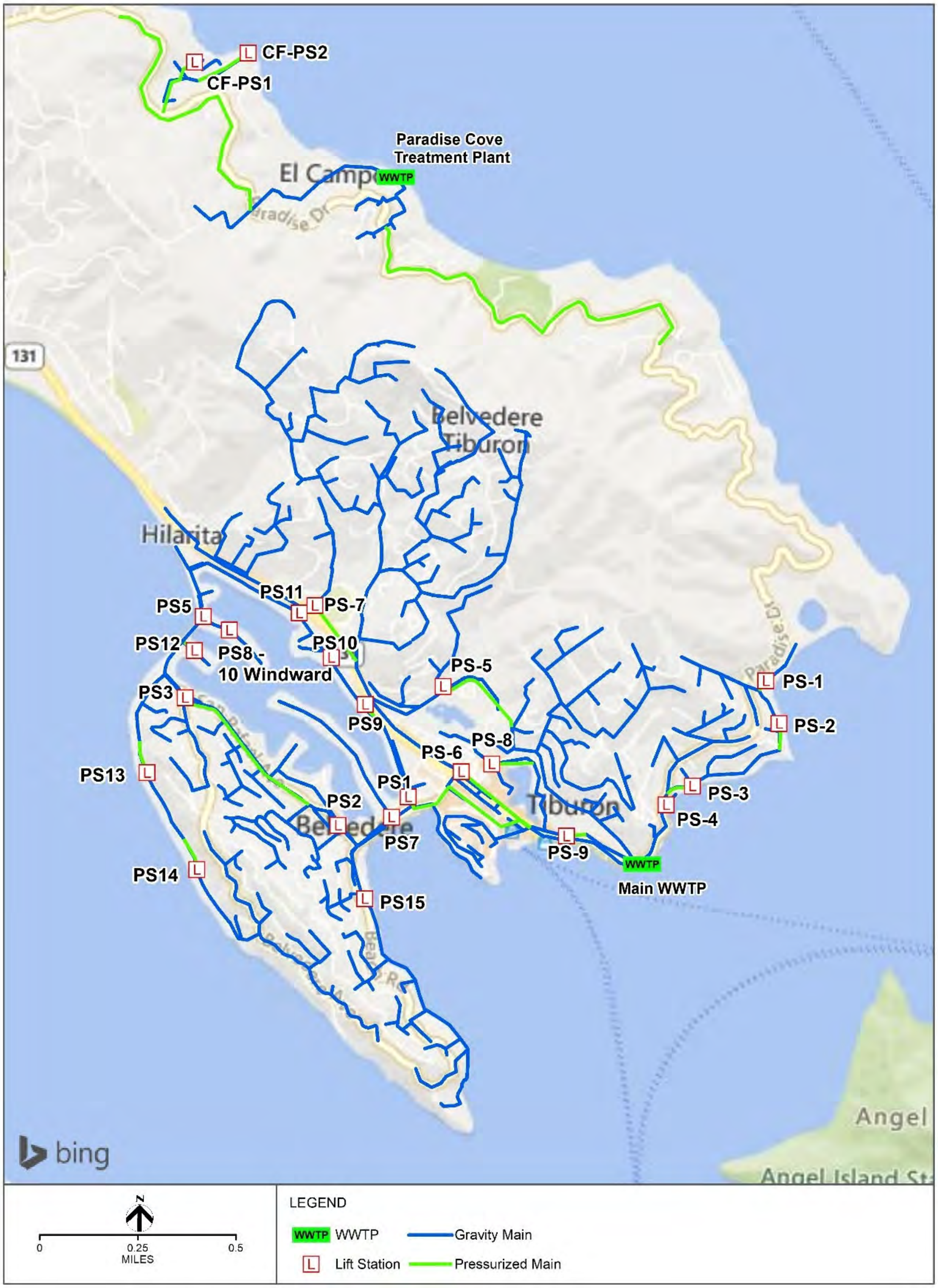
Figure 2 – SD5 Collection System and Lift Station Numbers



Source: SD5

The Main Tiburon WWTP, the Paradise Cove WWTP, and the 24 pump stations are located across Tiburon and Belvedere, as indicated in Table 3. This study benchmarks the current energy use at each of these locations and assesses whether each one is feasible for an on-site renewable energy system.

Figure 3 – SD5 Collection System and Lift Station Locations



Source: SD5

2.2 Current Energy Usage

SD5 uses both electricity and natural gas in its operations. This study looks at a full 12 months of data, from February 2020 through January 2021, to establish baseline energy use for the organization. This energy use is used to determine the impacts and/or sizing of any proposed renewable energy systems. During this period, SD5 used 1,256,007 kWh of electricity and 3,528 therms of natural gas. This usage data, broken out by each SD5 facility, is provided in Table 1.

Table 1 – SD5 Annual Energy Use, February 2020 to January 2021

Service Area	Lift station number	PG&E Account Name	Annual Natural Gas Use (therms)	Annual Electricity Use (kWh)
Tiburon	Main WWTP PS-8, PS-9	Mar West St, 2001 Paradise Drv	3,331	1,045,185.50
Paradise Cove	PC WWTP	Paradise Cove	0	75,931.35
Tiburon	PS-1, PS-2	About 2440 Mar East Opp 2514 Mar East St	28	9,509.35
Tiburon	PS-3, PS-4	S/W COR Solano & Mar East, Solano & Mar East St SW	24	12,250.57
Tiburon	PS-5	Mar West	0	40,440.60
Tiburon	PS-6	Tib Blvd COR/Beach, Corner Beach & Tiburon Blvd	23	2,173.25
Tiburon	PS-7	Tiburon Blvd MT, Tib Blvd Btw Reed Sch	19	4,678.42
Belvedere	PS-1, PS-7	Cove Road	28	23,575.68
Belvedere	PS-2	ACR 532 San Rafael Ave.	0	6,646.16
Belvedere	PS-3	CRNR San Rafael Ave, 00 Golden Gate Ave	17	9,569.20
Belvedere	PS-5	00 San Rafael Ave	20	1,413.62
Belvedere	PS-8	10 Windward Rd	0	1,072.05
Belvedere	PS-9	85 Lagoon Rd	0	2,227.05
Belvedere	PS-10	ABT 66 Lagoon Rd	0	1,110.36
Belvedere	PS-11	ABT 46 Lagoon Rd	0	1,465.50
Belvedere	PS-12	00 Edgewater Rd	0	1,096.61
Belvedere	PS-13	W Shore Road	0	1,850.68
Belvedere	PS-14	End of W Shore Road	0	3,300.06
Belvedere	PS-15	98 Beach Rd	0	2,350.96
Paradise Cove	CF-PS1	33 Seafirth Pl Pump Station	0	8,707.03
Paradise Cove	CF-PS2	95 Seafirth Rd	0	1,453.62
		Total	**3,528**	**1,256,006.96**

2.3 Energy Purchases

SD5 participates in the Marin Clean Energy (MCE) program, where electricity is distributed by PG&E, but generated and/or procured through Marin Clean Energy. SD5 is enrolled in the MCE Light Green service, which means that 60 percent of the electricity currently used by the organization is considered clean renewable power, sourced from either wind, solar, geothermal, small hydro, or biomass. Table 2 outlines the amount of current SD5 electricity that is considered clean power.

Table 2 – SD5 Annual Electricity Use, MCE Light Green Clean Power

Data Year	Total Electricity Use (kWh)	MCE Light Green Carbon Free Renewables (kWh)	Other Electricity Use (kWh)
February 2020 – January 2021	1,256,006.96	753,604.18 *(60 percent)*	502,402.78 *(40 percent)*

On-site renewable electricity generation systems, from sources such as wind and solar, will offset total electricity use used by SD5. By enrolling in the MCE Light Green service, 60 percent of the total net electricity used will be sourced from carbon free renewable sources. This means that if renewable energy systems are installed at SD5 facilities, but the total value of renewable energy generated on-site is less than the total value of energy consumed, then a static 60 percent of the remaining energy used will be carbon free.

On-site sources of renewable combustion, such as biogas, will offset natural gas use. This study will focus on opportunities for on-site renewable electricity generation only. The existing natural gas use will be excluded from the analysis. If SD5 wishes to reduce its carbon emissions from natural gas combustion, then it may consider electrification upgrades or the purchase of carbon offsets. These options are outside the scope of this analysis.

3.0 Renewable Energy Opportunities

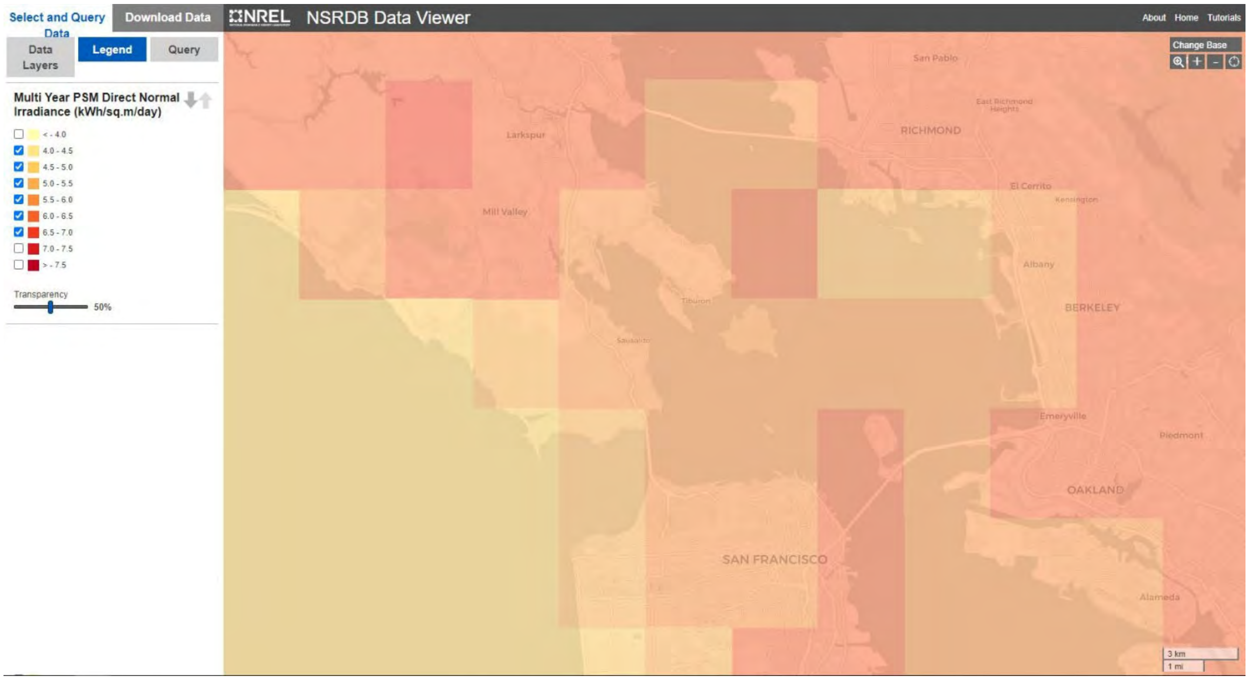
3.1 Renewable Energy

This study assessed five renewable energy sources to determine those that would be viable options to for further development and consideration. These sources include solar photovoltaic, solar hot water, wind, tidal power, biofuels, and offsets.

3.1.1 Solar Energy

The National Renewable Energy Laboratory (NREL) publishes solar resource data for the U.S., providing annual average daily total solar resources averages over a given surface area by state, and annual average photovoltaic solar resource data for a reference panel tilt for the entire country. The current data shows that Belvedere and Tiburon receives between 5.5 and 6.0 kWh/m2/day of solar insolation, averaged over the course of the calendar year.

Figure 4 – Solar Resource Map, Belvedere and Tiburon



Source: NREL, National Solar Radiation Database (NSRDB) Data Viewer, 2021

3.1.1.1 Photovoltaic (PV) Panels

Photovoltaic (PV) panels, also known as solar panels, convert light into electricity. These panels utilize solar modules and solar cells to generate electricity. PV systems can be installed in a number of methods, typically ground mounted, roof mounted, and canopy mounted. They are likely suitable for all locations that offer optimal solar generation conditions, which require a mostly clear, south facing orientation with minimal shading from potential obstructions.

3.1.1.2 Solar Hot Water (SHW)

SHW systems use evacuated tube or flat plate collectors to capture solar energy and use it to heat water. Evacuated tube collectors are more expensive than flat plate collectors, but they are commonly used in cold climates because they are more efficient and can heat water to significantly higher temperatures. The hot water generated by SHW systems can be used to supplement domestic hot water or to provide necessary supply for HVAC systems. Although SHW systems are an efficiency measure for

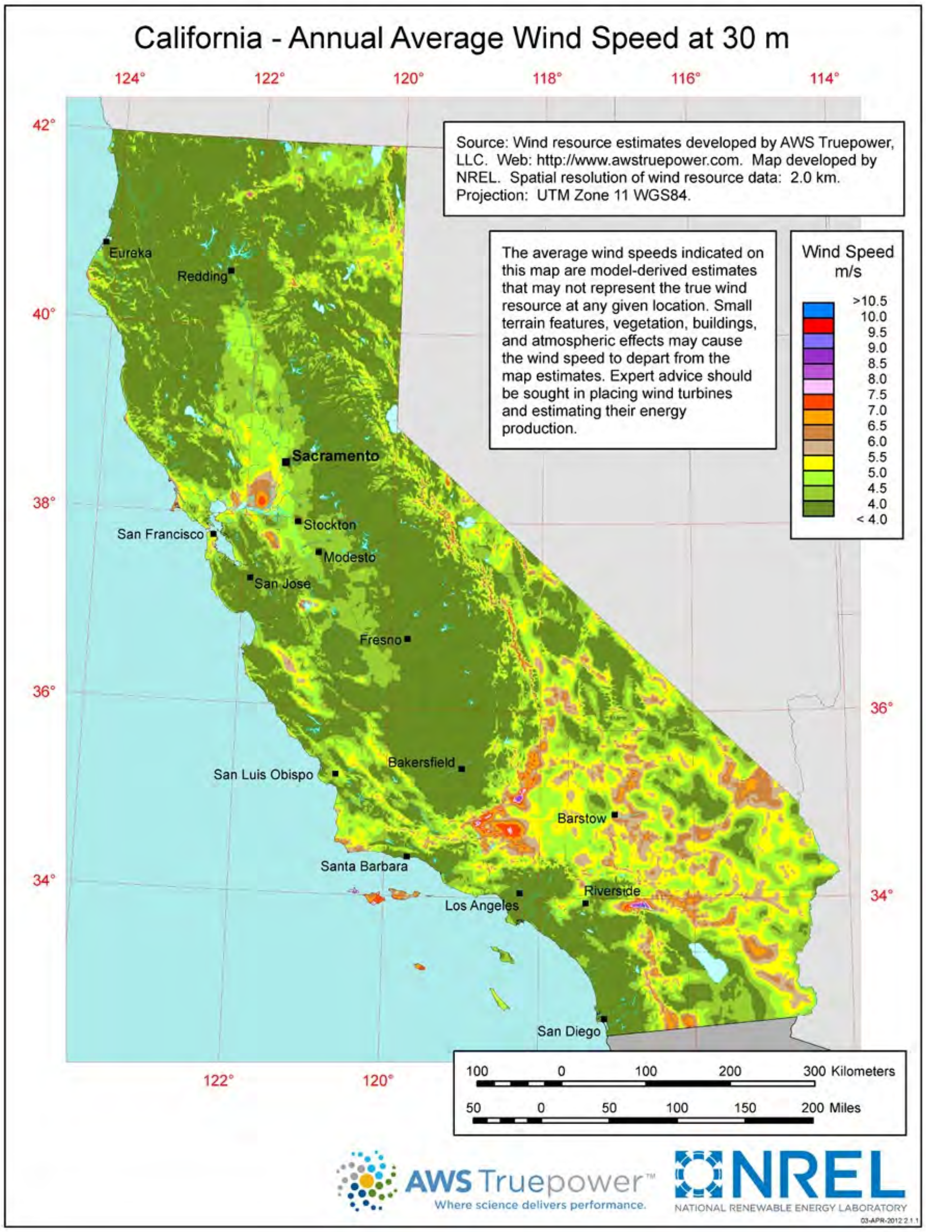
3.1.2 Wind

Wind energy, or wind power, is the process through which wind is used to generate electricity. A wind turbine uses the flow of wind to turn blades that then rotate a generator to create electricity.

NREL publishes wind resource data for different heights above the ground plane for each state within the U.S. The 30-meter height is typically assessed for small scale wind projects, which are typically installed between 15 meters and 40 meters in height. Areas with good exposure to prevailing winds and annual average wind speeds of 4 meters per second or more are considered to have suitable wind resources for small projects.

The 30 meter residential-scale wind resource map for California shows that the San Francisco Bay Area has an average annual wind speed at 30 meters between 4 and 5 meters per second, which generally suggests that the area is not ideal, but may be suitable for small scale wind projects. Local weather data for the Oakland International Airport shows that the average wind-speed is around 4.41 meters per second at an elevation of approximately 20 meters. This results in a capacity factor around 17 percent for wind turbines, which is not sufficient to make wind energy a feasible solution. It also suggests that large wind turbines would be required to make wind a feasible solution; however, large wind turbines would likely impact views for residents and visitors. Based on this information, wind is not considered a realistic solution for SD5.

Figure 5 – California Wind Resource Map



Source: NREL, 2021

3.1.3 Tidal Power

Tidal power uses moving water to produce electricity, drawing from a large volume of flow or change in water levels to turn turbines. The SD5 Paradise Cove WWTP is located adjacent to the San Francisco Bay, with the opportunity to harness energy from the changing tides. However, tidal power projects are cost-prohibitive and are only suited for high tidal environments and high energy sites. Per the U.S. Energy Information Administration, the U.S. does not have any commercial operating tidal energy power plants. Although the resource is available, this system type is not recommended due to cost concerns, the low amount of energy used at the Paradise Cove site, and for the potential permitting and environmental concerns associated with development in the San Francisco Bay.

3.1.4 Biofuels

Biofuel energy utilizes the combustion of fuels derived from digesting organic matter to generate electricity. Biomass is not recognized as a renewable resource due to the emissions associated with the combustion process. To be considered a renewable resource, biofuels must be a byproduct of an anaerobic process, such as the methane produced from wastewater treatment or composting. SD5 generates digester gas that could be used as a biofuel source for an on-site combined heat and power (CHP) cogeneration system. These biofuels qualify as a renewable resource because the impacts of their combustion are less harmful than the impacts of their direct emissions. However, this is not considered a viable resource for SD5, as the facility does not treat an adequate volume of wastewater to generate the biogas needed to make a CHP economically viable. Per the EPA, influent flow rates of 5 million gallons per day or greater are needed to create a consistent source of energy to make CHP cost-effective. For this reason, biofuel is not included as part of the renewable energy study. If SD5 would like to look more closely at this as a renewable resource, then a separate study is required.

3.1.5 Other Carbon Offsets and Renewable Energy Sources

Other carbon offsets and/or renewable energy sources that are not outlined in this section, including, but not limited to, the MCE Deep Green or MCE Local Sol programs, Carbon Offsets and/or Renewable Energy Credits (RECs), and the Climate Action Reserve’s Forest Project Protocol are not included in this analysis. These sources may be considered by SD5 to further reduce or offset any carbon emissions that are not eliminated through on-site renewable energy systems, or if on-site renewable energy is determined to be not feasible or cost effective.

3.2 Recommended System Type

Solar energy, specifically PV, is the most appropriate and cost-effective approach to generate clean energy for SD5. Wind, wave turbines, solar hot water, and biofuel energy sources are not considered feasible or cost-effective at this time and are not proposed for any of the SD5 facilities. Carbon offsets are also an option for SD5 to further reduce their carbon footprint.

4.0 System Interconnection

4.1 Utility Companies

PG&E provides electricity distribution and natural gas service to SD5 facilities. Since SD5 is enrolled in the MCE Light Green, electricity is generated and procured through MCE. To have a grid connected renewable energy system on-site, SD5 will need to complete an interconnection agreement with the utility and meet all their requirements for interconnection.

4.2 Interconnection Requirements

The California Public Utility Commission (CPUC) allows electricity customers to participate in renewable energy net-metering (NEM) and net-metering aggregation (NEMA) programs with their local utility. Customers who receive their energy under a CCA program, such as MCE, are eligible for NEM. CCA customers get a credit for the non-generation portion of rates from PG&E, and the CCA may provide a generation credit. Where CCA's have their own NEM programs, customers must still go through PG&E's interconnection process and receive permission to operate their generating facility from PG&E.

4.2.1 Energy Net-Metering

NEM is the process through which owners of on-site renewable energy systems are credited for the renewable energy that is generated and added to the grid. This allows owners to utilize electricity whenever it is needed, rather than when it is produced. Each month, the owner is credited for each kWh of electricity generated, and then billed against that credit for each kWh of electricity used. During periods of peak generation, the credits may exceed the amount of electricity used, with the additional credits carrying over to future months to offset periods of time the amount of electricity generated is less than the amount of electricity used. Over the course of a 12-month period, the owner will be billed or reimbursed for the delta between the amount of electricity generated compared to the amount of electricity used, with net usage being billed monthly.

Figure 6 – Energy Net Metering

Source: PG&E, 2021

4.2.2 Net-Metering Aggregation

In NEM programs, renewable energy that is generated and credited to the customer's account may only be used to offset the electricity that is used at a single electricity meter.

Net-Metering Aggregation (NEMA) is the process through which the credits that are allocated for the renewable electricity generated, when greater than the amount of electricity used, may be used to offset electricity used at other meters under the owner's account. Customers are eligible if all of the metered accounts are owned, leased or rented by the same PG&E customer of record, and the meters must be located on the same property as the renewable generator or on properties adjacent or contiguous to it.

Although all SD5's facilities are under the same account with PG&E, they are located throughout Belvedere and Tiburon and would not be considered adjacent or contiguous with the property on which any renewable energy system may be located. For this reason, NEMA programs likely do not apply and are considered not applicable for the systems outlined in this study.

4.2.3 Credit and Usage Billing Rates

All credits received by the renewable energy system owner for the electricity generated will offset all units of electricity used at a one to one ratio. Any electricity generated that is more than the electricity used, over the course of the 12-month period, will be purchased by the utility and paid to the owner at the designated wholesale rate, minus distribution costs. MCE customers who generate more electricity than they've used, will receive payment from MCE for the excess generation at twice the published wholesale rate. Any electricity used that is in excess of the electricity generated will be billed to the owner at the standard retail rate, including distribution costs.

Table 3 – MCE NEM Program Credit and Usage

	MCE NEM Program
Usage Cycle	12 Months, April through March
Generation Accrual	Credits (renewable electricity generated) accrue at retail rates and are applied toward your monthly bills during the year. If you generate more electricity than you use during a month, you will receive a credit for excess generation. This credit is automatically applied toward future electricity usage within the same 12-month cycle starting each April.
Surplus Generation	Annual surplus generation is credited at two times the wholesale rate (double what PG&E offers) on MCE's annual cash out date each spring. Cash-out payments over $50 will be automatically processed annually. You will receive a check, sent to the mailing address tied to your electric account. Payments under $50 will be added to your retail credit balance for the next 12-month cycle. Cash-out payments are subject to a maximum of $5,000 per account.
Billing	Billing occurs monthly and retail credits for excess generation are applied toward bills as they accumulate.

4.2.3.1 Time of Use Billing Rates

California utilities use a time of use rate plan in which rates vary depending on the season, day of the week, and time of day. These rates are typically identified as Peak, Part-Peak, and Off-Peak, with Peak rates often being twice as expensive as Off-Peak rates. Electricity generated by a solar system and sent back to the grid is credited at the time of use retail rate in effect at that time. If a PV system has battery storage, then power generated during Off-Peak periods may be stored on-site and sent to the gride later in the day during a Peak period, when the credit is more valuable.

4.2.4 Application for Interconnection

To connect the PV system to the electric grid and participate in NEM, SD5 will need to complete an Application for Interconnection with PG&E, and have it approved prior to the PV system being operational. All PV systems must meet all requirements for interconnection to be approved and SD5 will need to pay any fees associated with the application review. Any Application for Interconnection approved by PG&E is eligible to participate in NEM with MCE.

Table 4 – Interconnection Requirements

	Interconnection Requirements	SD5 Renewable Energy Systems
System Type	Eligible renewable generators include solar, wind, hydro, biogas, biomass, wave, tidal, fuel cells running on biogas, and others.	Solar renewable energy generation is proposed.
System Size	Standard NEM: 30 kW or less Expanded NEM: 30 kW to 1 MW	The proposed solar systems are within the size thresholds established for Standard and Expanded NEM.

Additional information regarding the PG&E NEM program is available on their website, at: https://www.pge.com/en_US/for-our-business-partners/interconnection-renewables/simple-solar-wind/contractor-resources/standard-nem-process-and-requirements.page?WT.mc_id=Vanity_standardnem&ctx=large-business.

4.3 Code Requirements

All PV systems must comply with the requirements outlined in the applicable version of the California Building Code, including but not limited to, Part 3 – California Electrical Code, Part 6 – California Energy Code, and Part 9 – California Fire Code. These codes stipulate testing, access and setback requirements that may impact and define the areas deemed to be solar ready.

5.0 SD5 Renewable Energy Potential

5.1 Facilities Feasibility Assessment

HDR and SD5 reviewed the WWTPs and each of the pump stations to determine whether they were suitable for on-site solar energy generation. Table 5 summarizes the findings of this assessment and identifies each of the locations for which a PV system is proposed.

Table 5 – SD5 Facilities, PV Feasibility Assessment

Service Area	Lift station number	PG&E Account Name	PV Proposed (Y/N)	Notes
Tiburon	Main WWTP PS-8, PS-9	Mar West St, 2001 Paradise Drv	Y	Good rooftop location with large electrical service and loads. Potential for large array on the adjacent hill.

Service Area	Lift station number	PG&E Account Name	PV Proposed (Y/N)	Notes
Paradise Cove	PC WWTP	Paradise Cove	Y	Large site with E/SE exposure. Likely shading from the SW/W due to the large hill adjacent to the site.
Tiburon	PS-1, PS-2	About 2440 Mar East Opp 2514 Mar East St	Y	Located between two homes. Solar access is viable with a canopy above the facility.
Tiburon	PS-3, PS-4	S/W COR Solano & Mar East, Solano & Mar East St SW	Y	Located between two homes and includes adjacent parking space. Solar access is viable with a canopy above the facility.
Tiburon	PS-5	Mar West	Y	S/SE exposure. Shading from adjacent trees may impact production. Likely location for an elevated canopy near the entrance.
Tiburon	PS-6	Tib Blvd COR/Beach, Corner Beach & Tiburon Blvd	N	Not feasible. Facility is located on the NW façade of the Bank of America.
Tiburon	PS-7	Tiburon Blvd MT, Tib Blvd Btw Reed Sch	Y	SW exposure. Shading from adjacent trees may impact production. Likely location for an elevated canopy near the entrance.
Belvedere	PS-1, PS-7	Cove Road	Y	Good solar access. Panels location feasible on the SE/SW roof surfaces and in the paved open space to the north of the building. Tree may shade afternoon solar access for the paved open space.
Belvedere	PS-2	ACR 532 San Rafael Ave.	Y	Small SE exposure on rooftop. Shading concerns from trees and adjacent homes.
Belvedere	PS-3	CRNR San Rafael Ave, 00 Golden Gate Ave	N	Located in a small, acute angled area of land at a street intersection. Likely not feasible due to NE exposure and shading from adjacent hill.
Belvedere	PS-5	00 San Rafael Ave	N	Good solar access. However, likely not feasible due to issues with obstructing views for adjacent homeowners.
Belvedere	PS-8	10 Windward Rd	N	Not feasible. Narrow, shaded facility adjacent to a single-family home.
Belvedere	PS-9	85 Lagoon Rd	N	Not feasible. Heavily shaded location along the road.
Belvedere	PS-10	ABT 66 Lagoon Rd	N	Not feasible. Heavily shaded location along the road.

Service Area	Lift station number	PG&E Account Name	PV Proposed (Y/N)	Notes
Belvedere	PS-11	ABT 46 Lagoon Rd	N	Not feasible. Heavily shaded location along the road.
Belvedere	PS-12	00 Edgewater Rd	N	Not feasible. Located on the north side of a residential fence.
Belvedere	PS-13	W Shore Road	N	Marginal W exposure. Will be shaded for much of the day from adjacent trees.
Belvedere	PS-14	End of W Shore Road	N	Not feasible. Significant shading from adjacent trees.
Belvedere	PS-15	98 Beach Rd	N	Not feasible. Located on the east side of a large hill with significant shading from adjacent trees.
Paradise Cove	CF-PS1	33 Seafirth Pl Pump Station	Y	Very good south exposure. Opportunity for small elevated canopy system above the facility.
Paradise Cove	CF-PS2	95 Seafirth Rd	Y	Opportunity for ground mounted system on the open space down the hill from the facility. SD5 will need to confirm ownership and development potential of the site. The paved area at the site of the facility is not feasible due to shading and obstructed views.

Most of the pump stations are not considered to be viable locations for renewable energy. The stations that are not considered viable are generally located in areas that have significant shading from adjacent trees and structures, or they are in locations where additional structures would likely create issues within the community due to impacts on views. For the pump stations that are considered viable, most of these have decent solar access, available space, and limited impacts on adjacent homes or views. Both the Main Tiburon WWTP and the Paradise Cove WWTP are considered viable for renewable energy.

5.2 Basis of Design

Conceptual plans are provided for each of the facilities determined to be viable for renewable energy, with the intent to maximize the solar generation potential while sizing the proposed systems to supply no more than 110 percent of the current electricity use for that location.

All calculations for the performance of the proposed systems are based on the following equipment, constituting a conceptual Basis of Design (BOD). It is likely that any system undergoing detailed design and ultimately being constructed at a referenced facility will have performance aspects that differ from this BOD. These calculations are meant to convey the renewable energy potential for each site and are not intended to demonstrate detailed design for any of the system locations.

5.2.1 PV Module

The calculations use the SunPower 450W Maxeon 5 Module as the basis of design (BOD) for the conceptual layouts and generation potential calculations. They have an efficiency of 22.2 percent and a minimum warranted power output of 92 percent of the first 25 years of use. The maximum annual degradation factor is 0.25 percent and the anticipated lifespan is 40 years. Refer to Figure 7.2.1 for specific electrical data for the Maxeon 5 Modules.

Figure 7 – SunPower 450W Maxeon 5 Electrical Data

MAXEON 5 COM POWER: 430–450 W

Electrical Data			
	SPR-MAX5-450-COM	SPR-MAX5-440-COM	SPR-MAX5-430-COM
Nominal Power (Pnom)[1]	450 W	440 W	430 W
Power Tolerance	+5/0%	+5/0%	+5/0%
Panel Efficiency	22.2%	21.7%	21.2%
Rated Voltage (Vmpp)	44.0 V	43.4 V	42.7 V
Rated Current (Impp)	10.2 A	10.2 A	10.1 A
Open-Circuit Voltage (Voc) (+/−3%)	51.9 V	51.69 V	51.2 V
Short-Circuit Current (Isc) (+/−3%)	11.0 A	10.9 A	10.9 A

Source: SunPower

Other sustainability elements for the SunPower Maxeon 5 Module include Cradle to Cradle Bronze Certification, International Living Future Institute (ILFI) Red-List Material Compliance with a Declare Label for material ingredient reporting, a 100% recyclable panel system, and a top score with the Silicon Valley Toxics Coalition.

5.2.1.1 Bifacial PV Modules

The BOD Maxeon 5 product is a monofacial module, which uses solar cells on one side of the module to generate electricity. Bifacial modules have solar cells on both sides of the module, which generates electricity from direct solar radiation on the top surface and from reflected solar radiation on the bottom surface.

This analysis does not assess the production associated with a bifacial module. To accurately predict the performance for these panels, a detailed design and cost analysis study should be completed for the specific PV systems that are being considered. This analysis will require reflectivity data for the surface above which the PV system will be installed. Any increase in production should be reviewed against the bifacial PV system cost increases, including both modules and the mounting structure, to determine whether they are cost-effective relative to a typical monofacial PV system.

5.2.1.2 PV System Design Assumptions

5.2.1.2.1 PV Module Orientation

Each of the proposed PV systems are oriented towards the south, where possible. For locations where a direct southern exposure is not possible, the PV system is oriented to align with existing roofs or lot line boundaries.

5.2.1.2.2 PV Module Tilt Angles

The calculations assume a PV module tilt angle of 5 degrees, unless otherwise indicated in this report. This tilt angle allows the system to maximize generation within a given footprint, as more PV modules may be placed within the footprint because the interrow spacing requirements are reduced due to decreased shading impacts. The 5-degree tilt angle also reduces maintenance and allows water to shed off the surface.

5.2.1.2.3 System Losses

The calculations assume an annual derate factor of 0.859 (14.1 percent) in accordance with NREL methodology. This derate factor is outlined the Table 6.

Table 6 – Solar Derate Factors

Derate Factor	Value
Soiling	2.0%
Nominal Nearby Object Shading*	3.0%
Snow	0.0%
Mismatch	2.0%
AC/DC Wiring	2.0%
Diodes and Connections	0.5%
Light-Induced Degradation	1.5%
PV Module Nameplate DC Rating	1.0%
Age	0.0%
System Availability	3.0%
Grand Total	**14.1%**

** Nominal nearby object shading is adjusted for locations where nearby object shading is expected to exceed NREL base derate factors.*

5.2.2 Inverters

Inverters convert the DC electricity generated by the PV system into AC electricity useable for the grid. The BOD system and the calculations provided in this study do not include any specific inverter manufacturers or models. This analysis assumes that any inverters are at least 96 percent efficient and will be sized to match the system size and generation provided at a specific location. All inverters must be certified to UL 1741 and be eligible with the California Energy Commissioners list. Any future detailed design shall confirm whether the system shall use a central inverter system or a microinverter system.

5.2.2.1 Central Inverters

A central inverter converts the DC electricity produced by the entire PV system into AC electricity. It is typically located in a central location that is close to the utility meter.

5.2.2.2 Microinverters

Microinverters are smaller units connected to the back of each individual PV module. This system is generally more expensive than a central inverter but offers operational efficiencies because any impacts on a specific module’s production from shading or other elements does not reduce the output from the rest of the PV system.

5.2.3 Battery Storage System

XXXX

5.2.3.1 Lithium Ion

XXXX

5.2.3.2 Vanadium Redox Batteries

XXXX

5.2.4 Mounting System

PV systems can be located and mounted in a variety of locations – building roofs and facades, parking lots, parking garages, and open space. Depending on the proposed location, the PV system should utilize a mounting system that maximizes generation potential, minimizes system costs, and minimizes impacts on its surrounding environment. The following mounting methods are referenced options for the proposed SD5 PV systems.

5.2.4.1 Roof Mounted

Roof mounted systems allow PV modules to be located on both steep and low-sloped roofs. The racking systems can mount the PV modules perpendicular to the slope of the roof, or they can provide a custom tilt to maximize generation based on the solar access for the given site. Roof mounted systems are proposed for the Main Tiburon WWTP and a few of the pump stations.

Figure 8 – Example, Roof Mounted PV System

Source: HDR

5.2.4.2 Ground Mounted

Ground mounted systems allow PV modules to be placed in areas of open space. The racking systems can mount the PV modules at any angle to maximize generation based on the solar access for the given site. Ground mounted systems are proposed for the hill adjacent to the Main Tiburon WWTP.

Figure 9 – Example, Ground Mounted PV System

Source: HDR

5.2.4.3 Canopy Mounted

Canopy mounted systems allow PV modules to be located above a useable plane. These mounting systems are typically used over parking lots, where the elevated PV system allows the area to generate power and provide storage for vehicles. These systems may also be used to maximize the solar area while maintaining required clearances over roof mounted equipment.

Figure 10 shows an example of a canopy mounted system that spans an entire area. Depending on the length of the span, the structural columns can be located at the edges of the structure, leaving the area underneath canopy clear of obstructions. This canopy system is a good option for the Main Tiburon WWTP and the Paradise Cove WWTP, where it could span above any buildings and rooftop equipment. This maximizes the solar area by minimizing the area required for setbacks and access aisles.

Figure 11 shows an example of a carport canopy mounted systems. These structures are commonly located above the parking spaces in a parking lot, while the drive aisle is open. The structural columns are in the middle of the canopy, with the PV modules placed on cantilevering beams to span the planned width. The entire canopy is generally tilted at a set angle, which butts the PV modules together and eliminates spacing requirements. These systems are good options for a number of pump stations.

Figure 10 – Example, Canopy Mounted PV System

Source: HDR

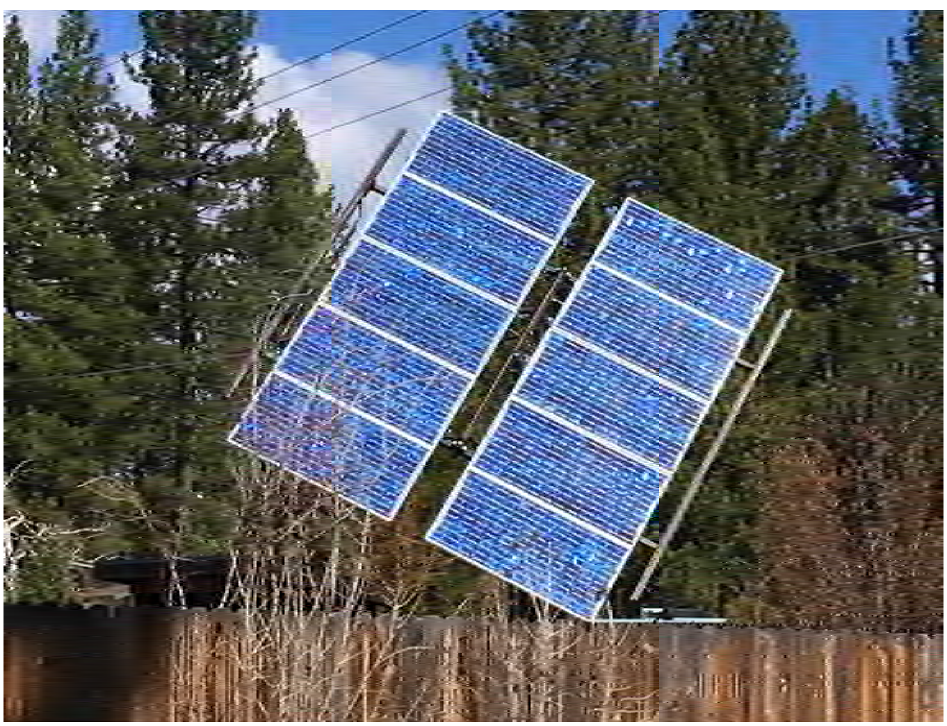
Figure 11 – Example, Carport Mounted PV System

Source: HDR

5.2.4.4 Active Tracking Systems

Active tracking systems allow the PV modules to rotate along dual axes, which optimally orients the system towards the sun to maximize production throughout each day and throughout different times of the year. These mounting systems are more expensive and include motors and other moving parts that increase maintenance. These systems would be good options for several SD5 locations, including the Belvedere Cove Road pump station.

Figure 12 – Example, Active Tracking PV System



Source: HDR

5.3 Proposed Systems

5.3.1 Main Tiburon WWTP

XXXX

5.3.1.1 WWTP Roof Mounted Systems

XXXX

5.3.1.1.1 WWTP Canopy Mounted Systems

XXXX. Clearances for equipment. Elevated above. Structural impacts. Fire access as equipment.

5.3.1.1.2 WWTP Roof Mounted Systems

XXXX

5.3.1.1.3 WWTP Future Roof Construction

XXXX

Figure 13 – Main Tiburon WWTP PV Potential, Roof Mounted Systems

5.3.1.2 WWTP Hillside Ground Mounted System

XXXX

- RECS
- Coordination with Owner – Easement

5.3.1.3 WWTP Battery Storage

XXXX

Figure 14 – Main Tiburon WWTP PV Potential, Hillside System

5.3.2 Paradise Cove WWTP

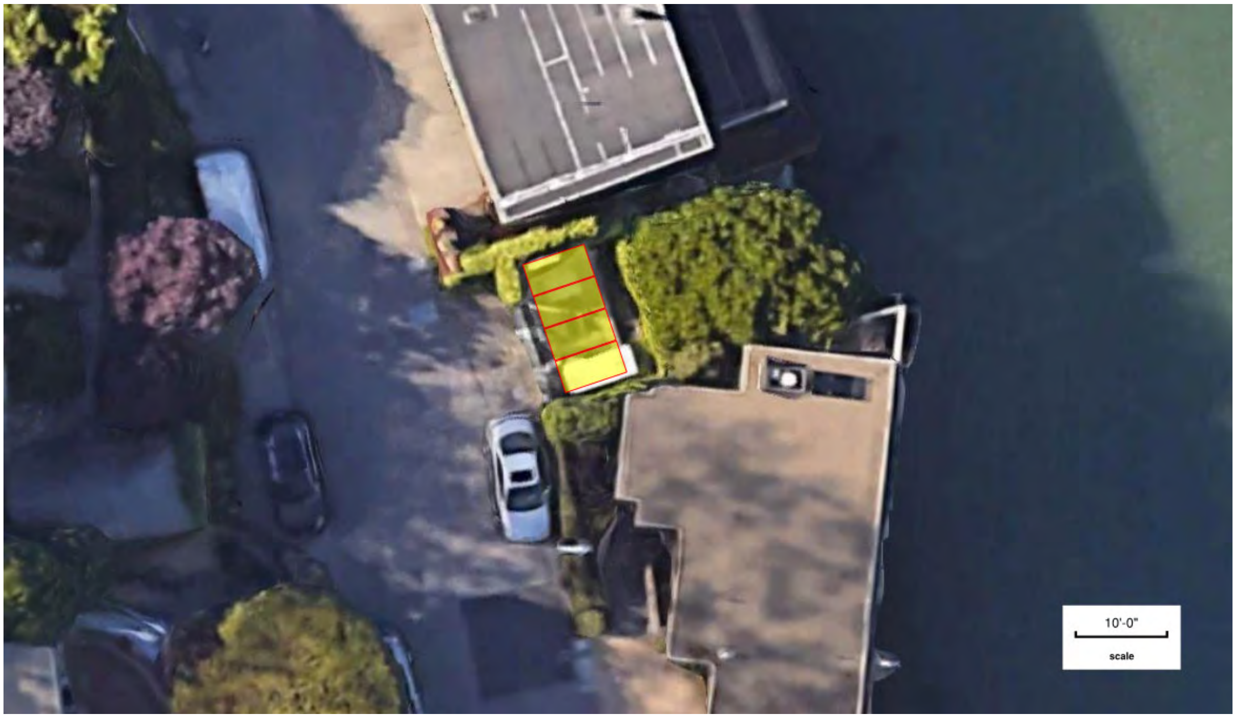
XXXX

Figure 15 – Paradise Cove WWTP PV Potential

5.3.3 Tiburon PS-1, About 2440 Mar East

XXXX

Figure 16 – Tiburon PS-1 PV Potential



5.3.4 Tiburon PS-3, S/W COR Solano & Mar East

XXXX

Figure 17 – Tiburon PS-3 PV Potential

5.3.5 Tiburon PS-5, Mar West

XXXX

Figure 18 – Tiburon PS-5 PV Potential

5.3.6 Tiburon PS-7, Tiburon Blvd MT

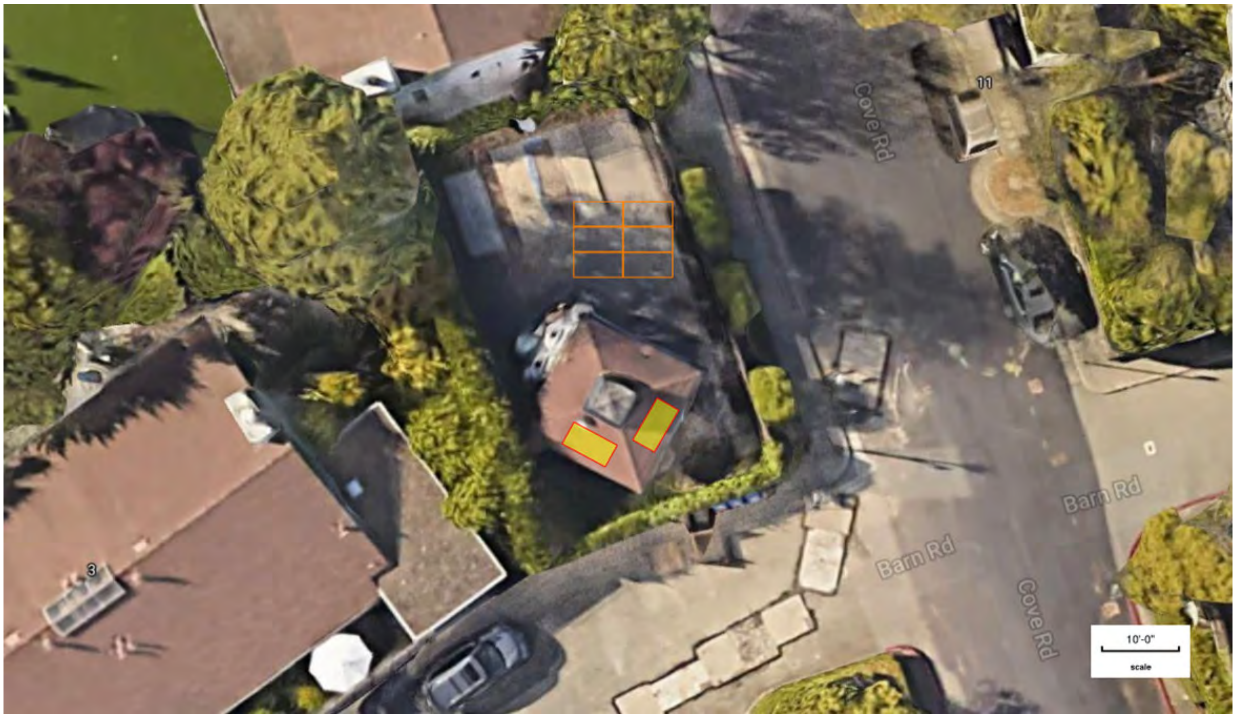
XXXX

Figure 19 – Tiburon PS-7 PV Potential

5.3.7 Belvedere PS-1, Cove Road

XXXX

Figure 20 – Belvedere PS-1 PV Potential



5.3.8 Belvedere PS-2, ACR 532 San Rafael Ave.

XXXX

Figure 21 – Tiburon PS-2 PV Potential

5.3.9 Paradise Cove CF-PS1, 33 Seafirth Pl Pump Station

XXXX

Figure 22 – Paradise Cove CF-PS1 PV Potential

5.3.10 Paradise Cove CF-PS2, 95 Seafirth Rd

XXXX

Figure 23 – Paradise Cove CF-PS2 PV Potential

5.4 Proposed Systems Summary

5.4.1 SD5 Facilities PV Systems Generation Potential

If SD5 was to develop all the PV systems outlined in this study to maximize the generation potential, then the District could offset up to 74.2 percent of its annual electricity use. These systems have a predicted annual electricity generation of 931,901.78 kWh, which results in a net-annual electricity use of 324,105.18 kWh. The summary of the generation potential across the SD5 facilities outlined in study are shown in Table 7.

Table 7 – SD5 Facilities, PV System Generation Summary

Service Area	Lift station number	PG&E Account Name	Annual Electricity Use (kWh)	Predicted Electricity Generation (kWh)	Net Electricity Use (kWh)	% Reduction
Tiburon	Main WWTP PS-8, PS-9	Mar West St, 2001 Paradise Drv	1,045,185.50	*341,687* *(roof)* *485,141* *(hill)* 826,828 (total)	218,357.5	79.1%
Paradise Cove	PC WWTP	Paradise Cove	75,931.35	68,910.40	7,020.94	90.8%
Tiburon	PS-1, PS-2	About 2440 Mar East Opp 2514 Mar East St	9,509.35	2,492.50	7,016.85	26.2%
Tiburon	PS-3, PS-4	S/W COR Solano & Mar East, Solano & Mar East St SW	12,250.57	3,089.40	9,161.17	25.2%
Tiburon	PS-5	Mar West	40,440.60	18,542.90	21,897.70	45.9%
Tiburon	PS-6	Tib Blvd COR/Beach, Corner Beach & Tiburon Blvd	2,173.25	-	2,173.25	-
Tiburon	PS-7	Tiburon Blvd MT, Tib Blvd Btw Reed Sch	4,678.42	4,980.60	(-302.18)	106.5%
Belvedere	PS-1, PS-7	Cove Road	23,575.68	1,239.20	22,336.48	5.3%
Belvedere	PS-2	ACR 532 San Rafael Ave.	6,646.16	1,924.70	4,721.46	29.0%
Belvedere	PS-3	CRNR San Rafael Ave, 00 Golden Gate Ave	9,569.20	-	9,569.20	-
Belvedere	PS-5	00 San Rafael Ave	1,413.62	-	1,413.62	-
Belvedere	PS-8	10 Windward Rd	1,072.05	-	1,072.05	-
Belvedere	PS-9	85 Lagoon Rd	2,227.05	-	2,227.05	-
Belvedere	PS-10	ABT 66 Lagoon Rd	1,110.36	-	1,110.36	-
Belvedere	PS-11	ABT 46 Lagoon Rd	1,465.50	-	1,465.50	-
Belvedere	PS-12	00 Edgewater Rd	1,096.61	-	1,096.61	-
Belvedere	PS-13	W Shore Road	1,850.68	-	1,850.68	-
Belvedere	PS-14	End of W Shore Road	3,300.06	-	3,300.06	-
Belvedere	PS-15	98 Beach Rd	2,350.96	-	2,350.96	-
Paradise Cove	CF-PS1	33 Seafirth Pl Pump Station	8,707.03	1,877.30	6,829.73	21.6%
Paradise Cove	CF-PS2	95 Seafirth Rd	1,453.62	2,016.90	(-563.28)	138.8%
		Total	**1,256,006.96**	**931,901.78**	**324,105.18**	**74.2%**

Since SD5 is enrolled in the MCE Light Green Clean Power plan, 60 percent of the net-annual electricity use is sourced from carbon free renewables. The net-annual "other electricity use" that is not sourced from carbon free renewables totals 129,642.07 kWh.

Table 8 – SD5 Annual Electricity Use with Potential PV Systems, MCE Light Green Clean Power

Data Year	Total Net Electricity Use (kWh)	MCE Light Green Carbon Free Renewables (kWh)	Other Electricity Use (kWh)
February 2020 – January 2021	324,105.18	194,463.11 *(60 percent)*	129,642.07 *(40 percent)*

If SD5 wanted to source 100 percent of the electricity use across the District from renewables, then it could either purchase RECs from a carbon offset provider to offset the remaining net-annual "other electricity use", or it could upgrade the MCE Deep Green Clean Power program. MCE's rate schedule notes that the increase in costs to upgrade from the MCE Light Green Clean Power program to the MCE Deep Green Clean Power program is $0.01 per kWh. Based on a net-annual electricity use of 324,105.18 kWh, this cost would be approximately $3,241.06.

6.0 Cost and Ownership Options

The District has a variety of means through which a solar system can be purchased, installed, and operated. Each ownership model has its benefits and drawbacks, and each one comes with its own costs. These options are outlined below.

6.1 Federal Tax Credits

The U.S. Federal Government offers a Federal Income Tax Credit (ITC) for qualified renewable energy systems. This ITC allows eligible owners to deduct a percentage of the cost of the solar system from their federal taxes. If the ITC exceeds the owner's tax liability, then the remaining ITC will carry over to the following year.

As a local government entity, SD5 is not eligible for these tax credits. However, third parties are eligible for the tax credit, and in the event SD5 elects to pursue a third party owned and operated system, the third party may factor some of the tax savings into any system cost agreements.

6.2 Ownership Options

6.2.1 Direct Ownership

In a direct ownership model, SD5 finances, owns and maintains the renewable energy system. The installed costs include all elements of the solar system, including the mounting structure, solar panels, inverters, and wiring. There may be additional costs associated with connecting to the local utility infrastructure, which may include, but are not limited to, increased transformer size, and upgraded distribution lines.

6.2.2 Third Party Owned and Operated Systems

In a third-party ownership model, SD5 engages in a contract with a qualified third-party to have them install, own, and operate a renewable energy system. The costs associated with each model vary depending on the terms and conditions for each one.

6.2.2.1 Solar Leases

Solar leases are agreements with a third party, where the third party would charge the District a flat monthly fee for the system, regardless of the amount of energy generated by the system. This ownership model is not preferred, as the cost generally outweighs that of a power purchase agreement (PPA), especially as the system ages and the amount of electricity generated is reduced.

6.2.2.2 Power Purchase Agreements (PPA)

A PPA is an agreement with a third-party, where the third party would charge SD5 an agreed upon rate for each unit of electricity that is generated by the system. The agreed upon rate may exceed the rate that SD5 currently pays to the local utility; however, these rates usually have a lower escalation rate than is typical for electricity purchased from the utility. Over the life of the system, the agreed upon PPA rate usually becomes less than the local utility rate, which typically makes this ownership model cost-effective.

The benefits of this ownership model are:

- PPAs do not require any up-front investment from SD5. The third-party fully finances the system and can make a return on its investment by charging an agreed upon rate per unit of electricity. This rate, when paid over the life of the system, offsets the up-front investment and any interest that is paid by the third-party.
- The third party typically maintains and operates the system. SD5 will not need to provide ongoing maintenance.
- As a third-party owned system, PPAs are eligible for the Federal ITC. The PPA agreement may pass some of the ITC savings to SD5 in the form of a reduced electricity rate.

The drawbacks of this ownership model are:

- It is possible that the local utility rates do not escalate as expected, which could result in the SD5 paying more money over the life of the system than they would in other ownership models.

6.2.2.3 Pre-Paid Power Purchase Agreements (PPA)

A Pre-Paid PPA is an agreement with a third-party, where SD5 would fully finance the system up-front, however, it is technically owned by the third party for an agreed upon time. This agreement allows the third-party to share the Federal ITC with SD5, reducing up-front costs associated with the direct ownership model.

The benefits of this ownership model are:

- The Pre-Paid PPA could reduce the up-front cost for SD5, as the third-party shares the Federal ITC savings with SD5 at an agreed upon percentage. This could make the system more cost-effective than a direct ownership model.
- The Pre-Paid PPA includes maintenance of the system for duration of the contract, at which point the ownership and maintenance transfers to SD5.

The drawbacks of this ownership model are:

- It is tied closely to the Federal ITC rate. When the ITC rate sunsets, this agreement may be less attractive to third party providers, and there may be fewer bidders and options available for SD5.

6.2.2.4 Renewable Energy Credits

All qualified electricity generated by a renewable energy system may be bought and sold on an open market as a renewable energy credit (REC). These RECs are often purchased by individuals, organizations, or utilities looking to offset their regular energy use. Third-party owned and operated systems often do not retain the RECs associated with the system in their contracts, as the ability to sell these credits on the open market increases their profitability. Any contract agreed to between the SD5 and a third-party should include the RECs, or else the renewable energy generated by the system is allocated to the REC purchaser.

6.3 Potential Costs

6.3.1 Direct Ownership

HDR contacted local renewable energy providers to identify costs associated with the direct ownership model for ground mounted, roof mounted, and parking canopy mounted solar installations. These installed costs include all elements of the solar system, including the mounting structure, solar panels, inverters, and wiring. There may be additional costs associated with connecting to the local utility's distribution lines, which may include, but are not limited to, increased transformer size and upgraded distribution lines. Depending on market conditions at the time the RFP is released, actual proposed costs may vary from those shown below.

Table 9 – PV System Cost Estimates, Direct Ownership

	Low Cost Range	Average Cost	High Cost Range
Ground Mounted			
Roof Mounted	$4,900 per kW	$5,000 per kW	
Canopy Mounted			

XXXX.

Table 10 – SD5 Facilities, Cost Summary, Direct Ownership

Service Area	Lift station number	PG&E Account Name	Proposed PV System Size (kW)	PV Cost Estimate	Battery Storage Cost Estimate
Tiburon	Main WWTP PS-8, PS-9	Mar West St, 2001 Paradise Drv	554 (Roof)		
Tiburon	Main WWTP PS-8, PS-9	Mar West St, 2001 Paradise Drv	741 (Hill)		
Paradise Cove	PC WWTP	Paradise Cove	48.6		
Tiburon	PS-1, PS-2	About 2440 Mar East Opp 2514 Mar East St	1.8		N/A
Tiburon	PS-3, PS-4	S/W COR Solano Mar East, Solano & Mar East St SW	2.3		N/A
Tiburon	PS-5	Mar West	13.5		N/A
Tiburon	PS-6	Tib Blvd COR/Beach, Corner Beach & Tiburon Blvd	-	-	-
Tiburon	PS-7	Tiburon Blvd MT, Tib Blvd Btw Reed Sch	3.6		N/A
Belvedere	PS-1, PS-7	Cove Road	0.9		N/A
Belvedere	PS-2	ACR 532 San Rafael Ave.	1.4		N/A
Belvedere	PS-3	CRNR San Rafael Ave, 00 Golden Gate Ave	-	-	-
Belvedere	PS-5	00 San Rafael Ave	-	-	-
Belvedere	PS-8	10 Windward Rd	-	-	-
Belvedere	PS-9	85 Lagoon Rd	-	-	-
Belvedere	PS-10	ABT 66 Lagoon Rd	-	-	-
Belvedere	PS-11	ABT 46 Lagoon Rd	-	-	-
Belvedere	PS-12	00 Edgewater Rd	-	-	-
Belvedere	PS-13	W Shore Road	-	-	-
Belvedere	PS-14	End of W Shore Road	-	-	-
Belvedere	PS-15	98 Beach Rd	-	-	-
Paradise Cove	CF-PS1	33 Seafirth Pl Pump Station	1.4		N/A
Paradise Cove	CF-PS2	95 Seafirth Rd	1.4		N/A
		Total	**1,369.9**	**$**	**$**

6.3.2 Third Party Ownership

Potential costs for third party ownership will need to be determined by solar providers. These costs are specific to the individual terms and conditions proposed by each company. In general, SD5 can expect the following:

- A traditional PPA will cost more per unit of electricity than is currently paid to the local utility, with an assumed payback over the life of the system.
- A pre-paid PPA may cost less than the direct ownership model. The actual pre-paid PPA cost depends on the Federal ITC rate that each bidder proposes to share with the SD5.

6.4 Return on Investment Analysis

6.4.1 Direct Ownership

XXXX.

7.0 Implementation

XXXX.

7.1 Implementation

XXXX

7.2 Recommendation

XXXX

SANITARY DISTRICT of MARIN COUNTY No.5

Capital Improvement Projects

Date: **April 13, 2021**

To: **CIP Committee**

From: **Tony Rubio, District Manager**

Subject: **Ongoing 10 Year Capital Assumptions and Cost Estimate**

General Summary:

This Capital Improvement Project List is a general up to date list of anticipated projects with budget estimates and priority ranked 1-5 (1 being the highest priority and 5 being the least priority) broken down by zone and treatment plant. This list will help assist in the budget making process and prioritization of projects by year. The list is updated annually, as projects are completed, they are removed from the list and as management and staff encounter new projects they are added with an estimated assumption. Detailed information on these projects can be found in attachment A, B, C and D of this summary report.

Main Treatment Plant: (attachment A)	**Cost:**	**Priority**
Maintenance Shop/Operations Control Room Replacement	*$1,000,000*	*4*
Headworks Grinder Replacement	*$25,000*	*1*
Headworks Grinder Retrofit- Channel Monster	*$75,000*	*3*
Headworks Valve and Check Valve Replacement	*$50,000*	*3*
Boiler Exhaust Permanent Stainless Piping	*$50,000*	*2*
Influent DW Pump Replacement	*$40,000*	*1*
Influent WW Pump Replacement	*$65,000*	*5*
Odor Control Upgrades-System	*$100,000*	*3*
Influent Sample Room Drain Replacement and Secondary Drain	*$75,000*	*1*
Cl2 Flash Mixer Redundancy	*$15,000*	*1*
Emergency Outfall Rehabilitation	*$200,000*	*3*
Aerations Basin Diffuser Upgrade	*$200,000*	*4*
Piping Area Roof Replacement	*$75,000*	*2*
Utility Truck Replacement	*$75,000*	*3*
Headworks Explosion Proof Electric Hoist	*$10,000*	*1*
Electric Roll up doors	*$20,000*	*3*
Chemical Feed Transfer Pump Replacement	*$20,000*	*1*
Dry Weather Primary Tank Cover Replacement	*$50,000*	*4*
Digester Takedown and Lid Rehabilitation Project	*$250,000*	*3*
TOTAL	***$2,395,000***	

SANITARY DISTRICT of MARIN COUNTY No.5

Capital Improvement Projects

Paradise Cove Plant: (attachment B)		
Blower Replacement	*$20,000*	*2*
Influent Pump Replacement	*$15,000*	*3*
Communications Upgrade (cell)	*$50,000*	*1*
UV Upgrade Project	*$50,000*	*5*
Grit Removal System	*$50,000*	*4*
Total	***$185,000***	
Tiburon Collection System: (attachment C)		
Sewer Line Rehab – 8,637 LF of Pipe remaining to date ($300lf)	*$2,591,100*	*1-5*
Man Hole Rehabilitation	*$150,000*	*3*
Flow Meter Installation Project	*$150,000*	*5*
Station #2 Force Main Rehabilitation 357lf- 6"	*$200,000*	*3*
Station #3 Force Main Rehabilitation 379lf- 6"	*$200,000*	*3*
Station #5 Force Main Rehabilitation 1303lf - 8"	*$700,000*	*2*
Station#6 Force Main Rehabilitation 1168lf- 6" ?	*$500,000*	*5*
Station #7 Force Main Rehabilitation 903lf – 6"	*$350,000*	*5*
Station #9 Wetwell Repair/Replacement Project	*$250,000*	*1*
Station #4 Wetwell Coating/Seal Project	*$50,000*	*1*
Total	***$5,141,100***	
Belvedere Collection System: (attachment D)		
Sewer Line Rehab- 6,144 LF of Pipe remaining to date	*$1,843,200*	*1-5*
Cove Road Emergency Generator and Roof Replacement	*$75,000*	*1*
Power Feed Improvement Project 9, 10, 11	*$300,000*	*5*
San Rafael Ave- Diverter Line	*$100,000*	*3*
Cove Road Control Panel Replacement	*$150,000*	*2*
Man Hole Rehabilitation	*$100,000*	*3*
Flow Meter Installation Project	*$195,000*	*4*
Station #13 Force Main Rehabilitation 437lf - 4"	*$200,000*	*3*
Station #14 Force Main Rehabilitation 457lf – 4"	*$200,000*	*3*
Station #3 Force Main Rehabilitation 1972lf – 8"	*$750,000*	*4*
Station #7 Wet Well Rehabilitation Project	*$75,000*	*1*
Total	***$3,988,200***	

Estimate CIP Project Grand Total: $11,699,300

Collection System Master Plan

Sanitation District No.5 of Marin County

Sanitary District no5

Tiburon & Belvedere, California

April 8, 2021

This page is left intentionally blank.

Contents

List of Figures

List of Tables

Executive Summary

Introduction

Located on the Tiburon Peninsula north of San Francisco, Sanitary District No. 5 of Marin County (SD5) provides wastewater services to Tiburon, Belvedere, and the surrounding unincorporated areas. The population in SD5's service area is about 8,400, has stabilized, and significant future growth is not anticipated. Land use changes and additional build-out development is unlikely because of stringent building and planning requirements. Most of SD5's current service area is expected to remain unchanged into the future, except for continued low-level expansion in the unincorporated northeastern part of its service area.

SD5 completed a sanitary sewer investigation study in 2005 (Harris and Associates, 2005) that produced a set of recommendations for capital improvements to its collection systems (i.e., pipelines) and supporting facilities (i.e., lift stations). Since that time, SD5 has implemented many of the recommendations and made considerable investment in its wastewater collection system infrastructure. SD5 believes that it is time to reassess its collection system infrastructure to determine its current condition and identify rehabilitation priorities.

HDR Engineering, Inc. (HDR) was retained by SD5 to develop a Collection System Master Plan (Master Plan) that will support its objectives of continuing to meet regulatory requirements and service-level goals for the communities it serves. Prior engineering reports and studies, including CCTV inspection videos, construction as-built drawings, and GIS database information, served as the basis for developing the Master Plan. Data collected during recent in-field inspections/assessments, along with the prior work, were used to develop recommendations for system performance improvements, as well as a list of recommended capital improvements (i.e., 15-year Capital Improvement Plan or CIP), recommended timing or prioritization of the improvements, and estimated costs of the improvements.

Approach and Workflow

Figure 1 provides the approach to developing the Master Plan. The three primary components of the collection system - gravity mains, lift stations, and force mains - were each evaluated using existing information from SD5 and new data developed for this study. Evaluation of the gravity mains consisted of developing a risk model from the available CCTV inspection data and a rehabilitation decision model that also incorporated findings from the evaluation of the 2010-2011 flow monitoring study (E2 Consulting Engineers Inc., 2011) and sea level rise assessment (BVB Consulting LLC, 2017). The lift station evaluation incorporated existing data from SD5 as well as new data from physical inspections and interviews of operations staff. The force mains were evaluated using available data from the GIS and sample analysis results of four pipe samples from 2018 Visual Condition Assessment Report (V&A Consulting Engineers, 2018). Each of these three primary components was evaluated separately to identify prioritized recommendations, which were then integrated into a comprehensive 15-year capital improvement plan (CIP).

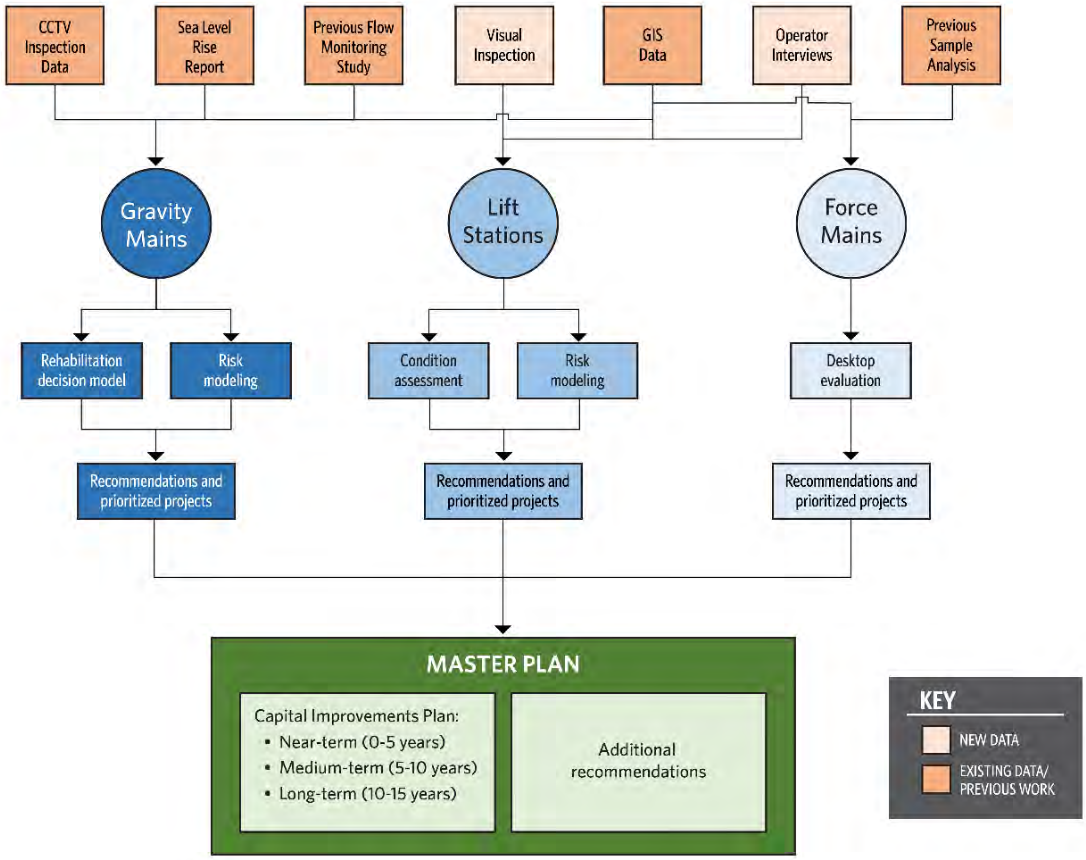


Figure 1. Master plan project approach

Key conclusions

The primary findings from these analyses are as follows:

- Gravity Mains (Section 4.1.5)
  - The collection system is relatively old and has not been inspected recently and will need additional inspection.
  - Depending upon the addition inspection results, more rehabilitation actions may be identified for the near term (0-5 years).
  - Based on the available data, 2.2 miles of mains should be rehabilitated within the next 5 years (approximately 7 percent of system).
  - Some areas of the system have significant I&I issues that allow excess stormwater and ground water (and possibly tidal flow) to enter the system, which may cause odor, capacity problems, and impacts wastewater treatment plant operations (Section 4.2.11). The previous study evaluated approximately 50 percent of the SD5 collection system and there may be more areas that have not been evaluated that are significant contributors of excess flow to the system. This issue could be magnified by medium- and long-term (greater than 30 years) sea level rise.

- Lift Stations (Section 4.3.5)
  - 50 percent of the 24 lift stations evaluated are found to be in fair to poor condition.
  - Four of these stations should be rehabilitated within the next 5 years and another four in 5 to 10 years.
- Force Mains (Section 5.3)
  - Based on desktop review of available force main information, 4 of the 28 force mains should have a detailed condition assessment within the next 5 years.
  - Depending upon the results of these assessment, additional assessments and capital projects may be needed.

A summary of each of the analyses is provided below, followed by a discussion of the 15-year CIP.

Gravity Mains

The main objective of the gravity main analysis was to identify and prioritize rehabilitation and reinspection actions based on available inspection data. This analysis also included evaluation of the 2010-2011 flow monitoring study (E2 Consulting Engineers Inc., 2011) to characterize inflow and infiltration issues within the system, and incorporation of findings from the regional Marin Shoreline Sea Level Rise Vulnerability Assessment (BVB Consulting LLC, 2017).

Gravity Main Risk Modeling

To develop rehabilitation recommendations for the collection system, a risk model was constructed to calculate a relative risk score for every sewer main (e.g., gravity pipeline) based on likelihood of failure (LoF) and consequence of failure (CoF) criteria. The relative risk score was used to prioritize rehabilitation and reinspection recommendations for the gravity mains.

The LoF and CoF scores are comprised of several components based on physical characteristics of the system, CCTV inspection results, regulatory history and customer service. These were tabulated for every gravity main to develop the final risk score. The risk model for the system, summarized in Figure 2, shows that about 27 percent (8.22 miles) of the gravity mains have a relatively high risk compared to the rest of the system. However, these pipes do not all require rehabilitation.

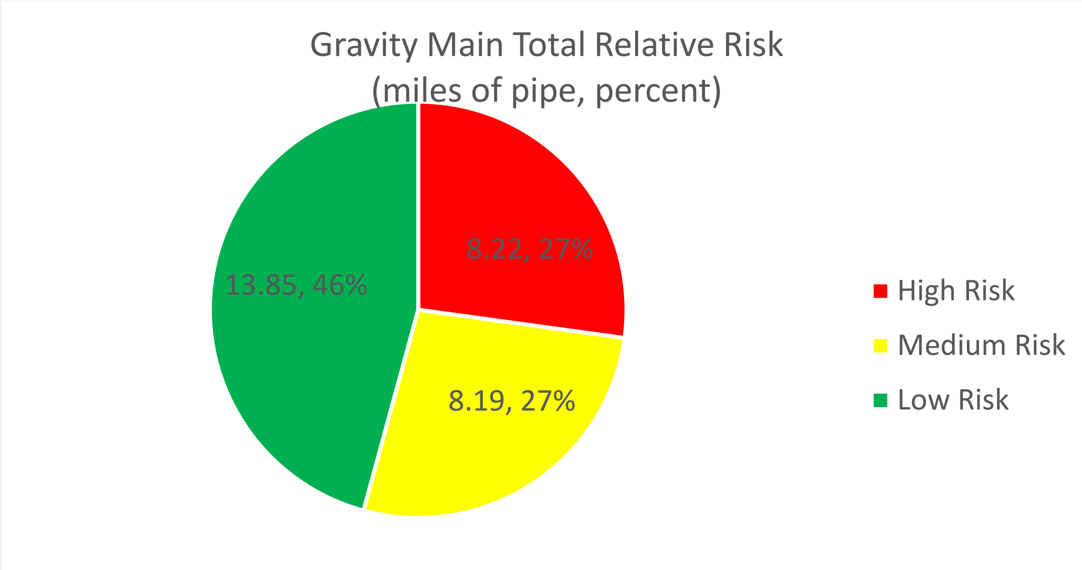


Figure 2. Risk modeling results for gravity mains

Inflow and Infiltration

The 2010-2011 flow monitoring study (E2 Consulting Engineers Inc., 2011) was then analyzed to identify additional factors that should be considered when developing rehabilitation recommendations for the gravity mains. This previous study was reviewed and analyzed to determine which of the basins studied were the largest contributors to excess flow that enters the system from groundwater or stormwater events. The analysis revealed that Peninsula Road in Belvedere and the basin at the south end of the Tiburon Peninsula along Paradise Drive are the biggest contributors to inflow and infiltration (I&I) and should be further investigated to identify and eliminate specific I&I sources. There are other basins that may be significant contributors to I&I as well. In addition, the gravity mains in these areas are given additional consideration when prioritizing and planning annual rehabilitation work.

Rehabilitation Decision Model

Each of the sewer mains was then processed through a rehabilitation decision support model that identified the most appropriate rehabilitation or reinspection action for each gravity main depending on its physical characteristics, previous CCTV inspection results (SD5 2020a), and additional input from a prior I&I evaluation (E2 Consulting Engineers Inc., 2011). This model uses the risk model results as well as additional parameters to select the best rehabilitation or reinspection options for each pipe according to SD5 decision criteria. By applying unit cost information derived from previous SD5 construction bid tables and regional experience, costs for each of the rehabilitation actions was calculated for each pipe.

Recommendations

The results from the modeling and prioritization are summarized in Table 1 below.

Table 1. Gravity main capital improvement recommendations

Tier	Timeframe	Number of gravity mains	Sum of miles	Percent of system	Gravity main costs
1	0–5 years	57	2.2	7%	$3,089,575
2	5–10 years	56	2.3	8%	$2,838,803
3	10–15 years	32	1.5	5%	$2,474,083
4	15+ years	13	0.6	2%	$592,900
Grand total		**158**	**6.6**	**22%**	**$8,995,361**

Lift Stations

A visual condition assessment of the lift stations was conducted as part of the planning effort. The assessment included review of available documentation and reference material, visual inspection of the lift stations, and interviews of SD5 staff. The information collected was analyzed to develop recommendations for needed improvements, which were considered in the development of the overall CIP. To prioritize the recommendations, a risk analysis was conducted to determine the relative criticality of each lift station.

Condition Assessment

Overall, the condition of the lift stations varied, with the Tiburon and Seafirth lift stations generally being in better overall condition than the Belvedere lift stations. Actual station age and capacity assessment were not determined because of limited data; therefore, the assessments relied on interviews with SD5 staff for historical knowledge, visual condition assessment based on experience evaluating similar assets evaluated at other utilities, and comparison to industry best practices. None of the stations received a very poor rating. The most significant issues were identified at Tiburon PS-4, Tiburon PS-9, Belvedere PS-1, and Belvedere PS-7. These results are summarized in Table 2.

This page is intentionally left blank.

Table 2. Lift station condition assessment results

Service area	Lift station criticality	Lift station location	Description	Very good (New or excellent condition)	Good (Minor defects only)	Fair (Moderate deterioration)	Poor (Significant deterioration)	Very poor (Virtually unserviceable)
Tiburon	1	PS-5	Mar W St.	✓				
Tiburon	2	PS-3	Paradise Dr. & Solano St.			✓		
Tiburon	3	PS-2	Mar E St. near Agreste Way			✓		
Tiburon	3	PS-6	Tiburon Blvd. and Beach Rd.			✓	✓	
Tiburon	3	PS-9	Paradise Dr. near Shoreline Park				✓	
Tiburon	4	PS-1	Mar E St. near Mar E Dr.			✓		
Tiburon	4	PS-4	Paradise Dr. near Lyford's Tower				✓	
Tiburon	4	PS-7	Tiburon Blvd. near Ned's Way			✓		
Tiburon	4	PS-8	Beach Rd. and Lagoon Vista Rd.			✓		
Belvedere	1	PS-1	Cove Rd. & Barn Rd.				✓	
Belvedere	2	PS-3	San Rafael Ave. and Golden Gate Ave.			✓	✓	
Belvedere	2	PS-9	Lagoon Rd. (south)			✓	✓	
Belvedere	3	PS-5	San Rafael Ave. and Windward Rd.			✓	✓	
Belvedere	3	PS-10	Lagoon Rd. near Maybridge Rd.			✓	✓	
Belvedere	3	PS-13	West Shore Rd. (north)			✓		
Belvedere	4	PS-2	San Rafael Ave. & Teal Rd.			✓	✓	
Belvedere	4	PS-7	Peninsula Rd. and Beach Rd.			✓	✓	
Belvedere	4	PS-15	Beach Rd. near Embarcadero Dr.			✓		
Belvedere	4	PS-14	West Shore Rd. (south)			✓		
Belvedere	4	PS-8	Windward Rd.			✓		
Belvedere	4	PS-11	Lagoon Rd. (north)			✓	✓	
Belvedere	4	PS-12	San Rafael Ave. & Edgewater Rd.			✓	✓	
Seafirth	1	CF-PS1	Seafirth Pl.		✓			
Seafirth	2	CF-PS2	Seafirth Rd.		✓			

This page is intentionally left blank.

The outcome of each assessment was a list of rehabilitation and repair recommendations for each lift station. Costs for these recommendations was calculated using an industry standard cost estimating database (RS Means).

Lift Station Risk Modeling

Risk assessment was also used to prioritize lift station rehabilitation and develop the prioritized CIP. Risk was determined based on each lift stations pumping capacities, impact on the District if it fails and is taken out of service, and the potential for flooding or causing environmental damage. Based on these characteristics, four of the pump stations were identified to be the most critical (Tiburon LS-5, Belvedere LS-1, Seafirth LS-1, and Seafirth LS-2) and five others have been determined to be the next highest priority (Tiburon LS-3, Tiburon LS-4, Tiburon LS-6, Tiburon LS-9 and Belvedere LS-7). These criticality ratings were used to prioritize the rehabilitation recommendations.

Recommendations

The capital improvement recommendations and priorities for SD5 lift stations is provided in Table 3.

Table 3. Lift station capital improvement recommendations

Service area	Lift station number	Lift station location	Rehabilitation schedule			
			0-5 years	5-10 years	10-15 years	15+ years
Tiburon	PS-1	Mar E St. near Mar E Dr.				$11,154
Tiburon	PS-2	Mar E St. near Agreste Way			$99,725	
Tiburon	PS-3	Paradise Dr. and Solano St.			$129,910	
Tiburon	PS-4	Paradise Dr. near Lyford's Tower	$386,515			
Tiburon	PS-5	Mar W St.				$50,833
Tiburon	PS-6	Tiburon Blvd. and Beach Rd.		$431,013		
Tiburon	PS-7	Tiburon Blvd. near Ned's Way			$91,464	
Tiburon	PS-8	Beach Rd. and Lagoon Vista Rd.			$40,631	
Tiburon	PS-9	Paradise Dr. near Shoreline Park	$400,747			
Belvedere	PS-1	Cove Rd. and Barn Rd.	$668,323			
Belvedere	PS-2	San Rafael Ave. and Teal Rd.		$498,934		
Belvedere	PS-3	San Rafael Ave. and Golden Gate Av		$500,590		
Belvedere	PS-5	San Rafael Ave. and Windward Rd.			$418,832	
Belvedere	PS-7	Peninsula Rd. and Beach Rd.	$411,031			
Belvedere	PS-8	Windward Rd.				$53,473
Belvedere	PS-9	Lagoon Rd. (south)		$83,478		
Belvedere	PS-10	Lagoon Rd. near Maybridge Rd.			$48,632	
Belvedere	PS-11	Lagoon Rd. (north)			$48,632	
Belvedere	PS-12	San Rafael Ave. and Edgewater Rd.			$36,050	
Belvedere	PS-13	West Shore Rd. (north)				$70,896
Belvedere	PS-14	West Shore Rd. (south)				$31,165
Belvedere	PS-15	Beach Rd. near Embarcadero Dr.				$58,054
Seafirth	CF-PS1	Seafirth Pl.				$50,833
Seafirth	CF-PS2	Seafirth Rd.				$0
Total			$1,866,616	$1,514,015	$913,876	$326,408

Force Mains

A detailed assessment of SD5's force mains was not part of the master plan scope however available information was reviewed to develop recommendations for further evaluation. From the information available, the Tiburon force mains PS-5-14 and PS-6-621, and Belvedere force mains PS1-TIB and the PS3 force mains (GIS segments PS3-ND5 - PS3-ND5.1 and PS3-ND5.1.1) should be prioritized first for condition assessment. This is mostly due to their lengths, their associated pump station criticality, and their ages.

The most common assessment technologies for these force mains range between $12 thousand and $60 thousand per force main depending upon the technology used. These costs are based on previous project experience but would need to be refined with a quote from each vendor. For the purposes of this analysis, middle-range cost estimates were applied, which total approximately $215 thousand to assess all four pipelines.

Capital Improvement Plan

Table 4 provides a summary of the gravity main, lift station and force main recommendations and costs prioritized for the CIP. These recommendations have been divided into near-term (0-5 years), mid-term (5-10 years), and long-term (10-15 years) actions. These actions include additional condition assessments as well as rehabilitations, which could identify additional rehabilitation actions to these identified costs and could also impact CIP priorities. A similar budget was planned for additional force main assessment in the long-term CIP (10-15 year range).

Table 4. Summary of SD5 capital improvement plan

	Total	Tiburon	Paradise Cove	Belvedere	Yearly average
Short-term (0-5 years)					
Gravity main rehabilitation and inspection	$ 3,159,575	$2,236,717	$ -	$ 922,858	$631,915
Lift station rehabilitation	$ 1,896,617	$ 817,263	$ -	$1,079,354	$379,323
Force main inspection	$216,000	$ 108,000	$ -	$ 108,000	$ 43,200
Short-term total	**$ 5,272,192**	**$3,161,980**	**$ -**	**$2,110,212**	**$ 1,054,438**
Mid-term (5-10 years)					
Gravity main rehabilitation and inspection	$ 2,838,802	$1,838,902	$115,933	$ 883,967	$567,760
Lift station rehabilitation	$ 1,514,015	$ 431,013	$ -	$1,083,002	$302,803
Force main inspection	$ -	$-	$ -	$-	$ -
Mid-term total	**$ 4,352,817**	**$2,269,915**	**$115,933**	**$1,966,969**	**$870,563**
Long-term (10-15 years)					
Gravity main rehabilitation and inspection	$ 2,474,083	$1,614,805	$315,363	$ 543,915	$494,817
Lift station rehabilitation	$913,877	$ 361,730	$ -	$ 552,147	$182,775
Force main inspection	$ -	$-	$ -	$-	$ -
Long-term total	**$ 3,387,960**	**$1,976,535**	**$315,363**	**$1,096,062**	**$677,592**

Figure 3 shows a graph of the expected CIP expenditures over time for the next 15 fiscal years. Each of the bars represents a specific type of activity on either the gravity mains, lift stations, or force mains, while the total cost by fiscal year is shown as the green line. Annual expenditures are expected to average about $1 million over the next 10 years.

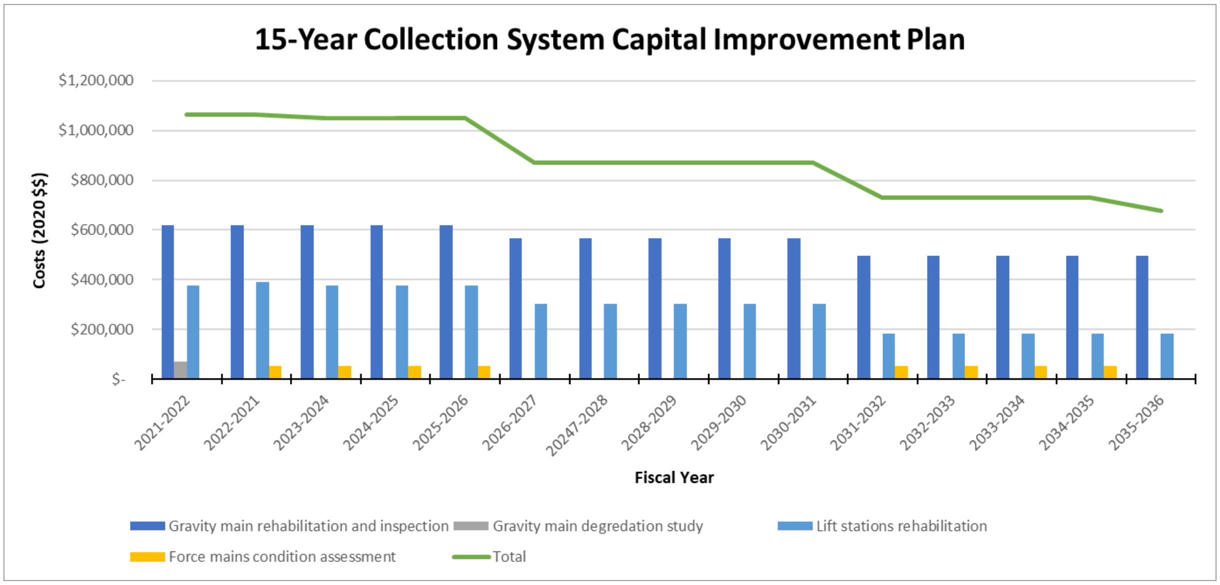


Figure 3. Recommended 15-year CIP

Figure 4 compares the existing SD5 capital plan as provided in the FY 2020-2021 Final Budget report (SD5, 2020b) to the recommendations from this master plan. The planned budget averages approximately $1.2 million whereas the recommended projects from this Master Plan average approximately $1.0 million over the same time period.

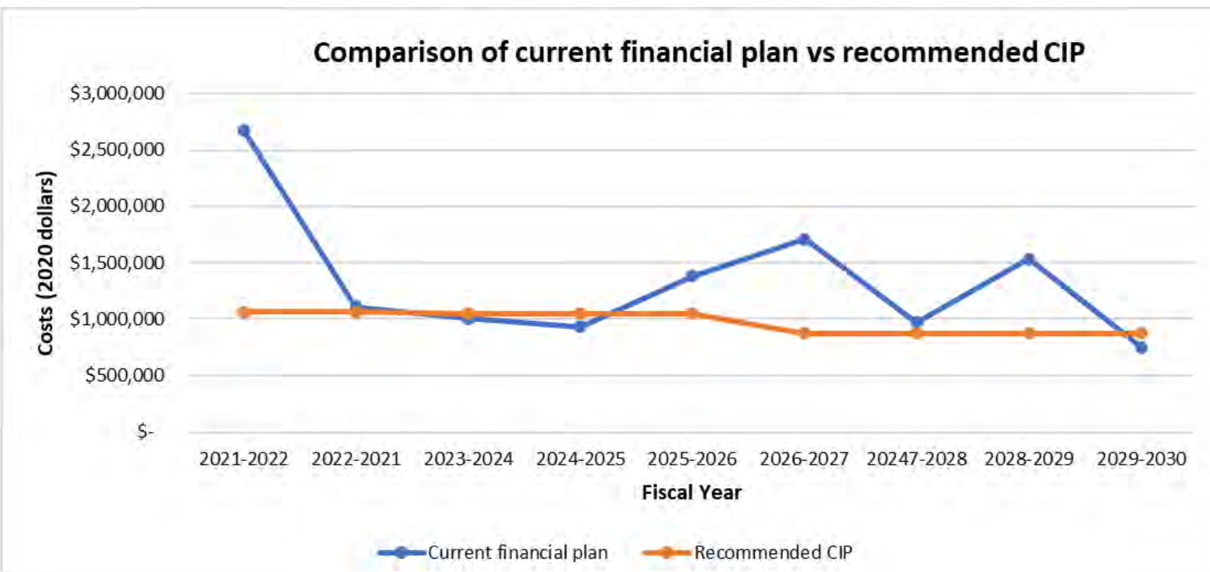


Figure 4. Comparison of the recommended CIP and the SD5 financial plan

1.0 Introduction

This section provides an overview of the project and describes the goals and objectives.

1.1 Project Background

Sanitary District No. 5 of Marin County (SD5) has developed this Collection System Master Plan (Master Plan) to better understand the current conditions of its collection systems, anticipate future needs, and identify potential items for operational improvement and capital investment. This Master Plan covers both the Main Treatment Plant collection system, which consists of 28.8 miles of gravity sewer line, 2.6 miles of force mains, and 22 pump stations, and the Paradise Cove collection system, which consists of 1.5 miles of gravity sewer line, 2.3 miles of force mains, and two pump stations within its service area. The Master Plan describes the assessment of these facilities, provides a 15-year capital improvement plan (CIP), and presents other system performance improvement recommendations.

SD5 previously completed a study in 2005 that produced a set of recommendations for capital improvements (Harris and Associates, 2005). Since that time, SD5 has implemented many of the recommendations and made considerable investment in the wastewater collection system infrastructure. SD5 believes that it is time to reassess the system to determine its current condition and identify rehabilitation priorities. This master planning effort provides an updated road map for capital investment and operational improvements that accounts for anticipated growth and demographic changes and identifies rehabilitation and renewal needs that will enable SD5 to continue to meet regulatory and service-level goals for the community.

1.2 Goals and Objectives

This Master Plan is intended to achieve the following goals and objectives:

- Assess the current condition of the sewer gravity system and lift stations
- Provide recommendations for capital improvement and infiltration and inflow (I&I) reduction
- Review available information on force mains and provide condition assessment recommendations
- Identify operational improvements for odor control
- Develop a 15-year collection system CIP
- Discuss potential system vulnerabilities, such as sea level rise (SLR), and support other potential changes including environmental, social and economic conditions that could present challenges to SD5.

SD5 is a special district that serves a small population with a limited rate payer base. This Master Plan is structured to align with SD5’s needs and must balance out prioritized strategic capital investment with affordability.

1.3 Report Purpose and Organization

SD5 will use this Master Plan as a reference and baseline for implementing capital improvements and other recommendations necessary to continue to meet expected service levels to the community and regulatory requirements for the next 15 years.

The following sections are included in the Master Plan:

1. Introduction: documents the project background, goals and objectives, the purpose and structure of the Master Plan, assumptions and dependencies, acronyms and abbreviations and a summary of data sources used or reviewed.
2. Service Area Description: describes the service areas served by SD5 and specific characteristics including geography, climate, land use, and population; both current and anticipated in the future.
3. Existing System Description: presents the physical and operational characteristics for SD5's Main Treatment Plant and Paradise Cove collection systems.
4. Facility and Infrastructure Assessment: discusses the assessments completed for SD5s assets, including the gravity mains and lift stations including the need to reduce I&I.
5. Capital Improvement Plan: lists the specific capital improvement recommendations and describes the methodology for establishing implementation priorities and costs.

1.4 Assumptions and Dependencies

The analyses and recommendations in this Master Plan are based on the following assumptions and dependencies:

- The information, data and interpretations obtained from the data sources and reports provided are assumed to be accurate and correct. No attempt has been made to verify these sources of information.
- Rehabilitation decision modeling used to evaluate the closed-circuit television (CCTV) inspection results (Harris and Associates, 2005) is based on existing models used at other utilities. Only minor customizations have been made specific to SD5's needs.
- This Master Plan also relies on institutional knowledge from Nute Engineering based on its history of capital improvement and design work for SD5

1.5 Abbreviations and Definitions

The following abbreviations and definitions are used in this report:

ADWF	Average dry weather flow.
BSF	Base sanitary flow.
CCTV	Closed-circuit television video. Used to inspect gravity sewer pipe.
CIP	Capital improvement plan.
CIPP	Cured-in-place pipe. A pipe rehabilitation method.
CIWQS	California Integrated Water Quality System. Website used for reporting sewer system overflows.
CoF	Consequence of failure. A measure indicating the impact if an asset fails.
District	Sanitary District No. 5 of Marin County
EUL	Estimated useful life. The average service life of an asset.
Flow monitoring hydrograph	A graph that shows the rate of flow over time for a specific location in the sewer system.
FOG	Fats, oils, and grease.

Force main	A pressurized sewer pipe that conveys wastewater under pressure from the discharge side of a pump.
FY	Fiscal year.
GIS	Geographic information system.
gpm	Gallon(s) per minute.
Gravity main	A sewer main that conveys wastewater via gravity.
GWI	Groundwater infiltration.
H2S	Hydrogen sulfide.
HDR	HDR Engineering, Inc.
hp	Horsepower.
I&C	Instrumentation and controls.
I&I	Inflow and infiltration. Non-wastewater-related flow in a sewer pipe that causes excess flow and dilution.
in.	inch(es).
Infiltration	Water entering a sewer pipe through defects in the pipe or joints.
Inflow	Water entering a sewer pipe from inappropriate connections.
InfoAsset Planner	Spatial software that is used to model risk in the collection system and to plan for and estimate rehabilitation actions.
KPI	Key performance indicator.
lb	Pound(s).
LF	Linear foot/feet.
Lift station	A pumping station in the collection system used to move wastewater from a lower elevation to a higher elevation.
LoF	Likelihood of failure. A measure indicating how soon an asset is likely to fail.
Master Plan	Collection System Master Plan
mi	Mile(s).
MWLS	Miscellaneous water level sag.
N/A	Not applicable.
NASSCO	National Association of Sewer Service Companies. NASSCO provides the standard for inspection and assessment of gravity mains using CCTV.
NPDES	National Pollutant Discharge Elimination System.
O&M	Operations and maintenance.
PACP	Pipeline Assessment and Certification Program. Defines standards and conventions for assessing sewer pipe.
Peak structural defect score	The highest (most severe) score identified on a pipe segment.
Rainfall hyetograph	A graphical representation of the distribution of rainfall over time.

RDI/I	Rain-dependent infiltration and inflow.
Risk score	The numeric score calculated for a pipe segment based on the likelihood of failure and consequence of failure grading.
SLR	Sea level rise.
Smoke testing	An assessment method using smoke that is pumped into the sewer system to determine locations where the system could be leaking to determine connectivity and potential problems in the system. Used to identify I&I vulnerabilities.
SSMP	Sewer System Management Plan. A plan required of all organizations that manage collections systems that defines how the system is managed and maintained, and how the organization responds to overflows.
SSO	Sewer system overflow.
TDH	Total dynamic head.
V	Volt(s).
WWTP	Wastewater treatment plant.

1.6 Data Sources and Review

Many data sources were reviewed and analyzed during the development of this Master Plan. The following key data sources and documents used were:

1. BVB Consulting LLC (2017). Marin Shoreline Sea Level Rise Vulnerability Assessment
2. E2 Consulting Engineers Inc. (2011). Sanitary District No. 5 of Marin County Flow Monitoring Report
3. Harris and Associates (2005). City of Belvedere Sanitary Sewer Investigation and GIS Program Report
4. Nute Engineering (2017). Pump Station No. 5 Improvements – Phase 2
5. Nute Engineering (2016a). Belvedere Pump Station Assessment Project
6. Nute Engineering (2016b). Tiburon Pump Station Assessment Project
7. Nute Engineering (2014). Pump Station No. 5 Improvements – Phase 1
8. Sanitary District No. 5 of Marin County (2020a). Geodatabases for Tiburon and Belvedere, including previous CCTV inspection results.
9. Sanitary District No. 5 of Marin County (2020b). FY 2020 – 2021 Final Budget,
10. Sanitary District No. 5 of Marin County (2020c). Updated Strategic Plan
11. Sanitary District No. 5 of Marin County (2018a). Main Plant Sewer System Management Plan
12. Sanitary District No. 5 of Marin County (2018b). Paradise Cove Sewer System Management Plan
13. Sanitary District No. 5 of Marin County (2018c). Succession Plan
14. Sanitary District No. 5 of Marin County (2017). Emergency Response Plan
15. Sanitary District No. 5 of Marin County (2015). Minimum Staffing Requirements
16. US Environmental Protection Agency (2017). Effective Utility Management: A Primer for Water and Wastewater Utilities
17. V&A Consulting Engineers (2018). Sanitary District No.5 of Marin County Four Pipe Samples Visual Condition Assessment Letter Report

Additional information was obtained from various websites including the Town of Tiburon, City of Belvedere, US Census Bureau, the California State Water Resources Control Board, and the National Oceanic and Atmospheric Administration.

2.0 Service Area Description

Sanitary District No. 5 of Marin County is a special district established in 1922 that has been providing wastewater collection and treatment services to parts of the Tiburon Peninsula and the City of Belvedere since the early 1940s (SD5, 2020c). It currently provides services to more than 3,500 households and covers approximately 2,550 acres. Commercial interests include downtown Tiburon, which is composed mostly of small boutiques, hotels, marinas, and restaurants supporting local tourism, and commuter ferry services to San Francisco.

SD5 has consistently been in compliance with state and federal regulations under a National Pollutant Discharge Elimination System (NPDES) Permit that regulates sanitary agencies (SD5, 2020c). SD5's mission as stated on the District website is as follows:

> *Sanitary District No.5 of Marin County is a special District, which while meeting or exceeding all applicable local, state and federal laws and regulations, is dedicated to the protection of public health and the environment through effective and economical collection, conveyance, treatment and disposal of wastewater*

2.1 Service Area and Population Served

Located on the Tiburon Peninsula north of the city of San Francisco and on the San Francisco Bay, SD5 serves a population of approximately 8,400 people in the town of Tiburon, the city of Belvedere, and the surrounding, unincorporated areas (Figure 5). SD5's Main Treatment Plant collection system consists of 28.8 miles of gravity sewer line, 2.6 miles of force main, and 22 pump stations. The treatment plant provides secondary treatment of residential and commercial wastewater. The Paradise Cove collection system has an additional 1.5 miles of gravity sewer line, 2.3 miles of force mains and two pump stations that direct wastewater flow to the Paradise Cove treatment plant.

Figure 5. Location map showing SD5 service area

The Town of Tiburon, which was incorporated in 1964, had an estimated population of 9,084 in 2019 (www.census.gov). It is bordered on the south-west by the City of Belvedere and Corte Madera to the north, but otherwise is surrounded by San Francisco Bay. It has a total area of about 13.2 square miles of which about 66 percent is water. SD5 serves approximately the southern half of the town.

The City of Belvedere, which was incorporated in 1896, had an estimated population of 2,104 in 2019 (www.census.gov). It consists of two islands and is connected to the Town of Tiburon by two causeways. It is an entirely residential community of about 2.42 square miles of which about 78 percent is water. SD5 provides wastewater collection and treatment for the entire city.

The remaining District service area on the Tiburon Peninsula is unincorporated serving residences and small communities throughout the hills and along the peninsula coastline. Topography within the service area ranges from sea level to about 740 feet above sea level along the peninsula ridgeline.

2.2 Climate

The weather in the service area is very moderate with average temperatures ranging from the mid-70's in summer to the low 40's in winter. Rainfall averages about 29 inches per year, with most of it falling in the winter months. Monthly averages range from 6.2 inches per month in January to less than 1 inch of rain in July. On average, it rains only 80 days throughout the year.

2.3 Land Use

The land use in SD5's service area is designated predominantly as low-density residential and open space or parklands. Commercial property makes up a very small percentage and is concentrated primarily in downtown Tiburon. The city of Belvedere is almost entirely built out and future changes in its land use designations are not likely. Future development will primarily be renovations or replacement of existing homes. The town of Tiburon has more undeveloped land and could continue to build out based on the current land use designations; however, General Plan policies on open space, safety, and conservation make it unlikely that significant changes will occur in the future. Land use and development in the unincorporated areas that SD5 services fall under the Town of Tiburon's sphere of influence and are also unlikely to change in the future. There are no current or anticipated industrial activities within SD5's service area.

SD5's service area is bordered on its northern side by Richardson Bay Sanitary District and Sanitary District No. 2 and is unlikely to spread farther to the north. The remainder of the service area is surrounded by water. Some parts of the unincorporated areas, mostly within SD5 boundaries, are still on individual septic systems.

2.4 Future Conditions

As discussed previously, the population within the service area has stabilized and significant future increases are not anticipated. Land use changes and additional build-out development is unlikely because of stringent building and planning requirements. Therefore, most of the current service area is expected to remain unchanged into the future. However, SD5 will likely continue to incorporate the individual residences that are currently on stand-alone septic systems and development projects in the eastern and northern unincorporated areas as the individual septic systems fail or the properties get developed. Currently another 25 to 50 connections are expected between residential conversions and new development. In addition, the San Francisco State Estuary and Ocean Science Center is connected to SD5 collection system in this area through a special outside service agreement. This property has potential for significant development and increased wastewater flows. These impacts may be able to be accommodated with the existing infrastructure, but additional expansion and improvements could be required in the future. Studies or assessments have not currently been completed and are not part of the scope of this Master Plan as they are typically performed during the property development process.

3.0 Existing System Description

SD5 collection system infrastructure is divided into two systems as shown in Figure 6: (1) the Main Treatment Plant collection system, which services all of the City of Belvedere and the southeastern and central portion of the Tiburon peninsula and (2) the Paradise Cove collection system, which services the northern portion of the Tiburon peninsula along the coast. In these two systems, SD5 manages about 30 miles of gravity pipelines, which include 772 manholes, 98 rod holes, and 19 cleanouts (Figure 7). Where gravity flow is not viable, SD5 pumps wastewater to its treatment plants through 24 lift stations and about 4.5 miles of force mains. Each of these systems is described in more detail in the following paragraphs. Information provided is based on SD5s geographic information system (GIS) database (SD5, 2020a).

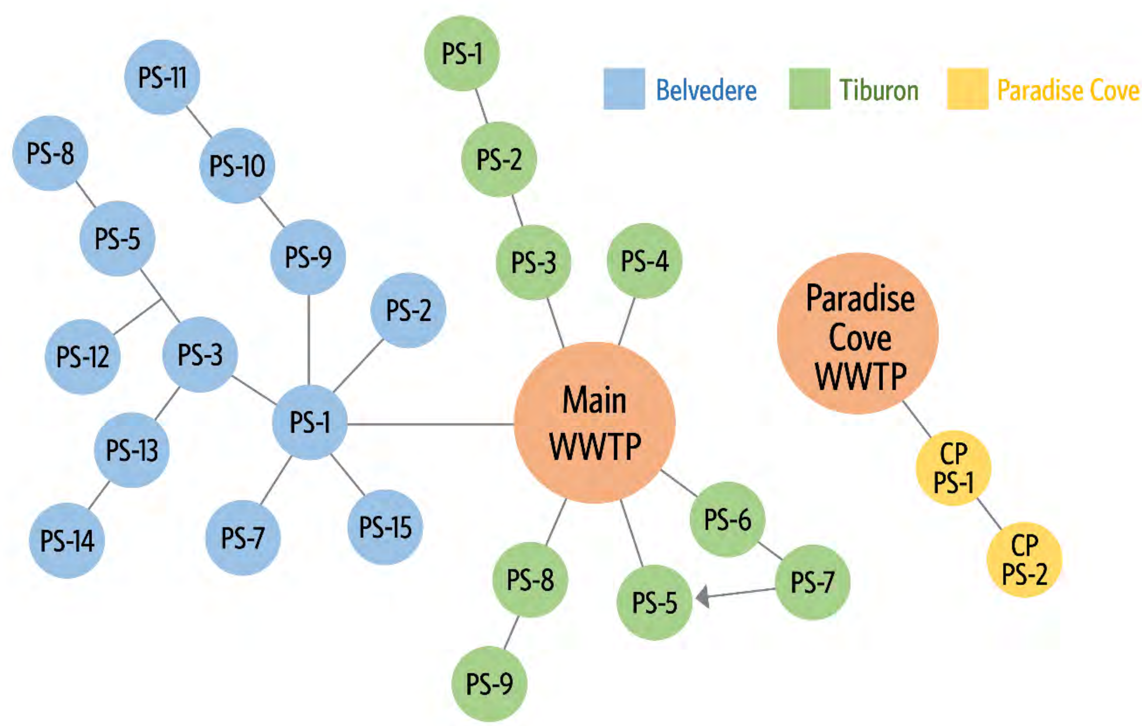


Figure 6. SD5 collection system schematic. Tiburon PS-7 flows can be diverted to PS-5 during non-normal flows scenarios.

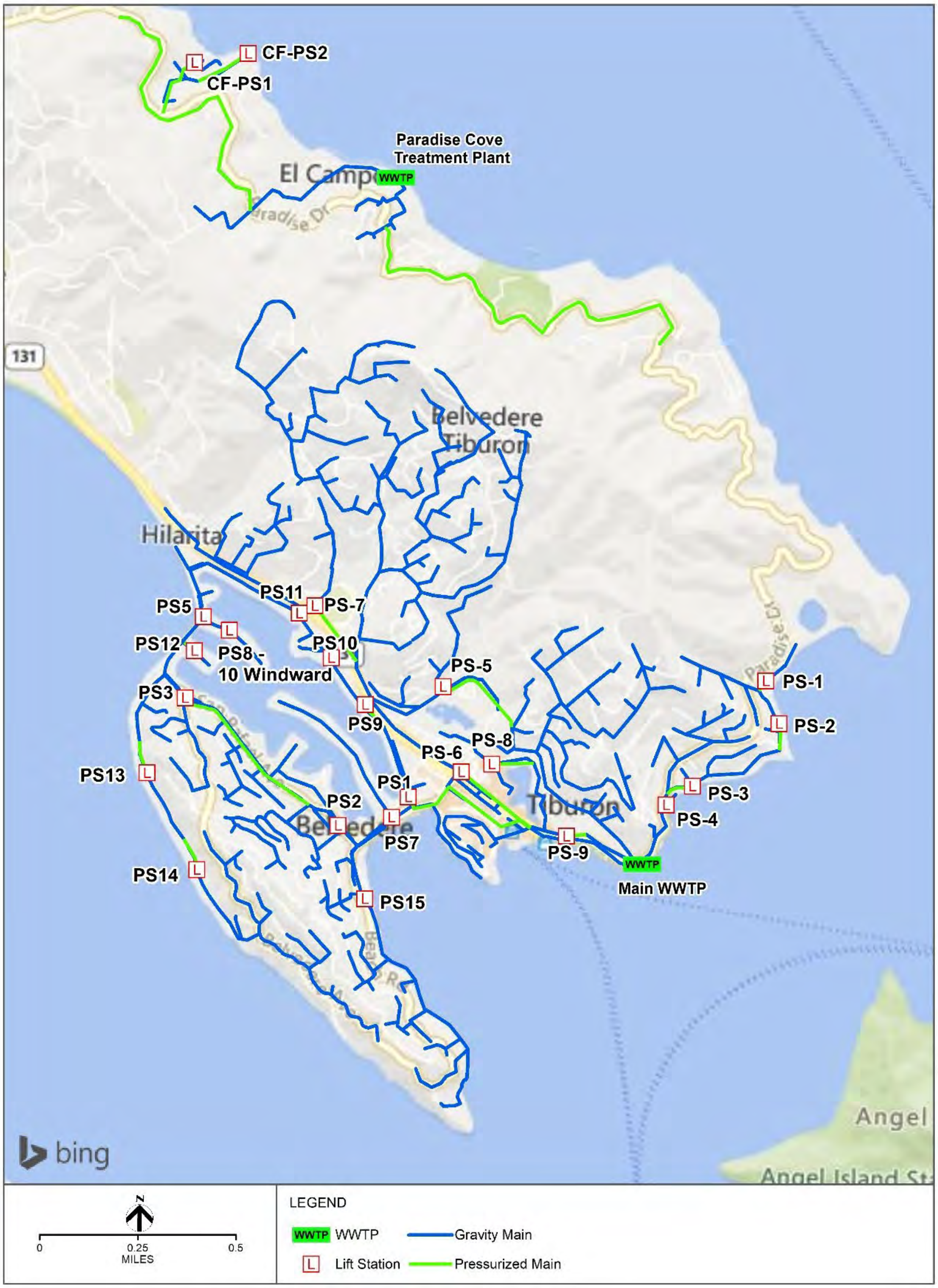


Figure 7. District 5 collection system

3.1 Collection System Gravity Pipelines

The collection system gravity pipelines consist of various diameters and materials installed at various times since the 1940's. Fifty-seven percent of the systems is comprised of 6-inch diameter vitrified clay pipe; pipe diameters range from 4 inches to 18 inches and the remaining portion of the system is comprised of pipes made from a variety of materials. Pipeline sizes are shown in Table 5, and material characteristics are provided in Table 6. The system has been constructed over the past 70 years based on the data provided in the GIS. System installation data are shown in Table 7. Almost 80 percent of the collection system pipes are over 50 years old, as shown in Figure 8.

Table 5. Pipe diameters and lengths in SD5's service areas

Diameter (in.)	Belvedere (mi.)	Tiburon (mi.)	Paradise Cove (mi.)	Grand Total (mi.)	Percent of length
4	0.5	0.1	0.0	0.6	2%
5	0.0	0.0	0.0	0.0	0%
6	8.6	14.8	1.4	24.8	82%
8	1.7	1.2	0.1	3.0	10%
10	0.2	0.2	0.0	0.4	1%
12	0.1	0.6	0.0	0.7	2%
14	0.0	0.0	0.0	0.0	0%
15	0.2	0.2	0.0	0.4	1%
18	0.0	0.3	0.0	0.3	1%
Unknown	0.1	0.0	0.0	0.1	0%
Grand total	**11.5**	**17.3**	**1.5**	**30.3**	**100%**

Table 6. Summary of collection system pipe material

Material	Belvedere (mi.)	Tiburon (mi.)	Paradise Cove (mi.)	Grand Total (mi.)	Percent of length
Asbestos Cement	0.1	0.1	0.4	0.6	2%
Cast Iron	0.2	0.0	0.0	0.2	1%
Corrugated Metal Pipe	0.0	0.0	0.0	0.0	0%
Corrugated High Density Polyethylene Pipe	0.4	1.0	0.0	1.4	4%
Orangeburg Fiber	0.0	0.1	0.0	0.1	0%
Polyethylene	2.5	2.0	0.0	4.5	15%
Polypropylene	0.0	0.1	0.0	0.1	0%
Polyvinyl Chloride	0.5	0.9	0.9	2.3	8%
Transite	0.0	0.0	0.0	0.0	0%
Vitrified Clay Pipe	7.7	13.1	0.2	21.0	69%
Unknown	0.1	0.0	0.0	0.1	0%
Grand Total	**11.5**	**17.3**	**1.5**	**30.3**	**100%**

Table 7. Installation decade of collection system pipes

Installation decade	Belvedere (mi.)	Tiburon (mi.)	Paradise Cove (mi.)	Grand Total (mi.)	Percent of length
Unknown	0.5	0.1	0.2	0.8	3%
1950-1959	8.3	4.1	0.2	12.6	42%
1960-1969	1.4	8.7	0.0	10.1	33%
1970-1979	0.0	1.0	0.3	1.3	4%
1980-1989	0.0	1.1	0.2	1.3	4%
1990-1999	0.9	0.4	0.6	1.9	6%
2000-2009	0.4	1.5	0.0	1.9	6%
2010-2019	0.0	0.4	0.0	0.4	1%
Grand Total	**11.5**	**17.3**	**1.5**	**30.3**	**100%**

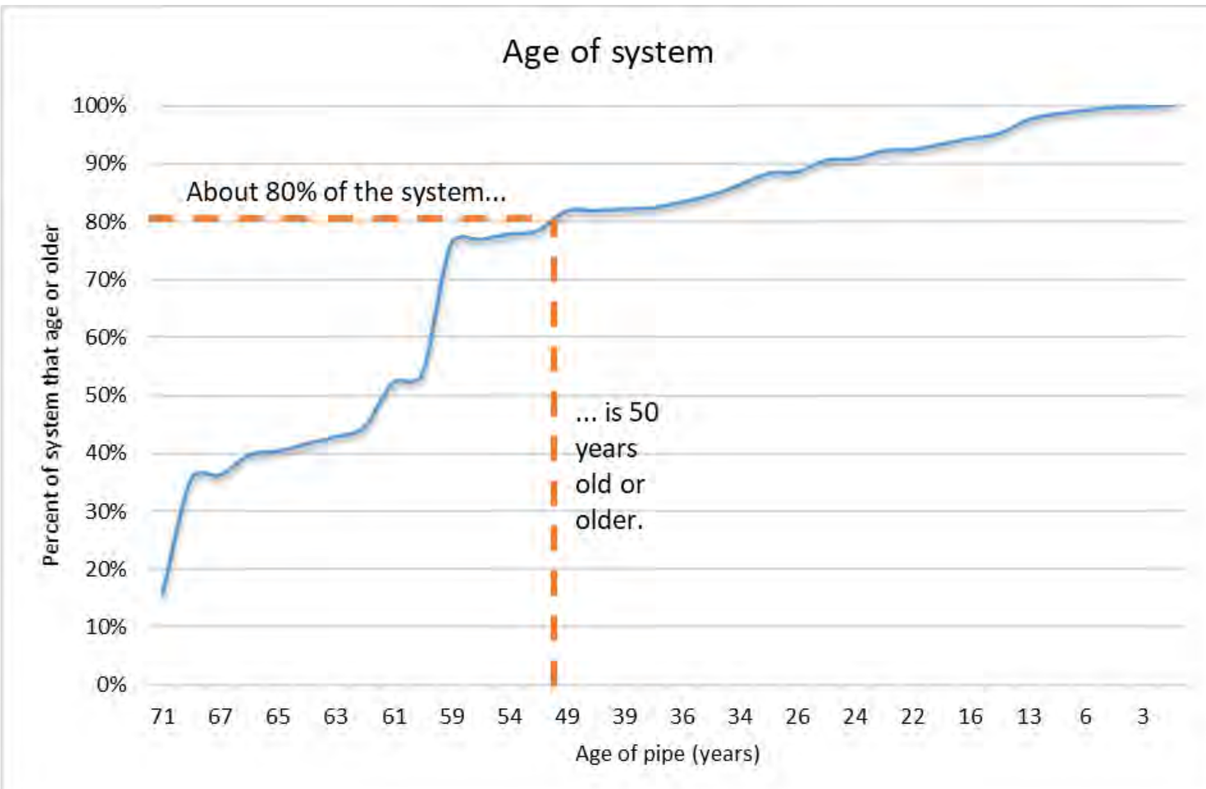


Figure 8. Age as a percentage of collection system pipes

Since the previous collection system assessment, SD5 has replaced or rehabilitated 2.2 miles of gravity main in its service area. The District maintains a regular gravity main cleaning program and purchased new rodder and vactor equipment in 2020 to increase sewer main cleaning and maintenance performance.

3.2 Force Mains

There are about 4.8 miles of force main throughout the collection system. The Tiburon and Belvedere service areas contain about 2.6 miles and the Paradise Cove service area has about 2.3 miles. Force main sizes are shown in Table 8 and force main materials are provided in Table 9.

Table 8. Force mains by diameter

Diameter	Belvedere (mi.)	Tiburon (mi.)	Paradise Cove (mi.)	Grand Total
4	0.3	0.2	1.2	1.6
6	0.1	0.3	1.1	1.6
8	0.4	0.5	-	0.8
10	0.4	0.1	-	0.4
Unknown	-	0.4	-	0.4
Grand Total	**1.2**	**1.4**	**2.3**	**4.8**

Table 9. Force mains by material

Material	Belvedere (mi.)	Tiburon (mi.)	Paradise Cove (mi.)	Grand Total
Asbestos cement	0.6	0.2	-	0.8
Cast iron	0.5	0.6	-	1.1
Polyethylene	0.1	0.4	2.0	2.4
Polyvinyl chloride	0.1	0.1	0.1	0.3
Steel pipe	-	0.0	-	0.0
Clay Pipe	0.0	-	0.2	0.2
Grand total	**1.2**	**1.4**	**2.3**	**4.8**

3.3 Lift Stations

SD5 operates 24 lift stations that convey wastewater flow from the collection system to the treatment plants. These lift stations and their known characteristics are provided in Table 10 and their locations are shown in Figure 9. Overall lift station capacities and total dynamic head (TDH), which are typical attributes to describe lift stations, were not available, so other key characteristics are shown. The Tiburon service area has nine lift stations that pump wastewater to the Main Treatment Plant. In the Belvedere service area, SD5 operates 13 lift stations that also convey wastewater into the Main Treatment Plant. The Paradise Cove treatment plant receives wastewater from the two Seafirth lift stations. Each of these service areas operate independently of each other.

SD5 has an ongoing pump replacement program to replace lift station pumps that have reached the end of their useful life. Pumps are replaced on approximately 15-year intervals. The District has also recently upgraded most of the electrical systems, installed generators on raised pads and purchased portable generators to supply as-needed emergency backup power and to make the system more resilient to sea level rise. The raised electrical panels and generators at Belvedere PS-3, and Tiburon PS-5, PS-6, and PS-7 are likely to keep these components away from the effects of rising sea level throughout their service life for the near-term and medium-term (i.e. to 2050). To protect against long-term sea level rise as defined in the Marine Shoreline Sea Level Rise Vulnerability Assessment (BVB Consulting LLC, 2017), these components should be raised again when they are replaced. The predicted effects of sea level rise are discussed in Section 4.2.12.

All of the lift stations except for Tiburon PS-1 contain multiple pumps to achieve pumping capacity and for redundancy. These pumps generally range from 3 hp to 5 horsepower (hp), however Tiburon PS-5 and Belvedere PS-1 have larger pumps as they convey water from about 45 percent and 97 percent of the collection system mains in their respective service areas (by linear miles).

Table 10. Summary of District lift stations

Service Area	Lift station number	Lift station location	Number of pumps	Largest motor (hp)	Collection system serviced (mi of main)	Collection of service area serviced (percentage of main)*
Tiburon	PS-1	Mar E St. near Mar E Dr.	1	3	0.1	1%
Tiburon	PS-2	Mar E St. near Agreste Way	2	3	0.7	4%
Tiburon	PS-3	Paradise Dr. and Solano St.	2	5	1.2	7%
Tiburon	PS-4	Paradise Dr. near Lyford's Tower	2	5	0	0%
Tiburon	PS-5	Mar W St.	2	60	7.7	45%
Tiburon	PS-6	Tiburon Blvd. and Beach Rd.	2	5	2.3	13%
Tiburon	PS-7	Tiburon Blvd near Ned's Way	2	5	1.6	9%
Tiburon	PS-8	Beach Rd. & Lagoon Vista Rd.	2	3	1.2	7%
Tiburon	PS-9	Paradise Dr. near Shoreline Park	2	5	0.8	5%
Belvedere	PS-1	Cove Rd. and Barn Rd.	2	10/15	11.1	97%
Belvedere	PS-2	San Rafael Ave. and Teal Rd.	2	3	5.1	44%
Belvedere	PS-3	San Rafael Ave. and Golden Gate Ave.	3	5	3.7	32%
Belvedere	PS-5	San Rafael Ave and Windward Rd.	2	5	0.6	5%
Belvedere	PS-7	Peninsula Rd. and Beach Rd.	2	3	7.3	63%
Belvedere	PS-8	Windward Rd.	2	3	0.1	1%
Belvedere	PS-9	Lagoon Rd. (south)	2	3	0.9	8%
Belvedere	PS-10	Lagoon Rd. near Maybridge Rd.	2	3	0.4	3%
Belvedere	PS-11	Lagoon Rd. (north)	2	3	0.2	2%
Belvedere	PS-12	San Rafael Ave. & Edgewater Rd.	2	3	0.1	1%
Belvedere	PS-13	West Shore Rd. (north)	2	3	1.8	16%
Belvedere	PS-14	West Shore Rd (south)	2	3	1.6	14%
Belvedere	PS-15	Beach Rd. near Embarcadero Dr.	2	3	1.8	16%
Seafirth	CF-PS1	Seafirth Pl.	2	25	0.3	20%
Seafirth	CF-PS2	Seafirth Rd.	2	3	0.1	7%

* Including gravity mains that flow into upstream lift stations

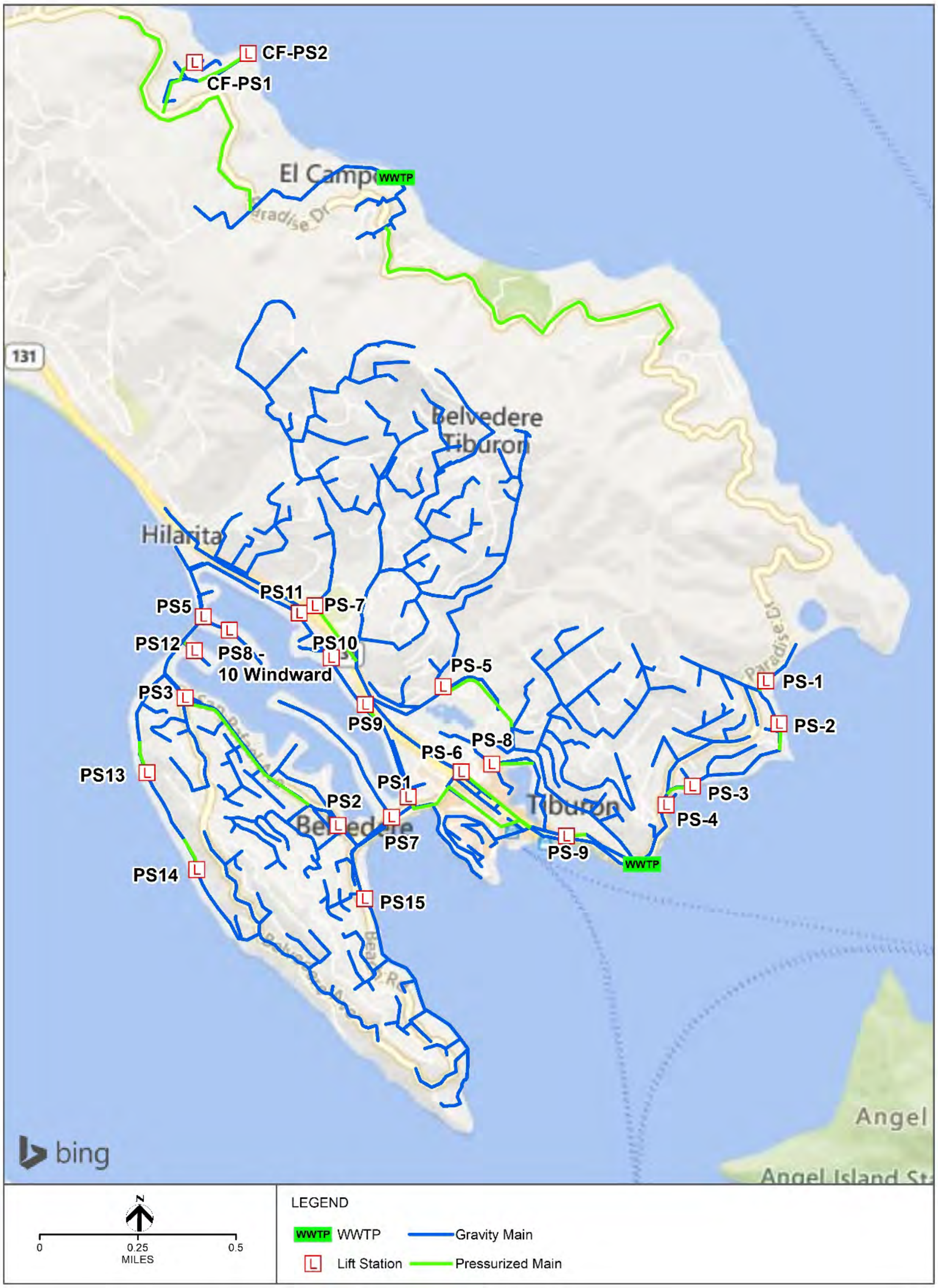


Figure 9. Approximate locations of Tiburon and Belvedere lift stations

A schematic of the lift stations and how they pump water to the treatment plants is shown on Figure 6. Tiburon lift stations PS-3, PS-5, PS-6, and PS-8 are main collection points in the Tiburon service areas, receiving all wastewater from other lift stations and the remaining parts of the collection system (Table 10). In the Belvedere service area, all flows are received at PS-1, which pumps directly to the Main treatment plant. Other important Belvedere lift stations include PS-2, PS-3, and PS-7 which collect wastewater from 44 percent, 32 percent, and 63 percent of the service area by miles respectively (including gravity mains that flow into upstream lift stations).

4.0 Facility and Infrastructure Assessment

An assessment of SD5's collection system infrastructure was performed to identify repair, replacement, and rehabilitation actions that will help SD5 continue to provide reliable wastewater collection and conveyance and meet customer and stakeholder expectations. The following activities were performed as part of this planning effort:

- Condition assessment of the gravity mains using existing CCTV data (SD5 2020a), collected over the last 15 years to identify and prioritize structural improvements to the gravity mains and recommendations for future CCTV inspections
- Analysis of the 2010 Flow Monitoring Study (E2 Consulting Engineers Inc., 2011) results to determine recommendations to reduce I&I in selected drainage basins
- Evaluation of the Marin Shoreline Sea Level Rise Vulnerability Assessment report (BVB Consulting LLC, 2017) (https://www.marinwatersheds.org/sites/default/files/2019-04/BAYWAVE%20final.pdf) to assess the potential impact and provide recommendations to mitigate future SLR within the SD5's services area
- Visual inspection of SD5's 24 lift stations to develop capital improvement recommendations
- Evaluation of odor control issues occurring at some of the lift stations and recommendations for mitigation

This section describes how these analyses were conducted and the recommended actions identified.

4.1 Condition Assessment of Gravity Mains

The available CCTV inspection information was completed using the National Association of Sewer Service Companies (NASSCO) Pipeline Assessment and Certification Program (PACP) inspection standard for coding defects observed. NASSCO PACP is the North American standard for pipeline defect identification and assessment, which provides standard codes for conditions and defects observed through televised pipe inspection (i.e., CCTV). Approximately 85 percent of the system was inspected. SD5 has used these data to guide its gravity main rehabilitation program and repair many of the defective pipes. Since 2006, about 20,500 linear feet (LF) of pipe have been replaced or rehabilitated and SD5 has added more than 200 additional inspections to its database. These data have been used as the basis for the new assessment.

The assessment was performed using InfoAsset Planner from Innovyze. The software uses readily available sewer system data extracted from SD5's GIS database, applies risk modeling to calculate a relative risk score for each pipe, and identifies rehabilitation and/or inspection recommendations based on inspection data, pipe characteristics, and spatial analysis.

The risk model (i.e., InfoAsset Planner) considers two major factors:

- Likelihood of failure (LoF): a numerical score related to the condition of the pipe and a determination of how soon it may fail, and
- Consequence of failure (CoF): a numerical score that quantifies the impact on SD5 and the community if the pipe does fail.

Both the LoF and CoF scores are a product of calculation using additional scoring criteria. These criteria and how they are applied are described in Section 4.1.3. The LoF and CoF scores are then added together to produce the relative risk score for the pipe. This relative risk score is used to prioritize rehabilitation and reinspection actions.

InfoAsset Planner also processes each pipe through a rehabilitation decision support model to determine appropriate actions based on pipe characteristics. This model, which is based on SD5's criteria (described in Section 4.1.4), uses a decision tree to determine the most appropriate action and assigns it to each respective pipe. The end result is a rehabilitation or reinspection recommendation for every pipe based on its unique characteristics and risk profile. The model also applies planning-level cost factors to develop estimated costs, which can then be used as input into a CIP. The outcomes of these models have been verified though workshops and discussions with SD5 to make sure that the actions assigned are appropriate.

The remainder of this section describes the details the data used and the assessment itself. The findings of the assessment are provided in Section 4.1.5. For the assessment details, please refer to the following:

- Summary of data from the previous inspection: Section 4.1.1
- Characteristics of the inspection results: Section 4.1.2
- Development of the risk model formula and factors used: Section 4.1.3
- Discussion of the rehabilitation decision support analysis: Section 4.1.4

4.1.1 Previous Inspection

The InfoAsset Planner analysis was performed using sewer and inspection data provided by SD5, as well as other published local and regional data sources. The provided data were reviewed, processed, and mapped as InfoAsset Planner facility types. GIS data were provided in geodatabase format. Two geodatabase files, FacilityBelvedere.mdb and FacilityTiburon.mdb, were copied and converted into an InfoAsset Planner database. By using the existing database, all of the required information could be provided from SD5's GIS data fields and feature classes to perform the InfoAsset Planner analysis. The GIS feature classes representing the sewer mains and how they were assigned in InfoAsset Planner's Facility and Asset Type Manager Tool are shown in Table 11.

Table 11. GIS data – feature classes

Feature class	Source	Application
SS_LINK	FacilityBelvedere.mdb	InfoAsset Planner Gravity Main
SS_LINK	FacilityTiburon.mdb	InfoAsset Planner Gravity Main

The sewer main feature class in both of these geodatabases contained both force mains and gravity mains. Table 12 summarizes the sanitary sewer collection system pipe type breakdown. For the purposes of this facility assessment, the force mains were removed from the analysis.

Table 12. GIS data – gravity main breakdown

Area	Type	Count	Total length (mi)
Belvedere	Force Main	17	1.2
	Gravity Main	337	11.4
Tiburon	Force Main	21	3.7
	Gravity Main	548	18.9
Total	Force Main	38	4.9
	Gravity Main	885	30.3

The previous gravity main CCTV inspection data were also provided in the "FacilityBelvedere.mdb" and "FacilityTiburon.mdb" geodatabases. In both databases, the "PACP_Inspections" table contains the general CCTV inspection data and the "PACP_Conditions" table contains the defect data.

Table 13 shows the number of records provided in each geodatabase. Of the total 1,104 records, 1,034 of them could be imported into InfoAsset Planner. The 80 records that were not imported into InfoAsset Planner failed to import because of a geocoding mapping failure. The inspection's Pipe Segment Reference and Upstream Manhole and Downstream Manhole references do not match the pipe data and therefore could not be used.

Table 13. CCTV inspection data summary

Source	Source CCTV inspections	Imported CCTV inspections
FacilityBelvedere.mdb	416	378
FacilityTiburon.mdb	688	656
Total	**1,104**	**1,034**

The 1,034 imported CCTV inspections were successfully linked to 795 gravity mains with a unique CCTV inspection, as shown in Table 14. Roughly 90 percent of the gravity main system has been inspected. Only 90 of the 885 gravity main segments have not been inspected since 2004. These mains will be recommended for CCTV inspection during the modeling and scheduled based on risk score.

Table 14. Gravity mains with CCTV data

Area	Type	Total gravity mains	Gravity mains w/ CCTV	Percent CCTV
Belvedere	Gravity main	337	285	85%
Tiburon	Gravity main	548	510	93%
Total		**885**	**795**	**90%**

Table 15 shows the number of inspections completed each year. Only the most recent inspection for any given pipe is counted. Most of the CCTV inspections were completed in 2004 and 2005 as part of the comprehensive Sewer System Evaluation by Harris & Associates (Harris and Associates, 2005).

Table 15. Most recent CCTV inspection

Most recent inspection year	Count of gravity mains
Not Inspected	90
2004	198
2005	387
2006	1
2008	22
2009	8
2010	53
2011	67
2013	2
2014	37
2015	2
2017	13
2018	3
2019	2
Grand total	**885**

4.1.2 Characterization of Existing CCTV Findings

A review of the existing CCTV findings was performed to understand the primary issues found during the CCTV inspections. These findings were not verified against the actual CCTV videos as part of this study. It is assumed that the coding provided by SD5 is accurate and complete. A list of the top 10 structural or operational (O&M) PACP defects and the number of times that they occur in the data are shown in Table 16. This indicates that the primary defects found in the gravity main system are roots, sags, joint offsets, cracks, and fractures. The defect codes were used to develop the decision logic to identify rehabilitation and reinspection recommendations.

Table 16. PACP defect code summary for SD5's CCTV database

PACP defect code	Description	Count
RFJ	Roots fine joint	1842
MWLS	Sag	453
RMJ	Roots medium joint	406
JOM	Joint offset medium	372
CL	Longitudinal crack	288
CC	Circumferential crack	278
FC	Circumferential fracture	153
FL	Longitudinal fracture	123
JOL	Joint offset large	89
RBJ	Root ball joint	79

4.1.3 Risk Model Development

Risk is the combination of an asset's LoF and CoF. It is a numerical score that gets calculated for each asset to quantify the assets relative risk. Both the LoF and CoF components are based on other factors used for scoring. To develop a risk model, it is critical to understand all of the LoF and CoF factors that contribute to risk. Risk scoring was developed and reviewed with SD5 both graphically and spatially on a map, to enable District staff to understand the model results and determine if it makes sense based on what has been experienced in the field. This understanding of the risk model will help SD5 evaluate and communicate the tradeoffs of various investment options and to gain consensus amongst staff, stakeholders, and decision-makers during the capital improvement planning process.

The risk score is calculated as the weighted summation of the LoF and CoF values. The formula used is shown in Figure 10. For each pipe, numerical values assigned for each of the CoF and LoF categories are multiplied by the weighting factor shown in parentheses. The LoF scores are summed together, the CoF scores are summed together, and the total values for each are added together to obtain the final risk score. The LoF represents the majority of the risk score (70 percent) to identify pipes that can be rehabilitated to drive down the risk. In other words, if more emphasis is placed on CoF values, pipes that are in good condition that have a high CoF (e.g., large pipes next to schools or hospitals with no structural problems) may consistently show higher risk scores than pipes that are more likely to fail (e.g., smaller-diameter pipes with structural problems that could cause a sewer system overflow [SSO]).

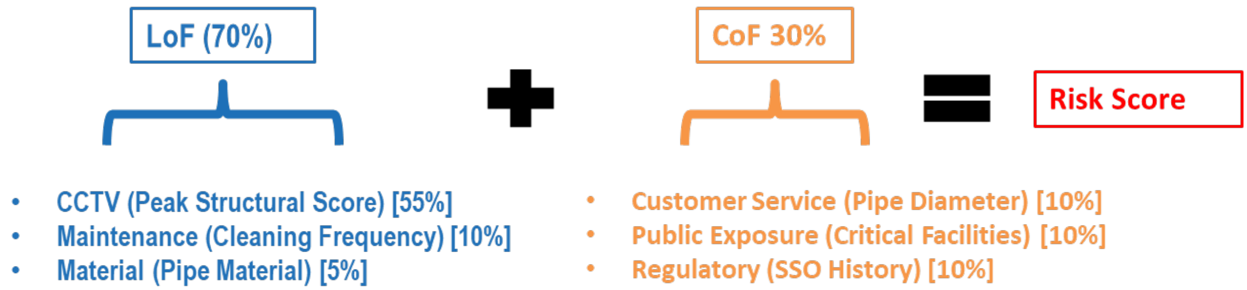


Figure 10. Gravity main risk formula

The components and the scoring for the CoF and LoF values are described below.

4.1.3.1 Consequences of Failure

CoF refers to the relative magnitude of the impact that the failure of a gravity main would have on the system or the community. For example, pipes that potentially produce larger spills or are close to schools will likely have a greater consequence if they fail compared to a smaller pipe that services a small cul-de-sac. The consequences evaluated for this analysis consider customer service, public exposure, and regulatory components.

The CoF criteria makes up 30 percent of the overall Risk Score and the breakdown of the weighting for each criterion is shown in Table 17 and discussed below.

Table 17. CoF criteria weighting

CoF criterion	Risk weighting
Customer Service (diameter)	10%
Public Exposure (critical facilities)	10%
Regulatory (SSO category)	10%

4.1.3.2 Customer Service

Customer service represents the relative impact on customers if a given pipe experiences an SSO. In general, larger diameter sewer pipes that have an SSO will potentially cause larger spills, in busier areas of the community and will be more difficult to clean up and repair. Therefore, larger diameter pipes will receive a higher score than smaller diameter pipes. This criterion uses diameter data from the SS_Link feature class with criteria and scoring developed by HDR for use in the risk analysis. Table 18 shows how this CoF was created and scored.

Table 18. CoF1: customer service

Category	Data source	Target field	Criteria	Score
Customer Service	SS_Link Feature Class	Diameter	> 15"	10
			12" < x <= 15"	9
			10" < x <= 12"	7
			8" < x <= 10"	6
			6" < x <= 8" or null	5
			4" < x <= 6"	4
			<= 4"	2

4.1.3.3 Public Exposure

Public Exposure represents the potential impact on critical facilities around SD5 should a given sewer pipe experience an SSO. Critical facilities represent locations where an SSO may have a greater safety impact on the community. This category uses the distance from the pipe to the closest critical facility to assign a score. Proximity to Schools, Fire Stations, Parks, and Belvedere Lagoon data from the various Marin County shapefiles was used and the criteria and scoring developed by HDR for the risk analysis. Table 19 shows how this CoF was created and scored.

Table 19. CoF2: public exposure

Category	Data Source	Target Field	Criteria	Score
Public Exposure	Marin County School Shapefile, Marin County Park Shapefile, and Marin County Fire Station Shapefile	School, fire station, park, Belvedere Lagoon	<= 200’	10
			200’ < x <= 500’	7
			500’ < x <= 1000’	5
			1000’ < x <= 2000’ or Null	3
			> 2000’	0

4.1.3.4 Regulatory

The Regulatory category considers previous spill information as an indicator of the size of potential future SSOs. Historically, if a previous spill on a given pipe was large, was difficult to clean up, or reached the storm system it is reasonable to assume that future spills could have the same impact. This category uses the SSO category criteria provided by the California State Water Resources Control Board and generally applies as defined in SD5’s Sewer System Management Plan (SSMP)[SD5, 2018a]:

- Category 1: any spill that reaches a surface water body or the storm system and is not fully recovered and disposed of properly
- Category 2: spills of over 1000 gallons that do not reach a surface water body or the storm system that are not fully recovered and disposed of properly
- Category 3: all other discharges from the sanitary sewer system

The higher the category is, the greater the score is for this criterion. The analysis for SD5 uses the designated SSO category from the SSO data reported to the California Integrated Water Quality System (CIWQS) website with criteria and scoring developed by HDR for use in the risk analysis. Table 20 shows how this consequence of failure was created and scored.

Table 20. CoF3: regulatory

Category	Data source	Target field	Criteria	Score
Regulatory	CIWQS	SSO Category	Category 1	10
			Category 2	8
			Category 3	6
			No historical SSOs	0

4.1.3.5 Likelihoods of Failure

LoF represents an estimate of how soon a given sewer main may fail based on evidence of its condition, its maintenance requirements, and expected useful life. For this analysis, failure represents the likelihood that a sewer main could cause an SSO. Typically, sewer pipes that are likely to fail sooner should be rehabilitated or replaced sooner than pipes that do not show evidence of potential failure.

A higher importance has been placed on the LoF score than the CoF because of the high confidence in SD5's condition data. Therefore, it was determined that the LoF criteria would make up 70 percent of the overall risk score. The LoF criterion makes up 70 percent of the overall risk score and the breakdown of the weighting for each criterion is shown in Table 21. Each of these criteria are discussed below.

Table 21. LoF criteria weighting

LoF criterion	Risk weighting
CCTV observed defects (peak structural defect score)	55%
Maintenance (cleaning frequency)	10%
Material (pipe material)	5%

4.1.3.6 CCTV-Observed Defects

CCTV-observed defects uses the peak structural defect score assigned to each sewer main from the most recent PACP CCTV inspection. Each of the defect scores is based on condition grades assigned using NASSCO PACP methodology. These grades range from 1 to 5, with 5 being the most severe. The peak structural defect score represents the highest-grade structural defect observed on the pipe during the inspection. For this analysis, the higher the peak structural defect score for a given sewer pipe, the higher the score is for this LoF category. Table 22 shows how these scores were assigned.

Table 22. LoF1: CCTV

Category	Data source	Target field	Criterion	Score
CCTV	PACP CCTV inspections	Peak structural defect score	Grade 5	10
			Grade 4	8
			Grade 3 or no CCTV	6
			Grade 2	4
			Grade 1	2
			No structural defects	0

4.1.3.7 Maintenance

The Maintenance category uses SD5's cleaning history for a given pipe to identify pipes that require higher maintenance to prevent SSOs. In general, pipes that require more frequent cleaning tend to more quickly build up conditions that cause blockages and potentially SSOs. In addition, more frequent cleaning can cause more rapid pipe deterioration depending on pipe materials and cleaning techniques. SD5 assigns each sewer pipe to a cleaning frequency and schedule based on how quickly buildup has historically been observed in the pipe and other factors. This analysis uses the current cleaning frequency assigned for each pipe from the GIS data with criteria and scoring developed by HDR. Higher cleaning frequencies have received higher scores for this category. Table 23 shows how this LoF was created and scored.

Table 23. LoF2: maintenance

Category	Data source	Target field	Criterion	Score
Maintenance	SS_Link Feature Class	MaintFreq	4 months or more	10
			Semi-annual	8
			Yearly	6
			Two years	4
			None	0

4.1.3.8 Material

The Material category represents the manufactured characteristics of a given pipe. Some types of pipe are expected to last longer than others before they begin to degrade. Material uses the pipe material information for each pipe from the GIS data with criteria and scoring developed by HDR for use in the Risk analysis. Table 24 shows how this LoF was created and scored.

Table 24. LoF3: material

Category	Data source	Target field	Criterion	Score
Maintenance	SS_Link Feature Class	Material	Cast Iron, Concrete, or Fiber (CAS, CMP, or OB)	10
			Clay, Transite, Asbestos, or no value (VCP, CT, TTE, AC, or null)	8
			Polyvinyl chloride (PVC)	5
			Plastic, Polyethylene, or Polypropylene (CPP, PE, PLP, or PP)	2

4.1.3.9 Relative Risk Scoring

The focus of this analysis is assessment and mitigation of risk in order to prevent SSOs. Risk was calculated using the formula shown in Figure 10, above, which yielded a relative risk score for each gravity sewer main. The risk scores are relative to SD5's collection system as a whole, meaning that they are used to determine priorities within the system, not to quantify potential failure. The risk results are shown on the pie chart in Figure 7 which shows the percentage in each category by linear footage. For the gravity pipes in SD5, the risk scores ranged from 5 to 78 out of a total possible score of 100. A risk score of 100 represents the highest possible risk (e.g., the maximum scores for each category assigned to a given pipe). A risk score of 0 represents the lowest possible risk. The risk scores represent a score relative to the calculated risk for other pipes in the system and not an absolute risk score and is a general indication of which pipes should be rehabilitated or replaced first according to the criteria.

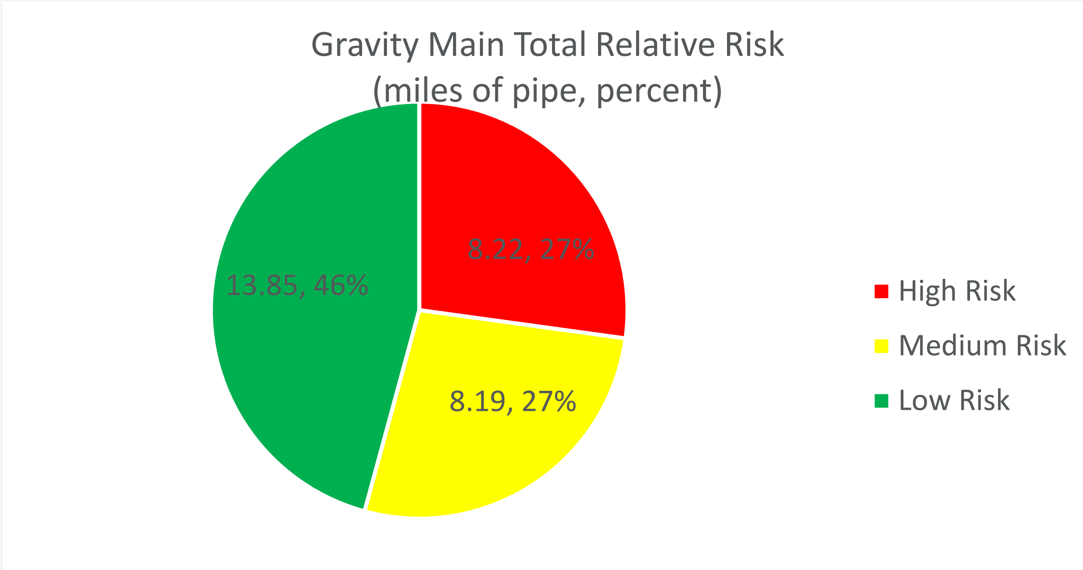


Figure 11. Risk results showing percentage of relative risk categories

The risk scores have been divided into "high," "medium," and "low" categories based on discussions with SD5 and natural cutoff points in some of the risk categories (e.g., structural defects). Approximately eight miles (27 percent) of SD5's pipes fall into the high category, while almost 14 miles (46 percent) are considered relatively low risk. Figure 12 shows the general risk for each of the gravity sewer mains in SD5. Green gravity mains are considered "low risk" and red gravity mains are considered "high risk." Appendix A provides a listing of each pipe and its respective LoF, CoF, and total risk scores.

These relative risk scores are used for prioritizing replacement or rehabilitation actions during the capital improvement planning process, which is described in more detail in the sections below.

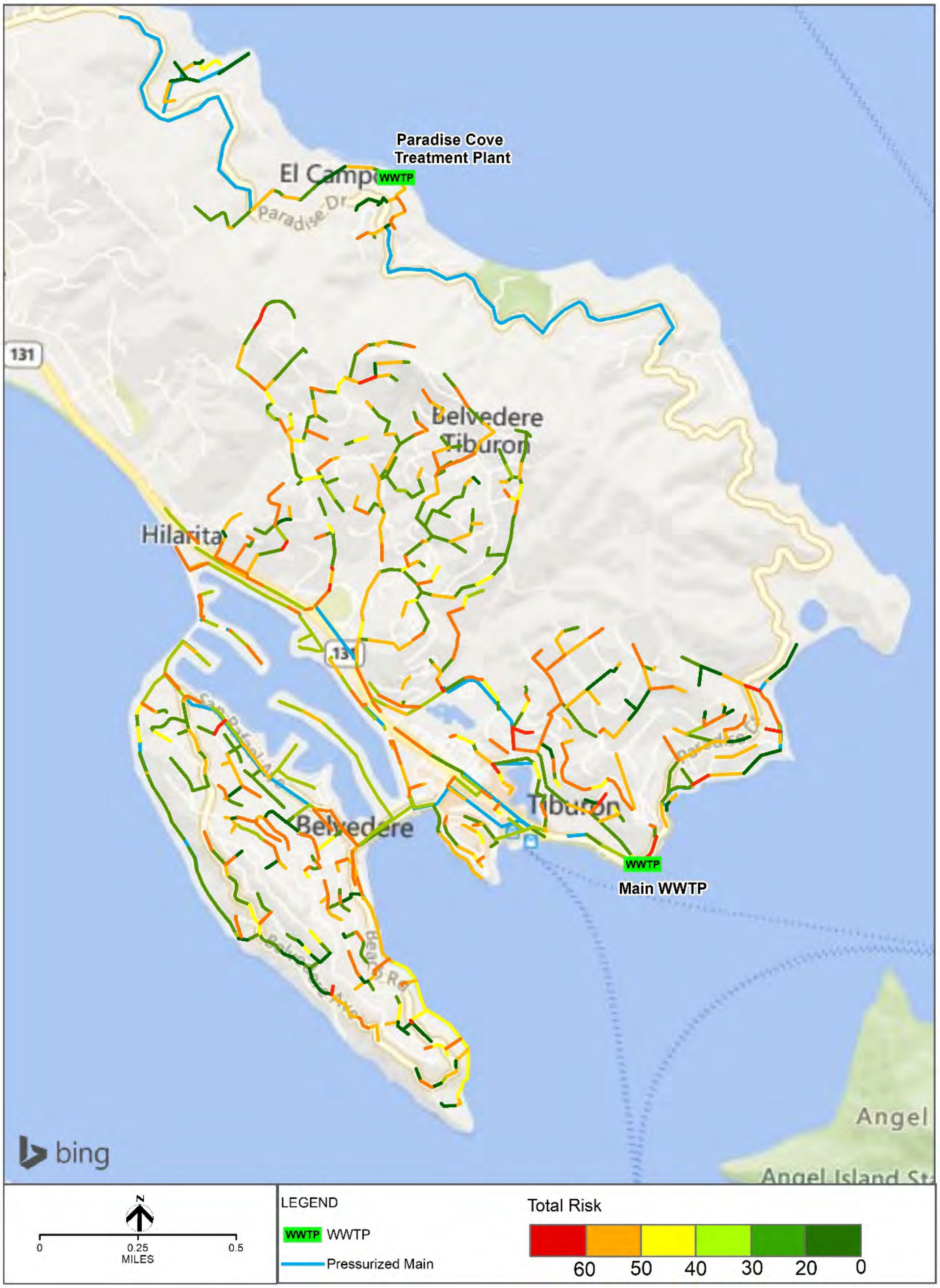


Figure 12. Risk model results

4.1.4 Rehabilitation Decision Support Analysis

This section summarizes the methodology for determining the appropriate rehabilitation recommendation for each gravity main. This was performed by developing a decision support model and rehabilitation plan based on industry experience, input from District and Nute Engineering staff, and the gravity sewer main risk modeling. Once the decision logic and initial rehabilitation plan were generated, a sensitivity analysis was performed to calibrate the model and verify that the actions identified in the model reflect what SD5 would normally do given the information provided.

The model will be provided to SD5 so that it can be updated and maintained by District staff or other consultants who use the Innovyze InfoAsset Planer software. The risk score thresholds that trigger specific risk mitigation actions may be adjusted by SD5 over time to balance budget and level-of-service targets, as additional condition assessment data are gathered, and the program is refined.

4.1.4.1 Rehabilitation Methods

The model is based on a decision tree that uses data developed for each gravity main to determine a rehabilitation or replacement action. The path that a given pipe follows in the model is based on specific data thresholds in the decision logic. A workshop was held with SD5 to review and edit the initial decision logic. The decision logic aggregates the information from the inspections and risk score and provides an automated identification of a primary action to address the identified risks within the gravity mains. The primary action documents the primary risk management action for the gravity mains. The following primary actions were included in the decision logic:

- **Replacement:** complete open-trench replacement of the pipe
- **Pipe bursting:** a trenchless method of sewer construction that uses the path of the existing pipe as a guide for constructing the new pipe
- **Full CIPP lining:** a trenchless construction process that installs a cured-in-place-pipe (CIPP) liner within an existing pipe that repairs structural defects
- **Point repair:** a trenchless process that uses a liner to repair a small section of pipe
- **CCTV inspections:** if no repairs are required, a future-scheduled reinspection of the entire pipe using a CCTV camera

4.1.4.2 Recently Replaced Pipes

One of the first steps in the decision logic is to remove pipes that have their most recent inspection date prior to the date it was replaced. The related CCTV video for these pipes is for the original pipe and do not apply to the replacement pipe. These pipes are considered new and therefore do not need rehabilitation.

There are 69 pipes that have been recently replaced and can be seen in Figure 13.

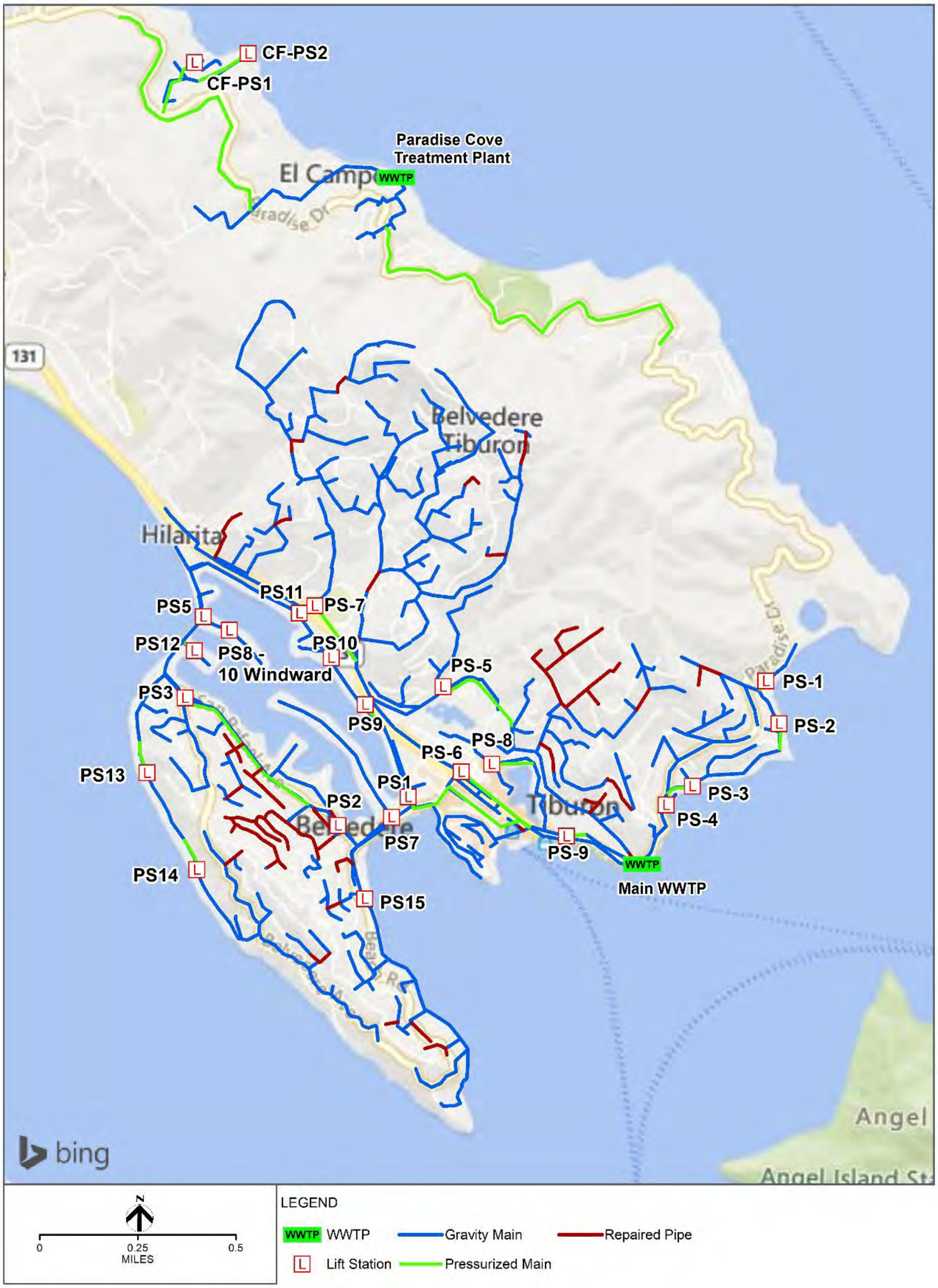


Figure 13. Recently replaced pipes

4.1.4.3 Decision Logic Development

The decision logic is modeled in a flow chart that shows the basic planning strategy for identifying defects and the subsequent recommended action. The flow chart for SD5 was first modeled in Microsoft Visio to capture accurate decision points and actions and was then converted into a decision logic algorithm in Innovyze's InfoAsset Planner software. This enables the software to automate the process of recommending rehabilitation and reinspection actions for each gravity main.

This method provides a transparent, defensible, and repeatable approach that decision makers can use to consistently develop recommended actions and timing for capital planning. The process makes it easy to correlate desired level-of-service goals to justify actions, determine priorities, communicate risk, and identify anticipated costs to stakeholders. The logic is used to develop highly confident and defensible renewal forecasts.

The gravity main rehabilitation decision logic flow chart developed for SD5 is shown in Figure 14. The process starts in the upper left corner of the figure and first identifies if the given pipe has the potential to improve I&I issues identified during the I&I analysis (discussed in detail in Section 4.2), which can be used for additional prioritization if a repair action can help mitigate known areas of I&I. Note that the I&I mitigation potential does not determine a specific rehabilitation method but it can be used as additional background information to determine final priorities during the last stages of capital planning. Therefore, the potential impact is noted for each pipe. Next, if the miscellaneous water level sag (MWLS) is greater than 50 percent, this indicates the presence of one or more sags on the pipe, which is applied as another note for planning purposes (e.g., does not dictate the rehabilitation method). If the pipe does not have any CCTV inspection data, it is routed to be scheduled for an inspection with the priority determined by the pipe relative risk score. If the pipe does contain inspection results and shows at least one structural defect related to rehabilitation, it is routed to the main section of the decision process.

The PACP defects that have been selected for rehabilitation are shown in Table 25.

Table 25. Significant defects identified in SD5 CCTV inspections

Defect code	Description	Severity (5 = worst)	Count of occurrences
BVV	Broken void visible	5	28
SRP	Surface reinforcement projecting	5	27
SMWM	Surface missing wall mechanical	5	17
BSV	Broken soil visible	5	11
HVV	Hole void visible	5	10
SMW	Surface damage missing wall	5	9
HSV	Hole soil visible	5	9
XP	Collapsed pipe sewer	5	5
SRC	Surface damage reinforcement cement	5	2
DI	Dropped invert	5	2
OBI	Obstruction intruding through wall	5	1
IG	Infil gusher	5	1
SRVM	Surface reinforcement visible mechanical	5	1
RBB	Roots ball barrel	5	1
MCU	Miscellaneous camera underwater	4	99
JOL	Joint offset large	4	89
RBJ	Roots ball joint	4	79

Defect code	Description	Severity (5 = worst)	Count of occurrences
FM	Fracture multiple	4	68
B	Broken	4	47
JSL	Joint separated large	4	28
IR	Infil runner	4	16
RBL	Roots ball lateral	4	6
RMB	Roots medium barrel	4	5
JAL	Joint angular large	4	3
RPRD	Point repair replacement defective	4	1
RBC	Roots ball connection	4	1
RMJ	Roots medium joint	3	406
JOM	Joint offset medium	3	369
FL	Fracture longitudinal	3	116
JSM	Joint separated medium	3	57
ID	Infil dripper	3	44
JAM	Joint angular medium	3	23
CM	Crack multiple	3	20
SAVC	Surface aggregate visible chemical	3	18
SCP	Surface corrosion metal pipe	3	16
TBD	Tap break-in defective	3	13
RMC	Roots medium connection	3	6
FH2	Fracture longitudinal hinge, 2	3	5
RML	Roots medium lateral	3	5
LFB	Lining feature blistered	3	4
MMM	Missing mortar medium	3	2
SRPM	Surface reinforcement projecting	3	2
FS	Fracture spiral	3	1
SAP	Surface damage aggregate projecting	3	1

Each of the rehabilitation methods that SD5 may perform are shown as colored columns in the flow chart. Depending upon the characteristics of the defect, the configuration of the pipe, the relative risk score, and the repair history on the pipe the type of rehabilitation will be identified. These results can be used to plan capital improvement actions discussed in more detail below.

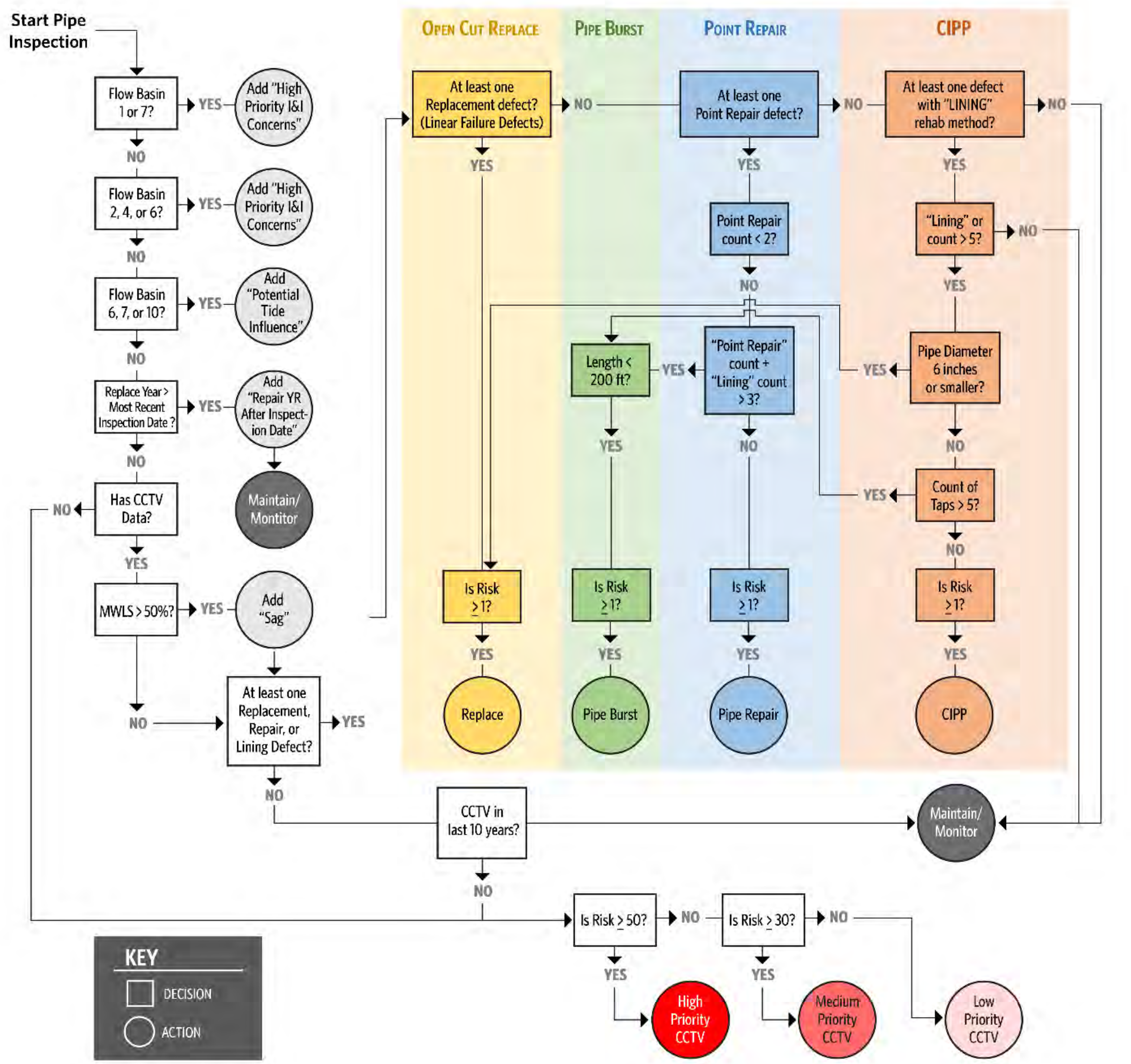


Figure 14. Gravity main decision logic

4.1.5 Assessment and Recommendations

Based on the risk model, decision logic, and rehabilitation unit costs, a rehabilitation or condition assessment recommendation was assigned to each gravity main in the Tiburon and Belvedere systems. A summary of the rehabilitation recommendations is shown in Figure 15. This figure summarizes the results of the different recommended actions showing total estimated cost and length of pipe for each alternative. This view includes all the pipes in the collection system for SD5; however, it is unlikely that all of these actions will need to take place in the next 15 years. SD5 can select the amount of work that is appropriate to do based on the pipe risk scores, available budgets, and consideration of other necessary capital work. The capital planning section of this Master Plan discusses these topics in more detail. A listing of each District gravity main and the recommended rehabilitation action is provided in Appendix B. The cost basis for developing the rehabilitation estimates is provided in Appendix C.

Figure 15. Rehabilitation model results: no risk threshold

Figure 16 provides a similar summary for all future pipe inspections identified in the model. These inspections are categorized as high, medium, and low priority based on pipe risk scores and the established cutoff values. The cost and total sewer main length is provided for each category, as well as category percentages (shown in the pie chart). Gravity mains are identified for future inspections if they meet one of the following criteria:

- No historical CCTV data
- No structural PACP defects on the most recent CCTV
- Does not meet the required criteria to receive a rehabilitation recommendation

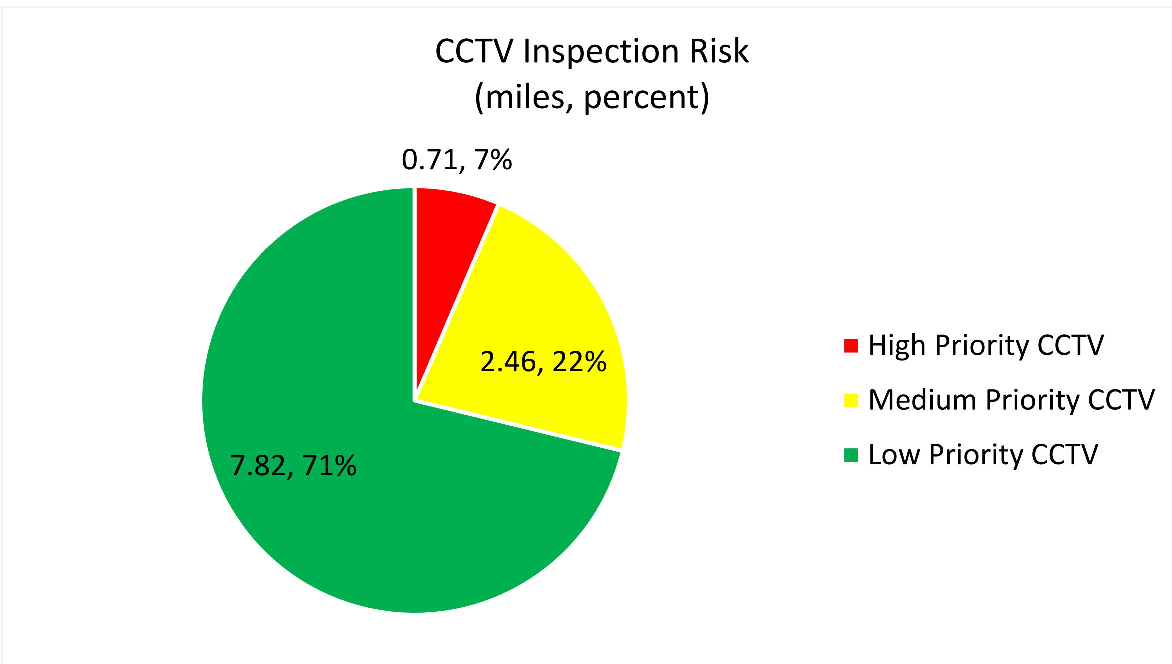


Figure 16. CCTV model results – no risk threshold

A breakdown of the previously uninspected gravity mains based on their risk is shown in Table 26. It is recommended that the high-priority uninspected pipes to be inspected as soon as possible.

Table 26. Uninspected gravity main recommendations

CCTV recommendations	Count of uninspected pipes
High priority CCTV	10
Medium priority CCTV	79
Low priority CCTV	1
Grand total	**90**

Based on the risk modeling only a relatively small amount of gravity main has been identified as high priority for reinspection, even though the last inspection for most of the system is over 15 years old. However, it is important for SD5 to determine if additional deterioration has occurred in the lower risk pipes over that time period. In order to verify that these lower-grade issues have not become more urgent repairs, a degradation analysis is recommended. The degradation analysis selects several pipes for another CCTV inspection. By comparing the current CCTV results with the original results, SD5 will be able to determine the amount of degradation that has occurred, which types of defects degrade the fastest, and if there are any additional pipes that require urgent rehabilitation.

4.1.5.1 Rehabilitation

SD5 can use the pipe risk scores to select the highest-risk rehabilitation recommendations that fit within its resource constraints. To demonstrate this, three scenarios are presented here corresponding to different risk levels calculated for each pipe. An overview of the three scenarios is provided in Table 27, below.

This page is left intentionally blank.

Table 27. Summary rehabilitation scenarios for collection system pipes

Scenario number	Risk level	Percentage of system	Total		Replacement		Point repair		Pipe bursting		CIPP	
			Cost ($ thousands)	Length (mi)	Cost ($ thousands)	Length (mi)	Cost ($ thousands)	Length (mi)	Cost ($ thousands)	Length (mi)	Cost ($ thousands)	Length (mi)
0	All risk levels	22%	$8,729	6.6	$6,841	3.7	$650	1.7	$1,145	1.0	$85	0.2
1	50 or greater	14%	$5,560	4.3	$4,132	2.3	$379	1.0	$967	0.8	$81	0.2
2	60 or greater	7%	$2,771	2.1	$2,037	1.1	$169	0.5	$515	0.4	$48	0.1
3	70 or greater	3%	$1,037	0.8	$628	0.3	$82	0.3	$327	0.2	$0	0.0

This page is left intentionally blank.

Scenario 0 shows all rehabilitation recommendations regardless of risk. This is shown for comparison purposes. Scenario 1 is the most conservative rehabilitation strategy of the remaining three scenarios. It selects rehabilitation actions on pipes that have a risk level of 50 or greater. It addresses rehabilitation on 15 percent of the system for a total of $5.9 million. Scenario 2 provides rehabilitation for pipes with a risk score of 60 or greater, or about 7 percent of the system. Total cost for Scenario 2 is $2.8 million. The highest-risk scenario is Scenario 3, which addresses rehabilitation on pipes with a risk level of 70 or greater. This comprises only 3 percent of the pipes and will cost approximately 1.0 million.

The amount of sewer main rehabilitation and reinspection that SD5 desires to accomplish in the coming years will depend on funding availability, competition with other capital needs, and SD5's strategy on mitigating risk. These are discussed in detail in the Section 5.0 below.

4.2 Inflow and Infiltration Analysis

This section describes the I&I analysis of the 2012-2011 flow monitoring study (E2 Consulting Engineers Inc., 2011) and provides a discussion of the potential impacts of sea level rise based on the analysis from the Marin Shoreline Sea Level Rise Vulnerability Assessment report (BVB Consulting LLC, 2017). The results of these analyses have been incorporated into the gravity main rehabilitation decision support analysis described in Section 4.1.4, as well as additional recommendations described in more detail in Sections 4.2.11 and 4.2.12 below. The detailed analysis is described here in Sections 4.2.1 through 4.2.10.

4.2.1 Background and Previous Study

I&I is excess water that flows into the collection system from groundwater, stormwater, and other non-sewage sources. I&I causes dilution at the treatment plant, which makes the treatment process less efficient and may even damage some of the treatment processes. Excess flow in the system may cause surcharging and lead to SSOs.

I&I has been recognized as a problem for SD5 and was studied during the 2010–2011 wet season to determine where it might be originating from. A flow monitoring study was performed in selected areas to measure wet weather and dry weather flows for a 3-month period. As part of this Master Plan, HDR was asked to review the report and evaluate the data provided to determine the impact on I&I on the basins monitored and develop recommendations for mitigation. This section summarizes SD5's current system conditions and anticipated future needs from an I&I perspective. Recommendations are provided to help improve the system, inform the capital improvement planning process, and ensure a resilient sewer system for present and future customers.

Infiltration is extraneous flow that enters the sanitary sewer through cracks and holes in sewer pipe below the ground and can take many forms. Infiltration can occur from groundwater when the water table rises above the level of the sewer because of storms or other factors, including rising tidewater. Stormwater can also cause infiltration when rainwater percolates into the ground and enters the sewer through pipe cracks and other structural defects where the sewer is located above the groundwater table. Stormwater infiltration begins during storm events and may continue for several days after the rain event ends.

Inflow occurs where rainwater runs directly into the sewer from other direct connections such as catch basins, street inlets, roof downspouts, yard drains, foundation drains, and manhole lids. Typically, inflow enters the system rapidly during rain events and ceases quickly once the rain event ends. Once located, inflow sources can be disconnected at usually a relatively low cost. Inflow can be recognized by a sharp increase in flow during and immediately after a rain event.

4.2.2 The Impact of I&I

During dry weather, the impact of I&I is usually less of an issue while wet weather conditions produce a much larger problem by introducing stormwater into the system from existing I&I sources. As the wet season progresses, soils become saturated and the groundwater table rises, further magnifying the problem. Available flow capacity for sewage is reduced during storms and during the wet season, which can lead to damaging and costly SSOs when the combined I&I and sewage flows can exceed conveyance capacity, resulting in overflows from low-lying manholes or backups into basements of low-lying homes.

I&I can also impact a treatment plant's ability to treat domestic and industrial wastewater. During periods of high I&I, wastewater treatment processes are forced to process higher flows, which can exceed design capacity and potentially upset the treatment process. As a result, wastewater agencies may also face violation of their regulatory discharge limits because the extraneous flow stress treatment units and processes and degrades their performance.

4.2.3 Inflow and Infiltration Mitigation

Efforts to mitigate I&I vary depending upon the causes. Inflow can be relatively easy to mitigate by locating and disconnecting inappropriate connections to the system (in the case of private sector sources) or repairing or improving the system at the point of inflow (in the case of public sector sources). . Infiltration is more difficult to eliminate because it can potentially travel through any defects in the system and thus may not be eliminated until all the defects are repaired (often including repairs on private sewer laterals).

A key differentiator between infiltration and inflow is that peak wet weather flow can take several days to return to dry weather state if the increased flow is caused by infiltration, while inflow-related flow increase will likely return to dry weather levels within a couple of days of the end of a storm event.

4.2.4 Summary of 2010-2011 Study

SD5 previously conducted a flow monitoring program to measure the magnitude and components of flow that enter into the sewer collection system. The flow monitoring program lasted from December 21, 2010, to March 31, 2011. Flow monitors were installed at the lowest point in 10 sewer basins in the system. In addition, four rain gauges were installed to continuously record rainfall data for the monitoring period. This program was conducted only on the selected basins within SD5's collection system and approximately 50 percent of the system was evaluated as measured by miles of pipe. Figure 17 shows the rain gauge and flow meter locations and Figure 18 shows the basins monitored. It is important to note that, because the I&I study was limited, a significant portion of the collection system was not monitored. The logic for selecting the I&I basins for the study is unknown; however, there may be additional I&I issues in some of the unmonitored low-lying areas where larger-diameter pipe is present. These areas may also contain undetected significant I&I issues.

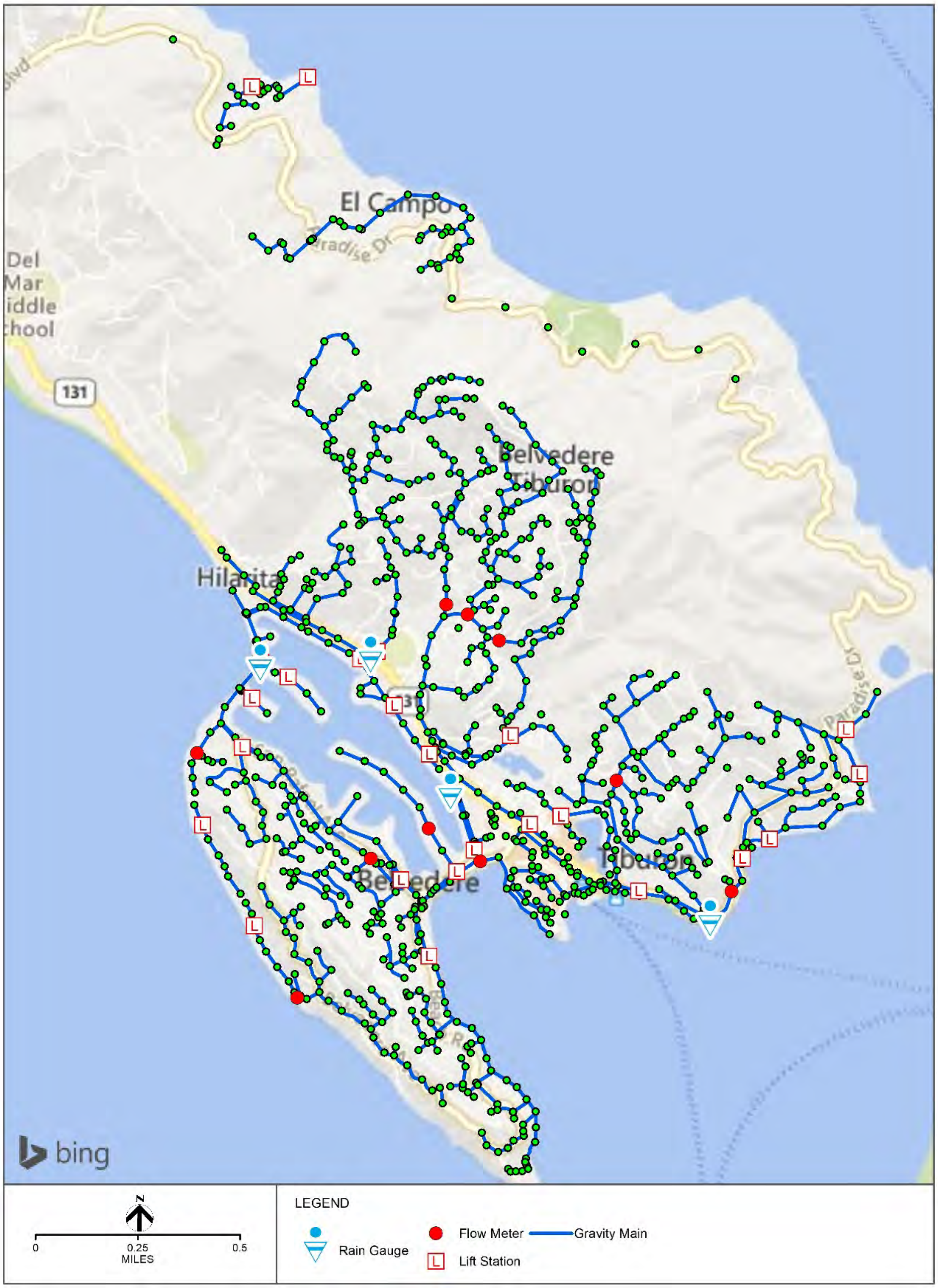


Figure 17. Rain gauge and flow meter locations

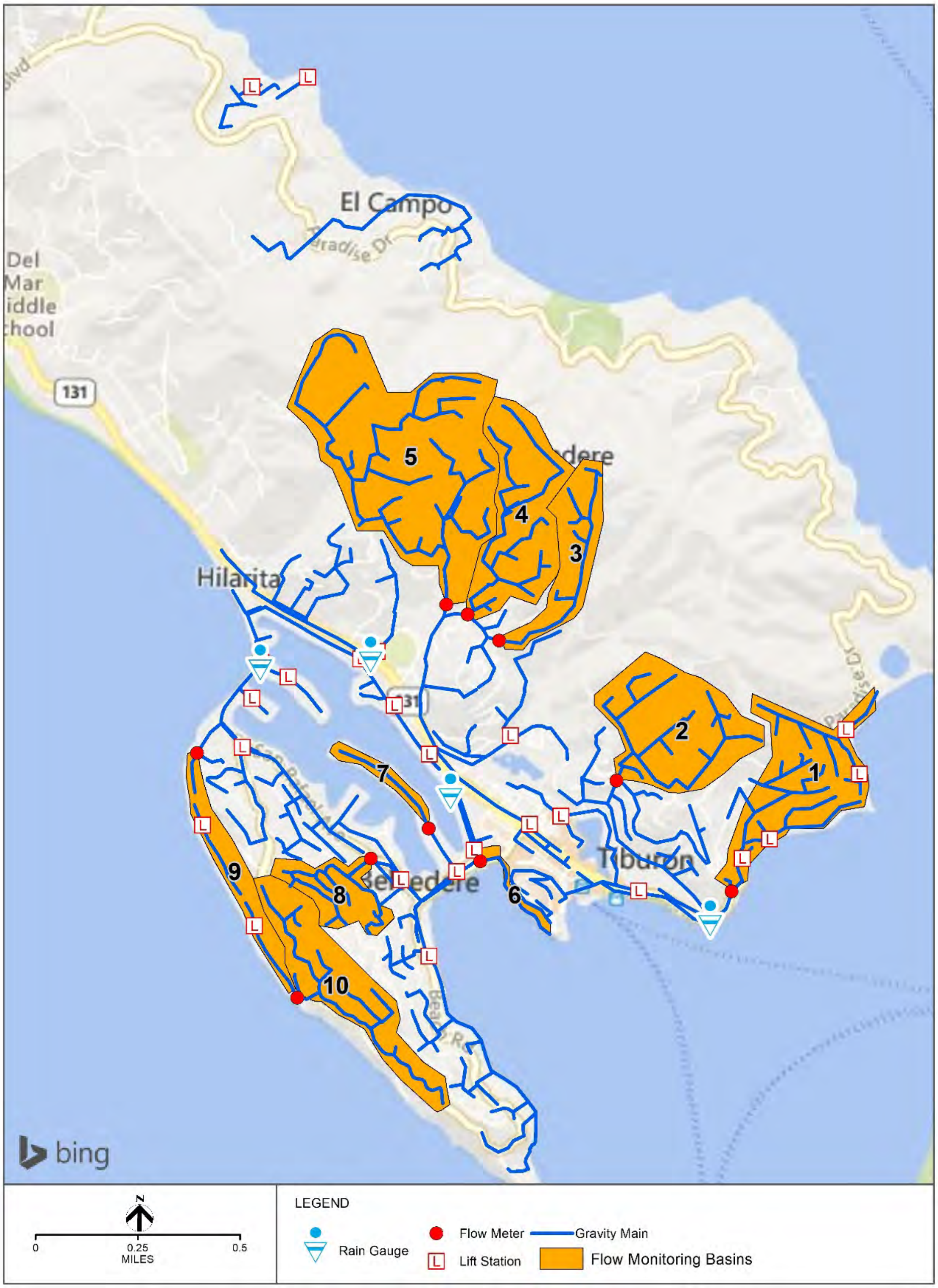


Figure 18. Flow monitoring basins established for the study

During the 93 days of the study, rainfall occurred on 40 of those days totaling 17 inches. The study provided hydrographs for the 10 flow monitors and rainfall data at each of the rain gauges. The study identified four of the basins with high rain-dependent infiltration and inflow (RDI/I), and offered recommendations on additional flow monitoring, smoke testing, and CCTV inspection.

4.2.5 Current evaluation

For this Master Plan HDR analyzed the results of the previous study to further refine the results and identify specific mitigation actions. Although the raw data were unavailable, the hydrographs produced from the work were used as well as the summary tables for each basin in the report. The primary analyses performed included:

- Comparison of the flow monitoring hydrographs to rainfall hyetographs to try to distinguish between inflow and infiltration contributions in each basin
- Comparison of flow monitoring metrics between basins to determine which are most impacted by I&I and to further understand inflow versus infiltration impacts
- Analysis of tide fluctuations during the study period in comparison to the hydrographs to determine if there was evidence of tidal influence on infiltration occurring in the near-shore basins
- Evaluation of the flow monitoring hydrographs to identify unusual flow anomalies not explained by wet weather events and to determine if there are any potential pipe capacity issues

Through these analyses, HDR has provided recommendations for mitigation of I&I in the system as well as actions for further study to better understand how I&I is impacting the system. These analyses have been completed assuming that the data and calculations provided in the original report are accurate and representative of the original study. Analytical quality review of the original analysis or confirmation of calculations has not been performed.

In addition to the evaluation of the previous flow monitoring study, an analysis of the potential impacts of SLR on SD5 were evaluated by reviewing the Tiburon and Belvedere sections of the Marin Shoreline Sea Level Rise Vulnerability Assessment. This report, prepared by the Marin County Department of Public Works in 2017, modeled several SLR scenarios and their impacts around the county. This Master Plan also provides a summary of potential impacts to SD5 based on the scenarios modeled and offers recommendations for mitigation.

4.2.6 Flow Basin Data Analysis

The following definitions are used for this analysis:

- Base sanitary flow (BSF): the contribution of sewer flow that is composed of sewage (i.e. not inflow or infiltration). BSF can be calculated by subtracting groundwater infiltration from the average dry weather flow.
- Groundwater Infiltration (GWI): the contribution of sewer flow that is due to infiltration by groundwater. This is usually determined from the average low nighttime flows measured during dry periods.
- Average dry weather flow (ADF): the portion of sewer flow not related to RDI/I primarily composed of both BSF and GWI. This is usually calculated by averaging flow data measured during dry periods.
- Rain dependent inflow and infiltration (RDI/I): extraneous flow that enters the sewer system in response to intensive rainfall events. RDI/I is calculated by subtracting the ADF from the total measured flows.
- Peak I&I flow: the largest RDI/I flow each basin experiences throughout the monitoring period

These values are used to calculate the basin performance metrics described below.

4.2.7 Inflow vs. Infiltration

Review of the flow monitoring results and hydrographs from the study (E2 Consulting Engineers Inc, 2011) suggest that the system is predominantly impacted by inflow as opposed to infiltration. Evaluation of flow monitoring hydrographs during storm events throughout the monitored basins show that the flow mostly returns to dry weather conditions within one to two days after each of the recorded rain events. Figure 19 shows a typical example of this behavior during the February 24, 2011, storm event. The rainfall throughout the storm is depicted by the bar hyetograph shown at the top, and the response in the system is shown by the flow line below. As shown, the measured flow increased sharply upon initiation of the storm event, then dropped significantly within a day after the rainfall stopped, indicating that inflow has more influence on the system than infiltration. Flow predominantly impacted by RDI/I would show a prolonged period after the wet weather event where the flow level gradually returns to pre-storm levels only after several days. There is some infiltration influence observed in the graph in the somewhat higher peaks after the end of the storm event, but these are relatively small.

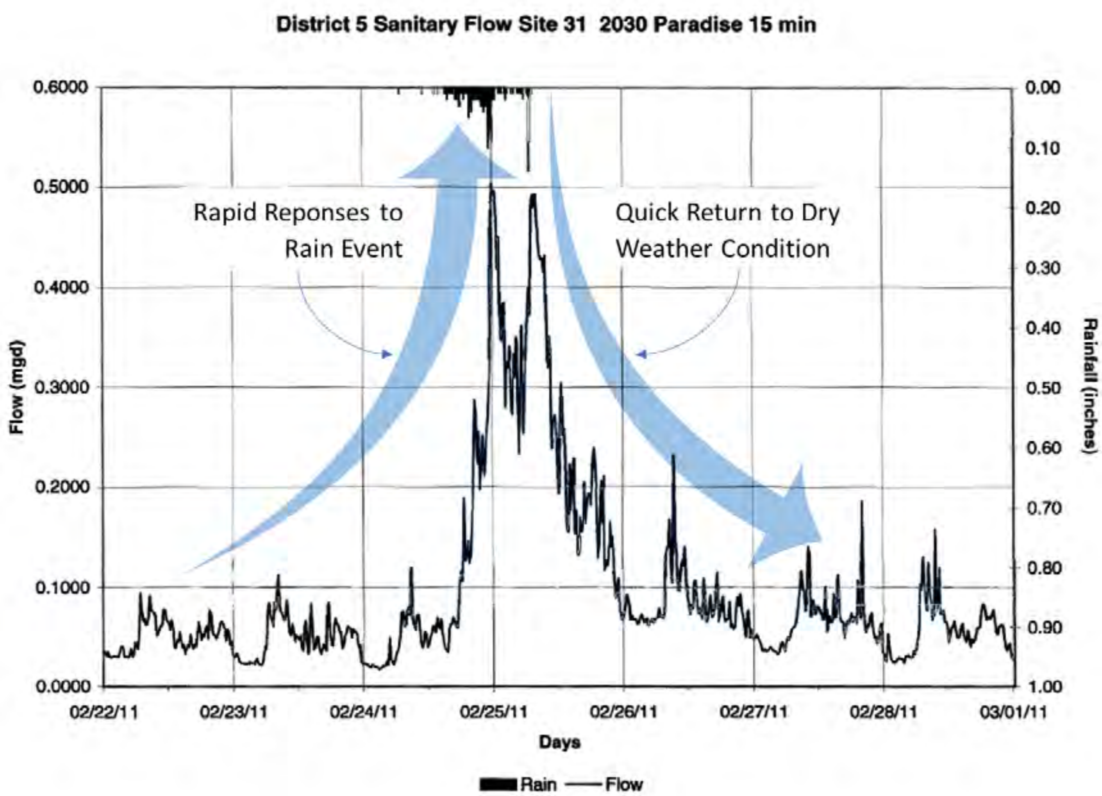


Figure 19. Typical example of the system response to rain events

The flow patterns during and after rain events materially increases peak flow in other flow monitoring basins as well. Some areas are impacted severely while others show only a minor increase. The nearly instantaneous increase in peak flow is indicative of inflow rather than RDI/I as driving the storm-related flow response. In addition, the other flow hydrographs typically show a rapid decline in flow after each storm ends, indicating that water is quickly entering the sewer system rather than slowly filtering through the soil and entering the system through defects in sewer pipes.

Groundwater infiltration does not appear to be significant within SD5 sewer system. However, summer dry weather flow measurements were not obtained during the study. It is possible that the actual dry weather flow is even lower during the driest times of the year. The difference between summer dry weather flow and the observed dry weather flow during the study would be a good indicator of groundwater (seasonal) infiltration. In addition, no groundwater level data were provided in the study, which can be used to determine if the water table is high enough to cause groundwater infiltration. If all the sewers are located above the ground-water table, the groundwater infiltration can be eliminated as an infiltration source. If SD5 observes evidence of water leakage into manholes during dry flow periods, it is likely that the sewer is below the water table.

4.2.8 Basin Comparisons

To understand how each basin responded to rainfall, flow data from the monitoring program were used to calculate four key performance indicators (KPIs). Each of the flow monitoring basins differs in characteristics such as area served, length of pipe, and size of pipe. This makes it difficult to compare flow results between the basins to understand how well they are performing related to I&I. These KPIs provide normalized metrics that enable a more consistent comparison to help SD5 prioritize where to focus its I&I reduction efforts. In addition, the four KPIs can be used to provide additional insight on the influence of inflow versus infiltration in each basin. The KPIs calculated are:

- R-factor: This number represents the percentage of rainfall by volume that enters each basin during rainstorms. These values were calculated for each basin during the original study. It is one measure of the impact of rainfall-induced flow increase and is a good indicator of where the system is leaking. The R-factor reflects the percentage of rainfall getting into the system and does not convert directly to the actual amount of I&I entering the system.
- Peak I&I per acre served: This metric calculates the peak I&I flow divided by the number of acres in the basin.
- Peak I&I per mile of pipe: This is the calculation of the peak I&I flow divided by the number of miles of sewer main contained in the basin
- Peak I&I per inch diameter mile of pipe: This measurement is the calculation of the peak I&I flow divided by the surface area of the sewer mains contained in the basin

The R-factor and the peak I&I per acre served are better indicators of inflow while the peak I&I per mile of pipe and the peak I&I per inch diameter mile of pipe are better indicators of infiltration.

The abovementioned four KPIs were calculated for each monitored basin as shown in Table 28. Figure 18 above shows the flow monitoring basins area and their number.

This page is left intentionally blank.

Table 28. Flow data metrics by basin

Basin no.	Monitor site	Basin name	Basin area (acres)	Length of gravity main (miles)	R-factor	Peak I&I per gross acre (gallon/acre/day)	Peak I&I per mile of pipe (gallon/mile/day)	Peak I&I per inch diameter mile of pipe (gallon/inch-mile/day)
1	31	2030 Paradise Dr.	52.3	2.60	**20%**	**14,000**	**282,000**	**48,000**
2	73	Raccoon at Central	57.0	1.62	5%	**10,000**	**351,000**	**58,000**
3	132	80 Lyford Dr.	27.5	0.84	9%	8,000	262,000	43,000
4	129	Marinero Circle	52.0	2.24	**11%**	5,000	116,000	19,000
5	215	Round Hill at Lyford	127.0	3.66	3%	3,000	104,000	17,000
6	NA2	Beach at Cove	3.5	0.87	**11%**	**29,000**	117,000	15,000
7	H2	17 Peninsula	6.4	0.30	**60%**	**52,000**	**1,100,000**	**183,000**
8	ND5	Laurel Ave. and San Rafael	19.8	1.16	6%	3,000	51,000	8,000
9	CA2	15 West Shore	19.9	0.96	4%	**10,000**	208,000	31,000
10	F7	End of West Shore	45.6	1.59	4%	6,000	172,000	27,000

This page is left intentionally blank.

Based on the calculated KPIs, the following two sewer basins warrant further inflow investigation and remediation:

- **Basin 7 – 17 Peninsula:** This basin has substantially higher metrics in all categories than the other basins. Because it covers a very small area and a has a low pipe mileage, it is potentially the most cost-effective opportunity to reduce a significant amount of inflow into the system.
- **Basin 1 – 2030 Paradise Dr.:** This is one of the larger basins monitored. It has the second highest R-factor and has high numbers in every category. This basin likely contributes a significant amount of I&I to the system because of its large size and high metrics.

The following sewer basins should also be considered due to unusual metrics:

- **Basin 6 – Beach at Cove:** This is the smallest basin in the study but produced a notable R-factor and very high peak I&I per gross acre. Because of its small size, it may be very cost-effective to target inflow reduction; however, the total volume reduction to the system will be much lower than for Basins 1 or 7.
- **Basin 2 – Raccoon at Central:** Even though this basin has a low R-factor, it has significantly high numbers in all categories and could provide significant reduction in I&I in the system.
- **Basin 4 – Marinero Circle:** This basin also has a notable R-Factor and could provide some reduction in overall I&I, but would not make as large an impact as the other basins because of comparably lower peak I&I numbers.

In general, basins with R-factors below 10 percent or that have I&I rates under 5,000 gallons per acre per day are not likely to show significant improvement in I&I reduction in the system. Among the basins described above, the actual conditions for Basins 6 and 7 may be worse than what the metrics indicate as they may possibly be having capacity issues during peak flow periods. This is discussed in more detail below.

The investigation and remediation should concentrate on inflow rather than infiltration as inflow is likely the bigger issue, as shown on the hydrographs. Inflow is usually easier to identify and more cost-effective to remediate than infiltration (however it can be more challenging politically). By identifying and eliminating illicit connections to the system, a significant impact on I&I can be achieved. In contrast, it is possible that SD5 may not achieve a material reduction in infiltration until many of the sewer main, service laterals, manholes, and other structures are rehabilitated or replaced.

4.2.9 Tidal Impacts on Flow

Tides are the sea level changes caused by the combined effects of the gravitational forces exerted by the moon and the sun, and the rotation of the earth. The tidal change in sea level can also temporarily elevate the groundwater table near shorelines, which increases the amount of groundwater infiltration as more of the sewer infrastructure is covered by groundwater. When sea water gets into the sanitary sewer system, it not only reduces collection system capacity to carry sanitary flow, but it also disrupts wastewater treatment process because of the higher-than-normal wastewater salinity.

Tide level could have a significant impact on the collection system because much of SD5 is located adjacent to the coastline where tidal fluctuations would be observed. Tide analyses were performed on basins located near the coastline (i.e., Basins 1, 6, 7, 8, 9, and 10). Basins 2, 3, 4, and 5 are located farther inland along the spine of the Tiburon Peninsula and are thus far enough away from the coastline to not be affected by the tides.

To analyze tidal influence, tidal data were compared to the flow captured on the flow monitoring hydrographs to determine if there was any correlation between measured flow and tide level. Two approaches were evaluated: (1) an hourly tidal analysis to determine if measured flow levels fluctuate under the influence of tide on an hourly basis and (2) a daily tidal analysis where the normalized daily peak flow is compared to normalized daily peak tide level to determine if there are any longer-term correlations or trends.

7.1 Hourly Tide Analysis

In basins monitored near the bay, the flow data generally do not show an increase that corresponds to the time of high tide during non-rain days. Figure 20 below presents an example of flow data from Basin 10 compared to tide level changes on an hourly basis (E2 Consulting Engineers Inc, 2011). The example period is chosen as there were no wet weather events to influence the data. As shown, measured flows are at the minimum level around midnight and gradually increase after around 6 a.m. Measured flows fluctuate through the daytime and gradually decrease after around 11 p.m. Such a flow pattern is typical for most monitored basins and is an indication that the hourly flow is driven mainly by diurnal sanitary flow when dry weather conditions are present. High tides in the bay occur approximately every 12 hours and 25 minutes and are shown on the graph in the bottom of the figure. The daily changes in flow do not appear to correlate with the tidal fluctuations shown for the same period. The lowest flow periods are consistently in the early morning hours of each day whereas the lowest tides are occurring around sunrise and sunset. There may be a daily contribution from tidal changes; however, it is not significant enough to be reflected in the flow monitoring hydrographs. Similar results were also observed in other basins reviewed.

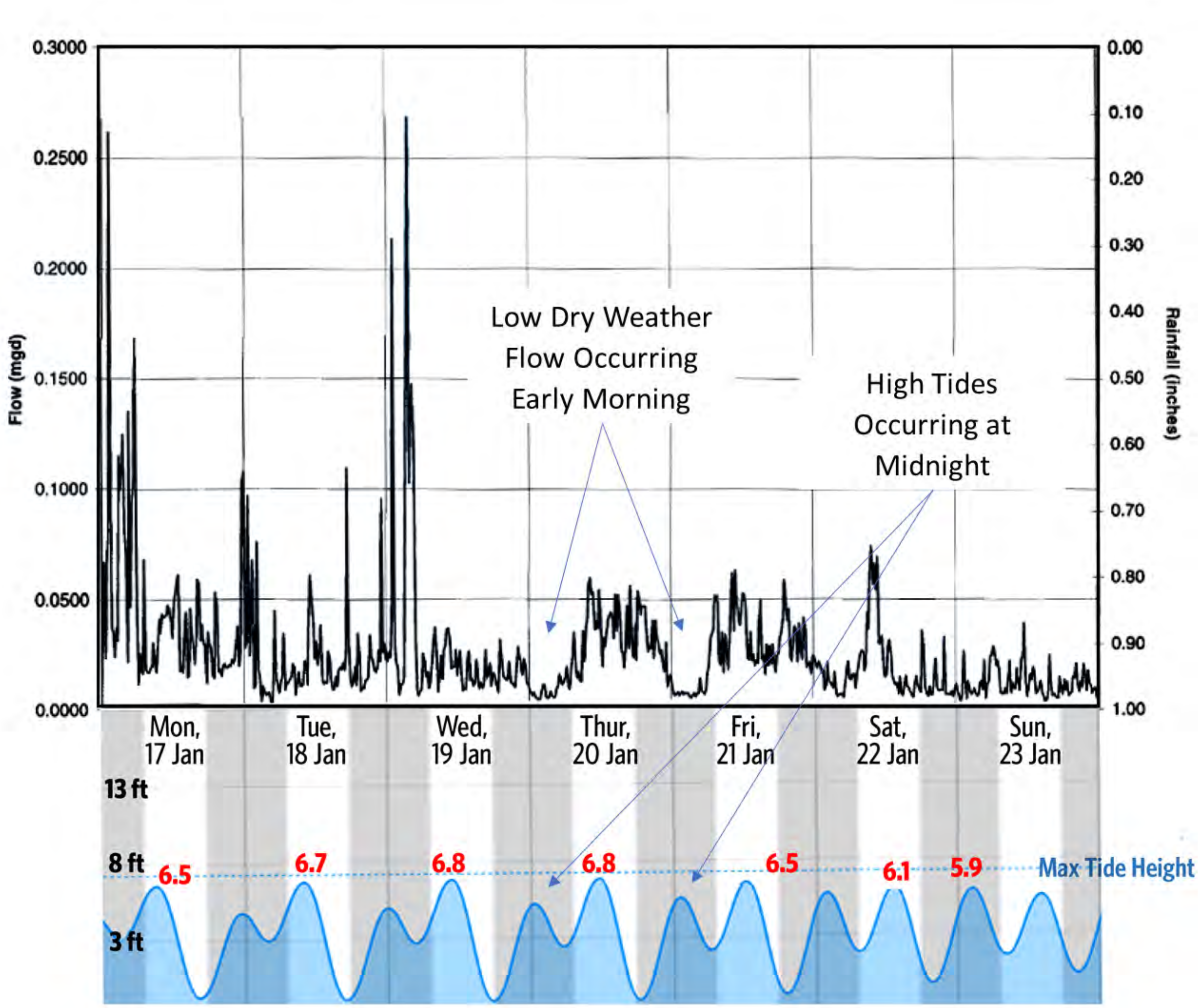


Figure 20. Measured flow correlated to hourly tides

7.2 Daily Tide Analysis

Tidal changes occur not only daily; they also change in magnitude over longer periods in response to many factors including weather and the relative positions of the sun and moon. This results in variations in the high- and low-water levels over time. To determine if there were any long-term tidal impacts from the highest tides during the study, an additional analysis was conducted. Daily high tide data along with daily peak flow data were normalized to a 0–1 scale and plotted against monitoring dates to observe longer-term trends. Rainfall data were also plotted into the graph to indicate when storm events occurred. To better understand the correspondence between flow and tide and avoid interference from storm events, the analysis considered the period between early January and mid-February 2011 when storm events were at a minimum.

Observations in Basin 10, as shown in Figure 21, indicate a consistency between normalized high flow data and normalized high tide data from early January to mid-February 2011. This suggests that Basin 10 flow may be influenced by high tides that exceed a certain height which cause infiltration or inflow. Smaller high tides may not be sufficient to enter the system. **This is not likely to be a major impact on I&I overall; however, it could become worse as sea level rises.**

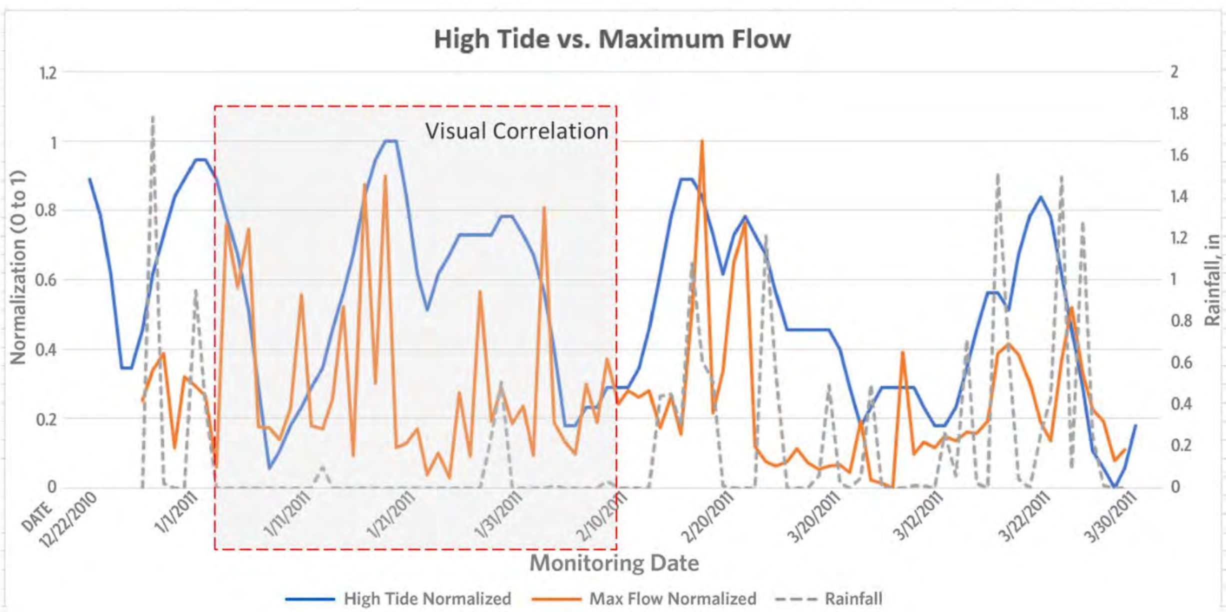


Figure 21. Peak flow data correlated to maximum tides in Basin 10

For comparison, Figure 22 shows a similar plot for Basin 1, where most of the basin collection area is sufficiently far from or higher than the coastline and is thus not impacted by high tides. The normalized peak flow value remains at a low level from early January to mid-February 2011 despite the high tide event occurring at the same time.

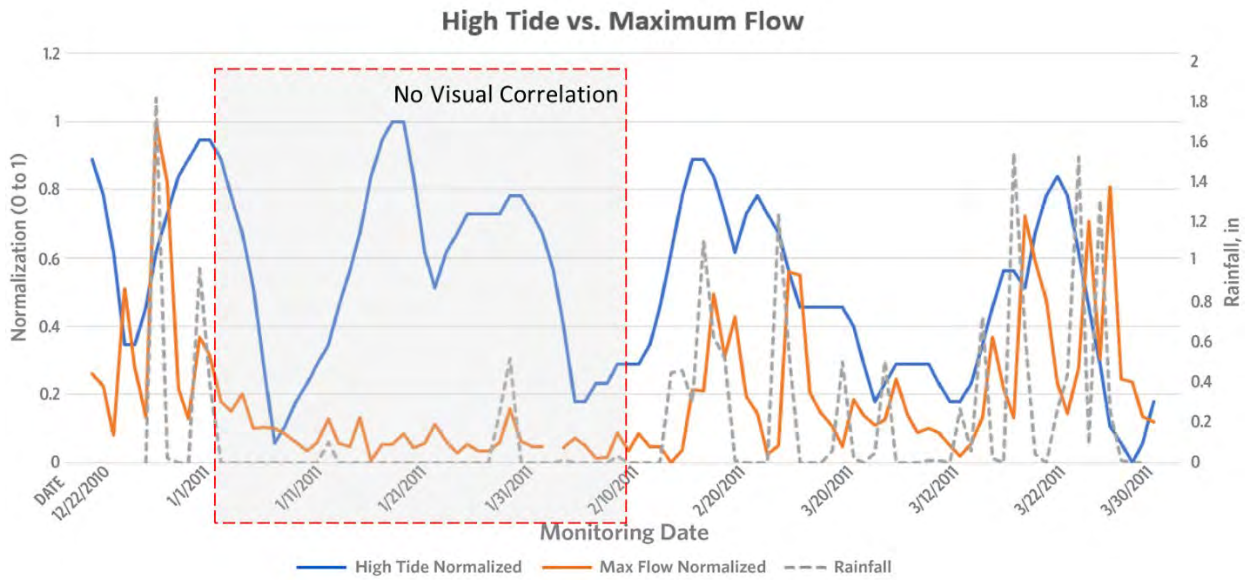


Figure 22. Peak flow data correlated to maximum tides in Basin 1

Other basins suspected to be influenced by longer-term high tide trends are Basin 6 and Basin 7. However, their correlations cannot be confirmed because of missing flow data in part of January 2011. Basin 6 and 7 peak flow versus high tide charts are presented in Figure 23 and Figure 24, respectively.

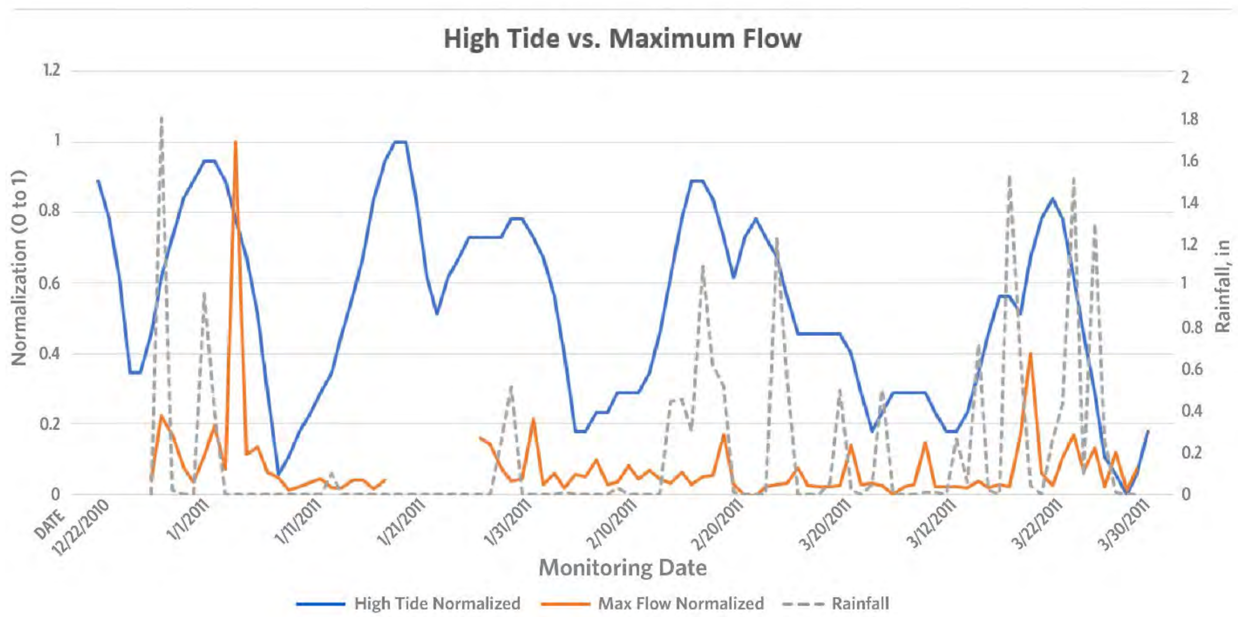


Figure 23. Peak flow data correlated to maximum tides in Basin 6

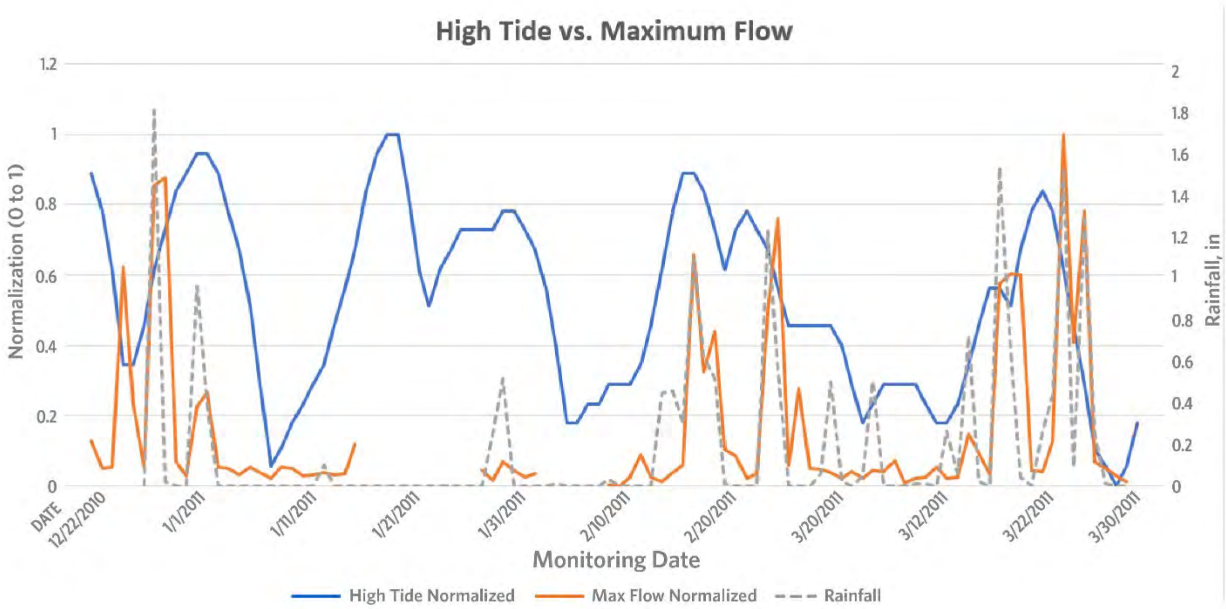


Figure 24. Peak flow data correlated to maximum tides in Basin 7

4.2.10 Flow Anomalies

In reviewing the monitoring program flow data, large flows were observed that were not correlated to rainfall events. These anomalies indicate that unusual flow is entering the system from an unknown source. Two examples occurred on March 24 and March 26, 2011 in Basin 7 as shown in Figure 25 (E2 Consulting Engineers Inc, 2011). This basin along Peninsula Road contains a single sewer main about 1,500 feet long in a residential area. No commercial activities are occurring in this basin; therefore, the expected flow pattern in this basin should reflect typical diurnal residential flow. These anomalies are difficult to explain without additional data; however, the two most likely causes are that (1) a swimming pool or other large water body was drained into the system or (2) I&I provided contributions from tidal changes.

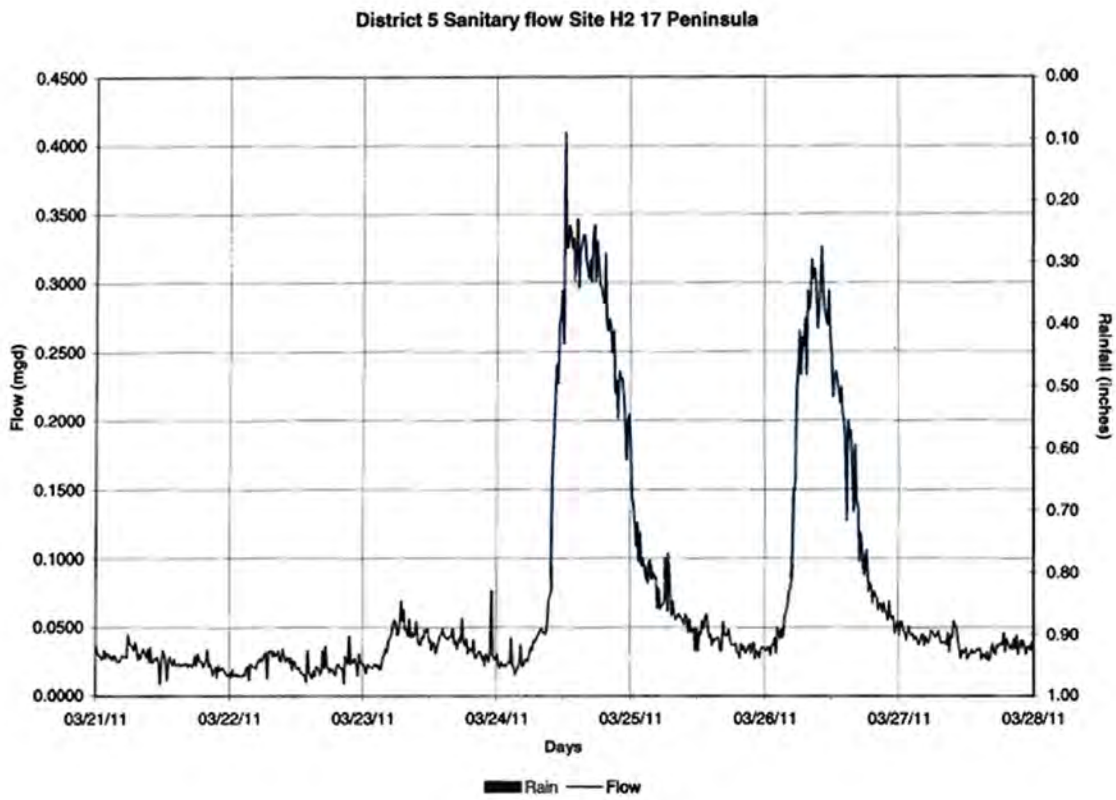


Figure 25. Anomalous flow surges without rainfall in Basin 7

There are other unexplained flow surges not related to rainfall observed in other basins throughout the flow monitoring period. A summary of these instances is recorded in Table 29 below.

Table 29. Counts of flow surges without correlated rain events by basin

Basin No.	Basin name	No. of flow surge events without rainfall
10	End of West Shore	13
6	Beach at Cove	13
7	17 Peninsula	9
1	2030 Paradise Dr.	0
2	Raccoon at Central	0
3	80 Lyford Dr.	0
4	Marinero Circle	0
5	Round Hill at Lyford	0
8	Laurel Ave and San Rafael	0
9	15 West Shore	0

Basins 6, 7, and 10 all show several of these anomalous flows. These basins could be good candidates for further I&I investigation. They are also the basins that potentially show long-term tidal influence, which could indicate that larger high tides are causing these flows.

The hydrographs were also reviewed to determine if the height of any of the wet weather flow surges exceeded the pipe diameter. ***This may indicate a potential capacity issue at the monitoring site. This condition was observed in Basins 6 and 7.*** Two examples are shown in Figure 26, which captures two storm events that occurred on March 24 and 26, 2011 in Basin 7 (E2 Consulting Engineers Inc, 2011). The count of these instances observed by basin is recorded in Table 30 below. The peaks of these flow surges are sharp, which suggests that they did not overflow the manhole. SD5 can estimate the surge elevation in the manhole if the total depth from the top of the manhole to the bottom of the pipe is known; however, this information was not available for this analysis. It is also not possible to determine the behavior of the flow in upstream or downstream manholes that were unmonitored, which could be experiencing worse surcharging. ***It is recommended that SD5 monitor Basins 6 and 7 manholes during peak storm events to determine capacity risks and consider installing remote sewer monitoring (e.g., SmartCovers) if necessary.***

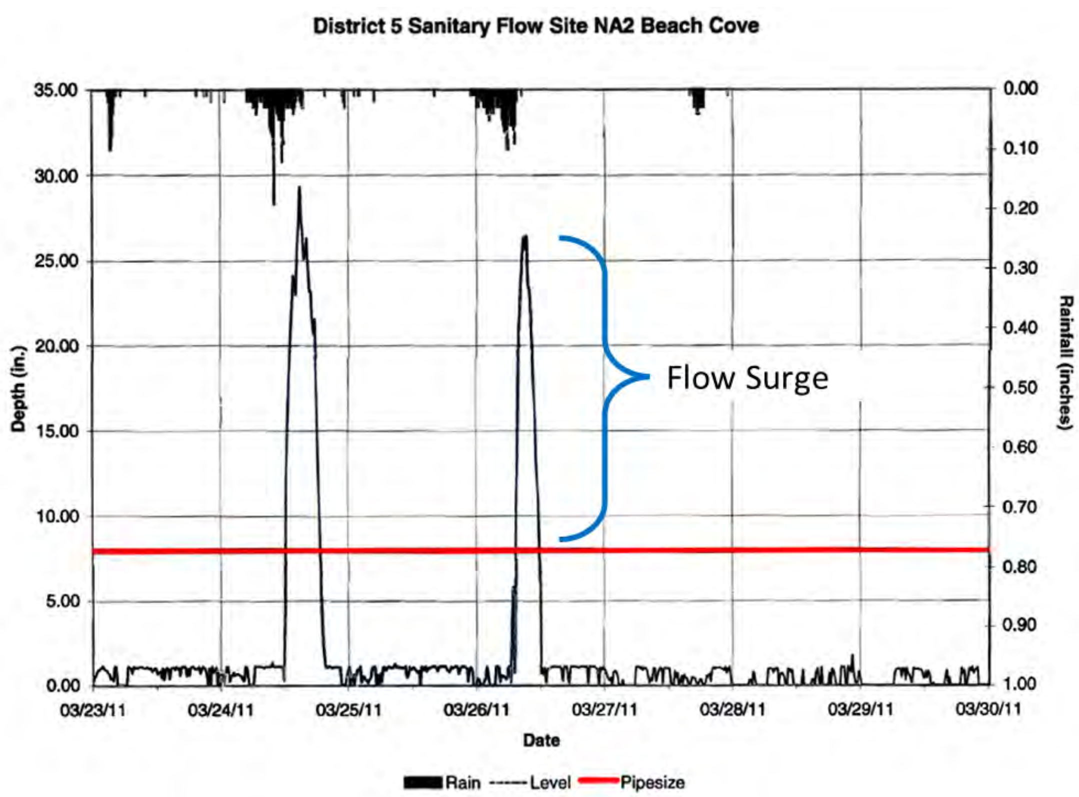


Figure 26. Example of flow surges larger than pipe diameter in Basin 7

Table 30. Count of flow surges larger than pipe diameter by basin

Basin no.	Basin name	No. of flow surge height larger than pipe diameter
7	17 Peninsula	11
6	Beach at Cove	6
1	2030 Paradise Dr.	0
2	Raccoon at central	0
3	80 Lyford Dr.	0
4	Marinero Circle	0
5	Round Hill at Lyford	0
8	Laurel Ave and San Rafael	0
9	15 West Shore	0
10	End of West Shore	0

The exact mechanism causing these dry weather flow surges and wet weather surcharges is unknown and could be related to either inflow or infiltration. However, this excess flow appears to be contributing to capacity issues in Basins 6 and 7, which could potentially lead to SSOs during stronger high tides or rain events. It is also possible that the anomalous flows are being caused by other factors (e.g., draining a swimming pool). Additional insight may be gained by checking the salinity of the wastewater flowing through these basins to determine if it indicates that sea water is getting into the sewer system.

4.2.11 Recommendations for I&I Mitigation

Table 31 summarizes the key concerns observed in the analysis of the 2010–2011 flow monitoring study. **The most problematic basins are Basin 7 along Peninsula Road and Basin 1 along the southern portion of Paradise Drive, which exhibit very high values in all of the categories evaluated.** Overall, the predominant issue within these study areas appears to be inflow. The most direct evidence for this comes from the flow monitoring hydrographs, which show that generally flows from wet weather events quickly return to dry level conditions once the event ends. I&I mitigation in Basins 2, 4, and 6 may also reduce excess flow in the system, but not to the extent that improvements in Basins 1 and 7 will likely have because of performance metrics and system configuration. This section discusses recommendations for inflow mitigation as well as additional options for addressing the other concerns.

Table 31. Summary of I&I findings

Basin no.	Basin name	High priority I&I concerns	Medium priority I&I concerns	Tidal correlations	Anomalous flow surges	Potential capacity issues
1	2030 Paradise Dr.	✓				
2	Raccoon at Central		✓			
3	80 Lyford Dr.					
4	Marinero Circle		✓			
5	Round Hill @ Lyford					
6	Beach at Cove		✓	g	✓	✓
7	17 Peninsula	✓		g	✓	✓
8	Laurel Ave and San Rafael					
9	15 West Shore					
10	End of West Shore			✓	✓	

g Insufficient information available

Addressing these concerns falls into two types of mitigation for the purposes of this Master Plan: inflow control and infiltration control. Tidal-related flow and anomalous flow surges are addressed as either inflow or infiltration problems and will therefore be covered under those mitigation types. The capacity issues observed in the flow monitoring graphs may be able to be addressed by removing I&I from the flow as well or through monitoring (either physical inspection or remote monitoring) if SD5 determines that there is sufficient risk for an SSO in these areas. This would be more cost-effective than system modifications to accommodate extraneous flow. If I&I reduction measures do not sufficiently reduce the flow in the system, then it may be appropriate to consider more costly system modifications to increase capacity.

4.2.11.1 Inflow Control

When attempting to reduce I&I from a collection system, focusing on inflow as a first step is usually very cost-effective and can produce immediate, tangible results. Disconnecting the flow source and directing elsewhere will likely solve the problem. For instance, flow from roof downspouts can be directed to the yard. The challenge with inflow is finding sources. Controlling and eliminating inflow sources is also more cost-effective than developing additional sewer system capacity and treatment plant capacity. The following outlines specific steps to start an inflow control program:

- **Manhole inspection**: Manhole inspection is probably the most cost-effective I&I reduction activity that SD5 can do since the manholes are directly in its control. Inspect all manholes in the system that could be inundated. Look for holes in the sides of the structures and manhole frames and lids that could allow water to flow in. Manhole frame and lid testing at other utilities shows that some frames and lids can leak up to 70 gallons per minute (gpm) with only 3 inches of water covering the lid while well-performing frames and lids leak less than 1 gpm. Manholes in creek corridors or near gutters in streets should be inspected regularly to identify candidates for frame and lid replacement. Consider replacing or rehabilitating the frame and lid on leaky manholes.

- **Pipeline inspection**: Inspect any sewer that are laid in a creek channel where erosion could have exposed the pipe or pulled pipe joints apart. Repair pipes and make improvements as necessary.
- **Smoke testing**: Consider smoke testing the four target basins (Basins 1, 4, 6, and 7). Follow up on inflow sources identified. Disconnect sources where possible. Smoke testing is effective in locating inflow sources as the smoke comes out at the source. Smoke testing is conducted by blowing smoke from a smoke generator into the sewer with a blower and then following the smoke through the system. This inexpensive process can be done quickly. The entire District could be possibly smoke tested within 2 or 3 months.
- **Flow analysis:** Conduct an analysis for the plant influent flow to see how the system is performing as a whole. This could lead to the identification of other areas outside of the flow monitoring study where inflow control strategies could mitigate I&I in the system.

After inflow sources are identified, remediation options are available to disconnect them. Table 32 lists the types of sources and ways to remediate.

Table 32. Remediation options for various inflow sources

Source	Remediation
Downspouts	Redirect flow to yards, storm system, or other safe discharge point
Yard drains	Remove and plug the connection and regrade the yard so that drain is not needed Connect yard drain to storm system
Inundated manholes	Replace lids with watertight lids
Holes in manholes and structures	Rehabilitate the manhole and structure so it is watertight
Foundation drains	Redirect flow to the storm system or street, if possible
Other sources	Redirect flow to the storm system or street
Street catch basins	Disconnect and direct flow to storm system or other surface water discharge point

Many of these remediation actions can be easily accomplished while some of them may be more difficult, especially for those connections on private properties. However, the benefits in reduced peak flow can be significant. Downspout and yard drain disconnection requires property owner cooperation to complete. The City of Portland, Oregon, conducted an extensive downspout disconnection program that was quite successful in reducing peak flow from its combined storm/sanitary system that it was separating. Portland offered property owners a discount on their sewer bills if they disconnected. The City provided materials and engaged Boy Scout troops to help property owners complete the disconnection. Citizens were very supportive of the program because they understood that it would help reduce sewage discharges to the river.

SD5 may want to consider an outreach effort to work with property owners to generate their support. This has been found to be effective in other communities where the agency funds the work but allows the property owner to direct it. SD5 will need to be able to explain the problem, the choices and the benefits in financial terms so that customers will be able to understand the situation. The community will be more motivated to work with SD5 if they understand why it is necessary, what will be saved, and the impacts if they do not collaborate. The most difficult position for SD5 to take is to mandate the property owners improve their system at their cost, which will generate the least amount of motivation in the community.

4.2.11.2 Infiltration Control

The primary method of reducing infiltration is to repair all cracks, holes, and other defects in the basin. However, this may not be cost-effective if taken as the primary objective. Although rehabilitation of old sewers can reduce infiltration in the defective pipe, overall infiltration reduction is not usually found because the groundwater level may just rise and find other defects in adjacent mains or in-service lines and still get in. Some agencies have not achieved a material reduction in infiltration until most or all of the pipe, manholes, and structures have been substantially rehabilitated or replaced including service lines all the way to the building they serve. One public utility replaced its existing system with a new sanitary sewer system and service line to the property line. The work resulted in cutting the infiltration rate from extremely high values to about 3,000 gallons per acre served per day, which is about the best that can be expected from a watertight system (this is the current performance of Basins 5 and 6 in SD5's I&I study). Additionally, spending public dollars replacing the pipe owned by a property owner can be difficult to justify to stakeholders and the community, and it is intrusive to the property. Therefore, work on privately owned sewers is difficult to accomplish. However, without it, infiltration becomes very difficult to reduce.

However, it is always recommended to repair, rehabilitate, or replace sewers that are structurally failing even though the work may not materially reduce infiltration. As part of the CCTV investigation, defective pipes have been selected and prioritized for rehabilitation and replacement. The general results of this I&I evaluation were incorporated into the decision-support modeling. The recommendations identified for each basin in Table 32 above, were annotated to each of the basin pipes so that pipe repairs that would impact infiltration issues can be more effectively planned and prioritized.

While it may not be practical to spend District resources on repairs on private laterals, it may be possible to identify poor laterals through smoke testing or by leveraging SD5's sewer lateral inspection program. Smoke testing is a low-cost method to identify problematic issues in most cases with minimal impact to the customer. SD5's lateral inspection program will produce more direct evidence of lateral problems. SD5's Sanitary Sewer Code authorizes SD5 to require property owners to conduct a sewer lateral inspection whenever the significant property improvements, property transfer, road surfacing, or sewer main repairs occur (Section 3.05.350, Events requiring a lateral sewer inspection – All properties). SD5 may consider putting more focus on reviewing inspection results and required lateral repairs in areas where it believes that infiltration issues exist.

4.2.11.3 Flow Metering

SD5 may wish to consider implementing a flow metering program to monitor changes in flow through their lift stations and collection system. This can serve the dual purpose of identifying areas where I&I may be getting worse over time as well as monitor the efficiency and changes in the performance of the lift station pumps which can signal the need for replacement.

Flow metering can be done by installing flow meters along selected force mains or it can be indirectly measured by recording wet well levels and pump run times on locations with constant speed pumps. The installation of flow meters requires the ability to install the meter along the force main, including a valve vault and bypass pumping which was not assessed as part of this study.

Priority locations for flow metering are:

- **Belvedere PS-7:** Monitor changes in I&I flow along Peninsula Road (Basin 7) and the pump performance at PS-7
- **Tiburon PS-3:** Monitor changes in I&I flow from Basin 1 and monitor the pump performance of PS-3
- **Tiburon PS-5:** Monitor changes in I&I flow in Basins 3, 4 and 5 and monitor the pump performance at PS-5
- **Belvedere PS-3:** Monitor changes in I&I flow in Basins 9 and 10 as well as in the collection system up-gradient of PS-5, PS-8, PS-12, PS-13, and PS14. Monitor the pump station performance at PS-3

Flow metering at other lift stations would be beneficial as well and help the District isolate more specifically where I&I is originating. For example, if flow metering is added at Tiburon PS-2 above PS-3, the District would be able to determine if I&I is getting worse between PS-1 and PS2, or PS-2 and PS-3.

4.2.12 Potential Impacts of Sea Level Rise

To understand the potential impacts of SLR on SD5, the Tiburon and Belvedere sections of the Marin Shoreline Sea Level Rise Vulnerability Assessment were reviewed (BVB Consulting LLC, 2017). This report used a statewide SLR model developed by the United States Geological Survey that modeled several SLR scenarios and their impacts around the county. Six scenarios were modeled to determine the near-, medium-, and long-term impacts of projected SLR and the combined impact of these conditions with a 100-year storm (Table 33).

Table 33. The six sea level rise scenarios modeled in the vulnerability assessment

Term	Timeframe	Sea level rise	Sea level rise with a 100-year storm
Near term	By 2030	10 inches	46 inches
Medium term	By 2050	20 inches	56 inches
Long term	By 2100	60 inches	96 inches

The report described significant potential impacts across the county to transportation, emergency services, water, sewer, and other utilities, as well as many neighborhoods, commercial areas, and public areas (e.g., beaches, wetlands, and access to the water). A summary of potential impacts to SD5 based on the scenarios modeled is presented here and recommendations for mitigation are provided.

Based on the modeling analysis, the bay shoreline is vulnerable to SLR and intensifying storm patterns with the projected range of SLR of 4.7 to 24.0 inches by 2050 and 16.6 to 65.8 inches by 2100. Therefore, it is critical for SD5 to understand the impact from SLR to ensure a resilient sewer system for present and future generations.

4.2.12.1 Potential District Impacts

SLR could potentially affect multiple components of SD5's sanitary system including the lift stations, collection system, treatment plant, and utility users. General vulnerabilities are increased flow and water quality, which could lead to SSOs; damaged infrastructure, which could potentially cause SSOs; and system accessibility, which can delay emergency response, repairs, and maintenance. The following are specific vulnerabilities identified in the report that SD5 may experience:

- The wastewater treatment plant (WWTP) could be impacted from flooding. However, direct flooding is unlikely because the WWTP is at a slightly higher elevation than downtown Tiburon. There will more likely be indirect impacts from higher head in effluent pumps.
- Flow into the WWTP could be subject to increasing saltwater infiltration which may cause capacity and treatment problems.
- Lift stations could be overburdened by increased flow from saltwater infiltration into the collection system if influent flows exceed pump capacities. Equipment corrosion may also be accelerated. Lift stations located within the impacted SLR zone (e.g., Tiburon Lift Stations PS-4 and PS-6) may be inundated from high tides.
- Metallic force mains could be corroded at a faster pace because of increased saltwater exposure.
- Subsidence could cause underlying sewer pipes in low-lying areas to sag and settle in the near and medium terms, creating alignment issues, maintenance problems, and possibly SSOs.
- Increased I&I from SLR and larger storm events may cause an increase in SSOs and potentially additional regulatory actions.

- Downtown Tiburon and marine facilities can be flooded in the near term, creating accessibility problems, increased I&I, and increased maintenance.
- The steep shoreline bluffs around the Tiburon Peninsula may be subject to increased erosion and collapse during storm events, which could destroy utility infrastructure and damage homes.
- Access to Belvedere could be compromised or blocked because of flooding of access roads in the near and medium terms.
- The ability of utility works to access infrastructure and maintain the system may become difficult and may be blocked at times.
- U.S. Highway 101 and other primary access roads into the SD5 service area may be subject to increased flooding, which may delay or prevent critical services and supplies needed by SD5.

4.2.12.2 Vulnerable Assets

According to the Marin Shoreline Sea Level Rise Vulnerability Assessment, the Paradise Cove WWTP would be minorly impacted under the storm-related long-term SLR scenario (a sea level increase of 60 inches plus a 100-year storm surge). ***The most vulnerable asset owned by SD5 according to the SLR report is Lift Station PS-6 in Tiburon and the nearby manholes around Beach Road and Tiburon Boulevard, where flooding already occurs occasionally*** (Figure 27). The electrical system has already been upgraded to prevent flood damage and it is recommended that structural repairs be completed as described in the capital improvement recommendations. ***Tiburon Lift Station PS-4 is also currently subjected to tidal flooding, although it is not identified in the SLR report.*** As discussed in Section 5.2, this lift station will need significant structural improvements, which should incorporate flooding resilience when these improvements are designed. Other sewer main and manhole assets may also be vulnerable; however, further investigation will be needed to identify them. A study of the groundwater table and the elevation of manhole lids and other buried infrastructure should be completed to identify these additional vulnerabilities.

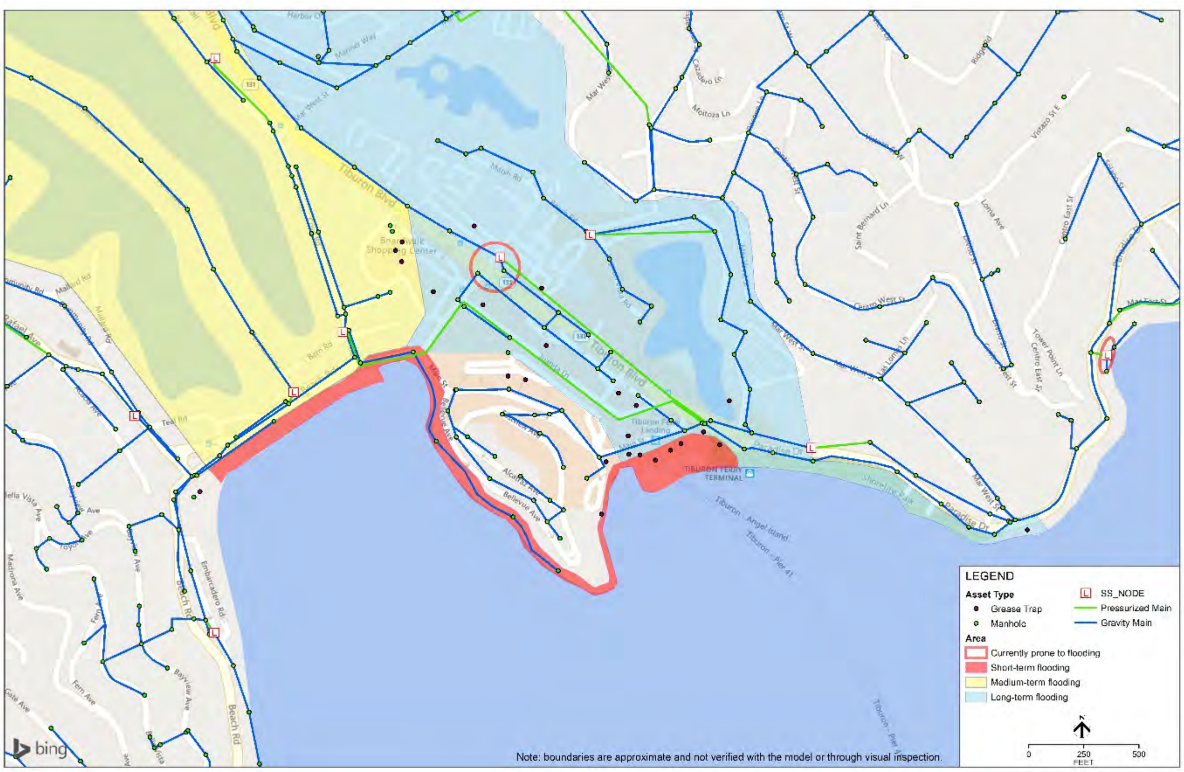


Figure 27. Tiburon vulnerable utility assets

It is also noted in the report that flooding during this scenario could reach the parking lot at the main treatment facility during storm surges, which may create access issues for employees and accelerate wear and tear on facility vehicles and equipment. The installation of berms may help mitigate this, but proper design and installation may not be cost-effective because of the potential geotechnical issues with managing the impacts of berm installation to overland and groundwater flow.

Table 34 provides a summary of vulnerabilities and recommendations based on the short-term, medium-term, and long-term modeled scenarios.

Table 34. Summary of sea level vulnerabilities and recommendations

Time period	Projected range	Key vulnerabilities	SLR mitigation recommendations
By 2030	1.6 – 11.8 inches	• Main street shoreline, hotels, shops and restaurants • Manholes and infrastructure near Tiburon Blvd and Beach Rd subject to flooding, including Tiburon Lift Station 6 • I&I along West Shore and Beach roads • Residential flooding along Beach Rd • Tidal flooding at Tiburon Lift Station 4 already occurring (through local knowledge)	• Incorporate SLR into decision-making process Keep up to date with science and policy to identify additional recommendations regarding SLR-related activities and threats as new information develops • Review standard District planning level assumptions and design guidelines to consider SLR • Rehabilitate Tiburon Lift Stations PS-4 and PS-6 to minimize environmental impact from flooding • Address high-priority I&I mitigation recommendations, especially those subjected to tidal influence and coastal flooding • Conduct a District-specific Sea Level Rise Vulnerability Assessment toward end of period that includes a detailed study of tidal influence on the groundwater table
By 2050	4.7 – 24 inches	• Yacht Club storm damage and flooding • Flooding and compromised access to town of Tiburon and Cove Shopping Center • San Rafael Ave access to Belvedere may be blocked • Residences in flat areas and the lagoon could be vulnerable to flooding	• Implement priority capital improvements as a result of Sea Level Rise Vulnerability Assessment • Continue collection system and lift station CIP, incorporating SLR mitigation strategies and design improvements • Phased adaptation to address groundwater, hydraulic impacts, and storm surge as required

Time period	Projected range	Key vulnerabilities	SLR mitigation recommendations
By 2100	16.6 – 65.8 inches	• Vehicular access along Tiburon Blvd and downtown • Municipal buildings flooding • Minor flooding and erosion during storm surge at Paradise Cove Treatment Plant • Saltwater intrusion along sewer lines that run along the beach • Possible flooding in parking lot of Main WWTP during storm surges • Access roads to Belvedere flooded • Erosion and bluff collapse during storm surges damaging residences and infrastructure	• Incorporate effects of SLR and storm surges on emergency operations planning as required • Phased adaptation to address groundwater, hydraulic impacts, and storm surge as required

4.3 Lift Stations

A condition assessment was performed on each of SD5's lift stations to evaluate current conditions and identify rehabilitation recommendations to maintain service levels and to identify operational recommendations to reduce odor complaints. The assessment included a review of available documentation and reference material on the lift stations, visual inspection of the stations, and interviews with District operations staff. This information was analyzed to develop recommendations to be incorporated into the CIP. To prioritize these recommendations, a risk analysis was conducted to determine the relative criticality of each lift station in terms of area served, pumping capacity, potential environmental impacts, and likelihood of flooding.

4.3.1 Information Review

To start the assessment, SD5 provided available documentation and reference materials to describe the configuration and operations of the lift stations. Additional data were provided by Nute Engineering, which has historically performed many of the previous lift station upgrades and repairs. Key documents evaluated are described in the introduction of this report.

There were limited available lift station as-built documents or other documents stating lift station flow rates and TDHs with the exception of Tiburon Lift Station 5.

4.3.2 Site Visit and Visual Condition Assessment

HDR visited each of SD5's lift stations to perform an inspection and visual condition assessment on October 14 and 15, 2020. SD5 provided a lead operator to guide the HDR engineer through the stations. All 24 lift stations were visited and assessed over these 2 days.

During the field visit, the following potential issues were visually assessed:

- Condition of the wet well lining
- Condition of the wet well concrete
- Fats, oils, and grease (FOG) accumulation
- Inlet and outlet pipe configuration
- Electrical panel

- Telemetry panel
- Condition of pumps, valves, and other components, including estimating remaining useful life
- General lift station condition

The condition of each of the stations was documented and photographs were taken to note key features observed. These are provided in Appendix E.

4.3.3 Operations Interviews

During the site visits, the lead operator provided additional insight and commentary on the history, performance, and operation of each facility. Topics addressed included:

- Recent lift station upgrades
- Odor and other operational concerns
- Facility configuration and design issues encountered
- Operation and condition history
- Discussion of necessary rehabilitation or operational improvements identified by O&M staff

Additional details and context have been provided through discussions with the District Manager. This information has been documented and incorporated into the analysis.

4.3.4 Approach to Assessing Criticality

The criticality of each lift station needs to be determined to understand how to prioritize rehabilitation work through the 15-year capital planning horizon. Criticality can then be combined with the condition of each station to make objective decisions about which repairs to make first and which can be scheduled further in the future.

Criticality is mainly a function of the impact of the failure of each of the facilities. To assess criticality each lift station needs to be evaluated based on the impact to SD5 and the community if it were unable to function. The lift station criticalities have been determined by the following:

- **Pumping capacities of each station:** Each of the lift stations is responsible for pumping wastewater from different parts of SD5's service area. The greater the amount of water that flows through a given lift station, the greater the impact to SD5 and the community if it cannot perform its function. Because flow data were not readily available for all the lift stations, the total length of system pipe that contributes flow to each lift station was used. This factor combined with the contribution from other lift stations that also convey flow to each station were used as an indicator of flow.
- **Impact on SD5's service area:** Some lift stations can be more critical than others, depending upon their location and the amount of wastewater that must flow through them. For example, a lift station serving downtown businesses and restaurants is usually more critical than a lift station serving a small residential area because the loss of the downtown lift station is likely to have a greater impact on the community through citizen inconveniences and business revenue loss. Also, lift stations that convey water from other stations would have a greater impact should they fail.
- **Potential for environmental damage:** Environmental damage can be caused by a lift station pump or power failure if the flow to the station exceeds its storage capacity before bypass pumping or other mitigations can be put into place. This may cause SSOs. A lift station more prone to pump or power failure will be more critical than a lift station less prone to pump or power failure. In general, SD5's vulnerabilities to overflows at the lift station are generally low and lift station failure can be addressed by standby pumps, on-site or portable backup power generation, and portable backup pumps.

- **Potential for lift station flooding due to tides and storms:** Flooding is the likelihood of a lift station being flooded by high or king tides and storm surges. This factor was considered to be for current conditions and did not incorporate the potential impacts of future SLRs because SLR impacts are anticipated to be minimal during the capital planning period.

Of these four criteria, the most significant related to criticality are the pumping capacities of each station and the impact on SD5's service area. These two components had the most influence on the criticality level assignment and analyses of these components are described in more detail below. Only one station in SD5 exhibited relatively high vulnerability to cause environmental damage or station flooding (Tiburon PS-4). This station is located directly adjacent to the shoreline, is already prone to tidal flooding, and has difficult accessibility to implement repairs or bypass pumping should the facility fail. These concerns were incorporated into the analysis and increased the station's criticality level assignment.

4.3.4.1 Station Pumping Capacities

The pumping capacity is the design flow rate and TDH of the lift station. For example, Belvedere PS-1 conveys much higher wastewater flows than Belvedere PS-11 and thus would be considered more critical. Design flow rates and TDH for each lift station were unavailable for analysis; therefore, available electrical service sizes and collection system pipe length contributing to the station were used for comparing the lift station capacities instead. Table 35 shows the electrical service characteristics for each lift station. The lift stations are all 240-volt (V) services with mostly three-phase power and two pumps. Because the lift stations' electrical service sizes are very similar, additional metrics have been considered.

Table 35. Lift station electrical service sizes for capacity comparison

Service area	Lift station number	Number of pumps	Voltage (V)	Phase	Largest motor (hp)
Tiburon	PS-1	1	240	1	3
Tiburon	PS-2	2	240	3	3
Tiburon	PS-3	2	240	3	5
Tiburon	PS-4	2	240	3	5
Tiburon	PS-5	2	240	3	60
Tiburon	PS-6	2	240	3	5
Tiburon	PS-7	2	240	3	5
Tiburon	PS-8	2	240	3	3
Tiburon	PS-9	2	240	3	5
Belvedere	PS-1	2	208	3	10/15
Belvedere	PS-2	2	240	3	3
Belvedere	PS-3	3	240	3	5
Belvedere	PS-5	2	240	3	5
Belvedere	PS-7	2	Unk.	Unk.	3
Belvedere	PS-8	2	220	1	3
Belvedere	PS-9	2	240	3	3
Belvedere	PS-10	2	240	1	3
Belvedere	PS-11	2	240	1	3
Belvedere	PS-12	2	240	1	3
Belvedere	PS-13	2	240	3	3
Belvedere	PS-14	2	240	3	3

Service area	Lift station number	Number of pumps	Voltage (V)	Phase	Largest motor (hp)
Belvedere	PS-15	2	240	1	3
Seafirth	CF-PS-1	2	240	3	25
Seafirth	CF-PS-2	2	240	1	3

Table 36 shows the system sewer main pipe lengths associated with each pipe in the system. This metric uses the pipe length as an indicator of the size of flow conveyed through each station. In general, the greater the length of sewer mains that contribute wastewater to the lift station, the more flow will be received. This can be generally applied because SD5's service area land use is almost entirely residential, which indicates that almost all parts of the system will exhibit similar flow characteristics.

Table 36. Lift station collection system pipeline lengths for capacity comparison

Service Area	Lift station number	Collection length (mi.)
Tiburon	PS-1	0.1
Tiburon	PS-2	0.7
Tiburon	PS-3	1.2
Tiburon	PS-4	0
Tiburon	PS-5	7.7
Tiburon	PS-6	2.3
Tiburon	PS-7	1.6
Tiburon	PS-8	1.2
Tiburon	PS-9	0.8
Belvedere	PS-1	11.1
Belvedere	PS-2	5.1
Belvedere	PS-3	3.7
Belvedere	PS-5	0.6
Belvedere	PS-7	7.3
Belvedere	PS-8	0.1
Belvedere	PS-9	0.9
Belvedere	PS-10	0.4
Belvedere	PS-11	0.2
Belvedere	PS-12	0.1
Belvedere	PS-13	1.8
Belvedere	PS-14	1.6
Belvedere	PS-15	1.8
Seafirth	CF-PS-1	0.3
Seafirth	CF-PS-2	0.1

4.3.4.2 Impact on SD5's Service Area

For this part of the assessment, each station was ranked based on impact to the service area if the station was taken out of service. In general, lift stations that receive wastewater conveyed from other lift stations upstream in the collection system will have a greater impact if they are unable to pump water. Table 37 shows the assessment of impact based on the number of lift stations linked to each station. The lift stations are sorted in descending order within each of the three service areas. These relationships can be seen in detail in the lift station schematic diagram in Figure 6, above, and in Table 37, below.

Table 37. Lift station hierarchy showing the number of stations that convey wastewater to each station

Service area	Lift station number	Lift station location	Number of stations
Tiburon	PS-5	Mar W St.	3
Tiburon	PS-3	Paradise Dr. and Solano St.	2
Tiburon	PS-6	Tiburon Blvd. and Beach Rd.	1
Tiburon	PS-2	Mar E St. near Agreste Way	1
Tiburon	PS-9	Paradise Dr. near Shoreline Park	1
Tiburon	PS-8	Beach Rd. and Lagoon Vista Rd.	0
Tiburon	PS-4	Paradise Dr. near Lyford's Tower	0
Tiburon	PS-7	Tiburon Blvd. near Ned's Way	0
Tiburon	PS-1	Mar E St. near Mar E Dr.	0
Belvedere	PS-1	Cove Rd. and Barn Rd.	12
Belvedere	PS-3	San Rafael Ave. And Golden Gate Av.	5
Belvedere	PS-9	Lagoon Rd. (south)	2
Belvedere	PS-5	San Rafael Ave. and Windward Rd.	1
Belvedere	PS-10	Lagoon Rd. near Maybridge Rd.	1
Belvedere	PS-13	West Shore Rd. (north)	1
Belvedere	PS-2	San Rafael Ave. and Teal Rd.	0
Belvedere	PS-7	Peninsula Rd. and Beach Rd.	0
Belvedere	PS-15	Beach Rd. near Embarcadero Dr.	0
Belvedere	PS-14	West Shore Rd. (south)	0
Belvedere	PS-8	Windward Rd.	0
Belvedere	PS-11	Lagoon Rd. (north)	0
Belvedere	PS-12	San Rafael Ave. and Edgewater Rd.	0
Seafirth	CF-PS1	Seafirth Pl.	1
Seafirth	CF-PS2	Seafirth Rd.	0

4.3.4.3 Criticality Ranking

Table 38 shows a summary of the criticality ranking information and the interpreted ranking. Rather than developing an individual ranking for each station, the stations were grouped into criticality levels to indicate repair priorities. Each of the service areas – Tiburon, Belvedere, and Paradise Cove – was ranked individually because each area operates independently from the others.

Table 38. Summary of criticality ranking data

Service area	Lift station number	Lift station location	Pipeline lengths	Lift station hierarchy (no. of linked)	Environ-mental	Flooding	Criticality level
Tiburon	PS-5	Mar W St.	7.7	3	No	No	L1
Tiburon	PS-3	Paradise Dr. and Solano St.	1.2	2	No	No	L2
Tiburon	PS-2	Mar E St. near Agreste Way	0.7	1	No	No	L3
Tiburon	PS-6	Tiburon Blvd and Beach Rd.	2.3	1	No	No	L3
Tiburon	PS-9	Paradise Dr. near Shoreline Park	0.8	0	No	No	L3
Tiburon	PS-1	Mar E St. near Mar E Dr.	0.1	0	No	No	L4
Tiburon	PS-4	Paradise Dr. near Lyford's Tower	0	0	Yes	Yes	L4
Tiburon	PS-7	Tiburon Blvd. near Ned's Way	1.6	0	No	No	L4
Tiburon	PS-8	Beach Rd. and Lagoon Vista Rd.	1.2	1	No	No	L4
Belvedere	PS-1	Cove Rd. and Barn Rd.	11.1	12	No	No	L1
Belvedere	PS-3	San Rafael Ave. & Golden Gate Ave.	3.7	5	No	No	L2
Belvedere	PS-9	Lagoon Rd. (south)	0.9	2	No	No	L2
Belvedere	PS-5	San Rafael Ave. & Windward Rd.	0.6	1	No	No	L3
Belvedere	PS-10	Lagoon Rd. near Maybridge Rd.	0.4	1	No	No	L3
Belvedere	PS-13	West Shore Rd. (north)	1.8	1	No	No	L3
Belvedere	PS-2	San Rafael Ave. & Teal Rd	5.1	0	No	No	L4
Belvedere	PS-7	Peninsula Rd. and Beach Rd.	7.3	0	No	No	L4
Belvedere	PS-15	Beach Rd. near Embarcadero Dr.	1.8	0	No	No	L4
Belvedere	PS-14	West Shore Rd. (south)	1.6	0	No	No	L4
Belvedere	PS-8	Windward Rd.	0.1	0	No	No	L4
Belvedere	PS-11	Lagoon Rd. (north)	0.2	0	No	No	L4
Belvedere	PS-12	San Rafael Ave. & Edgewater Rd.	0.1	0	No	No	L4
Seafirth	CF-PS1	Seafirth Pl.	0.3	1	No	No	L1
Seafirth	CF-PS2	Seafirth Rd.	0.1	0	No	No	L2

The lift station priority is shown in the criticality level column, which was interpreted based on the information provided in the other columns in the table.

Figure 29 shows a graphical view of this determination for the Tiburon service area. Based on the information provided, Tiburon PS-5 is the most critical lift station. Even though there are no other lift stations dependent upon it, it captures wastewater from 62 percent of the Tiburon service area by linear miles of sewer main. PS-3 is the second-most critical since it pumps water from other stations and has no bypass alternatives. The third level includes PS-2, PS-6, and PS-8 which also receive water from other stations. Finally, PS-1, PS-4, PS-7, and PS-9 are all at the fourth criticality level.

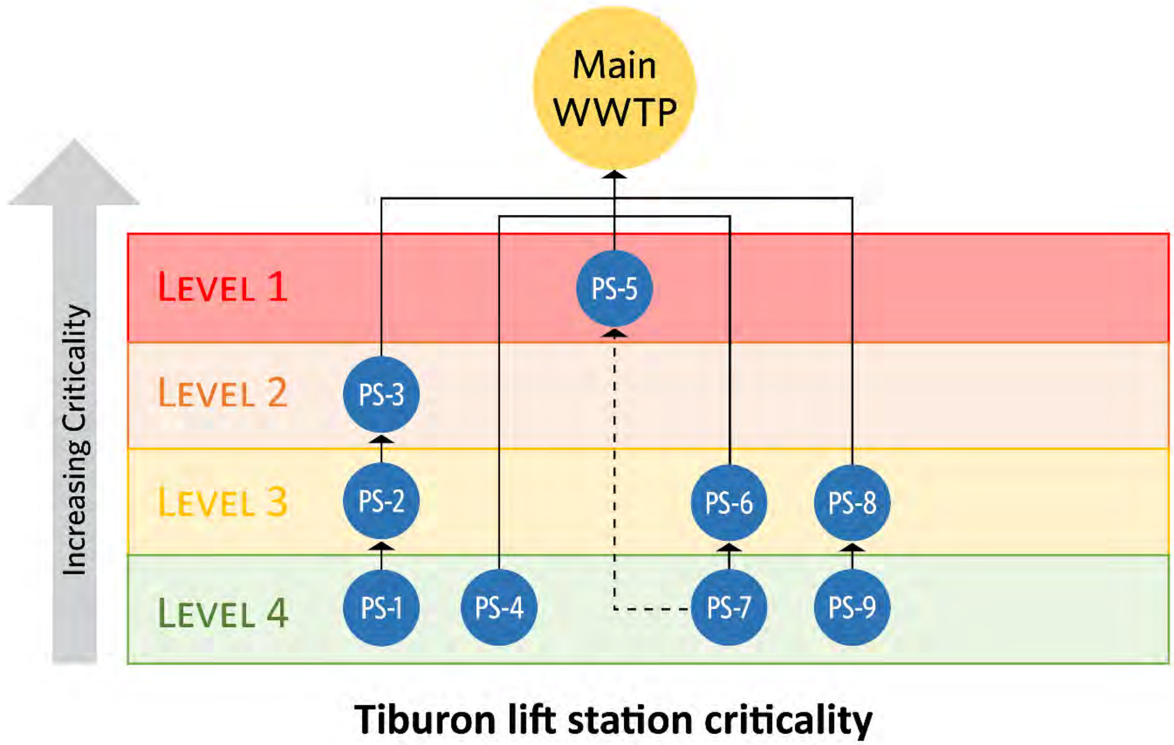


Figure 28. Tiburon lift station assigned criticality levels
(Arrows illustrate flow path to the WWTP. Dashed arrow indicates bypass flow.)

Figure 30 shows the lift station priority levels for the Belvedere service area. Lift Station PS-1 is the highest-ranking lift station as the entire service area flows into it. Lift Stations PS-3 and PS-9 are assigned to the second-level priority because they receive wastewater from seven other stations and collects water from about 41 percent of the Belvedere system. Next in priority are Lift Stations PS-5, PS-10, and PS-13, which capture 25 percent of the system. The remaining Belvedere list stations are assigned to the fourth level.

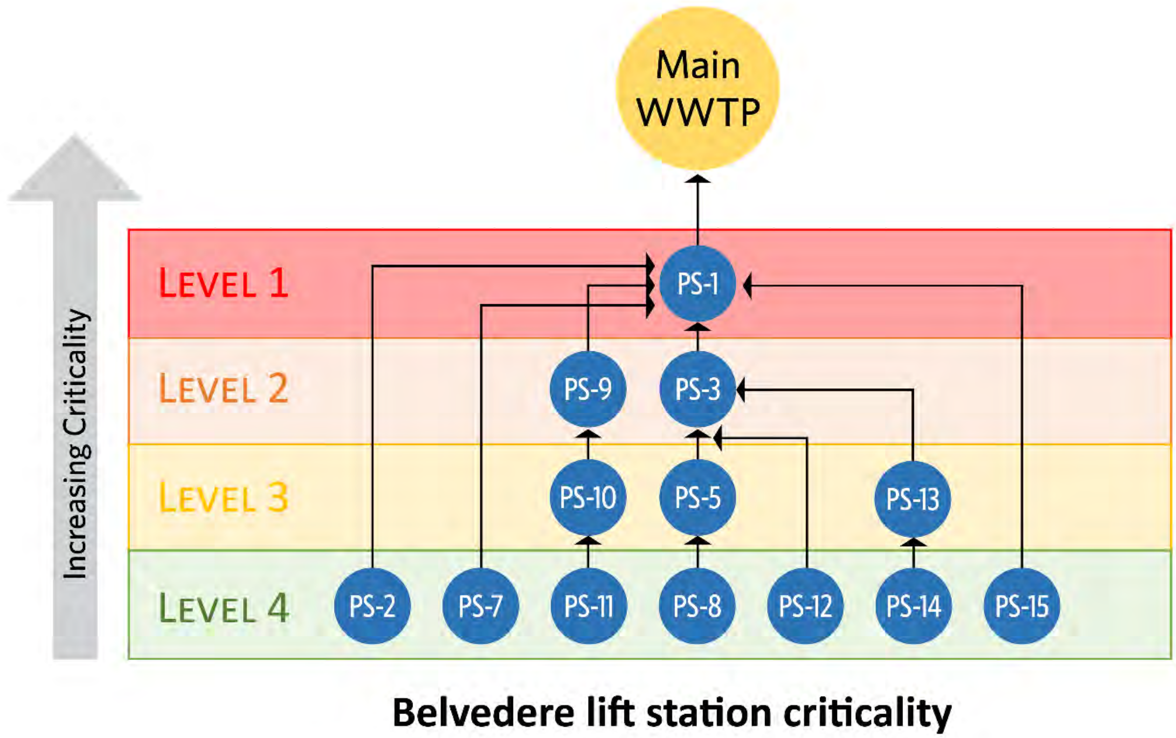


Figure 29. Belvedere lift station criticality
(Arrows illustrate flow path to the WWTP)

Figure 31 shows the criticality of the Seafirth lift stations. PS-1 is a at a higher criticality level than PS-2 because it receives flow from PS-2 and collects water from a larger area.

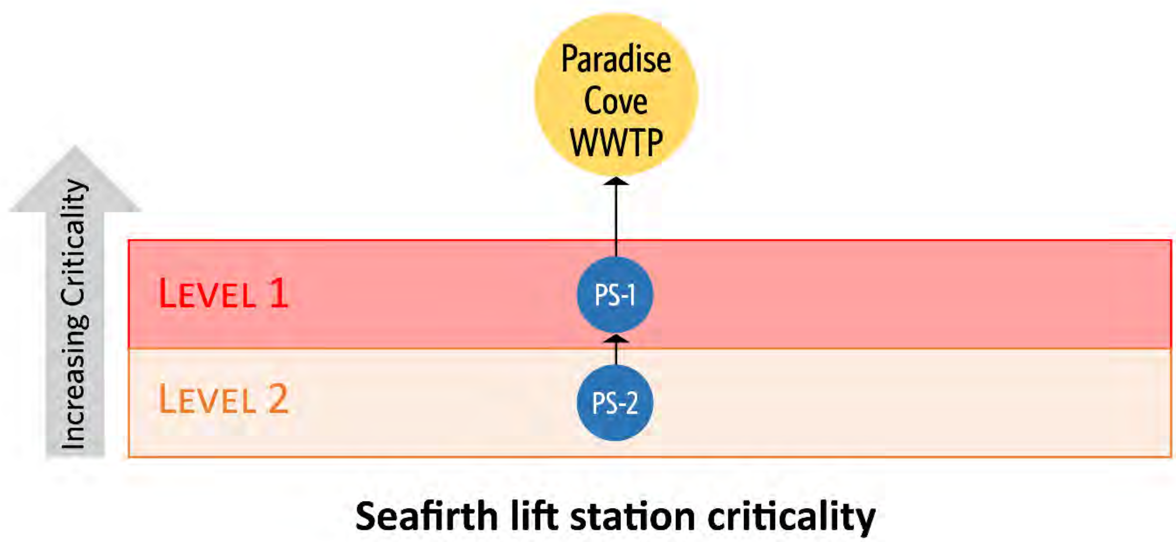


Figure 30. Seafirth lift stations criticality

4.3.5 Condition Assessment

This section summarizes the visual condition assessment of the lift stations. Each lift station was assigned an overall condition rating based on the summary of conditions observed. Table 44 summarizes these ratings.

Table 39. Visual condition assessment rating terminology

CR	Condition	EUL	Description	General recommendation
1	Very good	100% of EUL	New or excellent condition	Normal preventive maintenance
2	Good	75% of EUL	Minor defects only	Normal preventive maintenance, minor corrective maintenance
3	Fair	50% of EUL	Moderate deterioration	Normal preventive maintenance, major corrective maintenance
4	Poor	25% of EUL	Significant deterioration	Rehabilitation, if possible
5	Very poor	5% of EUL	Virtually unserviceable	Replace

Notes: EUL = estimated useful life

Table 40 presents a summary of the condition assessment findings for each station sorted by criticality.

This page is intentionally left blank.

Table 40. Summary of condition assessment findings

Service area	Criticality level	Lift station number	Lift station location	Overall condition	Recent upgrades	Odor issues	Backup power	Notes
Tiburon	1	PS-5	Mar W St.	Very good	Completely upgraded in 2019. Electrical and I&C upgraded in 2015.		Backup power provided by fixed mount diesel powered emergency generator	No significant issues observed or reported.
Tiburon	2	PS-3	Paradise Dr. and Solano St.	Fair	Electrical and I&C upgraded in 2015.		Backup power provided by fixed mount diesel powered emergency generator	Wet well is in adjacent private property driveway. Some access issues. Generator had several radiator failures and provides backup power to Tiburon 3 and 4.
Tiburon	3	PS-2	Mar E St. near Agreste Way	Fair	Electrical and I&C upgraded recently.		Backup power provided by fixed mount natural gas-powered emergency generator	Wet well concrete and hatch in fair conditions. Check valves have not been upgraded.
Tiburon	3	PS-6	Tiburon Blvd. and Beach Rd.	Fair–poor	Natural gas generator, electrical, and I&C upgraded in 2018.		Backup power provided by fixed mount natural gas-powered emergency generator	Wet well concrete in poor condition with exposed aggregate and H_2S attack.
Tiburon	3	PS-9	Paradise Dr. near Shoreline Park	Poor	The check valves were recently replaced because of failure. Electrical and I&C upgraded in 2015.		Backup power provided by Main Plant fixed mount diesel powered emergency generator	Wet well concrete with exposed aggregate and H2S corrosion and in poor condition. Wet well upper concrete cylinder sections leaning toward shoreline. Offset cylinders show evidence of sealing. Submersible pumps are difficult to remove because of leaning. Standing water was pumped out with manually operated sump pump.
Tiburon	4	PS-1	Mar E St. near Mar E Dr.	Good	Electrical and I&C upgraded in 2014.		Backup power provided by Tiburon PS-2	Serves only several residential homes.
Tiburon	4	PS-4	Paradise Dr. near Lyford's Tower	Poor			Backup power provided by Tiburon 3.	There is no dedicated or adjacent street parking. Lift station accessed through private property narrow stairs. Stairs are cracked and with uneven rises and runs. Access difficult. Susceptible to high tides and overflows into the bay. Deteriorated concrete. Corrosion and deterioration in wet well.
Tiburon	4	PS-7	Tiburon Blvd. near Ned's Way	Fair	Electrical and I&C upgraded in 2017. Recently upgraded natural gas backup generator.		Backup power provided by fixed mount natural gas-powered emergency generator	Heavy FOG exhibited during inspection.
Tiburon	4	PS-8	Beach Rd. and Lagoon Vista Rd.	Fair	Electrical and I&C upgraded in 2018.		Backup power provided by Main Plant fixed mount diesel powered emergency generator	Hatch and wet well concrete in fair condition. Check and isolation valve in fair to poor condition.
Belvedere	1	PS-1	Cove Rd. and Barn Rd.	Poor	New parallel force main was being installed during inspection.	Odor issues reported.	Backup power provided by fixed mount natural gas-powered emergency generator	Wet well access hatches in fair condition. High ground water exhibited in the new parallel force main trench. Wet well lined with membrane sealant. It was reported that the membrane is delaminating near the floor. Heavy FOG exhibited during inspection. Older electrical, I&C, and backup generator beyond their useful life. Odor control disconnected. Building roof in very poor condition.

Service area	Criticality level	Lift station number	Lift station location	Overall condition	Recent upgrades	Odor issues	Backup power	Notes
Belvedere	2	PS-3	San Rafael Ave. and Golden Gate Ave.	Fair–poor	Natural gas backup generator, electrical and I&C upgraded in 2017 and in very good condition.	Odor issues reported.	Backup power provided by fixed mount natural gas-powered emergency generator	Currently utilizing manhole odor control inserts. Wet well access hatches in fair condition exhibiting corrosion. Wet well concrete in poor condition/corrosion. Isolation and check valves are in fair to poor condition.
Belvedere	2	PS-9	Lagoon Rd. (south)	Fair–poor	Electrical and I&C recently upgraded.		Backup power provided by portable generator	Wet well concrete top cracked and in poor condition. Standing water in valve vault causing piping surface corrosion. Isolation and check valves are in fair and poor conditions, respectively.
Belvedere	3	PS-5	San Rafael Ave. and Windward Rd.	Fair–poor	Electrical and I&C recently upgraded.		Backup power provided by portable generator	Wet well hatch, wet well concrete in poor condition and exhibiting exposed aggregate and H_2S corrosion. Isolation and check valves in fair and poor conditions, respectively. Check valves were stuck.
Belvedere	3	PS-10	Lagoon Rd. near Maybridge Rd.	Fair–poor	Electrical and I&C recently upgraded.		Backup power provided by portable generator	Wet well concrete top cracked and in poor condition. Wet well grout cracking and in fair condition. Isolation and check valves are in fair and poor conditions, respectively.
Belvedere	3	PS-13	West Shore Rd. (north)	Fair	Electrical and I&C recently upgraded.		Backup power provided by portable generator.	Wet well grout cracking and is in fair condition. Isolation and check valves are in fair and poor conditions, respectively
Belvedere	4	PS-2	San Rafael Ave. and Teal Rd	Fair–poor	New generator, electrical, I&C, and automatic transfer switch are being upgraded during the time of the inspection.		Backup power provided by fixed mount natural gas-powered emergency generator	Access hatches to wet well in fair condition. Wet well in fair condition and appeared to be coated with coal tar.
Belvedere	4	PS-7	Peninsula Rd. and Beach Rd.	Fair–poor	Electrical and I&C recently upgraded.	Odor issues reported.	Backup power provided by Belvedere PS-1	Pipeline settling issues reported. Wet well concrete aggregate exposed, exhibiting softness, and H_2S corrosion. Check valves in poor condition with operational issues reported.
Belvedere	4	PS-15	Beach Rd. near Embarcadero Dr.	Fair			Backup power provided by portable generator.	Electrical and I&C recently upgraded and in very good condition.
Belvedere	4	PS-14	West Shore Rd. (south)	Fair	Electrical and I&C upgraded in 2018.		Backup power provided by portable generator.	Wet well concrete is in fair condition. Access ladder is in very poor condition, extremely corroded, and should not be used
Belvedere	4	PS-8	Windward Rd.	Fair	Older I&C scheduled to be upgraded.		Backup power provided by portable generator	Wet well access hatch in very poor condition. Excessive corrosion might be caused by brackish water. Wet well concrete in poor condition; exposed aggregate, softness and corrosion. Check valve issues reported.
Belvedere	4	PS-11	Lagoon Rd. (north)	Fair–poor	Electrical and I&C recently upgraded.		Backup power provided by portable generator.	Wet well concrete top cracked and in poor condition. Isolation and check valves are in fair and poor conditions, respectively.
Belvedere	4	PS-12	San Rafael Ave. and Edgewater Rd.	Fair–poor	Electrical and I&C recently upgraded.		Backup power provided by portable generator.	Wet well grout exhibiting cracking.

Service area	Criticality level	Lift station number	Lift station location	Overall condition	Recent upgrades	Odor issues	Backup power	Notes
Seafirth	1	CF-PS1	Seafirth Pl.	Good	Natural gas backup generator, electrical and I&C upgraded in 2009.	Odor issues reported.	Backup power provided by fixed mount natural gas-powered emergency generator	
Seafirth	2	CF-PS2	Seafirth Rd.	Good		Odor issues reported.	Electrical and I&C upgraded in 2009 and is in good condition	

This page is intentionally left blank.

4.3.5.1 Overall

Overall, the condition of the lift stations varied, with the Tiburon and Seafirth lift stations generally being in better overall condition than the Belvedere lift stations. Actual station age and capacity assessment were not determined because of limited data; therefore, the assessments relied on interviews with District staff for historical knowledge, visual condition assessment based on experience evaluating similar assets evaluated at other utilities, and comparison to industry best practices.

In general, the lift stations were well maintained. None of the stations received a very poor rating. The most significant issues identified were as follows:

- **Tiburon PS-4:** Access to the lift station is difficult. Access is on private property down steep, narrow, and degrading stairs. This lift station is also subject to tidal flooding and bay contamination. The Tiburon PS-4 force main may not lie within the dedicated easement, but instead could be on adjacent private property. However, the evaluation, legality, relocation, or replacement of force mains were not within the scope of this study.
- **Tiburon PS-9:** This station is in poor condition. The wet well upper concrete cylinder sections are leaning toward the shoreline, making it difficult to remove or maintain the submersible pumps.
- **Belvedere PS-1:** This station is in poor condition overall, with high groundwater infiltration likely. Poor structural condition of the facilities and the electrical, instrumentation and controls (I&C) and backup generator are beyond their useful life.
- **Belvedere PS-7:** This station is in poor condition. Wet well concrete is in poor condition and exhibiting exposed aggregate and hydrogen sulfide (H_2S) corrosion. The station check valve is in poor condition with operational issues reported.

In most cases, lift stations in poor or fair-poor condition exhibited significant corrosion or degradation of the wet well concrete. Station improvements to improve the grade of these stations must address repairing the concrete to a structurally sound condition. There are a variety of technologies that may be able to achieve this, however evaluation of these technologies was not part of the scope of this study.

4.3.5.2 Operational Issues

Odor issues were reported in several lift stations in the Belvedere and Seafirth service areas as shown in Table 40, above. Options for odor control include the following:

1. Install passive airtight and watertight gasketed access hatches and manholes that prevent foul air from escaping uncontrolled and infiltration water flow from entering the system. However, this eliminates the wet wells and manholes ability to breathe and might adversely affect hydraulic performance. The trapped foul air will escape at the exit unsealed upstream or downstream opening.
2. Install a passive a 10 to 12 foot high gooseneck pipe, 4 to 6 inches in diameter, that connects the annular space to the exterior. The height of the pipe may allow for air dispersal.
3. Install passive manhole inserts with activated carbon units, as shown in Figure 31.
4. Install passive external activated carbon units, as shown in Figure 32.
5. Implement active chemical injection such as Bioxide® calcium nitrate solution to control H_2S or other similar chemical injection methods.
6. Install a combination of airtight and watertight gasketed access hatches and gooseneck piping described in alternative 2.
7. Install an active exhaust fan with odor control unit.
8. Eliminate upstream pipeline belly, sag, and low area causing stagnation and putrefaction. This strategy would eliminate the cause of the odor, however, it is also the costliest.

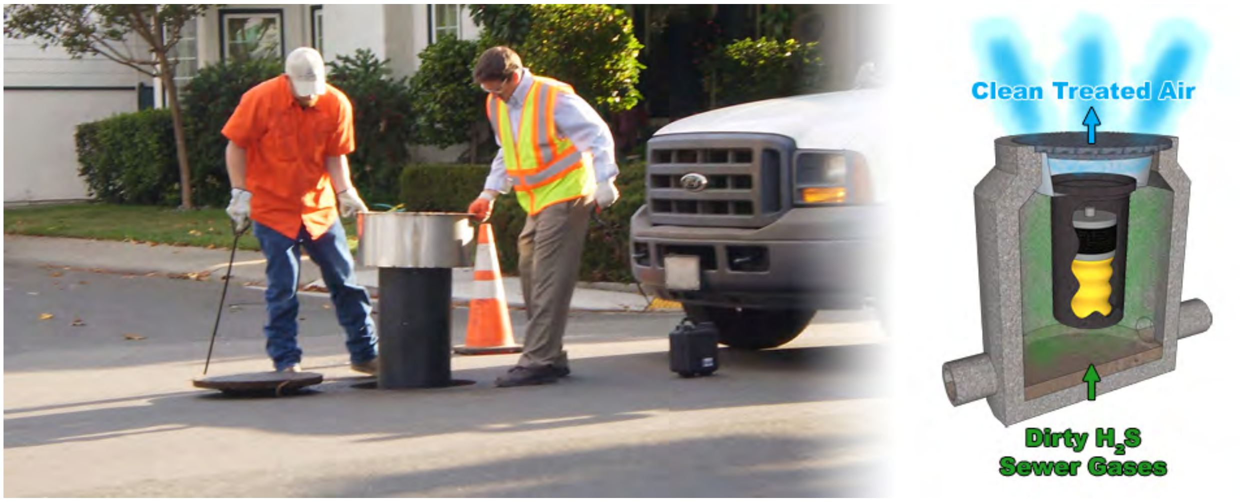


Figure 31. The Mole™ manhole insert with 20 lb. activated carbon to eliminate odors or equivalent device

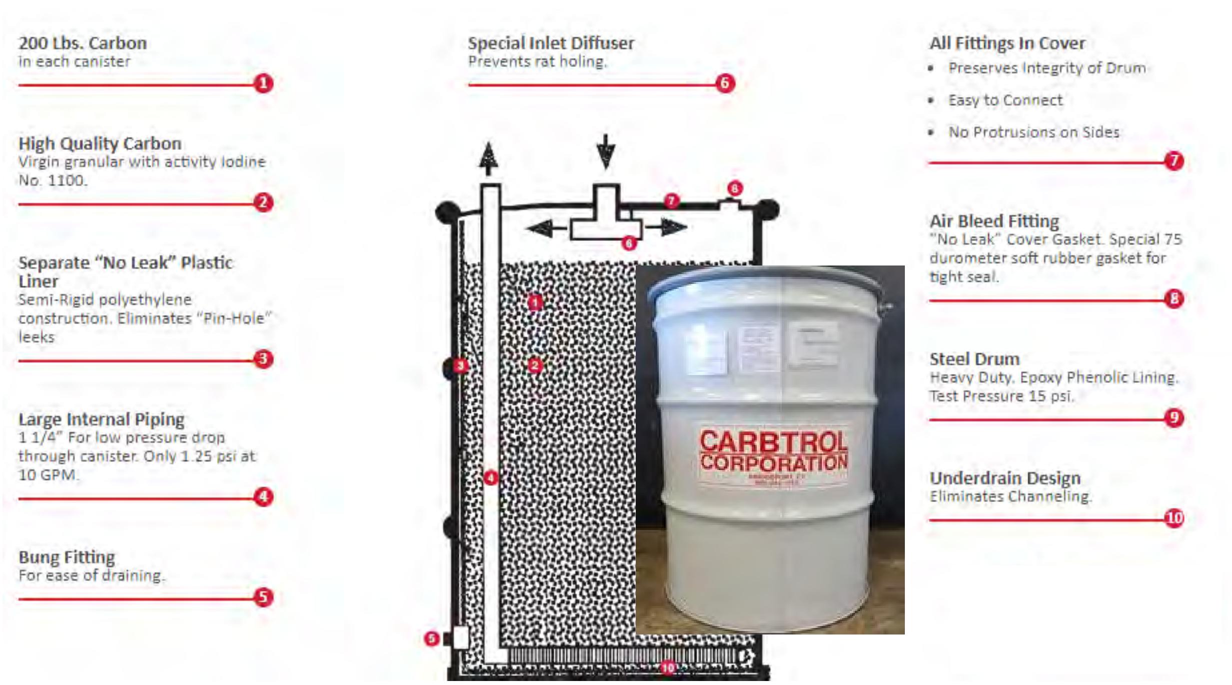


Figure 32. The Carbtrol® L-1 Canister with 200 lb. activated carbon to eliminate odors or equivalent device

5.0 Capital Improvement Plan

This section summarizes of the results of the gravity main and lift station assessments and presents SD5's 15-year CIP and planning-level cost estimates for each project.

5.1 Summary of Gravity Main Recommendations

The analysis of the gravity mains generated rehabilitation recommendations for all designated rehabilitation-related defects observed in the CCTV inspection data and other characteristics as defined in the rehabilitation decision logic in the previous section. Addressing all of these recommendations is both impractical and unnecessary because of District resource constraints and because some of the defects observed do not present a risk for SSOs or pipe failure at their current condition level. This CIP focuses on the most severe defects and highest-risk pipes for near-term capital improvements. However, because the inspections of many of these pipes were completed more than 15 years ago, it is assumed that many of the pipes with moderate defects (grades 3 and 4) continued to degrade and may currently be in worse physical condition. Therefore, these pipes (or a representative sample) should be re-inspected soon to determine if continued deterioration has occurred.

5.1.1 Rehabilitation

SD5's approach to selecting pipes for rehabilitation is based on the risk values calculated for each pipe and the overall severity of defects observed. Calculation of the risk values has been described in detail in the Section 4.1.3 above. The severity of the defects observed is based on the highest PACP defect grade observed on each pipe.

The PACP inspection process assigns a grade number for each defect observed. This grade is a 1 through 5 score that identifies the severity:

- **5:** immediate attention needed
- **4:** poor; will become Grade 5 in near future
- **3:** fair; moderate
- **2:** good; has not begun to deteriorate
- **1:** excellent; minor defects

It is common industry practice to use these defect grades to determine remaining useful life of the pipe. The most common application is:

- **5:** pipe has failed or will likely fail within 5 years
- **4:** pipe will probably fail in 5 to 10 years
- **3:** pipe may fail in 10 to 20 years
- **2:** pipe unlikely to fail for at least 20 years
- **1:** failure unlikely in foreseeable future

This is a general guideline and is applicable for SD5 based on the information available. However, NASSCO has revised the grading of its defects since the original District inspections were completed based in lessons learned in the industry (which could reclassify some of the original observations) and other PACP defect studies have shown that some defects deteriorate at a faster rate than others. Therefore, it is recommended that the pipes with grade 5 defects be addressed as soon as possible (e.g., within 5 years) and that pipes with grade 4 and grade 3 defects be reevaluated to determine the amount of degradation that has taken place since the original inspection. Some of these may now be grade 5 defects. Re-inspection is discussed further, below.

SD5 pipeline rehabilitation plan has been divided into the following four tiers for prioritization:

- 1 – Peak structural grade 5 defects or risk score greater than or equal to 58
- 2 – Peak structural grade 4 defects or risk score between 50 and 57.5
- 3 – Peak structural grade 3 defects or risk score between 36 and 49.5
- 4 – Others

Table 41 shows a summary of rehabilitation recommendations and costs per tier.

Table 41. Summary of pipeline rehabilitation recommendations

Tier	Timeframe	Number of gravity mains	Sum of miles	Percent of system	Gravity main costs
1	0–5 years	57	2.2	7%	$3,089,575
2	5–10 years	56	2.3	8%	$2,838,803
3	10–15 years	32	1.5	5%	$2,474,083
4	15+ years	13	0.6	2%	$592,900
Grand total		**158**	**6.6**	**22%**	**$8,995,361**

Within the Tier 1 collection of pipes, additional refinement and prioritization can be applied by considering I&I and road paving. Based on the I&I study, pipes that fall within a basin that has I&I issues is noted in the model. While this does not impact the quantitative analysis, it can influence the annual priorities for rehabilitation. Road paving information from the Town of Tiburon (and any other data available) may also be used to determine the schedule for rehabilitation over the next five years.

5.1.2 Reinspection

The gravity mains recommended for CCTV inspection are a combination of pipes that have never been inspected, pipes that have inspection results showing inconsequential or no PACP defects, and pipes that have been previously inspected that should be reevaluated.

The decision support model relies on CCTV captured for analysis from about 15 years ago and therefore, it is likely that the system has continued to age and degrade after the analysis was completed, which is not accounted for in the model. In order to verify that these lower-grade issues have not become more urgent repairs, a degradation analysis is recommended. For the analysis, several pipes should be selected for another CCTV inspection. By comparing the current CCTV results with the original results, SD5 will be able to determine the amount of degradation that has occurred, which types of defects degrade the fastest, and if there are any that require urgent rehabilitation. SD5 can use this information to prioritize additional work for the remaining lower priority defects as well as more effectively plan future inspections.

There is approximately 45,000 feet of pipe in the system that has grade 4 and grade 3 defects. A degradation analysis can be performed on about 10 to 15 percent of these pipes, preferably selecting pipes with more than one defect. This analysis would cost between $50,000 and $75,000 to complete.

A breakdown of these gravity mains and their prioritized CCTV inspection recommendations by timeframe is shown in Table 42. Risk priority thresholds were assigned qualitatively based on the distribution of the results and represent relative priorities. Roughly 40 percent of the gravity main system is being recommended for CCTV inspections with varying priorities and time frames based on current information**.** However, this may drop significantly if it is determined that the system is deteriorating at a slower rate after completion of the Tier 1 inspections. This is discussed further in Section 5.6.1 under Additional Recommendations.

Table 42. Summary of prioritized CCTV inspection recommendations

Tier	Timeframe	Strategy	Count of gravity mains	Sum of miles	Percent of system	Follow up CCTV costs
1	0–5 years	Decision model	24	0.71	2%	$26,115
		Degradation analysis		1.0 - 1.5	3% - 5%	$75,000 (approx.)
2	5–10 years	Decision model	94	2.46	9%	$90,748
3	10–15 years	Decision model	111	4.05	13%	$149,553
4	15+ years	Decision model	111	3.78	12%	$139,531
Grand total			**340**	**12.00(approx.)**	**40%**	**$480,947**

5.2 Summary of Lift Station Recommendations

This section describes the aggregation of the condition assessment findings into recommended improvement projects. Key assumptions that were considered to develop the lift station recommendations were applied based on industry knowledge and District-specific considerations. These are:

- Generators have fifteen (15) year estimated useful life based on District experience because of deterioration from sea air corrosion, usage, and age. Although Tiburon 5, Belvedere 3, and other standby generators were recently upgraded, they will still require one replacement cycle within the next 15 years. Therefore, all standby generators will require one replacement cycle within the next 15 years.
- SD5 has an ongoing pump preventive maintenance replacement program for the lift stations which is tracked in their maintenance management database, If there is no record in the database for replacement of a given pump and its age unknown, then it will be assumed that the it will require one replacement cycle within the next 15 years. The pumps estimated useful life is assumed to be 30 years.

Overall, the lift stations were in varying condition with Tiburon and Seafirth lift stations in better overall condition than the Belvedere lift stations*. **Three of the stations that are in poor condition will require additional investigation to determine the best alternatives to fully address issues observed:***

- **Tiburon PS-4** requires additional investigation because of its sensitive location and force main easement issues. The resulting redesign, repairs, upgrades, and costs are not accounted for in this Master Plan.
- **Tiburon PS-9** requires additional investigation because of the leaning wet well concrete sections. The investigation and technical memorandum to provide recommended repairs and upgrades is estimated at approximately $15,000. The resulting repairs, upgrades, and costs are not accounted for in this document.

- **Belvedere PS-1** requires additional investigation because of its system criticality, age, and conditions. The resulting redesign, repairs, upgrades, and costs are not accounted for in this Master Plan.

Odor control will be required for Belvedere Lift Stations PS-1, PS-3, and PS-7. Belvedere PS-1 and PS-3 are generally not near residential or public spaces and can apply odor controls that focus on efficiency and familiarity of operation. Chemical injection is recommended for these stations. Belvedere PS-7 is located next to residential property and will need a solution that is both aesthetic and functional. It is recommended that this station incorporate an exterior activated carbon odor control unit.

The overall condition summary of each lift station is shown in Table 43.

Table 43. Condition assessment summary for lift stations sorted by criticality level

Service area	Lift station criticality	Lift station location	Description	Very good (New or excellent condition)	Good (Minor defects only)	Fair (Moderate deterioration)	Poor (Significant deterioration)	Very poor (Virtually unserviceable)
Tiburon	1	PS-5	Mar W St.	✓				
Tiburon	2	PS-3	Paradise Dr. & Solano St.			✓		
Tiburon	3	PS-2	Mar E St. near Agreste Way			✓		
Tiburon	3	PS-6	Tiburon Blvd. and Beach Rd.			✓	✓	
Tiburon	3	PS-9	Paradise Dr. near Shoreline Park				✓	
Tiburon	4	PS-1	Mar E St. near Mar E Dr.			✓		
Tiburon	4	PS-4	Paradise Dr. near Lyford's Tower				✓	
Tiburon	4	PS-7	Tiburon Blvd. near Ned's Way			✓		
Tiburon	4	PS-8	Beach Rd. and Lagoon Vista Rd.			✓		
Belvedere	1	PS-1	Cove Rd. & Barn Rd.				✓	
Belvedere	2	PS-3	San Rafael Ave. and Golden Gate Ave.			✓	✓	
Belvedere	2	PS-9	Lagoon Rd. (south)			✓	✓	
Belvedere	3	PS-5	San Rafael Ave. and Windward Rd.			✓	✓	
Belvedere	3	PS-10	Lagoon Rd. near Maybridge Rd.			✓	✓	
Belvedere	3	PS-13	West Shore Rd. (north)			✓		
Belvedere	4	PS-2	San Rafael Ave. & Teal Rd.			✓	✓	
Belvedere	4	PS-7	Peninsula Rd. and Beach Rd.			✓	✓	
Belvedere	4	PS-15	Beach Rd. near Embarcadero Dr.			✓		
Belvedere	4	PS-14	West Shore Rd. (south)			✓		
Belvedere	4	PS-8	Windward Rd.			✓		
Belvedere	4	PS-11	Lagoon Rd. (north)			✓	✓	
Belvedere	4	PS-12	San Rafael Ave. & Edgewater Rd.			✓	✓	
Seafirth	1	CF-PS1	Seafirth Pl.		✓			
Seafirth	2	CF-PS2	Seafirth Rd.		✓			

This page is intentionally left blank.

5.2.1 Lift Station Improvement Projects

Recommended improvements for the SD5 lift stations fall into the following categories:

- **Additional investigation:** A few stations have unique issues that require a more detailed engineering analysis as described previously.
- **Concrete repair:** Repair of the wet well and other concrete structures is needed.
- **Epoxy coating:** Application of an epoxy coating to the wet well should be applied to slow down observed corrosion and extend the wet well useful life.
- **Epoxy coating (optional):** Optional epoxy coatings are recommended on stations where minor concrete deterioration or wear in the existing coating has been observed. The cost to recoat these structures is relatively low; however, the cost of mobilization and required bypass pumping is significant. Therefore, these recommendations should be applied as cost-effective opportunities allow.
- **Check valve:** Poor check valve condition is one of the more predominant issues observed in the lift stations. These should be replaced.
- **Pump replacement:** Pump replacement program in effect—$25,000 each zone. Replace as needed. Most pumps are 5 years old or newer.
- **Standby backup generator:** Generator replacement is assumed to be required every 15 years because of the corrosive marine conditions on the Tiburon Peninsula.
- **Access hatch replacement:** Replacement of access hatches that are in poor condition.
- **Access hatch repair:** Rehabilitation of access hatches in fair condition.
- **Fall protection safety grate:** Many of the older fall protection nets are deteriorated or approaching the end of their expected lives.
- **Odor control:** Odor control recommendations as described earlier.
- **Preventive maintenance:** Current preventive maintenance procedures and frequencies are sufficient and appropriate for proper maintenance and continued implementation is recommended. Note that these costs are considered operational and are not incorporated into the CIP.

Tables 49, 50, and 51 summarize the lift station recommended improvements for Tiburon, Belvedere, and Seafirth within the next 15 years, respectively.

Table 44. Tiburon lift station recommended improvements within the next 15 years

		Tiburon lift stations								
	Improvements	PS-1	PS-2	PS-3	PS-4	PS-5	PS-6	PS-7	PS-8	PS-9
1	Additional investigation				✓					✓
2	Concrete repair				✓					✓
3	Epoxy coating				✓		✓			✓
4	Epoxy coating (optional)	✓	✓	✓				✓	✓	
5	Check valve	✓	✓	✓			✓	✓	✓	
6	Pump replacement		✓	✓	✓					✓
7	Standby backup generator		✓	✓		✓	✓	✓	✓	
8	Access hatch replacement			✓	✓		✓	✓	✓	✓
9	Access hatch repair									

	Improvements	Tiburon lift stations PS-1	PS-2	PS-3	PS-4	PS-5	PS-6	PS-7	PS-8	PS-9
10	Fall protection safety grate		✓	✓	✓		✓	✓	✓	
11	Odor control									
12	Preventive maintenance	✓	✓	✓	✓	✓	✓	✓	✓	✓

Table 45. Belvedere lift station recommended improvements within the next 15 years

	Improvements	Belvedere lift stations PS-1	PS-2	PS-3	PS-5	PS-7	PS-8	PS-9	PS-10	PS-11	PS-12	PS-13	PS-14	PS-15
1	Additional investigation	✓												
2	Concrete repair	✓	✓	✓	✓	✓		✓	✓	✓	✓			
3	Epoxy coating	✓	✓	✓	✓	✓								
4	Epoxy coating (optional)						✓	✓	✓	✓	✓	✓	✓	✓
5	Check valve	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓
6	Pump replacement	✓	✓						✓	✓	✓			
7	Standby backup generator	✓		✓										
8	Access hatch replacement	✓	✓	✓	✓	✓		✓	✓	✓				✓
9	Access hatch repair						✓				✓	✓	✓	
10	Fall protection safety grate	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓
11	Odor control	✓	✓	✓		✓								
12	Preventive maintenance	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Table 46. Seafirth lift station recommended improvements within the next 15 years

		Seafirth lift stations	
	Improvements	PS-1	PS-2
1	Additional investigation		
2	Concrete repair		
3	Epoxy coating		
4	Epoxy coating (optional)	✓	✓
5	Check valve		
6	Pump replacement		
7	Standby backup generator	✓	
8	Access hatch replacement		
9	Access hatch repair		
10	Fall protection safety grate		
11	Odor control		
12	Preventive maintenance	✓	✓

These recommended rehabilitations have been prioritized into the same tier structure used for prioritizing pipeline replacements and is based on the criticality analysis described above. ***Table 47 provides the recommended schedule and opinion of costs for each lift station.*** Detailed cost basis for these estimates can be found in Appendix D.

Table 47. Recommended lift station schedule and rehabilitation costs

Service area	Lift station number	Lift station location	Rehabilitation schedule			
			0-5 years	5-10 years	10-15 years	15+ years
Tiburon	PS-1	Mar E St. near Mar E Dr.				$11,154
Tiburon	PS-2	Mar E St. near Agreste Way			$99,725	
Tiburon	PS-3	Paradise Dr. and Solano St.			$129,910	
Tiburon	PS-4	Paradise Dr. near Lyford's Tower	$386,515			
Tiburon	PS-5	Mar W St.				$50,833
Tiburon	PS-6	Tiburon Blvd. and Beach Rd.		$431,013		
Tiburon	PS-7	Tiburon Blvd. near Ned's Way			$91,464	
Tiburon	PS-8	Beach Rd. and Lagoon Vista Rd.			$40,631	
Tiburon	PS-9	Paradise Dr. near Shoreline Park	$400,747			
Belvedere	PS-1	Cove Rd. and Barn Rd.	$668,323			
Belvedere	PS-2	San Rafael Ave. and Teal Rd.		$498,934		
Belvedere	PS-3	San Rafael Ave. and Golden Gate Av		$500,590		
Belvedere	PS-5	San Rafael Ave. and Windward Rd.			$418,832	
Belvedere	PS-7	Peninsula Rd. and Beach Rd.	$411,031			
Belvedere	PS-8	Windward Rd.				$53,473
Belvedere	PS-9	Lagoon Rd. (south)		$83,478		
Belvedere	PS-10	Lagoon Rd. near Maybridge Rd.			$48,632	
Belvedere	PS-11	Lagoon Rd. (north)			$48,632	
Belvedere	PS-12	San Rafael Ave. and Edgewater Rd.			$36,050	
Belvedere	PS-13	West Shore Rd. (north)				$70,896
Belvedere	PS-14	West Shore Rd. (south)				$31,165
Belvedere	PS-15	Beach Rd. near Embarcadero Dr.				$58,054
Seafirth	CF-PS1	Seafirth Pl.				$50,833
Seafirth	CF-PS2	Seafirth Rd.				$0
Total			**$1,866,616**	**$1,514,015**	**$913,876**	**$326,408**

Notes:

Costs are in 2020 dollars from RS Means (a publication and database for construction industry materials, equipment, labor, etc. cost estimating.

Detailed cost basis for these estimates can be found in Appendix D.

5.3 Force Main Recommendations

A detailed assessment of SD5's force mains was not part of the master plan scope, however available information was reviewed to develop recommendations on further evaluation. This analysis considered both prioritizing the force mains to determine which ones should be evaluated first and identifying appropriate technologies to be used for the condition assessment. To simplify the analysis, the force main segments in the GIS were aggregated based on the upstream and downstream connectivity with other segments, similar materials, and similar diameters. The resulting force main records are provided in Table 48, below. There are six pipe materials found in the SD5 force mains. Those include: asbestos cement (AC), vitrified clay pipe (VCP), cast iron (CAS), polyethylene (PE), poly-vinyl chloride (PVC), and steel. The pipe diameters in this system range from 4 inches to 10 inches.

Accurately prioritizing SD5's force mains would require a full risk analysis with LoF and CoF scoring for each pipe to determine the criticality of each (similar to what was performed on the gravity mains). Lacking such a study but based on experience and information available in the SD5's GIS database, the following recommendations are provided. It should be noted that a full risk analysis may identify different priorities.

From the information available, the Tiburon force mains PS-5-14 and PS-6-621, and Belvedere force mains PS1-TIB and the PS3 force mains (PS3-ND5 - PS3-ND5.1 and PS3-ND5.1.1) should be prioritized first for condition assessment. This is mostly due to their lengths, their associated pump station criticality, and their ages.

The possible assessment technologies for each force main is also shown in Table 48. The available technologies and vendors for assessment of these pipes is provided in Table 49. A more detailed description of each assessment technology can be found in Appendix F. The estimated cost for different assessment tools for each higher priority force main is provided in Table 50. These costs are based on previous project experience but would need to be refined with a quote from each vendor.

This page is intentionally left blank.

Table 48. Summary of District force mains and recommendations including sample results from V&A Consulting Engineers, 2018

Force main ID	Pump station	Pump station priority	Percent service area of collection system covered	Diameter (in.)	Material	Length (ft.)	Installation year	GIS comment	Sample material	Vanda rating	Metal loss	Possible assessment technologies
PS1-TIB	**(B)PS1[1]**	**1**	**100%**	**10**	**AC**	**2,107**	**1950**	**FORCEMAIN 10""**				**Acoustic**
PS3-ND5 - PS3-ND5.1	**(B)PS3**	**4**	**33%**	**6**	**PE**	**285.4**	**1950**	**FORCEMAIN 7.5"" NEAR CURB**				**Acoustic**
PS3-ND5.1.1	**(B)PS3**	**4**	**33%**	**8**	**CAS**	**1973**	**1950**		**Steel**	**2 (minor)**	**23.68%**	**Acoustic, electromagnetic**
PS9-N7	(B)PS9	4	4%	4	PVC	397	1952	FORCEMAIN 4""				Acoustic
PS5-C5	(B)PS5	5	5%	6	CAS	72	1952	FORCEMAIN				Acoustic
PS10-M5	(B)PS10	5	4%	6	CAS	35	1950	FORCEMAIN				Acoustic
PS13-CA5.1	(B)PS13	5	16%	4	AC	438	1956	FORCEMAIN 4""				Acoustic
PS2-ND2	(B)PS2	3	13%	6	CAS	16		FORCEMAIN				Acoustic
PS7-NB2	(B)PS7	2	4%	4	CAS	57	1950	FORCEMAIN 4""				Acoustic
PS15-NF3	(B)PS15	6	16%	6	CAS	69	1959	FORCEMAIN				Acoustic
PS14-E6.1	(B)PS14	6	14%	4	AC	458	1950	FORCEMAIN 4""				Acoustic
PS8 - 10 Windward-A7A	(B)PS8	6	1%	6	CAS	53	1952	FORCEMAIN 6"" VC				Acoustic
PS11-K4	(B)PS11	6	2%	6	CAS	49	1950	FORCEMAIN 4""				Acoustic
PS12-C6	(B)PS12	6	1%	6	CAS	179	1955	FORCEMAIN				Acoustic
PS-5-14	**(T)PS5[2]**	**1**	**62%**	**8**	**CAS**	**1,303**	**1960**		**Cast iron**	**3 (moderate to significant)**	**18.95%**	**Acoustic, electromagnetic**
PS-3-33	(T)PS3	2	10%	6	CAS	379	1952					Acoustic
PS-2-38	(T)PS2	3	6%	6	CAS	357	1952		Cast iron	4 (severe)	22.12%	Acoustic
PS-6-621	**(T)PS6**	**2**	**19%**	**8**	**AC**	**1,168**	**1960**					**Acoustic**
PS-8-808	(T)PS8	3	10%	4	PVC	565	1987					Acoustic
PS-1-41	(T)PS1	4	1%	4	CAS	140	1970					Acoustic
PS-4-608	(T)PS4	2	0%	4	SP	100	1960					Acoustic
PS-7-121	(T)PS7	3	13%	6	CAS	903	1962		Cast iron	2 (minor)	11.95%	Acoustic, electromagnetic
PS-9-642	(T)PS9	2	6%	10	CAS	235	1962					Acoustic
4185 Paradise Dr.-Valve Box - End of Sewer Line Extension	PDE[3]	N/A	23%	4	PE	4,603	2008					Acoustic
473-474, 626-473, 627-626, 630-627, 628-630, 629-628	SE[4]	N/A	23%	6	PE	4634	2003					Acoustic
629-630	VE5	N/A	3%	6	PE	562	2003					Acoustic
CF-PS1-	(SF)PS1[6]	1	11%	4	VCP	870	NA					Acoustic
SF5-CF-PS2	(SF)PS2	2	7%	4	PVC	772	NA					Acoustic

[1](B) – Belvedere service area
[2](T) – Tiburon service area
[3]PDE – Paradise Drive extension
[4]SE – Shaw extension
[5]VE – Vogt extension
[6](SF) – Seafirth lift stations

This page is left intentionally blank.

Table 49. Possible condition assessment technologies and vendors

Technology description	Vendor	Name
Acoustic • Leak detection • Gas pocket detection • Any pipe material • Pipe diameters 4" and up • Free-swimming • Pipe online	Pure	SmartBall[1]
	PICA	Recon +[1]
Electromagnetic • Wall loss • Metallic pipes • Pipe diameters 4" and up • Free-swimming or tethered • Pipe online or offline	Pure	PipeDiver[1]
	PICA	SeeSnake[1]
Multi-sensor attachments • CCTV • LIDAR • 3D scanning • Elevation profiling	Various	Robotic Surveyor[2]

[1]Suitability of these tools for this system is contingent upon a review of the pipeline records by the vendor, and possible access improvements and cleaning.
[2]Not likely to be suitable for these force mains as the line needs to be offline, drained, and cleaned.

Table 50. Estimated assessment cost

Force main	Diameter (in.)	Length (ft.)	Pipe material	Possible assessment tools	Estimated cost
PS1-TIB	10	2,107	AC	Recon + SmartBall[1]	$12,000 $60,000
PS3-ND5 - PS3-ND5.1, PS3-ND5.1.1	6	2,258	PE	Recon + SmartBall[1]	$12,000 $60,000
PS-5-14	8	1,303	CAS	Recon + SmartBall[1] SeeSnake	$12,000 $55,000 $250,000
PS-6-621	8	1,168	AC	Recon + SmartBall[1]	$12,000 $55,000

[1]There is potential cost savings if all the force mains are inspected under a single mobilization and single inspection report, about $140,000 deduction.

5.4 CIP Budgeting

SD5's overall income is around $6.5 million based on information from the fiscal year (FY) 2020-2021 Budget Report. Previous capital expenditures have ranged between $1.3 million and $2.6 million over the past 5 years, which include collection system, lift station, and WWTP improvements and upgrades, as well as current debt service. Because significant improvements have already been completed on the SD5 WWTPs it is assumed that priorities can be shifted to the collection system and lift stations.

Planned capital expenditures for the next 9 years average about $1.2 million per year totaling approximately $11 million for the lift stations and gravity mains based on SD5's financial plan. This CIP is structured to conform to this target budget.

5.5 CIP Summary

This section provides a summary of the comprehensive CIP for the collection system. Table 51 shows the expenditures by asset category: gravity mains, pump stations, and force mains. These expenditures are categorized into near-term, mid-term, and long-term expenses covering the next 15 to 20 years. Each of the categories is further divided by service area and finally, a 5-year annual average cost is calculated.

Table 51. Summary of CIP expenses for gravity mains and lift stations

	Total	Tiburon	Paradise Cove	Belvedere	Yearly average
Short-term (0-5 years)					
Gravity main rehabilitation and inspection	$ 3,159,575	$2,236,717	$ -	$ 922,858	$631,915
Lift station rehabilitation	$ 1,896,617	$ 817,263	$ -	$1,079,354	$379,323
Force main inspection	$216,000	$ 108,000	$ -	$ 108,000	$ 43,200
Short-term total	**$ 5,272,192**	**$3,161,980**	**$ -**	**$2,110,212**	**$ 1,054,438**
Mid-term (5-10 years)					
Gravity main rehabilitation and inspection	$ 2,838,802	$1,838,902	$115,933	$ 883,967	$567,760
Lift station rehabilitation	$ 1,514,015	$ 431,013	$ -	$1,083,002	$302,803
Force main inspection	$ -	$-	$ -	$-	$ -
Mid-term total	**$ 4,352,817**	**$2,269,915**	**$115,933**	**$1,966,969**	**$870,563**
Long-term (10-15 years)					
Gravity main rehabilitation and inspection	$ 2,474,083	$1,614,805	$315,363	$ 543,915	$494,817
Lift station rehabilitation	$913,877	$ 361,730	$ -	$ 552,147	$182,775
Force main inspection	$ -	$-	$ -	$-	$ -
Long-term total	**$ 3,387,960**	**$1,976,535**	**$315,363**	**$1,096,062**	**$677,592**

These costs and schedule are also shown on the graph in Figure 33. This graph shows the average expenditures annually by fiscal year. The gravity main rehabilitation and inspection category is further broken out int gravity main rehabilitation (dark blue bars), gravity main inspection (orange bars), and gravity main degradation study (grey bars). The gravity main degradation study is described in more detail in the additional recommendations in Section 5.6, below.

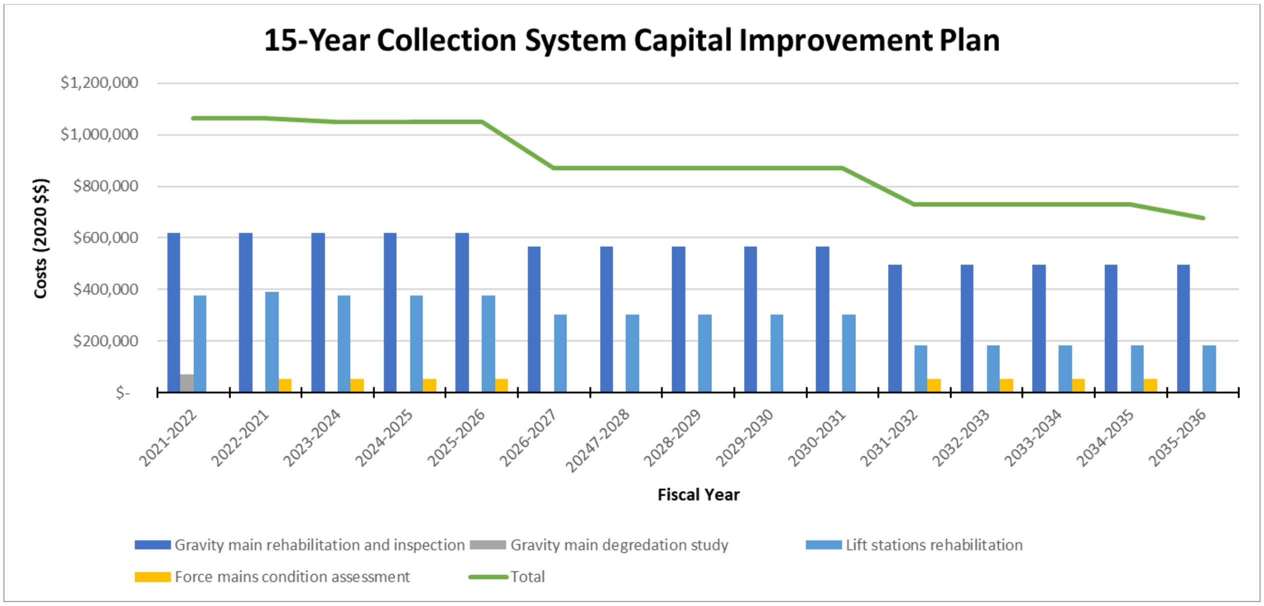


Figure 33. Collection system capital improvement plan

The proposed CIP is also compared to SD5's planned capital expenditures as provided in the FY 2020–2021 Final Budget report (Figure 34) [SD2, 2020b]. The blue line represents the capital budget planned in the Budget Report and the orange line represents the planned expenditures from the proposed CIP. ***The total planned budget from FY 2020–2021 to FY 2028–2029 is $11 million and the proposed budget for the same period is approximately $9 million, which shows strong alignment between the planned budget in the Budget Report and the proposed CIP.***

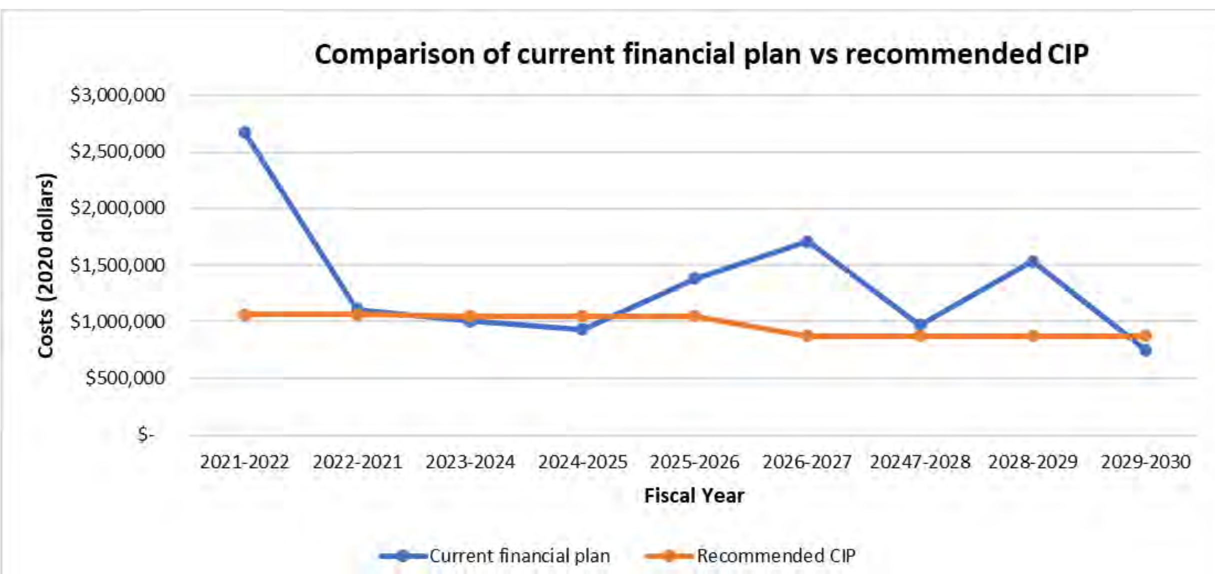


Figure 34. Comparison of planned capital expenditures in comparison to the proposed CIP

Figure 35, Figure 36, and Figure 37 provide maps of the proposed capital improvement projects in the near-term, mid-term, and long-term respectively.

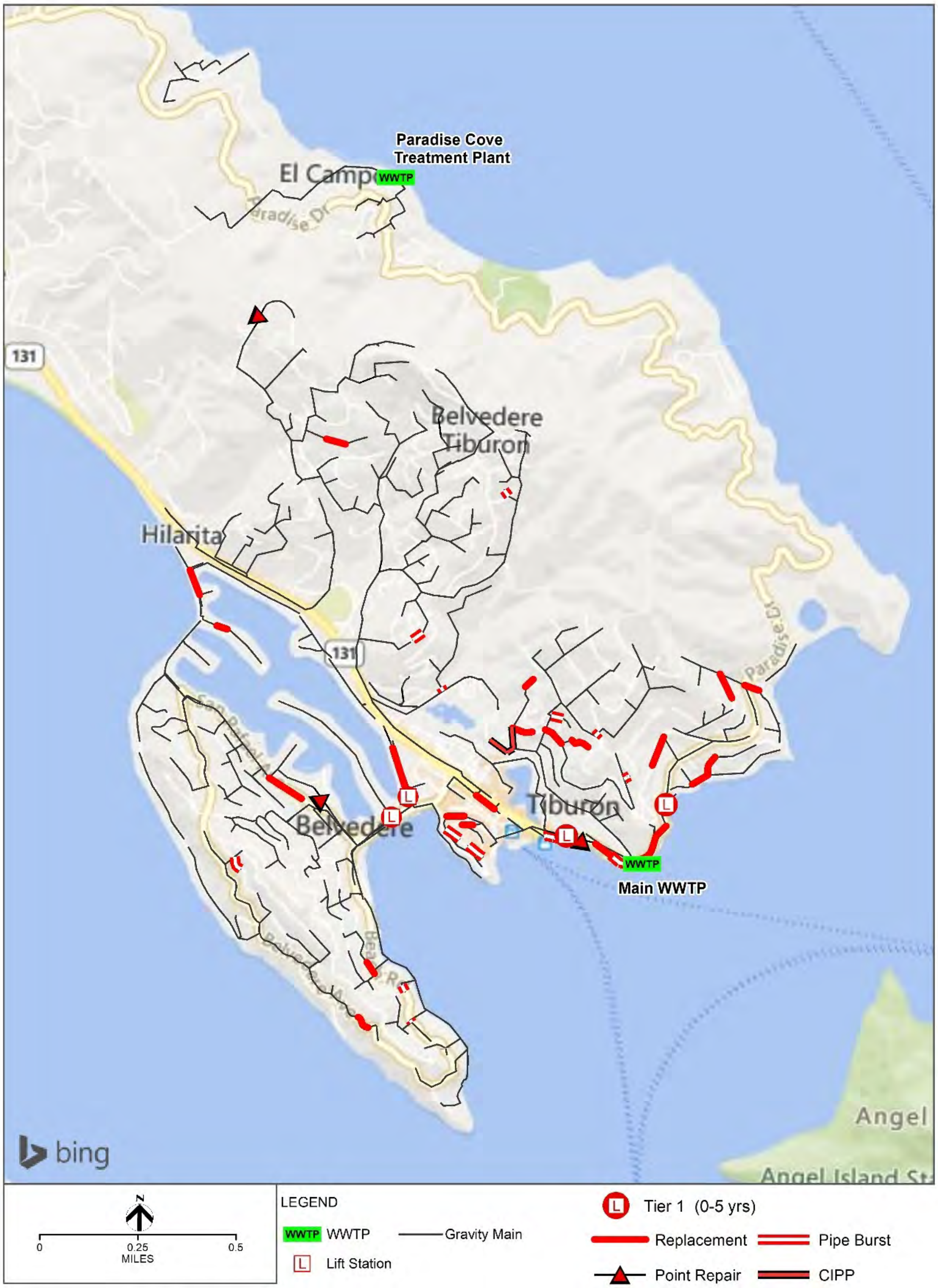


Figure 35. Near-term collection system capital plan

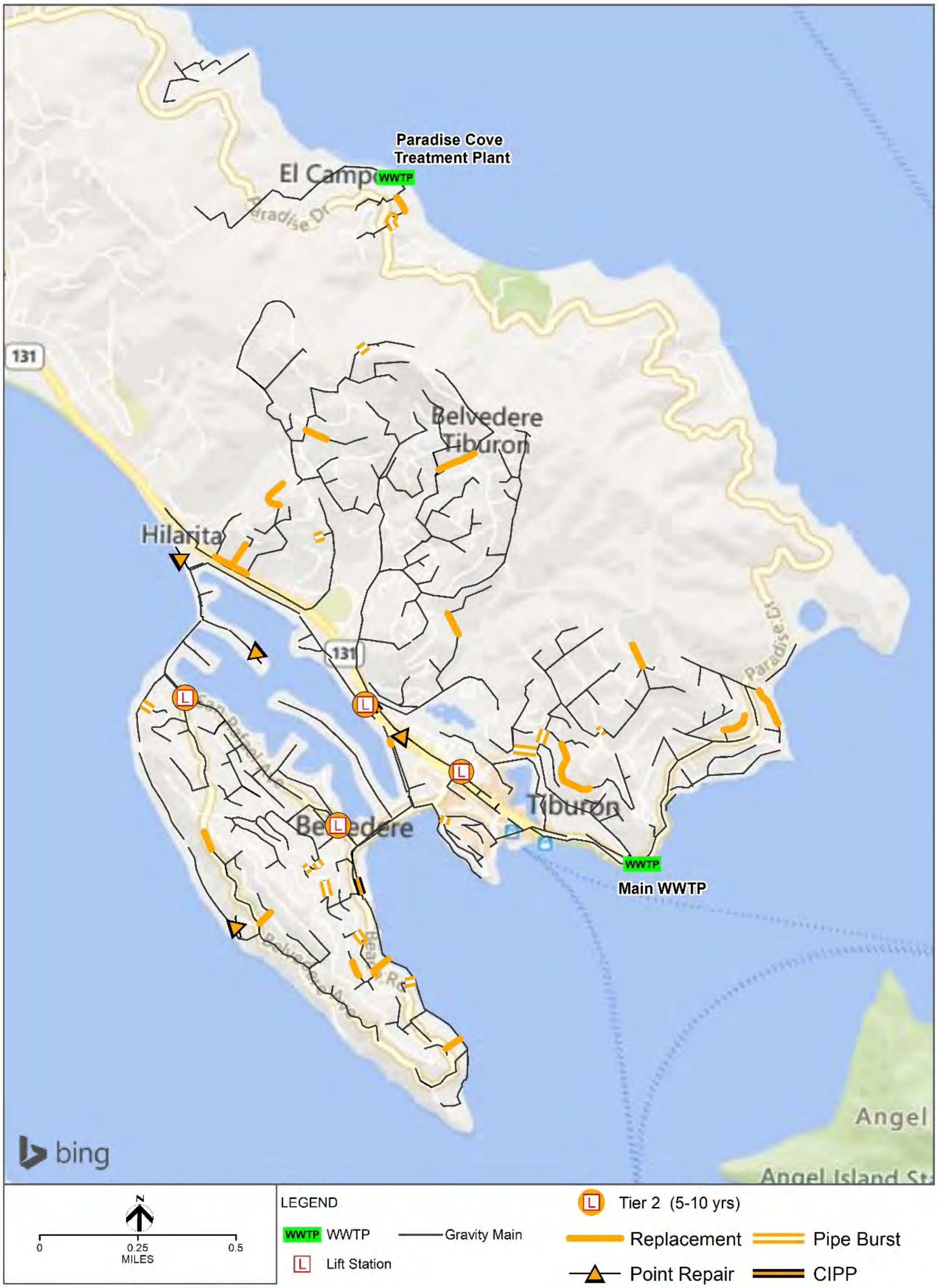


Figure 36. Mid-term collection system capital plan

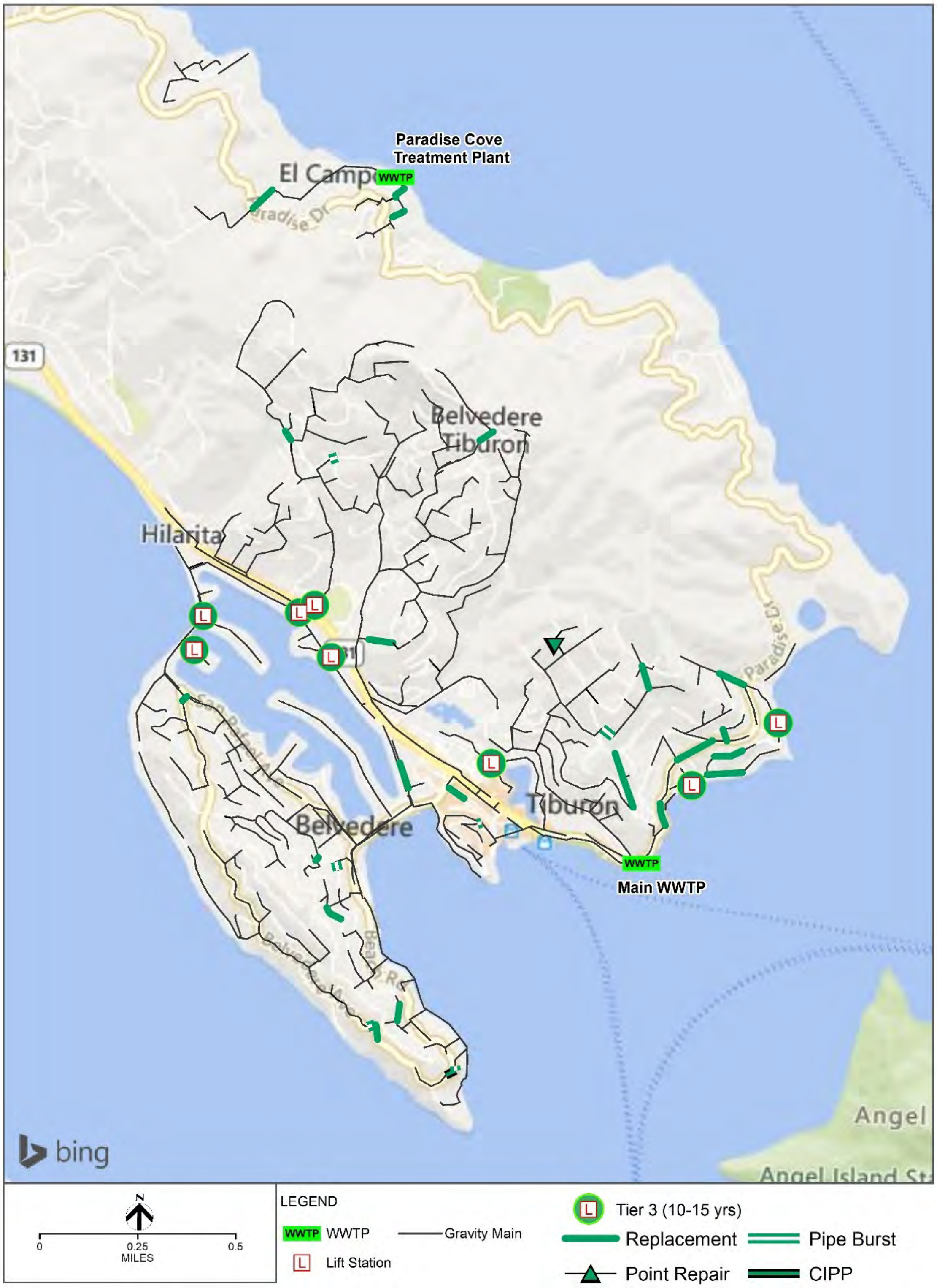


Figure 37. Long-term collection system capital plan

5.6 Additional Recommendations

Recommendations identified in this Master Plan that were not incorporated into the capital plan area summarized below.

5.6.1 Gravity Mains

The capital plan identifies specific rehabilitation and reinspection actions based on the CCTV data collected previously. In general, grade 5 defects should be addressed in the next 5 years and are incorporated into the capital plan. Grade 4 and grade 3 defects typically do not require immediate attention and therefore have been designated to be repaired between 5 and 15 years, which assumes that they will continue to degrade.

However, most of the CCTV captured for analysis is about 15 years old and therefore, it is expected that the system continued to age and degrade after the analysis was completed. ***In order to verify that these lower-grade issues have not become more urgent repairs, a degradation analysis is recommended.*** For the analysis, several pipes will be selected for another CCTV inspection. By comparing the current CCTV results with the original results, SD5 will be able to determine the amount of degradation that has occurred, which types of defects degrade the fastest, and if there are any that require urgent rehabilitation. SD5 can use this information to prioritize additional work for the remaining lower priority defects as well as more effectively plan future inspections.

There is approximately 40,000 feet of pipe in the system that has grade 4 and grade 3 defects. A degradation analysis can be performed on about 10% of these pipes, preferably selecting pipes with more than one defect. This analysis would cost between $75,000 and $100,000 to complete.

5.6.2 Inflow and Infiltration

The 2010-2011 flow monitoring study captured flow information for about 50 percent of SD5's collection system. ***A general qualitative review of the available data indicates that there may be additional areas where I&I are significant.*** From the information available in the flow monitoring study and flow data for the Main WWTP during that time period, it appears that the average daily dry weather flow from the monitored basins makes up about 50 percent of the flow to the plant, but only about 30 to 40 percent during wet weather events. For example, average flow on February 3, 2011 totaled about 0.32 MGD from the monitored basins and 0.62 MGD at the plant. This accounts for about half the flow. During a rain event on February 24, 2011, the average daily flow from the monitored area averaged about 0.51 MGD, and the average daily flow at the plant ranged from 0.69 MGD to 1.61 MGD over the following three days. This suggests that the flow contributed from the monitored areas contributed about 30 to 40 percent of the total flow to the plant instead of the expected 50 percent, therefore additional analysis is recommended. Areas to monitor may be prioritized by additional inspection of manholes and pipes that could be susceptible to surface flow or potential damage in creek channels.

General investigation for inflow reduction is recommended for Basins 1 and 7, and possibly for Basins 2, 4, and 6. SD5 may consider a variety of strategies for identifying and removing illicit connections including smoke testing, public outreach, offering of rebates, and community assistance from local organizations (e.g. Scout troops helping residence disconnect downspouts from the sewer system), and augmenting the sewer lateral inspection program to prioritize higher I&I areas.

SD5 may wish to consider other options for Peninsula Road which has the greatest issues related to I&I. Because this line has many sags and is located in the lagoon, it may become a bigger issue if additional settling occurs or sea level continues to rise. Options for addressing the line itself are varied and the most cost-effective solution depends upon the impacts of I&I, need for odor control, amount of regular and emergency maintenance required and other factors. Table 52 summarizes potential options, their advantages and disadvantages

Table 52. Summary of options to address Peninsula Road I&I

Option	Advantages	Disadvantages
Maintain the line as is	Low capital cost	Won't improve I/I. costly for maintenance.
CIPP the main line	May reduce callouts for blockages. May reduce I/I slightly.	Does not remedy the sags, will likely not reduce I/I significantly
Pipe Burst Main line	May reduce callouts for blockages. May reduce I/I slightly.	May reduce some sags. Will not improve the grade of the line.
Open cut main replacement	Sags are fixed. May reduce I/I slightly. Could improve grade of the main.	Services lines may need to be replaced because the new main may be higher in elevation. Susceptible to sagging in the future. Capital cost would be high. Excavation would be extensive.
Replace main line and services	I/I would be reduced. Sags could be fixed. Maintenance cost would be reduced	Costly for construction. Requires cooperation from property owners. Excavation is extensive.
Replace the main in the street with a vacuum sewer system.	Future settlement would not affect the system. Excavation could be minimized. I/I from the public system would be eliminated.	Need a site for the vacuum system/lift station. Capital cost would be high. I/I from private property would not be reduced. Maintenance activities would be new and require training.
Construct vacuum system and replace services	The greatest reduction in I/I. fixes the system so that future settlement does not harm the system.	Capital cost would be high. Excavation would be extensive. Private property owner support is required. Maintenance activities would be new and require training.

5.6.3 Sea Level Rise

SD5 currently experiences local impacts from the bay, storm surges, and high tides, and it is likely that these will become a greater issue in the next 20 to 30 years. It is difficult to determine how great these current impact are and therefore difficult to predict how much they significant they will be in the future. ***SD5 has done a good job of improving its lift stations to be more resilient to flooding or SLR and should continue to evaluate Tiburon lift stations PS-4 and PS-6 as they appear to be the most susceptible to current flooding and future SLR impacts.***

Over the next 10 to 15 years, it would be useful for SD5 to conduct a Sea Level Rise Vulnerability Assessment to determine how and where the most significant SLR impacts will occur. This should include further evaluation of tidal influences and the behavior of the local groundwater table to identify areas where additional I&I could be introduced. This will enable SD5 to develop system design, maintenance and emergency response plans that account for future SLR impacts.

5.6.4 Current Process Recommendations

Based on the information reviewed during development of this master plan and discussions with SD5 staff, the District has a good foundation for collecting and utilizing system data to make strategic and tactical operational decisions. The documents reviewed and data received were mostly up to date and provided a strong foundation for the analysis and development of this master plan.

The following recommendations are provided in order to streamline future analysis, efficiently leverage all information previously created by prior analyses, and avoid extra work correcting errors or filling in missing data. Note that these recommendations represent industry best practices and may already be in place but were not verified as part of this effort.

Establish data management best practices to maintain complete, accurate, and up-to-date data in SD5's enterprise data management systems (e.g. GIS and CMMS). Determine what the minimum set of data that should be maintained for all of the SD5 assets and identify the official location where that data will be managed. Develop change management procedures that trigger data updates (e.g. when a pump is replaced at a lift station, what information should be collected and where should it be stored?). Develop a quality control process to assure that the data managed is accurate and complete.

Establish document management standards to maintain source control on documents produced for the District. Documents produced should be in editable electronic format and organized in a logical filing/document management system for easy location and retrieval. The latest version of each document should be identified. Supporting data associated with the documents should be provided in electronic-database or spreadsheet format for future use. Lift station as-built drawings should also be incorporated, if available. These requirements can be incorporated into both internal and external future document deliverables.

Define data management standards for the GIS. These include standardized naming conventions, identification of required data, and data accuracy requirements. Procedures for updating data should be established(e.g. what happens to historical data when an asset is replaced or retired?). Typically, GIS manages asset information that is relatively static (e.g. asset physical characteristics, installation details, current status, etc.) and should be updated when assets are improved, replaced, or retired.

Track all maintenance activity in the CMMS. The CMMS should be the central repository of all maintenance and repair activity that is performed on the system. The CMMS should track work performed on pipes, and appurtenances, as well as on pump stations and the treatment plants. The CMMS should have a set of data management and quality control requirements to ensure accurate, up-to-date information and complete asset history. Other key activities that should be recorded in the CMMS include:

- Warranty requirements should be tracked so that they can be leveraged to replace or repair poorly performing new assets.
- Preventive maintenance should be established and scheduled through the CMMS. This will help maximize the useful life of assets and measure the effectiveness of preventive maintenance strategies.
- Record gravity main cleaning events and results in CMMS to look for trends and optimize cleaning frequencies and schedules for each pipe
- Develop a process for establishing the next inspection date for each gravity main using the gravity main rehabilitation decision logic flow chart provided in Figure 14 in this report as a guide. As CCTV results come in, determine and document needed rehabilitation, cleaning schedule adjustments, and the next scheduled inspection date in the CMMS so that there is an ongoing inspection plan for the collection system.

- Document manhole inspections during pipe cleaning or CCTV inspection activities. Manhole condition can provide key information to help identify locations that are contributing to I&I flow and where groundwater may be entering the system.
- Equipment replacement schedules can be setup based on run time, age, and/or other specific metrics. The pump station equipment information (makes, models, capacities, speeds, voltages, amps, etc.) should be entered for easy and quick reference for in kind equipment replacement.

The GIS and the CMMS should be integrated. Several CMMS and GIS systems have this capability built in; however it is also possible to develop manual processes for combining GIS and CMMS data for effective operational decision-making. If the CMMS is recording maintenance activities throughout the collection system, the GIS provides an excellent tool to see the results and to plan future work. Ideally, the field crews would be able to view the maintenance history, interact with electronic maps, and record maintenance work through mobile devices directly in the field (although this may not be cost effective for SD5 given its size and resource needs).

5.6.5 Utility Performance

SD5 is a very small utility, with a small amount of infrastructure to manage and a small staff to manage it. Because of its size, it has different challenges and different advantages than larger systems. Comparison to other utilities may not be very beneficial because of the unique characteristics of the District.

One objective measure of utility performance is comparison to the ten attributes of effectively managed utilities provided by the US Environmental Protection Agency (USEPA, 2017) . This resource provides a comprehensive framework that water and wastewater utilities can use to identify and prioritize areas to systematically evaluate and improve their performance. More details about this framework can be found in the following link:

https://www.epa.gov/sustainable-water-infrastructure/effective-utility-management-primer-water-and-wastewater-utilities

The ten attributes are shown in Figure 38 below.

Figure 38. The ten attributes of effectively managed utilities and five keys to management success (USEPA, 2017)

A complete assessment using this framework is beyond the scope of this effort, however there a few key areas that can be discussed:

Operational Optimization – Operational Optimization "Ensures ongoing, timely, cost-effective, reliable, and sustainable performance improvements in all facets of its operations in service to public health and environmental protection." (USEPA, 2017). Based on the work completed, SD5 is performing adequately in this area. One primary metric to consider is the annual SSOs performance. Over the past 10 years, SD5 has shown consistent progress in reducing both the number and volume of SSOs which demonstrates continual improvement in management of the collection system. The current performance of the utility is better than both the state and regional averages (California Environmental Protection Agency CIWQS Collection System Operational Report from 1/1/2019 to 1/1/2021).

The work coming out of this master plan can provide additional improvements in I&I mitigation. If resources and time allow, the District would benefit from additional data management procedures and specifications as described in the section above to further optimize their operations. SD5 would further improve their SSO reduction efforts through periodic or on-going adjustment of their pipe cleaning program based on the latest cleaning results (also described in the section above) if these are not being done already.

Infrastructure Strategy and Performance – Infrastructure Strategy and Performance demonstrates that the utility "Understands the condition of and costs associated with critical infrastructure assets." (USEPA, 2017). Based on the work completed, the SD5 collection system is in fairly good shape, although there are some gravity mains that scored greater than 70 out of 100 points as their relative risk score, which likely indicates that their condition should be improved. These are identified and prioritized in the CIP as part of this study. Additional condition assessment of the gravity mains should continue to be performed on an ongoing basis to identify emerging rehabilitation needs which will further improve system performance when completed. The ongoing maintenance of pump stations is very good, and the District is maximizing its investment in these assets and the knowledge base to maintain them. The recent upgrades to the electrical and I&C, emergency generators, and pumps have also addressed the critical aspects of pump station performance. Implementation of the recommendations provided in this plan should keep all the pump stations at an acceptable level of service (or better) over the next 15 years.

THE ARK

April 7, 2021 | $1.50
TIBURON · BELVEDERE · STRAWBERRY
Named California's best small community weekly
General Excellence winner, 2019 California News Publishers Association, 2018 & 2019 National Newspaper Association
Volume 49, Issue 14 | thearknewspaper.com

inside

ONLY SURVIVING PIECE OF HISTORIC WOODEN BOAT IS SITTING IN TIBURON RESIDENT'S BACKYARD
Page 5

HAWTHORNE TERRACE TAKES MAJOR STEP TOWARD START OF UTILITY-BURYING WORK
Page 8

Latina attorney picked for Diversity Task Force

By DEIRDRE McCROHAN
dmccrohan@thearknewspaper.com

Tiburon declares climate emergency, echoing state emissions, energy goals

By DEIRDRE McCROHAN
dmccrohan@thearknewspaper.com

The Tiburon Town Council has declared a climate emergency and is calling on officials to take steps toward meeting a goal of net-zero greenhouse-gas emissions and 100-percent clean electricty by 2045.

Following through with a commitment made at its March 17 meeting, councilmembers voted 4-0 March 31 to adopt a resolution declaring the emergency, joining the growing number of Marin and the Bay Area jurisdictions to set the climate goal and support actions consistent with the county and state in achieving it. Councilmember David Kulik is on leave.

The resolution commits the town to updating its environmental documents, to seeking funding needed to meet the emissions goal and commits the town to viewing every policy and action with the climate emergency in mind.

The language incorporates and acknowledges state goals, such as the 2016 mandate to reduce greenhouse-gas emissions to 40-percent below 1990 levels by 2030 and 2018 mandates for carbon neutrality and clean electricity no later than 2045.

The resolution also commits the town to educating the community on the urgency of its climate policies and strategies and to

See **CLIMATE, PAGE 20**

Climate, *continued from page 1*

providing annual progress reports on its efforts to reduce greenhouse-gas emissions.

Despite its ambition, the resolution is a largely symbolic measure meant to reinforce the town's commitment to reducing greenhouse-gas emissions and educating about the threat of climate change — though councilmembers said they have made it as "actionable" as possible.

Mayor Holli Thier brought the issue to the council, encouraged by environmental activists in Marin. A number of other communities in Marin have already adopted their own versions, including Novato in November.

Tiburon first adopted a Climate Action Plan in 2011 and has since implemented a wide range of measures to reduce greenhouse-gas emissions, according to Tiburon Town Manager Greg Chanis.

Those include installing solar panels on Town Hall and Tiburon Police Department facilities, converting about 125 streetlights to energy-saving LED fixtures and purchasing four electric cars and two hybrid cars for the town fleet.

The town has also enrolled in Marin Clean Energy's deep-green electricity program, which purchases 100 percent of its electricity from renewable sources and adopted Tier 1 provisions included in the California Green Building Standards Code, which are more stringent than the energy-saving provisions mandated by the state.

The town was able to reduce greenhouse-gas emissions to 26 percent below 2005 levels by 2018, beating the state's goal of 15 percent by 2020.

"A climate-emergency resolution will reinforce the town's commitment to reduce greenhouse-gas emissions and to educate the community about a climate emergency," Chanis wrote in his report prepared for the council.

He said the resolution may also serve to reinforce the town's greenhouse-gas reduction goals, which are laid out in the town's existing Climate Action Plan and General Plan.

Both of those documents are in the process of being updated.

Adoption of a climate resolution had been part of plans for Tiburon's commemoration of the 50th anniversary of Earth Day in April 2020, said Councilmember Alice Fredericks, but those plans — which included celebratory events — were canceled due to the coronavirus pandemic.

In the weeks leading up to the March 17 discussion, the town received 29 letters from members of the public urging support for the resolution, many of them from outside Tiburon. This time, the correspondence had dwindled, likely because the council had already committed to adopting the resolution in some form.

Renowned environmentalist Martin Griffin of Belvedere was among those to add his voice.

"Today we are facing a climate crisis that threatens the natural world and entire human community," he said by email. "We are in a state of emergency that calls for a comprehensive top-to-bottom, whole-society response. … The climate crisis is accelerating and so must our policies and actions. We now must move at emergency speed, scale and scope if we hope to avert climate catastrophe."

Carolyn Rice Losee of Tiburon, who wrote letters and spoke at the first hearing, asked councilmembers to "be bold in your actions" in urging them to adopt the resolution.

Tiburon resident Tom Cote said he was "delighted to see this issue being addressed."

"I have two adult children and three grandchildren. As I turn into my last lap, I think about them," he said. "We're an influential community and can influence others. Adopting the climate-emergency resolution can serve as a hallmark of leading by example."

In her March 31 email, sent less than an hour before the meeting, Sanna Thomas of Paradise Cay urged the council to add language to the resolution elevating climate issues "to the highest priority" rather than a "high" priority.

During deliberations, Fredericks gently pushed back.

"We need to pass the climate-emergency resolution, but we need to balance it with reality," she said, explaining the recommendation of the sustainability committee.

She said Tiburon is constrained by what "bigger systems" are doing, such as waste, recycling and electrical-grid systems. Some housing bills being proposed for the state legislature take climate considerations off the table when they conflict with housing needs, she noted.

Vice Mayor Jon Welner said he was "delighted" by the resolution.

"We don't say it enough. … I'm very afraid of what is happening to our planet, and I fear for my children," he said.

Councilmember Jack Ryan said he agreed with his fellow councilmembers. "I am excited to support it. … This is not a watered-down throwaway resolution."

Thier suggested a change that would align the town's climate-action plan with that of the county, but Fredericks and Welner noted similar language was already in the resolution and they were trying to reduce redundancies.

"We're trying to make this as actionable as possible," Welner said.

Deirdre McCrohan has reported on Tiburon local government and community issues for more than 30 years. Reach her at 415-944-4634.

Item #12: Agenda – Notes of Explanation

Sanitary District No. 5 Regular Board Meeting

April 15, 2021

Review and discuss total project cost and project time duration on the Cove Road Force Main Project, cost breakdown per zone and related discussion of contract terms on capital projects, administration of capital projects, use of consultants, and selection of consultants, oversight over contractors and consultants, and cost and time overruns

STAFF REPORT:

The Cove Road Force Main Project is now complete. The District began the work on this project back in 2016 when we approved the Cove Road Force Main Condition Assessment and Rehabilitation Options Investigation report. At the time of that report in 2016, the estimated construction cost was $1,125,000. In the summer of 2018, a contractor working for Comcast, bored through the force main on Juanita Ln requiring an emergency repair which further identified the condition of the force main. In late 2018 the District moved forward with authorizing Nute Engineers to begin the design work for the Cove Road Force Main Project. The Design work took longer than expected due to difficulties working with Caltrans and getting approvals for the proper design for work in there right of way – the final design was finally accepted in late 2019. The Project then went out to bid in April of 2020. The engineers estimate upon the completion of the final design was for $1,902,385 which included a 15% construction contingency of $285,358 bringing the total estimated project estimate to $2,187,743. On May 19, 2020 the District received a total of 5 Bids. The low bid for the project was from Maggiora & Ghilotti for $1,971,971 and a CDF alternative bid item of $270,000 bringing the total construction bid amount to $2,241,971. On May 19, 2020 the District accepted the Low Bid from M&G and authorized the District Manager to issue a notice to proceed.

Pre-Construction Fact Summary:

- Total Construction Cost Bid Amount: $2,241,971
- Total Contract Time: 90 days
- Notice to proceed issued: July 27, 2020

Pre-Construction Engineering Fact Summary:

- 2016 Condition Assessment and Options Report: $27,990
- 2018 Cove Road FM Project Design: $85,000
- 2020 Cove Road FM Construction Management Services and Inspection: $141,587
    1. *Construction Management: $57,231*
    2. *Inspection Services: $84,356*

STAFF REPORT CONTINUES:

The initial construction work started at the Cove Road Pump Station location with the plan of moving towards the terminus point on Paradise Drive neat the round about. At the very beginning of the project we encountered changed conditions that required a quick decision to continue the project without delay. That was approving a time and material change order for work to get the force main lower to clear a water line that was deeper than shown on the plans as well as working around many unmarked utilities that turned out to be abandoned services. Lowering the depth of the Force Main also led to increased groundwater management. Groundwater was expected but lowering the depth of the force main led to increased ground water and additional shoring requirements. These requirements continued through until we got to the Tiburon service area. Work in the Tiburon service area was fairly straight forward until we reached Tiburon Blvd (Caltrans Right of Way) The District submitted a change of design to the project with Caltrans in order to eliminate what was looking to be an impossible installation of a casing around the force main in the Caltrans right of way. As this request was in for review the contractor began working from the terminus point back towards the Caltrans right of way. Changed conditions were encountered in the round about area (large rip rap and creosote pilings that required special handling) As this work was being completed, the District received approval from Caltrans for the changed design which led to a contract savings with the Contractor. As work progressed towards Juanita Ln, the contractor noted a leaking MMWD water line. MMWD was notified and planned to replace the valve prior to the contractor back filling the trench. MMWD replaced their valve and the contractor completed the installation of the 14" HDPE Cove Road Force Main Sewer Line. Work then moved towards the Beach and Tiburon Blvd intersection for the installation of the bypass 6" sewer force main serving Tiburon Pump Station #6. This work was straightforward as the size of the line and depth made the installation simple work. On February 23, 2021 the contractor was substantially complete with the project. The force mains were installed and tested and ready for operation. Daily inspections were performed on this project. Construction inspections was performed by Karen Cheu, Mark Wilson and Myself. The project had a total of 15 Change Orders. Three (3) of which were change orders that resulted in a credit (-$247,762.06). Total change order amount minus the credit is $306,414.63. Final Paving was completed on March 19, 2021. There was several days delay on paving due to the District submitting a potential change in paving to Caltrans for additional cost savings- this request was denied after a 7 day Caltrans review and response. The District also had to work with the Town of Tiburon to establish the final paving boundaries per their restoration standards and at the same time we were also trying to accommodate the final paving at Juanita Ln by the New Morning Café. The town was cooperative with the District and requested additional paving on Beach Blvd to restore a section of the there lane along with the replacement of the signal loops which they agreed to contribute half the cost. In total the District will be Invoicing the Town of Tiburon for $22,992.50 for work that was done for the Towns benefit.

<u>Total Construction Fact Summary:</u>

- Approved to date contract end date (substantially complete) = February 20, 2021. Contractor substantially complete on February 23, 2021.

1. Total Completed Construction Costs: $2,278,382.63
   Total Construction Bid Amount $2,241,971.00
   Amount Over Approved Contract: + $36,411.60
   Reimbursement amount from Town: -$22,992.50
   Total SD5 Construction amount: $2,264,963.50 (+$13,419.10 over) 1% incr.

2. 106 Total Calendar Days added to contract
   96 Total Change Order approved days (of these 96- 18 days were Caltrans related delays)
   10 Weather Days

3. Cost allocation per zone: Estimated at 61% Belvedere 39% Tiburon at beginning of project (Total actual split per zone on total is 63% Belvedere and 37% Tiburon

   Belvedere: Total cost is $1,427,502.70 (100% Belvedere @ $601,278.43 and 61% @ $826,224.32)

   Tiburon: Total cost is $837,460.8 (100% Tiburon @ $309,219 and 39% @ $528,241.8)


CAT


UNITED STATES POSTAL SERVICE

STAFF REPORT CONTINUES:

In summary, the project was successful as the project was completed without any disruption to sewer service for the City of Belvedere or the Town of Tiburon. Staff was able to accommodate the groundwater from this project without compromising the treatment plant operations and the biggest accomplishment is that the existing force main was able to remain in service the entire time without disruption. The old existing line is now located and will be included on the as built drawings for future location markings. The need for bypass pumping was not needed as result of careful construction and good planning. The negatives of the project was the work in the Belvedere Zone near the pump station where changed conditions mandated changes to the contract in terms of time and cost increases. We could have avoided this had we spent more time and effort potholing in this location prior to bid time, but because we did not know the location of the existing force main we opted not to pursuit that work until we had a contract in place. We did not want to risk damage to the existing force main. Based off my daily observations, the contractor was diligent in getting the project completed per the terms of the contract, two crews were out at several junctions of the project when it was feasible. (Juanita Ln, the Vault Construction and Belvedere Paving). This project is the largest underground project the District has performed in over 60+ years. Couple that with the fact that it was performed during the middle of a Covid-19 pandemic, I would say the project was pretty successful.

FISCAL IMPACT:

$2,264,963.50 Total SD5 Construction Costs

CEQA (California Environmental Quality Act)

Exempt

Recommendation:

Will be to approve and accept the project as completed and final once we receive the final approved progress billing from the contractor. Final progress billing will be ready for approval at the soon to be scheduled Budget Workshop.

Tony Rubio, District Manager ______________________________

ATTACHMENT:

DECISION/ACTION ITEM LOG
CIP Committee: April 13, 2021
Sanitary District No. 5 of Marin County
ACTIVE ITEMS SHEET

No.	Item	Submission Date	Responsible Party	DECISION ONLY Due / Completed		ACTION REQUIRED Due / Completed		Comment/Reference Document
29	Cove Rd. Force Main Replacement Project	3.12.19	Nute/TR/CIP					Nute Preparing Bid Docs, as of 3.12.19; Waiting for CalTrans response re horizontal drilling, as of 5.14.19; Still working w/ CalTrans, waiting for approval, as of 11.12.19; Design Review from Nute, 12.10.19, 1.14.19, 2.11.20; Received Caltrans Permit, 3.9.2020; Notice for Sealed Bid @ Marin IJ on 4.28.2020 w/ Bids due 5.19.2020; Posted RFP at SD5 Wesbite, (http://www.sani5.org/about/contracts-proposals-bidding), 5.5.2020; Project granted to Maggiora & Ghilotti, Inc.; Work to begin on 7.27.2020; Job well underway and progressing smoothly, as of 10.13.2020; ~~Job is 70% complete, as of 11.10.2020; Job is 95% complete, as of 2.9.2021;~~ **Project substantially completed as of 2.25.2021;**
31	FY2020-2021 Sewer Rehab Project		CIP/TR					Small project for Paradise Cove; Enginnering to begin in ~~Dec 2020, as of 7.14.2020; Jan 2021, as of 12.8.2020;~~ **Will begin once SD5 Collection System Master Plan is in place, as of April 13, 2021**
32	SD5 Collection Sytsem Master Plan		CIP/TR					Posted RFP at SD5 Wesbite, (http://www.sani5.org/about/contracts-proposals-bidding), 5.5.2020; Revised RFP from HDR, as of 7.14.2020; ~~Underway, as of 11.10.2020; CIP asking final questions.tweaking reports, etc., as of 2.9.2021;~~ **Presenting Final Draft @ 4.15.2021 Regular Board Mtg**