Brown AND Caldwell

701 Pike Street, Suite 1300
Seattle, WA 98101-2310

T: 206.624.0100

Technical Memorandum

Prepared for: Daly City

Project Title: Wastewater System Hydraulic Modeling Services

Project No.: 169886

Technical Memorandum 1

Subject: Wastewater Collection System Evaluation: 455 Hickey Boulevard

Date: July 7, 2023

To: Alex Yuen, Daly City, Engineer II

From: Kevin Kai, Brown and Caldwell Project Manager
Daniel Shapiro, Brown and Caldwell Senior Staff Engineer

Prepared by: ______________________
Daniel Shapiro, P.E. *

Reviewed by: ______________________
Kevin Kai, P.E., Project Manager

REGISTERED PROFESSIONAL ENGINEER — FAN KAI — No. C-60024 — CIVIL — STATE OF CALIFORNIA

Digitally signed by KKai@BrwnCald.com
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**Professionally registered in another State.*

Limitations:

This document was prepared solely for the City of Daly City in accordance with professional standards at the time the services were performed and in accordance with the contract between the City of Daly City and Brown and Caldwell dated October 26, 2022. This document is governed by the specific scope of work authorized by the City of Daly City; it is not intended to be relied upon by any other party except for regulatory authorities contemplated by the scope of work. We have relied on information or instructions provided by the City of Daly City and other parties and, unless otherwise expressly indicated, have made no independent investigation as to the validity, completeness, or accuracy of such information.

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Executive Summary and Results

The City of Daly City (Daly City) requested Brown and Caldwell (BC) to evaluate a proposed development at 455 Hickey Boulevard, in Daly City, California, as described in the document prepared by BKF Engineers (BKF). This Technical Memorandum 1 (TM) describes the model development and analysis completed by BC.

The BKF TM, included in Attachment A, outlined two possible development scenarios with different proposed sewage generation quantities. BC's analysis considers only Scenario 1 because the sewer demands associated with this scenario were higher.

Table 1 presents the proposed sewage generation demands for both development scenarios. Figure 1 shows the pattern of flow leaving the Hickey site.

Table 1. Proposed Sewage Generation

Building Type	Total Floor Area (gsf)	Factor (gpd/sf)	Flow (gpd)
Medical Office Building (Development Scenario 1)	180,000	0.25	45,000
Tech Office Building (Development Scenario 2)	280,000	0.10	28,000

Table abbreviations:

gsf = gross square feet

gpd/sf = gallons per day per square foot

gpd = gallons per day

The analysis concluded that, while surcharging occurs within the system in both the existing and proposed scenarios, the increase in surcharging is minimal (approximately 3 inches at the tie-in location); 5 feet of freeboard from the surface will be maintained, as required by current Daly City design standards. City staff noted there have been no issues of surcharging documented in this area. Flows occurring downstream at the I-280 crossing increased minimally, as did total hydraulic grade line (HGL) elevations, as shown in Table 2.

Table 2. Results Summary

Flow Condition	455 Hickey Tie-in Location		I-280 Crossing	
	Max. HGL (elevation, ft)	Max. Flow (mgd)	Max. HGL (elevation, ft)	Max. Flow (mgd)
EX-Dry	360.32	1.25	262.74	3.98
PR-Dry	360.34	1.34	262.75	4.09
EX-Wet	363.21	4.56	263.33	8.10
PR-Wet	363.67	4.65	263.33	8.10

Table abbreviations:

mgd = million gallons per day

EX = existing scenario

PR = proposed scenario with development

Figure 2 is a vicinity map showing location indicators for the two areas analyzed in this TM and Figure 3 provides an overview of the proposed layout. Figures 4 through 7 provide profiles of the proposed tie-in from the 455 Hickey Blvd. property. Figure 8 shows the plan view of the I-280 crossing. Figures 9 through 12 illustrate changes in HGL elevations. The Daly City Department of Water and Wastewater Resources (DWWR)

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indicated that projects upstream of the deficient I-280 sewer crossing will be required to share costs in the upgrading of the crossing at a rate to be determined based on a specific project's flow contributions.

Section 1: Model Input

The following sections summarize the existing sewer network and provide information on the process used to complete model updates.

1.1 Sewer Network

In August of 2022, BC updated the collection system model for City's 10-year Wastewater System Master Plan (Master Plan). This updated model was used to analyze the proposed development at 455 Hickey Blvd. For more on the foundations of this model please see Section 3 of the Master Plan included as Attachment B to this TM.

Updates to the Sewer Network: To model the proposed development, initial design plans were georeferenced in Esri's ArcGIS Pro to determine the location of proposed sanitary sewer manholes (SSMH) as well as the layout for the relocated existing sewer line. The project proposes moving the existing sewer line slightly to the east, closer to the parcel boundary. The proposed reroute begins at existing manhole MH-D11-006 and reconnects at manhole MH-D11-060 (shown in green in Figure 3).

All flows from the 455 Hickey site will discharge to a new line along Hickey Blvd. via a private pump station and force main from building's basement to the existing sewer system. Neither the pump station within the building nor the force main were modeled; the modeling effort began where gravity flow occurs at the terminus of the force main. See Figure 3 for an overview of the proposed layout.

1.2 Sewer Loads

Flows developed for the Master Plan modeling efforts were used for the dry-weather run. These same base flows were used in addition to the 5-year, 4-hour design storm to simulate wet-weather conditions, which is consistent with City design standards.

To account for the new development, a single subcatchment was added to the model with an average flow equaling 45,000 gallons per day. Next, a contrived diurnal pattern was applied to this average flow which assumed flow was limited to the working hours of the building, between 7 a.m. and 6 p.m.. This was considered a conservative approach to modeling flows from the site, as opposed to averaging flows out over 24 hours.

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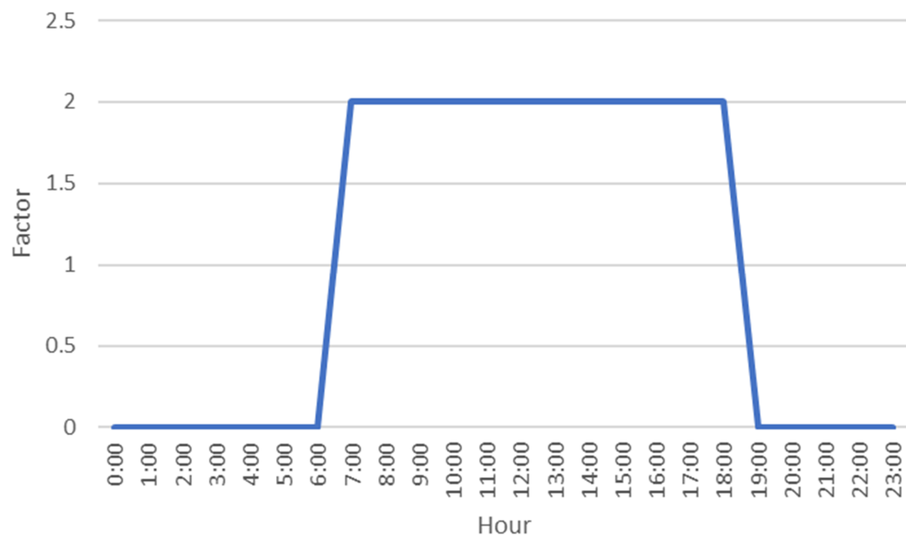

Figure 1. Diurnal pattern applied to the flow leaving 455 Hickey Blvd.

Section 2: Model Results

As shown in Table 2, the proposed development will have minimal impact on the system. In terms of percentages, the development represents an increase of 7.2 percent of the existing dry-weather peak at the tie-in location, which falls to 2.8 percent during the wet-weather scenario. When the system is analyzed further downstream, increases in flow and HGL are virtually unnoticeable, with increases below a fraction of a percent.

While the model predicts surcharging, the required 5 feet of freeboard to the ground surface is still available. In addition to meeting this City design requirement, City staff indicated that neither sanitary sewer overflows (SSOs) nor backups have ever occurred at this location. The I-280 crossing was previously identified as deficient and is currently scheduled to be upsized. The Daly City DWWR indicated that projects upstream of the deficient I-280 sewer crossing will be required to share costs in the upgrading of the crossing at a rate to be determined based on a specific project's flow contributions.

See Figures 4 through 7 and 9 through 12 for the resulting hydraulic profiles from the existing and proposed conditions, both at the tie-in location and at the I-280 crossing, where the blue lines indicate the HGL, and the red lines indicate the energy grade line.

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Figure 2. Project vicinity map

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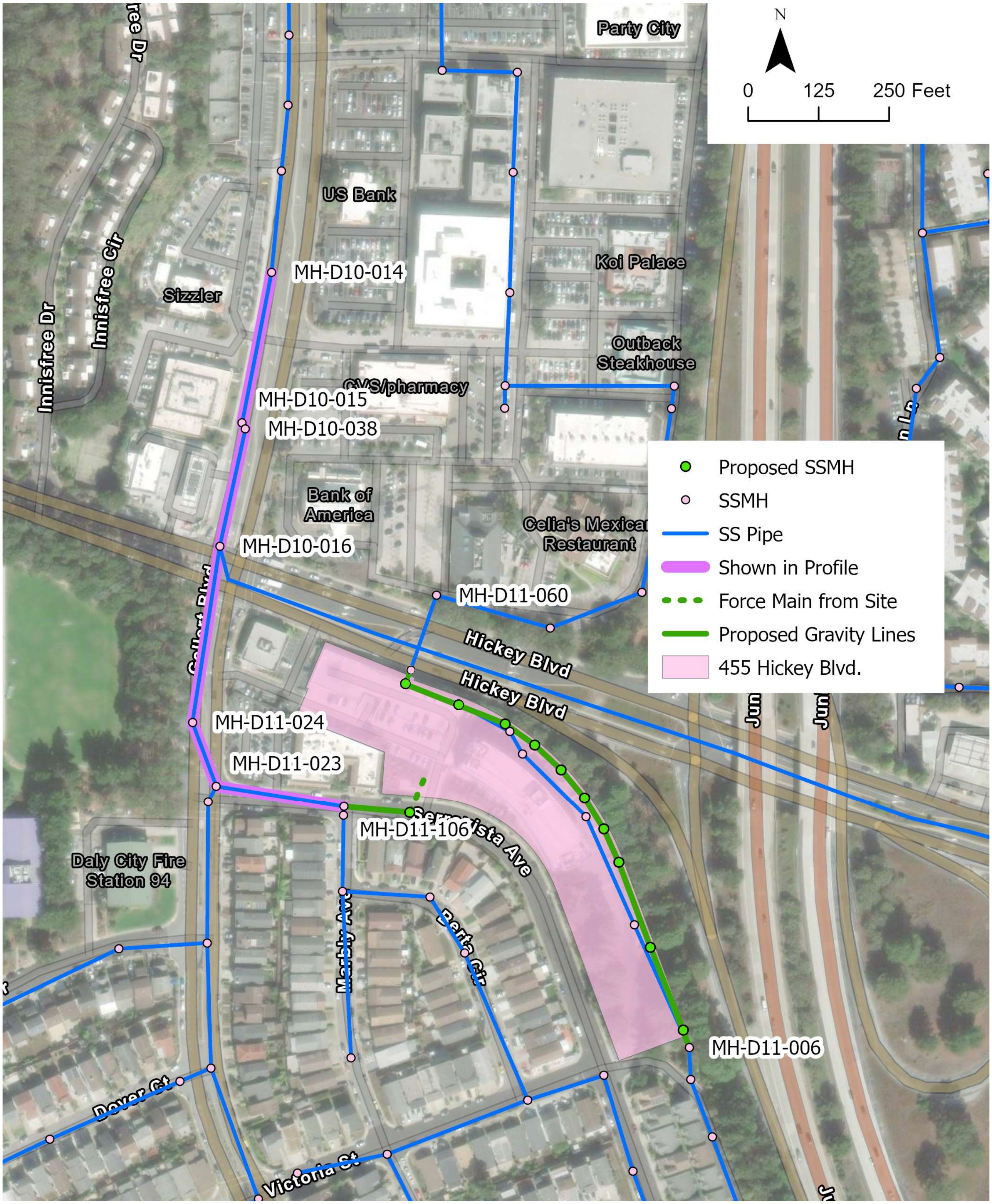

Figure 3. 455 Hickey Blvd. and the surrounding wastewater collection system

Brown AND Caldwell

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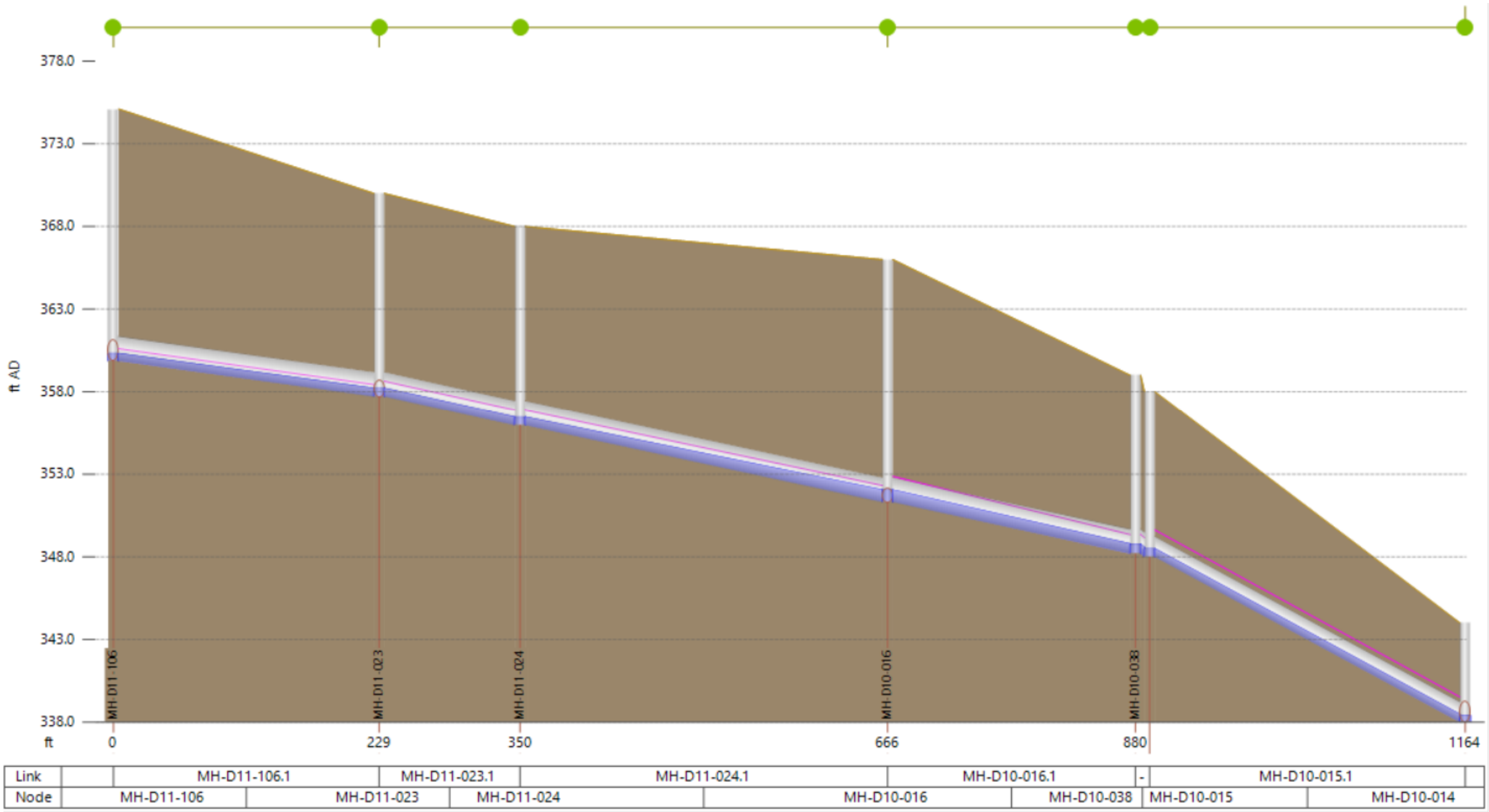

Figure 4. Hickey–Serramonte profile, existing, dry-weather

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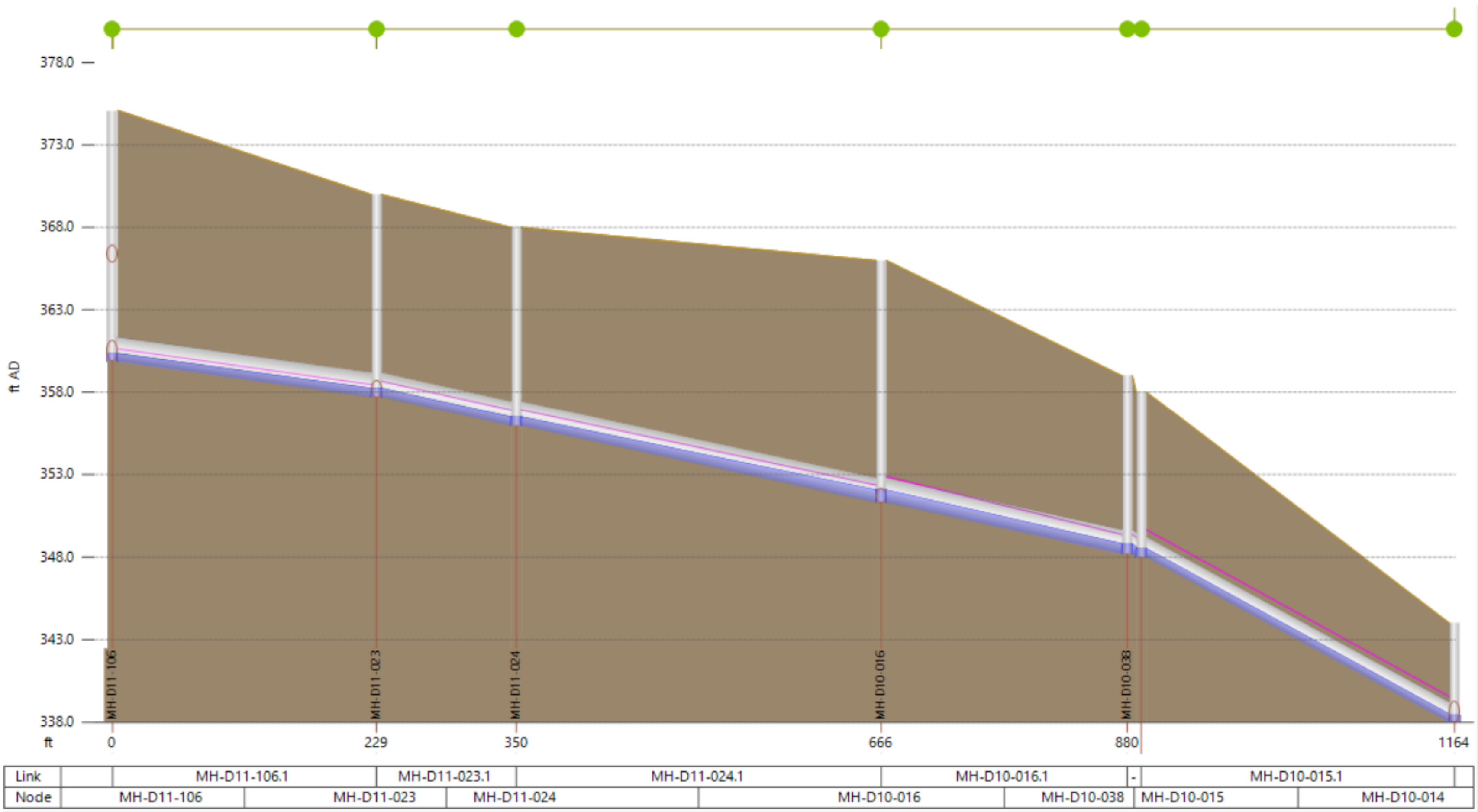

Figure 5. Hickey–Serramonte profile, proposed, dry-weather

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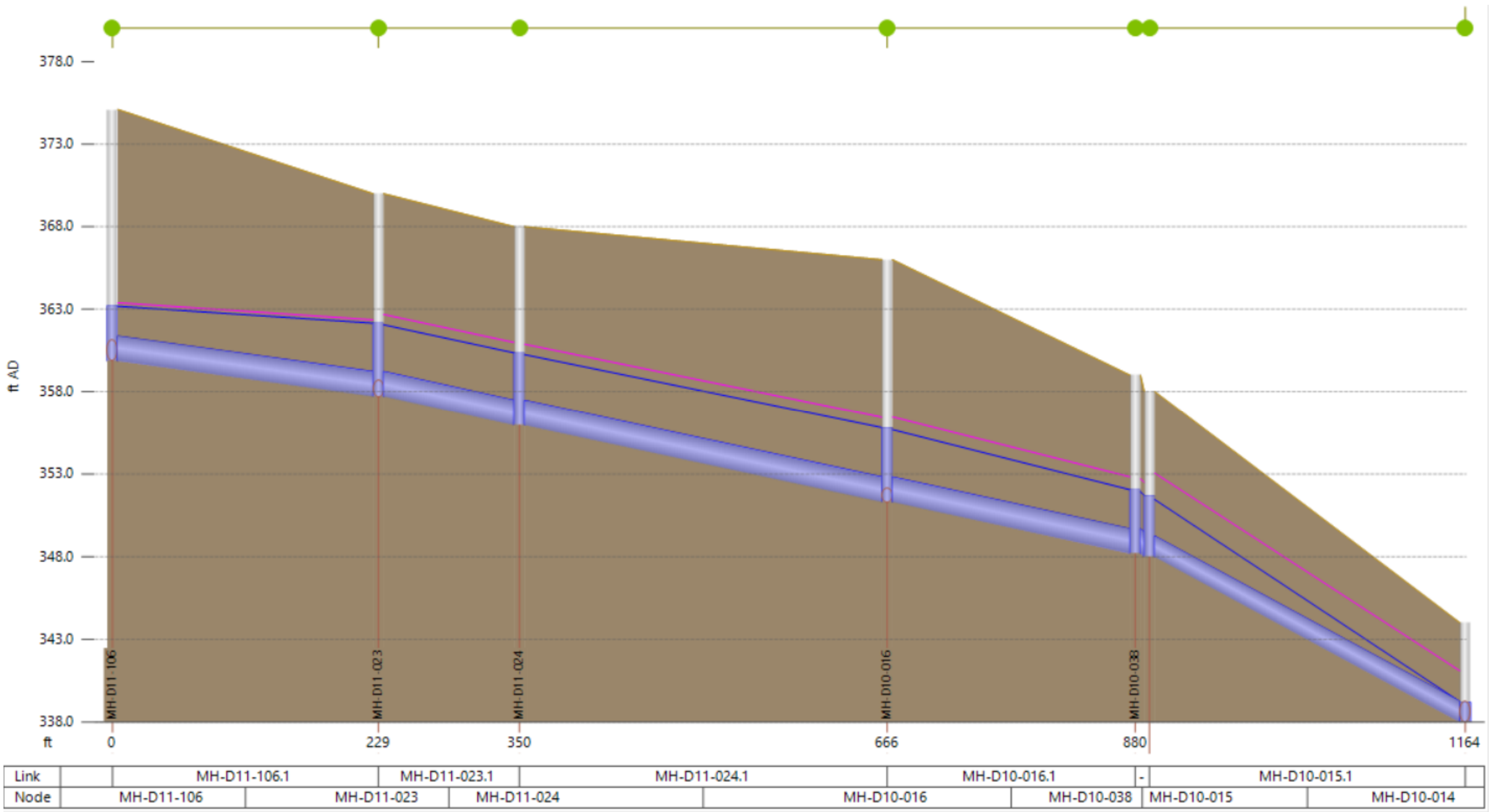

Figure 6. Hickey–Serramonte profile, existing, wet-weather

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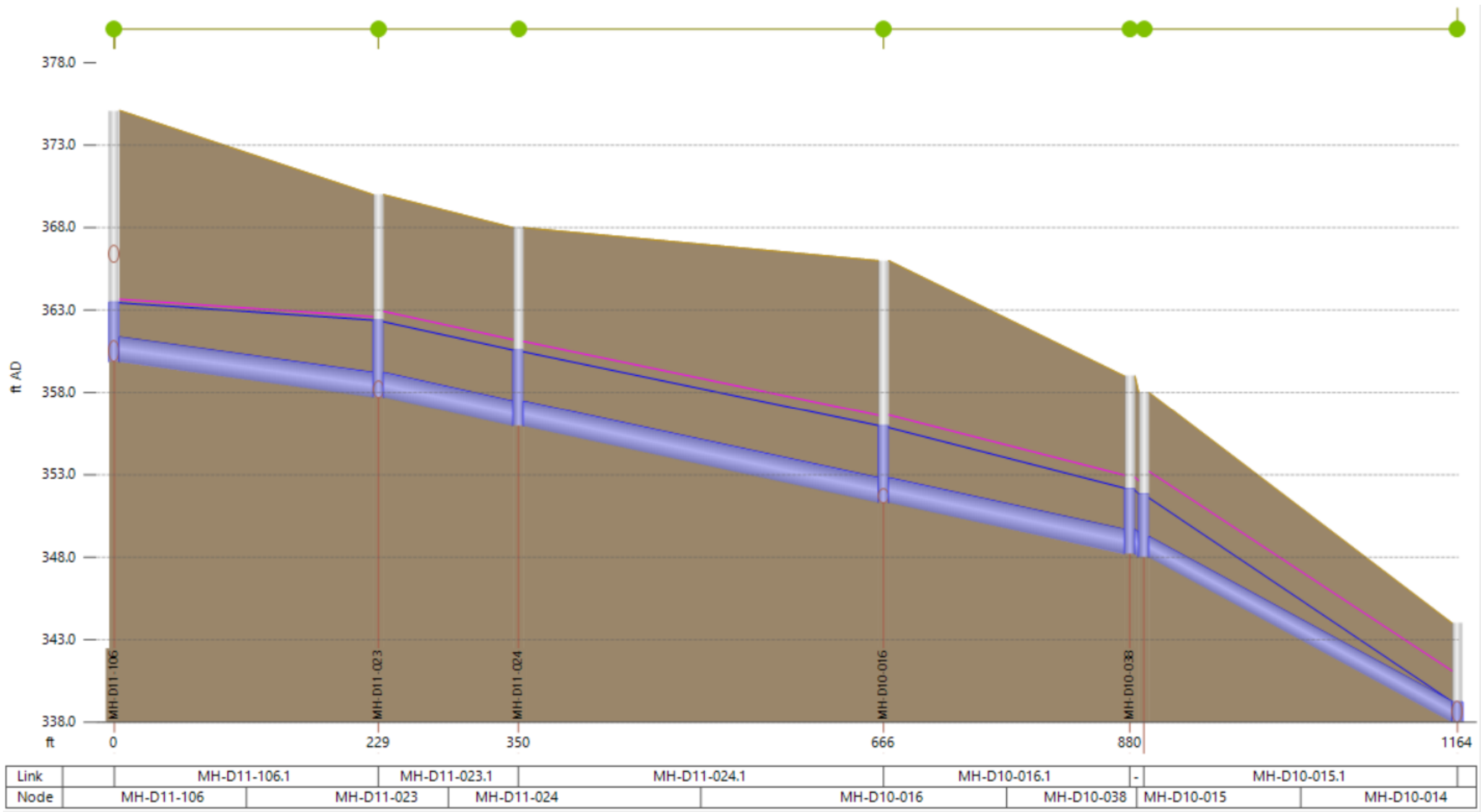

Figure 7. Hickey–Serramonte profile, proposed, wet-weather

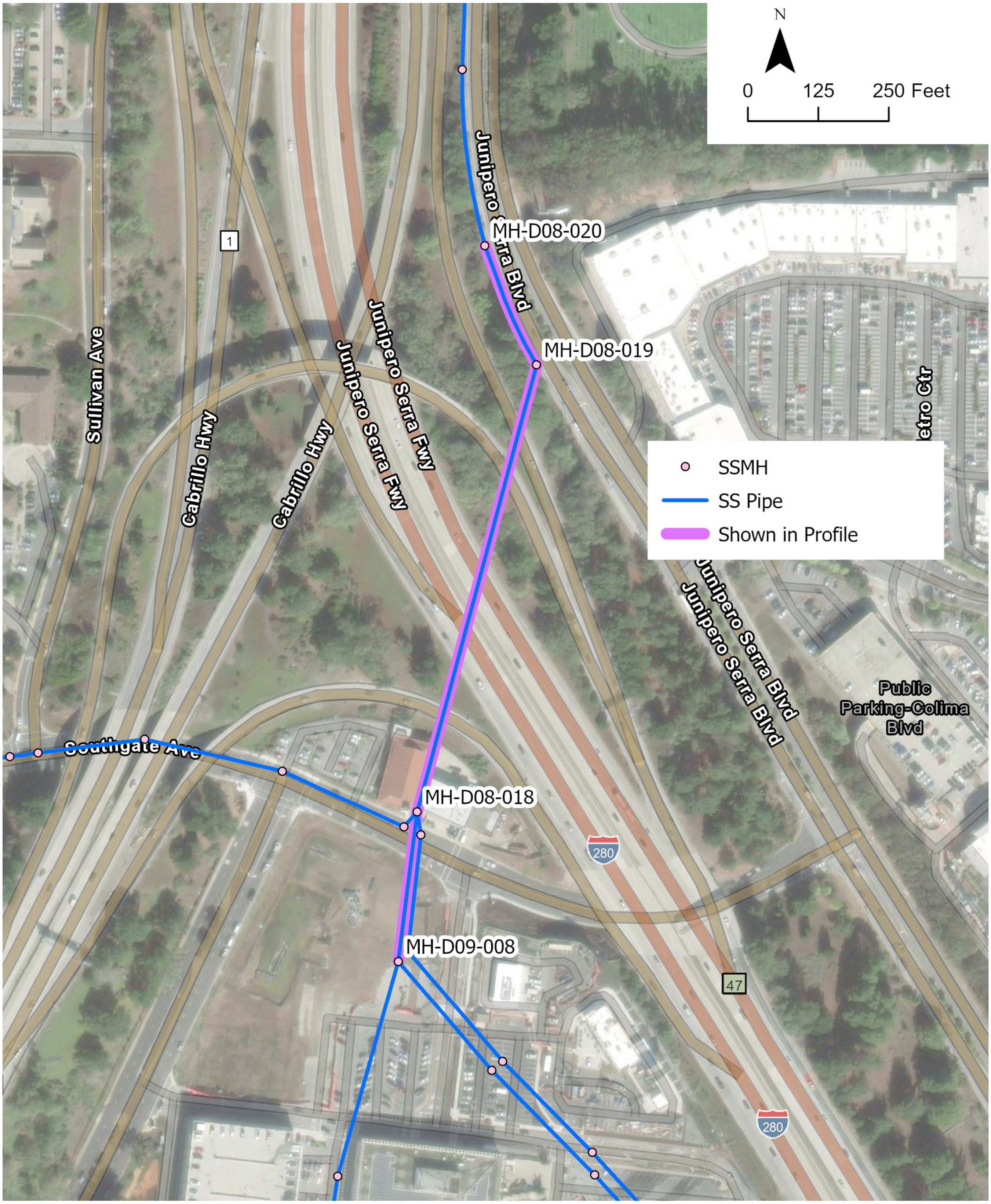

Figure 8. I-280 plan view

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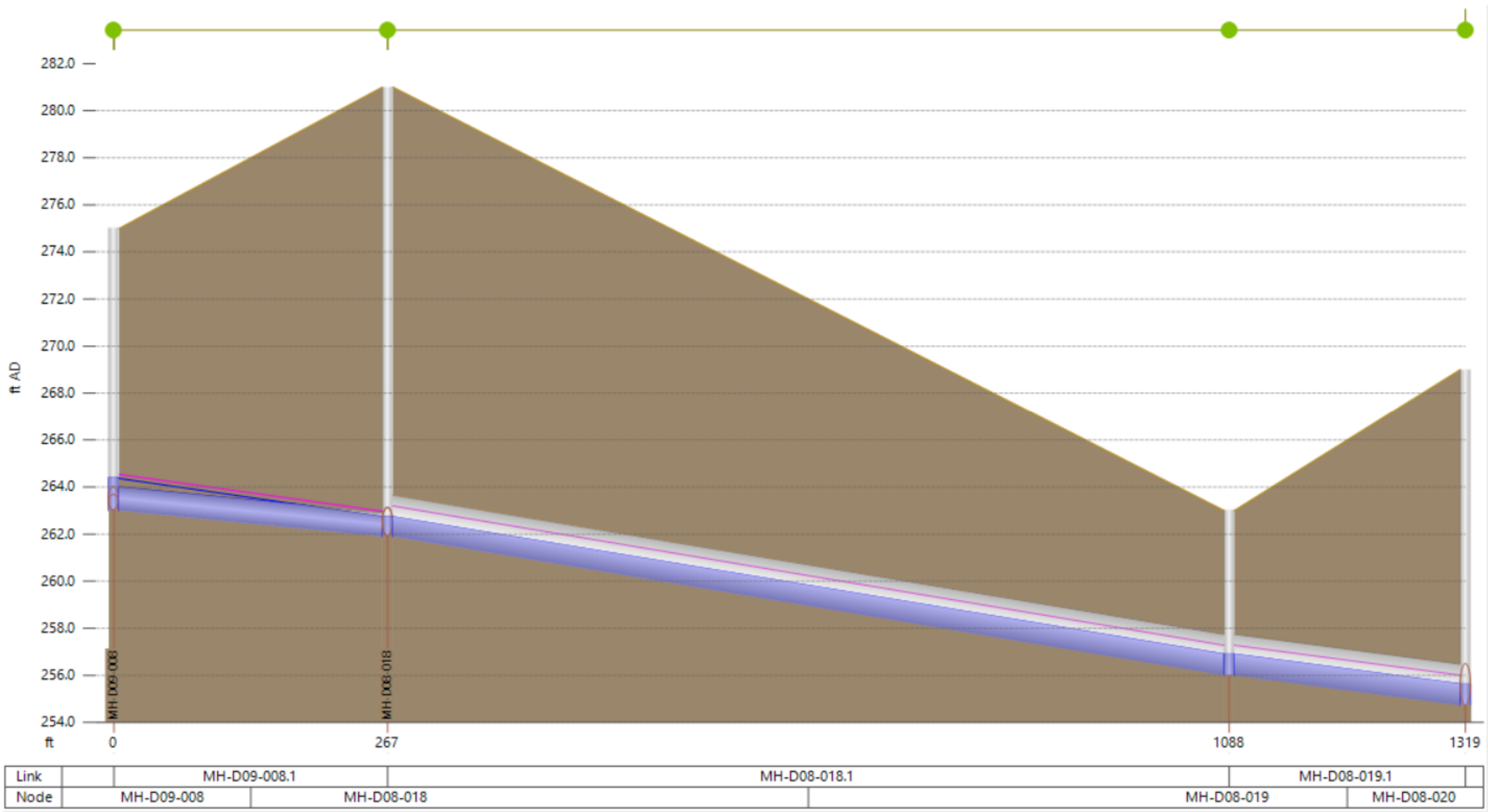

Figure 9. I-280 profile, existing, dry-weather

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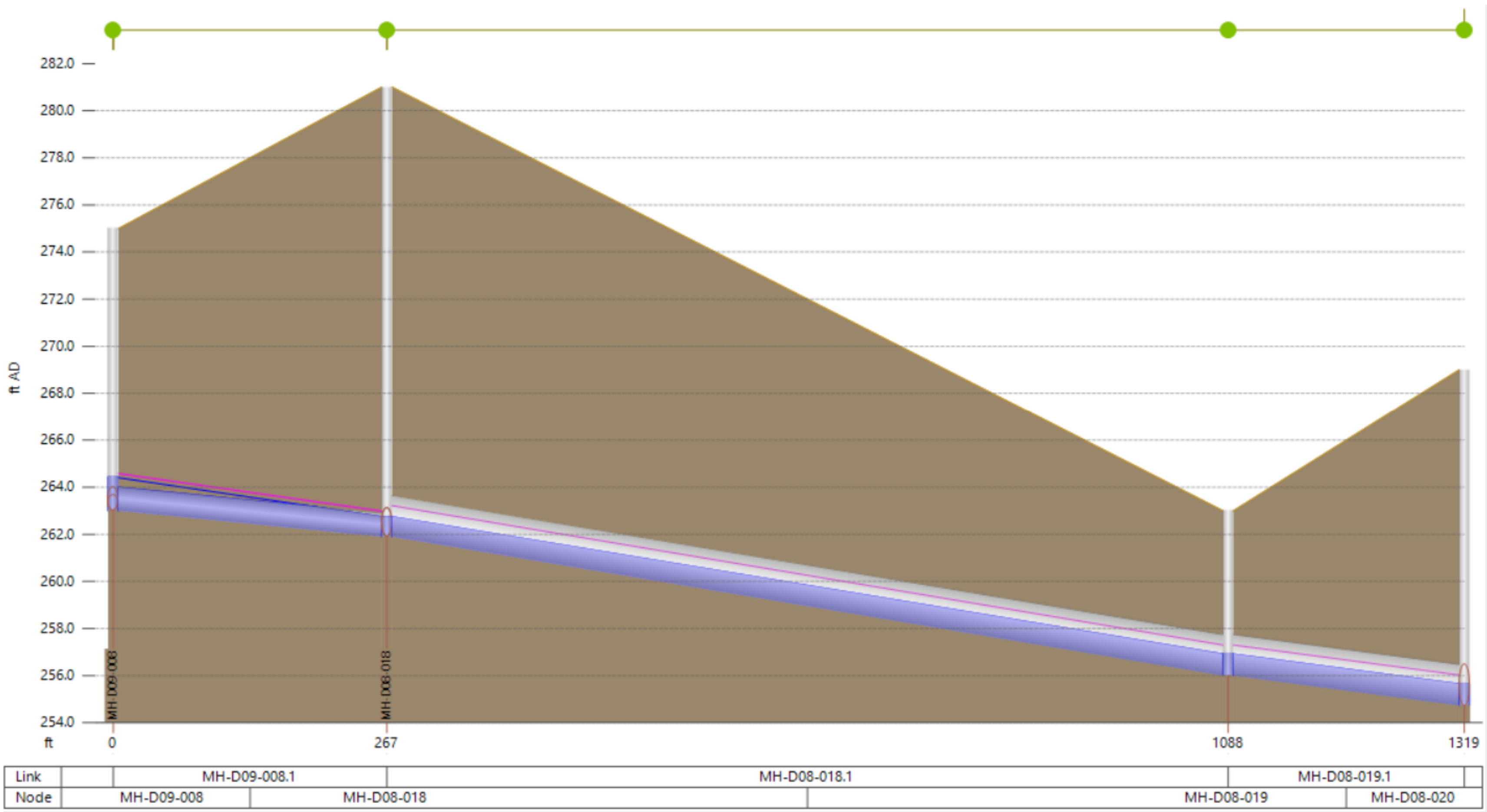

Figure 10. Hickey–I-280 profile, proposed, dry-weather

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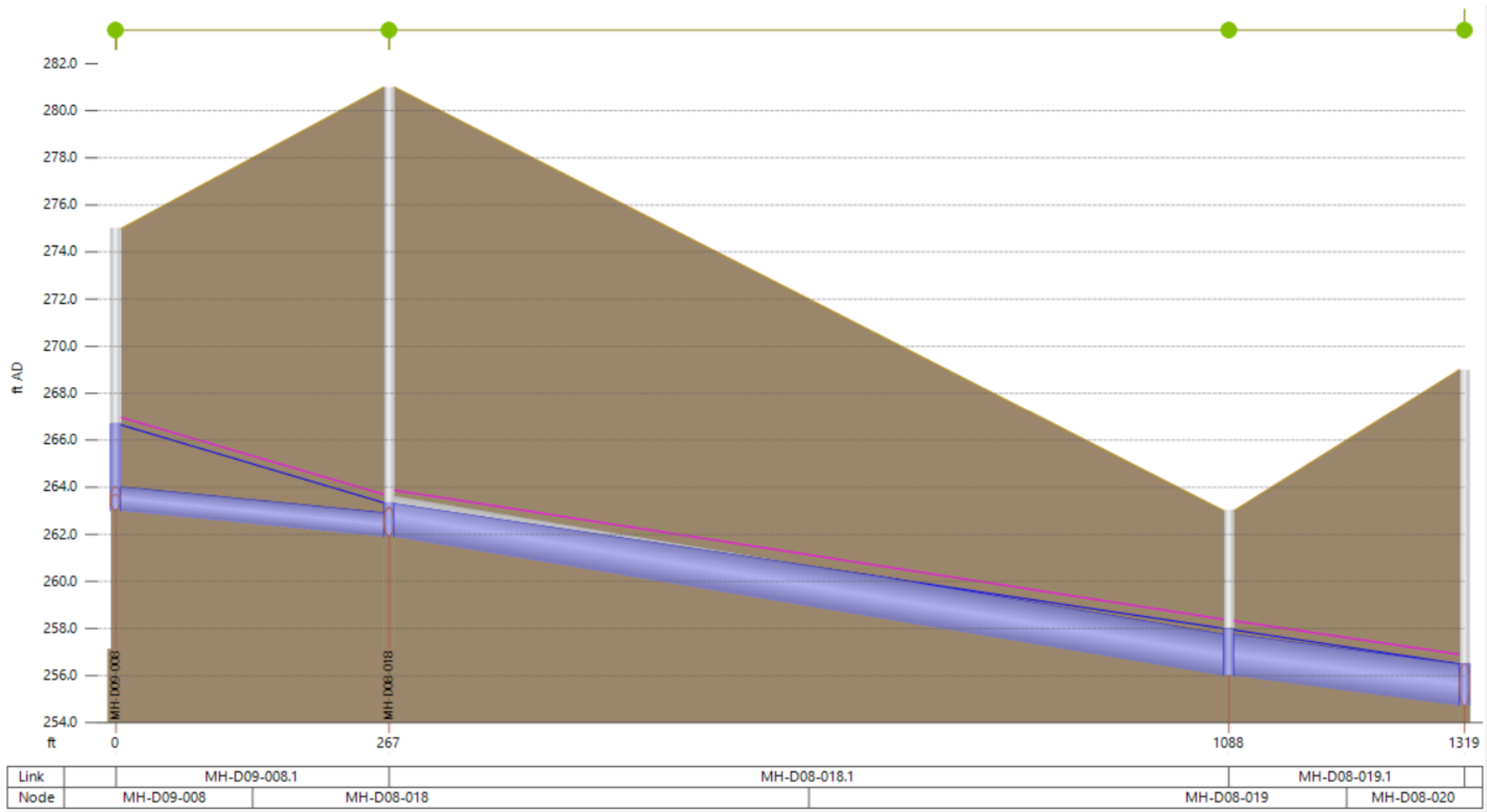

Figure 11. Hickey–I-280 profile, existing, wet-weather

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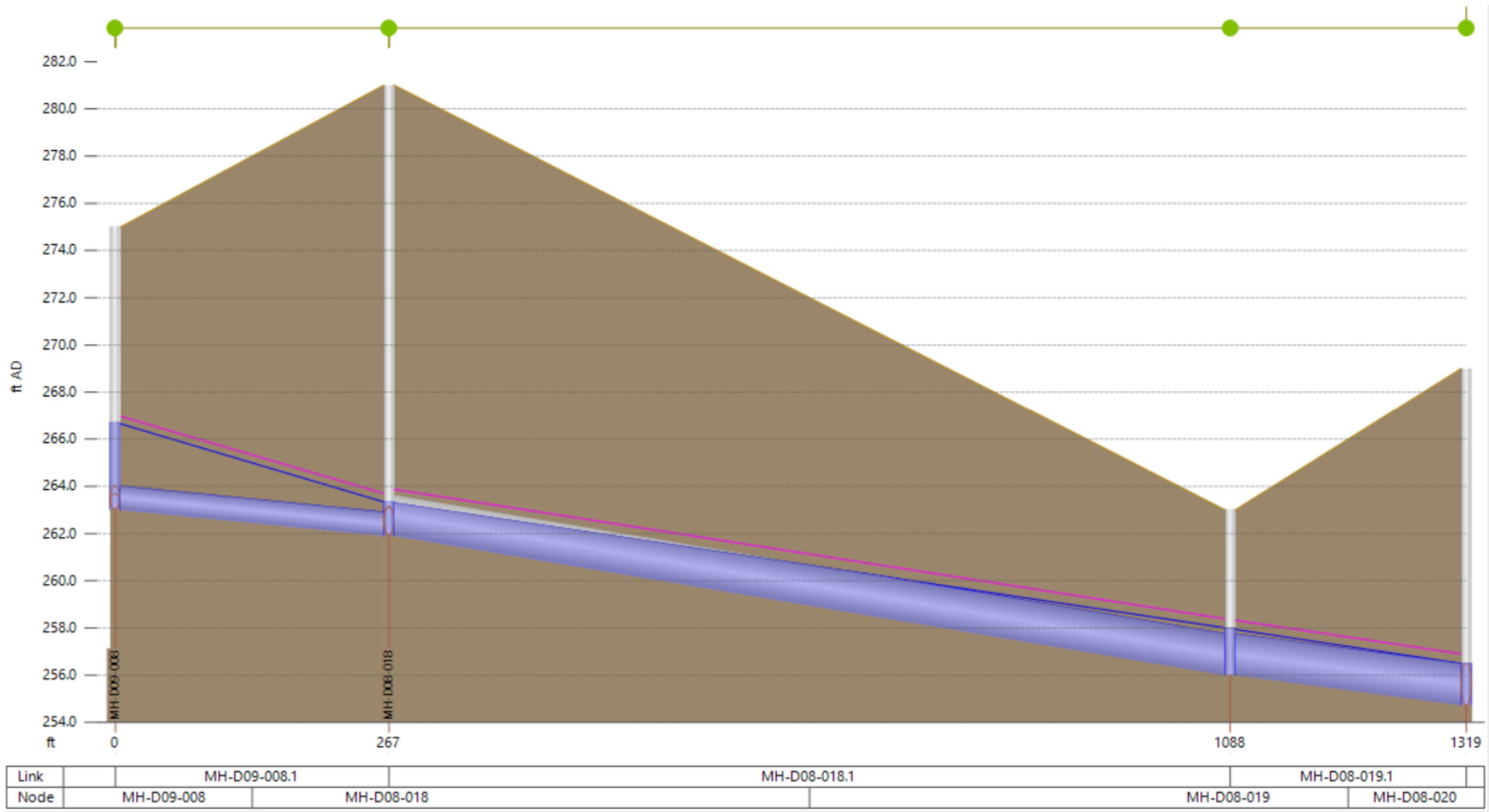

Figure 12. I-280 profile, proposed, wet-weather

References

BKF, Technical Memorandum: 455 Hickey Boulevard Redevelopment Project, Sanitary Sewer Modeling Request, 2023.

Brown and Caldwell, 10-Year Wastewater System Master Plan, 2022.

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Attachment A: BKF Technical Memorandum

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TECHNICAL MEMORANDUM

Date:	March 10, 2023	BKF Job Number: C20210394

Deliver To: Alex Yuen
Daly City Public Works Engineering Division
333 90th Street
Daly City, CA 94015

From: Jonathan Tang, BKF

Subject: 455 Hickey Boulevard Redevelopment Project
Sanitary Sewer Modeling Request

I. Introduction

The project proposes to demolish the existing office building, parking garage, and site improvements for redevelopment on an approximately 3.2-acre site located at 455 Hickey Boulevard in Daly City, California. The 455 Hickey Boulevard project site is bounded by Hickey Boulevard to the north, the Caltrans Interstate-280 on-ramp to the east, Serra Lane to the south, and Serravista Avenue to the west.

The proposed project is evaluating two potential development scenarios:

Scenario 1: Medical Office Building
Scenario 2: Tech Office Building

It is anticipated the Medical Office Building development scenario will be the worst-case for system capacity modeling purposes.

II. Existing Sewer System

The project site currently discharges sewer flows to the existing 6” public sewer main on the property that runs from Serra Lane to Hickey Boulevard. This 6” sewer main conveys flow from the upstream residential developments to Hickey Boulevard. There is also an existing 18” sewer main at the intersection of Serravista Avenue and Marbly Avenue, and a 15” sewer main at the intersection of Serravista Avenue and Victoria Street. Refer to Attachment 1: Sewer Block Map.

III. Proposed Sewer System

Per City Department of Water and Wastewater Resources input, the existing sewer system on Hickey Boulevard is over capacity and the proposed project will be required to discharge sewer flow to Serravista Avenue. The project proposes to discharge site sewer flow to the existing City sewer system in Serravista Avenue at the intersection with Marbly Avenue. The project would extend the sewer line from the existing manhole at the Serravista Avenue and Marbly Avenue intersection to the new proposed sewer lateral for the project site.

The project will also relocate the existing 6" public sewer main that runs within the property to the eastern property line proposed with 20' wide access road and Public Service Utility Easement. The relocated sewer main will also be upsized to 12" diameter pipe.

IV. Sewage Generation Calculations

We understand the City establishes sewage demand numbers for different building type uses and floor areas based on the demands provided in the City's Master Sewer Study performed in 2009. Table 1 shows the existing building type, floor area, loading factor and flow based on the 2009 Study. Table 2 shows the proposed building type, floor area, loading factor and flow based on the 2009 Study. This information will be used by the City to determine the impacts the proposed project will have on the City's existing sanitary sewer system and determine if the City's system has adequate capacity to serve the proposed project. The project site has an existing medical office building, we assume there will be a reduction of flows, or credit, to the existing system on Hickey Boulevard from the existing condition. However, the proposed project will increase the sewer flow to the Serravista Avenue system.

Table 1: Existing Sewage Generation

Building Type	Total Floor Area (gsf)	Factor (gpd/gsf)	Flow (gpd)
Medical Office Building	80,652	0.25	20,163

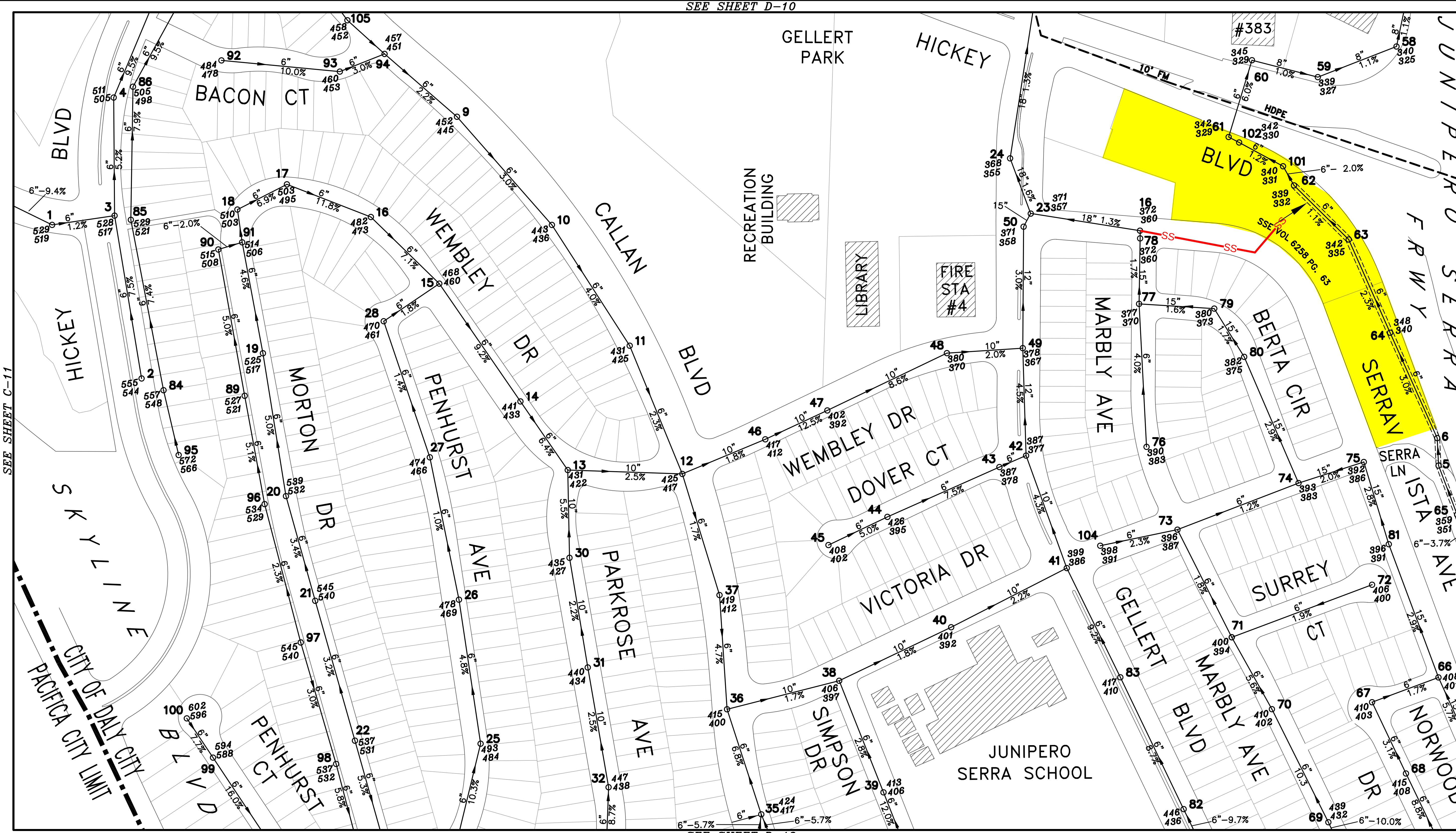
Table 2: Proposed Sewage Generation

Building Type	Total Floor Area (gsf)	Factor (gpd/gsf)	Flow (gpd)
Medical Office Building (Development Scenario 1)	180,000	0.25	45,000
Tech Office Building (Development Scenario 2)	280,000	0.10	28,000

1) Project building information is based on preliminary Architectural plans. Final project building information shall be confirmed with the Permit Drawings.

ATTACHMENT 1

(SEWER BLOCK MAP)



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NOTE: FOR LEGEND SEE GRID INDEX MAP	SCALE: 1"=200'	NORTH SAN MATEO COUNTY SANITATION DISTRICT	JUNE 1999	REVISED MAY 2008	D-11

Attachment B: 10-Year Wastewater System Master Plan

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FINAL

10-Year Wastewater System Master Plan

Prepared for

North San Mateo County Sanitation District

August 5, 2022

FINAL

10-Year Wastewater System Master Plan

Prepared for

North San Mateo County Sanitation District

August 5, 2022

Christopher M. Peters, P.E.
California License C69669
August 5, 2022

BC Project No. 154530

Brown AND Caldwell

201 N. Civic Drive, Suite 300
Walnut Creek, CA 94596
T: 925.937.9010

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List of Abbreviations

BART	Bay Area Rapid Transit
BC	Brown and Caldwell
BWF	base wastewater flow
CCTV	closed-circuit television
CIP	capital improvement plan
City	City of Daly City
CMMS	computerized maintenance management system
COF	consequence of failure
d/D	depth to diameter ratio
District	North San Mateo County Sanitation District
GIS	geographic information system
gpd	gallons per day
GWI	groundwater infiltration
IAM	InfoAsset Manager
IAP	InfoAsset Planner
LOF	likelihood of failure
mgd	million gallons per day
NSMCSD	North San Mateo County Sanitation District
O&M	operation and maintenance
PACP	Pipeline Assessment and Certification Program
Plan	Wastewater System Master Plan
q/Q	flow to capacity ratio
QC	quality control
RCP	reinforced concrete pipe
RDII	rainfall-derived infiltration and inflow
RMC	RMC Water and Environment
RTK	real-time kinematic
SFPUC	San Francisco Public Utilities Commission
SSO	sanitary sewer overflow
USGS	U.S. Geological Survey
UWMP	Urban Water Management Plan
VCP	vitrified clay pipe
WD	(Westborough) Water District
WWTP	wastewater treatment plant

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Executive Summary

North San Mateo County Sanitation District (NSMCSD or District), a subsidiary agency of the City of Daly City (City), collects, treats, and disposes of wastewater for Daly City and Westborough Water District. The District prepared a wastewater system master plan in 2009. Since then, the District has successfully completed a series of capital improvement plan (CIP) projects that addressed most of the known deficiencies in the collection system. In addition, Daly City completed and updated its 2030 General Plan. With these changes since 2009, the District wanted to update its wastewater system master plan (Plan) to ensure continued conveyance of wastewater to the wastewater treatment plant (WWTP). The District engaged Brown and Caldwell (BC) to prepare the Plan.

This Plan focuses on hydraulic capacity and condition of the wastewater collection system. The District's existing hydraulic model was updated and used to analyze the collection system. Piping in the model was updated to match the District's latest geographic information system (GIS) piping. Existing flows were updated and flows for planned developments were added to the model. The updated model was then analyzed to identify deficiencies for dry and wet weather flows. CIP projects were developed for identified capacity deficiencies.

Hydraulic Capacity

BC updated the District's existing InfoWorks ICM hydraulic model developed by RMC Water and Environment (RMC) in 2009. For this model update, all piping from the District's June 2020 GIS was added, and data from the 2007-2008 flow metering program were used to help calibrate dry weather flows. The average WWTP dry weather flow during the 2007-2008 calibration period was 5.81 million gallons per day (mgd). Flows at the WWTP increased by 18 percent from the 2007-2008 calibration period (5.81 mgd) to the 2017-2018 calibration period (6.84 mgd). Additional temporary flow metering was not performed in the collection system for this project.

The system's capacity was analyzed for existing and future conditions during dry and wet weather periods. No issues were found for dry weather flows. The model predicts several locations of surcharging and sanitary sewer overflows (SSO). These results were reviewed with District staff in November 2021. District staff reported seeing very little evidence of surcharging or SSOs, especially in the Serramonte Center, as shown in the model. Based on discussions with District staff, it was decided that the model results will not be used for developing CIP projects because the model calibration is based on old flow data and District staff are not seeing the surcharging predicted by the model in the existing collection system.

Most of the projects identified for improvements from the 2009 model have been constructed. The District decided that the following remaining CIP projects or known deficiencies, which also showed up as deficiencies in the updated model, should remain in the CIP for this project:

- **Existing pipe.** An existing 21-inch pipe does not have sufficient capacity. The pipe starts at Southgate Avenue just north of the Serramonte Center, then crosses I-280 to Junipero Serra Blvd. This project was listed as project C-5 for the 2009 modeling (RMC TM 3B, 2009). Figure ES-1 provides the extents of project C-5. The project description included:
  - Project C-5 – I-280 Crossing – New 30" I-280 crossing from Southgate Ave to Junipero Serra (750 feet of 48-inch casing and 275 feet open-cut pipe)

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- **Lift stations.** The District noted the following lift station issues during a meeting in November 2021:
  - **El Portal.** The District said that both pumps run at the El Portal lift station during large storms and there have been issues upstream of the lift station. It is recommended that additional flow metering be performed to analyze the capacity of this lift station and the collection system upstream of the lift station.
  - **Skyline.** The District said that the Skyline lift station has backup power but it is worried about losing that backup power during an outage. It is recommended that the District study power requirements and available backup power at this lift station.

Additional recommendations to finish calibrating and analyzing the model include:

- **Field investigation.** The District may want to verify pipe sizes and inverts for areas with discrepancies between the latest GIS and the previous model, including:
  - **The Colma force main.** This force main was 8 inches in the GIS but 12 inches in the 2009 model. As discussed in Table 2-3, the pipe was assumed to be 12 inches because the pump station could not pump flows reported in Table 2-4 when the force main was 8 inches. This size should be verified.
- **Conduct additional temporary flow metering.** Flow metering could be done at the same locations as for the 2009 model. At a minimum, flow metering should be done up and downstream of the deficiencies identified in this project.
- **Recalibrate model.** The model should be recalibrated using new flow metering data.
- **Re-analyze model.** The recalibrated model can then be used to identify deficiencies and identify improvement projects.

Several locations that were identified in the previous RMC evaluation have also been identified as deficiencies in this analysis. Since several of these areas have already had CIP projects in recent years, BC recommends further investigation and flow metering in these areas to validate model results or current system capacity. Among these areas are Southgate Avenue between St. Francis Boulevard and Serramonte Center, and the mainlines upstream of the I-280 crossing between Serramonte Center and Hickey Boulevard.

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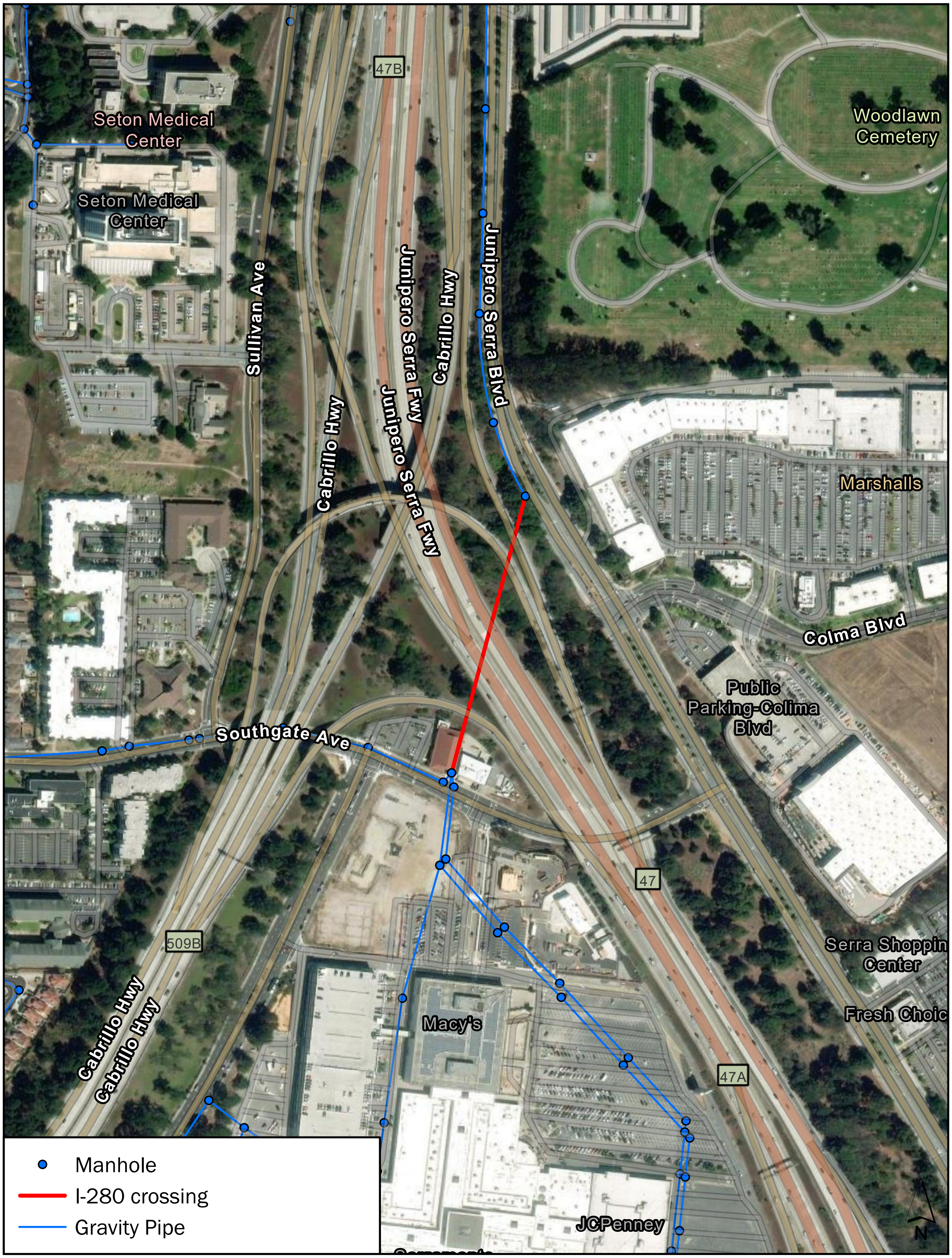

Figure ES-1. Improvement project C-5, I-280 crossing

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Pipe Condition

A pipe risk analysis examined the risk of failure for the District's 925,000 linear feet (LF) of sewer gravity piping. The risk analysis was done to provide the District with priorities for closed-circuit television (CCTV) inspections and to help in developing and prioritizing CIP projects.

This collective analysis resulted in the following conclusions:

1. Of the approximately 99,000 LF (409 GIS pipe segments) of sewer gravity pipeline inspected by Daly City, approximately 23,000 LF require system improvements totaling approximately $2.4 million in construction costs.
2. BC recommends that the City inspect pipes without existing CCTV inspection data over the next 10 years. This effort should focus on pipes with a risk rating of 3, 4, or 5. This can be accomplished through in-house inspection (as performed for this project) or through outside contractors, or a combination of the two methods. Approximately 730,000 feet of pipes are recommended for CCTV inspection. The District should prioritize the inspections based on the risk scores provided that will be provided with this report in a GIS format.
3. Lastly, through discussions with the District and review of the risk model, BC developed a programmatic replacement project for high-risk terracotta pipes in some of the oldest parts of the District's collection system. This includes all terracotta pipes in the system with a risk score of 4 or 5. Table ES-1 summarizes the terracotta pipe risk distribution. Approximately 12,800 feet of terracotta pipe is recommended for replacement over the next 10 years.

Table ES-1. Programmatic Terracotta Pipe Replacement

Risk	Total Pipe Length (feet)
4	3,100
5	9,700
Total	**12,800**

Capital Improvement Plan

A CIP was developed to improve the performance of the District's wastewater collection system and reduce the risk of SSOs.

Capacity Improvement Projects. Capacity improvement projects are based on the results of the hydraulic assessment and are intended to provide hydraulic capacity in the system for the design storm condition. As previously discussed, the CIP will only include one capacity improvement project at this time due to a lack of confidence in the 2008 flow monitoring data.

Condition and Risk-based Projects. Condition-based projects are based on the results of the condition assessment; repair recommendations were made based on the observed defects. Prior to implementing a proposed repair recommendation, District staff should review the CCTV data to confirm that recorded defects match the observed pipe condition. Only one risk-based project was identified for implementation at this time, which is the replacement of high-risk terracotta pipes.

The City will identify new condition-based projects as CCTV progresses. BC recommends that the District evaluates new CCTV data and develops rehabilitation projects periodically (e.g., annually, every 5 years, every 10 years).

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Other Recommendations. Several other non-construction projects are included in the CIP under Other Recommendations. These projects include additional CCTV and condition assessment work and addition flow monitoring and model recalibration. A project for lift station condition assessments was also included in the CIP. Lift station condition assessments were not performed as part of this project.

Project Prioritization. Hydraulic- and condition-related construction projects were prioritized using the risk model. Projects located on pipes receiving a risk score of 3 were categorized as medium priority. Projects located on pipes receiving a risk score of 4 or 5 were categorized as high priority. High-priority projects should be completed in the next 3 to 5 years. Medium-priority projects should be completed in the next 10 years. Each CIP project was listed as either a medium- or high-priority project.

The CIP is presented in Table ES-2 and Figure ES-2.

Table ES-2. CIP Summary

Priority	Description	Construction/Inspection Cost	Engineering and Administration	Total Project Cost
Hydraulic Capacity Projects				
High	I-280 Sewer Crossing	$6,210,000	$2,174,000	$8,384,000
Condition Assessment Projects				
Medium	Pipeline Rehabilitation	$1,814,000	$635,000	$2,449,000
Risk-based Projects				
High	Terracotta Replacement	$6,672,000	$2,335,000	$9,007,000
Other Projects				
	Pipeline CCTV Inspection	$2,950,000	$1,033,000	$3,983,000
	Flow Monitoring and Model Update	$250,000	$88,000	$338,000
	Lift Station Condition Assessment	$100,000	$35,000	$135,000
	Skyline Pump Station Power Study	$50,000	$18,000	$68,000
	Grand Total	**$18,046,000**	**$6,318,000**	**$24,364,000**

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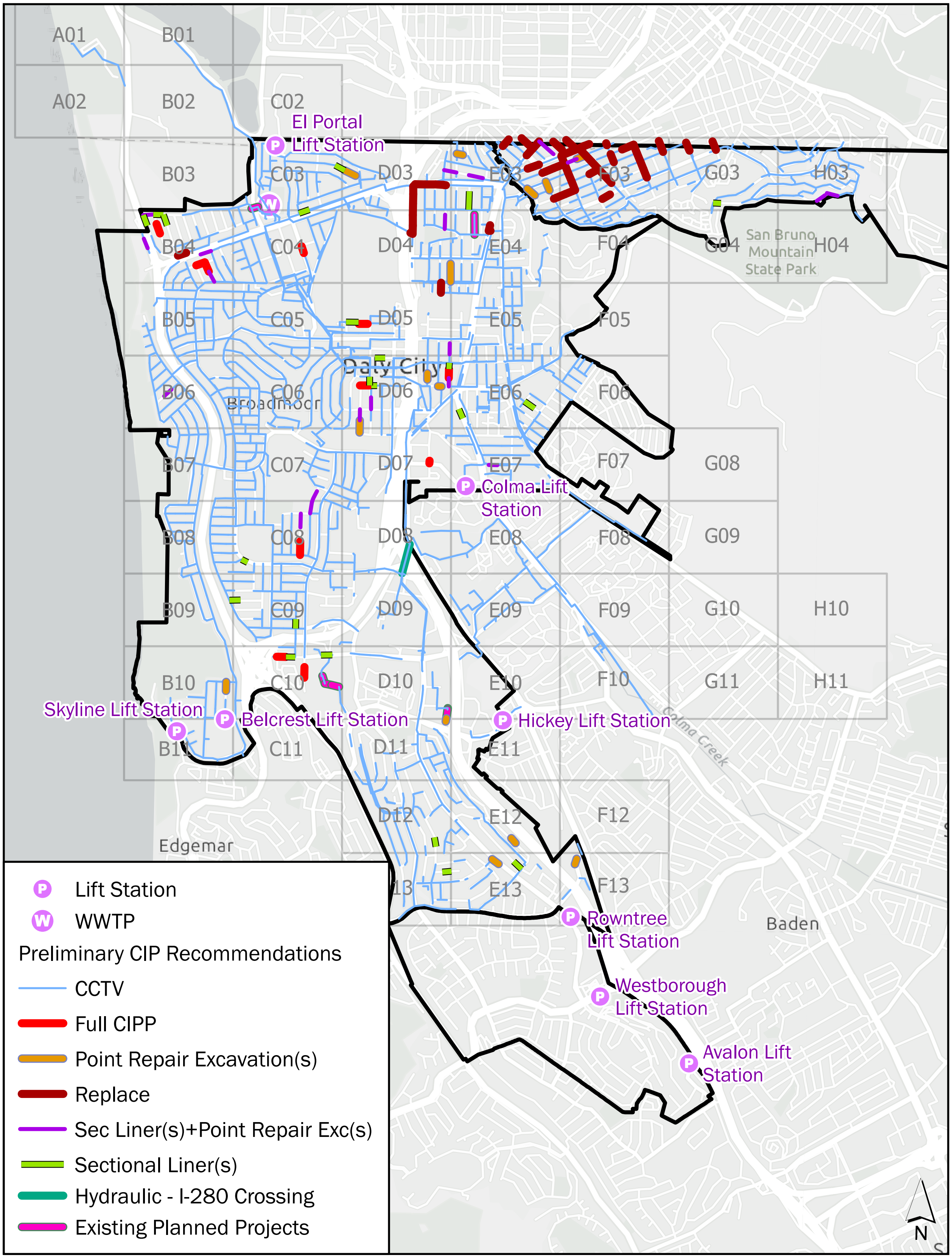

Figure ES-2. Capital improvement plan

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Section 1

Introduction

North San Mateo County Sanitation District (NSMCSD or District), a subsidiary agency of the City of Daly City (City), collects, treats, and disposes of wastewater for Daly City and Westborough Water District (WD). The District prepared a wastewater system master plan in 2009. Since then, the District has completed a series of successful capital improvement plan (CIP) projects that addressed most of the collection system's known deficiencies. In addition, the City completed and updated its 2030 General Plan. With these changes since 2009, the District wanted to update its wastewater system master plan (Plan) to ensure continued conveyance of wastewater to the wastewater treatment plant (WWTP). The District engaged Brown and Caldwell (BC) to prepare the Plan.

This Plan focuses on the wastewater collection system's hydraulic capacity and condition. The District's existing hydraulic model was updated and used to analyze the collection system. Piping in the model was updated to match the District's latest geographic information system (GIS) piping. Existing flows were updated, and flows for planned developments were added to the model. The updated model was then analyzed to identify deficiencies for dry and wet weather flows. CIP projects were developed for identified capacity deficiencies.

A pipe risk analysis evaluated the risk of failure for the District's sewer gravity piping. The risk analysis was done to provide the District with priorities for closed-circuit television (CCTV) inspections and to help in developing CIP projects.

1.1 Limitations

This document was prepared solely for NSMCSD, a subsidiary of the City of Daly City, in accordance with professional standards at the time the services were performed and in accordance with the contract between NSMCSD and Brown and Caldwell dated December 16, 2019. This document is governed by the specific scope of work authorized by NSMCSD; it is not intended to be relied upon by any other party except for regulatory authorities contemplated by the scope of work. We have relied on information or instructions provided by NSMCSD and other parties and, unless otherwise expressly indicated, have made no independent investigation as to the validity, completeness, or accuracy of such information.

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Section 2

Existing Collection System

This section describes the District's collection system.

2.1 Collection System Description

As of 2019, the District was estimated to serve approximately 107,864 people and 22,995 service connections (NSMCSD, 2019). Figure 2-1 shows the District's wastewater facilities and the service area, which includes the following three areas:

- **Treated by NSMCSD.** Piping in most of Daly City, in Broadmoor (unincorporated area of San Mateo County), and in a portion of the Town of Colma is owned by the District and drains to the District's WWTP.
- **Treated by SFPUC.** The northeast portion of Daly City drains to the San Francisco Public Utilities Commission (SFPUC). This includes piping owned by two entities:
  - The District, which owns piping in this area within the City boundary.
  - Bayshore Sanitary District, which owns piping in this area east of the City boundary (and just off Figure 2-1).
- **Treated by NSMCSD, owned by Westborough WD.** Piping within the Westborough WD service area in South San Francisco is owned by the Westborough WD but drains into District piping and then to the District's WWTP.

This study only includes piping that drains to the District's WWTP (the blue area on the Figure 2-1).

2.2 WWTP Flows

Figure 2-2 shows daily flows at the WWTP for 2018. The graph also shows daily rainfall totals at a rain gauge in South San Francisco for 2018 (Weather Underground, 2020).

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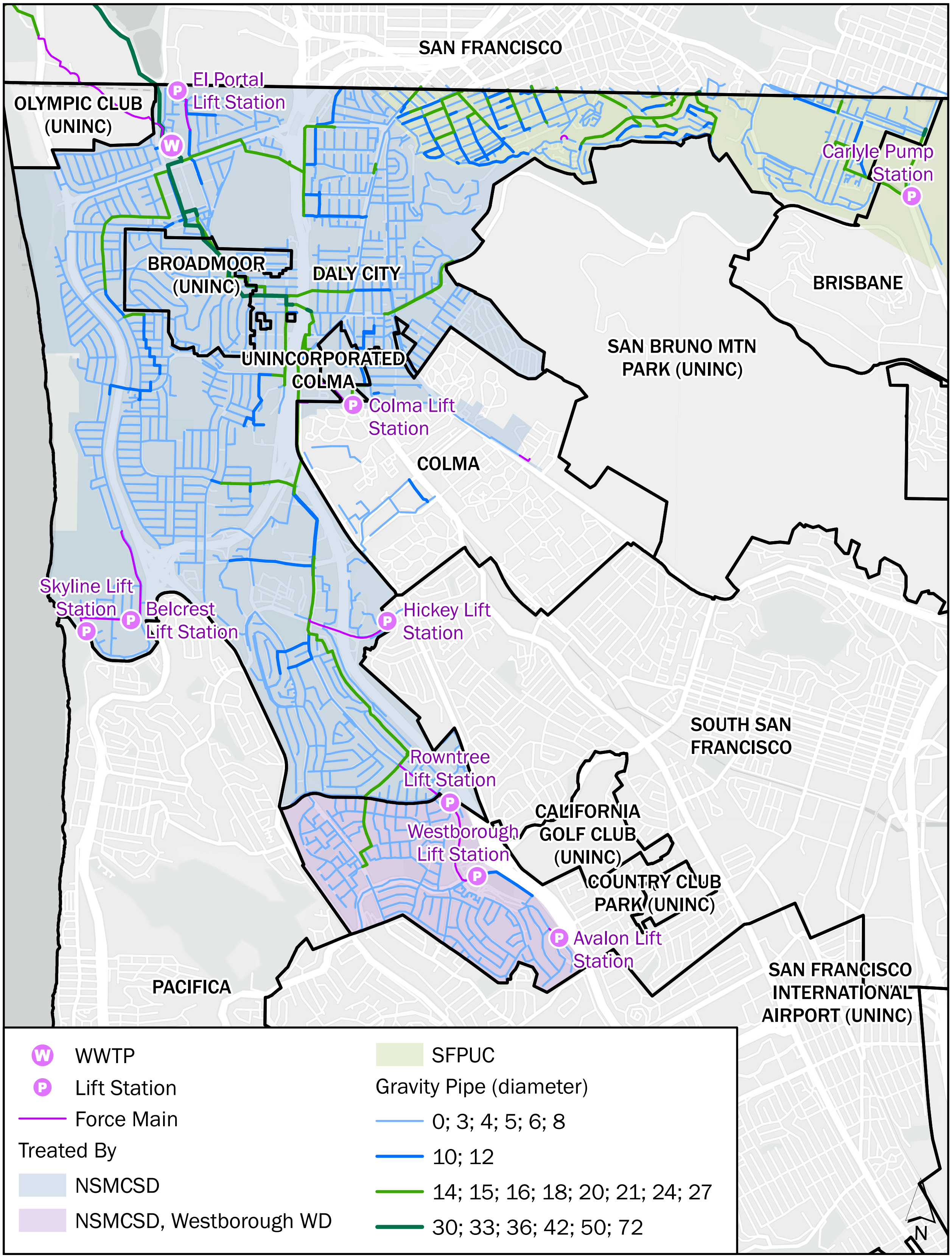

Figure 2-1. Collection system facilities and service area

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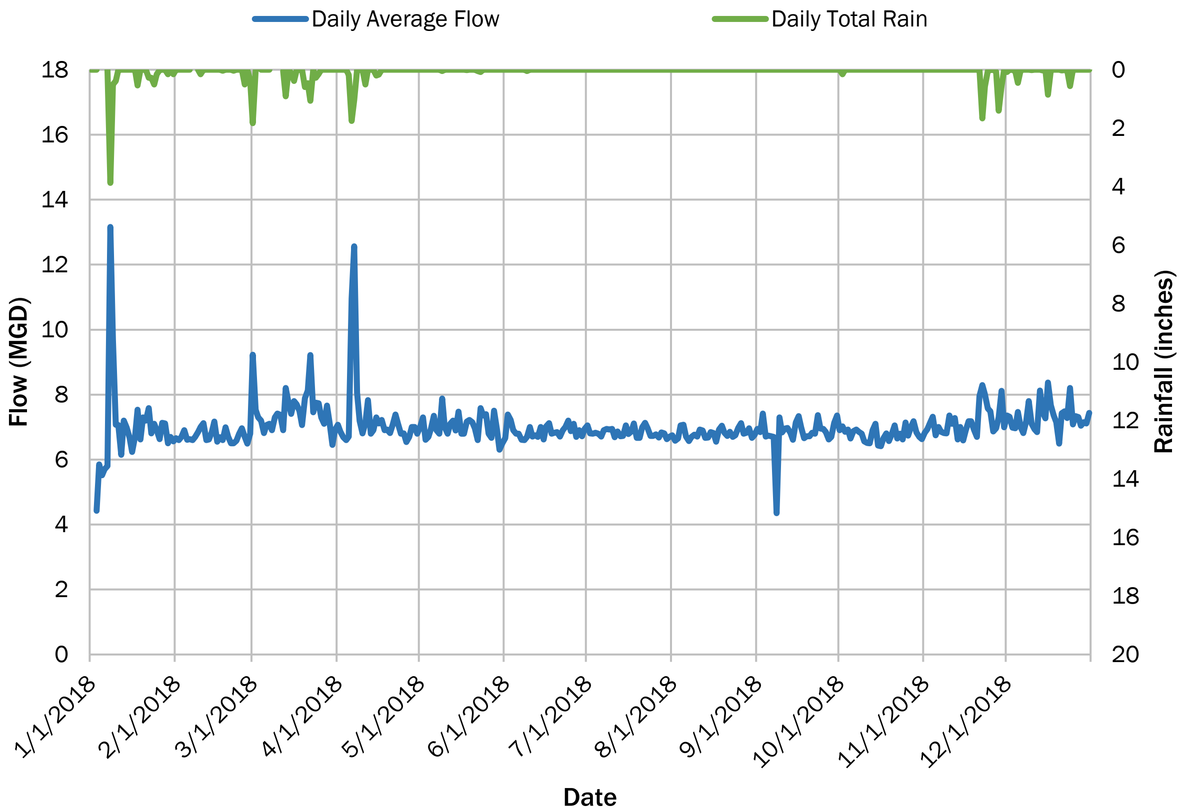

Figure 2-2. 2018 WWTP daily flows

2.3 Piping

The District's sewer system consists of about 180 miles of piping. Per the District, about 46 percent of the system was installed in the 1940s and 1950s (NSMCSD, 2019). Table 2-1 summarizes gravity piping by location and Table 2-2 summarizes gravity piping by material. Table 2-3 lists the force main piping serving each lift station. The three tables are based on the District's collection system piping GIS.

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Table 2-1. Gravity Piping in GIS by Location

Diameter (inches)	Length (feet)							Total Length (feet)	Total Length (miles)
	Daly City	Bayshore San. Dist.	Colma	SFPUC	South San Francisco	Westborough	Private		
Unknown	3,597	11,250	4,802	14,639	-	2,680	1,428	38,395	7.3
3	127	-	-	-	-	-	-	127	< 0.1
4	730	-	144	-	-	-	-	874	0.2
5	791	-	-	-	-	-	-	791	0.1
6	425,070	9,539	6,661	14,060	12,707	51,261	5,765	525,063	99.4
8	91,969	22,206	9,741	31,379	464	40,232	-	195,992	37.1
10	19,394	2,734	4,936	5,280	-	1,748	-	34,092	6.5
12	19,845	-	-	16,233	-	47	-	36,125	6.8
14	-	790	-	2,137	-	-	-	2,927	0.6
15	31,282	1,752	-	3,665	-	2,468	-	39,168	7.4
16	233	25	-	-	-	-	-	258	< 0.1
18	7,489	2,193	-	4,957	-	-	-	14,639	2.8
20	216	-	-	26	-	-	-	241	< 0.1
21	8,133	3,649	-	1,337	-	-	-	13,119	2.5
24	2,270	82	-	2,375	-	-	-	4,727	0.9
27	2,788	-	-	1,042	-	-	-	3,830	0.7
30	8,425	-	-	136	-	-	-	8,560	1.6
33	4,459	-	-	-	-	-	-	4,459	0.8
36	574	186	-	-	-	-	-	761	0.1
42	117	-	-	-	-	-	-	117	< 0.1
50	754	-	-	-	-	-	-	754	0.1
72	165	-	-	-	-	-	-	165	< 0.1
Total (feet)	628,427	54,407	26,285	97,266	13,171	98,436	7,193	925,185	175.2
Total (miles)	119.0	10.3	5.0	18.4	2.5	18.6	1.4	175.2	
Percent	68%	5.9%	2.8%	11%	1.4%	10.6%	0.8%	100%	

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Table 2-2. Piping in GIS by Material

Diameter (inches)	Length (feet)						Total Length (feet)	Total Length (miles)
	Unknown	DIP	PE	PVC	RCP	Terracotta / VCP		
Unknown	26,551	-	-	-	-	11,844	38,395	7.3
3	-	-	-	-	-	127	127	< 0.1
4	-	-	-	-	-	874	874	0.2
5	-	-	-	-	-	791	791	0.1
6	2,547	59	-	1,296	210	520,951	525,063	99.4
8	1,842	645	469	7,651	-	185,384	195,992	37.1
10	28	340	-	827	-	32,897	34,092	6.5
12	47	-	575	1,061	-	34,442	36,125	6.8
14	-	-	-	-	-	2,927	2,927	0.6
15	-	-	-	144	261	38,763	39,168	7.4
16	-	30	-	-	-	229	258	< 0.1
18	537	-	581	-	-	13,520	14,639	2.8
20	176	-	-	-	-	66	241	< 0.1
21	810	-	-	-	821	11,488	13,119	2.5
24	-	150	-	-	472	4,105	4,727	0.9
27	-	-	-	-	348	3,482	3,830	0.7
30	-	123	-	-	-	8,437	8,560	1.6
33	-	-	-	-	-	4,459	4,459	0.8
36	186	-	-	-	-	574	761	0.1
42	-	-	-	-	-	117	117	< 0.1
50	368	-	-	-	-	386	754	0.1
72	165	-	-	-	-	-	165	< 0.1
Total (feet)	33,257	1,347	1,626	10,979	2,113	875,864	925,185	175.2
Total (miles)	6.3	0.3	0.3	2.1	0.4	165.9	175.2	
Percent	3.6%	0.1%	0.2%	1.2%	0.2%	95%	100%	

DIP = ductile iron pipe, PE = polyethylene, PVC = polyvinyl chloride, RCP = reinforced concrete pipe, VCP = vitrified clay pipe

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Table 2-3. Force Main Piping			
Lift Station	Material	Diameter (inches)	Length (feet)
Avalon	Unknown	4	391
Belcrest	Unknown	6	3,062
Colma[a]	Unknown	12	1,859
El Portal	Unknown	6	1,363
Hickey	Unknown	10	2,667
Rowntree	ACP	12	1,884
Skyline	Unknown	6	1,936
Westborough	Unknown	12	2,929
Private/Unknown	DIP, Unknown	3, 4, Unknown	2,010
WWTP to outfall	CCP	27	5,796
Total			23,896

ACP = asbestos cement pipe, CCP = concrete cylinder pipe, DIP = ductile iron pipe

a. The Colma force main was 8 inches in the GIS but 12 inches in the 2009 model. The pipe was assumed to be 12 inches because the pump station could not pump flows reported in Table 2-4 when the force main was 8 inches. This assumption should be verified by the District.

2.4 Lift Stations

Table 2-4 lists the collection system's lift stations. Information in the table was taken from the 2009 RMC Water and Environment (RMC) report (RMC TM 3B, 2009). The 2009 report explains the calculations for design and firm capacities. Information was not available for three of the lift stations.

Table 2-4. Lift Stations						
Lift Station	Owner	Number of Pumps[a]	Design Capacity Each Pump (mgd)	Calculated Firm Capacity (mgd)	Modeled Firm Capacity (mgd)	Speed Type
Avalon	Westborough WD	-	-	-	-	-
Belcrest	NSMCSD	2	0.433	0.3	0.36	Constant
Colma	Town of Colma	3	1.3	1.94	2.45	Constant
El Portal	NSMCSD	2	0.58	0.46	0.56	Variable
Hickey	NSMCSD	2	0.94	0.75	1.1	Constant
Rowntree	Westborough WD	3	1.87	2.81	2.814	Variable
Skyline	NSMCSD	2	0.433	0.3	0.38	Constant
Westborough	Westborough WD	-	-	-	-	-

a. Belcrest and Skyline consist of two sets of two pumps in series, for a total of four pumps at each lift station. Each set is configured for 0.43 million gallons per day (mgd).

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Section 3

Model Development

BC updated the District's wastewater collection system model. This section describes the model update and calibration.

3.1 Model Build

BC updated the District's existing InfoWorks ICM model. RMC developed the model in 2009. The District and consultants have updated the model since 2009 with changes to piping and flows. The modeling software, InfoWorks ICM adds a date stamp for each model update and allows users to provide comments for updates. The model listed updates, but many of the updates did not include comments. Because BC was unsure of how up to date the model, BC rebuilt the model using the latest District GIS data as described below. Figure 3-1 shows the facilities added to the model.

3.1.1 Piping

For this model update, all piping from the District's June 2020 GIS was added to the model. Model piping was classified in the GIS according to the three service areas shown on Figure 3-1 (and described in Section 2-1):

- **Treated by NSMCSD.** Most piping in this area was used in the model. Scattered pipes that did not connect to the rest of the collection system and dead-end pipes without elevations and/or diameters were inactivated in the model. A small area that drains to South San Francisco at the south end of this service area was also inactivated because it is not actually treated by the District.
- **Treated by SFPUC.** This area was not modeled, so piping was inactivated.
- **Treated by NSMCSD, owned by Westborough WD.** This area drains north into Daly City. Flows were added to the piping in this area as described in Section 3.2; however, piping in this area was inactivated and flows were routed downstream to the first District-modeled pipe.

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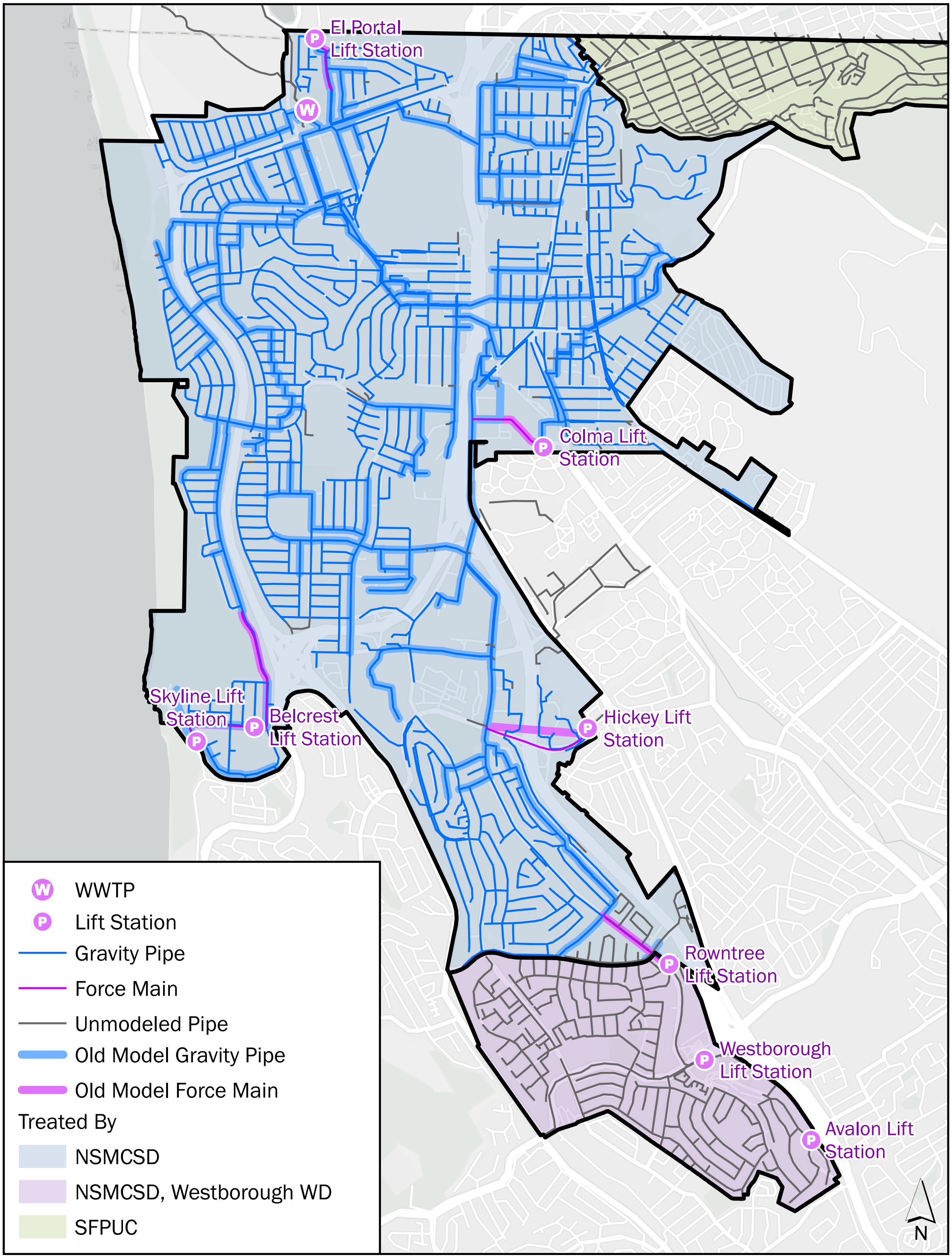

Figure 3-1. Modeled facilities

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Of the piping that was modeled, 2 percent of pipes were missing diameters, 10 percent of the pipes were missing invert elevations, and 6 percent of the manholes were missing rim elevations. Pipe inverts and manhole rim elevations were also rounded to the nearest foot in the GIS. Incorrect elevations and rounded inverts caused some negative slopes in piping. Missing and negative pipe inverts were interpolated using values from neighboring pipes. Missing diameters were assumed from neighboring pipes. Missing manhole rim elevations were interpolated from a light detection and ranging (aka LiDAR) dataset from the National Elevation Dataset published by the U.S. Geological Survey (USGS) in 2013.

The imported piping was cleaned up by snapping pipes to manholes. For the 2009 model, extensive work was done to investigate pipe inverts at flow splits (RMC TM 3B, 2009). Where pipe inverts at flow splits were different between the current GIS and 2009 model, 2009 pipe inverts were imported into this updated model.

As a comparison, the 2009 model included 35 miles of pipelines, or 29 percent of the District's collection system tributary to the WWTP. The 2009 model piping included most of the District's 10-inch and larger piping (RMC TM 3B, 2009). Piping modeled in 2009 is shown on Figure 3-1.

3.1.2 Lift Stations

Lift stations were maintained from the 2009 model. No investigation was performed to verify if pump model information was correct or if there have been any changes to pumps since the 2009 model was developed. The six lift stations listed in Table 2-4 with pump and flow information were carried over from the old to the new model. The other three lift stations without information are in areas that were not modeled.

3.2 Model Flows

The following section describes flows used in the collection system model.

3.2.1 Flow Metering

As shown in Section 2.2, the District provided daily average WWTP flows for September 2017 through December 2018. The period between July 1 and November 19, 2018, when there was little rainfall, was selected for dry weather calibration. Figure 3-2 shows average daily WWTP flows and rainfall from the San Francisco International Airport (SFO) rain gauge for the calibration period.

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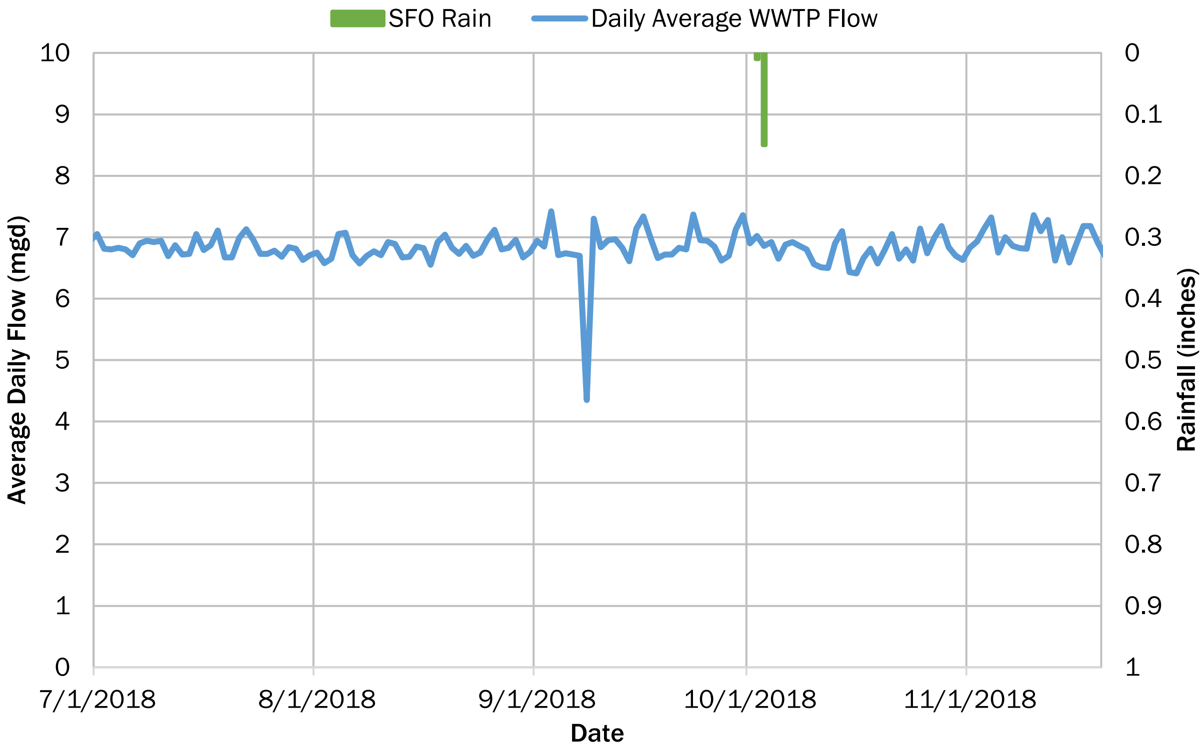

Figure 3-2. WWTP flow during calibration period July 1 through November 19, 2018

Temporary flow metering was performed in 2007 and 2008 to help calculate model flows by placing 11 temporary flow meters throughout the collection system (RMC TM 3A, 2009). Figure 3-3 shows the location of the 2007-2008 flow meters. Data from the 2007-2008 flow metering program was used to help calibrate dry weather flows for this model update. The average WWTP dry weather flow during the 2007-2008 calibration period was 5.81 million gallons per day (mgd). Flows at the WWTP increased by 18 percent from the 2007-2008 calibration period (5.81 mgd) to the 2017-2018 calibration period (6.84 mgd). Additional temporary flow metering was not performed in the collection system for this project.

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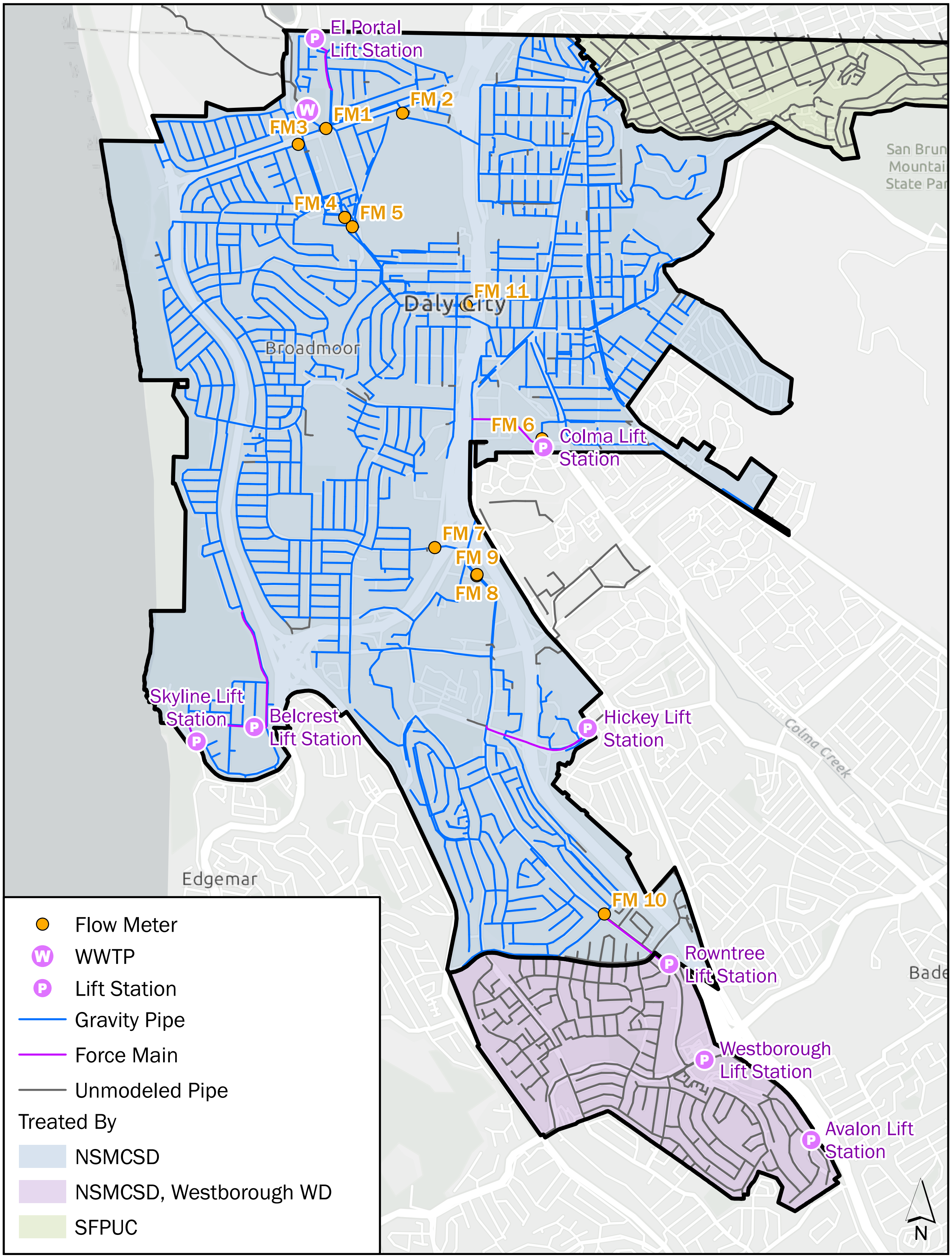

Figure 3-3. 2007-8 flow meter locations

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3.2.2 Wastewater Flow Components

Wastewater has three basic flow components: base wastewater flow (BWF), groundwater infiltration (GWI), and rainfall-derived infiltration and inflow (RDII). Figure 3-4 shows a typical representation of these wastewater components.

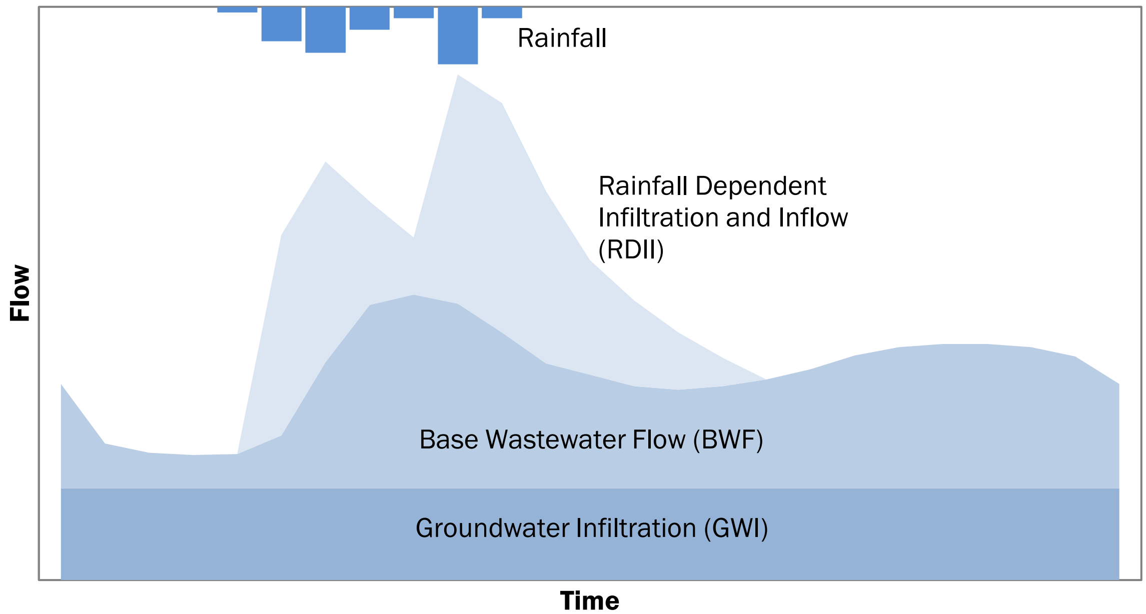

Figure 3-4. Wastewater flow components

Each component is described below.

Base Wastewater Flow

BWF is wastewater flow generated from residential, commercial, industrial, and public or institutional sources that discharges into the wastewater collection system. BWF may vary in magnitude throughout the day, but it generally follows a predictable diurnal pattern with peak flow occurring during the morning and evening hours. Predominantly commercial or industrial areas may have patterns that are different from residential areas, depending on the type of use. Peak flows may also be higher or lower on weekends than on weekdays, particularly in predominantly residential areas. BWF may be impacted by water use practices, such as water conservation.

Diurnal patterns, or hourly peaking factors, define how BWF varies throughout a day. In the model, BWF applied at model manholes is multiplied by diurnal patterns. The 2009 model residential diurnal patterns were used in the updated model. Figure 3-5 shows the weekday and weekend diurnal residential patterns. Table 3-1 lists the hourly peaking factors.

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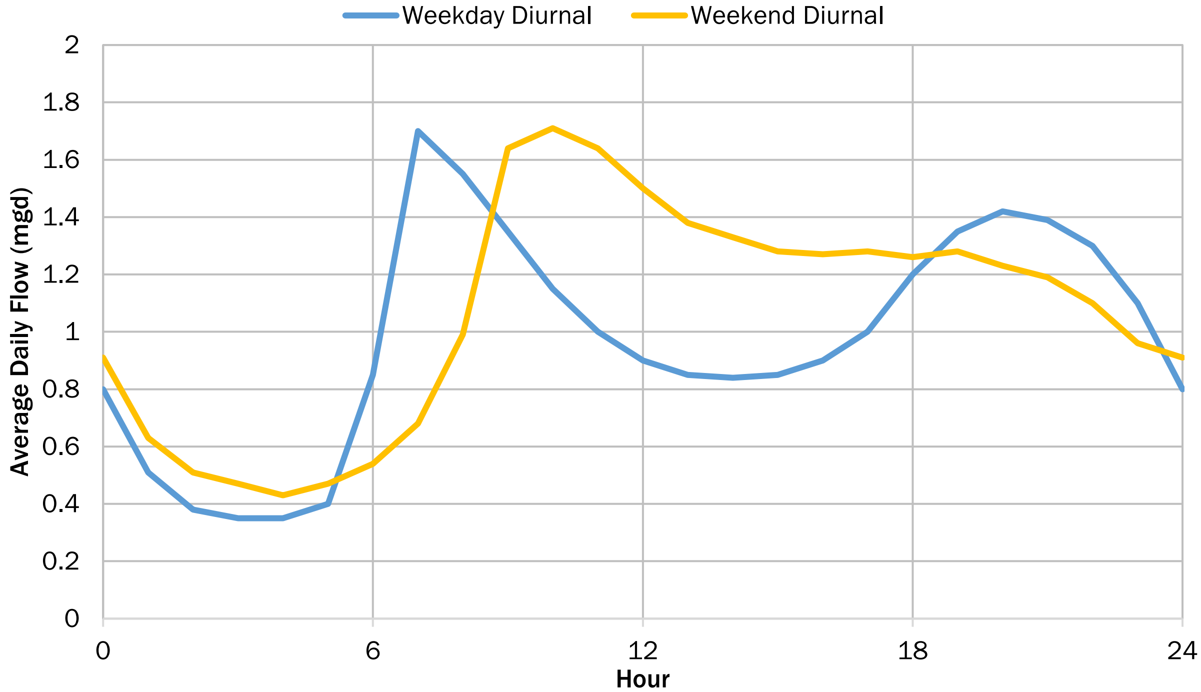

Figure 3-5. Wastewater flow diurnal patterns

Table 3-1. Diurnal Pattern Peaking Factors

Hour	Weekday Diurnal	Weekend Diurnal
0	0.8	0.91
1	0.51	0.63
2	0.38	0.51
3	0.35	0.47
4	0.35	0.43
5	0.4	0.47
6	0.85	0.54
7	1.7	0.68
8	1.55	0.99
9	1.35	1.64
10	1.15	1.71
11	1	1.64
12	0.9	1.5
13	0.85	1.38
14	0.84	1.33
15	0.85	1.28
16	0.9	1.27
17	1	1.28

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Table 3-1. Diurnal Pattern Peaking Factors		
Hour	Weekday Diurnal	Weekend Diurnal
18	1.2	1.26
19	1.35	1.28
20	1.42	1.23
21	1.39	1.19
22	1.3	1.1
23	1.1	0.96
24	0.8	0.91

Groundwater Infiltration

GWI is groundwater that infiltrates into the wastewater system through joints and cracks in pipes and manholes. GWI varies by area depending on the condition of the pipes and manholes and their location with respect to the local groundwater table. GWI typically stays constant throughout a single day but can vary seasonally. GWI is assigned to the model as a constant inflow into specific manholes.

Rainfall-Derived Infiltration and Inflow

RDII consists of stormwater entering the collection system as the direct inflow of stormwater runoff or rainfall-induced infiltration. Inflow occurs when stormwater flows directly into the collection system through connected catch basins, manhole covers, roof drains, or yard drains. Inflow usually occurs very rapidly during rain events and can become more severe if surface flooding occurs and manholes are submerged or are used to drain low-lying areas. Rainfall-induced infiltration is caused by stormwater percolating through the ground and entering pipes, manholes, and service laterals through cracks and defective joints. RDII may also include flow from basement drains or sump pumps. If these defects are combined with a high water table, RDII can last several days after the end of a rainfall event.

The magnitude of RDII is related to the intensity and duration of the rainfall, relative soil moisture at the time of the rainfall event (typically a function of the amount of rainfall prior to the event), condition of the pipes, and other factors such as soil type and topography. In most areas, peak flows during rainfall events are the highest flow rates that occur in the wastewater system. However, in areas where the pipes are relatively “tight” and RDII is minimal, peak wet weather flows may not be appreciably higher than peak dry weather flows.

RDII is assigned in the model to subcatchments, aka drainage basins. Wet weather flows from subcatchments drain to model manholes. Wet weather runoff includes the following parameters that are assigned to subcatchments:

- **Contributing area.** Each subcatchment has a contributing area, or the area that contributes wet weather runoff.
- **RTK runoff parameters.** The 2009 model used the RTK method to model RDII. The RTK method includes R, T, and K factors. The R factor is the percent of rainfall that enters the sewer system and the T and K parameters define how quickly rainfall enters the system. RTK factors are calculated for the following three sets of runoff:
  - **Short-term runoff.** Direct inflow due to rainwater draining into the collection system from surfaces that drain quickly, such as impermeable roads and roofs.

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- **Medium-term runoff.** Inflow similar to short-term runoff, except that the precipitation takes longer to drain into the system, such as from fields.
- **Long-term runoff.** Slower runoff response that can last several days after the end of the rainfall. Slow response is a result of saturated soil and temporarily raised groundwater due to a rain event.

Table 3-2 lists the RTK wet weather runoff parameters used in the 2009 model. These same parameters were used in the updated model.

Table 3-2. Wet Weather Runoff Parameters

RTK Hydrograph ID	Short Term			Medium Term			Long Term		
	Response Ratio R	Time to Peak T (hours)	Recession Limb Ratio K	Response Ratio R	Time to Peak T (hours)	Recession Limb Ratio K	Response Ratio R	Time to Peak T (hours)	Recession Limb Ratio K
FM1	0.037	0.25	1	0.003	5	3	0.003	8	4
FM2	0.049	0.5	1	0	5	3	0.013	8	4
FM3	0.02	1	2	0.01	8	3	0.005	10	4
FM4+5	0.003	0.5	1	0.003	5	3	0.003	8	4
FM6	0.018	0.5	2	0.003	5	3	0.003	8	4
FM7	0.013	0.5	2	0.007	5	3	0.003	8	4
FM8+9	0.025	0.5	1	0.01	5	3	0.013	8	4
FM10	0.005	1.5	2	0.004	15	2	0.001	18	4
FM11	0.024	0.5	1	0.005	5	3	0.003	8	4

3.3 Flow Calculation and Calibration

This section describes the calculation and calibration of BWF, GWI, and RDII in the updated model. Calibration is the process of adjusting modeling input parameters to match model results with measured data or observed conditions within the system.

Dry Weather Flows

Average daily BWF was calculated from average wintertime water billing data. Wintertime water billing data gives a good idea of how to distribute customer sewer flows because there is not as much irrigation in the winter and a percentage of indoor use will be discharged into the sewer. It was assumed that 90 percent of winter water use is discharged into the sewer. Dry weather flows were calculated using the following steps:

1. Water billing data was obtained for Daly City, Westborough WD, and Broadmoor and the average wintertime billed water use was calculated for each customer for November 2018 through February 2019.
2. The location of each customer was geocoded, or located spatially, from each customer address. The District geocoded the customers for Daly City and the Westborough WD. BC geocoded customers in Broadmoor.
3. Each customer was assigned to the closest collection system pipe. The customer was then assigned to the downstream manhole on that pipe. Customers more than 1,500 feet from a pipe were not assigned and were assumed to not drain to the sewer system. Less than 0.5 percent of the customers were not assigned.

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4. Total BWF for each model manhole was calculated as the sum of 90 percent of the water use for all customers assigned to that manhole. Flows were added to the model.
5. The model was run and the total BWF was found at each 2007-2008 flow meter location. This new BWF was compared to the average 2007-2008 dry weather flow at each flow meter. If the total BWF was less than the 2007-2008 flow meter data, additional flow was added to the model as GWI. The additional GWI was spread out to the manholes draining to the meter based on the length of pipe flowing into each manhole.

Table 3-3 summarizes dry weather flows added to the model upstream of each meter. For example, meter 2 flows into meter 1, so meter 1 flows only include flows for areas downstream of meter 2 and upstream of meter 1. As shown in the table, the total flow at the WWTP increased from about 5.8 mgd to about 6.8 mgd from 2007-2008 to the 2018 calibration period (see Section 3.2.1 for a comparison of WWTP flows).

Table 3-3. Calibration Summary at Flow Meters

Flow Meter [a]	Updated Model Flow (gpd) [b]			Average 2007-8 Flow (gpd) [b]
	90% of Water Use	GWI	Total Dry Weather Flow (GWI + 90% Water Use)	
WWTP	352,080	418,000	770,080	0[c]
1	260,064	-	260,064	260,000
2	473,641	237,000	710,641	790,000
3	561,101	381,000	942,101	790,000
4+5	610,349	-	610,349	390,000
6	437,454	-	437,454	410,000
7	553,179	80,000	633,179	660,000
8+9	709,967	593,000	1,302,967	1,500,000
10	680,805	-	680,805	640,000
11	245,707	183,000	428,707	490,000
Total	4,884,347	1,892,000	6,776,349	5,810,000

a. *Meters 4 and 5 and meters 8 and 9 were on parallel lines next to each other, so the 2009 model was calibrated by combining flows for each pair of meters.*

b. *These flows only include metered flows at the meter minus flows from upstream meters. For example, meter 2 flows into meter 1. The meter 1 flow in this table is the average meter 1 flow minus the average meter 2 flow.*

c. *The total flow measured in the system by the 2009 temporary flow metering was higher than the flow measured at the WWTP. Therefore, the 2009 model did not account for flows downstream of the temporary flow meters and upstream of the WWTP.*

gpd = gallons per day

Wet Weather Flows

Because new flow metering was not performed for the updated model, the same wet weather parameters used for the 2009 model were used in the updated model; however, the subcatchments in the new model were updated to match the latest drainage area. Subcatchments in the 2009 model were drawn by hand and the contributing area was calculated based on the area of the subcatchments. For the updated model, BC used its automated tool that draws subcatchments as the areas draining to each manhole. To keep the same runoff between the 2009 and updated models, the 2009 contributing area was totaled for the subcatchments draining to each flow meter. That contributing area was then spread out to the subcatchments in the new model. The 2009 RTK parameters were then applied to the new subcatchments.

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Flows at the WWTP were only available as average daily flows during the 2017-2018 calibration period. Therefore, peak wet weather model flows could not be validated at the WWTP using newer WWTP flow data.

3.4 Future Flows

The City supplied a list of projected future developments along with their projected water use. These developments were added to a future scenario in the model. Table 3-4 lists anticipated developments and Figure 3-6 highlights the parcels where the development is expected to occur. To be conservative, the water-use values were applied directly as sewer flows and were not reduced to 90 percent as done with existing flows, as described in Section 3.3.

Table 3-4. Future Developments

Description	Address	Projected Water Use (gpd)	Figure Label
Westlake Shopping Center Mixed-Use Building	10 Park Plaza Drive, Daly City	33,673	A
88 Hillside - Phase II Residential Apartments	6401 Mission Street, Daly City	31,262	B
Jefferson Union High School District Faculty and Staff Housing	699 Serramonte Blvd, Daly City	21,715	C
Eastmoor Residential Development	493 Eastmoor Ave, Daly City	13,478	D
Serramonte Shopping Center Northwest Quadrant (theater, hotel, and retail)	3 Serramonte Center, Daly City	12,630	E
Serra Station Mixed-Use Residential/Commercial	3301 Junipero Serra Boulevard, Daly City	12,060	F
Westborough development / Condos, Shannon Place	Shannon Place, South San Francisco	5,242	G
Woods Condominiums	89 Second Avenue, Daly City	3,744	H
Mission Street Mixed Use	7310 Mission St, Daly City	3,370	I
Bryant Street Mixed Use	1590 Bryant Street, Daly City	2,922	J
Westborough development, Carter Drive	Carter Drive, South San Francisco	1,872	K
North East Medical Services Building Expansion	211 Eastmoor Ave, Daly City	1,257	L
Sullivan Avenue Apartments (office conversion)	1784 Sullivan Ave, Daly City	1,225	M
Serramonte Shopping Center Northeast Quadrant (two fast food drive-throughs)	3 Serramonte Center, Daly City	980	N
Duggan's Serra Mortuary Expansion and Carvana Vending Machine Fulfillment Center	500 Westlake Ave, Daly City	708	O
Popeye's Chicken Drive-Through Restaurant (previous Steak N Shake)	362 East Market Street, Colma	442	P
Vista Grande Parcel Map	489 Vista Grande Avenue, Daly City	319	Q
7330 Mission Street Mixed Use	7330 Mission Street, Daly City	306	R
Hilldale School Expansion	25 Florence St, Daly City	284	S
Vista Grande Duplex	201 Vista Grande Ave, Daly City	102	T
San Pedro/Hill Retail Expansion	205 San Pedro Road, Daly City	54	U
Total		147,699	

gpd – gallons per day

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Projected water use in the table came from the following sources:

- Single-family and multi-family demands were supplied by Maddaus Water Management, who prepared projections for the 2020 Urban Water Management Plan (UWMP) (BC, 2021).
- The 2020 UWMP did not have sufficient information to calculate commercial demands; therefore, commercial demands were used from the Near- and Long-term Water Resources Planning Report for Daly City (BC, 2012).
- Locations and the number of units for developments were identified using information in the "Current Residential Project List" dated January 2021 on the City's Planning Division website (City of Daly City, 2021).

The additional flow from future developments had minimal effects on peak flows and the model analysis. The additional 147,699 gallons per day (gpd) shown in Table 3-4 was only 2.5 percent of the average dry weather flow of 5.81 mgd at the WWTP. The model was analyzed with existing and future flows, and model results did not change; therefore, the evaluation described in Section 4 only includes results with the addition of the future flows listed in Table 3-4.

No additional GWI or RDII was added to the model for future developments as was done for the 2009 model.

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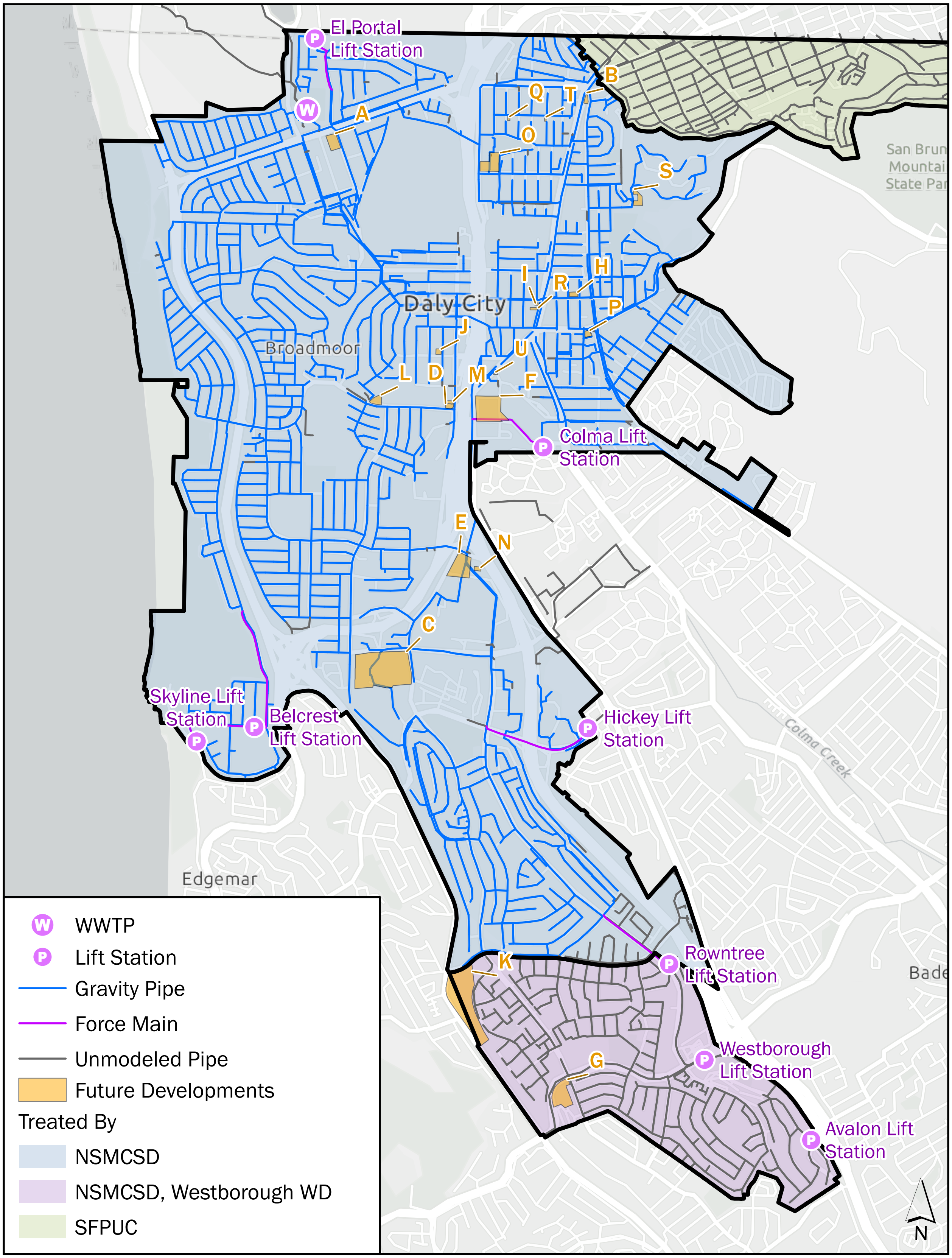

Figure 3-6. Future development locations

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Section 4

Collection System Evaluation

4.1 Capacity Evaluation

The system's capacity was analyzed for existing and future conditions during dry- and wet-weather periods. The analysis was done using the same criteria used for the 2009 modeling (RMC TM 3B, April 2009):

- **Design storm.** A 4-hour varying-intensity design storm was used to evaluate the system's wet weather capacity. This design storm, shown on Figure 4-1, has a peak intensity of 0.93 inches per hour, and is equivalent to a 4-hour, 5-year-frequency storm.
- **Pipe capacity.** A model pipe was flagged as deficient if the following criteria were exceeded under peak wet weather conditions:
  - The pipe did not have sufficient capacity (the peak flow to capacity ratio (q/Q) was greater than 1.0).
  - The pipe was surcharged (the depth to diameter (d/D) ratio was greater than 1.0) to within 5 feet of the surface.
  - Piping smaller than 8 inches was not analyzed because the model results do not have enough accuracy to flag deficiencies for smaller-diameter piping.
  - Some piping that slightly exceeded the criteria was not flagged as deficient. For example, large-diameter, shallow piping with minor surcharging or a single flat pipe segment that caused minor backups were not flagged as deficient.
- **Wet weather flows.** Existing RDII was assumed to stay the same for the future. This means that there would be no RDII increase due to sewer deterioration and no RDII decrease due to pipe rehabilitation or replacement.

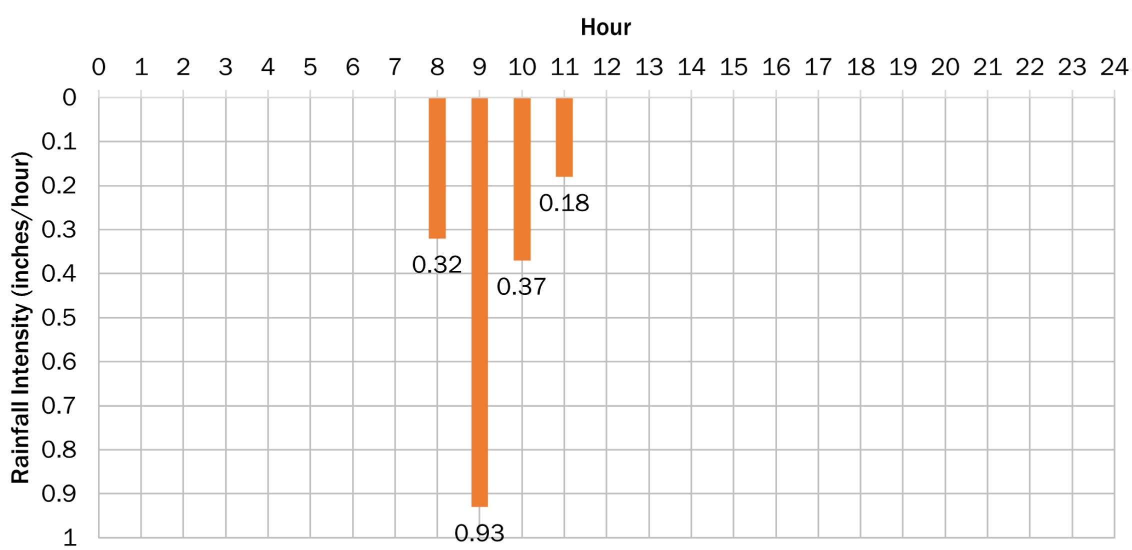

Figure 4-1. Design-storm rainfall

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4.2 Model Flows at WWTP

Figure 4-2 shows the model future, dry weather, and wet weather flows at the WWTP. Existing model flows are not shown because they are almost identical to future flows. As discussed in Section 3.4, additional flows from future developments only slightly increased existing model flows. The curve "Future Wet Weather (with CIP)" in the figure shows higher peak flows at the WWTP after CIP projects that increase pipeline capacity and remove restrictions are added to the model (see Section 4.4 for a discussion of the CIP projects). Table 4-1 summarizes minimum, average, and maximum flows for each condition.

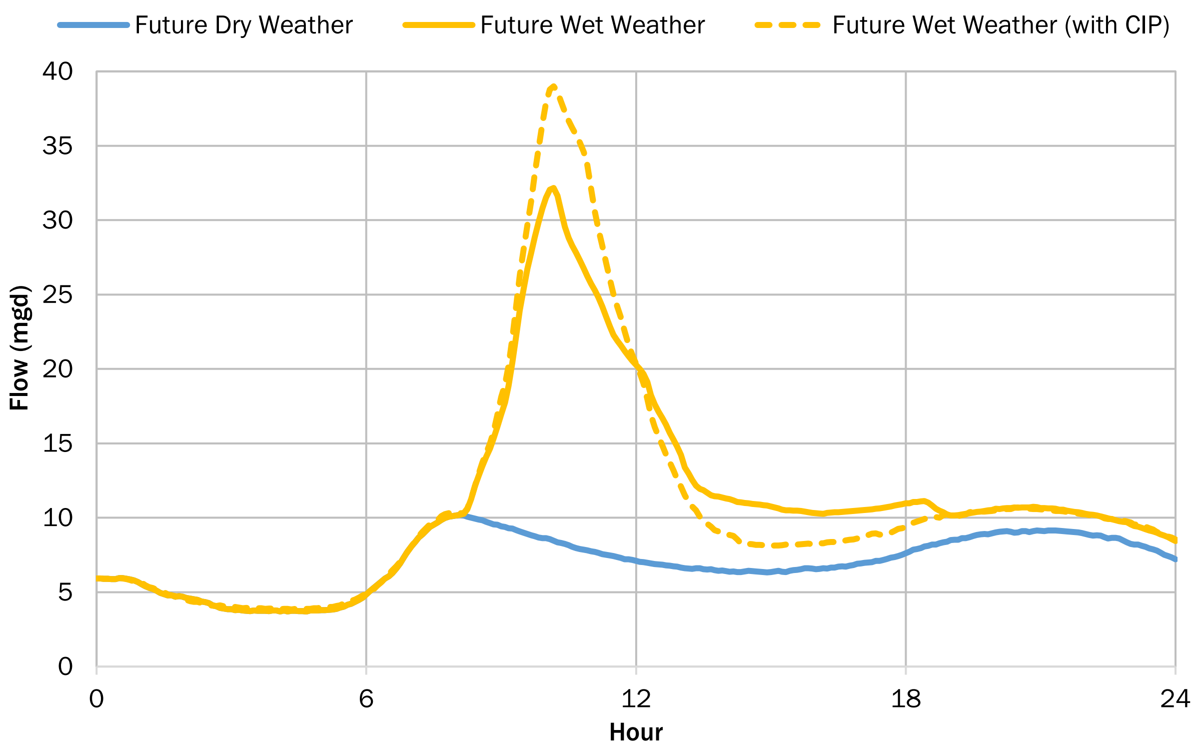

Figure 4-2. Modeled flows at WWTP

Table 4-1. Summary of Model Flows			
Condition		Flow (mgd)	
		Existing	Future
Minimum hour		3.7	3.7
Average day		6.9	7.0
Peak dry weather		9.7	10.2
Peak wet weather (5-yr, 4-hour storm event)	Before implementing CIP projects	32.0	32.2
	After implementing CIP projects	38.8	39.0

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4.3 Analysis Results

The system was evaluated using the criteria listed above for future, dry, and wet weather flows. No issues were found for dry weather flows. Figure 4-3 shows the capacity deficiencies identified by the model for peak wet weather flows. The model predicts several locations of surcharging and sanitary sewer overflows (SSO).

The results shown on Figure 4-3 were reviewed with District staff in November 2021. District staff reported seeing very little evidence of surcharging or SSOs, especially in the Serramonte Center. The District has a smart cover in the Serramonte Center and has not seen the levels of surcharging shown in the model.

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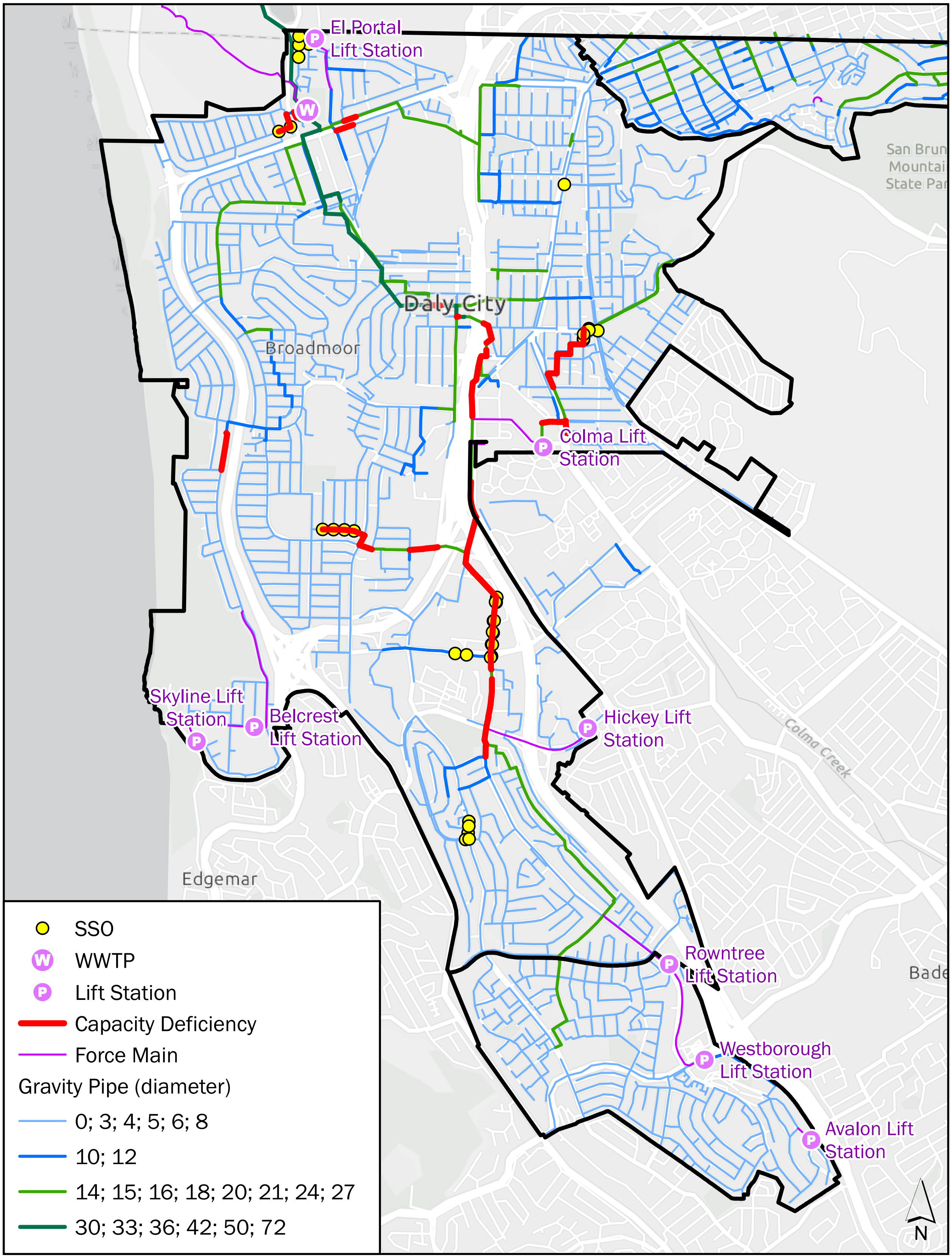

Figure 4-3. Identified problem areas

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4.4 Recommendations

Based on discussions with District staff, it was decided that the model results will not be used for developing CIP projects because the model calibration is based on old flow data and District staff are not seeing the surcharging predicted by the model in the existing collection system. The primary flow data used to calibrate the model is from 2007-2008. Dry weather flows were scaled to actual WWTP flows from 2018, but peak wet weather flows, which cause the deficiencies, were calculated based on 2007-2008 flows and could not be verified using newer data.

Most of the projects identified for improvements from the 2009 model have been constructed. The District decided that the following remaining CIP projects or known deficiencies, which also showed up as deficiencies in the update model, should remain in the CIP for this project:

- **Existing pipe.** An existing 21-inch pipe does not have sufficient capacity. The pipe starts at Southgate Avenue just north of the Serramonte Center, then crosses I-280 to Junipero Serra Blvd. This project was listed as project C-5 for the 2009 modeling (RMC TM 3B, 2009). Figure 4-4 provides the extents of project C-5. The project description included:
  - Project C-5 – I-280 Crossing – New 30" I-280 crossing from Southgate Ave to Junipero Serra (750 feet of 48-inch casing and 275 feet open-cut pipe)
- **Lift stations.** The District noted the following lift station issues during a meeting in November 2021:
  - **El Portal.** The District said that both pumps run at the El Portal lift station during large storms and there have been issues upstream of the lift station. It is recommended that additional flow metering be performed to analyze the capacity of this lift station and the collection system upstream of the lift station.
  - **Skyline.** The District said that the Skyline lift station has backup power but it is worried about losing that backup power during an outage. It is recommended that the District study power requirements and available backup power at this lift station.

4.4.1 Additional Recommendations

Additional recommendations to finish calibrating and analyzing the model include:

- **Field investigation.** The District may want to verify pipe sizes and inverts for areas with discrepancies between the latest GIS and the previous model, including:
  - **The Colma force main.** This force main was 8 inches in the GIS but 12 inches in the 2009 model. As discussed in Table 2-3, the pipe was assumed to be 12 inches because the pump station could not pump flows reported in Table 2-4 when the force main was 8 inches. This size should be verified.
- **Conduct additional temporary flow metering.** Flow metering could be done at the same locations as for the 2009 model. At a minimum, flow metering should be done up and downstream of the deficiencies identified in this project.
- **Recalibrate model.** The model should be recalibrated using new flow metering data.
- **Re-analyze model.** The recalibrated model can then be used to identify deficiencies and identify improvement projects.

Several locations that were identified in the previous RMC evaluation have also been identified as deficiencies in this analysis. Since several of these areas have already had CIP projects in recent years, BC recommends further investigation and flow metering in these areas to validate model results or current system capacity. Among these areas are Southgate Avenue between St. Francis Boulevard and Serramonte Center, and the mainlines upstream of the I-280 crossing between Serramonte Center and Hickey Boulevard.

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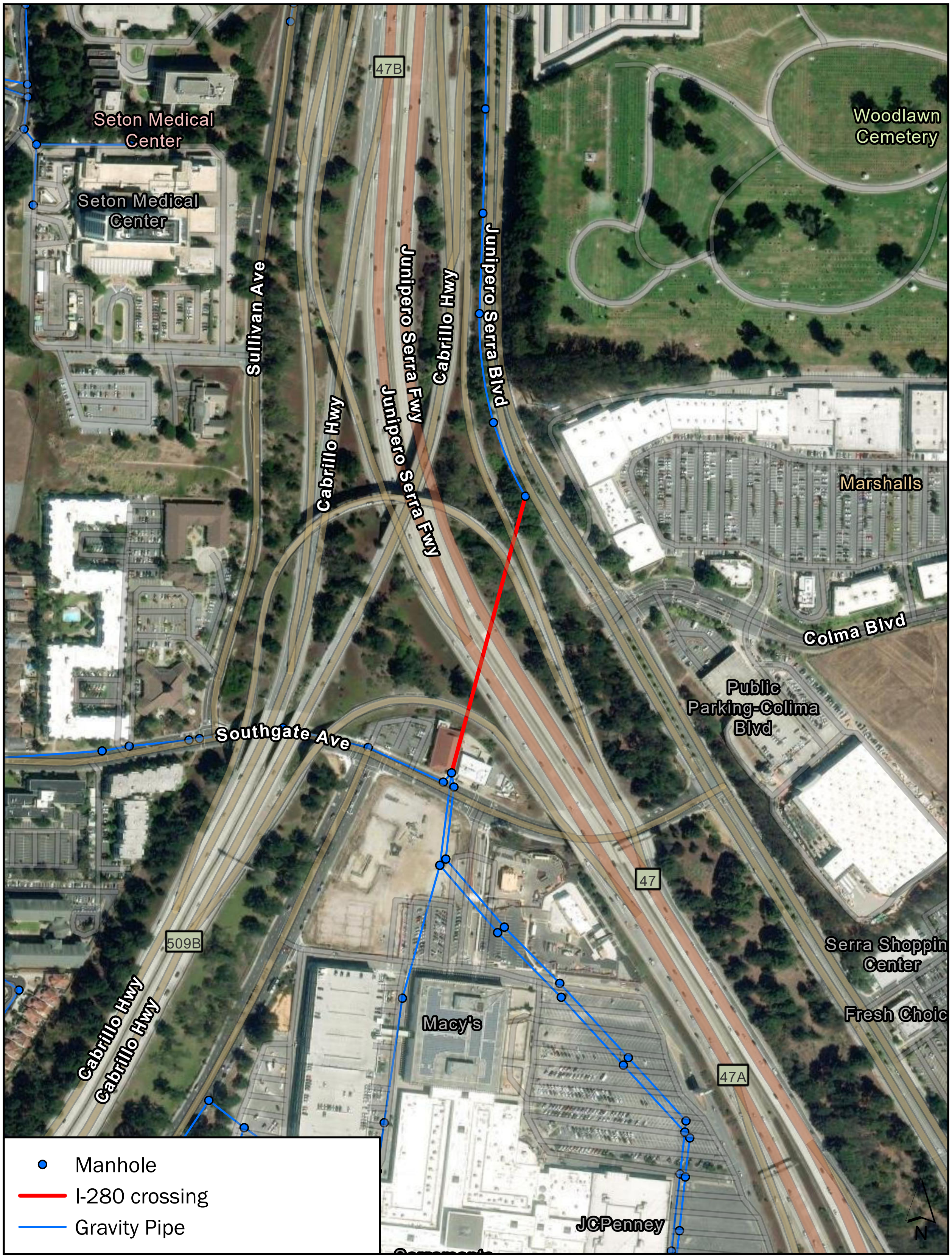

Figure 4-4. Improvement project C-5, I-280 crossing

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Section 5

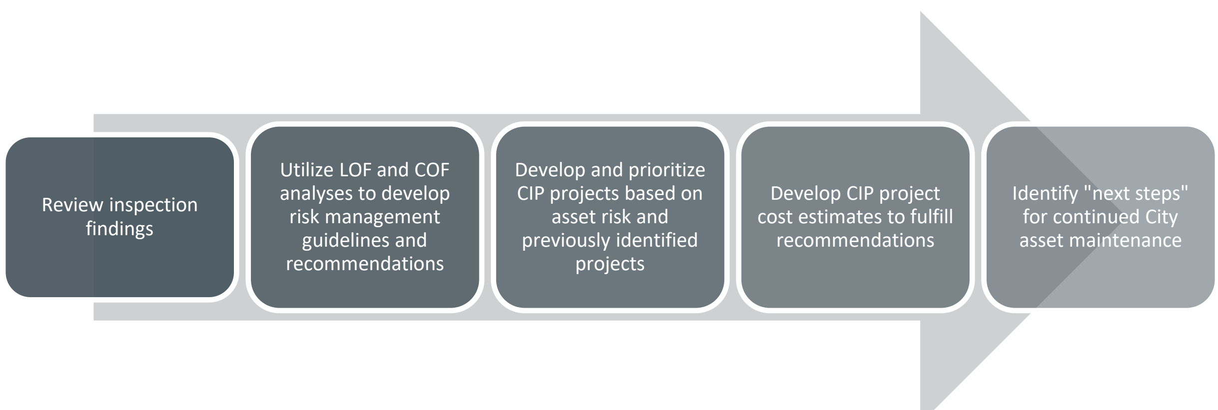
Pipe Risk Analysis

The pipe risk analysis provides the District with priorities for CCTV inspections and projects for the CIP. The final recommendations will be discussed further in the CIP report chapter addressing recommendations, alongside hydraulic capacity evaluation considerations and staff operational experience considerations.

In this desktop risk analysis, BC analyzed the relative risk of failure for each of the District's sewer gravity pipeline segments by performing a likelihood of failure (LOF) and consequence of failure (COF) analysis. Understanding the relative risk of failure for various sewer pipeline sections is critical to effectively plan sewer CIP projects by prioritizing the highest-risk projects. BC is working closely with District staff to develop an appropriate failure ranking and weighting system to predict risk of failure. In general, overall risk of failure was determined by considering pipe characteristics (age, material, depth, location, condition, etc.), internal pipe video inspection findings, and criticality of the pipe or service location (large diameter, critical infrastructure, road type, difficult access, pipe depth, etc.).

5.1 Objectives

The collections system pipe risk analysis provides the District with applicable sewer condition and risk information to support CIP project prioritization. Steps associated with this report are presented below.



5.2 Inspection Condition Assessment

Understanding the internal pipe condition (presence of structural and operation and maintenance [O&M] defects) is critical to understanding asset condition and LOF. The District recently updated its computerized maintenance management system (CMMS) program, which resulted in a disconnect from historical CCTV inspection; therefore, BC had only 2 years of Pipeline Assessment and Certification Program (PACP)-certified CCTV data to incorporate into the risk analysis.

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Inspection Results

BC received a PACP database containing data for 484 pipe inspections performed between August 2018 and October 2021. These 484 inspections were associated with 99,000 linear feet (LF) of sanitary sewer pipe. BC checked connectivity between the inspection database and the pipe data in the District's GIS and resolved 10 connections. There are 409 pipes associated with those inspections (some pipes received multiple inspections). The defect coding section below describes the inspection scoring methodology.

Defect Coding

The District provided the inspection data in a National Association of Sewer Service Companies (NASSCO) PACP-compliant format, which provides sewer pipeline conditions and identifies defects.

The defect coding of pipelines typically consists of:

- Identifying defects along each pipeline segment through visual inspection
- Assigning individual grades to each defect based on type and severity
- Developing an overall condition grade for each pipeline segment by assessing type and number of defects along the pipeline segment
- Assigning a final condition rating to each pipeline segment based on the condition grades and the potential for further deterioration and/or failure

Under PACP, defects are categorized as either structural or O&M related. Structural defects are those that directly impair the pipeline's structural condition, such as joint separation, joint deflections, cracks, fractures, broken and collapsed pipe or wall, corrosion, worn inverts, and sag conditions. Structural defects are those that are typically addressed through repairs, rehabilitation, or replacement. O&M defects include a range of conditions that can either directly affect the sewer's performance or are indicators of potential future structural defects. O&M conditions include debris, grease, infiltration, intrusions (root or service laterals), and hydraulic problems. O&M defects are typically addressed through maintenance, although some (such as infiltration) may require additional rehabilitation.

In general, PACP grades range from 1 to 5, with 1 being a minor defect grade and 5 being the most significant defect grade. Table 5-1 provides a description of the defect related to the condition grade it receives.

Table 5-1. Structural Condition Grade Implications

Condition Grade	Condition Rating	Defect Description
1	Mild	Minor defects
2		Defects that have not begun to deteriorate
3	Moderate	Moderate defects that will continue to deteriorate
4	Severe	Severe defects that will become Grade 5 defects within the foreseeable future
5		Defects requiring attention soon

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When rating a pipe's condition, three factors best characterize the inspection results:

- **Structural Peak Score.** The highest rated condition grade for structural defects present in a pipe
- **O&M Peak Score.** The highest rated condition grade for O&M defects present in a pipe
- **Peak Score.** The greater of structural peak score and O&M peak score

Table 5-2 presents the peak scores by pipe diameter as determined from CCTV inspection. "No Score" means defect codes that are not typically associated with a defect score, such as AMH (manhole) or MWL (mean water level), which are observations rather than defects.

Table 5-2. Peak Structural and O&M Scores by Pipe Diameter (CCTV)

Pipe Diameter (inches)	Peak Score	Total Pipe Length (feet)
6 and less	No Score	35,324
	1	3,328
	2	4,415
	3	9,758
	4	11,678
	5	12,597
8 to 12	No Score	10,027
	1	1,255
	2	1,529
	3	2,433
	4	2,529
	5	2,629
14 to 18	No Score	855
	1	226
	2	-
	3	563
	4	109
	5	-
Unknown	No Score	-
	1	-
	2	-
	3	98
	4	18
	5	-
Total	-	99,371

A map of the overall peak score by pipe segment can be found on Figure 5-1.

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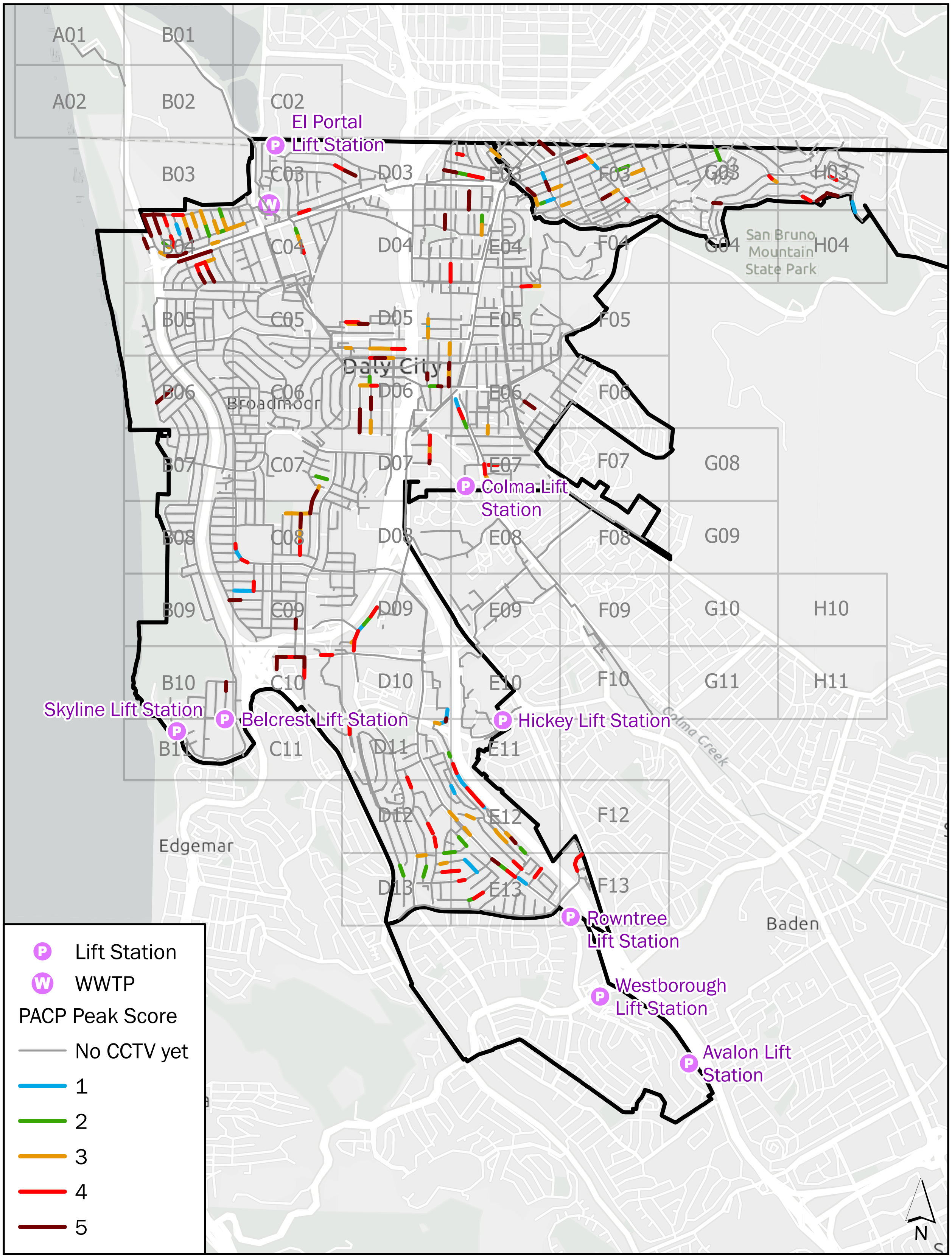

Figure 5-1. Overall PACP peak score

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The "No Inspection Data" category refers to pipes without PACP-coded inspections. Per the June 17, 2021, workshop with District staff, half of the system pipelines may have inspections on an older database; that data was unavailable at the time of this report. Section 5.9 of this report provides a CCTV prioritization plan based on risk.

Quality Control Review

Following CCTV inspection, the CCTV database was imported into InfoAsset Manager (IAM) to compare CCTV data to existing GIS data. After the import, several quality control (QC) queries were performed to confirm that CCTV data was appropriately matched with existing GIS data. For example, a conflict between CCTV data and GIS data can occur when a new structure is found in the field, or when CCTV inspection verifies that a structure in the GIS does not to exist. Once QC in IAM was completed, the data with updated manhole and pipe connectivity (as confirmed by CCTV) was exported for use in InfoAsset Planner (IAP) for the risk assessment.

5.3 Desktop Condition Assessment Task

BC prepared a desktop condition assessment analysis to assess asset risk for all pipe segments. The overall risk of pipeline failure considers both the *likelihood* that an asset is unable to provide its intended function, as well as the *consequence* or impacts resulting from an asset's failure.

Overall LOF and COF scores were determined by considering both factor ratings and factor weightings. The LOF factor rating predicts how likely an asset is to fail; the consequence factor rating predicts how consequential an asset failure would be. Assigned factor ratings range between 1 and 5, with 1 being the least likely to fail/least consequential and 5 being the most likely to fail/most consequential.

BC's analyses assigned the likelihood/consequence factor weighting value, which reflects the relative importance of a specific factor category compared to other factor categories. More-critical factors naturally receive greater weighting values than less-critical factors.

The following equations provide the basis for determining risk scores.

$$\text{Risk} = \text{LOF Score} \times \text{COF Score}$$

$$\text{LOF Score} = \sum (\text{LOF Rating} \times \text{LOF Weighting})$$

$$\text{COF Score} = \sum (\text{COF Rating} \times \text{COF Weighting})$$

Figure 5-2. Risk equations

The ∑ symbol represents a sum of each factor.

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5.4 Likelihood of Failure

The LOF analysis predicts the likelihood that an asset is unable to provide its intended function. It is determined by assigned ratings and weightings. BC evaluated the District's wastewater pipelines using factors typical for desktop risk analysis and eliminated factors not relevant to the District.

The evaluation considered asset characteristics, asset condition, and asset location during the LOF analysis. In all cases, BC assigned items with unknown data medium risk. Specifically, BC used the following factors (data sources included in parentheses):

- **Pipe Age.** In general, as a pipe ages, it has a higher likelihood to fail. (Pipe age provided by District GIS.)
- **Pipe Material.** Different pipe material has different life expectancy and failure modes. Table 2-2 provides a summary of the District's pipe materials. (Pipe material provided by District GIS.)
- **Structural Condition, if available.** This includes known structural defects. (Defects based on 2018-2021 CCTV inspections.)
- **Presence of Pipe Obstructions, if available.** Includes known O&M-related defects, including roots, grease, debris, infiltration, etc. (Defects based on 2018-2021 CCTV inspections.)
- **Required Pipe Cleaning Frequency.** Pipes requiring higher cleaning frequency often experience problems when not maintained; however, the act of cleaning (with high-pressure jets of water at a minimum) can cause premature failure and inadvertently remove the top layer of potentially corroded concrete or metal pipe. (Cleaning frequency provided by the District.)
- **Proximity to Earthquake Faults.** Pipes located within 500 feet of the San Andreas Fault Zone or Serra Fault Zone are rated higher likelihood to fail. This factor also accounts for the impact of smaller seismic events on pipe structural integrity. Per California Geological Survey's Fault Evaluation and Zoning Program, the policy since 1977 is to position fault zone boundaries about 500 feet from major active faults and about 200 to 300 feet from well-defined, minor faults. While the Serra Fault Zone is not active and San Andreas Fault zone is active, both are given a buffer of 500 feet in this analysis to remain conservative. (The quaternary fault zone GIS layer was downloaded from the USGS website.)
- **Local Geology (Liquefaction).** A liquefaction layer provided soil resiliency ratings to seismic events. This factor accounts for the impact of smaller seismic events on pipe structural integrity. (The liquefaction layer was downloaded from the USGS website.)

BC also reviewed the following LOF factors but decided not to include them in this risk evaluation for the reasons stated:

- **Pipe Capacity.** Pipe capacity is not considered as an LOF factor in this analysis due to uncertainty with the data.
- **Sanitary Sewer Overflows or CMMS.** Work orders were considered but the current dataset is too small and could skew the data.
- **Soil factors (corrosion and erosion).** These factors are mostly relevant to metal pipes, but most wastewater pipes in the system are vitrified clay pipe (VCP) (not metal). On the USGS soil map, small areas have a moderate level of corrosivity or erosivity; however, there are no metal pipes in those areas.
- **Landslide.** There were no significant landslide threats identified.

Details and scoring basis for each factor are listed in Table 5-3.

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Table 5-3. LOF Factors and Ratings

Broad Category	LOF Factor	LOF Rating 1 (Least Likely to Fail)	2	3	4	5 (Most Likely to Fail)	Factor Weighting
Asset Characteristics	Age (Installation Year)	Installed after 2000	Installed between 1985 and 1999	Installed between 1970 and 1984	Installed between 1955 and 1969 OR Unknown (most common – 65 miles out of 144 miles)	Installed before 1954	15%
	Pipe Material	PE, PVC	-	VCP	RCP (lined)	RCP (unlined), DIP, terracotta	20%
Asset Condition	Structural PACP Grade/Defect Type [a]	Grade 2 defect(s) or lower	Grade 3 defect(s)	One Grade 4 defect	One Grade 5 defect or multiple Grade 4 defects	Multiple Grade 5 defects	20%
	O&M PACP Grade	Grade 2 defect(s) or lower	Grade 3 defect(s)	One Grade 4 defect	One Grade 5 defect or multiple Grade 4 defects	Multiple Grade 5 defects	15%
	Required Pipe Cleaning	-	-	greater than 12 months OR No record of cleaning	6-12 months cleaning	Historically has required cleaning more frequently than every 6 months	20%
Asset Location	Proximity to Earthquake Faults	Not within fault area	-	-	-	Crossing or within 500 feet of fault line	5%
	Likelihood of Liquefaction	Very low	Low	Medium	High	Very High	5%

a. It is assumed that the most severe structural and O&M defects have been resolved. Note that there are approximately 19 miles of CCTV inspections (around 10% of the system).

DIP = ductile iron pipe, PE = polyethylene, PVC = polyvinyl chloride, RCP = reinforced concrete pipe

5.5 Consequence of Failure

The COF analysis predicts the impact resulting from the failure of an asset by assigned ratings and weightings. COF categories capture both community impacts and cost of replacement.

In a similar fashion to the LOF analysis, the COF factors selected for analysis are typical for desktop risk analysis of sewer renewal/replacement projects. Additional COF factor descriptions and data sources are provided below:

- **Sewer size (pipe diameter).** Larger-diameter pipes are more expensive to replace and provide a greater service area than smaller-diameter pipes (pipe diameter provided by District GIS).
- **Critical pipes.** Pipes that are considered critical to the collection system typically include pipes that if isolated would result in a service outage to a specific area, east- to-westside connections, limited redundancy, interstate crossings, or complicated repairs, or are a critical customer. District staff considered critical pipes to be:
  - All force mains
  - All mains larger than 12 inch (over 13 miles of piping)
  - All freeway/highway crossings (2 miles of piping)

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  - All overflow piping to neighboring systems (1 mile of piping)
- **Road type.** Different road types, such as arterial or highway, will impact more people than a neighborhood street; therefore, pipe intersections with major traffic conveyance routes, such as the Bay Area Rapid Transit (BART) Daly City station, freeways, state routes, arterial streets, or major roads were determined. The GIS used for major roads was downloaded from the San Mateo County GIS. The BART GIS was downloaded from the BART website and a buffer of 800 feet was applied to the geocoded coordinate point to capture the frontage and segments adjacent to the frontage. A buffer of 35 feet was applied to the major roads layer to capture potential overflow impact and GIS alignment differences between the road type and pipe layers.
- **Difficult access.** District staff provided a .PDF map markup of the pipes with difficult access. Approximately 7 miles of pipe are difficult to access.
- **Pipeline depth.** In general, the deeper the pipe, the more difficult it is to replace due to trenching and shoring requirements. BC calculated pipe depth by subtracting pipe inverts from manhole rim elevations (where available) from District GIS. BC also corrected obvious typos and did not use anomalous depths (for example, depths over 100 feet). BC then used the maximum depth of the calculated upstream or downstream depth. These calculated values are only estimates, as both the invert and rim elevations had been rounded to the nearest foot.

Details and scoring basis for each factor are elaborated in Table 5-4.

Table 5-4. COF Factors and Ratings for the Wastewater System

Broad Category	COF Factor	COF Rating: 1 (Negligible Consequence)	2 (Minimal Consequence)	3 (Moderate Consequence)	4 (Severe Consequence)	5 (Critical Consequence)	Factor Weight
Service Interruptions and Overflow Potential	Diameter	6 inches and less	8 to 12 inches and unknown diameter	14 to 18 inches	20 to 24 inches	Greater than 24 inches	25%
	Critical Pipes	Not critical				Critical with no redundancy	25%
Transportation/ Transit	Road Type [a]	Neighborhood streets (<30 mph)	Collector streets (<=45 mph)	Arterial streets (<=60 mph)	Expressway or state routes	Freeway OR within 50 feet of BART track	25%
Response Time	Difficult Access	No				Yes	15%
Pipeline Cost	Pipeline Depth [b]	0-4 feet	4-8 feet or unknown	8-12 feet	12-16 feet	More than 16 feet	10%

a. *The roads layer doesn't necessarily coincide with pipes. Selected "intersection" with a 50-foot buffer in InfoAsset. Speed limit was used as a proxy for impacts to transportation given data limitations. Assumed neighborhood streets = <30 mph, collector streets =<45 mph, arterial streets =<60 mph. Expressways, state routes, and freeways as identified in road name.*

b. *The average maximum depth (between upstream and downstream depths) is 7.7 feet. As such, pipes with unknown depth were assigned a depth of 4 to 8 feet, or a COF score of 2 for the depth factor.*

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5.6 Asset Risk

After the LOF and COF rating and weighting were determined for individual factors, an overall LOF and COF score was determined by summing the factor scores. Combining the two overall scores determines the overall asset risk (Risk = LOF x COF).

BC performed a desktop risk assessment using Innovyze's IAP program, which is a GIS extension tool. Using the criteria described previously, the tool predicts the relative probability that each asset could fail (LOF) and the relative consequence of its failure (COF) based on its GIS data and spatial interaction with other GIS layers.

For example, for the assessment of earthquake fault threat, the tool computed pipe proximity to faults for each of the 13,941 District pipes (212 miles) and assigned a score of 5 if it was within 500 feet of a fault (per the California Fault Program's policy described in Section 5.4) or a score of 1 if it was not within the threat area. Likewise, COF analysis determines the severity of each asset if it fails. The tool scores each pipe for COF based on asset data, such as diameter and proximity, to other GIS layers, such as road type. Once the user defines the rating (1 through 5) for each factor and weighting of these factors relative to one another, the tool produces a holistic risk score for each pipe GIS asset.

5.7 District Input

This section describes two workshops that were held to discuss the wastewater pipe risk assessment.

Workshop 1

On June 17, 2021, District staff and BC conducted a risk assessment workshop. The workshop provided an opportunity to present an overview of the risk assessment approach and preliminary results, and to receive District input regarding specific risk assessment criteria and weighting. Following the workshop, BC sent the presentation slides and meeting notes for the District to discuss internally.

Workshop 2

On September 14, 2021, District staff and BC conducted a risk assessment review call. The call was to review the risk analysis section and to receive District input on criteria and on pipe material description and historical performance, and to identify remaining data items that could improve the analysis. Following the call, District staff provided BC with additional CCTV from April through October 2021 and .PDF map markups that provided planned pipe replacement projects, terracotta pipe locations, pipes with difficult access, and critical pipes. Following the workshop, BC updated the analysis accordingly.

5.8 Sensitivity Analysis

With the LOF and COF criteria finalized and preliminary weighting of the relative impact of each factor determined, BC conducted a sensitivity analysis. The factor weightings were adjusted using engineering judgment to evaluate pipe risk against various weighting scenarios to determine which pipes are consistently evaluated to be high or extreme risk. The final weighting scenarios are as presented previously in Tables 5-3 and 5-4.

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5.9 Risk Assessment Results

Overall LOF and COF score assignments were determined for all pipe segments based on the criteria outlined in the Likelihood of Failure and Consequence of Failure sections in this report (5.4 and 5.5, respectively). A total risk score was then determined from the product of the overall LOF and COF scores, which was normalized from 1 (negligible risk) to 5 (extreme risk). This GIS dataset was then imported to an ArcGIS Online dashboard as seen on Figures 5-3 and 5-4. Understanding the relative risk of failure for various sewer pipeline sections is critical to effectively plan a risk-based CCTV prioritization plan as well as sewer CIP projects by prioritizing the highest-risk projects. BC will provide the District with access to the dashboard as part of this project.

Figure 5-5 presents the risk scores for all gravity main pipelines.

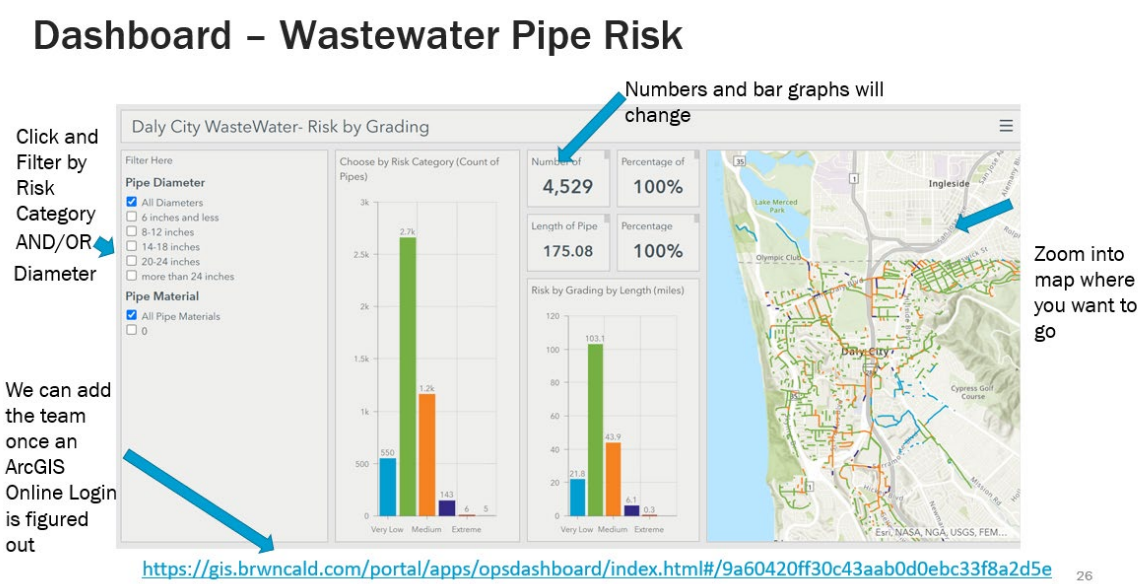

Figure 5-3. ArcGIS online dashboard guide

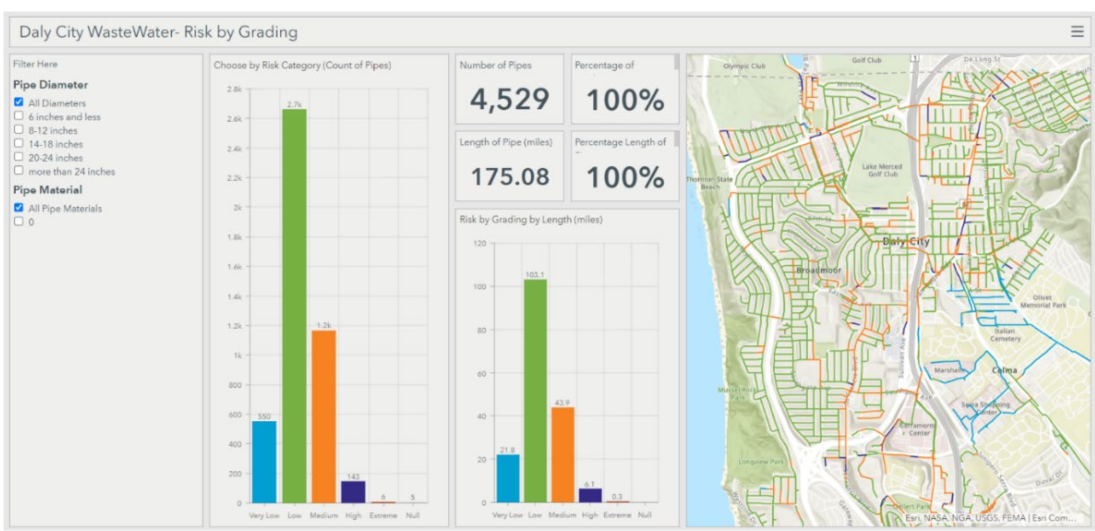

Figure 5-4. ArcGIS online preliminary dashboard

Brown AND Caldwell

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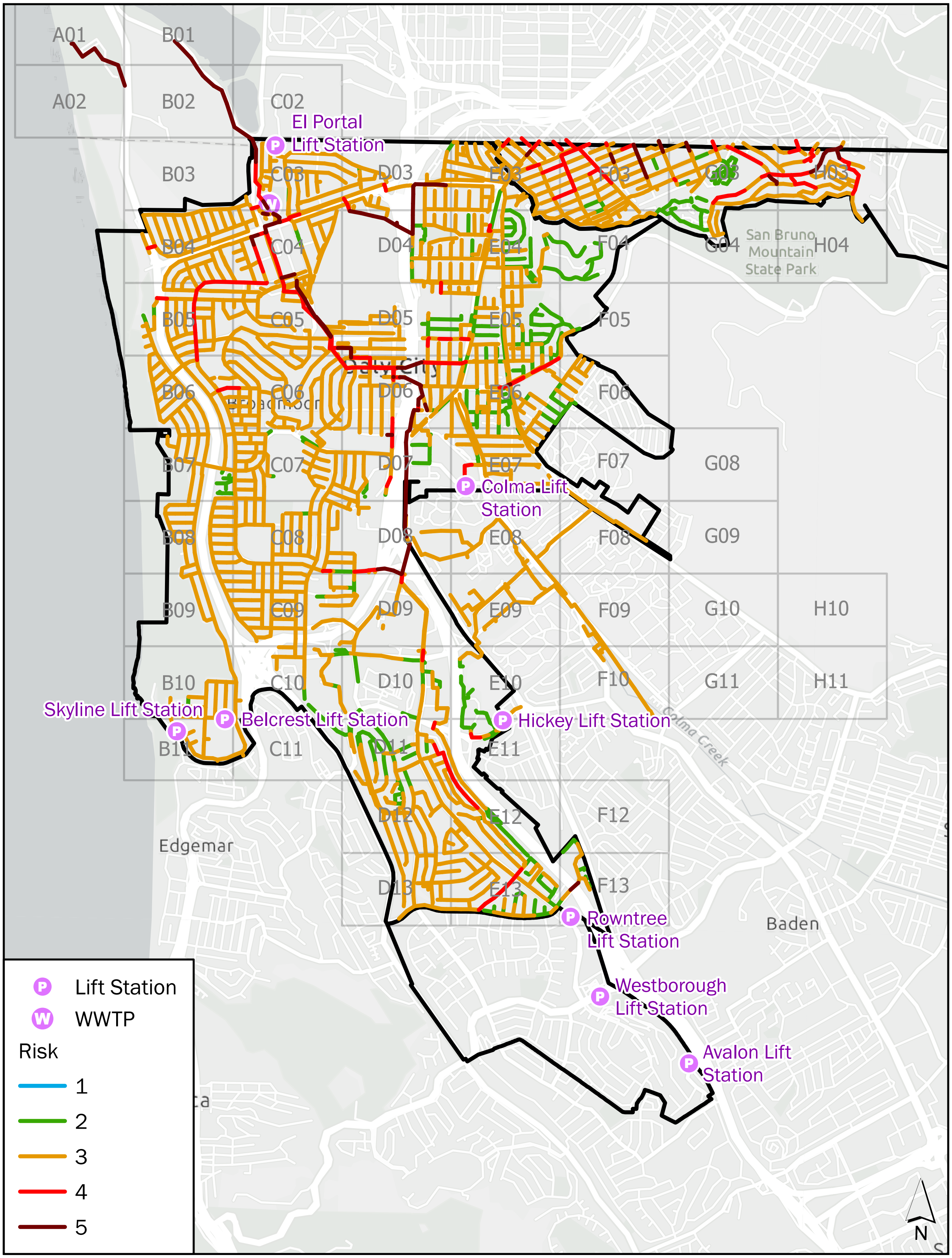

Figure 5-5. Asset risk rating

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Risk Analysis Details

A risk matrix for the pipe segments is presented in Table 5-5. The risk grades were derived from the LOF-COF pairing on the matrix, with the bottom left tile representing the subset of pipes with the least risk while the top right tile represents the subset of pipes with the most risk. Risk categories are colored in the table as follows:

- Light blue – Negligible risk
- Green – Low risk
- Peach – Medium risk
- Magenta – High risk
- Dark Red – Extreme risk

Pipe rehabilitation and future CCTV survey inspection recommendations were prioritized by pipe risk category.

Table 5-5. Pipeline Risk LOF COF Matrix

	Number of Pipes, Miles of Gravity Piping				
	LOF Low	LOF Medium Low	LOF Medium	LOF Medium High	LOF High
COF - High	0 pipes, 0 miles	0 pipes, 0 miles	50 pipes, 1.6 miles	107 pipes, 4.5 miles	10 pipes, 0.5 miles
COF – Medium High	3 pipes, 0.1 miles	0 pipes, 0 miles	62 pipes, 2.3 miles	157 pipes, 5.7 miles	29 pipes, 1.0 miles
COF - Medium	0 pipes, 0 miles	0 pipes, 0 miles	15 pipes, 0.4 miles	45 pipes, 1.6 miles	23 pipes, 1.0 miles
COF – Medium Low	2 pipes, 0.1 miles	2 pipes, < 0.1 miles	68 pipes, 2.3 miles	204 pipes, 7.9 miles	89 pipes, 3.4 miles
COF - Low	3 pipes, 0.1 miles	1 pipe, 0.1 miles	505 pipes, 16.4 miles	2516 pipes, 101.0 miles	633 pipes, 24.9 miles

Figure 5-6 provides the risk distribution for the pipe segments. Most of the pipe segments are classified as medium risk; 0.2% of pipes are negligible (scoring 1 of 5) or low risk (2 of 5).

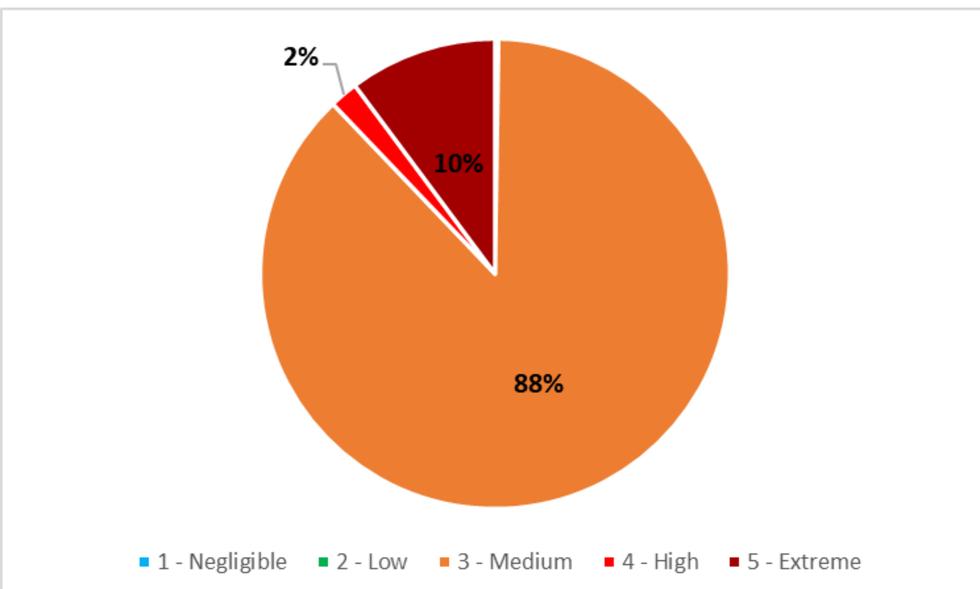

Figure 5-6. Pipeline risk distribution by length of pipe

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Risk scores for each pipe segment are in the GIS that will be delivered to the District at the end of this project.

5.10 Recommendations

This section provides the recommendations for required system improvements. The recommendations are shown in the following groups of projects, which are described below:

- Pipe rehabilitation based on desktop condition assessment and CCTV inspection results
- Collection system inspection through recommended CCTV surveys
- Programmatic replacement of high-risk terracotta pipes

Preliminary CIP actions based on risk and inspection are provided in Figure 5-7. Additionally, should there be a seismic event, the City should inspect pipelines at seismic risk (crossing or within 500 ft of a fault line).

5.10.1 Pipe Rehabilitation

Pipeline rehabilitation projects are summarized in Table 5-6 by rehabilitation action and length. Approximately 23,000 LF of pipe is recommended for rehabilitation based on PACP inspection results included in this study. Appendix A discusses the pipe rehabilitation decision tool. Appendix B provides the full list of pipes requiring rehabilitation.

Table 5-6 Preliminary Recommend Pipe Rehabilitation Actions

Preliminary Recommended Rehabilitation	Total Pipe Length (feet) [a]
Full cured-in-place-pipe (CIPP)	2,737
Point Repair Excavation(s)	3,285
Replace	5,197
Sectional Liner(s)+Point Repair Excavation(s)	5,117
Sectional Liner(s)	6,488
Total	**22,824**

a. Total pipe length refers to the length of piping needing the recommended rehabilitation, not the length of needed repairs.

5.10.2 Collection System CCTV Inspection

BC recommends that the City inspect pipes without existing CCTV inspection data over the next 10 years. This should focus on pipes with a risk rating of 3, 4, or 5. This can be accomplished through in-house inspection (as performed for this project) or through outside contractors, or a combination of the two methods. Approximately 730,000 LF of pipes are recommended for CCTV inspection. The District should prioritize the inspections based on the risk scores provided that will be provided in a GIS format.

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5.10.3 Programmatic Replacement

Through discussions with the District and review of the risk model, BC developed a programmatic replacement project for high-risk terracotta pipes in some of the oldest parts of the District's collection system. This includes all terracotta pipes in the system with a risk score of 4 or 5. Table 5-7 summarizes the terracotta pipe risk distribution. Approximately 12,800 LF of terracotta pipe is recommended for replacement over the next 10 years.

Table 5-7. Programmatic Terracotta Pipe Replacement

Risk	Total Pipe Length (feet)
4	3,100
5	9,700
Total	**12,800**

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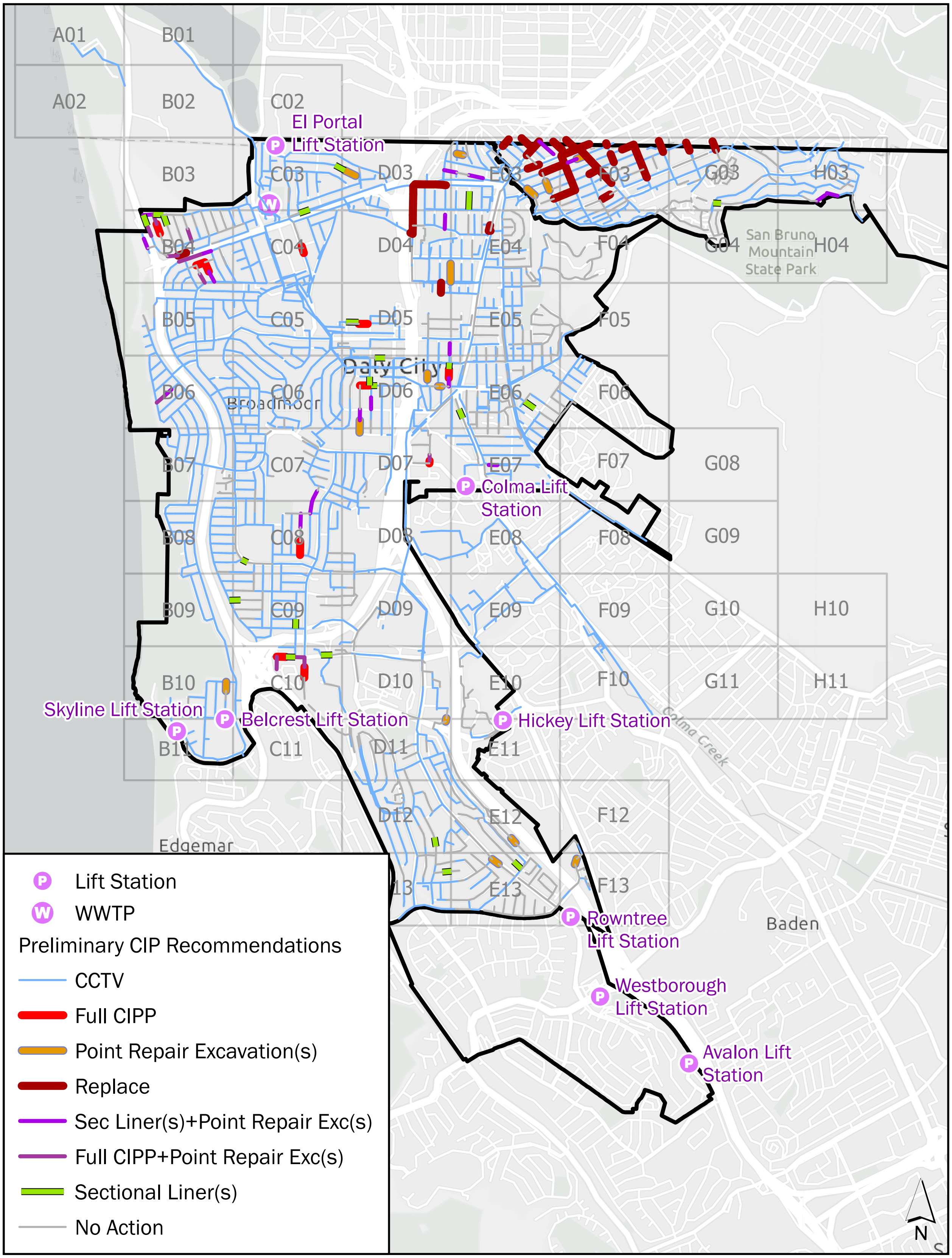

Figure 5-7. Preliminary condition assessment-based rehabilitation and CCTV recommendations

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Section 6

Capital Improvement Plan

This section recommends a CIP to improve the performance of the District's wastewater collection system and reduce the risk of SSOs.

This section is organized into the following subsections:

1. Project Development and Prioritization
2. Construction Costs
3. Capital Improvement Plan

6.1 Project Development and Prioritization

CIP projects are based on capacity-related surcharging as identified in Section 4 and on condition and risk-based projects identified in Section 5.

6.1.1 Capacity Improvement Projects

Capacity improvement projects are based on the results of the hydraulic assessment and are intended to provide hydraulic capacity in the system for the design storm condition. Section 4 identified hydraulic deficiencies by pipe reach and highlighted those that were deemed critical at this time. As previously discussed, the CIP will only include one capacity improvement project at this time due to a lack of confidence in the 2008 flow monitoring data.

6.1.2 Condition and Risk-based Projects

Condition-based projects are based on the results of the condition assessment discussed in Section 5. Preliminary repair recommendations were made based on the observed defects. Prior to implementing a proposed repair recommendation, District staff should review the CCTV to confirm that recorded defects match the observed pipe condition.

Only one risk-based project was identified for implementation at this time, which is replacement of high-risk terracotta pipes as identified in Section 5.

The City will identify new condition-based projects as CCTV progresses. BC recommends the District evaluate new CCTV data and develop rehabilitation projects periodically (e.g., annually, every 5 years, every 10 years).

6.1.3 Other Recommendations

Several other projects, discussed in Sections 4 and 5, are not construction projects but are included in the CIP under Other Recommendations. These projects include additional CCTV and condition assessment work and addition flow monitoring and model recalibration. A project for lift station condition assessments was also included in the CIP. Lift station condition assessments were not performed as part of this project.

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6.1.4 Project Prioritization

Hydraulic- and condition-related construction projects were prioritized using the risk model described in Section 5. Projects located on pipes receiving a risk score of 3 were categorized as medium priority. Projects located on pipes receiving a risk score of 4 or 5 were categorized as high priority. High-priority projects should be completed in the next 3 to 5 years. Medium-priority projects should be completed in the next 10 years. As discussed in Section 6.3, each CIP project was listed as either a medium- or high-priority project.

6.2 Total Project Costs

This section describes the development of construction and capital costs for recommended improvement projects. Construction costs are based on recent bid tab unit costs, which are discussed below.

6.2.1 Construction Costs

Pipeline construction costs were developed based on planning-level unit costs and preliminary pipeline lengths and diameters. Planning-level unit costs were developed from bid tabs from recent pipeline construction projects, details of which can be found in Appendix C. A detailed cost estimate for the I-280 sewer crossing is found in Appendix D. Unit costs for sanitary sewer replacement include mobilization; demobilization; traffic control; normal sheeting, shoring, and bracing; excavation and typical dewatering; standard manholes at typical intervals; lower lateral and cleanout at typical intervals; typical surface restoration; erosion, sediment, and stormwater control; overhead; and profit.

6.2.2 Other Costs

Contingency. A contingency of 35 percent was added to the planning-level costs to obtain planning-level construction costs. Planning-level projects have inherent uncertainties, and it is appropriate to include a contingency allowance to cover the potential for additional construction costs. Uncertainties associated with planning-level projects include unexpected geotechnical conditions, extraordinary utility relocation, alignment changes, and permitting.

Engineering and Administration. A 35 percent allowance was added to the planning-level costs to account for design, construction services, administration, legal and environmental services, and construction change orders. Engineering services associated with projects are estimated at 15 to 17 percent of the construction cost and include preliminary investigations and design services, site and route surveys, geotechnical explorations, preparation of drawings and specifications, construction services, surveying and staking, and materials sampling and testing. Administrative charges are estimated at 8 to 10 percent of the construction cost and include administrative costs, legal and environmental services, financing expenses, and interest during construction. A 10 percent allowance is also included for unforeseen construction change orders. The total allowance for engineering, administrative, and change orders costs is 35 percent of the construction cost.

6.3 Capital Improvement Plan

The CIP is presented in Table 6-1 and Figure 6-1. Appendix B provides detailed project descriptions for pipes requiring rehabilitation and include manhole numbers, pipe lengths, diameters, and project costs.

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Table 6-1. CIP Summary				
Priority	Description	Construction/ Cost	Engineering and Administration	Total Project Cost
Hydraulic Capacity Projects				
High	I-280 Sewer Crossing	$6,210,000	$2,174,000	$8,384,000
Condition Assessment Projects				
Medium	Pipeline Rehabilitation	$1,814,000	$635,000	$2,449,000
Risk-based Projects				
High	Terracotta Replacement	$6,672,000	$2,335,000	$9,007,000
Other Projects				
	Pipeline CCTV Inspection	$2,950,000	$1,033,000	$3,983,000
	Flow Monitoring and Model Update	$250,000	$88,000	$338,000
	Lift Station Condition Assessment	$100,000	$35,000	$135,000
	Skyline Pump Station Power Study	$50,000	$18,000	$68,000
	Grand Total	$18,046,000	$6,318,000	$24,364,000

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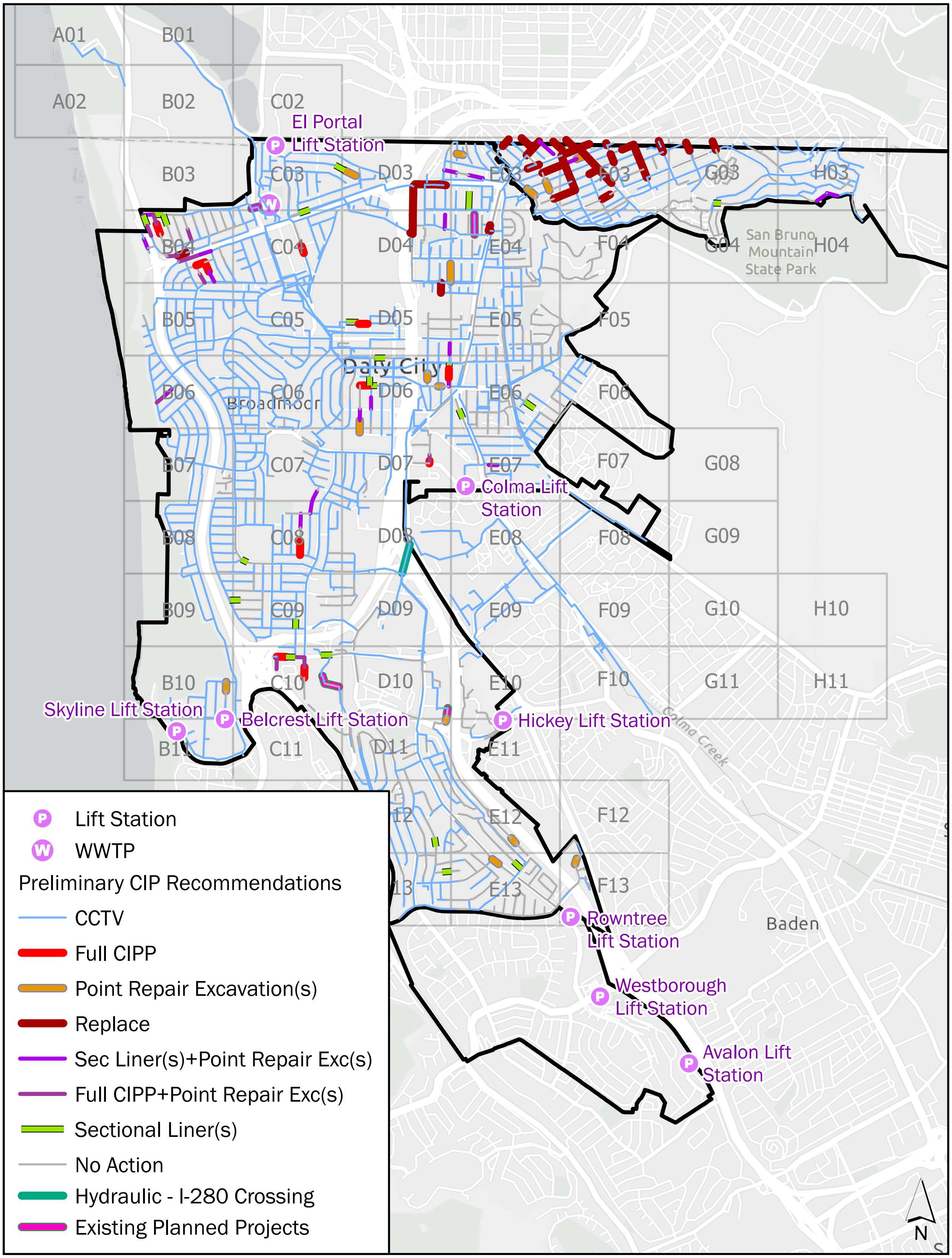

Figure 6-1. Capital improvement plan

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Section 7

References

Brown and Caldwell, *2020 Urban Water Management Plan*, June 2021.

Brown and Caldwell, *Near- and Long-Term Water Resources Planning*, July 2012.

City of Daly City, *Current Residential Project List*, https://www.dalycity.org/DocumentCenter/View/4567/Current-Projects-List-Updated-01-01-21-PDF?bidId=, January 2021.

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Weather Underground, Brentwood (KCASOUTH97) gauge in South San Francisco, CA, https://www.wunderground.com/dashboard/pws/KCASOUTH97, downloaded December 2020.

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Appendix A: CCTV and Rehabilitation Decision Process

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Appendix A

CCTV and Rehabilitation Decision Process

This appendix describes the rehabilitation decision process. Figure A-1 provides the decision process flow chart.

First, terracotta pipes with a risk score of 4 or 5 (out of 5) are recommended for replacement.

Next, pipe segments without inspection data were evaluated for CCTV prioritization based on risk and diameter. Pipe segments with a risk rating of medium of greater (three of five or greater) were recommended to be surveyed. In addition, large diameter pipes (24-inch diameter pipe or larger) of any risk rating were recommended to be surveyed.

For pipe segments with survey data, a two-part process determined a pipe’s final rehabilitation recommendation. First, defect-level rehabilitation methods such as point repair, lining, or no action (blank) were selected for each defect. Second, a decision tree was prepared that determined the pipe rehabilitation recommendation by analyzing the following:

- CCTV structural peak score and overall peak score
- Number of point repairs and lining recommendations (output) by the defect-level rehabilitation methods or “defect codes” module
- Number of defects
- Length of major (score of four or five) and/or minor defects (score of three)
- Presence of specific defects such as ID (infiltration drippers) or SRCC (Reinforcement Corroded Chemical)

While all defects have a repair associated with them, whether or not that repair is recommended depends on the results of the decision tree.

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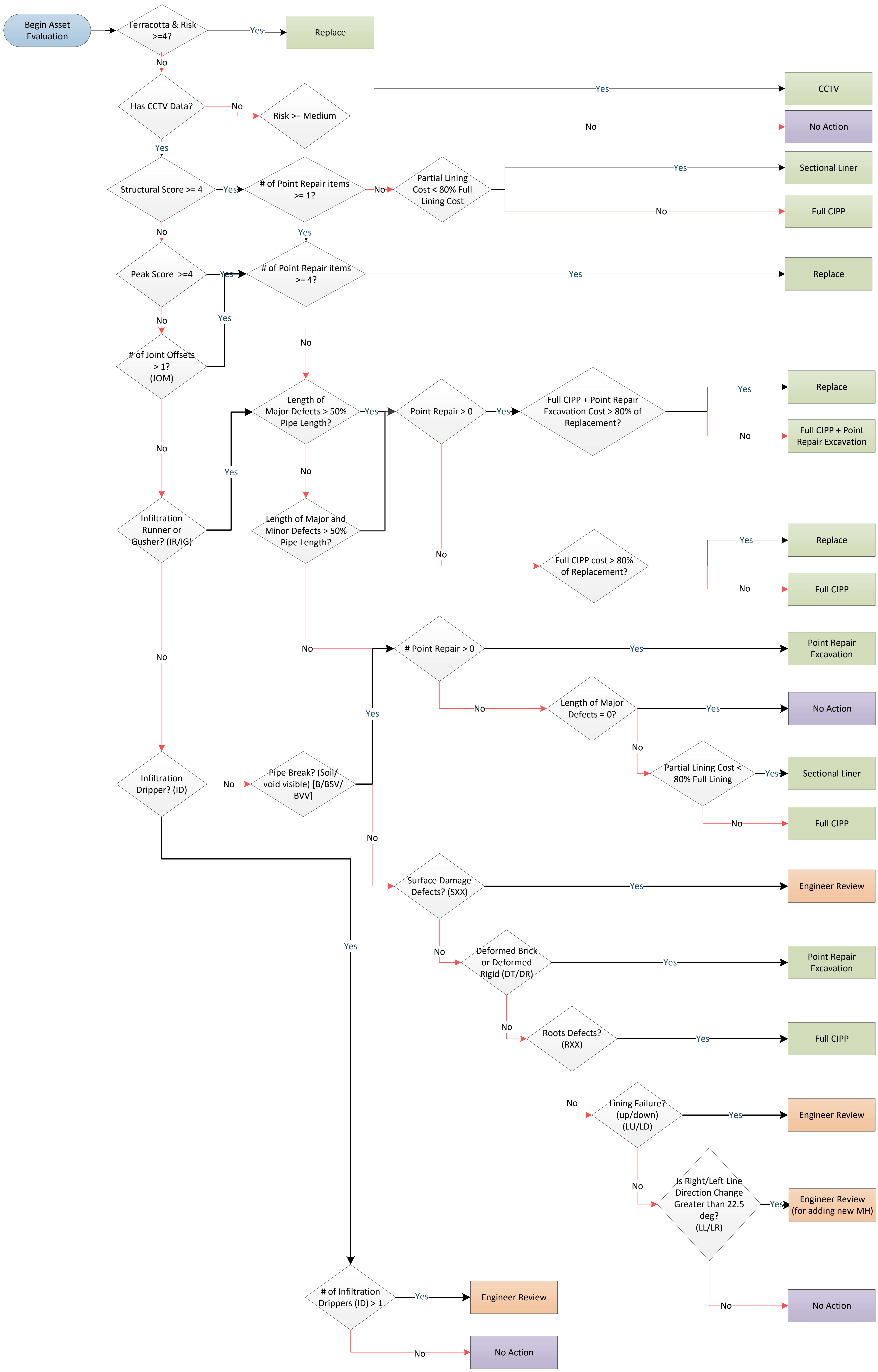
Sewer Pipe Rehabilitation Plan Decision Process – Based on risk, cost and defect type



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Appendix B: Pipes Requiring Rehabilitation

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Appendix B

Pipes Requiring Rehabilitation

This appendix provides the list of pipes requiring rehabilitation based on the inspection condition assessment results and the decision tree shown in Appendix A. This does not include pipes requiring CCTV or projects related to hydraulics or capacity.

Table B-1. Pipes Requiring Rehabilitation

Grid	GIS Facility ID	Action	Cost	Diameter (inches)	Material	Length (feet)	Depth (feet)	Risk [a]
B04	MH-B04-057-MH-B04-059	Full CIPP	$19,290	6	VCP	276	6	3
B04	MH-B04-021-MH-B04-022	Full CIPP	$19,533	6	VCP	279	6	3
B04	MH-B04-056-MH-B04-057	Full CIPP	$17,328	6	VCP	248	6	3
B04	MH-B04-048-MH-B04-049	Full CIPP+Point Repair Exc(s)	$29,355	6	VCP	319	7	3
B04	MH-B04-018-MH-B04-019	Full CIPP+Point Repair Exc(s)	$26,737	6	VCP	282	5	3
B04	MH-B04-070-MH-B04-069	Full CIPP+Point Repair Exc(s)	$37,433	6	VCP	278	9	3
B04	MH-B04-031-MH-B04-032	Full CIPP+Point Repair Exc(s)	$32,585	6	VCP	366	6	3
B04	MH-B04-019-MH-B04-020	Replace	$38,042	6	VCP	240	4	3
B04	MH-B04-049-MH-B04-050	Full CIPP+Point Repair Exc(s)	$28,544	6	VCP	308	6	3
B04	MH-B04-002-MH-B04-021	Full CIPP+Point Repair Exc(s)	$26,183	6	VCP	274	6	3
B04	MH-B04-011-MH-B04-012	Full CIPP+Point Repair Exc(s)	$27,944	6	VCP	299	6	3
B04	MH-B04-059-MH-B04-071	Sec Liner(s)+Point Repair Exc(s)	$43,520	6	VCP	315	11	3
B04	MH-B04-001-MH-B04-002	Sec Liner(s)+Point Repair Exc(s)	$10,500	6	VCP	280	6	3
B04	MH-B04-063-MH-B04-015	Sec Liner(s)+Point Repair Exc(s)	$14,000	6	VCP	284	6	3
B04	MH-B04-050-MH-B04-051	Sec Liner(s)+Point Repair Exc(s)	$10,022	6	VCP	302	6	3
B04	MH-B04-001-MH-B04-011	Sectional Liner(s)	$17,500	6	VCP	315	6	3
B04	MH-B04-002-MH-B04-003	Sectional Liner(s)	$14,000	6	VCP	277	6	3
B04	MH-B04-003-MH-B04-026	Sectional Liner(s)	$7,000	6	VCP	318	6	3
B06	MH-B06-018-MH-B06-017	Full CIPP+Point Repair Exc(s)	$33,064	6	VCP	272	6	3
B06	MH-B06-017-MH-B06-016	Sec Liner(s)+Point Repair Exc(s)	$17,500	6	VCP	270	5	3
B09	MH-B09-022-MH-C09-026	Sectional Liner(s)	$3,500	6	VCP	308	5	3
B10	MH-B10-002-MH-B10-003	Point Repair Excavation(s)	$7,000	6	VCP	246	8	3
C03	MH-D03-076-MH-C03-043	Sectional Liner(s)	$7,000	6	VCP	300	5	3
C03	MH-C03-094-MH-C04-030	Sectional Liner(s)	$14,000	6	VCP	303	6	3

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Table B-1. Pipes Requiring Rehabilitation								
Grid	GIS Facility ID	Action	Cost	Diameter (inches)	Material	Length (feet)	Depth (feet)	Risk [a]
C04	MH-C04-072-MH-C04-071	Full CIPP	$13,496	8	VCP	193	6	3
C07	MH-C07-063-MH-C08-043	Sec Liner(s)+Point Repair Exc(s)	$17,500	6	VCP	333	7	3
C08	MH-C08-040-MH-C08-039	Full CIPP	$26,492	6	VCP	378	8	3
C08	MH-C08-043-MH-C08-044	Sec Liner(s)+Point Repair Exc(s)	$31,500	6	VCP	317	6	3
C08	MH-C08-042-MH-C08-041	Sec Liner(s)+Point Repair Exc(s)	$24,500	6	VCP	377	6	3
C08	MH-C08-013-MH-C08-015	Sectional Liner(s)	$3,500	8	VCP	186	7	3
C09	MH-C09-051-MH-C09-045	Sectional Liner(s)	$10,500	6	VCP	256	8	3
C10	MH-C10-023-MH-C10-022	Full CIPP	$20,713	6	VCP	296	5	3
C10	MH-C10-016-MH-C10-018	Full CIPP	$17,188	6	VCP	246	7	3
C10	MH-C10-017-MH-C10-016	Full CIPP+Point Repair Exc(s)	$34,727	6	VCP	343	7	3
C10	MH-C10-022-MH-C10-020	Full CIPP+Point Repair Exc(s)	$25,598	6	VCP	266	7	3
C10	MH-C10-019-MH-C10-020	Full CIPP+Point Repair Exc(s)	$25,168	6	VCP	260	7	3
C10	MH-C10-029-MH-C10-030	Sectional Liner(s)	$3,500	6	VCP	309	11	3
C10	MH-C10-018-MH-C10-019	Sectional Liner(s)	$10,500	6	VCP	255	6	3
D03	MH-D03-009-MH-D03-076	Point Repair Excavation(s)	$7,000	6	VCP	328	8	3
D03	MH-D03-058-MH-D03-059	Replace	$30,854	15	Terracotta	82	8	5
D03	MH-D03-053-MH-D03-054	Replace	$10,518	15	Terracotta	28	8	5
D03	MH-D03-048-MH-D03-071	Replace	$98,396	15	Terracotta	262	6	5
D03	MH-D03-059-MH-D03-048	Replace	$78,323	15	Terracotta	209	6	5
D03	MH-D03-055-MH-D03-056	Replace	$106,998	15	Terracotta	285	6	5
D03	MH-D03-052-MH-D03-053	Replace	$18,170	15	Terracotta	48	7	5
D03	MH-E03-061-MH-D03-034	Sec Liner(s)+Point Repair Exc(s)	$35,900	8	Terracotta	343	12	3
D03	MH-D03-056-MH-D03-058	Replace	$102,590	15	Terracotta	274	8	5
D03	MH-D03-054-MH-D03-055	Replace	$78,037	15	Terracotta	208	8	5
D03	MH-D03-071-MH-D04-020	Replace	$119,182	15	Terracotta	318	7	5
D03	EN-D03-003-MH-D03-049	Replace	$32,544	6	Terracotta	217	0	4
D04	MH-D04-058-MH-D04-090	Point Repair Excavation(s)	$7,000	6	Terracotta	492	4	3
D04	MH-D04-061-MH-D04-022	Replace	$130,621	18	Terracotta	231	14	5
D04	MH-D05-012-MH-D04-093	Replace	$83,894	8	Terracotta	274	15	4
D04	MH-D04-022-MH-D04-018	Replace	$45,384	21	Terracotta	68	14	5
D04	MH-D04-020-MH-D04-061	Replace	$107,700	15	Terracotta	287	7	5
D04	MH-D04-037-MH-D04-040	Sec Liner(s)+Point Repair Exc(s)	$28,000	6	Terracotta	394	5	3

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Table B-1. Pipes Requiring Rehabilitation								
Grid	GIS Facility ID	Action	Cost	Diameter (inches)	Material	Length (feet)	Depth (feet)	Risk [a]
D05	MH-D05-054-MH-D05-053	Full CIPP	$17,232	6	VCP	246	6	3
D05	MH-D05-041-MH-D05-092	Sec Liner(s)+Point Repair Exc(s)	$10,500	6	VCP	310	7	3
D05	MH-D05-051-MH-D05-094	Sectional Liner(s)	$7,000	6	VCP	341	3	3
D06	MH-D06-044-MH-D06-048	Full CIPP	$18,457	6	VCP	264	8	3
D06	MH-D06-086-MH-D06-085	Full CIPP	$17,149	6	VCP	245	7	3
D06	MH-D06-078-MH-D06-077	Point Repair Excavation(s)	$7,000	6	VCP	175	8	3
D06	MH-D06-083-MH-D06-080	Point Repair Excavation(s)	$8,640	6	VCP	92	9	3
D06	MH-D07-002-MH-D06-047	Point Repair Excavation(s)	$9,360	6	VCP	330	9	3
D06	MH-D06-085-MH-D06-084	Sec Liner(s)+Point Repair Exc(s)	$16,000	6	VCP	238	11	3
D06	MH-D06-047-MH-D06-046	Sec Liner(s)+Point Repair Exc(s)	$16,000	6	VCP	307	9	3
D06	MH-D06-051-MH-D06-050	Sec Liner(s)+Point Repair Exc(s)	$16,170	6	VCP	328	6	3
D06	MH-D06-049-MH-D06-111	Sectional Liner(s)	$7,000	8	VCP	163	7	3
D06	MH-D06-086-MH-D06-073	Sectional Liner(s)	$7,000	6	VCP	171	8	3
D06	MH-D06-048-MH-D06-030	Sectional Liner(s)	$10,500	6	VCP	242	9	3
D06	MH-D06-012-MH-D06-011	Sectional Liner(s)	$3,500	6	VCP	284	7	3
D07	MH-D07-037-MH-D07-038	Full CIPP	$4,717	8	VCP	67	7	3
D07	MH-D07-038-MH-D07-039	Full CIPP+Point Repair Exc(s)	$31,659	10	VCP	171	8	3
D10	MH-D11-058-MH-D10-043	Point Repair Excavation(s)	$15,000	8	VCP	91	17	3
D10	MH-D11-086-MH-D10-036	Sectional Liner(s)	$3,500	6	VCP	299	8	3
D12	MH-D12-045-MH-D12-046	Sectional Liner(s)	$7,000	6	VCP	258	6	3
D13	MH-E13-001-MH-D13-024	Sectional Liner(s)	$10,500	6	VCP	250	5	3
E03	MH-E03-S59-MH-E03-S53	Point Repair Excavation(s)	$8,792	10	Terracotta	260	8	3
E03	MH-E03-S56-MH-E03-S55	Point Repair Excavation(s)	$16,000	8	Terracotta	278	8	3
E03	MH-E03-081-MH-E03-058	Point Repair Excavation(s)	$7,000	6	Terracotta	167	5	3
E03	MH-E03-S44-MH-E03-S46	Replace	$123,752	14	Terracotta	330	7	5
E03	MH-E03-S23-MH-E03-S25	Replace	$113,316	15	Terracotta	260	10	5
E03	MH-E03-S36-MH-E03-S34	Replace	$123,962	15	Terracotta	331	8	5
E03	MH-E03-S66-MH-F03-C25	Replace	$125,731	14	Terracotta	335	7	5
E03	MH-E03-S22-MH-E03-S70	Replace	$53,740	15	Terracotta	143	6	5
E03	MH-E03-S46-MH-F03-C20	Replace	$123,631	14	Terracotta	330	7	5
E03	MH-F03-C12-MH-E03-S27	Replace	$65,211	8	Terracotta	326	8	4
E03	MH-E03-S70-MH-E03-S03	Replace	$36,298	15	Terracotta	97	0	5

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Table B-1. Pipes Requiring Rehabilitation								
Grid	GIS Facility ID	Action	Cost	Diameter (inches)	Material	Length (feet)	Depth (feet)	Risk [a]
E03	MH-E03-S03-MH-E03-S23	Replace	$7,395	15	Terracotta	20	0	5
E03	MH-E03-S81-E03-S01	Replace	$44,178	6	Terracotta	295	0	4
E03	MH-E03-S07-E03-S01	Replace	$71,888	12	Terracotta	240	0	4
E03	MH-E03-021-MH-E03-020	Sec Liner(s)+Point Repair Exc(s)	$11,500	8	Terracotta	388	4	3
E03	MH-E03-S26-MH-E03-S25	Sec Liner(s)+Point Repair Exc(s)	$13,500	8	VCP	530	10	3
E03	MH-E03-032-MH-E03-067	Sectional Liner(s)	$14,000	6	Terracotta	510	4	3
E04	MH-E04-114-MH-E04-142	Replace	$51,429	15	Terracotta	137	8	5
E04	MH-E04-142-MH-E04-143	Replace	$17,003	15	Terracotta	45	0	5
E04	EN-E04-006-MH-E04-114	Replace	$9,082	15	Terracotta	24	0	5
E06	MH-E06-180-MH-E06-014	Sectional Liner(s)	$7,000	6	VCP	279	7	3
E06	MH-E06-088-MH-E06-089	Sectional Liner(s)	$3,500	6	VCP	338	10	3
E07	MH-E07-034-MH-E07-036	Sec Liner(s)+Point Repair Exc(s)	$21,500	6	VCP	239	16	3
E12	MH-E12-069-MH-E12-070	Point Repair Excavation(s)	$7,000	6	VCP	180	8	3
E13	MH-E13-033-MH-E13-032	Point Repair Excavation(s)	$4,270	6	VCP	222	8	3
E13	MH-E13-045-MH-E13-046	Sectional Liner(s)	$3,500	6	VCP	305	11	3
F03	MH-F03-C18-MH-F03-S03	Point Repair Excavation(s)	$8,000	8	Terracotta	265	7	3
F03	MH-F03-C16-MH-F03-S01	Replace	$171,100	24	Terracotta	285	7	5
F03	MH-F03-S21-MH-F03-S13	Replace	$105,815	15	Terracotta	243	10	5
F03	MH-F03-S01-MH-F03-C05	Replace	$66,768	24	Terracotta	111	7	5
F03	MH-F03-C05-F03-C01	Replace	$25,855	0	Terracotta	172	0	4
F03	MH-F03-C08-MH-F03-S88	Replace	$65,314	15	Terracotta	150	9	5
F03	MH-F03-S43-MH-F03-S26	Replace	$96,017	14	Terracotta	256	7	5
F03	MH-F03-S90-MH-F03-S54	Replace	$11,702	15	Terracotta	23	13	5
F03	MH-F03-C19-MH-F03-C15	Replace	$13,560	20	Terracotta	26	8	5
F03	MH-F03-S06-F03-S01	Replace	$9,698	0	Terracotta	65	0	4
F03	MH-F03-C15-MH-F03-C16	Replace	$148,203	24	Terracotta	247	8	5
F03	MH-F03-S14-MH-F03-S15	Replace	$95,010	14	Terracotta	253	7	5
F03	MH-F03-S26-MH-F03-S16	Replace	$110,958	14	Terracotta	296	7	5
F03	MH-F03-C22-MH-F03-C21	Replace	$116,951	18	Terracotta	260	7	5
F03	MH-F03-C23-MH-F03-C22	Replace	$116,987	18	Terracotta	260	6	5
F03	MH-F03-S16-MH-F03-S09	Replace	$112,988	18	Terracotta	226	7	5
F03	MH-F03-S31-MH-F03-S21	Replace	$106,194	15	Terracotta	244	9	5

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Table B-1. Pipes Requiring Rehabilitation								
Grid	GIS Facility ID	Action	Cost	Diameter (inches)	Material	Length (feet)	Depth (feet)	Risk [a]
F03	MH-F03-S03-MH-F03-S02	Replace	$110,155	18	Terracotta	245	7	5
F03	MH-F03-S54-MH-F03-S46	Replace	$114,283	15	Terracotta	224	13	5
F03	MH-F03-C20-MH-F03-C19	Replace	$120,069	21	Terracotta	229	8	5
F03	MH-F03-S02-MH-F03-S01	Replace	$10,157	18	Terracotta	23	7	5
F03	MH-F03-S34-MH-F03-C08	Replace	$75,158	15	Terracotta	173	11	5
F03	MH-F03-C13-MH-F03-C14	Replace	$51,408	8	Terracotta	203	9	4
F03	MH-F03-C07-MH-F03-C05	Replace	$7,120	24	Terracotta	12	6	5
F03	MH-F03-S86-MH-F03-S87	Replace	$54,914	12	Terracotta	153	11	4
F03	MH-F03-S12-MH-F03-S13	Replace	$123,089	12	Terracotta	342	10	4
F03	MH-F03-S09-MH-F03-S03	Replace	$131,876	18	Terracotta	261	7	5
F03	MH-F03-S15-MH-F03-S16	Replace	$14,857	14	Terracotta	40	7	5
F03	MH-F03-S49-MH-F03-S52	Replace	$54,950	6	Terracotta	243	7	3
F03	MH-F03-S46-MH-F03-S31	Replace	$105,649	15	Terracotta	243	10	5
F03	MH-F03-S19-MH-F03-S11	Replace	$123,599	18	Terracotta	243	9	5
F03	MH-F03-C21-MH-F03-C20	Replace	$136,370	21	Terracotta	260	7	5
F03	MH-F03-C25-MH-F03-C23	Replace	$111,368	14	Terracotta	297	7	5
F03	MH-F03-C14-F03-C01	Replace	$19,348	0	Terracotta	129	0	4
F03	MH-F03-C17-MH-F03-C18	Sec Liner(s)+Point Repair Exc(s)	$21,393	8	Terracotta	265	6	3
F04	EN-F04-002-MH-F04-S16	Replace	$107,296	8	Terracotta	424	11	4
F13	MH-F13-007-MH-F13-008	Point Repair Excavation(s)	$9,000	6	VCP	159	11	3
G03	MH-G03-S04-G03-001	Replace	$37,201	0	Terracotta	248	0	4
G03	MH-G03-C21-MH-G03-C20	Replace	$105,443	15	Terracotta	242	10	5
G03	MH-G03-S43-MH-G03-S32	Sectional Liner(s)	$3,500	8	VCP	219	6	3
H03	MH-H03-S51-MH-H03-S52	Sec Liner(s)+Point Repair Exc(s)	$29,500	12	VCP	302	7	3
H03	MH-H03-S49-MH-H03-S50	Sec Liner(s)+Point Repair Exc(s)	$11,500	8	VCP	273	5	3

a. Risk Categories (1 through 5):
1 = negligible risk
2 = low risk
3 = medium risk
4 = high risk
5 = extreme risk

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Appendix C: Basis of Cost Assumptions

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Appendix C

Basis of Cost Assumptions

This appendix describes the cost basis for rehabilitation items. Items related to quotes from manufacturers only include material and installation costs. These do not include labor or agency costs used for master planning such as administrative, permitting, or other costs. For pipes with unknown diameters, the average pipe diameter of six inches was used for costing (87 miles, 60% of all pipes). Note that the GIS indicates there are small traces of 3, 4, 5, 14, 16, 36, 42, and 50-inch pipes but these pipes have 0 miles when rounded to nearest mile.

C.1 CCTV Costs

Table C-1 presents CCTV costs used in the analysis in dollars per linear feet ($/LF).

Table C-1. CCTV Cost by Pipe Diameter

Pipe Diameter (inches) [a,b]	Cost ($/LF)
Up to 18	4
19 to 24	5
25 to 36	6
Greater than 36	7

a. *CCTV bids are from City of Bloomington FY 2017 CCTV Inspections PROJECT NO. # 50-18-53007-17-00. CITY BID NO. 2017-16. The costs shown here are an average of the bids from Michels Pipe Services, National Power Rodding Corp., and Bloomington City engineer estimate. G.A. Rich & Sons, Inc. was excluded due to low bids.*

b. *Costs for greater than 36-inch pipe were extrapolated.*

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C.2 Pipe Replacement

Table C-2 presents pipe replacement costs. The cost shown on the tables below reflect pipe material, installation, backfill, and excavation costs but do not include engineering or contingency costs, which were added separately in Table 6-1.

Table C-2. Pipe Replacement

Pipe Diameter (inches) [a]	Cost ($/LF) [b,c,d]			
	0-8 Feet Below Grade	8-12 Feet Below Grade	12-16 Feet Below Grade	Over 16 Feet Below Grade
6	$150	$182	$225	$300
8	$200	$253	$307	$413
10	$250	$324	$368	$485
12	$300	$360	$405	$540
15	$375	$435	$510	$645
18	$450	$508	$566	$711
21	$525	$610	$667	$823
24	$600	$668	$750	$900
27	$620	$692	$751	$894
30	$690	$772	$830	$971
33	$760	$830	$900	$1,030
36	$830	$902	$973	$1,107
42	$970	$1,061	$1,130	$1,312
50	$1,150	$1,236	$1,314	$1,477

a. *Pipe material costs were provided by 2020 quotes from Northern Pipe (RCP) and Mission Clay Products (VCP).*

b. *Backfill, excavation, and pavement costs were obtained from the RSMeans construction cost database.*

c. *Costs were scaled to 2021 using the 20 City Construction Cost Index (CCI) published by Engineering News-Record (ENR).*

d. *Costs for 3, 4 and 5-inch pipes were extrapolated; costs for 50-inch diameter pipes were interpolated between the ENR CCI-scaled quotes for 48-inch and 54-inch pipes.*

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C.3 Point Repairs by Excavation

Table C-3 presents costs associated with one point repair by excavation. A pipe assigned the rehabilitation recommendation "point repair(s)" or a combination of lining and "point repair(s)" may have more than one point repair. The excavation costs assume 10 feet sections. The unit costs ($/LF) were taken from the pipe replacement section and multiplied by 10; no additional multipliers were used which may result in a lower end of cost estimation. Typically, a point repair compared to a full pipe replacement will have a much greater unit cost due to similar equipment, machine rental, and labor costs.

Table C-3. Point Repair by Excavation

Pipe Diameter (inches) [a]	Cost ($/LF) [b,c,d]			
	0-8 Feet Below Grade	8-12 Feet Below Grade	12-16 Feet Below Grade	Over 16 Feet Below Grade
6	$700	$900	$1,100	$1,400
8	$800	$1,000	$1,100	$1,500
10	$900	$1,100	$1,300	$1,600
12	$1,000	$1,200	$1,400	$1,700
15	$1,200	$1,500	$1,700	$2,200
18	$1,500	$1,700	$2,000	$2,400
21	$1,900	$2,100	$2,400	$2,800
24	$2,200	$2,500	$2,700	$3,300
27	$2,600	$2,900	$3,200	$3,800
30	$2,900	$3,300	$3,600	$4,100
33	$3,800	$4,100	$4,500	$5,100
36	$4,000	$4,400	$4,700	$5,500
42	$4,300	$4,600	$5,000	$5,800
50	$6,000	$6,300	$6,700	$7,600

a. *Pipe material costs were provided by 2020 quotes from Northern Pipe (RCP) and Mission Clay Products (VCP).*
b. *Backfill, excavation, and pavement costs were obtained from the RSMeans construction cost database.*
c. *Costs were scaled to 2021 using the 20 City CCI published by ENR.*
d. *Costs for 3, 4 and 5-inch pipes are extrapolated; costs for 50-inch diameter pipes are interpolated between the ENR CCI-scaled quotes for 48-inch and 54-inch pipes.*

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C.4 Sectional Liners

Table C-4 presents sectional liner costs used in the analysis.

Table C-4. Sectional Lining Costs

Pipe Diameter (inches) [a]	Cost ($/LF) [b,c]
6	3,500
8	3,500
10	5,000
12	6,500
15	8,000
18	8,000
21	10,000
24	10,000
27	11,500
30	11,500
33	13,000
36	13,000
42	14,500
50	14,500

a. *Other medium to large diameter sectional lining costs were extrapolated.*
b. *Prices from 2020 Virginia Beach Annual Services Construction Contract #17 bid tab.*
c. *Costs were scaled to 2021 using the 20 City CCI published by ENR.*

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C.5 Full Pipe Length Cured-in-Place-Pipe (Full CIPP)

Table C-5 presents full cured-in-place-pipe (CIPP) costs used in the analysis.

Table C-5. Full CIPP Costs	
Pipe Diameter (inches) [a]	Cost ($/LF) [b,c,d]
6	70
8	70
10	80
12	95
15	105
18	125
21	145
24	170
27	190
30	210
33	245
36	360
42	380
50	420

a. *Based on evaluations of North Davis Sewer District Bid Tabs, Project 3 through Project 7, escalated to 2020 dollars. Costs do not include bypass pumping or traffic control. Unit diameter costs were based on 200 ft lateral spacing and 2000 ft project length.*

b. *Larger diameter (36 <= diameter <= 66) full CIPP was based on SLC BODR.*

c. *Costs were scaled to 2021 using the 20 city CCI published by ENR.*

d. *Costs for 3, 4 and 5-inch pipes were extrapolated; costs for 50-inch diameter pipes were interpolated between the scaled bid prices of 48-inch and 54-inch pipes.*

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Appendix D: I-280 Sewer Crossing Cost Estimate

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Brown AND Caldwell

Memorandum

Date: December 10, 2021

To: Chris Peters, Walnut Creek

From: Stefani Couch, Sunrise

Reviewed by: Catherine Dummer, Portland

Copy to: Dan Shapiro, Seattle

Andrew Fugal, Salt Lake City

Project No.: 154530.500

Subject: Wastewater Collection System Master Plan

Planning Level-Percent Design Completion

Basis of Estimate of Probable Construction Cost

The Basis of Estimate Report and supporting estimate reports for the subject project are attached. Please call me if you have questions or need additional information.

Enclosures (2):

1. Basis of Estimate Report
2. Summary Estimate

Basis of Estimate Report

WASTEWATER COLLECTION SYSTEM MASTER PLAN

Introduction

Brown and Caldwell (BC) is pleased to present this opinion of probable construction cost (estimate) prepared for the Wastewater Collection System Master Plan, Daly City, CA.

Estimated Project Costs

Based on the typical accuracy of a Class 5 estimate, the expected range of costs is:

Upper Range	Estimated Cost	Lower Range
100%		-50%
$9,204,800	$4,602,415	$2,301,200

Summary

This Basis of Estimate contains the following information:

- Scope of work
- Background of this estimate
- Class of estimate
- Estimating methodology
- Direct cost development
- Indirect cost development
- Bidding assumptions
- Estimating assumptions
- Estimating exclusions
- Allowances for known but undefined work
- Contractor and other estimate markups

Scope of Work

This project consists of the installation of a new 30-inch diameter highway crossing. The project will involve approximately 750 LF of 48-inch diameter casing and 275 LF of open cut pipe at the upstream and downstream ends of the casing, to connect to the existing gravity system.

Background of this Estimate

There have been no previous estimate prepared by the BC Estimating Department for this project.

The attached estimate of probable construction cost is based on documents dated December 2021, received by the Estimating and Scheduling Group (ESG). These documents are described as planning level based on the current project progression, additional or updated scope and/or quantities, and ongoing discussions with the project team. Further information can be found in the detailed estimate reports.

Class of Estimate

In accordance with the Association for the Advancement of Cost Engineering International (AACE) criteria, this is a Class 5 estimate. A Class 5 estimate is defined as a Conceptual Level or Project Viability Estimate. Typically, engineering is from 0 to 2 percent complete. Class 5 estimates are used to prepare planning level cost scopes or evaluation of alternative schemes, long range capital outlay planning and can also form the base work for the Class 4 Planning Level or Design Technical Feasibility Estimate.

Expected accuracy for Class 5 estimates typically ranges from -50 to +100 percent, depending on the technological complexity of the project, appropriate reference information and the inclusion of an appropriate contingency determination. In unusual circumstances, ranges could exceed those shown.

Estimating Methodology

This estimate was prepared using quantity take-offs, vendor quotes and equipment pricing furnished either by the project team or by the estimator. The estimate includes direct labor costs and anticipated productivity adjustments to labor and equipment. Where possible, estimates for work anticipated to be performed by specialty subcontractors have been identified.

Construction labor crew and equipment hours were calculated from production rates contained in documents and electronic databases published by R.S. Means, Mechanical Contractors Association (MCA), National Electrical Contractors Association (NECA), and Rental Rate Blue Book for Construction Equipment (Blue Book).

This estimate was prepared using BC's estimating system, which consists of Sage Construction and Real Estate 300 estimating software engine (formerly Timberline) using RS Means database, historical project data, the latest vendor and material cost information, and other costs specific to the project location.

Direct Cost Development

Costs associated with the General Provisions and the Special Provisions of the construction documents, which are collectively referred to as Contractor General Conditions (CGC), were based on the estimator's interpretation of the contract documents. The estimates for CGCs are divided into two groups: a time-related group (e.g., field personnel) and non-time-related group (e.g., bonds and insurance). Labor burdens such as health and welfare, vacation, union benefits, payroll taxes, and worker's compensation insurance are included in the labor rates. No trade discounts were considered.

Indirect Cost Development

Local sales tax has been applied to material and equipment rentals. A percentage allowance for contractor's home office expense has been included in the overall rate markups. The rate is standard for this type of heavy construction and is based on typical percentages outlined in Means Heavy Construction Cost Data.

The contractor's cost for builder's risk, general liability and vehicle insurance has been included in this estimate. Based on historical data, this is typically two to four percent of the overall construction contract amount. These indirect costs have been included in this estimate as a percentage of the gross cost and are added after the net markups have been applied to the appropriate items.

Bidding Assumptions

The following bidding assumptions were considered in the development of this estimate.

1. Bidders must hold a valid, current Contractor's credentials, applicable to the type of project.
2. Bidders will develop estimates with a competitive approach to material pricing and labor productivity, and will not include allowances for changes, extra work, unforeseen conditions or any other unplanned costs.
3. Estimated costs are based on a minimum of four bidders. Actual bid prices may increase for fewer bidders or decrease for a greater number of bidders.
4. Bidders will account for General Provisions and Special Provisions of the contract documents and will perform all work except that which will be performed by traditional specialty subcontractors.

Estimating Assumptions

As the design progresses through different completion stages, it is customary for the estimator to make assumptions to account for details that may not be evident from the documents. The following assumptions were used in the development of this estimate.

1. Junction structures will be cast in place structures with manual bulkhead gates to control flow into/from each sewer line under I280.
2. The existing line under I280 will remain in service during construction until the new facilities are ready to be tied in.
3. Contractor performs the work during normal daylight hours, nominally 7 a.m. to 5 p.m., Monday through Friday, in an 8-hour shift. No allowance has been made for additional shift work or weekend work.
4. Contractor has complete access for lay-down areas and mobile equipment.
5. Equipment rental rates are based on verifiable pricing from the local project area rental yards, Blue Book rates, and/or rates contained in the estimating database.
6. Contractor markup is based on conventionally accepted values that have been adjusted for project-area economic factors.
7. Bulk material quantities are based on manual quantity take-offs.
8. Soils are of adequate nature to support the structures. No piles have been included in this estimate.

Estimating Exclusions

The following estimating exclusions were assumed in the development of this estimate.

1. Demolition of existing facilities.
2. Hazardous materials remediation and/or disposal.
3. O&M costs for the project except for the vendor supplied O&M manuals.
4. Permits beyond those normally needed for the type of project and project conditions.
5. Impacts from COVID-19 including additional labor and management hours required to meet social distancing, personal protection, and cleaning routines, additional costs of protective equipment, supply chain impacts, and material shortages.

Allowances for Known but Undefined Work

No allowances were made in the development of this estimate.

Contractor and Other Estimate Markups

Contractor markup is based on conventionally accepted values which have been adjusted for project-area economic factors. Estimate markups are shown in Table 1.

Table 1. Estimate Markups

Item	Rate (%)
Gross Cost Markups	
Contractor Overhead and Profit	15
Sales Tax (State and local for materials, process equipment and construction equipment rentals, etc.), applied to 50% of total cost	9.875
Contractor General Conditions	12
Bay Area Market Factor	10
Performance and Payment Bonds	3.5

Labor Rates

The labor rates used in the estimate were derived from RS Means latest national average wage rate tables and city cost indexes. These include base rate paid to the laborer plus fringes. A labor burden factor is applied to these such that the final rates include all employer paid taxes. These taxes are FICA (which covers social security plus Medicare), Workers Comp (which varies based on state, employer experience and history) and unemployment insurance. The result is fully loaded labor rates. In addition to the fully loaded labor rate, an overhead and profit markup is applied at the back end of the estimate. This covers payroll and accounting, estimator's wages, home office rent, advertising and owner profit.

Sales Tax (Materials, Process Equipment and Construction Equipment)

This is the tax that the contractor must pay according to state and local tax laws. The percentage is applied to both the material and equipment the GC purchases as well as the cost for rental equipment. The percentage is based on the local rates in place at the time the estimate was prepared.

Bonds and Insurance

Builders Risk, Liability, and Vehicle Insurance: There are many factors which make up this percentage, including the contractor's track record for claims in each of the categories. Another factor affecting insurance rates has been a dramatic price increase across the country over the past several years due to domestic and foreign influences. Consequently, in the construction industry we have observed a range of 0.5 to 1 percent for Builders Risk Insurance, 1 to 1.25 percent for General Liability Insurance, and 0.85 to 1 percent for Vehicle Insurance. Many factors affect each area of insurance, including project complexity and contractor's requirements and history. Instead of using numbers from a select few contractors, we believe it is more prudent to use a combined 2 percent to better reflect the general costs across the country. Consequently, the actual cost could be higher or lower based on the bidder, region, insurance climate, and the contractor's insurability at the time the project is bid.

Performance and Payment Bonds: Based on historical and industry data, this can range from 0.75 to 3 percent of the project total. There are several contributing factors including such items as size of the project, regional costs, contractor's historical record on similar projects, complexity and current bonding limits. BC uses 1.5 percent for bonds, which we have determined to be reasonable for most heavy construction projects.

Performance and Payment Bonds

Based on historical and industry data, this can range from 0.75 to 3 percent of the project total. There are several contributing factors including such items as size of the project, regional costs, contractor's historical record on similar projects, complexity and current bonding limits. BC uses 1.5 percent for bonds, which we have determined to be reasonable for most heavy construction projects.

Escalation to Midpoint for Labor, Materials and Subcontractors

In addition to contingency, it is customary for projects that will be built over several years to include an escalation to midpoint of anticipated construction to account for the future escalation of labor, material and equipment costs beyond values at the time the estimate is prepared. There is no escalation added to this project as the estimate is to reflect a cost in 2021 dollars.

Project Name: Wastewater Collection System Master Plan				
Last Updated: 12/10/2021				
Detail Capital Costs				
Component/Item	Quantity	Units	Unit Cost	Bare Cost
Jack/Bore				
Upstream Pit	22	vlf	14,400	$316,800
Downstream Pit	10	vlf	7,800	$78,000
Crossing, with carrier (30") and casing pipe (48")	750	lf	2,100	$1,575,000
Open Cut				
30" Steel Upstream	275	lf	1,493	$410,599
Junction Structures				
Upstream Junction Structure	1	ea	162,465	$162,465
Downstream Junction Structure	1	ea	162,465	$162,465
Traffic Control	1	ls	120,000	$120,000
Bypass Pumping during connection to existing	2	weeks	52,800	$105,600
Surface Restoration				
Asphalt RemovaL & Replacement	1	ls	60,000	$60,000
No demolition included				
Assumes project will be D/B/B				
Assumes no ground improvements and minimal dewatering				
Subtotal				$2,990,930
Construction Markups				
Material Sales Tax (assume 50% of cost is materials)	9.875	%		$147,677
Subtotal				$3,138,607
Contractor Overhead and Profit	15	%		$470,791
Subtotal				$3,609,398
Contractor General Conditions	12	%		$433,128
Subtotal				$4,042,526
Bay Area Market Factor	10	%		$404,253
Subtotal				$4,446,778
Bonds and Insurance	3.5	%		$155,637
Subtotal				$4,602,415
Other Markups				
Risk Based Contingency	0	%		$0
Subtotal				$4,602,415
Soft Costs	0	%		$0
TOTAL CAPITAL COST				**$4,602,415**

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