WEST BAY
SANITARY DISTRICT

2023 Wastewater Collection System Master Plan Update

FINAL

December 31, 2023

V.W. HOUSEN
& ASSOCIATES

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SANITARY DISTRICT

West Bay Sanitary District

2023 Wastewater Collection System

Master Plan

Final
December 2023

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ACRONYMS & TERMS

AAD	Average annual demand
ADWF	Average Dry Weather flow
BWF	See ADWF
CCTV	Closed Circuit Television
CEQA	California Environmental Quality Act
CIP	Capital Improvement Program
CIWQS	California Integrated Water Quality System
CMMS	Computerized Maintenance Management System
d/D	Depth over Diameter
District	West Bay Sanitary District
Diurnal	Daily Variation in base wastewater flow
ENR CCI	Engineering News Record Construction Cost Index
FERRF	Flow Equalization and Resource Recovery Facility
GIS`	Geographic Information System
GPCPD	Gallons per Capita per Day
GWI	Groundwater Infiltration
HDR	High Density Residential
I&I	Inflow and Infiltration
LAMP	Linear Asset Management Plan
LDR	Low-density Residential
MDD	Maximum Day Demand. Average daily demand during the peak demand month.
MDR	Medium-density Residential
MGD	Million Gallons per Day
PHD	Peak Hour Demand. Maximum flow rate during MDD conditions
MPMW	Menlo Park Municipal Water District
MPS	Menlo Pump Station
NASSCO	National Association of Sewer Service Companies
NEPA	National Environmental Policy Act
NOAA	National Oceanographic and Atmospheric Administration
PACP	Pipeline Assessment and Certification Program
PDWF	Peak Dry Weather Flow
PWWF	Peak Wet Weather Flow
RDII	Rainfall-Dependent Inflow and Infiltration
RWFP	Bayfront Recycled Water Facilities Plan
RWQCB	Regional Water Quality Control Board
SFPUC	San Francisco Public Utilities Commission
SHGCC	Sharon Heights Golf and Country Club
SRF	State Revolving Fund (Loan)
SVCW	Silicon Valley Clean Water
SWRCB	State Water Resources Control Board
TM	Technical Memorandum
V&A	V&A Consulting Engineers
VLDR	Very Low-density Residential
W&C	Woodard & Curran

WBSD	West Bay Sanitary District
WDR	2023 Statewide WDR or Order 2022-0103-DWQ
WEF	Water Environment Federation
WWPF	Wet Weather Peaking Factor

ACKNOWLEDGEMENTS

We would like to extend our sincere appreciation to the many project team members, including the key project participants listed below, who contributed knowledge, information, and time to assure the success of this Master Plan.

West Bay Sanitary District

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EXECUTIVE SUMMARY

The 2023 Wastewater Master Plan presents results and recommendations from four separate but related studies that were completed for the West Bay Sanitary District's ("District") wastewater collection and recycled water systems. These studies include: 1) Hydraulic Model and Capacity Assessment; 2) Linear Asset Management Plan; 3) Pump Station Assessments; and 4) Recycled Water Plan. Together, the four studies provide recommended projects, priorities, and costs for input into the District's capital improvement program ("CIP"). The District's previous Wastewater Collection System Master Plan was completed in 2011 and partially updated in 2013 to reflect changes near Marsh Road. Since this time, the District has experienced significant development north of Highway 101, conducted system-wide sewer inspection, completed significant repairs and replacements, and expanded the services provided to include recycled water treatment and distribution. In addition to providing information for use in developing the District's CIP, the Master Plan addresses topics that are discussed in the 2023 State Water Resources Control Board Order No. WQ 2022-0103-DWQ (Statewide Waste Discharge Requirements) as related to system capacity.

ES-1 EXISTING SERVICE AREA

The District provides wastewater collection and conveyance services to the City of Menlo Park, Atherton, and Portola Valley, and portions of East Palo Alto, Woodside and unincorporated San Mateo and Santa Clara counties as shown on Figures ES.1 and ES.2 on the following pages. Wastewater is conveyed from south to north through approximately 220 miles of gravity sewers and 11 pump stations[1].

During dry weather months, the District diverts system flows in varying quantities from a location near Sand Hill Road and Oak Avenue in Menlo Park and treats this flow to recycled water standards to serve the Sharon Heights Golf and Country Club ("SHGCC"). During the non-irrigation months, a smaller volume of water must still be diverted from the system and treated by the SHGCC recycled water plant in order to maintain plant operations. These flows are then discharged back into a different part of the wastewater collection system on the north side of the SHGCC.

[1] Asset information from California Integrated Water Quality System ("CIWQS") public reports (Interactive SSO Report. https://www.waterboards.ca.gov/ciwqs/publicreports.html

Figure ES.1 West Bay Sanitary District Service Area and Pipeline Assets

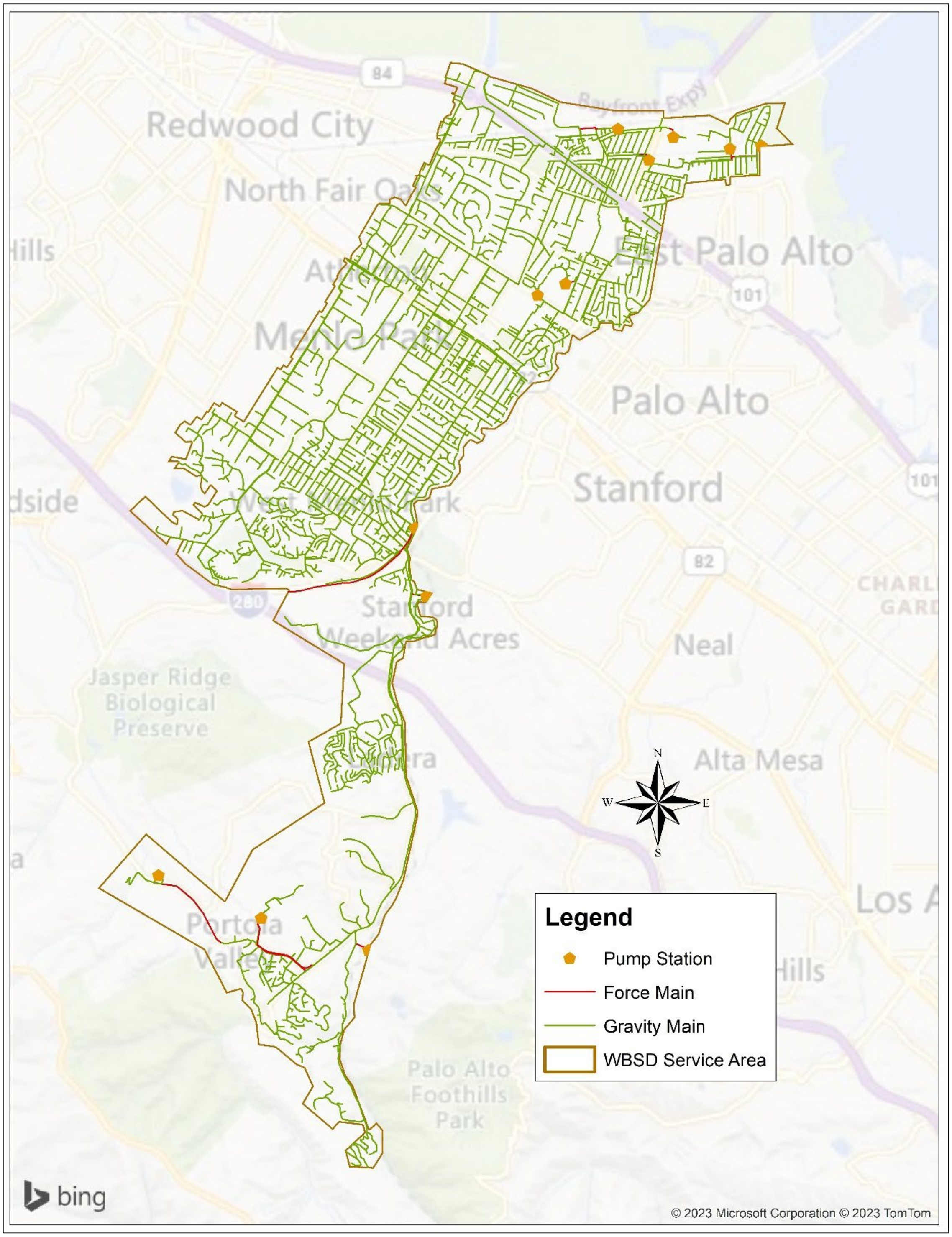
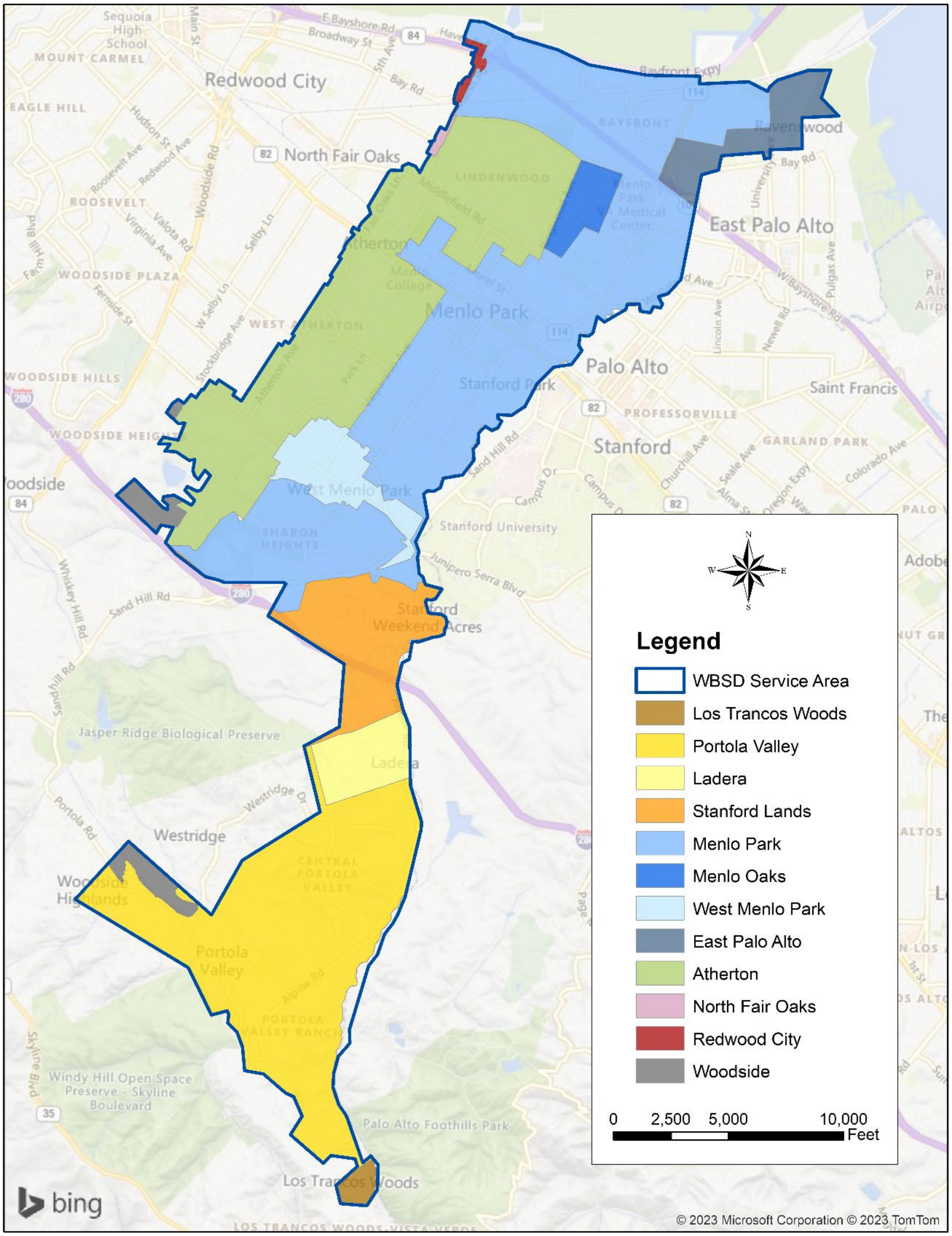


Figure ES.2 Jurisdictions Receiving Wastewater Collection Service from West Bay Sanitary District



Flow terminates at the Menlo Pump Station ("MPS") near Bayshore Expressway and Marsh Avenue, where it is pumped to the Silicon Valley Clean Water ("SVCW") wastewater treatment plant for treatment and discharge to the San Francisco Bay.

The District's gravity pipes range in diameter from 4 to 54 inches. Land use in the District's service area is primarily residential, with dense business corridors located along El Camino Real and on Santa Cruz Avenue in Menlo Park, and a rapidly-developing commercial area near Highway 101 and the Bayshore Expressway. Figure ES.3 shows the current pipeline inventory sorted by material and Figure ES.4 shows the distribution of land uses.

The District owns several emergency storage basins located within the District's Flow Equalization and Resource Recovery Facility ("FERRF"), located within Bedwell Bayfront Park, northeast of the Bayshore Expressway. The FERRF storage ponds include an existing pump station that is used to return flows to the MPS.

The District's average dry weather flow as measured on December 7, 2022 is approximately 3 million gallons per day (mgd). This flow translates to approximately 55 gallons per capita per day.

Figure ES.3 Gravity Sewer Pipeline Inventory and Material of Construction

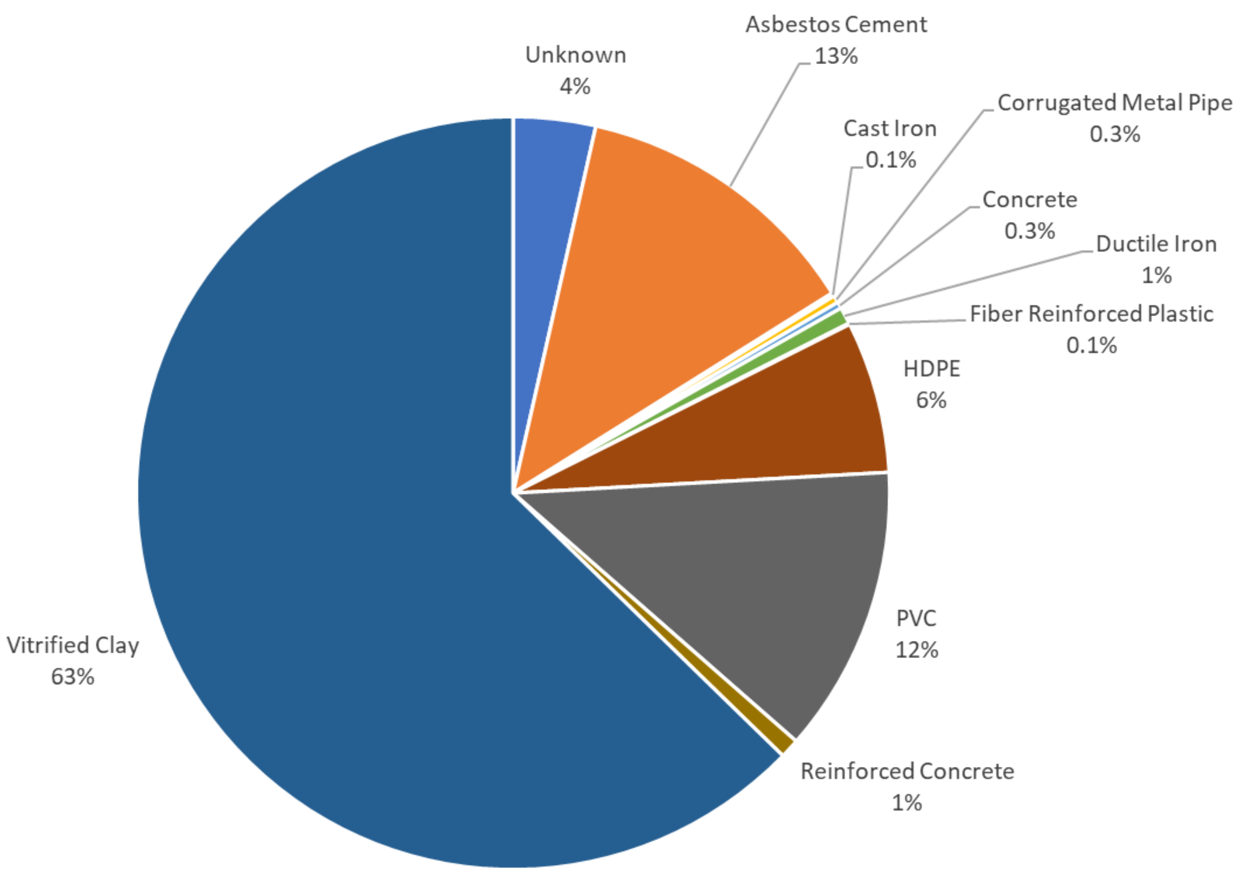
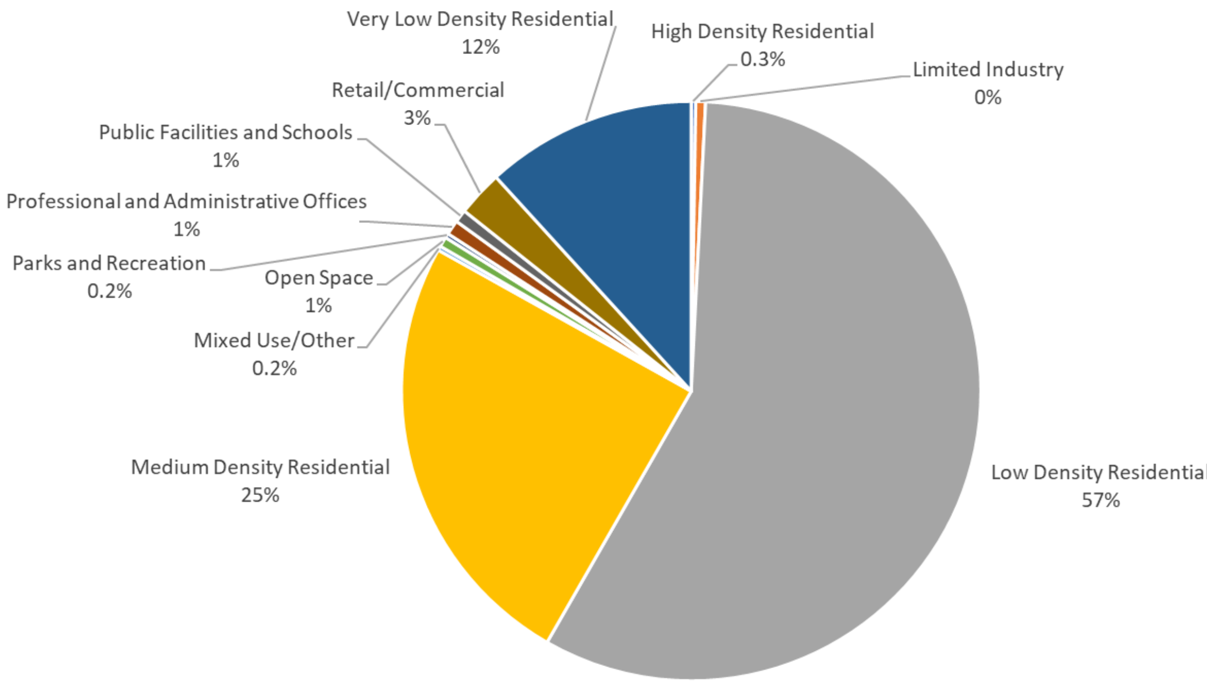


Figure ES.4 Distribution of Land Uses



ES-2 HYDRAULIC MODEL AND CAPACITY ASSESSMENT

The District's hydraulic model is a tool for assessing the flows and capacities of the District's trunk sewers, and for identifying solutions to sewer capacity issues. The hydraulic model is also a tool for performing "what if" scenarios to assess the impacts of future developments, land use changes, and system configuration changes.

ES-2.1 Hydraulic Model Components

The hydraulic model includes the District's trunk sewers and associated facilities. The model also includes some smaller diameter sewers as needed to provide system connectivity or to represent available relief sewers. The hydraulic model applies a sewer flow from each of the District's parcels to the pipe network, simulating dry weather flow. The model then applies wet weather parameters that represent rainfall-dependent inflow and infiltration ("RDII"), thereby introducing the impacts of wet weather flow. Different rainfall events can be applied to the calibrated model to simulate flows in different wet weather conditions.

RDII is the collective description for stormwater and groundwater that enters the sewer system through pipe defects and unpermitted direct connections. Inflow describes water that enters through structures such as roof leaders and private drains, or from holes in manhole covers. Infiltration describes water that enters through defects in pipes, joints, and manhole walls such as cracks, open joints, or breaks.

Figure ES.5, also included as Figure 2.4 in the V&A Flow Monitoring Report (Appendix A), shows common sources of infiltration and inflow.

Figure ES.5 Typical Sources of Infiltration and Inflow

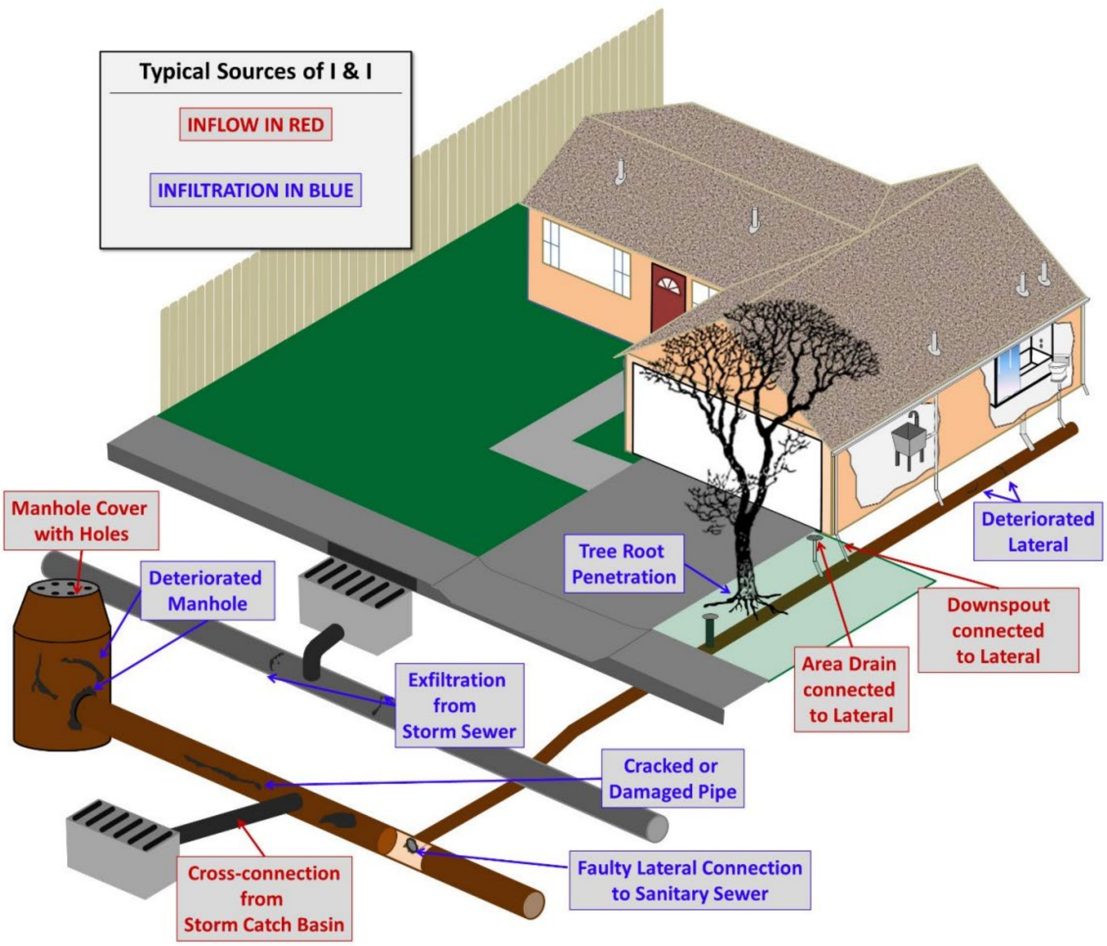


Figure 2-4. Typical Sources of Infiltration and Inflow

ES-2.2 Flow Monitoring Program

From December 15, 2022 through February 12, 2023, the District, through V&A Consulting Engineers, conducted a system-wide flow monitoring program. This program collected flow data using 25 permanent and temporary flowmeters. Figure ES.6 shows the rainfall that was received during the flow monitoring period. Notable rainfall was received on December 10, December 27, and December 31, 2022 and January 9 and 14, 2023. Additional rainfall fell on other dates within this timeframe.

Figure ES.6 - Rainfall Received during 2022-23 Flow Monitoring Period

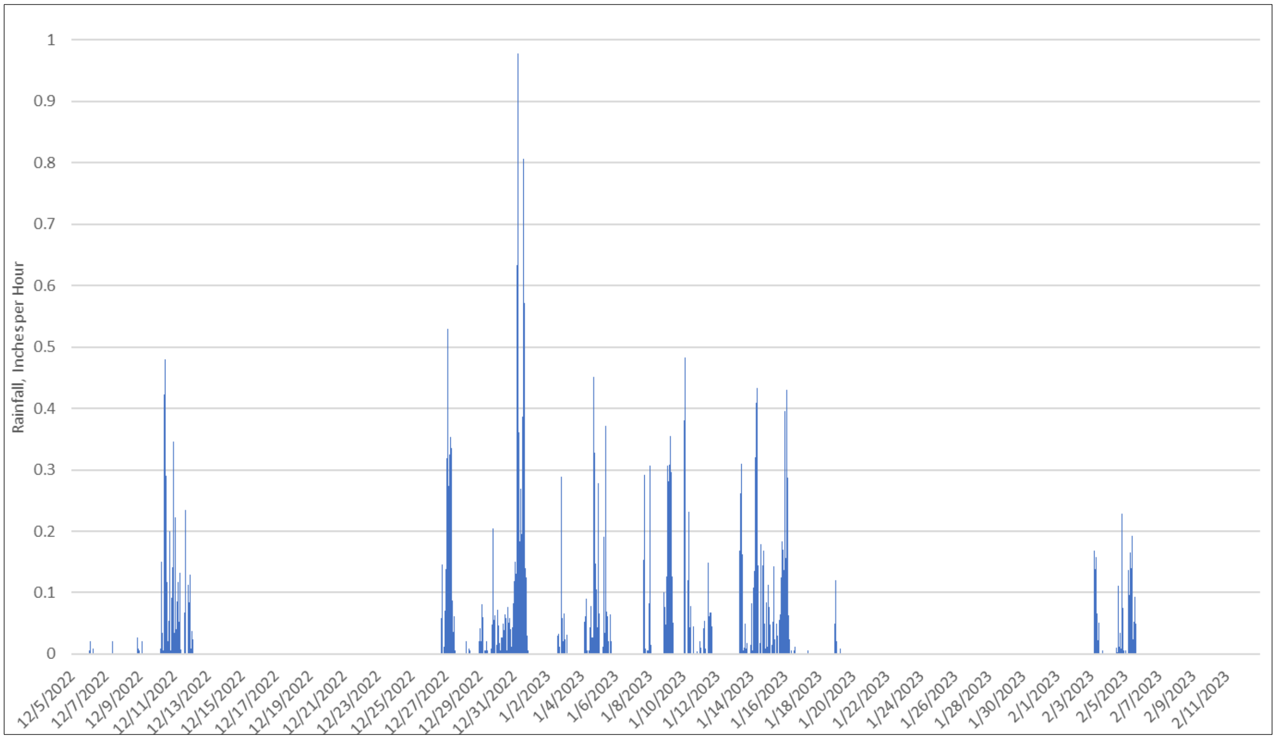


Figure ES.7 on the following page shows the locations of the meters and their associated sewer basins. Dry and wet weather flows for the meters closest to the terminus of the system are shown on Table ES.1. The wet weather peaking factor ("WWPF") was calculated for each of the five distinct rainfall events by adding measured flows at these locations. WWPF is determined by dividing the peak wet weather flow ("PWWF") by the average dry weather flow ("ADWF").

ES-2.3 Capacity Assessment – Gravity Pipelines

The hydraulic model evaluates the predicted capacity of the District's wastewater collection system under flow loading from a hypothetical design storm. The selected design storm has a recurrence interval of 10 years (*i.e.*, 10 percent probability of occurring in any given year) and duration of 24 hours. Flow characteristics for the 10-year, 24-hour design storm were derived from data that is published by the National Oceanographic Atmospheric Administration ("NOAA"). For comparison, a 10-year, 6-hour design storm was also reviewed.

Figure ES.7 Metered Sewer Basins

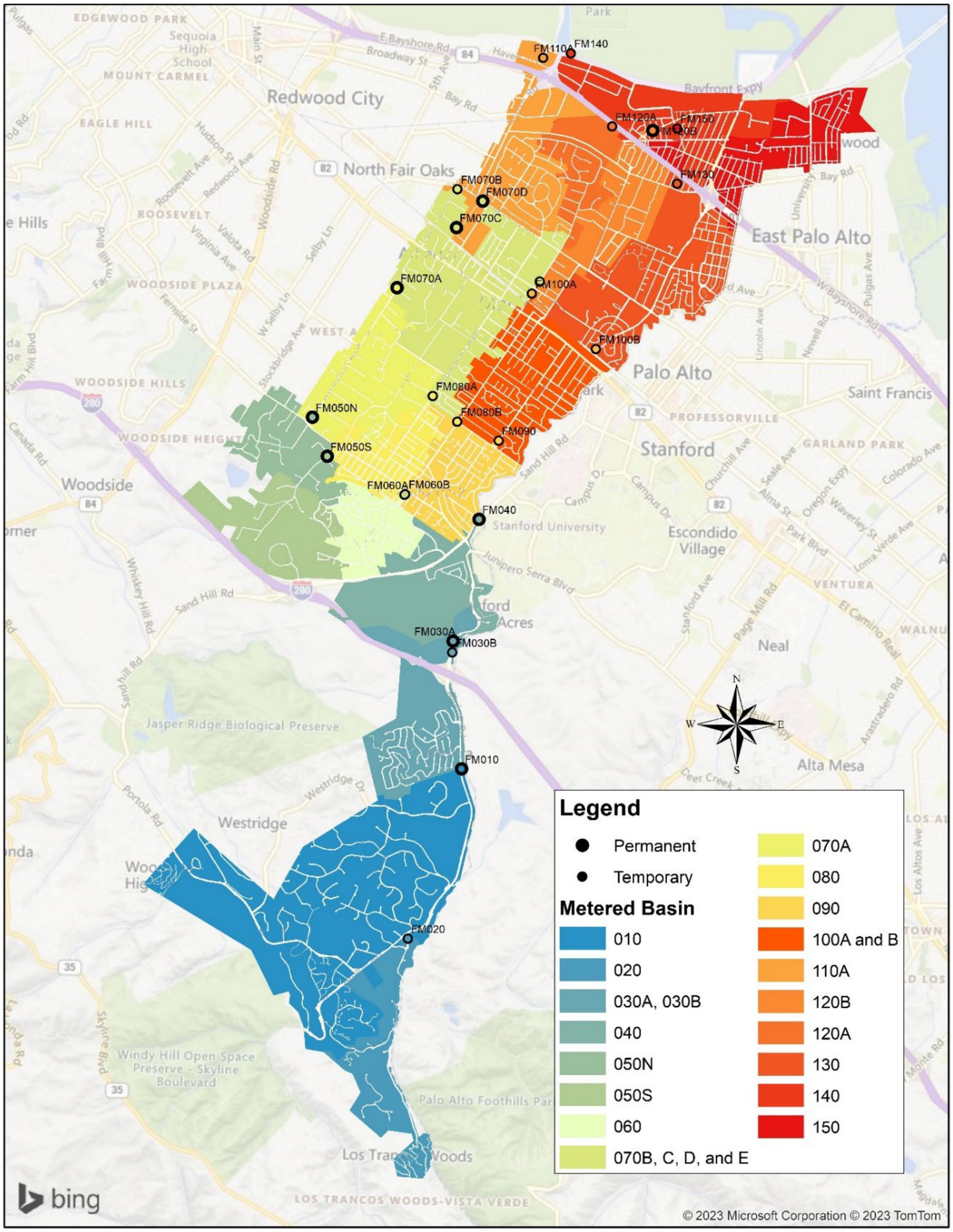


Table ES.1 Rainfall and Measured Flows at Meters 110, 120A, and 140

Monitoring Period(Notes 1,2)	Rainfall at FM110 (inches)	FM110 (mgd)	FM140 (mgd)	FM120A (mgd)	Total Flow (mgd)	WWPF
12/07/2022 (ADWF)	0.005	1.01	0.77	0.06	1.8	N/A
12/27/2022 (PWWF)	1.7	2.6	3.1	0.15	5.8	3.2
12/31/2022 (PWWF)	4.4	5.9	6.6	0.43	12.9	7.2
01/09/2023 (PWWF)	1.5	3.3	6.2	0.18	9.7	5.4
01/14/2023 (PWWF)	1.6	3.5	6.1	0.17	9.8	5.4

Note 1: Peak flows may not have occurred during the same timestep for all meters. Therefore, Total Flow may be slightly higher than actual.

Note 2: The WWPF of 7.2 for the 12/31/2022 rainfall event is higher than the District's systemwide WWPF, because the 12/31/2022 event was more severe than the District's design storm.

NOAA publishes statistically-derived rainfall depths and distribution profiles for use in assigning a rainfall recurrence event[2,3]. The NOAA rainfall depth table for the City of Menlo Park is included as Figure ES.8 on the following page. As shown on the table, the most likely rainfall depth for a 10-year, 24 hour rainfall event is 2.93 inches. Similarly, the most likely rainfall depth for a 10-year, 6-hour rainfall event is 1.87 inches. The hydraulic analysis reviewed system performance under both scenarios. After comparing hydraulic model results, the two storms produce similar results, with the 10-year, 24-hour storm being more conservative (i.e., severe). Therefore, the 10-year, 24-hour rainfall event was selected as the District's design storm.

Figure ES.8 also shows the recurrence interval for the rainfall event that occurred on December 31, 2022. This storm, which deposited over 4.5 inches of rain over a 24-hour period, is categorized by NOAA as having a recurrence period of 100-years.

[2] https://hdsc.nws.noaa.gov/pfds/pfds_map_cont.html?bkmrk=ca

[3] https://hdsc.nws.noaa.gov/pfds/pfds_temporal.html

Figure ES.8 NOAA Rainfall Depths for Various Storm Frequencies and Durations

NOAA Atlas 14, Volume 6, Version 2
Location name: Menlo Park, California, USA*
Latitude: 37.4555°, Longitude: -122.1788°
Elevation: 65.86 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Sarah Dietz, Sarah Heim, Lillian Hiner, Kazungu Maitaria, Deborah Martin, Sandra Pavlovic, Ishani Roy, Carl Trypaluk, Dale Unruh, Fenglin Yan, Michael Yekta, Tan Zhao, Geoffrey Bonnin, Daniel Brewer, Li-Chuan Chen, Tye Parzybok, John Yarchoan

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.106 (0.094-0.121)	0.136 (0.121-0.155)	0.177 (0.157-0.203)	0.211 (0.185-0.243)	0.258 (0.217-0.309)	0.294 (0.242-0.361)	0.332 (0.266-0.419)	0.372 (0.288-0.484)	0.426 (0.315-0.581)	0.468 (0.334-0.664)
10-min	0.152 (0.135-0.173)	0.196 (0.173-0.223)	0.254 (0.225-0.290)	0.302 (0.265-0.349)	0.370 (0.312-0.443)	0.422 (0.347-0.518)	0.476 (0.381-0.601)	0.533 (0.413-0.693)	0.610 (0.452-0.832)	0.671 (0.478-0.951)
15-min	0.184 (0.163-0.209)	0.236 (0.210-0.270)	0.307 (0.272-0.351)	0.366 (0.320-0.422)	0.447 (0.377-0.536)	0.510 (0.420-0.626)	0.576 (0.461-0.726)	0.644 (0.500-0.839)	0.738 (0.546-1.01)	0.811 (0.578-1.15)
30-min	0.253 (0.224-0.287)	0.325 (0.288-0.371)	0.423 (0.374-0.483)	0.503 (0.441-0.581)	0.615 (0.518-0.737)	0.702 (0.578-0.862)	0.792 (0.634-1.00)	0.886 (0.688-1.15)	1.01 (0.752-1.39)	1.12 (0.796-1.58)
60-min	0.356 (0.316-0.405)	0.459 (0.406-0.523)	0.596 (0.526-0.681)	0.709 (0.621-0.818)	0.866 (0.730-1.04)	0.990 (0.815-1.21)	1.12 (0.894-1.41)	1.25 (0.969-1.63)	1.43 (1.06-1.95)	1.57 (1.12-2.23)
2-hr	0.526 (0.467-0.599)	0.674 (0.598-0.768)	0.869 (0.768-0.993)	1.03 (0.899-1.19)	1.24 (1.05-1.49)	1.41 (1.16-1.73)	1.58 (1.26-1.99)	1.75 (1.36-2.28)	1.99 (1.47-2.71)	2.17 (1.55-3.07)
3-hr	0.667 (0.592-0.759)	0.853 (0.756-0.972)	1.10 (0.969-1.25)	1.29 (1.13-1.48)	1.56 (1.32-1.87)	1.77 (1.45-2.17)	1.97 (1.58-2.49)	2.19 (1.70-2.85)	2.47 (1.83-3.38)	2.70 (1.92-3.82)
6-hr	0.970 (0.861-1.10)	1.24 (1.10-1.41)	1.59 (1.40-1.81)	1.87 (1.64-2.16)	2.25 (1.90-2.70)	2.55 (2.10-3.12)	2.84 (2.28-3.59)	3.15 (2.44-4.10)	3.56 (2.64-4.86)	3.88 (2.76-5.50)
12-hr	1.29 (1.15-1.47)	1.65 (1.46-1.88)	2.12 (1.87-2.42)	2.50 (2.19-2.88)	3.03 (2.55-3.63)	3.44 (2.83-4.22)	3.86 (3.09-4.87)	4.30 (3.33-5.59)	4.89 (3.62-6.67)	5.36 (3.82-7.60)
24-hr	1.51 (1.36-1.70)	1.92 (1.73-2.17)	2.47 (2.23-2.80)	2.93 (2.62-3.34)	3.56 (3.09-4.18)	4.06 (3.46-4.85)	4.57 (3.82-5.59)	5.11 (4.17-6.40)	5.86 (4.60-7.61)	6.45 (4.91-8.63)
2-day	1.92 (1.74-2.17)	2.44 (2.20-2.76)	3.13 (2.82-3.55)	3.70 (3.31-4.22)	4.48 (3.89-5.26)	5.08 (4.34-6.08)	5.70 (4.76-6.97)	6.34 (5.17-7.94)	7.22 (5.67-9.38)	7.90 (6.02-10.6)
3-day	2.22 (2.01-2.51)	2.82 (2.55-3.19)	3.62 (3.26-4.10)	4.26 (3.82-4.86)	5.14 (4.47-6.04)	5.82 (4.96-6.96)	6.50 (5.43-7.95)	7.21 (5.88-9.03)	8.16 (6.42-10.6)	8.91 (6.79-11.9)
4-day	2.47 (2.23-2.79)	3.14 (2.84-3.55)	4.02 (3.62-4.56)	4.74 (4.24-5.40)	5.70 (4.95-6.69)	6.44 (5.49-7.70)	7.18 (6.00-8.78)	7.95 (6.48-9.95)	8.97 (7.05-11.7)	9.76 (7.44-13.1)
7-day	3.10 (2.80-3.50)	3.96 (3.58-4.47)	5.07 (4.57-5.75)	5.97 (5.34-6.81)	7.16 (6.23-8.41)	8.07 (6.88-9.65)	8.97 (7.49-11.0)	9.88 (8.06-12.4)	11.1 (8.72-14.4)	12.0 (9.16-16.1)
10-day	3.45 (3.12-3.89)	4.42 (3.99-5.00)	5.68 (5.11-6.43)	6.67 (5.97-7.61)	8.00 (6.95-9.39)	8.99 (7.67-10.8)	9.98 (8.34-12.2)	11.0 (8.94-13.7)	12.3 (9.65-16.0)	13.3 (10.1-17.8)
20-day	4.49 (4.06-5.07)	5.82 (5.26-6.58)	7.50 (6.76-8.49)	8.82 (7.89-10.1)	10.5 (9.16-12.4)	11.8 (10.1-14.1)	13.1 (10.9-16.0)	14.3 (11.7-17.9)	15.9 (12.5-20.7)	17.1 (13.0-22.9)
30-day	5.37 (4.85-6.06)	6.98 (6.31-7.89)	9.01 (8.11-10.2)	10.6 (9.47-12.1)	12.6 (11.0-14.8)	14.1 (12.0-16.9)	15.6 (13.0-19.0)	17.0 (13.8-21.3)	18.8 (14.8-24.4)	20.1 (15.3-27.0)
45-day	6.56 (5.93-7.41)	8.54 (7.71-9.65)	11.0 (9.90-12.4)	12.9 (11.5-14.7)	15.3 (13.3-18.0)	17.1 (14.6-20.4)	18.8 (15.7-22.9)	20.4 (16.6-25.6)	22.5 (17.7-29.2)	24.0 (18.3-32.1)
60-day	7.86 (7.10-8.87)	10.2 (9.20-11.5)	13.1 (11.8-14.8)	15.3 (13.6-17.4)	18.1 (15.7-21.2)	20.1 (17.1-24.0)	22.0 (18.4-26.9)	23.9 (19.5-29.9)	26.2 (20.6-34.0)	27.9 (21.2-37.3)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

The hydraulic model identified two locations with predicted spills during the design storm. Overall, the design storm did not cause widespread overflow issues within the District's system. The locations with predicted spills during the design storm event are shown on Figures ES.9 and ES.10 on the following pages and described below.

Location 1 - Downstream of Willow Pump Station (Ivy Drive)

The Willow Pump Station has sufficient capacity to convey incoming flows. However, the hydraulic model predicts a spill at the discharge manhole on Ivy Drive (B12029). This shallow manhole has a depth of approximately 2.5 feet. During the December 31, 2022 rainfall event, the pipes beginning from the MPS and back through Chilco Street and the Ivy Drive easement became surcharged. As a result, the flow that is normally discharged to a gravity pipeline within Ivy Drive could not enter this pipe and was released from the shallow manhole B12029. After the December 31, 2022 rainfall event ended, a locking manhole was installed on structure B12029 to prevent future spills from this location.

The locking manhole is sufficient to prevent spills from this location. However, a long-term solution involves extending the existing force main through Ivy Drive to a termination point on Chilco Street. The existing pipeline on Ivy Drive is located with a San Francisco Public Utilities Commission easement, making replacement of this pipeline difficult or possibly infeasible. The proposed project installs 2,456 lineal feet of 12-inch force main pipe within the existing 15-inch gravity line on Ivy Drive. Larger pumps would be required at Willow Pump Station to convey this flow. Therefore, alternative lining methods and/or a shorter force main extension should be reviewed during preliminary design to lower friction losses and reduce the added load on the pumps.

This is a long-term project, as the issues have been addressed in the near-term through the installation of three sealed manhole covers on structures B12029, B12141, and B12147. The hydraulic profile for the Ivy Drive capacity constraint and predicted spill location are show on Figure ES.9 on the following page.

Location 2 - Elena Avenue near Park Lane

The District has an existing 8-inch diameter pipe that begins where Camino al Lago turns into Park Lane in Atherton and continues north to Elena Avenue. The pipe continues west on Elena Avenue to Atherton Avenue. This pipe is on the high-frequency cleaning schedule to minimize the potential for surcharging during wet weather events. This pipeline did not have any spills during the December 31, 2022 wet weather event.

The hydraulic model predicts spills from two manholes on this alignment during the design storm. The first spill occurs on Elena Avenue and the second spill occurs on Park Lane. Although these predicted spills have not been observed during heavy rainfall events, they indicate locations where spills are more likely to occur in the future. Therefore, a future project to address the predicted surcharge is recommended for consideration in the long-term CIP.

The recommended project upsizes 4,833 lineal feet of existing pipe on Park Lane and Elena Avenue from 8-inches to 10-inches in diameter. An existing siphon that goes under a creek near Atherton Avenue has a diameter of 10 inches and will not need to be replaced.

Prior to finalizing the scope of work for the Elena Avenue Capacity Improvement Project, it is recommended that District use one or more SmartCovers or other methods to monitor water levels within the alignment during future wet weather events. If the District receives a rainfall event that is similar to the rainfall that was captured during the 2022/23 wet weather season and water levels within the project alignment do not rise as predicted by the hydraulic model, then the project scope can be reviewed and reduced as needed to address field conditions. The hydraulic profile and predicted spill locations are shown on Figure ES.10.

Figure ES.9 Capacity Constraint Downstream of Willow Pump Station

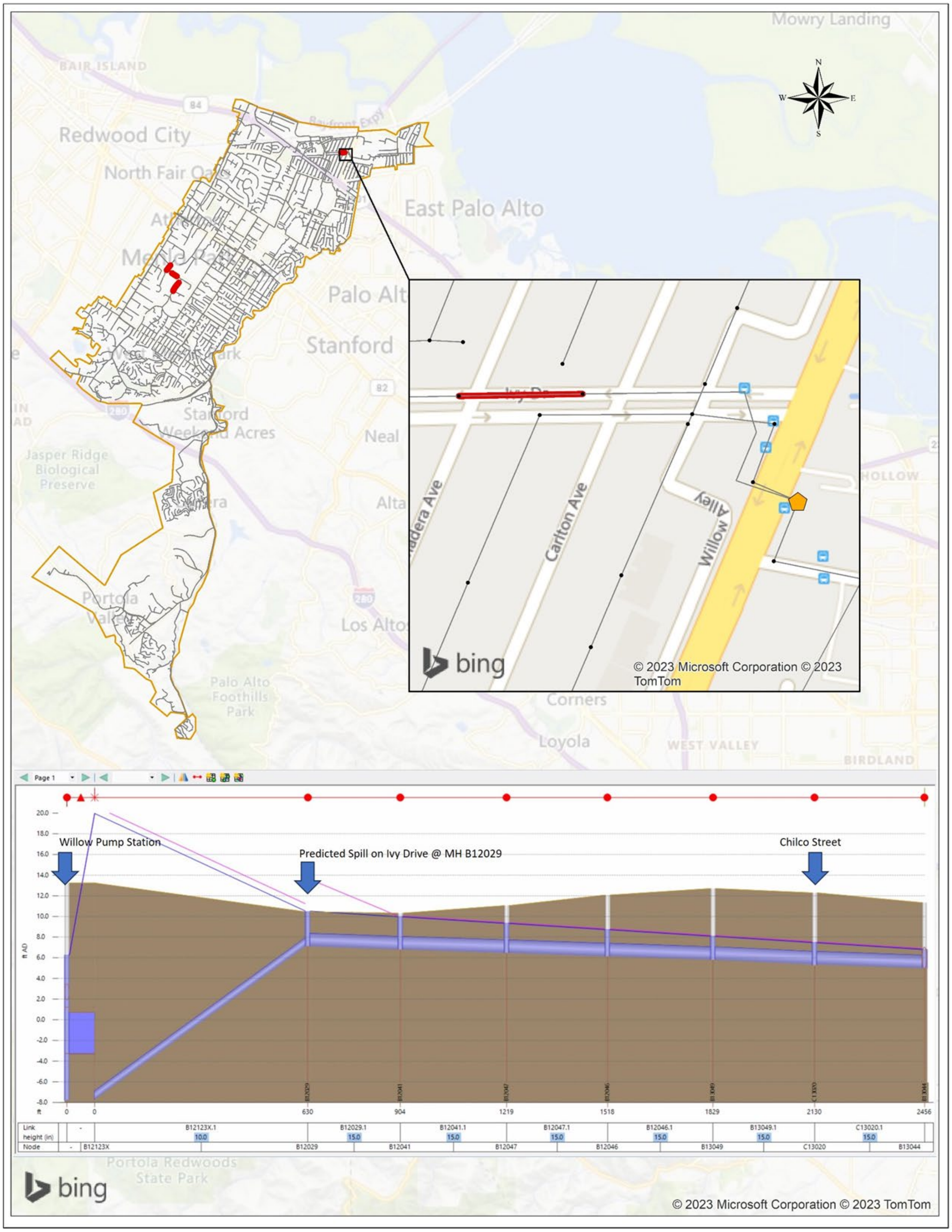


Figure ES.10 Capacity Constraint on Elena Avenue and Park Lane

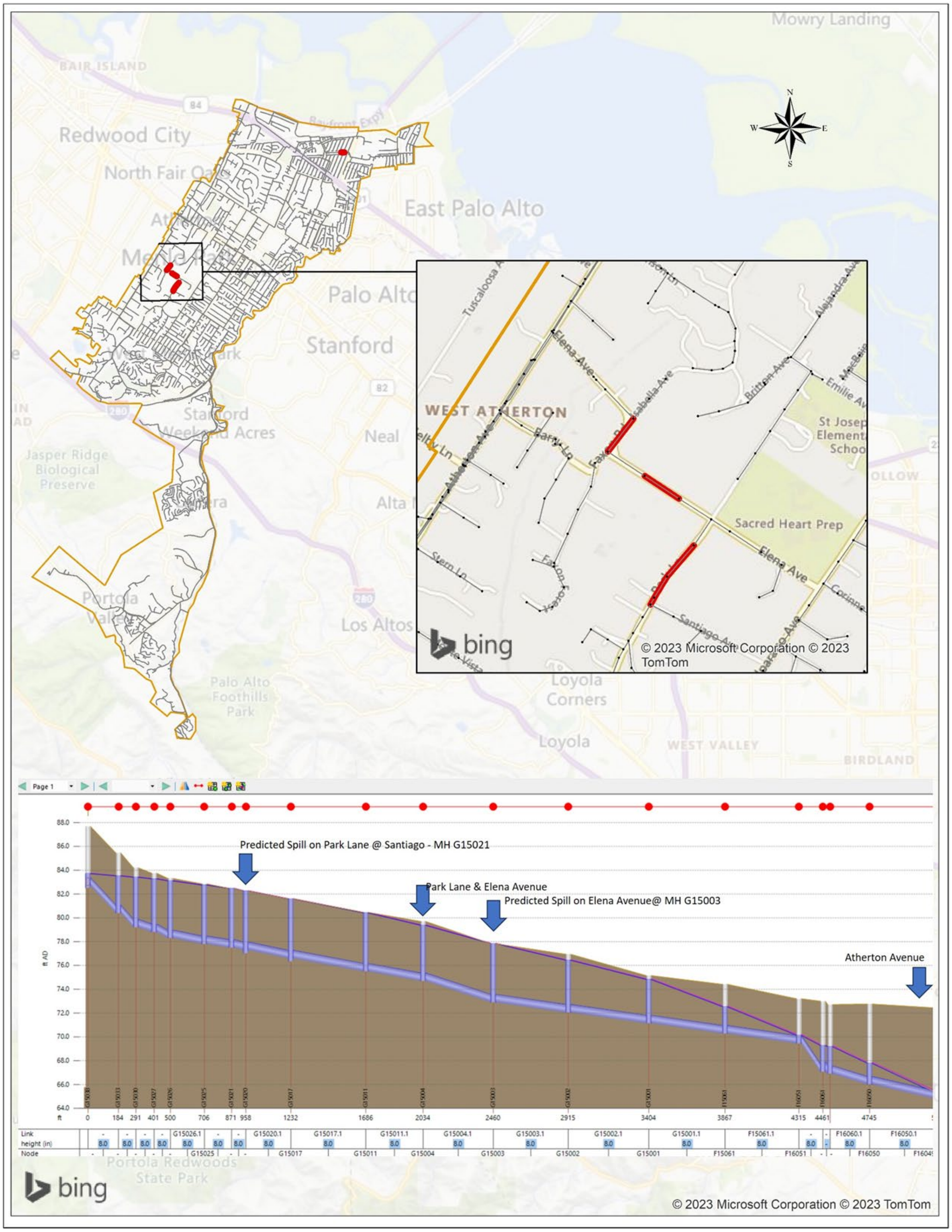


Table ES.2 lists the proposed capacity improvement projects and associated costs.

Table ES.2 Estimated Costs for Capacity Projects

Project Name	Pipe Length (ft)	New Diameter (in)	Construction Cost	Total Project Cost
Willow Pump Station Discharge (Ivy Drive) Capacity Improvement Project	2,456	12	$1,034,467 +$50,000 for pump upgrades TBD	$1,409,807
Elena Avenue Capacity Improvement Project	4,833	10	$2,827,305	$3,675,496

Notes:

1. Willow pump sizing will depend on the final length, diameter, and material selected for the extended force main. Costs shown are a placeholder, assuming the force main is extended to Chilco Street.

ES-2.4 Capacity Assessment – Pump Stations

Model-generated flows from the design storm event were compared to firm pump station capacity (i.e., capacity with the largest pump out of service) as provided by the District during model development. Ten of the District's eleven pump stations were included in the hydraulic model.

All of the District's pump stations are sufficiently sized to convey design storm flows. However, as discussed above, the gravity sewer directly downstream of the discharge manhole for the Willow Pump Station is not able to convey design storm peak flows without predicted spills and requires a capacity upgrade.

ES-2.5 Review of Statewide Waste Discharge Requirements for Capacity Analysis

The new State Water Resources Control Board Order WQ 2022-103-DWQ (Statewide WDR) became effective as of June 5, 2023. The hydraulic analysis and capacity assessment address most of the requirements of the Statewide WDR without the need for supplemental analysis. However, two items from the Statewide WDR require additional discussion:

1) Capacity of systems subject to increased inflow and infiltration ("I&I") due to larger and/or higher-intensity storm events as a result of climate change; and

2) increase of erosive forces in canyons and streams near underground and aboveground system components due to larger and/or higher intensity storm events.

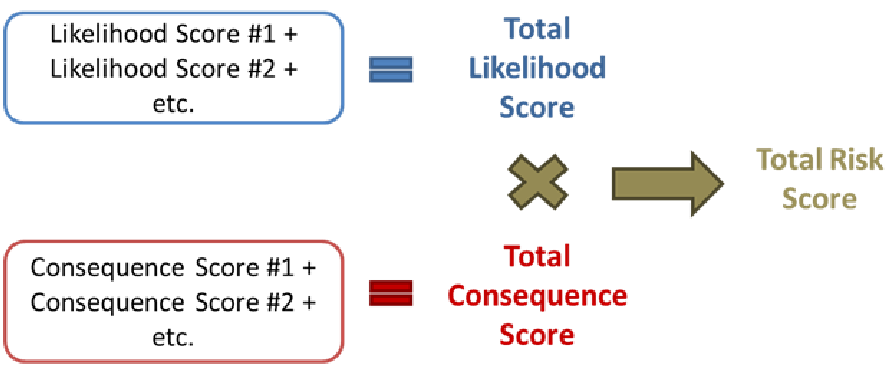
Chapter 5, Capacity Analysis, provides information to address these two topics from the Statewide WDR.

ES-3 LINEAR ASSET MANAGEMENT PLAN

The Linear Asset Management Plan ("LAMP") identifies gravity sewer pipelines with the highest risk of failure, develops rehabilitation recommendations for these pipelines, estimates costs, and prioritize repairs to assist in capital project planning. The LAMP uses a numerical risk model to assign a Risk Score to every gravity pipe segment. The risk model calculates Risk as a product of Likelihood and Consequence of Failure as shown on Figure ES.11. The LAMP focuses on the District's linear gravity assets, which include all gravity collector sewers and trunk lines.

Likelihood and Consequence of Failure factors were collected from the District's asset database, computerized maintenance management system ("CMMS"), publicly available information obtained through the San Mateo County geographic information system ("GIS") portal, results from the District's sewer hydraulic model, and sanitary sewer spill data from the California Integrated Water Quality System ("CIWQS") database.

Figure ES.11 Total Risk Score Calculation



The results from the risk model were analyzed, high risk pipes mapped and grouped, and near- and long-term rehabilitation needs identified. The resulting projects were grouped and prioritized by drainage basin. Conceptual costs were then developed for each of these projects based on the expected repair method. The replacement strategy integrates the District's current repairs and replacement projects and provides a systematic repair program for the next ten years.

ES-3.1 Likelihood and Consequence of Failure

Likelihood of Failure parameters were selected to most effectively utilize the District's stored data, and include the following:

- Sanitary sewer spill history (5 years)
- Structural and Operation & Maintenance defects
- Pipe material
- Liquefaction potential and seismic risk
- Pipeline capacity for interceptor pipelines

- Pipe size (i.e., less than 6 inches in diameter)

The Consequence of Failure score is based on parameters that, when adjacent to a failed pipeline, would result an increased impact to the community. Consequence of Failure parameters include the following:

- Proximity to a waterway
- Proximity to a primary or secondary transportation corridor
- Proximity to public facilities, including schools, parks, and hospitals
- Area served, as indicated by pipe size (i.e., greater than 12 inches in diameter)

ES-3.2 Risk Model Results

The Total Risk Scores that were generated by the LAMP model were linked back to their respective pipe segment by the Pipe ID. Risk Scores were grouped by priority, as noted below.

- **Priority 1:** 10 Pipes with structural Grade 5 defects and proximity to a waterway.
- **Priority 2:** Remaining pipes with known Grade 5 defects.
- **Priority 3:** 35 pipes with structural Grade 4 defects and proximity to a waterway.
- **Priority 4:** 261 pipes with at least one structural Grade 4 defect and lower risk profiles.

The District may decide to extend the service life of pipes that have lower-priority Grade 4 defects in parallel with the Capital Improvement Program using pipe patching or other interim repairs.

Table ES.3 lists pipes with NASSCO PACP structural Grade 4 and 5 defects in each basin. The estimated costs for repair and replacement are as follows:

- Priority 1 and Priority 2 Grade 5 Pipes: 101 lines with 25,398 lineal feet of combined length. 10 manholes are also assumed to be replaced. Total estimated cost is $6,295,000.
- Priority 3 Grade 4 Pipes: 250 lines with 54,193 lineal feet of combined length. 16 manholes are also assumed to be replaced. Total estimated cost is $9,843,200.
- Priority 4 Grade 4 Pipes: 261 lines with 60,812 lineal feet of combined length. 12 manholes are also assumed to be replaced. Total estimated cost is $10,128,277.

Table ES.3 CIP Pipes with Structural Grade 4 and 5 Defects by Basin

Basin	Structural Grade 5		High Priority Structural Grade 4		Structural Grade 4 Watch List	
	# of Pipes	Length (ft)	# of Pipes	Length (ft)	# of Pipes	Length (ft)
010	1	185	0	0	4	456
020	0	0	1	217	3	772
030A	7	1446	12	2700	59	11929
040	4	782	4	498	6	1912
050NS	20	5440	6	1142	32	6053
060AB	7	1592	0	0	16	2904
070AB	21	5,037	8	1835	78	19238
070CDE	5	1649	4	1001	33	6440
080AB	4	1182	0	0	30	6820
090	4	961	0	0	42	9956
100AB	10	2590	0	0	47	11498
110A	1	307	0	0	38	9146
120AB	4	1235	0	0	5	6275
130	3	771	0	0	18	4923
140	6	1222	0	0	20	3402
150	4	999	0	0	15	5888
Total	**101**	**25,398**	**35**	**7,393**	**476**	**107,612**
Note: Blue shaded rows are the basins with the Highest Priority pipes having structural Grade 5 defects.						

ES-4 PUMP STATION ASSESSMENTS

The District's pump stations were assessed to review the current condition of the 11 existing pump stations and force mains. District operations staff assisted with the field evaluation. The assessment findings were used to determine the potential for large-scale rehabilitations that may fall outside the scope of the District's proactive pump replacement program. The site assessment included a review of the pump station wet wells and valve vaults, open cabinets, generators, and other above-grade facilities. In addition to the 11 lift stations, the team provided a visual assessment of the FERRF pump station. Table ES.4 summarizes the results from the pump station assessments.

Table ES.4 Pump Station Assessment Summary

Pump Station	Observed Conditions to be Addressed	CIP Project Required?	Existing CIP Projects?
Willow PS	- Safety Grates absent - Hatches do not conform to current District Standards - Force mains in need of replacement - Flow meter required - Wet Well Coating required - Odor control required	Yes	Yes
University PS	- Safety Grates absent under wet well hatch - Hatches do not conform to current District Standards	No	No
Illinois PS	- Safety Grates absent under wet well hatch	No	No
Menlo Industrial PS	- No Deficiencies Observed - PS may be replaced for Willow Village Development	No	No
Hamilton-Henderson PS	- Exposed aggregate above water line indicative of hydrogen sulfide corrosion	Yes	No
FERRF PS	- Electrical equipment at end of life - Pumps at end of life - Communications equipment at end of life - Valves and piping show signs of corrosion and may not be routinely exercised	Yes	No
Vintage Oaks 1 PS	- No deficiencies observed	No	No
Vintage Oaks 2 PS	- No deficiencies observed	No	No
Stowe Lane PS	- Dry pit pump configuration - Pumps are in confined space - Aging electrical equipment	Yes	Yes
Los Trancos PS	- No deficiencies observed	No	No
Sausal Vista PS	- No deficiencies observed	No	No
Village Square PS	- No deficiencies observed	No	No

ES-4.1 Pump Station Recommendations

The District is preparing design documents for improvements to the Willow Pump Station, including a new generator, new piping from the wet well through the valve box, new valves, and wet well coating. The District is also preparing design documents for improvements to the Stowe Lane pump station, including conversion to a submersible pump station and adding a new generator. The costs for these projects are $1.7M and $3M for the Willow Pump Station upgrades and Stowe Lane pump station upgrades, respectively.

In addition to these projects, the Master Plan includes a project to install a new wet well lining to the Hamilton-Henderson wet well. The total cost for this improvement is $77,000.

Budget is also allocated to perform a complete upgrade to the FERRF pump station including replacing existing pump drives and electrical equipment, replacing existing submersible pumps and wet well piping, replacing discharge piping valves, recoating existing piping, lining the existing concrete wet well, and cleaning/recoating the existing metal building. The total cost for an upgraded FERRF pump station is $1,420,000.

To supplement the pump station improvements, replacement force mains for the oldest force mains at the Willow, University, and Illinois pump stations are recommended for a total combined cost of $2.1M.

The CIP also includes current facility projects that are planned for completion in the CIP timeframe, such as telemetry upgrades and upgrades to the District's maintenance building.

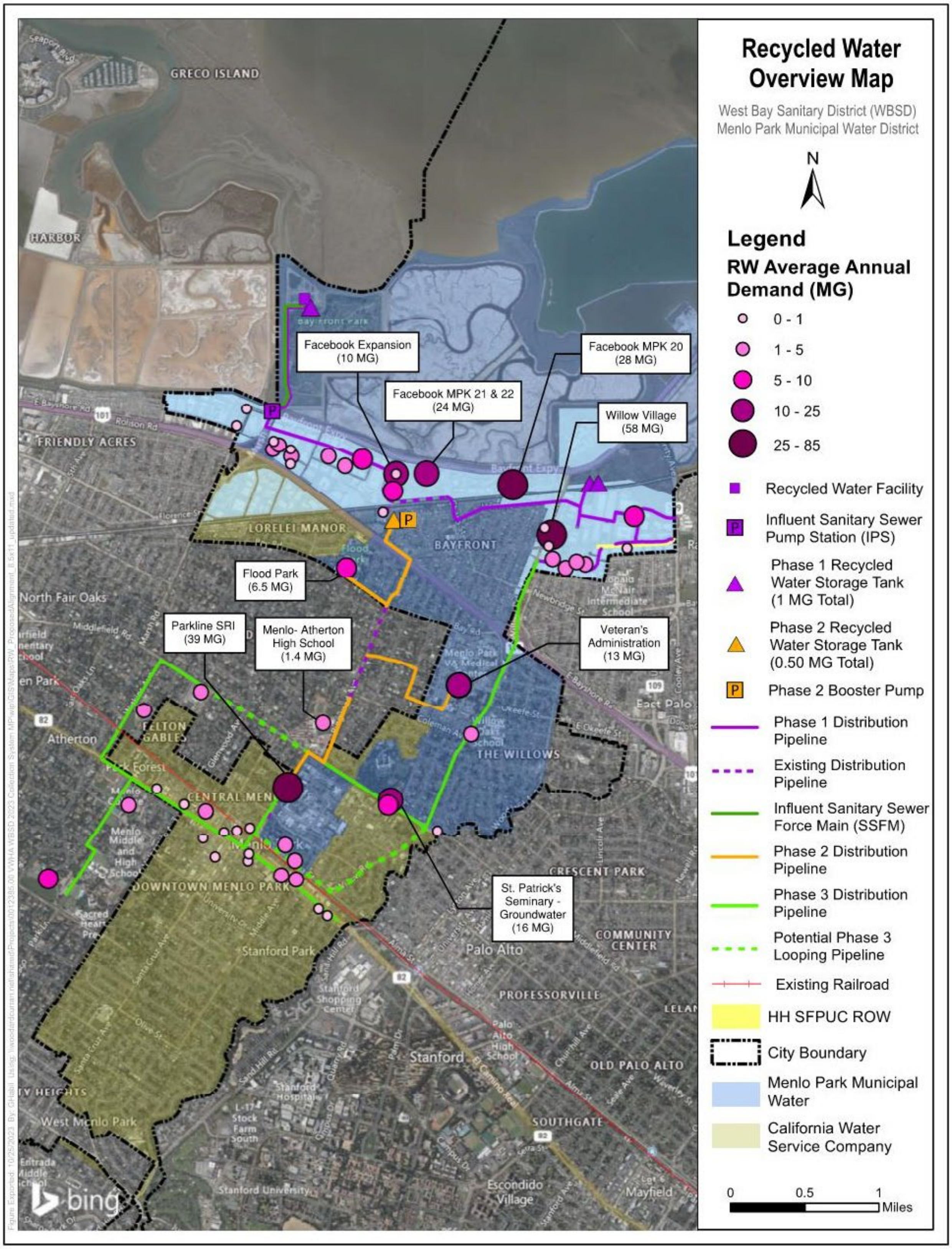
ES-5 RECYCLED WATER PLAN

In 2014, the District completed a Recycled Water Market Survey and evaluated three conceptual alternatives to serve potential recycled water customers. This effort led to construction of a satellite treatment plant at the SHGCC and recycled water use at the golf course and other potential customers near the golf course. In 2019, the District completed the Bayfront Recycled Water Facilities Plan ("RWFP"), which evaluated projects identified in the Market Survey in the Bayfront area. This plan updated and refined the market assessment and analyze various recycled water project alternatives.

The Bayfront facilities have been planned and are in the 30% design phase. The 2023 Recycled Water Plan that was prepared for this 2023 Master Plan focuses on additional distribution facilities that extend down to the central and southwest portions of the study area to serve new customers including Flood Park, Parkline (SRI International), Menlo-Atherton High School, and Veteran's Administration.

Figure ES.12 on the following page summarizes findings and recommendations from the 2023 Recycled Water Plan.

Figure ES.12 Recycled Water Overview Map



ES-5.1 Water Demand and Supply

Based on the 2020 Urban Water Management Plan for the Menlo Park Municipal Water District ("MPMW"), the population of the City of Menlo Park served by the MPMW is expected to increase by 65% by 2040. Concurrently, employment in the service area is expected to expand, increasing both overall and nonpotable recycled water demand. MPMW purchases all its water from the San Francisco Public Utilities Commission ("SFPUC"). Demand in the adjacent Cal Water service area is also expected to increase during this time, but not as significantly.

ES-5.2 Potential Recycled Water Customers and Demands

A preliminary recycled water market assessment was conducted as part of the 2014 Market Survey. The 2019 RWFP refined the preliminary recycled water market assessment to consider additional potential potable water customers (existing and future) that were not originally evaluated during the 2014 Market Survey. To supplement the information from the prior studies, a list of approved and pending development projects (Development Projects List) in the study area was provided by the District in May 2023. Figure ES.12 shows the recycled water study area and the location of the various customers described.

The seven largest customer demands and all Phase 2 customers are labeled by name and estimated recycled water average annual demand. Figure ES.12 also shows existing, planned, and proposed recycled water distribution pipeline alignments to service customers in the study area.

Phase 1 includes all planned purple pipe in the Bayfront area, which is currently being designed; Phase 2 includes the proposed orange pipelines that would service Flood Park, Veteran's Administration, Menlo-Atherton High School, and Parkline (SRI International); and Phase 3 includes additional potential pipe in the Southwest and Eastern portions of the study area. This infrastructure is included for discussion purposes. The purple dashed line is existing recycled water pipe.

The total non-potable demand for each customer is comprised of up to three demand types: irrigation, flushing, and cooling tower demands. Facilities for treating and conveying recycled water are sized based on peak demand periods. Two peak flow situations were defined as criteria for development of the recycled water distribution system in the market assessment: maximum day demand ("MDD") and peak hour demand ("PHD").

The potential recycled water customers were categorized into four service regions for the purposes of pipe and pump sizing: Phase 1 - East of Chilco St.; Phase 1 - West of Chilco St.; Phase 2; and Phase 3. Table ES.5 on the following page summarizes the total demand per pipeline service region. Customers that were more than 1,000 feet away from the pipelines were not included in this demand estimate.

Table ES.5 Customer Demands by Pipeline Service Region

Pipeline Service Region	RW Average Annual Demand (AFY)	RW Average Annual Demand (MG)	RW Average Daily Demand (MGD)
Phase 1, Northwest Area (Bayfront), West of Chilco Street[1]	81.40	26.53	0.07
Phase 1, Northeast Area (Bayfront), East of Chilco Street[1]	466.93	152.15	0.42
Total Phase 1	**548.33**	**178.64[4]**	**0.49**
Phase 2, Central Area[2]	182.55	59.48	0.16
Total Phase 1 and 2	**730.89**	**238.16**	**0.65**
Phase 3, Southwest and Eastern Area[3]	199.71	65.08	0.18
Total Phase 1, 2, and 3	**930.60**	**303.24**	**0.83**

Notes:

1. Area north of Highway 101.
2. Extending south of Highway 101 down Ringwood Ave. to connect to Parkline (SRI International).
3. Extending farther south and west to customers surrounding Downtown Menlo Park and east along Middlefield Road and Willow Road.
4. The recycled water demand for Phase 1 in this table is larger than the demand listed in the 2021 update, because the amount in this table includes two customers from the 2019 RWFP and some additional customers from the 2023 Development Projects List.

ES-5.3 Recycled Water Quality Requirements

Potential irrigation customers have different water quality needs according to their intended use. Water quality guidelines for landscape use are well established, with different degrees of restriction for various water quality constituents for the use of recycled water in landscaped irrigation. Except for nitrogen, the constituents that impact landscaping are not removed by conventional wastewater or tertiary treatment processes. Therefore, recycled water constituent levels are likely to be similar to the source wastewater constituent levels.

The satellite treatment project requires diversion of wastewater flow from the existing collection system to the new treatment facilities. The two main conduits for wastewater to the potential plant location at the FERRF are the 24-inch sewer on Haven and the 54-inch sewer on Kelly Park. Water quality sampling and flow monitoring at these two locations were used to develop conceptual treatment options for the future recycled water plant. Based on the results, recycled water treatment technologies were evaluated, including use of a filter bed, microfiltration, and ultrafiltration for the filtration method, combined with UV disinfection. In summary, the water supply from the Haven supply provided higher quality influent than the water supply from the Kelly Park supply.

ES-5.4 Recycled Water Project Components

Using the information described above, conceptual production and distribution facilities for the Phase 2 recycled water project were developed as follows:

- Influent conveyance system: Influent pump station, force main, and equalization. Raw wastewater would be pumped from a new manhole at Marsh Road and Bayfront Expressway, diverting flow from the existing 36-inch sewer to the satellite treatment plant.
- Water recycling facility (WRF): Grit removal, screening, MBR, UV, chlorination, de-colorization. The WRF would be sized to meet the max day demand and would operate as a dry weather satellite plant – operating at a constant flow rate over 24 hours a day for 8 months of the year and at half capacity for 4 months of wet weather to maintain the biological processes.
- Waste return pump station and force main. Grit and screenings produced at the facility would be washed, compacted, and hauled offsite for disposal. Waste sludge and the de-colorization waste product would be discharged by force main to an existing 30-inch sewer and conveyed to SVCW.
- Recycled water distribution system: storage, pump station, and pipelines. The recycled water distribution system would be sized to meet peak hour demand. Recycled water storage would be provided to collect excess supply during periods of low demand so that sufficient supply is available on demand.

The Phase 1 Project (Bayfront Project, Currently in Design Phase) involves the construction of an influent pump station to divert wastewater from the District's collection system, approximately 4,900-LF of influent pipeline, a satellite MBR/UV treatment facility to treat and ultimately produce a maximum daily flow of 0.6 MGD (for Bayfront Project only), and recycled water distribution system including a recycled water storage tank, recycled water pump station, and approximately 30,800-LF of distribution pipeline (approximately 27,400-LF planned and 3,400-LF existing) to various customers.

The Phase 2 Project described in this Master Plan would involve the construction of a booster pump station at the intersection of Terminal Ave and Del Norte Ave, where the Phase 2 pipeline begins, to divert recycled water from the Phase 1 system to the Phase 2 system, approximately 18,800-LF of distribution pipeline (approximately 15,700-LF proposed and 3,100-LF existing) to various customers, and a 0.5 MG storage tank. This project would deliver an estimated total of 930 AFY (Average Annual Demand) for irrigation, cooling towers, and other indoor uses.

The Phase 2 Project would divert wastewater from the 36-in sewer pipeline near the intersection of Bayfront Expressway and Marsh Road and pump the wastewater to the Bayfront satellite treatment facility. The treatment facility includes grit removal and fine screening, biological reactor tanks, MBR treatment system, UV disinfection, de-colorization and all appurtenances required for a fully functional treatment system. The product water would be stored in a recycled water tank and a distribution pump station would be used to deliver recycled water to customers. Distribution from the satellite treatment facility to customers would be through an 8-inch pipeline.

The possible future Phase 3 Project, would likely involve construction of approximately 38,500 lineal feet of additional distribution pipeline to various customers, 18,800 lineal feet of additional pipeline for possible looping purposes, and two additional pumps.

ES-5.5 Potential Recycled Water Project Cost Estimate

Table ES.6 on the following page summarizes the estimated cost for the Phase 2 facilities. Costs for Phase 3 are included for reference only. The Phase 1 facilities (the Bayfront Project) are not included in this estimate because, while not yet built, they have already been financed and are currently in the 30% design phase.

Table ES.6 Estimated Recycled Water Project Costs

Description	Phase 2[1]	Phase 2 and 3[1]
Influent Facilities (Pump Station and Pipeline)[2]	$-	$-
Treatment Facilities[2]	$-	$-
Distribution Facilities (Pump Station, Storage Tank, and Pipeline)	$9,720,000	$28,211,000
Raw Construction Cost	**$9,720,000**	**$28,211,000**
Construction Contingency (30% of Raw Construction Cost)	$2,916,000	$8,464,000
Total Construction Cost	**$12,636,000**	**$36,675,000**
Implementation Cost	$3,664,000	$10,636,000
Total Capital Cost	**$16,300,000**	**$47,300,000**
Annual Cost of Distribution Facilities	$64,000	$163,000
Annual Treatment Cost	$500,000	$1,000,000
Annual Cost of Power	$16,000	$33,000
Annual Labor Costs	$18,000	$18,000
Total Annual O&M	**$598,000**	**$1,214,000**
Annualized Total Project Cost[3]	$887,000	$2,572,000
Annual O&M Costs	$598,000	$1,214,000
Annual Recycled Water Cost	$7,000	$9,000
Total Annualized Cost	**$1,492,000**	**$3,795,000**
Estimated Recycled Water Yield (AFY)	183	382
Unit Cost, Annualized ($/AF)	**$8,200**	**$9,900**

Notes:

1. Planning level estimate; costs are in September 2023 dollars.
2. These costs are not included because they are considered part of Phase 1 (the Bayfront Project).
3. Annualized at 30 years, 3.5%.

ES-5.6 Schedule and Critical Path for Implementation

Full implementation of the Phase 2 project is anticipated to take approximately 10 years and implementation of the Phase 2 pipe will occur simultaneously with the sewer improvements associated with new development. In summary, all the preliminary studies required to further refine the project need to be completed in order to: 1) prepare the Engineering Report for DDW; 2) initiate environmental documentation; and 3) refine project cost estimates. The environmental documentation should be completed in parallel with the Engineering Report.

Several permits are necessary for the implementation of the Phase 2 project. Foremost, the District would need to obtain an individual Water Reclamation Requirement permit from the San Francisco Bay Regional Water Quality Control Board to cover the production of recycled water. A Title 22 Engineering Report would also be needed to satisfy SWRCB Division of Drinking Water requirements. In addition, standard construction permits including encroachment and air quality permits would be required. Depending on whether MPMW or the District decides to be the recycled water purveyor, that agency would need to enroll under the State Water Resources Control Board General Order WQ 2016-0068-DDW for permit coverage of the distribution and use of recycled water.

All public projects in California must comply with the California Environmental Quality Act (“CEQA”). Based on a preliminary review, it is likely that the District can prepare a Mitigated Negative Declaration for the project to meet CEQA requirements. A Mitigated Negative Declaration is allowed if an Initial Study determines that impacts can be reduced to less than significant levels with implementation of mitigation measures.

In addition to CEQA, a project is subject to the National Environmental Policy Act (“NEPA”) if it is jointly carried out by a federal agency, requires a federal permit, entitlement, or authorization, requires federal funding, and/or occurs on federal land. The State Water Resources Control Board (“SWRCB”) State Revolving Fund (“SRF”) loan program is partially funded by the U.S. Environmental Protection Agency and, as a result, requires additional environmental documentation beyond CEQA – but not as extensive as NEPA – that is referred to as “CEQA-Plus.”

From a project funding and financing perspective, CEQA certification is the critical path for gaining preliminary approval for grant funding and low-interest loans from the SWRCB. From a project start-up perspective, the Engineering Report approval is the critical path for acquiring a recycled water permit from the San Francisco Bay Regional Water Quality Control Board (“RWQCB”), which is needed prior to start of operations. CEQA certification is also needed before the RWQCB can issue the tentative permit.

Design of the infrastructure improvements would continue after completion of the relevant preliminary studies in coordination with CEQA and permitting efforts. Applications for funding and stakeholder/public outreach efforts would occur over the lifetime of the project.

ES-5.7 Financing Plan

This section discusses potential funding sources for the Recommended Project, the construction financing plan, and associated cash flow over the implementation period. Typically, recycled water projects are financed through a combination of grants, partnerships relative to project benefits, and the SWRCB SRF. There are also several bond measures currently in development in the California State Legislature that may provide additional funding streams.

Other potential funding opportunities are possible for this project, including the following:

- US Bureau of Reclamation (USBR) WaterSMART: Title XVI Water Reclamation and Reuse Program. The Bureau of Reclamation offers three categories of WaterSMART Grants through separate funding opportunities. Water and Energy Efficiency Grants, the primary category of funding under WaterSMART Grants, provide funding of up to $500,000 for projects to be completed within two years, up to $2 million for projects to be completed within three years; and up to $5 million for projects to be completed within three years, with a non-Federal cost share of 50% or more of the total project cost.
- SWRCB CWSRF / Water Recycling Funding Program (WRFP). The SWRCB administers the Water Recycling Funding Program and CWSRF loans. The Water Recycling Funding Program (WRFP) has approximately $231.4 million in state-sourced grant funds and approximately $21.7 million available in state-sourced loans for construction projects. In addition, the SWRCB administers the CWSRF Loan Program, which offers low-interest loans to eligible applicants. CWSRF loans typically have a lower interest rate than bonds loans are paid back over 20 or 30 years. Annually, the CWSRF program disburses $200 million to $300 million to agencies in California. Finally, the SWRCB administers a grant program to cover construction of recycled water facilities. A construction grant can cover 35% of eligible construction costs up to $15 million, including construction allowances. To be eligible to receive grant funds, at least a 50% local cost share match must be provided.
- California Infrastructure and Economic Development Bank (I-Bank) Infrastructure State Revolving Fund (ISRF) Program. The ISRF Program provides low-interest loan financing to public agencies for a wide variety of infrastructure projects. Funding is available in amounts up to $25 million with loan terms up to 30 years. The interest rate is set at the time the loan is approved. Applicants must demonstrate project readiness and feasibility to complete construction within two years after I-Bank loan approval. Additionally, eligible projects must promote economic development and attract, create, and sustain long-term employment opportunities. There is no required match; however, there is a one-time origination fee of 1% of the ISRF financing amount or $10,000, whichever is greater.

ES-5.8 Additional Considerations

Nonpotable reuse, as envisioned in the Bayfront area and beyond allows for the highest and best use of the District's water resource. Centralized treatment for IPR and DPR is being investigated now by SVCW for advanced treatment associated with the SVCW Regional Wastewater Treatment Plant in Redwood City. In partnership with the City of San Mateo, the SFPUC, the water wholesaler for much of the region, and with Cal Water, a retailer in much of the SVCW and San Mateo Service areas, the Crystal Springs Purified Water project is being developed and may bring the opportunity for District to receive some of those regional benefits. These future opportunities will allow the District to potentially repurpose some of its nonpotable recycling treatment and distribution assets. In the meantime, investment in nonpotable reuse treatment and distribution in the District's service area provides for the best short-term, and potentially long-term, utilization of this precious wastewater resource.

ES-6.0 CAPITAL IMPROVEMENT PLAN

The Capacity Assessment (Chapter 5), Linear Asset Management Plan (Chapter 6), Pump Station Assessment (Chapter 7), and Recycled Water Program (Chapter 8) each evaluated infrastructure needs for the next 10 years and developed proposed recommendations, priorities, and costs. These projects, priorities, and costs are summarized in Table ES.7. The basis behind each of the projects is discussed in further detail within each respective chapters in this Master Plan.

All costs are presented in current dollars and indexed to Engineering News Record ("ENR") Construction Cost Index ("CCI"), San Francisco, October 2023, 15473.38.

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Table ES.7 Capital Improvement Plan

	Project	Project Cost		2024-25	2025-26	2026-27	2027-28	2028-29	2029-30	2030-31	2031-32	2032-33	2033-34	Future
LAMP Projects	L.1. Near-term Pipe Repair Projects	$8,000,000		$4,000,000	$4,000,000									
	L.2. Grade 5 Priority Basins 010, 030, 040, 050, 070AB													
	L.2.1. Priority 1 Grade 5 Defects	$284,300		$284,300										
	L.2.2. Priority 2 Grade 5 Defects	$3,651,000		$730,200	$2,190,600	$730,200								
	L.2.3. Contiguous Grade 4 Defects	$2,175,200		$435,000	$1,305,100	$435,000								
	L.3. Grade 5 Basins 020, 060, 070CD, and 080 through 150													
	L.3.1. Priority 2 Grade 5 Defects	$2,229,700				$2,229,700								
	L.3.2. Contiguous Grade 4 Defects	$672,900				$672,900								
	L.4. Grade 4 Basins 020, 030, 040, 050, 070													
	L.4.1. Priority 3 Grade 4 Defects	$1,340,000					$1,340,000							
	L.4.2. Other Grade 4 Defects	$5,925,900						$5,925,900						
	L.5. Grade 4 Basins 010, 060, 080, 090 through 150													
	L.5.1. Other Grade 4 Defects	$9,493,400						$3,164,500	$6,328,900					
	L.6. Future Repairs and Replacements (1.5% per year)	$40,282,900							$3,021,200	$10,070,700	$10,070,700	$10,070,700	$10,070,700	
	L.7 Middle Undercrossing	$500,000			$500,000									
Capacity Improvements	C.1. Willow PS Discharge (Ivy Drive) Capacity Improvements													
	C.1.1. Interim Solution	Completed												
	C.1.2. Convert Gravity Main to Extended Forcemain	$1,409,800			$704,900	$704,900								
	C.2. Elena Ave and Park Lane Capacity Improvements													
	C.2.1. Flow/Level Monitoring	$15,000		$15,000										
	C.2.2. Upsize Pipe to 10" on Elena Avenue and Park Lane	$3,675,500					$3,675,500							
Pump Station Improvements	P.0 Pump Station Telemetry Project	$600,000		$600,000										
	P.1 Willow Pump Station Near-Term Improvements	$1,700,000		$1,700,000										
	P.2 Stowe Lane Pump Station Improvements	$3,000,000		$3,000,000										
	P.3 Hamilton Henderson Wetwell Lining	$77,000			$77,000									
	P.4 FERRF Pump Station Improvements	$1,420,000			$142,000	$1,278,000								
	P.5 Willow, University, and Illinois Forceman Replacements	$2,078,000			$1,039,000	$1,039,000								
Other	Maintenance Building Upgrades	$7,000,000				$3,000,000	$4,000,000							
	Total without Recycled Water	**$47,647,700**	**Prior Allocation**	**$10,164,500**	**$9,958,600**	**$10,089,700**	**$9,015,500**	**$9,090,400**	**$9,350,100**	**$10,070,700**	**$10,070,700**	**$10,070,700**	**$10,070,700**	
Recycled Water Projects	Bayfront Phase 1 Treatment	$66,700,000	$66,700,000											
	Recycled Water Phase 2	$16,300,000					$2,328,600	$2,328,600	$2,328,600	$2,328,600	$2,328,600	$2,328,600	$2,328,600	
	Recycled Water Phase 3	$31,000,000												$31,000,000
	Total with Recycled Water	**$94,947,700**		**$10,164,500**	**$9,958,600**	**$10,089,700**	**$11,344,100**	**$11,419,000**	**$11,678,700**	**$12,399,300**	**$12,399,300**	**$12,399,300**	**$12,399,300**	**$31,000,000**

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CHAPTER 1 EXISTING INFORMATION

The West Bay Sanitary District ("District") owns, operates, and maintains a wastewater collection system and a recycled water treatment facility and distribution system. The District has compiled a comprehensive library of documents that describe these assets, including a computerized maintenance management system ("CMMS"), a computerized hydraulic model of the wastewater collection system, geographical information system ("GIS") maps, and paper and/or electronic records documenting system evaluations, repairs, replacements, new construction, operations, and maintenance. To supplement the District's information, other agencies within the District's service area maintain related information including but not limited to development plans, land use, potential recycled water customers, paving projects, and water usage. The purpose of this Technical Memorandum ("TM") is to document the reports and other documents and data that were used to prepare the 2023 Master Plan update.

This Chapter is organized as follows.

1.1 Description of Existing Service Area

1.2 Summary of Existing Information

1.1 EXISTING SERVICE AREA

West Bay Sanitary District provides wastewater collection and conveyance services to the City of Menlo Park, Atherton, and Portola Valley, and portions of East Palo Alto, Woodside, and unincorporated San Mateo and Santa Clara counties as shown on Figures 1.1 and 1.2 on the following pages. Wastewater is conveyed from wooded, hilly, residential areas in the south to a relatively flat and industrial area that borders the San Francisco Bay on the north. The District has approximately 220 miles of gravity sewers and 11 pump stations that pump flow through approximately 10 miles of force main or pressurized pipes[4].

During dry weather months, the District diverts system flows in varying quantities from a location near Sand Hill Road and Oak Avenue in Menlo Park and treats this flow to recycled water standards to serve the Sharon Heights Golf and Country Club ("SHGCC"). During the non-irrigation months, a smaller volume of water must still be diverted from the system and treated by the SHGCC recycled water plant in order to maintain plant operations. These flows are then discharged back into a different part of the wastewater collection system on the north side of the SHGCC.

[4] Asset information from California Integrated Water Quality System ("CIWQS") public reports (Interactive SSO Report). https://www.waterboards.ca.gov/ciwqs/publicreports.html

Figure 1.1 West Bay Sanitary District Service Area and Pipeline Assets

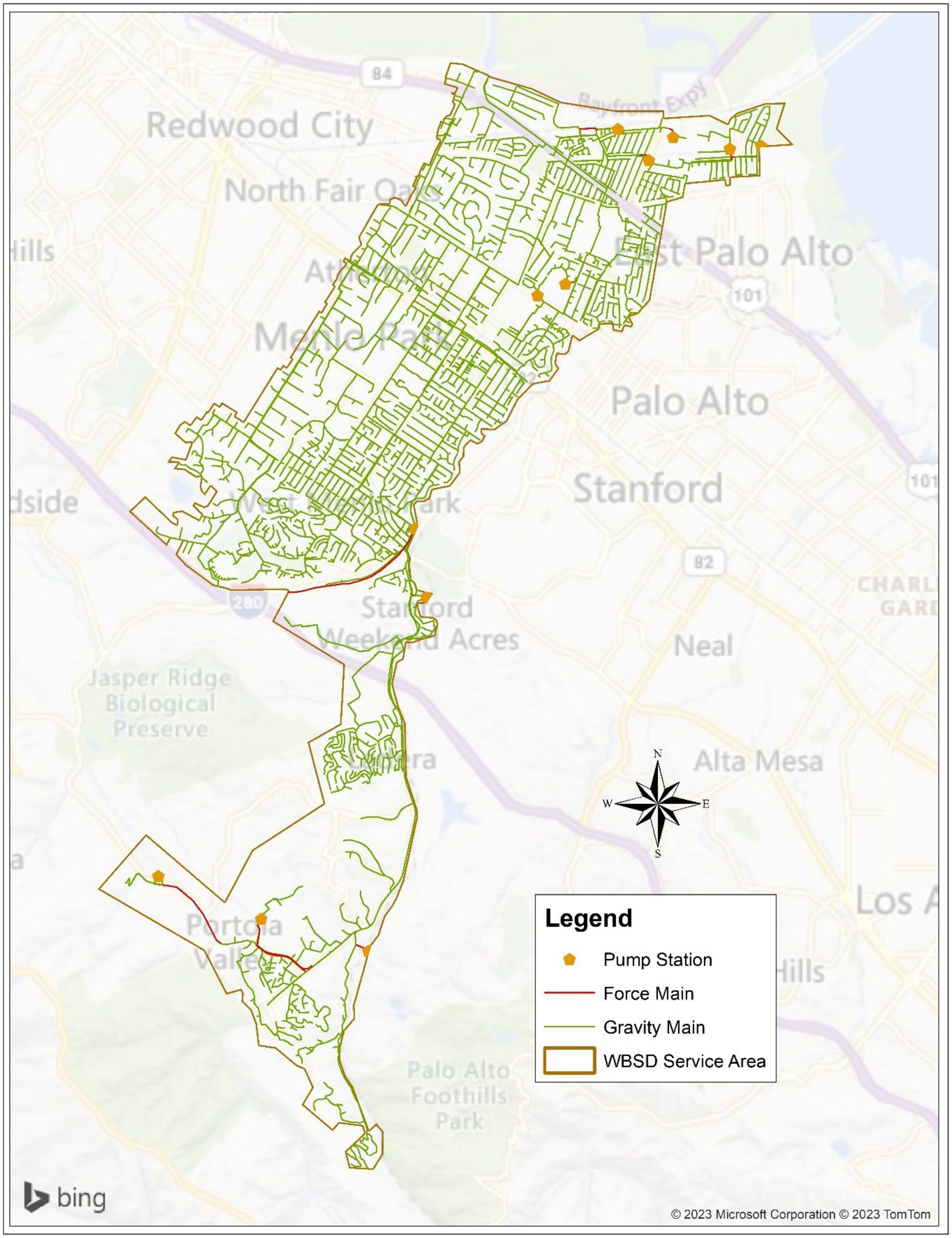
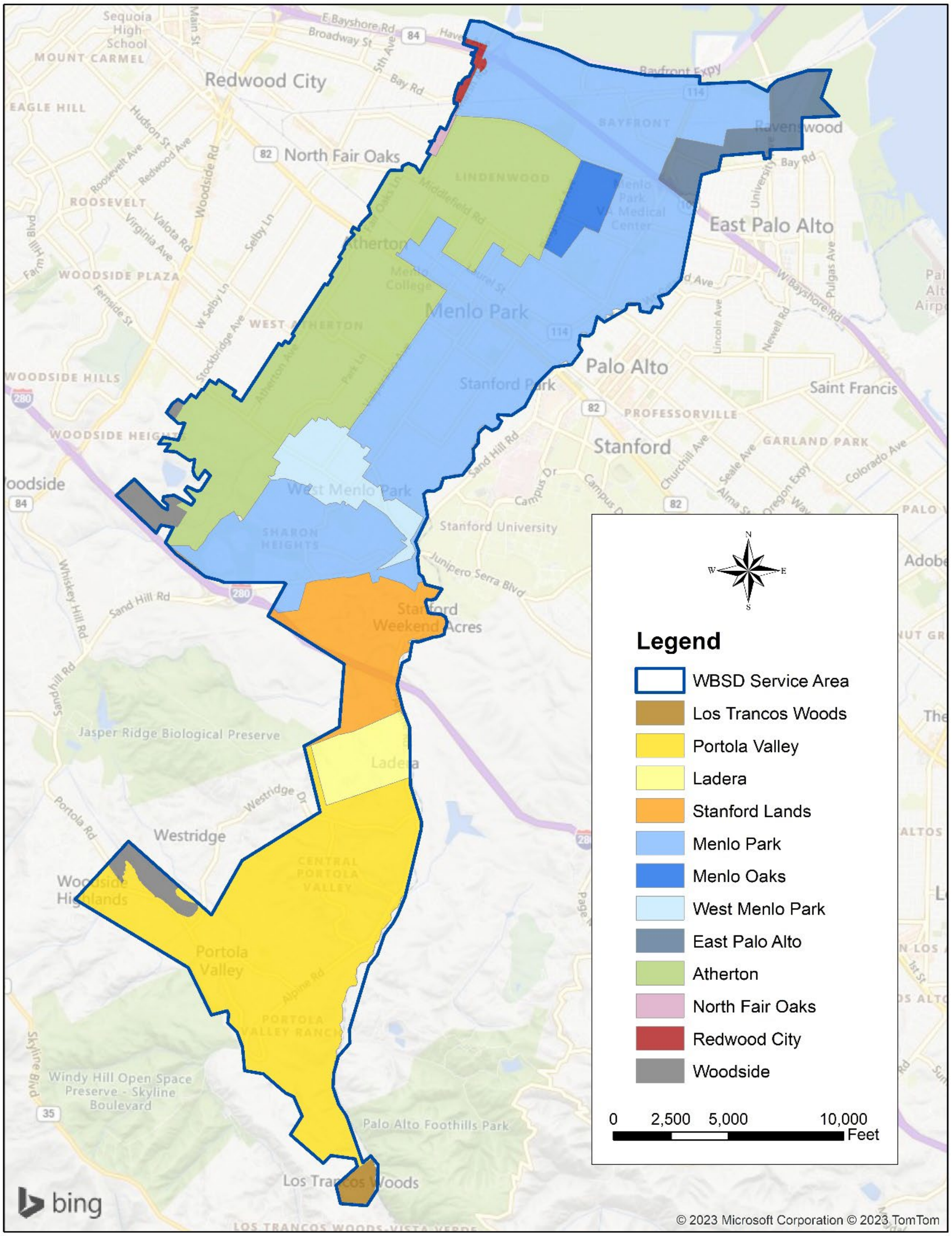


Figure 1.2 Jurisdictions Receiving Wastewater Collection Service from West Bay Sanitary District



Wastewater flow terminates at the Menlo Pump Station ("MPS") near Bayshore Expressway and Marsh Avenue, where it is pumped to the Silicon Valley Clean Water ("SVCW") wastewater treatment plant for treatment and discharge to the San Francisco Bay. SVCW owns and maintains the MPS.

The District owns several emergency storage basins located within the District's Flow Equalization and Resource Recovery Facility ("FERRF"), located within Bedwell Bayfront Park, northeast of the Bayshore Expressway. The FERRF storage ponds include an existing pump station that is used to return flows to the MPS. The District has the ability to divert flow from the MPS to the emergency storage basins during peak flow periods, or during maintenance of the MPS and its associated force main. Currently, the FERRF pump station is operated and maintained by SVCW. After SVCW completes construction of the SVCW plant expansion, responsibility for operation and maintenance of the FERRF pump station will revert to the District.

The District's average dry weather flow as measured on December 7, 2022 is approximately 3 million gallons per day (mgd). On December 7, 2022, 218,120 gallons of flow was pumped from the system for treatment at the SHGCC recycled water plant. 184,810 gallons of flow was returned to the system from the recycled water plant on the same day.

1.2 SUMMARY OF EXISTING INFORMATION

This section describes existing information that was reviewed and utilized in the development of the 2023 Master Plan.

1.2.1 Prior District Studies, Documents, and Data

The following information was provided by the District and/or the District's consultants for the 2023 Master Plan update.

Prior District Studies and Documents

- WBSD Collection System Master Plan (2011 with 2013 Update)
- WBSD Linear Asset Management Plan (2015)
- WBSD Recycled Water Project – Sharon Heights (November 2015)
- Bayfront Recycled Water Facilities Plan (May 2019)
- FERRF Levee Improvements and Bayfront Recycled Water Facility Project (May 2021)
- EPA Waterfront Development Application (December 2021)
- Sewer System Management Plan (2022)
- WBSD Strategic Plan 2022 (April 2022)
- Plans and Profiles for Completed Rehabilitation Projects
    - Relocation of Willow Road Pump Station Drawings (October 1980)
    - University Lift Station Mechanical Drawings (November 1981 and November 1983)
    - Stowe Lane Lift Station Drawings (June 1983)
    - Illinois-Purdue Force Main Drawing Excerpts (August 1985)

  - Village Square Step Sewer System Drawings (November 1989)
  - Henderson Pump Station Replacement As-Built Drawings (May 1990)
  - Henderson Pump Station Influent Sewer and Force Main As-Built Drawings (January 1991)
  - Vintage Oaks Pump Station Drawing Sheets (December 1996)
  - Los Trancos Sanitary Sewer and Pump Station Drawings (May 2000)
  - Stowe Lane Force Main Project Drawings (March 2002)
  - Menlo Industrial Pump Station Drawings (April 2002)
  - Illinois Pump Station Reconstruction Drawings (March 2008)
  - CIP 2010-2011 Drawings (April 2011)
  - CIP 2010-2011 Phase 2 Drawings (July 2011)
  - Frederick and Suburban Park Project Drawings (March 2012)
  - 30-inch Sanitary Sewer Rehabilitation Project Drawings (April 2012)
  - North Palo Alto and Burns Easement Project Drawings (October 2013)
  - Belle Haven Sewer Project Drawings (May 2014)
  - Sausal Vista Pump Station Phase 1 Drawings (March 2015)
  - Belle Haven Sewer Project Phase 2 Drawings (June 2015)
  - Sausal Vista Pump Station Phase 2 Drawings (September 2015)
  - Marsh Road Trunkline Rehabilitation Project Drawings (May 2016)
  - Sharon Road Sewer Replacement Project Drawings (March 2017)
  - Belle Haven Sewer Project Phase 3 Drawings (February 2018)
  - Alpine Road Sanitary Sewer Replacement Project Drawings (September 2018)
  - North Bay Road and Ringwood Avenue Drawings (October 2020)
  - Bayfront Park Sanitary Sewer Improvement Project Drawings (September 2022)
  - Avy/Atschul Sanitary Sewer Pump Station Drawings (May 2022)

Available System Data

- WBSD Manhole and Sewer Main shapefiles (March 15, 2023 download)
- Manhole Depth Measurements (February 2023)
- List of Upcoming Point Repair Projects (March 2023)
- Pump Station Characteristics and Setpoints (2 documents - April 2023)
- Approved and Pending Recycled Water Project List (May 2023)
- Closed Circuit Inspection Data
  - GNET_WestBay (March 13, 2023 download)

- GranitNet_WBSD_DB (March 15, 2023 download)
- GranitNet_WBSD_DB_historical (April 2023 download)
- Inspection Videos (April 27, 2023 download)

- Water and Flow Data
  - Water Usage Data for Menlo Park and Cal Water for 2018-2022
  - SLAC Water Balance 2011 to Present
  - Draft Raw Flow Data from V&A Engineering Consultants dated 4/28/2023 (V&A meters) and 6/20/2023 (WBSD meters)

1.2.2 Other Resources

The following information is available to the public from the agencies within the District's service area, and was downloaded for use during this project.

- GIS Layers
- San Mateo County GIS Layers including: Parcels; City Boundaries; Water District Boundaries; Natural Features; Landmark Features; and County Streets
- Land Use Documentation
- Menlo Park General Plan (November 2016)
- Menlo Park Zoning Ordinance + Interactive Land Use and Zoning Map (September 2022)
- El Camino Real and Downtown Specific Plan (September 2022)
- City of Menlo Park 6th Cycle Housing Element 2023-2031 (June 30, 2023)
- Ravenswood Business District /4 Corners Specific Plan Update including EPA Waterfront and others (February 2013)
- Vista 2035 East Palo Alto General Plan (October 2017)
- City of East Palo Alto 2023-2031 Housing Element (February 2023)
- Portola Valley General Plan (Not Dated)
- Town of Portola Valley 2023-2031 Draft Housing Element Update (August 2022)
- Redwood City General Plan (Last update January 2020)
- Redwood City Housing Element (February 2023)
- San Mateo County General Plan (November 1986)
- San Mateo County 2023-2031 Housing Element (January 2023)
- Town of Atherton General Plan (January 2020)
- Town of Atherton 2023-2031 Housing Element (January 2023)
- Town of Woodside General Plan (2012)
- Town of Woodside 2023-2031 Housing Element Draft 2 (March 2023)

CHAPTER 2 LAND USES

The purpose of this Chapter is to summarize the District's existing system, including current and projected average dry weather flows ("ADWF").

This Chapter is organized as follows.

1.1 Existing Wastewater System

1.2 Land Use Characteristics

1.3 Initial Estimate of System Flows Using District Criteria

2.1 EXISTING WASTEWATER SYSTEM

The District's wastewater collection system is represented in the District's geographic information system ("GIS") map as having approximately 203 miles of gravity sewer pipe and 7 miles of force mains. The District's gravity pipes range in diameter from 4 to 54 inches. In addition, the District's customers own and maintain approximately 360 miles of private service laterals.

The predominant pipeline materials are vitrified clay, polyvinyl chloride (plastic), and asbestos cement pipe, with isolated occurrences of reinforced and unreinforced concrete and ductile iron pipe. Figure 2.1 on the following page shows the current pipeline inventory sorted by material.

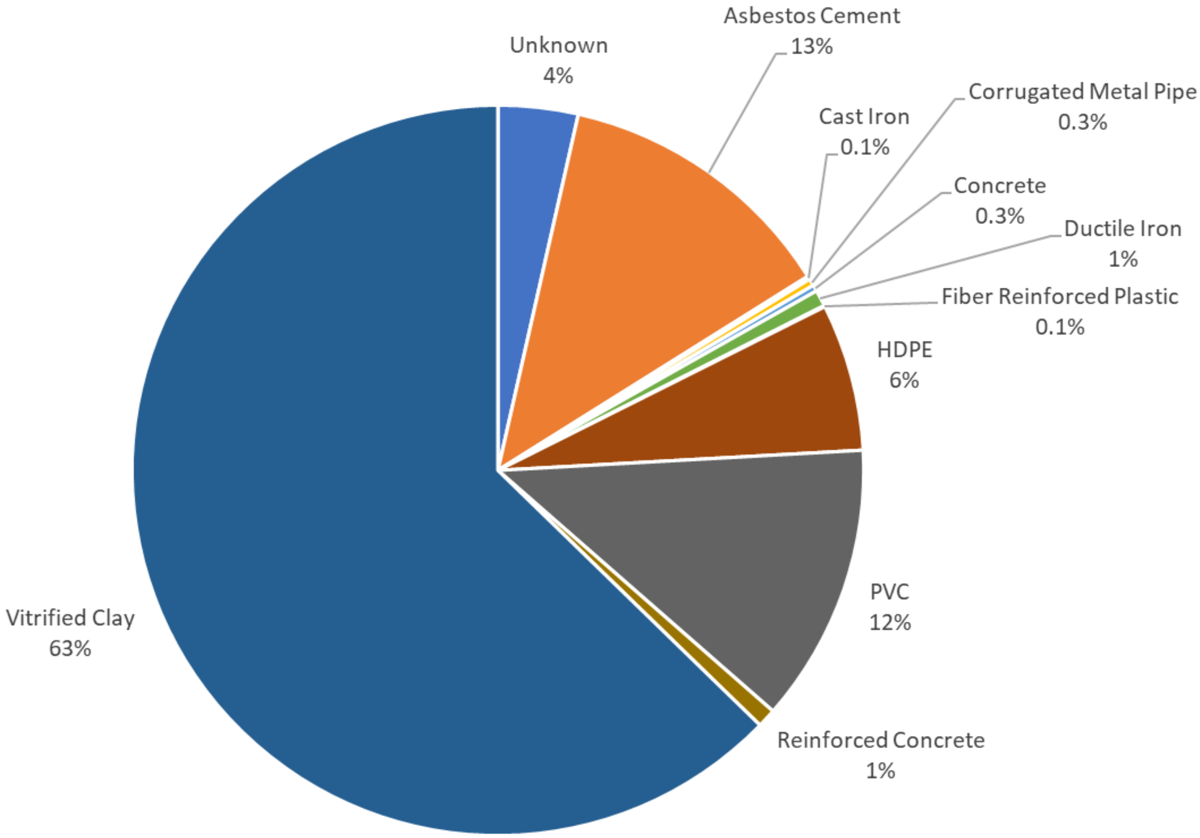
The District's service area includes four major sewer basins. Several known interconnections allow flow to travel between basins. In addition, flows of varying amounts are transferred between basins on a year-round basis in order to operate the District's SHGCC recycled water facility. The four major sewer basins are described below and are shown on Figure 2.2 on the following page.

1) Portola Valley to Highway 101 (Basin 20-10-30-40-90-100-130-150-140-MPPS)
2) Downtown Core to Highway 101 (120-MPPS)
3) Atherton to Highway 101 (50-70-110-MPPS)
4) North of Highway 101 (150-140-MPS)

The Menlo Pump Station ("MPS") is located at terminus of the system, at the intersection of Marsh Road and the Bayfront Expressway in Menlo Park. This station conveys all of the District's flows northwest to the SVCW wastewater treatment plant. The District also owns a return pump station at the District's FERRF Facility, located at the northernmost end of Marsh Road.

The District owns and operates eleven wastewater pump stations that are listed in Table 2.1, which follows Figure 2.2. In addition to the eleven pump stations, the District also owns and operates the Phil Scott pump station, which is used to divert flow to the Sharon Heights Golf and Country Club for recycled water treatment. The District currently owns but does not operate the FERRF return pump station which is discussed above.

Figure 2.1 Gravity Sewer Pipeline Inventory and Material of Construction



The District owns approximately 20 acres of land at the northern terminus of Marsh Road in Menlo Park. This land was the site of the District's original wastewater treatment facility, prior to the forming of SVCW in 1980. The prior treatment ponds now serve as emergency storage basins. This land and the four associated basins are collectively referred to as the FERRF. The two basins closest to the Menlo Pump Station are maintained and used for wet weather storage by the District. The estimated capacity of Pond 1, which is the District's primary wet weather storage facility, is under 10 million gallons.

The District has the capability to bypass the Menlo Pump Station and flow directly to the FERRF during extreme wet weather events. The District also owns a transfer pump station that returns stored flow back to the Menlo Pump Station after wet weather events. Figure 2.4 provides an aerial view of the District's FERRF and its location as related to the gravity sewer system and MPS.

Figure 2.2 Wastewater Collection System Sewer Basins and Flow Paths

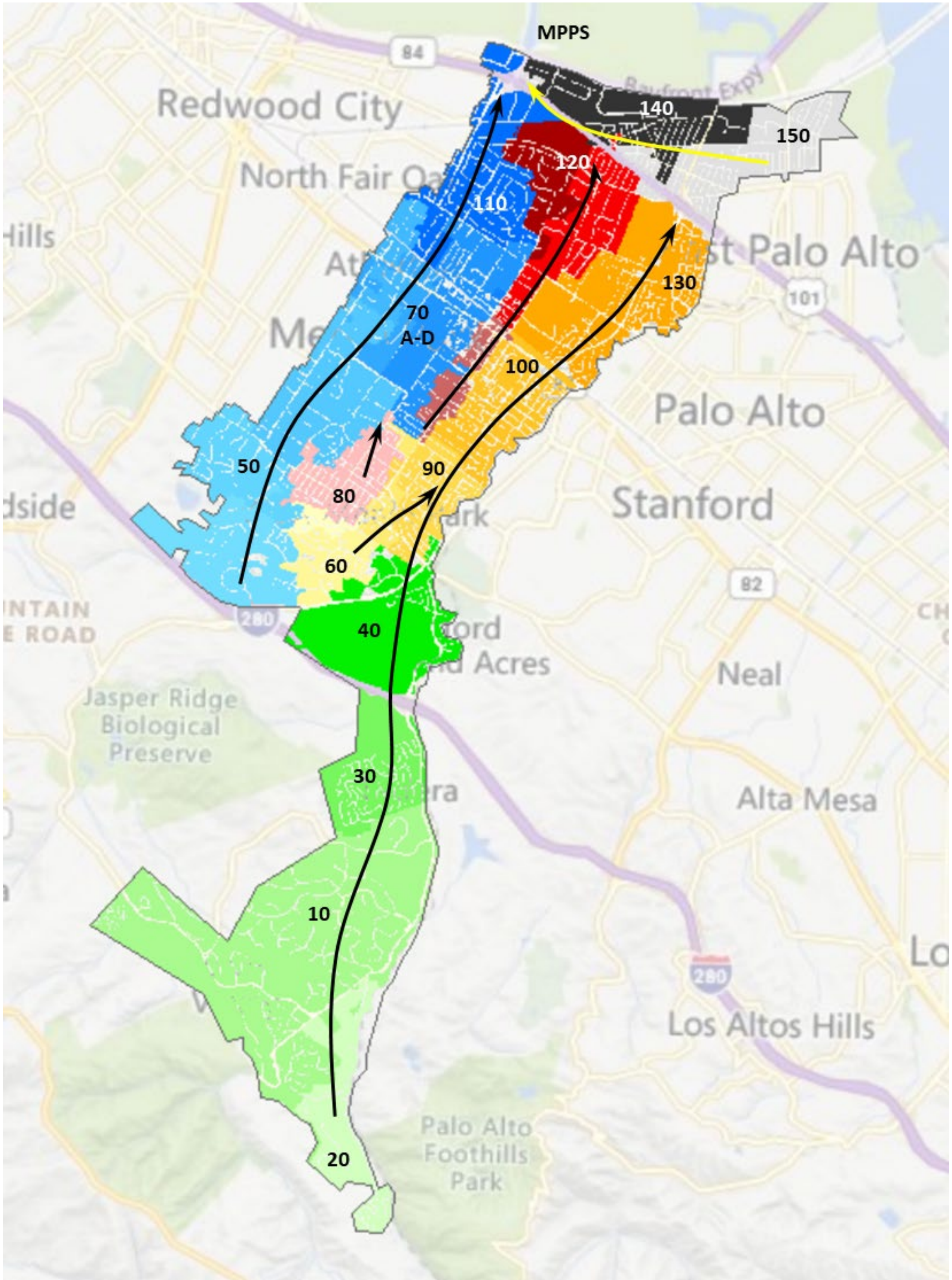


Table 2.1 District's Pump Station Inventory

Pump Station	Type	Location
Hamilton Henderson	Submersible	North end of Henderson Avenue
Willow	Submersible	Willow Road north of O'Brien Drive
Menlo Industrial	Submersible	Hamilton Avenue and Hamilton Court
University	Submersible	University Avenue north of O'Brien Drive
Illinois	Submersible	North end of Demeter Street
Vintage Oaks 1	Submersible	Near St. Patrick's Seminary
Vintage Oaks 2	Submersible	Near St. Patrick's Seminary
Stowe Lane	Dry Pit	East end of Stowe Lane
Los Trancos	Submersible	East end of Meadow Creek Court
Sausal Vista	Submersible	North end of Georgia Lane
Village Square	Submersible	North of Portola Road and east of Ann Road
Flow Equalization	Submersible	Flow Equalization & Resource Recovery Facility Return Pump Station
Phil Scott PS	Submersible	Diverts flow to the SHGCC Recycled Water Treatment Plant from cul-de-sac near Oak Avenue and Sand Hill Road

Figure 2.3 Aerial View of District Flow Equalization and Resource Recovery Facility

2.2 LAND USE CHARACTERISTICS

Land use in the District's service area is primarily residential, with dense business corridors located along El Camino Real and on Santa Cruz Avenue in Menlo Park, and a rapidly-developing commercial area near Highway 101 and the Bayshore Expressway.

Land use information is available through the following sources:

- Land Use Database – General Plan land use information in pdf format (2016) was acquired from the City of Menlo Park ("Menlo Park") website document database. Specific Plans adopted for various developments including the Downtown Specific Plan and Ravenswood Business District 4 Corners Specific Plan were also obtained. This information has been compared and updated using the 2023-2031 Housing Element and available land use data in GIS format.

- Town of Atherton. The Town of Atherton publishes a General Plan in pdf format. The prior General Plan, most recently adopted in January 2020, provided anticipated land uses through buildout. This information has been updated further using relevant information from the 2023-2031 Housing Element.

- Town of Portola Valley. The Town of Portola Valley is a unique contributor to sanitary sewer flow as this community is transferring from septic to sewered systems over time. The Town provided its General Plan in pdf format. The General Plan, which also includes the unincorporated community of Ladera, has been recently supplemented with the 2023-2031 draft Housing Element.
- County of San Mateo, City of Redwood City, and Town of Woodside. General Plan documents for the County of San Mateo, City of Redwood City, and Town of Woodside include maps in pdf format that include the small portions of these agencies that are located in the District's service area. The General Plans are also supplemented by recent information from the individual 2023-2031 Housing Elements.
- City of East Palo Alto. The District serves a small portion of the City of East Palo Alto. The City's Vista 2035 General Plan was developed in 2017 and is available through the City's website in pdf format. To supplement this document, the City has completed a 2023-2031 Housing Element.
- Aerial Imagery. In addition to land use information, aerial imagery was reviewed for the District's service area to identify parcels that are currently vacant, or where actual uses may vary significantly from the designated land use.

Figure 2.4 shows the land use designations that were assigned to parcels within the District's service area, using the references described above. Different land use naming conventions were used in the different General Plan documents. To create consistency across the entire service area, land use titles were reviewed and consolidated into the following nine land use designations for use in the District's hydraulic model:

- Very Low Density Residential
- Low Density Residential
- Medium Density Residential
- High Density Residential
- Professional And Administrative Offices
- Retail/Commercial
- Limited Industry
- Public Facilities
- Parks And Recreation
- Open Space

Table 2.2 shows how land use designations were consolidated. 93 percent of the service area is comprised of residential land uses, with the predominant land use being low density residential. Seven percent of the service area is comprised of non-residential land uses, with the most of the non-residential uses assigned to retail and commercial. Figure 2.5 shows the distribution of land uses.

A notable amount of development and densification is planned for areas within the service area. For example, the lands closer to the San Francisco Bay are in the process of being developed for commercial, research, and residential uses. Most of this development is underway or planned for near-term implementation. For this reason, all of the planned flows are treated as "existing" in the hydraulic model.

Figure 2.4 Land Uses in the West Bay Sanitary District Service Area

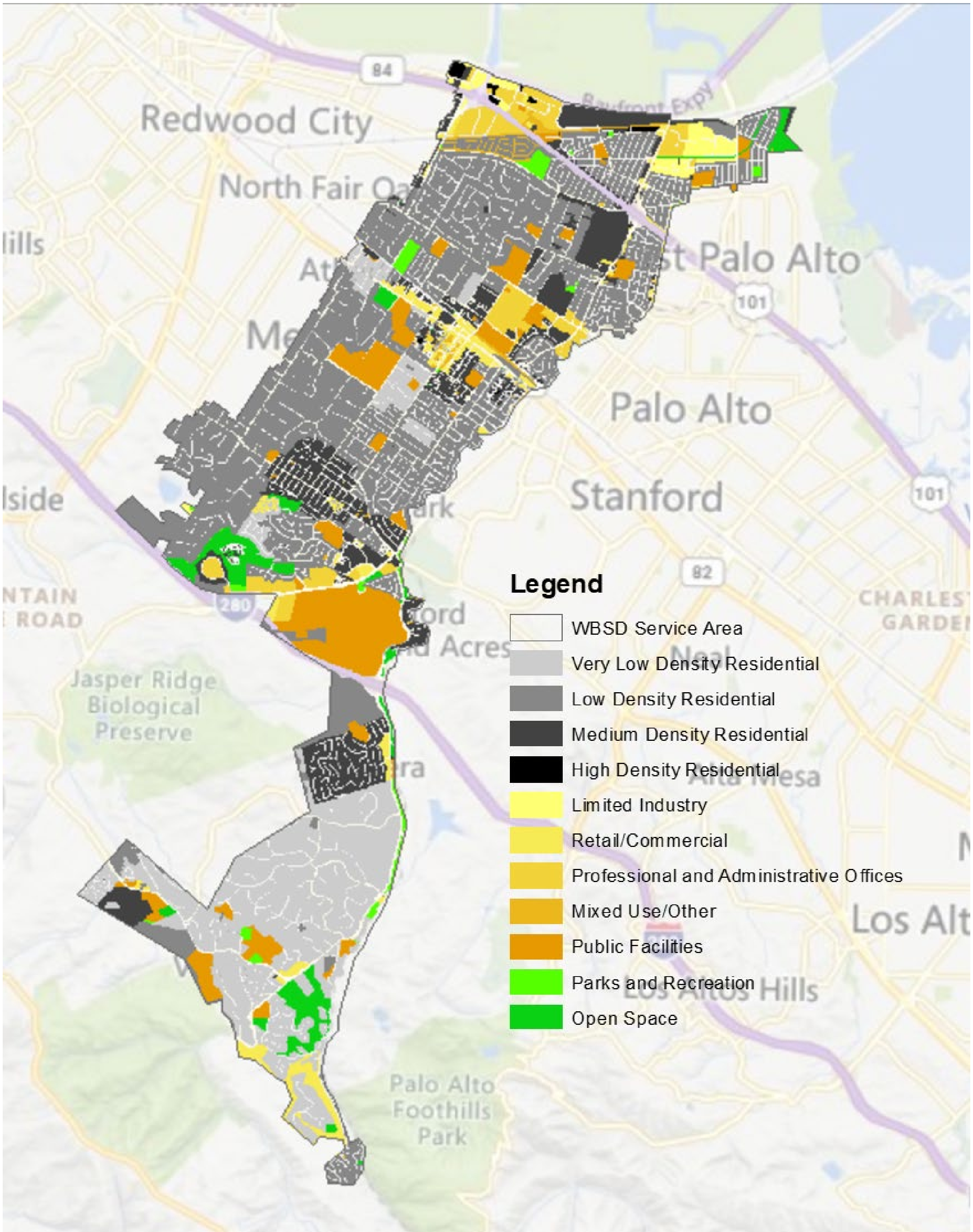
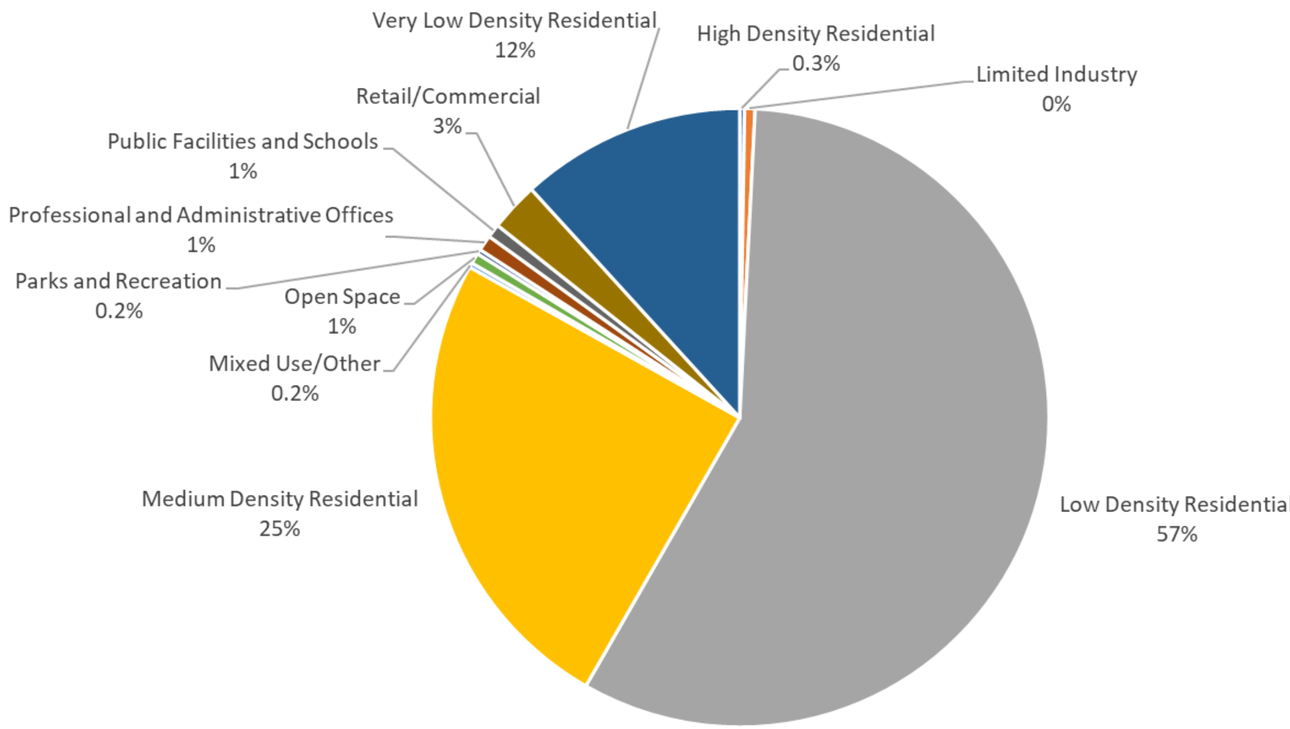


Table 2.2 Consolidated Land Use Designations

Land Use	Generalized Land Use
R-1B	Very Low Density Residential
Very Low Density Residential	
Low Density Single-Family Residential	Low Density Residential
Low Density Residential	
Residential - Medium (20 DU/AC Max.)	Medium Density Residential
Residential Medium Density	
Medium Low Density Residential	
Medium High Density Residential	
High Density Residential	High Density Residential
Light Industrial, Limited Industry, General Industrial, Industrial Buffer	Limited Industry
Parks & Recreation	Parks and Recreation
Parks and Open Space	
Parks/Recreation/Conservation	
Commercial Offices	Professional and Administrative Offices
Public Facilities and Schools	Public Facilities
Institutional	
Public/Institutional	
Institutional/OpenStudy/FutureStudy	
Commercial Neighborhood	Retail/Commercial
Commercial Business Park	
Commercial Retail	
Commercial - Neighborhood (0.60 FAR Max.)	
Neighborhood Commercial	
Mixed Use Low	
Mixed Use High	
Office Commercial	
Commercial	
El Camino Real Mixed Use	
El Camino Real Mixed Use/Residential	
El Camino Real Mixed Use/Retail	

Note: Some areas of the general plan had mixed designations. For these areas, aerial photography was used for assigning parcels or groups of parcels with the appropriate land use designations.

Figure 2.5. Distribution of Land Uses in District Service Area



2.3 INITIAL ESTIMATE OF SYSTEM FLOWS USING DISTRICT CRITERIA

The District publishes standard design criteria for the sizing of new sewers, which includes theoretical unit flow factors to be applied to individual customer classes. These factors are shown in Table 2.3. The criteria are intended for new developers, homeowners, or businesses that request to connect to the existing system, and are intended to be conservative.

These sewer sizing factors were used to define initial base wastewater flow factors for use in defining average dry weather flow. During model development dry weather calibration process, model-generated flows per basin were reviewed and adjusted to correlate with measured flow. As a result, the final unit flows that were assigned to each customer class in the model are lower than the theoretical values shown in Table 2.3. Additional information on unit flows is presented in Chapter 4, Hydraulic Model Development and Calibration.

Table 2.3 District's Design Criteria for New Developments

Customer Class	Unit Flow from Design Standard
Commercial	90 gallons per day per 1,000 square feet or 2,500 gallons per acre per day
Office	300 square feet per employee and 15 gallons per day per employee or 2,000 gallons per acre per day
Restaurant	1 gallon per day per square foot
Industrial	3,000 gallons per acre per day
Average Dry Weather Flow Per Capita	85 gallons per day
Average Dry Weather per Single Family Dwelling	220 gallons per day

CHAPTER 3 FLOW MONITORING PROGRAM

The purpose of this Chapter is to summarize key components and findings from the District's 2023-24 flow monitoring program that was conducted by V&A Consulting Engineers. The full report from V&A Consulting Engineers is included in Appendix A.

This Chapter is organized as follows.

3.1 Introduction
3.2 Flowmeter Locations
3.3 Flow Integrity
3.4 System Flows

3.1 INTRODUCTION

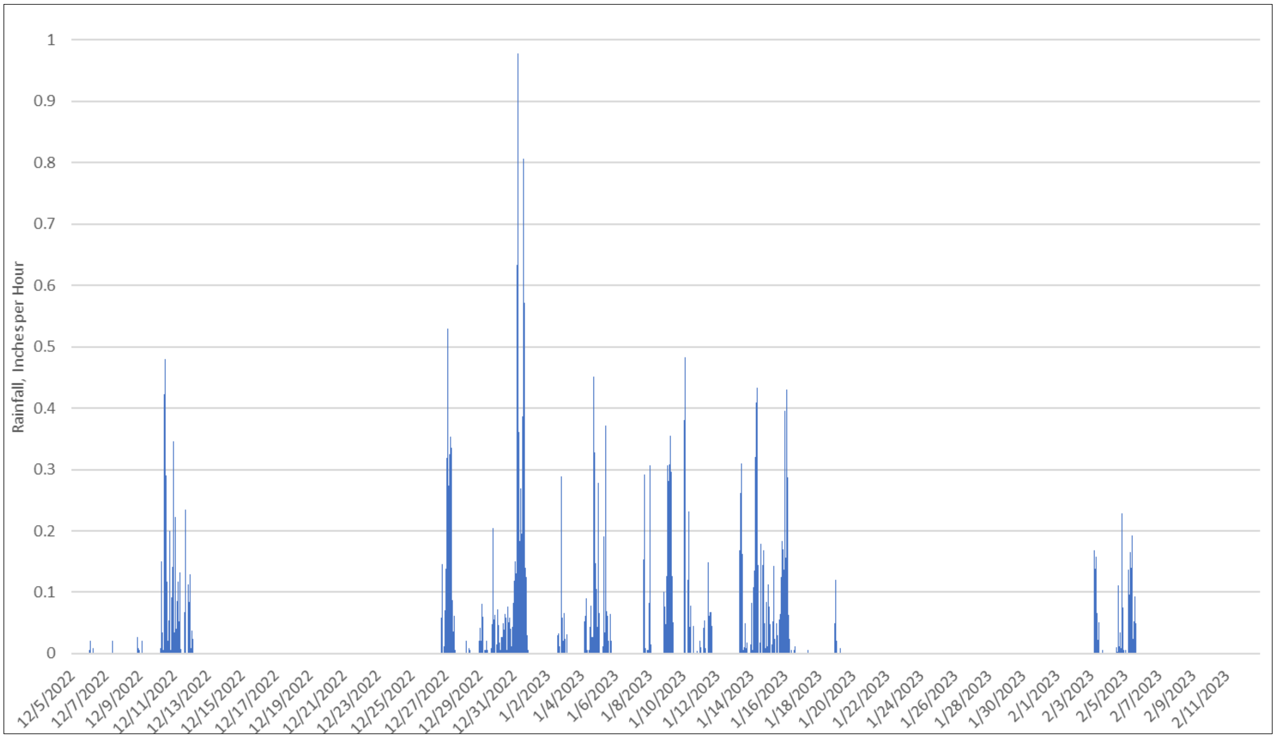
From December 15, 2022 through February 12, 2023, V&A Consulting Engineers conducted a system-wide flow monitoring program. This program collected flow data using 10 temporary flowmeters, 15 District-owned permanent flow meters, and rainfall data from six privately-owned rain gauges. Depth and velocity readings were collected at each flow meter in 15-minute increments.

Numerous rainfall events occurred during the flow monitoring period. On December 31, 2022, the District received 4.48 inches of rain as measured near Basin 70A (Atherton Avenue). The National Association and Atmospheric Administration ("NOAA") characterizes this rainfall depth as a 100-year, 24-hour rainfall event.[5] This rainfall event was more severe than the District's design storm. Figure 3.1 shows the rainfall that was received during the flow monitoring period. In addition to the December 31, 2022 rainfall event, notable rainfall occurred on the following dates:

• December 10, 2022	1.6 inches	1 year, 24-hour
• December 27, 2022	1.8 inches	All rainfall fell before noon. 2-year, 12-hour
• January 9, 2023	1.5 inches	< 1 year, 24-hour
• January 14, 2023	1.6 inches	All rainfall fell before noon. 1-year, 12-hour.

[5] Point precipitation frequency (pf) estimates from the National Oceanographic and Atmospheric Administration ("NOAA") Atlas 14, Volume 6, Version 2. See https://hdsc.nws.noaa.gov/pfds/pfds_map_cont.html?bkmrk=ca

Figure 3.1 - Rainfall Received during 2022-23 Flow Monitoring Period



As shown on Figure 3.1, on January 4, 15, and 16, 2023, peak rainfall rates were high, but 24-hour volumes were lower than the four storms listed.

December 7, 2022 was selected as the representative dry weather flow day, as this day preceded the series of rainfall events that began on December 11. The District's average dry weather flow or base wastewater flow ("ADWF" or "BWF") as measured on December 7, 2022 was approximately 3 million gallons per day ("mgd"). The flow was calculated by summing up flows at four V&A meters capturing the northernmost basins prior to their connection points to the Menlo Pump Station. The three meters included: FM140 adjacent to Bayfront Parkway, FM110A on Marsh Avenue, and FMs 120A and 130 and on Commonwealth Drive. This flow was confirmed by SVCW, using the metered flow at the MPPS.

The flow that was measured on December 7, 2022 translates to approximately 55 gallons per capita per day ("gpcpd").

3.2 FLOWMETER LOCATIONS

The 2022-23 flow monitoring program included 10 temporary meters and 15 permanent District meters. The District meters were calibrated by V&A before the beginning of the flow monitoring period. Figure 3.2 on the following pages shows the metered sewer basins. Each meter uses the same name as the contributing basin.

Figure 3.2 Metered Sewer Basins

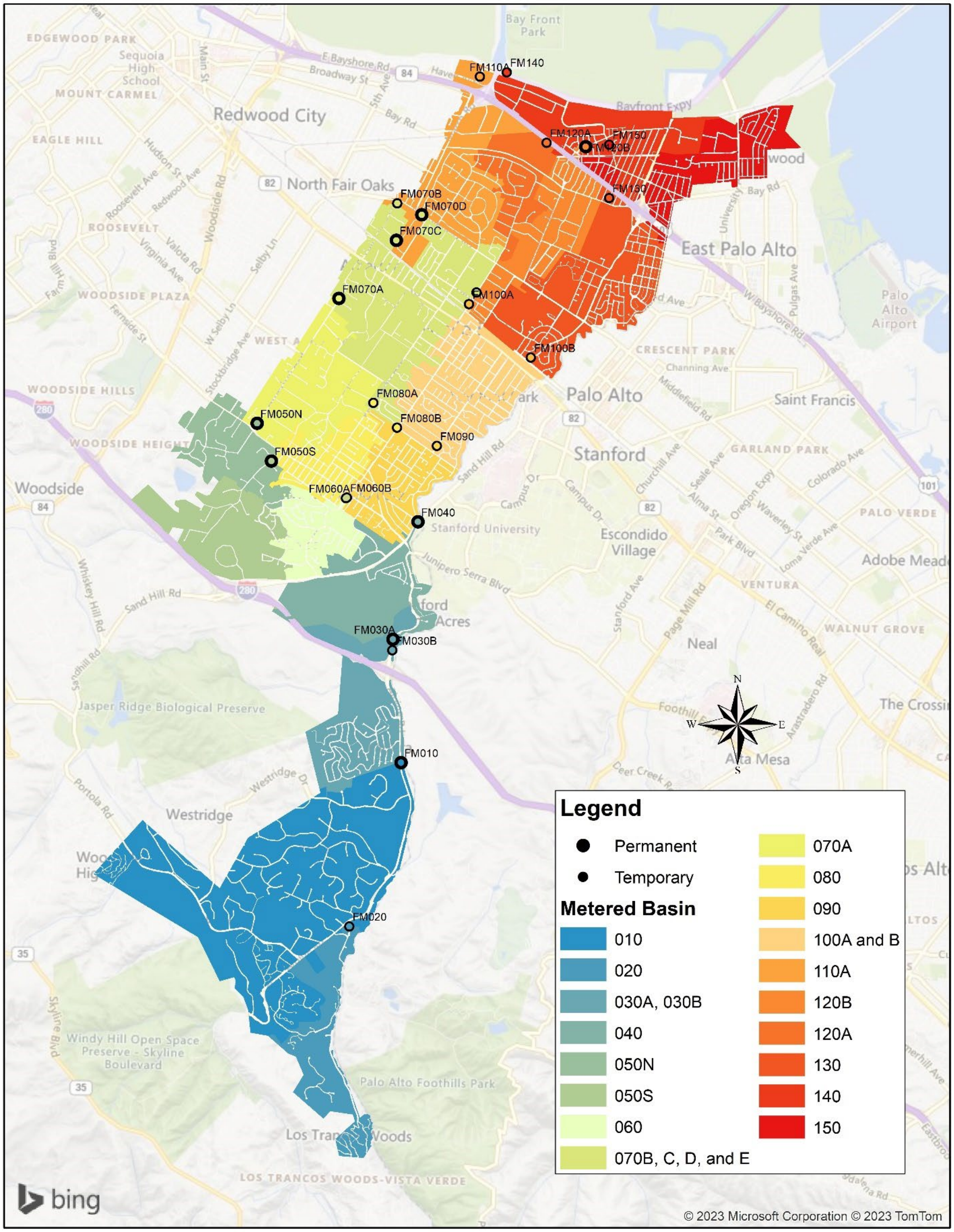


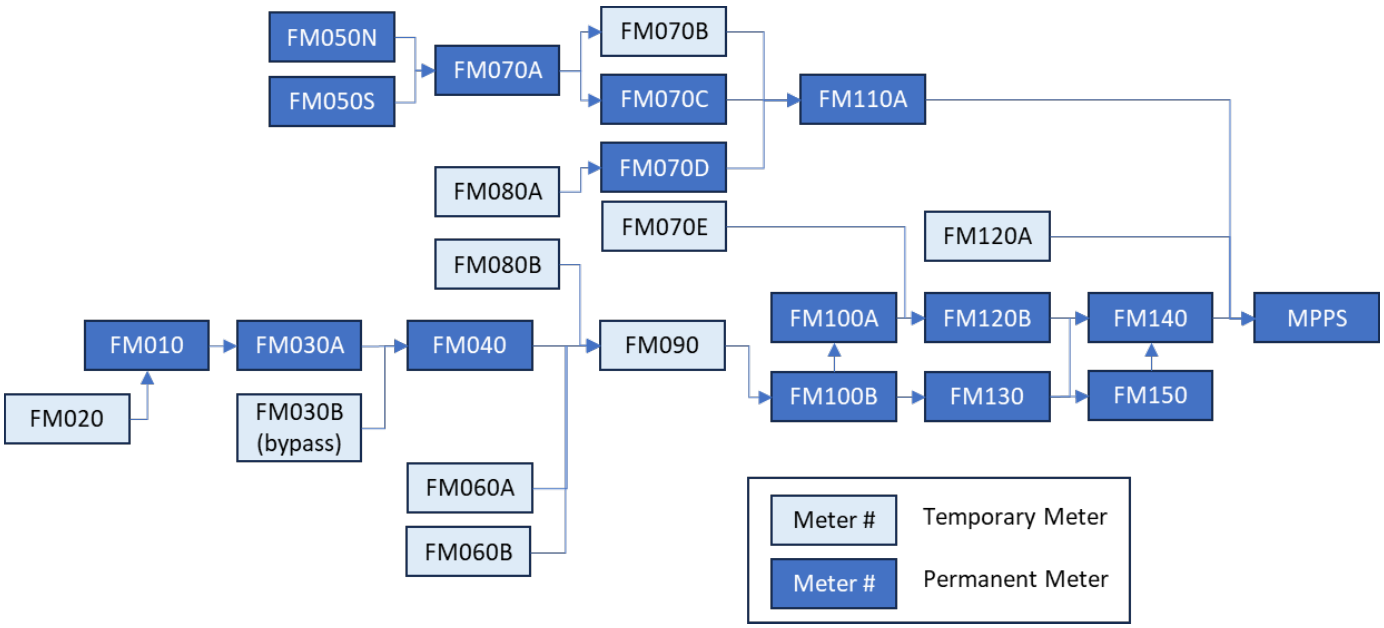
Table 3.1 lists the meters, their associated manhole ID, pipe diameter, and meter location. Each meter was installed in the pipe directly upstream of the named manhole.

Table 3.1 Meter Names, Locations, and Whether Temporary or Permanent

2022 Meter Name	Manhole ID	Pipe Diameter	Location
FM020 (T)	M09014	10”	Los Trancos Road @ Alpine Road. Flows to FM010.
FM010 (P)	K10023	30”	Alpine Road near La Mesa Drive. Flows to FM030A
FM030A (P)	I12085	21”	Alpine Road north of Hwy 280. Flows to FM040.
FM030B (T)	J11006	10”	Abandoned pipe. Meter registered flow – District is reviewing.
FM040 (P)	H12067	36”	Sand Hill Road, downstream of SHGCC diversion. Flows to FM090.
FM090 (T)	G13222	24”	Middle Avenue at Olive Street. Flows to FM100B.
FM100A (T)	E14053	12”	Oak Grove at Laurel Street. Flows to FM120B.
FM100B (T)	E12158	24”	Willow Road at Alma Street. Some flow appears to split to FM100A. Also flows to FM130.
FM130 (T)	C12089	24”	Hollyburne Avenue at Bay Road. Flows to FM150 or FM140 depending on flow split.
FM150 (T)	B13043	24”	Chilco Street near Hamilton Avenue. Flows to FM140.
FM140 (T)	B15047	30”	Bayshore Expressway near Marsh Road. Flows to MPPS.
FM050N (P)	H16023	10”	Atherton Avenue (west side) near Mulberry Lane. Flows to FM070A.
FM050S (P)	H15134	15”	Walsh Road (east side) at Broadacres Road. Flows to FM070A.
FM070A (P)	F16032	18”	Atherton Avenue (west side) at Inglewood Lane. Splits to FM070B and FM70C.
FM070B (T)	D16027	10”	Fair Oaks Lane at Middlefield Road. Flows to FM110.
FM070C (P)	E15047	18”	Burns Easement north of Dinkelspiel Station Lane. Flows to FM110.
FM070D (P)	D15128	21”	Middlefield Road east of Marsh Road. Flows to FM110.
FM070E (T)	E14034	10”	Oak Grove (east side) north of Laurel Street. Flows to FM120B.
FM110A (T)	B16004	24”	Haven Avenue and Haven Court. Flows to MPPS.
FM060A (T)	H14109	6”	Avy Avenue (west side) and Alameda de las Pulgas. This meter is combined with FM060B in the hydraulic analysis. Flows to FM090.
FM060B (T)	H14175	12”	Avy Avenue (east side) at Atschul Avenue. Flows to FM090.
FM080A (T)	G14189	15”	Valparaiso Avenue at Santiago Avenue. Flows to FM070D.
FM080B (T)	G14071	15”	Hillview Middle School at Olive Street, west of Santa Cruz Avenue. Flows to FM090.
FM120A (T)	C14036	10”	End of Sheridan Drive. Flows to Commonwealth Drive and then to MPPS.
FM120B (P)	C13029	16”	Hamilton Avenue at Hill Avenue. Flows to FM140.

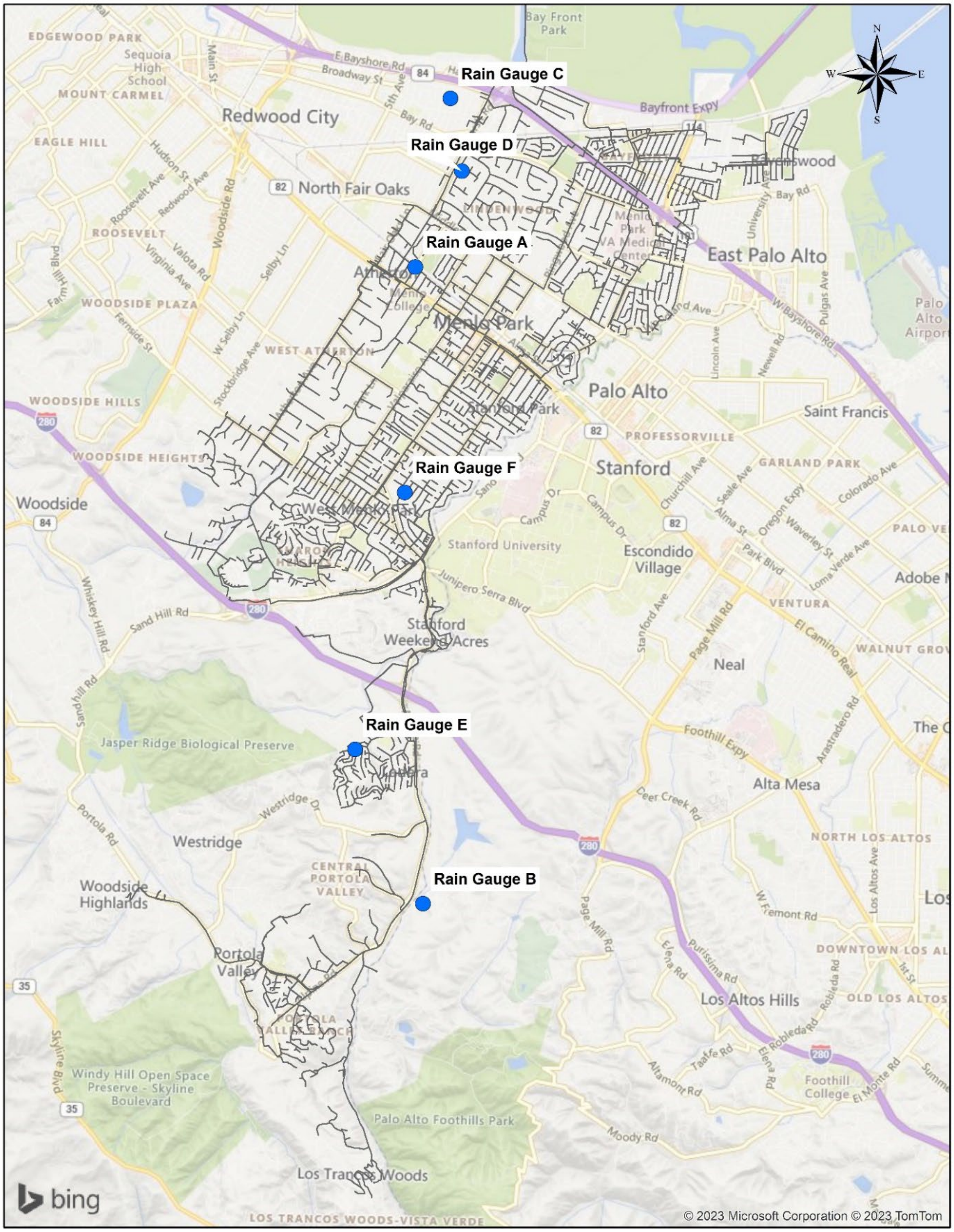
The connectivity of the metered basins is shown in Figure 3.3.

Figure 3.3 Meter Connectivity



The flow monitoring study included six publicly-owned rain gauges located throughout the service area. The gauges captured rainfall from locations spanning from the San Francisco Bay to Portola Valley. V&A used a mathematical equation to triangulate and assign rainfall to each of the flowmeter locations. Figure 3.4 on the following page shows the locations of the six public rain gauges. The gauges were located using the latitude and longitude coordinates presented in the V&A report.

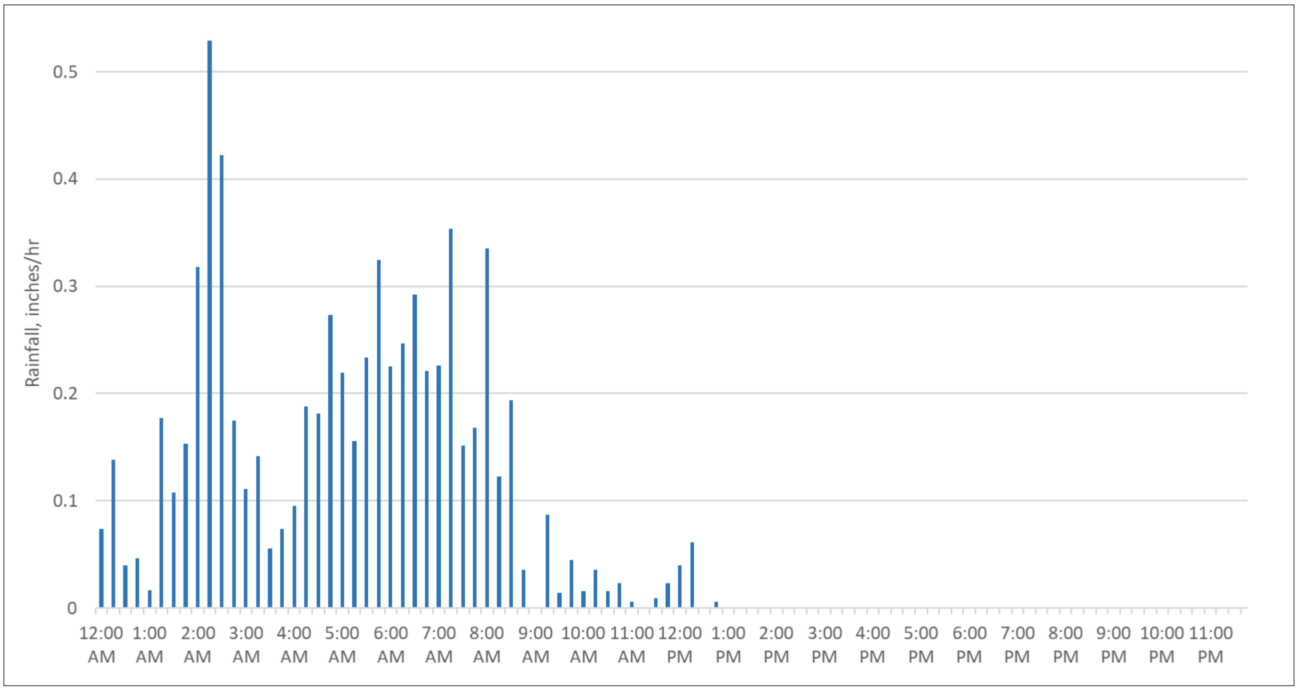
Figure 3.4 Rain Gauge Locations (from V&A Flow Monitoring Report)



As discussed above, multiple rainfall events occurred during the flow monitoring period. The December 27, 2022 rainfall event was selected as the calibration storm for three reasons: 1) preceding rainfall events created favorable antecedent conditions (i.e., groundwater saturation), 2) this was the largest event that occurred other than the rainfall event on December 31, 2022, 3) the system exhibited distinct response characteristics, and 4) the system had no known spills during this period. The larger December 31, 2022 event was not used for calibration because the District experienced surcharging to the extent that flow data was not available from FM140. In addition, during the latter part of the storm, the District lost flow from the system downstream of the Willow Pump Station.

Figure 3.5 shows the rainfall that occurred during the selected calibration date of December 27, 2022.

Figure 3.5 Calibration Rainfall Event (December 27, 2022)



3.3 FLOW INTEGRITY

Data from specific meters were not used in the hydraulic analysis due to missing information or questionable data quality. This section discusses the flow data that was not used, and steps that were taken to account for the missing data.

Table 3.2 on the following page lists the meters and provides observations based on the data provided. In summary:

- FM030 reports flows that are lower than the flow measured at the upstream meter FM010. It appears that Basin 010 flows are bypassing Meter FM030 and reappearing in Meter FM040. As a result, FM030 was not used for calibration. Basins 030 and 040 were calibrated together, using FM040.
- Flows measured by FM100A and FM100B show that the basins are connected at an unknown location upstream of both meters. For this reason, FM100A and FM100B were calibrated together.
- FM050N, FM070B, and FM140 did not record flows during some or all wet weather events. FM050N and FM070B appeared to be out of service during the calibration event. Flows were calibrated at FM110, which is located downstream of the 070 basins. FM140 was operational during the calibration event but became surcharged during the December 31 rainfall event and did not return flow readings for long periods of time as a result.
- FM060B, FM080A, and FM070D were installed to measure or confirm flow splits. These meters capture intermittent flows and were not used during calibration.

Table 3.2 Observations from Dry and Wet Weather Meter Data

2022 Meter Name	Manhole ID	Discussion	Additional Comments
FM010	K10023	No issues	Water usage records were used to help assign sewered vs. septic parcels.
FM020	M09014	No issues	
FM030A	I12086	This meter reads flows that are lower than the upstream basin and is not reliable.	Downstream FM040 was used for calibration.
FM030B	J11006	This pipe is abandoned.	
FM040	H12067	No issues	SHGCC diversion occurs upstream of this meter.
FM050N	H16023	This meter stopped recording flow. Not reliable.	Downstream FM070A was used for wet weather calibration.
FM050S	H15134	No issues	
FM060A	H14109	No issues. Low flow.	Combined with FM060B.
FM060B	H14165	No issues	
FM070A	F16032	No issues	
FM070B	D16027	This meter stopped recording flow. Not reliable.	Downstream FM110A was used for wet weather calibration.
FM070C	E15047	This meter had numerous periods with no flow. Not reliable.	See above
FM070D	D15128	No issues	See above
FM070E	E14134	No issues	
FM080A	G14189	No issues	
FM080B	G14071	No issues	
FM090	G13222	No issues	
FM100A	E14053	Flow appears to be shared between FM100A and FM100B.	Basin 100A/B calibrated as a single basin.
FM100B	E12158	See above	See above.
FM110A	B16004	No issues	
FM120A	C14036	No issues	
FM120B	C13029	No issues	
FM130	C12089	No issues	
FM140	B15047	Meter stopped registering flow during December 31 storm	Judgment was used to “fill in” missing data during peak periods.
FM150	B13043	No issues	

3.4 SYSTEM FLOWS

This section summarizes wastewater system dry and wet weather flow characteristics as measured during the 2022-23 flow monitoring program.

3.4.1 Base Wastewater Flows

Table 3.3 lists average dry weather flows that were measured at the 25 metered locations on December 7, 2023. Flows from FM110, FM120A, FM130, and FM140, when combined, represent system-wide flow on this day. The sum of flows measured at these four meters was 2.96 mgd. By comparison, the flowmeter at the MPPS measured 3.1 mgd on this day. The difference of less than five percent in flow measurements is within the expected tolerance of flowmeter accuracy.

3.4.2 Dry and Wet Weather Groundwater Infiltration

The V&A report discusses expected minimum-to-average flow ratios and associated indicators of groundwater infiltration. The report references Water Environment Foundation ("WEF") minimum-to-average flow ratios that were used to evaluate potential groundwater infiltration during weather flow as discussed further below. The V&A analysis concludes that some basins, such as Basin 070A, have potential groundwater contributions using this calculation. However, if the V&A assessment is adjusted to account for the transfer of SHGCC flows from FM040 to FM050S (and consequently to FM070A, B, and C and FM110A), the indicators for groundwater infiltration change.

The following findings related to dry and wet groundwater infiltration supplement the information provided in the V&A report.

Dry Weather Groundwater Infiltration

The dry weather flow patterns from December 7, 2022 were evaluated further to identify basins that may have a dry weather groundwater infiltration ("GWI") component.

Table 3.4 lists the minimum flow for each metered basin, and the ratio of minimum flow to measured average flow on December 7, 2022. Basins with a minimum flow greater than 20 percent of the average flow were reviewed for indications of dry weather groundwater. If low flows were consistently high over the dry weather period of December 6 through 8, 2022, then dry weather GWI was added to the model as a constant flow as discussed in the comments field of the table.

When reviewing flow patterns, it is important to know that on December 7, 2022, 218,120 gallons of flow was diverted from FM040 (and downstream basins 90, 100A/B, and 130) to the SHGCC plant and 184,810 gallons of this flow was returned to Basin FM50S and its downstream basins (70A, B, C, D, and 110A).

Table 3.3 Average Dry Weather Flows (December 7, 2022)

2022 Meter Name	Manhole ID	Average Dry Weather Flow (gpd)	Comments
FM010	K10023	168,000	
FM020	M09014	19,000	
FM030A	I12086	128,000	This flow should have been at least 168,000 gpd (from FM010).
FM030B	J11006	0 (abandoned line)	
FM040	H12067	225,000	218,120 gallons were diverted to SHGCC upstream of FM040.
FM050N	H16023	64,000	
FM050S	H15134	216,000	Includes 184,810 gallons from SHGCC.
FM060A	H14109	5,000	
FM060B	H14165	46,000	
FM070A	F16032	362,000	Includes 184,810 gallons from SHGCC.
FM070B	D16027	28,000	FM070B, C, and D share flows from FM070A. Includes 184,810 gallons from SHGCC.
FM070C	E15047	294,000	
FM070D	D15128	564,000	
FM070E	E14134	69,280	Flows to FM120B.
FM080A	G14189	84,000	
FM080B	G14071	67,000	
FM090	G13222	489,000	218,120 gallons were diverted to SHGCC upstream of FM090.
FM100A	E14053	157,000	Basins 100A and 100B share flow.
FM100B	E12158	413,000	
FM110A	B16004	1,014,000	Includes 184,810 gallons from SHGCC.
FM120A	C14036	65,000	
FM120B	C13029	119,000	
FM130	C12089	1,110,000	218,120 gallons were diverted to SHGCC upstream of FM130.
FM140	B15047	772,000	
FM150	B13043	232,000	

Table 3.4 Ratio of Minimum Flow to Average Flow per Basin (December 7, 2022)

2022 Meter Name	Manhole ID	Average Dry Weather Flow (gpd)	Minimum Flow (gpd)	Ratio	Comments
FM010	K10023	168,000	32,000	0.19	
FM020	M09014	19,000	5,700	0.3	Small basin. OK.
FM030A	I12086	128,000	9,600	0.08	
FM030B	J11006	0	0		
FM040	H12067	225,000	20,000	0.04	
FM050N	H16023	64,000	33,400	0.52	**20,000 gal of GWI**
FM050S	H15134	216,000	122,400	0.57	Ratio is skewed due to SHGCC flows
FM060A	H14109	5,000	3,800	0.76	Small basin. OK.
FM060B	H14165	46,000	9,900	0.22	
FM070A	F16032	362,000	217,000	0.60	0.18 after SHGCC flows are considered. OK.
FM070B	D16027	28,000	4,100	0.15	
FM070C	E15047	294,000	Not Reliable		
FM070D	D15128	564,000	160,300	0.28	Impacted by SHGCC flows. OK.
FM070E	E14134	69,280	13,500	0.19	
FM080A	G14189	84,000	14,500	0.17	
FM080B	G14071	67,000	1,700	0.03	
FM090	G13222	489,000	73,900	0.15	
FM100A	E14053	157,000	39,400	0.25	< 10,000 gal of GWI. Don’t add.
FM100B	E12158	413,000	62,100	0.15	
FM110A	B16004	1,014,000	496,400	0.49	0.49 after SHGCC are considered. **Add 90,000 gal. to 70B,C,D and 110A**
FM120A	C14036	65,000	16,800	0.26	< 10,000 gal of GWI. Don’t add.
FM120B	C13029	119,000	31,200	0.26	**10,000 gal of GWI**
FM130	C12089	1,110,000	251,400	0.23	**30,000 gal of GWI**
FM140	B15047	772,000	199,200	0.26	**35,000 gal of GWI**
FM150	B13043	232,000	9,200	0.04	

Wet Weather Groundwater Infiltration

To be consistent with the GWI evaluation that was completed by V&A for the flow monitoring study, WEF guidelines were utilized to assess the potential for wet weather GWI on December 27, 2022. Table 3.5 lists the minimum flow for each metered basin, and the ratio of minimum flow to measured average flow on December 27, 2022. Basins with a minimum-to-average flow ratio greater than WEF-expected values as shown on Figure 3-14 of the V&A report (repeated in this report as Figure 3.6) were assumed to include wet weather groundwater.

On December 27, 2022, 172,000 gallons of flow was diverted from FM040 to the SHGCC plant and 33,000 gallons of this flow was returned to Basin FM50S and its downstream basins (70A, B, C, D, and 110A).

Although Figure 3.6 shows eight meters as exceeding the WEF threshold, Table 3.5 indicates that only one meter, FM120B, exceeded the threshold on December 27, 2022. For many of the meters shown in Figure 3.6 (FM070A, FM070B, FM070C, FM070E, and FM110A) , the GWI assessment changed after the minimum and average flows were adjusted to account for the SHGCC flows.

Figure 3.6 Groundwater Infiltration Evaluation from Figure 3-14 of V&A Report

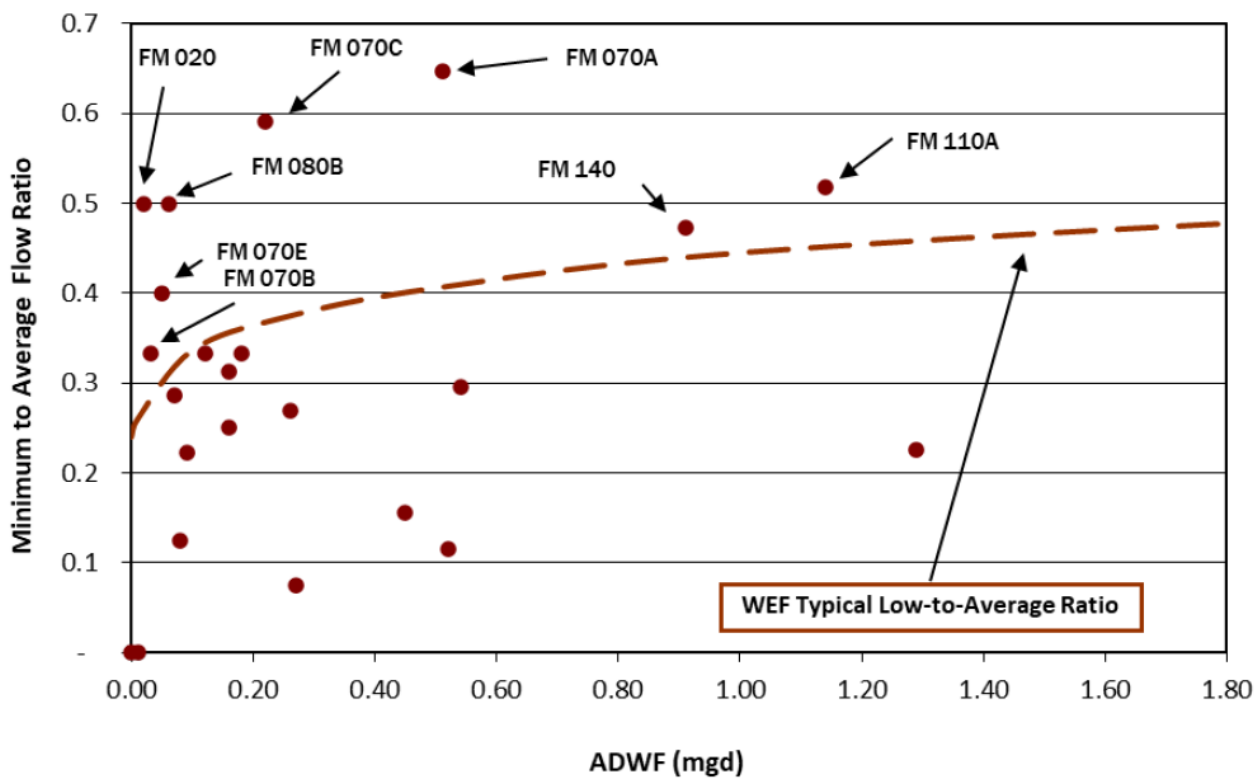


Table 3.5 Ratio of Minimum Flow to Average Flow per Basin (December 27, 2022)

2022 Meter Name	Manhole ID	Average Wet Weather Flow (gpd)	Minimum Wet Weather Flow (gpd)	Ratio	Comments
FM010	K10023	448,000	68,200	0.15	
FM020	M09014	39,300	9,114	0.23	
FM030A	I12086	391,000	43,400	0.11	
FM030B	J11006	0	0		
FM040	H12067	771,000	11,500	0.01	
FM050N	H16023	0	0	0	
FM050S	H15134	256,500 (223,500 w/o SHGCC flows)	113,000 (80,000 w/o SHGCC flows)	0.44 (0.36 w/o SHGCC flows)	Ratio is skewed due to SHGCC flows. OK.
FM060A	H14109	11,300	5,300	0.47	Small basin. OK.
FM060B	H14165	137,000	29,700	0.22	
FM070A	F16032	673,000	220,000	0.33	0.29 after SHGCC flows are considered.
FM070B	D16027	51,000	22,600	0.44	Data is not reliable. Flow is shared between the FM070 basins and FM070C was out of service.
FM070C	E15047	0	0	0	
FM070D	D15128	935,000	350,000	0.37	
FM070E	E14134	116,900	30,900	0.26	
FM080A	G14189	197,000	55,600	0.28	
FM080B	G14071	214,900	0	N/A	Bypass Line
FM090	G13222	1,228,000	120,800	0.10	
FM100A	E14053	264,000	85,100	0.32	
FM100B	E12158	1,209,000	197,000	0.16	
FM110A	B16004	1,552,000	738,000	0.48	0.46 after SHGCC flows are considered. OK given large average flow.
FM120A	C14036	75,000	28,400	0.38	
FM120B	C13029	153,000	71,800	0.47	**18,000 gal of GWI**
FM130	C12089	2,183,000	656,000	0.30	
FM140	B15047	1,524,000	654,000	0.43	
FM150	B13043	396,000	65,200	0.16	

Rainfall-Dependent Inflow and Infiltration

In addition to reviewing dry weather flows and groundwater infiltration, the flow data was used to assess basin-specific inflow and infiltration. The V&A report provides an assessment of I&I for the flow monitoring period. Table 3.6 provides an I&I snapshot for the calibration date of December 27, 2022.

Rainfall-dependent I&I ("RDII") is the collective description for stormwater and groundwater that enters the sewer system through pipe defects and unpermitted direct connections. Inflow describes water that enters through structures such as roof leaders and private drains, or from holes in manhole covers. Infiltration describes water that enters through defects in pipes, joints, and manhole walls such as cracks, open joints, or breaks.

Figure 3.7 shows sources of infiltration and inflow, as presented in Figure 2-4 of the V&A report.

Figure 3.7 Typical Sources of Infiltration and Inflow from Figure 2-4 of V&A Report

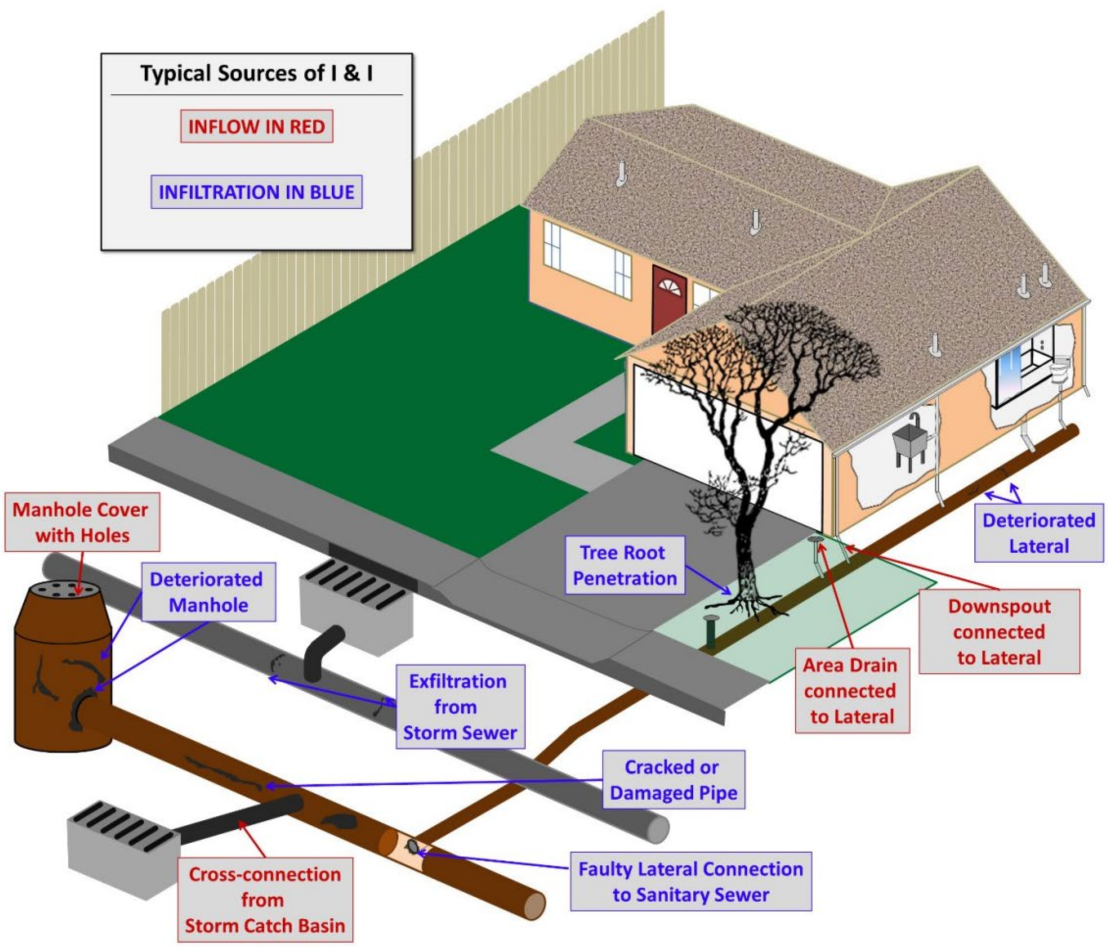


Figure 2-4. Typical Sources of Infiltration and Inflow

Wet weather peaking factors are calculated as peak flow divided by average flow. Smaller basins usually have higher peaking factors. Therefore, peaking factor alone cannot be used to assess whether a basin has high I&I. For the purposes of comparison, the basin I&I rankings shown in Table 3.6 are based on the ratio of I&I in gallons as compared to average dry weather flow.

FM070A registers the most I&I. This result may be related in part to the transfer of flow that occurred on this day from Basin 040 to Basin 050 (and downstream to Basin 070A). FM070A is located east of Atherton Avenue from Fernside Street to Middlefield Road.

FM100A/B has the second highest I&I. This basin is located south of El Camino Real and west of Sand Hill Road.

FM010, FM020 (both in Portola Valley), FM060 (Sharon Heights), and FM080 (Upper Valparaiso) also show elevated values for I&I.

Table 3.6 Wet Weather Peaking Factor, I&I, and Ranking (December 27, 2022)

2022 Meter Name	Manhole ID	Basin-Specific ADWF from Dec 7, 2022 (gpd) Note 1	Basin-Specific PWWF from Dec 27, 2022 (gpd) Note 2	Peaking Factor	I&I Ranking
FM010	K10023	149,000	1,178,000	7.9	3
FM020	M09014	19,000	104,000	5.5	6
FM030A	I12086	0	232,000		DWF Not Reliable
FM040	H12067	97,000	419,000	4.4	9
FM050N	H16023	64,000	0	0	No Flow
FM050S	H15134	216,000	506,628	2.3	13
FM060A	H14109	5,000	16,200	3.2	11
FM060B	H14165	46,000	326,000	7.1	4
FM070A	F16032	82,000	905,472	11.0	1
FM070B	D16027	593,280	1,050,900	1.8	16
FM070C	E15047				
FM070D	D15128				
FM070E	E14134				
FM080A	G14189	84,000	424,700	5.1	7
FM090	G13222	151,000	761,800	5.0	8
FM100A	E14053	81,000	877,200	10.8	2
FM100B	E12158				
FM110A	B16004	128,000	725,100	5.7	5
FM120A	C14036	65,000	150,500	2.3	13
FM120B	C13029	49,720	0		WWF Not Reliable
FM130	C12089	697,000	1,576,100	2.3	13
FM140	B15047	540,000	2,372,300	4.4	9
FM150	B13043	232,000	742,300	3.2	11

Notes:

1. On December 7, 2022, 218,120 gallons were diverted from FM040 (and FM090, FM100A/B, FM130) and 184,810 gallons were returned to FM050N (and FM070A/B/C/D, FM110A).
2. On December 27, 2022, 172,000 gallons were diverted from FM040 and 33,000 gallons were returned to FM050N.

3.4.3 Systemwide Wet Weather Peaking Factors

The four flowmeters that are closest to the MPPS are FM110A (Marsh Road), FM120A (Commonwealth Drive), FM130 (Commonwealth Drive), and FM140 (Bayfront Expressway). Some FM130 flows appear to also flow to FM140 during high flow events. Dry and wet weather flows for these meters are listed in Table 3.7. The wet weather peaking factor ("WWPF") was calculated for each of the five distinct rainfall events by adding measured flows at these locations. WWPF is determined by dividing the peak wet weather flow ("PWWF") by the ADWF.

Table 3.7 Rainfall and Measured Flows at Terminal Meters

Monitoring Period(Notes 1,2)	Rainfall at FM110 (inches)	FM110 (mgd)	FM140 (mgd)	FM120A (mgd)	Total Flow (mgd)	WWPF
12/07/2022 (ADWF)	0.005	1.01	0.77	0.06	1.8	N/A
12/27/2022 (PWWF)	1.7	2.6	3.1	0.15	5.8	3.2
12/31/2022 (PWWF)	4.4	5.9	6.6	0.43	12.9	7.2
01/09/2023 (PWWF)	1.5	3.3	6.2	0.18	9.7	5.4
01/14/2023 (PWWF)	1.6	3.5	6.1	0.17	9.8	5.4

Note 1: Peak flows may not have occurred during the same timestep for all meters. Therefore, Total Flow may be slightly higher than actual.

Note 2: The WWPF of 7.2 for the 12/31/2022 rainfall event is higher than the District's systemwide WWPF, because the 12/31/2022 event was more severe than the District's design storm. See Chapter 4, Hydraulic Model Development and calibration, for additional information.

As observed in Table 3.7, on the days following the December 31, 2022 rainfall event, the effects of this storm were still apparent in flows measured on January 9 and 14. As discussed in Chapter 4, Hydraulic Model Development and Calibration, inflow and infiltration enters the system over time and specific parameters are used to model the time for inflow and infiltration to peak and recede. The flow measured on January 9 and 14 includes residual I&I contributions from rainfall that occurred between December 31 and these dates. For example, minimum (nighttime) flows measured at FM140 prior to the start of the January 9 rainfall event included over 700,000 gallons of I&I that had entered the system from prior wet weather periods. The hydraulic analysis assumes that the design storm will occur during a period in which system flows have recovered from any prior rainfall events.

CHAPTER 4 HYDRAULIC MODEL DEVELOPMENT

The purpose of this Chapter is to summarize assumptions, items considered during model development and calibration, and key components of the completed hydraulic model.

This Chapter is organized as follows.

4.1 Model Components

4.2 Wastewater Loads

4.3 Model Calibration

The 2023 hydraulic model is an updated version of the District's existing wastewater collection system hydraulic model, which was developed using Innovyze InfoWorks ICM software. The model can be used a tool for assessing the flows and capacities of the District's trunk sewers and for identifying solutions to sewer capacity issues. The hydraulic model is also a tool for performing "what if" scenarios to assess the impacts of future developments, land use changes, and system configuration changes.

The hydraulic model includes the District's trunk sewers (typically 10-inch diameter and larger) and associated facilities, and is a skeletonized representation of the wastewater collection system in its configuration and operation. The model also includes some smaller diameter sewers as needed to provide system connectivity, to include pump station facilities, or to represent available relief sewers. In 2018, VWHA reviewed the District's hydraulic model to assess whether there would be benefit to converting this model to a "full pipe" model. At that time, invert data was not available for many of the smaller diameter collector sewers. Further, the District has very few predicted spills from the system during the design storm. Therefore, assessing the capacity of the collector sewers is not required and adding these pipes would add unnecessary complexity to the hydraulic model.

4.1 MODEL COMPONENTS

The hydraulic model transforms information about the physical and operational characteristics of the sewer system into a mathematical model. The model solves a series of differential equations for continuity and momentum (Saint-Venant equations) to simulate various flow conditions for specified sets of flow loads. The modeling results provide information on flows, flow depth, velocity, surcharging, and backwater conditions that are used to analyze system performance and identify system deficiencies. The model is also used to verify the adequacy of recommended or proposed system improvements.

4.1.1 General

The hydraulic model comprises a skeletonized network of nodes (*e.g.*, manholes) and conduits (*e.g.,* pipelines). The following descriptions provide additional information on elements used in the hydraulic model.

- Nodes represent manholes, split manholes, and lift station wet wells. The MPS wet well is modeled as an open outfall. All flows loaded into the model are attached to node structures. The data required for node structures include elevation data (pipe invert and manhole rim), manhole diameter, and whether the system is open or sealed.

- Conduits represent facilities that convey wastewater from one point in the system to another. Conduits include gravity pipes, force mains, and pumps. The physical data for gravity pipes and force mains include invert elevation, size, length, and friction factor. The physical data for pumps include type of pump, elevation, pump capacity, and operational parameters such as on/off setpoint elevations and sequencing.
- Subcatchments represent a tributary area that flows to an individual node in the model. Each parcel in the system is assigned a subcatchment and this subcatchment is then connected to the nearest trunk sewer manhole. The subcatchment layer serves several purposes, including defining land use, assigning diurnal curves, and assigning dry and wet weather flow inputs. The data required for subcatchments are node connection, land use, flow factors, total and contributing area, diurnal curve profile, rainfall profile, I&I parameters, and groundwater parameters.

Pipelines and Manholes

The initial model network was developed using the District's *WBSD MH* and *WBSD SM* shapefiles. Model development and validation involved the following steps.

- All pipes 10-inches and diameter were isolated from the GIS layers. These pipes were inspected to find locations where pipes were discontinuous or otherwise ambiguous. The GIS file was then reviewed further to identify smaller diameter pipes, force mains, or other infrastructure needed to assure connectivity and these lines were added to the trunkline network. The resulting network has upstream and downstream manhole IDs, pipe sizes, and lengths for each pipe segment. Each reach of pipe is continuous from top to bottom.
- At the same time, node structures associated with the pipes discussed above were added to the network.
- Known manhole rim and invert elevations were added to the network (i.e., using as-built records and available spreadsheet data). In cases where a single invert elevation was provided for a manhole that had multiple pipes attached, the invert was assumed to be the elevation of the center of the manhole base.
- Rim elevations for the remaining inverts were interpolated from publicly-available digital elevation model data as provided via Google Earth.
- Invert elevations for the remaining inverts were established as follows:
  - Inverts were first set at six feet below the rim elevation
  - Where gravity flow could not be maintained using these elevations, inverts were adjusted using engineering judgment to first provide minimum allowable slopes, and then provide continuous slopes relative to adjacent manhole and pipe structures. Slopes, inverts, and pipe diameters were compared to previous hydraulic model files as needed to complete or confirm missing information.
  - Flow splits were brought forward from previous hydraulic model networks. Where two pipes leave an manhole in a potential flow split, the largest downstream pipe was assumed to convey primary flows. The invert for smaller downstream pipe was raised to

match the crown of the primary downstream pipe to avoid dry weather flow splitting at this intersection.

- All gravity pipelines were assigned a Manning's friction factor ("n") of 0.013.
- Force main pipelines were conservatively assigned a Hazen-Williams Coefficient of 130.

The hydraulic model consists of 992 gravity pipe segments comprising approximately 42.3 miles of pipe. Modeled gravity pipelines range from 6 to 54 inches in diameter. The model includes all 10-inch diameter and larger trunk lines, and associated manholes plus additional smaller diameter pipelines. The 42.3 miles of pipeline represent approximately 21 percent of the District's gravity collection system.

The hydraulic model includes ten of the District's pump stations and associated force main pipes with a combined modeled length of 3.2 miles. Force mains vary in diameter from 6 to 10 inches.

The modeled collection system pipelines are shown on Figure 4.1 on the following page.

Pump Stations

Table 4.1, which follows Figure 4.1, lists information used to model the District's pump stations. Each station includes fixed pumps with specific pumping capacities and on and off elevations to define pump setpoints.

Subcatchments

The District's service area includes 15,822 parcels. Each parcel is represented in the model as a subcatchment with an assigned land use. Loads were developed and assigned to each subcatchment based on the assigned land use, as follows:

- Residential land uses (VLDR, LDR, MDR, HDR) were assigned a flow per parcel based on the assigned land use
- Schools were assigned a flow of 7 gallons per student
- All other land uses (commercial, industrial, office/administrative, recreational, public facility) were assigned a flow per acre based on the assigned land use. The applicable acreage for buildings on large parcels with substantial undeveloped land was reduced on a parcel by parcel basis.

Unit flows and land uses are discussed in more detail later in this Chapter, as part of the discussion on dry weather calibration.

Figure 4.1 Modeled Gravity Sewer and Force Main Pipelines

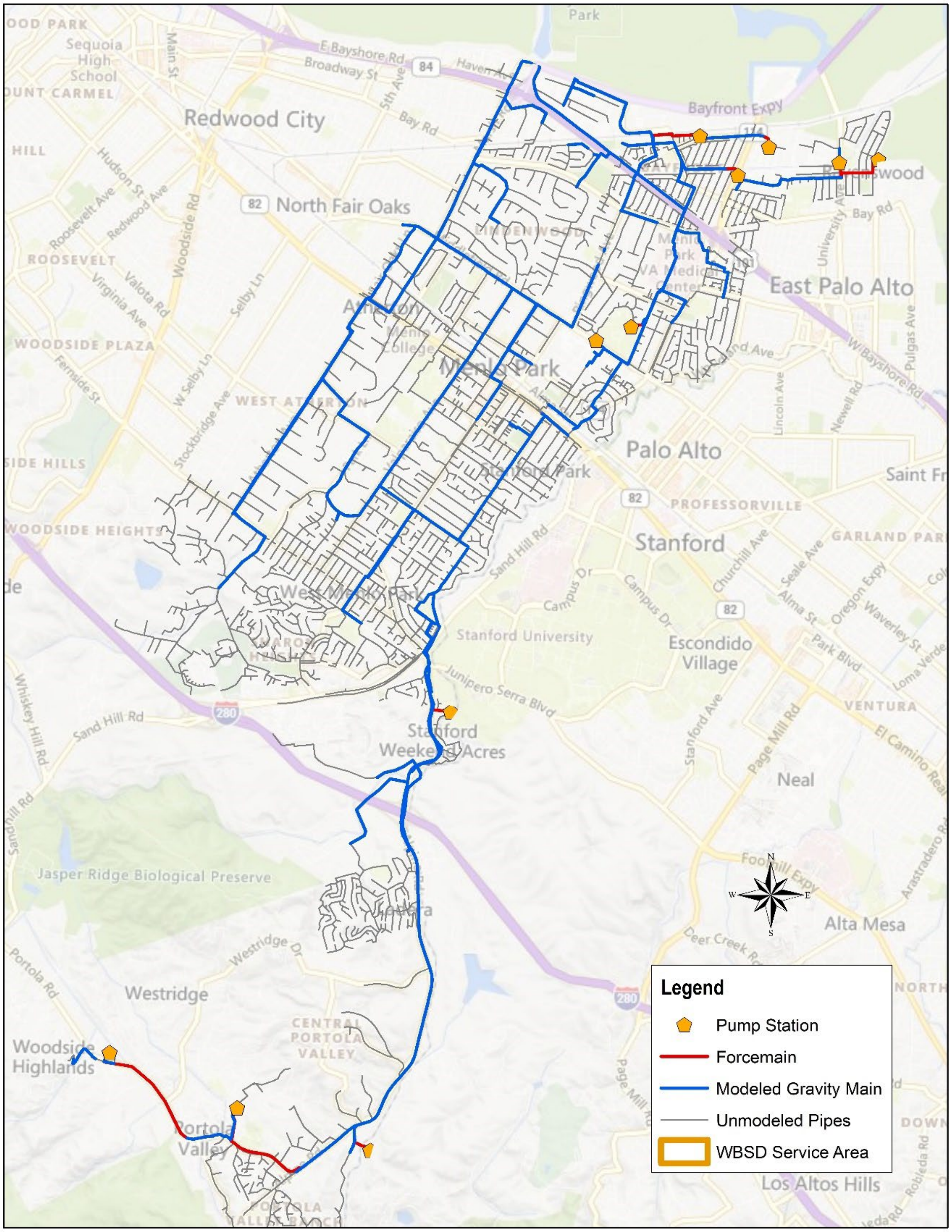


Table 4.1 Pump Station Parameters

Pump Station Name	Node ID	Wet Well Size	Modeled Ground Elevation (ft)	Modeled Wet Well Floor Elevation (ft)	No of Pumps	Pumping Capacity (gpm) (Note 1)	Pump On Level from Bottom (ft)	Pump Off Level from Bottom (ft)
Hamilton Henderson	B13079	12' diameter x 21' deep	7.34	-13.66	2	2100	8’ 9” / 9’ 9”	4’ 7”
Willow	B12123	10' x 10' x 21' deep	13.23	-7.77	2	1650	8’ 5” / 9’ 5”	4’ 5”
Menlo Industrial	B12121	8' diameter x 15' deep	9.34	-5.66	2	310	5’ / 6’	2’
University	B11117	8' diameter x 23' deep	10.04	-12.96	3	640	8’ / 8’ 5” / 9’	4’
Illinois	A10029	12' diameter x 24' deep	12.86	-11.14	2	580	7’ / 8’ 5”	3’
Vintage Oaks 1	D12171	8' diameter x 24' deep	47.44	23.44	2	330	6’ / 6’ 3”	3’ 2”
Vintage Oaks 2	E12139	8' diameter x 24' deep	56.67	32.67	2	330	5’ / 6’ 5”	3’ 5”
Stowe Lane	I11062	8' x 8' dry well and 4' x 8' wet well X 25' deep	147.16	122.16	2	340	6’ / 7’	3’
Los Trancos (not modeled)	M09031	8' diameter x 14' deep	452.14	438.14	2	100	5’ / 5’ 5”	2’ 5”
Sausal Vista	M11016	12' diameter x 27' deep	495.61	468.60	2	715	7’ 5” / 8’5”	4’
Village Square	M13003	10' diameter x 17' deep	435.19	418.19	2	160	6’ 5” / 7’ 5”	4’ 5”

Note 1. Pumping capacity assumes the largest pump is out of service.

4.2 WASTEWATER LOADS

Wastewater loads or flows are divided into three categories. All of these flows are discussed further in this section.

- ADWF or base wastewater flow (“BWF”) includes the average daily dry weather sanitary flow contribution from permitted connections to the collection system
- Groundwater infiltration (“GWI”) includes a constant flow that is found in the flow monitoring in addition to BWF. Different dry weather and wet weather GWI values were assigned.
- Rainfall-dependent inflow and infiltration (“RDII”) results when flows from wet weather events infiltrate the system through defects in existing wastewater collection system assets

4.2.1 Dry Weather Flow Generation

This section describes the tasks completed to calculate dry weather flows.

Dry Weather Sewer Flows

Dry weather flows were calculated using land uses and unit flow factors. The key elements of dry weather flow generation in the hydraulic model include ADWF, Peak Dry Weather Flow (“PDWF”), and dry weather GWI.

The initial step in assigning ADWF or BWF in the hydraulic model was to assign a unit flow to each assigned land use designation. Following is the process that was followed to assigned BWF.

1. Land use categories from the City of Menlo park GIS database were grouped into a shortlist of land use descriptions as discussed in Chapter 2.
2. A unique land use designation was assigned to each modeled parcel within the service area.
3. Large non-wastewater generating parcels were identified through a review of aerial imagery and water billing records.
4. The District’s designated unit flows for new construction established in the District’s design criteria were assigned to each parcel based on the land use designation. Initial unit flow factors were assigned per parcel to residential classifications, and per acre to other classifications, as shown in Table 4.2.
5. The hydraulic model was used to generate flows for the service area. Model-generated flows were compared to the measured systemwide base wastewater flow of 3.0 mgd on December 7, 2022.
6. The initial land use factors yielded flows that were nearly double the measured flows on December 7, 2023. The unit flow factors were adjusted globally for each land use category until general consistency was found between the model-generated and metered flows. Table 4.2 lists the final initial unit flow factors. These flow factors received further refinement during dry weather calibration.

Table 4.2 Initial Unit Factors for Base Wastewater Flow

Land Use	Unit flow factor (gpd/parcel or gal/acre)
Very Low Density Residential	125 gpd/parcel
Low Density Residential	125 gpd/parcel
Medium Density Residential	180 gpd/parcel
High Density Residential	350 gpd/parcel
Professional and Administrative Offices	1000 gal/acre
Retail/Commercial	1000 gal/acre
Limited Industry	1000 gal/acre
Public Facilities	250 gal/acre
Parks and Recreation	50 gal/acre
Schools	7 gal/student

In addition to the flow factors shown in Table 4.2, specific parcels with high point loadings were assigned a unique load per parcel that represents either General Plan estimates for wastewater discharge (for unbuilt structures) or estimated discharge calculated as 80% of average winter water use (for existing structures). Point flows were assigned to the following developments:

- Facebook (300 Constitution Avenue)
- Facebook (1 Hacker Way)
- Menlo Gateway
- Rosewood Sandhill
- Stanford Linear Accelerator Center (12 separate parcels)
- Sequoias Retirement Home
- Sequoia Bell Haven

Twenty one schools throughout the service area were assigned a unit flow per student as noted in Table 4.3.

Table 4.3 Schools with Unit Flows in Hydraulic Model

School and City/Town	Number of Students
Corte Madera School/Portola Valley	356
Woodside Priory School/Portola Valley	375
Ormondale Elementary School/Portola Valley	271
Woodland School/Portola Valley	292
La Entrada Middle School/Menlo Park	803
Phillips Brooks School/Menlo Park	292
Oak Knoll Elementary School/Menlo Park	738
Las Lomitas Elementary School/Atherton	579
Hillview Middle School/Menlo Park	972
Sacred Hearts Catholic School/Atherton	615
Menlo School/Atherton	700
Menlo College/Atherton	700
Menlo-Atherton High School/Atherton	2275
Encinal Elementary School	700
Laurel School/Atherton	706
Peninsula School/Menlo Park	218
Alto International School/Menlo Park & Willow Oaks Elementary School/Menlo Park	948
Cesar Chavez Elementary School/East Palo Alto	168
Costano Elementary School/East Palo Alto	558
Belle Haven Elementary School/Menlo Park	577
St. Raymond Catholic Elementary School	300

Diurnal (24-Hour) Flows

24-hour diurnal patterns were developed for each monitored basin from the V&A 2022-23 flow monitoring data. Four example diurnal curves are presented in Figures 4.2 and 4.3. The top set of curves were taken from the three large basins that discharge to the MPS. In the grey plot for M130, the peaks and valleys created by the diversion of flows far upstream at the SHGCC are still apparent. Flows in residential areas tend to peak mid-morning and again in the evening as residents utilize water for showers, laundry, and cooking. Flows in more commercial or industrial basins, such as FM140, exhibit less of a diurnal pattern.

The lower set of curves were taken from two basins near the "top" or upstream end of the system. M10 captures Portola Valley flows. The pumping that occurs in order to lift flows to the main system is visible through the multiple short flow peaks. A diurnal pattern can still be observed in this flow. M50B is located within the upper reaches of Santa Cruz Avenue. This basin receives return flow from the SHGCC. As seen in the FM050S graph, the return flow is constant and occurs aver the entire 24-hour period.

Figure 4.2 Example Diurnal Patterns Upstream of the MPS
FM130 (Constitution Avenue), FM110A (Marsh Road), and FM140 (Bayfront Expressway)

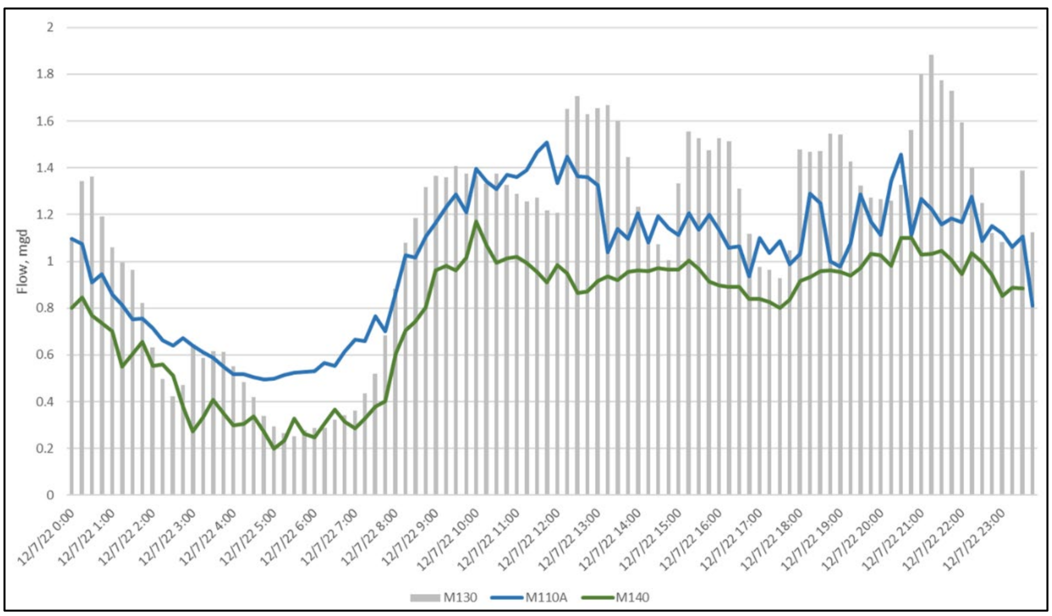
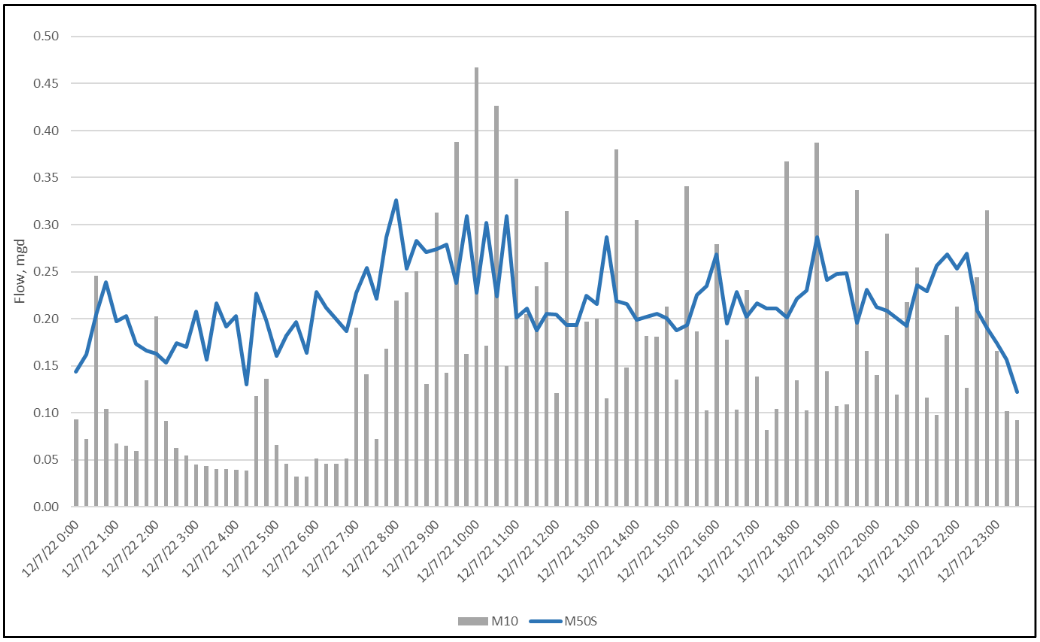


Figure 4.3 Example Diurnal Patterns Near Top (Upstream Portion) of System FM20 (Portola Valley), FM50S (Alameda de las Pulgas)



4.3 MODEL CALIBRATION

The hydraulic model was calibrated for the dry and wet weather conditions. This section provides more information on the calibration effort and presents results.

4.3.1 Dry Weather Flow Calibration

The initial dry weather flow values discussed in Table 4.2 were assigned to each subcatchment in the hydraulic model. Subcatchments were grouped into larger sewer basins that were defined by 23 (of 25) temporary and permanent flowmeters that were monitored from December 2022 through February 2023. Figure 4.4 on the following page shows the sewer basins and their associated flowmeter. Table 4.4 provides a description of each sewer basin.

Modeled dry weather flows were then compared to average metered dry weather flows from December 7, 2022. Although some rainfall had occurred prior to this time, flow data indicates that the system flows on this day were not elevated as a result. The total system ADWF measured by V&A Engineering on December 7, 2022 was 3 mgd.

Dry weather flow components were adjusted beginning with the metering basins that are the furthest upstream (FM010 and FM020), and ending with the metering basins closest to the MPPS (FM110A, FM120A, FM130, and FM140). Flows were adjusted as follows, until average modeled flows were, for most basins, within five to ten percent of measured flows:

- If modeled flows were different than measured flows, the land use distribution within the basin was reviewed and unit flow factors increased or decreased as needed to adjust generated flows.

- A constant dry weather groundwater infiltration component was considered for the basins measured by FM050N, FM070B, C, & D, FM110A, FM130, and FM140. Groundwater was added only if the unit flow factors in these basins also needed to be increased.

- Calculated flows for upstream basins were allowed to vary more than five to ten percent from measured flows if, by the time these flows were aggregated further downstream, the accuracy remained within this tolerance.

A completed dry weather calibration was achieved when minimum, maximum, and average modeled flows, as well as the temporal distribution of flow over a 24-hour period, were within ten percent of measured flows. Exceptions were made for very small basins, for which a minor increment in flow may constitute a large percentage change.

The final adjusted unit flow factors for each basin and shown on Table 4.5. Dry weather calibration results are presented in Table 4.6. The basins in Table 4.6 are grouped by color to represent the general direction of flow from upstream to downstream. Some flows split between basins – these splits are not defined in Table 4.6.

Appendix B presents dry weather flow calibration plots for meters that measured flow on December 7, 2022.

Figure 4.4 Sewer Basins and Associated Flowmeters

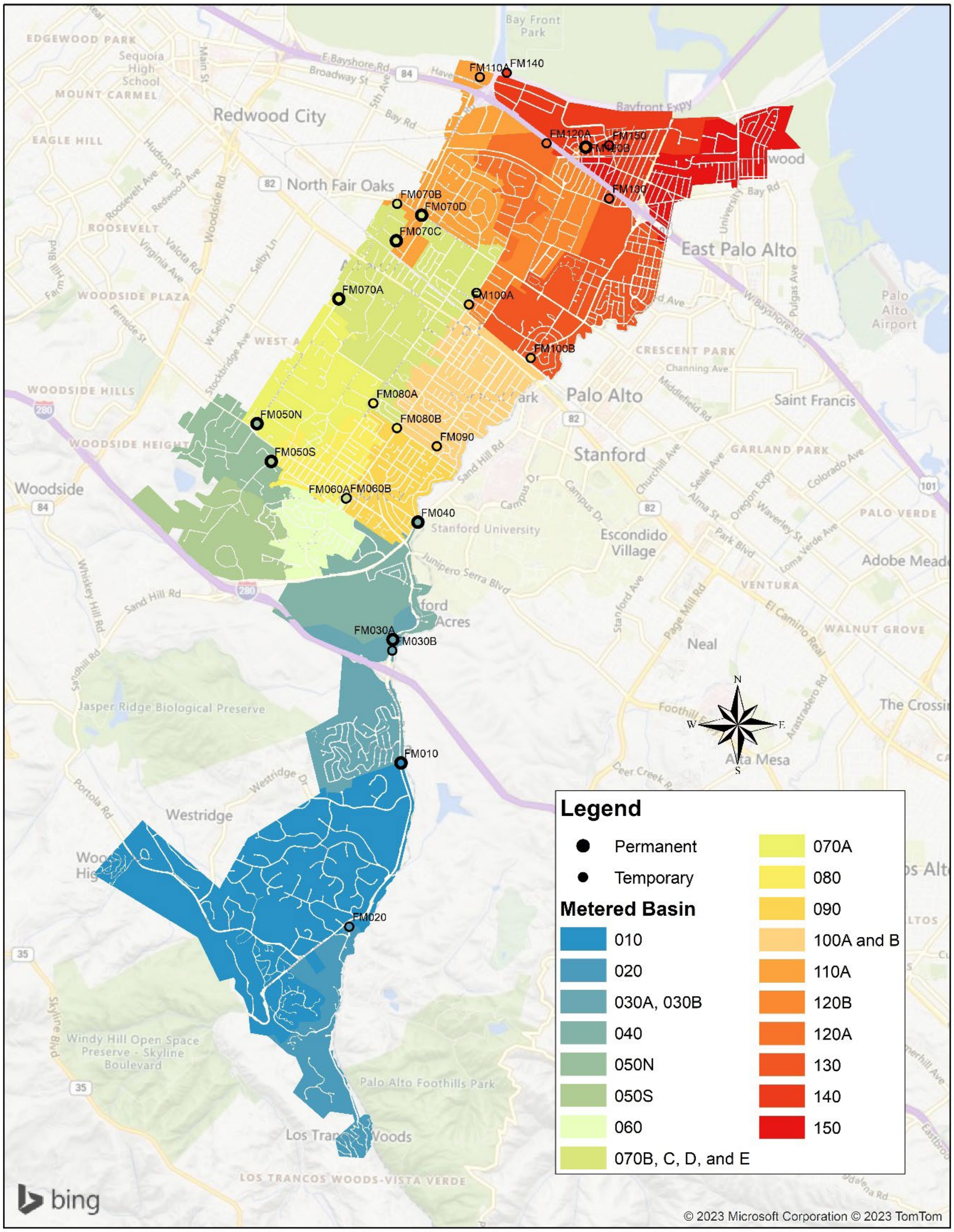


Table 4.3 Description of Sewer Basins

Basin	Location
010	Portola Valley neighborhoods
020	Los Trancos neighborhoods
030	Ladera. This basin includes numerous Grade 4 defects. Further, a 10-inch pipe with known surcharge has Grade 4 and 5 defects; upsizing may be beneficial. A basin-wide strategy is recommended prior to scheduling repairs.
040	SLAC and Stanford Hills
050NS	Between Alameda de las Pulgas, Sharon Heights, Alta Vista Drive and Stockbridge.
060AB	Sharon Heights
070AB	Southeast of Atherton Avenue between Alameda de las Pulgas and El Camino Real. This basin includes numerous Grade 4 defects. Further, the pipeline on Elena Avenue is recommended for upsizing. A basin-wide strategy is recommended prior to scheduling repairs.
70CD	Southeast of Atherton Avenue between El Camino Real and Middlefield Avenue
080AB	Between Alameda de las Pulgas, Santa Cruz, Olive Avenue, and Camino al Lago
090	Between Alameda de las Pulgas, Santa Cruz Avenue, Olive St., and Bay Laurel Dr.
100AB	Between El Camino Real, Valparaiso, Olive Street, and Bay Laurel Drive
110	Between Middlefield and Highway 101, adjacent to Marsh Rd, incl. Flood Circle
120AB	South of Highway 101 including Menlo Oaks and Oak Grove Avenue
130	Between El Camino Real and Highway 101 including the communities to the north and south of Willow Road (Linfield Oaks, Vintage Oaks, and the Willows)
140	Between Bayfront Expressway, Highway 101, Belle Haven, and Willow Road
150	Between Menalto Ave., Bay Rd., Bayfront Expwy, Willow Rd., and Belle Haven

Table 4.4 Wastewater Adjusted Unit Flow Factors

2022 Meter Name	Model Profile	VLD	LDR	MDR	HDR	Park & Rec	Public Facility	Retail and Comm (gal/acre)	Public and Admin Ofc (gpd)	Light Ind	Schools (gal/ student)
FM010	7	175	175	175	350	50	250	1000	--	--	7
FM020	7	175	175	175	350	50	250	1000	--	--	7
FM030A/B	8	125	175	175	225	--	250	1000	--	--	7
FM040	8	125	175	175	225	--	250	1000	--	--	7
FM050N	13	75	75	75	75	--	--	--	--	--	--
FM050S	14	75	75	75	75	50	--	--	1000	1000	--
FM060A/B	15	75	75	75	75	--	1200	--	--	--	7
FM070A/B/C	10	65	65	65	65	--	150	500	--	--	7
FM070D	13	75	75	75	75	--	--	--	--	--	--
FM070E	9	80	80	90	225	--	250	1000	1000	--	--
FM080A/B	6	75	75	75	75	50	250	1000	1000	--	7
FM090	9	80	80	90	225	--	250	1000	1000	--	7
FM100A	12	75	75	75	350	50	250	1000	--	--	7
FM100B	9	80	80	90	225	--	250	1000	1000	--	--
FM110A	1	75	75	75	75	--	--	--	--	--	--
FM120A	11	125	125	125	350	50	250	--	1000	--	7
FM120B	3	75	75	75	75	50	250	--	1000	--	7
FM130	5	125	125	150	350	50	250	--	1000	1000	7
FM140	2	75	75	75	75	50	250	1000	1000	1000	--
FM150	4	125	100	125	350	50	250	1000	1000	1000	7

Table 4.5 Dry Weather Calibration Results (December 7, 2022)

2022 Meter Name	Manhole ID	ADWF from Dec 7, 2022 (gpd)	ADWF from Model	Model Accuracy	Comments
FM020	M09014	19,000	25,633	34.9%	Small basin
FM010	K10023	168,000	181,673	8.1%	
FM030A/B	I12086	128,000*	--	--	*FM030A is missing flow. Skip to FM040
FM060A/B	H14165	51,000	67,281	31.9%	Note 1
FM080A/B	G14189/G14071	151,000	167,694	11.0%	
FM040	H12067	225,000	197,470*	(12.2%)	Note 2
FM090	G13222	489,000	548,457*	12.2%	
FM100A/B	E14053/E12158	570,000	764,981*	34.2%	Note 3
FM130	C12089	1,110,000	1,083,605*	(2.4%)	
FM120B	C13029	119,000	116,098	(2.4%)	
FM050N	H16023	64,000	23,212	(64%)	
FM050S	H15134	216,000	286,666*	32.7%	
FM070A	F16032	362,000	670,484*	85.2%	Note 4
FM070B/C/D	Various	955,280	1,032,386*	8.1%	
FM110A	B16004	1,014,000	1,154,983*	13.9%	
FM120A	C14036	65,000	63,015	(3.0%)	OK
FM140	B15047	772,000	1,004,234	30.1%	Note 5
FM150	B13043	232,000	238,240	2.7%	OK

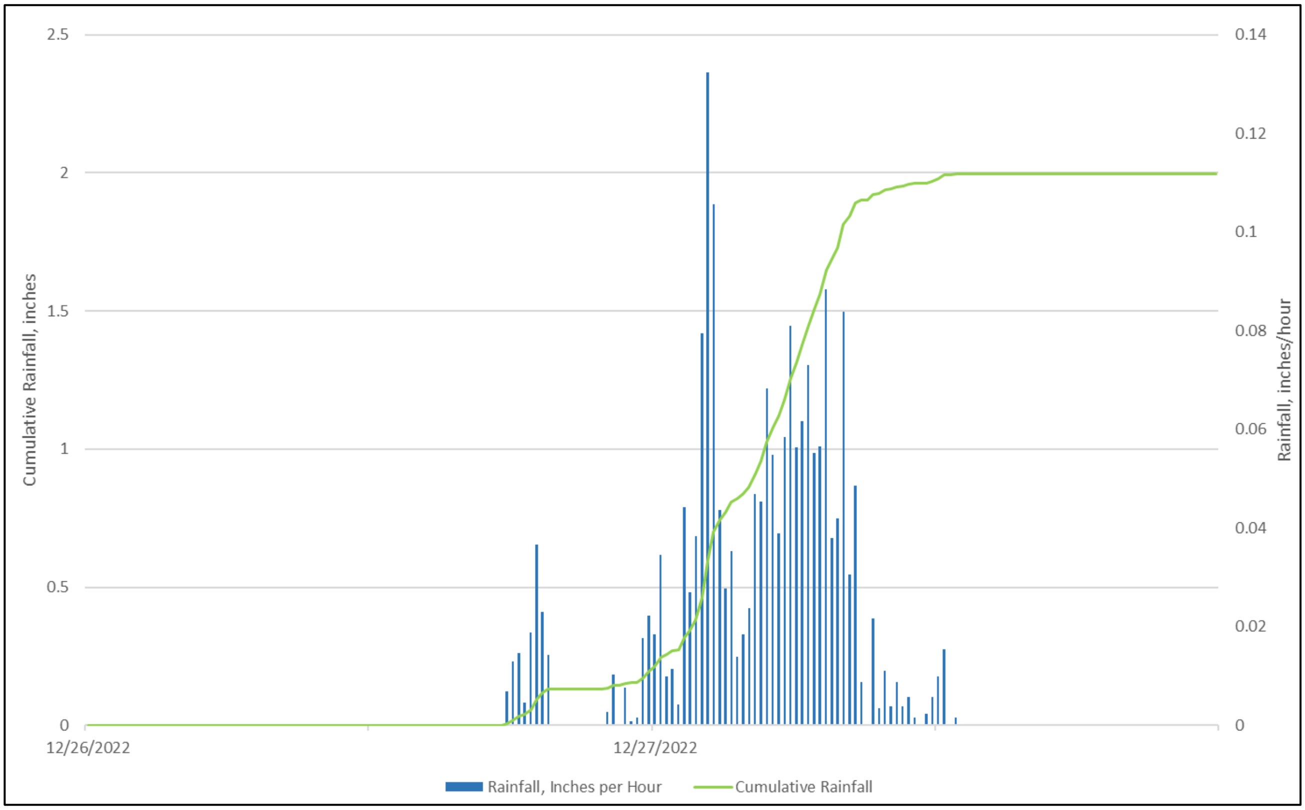
Note 1. Basins 060 and 080 include low residential unit flows of 75 gpd/EDU. These basins flow into Basin 090 which calibrates within 10%.
Note 2. Basin 040 flows to Basin 090 which has modeled flow that is more than 110% of measured flow.
Note 3. Basins 100A and 100B share flow and were calibrated together using residential unit flows of 75 gpd/EDU. Although flows are high, their downstream basins, 120B and 130, respectively, calibrate within 10%.
Note 4. Basins 050S through 070 and 110A include return flow from the SHGCC. FM70B/C/D and FM110A are acceptable. Attribute flows in FM050S and 070A to influences from SHGCC return flows.
Note 5. This basin includes 226,000 of expected flows from Facebook. The difference between metered and measured flows might be attributable to currently unoccupied office space.

* 218,120 gallons of flow was diverted upstream of FM040; 184,810 gallons of flow was returned upstream of FM050S. These flows were accounted for arithmetically, and resulting flows are calculated, not measured.

4.3.2 Wet Weather Calibration

After the hydraulic model was calibrated to dry weather flows, the system was evaluated under the selected calibration storm, which was measured on December 27, 2022. Figure 4.5 shows the rainfall depth, duration, and distribution that occurred on December 27, 2022.

Figure 4.5 Calibration Storm Parameters



Wet Weather Flow Generation

The wet weather calibration process assigns parameters that represent the amount of inflow and infiltration that enters the gravity sewer pipeline during a wet weather event.

The RTK method was used to model rainfall-dependent inflow and infiltration "RDII". The RTK method generates three hydrographs for each metered basin that represent the three different patterns of I&I that can enter the system during a wet weather event.

The three triangular hydrographs represent short-term, medium-term, and long-term RDII. RTK parameters include:

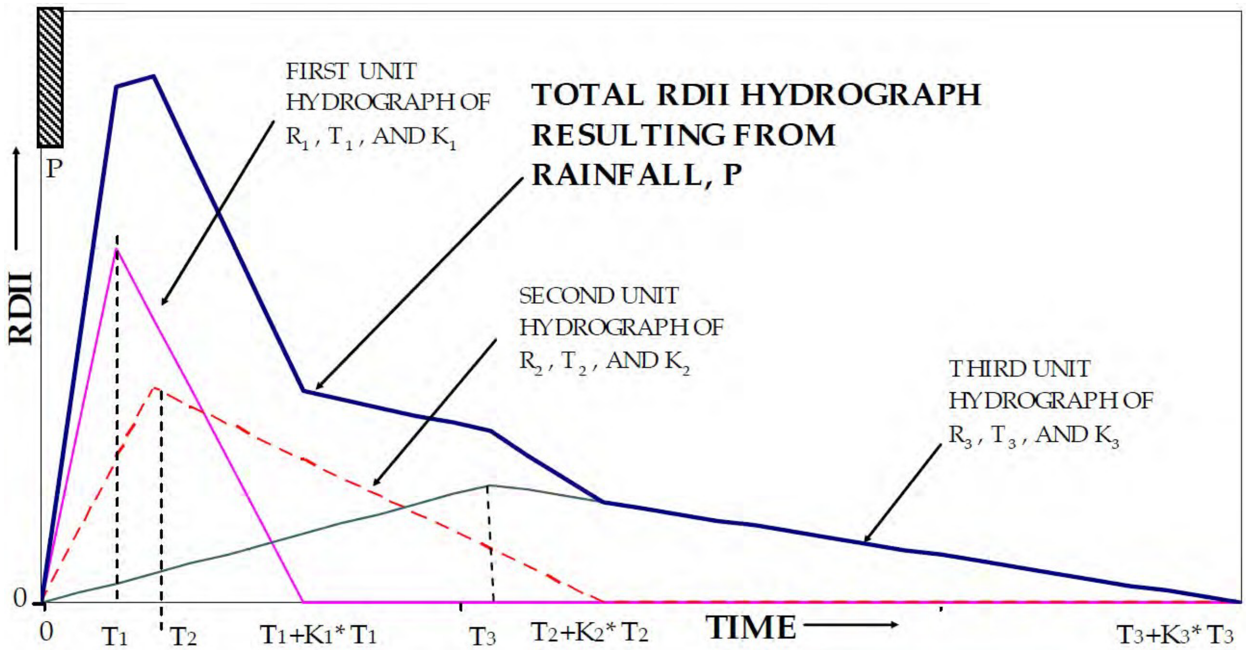
R = the area of the graph representing the portion of rainfall falling on a subcatchment that enters the sewer collection system.

T = the time from the onset of rainfall to the peak of the triangle.

K = the ratio of the "time to recession" to the "time to peak" of the hydrograph.

Components of the RTK hydrograph are provided courtesy of the United States Environmental Protection Agency (EPA) Office of Research and Development, and are presented in Figure 4.6.

Figure 4.6 Components of RTK Hydrograph



The hydraulic model includes fifteen separate profiles, each with an independent set of RTK hydrographs. The model adds RDII to the dry weather values that were obtained through the dry weather calibration to obtain predicted wet weather flows.

Wet Weather Flow Calibration

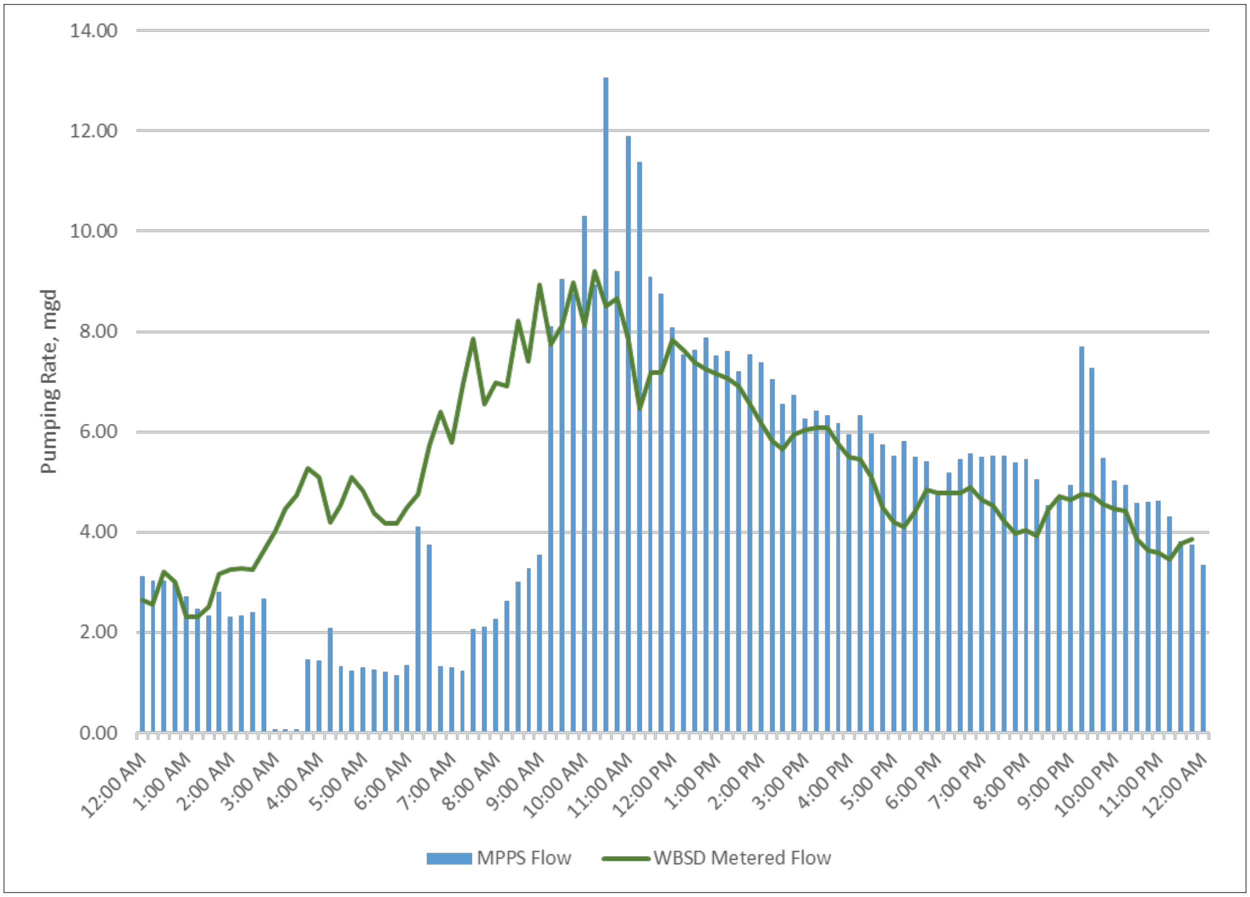
Wet weather flow calibration consisted of the following steps:

- Identify a wet weather calibration event with heavy rainfall, visible collection system response (increased flows), and without any spills. The selected rainfall event occurred on December 27, 2022.
- Assign and adjust R, T, and K parameters for the three wet weather hydrographs and assigned to the appropriate metering basins.
- Complete a hydraulic model run using the initial wet weather scenario and compare metered data with model simulation results.
- Adjust RTK parameters and conduct subsequent runs to maximize agreement for the calibration event, beginning with upstream and proceeding through all downstream metered basins.

A completed calibration was achieved when minimum, maximum, and average modeled flows, as well as the temporal distribution of flow over the calibration period were within ten percent of measured flows. The District's system has a number of known and some unknown wet weather flow diversions. In addition, during dry and wet weather periods, the District diverts flow in varying amounts from Basin FM040 and returns a portion of this flow to Basin FM050S. Due to this complex movement of flow, in some cases, variances from this calibration targets were accepted using engineering judgment.

The peak combined instantaneous (i.e., 15-minute duration) flow measured by FM110A, FM120A, FM130, and FM140 meters was 9.2 mgd on December 27, 2023. Average metered flow was 5.33 mgd. This flow compares to the total reported MPS average flow of 4.87 mgd and peak pumped flow of 13.05 mgd. Figure 4.7 shows MPS metered flow vs. WBSD metered flow. When the 24-hour flow patterns are compared, it is apparent that the MPPS stored flow in the morning and pumped this flow beginning at approximately 10 am, thus explaining the difference in reported peak flow rates.

Figure 4.7 MPPS Flows vs. WBSD Metered Flows on December 27, 2022



Appendix C includes graphs showing wet weather calibration results for all meters that were operational during the calibration storm. These results are also summarized in Table 4.6.

Validation of Wet Weather Model Results

After the hydraulic model was calibrated for wet and dry weather conditions, the model was validated by conducting a long-term simulation for the December 7 through January 31 flow monitoring period. The two-month timeframe includes the calibration storm and several additional storms. The purpose of the validation was to provide a level of confidence in model performance in predicting flow under a range of wet weather events. Appendix D includes modeled vs. metered flows for the validation period for selected upstream meters and the three major meters that discharge to the MPPS.

Table 4.6 Wet Weather Calibration Results

2022 Meter Name	Meter Avg (gpd)	Meter PWWF (gpd)	Model Average	Model Peak	Model Accuracy (Average)	Model Accuracy (Peak)	Comments
FM020	39,300	104,000	58,345	112,220	48.5%	7.9%	
FM010	448,000	1,282,000	439,256	1,274,020	(1.9%)	(0.6%)	
FM030A	391,000	1,514,000					Missing data. See FM040.
FM060A/B	158,300	342,200	122,609	253,120	(22.5%)	(26.0%)	Note 1
FM080A/B	197,000	424,700	218,562	430,490	10.9%	1.4%	
FM040*	771,000	1,933,000	814,856	2,210,431	5.7%	*	
FM090*	1,228,000	3,020,300	1,233,389	2,273,380	0.4%	*	
FM100A/B*	1,473,000	3,897,500	1,514,983	Combined	2.8%	*	
FM130*	2,183,000	4,593,300	1,992,513	3,477,790	(8.7%)	*	
FM120B*	153,000	307,250	137,869	192,630	(9.9%)	*	
FM050N							Out of service
FM050S*	256,500	506,628	190,707	361,910	(25.6%)	N/A	Note 2
FM070A*	673,000	1,412,100	662,433	1,193,510	(1.6%)	*	
FM070B/C/D*	1,102,900 + FM070C	Varies	1,220,969				FM070C is missing data. See FM110A
FM110A*	1,552,000	2,643,400	1,394,367	2,317,260	(10.1%)	*	
FM120A	75,000	150,500	72,603	96,110	(3.2%)	(36.1%)	Note 3
FM140	1,524,000	3,114,600	1,031,410	1,802,510	(32.3%)	(47.6%)	Note 4
FM150	396,000	742,300	373,299	749,440	(5.7%)	1.0%	

Note 1. Basin 060A/B has high R. Downstream FM040 calibrates well. Leave as is.
Note 2. Basin 050S has high R. SHGCC return flow is discharged to this basin and may be skewing results. FM070A downstream is acceptable. Leave as is.
Note 3. This is a relatively small basin with a low peaking factor. The average is within acceptable tolerances. Leave as is.
Note 4. FM140 has significant R. This basin appears to receives wet weather flow from FM130. Leave as is.
*On December 27, 2022, 172,000 gallons of flow was diverted from FM040 to the SHGCC plant and 33,000 gallons of this flow was returned to Basin FM50S and its downstream basins (70A, B, C, D, and 110A). Modeled vs. metered peak flows on this date are not directly comparable and provided for information only

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CHAPTER 5 CAPACITY ANALYSIS

In 2023, the District updated its hydraulic model as a component of the 2023 Wastewater Master Plan. Chapter 4, Hydraulic Model Development and Calibration, provides information on the model network, sewer loads, and wet weather calibration factors. The calibrated hydraulic model was used to evaluate the District's wastewater collection system for capacity constraints resulting from flow conditions that are predicted to occur during the District's design storm. The purpose of this Chapter is to summarize planning and capacity criteria, to discuss predicted capacity constraints, and present recommended solutions and strategies to address the identified issues. This Chapter also discussed specific capacity-related considerations that are required by Statewide Order 2022-0103-DWQ ("Statewide WDR").

This Chapter is organized as follows.

5.1 Planning and System Deficiency Criteria

5.2 Capacity Analysis

5.3 Project Costs

5.4 Review of Statewide Waste Discharge Requirements for Capacity Analysis

5.1 PLANNING AND SYSTEM DEFICIENCY CRITERIA

This section includes information on the selected design storm and also presents criteria that was used to evaluate system deficiencies that are predicted to occur during the design storm wet weather event.

5.1.1 Design Storm

The hydraulic model evaluates the predicted capacity of the District's wastewater collection system under flow loading from a hypothetical design storm. The selected design storm has a recurrence interval of 10 years (*i.e.*, 10 percent probability of occurring in any given year) and duration of 24 hours. Flow characteristics for the 10-year, 24-hour design storm were derived from data that is published by the National Oceanographic Atmospheric Administration ("NOAA"). For comparison, a 10-year, 6-hour design storm was also reviewed.

NOAA publishes statistically-derived rainfall depths for use in assigning a rainfall recurrence event[6]. The NOAA rainfall depth table for the City of Menlo Park is included as Figure 5.3 on the following pages. As shown on the table, the most likely rainfall depth for a 10-year, 24 hour rainfall event is 2.93 inches. Similarly, the most likely rainfall depth for a 10-year, 6-hour rainfall event is 1.87 inches.

In addition to providing rainfall depths, NOAA provides statistically probable distribution profiles for the rainfall over the defined period[7]. Rainfall temporal distributions were taken from Volume 6 (California); Temporal Distribution System 8, as shown in Figure 5.1 on the following page.

[6] https://hdsc.nws.noaa.gov/pfds/pfds_map_cont.html?bkmrk=ca
[7] https://hdsc.nws.noaa.gov/pfds/pfds_temporal.html

NOAA provides 36 temporal distributions for rainfall that could occur during each of the four quartiles of the storm duration, with zero to 90 percent chance of occurring within each quartile.

For the purposes of evaluating capacity needs, the temporal distribution that resulted in the highest hourly peak flow was selected for the hydraulic model analysis. This distribution has a 10 percent chance of occurring during the first quartile, and is shown in Figure 5.3 for both storms.

As shown on Figure 5.2, below, although the volume of rainfall is greater for the 10-year, 24-hour storm, the distribution of this volume is also over a longer period, leading to a lower peak hourly rate. The rainfall distribution was shifted to 9:30 a.m. in each case so the peak rainfall would occur at approximately the same time as the peak diurnal flow.

Figure 5.1 NOAA Rainfall Temporal Distribution Systems for Volume 6: California

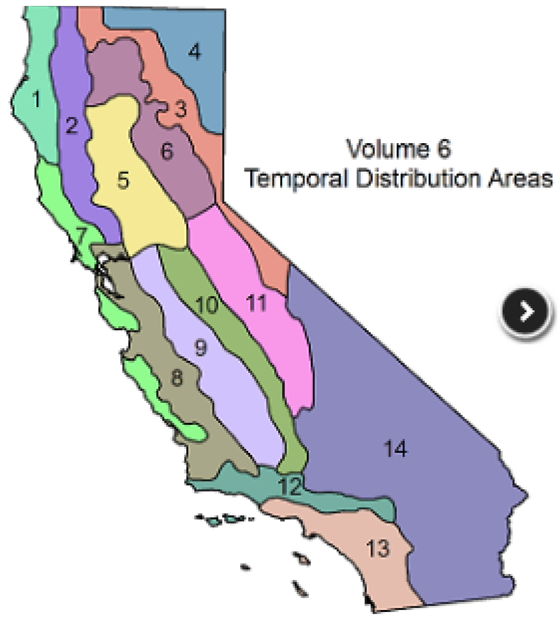


Figure 5.2 NOAA Temporal 6-Hour and 24-Hour Rainfall Distributions for the City of Menlo Park (10% Probability of Occurring in the First Quartile)

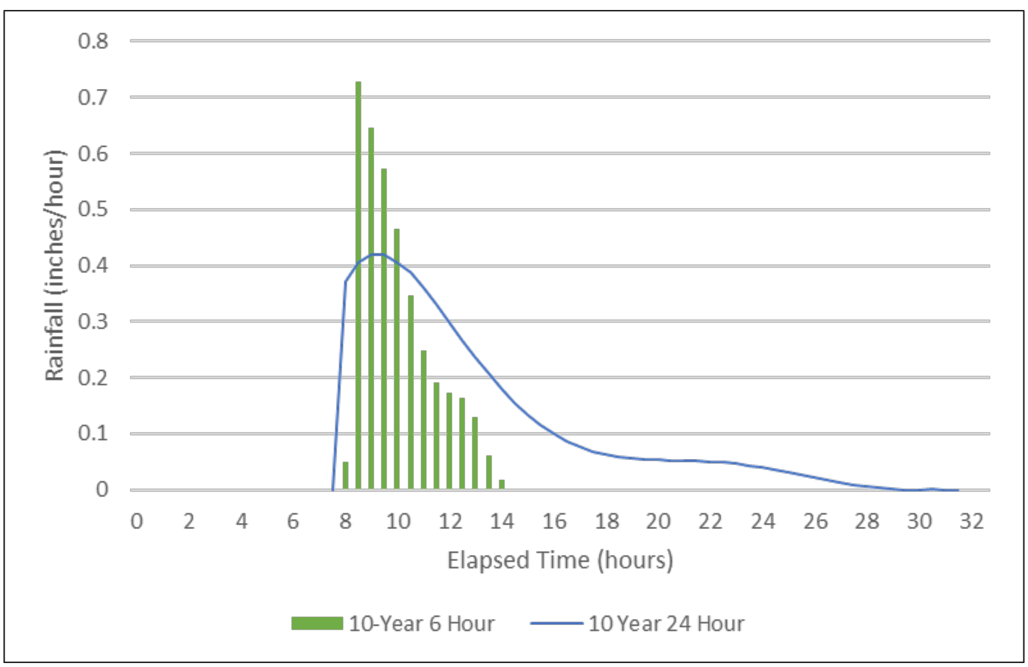


Figure 5.3 NOAA Rainfall Depths for Various Storm Frequencies and Durations

NOAA Atlas 14, Volume 6, Version 2
Location name: Menlo Park, California, USA*
Latitude: 37.4555°, Longitude: -122.1788°
Elevation: 65.86 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Sarah Dietz, Sarah Heim, Lillian Hiner, Kazungu Maitaria, Deborah Martin, Sandra Pavlovic, Ishani Roy, Carl Trypaluk, Dale Unruh, Fenglin Yan, Michael Yekta, Tan Zhao, Geoffrey Bonnin, Daniel Brewer, Li-Chuan Chen, Tye Parzybok, John Yarchoan

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.106 (0.094-0.121)	0.136 (0.121-0.155)	0.177 (0.157-0.203)	0.211 (0.185-0.243)	0.258 (0.217-0.309)	0.294 (0.242-0.361)	0.332 (0.266-0.419)	0.372 (0.288-0.484)	0.426 (0.315-0.581)	0.468 (0.334-0.664)
10-min	0.152 (0.135-0.173)	0.196 (0.173-0.223)	0.254 (0.225-0.290)	0.302 (0.265-0.349)	0.370 (0.312-0.443)	0.422 (0.347-0.518)	0.476 (0.381-0.601)	0.533 (0.413-0.693)	0.610 (0.452-0.832)	0.671 (0.478-0.951)
15-min	0.184 (0.163-0.209)	0.236 (0.210-0.270)	0.307 (0.272-0.351)	0.366 (0.320-0.422)	0.447 (0.377-0.536)	0.510 (0.420-0.626)	0.576 (0.461-0.726)	0.644 (0.500-0.839)	0.738 (0.546-1.01)	0.811 (0.578-1.15)
30-min	0.253 (0.224-0.287)	0.325 (0.288-0.371)	0.423 (0.374-0.483)	0.503 (0.441-0.581)	0.615 (0.518-0.737)	0.702 (0.578-0.862)	0.792 (0.634-1.00)	0.886 (0.688-1.15)	1.01 (0.752-1.39)	1.12 (0.796-1.58)
60-min	0.356 (0.316-0.405)	0.459 (0.406-0.523)	0.596 (0.526-0.681)	0.709 (0.621-0.818)	0.866 (0.730-1.04)	0.990 (0.815-1.21)	1.12 (0.894-1.41)	1.25 (0.969-1.63)	1.43 (1.06-1.95)	1.57 (1.12-2.23)
2-hr	0.526 (0.467-0.599)	0.674 (0.598-0.768)	0.869 (0.768-0.993)	1.03 (0.899-1.19)	1.24 (1.05-1.49)	1.41 (1.16-1.73)	1.58 (1.26-1.99)	1.75 (1.36-2.28)	1.99 (1.47-2.71)	2.17 (1.55-3.07)
3-hr	0.667 (0.592-0.759)	0.853 (0.756-0.972)	1.10 (0.969-1.25)	1.29 (1.13-1.46)	1.56 (1.32-1.87)	1.77 (1.45-2.17)	1.97 (1.58-2.49)	2.19 (1.70-2.85)	2.47 (1.83-3.38)	2.70 (1.92-3.82)
6-hr	0.970 (0.861-1.10)	1.24 (1.10-1.41)	1.59 (1.40-1.81)	1.87 (1.64-2.16)	2.25 (1.90-2.70)	2.55 (2.10-3.12)	2.84 (2.28-3.59)	3.15 (2.44-4.10)	3.56 (2.64-4.86)	3.88 (2.76-5.50)
12-hr	1.29 (1.15-1.47)	1.65 (1.46-1.88)	2.12 (1.87-2.42)	2.50 (2.19-2.88)	3.03 (2.55-3.63)	3.44 (2.83-4.22)	3.86 (3.09-4.87)	4.30 (3.33-5.59)	4.89 (3.62-6.67)	5.36 (3.82-7.60)
24-hr	1.51 (1.36-1.70)	1.92 (1.73-2.17)	2.47 (2.23-2.80)	2.93 (2.62-3.34)	3.56 (3.09-4.18)	4.06 (3.46-4.85)	4.57 (3.82-5.59)	5.11 (4.17-6.40)	5.86 (4.60-7.61)	6.45 (4.91-8.63)
2-day	1.92 (1.74-2.17)	2.44 (2.20-2.76)	3.13 (2.82-3.55)	3.70 (3.31-4.22)	4.48 (3.89-5.26)	5.08 (4.34-6.08)	5.70 (4.76-6.97)	6.34 (5.17-7.94)	7.22 (5.67-9.38)	7.90 (6.02-10.6)
3-day	2.22 (2.01-2.51)	2.82 (2.55-3.19)	3.62 (3.26-4.10)	4.26 (3.82-4.86)	5.14 (4.47-6.04)	5.82 (4.96-6.96)	6.50 (5.43-7.95)	7.21 (5.88-9.03)	8.16 (6.42-10.6)	8.91 (6.79-11.9)
4-day	2.47 (2.23-2.79)	3.14 (2.84-3.55)	4.02 (3.62-4.56)	4.74 (4.24-5.40)	5.70 (4.95-6.69)	6.44 (5.49-7.70)	7.18 (6.00-8.78)	7.95 (6.48-9.95)	8.97 (7.05-11.7)	9.76 (7.44-13.1)
7-day	3.10 (2.80-3.50)	3.96 (3.58-4.47)	5.07 (4.57-5.75)	5.97 (5.34-6.81)	7.16 (6.23-8.41)	8.07 (6.88-9.65)	8.97 (7.49-11.0)	9.88 (8.06-12.4)	11.1 (8.72-14.4)	12.0 (9.16-16.1)
10-day	3.45 (3.12-3.89)	4.42 (3.99-5.00)	5.68 (5.11-6.43)	6.67 (5.97-7.61)	8.00 (6.95-9.39)	8.99 (7.67-10.8)	9.98 (8.34-12.2)	11.0 (8.94-13.7)	12.3 (9.65-16.0)	13.3 (10.1-17.8)
20-day	4.49 (4.06-5.07)	5.82 (5.26-6.58)	7.50 (6.76-8.49)	8.82 (7.89-10.1)	10.5 (9.16-12.4)	11.8 (10.1-14.1)	13.1 (10.9-16.0)	14.3 (11.7-17.9)	15.9 (12.5-20.7)	17.1 (13.0-22.9)
30-day	5.37 (4.85-6.06)	6.98 (6.31-7.89)	9.01 (8.11-10.2)	10.6 (9.47-12.1)	12.6 (11.0-14.8)	14.1 (12.0-16.9)	15.6 (13.0-19.0)	17.0 (13.8-21.3)	18.8 (14.8-24.4)	20.1 (15.3-27.0)
45-day	6.56 (5.93-7.41)	8.54 (7.71-9.65)	11.0 (9.90-12.4)	12.9 (11.5-14.7)	15.3 (13.3-18.0)	17.1 (14.6-20.4)	18.8 (15.7-22.9)	20.4 (16.6-25.6)	22.5 (17.7-29.2)	24.0 (18.3-32.1)
60-day	7.86 (7.10-8.87)	10.2 (9.20-11.5)	13.1 (11.8-14.8)	15.3 (13.6-17.4)	18.1 (15.7-21.2)	20.1 (17.1-24.0)	22.0 (18.4-26.9)	23.9 (19.5-29.9)	26.2 (20.6-34.0)	27.9 (21.2-37.3)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

The District's hydraulic analysis reviewed system performance under both wet weather scenarios. After comparing hydraulic model results, the two storms produce similar results, with the 10-year, 24-hour storm being more conservative (i.e., severe). Therefore, the 10-year, 24-hour rainfall event was selected as the District's design storm.

5.1.2 Hydraulic Deficiency and Pipeline Design Criteria

The Master Plan addresses capacity deficiencies by upsizing, replacing, or otherwise addressing existing pipelines and increasing the pumping capacity at lift stations as needed. The primary purpose of developing each capacity recommendation is to establish a budget for planning future capital improvement projects. During the design phase for each project, alternative solutions may be identified. In addition, if the District is able to sufficiently reduce I&I through collector sewer rehabilitation and replacement, and can thereby avoid or reduce the scope of a proposed capacity upgrade for a comparable cost, then the District should consider completing the I&I reduction project in lieu of upsizing undersized infrastructure.

On December 31, 2022, the District received a rainfall event with approximately 4.5 inches of rainfall depth over a 24-hour period in sewer basin 070A (Atherton). Using the NOAA precipitation depth tables from Figure 5.2, the December 31, 2022 storm had a recurrence interval of 50 to 100 years (for a 24-hour event) and exceeded the District's design storm. During this rainfall event, the District had one spill at the Willow Pump Station point of discharge. This spill is predicted by the hydraulic model and was addressed through the installation of a bolt-down cover immediately after this rainfall event. On December 31, 2022, the District also conducted preventive bypassing to avoid potential spills in the Alberni easement, which is an area that is directly upstream of the Willow Pump Station and shows predicted surcharging during the design storm. No other spills were identified on this day.

The following capacity criteria were developed with the understanding that the system was able to convey flows with limited spills during the December 31, 2022 rainfall event. If the hydraulic model predicts a spill during the design storm, which is less severe than the December 31 event, this predicted spill is likely due to conservatism in the model. With this in mind, it does not seem reasonable to introduce further conservatism into the capacity criteria.

Existing Pipelines

- For existing pipelines, the pipe is considered to have a capacity deficiency when, under peak wet weather flow conditions for the design storm, the water level or hydraulic gradeline is higher than the rim elevation and is predicted to spill from a manhole. Surcharged pipes that are not predicted to have a sewer spill are reviewed but do not automatically result in a capacity project.
- A force main is be considered capacity-deficient if the maximum velocity exceeds 8 feet per second during peak hourly flows.
- A lift station is determined to require capacity upgrades if the tributary (i.e., upstream) system experiences a spill because the existing pump or pumps are undersized. This evaluation is completed with the largest pump at each pump station out of service.

New Pipelines

- Under peak dry weather flow conditions and where feasible, velocity should remain above 2.5 feet per second to facilitate self-cleaning
- Under PWWF conditions, maximum depth of flow divided by diameter ("d/D") should be equal to or less than the following where practical:
    - 10-inch diameter and smaller: Max d/D = 0.67

  - 12-inch diameter and above: Max d/D = 0.80
- Under all conditions, maximum allowable velocity should be 10 feet per second. Under sustained operations, maximum velocity of 6 feet per second is recommended.

5.1.3 Emergency Storage at the Flow Equalization and Resource Recovery Facility

The District's FERRF is available to store peak flows that are conveyed to the Menlo Park Pump Station in excess of the pump station pumping capacity during a design storm. Further, during some wet weather periods when downstream SVCW member flows exceed their allocated SVCW capacity, SVCW has requested that that the District divert its flows to the FERRF to make the District's SVCW capacity available for the downstream agencies.

The hydraulic model and master plan analysis does not include an evaluation of FERRF operations. However, the master plan recognizes that if flows at the MPPS exceed capacity, FERRF storage is available for use by the District.

5.2 CAPACITY ANALYSIS

The District's modeled collection system network was evaluated for its capacity to convey flows that are predicted to occur during the design storm event, taking into consideration the existing system capacity criteria discussed above. The hydraulic model identified two locations with predicted spills during the design storm. At each location, predicted overflows were limited to one or several manholes along the alignment. One of these locations, downstream of the Willow Pump Station, had a spill during the December 31, 2022 rainfall event. The second location, on Elena Avenue near Park Lane, surcharged but did not have any spills during this event. The second location is directly upstream of a siphon, which is on the District's high frequency cleaning list. Overall, the design storm did not cause widespread wastewater spills within the District's service area.

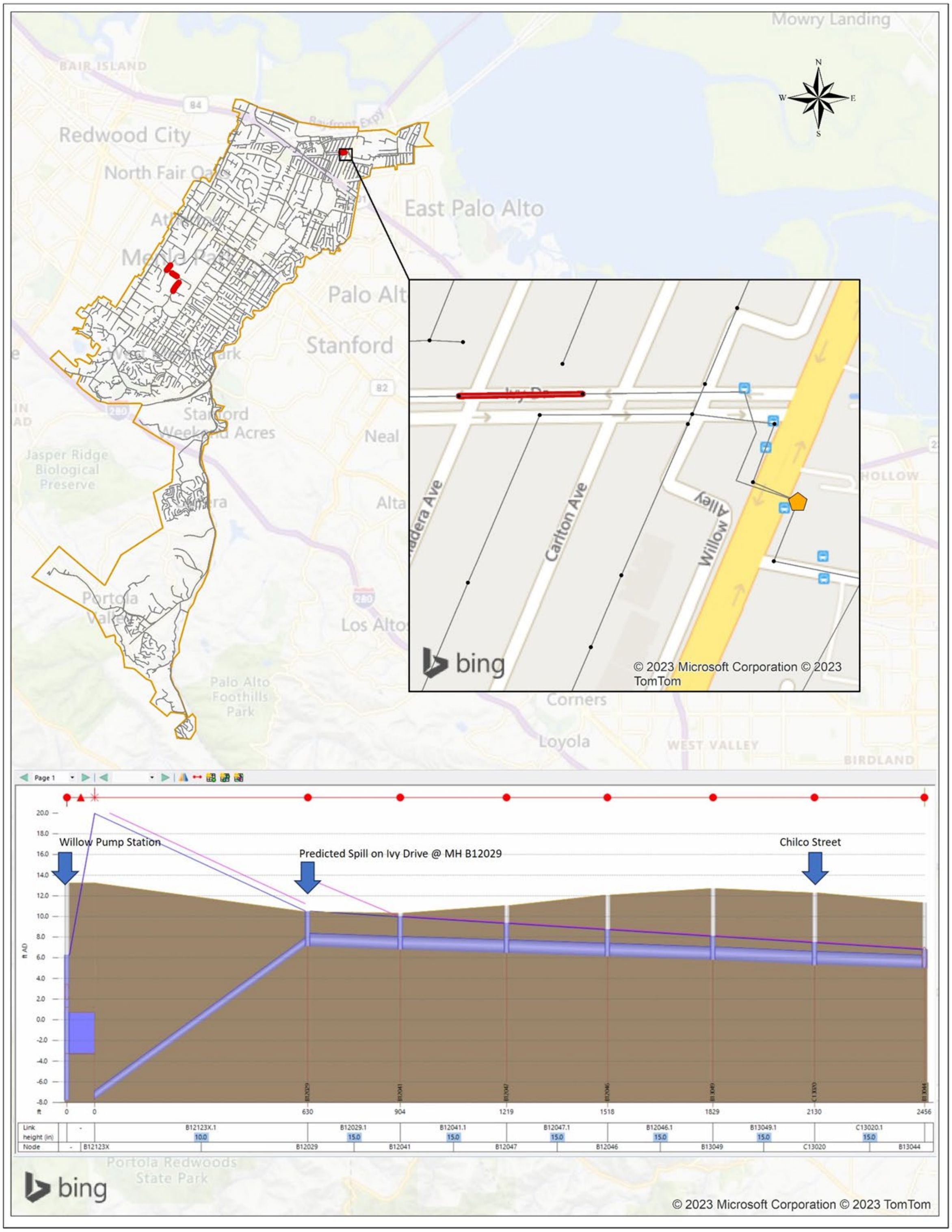
The locations with predicted spills during the design storm event are shown on Figures 5.4 and 5.5 on the following pages and described below.

5.2.1 Location 1 - Downstream of Willow Pump Station (Ivy Drive)

The Willow Pump Station has sufficient capacity to convey incoming flows. However, the hydraulic model predicts a spill at the discharge manhole on Ivy Drive (B12029). This shallow manhole has a depth of approximately 2.5 feet. During the December 31, 2022 rainfall event, the Menlo Pump Station did not keep pace with incoming flows. As a result, the system backed up and the gravity pipe on Chilco Street back up to and through Ivy Drive became surcharged. The Willow Pump Station discharged flow to the Ivy Drive gravity sewer. However, because this sewer was full, the flow could not enter and spilled from the discharge manhole. After the December 31, 2022 rainfall event ended, a locking manhole was installed on structure B12029 to prevent future spills from this location.

The hydraulic model predicts surcharge but no additional spills from the pipeline downstream of B12029. If the District implements a future project to alleviate the surcharge condition, upsizing this line may not be feasible due to permitting constraints. The pipeline on Ivy Drive from the Willow Pump Station to Chilco Street is located with a San Francisco Public Utilities Commission easement. Any construction that is planned for this line must consider and attempt to avoid the difficult longitudinal permitting process that would be involved related to construction within this easement. The hydraulic profile for the Ivy Drive capacity constraint and predicted spill location are show on Figure 5.4 on the following page.

Figure 5.4 Capacity Constraint Downstream of Willow Pump Station



5.2.2 Location 2 - Elena Avenue near Park Lane

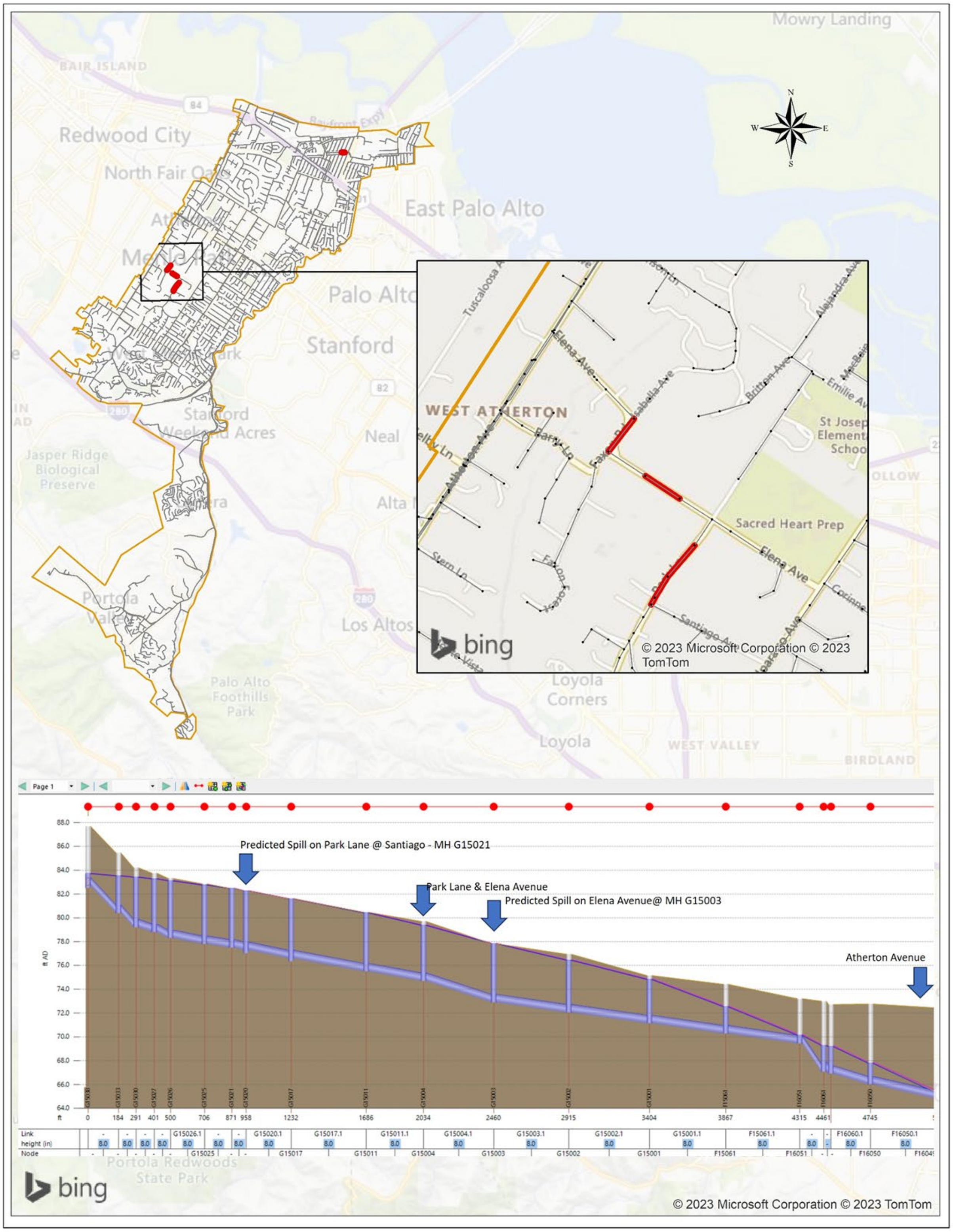
The District has an existing 8-inch pipe that begins where Camino al Lago turns into Park Lane in Atherton. This line continues north to Elena Avenue, then west on Elena Avenue to Atherton Avenue. The entire line has a diameter of 8 inches other than the siphon upstream of Atherton Avenue, which has a diameter of 10 inches. This pipe has experienced surcharging during prior wet weather events. The siphon is on a high frequency cleaning schedule to make sure that debris within this structure does not exacerbate surcharge conditions on Elena Avenue. This pipeline has not had recent spills and did not have any spills during the December 31, 2022 wet weather event.

The hydraulic model predicts spills from two manholes along this stretch during the design storm. The first spill occurs at structure G15003 on Elena Avenue. The second spill occurs at structure G15021 on Park Lane. Although these predicted spills have not been observed during heavy rainfall events, they indicate locations where spills are more likely to occur in the future. Therefore, a future project to address the predicted surcharge is included for consideration in the long-term capital improvement plan.

Prior to finalizing the scope of work for the Elena Avenue Capacity Improvement Project, it is recommended that District use one or more smart covers or other methods to monitor water levels within the alignment between G15030 and F16051 during future wet weather events. If the District receives a rainfall event that is similar to the rainfall that was captured during the 2022/23 wet weather season and water levels within the project alignment do not rise as predicted by the hydraulic model, then the project scope should be reviewed and adjusted as needed to address field conditions.

The hydraulic profile and predicted spill locations are shown on Figure 5.5 on the following page.

Figure 5.5 Capacity Constraint on Elena Avenue and Park Lane



5.2.3 Recommended Interceptor Capacity Improvement Projects

Two pipeline capacity improvement projects are recommended to address the hydraulic capacity constraints that are discussed in Sections 5.2.1 and 5.2.2. These projects are summarized in Table 5.1.

Table 5.1 Recommended Capacity Improvement Projects

Project Name	Project Description
Elena Avenue Capacity Improvement Project	This project upsizes 4,833 lineal feet of existing pipe on Park Lane and Elena Avenue from manhole G15030 to F16049 from 8-inches to 10-inches in diameter. The existing siphon between F16051 to F16060 has a diameter of 10 inches and will not need to be replaced.
Willow Pump Station Discharge Capacity Improvement Project	This project installs 2,456 lineal feet of 12-inch DR-18 force main pipe within the 15-inch gravity line on Avy Drive, converting this pipe to an extended force main from the Willow Pump Station discharge manhole B12029 to Manhole B13044 on Chilco Street. Larger pumps will be required at Willow Pump Station based on available pump curves. This is a long-term project that is being addressed in the near-term through the installation of three sealed manhole covers on structures B12029 (completed), B12141 (planned), and B12147 (planned). Alternative lining methods should be reviewed during preliminary design to minimize the reduction in pipe diameter and reduce headloss through the extended force main.

A confirmation hydraulic run was conducted assuming completion of the capacity improvements discussed in Table 5.1. Figures 5.6 and 5.7 show the post-construction hydraulic profile for each location.

Figure 5.6 Hydraulic Profile after Conversion of the Willow Pump Station Discharge (Ivy Drive) Gravity Sewer to an Extended Force Main

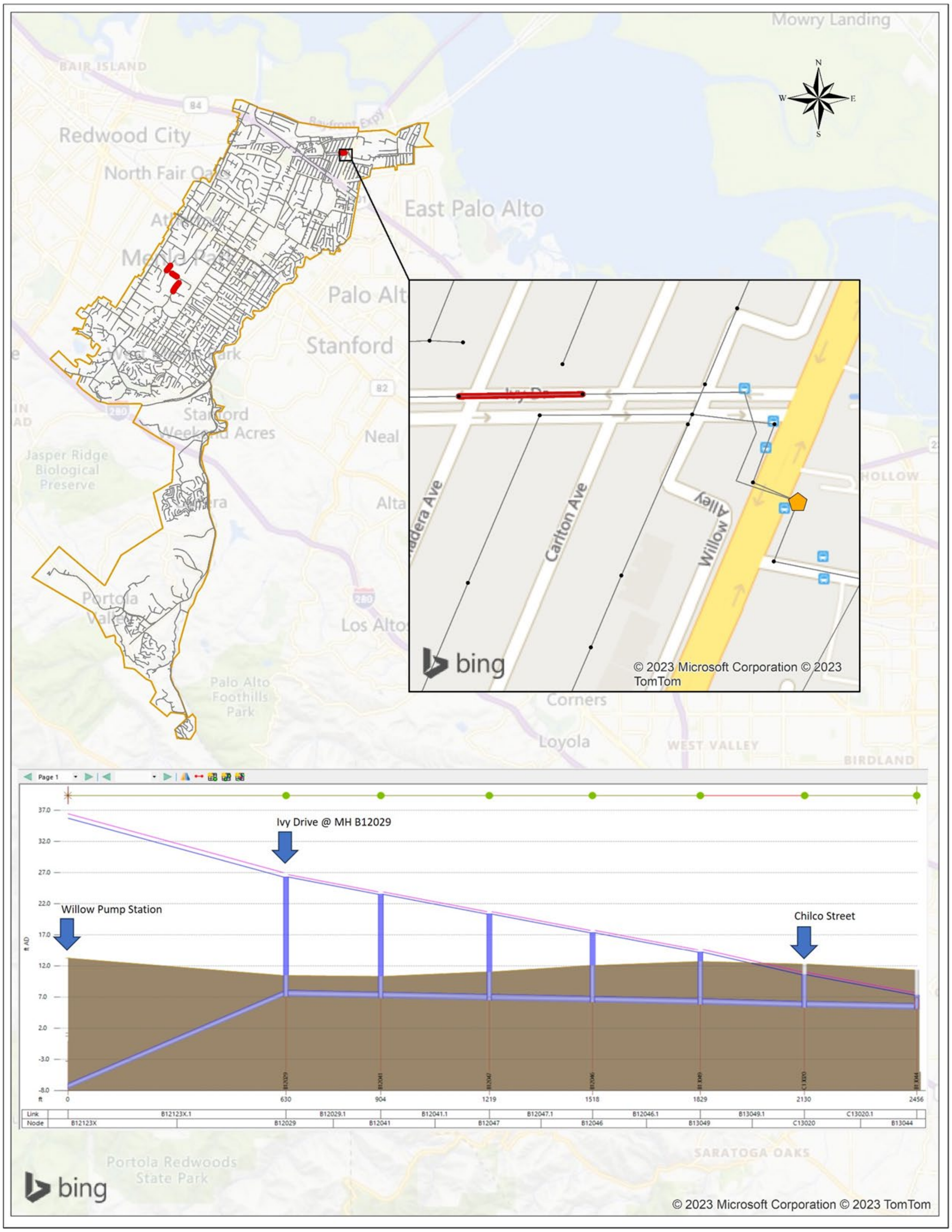
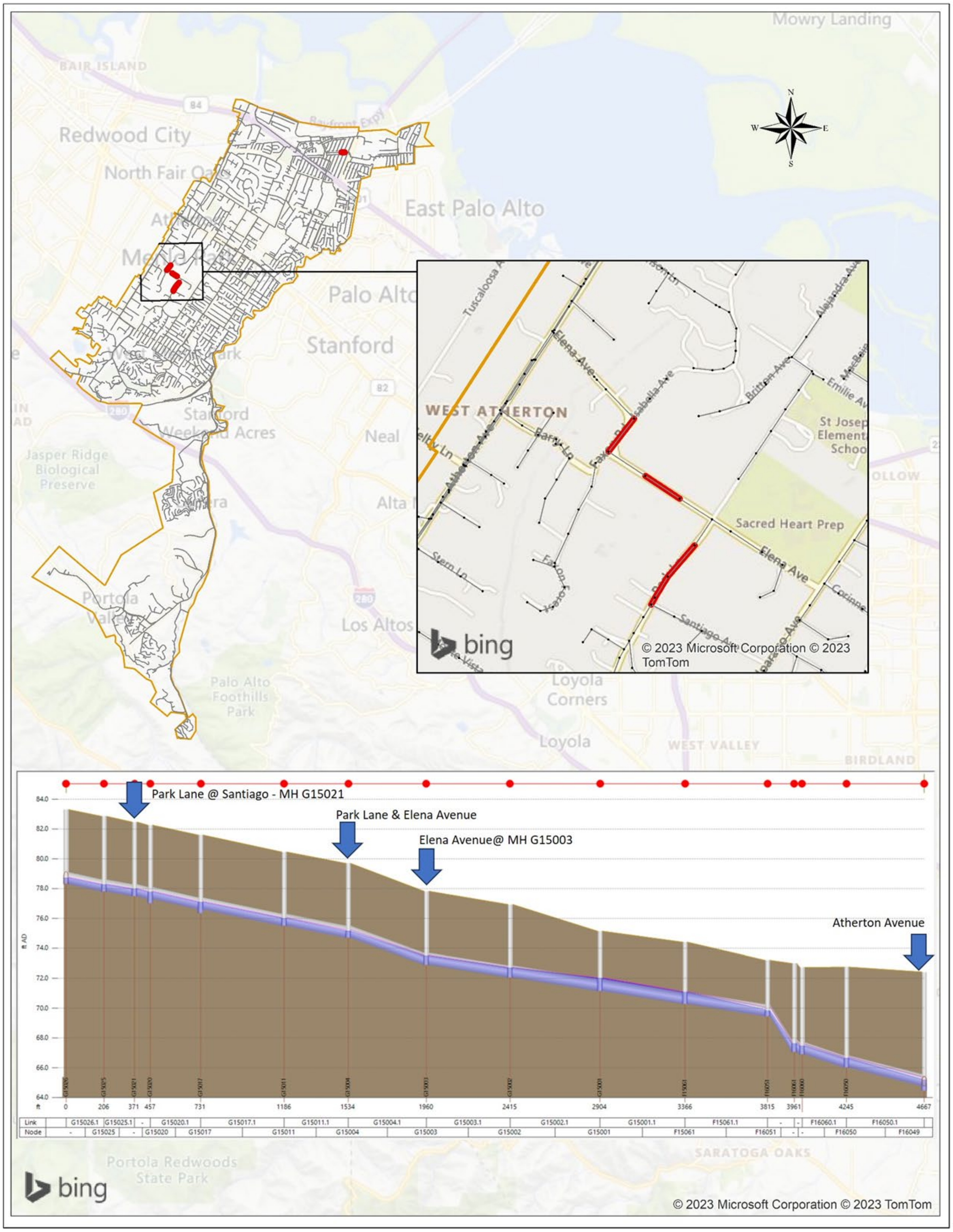


Figure 5.7 Hydraulic Profile after Completion of Elena Ave and Park Lane Capacity Improvements



5.2.4 Pump Station Capacity Analysis

Model-generated flows from the design storm event were compared to firm pump station capacity as provided by the District during model development. Ten of the District's eleven pump stations were included in the hydraulic model, as discussed in Chapter 4, Hydraulic Model Development and Calibration and listed in Table 5.2. The pumping capacities shown are taken from data provided by District staff, and not the original pump curves.

Table 5.2 Pump Station Parameters

Pump Station Name	Node ID	No of Pumps	Pumping Capacity (gpm) (Note 1)
Hamilton Henderson	B13079	2	2100
Willow	B12123	2	1650
Menlo Industrial	B12121	2	310
University	B11117	3	640
Illinois	A10029	2	580
Vintage Oaks 1	D12171	2	330
Vintage Oaks 2	E12139	2	330
Stowe Lane	I11062	2	340
Los Trancos	M09031	2	100 (not modeled)
Sausal Vista	M11016	2	715 (see Note 2)
Village Square	M13003	2	160

Notes:

1. Pumping capacity assumes the largest pump is out of service.
2. Data provided shows the Sausal Vista as having 650 gpm capacity. This station conveyed flows without issues during the December 31, 2022 rainfall event. Therefore, the predicted flow of 715 appears conservative and does not trigger the need for a capacity improvement project.

Table 5.3 on the following page lists pump station inflows that are predicted by the hydraulic model during the design storm.

Table 5.3 Pump Station Influent Flow During Design Storm

Pump Station Name	Node ID	Pumping Capacity (gpm) (Note 1)	Model Inflow During Design Storm (gpm)
Hamilton Henderson	B13079	2100	1848
Willow	B12123	1650	1597 (Note 3)
Menlo Industrial	B12121	310	310
University	B11117	640	558
Illinois	A10029	580	428
Vintage Oaks 1	D12171	330	142
Vintage Oaks 2	E12139	330	212
Stowe Lane	I11062	340	161
Los Trancos	M09031	100	Not Modeled
Sausal Vista	M11016	650	715 (Note 2)
Village Square	M13003	160	72

Notes:

1. Pumping capacity assumes the largest pump is out of service.
2. Data provided shows the Sausal Vista as having 650 gpm capacity. The model predicts influent flow of 715 gpm during the design storm. However, this station conveyed flows without issues during the December 31, 2022 rainfall event. Therefore, the modeled flows are conservatively high and do not trigger the need for capacity improvements at this station.
2. Although Willow Pump Station is sufficiently sized to convey design storm flows, as discussed above, the gravity sewer directly downstream of the discharge manhole for the Willow Pump Station is not able to convey design storm peak flows without predicted spills and requires a capacity upgrade.

5.3 PROJECT COSTS

Planning level costs were developed for the proposed pipeline improvements using the following unit cost and contingency data. Since project needs and construction details will be site-specific, actual project configurations and associated costs should be refined during project design.

Cost Assumptions:

- Pipe replacement unit cost: $30 per inch-diameter-foot of pipe. Cost estimates for 18- and 24-inch lines requiring repair should use a reduced unit cost of $24 per inch-diameter-foot of pipe.
- Appurtenances, laterals, mobilization, and shoring: 50% of pipe installation unit cost
- Force main through existing conduit: 60% of pipeline installation cost
- Construction contingency: 30%
- Engineering and Administration: 30% of construction cost, including contingencies.

The cost estimate assumed open cut construction for the Elena Avenue and Park Lane pipeline replacements. However, an evaluation will need to be completed in order to determine which construction method represents the most viable alternative for each asset in terms of both cost and construction feasibility.

All costs are indexed to Engineering News Record Construction Cost Index, San Francisco, October 2023, 15473.38.

Table 5.4 shows the estimated conceptual costs for the recommended capacity improvement projects.

Table 5.4 Estimated Costs for Capacity Projects

Project Name	Pipe Length (ft)	New Diameter (in)	Construction Cost	
Elena Avenue Capacity Improvement Project	4,833	10	$2,827,305	$3,675,496
Willow Pump Station Discharge (Ivy Drive) Capacity Improvement Project	2,456	12	$1,034,467 +$50,000 for pump upgrades TBD	$1,409,807

Notes:

1. Willow pump sizing will depend on the final length, diameter, and material selected for the extended force main. Costs shown are a placeholder, assuming the force main is extended to Chilco Street.

5.4 REVIEW OF STATEWIDE WASTE DISCHARGE REQUIREMENTS FOR CAPACITY ANALYSIS

The new State Water Resources Control Board Order WQ 2022-103-DWQ (Statewide WDR) became effective as of June 5, 2023. The Statewide WDR includes specific requirements for capacity analyses that are discussed in this section. The requirements of the Statewide WDR are summarized in Section 5.10 as follows:

The Enrollee shall maintain the system capacity necessary to convey: (1) base flows during dry weather conditions, and (2) wet weather peak flows consistent with designated local historic storms. Design storms must take into account system-specific stormwater contributions via inflow and infiltration, and location-specific depth of groundwater and storm frequencies. The Enrollee shall implement capital improvements to provide adequate hydraulic capacity to: • Meet or exceed the design criteria as defined in the Enrollee's System Evaluation and Capacity Assurance element of its Sewer System Management Plan; and • Prevent system capacity-related spills, and adverse impacts to the treatment efficiency of downstream wastewater treatment facilities.

The capacity analysis described in this Chapter addresses all of these requirements. However, Section 8.2 of the WDR further describes the following:

The capacity assessment must consider: • Data from existing system condition assessments, system inspections, system audits, spill history, and other available information; • Capacity of flood-prone *systems subject to increased infiltration and inflow, under normal local and regional storm conditions; • Capacity of systems subject to increased infiltration and inflow due to larger and/or higher-intensity storm events as a result of climate change; • Increases of erosive forces in canyons and streams near underground and aboveground system components due to larger and/or higher-intensity storm events; • Capacity of major system elements to accommodate dry weather peak flow conditions, and updated design storm and wet weather events; and • Necessary redundancy in pumping and storage capacities.*

The District's Master Plan addresses data from system condition assessments via the Linear Asset Management Plan evaluation, considers both wet and dry weather peak flow conditions, and reviews the system under a number of wet weather events including the design storm event. Further, the hydraulic analysis reviews and confirms that the District has sufficient pump station capacity. The District has a redundant pump at each station.

This section discusses two areas of the Statewide WDR that are not otherwise addressed and evaluated through the capacity assessment described above: 1) Capacity of systems subject to increased I&I due to larger and/or higher-intensity storm events as a result of climate change; and 2) increase of erosive forces in canyons and streams near underground and aboveground system components due to larger and/or higher intensity storm events.

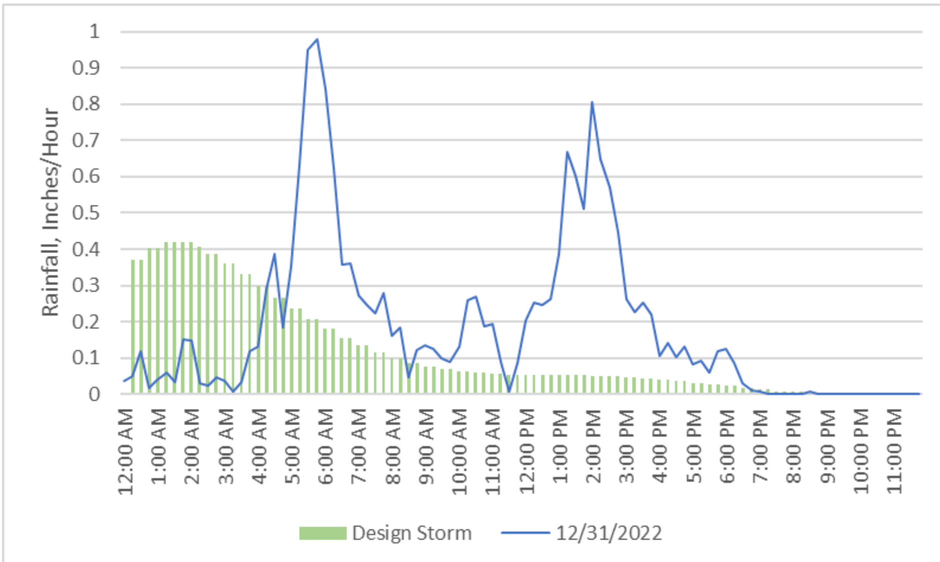
5.4.1 Capacity of Systems Subject to Increased I&I from Larger or Higher-Intensity Storms

During the 2022/2023 flow monitoring period, the District captured flows during the December 31, 2022 wet weather event. Figure 5.8 shows the December 31, 2022 rainfall profile for Basin 070A overlaid onto the profile for the 10-year, 24-hour design storm. The December 31 storm contained 4.48 inches of rain over a 24-hour period as compared to 2.93 inches for the design storm.

During the December 31, 2022 rainfall event, the District had one spill from Manhole B12029, which is the discharge manhole for the Willow Pump Station. This spill is predicted to occur during the design storm by the hydraulic model. The District also manually managed flow near the Alberni easement, which is a tributary basin to the Willow Pump Station.

The December 31, 2022 rainfall event is indicative of system performance during a storm that is larger than the design storm, and potentially indicative of hydraulic conditions that will be observed more frequently in the future as a result of climate change. The proposed capacity improvements address the capacity constraint that was observed during the December 31, 2022 event, and are therefore expected to be sufficient to address other similar rainfall events that are more severe than the design storm event.

Figure 5.8 Comparison of December 31, 2022 Rainfall with Design Storm



As related to climate change, sea level rise along the coastal areas of the District's service area is predicted to be between three and four feet in a 100-year event as a result of climate change. The District's gravity sewers are set back from the shoreline and ground surface is approximately eight feet in elevation at Menlo Park Pump Station, which is the terminus of the gravity collection system. Therefore, the District's gravity system is not expected to be inundated by flooding as a result of sea level rise resulting from climate change.

5.4.2 Increase Of Erosive Forces in Canyons and Streams due to Higher Intensity Storm Events

The District did not observe any new erosion over the existing sewer pipelines in canyons and near streams as a result of the December 31, 2022 rainfall event. However, a closer inspection of the system should be conducted after the 2023-24 wet weather season to identify any areas of concern related to potential future erosion in the vicinity of existing gravity sewers.

CHAPTER 6 LINEAR ASSET MANAGEMENT PLAN

The purpose of this Technical Memorandum No. 5 is to provide background on the District's Linear Asset Management Plan ("LAMP"), including the risk model that forms the basis for the LAMP. This Chapter presents recommended projects and priorities, and describes the cost estimating methodology and estimated budget for proposed projects.

This Chapter is organized as follows.

6.1 Introduction and LAMP Approach

6.2 LAMP Risk Model

6.3 LAMP Model Results and Project Recommendations

6.4 Estimated Costs

6.1 INTRODUCTION AND LAMP APPROACH

The purpose of the Linear Asset Management Plan is to identify gravity sewer pipelines with the highest risk of failure, develop rehabilitation recommendations for these pipelines, estimate associated costs, and prioritize repairs to assist in capital project planning. The recommendations from the LAMP are reviewed in parallel with recommendations from the capacity analysis, pump station analysis, and recycled water program.

The Linear Asset Management Plan is a dynamic planning tool that has, as its foundation, a numerical risk model that assigns a Risk Score to every gravity pipe segment. The risk model calculates Risk as a product of Likelihood and Consequence of Failure. The LAMP focuses on the District's linear gravity assets, which include all gravity collector sewers and trunk lines.

The risk model uses the Microsoft® Access platform as a tool to calculate the risk score for every gravity sewer pipe segment through a series of queries. To begin this process, Likelihood and Consequence of Failure factors were collected from the District's asset database, computerized maintenance management system ("CMMS"), publicly available information obtained through the San Mateo County geographic information system ("GIS") website portal, results from the District's sewer hydraulic model, and sanitary sewer spill data from the California Integrated Water Quality System ("CIWQS") database.

The results from the risk model were analyzed, high risk pipes mapped and grouped, and near- and long-term rehabilitation needs identified. The resulting projects were grouped and prioritized by drainage basin. Conceptual costs were then developed for each of these projects, based on the expected repair method. The replacement strategy integrates the District's current repairs and replacement projects and provides a systematic repair program for the next ten years.

6.2 LAMP RISK MODEL

The basis for the development of the LAMP is an asset management tool that is referenced throughout this Chapter as the risk model or LAMP model. The risk model is a numerical tool model that assigns a risk score to every mainline sewer in the District's asset database. Risk is defined as the product of Likelihood and Consequence of Failure. This section provides an overview of the risk model, summarizes the data used in the model, describes Likelihood and Consequence of Failure parameters, and discusses the final risk score that is generated by the risk model.

6.2.1 LAMP Model Overview

The risk model was developed using Microsoft® Access and utilizes the tables, forms and formulas that are provided within the program's user interface. Through this process, the contents, use and functionality of the risk model are easily understood by a user who is proficient in MS Access. Use of the risk model requires a general understanding of Microsoft® Office tools without specific knowledge of MS Access. Also, viewing and updating the risk model components can be achieved without specialized programming expertise.

The risk model first considers Likelihood of Failure, and then refines priorities based on Consequence of Failure, using assigned factors, weights, and scores. The product of the Likelihood and Consequence of Failure scores is the Risk Score. Likelihood of Failure parameters were selected to most effectively utilize the District's stored data, and include the following:

- Sanitary sewer spill history (5 years)
- Structural and Operation & Maintenance defects, as determined through closed circuit television ("CCTV") inspection
- Pipe material
- Liquefaction potential and seismic risk
- Pipeline capacity for interceptor pipelines
- Pipe size (i.e., less than 6 inches in diameter)

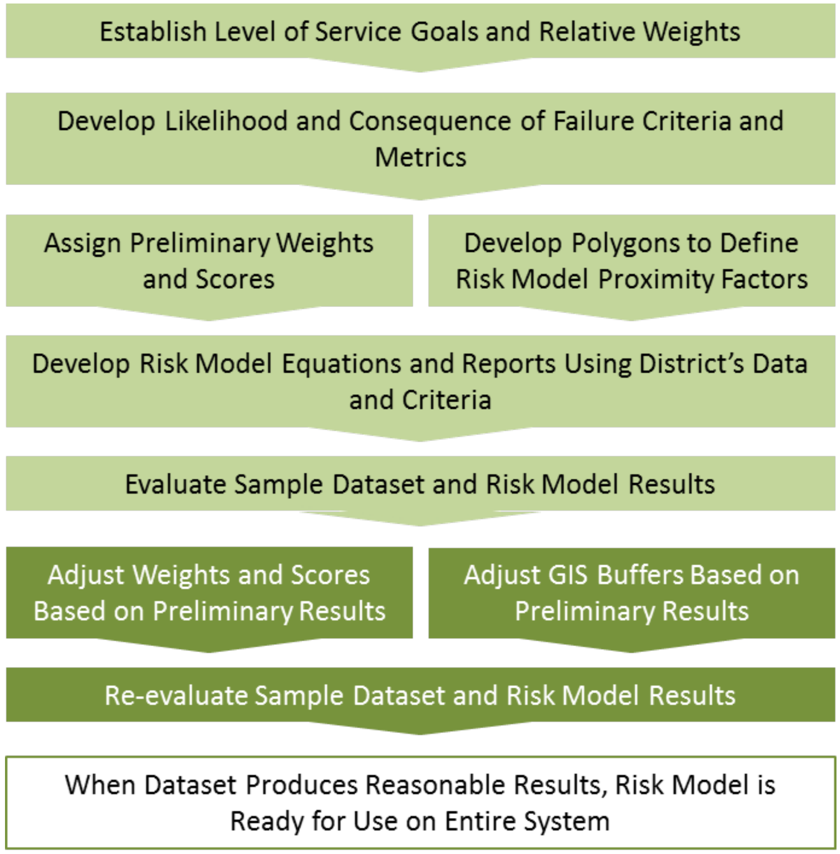
The Consequence of Failure score is based on parameters that, when adjacent to a failed pipeline, would result an increased impact to the community. Consequence of Failure parameters include the following:

- Proximity to a waterway
- Proximity to a primary or secondary transportation corridor
- Proximity to public facilities, including schools, parks, and hospitals
- Area served, as indicated by pipe size (i.e., greater than 12 inches in diameter)

Maps showing the likelihood and consequence of failure parameters are included in Appendix E.

The results from the risk model are sensitive to the assigned weights and scores that are used in the numerical algorithm. Therefore, the numerical model was developed using an iterative process that is shown in Figure 6.1, below.

Figure 6.1 LAMP Model Development Process



6.2.2 LAMP Model Data

LAMP model data was derived from five sources:

- The District's CCTV records, which are stored in the District's computerized maintenance management system and supplemental hard drives
- The District's ESRI GIS database
- County of San Mateo GIS shapefiles obtained through the County's website
- District's InfoWorks ICM hydraulic model
- CIWQS database of sanitary sewer spills

The District's approach toward pipeline repair or replacement is to address structural Grade 5 defects first and to include structural Grade 4 defects on any adjacent, contiguous pipes. After these pipelines are repaired, then the program will expand to address pipes without structural Grade 5 defects. Depending on the nature of the Grade 4 defect, judgment should be used to determine whether the defect warrants repair or should receive continued observation to confirm that it does not degrade into a structural Grade 5 defect. In parallel, the District plans to continue to extend the lives of less critical pipes through the point repair program.

CCTV Data and GIS Database

WBSD provided a download of the District's CCTV inspection records and logs via hard drive and supplemented these files with additional inspection data that is stored apart from the District's CMMS. The District also provided GIS shapefiles showing pipes, manholes, pump stations, force mains, and associated asset information.

Data from the District's sources that were included in the LAMP model are shown in Table 6.1.

Table 6.1. Data Derived from District's CCTV Inspection and GIS Databases

Data Description	Likelihood of Failure Parameter	Consequence of Failure Parameter
Pipe Size (Diameter)	X	X
Pipe Length	X	
CCTV Defect Codes and Scores	X	
Pipe Material	X	
Pipe Spatial Location		X

The CMMS database reports defects using National Association of Sewer Service Companies ("NASSCO") Pipeline Assessment and Certification Program ("PACP") Structural and Operations & Maintenance defect scores and codes for each pipe segment.

The CCTV database included information for 4,484 gravity pipelines. These pipelines represent 85.3 percent of the gravity pipeline inventory listed in GIS. The CCTV data was evaluated and pre-processed to identify and resolve the following occurrences:

1. If multiple CCTV inspection records were available for a single pipe, the most recent inspection record was used.
2. If multiple CCTV inspections are available for a single asset on the same day, the records were reviewed to determine the relevant record and/or combine the scores from what may be forward and reverse inspections.
3. Pipes without a matching ID in GIS were reviewed to attempt to identify the issue (reverse manhole IDs, inspection of two adjacent pipes in one record, misspelled ID, etc.).

County of San Mateo GIS Database

The County of San Mateo maintains a database of publicly-available GIS-based information. The County's GIS layers were downloaded as shapefiles. These shapefiles were then overlaid onto the District's sewer system GIS layer to define risk parameters for the risk model. Information from the County GIS library that was used for the risk model is shown in Table 6.2.

Table 6.2 Data Derived from County of San Mateo GIS Database

Data Description	Likelihood of Failure Parameter	Consequence of Failure Parameter
Parks, schools, and hospital polygons from County "Landmark Features" shapefile		X
Roads from the County "SMCO Streets" shapefile		X
Waterways from the County "Natural Features" shapefile		X
Fault crossing or liquefaction potential from the County "Faulting" and "Geology" shapefiles, respectively	X	

CIWQS Sanitary Sewer Spill Data and InfoWorks ICM Capacity Data

The California Integrated Water Quality System ("CIWQS") sanitary sewer spill database is a publicly available record of reported sanitary sewer spills in California. The CIWQS database is accessible through an interactive link on following website: https://www.waterboards.ca.gov/ciwqs/publicreports.html.

Pipelines associated with spills from January 2018 through December 2022 received an elevated score in the LAMP model. For these lines, the spill was assumed to indicate an increased maintenance requirement or capacity constraint in the system. Spills associated with contractor activities, pump station operations, or other issues not directly related to pipeline configuration or condition were excluded from this analysis.

Spill data was supplemented by a surcharge indicator that was extracted from the District's sewer hydraulic model results output file. The surcharge indicator identifies pipes that are predicted to have flow levels that exceed the pipe crown during a design storm event.

6.2.3 Likelihood and Consequence of Failure

Likelihood and Consequence of Failure parameters, metrics, and scores are described in this section.

Likelihood of Failure

Likelihood of Failure metrics include the following:

- **Sanitary Sewer Spill.** The risk model assigns higher scores to pipe segments that have had spills caused by maintenance or structural issues.
- **NASSCO PACP Structural CCTV Inspection Rating**. The risk model assigns scores to pipes with Structural PACP ratings of 4 and 5, and differentiates between collapsed pipe, pipes with voids visible, hinged pipe, and other Grade 5 defects.
- **O&M CCTV Inspection Rating**. Similarly, the risk model assigns scores to pipes with O&M PACP defect codes indicating root balls, grease, paper/debris, infiltration, and sags.

- **Pipe Size**. Pipes that are less than 6 inches in diameter are difficult to maintain, and have a higher potential to have issues that lead to spills. Therefore, the model assigns an elevated score to all pipes with diameter less than 6-inches. Of note is that the District has a number of VCP pipes with diameters between 5 and 6 inches.
- **Pipe Material.** Pipes comprised of corrugated metal pipe and concrete (but not reinforced concrete) receive elevated scores in the risk model.
- **Geology/Liquefaction**. The risk model assigns a higher score to pipes situated in Bay Mud[8] and assigns the highest score to a pipe that crosses a major fault.
- **Capacity**. Pipes that are predicted to surcharge during the design storm receive an elevated score in the LAMP model. Different scores are assigned to pipes that are 80% and 100% full.

The District's Likelihood of Failure metrics and their associated weights and scores are presented in Table 6.3.

[8] Using GIS, if an asset intersected with a specific polygon, or a defined buffer around a point or line feature, a flag was assigned in the GIS database. Flagged assets received consequence of failure scores in the risk model based on these results.

Table 6.3 Likelihood of Failure Metrics, Weights, and Scores

Likelihood of Failure Metric	Relative Weight	Metric Score	Total Possible Score
Spills	6	Multiple spills: 10	60
		Single spill: 7	
		No spill: 0	
Structural PACP	6	Grade 5 Collapsed: 10	60
		Grade 5 High Risk (_VV, _SV, Hole, Broken): 8	
		Grade 5 Hinge: 4	
		Grade 4: 3	
O&M PACP	2	Root Ball Barrel: 10	20
		Grease: 7	
		Paper or Debris: 5	
		Infiltration: 3	
		Sag greater than 20% of Pipe Depth: 1	
Material	4	Corrugated Metal Pipe: 10	40
		Concrete Pipe: 7	
		Clay > 100 Years Old: 3	
Pipe Size	1	< 6-inches in Diameter: 10	10
Geology	1	San Andreas Fault: 10	10
		Bay Mud: 7	
Capacity	1	Flow Depth / Diameter > 1: 10	10
		Flow Depth / Diameter > 0.8: 7	
Maximum Possible Likelihood of Failure Score			210

Consequence of Failure

Consequence of Failure metrics provide information on how the failure of an asset will impact the ability of the District to meet its Level of Service goals. The relative weight held by the Consequence score varies, and depends on the District's strategic planning objectives. Consequence of Failure metrics that were used in the LAMP risk model are listed below.

- **Proximity to Waterway**. Waterways are shown as line features in the County of San Mateo "Natural Features" shapefile. The pipe segment was assigned an elevated consequence of failure score if it was located within 200 feet of a designated waterway.
- **Proximity to Parks, Schools, and Hospital.** Parks, Schools, and Hospitals are all considered critical facilities in the District's service area. These facilities were located using information from the County of San Mateo "Landmark Features" shapefile. The landmarks are shown as polygons in the shapefile. Therefore, any pipe crossing a critical facility polygon received an elevated consequence of failure score. Similarly, a pipe that is located within 200 feet of these features was assigned an elevated consequence of failure.
- **Area Impacted**. Failure of a large pipe, which typically serves a larger area, has a higher consequence than failure of a small collector sewer. To model this understanding, pipes greater than 12 inches in diameter received elevated consequence of failure scores.
- **Transportation Impact**. Roadways are designated as a line feature in the San Mateo County "SMCO Streets" shapefile. Any pipes located within 200 feet of a primary or secondary arterial roadway, or a railroad, were assigned a higher consequence of failure in the LAMP model. Primary roadways included Highways 101 and 280, Alameda de las Pulgas, Alpine Road, Atherton Avenue, El Camino Real, Fair Oaks Lane, Middlefield Road, Marsh Road, Portola Road, Ravenswood Avenue, Ringwood Avenue, Willow Avenue, and Sand Hill Road. Secondary roadways included Santa Cruz Avenue, Valparaiso Avenue, Middle Avenue, Bay Road, and Olive Avenue.

Consequence of Failure metrics, weights, and scores are presented in Table 6.4.

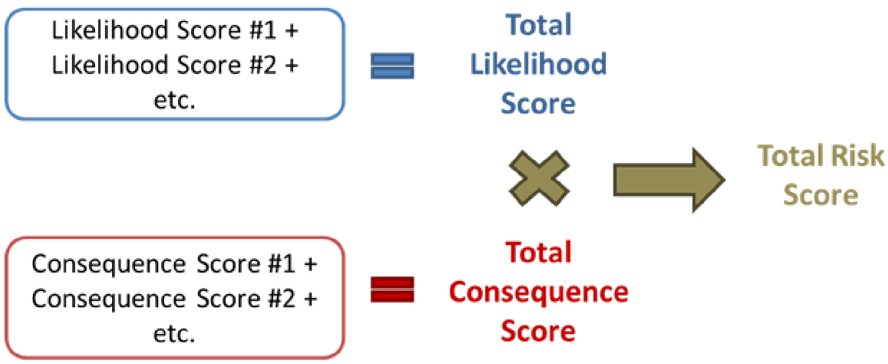
Table 6.4 Consequence of Failure Metrics, Weights, and Scores

Consequence of Failure Metric	LOS Goal	Weight	Metric Score	Total Possible Score
Proximity to Waterway	Preserve Health and the Environment. LOS Weight = 6	9	Within 200 feet of waterway feature: 5	90
Proximity to School, Park, or Hospital		2	Inside park, school, or hospital boundary: 5	60
			Within 200' of park, school, or hospital boundary: 3	
Area Impacted	Provide Reliable Service. LOS Weight = 4	1	Pipe diameter > 12 inches: 5	20
Transportation Impact		2	Within 200 feet of primary arterial road or railway line: 5	40
			Within 200 feet of secondary road: 3	
Total Possible Consequence of Failure Score				210

6.2.4 Total Risk Score

The LAMP model uses a series of queries to filter or perform calculations on the District's sewer data. The model overlays Likelihood and Consequence metrics and scores, and develops an associated Total Risk Score. The process used to compile these scores is shown in Figure 6.2. The Likelihood and Consequence of Failure components that are shown in Figure 6.2 are discussed further in this Chapter.

Figure 6.2 Total Risk Score Calculation



The Risk Score is a relative number and is intended to be compared to similar scores for other pipes in the same model run. The Risk Score, when considered alone, has no numerical significance. Risk Scores were plotted in GIS to help identify the areas with the highest risk.

Specific to the District's system, the highest risk scores include pipelines that have a Structural Grade 4 or 5 defect and proximity to a waterway.

6.3 LAMP MODEL RESULTS AND PROJECT RECOMMENDATIONS

The Total Risk Scores that were generated by the LAMP model were linked back to their respective pipe segment by the Pipe ID, which was developed by concatenating the upstream and downstream manhole IDs. Risk Scores were grouped by priority, as noted below. The basins listed are shown on Figure 6.3. Basin descriptions are provided in Chapter 4, Hydraulic Model Development.

- **Priority 1:** 10 Pipes with structural Grade 5 defects and proximity to a waterway. This category includes pipes in Basins 010, 030A, 040, 50S, and 070A.

  The capital improvement plan prioritizes the ten Priority 1 pipes and all other pipes with Grade 5 defects in these five basins. In total, 53 lines with a combined length of 12,890 lineal feet are repaired or replaced.

- **Priority 2:** Remaining pipes with known Grade 5 defects.

  This category includes 48 pipes with a combined length of 12,508 lineal feet. Pipe are prioritized for repair by basin based on the cumulative risk scores divided by acreage.

- **Priority 3:** 35 pipes with structural Grade 4 defects and proximity to a waterway. This category includes pipes in Basins 20, 30, 40, 50, and 70.

The 35 Priority 3 pipes and 211 other pipes with Grade 4 defects in these five basins may continue to degrade and require repair within a 5 to 10-year timeframe. Priority 3 pipes have a combined length of 53,769 lineal feet (10.2 miles). Grade 4 pipes that are located on the same City block as Priority 1 and 2 pipes should be reviewed at the time of project development and grouped with the Grade 5 pipes as needed.

- **Priority 4:** 265 pipes with at least one structural Grade 4 defect and lower risk profiles.

  These pipes should be reviewed regularly to assess whether the Grade 4 defects have degraded to Grade 5 status.

  The District may extend the service life of pipes with lower priority Grade 4 defects in parallel with the Capital Improvement Program using pipe patching or other interim repairs.

6.3.1 Recommendations for Rehabilitation

After the priority project groupings were defined, the following approach was used to form the CIP project list:

- Step 1: All pipes with structural Grade 4 and 5 defects were categorized as requiring repair or replacement. Each project assumes that when structural Grade 5 defects are repaired on a pipe, all structural Grade 4 defects on the same pipe will also be repaired. Defects will receive point repairs until there is more than one defect, on average, within 40 linear feet of pipe (i.e., more than 2.5 defects per 100 lineal feet of pipe). For approximately every three pipe sections replaced, it is assumed that one manhole will also be replaced.
- Step 2: When a high priority pipeline is addressed, all structural Grade 5 defects in that basin are also assumed to be scheduled for repair or replacement. Pipes with Grade 4 defects and no Grade 5 defects that are adjacent to (i.e., contiguous to) a pipe with Grade 5 defects are also prioritized for repair.
- Step 3: Pipes are scheduled for replacement on a basin-wide basis, forming the priorities listed in Tables 6.5 and 6.6. Basin priority is calculated as the combined risk scores for all pipes in that basin divided by the basin acreage.

Table 6.5 Priority Basins Ranked by Risk (1 is Highest) Containing Pipes with Structural Grade 5 Defects

Ranking	Basin	Location
5	010	Portola Valley
3	030	Ladera. This basin includes numerous Grade 4 defects. Further, a 10-inch pipe with known surcharge has Grade 4 and 5 defects; upsizing may be beneficial. A basin-wide strategy is recommended prior to scheduling repairs.
4	040	SLAC and Stanford Hills
2	050NS	Between Alameda de las Pulgas, Sharon Heights, Alta Vista Drive and Stockbridge.
11	060AB	Sharon Heights
1	070AB	Southeast of Atherton Avenue between Alameda de las Pulgas and El Camino Real. This basin includes numerous Grade 4 defects. Further, the pipeline on Elena Avenue is recommended for upsizing. A basin-wide strategy is recommended prior to scheduling repairs.
13	70CD	Southeast of Atherton Avenue between El Camino Real and Middlefield Avenue
7	080AB	Between Alameda de las Pulgas, Santa Cruz, Olive Avenue, and Camino al Lago
8	090	Between Alameda de las Pulgas, Santa Cruz Avenue, Olive St., and Bay Laurel Dr.
6	100AB	Between El Camino Real, Valparaiso, Olive Street, and Bay Laurel Drive
15	110	Between Middlefield and Highway 101, adjacent to Marsh Rd, incl. Flood Circle
9	120AB	South of Highway 101 including Menlo Oaks and Oak Grove Avenue
14	130	Between El Camino Real and Highway 101 including the communities to the north and south of Willow Road (Linfield Oaks, Vintage Oaks, and the Willows)
12	140	Between Bayfront Expressway, Highway 101, Belle Haven, and Willow Road
10	150	Between Menalto Ave., Bay Rd., Bayfront Expwy, Willow Rd., and Belle Haven
Note: Blue shaded rows include pipes in proximity to a waterway and are the highest priority basins.		

Figure 6.3 Locations of District Sewer Basins

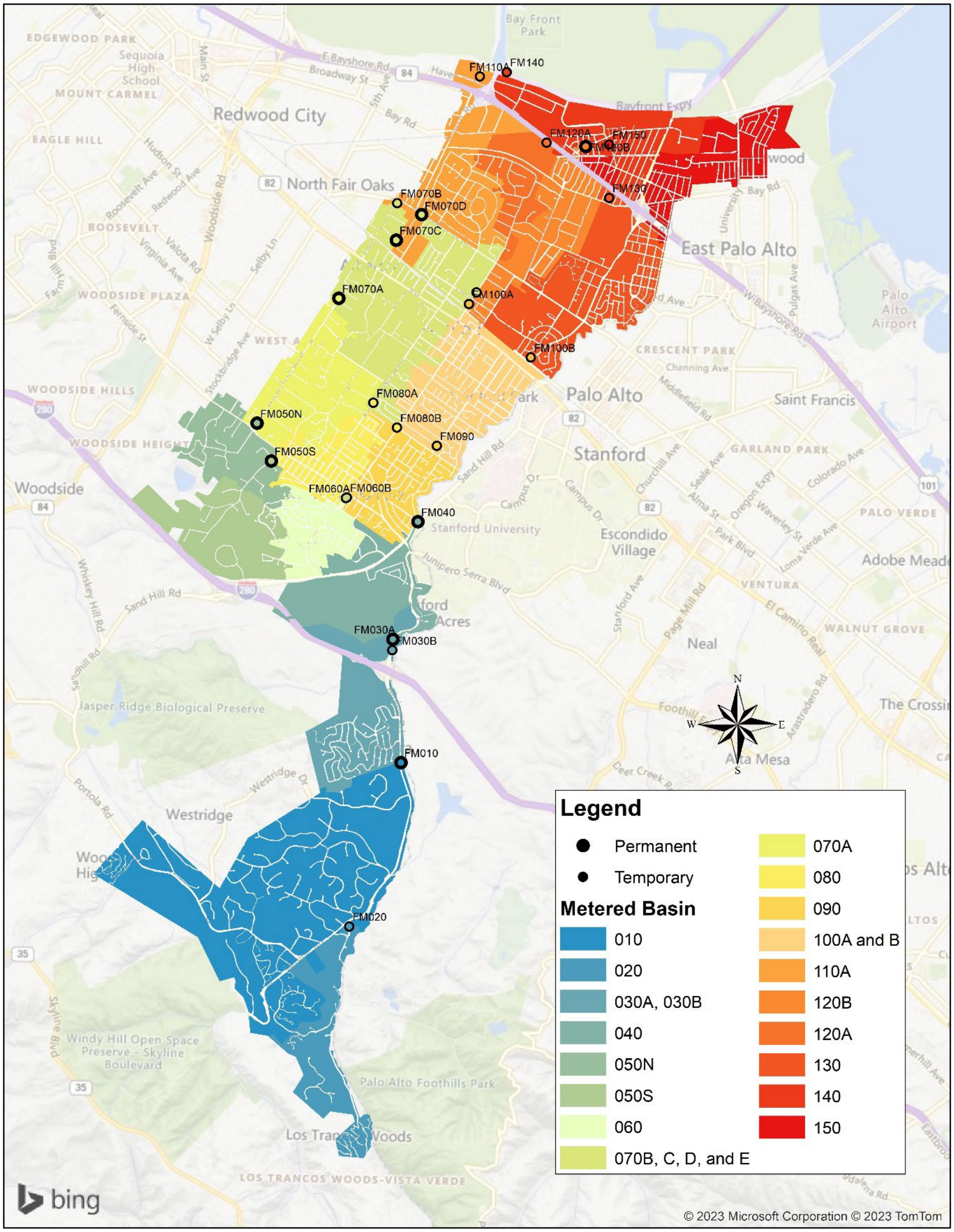


Table 6.6 Priority Basins Ranked by Risk (1 is Highest) Containing Pipes with Structural Grade 4 Defects

Ranking	Basin	Location
16	010	Portola Valley
5	020	Los Trancos
1	030	Ladera
4	040	SLAC and Stanford Hills
3	050NS	Between Alameda de las Pulgas, Sharon Heights, Alta Vista Drive and Stockbridge
15	060AB	Sharon Heights
2	070AB	Southeast of Atherton Avenue between Alameda de las Pulgas and El Camino Real
12	70CD	Southeast of Atherton Avenue between El Camino Real and Middlefield Avenue
7	080AB	Between Alameda de las Pulgas, Santa Cruz, Olive Avenue, and Camino al Lago
6	090	Between Alameda de las Pulgas, Santa Cruz Avenue, Olive Street, and Bay Laurel Drive
8	100AB	Between El Camino Real, Valparaiso, Olive Street, and Bay Laurel Drive
9	110	Between Middlefield and Highway 101, adjacent to Marsh Rd, incl. Flood Circle
11	120AB	South of Highway 101 including Menlo Oaks and Oak Grove Avenue
14	130	Between El Camino Real and Highway 101 including the communities to the north and south of Willow Road (Linfield Oaks, Vintage Oaks, and the Willows)
13	140	Between Bayfront Expressway, Highway 101, Belle Haven, and Willow Road
10	150	Between Menalto Avenue, Bay Road, Bayfront Expressway, Willow Road, and Belle Haven
Note: Blue shaded rows include pipes in proximity to a waterway and are the highest priority basins.		

Table 6.7 lists the number and length of pipe requiring repair in every basin. Tables 6.8 through 6.10 provide additional information on planned repairs vs. replacement.

Additional maps showing the basins by risk, including individual basin maps showing associated projects are included in Appendix F.

Table 6.7 CIP Pipes with Structural Grade 4 and 5 Defects by Basin

Basin	Structural Grade 5		High Priority Structural Grade 4		Structural Grade 4 Watch List	
	# of Pipes	Length (ft)	# of Pipes	Length (ft)	# of Pipes	Length (ft)
010	1	185	0	0	4	456
020	0	0	1	217	3	772
030A	7	1446	12	2700	59	11929
040	4	782	4	498	6	1912
050NS	20	5440	6	1142	32	6053
060AB	7	1592	0	0	16	2904
070AB	21	5,037	8	1835	78	19238
070CDE	5	1649	4	1001	33	6440
080AB	4	1182	0	0	30	6820
090	4	961	0	0	42	9956
100AB	10	2590	0	0	47	11498
110A	1	307	0	0	38	9146
120AB	4	1235	0	0	5	6275
130	3	771	0	0	18	4923
140	6	1222	0	0	20	3402
150	4	999	0	0	15	5888
Total	**101**	**25,398**	**35**	**7,393**	**476**	**107,612**
Note: Blue shaded rows are the basins with the Highest Priority pipes having structural Grade 5 defects.						

Table 6.8 Pipes with Grade 5 Defects Requiring Repair and Replacement (Years 1 through 5)

Basin	Method	No of Pipes	Length	Manholes	Project Cost
010	Repair	1	185	0	$13,000
	Replace	0	0	0	$0
030A	Repair	6	1247	0	$156,000
	Replace	1	199	0	$121,384
040	Repair	4	782	0	$52,000
	Replace	0	0	0	$0
050N/S	Repair	9	2010	0	$195,000
	Replace	11	3430	4	$2,138,732
060A/B	Repair	6	1329	0	$117,000
	Replace	1	263	0	$159,967
070A/B	Repair	11	3402	0	$312,000
	Replace	10	1635	3	$1,038,246
070C/D/E	Repair	3	905	0	$52,000
	Replace	2	744	1	$465,479
080A/B	Repair	4	1182	0	$78,000
	Replace	0	0	0	$0
090	Repair	2	390	0	$52,000
	Replace	2	571	1	$360,714
100A/B	Repair	10	2590	0	$182,000
	Replace	0	0	0	$0
110	Repair	1	307	0	$39,000
	Replace	0	0	0	$0
120	Repair	3	1011	0	$52,000
	Replace	1	224	0	$170,327
130	Repair	3	771	0	$78,000
	Replace	0	0	0	$0
140	Repair	3	728	0	$52,000
	Replace	3	494	1	$345,191
150	Repair	4	999	0	$65,000
	Replace	0	0	0	$0
Total		**101**	**25,398**	**10**	**$6,295,040**

Notes:

1: Blue shaded rows are the basins with the Highest Priority pipes having structural Grade 5 defects.
2. If adjacent/contiguous pipes with Grade 4 defects are repaired concurrently, the total cost increases by $2,848,053 and costs in Tables 4.5 and 4.6 decrease accordingly.

Table 6.9 Pipes with Grade 4 Defects in High Priority Basins (Future)

Basin	Method	No of Pipes	Length	Manholes	Project Cost
20	Repair	4	989	0	$52,000
	Replace	0	0	0	$0
030A	Repair	56	11436	0	$1,209,000
	Replace	15	3193	5	$2,007,907
40	Repair	8	2203	0	$169,000
	Replace	2	206	1	$138,599
050N/S	Repair	28	5696	0	$637,000
	Replace	10	1499	3	$950,774
070A/B	Repair	73	18528	0	$1,716,000
	Replace	13	2545	4	$1,870,809
070CDE	Repair	28	6641	0	$546,000
	Replace	9	833	3	$546,072
Total		**246**	**53,769**	**16**	**$9,843,161**
Note: Blue shaded rows are the basins with the Highest Priority pipes having structural Grade 4 defects.					

Table 6.10 Pipes with Grade 4 Defects on "Watch" (Future)

Basin	Method	No of Pipes	Length	Manholes	Project Cost
10	Repair	3	368	0	$39,000
	Replace	1	88	0	$53,375
60	Repair	16	2904	0	$286,000
	Replace	0	0	0	$0
080AB	Repair	29	6572	0	$546,000
	Replace	1	248	0	$151,114
90	Repair	36	8831	0	$780,000
	Replace	6	1125	2	$710,410
100AB	Repair	42	10882	0	$689,000
	Replace	5	616	2	$400,821
110	Repair	34	8056	0	$546,000
	Replace	4	1090	1	$676,006
120	Repair	18	4179	0	$312,000
	Replace	5	2096	3	$2,983,877
130	Repair	16	3860	0	$273,000
	Replace	4	1063	1	$660,093
140	Repair	11	3154	0	$208,000
	Replace	4	247	1	$222,106
150	Repair	25	5629	0	$403,000
	Replace	5	259	2	$188,475
Total		**265**	**61267**	**12**	**$10,128,277**

6.4 ESTIMATED COSTS

Planning level costs were developed for the proposed pipeline improvements using the following unit cost and contingency data. Since project needs and construction details will be site-specific, actual project configurations and associated costs should be refined during project design.

Cost Assumptions:

- Pipe replacement unit cost: $30 per inch-diameter-foot of pipe. Cost estimates for 18- and 24-inch lines requiring repair used a reduced unit cost of $24 per inch-diameter-foot of pipe.
- Appurtenances, laterals, mobilization, and shoring: 50% of pipe installation unit cost
- Construction contingency: 30%
- Point repairs: $10,000/repair, plus 30% contingency
- Engineering and Administration: 30% of construction cost, including contingencies for pipe replacements. No additional Engineering or Administration cost was applied to point repairs.

- Manholes were assigned the same cost as point repairs.

The cost estimate assumed open cut construction for pipeline replacement. However, an evaluation will need to be completed in order to determine which construction method represents the most viable alternative for each asset in terms of both cost and construction feasibility.

All costs are indexed to Engineering News Record Construction Cost Index, San Francisco, October 2023, 15473.38.

Appendix G lists the pipes, repair recommendation, associated drainage basin, and assigned costs. This information was used to develop timelines for the proposed capital improvement plan. Projects timelines were established as follows:

1. Previously-scheduled point repair projects were included in FY2024-25 and FY2025-26. These projects are not included in the LAMP project lists and have a total estimated cost of $8 million.
2. Priority 1 and 2 projects are scheduled for completion beginning in FY2024-25 through FY2029-30. These projects repair pipes with known structural Grade 5 defects.
3. Priority 3 and 4 projects include placeholder budgets in FY2029-30 through FY2034-39. Priority 3 projects repair pipes with proximity to a waterway with known structural Grade 4 defects that may degrade over time.
4. Priority 3 and 4 projects that are located on the same block as a Priority 1 or 2 project could be implemented ahead of schedule to improve construction efficiency, as budgets allow. Appendix 3 lists pipes with Grade 4 defects that are adjacent to Grade 5 pipes in each risk category.

CHAPTER 7 PUMP STATION ASSESSMENT

On August 3, 2023, Woodard & Curran staff visited and assessed the condition of twelve pump stations within the District's collection system. W&C staff were accompanied by the District's Pump Facility Supervisor, who facilitated the site visits and provided further detail regarding the function and condition of each pump station. The purpose of the assessment was to determine the potential for large-scale rehabilitations that may fall outside the scope of the District's proactive pump replacement program. Where such projects were identified, planning level capital cost estimates and approximate timelines for pump station rehabilitation were developed.

This Chapter summarizes the process and findings of the pump station site assessments. Additional information can be found in Appendix H, Pump Station Assessments TM prepared by Woodard & Curran.

7.1 GENERAL PUMP STATION CHARACTERISTICS

With the exception of Stowe Lane Pump Station, all of the District's wastewater pump stations feature Flygt (Xylem) submersible pumps in circular concrete wet wells. Stowe Lane Pump Station is the only dry pit pump station owned by the District. This aging facility does not match the design standard of the other submersible stations, and features pumps that are housed in a below grade dry pit.

The other atypical station is the District's FERRF Pump Station. The FERFF is a located at the District's abandoned wastewater treatment facility just north of the Menlo Park Pump Station, which is owned and operated by SVCW. The FERFF, serves as repository for flows that exceed the capacity of the Menlo Pump Station and the downstream system, storing these peak flows in lined basins until they can be pumped back into the collection system by the FERRF pump station. The FERFF is therefore not in continuous use and serves as a standby facility. The FERFF has not been recently operated by WBSD, but rather has been operated by SVCW in its capacity to relieve excess conveyance and wastewater treatment plant flows. Recent improvements at the SVCW treatment plant are expected to minimize future use of the FERFF Pump Station, however the District would like to maintain this facility in order to manage emergencies, unanticipated flows and planned maintenance within the system.

7.2 SUMMARY OF SITE VISIT OBSERVATIONS / RECOMMENDATIONS

Table 7.1 provides a summary of the observed pump stations, the major aspects or issues, and the potential for CIPs that may not be included in the routine operations and maintenance budget.

Table 7.1 Pump Station Assessment Summary

Pump Station	Observed Conditions to be Addressed	CIP Project Required?	Existing CIP Projects?
Willow PS	Safety Grates absent Hatches do not conform to current District Standards Force mains in need of replacement Flow meter required Wet Well Coating required Odor control required	Yes	Yes
University PS	Safety Grates absent under wet well hatch Hatches do not conform to current District standards	No	No
Illinois PS	Safety Grates absent under wet well hatch	No	No
Menlo Industrial PS	No Deficiencies Observed PS may be replaced for Willow Village Development	No	No
Hamilton – Henderson PS	Exposed aggregate above water line indicative of hydrogen sulfide corrosion	Yes	No
Flow Equalization and Resource Recovery Facility	Electrical equipment at end of life Pumps at end of life Communications equipment at end of life Valves and piping show signs of corrosion and may not be routinely exercised	Yes	No
Vintage Oaks 1 PS	No Deficiencies Observed	No	No
Vintage Oaks 2 PS	No Deficiencies Observed	No	No
Stowe Lane PS	Dry pit pump configuration Pumps are in confined space Aging Electrical Equipment	Yes	Yes
Los Trancos PS	No Deficiencies Observed	No	No
Sausal Vista PS	No Deficiencies Observed	No	No
Village Square PS	No Deficiencies Observed	No	No

As indicated in the Table 7.1, the majority of pump stations did not have observed deficiencies that warrant action through a capital improvement project. With the exception of Willow Pump Station, Stowe Lane Pump Station and the FERFF Pump Station, the District's stations all share common design features and have been well maintained by District staff. One of the more common deficiencies noted – the lack of fall protection safety grates beneath wet well hatches – is relatively minor in nature and, along with wet well grating and covers that do not comply with current District standards, do not require a capital improvement program at this time.

Four pump stations have needs that can be addressed through capital improvement projects, two of which are already included in the District's existing CIP. These stations are:

- Willow Pump Station
- Stowe Lane Pump Station
- Hamilton-Henderson Pump Station
- FERRF Pump Station

7.2.1 Willow Pump Station

The Willow Pump Station is located at the intersection of Willow Rd. and O'Brien St in Menlo Park. This pump station is currently receiving upgrades to the generator, piping, and valves, and is receiving a wet well coating. The established project budget of $1.7M was included in the capital improvement plan.

Figure 7.1 Willow Pump Station Wet Well Cover and Equipment

7.2.2 Stowe Lane

Stowe Lane Pump Station is the District's only dry pit station. Design documents for replacement of this pump station are in process. A new generator will be included with the new station. The current project budget of $3.0M was included in the capital improvement plan.

Figure 7.2 – Stowe Lane Pump Station

7.2.3 Hamilton-Henderson Pump Station

Generally, this pump station is in good condition. However, as shown on Figure 7.3 on the following page, during visual inspection of the wet well walls, it was noted that the concrete aggregate is exposed on the surface of the wet well wall. By contrast, the concrete below the water line does not exhibit this condition. This typically indicates hydrogen sulfide corrosion of the concrete, which softens the cement and allows for erosion of the wall aggregate matrix over time. A new epoxy liner over cleaned concrete is recommended. Prior to executing this work, the concrete should be checked for soundness using non-destructive testing ("sounding" of the wall with a special hammer) to ensure that the damage does not extend deeper into the wall, and that reinforcement bars are not impacted.

Figure 7.3 Wet Well Corrosion Above Water Surface at Hamilton-Henderson Wet Well Walls

While the lining of the Hamilton-Henderson Pump Station wet well is straightforward, it requires full access to the wet well for sufficient time to clear and prepare the walls, then coat the walls and allow time for curing. This requires short-term bypassing of the wet well, typically using portable pumps to move water from an upstream manhole to the force main. For this reason, the project is included in the CIP with an estimated project cost of $77,000.

7.2.4 Flow Equalization and Resource Recovery Facility Pump Station

The FERRF pump station consists of a wet well and valve box with three 60 horsepower (hp) pumps, 14-inch diameter pump discharges, and 30” and 24” isolation valves that determine the direction of flow to and from the station. Additionally, there is an adjacent metal building that houses the electrical and control systems.

The FERRF is nearing the end of useful life. Electrical equipment is showing signs of aging and deterioration. The three pumps, valves, and piping appeared to be corroded and the District informed W&C that the pumps are in need of replacement. Additionally, exposed aggregate was observed on the wet well walls, indicating potential hydrogen sulfide corrosion of the concrete.

Figure 7.4 FERRF Pump Station

Figure 7.5 FERRF Pump Discharge Valves

The District wishes to maintain the operational and emergency flexibility provided by the FERFF. As such, rehabilitation of this aging facility has been established as a CIP project. This project will include the following:

- Replace existing pump drives and electrical equipment
- Replace existing submersible pumps (60 Hp) and wet well piping (14")
- Replace discharge piping valves (gate valve and check valves)
- Recoat existing piping
- Line existing concrete wet well
- Clean and recoat metal building

Due to its intermittent, wet weather use, the FERFF can be improved without operational impacts to the District's collection system or to SVCW conveyance operation. All improvements listed above can be completed within a single dry season, assuming equipment is procured ahead of time. Therefore, bypassing of flows should not be required to complete this project. The estimated cost for this project is $1.4M.

7.2.5 Force Main Replacements

The District has identified three force main segments that, based on pipeline age and repair history, are in need of replacement. These force mains are downstream of the following pump stations (approximate force main installation date as noted, based on District records)

- Willow Pump Station (circa 1980s)
- University Pump Station (1985)
- Illinois Pump Station (1985)

The force mains above total 3,600 linear feet and can be replaced as part of a combined capital improvement project. Open-cut replacement of these force mains is assumed, for a combined cost of $2.1. The Willow force main replacement is separate from the Willow discharge force main extension discussed above, and should be scheduled to occur at the same time as the force main extension project.

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CHAPTER 8 RECYCLED WATER PROGRAM

This Chapter summarizes the key topics presented in the Recycled Water Program Technical Memorandum that was prepared by Woodard & Curran for this Master Plan. The Recycled Water Program TM is included in Appendix I.

8.1 BACKGROUND

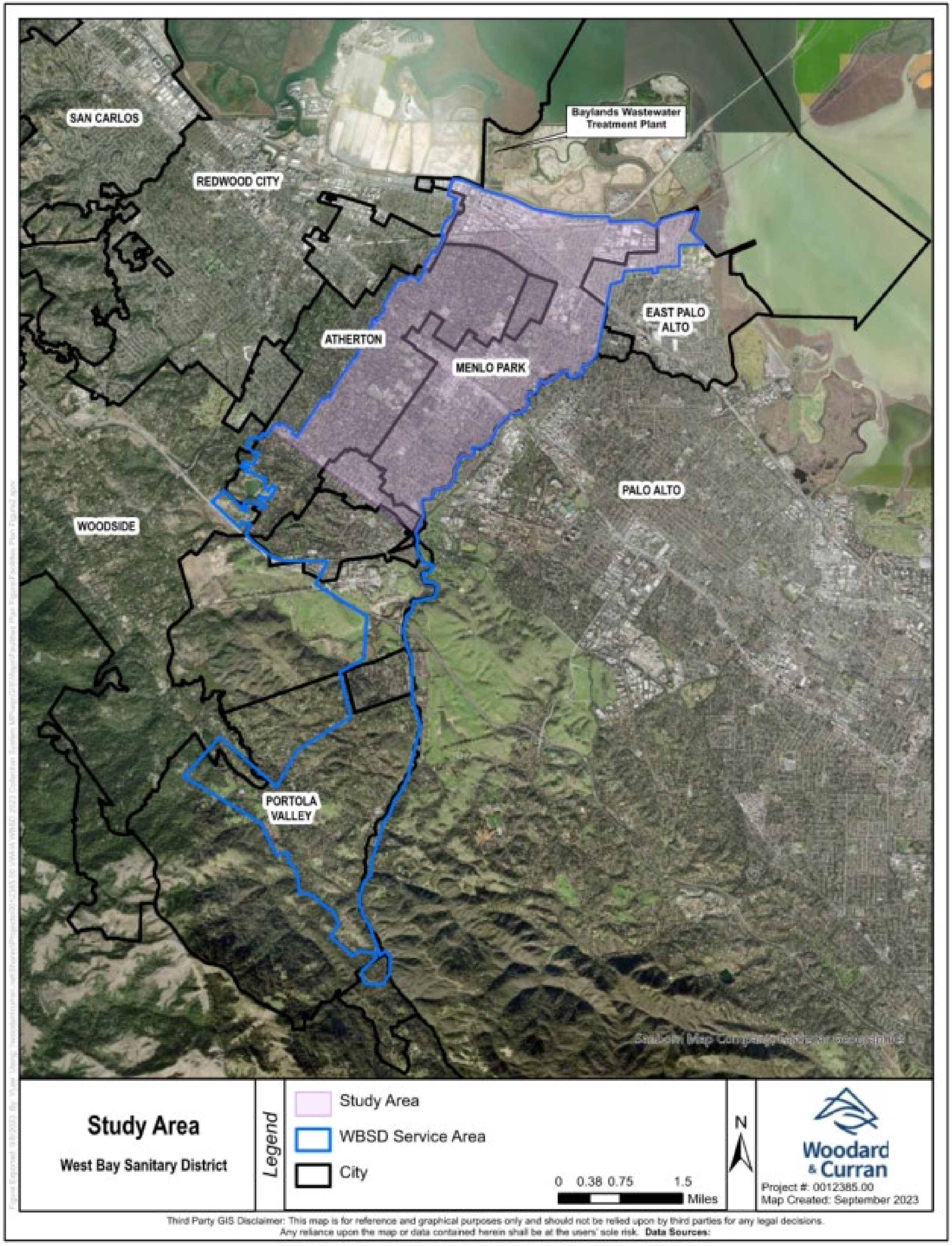
In 2014, the District completed a Recycled Water Market Survey and evaluated three conceptual alternatives to serve potential recycled water customers. This effort led to construction of a satellite treatment plant at the Sharon Heights Golf and Country Club ("SHGCC") and recycled water use at the golf course and other potential customers near the golf course. In 2019, the District completed the Bayfront Recycled Water Facilities Plan ("RWFP"), which evaluated projects identified in the Market Survey in the Bayfront area. This plan updated and refined the market assessment and analyze various recycled water project alternatives.

The Bayfront facilities, including the influent facilities (pump station and pipeline), treatment facilities, and distribution facilities (pump station and pipeline) have been planned and are in the 30% design phase. The 2023 Recycled Water Plan that was prepared for the 2023 Master Plan focuses on additional distribution facilities that extend down to the central and southwest portions of the study area to serve new customers including Flood Park, Parkline (SRI International), Menlo-Atherton High School, and Veteran's Administration, as shown on Figure 8.1 on the following page.

The objectives of the 2023 Recycled Water Plan include the following:

1. Review current and future plans for recycled water production throughout the District;
2. Identify a recycled water expansion and production strategy for the Bayfront area to the Government Center, including target customers, planning-level design criteria, and a planning-level cost estimate; and
3. Prepare an implementation plan for the recommended project, including implementation schedule and construction financing plan.

Figure 8.1 Recycled Water Study Area



8.2 WATER DEMAND AND SUPPLY

Based on the 2020 Urban Water Management Plan for the Menlo Park Municipal Water District ("MPMW"), the population of the City of Menlo Park served by the MPMW is expected to increase by 65% by 2040. Concurrently, employment in the service area is expected to expand, increasing both overall and nonpotable recycled water demand. Demand in the adjacent Cal Water service area is also expected to increase during this time, but not as significantly.

MPMW purchases all its water from the San Francisco Public Utilities Commission ("SFPUC"). With increasing water demands forecasted over the next 20 years and the MPMW's dependence on the SFPUC water supply, adequate water supply for the region is an issue that recycled water could help address. For example, supplying recycled water to non-potable demands would dampen drought impacts on potable water supply. In addition, having a recycled water supply would also provide a local, local, reliable water source for non-potable demands in the event of SFPUC service disruptions.

8.3 POTENTIAL RECYCLED WATER CUSTOMERS AND DEMANDS

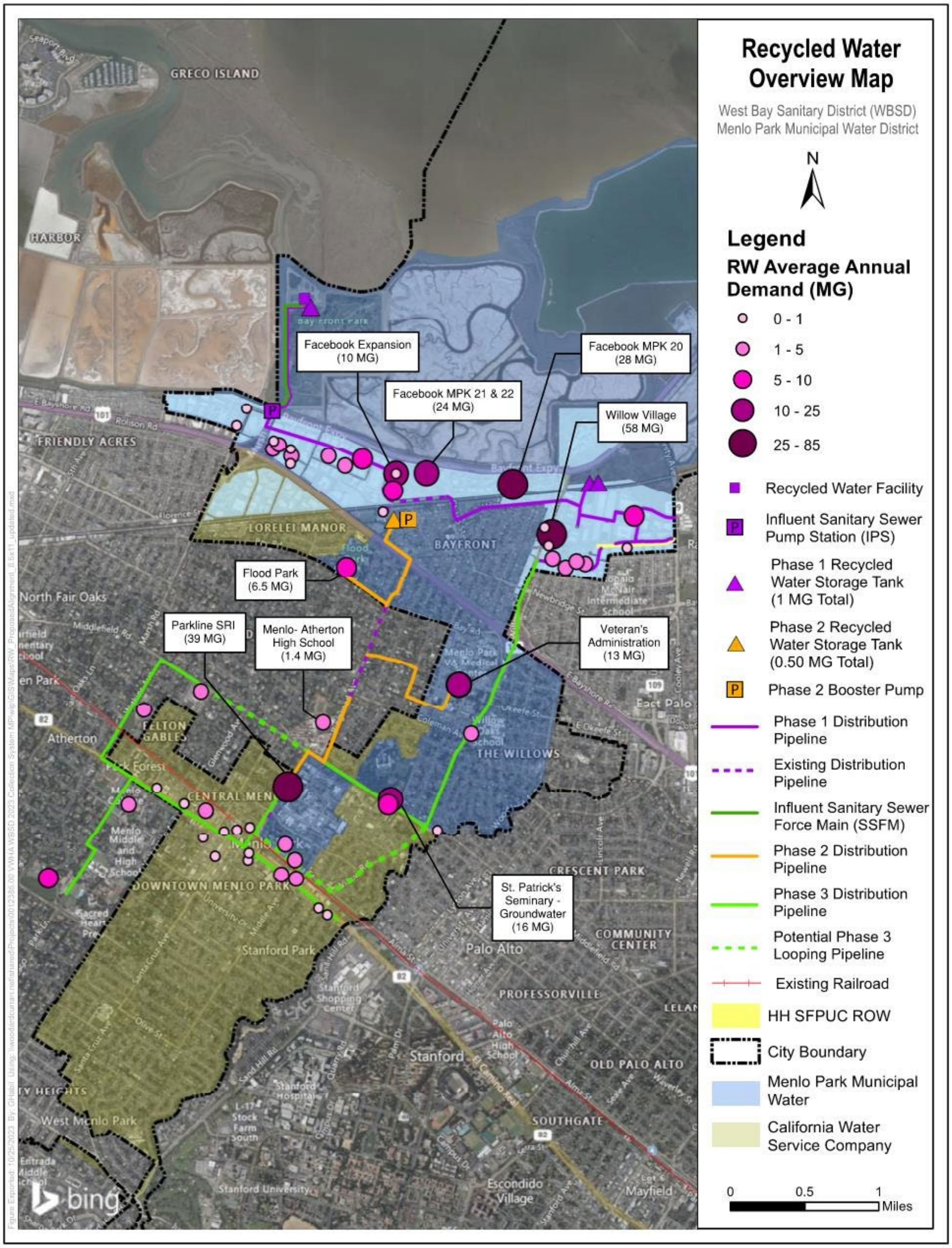
A preliminary recycled water market assessment was conducted as part of the 2014 Market Survey. The 2019 RWFP refined the preliminary recycled water market assessment to consider additional potential potable water customers (existing and future) that were not originally evaluated during the 2014 Market Survey. To supplement the information from the prior studies, a list of approved and pending development projects (Development Projects List) in the study area was provided by the District in May 2023.

Figure 8.2 shows existing, planned, and proposed recycled water distribution pipeline alignments to service customers in the study area. Phase 1 serves the Bayfront area, which is currently being designed; Phase 2 serves Flood Park, Veteran's Administration, Menlo-Atherton High School, and Parkline (SRI International); and Phase 3 includes additional potential pipe in the Southwest and Eastern portions of the study area. Figure 8.2 also shows existing recycled water pipelines.

The total non-potable demand for each customer is comprised of up to three demand types: irrigation, flushing, and cooling tower demands. Facilities for treating and conveying recycled water are sized based on peak demand periods. Two peak flow situations were defined as criteria for development of the recycled water distribution system in the market assessment: maximum day demand ("MDD") and peak hour demand ("PHD"). The average daily demand during the peak demand month of the year is the assumed MDD. PHD is defined as the maximum anticipated flow rate delivered to a customer (in gallons per minute) during MDD conditions. MDD and PHD factors were updated from the market assessment based on use type and are discussed as follows. Revised MDD and PHD values are presented and are summarized in Table 8.1.

MDD for irrigation is based on net evapotranspiration data from the Western Regional Climate Center, which shows that July is the peak demand month for the District's service area for irrigation customers. The MDD peaking factor is 2.0 times the average annual demand (AAD) based on the estimated irrigation demand in July being twice the AAD. Irrigation-only customers without on-site storage typically operate at night for an 8-hour irrigation period. Therefore, the PHD factor was estimated at 3.0 (24-hour/8-hour irrigation = 3.0).

Figure 8.2 Recycled Water Overview Map



The potential recycled water customers were categorized into four service regions for the purposes of pipe and pump sizing. Customers that were more than 1,000 feet away from the pipelines were not included in this demand estimate.

Table 8.1 Recycled Water Customer Demands by Pipeline Service Region

Pipeline Service Region	RW Average Annual Demand (AFY)	RW Average Annual Demand (MG)	RW Average Daily Demand (MGD)
Phase 1, Northwest Area (Bayfront), West of Chilco Street[1]	81.40	26.53	0.07
Phase 1, Northeast Area (Bayfront), East of Chilco Street[1]	466.93	152.15	0.42
Total Phase 1	**548.33**	**178.64[4]**	**0.49**
Phase 2, Central Area[2]	182.55	59.48	0.16
Total Phase 1 and 2	**730.89**	**238.16**	**0.65**
Phase 3, Southwest and Eastern Area[3]	199.71	65.08	0.18
Total Phase 1, 2, and 3	**930.60**	**303.24**	**0.83**

Notes:
5. Area north of Highway 101.
6. Extending south of Highway 101 down Ringwood Ave. to connect to Parkline (SRI International).
7. Extending farther south and west to customers surrounding Downtown Menlo Park and east along Middlefield Road and Willow Road.
8. The recycled water demand for Phase 1 in this table is larger than the demand listed in the 2021 update, because the amount in this table includes two customers from the 2019 RWFP and some additional customers from the 2023 Development Projects List.

8.4 RECYCLED WATER QUALITY REQUIREMENTS

Potential irrigation customers have different water quality needs according to their intended use. Water quality guidelines for landscape use are well established, with different degrees of restriction for various water quality constituents for the use of recycled water in landscaped irrigation. Except for nitrogen, the constituents that impact landscaping are not removed by conventional wastewater or tertiary treatment processes. Therefore, recycled water constituent levels are likely to be similar to the source wastewater constituent levels.

The satellite treatment project requires diversion of wastewater flow from the existing collection system to the new treatment facilities. The two main conduits for wastewater to the potential plant location at the FERRF are the 24-inch sewer on Haven and the 54-inch sewer on Kelly Park. Water quality sampling and flow monitoring at these two locations were used to develop conceptual treatment options for the future recycled water plant. The water supply from the Haven supply provided higher quality influent than the water supply from the Kelly Park supply.

8.5 RECYCLED WATER PROJECT COMPONENTS

Using the information described above, conceptual production and distribution facilities for the Phase 2 recycled water project were developed as follows:

Influent conveyance system: Influent pump station, force main, and equalization. These facilities would be sized to provide a constant feed to the new WRF. Raw wastewater would be pumped from a new manhole at Marsh Road and Bayfront Expressway, diverting flow from the existing 36-inch sewer to the satellite treatment plant.

- Water recycling facility (WRF): Grit removal, screening, MBR, UV, chlorination, de-colorization. The WRF would be sized to meet the max day demand. Due to seasonal irrigation demands, the facility would operate as a dry weather satellite plant – operating at a constant flow rate over 24 hours a day for 8 months of the year and operate at half capacity for 4 months of wet weather to maintain the biological processes.

- Waste return pump station and force main. Grit and screenings produced at the facility would be washed, compacted, and hauled offsite for disposal. Waste sludge and the de-colorization waste product would be discharged by force main to an existing 30-inch sewer main running along the north side of the Bayfront Expressway to be conveyed to SVCW.

- Recycled water distribution system: storage, pump station, and pipelines. The recycled water distribution system would be sized to meet peak hour demand, which typically occurs during an 8-hour period overnight between 10 PM and 6 AM. The peak hour demand exceeds the WRF capacity so recycled water storage would be provided to collect excess supply during periods of low demand so that sufficient supply is available on demand.

The Phase 1 (Bayfront Project) involves the construction of an influent pump station to divert wastewater from the District's collection system, approximately 4,900-LF of influent pipeline, a satellite MBR/UV treatment facility to treat and ultimately produce a maximum daily flow of 0.6 MGD (for Bayfront Project only), and recycled water distribution system including a recycled water storage tank, recycled water pump station, and approximately 30,800-LF of distribution pipeline (approximately 27,400-LF planned and 3,400-LF existing) to various customers.

The Phase 2 Project described in this Master Plan would involve the construction of a booster pump station at the intersection of Terminal Ave and Del Norte Ave, where the Phase 2 pipeline begins, to divert recycled water from the Phase 1 system to the Phase 2 system, approximately 18,800-LF of distribution pipeline (approximately 15,700-LF proposed and 3,100-LF existing) to various customers, and a 0.5 MG storage tank.

This project would deliver an estimated total of 930 AFY (Average Annual Demand) for irrigation, cooling towers, and other indoor uses. A list of recycled water customers for the Recommended Project and their respective estimated average annual demands are presented in more detail in the Recycled Water Program TM.

The Phase 2 Project would divert wastewater from the 36-in sewer pipeline near the intersection of Bayfront Expressway and Marsh Road and pump the wastewater to the Bayfront satellite treatment facility. The treatment facility includes grit removal and fine screening, biological reactor tanks, MBR treatment system, UV disinfection, de-colorization and all appurtenances required for a fully functional treatment system. The product water would be stored in a recycled water tank and a distribution pump station would be used to deliver recycled water to customers. Distribution from the satellite treatment facility to customers would be through an 8-inch pipeline.

The possible future Phase 3 Project, would likely involve construction of approximately 40,700-LF of distribution pipeline to various customers and additional 1,200-LF of pipeline for possible looping purposes.

8.6 POTENTIAL RECYCLED WATER PROJECT COST ESTIMATE

Table 8.2 on the following page summarizes the estimated cost for the Phase 2 facilities. Costs for Phase 3 are included for reference only. The Phase 1 facilities (the Bayfront Project) are not included in this estimate because, while not yet built, they have already been financed and are currently in the 30% design phase.

8.7 SCHEDULE AND CRITICAL PATH FOR IMPLEMENTATION

Full implementation of the Phase 2 project is anticipated to take approximately 10 years. All of the preliminary studies required to further refine the project need to be completed in order to: 1) prepare the Engineering Report for DDW; 2) initiate environmental documentation; and 3) refine project cost estimates. The environmental documentation should be completed in parallel with the Engineering Report.

Several permits are necessary for the implementation of the Phase 2 project. Foremost, the District would need to obtain an individual Water Reclamation Requirement permit from the San Francisco Bay Regional Water Quality Control Board to cover the production of recycled water. A Title 22 Engineering Report would also be needed to satisfy SWRCB Division of Drinking Water requirements. In addition, standard construction permits including encroachment and air quality permits would also be required. Depending on whether MPMW or the District decides to be the recycled water purveyor, that agency would need to enroll under the State Water Resources Control Board General Order WQ 2016-0068-DDW for permit coverage of the distribution and use of recycled water.

All public projects in California must comply with the California Environmental Quality Act (“CEQA”). Based on a preliminary review, it is likely that the District can prepare a Mitigated Negative Declaration for the project to meet CEQA requirements. A Mitigated Negative Declaration is allowed if an Initial Study determines that impacts can be reduced to less than significant levels with implementation of mitigation measures.

Table 8.2 Estimated Recycled Water Project Costs

Description	Phase 2[1]	Phase 2 and 3[1]
Influent Facilities (Pump Station and Pipeline)[2]	$-	$-
Treatment Facilities[2]	$-	$-
Distribution Facilities (Pump Station, Storage Tank, and Pipeline)	$9,720,000	$28,211,000
Raw Construction Cost	**$9,720,000**	**$28,211,000**
Construction Contingency (30% of Raw Construction Cost)	$2,916,000	$8,464,000
Total Construction Cost	**$12,636,000**	**$36,675,000**
Implementation Cost	$3,664,000	$10,636,000
Total Capital Cost	**$16,300,000**	**$47,300,000**
Annual Cost of Distribution Facilities	$64,000	$163,000
Annual Treatment Cost	$500,000	$1,000,000
Annual Cost of Power	$16,000	$33,000
Annual Labor Costs	$18,000	$18,000
Total Annual O&M	**$598,000**	**$1,214,000**
Annualized Total Project Cost[3]	$887,000	$2,572,000
Annual O&M Costs	$598,000	$1,214,000
Annual Recycled Water Cost	$7,000	$9,000
Total Annualized Cost	**$1,492,000**	**$3,795,000**
Estimated Recycled Water Yield (AFY)	183	382
Unit Cost, Annualized ($/AF)	**$8,200**	**$9,900**

Notes:

4. Planning level estimate; costs are in September 2023 dollars.
5. These costs are not included because they are considered part of Phase 1 (the Bayfront Project).
6. Annualized at 30 years, 3.5%.

In addition to CEQA, a project is subject to National Environmental Policy Act (NEPA) if it is jointly carried out by a federal agency, requires a federal permit, entitlement, or authorization, requires federal funding, and/or occurs on federal land. The SWRCB SRF loan program is partially funded by the U.S. Environmental Protection Agency and, as a result, requires additional environmental documentation beyond CEQA – but not as extensive as NEPA – that is referred to as “CEQA-Plus.”

From a project funding and financing perspective, CEQA certification is the critical path for gaining preliminary approval for grant funding and low-interest loans from the SWRCB. From a project start-up perspective, the Engineering Report approval is the critical path for acquiring a recycled water permit from the San Francisco Bay Regional Water Quality Control Board (RWQCB), which is needed prior to start of operations. CEQA certification is also needed before the RWQCB can issue the tentative permit.

Design of the infrastructure improvements would continue after completion of the relevant preliminary studies in coordination with CEQA and permitting efforts. Applications for funding and stakeholder/public outreach efforts would occur over the lifetime of the project.

8.8 FINANCING PLAN

Typically, recycled water projects are financed through a combination of grants, partnerships relative to project benefits, and the SWRCB State Revolving Fund (SRF). There are also several bond measures currently in development in the California State Legislature that may provide additional funding streams.

Potential funding opportunities are possible for this project, including the following. These options are discussed further in the Woodard & Curran Recycled Water Program Technical Memorandum.

- US Bureau of Reclamation (USBR) WaterSMART: Title XVI Water Reclamation and Reuse Program. The Bureau of Reclamation offers three categories of WaterSMART Grants through separate funding opportunities.
- SWRCB CWSRF / Water Recycling Funding Program (WRFP). The SWRCB administers the Water Recycling Funding Program and CWSRF loans. The Water Recycling Funding Program (WRFP) has approximately $231.4 million in state-sourced grant funds and approximately $21.7 million available in state-sourced loans for construction projects. In addition, the SWRCB administers the CWSRF Loan Program, which offers low-interest loans to eligible applicants. Finally, the SWRCB administers a grant program to cover construction of recycled water facilities.
- California Infrastructure and Economic Development Bank (I-Bank) Infrastructure State Revolving Fund (ISRF) Program. The ISRF Program provides low-interest loan financing to public agencies for a wide variety of infrastructure projects. Funding is available in amounts up to $25 million with loan terms up to 30 years. The interest rate is set at the time the loan is approved. There is a one-time origination fee of 1% of the ISRF financing amount or $10,000, whichever is greater.

8.9 ADDITIONAL CONSIDERATIONS

Nonpotable reuse, as envisioned in the Bayfront area and beyond allows for the highest and best use of the District's water resource. Centralized treatment for IPR and DPR is being investigated right now by Silicon Valley Clean water for advanced treatment associated with the Regional WWTP in Redwood City. In partnership with the City of San Mateo, the SFPUC, the Water Wholesaler for much of the region, and with Cal Water, retailer in much of the Silicon Valley Clean Water and San Mateo Service areas, the Crystal Springs Purified Water project is being developed and may bring the opportunity for District to receive some of those regional benefits. These future opportunities will allow the District to potentially repurpose some of its nonpotable recycling treatment and distribution assets. But, in the meantime, investment in nonpotable reuse treatment and distribution in the District's service area provides for the best short term, and potentially long term, utilization of this precious wastewater resource.

CHAPTER 9 CAPITAL IMPROVEMENT PROGRAM

This Chapter consolidates the Capital Improvement Program ("CIP") components of Chapter 5 - Capacity Analysis, Chapter 6 - Linear Asset Management Plan, Chapter 7 - Pump Station Assessments, and Chapter 8 - Recycled Water Program. For more information about each of these planning efforts and about the individual projects listed in this consolidated CIP, please see the individual plans that are included in the respective Chapters.

The Capital Improvement Program is designed to include approximately $10 million annually in current dollars to complete the proposed projects. The first two years of the CIP include budget placeholders for projects that are in progress, as well as the projects that are discussed in this Master Plan.

Table 9.1 presents a summarized scope of work for each project. Table 9.2 presents the project costs and proposed year, designating project priority

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Table 9.1 Summarized Project Descriptions

	Project Name	Project Description
LAMP Projects	L.1. Near-term Pipe Repair Projects	Point repairs and replacements that have been planned and are being implemented by the District during the first two fiscal years of the CIP. These repairs are not included in the projects described below.
	L.2. Grade 5 Priority Basins 010, 030, 040, 050, 070AB	
	L.2.1. Priority 1 Grade 5 Defects	Projects to repair or replace pipes with Grade 5 defects that have the highest risk. The pipes all have close proximity to a waterway and other concurrent risk factors.
	L.2.2. Priority 2 Grade 5 Defects	Projects to repair or replace pipes with Grade 5 defects but lower risk. The pipes do not have proximity to a waterway but are located in the same basins as the Priority 1 Grade 5 projects.
	L.2.3. Contiguous Grade 4 Defects	Projects to repair or replace pipes with Grade 4 defects that are contiguous to the pipes listed above.
	L.3. Grade 5 Basins 020, 060, and 080 through 150	
	L.3.1. Priority 2 Grade 5 Defects	Projects to repair or replace pipes with Grade 5 defects that are located in basins without any Priority 1 Grade 5 projects.
	L.3.2. Contiguous Grade 4 Defects	Projects to repair or replace pipes with Grade 4 defects that are contiguous to the pipes listed above.
	L.4. Grade 4 Basins 020, 030, 040, 050, 070	
	L.4.1. Priority 3 Grade 4 Defects	Projects to repair or replace pipes with Grade 4 defects that have close proximity to a waterway and are not contiguous to pipes with Grade 5 defects.
	L.4.2. Other Grade 4 Defects	Projects to repair or replace pipes with Grade 4 defects that do not have proximity to a waterway but are located in the same basins as the Priority 3 Grade 4 projects.
	L.5. Grade 4 Basins 010, 060, 080, 090 through 150	
	L.5.1. Other Grade 4 Defects	Projects to repair or replace pipes with Grade 4 defects with lower risk. These projects are currently recommended for observation and to be scheduled for repair or replacement with they reach Priorities 1 through 3.
	L.6. Future Repairs and Replacements (1% per year)	This budget placeholder replaces approximately one percent of the District's 202 mile gravity pipeline inventory each year for the duration of the CIP, after the other LAMP projects have been completed.
	L.7. Middle Undercrossing	This budget placeholder is for potential costs associated with the sewer main relocation @ Middle Avenue near El Camino Real.
Capacity Improvements	C.1. Willow PS Discharge (Ivy Drive) Capacity Improvements	
	C.1.1. Interim Solution - Sealed Manholes	The District has installed one sealed manhole on structure B12029 and plans to install additional sealed manhole lids on B12141 and B12147.
	C.1.2. Long-Term Solution - Extended Forcemain	Installs 2,456 feet of pipe or liner within the existing gravity pipeline between B12029 and B13044 to create an extended forcemain and upsizes the Willow pump station pumps accordingly.
	C.2. Elena Ave and Park Lane Capacity Improvements	
	C.2.1. Flow/Level Monitoring	Installs two SmartCovers or temporary flowmeters on Elena Avenue and Park Lane to measure water levels during the 2023/24 flow monitoring season. These flows would be used to confirm whether the pipe is significantly surcharged during rainfall events as predicted by the hydraulic model.
	C.2.2. Pipeline Replacement	Upsizes the existing 8-inch gravity sewer beginning at G15030 (Park Lane near Camino al Lago) to F16049 (Elena Avenue at Atherton Avenue). The existing 10-inch siphon on Elena Avenue will remain in place.
Pump Station Improvements	P.0 Pump Station Telemetry Improvements	The District is in the process of upgrading or installing new telemetry at the pump stations. This project is in process and included in the CIP for budgeting purposes.
	P.1. Willow Pump Station Near-Term Improvements	The District is preparing design documents for improvements to the station, including a new generator, new piping from the wetwell through the valve box, new valves, and wetwell coating. The estimated construction cost for this project is included in Year 1 of the CIP.
	P.2. Stowe Lane Pump Station Improvements	The District is preparing design documents for improvements to the station, including conversion to a submersible pump station and adding a new generator. The estimated construction cost for this project is included in Year 1 of the CIP.
	P.3. Hamilton Henderson Wetwell Lining	Installs a new wetwell lining, including bypassing operations.
	P.4. FERRF Pump Station Improvements	Rehabilitation of the station including replacing existing pump drives and electrical equipment, replacing existing submersible pumps and wet well piping, replacing discharge piping valves, recoating existing piping, lining the existing concrete wet well, and cleaning/recoating the existing metal building.
	P.5. Willow, University, and Illinois Forcemain Replacements	Replace forcemain pipelines that are nearing the end of their service lives. The forcemains range in size from 6 to 10 inches and have a combined length of 3,400 feet. The Willow pump station forcemain is scheduled later in the CIP to be completed concurrently with the Willow forcemain extension project.
Other	O.1. Maintenance Building Upgrades	The District is developing an approach for upgrading the Maintenance Building. Preliminary costs are included in the CIP for budgeting purposes.
Recycled Water Projects	RW.1. Recycled Water Phase 2	Construction of a booster pump station at the intersection of Terminal Ave and Del Norte Ave, approximately 15,700 lineal feet of distribution pipeline (to augment 3,100 lineal feet of existing pipe), and a 0.5 MG storage tank.
	RW.2. Recycled Water Phase 3	Placeholder for potential costs associated with a future Phase 3 Project that involves approximately 40,700 lineal feet of distribution pipeline and an additional 1,200 lineal feet of pipeline for possible looping purposes.

Table 9.2 Capital Improvement Program

	Project	Project Cost		2024-25	2025-26	2026-27	2027-28	2028-29	2029-30	2030-31	2031-32	2032-33	2033-34	Future
LAMP Projects	L.1. Near-term Pipe Repair Projects	$8,000,000		$4,000,000	$4,000,000									
	L.2. Grade 5 Priority Basins 010, 030, 040, 050, 070AB													
	L.2.1. Priority 1 Grade 5 Defects	$284,300		$284,300										
	L.2.2. Priority 2 Grade 5 Defects	$3,651,000		$730,200	$2,190,600	$730,200								
	L.2.3. Contiguous Grade 4 Defects	$2,175,200		$435,000	$1,305,100	$435,000								
	L.3. Grade 5 Basins 020, 060, 070CD, and 080 through 150													
	L.3.1. Priority 2 Grade 5 Defects	$2,229,700				$2,229,700								
	L.3.2. Contiguous Grade 4 Defects	$672,900				$672,900								
	L.4. Grade 4 Basins 020, 030, 040, 050, 070													
	L.4.1. Priority 3 Grade 4 Defects	$1,340,000					$1,340,000							
	L.4.2. Other Grade 4 Defects	$5,925,900						$5,925,900						
	L.5. Grade 4 Basins 010, 060, 080, 090 through 150													
	L.5.1. Other Grade 4 Defects	$9,493,400						$3,164,500	$6,328,900					
	L.6. Future Repairs and Replacements (1.5% per year)	$40,282,900							$3,021,200	$10,070,700	$10,070,700	$10,070,700	$10,070,700	
	L.7 Middle Undercrossing	$500,000			$500,000									
Capacity Improvements	C.1. Willow PS Discharge (Ivy Drive) Capacity Improvements													
	C.1.1. Interim Solution	Completed												
	C.1.2. Convert Gravity Main to Extended Forcemain	$1,409,800			$704,900	$704,900								
	C.2. Elena Ave and Park Lane Capacity Improvements													
	C.2.1. Flow/Level Monitoring	$15,000		$15,000										
	C.2.2. Upsize Pipe to 10" on Elena Avenue and Park Lane	$3,675,500					$3,675,500							
Pump Station Improvements	P.0 Pump Station Telemetry Project	$600,000		$600,000										
	P.1 Willow Pump Station Near-Term Improvements	$1,700,000		$1,700,000										
	P.2 Stowe Lane Pump Station Improvements	$3,000,000		$3,000,000										
	P.3 Hamilton Henderson Wetwell Lining	$77,000			$77,000									
	P.4 FERRF Pump Station Improvements	$1,420,000			$142,000	$1,278,000								
	P.5 Willow, University, and Illinois Forceman Replacements	$2,078,000			$1,039,000	$1,039,000								
Other	Maintenance Building Upgrades	$7,000,000				$3,000,000	$4,000,000							
	Total without Recycled Water	**$47,647,700**	**Prior Allocation**	**$10,164,500**	**$9,958,600**	**$10,089,700**	**$9,015,500**	**$9,090,400**	**$9,350,100**	**$10,070,700**	**$10,070,700**	**$10,070,700**	**$10,070,700**	
Recycled Water Projects	Bayfront Phase 1 Treatment	$66,700,000	$66,700,000	↔	↔	↔								
	Recycled Water Phase 2	$16,300,000					$2,328,600	$2,328,600	$2,328,600	$2,328,600	$2,328,600	$2,328,600	$2,328,600	
	Recycled Water Phase 3	$31,000,000												$31,000,000
	Total with Recycled Water	**$94,947,700**		**$10,164,500**	**$9,958,600**	**$10,089,700**	**$11,344,100**	**$11,419,000**	**$11,678,700**	**$12,399,300**	**$12,399,300**	**$12,399,300**	**$12,399,300**	**$31,000,000**

Appendix A

2022-23 FLOW MONITORING REPORT (V&A)

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West Bay Sanitary District, CA

West Bay District 2022/2023 Wet Weather Flow Monitoring



Prepared for:	Jed Beyer Water Quality Manager West Bay Sanitary District 500 Laurel St, Menlo Park, Ca 94025
Final Report Submittal Date:	September 29th, 2023
Prepared by:	V&A consulting engineers
	V&A Project No. 22-0324

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Tables

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Abbreviations and Acronyms

Abbreviations/Acronyms	Definition
ADWF	Average Dry Weather Flow
AVG.	Average
CCTV	Closed-Circuit Television
CDEC	California Data Exchange Center
CIP	Capital Improvement Plan
CO	Carbon Monoxide
DIA.	Diameter
d/D	Depth/Diameter Ratio
FPS	Feet/Second
FT.	Feet
FM	Flow Monitor
GPD	Gallons per Day
GPM	Gallons per Minute
GWI	Groundwater Infiltration
H2S	Hydrogen Sulfide
IN.	Inch
I/I	Inflow and Infiltration
IDM	Inch-Diameter Mile
IDW	Inverse Distance Weighting
LEL	Lower Explosive Limit
MAX.	Maximum
MGD	Million Gallons per Day
MIN.	Minimum
NOAA	National Oceanic and Atmospheric Administration
N/A	Not applicable
PF	Peaking Factor
PS	Pump Station
PWS	Personal Weather Station
Q	Flow Rate

QAQC .... Quality Assurance Quality Control

RDI .... Rainfall-Dependent Infiltration

RG .... Rain Gauge

SSO .... Sanitary Sewer Overflow

V&A .... V&A Consulting Engineers, Inc.

WEF .... Water Environment Federation

WRCC .... Western Regional Climate Center

WU .... Weather Underground

Terms and Definitions

Term	Definition
Average dry weather flow (ADWF)	The average flow rate or pattern from days without noticeable inflow or infiltration response. ADWF usage patterns for weekdays and weekends differ and must be computed separately. ADWF is expressed as a numeric average and may include the influence of normal groundwater infiltration (not related to a rain event).
Basin	Sanitary sewer collection system upstream of a given location (often a flow meter), including all pipelines, inlets, and appurtenances. Also refers to the ground surface area near and enclosed by pipelines. A basin may refer to the entire collection system upstream from a flow meter or exclude separately monitored basins upstream.
Depth/diameter (*d*/*D*) ratio	Depth of water in a pipe as a fraction of the pipe's diameter. A measure of the fullness of the pipe used in the capacity analysis.
Infiltration and inflow	**Infiltration and inflow (I/I)** rates are calculated by subtracting the ADWF flow curve from the instantaneous flow measurements taken during and after a storm event. Flow in excess of the baseline consists of inflow, rainfall-responsive infiltration, and rainfall-dependent infiltration. **Combined I/I** is the total sum in gallons of additional flow attributable to a storm event.
Infiltration, groundwater	**Groundwater infiltration (GWI)** is groundwater that enters the collection system through pipe defects. GWI depends on the depth of the groundwater table above the pipelines as well as the percentage of the system that is submerged. The variation of groundwater levels and subsequent groundwater infiltration rates are seasonal by nature. On a day-to-day basis, groundwater infiltration rates are relatively steady and will not fluctuate greatly.
Infiltration, rainfall-dependent	**Rainfall-dependent infiltration (RDI)** is similar to groundwater infiltration but occurs as a result of storm water. The storm water percolates into the soil, submerges more of the pipe system, and enters through pipe defects. RDI is the slowest component of storm-related infiltration and inflow, beginning gradually and often lasting 24 hours or longer. The response time depends on the soil permeability and saturation levels.
Inflow	Inflow is defined as water discharged into the sewer system, including private sewer laterals, from direct connections such as downspouts, yard, and area drains, holes in manhole covers, cross-connections from storm drains, or catch basins. Inflow creates a peak flow problem in the sewer system and often dictates the required capacity of downstream pipes and transport facilities to carry these peak instantaneous flows. Overflows are often attributable to high inflow rates.
Peak Wet Weather Flow	The highest daily flow during and immediately after a significant storm event. Includes sanitary flow, infiltration, and inflow.
Peaking factor (PF)	PF is the ratio of peak measured flow to average dry weather flow. This ratio expresses the degree of fluctuation in flow rate over the monitoring period and is used in the capacity analysis.
Surcharge	When the flow level is higher than the crown of the pipe, then the pipeline is said to be in a **surcharged** condition. The pipeline is surcharged when the *d*/*D* ratio is greater than 1.0.

Executive Summary

Scope and Purpose

V&A Consulting Engineers (V&A) was retained by West Bay Sanitary District (District) to perform sanitary sewer flow and rainfall monitoring (with I/I analysis) within the District's collection system. The District provides wastewater collection and conveyance services to the City of Menlo Park, Atherton, and Portola Valley, and areas of East Palo Alto, Woodside, and unincorporated San Mateo and Santa Clara counties. The District conveys raw wastewater, via the Menlo Park Pump Station and force main, to Silicon Valley Clean Water (SVCW) for treatment and discharge to the San Francisco Bay.

V&A performed flow monitoring over 2 months from December 5, 2022, through February 12, 2023. Open-channel flow monitoring was conducted at 10 flow monitoring locations and data was collected at 15 permanent metering District installations. There were three general purposes of this study:

- Establish the baseline sanitary sewer flows at the flow monitoring sites
- Measure the peak flow characteristics of the subject pipes during the monitoring period
- Isolate infiltration and inflow (I/I) and run analyses pertaining to I/I response levels

Monitoring Sites and Basins

The flow monitoring site locations were selected and approved by the District and V.W. Housen and are listed in Table ES-1 and shown in Figure ES-1.

Table ES-1. List of Monitoring Sites

Monitoring Site	Manhole ID	Type	Monitored Pipe	Measured Pipe Dia (in)	Location
FM 20	M09014	Temporary	S IN	10	61 Los Trancos Rd. before Alpine Rd.
FM 30B	J11006	Temporary	S IN	10	2699 Alpine Rd.
FM 60A	H14109	Temporary	S IN	6	2122-2164 Avy Ave., Center of St.
FM 60B	H14148	Temporary	S IN	12	2122-2164 Avy Ave.
FM 70B	D16027	Temporary	S IN	6	197 Fair Oak Ln.
FM 70E	E14131	Temporary	S IN	10	Oak Grove Ave. and Pine St.
FM 80A	G14189	Temporary	SW IN	15	1435 Valparaiso Ave.
FM 80B	G14071	Temporary	NW IN	15	Sidewalk, Olive St. and Santa Cruz Ave.
FM 90	G13222	Temporary	SW IN	24	Middle Ave. and Hobart St.
FM 120A	C14036	Temporary	SW IN	10	Past gate at the end of Sheridan Dr., north corner of the empty lot.
FM 010	K10023	Permanent	S IN	15	1945 Oak Ave.

Monitoring Site	Manhole ID	Type	Monitored Pipe	Measured Pipe Dia (in)	Location
FM 30A	I2085	Permanent	S IN	21	SW of Ansel Ln. & Alpine Rd.
FM 40	H12065	Permanent	S IN	36	3300 Alpine Rd.
FM 50N	H16023	Permanent	SW IN	10	291 Atherton Ave.
FM 50S	H15134	Permanent	SW IN	15	321 Walsh Rd.
FM 70A	F16032	Permanent	SW IN	18	82 Atherton Ave.
FM 70C	E15047	Permanent	SW IN	17.625	65 McCormick Ln.
FM 70D	D15128	Permanent	SE IN	21	Middlefield b/w Marsh & Watkins
FM 100A	E14053	Permanent	SW IN	12	445 Oak Grove Ave.
FM 100B	E12158	Permanent	SW IN	23.25	25 Willow Rd.
FM 110A	B16004	Permanent	SW IN	23.5	3715 Haven Ave.
FM 120B	C13029	Permanent	W IN	15	Int of Hamilton Ave. and Hill Ave.
FM 130	C12089	Permanent	S IN	24.75	1018 Hollyburn Ave.
FM 140	B15047	Permanent	E IN	30	Bedwell Bayfront Park
FM 150	B13043	Permanent	SE IN	15	1334 Chilco St.

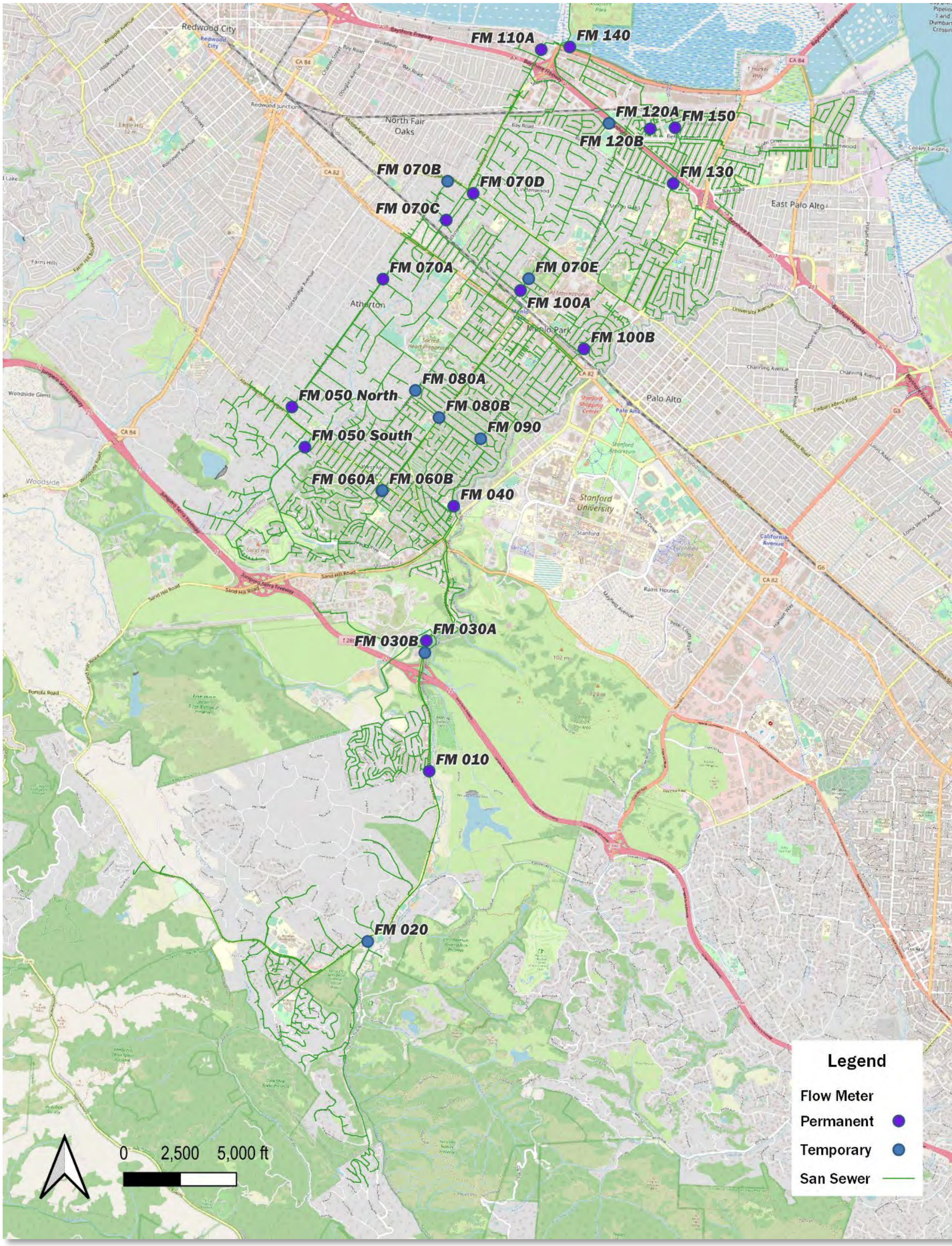


Figure ES-1. Map of Flow Monitoring Sites

Rainfall Monitoring

There were multiple rainfall events during this study that elicited solid I/I responses, as illustrated in Figure ES-2. Minor rainfall (>1 inch) on 12/02/23 and 12/04/23 proceeded the flow monitor installation on 12/05/23. Data did not indicate a significant increase in baseline flows.

A total of 19.88 inches of rainfall was recorded over the monitoring period. The highest rainfall intensity measured was 0.83 inches/hour on 12/30/22. This event saw 4.52 inches of rainfall over 20.75 hrs and has a return period of approximately 50 years based upon the depth of rainfall.

Monitored rainfall was plotted against the historical average rainfall. When this historical data is compared to the recorded rainfall, we see that cumulative precipitation was approximately 275% of historical precipitation.

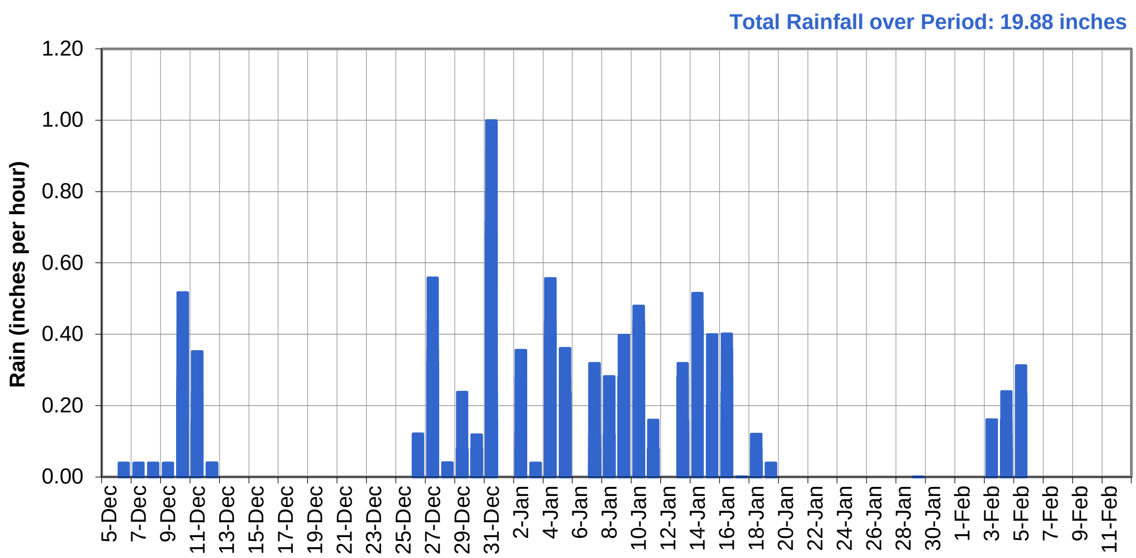


Figure ES-2. Rainfall Monitoring

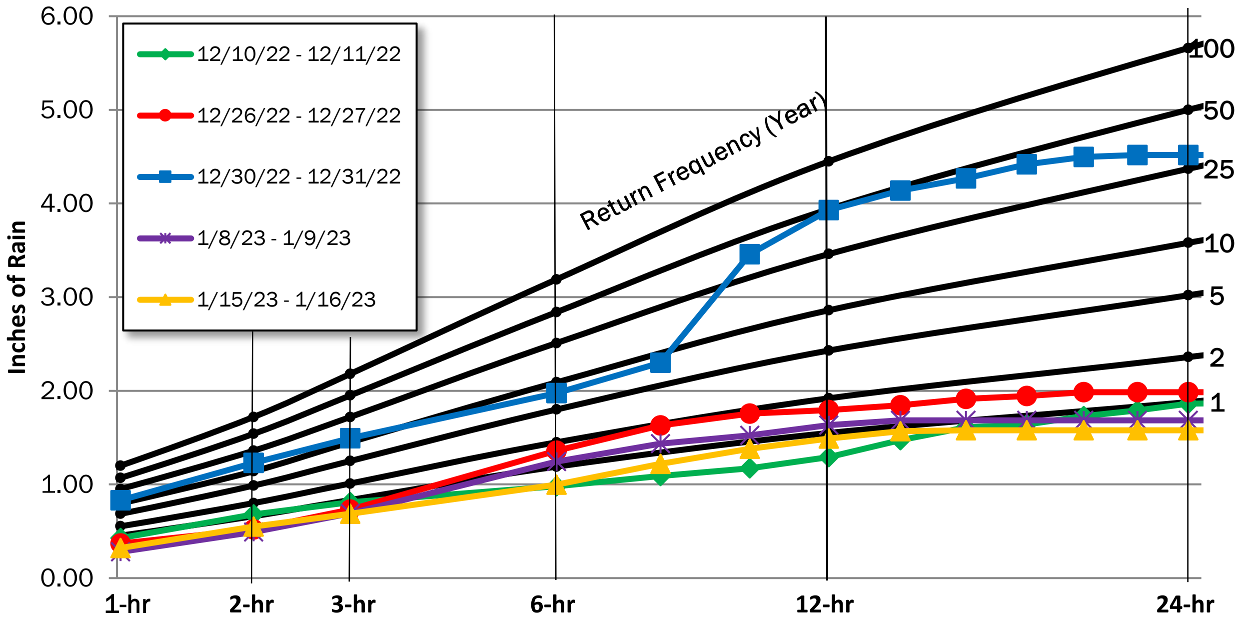


Figure ES-3. Rainfall Event Classification – 24-Hour Period

Site Flow Monitoring and Capacity Results

The flow monitoring program was successful in capturing both dry and wet weather flow data. Average dry weather flow (ADWF) curves were established during dry days when inflow and infiltration (I/I) had the least impact on the baseline flow. The following dry weather items relating to capacity are noted:

- **Sediment**: Site FM 080B was the only site with noted sediment. Site FM 080B appears to have mostly stagnant flow with little to no velocity.
- **d/D**: Average d/D ratios ranged from 0 – 0.51.

Peak measured flows and the hydraulic grade line data (flow depths) are important to understanding the capacity limitations of a collection system. The peak flows and flow levels are the peak measurements taken across the entirety of the flow monitoring period. For this study, peak flows and peak levels corresponded to rainfall events. The following capacity analysis definitions will be used:

- **Peaking Factor (PF)** is defined as the peak measured flow divided by the average dry weather flow (ADWF). Peaking factors are influenced by many factors including size and topography of the tributary area, flow attenuation, flow restrictions, characteristics of I/I entering the collection system, and hydraulic features such as pump stations.
  - For this report, PF > 7 is highlighted in ***RED***[1]; however, the District should refer to District standards when evaluating peaking factors. Peaking factor data should be used at the discretion of the District Engineer.
- **d/D Ratio** is the peak measured depth of flow (d) divided by the pipe diameter (D). The d/D ratio for each site is computed based on the maximum depth of flow for the study. Standards for the d/D ratio vary from agency to agency but typically range between d/D ≤ 0.5 and d/D ≤ 0.75
  - For this report, d/D ratios > 0.75 are highlighted in ***RED***; however, the District should refer to District standards when evaluating d/D ratios, to be used at the discretion of the District Engineer.

Table ES-2 summarizes the peak recorded flows, depths, *d/D* ratios, and peaking factors per site during the flow monitoring period. Capacity analysis data are presented on a site-by-site basis and represent the hydraulic conditions only at the site locations; hydraulic conditions in other areas of the collection system will differ. Figure ES-4 and Figure ES-5 show bar graph summaries of the peaking factors and d/D ratios, respectively.

The following capacity analysis results are noted:

- <u>Peaking Factors</u>
  - Most of the sites had wet-to-dry weather peaking factors greater than 7. Only sites FM 030B, FM 050 N, FM 070B, FM 110A, and FM 120A did not. The majority of the peak wet-weather flow occurred during the 12/31/22 event.
  - Several basins had extremely high PF's (PF's > 20). Upon further review, there is the potential for velocity anomalies at each of the 3 sites that occurred during the 12/31/22, and 1/1/23, events. However, no adjustments were made as these velocity spikes coincided with a substantial depth response and a wet-weather event.

[1] WEF Manual of Practice FD-6 and ASCE Manual No. 62 suggests typical peaking factor ratios range between 3 and 4, with higher values possibly indicative of pronounced I/I flows.

- d/D Ratio:
  - d/D > 0.75: Site FM 070C had a d/D ratio of greater than 0.75.
  - d/D > 1 (surcharge): Sites FM 070A, FM 070D, FM 080B, FM 100B, FM 110A, FM 140, and FM 150 had d/D ratios greater than 1.

Table ES-2. Capacity Analysis Summary

Site	ADWF (MGD)	Peak Measured Flow (MGD)	Peaking Factor	Pipe Diameter, *D* (IN)	Max Depth, *d* (IN)	Max d/D Ratio	Surcharge above pipe crown (FT)
FM 020	0.024	0.319	*13.4*	10	3.61	0.36	-
FM 030B	0.000	0.122	-	10	3.85	0.38	-
FM 060A	0.007	0.127	*18.4*	6	1.68	0.28	-
FM 060B	0.051	0.880	*17.4*	12	3.35	0.28	-
FM 070B	0.033	0.104	3.2	10	3.57	0.36	-
FM 070E	0.083	0.801	*9.6*	10	6.75	0.68	-
FM 080A	0.089	1.210	*13.5*	15	7.27	0.48	-
FM 080B	0.062	12.38	*200.6*	15	31.27	*2.08*	*1.4*
FM 090	0.438	7.036	*16.1*	24	16.44	0.68	-
FM 120A	0.071	0.430	6.1	10	6.41	0.64	-
FM 010	0.191	1.802	*9.5*	15	6.43	0.43	-
FM 030A	0.166	2.98	*18.0*	21	10.26	0.49	-
FM 040	0.282	4.25	*15.1*	36	14.79	0.41	-
FM 050N	0.074	0.374	5.1	10	5.69	0.57	-
FM 050S	0.242	1.943	*8.0*	15	10.77	0.72	-
FM 070A	0.558	5.507	*9.9*	18	18.93	*1.05*	*0.1*
FM 070C	0.211	1.977	*9.4*	17.625	16.17	*0.92*	-
FM 070D	0.534	12.04	*22.6*	21	25.54	*1.22*	*0.4*
FM 100A	0.155	1.593	*10.3*	12	8.32	0.69	-
FM 100B	0.524	22.17	*42.3*	23.25	23.62	*1.02*	*0.03*
FM 110A	1.131	5.924	5.2	23.5	23.44	*1.00*	*0.00*
FM 120B	0.120	1.064	*8.8*	15	7.78	0.52	-
FM 130	1.284	10.24	*8.0*	24.75	12.08	0.49	-
FM 140	0.891	6.854	*7.7*	30	35.63	*1.19*	*0.5*
FM 150	0.269	3.276	*12.2*	15	21.68	*1.45*	*0.6*

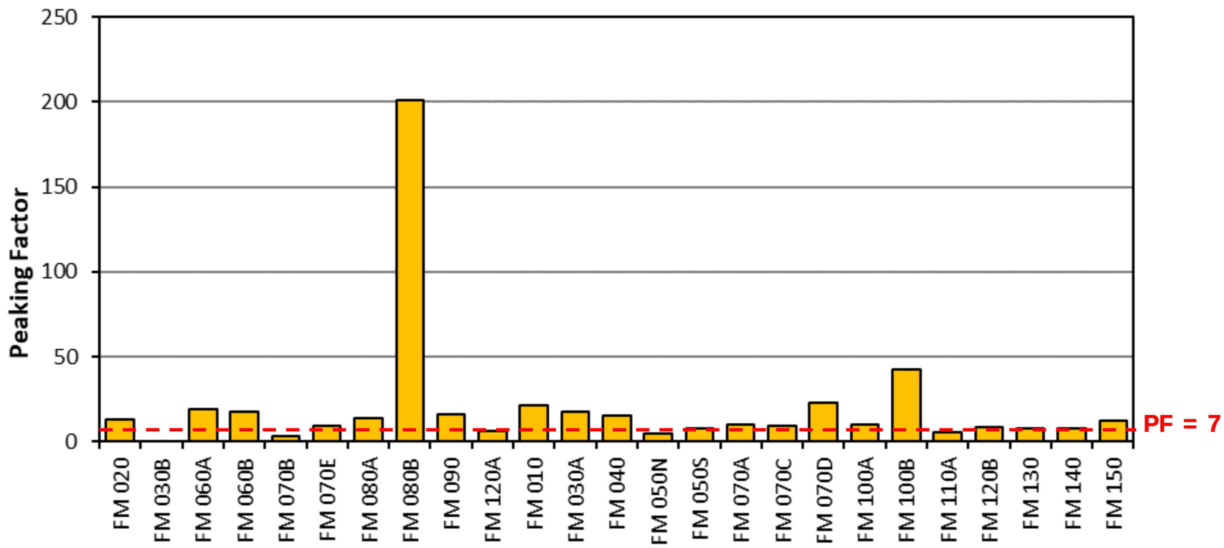


Figure ES-4. Peaking Factors

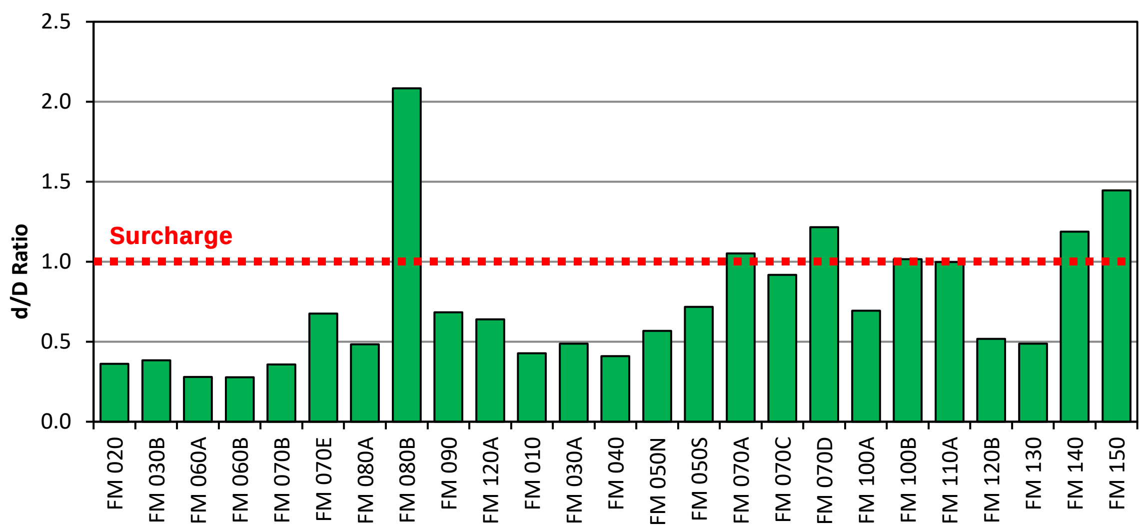


Figure ES-5. Capacity Summary: Max d/D Ratios

Infiltration and Inflow Analysis

Table ES-3 summarizes the I/I results for this study. The "Top 3" basins for each category have been shaded in *RED*. Please refer to the I/I Methods section for more information on inflow and infiltration analysis methods and ranking methods. Temperature maps for the ranked inflow, RDI, Total I/I, and GWI response metrics are shown in Figure ES-6, Figure ES-7, Figure ES-8, and Figure ES-9. The following infiltration and inflow results are noted:

- **Inflow**:
  - Inflow for meter sites FM 030B, FM 070B, and FM 080B was not calculated due to lack of or poor/missing flow conditions. Some sites had substantial spikes in velocity due to or following wet-weather events which yielded substantial spikes in flow. These may or may not be erroneous data and more collection system data is required to confirm or disprove these responses. These sites include FM 080B, FM 070D, FM 100B, and FM 150.
  - It is noted that there are mass flow balance issues where basins 40, 70S, 100, 120E are showing a potential loss in flow during wet-weather.
  - Basin 140 had the highest weighted individual inflow rate of 5.076 mgd. However, it should be noted that, as mentioned in Section 3.2.2, sites FM 070A, FM 070D, FM 080B, FM 100B, FM 110A, FM 140, and FM 150 surcharged during the 12/31/22 event where peak flow would have been restricted.
  - Basin 90 ranked the highest based on inflow per-ADWF and highest overall.
  - Basin 140 ranked the highest based on inflow per IDM and inflow per-Acre.
- **RDI**:
  - RDI for meter sites FM 030B, FM 070B, and FM 080B was not calculated due to lack of or poor/missing flow conditions.
  - It is noted that there are mass flow balance issues where Basins 40, 70S, 100, 120E are showing a potential loss in flow during wet-weather.
  - Basin 90 had the highest RDI rate at 0.360 mgd and ranked highest based upon RDI per-IDM, per-ADWF, and RDI per-Acre.
  - The "Top 3" ranked basin according to RDI, in order from 1st to 3rd, are 90, 30, 50N.
- **Combined I/I**:
  - Basin 90 saw the highest % of rainwater entering the collection at 40.1%. Basin 90 also ranked highest based on total I/I per acre and I/I per IDM. Basins 050N and 080 ranked 2nd and 3rd respectively for total I/I.
  - Combined I/I for meter sites FM 030B, FM 070B, and FM 080B was not calculated due to lack of or poor/missing flow conditions.
  - It is noted that there are mass flow balance issues where basins 40, 70S, 100, 120E are showing a potential loss in flow during wet-weather.
- **Groundwater Infiltration**:
  - 8 Sites, corresponding to 6 Basins, have ratios that indicated groundwater may be entering the collection system with higher than average low-ADWF ratios. These sites include FM 020, FM 070A, FM 070B, FM 070C, FM 070E, FM 080B, FM 110A, and FM 140.

Table ES-3. I/I Analysis Summary

Basin ID	ADWF (mgd)	Peak Inflow Rate (mgd)	RDI Rate (mgd)	Combined I/I (gallons)	R-Value	Inflow Rank	RDI Rank	Combined I/I Rank	Possible high GWI?
10	0.06	1.605	0.064	619,868	1.1%	10	12	12	Normal
20	0.02	0.325	0.063	631,458	4.3%	12	6	8	Yes
30	0.08	1.259	0.186	1,493,324	9.5%	5	2	5	Normal
40*	0.12	-0.362	-0.016	-1,589,363	-12.5%	15	17	17	Normal
50N	0.07	0.822	0.122	1,021,807	9.6%	8	3	2	Normal
50S	0.24	1.368	0.136	910,184	6.5%	6	5	9	Normal
60	0.06	0.697	0.070	571,406	6.5%	7	7	7	Normal
70N	0.24	2.126	0.217	1,206,942	4.4%	11	9	11	Yes
70S*	0.05	-2.572	-0.279	-2,397,095	-14.1%	18	18	18	Yes
80	0.15	1.032	0.096	1,075,605	12.4%	9	4	3	Yes
90	0.04	2.675	0.360	4,577,330	40.1%	1	1	1	Normal
100*	0.24	-1.762	0.155	241,118	1.3%	17	10	14	Normal
110	0.35	1.090	0.126	1,876,243	11.4%	13	11	4	Yes
120E*	-0.49	-3.343	-0.817	-6,529,434	-50.5%	16	14	15	Normal
120W	0.07	0.271	0.005	37,964	0.5%	14	16	16	Normal
130	0.76	3.962	0.046	807,506	3.4%	3	15	13	Normal
140	0.50	5.076	0.110	1,965,269	12.9%	2	13	6	Yes
150	0.27	2.379	0.164	1,319,874	9.0%	4	8	10	Normal

*Flow not adding up as it travels downstream.

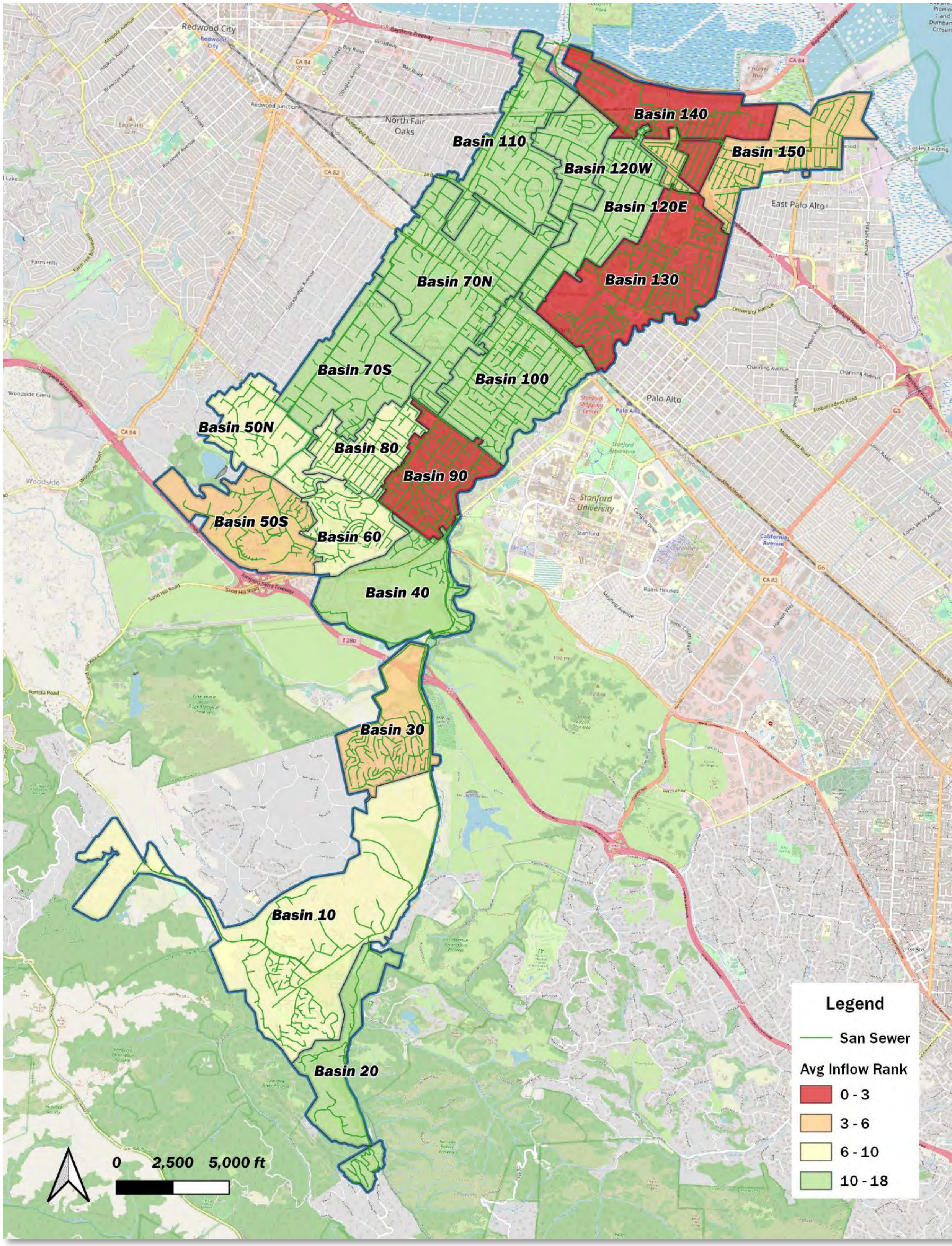


Figure ES-6. Temperature Map: Inflow Final Basin Rankings

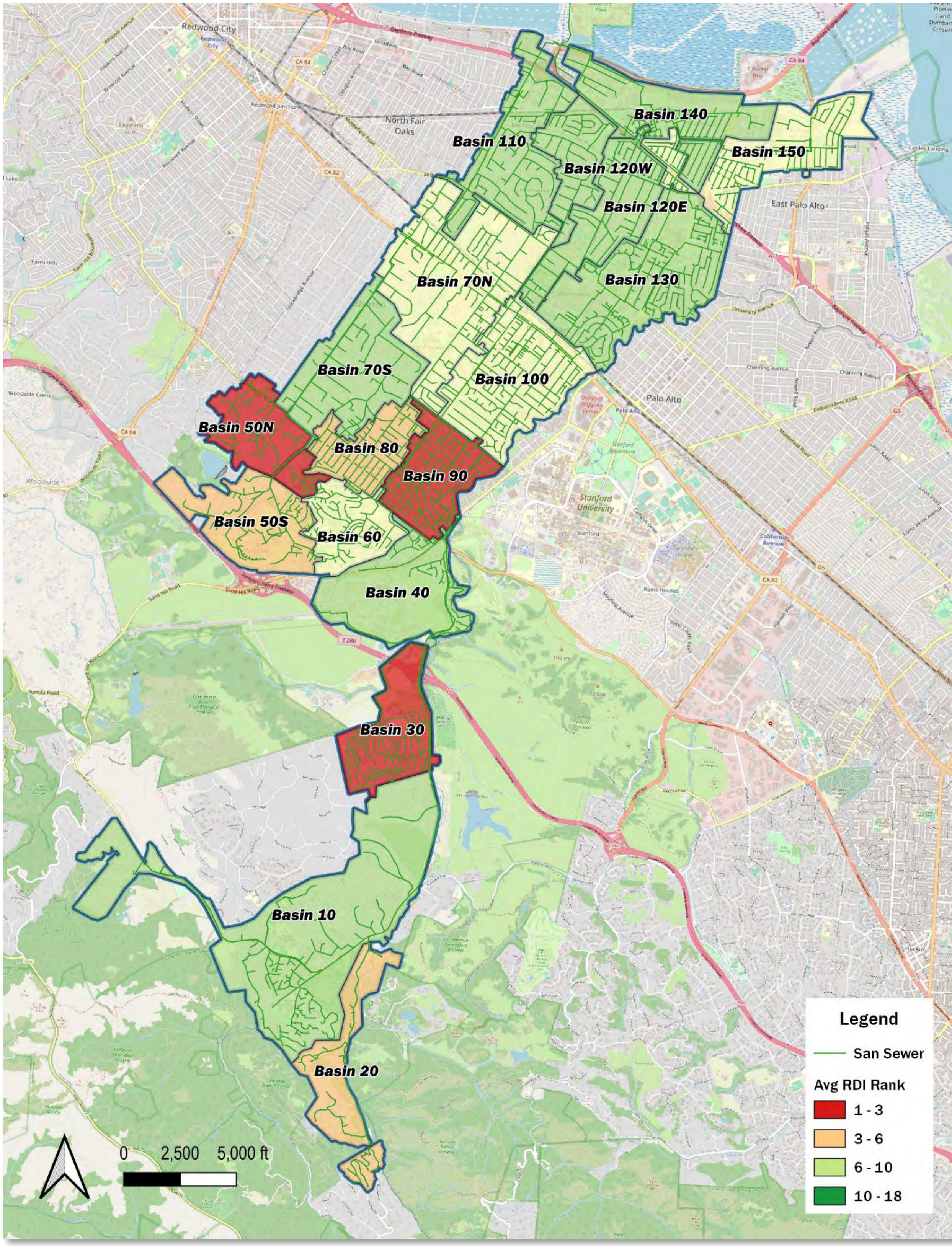


Figure ES-7. Temperature Map: RDI Final Basin Rankings

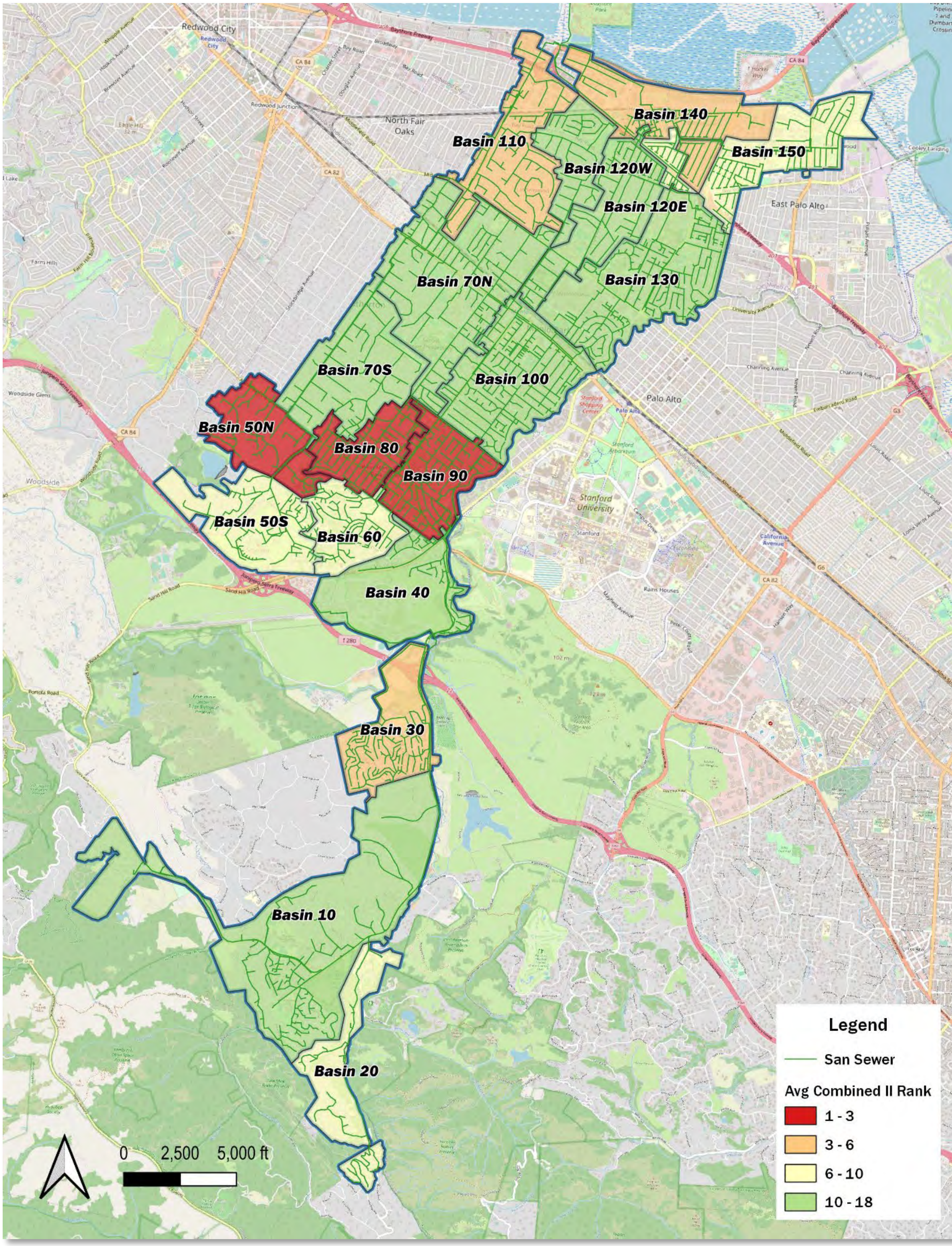


Figure ES-8. Temperature Map: Combined I/I Final Basin Rankings

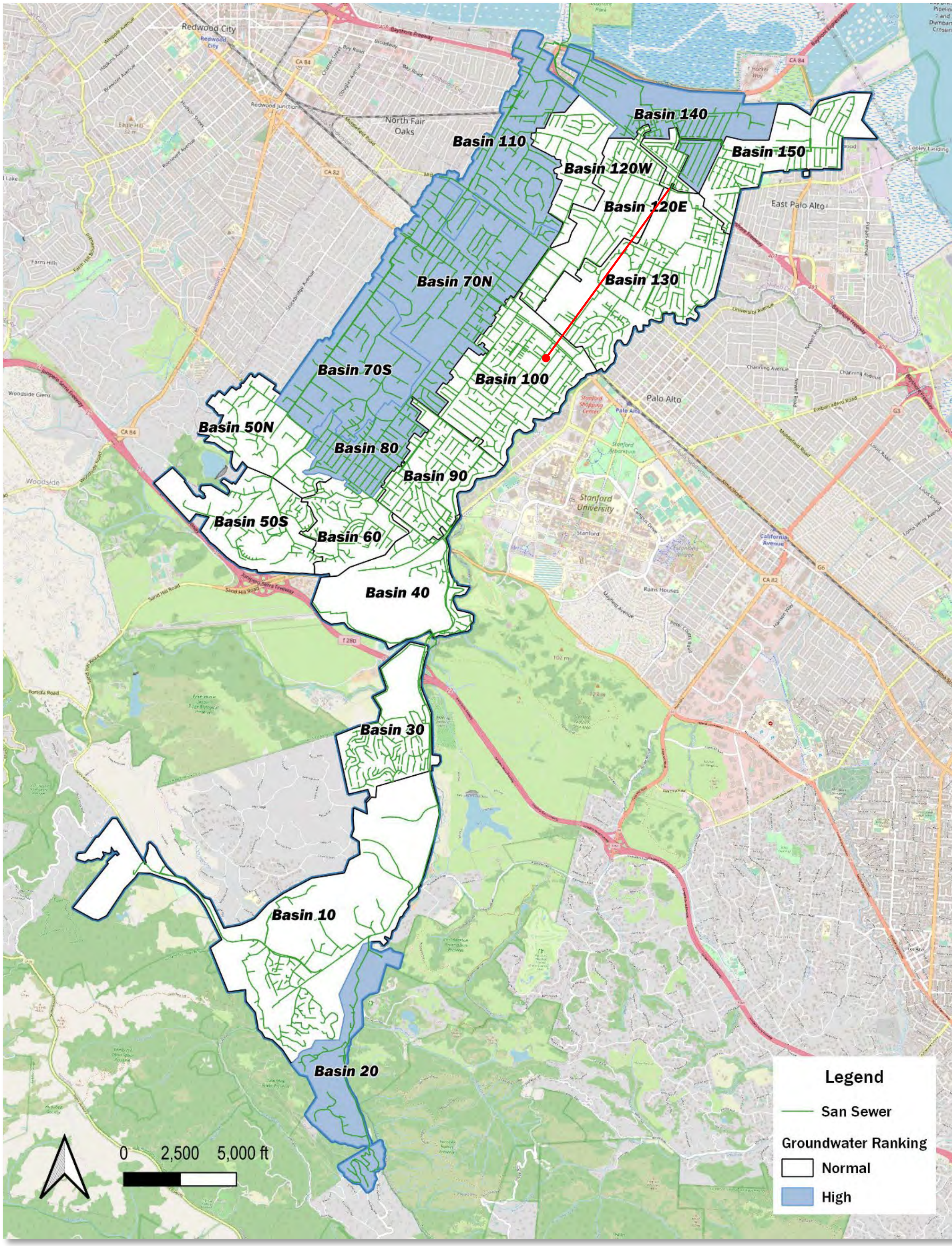


Figure ES-9. Temperature Map: Basins with Potentially High GWI

Recommendations

V&A advises that future I/I reduction plans consider the following recommendations:

1. **Master Plan and Model Implementation**: This study focuses on inflow and infiltration generation; the study results can be used to update the master plan and compare it with previous model assumptions and flow monitoring results.
2. **Verify Interconnections and Overflows**: Understanding the interconnections and overflows can help with the master plan, basin isolation, and I/I analysis. Multiple basin cross-connections exist which may be affecting flow analysis. These cross-connections should be field verified to determine where, and how much, flow is going through each basin.
    a. Mass flow balance issues were noted during this study. It is recommended that system characterization work be performed to identify, during both and wet-weather, manholes where flow could potentially be diverted to other areas of the system. Invert measurements and pipe connections should be verified, and basin flow responses (dry and wet) adjusted as appropriate.
3. **Capacity Analysis**: 8 sites were surcharged during the monitoring period during a 50-year storm event. It should also be noted that multiple rainfall events preceded the 12/31/22 event which would have saturated the soil and made the 12/31/22 system response more pronounced than for a single isolated wet-weather event. The calculated return period for this event is a triangulated average to the Study Area centroid; individual basins would have experienced rainfall with a slightly higher or lower return period. It is assumed that during the hydraulic modeling portion of this study that system capacity constraints for the design storm event will be identified and added to the capital improvement plan in the updated master plan. The following possible capacity concerns are noted:
    a. **Dry weather**: No issues with dry weather flow were noted. The highest d/D ratio noted was 0.51 at site FM 080B. All remaining sites ranged from 0 to 0.33.
    b. **Wet Weather**: The monitoring data indicates that meter sites FM 070A, FM 070D, FM 080B, FM 100B, FM 110A, FM 140, and FM 150 would lack capacity during a 50-storm event, as noted during the 12/31/22 storm event. Max d/D ratios ranged from 1 – 2.08 at these sites.
4. **Determine I/I Reduction Program**: The District should examine its I/I reduction needs to determine its goals for a future I/I reduction program.
    a. If peak flows, sanitary sewer overflows and pipeline capacity issues are of greater concern, then priority can be given to investigate and reduce sources of inflow within the basins with the greatest inflow problems. The highest-ranked basins according to inflow are 90, 140, and 130.
    b. If total infiltration and general pipeline deterioration are of greater concern, then the program can be weighted to investigate and reduce sources of infiltration within the basins with the greatest infiltration problems. The highest basins according to RDI are 090, 030, and 050N. Additionally, basins 20, 70N, 70S, 80, 110, and 140 may show evidence of excessive GWI.
5. **I/I Investigation Methods**: Potential I/I investigation methods include the following:
    a. Smoke testing.
    b. Manhole inspections
    c. Private building evaluations

d. Night-time[2] reconnaissance work to (1) investigate and determine direct point sources of inflow, and (2) determine the areas and/or pipe reaches responsible for high levels of infiltration contribution.

e. CCTV inspection.

f. Dye Testing: Dye testing can be performed to confirm connectivity or to indicate the extent of I/I entering the system.

6. **I/I Reduction Cost Effective Analysis**: The District should conduct a study to determine which is more cost-effective: (1) locating the sources of inflow/infiltration and systematically rehabilitating or replacing the faulty pipelines; or (2) continued treatment of the additional rainfall dependent I/I flow.

[2] Reconnaissance work is conducted during low-flow hours, typically between 12:00 A.M. and 4:30 A.M., to best differentiate and identify I/I contribution from sanitary flows.

1 Introduction

1.1 Scope and Purpose

V&A Consulting Engineers (V&A) was retained by West Bay Sanitary District (District) to perform sanitary sewer flow and rainfall monitoring (with I/I analysis) within the District's collection system. The District provides wastewater collection and conveyance services to the City of Menlo Park, Atherton, and Portola Valley, and areas of East Palo Alto, Woodside, and unincorporated San Mateo and Santa Clara counties. The District conveys raw wastewater, via the Menlo Park Pump Station and force main, to Silicon Valley Clean Water (SVCW) for treatment and discharge to the San Francisco Bay. Figure 1-1 shows the Districts service area.

Figure 1-1: District Service Area

Flow monitoring was performed over 2 months from 12/5/22, through 2/12/23. Open-channel flow monitoring was conducted at 10 flow monitoring locations and data was collected at 15 permanent metering District installations. There were three general purposes of this study:

- Establish the baseline sanitary sewer flows at the flow monitoring sites
- Measure the peak flow characteristics of the subject pipes during the monitoring period
- Isolate infiltration and inflow (I/I) and run analyses pertaining to I/I response levels

1.2 Flow Monitoring Sites and Isolated Sewerage Basins

Flow monitoring sites are defined as the manholes where flow monitors are secured and the pipelines in which flow sensors are placed. Capacity analysis and flow rate information are presented on a site-by-site basis. The flow monitoring sites were selected and approved by V.W. Housen and the District. Information regarding the flow monitoring locations is listed in Table 1-1 and illustrated in Figure 1-2. Detailed descriptions of the individual flow monitoring sites, including photographs, are included in Appendix A.

V&A proposed 10 new flow meters be used in conjunction with the existing 15 flow meters to isolate flow sewerage basins within the District collection system, and that also mostly conforms with the basins as already defined.

Flow monitoring site data may include the flows of one or many drainage basins. Flow monitoring basins are localized areas of a sanitary sewer collection system upstream of a given location (often a flow meter), including all pipelines, inlets, and appurtenances. The basin refers to the ground surface area near and enclosed by the pipelines. A basin may refer to the entire collection system upstream from a flow meter or may exclude separately monitored basins upstream, requiring basin isolation (subtraction of upstream flows). The I/I analysis results will be presented on an isolated basin basis. The basins, basin attributes, and basin isolation equations are listed in Table 1-2 and shown in Figure 1-3. Rain gauge locations about the drainage basins are also shown in Figure 1-3. The following notes regarding basin isolations are noted:

- Basin 10: Uses existing Flow Meter 010 (Site 7 flow meter on 15" line) that will capture approximately 120% of the original 10 basins (the northwest portion of the original 20 basin flows into Basin 10)
- Basin 20: New Flow Meter 020 (expected 10" line) that will capture approximately 70% of the original 020 basin. The northwest portion of the original 020 basin flows into Basin 010. The single flow meter will be stand-alone and capture the entirety of the proposed basin area. Basin 020 Isolation = FM 020
- Basin 30: Uses existing Flow Meter 030A (Site 8 Alpine on 21" line) and includes new Flow Meter 030B (expected 10" line) that will capture approximately 110% of the original 30 basins. There is a possible split near the downstream northeast corner of the original 30 basin – to properly capture this basin another flow meter (or possible plug) is included to capture the entirety of the basin including possible split/overflow situations. Basin 30 Isolation = FM 030A + FM 030B – FM 010.
- Basin 40: Proposed new Flow Meter 040 (expected 36" line) that will capture approximately 120% of the original 40 basin. This line is after an upstream split and should capture the basin shown as a whole. There are possible overflow relief lines that need to be investigated to confirm basin isolation (Leland and Stanford Ave near Sand Hill) Basin 40 Isolation = FM 040 – (FM 030A + FM 030B).
- Basin 50: Uses existing Flow Meter 050 South (Site 14 Walsh on 15" line) and uses existing Flow Meter 050 North (Site 13 Atherton/Mulberry on 10" line) that captures ~100% of the original 50 basin, but naturally splits the basin into north and south sub-basins based on existing flow meter locations. A potential cross-connection needs to be confirmed to be inactive. Basin 50 North Isolation = FM 050 North. Basin 50 South Isolation = FM 050 South.
- Basin 60: Propose new flow meters 060A (expecting 6" line) and 060B (expecting 12" line) that will capture ~85% of the original 60 basins. There currently are no WBSD meters that measure near this basin. There appears to be a possible split at Altschul/Avy that necessitates the use of two flow meters to meter this basin. It's possible a plug could be utilized as well to achieve basin isolation. Small portions of the east and northwest regions of the original basin flow out to other neighboring basins. Basin 60 Isolation = FM 060A + FM 060B.

- Basin 70N: Uses existing Flow Meter 070A (Site 15 Atherton/Stevenson on 18” line) to isolate Basin 70 North. Basin 70 North Isolation = FM 070A – (FM 050A + FM 050B)
- Basin 70S: Uses existing Flow Meter 070C (Site 10 Burns/McCormick on 17.625” line), existing Flow Meter 070D (Site 9 Middlefield on 21” line) and proposed new Flow Meter 070B (expected 10” line) and new Flow Meter 070E (possible overflow inlet condition to the basin on 12” line) to isolate Basin 70 South. Basin 70 South Isolation = (FM 070B + FM 070C + FM 070D) – (FM 070A + FM 070E + FM 080A). Proposed locations will measure ~120% of the original Basin 70 (which intrudes north into Basin 110).
- Basin 80: Propose new flow meters 080A (expecting 15” line) and 080B (expecting 16” line) that will capture ~95% of the original 80 basins. There currently are no WBSD meters that measure near this basin. There appears to be a split at Valparaiso, just north of Politzer Drive that necessitates the use of two flow meters to meter this basin. A possible overflow at Barney and A Los Cerros should be confirmed. Basin 80 Isolation = FM 080A + FM 080B.
- Basin 90: Propose a new flow meter 090 (expecting a 24” line) that will capture ~100% of the original 90 basins. Basin 90 Isolation = FM 090 – (FM 040 + FM 060A + FM 060B + FM 080B).
- Basin 100: Uses existing flow meters 100A (Site 12 Oak Grove on 12” line) and 100B (Site 6 Willow on 23.25” line) that will capture ~100% of the original 100 basins. Basin 100 Isolation = FM 100A + FM 100B – FM 090. Possible cross-basin connections on Arbor, San Mateo, and University for review.
- Basin 110: Uses existing Flow Meter 110 (Site 1 Haven on 23.5” line) to isolate Basin 110, capturing ~85% of the original 110 Basin. Basin 110 Isolation = FM 110 – (FM 070B + FM 070C + FM 070D).
- Basin 120W: Propose new FM 120A (expected 10”) to directly monitor Basin 120 West. Basin 120 West Isolated = FM 120A
- Basin 120E: Use existing FM 120B (Site 3 Hamilton/Hill on 15” line) to measure Basin 120 East. Both meters will capture ~100% of the original 120 basin. Basin 120 East Isolated = FM 120B – (FM 100A – FM 070E [overflow]).
- Basin 130: Uses existing FM 130 (Site 5 Hollyburne on 24.75” line) that will capture ~100% of the original 130 basin. Basin 130 Isolation = FM 130 – FM 100B.
- Basin 140: Uses existing FM 140 (Site 2 Levee on 30” line) that will capture ~95% of the original 140 basin. Basin 140 Isolation = FM 140 – (FM 120B + FM 150). Check overflow at Pierce and Hollyburne.
- Basin 150: Uses existing FM 150 (Site 4 Chilco on 15” line) that will capture ~120% of the original 150 basin. Basin 150 Isolation = FM 150. Check overflow at Pierce and Hollyburne.

Table 1-1. List of Monitoring Locations

Monitoring Site	Manhole ID	Type	Monitored Pipe	Measured Pipe Dia (in)	Location
FM 20	M09014	Temporary	S IN	10	61 Los Trancos Rd. before Alpine Rd.
FM 30B	J11006	Temporary	S IN	10	2699 Alpine Rd.
FM 60A	H14109	Temporary	S IN	6	2122-2164 Avy Ave., Center of St.
FM 60B	H14148	Temporary	S IN	12	2122-2164 Avy Ave.

Monitoring Site	Manhole ID	Type	Monitored Pipe	Measured Pipe Dia (in)	Location
FM 70B	D16027	Temporary	S IN	6	197 Fair Oak Ln.
FM 70E	E14131	Temporary	S IN	10	Oak Grove Ave. and Pine St.
FM 80A	G14189	Temporary	SW IN	15	1435 Valparaiso Ave.
FM 80B	G14071	Temporary	NW IN	15	Sidewalk, Olive St. and Santa Cruz Ave.
FM 90	G13222	Temporary	SW IN	24	Middle Ave. and Hobart St.
FM 120A	C14036	Temporary	SW IN	10	Past gate at the end of Sheridan Dr., north corner of the empty lot.
FM 010	K10023	Permanent	S IN	15	1945 Oak Ave.
FM 30A	I2085	Permanent	S IN	21	SW of Ansel Ln. & Alpine Rd.
FM 40	H12065	Permanent	S IN	36	3300 Alpine Rd.
FM 50N	H16023	Permanent	SW IN	10	291 Atherton Ave.
FM 50S	H15134	Permanent	SW IN	15	321 Walsh Rd.
FM 70A	F16032	Permanent	SW IN	18	82 Atherton Ave.
FM 70C	E15047	Permanent	SW IN	17.625	65 McCormick Ln.
FM 70D	D15128	Permanent	SE IN	21	Middlefield b/w Marsh & Watkins
FM 100A	E14053	Permanent	SW IN	12	445 Oak Grove Ave.
FM 100B	E12158	Permanent	SW IN	23.25	25 Willow Rd.
FM 110A	B16004	Permanent	SW IN	23.5	3715 Haven Ave.
FM 120B	C13029	Permanent	W IN	15	Int of Hamilton Ave. and Hill Ave.
FM 130	C12089	Permanent	S IN	24.75	1018 Hollyburn Ave.
FM 140	B15047	Permanent	E IN	30	Bedwell Bayfront Park
FM 150	B13043	Permanent	SE IN	15	1334 Chilco St.

NW = Northwest, SW = Southwest, NE = Northeast, SW = Southwest, IN = influent

Table 1-2. Isolated Flow Monitoring Basin Characteristics

Monitoring Site ID	Sub-Basin ID	Basin ID	Basin Flow Isolation Calculation	Basin Area (Acres)
FM 010	10	10	$Q_{10} - Q_{20}$	1,463
FM 020	20	20	Q_{20}	372
FM 030A	30A	30	$Q_{30A} + Q_{30B} - Q_{10}$	393
FM 030B	30B	30	$Q_{30A} + Q_{30B} - Q_{10}$	393
FM 040	40	40	$Q_{40} - (Q_{30A} + Q_{30B})$	526
FM 050N	50N	50	Q_{50N}	348
FM 050S	50S	50	Q_{50S}	456
FM 060A	60A	60	$Q_{60A} + Q_{60B}$	285
FM 060B	60B	60	$Q_{60A} + Q_{60B}$	285
FM 070A	70A	70N	$Q_{70A} - (Q_{50A} + Q_{50B})$	556
FM 070B	70B	70S	$(Q_{70B} + Q_{70C} + Q_{70D}) - (Q_{70A} + Q_{70E} + Q_{80A})$	897
FM 070C	70C	70S	$(Q_{70B} + Q_{70C} + Q_{70D}) - (Q_{70A} + Q_{70E} + Q_{80A})$	897
FM 070D	70D	70S	$(Q_{70B} + Q_{70C} + Q_{70D}) - (Q_{70A} + Q_{70E} + Q_{80A})$	897
FM 070E	70E	70S	$(Q_{70B} + Q_{70C} + Q_{70D}) - (Q_{70A} + Q_{70E} + Q_{80A})$	897
FM 080A	80A	80	$Q_{80A} + Q_{80B}$	284
FM 080B	80B	80	$Q_{80A} + Q_{80B}$	284
FM 090	90	90	$Q_{90} - (Q_{40} + Q_{60A} + Q_{60B} + Q_{80B})$	373
FM 100A	100A	100	$Q_{100A} + Q_{100B} - Q_{90}$	619
FM 100B	100B	100	$Q_{100A} + Q_{100B} - Q_{90}$	619
FM 110A	110	110	$Q_{110} - (Q_{70B} - Q_{70C} + Q_{70D})$	539
FM 120A	120W	120	Q_{120}	272
FM 120B	120E	120	$Q_{120} - (Q_{100B} - Q_{70E\ OVERFLOW})$	422
FM 130	130	130	$Q_{130} - Q_{100B}$	774
FM 140	140	140	$Q_{140} - (Q_{120B} + Q_{150})$	499
FM 150	150	150	Q_{150}	478

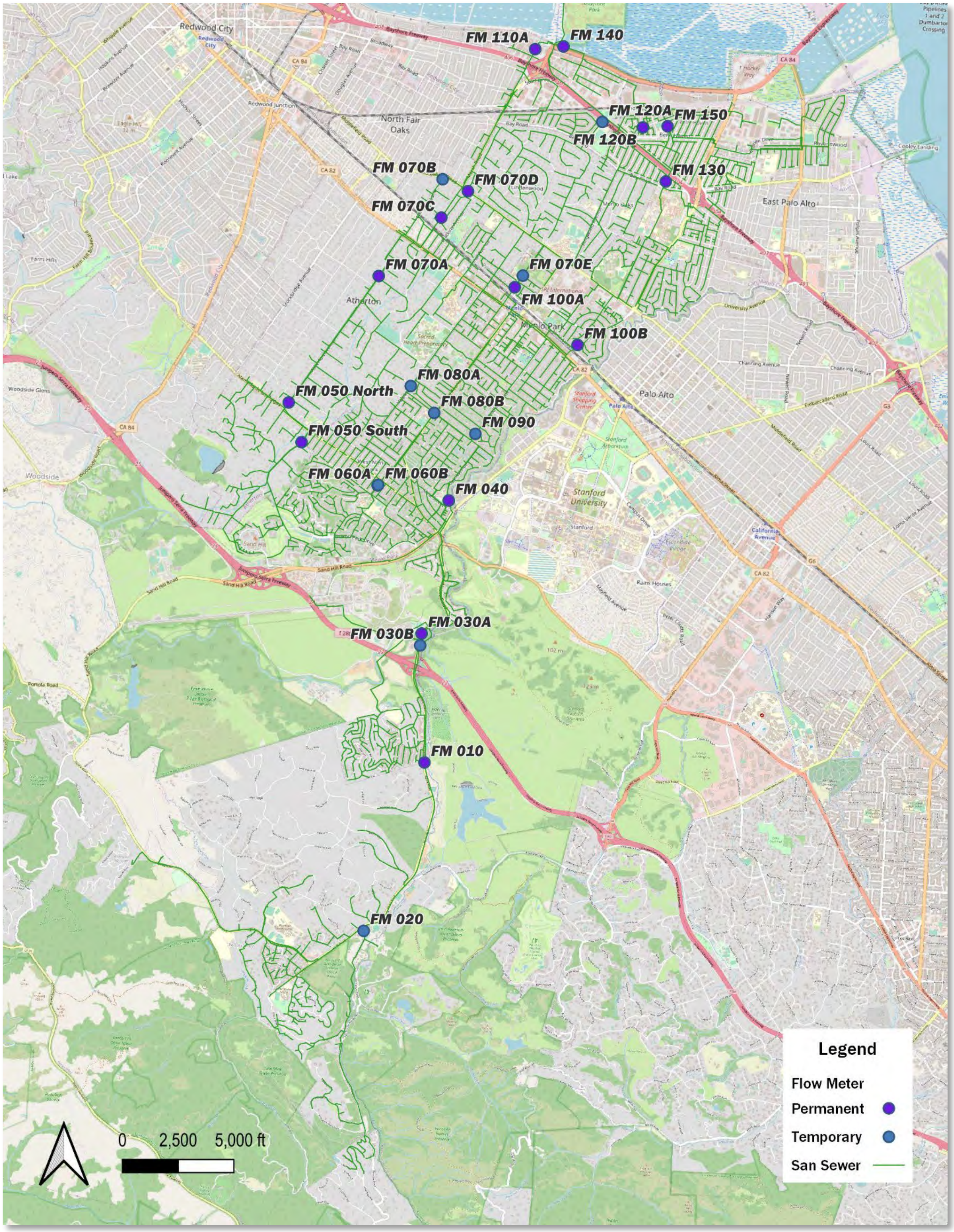


Figure 1-2. Map of Flow Monitoring Sites

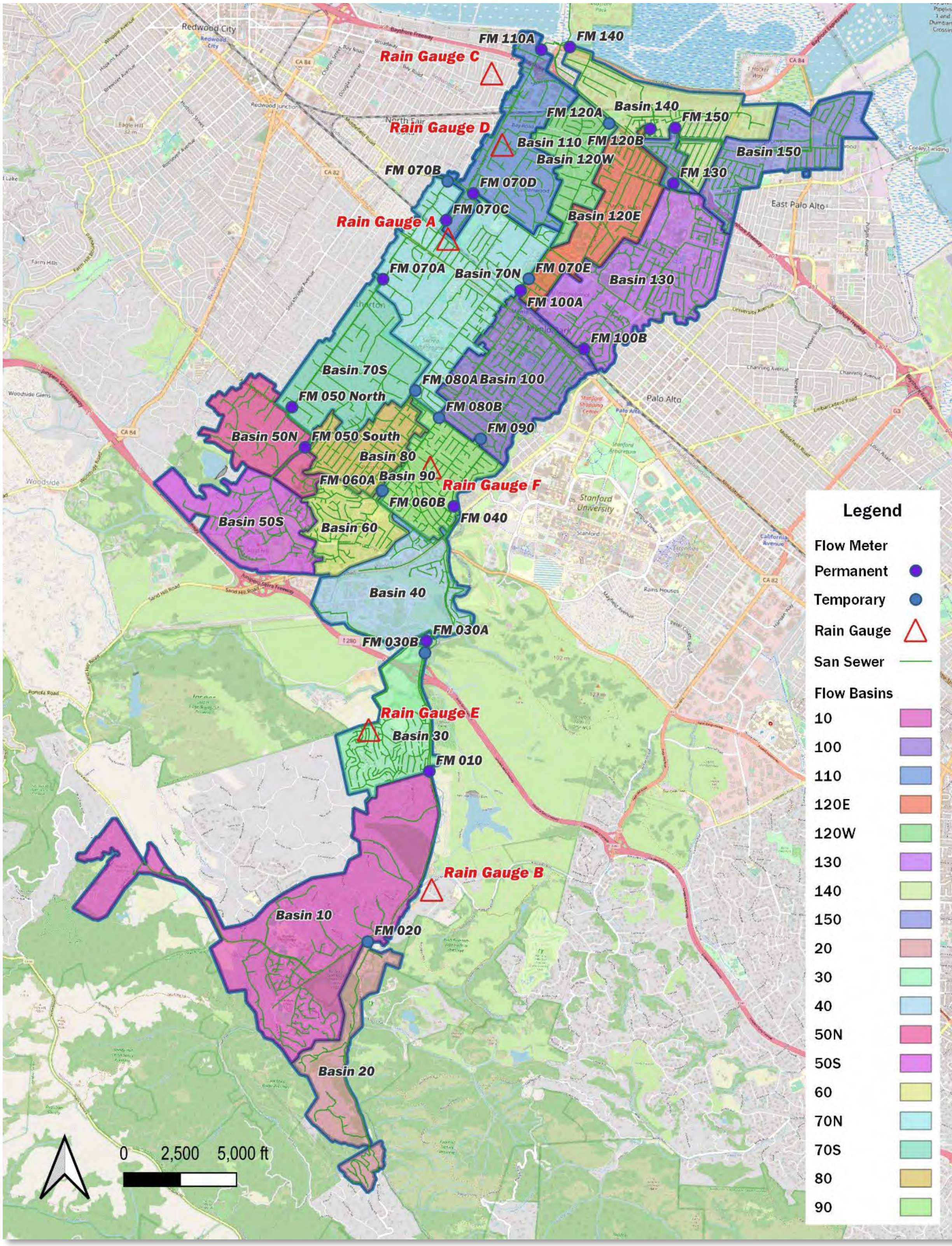


Figure 1-3. Map of Flow Monitoring Basins and Rain Gauges

2 Methods and Procedures

2.1 Confined Space Entry

A confined space (Photo 2-1) is defined as any space that is large enough and so configured that a person can bodily enter and perform assigned work, has limited or restricted means for entry or exit, and is not designed for continuous employee occupancy. In general, the atmosphere must be constantly monitored for sufficient levels of oxygen (19.5% to 23.5%), and the presence of hydrogen sulfide (H_2S) gas, carbon monoxide (CO) gas, and lower explosive limit (LEL) levels. A typical confined space entry crew has members with OSHA-defined responsibilities of Entrant, Attendant, and Supervisor. The Entrant is the individual performing the work. He or she is equipped with the necessary personal protective equipment needed to perform the job safely, including a personal four-gas monitor (Photo 2-2). If it is not possible to maintain line-of-sight with the Entrant, then more Entrants are required until line-of-sight can be maintained. The Attendant is responsible for maintaining contact with the Entrants to monitor the atmosphere using another four-gas monitor and maintaining records of all Entrants if there is more than one. The Supervisor is responsible for developing a safe work plan for the job at hand before entering.

Photo 2-1. Confined Space Entry

Photo 2-2. Typical Personal Four-Gas Monitor

2.2 Flow Meter Installation

V&A installed 10 temporary flow monitoring devices within the collection system using a combination of both contact and non-contact manufactured equipment. Three non-contact Flo-Dar assemblies and 7 Hach FL904 submerged sensor, with a pressure transducer, were utilized to collect depth readings, and an ultrasonic Doppler sensor to determine the average fluid velocity. The ultrasonic sensor emits high-frequency sound waves, which are reflected by air bubbles and suspended particles in the flow. The sensor receives the reflected signal and determines the Doppler frequency shift, which indicates the estimated average flow velocity. The sensor is typically mounted at a manhole inlet to take advantage of smoother upstream flow conditions. The sensor may be offset to one side of the pipe to lessen the chances of fouling and sedimentation where these problems are expected to occur. Manual level and velocity measurements were taken during the installation of the flow meters, and again when they were removed, and compared to simultaneous level and velocity readings from the flow meters to ensure proper calibration and accuracy. Figure 2-1 shows a typical installation for a flow meter with a submerged sensor. The non-contact sensor is mounted on a support system in the manhole, centered above the flow.

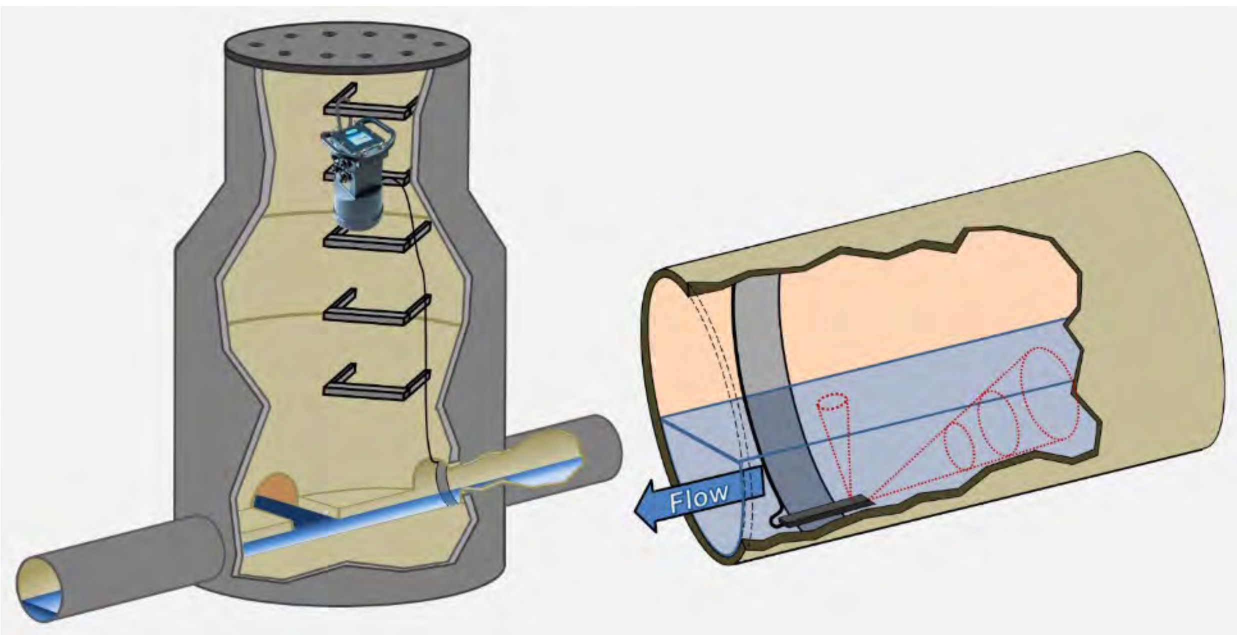


Figure 2-1. Typical Installation for temporary flow meter with a contact submerged sensor

2.3 Flow Calculation

Data retrieved from the flow meters is placed into a spreadsheet program for analysis. Data analysis includes comparison to field calibration measurements as well as necessary geometric adjustments as required for sediment (sediment reduces the pipe's wetted cross-sectional area available to carry flow). Area-velocity flow metering uses the continuity equation,

$$Q = v \cdot A = v \cdot (A_T - A_S)$$

where Q: volume flow rate

v: average velocity as determined by the ultrasonic sensor

A: cross-sectional area available to carry the flow

A_T: total cross-sectional area with both wastewater and sediment

A_S: cross-sectional area of sediment

For circular pipe,

$$A_T = \left[\frac{D^2}{4}\cos^{-1}\left(1 - \frac{2d_W}{D}\right)\right] - \left[\left(\frac{D}{2} - d_W\right)\left(\frac{D}{2}\right)\sin\left(\cos^{-1}\left(1 - \frac{2d_W}{D}\right)\right)\right]$$

$$A_S = \left[\frac{D^2}{4}\cos^{-1}\left(1 - \frac{2d_S}{D}\right)\right] - \left[\left(\frac{D}{2} - d_S\right)\left(\frac{D}{2}\right)\sin\left(\cos^{-1}\left(1 - \frac{2d_S}{D}\right)\right)\right]$$

where d_W: distance between wastewater level and pipe invert

d_S: depth of sediment

D: pipe diameter

2.4 Measurement Error and Uncertainty

For traditional engineering applications, measurement "error" is explained as a difference between a computed, estimated, or measured value and the generally accepted true or theoretically correct value. It can also be thought of as a difference between the desired and the actual performance of equipment. For equipment, an error is usually expressed as a percentage relative to accuracy (i.e., "…the velocity sensor has an accuracy of ±2% of the reading…").

However, for this study and flow monitoring applications, the cause of the measurement difference is important, and a distinction will be made between the equipment not performing to industry standards ("error") and expected inaccuracies ("uncertainty") associated with monitoring technology limitations.

Gauging **"error"** occurs when the equipment is not performing to industry standards. This can occur as a result of the following common categories of conditions that can be encountered at a wastewater monitoring site.

- Malfunctioning equipment (i.e. a sensor is damaged, battery life ends, or a desiccant canister becomes saturated)
- Improper equipment choice or maintenance (i.e. the selected gauging equipment technologies are incompatible with hydraulic conditions within the sewer, or excessive gravel deposits are allowed to accumulate around the sensors without being removed)
- Improper equipment calibration (i.e. depth and/or velocity measurements are incorrectly taken within the sewer, or equipment is allowed to drift out of calibration)
- Field conditions within the sewer, (i.e. foaming at the water surface that "blinds" an ultrasonic depth sensor or toilet paper catching and accumulating on a combination sensor, blinding the acoustic Doppler velocity meter)

For flow monitoring applications, gauging **"uncertainty"** is used to describe and quantify the expected inaccuracies that result from the limitations of the technologies that utilize indirect measurements to quantify wastewater flow.

It is important to try and install flow meters in "ideal" flow conditions. Ideal flow conditions are generally defined as laminar flow in a straight-through, constant-slope pipeline with no disturbances (elbows, tees, hydraulic shifts, etc.) 10 diameters upstream and 5 diameters downstream from the flow monitoring location. If ideal flow conditions are met, then an expected uncertainty of final flow calculation from an open-channel flow meter may be approximately ±5%. In many situations, ideal flow conditions cannot be met, and uncertainties increase.

2.4.1 Flow Addition versus Flow Subtraction

Due to the uncertainties involved in subtracting flows of similar magnitudes, the addition of flows at multiple monitoring sites is usually preferred over the subtraction of flows. Subtraction becomes an issue especially when the flow difference from the subtraction falls within the measurement uncertainty range of the two larger flow data sets (i.e. subtracting a large flow from another large flow to obtain a small difference).

This concept is best demonstrated by the following example:

1. Meter A measures 2.00 MGD of flow and has an expected uncertainty of ±5%, thus the uncertainty range of the flow measurement is ±0.10 MGD.
2. Meter B measures 2.50 MGD of flow and has an expected uncertainty of ±6%, thus the uncertainty range of the flow measurement is ±0.15 MGD.

3. Meter C measures 0.50 MGD of flow and has an expected uncertainty of ±8%, thus the uncertainty range of the flow measurement is ±0.04 MGD.

Scenario 1 – Flow Addition

- Meter A + Meter B = 2.00 MGD (±0.10) + 2.50 MGD (±0.15) = 4.50 MGD (±0.25)
- Overall uncertainty = ±0.25 / 4.50 = ±5.6%
- For flow addition, the final uncertainty is essentially a weighted average of the component uncertainties.

Scenario 2 – Flow Subtraction, Large Flow less Small Flow

- Meter B – Meter C = 2.50 MGD (±0.15) – 0.50 MGD (±0.04) = 2.00 MGD (±0.19)
- Overall uncertainty = ±0.19 / 2.00 = ±9.5%
- For flow subtraction, the final uncertainty will always be greater than the component uncertainties.
- When subtracting a small flow from a large flow, the resulting uncertainties can still be manageable.

Scenario 3 – Flow Subtraction, Large Flow less a similarly Large Flow

- Meter B – Meter A = 2.50 MGD (±0.15) – 2.00 MGD (±0.10) = 0.50 MGD (±0.25)
- Overall uncertainty = ±0.25 / 0.50 = ±50%
- When subtracting similarly sized flow rates, the resulting uncertainties may not be manageable. In this example, an uncertainty of ±50% may be considered unacceptable for confident analyses.

Scenario 3 is a very “real-world” situation. The uncertainties for Meter A and Meter B are extremely reasonable (indeed, most flow monitoring service providers would be extremely pleased with true meter uncertainties of ±5% to ±6%). However, the reality of the math is clear, and the above example demonstrates the concept of flow subtraction and compounding or inflating uncertainty ranges.

The following points are emphasized in relation to the items of this section:

- For subtraction of flows, the overall uncertainty can be an inflated value that far exceeds the component uncertainties.
- The smaller the resultant flow from the subtraction equation, the larger the percentage uncertainty.
- Whenever possible, basin flows should be directly measured, rather than calculated as a subtraction of two or more flow meters.
- If flow subtraction cannot be avoided, it is better to have the magnitudes of the component flows be as dissimilar as possible.

2.5 Average Dry Weather Flow Determination

For this study, four distinct average dry weather flow curves were established for each site location:

- Mondays – Thursdays
- Fridays
- Saturdays
- Sundays

Flows for many sites differ on Friday evenings compared to Mondays through Thursdays. Starting around 7 p.m., the flows are often decreased (compared to Monday through Thursday). Similarly, flow patterns for Saturday and Sunday were also separated due to their unique evening flow pattern. This type of differentiation can be important when determining I/I response, especially if a rain event occurs on a Friday, Saturday, or Sunday evening.

Figure 2-2 illustrates a sample of varying flow patterns within a typical dry week[3].

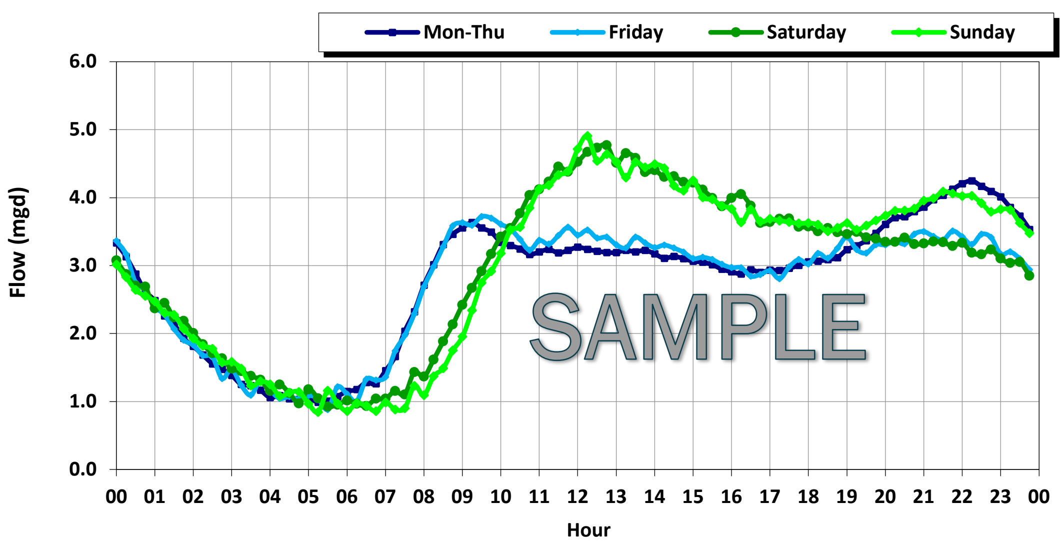


Figure 2-2. Sample ADWF Diurnal Flow Patterns

ADWF curves are taken from "Dry Days" when RDI had the least impact on the baseline flow. The overall average dry weather flow (ADWF) is calculated using the following equation:

$$ADWF = \left(ADWF_{Mon-Thu} \times \frac{4}{7}\right) + \left(ADWF_{Fri} \times \frac{1}{7}\right) + \left(ADWF_{Sat} \times \frac{1}{7}\right) + \left(ADWF_{Sun} \times \frac{1}{7}\right)$$

[3] Holiday flows can be extremely variable. Christmas flows are different from Thanksgiving flows and different from MLK Day flows. See Section 0 for details on whether holiday ADWF curves were established for this project's I/I analysis.

2.6 Flow Attenuation

Flow attenuation in a sewer collection system is the natural process of the reduction of the peak flow rate through redistribution of the same volume of flow over a longer period of time. This occurs as a result of friction (resistance), internal storage and diffusion along the sewer pipes. Fluids are constantly working towards equilibrium. For example, a volume of fluid poured into a static vessel with no outside turbulence will eventually stabilize to a static state, with a smooth fluid surface without peaks and valleys. Attenuation within a sanitary sewer collection system is based upon this concept. A flow profile with a strong peak will tend to stabilize towards equilibrium, as shown in Figure 2-3.

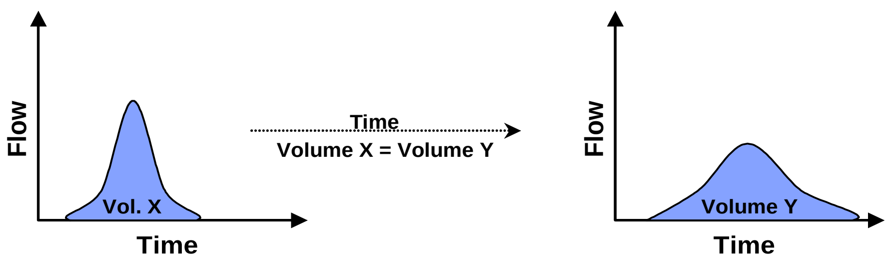


Figure 2-3. Attenuation Illustration

Within a sanitary sewer collection system, each individual basin will have a specific flow profile. As the flows from the basins combine within the trunk sewer lines, the peaks from each basin will not necessarily coincide at the same time, and peak flows may attenuate before reaching the treatment facility due to the length and time of travel through the trunk sewers. The sum of the peak flows of the individual basins within a collection system will usually be greater than the peak flows observed at the treatment facility.

2.7 Inflow / Infiltration Analysis: Definitions and Identification

Inflow and infiltration (I/I) consists of stormwater and groundwater that enters the sewer system through pipe defects and improper storm drainage connections and is defined as follows:

- **Inflow**: Stormwater inflow is defined as water discharged into the sewer system, including private sewer laterals, from direct connections such as downspouts, yard, and area drains, holes in manhole covers, cross-connections from storm drains, or catch basins.
- **Infiltration**: Infiltration is defined as water entering the sanitary sewer system through defects in pipes, pipe joints, and manhole walls, which may include cracks, offset joints, root intrusion points, and broken pipes.

Figure 2-4 illustrates the possible sources and components of I/I.

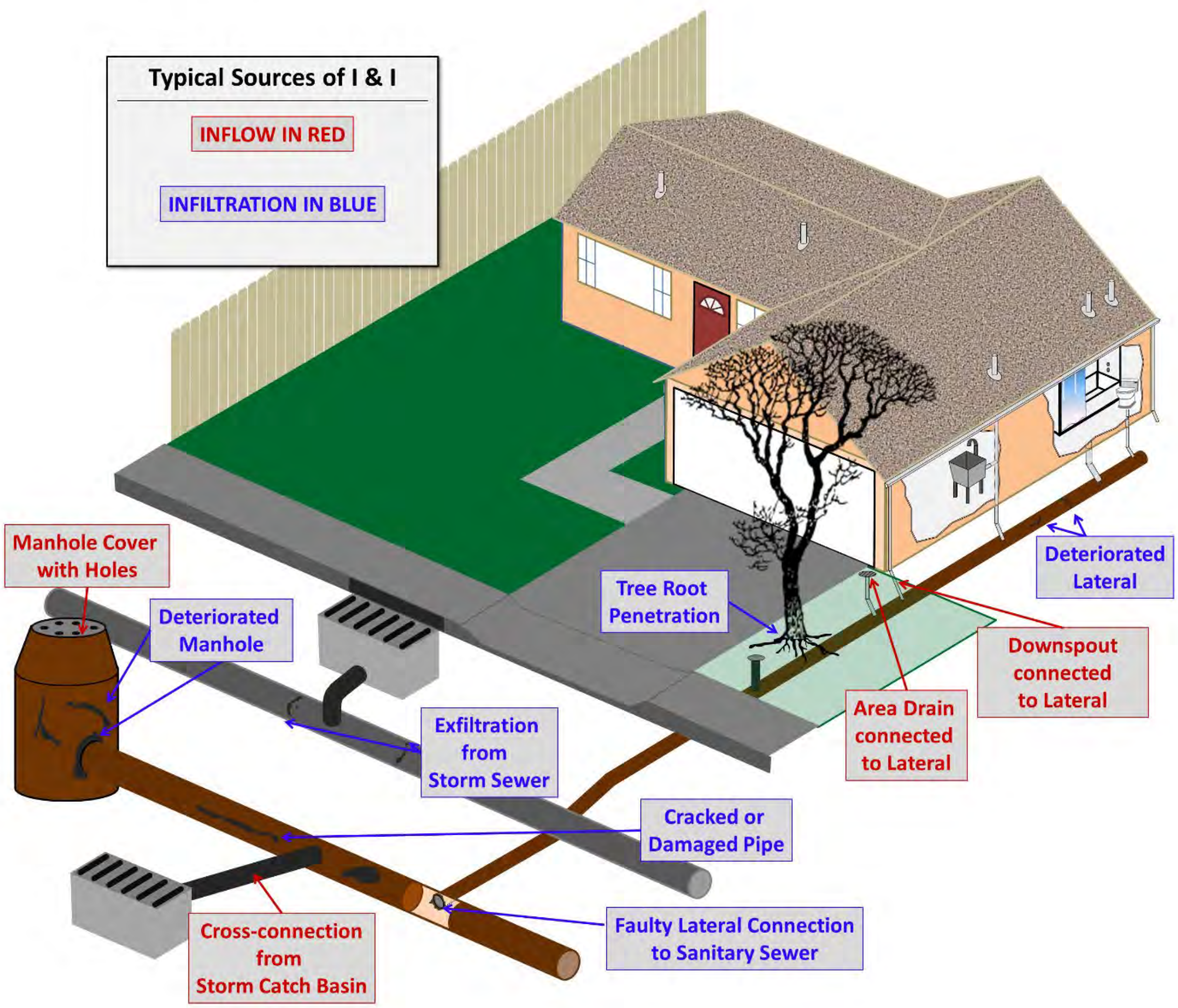


Figure 2-4. Typical Sources of Infiltration and Inflow

2.7.1 Infiltration Components

Infiltration can be further subdivided into components as follows:

- **Groundwater Infiltration**: Groundwater infiltration depends on the depth of the groundwater table above the pipelines as well as the percentage of the system submerged. The variation of groundwater levels and subsequent groundwater infiltration rates are seasonal by nature. On a day-to-day basis, groundwater infiltration rates are relatively steady and will not fluctuate greatly.
- **Rainfall-Dependent Infiltration**: This component occurs as a result of stormwater and enters the sewer system through pipe defects, as with groundwater infiltration. The stormwater first percolates directly into the soil and then migrates to an infiltration point. Typically, the time of concentration for rainfall-related infiltration maybe 24 hours or longer, but this depends on the soil permeability and saturation levels.
- **Rainfall-Responsive Infiltration** is stormwater that enters the collection system indirectly through pipe defects, but normally in sewers constructed close to the ground surface such as private laterals. Rainfall-responsive infiltration is independent of the groundwater table and reaches defective sewers via the pipe trench in which the sewer is constructed, particularly if the pipe is placed in impermeable soil and is bedded and backfilled with granular material. In this case, the pipe trench serves as a conduit similar to a French drain, conveying storm drainage to defective joints and other openings in the system. This type of infiltration can have a quick response and graphically can look very similar to inflow.

2.7.2 Impact and Cost of Source Detection and Removal

- **Inflow**:
  - Impact: Inflow creates a peak flow problem in the sewer system and often dictates the required capacity of downstream pipes and transport facilities to carry these peak instantaneous flows. Because the response and magnitude of inflow are tied closely to the intensity of the storm event, the short-term peak instantaneous flows may result in surcharging and overflows within a collection system. Severe inflow may result in sewage dilution, resulting in upsetting the biological treatment (secondary treatment) at the treatment facility.
  - Cost of Source Identification and Removal: Inflow locations are usually less difficult to find and less expensive to correct. These sources include direct and indirect cross-connections with storm drainage systems, roof downspouts, and various types of surface drains. Generally, the costs to identify and remove sources of inflow are low compared to potential benefits to public health and safety or the costs of building new facilities to convey and treat the resulting peak flows.
- **Infiltration**:
  - Impact: Infiltration typically creates long-term annual volumetric problems. The major impact is the cost of pumping and treating the additional volume of water, and of paying for treatment (for municipalities that are billed strictly on flow volume).
  - Cost of Source Detection and Removal: Infiltration sources are usually harder to find and more expensive to correct than inflow sources. Infiltration sources include defects in deteriorated sewer pipes or manholes that may be widespread throughout a sanitary sewer system.

2.7.3 Graphical Identification of I/I

Inflow is usually recognized graphically by large-magnitude, short-duration spikes immediately following a rain event. Infiltration is often recognized graphically by a gradual increase in flow after a wet-weather event. The increased flow typically sustains for a period after rainfall has stopped and then gradually drops off as soils become less saturated and as groundwater levels recede to normal levels. Real-time flows are plotted against ADWF to analyze the I/I response to rainfall events. Figure 2-5 illustrates a sample of how this analysis is conducted and some of the measurements that are used to distinguish infiltration and inflow. Similar graphs have been generated for the individual flow monitoring sites and can be found in Appendix A.

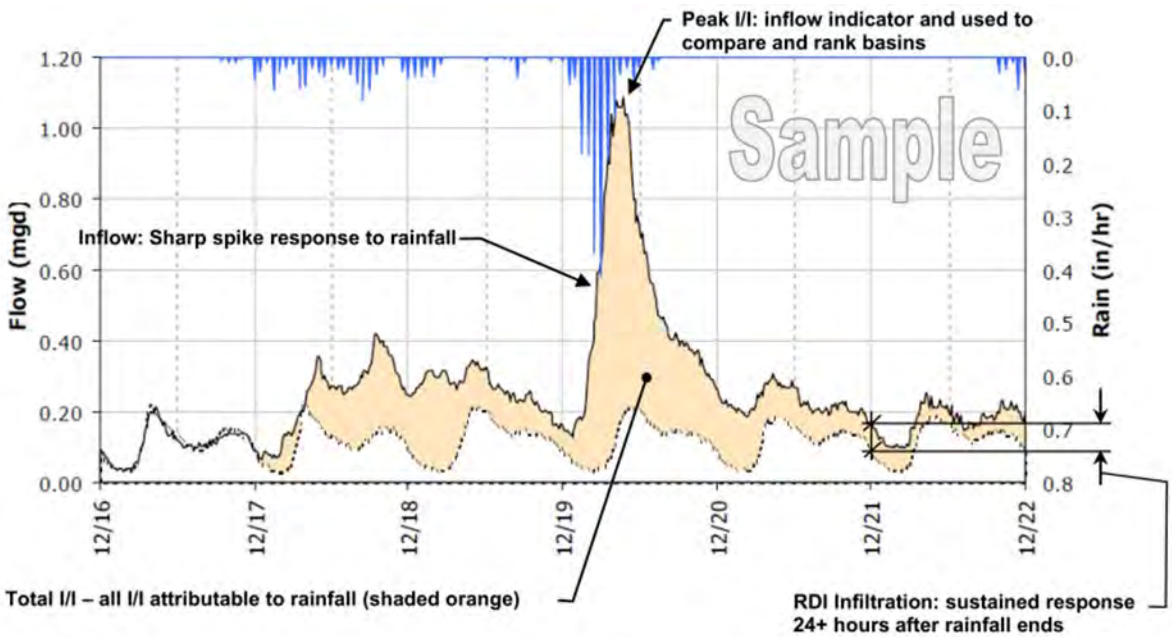


Figure 2-5. Sample Infiltration and Inflow Isolation Graph

2.7.4 Analysis Metrics

After differentiating I/I flows from ADWF flows, various calculations can be made to determine which I/I component (inflow or infiltration) is more prevalent at a particular site and to compare the relative magnitudes of the I/I components between drainage basins and between storm events:

- **Inflow – Peak I/I Flow Rate**: Inflow is characterized by sharp, direct spikes occurring during a rainfall event. Peak I/I rates are used for inflow analysis[4].
- **Groundwater Infiltration (GWI)**: GWI analysis is conducted by looking at minimum dry weather flow to average dry weather flow ratios and comparing them to established standards to quantify the rate of excess groundwater infiltration.
- **Rainfall-Dependent Infiltration (RDI)**: RDI Analysis is conducted by looking at the infiltration rates at set periods after the conclusion of a storm event. Depending on the particular collection system and the time required for flows to return to ADWF levels, different periods may be examined to determine the basins with the greatest or most sustained rainfall-dependent infiltration rates.
- **Combined I/I**: The combined inflow and infiltration are measured in gallons per site and per storm event. Because it is based on combined I/I volume, it is used to identify the overall volumetric influence of I/I within the monitoring basin.

[4] I/I flow rate is the real time flow less the estimated average dry weather flow rate. It is an estimate of flows attributable to rainfall. By using peak measured flow rates (inclusive of ADWF), the I/I flow rate would be skewed higher or lower depending on whether the storm event I/I response occurs during low-flow or high-flow hours.

2.7.5 Normalization Methods

There are three ways to *normalize* the I/I analysis metrics for an "apples-to-apples" comparison among the different drainage basins:

- **per-ADWF**: The metric is divided by the established average dry weather flow rate and is typically expressed as a ratio. Peaking Factors are examples of using ADWF to normalize data from different sites.
- **per-IDM**: The metric is divided by the length of pipe (IDM [inch-diameter mile]) contained within the upstream basin. Final units typically are gallons per day (gpd) per IDM.
- **per-ACRE**: The metric is divided by the acreage of the upstream basin. Final units typically are gallons per day (gpd) per ACRE.

The infiltration and inflow indicators were normalized by the per-ADWF, per-IDM, and per-ACRE methods in this report and these results will be shown in the following I/I analysis results sections. For basin rankings, the following weighting decisions are given:

- **per-ADWF:** Per-ADWF metrics were assigned 30% weighting towards final rankings. It is noted that abnormal waste usage could result in low ADWF values, which could skew results and lend to possible misinterpretation of data.
- **per-IDM:** Per-IDM values were assigned 40% weighting towards final rankings. Most of the diameters are in the GIS and should result in valid per-IDM analyses.
- **Per-ACRE:** Per-ACRE rankings were assigned a 30% weighting towards final rankings. Basin acreage was calculated using GIS.

3 Results and Analysis

3.1 Rainfall Monitoring

3.1.1 Rain Gauge Locations

V&A analyzed rainfall data from 15 publicly available private weather stations (PWS) on Weather Underground[5], choosing the best 6 locations, allowing for solid coverage over the collection system which has a diverse range of topographical features. Table 3-1 lists the identification label, PWS ID, location, elevation, and measured rainfall of the selected gauges. Figure 3-1 illustrates the locations and labeling convention used for the 6 rain gauges.

Table 3-1: List of Rain Gauge Locations

RG Name	PWS RG ID	Lat.	Long.	Elev. (ft)	Rain (in)
A	KCAATHER30	37.462	-122.194	56	18.6
B	KCAPORTO103	37.383	-122.191	554	24.6
C	KCAREDWO119	37.483	-122.189	20	16.5
D	KCAATHER23	37.474	-122.187	43	17.2
E	KCAMENLO105	37.402	-122.202	302	24.7
F	KCAMENLO53	37.434	-122.195	112	19.9

[5] Weather Underground (wunderground.com) collects data from 180,000+ weather stations across the country, including Automated Surface Observation System (ASOS) at airports, personal weather stations (PWS), and Meteorological Assimilation Data Ingest System (MADIS) managed by the National Oceanic and Atmospheric Administration (NOAA). While V&A has no direct control over the rain gauges, V&A performs additional QA/QC on the data to assure its suitability for use.

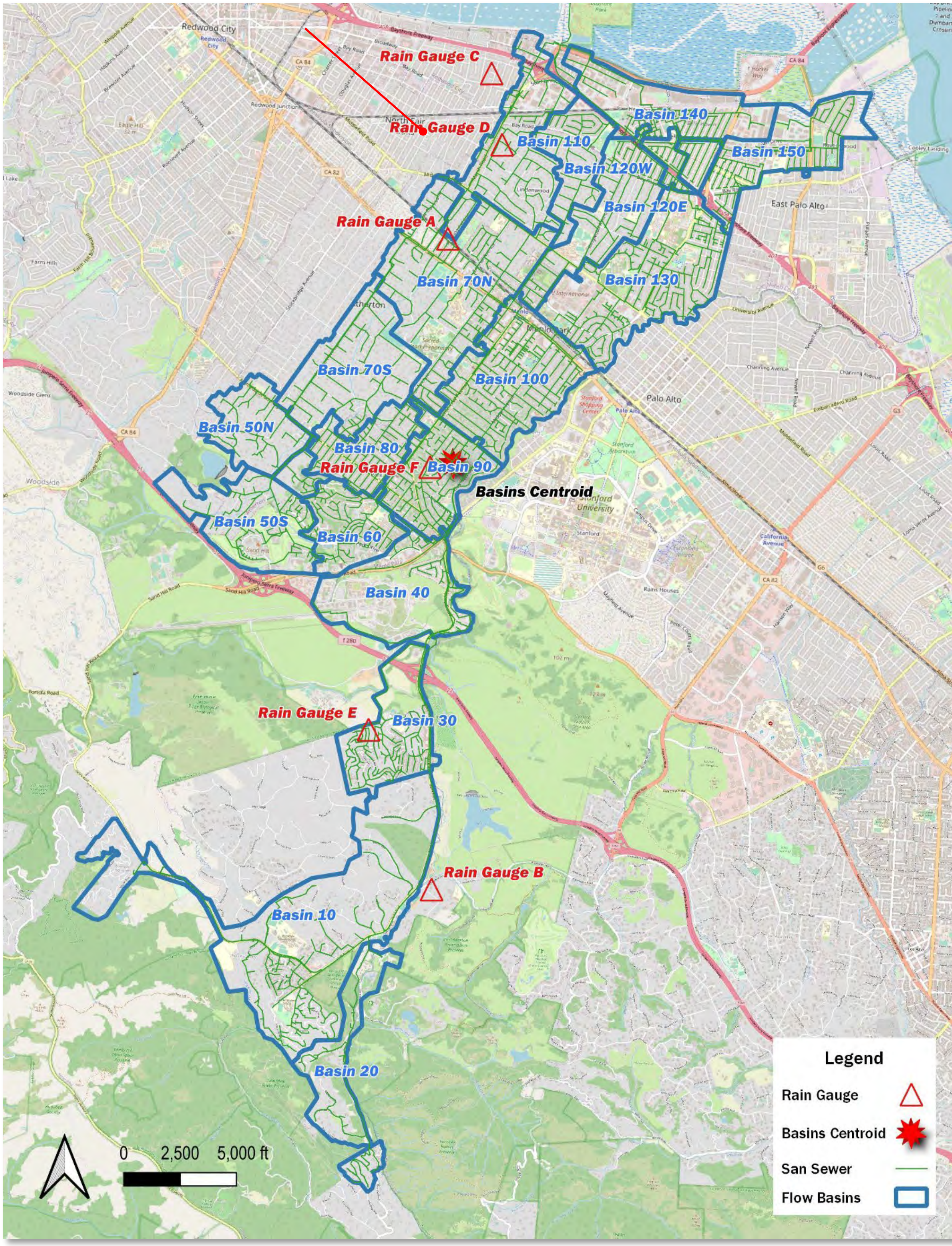


Figure 3-1. Location of Rain Gauges

3.1.2 Flow Study Rainfall Data

There were multiple rainfall events during this study that elicited solid I/I responses, as illustrated in Figure 3-2. Minor rainfall (>1 inch) on 12/02/23 and 12/04/23 proceeded the flow monitor installation on 12/05/23. Data did not indicate a significant increase in baseline flows.

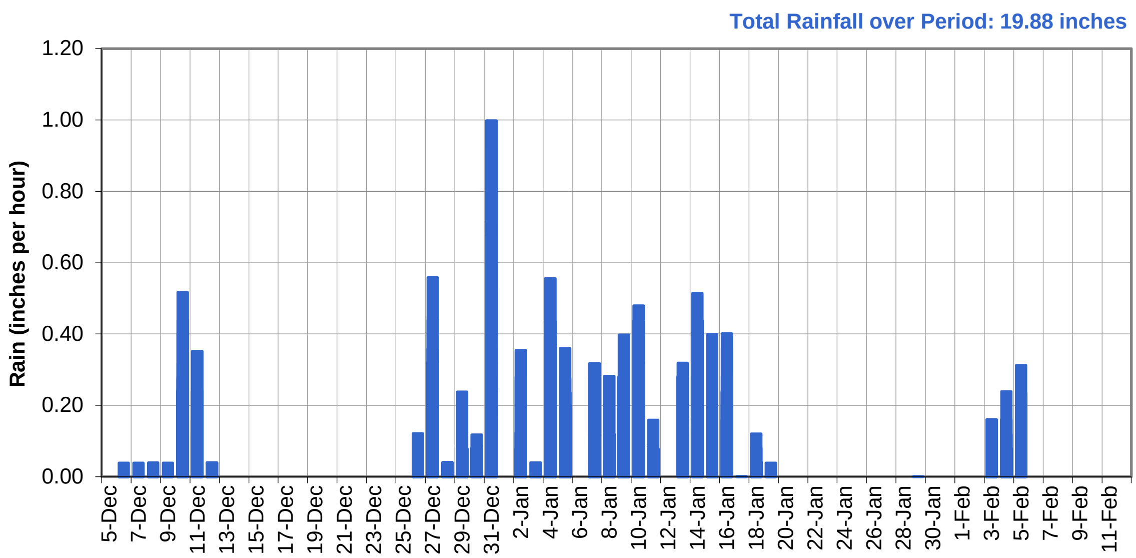


Figure 3-2. Rainfall Monitoring (Triangulation of 6 selected rain gauges)

A total of 19.88 inches of rainfall was recorded over the monitoring period, triangulated to the centroid of the Study Area. Table 3-2 lists the significant rainfall events recorded (events > 0.5-inch). The highest rainfall intensity measured was 0.83 inches/hour on 12/30/22. This event saw 4.52 inches of rainfall over 20.75 hrs and has a return period of approximately 50 years based on the depth of rainfall.

Table 3-2. Significant Rainfall Events

Storm Start Date	Duration (hrs)	Total Rainfall (in)	1-hr intensity (in/hr)	Return Period
12/10/2022 5:45	27.25	1.93	0.43	~ 1-YR
12/26/2022 17:45	18.75	1.98	0.37	< 2-YR
12/30/2022 22:00	20.75	4.52	0.83	~ 50-YR
1/4/2023 11:30	13.00	1.31	0.45	< 1-YR
1/8/2023 19:45	13.25	1.68	0.28	~ 1-YR
1/13/2023 7:45	4.00	0.59	0.22	< 1-YR
1/13/2023 23:45	9.25	1.27	0.30	~ 1-YR
1/15/2023 15:15	14.25	1.58	0.32	~ 1-YR
Note: Only events > 0.5-inch listed				

Figure 3-3 shows the rain accumulation plot of the period rainfall, as well as the historical average rainfall[6] (triangulated to the historical WRCC Redwood City rain gauge 047339) over the project duration. When this historical data is compared to the recorded rainfall, we see that cumulative precipitation was approximately 275% of historical precipitation averages over the specific duration of the flow monitoring when compared to the triangulated average.

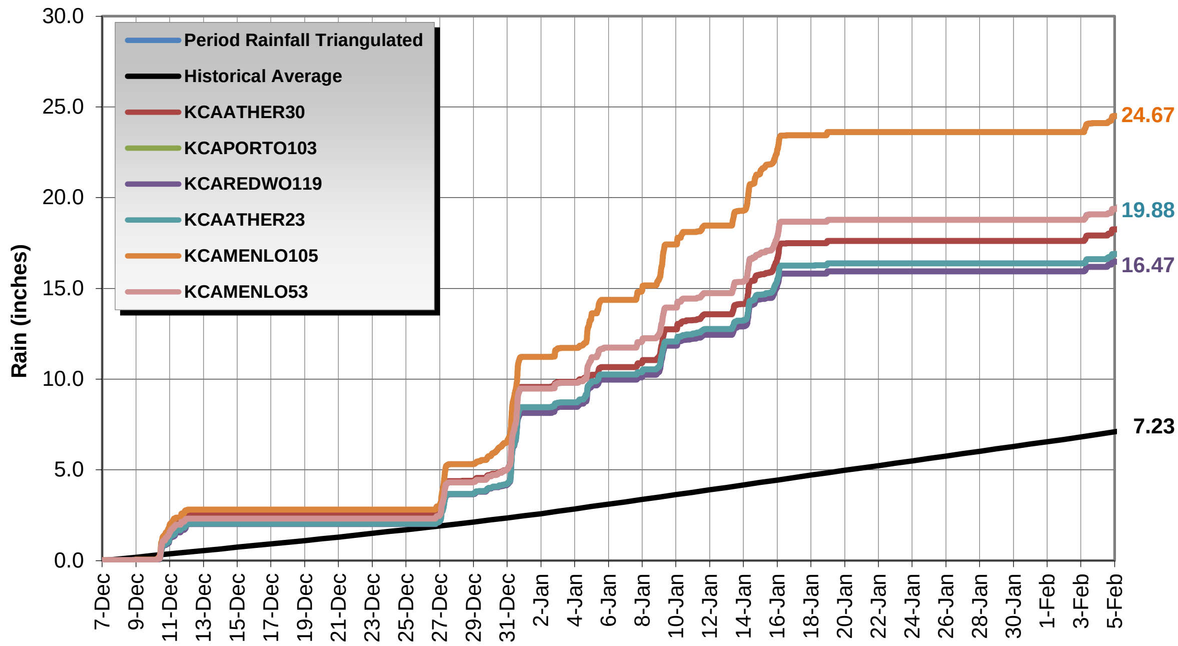


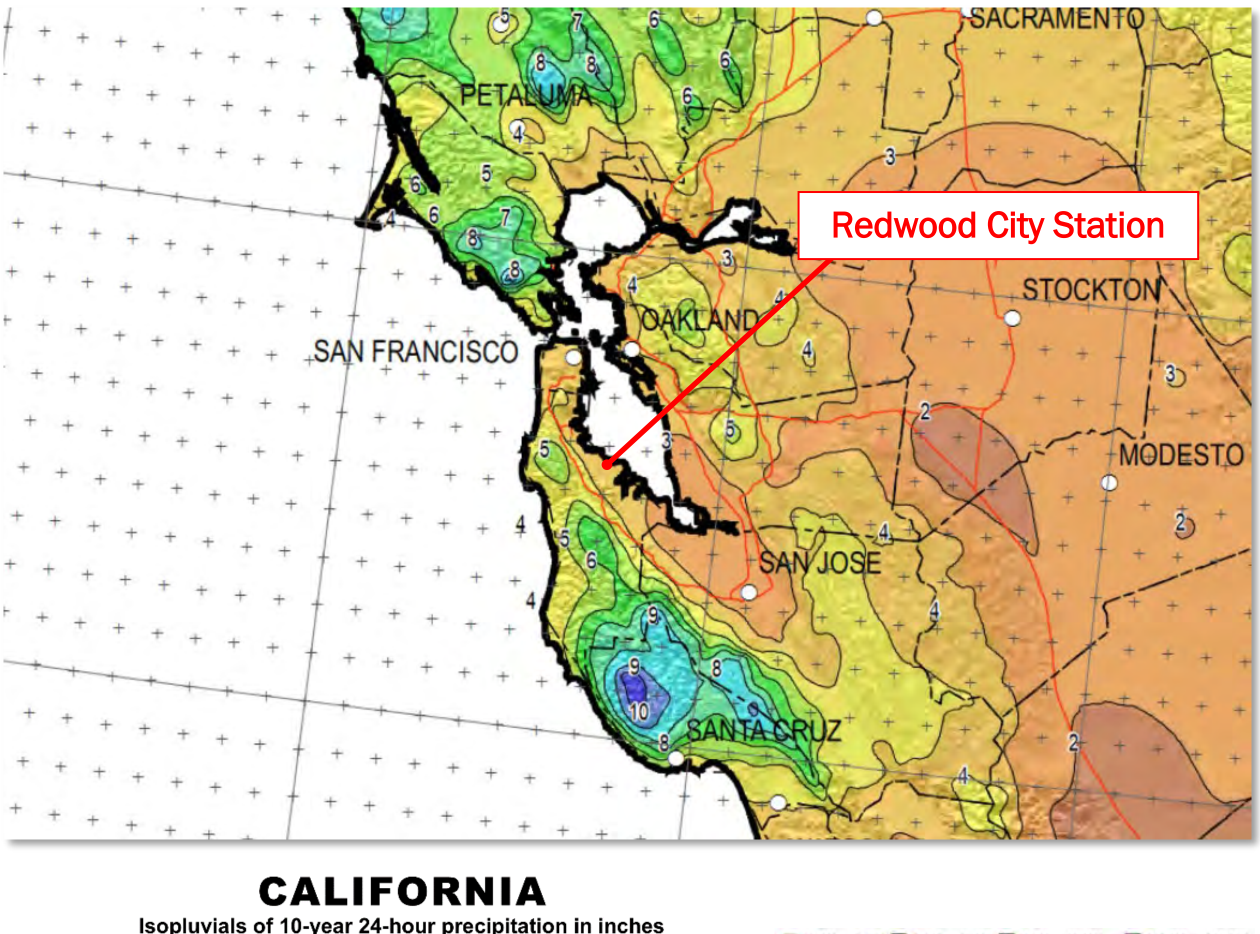
Figure 3-3. Rainfall Accumulation Plot

[6] Historical data taken from the WRCC (Station 047339 in Redwood City: http://www.wrcc.dri.edu/summary/climsmnca.html

3.1.3 Regional Rainfall Event Classification

It is important to classify the relative size of a major storm event that occurs throughout a flow monitoring period[7]. Rainfall events are classified by intensity and duration. Based on historical data, frequency contour maps for storm events of given intensity and duration have been developed by the NOAA for all areas within the continental United States (Figure 3-4).

For example, the NOAA Rainfall Frequency Atlas[8] classifies a 10-year, 24-hour storm event at the Redwood City (Site ID 04-7339) rain gauge location as 3.58 inches. This means that in any given year, at this specific location, there is a 10% chance that 3.58 inches of rain will fall in any 24-hour period.



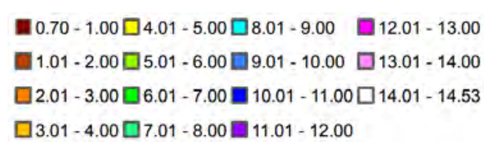


Figure 3-4. NOAA Northern California Rainfall Frequency Map

From the NOAA frequency maps, for a specific latitude and longitude, the rainfall densities for period durations ranging from 1 hour to 20 days are known for rain events ranging from 1-year to 10-year intensities. These are plotted to develop a rain event frequency map specific to each rainfall monitoring site. Superimposing the peak measured densities for the rainfall events on the rain event frequency plot

[7] Sanitary sewers are often designed to withstand I/I contribution to sanitary flows for specific-sized "design" storm events.

[8] NOAA Western U.S. Precipitation Frequency Maps Atlas 14, Volume 6, 2011: ftp://hdsc.nws.noaa.gov/pub/hdsc/data/sw/ca10y24h.pdf

determines the classification of the rainfall event.

Figure 3-5 shows the peak classification plot for the top 5 triangulated rainfall events. The following items are noted:

- The 12/30/22 – 12/31/22 event includes multiple small back-to-back events on 12/30 prior to larger events on 12/31. Analysis indicates that this triangulated event was approximately a 50-yr, 12-hr event with individual gauges being slightly more or less intense. For triangulation, an event was not considered separate unless the time between recorded rainfall exceeded 2.5 hrs.

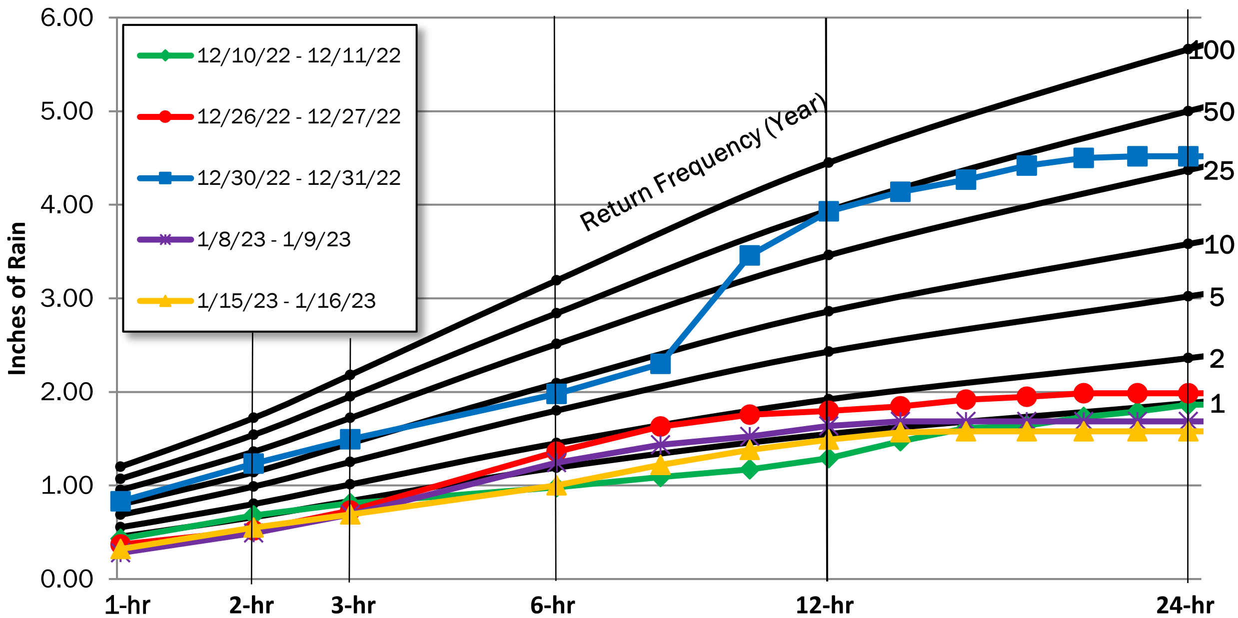


Figure 3-5. Rainfall Event Classification – 24-Hour Period

To determine peak collection system flows, it is essential that associated rainfall events have moderate intensities. High-intensity rainfall events usually result in peak wastewater flows that create surcharge, backups, and possibly overflows. The goal of the design flow projection analysis is to evaluate the hydraulic behavior of the sewer system under open-channel flow conditions. Therefore, surcharges and backups produce non-representative data and must be used cautiously. Also, projecting the theoretical peak wastewater flows under these conditions is virtually impossible since storage and other volumetric losses reduce peak measured flows.

It Is also important to use caution when evaluating the hydraulic performance of a collection system based on total rainfall only. For example, a low-intensity rainfall with a cumulative total of 2 to 3 inches may fall during a period of several hours, resulting in only moderate inflow (peak) responses in the collection system. However, a high-intensity rainfall of 0.5 to 1.0 inches in 60 minutes may result in a greater inflow response in the collection system. Ideally, several rainfall events ranging from 0.2 to 1.0 inches per hour are normally required to project peak sanitary sewer system flows

3.1.4 Rain Gauge Triangulation Distribution

The rainfall affecting the sanitary sewer collection system basins must be calculated based on the proximity to the rain gauge locations. The mean precipitation for each site's upstream basin was calculated by taking data from the rain gauges and using the inverse distance weighting (IDW) method. IDW is an interpolation method that assumes the influence of each rain gauge location diminishes with distance. The center of an upstream basin[9] is identified, and a weighted triangulated average is taken of the precipitation data from nearby rain gauge locations.

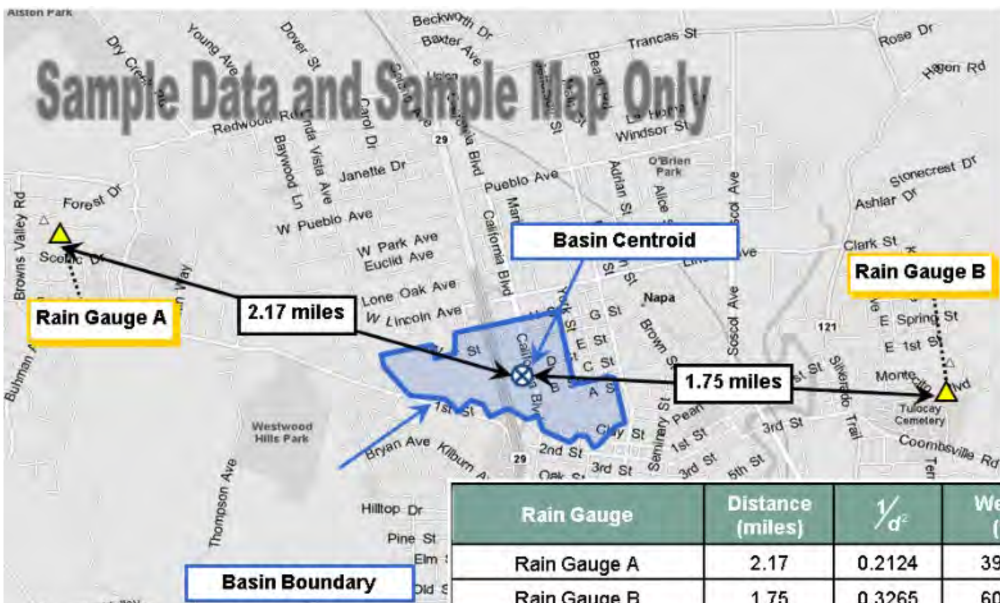
The IDW function is as follows:

$$weight(d) = \frac{1/d^p}{\sum 1/d^p},$$

where: d = distance
p = power ($p > 0$)

The value of p is user-defined. The most common choice for hydrological studies of watershed areas is p = 2.

Figure 3 6 illustrates the IDW method with sample data. The rain gauge distribution as calculated for each flow monitoring site is shown in Table 3-2.



Rain Gauge	Distance (miles)	$1/d^2$	Weight (%)
Rain Gauge A	2.17	0.2124	39.4%
Rain Gauge B	1.75	0.3265	60.6%
Totals		**0.5389**	**100%**

Figure 3-6. Rainfall Inverse Distance Weighting Method

[9] Note that the full basin upstream of the site was used instead of the isolated basins as the rain data will be compared to the flow at each site

Table 3-3. Rain Gauge Distribution per Monitoring Site

Monitoring Site ID	Sub-Basin ID	Basin ID	RG A	RG B	RG C	RG D	RG E	RG F
FM 020	20	20	0.0%	69.4%	0.0%	0.0%	29.1%	1.5%
FM 030B	30B	30	0.0%	57.5%	0.0%	0.0%	41.1%	1.4%
FM 060A	60A	60	8.0%	0.0%	0.0%	0.0%	18.0%	73.9%
FM 060B	60B	60	8.0%	0.0%	0.0%	0.0%	18.0%	73.9%
FM 070B	70B	70S	63.9%	0.0%	5.0%	8.7%	0.0%	22.4%
FM 070E	70E	70S	30.2%	0.0%	7.6%	12.7%	0.0%	49.6%
FM 080A	80A	80	7.8%	0.0%	0.0%	1.4%	12.7%	78.2%
FM 080B	80B	80	7.9%	0.0%	0.0%	0.5%	16.0%	75.5%
FM 090	90	90	0.0%	38.0%	0.0%	0.0%	43.1%	18.9%
FM 120A	120W	120	14.5%	0.0%	23.0%	59.7%	0.0%	2.8%
FM 010	10	10	0.0%	69.5%	0.0%	0.0%	30.5%	0.0%
FM 030A	30A	30	0.0%	2.0%	0.0%	0.0%	97.2%	0.8%
FM 040	40	40	0.0%	42.5%	0.0%	0.0%	48.2%	9.3%
FM 050N	50N	50	23.2%	0.0%	0.0%	0.0%	17.3%	59.5%
FM 050S	50S	50	18.8%	0.0%	0.0%	0.0%	25.6%	55.6%
FM 070A	70A	70N	23.5%	0.0%	3.0%	4.4%	15.1%	53.9%
FM 070C	70C	70S	84.6%	0.0%	3.5%	7.4%	0.0%	4.4%
FM 070D	70D	70S	84.6%	0.0%	3.5%	7.4%	0.0%	4.4%
FM 100A	100A	100	30.1%	0.0%	7.6%	13.0%	0.0%	49.3%
FM 100B	100B	100	0.9%	37.0%	0.2%	0.4%	41.9%	19.7%
FM 110A	110	110	42.0%	0.0%	3.3%	21.7%	6.9%	26.1%
FM 120B	120E	120	3.6%	33.1%	2.4%	5.0%	37.5%	18.4%
FM 130	130	130	6.3%	30.4%	3.6%	6.2%	34.5%	19.0%
FM 140	140	140	38.8%	0.0%	8.2%	24.7%	5.9%	22.4%
FM 150	150	150	25.7%	0.0%	34.4%	39.9%	0.0%	0.0%

Notes: Rain gauge ID's listed below. % Distribution rounded to the nearest tenth

A=KCAATHER30
B=KCAPORTO103
C=KCAREDWO119
D=KCAATHER23
E=KCAMENLO105
F=KCAMENLO53

3.2 Flow Monitoring

3.2.1 Average Flow Analysis

Average dry weather flow (ADWF) curves were established during dry days when I/I had the least impact on the baseline flow. Table 3-3 summarizes the dry weather flow data measured for this study. ADWF curves for each site can be found in Appendix A. The following ADWF analysis results are noted:

- **Sediment**: Site FM 080B was the only site with noted sediment. Site FM 080B appears to have mostly stagnant flow with little to no velocity.
- **d/**D: Average d/D ratios ranged from 0 – 0.51.

Table 3-4. Dry Weather Flow

Monitored Site	Sediment* (in.)	Average d/D Ratio	Mon-Thu ADWF (MGD)	Friday ADWF (MGD)	Saturday ADWF (MGD)	Sunday ADWF (MGD)	Overall ADWF (MGD)
FM 020	0	0.11	0.023	0.018	0.025	0.034	0.024
FM 030B**	0	0.00	0.000	0.000	0.000	0.000	0.000
FM 060A	0	0.09	0.007	0.006	0.008	0.007	0.007
FM 060B	0	0.06	0.049	0.044	0.049	0.063	0.051
FM 070B	0	0.25	0.032	0.035	0.033	0.034	0.033
FM 070E	0	0.22	0.082	0.086	0.088	0.084	0.083
FM 080A	0	0.13	0.090	0.085	0.094	0.087	0.089
FM 080B	2	0.51	0.060	0.058	0.071	0.065	0.062
FM 090	0	0.16	0.453	0.418	0.417	0.418	0.438
FM 120A	0	0.30	0.073	0.066	0.066	0.073	0.071
FM 010	0	0.16	0.078	0.099	0.089	0.084	0.084
FM 030A	0	0.10	0.163	0.147	0.180	0.180	0.166
FM 040	0	0.15	0.273	0.284	0.337	0.261	0.282
FM 050N	0	0.33	0.072	0.076	0.076	0.073	0.074
FM 050S	0	0.25	0.229	0.269	0.237	0.270	0.242
FM 070A	0	0.20	0.507	0.536	0.617	0.725	0.558
FM 070C	0	0.31	0.216	0.210	0.213	0.189	0.211
FM 070D	0	0.27	0.536	0.554	0.532	0.509	0.534
FM 100A	0	0.28	0.155	0.163	0.157	0.142	0.155
FM 100B	0	0.19	0.516	0.560	0.536	0.508	0.524
FM 110A	0	0.33	1.139	1.152	1.131	1.073	1.131
FM 120B	0	0.16	0.121	0.122	0.120	0.119	0.120
FM 130	0	0.17	1.287	1.326	1.265	1.247	1.284
FM 140	0	0.26	0.914	0.886	0.881	0.816	0.891
FM 150	0	0.30	0.263	0.267	0.282	0.281	0.269

* Max recorded sediment. Sediment can fluctuate over the course of the monitoring period.
** Possibly an overflow line. Inconsistent levels and velocities throughout the period.

3.2.2 Peak Measured Flows and Pipeline Capacity Analysis

Peak measured flows and the hydraulic grade line data (flow depths) are important to understanding the capacity limitations of a collection system. The peak flows and flow levels are the peak measurements taken across the entirety of the flow monitoring period. For this study, peak flows and peak levels corresponded to rainfall events. The following capacity analysis definitions will be used:

- **Peaking Factor (PF)** is defined as the peak measured flow divided by the average dry weather flow (ADWF). Peaking factors are influenced by many factors including size and topography of the tributary area, flow attenuation, flow restrictions, characteristics of I/I entering the collection system, and hydraulic features such as pump stations.
  - For this report, PF > 7 is highlighted in ***RED***[10]; however, the District should refer to District standards when evaluating peaking factors. Peaking factor data should be used at the discretion of the District Engineer.
- **d/D Ratio** is the peak measured depth of flow (d) divided by the pipe diameter (D). The d/D ratio for each site is computed based on the maximum depth of flow for the study. Standards for d/D ratio vary from agency to agency but typically range between d/D ≤ 0.5 and d/D ≤ 0.75
  - For this report, d/D ratios > 0.75 are highlighted in ***RED***; however, the District should refer to District standards when evaluating d/D ratios, to be used at the discretion of the District Engineer.

Table 3-4 summarizes the peak recorded flows, depths, *d/D* ratios, and peaking factors per site during the flow monitoring period. Capacity analysis data are presented on a site-by-site basis and represent the hydraulic conditions only at the site locations; hydraulic conditions in other areas of the collection system will differ. Figure 3-7 and Figure 3-8 show bar graph summaries of the peaking factors and d/D ratios, respectively.

The following capacity analysis results are noted:

- <u>Peaking Factors:</u>
  - Most of the sites had wet-to-dry weather peaking factors greater than 7. Only sites FM 030B, FM 050 N, FM 070B, FM 110A, and FM 120A did not. The majority of the peak wet-weather flow occurred during the 12/31/22 event.
  - Several basins had extremely high PFs, PFs> 20. Upon further review, there is the potential for velocity anomalies at each of the 3 sites that occurred during the 12/31/22, and 1/1/23, events. However, no adjustments were made as these velocity spikes coincided with a substantial depth response and a wet-weather event.
- <u>d/D Ratio:</u>
  - d/D > 0.75: Site FM 070C had a d/D ratio greater than 0.75.
  - d/D > 1 (surcharge): Sites FM 070A, FM 070D, FM 080B, FM 100B, FM110A, FM 140, and FM 150

[10] WEF Manual of Practice FD-6 and ASCE Manual No. 62 suggests typical peaking factor ratios range between 3 and 4, with higher values possibly indicative of pronounced I/I flows.

Table 3-5. Capacity Analysis Summary

Site	ADWF (MGD)	Peak Measured Flow (MGD)	Peaking Factor	Pipe Diameter, *D* (IN)	Max Depth, *d* (IN)	Max d/D Ratio	Surcharge above pipe crown (FT)
FM 020	0.024	0.319	*13.4*	10	3.61	0.36	-
FM 030B	0.000	0.122	-	10	3.85	0.38	-
FM 060A	0.007	0.127	*18.4*	6	1.68	0.28	-
FM 060B	0.051	0.880	*17.4*	12	3.35	0.28	-
FM 070B	0.033	0.104	3.2	10	3.57	0.36	-
FM 070E	0.083	0.801	*9.6*	10	6.75	0.68	-
FM 080A	0.089	1.210	*13.5*	15	7.27	0.48	-
FM 080B	0.062	12.377	*200.6*	15	31.27	*2.08*	*1.4*
FM 090	0.438	7.036	*16.1*	24	16.44	0.68	-
FM 120A	0.071	0.430	6.1	10	6.41	0.64	-
FM 010	0.191	1.802	*9.5*	15	6.43	0.43	-
FM 030A	0.166	2.980	*18.0*	21	10.26	0.49	-
FM 040	0.282	4.250	*15.1*	36	14.79	0.41	-
FM 050N	0.074	0.374	5.1	10	5.69	0.57	-
FM 050S	0.242	1.943	*8.0*	15	10.77	0.72	-
FM 070A	0.558	5.507	*9.9*	18	18.93	*1.05*	*0.1*
FM 070C	0.211	1.977	*9.4*	17.625	16.17	*0.92*	-
FM 070D	0.534	12.044	*22.6*	21	25.54	*1.22*	*0.4*
FM 100A	0.155	1.593	*10.3*	12	8.32	0.69	-
FM 100B	0.524	22.170	*42.3*	23.25	23.62	*1.02*	*0.03*
FM 110A	1.131	5.924	5.2	23.5	23.44	*1.00*	*0.00*
FM 120B	0.120	1.064	*8.8*	15	7.78	0.52	-
FM 130	1.284	10.240	*8.0*	24.75	12.08	0.49	-
FM 140	0.891	6.854	*7.7*	30	35.63	*1.19*	*0.5*
FM 150	0.269	3.276	*12.2*	15	21.68	*1.45*	*0.6*

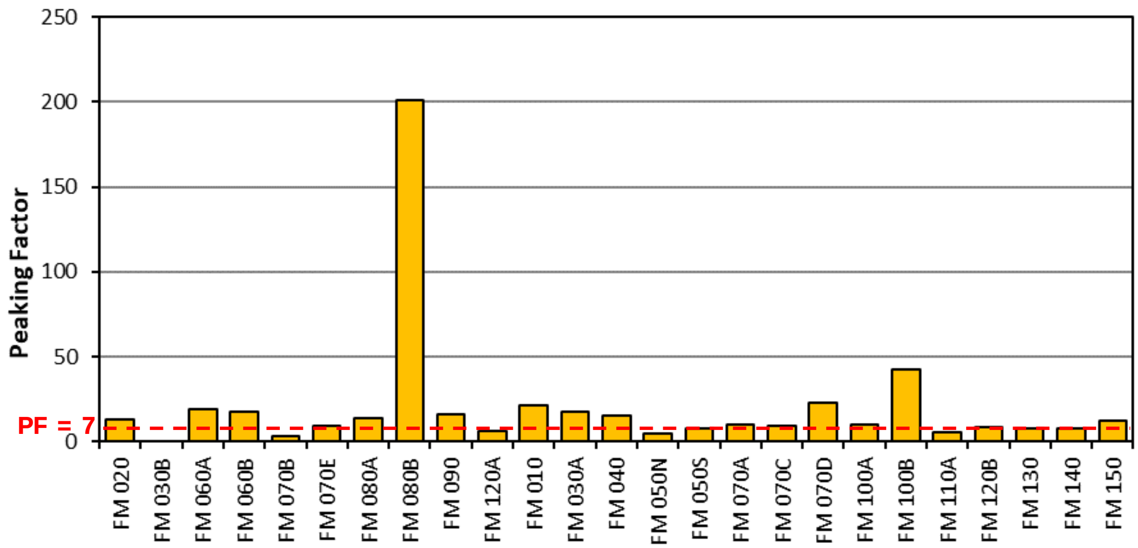


Figure 3-7. Peaking Factors

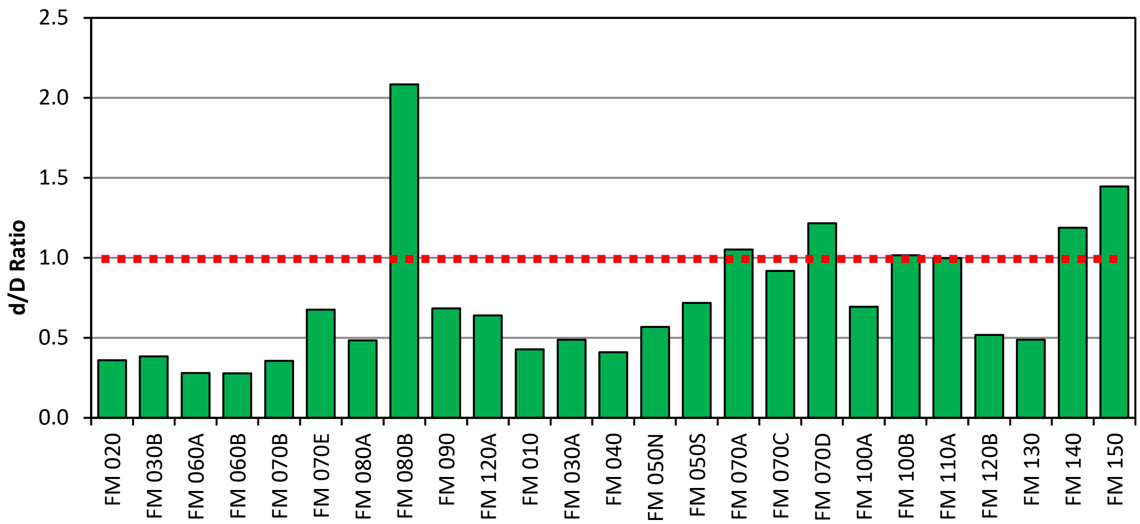


Figure 3-8. Capacity Summary: Max d/D Ratios

3.3 Inflow and Infiltration: Results

3.3.1 Preface

I/I analyses are presented on a basin-by-basin basis. Items relevant to the analysis in this study are noted below and referenced in Figure 3-9:

- **I/I Isolation**: The I/I flow rate is the real-time flow less the estimated average dry weather flow rate (shown below as the RED line).
- **Inflow**: Inflow is usually recognized graphically by large-magnitude, short-duration spikes immediately following a rain event. The peak inflow rate is the highest spike in the isolated I/I hydrograph immediately following the evaluated rainfall event. For this project, peak inflow rates were taken as a weighted average of the 12/31/22 and 1/13/23 storm events.
- **RDI**: RDI is typically taken as the average I/I flow rate measured after the peak inflow response has receded. Depending upon the size and characteristics of the basin (impervious/pervious area, soil types, collection system defects, etc.) peak RDI response can typically take approximately 24 – 96 hours after the rainfall event has concluded. For this project, RDI rates were a weighted average taken from a period between 24-hr and 96-hr following the storm events depending on the event.
- **Combined I/I**: the totalized volume (in gallons) of both inflow and RDI throughout a rainfall event (shown below as the shaded orange area). For this project, combined I/I was calculated utilizing a weighted average from the selected wet weather events.

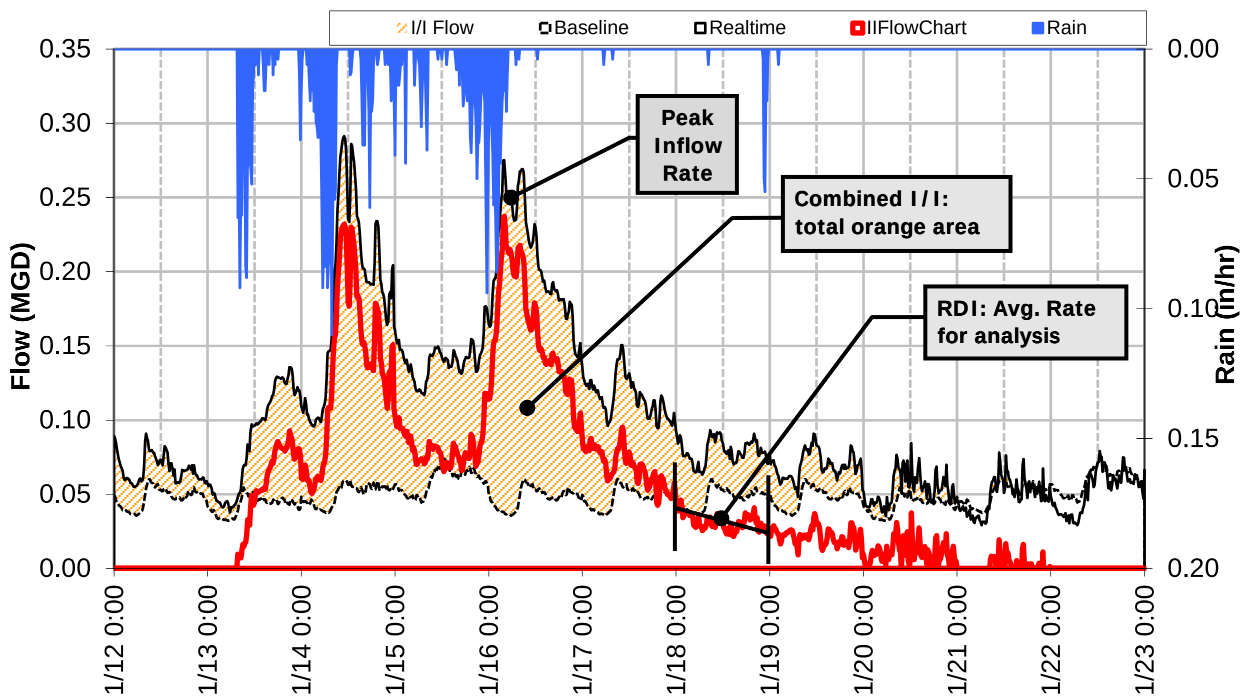


Figure 3-9. I/I Isolation, FM 20, January 13th Storm Event

3.3.2 Inflow Results Summary

Inflow is stormwater discharged into the sewer system through direct connections such as downspouts, area drains, cross-connections to catch basins, etc. These sources transport rainwater directly into the sewer system and the corresponding flow rates are tied closely to the intensity of the storm. This component of I/I often causes a peak flow problem in the sewer system and often dictates the required capacity of downstream pipes and transport facilities to carry these peak instantaneous flows.

Table 3-5 summarizes the peak measured inflow and inflow analysis results for the relevant flow monitoring basins. Figure 3-10 shows a temperature map summary of the inflow analysis results per basin. The "Top 3" basins for each category have been shaded in RED. The following inflow results are noted:

- Inflow for meter sites FM 030B, FM 070B, FM 080B was not calculated due to lack of or poor / missing flow conditions.
- It is noted that there are mass flow balance issues where basins 40, 70S, 100, 120E are showing a potential loss in flow during wet-weather.
- Some sites had substantial spikes in velocity due to or following wet-weather events which yielded substantial spikes in flow. These may or may not be erroneous data and more collection system data is required to confirm or disprove these responses. These sites include FM 080B, FM 070D, FM 100B, FM 150.
- Basin 140 had the highest weighted individual inflow rate of 5.076 mgd. However, it should be noted that, as previously mentioned in Section 3.2.2, sites FM 70A, FM 70D, FM 80B, FM 100B, FM110A, FM 140, and FM 150 surcharged during the 12/31/22 event where peak flow would have been restricted.
- Basin 90 ranked the highest based on inflow per-ADWF and highest overall.
- Basin 140 ranked the highest based on inflow per-IDM and inflow per-Acre.

Table 3-6. Results and Rankings of Inflow Analysis

Basin ID	ADWF (mgd)	Basin Acres	Peak Inflow Rate (mgd)	Peak Inflow per-IDM (gpd/IDM)	Peak Inflow per-Acre (gpd/acre)	Peak Inflow/ ADWF Ratio	Inflow per-IDM Rank	Inflow per-Acre Rank	Inflow per-ADWF Rank	Final Inflow Rank
10	0.06	1,463	1.605	12,482	1,097	26.9	11	12	2	10
20	0.02	372	0.325	8,007	874	13.7	13	14	4	12
30	0.08	393	1.259	14,687	3,203	15.3	9	6	3	5
40*	0.12	526	-0.362	-3,584	-688	-3.1	15	15	16	15
50N	0.07	348	0.822	19,581	2,363	11.2	6	10	6	8
50S	0.24	456	1.368	24,883	2,999	5.7	3	7	12	6
60	0.06	285	0.697	14,859	2,445	12.1	8	8	5	7
70N	0.24	898	2.126	13,522	2,367	8.7	10	9	9	11
70S*	0.05	556	-2.572	-28,676	-4,626	-54.8	17	17	18	18
80	0.15	284	1.032	17,518	3,633	6.8	7	5	11	9
90	0.04	373	2.675	22,994	7,170	72.6	4	2	1	1
100*	0.24	619	-1.762	-11,687	-2,847	-7.3	16	16	17	17
110	0.35	539	1.090	10,094	2,023	3.1	12	11	15	13
120E*	-0.49	422	-3.343	-42,284	-7,921	6.9	18	18	10	16
120W	0.07	272	0.271	7,286	997	3.8	14	13	14	14
130	0.76	774	3.962	24,972	5,119	5.2	2	3	13	3
140	0.50	499	5.076	37,571	10,173	10.1	1	1	7	2
150	0.27	478	2.379	19,762	4,978	8.9	5	4	8	4

*Flow not adding up as it travels downstream.

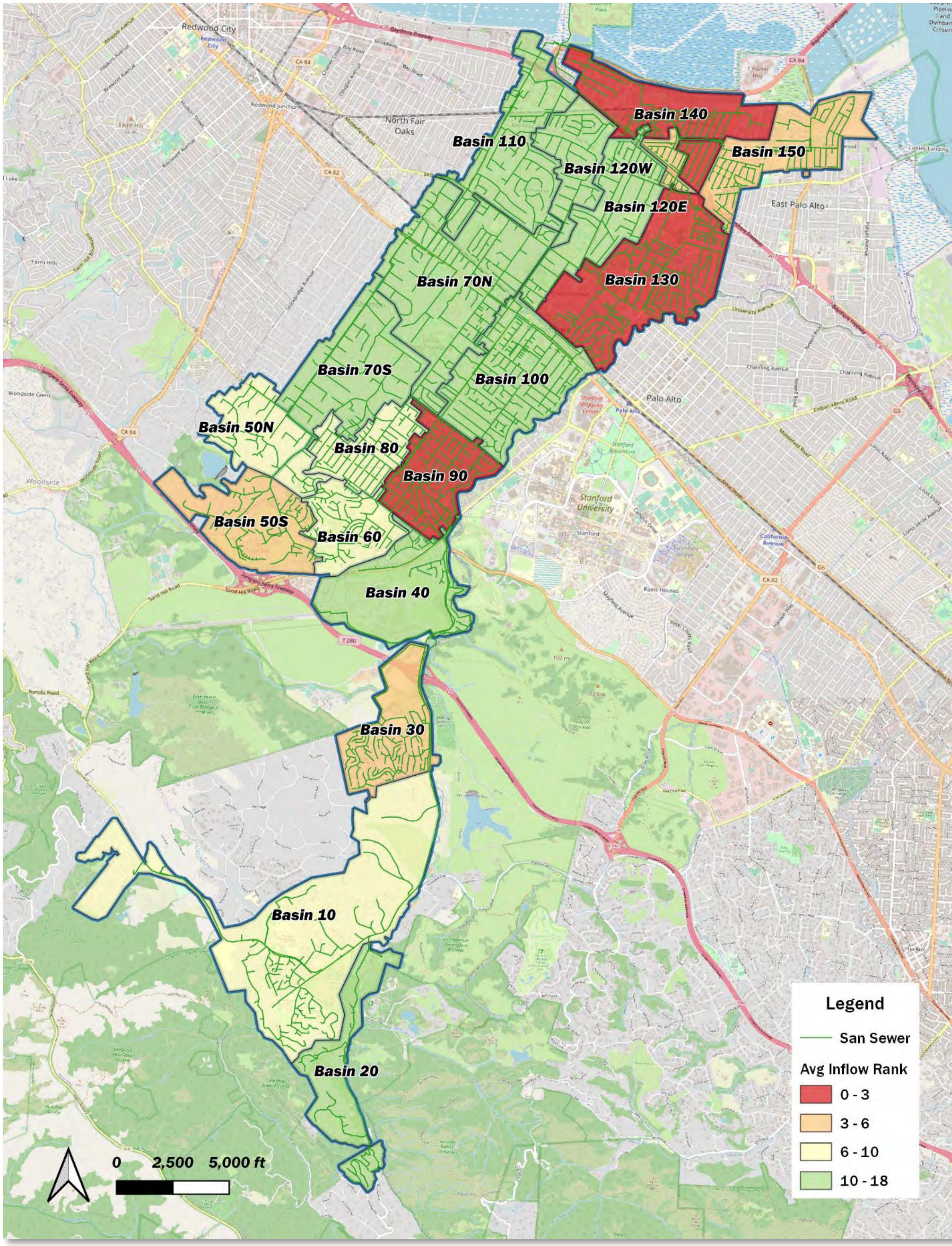


Figure 3-10. Temperature Map: Inflow Final Basin Rankings

3.3.3 Rainfall-Dependent Infiltration Results Summary

Infiltration is defined as water entering the sanitary sewer system through defects in pipes, pipe joints, and manhole walls, which may include cracks, offset joints, root intrusion points, and broken pipes. Increased flows into the sanitary sewer system are usually tied to groundwater levels and soil saturation levels. Infiltration sources transport rainwater into the system indirectly; flow levels in the sanitary system increase gradually, are typically sustained for a period after rainfall has stopped, and then gradually decrease as soils become less saturated and groundwater levels recede to normal.

Infiltration typically creates long-term annual volumetric problems. The major impact is the cost of pumping and treating the additional volume of water, and of paying for treatment (for municipalities that are billed strictly on flow volume).

Table 3-6 summarizes the RDI analysis results for the relevant flow monitoring basins. The "Top 3" basins for each category have been shaded in RED. The following RDI results are noted:

- RDI for meter sites FM 030B, FM 070B, and FM 080B was not calculated due to lack of or poor/missing flow conditions.
- It is noted that there are mass flow balance issues where basins 40, 70S, 100, 120E are showing a potential loss in flow during wet-weather.
- Basin 90 had the highest RDI rate at 0.360 mgd and ranked highest based upon RDI per-IDM, per-ADWF, and RDI per-Acre.
- The "Top 3" ranked basin according to RDI, in order from 1st to 3rd, are 90, 30, 50N.

Figure 3-11 shows a temperature map summary of the average final RDI analysis rankings per basin.

Table 3-7. Results and Rankings of RDI Analysis

Basin ID	RDI Rate (mgd)	RDI per IDM	RDI per-Acre (gpd/acre)	RDI per ADWF ratio	RDI per-IDM Rank	RDI per-Acre Rank	RDI per-ADWF Rank	Final RDI Rank
10	0.064	499	44	1.1	13	14	7	12
20	0.063	1,539	168	2.6	6	12	2	6
30	0.186	2,175	474	2.3	4	2	3	2
40*	-0.016	-157	-30	-0.1	16	16	17	17
50N	0.122	2,915	352	1.7	2	3	5	3
50S	0.136	2,467	297	0.6	3	6	12	5
60	0.070	1,484	244	1.2	7	8	6	7
70N	0.217	1,380	241	0.9	8	9	8	9
70S*	-0.279	-3,106	-501	-5.9	17	17	18	18
80	0.096	1,629	338	0.6	5	5	10	4
90	0.360	3,095	965	9.8	1	1	1	1
100*	0.155	1,028	251	0.6	11	7	9	10
110	0.126	1,170	234	0.4	10	10	13	11
120E*	-0.817	-10,336	-1,936	1.7	18	18	4	14
120W	0.005	125	17	0.1	15	15	15	16
130	0.046	289	59	0.1	14	13	16	15
140	0.110	813	220	0.2	12	11	14	13
150	0.164	1,360	342	0.6	9	4	11	8

*Flow not adding up as it travels downstream.

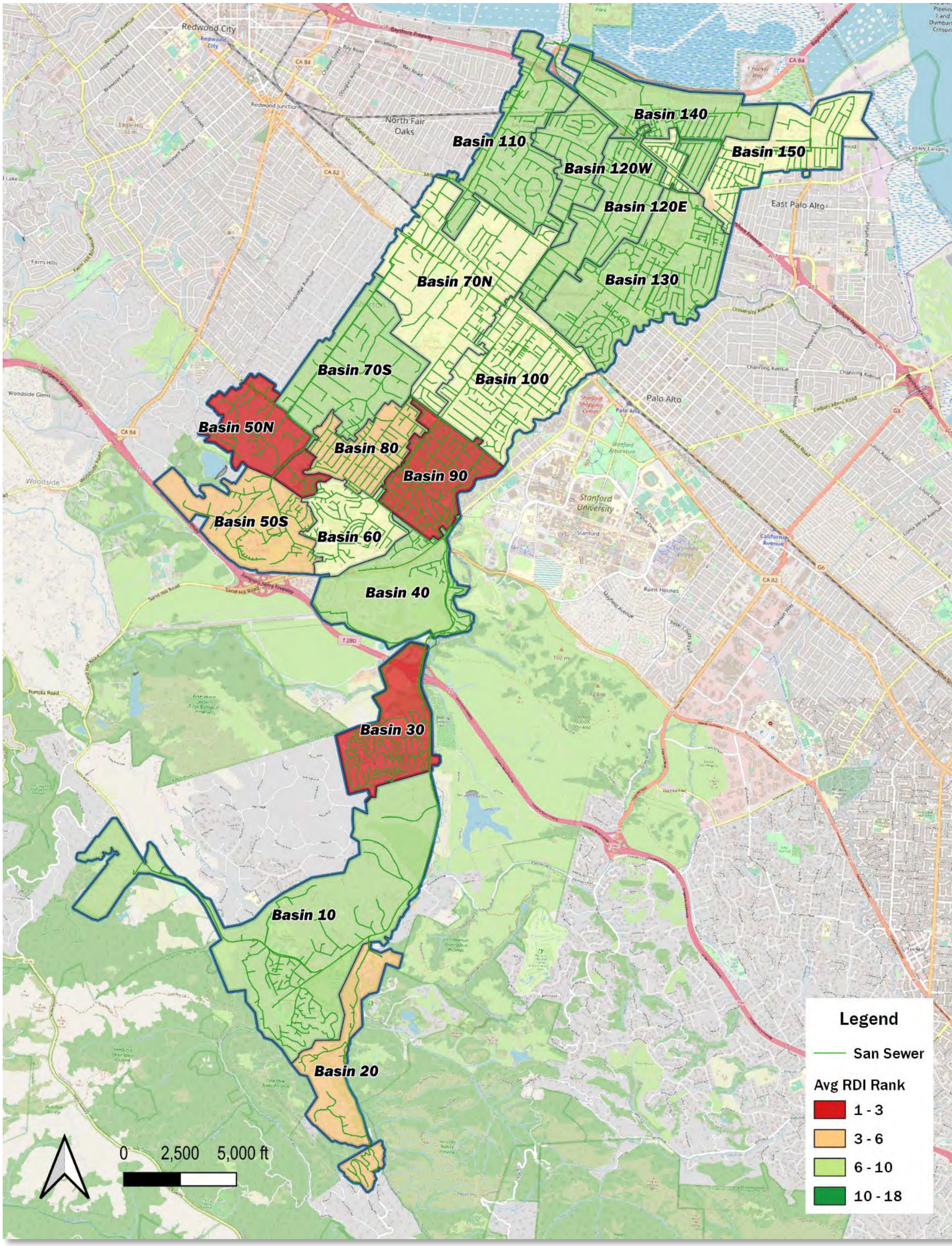


Figure 3-11. Temperature Map: RDI Final Basin Rankings

3.3.4 Combined I/I Results

Combined (total) I/I analysis considers the totalized volume (in gallons) of both inflow and rainfall-dependent infiltration over the course of a storm event. Table 3-7 summarizes the combined I/I analysis results for the relevant flow monitoring basins. Figure 3-12 shows a temperature map summary of the combined I/I analysis results per basin. The "Top 3" basins for each category have been shaded in *RED*. The following combined I/I results are noted:

- Combined I/I for meter sites FM 030B, FM 070B, and FM 080B was not calculated due to lack of or poor/missing flow conditions.
- It is noted that there are mass flow balance issues where basins 40, 70S, 100, 120E are showing a potential loss in flow during wet-weather.
- Basin 90 saw the highest % of rainwater entering the collection at 40.1%. Basin 090 also ranked highest based on total I/I per acre and I/I per IDM.
- Basins 50N and 80 ranked 2nd and 3rd respectively for total I/I.

Table 3-8. Combined I/I Analysis Summary

Basin ID	Total I/I (gallons)	Total I/I per IDM	Total I/I per ACRE	Total I/I per ADWF	Total I/I per IDM	Total I/I per-ADWF Ranking	Total I/I per-Acre Ranking	Final Total I/I Ranking
10	619,868	3,508	1.1%	7.55	13	14	7	12
20	631,458	10,574	4.3%	18.03	9	11	2	8
30	1,493,324	11,827	9.5%	12.32	7	6	4	5
40*	-1,589,363	-17,674	-12.5%	-15.41	16	16	17	17
50N	1,021,807	21,571	9.6%	12.32	2	5	3	2
50S	910,184	14,680	6.5%	3.34	5	9	13	9
60	571,406	10,803	6.5%	8.81	8	8	6	7
70N	1,206,942	6,808	4.4%	4.40	11	10	10	11
70S*	-2,397,095	-23,692	-14.1%	-45.27	17	17	18	18
80	1,075,605	16,190	12.4%	6.31	3	3	8	3
90	4,577,330	34,890	40.1%	110.23	1	1	1	1
100*	241,118	1,418	1.3%	0.89	14	13	15	14
110	1,876,243	15,400	11.4%	4.72	4	4	9	4
120E*	-6,529,434	-73,230	-50.5%	11.88	18	18	5	15
120W	37,964	905	0.5%	0.47	15	15	16	16
130	807,506	4,513	3.4%	0.94	12	12	14	13
140	1,965,269	12,896	12.9%	3.47	6	2	12	6
150	1,319,874	9,719	9.0%	4.36	10	7	11	10

*Flow not adding up as it travels downstream.

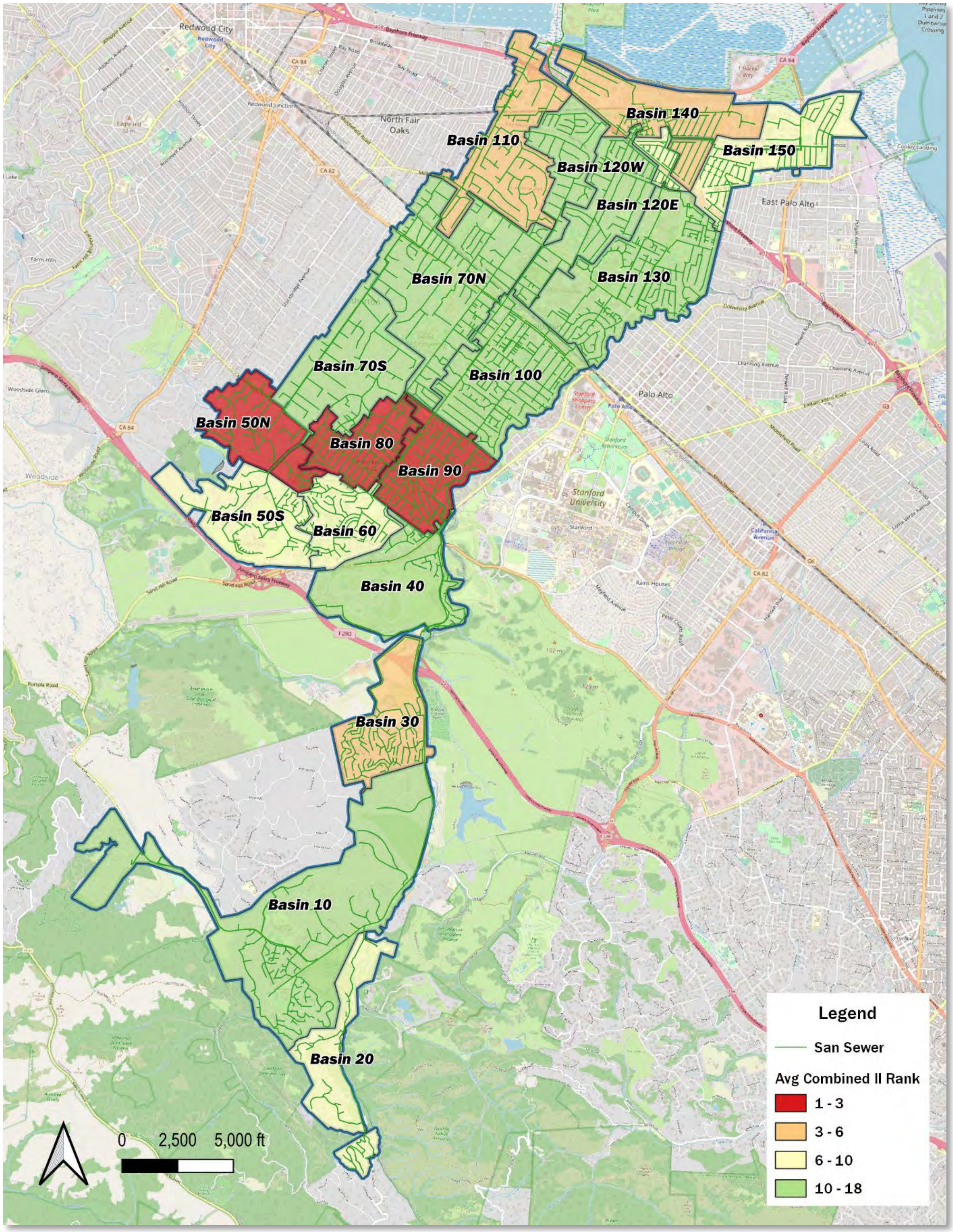


Figure 3-12. Temperature Map: Combined I/I Final Basin Rankings

3.3.5 Groundwater Infiltration Results Summary

Dry weather (ADWF) flow can be expected to have a predictable diurnal flow pattern. While each site is unique, experience has shown that, given a reasonable volume of flow and typical loading conditions, the daily flows fall into a predictable range when compared to the daily average flow. If a site has a large percentage of groundwater infiltration occurring during the periods of dry weather flow measurement, the amplitudes of the peak and low flows will be dampened[11]. Figure 3-13 shows a sample of two flow monitoring sites, both with nearly the same average daily flow, but with considerably different peak and low flows. In this *sample* case, Site B1 may have a considerable volume of groundwater infiltration.

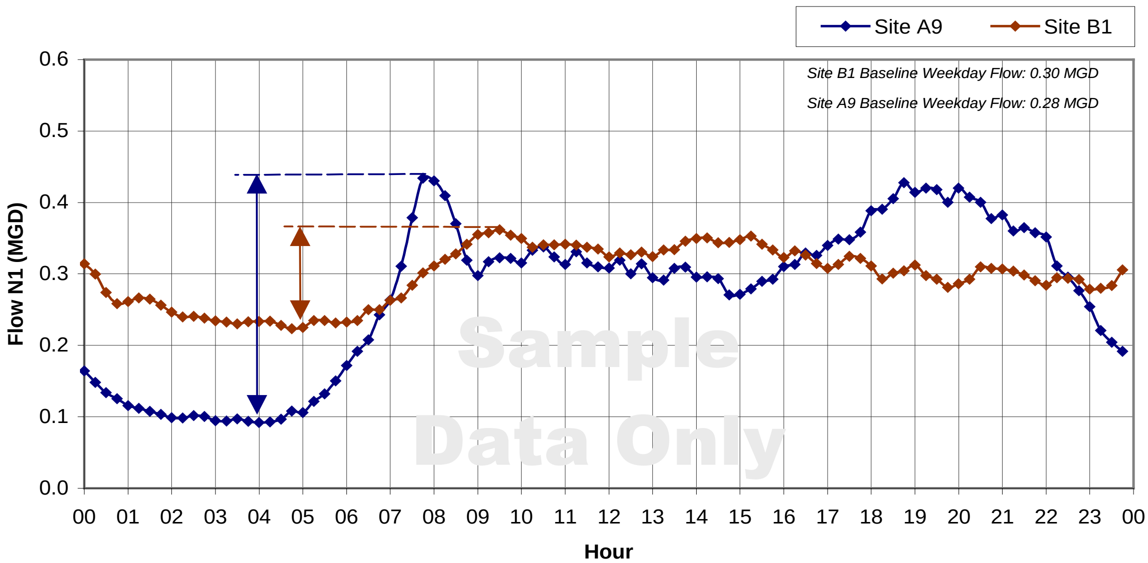


Figure 3-13. Groundwater Infiltration Sample Figure

It can be useful to compare the low-to-ADWF flow ratios for the flow monitoring sites. A site with abnormal ratios, and with no other reasons to suspect abnormal flow patterns (such as proximity to a pump station, treatment facilities, etc.), has a possibility of higher levels of groundwater infiltration in comparison to the rest of the collection system.

Figure 3-14 plots the low-to-ADWF flow ratios[12] against the ADWF flows for the relevant flow monitoring sites. The brown dashed line shows "typical" low-to-ADWF ratios per the Water Environment Federation (WEF). Figure 3-15 shows a color-coded map of the basins with rates of groundwater infiltration considerably above typical groundwater infiltration standards (as set forth by WEF).

WEF derived these ratios from residential sanitary sewer data. It is noted that if the type of service is not residential (industrial, for example), there exists the possibility of excessive early-morning flows due to abnormal working hours. This analysis is presented <u>for reference only</u>. The following GWI results are noted:

- 8 Sites, corresponding to 5 Basins, have ratios that indicated groundwater may be entering the collection system with higher than average low-ADWF ratios. These sites include FM 020, FM 070A,

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[11] In an extreme case, perhaps 0.2 mgd of ADWF flow and 2.0 mgd of groundwater infiltration, the peaks and lows would be barely recognizable; the ADWF flow would be nearly a straight line.

[12] The Minimum to Average flow ratio is calculated by taking the minimum flow and dividing by the ADWF value (using the Mon-Thu ADWF curve).

FM 070B, FM 070C, FM 070E, FM 080B, FM 110A, and FM 140. Only sites greater than the WEF average are labeled below to keep the figure less congested.

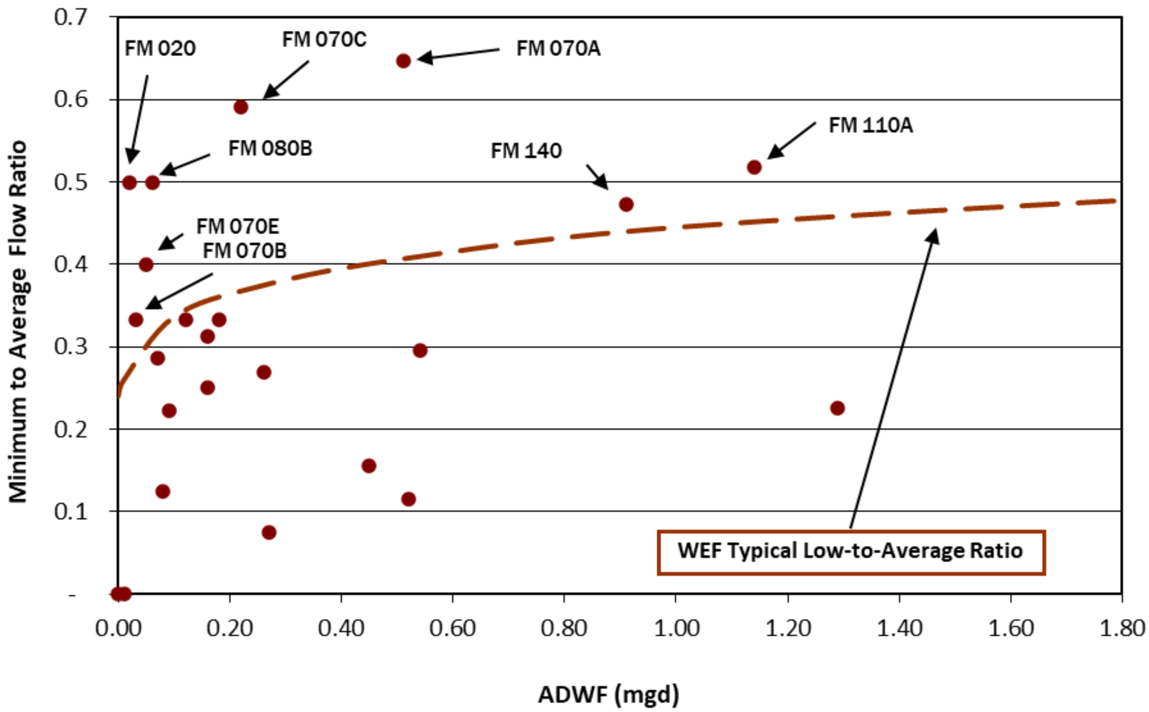

Figure 3-14. Minimum Flow Ratios vs ADWF[13]

[13] Due to attenuation, it should be expected that sites with larger flow volumes should not have quite the peak-to-average and low-to-average flow ratios as sites with lesser flow volumes. This is why the WEF typical trend line's slope is closer to 1.0 as the ADWF increases, as shown in the figure.

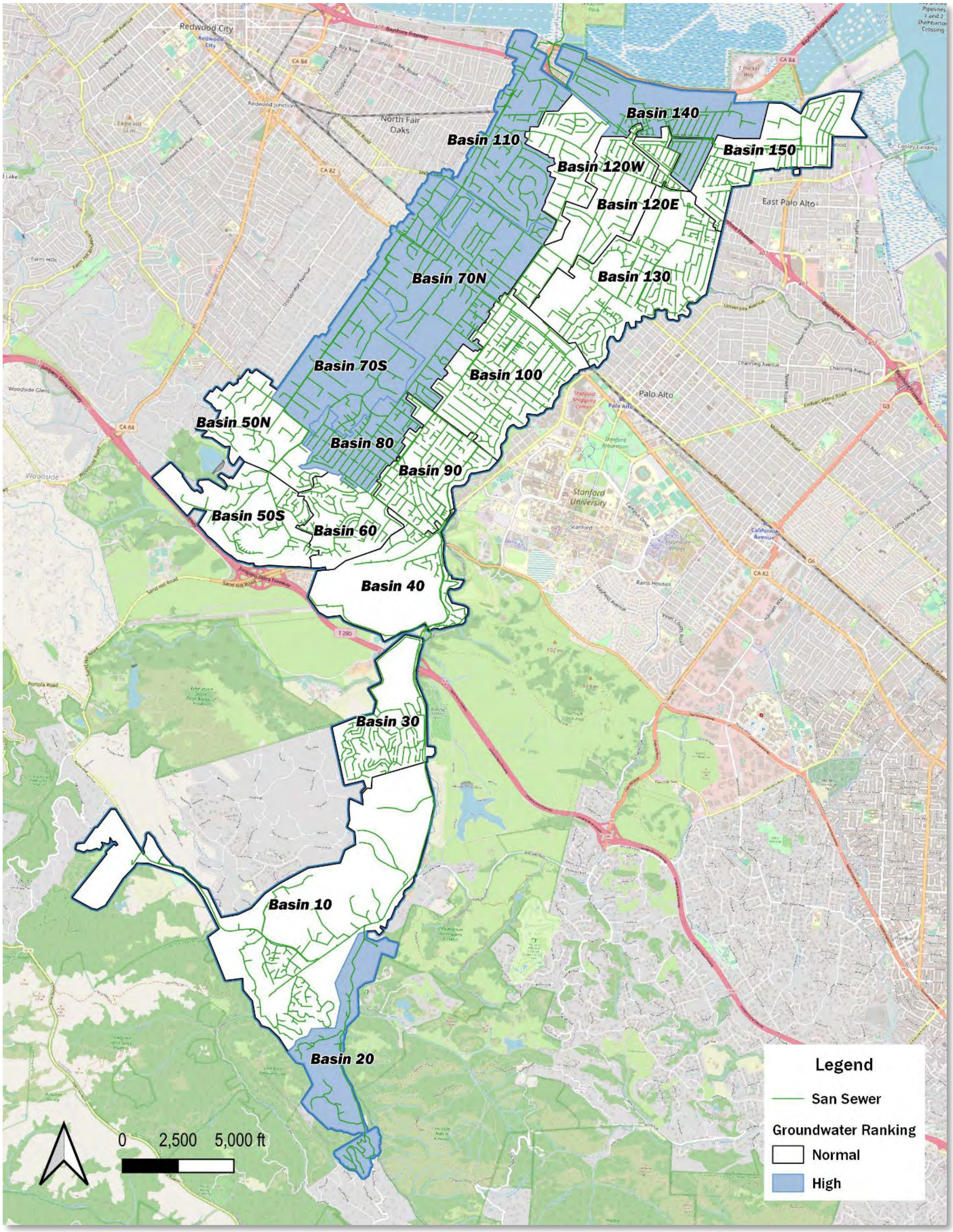

Figure 3-15. Temperature Map: Basins with Potentially High GWI

3.4 Summary

The resulting data from the flow and rainfall monitoring program indicates the presence of system-wide RDII entering the collection system by responding quickly to rainfall events. This is a typical response from a system containing deficiencies that allow surface run-off to enter the sanitary sewer. The quick flow responses shown in the monitoring data are believed to be caused by inflow entering the collection system through defects, e.g., vented covers, uncapped cleanouts, connected downspouts, and directly connected storm sewers. Typically, an inflow response is followed by a period of extended and elevated flow conditions, referred to as infiltration. Infiltration is caused by seeping into the collection system through defects, e.g., offset or separated pipe joints, broken pipes, and deteriorated manhole structures.

The monitoring data indicates that meter sites FM 070A, FM 070D, FM 080B, FM 100B, FM 110A, FM 140, and FM 150 would lack capacity during a 50-year storm event, as noted by system flow responses during the 12/31/22 storm event. It should also be noted that multiple rainfall events preceded the 12/31/22 event which would have saturated the soil and made the 12/31/22 system response more pronounce than for a single isolated wet-weather event. The calculated return period for this event is a triangulated average to the Study Area centroid, individual basins would have experienced rainfall with a slightly higher or lower return period.

Some sites indicated a flow loss between upstream and downstream sites. This could be due to unknown cross connections in the system, unknown dry or wet-weather overflows, inaccurate data, or monitoring sites not located where they were presumed to be. Final flow monitoring data was double-checked against site reconnaissance/maintenance data and no further adjustments were deemed justified. Additional field verification may be necessary to determine why flows were not continually adding up as they moved downstream based on the agreed-upon basin flow schematic.

4 Recommendations

V&A advises that future I/I reduction plans consider the following recommendations:

1. **Master Plan and Model Implementation**: This study focuses on inflow and infiltration generation; the study results can be used to update the master plan and compare it with previous model assumptions and flow monitoring results.
2. **Verify Interconnections and Overflows**: understanding the interconnections and overflows can help with the master plan, basin isolation, and I/I analysis. Multiple basin cross-connections exist which may be affecting flow analysis. These cross-connections should be field verified to determine where, and how much, flow is going through each basin.
    a. Mass flow balance issues were noted during this study. It is recommended that system characterization work be performed to identify, during both and wet-weather, manholes where flow could potentially be diverted to other areas of the system. Invert measurements and pipe connections should be verified, and basin flow responses (dry and wet) adjusted as appropriate.
3. **Capacity Analysis**: 8 sites were surcharged during the monitoring period during a 50-year storm event. It should also be noted that multiple rainfall events preceded the December 31st event which would have saturated the soil and made the 12/31/22 system response more pronounced than for a single isolated wet-weather event. The calculated return period for this event is a triangulated average to the Study Area centroid, individual basins would have experienced rainfall with a slightly higher or lower return period. It is assumed that during the hydraulic modeling portion of this study that system capacity constraints for the design storm event will be identified and added to the capital improvement plan in the updated master plan. The following possible capacity concerns are noted:
    a. **Dry weather**: No issues with dry weather flow were noted. The highest d/D ratio noted was 0.51 at site FM 080B. All remaining sites ranged from 0 to 0.33.
    b. **Wet Weather**: The monitoring data indicates that meter sites FM 070A, FM 070D, FM 080B, FM 100B, FM 110A, FM 140, and FM 150 would lack capacity during a 50-storm event, as noted during the 12/31/22 storm event. Max d/D ratios ranged from 1 – 2.08 at Site FM 080B.
4. **Determine I/I Reduction Program**: The District should examine its I/I reduction needs to determine its goals for a future I/I reduction program.
    a. If peak flows, sanitary sewer overflows and pipeline capacity issues are of greater concern, then priority can be given to investigate and reduce sources of inflow within the basins with the greatest inflow problems. The highest-ranked basins according to inflow are 090, 140, and 130.
    b. If total infiltration and general pipeline deterioration are of greater concern, then the program can be weighted to investigate and reduce sources of infiltration within the basins with the greatest infiltration problems. The highest basins according to RDI are 90, 30, and 50N. Additionally, basins 20, 70N, 70S, 80, 110, and 140 may show evidence of excessive GWI.
5. **I/I Investigation Methods**: Potential I/I investigation methods include the following:
    a. Smoke testing.
    b. Manhole inspections
    c. Private building evaluations

d. Night-time[14] reconnaissance work to (1) investigate and determine direct point sources of inflow, and (2) determine the areas and/or pipe reaches responsible for high levels of infiltration contribution.

e. CCTV inspection.

f. Dye Testing: Dye testing can be performed to confirm connectivity or to indicate the extent of I/I entering the system.

6. **I/I Reduction Cost Effective Analysis**: The District should conduct a study to determine which is more cost-effective: (1) locating the sources of inflow/infiltration and systematically rehabilitating or replacing the faulty pipelines; or (2) continued treatment of the additional rainfall dependent I/I flow.

[14] Reconnaissance work is conducted during low-flow hours, typically between 12:00 A.M. and 4:30 A.M., to best differentiate and identify I/I contribution from sanitary flows.

Appendix A
Flow Monitoring Sites: Data, Graphs, Information

V&A Project No. 22-0324

V&A
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Appendix B

DRY WEATHER CALIBRATION PLOTS

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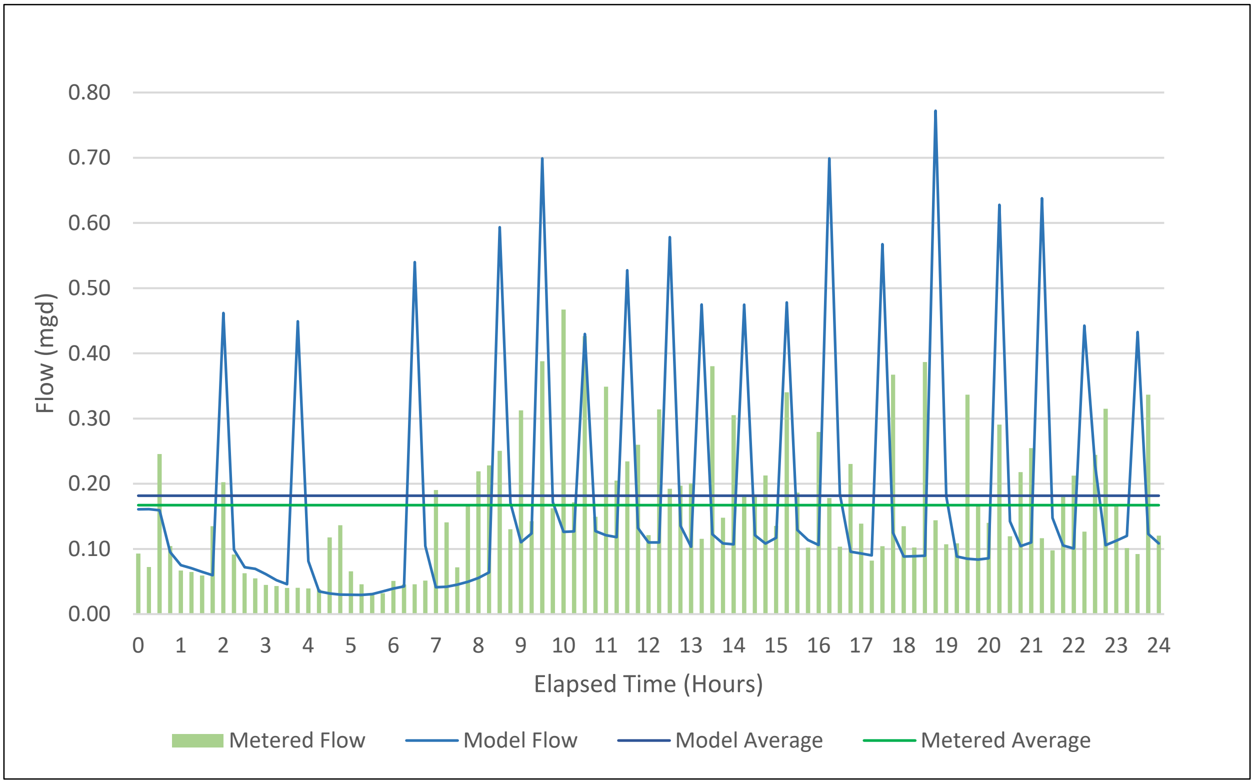
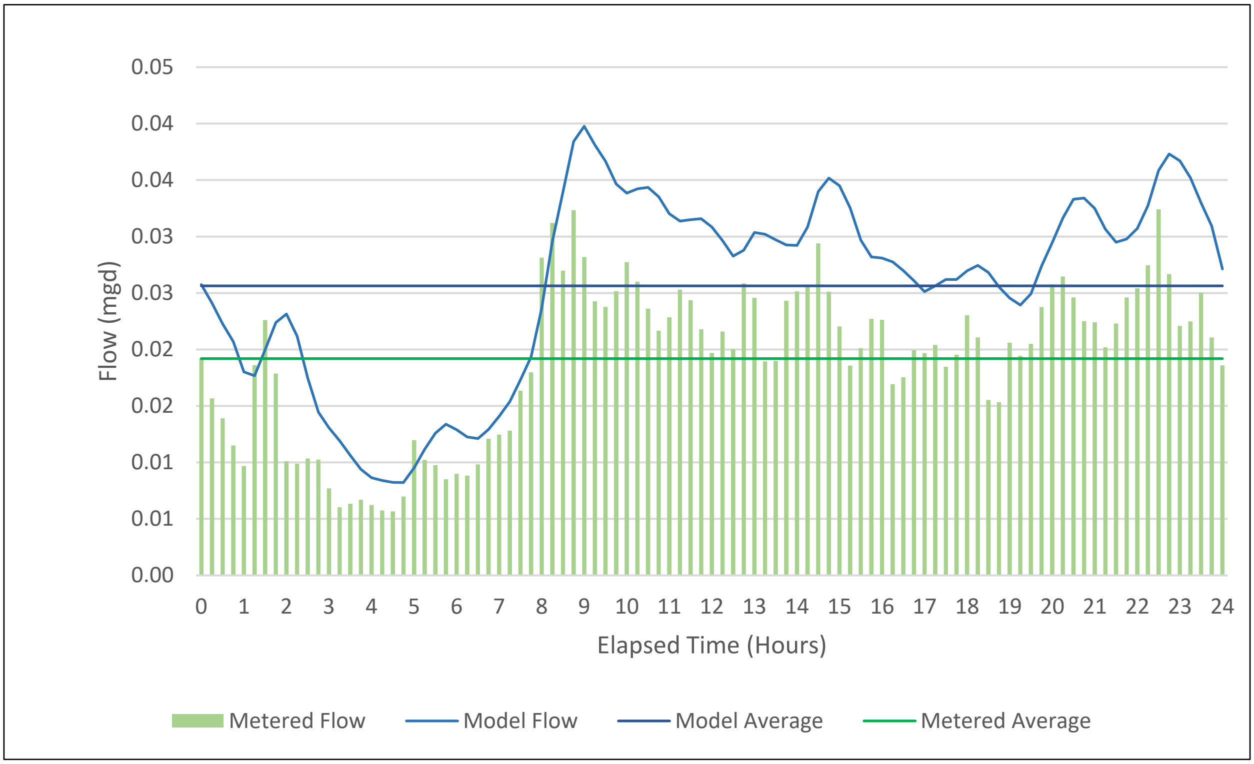
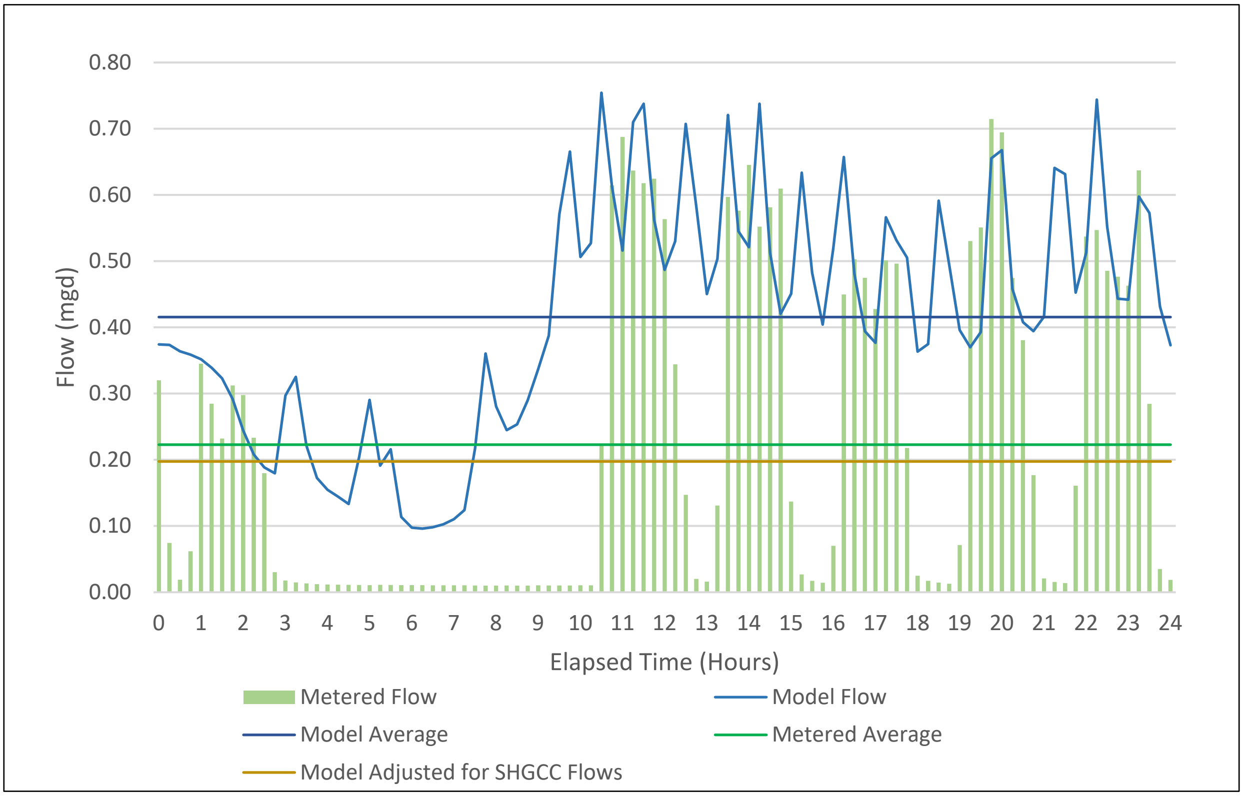
Basin 010 Dry Weather Calibration – 12/07/2023



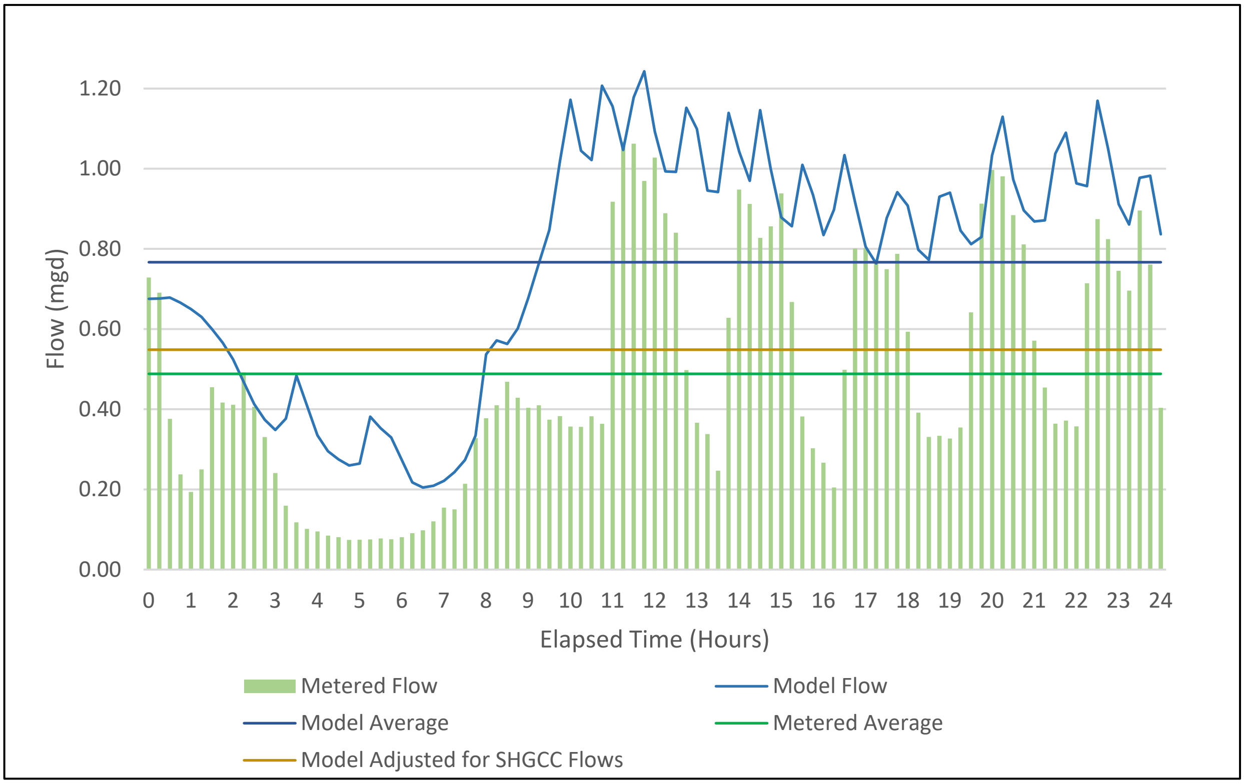
Basin 020 Dry Weather Calibration – 12/07/2023



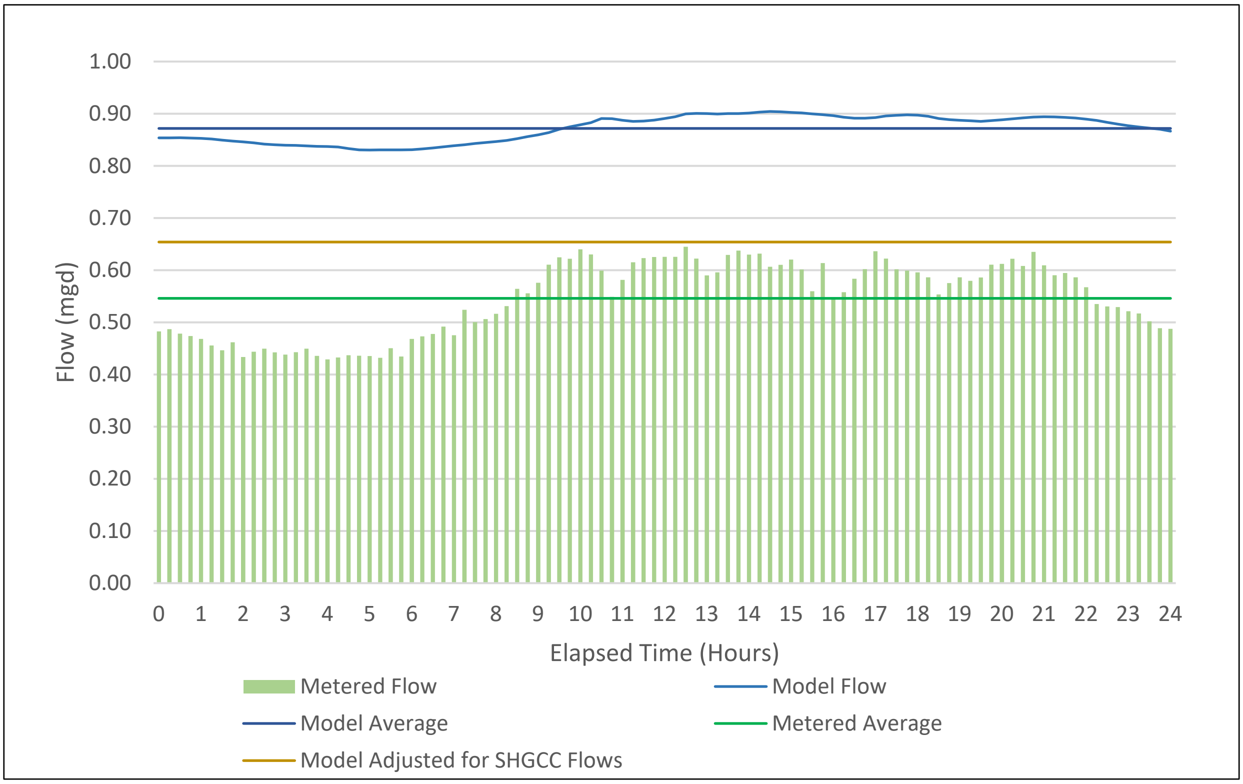
Basin 040 Dry Weather Calibration – 12/07/2023
Pumped Flow to SHGCC is Visible in Metered Flow



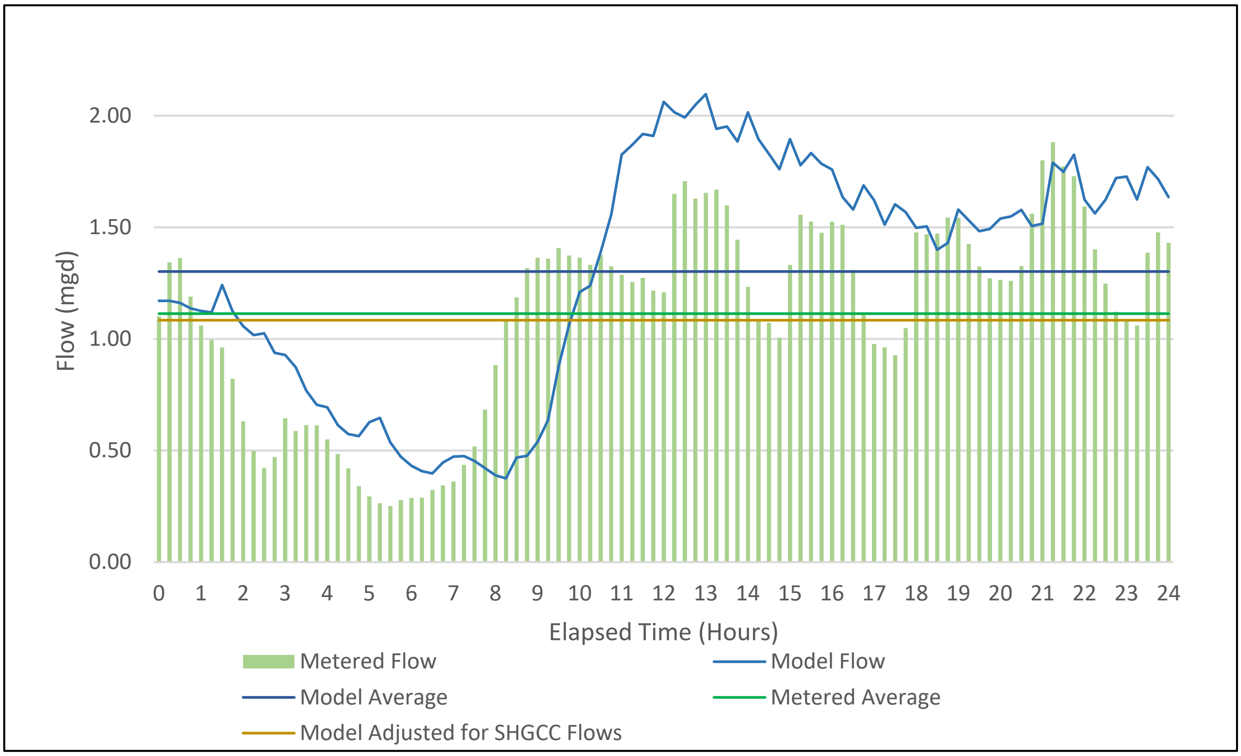
Basin 090 Dry Weather Calibration – 12/07/2023
Pumped Flow to SHGCC is Visible in Metered Flow



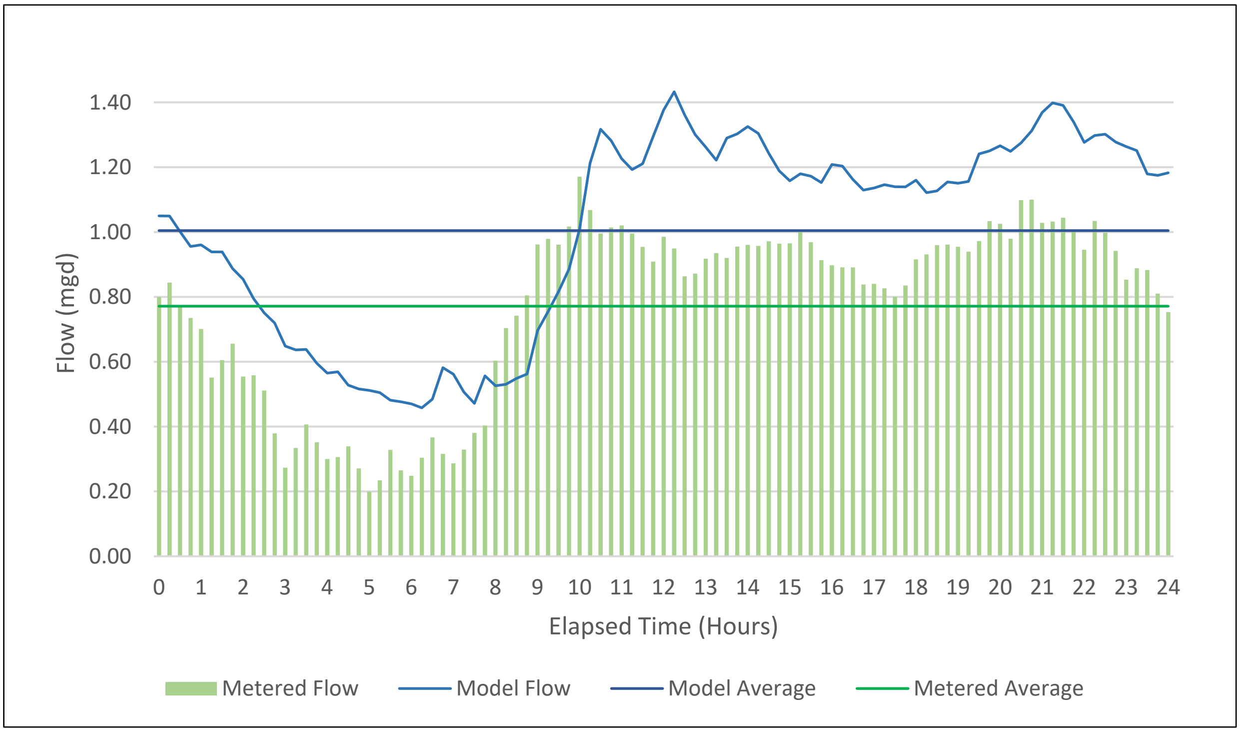
Basin 100A/B Dry Weather Calibration – 12/07/2023
Pumped Flow to SHGCC is Removed Mathematically to Create Adjusted Model Average



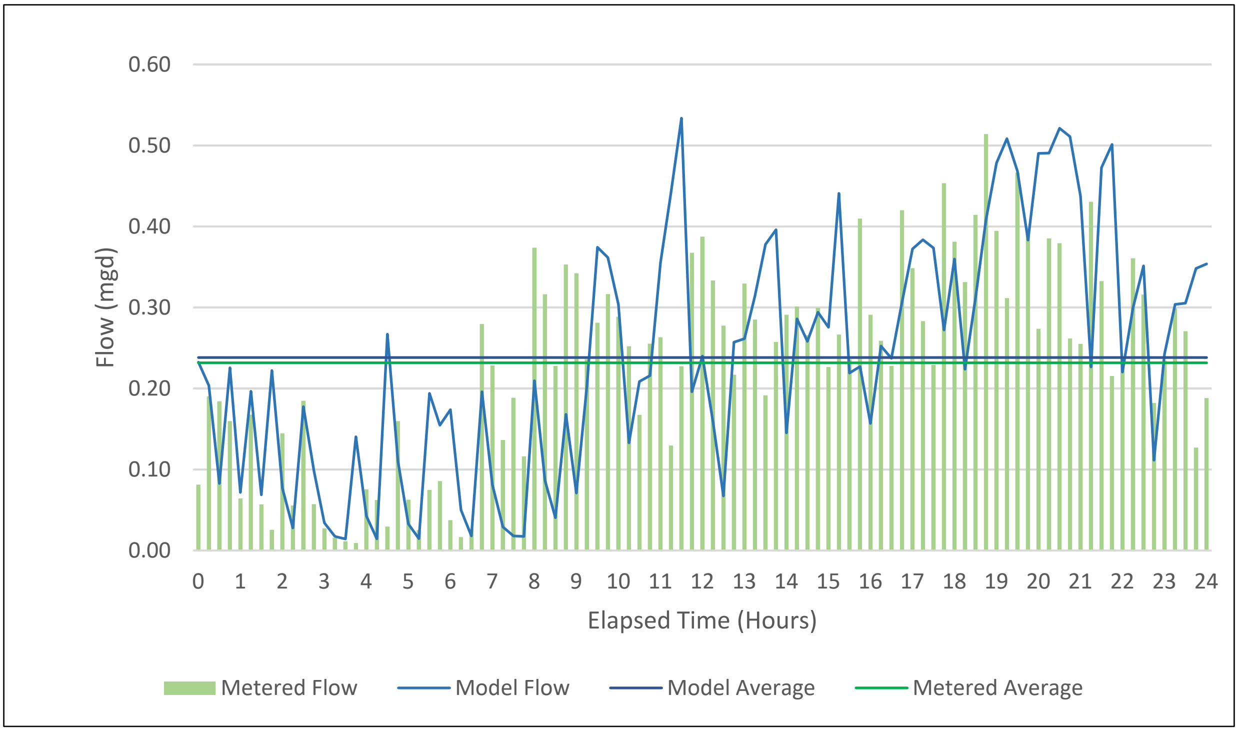
Basin 130 Dry Weather Calibration – 12/07/2023
Pumped Flow to SHGCC is Removed Mathematically to Create Adjusted Model Average



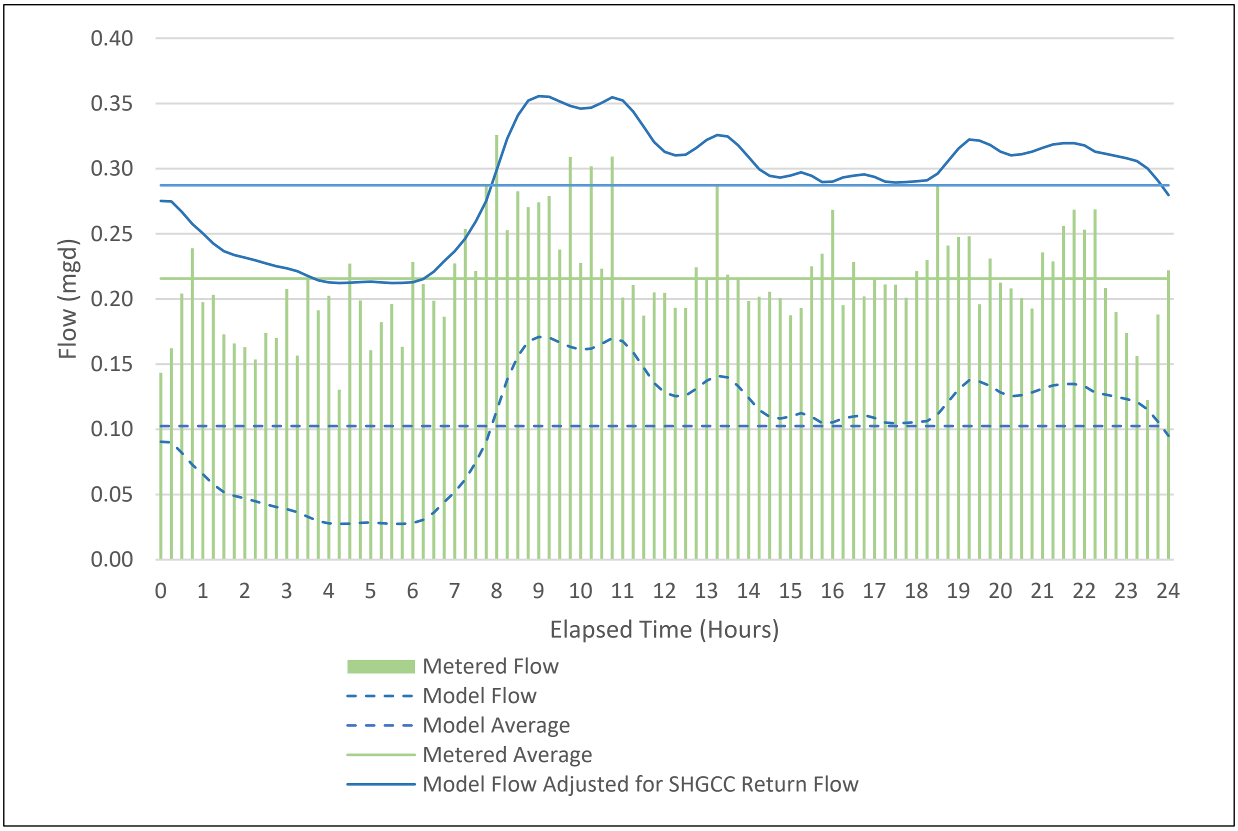
Basin 140 Dry Weather Calibration – 12/07/2023



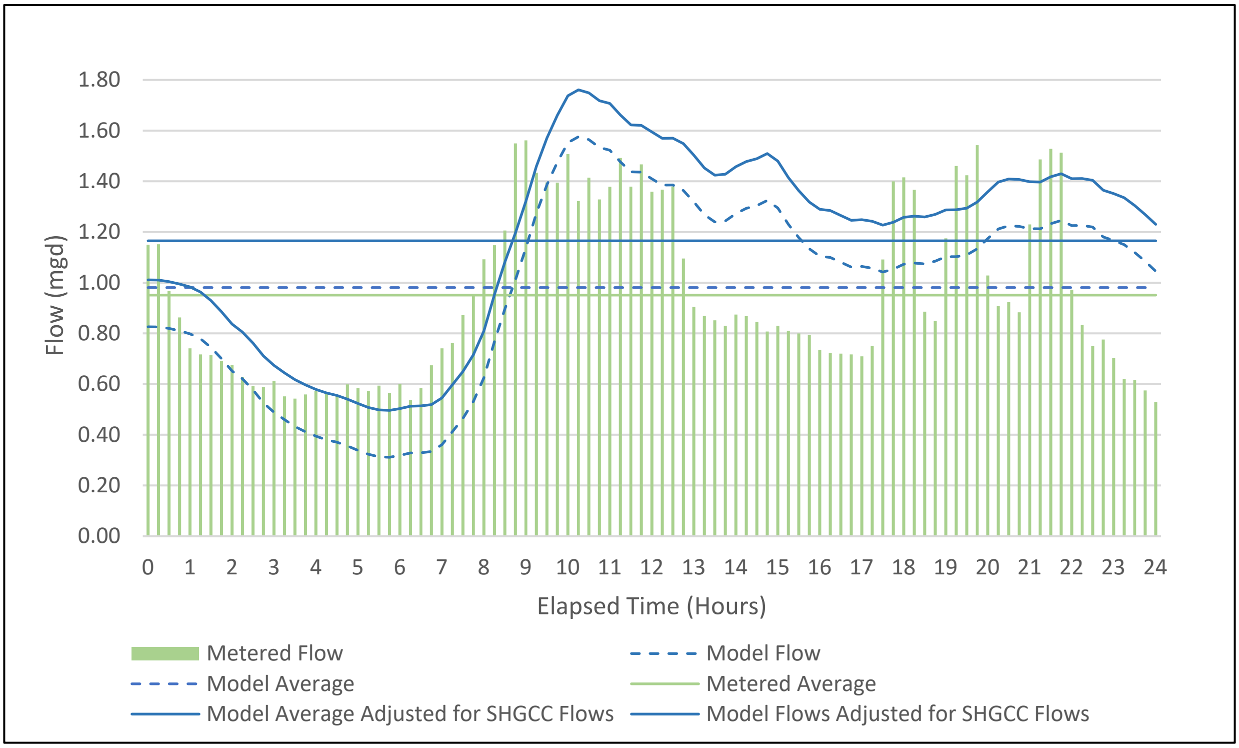
Basin 150 Dry Weather Calibration – 12/07/2023



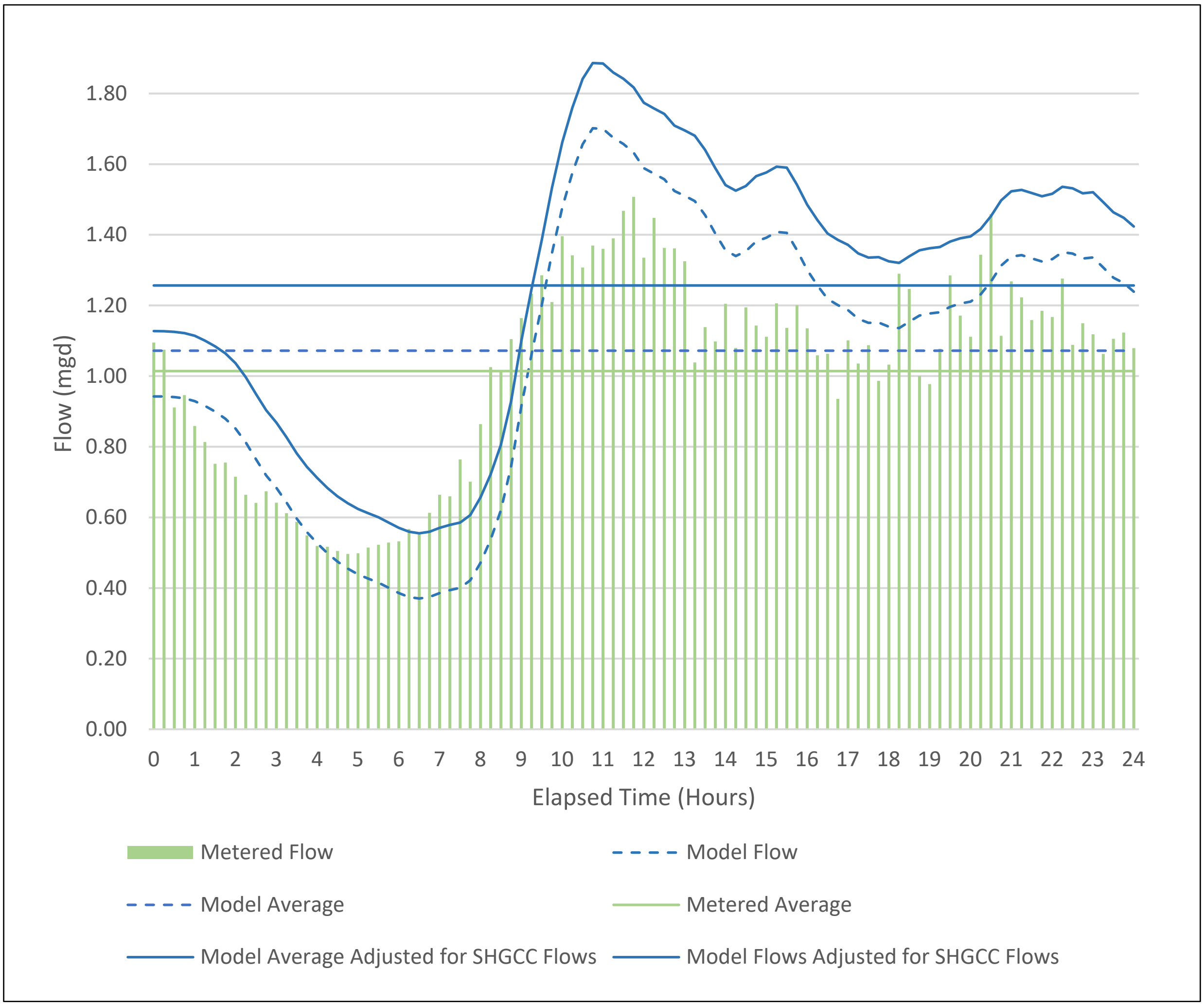
Basin 050_S Dry Weather Calibration – 12/07/2023
SHGCC Flows are Added Mathematically



Basin 070BCD Dry Weather Calibration – 12/07/2023
SHGCC Flows are Added Mathematically



Basin 050_S Dry Weather Calibration – 12/07/2023
SHGCC Flows are Added Mathematically



Appendix C

WET WEATHER CALIBRATION PLOTS

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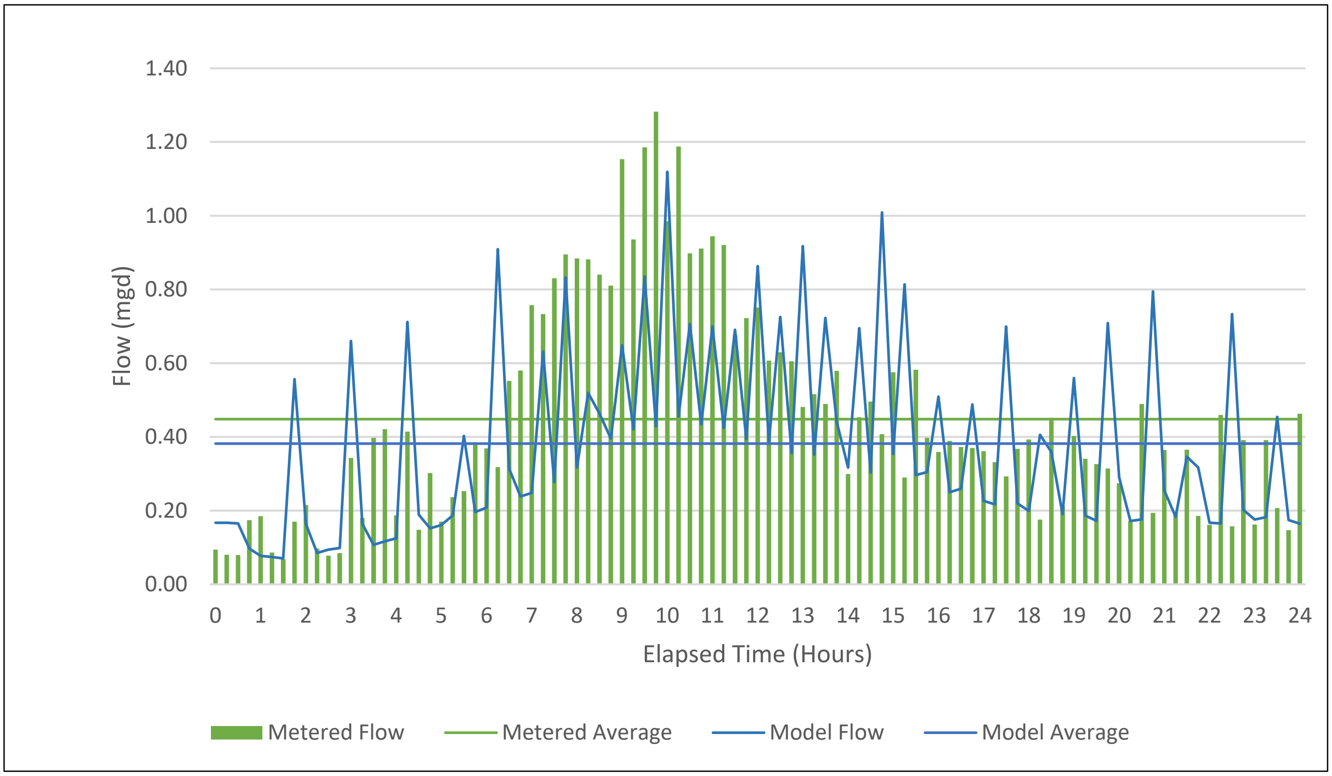
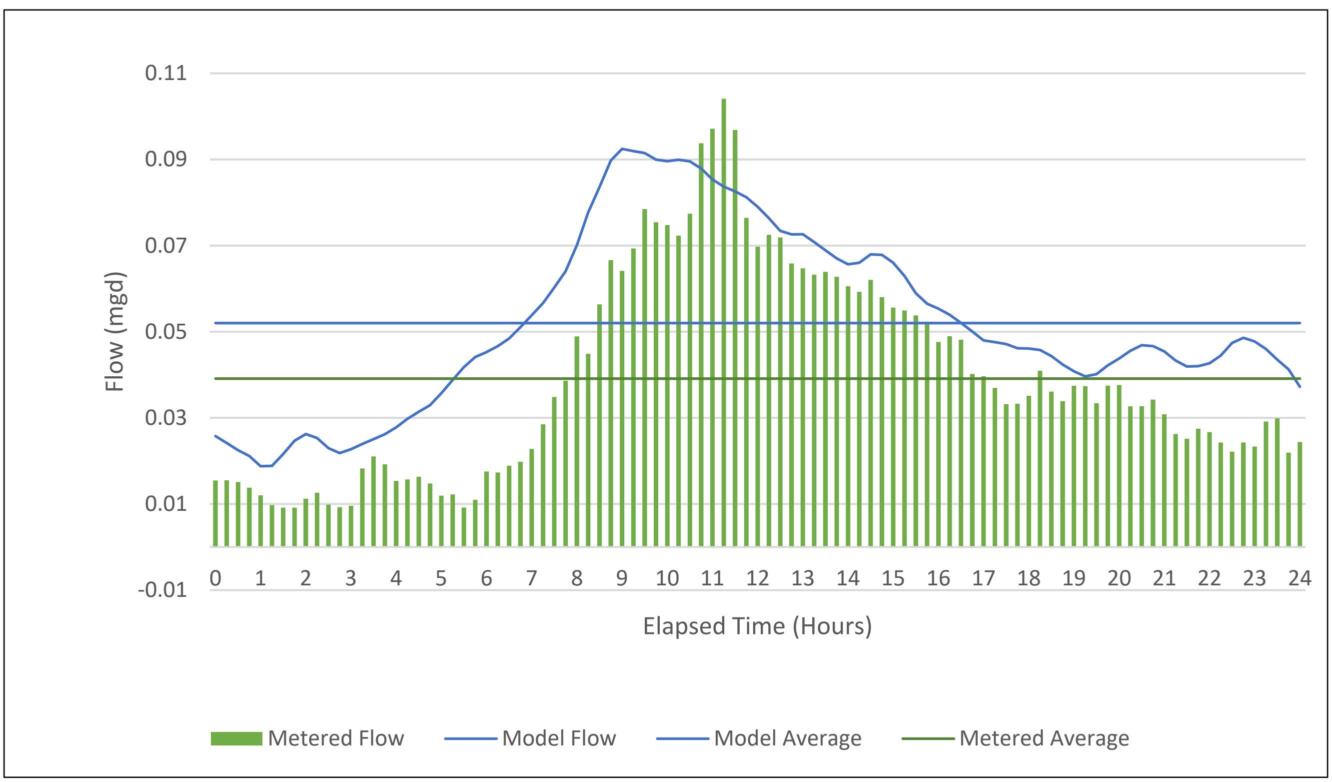
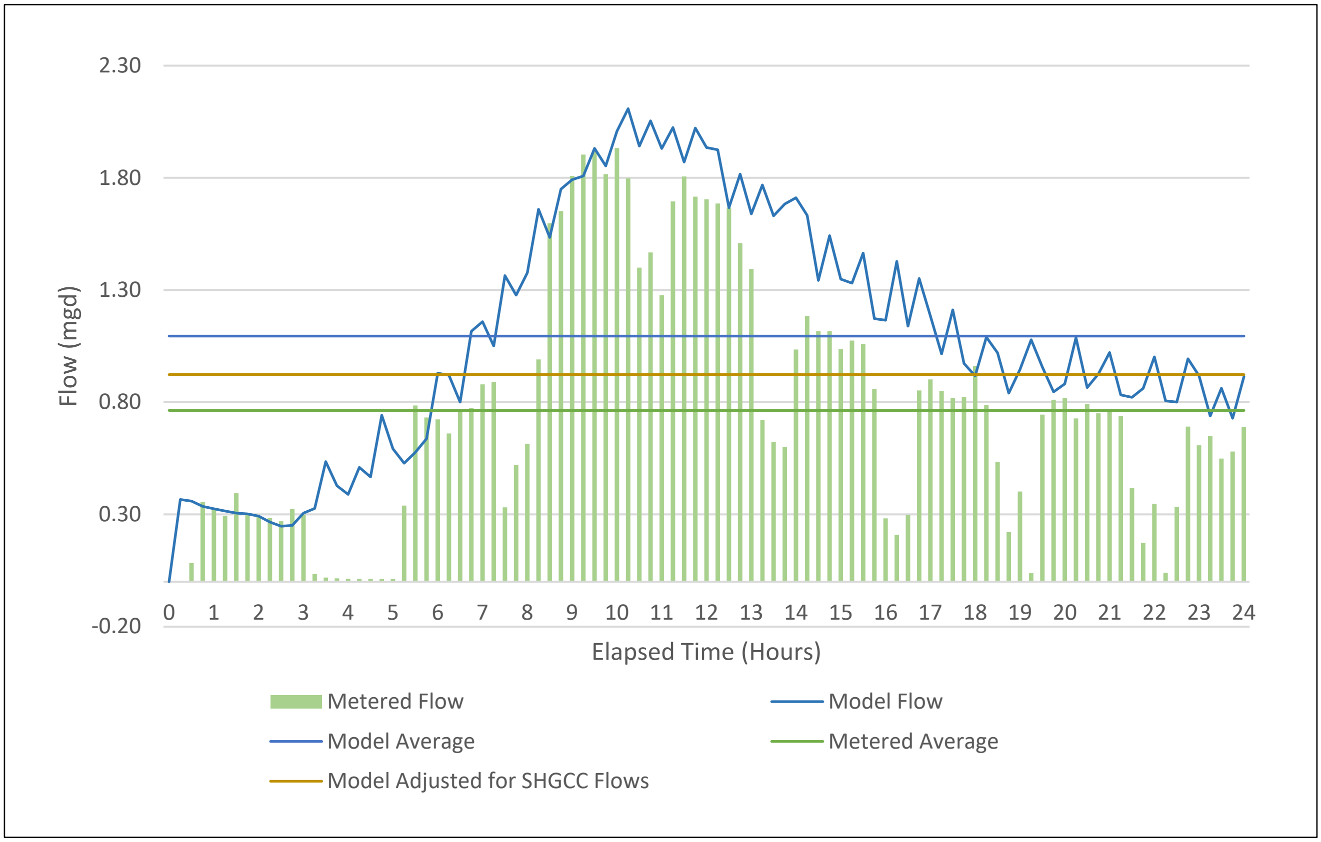
Basin 010 Wet Weather Calibration – 12/27/2023



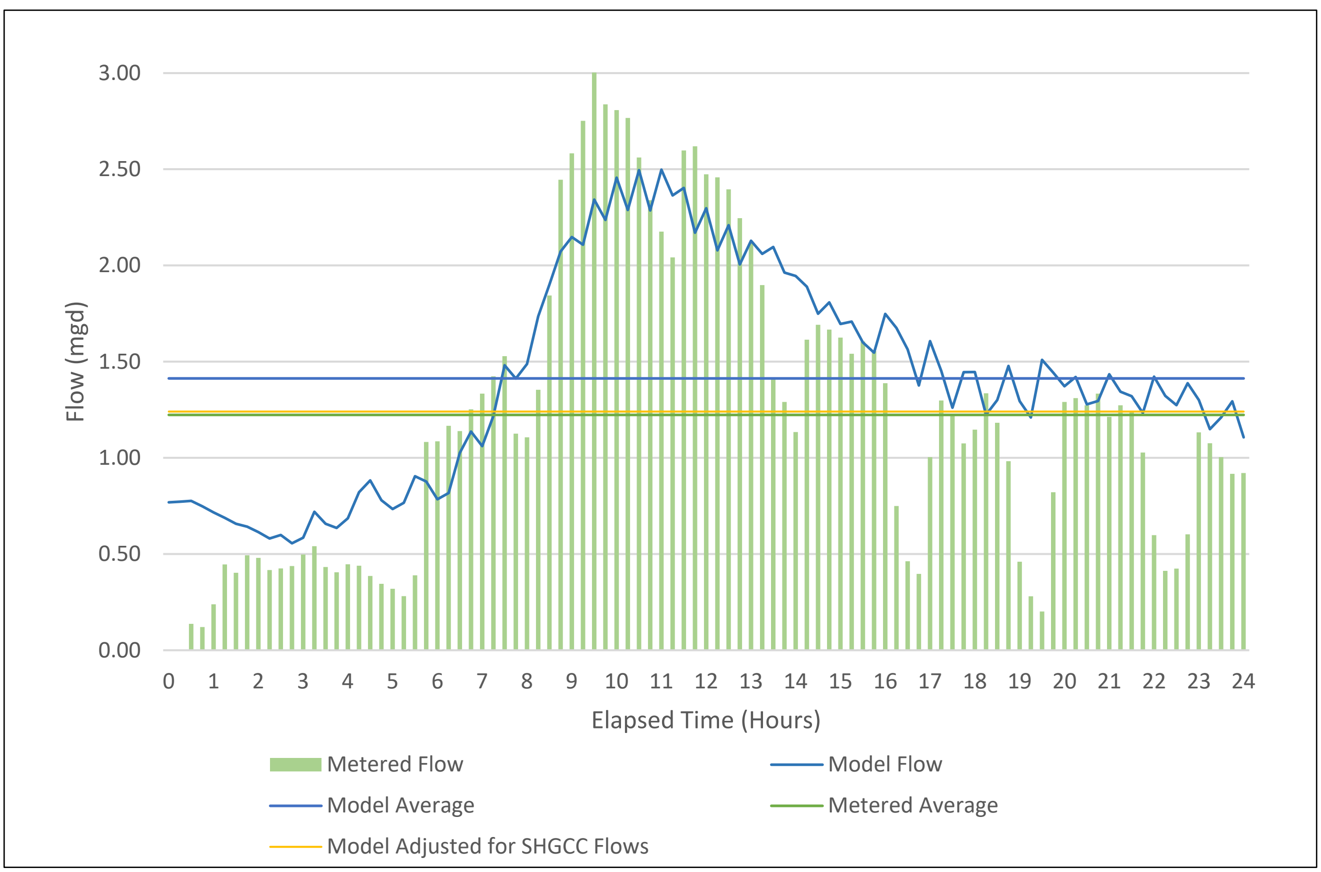
Basin 020 Wet Weather Calibration – 12/27/2023



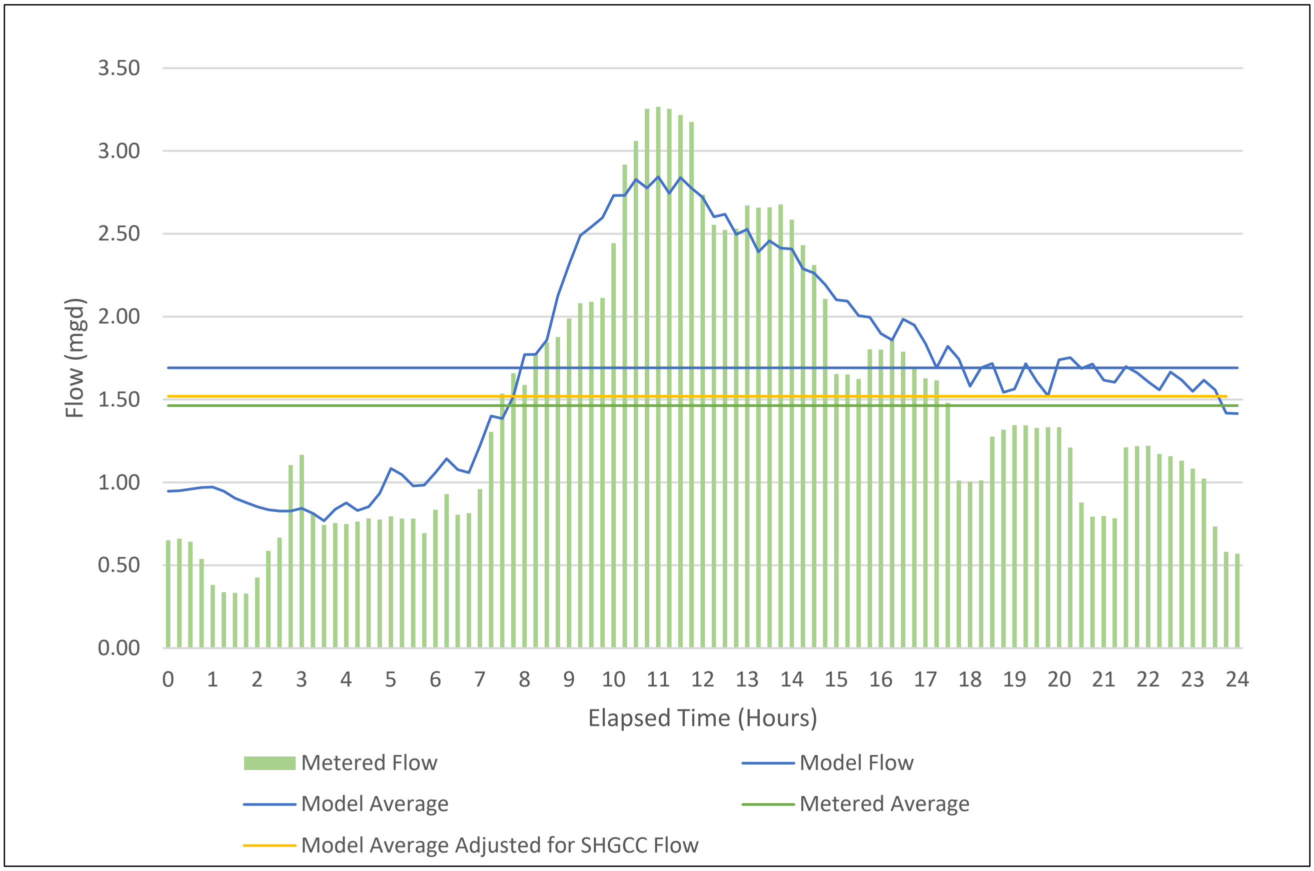
Basin 040 Wet Weather Calibration – 12/27/2023
Pumped Flow to SHGCC is Visible in Metered Flow



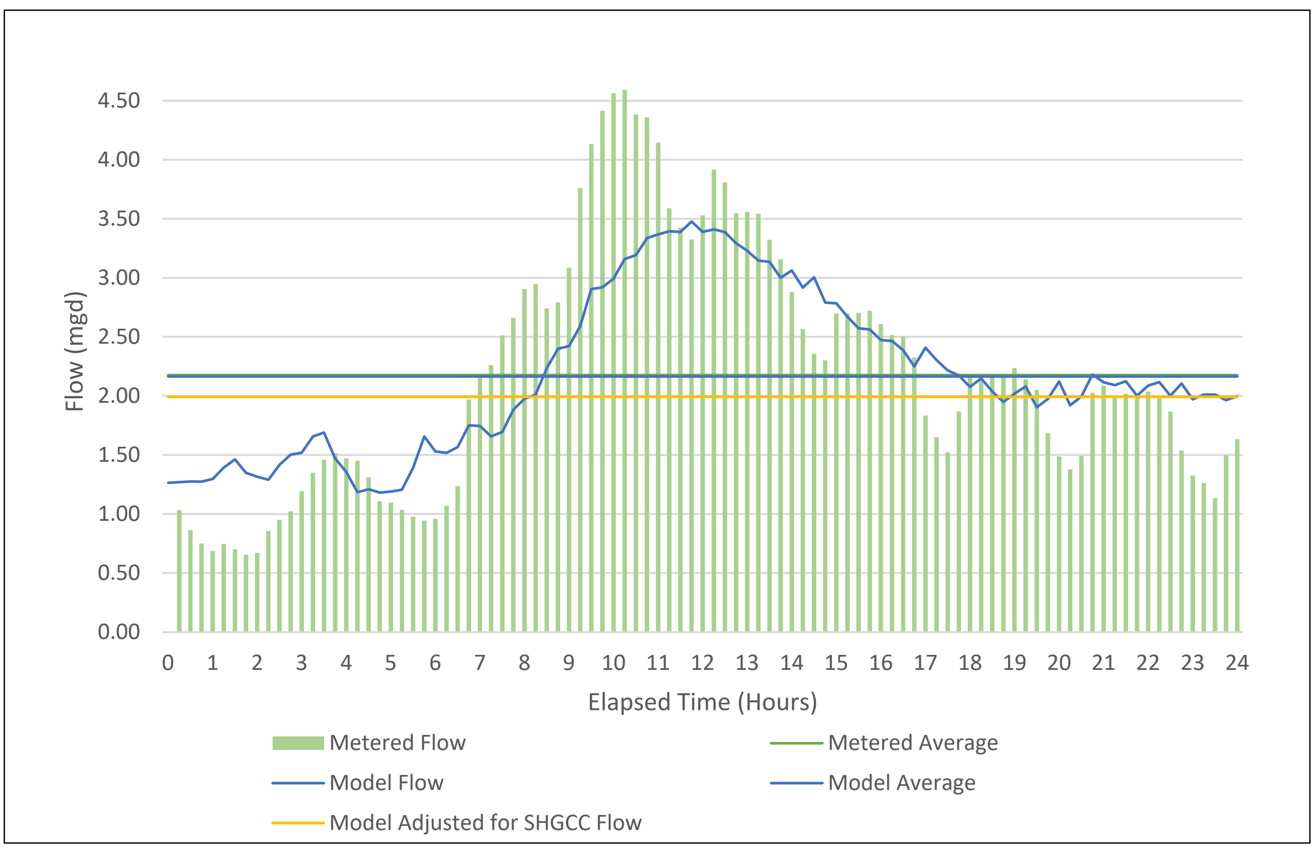
Basin 090 Wet Weather Calibration – 12/27/2023
Pumped Flow to SHGCC is Visible in Metered Flow



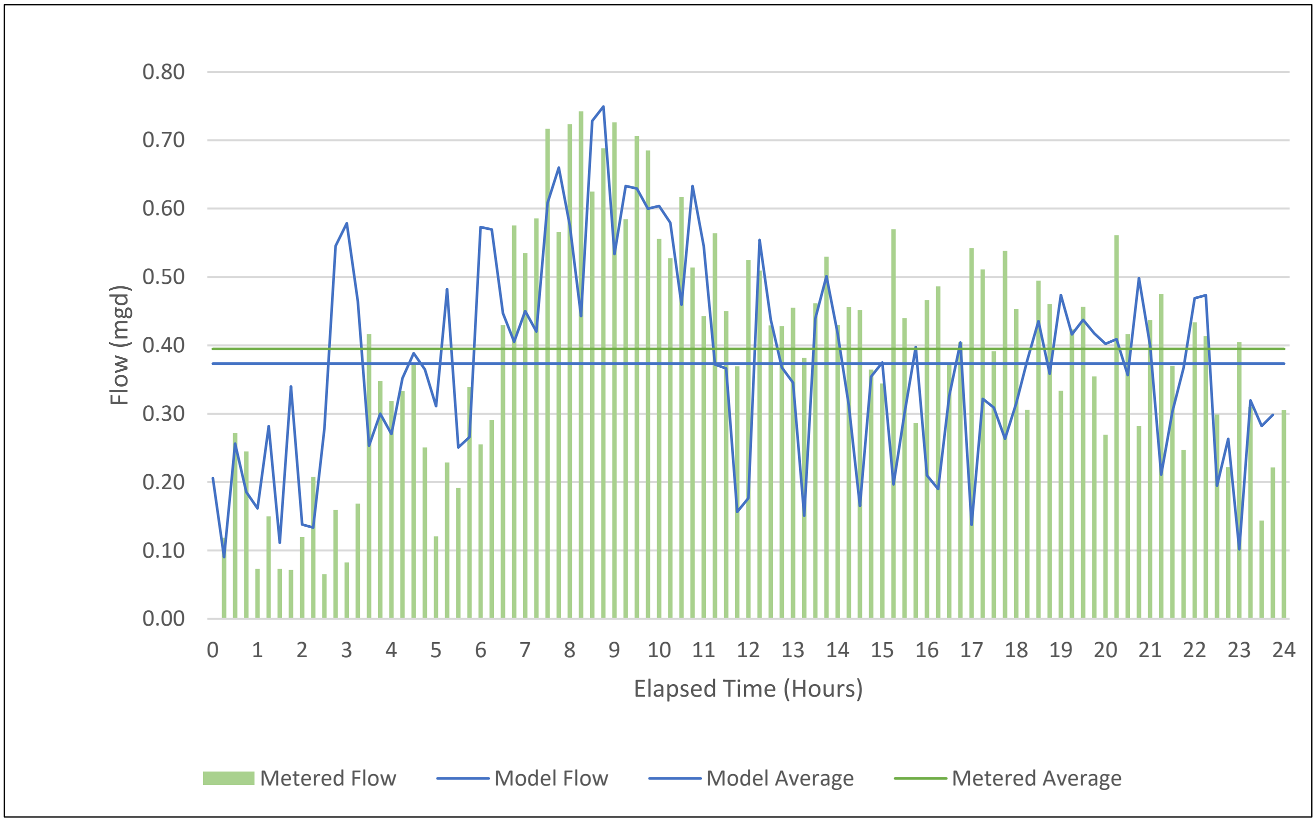
Basin 100A/B Wet Weather Calibration – 12/27/2023
Pumped Flow to SHGCC is Removed Mathematically to Create Adjusted Model Average



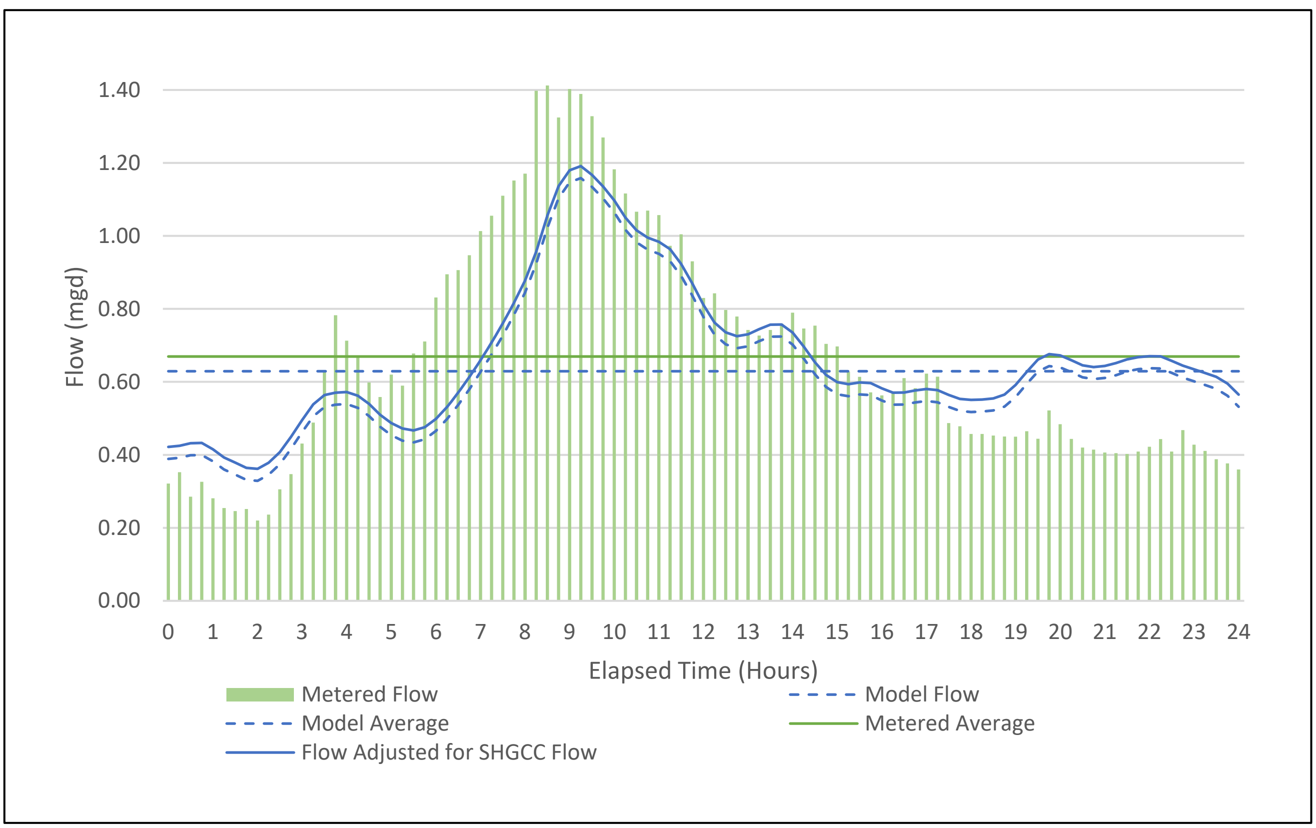
Basin 130 Wet Weather Calibration – 12/27/2023
Pumped Flow to SHGCC is Removed Mathematically to Create Adjusted Model Average



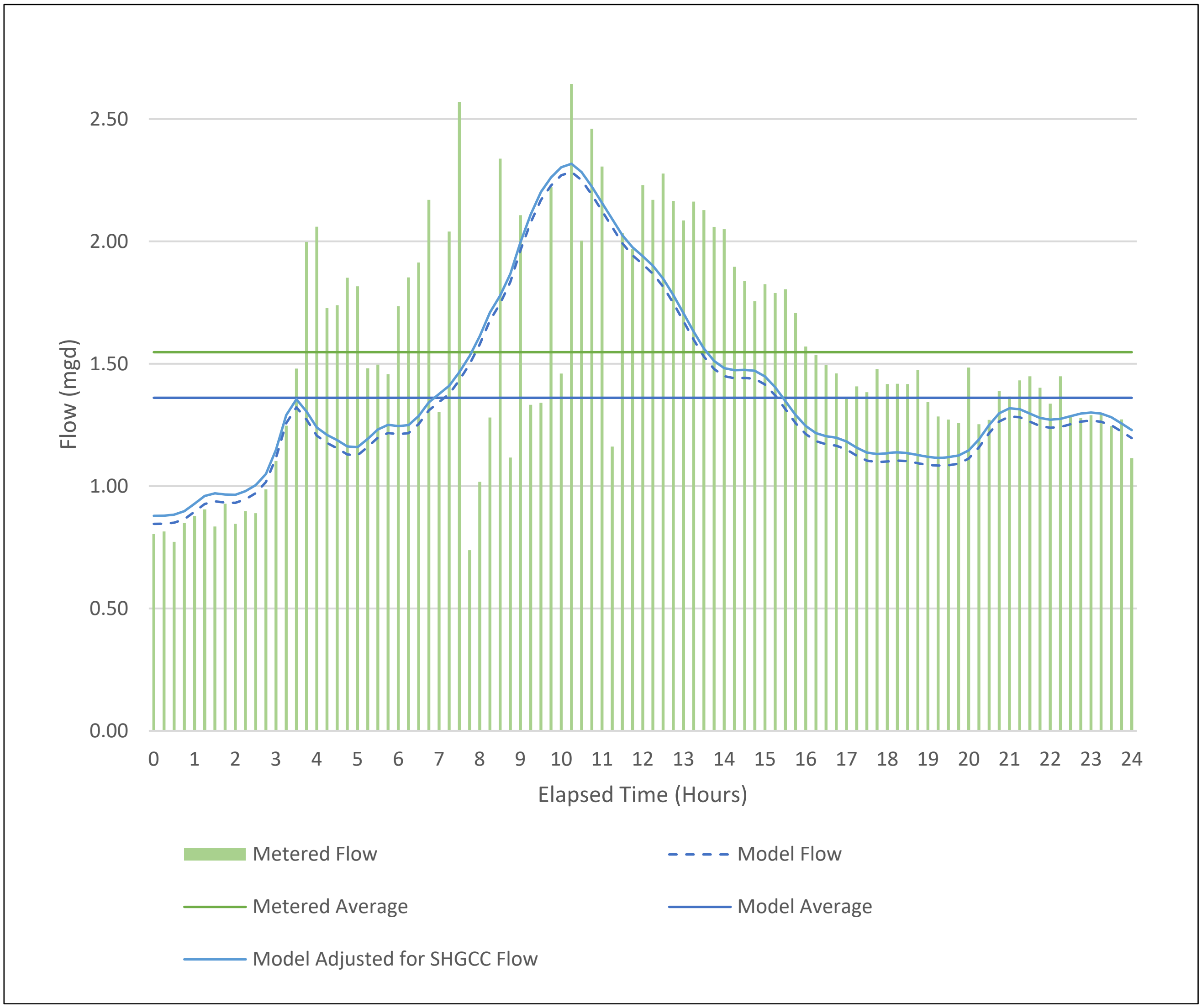
Basin 150 Wet Weather Calibration – 12/27/2023



Basin 070A Wet Weather Calibration – 12/27/2023
SHGCC Flows are Added Mathematically



Basin 110 Wet Weather Calibration – 12/27/2023
SHGCC Flows are Added Mathematically



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Appendix D

EXTENDED RUN – CONFIRMATION PLOTS

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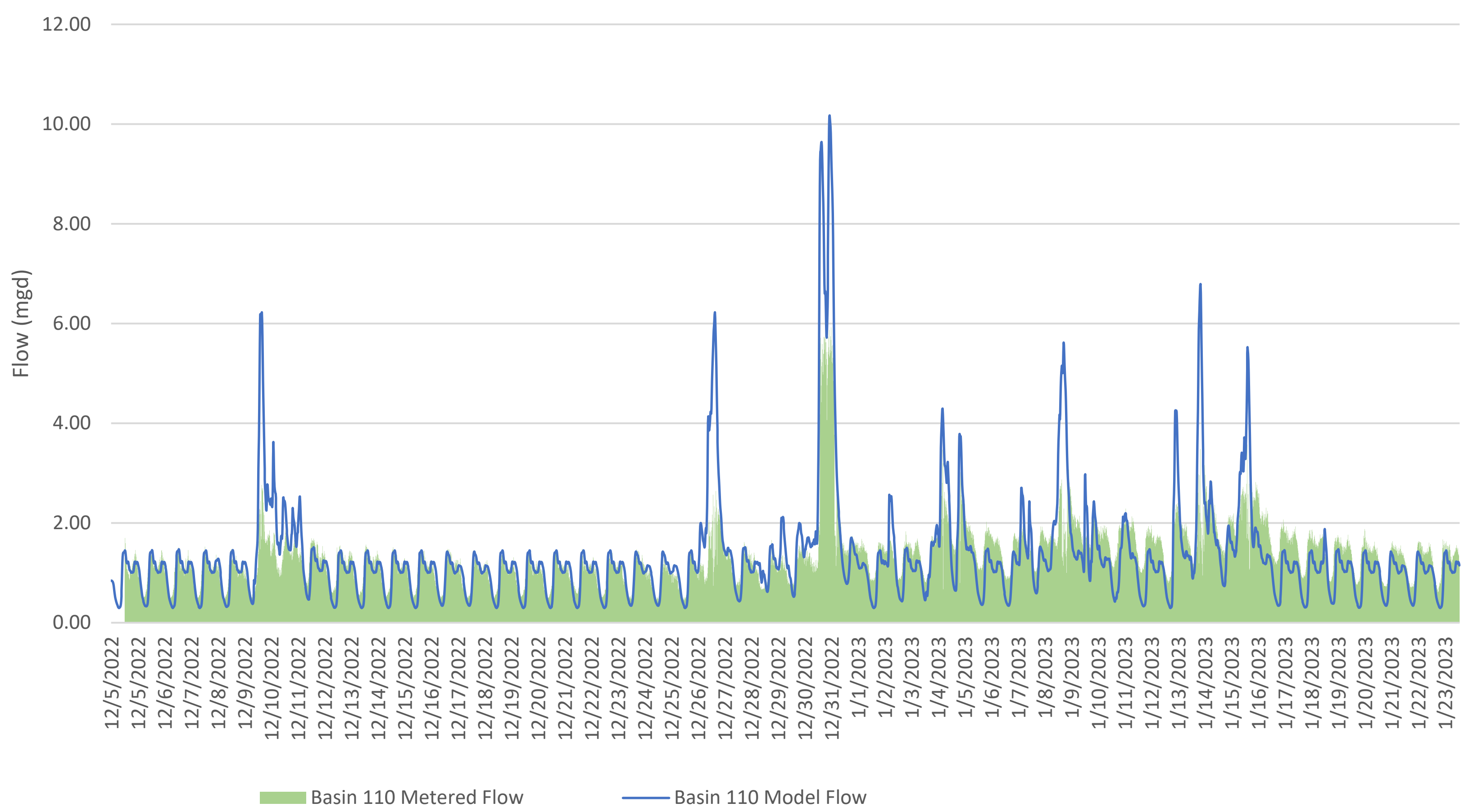
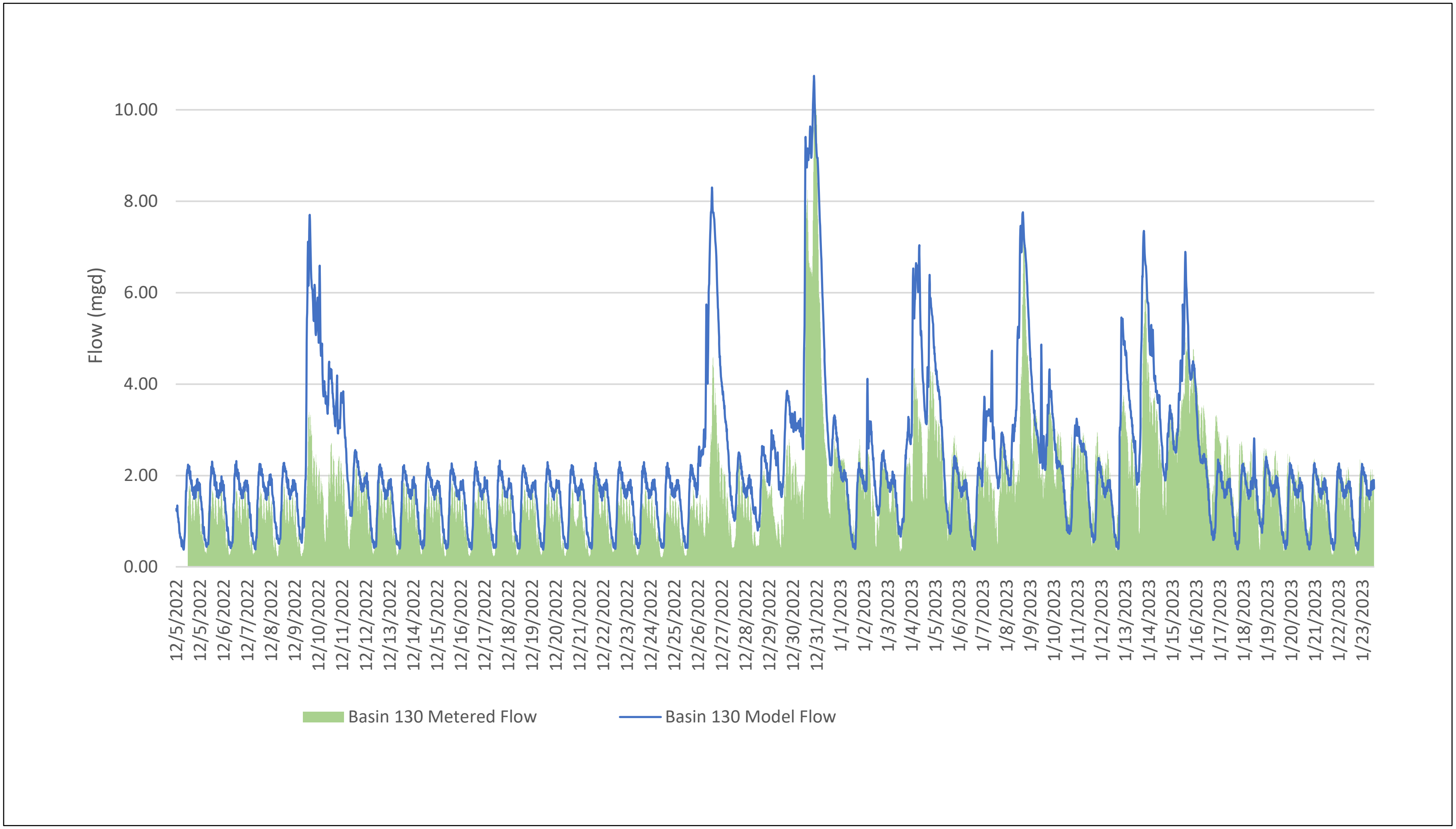
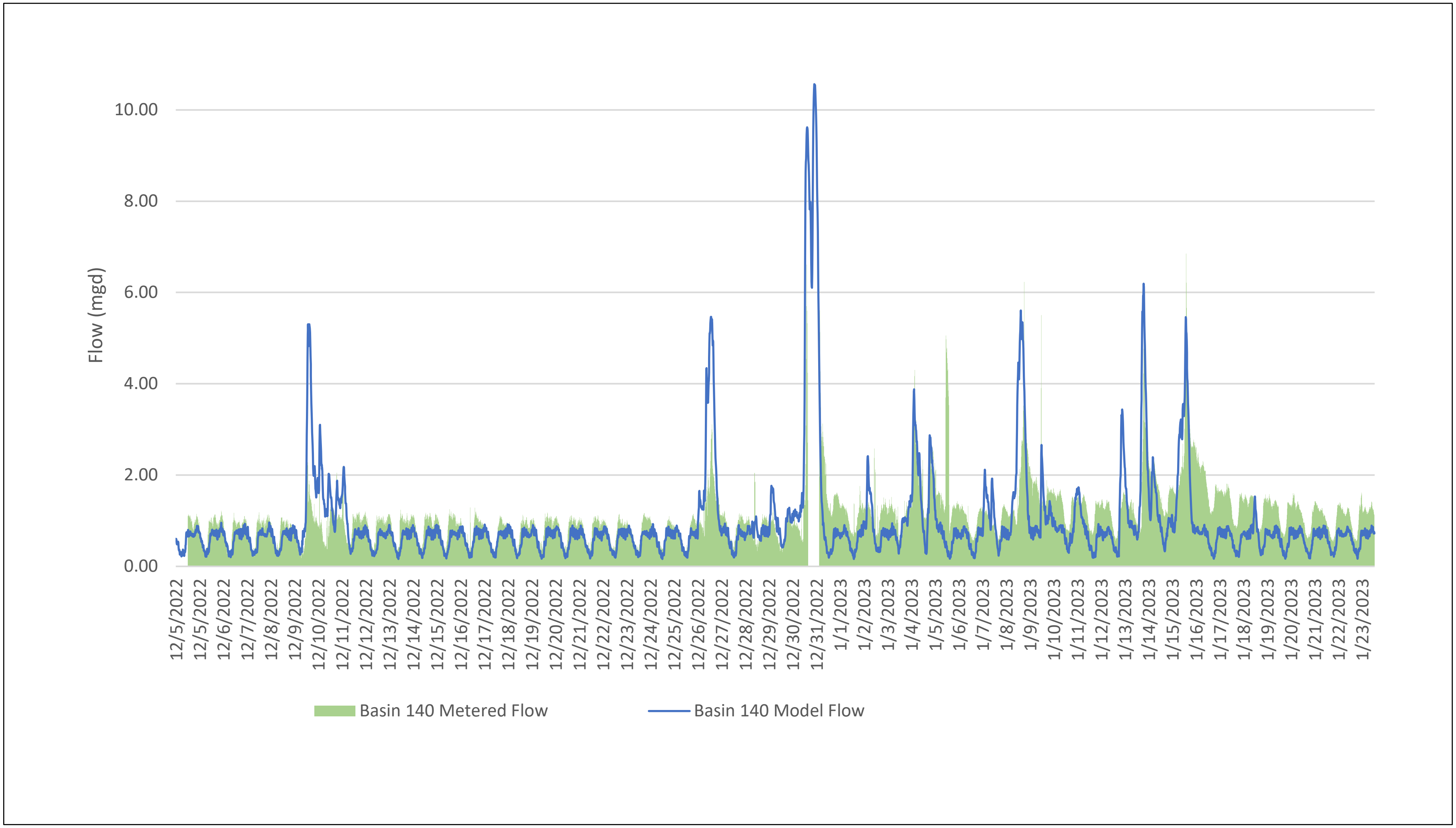
Basin 110 Confirmation Run – 12/5/2022 through 1/23/2023
Marsh Road between Middlefield and Highway 101



Basin 130 Confirmation Run – 12/5/2022 through 1/23/2023
Willow Road Communities between El Camino Real and Highway 101

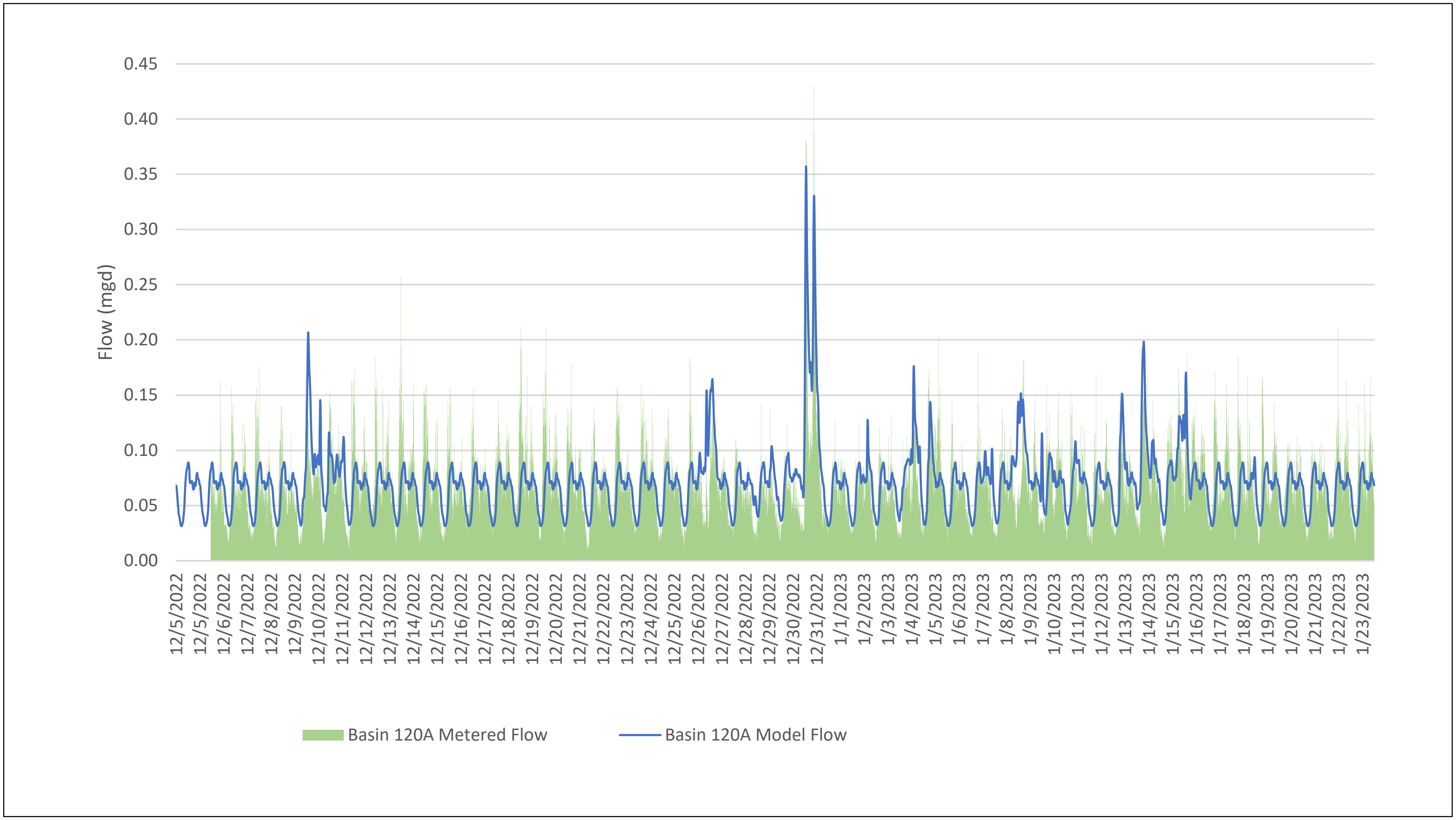


Basin 140 Confirmation Run – 12/5/2022 through 1/23/2023
Bounded by Bayfront Expressway, Highway 101, Belle Haven, and Willow Road



Notes:
1. Basin 130 split and appear in Basin 140 during wet weather events.
2. On December 31, 2022 the meter at Basin 140 surcharged and stopped registering flow for 14 hours.

Basin 120A Confirmation Run – 12/5/2022 through 1/23/2023
Oak Grove Avenue south of Highway 101



Notes:

1. Peaks shown in metered flows are dry and wet weather diversions from Basin 070.

Appendix E

Likelihood and Consequence of Failure Parameters

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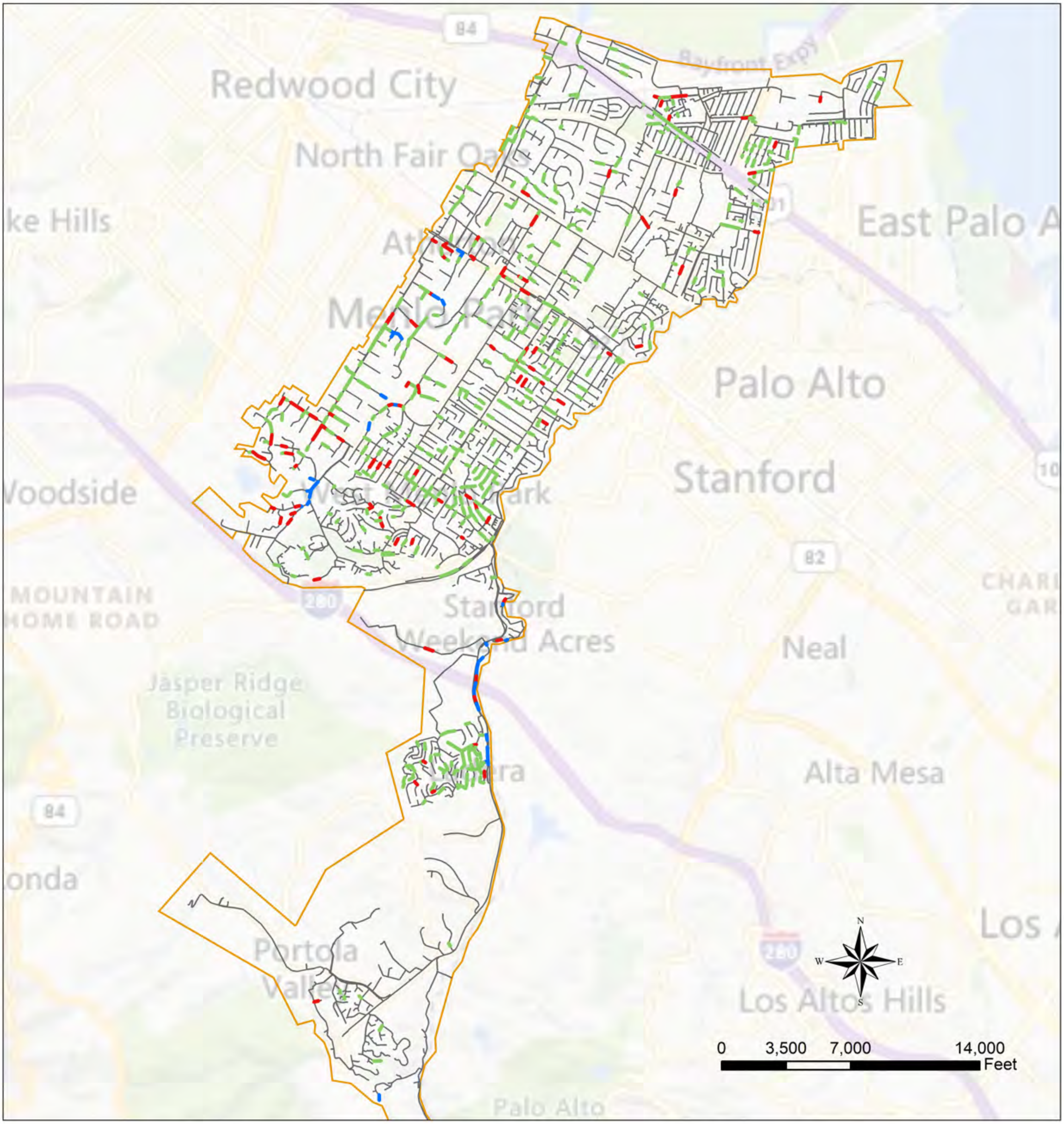


WEST BAY SANITARY DISTRICT

V.W. HOUSEN & ASSOCIATES

Map A1

West Bay Sanitary District
Linear Asset Management Plan

LOF and COF Parameters

Structural Grade 4 and 5 Defects

Legend

- Priority 1 and 2 Grade 5
- Priority 3 Grade 4
- Other Grade 4 Defects
- Sewer Pipelines
- WBSD Service Area

WEST BAY SANITARY DISTRICT

V.W. HOUSEN & ASSOCIATES

Map A2

West Bay Sanitary District
Linear Asset Management Plan

LOF and COF Parameters

Pipe Material

WEST BAY SANITARY DISTRICT

V.W. HOUSEN & ASSOCIATES

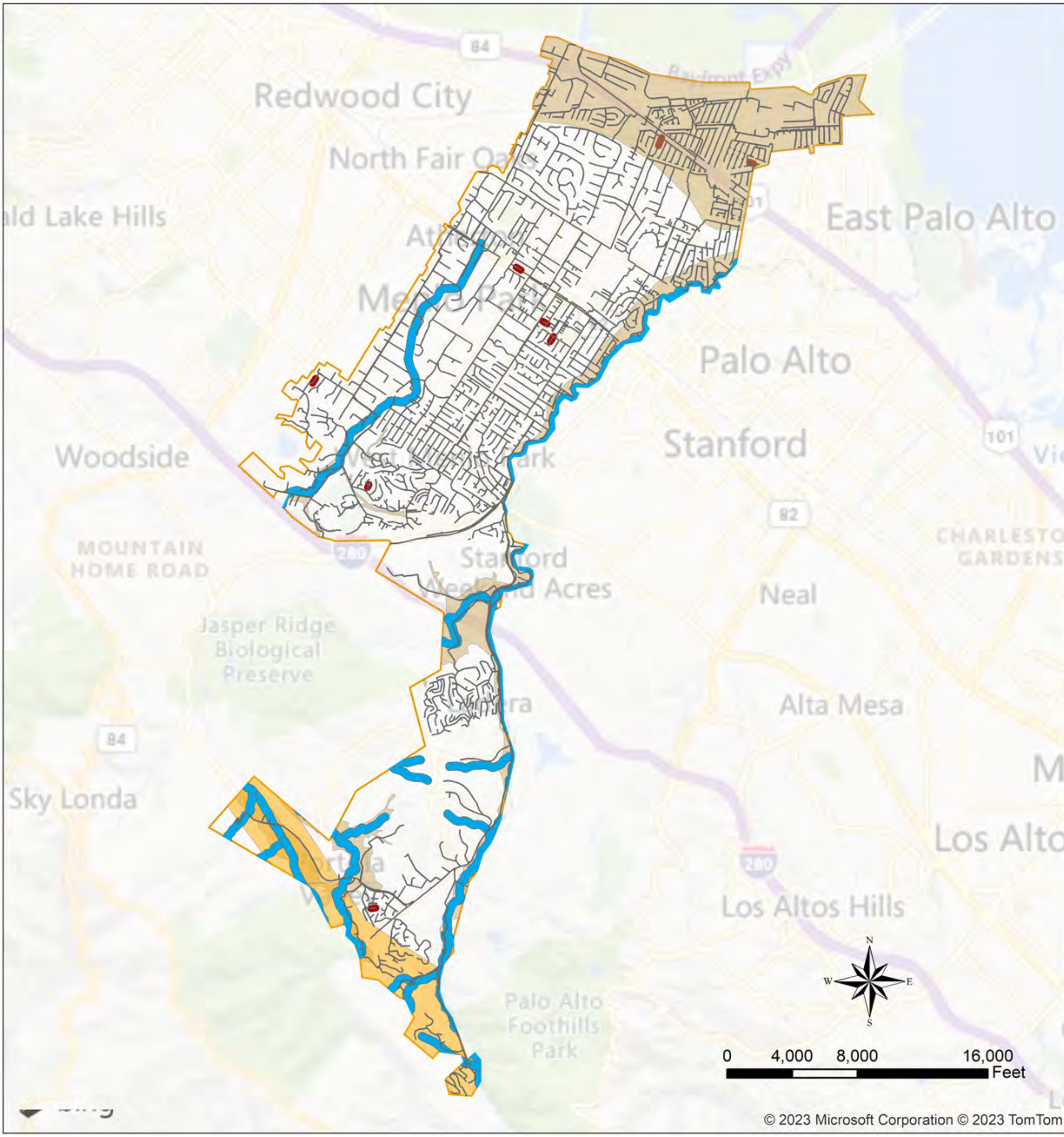
Map A3

West Bay Sanitary District
Linear Asset Management Plan

LOF and COF Parameters
Pipe Size

Legend

- < 6 Inches in Diameter
- > 12 Inches in Diameter
- Other Sewer Pipelines
- WBSD Service Area



V.W. HOUSEN & ASSOCIATES

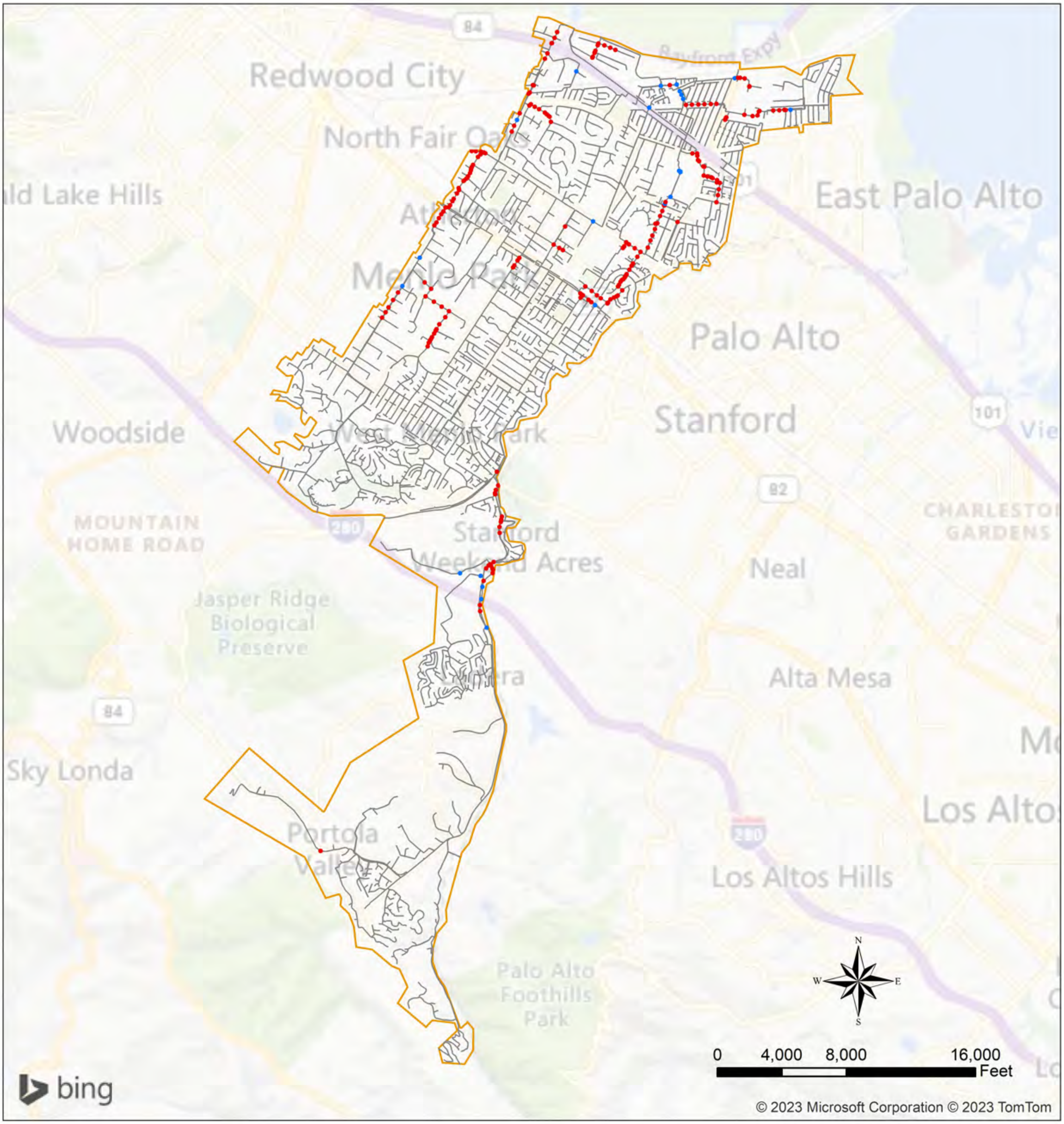
Map A4

West Bay Sanitary District
Linear Asset Management Plan

LOF and COF Parameters
Geology, Spills, Waterways

Legend

- Sewer Pipelines
- Waterway with 200-ft Buffer
- Loma Prieta Fault Zone
- Liquefaction
- Spills (5 Years)
- WBSD Service Area



Map A5

West Bay Sanitary District
Linear Asset Management Plan

LOF and COF Parameters

Manholes with Surcharge (d/D)

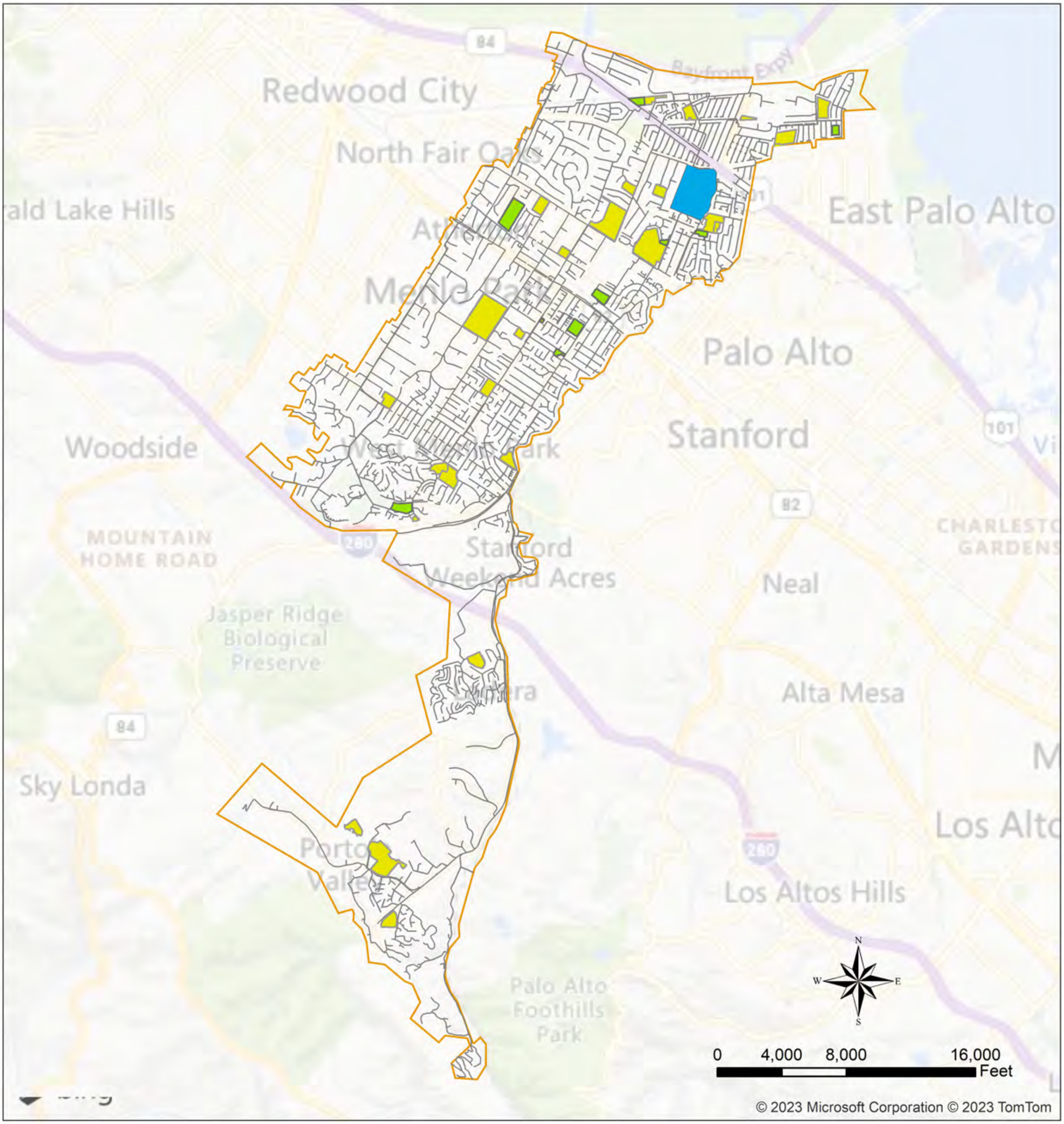
Legend

Water Level (d) / Pipe Diameter (D)

- d/D is over 0.8
- d/D is over 1
- Other Sewer Pipelines

WEST BAY SANITARY DISTRICT

V.W. HOUSEN & ASSOCIATES



WEST BAY SANITARY DISTRICT

V.W. HOUSEN & ASSOCIATES

Map A6

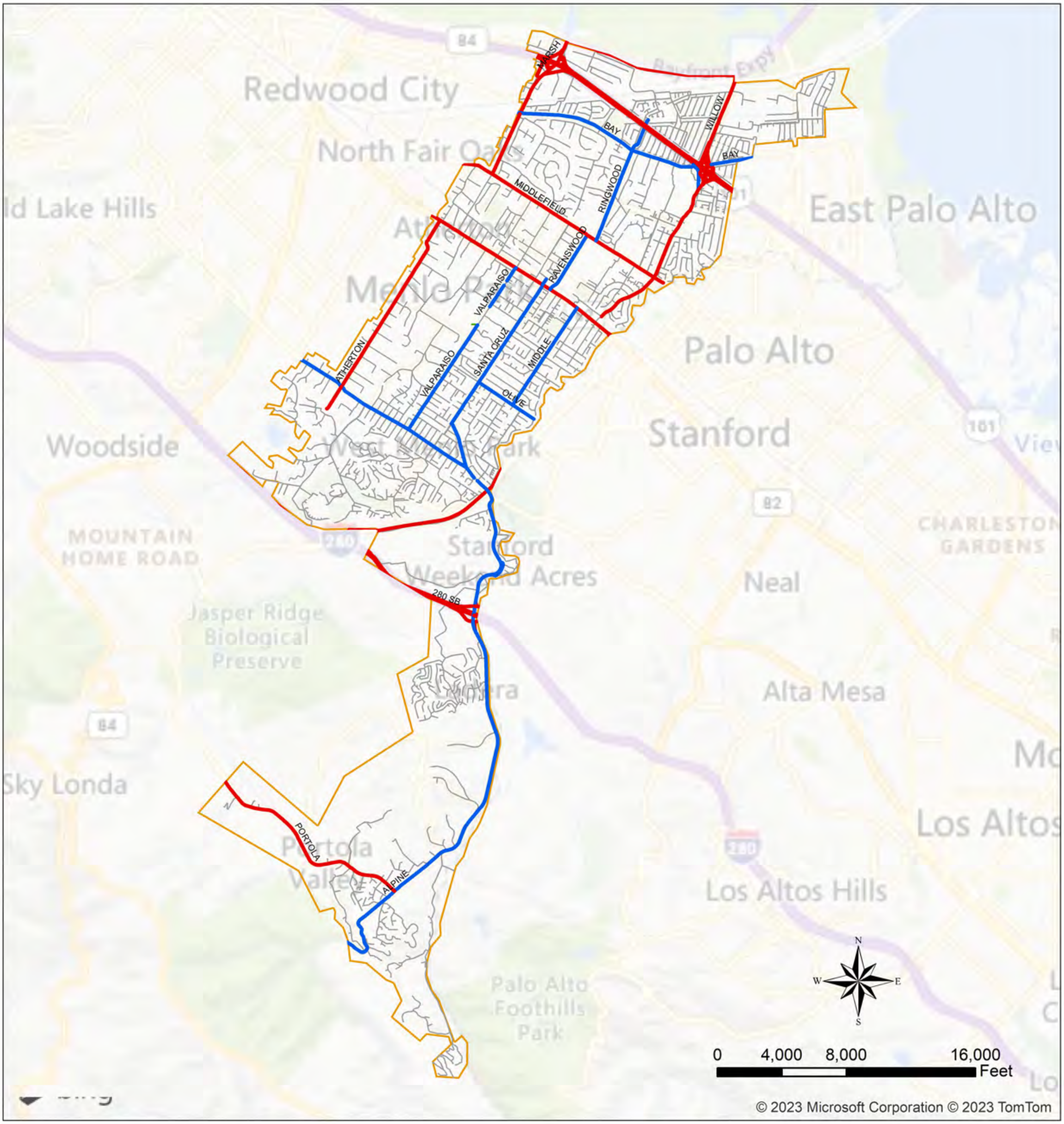
West Bay Sanitary District
Linear Asset Management Plan

LOF and COF Parameters

Parks, Schools, Hospitals

Legend

- Schools
- Parks
- Hospital
- Other Sewer Pipelines
- WBSD Service Area



WEST BAY SANITARY DISTRICT

V.W. HOUSEN & ASSOCIATES

Map A7

West Bay Sanitary District
Linear Asset Management Plan

LOF and COF Parameters

Primary and Secondary Arterial Roadways

Legend

- Primary Arterial
- Secondary Arterial
- Other Sewer Pipelines
- WBSD Service Area

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Appendix F

LAMP Project Maps

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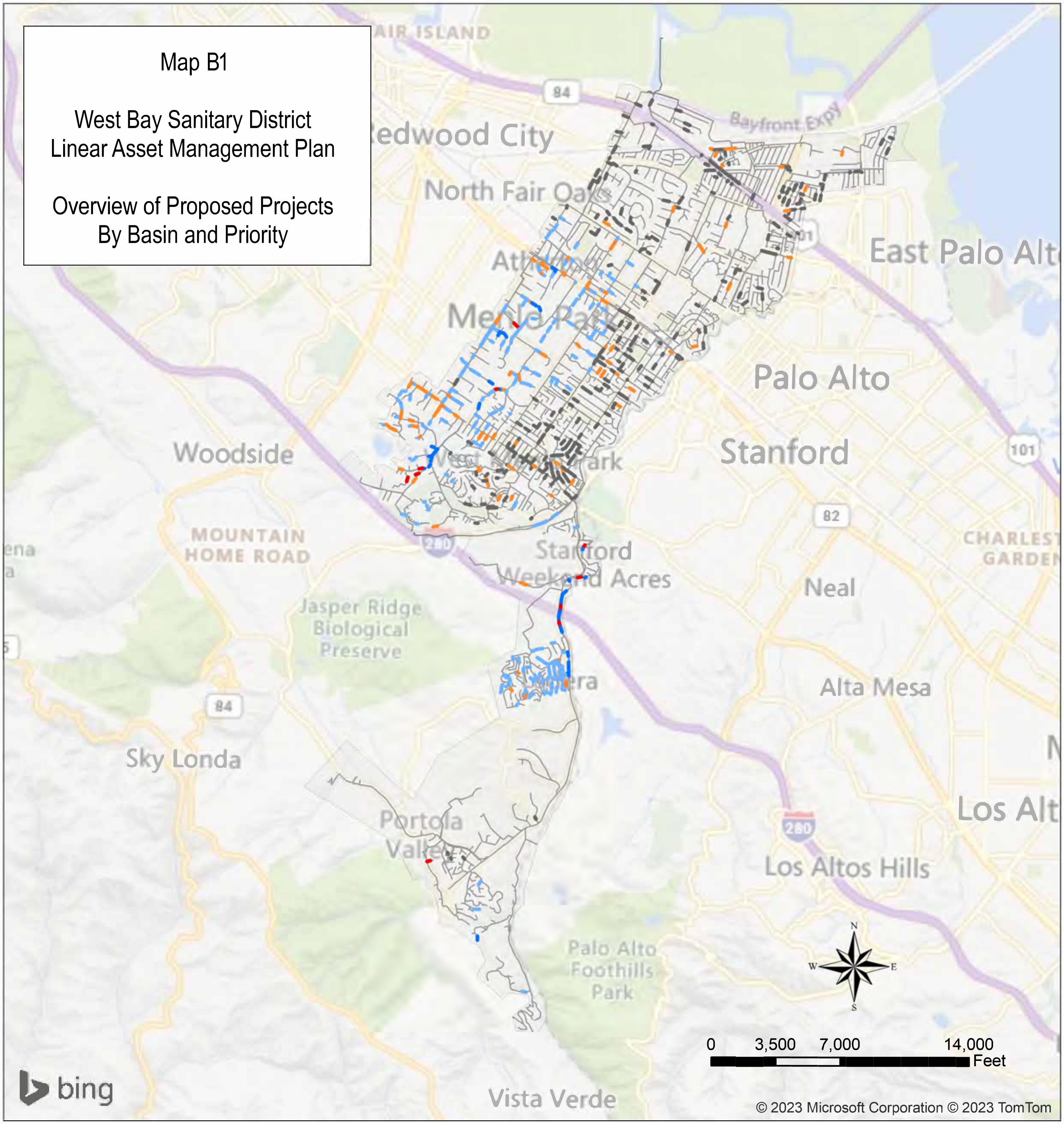
Map B1

West Bay Sanitary District
Linear Asset Management Plan

Overview of Proposed Projects
By Basin and Priority



WEST BAY SANITARY DISTRICT

V.W. HOUSEN & ASSOCIATES

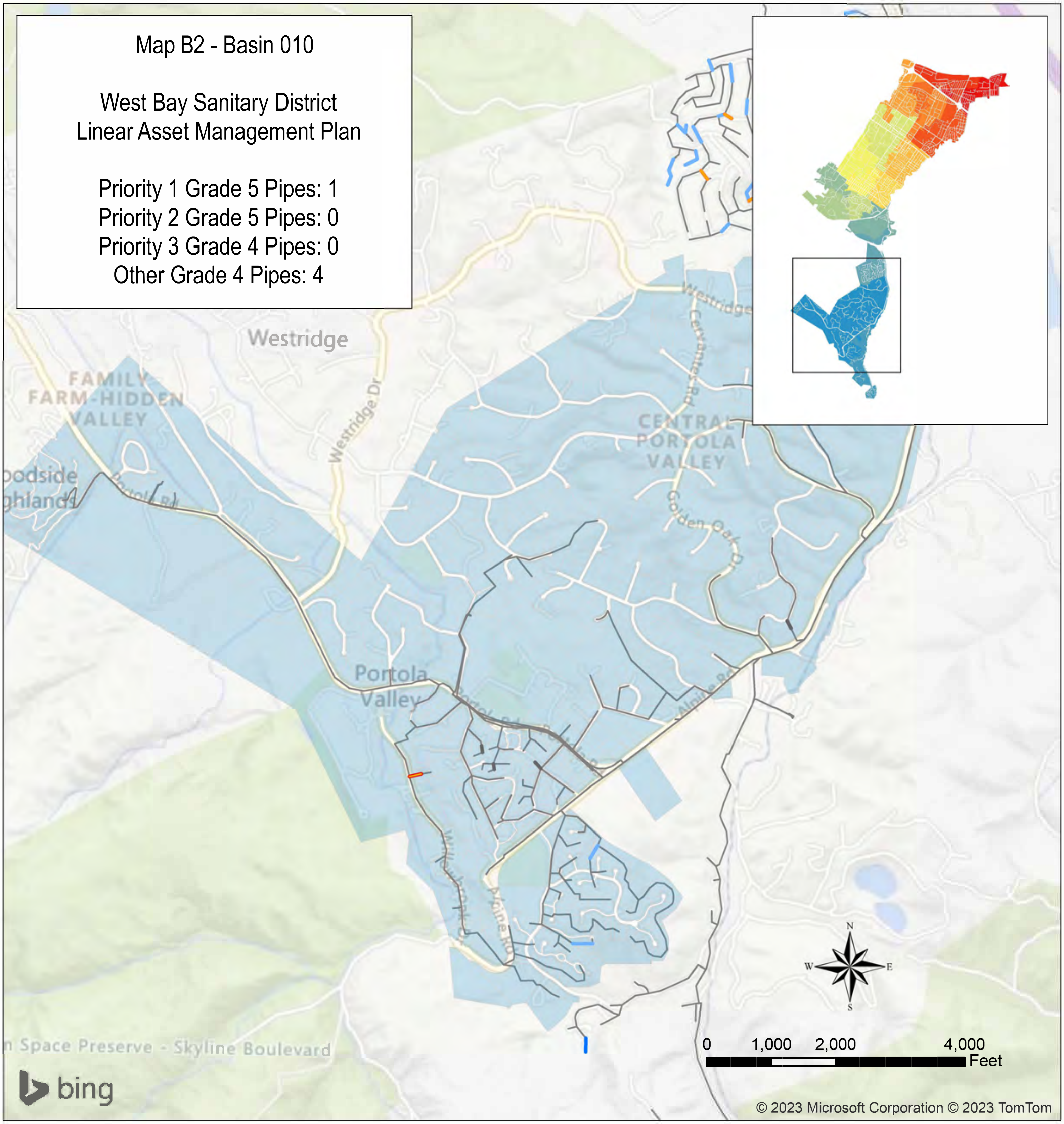
Legend

- Priority 1 Grade 5 Pipes
- Priority 2 Grade 5 Pipes
- Priority 3 Grade 4 Pipes
- Priority 3a Additional Grade 4 Pipes
- Priority 4 Future Grade 4 Repairs
- WBSD Service Area
- WBSD_SM

Map B2 - Basin 010

West Bay Sanitary District
Linear Asset Management Plan

Priority 1 Grade 5 Pipes: 1
Priority 2 Grade 5 Pipes: 0
Priority 3 Grade 4 Pipes: 0
Other Grade 4 Pipes: 4



WEST BAY SANITARY DISTRICT

V.W. HOUSEN & ASSOCIATES

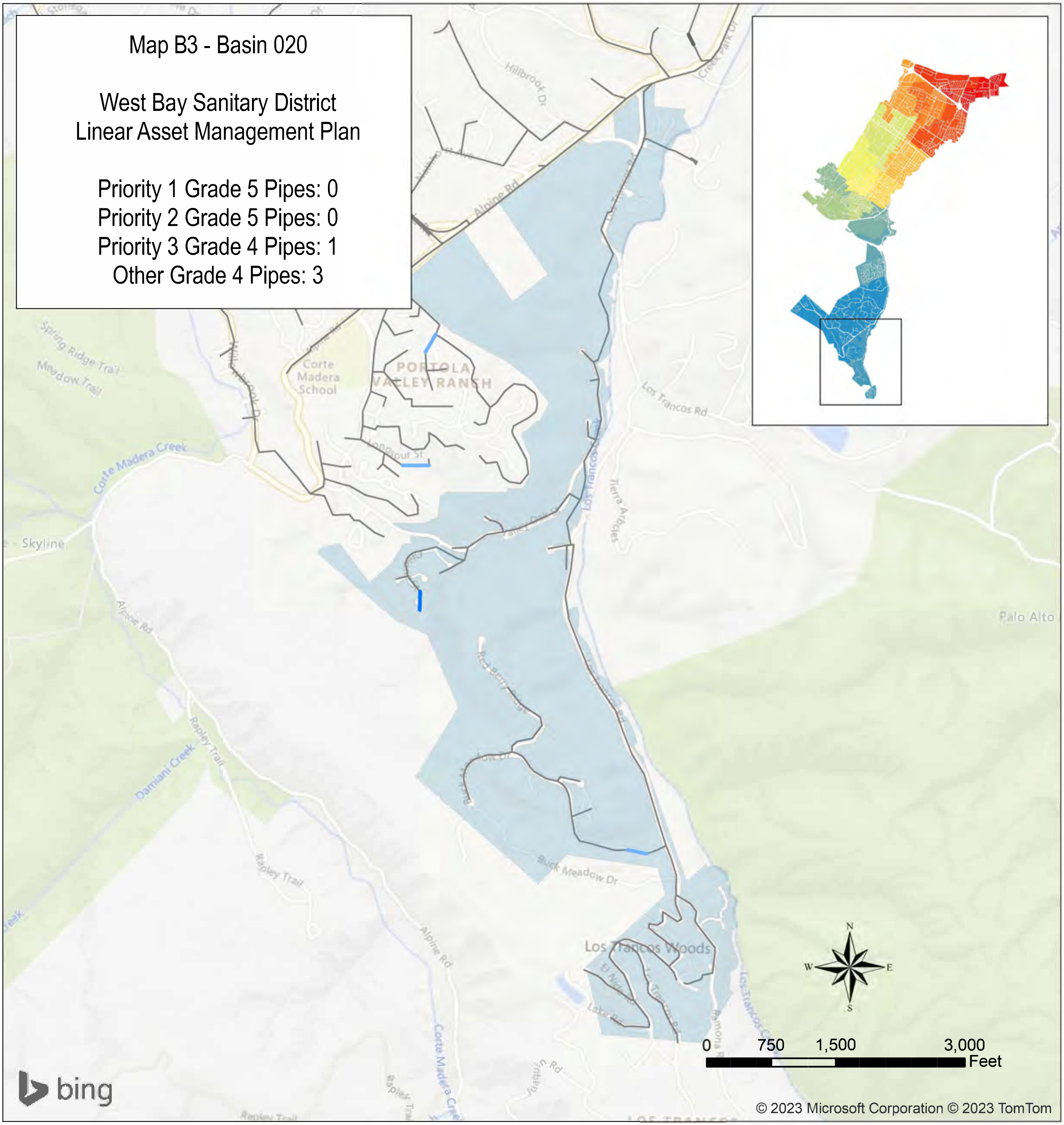
Legend

- Priority 1 Grade 5 Pipes
- Priority 2 Grade 5 Pipes
- Priority 3 Grade 4 Pipes
- Priority 3a Additional Grade 4 Pipes
- Priority 4 Future Grade 4 Repairs
- Basin 010
- Sewer Pipeline

Map B3 - Basin 020

West Bay Sanitary District
Linear Asset Management Plan

Priority 1 Grade 5 Pipes: 0
Priority 2 Grade 5 Pipes: 0
Priority 3 Grade 4 Pipes: 1
Other Grade 4 Pipes: 3



WEST BAY SANITARY DISTRICT

V.W. HOUSEN & ASSOCIATES

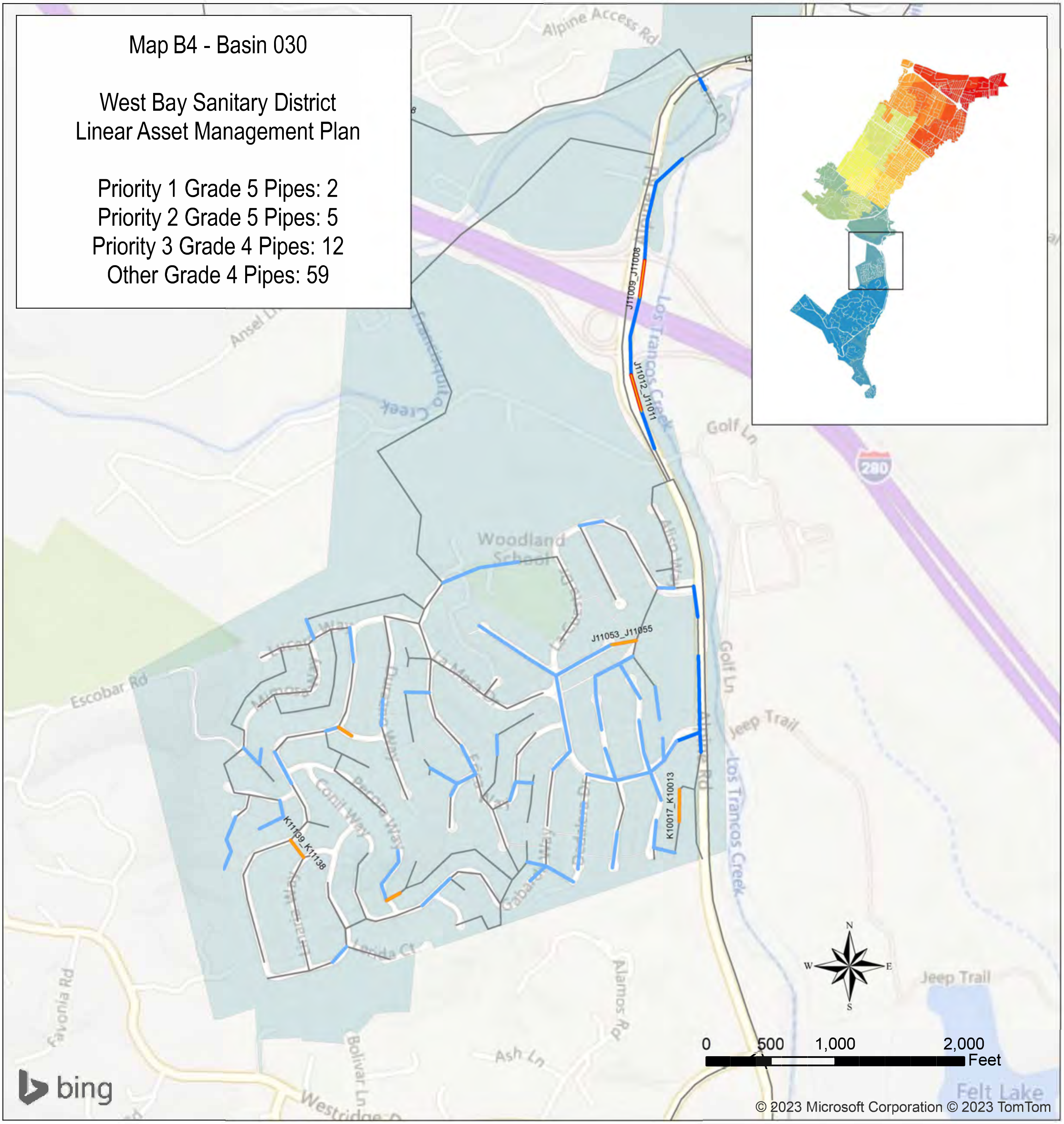
Legend

- Priority 1 Grade 5 Pipes
- Priority 2 Grade 5 Pipes
- Priority 3 Grade 4 Pipes
- Priority 3a Additional Grade 4 Pipes
- Priority 4 Future Grade 4 Repairs
- 020 Equiv
- Sewer Pipeline

Map B4 - Basin 030

West Bay Sanitary District
Linear Asset Management Plan

Priority 1 Grade 5 Pipes: 2
Priority 2 Grade 5 Pipes: 5
Priority 3 Grade 4 Pipes: 12
Other Grade 4 Pipes: 59



WEST BAY SANITARY DISTRICT

V.W. HOUSEN & ASSOCIATES

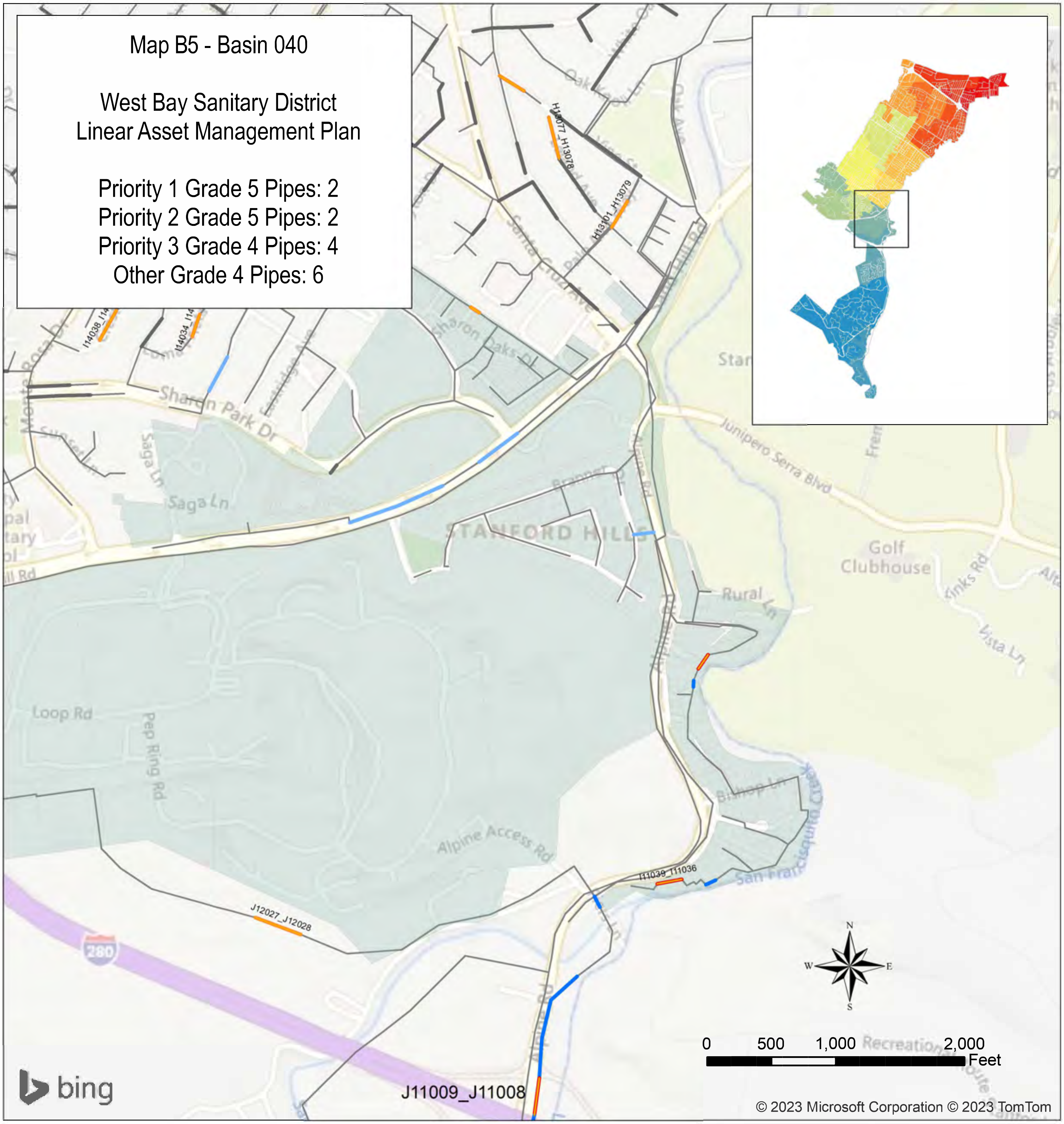
Legend

- Priority 1 Grade 5 Pipes
- Priority 2 Grade 5 Pipes
- Priority 3 Grade 4 Pipes
- Priority 3a Additional Grade 4 Pipes
- Priority 4 Future Grade 4 Repairs
- 030 Equiv
- Sewer Pipeline

Map B5 - Basin 040

West Bay Sanitary District
Linear Asset Management Plan

Priority 1 Grade 5 Pipes: 2
Priority 2 Grade 5 Pipes: 2
Priority 3 Grade 4 Pipes: 4
Other Grade 4 Pipes: 6

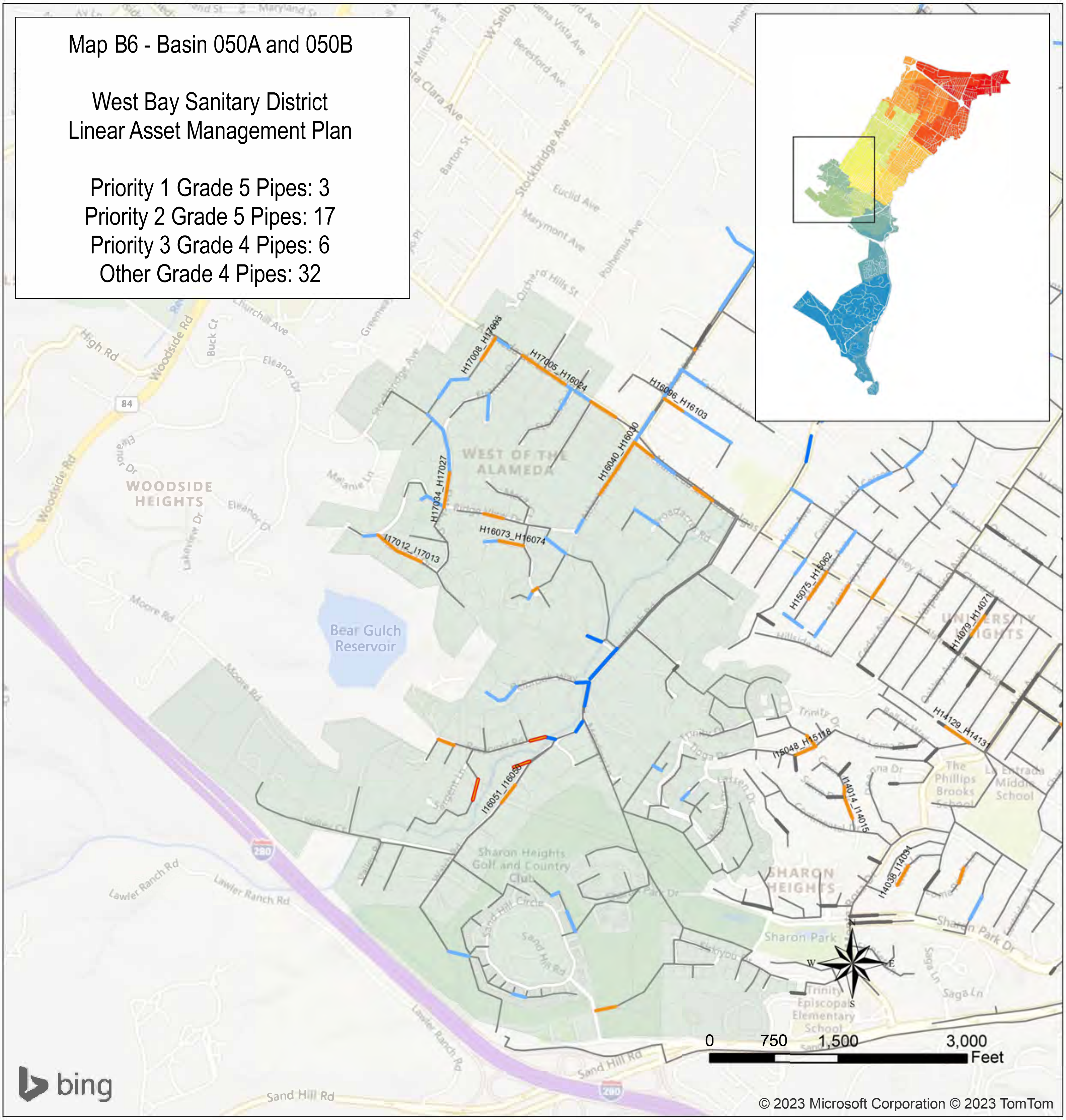


WEST BAY SANITARY DISTRICT

V.W. HOUSEN & ASSOCIATES

Legend

- Priority 1 Grade 5 Pipes
- Priority 2 Grade 5 Pipes
- Priority 3 Grade 4 Pipes
- Priority 3a Additional Grade 4 Pipes
- Priority 4 Future Grade 4 Repairs
- Basin040
- Sewer Pipeline



Legend

- Priority 1 Grade 5 Pipes
- Priority 2 Grade 5 Pipes
- Priority 3 Grade 4 Pipes
- Priority 3a Additional Grade 4 Pipes
- Priority 4 Future Grade 4 Repairs
- 050 South Equiv S14
- 050 North Equiv S13
- Sewer Pipeline

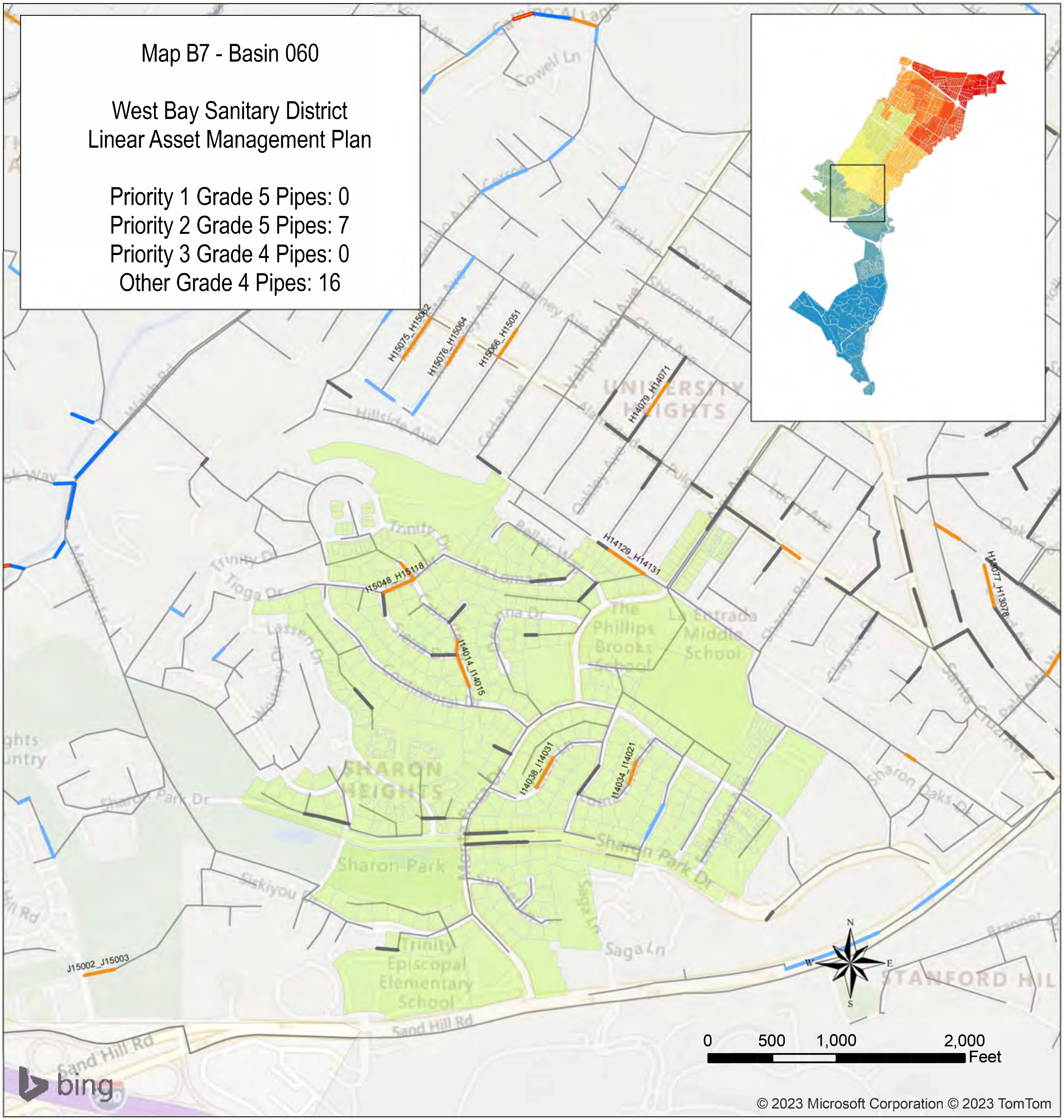
WEST BAY SANITARY DISTRICT

V.W. HOUSEN & ASSOCIATES

Map B7 - Basin 060

West Bay Sanitary District
Linear Asset Management Plan

Priority 1 Grade 5 Pipes: 0
Priority 2 Grade 5 Pipes: 7
Priority 3 Grade 4 Pipes: 0
Other Grade 4 Pipes: 16



WEST BAY SANITARY DISTRICT

V.W. HOUSEN & ASSOCIATES

Legend

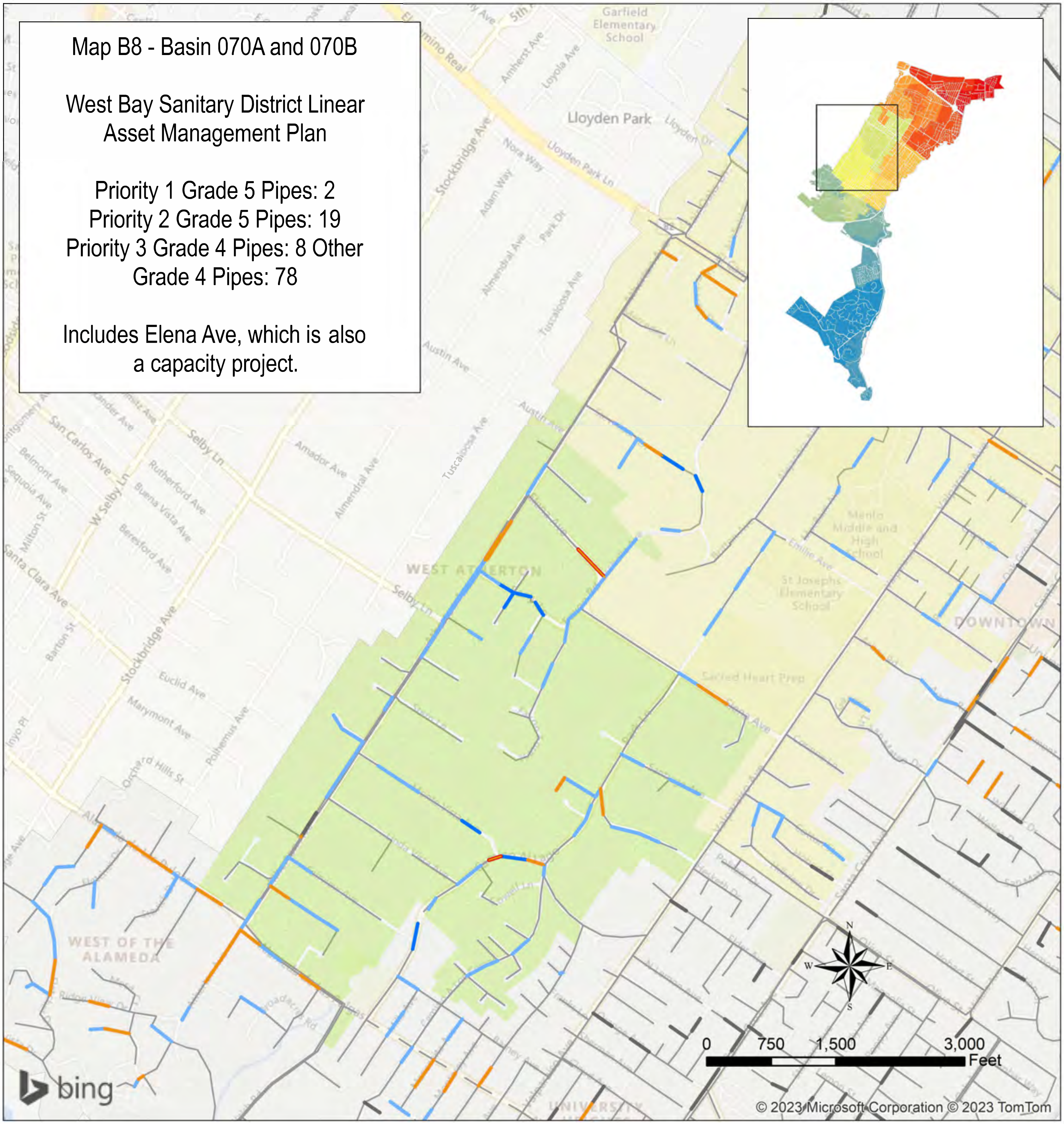
- Priority 1 Grade 5 Pipes
- Priority 2 Grade 5 Pipes
- Priority 3 Grade 4 Pipes
- Priority 3a Additional Grade 4 Pipes
- Priority 4 Future Grade 4 Repairs
- Basin 060
- WBSD Service Area
- Sewer Pipeline

Map B8 - Basin 070A and 070B

West Bay Sanitary District Linear Asset Management Plan

Priority 1 Grade 5 Pipes: 2
Priority 2 Grade 5 Pipes: 19
Priority 3 Grade 4 Pipes: 8 Other Grade 4 Pipes: 78

Includes Elena Ave, which is also a capacity project.

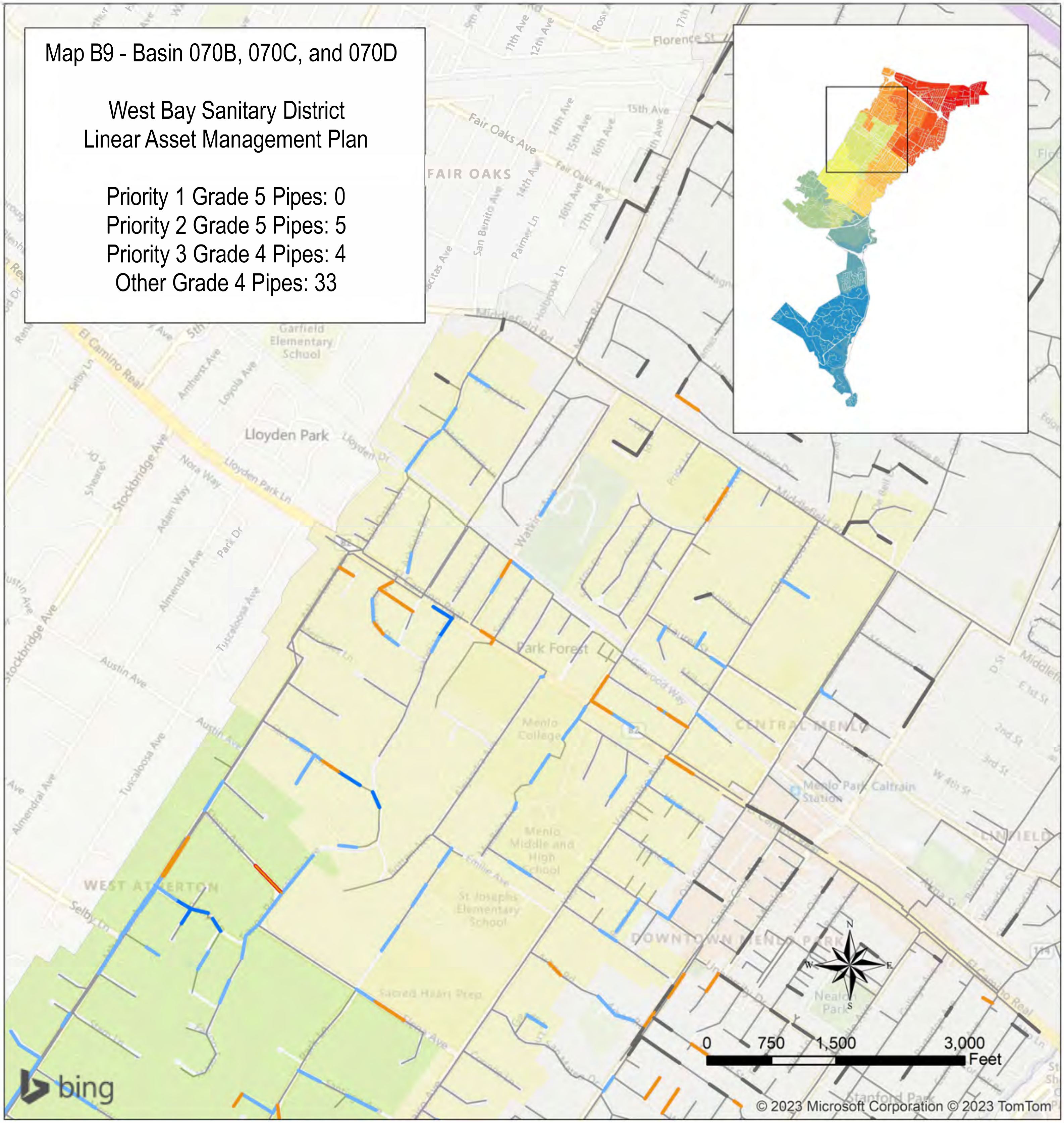


Legend

- Priority 1 Grade 5 Pipes
- Priority 2 Grade 5 Pipes
- Priority 3 Grade 4 Pipes
- Priority 3a Additional Grade 4 Pipes
- Priority 4 Future Grade 4 Repairs
- Basin 070A
- Basin 070BCD
- WBSD Service Area
- Sewer Pipeline

WEST BAY SANITARY DISTRICT

V.W. HOUSEN & ASSOCIATES



WEST BAY SANITARY DISTRICT

V.W. HOUSEN & ASSOCIATES

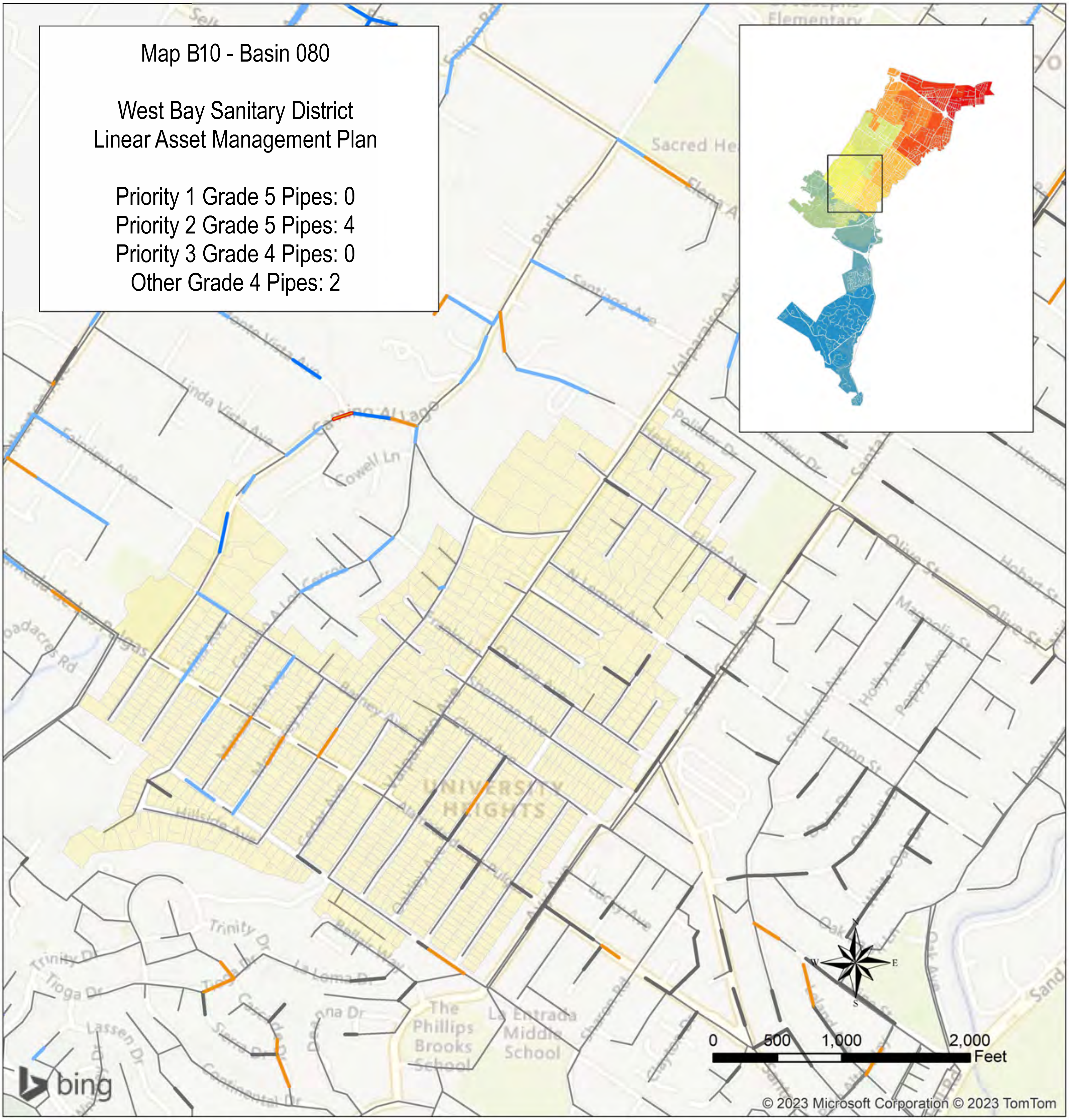
Legend

- Priority 1 Grade 5 Pipes
- Priority 2 Grade 5 Pipes
- Priority 3 Grade 4 Pipes
- Priority 3a Additional Grade 4 Pipes
- Priority 4 Future Grade 4 Repairs
- Basin 070A
- Basin 070BCD
- WBSD Service Area
- Sewer Pipeline

Map B10 - Basin 080

West Bay Sanitary District
Linear Asset Management Plan

Priority 1 Grade 5 Pipes: 0
Priority 2 Grade 5 Pipes: 4
Priority 3 Grade 4 Pipes: 0
Other Grade 4 Pipes: 2

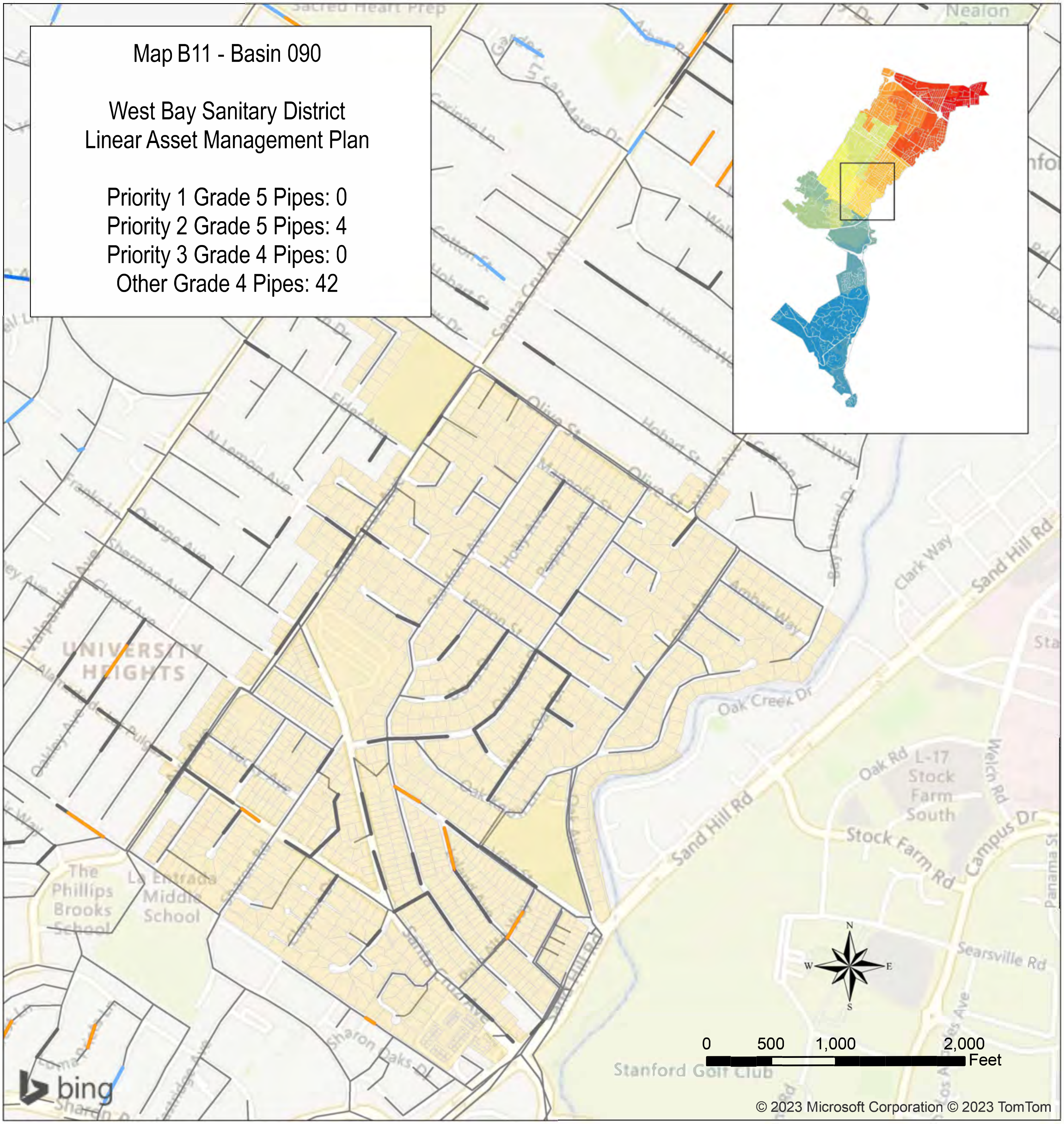


Legend

- Priority 1 Grade 5 Pipes
- Priority 2 Grade 5 Pipes
- Priority 3 Grade 4 Pipes
- Priority 3a Additional Grade 4 Pipes
- Priority 4 Future Grade 4 Repairs
- Basin 080
- Sewer Pipeline

WEST BAY SANITARY DISTRICT

V.W. HOUSEN & ASSOCIATES



WEST BAY
SANITARY DISTRICT

V.W. HOUSEN
& ASSOCIATES

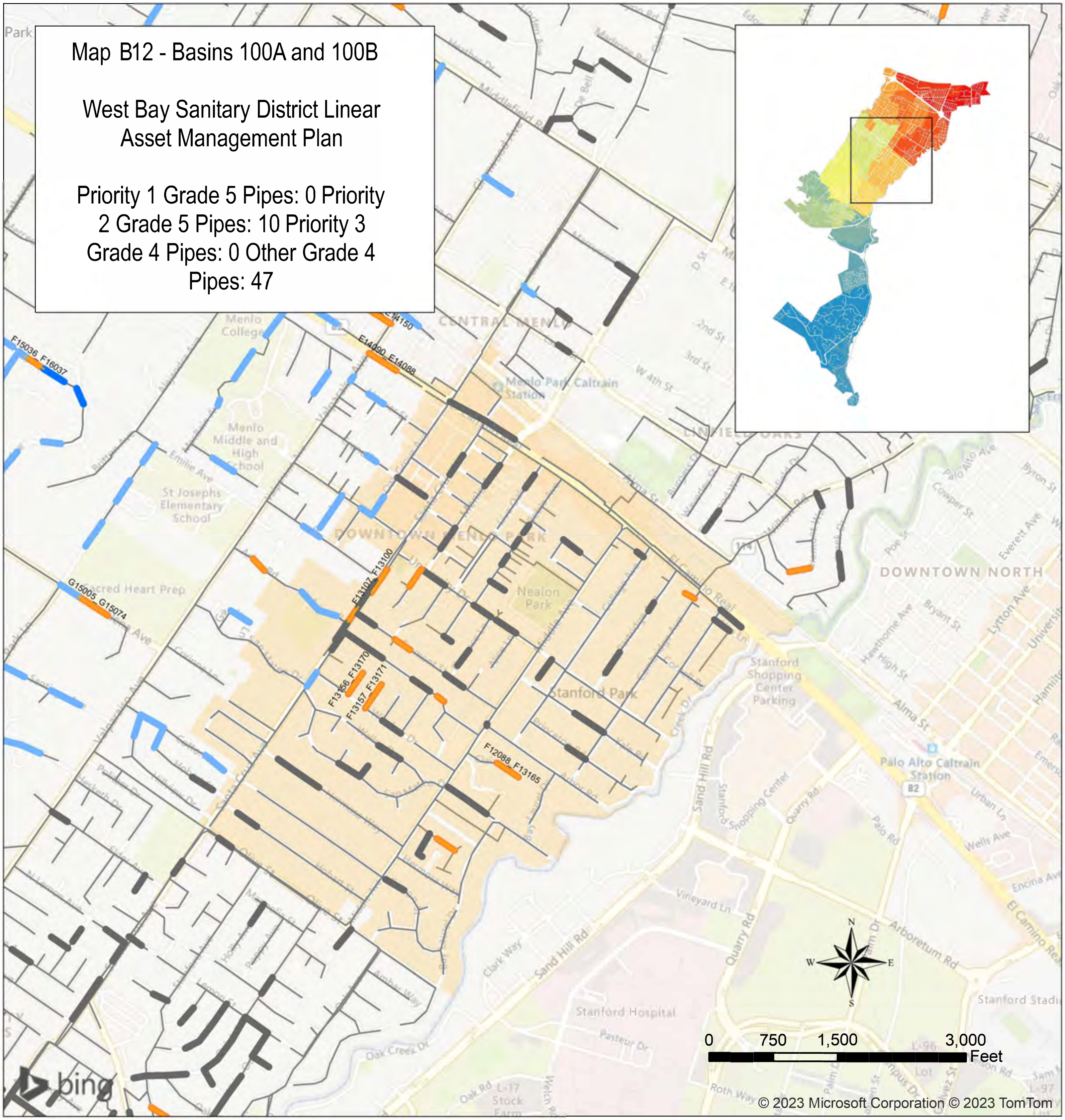
Legend

- Priority 1 Grade 5 Pipes
- Priority 2 Grade 5 Pipes
- Priority 3 Grade 4 Pipes
- Priority 3a Additional Grade 4 Pipes
- Priority 4 Future Grade 4 Repairs
- Basin 090
- Sewer Pipeline

Map B12 - Basins 100A and 100B

West Bay Sanitary District Linear Asset Management Plan

Priority 1 Grade 5 Pipes: 0 Priority 2 Grade 5 Pipes: 10 Priority 3 Grade 4 Pipes: 0 Other Grade 4 Pipes: 47



WEST BAY SANITARY DISTRICT

V.W. HOUSEN & ASSOCIATES

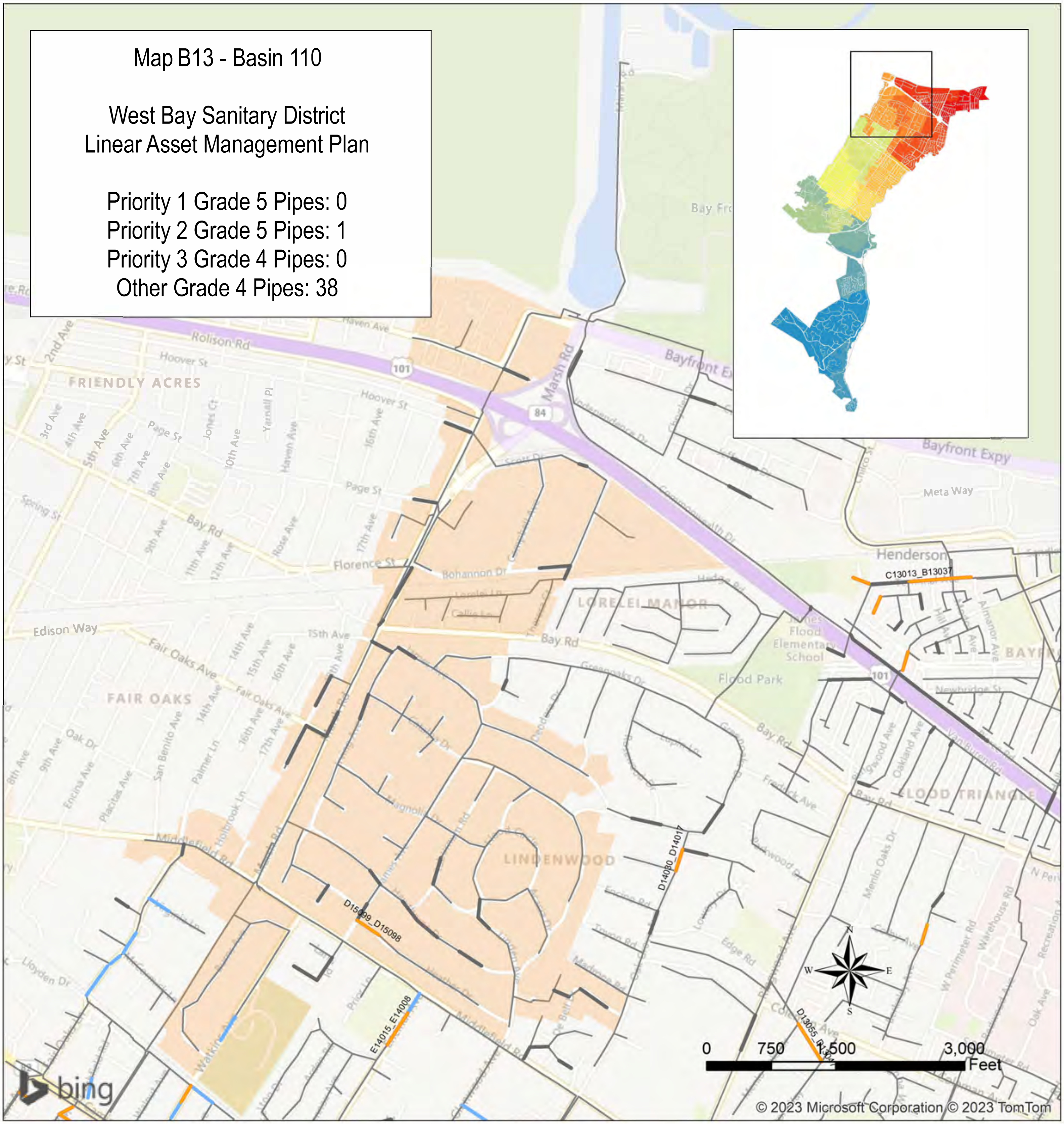
Legend

- Priority 1 Grade 5 Pipes
- Priority 2 Grade 5 Pipes
- Priority 3 Grade 4 Pipes
- Priority 3a Additional Grade 4 Pipes
- Priority 4 Future Grade 4 Repairs
- Basin 100AB
- Sewer Pipeline

Map B13 - Basin 110

West Bay Sanitary District
Linear Asset Management Plan

Priority 1 Grade 5 Pipes: 0
Priority 2 Grade 5 Pipes: 1
Priority 3 Grade 4 Pipes: 0
Other Grade 4 Pipes: 38



WEST BAY SANITARY DISTRICT

V.W. HOUSEN & ASSOCIATES

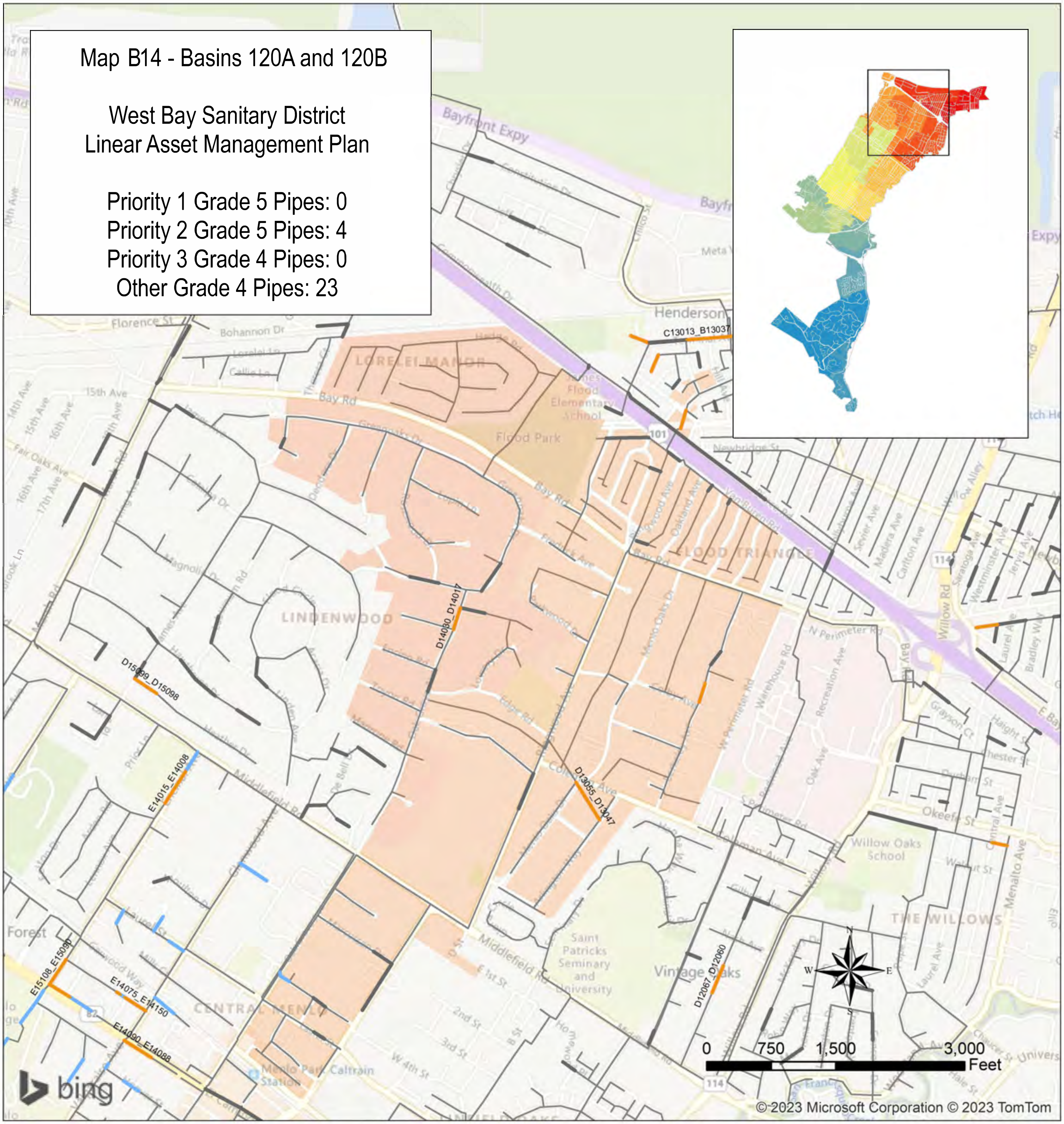
Legend

- Priority 1 Grade 5 Pipes
- Priority 2 Grade 5 Pipes
- Priority 3 Grade 4 Pipes
- Priority 3a Additional Grade 4 Pipes
- Priority 4 Future Grade 4 Repairs
- Basin 110
- Sewer Pipeline

Map B14 - Basins 120A and 120B

West Bay Sanitary District
Linear Asset Management Plan

Priority 1 Grade 5 Pipes: 0
Priority 2 Grade 5 Pipes: 4
Priority 3 Grade 4 Pipes: 0
Other Grade 4 Pipes: 23

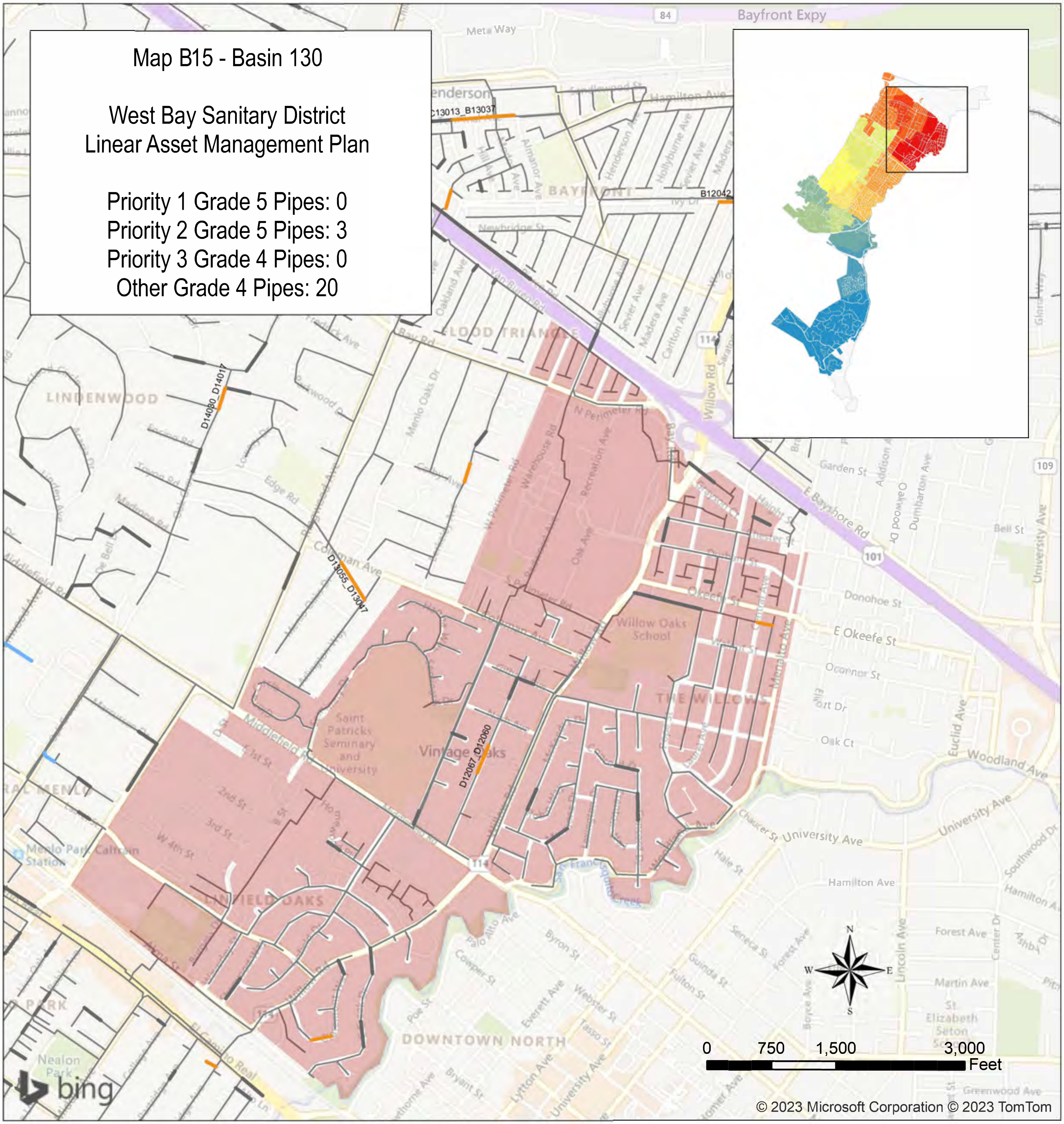


WEST BAY SANITARY DISTRICT

V.W. HOUSEN & ASSOCIATES

Legend

- Priority 1 Grade 5 Pipes
- Priority 2 Grade 5 Pipes
- Priority 3 Grade 4 Pipes
- Priority 3a Additional Grade 4 Pipes
- Priority 4 Future Grade 4 Repairs
- 120A
- 120B
- Sewer Pipeline



WEST BAY SANITARY DISTRICT

V.W. HOUSEN & ASSOCIATES

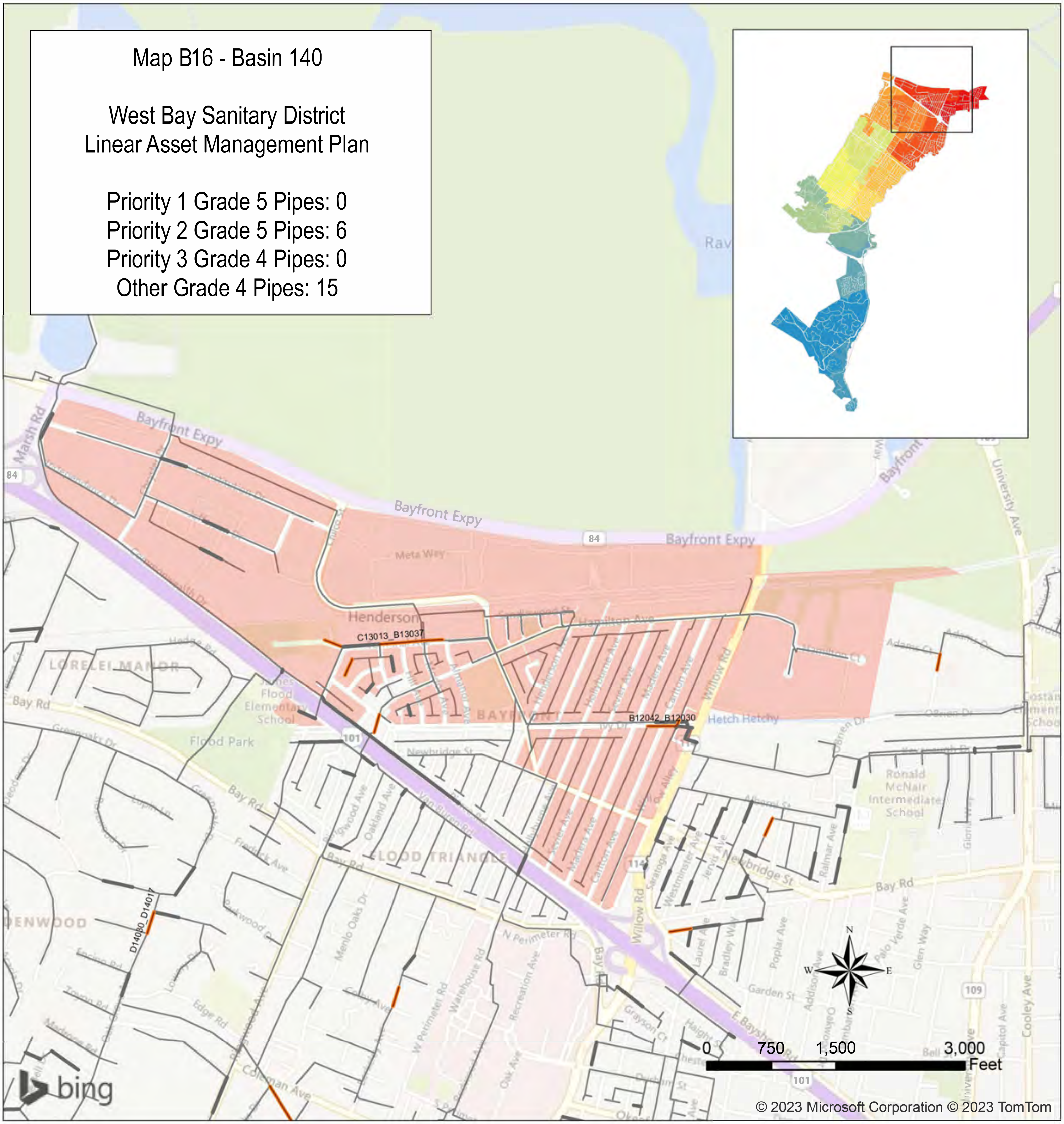
Legend

- Priority 1 Grade 5 Pipes
- Priority 2 Grade 5 Pipes
- Priority 3 Grade 4 Pipes
- Priority 3a Additional Grade 4 Pipes
- Priority 4 Future Grade 4 Repairs
- Basin 130
- Sewer Pipeline

Map B16 - Basin 140

West Bay Sanitary District
Linear Asset Management Plan

Priority 1 Grade 5 Pipes: 0
Priority 2 Grade 5 Pipes: 6
Priority 3 Grade 4 Pipes: 0
Other Grade 4 Pipes: 15



WEST BAY SANITARY DISTRICT

V.W. HOUSEN & ASSOCIATES

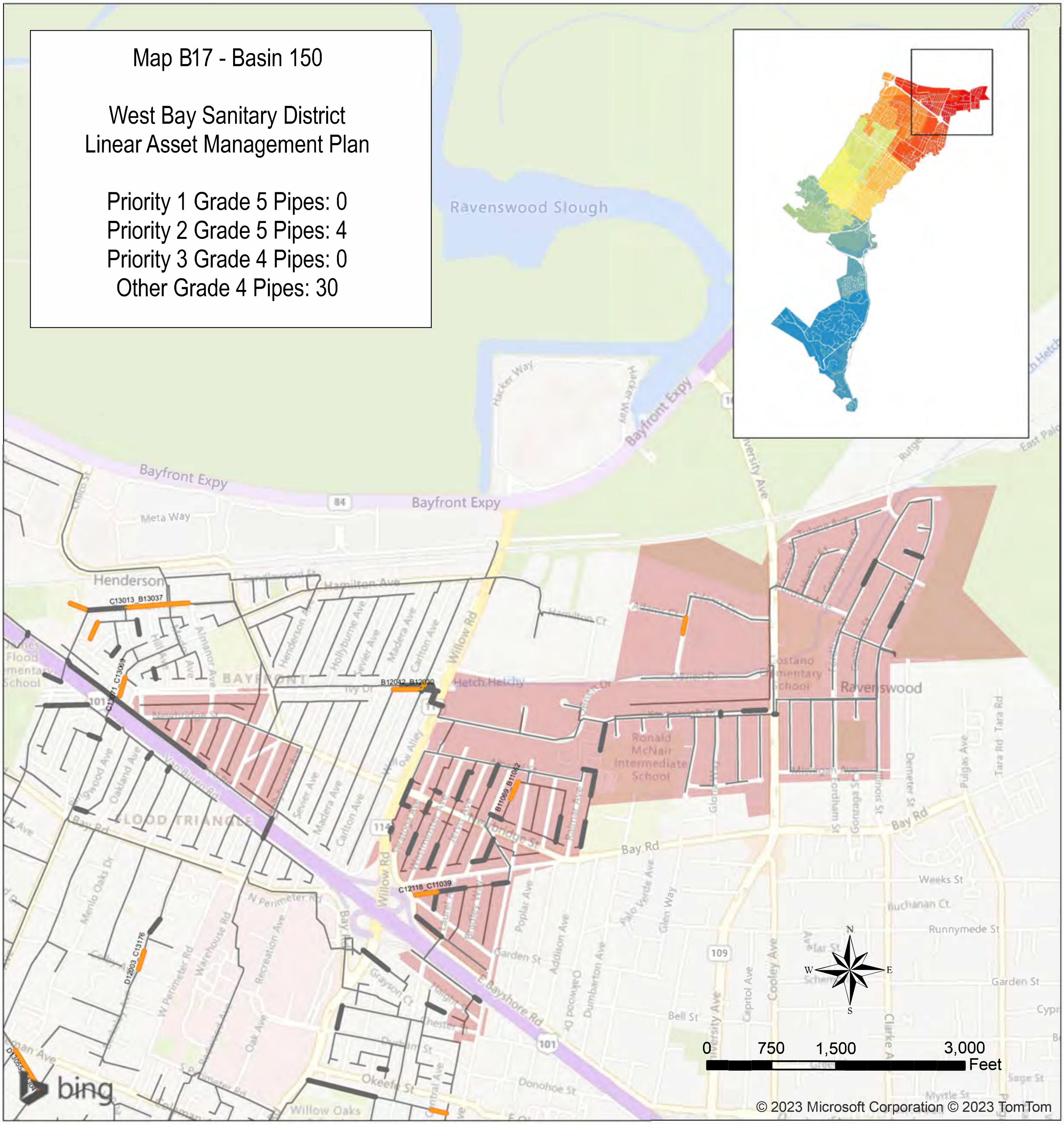
Legend

- Priority 1 Grade 5 Pipes
- Priority 2 Grade 5 Pipes
- Priority 3 Grade 4 Pipes
- Priority 3a Additional Grade 4 Pipes
- Priority 4 Future Grade 4 Repairs
- Basin 140
- Sewer Pipeline

Map B17 - Basin 150

West Bay Sanitary District
Linear Asset Management Plan

Priority 1 Grade 5 Pipes: 0
Priority 2 Grade 5 Pipes: 4
Priority 3 Grade 4 Pipes: 0
Other Grade 4 Pipes: 30



WEST BAY SANITARY DISTRICT

V.W. HOUSEN & ASSOCIATES

Legend

- Priority 1 Grade 5 Pipes
- Priority 2 Grade 5 Pipes
- Priority 3 Grade 4 Pipes
- Priority 3a Additional Grade 4 Pipes
- Priority 4 Future Grade 4 Repairs
- Basin 150
- Sewer Pipeline

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Appendix G

Project Information, Priorities, and Costs

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West Bay Sanitary District
2023 Linear Asset Management Plan
Pipeline Rehabilitation Project Information

PipeID	Priority	US MH	DS MH	Str PACP	Basin	Length	Diam (in)	Action	Constr. Cost	Project Cost	Risk Score	Structural PACP	O&M PACP	Material	Pipe Size	Geology	Capacity	Waterway	Critical Facilities	Area Served	Arterial Roadway
Priority 1 Grade 5 Pipes																					
N11054_N11053	1	N11054	N11053	5100	010	185	6	Repair	$13,000	$13,000	6380	● (red)				● (red)		● (red)			
J11009_J11008	1	J11009	J11008	5143	030	293	10	Repair	$52,000	$52,000	7650	● (green)				● (green)		● (red)			● (red)
J11012_J11011	1	J11012	J11011	5141	030	297	10	Repair	$26,000	$26,000	8174	● (green)				● (green)	● (red)	● (red)			● (green)
I11039_I11036	1	I11039	I11036	5100	040	194	6	Repair	$13,000	$13,000	4154	● (green)				● (green)		● (red)			● (green)
I12047_I12040	1	I12047	I12040	5132	040	132	6	Repair	$13,000	$13,000	2640	● (green)						● (red)			
I16043_I16039	1	I16043	I16039	5141	050	181	8	Repair	$26,000	$26,000	5610	● (green)				● (green)		● (red)			
I16067_I16066	1	I16067	I16066	5121	050	247	6	Repair	$13,000	$13,000	3410	● (green)				● (green)		● (red)			
I16083_I16082	1	I16083	I16082	5121	050	195	6	Repair	$13,000	$13,000	3410	● (green)				● (green)		● (red)			
F15061_F16051	1	F15061	F16051	5141	070AB	449	6	Repair	$26,000	$26,000	5940	● (green)					● (red)	● (red)			
G15050_G15047	1	G15050	G15047	5145	070AB	147	6	Replace	$68,727	$89,345	5610	● (green)				● (green)		● (red)			
Adjacent Grade 4 Pipes																					
J11010_J11009	3	J11010	J11009	4600	030	307	10	Repair	$78,000	$78,000	6855	● (tan)				● (green)	● (green)	● (red)			● (red)
J11011_J11010	3	J11011	J11010	4100	030	298	10	Repair	$13,000	$13,000	8250	● (tan)				● (green)	● (red)	● (red)			● (red)
J11013_J11012	3	J11013	J11012	4121	030	301	10	Repair	$13,000	$13,000	6030	● (tan)				● (green)		● (red)			● (green)
I16039_I16040	3	I16039	I16040	4232	050	121	8	Repair	$26,000	$26,000	4950	● (tan)				● (green)		● (red)			
F15056_F15057	3a	F15056	F15057	4533	070AB	288	6	Repair	$65,000	$65,000	760	● (tan)									
F15057_F15061	3a	F15057	F15061	4231	070AB	281	8	Repair	$26,000	$26,000	960	● (tan)					● (red)				
G15001_F15061	3a	G15001	F15061	4131	070AB	462	8	Repair	$13,000	$13,000	560	● (tan)					● (red)				
G15009_G15001	3a	G15009	G15001	4133	070AB	188	6	Repair	$13,000	$13,000	1240	● (tan)	● (green)				● (red)				
G15010_G15009	3a	G15010	G15009	442A	070AB	266	6	Repair	$52,000	$52,000	760	● (tan)									
G15047_G15048	3	G15047	G15048	4338	070AB	316	6	Repair	$39,000	$39,000	5170	● (tan)				● (green)		● (red)			
G15049_G15042	3a	G15049	G15042	412A	070AB	124	8	Repair	$13,000	$13,000	760	● (tan)									
Priority 2 Grade 5 Pipes																					
K10017_K10013	2	K10017	K10013	5200	030	248	6	Repair	$26,000	$26,000	1056	● (green)									● (green)
J11053_J11055	2	J11053	J11055	5145	030	200	6	Replace	$93,372	$121,384	880	● (green)									
K11097_K11095	2	K11097	K11095	5100	030	123	6	Repair	$13,000	$13,000	480	● (green)									
K11139_K11138	2	K11139	K11138	5100	030	167	6	Repair	$13,000	$13,000	480	● (green)									
K11144_K11145	2	K11144	K11145	5141	030	120	6	Repair	$26,000	$26,000	480	● (green)									
J12027_J12028	2	J12027	J12028	5100	040	375	8	Repair	$13,000	$13,000	1500	● (red)				● (green)					
H13164_H13192	2	H13164	H13192	5124	040	81	6	Repair	$13,000	$13,000	1360	● (red)									
H16034_H16033	2	H16034	H16033	5147	050	263	8	Replace	$122,886	$159,752	132	● (green)							● (green)		● (green)
H16027_H16028	2	H16027	H16028	514A	050	335	8	Replace	$156,989	$204,086	1936	● (green)									● (green)
H17004_H17005	2	H17004	H17005	5141	050	299	8	Repair	$26,000	$26,000	1936	● (green)									● (green)
H17005_H16024	2	H17005	H16024	5146	050	304	8	Replace	$142,040	$184,652	1936	● (green)									● (green)
H17008_H17003	2	H17008	H17003	5249	050	302	6	Replace	$141,503	$183,954	1936	● (green)									● (green)
H16040_H16030	2	H16040	H16030	534A	050	371	6	Replace	$173,479	$225,523	1360	● (red)									
H16045_H16040	2	H16045	H16040	514B	050	353	6	Replace	$165,389	$215,005	1360	● (red)									
H16060_H16061	2	H16060	H16061	5200	050	233	6	Repair	$26,000	$26,000	1360	● (red)									
I16051_I16050	2	I16051	I16050	5224	050	262	8	Repair	$26,000	$26,000	1360	● (red)		● (green)							
H16031_H16030	2	H16031	H16030	514A	050	299	8	Replace	$139,986	$181,982	880	● (green)									
H17034_H17027	2	H17034	H17027	544A	050	408	6	Replace	$190,816	$248,061	880	● (green)									
I16061_I16063	2	I16061	I16063	5143	050	200	6	Replace	$93,817	$121,962	880	● (green)									
I17011_I17012	2	I17011	I17012	514A	050	281	6	Replace	$131,577	$171,051	880	● (green)									
I17012_I17013	2	I17012	I17013	5346	050	313	6	Replace	$146,696	$190,705	880	● (green)									
H16073_H16074	2	H16073	H16074	5241	050	287	6	Repair	$39,000	$39,000	960	● (red)									
I16012_I16014	2	I16012	I16014	5100	050	67	6	Repair	$13,000	$13,000	480	● (green)									
J15002_J15003	2	J15002	J15003	5100	050	239	6	Repair	$13,000	$13,000	480	● (green)									

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PipeID	Priority	US MH	DS MH	Str PACP	Basin	Length	Diam (in)	Action	Constr. Cost	Project Cost	Risk Score	Structural PACP	O&M PACP	Material	Pipe Size	Geology	Capacity	Waterway	Critical Facilities	Area Served	Arterial Roadway
H14129_H14131	2	H14129	H14131	5142	060	330	6	Repair	$39,000	$39,000	1360	🔴									
H15117_H15118	2	H15117	H15118	5121	060	163	6	Repair	$13,000	$13,000	880	🟢		🟢							
I14034_I14021	2	I14034	I14021	5132	060	183	6	Repair	$13,000	$13,000	960	🔴									
I14006_I14014	2	I14006	I14014	5126	060	118	6	Repair	$13,000	$13,000	480	🟢									
I14014_I14015	2	I14014	I14015	5125	060	268	6	Repair	$13,000	$13,000	480	🟢									
I14038_I14031	2	I14038	I14031	5145	060	263	6	Replace	$123,051	$159,967	480	🟢									
I15048_H15118	2	I15048	H15118	5221	060	267	6	Repair	$26,000	$26,000	480	🟢									
E15085_E15075	2	E15085	E15075	5133	070AB	239	6	Repair	$13,000	$13,000	204	🔴							🟢		🔴
E15145_E15151	2	E15145	E15151	5221	070AB	178	8	Repair	$26,000	$26,000	4080	🔴									🔴
E15104_E15145	2	E15104	E15145	5141	070AB	65	8	Replace	$30,390	$39,507	2640	🟢									🔴
E15108_E15090	2	E15108	E15090	5141	070AB	349	8	Repair	$26,000	$26,000	2640	🟢									🔴
E16066_E16064	2	E16066	E16064	5144	070AB	175	6	Replace	$82,100	$106,730	2640	🟢									🔴
E14090_E14088	2	E14090	E14088	5145	070AB	376	6	Repair	$78,000	$78,000	1936	🟢									🟢
G15034_G15027	2	G15034	G15027	5141	070AB	302	6	Repair	$26,000	$26,000	1560	🔴					🔴				
E16080_E16079	2	E16080	E16079	5341	070AB	187	6	Replace	$87,603	$113,884	1080	🟢					🔴				
G15032_G15028	2	G15032	G15028	5141	070AB	173	6	Repair	$26,000	$26,000	1360	🔴		🟢							
H16009_H16008	2	H16009	H16008	5100	070AB	29	10	Replace	$16,915	$21,990	1360	🔴									
E14167_E14168	2	E14167	E14168	5141	070AB	64	6	Replace	$29,952	$38,938	880	🟢									
F15036_F16037	2	F15036	F16037	5244	070AB	260	8	Replace	$121,645	$158,138	880	🟢									
F16006_F16005	2	F16006	F16005	5149	070AB	181	6	Replace	$84,485	$109,831	880	🟢									
F16056_F16054	2	F16056	F16054	514A	070AB	324	8	Replace	$151,487	$196,933	880	🟢									
G16005_F16055	2	G16005	F16055	5142	070AB	360	10	Repair	$39,000	$39,000	880	🟢									
G16005_F16056	2	G16005	F16056	5123	070AB	238	8	Repair	$13,000	$13,000	880	🟢									
H16096_H16103	2	H16096	H16103	5141	070AB	271	6	Repair	$26,000	$26,000	880	🟢		🟢							
E15110_E16066	2	E15110	E16066	5100	070AB	469	8	Repair	$13,000	$13,000	480	🟢									
G15048_G15042	2	G15048	G15042	5244	070AB	204	6	Replace	$95,346	$123,949	880	🟢									
E14084_E15108	2	E14084	E15108	5233	070CDE	296	6	Repair	$26,000	$26,000	4080	🔴									🔴
E14015_E14008	2	E14015	E14008	514B	070CDE	438	8	Replace	$205,080	$266,604	204	🔴							🟢		
G15005_G15074	2	G15005	G15074	5131	070CDE	417	6	Repair	$13,000	$13,000	204	🔴							🟢		
E14075_E14150	2	E14075	E14150	5244	070CDE	306	6	Replace	$142,981	$185,875	1360	🔴									
F14072_F14071	2	F14072	F14071	5126	070CDE	192	6	Repair	$13,000	$13,000	1360	🔴									
H15066_H15051	2	H15066	H15051	5141	080	258	6	Repair	$26,000	$26,000	2992	🔴									🟢
H15075_H15062	2	H15075	H15062	5141	080	383	6	Repair	$26,000	$26,000	2992	🔴									🟢
H15076_H15064	2	H15076	H15064	5133	080	249	6	Repair	$13,000	$13,000	1936	🟢									🟢
H14079_H14071	2	H14079	H14071	5131	080	292	6	Repair	$13,000	$13,000	1360	🔴									
H13109_H14101	2	H13109	H14101	5231	090	165	6	Repair	$26,000	$26,000	2992	🔴									🟢
H13059_H13058	2	H13059	H13058	5141	090	225	6	Repair	$26,000	$26,000	1360	🔴									
H13077_H13078	2	H13077	H13078	5147	090	337	6	Replace	$157,762	$205,091	1360	🔴									
H13101_H13079	2	H13101	H13079	5243	090	234	6	Replace	$109,710	$142,623	880	🟢									
F13107_F13100	2	F13107	F13100	5142	100	328	8	Repair	$39,000	$39,000	132	🟢							🟢		🟢
G12013_G13041	2	G12013	G13041	5131	100	250	6	Repair	$13,000	$13,000	3300	🔴				🟢					🟢
F13125_F13212	2	F13125	F13212	5141	100	378	6	Repair	$26,000	$26,000	2992	🔴									🟢
F13101_F13085	2	F13101	F13085	5141	100	250	6	Repair	$26,000	$26,000	204	🔴							🟢		
F13143_F13144	2	F13143	F13144	5132	100	103	6	Repair	$13,000	$13,000	204	🔴							🟢		
F12088_F13165	2	F12088	F13165	5133	100	299	6	Repair	$13,000	$13,000	1360	🔴									
F13156_F13170	2	F13156	F13170	5100	100	300	6	Repair	$13,000	$13,000	1360	🔴									
F13157_F13171	2	F13157	F13171	5135	100	338	6	Repair	$13,000	$13,000	1360	🔴									
F13216_F13130	2	F13216	F13130	5131	100	218	6	Repair	$13,000	$13,000	1360	🔴									

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F12017_F12018	2	F12017	F12018	5100	110	127	6	Repair	$13,000	$13,000	4080	● (red)									● (red)
D15099_D15098	2	D15099	D15098	5333	110	307	6	Repair	$39,000	$39,000	1360	● (red)									
C13071_C13069	2	C13071	C13069	524A	120A	224	10	Replace	$131,021	$170,327	4500	● (red)				● (green)			● (green)		● (red)
D14030_D14017	2	D14030	D14017	5113	120A	265	6	Repair	$13,000	$13,000	1360	● (red)									
D12003_C13176	2	D12003	C13176	5141	120B	229	6	Repair	$26,000	$26,000	204	● (red)							● (green)		
D13055_D13047	2	D13055	D13047	5123	120B	516	6	Repair	$13,000	$13,000	1360	● (red)									
E12082_E12092	2	E12082	E12092	5141	130	245	6	Repair	$26,000	$26,000	1500	● (red)				● (green)					
C11113_C11128	2	C11113	C11128	5133	130	181	6	Repair	$13,000	$13,000	1020	● (green)				● (green)					
D12067_D12060	2	D12067	D12060	5142	130	345	6	Repair	$39,000	$39,000	1360	● (red)									
B12030_B12031	2	B12030	B12031	5141	140	72	6	Replace	$33,805	$43,947	3060	● (green)				● (green)					● (red)
C14011_C14012	2	C14011	C14012	5249	140	209	10	Replace	$122,229	$158,898	225	● (red)				● (green)			● (red)		
C14022_C14015	2	C14022	C14015	5131	140	208	6	Repair	$13,000	$13,000	225	● (red)				● (green)			● (green)		
B13025_B13064	2	B13025	B13064	5143	140	213	6	Replace	$99,498	$129,347	1500	● (red)				● (green)					
B13037_B13064	2	B13037	B13064	5131	140	252	6	Repair	$13,000	$13,000	1500	● (red)				● (green)					
C13013_B13037	2	C13013	B13037	5141	140	269	6	Repair	$26,000	$26,000	1500	● (red)				● (green)					
B12042_B12030	2	B12042	B12030	5141	150	338	6	Repair	$26,000	$26,000	4500	● (red)				● (green)			● (green)		● (red)
B11069_B11062	2	B11069	B11062	5134	150	221	6	Repair	$13,000	$13,000	1500	● (red)				● (green)					
C12118_C11039	2	C12118	C11039	5122	150	249	6	Repair	$13,000	$13,000	1500	● (red)				● (green)					
B11097_B11098	2	B11097	B11098	5100	150	191	6	Repair	$13,000	$13,000	1100	● (red)				● (green)					
Adjacent Grade 4 Pipes																					
K11015_K11016	Other Grade 4	K11015	K11016	4337	030	241	6	Repair	$39,000	$39,000	54	● (tan)							● (green)		
K11016_K11017	3a	K11016	K11017	4133	030	235	6	Repair	$13,000	$13,000	54	● (tan)							● (green)		
K11017_K11018	3a	K11017	K11018	4232	030	234	6	Repair	$26,000	$26,000	54	● (tan)							● (green)		
K11005_J11053	3a	K11005	J11053	4323	030	241	6	Repair	$39,000	$39,000	360	● (tan)									
K11018_K11005	3a	K11018	K11005	4134	030	247	6	Repair	$13,000	$13,000	360	● (tan)									
K11042_K11018	3a	K11042	K11018	4634	030	303	6	Replace	$141,603	$184,083	360	● (tan)									
K11043_K11042	3a	K11043	K11042	4532	030	293	6	Repair	$65,000	$65,000	360	● (tan)									
K11066_K11043	3a	K11066	K11043	4333	030	195	6	Repair	$39,000	$39,000	360	● (tan)									
K11129_K11130	3a	K11129	K11130	4121	030	86	6	Repair	$13,000	$13,000	360	● (tan)									
K11130_K11143	3a	K11130	K11143	4311	030	221	6	Repair	$39,000	$39,000	360	● (tan)									
K11143_K11144	3a	K11143	K11144	4200	030	131	6	Repair	$26,000	$26,000	360	● (tan)									
H16024_H16025	3a	H16024	H16025	4332	050	91	8	Replace	$42,809	$55,652	1672	● (tan)									● (green)
H16026_H16027	3a	H16026	H16027	4331	050	225	8	Repair	$39,000	$39,000	1672	● (tan)									● (green)
H16032_H16031	3a	H16032	H16031	4332	050	293	8	Repair	$39,000	$39,000	1672	● (tan)									● (green)
H17003_H17048	3a	H17003	H17048	4633	050	190	8	Replace	$89,129	$115,868	1672	● (tan)									● (green)
H16029_H16023	3a	H16029	H16023	4334	050	292	10	Repair	$39,000	$39,000	760	● (tan)									
H16030_H16029	3a	H16030	H16029	4231	050	124	10	Repair	$26,000	$26,000	760	● (tan)									
H17023_H17022	3a	H17023	H17022	4731	050	90	6	Replace	$42,102	$54,732	760	● (tan)									
H17024_H17023	3a	H17024	H17023	4425	050	174	6	Replace	$81,341	$105,743	760	● (tan)									
H17026_H17024	3a	H17026	H17024	4333	050	261	6	Repair	$39,000	$39,000	760	● (tan)									
H17027_H17026	3a	H17027	H17026	4933	050	244	6	Replace	$114,234	$148,505	760	● (tan)									
H17033_H17034	3a	H17033	H17034	4131	050	237	6	Repair	$13,000	$13,000	760	● (tan)									
H17039_H17033	3a	H17039	H17033	4737	050	83	6	Replace	$38,609	$50,192	760	● (tan)									
I17010_I17011	3a	I17010	I17011	493A	050	170	6	Replace	$79,552	$103,418	760	● (tan)									
H16072_H16073	3a	H16072	H16073	4235	050	170	6	Repair	$26,000	$26,000	360	● (tan)									
I16013_I16012	3a	I16013	I16012	4131	050	100	6	Repair	$13,000	$13,000	360	● (tan)									
I14013_I14014	Other Grade 4	I14013	I14014	4231	060	193	6	Repair	$26,000	$26,000	360	● (tan)									
I15049_I15048	Other Grade 4	I15049	I15048	4221	060	173	6	Repair	$26,000	$26,000	360	● (tan)									

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G15074_G15004	3a	G15074	G15004	4134	070AB	246	8	Repair	$13,000	$13,000	186	● (tan)	● (green)				● (red)		● (green)		
H16098_H16097	3a	H16098	H16097	4200	070AB	366	6	Repair	$26,000	$26,000	114	● (tan)							● (green)		
G15029_G15030	3a	G15029	G15030	4300	070AB	203	6	Repair	$39,000	$39,000	960	● (tan)					● (red)				
G15030_G15027	3a	G15030	G15027	423B	070AB	110	8	Replace	$51,569	$67,040	960	● (tan)					● (red)				
G16023_G16015	3a	G16023	G16015	432A	070AB	446	8	Repair	$39,000	$39,000	960	● (tan)					● (red)				
G16015_G16004	3a	G16015	G16004	4331	070AB	381	8	Repair	$39,000	$39,000	774	● (tan)					● (green)				
F15008_F16006	3a	F15008	F16006	4533	070AB	219	6	Replace	$102,267	$132,947	760	● (tan)									
F16005_E16069	3a	F16005	E16069	432D	070AB	265	6	Repair	$39,000	$39,000	760	● (tan)									
G15028_G15029	3a	G15028	G15029	4131	070AB	218	6	Repair	$13,000	$13,000	760	● (tan)									
G16013_G16005	3a	G16013	G16005	4132	070AB	267	10	Repair	$13,000	$13,000	760	● (tan)									
G16016_G16013	3a	G16016	G16013	4135	070AB	286	10	Repair	$13,000	$13,000	760	● (tan)									
G16019_G16016	3a	G16019	G16016	4134	070AB	232	10	Repair	$13,000	$13,000	760	● (tan)									
H16097_H16096	3a	H16097	H16096	4121	070AB	295	6	Repair	$13,000	$13,000	760	● (tan)		● (green)							
E14008_D14114	3a	E14008	D14114	4138	070CDE	267	8	Repair	$13,000	$13,000	156	● (tan)	● (green)						● (green)		● (red)
E14085_E14084	3a	E14085	E14084	4132	070CDE	283	6	Repair	$13,000	$13,000	6600	● (tan)									● (red)
F15037_F15036	3	F15037	F15036	4225	070CDE	281	8	Repair	$26,000	$26,000	4950	● (tan)				● (green)		● (red)			
E14168_E14075	3a	E14168	E14075	4129	070CDE	34	6	Replace	$15,912	$20,686	760	● (tan)									
E15086_E15085	3a	E15086	E15085	432A	070CDE	199	6	Repair	$39,000	$39,000	760	● (tan)									
F16037_F16062	3a	F16037	F16062	4331	070CDE	94	8	Replace	$44,179	$57,432	760	● (tan)									
H14090_H14091	Other Grade 4	H14090	H14091	412C	080	212	6	Repair	$13,000	$13,000	1760	● (tan)									● (green)
H14091_H14079	Other Grade 4	H14091	H14079	4A36	080	248	6	Replace	$116,242	$151,114	1672	● (tan)									● (green)
H16008_H16003	Other Grade 4	H16008	H16003	463C	080	306	10	Repair	$78,000	$78,000	800	● (tan)	● (tan)								
H14071_H14060	Other Grade 4	H14071	H14060	4132	080	249	6	Repair	$13,000	$13,000	760	● (tan)									
H14127_H14129	Other Grade 4	H14127	H14129	4132	080	104	6	Repair	$13,000	$13,000	760	● (tan)									
H13078_H13091	Other Grade 4	H13078	H13091	4239	090	244	6	Repair	$26,000	$26,000	760	● (tan)									
H13091_H13100	Other Grade 4	H13091	H13100	413B	090	245	6	Repair	$13,000	$13,000	760	● (tan)									
F13212_F13099	Other Grade 4	F13212	F13099	422A	100	196	6	Repair	$26,000	$26,000	1672	● (tan)									● (green)
F13085_F13086	Other Grade 4	F13085	F13086	4131	100	333	6	Repair	$13,000	$13,000	156	● (tan)	● (green)						● (green)		
D15098_D15091	Other Grade 4	D15098	D15091	412D	110	225	6	Repair	$13,000	$13,000	800	● (tan)									
B12030_B12032	Other Grade 4	B12030	B12032	4221	140	184	6	Repair	$26,000	$26,000	225	● (tan)				● (green)			● (green)		● (red)
B12143_B12030	Other Grade 4	B12143	B12030	4122	140	24	6	Replace	$11,261	$14,640	3540	● (tan)				● (green)					● (red)
C14013_C13013	Other Grade 4	C14013	C13013	4234	140	424	6	Repair	$26,000	$26,000	141	● (tan)	● (tan)			● (green)			● (green)		
C11039_C11041	Other Grade 4	C11039	C11041	4122	150	336	6	Repair	$13,000	$13,000	1180	● (tan)	● (green)			● (green)					
C11040_C11039	Other Grade 4	C11040	C11039	4131	150	203	6	Repair	$13,000	$13,000	900	● (tan)				● (green)					
Other Grade 4 Pipes																					
M09027_M09026	Other Grade 4	M09027	M09026	4100	010	132	8	Repair	$13,000	$13,000	360	● (tan)									
N10014_N10015	Other Grade 4	N10014	N10015	4131	010	136	6	Repair	$13,000	$13,000	360	● (tan)									
N11057_N11017	Other Grade 4	N11057	N11017	4100	010	100	6	Repair	$13,000	$13,000	360	● (tan)									
N11060_N11028	Other Grade 4	N11060	N11028	4331	010	88	6	Replace	$41,058	$53,375	360	● (tan)									
O09009_O09008	3	O09009	O09008	4100	020	217	6	Repair	$13,000	$13,000	5280	● (tan)				● (red)		● (red)			
N09028_N10117	3a	N09028	N10117	4100	020	311	6	Repair	$13,000	$13,000	960	● (tan)				● (red)					
O08013_O08012	3a	O08013	O08012	4121	020	228	8	Repair	$13,000	$13,000	560	● (tan)				● (red)					
N10083_N10072	3a	N10083	N10072	4100	020	234	6	Repair	$13,000	$13,000	360	● (tan)									
J11007_J11006	3	J11007	J11006	4300	030	307	10	Repair	$39,000	$39,000	8250	● (tan)				● (green)	● (red)	● (red)			● (red)
J11008_J11007	3	J11008	J11007	4100	030	308	10	Repair	$13,000	$13,000	6855	● (tan)				● (green)	● (green)	● (red)			● (red)
J11036_J11029	3	J11036	J11029	4534	030	238	8	Replace	$111,613	$145,097	7906	● (tan)				● (green)		● (red)			● (green)
J10001_J11058	3	J10001	J11058	4121	030	116	8	Repair	$13,000	$13,000	6030	● (tan)				● (green)		● (red)			● (green)
J11045_J11044	3	J11045	J11044	4100	030	71	8	Repair	$13,000	$13,000	6030	● (tan)				● (green)		● (red)			● (green)

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PipeID	Priority	US MH	DS MH	Str PACP	Basin	Length	Diam (in)	Action	Constr. Cost	Project Cost	Risk Score	Structural PACP	O&M PACP	Material	Pipe Size	Geology	Capacity	Waterway	Critical Facilities	Area Served	Arterial Roadway
J11058_J11045	3	J11058	J11045	4400	030	122	8	Replace	$56,867	$73,927	6030	●				●		●			●
K10007_K10004	3	K10007	K10004	4200	030	195	6	Repair	$26,000	$26,000	6030	●				●		●			●
K10008_K10004	3	K10008	K10004	4100	030	154	8	Repair	$13,000	$13,000	6030	●				●		●			●
K10004_J10001	3	K10004	J10001	4234	030	284	8	Repair	$26,000	$26,000	3350	●				●		●			●
J11039_J11049	3a	J11039	J11049	4121	030	307	8	Repair	$13,000	$13,000	114	●							●		
J11034_J11028	3a	J11034	J11028	4131	030	127	6	Repair	$13,000	$13,000	900	●				●					
K10029_K10024	3a	K10029	K10024	4134	030	278	6	Repair	$13,000	$13,000	800	●	●								
J11021_J11022	3a	J11021	J11022	4100	030	185	6	Repair	$13,000	$13,000	760	●									
J11054_J11056	3a	J11054	J11056	4200	030	118	6	Repair	$26,000	$26,000	760	●									
K10010_K10007	3a	K10010	K10007	4100	030	181	6	Repair	$13,000	$13,000	760	●									
K10012_K10010	3a	K10012	K10010	4300	030	137	6	Replace	$64,093	$83,321	760	●									
K10016_K10012	3a	K10016	K10012	4200	030	230	6	Repair	$26,000	$26,000	760	●									
K10020_K10025	3a	K10020	K10025	4100	030	211	6	Repair	$13,000	$13,000	760	●									
K10025_K10027	3a	K10025	K10027	4100	030	169	6	Repair	$13,000	$13,000	760	●									
K11080_K11081	3a	K11080	K11081	4200	030	241	6	Repair	$26,000	$26,000	760	●									
K11124_K12030	3a	K11124	K12030	4122	030	278	6	Repair	$13,000	$13,000	760	●									
K12052_K12050	3a	K12052	K12050	4431	030	189	6	Replace	$88,536	$115,097	760	●									
K12053_K12052	3a	K12053	K12052	4131	030	99	6	Repair	$13,000	$13,000	760	●									
K12054_K12053	3a	K12054	K12053	4200	030	148	6	Repair	$26,000	$26,000	760	●									
K11022_J11057	3a	K11022	J11057	4636	030	257	6	Replace	$120,200	$156,260	640	●	●								
K11009_J11054	3a	K11009	J11054	4200	030	315	6	Repair	$26,000	$26,000	360	●									
K11019_J11054	3a	K11019	J11054	4632	030	212	6	Replace	$99,255	$129,031	360	●									
K11020_K11019	3a	K11020	K11019	4431	030	160	6	Replace	$75,015	$97,520	360	●									
K11021_K11048	3a	K11021	K11048	4533	030	249	6	Replace	$116,371	$151,283	360	●									
K11023_K10010	3a	K11023	K10010	4332	030	175	6	Repair	$39,000	$39,000	360	●									
K11044_K11020	3a	K11044	K11020	4700	030	260	6	Replace	$121,514	$157,969	360	●									
K11045_K11047	3a	K11045	K11047	4131	030	232	6	Repair	$13,000	$13,000	360	●									
K11046_K11047	3a	K11046	K11047	4200	030	263	6	Repair	$26,000	$26,000	360	●									
K11047_K10012	3a	K11047	K10012	4221	030	274	6	Repair	$26,000	$26,000	360	●									
K11048_K10012	3a	K11048	K10012	4412	030	165	6	Replace	$77,327	$100,525	360	●									
K11053_K12006	3a	K11053	K12006	4100	030	265	6	Repair	$13,000	$13,000	360	●									
K11056_K11058	3a	K11056	K11058	4200	030	187	6	Repair	$26,000	$26,000	360	●									
K11061_K11062	3a	K11061	K11062	4100	030	147	6	Repair	$13,000	$13,000	360	●									
K11064_K11086	3a	K11064	K11086	4110	030	150	6	Repair	$13,000	$13,000	360	●									
K11065_K11064	3a	K11065	K11064	4100	030	132	6	Repair	$13,000	$13,000	360	●									
K11078_K11055	3a	K11078	K11055	4131	030	206	6	Repair	$13,000	$13,000	360	●									
K11081_K11082	3a	K11081	K11082	4121	030	162	6	Repair	$13,000	$13,000	360	●									
K11082_K11060	3a	K11082	K11060	4100	030	247	6	Repair	$13,000	$13,000	360	●									
K11090_K11068	3a	K11090	K11068	4A31	030	226	6	Replace	$105,671	$137,373	360	●									
K11093_K11095	3a	K11093	K11095	4100	030	103	6	Repair	$13,000	$13,000	360	●									
K11102_K11081	3a	K11102	K11081	4132	030	103	6	Repair	$13,000	$13,000	360	●									
K11110_K11111	3a	K11110	K11111	4100	030	167	6	Repair	$13,000	$13,000	360	●									
K11111_K11109	3a	K11111	K11109	4121	030	148	6	Repair	$13,000	$13,000	360	●									
K11113_K11111	3a	K11113	K11111	4200	030	247	6	Repair	$26,000	$26,000	360	●									
K11114_K11090	3a	K11114	K11090	4634	030	289	6	Replace	$135,458	$176,095	360	●									
K11148_K11133	3a	K11148	K11133	4221	030	302	6	Repair	$26,000	$26,000	360	●									
K11164_K11159	3a	K11164	K11159	4100	030	163	6	Repair	$13,000	$13,000	360	●									
K11172_K11170	3a	K11172	K11170	4200	030	130	6	Repair	$26,000	$26,000	360	●									

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PipeID	Priority	US MH	DS MH	Str PACP	Basin	Length	Diam (in)	Action	Constr. Cost	Project Cost	Risk Score	Structural PACP	O&M PACP	Material	Pipe Size	Geology	Capacity	Waterway	Critical Facilities	Area Served	Arterial Roadway
K11174_K11172	3a	K11174	K11172	4432	030	210	6	Replace	$98,229	$127,698	360	●									
K12011_K12008	3a	K12011	K12008	4100	030	162	6	Repair	$13,000	$13,000	360	●									
K12042_K12043	3a	K12042	K12043	4231	030	119	6	Repair	$26,000	$26,000	360	●									
K12043_K12040	3a	K12043	K12040	4500	030	177	6	Replace	$82,791	$107,629	360	●									
I13010_H12046	3a	I13010	H12046	4100	040	373	8	Repair	$13,000	$13,000	1080	●									●
I13026_I13019	3a	I13026	I13019	4200	040	376	8	Repair	$26,000	$26,000	1080	●									●
I13034_I13026	3a	I13034	I13026	4121	040	398	8	Repair	$13,000	$13,000	1080	●									●
I12060_I12058	3	I12060	I12058	4221	040	93	12	Repair	$26,000	$26,000	4690	●				●	●	●		●	●
J11006_I11052	3	J11006	I11052	4100	040	274	10	Repair	$13,000	$13,000	6030	●				●		●			●
I12016_I12010	3a	I12016	I12010	4711	040	157	6	Replace	$73,619	$95,705	792	●									●
J11049_K11002	3a	J11049	K11002	4400	040	306	8	Repair	$52,000	$52,000	114	●							●		
I11034_I11035	3	I11034	I11035	4100	040	82	6	Repair	$13,000	$13,000	2750	●				●		●			
I12049_I12048	3	I12049	I12048	4125	040	49	6	Replace	$22,995	$29,894	1980	●						●			
I13023_I13016	3a	I13023	I13016	4134	040	301	6	Repair	$13,000	$13,000	360	●									
H16093_H16025	3a	H16093	H16025	4134	050	269	6	Repair	$13,000	$13,000	880	●	●								●
I16033_I16034	3	I16033	I16034	4831	050	137	8	Replace	$64,016	$83,221	5170	●				●		●			
I16026_I16079	3	I16026	I16079	4131	050	141	6	Repair	$13,000	$13,000	4950	●				●		●			
I16031_I16028	3	I16031	I16028	4339	050	274	8	Repair	$39,000	$39,000	4950	●				●		●			
I16019_I16020	3	I16019	I16020	4132	050	110	8	Repair	$13,000	$13,000	4180	●						●			
I16027_I16019	3	I16027	I16019	4133	050	359	8	Repair	$13,000	$13,000	4180	●						●			
J15005_J16004	3a	J15005	J16004	4100	050	243	8	Repair	$13,000	$13,000	620	●	●			●					
H16058_H16050	3a	H16058	H16050	4112	050	166	6	Repair	$13,000	$13,000	760	●									
H16095_H16019	3a	H16095	H16019	412B	050	96	10	Repair	$13,000	$13,000	760	●									
H17010_H17011	3a	H17010	H17011	4425	050	201	6	Replace	$93,989	$122,186	760	●									
H17018_H17010	3a	H17018	H17010	4233	050	253	6	Repair	$26,000	$26,000	760	●									
I16036_I16037	3a	I16036	I16037	4100	050	163	6	Repair	$13,000	$13,000	760	●									
I16037_I16038	3a	I16037	I16038	4124	050	81	6	Repair	$13,000	$13,000	760	●									
I16038_I16029	3a	I16038	I16029	4131	050	201	6	Repair	$13,000	$13,000	760	●									
H16046_H16047	3a	H16046	H16047	4100	050	317	8	Repair	$13,000	$13,000	640	●									
H16065_H16066	3a	H16065	H16066	4232	050	294	6	Repair	$26,000	$26,000	360	●									
H17016_H17012	3a	H17016	H17012	4534	050	290	6	Repair	$65,000	$65,000	360	●									
I15064_I15063	3a	I15064	I15063	4333	050	119	6	Replace	$55,582	$72,257	360	●									
I15099_I15097	3a	I15099	I15097	4200	050	113	6	Repair	$26,000	$26,000	360	●									
I15119_I15120	3a	I15119	I15120	4100	050	91	6	Repair	$13,000	$13,000	360	●									
I15121_I15122	3a	I15121	I15122	4236	050	256	6	Repair	$26,000	$26,000	360	●									
J15021_J15019	3a	J15021	J15019	4132	050	154	6	Repair	$13,000	$13,000	360	●									
H14195_H14150	Other Grade 4	H14195	H14150	4135	060	195	6	Repair	$13,000	$13,000	114	●		●					●		
I14057_I14056	Other Grade 4	I14057	I14056	4112	060	250	6	Repair	$13,000	$13,000	54	●							●		
I14103_I14055	Other Grade 4	I14103	I14055	4321	060	322	6	Repair	$39,000	$39,000	54	●							●		
I14104_I14105	Other Grade 4	I14104	I14105	4131	060	195	6	Repair	$13,000	$13,000	54	●							●		
I15108_H15108	Other Grade 4	I15108	H15108	4131	060	65	6	Repair	$13,000	$13,000	500	●				●					
H14198_H14199	Other Grade 4	H14198	H14199	4111	060	90	6	Repair	$13,000	$13,000	760	●									
I13051_I13045	Other Grade 4	I13051	I13045	4100	060	78	8	Repair	$13,000	$13,000	360	●									
I14036_I14102	Other Grade 4	I14036	I14102	4125	060	143	6	Repair	$13,000	$13,000	360	●									
I14039_I14032	Other Grade 4	I14039	I14032	4200	060	271	6	Repair	$26,000	$26,000	360	●									
I14058_I14057	Other Grade 4	I14058	I14057	4100	060	233	6	Repair	$13,000	$13,000	360	●									
I14108_I14147	Other Grade 4	I14108	I14147	4131	060	178	6	Repair	$13,000	$13,000	360	●									
I14133_I14104	Other Grade 4	I14133	I14104	4121	060	158	6	Repair	$13,000	$13,000	360	●									

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I14135_I14085	Other Grade 4	I14135	I14085	4231	060	161	6	Repair	$26,000	$26,000	360	●									
I14142_I14141	Other Grade 4	I14142	I14141	4100	060	200	6	Repair	$13,000	$13,000	360	●									
G14107_G14095	Other Grade 4	G14107	G14095	433A	080	178	8	Repair	$39,000	$39,000	114	●							●		●
H14109_H14097	Other Grade 4	H14109	H14097	4131	080	228	6	Repair	$13,000	$13,000	1760	●									●
H14111_H14101	Other Grade 4	H14111	H14101	4131	080	235	6	Repair	$13,000	$13,000	1760	●	●								●
G14099_G14182	Other Grade 4	G14099	G14182	4200	080	215	6	Repair	$26,000	$26,000	1672	●									●
G14137_G14139	Other Grade 4	G14137	G14139	4113	080	271	6	Repair	$13,000	$13,000	1672	●									●
G14140_G14138	Other Grade 4	G14140	G14138	4131	080	176	6	Repair	$13,000	$13,000	1672	●									●
H14031_H14213	Other Grade 4	H14031	H14213	4134	080	267	6	Repair	$13,000	$13,000	1672	●									●
H14039_H14025	Other Grade 4	H14039	H14025	4232	080	260	8	Repair	$26,000	$26,000	1672	●									●
H14049_H14039	Other Grade 4	H14049	H14039	4132	080	305	8	Repair	$13,000	$13,000	1672	●									●
H14089_H14078	Other Grade 4	H14089	H14078	4131	080	221	6	Repair	$13,000	$13,000	1672	●									●
H14092_H14093	Other Grade 4	H14092	H14093	4134	080	199	6	Repair	$13,000	$13,000	1672	●									●
H14096_H14095	Other Grade 4	H14096	H14095	4131	080	184	6	Repair	$13,000	$13,000	1672	●									●
H14097_H14082	Other Grade 4	H14097	H14082	4211	080	322	6	Repair	$26,000	$26,000	1672	●									●
H14098_H14097	Other Grade 4	H14098	H14097	4335	080	256	6	Repair	$39,000	$39,000	1672	●									●
H14099_H14084	Other Grade 4	H14099	H14084	4100	080	153	6	Repair	$13,000	$13,000	1672	●									●
H14100_H14098	Other Grade 4	H14100	H14098	4131	080	219	6	Repair	$13,000	$13,000	1672	●									●
H14107_H14093	Other Grade 4	H14107	H14093	4134	080	253	6	Repair	$13,000	$13,000	1672	●									●
G14114_G14105	Other Grade 4	G14114	G14105	4100	080	220	6	Repair	$13,000	$13,000	114	●							●		
H14016_H14018	Other Grade 4	H14016	H14018	4129	080	233	6	Repair	$13,000	$13,000	1040	●									
G14150_H14017	Other Grade 4	G14150	H14017	4121	080	176	6	Repair	$13,000	$13,000	760	●									
H14033_H14032	Other Grade 4	H14033	H14032	4132	080	262	6	Repair	$13,000	$13,000	760	●									
H14120_H15092	Other Grade 4	H14120	H15092	4100	080	214	6	Repair	$13,000	$13,000	760	●									
H14154_H14148	Other Grade 4	H14154	H14148	4100	080	263	6	Repair	$13,000	$13,000	760	●									
H14156_I14005	Other Grade 4	H14156	I14005	4232	080	180	6	Repair	$26,000	$26,000	760	●									
H15111_H15110	Other Grade 4	H15111	H15110	4100	080	215	6	Repair	$13,000	$13,000	760	●									
F14075_F14076	3a	F14075	F14076	422A	070AB	223	6	Repair	$26,000	$26,000	120	●	●						●		●
F14005_E14112	3a	F14005	E14112	4100	070AB	66	12	Repair	$13,000	$13,000	2112	●					●			●	●
F14102_F13168	3a	F14102	F13168	4124	070AB	200	8	Repair	$13,000	$13,000	1760	●									●
H15058_H15047	3a	H15058	H15047	4131	070AB	347	6	Repair	$13,000	$13,000	1672	●									●
H15073_H15060	3a	H15073	H15060	4332	070AB	216	6	Repair	$39,000	$39,000	1672	●									●
F14074_F14075	3a	F14074	F14075	4132	070AB	292	6	Repair	$13,000	$13,000	114	●							●		
F15047_F15041	3a	F15047	F15041	4231	070AB	256	6	Repair	$26,000	$26,000	120	●							●		
F15062_F15059	3a	F15062	F15059	4237	070AB	343	6	Repair	$26,000	$26,000	120	●	●						●		
F15055_F15049	3a	F15055	F15049	4232	070AB	291	6	Repair	$26,000	$26,000	114	●							●		
H15039_H15040	3a	H15039	H15040	433B	070AB	280	8	Repair	$39,000	$39,000	114	●							●		
H15024_H15031	3	H15024	H15031	4A33	070AB	304	6	Replace	$142,039	$184,651	5170	●				●		●			
G16009_G16008	3	G16009	G16008	4222	070AB	206	6	Repair	$26,000	$26,000	4950	●				●		●			
I16016_I16017	3	I16016	I16017	4431	070AB	176	6	Replace	$82,208	$106,870	2750	●				●		●			
G15046_G15045	3	G15046	G15045	4233	070AB	251	6	Repair	$26,000	$26,000	4840	●						●			
G16008_G16007	3	G16008	G16007	4634	070AB	205	6	Replace	$96,008	$124,810	4180	●						●			
G16012_G16011	3	G16012	G16011	4132	070AB	173	6	Repair	$13,000	$13,000	4180	●						●			
G16014_G16008	3	G16014	G16008	4131	070AB	206	6	Repair	$13,000	$13,000	4180	●						●			
G15038_G15033	3a	G15038	G15033	423B	070AB	184	8	Repair	$26,000	$26,000	960	●					●				
G15039_G15038	3a	G15039	G15038	4234	070AB	227	8	Repair	$26,000	$26,000	960	●					●				
G15075_G15021	3a	G15075	G15021	4326	070AB	288	6	Repair	$39,000	$39,000	960	●					●				
F14061_F14059	3a	F14061	F14059	412A	070AB	229	6	Repair	$13,000	$13,000	1040	●	●								

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PipeID	Priority	US MH	DS MH	Str PACP	Basin	Length	Diam (in)	Action	Constr. Cost	Project Cost	Risk Score	Structural PACP	O&M PACP	Material	Pipe Size	Geology	Capacity	Waterway	Critical Facilities	Area Served	Arterial Roadway
G14045_G15022	3a	G14045	G15022	4133	070AB	384	6	Repair	$13,000	$13,000	1040	●									
G14047_G14037	3a	G14047	G14037	4234	070AB	264	6	Repair	$26,000	$26,000	1040	●									
G16049_G16048	3a	G16049	G16048	4137	070AB	308	6	Repair	$13,000	$13,000	1040	●									
G16050_G16049	3a	G16050	G16049	4532	070AB	247	6	Replace	$115,778	$150,511	1040	●									
F14040_F14041	3a	F14040	F14041	4122	070AB	149	6	Repair	$13,000	$13,000	800	●	●								
F14171_F14026	3a	F14171	F14026	413A	070AB	133	6	Repair	$13,000	$13,000	800	●									
G16045_G16046	3a	G16045	G16046	4435	070AB	291	6	Repair	$52,000	$52,000	800	●									
F14008_F14007	3a	F14008	F14007	4111	070AB	58	6	Repair	$13,000	$13,000	760	●									
F14041_F14126	3a	F14041	F14126	4200	070AB	255	8	Repair	$26,000	$26,000	760	●									
F14060_F14038	3a	F14060	F14038	4100	070AB	455	6	Repair	$13,000	$13,000	760	●									
F14124_F14006	3a	F14124	F14006	4111	070AB	119	6	Repair	$13,000	$13,000	760	●									
F16036_F16035	3a	F16036	F16035	4131	070AB	244	8	Repair	$13,000	$13,000	760	●									
F16048_F16043	3a	F16048	F16043	4100	070AB	397	18	Repair	$13,000	$13,000	760	●								●	
F16063_F16062	3a	F16063	F16062	4321	070AB	240	6	Repair	$39,000	$39,000	760	●									
F16064_F16063	3a	F16064	F16063	4131	070AB	158	6	Repair	$13,000	$13,000	760	●									
G14038_G14037	3a	G14038	G14037	4432	070AB	308	6	Repair	$52,000	$52,000	760	●									
G14041_G14040	3a	G14041	G14040	423A	070AB	280	6	Repair	$26,000	$26,000	760	●									
G14048_G14038	3a	G14048	G14038	4234	070AB	258	6	Repair	$26,000	$26,000	760	●									
G14079_G15036	3a	G14079	G15036	4331	070AB	246	6	Repair	$39,000	$39,000	760	●									
G15019_G15016	3a	G15019	G15016	4439	070AB	292	6	Repair	$52,000	$52,000	760	●									
G15036_G15035	3a	G15036	G15035	4134	070AB	333	6	Repair	$13,000	$13,000	760	●									
G15057_G15070	3a	G15057	G15070	4427	070AB	60	6	Replace	$27,994	$36,392	760	●									
G15062_G15057	3a	G15062	G15057	4234	070AB	290	6	Repair	$26,000	$26,000	760	●									
G16007_G16006	3a	G16007	G16006	4132	070AB	298	6	Repair	$13,000	$13,000	760	●									
G16021_G16020	3a	G16021	G16020	4111	070AB	171	6	Repair	$13,000	$13,000	760	●									
G16022_G16018	3a	G16022	G16018	4100	070AB	244	6	Repair	$13,000	$13,000	760	●		●							
G16027_G16024	3a	G16027	G16024	4232	070AB	317	10	Repair	$26,000	$26,000	760	●									
G16028_G16027	3a	G16028	G16027	4422	070AB	167	10	Replace	$97,449	$126,683	760	●									
G16042_G16037	3a	G16042	G16037	473A	070AB	172	12	Replace	$120,825	$157,072	760	●								●	
G16044_G16045	3a	G16044	G16045	4233	070AB	186	6	Repair	$26,000	$26,000	760	●									
G16047_G16046	3a	G16047	G16046	4234	070AB	135	12	Repair	$26,000	$26,000	760	●								●	
G16052_G16047	3a	G16052	G16047	4934	070AB	343	12	Replace	$240,483	$312,628	760	●								●	
G16053_G16052	3a	G16053	G16052	4B31	070AB	291	12	Replace	$204,184	$265,439	760	●								●	
G16059_G16058	3a	G16059	G16058	4100	070AB	307	15	Repair	$13,000	$13,000	760	●								●	
H15015_H15016	3a	H15015	H15016	4222	070AB	41	8	Replace	$19,157	$24,905	760	●									
H15017_H15010	3a	H15017	H15010	4126	070AB	153	6	Repair	$13,000	$13,000	760	●									
H15025_H15019	3a	H15025	H15019	4139	070AB	160	6	Repair	$13,000	$13,000	760	●									
H15032_H15025	3a	H15032	H15025	4138	070AB	239	6	Repair	$13,000	$13,000	760	●									
H15049_H15042	3a	H15049	H15042	4233	070AB	300	6	Repair	$26,000	$26,000	760	●									
H15086_H15087	3a	H15086	H15087	4123	070AB	143	6	Repair	$13,000	$13,000	760	●									
H15090_H15077	3a	H15090	H15077	462B	070AB	212	6	Replace	$99,122	$128,859	760	●									
H15148_H15087	3a	H15148	H15087	4131	070AB	122	6	Repair	$13,000	$13,000	760	●									
H16011_H16010	3a	H16011	H16010	4137	070AB	326	6	Repair	$13,000	$13,000	760	●									
H16019_H16010	3a	H16019	H16010	4531	070AB	298	10	Repair	$65,000	$65,000	760	●									
H15012_H15007	3a	H15012	H15007	4131	070AB	253	6	Repair	$13,000	$13,000	640	●									
E15076_E15075	3a	E15076	E15075	4100	070CDE	321	6	Repair	$13,000	$13,000	114	●							●		●
E15111_E15101	3	E15111	E15101	4A3B	070CDE	267	6	Replace	$125,056	$162,572	7800	●						●			●
E15098_E15101	3	E15098	E15101	433A	070CDE	254	6	Repair	$39,000	$39,000	5700	●						●			●

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PipeID	Priority	US MH	DS MH	Str PACP	Basin	Length	Diam (in)	Action	Constr. Cost	Project Cost	Risk Score	Structural PACP	O&M PACP	Material	Pipe Size	Geology	Capacity	Waterway	Critical Facilities	Area Served	Arterial Roadway
E16033_E16031	3a	E16033	E16031	4226	070CDE	420	10	Repair	$26,000	$26,000	3000	●					●				●
E14070_E14151	3a	E14070	E14151	4100	070CDE	291	6	Repair	$13,000	$13,000	2280	●		●							●
E15113_E15109	3a	E15113	E15109	4431	070CDE	164	6	Replace	$76,666	$99,666	2280	●									●
E16052_E16048	3a	E16052	E16048	4100	070CDE	226	6	Repair	$13,000	$13,000	2280	●									●
E15148_E15150	3a	E15148	E15150	4100	070CDE	33	8	Replace	$15,409	$20,031	1080	●									●
E14035_E14034	3a	E14035	E14034	4100	070CDE	43	6	Replace	$19,977	$25,970	156	●							●		
E14136_E14035	3a	E14136	E14035	4122	070CDE	119	6	Repair	$13,000	$13,000	156	●							●		
E15057_E15050	3a	E15057	E15050	4137	070CDE	317	6	Repair	$13,000	$13,000	120	●	●						●		
F15042_F15038	3	F15042	F15038	4233	070CDE	198	6	Repair	$26,000	$26,000	4180	●						●			
E16010_E16009	3a	E16010	E16009	4221	070CDE	275	6	Repair	$26,000	$26,000	1240	●	●				●				
E16021_E16018	3a	E16021	E16018	4138	070CDE	189	10	Repair	$13,000	$13,000	1240	●					●				
E16022_E16021	3a	E16022	E16021	4134	070CDE	88	10	Repair	$13,000	$13,000	960	●					●				
E16030_E16077	3a	E16030	E16077	4236	070CDE	144	10	Repair	$26,000	$26,000	960	●					●				
E14019_E14164	3a	E14019	E14164	4137	070CDE	368	6	Repair	$13,000	$13,000	1040	●									
E14043_E14155	3a	E14043	E14155	413F	070CDE	201	6	Repair	$13,000	$13,000	1040	●									
E14052_E14038	3a	E14052	E14038	4132	070CDE	174	6	Repair	$13,000	$13,000	1040	●									
F14018_F14003	3a	F14018	F14003	4132	070CDE	302	6	Repair	$13,000	$13,000	1040	●									
F15023_F15018	3a	F15023	F15018	422A	070CDE	129	6	Repair	$26,000	$26,000	1040	●	●								
E14036_E14042	3a	E14036	E14042	4231	070CDE	204	6	Repair	$26,000	$26,000	760	●									
E15117_E15111	3a	E15117	E15111	4132	070CDE	189	6	Repair	$13,000	$13,000	760	●									
E15120_E15113	3a	E15120	E15113	4331	070CDE	223	8	Repair	$39,000	$39,000	760	●									
F14054_F14053	3a	F14054	F14053	4133	070CDE	299	6	Repair	$13,000	$13,000	760	●									
F14084_F14083	3a	F14084	F14083	4126	070CDE	256	6	Repair	$13,000	$13,000	760	●									
F15014_F15085	3a	F15014	F15085	4100	070CDE	45	6	Replace	$20,920	$27,197	760	●									
F15018_F15014	3a	F15018	F15014	4223	070CDE	215	6	Repair	$26,000	$26,000	760	●									
F15027_F15074	3a	F15027	F15074	4B3A	070CDE	78	6	Replace	$36,381	$47,296	760	●									
F15053_F15052	3a	F15053	F15052	4131	070CDE	208	6	Repair	$13,000	$13,000	760	●									
F15083_E15120	3a	F15083	E15120	4428	070CDE	76	6	Replace	$35,556	$46,222	760	●									
H12033_H12029	Other Grade 4	H12033	H12029	4335	090	137	6	Replace	$64,150	$83,395	2880	●					●				●
H12032_H12076	Other Grade 4	H12032	H12076	4100	090	66	6	Repair	$13,000	$13,000	2280	●									●
H13089_H13096	Other Grade 4	H13089	H13096	4231	090	301	6	Repair	$26,000	$26,000	2288	●									●
H13118_H13098	Other Grade 4	H13118	H13098	4136	090	302	6	Repair	$13,000	$13,000	2288	●									●
H13180_H13178	Other Grade 4	H13180	H13178	4100	090	149	6	Repair	$13,000	$13,000	1760	●									●
H13201_H13055	Other Grade 4	H13201	H13055	4236	090	201	6	Repair	$26,000	$26,000	1760	●									●
G13123_G13107	Other Grade 4	G13123	G13107	4136	090	265	6	Repair	$13,000	$13,000	1672	●									●
H12031_H13130	Other Grade 4	H12031	H13130	4131	090	290	6	Repair	$13,000	$13,000	1672	●									●
H13049_H13039	Other Grade 4	H13049	H13039	4133	090	149	6	Repair	$13,000	$13,000	1672	●									●
H13074_H13073	Other Grade 4	H13074	H13073	4121	090	63	6	Repair	$13,000	$13,000	1672	●									●
H13088_H13075	Other Grade 4	H13088	H13075	4131	090	324	6	Repair	$13,000	$13,000	1672	●									●
H13111_H13112	Other Grade 4	H13111	H13112	4232	090	197	6	Repair	$26,000	$26,000	1672	●									●
H13112_H13113	Other Grade 4	H13112	H13113	4322	090	26	6	Replace	$12,309	$16,002	1672	●									●
H13113_H13086	Other Grade 4	H13113	H13086	4232	090	309	6	Repair	$26,000	$26,000	1672	●									●
H13127_H13114	Other Grade 4	H13127	H13114	4139	090	243	6	Repair	$13,000	$13,000	1672	●									●
H14020_G14139	Other Grade 4	H14020	G14139	4136	090	254	8	Repair	$13,000	$13,000	1672	●									●
H13043_H13031	Other Grade 4	H13043	H13031	4333	090	296	6	Repair	$39,000	$39,000	114	●							●		
H13061_H13062	Other Grade 4	H13061	H13062	463B	090	311	6	Replace	$145,592	$189,270	114	●							●		
H13066_H13064	Other Grade 4	H13066	H13064	4132	090	268	6	Repair	$13,000	$13,000	114	●							●		
H13068_H13066	Other Grade 4	H13068	H13066	4332	090	259	6	Repair	$39,000	$39,000	114	●							●		

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PipeID	Priority	US MH	DS MH	Str PACP	Basin	Length	Diam (in)	Action	Constr. Cost	Project Cost	Risk Score	Structural PACP	O&M PACP	Material	Pipe Size	Geology	Capacity	Waterway	Critical Facilities	Area Served	Arterial Roadway
H13029_H13021	Other Grade 4	H13029	H13021	4100	090	196	6	Repair	$13,000	$13,000	1160	●	●								
G13132_G13117	Other Grade 4	G13132	G13117	4131	090	270	6	Repair	$13,000	$13,000	1040	●	●								
H13012_G13183	Other Grade 4	H13012	G13183	4138	090	315	6	Repair	$13,000	$13,000	1040	●	●								
H13098_H13099	Other Grade 4	H13098	H13099	4535	090	343	6	Repair	$65,000	$65,000	800	●									
G13168_G13153	Other Grade 4	G13168	G13153	4221	090	227	8	Repair	$26,000	$26,000	760	●									
G13184_G13183	Other Grade 4	G13184	G13183	4132	090	322	6	Repair	$13,000	$13,000	760	●									
H13008_H13009	Other Grade 4	H13008	H13009	4121	090	185	6	Repair	$13,000	$13,000	760	●									
H13011_G13181	Other Grade 4	H13011	G13181	4139	090	271	6	Repair	$13,000	$13,000	760	●									
H13013_G13184	Other Grade 4	H13013	G13184	4137	090	325	6	Repair	$13,000	$13,000	760	●									
H13014_H13013	Other Grade 4	H13014	H13013	4136	090	232	6	Repair	$13,000	$13,000	760	●									
H13019_G13194	Other Grade 4	H13019	G13194	453A	090	235	6	Replace	$110,141	$143,183	760	●									
H13020_H13011	Other Grade 4	H13020	H13011	4234	090	267	6	Repair	$26,000	$26,000	760	●									
H13021_H13012	Other Grade 4	H13021	H13012	4338	090	280	6	Repair	$39,000	$39,000	760	●									
H13025_H13020	Other Grade 4	H13025	H13020	4338	090	184	6	Repair	$39,000	$39,000	760	●									
H13028_H13040	Other Grade 4	H13028	H13040	4431	090	263	6	Repair	$52,000	$52,000	760	●									
H13030_H13029	Other Grade 4	H13030	H13029	4A32	090	196	6	Replace	$91,764	$119,293	760	●									
H13031_H13022	Other Grade 4	H13031	H13022	4132	090	278	6	Repair	$13,000	$13,000	760	●									
H13040_H13039	Other Grade 4	H13040	H13039	4231	090	205	6	Repair	$26,000	$26,000	760	●									
H13086_H13074	Other Grade 4	H13086	H13074	4629	090	219	6	Replace	$102,513	$133,267	760	●									
H13097_H13090	Other Grade 4	H13097	H13090	4235	090	243	6	Repair	$26,000	$26,000	760	●									
F12013_F12012	Other Grade 4	F12013	F12012	4235	100	312	6	Repair	$26,000	$26,000	2820	●	●			●					●
F12023_F12021	Other Grade 4	F12023	F12021	4134	100	219	6	Repair	$13,000	$13,000	2820	●				●					●
F13009_E13090	Other Grade 4	F13009	E13090	4131	100	189	6	Repair	$13,000	$13,000	3120	●									●
F12106_F12008	Other Grade 4	F12106	F12008	4232	100	98	6	Replace	$45,645	$59,339	2280	●									●
F13151_F13248	Other Grade 4	F13151	F13248	4100	100	22	6	Replace	$10,315	$13,409	54	●							●		●
E13067_E14096	Other Grade 4	E13067	E14096	4111	100	470	10	Repair	$13,000	$13,000	2288	●									●
F13128_F13127	Other Grade 4	F13128	F13127	412A	100	249	6	Repair	$13,000	$13,000	2288	●	●								●
F13139_F13138	Other Grade 4	F13139	F13138	4131	100	321	6	Repair	$13,000	$13,000	2288	●	●								●
F12094_F13195	Other Grade 4	F12094	F13195	4134	100	300	6	Repair	$13,000	$13,000	1760	●	●								●
E13069_E13067	Other Grade 4	E13069	E13067	4231	100	405	6	Repair	$26,000	$26,000	1672	●									●
F13028_F13012	Other Grade 4	F13028	F13012	4131	100	277	12	Repair	$13,000	$13,000	1672	●								●	●
F13041_F14028	Other Grade 4	F13041	F14028	4112	100	392	6	Repair	$13,000	$13,000	1672	●									●
F13154_F13138	Other Grade 4	F13154	F13138	4121	100	256	8	Repair	$13,000	$13,000	1672	●									●
F13195_F13243	Other Grade 4	F13195	F13243	4134	100	250	6	Repair	$13,000	$13,000	1672	●									●
F13213_F13126	Other Grade 4	F13213	F13126	4100	100	230	6	Repair	$13,000	$13,000	1672	●									●
F13228_F13094	Other Grade 4	F13228	F13094	4100	100	175	6	Repair	$13,000	$13,000	1672	●									●
G13072_G13224	Other Grade 4	G13072	G13224	413A	100	249	6	Repair	$13,000	$13,000	1672	●									●
G13078_G13079	Other Grade 4	G13078	G13079	4136	100	278	6	Repair	$13,000	$13,000	1672	●									●
G13096_G14075	Other Grade 4	G13096	G14075	4232	100	187	6	Repair	$26,000	$26,000	1672	●									●
G14051_G14050	Other Grade 4	G14051	G14050	4339	100	284	6	Repair	$39,000	$39,000	1672	●									●
F13089_F13088	Other Grade 4	F13089	F13088	4121	100	244	6	Repair	$13,000	$13,000	156	●							●		
F13132_F13133	Other Grade 4	F13132	F13133	4131	100	262	6	Repair	$13,000	$13,000	156	●	●						●		
F13232_F13091	Other Grade 4	F13232	F13091	4131	100	278	6	Repair	$13,000	$13,000	156	●	●						●		
F13236_F13078	Other Grade 4	F13236	F13078	4100	100	199	6	Repair	$13,000	$13,000	114	●		●					●		
F12073_F12074	Other Grade 4	F12073	F12074	4126	100	253	6	Repair	$13,000	$13,000	1180	●	●			●					
F13017_E13094	Other Grade 4	F13017	E13094	4111	100	300	6	Repair	$13,000	$13,000	1040	●									
F13032_F13227	Other Grade 4	F13032	F13227	4222	100	116	6	Repair	$26,000	$26,000	1040	●	●								
F13051_F13033	Other Grade 4	F13051	F13033	4133	100	107	6	Repair	$13,000	$13,000	1040	●	●								

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PipeID	Priority	US MH	DS MH	Str PACP	Basin	Length	Diam (in)	Action	Constr. Cost	Project Cost	Risk Score	Structural PACP	O&M PACP	Material	Pipe Size	Geology	Capacity	Waterway	Critical Facilities	Area Served	Arterial Roadway
F13067_F13050	Other Grade 4	F13067	F13050	4322	100	124	6	Replace	$58,233	$75,703	1040	● tan									
F13073_F13044	Other Grade 4	F13073	F13044	4131	100	300	6	Repair	$13,000	$13,000	1040	● tan	● green								
F13120_F13113	Other Grade 4	F13120	F13113	4100	100	225	6	Repair	$13,000	$13,000	1040	● tan									
G13029_G13030	Other Grade 4	G13029	G13030	4132	100	292	6	Repair	$13,000	$13,000	1040	● tan	● green								
F13021_F13022	Other Grade 4	F13021	F13022	4339	100	244	6	Repair	$39,000	$39,000	800	● tan	● tan								
G13019_G13030	Other Grade 4	G13019	G13030	4232	100	156	6	Repair	$26,000	$26,000	800	● tan									
F12032_F12031	Other Grade 4	F12032	F12031	4100	100	115	6	Repair	$13,000	$13,000	760	● tan									
F12050_F12046	Other Grade 4	F12050	F12046	4131	100	290	6	Repair	$13,000	$13,000	760	● tan									
F12066_F12065	Other Grade 4	F12066	F12065	4124	100	408	6	Repair	$13,000	$13,000	760	● tan									
F13112_F13111	Other Grade 4	F13112	F13111	4222	100	109	6	Replace	$51,077	$66,400	760	● tan		● green							
F13140_F13139	Other Grade 4	F13140	F13139	4138	100	221	6	Repair	$13,000	$13,000	760	● tan									
F13141_F13142	Other Grade 4	F13141	F13142	4135	100	247	6	Repair	$13,000	$13,000	760	● tan									
F13172_F13173	Other Grade 4	F13172	F13173	4632	100	263	6	Replace	$123,054	$159,970	760	● tan									
F13187_F13188	Other Grade 4	F13187	F13188	4111	100	300	6	Repair	$13,000	$13,000	760	● tan									
G13047_G13048	Other Grade 4	G13047	G13048	423A	100	255	6	Repair	$26,000	$26,000	760	● tan									
G13048_G13049	Other Grade 4	G13048	G13049	413B	100	324	6	Repair	$13,000	$13,000	760	● tan									
E13102_E13025	Other Grade 4	E13102	E13025	412C	100	173	6	Repair	$13,000	$13,000	640	● tan	● green								
C16045_C16005	Other Grade 4	C16045	C16005	4236	110	303	6	Repair	$26,000	$26,000	3660	● tan	● tan			● green	● red				● red
C16035_C16032	Other Grade 4	C16035	C16032	4137	110	399	12	Repair	$13,000	$13,000	3420	● tan				● green	● red			● red	● red
D16015_D16016	Other Grade 4	D16015	D16016	493A	110	262	6	Replace	$122,640	$159,432	3720	● tan	● green				● red				● red
D16016_D16013	Other Grade 4	D16016	D16013	4133	110	313	24	Repair	$13,000	$13,000	2322	● tan					● green			● red	● red
C15049_C15038	Other Grade 4	C15049	C15038	4135	110	166	6	Repair	$13,000	$13,000	3540	● tan		● green		● green					● red
C15023_C15022	Other Grade 4	C15023	C15022	4111	110	95	12	Repair	$13,000	$13,000	2700	● tan				● green				● red	● red
C15047_C15038	Other Grade 4	C15047	C15038	4100	110	361	8	Repair	$13,000	$13,000	2700	● tan				● green					● red
C16020_C16021	Other Grade 4	C16020	C16021	4233	110	263	6	Repair	$26,000	$26,000	2700	● tan				● green					● red
C16041_C16040	Other Grade 4	C16041	C16040	4121	110	75	12	Repair	$13,000	$13,000	2700	● tan				● green				● red	● red
D14096_D14095	Other Grade 4	D14096	D14095	4132	110	209	6	Repair	$13,000	$13,000	3120	● tan									● red
D14095_D14113	Other Grade 4	D14095	D14113	4132	110	153	5	Repair	$13,000	$13,000	2480	● tan			● red						● red
G13055_G13040	Other Grade 4	G13055	G13040	4131	110	271	6	Repair	$13,000	$13,000	2288	● tan									● green
G13056_G13055	Other Grade 4	G13056	G13055	4114	110	58	6	Repair	$13,000	$13,000	2288	● tan	● green								● green
D16027_D16026	Other Grade 4	D16027	D16026	4131	110	127	8	Repair	$13,000	$13,000	1240	● tan					● red				
D15014_D15013	Other Grade 4	D15014	D15013	4131	110	232	10	Repair	$13,000	$13,000	1000	● tan	● tan				● red				
C16013_C16014	Other Grade 4	C16013	C16014	4A37	110	318	6	Replace	$148,909	$193,581	1180	● tan				● green					
E14028_E14029	Other Grade 4	E14028	E14029	4333	110	181	6	Repair	$39,000	$39,000	1160	● tan	● red								
D14082_D14080	Other Grade 4	D14082	D14080	4132	110	191	6	Repair	$13,000	$13,000	1040	● tan									
D14098_D14097	Other Grade 4	D14098	D14097	4100	110	166	6	Repair	$13,000	$13,000	1040	● tan									
D15012_D16005	Other Grade 4	D15012	D16005	4131	110	266	12	Repair	$13,000	$13,000	1040	● tan	● green							● red	
D15075_D15067	Other Grade 4	D15075	D15067	4124	110	319	6	Repair	$13,000	$13,000	1040	● tan	● green								
D16012_D16009	Other Grade 4	D16012	D16009	4A3A	110	393	6	Replace	$183,794	$238,932	1040	● tan	● green								
C15100_C15099	Other Grade 4	C15100	C15099	4331	110	117	6	Replace	$54,662	$71,060	800	● tan									
D14062_D14057	Other Grade 4	D14062	D14057	4135	110	214	6	Repair	$13,000	$13,000	800	● tan									
D14063_D14062	Other Grade 4	D14063	D14062	4131	110	181	6	Repair	$13,000	$13,000	800	● tan									
D14075_D14074	Other Grade 4	D14075	D14074	4131	110	305	6	Repair	$13,000	$13,000	800	● tan									
D15084_D15083	Other Grade 4	D15084	D15083	4132	110	204	6	Repair	$13,000	$13,000	800	● tan									
D15097_D15094	Other Grade 4	D15097	D15094	4132	110	217	6	Repair	$13,000	$13,000	800	● tan	● tan								
D14071_D14070	Other Grade 4	D14071	D14070	4132	110	379	6	Repair	$13,000	$13,000	760	● tan									
D15041_D15028	Other Grade 4	D15041	D15028	4200	110	306	6	Repair	$26,000	$26,000	760	● tan									
D15086_D15085	Other Grade 4	D15086	D15085	4222	110	286	6	Repair	$26,000	$26,000	760	● tan									

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D15087_D15086	Other Grade 4	D15087	D15086	4121	110	296	6	Repair	$13,000	$13,000	760	●									
D16035_D16015	Other Grade 4	D16035	D16015	413A	110	237	6	Repair	$13,000	$13,000	760	●									
E15023_E15024	Other Grade 4	E15023	E15024	4131	110	315	6	Repair	$13,000	$13,000	760	●									
E15024_E15017	Other Grade 4	E15024	E15017	4232	110	320	6	Repair	$26,000	$26,000	760	●									
D16020_D16035	Other Grade 4	D16020	D16035	423A	110	255	6	Repair	$26,000	$26,000	640	●	●								
E16015_E16016	Other Grade 4	E16015	E16016	4122	110	169	6	Repair	$13,000	$13,000	360	●									
C14109_C14108	Other Grade 4	C14109	C14108	4132	120A	177	6	Repair	$13,000	$13,000	1040	●									
D14108_D14042	Other Grade 4	D14108	D14042	4131	120A	276	6	Repair	$13,000	$13,000	1040	●									
D14007_C14109	Other Grade 4	D14007	C14109	4336	120A	216	6	Repair	$39,000	$39,000	760	●									
D14014_D14015	Other Grade 4	D14014	D14015	4231	120A	348	6	Repair	$26,000	$26,000	760	●									
D14018_D14017	Other Grade 4	D14018	D14017	4129	120A	293	6	Repair	$13,000	$13,000	760	●		●							
C12083_C12073	Other Grade 4	C12083	C12073	4121	120B	250	24	Repair	$13,000	$13,000	3540	●				●				●	●
C13103_C13095	Other Grade 4	C13103	C13095	4337	120B	316	8	Repair	$39,000	$39,000	3540	●	●			●					●
C13068_C14029	Other Grade 4	C13068	C14029	4Q00	120B	459	24	Replace	$515,679	$670,382	2700	●		●		●				●	●
C13083_C13068	Other Grade 4	C13083	C13068	4R00	120B	516	24	Replace	$580,065	$754,084	2700	●		●		●				●	●
C13085_C13083	Other Grade 4	C13085	C13083	4R00	120B	484	24	Replace	$543,838	$706,989	2700	●		●		●				●	●
C13088_C13085	Other Grade 4	C13088	C13085	4R00	120B	501	24	Replace	$562,249	$730,923	2700	●		●		●				●	●
C13107_C13106	Other Grade 4	C13107	C13106	4100	120B	81	6	Repair	$13,000	$13,000	2700	●				●					●
C13109_C13108	Other Grade 4	C13109	C13108	4100	120B	56	6	Repair	$13,000	$13,000	2700	●				●					●
D13061_D13054	Other Grade 4	D13061	D13054	413B	120B	445	12	Repair	$13,000	$13,000	156	●	●						●	●	
C14051_C13103	Other Grade 4	C14051	C13103	4131	120B	178	8	Repair	$13,000	$13,000	1180	●	●			●					
C13098_C13097	Other Grade 4	C13098	C13097	4231	120B	169	8	Repair	$26,000	$26,000	900	●				●					
C13186_C13105	Other Grade 4	C13186	C13105	453A	120B	136	6	Replace	$63,460	$82,498	900	●				●					
C13205_C13135	Other Grade 4	C13205	C13135	4131	120B	133	6	Repair	$13,000	$13,000	900	●				●					
E13017_E13018	Other Grade 4	E13017	E13018	4131	120B	258	6	Repair	$13,000	$13,000	1040	●									
E13033_E13032	Other Grade 4	E13033	E13032	4127	120B	153	6	Repair	$13,000	$13,000	1040	●	●								
C13219_C13150	Other Grade 4	C13219	C13150	4121	120B	192	6	Repair	$13,000	$13,000	760	●									
E13020_E13018	Other Grade 4	E13020	E13018	4132	120B	282	8	Repair	$13,000	$13,000	760	●									
E13022_E13020	Other Grade 4	E13022	E13020	4135	120B	357	8	Repair	$13,000	$13,000	760	●									
D11130_D11004	Other Grade 4	D11130	D11004	4K35	130	289	6	Replace	$135,349	$175,954	177	●				●			●		●
D12016_D11130	Other Grade 4	D12016	D11130	4D37	130	145	6	Replace	$67,688	$87,994	141	●	●			●			●		●
E12012_D12077	Other Grade 4	E12012	D12077	4100	130	170	6	Repair	$13,000	$13,000	114	●							●		●
E12052_E12044	Other Grade 4	E12052	E12044	4133	130	301	6	Repair	$13,000	$13,000	3540	●				●					●
C11052_C12181	Other Grade 4	C11052	C12181	4331	130	371	8	Repair	$39,000	$39,000	2700	●				●					●
E12055_E12050	Other Grade 4	E12055	E12050	4122	130	168	6	Repair	$13,000	$13,000	2700	●				●					●
C12139_C12136	Other Grade 4	C12139	C12136	4132	130	269	6	Repair	$13,000	$13,000	177	●	●			●			●		
D11004_C11116	Other Grade 4	D11004	C11116	4M27	130	370	6	Replace	$173,367	$225,377	177	●				●			●		
D12064_D12062	Other Grade 4	D12064	D12062	4232	130	168	6	Repair	$26,000	$26,000	156	●							●		
C11061_C11060	Other Grade 4	C11061	C11060	4227	130	219	6	Repair	$26,000	$26,000	1180	●				●					
D11069_D11066	Other Grade 4	D11069	D11066	4126	130	266	6	Repair	$13,000	$13,000	1180	●				●					
E12083_E12073	Other Grade 4	E12083	E12073	4126	130	297	6	Repair	$13,000	$13,000	1180	●				●					
C11109_C11110	Other Grade 4	C11109	C11110	4121	130	89	6	Repair	$13,000	$13,000	900	●				●					
D11088_D11071	Other Grade 4	D11088	D11071	4100	130	312	6	Repair	$13,000	$13,000	900	●				●					
D11110_D11097	Other Grade 4	D11110	D11097	4131	130	299	6	Repair	$13,000	$13,000	900	●				●					
D11094_D11082	Other Grade 4	D11094	D11082	4122	130	267	6	Repair	$13,000	$13,000	1040	●									
D12046_D12117	Other Grade 4	D12046	D12117	4100	130	202	6	Repair	$13,000	$13,000	760	●									
D12051_D12046	Other Grade 4	D12051	D12046	4528	130	259	6	Replace	$121,360	$157,768	760	●									
E12018_E12019	Other Grade 4	E12018	E12019	4238	130	176	6	Repair	$26,000	$26,000	760	●									

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E12087_E12075	Other Grade 4	E12087	E12075	412A	130	285	6	Repair	$13,000	$13,000	760	●									
B12123_B12029	Other Grade 4	B12123	B12029	4121	140	713	10	Repair	$13,000	$13,000	105	●				●	●		●		●
C14023_C14122	Other Grade 4	C14023	C14122	4111	140	34	10	Replace	$20,144	$26,187	135	●				●			●		●
B15015_B15009	Other Grade 4	B15015	B15009	4300	140	318	6	Repair	$39,000	$39,000	3540	●	●			●					●
C14040_C14041	Other Grade 4	C14040	C14041	4100	140	205	6	Repair	$13,000	$13,000	3540	●	●			●					●
C12149_C12011	Other Grade 4	C12149	C12011	4100	140	127	6	Repair	$13,000	$13,000	2700	●				●					●
C14029_C14028	Other Grade 4	C14029	C14028	4700	140	63	24	Replace	$70,543	$91,705	1500	●				●				●	●
B15032_B15013	Other Grade 4	B15032	B15013	4100	140	309	10	Repair	$13,000	$13,000	1100	●				●	●				
C14006_C14005	Other Grade 4	C14006	C14005	4121	140	280	8	Repair	$13,000	$13,000	1180	●				●					
B14010_B14009	Other Grade 4	B14010	B14009	4131	140	311	8	Repair	$13,000	$13,000	940	●	●			●					
C13028_C13015	Other Grade 4	C13028	C13015	4231	140	170	6	Repair	$26,000	$26,000	900	●				●					
C13040_C13041	Other Grade 4	C13040	C13041	493B	140	126	6	Replace	$58,903	$76,574	900	●				●					
C13049_C13048	Other Grade 4	C13049	C13048	4100	140	113	8	Repair	$13,000	$13,000	500	●				●					
C12026_C12025	Other Grade 4	C12026	C12025	4100	150	88	6	Repair	$13,000	$13,000	3540	●				●					●
C11046_C11047	Other Grade 4	C11046	C11047	4126	150	372	6	Repair	$13,000	$13,000	2820	●				●					●
C11065_C11064	Other Grade 4	C11065	C11064	4131	150	78	6	Repair	$13,000	$13,000	2700	●				●					●
C12025_C12149	Other Grade 4	C12025	C12149	4235	150	167	6	Repair	$26,000	$26,000	2700	●				●					●
C12055_C12054	Other Grade 4	C12055	C12054	4132	150	53	6	Replace	$24,570	$31,941	2700	●				●					●
B11057_B11056	Other Grade 4	B11057	B11056	4132	150	144	6	Repair	$13,000	$13,000	177	●				●			●		
B11060_B11057	Other Grade 4	B11060	B11057	4131	150	288	6	Repair	$13,000	$13,000	177	●				●			●		
B11087_B11067	Other Grade 4	B11087	B11067	4131	150	293	6	Repair	$13,000	$13,000	177	●	●			●			●		
B11051_B11044	Other Grade 4	B11051	B11044	4112	150	309	6	Repair	$13,000	$13,000	135	●				●			●		
B12064_B12053	Other Grade 4	B12064	B12053	4132	150	256	6	Repair	$13,000	$13,000	1180	●	●			●					
C11029_C11030	Other Grade 4	C11029	C11030	4100	150	142	6	Repair	$13,000	$13,000	1180	●				●					
C11042_C11004	Other Grade 4	C11042	C11004	4122	150	171	6	Repair	$13,000	$13,000	1180	●				●					
C12016_B12063	Other Grade 4	C12016	B12063	4131	150	258	6	Repair	$13,000	$13,000	1180	●	●			●					
C12057_C12043	Other Grade 4	C12057	C12043	4233	150	244	6	Repair	$26,000	$26,000	1180	●	●			●					
A10020_A10024	Other Grade 4	A10020	A10024	4126	150	300	6	Repair	$13,000	$13,000	940	●				●					
C11030_C11022	Other Grade 4	C11030	C11022	4223	150	266	6	Repair	$26,000	$26,000	940	●	●			●					
C12028_C12147	Other Grade 4	C12028	C12147	4131	150	140	6	Repair	$13,000	$13,000	940	●				●					
C12058_C12044	Other Grade 4	C12058	C12044	4424	150	293	6	Repair	$52,000	$52,000	940	●	●			●					
A10011_A10012	Other Grade 4	A10011	A10012	4100	150	200	6	Repair	$13,000	$13,000	900	●				●					
A10018_A10014	Other Grade 4	A10018	A10014	4100	150	305	6	Repair	$13,000	$13,000	900	●				●					
B10023_B10046	Other Grade 4	B10023	B10046	4136	150	33	10	Replace	$19,130	$24,869	900	●				●					
B11004_B11008	Other Grade 4	B11004	B11008	4126	150	260	6	Repair	$13,000	$13,000	900	●				●					
B11012_B11013	Other Grade 4	B11012	B11013	4100	150	49	6	Replace	$22,768	$29,599	900	●				●					
B11084_B11071	Other Grade 4	B11084	B11071	4131	150	303	6	Repair	$13,000	$13,000	900	●				●					
B12063_B12087	Other Grade 4	B12063	B12087	4300	150	87	6	Replace	$40,670	$52,870	900	●				●					
B12087_B12086	Other Grade 4	B12087	B12086	4100	150	38	6	Replace	$17,843	$23,197	900	●				●					
C11005_C11006	Other Grade 4	C11005	C11006	4132	150	147	6	Repair	$13,000	$13,000	900	●				●					
C12014_C12013	Other Grade 4	C12014	C12013	4131	150	65	6	Repair	$13,000	$13,000	900	●				●					

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Appendix H

Pump Station Assessment TM (Woodard & Curran)

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TECHNICAL MEMORANDUM

TO: Vivian Housen, Principal, V.W. Housen & Associates, Inc.

PREPARED BY: Tony Valdivia, Woodard & Curran, CA PE No. 66847

REVIEWED BY: Dave Richardson, Woodard & Curran

DATE: December 8, 2023

RE: WBSD Wastewater Pump Station Condition Assessment

12/8/23

1. BACKGROUND

The West Bay Sanitary District (District) adopted a Wastewater Collection System Master Plan Update in 2011 and an Update in 2013 based on updated flow monitoring results. The District is interested in replacing those Master Plans with this update which evaluates the current system that has been improved since 2011, prioritizes the capital improvement program, minimizes inflow and infiltration, ensures compliance with regulatory requirements, includes recycled water planning, and increases efficiencies in operations and maintenance. The updated sanitary sewer master plan ("Master Plan") is intended recommend short term and long-term capital improvement projects (CIPs) that will improve system reliability, resiliency, functionality, and flexibility. The Master Plan will guide the management and implementation of the sanitary sewer facility improvement projects within the District's collection system. The Master Plan will incorporate evaluation from the existing Master Plan, recently completed sewer rehabilitation projects, flow studies provided by the District, and any new or additional data and analysis necessary to complete the Master Plan update.

In conjunction with the hydraulic analysis and recycled water planning, a Pump Station Assessment will be conducted as a part of the Master Plan and is documented herein. The purpose of the Pump Station Assessment is to review the current condition of the existing pump station and force mains, to visit the District's pump stations to interview District operations staff and to determine the potential for large scale rehabilitations that may fall outside the scope of the District's proactive pump replacement program. Where such projects are identified, planning level capital cost estimates and approximate timelines for pump station rehabilitation have been developed.

This Technical Memorandum summarizes the execution and findings of the Pump Station Site Visits. Details regarding the procedures in evaluating pump stations and recommendations for improvement projects are provided in the following sections.

2. PROCEDURES AND RESULTS

On August 3, 2023, Woodard & Curran (W&C) visited and assessed the condition of twelve pump stations within the District's collection system. W&C staff were accompanied by the District's Pump Facility Supervisor, who facilitated the site visits and provided further detail regarding the function and condition of each pump station.

2.1 General Pump Station Characteristics

With the exception of Stowe Lane Pump Station, all of the District's wastewater pump stations feature Flygt (Xylem) submersible pumps in circular concrete wet wells, with an adjacent concrete valve vault housing discharge isolation and check valves. None of the concrete wet wells are currently lined, with the exception of the FERRF Pump Station. Each of these submersible stations has an above-grade electrical cabinet and communication cabinet/equipment and an installed diesel generator with either onboard or separate fuel storage. Sites are secured by fences or concrete walls. At each of these stations, W&C was allowed to observe the wet wells and valve vault, observe the cabinets with open doors, and visually inspect generators and other above-grade facilities.

Stowe Lane Pump Station is the only dry pit pump station owned by the District. This aging facility does not match the design standard of the other submersible stations, and features pumps that are housed in a below grade dry pit. Both the wet well and dry pit are OSHA-defined confined spaces. And, as such, W&C was not able to directly observe the pumping equipment or wet well at this facility. However, this facility is currently slated for replacement with a submersible pump station, with design underway; consequently, assessment of the station is not required.

The other atypical station is the District's Flow Equalization and Resource Recovery Facility (FERRF) Pump Station. The FERFF is a located at the District's abandoned wastewater treatment facility just north of the Menlo Park Pump Station, which is owned and operated by Silicon Valley Clean Water (SVCW), the Joint Powers Authority (JPA) that handles wastewater conveyance and treatment for the region. WBSD is a member of the JPA. The FERFF, in general, serves as repository for flows that exceed the capacity of the Menlo Pump Station and the downstream system, storing these peak flows in lined basins until they can be pumped back into the collection system by the FERRF pump station. The FERFF is therefore not in continuous use and serves as a standby facility. Also, the FERFF has not been recently operated by WBSD, but rather has been operated by SVCW in its capacity to relieve excess conveyance and wastewater treatment plant flows. Recent improvements at the SVCW treatment plant are expected to minimize future use of the FERFF Pump Station, however the District would like to maintain this facility in order to manage emergencies, unanticipated flows and planned maintenance within the system.

2.2 Site Visit Observations

Table 1 provides a summary of the observed pump stations, the major aspects or issues, and the potential for CIPs that may not be included in the routine operations and maintenance budget. As noted above, W&C was able to directly observed many aspects of the District's pump stations,

Table 1 - Pump Station Assessment Summary

Pump Station	Observed Conditions to be Addressed	CIP Project Required?	Existing CIP Projects?
Willow PS	• Safety Grates absent • Hatches do not conform to current District Standards • Force mains in need of replacement • Flow meter required • Wet Well Coating required • Odor control required	Yes	Yes
University PS	• Safety Grates absent under wet well hatch • Hatches do not conform to current District standards	No	No
Illinois PS	• Safety Grates absent under wet well hatch	No	No
Menlo Industrial PS	• No Deficiencies Observed • PS may be replaced for Willow Village Development	No	No
Hamilton – Henderson PS	• Exposed aggregate above water line indicative of hydrogen sulfide corrosion	Yes	No
Flow Equalization and Resource Recovery Facility	• Electrical equipment at end of life • Pumps at end of life • Communications equipment at end of life • Valves and piping show signs of corrosion and may not be routinely exercised	Yes	No
Vintage Oaks 1 PS	No Deficiencies Observed	No	No
Vintage Oaks 2 PS	No Deficiencies Observed	No	No
Stowe Lane PS	• Dry pit pump configuration • Pumps are in confined space • Aging Electrical Equipment	Yes	Yes
Los Trancos PS	No Deficiencies Observed	No	No
Sausal Vista PS	No Deficiencies Observed	No	No
Village Square PS	No Deficiencies Observed	No	No

As indicated in the above table, the majority of pump stations did not have deficiencies that were observed or informed to warrant a CIP. With the exception of Willow Pump Station, Stowe Lane Pump Station and the FERFF Pump Station, the District's stations all share common design features and have been well maintained by District staff. One of the more common deficiencies noted – the lack of fall protection safety grates beneath wet well hatches – is relatively minor in nature and, along with wet well grating and covers that do not comply with current District standards, do not require a capital improvement program to correct at this time.

Four pump stations have needs that can be addressed through capital improvement projects, two of which are already included in the District's existing CIP. These stations are:

- Willow Pump Station
- Stowe Lane Pump Station
- Hamilton-Henderson Pump Station
- FERRF Pump Station

2.2.1 Willow Pump Station

Willow Pump Station is located at the intersection of Willow Rd. and O'Brien St. This pump station has been evaluated as a part of previous assessments and a current design approach and budget have been developed for upgrades. The planned upgrades are as follows:

- Replacements:
    - Generator
    - Piping from wet well through valve box
    - Valves
- Additions:
    - Wet well coating

The existing CIP budget for improvements at Willow Pump Station is $1,700,000. The project is currently under design and a new Engineer's Estimate of Probable Cost is pending.

Figure 1 - Willow Pump Station Wet Well Cover and Equipment

2.2.2 Stowe Lane

Stowe Lane Pump Station is the District's only dry pit station. A CIP project has already been developed for design and construction of a replacement station to create a submersible pump station to match the District's other stations. The following improvements are planned:

- Demolish existing dry pit pump station
- Construct submersible pump station
- Add new generator

The existing CIP budget for improvements at Stowe Lane Pump Station is $3,000,000. The project is currently under design and a new Engineer's Estimate of Probable Cost is pending.

Figure 2 - Stowe Lane Pump Station

2.2.3 Hamilton-Henderson Pump Station

Generally, this pump station is in good condition. However, during visual inspection of the wet well walls, it was noted that the concrete aggregate is exposed on the surface of the wet well wall. By contract, the concrete below the water line does not exhibit this condition. This typically indicates hydrogen sulfide corrosion of the concrete, which softens the cement and allows for erosion of the wall aggregate matrix over time. Often, this situation is limited to the surface of the concrete, and can be corrected by installing an epoxy liner over the top of the cleaned concrete. Prior to executing this work, the concrete should be checked for soundness using non-destructive testing ("sounding" of the wall with a special hammer) to ensure that the damage does not extend deeper into the wall, and that reinforcement bars are not impacted.

Figure 3 - Wet Well Corrosion Above Water Surface at Hamilton-Henderson Wet Well Walls

While the lining of the Hamilton-Henderson Pump Station wet well is straight forward, it does require full access to the wet well for sufficient time to clear and prepare the walls, then coat the walls and allow time for curing. This requires short-term bypassing of the wet well, typically using portable pumps to move water from an upstream manhole to the force main. For this reason, the project is considered worthy of a new CIP project to rehabilitate the wet well.

2.2.4 Flow Equalization and Resource Recovery Facility Pump Station

The Flow Equalization and Resource Recovery Facility (FERRF) is a pump station located at the end of Marsh Road, in the very northeast portion of the City of Menlo Park. The FERRF currently pumps water from the adjacent emergency storage pond back into the WBSD sewer system. This pump station is an important fail safe to the collections system. The FERRF is operated by the Silicon Valley Clean Water Agency, and therefore the condition and operations of this pump station is not thoroughly known.

Figure 4 - FERRF Pump Station

It was observed that the pump station consists of a wet well and valve box with three 60 horsepower (hp) pumps, 14-inch diameter pump discharges, and 30" and 24" isolation valves that determine the direction of flow to and from the station. Additionally, there is an adjacent metal building housing the electrical and control systems.

According to the visual observations and District input, the FERRF is aging and reaching its end of useful life. While performing the site visits, we observed that the electrical equipment is showing signs of aging and deterioration. The three pumps, valves, and piping appeared to be corroded and the District informed W&C that the pumps are in need of replacement. Additionally, exposed aggregate was observed on the wet well walls, indicating potential hydrogen sulfide corrosion of the concrete.

Figure 5 - FERFF Pump Discharge Valves

The District wishes to maintain the operational and emergency flexibility provided by the FERFF. As such, rehabilitation of this aging facility has been established as a CIP project. This project will include the following:

- Replace existing pump drives and electrical equipment
- Replace existing submersible pumps (60 Hp) and wet well piping (14")
- Replace discharge piping valves (gate valve and check valves)
- Recoat existing piping
- Line existing concrete wet well
- Clean and recoat metal building

Due to its intermittent, wet weather use, the FERFF can be improved without operational impacts to the WBSD collection system or to SVCW conveyance operation. All improvements listed above can be completed within a single dry season, assuming equipment is procured ahead of time. Therefore, bypassing of flows should not be required to complete this project.

2.2.5 Force Main Replacements

The District has identified three force main segments that, based on pipeline age and repair history, are in need of replacement. These force mains are downstream of the following pump stations (approximate force main installation date as noted, based on District records)

- Willow Pump Station (circa 1980s)
- University Pump Station (1985)
- Illinois Pump Station (1985)

The force mains above total 3,600 linear feet and can be replaced as part of a combined capital improvement project. Open-cut replacement of these force mains is assumed.

3. COST ESTIMATES

Cost estimates for the two new pump station CIP projects (Hamilton-Henderson and FERRF) are presented here. As noted above, the Willow Pump Station and Stowe Lane Pump Station are currently included in the District's CIP, with updated costs to be developed by the Engineer of Record for the improvements in early November 2023. Updated costs from the design engineer should supercede existing CIP costs.

Costs are referenced to an ENR Construction Cost Index (CCI) of 15489.7 (San Francisco, September 2023)

Unless otherwise noted, equipment costs include 25% markups for installation and testing.

Hamilton-Henderson Pump Station

Project: Wet well lining

Description:
The wet well will be isolated from the upstream collection system throughout the cleaning and lining operation, which is assumed to require bypass pumping from the upstream manhole to the downstream forcemain. Bypass pumping will consist of trailer mounted trash pumps. Once the pump station has been bypassed, the wet well will be emptied and cleaned (typically sandblasted to remove loose cement and biological growth). The pump station will then be lined with an epoxy lining to reduce future corrosion, extending the useful life of the wet well and simplifying wet well maintenance. This project adds no new operations or maintenance costs.

Costs are summarized in Table 2.

Table 2 - Hamilton-Henderson Wet Well Lining Cost Estimate

Planning Level Cost Estimate							
	size	Qty	Unit Cost		Unit		Subtotal
Wet Well Lining and Cleaning	-	1	$	25,000	LS	$	25,000
Bypass Pumping	PDWF	1	$	20,000	LS	$	20,000
Baseline Construction Cost						**$**	**45,000**
Construction Contingency				30%		$	14,000
Total Construction Cost						**$**	**59,000**
Allowance for Change Orders				10%		$	5,900
Construction Inspection				5%		$	2,950
Engineering Design				7%		$	4,130
Permits				2%		$	1,180
Construction Administration				5%		$	2,950
Legal, Fiscal, and Administrative				2%		$	1,180
Implementation (Rounded Up)						**$**	**18,000**
Total Project Cost (Rounded Up)						**$**	**77,000**
Annualized Total Project Cost (3%, 30 years)				0.05437		$	5,000
Total Annualized Cost ($/Year)						**$**	**5,000**

FERRF Pump Station

Project: Pump Station Rehabilitation

Description:
All major mechanical, electrical and control components will be replaced, including pumps, drives, panel boards and valving. These components have reached the end of their useful lives. Equipment is assumed to be replaced in-kind to match existing equipment/capacity. The existing pump station building exterior wil be cleaned and recoated, and the interior of the wet well will be cleaned and relined to reduce future corrosion. The project does not include replacement of the large wastewater routing valves that control the direction of flow, as WBSD has indicated that they do not control these valves. SVCW would need to address these valves, as they are responsible for their operation. New variable frequency drives will be provided. It is assumed that the existing power service is sufficient for the rehabilitated facility.

Because this facility is used only intermittently and typically only during wet weather or planned maintennce, no pump station bypass or temporary pumping is included.

Costs for the project are summarized in Table 3.

Table 3 - FERRF Rehabilitation Capital and Operating Cost Estimates

Planning Level Cost Estimate: FERRF Pump Station					
Item	**Size**	**Qty**	**Unit Cost**	**Unit**	**Subtotal**
Pump Station/Wet Well					
New Submersible Pumps	60 Hp	3	$ 120,000	EA	$ 360,000
Wet well cleaning and lining	-	1	$ 40,000	EA	$ 40,000
Piping Recoating Allowance	-	1	$ 10,000	AL	$ 10,000
Building HVAC Replacement	-	1	$ 20,000	AL	$ 20,000
Building Coating	--	1	$ 20,000	LS	$ 20,000
Subtotal					**$ 450,000**
Piping, Valves, Accessories					
Plug Valve (replaces gate valve)	14	14,219	$ 3	EA	$ 43,000
Check Valve	14	17,719	$ 3	EA	$ 53,000
Miscellaneous Piping and Accessories	-	10,000	$ 1	AL	$ 10,000
Subtotal					**$ 106,000**
Electrical/SCADA Cost					
Electrical , incl. VFDs (60 Hp), Panelboards, and Switchgear	-	1	$ 175,000	LS	$ 175,000
Instrumentation and Controls	-	1	$ 20,000	LS	$ 20,000
Programming and Integration	-	1	$ 5,000	LS	$ 5,000
Subtotal					**$ 200,000**
Demolition and Removal				LS	$ -
Subtotal					**$ 756,000**
General Allowance					
Mobilization (Rounded Up)			5%		$ 38,000
Subtotal					**$ 38,000**
Baseline Construction Cost					**$ 794,000**
Construction Contingency (Rounded Up)			30%		$ 239,000
Total Construction Cost					**$ 1,033,000**
Allowance for Change Orders			10%		$ 103,300
Construction Inspection			5%		$ 51,650
Engineering Design			10%		$ 103,300
Permits/Easements			5%		$ 51,650
Construction Administration			5%		$ 51,650
Legal, Fiscal, and Administrative			2%		$ 21,000
Implementation					**$ 382,550**
Total Project Cost (Rounded Up)					**$ 1,420,000**
Annualized Total Project Cost (3%, 30 years)			0.05102		$ 72,000
Annual O&M Cost ($/year)					$ 81,000
Total Annualized Cost ($/year) (Rounded Up)					**$ 160,000**
Annual Operations & Maintenance Cost					
			Basis	**Unit Cost**	
Pipelines, Valves, Accessories			$106,000	0.5%	$ 1,000
Pumps			360,000	2.5%	$ 9,000
Pumping Energy (5 days operation/year)		kWh	120,000	$ 0.38	$ 46,000
Labor				$ 25,000	$ 25,000
Total Annual Operations & Maintenance Cost					**$ 81,000**

Force Main Replacements

Project: Replace force mains downstream of the following stations:

- Willow Pump Station (circa 1980s), 10" diameter, 700 linear feet
- University Pump Station (1985), 8" diameter, 600 linear feet
- Illinois Pump Station (1985), 6" diameter, 2,100 linear feet

Description:
Based on age and maintenance history, these three force mains are planned to be replaced. For planning purposes, it is assumed that the force mains will be replaced through open cut construction, placing a new force main parallel to the existing to avoid the need for long term bypassing of the entire force main. Design may allow for trenchless replacement (pipe bursting) at lower cost, however bypass pumping will be required, at additional cost. This project adds no new operating or maintenance costs and may offset savings of trenchless methodology. Additionally, it may be beneficial to leave the existing force mains in place as redundant spares for future use.

Costs are summarized in Table 4.

Table 4 - Force Main Replacement Capital Cost Estimate

Planning Level Cost Estimate					
	size	Qty	Unit Cost	Unit	Subtotal
Forcemain Replacements (Downstream of)					
Willow Pump Station	10	700	$ 50	in-diam/LF	$ 350,000
University Pump Station	8	600	$ 50	in-diam/LF	$ 240,000
Illinois Pump Station	6	2,100	$ 50	in-diam/LF	$ 630,000
Baseline Construction Cost					**$ 1,220,000**
Construction Contingency			30%		$ 366,000
Total Construction Cost					**$ 1,586,000**
Allowance for Change Orders			10%		$ 158,600
Construction Inspection			5%		$ 79,300
Engineering Design			7%		$ 111,020
Permits			2%		$ 31,720
Construction Administration			5%		$ 79,300
Legal, Fiscal, and Administrative			2%		$ 31,720
Implementation (Rounded Up)					**$ 492,000**
Total Project Cost (Rounded Up)					**$ 2,078,000**
Annualized Total Project Cost (3%, 30 years, Rounded Up)			0.05437		$ 113,000
Total Annualized Cost ($/Year)					**$ 113,000**

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Appendix I

Recycled Water Program TM (Woodard & Curran)

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Woodard & Curran

TECHNICAL MEMORANDUM

TO: Vivian Housen, Principal, V.W. Housen & Associates, Inc.

PREPARED BY: Kelsey Bradley, Woodard & Curran, CA PE No. 94000

REVIEWED BY: Dave Richardson, Woodard & Curran, CA PE No. 37097

DATE: November 30, 2023

RE: Final West Bay Sanitary District Recycled Water Plan

12/8/23

1. INTRODUCTION

1.1 Background

West Bay Sanitary District (WBSD or District) maintains and operates over 200 miles of main line sewer in the City of Menlo Park (City) and portions of the Cities of East Palo Alto, Redwood City, the Towns of Atherton, Woodside and Portola Valley and portions of Unincorporated San Mateo and Santa Clara Counties. The raw wastewater collected by WBSD is conveyed to Silicon Valley Clean Water (SVCW) where the wastewater is treated and discharged or reused. **Figure 1** illustrates the WBSD boundaries and the study area.

In 2014, WBSD completed a Recycled Water Market Survey (Market Survey) (RMC, 2014), including a preliminary market and recycled water supply assessment and an evaluation of three conceptual alternatives to serve recycled water customers to assess overall feasibility of expanding the service area water supply portfolio to include recycled water.

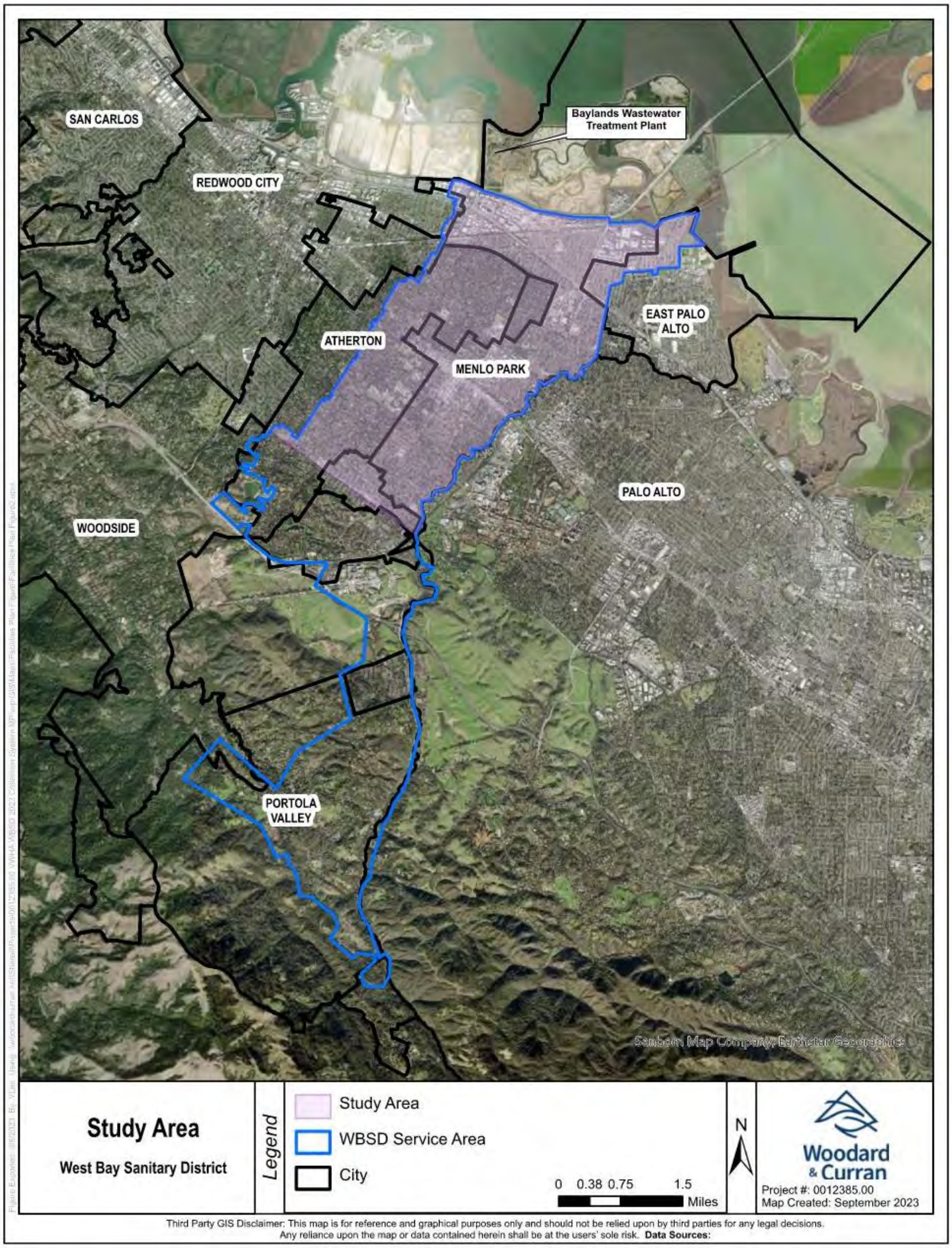
WBSD decided to further evaluate a satellite treatment plant at Sharon Heights Golf & Country Club (SHGCC) and recycled water use at the golf course and other potential customers near the golf course. This evaluation was documented in the Sharon Heights Recycled Water Facilities Plan (RMC, 2015), and WBSD completed the construction of this new satellite water reclamation plant, herein referred to as the Sharon Heights Recycled Water Project, in May 2020.

In 2019, Woodard & Curran completed the WBSD Bayfront Recycled Water Facilities Plan (Bayfront RWFP), which evaluated projects identified in the Market Survey in the Bayfront area. This Recycled Water Plan Technical Memorandum (TM) builds off the work completed in the Bayfront RWFP to update and refine the market assessment and analyze various recycled water project alternatives.

The Bayfront facilities, including the influent facilities (pump station and pipeline), treatment facilities, and distribution facilities (pump station and pipeline) have already been planned and are in the 30% design phase. Therefore, this report focuses on additional distribution facilities that extend down to the central and southwest portions of the study area.

This chapter of the report includes background on the District and previous planning efforts, a description of the study area, documentation of the goals and drivers for considering implementation of additional recycled water distribution pipeline in the study area, and a discussion of the TM objectives and approach.

Figure 1: Study Area



1.2 Objectives and Approach

The objectives of this TM are to expand on the previous recycled water market and supply evaluation from the Bayfront RWFP developed by Woodard & Curran in May 2019 and:

1. Identify optimal areas for recycled water distribution pipe such that installation can occur simultaneously with sewer improvement projects in WBSD's service area;

2. Identify a recycled water expansion and production strategy for the Bayfront area to the Government Center, including target customers, planning-level design criteria, and a planning-level cost estimate;

3. Prepare an implementation plan for the recommended project, including an implementation schedule and a construction financing plan.

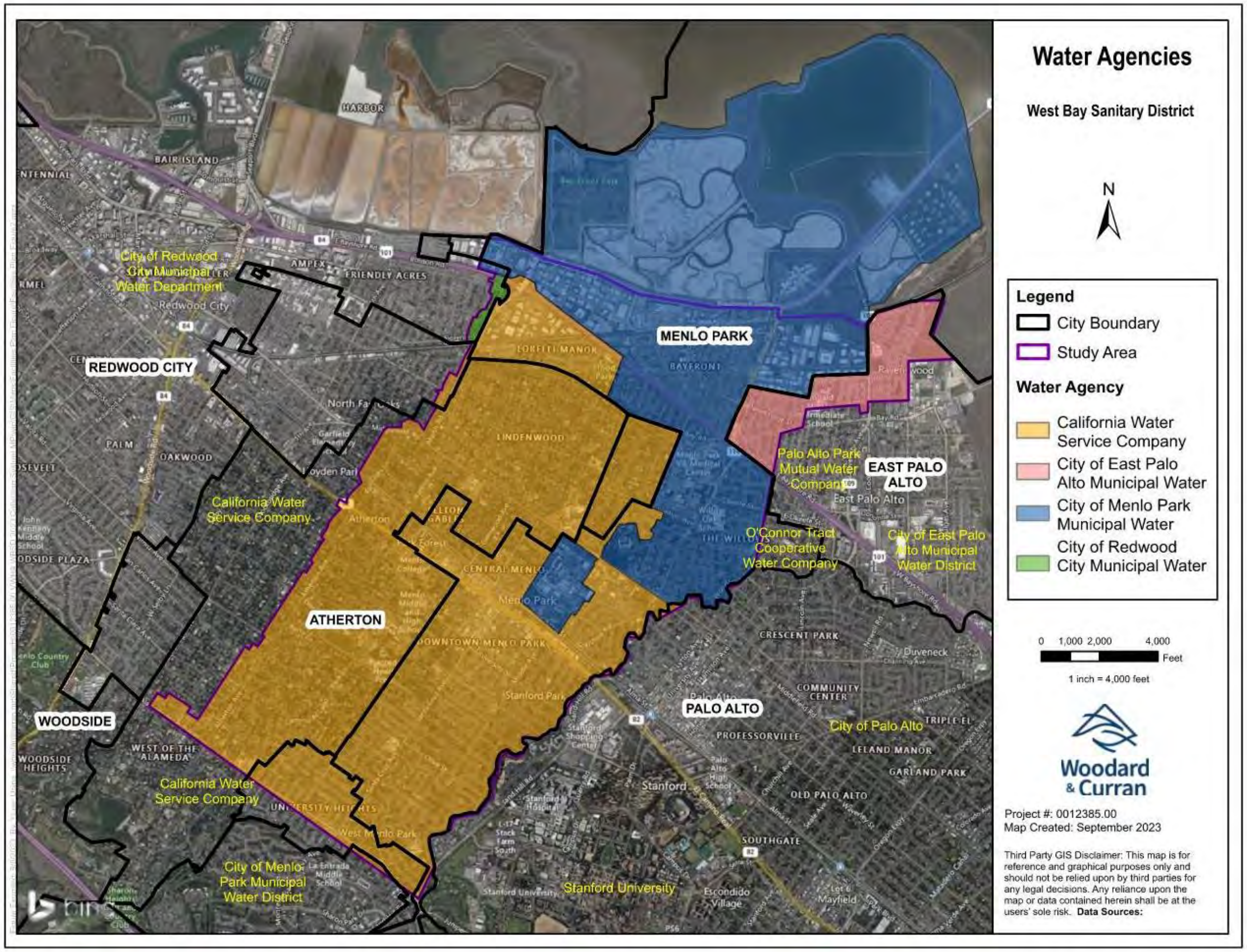
1.3 Study Area Characteristics

This section provides additional background information on the characteristics of the study area, including a discussion of water demand and supply.

1.3.1 Study Area

The study area for this TM is defined as the northwestern section of the WBSD service area, as shown in **Figure 1**. The study area includes the Bayfront area, which has experienced a surge of development in recent years. An increased interest in recycled water has been seen from potential future customers in the Bayfront area that prompted the study of the potential demand for recycled water. The recycled water facility will be located at the abandoned WBSD wastewater treatment plant (WWTP) site; hence, the southeastern section of the WBSD service area was not considered for this Report. There is limited development potential in the southeastern section of the service area, and therefore less incentive for WBSD to invest in additional recycled water infrastructure. Potable water in this section of the District's service area is supplied by Menlo Park Municipal Water (MPMW) and California Water Service (Cal Water) as shown in **Figure 2.**

Figure 2: Study Area Water Agencies



1.3.2 Water Demand

Based on the 2020 Urban Water Management Plan for the Menlo Park Municipal Water District (EKI, 2021), the population of the City of Menlo Park served by the MPMW is expected to increase from 18,276 in 2020 to 30,184 in 2040, increasing overall water demand substantially. In addition to residential growth, the City is anticipating commercial development in the future, and employment in the service area is estimated to increase from 23,574 jobs in 2020 to 37,311 jobs in 2040, which is an increase of 58%, increasing both overall and nonpotable recycled water demand.

Cal Water serves the Bear Gulch District, which includes Portola Valley, Woodside, Atherton, and portions of Menlo Park, Redwood City, and San Mateo County. Based on the 2020 Urban Water Management Plan, Bear Gulch District (EKI, M.Cubed, Gary Fiske and Associates, 2021), population in Cal Water's service area is expected to reach 62,302 in 2040, increasing from an estimated 60,814 in 2020. While Cal Water supplies water to residential, commercial, industrial, and governmental customers, about 84 percent of them are residential customers.

MPMW demands are expected to grow from 1,069 AFY in 2020 to 4,183 AFY in 2040, and Cal water demands are expected to decrease from 12,972 AFY in 2020 to 12,675 AFY in 2040 (EKI, M.Cubed, Gary Fiske and Associates, 2021). For this reason, the driver for recycled water expansion in Cal Water's service area served by WBSD is much lower. Expected water savings and estimated growth were considered for projected water demands.

1.3.3 Water Supply

MPMW purchases all its water from the San Francisco Public Utilities Commission (SFPUC), while Cal Water's supply for all three of its districts on the San Francisco Peninsula is a combination of mostly water purchased from SFPUC and a small percentage of local surface water sources. For the Bear Gulch District, about 95 percent of the water is purchased from SFPUC and 5 percent is produced from the District's reservoir and treatment plant in Atherton (EKI, M.Cubed, Gary Fiske and Associates, 2021).

With increasing water demands forecasted over the next 20 years and the Study Area's dependence on the SFPUC water, adequate water supply for the region is an issue that recycled water could help address.

Since the 1960s, the City's primary source of potable water has been the SFPUC's Hetch Hetchy Regional Water System. The SFPUC system supply is predominantly snowmelt from the Sierra Nevada Mountains, delivered through the Hetch Hetchy aqueducts. The SFPUC wholesales water to MPMW and Cal Water, which are the water retailers for the majority of the customers within the City.

The MPMW's and Cal Water's dependence on SFPUC for potable water supplies leads to several potential issues that may be addressed or reduced by using recycled water in the City:

- **Water Supply Availability during Average Year.** Per the MPMW's contract with SFPUC, the MPMW has an Individual Supply Guarantee of approximately 4,991 AFY through 2034.
- **Water Supply Reliability during Periods of Drought.** The majority of SFPUC water supplies are surface water and susceptible to drought conditions. Supplying recycled water to non-potable demands would dampen drought impacts on potable water supply.

- **Water Supply Reliability during Service Disruptions.** The majority of SFPUC water supplies are piped in from outside the City's immediate area. The City's exclusive dependence on the SFPUC for potable water leaves the City in a vulnerable position to service disruptions and outages if an event (e.g., earthquake) damages the transmission system. To address this issue, SFPUC undertook the Water System Improvement Program to address reliability and seismic protection in their system. In addition, recycled water would allow for the use of a local, reliable water supply for non-potable demands in the event of service disruptions.

2. POTENTIAL RECYCLED WATER CUSTOMERS AND DEMANDS

This section discusses updates to previous efforts to determine potential recycled water customers and demands in the study area. The previous work consists of the Bayfront RWFP (Woodard & Curran, 2019) and the Bayfront Recycled Water Project (Woodard & Curran, 2021).

2.1 Market Assessment

2.1.1 Bayfront RWFP (2019)

A preliminary recycled water market assessment was conducted as part of the Market Survey (RMC, 2014) that included a preliminary definition of the Baylands WWTP Facility project concept in the Bayfront area. For the Bayfront RWFP, the preliminary recycled water market assessment was refined to:

- **Refine customer demand estimates, define demand profiles, and identify other potential customers near Bayfront.** The Bayfront RWFP considered additional potential potable water customers (existing and future) that were not originally evaluated during the 2014 Markey Survey.

- **Confirm/refine the water quality needs.** The Bayfront RWFP expanded upon the original water quality needs identified in the Markey Survey by considering additional monitoring as well as identifying any customer needs related to water quality.

The refined market assessment formed the basis for evaluating recycled water distribution alternatives in the Bayfront RWFP. Refinements to potential uses, customers, and recycled water demands applied specifically to the development of a satellite treatment plant at the old WBSD Baylands WWTP site and recycled water delivery to potential local customers in the Bayfront area.

Figure 6 of the Bayfront RWFP shows the potential recycled water customers that were considered when developing the recycled water distribution alternatives and recommended project. See Section 3.2.6 of the Bayfront RWFP, in which Table 7 presents the list of potential recycled water customers with potable water offset and Table 8 presents the list of potential recycled water customers with groundwater offset.

2.1.2 Bayfront Recycled Water Project (2021 Update)

The 2021 Bayfront Recycled Water Project expanded the list of potential recycled water customers to include existing and future developments not previously included in the Bayfront RWFP. The potential recycled water customers evaluated in this project were existing Facebook facilities, the Menlo Park Community Center, and new developments within the Bayfront area. **Table 1** lists the customers evaluated in this update. The recycled water demands for potential new development customers were provided by developers and Menlo County Club.

Table 1: Potential Bayfront Recycled Water Demands (New Development, Menlo Park Community Center, and Existing Facebook)

Project/Developer	Average Day Peak Month (MGD)	Average Day (Annual) (MGD)	Annual Total (MG)
Willow Village (Signature)	0.26	0.17	58
123 Independence (Sobrato)	0.00058	0.00039	0.14
Commonwealth 3 (Sobrato)	*Information needed*		
1350 Adams (Tarlton)	0.039	0.026	9.5
Menlo Portal (Greystar)	0.013	0.0085	3.1
Menlo Uptown (Greystar)	0.012	0.0079	2.9
Menlo Flats (Greystar)	0.007	0.0044	1.6
CS Bio		0.004	1.5
Mid Pen	*Small demand*		
Subtotal (New Development)	**0.34**	**0.22**	**77**
Menlo Park Community Center (KPFF)	0.0029	0.0019	0.7
Subtotal (New Development + Menlo Park Community Center)	**0.34**	**0.22**	**77**
Facebook Campus Expansion	0.04	0.028	10
Facebook MPK 20	0.12	0.077	28
Facebook MPK 21 & 22	0.098	0.065	24
Facebook MPK 23	0.028	0.019	6.8
Subtotal (Existing Facebook)	**0.28**	**0.19**	**69**
TOTAL	**0.62 MGD**	**0.41 MGD**	**146 MG**

2.1.3 Approved and Pending Development Projects (2023)

A list of approved and pending development projects (Development Projects List) in the study area was provided by WBSD in May 2023. Development projects that were provided on this list but not accounted for in the Bayfront RWFP or the 2021 Bayfront Recycled Water Project were also included as potential recycled water customers in this TM. A complete list of customers developed for this TM is provided in **Appendix A**.

2.2 Non-Potable Demand Estimate Methodologies

The existing and potential customers considered in this TM were sourced from the Bayfront RWFP, the 2021 Bayfront Recycled Water Project, and the 2023 Development Projects List provided by WBSD. The total non-potable demand for each customer is comprised of three demand types: irrigation, flushing, and cooling tower demands. The methodologies listed below were used to estimate these demands based on available data and use type:

Method 1 – Irrigation and Cooling Demands from the Bayfront RWFP

Irrigation and cooling tower demands were estimated for potential recycled water customers in the Bayfront RWFP and used in this analysis. The non-potable demand for these customers was based on use type: either irrigation or multi-use. Note that all potential customers considered in the Bayfront RWFP had estimated irrigation demands, but only two customers, USGS and the Menlo Park Veteran's Administration (VA) Medical Center (Veteran's Administration), were estimated to have cooling demands. No customers considered in the Bayfront RWFP were estimated to have flushing demands. The ConnectMenlo customer listed in the Bayfront RWFP was identified as the 2014-2016 update of the Land Use and Circulation Elements of the City of Menlo Park General Plan. The City Council identified the area generally between US 101 and the Bay adjoining the Belle Haven Neighborhood, where the transition from traditional industrial uses was well underway, as the primary location for potential change in the city over the coming decades (Woodard & Curran, 2019). This customer was removed in this TM since more recent updates, including the Bayfront Recycled Water Project from 2021 and the Approved and Pending projects list from May 2023, gave a more up-to-date picture of future development in the Bayfront area. A list of the customers from the Bayfront RWFP and the basis for their irrigation and cooling demands is provided in **Appendix B**.

Method 2 – Irrigation, Cooling, and Flushing Demands from Bayfront Recycled Water Project (2021 Update)

Irrigation, cooling, and flushing demands were estimated for potential recycled water customers in the Bayfront Recycled Water Project. These demands were refined in September 2021. Estimates were based on annual average demands (AAD). Note that some customers did not have available data on cooling or flushing. A list of the customers from the Bayfront Recycled Water Project 2021 update and the basis for their irrigation and cooling demands is provided in **Appendix C**.

Method 3 – Irrigation Demands for Development Projects List (2023)

Irrigation demands for potential customers from the Development Projects List were estimated depending on the available information for each customer. One of the following methods was used to estimate the recycled water demand for each customer:

- **Method 3.1:** Estimated Total Water Use (ETWU) from Development Planning Documents – Irrigation demand for some customers corresponds to the ETWU, if available, from their development planning documents downloaded from Menlo Park's website: Projects City of Menlo Park.
- **Method 3.2:** Development Planning Documents (estimate using irrigated area) – Irrigation demand for some customers corresponds to the total irrigated area, if available, from their development planning documents downloaded from Menlo Park's website.
- **Method 3.3:** Development Planning Documents (estimate using 10% irrigated area) – Customers that had development planning documents available but did not have irrigated areas listed were assumed to have 10% of the total site area irrigated.
- **Method 3.4:** Aerial View Approximation – Irrigation estimates for customers that did not have the above information were determined by measuring the approximate building area from the aerial view in Google Earth. 10% of the approximated area was assumed to be irrigated.

For Method 3.2, 3.3, and 3.4, once the irrigated area was retrieved/estimated for each customer, the area was multiplied by an irrigation demand factor of 3.3 AFY per year, which was adopted from the irrigation demand estimates in the Bayfront RWFP. One customer from the Development Projects List, Guild Theater, was deemed unlikely to have irrigation demands. The Development Projects List is included in **Appendix D**.

Method 4 – Cooling and Flushing Demand Calculations for Development Projects List (2023)

Cooling and flushing demands for the customers on the development projects list that did not already have cooling and flushing demands from Method 1 or Method 2 were calculated using the average ratio of demand (number of gallons) per commercial building area (square foot) for both flushing and cooling for the Bayfront customers from the 2021 Bayfront Recycled Water project. The average ratios were then multiplied by the total commercial building area for customers from the Development Projects List. Note that the average cooling and flushing ratios were derived from customers that had both flushing and cooling demands (no demands of 0 were included). All Greystar customers were also excluded since they are mixed-use buildings with unrepresentative commercial area to building area ratios. The calculated flushing and cooling ratios are provided in **Appendix E**.

Commercial customers were assumed to have both cooling and flushing demands. However, hotels and some customers, such as Parkline (SRI International), were assumed to have no flushing demands due to not having dual plumbing.

2.3 Demand Peaking Factors

Facilities for treating and conveying recycled water are sized based on the periods of highest demand. Two peak flow situations were defined as criteria for development of the recycled water distribution system in the market assessment: maximum day demand (MDD) and peak hour demand (PHD). The average daily demand during the peak demand month of the year is the assumed MDD. PHD is defined as the maximum anticipated flow rate delivered to a customer (in gallons per minute) during MDD conditions. MDD and PHD factors were updated from the market assessment based on use type and are discussed as follows. Revised MDD and PHD values are presented and are summarized in **Table 2**.

MDD for irrigation is based on net evapotranspiration data from the Western Regional Climate Center, which shows that July is the peak demand month for the WBSD service area for irrigation customers. The MDD peaking factor is 2.0 times the average annual demand (AAD) based on the estimated irrigation demand in July being twice the AAD. Irrigation-only customers without on-site storage typically operate at night for an 8-hour irrigation period. Therefore, the PHD factor was estimated at 3.0 (24-hour/8-hour irrigation = 3.0).

MDD for a cooling tower is based on an assumption that cooling towers operate 8 months out of the year. The MDD peaking factor of 1.5 recognizes the differences in water demand during the cooler months in the 8-month operating window and during the months with higher temperatures/higher water demands. As projects progress, it's important to work with the individual facility managers to understand their specific cooling towers and the water demand (i.e., onsite storage/break tanks, etc.). Furthermore, it is assumed that cooling towers operate for 12 hours daily. Consequently, the PHD is calculated as 2 times the MDD to accommodate this operating pattern.

For flushing demand, the MDD peaking factor of 1 is applied, as the demand remains consistent throughout the year and does not fluctuate with seasons. The PHD is set at 2, considering a 12-hour daily pumping cycle to fill the flushing roof tank.

Table 2: Demand Peaking Factors

Peaking Factors	Type of Use		
	Irrigation	Flushing	Cooling Tower
ADD to MDD	2.0	1.0	1.5
MDD to PHD	3.0	2.0	2.0
AAD to PHD	6.0	2.0	3.0

2.4 Customer Demands and Planned/Proposed Recycled Water Distribution System

A map of the estimated customer average annual demands in million gallons per year (MG) is shown in **Figure 3**. The seven largest customer demands and all customers in addition to Bayfront customers that are the focus of this TM are labeled by name and estimated recycled water average annual demand. **Figure 3** also shows existing, planned, and proposed recycled water distribution pipeline alignments to service customers in the study area. Phase 1 includes all planned purple pipe in the Bayfront area, which is currently being designed; Phase 2 includes the proposed orange pipelines that would service Flood Park, Veteran's Administration, Menlo-Atherton High School, and Parkline (SRI International); and Phase 3 includes additional potential pipe in the Southwest and Eastern portions of the study area. Phase 3 pipelines are broken out into dashed and solid; the solid lines are the primary proposed pipes, and the dashed lines represent possible looping of the system. The purple dashed line is existing recycled water pipe. As stated previously, the focus of this TM is on the proposed Phase 2 recycled water distribution facilities, but the Phase 3 pipeline is included for discussion purposes.

Table 3 summarizes the total demand per phase. Customers that were more than 1,000 feet away from the pipelines were not included in this demand estimate.

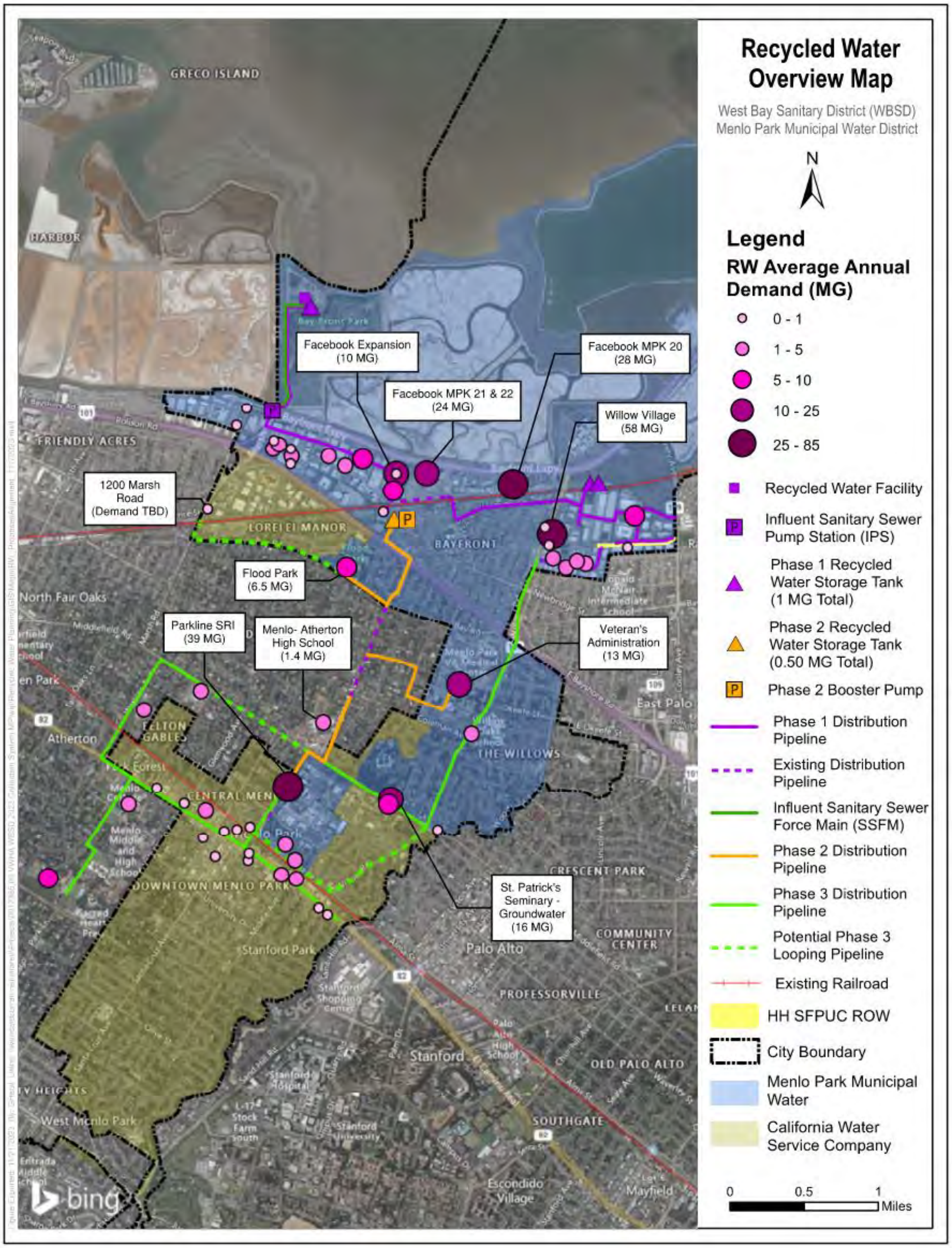
Table 3: Customer Demands by Pipeline Service Region

Pipeline Service Region	RW Average Annual Demand (AFY)	RW Average Annual Demand (MG)	RW Average Daily Demand (MGD)
Phase 1, Northwest Area (Bayfront)[1]	548.33	178.64[4]	.49
Phase 2, Central Area[2]	182.55	59.48	0.16
Total Phase 1 and 2	**730.89**	**238.16**	**0.65**
Phase 3, Southwest and Eastern Area[3]	199.71	65.08	0.18
Total Phase 1, 2, and 3	**930.60**	**303.24**	**0.83**

Notes:

1. Area north of Highway 101.
2. Extending south of Highway 101 down Ringwood Ave., with an endpoint at Parkline (SRI International).
3. Extending farther south and west to customers surrounding Downtown Menlo Park and east along Middlefield Road and Willow Road.
4. The recycled water demand for Phase 1 in this table is larger than the demand listed in Table 1, from the 2021 update, because the amount in this table includes two customers from the Bayfront RWFP and some additional customers from the 2023 Development Projects List.

Figure 3: Recycled Water Overview Map



3. TREATMENT PLAN

This section describes the potential recycled water supplies available for production of recycled water generated in the Bayfront area of the WBSD service area.

3.1 Recycled Water Quality Requirements

Potential irrigation customers have different water quality needs according to their intended use. The following section describes water quality guidelines for landscape irrigation, the primary type of demand within WBSD. The section also describes the recommended level of treatment based on these requirements.

3.1.1 Irrigation Water Quality Requirements

Water quality guidelines for landscape use are well established. **Table 4** characterizes three degrees of restriction (none, slight to moderate, and severe) for use of recycled water in landscaped irrigation based on various water quality constituents (although specific requirements vary depending on the tyoe of plant).

Table 4: Landscape Irrigation Water Quality Comparison

Constituent	Units	Degree of Restriction on Use[1]		
		None	Slight to Moderate	Severe
Salinity				
TDS	mg/L	<450	450-2,000	>2,000
Specific Ion Toxicity				
Sodium (Na)[2,3]	mg/L	<70	>70	
Chloride (Cl)[2,3]	mg/L	<100	>100	
Boron (B)	mg/L	<0.7	0.7-3.0	>3.0
Miscellaneous Effects				
pH	-	6.5-8.4		
Total Nitrogen[4]	mg/L	<5	5-30	>30
Bicarbonate[5]	mg/L	<90	90-500	>500

Notes:

1. Adapted from Metcalf and Eddy, 2007.
2. Values apply to most tree crops and woody ornamentals which are sensitive to sodium and chloride.
3. With overhead sprinkler irrigation and low humidity (<30%), sodium or chloride levels greater than 70 or 100 mg/L, respectively, have resulted in excessive leaf adsorption and crop damage to sensitive crops.
4. Total nitrogen should include nitrate-nitrogen, ammonia-nitrogen, and organic-nitrogen. Although forms of nitrogen in wastewater vary, the irrigated plant responds to the total nitrogen.
5. Overhead sprinkling only.

Except for nitrogen, the constituents in **Table 4** are not removed by conventional wastewater or tertiary treatment processes. Therefore, recycled water constituent levels are likely to be similar to the source wastewater constituent levels.

3.2 Non-Potable Treatment

3.2.1 Baylands Wastewater Treatment Plant (WWTP) Site

WBSD previously owned and operated its own WWTP located adjacent to San Francisco Bay north of Highway 101, referred to herein as the Baylands WWTP site. The entire flow from the WBSD collection system converges at the Baylands WWTP site and from there is pumped to SVCW. Structures from the WWTP still exist at the site but are in poor condition and not likely capable for reuse in a new plant. Due to its location relative to the collection system and the availability of land to construct a new treatment plant, the Baylands WWTP is an advantageous location for a new centralized treatment plant that could be used to produce recycled water. The three storage ponds on the west and north side of the site are used for storage during wet weather flows and are referred to as the Flow Equalization and Resource Recovery Facility.

3.2.2 Baylands Wastewater Characterization

This section presents the preliminary wastewater quality and flow characterization of potential influent wastewater.

3.2.2.1 Preliminary Wastewater Quality Characteristics

The satellite treatment project requires diversion of wastewater flow from the existing collection system to the new treatment facilities. Two locations in the collection system were measured for water quality and flow:

1. 24-in Sewer – Haven (Flow and Water Quality)
2. 54-in Sewer – Kelly Park (Flow and Water Quality)

Table 5 summarizes the average of the sampling results from 10 to 20 sample events (2 times per day for 5 to 10 days) in June, August, and September 2023.

Table 5: Water Quality Sampling Results

Constituent[1]	Unit	Haven	Kelly Park
Ammonia	mg/L	48	60
BOD	mg/L	206	231
EC	umhos/cm	773	761
TDS	mg/L	317	269
TSS	mg/L	194	237
TKN	mg/L	52	67
Tannins & Lignins	mg/L	11	10
Total Phosphorus	mg/L	6	6
Silica	mg/L	30	35
Calcium	mg/L	21	14
Alkalinity	mg/L	216	234
pH	-	7	7
Temperature	F	55	56

Notes:

1. Ammonia, BOD, EC, TDS, TSS, and TKN were measured with 20 sample events (2 times per day for 5 days in June and 5 days in September); Tannins & Lignins were measured with 10 sample events (2 times per day for 5 days in August); Total Phosphorus, Silica, Calcium, Alkalinity, pH, and Temperature were measured with 10 sample events (2 times per day for 5 days in September).

3.2.2.2 Preliminary Wastewater Flows

Flow monitoring was conducted by WBSD in June 2023 for 5 days at the two sites mentioned previously. **Table 6** summarizes preliminary data for the average flow during the monitoring period, average minimum hourly flow, and average maximum hourly flow.

Table 6: Available Wastewater Flows (MGD)

Site	Monitoring Period	Minimum Flow	Average Flow	Maximum Flow
Haven	6/18/26 – 6/22/23	0.6	1.1	1.6
Kelly Park	6/18/26 – 6/22/23	0.3	0.9	1.6

3.3 Treatment Requirements for Reuse

Based on the target uses, the treatment facilities would need to meet Title 22 Disinfected Tertiary Recycled Water requirements. **Table 7** summarizes the water quality requirements, which vary depending on the type of filtration technology used.

Table 7: Title 22 Disinfection Tertiary Recycled Water Quality Requirements

Process	Requirement
Filtration Method	
Coagulated[1] and passed through a bed of filter media	Rate does not exceed 5 gallons per minute per square foot of surface area in mono, dual or mixed media gravity, upflow or pressure filtration systems. Turbidity of the filtered wastewater does not exceed any of the following: An average of 2 NTU within a 24-hour period; 5 NTU more than 5 percent of the time within a 24-hour period; and 10 NTU at any time
Microfiltration, Ultrafiltration	Turbidity does not exceed any of the following: 0.2 NTU more than 5 percent of the time within a 24-hour period; and 0.5 NTU at any time
Disinfection	
UV	A disinfection process that, when combined with filtration, has been demonstrated to achieve 5-log inactivation of virus. The median concentration of total coliform bacteria measured in the disinfected effluent does not exceed a most probable number (MPN) of 2.2 per 100 milliliters utilizing the bacteriological results of the last seven days for which analyses have been completed and the number of total coliform bacteria does not exceed an MPN of 23 per 100 milliliters in more than one sample in any 30-day period. No sample shall exceed an MPN of 240 total coliform bacteria per 100 milliliters.

NTU: Nephelometric Turbidity Units
Note:

1. Coagulation need not be used as part of the treatment process provided that the filter effluent turbidity does not exceed 2 NTU, the turbidity of the influent to the filters is continuously measured, the influent turbidity does not exceed 5 NTU for more than 15 minutes and never exceeds 10 NTU, and that there is the capability to automatically activate chemical addition or divert the wastewater should the filter influent turbidity exceed 5 NTU for more than 15 minutes.

3.4 Potential for Direct Potable Reuse

Nonpotable reuse, as envisioned in the Bayfront area and beyond, allows for the highest and best use of the WBSD water resource. Centralized treatment for IPR and DPR is being investigated right now by Silicon Valley Clean Water for advanced treatment associated with the Regional WWTP in Redwood City. In partnership with the City of San Mateo, the SFPUC (the water wholesaler for much of the region), and with Cal Water (retailer in much of the Silicon Valley Clean Water and San Mateo Service areas), the San Francisco-Peninsula Regional PureWater project is being developed and may bring the opportunity for WBSD to receive some of those regional benefits. Future DPR opportunities could allow WBSD to potentially repurpose some of its nonpotable recycling treatment and distribution assets. But, in the meantime, investment in nonpotable reuse treatment and distribution in the WBSD service area provides for the best short term, and potentially long term, utilization of this precious wastewater resource.

4. PROJECT DEVELOPMENT

This Chapter documents the Project recycled water production assumptions and the process of determining the Recommended Project.

4.1 Planning and Design Assumptions

Table 8 summarizes the design criteria used to size infrastructure.

Table 8: Facilities Criteria and Hydraulic Criteria

Item	Value	Units/Notes
Pump Stations		
Pump Efficiency	75	%
Pipelines		
Max Velocity for Sizing	5	ft per second
C Coefficient for Headloss	130	Assuming PVC pipe
Max Headloss	5	ft per 1,000 ft
Storage		
Delivery Pressure	70	psi

4.1.1 Cost Estimate Basis

Cost estimates were developed to evaluate and support the selection of a recommended project. The actual final costs of the project will depend on a variety of factors, including but not limited to actual labor costs, material costs, site conditions, market conditions, project scope, and implementation schedule.

4.1.1.1 Capital Cost Basis

Capital cost estimates were based on similar recycled water projects, cost quotations from suppliers, and industry publications. The Recycled Water Plan is a preliminary planning phase project, the provided estimates are considered Class 5 estimates based on the International (AACEI) Recommended Practice No. 56R-08, Cost Estimate Classification System – As Applied for the Building and General Construction Industries (revised August 2020). Class 5 estimates are based on a level of project definition of 0 to 2 percent and are suitable for alternatives analysis. The typical accuracy ranges for a Class 5 estimate are -20 to -50 percent on the low end and +30 to +100 percent on the high end. In addition, the capital costs include the following contingency and markups:

- Construction Contingency: 30% of raw construction costs to account for unknown or unforeseen construction costs.
- Implementation Allowance:
  - Allowance for Change Orders (5%)
  - Construction Inspection (5%)
  - Engineering Design (7%)
  - Permits/Easements (5%)
  - Construction Administration (5%)
  - Legal, Fiscal, and Administrative (2%)

Estimated costs are referenced to the September 2023 Engineering Construction Cost Index for San Francisco 15489.7.

4.1.1.2 Capital Financing Assumptions

The SWRCB Clean Water State Revolving Fund (CWSRF) offers low interest financing for publicly-owned facilities including recycled water projects. The CWSRF program offers 30-year financing at an interest rate of half the most recent General Obligation Bond rate at time of funding approval rounded up to the nearest one-tenth percent. The interest rate has typically ranged from 2.5 percent to 3.0 percent and is currently 2.1%. CWSRF financing assumptions used to annualize capital costs are:

- Annual Interest Rate: 3.0%
- Term of Financing: 30 years

The rates for CWSRF financing are adjusted every year and change based on the current market conditions, so the actual project financing rate will likely differ from the assumption above.

4.1.1.3 O&M Cost Basis

Operations and Maintenance (O&M) costs are the recurring annual expense to operate and maintain the facilities after construction is completed. The O&M cost estimate is developed based on similar recycled water projects, vendor quotes, industry publications, and pumping estimates. A contingency is not applied to O&M costs. **Table 9** summarizes O&M cost assumptions.

Table 9: O&M Cost Assumptions

O&M Costs	Unit	Value
Pipeline Consumables	-	0.5% of Pipeline Costs
Pump Station Consumables	-	2.5% of Pump Station Costs
Storage Consumables	-	1% of Storage Tank Costs
Power Costs	$ per kwh	$0.30
Labor Costs	$ per month	$1,476

4.1.2 Unit Costs and Assumptions

Process facilities, including pipelines, pump stations, and storage tanks, were preliminary sized.

Unit costs were developed based on estimates from recent recycled water projects in California, vendor quotes, and RSMeans construction cost data. Pipeline unit costs were developed using Woodard & Curran's pipeline cost estimating tool with inputs specific to the study area.

4.1.3 Recycled Water Project Components

Production and distribution of disinfected tertiary recycled water from raw wastewater diverted from local sewers includes several components:

- Influent conveyance system: Influent pump station, force main, and equalization
- Water recycling facility (WRF): Grit removal, screening, MBR, UV, chlorination, de-colorization
- Waste return pump station and force main
- Recycled water distribution system: storage, pump station, and pipelines

The influent conveyance system (pump station, force main, and equalization) will be sized to provide a constant feed to the new WRF. Raw wastewater would be pumped from a new manhole at Marsh Road and Bayfront Expressway, which would divert flow from the existing 36-inch sewer to the satellite treatment plant.

The WRF would be sized to meet the max day demand. Due to seasonal irrigation demands, the facility would operate as a dry weather satellite plant – operating at a constant flow rate over 24 hours a day for 8 months of the year and operate at half capacity for 4 months of wet weather to maintain the biological processes.

Grit and screenings produced at the facility would be washed, compacted, and hauled offsite for disposal. Waste sludge and the de-colorization waste product would be discharged by force main to an existing 30-inch sewer main running along the north side of the Bayfront Expressway to be conveyed to SVCW.

The recycled water distribution system would be sized to meet peak hour demand, which typically occurs during an 8-hour period overnight between 8 PM and 4 AM. The peak hour demand for Phase 1 and Phase

2 exceeds the WRF capacity, so recycled water storage would be provided to collect excess supply during periods of low demand so that sufficient supply is available on demand.

4.2 Potential Recycled Water Project

This section describes the Recommended Recycled Water Project (Recommended Project) and includes target customers, project facilities descriptions, cost estimates, and project benefits.

4.2.1 Proposed Recycled Water Project Facilities

The Phase 1 (Bayfront Project) involves the construction of an influent pump station to divert wastewater from the WBSD collection system, approximately 4,900-LF of influent pipeline, a satellite MBR/UV treatment facility to treat and ultimately produce a maximum daily flow of 0.6 MGD (for Bayfront Project only), and a recycled water distribution system including a recycled water storage tank, recycled water pump station, and approximately 30,800-LF of distribution pipeline (approximately 27,500-LF planned and 3,300-LF existing) to various customers.

The Phase 2 Project (focus of this TM) involves the construction of a booster pump station at the intersection of Terminal Ave and Del Norte Ave, where the Phase 2 pipeline begins, to divert recycled water from the Phase 1 system to the Phase 2 system, approximately 19,500-LF of distribution pipeline (approximately 15,900-LF proposed and 3,600-LF existing) to various customers, and a 0.5 MG storage tank.

The possible future Phase 3 Project (not part of the scope of this TM), would involve construction of approximately 38,500-LF of distribution pipeline to various customers and an additional 18,800-LF of pipeline for possible looping purposes.

The Recommended Project (Phase 1 and Phase 2) would deliver an estimated total of 731 AFY (Average Annual Demand) for irrigation, cooling towers, and flushing uses, and a future Phase 3 would deliver an additional estimated total of 200 AFY. A list of recycled water demands (AAD, MDD, and PHD) by customer area and customer use type for the Recommended Project is presented in **Table 10**. WBSD will need to expand the treatment facilities to 1.0 MGD to increase treatment capacity due to Phase 2 increased demand. This increase would allow WBSD to connect to future customers and expand the recycled water distribution system for the future.

Table 10: Recommended Project, Recycled Water Customers

Customer Area	Customer Use Type	AAD (AFY)	MDD (AFY)	PHD (AFY)	AAD (MGD)	MDD (MGD)	PHD (MGD)
Northeast Area (Bayfront)[1]	Irrigation	244	488	1,464	0.22	0.44	1.31
	Toilet Flushing	244	244	390	0.22	0.22	0.35
	Cooling Tower	60	91	181	0.05	0.08	0.16
Total Phase 1		**548**	**822**	**1,562**	**0.49**	**0.73**	**1.39**
Phase 2, Central Area[2]	Irrigation	144	289	866	0.13	0.26	0.77
	Toilet Flushing	0	0	0	0.00	0.00	0.00

Customer Area	Customer Use Type	AAD (AFY)	MDD (AFY)	PHD (AFY)	AAD (MGD)	MDD (MGD)	PHD (MGD)
	Cooling Tower	38	58	115	0.03	0.05	0.10
Total Phase 2		**183**	**346**	**866**	**0.16**	**0.31**	**0.77**
Total Phases 1 and 2		**731**	**1,169**	**2,428**	**0.65**	**1.04**	**2.17**
Phase 3, Southwestern and Eastern Area[3]	Irrigation	161	322	965	0.14	0.29	0.86
	Toilet Flushing	22	22	35	0.02	0.02	0.03
	Cooling Tower	17	26	51	0.02	0.02	0.05
Total Phase 3		**200**	**369**	**974**	**0.18**	**0.33**	**0.87**
Total Phases 2 and 3		**382**	**715**	**1,840**	**0.34**	**0.64**	**1.64**
Total Phases 1, 2, and 3		**931**	**1,538**	**3,402**	**0.83**	**1.37**	**3.04**

Notes:

1. Area north of Highway 101.
2. Central: Extending south of Highway 101 down Ringwood Ave., with an endpoint at Parkline (SRI International).
3. Southwestern and Eastern Area: Extending farther south and west to customers surrounding Downtown Menlo Park and east along Middlefield Road and Willow Road.

The Recommended Project would divert wastewater from the 36-in sewer pipeline near the intersection of Bayfront Expressway and Marsh Road and pump the wastewater to the Bayfront satellite treatment facility. The treatment facility includes grit removal and fine screening, biological reactor tanks, MBR treatment system, UV disinfection, de-colorization and all appurtenances required for a fully functional treatment system. The product water would be stored in a recycled water tank, and a distribution pump station would be used to deliver recycled water to customers. Grit and screenings would be collected in a common dumpster and hauled offsite for disposal.

Distribution from the satellite treatment facility to customers would be through an 8-inch pipeline (Phase 1). Solids produced from the MBR system would be discharged by gravity through a 4-inch pipeline to the existing 30-inch sewer main running along the north side of the Bayfront Expressway to be conveyed to SVCW. Distribution from the Phase 1 system to Phase 2 would be through a 10-inch pipe, and there would be two 6-inch pipes that would branch off to connect to Flood Park and Veteran's Administration. There is already an existing 8-inch pipe on Ringwood Ave., so that would exist between the two main 10-inch pipes. The Phase 3 pipes were not sized using hydraulic analysis and were assumed to be 8-inch pipes.

Figure 3 maps the customers for the Recommended Project and major facilities.

A summary of key planning-level design criteria for the Phase 2 facilities is presented in **Table 11**.

Table 11: Design Criteria for Recommended Project Phase 2

Component	Value	Units	Notes
Storage and Distribution			
Storage Tank	0.50	MG	
10-inch Pipe	8,600	LF	Proposed
6-inch Pipe	7,300	LF	Proposed
8-inch Pipe	*3,600*	*LF*	*Existing*
No. of Pumps	2	-	1 Duty, 1 Standby
TDH	240	ft	
hp per Pump	50	hp	

With Phase 3 added, there would be an additional 38,500-LF of distribution pipe as well as 18,800-LF of pipe (all 8-inch) for possible looping purposes. Also, Phase 3 would require the installation of two additional 50 hp pumps (3 duty, 1 standby), and the TDH would be approximately 350 ft. The amount of storage would stay the same. Additional treatment capacity beyond 1 MGD would be required for Phase 3 since the MDD for Phases 1, 2, and 3 is approximately 1.4 MGD.

4.2.2 Potential Recycled Water Project Cost Estimate

Table 12 summarizes the estimated cost for the Phase 2 facilities. Costs for both Phase 2 and Phase 3, combined, are also included for reference only, as Phase 3 is a future phase and not included as part of this planning TM for capital improvement plan (CIP) budgeting purposes. The Phase 1 facilities (the Bayfront Project) are also not included in this estimate because, while not yet built, they have already been financed and are currently in the 30% design phase. See **Appendix F** for detailed cost information. **Appendix F** also includes a cost estimate for Phases 2 and 3 with the Phase 3 dashed pipe (proposed looping) included, which is not presented in **Table 12**.

Table 12: Recommended Project Costs

Description	Phase 2[1]	Phase 2 and 3[1]
Influent Facilities (Pump Station and Pipeline)[2]	$-	$-
Treatment Facilities[2]	$-	$-
Distribution Facilities (Pump Station, Storage Tank, and Pipeline)	$9,720,000	$28,211,000
Raw Construction Cost	**$9,720,000**	**$28,211,000**
Construction Contingency (30% of Raw Construction Cost)	$2,916,000	$8,464,000
Total Construction Cost	**$12,636,000**	**$36,675,000**
Implementation Cost	$3,664,000	$10,636,000
Total Capital Cost	**$16,300,000**	**$47,300,000**
Annual Cost of Distribution Facilities	$64,000	$163,000
Annual Treatment Cost	$500,000	$1,000,000
Annual Cost of Power	$16,000	$33,000
Annual Labor Costs	$18,000	$18,000
Total Annual O&M	**$598,000**	**$1,214,000**

Description	Phase 2[1]	Phase 2 and 3[1]
Annualized Total Project Cost[3]	$887,000	$2,572,000
Annual O&M Costs	$598,000	$1,214,000
Annual Recycled Water Cost	$7,000	$9,000
Total Annualized Cost	**$1,492,000**	**$3,795,000**
Estimated Recycled Water Yield (AFY)	183	382
Unit Cost, Annualized ($/AF)	**$8,200**	**$9,900**

Notes:

1. Planning level estimate; costs are in September 2023 dollars.
2. These costs are not included because they are considered part of Phase 1 (the Bayfront Project).
3. Annualized at 30 years, 3.5%.

5. IMPLEMENTATION PLAN

5.1 Institutional Needs

5.1.1 Water Rights

No water rights issues were identified. Water Code Section 1210 states that the WWTP owner shall hold the exclusive right to the treated wastewater as against anyone who has supplied the water discharged into the wastewater collection and treatment system, including a person using water under a water service contract, unless otherwise provided by agreement. WBSD will curtail the sewer flow diverted to SVCW by up to 0.4 MGD; however, no formal agreement is required to reduce the flow to SVCW. The flow reduction will result in a slightly reduced flow charge to WBSD.

WBSD does not currently have an NPDES permit as its wastewater is diverted to SVCW for treatment and discharge to the San Francisco Bay at the Redwood City facility. Water Code Section 1211 requires that before making a change in the point of discharge, place of use, or purpose of use of treated wastewater being discharged to a water body with downstream water rights, the WWTP owner must seek approval from the SWRCB Division of Water Rights, which is accomplished by filing a Petition for Change for Owners of Wastewater Treatment Plants (Petition for Change). The SWRCB must be able to find that the proposed change will not injure other legal customers of water, will not unreasonably harm in-stream uses, and is not contrary to the public interest. Because SVCW is a bay discharger, they do not need a Petition for Change to be filed with the SWRCB due to the change in wastewater discharge volume associated with effluent diverted to the project.

5.1.2 Permitting and Agreements

Several permits were identified as necessary for the implementation of the Recommended Project. Foremost, WBSD would need to obtain a recycled water permit to produce recycled water. WBSD currently operates its sewers under the SWRCB Collection System General Order and will need to obtain an individual Water Reclamation Requirement permit to cover the production of recycled water with the San Francisco Bay Regional Water Quality Control Board for the Bayfront Recycled Water Facility. A Title 22 Engineering Report would be needed to satisfy SWRCB Division of Drinking Water requirements. Standard construction permits including encroachment and air quality permits would also be required. In addition, if MPMW decides to be the recycled water purveyor, MPMW would need to enroll under the State Water Resources

Control Board General Order WQ 2016-0068-DDW for permit coverage of the distribution and use of recycled water, and a recycled water purchase agreement between WBSD and the City / MPMW would be required. If MPMW declines to become the purveyor, WBSD would need to apply for a recycled water permit for the production, distribution, and use of recycled water.

5.1.3 Right of Way Acquisition

No right of way acquisition was identified.

5.2 Financing Plan

This section discusses potential funding sources for the Recommended Project, the construction financing plan, and associated cash flow over the implementation period. Typically, recycled water projects are financed through a combination of grants, partnerships relative to project benefits, and the SWRCB State Revolving Fund (SRF). There are also several bond measures currently in development in the California State Legislature that may provide additional funding streams.

5.2.1 Funding Opportunities

A variety of potential funding opportunities are possible for this project, including the following:

- US Bureau of Reclamation (USBR) WaterSMART: Title XVI Water Reclamation and Reuse Program
- SWRCB CWSRF / Water Recycling Funding Program (WRFP)
- California Infrastructure and Economic Development Bank (I-Bank) Infrastructure State Revolving Fund (ISRF) Program

Each of these funding opportunities is described in further detail in the following sections.

5.2.1.1 US Bureau of Reclamation (USBR) WaterSMART Grants

Through WaterSMART Grants, the Bureau of Reclamation (Reclamation) provides financial assistance to water managers for projects that seek to conserve and use water more efficiently, implement renewable energy, investigate and develop water marketing strategies, mitigate conflict risk in areas at a high risk of future water conflict, and accomplish other benefits that contribute to sustainability in the western United States. Cost-shared projects that can be completed within two or three years are selected annually through a competitive process.

Three categories of WaterSMART Grants are offered through separate funding opportunities: Water and Energy Efficiency Grants; Small-Scale Water Efficiency Projects; and Water Marketing Strategy Grants.

Eligible applicants for all WaterSMART Grants funding opportunities include states; tribes; irrigation districts; water districts; state, regional, or local authorities, whose members include one or more organization with water or power delivery authority; other organizations with water or power delivery authority; and nonprofit conservation organizations that are acting in partnership with and with the agreement of an entity previously described. To be eligible, applicants must be located in the Western United States or U.S. Territories.

5.2.1.1.1 Water and Energy Efficiency Grants

Water and Energy Efficiency Grants, the primary category of funding under WaterSMART Grants, focuses on projects that result in quantifiable and sustained water savings, including canal lining and piping projects, municipal metering projects, and Supervisory Control and Data Acquisition (SCADA) and automation projects. Criteria also place a priority on projects that support broader sustainability benefits, including addressing the impacts of climate change, enhancing drought resiliency, and projects that will complement on-farm irrigation improvements, including those that may be eligible for Natural Resource Conservation Service funding. Applicants may request federal funding: (I) up to $500,000 for projects to be completed within two years, (II) up to $2 million for projects to be completed within three years; and (III) up to $5 million for projects to be completed within three years, with a non-Federal cost share of 50% or more of the total project cost.

The FY23 and FY24 Large-Scale Water Recycled Projects Funding Opportunity was posted September 7, 2023. There are three submission periods: first round of applications are due November 21, 2023; second round of applications are due March 29, 2024; final round of applications are due September 30, 2024.

More information is available here: View Opportunity | GRANTS.GOV.

5.2.1.2 State Water Resources Control Board Recycled Water Funding

The SWRCB administers the Water Recycling Funding Program and CWSRF loans. Construction grants and loans specific to recycled water programs fall under the Water Recycling Funding Program (WRFP) and follow the CWSRF policy.

5.2.1.2.1 Water Recycling Funding Program

The WRFP funds planning and construction grant, funded through a mix of Proposition 1, Proposition 13, Proposition 68, and CWSRF funds. The WRFP will fund projects that offset or augment state or local fresh water supplies and water recycling research. Construction grants can fund up to 35 percent of the construction cost up to $15 million. Eligible costs include planning, design, construction management, value engineering, and administration, as well as construction contingencies. As of March 1, 2022, the WRFP has approximately $231.4 million in state-sourced grant funds and approximately $21.7 million available in state-sourced loans for construction projects. The SWRCB also has authority to commit approximately $22.3 million in planning grants. Guidelines were developed for the WRFP in 2019 and are available at https://www.waterboards.ca.gov/water_issues/programs/grants_loans/docs/wrfp_guidelines.pdf.

5.2.1.2.2 Clean Water State Revolving Fund (CWSRF) Program

The SWRCB administers the CWSRF Loan Program. This Program offers low-interest loans to eligible applicants for construction of publicly owned facilities including wastewater treatment, local sewers, sewer interceptors, water reclamation facilities, and stormwater treatment. Funding under this Program is also available for expanded use projects including implementation of nonpoint source projects or programs and development and implementation of estuary comprehensive conservation and management plans.

The process for securing funds includes submitting a CWSRF application, in addition to additional water recycling project-specific application items. CWSRF loans typically have a lower interest rate than bonds, at half of the General Obligation bond (typically 2.5 percent to 3 percent, currently 2.1 percent) at the time of the Preliminary Funding Commitment. Loans are paid back over 20 or 30 years. Annually, the CWSRF program disburses $200 million to $300 million to agencies in California. There is now a $50 million maximum for each new project added to the CWSRF Fundable List. Repayment begins one year after construction is complete. SWRCB funds projects on a readiness-to-proceed basis. The application process can take up to 6 months; SWRCB recommends collecting required information and applying once the draft CEQA and additional federal requirements (i.e., CEQA+) documents, required resolutions, and financial package are completed. Historically, SWRCB has offered up to $3 million in principal forgiveness (PF) (i.e., grants) to applicants if the project directly benefits a disadvantaged community (DAC). It is anticipated PF/grants will be made available to DACs in the future. Guidelines for the amounts of PF/grants available to DACs are outlined in the annual Intended Use Plan released by SWRCB each year.

Projects may receive a combination of grant and low interest construction financing. The application process for construction grants and loans is the same and involves completion of an application package consisting of four separate applications to document general project information, financial security, technical project information, and environmental documentation and placement on the competitive funding list. The process is summarized in Figure 7-1. Projects can also apply for planning grants to fund the construction grant application process along with any other planning or design needs.

More information about the SWRCB CWSRF Program can be found at:
http://www.waterboards.ca.gov/water_issues/programs/grants_loans/srf/srf_forms.shtml.

5.2.1.2.3 Facility Construction Grants

The SWRCB administers a grant program to cover construction of recycled water facilities. Per the SWRCB's WRFP Guidelines adopted on June 16, 2015, a construction grant can cover 35% of eligible construction costs up to $15 million, including construction allowances. Eligible costs include construction allowances which may include engineering during construction, construction management, and contingencies limited to 15% of the construction grant value. To be eligible to receive grant funds, at least a 50% local cost share match must be provided. In the past, WRFP grant funding came from Proposition 1, but the $725 million available for recycled water and desalination projects has been exhausted. It is possible the funding could be replenished through another source in the future, such as Proposition 68, the Parks, Environment, and Water Bond approved in June 2018.

A CWSRF application would be submitted, and SWRCB would award the project the best package of funding available at the time of financing agreement execution, which could be a combination of a low-interest loan, grant funding, and/or principal forgiveness.

5.2.1.3 Infrastructure State Revolving Fund (ISRF) Program – I-Bank

The ISRF Program provides low-interest loan financing to public agencies for a wide variety of infrastructure projects such as water supply, parks and recreation facilities, sewage collection and treatment, and water treatment and distribution projects. Funding is available in amounts up to $25 million with loan terms up to 30 years. The interest rate is set at the time the loan is approved. Eligible applicants include cities, counties, special districts, assessment districts, joint powers authorities, and nonprofit organizations. Applicants must demonstrate project readiness and feasibility to complete construction within two years after I-Bank loan approval. Additionally, eligible projects must promote economic development and attract, create, and sustain long-term employment opportunities. There is no required match; however, there is a one-time origination fee of 1% of the ISRF financing amount or $10,000, whichever is greater. Applications are accepted on a continuous basis. The I-Bank recommends applications be submitted upon completion of design, as construction must begin within six months of the I-Bank's loan commitment.

More information about the ISRF Program can be found here: http://www.ibank.ca.gov/infrastructure-state-revolving-fund-isrf-program/.

5.2.2 Construction Financing and Cash Flow

The Phase 2 total capital cost is about $16.3M. The anticipated cash flow over the implementation period of the recommended project is about $1.6M per year for 10 years. Costs were summarized as part of Section 4, and the unit cost for water at this feasibility is $8,200/AF. As grants and loans become available to the Recommended Project, rates and charges will be refined. Additionally, the District is in the process of establishing reclaimed water connection and user fees, which will also help offset the capital cost.

5.3 Preliminary Environmental Review

All public projects in California must comply with the CEQA. If a project is not exempt, CEQA provides for the preparation of an Initial Study to analyze whether the project would have a significant impact upon the environment. A Negative Declaration/Mitigated Negative Declaration could be issued if the analysis in the Initial Study determines that the project or action, as proposed or as proposed with specific mitigation measures, would not have a significant impact upon the environment. If the analysis in the Initial Study determines that the project or action has the potential to result in a significant impact(s) to the environment, then an Environmental Impact Report (EIR) would need to be prepared to further address such impacts. If the Initial Study determines that impacts can be reduced to less than significant levels with implementation of mitigation measures, then a Mitigated Negative Declaration can be prepared, and is a shorter process than preparation of an EIR. Based on a preliminary review, it is likely that the District can prepare a Mitigated Negative Declaration for the project, but would be confirmed during the Initial Study phase when preliminary designs for the project are available. In addition to CEQA, a project is subject to National Environmental Policy Act (NEPA) if it is jointly carried out by a federal agency, requires a federal permit, entitlement, or authorization, requires federal funding, and/or occurs on federal land. The SWRCB SRF loan program (see Section 5.2.1 for further discussion) is partially funded by the U.S. Environmental Protection Agency and, as a result, requires additional environmental documentation beyond CEQA – but not as extensive as NEPA – that is referred to as "CEQA-Plus."

5.4 Engineering, Design, and Construction Activities

The new facilities for the Recommended Project were presented in Section 4.2. This section discusses the effort needed to develop and implement the capital improvement projects identified for the Recommended Project, including advanced water treatment facilities, conveyance pump stations, pipelines, and recycled water storage.

5.4.1 Pre-Design Report

Detailed facilities plans would be prepared for all the new facilities identified for the project, including facilities layouts for the advanced water treatment facilities, conveyance pump stations, pipeline alignments, and recycled water storage. The plans would also include revised capital and O&M cost estimates based on vendor quotes and proposals. During pre-design, the conceptual design developed in this report would be further developed, and assumptions would be updated, validated and documented. The draft pre-design report is anticipated to take approximately six months.

5.4.2 Final Design

Following preliminary design, design packages would be prepared for the advanced water treatment facilities. Design for the conveyance pump stations and pipelines could proceed independently of the advanced water treatment facility design. The advanced water treatment facilities design is expected to be completed within six to ten months. A bid package (after permitting is completed) could be prepared in two months.

5.4.3 Bidding/Contract Award, Construction, and Startup

Bidding and contract award would commence once the bid package is complete. These tasks are assumed to take three months. The bidding and contract award period is defined as starting from when the bid package is sent for advertisement to the day that the notice to proceed to the contractor is issued. Construction of the advanced water treatment facilities, conveyance pump stations, and conveyance pipelines is anticipated to take one year. The startup period and final approvals of the advanced water treatment facilities and overall project are anticipated to take three months.

5.5 Implementation Schedule

Full implementation of the Phase 2 project is anticipated to take approximately 10 years, and implementation of the Phase 2 pipe will occur simultaneously with the sewer improvements. In summary, all the preliminary studies required to further refine the project need to be completed in order to: 1) prepare the Engineering Report for DDW; 2) initiate environmental documentation; and 3) refine project cost estimates. The environmental documentation should be done in parallel with the Engineering Report.

From a project funding and financing perspective, CEQA certification is the critical path for gaining preliminary approval for grant funding and low-interest loans from the SWRCB. From a project start-up perspective, the Engineering Report approval is the critical path for acquiring a recycled water permit from the San Francisco Bay Regional Water Quality Control Board (RWQCB), which is needed prior to start of operations. CEQA certification is also needed before the RWQCB can issue the tentative permit.

Design of the infrastructure improvements would continue after completion of the relevant preliminary studies in coordination with CEQA and permitting efforts. Applications for funding and stakeholder/public outreach efforts would occur over the lifetime of the project.

6. CONCLUSION AND NEXT STEPS

The possibility of a Bayfront Recycled Water Facility was first presented in the WBSD 2014 Recycled Water Facilities Plan, which identified the Sharon Heights Recycled Water Project as the recommended alternative. Increasing interest in recycled water from potential customers in the Bayfront led to the preparation of the Bayfront RWFP to reassess and update potential demands and alternatives to serve the area. The facilities in the Bayfront, or the Phase 1 facilities, are currently being designed.

The desire to identify optimal areas for additional recycled water distribution pipe beyond Phase 1, such that installation could occur simultaneously with sewer improvement projects in WBSD's service area, led to the development of this TM, which builds upon the Bayfront RWFP to present an extension of the Recycled Water Project, or Phase 2, south of Bayfront to larger customers including Flood Park, Parkline (SRI International), Menlo-Atherton High School, and Veteran's Administration.

Customers include new commercial and residential development planned as well as existing customers. Some of these customers will include indoor use for dual-plumbing systems with demands largely outside of the peak irrigation season and hours and year-round demands. The City and WBSD have been working together to evaluate potential recycled water projects. The City has expressed support for the recycled water project, and WBSD is going to be both the producer and purveyor of recycled water.

The Bayfront Recycled Water Facility and Sharon Heights Recycled Water Project will support the statewide water conservancy efforts by providing a reliable source of water and offsetting potable water use within the Menlo Park Municipal Water Service area, which will also offset the demand in the SFPUC Hetch Hetchy water system. However, the economics of the Phase 2 project will require securing outside funding (e.g. grant funding or new development contributions) to lower the estimated unit cost ($8,200/AF) to an acceptable level.

The project has the ability to expand in the future to incorporate Phase 3 pipeline. This TM also presents preliminary costs for Phase 3, which would expand the recycled water distribution to customers farther south surrounding Downtown Menlo Park and east along Middlefield Rd and Willow Rd. It is important to note that the addition of Phase 3 would require additional treatment capacity beyond 1 MGD. In addition, Phase 3 would require a high-pressure system of about 150 psi. To counteract this, the District could install a booster pump at another location midway through the Phase 2 and Phase 3 system or reduce the service pressure and require some users to boost in order to receive the minimum 70 psi delivery pressure. WBSD is continuing coordination with the City to determine next steps in project planning.

7. REFERENCES

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APPENDIX A: 2023 RECYCLED WATER CUSTOMERS LIST

2023 Recycled Water Customers List

							Average Annual Demand (AFY)				Average Annual Demand (MG)					
Project Name	Type of Use	Project Address	City	Total Site Area	Irrigated Area	Commercial Space	Irrigation Demand	Flushing Demand	Cooling Demand	Total Demand	Irrigation Demand	Flushing Demand	Cooling Demand	Total	Associated Pipe Segment*	Method(s) Used
Menlo Gateway Phase I	Office	100 Independence Dr	Menlo Park	4.08	0.41	177,640	1.35	7.38	2.34	11.07	0.44	2.40	0.76	3.61	Phase 1	Method 3, Method 4
Menlo Gateway Phase II	Office	101 and 155 Constitution Dr	Menlo Park	8.30	0.83	495,000	2.74	20.56	6.53	29.83	0.89	6.70	2.13	9.72	Phase 1	Method 3, Method 4
1010 Alma St	Office	1010 Alma St	Menlo Park	0.70	0.07	25,156	0.23	1.04	0.33	1.61	0.08	0.34	0.11	0.52	Phase 3	Method 3, Method 4
650 Live Oak Ave	Office	650 Live Oak Ave	Menlo Park	0.69	0.41	16,854	1.36	0.70	0.22	2.28	0.44	0.23	0.07	0.74	Phase 3	Method 3, Method 4
Facebook Expansion Project	Office/Hotel	301 Constitution Dr	Menlo Park			962,400	11.97	15.20	4.50	31.68	3.90	4.95	1.47	10.32	Phase 1	Method 3, Method 4
1430 O'Brien Dr	R&D/Restaurant/Recreation	1430 O'Brien Dr	Menlo Park	1.71	0.17	18,506	0.56	0.77	0.24	1.58	0.18	0.25	0.08	0.51	Phase 1	Method 3, Method 4
Guild Theater	Entertainment	949 El Camino Real	Menlo Park			10,854	0.00	0.45	0.14	0.59	0.00	0.15	0.05	0.19	Phase 3	Method 3, Method 4
506 Santa Cruz Ave, 556 Santa Cruz Ave, 1125 Merrill St	Office	506 Santa Cruz Ave, 556 Santa Cruz Ave, 1125 Merrill St	Menlo Park	0.97	0.10	26,843	0.32	1.11	0.35	1.79	0.10	0.36	0.12	0.58	Phase 3	Method 3, Method 4
Hotel Nia	Hotel	200 Independence Dr	Menlo Park	3.84	0.38	68,258	1.27	0.00	0.90	2.17	0.41	0.00	0.29	0.71	Phase 1	Method 3, Method 4
Park James Hotel	Hotel	1400 El Camino Real	Menlo Park	0.49	0.05	9,631	0.16	0.00	0.13	0.29	0.05	0.00	0.04	0.09	Phase 3	Method 3, Method 4
Stanford - 500 El Camino Real	Residential/Office/Retail/ Restaurant	500 El Camino Real	Menlo Park		1.37	153,126	4.51	6.36	2.02	12.89	1.47	2.07	0.66	4.20	Phase 3	Method 3, Method 4
Springline	Residential/Office/Retail/ Personal Service	1300 El Camino Real	Menlo Park	0.96	0.10	224,103	0.32	9.31	2.96	12.58	0.10	3.03	0.96	4.10	Phase 3	Method 3, Method 4
1021 Evelyn St.	Residential/Office	1021 Evelyn St.	Menlo Park	0.26	0.03	6,610	0.09	0.27	0.09	0.45	0.03	0.09	0.03	0.15	Not Included	Method 3, Method 4
Stanford - 2111 Sand Hill Road	Office/Residence	2111 Sand Hill Road	Menlo Park	1.54	0.15	87,034	0.51	3.61	1.15	5.27	0.17	1.18	0.37	1.72	Not Included	Method 3, Method 4
40 Middlefield Rd	Office	40 Middlefield Rd	Menlo Park	0.08	0.01	3,584	0.03	0.15	0.05	0.23	0.01	0.05	0.02	0.07	Phase 3	Method 3, Method 4
115 El Camino Real	Residential/Retail/Personal Service/Non-Medical Office	115 El Camino Real	Menlo Park	0.21	0.02	1,543	0.07	0.06	0.02	0.16	0.02	0.02	0.01	0.05	Phase 3	Method 3, Method 4
409 Glenwood Ave	Residential	409 Glenwood Ave	Menlo Park		0.17	0	0.55	0.00	0.00	0.55	0.18	0.00	0.00	0.18	Not Included	Method 3, Method 4
1350 Adams Court	R&D	1350 Adams Court	Menlo Park		0.24	260,400	13.80	16.40	0.00	30.20	4.50	5.34	0.00	9.84	Phase 1	Method 2
Willow Village	Residential/Office/Retail/ Hotel	1350 Willow Road	Menlo Park			1,800,000	67.52	85.93	24.55	178.00	22.00	28.00	8.00	58.00	Phase 1	Method 2
111 Independence Drive	Residential/Retail	111 Independence Drive	Menlo Park	0.92	0.04	746	0.13	0.03	0.01	0.17	0.04	0.01	0.00	0.06	Phase 1	Method 3, Method 4
1125 O'Brien Drive	R&D/Retail/Non-Office Commercial	1125 O'Brien Drive	Menlo Park		0.28	131,285	0.94	5.45	1.73	8.12	0.31	1.78	0.56	2.65	Phase 1	Method 3, Method 4
Commonwealth Corporate Center	Commercial Office	162 Jefferson Dr	Menlo Park	5.73	2.05	249,500	2.56	0.00	0.00	2.56	0.83	0.00	0.00	0.83	Not Included	Method 3, Method 4
706 Santa Cruz Avenue	Residential/Office/Retail	706 Santa Cruz Avenue	Menlo Park			35,489	0.04	1.47	0.47	1.98	0.01	0.48	0.15	0.65	Phase 3	Method 3, Method 4
MidPen	Residential	1345 Willow Road	Menlo Park		0.77	0	2.53	0.00	0.00	2.53	0.82	0	0	0.82	Phase 1	Method 2

2023 Recycled Water Customers List

							Average Annual Demand (AFY)				Average Annual Demand (MG)					
Project Name	**Type of Use**	**Project Address**	**City**	**Total Site Area**	**Irrigated Area**	**Commercial Space**	**Irrigation Demand**	**Flushing Demand**	**Cooling Demand**	**Total Demand**	**Irrigation Demand**	**Flushing Demand**	**Cooling Demand**	**Total**	**Associated Pipe Segment**	**Method(s) Used**
201 El Camino Real	Residential/Retail/Restaurant	201 El Camino Real	Menlo Park	0.40	0.14	7,076	0.12	0.29	0.09	0.50	0.04	0.10	0.03	0.16	Phase 3	Method 3, Method 4
Menlo Uptown	Residential/Retail/Non-Office Commercial	141 Jefferson Drive	Menlo Park			2,940	3.38	4.29	1.27	8.94	1.10	1.40	0.41	2.91	Phase 1	Method 2
1162 El Camino Real	Residential	1162 El Camino Real	Menlo Park	0.19	0.02	0	0.06	0.00	0.00	0.06	0.02	0	0	0.02	Phase 3	Method 3, Method 4
Hotel Moxy	Hotel	3723 Haven Ave	Menlo Park	0.76	0.15	58,027	0.51	0.00	0.77	1.27	0.17	0.00	0.25	0.42	Phase 1	Method 3, Method 4
Menlo Portal Project	Office/Retail/Non-Office Commercial	115 Independence Drive	Menlo Park			36,427	3.68	4.59	1.36	9.63	1.20	1.49	0.44	3.14	Phase 1	Method 2
(CitizenM Hotel CDP Amendment)	Hotel	301 Constitution Drive	Menlo Park	2.61	0.26	90,868	0.86	0.00	1.20	2.06	0.28	0.00	0.39	0.67	Phase 1	Method 3, Method 4
CSBio Phase 3	R&D/Office/Restaurant/Commercial	1075 O'Brien Drive and 20 Kelly Court	Menlo Park	0.70		124,454	2.24	0.00	2.24	4.48	0.73	0.00	0.73	1.46	Phase 1	Method 2
1550 El Camino Real	Residential/Office	1550 El Camino Real	Menlo Park	1.37	0.14	18,500	0.45	0.77	0.24	1.46	0.15	0.25	0.08	0.48	Phase 3	Method 3, Method 4
Menlo Flats	Residential/Commercial	165 Jefferson Drive	Menlo Park			15,000	1.84	2.37	0.70	4.91	0.60	0.77	0.23	1.60	Phase 1	Method 2
Sobrato	Residential	123 Independence Drive	Menlo Park			0	0.43	0.00	0.00	0.43	0.14	0.00	0.00	0.14	Phase 1	Method 2
Parkline - SRI Master Plan	Residential/Office/Commercial/R&D	333 Ravenswood Ave	Menlo Park	63.22	30.30	1,379,545	99.99	0.00	18.20	118.18	32.58	0.00	5.93	38.51	Phase 2	Method 3, Method 4
995-1005 O'Brien Drive and 1320 Willow Road	Office/R&D	995-1005 O'Brien Drive and 1320 Willow Road	Menlo Park	4.22	0.78	227,998	2.57	9.47	3.01	15.05	0.84	3.09	0.98	4.90	Phase 1	Method 3, Method 4
Philips Brooks School Gymnasium/Flex Building	Recreational/Educational	2245 Avy Avenue	Menlo Park	8.01	0.15	15,011	0.49	0.62	0.20	1.31	0.16	0.20	0.06	0.43	Not Included	Method 3, Method 4
1220 Hoover Street	Residential	1220 Hoover Street	Menlo Park	0.30	0.03	0	0.10	0.00	0.00	0.10	0.03	0.00	0.00	0.03	Phase 3	Method 3, Method 4
3705 Haven	Residential	3705 Haven	Menlo Park	0.66	0.10	0	0.32	0.00	0.00	0.32	0.10	0.00	0.00	0.10	Phase 1	Method 3, Method 4
1030 O'Brien	R&D/Office & Commercial	1030 O'Brien	Menlo Park	3.58	0.41	154,641	1.36	6.42	2.04	9.82	0.44	2.09	0.66	3.20	Phase 1	Method 3, Method 4
Veteran's Administration	Residential/Commercial	795 Willow	Menlo Park	0.38	0.04	0	20.00	0.00	20.00	40.00	6.52	0.00	6.52	13.03	Phase 2	Method 3, Method 4
4055 Bohannon Drive	R&D	4055 Bohannon Drive	Menlo Park	4.69	0.47	33,300	1.55	1.38	0.44	3.37	0.50	0.45	0.14	1.10	Not Included	Method 3, Method 4
985 Santa Cruz Avenue	Residential	985 Santa Cruz Avenue	Menlo Park	0.23	0.02	0	0.08	0.00	0.00	0.08	0.03	0.00	0.00	0.03	Not Included	Method 3, Method 4
Menlo Park Community Campus (MPCC)	Multi-Service Public Facility	100 Terminal Ave	Menlo Park	0.8494		37,000	1.29	0.83	0.00	2.12	0.42	0.27	0.00	0.69	Phase 1	Method 2
Facebook MPK 20	Office	1 Meta Way	Menlo Park	9.95305		433,555	73.65	9.15	2.71	85.51	24.00	2.98	0.88	27.86	Phase 1	Method 2
Facebook MPK 21 & 22	Office	305 Constitution Dr.	Menlo Park	22.4977		980,000	31.92	40.96	0.00	72.87	10.40	13.35	0.00	23.75	Phase 1	Method 2
Facebook MPK 23	Office	300 Constitution Dr.	Menlo Park	4.13223		180,000	2.46	14.20	4.21	20.87	0.80	4.63	1.37	6.80	Phase 1	Method 2
Menlo College	Commercial - Business	1000 El Camino Rd	Atherton				15.00	0.00	0.00	15.00	4.89	0.00	0.00	4.89	Phase 3	Method 1
Caltrans	Farm - Irrigation	100 Independence Dr	Menlo Park				12.67	0.00	0.00	12.67	4.13	0.00	0.00	4.13	Phase 1	Method 1
Burgess Park	Farm - Irrigation	601 Laurel St	Menlo Park				10.38	0.00	0.00	10.38	3.38	0.00	0.00	3.38	Phase 3	Method 1
Menlo Atherton High School	Commercial - Public Authority	555 Middlefield Rd	Atherton				4.37	0.00	0.00	4.37	1.42	0.00	0.00	1.42	Phase 2	Method 1
USGS	Commercial - Public Authority	345 Middlefield Rd	Menlo Park				10.00	0.00	10.00	20.00	3.26	0.00	3.26	6.52	Phase 3	Method 1
Arrillage Family Gymnasium	Farm - Irrigation	600 Alma St	Menlo Park				7.38	0.00	0.00	7.38	2.40	0.00	0.00	2.40	Phase 3	Method 1

2023 Recycled Water Customers List

							Average Annual Demand (AFY)				Average Annual Demand (MG)					
Project Name	**Type of Use**	**Project Address**	**City**	**Total Site Area**	**Irrigated Area**	**Commercial Space**	**Irrigation Demand**	**Flushing Demand**	**Cooling Demand**	**Total Demand**	**Irrigation Demand**	**Flushing Demand**	**Cooling Demand**	**Total**	**Associated Pipe Segment**	**Method(s) Used**
Bohannon Development	Commercial - Business	1020 Marsh Rd	Menlo Park				1.42	0.00	0.00	1.42	0.46	0.00	0.00	0.46	Not Included	Method 1
Safeway Inc.	Commercial - Business	525 El Camino Real	Menlo Park				13.90	0.00	0.00	13.90	4.53	0.00	0.00	4.53	Phase 3	Method 1
Willow Oaks Park	Farm - Irrigation	490 Willow Rd	Menlo Park				5.52	0.00	0.00	5.52	1.80	0.00	0.00	1.80	Phase 3	Method 1
St. Patrick's Seminary	Commercial	320 Middlefield Rd	Menlo Park				50.00	0.00	0.00	50.00	16.29	0.00	0.00	16.29	Phase 3	Method 1
Round Meadow Farm	Commercial/Recreation	190 Park Ln	Atherton				26.00	0.00	0.00	26.00	8.47	0.00	0.00	8.47	Phase 3	Method 1
Flood Park	Park	215 Bay Rd	Menlo Park				20.00	0.00	0.00	20.00	6.52	0.00	0.00	6.52	Phase 2	Method 1
Holbrook Palmer Park	Park	150 Watkins Ave	Atherton				10.00	0.00	0.00	10.00	3.26	0.00	0.00	3.26	Phase 3	Method 1
Encinal Elementary School	Commercial	195 Encinal Ave	Atherton				5.00	0.00	0.00	5.00	1.63	0.00	0.00	1.63	Phase 3	Method 1
MidPen High School	Commerical	1340 Willow Rd.	Menlo Park				2.05	0.00	0.00	2.05	0.67	0.00	0.00	0.67	Phase 1	Method 1
					Total		**557**	**272**	**117**	**946**	**181**	**89**	**38**	**308**		
Key																
Hard entry														**0.84**		
Groundwater users																

*Customers not included are not within 1,000 feet of the planned/proposed pipelines.

APPENDIX B: RECYCLED WATER CUSTOMERS FROM THE BAYFRONT RWFP

Recycled Water Customers from the 2019 RWFP

Address Consolidated	City	ZIP	General Meter Type	Customer Name	Use Type	Potable Water Usage (AFY)	% RW Usage	Potential RW Demand (AFY) - Adjusted		MMD		PHD	Notes
				ConnectMenlo	Irrigation			104	2.0	0.186	3.0	0.557	
				ConnectMenlo	Multi-Use			101	1.5	0.135	0.0	0.000	
100 independence dr	Menlo Park	94025	Farm - Irrigation	Caltrans	Irrigation	13	100%	12.7	2.0	0.023	3.0	0.068	
1 hacker way	Menlo Park	94025	Commercial - Business	Facebook East	Irrigation								
									2.0	0.000	3.0	0.000	
1320 willow rd	Menlo Park	94025	Commercial - Industrial	Mid Peninsula High School	Irrigation	4	50%	2.1	2.0	0.004	3.0	0.011	
1020 Marsh Rd	Menlo Park	94025	Commercial - Business	David Bohannon Organizatio	Irrigation	14	10%	1.4	2.0				Not part of Alternatives due to location
215 Bay Rd	Menlo Park	94025		Flood Park	Groundwater - Irrigation		GW	20.0	2.0				Not part of Alternatives due to location
320 Middlefield Rd	Menlo Park	94025		St. Patricks Seminary	Groundwater - Irrigation		GW	50.0	2.0	0.089	3.0	0.268	
795 willow rd	Menlo Park	94025	Commercial - Public Authority	Menlo Park VA Medical Cent	Multi-Use	111	est	40.0	2.0	0.071	1.5	0.107	20 for IRR; 20 for cooling towers
490 willow rd	Menlo Park	94025	Farm - Irrigation	Willow Oaks Park	Irrigation	6	100%	5.5	2.0	0.010	3.0	0.030	
345 Middlefield Rd 3	Menlo Park	94025	Commercial - Public Authority	USGS	Multi-Use	19	est	20.0	2.0	0.036	1.5	0.054	private wells for irrigation (10) + cooling towers (10)
555 Middlefield Rd.	Atherton	94027	Commercial - Public Authority	Menlo-Atherton High School	Irrigation	17	25%	4.4	2.0	0.008	3.0	0.023	
190 Park Ln	Atherton	94027		Menlo Circus Park	Groundwater - Irrigation		GW	26.0	2.0	0.046	3.0	0.139	
1000 El Camino Real	Atherton	94027	Commercial - Business	Menlo College	Groundwater - Irrigation	49	GW	15.0	2.0	0.027	3.0	0.080	
333 Ravenswood Ave	Menlo Park	94025	Commercial - Business	S R I International	Irrigation	134	10%	13.4	2.0	0.024	3.0	0.072	
601 laurel st	Menlo Park	94025	Farm - Irrigation	Burgess Park	Irrigation	10	100%	10.4	2.0	0.019	3.0	0.056	
150 Watkins Ave	Atherton	94027		Holbrook Palmer Park	Groundwater - Irrigation		GW	10.0	2.0	0.018	3.0	0.054	
600 alma st	Menlo Park	94025	Farm - Irrigation	Arrillaga Family Gymnasium	Irrigation	7	100%	7.4	2.0	0.013	3.0	0.040	
195 Encinal Ave	Atherton	94027		Encinal Elementary School	Groundwater - Irrigation		GW	5.0	2.0	0.009	3.0	0.027	
525 El Camino Real	Menlo Park	94025	Commercial - Business	Safeway, Inc.	Irrigation	14	10%	1.4	2.0	0.002	3.0	0.007	
					Subtotal Alt A			**220**		**0.35**		**0.64**	
					Subtotal Alt B			**340**		**0.56**	0.91	**1.12**	1.75
					Subtotal Alt C			**428**		**0.72**		**1.59**	
										0.35			
										0.22	0.58		
										0.17			
										0.75			

Removed
- 100 Independece, David Bohannon Org because RW demand was close to 0 AFY RW demand.
- 300 Constitution, Tyco Corp; 1 Facebook, Hines because Facebook is using/going to use this building (part of ConnectMenlo development).
- 1320 Willow, Balco because RW demand was close to 0 AFY RW demand.
- 190 Jefferson, Intuit (Facebook) because it's part of ConnectMenlo.

From file Combined Data 2014-2016_10-24 "\\woodardcurran.net\shared\Projects\RMC\SF\0606 West Bay Sanitary District\0606-008 - WBSD Bayfront RW Facilities Plan\2. Project Work\3. Market Assessment\1. Data Analysis\Combined Data 2014-2016_10-24.xlsx", tab Bayfront Top Customers. We are not considering those customers in groups B and F. Note: Group A is Alt A, Group D is Alt B, and

APPENDIX C: RECYCLED WATER CUSTOMERS FROM THE BAYFRONT RECYCLED WATER PROJECT 2021 UPDATE

Recycled Water Customers - Bayfront Recycled Water Project 2021 Update

WBSD Bayfront - Recycled Water Estimated Demands
Date **9/7/2021**

Source: W&C 2021.09.07 RW Demand Data with Buy-In Cost_0.4MGD&0.6MGD

Plant Capacity (MGD)		0.4
Peaking factor (peak month/average day)		1.5
Estimated Site/Land/Upfront WBSD Investment	$	-
Estimated Cost for Plant and Distribution System	$	56,600,000
Total Estimated Cost	$	56,600,000

Table 2: Annual Average Recycled Water Demand by Use

Project/Developer	Irrigation		Cooling		Toilet Flushing		Total	
	(MG)	(%)	(MG)	(%)	(MG)	(%)	(MG)	(%)
Willow Village (Signature)	22	38%	8	14%	28	48%	58	100%
123 Independence (Sobrato)	0.14	100%					0	100%
Commonwealth 3 (Sobrato)								
1350 Adams (Tarlton)	4.2	44%	0.0	0%	5.3	56%	9.5	100%
Menlo Portal (Greystar)	1.2	38%	0.4	14%	1.5	48%	3.1	100%
Menlo Uptown (Greystar)	1.1	38%	0.4	14%	1.4	48%	2.9	100%
Menlo Flats (Greystar)	0.6	38%	0.2	14%	0.8	48%	1.6	100%
CS Bio	0.73	50%	0.73	50%	0.00	0%	1.46	100%
Mid Pen	0.0		0.0		0.0		0.0	0%
WBSD Extra Capacity								
Subtotal (New Development)	**30**	**32%**	**10**	**11%**	**37**	**40%**	**77**	**83%**
Menlo Park Community Center (KPFF)	0.42	60%	0.0	0%	0.27	39%	0.69	99%
Subtotal (New Development+MPCC)	**30**	**33%**	**10**	**11%**	**37**	**40%**	**77**	**83%**
Facebook Campus Expansion	3.9	38%	1.5	14%	5.0	48%	10	100%
Facebook MPK 20	24	86%	0.88	3%	3.0	11%	28	100%
Facebook MPK 21 & 22	10.4	44%	0	0%	13.3	56%	24	100%
Facebook MPK 23	0.80	12%	1.4	20%	4.6	68%	6.8	100%
Subtotal (Existing Development)	**39**	**57%**	**4**	**5%**	**26**	**38%**	**69**	**100%**
Total (MG)	**70**	**43%**	**14**	**8%**	**63**	**39%**	**146**	**90%**

Notes:

General Notes
- Estimates are based on annual average demands.
- Willow Village (Signature) provided breakdowns by use of non-potable water demands.
- Estimates for 1350 Adams (Tarlton) and all 3 Greystart projects are calculated using Willow Village (Signature) data.
- Tarlton estimates do not include cooling as non-potable demand use estimate does not include cooling.
- Facebook Campus Extension irrigation, cooling, and toilet flushing estimates are calculated using Willow Village (Signature) data.
- MPK 20, and MPK 23 cooling and toilet flushing estimates are calculated using Willow Village (Signature) data.
- See ConnectMenlo+FB Demands tab for MPK 20 and MPK 23 demand analysis.

Recycled Water Customers - Bayfront Recycled Water Project 2021 Update

- Facebook MPK 21 and MPK 22 irrigation and toilet flushing estimates are calculated using Willow Village (Signature) data. Cooling demand data not available.
- Menlo Park Community Center (KPFF) provided non-potable water demands for irrigation and toilet flushing. Estimates provided on 7/27/2021.
- Independence 123 (Sobrato) demand is for irrigation only.
- Demand values were provided by developers and Menlo County Club on 9/16/2020.
- The non-potable demand values provided by Signature for Willow Village are used to calculate a peaking factor to calculate other projects' peak month demands.
- The peak month is assumed to be July.

<u>Willow Village (Signature)</u>
- Previous meeting peak month demand estimate provided was 0.16 - 0.18 MGD.
- Previous peak month demand estimated was an average of the range 0.21 - 0.26 MGD provided on 9/16/2020.
- Annual average non-potable demand breakdown provided on 9/16/2020: 27 MG toilet flushing, 21 MG irrigation, and 8 MG cooling.
- EKI provided updated annual, average day, and average day peak month data and anticipated % of annual average demand information on 10/19/2020.

<u>123 Independence (Sobrato)</u>
- Peak month demands provided are assumed to be non-potable water. Updated on 7/20/2021 to only includes peak estimates provided on 9/16/2020 for open space 12,000 gal, off-site 6,000 gal.
- Anticipated percentage of annual average demand needed not provided by developer. Estimate assumes 100% by 2027.
- Project was updated to be all residential.

<u>Commonwealth 3 (Sobrato)</u>
- Water demand data were not provided by developer during 7/15/2021 meeting.

<u>1350 Adams (Tarlton)</u>
- Tarlton provided the following annual average demand values: 41 MG potable, 9.5 MG non-potable (irrigation + toilet flushing).
- Anticipated percentage of annual average demand needed not provided by developer. Estimate assumes 100% by 2027.

<u>Greystar</u>
- Greystar provided updated total demands for the 3 projects anticipated % of annual averaga demand information during meeting on 10/20/2020.

<u>Facebook</u>
- See tab ConnectMenlo+FB Demands tab for demand analysis for Facebook Campus Expansion, MPK 20, and MPK 23.
- It is assumed that all buildings have dual-plumbing.
- For MPK 21 and MPK 22, we assumed an average demand of 65,000 gpd for irritaion and toilet flushing combined for both buildings.

<u>CS Bio</u>
- CS Bio provided demand information during meeting on 10/23/2020.

<u>Mid Pen</u>
- Meeting with Mid Pen took place on 10/21/2020. Demand data were not available.

<u>Menlo Park Community Center (KPFF)</u>
- Meeting with KPFF and Facebook took place on 6/29/2021. Estimated total annual demand provided: irrigation demand 0.42 MG; toilet flushing demand 0.27 MG; total demand 0.69 MG on 7/27/2021.

<u>Sharon Heights Capacity Information (for reference only)</u>

Peak Hour/Day (MGD)	0.9
Average Day (MGD)	0.14
Peak Month (MGD)	0.5
Annual Average (MG)	50

Recycled Water Customers - Bayfront Recycled Water Project 2021 Update

ConnectMenlo and Facebook Estimated Demand Data

Source: W&C 2021.09.07 RW Demand Data with Buy-In Cost_0.4MGD&0.6MGD

Sources of data: Water Supply Evaluation Study, ConnectMenlo - General Plan and M-2 Area Zoning Update prepared by Erler & Kalinowski, Inc (Feb 3, 2016); Water Supply Assessment Study - Facebook Campus Expansion prepared by EKI (Feb 3, 2016); Menlo Park water use data 2015-2016 (provided by WBSD)

Total water demand for Bayfront area at buildout by 2040 - 343 MG per year

For the Facility Plan, we assumed 1/3 of the non-residential indoor uses are non-potable and 100% of all outdoor uses are non-potable.

The values presented are averages.

Non-potable portion of indoor demand	0.33
Peaking factor (peak month/average day)	1.50 *(from Bayfront RW Demands tab)*

Table 1. ConnectMenlo Estimated Water Demand

Demand	Total Indoor Non-residential	Total Indoor Transit Center	Total Outdoor Multi-family Residential	Total Outdoor Non-residential	TOTAL
Total Annual (MG)	99	0.4	10	24	**133**
Total Annual (AF)	304	1.23	30.7	73.7	**409**
Avg Day (MGD)	0.27	0.0011	0.027	0.066	**0.37**

Table 1 Notes

Source: EKI's General Plan report

The estimates do NOT include Facebook Building MPK 20 and Building MPK 23

The estimates do NOT include Facebook Campus Expansion (approximate total annual water demand = 88 MG)

Table 2. ConnectMenlo Estimated Non-potable Water Demand

Demand	Non-potable Indoor Non-residential (Excludes	Non-potable Indoor Transit Center	Non-potable Outdoor Multi-family Residential	Non-potable Outdoor Non-residential	TOTAL (Non-potable)
Total Annual (MG)	33	0.32	10	24	**67**
Total Annual (AF)	101	0.98	30.7	73.7	**207**
Avg Day (MGD)	0.090	0.00088	0.027	0.066	**0.18**
Avg Day Peak Month (MGD)	0.136	0.00132	0.041	0.099	**0.28**

Table 2 Notes

Source: EKI's General Plan report

The EKI report included a breakdown of water use for indoor Transit Center. The estimated non-potable demand is a sum of toilet flushing and urinal water demands.

Table 3. Facebook Estimated Water Demand

	Campus Expansion			Building MPK 23			Building MPK 20 (average of 2015-2016 water use data)			
Demand	**Total Indoor**	**Total Outdoor**	**Subtotal**	**Total Indoor**	**Total Outdoor**	**Subtotal**	**Total Domestic Meter**	**Total Irrigation Meter**	**Subtotal**	**TOTAL**
Total Annual (MG)	81	7	88	18.00	0.8	19	12	24	36	**143**
Total Annual (AF)	249	21	270	55	2	58	36	75	110	**438**
Avg Day (MGD)	0.22	0.019	0.24	0.05	0.0022	0.052	0.03	0.0666	0.098	**0.39**

Recycled Water Customers - Bayfront Recycled Water Project 2021 Update

Table 3 Notes

Sources: EKI's General Plan report and Facebook Campus Expansion report; Menlo Park water use data provided by WBSD (see above note)

Facebook Campus Expansion does not include Willow Village

Facebook Campus Expansion includes Building MPK 21, MPK 22, and a hotel.

Building MPK 20 is NOT included in either ConnectMenlo or Campus Expansion's demand estimates; it was a project approved under the prior General Plan.

Table 4. Facebook Estimated Non-potable Water Demand

	Campus Expansion			Building MPK 23			Building MPK 20 (average of 2015-2016 water use data)			
Demand	Non-potable Indoor	Non-potable Outdoor	Subtotal Non-potable	Non-potable Indoor	Non-potable Outdoor	Subtotal Non-potable	Domestic Meter Non-potable	Irrigation Meter	Subtotal Non-potable	TOTAL (Non-potable)
Total Annual (MG)	27	7	34	6	0.8	6.8	3.9	24	28	**69**
Total Annual (AF)	83	21	104	18	2	21	12	75	86	**212**
Avg Day (MGD)	0.074	0.019	0.093	0.016	0.0022	0.019	0.011	0.067	0.077	**0.19**
Avg Day Peak Month (MGD)	0.111	0.029	0.14	0.025	0.0033	0.028	0.016	0.100	0.116	**0.28**

Table 4 Notes

Sources: EKI's General Plan report and Facebook Campus Expansion report; Menlo Park water use data provided by WBSD

Building MPK 20 water use data from 2015-2016 were provided by WBSD (from Menlo Park) for the Bayfront Recycled Water Facilities Plan.

At the time the Bayfront Recycled Water Facilities Plan was developed, water use data for Buildings MPK 21 and MPK 22 were not available.

Building MPK 20 is NOT included in either ConnectMenlo or Campus Expansion's demand estimates; it was a project approved under the prior General Plan.

Table 5. Total Non-potable Demand - ConnectMenlo + Facebook Campus Expansion

Demand	Non-potable	Non-potable	TOTAL (Non-
Total Annual (MG)	70	66	**136**
Total Annual (AF)	215	203	**418**
Avg Day (MGD)	0.19	0.18	**0.37**
Avg Day Peak Month (MGD)	0.29	0.27	**0.56**

APPENDIX D: 2023 DEVELOPMENT PROJECTS LIST

2023 Development Projects List

Non-Residential and Hotel 2017-2021

Project Name/Address	Type of Use	Net New Square Footage		Project Name/Address	Type of Use	New Hotel Rooms
Commonwealth Corporate Center 162-164 Jefferson Dr	Office	240,747		Hotel Nia	Hotel	250
Menlo Gateway Phase I Independence Dr	Office	177,640		Park James Hotel	Hotel	61
Menlo Gateway Phase II Constitution Dr	Office	361,362				
1010-1026 Alma St	Office	25,156				
650-660 Live Oak Ave	Office	10,858				
Facebook Expansion Project 301-309 Constitution Dr	Office	835,388				
1430 O'Brien Dr	R&D	631				
1430 O'Brien Dr	Restaurant	7,652				
1430 O'Brien Dr	Recreation	10223				
Guild Theater 949 El Camino Real	Entertainment	6682				
505-556 Santa Cruz Ave	Office	17877				
1125 Merrill St	Office	4366				

2023 Development Projects List

List of Development Projects Based on Applications Received before May 31, 2023

PROJECT ADDRESS	TYPE OF USE	SIZE	UNITS OF MEASURE	APPROVED OR PENDING	STATUS As of May 31, 2023	PROJECT LOCATION
Facebook/Meta Expansion Project	Office	450,400	sf	Approved	Completed/Occupied	East of US 101
301-309 Constitution Dr	Office	512,000	sf	Approved	Completed/Occupied	
	Hotel	200	rooms	Approved	Under Construction	
	Hotel	174,800	sf	Approved	Hotel sf for reference only	
	Manufacturing	-308,142	sf	Existing	Demolished	
	R&D	-76,533	sf	Existing	Demolished	
	Office	-127,012	sf	Existing	Demolished	
Stanford	Residential	215	du	Approved	Under Construction	West Menlo/Downtown/El Camino Real
500 El Camino Real	Office	142,840	sf	Approved	Under Construction	
	Retail/Restaurant	10,286	sf	Approved	Under Construction	
	Temporary Art Gallery	-35,275	sf	Existing	Demolished	
	Auto Dealer (Vacant)	-35,270	sf	Existing	Demolished	
Springline	Residential	183	du	Approved	Completed	West Menlo/Downtown/El Camino Real
1300 El Camino Real	Office	199,054	sf	Approved	Completed/Partially occupied	
	Retail/Personal Service	25,049	sf	Approved	Completed/Partially occupied	
	Dance Studio	-3,800	sf	Existing	Demolished	
	Fast Food Restaurant	-1,200	sf	Existing	Demolished	
	Hardware Storage	-5,000	sf	Existing	Demolished	
1021 Evelyn St	Residential	3	du	Approved	Under Construction	West Menlo/Downtown/El Camino Real
(Old: 841 Menlo Ave)	Office	6,610	sf	Approved	Under Construction	
Stanford	Office	39,010	sf	Pending	Proposed Construction	Sharon Heights/Sand Hill
2111-2121 Sand Hill Road	Office	48,024	sf	Existing	Existing (Would Remain)	
	Residence	1	du	Existing	Existing (Would Remain)	
40 Middlefield Rd	Office	3,584	sf	Approved	Proposed Construction	West of US 101
115 El Camino Real	Residential	4	du	Approved	Under Construction	West Menlo/Downtown/El Camino Real
	Retail/personal service/non-medical office	1,543	sf	Approved	Under Construction	

2023 Development Projects List

List of Development Projects Based on Applications Received before May 31, 2023

PROJECT ADDRESS	TYPE OF USE	SIZE	UNITS OF MEASURE	APPROVED OR PENDING	STATUS As of May 31, 2023	PROJECT LOCATION
	Hotel	-13	rooms	Existing	Demolished	
409 Glenwood Ave.	Residential	7	du	Approved	Proposed Construction	West Menlo/Downtown/El Camino Real
	Residential	-2	du	Existing	Proposed Demo	
	Residential (Historic Home)	1	du	Existing	Existing (Would Remain)	
1350 Adams Court (1315 O'Brien Drive)	R&D	260,400	sf	Approved	Under construction	East of US 101
1350 Willow Road (Facebook Willow Village)	Residential	1,730	du	Approved	Proposed Construction	East of US 101
	Office	1,600,000	sf	Approved	Proposed Construction	
	Retail (Non Office Commercial)	200,000	sf	Approved	Proposed Construction	
	Hotel	193	rooms	Approved	Proposed Construction	
	Office/Lab	-390,663	sf	Existing	Proposed Demolition	
	Warehouse	-446,483	sf	Existing	Proposed Demolition	
	Warehouse/Office	-137,819	sf	Existing	Proposed Demolition	
111 Independence Drive	Residential	105	du	Approved	Proposed Construction	East of US 101
	Retail	746	sf	Approved	Proposed Construction	
	Office	-15,000	sf	Existing	Proposed Demolition	
1125 O'Brien Drive	R&D	128,525	sf	Pending	Proposed Construction	East of US 101
	Retail/Non-office commercial	2,760	sf	Pending	Proposed Construction	
	Office/Warehouse	-38,688	sf	Existing	Proposed Demolition	
	Warehouse (1 Casey)	-20,955	sf	Existing	Proposed Demolition	
162-164 Jefferson Drive (formerly 151 Commonwealth Drive)	Office	249,500	sf	Pending	Proposed Construction	East of US 101
706-716 Santa Cruz Avenue	Residential	4	du	Approved	Proposed Construction	West Menlo/Downtown/El Camino Real
	Office	23,454	sf	Approved	Proposed Construction	
	Retail	12,035	sf	Approved	Proposed Construction	
	Retail/Restaurant/Bank	-15,175	sf	Existing	Proposed Demolition	

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1345 Willow Road	Residential	140	du	Approved	Under Construction	East of US 101
	Residential	-82	du	Existing	Demolished	
201 El Camino Real	Residential	14	du	Approved	Proposed Construction	West Menlo/Downtown/El Camino Real
	Retail	5,876	sf	Approved	Proposed Construction	
	Restaurant	1,200	sf	Approved	Proposed Construction	
	Residential	-4	du	Existing	Proposed Demolition	
	Commercial	-5,949	sf	Existing	Proposed Demolition	
141 Jefferson Drive	Residential	483	du	Approved	Under Construction	East of US 101
	Retail/Non-office commercial	2,940	sf	Approved	Under Construction	
(Menlo Uptown)	Industrial	-67,161	sf	Existing	Demolished	
	Industrial	-30,000	sf	Existing	Demolished	
	Industrial	-11,250	sf	Existing	Demolished	
1162 El Camino Real	Residential	9	du	Approved	Under Construction (Demo only)	West Menlo/Downtown/El Camino Real
	Commercial/Office/Retail	-11,062	sf	Existing	Demolished	
3723 Haven Ave	Hotel	163	rooms	Approved	Proposed Construction	East of US 101
	Hotel	58,027	sf	Approved	Hotel sf for reference only	
(Hotel Moxy)	Office/Warehouse	-13,700	sf	Existing	Proposed Demolition	
110 Constitution Drive	Residential	335	du	Approved	Under Construction	East of US 101
115 Independence Drive	Office	34,819	sf	Approved	Proposed Construction	
	Retail/non-office commercial	1,608	sf	Approved	Proposed Construction	
(Menlo Portal)	Office/Industrial	-25,091	sf	Existing	Demolished	
	Office	-23,212	sf	Existing	Demolished	
	Office	-16,529	sf	Existing	Demolished	
301 Constitution Drive*	Hotel	40	rooms	Approved	Under construction	East of US 101
(CitizenM Hotel CDP Amendment)						

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PROJECT ADDRESS	TYPE OF USE	SIZE	UNITS OF MEASURE	APPROVED OR PENDING	STATUS As of May 31, 2023	PROJECT LOCATION
1075 O'Brien Drive	R&D/Office	89,191	sf	Pending	Proposed Construction	East of US 101
	Restaurant/Commercial	9,869	sf	Pending	Proposed Construction	
	Warehouse	-14,523	sf	Existing	Proposed Demolition	
20 Kelly Court	R&D	25,394	sf	Existing	Existing to Remain	
	R&D	-12,192	sf	Existing	Proposed Demolition	
1550 El Camino Real	Residential	8	du	Approved	Proposed Construction	West Menlo/Downtown/El Camino Real
	Office	18,500	sf	Existing	Existing office building to remain (sf for reference)	
165 Jefferson Drive (Menlo Flats)	Residential	158	du	Approved	Proposed Construction	East of US 101
	Commerical	15,000	sf	Approved	Proposed Construction	
	Office	-24,300	sf	Existing	Proposed Demolition	
123 Independence Drive **Development Proposed within amount studied in ConnectMenlo Program Level EIR	Residential	281	du	Pending	Proposed Construction	East of US 101
	Warehouse/manufacturing	-108,461		Existing	Proposed Demolition	
123 Indendence Drive (Sobrato) **Development Proposed greater than amount studied in ConnectMenlo Program Level EIR	Residential	151	du	Pending	Proposed Construction	
333 Ravenswood Ave. (Parkline - SRI Master Plan)	Residential	550 (800 variant)	du	Pending	Proposed Construction	West of US 101
	Office/Commercial	1,095,719	sf	Pending	Proposed Construction	
	Office/R&D	283,826	sf	Existing	Existing buildings to remain (sf for reference)	
	Office/R&D	1,095,719	sf	Existing	Proposed Demolition	
995-1005 O'Brien Drive and 1320 Willow Road	Office/R&D	227,998	sf	Pending	Proposed Construction	East of US 101
	Office/R&D	40,586	sf	Existing	Proposed Demolition	
	Commercial/Warehouse	50,045	sf	Existing	Proposed Demolition	
2245 Avy Avenue - Philips Brooks School Gymnasium/Flex Building	Recreational	12,961	sf	Proposed	Proposed Construction	Sharon Heights/Sand Hill
	Educational	2,050	sf	Proposed	Proposed Construction	

2023 Development Projects List

List of Development Projects Based on Applications Received before May 31, 2023

PROJECT ADDRESS	TYPE OF USE	SIZE	UNITS OF MEASURE	APPROVED OR PENDING	STATUS As of May 31, 2023	PROJECT LOCATION
1220 Hoover Street	Residential	8	du	Proposed	Proposed Construction	West Menlo/Downtown/El Camino Real
	Residential	2	du	Existing	Proposed Demolition	
3705 Haven	Residential	99	du	Proposed	Proposed Construction	East of US 101
	Office	10,362	sf	Existing	Proposed Demolition	
1030 O'Brien	R&D/Office & Commercial	92,522	sf	Proposed	Proposed Construction	East of US 101
	Commercial/Office	62,119	sf	Existing	Proposed Demolition (partial)	
795 Willow	Residential	62	du	Proposed	Proposed Construction	West of US 101
					(existing space used as overflow parking lot)	
4055 Bohannon Drive	R&D	33,300	sf	Proposed	Proposed Construction	West of US 101
	Residential	31,559	sf	Existing	Proposed Demolition (partial)	
985 Santa Cruz Avenue	Residential	7	du	Proposed	Proposed Construction	West Menlo/Downtown/El Camino Real
	Residential	2	du	Existing	Proposed Demolition	

Notes:

Table includes all projects in City of Menlo Park that have filed a complete development application for 5 or more NET NEW residential units or 5,000 sf or more of NET NEW commercial.
For residential projects, occupancy is based on date of final building inspection.
For commercial projects, occupancy is based on date of final building inspection of applicable tenant improvements.
Some projects involve the demolition of existing structures. Demolished buildings are only listed for projects that receive credit for traffic purposes.

Project location corresponds to the four categories in the CSA as follows from west to east: Sharon Heights/Sand Hill; West Menlo/Downtown/El Camino; West of US 101; and East of US 101.
n/a = not applicable

Key
- Commercial
- Residential
- Demolished/Proposed Demolition

Project Specific Notes:

*40 additional hotel rooms being requested beyond the 200 listed in the Facebook Campus Expansion project detailed earlier in this list -- project remains subject to West Campus trip cap
**123 Independence Drive exceeds the number of residential unit studied in the ConnectMenlo EIR but does not exceed the total cap on residential units. A full EIR is required and the 107 additional units should be considered in cumualtive analyses for other projects in the City

APPENDIX E: CALCULATED FLUSHING AND COOLING RATIOS

Calculated Flushing and Cooling Ratios

Project Name	Project Address	Building Area (SF)	Irrigation (MG)	Flushing Demand (MG)	Cooling Demand (MG)	Total (MG)	Calc	Flushing Ratio (gal/SF)	Cooling Ratio (gal/SF)
Facebook E	301 Consti	962,400	3.90	4.95	1.47	10.00	10.32	5.15	1.53
Tarlton	1350 Adam	260,400	4.50	5.34	0.00	9.80	9.84	20.52	
Willow Vill	1350 Willo	1,800,000	22.00	28.00	8.00	58.00	58.00	15.56	4.44
Commonw	162 Jeffers	249,500	0.83	0.00	0.00	0.83	0.83		
MidPen	1345 Willo	-	0.82	0.00	0.00	0.82	0.82		
Menlo Upt	141 Jeffers	2,940	1.10	1.40	0.41	2.90	2.91	475.58	140.91
Menlo Port	115 Indepe	36,427	1.20	1.49	0.44	3.10	3.14	41.03	12.16
CSBio Phas	1075 O'Bri	124,454	0.73	0.00	0.73	1.50	1.46		5.87
Menlo Flat	165 Jeffers	15,000	0.60	0.77	0.23	1.60	1.60	51.43	15.24
Sobrato	123 Indepe	-	0.14	0.00	0.00	0.14	0.14		
Menlo Park	100 Termir	37,000	0.42	0.27	0.00	0.70	0.69	7.30	
Facebook N	1 Meta Wa	433,555	24.00	2.98	0.88	28.00	27.86	6.88	2.04
Facebook N	305 Consti	980,000	10.40	13.35	0.00	24.00	23.75	13.62	
Facebook N	300 Consti	180,000	0.80	4.63	1.37	6.80	6.80	25.71	7.62
					66.28	23.72511	<- with Menlo Uptown		
					13.53	4.29838	<-without Menlo Uptown, Menlo Portal, or Menlo Flats		
				EL Calcs (in MG/SF)	13.53	3.91			

1075 O'Brien Drive	R&D/Office	89,191	sf	Pending	Proposed Construction	East of US 101
	Restaurant/Commercial	9,869	sf	Pending	Proposed Construction	
	Warehouse	-14,523	sf	Existing	Proposed Demolition	
20 Kelly Court	R&D	25,394	sf	Existing	Existing to Remain	
	R&D	-12,192	sf	Existing	Proposed Demolition	

APPENDIX F: PHASE 2 AND PHASE 3 COST ESTIMATE

WBSD Phase 2 Recycled Water Project

Planning Level Cost Estimate						
	size	Qty	Unit Cost		Unit	Subtotal
Recycled Water Alignment (Phase 2)	10	8,600	$	50	in-diam/LF	$ 4,300,000
Recycled Water Alignment (Phase 2)	6	7,300	$	50	in-diam/LF	$ 2,190,000
Special Crossings - Railroad crossings		-	$	460,310	per crossing	$ -
Special Crossings - HWY 101		1	$	1,334,233	per crossing	$ 1,400,000
Booster Pump Station		100	$	8,700	horsepower	$ 870,000
Storage Tank	0.5 MG	500,000	$	1.91	per gallon	$ 960,000
Baseline Construction Cost						**$ 9,720,000**
Construction Contingency				30%		$ 2,916,000
Total Construction Cost						**$ 12,636,000**
Allowance for Change Orders				5%		$ 631,800
Construction Inspection				5%		$ 631,800
Engineering Design				7%		$ 884,520
Permits/Easements				5%		$ 631,800
Construction Administration				5%		$ 631,800
Legal, Fiscal, and Administrative				2%		$ 252,720
Implementation						**$ 3,664,000**
Total Project Cost						**$ 16,300,000**
Annualized Total Project Cost				0.05437		$ 887,000
Annual O&M Cost						$ 598,000
Annual Recycled Water Cost		650,000	$	0.0098	gal	$ 7,000
Total Annualized Cost						**$ 1,492,000**
Annual Operations & Maintenance Cost						
				Basis	**Unit Cost**	
Recycled Water Alignment				6,490,000	0.5%	$ 32,450
Treatment Cost		MGD		1.0	$ 500,000	$ 500,000
Booster Pump Station				870,000	2.5%	$ 22,000
Pumping Energy		kWh		51,000	$ 0.30	$ 16,000
Storage				960,000	1.0%	$ 10,000
Monthly Service		mo		12	$ 1,476	$ 18,000
Total Annual Operations & Maintenance Cost						**$ 598,000**

**Not included: recycled water wheeling; potable water for blending; onsite irrigation system improvements; cross connection testing and site inspections*

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WBSD Phase 2 and Phase 3 Recycled Water Project

Planning Level Cost Estimate						
	size	Qty	Unit Cost		Unit	Subtotal
Recycled Water Alignment (Phase 2)	10	8,600	$	50	in-diam/LF	$ 4,300,000
Recycled Water Alighment (Phase 2)	6	7,300	$	50	in-diam/LF	$ 2,190,000
Recycled Water Alignment (Phase 3)	8	38,500	$	50	in-diam/LF	$ 15,400,000
Special Crossings - Railroad crossings		2	$	460,310	per crossing	$ 921,000
Special Crossings - HWY 101		2	$	1,334,233	per crossing	$ 2,700,000
Booster Pump Station		200	$	8,700	horsepower	$ 1,740,000
Storage Tank	0.5 MG	500,000	$	1.91	per gallon	$ 960,000
Baseline Construction Cost						**$ 28,211,000**
Construction Contingency				30%		$ 8,464,000
Total Construction Cost						**$ 36,675,000**
Allowance for Change Orders				5%		$ 1,833,750
Construction Inspection				5%		$ 1,833,750
Engineering Design				7%		$ 2,567,250
Permits/Easements				5%		$ 1,833,750
Construction Administration				5%		$ 1,833,750
Legal, Fiscal, and Administrative				2%		$ 733,500
Implementation						**$ 10,636,000**
Total Project Cost						**$ 47,300,000**
Annualized Total Project Cost				0.05437		$ 2,572,000
Annual O&M Cost						$ 1,214,000
Annual Recycled Water Cost		830,000	$	0.0098	gal	$ 9,000
Total Annualized Cost						**$ 3,795,000**
Annual Operations & Maintenance Cost						
				Basis	**Unit Cost**	
Recycled Water Alignment				21,890,000	0.5%	$ 109,450
Treatment Cost		MGD		2.0	$ 500,000	$ 1,000,000
Booster Pump Station				1,740,000	2.5%	$ 44,000
Pumping Energy		kWh		108,400	$ 0.30	$ 33,000
Storage				960,000	1.0%	$ 10,000
Monthly Service		mo		12	$ 1,476	$ 18,000
Total Annual Operations & Maintenance Cost						**$ 1,214,000**

**Not included: recycled water wheeling; potable water for blending; onsite irrigation system improvements; cross connection testing and site inspections*

WBSD Phase 2 and Phase 3 Recycled Water Project
Including Potential Phase 3 Looping

Planning Level Cost Estimate					
	size	**Qty**	**Unit Cost**	**Unit**	**Subtotal**
Recycled Water Alignment (Phase 2)	10	8,600	$ 50	in-diam/LF	$ 4,300,000
Recycled Water Alignment (Phase 2)	6	7,300	$ 50	in-diam/LF	$ 2,190,000
Recycled Water Alignment (Phase 3)	8	38,500	$ 50	in-diam/LF	$ 15,400,000
Recycled Water Alignment (Phase 3, potential looping)	8	18,800	$ 50	in-diam/LF	$ 7,520,000
Special Crossings - Railroad crossings		3	$ 460,310	per crossing	$ 1,381,000
Special Crossings - HWY 101		2	$1,334,233	per crossing	$ 2,700,000
Booster Pump Station		200	$ 8,700	horsepower	$ 1,740,000
Storage Tank	0.5 MG	500,000	$ 1.91	per gallon	$ 960,000
Baseline Construction Cost					**$ 36,191,000**
Construction Contingency			30%		$ 10,858,000
Total Construction Cost					**$ 47,049,000**
Allowance for Change Orders			5%		$ 2,352,450
Construction Inspection			5%		$ 2,352,450
Engineering Design			7%		$ 3,293,430
Permits/Easements			5%		$ 2,352,450
Construction Administration			5%		$ 2,352,450
Legal, Fiscal, and Administrative			2%		$ 940,980
Implementation					**$ 13,644,000**
Total Project Cost					**$ 60,700,000**
Annualized Total Project Cost			0.05437		$ 3,301,000
Annual O&M Cost					$ 1,252,000
Annual Recycled Water Cost		830,000	$ 0.0098	gal	$ 9,000
Total Annualized Cost					**$ 4,562,000**
Annual Operations & Maintenance Cost					
			Basis	**Unit Cost**	
Recycled Water Alignment			29,410,000	0.5%	$ 147,050
Treatment Cost		MGD	2.0	$ 500,000	$ 1,000,000
Booster Pump Station			1,740,000	2.5%	$ 44,000
Pumping Energy		kWh	108,400	$ 0.30	$ 33,000
Storage			960,000	1.0%	$ 10,000
Estimated O&M for Bayfront RW Facility					
Monthly Service		mo	12	$ 1,476	$ 18,000
Total Annual Operations & Maintenance Cost					**$ 1,252,000**

**Not included: recycled water wheeling; potable water for blending; onsite irrigation system improvements; cross connection testing and site inspections*

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Unit Costs

Construction costs	Unit Cost		Source
Force Main	**$50**	per in-diam/LF	
Gravity Sewer	**$50**	per in-diam/LF	
Recycled Force Main (onsite)	**$24**	per in-diam/LF	*HDR (2017)**
Booster Pump Station	**$8,700**	per HP	*HDR (2017)**
Storage Tank	**$1.91**	per gallon	*Kennedy Jenks (2010) Escalated*
4" - 6" Service Line with Meter	**$50,000**	each	*Woodard & Curran database*
System Connection	**$307,000**	each	*Kennedy Jenks (2010) Escalated*
Special Crossings	**$345,000**	per crossing	*Kennedy Jenks (2010) Escalated*
Implementation	**25%**	of Construction cost	
Legal/Admin/Environmental	*5%*		
Design	*8%*		
Construction Management	*8%*		
Services during Construction	*4%*		
Project Contingency	**30%**	of Capital cost	
Annual Operation & Maintenance Costs			
Pipelines	**0.5%**	of Construction cost	
Pump Station	**2.5%**	of Construction cost	
Storage	**1.0%**	of Construction cost	
MBR Power	**$33,641**	Annual	*Cloacina MBR .15 MGD Estimate (2020)*
MBR Replacements, Consumables and Parts	**$60,924**	Annual	*Cloacina MBR .15 MGD Estimate (2020)*
MBR Labor	**$160,000**	Annual	*Cloacina MBR .15 MGD Estimate (2020)*
Financing			
Interest Rate	**3.5%**		
Period	**30**	years	
Capital Recovery Factor	**0.05437**		
Escalation Factor Applied to Kennedy/Jenks 2010 Unit Costs			
December 2010 SF CCI	**10120**	January 2017 SF CCI	**11609**
September 2023 SF CCI	**15490**		
Escalation	**1.53**	Escalation	**1.33**
** HDR costs based on recent applicable construction projects*			


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