Sanitary District No. 1 of Marin County
Infrastructure Asset Management Plan

October 1, 2013

RWQCB Order No. R2-2013-0020

Prepared by

V.W. Housen & Associates

in association with

Schaaf & Wheeler
JDH Corrosion
Humphrey Consulting
# TABLE OF CONTENTS

Acronyms and Terms ............................................................................................................................................. i

## EXECUTIVE SUMMARY

**ES.1** IAMP Components ................................................................................................................................. ES-2
**ES.2** System Description ......................................................................................................................................... ES-2
**ES.3** Planning Criteria ........................................................................................................................................... ES-5
**ES.3.1** Risk Criteria ................................................................................................................................................ ES-5
**ES.3.2** Design Storm Criteria ............................................................................................................................... ES-6
**ES.4** Mainline And Trunk Line Pipeline Assessments ............................................................................................ ES-6
**ES.4.1** SMARTool Database Model ...................................................................................................................... ES-6
**ES.4.2** Likelihood And Consequence of Failure .................................................................................................. ES-7
**ES.4.3** Risk Calculation .......................................................................................................................................... ES-9
**ES.4.4** SMARTool Results ...................................................................................................................................... ES-9
**ES.5** Pump Station Assessments ......................................................................................................................... ES-11
**ES.5.1** Pump Station Inflows And Capacities ..................................................................................................... ES-12
**ES.5.2** Flow Monitoring ....................................................................................................................................... ES-13
**ES.5.3** Pump Station Reliability ......................................................................................................................... ES-13
**ES.5.4** Recommended Improvements ................................................................................................................. ES-14
**ES.6** Force Main Assessments ............................................................................................................................ ES-16
**ES.6.1** Findings ..................................................................................................................................................... ES-17
**ES.6.2** Recommendations ................................................................................................................................... ES-18
**ES.7** Operations and Maintenance Program ....................................................................................................... ES-19
**ES.7.1** Cleaning And Maintenance ...................................................................................................................... ES-19
**ES.7.3** Condition Assessment .............................................................................................................................. ES-20
**ES.7.4** Historical SSOs And SSO Reduction Goals ............................................................................................. ES-21
**ES.7.5** Potential Enhancements To Cleaning And Condition Assessment Programs ........................................... ES-21
**ES.8** Recommended Projects, Timeline, And Costs .............................................................................................. ES-22

## CHAPTER 1 - INTRODUCTION

**1.1** Background And Project Objectives .............................................................................................................. 1-1
**1.2** IAMP Report Organization ............................................................................................................................ 1-2

## CHAPTER 2 – EXISTING SYSTEM DESCRIPTION

**2.1** Facilities and Flows ........................................................................................................................................ 2-1
**2.2** Pipeline Assets ............................................................................................................................................... 2-2
**2.3** Pump Stations ................................................................................................................................................ 2-3
**2.4** Central Marin Sanitation Agency .................................................................................................................... 2-4
CHAPTER 3 – PLANNING CRITERIA
3.1 Risk Criteria ........................................................................................................ 3-1
3.1.1 Level Of Service Objectives ............................................................................. 3-1
3.1.2 Likelihood Of Failure Metrics ........................................................................... 3-3
3.1.3 Consequence Of Failure Metrics ..................................................................... 3-4
3.2 Hydraulic Criteria .................................................................................................. 3-4
3.3 Cost Estimating Guidelines ................................................................................... 3-5

CHAPTER 4 – MAINLINE AND TRUNK LINE PIPELINE ASSESSMENT
4.1 Available Data ......................................................................................................... 4-2
4.1.1 Computerized Maintenance Management System .......................................... 4-2
4.1.2 Hydraulic Model Information ............................................................................. 4-3
4.1.3 Other System Information .................................................................................. 4-4
4.2 Mainline And Trunk Line Assessments ................................................................ 4-5
4.2.1 Smartool Database Model .................................................................................. 4-5
4.2.2 Rehabilitation And Replacement Project Recommendations ....................... 4-11
4.3 Mainline And Trunk Line Capital Improvement Plan Development .................... 4-13
4.3.1 Summary Of Pipeline Rehabilitation And Replacement Projects ................... 4-13
4.3.2 Additional Rehabilitation Projects From Attachment D Of The Order .......... 4-13
4.3.3 Capacity Improvement Projects From Attachment D Of The Order ............... 4-14
4.4 Summary Of Project Needs, Costs, And Implementation Timeline .................... 4-16

CHAPTER 5 – PUMP STATION ASSESSMENTS
5.1 Assessment Methodology ....................................................................................... 5-1
5.2 Pump Station Inflows and Capacities ................................................................... 5-3
5.3 Flow Monitoring ..................................................................................................... 5-4
5.4 Pump Station Mechanical and Electrical Reliability .......................................... 5-5
5.5 Structural Reliability .............................................................................................. 5-5
5.6 Recommended Improvements ................................................................................. 5-6
5.7 Pump Station IAMP Costs ..................................................................................... 5-7
5.8 Pump Station Assessment Report .......................................................................... 5-8

CHAPTER 6 – FORCE MAIN ASSESSMENTS
6.1 Condition Assessment Methodology ..................................................................... 6-1
6.2 Findings .................................................................................................................. 6-5
6.3 Recommendations .................................................................................................. 6-7
6.4 Corrosion Assessment Report ............................................................................... 6-8
CHAPTER 7 – OPERATIONS AND MAINTENANCE PROGRAM
7.1 Line Cleaning Methods and Opportunities .............................................................. 7-1
7.1.1 Cleaning and Maintenance ................................................................................. 7-1
7.1.2 Sewer Cleaning Results ....................................................................................... 7-2
7.1.3 New Cleaning Tool and Technologies ................................................................. 7-2
7.1.4 Maintenance Work Orders ................................................................................... 7-3
7.1.5 Cleaning QA/QC Program ................................................................................... 7-3
7.1.6 Chemical Root Control ......................................................................................... 7-3
7.2 Condition Assessment Methods And Opportunities ............................................... 7-3
7.2.1 Main Line Pipeline Inspections ........................................................................... 7-3
7.2.2 Manhole Inspections ........................................................................................... 7-5
7.3 Historical SSOs And SSO Reduction Goals ............................................................. 7-5
7.4 Potential Enhancements To Cleaning And Condition Assessment Programs ........ 7-6
7.4.1 Cleaning Program Enhancements ....................................................................... 7-6
7.4.2 Condition Assessment Program Enhancements .................................................... 7-6

CHAPTER 8 – IMPLEMENTATION SCHEDULE
8.1 Basis For IAMP Implementation Plan Development ............................................... 8-1
8.2 Proposed Implementation Plan ............................................................................... 8-2

APPENDICES
Appendix A – Order No. R2-2013-0020, including referenced attachments
List of additional reference documents
Appendix B – Sewer Main Asset Replacement Tool example printouts
Mainline Assessment supporting documentation
Appendix C – Pump Station Assessment Report and additional documentation
Appendix D – Force Main Assessment Report and additional documentation
Appendix E – Operations and Maintenance field forms and documents

TABLES
Table ES-1. IAMP Requirements from Order
Table ES-2. Mainline And Interceptor Pipelines by Diameter
Table ES-3. Pipeline Distribution by Material
Table ES-4. Mainline And Trunk Line Sewer Pipeline Projects That Continue to be Required
Table ES-5. Pump Station Firm Capacities and Inflows
Table ES-6. Proposed Pump Station Improvements
Table ES-7. Estimated Pump Station Project Costs
Table ES-8. SSOs for 2013 and Three Prior Years
Table ES-9. IAMP and Capital Program Implementation Plan
TABLES (cont’d)
Table 1-1. IAMP Requirements from Order No. R2-2103-0020

Table 3-1. RVSD Level Of Service Goals And Relative Importance Factors

Table 4-1. Mainline And Interceptor Pipelines By Diameter
Table 4-2. Pipeline Distribution By Material
Table 4-3. CMMS Data Used In RVSD Smartool
Table 4-4. Likelihood Of Failure Metrics, Weights And Scores
Table 4-5. Average Service Life Estimates For RVSD Pipe
Table 4-6. Consequence Of Failure Metrics, Weights, And Scores
Table 4-7. Review Of Projects From Table D Of Order No. R2-2013-0020
Table 4-8. Summary Of IAMP Costs For Mainline And Trunk Line Sewers
Table 4-9. Implementation Timeline For Mainline And Trunk Line Projects

Table 5-1. List Of Pump Stations And Lift Stations
Table 5-2. Pump Station Firm Capacities And Inflows
Table 5-3. Pump Station Reliability Concerns
Table 5-4. Proposed Pump Station Improvements
Table 5-5. Estimated Costs For The Six Evaluated Pump Stations
Table 6-1. District Force Mains Descriptions
Table 7-1. Approximate CCTV Inspection Plan for Future Inspection Program
Table 7-2. SSOs for 2013 and Three Prior Years
Table 8-1. IAMP And Capital Program Implementation Plan
Table 8-2. IAMP Cost Detail

FIGURES
Figure ES-1. District Service Area
Figure ES-2. IAMP Components and Relationships
Figure ES-3. Pump Stations Reviewed For Iamp
Figure ES-4. Smartool Development Process
Figure ES-5. Example Likelihood And Consequence Of Failure Buffers
Figure ES-6. Summary Of The Risk Calculation
Figure ES-7. Group 1 Rehabilitation Projects
Figure ES-8. Group 2 Rehabilitation Projects
Figure ES-9. Pump Station Location Map
FIGURES (cont’d)
Figure ES-10. Mainline Cleaning Frequencies
FIGURES (cont’d)
Figure ES-11. Pipes with CCTV Condition Ratings

Figure 2-1. District Service Area and Communities Served
Figure 2-2. RVSD Mainline, Trunk Lines, and Force Mains
Figure 2-3. Major and Minor Pump Stations

Figure 4-1. Mainline and Trunkline Pipelines by Diameter
Figure 4-2. Mainline and Trunkline Pipelines by Material
Figure 4-3. Mainline and Trunkline Pipelines by Year Installed
Figure 4-4. Risk Model Buffers, Parks and Schools
Figure 4-5. Risk Model Buffers, Potential Landslide Areas and Extent of SF Bay Mud
Figure 4-6. Primary and Secondary Arterial Roadways
Figure 4-7. Arterial Waterways
Figure 4-8. Smartool Development Process
Figure 4-9. Summary Of The Risk Calculation
Figure 4-10. Group 1 Projects
Figure 4-11. Group 2 Projects

Figure 5-1. Pump Stations Reviewed For IAMP
Figure 5-2. Pump Stations

Figure 6-1. Force Main Locations

Figure 7-1. Mainline Cleaning Frequencies
Figure 7-2. Pipes with CCTV Condition Ratings
This page left blank intentionally
Acknowledgements

V. W. Housen & Associates would like to thank the following individuals for their knowledge, ideas, responsiveness, dedication, and hard work in developing the Infrastructure Asset Management Plan.

Sanitary District No. 1 of Marin County (Ross Valley Sanitary District)

RVSD Board of Directors
Greg Norby, Interim General Manager
Randell Ishii, District Engineer
John Clark, Chief of Operations
Katherine Hayden, Steve Miksis, Dennis Gavallos, Rafael Zarco, Wendy Martin-Miller, Julia Blue, Elena Hastings, and the many other District staff who contributed to this effort.

Consultant Team

Vivian Housen & Jing Yang, V. W. Housen & Associates
Ben Schick and Glen Anderson, Schaaf & Wheeler
Doug Humphrey, Humphrey Consulting
Darby Howard and David Kashifi, JDH Corrosion
LIST OF ACRONYMS

AACE  Association for Advancement of Cost Engineering
ABAG  Association of Bay Area Governments
ATS   Anode Test Station
BWCCP Bar-Wrapped Concrete Cylinder Pipe
CCTV  Closed Circuit Television
CEQA  California Environmental Quality Act
CDO   Cease and Desist Order
CGS   California Geological Survey
CIP   Capital Improvement Plan
CIWQS California Integrated Water Quality System
CMMS  Computerized Maintenance Management System
CMSA  Central Marin Sanitation Agency
ENR CCR Engineering News Record Construction Cost Index (San Francisco Bay Area)
DIP   Ductile Iron Pipe
F_C  Consequence of Failure
FEMA  Federal Emergency Management Agency
F_L  Likelihood of Failure
FOG   Fats, Oils & Grease
FY    Fiscal Year
GIS   Geographic Information System
HDPE  High Density Polyethylene
I&I   Inflow and Infiltration
IAMP  Infrastructure Asset Management Plan
LOS   Level of Service
MACP  Manhole Assessment and Certification Program
MGD   Million Gallons per Day
NACE  National Association of Corrosion Engineers
NASSCO National Association of Sewer Service Companies
NEC   National Electrical Code
NFPA  National Fire Protection Agency
NOAA  National Oceanographic and Atmospheric Administration
<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOV</td>
<td>Notice of Violation</td>
</tr>
<tr>
<td>O&amp;M</td>
<td>Operations and Maintenance</td>
</tr>
<tr>
<td>PACP</td>
<td>Pipeline Assessment Certification Program</td>
</tr>
<tr>
<td>PPE</td>
<td>Personal Protective Equipment</td>
</tr>
<tr>
<td>PVC</td>
<td>Polyvinyl Chloride</td>
</tr>
<tr>
<td>PWWF</td>
<td>Peak Wet Weather Flow</td>
</tr>
<tr>
<td>QA/QC</td>
<td>Quality Assurance and Quality Control</td>
</tr>
<tr>
<td>R&amp;R</td>
<td>Rehabilitation and Replacement</td>
</tr>
<tr>
<td>RCCP</td>
<td>Reinforced Concrete Cylinder Pipe</td>
</tr>
<tr>
<td>RCP</td>
<td>Reinforced Concrete Pipe</td>
</tr>
<tr>
<td>RTU</td>
<td>Remote Terminal Unit</td>
</tr>
<tr>
<td>RVSD</td>
<td>Ross Valley Sanitary District</td>
</tr>
<tr>
<td>RWQCB</td>
<td>Regional Water Quality Control Board</td>
</tr>
<tr>
<td>SCADA</td>
<td>Supervisory Control and Data Acquisition</td>
</tr>
<tr>
<td>SCS</td>
<td>U.S. Soil Conservation Service (now Natural Resource Conservation Service)</td>
</tr>
<tr>
<td>SHECAP</td>
<td>Sewer Hydraulic Evaluation and Capacity Assurance Plan</td>
</tr>
<tr>
<td>SMARTool</td>
<td>Sewer Main Asset Replacement Tool</td>
</tr>
<tr>
<td>SSMP</td>
<td>Sewer System Management Plan</td>
</tr>
<tr>
<td>SSO</td>
<td>Sanitary Sewer Overflow</td>
</tr>
<tr>
<td>SSRMP</td>
<td>Sewer System Replacement Master Plan</td>
</tr>
<tr>
<td>USGS</td>
<td>U.S. Geological Survey</td>
</tr>
<tr>
<td>VCP</td>
<td>Vitrified Clay Pipe</td>
</tr>
<tr>
<td>VFD</td>
<td>Variable Frequency Drive</td>
</tr>
<tr>
<td>VWHA</td>
<td>V. W. Housen &amp; Associates</td>
</tr>
<tr>
<td>WS L/C</td>
<td>Cement Mortar Lined and Coated Welded Steel Pipe</td>
</tr>
</tbody>
</table>
LIST OF TERMS

**Arc Flash Hazard** – a condition associated with the possible release of energy caused by an electric arc.

**Autodialer** – an electronic automatic phone dialing device.

**Bypass Pumping** – the rerouting of sewage, usually using pumps and temporary piping, around a specific facility while the facility is out of service.

**California Environmental Quality Act (CEQA)** – a California statute passed in 1970. CEQA requires state and local agencies within California to follow a protocol of analysis and public disclosure of environmental impacts of proposed projects.

**California Integrated Water Quality System (CIWQS)** – a computer database that the California Water Boards created to combine and make publicly available discharger and environmental reporting data.

**CalTrans** – the California Department of Transportation is a public agency that manages roadways and highways within the State of California.

**Cathodic (Corrosion) Protection System** – a technique used to control the corrosion of a metal surface by making it the cathode of an electrochemical cell.

**Closed Circuit Television Inspection (CCTV Inspection)** – Closed Circuit Television Inspection is a digital video technology for pipeline assessment.

**Computerized Maintenance Management System (CMMS)** – a computerized system that stores physical asset data and maintenance information, and can be used to plan and prioritize future maintenance work and asset replacements.

**Consequence of Failure or FC** – the results associated with the failure of an asset.

**Firm Capacity** – the capacity of the pump station with the largest pump out of service.

**Geographical Information System (GIS)** – a database linked with mapping that records asset information and geographic features. The GIS database could also include CMMS data, or in some cases, serves as an agency’s CMMS.

**Groundwater Infiltration** – infiltration that enters the sewer system through pipe defects located below the normal groundwater table.
Hydraulic Gradeline – The sum of pressure head and elevation head. In a pipeline with flow that is not full or under pressure, the hydraulic gradeline is equal to the free water surface within the pipe.

Infrastructure Asset Management Plan (IAMP) – a plan developed for the management of one or more infrastructure asset classes with the goal of operating, maintaining and renewing the assets within the class in the most cost effective manner possible, while providing a specific Level of Service.

Lateral or Private Lateral – the privately-owned sewer pipeline that conveys wastewater from the private property to the District’s sewer system. The upper lateral extends from the building to property line (or easement line). The lower lateral extends from the property or easement line to the connection to the pipe.

Level of Service (LOS) – factors that define, from the customer perspective, the overall service that is expected from, and should be provided by the District

Linear Assets – an asset whose length plays a critical role in its maintenance.

Liquefaction – the conversion of solid soils into liquid form, usually through groundshaking associated with a seismic event.

National Association of Corrosion Engineers (NACE) – a professional organization for the corrosion control industry established in 1943.

National Association of Sewer Service Companies (NASSCO) – sets the industry standards for the rehabilitation of underground utilities through education, technical resources, and industry advocacy.

Overflow – see Sanitary Sewer Overflow (SSO).

Peak Wet Weather Flow (PWWF) – the maximum volume of water that is conveyed through a sewer collection system to a wastewater treatment plant, following a period of rainfall during a design storm event.

Probabilistic Approach – the assessment focuses on elements with a greater probability of failure during an event or a greater hazard associated with their failure during such event.

Quality Assurance and Quality Control (QA/QC) – a system of procedures, checks and audits to judge and control the quality of measurements and reduce the uncertainty of data.

Regional Water Quality Control Board (RWQCB) – San Francisco Bay Area Regional Water Quality Control Board, also known as the Regional Board or Region 2.
Rehabilitation and Replacement Plan (R&R or also called a Capital Improvement Plan) – a program that identifies and prioritizes system deficiencies and implements short-term and long-term rehabilitation actions to address each deficiency.

San Francisco Construction Cost Index – a list of construction costs in the San Francisco Bay Area that are updated, monitored, and published over time.

Sanitary Sewer Overflow (SSO) – any overflow, spill, release, discharge or diversion of untreated or partially treated wastewater from a sanitary sewer system, including overflows or releases that reach waters of the United States, overflows or releases that do not reach water of the United States, and backups into buildings and/or private property caused by conditions within the publicly owned portion of the sewer system.

Sewage Grinder – a grinder that can grind the waste into a fine slurry form before it enters the sewer lines.

Sewer Hydraulic Model – a simulation software that is used to predict hydraulic conditions within a sewer system.

Sewer Main Asset Replacement Tool (SMARTool) – a computerized risk management tool that uses Microsoft Access to determine a risk score for every inspected pipe based on likelihood and consequence of failure.

Sewer System Management Plan (SSMP) – a document that describes the activities the agency uses to manage the wastewater collection system. The contents of this document follow guidelines established by the Regional Water Quality Control Board and State Water Resources Control Board.

Supervisory Control and Data Acquisition (SCADA) – a computer system that stores, monitors, and controls pump station functions and relays this information to a centralized location. Field devices control local operations such as opening and closing valves and breakers, collect data from sensor systems, and monitor the local environment for alarm conditions.

Variable Frequency Drives (VFDs) – a type of adjustable-speed drive used in electro-mechanical drive systems to control AC motor speed and torque by varying motor input frequency and voltage.
This page left intentionally blank
EXECUTIVE SUMMARY

On May 13, 2013, the San Francisco Bay Regional Water Quality Control Board (RWQCB) issued Order No. R2-2013-0020, a Cease and Desist Order (Order) for Sanitary District No. 1 of Marin County, also known as Ross Valley Sanitary District (RVSD or District). Provision I.e, subparagraphs i. through viii. of the Order require the District to submit an Infrastructure Asset Management Plan (IAMP) by October 1, 2013. The IAMP recommendations replace in their entirety recommendations from the District’s previous capital improvement planning document, which is named the Sewer System Replacement Master Plan (SSRMP, RMC, 2007).

The IAMP must present a prioritized plan for infrastructure assessment and replacement that meets specific requirements of the Order that are summarized in Table ES-1.

Table ES-1. IAMP Requirements from Order

- Replace or rehabilitate specific pipes with Grade 5 structural defects by June 30, 2018. If certain conditions are met, this action may be deferred up to June 30, 2021.
- Reinspect pipes with Grade 4 structural defects on a five-year cycle. Establish a schedule for inspection of other uninspected mainline sewers, force mains and pump stations within three years.
- Prioritize rehabilitation or replacement of other pipes using a methodology that considers condition and risk factors. The District must rehabilitate, on average, 4 miles of pipe per year.
- Prioritize pump station, force main, and trunk line capital improvement needs and integrate these replacements, and their needed funding, into the District’s capital improvement plan (CIP).
- The proposed capital needs must consider the project implementation schedule from the District’s Sewer System Replacement Master Plan (SSRMP, RMC, 2007). The SSRMP projects must be completed by June 30, 2019, or later if approved by the Executive Officer.
- Provide an ongoing process for the assessment and prioritization of pipeline, force main, and pump station replacement and rehabilitation based on the results of condition assessments completed.
- Evaluate and provide recommended improvements to cleaning and condition assessment programs with a focus on continued reduction in maintenance-related SSOs with roots, fats, oils and grease, or debris as their primary cause.

In April 2013, the District retained V. W. Housen & Associates (VWHA) to begin development of the IAMP based on a general understanding of the requirements that would be included in the
Order. VWHA, in association with Schaaf & Wheeler, JDH Corrosion, and Humphrey Consulting, have completed the necessary evaluations and present the project findings and recommendations in this report. The information presented in this report benefited substantially from the District’s knowledge base, and from input and insight provided by District staff throughout the project.

**ES.1 IAMP COMPONENTS**

The IAMP represents a snapshot in time that was documented in the District’s computerized maintenance management system (CMMS) as of May 2013. This date corresponds with the effective date of the Order, and also marked the start of data cleanup and analysis as required to develop the IAMP. Five months have progressed between the effective date of the Order and the submittal date for this IAMP. During this time, District crews have conducted additional closed circuit television (CCTV) inspection and pipeline cleaning activities, and have continued with pipeline repairs. The results from these activities have been recorded in the District’s CMMS and will be integrated into future analyses and reports.

The IAMP is intended to be a flexible planning document that is reviewed and amended periodically to incorporate and accommodate new information. Figure ES-1 shows the IAMP components and their relationships. The IAMP continues the District’s vision for sewer collection system asset management.

*Figure ES-1. IAMP Components and Relationships*


ES.2 SYSTEM DESCRIPTION

The Ross Valley Sanitary District was established in 1899, and is believed to be California’s oldest sanitary district. The District is located in Marin County, approximately 15 miles north of San Francisco and directly south of the City of San Rafael. The service area is bounded on the east by the San Francisco Bay, and on the west by the coastal hills. Numerous seasonal and perennial waterways traverse the service area and terminate in Corte Madera Creek, which is the main drainage from the District’s service area to the San Francisco Bay.

The District serves the communities of Sleepy Hollow, Fairfax, San Anselmo, Ross, Larkspur, Kentfield, and Greenbrae, serves Murray Park by contract, and conveys wastewater to the Central Marin Sanitation Agency (CMSA) wastewater treatment plant. Figure ES-2 at the end of this section shows a map of the District service area.

The District maintains approximately 194 miles of mainline and trunk line sewers and 8.4 miles of force main pipe. In addition, the District owns and operates five major pump stations, and 14 minor pump stations and lift stations. The major pump stations collect and pump flow from the minor stations and trunk lines to the CMSA treatment plant.

Average dry weather flow is approximately 5 million gallons per day (mgd). During wet weather events, flows increase due to elevated groundwater and rainfall dependent inflow and infiltration (I&I).

The District’s linear assets comprise mainline pipelines, trunk lines, and force mains. The District stores asset information in a CMMS program that uses Innovyze® InfoNet™ software. Tables ES-2 and ES-3 summarize the distribution of linear assets by diameter and by material.

Table ES-2. Mainline and Interceptor Pipelines by Diameter

<table>
<thead>
<tr>
<th>Pipeline Diameter</th>
<th>Approximate Percent of System</th>
</tr>
</thead>
<tbody>
<tr>
<td>6-inches and less</td>
<td>73 percent</td>
</tr>
<tr>
<td>8 to 12 inches</td>
<td>20 percent</td>
</tr>
<tr>
<td>14 to 18 inches</td>
<td>3 percent</td>
</tr>
<tr>
<td>20 to 24 inches</td>
<td>1 percent</td>
</tr>
<tr>
<td>Greater than 24 inches</td>
<td>3 percent</td>
</tr>
</tbody>
</table>
Table ES-3. Pipeline Distribution by Material

<table>
<thead>
<tr>
<th>Pipeline Material</th>
<th>Approximate Percent of System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asbestos Cement</td>
<td>2 percent</td>
</tr>
<tr>
<td>Cast Iron</td>
<td>3 percent</td>
</tr>
<tr>
<td><strong>Cured-in-Place Pipe</strong></td>
<td><strong>Less than 1 percent</strong></td>
</tr>
<tr>
<td>Ductile Iron Pipe</td>
<td>Less than 1 percent</td>
</tr>
<tr>
<td>High Density Polyethylene</td>
<td>3 percent</td>
</tr>
<tr>
<td>Polyvinyl Chloride</td>
<td>11 percent</td>
</tr>
<tr>
<td>Reinforced Concrete or Concrete Cylinder Pipe</td>
<td>2 percent</td>
</tr>
<tr>
<td>Welded Steel</td>
<td>Less than 1 percent</td>
</tr>
<tr>
<td>Techite</td>
<td>Less than 1 percent</td>
</tr>
<tr>
<td>Vitrified Clay</td>
<td>79 percent</td>
</tr>
<tr>
<td>Other</td>
<td>Less than 1 percent</td>
</tr>
</tbody>
</table>

Flow is conveyed in a southeast direction to Larkspur, and then through a 54-inch tunnel to the CMSA wastewater treatment plant. Figure ES-3 shows the main pump station and force main network that conveys flow from the District’s system to CMSA.

**Figure ES-3. Pump Stations Reviewed for IAMP**
ES.3 PLANNING CRITERIA

The IAMP uses two different sets of planning criteria. The first criteria define the level of risk that the District can accept and still provide the desired level of service to its customers. The second criteria define the design storm.

ES.3.1 Risk Criteria

Level of Service (LOS) objectives were developed through several workshops, and are defined from the customer’s viewpoint, in order to create goals that are broad and policy-based.

An example of how LOS is defined can be demonstrated with a hypothetical sewer system overflow (SSO) event. A customer would likely insist that the District prevent SSOs that create backups onto their private property. However, they may not be interested in whether the District’s process for prioritizing CCTV inspection or cleaning will mitigate this SSO. In this case, the LOS goal is the prevention of SSOs. Targets related to cleaning or inspecting pipe are the internal metrics that support the LOS goal.

The District’s objectives for Level of Service are summarized as follows:

- Protect Public Health and Waterways. Protection of public health can be measured through reduced SSOs, with emphasis on reducing SSOs to private property, schools, and parks.
- Provide Reliable and Responsive Service. Service is enhanced by preempting system issues in areas that are difficult to access, so as to improve response time. A less tangible indicator of good service is increased confidence in the District’s ability to manage the agency and its assets.
- Provide Value to the Customer. Value is measured by a steady reduction in failure indicators resulting from judicious spending on operations and maintenance (O&M) activities and capital improvements. Value may be inversely related to cost, since lowering expenses in an aging system could lead to an increase in failure indicators.

Risk criteria were different for each set of assets (i.e., mainline and trunk line sewers, pump stations, and force mains). Mainline and trunk line sewer analyses defined risk through layers of metrics and scores that defined the Likelihood and Consequence of Failure for each pipe segment. Pump station analyses defined risk based on criteria that has been supported by the RWQCB to assess pump station reliability. Force main analyses defined risk based on anticipated failure mechanisms of pipe, as determined through an evaluation of pipe material, setting, and historical cathodic protection.
ES.3.2 Design Storm Criteria

A second criteria established new hydraulic criteria for the sewer collection system. The District’s previous hydraulic analysis evaluated system capacity under a 5-year recurrence storm. Pipes were designated as requiring upsizing if the hydraulic gradeline (or water surface for mainline and trunk line sewers) rose within ten feet of the manhole rim. The IAMP applies a 10-year, 24-hour design storm, using National Oceanographic and Atmospheric Administration (NOAA) precipitation data.

The IAMP assumed that pipes with predicted sewer system overflows (SSOs) would require capacity improvements. However, if the capacity issue appeared to result from sources of I&I that could be abated in lieu of upsizing downstream infrastructure (such as tidal inflow or highly localized I&I), these projects were scheduled toward the end of the implementation timeline to allow the District time to investigate and possibly address the I&I source.

ES.4 MAINLINE AND TRUNK LINE PIPELINE ASSESSMENTS

The IAMP used a numerical database model to assign risk to every mainline and trunk line pipe segment in the CMMS database. This model, also known as the RVSD Sewer Main Asset Replacement Tool (SMARTool), was developed in Microsoft® Access.

ES.4.1 SMARTool Database Model

The SMARTool evaluates the Risk of Failure for an individual pipe segment, given that asset’s Likelihood and Consequence of Failure. Risk is measured with respect to the District’s ability to meet established Level of Service goals. Figure ES-4 shows the process that was used to develop the SMARTool.
The SMARTool database contains over 5,000 unique pipeline segments which span from node to node and represent the District’s sewer pipeline network. The May 2013 database included over 3,000 assets with assigned CCTV inspection ratings, comprising approximately 53 percent of the system. The District regularly adds new CCTV inspection data to the CMMS database, and plans to update the SMARTool results periodically to integrate this new data.

Assets without CCTV data received lower Risk Scores and were not prioritized for replacement. Although attributes such as age and proximity to a waterway may indicate that the asset may need replacement, an asset’s theoretical useful life may vary greatly from actual useful life depending on actual condition, setting, use, and maintenance history. Therefore, assigning a Risk Score to a single pipe segment without having first inspected this segment would be speculative.

**ES.4.2 Likelihood and Consequence of Failure**

The SMARTool calculates Total Risk as the product of Likelihood and Consequence of Failure.

Likelihood of Failure ($F_L$) metrics comprise the following:

- Pipe Material (techite), which is very likely to fail or have failed
- Capacity as determined through the District’s existing hydraulic model
- Structural CCTV Inspection Rating and associated defect code
- O&M CCTV Inspection Rating with specific defect scores indicating severe root intrusion or visible infiltration
- Pipe Size for small diameter pipes that are difficult to maintain
- Known Maintenance issues including historical SSOs and special cleaning needs
- Geologic Conditions such as landslide potential and proximity to San Francisco Bay Mud
- Structural CCTV Defect Density Factor which considers the number of defects per foot of pipe

Consequence of Failure ($F_C$) metrics provide information on how the failure of an asset will impact the ability of the District to meet its Level of Service goals. Consequence of Failure metrics that were used in the SMARTool comprise the following:

- Proximity to a perennial waterway
- Proximity to critical facilities, which are defined as schools or parks
- Impact on primary and secondary arterial roadways
- Area impacted as determined by pipe size

Figure ES-5 shows example Likelihood and Consequence of Failure buffers as developed through GIS.

**Figure ES-5. Example Likelihood and Consequence of Failure Buffers**
ES.4.3 Risk Calculation

The SMARTool uses a series of queries to overlay Likelihood and Consequence metrics and develop an associated Total Risk Score. The process used to compile these scores is shown in Figure ES-6.

The Total Risk Score is a relative number, to be compared to similar scores from the same model run from other pipes. The risk score, when considered alone, has no numerical significance.

ES.4.4 SMARTool Results

Twenty mainline sewer rehabilitation projects were identified as the Group 1 projects that are required to address the Order. Project development began with a review of the critical segment(s), and then added adjacent pipelines with PACP Structural Grade 5 defects. Many of these pipes also had Structural Grade 4 and lesser defects. An allowance was provided to allow the addition of interstitial pipelines with minor defects, or to otherwise reroute or address local system issues as part of the project. The projects also integrated needed capacity improvements from Attachment D of the Order.

Based on the number and nature of defects, as well as other pipeline characteristics, assumptions related to the anticipated pipe replacement methodology were made. Pipes are expected to be replaced through segment repairs (i.e., joint to joint), lining, pipe bursting, or full pipe replacement (i.e., node to node).

The Group A,B, and 1 projects will replace or rehabilitate over 20 miles of main line sewer pipelines, for a total estimated cost of $16 million\(^1\). These projects address pipelines with Grade 5 defects and also several consequence of failure factors. The Group A and B projects address the 45 projects that are described in Attachment A of the Order. The proposed Group 1 projects are shown in Figure ES-7 at the end of this section.

\(^1\) The District has budgeted for additional collection system improvements beyond the requirements of the Order that may be integrated with these projects during implementation.
Group 2 includes an additional 12.3 miles of pipeline rehabilitation for a cost of $8.8M. These projects are also required to address pipe segments from Attachment B of the Order. The Group 2 projects have Structural Grade 5 defects, but are not associated with a high number of consequence factors. The proposed Group 2 projects are shown in Figure ES-8 at the end of this section.

In addition to the proposed projects that were identified through development of the IAMP, Attachment D of the Order lists 15 mainline sewer projects that require completion by June 2019 unless otherwise determined by the Executive Officer. Many of the projects were intended to rehabilitate aging pipelines.

In the absence of CCTV inspection data, assumptions on actual condition were used to develop the Attachment D replacement projects. However, CCTV inspections have shown that most of the previously-planned projects would replace pipes that do not have Structural Grade 5 defects. Therefore, the following projects were removed from the CIP list:

- Sir Francis Drake/Winship (included in Group 2 projects)
- Sequoia Park/Tozzi Creek (critical location was repaired)
- Red Hill Avenue
- Hillside Avenue (to be reprioritized after CCTV inspection is complete)

Attachment D also described needed capacity improvement projects. In order to test these recommendations, the capacity analysis was repeated using a 10-year, 24-hour storm. Based on the results, two projects were removed from the CIP list and several projects may no longer be needed after closer evaluation of I&I and further hydraulic modeling. These projects include:

- Eliseo (no SSO is predicted in 10-year, 24-hour storm)
- Sir Francis Drake/Winship (pipe is simplistically modeled – need to confirm predicted SSO. Project will be confirmed through flow monitoring and a hydraulic model update, which are included in the IAMP implementation schedule)
- Magnolia Avenue (pipe size is sufficient – incorrect pipe was included in original hydraulic model)
- Sir Frances Drake/Berry. The District plans to collect additional flow data during the 2013/14 wet weather season, and to refine the hydraulic model using this additional data)
- Alameda/Brookmead (no SSO predicted in 10-year, 24-hour storm)
The Attachment D mainline and trunk line sewer replacement projects have a total estimated cost of approximately $14.3M$, when escalated to current dollars (ENR 10388.84) from the March 2006 basis of ENR 8444. These projects are shown in Table ES-4.

**Table ES-4. Mainline and Trunk Line Sewer Pipeline Projects that Continue to be Required from Table D of the Order**

<table>
<thead>
<tr>
<th>Project Name &amp; Updated Cost</th>
<th>How Project is Addressed in the IAMP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Miracle Mile $2.1M</td>
<td>Included in 5-year plan.</td>
</tr>
<tr>
<td>Upper Butterfield $2M</td>
<td>Included in 5-year plan. Project may be reduced after flow monitoring and hydraulic model update.</td>
</tr>
<tr>
<td>Westbrae/Hawthorne $1M</td>
<td>In 5-year plan. District has rehabilitated one creek crossing and will remove a second crossing with the Fairfax Downtown rehabilitation project. Flow monitoring and refined modeling will confirm the need for this project.</td>
</tr>
<tr>
<td>Laurel Grove/McAllister $1.2M</td>
<td>In 5-year plan. District will review I&amp;I in this basin, and determine whether I&amp;I reduction will improve hydraulics sufficiently to eliminate predicted SSOs. The McAllister capacity upgrade is included in the Group 1 Manor Easement/Lower McAllister project.</td>
</tr>
<tr>
<td>Sonoma/ Nokomis $2.2M</td>
<td>Included in 5-year plan. Will likely require preliminary design.</td>
</tr>
<tr>
<td>Lower Butterfield/ Meadowcroft $2.4M</td>
<td>Capacity improvement project will be combined with rehabilitation project scheduled toward the end of the implementation plan.</td>
</tr>
<tr>
<td>Manor Easement $2.2M</td>
<td>This project will be completed with the Group 1 Manor Easement/Lower McAllister project.</td>
</tr>
<tr>
<td>Spruce/ Park/ Merwin/ Broadway $2.2M</td>
<td>Included in 5-year plan.</td>
</tr>
</tbody>
</table>

**ES.5 PUMP STATION ASSESSMENTS**

Schaaf & Wheeler and subconsultants MTH Engineering (electrical) and Finn Design Group (structural) visited and evaluated six of the District’s 19 pump and lift stations with regard to reliability, safety, and capacity. The six stations were selected by the District based on their relative criticality to overall pumping operations. The location of each pump station evaluated is shown in Figure ES-9.

2 For IAMP-related projects. The District has budgeted additional collection system improvements that may be integrated with these projects during implementation.
Pump station evaluations included visual inspections, review of previous reports, and review of information provided by District staff. Recommended improvements for each pump station were developed, and then prioritized based on risk. Risk was defined based on age, inflow rate, and reliability. Projects were determined to be either high or medium risk.

In addition, recommendations for the additional pump stations and lift stations that are included in Attachment D of the Order have been carried forward from previous planning documents and included in the IAMP implementation plan.

**ES.5.1 Pump Station Inflows and Capacities**

Sanitary sewer pump stations should have a firm capacity equal to or greater than the peak wet weather inflow (PWWF) to the station. Firm capacity is defined as the capacity of the pump station with the largest pump out of service. Pump station inflow data was generated from the hydraulic model, using a 10-year, 24-hour design storm. Pump station capacity was then evaluated by turning the largest pump “off” in the hydraulic model.

The hydraulic analysis determined that the Bon Air Pump Station (PS12), Kentfield Pump Station (PS15), and Larkspur Pump Station (PS14) lack firm capacity. PS12 has also exceeded
its practical service life and is recommended for rehabilitation. The PS15 deficiency can be restored through the installation of parallel force main section in South Eliseo Drive\(^3\). The PS14 capacity issue can be managed in the near-term, and will only occur if the existing bypass to the Greenbrae PS (PS13) is discontinued.

A comparison of the pump station firm capacities and inflows under existing conditions are shown in Table ES-5.

<table>
<thead>
<tr>
<th>Pump Station</th>
<th>No. of Pumps</th>
<th>PWWF (MGD)</th>
<th>Firm Capacity (MGD)</th>
<th>Sufficient (Y/N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PS12 – Bon Air</td>
<td>2</td>
<td>1.93</td>
<td>1.26</td>
<td>N</td>
</tr>
<tr>
<td>PS13 – Greenbrae</td>
<td>5</td>
<td>8.97</td>
<td>10.86</td>
<td>Y</td>
</tr>
<tr>
<td>PS14 – Larkspur</td>
<td>3</td>
<td>9.87</td>
<td>8.74</td>
<td>N</td>
</tr>
<tr>
<td>PS15 – Kentfield</td>
<td>5</td>
<td>43.1</td>
<td>37.9</td>
<td>N</td>
</tr>
<tr>
<td>PS24 – Eliseo</td>
<td>2</td>
<td>0.45</td>
<td>1.54</td>
<td>Y</td>
</tr>
<tr>
<td>PS25 – S. Eliseo</td>
<td>3</td>
<td>0.65</td>
<td>1.83</td>
<td>Y</td>
</tr>
</tbody>
</table>

**ES.5.2 Flow Monitoring**

The District’s ability to collect flow data was reviewed for the IAMP. Currently, the District does not have a consistent means to collect flow data. Installation of flow meters and completing the SCADA project to provide a means to monitor and record the data are considered the highest near-term pump station priorities in the IAMP implementation plan.

The solution for PS13 and PS14 is straightforward, as flow meters have been installed on force mains. If the District hooks up the flow meters to the District’s future SCADA system, then flows will be continuously monitored and collected. Installation of a flow meter at PS15 is also fairly straightforward as the station has a vault in place for this device. A new flow meter is recommended for installation during the PS12 pump station capacity upgrade.

**ES.5.3 Pump Station Reliability**

The reliability assessment followed requirements that have been endorsed by the Regional Water Quality Control Board (RWQCB). The requirements included the following:

- Each station and force main should be capable of handling the PWWF, with the largest pump out service, without overflow.

\(^3\) The Kentfield Pump Station has sufficient firm capacity using the previous 5-year design storm. The capacity deficiency that is described in the IAMP results from a change in design criteria from a 5-year design storm to a 10-year, 24-hour design storm.
Each pump station should have an automatic alarm and communication system that notifies operations staff in the event of an electrical or mechanical failure.

Each station should have backup or redundant equipment (pumps and power supply) including a permanent backup generator or alternative means for backup power.

The District shall have a plan for bypass pumping at each station.

In general, the six pump stations evaluated appear to be fully operational per the original design. However, there are components in every station that are aged, and will eventually fail. Furthermore, numerous conditions from the list of criteria above have not been met, and the stations require remediation in order to provide reliable operations.

A separate structural and seismic assessment involved a visual survey of the pump station facilities focusing on the general structural condition of the pump stations and their components and the presence of any conditions which would pose a potential hazard in the event of an earthquake. The field assessments yielded no major recommendations regarding needed improvements to address structural or seismic deficiencies. However, additional support and bracing of suspended items is needed at some of the pump stations. As the pump station components are upgraded, the District should install additional support and bracing of suspended items that meets the most recent version of the California Building Code.

**ES.5.4 Recommended Improvements**

Improvements and operational changes to the force main system are proposed to improve the capacity, operation, and reliability of the pump stations. These projects are described in conjunction with the pump station improvements for clarity, but are budgeted as a force main improvement project in the IAMP implementation plan.

Improvements at each of the six pump stations assessed are also recommended. The recommended force main, system operation, and pump station improvements are shown in Table ES-6.
Table ES-6. Proposed Pump Station Improvements

<table>
<thead>
<tr>
<th>Recommended Improvement</th>
<th>Near-Term Improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bon (PS12)</td>
</tr>
<tr>
<td>Increase Pumping Capacity to Meet PWWF</td>
<td>X</td>
</tr>
<tr>
<td>Add Parallel Force Main to Address Capacity Deficiency</td>
<td></td>
</tr>
<tr>
<td>Install Control Modifications for (N) Pumps</td>
<td>X</td>
</tr>
<tr>
<td>Install SCADA System</td>
<td>X</td>
</tr>
<tr>
<td>Install (N) Flow Meter</td>
<td>X</td>
</tr>
<tr>
<td>Connect (E) Flow Meter to (N) SCADA System</td>
<td>X</td>
</tr>
<tr>
<td>Install Bypass Pumping Connection</td>
<td>X</td>
</tr>
<tr>
<td>Replace Ventilation System &amp; Install Alarm</td>
<td>X</td>
</tr>
<tr>
<td>Install Secondary Controller</td>
<td>X</td>
</tr>
<tr>
<td>Replace VFDs</td>
<td></td>
</tr>
<tr>
<td>Upgrade PG&amp;E Electrical Service</td>
<td></td>
</tr>
<tr>
<td>Test and Service Transformer</td>
<td></td>
</tr>
<tr>
<td>Arc-Flash Study and Panel Labels</td>
<td>X</td>
</tr>
</tbody>
</table>

Each pump station has reliability deficiencies. In order to maintain a safe and operable system, it is recommended that the District implement the improvements as soon as feasibly possible. Until the improvements are constructed, it is recommended that the District’s maintenance crews monitor the condition of the facilities and replace items as necessary, as some of the pump station equipment is already past the recommended 25-year service life.

After the Kentfield parallel force main project is constructed, it is recommended that the District perform a detailed flow study to confirm the inflow and discharge rates at each of the remaining pump stations to be rehabilitated. The District’s sewer hydraulic model should also be updated so that accurate design points can be identified for each pump station.

Table ES-7 shows the estimated cost for each project.
Table ES-7. Estimated Pump Station Project Costs

<table>
<thead>
<tr>
<th>Priority</th>
<th>Pump Station</th>
<th>Recommended Improvements</th>
<th>Cost Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Kentfield Parallel Force Main</td>
<td>Install Parallel Force Main</td>
<td>$1,470,000</td>
</tr>
<tr>
<td>1</td>
<td>PS12 – Bon Air</td>
<td>Full Pump Station Rehabilitation</td>
<td>$1,882,000</td>
</tr>
<tr>
<td>2</td>
<td>PS13 – Greenbrae</td>
<td>Full Pump Station Rehabilitation</td>
<td>$3,908,000</td>
</tr>
<tr>
<td>3</td>
<td>PS15 – Kentfield</td>
<td>Immediate Improvements</td>
<td>$1,124,000</td>
</tr>
<tr>
<td>5</td>
<td>PS14 – Larkspur</td>
<td>Immediate Improvements</td>
<td>$1,186,000</td>
</tr>
<tr>
<td>6</td>
<td>PS24 – Eliseo</td>
<td>Full Pump Station Rehabilitation</td>
<td>$794,000</td>
</tr>
<tr>
<td>7</td>
<td>PS25 – S. Eliseo</td>
<td>Full Pump Station Rehabilitation</td>
<td>$794,000</td>
</tr>
<tr>
<td></td>
<td><strong>Total Cost of all Recommended IAMP Improvements</strong></td>
<td></td>
<td><strong>$11,158,000</strong></td>
</tr>
</tbody>
</table>

Attachment D of the IAMP included additional pump station upgrade projects that must be considered in the IAMP. The District continues to have a need for these projects, which comprised reliability and safety improvements.

The projects and their costs, escalated to current dollars from prior planning documents, are listed below. These projects are currently shown in the implementation plan as being completed by 2019. However, each project will be reevaluated in the context of how the station fits into the District’s overall pumping strategy. Flow diversions may allow some stations to be abandoned, or may require the installation of new, more strategically located pump stations. Changes in project scope may require changes to the proposed implementation timeline in order to properly sequence work and provide sufficient advance time for the needed studies.

- Pump Station 20, 21, 31, 32, 33, 34, 35, and 36 improvements. Total estimated cost: $1.88 million
- Pump Station 30 improvements. Estimated cost: $113,000
- Pump Station 22, 23, and 37 improvements. Estimated cost: $159,000

**ES.6 FORCE MAIN ASSESSMENTS**

Force main assessments were conducted by JDH Corrosion, and began with a review of existing pipe materials. Through discussions with the original pipe manufacturer and review of as-built drawings, it was confirmed that reinforced concrete cylinder pipe (RCCP) is the material used for the main force main pipelines (FM-1 and FM-2) from the Kentfield force main to Sir Francis Drake Blvd, and on to the CMSA Wastewater Treatment Plant. The failure mechanism of RCCP is very slow, and the pipe manufacturer knows of no known failures of pipe with this material. Therefore, the need for replacement of these two force main pipelines is not expected in the
foreseeable future. Other sections of the force mains which have been replaced with non-metallic pipe such as high density polyethylene (HDPE) pipe are also assumed to not require replacement in the foreseeable future.

With this information in mind, the evaluation considered other metallic sections of pipe that included ductile iron, bar-wrapped concrete cylinder pipe, mortar lined and coated welded steel, and other ferrous pipes. Upon review of the project documents, discussions with RVSD staff, and other investigations, the following locations were determined to have the highest priority for investigation:

- FM-10, Larkspur Landing (ductile iron pipe)
- FM-13, Greenbrae (welded steel pipe) between PS-13 and Highway 101
- FM-14, Larkspur bypass force main (welded steel pipe) between PS-14 and PS-13
- FM-33, Riviera Circle welded steel creek crossing with rubber pipe connectors to either HDPE or PVC pipe

These pipes comprised approximately 42 percent of the District’s force mains by length, and all of the original force mains greater than 10-inches in diameter.

The initial investigations involved attempting to locate existing contact points on these pipes to make electrical contact to the pipes and perform various tests as related to corrosion investigations, electrical continuity and other related tasks.

Most of these pipelines did not present good points of contact for field personnel to readily perform the electrical continuity and current requirement tests. Therefore, testing of the cathodic protection system on the identified force main pipes was conducted only where possible during the timeframe available for development of the IAMP. Structure-to-soil potentials were measured using a Fluke 87 Voltmeter. Potentials were measured versus a copper, copper-sulfate reference electrode placed in contact with the soil directly over the test location. Measurements were evaluated based on National Association of Corrosion Engineers (NACE) standards to determine the adequacy of cathodic protection.

**ES.6.1 Findings**

Findings from the force main investigations are as follows:

- FM-14 bypass welded steel pipe was found electrically continuous along a 550-foot section from Pump Station 13 to the easterly direction, where a new anode test station (ATS) was installed. A cathodic protection system for the anode test station (ATS) was installed on FM-14 bypass pipe at a location 550 feet east of Pump Station 13. This test station included two (2) wires from the concrete cylinder pipe and one (1), high-potential magnesium anode.
At FM-10, the team attempted to install a new anode test station across the street from PS10 (Landing B), on the south side of Sir Francis Drake Blvd. The existing pipe was 10 feet deep and the groundwater table was located 4 feet below surface grade. Therefore, test station installation was abandoned and electrical continuity of this section of pipe could not be confirmed.

At FM-13 between FM-15 and Highway 101, the team attempted to install three (3) new anode test stations at various locations. The pipe was approximately seven (7) feet deep and the groundwater table was at 3 to 4 feet below surface grade. Therefore, this work was also abandoned and electrical continuity of this section of pipe could not be confirmed. During this work, a second attempt was made to install test leads on a portion of the pipe downstream of the initial location. This pipe was discovered to be comprised of Reinforced Concrete Pipe (RCP) in lieu of the concrete cylinder pipe material found further upstream. The change in material is documented in the as-built drawings for the 1959 Caltrans Highway 101 relocation project. A concrete core that was taken from the RCP pipe at this location showed the pipe material as in excellent condition.

For FM-33 at Corte Madera Creek, the steel section of pipe could not be located. Additional work remains to expose this steel section of pipe, install test wires and anodes, perform electrical continuity tests and possibly provide a cathodic protection system.

ES.6.2 Recommendations

The following activities are recommended for implementation between FY2013/14 and FY2019/20, based on the findings from the field investigations completed by JDH Corrosion. The difficulty in accessing pipe to install test stations is reflected in the costs that are provided for the listed activities.

- Install anode test stations on the Greenbrae force main (FM-13) and Larkspur force main (FM-14). Estimated Cost: $300,000
- Continue field evaluation and installation of an anode test station on the Riviera Circle force main (FM-33). Estimated Cost: $100,000. This budget would also apply to environmental permitting, should the District decided to replace FM-33 with new, non-ferrous pipe in lieu of protecting the existing pipe.
- Isolate and provide corrosion protection on FM-10. Estimated cost: $100,000
- In the future, install new anode test stations on FM-1 and FM-2 to protect existing reinforcing steel and extend useful life. Estimated Cost: $200,000
- Replace approximately 15 force main air valves to eliminate the potential for trapped air and resulting internal pipe deterioration. Each of these projects would require a project
The Operations and Maintenance (O&M) Program provides information that is or will be included in the District’s Sewer System Management Plan (SSMP), which is required for completion by December 2, 2013. The IAMP evaluation included an assessment of line cleaning methods, condition assessment methods, and SSO history. Potential enhancements to these processes were recommended. These improvements are not intended to increase the District’s current budgeted costs.

ES.7.1 Cleaning and Maintenance

The District targets cleaning of its mainline sewers on a 6-month or 12-month preventive maintenance schedule. The schedule is determined based on the history of the individual line segment, and is approximate. Figure ES-10 at the end of this section shows the District’s sewer system and cleaning frequencies as of May 2013, which is the computerized maintenance management system (CMMS) download date that was established for the IAMP. In May 2013, approximately one quarter of the pipeline asset inventory was on a 6-month maintenance schedule.

The District implemented a zone cleaning maintenance approach for the 12-month cleaning schedule in 2012 as part of its program to reduce SSOs. Under this program, all the sewer main lines in a given area or “zone” are cleaned as a group in the same time period before the cleaning crew moves to clean the lines in another zone.

Cleaning results are collected and entered into the District’s Infonet CMMS system for use in scheduling future cleaning cycles. The cleaning frequency was also used to help define the “Likelihood of Failure” score in the risk model that was developed for this IAMP.

Once the second cycle of the 12-month cleaning schedule is completed, the District will have information needed to implement an asset management approach to cleaning. Results from the second cycle will also identify areas that require more data gathering during the third cycle of zone cleaning. Using this information, the Sewer Collection System Supervisor will modify the frequency or method of cleaning for a pipe segment based on a multi-year record of field data. The result will be a program where each asset follows a dynamic cleaning schedule that is continuously adjusted and optimized based on prior results. The expanding CMMS database will
also be used to improve the coordination of cleaning activities with CCTV inspection and capital improvement activities.

Concurrently, the District is initiating a trunk line cleaning program. Because trunk line cleaning and inspection are time-intensive processes, it is important that these activities do not divert resources from the needed mainline cleaning. The District plans to budget for and use contract services for this work, which will be completed on a separate schedule from the mainline efforts.

The District is initiating a sewer cleaning quality assurance and quality control (QA/QC) protocol to measure success and provide feedback to cleaning crews regarding the quality of cleaning operations. The QA/QC protocol will include the implementation of a documented and measurable guideline for determining whether cleaning passes or fails the cleaning quality review, and whether cleaning methods and tools are appropriate and effective. The program will be phased in over time; the current priority is to complete the initial cycle of CCTV inspection by 2016.

**ES.7.3 Condition Assessment**

Condition assessment activities for the District’s linear assets are completed for main line pipelines, manholes, and structures. The District’s mainline sewer condition assessment program includes CCTV inspection of main line pipes to determine their condition and to identify cleaning issues. The District also follows up all SSOs with video inspections.

Using the industry-standard National Association of Sewer Service Companies (NASSCO) Pipeline Assessment and Certification Program (PACP), all structural and O&M defects discovered in main lines are assigned a condition grade. Each pipe segment, defined as a length of pipe from manhole to manhole, is also assigned a NASSCO PACP Quick Rating. The quick rating comprises four individual numbers that, together, describe the number of occurrences of the two highest PACP scores.

As of May 2013, the District had completed CCTV inspection of approximately 53 percent, or 540,000 linear feet of the collection system, as shown in Figure ES-1 at the end of this section. The initial cycle of CCTV inspection for all main lines is planned for completion by 2016. After the initial cycle of assessment, the District will continue a cyclical CCTV inspection of main lines based on the current condition rating. The inspection frequency for Structural Grade 4 and Grade 5 defects follows the requirements of the Order. A line segment will not require re-inspection if it has PACP Structural Grade 4 or Grade 5 defect and is included in the District’s 5-year capital improvement plan (CIP) for rehabilitation or repair.

The District assesses the condition of manholes and other structures during the CCTV inspection work, using field crews and visual inspection methods. The District is formalizing the procedure for collecting manhole data. Additional information will be included in the District’s SSMP.
ES.7.4 Historical SSOs and SSO Reduction Goals

Table ES-8 lists SSOs from the past three years, and further identifies the number of reported maintenance-related SSOs by cause: Roots, Fats, Oils & Grease (FOG), and Debris. The number of SSOs in total and with maintenance-related causes has steadily decreased since 2010.

<table>
<thead>
<tr>
<th>Year</th>
<th>Total SSOs</th>
<th>Cause</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Roots</td>
</tr>
<tr>
<td>2013 (8 months)</td>
<td>11</td>
<td>4</td>
</tr>
<tr>
<td>2012</td>
<td>34</td>
<td>7</td>
</tr>
<tr>
<td>2011</td>
<td>35</td>
<td>13</td>
</tr>
<tr>
<td>2010</td>
<td>49</td>
<td>25</td>
</tr>
</tbody>
</table>

The Order indicates that if the District reduces the number of SSOs by six per year during the time that actions are implemented with respect to the Order, the RWQCB would consider this reduction as favorable progress. In order to achieve this objective, the District must have fewer than 28 SSOs during 2013 and 22 SSOs in 2014. The O&M plan was structured to maximize the District’s success in meeting these SSO reduction objectives.

ES.7.5 Potential Enhancements to Cleaning and Condition Assessment Programs

The following changes and improvements to the District’s cleaning and condition assessment programs are under consideration. These activities will be finalized and documented as part of the District’s SSMP, which will be re-certified by December 2, 2013.

- Continue zone cleaning one more cleaning cycle, and use these results to refine the preventive maintenance program.
- Initiate a cleaning QA/QC program.
- Use CMMS to inform future cleaning efforts, and to coordinate cleaning with ongoing CCTV inspection, spot repairs, and mainline pipeline rehabilitation projects.
- Initiate a trunk line (cleaning and) CCTV inspection program. These activities are likely to be conducted by outside forces in parallel with mainline cleaning efforts, in order to allow District crews to continue to make substantial progress in addressing the requirements of the CDO.
- Use a revised manhole inspection form to obtain manhole information for download and use in the District’s CMMS.
ES.8  RECOMMENDED PROJECTS, TIMELINE, AND COSTS

Table ES-9 on the following page summarizes the projects and activities presented in the IAMP, and presents associated costs and a preliminary implementation timeline.

In addition, the implementation schedule includes a separate line item for activities and projects that are not required to meet the requirements of the Order. These costs are included in the implementation schedule to facilitate the Fiscal Year budgeting process, which must be sufficient to fund projects that are required to meet the requirements of the Order, as well as other District needs. However, the projects are not described in this document, and are not a part of the IAMP.
Table ES-9. IAMP and Capital Program Implementation Plan

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A &amp; B Projects (to address Attachment A needs)</td>
<td>$4.4M</td>
<td>$4.4M</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sewer Rehabilitation Projects - Group 1</td>
<td>$15.9M</td>
<td>$5.3M</td>
<td>$3.3M</td>
<td>$2.2M</td>
<td>$2.6M</td>
<td>$0.1M</td>
<td>$1.4M</td>
<td>$1.0M</td>
</tr>
<tr>
<td>Sewer Rehabilitation Projects – Group 2</td>
<td>$8.9M</td>
<td></td>
<td></td>
<td>$0.3M</td>
<td>$3.0M</td>
<td>$3.0M</td>
<td>$2.6M</td>
<td></td>
</tr>
<tr>
<td>Flow Monitoring Other Plans and Studies</td>
<td>$0.6M</td>
<td>$0.4M</td>
<td>$0.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Capacity Improvement Projects</td>
<td>$14.2M</td>
<td>$0.1M</td>
<td>$1.8M</td>
<td>$2.1M</td>
<td>$2.8M</td>
<td>$2.4M</td>
<td>$2.1M</td>
<td>$2.9M</td>
</tr>
<tr>
<td>Pump Station Rehabilitation Projects</td>
<td>$12.8M</td>
<td>$0.7M</td>
<td>$1.1M</td>
<td>$2.0M</td>
<td>$2.6M</td>
<td>$1.7M</td>
<td>$1.9M</td>
<td>$2.1M</td>
</tr>
<tr>
<td>Force Main Projects</td>
<td>$5.2M</td>
<td>$0.3M</td>
<td>$1.9M</td>
<td>$0.6M</td>
<td>$0.6M</td>
<td>$1.6M</td>
<td>$0.3M</td>
<td></td>
</tr>
<tr>
<td>Total IAMP Implementation Plan</td>
<td>$57.1M</td>
<td>$6.8M</td>
<td>$8.3M</td>
<td>$6.9M</td>
<td>$8.9M</td>
<td>$8.8M</td>
<td>$8.7M</td>
<td>$8.6M</td>
</tr>
</tbody>
</table>

| Miles of Pipe | 3.4 | 4.2 | 4.6 | 4.1 | 4.6 | 6.1 | 5.3 |

Additional District Costs – Separately Planned and Budgeted from IAMP

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Additional Capital Needs</td>
<td>$38.7M</td>
<td>$4.1M</td>
<td>$5.7M</td>
<td>$7.9M</td>
<td>$6.2M</td>
<td>$5.6M</td>
<td>$4.8M</td>
<td>$4.4M</td>
</tr>
</tbody>
</table>

Total Planned Expenditures (For Annual Budgeting Purposes Only)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Capital Budget</td>
<td>$95.8M</td>
<td>$10.9M</td>
<td>$14.0M</td>
<td>$14.8M</td>
<td>$15.1M</td>
<td>$14.4M</td>
<td>$13.5M</td>
<td>$13.0M</td>
</tr>
</tbody>
</table>