CARMEL AREA WASTEWATER DISTRICT

Wastewater Collection System Asset Management Plan

DECEMBER 2018

WEST YOST ASSOCIATES

FINAL REPORT | DECEMBER 2018

Wastewater Collection System Asset Management Plan

Prepared for

Carmel Area Wastewater District

Project No. 683-21-17-03

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Table of Contents

List of Tables

List of Figures

List of Appendices

List of Acronyms and Abbreviations

AMP	Asset Management Plan
ARV	Air Relief Value
BEM	Broadband Electro-Magnetic
CCTV	Closed-Circuit Television
CIP	Cast Iron Pipe
CIPP	Cured-in-Place Pipe
CIWQS	California Integrated Water Quality System
CMMS	Computerized Maintenance Management System
District	Carmel Area Wastewater District
ENR	Engineering New Record
FEMA	Federal Emergency Management Agency

GIS	Graphic Information System
HDPE	Joint High-Density Polyethylene
HDPE	High-Density Polyethylene
M	Million Dollars
MFL	Magnetic Flux Leakage
MWLS	Mean Water Levels
NASSCO	National Association of Sewer Service Companies
PACP	Pipeline Assessment Certification Program
PVC	Polyvinylchloride
RFEC	Remote Field Eddy Current
SCADA	Supervisory Control and Data Acquisition
SSO	Sanitary Sewer Overflow
VCP	Vitrified Clay Pipe
VRV	Vacuum Relief Value
West Yost	West Yost Associates

1.0 INTRODUCTION

This report presents the Asset Management Plan (AMP) for the Carmel Area Wastewater District's (District) existing wastewater collection system infrastructure. Like public agencies everywhere, the District is facing important challenges in managing aging collection system infrastructure and balancing utility services and costs. The decision between maintaining individual collection system assets versus repairing or replacing them involves many factors such as capital and long-term costs and the risk of potential failures.

This AMP includes three major asset classes in the collection system: gravity sewers, pump stations, and force mains. While the District is operating at different stages of asset management with each of these three asset classes (with gravity sewers being the most mature program), the intent of this AMP is to document the current status of each facet of the collection system program and provide recommendations for future improvements and next steps. Manholes, the fourth asset class, are not separately assessed at this time, but can generally be considered similar in condition and risk to the adjacent gravity sewers.

1.1 Purpose and Organization

The goal of this AMP is to use a robust risk assessment process to prioritize a long-term Rehabilitation and Replacement Program (Rehab/Replacement) for gravity sewers, pump stations, and force mains.

The major elements of this report include the following:

- Section 1 Introduction
- Section 2 Gravity Sewer Asset Management Plan
- Section 3 Pump Station Asset Management Plan
- Section 4 Force Main Asset Management Plan
- Section 5 Summary and Next Steps

1.2 Information Sources

The following information sources were provided by the District and were used for this analysis:

- Carmel Area Wastewater District Geographic Information System, provided in December 2016 and partially supplemented in July 2018 (District GIS)
- Closed-circuit television (CCTV) inspection records database *Carmel, CA FULL PACP.mdb*, provided on March 20, 2018
- Carmel Area Wastewater District ICOMM asset registry and related *Age of Sewers at CAWD.xls* and *revised MH data.xls* (provided May 2018)

- Sewer Repair Records (*2001 replaced.xls, Rehab since 2001.xls, Spot repairs.xlsx*), provided April 2018
- California Integrated Water Quality System Public Records (CIWQS database) and District Sanitary Sewer Overflow (SSO) records *SSO History.xls*, provided April 2018
- Carmel Area Wastewater District Draft Collection System Hydraulic Modeling Notebook by West Yost Associates, dated December 23, 2016
- Carmel Area Wastewater District Draft Collection System Hydraulic Modeling Phase 2 Notebook by West Yost Associates, dated June 29, 2018 and the associated hydraulic model output
- Pump Station Inspection Forms, provided on April 4, 2018
- Carmel Area Wastewater District Pump Station Evaluation Report of Observations by V&A Consulting Engineers, Inc. dated November 1999
- Carmel Area Wastewater District 2013 Sewer System Management Plan, dated October 2013
- Sewer System Record Drawings *ALL-AS-BUILT.pdf*, provided in March 2018

1.3 System Description

The District's wastewater collection system is comprised of approximately 77.3-miles of gravity sewers, seven pump stations, and approximately 4.4 miles of force mains (shown in Figure 1). The District currently has a fairly robust asset registry in its computerized maintenance management system (CMMS), ICOMM, which stores physical asset properties (including pipe diameter, material, and installation date), and maintenance work order history such as preventative maintenance schedules and blockage and SSO records. The District's graphic information system (GIS) is also populated with the geospatial coordinates of the collection system assets.

2.0 GRAVITY SEWER ASSET MANAGEMENT PLAN

2.1 Gravity Main Asset Inventory

The majority of collection system's 77.3 miles of gravity sewer mains are composed of vitrified clay pipe (VCP) with newer installations being primarily constructed with polyvinylchloride (PVC) pipe, as shown in Table 1.

Figure 2 shows the installation decade of the gravity sewers in the collection system. The average gravity sewer age in the system as a whole is 59-years, indicating that a significant portion of the system is nearing the end of its useful life.

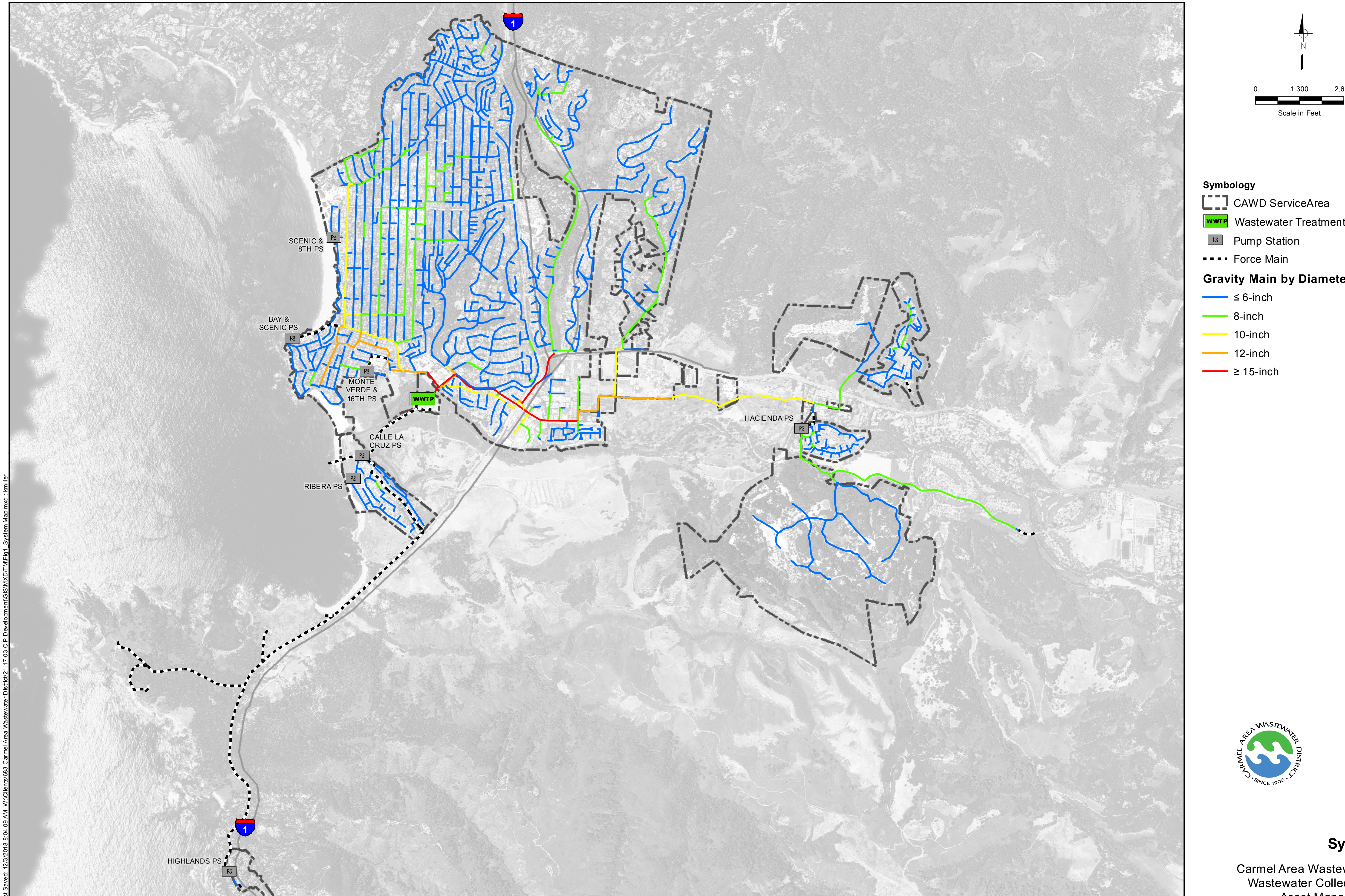


Figure 1

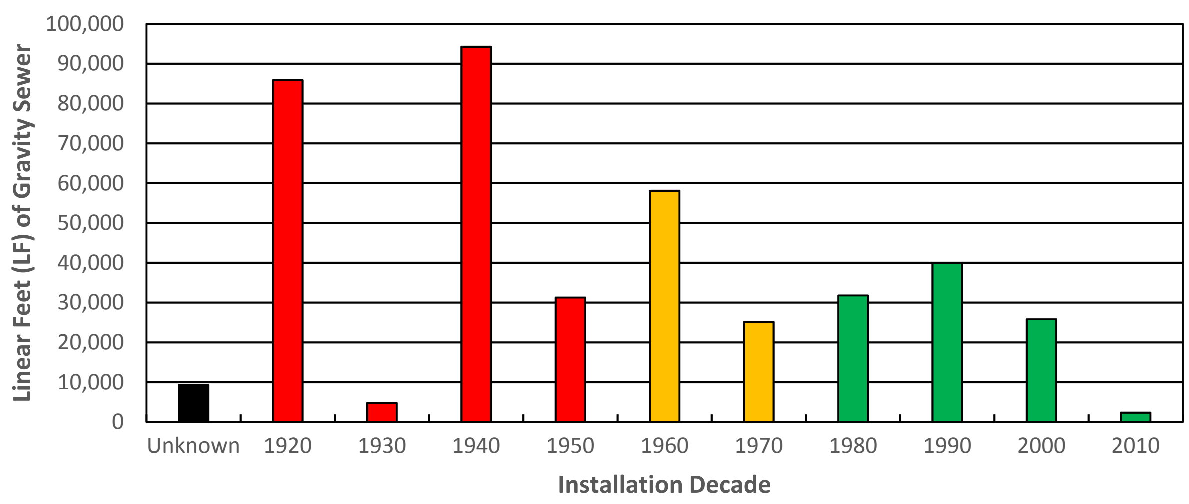
System Map

Carmel Area Wastewater District
Wastewater Collection System
Asset Management Plan

Table 1. Installed Gravity Main Pipe Materials

Material Type	Length of Pipe (LF) Sewer Diameter ≤ 6"	8"	10" - 18"	> 18"	Total LF	% of System
AC				2,925	2,925	0.7
AT		395	7,933		8,328	2.0
Cast Iron Pipe	1,318	972	122		2,412	0.6
HDPE	582	4,302			4,884	1.2
PVC	48,770	21,510	3,209		73,489	18.0
Steel	1,130			409	1,539	0.4
VCP	245,861	29,856	18,869	1,761	296,347	72.5
VCP/PVC	16,115	1,985	539		18,639	4.6
Total	**313,776**	**59,020**	**30,672**	**5,095**	**408,563**	**100%**

Figure 2. Gravity Main Asset Age



VCP sewers installed before 1958 (shown in red on Figure 2) have short lengths (therefore, numerous joints) with cement mortar joints, which shrink and crack and allow much higher rates of infiltration and root intrusion[1] than post-1958 sewers that use rubber-gasket joints. While VCP

[1] Control of Infiltration and Inflow into Sewer System Manual of Practice, USEPA, January 1971

is reported to have a structural life expectancy of 70-100 years, the failure of its joints in pre-1958 sewers increase maintenance failures, and in some cases capacity failure through I/I. The majority of these pre-1958 sewers are also 6-inches in diameter or less, which carry a higher probability of maintenance blockages occurring from root intrusion, sediment, or grease accumulation since 6-inch diameter sewers have only half the cross-sectional area of 8-inch diameter sewers. These pre-1958 sewers, which make up approximately 55 percent of the gravity sewer system, have reached the 70-year life expectancy mark and have also experienced significant structural failures, as evidenced by the District's CCTV inspection program discussed further in Section 4.0.

2.2 Replacement Values

A planning level replacement value estimate was developed for the gravity portion of the collection system. The estimate varies by depth of cover and construction method, and was prepared using West Yost Associates (West Yost) experience and recent bid results from similar projects. A combined estimating and construction contingency of 30 percent is included in the unit costs to account for unknown conditions, design completion level of the project, and bidding climate factors. The total capital costs include an allowance of 30 percent to account for planning level activities, design, environmental reviews, legal administration, construction services, change orders, and other related items.

The replacement of the gravity portion of the collection system is currently valued at approximately $169 million (M) in September 2018 dollars Engineering New Record (ENR) Construction Index of 12103.88), as summarized in Table 2. Note that this estimate assumes that sewer mains 6-inches in diameter or less are upsized to 8-inches upon replacement, which meets the District's current minimum design standard.

Table 2. Gravity Sewer Replacement Values

Average Depth: Construction Method: Unit Cost:	Less than 15 feet Pipe Bursting $25/in-Diameter-LF			Greater than 15 feet Open Cut $42/in-Diameter-LF		
Pipe Diameter, inch	Length, LF	Unit Cost (per LF) $	Cost $	Length, LF	Unit Cost (per LF) $	Cost $
4	219	224	49,000	-	376	-
5	105	224	24,000	-	376	-
6	310,342	224	69,517,000	3,110	376	1,169,000
8	58,780	224	13,166,720	240	376	90,000
10	17,190	280	4,813,000	-	470	-
12	11,202	336	3,764,000	-	564	-
15	1,766	420	742,000	-	705	-
18[(a)]				514	756	435,000
24[(a)]				2,375	1,008	2,679,000
27[(a)]				2,721	1,134	3,453,000
Subtotal by Depth:	**75.6 mi**		**$82,210,000**	**1.7 mi**		**$7,826,000**
			Gravity Sewer Subtotal:	**77.3 mi**		**$99,902,000**
					30% Contingency:	$29,971,000
					Construction Cost Subtotal:	**$129,873,000**
					30% Engineering, Legal, Administration, etc.:	$38,962,000
					Total Capital Cost:	**$168,835,000**

(a) All pipes greater than 18” in diameter assume open cut method of construction.

Assuming a 75-year replacement cycle, an average of one-mile of gravity sewers should be replaced per year to keep pace with the average rate of sewers exceeding their useful lives. Considering average gravity sewer depth and diameter, the average replacement value is $2.0 M per mile.

2.3 Gravity Sewer Inspections

The methodology used to assess the condition of the sewers that have valid CCTV inspection data available consists of the following two-step process:

1. **Defect Scoring:** Score the severity of individual defects
2. **Pipe Segment Scoring:** Assign a severity score to each pipe segment (from manhole to manhole) based on the severity of the individual defects on that pipe segment

2.3.1 Defect Scoring

Gravity sewer structural defect coding and scoring is based on the National Association of Sewer Service Companies (NASSCO) Pipeline Assessment Certification Program (PACP), which is the North American Standard for pipeline defect identification and assessment. A summary of the PACP defect scoring system is located in Appendix A for reference.

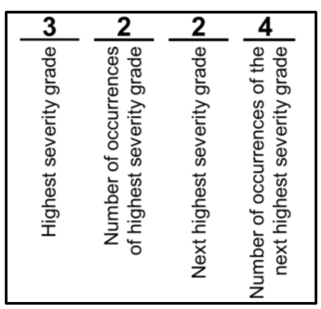
Based on the significance of the defect, extent of damage, percentage of restriction to flow capacity, or the amount of wall loss due to deterioration, PACP grades each recorded defect according to the 1 to 5 scale (with 5 being the most severe) shown in Table 3.

Table 3. PACP Condition Grading System

Condition Grade	Severity
5	Most significant defect grade
4	Significant defect grade
3	Moderate defect grade
2	Minor to moderate defect grade
1	Minor defect grade

2.3.2 Pipe Segment Scoring

For each CCTV inspection, the defects recorded for each pipe segment (from manhole to manhole) were compiled into a four-digit code denoted as the "Pipe Segment Quick Score" (shown below) through a count of the number of defects rated 1, 2, 3, 4, and 5. Any count greater than nine defaulted to a count of nine to adhere to the four-digit system. Any score of 0 through this system refers to an inspection with zero defects.



2.4 Gravity Sewer Risks

This risk assessment evaluated the likelihood and consequence of a gravity sewer failure. For this analysis, a sewer failure is considered to be a failure that could result in a SSO. SSOs are violations of state and federal laws and can adversely impact the environment and public health. SSOs can also require costly emergency repairs which are disruptive to the community.

The likelihood of failure assesses the probability that a failure will occur. The consequence of failure considers the impact an SSO may have on public health, the environment, and the community. A risk model was developed in MS Access to perform the risk assessment calculations. A rating for both likelihood and consequence of failure was assigned by the model to each pipe segment. The risk assessment model then combined the likelihood of failure ratings with the consequence of failure ratings to develop a comprehensive risk rating. This section summarizes the analysis that used available information to assign a risk level for each pipeline segment.

2.4.1 Likelihood of Failure Analysis

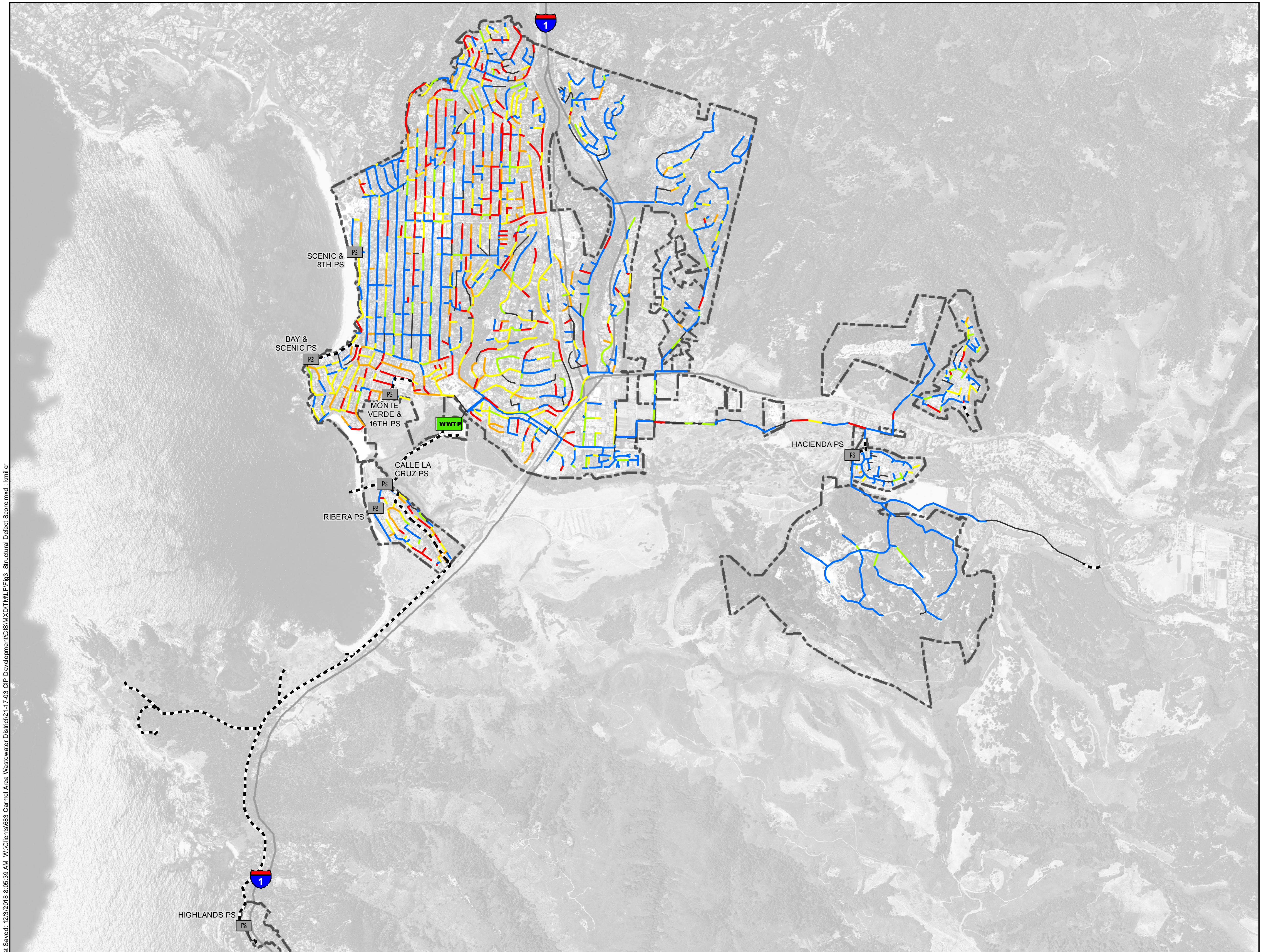
The likelihood of failure analysis considers the probability that a failure will occur in a given pipeline segment. The District's collection system consists primarily of VCP and PVC. These sewer pipelines have the following principal failure modes:

1. Structural Failure
2. Maintenance Blockages
3. Capacity-Related SSOs

For each failure mode, one or more factors are considered in determining the likelihood of a failure, as discussed below.

Structural Failure: VCP is brittle, and cracks or breaks can progress to pipeline collapse. The severity of cracks and defects is documented through CCTV inspection. The likelihood of structural failure is determined by using the PACP Structural Quick Score (shown on Figure 3), which provides a standardized metric for comparing CCTV defects across the system. Of the 1,848 gravity pipes in the system, 148 pipes (eight percent) did not have any history of CCTV inspection. The missing CCTV inspection can either be due to miscoded inspections that do not link back to the proper pipe or areas of the system that the District has not inspected since 2007. When CCTV inspection data was not available, the structural failure likelihood was assessed using the installation year (shown on Figure 4).

Maintenance Blockages: Maintenance problems related to root intrusions, grease accumulations, and debris can cause blockages and result in SSOs. The likelihood of maintenance failure is determined by using both the PACP Maintenance Defect Score (shown on Figure 5) and the root and grease condition recorded during cleaning (shown on Figure 6). The severity of maintenance issues with root intrusion and grease accumulation was analyzed from District-recorded maintenance information for each asset from 2007 to 2017. Additionally, the severity of maintenance defects is documented through CCTV inspection. The PACP Maintenance Quick Score (discussed in Section 4.1) provides a standardized metric for comparing CCTV defects across the system.



Symbology

- CAWD ServiceArea
- Wastewater Treatment Plant
- Pump Station
- Force Main

Gravity Main - Structural Peak Score

- Grade 1 Defect or No Defect
- Grade 2 Defect
- Grade 3 Defect
- Grade 4 Defect
- Grade 5 Defect
- No Inspection

Figure 3

Likelihood of Failure Structural Failure by Defect Score

Carmel Area Wastewater District
Wastewater Collection System
Asset Management Plan

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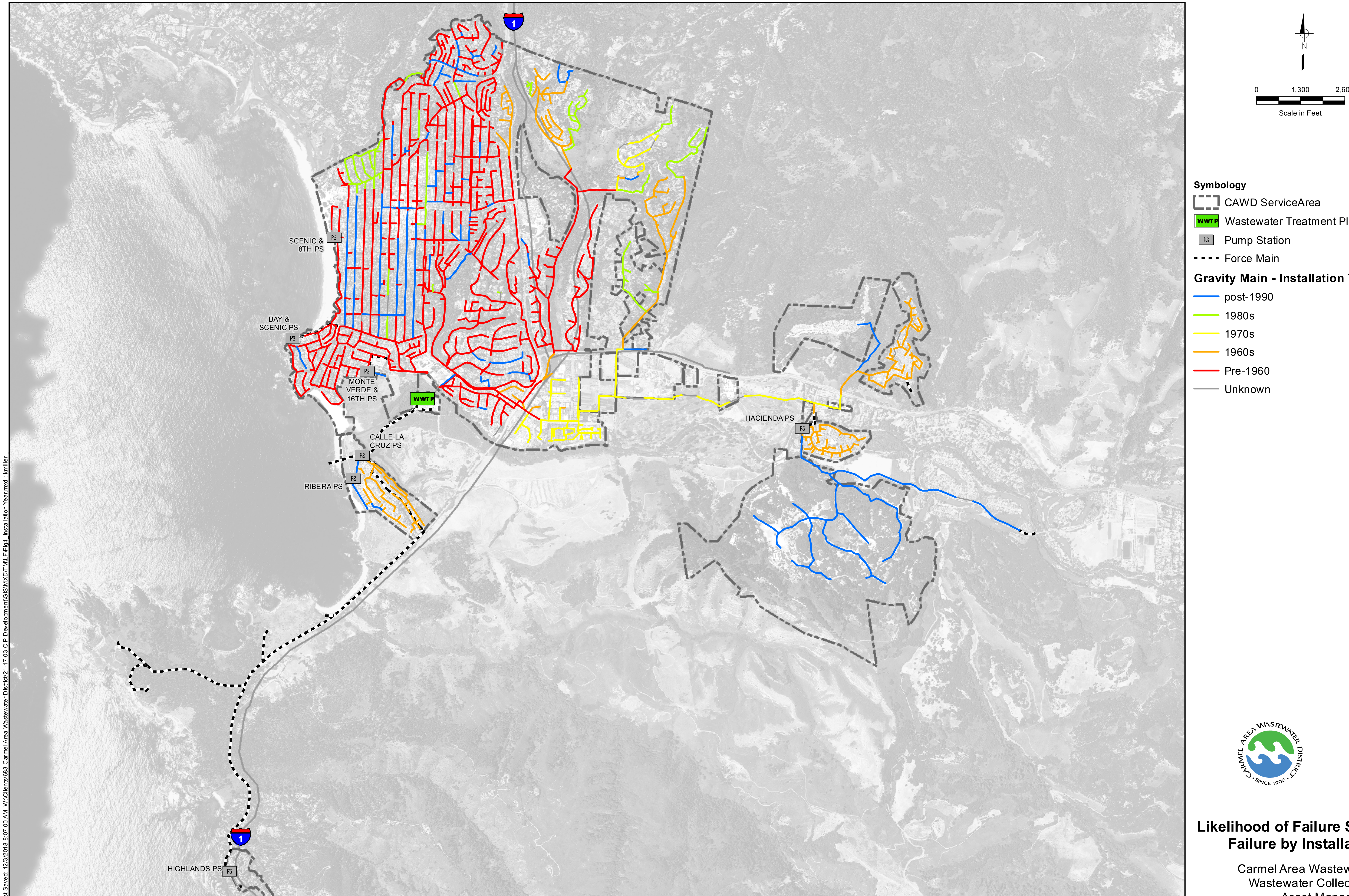

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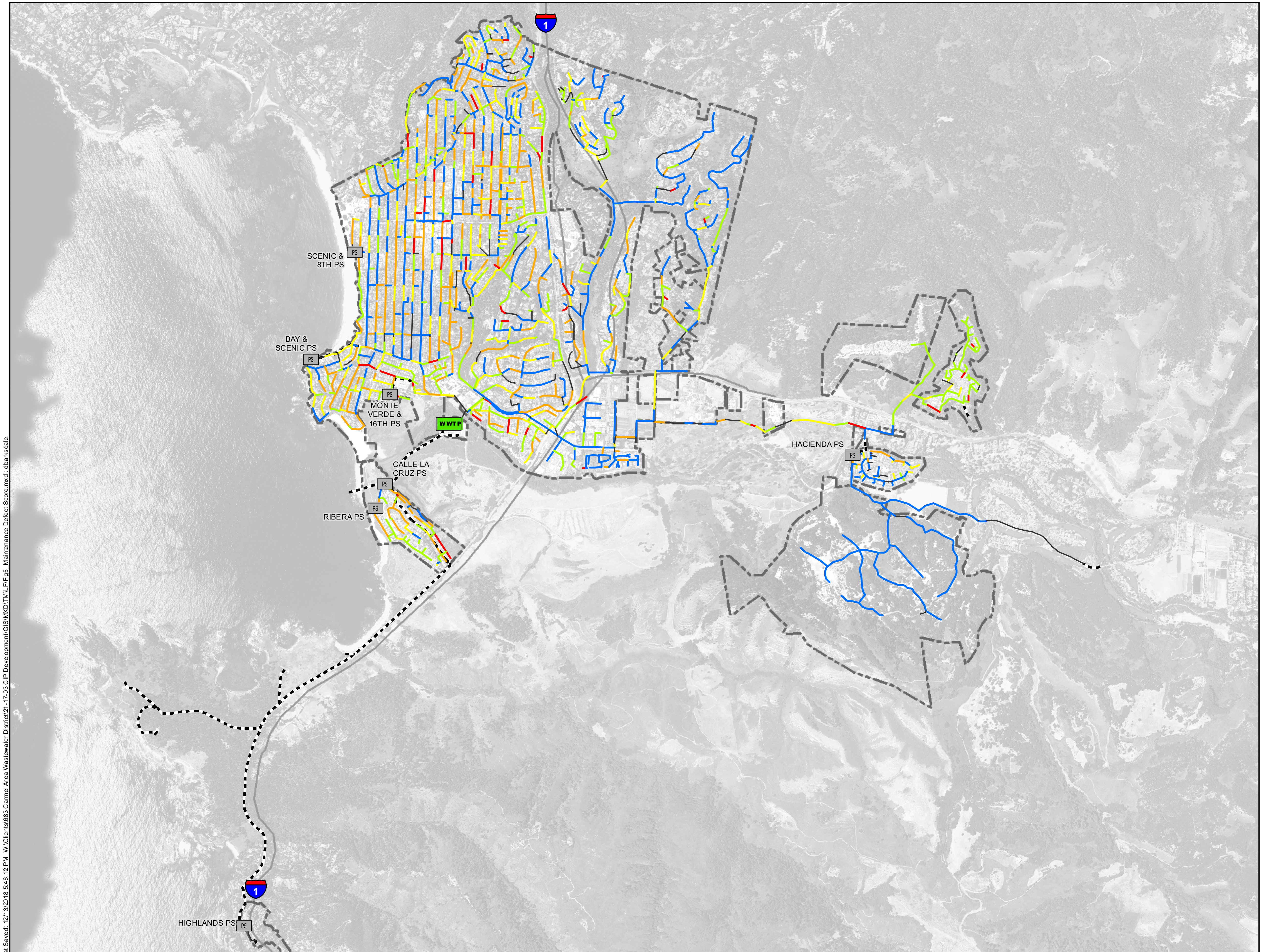
Figure 4

Likelihood of Failure Structural Failure by Installation Year

Carmel Area Wastewater District
Wastewater Collection System
Asset Management Plan



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N

0 1,300 2,600

Scale in Feet

Symbology

CAWD ServiceArea

Wastewater Treatment Plant

Pump Station

Force Main

Gravity Main - Peak Maintenance Defect Rating

Grade 1 Defect or No Defect

Grade 2 Defect

Grade 3 Defect

Grade 4 Defect

Grade 5 Defect

No Inspection

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Figure 5

Likelihood of Failure Maintenance Failure by Defect Score

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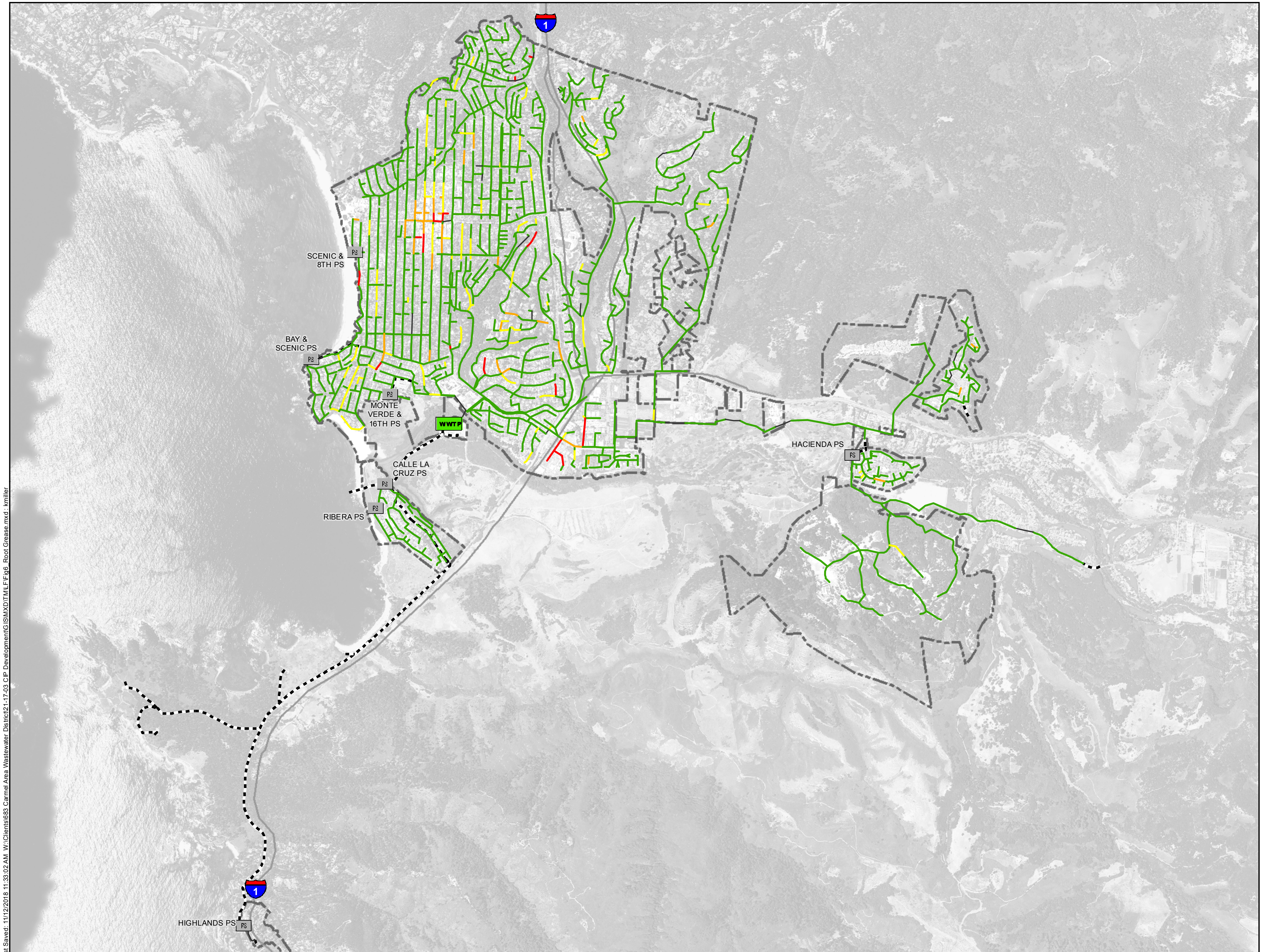
Wastewater Collection System
Asset Management Plan



N

0 1,300 2,600

Scale in Feet

Symbology

- CAWD ServiceArea
- WWTP Wastewater Treatment Plant
- PS Pump Station
- Force Main

Gravity Main - Root/Grease Condition

- Good Condition
- Light
- Medium
- Heavy
- No Records

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Figure 6

LOF Maintenance Failure by Root/Grease Observed During Cleaning

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Wastewater Collection System
Asset Management Plan

Inadequate Hydraulic Capacity: Hydraulic restrictions or bottlenecks cause surcharging, which can lead to SSOs at, or upstream of, the location of the restriction. A sewer main with inadequate hydraulic capacity is defined as a segment for which the projected maximum depth of flow (d) exceeds the diameter of the pipe (D), as estimated by the District's hydraulic model. The hydraulic model, updated in 2018, was used to identify areas of hydraulic capacity deficiency (Figure 7).

Each pipe segment is rated by the risk model for each likelihood of failure category factor on a scale of 1 to 5, with 5 indicating the highest likelihood of failure. The methodology for rating each pipeline segment is summarized in Table 4.

Once rated for each factor, the risk model is applied to each pipe segment to produce a single rating for each category on a scale of 1 to 5 with 5 being the highest possible score. This rating is determined according to the Rating Logic shown in Table 4. Finally, the risk model calculates the total of the three scores for each category as the single Likelihood of Failure rating with 23 and 115 being the lowest and highest possible ratings, respectively.

2.4.2 Consequence of Failure Analysis

The consequence of failure is based on the potential impacts from an SSO in each segment of the collection system.

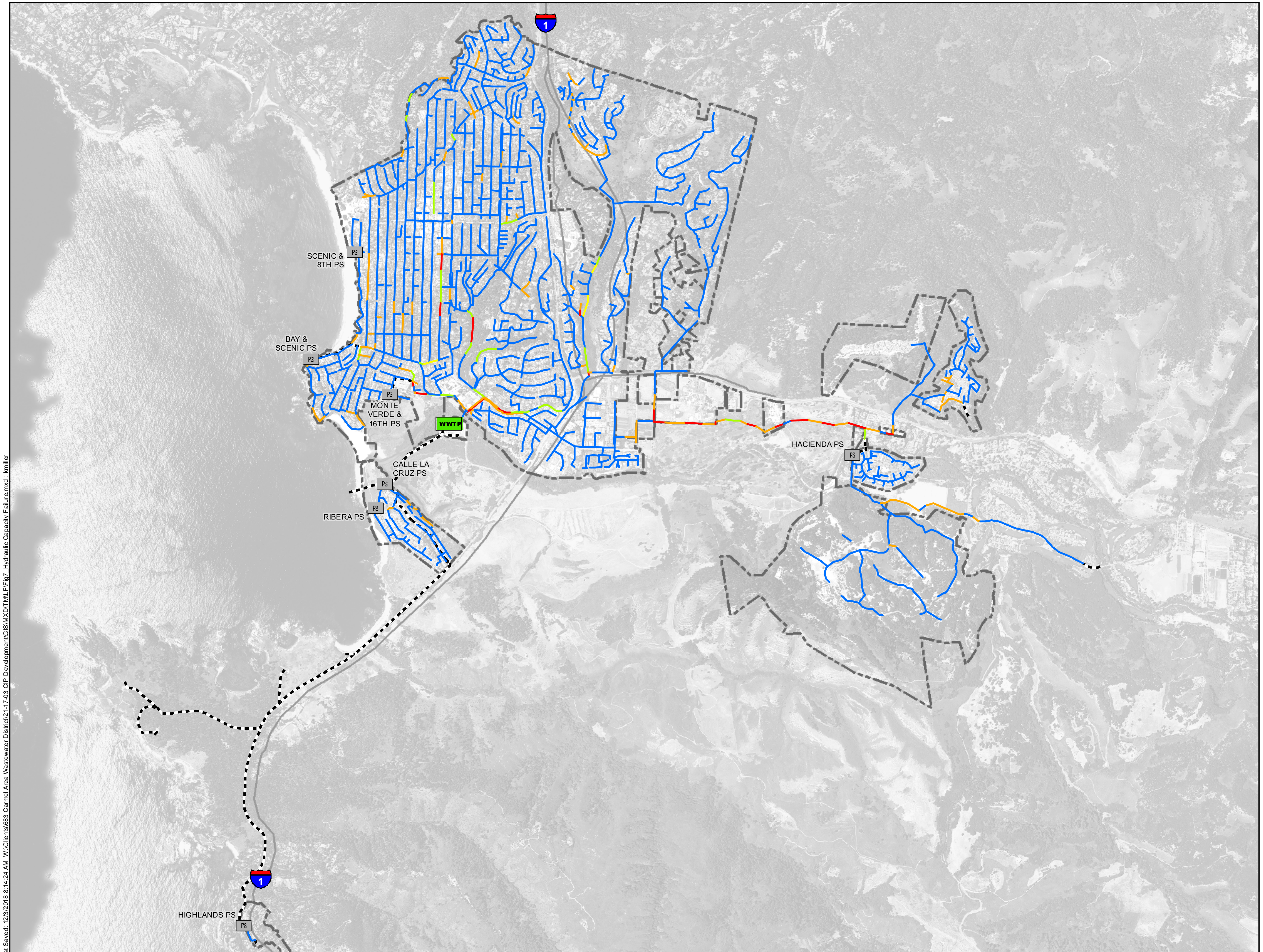
2.4.2.1 Consequence Criteria

The consequence of failure analysis is divided into four categories:

1. Potential Spill Volume
2. Environmental Impact
3. Emergency Response and Traffic Impact
4. Public Health Impact

For each category, one or more factors are considered in determining the potential consequence of a failure, as discussed below.

Potential Spill Volume: SSOs are prohibited by state and federal environmental laws because of their potential adverse impacts on the environment and public health. Large-volume SSOs have greater potential to adversely impact the environment and public health. The potential SSO volume was estimated from the peak wet weather flow in each pipe, as estimated by the District's hydraulic model. Flow in any pipes with missing or suspect hydraulic model flow projections were estimated using pipe diameter. The results are shown on Figure 8.



Symbology

- CAWD ServiceArea
- Wastewater Treatment Plant
- Pump Station
- Force Main

Gravity Main - PWWF d/D Ratio

- < 0.5 or Unmodeled
- 0.5 - 0.74
- 0.75 - 0.99
- Surcharge due to Backwater
- Surcharge due to Throttle

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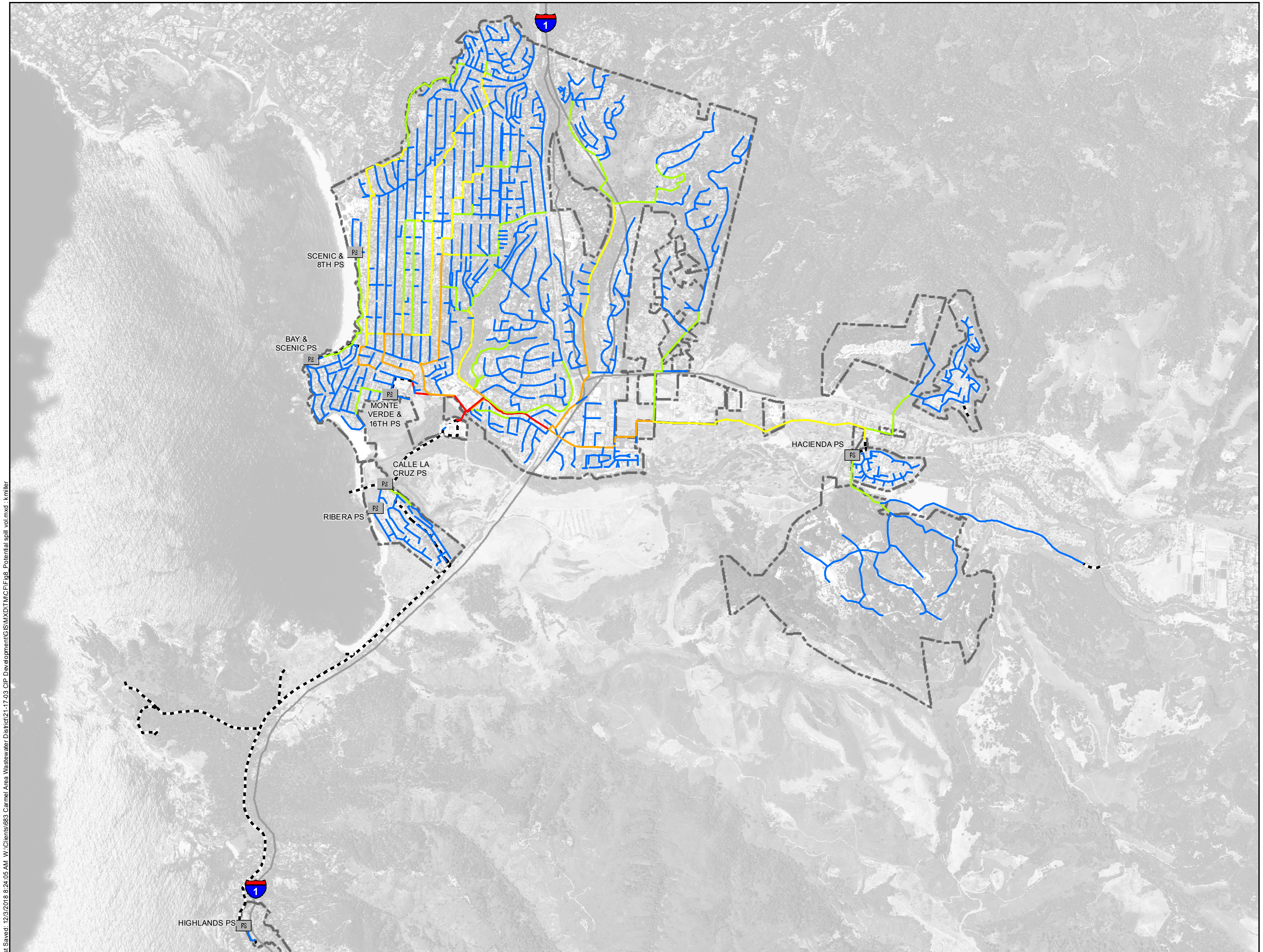
Figure 7

Likelihood of Failure
Hydraulic Capacity Failure

Carmel Area Wastewater District
Wastewater Collection System
Asset Management Plan

Table 4. Likelihood of Failure Rating Factors

Category	Factor	Rating (1 being the lowest, 5 being the highest)					Rating Logic	Weighting Factor
		1	2	3	4	5		
Structural Failure	Highest Severity Structural Defect Rating	Grade 1 Defect or No Defect	Grade 2 Defect	Grade 3 Defect	Grade 4 Defect	Grade 5 Defect	Defect Rating (if no CCTV record, then Installation Year)	8
	Installation Year	Post-1990	Between 1980-1990	Between 1970-1980	Between 1960-1970	Pre-1960 or Unknown		
Maintenance Failure	Highest Severity Maintenance Defect Rating	Grade 1 Defect or No Defect	Grade 2 Defect	Grade 3 Defect	Grade 4 Defect	Grade 5 Defect	Maximum of Two Rating Values	10
	Roots/Grease Observed During Cleaning	Good Condition	-	Light	Medium	Heavy		
Hydraulic Capacity Failure	Modeled PWWF d/D Ratio	< 0.5 or Not Modeled	0.5 – 0.75	0.75 – 1.0	Surcharge due to Backwater	Surcharge due to Throttle	Single Rating	5



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N

0 1,300 2,600
Scale in Feet

Symbology

- CAWD ServiceArea
- PS Pump Station
- Force Main

Gravity Main - Potential Spill Volume

- ≤ 0.09 MGD or ≤ 6-inch Diameter
- 0.09 - 0.25 MGD or 8-inch Diameter
- 0.26 - 0.5 MGD or 10-inch Diameter
- 0.51 - 1 MGD or 12-inch Diameter
- > 1 MGD or ≥15-inch Diameter

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Figure 8

Consequence of Failure Potential Spill Volume

Carmel Area Wastewater District
Wastewater Collection System
Asset Management Plan

Environmental Impact: Wastewater that contaminates waterways poses a direct impact to the environment. A proximity analysis was performed in GIS to determine which gravity mains were located within 100 and 250 feet of waterways, within intersecting waterways, and within the Federal Emergency Management Agency (FEMA) National Flood Hazard 100-year flood zone, as shown on Figure 9.

Emergency Response and Traffic Impact: Emergency response and repair costs can increase substantially when the gravity main is difficult to access by SSO response crews. The District provided accessibility ratings (on an easy to-difficult-to-access scale) for pipelines located in easements. Also, the downtown Carmel-by-the-Sea area (from Monte Verde to Junipero Streets and 5th to 8th Avenues) is covered by a concrete cap, causing access to buried pipelines under this cap to be slightly more difficult.

Repairs in arterial streets or highways require additional efforts to redirect traffic and are more difficult to respond to than spills on smaller collector streets. A proximity analysis was used to find gravity mains located within these streets. The following facilities were used to identify increased traffic consequences: gravity mains located near highways or in access ramps, along arterial streets, and along collector streets.

The results of the emergency response and traffic impact analysis are shown on Figure 10.

Public Health Impact: Human exposure to a wastewater spill poses a public health risk, and the potential for human exposure increases in areas with higher pedestrian traffic such as public facilities like parks and schools, and in tourist areas. The proximity of gravity mains to high pedestrian traffic areas was estimated using GIS data, as shown on Figure 11.

2.4.2.2 Consequence Criteria Rating Methodology

Each pipe segment is rated by the risk model for each consequence of failure factor on a scale of 1 to 5 with 5 indicating the highest adverse consequence of failure. The methodology for rating each pipeline segment is summarized in Table 5.

The risk model is applied to each pipe segment to produce a single rating for each category on a scale of 1 to 5, with 5 being the highest possible score. This rating is determined according to the Rating Logic shown in Table 5. Finally, the risk model calculates the aggregate of the three scores for each category as the single Consequence of Failure rating with 27 and 135 being the lowest and highest possible ratings, respectively.

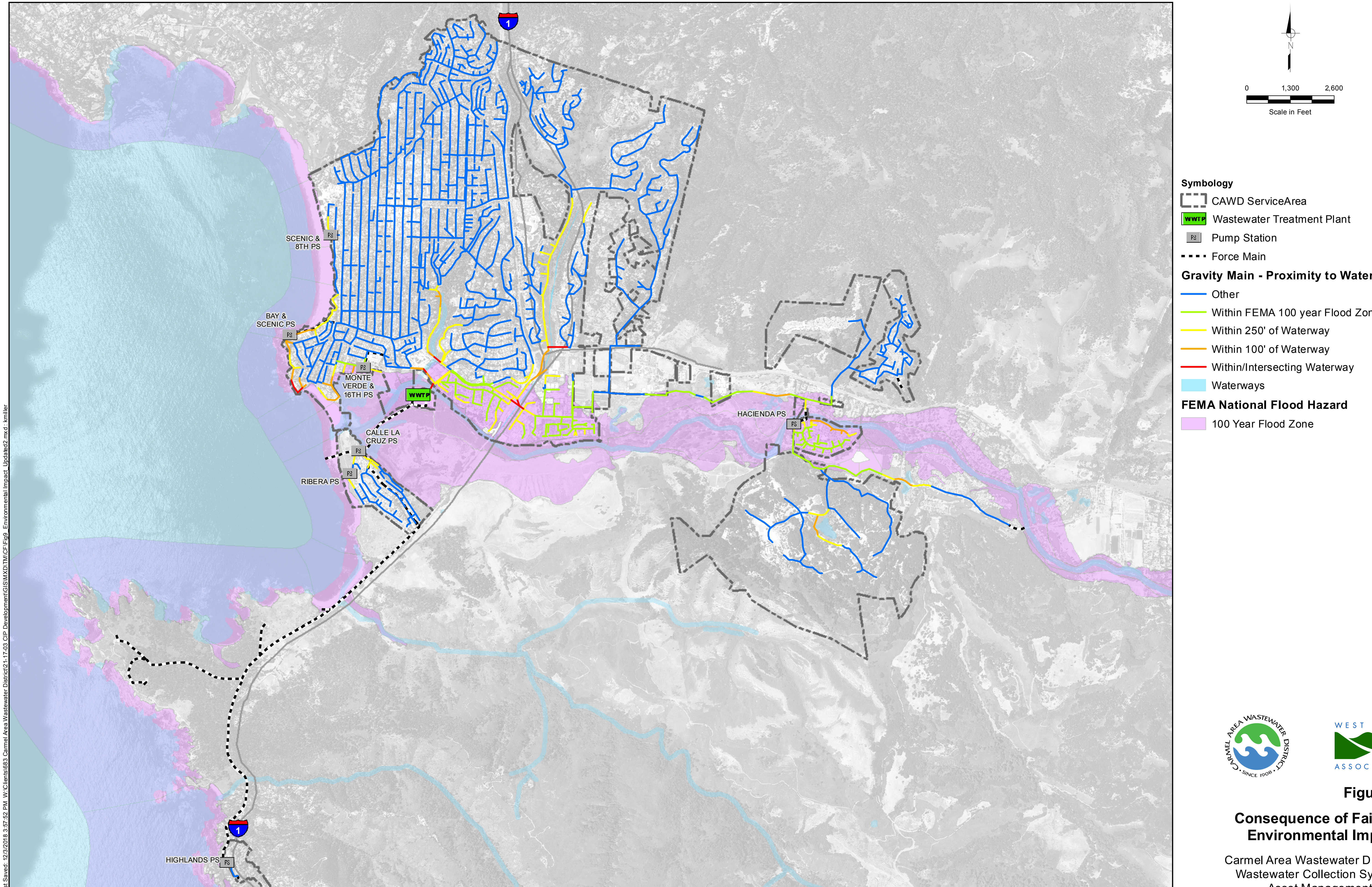

Figure 9

Consequence of Failure Environmental Impact

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Wastewater Collection System
Asset Management Plan

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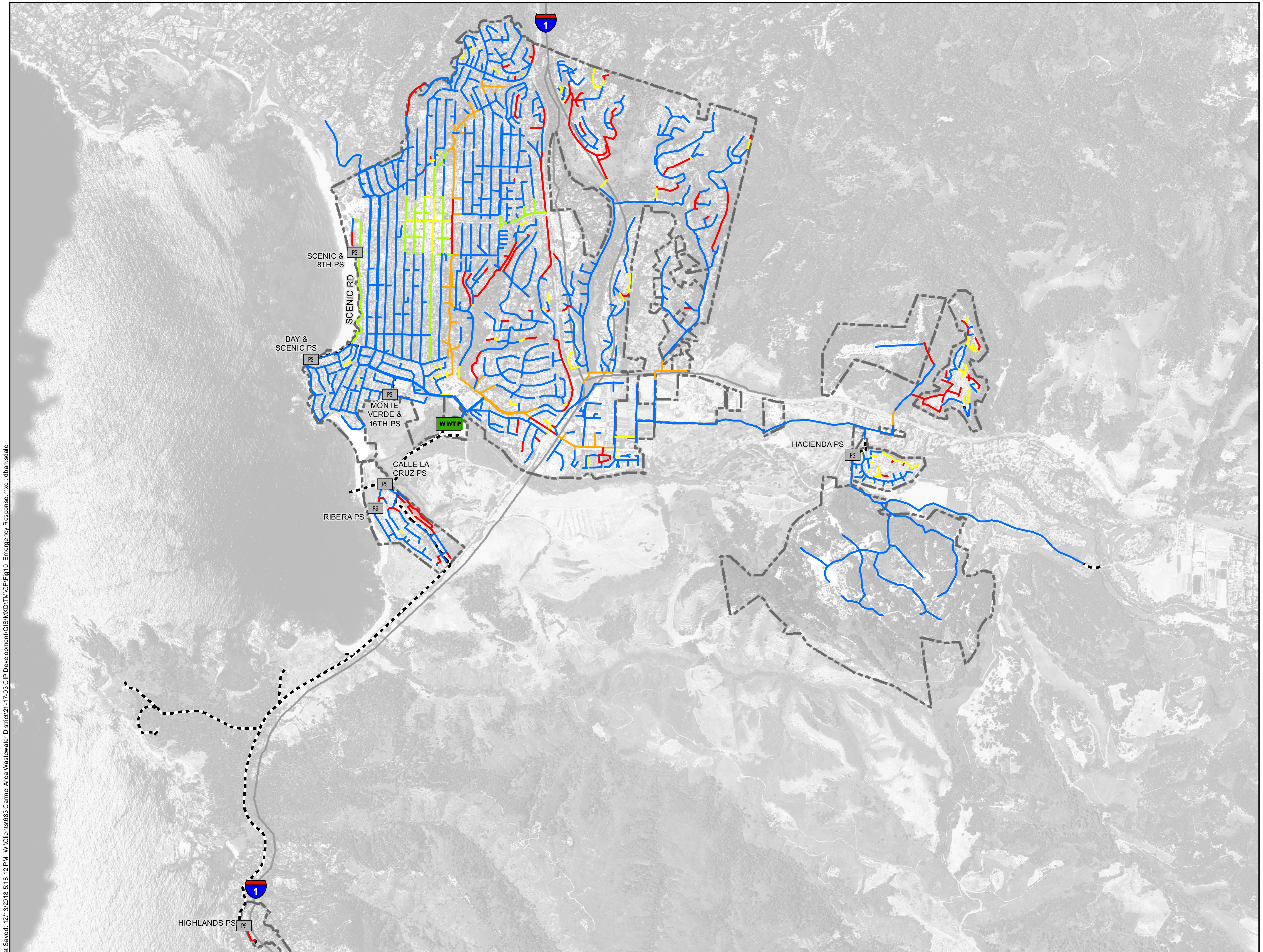

N

0 1,300 2,600
Scale in Feet

Symbology

CAWD ServiceArea

Wastewater Treatment Plant

Pump Station

Force Main

Gravity Main - Response Impact

Local Street/ Easement with Easy Access

Collector Street/ Concrete Local Street

Easement with Limited Access/ Conrete Collector Street

Arterial Street

Highway/Ramp/Easement with Difficult Access/ Concrete Arterial Street

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Figure 10

Consequence of Failure Emergency Response and Construction Impact

Carmel Area Wastewater District
Wastewater Collection System
Asset Management Plan

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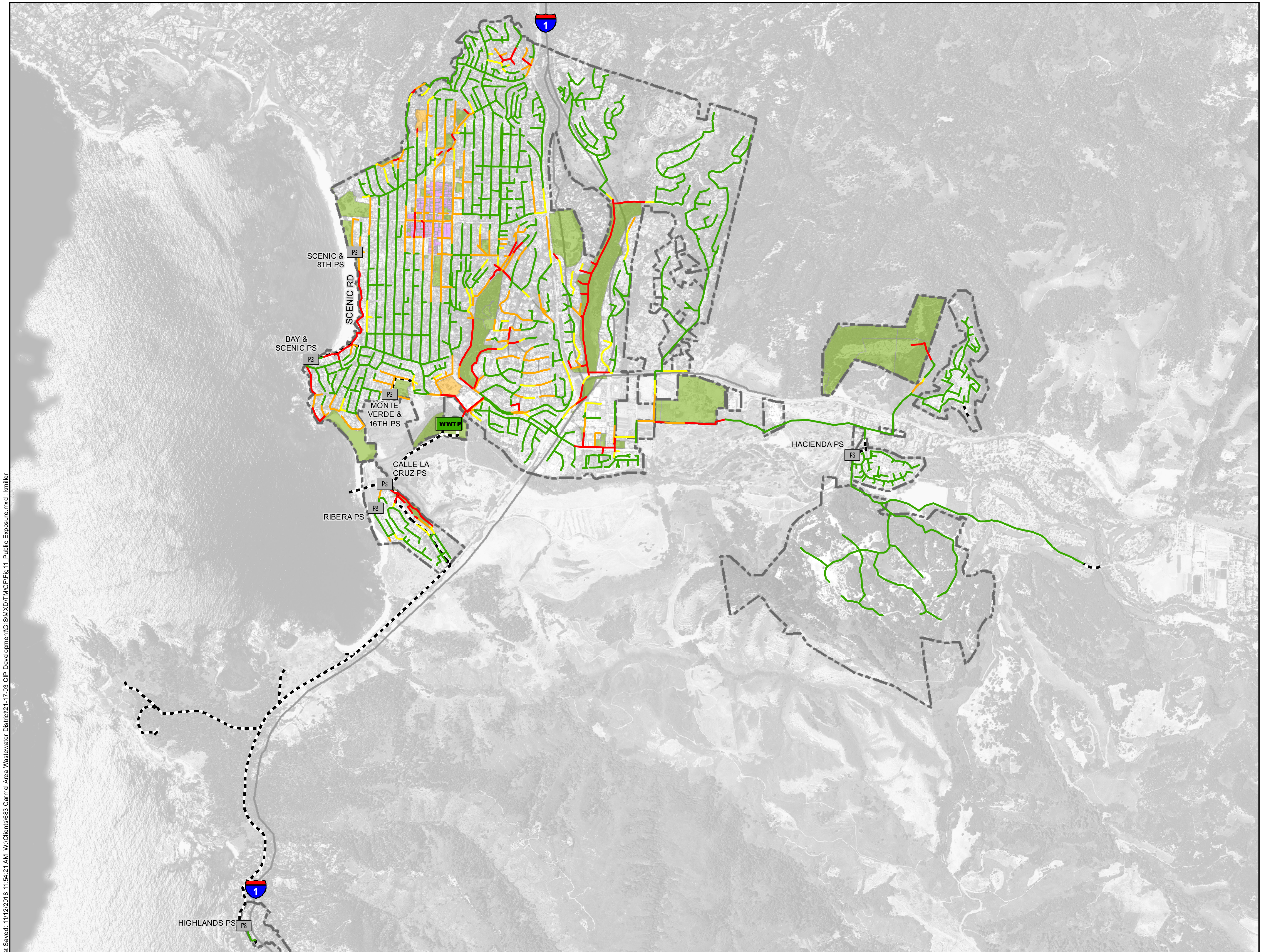

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Figure 11

Consequence of Failure Public Exposure

Carmel Area Wastewater District
Wastewater Collection System
Asset Management Plan

Table 5. Consequence of Failure Rating Factors								
Category	Factor	Rating (1 being the lowest, 5 being the highest) 1	2	3	4	5	Rating Logic	Weighting Factor
Potential Spill Volume	Modeled Peak Wet Weather Flow (PWWF)	≤ 0.09 MGD	0.09 – 0.25 MGD	0.26 - 0.5 MGD	0.51 - 1 MGD	> 1 MGD	Modeled PWWF (if not modeled, Pipe Diameter)	10
	Pipe Diameter	≤ 6-inch	8-inch	10 inch	12 inch	≥ 15 inch		
Environmental Impact	Proximity to Waterways	Other	Within FEMA 100-year Flood Zone	Within 250 feet of Waterway	Within 100 feet of Waterway	Within/ Intersecting of Waterway	Single Rating	6
Emergency Response and Construction Impact	Location within Streets, and Easements	Local Street/ Easement with Easy Access	Collector Street/ Concrete Local Street	Easement with Limited Access/ Concrete Collector Street	Arterial Street	Highway/Ramp/Easement with Difficult Access/ Concrete Arterial Street	Single Rating	3
Public Exposure	Proximity to High Pedestrian Traffic Area	Other	-	Within 150' of High Pedestrian Traffic Area	Within 75' of High Pedestrian Traffic Area	Within/ Intersecting High Pedestrian Traffic Area	Single Rating	8

2.4.3 Risk Assessment Results

The risk model applies a series of algorithms to generate the total likelihood and consequence of failure scores for each asset, as described above. In Table 6, the scores are divided into five ranges (A through E) for both the likelihood and consequence of failure with E being the highest risk level. By plotting the consequence of failure and the likelihood of failure scores against each other, an overall risk level was assigned to each segment. Risk was prioritized into five levels, as shown in Table 6 (which shows the total number of pipes out of a total of 1,848 that fall into each range). The results of the risk assessment are shown graphically on Figure 12 and are listed in detail in Appendix B.

Table 6. Risk Assessment Results

Number of Pipe		Likelihood of Failure					
		A (23-37)	B (38-48)	C (49-54)	D (55-74)	E (75-115)	Total
Consequence of Failure	A (27-37)	392	157	88	190	160	987
	B (38-54)	184	126	40	93	64	507
	C (55-77)	61	51	22	70	45	249
	D (78-104)	26	24	7	25	12	94
	E (105-135)	-	6	-	3	2	11
	Total	**663**	**364**	**157**	**381**	**283**	**1,848**

Risk Level: Low Risk, Medium-Low Risk, Medium Risk, Medium-High Risk, High Risk

Low Risk: Approximately 18 percent of the system by length (13.8 out of 77.4 miles) falls in the Low Risk Category, as shown in blue in Table 6 and Figure 12. Gravity mains in this category typically contain the following characteristics:

- At the lower end of the scoring section (and the majority of this risk category), these mains are six-inch pipes and installed after 1990 in residential streets away from public and environmental areas. These mains do not have any structural, maintenance, or hydraulic capacity concerns.
- At the highest end of the scoring section, these mains are eight-inch pipes in a collector street, away from public and environmental areas. These mains have maintenance and hydraulic capacity concerns but have light structural concerns. The structural defects are not more than a severity Grade 2.

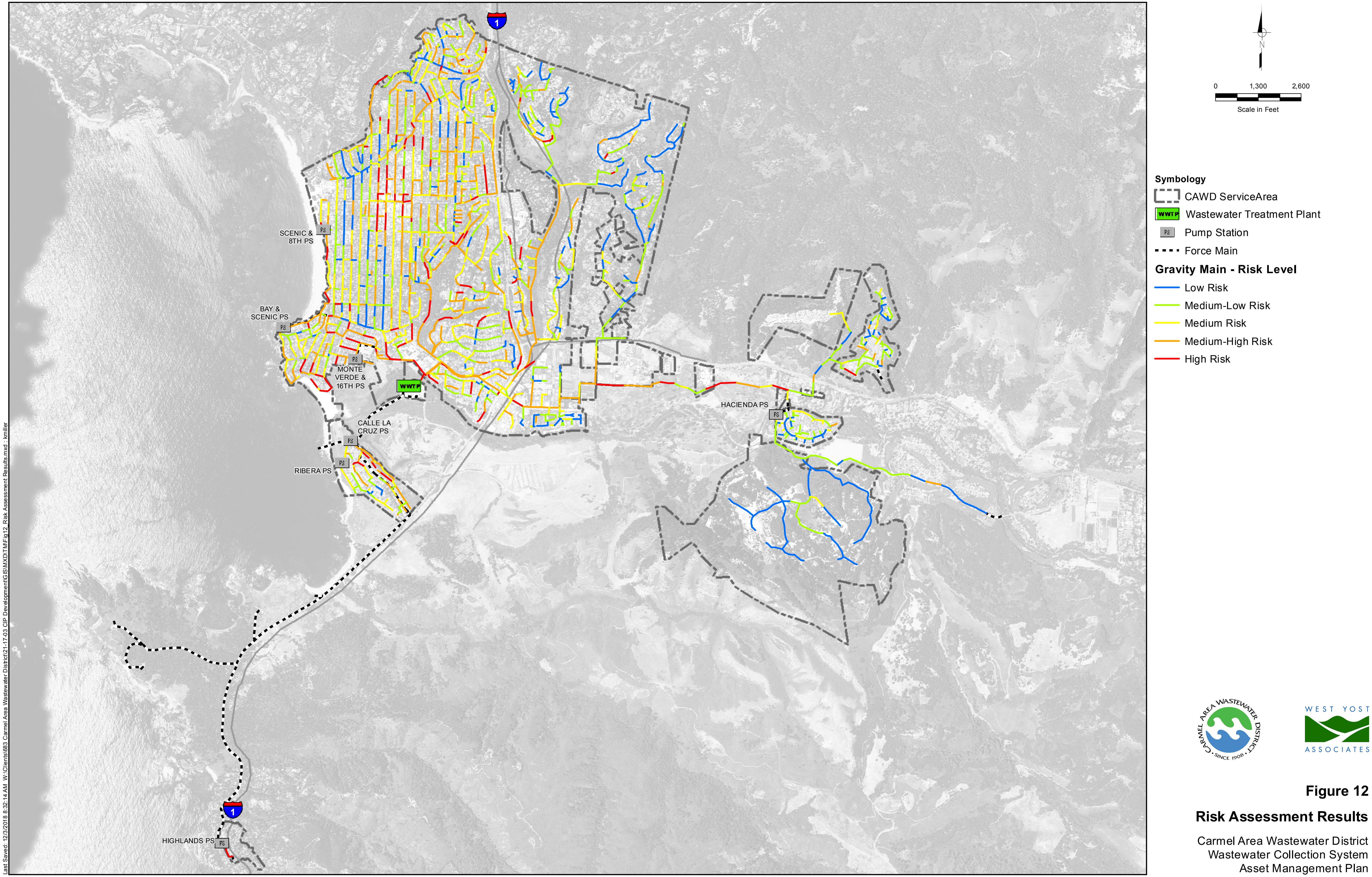


Figure 12

Risk Assessment Results

Carmel Area Wastewater District
Wastewater Collection System
Asset Management Plan

Last Saved: 12/3/2018 8:32:14 AM W:\Clients\683 Carmel Area Wastewater District\21-17-03 CIP Development\GIS\MXD\TM\Fig12_Risk Assessment Results.mxd : kmiller

Medium-Low Risk: Approximately 20 percent of the system by length (15.4 out of 77.4 miles) is Medium-Low Risk, as shown in light green in Table 6 and Figure 12. Gravity mains in this category typically contain the following characteristics:

- At the lower end of the scoring section, these mains are 6-inch sewers located away from public areas. These mains are either within easements with limited access or are under a concrete cap. These mains do not have any structural, maintenance, or hydraulic capacity concerns.
- At the highest end of the scoring section, these mains are 6-inch pipes within easements with limited access or under a concrete cap away from a high pedestrian traffic but within 100-feet of waterways. These mains have no hydraulic capacity or maintenance concerns but have Grade 3 structural defects.

Medium Risk: Approximately 26 percent of the system by length (20.2 out of 77.4 miles) is Medium Risk, as shown in yellow in Table 6 and Figure 12. Gravity mains in this category typically contain the following characteristics:

- At the lower end of the scoring section, these mains are 6-inch pipes in Highway/Ramp/Easement with Difficult Access or an Arterial street under a concrete cap. These mains are within 150 feet of a high pedestrian traffic area but are away from waterways. These mains have no hydraulic capacity and maintenance concerns but have Grade 3 structural defects.
- At the highest end of the scoring section, these mains are 10-inch pipes in easements with limited access or a concrete-capped collector street. They are away from waterways, but within 75-feet of high pedestrian traffic areas. These mains have no hydraulic capacity and structural concerns but have moderate maintenance concerns. The most severe pipe maintenance defects are Grade 4 or medium level of Roots/Grease Observed During Cleaning.

Medium-High Risk: Approximately 26 percent of the system by length (20.6 out of 77.4 miles) is Medium-High Risk, as shown in orange in Table 6 and Figure12. Gravity mains in this category typically contain the following characteristics:

- At the lower end of the scoring section, these mains are 6-inch pipes within a high pedestrian traffic area and located within an easement with limited access or a concrete-capped collector street; but are away from waterways and high pedestrian traffic. These mains have no hydraulic capacity and maintenance concerns but have severe Grade 5 structural defects.
- The majority of this risk category have no hydraulic capacity concerns or maintenance defects. However, these mains have high structural concerns with Grade 5 pipe defects.

- At the highest end of this scoring section, these mains are 12-inch pipes, away from waterways, but within 75-feet of a high pedestrian traffic area. These mains have no structural concerns. However, these mains have high hydraulic capacity and maintenance concerns with Grade 4 maintenance defects.

High Risk: Approximately 10 percent of the system by length (7.4 out of 77.4 miles) is High Risk, as shown in red in Table 6 and Figure 12. Gravity mains in this category typically contain the following characteristics:

- At a minimum, these mains are 6-inch pipes within a high pedestrian traffic area and located within a concrete-capped collector street, but are away from waterways. These mains have no hydraulic capacity concerns but have high structural concerns and moderate maintenance concerns. The most severe pipe structural defects are Grade 5, with Grade 3 maintenance defects or observed light root/grease during cleaning.
- At the higher end of the scoring section, these mains are 15-inch pipes and larger within 100-feet of a waterway, within a high pedestrian traffic area, and located within an easement with limited access (or a concrete-capped collector street). These mains have high structural, maintenance and capacity concerns and are surcharged during peak wet weather conditions.

2.5 Gravity Sewer Rehab/Replacement Program

This section develops rehab/replacement recommendations and discusses the contributing construction method options, rehab/replacement strategy, and cost assumptions.

2.5.1 Rehab/Replacement Construction Options

A variety of gravity sewer repair, rehabilitation, and replacement methods are available. This section provides an overview of the advantages and disadvantages of the common rehab/replacement construction methods employed by the District, which are listed below in order of construction cost with the least expensive options discussed first.

CIPP (Cured-in-Place Pipe) Patch (spot repair): Short CIPP patches use the CIPP lining technology (described in detail below) in short lengths, typically 24- and 48-inches. The patch acts similar to a stent in an artery to repair a localized defect. CIPP patches are a quick and cost-effective method for mitigating isolated defects such as sealing cracks where roots have intruded and can extend the life of the pipe as a whole.

Advantages:

- No need for excavation
- Lower cost than full-line rehab/replacement

Disadvantages:

- Localized at defects instead of repairing entire sewer
- Effectiveness can vary depending on installation conditions
- Sags, defective taps, and offset joints are not corrected
- Reduction in pipe capacity

Open Cut Spot Repair: Spot repairs involve an excavation repair of the underlying sewer pipe over a length less than a full manhole to manhole segment. Spot repairs can repair an isolated defect or correct a sag or severe offset/broken pipe in advance of pipe bursting or CIPP lining. If performed prior to a comprehensive trenchless replacement method, the excavation spot repair would typically use sacrificial PVC pipe material that would be either lined through or replaced via pipe bursting.

Depending on the linear foot unit price, spot repairs beyond a certain length and/or beyond a certain quantity of locations within a single manhole to manhole segment may become more expensive than a full manhole to manhole replacement.

Advantages:

- Lower cost than full-line rehab/replacement
- Corrects all types of defects

Disadvantages:

- Localized at defects instead of repairing entire sewer

CIPP Lining Rehabilitation: CIPP linings result in a new sewer pipe within the existing pipe without any joints. The method is often described as pipe rehabilitation. The existing pipe is not removed, but the structural CIPP liner is not dependent on the host pipe to maintain integrity of the sewer, even though the existing pipe material remains in place. The installation process involves inverting a fabric liner infused with resin down the sewer pipe. The CIPP liner inversion starts from a manhole-access-point and proceeds by way of water or air pressure. This force pushes the liner through the sewer to an end manhole where it is monitored for proper alignment. The air or water is then heated to a sustained temperature to allow the resin to properly cure. After several hours, where durations depend on factors such as diameter and pipe defects, the liner is allowed to cool and both ends are cut and drained.

The new liner is then CCTV inspected to check the quality and a robotic cutting device is used to reinstate each service lateral. The newly opened lateral connections are then sealed either with grout to fill any void space and seal the wall/liner interface at the lateral opening and/or with a top hat style cured in place lining to add further support at this connection point. The grouting and/or top hat liner help exclude any infiltration that may travel in between the former pipe wall and the new CIPP liner. The grouting method typically has a significantly shorter life than the top-hat liner, so the more expensive top-hat liner is preferred.

Advantages:

- Internal structural pipe replacement
- No need for excavation
- Zero joints, lateral wye joints sealed with grouting

Disadvantages:

- Effectiveness can vary depending on installation conditions
- Sags, offset joints, and pipe deformities/collapses are not corrected unless spot repaired first
- Reduction in pipe capacity
- Cost increases with the number of lateral connections, especially when top-hat lateral liners are used
- Grouting of lateral and manhole connections may need repairs every 5-10 years
- 6-inch diameter mains will be further reduced in size, restricting maintenance and inspection equipment

Pipe Bursting Replacement: Pipe bursting creates a new sewer along the same alignment as the existing pipeline but involves pulling a pneumatic hammer head through the existing sewer pipe to break it apart. This pneumatic head simultaneously pulls through a new fused joint high-density polyethylene (HDPE) plastic sewer pipe in its place from an excavated access pit. This method also allows for upsizing the pipe diameter by up to two sizes (e.g., from 8-inches to 10 or 12 inches), depending on soil conditions, crossing utility locations, and other considerations. Pipe bursting also provides the ability to replace a sewer in its existing location with much less excavation than a full open trench. To access the existing sewer pipe with the bursting device, excavation pits are required approximately every 600-feet, or usually at every other manhole.

Each existing lateral requires an individual open excavation to reconnect the existing service laterals to the newly installed sewer. Sags beyond the 30 percent threshold are recommended for spot repairs, also requiring excavation. The degree to which pipe bursting reduces the amount of excavation and disruption relative to open cut replacement will depend on the distance between lateral connections and the number of sag spot repairs required in a given segment of sewer.

Laterals are reconnected by cutting into the newly installed HDPE pipe and fusing a service lateral saddle at the appropriate location. Again, this fusing of the HDPE material helps minimize joints and prevent future infiltration and other defects. The newly fused service lateral saddle is then connected to the existing lateral pipe. The lack of joints helps prevent future root intrusion and the associated increase in infiltration and risk of backups. Pipe bursting does not have the ability to correct existing sags and can sometimes make sags more severe.

Advantages:

- Full replacement of sewer main and lateral connections
- Can upsize pipe up to two-diameters
- Less excavation and traffic impact to the public than open cut replacement (typically at every two MHs and at lateral connections)
- Zero joints with fused HDPE pipe; laterals and MH connections also fused

Disadvantages:

- Sags are not corrected unless spot repaired first
- Costs increase with the number of lateral connections
- Excavation access pits needed every two manholes and at each lateral connection
- Certain soil conditions can transmit vibrations and movement of the pipe bursting hammer head to other nearby utilities and structures
- Les desirable in areas with less than three feet of cover or congested utilities due to potential soil heave

Open Cut Replacement: Open cut replacement (open cut construction) involves excavating a trench to install a brand-new sewer pipe and manholes. This is the conventional construction method for sewers. The new pipeline can follow an existing alignment or can be relocated to a new alignment. Open cut replacement is typically the costliest option for replacement along an existing alignment, especially in the presence of poor soil conditions or access limitations (e.g., in an easement on private property).

Advantages:

- Full replacement of sewer main and lateral connections
- The only option for changing pipe horizontal or vertical alignment
- Corrects all types of defects
- Backfill with low density fill could help prevent future uneven settlement
- Can use fused HDPE to eliminate joints

Disadvantages:

- Usually the costliest option
- In high groundwater, it requires more soil dewatering due to full excavation of the pipe

- Most disruptive to traffic
- Most likely to encounter other utilities during excavation

2.5.2 Rehab/Replacement Strategy

In general, the strategy for specifying gravity sewer rehab/replacement methodologies is as follows:

- Defects of severity Grade 3 or higher are repaired using the least expensive method of construction.
- All sewers 6-inches in diameter or less are upsized to 8-inches.
- Sags are only repaired if they raise the water level at the time of inspection to 30 percent or more of the pipe diameter (PACP defect code meal water levels (MWL) ≥ 30 percent).
- If there are significant sags of severity Grade 3 or higher, open cut construction is specified or spot repairs.
- Roots do not trigger repairs, but a high frequency of root intrusion can trigger full-line rehab/replacement instead of performing spot repair(s).

The construction method selection process used is as follows:

- Spot repair methods are selected by their ability to repair each individual structural defect according to the PACP defect code list.
- The District has concerns with the diameter restrictions and poor lateral connections associated with its past CIPP projects. To limit these impacts in the future, 6-inch diameter sewers were only CIPP lined if flows are low (PWWF < 0.1 mgd), there are no severe sags, there are no lateral connections on the pipe, and offset joints are open-cut repaired first.
- Full line replacement is specified if:
  - There are continuous structural defects of severity Grade 3 or higher or roots (of any severity) for more than 25 percent of the pipe length.
  - There are any infiltration defect codes recorded, which applies to 46-sewers (infiltration will simply move to the next defect if spot repairs are performed).
  - More than one spot repair is required per 100-LF of sewer in a single segment (for cost effectiveness).
  - The pipe diameter is less than 6-inches so that it can be upsized to 8-inches to accommodate maintenance equipment.
  - Full line rehab/replacement if spot repairs are more than 50 percent of the cost of full-line rehab.

- Pipe bursting is selected if cost to CIPP is more than 75 percent of the cost of pipe bursting.
- Open cut construction is selected if cost to pipe burst and repair sags is more than 75 percent of the cost of open cut construction.

2.5.3 Unit Construction Costs

Estimated construction costs were developed by applying the unit construction costs listed in Table 7 to the size and scope of each gravity sewer. Construction costs do not include inflation costs. These planning-level unit costs were used to select the most cost-effective construction method and to provide total rehab/replacement costs for each pipe. These unit construction costs include a 30 percent construction contingency in order to estimate construction costs, but do not include additional capital costs for engineering, legal, administration, etc. (typically an additional 30 percent).

Table 7. Planning-Level Unit Construction Costs

Construction Method	Unit Construction Cost
CIPP Patch	$1,400/inch diameter
Spot Repair (Open Cut)	$2,400/inch diameter
CIPP Lining Rehabilitation	$30/inch diameter-foot
Pipe Bursting Replacement	$36/inch diameter-foot
Open Cut Replacement	$60/inch diameter-foot

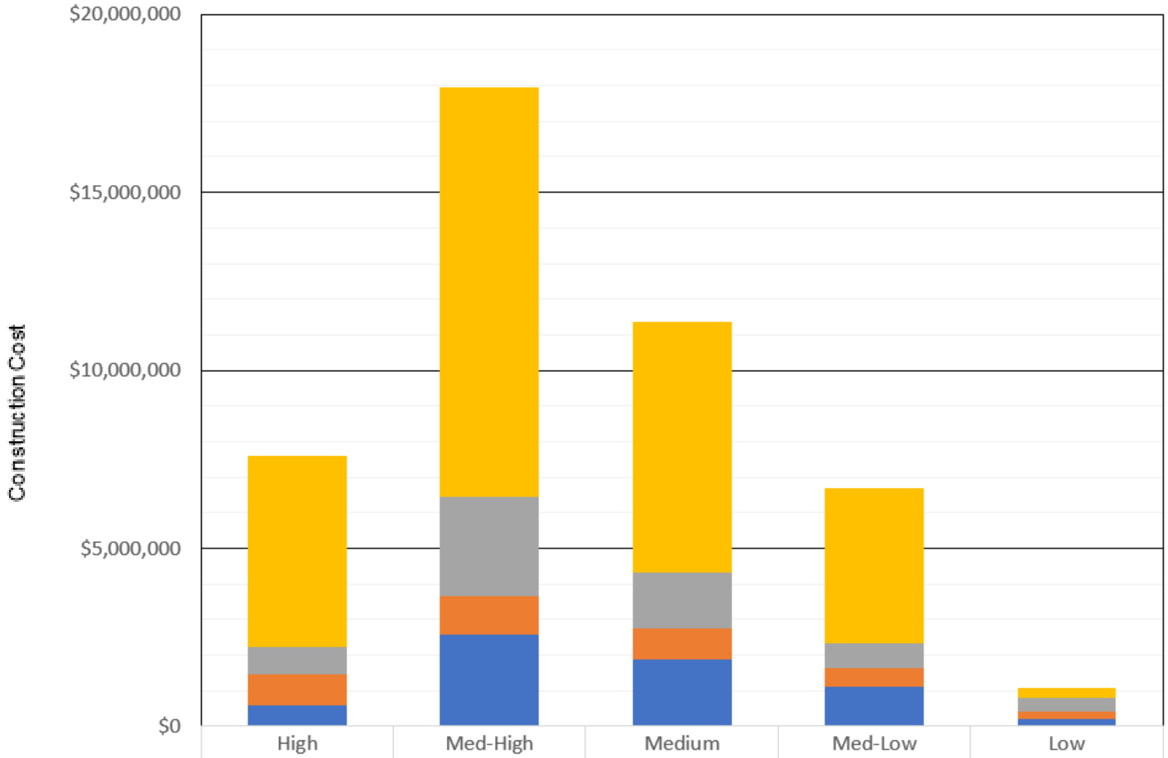
2.5.4 Rehab/Replacement Program

This section documents the existing rehab/replacement needs, discusses investment strategy options, and presents a 20-year Rehab/Replacement Program for gravity sewers in the collection system.

2.5.4.1 Existing Rehab/Replacement Needs

The rehab/replacement strategy and unit costs described above were applied to each individual gravity sewer and its PACP-coded defects, and the rehab/replacement needs shown in Figure 13 were identified. Figure 13 shows rehab/replacement construction cost estimates by risk level and construction method. Table 8 shows the system-wide rehab/replacement needs by risk level and capital cost.

Figure 13. System-Wide Rehab/Replacement Needs by Construction Method



	High	Med-High	Medium	Med-Low	Low
Pipe Bursting	$5,375,016	$11,486,736	$7,017,012	$4,384,152	$297,504
Open Cut Replacement	$739,680	$2,783,040	$1,577,280	$688,320	$391,200
Full CIPP	$868,860	$1,086,840	$891,000	$497,340	$186,000
Point Repairs	$606,000	$2,581,200	$1,869,600	$1,130,800	$220,800

Table 8. System-Wide Rehab/Replacement Needs by Risk Level

Pipeline Infrastructure Risk	Total Length of Sewers (Miles)	Percent of Total System	Repair/ Replacement Construction Cost[(a)]	30% Capital Cost Markup[(b)]	Total Capital Cost
Low Risk	14.14	18	1,096,000	328,800	1,424,800
Medium-Low Risk	17.19	22	6,701,000	2,010,300	8,711,300
Medium Risk	20.01	26	11,355,000	3,406,500	14,761,500
Medium-High Risk	19.47	25	17,938,000	5,381,400	23,319,400
High Risk	6.57	8	7,590,000	2,277,000	9,867,000
Total	**77.38**	**100%**	**$44,680,000**	**$13,404,000**	**$58,084,000**

(a) Includes 30 percent construction cost contingency.
(b) Includes 30 percent for Engineering, Legal, Administration, etc.

2.5.4.2 Investment Strategy Options

In recent years, the District has invested approximately $750,000 per year (in construction costs) in collection system rehab/replacement projects. As discussed previously in this report, an increase in the level of investment is warranted due to the age and condition of the system. Figure 14 and Table 9 explore new annual investment strategies: $1M/year, $1.5M/year, and $2M/year. Figure 14 shows the current risk level of the system (in solids bars) and compares that to the risk level of the system after a 20-year rehab/replacement program at each of the three annual investment strategy scenarios. Figure 14 also shows the impacts to the existing system risk levels under each scenario improvements are made. It should be noted that under the $1M/year investment option, it takes nearly 26-years to complete the existing backlog of high and medium-high risk repair projects.

Figure 14. Risk Level of All Pipes After 20-Year Rehab/Replacement Program Options

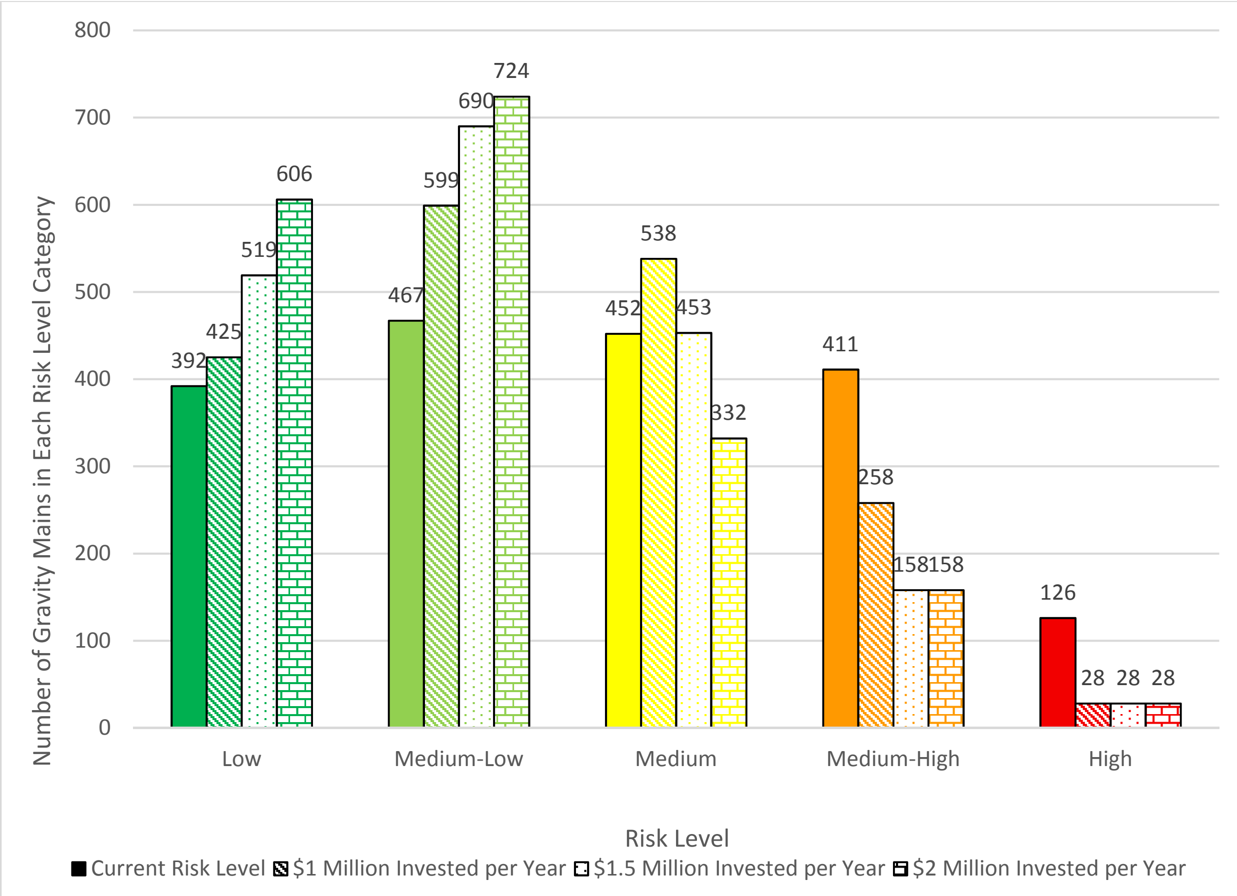


Table 9. Investment Strategy Options for 20-Year Rehab/Replacement Program

R/R Program Year	$1.0M/Year			$1.5M/Year				$2.0M/Year				
	High Risk	Med-High Risk	Total Gravity Sewers	High Risk	Med-High Risk	Medium Risk	Total Gravity Sewers	High Risk	Med-High Risk	Medium Risk	Med-Low Risk	Total Gravity Sewers
Years 1-5	$5.0M	-	**$5.0M**	$7.5M	-	-	**$7.5M**	$7.6M	$2.4M	-	-	**$10.0M**
Years 6-10	$2.6M	$2.3M	**$4.9M**	$0.1M	$7.4M	-	**$7.5M**	-	$10.0M	-	-	**$10.0M**
Years 11-15	-	$5.1M	**$5.1M**	-	$7.6M	-	**$7.6M**	-	$5.5M	$4.5M	-	**$10.0M**
Years 16-20	-	$5.0M	**$5.0M**	-	$3.0M	$4.5M	**$7.5M**	-	-	$6.9M	$3.1M	**$10.0M**
Total Construction Costs			**$20.0M**				**$30.1M**					**$40.0M**
30% Engineering, Legal, Admin., etc.			$6.0M				$9.0M					$12.0M
Total Capital Costs			**$26.0M**				**$39.1M**					**$52.0M**

2.5.4.3 Recommended 20-Year Rehab/Replacement

To develop a 20-year Rehab/Replacement, annual projects are prioritized by the risk level of each sewer, with the highest-risk pipes prioritized for rehab/replacement first. At an investment level of $1M in construction costs per year, the Rehab/Replacement summarized in Table 10 shows that high risk pipes are repaired first in years one through eight of the program, followed by medium-high risk pipes in years eight through 20. The location of the sewers in the 20-year Rehab/Replacement are shown in Figure 15 by priority, and Figure 16 by construction method. Pipe-by-pipe cost estimates and Rehab/Replacement details are provided in Appendix C.

Table 10. 20-Year Gravity Sewer Rehab/Replacement Program by Risk Level (Annual Investment of $1M)

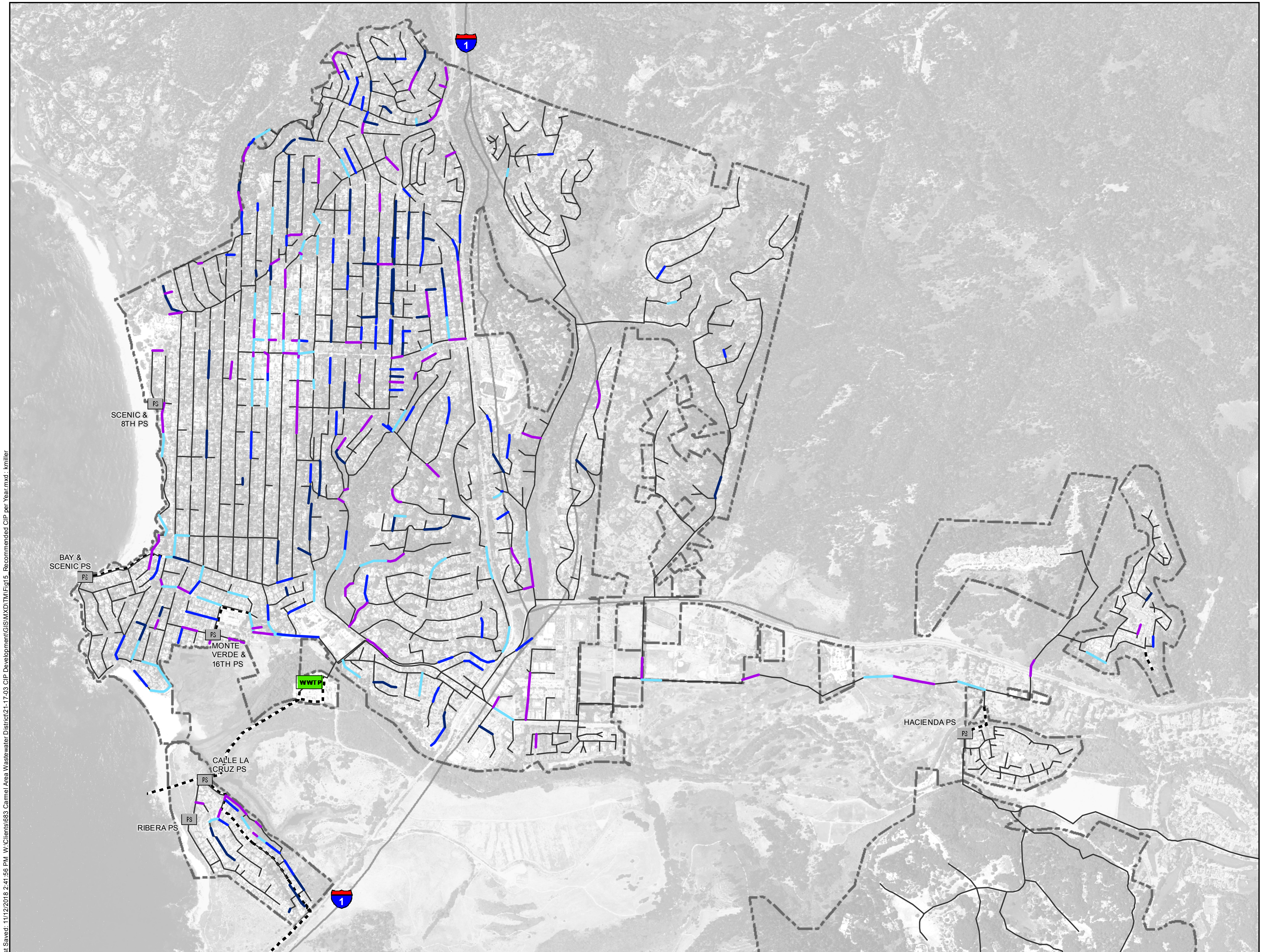
Rehab/Replacement Year	High Risk Sewers	Med-High Risk Sewers	Total
Years 1-5	4,996,000	-	4,996,000
Years 6-10	2,595,000	2,324,000	4,919,000
Years 11-15	-	5,070,000	5,070,000
Years 16-20	-	5,002,000	5,002,000
		Total Construction Costs[a]	**$19,987,000**
		30 percent Engineering, Legal, Administration, etc.	$5,996,100
		Total Capital Costs	**$25,983,100**

(a) Includes 30 percent construction cost contingency.

3.0 PUMP STATION ASSET MANAGEMENT PLAN

3.1 Pump Station Asset Inventory

The District's collection system includes seven pump stations, which are described in Table 11. ICOMM, the District's CMMS has a partially-developed pump station asset registry, which stores these physical asset properties (including size, material, manufacturer, and installation date) and maintenance work order history.



0 800 1,600
Scale in Feet

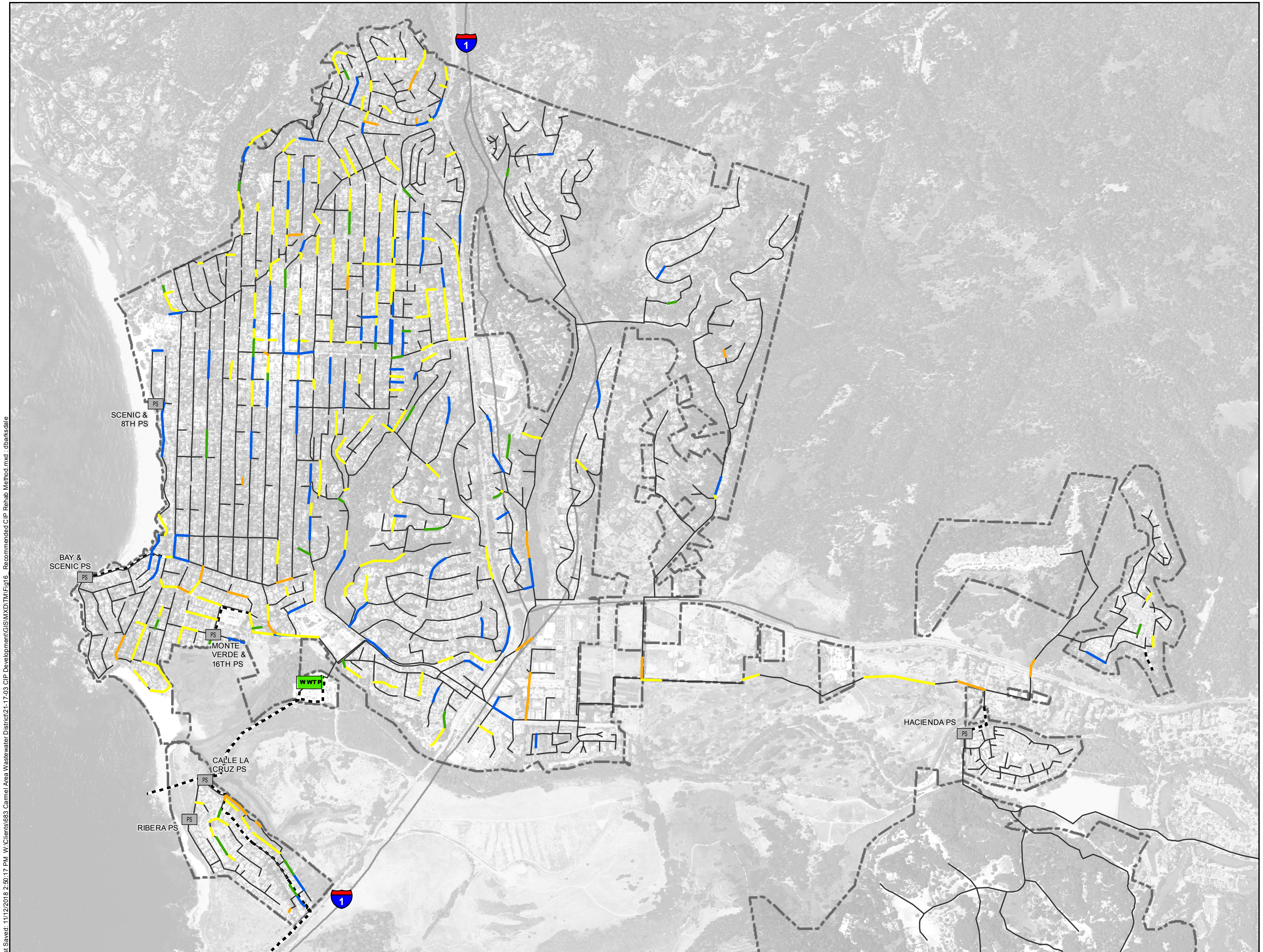
Symbology
- CAWD ServiceArea
- Wastewater Treatment Plant
- Pump Station
- Gravity Main
- Force Main

CIP Year
- 1 - 5
- 6 - 10
- 11 - 15
- 16 - 20

Figure 15

Recommended Gravity Sewer R/R Program by Year

Carmel Area Wastewater District
Wastewater Collection System
Asset Management Plan



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0 800 1,600

Scale in Feet

Symbology

CAWD ServiceArea

Wastewater Treatment Plant

Pump Station

Gravity Main

Force Main

Rehab Method

Pipe Bursting

Open Cut Replacement

Full CIPP

Point Repairs

WEST YOST ASSOCIATES

Figure 16

Recommended Gravity Sewer R/R Program by Construction Method

Carmel Area Wastewater District
Wastewater Collection System
Asset Management Plan

Table 11. Pump Station Descriptions

Pump Station Name	Location	Construction Year	No. of Pumps	Pump HP	Pump GPM		PS Firm Capacity (GPM)	Standby Generation, kW[a]
					Pump 1	Pump 2		
Scenic & 8th	West of intersection of 8th Ave & Scenic	1949	2	3.2	157	136	136	20
Bay & Scenic	Across from 26189 Scenic Rd.	1938	2	10	78	69	69	External[b]
Monte Verde & 16th	SE Corner of Monte Verde St. at 16th Ave	1938	2	10	215	187	187	External[b]
Calle la Cruz	Behind 2737 Calle La Cruz	1950's	2	18	435	421	421	60
Ribera	West of Ribera Rd along walking trail	1953	2	3.2	84	98	84	External[c]
Hacienda	West of Hacienda Carmel at T intersection	1966	2	5	392	277	277	35
Highlands	~104 Highlands Drive.	2004	2	23	114	109	109	75

(a) Standby generation is portable unless otherwise noted.

(b) This station is equipped with a transfer switch and external power connection port.

(c) Backup power is handled by the Calle la Cruz pump station and only a single power feed connects to the Ribera Pump Station.

3.2 Pump Station Inspections

West Yost prepared Visual Inspection Instruction Forms for District staff to use to perform evaluations of its pump stations. The forms provided suggestions and instructions on who should perform the inspections, when to perform the inspections, how to perform the inspections, and which assets should be inspected. The forms also provide suggested rankings for condition and performance and standard life expectancies for assets that are commonly associated with pump stations. A facility summary sheet is included, as well as separate inspection sheets for performing condition assessments on the civil, structural, mechanical, electrical and instrumentation assets.

The District performed inspections for each of its seven pump stations in January 2018. The scope of the visual assessment was to provide a broad overview of the most pressing issues at each pump station. Supervisory control and data acquisition (SCADA) upgrade needs were not included because a SCADA upgrade for all pump stations is planned for fiscal year 2018/19. The results of the District's visual inspections are summarized below for each pump station.

3.2.1 Eighth & Scenic Pump Station

PRIORITY: Low

Observations:

- Original pump station constructed in 1949
- New submersible Flygt pumps in 2012
- New Onan Generator in 2011
- New Tesco electrical panel in 2017

Condition Defects:

- The wet well has some metal struts that do not seem to serve any further purpose since construction was completed. Removal of this cumbersome interference will allow better access to the pumps during installation and removal.
- Needs the addition of a float tree and a better transducer mount to more easily access these critical components during repairs or servicing without the need for a confined space entry.
- This station location is near the Pacific Ocean, and sea mist and coastal weather accelerate corrosion.
- This station is susceptible to vandalism.

Force Main Notes:

- Force main is very short: 179-LF, 4-inch diameter DIP. Staff can by-pass sewage if it fails.

3.2.2 Bay & Scenic Pump Station

PRIORITY: Medium-High

Observations:

- Original pump station constructed in 1939
- Last rehabilitation in 2006
- New dry-pit Flygt pumps in 2006
- Flygt control panel in 2006
- No generator on site, staff use portable Generac generator
- New power service installed in 2016 from power pole to station

Condition Defects:

- This station is adjacent to the Pacific Ocean, and sea mist and coastal weather accelerate corrosion
- Subject to tidal flooding when big waves hit the station; under a sea level rise study
- Need coastal retaining wall to prevent erosion
- Subject to vandalism

Force Main Notes:

- 6-inch DIP 1,512 feet force main is too long to bypass. Requires hauling of sewage from the pump station wetwell if the force main needs to be replaced/repaired

3.2.3 Monte Verde and 16th Pump Station*

PRIORITY: Medium

Observations:

- Original pump station constructed in 1939
- Last rehabilitation in 2005
- Flygt submersible pumps 2005
- Flygt control panel in 2005
- Built in by-pass pump quick-connect in force main at station
- No generator on site (Staff use portable Onan generator)

Condition Defects:

- Subject to tidal flooding; when last flooded in 2008, lost all electrical and SCADA; currently under a sea level rise study.
- Wet well hatch is not traffic rated and needs to be replaced
- Needs new transfer switch

Force Main Notes:

- 6-inch, 998-LF DIP force main

3.2.4 Calle La Cruz Pump Station

PRIORITY: High

- It is crucial that this station remains operational. It has 3 major pump stations (Highlands, Point Lobos, Ribera) and several smaller pocket stations (Highlands fire O'Boyle) and a local neighborhood that feed into it. Therefore, any problem with the functionality of this station is a critical matter.

Although the station has a bypass connection to the force main, it only allows a bypass of the pumps. If something were to happen to the force main itself, which crosses a waterway, it would be difficult to manage incoming flows. There is virtually no storage for influent flows in the pump station wet well, and it would take only minutes before a breach at the station would occur, causing sewage to flow directly into the adjacent lagoon.

Observations:

- Original pump station constructed in 1953
- New dry pit Flygt pumps in 2004
- Onan Generator and Flygt electrical panel was part of the upgrade in 2004

Condition Defects:

- Due to the high hydrogen sulfide concentrations at the station, the wet well was lined with a mortar seal (sewer coat) to extend its life. However, the high hydrogen sulfide levels still exist and continue to erode the liner. Furthermore, hydrogen sulfide has caused the surrounding homes and passersby to file multiple odor complaints.
- This station has a history of both vandalism and vegetation overgrowth.
- This station also gets a heavy grease mat build-up on the water surface in the wet well.

Force Main Notes:

- 2,685-LF, 6-inch DIP force main crosses the lagoon (300-LF span) and state parks. There is no way to by-pass the force main. This requires hauling sewage from the pump station during an emergency.

- In March 2018, there was a circumferential crack detected on the force main. This section of the pipe was repaired.

3.2.5 Ribera Pump Station

PRIORITY: Low

Observations:

- Original pump station constructed in 1953
- New pumps in 2012 (Flygt Submersible)
- New electrical control panel in 2015 (Tesco)
- Receives power and communication from Calle La Cruz Pump Station through a single feed

Condition Defects:

- The wet well has some metal struts that do not seem to serve any further purpose since rehabilitation was completed. Removal of this cumbersome interference will allow better access to the pumps during installation and removal.
- Needs the addition of a float tree and a better transducer mount to more easily access critical components during servicing without the need for a confined space entry.
- This station is susceptible to vandalism and overgrowth of the surrounding vegetation.
- This station location is adjacent to the Pacific Ocean, and sea mist and costal weather accelerate corrosion.

Force Main Notes:

- Force main is very short: 173-LF, 4-inch DIP. Staff can by-pass the force main using District equipment if it fails.

3.2.6 Hacienda Pump Station

PRIORITY: Low

Observations:

- Original pump station constructed in 1967
- This station was rehabilitated in 1999
- Flygt Control Panel in 1999
- Submersible Flygt pumps replaced in 1999
- Generac Generator and transfer switch installed in 1999

- New power service and power panel in 2017
- Wet well is deep, but the working volume of the wet well is only three to four feet

Condition Defects:

- Many left over metal struts remain after rehabilitation project that could be removed in wet well.

Force Main Notes:

- Force main is 8-inch DIP and is 740 LF

3.2.7 Highlands Pump Station

PRIORITY: Medium

- This station in the past had a hard time keeping up with the inflows during a massive potable water purge event in the area. Due to a water supply issue, the entire community surrounding the station flushed their lines at practically the same time to purge the bad water that entered the potable water supply. This event caused the station to fill up the main wet well, grinder vault well, and storm drain. Once those were all full, it then started to fill the secondary wet well onsite. Unfortunately, the overflow line in the main wet well is placed too high for it to overflow into the secondary onsite wet well before flooding the grinder vault. Eventually, things equalized, and the pumps returned the water back to normal levels. This event was indicative of a potential future catastrophe. There are plans to add more flow to this station by adding a pump station farther south that would pump to Highlands as well as several more pocket station tie ins. With these added flows, if another purge event were to happen, and it stands to reason that the station will most likely breach and sewage would flow to the ocean. In an extreme case, the additional water, the purge event, and heavy rainfalls would most certainly lead to imminent overflow.

Observations:

- Original pump station constructed in 2005
- Has Tesco panel and submersible Flygt pumps

Condition Defects:

- The force main length has caused premature failure of the pumps that operate at the station. Pumps are in the high range of the curve.
- There currently is no bypass set up at this station
- The grinder vault has a broken weir gate handle

Force Main Notes:

- The force main is approximately three miles in length: 15,312-LF, 4-inch HDPE.

- If the force main failed, the only solution would be to haul the water out.
- Due to the length of the force main and the amount of pump cycles required to move water from the beginning to the end of the line, hydrogen sulfide builds up tremendously and damages the downstream infrastructure in contact with it.
- The force main has several vaults along the length of it, containing air relief value's (ARV) vacuum relief value's (VRV), and flush valves. ARV's need to be replaced with stainless or composite material as they are very corroded.

3.3 Pump Station Risks

Based on their working knowledge and recent inspections of the pump stations, District staff evaluated known pump station concerns and risks, which are summarized in Table 12.

Table 12. Pump Station Risks and Concerns

Pump Station	No. of Pumps	Pump HP	PS Firm Capacity	Standby Generation, kW[(a)]	Risk/Concerns	Relative Risk
Scenic & 8th	2	3.2	136	20	By the Ocean in Sand Dunes.	Low
Bay & Scenic	2	10	69	External[(b)]	On Ocean cliffside. No generator. Portable hookup only.	Medium-High
Monte Verde & 16th	2	10	187	External[(b)]	Flooding of pump station electrical. Can bypass station with portable pump.	Medium
Calle la Cruz	2	18	421	60	Right next to body of water with very little retention time in case of dual pump failure or main and standby power failure. Can potentially bypass by running two pumper trucks.	High
Ribera	2	3.2	84	External[(c)]	Gets power from Calle La Cruz. Lots of holding time, can truck if necessary in emergency.	Low
Hacienda	2	5	277	35	Really deep wet well. Lots of old abandoned metal in wet well. Lots of holding time	Low
Highlands	2	23	109	75	Force main hydraulics are difficult to pump due to long distance -> leads to early pump failures. Odor issues downstream caused by long detention time in force main.	Medium

(a) Standby generation is portable unless otherwise noted.
(b) This station is equipped with a transfer switch and external power connection port.
(c) Backup power is handled by the Calle la Cruz pump station and only a single power feed connects to the Ribera Pump Station.

3.4 Pump Stations Rehab/Replacement Program

Based on their working knowledge, recent inspections, and risk summary of the pump stations, District staff summarized pump station rehabilitation priorities and budget estimates in Table 13.

Table 13. Pump Station Rehabilitation Priorities

Pump Station	PS Firm Capacity, GPM	Standby Generation, kW(a)	Rehabilitation Priorities	Rehabilitation Budget Estimates
Scenic & 8th	136	20	No major rehab, except for minor electrical and SCADA work.	$~20K per year average for next ~20 years (including force main rehab).
Bay & Scenic	69	External(b)	Convert to submersible pumps in wet well (currently dry pit submersible). Look at structure erosion issues vs. relocate electrical in a pedestal away from cliff.	$350K for converting pump station to submersible and moving electrical out of dry well. $100K for shotcrete exterior for erosion control. Plan for 5- to 10-year horizon.
Monte Verde & 16th	187	External(b)	Waterproof electrical in dry well.	$200K for new waterproof electrical.
Calle la Cruz	421	60	Fix H_2S issues upstream - wet well corrosion. General rehab due to corrosion outside of the station. Need to replace flood door and flood proof the louvers.	Requires a rehab project in next 10 years at a cost of about $450K.
Ribera	84	External(c)	None	$5K per year average for next ~20 years (including force main rehab).
Hacienda	277	35	Needs new generator transfer switch.	$~20K per year average for next ~20 years (including force main rehab).
Highlands	109	75	Frequent pump rebuilds due to difficult hydraulic conditions.	$~20K per year average for next ~20 years.

(a) Standby generation is portable unless otherwise noted.
(b) This station is equipped with a transfer switch and external power connection port.
(c) Backup power is handled by the Calle la Cruz pump station and only a single power feed connects to the Ribera Pump Station.

4.0 FORCE MAIN ASSET MANAGEMENT PLAN

4.1 Force Main Asset Inventory

The District's collection system includes approximately 4.4 miles of wastewater force mains. The older 1.3 miles of force mains are constructed of cast iron pipe (CIP), while the newer installations are of high-density polyethylene (HDPE), as summarized in Table 14.

Table 14. Force Main Descriptions

Associated Pump Station	Force Main Asset Information				
	Installation Year[(a)]	Material Type	Diameter, Inches	Length, Linear Feet	Notes
Scenic & 8th	1949	Cement Lined CIP	4	145	
Bay & Scenic	1938	Cement Lined CIP	6	1,490	
Monte Verde & 16th	1938	Cement Lined CIP	6	1,000	
Calle la Cruz	1950	DIP	6	3,109	
Ribera	1953	Cement Lined CIP	4	135	
Hacienda	1966	CIP	8	727	
Highlands	2006	HDPE	4	16,134	
T12Plug (Southeast of Hacienda PS)	2003	HDPE	4	501	Not in Use (Future)
Total Force Mains				**23,241-LF (4.4 miles)**	

Source of installation dates: "Age of Sewers CAWD.xls" provided by the District

4.2 Replacement Values

A planning level replacement value estimate was developed for the District's force mains. The estimate was prepared using West Yost experience and recent bid results from similar projects. A combined estimating and construction contingency of 30 percent is included in the unit costs to account for unknown conditions, design completion level of the project, and bidding climate factors. The total capital costs include an allowance of 30 percent to account for planning level activities, design, environmental reviews, legal administration, construction services, change orders, and other related items. The replacement of the force mains is currently valued at approximately $5.1 M in September 2018 dollars (ENR Construction Index of 12103.88), as summarized in Table 15.

Table 15. Force Main Replacement Values

Construction Method Unit Cost ($/in-Diam-LF) Pipe Diameter, Inch	Pipe Bursting $28		
	Length, Linear Feet	Unit Cost ($/LF)	Cost $
4	16,915	112	1,894,000
6	5,599	168	941,000
8	727	224	163,000
Total	**4.4 Miles**		**$2,998,000**
		30% Contingency:	$899,000
		Construction Cost Subtotal:	**$3,897,000**
		Engineering, Legal, Admin., etc. @ 30%:	$1,169,000
		Total Capital Cost:	**$5,066,000**

4.3 Force Main Risks

Based on their working knowledge of the system, District staff evaluated known force main concerns and risks, which are summarized in Table 16.

Table 16. Force Main Risks and Concerns

	Force Main Asset Information					
Associated Pump Station	Installation Date[(a)]	Diameter, Inches	Length, Linear Feet	Material Type	Risks & Concerns	Relative Risk
Scenic & 8th	1949	4	145	Cement Lined CIP	Short run is easy to bypass.	Low
Bay & Scenic	1938	6	1,490	Cement Lined CIP	Have had force main blockage caused by pipe corrosion (occlusion) in section of pipe exposed to air pockets. Too long to bypass pump; requires hauling.	Medium-High
Monte Verde & 16th	1938	6	1,000	Cement Lined CIP	Have had force main blockage caused by pipe corrosion (occlusion) in section of pipe exposed to air pockets.	Medium
Calle la Cruz	1950'S	6	3,109	DIP	Arial crossing over lagoon is high risk. A crack was discovered in the buried force main in the last year and was repaired. This could have been an isolated defect or could be a sign of future failure potential.	High
Ribera	1953	4	135	Cement Lined CIP	Short run is easy to bypass.	Low
Hacienda	1966	8	727	CIP	Could bypass if necessary in an emergency.	Medium-Low
Highlands	2006	4	16,134	HDPE	Very long pipe with long detention time, material accumulation and H_2S formation.	Medium-High

(a) Installation dates obtained from "Age of Sewers CAWD.xls" given to West Yost from Carmel Area Wastewater District.

4.4 Force Main Inspections

Proper inspection of sewer lines is essential to the successful implementation of any collection system management program. Condition assessments are a vital component to risk analysis, ultimately determining a replacement and rehabilitation prioritization schedule. Currently, the District uses CCTV to inspect approximately 77-miles of gravity sewer mains, however, the District does not currently place force mains on a regular inspection schedule.

There are many obstacles to implementing a force main inspection program, including the need to remove the force main from service during inspection, bypass pumping or hauling challenges, as well as difficulties dewatering the force main for interior inspection. Exterior inspection of buried force mains requires expensive excavations and can only provide limited information along the length of the pipe.

4.4.1 Inspection Technologies

There are many pressure-pipe assessment technologies, all of which have limitations to their applicability on certain pipe parameters and the level of information provided. Before embarking on an expensive force main condition assessment effort, it is essential to: 1) focus District funds only on the force mains that pose the highest risks to the District, and 2) balance the cost of the inspection technology (and associated bypass pumping/hauling and pipe dewatering costs) with the information provided by the technology. For example, leak detection technologies are less expensive and do not require shut-down and dewatering of the pipeline, however they only provide data on existing leaks and do not identify defects that may lead to future leaks or catastrophic failures.

Inspection technologies can be categorized into: visual inspection, structural condition assessment, leak detection, and multi-sensor platforms.

4.4.1.1 Visual Inspection

Visual inspection techniques include CCTV inspection, digital scanning, and laser profiling:

- A permanent video record of the defects of pipe segments is captured through CCTV inspections.
- Digital scanning is a subset of the camera inspection technology where multiple high-resolution cameras are transported through the force main using self-propelled crawlers. The practical applications of CCTV inspection and digital scanning include detection of defects at the downstream sections of the force mains near the discharge point where the pipeline is accessible.
- The changes in pipe shape due to deflections and deformations can be detected through laser-based pipe inspection.

4.4.1.2 Structural Condition Assessment

The structural integrity of the pipes cannot be determined through visual inspection techniques. The structural condition of the pipes can be assessed through ultrasonic wall thickness measurement and electromagnetic corrosion detection techniques.

Ultrasonic Wall Thickness: The pipe wall thickness, corrosion intensity and the presence of cracks in ferrous pipeline can be detected through in-line inspection and guided wave ultrasonic testing.

- The external remote detection of pipe structural condition is carried out through Guided Wave Ultrasonic Testing. The guided-wave method is used primarily as a screening tool that indicates an existing wall anomaly along the pipeline but does not return actual wall thickness data.
- The wall thickness and corrosion of the pipelines can be measured by an in-line inspection technique, which uses a piezo-electric transducer to generate an ultrasonic pulse.
- The ultrasonic wave is stopped by the joints in DI and CI pipes and therefore is suitable only for one pipe length.

Electromagnetic Corrosion Detection: The defects in ferrous (metallic) pipes are detected using electrical/electromagnetic current. The defects in the pipe wall and the wall thickness are quantified using three major techniques: Magnetic Flux Leakage (MFL), Remote Field Eddy Current (RFEC), and Broadband Electro-Magnetic (BEM):

- Magnetic Flux Leakage: The pipe wall surface is magnetized, and the leakages produced because of defects or metal loss in the pipe wall is measured by the MFL technique. The disadvantages of the MFL technique include the large amount of data that need to be analyzed to quantify the defects. The magnets and the Hall Effect sensors should be placed very close to the pipe wall in the MFL technique, which makes it impractical for the DI and CI pipes due to wall variations and joints. This adds significantly to the cost of inspection.
- Remote Field Eddy Current: The corrosion intensity and location can be evaluated by the RFEC inspection technique. Pipes with internal linings can be scanned using the RFEC tool.
- Broadband Electro-Magnetic: The wall thickness of ferrous pipe is measured through the BEM non-destructive testing technique. The advantage of employing the BEM technology is its ability to scan through coatings and linings without requiring contact with the pipe wall. The disadvantage when scanning pipelines internally, compared to intelligent pigs, is that the process is not continuous and therefore it takes more time to survey a pipeline.

4.4.1.3 Leak Detection

The leaks in force mains are detected by analyzing the vibrations or sound generated through leak detectors. The various types of leak detectors are hand-held listening devices, leak noise correlators and in-line devices. The major acoustic leak detection monitoring techniques are free-swimming leak detection and tethered leak detection:

- Free-Swimming Leak Detection: SmartBall is a free-swimming leak detection product that continuously measures the acoustic signal and detects an increase in the signal when it encounters a leak. Gas pockets can also be detected through this technique.
- Tethered Leak Detection: The Sahara system is a tethered leak detection product that can detect acoustic signals indicating leaks, gas pockets or areas of turbulence within the pipeline. An advantage of the Sahara system is that it can be used to track the location of the pipeline from the ground surface.

4.4.1.4 Multi-Sensor Inspection

Various types of defects in the wastewater collection system can be detected by employing multiple technologies. The extensively used camera-based technologies can be supplemented with other leak detection, ultrasonic testing and electromagnetic technologies to offset the drawbacks of visual inspection technologies. Multi-sensor inspection robots are available that incorporate CCTV, laser profiling etc., to identify the defects in the system. Hydromax USA, Redzone Robotics and Hibbard Inshore provide multi-sensor platforms.

4.4.2 Preliminary Inspection Recommendations

Considering the risks identified above, potential inspection methods are recommended for further evaluation in Table 17 for each force main. Each inspection method has limitations on pipe bends, access points, dewatering capabilities, etc., so further evaluation is needed to select the appropriate inspection method.

Table 17. Preliminary Force Main Inspection Method Recommendations					
Associated Pump Station	Force Main Asset Information				Inspection Methods Recommended for Further Evaluation
	Installation Date[(a)]	Diameter, Inches	Length, Linear Feet	Material Type	
Scenic & 8th	1949	4	145	Cement Lined CIP	Interior inspection using CCTV from discharge point.
Bay & Scenic	1938	6	1,490	Cement Lined CIP	If dewatering is possible, inspect interior using CCTV. If dewatering is not possible, consider leak detection.
Monte Verde & 16th	1938	6	1,000	Cement Lined CIP	If dewatering is possible, inspect interior using CCTV. If dewatering is not possible, consider leak detection.
Calle la Cruz	1950'S	6	3,109	DIP	Due to long length with no access points, consider free-swimming leak detection, possibly coupled with exterior ultrasonic wall thickness testing along the exterior of the above-ground pipe.
Ribera	1953	4	135	Cement Lined CIP	Interior inspection using CCTV from discharge point.
Hacienda	1966	8	727	CIP	Progressively-pig, then inspect interior using CCTV.
Highlands	2006	4	16,134	HDPE	-

(a) Installation dates obtained from "Age of Sewers CAWD.xls" given to West Yost from Carmel Area Wastewater District

4.5 Force Mains Rehab/Replacement Program

Based on their working knowledge and risk summary, District staff summarized force main rehabilitation priorities and budget estimates in Table 18.

Table 18. Force Main Rehabilitation Priorities				
Associated Pump Station	Diameter, inches	Length, LF	Rehabilitation Priorities	Rehabilitation Estimates
8th & Scenic	4	145	Assess installing a liner (or likely replace this short pipe) in 10 to 20 years.	Included in Pump Station Cost
Bay & Scenic	6	1,490	Replace short section of pipe with corrosion with PVC and install air release valves at high points.	$50K sometime in the next 10 years
Monte Verde & 16th	6	1,000	Replace short section of pipe with corrosion with PVC and install air release valves at high points.	$50K sometime in the next 10 years
Calle la Cruz	6	3,109	May need to replace entire pipeline.	$500K in next 10 years
Ribera	4	135	Assess installing a liner (or likely replace this short pipe) in 10 to 20 years.	Included in Pump Station Cost
Hacienda	8	727	Assess installing a liner in 10 to 20 years.	Included in Pump Station Cost
Highlands	4	16,134	Replace air release and vacuum valves.	$50K to replace air and vacuum valves

5.0 SUMMARY AND NEXT STEPS

5.1 Rehab/Replacement Program Summary

Table 19 summarizes the total 20-year Collection System Rehab/Replacement Program for each of the primary asset classes in the collection system.

Table 19. 20-Year Rehab/Replacement Program Summary				
Program Year	**Gravity Sewer $**	**Pump Station $**	**Force Main $**	**Total Rehab/Replacement**
Years 1-5	4,996,000	775,000	500,000	**6,271,000**
Years 6-10	4,919,000	975,000	150,000	**6,044,000**
Years 11-15	5,070,000	325,000	-	**5,395,000**
Years 16-20	5,002,000	325,000	-	**5,327,000**
Subtotals	**$19,987,000**	**$2,400,000**	**$650,000**	**-**
			Total Construction Costs[(a)]	**$23,037,000**
			30% Engineering, Legal, Administration, etc.	$6,911,100
			Total Capital Costs	**$29,948,100**
(a) Includes 30 percent construction cost contingency.				

5.2 Next Steps

While this AMP documents the foundation and current status of the District's collection system program, it is also intended to be a working document that the District can use to further advance its program going forward. Recommended next steps for the District are:

- **Gravity Sewer Project Packaging and Prioritization**. Considerations for developing and prioritizing construction project packages for the first five years include:
  - **Capacity/Upsizing**. Coordinate rehab/replacement priorities with capacity improvements identified by the District's on-going hydraulic modeling efforts. Where sewers are upsized for capacity improvements, construct downstream upgrades first in order to avoid moving potential overflow locations downstream.
  - **Public Impacts**. While high-risk sewers should be prioritized for rehab/replacement first, construction impacts on the public must also be balanced. Group rehab/replacement projects so that the same street or major traffic thoroughfares are under construction only once in a five-year period.
  - **Planning/Permitting**. Allow for the appropriate planning and permitting activities to occur before project design begins – including easement acquisitions or rights-of-entry, environmental permitting, City encroachments, etc.
  - **Competitive Pricing**. Pipeline construction packages of less than $1M tend to limit the bidding pool and attract smaller contractors with less experience – both of which increase the unit costs of the project. To benefit from economies of scale and increase the competitiveness of bids, consider implementing larger construction packages, say every-other year, or issue multi-year on-call contracts with fixed unit pricing and annual increases that guarantee a minimum scope and contract amount per year. Also, where possible, consider allowing multiple construction methods to be bid (e.g. either pipe bursting or open-cut at the contractor's discretion) to broaden the pool of contractors qualified for each project.
  - **Staffing and Resources**. In order to limit the number of contracts for planning, design, construction, and construction management of sanitary sewer projects in any given year, consider implementing larger or multi-year contracts for engineering and construction management services and construction packages.
- **Gravity Sewer Preventative Maintenance Program**. Optimize the preventative maintenance program using the risk assessment results:
  - Review condition assessment data and maintenance records for low risk, high maintenance frequency assets.
  - Confirm the adequacy of routine maintenance for high-risk assets.
- **Pump Station Program**. Build upon the foundation presented in this report in the following areas:

— **Tidal Impacts**. Continue the District's efforts to understand the impacts of sea-level rise on tidally-impacted pump stations, and plan accordingly for sea wall or spill containment improvements.

— **Condition Assessment.** Continue to monitor the condition and performance of medium-high and high-risk pump stations and their critical components.

— **Rehab/Replacement**. Refine the next five years of improvements to resolve existing condition defects and maintenance issues, mitigate high risk factors, and improve reliability and emergency response capabilities.

- **Force Main Program**. Build upon the foundation presented in this report by:

— **Assess Condition**. Inspect high and medium-high risk force mains within the next five years, and medium risk force mains within the next ten years.

— **Rehab/Replacement Program**. Proactively identify and refine planned improvements on high and medium-high risk force mains. Budget for the replacement of old low and medium-low risk force mains that may be run-to-failure in the next 10 years.

- **Manhole Program.** Develop an AMP for the manholes in the collection system. Begin by collecting condition information for manholes connected to high and medium-high gravity sewers, and applying a risk assessment and rehab/replacement process similar to the gravity sewer risk assessment presented in this AMP.

- **Data and Record Keeping**. Improve District records by:

— Populating the age of District assets in the ICOMM asset registry.

— Improving records of asset improvements by populating rehabilitation/replacement projects in the District's CMMS database as a project consisting of a batch of asset ID's, or at a minimum as project name and date fields in the individual asset records.

- **Continuous Improvement**. Continually review and improve this Collection System AMP to improve efficiency and reduce risks to the District over time.

APPENDIX A

CCTV Defect Code List

Color Coded Chart

NASSCO'S PIPELINE ASSESSMENT CERTIFICATION PROGRAM® (PACP®)

Section 4 — Structural Defect Coding

C — CRACK — 4-3
- CL Longitudinal
- CC Circumferential
- CM Multiple
- CS Spiral
- CH Hinge (2, 3, 4)

F — FRACTURE — 4-9
- FL Longitudinal
- FC Circumferential
- FM Multiple
- FS Spiral
- FH Hinge (2, 3, 4)

B — BROKEN — 4-17
- BSV Soil Visible
- BVV Void Visible

H — HOLE — 4-21
- HSV Soil Visible
- HVV Void Visible

D — DEFORMED (Rigid) — 4-26
- DR Deformed Rigid

No modifiers used.

D — DEFORMED (Flexible) — 4-26
- DFBR Bulging Round
- DFBI Bulging Inv.Curv.
- DFC Creasing
- DFE Elliptical

D — DEFORMED (Brick) — 4-26
- DTBR Bulging Round
- DTBI Bulging Inv.Curv.

X — COLLAPSE — 4-37
- X Collapse

No descriptors and no modifiers used.

J — JOINT — 4-45
- JOS Offset Small
- JOM Offset Medium
- JOL Offset Large

J — JOINT — 4-45
- JOSD Offset Small Defect
- JOMD Offset Medium Defect
- JOLD Offset Large Defect

J — JOINT — 4-45
- JSS Separation Small
- JSM Separation Med.
- JSL Separation Large

J — JOINT — 4-45
- JAS Angular Small
- JAM Angular Medium
- JAL Angular Large

S — SURFACE DAMAGE — 4-51
- SRI Roughness Increased
- SAV Aggregate Visible
- SAP Aggregate Projecting
- SAM Aggregate Missing

S — SURFACE DAMAGE — 4-52
- SRV Reinforcement Visible
- SRP Reinforcemt.Projecting
- SRC Reinforcemt.Corroded
- SMW Missing Wall

S — SURFACE DAMAGE — 4-52
- SSS Surface Spalling
- SSC Surface Spalling Coating
- SCP Chemical Attack
- SZ Other

LF — LINING FEATURES — 4-67
- LFAC Abdn'd Connection
- LFAS Annular Space
- LFB Blistered Lining
- LFCS Service Cut Shifted

LF — LINING FEATURES — 4-67
- LFD Detached
- LFDC Discoloration
- LFDE Defective End
- LFDL Delamination

LF — LINING FEATURES — 4-67
- LFOC Overcut Service
- LFRS Resin Slug
- LFUC Undercut Service
- LFW Wrinkled
- LFZ Other

WF — WELD FAILURE — 4-85
- WFC Circumferential
- WFL Longitudinal
- WFM Multiple
- WFS Spiral
- WFZ Other

RP — POINT REPAIR — 4-89
- RPL Liner
- RPLD Liner Defective
- RPP Patch
- RPPD Patch Defective

RP — POINT REPAIR — 4-89
- RPR Replacement
- RPRD Replmt. Defective
- RPZ Other
- RPZD Other Defective

BRICKWORK — 4-97
- DB Displaced
- MB Missing
- DI Dropped Invert

BRICKWORK — 4-97
- MMS Mortar Missing Small
- MMM Mortar Missing Med.
- MML Mortar Missing Large

Color Coded Chart

NASSCO'S PIPELINE ASSESSMENT CERTIFICATION PROGRAM® (PACP)®

Section 5 — Operation and Maintenance

D DEPOSITS (Attached) 5-3
DAE Encrustation
DAGS Grease
DAR Ragging
DAZ Other

D DEPOSITS (Settled) 5-4
DSF Fine
DSGV Gravel
DSC Hard/Compact
DSZ Other

D DEPOSITS (Ingress) 5-4
DNF Fine (silt/sand)
DNGV Gravel
DNZ Other

R ROOT (Fine) 5-11
RFB Barrel
RFL Lateral
RFC Connection
RFJ Joint

R ROOTS (Medium) 5-12
RMB Barrel
RML Lateral
RMC Connection
RMJ Joint

R ROOTS (Ball) 5-12
RBB Barrel
RBL Lateral
RBC Connection
RBJ Joint

R ROOTS (Tap) 5-12
RTB Barrel
RTL Lateral
RTC Connection
RTJ Joint

I INFILTRATION 5-20
IS Stain
ISB Barrel
ISC Connection
ISJ Joint
ISL Lateral

I INFILTRATION 5-20
IW Weeper
IWB Barrel
IWC Connection
IWJ Joint
IWL Lateral

I INFILTRATION 5-20
ID Dripper
IDB Barrel
IDC Connection
IDJ Joint
IDL Lateral

I INFILTRATION 5-21
IR Runner
IRB Barrel
IRC Connection
IRJ Joint
IRL Lateral

I INFILTRATION 5-21
IG Gusher
IGB Barrel
IGC Connection
IGJ Joint
IGL Lateral

OB OBSTACLES OBSTRUCTIONS 5-31
OBB Brick or Masonry
OBC Object Through Connection
OBI Object Intruding Through Wall

OB OBSTACLES OBSTRUCTIONS 5-31
OBJ Object in Joint
OBM Pipe Material in Invert
OBN Construction Debris
OBP External Pipe Cable

OB OBSTACLES OBSTRUCTIONS 5-32
OBR Rocks
OBS Built In Structure
OBZ Other

V VERMIN 5-45
VR Rat
VC Cockroach
VZ Other

G GROUT TEST & SEAL 5-50
GTP Grout Test Passed
GTPJ Joint
GTPL Lateral
GTF Grout Test Failed
GTFJ Joint
GTFL Lateral

G GROUT TEST & SEAL 5-50
GTU Grout Test Unable
GTUJ Joint
GTUL Lateral
GRT Grout Test Location

Section 6 — Construction Features

T TAP 6-3
TB Break-In/Hammer
TBI Intruding
TBD Defective
TBC Capped
TBA Activity
TBB Abandoned

T TAP 6-3
TF Factory Made
TFI Intruding
TFD Defective
TFC Capped
TFA Activity
TFB Abandoned

T TAP 6-4
TR Rehabilitated
TRI Intruding
TRD Defective
TRC Capped
TRA Activity
TRB Abandoned

T TAP 6-4
TS Saddle
TSI Intruding
TSD Defective
TSC Capped
TSA Activity
TSB Abandoned

IS INTRUDING SEALING MATERIAL 6-15
ISSR Sealing Ring
ISSRB Broken
ISSRH Hanging
ISSRL Loose
ISGT Grout
ISZ Other

L LINE (of sewer) 6-21
LD Down
LL Left
LLD Left Down
LLU Left Up

L LINE (of sewer) 6-21
LR Right
LRD Right Down
LRU Right Up
LU Up

A ACCESS POINT 6-25
ACB Catch Basin
ACO Cleanout
ACOM Mainline
ACOP Property
ACOH House

A ACCESS POINT 6-25
ADP Discharge Point
AEP End of Pipe
AJB Junction Box
AM Meter
AMH Manhole

A ACCESS POINT 6-26
AOC Other Structure
ATC Tee Connection
AWA Wastewater Access
AWW Wetwell
AZ Other

Section 7 — Miscellaneous Features

M MISCELLANEOUS FEATURES 7-1
MCU Camera Underwater
MGO General Observation
MGP General Photograph
MJL Joint Length

M MISCELLANEOUS FEATURES 7-2
MLC Lining Change
MMC Material Change
MSC Shape/Size Change
MSA Survey Abandoned
MWL Water Level

M MISCELLANEOUS FEATURES 7-3
MWLS Water Level Sag
MWM Water Mark
MY Dye Test
MYV Dye Visible
MYN Not Visible

NASSCO'S PIPELINE ASSESSMENT CERTIFICATION PROGRAM® (PACP)®

Section 2 — Header Form Fields

14 Weather 2-5
- 1 = Dry
- 2 = Heavy Rain
- 3 = Light Rain
- 4 = Snow
- 5 = Dry Weather/Wet Ground

15 Pre-Cleaning 2-5
- H = Heavy Cleaning
- L = Light Cleaning (Jetting)
- N = No Pre-Cleaning
- X = Not Known
- Z = Other

17 Flow Control 2-6
- B = Bypassed
- D = Dewatered Using Jetter
- L = Lift Station
- N = Not Controlled
- P = Plugged

18 Purpose 2-7
- A = Maintenance
- B = Infiltration/Inflow Invest.
- C = Post-Rehabilitation
- D = Pre-Rehabilitation
- E = Pre-Acceptance
- F = Routine Assessment

18 Purpose 2-7
- G = Capital Improvement Program Assessment
- H = Resurvey
- I = SSES
- R = Pre-Existing Video
- X = Not Known

19 Direction 2-7
- D = Downstream
- U = Upstream

28 Location Code 2-11
- A = Primary Major Arterial Road
- B = Secondary Road
- C = Local/Rural Street
- D = Easement/Right-of-Way
- E = Woods

28 Location Code 2-11
- F = Sidewalk
- G = Parking Lot
- H = Alley
- I = Ditch
- J = Building
- K = Creek (or any waterway)

28 Location Code 2-11
- L = Railway
- M = Airport
- N = Levee/Floodwall
- O = Dam
- P = Levee Pump Station
- Y = Yard
- Z = Other

30 Pipe Use 2-12
- CB = Combined Pipe
- DP = Dam Pipe
- FM = Force Main
- LG = Levee Gravity Pipe
- LP = Levee Pressure Pipe

30 Pipe Use 2-12
- PR = Process Pipe
- SS = Sanitary Sewage Pipe
- SW = Stormwater Pipe
- XX = Not Known
- ZZ = Other

33 Shape 2-13 E-1
- A = Arched
- B = Barrel
- C = Circular
- E = Egg-Shaped
- H = Horseshoe
- O = Oval (elliptical)

33 Shape 2-13 E-1
- R = Rectangular
- S = Square
- T = Trapezoidal
- U = U-Shaped with Flat Top
- Z = Other

34 Material 2-14 E-4
- ABS = Acrylonitrile Butadiene Styrene
- AC = Asbestos Cement
- BR = Brick
- CAS = Cast Iron
- CLC = Clay-Lined Concrete
- CMP = Corrugated Metal Pipe

34 Material 2-14 E-4
- CP = Concrete Pipe
- CSB = Conc. Segments Bolted
- CSU = Conc. Segments Unbolted
- CT = Clay Tile
- DIP = Ductile Iron Pipe

34 Material 2-14 E-4
- FRP = Fiberglass Reinforced Pipe
- OB = Orangeburg/Pitch Fiber
- PCCP = Pre-Stressed Concrete Cylinder Pipe
- PCP = Polymer Concrete Pipe
- PE = Polyethylene

34 Material 2-14 E-4
- PP = Polypropylene
- PSC = Plastic/Steel Composite
- PVC = Polyvinyl Chloride
- RCP = Reinf. Concrete Pipe
- RMP = Reinf. Plastic Pipe
- SB = Segmented Block

34 Material 2-14 E-4
- SP = Steel Pipe
- VCP = Vitrified Clay Pipe
- WD = Wood
- XXX = Not Known
- ZZZ = Other

35 Lining Method 2-15 E-17
- CIP = Cured-In-Place Pipe
- FF = Fold and Form
- FP = Formed-In-Place Liner
- GP = Grout-In-Place Liner
- GRC = Glass Reinf. Cement
- N = None
- SC = Continuous Slip Liner

35 Lining Method 2-15 E-17
- SE = Sectional Slip Liner
- SL = Spray Liner
- SN = Segmented Panel
- SP = Segmented Pipe
- SW = Spiral Wound
- XX = Not Known
- ZZ = Other

36 Coating Method 2-16 E-23
- CT = Coal Tar
- CM = Cement Mortar
- EP = Epoxy
- PE = Polyethylene

36 Coating Method 2-16 E-23
- PO = Polyurethane
- PU = Polyurea
- PVC = Polyvinyl Chloride
- XX = Not Known
- ZZ = Other

APPENDIX B

Detailed Gravity Sewer Risk Assessment Results

Appendix B. Detailed Risk Assessment Results

						Likelihood of Failure Score				Consequence of Failure Score					Risk Score		
Pipe Number	Diameter, inches	Material	Length, linear feet	Installation Year	Basin	Structural Failure Rate	Maintenance Failure Rate	Hydraulic Capacity Failure Rate	Total Score	Potential Spill Volume	Environmental Impact	Emergency Response and Construction Impact	Public Exposure	Total Score	Total Risk	Normalized Risk	Risk Level
R622-R624	12	VCP	329	1949	WWTP	40	50	25	115	50	6	3	32	91	206	1000.0	High
R631-R641	12	VCP	379	1949	WWTP	32	40	5	77	50	24	9	40	123	200	970.9	High
R712-R713	12	VCP	26	1950	WWTP	40	10	25	75	50	18	3	40	111	186	902.9	High
Q708-Q709	6	VCP	340	1950	WWTP	40	40	10	90	30	18	3	40	91	181	878.6	High
Q805-Q806	8	VCP	461	1957	R822	40	40	5	85	40	6	3	40	89	174	844.7	High
R628-R631	12	VCP	366	1949	WWTP	32	40	10	82	50	6	3	32	91	173	839.8	High
O697-O698	6	VCP	220	1921	Q672	40	50	5	95	30	6	9	32	77	172	835.0	High
R6PS_3	6	UNK	92	0	Outfall	40	50	5	95	10	24	3	40	77	172	835.0	High
Q730-Q731	6	VCP	453	1950	WWTP	40	40	10	90	20	18	3	40	81	171	830.1	High
N654-N655	6	VCP	183	1921	Q672	32	40	10	82	30	6	12	40	88	170	825.2	High
Q707-Q708	6	VCP	338	1950	WWTP	24	30	25	79	30	18	3	40	91	170	825.2	High
Q6115-Q603	6	VCP	384	1947	Q631	40	40	5	85	20	18	6	40	84	169	820.4	High
R640-R641	12	UNK	17	1941	WWTP	40	10	5	55	40	24	9	40	113	168	815.5	High
R711-R713	27	UNK	5	1950	WWTP	40	10	5	55	50	18	3	40	111	166	805.8	High
R713-R794	27	VCP	33	1950	WWTP	40	10	5	55	50	18	3	40	111	166	805.8	High
R787-R710	6	VCP	107	1951	WWTP	40	40	20	100	10	18	3	32	63	163	791.3	High
R641A-R641B	18	VCP	253	0	WWTP	40	50	5	95	50	6	3	8	67	162	786.4	High
R641B-R641C	18	VCP	123	0	WWTP	40	50	5	95	50	6	3	8	67	162	786.4	High
R641C-R794	18	VCP	19	0	WWTP	40	50	5	95	50	6	3	8	67	162	786.4	High
R641-R641A	18	VCP	119	0	WWTP	40	50	5	95	50	6	3	8	67	162	786.4	High
R794A-R6PS_2	24	STL	93	0	WWTP	40	50	5	95	50	6	3	8	67	162	786.4	High
R794-R794A	24	STL	316	0	WWTP	40	50	5	95	50	6	3	8	67	162	786.4	High
R662-R532	6	VCP	415	1950	WWTP	32	40	20	92	10	24	3	32	69	161	781.6	High
R766-R708	27	AC	274	1950	R709	8	50	20	78	50	12	12	8	82	160	776.7	High
S614-S610	6	VCP	289	1962	WWTP	32	40	5	77	10	18	15	40	83	160	776.7	High
N602-N604	6	VCP	312	1921	N609	40	40	5	85	20	6	15	32	73	158	767.0	High
P657-P656	6	VCP	138	1921	Q679	40	50	5	95	10	6	15	32	63	158	767.0	High
R629-R632	12	VCP	307	1949	WWTP	32	40	5	77	40	6	3	32	81	158	767.0	High
O682-P635	6	VCP	400	1921	R621	40	40	5	85	20	6	6	40	72	157	762.1	High
S801-R752	24	AC	399	1950	R709	40	40	5	85	40	12	12	8	72	157	762.1	High
N604-N605	6	VCP	173	1921	N609	40	30	5	75	20	6	15	40	81	156	757.3	High
N661-O692	6	VCP	220	1921	Q672	32	30	20	82	30	6	6	32	74	156	757.3	High
S619-S617	6	VCP	216	1962	WWTP	40	40	5	85	10	6	15	40	71	156	757.3	High
R534-R662	6	VCP	380	1950	WWTP	40	40	5	85	10	24	3	32	69	154	747.6	High
P603-P604	6	VCP	418	1947	Q631	24	50	5	79	20	6	6	40	72	151	733.0	High
P635-P636	6	VCP	449	1921	R621	32	50	5	87	20	6	6	32	64	151	733.0	High
M768-M767	6	VCP	91	1921	N609	40	50	5	95	10	6	15	24	55	150	728.2	High
Q706-Q707	6	VCP	2	1950	WWTP	32	30	25	87	10	18	3	32	63	150	728.2	High
R784-R787	6	VCP	323	1951	WWTP	40	50	5	95	10	18	3	24	55	150	728.2	High
O685-O687	6	VCP	449	1921	Q649	40	50	5	95	10	6	6	32	54	149	723.3	High
P640-P641	6	VCP	450	1921	R663	40	50	5	95	10	6	6	32	54	149	723.3	High
Q655-R620	12	VCP	337	1949	R621	32	40	20	92	40	6	3	8	57	149	723.3	High
P736-P789	6	VCP	396	1942	WWTP	40	40	5	85	10	6	15	32	63	148	718.4	High
R1011-R1012	10	AT	461	1973	R809	40	30	25	95	30	12	3	8	53	148	718.4	High
T606-T605	6	VCP	201	1962	WWTP	40	40	5	85	10	6	15	32	63	148	718.4	High
O680-O681	6	VCP	219	1921	Q649	40	40	5	85	10	6	6	40	62	147	713.6	High
Q619-Q608	12	VCP	374	1943	Q631	40	40	20	100	30	6	3	8	47	147	713.6	High
Q511-Q504	6	VCP	222	1947	Q631	40	30	5	75	10	18	3	40	71	146	708.7	High
R608-R614	6	VCP	425	1950	WWTP	40	50	5	95	10	6	3	32	51	146	708.7	High
Q697-R638	6	VCP	506	1950	WWTP	40	40	5	85	10	6	12	32	60	145	703.9	High
R531-R532	6	VCP	269	1950	WWTP	40	40	20	100	10	24	3	8	45	145	703.9	High
N713-N712	6	VCP	317	1921	Q672	32	40	20	92	10	6	12	24	52	144	699.0	High
Q614-Q631	12	VCP	260	1943	Q631	32	50	5	87	40	6	3	8	57	144	699.0	High
Q635-Q6100	8	VCP	238	0	R621	40	40	5	85	40	6	3	8	57	142	689.3	High
Q637-Q638	12	VCP	266	1949	R621	40	40	5	85	40	6	3	8	57	142	689.3	High
Q719-Q720	6	VCP	176	1950	WWTP	32	50	5	87	10	6	15	24	55	142	689.3	High
R1012-R901A	10	AT	257	0	R809	40	50	5	95	30	6	3	8	47	142	689.3	High
R663-R629	10	VCP	316	1949	WWTP	40	40	5	85	40	6	3	8	57	142	689.3	High
R806A-R806	12	AT	253	0	R809	40	50	5	95	30	6	3	8	47	142	689.3	High
R901A-R901	10	AT	212	0	R809	40	50	5	95	30	6	3	8	47	142	689.3	High
R906-R907A	10	AT	169	0	R809	40	50	5	95	30	6	3	8	47	142	689.3	High
R907A-R907	10	AT	228	0	R809	40	50	5	95	30	6	3	8	47	142	689.3	High
R912-R806A	12	AT	264	0	R809	40	50	5	95	30	6	3	8	47	142	689.3	High
O6124-O680	6	VCP	161	1921	Q649	32	50	5	87	10	6	6	32	54	141	684.5	High
P639-P640	6	VCP	137	1921	R663	24	50	5	79	10	6	6	40	62	141	684.5	High
P784-P738	6	UNK	250	1942	WWTP	32	40	5	77	10	6	15	32	63	140	679.6	High
R533-R535	6	VCP	338	1950	WWTP	32	40	5	77	10	18	3	32	63	140	679.6	High
O6106-P648	6	VCP	400	1921	Q679	40	40	5	85	10	6	6	32	54	139	674.8	High
O727-O728	6	VCP	396	1921	Q679	40	40	5	85	10	6	6	32	54	139	674.8	High
Q608-Q610	12	VCP	133	1943	Q631	32	30	20	82	40	6	3	8	57	139	674.8	High
Q625-Q619	10	VCP	230	1943	Q631	32	40	20	92	30	6	3	8	47	139	674.8	High
P742-P740	6	VCP	205	1942	WWTP	24	50	5	79	10	6	3	40	59	138	669.9	High
R1006-R1008	10	AT	471	1973	R809	40	20	25	85	30	12	3	8	53	138	669.9	High
R827-R832	6	VCP	337	1962	R709	24	50	5	79	10	6	3	40	59	138	669.9	High
T605-T604	6	VCP	278	1962	WWTP	40	30	5	75	10	6	15	32	63	138	669.9	High
O6107-N658	6	VCP	306	1921	Q672	40	40	5	85	10	6	12	24	52	137	665.0	High
N664-N618	6	VCP	112	1921	Q631	32	40	5	77	10	6	3	40	59	136	660.2	High
O6101-O6102	6	VCP	432	1921	Q672	40	40	5	85	10	6	3	32	51	136	660.2	High
O6120-O6135	8	VCP	249	1921	Q672	24	50	5	79	10	6	9	32	57	136	660.2	High
O663-O664	6	VCP	410	1921	Q631	40	40	5	85	10	6	3	32	51	136	660.2	High
O684-O685	6	VCP	454	1921	Q649	40	40	5	85	10	6	3	32	51	136	660.2	High
O690-O691	6	VCP	73	1921	Q672	40	40	5	85	10	6	3	32	51	136	660.2	High
O821-O822	6	VCP	140	2014	R822	32	50	5	87	20	6	15	8	49	136	660.2	High
Q754-Q757	6	VCP	446	1950	WWTP	40	40	5	85	10	6	3	32	51	136	660.2	High
Q783-Q711	6	VCP	329	1950	WWTP	40	40	5	85	10	6	3	32	51	136	660.2	High
GRIZZLY-Y401	6	HDPE	521	0	WWTP	40	50	5	95	10	6	15	8	39	134	650.5	High
M744-M785	6	VCP	111	1921	N609	40	50	5	95	10	6	15	8	39	134	650.5	High
M775-M784	6	VCP	125	0	N609	40	50	5	95	10	6	15	8	39	134	650.5	High
P502-SCENIC&8TH	6	PVC	215	0	Q631	40	50	5	95	10	6	15	8	39	134	650.5	High
Q682-Q675	8	VCP	266	1945	R663	32	30	15	77	40	6	3	8	57	134	650.5	High
R1120-R1121	6	VCP	371	1966	R809	40	50	5	95	10	6	15	8	39	134	650.5	High
R627-R663	10	VCP	248	1949	R663	32	40	5	77	40	6	3	8	57	134	650.5	High
R731-R732	6	VCP	443	1950	WWTP	40	40	5	85	20	6	15	8	49	134	650.5	High
R754-R760	10	VCP	141	1959	WWTP	40	50	5	95	10	12	9	8	39	134	650.5	High
N799-N7100	6	VCP	122	1966	R822	24	40	20	84	20	6	15	8	49	133	645.6	High
O6103-O6104	6	VCP	134	1921	Q672	24	50	5	79	10	6	6	32	54	133	645.6	High
O6104-O6105	6	VCP	219	1921	Q672	24	50	5	79	10	6	6	32	54	133	645.6	High
R806-R807	12	AT	326	1973	R809	40	40	5	85	30	6	3	8	47	132	640.8	High
S611-S612	6	VCP	154	1962	WWTP	32	40	20	92	10	6	15	8	39	131	635.9	High
P753-Q702	6	VCP	534	1942	WWTP	40	30	5	75	10	6	15	24	55	130	631.1	High
R772-R771	6	VCP	386	1951	WWTP	40	40	5	85	10	12	15	8	45	130	631.1	High
N616-N617	6	VCP	441	1921	Q631	40	40	5	85	10	6	3	24	43	128	621.4	High
N651-O6111	6	VCP	403	1921	Q679	32	40	5	77	10	6	3	32	51	128	621.4	High
O726-O727	6	VCP	485	1921	Q679	32	40	5	77	10	6	3	32	51	128	621.4	High
P788-P789	6	VCP	118	1942	WWTP	32	40	5	77	10	6	3	32	51	128	621.4	High
R522-R523	8	VCP	443	1949	WWTP	32	40	5	77	10	6	3	32	51	128	621.4	High
R526-R525	12	VCP	316	1949	WWTP	40	40	5	85	10	6	3	24	43	128	621.4	High
R656-R636	6	VCP	323	1950	WWTP	32	40	5	77	10	6	3	32	51	128	621.4	High
O6129-O6144	6	UNK	138	1984	Q631	40	30	5	75	10	6	3	32	51	126	611.7	High
P722-P723	6	VCP	213	1921	Q679	40	30	5	75	10	6	3	32	51	126	611.7	High
Q760-Q761	6	UNK	180	1957	R822	32	50	5	87	10	6	15	8	39	126	611.7	High
R607-R615	6	VCP	543	1950	WWTP	40	30	5	75	10	6	3	32	51	126	611.7	High
O735-O737	6	VCP	199	2015	Q679	40	40	5	85	20	6	6	8	40	125	606.8	High
O702-O704	8	VCP	226	1921	Q679	32	40	5	77	30	6	3	8	47	124	601.9	High
Q748-Q749	6	VCP	551	1950	WWTP	40	40	5	85	10	6	15	8	39	124	601.9	High
R739-R789	6	VCP	255	1950	WWTP	32	40	5	77	20	6	12	8	46	123	597.1	High
M748-M776	6	VCP	169	1921	Q672	40	30	5	75	30	6	3	8	47	122	592.2	High
N829-O801	6	VCP	393	1966	R822	32	30	20	82	10	6	15	8	39	121	587.4	High
N626-O651	6	VCP	167	1921	Q631	32	40	5	77	10	6	3	24	43	120	582.5	High
P772-P773	6	VCP	279	1957	R822	32	40	5	77	10	6	3	24	43	120	582.5	High
P775-P776	6	VCP	386	1957	R822	32	40	5	77	10	6	3	24	43	120	582.5	High
O813-O814	6	VCP	226	1973	R822	32	40	5	77	10	6	15	8	39	116	563.1	High
Q761-Q762	6	UNK	21	1957	R822	32	40	5	77	10	6	15	8	39	116	563.1	High
S613-S612	6	VCP	204	1962	WWTP	32	40	5	77	10	6	15	8	39	116	563.1	High
S703-S705	6	VCP	387	0	WWTP	32	40	5	77	10	18	3	8	39	116	563.1	High
R610-R609	6	VCP	272	1950	WWTP	40	30	5	75	10	18	3	8	39	114	553.4	High
Q806-Q807	8	VCP	473	1957	R822	32	30	10	72	40	6	3	40	89	161	781.6	Medium-High
Q732-R701	6	VCP	281	1950	WWTP	32	30	5	67	20	18	15	40	93	160	776.7	Medium-High
R703-R704	6	VCP	274	1950	WWTP	32	10	5	47	30	30	12	40	112	159	771.8	Medium-High
Q502-Q503	6	VCP	346	1947	Q631	24	30	20	74	20	18	6	40	84	158	767.0	Medium-High
R632-R640	12	VCP	374	1949	WWTP	24	10	10	44	40	24	9	40	113	157	762.1	Medium-High
S802-S801	24	VCP	220	1971	R709	8	40	5	53	40	12	12	40	104	157	762.1	Medium-High
Q781-Q707	6	VCP	354	1950	WWTP	24	10	25	59	30	24	3	40	97	156	757.3	Medium-High
R707-R710	12	VCP	541	1950	WWTP	8	30	25	63	40	18	3	32	93	156	757.3	Medium-High
S601-CARMELMEADOWS_2	6	VCP	29	2003	WWTP	24	40	5	69	20	24	3	40	87	156	757.3	Medium-High
P649-P650	8	PVC	448	1994	Q679	8	40	25	73	40	6	3	32	81	154	747.6	Medium-High
R710-R712	12	VCP	93	1950	WWTP	8	10	25	43	50	18	3	40	111	154	747.6	Medium-High
S610-S609	6	VCP	75	1962	WWTP	16	50	5	71	10	18	15	40	83	154	747.6	Medium-High
Q731-Q732	6	VCP	337	1950	WWTP	40	10	10	60	20	18	15	40	93	153	742.7	Medium-High
R639-R703	6	VCP	240	1950	WWTP	32	10	5	47	30	24	12	40	106	153	742.7	Medium-High
R810-R811	12	AT	294	1973	R709	8	40	20	68	40	12	9	24	85	153	742.7	Medium-High
R907-R908	10	AT	290	1973	R809	8	40	20	68	30	12	3	40	85	153	742.7	Medium-High
O696-O697	6	VCP	452	1921	Q672	24	40	10	74	30	6	9	32	77	151	733.0	Medium-High
S615-S609	6	VCP	301	1962	WWTP	24	40	5	69	20	18	3	40	81	150	728.2	Medium-High
Q704-Q781	6	VCP	166	1950	WWTP	40	10	10	60	30	24	3	32	89	149	723.3	Medium-High
R705-R704	6	VCP	521	1950	WWTP	32	30	5	67	20	18	12	32	82	149	723.3	Medium-High
R709-R711	27	VCP	593	2017	WWTP	8	10	20	38	50	18	3	40	111	149	723.3	Medium-High
S618-S615	6	STL	182	1962	WWTP	8	40	20	68	20	6	15	40	81	149	723.3	Medium-High
Q703-Q704	6	VCP	103	1950	WWTP	32	30	10	72	30	18	3	24	75	147	713.6	Medium-High
R708-R709	27	VCP	21	1950	R709	40	10	20	70	50	6	12	8	76	146	708.7	Medium-High
S607-S601	6	VCP	224	1962	WWTP	24	30	5	59	20	24	3	40	87	146	708.7	Medium-High
O694-O695	6	VCP	300	1921	Q672	16	50	5	71	30	6	6	32	74	145	703.9	Medium-High
R763-R764	27	AC	278	1950	R709	8	10	20	38	50	12	12	32	106	144	699.0	Medium-High
R910-R911	12	AT	249	1973	R809	24	10	25	59	30	12	3	40	85	144	699.0	Medium-High
R864-R810	6	0	151	0	R709	40	50	20	110	10	12	3	8	33	143	694.2	Medium-High
N712-N714	6	VCP	138	1921	Q672	32	10	20	62	30	6	12	32	80	142	689.3	Medium-High
P648-P649	8	PVC	450	1994	Q679	8	40	20	68	30	6	6	32	74	142	689.3	Medium-High
R789-R743	6	VCP	263	1950	WWTP	16	40	10	66	20	12	12	32	76	142	689.3	Medium-High
R822-R823	8	VCP	106	1957	R709	8	10	25	43	40	6	12	40	98	141	684.5	Medium-High
R823-R824	15	VCP	305	1966	R709	24	30	5	59	40	6	12	24	82	141	684.5	Medium-High
R824-R831	15	VCP	407	1966	R709	16	30	5	51	40	6	3	40	89	140	679.6	Medium-High
T607-T606	6	VCP	82	1962	WWTP	24	40	5	69	10	6	15	40	71	140	679.6	Medium-High
O681-O682	6	VCP	60	1921	R621	32	30	5	67	20	6	6	40	72	139	674.8	Medium-High
P651-Q677	8	PVC	450	1995	Q679	8	40	10	58	40	6	3	32	81	139	674.8	Medium-High
T603-T648	6	STL	183	1962	WWTP	8	40	20	68	10	6	15	40	71	139	674.8	Medium-High
R1009-R1010	10	AT	354	1973	R809	8	40	25	73	30	24	3	8	65	138	669.9	Medium-High

Appendix B. Detailed Risk Assessment Results

Pipe Number	Diameter, inches	Material	Length, linear feet	Installation Year	Basin	Likelihood of Failure Score				Consequence of Failure Score					Risk Score		Risk Level
						Structural Failure Rate	Maintenance Failure Rate	Hydraulic Capacity Failure Rate	Total Score	Potential Spill Volume	Environmental Impact	Emergency Response and Construction Impact	Public Exposure	Total Score	Total Risk	Normalized Risk	
R746-R747	15	VCP	315	1955	R709	24	30	5	59	40	12	3	24	79	138	669.9	Medium-High
R811-R812	12	AT	285	1973	R709	8	40	5	53	40	12	9	24	85	138	669.9	Medium-High
O709-O708	6	VCP	173	0	Q679	40	50	20	110	10	6	3	8	27	137	665.0	Medium-High
P803-P805	8	VCP	236	1957	R822	8	40	10	58	30	6	3	40	79	137	665.0	Medium-High
R504-R503	6	VCP	407	1947	Q631	24	10	20	54	10	30	3	40	83	137	665.0	Medium-High
Q6114-R639	6	VCP	343	1950	WWTP	32	10	5	47	30	18	9	32	89	136	660.2	Medium-High
R702-R704	6	VCP	317	1950	WWTP	40	10	5	55	20	18	3	40	81	136	660.2	Medium-High
R854-S802	8	VCP	371	1971	R709	16	50	5	71	10	12	3	40	65	136	660.2	Medium-High
N647-N653	6	VCP	328	1921	Q672	40	10	5	55	30	6	12	32	80	135	655.3	Medium-High
R621-R622	12	VCP	159	1949	WWTP	32	20	10	62	40	6	3	24	73	135	655.3	Medium-High
O615-O616	8	PVC	61	1983	Q631	8	50	5	63	30	6	3	32	71	134	650.5	Medium-High
P801-P802	8	VCP	352	1957	R822	40	10	5	55	30	6	3	40	79	134	650.5	Medium-High
Q701-Q702	6	OTHER	67	1942	WWTP	32	30	5	67	20	6	9	32	67	134	650.5	Medium-High
R624-R628	12	VCP	372	1949	WWTP	32	10	25	67	50	6	3	8	67	134	650.5	Medium-High
R812-S806	12	AT	195	1973	R709	24	10	5	39	40	12	3	40	95	134	650.5	Medium-High
S609-S607	6	PVC	238	1962	WWTP	8	40	5	53	20	18	3	40	81	134	650.5	Medium-High
S622-S616	6	STL	115	1962	WWTP	8	50	5	63	10	6	15	40	71	134	650.5	Medium-High
P602-P603	6	VCP	492	1947	Q631	24	40	5	69	20	6	6	32	64	133	645.6	Medium-High
R1010-R1011	10	AT	378	1973	R809	24	30	20	74	30	18	3	8	59	133	645.6	Medium-High
S616-S608	6	STL	122	1962	WWTP	32	10	20	62	10	6	15	40	71	133	645.6	Medium-High
O695-O696	6	VCP	451	1921	Q672	8	40	10	58	30	6	6	32	74	132	640.8	Medium-High
P744-P745	6	UNK	416	2013	WWTP	24	30	5	59	20	6	15	32	73	132	640.8	Medium-High
P808-P810	8	VCP	307	1957	R822	8	40	5	53	30	6	3	40	79	132	640.8	Medium-High
Q506A-Q506B	6	VCP	16	0	Q631	40	50	5	95	20	6	3	8	37	132	640.8	Medium-High
Q658A-Q659	6	PVC	565	0	R621	40	50	5	95	20	6	3	8	37	132	640.8	Medium-High
Q658-Q658A	6	PVC	27	0	R621	40	50	5	95	20	6	3	8	37	132	640.8	Medium-High
Q804-Q805	8	VCP	385	1957	R822	8	30	5	43	40	6	3	40	89	132	640.8	Medium-High
R649-R658	6	PVC	273	2002	WWTP	24	40	5	69	10	18	3	32	63	132	640.8	Medium-High
R701-R702	6	VCP	286	1950	WWTP	24	10	5	39	20	18	15	40	93	132	640.8	Medium-High
R805-R808	10	VCP	347	1973	R809	16	30	25	71	20	6	3	32	61	132	640.8	Medium-High
O689-O6141	6	VCP	74	1921	Q649	24	40	5	69	10	6	6	40	62	131	635.9	Medium-High
P639-O689	6	VCP	284	1921	Q649	24	40	5	69	10	6	6	40	62	131	635.9	Medium-High
R909-R910	12	AT	376	1973	R809	16	10	20	46	30	12	3	40	85	131	635.9	Medium-High
Q504-Q518	6	VCP	384	1947	Q631	8	30	5	43	20	24	3	40	87	130	631.1	Medium-High
Q709-Q6114	6	VCP	357	1950	WWTP	24	10	5	39	30	18	3	40	91	130	631.1	Medium-High
R502-R501	6	VCP	421	1947	Q631	24	30	5	59	10	18	3	40	71	130	631.1	Medium-High
R704-R706	10	VCP	213	1950	WWTP	8	10	10	28	40	18	12	32	102	130	631.1	Medium-High
R807-R808	12	AT	24	1973	R809	24	10	25	59	30	6	3	32	71	130	631.1	Medium-High
R911-R912	12	AT	240	1973	R809	16	10	25	51	30	6	3	40	79	130	631.1	Medium-High
Q810-Q807	6	VCP/PVC	162	1957	R822	40	10	20	70	10	6	3	40	59	129	626.2	Medium-High
O6105-O698	8	PVC	256	1991	Q672	16	50	5	71	10	6	9	32	57	128	621.4	Medium-High
P665-Q684	6	VCP	304	1942	WWTP	32	40	20	92	10	6	12	8	36	128	621.4	Medium-High
R507-R505	6	VCP	299	1947	Q631	24	30	5	59	10	24	3	32	69	128	621.4	Medium-High
R617-R616	6	VCP	165	1950	WWTP	40	20	5	65	10	18	3	32	63	128	621.4	Medium-High
R769-R790	6	VCP	256	1951	WWTP	40	50	5	95	10	12	3	8	33	128	621.4	Medium-High
R841-R853	8	VCP	245	1971	R709	16	50	5	71	10	12	3	32	57	128	621.4	Medium-High
R853-R847	8	VCP	148	1971	R709	16	50	5	71	10	12	3	32	57	128	621.4	Medium-High
R908-R909	10	AT	61	1973	R809	8	10	25	43	30	12	3	40	85	128	621.4	Medium-High
N605-N606	6	VCP	261	1921	N609	32	20	10	62	20	6	15	24	65	127	616.5	Medium-High
N659-N660	6	VCP	29	1921	Q672	32	10	5	47	30	6	12	32	80	127	616.5	Medium-High
N737-O713	6	VCP	323	1921	Q679	40	40	20	100	10	6	3	8	27	127	616.5	Medium-High
Q603-Q502	6	VCP	106	1947	Q631	8	30	5	43	20	18	6	40	84	127	616.5	Medium-High
Q640-Q639	12	VCP	13	1949	WWTP	40	10	20	70	40	6	3	8	57	127	616.5	Medium-High
R737-R738	6	VCP	435	1950	WWTP	40	40	10	90	20	6	3	8	37	127	616.5	Medium-High
S804-S845	24	VCP	244	1971	R709	8	10	5	23	40	12	12	40	104	127	616.5	Medium-High
S807-S804	24	VCP	312	1971	R709	8	10	5	23	40	12	12	40	104	127	616.5	Medium-High
S845-S802	24	VCP	333	1971	R709	8	10	5	23	40	12	12	40	104	127	616.5	Medium-High
P735-P784	6	UNK	211	1942	WWTP	40	10	5	55	10	6	15	40	71	126	611.7	Medium-High
Q779-Q708	6	VCP	5	1950	WWTP	40	10	5	55	10	18	3	40	71	126	611.7	Medium-High
R658-R616	6	PVC	272	2002	WWTP	8	50	5	63	10	18	3	32	63	126	611.7	Medium-High
S617-S618	6	VCP	86	1962	WWTP	40	10	5	55	10	6	15	40	71	126	611.7	Medium-High
M776-N703	6	PVC	200	1921	Q672	24	40	5	69	30	6	12	8	56	125	606.8	Medium-High
O677-P628	8	PVC	460	1990	Q649	16	40	5	61	20	6	6	32	64	125	606.8	Medium-High
O691-O692	6	VCP	32	1921	Q672	24	30	20	74	10	6	3	32	51	125	606.8	Medium-High
M729-M731	8	VCP	363	1921	N609	40	20	5	65	10	6	3	40	59	124	601.9	Medium-High
N609-N610	6	VCP	375	1921	Q631	32	50	5	87	20	6	3	8	37	124	601.9	Medium-High
P740-P743	6	UNK	448	2013	WWTP	8	30	5	43	20	6	15	40	81	124	601.9	Medium-High
P807-P808	6	VCP	326	1957	R822	40	20	5	65	10	6	3	40	59	124	601.9	Medium-High
Q503-Q504	6	VCP	482	1947	Q631	8	30	5	43	20	18	3	40	81	124	601.9	Medium-High
Q613-Q615	12	VCP	124	1943	Q631	32	30	5	67	40	6	3	8	57	124	601.9	Medium-High
Q631-Q640	12	VCP	235	1949	WWTP	32	30	5	67	40	6	3	8	57	124	601.9	Medium-High
Q705-Q781	6	VCP	146	1950	WWTP	40	10	5	55	10	24	3	32	69	124	601.9	Medium-High
R612-R653	8	VCP	282	1950	WWTP	32	20	5	57	20	12	3	32	67	124	601.9	Medium-High
O6135-O6106	6	UNK	62	1921	Q679	24	40	5	69	10	6	6	32	54	123	597.1	Medium-High
O6136-O501	6	VCP	167	1947	Q631	24	40	5	69	10	6	6	32	54	123	597.1	Medium-High
O6147-O6104	6	VCP	121	1921	Q672	24	40	5	69	10	6	6	32	54	123	597.1	Medium-High
O678-O679	6	VCP	153	1921	Q649	24	40	5	69	10	6	6	32	54	123	597.1	Medium-High
O679-O680	6	VCP	177	1921	Q649	24	40	5	69	10	6	6	32	54	123	597.1	Medium-High
O686-O687	6	VCP	123	1921	Q649	24	40	5	69	10	6	6	32	54	123	597.1	Medium-High
Q602-Q6115	6	VCP	219	1947	Q631	24	10	5	39	20	18	6	40	84	123	597.1	Medium-High
M721-M723	6	VCP	169	1921	N609	40	50	5	95	10	6	3	8	27	122	592.2	Medium-High
M750-M749	6	VCP	211	1921	N609	40	50	5	95	10	6	3	8	27	122	592.2	Medium-High
M785-M746	6	VCP	203	0	N609	40	50	5	95	10	6	3	8	27	122	592.2	Medium-High
N7126-N7108	6	0	31	0	R822	40	50	5	95	10	6	3	8	27	122	592.2	Medium-High
N7127-N7114	6	0	49	0	R822	40	50	5	95	10	6	3	8	27	122	592.2	Medium-High
N717-N716	6	VCP	399	1921	Q672	40	50	5	95	10	6	3	8	27	122	592.2	Medium-High
N767-O723	6	VCP	396	1961	Q679	40	50	5	95	10	6	3	8	27	122	592.2	Medium-High
N780-N781	6	VCP	453	1961	Q679	40	50	5	95	10	6	3	8	27	122	592.2	Medium-High
N831A-O839	6	VCP	201	0	R822	40	50	5	95	10	6	3	8	27	122	592.2	Medium-High
N831-N831A	6	VCP	105	0	R822	40	50	5	95	10	6	3	8	27	122	592.2	Medium-High
N903A-O901	6	VCP	146	0	R822	40	50	5	95	10	6	3	8	27	122	592.2	Medium-High
N903-N903A	6	VCP	115	0	R822	40	50	5	95	10	6	3	8	27	122	592.2	Medium-High
O617-O619	8	PVC	92	1983	Q631	24	30	5	59	30	6	3	24	63	122	592.2	Medium-High
O769-O768	6	VCP	121	1921	Q679	40	50	5	95	10	6	3	8	27	122	592.2	Medium-High
O928-O929	6	VCP	123	1967	R809	40	50	5	95	10	6	3	8	27	122	592.2	Medium-High
P637-P638	6	VCP	449	1921	R621	40	40	5	85	20	6	3	8	37	122	592.2	Medium-High
P672-Q6101	6	VCP	591	1942	WWTP	40	40	5	85	20	6	3	8	37	122	592.2	Medium-High
P703-P706	6	VCP	378	1942	WWTP	40	50	5	95	10	6	3	8	27	122	592.2	Medium-High
P734A-P735	6	VCP	234	0	WWTP	40	50	5	95	10	6	3	8	27	122	592.2	Medium-High
P734-P734A	6	VCP	226	0	WWTP	40	50	5	95	10	6	3	8	27	122	592.2	Medium-High
Q1117A-Q1118	6	VCP	193	0	R809	40	50	5	95	10	6	3	8	27	122	592.2	Medium-High
Q506B-BAY&SCENIC	6	VCP	11	0	Q631	40	50	5	95	10	6	3	8	27	122	592.2	Medium-High
Q506-Q506A	6	VCP	195	0	Q631	40	50	5	95	10	6	3	8	27	122	592.2	Medium-High
Q518-Q506A	6	VCP	388	0	Q631	40	50	5	95	10	6	3	8	27	122	592.2	Medium-High
Q640-Q638	12	VCP	259	1949	R621	40	50	5	95	10	6	3	8	27	122	592.2	Medium-High
Q710-Q783	6	VCP	299	1950	WWTP	16	50	5	71	10	6	3	32	51	122	592.2	Medium-High
Q713A-Q714	6	VCP	133	0	WWTP	40	50	5	95	10	6	3	8	27	122	592.2	Medium-High
Q713-Q713A	6	VCP	125	0	WWTP	40	50	5	95	10	6	3	8	27	122	592.2	Medium-High
Q729-Q730	6	VCP	338	1950	WWTP	24	40	5	69	20	6	3	24	53	122	592.2	Medium-High
Q802A-Q803	6	UNK	139	0	R822	40	50	5	95	10	6	3	8	27	122	592.2	Medium-High
Q802-Q802A	6	UNK	180	0	R822	40	50	5	95	10	6	3	8	27	122	592.2	Medium-High
R733-R735	6	VCP	327	1950	WWTP	40	50	5	95	10	6	3	8	27	122	592.2	Medium-High
R745-R707	6	VCP	444	1950	WWTP	40	10	20	70	20	12	12	8	52	122	592.2	Medium-High
T1128A-T1201	8	PVC	230	0	R809	40	50	5	95	10	6	3	8	27	122	592.2	Medium-High
T1202-T1128A	8	PVC	271	0	R809	40	50	5	95	10	6	3	8	27	122	592.2	Medium-High
T609-T608	6	VCP	276	1962	WWTP	40	50	5	95	10	6	3	8	27	122	592.2	Medium-High
M740-M765	6	VCP	371	1921	N609	40	10	20	70	10	6	3	32	51	121	587.4	Medium-High
O6120-O6121	8	PVC	91	1986	Q679	8	10	20	38	30	6	15	32	83	121	587.4	Medium-High
O715-O713	6	VCP	124	1921	Q679	24	40	20	84	20	6	3	8	37	121	587.4	Medium-High
O725-O728	6	VCP	285	1921	Q679	40	20	5	65	20	6	6	24	56	121	587.4	Medium-High
Q688-Q694	6	VCP	221	1950	WWTP	40	40	5	85	10	6	12	8	36	121	587.4	Medium-High
Q691-Q692	6	VCP	222	1950	WWTP	40	40	5	85	10	6	12	8	36	121	587.4	Medium-High
R505-R504	6	VCP	205	1947	Q631	8	10	20	38	10	30	3	40	83	121	587.4	Medium-High
R762-R763	27	AC	254	1950	R709	8	10	5	23	50	12	12	24	98	121	587.4	Medium-High
P707-P708	6	VCP	126	1921	Q679	24	40	5	69	10	6	3	32	51	120	582.5	Medium-High
P812-Q801	6	VCP	227	1957	R822	16	10	15	41	30	6	3	40	79	120	582.5	Medium-High
Q749-R730	8	VCP	436	1950	WWTP	40	10	5	55	20	6	15	24	65	120	582.5	Medium-High
Q772-Q773	6	VCP/PVC	221	1957	R822	40	10	5	55	10	6	9	40	65	120	582.5	Medium-High
Q801-Q804	8	VCP	440	1957	R822	16	10	15	41	30	6	3	40	79	120	582.5	Medium-High
R1108-R1109	6	VCP	169	1966	R809	32	50	5	87	10	6	9	8	33	120	582.5	Medium-High
R730-R731	6	VCP	441	1950	WWTP	40	10	5	55	20	6	15	24	65	120	582.5	Medium-High
R764-R765	27	AC	301	1950	R709	8	10	20	38	50	12	12	8	82	120	582.5	Medium-High
R765-R766	27	AC	351	1950	R709	8	10	20	38	50	12	12	8	82	120	582.5	Medium-High
R832-R746	15	VCP	238	1955	R709	24	10	5	39	40	6	3	32	81	120	582.5	Medium-High
R847-R854	8	VCP	38	1971	R709	8	50	5	63	10	12	3	32	57	120	582.5	Medium-High
N714-N647	6	VCP	295	1921	Q672	24	10	5	39	30	6	12	32	80	119	577.7	Medium-High
P650-P651	8	PVC	452	1995	Q679	8	20	10	38	40	6	3	32	81	119	577.7	Medium-High
R620-R621	12	VCP	149	1949	R621	32	20	10	62	40	6	3	8	57	119	577.7	Medium-High
R804-R805	10	VCP	379	1973	R809	8	30	20	58	20	6	3	32	61	119	577.7	Medium-High
M773-M772	6	VCP	183	1921	N609	40	40	5	85	10	6	9	8	33	118	572.8	Medium-High
M793-M791	6	VCP	154	1921	N609	40	40	5	85	10	6	9	8	33	118	572.8	Medium-High
P719-P720	6	VCP	221	1921	Q679	32	30	5	67	10	6	3	32	51	118	572.8	Medium-High
P738-P739	6	UNK	289	1942	WWTP	40	10	5	55	10	6	15	32	63	118	572.8	Medium-High
Q516-Q503	6	VCP	270	1947	Q631	32	30	5	67	10	6	3	32	51	118	572.8	Medium-High
Q683-R626	6	VCP	131	1949	R663	40	40	5	85	10	6	9	8	33	118	572.8	Medium-High
Q723-Q728	6	VCP	348	1950	WWTP	24	30	5	59	10	6	3	40	59	118	572.8	Medium-High
R755-R756	6	VCP	345	1966	WWTP	40	40	5	85	10	12	3	8	33	118	572.8	Medium-High
S703-S702	6	VCP	263	1951	WWTP	40	40	5	85	10	12	3	8	33	118	572.8	Medium-High
S806-S807	12	AT	110	1973	R709	8	10	5	23	40	12	3	40	95	118	572.8	Medium-High
T644-T645	6	VCP	166	1962	WWTP	40	40	5	85	10	6	9	8	33	118	572.8	Medium-High
M710-M711	6	VCP	488	1921	N609	40	30	20	90	10	6	3	8	27	117	568.0	Medium-High
N607-N608	6	VCP	177	1921	N609	40	30	10	80	20	6	3	8	37	117	568.0	Medium-High
P676-P635	6	VCP	188	1921	R621	8	50	5	63	10	6	6	32	54	117	568.0	Medium-High
Q610-Q611	12	VCP	241	1943	Q631	40	10	10	60	40	6	3	8	57	117	568.0	Medium-High
Q611-Q613	12	VCP	149	1943	Q631	40	10	10	60	40	6	3	8	57	117	568.0	Medium-High
Q807-R822	8	VCP	221	1957	R822	8	10	10	28	40	6	3	40	89	117	568.0	Medium-High
N634-N626	6	VCP	260	1921	Q631	40	20	5	65	10	6	3	32	51	116	563.1	Medium-High
N642-N643	6	VCP	408	1921	Q672	40	20	5	65	10	6	3	32	51	116	563.1	Medium-High
N646-N654	6	VCP	88	1921	Q672	8	10	10	28	30	6	12	40	88	116	563.1	Medium-High
O6123-O685	6	VCP	181	1921	Q649	24	30	5	59	10	6	9	32	57	116	563.1	Medium-High
P730-P729	6	VCP	104	1942	WWTP	40	20	5	65	10	6	3	32	51	116	563.1	Medium-High
P758-P739	6	VCP	382	1950	WWTP	32	20	5	57	10	6	3	40	59	116	563.1	Medium-High
Q650-Q643	10	VCP	253	1921	R621	24	30	5	59	40	6	3	8	57	116	563.1	Medium-High
R616-R653	6	UNK	10	1950	WWTP	24	30	5	59	10	12	3	32	57	116	563.1	Medium-High
R821-R822	6	VCP	128	1957	R822	8	10	20	38	20	6	12	40	78	116	563.1	Medium-High
O6142-O6102	6	VCP	68	1921	Q672	16	40	5	61	10	6	6	32	54	115	558.3	Medium-High

Appendix B. Detailed Risk Assessment Results

Pipe Number	Diameter, inches	Material	Length, linear feet	Installation Year	Basin	Likelihood of Failure Score				Consequence of Failure Score					Risk Score		Risk Level
						Structural Failure Rate	Maintenance Failure Rate	Hydraulic Capacity Failure Rate	Total Score	Potential Spill Volume	Environmental Impact	Emergency Response and Construction Impact	Public Exposure	Total Score	Total Risk	Normalized Risk	
P601-P602	6	VCP	418	1947	Q631	16	40	5	61	10	6	6	32	54	115	558.3	Medium-High
Q673-Q674	6	VCP	374	1945	R663	40	40	5	85	10	6	6	8	30	115	558.3	Medium-High
R638-R656	6	VCP	164	1950	WWTP	40	10	5	55	10	6	12	32	60	115	558.3	Medium-High
N662-N714	6	VCP/PVC	197	1921	Q672	40	10	5	55	10	6	3	40	59	114	553.4	Medium-High
N709-N710	6	VCP	448	1921	Q672	32	50	5	87	10	6	3	8	27	114	553.4	Medium-High
N732-O710	6	VCP	442	1921	Q679	32	50	5	87	10	6	3	8	27	114	553.4	Medium-High
O657-O658	6	VCP	111	1921	Q631	32	50	5	87	10	6	3	8	27	114	553.4	Medium-High
O710-O707	8	VCP	254	1921	Q679	32	40	5	77	20	6	3	8	37	114	553.4	Medium-High
O798-O785	6	VCP	281	1921	Q679	32	50	5	87	10	6	3	8	27	114	553.4	Medium-High
Q638-Q655	12	VCP	513	1949	R621	32	20	5	57	40	6	3	8	57	114	553.4	Medium-High
Q733-R705	6	VCP	465	1950	WWTP	32	50	5	87	10	6	3	8	27	114	553.4	Medium-High
Q744-Q745	6	VCP	34	1950	WWTP	32	20	5	57	10	6	9	32	57	114	553.4	Medium-High
P764-P763	6	VCP	285	1950	WWTP	40	10	20	70	10	6	3	24	43	113	548.5	Medium-High
Q687-Q686	6	VCP	287	1942	WWTP	32	40	5	77	10	6	12	8	36	113	548.5	Medium-High
Q692-Q693	6	VCP	392	1950	WWTP	32	40	5	77	10	6	12	8	36	113	548.5	Medium-High
M723-M716	6	VCP	308	1921	N609	40	40	5	85	10	6	3	8	27	112	543.7	Medium-High
M728-M729	6	VCP	360	1921	N609	40	40	5	85	10	6	3	8	27	112	543.7	Medium-High
N608-N609	6	VCP	344	1921	N609	40	30	5	75	20	6	3	8	37	112	543.7	Medium-High
N612-N614	6	VCP	274	1921	Q631	40	40	5	85	10	6	3	8	27	112	543.7	Medium-High
N621-N622	6	VCP	441	1921	Q631	40	40	5	85	10	6	3	8	27	112	543.7	Medium-High
N623-N624	6	VCP	324	1921	Q631	40	40	5	85	10	6	3	8	27	112	543.7	Medium-High
N715-N716	6	VCP	357	1921	Q672	40	40	5	85	10	6	3	8	27	112	543.7	Medium-High
N722-O706	6	VCP	219	1921	Q679	40	40	5	85	10	6	3	8	27	112	543.7	Medium-High
N735-N737	6	VCP	451	1921	Q679	40	40	5	85	10	6	3	8	27	112	543.7	Medium-High
N736-O712	6	VCP	321	1921	Q679	40	40	5	85	10	6	3	8	27	112	543.7	Medium-High
N757-N759	6	VCP	151	1940	Q679	40	40	5	85	10	6	3	8	27	112	543.7	Medium-High
N764-O718	6	VCP	453	1921	Q679	40	40	5	85	10	6	3	8	27	112	543.7	Medium-High
N783-N735	6	VCP	181	1921	Q679	40	40	5	85	10	6	3	8	27	112	543.7	Medium-High
N803-N804	8	VCP	242	1966	R822	40	40	5	85	10	6	3	8	27	112	543.7	Medium-High
O606-O603	6	VCP	235	1947	Q631	40	40	5	85	10	6	3	8	27	112	543.7	Medium-High
O6117-O6118	6	VCP	366	1921	Q679	40	40	5	85	10	6	3	8	27	112	543.7	Medium-High
O6122-P666	6	VCP	424	1921	Q679	40	40	5	85	10	6	3	8	27	112	543.7	Medium-High
O660-O661	6	VCP	99	1921	Q631	40	40	5	85	10	6	3	8	27	112	543.7	Medium-High
O701-O702	6	VCP	224	1921	Q679	40	40	5	85	10	6	3	8	27	112	543.7	Medium-High
O714-O710	8	VCP	243	1921	Q679	40	30	5	75	20	6	3	8	37	112	543.7	Medium-High
O724-O725	8	VCP	643	1921	Q679	32	20	5	57	10	6	15	24	55	112	543.7	Medium-High
O739-O741	6	VCP	119	1921	Q679	40	40	5	85	10	6	3	8	27	112	543.7	Medium-High
O741-O743	6	VCP	200	1921	Q679	40	40	5	85	10	6	3	8	27	112	543.7	Medium-High
O760-O762	6	VCP	353	1921	Q679	40	40	5	85	10	6	3	8	27	112	543.7	Medium-High
O762-O763	6	VCP	224	1921	Q679	40	40	5	85	10	6	3	8	27	112	543.7	Medium-High
O766-O767	6	VCP	223	1921	Q679	40	40	5	85	10	6	3	8	27	112	543.7	Medium-High
O767-O768	6	VCP	227	1921	Q679	40	40	5	85	10	6	3	8	27	112	543.7	Medium-High
O774-O773	6	VCP	202	1921	Q679	40	40	5	85	10	6	3	8	27	112	543.7	Medium-High
O781-O783	6	VCP	399	1921	Q679	40	40	5	85	10	6	3	8	27	112	543.7	Medium-High
O786-O785	6	VCP	96	1921	Q679	40	40	5	85	10	6	3	8	27	112	543.7	Medium-High
O809-P813	6	VCP	345	1959	R822	16	40	5	61	10	6	3	32	51	112	543.7	Medium-High
P641-P642	6	PVC	450	1996	R663	16	40	5	61	10	6	3	32	51	112	543.7	Medium-High
P715-P716	6	VCP	215	1921	Q679	40	40	5	85	10	6	3	8	27	112	543.7	Medium-High
P717-P718	6	VCP	221	1921	Q679	40	40	5	85	10	6	3	8	27	112	543.7	Medium-High
P747-P785	6	VCP	313	1942	WWTP	24	40	5	69	10	6	3	24	43	112	543.7	Medium-High
P752-P750	6	VCP	289	1942	WWTP	40	40	5	85	10	6	3	8	27	112	543.7	Medium-High
P760-P761	6	VCP	446	1950	WWTP	40	40	5	85	10	6	3	8	27	112	543.7	Medium-High
P805-P808	8	VCP	276	1957	R822	8	10	15	33	30	6	3	40	79	112	543.7	Medium-High
P814-P815	6	VCP	235	1959	R822	24	40	5	69	10	6	3	24	43	112	543.7	Medium-High
P815-P816	6	VCP	219	1959	R822	24	40	5	69	10	6	3	24	43	112	543.7	Medium-High
P824-P826	6	VCP	229	1959	R822	40	40	5	85	10	6	3	8	27	112	543.7	Medium-High
Q517-Q604	6	VCP	431	1947	Q631	40	40	5	85	10	6	3	8	27	112	543.7	Medium-High
Q716-Q715	6	VCP	296	1950	WWTP	40	40	5	85	10	6	3	8	27	112	543.7	Medium-High
Q720-Q721	6	VCP	262	1950	WWTP	40	40	5	85	10	6	3	8	27	112	543.7	Medium-High
Q735-Q736	6	VCP	283	1950	WWTP	16	40	5	61	10	6	3	32	51	112	543.7	Medium-High
Q766-Q765	6	VCP/PVC	216	1957	R822	40	40	5	85	10	6	3	8	27	112	543.7	Medium-High
Q773-Q810	6	VCP/PVC	287	1957	R822	40	10	5	55	10	6	9	32	57	112	543.7	Medium-High
Q782-Q718	6	VCP	294	1950	WWTP	40	40	5	85	10	6	3	8	27	112	543.7	Medium-High
Q870-Q808	6	VCP/PVC	273	1957	R822	24	40	5	69	10	6	3	24	43	112	543.7	Medium-High
R615-R616	8	VCP	258	1950	WWTP	40	10	5	55	10	12	3	32	57	112	543.7	Medium-High
S612-S623	6	VCP	165	1962	WWTP	24	40	5	69	10	6	3	24	43	112	543.7	Medium-High
S708-S706	8	VCP	261	1971	R709	24	50	5	79	10	12	3	8	33	112	543.7	Medium-High
N660-N661	6	VCP	162	1921	Q672	8	10	5	23	30	6	12	40	88	111	538.8	Medium-High
N7102-N7103	6	VCP	80	1966	R822	32	10	20	62	20	6	15	8	49	111	538.8	Medium-High
N7107-N827	8	VCP	285	1966	R822	32	10	20	62	20	6	15	8	49	111	538.8	Medium-High
O603-O604	6	VCP	175	1947	Q631	24	40	20	84	10	6	3	8	27	111	538.8	Medium-High
O605-O604	6	VCP	214	1947	Q631	8	40	20	68	10	6	3	24	43	111	538.8	Medium-High
O6126-O606	6	UNK	59	1947	Q631	24	40	20	84	10	6	3	8	27	111	538.8	Medium-High
O743-O744	6	VCP	230	1921	Q679	24	40	20	84	10	6	3	8	27	111	538.8	Medium-High
Q627-Q608	10	VCP	257	1943	Q631	24	40	20	84	10	6	3	8	27	111	538.8	Medium-High
R1001-R1002	8	VCP	289	1966	R809	40	20	5	65	20	6	12	8	46	111	538.8	Medium-High
R744-R745	6	VCP	396	1950	WWTP	24	10	25	59	20	12	12	8	52	111	538.8	Medium-High
P708-P710	6	VCP	241	1921	Q679	24	30	5	59	10	6	3	32	51	110	534.0	Medium-High
P810-P812	8	VCP	279	1957	R822	16	10	5	31	30	6	3	40	79	110	534.0	Medium-High
Q1124-R1152	6	VCP	141	1966	R809	32	40	5	77	10	6	9	8	33	110	534.0	Medium-High
Q721-Q723	6	VCP	303	1950	WWTP	24	30	5	59	10	6	3	32	51	110	534.0	Medium-High
Q727-Q728	6	VCP	270	1950	WWTP	24	30	5	59	10	6	3	32	51	110	534.0	Medium-High
Q745-Q746	6	VCP	488	1950	WWTP	24	30	5	59	10	6	3	32	51	110	534.0	Medium-High
R523-R524	6	VCP	238	1949	WWTP	24	30	5	59	10	6	3	32	51	110	534.0	Medium-High
R538-R603	6	VCP	161	1950	WWTP	32	40	5	77	10	6	9	8	33	110	534.0	Medium-High
R609-R612	8	VCP	259	1950	WWTP	32	30	5	67	20	12	3	8	43	110	534.0	Medium-High
R780-R781	6	VCP	401	1951	WWTP	32	40	5	77	10	12	3	8	33	110	534.0	Medium-High
R751-R752	8	VCP	193	1968	R709	32	30	5	67	10	12	12	8	42	109	529.1	Medium-High
O723-O724	6	VCP	672	1921	Q679	24	40	5	69	10	6	15	8	39	108	524.3	Medium-High
O792-O793	6	VCP	250	1942	WWTP	40	30	5	75	10	6	9	8	33	108	524.3	Medium-High
Q774-Q734	6	UNK	180	1950	WWTP	24	30	5	59	10	6	9	24	49	108	524.3	Medium-High
R1127-R1128	6	VCP	174	1966	R809	24	40	5	69	10	6	15	8	39	108	524.3	Medium-High
R754-R762	27	AC	611	1950	R709	8	10	5	23	50	12	15	8	85	108	524.3	Medium-High
S812-S809	6	VCP	217	1976	R709	24	40	5	69	10	12	9	8	39	108	524.3	Medium-High
N826-O801	8	VCP	380	1966	R822	8	30	20	58	20	6	15	8	49	107	519.4	Medium-High
N706-N710	6	VCP	123	1921	Q672	24	30	5	59	30	6	3	8	47	106	514.6	Medium-High
O6115-O6116	8	PVC	233	1986	Q679	8	10	5	23	30	6	15	32	83	106	514.6	Medium-High
O6116-O6119	8	PVC	218	1986	Q679	8	10	5	23	30	6	15	32	83	106	514.6	Medium-High
O6119-O6120	8	PVC	182	1986	Q679	8	10	5	23	30	6	15	32	83	106	514.6	Medium-High
O6121-P656	8	PVC	394	1986	Q679	8	10	5	23	30	6	15	32	83	106	514.6	Medium-High
P656-P683	8	PVC	29	1986	Q679	8	10	5	23	30	6	15	32	83	106	514.6	Medium-High
P728-P729	6	VCP	77	1942	WWTP	40	10	5	55	10	6	3	32	51	106	514.6	Medium-High
P731-P732	6	VCP	216	1942	WWTP	40	10	5	55	10	6	3	32	51	106	514.6	Medium-High
P751-P752	6	VCP	246	1942	WWTP	32	30	5	67	10	6	15	8	39	106	514.6	Medium-High
P774-P781	6	VCP	342	1957	R822	24	50	5	79	10	6	3	8	27	106	514.6	Medium-High
Q809-Q810	6	VCP/PVC	216	1957	R822	40	10	5	55	10	6	3	32	51	106	514.6	Medium-High
R619-R614	6	VCP	368	1950	WWTP	40	10	5	55	10	6	3	32	51	106	514.6	Medium-High
T610-T609	6	VCP	323	1962	WWTP	24	50	5	79	10	6	3	8	27	106	514.6	Medium-High
M725-M726	6	VCP/PVC	163	2004	N609	32	40	5	77	10	6	3	8	27	104	504.9	Medium-High
M737-M775	6	VCP	211	1921	N609	40	20	5	65	10	6	15	8	39	104	504.9	Medium-High
M742-M785	6	VCP	232	0	N609	32	40	5	77	10	6	3	8	27	104	504.9	Medium-High
N606-N607	6	VCP	374	1921	N609	40	10	5	55	20	6	15	8	49	104	504.9	Medium-High
N7100-N7101	6	VCP	110	1966	R822	40	10	5	55	20	6	15	8	49	104	504.9	Medium-High
N762-N764	6	VCP	451	1921	Q679	32	40	5	77	10	6	3	8	27	104	504.9	Medium-High
N763-N764	6	VCP	181	1921	Q679	32	40	5	77	10	6	3	8	27	104	504.9	Medium-High
O601-O6126	6	VCP	132	1947	Q631	32	40	5	77	10	6	3	8	27	104	504.9	Medium-High
O656-O657	6	VCP	255	1921	Q631	32	40	5	77	10	6	3	8	27	104	504.9	Medium-High
O722-O726	6	VCP	342	1921	Q679	32	40	5	77	10	6	3	8	27	104	504.9	Medium-High
O729-O730	6	VCP	157	1921	Q679	32	40	5	77	10	6	3	8	27	104	504.9	Medium-High
O732-O731	6	VCP	208	1921	Q679	32	40	5	77	10	6	3	8	27	104	504.9	Medium-High
O744-O784	6	VCP	189	1921	Q679	24	30	10	64	20	6	6	8	40	104	504.9	Medium-High
O754-O756	6	VCP	364	1921	Q679	32	40	5	77	10	6	3	8	27	104	504.9	Medium-High
O758-O757	6	VCP	174	1921	Q679	32	40	5	77	10	6	3	8	27	104	504.9	Medium-High
O780-O782	6	VCP	396	1921	Q679	32	40	5	77	10	6	3	8	27	104	504.9	Medium-High
P619-P620	6	VCP	450	1921	R621	32	40	5	77	10	6	3	8	27	104	504.9	Medium-High
Q6110-Q703	6	VCP	216	1942	WWTP	40	10	5	55	20	18	3	8	49	104	504.9	Medium-High
Q901-Q911	8	VCP	40	1967	R809	32	40	5	77	10	6	3	8	27	104	504.9	Medium-High
R527-R526	12	VCP	303	1949	WWTP	32	40	5	77	10	6	3	8	27	104	504.9	Medium-High
R539-R527	6	VCP	160	1949	WWTP	32	40	5	77	10	6	3	8	27	104	504.9	Medium-High
R808-R809	12	AT	474	1973	R809	8	10	5	23	40	6	3	32	81	104	504.9	Medium-High
R831-R832	15	VCP	151	1966	R709	8	10	5	23	40	6	3	32	81	104	504.9	Medium-High
S1101-S1103	6	VCP	234	1966	R809	24	30	5	59	10	18	9	8	45	104	504.9	Medium-High
S604-S603	6	VCP	126	1962	WWTP	40	20	5	65	10	6	15	8	39	104	504.9	Medium-High
T613-T612	6	VCP	213	1962	WWTP	32	40	5	77	10	6	3	8	27	104	504.9	Medium-High
T614-T612	6	VCP	231	1962	WWTP	32	40	5	77	10	6	3	8	27	104	504.9	Medium-High
T645-T646	6	VCP	344	1962	WWTP	32	40	5	77	10	6	3	8	27	104	504.9	Medium-High
T647-S649	6	VCP	129	1962	WWTP	32	40	5	77	10	6	3	8	27	104	504.9	Medium-High
N655-N659	6	PVC	247	1997	Q672	8	10	5	23	30	6	12	32	80	103	500.0	Medium-High
O6114-O6115	8	PVC	274	2005	Q679	8	10	5	23	30	6	12	32	80	103	500.0	Medium-High
M602-M781	6	VCP	273	1921	N609	40	30	5	75	10	6	3	8	27	102	495.1	Medium-High
M700-M602	6	VCP	148	1921	N609	40	30	5	75	10	6	3	8	27	102	495.1	Medium-High
M701-M700	6	VCP	138	1921	N609	40	30	5	75	10	6	3	8	27	102	495.1	Medium-High
M765-M742	6	VCP	54	1921	N609	40	30	5	75	10	6	3	8	27	102	495.1	Medium-High
M777-M784	8	VCP	102	1921	N609	8	50	5	63	10	6	15	8	39	102	495.1	Medium-High
M778-M776	6	VCP	239	1921	Q672	40	30	5	75	10	6	3	8	27	102	495.1	Medium-High
M809-M810	6	VCP	36	1991	R822	8	50	5	63	10	6	15	8	39	102	495.1	Medium-High
N622-N623	6	VCP	450	1921	Q631	40	30	5	75	10	6	3	8	27	102	495.1	Medium-High
N629-N630	6	VCP	228	1921	Q631	40	30	5	75	10	6	3	8	27	102	495.1	Medium-High
N638-N637	6	VCP	249	1921	N609	40	30	5	75	10	6	3	8	27	102	495.1	Medium-High
N725-N726	6	VCP	297	1921	Q679	40	30	5	75	10	6	3	8	27	102	495.1	Medium-High
N730-N731	6	VCP	295	1921	Q679	40	30	5	75	10	6	3	8	27	102	495.1	Medium-High
N760-N761	6	VCP	446	1921	Q679	40	30	5	75	10	6	3	8	27	102	495.1	Medium-High
N769-N771	6	VCP	177	1961	Q679	40	30	5	75	10	6	3	8	27	102	495.1	Medium-High
O610-O614	8	PVC	188	1983	Q631	8	10	5	23	30	6	3	40	79	102	495.1	Medium-High
O6125-O6126	6	UNK	121	1947	Q631	40	30	5	75	10	6	3	8	27	102	495.1	Medium-High
O654-O657	8	CIP	159	1921	Q631	40	30	5	75	10	6	3	8	27	102	495.1	Medium-High
O672-P617	6	VCP	473	1921	R621	40	30	5	75	10	6	3	8	27	102	495.1	Medium-High
O711-O710	6	VCP	196	1921	Q679	40	30	5	75	10	6	3	8	27	102	495.1	Medium-High
O730-O731	6	VCP	453	1921	Q679	40	30	5	75	10	6	3	8	27	102	495.1	Medium-High
O765-O766	6	VCP	206	1921	Q679	40	30	5	75	10	6	3	8	27	102	495.1	Medium-High
O768-O770	6	VCP	257	1921	Q679	40	30	5	75	10	6	3	8	27	102	495.1	Medium-High
O787-O779	6	VCP	253	1921	Q679	40	30	5	75	10	6	3	8	27	102	495.1	Medium-High
O790-P707	6	VCP	276	1921	Q679	24	30	5	59	10	6	3	24	43	102	495.1	Medium-High
O806-O807	8	VCP	273	1957	R822	8	10	5	23	30	6	3	40	79	102	495.1	Medium-High
O807-O808	8	VCP	265	1957	R822	8	10	5	23	30	6	3	40	79	102	495.1	Medium-High
O808-P801	8	VCP	399	1957	R822	8	10	5	23	30	6	3	40	79	102	495.1	Medium-High

Appendix B. Detailed Risk Assessment Results

Pipe Number	Diameter, inches	Material	Length, linear feet	Installation Year	Basin	Likelihood of Failure Score				Consequence of Failure Score					Risk Score		Risk Level
						Structural Failure Rate	Maintenance Failure Rate	Hydraulic Capacity Failure Rate	Total Score	Potential Spill Volume	Environmental Impact	Emergency Response and Construction Impact	Public Exposure	Total Score	Total Risk	Normalized Risk	
P621-P622	6	VCP	291	1921	R621	40	30	5	75	10	6	3	8	27	102	495.1	Medium-High
P701-P702	6	VCP	431	1921	Q679	40	30	5	75	10	6	3	8	27	102	495.1	Medium-High
P802-P803	8	VCP	284	1957	R822	8	10	5	23	30	6	3	40	79	102	495.1	Medium-High
P911-Q901	8	VCP	338	1967	R809	40	30	5	75	10	6	3	8	27	102	495.1	Medium-High
Q6151-Q657	6	0	107	1921	Q649	40	30	5	75	10	6	3	8	27	102	495.1	Medium-High
R525-R531	6	VCP	185	1950	WWTP	24	30	5	59	10	6	3	24	43	102	495.1	Medium-High
R528-R529	6	VCP	150	1950	WWTP	40	30	5	75	10	6	3	8	27	102	495.1	Medium-High
R611-R612	6	VCP	210	1950	WWTP	32	20	5	57	10	24	3	8	45	102	495.1	Medium-High
R660-R659	6	VCP	159	1949	WWTP	40	30	5	75	10	6	3	8	27	102	495.1	Medium-High
R724-R788	6	VCP	308	1950	WWTP	24	30	5	59	10	6	3	24	43	102	495.1	Medium-High
R778-R783	10	VCP	250	1951	WWTP	24	30	5	59	20	12	3	8	43	102	495.1	Medium-High
T611-T610	6	VCP	217	1962	WWTP	8	50	5	63	10	6	15	8	39	102	495.1	Medium-High
T618-T617	6	VCP	53	1962	WWTP	40	30	5	75	10	6	3	8	27	102	495.1	Medium-High
T621-T619	6	VCP	241	1962	WWTP	24	30	5	59	10	6	3	24	43	102	495.1	Medium-High
Y401-Y402	6	HDPE	39	2006	WWTP	8	50	5	63	10	6	15	8	39	102	495.1	Medium-High
Y402-HIGHLANDS	6	HDPE	22	2006	WWTP	8	50	5	63	10	6	15	8	39	102	495.1	Medium-High
N795-N796	8	CIP	80	1966	R822	32	10	20	62	10	6	15	8	39	101	490.3	Medium-High
R1124-R1126	6	VCP	168	1966	R809	32	10	20	62	10	6	15	8	39	101	490.3	Medium-High
R1125-R1124	6	VCP	152	1966	R809	32	10	20	62	10	6	15	8	39	101	490.3	Medium-High
N614-N663	6	VCP	286	1921	Q631	32	20	5	57	10	6	3	24	43	100	485.4	Medium-High
O651-O653	6	VCP	97	1921	Q631	32	20	5	57	10	6	3	24	43	100	485.4	Medium-High
O737-O738	6	VCP	230	1921	Q679	40	10	10	60	20	6	6	8	40	100	485.4	Medium-High
R661-R659	6	VCP	107	1949	WWTP	32	20	5	57	10	6	3	24	43	100	485.4	Medium-High
M769-M725	4	VCP	140	0	N609	40	10	5	55	10	6	3	24	43	98	475.7	Medium-High
M779-M736	6	VCP	288	1921	N609	40	10	5	55	10	6	3	24	43	98	475.7	Medium-High
N652-N653	6	VCP	72	1921	Q672	40	10	5	55	10	6	3	24	43	98	475.7	Medium-High
N750-N751	6	VCP	290	1940	Q679	24	30	5	59	10	6	15	8	39	98	475.7	Medium-High
N751-N748	6	VCP	200	1940	Q679	24	30	5	59	10	6	15	8	39	98	475.7	Medium-High
N778-N779	6	VCP	255	1961	Q679	24	30	5	59	10	6	15	8	39	98	475.7	Medium-High
N789-N791	6	VCP	285	1966	R822	24	30	5	59	10	6	15	8	39	98	475.7	Medium-High
O952-O953	6	VCP	117	1966	R809	24	30	5	59	10	6	15	8	39	98	475.7	Medium-High
P786-P787	6	VCP	114	1942	WWTP	24	30	5	59	10	6	15	8	39	98	475.7	Medium-High
Q722-Q721	6	VCP	175	1950	WWTP	40	10	5	55	10	6	3	24	43	98	475.7	Medium-High
Q775-Q774	6	UNK	260	1950	WWTP	24	30	5	59	10	6	15	8	39	98	475.7	Medium-High
Q868-Q870	6	VCP/PVC	254	1957	R822	40	10	5	55	10	6	3	24	43	98	475.7	Medium-High
N777-N779	6	VCP	175	1961	Q679	32	20	5	57	10	6	15	8	39	96	466.0	Medium-High
P918-P917	6	UNK	68	1966	R809	32	20	5	57	10	6	15	8	39	96	466.0	Medium-High
M767-M780	6	VCP	80	1921	N609	40	10	5	55	10	6	15	8	39	94	456.3	Medium-High
Q762-Q763	6	UNK	93	1957	R822	40	10	5	55	10	6	15	8	39	94	456.3	Medium-High
O6141-O681	8	PVC	191	1991	Q649	8	40	5	53	30	6	9	32	77	130	631.1	Medium-High
S819-S804	6	VCP	219	1976	R709	8	40	5	53	10	12	15	40	77	130	631.1	Medium-High
P501-P502	6	VCP	336	1947	Q631	8	40	5	53	10	18	15	32	75	128	621.4	Medium-High
R501-Q506	6	VCP	450	1947	Q631	16	30	5	51	10	24	3	40	77	128	621.4	Medium-High
O688-O6141	8	PVC	65	1991	Q649	8	40	5	53	30	6	6	32	74	127	616.5	Medium-High
P645-P646	8	HDPE	448	2005	Q672	8	40	5	53	30	6	6	32	74	127	616.5	Medium-High
O608-O6143	10	VCP/PVC	301	1947	Q631	8	40	5	53	30	6	3	32	71	124	601.9	Medium-High
P743-P744	6	UNK	259	2013	WWTP	16	30	5	51	20	6	15	32	73	124	601.9	Medium-High
P651-P664	6	VCP	293	1942	WWTP	8	40	5	53	20	6	12	32	70	123	597.1	Medium-High
O681-O677	8	PVC	251	1991	Q649	8	40	5	53	20	6	9	32	67	120	582.5	Medium-High
O698-O688	8	PVC	263	1991	Q649	8	40	5	53	20	6	9	32	67	120	582.5	Medium-High
O699-P644	8	HDPE	397	2005	Q672	8	30	5	43	30	6	9	32	77	120	582.5	Medium-High
P644-P645	8	HDPE	451	2005	Q672	8	30	5	43	30	6	9	32	77	120	582.5	Medium-High
R743-R744	6	VCP	258	1950	WWTP	24	10	10	44	20	12	12	32	76	120	582.5	Medium-High
S608-S618	6	STL	95	1962	WWTP	32	10	5	47	10	6	15	40	71	118	572.8	Medium-High
T648-T602	6	STL	48	1962	WWTP	32	10	5	47	10	6	15	40	71	118	572.8	Medium-High
P628-P630	8	PVC	447	1990	Q649	8	40	5	53	20	6	6	32	64	117	568.0	Medium-High
P659-P653	8	VCP	194	1921	Q679	8	30	5	43	30	6	6	32	74	117	568.0	Medium-High
P683-P648	8	PVC	251	1986	Q679	8	30	5	43	30	6	6	32	74	117	568.0	Medium-High
T602-T601	6	STL	184	1962	WWTP	16	10	20	46	10	6	15	40	71	117	568.0	Medium-High
Q702-Q703	6	VCP	184	1942	WWTP	16	30	5	51	20	18	3	24	65	116	563.1	Medium-High
N653-N646	6	VCP	88	1921	Q672	8	30	5	43	30	6	3	32	71	114	553.4	Medium-High
O668-P606	10	PVC	475	1996	Q631	8	30	5	43	30	6	3	32	71	114	553.4	Medium-High
R748-R750	12	CIP	122	1959	R709	24	10	5	39	40	12	15	8	75	114	553.4	Medium-High
O692-O693	6	VCP	216	1921	Q672	24	10	5	39	30	6	6	32	74	113	548.5	Medium-High
R1008-R1009	10	AT	415	1973	R809	8	20	20	48	30	24	3	8	65	113	548.5	Medium-High
M730-M731	6	VCP	169	1921	N609	8	40	5	53	10	6	3	40	59	112	543.7	Medium-High
P653-P649	8	VCP	77	1921	Q679	8	10	20	38	30	6	6	32	74	112	543.7	Medium-High
R503-R502	6	VCP	371	1947	Q631	8	30	5	43	10	24	3	32	69	112	543.7	Medium-High
R747-R748	15	VCP	349	1955	R709	24	20	5	49	40	12	3	8	63	112	543.7	Medium-High
R750-R754	10	VCP	132	1959	R709	8	30	5	43	40	12	9	8	69	112	543.7	Medium-High
N658-N659	6	VCP	66	1921	Q672	16	30	5	51	10	6	12	32	60	111	538.8	Medium-High
Q601-Q602	6	VCP	445	1947	Q631	24	10	5	39	20	6	6	40	72	111	538.8	Medium-High
R786-R710	10	VCP	124	1951	WWTP	8	10	20	38	20	18	3	32	73	111	538.8	Medium-High
P732-P736	6	VCP	452	1942	WWTP	24	10	5	39	10	6	15	40	71	110	534.0	Medium-High
P777-P772	6	PVC	204	2009	R822	24	10	5	39	10	6	15	40	71	110	534.0	Medium-High
Q6100-Q637	8	VCP	277	1945	R621	8	40	5	53	40	6	3	8	57	110	534.0	Medium-High
Q659-Q650	8	HDPE	249	2005	R621	8	40	5	53	40	6	3	8	57	110	534.0	Medium-High
Q679-Q681	8	VCP	424	1995	R663	8	40	5	53	40	6	3	8	57	110	534.0	Medium-High
S623-S610	6	VCP	180	1962	WWTP	24	10	5	39	10	18	3	40	71	110	534.0	Medium-High
N611-O609	8	PVC	211	1983	Q631	8	10	20	38	30	6	3	32	71	109	529.1	Medium-High
P681-P649	6	VCP	126	1921	Q679	24	10	20	54	10	6	6	32	54	108	524.3	Medium-High
Q675-Q676	8	VCP	159	1945	R663	16	20	15	51	40	6	3	8	57	108	524.3	Medium-High
Q728-Q777	6	CIP	70	1950	WWTP	32	10	5	47	20	6	3	32	61	108	524.3	Medium-High
S826-S825	6	PVC	131	1973	R709	8	40	5	53	10	12	9	24	55	108	524.3	Medium-High
O687-O688	6	VCP	220	2006	Q649	8	40	5	53	10	6	6	32	54	107	519.4	Medium-High
M734-M736	6	VCP/PVC	94	2004	N609	32	10	5	47	10	6	3	40	59	106	514.6	Medium-High
Q724-Q725	6	VCP	140	1950	WWTP	8	30	5	43	10	6	15	32	63	106	514.6	Medium-High
R535-R534	6	VCP	100	1950	WWTP	8	30	5	43	10	18	3	32	63	106	514.6	Medium-High
R850-R851	6	VCP	142	1966	R709	24	20	5	49	10	12	3	32	57	106	514.6	Medium-High
N649-N652	6	VCP	176	1921	Q672	24	40	5	69	10	6	12	8	36	105	509.7	Medium-High
P647-Q669	8	HDPE	448	2005	Q672	16	10	5	31	30	6	6	32	74	105	509.7	Medium-High
P663-P664	6	VCP	344	1942	WWTP	24	40	5	69	10	6	12	8	36	105	509.7	Medium-High
Q6103-Q692	6	VCP	182	1950	WWTP	24	40	5	69	10	6	12	8	36	105	509.7	Medium-High
Q6105-Q696	6	VCP	349	1950	WWTP	24	40	5	69	10	6	12	8	36	105	509.7	Medium-High
M770-M733	6	VCP	196	1921	N609	8	40	5	53	10	6	3	32	51	104	504.9	Medium-High
N615-N616	6	VCP	450	1921	Q631	8	40	5	53	10	6	3	32	51	104	504.9	Medium-High
N635-O6140	6	UNK	130	1921	Q631	24	10	5	39	10	6	9	40	65	104	504.9	Medium-High
N643-N644	6	VCP	245	1921	Q672	8	40	5	53	10	6	3	32	51	104	504.9	Medium-High
O501-P501	6	VCP	373	1947	Q631	8	40	5	53	10	6	3	32	51	104	504.9	Medium-High
O832-O833	6	VCP	22	1973	R822	32	30	5	67	20	6	3	8	37	104	504.9	Medium-High
P714-P702	8	VCP	469	1921	Q679	8	30	5	43	20	6	3	32	61	104	504.9	Medium-High
Q615-Q614	12	VCP	6	1943	Q631	32	10	5	47	40	6	3	8	57	104	504.9	Medium-High
Q686-Q684	6	VCP	77	1942	WWTP	8	40	20	68	10	6	12	8	36	104	504.9	Medium-High
Q743-Q744	6	VCP	117	1950	WWTP	32	10	5	47	10	6	9	32	57	104	504.9	Medium-High
R1142-R1152	6	VCP	141	1966	R809	16	50	5	71	10	6	9	8	33	104	504.9	Medium-High
R614-R615	6	VCP	250	1950	WWTP	8	40	5	53	10	6	3	32	51	104	504.9	Medium-High
R637-R656	6	VCP	118	1950	WWTP	32	10	5	47	10	6	9	32	57	104	504.9	Medium-High
R734-R735	6	VCP/PVC	432	2004	WWTP	8	40	5	53	10	6	3	32	51	104	504.9	Medium-High
R803-R804	10	VCP	406	1973	R809	16	30	5	51	20	6	3	24	53	104	504.9	Medium-High
S1026-S1027	6	VCP	273	1966	R809	8	40	5	53	10	24	9	8	51	104	504.9	Medium-High
S1107-S1023	6	VCP	251	1966	R809	8	40	5	53	10	24	9	8	51	104	504.9	Medium-High
S825-S807	8	PVC	109	1973	R709	24	10	5	39	10	12	3	40	65	104	504.9	Medium-High
P661-P663	6	VCP	440	1942	WWTP	32	30	5	67	10	6	12	8	36	103	500.0	Medium-High
P818-P819	6	VCP	94	1959	R822	40	10	20	70	10	6	9	8	33	103	500.0	Medium-High
M604-M605	6	VCP	115	1921	N609	24	40	5	69	10	6	9	8	33	102	495.1	Medium-High
N797-N798	6	VCP	104	1966	R822	8	40	5	53	20	6	15	8	49	102	495.1	Medium-High
O793-P728	6	VCP	172	1942	WWTP	16	30	5	51	10	6	3	32	51	102	495.1	Medium-High
O796-P765	6	VCP	520	1950	WWTP	24	10	5	39	10	6	15	32	63	102	495.1	Medium-High
P636-P637	6	VCP	451	1921	R621	40	20	5	65	20	6	3	8	37	102	495.1	Medium-High
P804-P805	6	VCP	157	1957	R822	8	30	5	43	10	6	3	40	59	102	495.1	Medium-High
P809-P810	6	VCP	313	1957	R822	8	30	5	43	10	6	3	40	59	102	495.1	Medium-High
Q718-Q723	6	VCP	315	1950	WWTP	16	30	5	51	10	6	3	32	51	102	495.1	Medium-High
Q734-Q777	6	CIP	311	1950	WWTP	8	30	5	43	10	6	3	40	59	102	495.1	Medium-High
Q736-Q737	6	VCP	355	1950	WWTP	16	30	5	51	10	6	3	32	51	102	495.1	Medium-High
R509-R502	6	VCP	183	1947	Q631	24	10	5	39	10	18	3	32	63	102	495.1	Medium-High
R532-R657	6	VCP	288	1950	WWTP	32	10	5	47	20	24	3	8	55	102	495.1	Medium-High
R781-R778	6	VCP	354	1951	WWTP	24	40	5	69	10	12	3	8	33	102	495.1	Medium-High
R785-R786	6	VCP	251	1951	WWTP	24	40	5	69	10	12	3	8	33	102	495.1	Medium-High
S1046-HACIENDA	8	CIP	248	1966	R809	8	40	5	53	20	18	3	8	49	102	495.1	Medium-High
T601-S622	6	STL	117	1962	WWTP	16	10	5	31	10	6	15	40	71	102	495.1	Medium-High
T608-T604	6	VCP	160	1962	WWTP	32	10	5	47	10	6	15	24	55	102	495.1	Medium-High
Q671-Q672	8	HDPE	556	2005	Q672	16	30	5	51	30	6	6	8	50	101	490.3	Medium-High
Q676-Q668	8	VCP	107	1945	R663	24	10	10	44	40	6	3	8	57	101	490.3	Medium-High
R809-R810	12	AT	455	1973	R709	8	10	20	38	40	12	3	8	63	101	490.3	Medium-High
O620-O621	8	PVC	162	1983	Q631	8	40	5	53	30	6	3	8	47	100	485.4	Medium-High
O698-O699	8	VCP	61	1921	Q672	8	10	5	23	30	6	9	32	77	100	485.4	Medium-High
P711-P712	6	VCP	225	1921	Q679	24	20	5	49	10	6	3	32	51	100	485.4	Medium-High
P745-Q701	6	VCP	244	1942	WWTP	24	10	5	39	20	6	3	32	61	100	485.4	Medium-High
P782-Q710	6	VCP	478	1950	WWTP	24	20	5	49	10	6	3	32	51	100	485.4	Medium-High
P820-P821	6	VCP	293	1959	R822	32	30	5	67	10	6	9	8	33	100	485.4	Medium-High
Q668-R627	10	VCP	373	1949	R663	8	30	5	43	40	6	3	8	57	100	485.4	Medium-High
Q677-Q678	8	PVC	345	1995	Q679	8	10	25	43	40	6	3	8	57	100	485.4	Medium-High
Q678-Q679	8	PVC	553	1995	Q679	8	30	5	43	40	6	3	8	57	100	485.4	Medium-High
R655-R635	6	VCP	51	1950	WWTP	32	30	5	67	10	6	9	8	33	100	485.4	Medium-High
R903-R904	10	AT	154	1973	R809	8	20	25	53	30	6	3	8	47	100	485.4	Medium-High
R904-R905	10	AT	142	1973	R809	8	20	25	53	30	6	3	8	47	100	485.4	Medium-High
S1021-S1022	6	VCP	90	1966	R809	32	30	5	67	10	12	3	8	33	100	485.4	Medium-High
S1024-S1025	6	VCP	70	1966	R809	8	30	5	43	10	24	15	8	57	100	485.4	Medium-High
S1106-S1107	6	VCP	75	1966	R809	8	30	5	43	10	24	15	8	57	100	485.4	Medium-High
Q674-Q675	6	VCP	332	1945	R663	24	40	5	69	10	6	6	8	30	99	480.6	Medium-High
Q694-Q696	6	VCP	136	1950	WWTP	8	50	5	63	10	6	12	8	36	99	480.6	Medium-High
R659-R624	6	UNK	62	1949	WWTP	32	20	20	72	10	6	3	8	27	99	480.6	Medium-High
P766-P767	6	VCP	381	1950	WWTP	8	30	5	43	10	6	15	24	55	98	475.7	Medium-High
P789-P740	6	VCP	22	1942	WWTP	8	10	5	23	20	6	9	40	75	98	475.7	Medium-High
R753-R754	24	AC	300	1950	R709	8	10	5	23	40	12	15	8	75	98	475.7	Medium-High
S1027-S1028	6	VCP	275	1966	R809	8	40	5	53	10	24	3	8	45	98	475.7	Medium-High
S712-S711	8	CIP	160	1971	R709	40	20	5	65	10	12	3	8	33	98	475.7	Medium-High
O666-P601	6	VCP	389	1947	Q631	32	30	5	67	10	6	6	8	30	97	470.9	Medium-High
O693-O694	6	VCP	166	1921	Q672	8	10	5	23	30	6	6	32	74	97	470.9	Medium-High
P646-P647	8	HDPE	452	2005	Q672	8	10	5	23	30	6	6	32	74	97	470.9	Medium-High
R625-R622	6	VCP	146	1949	WWTP	24	10	20	54	10	6	3	24	43	97	470.9	Medium-High
R851-S845	8	VCP	384	1971	R709	16	10	5	31	10	12	12	32	66	97	470.9	Medium-High
M612-M613	6	VCP	342	1921	N609	24	40	5	69	10	6	3	8	27	96	466.0	Medium-High
M613-N636	6	VCP	368	1921	N609	24	40	5	69	10	6	3	8	27	96	466.0	Medium-High
N720-N721	6	VCP	219	1921	Q679	24	40	5	69	10	6	3	8	27	96	466.0	Medium-High
N742-N744	6	VCP	389	1940	Q679	24	40	5	69	10	6	3	8	27	96	466.0	Medium-High

Appendix B. Detailed Risk Assessment Results

Pipe Number	Diameter, inches	Material	Length, linear feet	Installation Year	Basin	Likelihood of Failure Score				Consequence of Failure Score					Risk Score		Risk Level
						Structural Failure Rate	Maintenance Failure Rate	Hydraulic Capacity Failure Rate	Total Score	Potential Spill Volume	Environmental Impact	Emergency Response and Construction Impact	Public Exposure	Total Score	Total Risk	Normalized Risk	
N774-N775	6	VCP	181	1961	Q679	24	40	5	69	10	6	3	8	27	96	466.0	Medium-High
O624-N610	6	VCP	440	1921	Q631	24	40	5	69	10	6	3	8	27	96	466.0	Medium-High
O625-O624	6	VCP	117	1921	Q631	24	40	5	69	10	6	3	8	27	96	466.0	Medium-High
O640-O641	6	PVC	427	1986	Q631	8	40	5	53	10	6	3	24	43	96	466.0	Medium-High
O665-O628	8	VCP	248	1921	Q631	24	40	5	69	10	6	3	8	27	96	466.0	Medium-High
O669-O670	6	PVC	296	1993	Q631	24	40	5	69	10	6	3	8	27	96	466.0	Medium-High
O719-O718	6	VCP	137	1921	Q679	24	40	5	69	10	6	3	8	27	96	466.0	Medium-High
O721-O718	6	VCP	354	1921	Q679	24	40	5	69	10	6	3	8	27	96	466.0	Medium-High
O746-O748	6	VCP	91	1921	Q679	24	40	5	69	10	6	3	8	27	96	466.0	Medium-High
O747-O749	6	VCP	152	1921	Q679	24	40	5	69	10	6	3	8	27	96	466.0	Medium-High
O770-O773	6	VCP	174	1921	Q679	24	40	5	69	10	6	3	8	27	96	466.0	Medium-High
O772-O770	6	VCP	259	1921	Q679	24	40	5	69	10	6	3	8	27	96	466.0	Medium-High
O776-O777	6	VCP	258	1921	Q679	24	40	5	69	10	6	3	8	27	96	466.0	Medium-High
P618-P619	6	VCP	450	1921	R621	24	40	5	69	10	6	3	8	27	96	466.0	Medium-High
P620-Q632	6	VCP	449	1921	R621	24	40	5	69	10	6	3	8	27	96	466.0	Medium-High
P737-P736	6	VCP	93	1942	WWTP	8	20	5	33	10	6	15	32	63	96	466.0	Medium-High
P741-P788	6	VCP	232	1942	WWTP	8	40	5	53	10	6	3	24	43	96	466.0	Medium-High
P761-P762	6	VCP	496	1950	WWTP	24	40	5	69	10	6	3	8	27	96	466.0	Medium-High
P768-P770	6	VCP	448	1950	WWTP	24	40	5	69	10	6	3	8	27	96	466.0	Medium-High
P769-P768	6	VCP	181	1950	WWTP	24	40	5	69	10	6	3	8	27	96	466.0	Medium-High
Q1111-Q1114	6	VCP	116	1966	R809	8	50	5	63	10	6	9	8	33	96	466.0	Medium-High
Q6100-Q636	6	VCP	138	1949	R663	24	40	5	69	10	6	3	8	27	96	466.0	Medium-High
Q6120-R537	12	VCP	359	1949	WWTP	24	40	5	69	10	6	3	8	27	96	466.0	Medium-High
Q738-R717	6	VCP	311	1950	WWTP	24	40	5	69	10	6	3	8	27	96	466.0	Medium-High
Q808-Q809	6	VCP/PVC	350	1957	R822	8	40	5	53	10	6	3	24	43	96	466.0	Medium-High
Q817-Q819	6	VCP	260	1959	R822	24	40	5	69	10	6	3	8	27	96	466.0	Medium-High
R513-Q514	6	VCP	243	1947	Q631	24	40	5	69	10	6	3	8	27	96	466.0	Medium-High
R515-R520	6	VCP	325	1949	WWTP	24	40	5	69	10	6	3	8	27	96	466.0	Medium-High
R519-R522	6	VCP	499	1949	WWTP	24	40	5	69	10	6	3	8	27	96	466.0	Medium-High
R520-R521	6	VCP	229	1949	WWTP	24	40	5	69	10	6	3	8	27	96	466.0	Medium-High
R530-R531	6	VCP	507	1950	WWTP	24	40	5	69	10	6	3	8	27	96	466.0	Medium-High
R537-R527	12	VCP	362	1949	WWTP	24	40	5	69	10	6	3	8	27	96	466.0	Medium-High
R604-R609	8	VCP	268	1950	WWTP	8	40	5	53	20	12	3	8	43	96	466.0	Medium-High
R647-R607	6	VCP	183	1950	WWTP	24	40	5	69	10	6	3	8	27	96	466.0	Medium-High
R715-Q738	6	VCP	331	1950	WWTP	24	40	5	69	10	6	3	8	27	96	466.0	Medium-High
R722-R723	6	VCP	326	1950	WWTP	24	40	5	69	10	6	3	8	27	96	466.0	Medium-High
R725-R723	6	VCP	127	1950	WWTP	24	40	5	69	10	6	3	8	27	96	466.0	Medium-High
R774-R775	6	VCP	402	1951	WWTP	8	50	5	63	10	12	3	8	33	96	466.0	Medium-High
R813-S805	8	VCP	494	1973	R709	24	10	5	39	10	12	3	32	57	96	466.0	Medium-High
S649-S611	6	VCP	108	1962	WWTP	24	40	5	69	10	6	3	8	27	96	466.0	Medium-High
S706-R752	10	VCP	400	1971	R709	8	50	5	63	10	12	3	8	33	96	466.0	Medium-High
S707-S706	10	VCP	330	1971	R709	8	50	5	63	10	12	3	8	33	96	466.0	Medium-High
S711-S708	8	VCP	260	1971	R709	8	50	5	63	10	12	3	8	33	96	466.0	Medium-High
S805-S806	8	VCP	27	1973	R709	16	10	5	31	10	12	3	40	65	96	466.0	Medium-High
S815-S814	4	VCP	79	1976	R709	8	50	5	63	10	12	3	8	33	96	466.0	Medium-High
T620-T619	6	VCP	246	1962	WWTP	24	40	5	69	10	6	3	8	27	96	466.0	Medium-High
T643-S613	8	VCP	305	1962	WWTP	24	40	5	69	10	6	3	8	27	96	466.0	Medium-High
O7101-O708	6	0	128	0	Q679	8	40	20	68	10	6	3	8	27	95	461.2	Medium-High
P604-Q601	6	VCP	461	1947	Q631	8	10	5	23	20	6	6	40	72	95	461.2	Medium-High
P660-P659	6	VCP	142	1921	Q679	24	30	5	59	10	6	12	8	36	95	461.2	Medium-High
Q634-Q623	6	VCP	141	1921	Q631	8	40	20	68	10	6	3	8	27	95	461.2	Medium-High
Q641-Q642	6	VCP	332	1921	R621	8	40	20	68	10	6	3	8	27	95	461.2	Medium-High
R738-R739	6	VCP	328	1950	WWTP	8	40	10	58	20	6	3	8	37	95	461.2	Medium-High
R752-R753	24	AC	158	1950	R709	8	10	5	23	40	12	12	8	72	95	461.2	Medium-High
N628-N629	6	VCP	220	1921	Q631	32	30	5	67	10	6	3	8	27	94	456.3	Medium-High
N710-N712	6	VCP	139	1921	Q672	8	10	20	38	30	6	12	8	56	94	456.3	Medium-High
N724-N726	6	VCP	201	1921	Q679	32	30	5	67	10	6	3	8	27	94	456.3	Medium-High
N770-N7125	6	VCP	31	1961	Q679	32	30	5	67	10	6	3	8	27	94	456.3	Medium-High
O609-O6148	8	PVC	62	1983	Q631	8	10	5	23	30	6	3	32	71	94	456.3	Medium-High
O6112-O6113	8	VCP/PVC	242	2003	Q679	8	10	5	23	30	6	3	32	71	94	456.3	Medium-High
O6113-O6114	8	VCP/PVC	204	2004	Q679	8	10	5	23	30	6	3	32	71	94	456.3	Medium-High
O6128-O668	10	VCP	54	1947	Q631	8	10	5	23	30	6	3	32	71	94	456.3	Medium-High
O6143-O6128	10	VCP/PVC	239	1947	Q631	8	10	5	23	30	6	3	32	71	94	456.3	Medium-High
O6148-O610	8	PVC	29	1983	Q631	8	10	5	23	30	6	3	32	71	94	456.3	Medium-High
O614-O615	8	PVC	275	1983	Q631	8	10	5	23	30	6	3	32	71	94	456.3	Medium-High
O616-O617	8	PVC	106	1983	Q631	8	10	5	23	30	6	3	32	71	94	456.3	Medium-High
O661-O662	6	VCP	85	1921	Q631	32	30	5	67	10	6	3	8	27	94	456.3	Medium-High
O704-O6112	8	VCP	259	2008	Q679	8	10	5	23	30	6	3	32	71	94	456.3	Medium-High
O706-O707	6	VCP	220	1921	Q679	32	30	5	67	10	6	3	8	27	94	456.3	Medium-High
O791-P701	6	VCP/PVC	402	2003	Q679	32	30	5	67	10	6	3	8	27	94	456.3	Medium-High
P781-Q763	6	UNK	360	1957	R822	32	30	5	67	10	6	3	8	27	94	456.3	Medium-High
Q1135-Q1134	6	PVC	323	1996	R809	8	10	5	23	10	6	15	40	71	94	456.3	Medium-High
Q1136-Q1135	6	PVC	202	1996	R809	8	10	5	23	10	6	15	40	71	94	456.3	Medium-High
Q699-Q6100	6	VCP	138	1949	R663	32	30	5	67	10	6	3	8	27	94	456.3	Medium-High
Q819-Q820	6	VCP	458	1959	R822	16	30	5	51	10	6	3	24	43	94	456.3	Medium-High
Q820-Q821	6	VCP	295	1959	R822	16	30	5	51	10	6	3	24	43	94	456.3	Medium-High
R529-R605	6	VCP	170	1950	WWTP	32	30	5	67	10	6	3	8	27	94	456.3	Medium-High
R706-R707	12	VCP	169	1950	WWTP	8	10	10	28	40	6	12	8	66	94	456.3	Medium-High
S602-S601	6	VCP/PVC	85	2003	WWTP	8	10	5	23	10	18	3	40	71	94	456.3	Medium-High
S836-S837	6	VCP	277	1973	R709	16	40	5	61	10	12	3	8	33	94	456.3	Medium-High
T604-T603	6	VCP	90	1962	WWTP	24	10	5	39	10	6	15	24	55	94	456.3	Medium-High
N828-N829	6	VCP	113	1966	R822	24	10	20	54	10	6	15	8	39	93	451.5	Medium-High
O6108-O6109	8	PVC	198	1986	Q679	8	20	5	33	10	6	12	32	60	93	451.5	Medium-High
O6118-O6119	8	VCP/PVC	283	2004	Q679	8	10	5	23	20	6	12	32	70	93	451.5	Medium-High
M727-M728	6	VCP	309	1921	N609	40	20	5	65	10	6	3	8	27	92	446.6	Medium-High
M781-M704	6	VCP	248	1921	N609	40	20	5	65	10	6	3	8	27	92	446.6	Medium-High
M792-M791	6	VCP	120	1921	N609	24	30	5	59	10	6	9	8	33	92	446.6	Medium-High
N779-N780	6	VCP	226	1961	Q679	40	20	5	65	10	6	3	8	27	92	446.6	Medium-High
N786-N762	6	VCP	118	1921	Q679	40	20	5	65	10	6	3	8	27	92	446.6	Medium-High
O655-O657	6	VCP	295	1921	Q631	40	20	5	65	10	6	3	8	27	92	446.6	Medium-High
O778-O779	8	VCP	145	1921	Q679	40	10	5	55	20	6	3	8	37	92	446.6	Medium-High
O805-O806	8	VCP	108	1957	R822	8	10	5	23	20	6	3	40	69	92	446.6	Medium-High
O834-O835	6	VCP	343	1957	R822	8	10	5	23	20	6	3	40	69	92	446.6	Medium-High
O835-O836	6	VCP	249	1957	R822	8	10	5	23	20	6	3	40	69	92	446.6	Medium-High
O836-O837	6	VCP	181	1957	R822	8	10	5	23	20	6	3	40	69	92	446.6	Medium-High
O837-O806	6	VCP	139	1957	R822	8	10	5	23	20	6	3	40	69	92	446.6	Medium-High
O918-O919	6	VCP	66	1967	R809	8	40	5	53	10	6	15	8	39	92	446.6	Medium-High
O951-O952	6	VCP	40	1966	R809	8	40	5	53	10	6	15	8	39	92	446.6	Medium-High
O960-O911	6	UNK	196	1967	R809	8	40	5	53	10	6	15	8	39	92	446.6	Medium-High
P720-P721	6	VCP	19	1921	Q679	40	10	5	55	20	6	3	8	37	92	446.6	Medium-High
Q726-Q727	6	VCP	147	1950	WWTP	24	30	5	59	10	6	9	8	33	92	446.6	Medium-High
Q777-Q729	6	UNK	56	1950	WWTP	8	10	5	23	20	6	3	40	69	92	446.6	Medium-High
R506-R505	6	VCP	131	1947	Q631	8	10	5	23	10	24	3	32	69	92	446.6	Medium-High
R736-R732	8	VCP	129	1950	WWTP	24	30	5	59	10	6	9	8	33	92	446.6	Medium-High
R756-R761	6	VCP	426	1966	WWTP	24	30	5	59	10	12	3	8	33	92	446.6	Medium-High
S1044-S1045	6	VCP	107	1966	R809	24	30	5	59	10	12	3	8	33	92	446.6	Medium-High
S1102-S1108	6	VCP	140	1966	R809	24	30	5	59	10	12	3	8	33	92	446.6	Medium-High
S605-S603	6	VCP/PVC	190	2003	WWTP	8	40	5	53	10	6	15	8	39	92	446.6	Medium-High
T636-S637	6	VCP/PVC	294	2003	WWTP	8	40	5	53	10	18	3	8	39	92	446.6	Medium-High
N644-N645	6	VCP	64	1921	Q672	16	10	5	31	10	6	12	32	60	91	441.7	Medium-High
O6109-O6110	8	PVC	346	1986	Q679	16	10	5	31	10	6	12	32	60	91	441.7	Medium-High
R819-R821	8	VCP/PVC	443	1957	R822	8	10	5	23	10	6	12	40	68	91	441.7	Medium-High
M610-M611	6	VCP	274	1921	N609	8	40	5	53	20	6	3	8	37	90	436.9	Medium-High
M774-M765	6	VCP	86	1921	N609	32	20	5	57	10	6	9	8	33	90	436.9	Medium-High
N711-N712	6	VCP	152	1921	Q672	24	10	20	54	10	6	12	8	36	90	436.9	Medium-High
N716-N649	6	VCP	251	1921	Q672	8	50	5	63	10	6	3	8	27	90	436.9	Medium-High
O712-O714	6	VCP	125	1921	Q679	8	40	5	53	20	6	3	8	37	90	436.9	Medium-High
O716-O715	6	VCP	228	1921	Q679	8	40	5	53	20	6	3	8	37	90	436.9	Medium-High
O779-O6118	8	VCP/PVC	253	2004	Q679	8	40	5	53	20	6	3	8	37	90	436.9	Medium-High
O917-O919	6	VCP	90	1967	R809	16	30	5	51	10	6	15	8	39	90	436.9	Medium-High
P754-P755	6	VCP	503	1950	WWTP	8	50	5	63	10	6	3	8	27	90	436.9	Medium-High
Q1101-Q1103	6	VCP	165	1966	R809	32	20	5	57	10	6	9	8	33	90	436.9	Medium-High
Q834-P828	6	UNK	159	1983	R809	8	50	5	63	10	6	3	8	27	90	436.9	Medium-High
R1136-R1137	6	VCP	206	1966	R809	16	30	5	51	10	6	15	8	39	90	436.9	Medium-High
S606-CARMELMEADOWS_1	6	VCP/PVC	16	2003	WWTP	8	50	5	63	10	6	3	8	27	90	436.9	Medium-High
N702-N703	6	VCP/PVC	286	2004	Q672	8	40	5	53	10	6	12	8	36	89	432.0	Medium-High
N754-N755	6	VCP	275	1940	Q679	32	10	20	62	10	6	3	8	27	89	432.0	Medium-High
O734-O735	6	VCP	251	1921	Q679	24	30	5	59	10	6	6	8	30	89	432.0	Medium-High
O736-O737	6	VCP	154	1921	Q679	32	10	20	62	10	6	3	8	27	89	432.0	Medium-High
O738-O744	6	VCP	114	1921	Q679	32	10	10	52	20	6	3	8	37	89	432.0	Medium-High
P662-P664	6	VCP	393	1942	WWTP	8	40	5	53	10	6	12	8	36	89	432.0	Medium-High
Q693-Q694	6	VCP	249	1950	WWTP	8	40	5	53	10	6	12	8	36	89	432.0	Medium-High
Q826-R818	6	VCP	217	1959	R822	32	10	20	62	10	6	3	8	27	89	432.0	Medium-High
M616-N601	6	PVC	310	1984	N609	16	30	5	51	20	6	3	8	37	88	427.2	Medium-High
M772-M747	6	VCP	190	1921	N609	16	40	5	61	10	6	3	8	27	88	427.2	Medium-High
M783-N640	6	VCP/PVC	409	2004	Q672	16	40	5	61	10	6	3	8	27	88	427.2	Medium-High
N7121-N738	6	VCP	400	1940	Q679	16	40	5	61	10	6	3	8	27	88	427.2	Medium-High
N761-O716	6	PVC	452	1992	Q679	16	30	5	51	20	6	3	8	37	88	427.2	Medium-High
N781-O723	6	VCP	336	1961	Q679	24	20	5	49	10	6	15	8	39	88	427.2	Medium-High
O630-O631	6	VCP	387	1921	Q631	16	40	5	61	10	6	3	8	27	88	427.2	Medium-High
O785-O787	6	VCP	253	1921	Q679	16	40	5	61	10	6	3	8	27	88	427.2	Medium-High
O788-O787	6	VCP	101	1921	Q679	16	40	5	61	10	6	3	8	27	88	427.2	Medium-High
P739-P789	6	STL	84	1942	WWTP	16	10	5	31	10	6	9	32	57	88	427.2	Medium-High
P779-P781	6	VCP	169	1957	R822	16	40	5	61	10	6	3	8	27	88	427.2	Medium-High
Q508-Q517	6	VCP	235	1947	Q631	40	10	5	55	10	6	9	8	33	88	427.2	Medium-High
Q632-Q633	6	VCP	445	1921	R621	16	40	5	61	10	6	3	8	27	88	427.2	Medium-High
Q642-Q643	6	VCP	564	1921	R621	16	40	5	61	10	6	3	8	27	88	427.2	Medium-High
Q689-Q636	6	VCP	114	1949	R663	40	10	5	55	10	6	9	8	33	88	427.2	Medium-High
Q737-R717	6	VCP	442	1950	WWTP	16	40	5	61	10	6	3	8	27	88	427.2	Medium-High
Q751-Q750	6	VCP	247	1950	WWTP	16	40	5	61	10	6	3	8	27	88	427.2	Medium-High
Q771-Q772	6	VCP/PVC	292	1957	R822	40	10	5	55	10	6	9	8	33	88	427.2	Medium-High
Q830-Q831	6	PVC	195	1983	R809	16	40	5	61	10	6	3	8	27	88	427.2	Medium-High
Q911-Q902	8	VCP	174	1967	R809	16	30	5	51	20	6	3	8	37	88	427.2	Medium-High
R1110-R1111	6	VCP	45	1966	R809	40	10	5	55	10	6	9	8	33	88	427.2	Medium-High
R741-R742	6	PVC	208	1991	WWTP	8	10	5	23	10	6	9	40	65	88	427.2	Medium-High
R742-R743	6	PVC	213	1991	WWTP	8	10	5	23	10	12	3	40	65	88	427.2	Medium-High
R749-R750	6	VCP	256	1966	R709	24	20	5	49	10	12	9	8	39	88	427.2	Medium-High
R848-R751	6	VCP	228	1968	R709	40	10	5	55	10	12	3	8	33	88	427.2	Medium-High
T642-T643	6	VCP	131	1962	WWTP	16	40	5	61	10	6	3	8	27	88	427.2	Medium-High
N723-N724	6	VCP	102	1921	Q679	16	30	5	51	10	6	12	8	36	87	422.3	Medium-High
P667-P659	8	VCP	274	1921	Q679	16	10	5	31	30	6	12	8	56	87	422.3	Medium-High
R1007-R1006	6	VCP	292	1966	R809	8	10	10	28	30	18	3	8	59	87	422.3	Medium-High
M705-M706	6	VCP	288	1921	N609	24	30	5	59	10	6	3	8	27	86	417.5	Medium-High
M708-M710	6	VCP	101	1921	N609	24	30	5	59	10	6	3	8	27	86	417.5	Medium-High
M775-M740	6	VCP	227	1921	N609	8	10	5	23	10	6	15	32	63	86	417.5	Medium-High
N617-O655	6	VCP	223	1921	Q631	24	30	5	59	10	6	3	8	27	86	417.5	Medium-High

Appendix B. Detailed Risk Assessment Results

Pipe Number	Diameter, inches	Material	Length, linear feet	Installation Year	Basin	Likelihood of Failure Score				Consequence of Failure Score					Risk Score		Risk Level
						Structural Failure Rate	Maintenance Failure Rate	Hydraulic Capacity Failure Rate	Total Score	Potential Spill Volume	Environmental Impact	Emergency Response and Construction Impact	Public Exposure	Total Score	Total Risk	Normalized Risk	
N650-N649	6	VCP	392	1921	Q672	24	30	5	59	10	6	3	8	27	86	417.5	Medium-High
N7124-N789	6	VCP	107	1966	R822	24	30	5	59	10	6	3	8	27	86	417.5	Medium-High
N726-N727	6	VCP	208	1921	Q679	24	30	5	59	10	6	3	8	27	86	417.5	Medium-High
N729-N730	6	VCP	303	1921	Q679	24	30	5	59	10	6	3	8	27	86	417.5	Medium-High
N752-N753	6	VCP	202	1940	Q679	24	30	5	59	10	6	3	8	27	86	417.5	Medium-High
N765-N7120	6	VCP	102	1961	Q679	24	30	5	59	10	6	3	8	27	86	417.5	Medium-High
N772-N773	6	VCP	126	1961	Q679	24	30	5	59	10	6	3	8	27	86	417.5	Medium-High
N822-N825	6	VCP	256	1966	R822	24	30	5	59	10	6	3	8	27	86	417.5	Medium-High
O6130-O659	6	VCP	96	1921	Q631	24	30	5	59	10	6	3	8	27	86	417.5	Medium-High
O6132-O662	6	VCP	231	1921	Q631	24	30	5	59	10	6	3	8	27	86	417.5	Medium-High
O745-O748	6	VCP	135	1921	Q679	24	30	5	59	10	6	3	8	27	86	417.5	Medium-High
O794-O795	6	VCP	158	1942	WWTP	24	30	5	59	10	6	3	8	27	86	417.5	Medium-High
O914-O915	6	VCP	211	1967	R809	24	30	5	59	10	6	3	8	27	86	417.5	Medium-High
P705-P706	6	VCP	110	1942	WWTP	24	30	5	59	10	6	3	8	27	86	417.5	Medium-High
P748-P749	6	VCP	129	1942	WWTP	24	30	5	59	10	6	3	8	27	86	417.5	Medium-High
P759-P758	6	VCP	174	1950	WWTP	24	30	5	59	10	6	3	8	27	86	417.5	Medium-High
P763-P758	6	VCP	351	1950	WWTP	24	30	5	59	10	6	3	8	27	86	417.5	Medium-High
P765-P766	6	VCP	393	1950	WWTP	8	10	5	23	10	6	15	32	63	86	417.5	Medium-High
P780-P749	6	VCP	64	1942	WWTP	24	30	5	59	10	6	3	8	27	86	417.5	Medium-High
P785-P748	6	VCP	365	1942	WWTP	24	30	5	59	10	6	3	8	27	86	417.5	Medium-High
P912-P909	6	VCP	68	1967	R809	24	30	5	59	10	6	3	8	27	86	417.5	Medium-High
Q1130-Q1114	6	VCP	79	1966	R809	8	40	5	53	10	6	9	8	33	86	417.5	Medium-High
Q605-Q606	10	VCP	445	1996	Q631	8	10	5	23	30	6	3	24	63	86	417.5	Medium-High
Q606-Q607	10	PVC	452	1996	Q631	8	10	5	23	30	6	3	24	63	86	417.5	Medium-High
Q647-Q637	10	VCP	262	1945	R621	24	30	5	59	10	6	3	8	27	86	417.5	Medium-High
Q715-Q782	6	VCP	293	1950	WWTP	24	30	5	59	10	6	3	8	27	86	417.5	Medium-High
Q740-Q741	6	VCP	122	1950	WWTP	24	30	5	59	10	6	3	8	27	86	417.5	Medium-High
Q746-Q747	6	VCP	488	1950	WWTP	24	30	5	59	10	6	3	8	27	86	417.5	Medium-High
Q752-Q750	6	VCP	142	1950	WWTP	24	30	5	59	10	6	3	8	27	86	417.5	Medium-High
Q753-Q754	6	VCP	437	1950	WWTP	24	30	5	59	10	6	3	8	27	86	417.5	Medium-High
R1138-R1140	6	VCP	41	1966	R809	24	30	5	59	10	6	3	8	27	86	417.5	Medium-High
R518-Q510	6	VCP	300	1947	Q631	24	30	5	59	10	6	3	8	27	86	417.5	Medium-High
R603-R602	6	VCP	139	1950	WWTP	24	30	5	59	10	6	3	8	27	86	417.5	Medium-High
R723-R726	8	VCP	525	1950	WWTP	24	30	5	59	10	6	3	8	27	86	417.5	Medium-High
R771-R775	10	VCP	262	1951	WWTP	8	40	5	53	10	12	3	8	33	86	417.5	Medium-High
R791-R771	10	VCP	127	1951	WWTP	8	40	5	53	10	12	3	8	33	86	417.5	Medium-High
R795-R705	6	VCP	165	1950	WWTP	24	30	5	59	10	6	3	8	27	86	417.5	Medium-High
S1006-S1015	6	VCP	276	1966	R809	8	40	5	53	10	12	3	8	33	86	417.5	Medium-High
S1012-S1015	6	VCP	93	1966	R809	8	40	5	53	10	12	3	8	33	86	417.5	Medium-High
S1038-S1039	6	VCP	97	1966	R809	8	40	5	53	10	12	3	8	33	86	417.5	Medium-High
S1043-S1045	8	VCP	143	1966	R809	8	40	5	53	10	12	3	8	33	86	417.5	Medium-High
S603-S602	6	VCP/PVC	332	2003	WWTP	8	10	5	23	10	18	3	32	63	86	417.5	Medium-High
S843-S842	6	PVC	125	1973	R709	8	40	5	53	10	12	3	8	33	86	417.5	Medium-High
M757-N7124	6	VCP	222	1966	R822	8	30	20	58	10	6	3	8	27	85	412.6	Medium-High
N825-N826	8	VCP	166	1966	R822	8	30	20	58	10	6	3	8	27	85	412.6	Medium-High
O761-O784	6	VCP	28	1921	Q679	40	10	5	55	10	6	6	8	30	85	412.6	Medium-High
P677-P636	6	VCP	134	1921	R621	40	10	5	55	10	6	6	8	30	85	412.6	Medium-High
Q672-Q673	6	VCP	52	1921	R663	40	10	5	55	10	6	6	8	30	85	412.6	Medium-High
R1123-R1124	6	VCP	105	1966	R809	8	30	20	58	10	6	3	8	27	85	412.6	Medium-High
T1036-T1003	6	PVC	180	1992	R809	8	30	20	58	10	6	3	8	27	85	412.6	Medium-High
O731-O734	6	VCP	229	1921	Q679	32	20	5	57	10	6	3	8	27	84	407.8	Medium-High
P713-P714	8	VCP/PVC	49	1921	Q679	8	10	5	23	20	6	3	32	61	84	407.8	Medium-High
P726-P713	6	VCP/PVC	254	2003	Q679	8	10	5	23	20	6	3	32	61	84	407.8	Medium-High
R792-R759	6	VCP	124	1951	WWTP	16	30	5	51	10	12	3	8	33	84	407.8	Medium-High
N645-N646	6	VCP	146	1921	Q672	8	10	5	23	10	6	12	32	60	83	402.9	Medium-High
O6110-O6115	8	PVC	444	1986	Q679	8	10	5	23	10	6	12	32	60	83	402.9	Medium-High
O629-O630	6	VCP	241	1921	Q631	8	40	5	53	10	6	6	8	30	83	402.9	Medium-High
M702-M701	6	VCP	169	1921	N609	40	10	5	55	10	6	3	8	27	82	398.1	Medium-High
M731-M734	6	VCP/PVC	224	2004	N609	8	10	5	23	10	6	3	40	59	82	398.1	Medium-High
M733-M734	6	VCP/PVC	143	2004	N609	8	10	5	23	10	6	3	40	59	82	398.1	Medium-High
M735-M779	6	VCP	344	1921	N609	40	10	5	55	10	6	3	8	27	82	398.1	Medium-High
M739-M740	6	VCP	286	1921	N609	8	10	5	23	10	6	3	40	59	82	398.1	Medium-High
N7120-N767	6	VCP	283	1961	Q679	40	10	5	55	10	6	3	8	27	82	398.1	Medium-High
N728-N729	6	VCP	307	1921	Q679	40	10	5	55	10	6	3	8	27	82	398.1	Medium-High
N733-N734	6	VCP	299	1921	Q679	40	10	5	55	10	6	3	8	27	82	398.1	Medium-High
N755-N756	6	VCP	27	1940	Q679	40	10	5	55	10	6	3	8	27	82	398.1	Medium-High
N759-N760	6	VCP	276	1921	Q679	40	10	5	55	10	6	3	8	27	82	398.1	Medium-High
N784-N735	6	VCP	169	1921	Q679	40	10	5	55	10	6	3	8	27	82	398.1	Medium-High
O664-O665	6	VCP	137	1921	Q631	40	10	5	55	10	6	3	8	27	82	398.1	Medium-High
O756-O757	6	VCP	223	1921	Q679	40	10	5	55	10	6	3	8	27	82	398.1	Medium-High
O783-O785	6	VCP	246	1921	Q679	40	10	5	55	10	6	3	8	27	82	398.1	Medium-High
P811-P812	6	VCP	202	1957	R822	8	10	5	23	10	6	3	40	59	82	398.1	Medium-High
P819-P820	6	VCP	260	1959	R822	24	20	5	49	10	6	9	8	33	82	398.1	Medium-High
Q1120-Q1121	8	VCP	192	1966	R809	40	10	5	55	10	6	3	8	27	82	398.1	Medium-High
Q1126-Q1120	6	VCP	153	1966	R809	40	10	5	55	10	6	3	8	27	82	398.1	Medium-High
Q1129-R1123A	6	VCP	141	0	R809	40	10	5	55	10	6	3	8	27	82	398.1	Medium-High
Q1137-Q1136	6	PVC	105	1996	R809	8	10	5	23	10	6	3	40	59	82	398.1	Medium-High
Q1138-Q1137	6	PVC	269	1996	R809	8	10	5	23	10	6	3	40	59	82	398.1	Medium-High
Q6102-Q6111	6	VCP	70	1942	WWTP	40	10	5	55	10	6	3	8	27	82	398.1	Medium-High
Q6109-Q6108	6	PVC	61	1989	WWTP	40	10	5	55	10	6	3	8	27	82	398.1	Medium-High
Q6111-Q6101	6	VCP	17	1942	WWTP	40	10	5	55	10	6	3	8	27	82	398.1	Medium-High
Q643-Q644	6	VCP	49	1921	R663	40	10	5	55	10	6	3	8	27	82	398.1	Medium-High
Q659-Q660	6	VCP	48	1921	R663	40	10	5	55	10	6	3	8	27	82	398.1	Medium-High
Q698-Q682	6	VCP	274	1945	R663	40	10	5	55	10	6	3	8	27	82	398.1	Medium-High
Q764-Q765	6	VCP/PVC	145	1957	R822	40	10	5	55	10	6	3	8	27	82	398.1	Medium-High
Q765-Q868	6	VCP/PVC	372	1957	R822	40	10	5	55	10	6	3	8	27	82	398.1	Medium-High
Q803-Q804	6	UNK	84	1957	R822	8	10	5	23	10	6	3	40	59	82	398.1	Medium-High
Q816-Q817	6	VCP	279	1959	R822	40	10	5	55	10	6	3	8	27	82	398.1	Medium-High
R601-R602	6	VCP	293	1950	WWTP	40	10	5	55	10	6	3	8	27	82	398.1	Medium-High
T623-T625	6	VCP	319	1962	WWTP	40	10	5	55	10	6	3	8	27	82	398.1	Medium-High
T624-T625	6	VCP	168	1962	WWTP	40	10	5	55	10	6	3	8	27	82	398.1	Medium-High
T625-T626	6	VCP	311	1962	WWTP	40	10	5	55	10	6	3	8	27	82	398.1	Medium-High
P762-P763	6	VCP	323	1950	WWTP	24	10	20	54	10	6	3	8	27	81	393.2	Medium-High
Q626-Q627	6	PVC	159	1992	Q631	24	10	20	54	10	6	3	8	27	81	393.2	Medium-High
Q629-Q611	6	VCP	284	1943	Q631	24	10	20	54	10	6	3	8	27	81	393.2	Medium-High
M606-M607	6	VCP	161	1921	N609	8	40	5	53	10	6	3	8	27	80	388.3	Medium-High
M745-M746	6	VCP	108	1921	N609	8	40	5	53	10	6	3	8	27	80	388.3	Medium-High
M751-M783	6	VCP/PVC	229	2004	Q672	8	40	5	53	10	6	3	8	27	80	388.3	Medium-High
M790-M723	6	VCP	64	1921	N609	8	40	5	53	10	6	3	8	27	80	388.3	Medium-High
N624-N625	6	VCP	128	1921	Q631	8	40	5	53	10	6	3	8	27	80	388.3	Medium-High
N668-N649	6	VCP	159	1921	Q672	8	40	5	53	10	6	3	8	27	80	388.3	Medium-High
N7122-M783	6	VCP/PVC	344	2004	Q672	8	40	5	53	10	6	3	8	27	80	388.3	Medium-High
N727-N729	6	VCP	244	1921	Q679	8	40	5	53	10	6	3	8	27	80	388.3	Medium-High
N744-N7121	6	CIP	129	1940	Q679	8	40	5	53	10	6	3	8	27	80	388.3	Medium-High
N768-N769	6	VCP	349	1961	Q679	8	40	5	53	10	6	3	8	27	80	388.3	Medium-High
N813-N814	6	VCP	188	1966	R822	8	40	5	53	10	6	3	8	27	80	388.3	Medium-High
N821-N822	6	VCP	134	1966	R822	8	40	5	53	10	6	3	8	27	80	388.3	Medium-High
N902-N903	6	VCP	186	1973	R822	8	40	5	53	10	6	3	8	27	80	388.3	Medium-High
O642-O644	8	PVC	203	1982	Q631	8	40	5	53	10	6	3	8	27	80	388.3	Medium-High
O674-P623	6	VCP	466	1921	R621	8	40	5	53	10	6	3	8	27	80	388.3	Medium-High
O7100-O707	6	0	172	0	Q679	8	40	5	53	10	6	3	8	27	80	388.3	Medium-High
O751-O753	6	VCP	135	1921	Q679	8	40	5	53	10	6	3	8	27	80	388.3	Medium-High
O763-O767	6	VCP/PVC	245	2003	Q679	8	40	5	53	10	6	3	8	27	80	388.3	Medium-High
O926-P904	6	VCP	182	1967	R809	8	40	5	53	10	6	3	8	27	80	388.3	Medium-High
P623-P624	6	VCP	456	1921	R621	8	40	5	53	10	6	3	8	27	80	388.3	Medium-High
P624-P625	6	VCP	451	1921	R621	8	40	5	53	10	6	3	8	27	80	388.3	Medium-High
P625-P626	6	VCP	450	1921	R621	8	40	5	53	10	6	3	8	27	80	388.3	Medium-High
P632-P633	6	VCP	147	1921	Q649	8	40	5	53	10	6	3	8	27	80	388.3	Medium-High
P670-P671	6	VCP	110	1942	WWTP	8	40	5	53	10	6	3	8	27	80	388.3	Medium-High
P682-P616	6	VCP	179	1921	Q631	8	40	5	53	10	6	3	8	27	80	388.3	Medium-High
P783-P702	6	VCP	103	1921	Q679	8	40	5	53	10	6	3	8	27	80	388.3	Medium-High
P823-P824	6	VCP	230	1959	R822	8	40	5	53	10	6	3	8	27	80	388.3	Medium-High
P829-P830	6	UNK	257	1983	R809	8	40	5	53	10	6	3	8	27	80	388.3	Medium-High
P831-P830	6	UNK	257	1983	R809	8	40	5	53	10	6	3	8	27	80	388.3	Medium-High
P904-P903	6	VCP	77	1967	R809	8	40	5	53	10	6	3	8	27	80	388.3	Medium-High
Q6104-Q6105	6	VCP	422	1950	WWTP	8	40	5	53	10	6	3	8	27	80	388.3	Medium-High
Q6113-Q649	6	VCP	150	1921	Q649	8	40	5	53	10	6	3	8	27	80	388.3	Medium-High
Q621-P616	6	PVC	404	1993	Q631	8	40	5	53	10	6	3	8	27	80	388.3	Medium-High
Q622-Q623	6	PVC	404	1993	Q631	8	40	5	53	10	6	3	8	27	80	388.3	Medium-High
Q623-Q624	6	PVC	425	1993	Q631	8	40	5	53	10	6	3	8	27	80	388.3	Medium-High
Q633-Q635	6	VCP	451	1921	R621	8	40	5	53	10	6	3	8	27	80	388.3	Medium-High
Q643-Q635	8	PVC	246	2003	R621	8	10	5	23	40	6	3	8	57	80	388.3	Medium-High
Q681-Q682	8	PVC	250	1995	R663	8	10	5	23	40	6	3	8	57	80	388.3	Medium-High
Q767-Q868	6	VCP/PVC	248	1957	R822	8	40	5	53	10	6	3	8	27	80	388.3	Medium-High
Q813-Q815	6	VCP	290	1959	R822	8	40	5	53	10	6	3	8	27	80	388.3	Medium-High
Q823-Q824	6	VCP	401	1959	R822	8	40	5	53	10	6	3	8	27	80	388.3	Medium-High
Q831-Q832	6	PVC	183	1983	R809	8	40	5	53	10	6	3	8	27	80	388.3	Medium-High
Q832-Q833	6	PVC	262	1983	R809	8	40	5	53	10	6	3	8	27	80	388.3	Medium-High
R510-R511	6	VCP/PVC	347	2004	Q631	8	40	5	53	10	6	3	8	27	80	388.3	Medium-High
R514-R513	6	VCP	251	1947	Q631	8	40	5	53	10	6	3	8	27	80	388.3	Medium-High
R735-R729	6	VCP/PVC	179	2004	WWTP	8	40	5	53	10	6	3	8	27	80	388.3	Medium-High
T635-T636	6	VCP/PVC	409	2003	WWTP	8	40	5	53	10	6	3	8	27	80	388.3	Medium-High
N703-N7119	6	PVC	275	1989	Q672	8	10	5	23	30	6	12	8	56	79	383.5	Medium-High
N619-N620	6	PVC	275	1996	Q631	16	30	5	51	10	6	3	8	27	78	378.6	Medium-High
N708-N788	6	VCP	302	1921	Q672	16	30	5	51	10	6	3	8	27	78	378.6	Medium-High
N788-N706	6	VCP	303	1921	Q672	16	30	5	51	10	6	3	8	27	78	378.6	Medium-High
P668-P667	6	VCP	106	1921	Q679	16	30	5	51	10	6	3	8	27	78	378.6	Medium-High
P757-P758	6	VCP	312	1950	WWTP	16	30	5	51	10	6	3	8	27	78	378.6	Medium-High
T1118-T1036	6	PVC	346	1992	R809	16	30	5	51	10	6	3	8	27	78	378.6	Medium-High
M714-M715	6	VCP	259	1921	N609	24	20	5	49	10	6	3	8	27	76	368.9	Medium-High
M716-M718	6	VCP	220	1921	N609	24	20	5	49	10	6	3	8	27	76	368.9	Medium-High
M791-M781	6	VCP	109	1921	N609	24	20	5	49	10	6	3	8	27	76	368.9	Medium-High
N613-N614	6	VCP	217	1921	Q631	24	20	5	49	10	6	3	8	27	76	368.9	Medium-High
O740-O741	6	VCP	89	1921	Q679	24	20	5	49	10	6	3	8	27	76	368.9	Medium-High
O764-O763	6	VCP	176	1921	Q679	24	20	5	49	10	6	3	8	27	76	368.9	Medium-High
O795-P790	6	VCP	315	1942	WWTP	24	20	5	49	10	6	3	8	27	76	368.9	Medium-High
R512-R513	6	VCP	276	1947	Q631	24	20	5	49	10	6	3	8	27	76	368.9	Medium-High
R626-R627	6	VCP	398	1949	R663	24	20	5	49	10	6	3	8	27	76	368.9	Medium-High
T629-T630	6	VCP	118	1962	WWTP	24	20	5	49	10	6	3	8	27	76	368.9	Medium-High
R901-R902	10	AT	323	1973	R809	8	20	20	48	30	12	3	8	53	101	490.3	Medium-Low
R902-R903	10	AT	287	1973	R809	8	20	20	48	30	12	3	8	53	101	490.3	Medium-Low
R905-R906	10	AT	183	1973	R809	8	20	20	48	30	12	3	8	53	101	490.3	Medium-Low
N669-N615	6	VCP	129	1921	Q631	32	10	5	47	10	6	3	32	51	98	475.7	Medium-Low
R788-R723	6	VCP	306	1950	WWTP	32	10	5	47	10	6	3	32	51	98	475.7	Medium-Low
O6102-O6104	6	VCP	452	1921	Q672	8	30	5	43	10	6	6	32	54	97	470.9	Medium-Low
N7105-N7106	8	VCP	41	1966	R822	32	10	5	47	20	6	15	8	49	96	466.0	Medium-Low

Appendix B. Detailed Risk Assessment Results

Pipe Number	Diameter, inches	Material	Length, linear feet	Installation Year	Basin	Likelihood of Failure Score				Consequence of Failure Score					Risk Score		Risk Level
						Structural Failure Rate	Maintenance Failure Rate	Hydraulic Capacity Failure Rate	Total Score	Potential Spill Volume	Environmental Impact	Emergency Response and Construction Impact	Public Exposure	Total Score	Total Risk	Normalized Risk	
N7106-N7107	8	VCP	106	1966	R822	32	10	5	47	20	6	15	8	49	96	466.0	Medium-Low
O824-O825	6	VCP	55	1966	R822	32	10	5	47	20	6	15	8	49	96	466.0	Medium-Low
O825-O826	6	VCP	136	1966	R822	32	10	5	47	20	6	15	8	49	96	466.0	Medium-Low
O845-O802	6	UNK	590	1966	R822	32	10	5	47	20	6	15	8	49	96	466.0	Medium-Low
N648-N668	6	VCP	115	1921	Q672	8	30	5	43	10	6	12	24	52	95	461.2	Medium-Low
M732-M733	6	VCP	234	1921	N609	8	30	5	43	10	6	3	32	51	94	456.3	Medium-Low
N704-N706	6	VCP	227	1921	Q672	32	10	5	47	30	6	3	8	47	94	456.3	Medium-Low
O6111-O6112	6	VCP	456	1921	Q679	8	30	5	43	10	6	3	32	51	94	456.3	Medium-Low
P702-P667	8	VCP	250	1921	Q679	32	10	5	47	30	6	3	8	47	94	456.3	Medium-Low
P709-P710	6	PVC	97	1989	Q679	8	30	5	43	10	6	3	32	51	94	456.3	Medium-Low
Q756-Q757	6	VCP	346	1950	WWTP	8	30	5	43	10	6	3	32	51	94	456.3	Medium-Low
O6135-O6105	6	UNK	7	1921	Q672	24	10	5	39	10	6	6	32	54	93	451.5	Medium-Low
P627-P628	6	VCP	141	1921	Q649	24	10	5	39	10	6	6	32	54	93	451.5	Medium-Low
O801-O845	8	VCP	139	1966	R822	8	30	5	43	20	6	15	8	49	92	446.6	Medium-Low
Q515-Q506	6	VCP	238	1947	Q631	32	10	5	47	10	24	3	8	45	92	446.6	Medium-Low
S1008-S1009	6	VCP	184	1966	R809	32	10	5	47	10	12	15	8	45	92	446.6	Medium-Low
S1029-S1030	6	VCP	40	1966	R809	32	10	5	47	10	18	9	8	45	92	446.6	Medium-Low
S1031-S1032	6	VCP	163	1966	R809	32	10	5	47	10	18	9	8	45	92	446.6	Medium-Low
M741-M740	6	VCP	266	1921	N609	24	10	5	39	10	6	3	32	51	90	436.9	Medium-Low
N663-N615	6	VCP	303	1921	Q631	24	10	5	39	10	6	3	32	51	90	436.9	Medium-Low
P606-P608	10	PVC	451	1996	Q631	8	30	5	43	30	6	3	8	47	90	436.9	Medium-Low
P750-P745	6	VCP	210	1942	WWTP	32	10	5	47	10	6	3	24	43	90	436.9	Medium-Low
P770-Q745	6	VCP	448	1950	WWTP	24	10	5	39	10	6	3	32	51	90	436.9	Medium-Low
Q635-Q625	10	VCP	253	1921	Q631	8	30	5	43	30	6	3	8	47	90	436.9	Medium-Low
Q711-Q714	6	VCP	442	1950	WWTP	24	10	5	39	10	6	3	32	51	90	436.9	Medium-Low
Q755-Q756	6	VCP	344	1950	WWTP	24	10	5	39	10	6	3	32	51	90	436.9	Medium-Low
Q818-Q819	6	VCP	225	1959	R822	32	10	5	47	10	6	3	24	43	90	436.9	Medium-Low
R635-R636	6	VCP	123	1950	WWTP	24	10	5	39	10	6	3	32	51	90	436.9	Medium-Low
R636-R632	6	VCP	417	1950	WWTP	24	10	5	39	10	6	3	32	51	90	436.9	Medium-Low
R761-R762	8	VCP	14	1966	WWTP	32	10	5	47	10	12	12	8	42	89	432.0	Medium-Low
R802-R803	10	VCP	251	1973	R809	8	30	5	43	20	6	12	8	46	89	432.0	Medium-Low
N7103-N7104	6	VCP	121	1966	R822	24	10	5	39	20	6	15	8	49	88	427.2	Medium-Low
O820-O821	6	VCP	100	2014	R822	24	10	5	39	20	6	15	8	49	88	427.2	Medium-Low
R634-R635	6	VCP	234	1950	WWTP	24	10	5	39	10	6	9	24	49	88	427.2	Medium-Low
R757-R758	6	VCP	191	1951	WWTP	8	30	5	43	10	12	15	8	45	88	427.2	Medium-Low
S1103-S1104	6	VCP	96	1966	R809	8	30	5	43	10	18	9	8	45	88	427.2	Medium-Low
N7104-N7105	8	VCP	119	1966	R822	8	10	20	38	20	6	15	8	49	87	422.3	Medium-Low
N827-N826	8	VCP	251	1966	R822	8	10	20	38	20	6	15	8	49	87	422.3	Medium-Low
O728-O735	6	VCP	305	1921	Q679	32	10	5	47	20	6	6	8	40	87	422.3	Medium-Low
N791-N795	8	CIP	72	1966	R822	32	10	5	47	10	6	15	8	39	86	417.5	Medium-Low
N792-N791	6	VCP	86	1966	R822	32	10	5	47	10	6	15	8	39	86	417.5	Medium-Low
N793-N792	6	VCP	109	1966	R822	32	10	5	47	10	6	15	8	39	86	417.5	Medium-Low
N794-N793	6	VCP	123	1966	R822	32	10	5	47	10	6	15	8	39	86	417.5	Medium-Low
O622-O623	8	PVC	163	1983	Q631	24	10	5	39	30	6	3	8	47	86	417.5	Medium-Low
O652-O653	6	VCP	191	1921	Q631	8	30	5	43	10	6	3	24	43	86	417.5	Medium-Low
O707-O708	6	VCP	226	1921	Q679	24	10	5	39	30	6	3	8	47	86	417.5	Medium-Low
P806-P807	6	VCP	184	1957	R822	8	30	5	43	10	6	3	24	43	86	417.5	Medium-Low
P813-P814	6	VCP	286	1959	R822	8	30	5	43	10	6	3	24	43	86	417.5	Medium-Low
Q747-Q748	6	VCP	116	1950	WWTP	32	10	5	47	10	6	15	8	39	86	417.5	Medium-Low
Q821-R819	6	VCP	260	1959	R822	8	30	5	43	10	6	3	24	43	86	417.5	Medium-Low
R1004-R1013	8	OTHER	210	1973	R809	8	10	25	43	20	12	3	8	43	86	417.5	Medium-Low
R1104-R1105	6	CIP	138	1966	R809	32	10	5	47	10	6	15	8	39	86	417.5	Medium-Low
R779-R781	6	VCP	503	1951	WWTP	32	10	5	47	10	18	3	8	39	86	417.5	Medium-Low
S1009-S1010	6	VCP	67	1966	R809	32	10	5	47	10	12	9	8	39	86	417.5	Medium-Low
S1034-S1036	6	VCP	36	1966	R809	32	10	5	47	10	12	9	8	39	86	417.5	Medium-Low
S1035-S1036	6	VCP	48	1966	R809	32	10	5	47	10	12	9	8	39	86	417.5	Medium-Low
S1037-S1038	6	VCP	102	1966	R809	32	10	5	47	10	12	9	8	39	86	417.5	Medium-Low
T630-T631	6	VCP/PVC	198	2003	WWTP	8	30	5	43	10	6	3	24	43	86	417.5	Medium-Low
O623-O604	10	PVC	108	1982	Q631	8	10	20	38	30	6	3	8	47	85	412.6	Medium-Low
P608-P610	10	PVC	449	1996	Q631	8	10	20	38	30	6	3	8	47	85	412.6	Medium-Low
P610-P612	10	PVC	447	1996	Q631	8	10	20	38	30	6	3	8	47	85	412.6	Medium-Low
P612-Q605	10	PVC	452	1996	Q631	8	10	20	38	30	6	3	8	47	85	412.6	Medium-Low
P664-P672	6	VCP	105	1942	WWTP	24	10	5	39	20	6	12	8	46	85	412.6	Medium-Low
Q649-Q650	8	PVC	568	1990	R621	8	10	20	38	30	6	3	8	47	85	412.6	Medium-Low
R1119-R1120	6	VCP	183	1966	R809	16	10	20	46	10	6	15	8	39	85	412.6	Medium-Low
M609-M610	6	VCP	55	1921	N609	32	10	5	47	20	6	3	8	37	84	407.8	Medium-Low
M611-N639	6	VCP	228	1921	N609	32	10	5	47	20	6	3	8	37	84	407.8	Medium-Low
Q905-Q827	8	VCP	264	1967	R809	32	10	5	47	20	6	3	8	37	84	407.8	Medium-Low
S701-R770	6	VCP	258	1951	WWTP	24	10	5	39	10	12	15	8	45	84	407.8	Medium-Low
S824-S822	6	VCP	95	1976	R709	24	10	5	39	10	12	15	8	45	84	407.8	Medium-Low
Q656-Q658	6	PVC	308	1989	R621	16	10	20	46	20	6	3	8	37	83	402.9	Medium-Low
S1122-S1121	8	PVC	139	2003	R809	8	10	20	38	10	24	3	8	45	83	402.9	Medium-Low
T1124-T1130	8	PVC	186	2003	R809	8	10	20	38	10	24	3	8	45	83	402.9	Medium-Low
T1125-T1124	8	PVC	19	2003	R809	8	10	20	38	10	24	3	8	45	83	402.9	Medium-Low
T1126-T1125	8	PVC	48	2003	R809	8	10	20	38	10	24	3	8	45	83	402.9	Medium-Low
N603-N601	6	VCP	322	1921	N609	24	10	5	39	10	6	3	24	43	82	398.1	Medium-Low
N747-N748	6	VCP	67	1940	Q679	8	30	5	43	10	6	15	8	39	82	398.1	Medium-Low
N787-N778	6	VCP	90	1961	Q679	8	30	5	43	10	6	15	8	39	82	398.1	Medium-Low
N806-N807	8	VCP	198	1966	R822	8	30	5	43	10	6	15	8	39	82	398.1	Medium-Low
N808-N809	6	VCP	91	1966	R822	8	30	5	43	10	6	15	8	39	82	398.1	Medium-Low
N819-N820	6	VCP	99	1966	R822	8	30	5	43	10	6	15	8	39	82	398.1	Medium-Low
N820-N821	6	VCP	190	1966	R822	8	30	5	43	10	6	15	8	39	82	398.1	Medium-Low
N875-N876	6	PVC	139	1987	R822	8	30	5	43	10	6	15	8	39	82	398.1	Medium-Low
O658-O6131	6	VCP	32	1921	Q631	8	30	5	43	10	6	15	8	39	82	398.1	Medium-Low
P724-P725	6	VCP	137	1921	Q679	24	10	5	39	10	6	3	24	43	82	398.1	Medium-Low
P877-P778	6	VCP	192	1957	R822	24	10	5	39	10	6	3	24	43	82	398.1	Medium-Low
P920-P919	6	UNK	82	1966	R809	8	30	5	43	10	6	15	8	39	82	398.1	Medium-Low
Q6112-Q606	6	VCP	127	1943	Q631	24	10	5	39	10	6	3	24	43	82	398.1	Medium-Low
R524-R525	6	VCP	56	1949	WWTP	16	10	5	31	10	6	3	32	51	82	398.1	Medium-Low
R775-R776	10	VCP	278	1951	WWTP	24	10	5	39	20	12	3	8	43	82	398.1	Medium-Low
R830-R836	6	VCP	283	1971	R709	24	10	5	39	10	6	3	24	43	82	398.1	Medium-Low
S1010-S1011	6	VCP	51	1966	R809	8	30	5	43	10	12	9	8	39	82	398.1	Medium-Low
S1041-S1042	6	VCP	183	1966	R809	8	30	5	43	10	18	3	8	39	82	398.1	Medium-Low
T622-T621	6	VCP	257	1962	WWTP	24	10	5	39	10	6	3	24	43	82	398.1	Medium-Low
P776-P877	6	VCP	128	1957	R822	8	10	20	38	10	6	3	24	43	81	393.2	Medium-Low
R1003-R1004	8	OTHER	239	1973	R809	8	10	20	38	20	12	3	8	43	81	393.2	Medium-Low
R1005-R1006	8	AT	395	1973	R809	8	10	20	38	20	12	3	8	43	81	393.2	Medium-Low
R777-R778	6	VCP	114	1951	WWTP	24	10	5	39	10	12	12	8	42	81	393.2	Medium-Low
S846-S801	8	VCP	84	1971	R709	24	10	5	39	10	12	12	8	42	81	393.2	Medium-Low
N7101-N7102	6	VCP	35	1966	R822	16	10	5	31	20	6	15	8	49	80	388.3	Medium-Low
O827-O832	6	VCP	67	1973	R822	8	30	5	43	20	6	3	8	37	80	388.3	Medium-Low
O912-O917	6	VCP	63	1967	R809	16	20	5	41	10	6	15	8	39	80	388.3	Medium-Low
P634-Q648	8	PVC	448	1990	Q649	8	30	5	43	20	6	3	8	37	80	388.3	Medium-Low
P638-Q656	6	PVC	450	1989	R621	8	30	5	43	20	6	3	8	37	80	388.3	Medium-Low
P723-P725	6	VCP	120	1996	Q679	8	30	5	43	20	6	3	8	37	80	388.3	Medium-Low
P924-P923	6	UNK	103	1966	R809	16	20	5	41	10	6	15	8	39	80	388.3	Medium-Low
Q828-Q829	8	VCP	393	1967	R809	8	30	5	43	20	6	3	8	37	80	388.3	Medium-Low
Q902-Q903	8	VCP	135	1967	R809	8	30	5	43	20	6	3	8	37	80	388.3	Medium-Low
R1140-R1141	8	VCP	259	1966	R809	8	30	5	43	20	6	3	8	37	80	388.3	Medium-Low
R657-R605	6	VCP	324	1950	WWTP	16	10	5	31	20	18	3	8	49	80	388.3	Medium-Low
R748-R793	10	VCP	172	1968	R709	32	10	5	47	10	12	3	8	33	80	388.3	Medium-Low
R790-R767	6	VCP	130	1951	WWTP	32	10	5	47	10	12	3	8	33	80	388.3	Medium-Low
R793-R753	10	VCP	49	1968	R709	32	10	5	47	10	12	3	8	33	80	388.3	Medium-Low
S1004-S1006	6	VCP	215	1966	R809	32	10	5	47	10	12	3	8	33	80	388.3	Medium-Low
S702-R758	6	VCP	169	1951	WWTP	32	10	5	47	10	12	3	8	33	80	388.3	Medium-Low
Q684-Q690	6	UNK	39	1942	WWTP	8	30	5	43	10	6	12	8	36	79	383.5	Medium-Low
Q690-Q6111	6	VCP	257	1942	WWTP	8	30	5	43	10	6	12	8	36	79	383.5	Medium-Low
Q696-Q697	6	VCP	163	1950	WWTP	8	30	5	43	10	6	12	8	36	79	383.5	Medium-Low
R1002-R1003	8	OTHER	159	1973	R809	8	20	5	33	20	6	12	8	46	79	383.5	Medium-Low
N749-N750	6	VCP	109	1940	Q679	24	10	5	39	10	6	15	8	39	78	378.6	Medium-Low
N812-N807	6	VCP	101	1966	R822	24	10	5	39	10	6	15	8	39	78	378.6	Medium-Low
N818-N819	6	VCP	95	1966	R822	24	10	5	39	10	6	15	8	39	78	378.6	Medium-Low
O812-O813	6	VCP	112	1973	R822	24	10	5	39	10	6	15	8	39	78	378.6	Medium-Low
O902-O903	6	VCP	201	1973	R822	24	10	5	39	10	6	15	8	39	78	378.6	Medium-Low
O958-O959	6	VCP	98	1966	R809	24	10	5	39	10	6	15	8	39	78	378.6	Medium-Low
O962-O928	6	VCP	70	1967	R809	24	10	5	39	10	6	15	8	39	78	378.6	Medium-Low
P733-P734	6	CIP	39	1942	WWTP	24	10	5	39	10	6	15	8	39	78	378.6	Medium-Low
P746-P786	6	VCP	94	1942	WWTP	24	10	5	39	10	6	15	8	39	78	378.6	Medium-Low
P767-P768	6	VCP	464	1950	WWTP	24	10	5	39	10	6	15	8	39	78	378.6	Medium-Low
P922-P921	6	UNK	100	1966	R809	24	10	5	39	10	6	15	8	39	78	378.6	Medium-Low
P923-P922	6	UNK	93	1966	R809	24	10	5	39	10	6	15	8	39	78	378.6	Medium-Low
Q1103-Q1104	8	VCP	157	1966	R809	24	10	5	39	10	6	15	8	39	78	378.6	Medium-Low
Q1104-Q1107	8	VCP	208	1966	R809	24	10	5	39	10	6	15	8	39	78	378.6	Medium-Low
Q1112-Q1113	6	VCP	134	1966	R809	24	10	5	39	10	6	15	8	39	78	378.6	Medium-Low
Q776-Q775	6	UNK	73	1950	WWTP	24	10	5	39	10	6	15	8	39	78	378.6	Medium-Low
R1128-R1129	6	VCP	340	1966	R809	24	10	5	39	10	6	15	8	39	78	378.6	Medium-Low
R1149-R1122	6	VCP	114	1966	R809	24	10	5	39	10	6	15	8	39	78	378.6	Medium-Low
T616-T615	6	VCP	138	1962	WWTP	24	10	5	39	10	6	15	8	39	78	378.6	Medium-Low
N807-N797	8	VCP	102	1966	R822	8	10	20	38	10	6	15	8	39	77	373.8	Medium-Low
O675-O676	6	PVC	180	1990	Q649	8	10	5	23	10	6	6	32	54	77	373.8	Medium-Low
O676-O677	6	PVC	218	1990	Q649	8	10	5	23	10	6	6	32	54	77	373.8	Medium-Low
P629-P630	6	VCP	147	1921	Q649	32	10	5	47	10	6	6	8	30	77	373.8	Medium-Low
P673-P602	6	VCP	123	1947	Q631	8	10	5	23	10	6	6	32	54	77	373.8	Medium-Low
P680-P648	6	VCP	136	1921	Q679	8	10	5	23	10	6	6	32	54	77	373.8	Medium-Low
R1129-R1134	6	VCP	156	1966	R809	8	10	20	38	10	6	15	8	39	77	373.8	Medium-Low
R1135-R1134	6	VCP	198	1966	R809	8	10	20	38	10	6	15	8	39	77	373.8	Medium-Low
S1121-S1120	8	PVC	399	2003	R809	8	10	20	38	10	18	3	8	39	77	373.8	Medium-Low
M707-M708	6	VCP	53	1921	N609	8	30	5	43	10	6	9	8	33	76	368.9	Medium-Low
N601-N602	6	VCP	166	1921	N609	24	10	5	39	20	6	3	8	37	76	368.9	Medium-Low
O775-O778	8	VCP	121	1921	Q679	24	10	5	39	20	6	3	8	37	76	368.9	Medium-Low
O802-O803	8	VCP	324	1957	R822	8	20	5	33	20	6	9	8	43	76	368.9	Medium-Low
O804-O805	8	VCP	232	1957	R822	8	10	5	23	20	6	3	24	53	76	368.9	Medium-Low
O833-O834	6	VCP	250	1957	R822	8	10	5	23	20	6	3	24	53	76	368.9	Medium-Low
O904-O905	6	VCP	137	1973	R822	24	10	5	39	20	6	3	8	37	76	368.9	Medium-Low
Q739-Q740	6	VCP	50	1950	WWTP	8	30	5	43	10	6	9	8	33	76	368.9	Medium-Low
R760-R759	10	VCP	251	1951	WWTP	8	30	5	43	10	12	3	8	33	76	368.9	Medium-Low
R767-R768	10	VCP	121	1951	WWTP	8	30	5	43	10	12	3	8	33	76	368.9	Medium-Low
R773-R774	6	VCP	268	2007	WWTP	8	30	5	43	10	12	3	8	33	76	368.9	Medium-Low
S1001-S1002	6	VCP	176	1966	R809	8	30	5	43	10	12	3	8	33	76	368.9	Medium-Low
S1019-S1020	6	VCP	123	1966	R809	8	30	5	43	10	12	3	8	33	76	368.9	Medium-Low
S847-S846	8	VCP	271	1971	R709	8	30	5	43	10	12	3	8	33	76	368.9	Medium-Low
T1016-T1006	6	PVC	366	1992	R809	16	10	5	31	10	24	3	8	45	76	368.9	Medium-Low
M615-M616	6	PVC	295	1984	N609	8	10	20	38	20	6	3	8	37	75	364.1	Medium-Low
R1122-R1123	6	VCP	131	1966	R809	8	20	20	48	10	6	3	8	27	75	364.1	Medium-Low
R726-R706	6	VCP	525	1950	WWTP	24	10	5	39	10	6	12	8	36	75	364.1	Medium-Low
R818-R819	6	VCP	88	1959	R822	8	10	5	23	10	6	12	24	52	75	364.1	Medium-Low

Appendix B. Detailed Risk Assessment Results

Pipe Number	Diameter, inches	Material	Length, linear feet	Installation Year	Basin	Likelihood of Failure Score: Structural Failure Rate	Maintenance Failure Rate	Hydraulic Capacity Failure Rate	Total Score	Consequence of Failure Score: Potential Spill Volume	Environmental Impact	Emergency Response and Construction Impact	Public Exposure	Total Score	Risk Score: Total Risk	Normalized Risk	Risk Level
R849-R801	6	PVC	417	1992	R809	8	10	5	23	10	6	12	24	52	75	364.1	Medium-Low
R913-R849	6	PVC	258	1992	R809	8	10	5	23	10	6	12	24	52	75	364.1	Medium-Low
M711-M706	6	VCP/PVC	138	2004	N609	32	10	5	47	10	6	3	8	27	74	359.2	Medium-Low
M738-M739	6	PVC	329	1994	N609	8	10	5	23	10	6	3	32	51	74	359.2	Medium-Low
M771-M772	6	VCP	70	1921	N609	16	20	5	41	10	6	9	8	33	74	359.2	Medium-Low
N618-N619	6	PVC	132	1996	Q631	8	10	5	23	10	6	3	32	51	74	359.2	Medium-Low
N630-N631	6	PVC	451	1986	Q631	8	10	5	23	10	6	3	32	51	74	359.2	Medium-Low
N631-N632	6	PVC	223	1986	Q631	8	10	5	23	10	6	3	32	51	74	359.2	Medium-Low
N632-N633	6	PVC	98	1986	Q631	8	10	5	23	10	6	3	32	51	74	359.2	Medium-Low
N633-N634	6	PVC	105	1986	Q631	8	10	5	23	10	6	3	32	51	74	359.2	Medium-Low
N641-N643	6	VCP	122	1921	Q672	8	10	5	23	10	6	3	32	51	74	359.2	Medium-Low
N665-N610	6	VCP	158	1921	Q631	32	10	5	47	10	6	3	8	27	74	359.2	Medium-Low
N7125-N771	6	VCP	158	1961	Q679	32	10	5	47	10	6	3	8	27	74	359.2	Medium-Low
N802-N803	8	VCP	336	1966	R822	32	10	5	47	10	6	3	8	27	74	359.2	Medium-Low
O6100-O6101	6	VCP	417	1921	Q672	8	10	5	23	10	6	3	32	51	74	359.2	Medium-Low
O611-O6144	6	PVC	191	1984	Q631	8	10	5	23	10	6	3	32	51	74	359.2	Medium-Low
O6140-O651	6	UNK	95	1921	Q631	8	10	5	23	10	6	3	32	51	74	359.2	Medium-Low
O6144-O6148	6	PVC	66	1984	Q631	8	10	5	23	10	6	3	32	51	74	359.2	Medium-Low
O6145-O6146	6	PVC	24	1988	Q631	8	10	5	23	10	6	3	32	51	74	359.2	Medium-Low
O6146-O614	6	PVC	43	1988	Q631	8	10	5	23	10	6	3	32	51	74	359.2	Medium-Low
O733-O734	6	VCP	200	1921	Q679	32	10	5	47	10	6	3	8	27	74	359.2	Medium-Low
O748-O749	6	VCP	228	1921	Q679	32	10	5	47	10	6	3	8	27	74	359.2	Medium-Low
O920-O921	8	VCP	293	1967	R809	32	10	5	47	10	6	3	8	27	74	359.2	Medium-Low
O925-O926	6	VCP	240	1967	R809	32	10	5	47	10	6	3	8	27	74	359.2	Medium-Low
P674-P610	6	VCP	144	1947	Q631	32	10	5	47	10	6	3	8	27	74	359.2	Medium-Low
P704-P705	6	VCP	268	1942	WWTP	32	10	5	47	10	6	3	8	27	74	359.2	Medium-Low
P710-P714	6	VCP/PVC	287	2003	Q679	8	10	5	23	10	6	3	32	51	74	359.2	Medium-Low
P712-P713	6	VCP/PVC	440	2003	Q679	8	10	5	23	10	6	3	32	51	74	359.2	Medium-Low
P729-P731	6	UNK	32	1942	WWTP	8	10	5	23	10	6	3	32	51	74	359.2	Medium-Low
P755-P756	6	VCP	447	1950	WWTP	8	10	5	23	10	6	3	32	51	74	359.2	Medium-Low
P790-P728	6	VCP	277	1942	WWTP	8	10	5	23	10	6	3	32	51	74	359.2	Medium-Low
P906-P905	6	VCP	49	1967	R809	32	10	5	47	10	6	3	8	27	74	359.2	Medium-Low
Q1116-Q1117	6	VCP	223	1966	R809	32	10	5	47	10	6	3	8	27	74	359.2	Medium-Low
Q604-Q503	6	VCP	151	1947	Q631	8	10	5	23	10	6	3	32	51	74	359.2	Medium-Low
Q654-Q655	6	VCP	138	1949	R621	32	10	5	47	10	6	3	8	27	74	359.2	Medium-Low
Q670-Q663	6	VCP	119	1921	R663	32	10	5	47	10	6	3	8	27	74	359.2	Medium-Low
Q741-Q742	6	VCP	116	1950	WWTP	32	10	5	47	10	6	3	8	27	74	359.2	Medium-Low
Q758-R714	6	VCP	388	1950	WWTP	8	10	5	23	10	6	3	32	51	74	359.2	Medium-Low
Q763-Q803	6	UNK	337	1957	R822	8	10	5	23	10	6	3	32	51	74	359.2	Medium-Low
Q780-Q722	6	VCP	294	1950	WWTP	8	10	5	23	10	6	3	32	51	74	359.2	Medium-Low
Q833-Q906	6	VCP	197	1983	R809	32	10	5	47	10	6	3	8	27	74	359.2	Medium-Low
R1146-R1139	6	PVC	255	1996	R809	8	10	5	23	10	6	3	32	51	74	359.2	Medium-Low
R1147-R1146	6	PVC	159	1996	R809	8	10	5	23	10	6	3	32	51	74	359.2	Medium-Low
R1152-Q1122	6	VCP	209	1966	R809	16	20	5	41	10	6	9	8	33	74	359.2	Medium-Low
R511-Q515	6	VCP/PVC	355	2004	Q631	32	10	5	47	10	6	3	8	27	74	359.2	Medium-Low
R714-R715	6	VCP	394	1950	WWTP	8	10	5	23	10	6	3	32	51	74	359.2	Medium-Low
R720-R721	6	VCP/PVC	475	2004	WWTP	8	10	5	23	10	6	3	32	51	74	359.2	Medium-Low
R776-R778	10	VCP	328	1951	WWTP	16	10	5	31	20	12	3	8	43	74	359.2	Medium-Low
S1023-S1025	6	VCP	51	1966	R809	8	10	5	23	10	24	9	8	51	74	359.2	Medium-Low
S1025-S1026	6	VCP	150	1966	R809	8	10	5	23	10	24	9	8	51	74	359.2	Medium-Low
S1104-S1105	6	VCP	110	1966	R809	8	10	5	23	10	24	9	8	51	74	359.2	Medium-Low
S1105-S1107	6	VCP	67	1966	R809	8	10	5	23	10	24	9	8	51	74	359.2	Medium-Low
S1113-S1112	6	VCP	126	1966	R809	16	20	5	41	10	12	3	8	33	74	359.2	Medium-Low
T612-T610	6	VCP	157	1962	WWTP	32	10	5	47	10	6	3	8	27	74	359.2	Medium-Low
T615-T612	6	VCP	121	1962	WWTP	32	10	5	47	10	6	3	8	27	74	359.2	Medium-Low
T632-T635	6	VCP	202	1962	WWTP	32	10	5	47	10	6	3	8	27	74	359.2	Medium-Low
T634-T635	6	VCP/PVC	139	2003	WWTP	8	10	5	23	10	6	3	32	51	74	359.2	Medium-Low
T646-T647	6	VCP	65	1962	WWTP	32	10	5	47	10	6	3	8	27	74	359.2	Medium-Low
Q669-Q671	8	HDPE	342	2005	Q672	8	10	5	23	30	6	6	8	50	73	354.4	Medium-Low
M605-M606	6	VCP	122	1921	N609	24	10	5	39	10	6	9	8	33	72	349.5	Medium-Low
N798-N799	6	VCP	115	1966	R822	8	10	5	23	20	6	15	8	49	72	349.5	Medium-Low
N811-N812	6	VCP	91	1966	R822	8	20	5	33	10	6	15	8	39	72	349.5	Medium-Low
O750-O751	6	VCP	115	1921	Q679	8	20	5	33	10	6	15	8	39	72	349.5	Medium-Low
O819-O820	6	VCP	101	1966	R822	8	10	5	23	20	6	15	8	49	72	349.5	Medium-Low
O822-O823	6	VCP	71	2014	R822	8	10	5	23	20	6	15	8	49	72	349.5	Medium-Low
O823-O824	6	VCP	122	2014	R822	8	10	5	23	20	6	15	8	49	72	349.5	Medium-Low
O954-O955	6	VCP	64	1966	R809	8	20	5	33	10	6	15	8	39	72	349.5	Medium-Low
O955-O956	6	VCP	121	1966	R809	8	20	5	33	10	6	15	8	39	72	349.5	Medium-Low
P826-Q811	6	VCP	306	1959	R822	24	10	5	39	10	6	9	8	33	72	349.5	Medium-Low
Q725-Q726	6	VCP	87	1950	WWTP	8	20	5	33	10	6	15	8	39	72	349.5	Medium-Low
R1107-R1108	6	VCP	291	1966	R809	24	10	5	39	10	6	9	8	33	72	349.5	Medium-Low
R1151-R1149	6	VCP	83	1966	R809	8	20	5	33	10	6	15	8	39	72	349.5	Medium-Low
R732-R737	6	VCP	228	1950	WWTP	8	10	5	23	20	6	15	8	49	72	349.5	Medium-Low
R782-R783	6	VCP	227	1951	WWTP	24	10	5	39	10	12	3	8	33	72	349.5	Medium-Low
R814-R813	8	VCP	495	1973	R709	24	10	5	39	10	12	3	8	33	72	349.5	Medium-Low
R839-R840	6	VCP	170	1971	R709	24	10	5	39	10	12	3	8	33	72	349.5	Medium-Low
S1016-S1017	6	VCP	173	1966	R809	24	10	5	39	10	12	3	8	33	72	349.5	Medium-Low
S811-S810	6	VCP	154	1976	R709	24	10	5	39	10	12	3	8	33	72	349.5	Medium-Low
S823-S825	8	PVC	159	1973	R709	8	10	5	23	10	12	3	24	49	72	349.5	Medium-Low
S1059-S1054	8	HDPE	223	2003	R809	8	10	20	38	10	12	3	8	33	71	344.7	Medium-Low
S1060-S1059	8	PVC	220	2003	R809	8	10	20	38	10	12	3	8	33	71	344.7	Medium-Low
S1116-S1060	8	PVC	359	2003	R809	8	10	20	38	10	12	3	8	33	71	344.7	Medium-Low
S1117-S1116	8	PVC	357	2003	R809	8	10	20	38	10	12	3	8	33	71	344.7	Medium-Low
S1119-S1118	8	PVC	231	2003	R809	8	10	20	38	10	12	3	8	33	71	344.7	Medium-Low
S1120-S1119	8	PVC	399	2003	R809	8	10	20	38	10	12	3	8	33	71	344.7	Medium-Low
M703-M701	6	VCP	261	1921	N609	8	30	5	43	10	6	3	8	27	70	339.8	Medium-Low
M713-M714	6	VCP	168	1921	N609	8	30	5	43	10	6	3	8	27	70	339.8	Medium-Low
M719-M720	6	VCP	122	1921	N609	8	30	5	43	10	6	3	8	27	70	339.8	Medium-Low
M810-M807	6	CIP	106	1991	R822	16	10	5	31	10	6	15	8	39	70	339.8	Medium-Low
N610-N611	8	PVC	137	1983	Q631	8	10	5	23	30	6	3	8	47	70	339.8	Medium-Low
N636-N637	6	VCP	57	1921	N609	8	30	5	43	10	6	3	8	27	70	339.8	Medium-Low
N7119-N704	6	PVC	278	1989	Q672	8	10	5	23	30	6	3	8	47	70	339.8	Medium-Low
N718-O701	6	VCP	398	1921	Q679	8	30	5	43	10	6	3	8	27	70	339.8	Medium-Low
N746-N747	6	VCP	101	1940	Q679	8	30	5	43	10	6	3	8	27	70	339.8	Medium-Low
N796-N797	8	CIP	86	1966	R822	16	10	5	31	10	6	15	8	39	70	339.8	Medium-Low
N804-N806	8	VCP	195	1966	R822	8	30	5	43	10	6	3	8	27	70	339.8	Medium-Low
N805-N806	6	VCP	289	1966	R822	8	30	5	43	10	6	3	8	27	70	339.8	Medium-Low
N814-N815	6	VCP	309	1966	R822	8	30	5	43	10	6	3	8	27	70	339.8	Medium-Low
N816-N824	6	VCP	245	1966	R822	8	30	5	43	10	6	3	8	27	70	339.8	Medium-Low
N865-N866	6	PVC	90	1987	R822	16	10	5	31	10	6	15	8	39	70	339.8	Medium-Low
O604-O608	10	VCP	44	1947	Q631	8	10	5	23	30	6	3	8	47	70	339.8	Medium-Low
O619-O620	8	PVC	271	1983	Q631	8	10	5	23	30	6	3	8	47	70	339.8	Medium-Low
O621-O622	8	PVC	430	1983	Q631	8	10	5	23	30	6	3	8	47	70	339.8	Medium-Low
O634-O639	6	VCP	216	1984	Q631	8	30	5	43	10	6	3	8	27	70	339.8	Medium-Low
O673-O674	6	VCP	502	1921	R621	8	30	5	43	10	6	3	8	27	70	339.8	Medium-Low
O708-O702	8	VCP/PVC	258	2003	Q679	8	10	5	23	30	6	3	8	47	70	339.8	Medium-Low
O753-O756	6	VCP	235	1921	Q679	8	30	5	43	10	6	3	8	27	70	339.8	Medium-Low
O799-O770	6	VCP	75	1921	Q679	8	30	5	43	10	6	3	8	27	70	339.8	Medium-Low
O915-O916	6	VCP	105	1967	R809	8	30	5	43	10	6	3	8	27	70	339.8	Medium-Low
P615-P616	6	PVC	449	1993	Q631	8	30	5	43	10	6	3	8	27	70	339.8	Medium-Low
P626-Q641	6	VCP	452	1921	R621	8	30	5	43	10	6	3	8	27	70	339.8	Medium-Low
P666-P667	6	VCP	421	1921	Q679	8	30	5	43	10	6	3	8	27	70	339.8	Medium-Low
P825-P824	6	VCP	222	1959	R822	8	30	5	43	10	6	3	8	27	70	339.8	Medium-Low
P903-P902	6	VCP	284	1967	R809	8	30	5	43	10	6	3	8	27	70	339.8	Medium-Low
P909-P910	8	VCP	379	1967	R809	8	30	5	43	10	6	3	8	27	70	339.8	Medium-Low
P910-P911	8	VCP	463	1967	R809	8	30	5	43	10	6	3	8	27	70	339.8	Medium-Low
P913-P912	6	VCP	67	1967	R809	8	30	5	43	10	6	3	8	27	70	339.8	Medium-Low
Q507-Q516	6	VCP	277	1947	Q631	8	30	5	43	10	6	3	8	27	70	339.8	Medium-Low
Q607-Q608	10	PVC	374	1996	Q631	8	10	5	23	30	6	3	8	47	70	339.8	Medium-Low
Q6116-Q662	10	VCP	257	1945	R663	8	30	5	43	10	6	3	8	27	70	339.8	Medium-Low
Q644-Q645	6	VCP	275	1945	R663	8	30	5	43	10	6	3	8	27	70	339.8	Medium-Low
Q648-Q649	8	PVC	328	1990	Q649	8	10	5	23	30	6	3	8	47	70	339.8	Medium-Low
Q666-Q659	8	HDPE	261	2005	R621	8	10	5	23	30	6	3	8	47	70	339.8	Medium-Low
Q672-Q666	8	HDPE	250	2005	R621	8	10	5	23	30	6	3	8	47	70	339.8	Medium-Low
R508-R507	6	VCP	279	1947	Q631	8	30	5	43	10	6	3	8	27	70	339.8	Medium-Low
R517-Q511	6	VCP	233	1947	Q631	8	30	5	43	10	6	3	8	27	70	339.8	Medium-Low
R718-R717	6	VCP/PVC	467	2004	WWTP	8	30	5	43	10	6	3	8	27	70	339.8	Medium-Low
R842-R841	6	VCP	76	1971	R709	8	30	5	43	10	6	3	8	27	70	339.8	Medium-Low
T640-T641	6	VCP	275	1962	WWTP	8	30	5	43	10	6	3	8	27	70	339.8	Medium-Low
T641-T642	6	VCP	140	1962	WWTP	8	30	5	43	10	6	3	8	27	70	339.8	Medium-Low
Q829-R801	8	VCP	322	1967	R809	8	10	5	23	20	6	12	8	46	69	335.0	Medium-Low
R801-R802	10	VCP	191	1973	R809	8	10	5	23	20	6	12	8	46	69	335.0	Medium-Low
O718-O716	6	VCP	225	1921	Q679	16	20	5	41	10	6	3	8	27	68	330.1	Medium-Low
Q750-Q749	6	VCP	260	1950	WWTP	16	20	5	41	10	6	3	8	27	68	330.1	Medium-Low
S1028-S1030	6	VCP	62	1966	R809	8	10	5	23	10	24	3	8	45	68	330.1	Medium-Low
S1040-S1041	6	VCP	51	1966	R809	8	10	5	23	10	18	9	8	45	68	330.1	Medium-Low
S810-S819	6	VCP	90	1976	R709	8	10	5	23	10	12	15	8	45	68	330.1	Medium-Low
S813-S810	6	VCP	200	1976	R709	8	10	5	23	10	12	15	8	45	68	330.1	Medium-Low
S820-S813	6	VCP	67	1976	R709	8	10	5	23	10	12	15	8	45	68	330.1	Medium-Low
S821-S820	6	VCP	204	1976	R709	8	10	5	23	10	12	15	8	45	68	330.1	Medium-Low
S822-S819	6	VCP	216	1976	R709	8	10	5	23	10	12	15	8	45	68	330.1	Medium-Low
T1017-T1016	6	PVC	73	1992	R809	8	10	5	23	10	24	3	8	45	68	330.1	Medium-Low
T1018-T1017	6	PVC	77	1992	R809	8	10	5	23	10	24	3	8	45	68	330.1	Medium-Low
T1019-T1018	6	PVC	161	1992	R809	8	10	5	23	10	24	3	8	45	68	330.1	Medium-Low
T1130-S1122	8	HDPE	223	2003	R809	8	10	5	23	10	24	3	8	45	68	330.1	Medium-Low
M712-M713	6	VCP	156	1921	N609	24	10	5	39	10	6	3	8	27	66	320.4	Medium-Low
M720-M721	6	VCP	350	1921	N609	24	10	5	39	10	6	3	8	27	66	320.4	Medium-Low
M736-M726	6	VCP	405	1921	N609	8	10	5	23	10	6	3	24	43	66	320.4	Medium-Low
N707-N708	6	VCP	145	1921	Q672	24	10	5	39	10	6	3	8	27	66	320.4	Medium-Low
N7118-N737	6	VCP	58	1921	Q679	24	10	5	39	10	6	3	8	27	66	320.4	Medium-Low
N740-N757	6	VCP	262	1940	Q679	24	10	5	39	10	6	3	8	27	66	320.4	Medium-Low
N741-N752	6	VCP	176	1940	Q679	24	10	5	39	10	6	3	8	27	66	320.4	Medium-Low
N745-N746	6	VCP	355	1940	Q679	24	10	5	39	10	6	3	8	27	66	320.4	Medium-Low
N753-N756	6	VCP	308	1940	Q679	24	10	5	39	10	6	3	8	27	66	320.4	Medium-Low
N758-N759	6	VCP	139	1940	Q679	24	10	5	39	10	6	3	8	27	66	320.4	Medium-Low
N771-N773	6	VCP	271	1961	Q679	24	10	5	39	10	6	3	8	27	66	320.4	Medium-Low
N785-N762	6	VCP	154	1921	Q679	24	10	5	39	10	6	3	8	27	66	320.4	Medium-Low
O6117-O6114	6	VCP	85	1921	Q679	24	10	5	39	10	6	3	8	27	66	320.4	Medium-Low
O613-O6145	6	PVC	70	1988	Q631	8	10	5	23	10	6	3	24	43	66	320.4	Medium-Low
O627-O628	6	VCP	118	1921	Q631	24	10	5	39	10	6	3	8	27	66	320.4	Medium-Low
O649-O650	6	PVC	250	1982	Q631	24	10	5	39	10	6	3	8	27	66	320.4	Medium-Low
O683-O684	6	VCP	100	1921	Q649	8	10	5	23	10	6	3	24	43	66	320.4	Medium-Low
O720-O721	6	VCP	292	1921	Q679	24	10	5	39	10	6	3	8	27	66	320.4	Medium-Low
O742-O743	6	VCP	79	1921	Q679	24	10	5	39	10	6	3	8	27	66	320.4	Medium-Low
O757-O763	6	UNK	30	1921	Q679	24	10	5	39	10	6	3	8	27	66	320.4	Medium-Low
O759-O758	6	VCP	51	1921	Q679	24	10	5	39	10	6	3	8	27	66	320.4	Medium-Low

Appendix B. Detailed Risk Assessment Results

Pipe Number	Diameter, inches	Material	Length, linear feet	Installation Year	Basin	Likelihood of Failure Score: Structural Failure Rate	Likelihood of Failure Score: Maintenance Failure Rate	Likelihood of Failure Score: Hydraulic Capacity Failure Rate	Likelihood of Failure Score: Total Score	Consequence of Failure Score: Potential Spill Volume	Consequence of Failure Score: Environmental Impact	Consequence of Failure Score: Emergency Response and Construction Impact	Consequence of Failure Score: Public Exposure	Consequence of Failure Score: Total Score	Risk Score: Total Risk	Risk Score: Normalized Risk	Risk Level
O771-O772	6	VCP	153	1921	Q679	24	10	5	39	10	6	3	8	27	66	320.4	Medium-Low
O777-O775	6	VCP	179	1921	Q679	24	10	5	39	10	6	3	8	27	66	320.4	Medium-Low
O789-P711	6	VCP	179	1921	Q679	24	10	5	39	10	6	3	8	27	66	320.4	Medium-Low
O814-O815	6	VCP	29	1973	R822	24	10	5	39	10	6	3	8	27	66	320.4	Medium-Low
O826-O827	6	VCP	295	1973	R822	8	10	5	23	20	6	9	8	43	66	320.4	Medium-Low
O939-O940	6	VCP	110	1987	R809	24	10	5	39	10	6	3	8	27	66	320.4	Medium-Low
P622-P623	6	VCP	129	1921	R621	24	10	5	39	10	6	3	8	27	66	320.4	Medium-Low
P773-P774	6	VCP/PVC	398	2006	R822	8	10	5	23	10	6	3	24	43	66	320.4	Medium-Low
P816-P817	6	VCP	167	1959	R822	8	10	5	23	10	6	3	24	43	66	320.4	Medium-Low
P828-Q830	6	PVC	313	1983	R809	24	10	5	39	10	6	3	8	27	66	320.4	Medium-Low
Q1109-Q1126	6	VCP	190	1966	R809	24	10	5	39	10	6	3	8	27	66	320.4	Medium-Low
Q1122-Q1119	8	VCP	63	1966	R809	24	10	5	39	10	6	3	8	27	66	320.4	Medium-Low
Q509-Q510	6	VCP	124	1947	Q631	24	10	5	39	10	6	3	8	27	66	320.4	Medium-Low
Q512-Q511	6	VCP	225	1947	Q631	24	10	5	39	10	6	3	8	27	66	320.4	Medium-Low
Q514-Q515	6	VCP	256	1947	Q631	24	10	5	39	10	6	3	8	27	66	320.4	Medium-Low
Q628-Q631	6	VCP	379	1943	Q631	24	10	5	39	10	6	3	8	27	66	320.4	Medium-Low
Q636-R626	6	VCP	137	1949	R663	24	10	5	39	10	6	3	8	27	66	320.4	Medium-Low
Q661-Q662	6	PVC	350	1989	R663	24	10	5	39	10	6	3	8	27	66	320.4	Medium-Low
Q714-Q715	6	VCP	151	1950	WWTP	24	10	5	39	10	6	3	8	27	66	320.4	Medium-Low
Q815-Q816	6	VCP	261	1959	R822	24	10	5	39	10	6	3	8	27	66	320.4	Medium-Low
R1013-R1005	8	OTHER	184	1973	R809	8	10	5	23	20	12	3	8	43	66	320.4	Medium-Low
R1106-R1107	6	VCP	253	1966	R809	24	10	5	39	10	6	3	8	27	66	320.4	Medium-Low
R1148-R1147	6	PVC	154	1996	R809	8	10	5	23	10	6	3	24	43	66	320.4	Medium-Low
R516-R517	6	VCP	113	1947	Q631	24	10	5	39	10	6	3	8	27	66	320.4	Medium-Low
R536-R521	6	VCP	129	1949	WWTP	24	10	5	39	10	6	3	8	27	66	320.4	Medium-Low
R540-R529	6	VCP	108	1950	WWTP	24	10	5	39	10	6	3	8	27	66	320.4	Medium-Low
R602-R604	6	VCP	246	1950	WWTP	24	10	5	39	10	6	3	8	27	66	320.4	Medium-Low
R717-R795	6	VCP	301	1950	WWTP	24	10	5	39	10	6	3	8	27	66	320.4	Medium-Low
R721-R722	6	VCP/PVC	376	2004	WWTP	8	10	5	23	10	6	3	24	43	66	320.4	Medium-Low
R783-R786	10	VCP	154	1951	WWTP	8	10	5	23	20	12	3	8	43	66	320.4	Medium-Low
R829-R830	6	VCP	400	1971	R709	8	10	5	23	10	6	3	24	43	66	320.4	Medium-Low
S1048-S1046	8	PVC	21	1992	R809	8	10	5	23	20	12	3	8	43	66	320.4	Medium-Low
S1049-S1048	8	PVC	359	1992	R809	8	10	5	23	20	12	3	8	43	66	320.4	Medium-Low
S1050-S1049	8	PVC	244	1992	R809	8	10	5	23	20	12	3	8	43	66	320.4	Medium-Low
S1051-S1050	8	PVC	293	1992	R809	8	10	5	23	20	12	3	8	43	66	320.4	Medium-Low
S1052-S1051	8	PVC	266	1992	R809	8	10	5	23	20	12	3	8	43	66	320.4	Medium-Low
S1053-S1052	8	PVC	192	1992	R809	8	10	5	23	20	12	3	8	43	66	320.4	Medium-Low
S1054-S1053	8	PVC	205	1992	R809	8	10	5	23	20	12	3	8	43	66	320.4	Medium-Low
S620-S604	6	VCP	166	1962	WWTP	24	10	5	39	10	6	3	8	27	66	320.4	Medium-Low
T619-T608	6	VCP	134	1962	WWTP	24	10	5	39	10	6	3	8	27	66	320.4	Medium-Low
T626-T628	6	VCP	214	1962	WWTP	24	10	5	39	10	6	3	8	27	66	320.4	Medium-Low
T631-T632	6	VCP/PVC	161	2003	WWTP	8	10	5	23	10	6	3	24	43	66	320.4	Medium-Low
T633-T632	6	VCP	431	1962	WWTP	24	10	5	39	10	6	3	8	27	66	320.4	Medium-Low
N748-N755	6	VCP	104	1940	Q679	8	10	20	38	10	6	3	8	27	65	315.5	Medium-Low
N801-N890	6	VCP	146	1966	R822	8	10	20	38	10	6	3	8	27	65	315.5	Medium-Low
N890-N7124	6	VCP	96	1966	R822	8	10	20	38	10	6	3	8	27	65	315.5	Medium-Low
R1111-R1117	6	VCP	387	1966	R809	8	10	20	38	10	6	3	8	27	65	315.5	Medium-Low
R1117-R1118	6	VCP	147	1966	R809	8	10	20	38	10	6	3	8	27	65	315.5	Medium-Low
R1118-R1119	6	VCP	166	1966	R809	8	10	20	38	10	6	3	8	27	65	315.5	Medium-Low
O784-P716	6	VCP	187	1996	Q679	8	10	5	23	20	6	6	8	40	63	305.8	Medium-Low
M808-M810	6	VCP	110	1991	R822	8	10	5	23	10	6	15	8	39	62	301.0	Medium-Low
N773-N777	6	VCP	446	1961	Q679	8	10	5	23	10	6	15	8	39	62	301.0	Medium-Low
N809-N810	6	VCP	94	1966	R822	8	10	5	23	10	6	15	8	39	62	301.0	Medium-Low
N810-N807	6	VCP	97	1966	R822	8	10	5	23	10	6	15	8	39	62	301.0	Medium-Low
N861-N862	6	PVC	137	1987	R822	8	10	5	23	10	6	15	8	39	62	301.0	Medium-Low
N862-N863	6	PVC	75	1987	R822	8	10	5	23	10	6	15	8	39	62	301.0	Medium-Low
N863-N864	6	PVC	209	1987	R822	8	10	5	23	10	6	15	8	39	62	301.0	Medium-Low
N864-N865	6	PVC	87	1987	R822	8	10	5	23	10	6	15	8	39	62	301.0	Medium-Low
N866-N867	6	PVC	122	1987	R822	8	10	5	23	10	6	15	8	39	62	301.0	Medium-Low
N867-N868	6	PVC	257	1987	R822	8	10	5	23	10	6	15	8	39	62	301.0	Medium-Low
N868-N869	6	PVC	237	1987	R822	8	10	5	23	10	6	15	8	39	62	301.0	Medium-Low
N869-N870	6	PVC	256	1987	R822	8	10	5	23	10	6	15	8	39	62	301.0	Medium-Low
N870-O843	6	PVC	61	1987	R822	8	10	5	23	10	6	15	8	39	62	301.0	Medium-Low
N876-N861	6	PVC	93	1987	R822	8	10	5	23	10	6	15	8	39	62	301.0	Medium-Low
N922-N923	6	VCP	136	1987	R809	8	10	5	23	10	6	15	8	39	62	301.0	Medium-Low
O6131-O6132	6	VCP	52	1921	Q631	8	10	5	23	10	6	15	8	39	62	301.0	Medium-Low
O6137-O6138	6	PVC	93	1991	Q631	8	10	5	23	10	6	15	8	39	62	301.0	Medium-Low
O811-O812	6	VCP	175	1973	R822	8	10	5	23	10	6	15	8	39	62	301.0	Medium-Low
O842-O826	6	VCP	54	1966	R822	8	10	5	23	10	6	15	8	39	62	301.0	Medium-Low
O843-O844	6	PVC	118	1987	R822	8	10	5	23	10	6	15	8	39	62	301.0	Medium-Low
O844-O845	6	PVC	215	1987	R822	8	10	5	23	10	6	15	8	39	62	301.0	Medium-Low
O903-O811	6	VCP	156	1973	R822	8	10	5	23	10	6	15	8	39	62	301.0	Medium-Low
O909-O910	6	VCP	248	1967	R809	8	10	5	23	10	6	15	8	39	62	301.0	Medium-Low
O910-O911	6	VCP	49	1967	R809	8	10	5	23	10	6	15	8	39	62	301.0	Medium-Low
O911-O912	6	UNK	35	1967	R809	8	10	5	23	10	6	15	8	39	62	301.0	Medium-Low
O916-O912	6	VCP	84	1967	R809	8	10	5	23	10	6	15	8	39	62	301.0	Medium-Low
O927-O961	6	VCP	39	1967	R809	8	10	5	23	10	6	15	8	39	62	301.0	Medium-Low
O949-O950	6	VCP	129	1966	R809	8	10	5	23	10	6	15	8	39	62	301.0	Medium-Low
O950-O951	6	VCP	92	1966	R809	8	10	5	23	10	6	15	8	39	62	301.0	Medium-Low
O953-O954	6	VCP	89	1966	R809	8	10	5	23	10	6	15	8	39	62	301.0	Medium-Low
O956-O957	6	VCP	89	1966	R809	8	10	5	23	10	6	15	8	39	62	301.0	Medium-Low
O957-O958	6	VCP	106	1966	R809	8	10	5	23	10	6	15	8	39	62	301.0	Medium-Low
O959-P925	6	VCP	119	1966	R809	8	10	5	23	10	6	15	8	39	62	301.0	Medium-Low
O961-O962	6	VCP	37	1967	R809	8	10	5	23	10	6	15	8	39	62	301.0	Medium-Low
P658-P659	6	VCP/PVC	283	2003	Q679	8	10	5	23	10	6	15	8	39	62	301.0	Medium-Low
P706-P753	6	VCP	479	1942	WWTP	8	10	5	23	10	6	15	8	39	62	301.0	Medium-Low
P821-P826	6	VCP	312	1959	R822	8	10	5	23	10	6	15	8	39	62	301.0	Medium-Low
P919-P918	6	UNK	53	1966	R809	8	10	5	23	10	6	15	8	39	62	301.0	Medium-Low
P921-P920	6	UNK	75	1966	R809	8	10	5	23	10	6	15	8	39	62	301.0	Medium-Low
P925-P924	6	UNK	93	1966	R809	8	10	5	23	10	6	15	8	39	62	301.0	Medium-Low
Q1102-Q1103	6	VCP	127	1966	R809	8	10	5	23	10	6	15	8	39	62	301.0	Medium-Low
Q1110-Q1112	6	VCP	263	1966	R809	8	10	5	23	10	6	15	8	39	62	301.0	Medium-Low
Q1134-Q1133	6	PVC	157	1996	R809	8	10	5	23	10	6	15	8	39	62	301.0	Medium-Low
Q712-Q713	6	PVC	95	1983	WWTP	8	10	5	23	10	6	15	8	39	62	301.0	Medium-Low
Q742-Q743	6	VCP	90	1950	WWTP	8	10	5	23	10	6	15	8	39	62	301.0	Medium-Low
Q912-Q909	6	PVC	180	1983	R809	8	10	5	23	10	6	15	8	39	62	301.0	Medium-Low
R1101-R1102	6	VCP	81	1966	R809	8	10	5	23	10	6	15	8	39	62	301.0	Medium-Low
R1102-R1103	6	VCP	132	1966	R809	8	10	5	23	10	6	15	8	39	62	301.0	Medium-Low
R1103-R1104	6	CIP	241	1966	R809	8	10	5	23	10	6	15	8	39	62	301.0	Medium-Low
R1121-R1145	6	VCP	138	1966	R809	8	10	5	23	10	6	15	8	39	62	301.0	Medium-Low
R1126-R1129	6	VCP	225	1966	R809	8	10	5	23	10	6	15	8	39	62	301.0	Medium-Low
R1130-R1102	6	VCP	89	1966	R809	8	10	5	23	10	6	15	8	39	62	301.0	Medium-Low
R1131-R1102	6	VCP	78	1966	R809	8	10	5	23	10	6	15	8	39	62	301.0	Medium-Low
R1134-R1136	6	VCP	373	1966	R809	8	10	5	23	10	6	15	8	39	62	301.0	Medium-Low
R1137-R1138	6	VCP	377	1966	R809	8	10	5	23	10	6	15	8	39	62	301.0	Medium-Low
R1144-R1128	6	VCP	58	1966	R809	8	10	5	23	10	6	15	8	39	62	301.0	Medium-Low
R1145-R1137	6	VCP	139	1966	R809	8	10	5	23	10	6	15	8	39	62	301.0	Medium-Low
S1007-S1011	6	VCP	258	1966	R809	8	10	5	23	10	12	9	8	39	62	301.0	Medium-Low
S1011-S1012	6	VCP	92	1966	R809	8	10	5	23	10	12	9	8	39	62	301.0	Medium-Low
S1013-S1014	6	VCP	56	1966	R809	8	10	5	23	10	12	9	8	39	62	301.0	Medium-Low
S1030-S1032	6	VCP	65	1966	R809	8	10	5	23	10	18	3	8	39	62	301.0	Medium-Low
S1032-S1033	6	VCP	79	1966	R809	8	10	5	23	10	18	3	8	39	62	301.0	Medium-Low
S637-S606	6	VCP/PVC	172	2003	WWTP	8	10	5	23	10	18	3	8	39	62	301.0	Medium-Low
S827-S823	6	PVC	160	1973	R709	8	10	5	23	10	12	9	8	39	62	301.0	Medium-Low
S835-S836	6	VCP	163	1973	R709	8	10	5	23	10	18	3	8	39	62	301.0	Medium-Low
S839-S838	6	PVC	119	1973	R709	8	10	5	23	10	18	3	8	39	62	301.0	Medium-Low
S841-S838	6	PVC	122	1973	R709	8	10	5	23	10	18	3	8	39	62	301.0	Medium-Low
T1004-T1003	6	PVC	109	1992	R809	8	10	5	23	10	18	3	8	39	62	301.0	Medium-Low
T1005-T1004	6	PVC	159	1992	R809	8	10	5	23	10	18	3	8	39	62	301.0	Medium-Low
T1006-T1005	6	PVC	151	1992	R809	8	10	5	23	10	18	3	8	39	62	301.0	Medium-Low
T1007-T1006	6	PVC	329	1992	R809	8	10	5	23	10	18	3	8	39	62	301.0	Medium-Low
T1020-T1019	6	PVC	177	1992	R809	8	10	5	23	10	18	3	8	39	62	301.0	Medium-Low
T1021-T1020	6	PVC	218	1992	R809	8	10	5	23	10	18	3	8	39	62	301.0	Medium-Low
T1122-T1021	6	PVC	238	1992	R809	8	10	5	23	10	18	3	8	39	62	301.0	Medium-Low
T1123-T1122	6	PVC	117	1992	R809	8	10	5	23	10	18	3	8	39	62	301.0	Medium-Low
T1127-T1126	8	PVC	184	2003	R809	8	10	5	23	10	18	3	8	39	62	301.0	Medium-Low
T1128-T1127	8	PVC	385	2003	R809	8	10	5	23	10	18	3	8	39	62	301.0	Medium-Low
T617-T616	6	VCP	99	1962	WWTP	8	10	5	23	10	6	15	8	39	62	301.0	Medium-Low
R605-R604	6	VCP	137	1950	WWTP	8	20	5	33	20	6	3	8	37	70	339.8	Low
Q827-Q828	8	VCP	393	1967	R809	16	10	5	31	20	6	3	8	37	68	330.1	Low
P771-Q739	6	VCP	209	1950	WWTP	8	20	5	33	10	6	9	8	33	66	320.4	Low
R1143-R1110	6	VCP	134	1966	R809	8	20	5	33	10	6	9	8	33	66	320.4	Low
R759-R767	10	VCP	243	1951	WWTP	8	20	5	33	10	12	3	8	33	66	320.4	Low
R768-R791	10	VCP	129	1951	WWTP	8	20	5	33	10	12	3	8	33	66	320.4	Low
S1110-S1111	6	VCP	91	1966	R809	8	20	5	33	10	12	3	8	33	66	320.4	Low
N7113-N7111	6	PVC	138	1987	R822	16	10	5	31	10	6	9	8	33	64	310.7	Low
Q1107-Q1108	8	VCP	118	1966	R809	16	10	5	31	10	6	9	8	33	64	310.7	Low
Q1113-Q1115	6	VCP	79	1966	R809	16	10	5	31	10	6	9	8	33	64	310.7	Low
R840-R841	6	VCP	251	1971	R709	16	10	5	31	10	12	3	8	33	64	310.7	Low
S1002-S1004	6	VCP	98	1966	R809	16	10	5	31	10	12	3	8	33	64	310.7	Low
S1111-S1112	6	VCP	31	1966	R809	16	10	5	31	10	12	3	8	33	64	310.7	Low
S1112-S1002	6	VCP	194	1966	R809	16	10	5	31	10	12	3	8	33	64	310.7	Low
S814-S808	6	VCP	350	1976	R709	16	10	5	31	10	12	3	8	33	64	310.7	Low
S848-S713	6	CIP	111	1971	R709	16	10	5	31	10	12	3	8	33	64	310.7	Low
M607-M609	6	VCP/PVC	110	2003	N609	8	10	5	23	20	6	3	8	37	60	291.3	Low
M726-M748	6	VCP/PVC	362	2004	N609	8	10	5	23	20	6	3	8	37	60	291.3	Low
M747-M748	6	VCP/PVC	218	2004	N609	8	10	5	23	20	6	3	8	37	60	291.3	Low
M782-M607	6	VCP/PVC	239	2004	N609	8	10	5	23	20	6	3	8	37	60	291.3	Low
N639-M615	6	VCP	202	1921	N609	8	10	5	23	20	6	3	8	37	60	291.3	Low
N705-N706	6	VCP	194	1921	Q672	8	20	5	33	10	6	3	8	27	60	291.3	Low
N776-N777	6	VCP	119	1961	Q679	8	20	5	33	10	6	3	8	27	60	291.3	Low
O713-O712	6	UNK	31	1921	Q679	8	10	5	23	20	6	3	8	37	60	291.3	Low
O803-O804	8	VCP	247	1957	R822	8	10	5	23	20	6	3	8	37	60	291.3	Low
O810-O815	6	VCP	201	1973	R822	8	10	5	23	20	6	3	8	37	60	291.3	Low
O815-O817	6	VCP	203	1973	R822	8	10	5	23	20	6	3	8	37	60	291.3	Low
O816-O904	6	VCP	194	1973	R822	8	10	5	23	20	6	3	8	37	60	291.3	Low
O817-O816	6	VCP	197	1973	R822	8	10	5	23	20	6	3	8	37	60	291.3	Low
O818-O819	6	VCP	85	1973	R822	8	10	5	23	20	6	3	8	37	60	291.3	Low
O838-O810	6	VCP	176	1973	R822	8	10	5	23	20	6	3	8	37	60	291.3	Low
O905-O906	6	VCP	78	1973	R822	8	10	5	23	20	6	3	8	37	60	291.3	Low
O906-O818	6	VCP	98	1973	R822	8	10	5	23	20	6	3	8	37	60	291.3	Low
P613-P614	6	PVC	452	1993	Q631	8	20	5	33	10	6	3	8	27	60	291.3	Low
P630-P633	8	PVC	454	1990	Q649	8	10	5	23	20	6	3	8	37	60	291.3	Low
P633-P634	8	PVC	448	1990	Q649	8	10	5	23	20	6	3	8	37	60	291.3	Low
P716-P718	6	VCP	124	1996	Q679	8	10	5	23	20	6	3	8	37	60	291.3	Low
P718-P720	6	VCP	97	1996	Q679	8	10	5	23	20	6	3	8	37	60	291.3	Low

Appendix B. Detailed Risk Assessment Results

Pipe Number	Diameter, inches	Material	Length, linear feet	Installation Year	Basin	Likelihood of Failure Score				Consequence of Failure Score					Risk Score		Risk Level
						Structural Failure Rate	Maintenance Failure Rate	Hydraulic Capacity Failure Rate	Total Score	Potential Spill Volume	Environmental Impact	Emergency Response and Construction Impact	Public Exposure	Total Score	Total Risk	Normalized Risk	
P721-P723	6	VCP	112	1996	Q679	8	10	5	23	20	6	3	8	37	60	291.3	Low
P725-P726	6	VCP	207	1996	Q679	8	10	5	23	20	6	3	8	37	60	291.3	Low
Q6101-Q6110	6	VCP	125	1942	WWTP	8	10	5	23	20	6	3	8	37	60	291.3	Low
Q903-Q904	8	VCP	264	1967	R809	8	10	5	23	20	6	3	8	37	60	291.3	Low
Q904-Q905	8	VCP	142	1967	R809	8	10	5	23	20	6	3	8	37	60	291.3	Low
R1141-R1001	8	VCP	325	1966	R809	8	10	5	23	20	6	3	8	37	60	291.3	Low
S1055-S1054	8	PVC	128	1992	R809	8	10	5	23	20	6	3	8	37	60	291.3	Low
S1056-S1055	8	PVC	142	1992	R809	8	10	5	23	20	6	3	8	37	60	291.3	Low
S1057-S1056	8	PVC	113	1992	R809	8	10	5	23	20	6	3	8	37	60	291.3	Low
N701-N702	6	VCP/PVC	352	2004	Q672	8	10	5	23	10	6	12	8	36	59	286.4	Low
Q685-Q686	6	VCP	143	1942	WWTP	8	10	5	23	10	6	12	8	36	59	286.4	Low
M717-M718	6	VCP	335	1921	N609	16	10	5	31	10	6	3	8	27	58	281.6	Low
N627-N628	6	VCP	179	1921	Q631	16	10	5	31	10	6	3	8	27	58	281.6	Low
N640-N713	6	VCP	373	1921	Q672	16	10	5	31	10	6	3	8	27	58	281.6	Low
N743-N744	6	VCP	261	1940	Q679	16	10	5	31	10	6	3	8	27	58	281.6	Low
N817-N822	6	VCP	400	1966	R822	16	10	5	31	10	6	3	8	27	58	281.6	Low
N855-N857	6	PVC	80	1987	R822	16	10	5	31	10	6	3	8	27	58	281.6	Low
N860-N861	6	PVC	109	1987	R822	16	10	5	31	10	6	3	8	27	58	281.6	Low
O6134-O6133	6	PVC	119	1984	Q631	16	10	5	31	10	6	3	8	27	58	281.6	Low
O638-O639	6	PVC	93	1989	Q631	16	10	5	31	10	6	3	8	27	58	281.6	Low
O717-O716	6	VCP	196	1921	Q679	16	10	5	31	10	6	3	8	27	58	281.6	Low
O752-O753	6	VCP	173	1921	Q679	16	10	5	31	10	6	3	8	27	58	281.6	Low
O921-P901	8	VCP	250	1967	R809	16	10	5	31	10	6	3	8	27	58	281.6	Low
P908-P909	8	VCP	364	1967	R809	16	10	5	31	10	6	3	8	27	58	281.6	Low
Q1106-Q1107	6	VCP	138	1966	R809	16	10	5	31	10	6	3	8	27	58	281.6	Low
Q1119-Q1129	8	VCP	182	1966	R809	16	10	5	31	10	6	3	8	27	58	281.6	Low
Q645-Q647	6	VCP	274	1945	R663	16	10	5	31	10	6	3	8	27	58	281.6	Low
Q660-Q661	6	PVC	327	1989	R663	16	10	5	31	10	6	3	8	27	58	281.6	Low
Q811-Q814	6	VCP	458	1959	R822	16	10	5	31	10	6	3	8	27	58	281.6	Low
R1123A-R1123	6	VCP	108	0	R809	16	10	5	31	10	6	3	8	27	58	281.6	Low
R521-R522	6	VCP	74	1949	WWTP	16	10	5	31	10	6	3	8	27	58	281.6	Low
R716-R715	6	VCP	148	1950	WWTP	16	10	5	31	10	6	3	8	27	58	281.6	Low
R727-R728	6	VCP	298	1950	WWTP	16	10	5	31	10	6	3	8	27	58	281.6	Low
R836-R841	6	VCP	128	1971	R709	16	10	5	31	10	6	3	8	27	58	281.6	Low
T1029-T1008	6	PVC	157	1992	R809	16	10	5	31	10	6	3	8	27	58	281.6	Low
T1119-T1118	6	PVC	213	1992	R809	16	10	5	31	10	6	3	8	27	58	281.6	Low
T638-T639	6	VCP	130	1962	WWTP	16	10	5	31	10	6	3	8	27	58	281.6	Low
M709-M708	6	VCP	31	1921	N609	8	10	5	23	10	6	9	8	33	56	271.8	Low
M804-N850	6	VCP	183	1991	R822	8	10	5	23	10	6	9	8	33	56	271.8	Low
M805-M804	6	VCP	208	1991	R822	8	10	5	23	10	6	9	8	33	56	271.8	Low
M806-M805	6	VCP	134	1991	R822	8	10	5	23	10	6	9	8	33	56	271.8	Low
M807-N849	6	VCP	209	1991	R822	8	10	5	23	10	6	9	8	33	56	271.8	Low
N7108-N794	6	PVC	119	1987	R822	8	10	5	23	10	6	9	8	33	56	271.8	Low
N7114-N7116	6	PVC	71	1987	R822	8	10	5	23	10	6	9	8	33	56	271.8	Low
N7115-N7116	6	PVC	47	1987	R822	8	10	5	23	10	6	9	8	33	56	271.8	Low
N7116-N7111	6	PVC	70	1987	R822	8	10	5	23	10	6	9	8	33	56	271.8	Low
N849-N802	6	VCP	26	1966	R822	8	10	5	23	10	6	9	8	33	56	271.8	Low
N850-N849	6	VCP	197	1991	R822	8	10	5	23	10	6	9	8	33	56	271.8	Low
N923-N924	6	VCP	220	1987	R809	8	10	5	23	10	6	9	8	33	56	271.8	Low
N924-N915	6	VCP	69	1987	R809	8	10	5	23	10	6	9	8	33	56	271.8	Low
O6138-O654	8	PVC	81	1991	Q631	8	10	5	23	10	6	9	8	33	56	271.8	Low
O6139-O6138	8	PVC	95	1991	Q631	8	10	5	23	10	6	9	8	33	56	271.8	Low
O901-O902	6	VCP	51	1973	R822	8	10	5	23	10	6	9	8	33	56	271.8	Low
Q1108-Q1109	8	VCP	153	1966	R809	8	10	5	23	10	6	9	8	33	56	271.8	Low
Q1114-Q1115	6	VCP	121	1966	R809	8	10	5	23	10	6	9	8	33	56	271.8	Low
Q1115-Q1109	6	VCP	314	1966	R809	8	10	5	23	10	6	9	8	33	56	271.8	Low
Q1123-Q1124	6	VCP	132	1966	R809	8	10	5	23	10	6	9	8	33	56	271.8	Low
R1105-R1106	6	VCP	60	1966	R809	8	10	5	23	10	6	9	8	33	56	271.8	Low
R1109-R1110	6	VCP	135	1966	R809	8	10	5	23	10	6	9	8	33	56	271.8	Low
R740-R741	6	VCP	153	1991	WWTP	8	10	5	23	10	6	9	8	33	56	271.8	Low
R758-R792	6	VCP	131	1951	WWTP	8	10	5	23	10	12	3	8	33	56	271.8	Low
R762-R768	8	VCP	133	1951	WWTP	8	10	5	23	10	12	3	8	33	56	271.8	Low
R770-R769	6	VCP	192	1951	WWTP	8	10	5	23	10	12	3	8	33	56	271.8	Low
S1003-S1004	6	VCP	114	1966	R809	8	10	5	23	10	12	3	8	33	56	271.8	Low
S1005-S1006	6	VCP	140	1966	R809	8	10	5	23	10	12	3	8	33	56	271.8	Low
S1014-S1015	6	VCP	108	1966	R809	8	10	5	23	10	12	3	8	33	56	271.8	Low
S1015-S1017	6	VCP	248	1966	R809	8	10	5	23	10	12	3	8	33	56	271.8	Low
S1017-S1020	8	VCP	66	1966	R809	8	10	5	23	10	12	3	8	33	56	271.8	Low
S1018-S1019	6	VCP	183	1966	R809	8	10	5	23	10	12	3	8	33	56	271.8	Low
S1020-S1022	8	VCP	115	1966	R809	8	10	5	23	10	12	3	8	33	56	271.8	Low
S1022-S1043	6	VCP	185	1966	R809	8	10	5	23	10	12	3	8	33	56	271.8	Low
S1033-S1039	6	VCP	109	1966	R809	8	10	5	23	10	12	3	8	33	56	271.8	Low
S1036-S1038	6	VCP	208	1966	R809	8	10	5	23	10	12	3	8	33	56	271.8	Low
S1039-S1042	8	VCP	76	1966	R809	8	10	5	23	10	12	3	8	33	56	271.8	Low
S1042-S1043	8	VCP	157	1966	R809	8	10	5	23	10	12	3	8	33	56	271.8	Low
S1045-S1046	8	VCP	103	1966	R809	8	10	5	23	10	12	3	8	33	56	271.8	Low
S1108-S1109	6	VCP	128	1966	R809	8	10	5	23	10	12	3	8	33	56	271.8	Low
S1109-S1111	6	VCP	57	1966	R809	8	10	5	23	10	12	3	8	33	56	271.8	Low
S1118-S1117	8	PVC	211	2003	R809	8	10	5	23	10	12	3	8	33	56	271.8	Low
S713-S847	8	CIP	167	1971	R709	8	10	5	23	10	12	3	8	33	56	271.8	Low
S808-S809	6	VCP	63	1976	R709	8	10	5	23	10	12	3	8	33	56	271.8	Low
S809-S811	6	VCP	129	1976	R709	8	10	5	23	10	12	3	8	33	56	271.8	Low
S816-S814	6	VCP	46	1976	R709	8	10	5	23	10	12	3	8	33	56	271.8	Low
S817-S818	6	VCP	165	1976	R709	8	10	5	23	10	12	3	8	33	56	271.8	Low
S818-S844	6	VCP	171	1976	R709	8	10	5	23	10	12	3	8	33	56	271.8	Low
S828-S827	6	PVC	171	1973	R709	8	10	5	23	10	12	3	8	33	56	271.8	Low
S829-S828	6	VCP	109	1973	R709	8	10	5	23	10	12	3	8	33	56	271.8	Low
S830-S831	6	VCP	122	1973	R709	8	10	5	23	10	12	3	8	33	56	271.8	Low
S831-S836	6	VCP	268	1973	R709	8	10	5	23	10	12	3	8	33	56	271.8	Low
S832-S831	6	VCP	124	1973	R709	8	10	5	23	10	12	3	8	33	56	271.8	Low
S833-S830	6	VCP	74	1973	R709	8	10	5	23	10	12	3	8	33	56	271.8	Low
S834-S828	5	VCP	105	1973	R709	8	10	5	23	10	12	3	8	33	56	271.8	Low
S837-S840	6	PVC	68	1973	R709	8	10	5	23	10	12	3	8	33	56	271.8	Low
S838-S837	6	PVC	75	1973	R709	8	10	5	23	10	12	3	8	33	56	271.8	Low
S840-S823	8	PVC	80	1973	R709	8	10	5	23	10	12	3	8	33	56	271.8	Low
S842-S840	6	PVC	269	1973	R709	8	10	5	23	10	12	3	8	33	56	271.8	Low
S844-S820	6	VCP	125	1976	R709	8	10	5	23	10	12	3	8	33	56	271.8	Low
O782-O761	6	VCP	224	1921	Q679	8	10	5	23	10	6	6	8	30	53	257.3	Low
M704-M782	6	VCP	219	1921	N609	8	10	5	23	10	6	3	8	27	50	242.7	Low
M706-M782	6	VCP/PVC	115	2004	N609	8	10	5	23	10	6	3	8	27	50	242.7	Low
M715-M716	6	VCP/PVC	143	2004	N609	8	10	5	23	10	6	3	8	27	50	242.7	Low
M718-M724	6	VCP/PVC	171	2004	N609	8	10	5	23	10	6	3	8	27	50	242.7	Low
M722-M723	6	VCP	86	1921	N609	8	10	5	23	10	6	3	8	27	50	242.7	Low
M724-M725	6	VCP/PVC	168	2004	N609	8	10	5	23	10	6	3	8	27	50	242.7	Low
M746-M747	6	VCP/PVC	451	2004	N609	8	10	5	23	10	6	3	8	27	50	242.7	Low
M748-M749	6	VCP/PVC	115	2004	N609	8	10	5	23	10	6	3	8	27	50	242.7	Low
M749-M711	6	VCP/PVC	210	2004	N609	8	10	5	23	10	6	3	8	27	50	242.7	Low
M802-N801	6	VCP	207	1966	R822	8	10	5	23	10	6	3	8	27	50	242.7	Low
N620-O659	6	PVC	451	1996	Q631	8	10	5	23	10	6	3	8	27	50	242.7	Low
N625-N626	6	VCP	20	1921	Q631	8	10	5	23	10	6	3	8	27	50	242.7	Low
N637-N639	6	VCP	194	1921	N609	8	10	5	23	10	6	3	8	27	50	242.7	Low
N670-N636	6	VCP	92	1921	N609	8	10	5	23	10	6	3	8	27	50	242.7	Low
N7109-N7108	6	PVC	116	1987	R822	8	10	5	23	10	6	3	8	27	50	242.7	Low
N7110-N7109	6	PVC	41	1987	R822	8	10	5	23	10	6	3	8	27	50	242.7	Low
N7111-N7109	6	PVC	149	1987	R822	8	10	5	23	10	6	3	8	27	50	242.7	Low
N7112-N7111	6	PVC	86	1987	R822	8	10	5	23	10	6	3	8	27	50	242.7	Low
N7117-N760	6	VCP	166	1921	Q679	8	10	5	23	10	6	3	8	27	50	242.7	Low
N719-N720	6	VCP	240	1921	Q679	8	10	5	23	10	6	3	8	27	50	242.7	Low
N721-N722	6	VCP	459	1921	Q679	8	10	5	23	10	6	3	8	27	50	242.7	Low
N731-N732	6	VCP	460	1921	Q679	8	10	5	23	10	6	3	8	27	50	242.7	Low
N734-N736	6	VCP	450	1921	Q679	8	10	5	23	10	6	3	8	27	50	242.7	Low
N738-N739	6	VCP	329	1940	Q679	8	10	5	23	10	6	3	8	27	50	242.7	Low
N739-N740	6	VCP	364	1940	Q679	8	10	5	23	10	6	3	8	27	50	242.7	Low
N756-N757	6	VCP	139	1940	Q679	8	10	5	23	10	6	3	8	27	50	242.7	Low
N775-N776	6	VCP	206	1961	Q679	8	10	5	23	10	6	3	8	27	50	242.7	Low
N815-N816	6	VCP	300	1966	R822	8	10	5	23	10	6	3	8	27	50	242.7	Low
N823-N824	6	VCP	120	1966	R822	8	10	5	23	10	6	3	8	27	50	242.7	Low
N824-N825	6	VCP	169	1966	R822	8	10	5	23	10	6	3	8	27	50	242.7	Low
N830-N831	6	VCP	297	1973	R822	8	10	5	23	10	6	3	8	27	50	242.7	Low
N854-N855	6	PVC	200	1987	R822	8	10	5	23	10	6	3	8	27	50	242.7	Low
N856-N855	6	PVC	151	1987	R822	8	10	5	23	10	6	3	8	27	50	242.7	Low
N857-N858	6	PVC	100	1987	R822	8	10	5	23	10	6	3	8	27	50	242.7	Low
N858-N859	6	PVC	164	1987	R822	8	10	5	23	10	6	3	8	27	50	242.7	Low
N859-N860	6	PVC	122	1987	R822	8	10	5	23	10	6	3	8	27	50	242.7	Low
N871-N872	6	PVC	183	1987	R822	8	10	5	23	10	6	3	8	27	50	242.7	Low
N872-N873	6	PVC	242	1987	R822	8	10	5	23	10	6	3	8	27	50	242.7	Low
N873-N874	6	PVC	86	1987	R822	8	10	5	23	10	6	3	8	27	50	242.7	Low
N874-N863	6	PVC	93	1987	R822	8	10	5	23	10	6	3	8	27	50	242.7	Low
N877-N864	6	PVC	199	1987	R822	8	10	5	23	10	6	3	8	27	50	242.7	Low
N878-N877	6	PVC	110	1987	R822	8	10	5	23	10	6	3	8	27	50	242.7	Low
N901-N830	6	VCP	394	1973	R822	8	10	5	23	10	6	3	8	27	50	242.7	Low
N904-N901	6	VCP	148	1973	R822	8	10	5	23	10	6	3	8	27	50	242.7	Low
N905-N904	6	VCP	198	1983	R822	8	10	5	23	10	6	3	8	27	50	242.7	Low
N906-N905	6	PVC	202	1983	R822	8	10	5	23	10	6	3	8	27	50	242.7	Low
N907-N906	6	PVC	125	1983	R822	8	10	5	23	10	6	3	8	27	50	242.7	Low
N908-N907	6	PVC	161	1983	R822	8	10	5	23	10	6	3	8	27	50	242.7	Low
N909-N908	6	PVC	140	1983	R822	8	10	5	23	10	6	3	8	27	50	242.7	Low
N910-N909	6	PVC	148	1983	R822	8	10	5	23	10	6	3	8	27	50	242.7	Low
N911-N910	6	PVC	209	1983	R822	8	10	5	23	10	6	3	8	27	50	242.7	Low
N915-N916	6	VCP	169	1987	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
N916-O933	6	PVC	118	1987	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
N917-N918	6	PVC	281	1987	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
N918-N919	6	PVC	219	1987	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
N919-N920	6	PVC	106	1987	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
N920-O932	6	PVC	83	1987	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
O612-O613	6	PVC	133	1988	Q631	8	10	5	23	10	6	3	8	27	50	242.7	Low
O6133-O639	8	PVC	163	1982	Q631	8	10	5	23	10	6	3	8	27	50	242.7	Low
O618-O619	6	PVC	476	1988	Q631	8	10	5	23	10	6	3	8	27	50	242.7	Low
O626-O627	6	VCP	152	1921	Q631	8	10	5	23	10	6	3	8	27	50	242.7	Low
O628-O631	8	VCP	64	1921	Q631	8	10	5	23	10	6	3	8	27	50	242.7	Low
O631-O6133	8	PVC	146	1982	Q631	8	10	5	23	10	6	3	8	27	50	242.7	Low
O632-O633	6	VCP	153	1989	Q631	8	10	5	23	10	6	3	8	27	50	242.7	Low
O633-O634	8	VCP	140	1989	Q631	8	10	5	23	10	6	3	8	27	50	242.7	Low
O635-O636	6	PVC	159	1988	Q631	8	10	5	23	10	6	3	8	27	50	242.7	Low
O636-O634	6	PVC	96	1988	Q631	8	10	5	23	10	6	3	8	27	50	242.7	Low
O637-O638	6	PVC	244	1989	Q631	8	10	5	23	10	6	3	8	27	50	242.7	Low

Appendix B. Detailed Risk Assessment Results

Pipe Number	Diameter, inches	Material	Length, linear feet	Installation Year	Basin	Likelihood of Failure Score				Consequence of Failure Score					Risk Score		Risk Level
						Structural Failure Rate	Maintenance Failure Rate	Hydraulic Capacity Failure Rate	Total Score	Potential Spill Volume	Environmental Impact	Emergency Response and Construction Impact	Public Exposure	Total Score	Total Risk	Normalized Risk	
O639-O642	8	PVC	93	1982	Q631	8	10	5	23	10	6	3	8	27	50	242.7	Low
O641-O642	6	PVC	266	1986	Q631	8	10	5	23	10	6	3	8	27	50	242.7	Low
O643-O644	6	PVC	183	1988	Q631	8	10	5	23	10	6	3	8	27	50	242.7	Low
O644-O647	8	PVC	86	1982	Q631	8	10	5	23	10	6	3	8	27	50	242.7	Low
O645-O646	6	PVC	119	1988	Q631	8	10	5	23	10	6	3	8	27	50	242.7	Low
O646-O647	6	PVC	211	1988	Q631	8	10	5	23	10	6	3	8	27	50	242.7	Low
O647-O648	8	PVC	82	1982	Q631	8	10	5	23	10	6	3	8	27	50	242.7	Low
O648-O650	8	PVC	104	1982	Q631	8	10	5	23	10	6	3	8	27	50	242.7	Low
O650-O623	8	PVC	127	1982	Q631	8	10	5	23	10	6	3	8	27	50	242.7	Low
O653-O6139	8	VCP	56	1921	Q631	8	10	5	23	10	6	3	8	27	50	242.7	Low
O659-O660	6	PVC	173	1996	Q631	8	10	5	23	10	6	3	8	27	50	242.7	Low
O662-O665	6	VCP	79	1921	Q631	8	10	5	23	10	6	3	8	27	50	242.7	Low
O670-P613	6	PVC	472	1993	Q631	8	10	5	23	10	6	3	8	27	50	242.7	Low
O671-O672	6	VCP	497	1921	R621	8	10	5	23	10	6	3	8	27	50	242.7	Low
O705-O704	6	VCP	146	1921	Q679	8	10	5	23	10	6	3	8	27	50	242.7	Low
O749-O759	6	VCP	179	1921	Q679	8	10	5	23	10	6	3	8	27	50	242.7	Low
O773-O775	8	VCP/PVC	253	2003	Q679	8	10	5	23	10	6	3	8	27	50	242.7	Low
O829-O830	6	PVC	122	1983	R822	8	10	5	23	10	6	3	8	27	50	242.7	Low
O830-O831	6	PVC	251	1983	R822	8	10	5	23	10	6	3	8	27	50	242.7	Low
O831-O832	6	PVC	182	1983	R822	8	10	5	23	10	6	3	8	27	50	242.7	Low
O839-O838	6	VCP	177	1973	R822	8	10	5	23	10	6	3	8	27	50	242.7	Low
O907-O908	6	VCP	73	1967	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
O908-O909	6	VCP	217	1967	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
O913-O914	6	VCP	101	1967	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
O919-O920	8	VCP	293	1967	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
O922-O923	6	VCP	224	1983	R822	8	10	5	23	10	6	3	8	27	50	242.7	Low
O923-O924	6	VCP	203	1983	R822	8	10	5	23	10	6	3	8	27	50	242.7	Low
O924-O967	6	CIP	174	1983	R822	8	10	5	23	10	6	3	8	27	50	242.7	Low
O929-P903	6	VCP	110	1967	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
O932-O933	6	VCP	157	1987	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
O933-O934	6	VCP	116	1987	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
O934-O935	6	VCP	110	1987	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
O935-O936	6	VCP	156	1987	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
O936-O937	6	VCP	172	1987	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
O937-O938	6	VCP	199	1987	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
O938-O939	6	VCP	200	1987	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
O940-O941	6	VCP	112	1987	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
O941-O942	6	VCP	108	1987	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
O942-O943	6	VCP	180	1987	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
O943-O944	6	VCP	198	1987	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
O944-O948	6	VCP	96	1987	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
O947-O949	6	VCP	110	1966	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
O948-O947	6	VCP	132	1987	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
O967-O829	6	PVC	191	1983	R822	8	10	5	23	10	6	3	8	27	50	242.7	Low
P614-P615	6	PVC	449	1993	Q631	8	10	5	23	10	6	3	8	27	50	242.7	Low
P616-P612	6	VCP	245	1943	Q631	8	10	5	23	10	6	3	8	27	50	242.7	Low
P617-P618	8	VCP	450	1921	R621	8	10	5	23	10	6	3	8	27	50	242.7	Low
P642-P643	6	PVC	449	1996	R663	8	10	5	23	10	6	3	8	27	50	242.7	Low
P643-Q663	6	PVC	450	1996	R663	8	10	5	23	10	6	3	8	27	50	242.7	Low
P669-P670	6	VCP	234	1942	WWTP	8	10	5	23	10	6	3	8	27	50	242.7	Low
P671-P672	6	VCP/PVC	458	2003	WWTP	8	10	5	23	10	6	3	8	27	50	242.7	Low
P675-P620	6	VCP	144	1921	R621	8	10	5	23	10	6	3	8	27	50	242.7	Low
P678-P637	6	VCP	142	1921	R621	8	10	5	23	10	6	3	8	27	50	242.7	Low
P679-P638	6	VCP	130	1921	R621	8	10	5	23	10	6	3	8	27	50	242.7	Low
P749-P750	6	VCP	256	1942	WWTP	8	10	5	23	10	6	3	8	27	50	242.7	Low
P756-P757	6	VCP	288	1950	WWTP	8	10	5	23	10	6	3	8	27	50	242.7	Low
P778-P781	6	VCP	106	1957	R822	8	10	5	23	10	6	3	8	27	50	242.7	Low
P787-P749	6	VCP	287	1942	WWTP	8	10	5	23	10	6	3	8	27	50	242.7	Low
P817-P818	6	VCP	382	1959	R822	8	10	5	23	10	6	3	8	27	50	242.7	Low
P822-P823	6	VCP	251	1959	R822	8	10	5	23	10	6	3	8	27	50	242.7	Low
P830-P828	6	UNK	294	1983	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
P832-P831	6	UNK	198	1983	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
P833-P832	6	UNK	402	1983	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
P901-P905	8	VCP	251	1967	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
P902-P901	6	VCP	81	1967	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
P905-P907	8	VCP	255	1967	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
P907-P908	8	VCP	253	1967	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
P914-P913	6	VCP	296	1967	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
P915-P914	6	VCP	107	1967	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
P916-P915	6	VCP	189	1967	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
P917-P915	6	UNK	114	1967	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
Q1105-Q1104	6	VCP	104	1966	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
Q1117-Q1117A	6	VCP	78	0	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
Q1118-Q1119	6	VCP	195	1966	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
Q1121-Q1122	8	VCP	184	1966	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
Q1132-R1150	6	PVC	157	1996	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
Q1133-Q1132	6	PVC	128	1996	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
Q510-R517	6	VCP	173	1947	Q631	8	10	5	23	10	6	3	8	27	50	242.7	Low
Q513-Q514	6	VCP	189	1947	Q631	8	10	5	23	10	6	3	8	27	50	242.7	Low
Q6106-Q642	6	VCP	179	1921	R621	8	10	5	23	10	6	3	8	27	50	242.7	Low
Q6108-Q6110	6	PVC	155	1989	WWTP	8	10	5	23	10	6	3	8	27	50	242.7	Low
Q624-Q626	6	PVC	297	1992	Q631	8	10	5	23	10	6	3	8	27	50	242.7	Low
Q637-Q627	10	VCP	264	1945	Q631	8	10	5	23	10	6	3	8	27	50	242.7	Low
Q650-Q651	6	VCP	52	1921	R663	8	10	5	23	10	6	3	8	27	50	242.7	Low
Q651-Q652	6	PVC	328	1990	R663	8	10	5	23	10	6	3	8	27	50	242.7	Low
Q652-Q653	6	PVC	290	1990	R663	8	10	5	23	10	6	3	8	27	50	242.7	Low
Q653-Q647	10	VCP	258	1945	R663	8	10	5	23	10	6	3	8	27	50	242.7	Low
Q657-Q648	6	PVC	129	1993	Q649	8	10	5	23	10	6	3	8	27	50	242.7	Low
Q662-Q653	10	VCP	263	1945	R663	8	10	5	23	10	6	3	8	27	50	242.7	Low
Q663-Q664	6	PVC	339	1996	R663	8	10	5	23	10	6	3	8	27	50	242.7	Low
Q664-Q665	6	PVC	530	1996	R663	8	10	5	23	10	6	3	8	27	50	242.7	Low
Q665-Q667	6	PVC	402	1945	R663	8	10	5	23	10	6	3	8	27	50	242.7	Low
Q667-Q668	6	PVC	413	1945	R663	8	10	5	23	10	6	3	8	27	50	242.7	Low
Q717-Q718	6	VCP	150	1950	WWTP	8	10	5	23	10	6	3	8	27	50	242.7	Low
Q757-R715	6	VCP	352	1950	WWTP	8	10	5	23	10	6	3	8	27	50	242.7	Low
Q759-Q761	6	VCP	117	1957	R822	8	10	5	23	10	6	3	8	27	50	242.7	Low
Q769-Q870	6	VCP/PVC	222	1957	R822	8	10	5	23	10	6	3	8	27	50	242.7	Low
Q812-Q813	6	VCP	173	1959	R822	8	10	5	23	10	6	3	8	27	50	242.7	Low
Q814-Q815	6	VCP	149	1959	R822	8	10	5	23	10	6	3	8	27	50	242.7	Low
Q824-Q826	6	VCP	147	1959	R822	8	10	5	23	10	6	3	8	27	50	242.7	Low
Q825-Q824	6	VCP	147	1959	R822	8	10	5	23	10	6	3	8	27	50	242.7	Low
Q906-Q905	6	PVC	118	1983	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
Q907-Q908	6	PVC	121	1983	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
Q908-Q909	6	PVC	98	1983	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
Q909-Q910	6	PVC	119	1983	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
Q910-Q911	6	PVC	129	1983	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
R1132-R1107	6	VCP	108	1966	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
R1139-R1140	6	PVC	72	1996	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
R1150-R1148	6	PVC	152	1996	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
R719-R720	6	VCP/PVC	266	2004	WWTP	8	10	5	23	10	6	3	8	27	50	242.7	Low
R728-R729	6	VCP	354	1950	WWTP	8	10	5	23	10	6	3	8	27	50	242.7	Low
R729-R736	6	VCP/PVC	212	2004	WWTP	8	10	5	23	10	6	3	8	27	50	242.7	Low
R855-R814	8	PVC	167	1973	R709	8	10	5	23	10	6	3	8	27	50	242.7	Low
T1001-S1057	6	PVC	276	1992	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
T1002-T1001	6	PVC	313	1992	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
T1003-T1002	6	PVC	330	1992	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
T1008-T1007	6	PVC	198	1992	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
T1009-T1008	6	PVC	268	1992	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
T1010-T1009	6	PVC	300	1992	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
T1011-T1010	6	PVC	241	1992	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
T1012-T1011	6	PVC	195	1992	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
T1013-T1012	6	PVC	184	1992	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
T1014-T1013	6	PVC	174	1992	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
T1015-T1014	6	PVC	150	1992	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
T1022-T1008	6	PVC	239	1992	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
T1023-T1022	6	PVC	165	1992	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
T1024-T1023	6	PVC	149	1992	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
T1025-T1024	6	PVC	222	1992	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
T1026-T1025	6	PVC	271	1992	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
T1030-T1029	6	PVC	199	1992	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
T1031-T1030	6	PVC	277	1992	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
T1033-T1052	6	PVC	397	1992	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
T1034-T1033	6	PVC	140	1992	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
T1035-T1034	6	PVC	122	1992	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
T1052-T1012	6	PVC	253	1992	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
T1058-S1057	6	PVC	173	1992	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
T1101-T1115	6	PVC	257	1992	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
T1102-T1101	6	PVC	177	1992	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
T1103-T1102	6	PVC	173	1992	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
T1104-T1103	6	PVC	189	1992	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
T1105-T1104	6	PVC	179	1992	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
T1106-T1105	6	PVC	156	1992	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
T1107-T1106	6	PVC	282	1992	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
T1108-T1107	6	PVC	202	1992	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
T1109-T1108	6	PVC	133	1992	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
T1110-T1109	6	PVC	173	1992	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
T1111-T1110	6	PVC	204	1992	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
T1112-T1111	6	PVC	176	1992	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
T1113-T1112	6	PVC	206	1992	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
T1114-T1113	6	PVC	185	1992	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
T1115-T1129	6	PVC	123	1992	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
T1120-T1119	6	PVC	397	1992	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
T1121-T1120	6	PVC	166	1992	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
T1129-T1058	6	PVC	287	1992	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
T1201-T1128	8	PVC	449	2003	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
T1203-T1202	8	PVC	345	2003	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
T1204-T1203	8	PVC	402	2003	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
T1205-T1204	8	PVC	400	2003	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
T1206-T1205	8	PVC	394	2003	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
T1207-T1206	8	UNK	109	2003	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
T627-T628	6	VCP	110	1962	WWTP	8	10	5	23	10	6	3	8	27	50	242.7	Low
T628-T630	6	VCP/PVC	104	2003	WWTP	8	10	5	23	10	6	3	8	27	50	242.7	Low
T639-T640	6	VCP	235	1962	WWTP	8	10	5	23	10	6	3	8	27	50	242.7	Low
U1001-U1028	6	PVC	45	1992	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
U1002-U1001	6	PVC	286	1992	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
U1003-U1002	6	PVC	126	1992	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low

Appendix B. Detailed Risk Assessment Results

Pipe Number	Diameter, inches	Material	Length, linear feet	Installation Year	Basin	Likelihood of Failure Score				Consequence of Failure Score					Risk Score		Risk Level
						Structural Failure Rate	Maintenance Failure Rate	Hydraulic Capacity Failure Rate	Total Score	Potential Spill Volume	Environmental Impact	Emergency Response and Construction Impact	Public Exposure	Total Score	Total Risk	Normalized Risk	
U1004-U1003	6	PVC	122	1992	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
U1005-U1004	6	PVC	185	1992	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
U1006-U1005	6	PVC	184	1992	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
U1007-U1006	6	PVC	155	1992	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
U1008-U1002	6	PVC	236	1992	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
U1009-U1008	6	PVC	196	1992	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
U1010-U1009	6	PVC	115	1992	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
U1027-T1026	6	PVC	89	1992	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
U1028-U1027	6	PVC	101	1992	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
U1101-U1126	6	PVC	245	1992	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
U1102-U1101	6	PVC	252	1992	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
U1103-U1102	6	PVC	145	1992	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
U1104-U1103	6	PVC	206	1992	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
U1105-U1104	6	PVC	181	1992	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
U1106-U1105	6	PVC	99	1992	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
U1107-U1103	6	PVC	204	1992	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
U1108-U1116	6	PVC	175	1992	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
U1115-T1114	6	PVC	217	1992	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
U1116-U1115	6	PVC	192	1992	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
U1124-T1123	6	PVC	205	1992	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
U1125-U1124	6	PVC	70	1992	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low
U1126-U1125	6	PVC	89	1992	R809	8	10	5	23	10	6	3	8	27	50	242.7	Low

APPENDIX C

Gravity Sewer Rehab/Replacement Program Details

Table D-1. System-Wide Rehab/Replacement Needs by Year

CIP Year	Low	Med-Low	Medium	Med-High	High	Grand Total
1					$1,005,788	$1,005,788
2					$974,208	$974,208
3					$994,980	$994,980
4					$1,006,848	$1,006,848
5					$1,013,488	$1,013,488
6					$999,876	$999,876
7					$968,256	$968,256
8				$289,020	$626,112	$915,132
9				$1,029,840		$1,029,840
10				$1,004,544		$1,004,544
11				$1,041,600		$1,041,600
12				$1,039,104		$1,039,104
13				$947,888		$947,888
14				$1,055,856		$1,055,856
15				$985,180		$985,180
16				$908,928		$908,928
17				$1,099,776		$1,099,776
18				$919,668		$919,668
19				$1,052,016		$1,052,016
20				$1,020,876		$1,020,876
			20-Year CIP Subtotal	**$12,394,296**	**$7,589,556**	**$19,983,852**
21				$997,824		$997,824
22				$968,088		$968,088
23				$912,120		$912,120
24				$1,064,328		$1,064,328
25				$1,044,804		$1,044,804
26			$471,384	$556,356		$1,027,740
27			$952,704			$952,704
28			$1,015,344			$1,015,344
29			$987,432			$987,432
30			$1,031,208			$1,031,208
31			$984,684			$984,684
32			$1,008,804			$1,008,804
33			$913,128			$913,128
34			$1,003,776			$1,003,776
35			$1,081,368			$1,081,368
36			$994,668			$994,668
37		$65,880	$910,392			$976,272
38		$1,042,932				$1,042,932
39		$919,368				$919,368
40		$1,073,440				$1,073,440
41		$1,000,392				$1,000,392
42		$962,496				$962,496
43		$1,029,600				$1,029,600
44	$384,516	$606,504				$991,020
45	$710,988					$710,988
Backlog Subtotal	**$1,095,504**	**$6,700,612**	**$11,354,892**	**$5,543,520**	**$0**	**$24,694,528**

Table D-2. 20-Year CIP Details

	Pipe Properties						Rehab/Replacement Method Analysis Input Factors								Recommended CIP			
CIP Year	PipeID	Risk	LOF	Pipe Length, LF	Exist Diameter, inches	New Diameter, inches	CIPP Patch Count	CIPP Patch Cost	Point Repair Count	Point Repair Cost	Sag Repair Count	Sag Repair Cost	Total Repair Count	No. of Repairs/ 100-LF	Rehab/Replacement Method	Rehab/ Replacement Cost	Cumulative CIP Cost	CIP Group
1	R622-R624	5	115	329	12		14	$235,200	13	$374,400			27	8.2	Pipe Burst	$142,128	$142,128	Years 1-5
1	Q619-Q608	5	100	374	12				1	$28,800			1	0.3	(1) Point Repair(s)	$28,800	$170,928	Years 1-5
1	R787-R710	5	100	107	6	8	1	$8,400	1	$14,400	2	$28,800	4	3.7	Open Cut Replacement	$51,360	$222,288	Years 1-5
1	R531-R532	5	100	269	6	8	5	$42,000	2	$28,800			7	2.6	Pipe Burst	$77,472	$299,760	Years 1-5
1	O685-O687	5	95	449	6				1	$14,400			1	0.2	(1) Point Repair(s)	$14,400	$314,160	Years 1-5
1	O697-O698	5	95	220	6				2	$28,800			2	0.9	(2) Point Repair(s)	$28,800	$342,960	Years 1-5
1	R1120-R1121	5	95	371	6				2	$28,800			2	0.5	(2) Point Repair(s)	$28,800	$371,760	Years 1-5
1	P640-P641	5	95	450	6				3	$43,200			3	0.7	(3) Point Repair(s)	$43,200	$414,960	Years 1-5
1	M744-M785	5	95	111	6		1	$8,400	1	$14,400			2	1.8	Full CIPP	$19,980	$434,940	Years 1-5
1	P657-P656	5	95	138	6	8	2	$16,800	7	$100,800			9	6.5	Pipe Burst	$39,744	$474,684	Years 1-5
1	R608-R614	5	95	425	6	8			9	$129,600			9	2.1	Pipe Burst	$122,400	$597,084	Years 1-5
1	R1011-R1012	5	95	461	10				1	$24,000			1	0.2	Pipe Burst	$165,960	$763,044	Years 1-5
1	R784-R787	5	95	323	6	8	2	$16,800	3	$43,200	1	$14,400	6	1.9	Repair Sags + Pipe Burst	$107,424	$870,468	Years 1-5
1	Q625-Q619	5	92	230	10		1	$14,000					1	0.4	(1) Point Repair(s)	$14,000	$884,468	Years 1-5
1	Q655-R620	5	92	337	12		5	$84,000			1	$28,800	6	1.8	Full CIPP	$121,320	$1,005,788	Years 1-5
2	S611-S612	5	92	154	6	8	1	$8,400	2	$28,800			3	1.9	Pipe Burst	$44,352	$1,050,140	Years 1-5
2	N713-N712	5	92	317	6	8			4	$57,600			4	1.3	Pipe Burst	$91,296	$1,141,436	Years 1-5
2	R662-R532	5	92	415	6	8	15	$126,000	11	$158,400	2	$28,800	28	6.7	Repair Sags + Pipe Burst	$148,320	$1,289,756	Years 1-5
2	Q708-Q709	5	90	340	6		2	$16,800	2	$28,800			4	1.2	(4) Point Repair(s)	$45,600	$1,335,356	Years 1-5
2	Q730-Q731	5	90	453	6	8			4	$57,600			4	0.9	Pipe Burst	$130,464	$1,465,820	Years 1-5
2	Q719-Q720	5	87	176	6				1	$14,400			1	0.6	(1) Point Repair(s)	$14,400	$1,480,220	Years 1-5
2	O821-O822	5	87	140	6	8			3	$43,200	1	$14,400	4	2.9	Open Cut Replacement	$67,200	$1,547,420	Years 1-5
2	Q760-Q761	5	87	180	6	8			1	$14,400	1	$14,400	2	1.1	Open Cut Replacement	$86,400	$1,633,820	Years 1-5
2	Q706-Q707	5	87	2	6	8	1	$8,400	1	$14,400			2	100.0	Pipe Burst	$576	$1,634,396	Years 1-5
2	O6124-O680	5	87	161	6	8			6	$86,400			6	3.7	Pipe Burst	$46,368	$1,680,764	Years 1-5
2	P635-P636	5	87	449	6	8	2	$16,800	17	$244,800			19	4.2	Pipe Burst	$129,312	$1,810,076	Years 1-5
2	Q614-Q631	5	87	260	12		3	$50,400	6	$172,800			9	3.5	Pipe Burst	$112,320	$1,922,396	Years 1-5
2	S801-R752	5	85	399	24				1	$57,600			1	0.3	(1) Point Repair(s)	$57,600	$1,979,996	Years 1-5
3	O682-P635	5	85	400	6				2	$28,800			2	0.5	(2) Point Repair(s)	$28,800	$2,008,796	Years 1-5
3	R731-R732	5	85	443	6				2	$28,800			2	0.5	(2) Point Repair(s)	$28,800	$2,037,596	Years 1-5
3	O684-O685	5	85	454	6		2	$16,800	2	$28,800			4	0.9	(4) Point Repair(s)	$45,600	$2,083,196	Years 1-5
3	Q754-Q757	5	85	446	6				4	$57,600			4	0.9	(4) Point Repair(s)	$57,600	$2,140,796	Years 1-5
3	Q805-Q806	5	85	461	8		2	$22,400	2	$38,400	4	$76,800	8	1.7	Full CIPP	$110,640	$2,251,436	Years 1-5
3	R663-R629	5	85	316	10		13	$182,000	4	$96,000	1	$24,000	18	5.7	Full CIPP	$94,800	$2,346,236	Years 1-5
3	R1006-R1008	5	85	471	10				2	$48,000	1	$24,000	3	0.6	Full CIPP	$141,300	$2,487,536	Years 1-5
3	Q637-Q638	5	85	266	12		7	$117,600	1	$28,800	1	$28,800	9	3.4	Full CIPP	$95,760	$2,583,296	Years 1-5
3	O680-O681	5	85	219	6	8			2	$28,800	2	$28,800	4	1.8	Open Cut Replacement	$105,120	$2,688,416	Years 1-5
3	O690-O691	5	85	73	6	8			5	$72,000			5	6.8	Pipe Burst	$21,024	$2,709,440	Years 1-5
3	O735-O737	5	85	199	6	8	8	$67,200	3	$43,200			11	5.5	Pipe Burst	$57,312	$2,766,752	Years 1-5
3	T606-T605	5	85	201	6	8	3	$25,200	7	$100,800			10	5.0	Pipe Burst	$57,888	$2,824,640	Years 1-5
3	S619-S617	5	85	216	6	8	1	$8,400	2	$28,800			3	1.4	Pipe Burst	$62,208	$2,886,848	Years 1-5
3	O6107-N658	5	85	306	6	8			5	$72,000			5	1.6	Pipe Burst	$88,128	$2,974,976	Years 1-5
4	N602-N604	5	85	312	6	8	2	$16,800	2	$28,800			4	1.3	Pipe Burst	$89,856	$3,064,832	Years 1-5
4	R534-R662	5	85	380	6	8	8	$67,200	2	$28,800			10	2.6	Pipe Burst	$109,440	$3,174,272	Years 1-5
4	Q6115-Q603	5	85	384	6	8			18	$259,200			18	4.7	Pipe Burst	$110,592	$3,284,864	Years 1-5
4	R772-R771	5	85	386	6	8			1	$14,400			1	0.3	Pipe Burst	$111,168	$3,396,032	Years 1-5
4	O727-O728	5	85	396	6	8	27	$226,800	34	$489,600			61	15.4	Pipe Burst	$114,048	$3,510,080	Years 1-5
4	P736-P789	5	85	396	6	8	3	$25,200	4	$57,600			7	1.8	Pipe Burst	$114,048	$3,624,128	Years 1-5
4	O6106-P648	5	85	400	6	8			3	$43,200			3	0.8	Pipe Burst	$115,200	$3,739,328	Years 1-5
4	O663-O664	5	85	410	6	8	1	$8,400	12	$172,800			13	3.2	Pipe Burst	$118,080	$3,857,408	Years 1-5
4	O6101-O6102	5	85	432	6	8			9	$129,600			9	2.1	Pipe Burst	$124,416	$3,981,824	Years 1-5
5	N616-N617	5	85	441	6	8			5	$72,000			5	1.1	Pipe Burst	$127,008	$4,108,832	Years 1-5
5	Q697-R638	5	85	506	6	8	12	$100,800	14	$201,600			26	5.1	Pipe Burst	$145,728	$4,254,560	Years 1-5
5	R526-R525	5	85	316	12		5	$84,000	2	$57,600			7	2.2	Pipe Burst	$136,512	$4,391,072	Years 1-5
5	R806-R807	5	85	326	12				3	$86,400			3	0.9	Pipe Burst	$140,832	$4,531,904	Years 1-5
5	Q748-Q749	5	85	551	6	8	7	$58,800	13	$187,200	1	$14,400	21	3.8	Repair Sags + Pipe Burst	$173,088	$4,704,992	Years 1-5
5	N799-N7100	5	84	122	6	8			2	$28,800	1	$14,400	3	2.5	Open Cut Replacement	$58,560	$4,763,552	Years 1-5
5	N661-O692	5	82	220	6		2	$16,800					2	0.9	(2) Point Repair(s)	$16,800	$4,780,352	Years 1-5
5	R628-R631	5	82	366	12		3	$50,400					3	0.8	(3) Point Repair(s)	$50,400	$4,830,752	Years 1-5
5	N654-N655	5	82	183	6	8			9	$129,600			9	4.9	Pipe Burst	$52,704	$4,883,456	Years 1-5
5	Q608-Q610	5	82	133	12		1	$16,800					1	0.8	Pipe Burst	$57,456	$4,940,912	Years 1-5
5	P603-P604	5	79	418	6				1	$14,400			1	0.2	(1) Point Repair(s)	$14,400	$4,955,312	Years 1-5
5	O6120-O6135	5	79	249	8		1	$11,200					1	0.4	(1) Point Repair(s)	$11,200	$4,966,512	Years 1-5
5	O6104-O6105	5	79	219	6				2	$28,800			2	0.9	(2) Point Repair(s)	$28,800	$4,995,312	Years 1-5
6	R827-R832	5	79	337	6				4	$57,600			4	1.2	Full CIPP	$60,660	$5,055,972	Years 6-10
6	P639-P640	5	79	137	6	8			1	$14,400	1	$14,400	2	1.5	Open Cut Replacement	$65,760	$5,121,732	Years 6-10
6	O6103-O6104	5	79	134	6	8			2	$28,800			2	1.5	Pipe Burst	$38,592	$5,160,324	Years 6-10
6	Q707-Q708	5	79	338	6	8	1	$8,400					1	0.3	Pipe Burst	$97,344	$5,257,668	Years 6-10
6	P742-P740	5	79	205	6	8			1	$14,400	1	$14,400	2	1.0	Repair Sags + Pipe Burst	$73,440	$5,331,108	Years 6-10
6	O813-O814	5	77	226	6		1	$8,400					1	0.4	(1) Point Repair(s)	$8,400	$5,339,508	Years 6-10
6	P772-P773	5	77	279	6		1	$8,400					1	0.4	(1) Point Repair(s)	$8,400	$5,347,908	Years 6-10
6	P788-P789	5	77	118	6		1	$8,400					1	0.8	(1) Point Repair(s)	$8,400	$5,356,308	Years 6-10
6	R656-R636	5	77	323	6		1	$8,400	1	$14,400			2	0.6	(2) Point Repair(s)	$22,800	$5,379,108	Years 6-10
6	O702-O704	5	77	226	8		7	$78,400	1	$19,200	1	$19,200	9	4.0	Full CIPP	$54,240	$5,433,348	Years 6-10
6	Q682-Q675	5	77	266	8		10	$112,000			1	$19,200	11	4.1	Full CIPP	$63,840	$5,497,188	Years 6-10
6	R522-R523	5	77	443	8		4	$44,800	7	$134,400	1	$19,200	12	2.7	Full CIPP	$106,320	$5,603,508	Years 6-10
6	P784-P738	5	77	250	6	8			3	$43,200	2	$28,800	5	2.0	Open Cut Replacement	$120,000	$5,723,508	Years 6-10
6	P775-P776	5	77	386	6	8					2	$28,800	2	0.5	Open Cut Replacement	$185,280	$5,908,788	Years 6-10
6	Q761-Q762	5	77	21	6	8			5	$72,000			5	23.8	Pipe Burst	$6,048	$5,914,836	Years 6-10
6	N664-N618	5	77	112	6	8	1	$8,400	1	$14,400			2	1.8	Pipe Burst	$32,256	$5,947,092	Years 6-10
6	N626-O651	5	77	167	6	8			3	$43,200			3	1.8	Pipe Burst	$48,096	$5,995,188	Years 6-10
7	S613-S612	5	77	204	6	8	3	$25,200	2	$28,800			5	2.5	Pipe Burst	$58,752	$6,053,940	Years 6-10
7	R739-R789	5	77	255	6	8	3	$25,200	1	$14,400			4	1.6	Pipe Burst	$73,440	$6,127,380	Years 6-10
7	S614-S610	5	77	289	6	8	2	$16,800	2	$28,800			4	1.4	Pipe Burst	$83,232	$6,210,612	Years 6-10
7	S703-S705	5	77	387	6	8	3	$25,200	1	$14,400			4	1.0	Pipe Burst	$111,456	$6,322,068	Years 6-10
7	N651-O6111	5	77	403	6	8	1	$8,400	4	$57,600			5	1.2	Pipe Burst	$116,064	$6,438,132	Years 6-10
7	O726-O727	5	77	485	6	8	3	$25,200					3	0.6	Pipe Burst	$139,680	$6,577,812	Years 6-10
7	R627-R663	5	77	248	10		7	$98,000					7	2.8	Pipe Burst	$89,280	$6,667,092	Years 6-10
7	R629-R632	5	77	307	12		5	$84,000	1	$28,800			6	2.0	Pipe Burst	$132,624	$6,799,716	Years 6-10
7	R631-R641	5	77	379	12		1	$16,800					1	0.3	Pipe Burst	$163,728	$6,963,444	Years 6-10
8	R533-R535	5	77	338	6	8	1	$8,400	2	$28,800	1	$14,400	4	1.2	Repair Sags + Pipe Burst	$111,744	$7,075,188	Years 6-10
8	O6129-O6144	5	75	138	6	8	1	$8,400	1	$14,400			2	1.4	Pipe Burst	$39,744	$7,114,932	Years 6-10
8	M748-M776	5	75	169	6	8			3	$43,200			3	1.8	Pipe Burst	$48,672	$7,163,604	Years 6-10
8	N604-N605	5	75	173	6	8	2	$16,800	3	$43,200			5	2.9	Pipe Burst	$49,824	$7,213,428	Years 6-10
8	P722-P723	5	75	213	6	8	3	$25,200	22	$316,800			25	11.7	Pipe Burst	$61,344	$7,274,772	Years 6-10
8	R610-R609	5	75	272	6	8	1	$8,400	3	$43,200			4	1.5	Pipe Burst	$78,336	$7,353,108	Years 6-10
8	T605-T604	5	75	278	6	8	8	$67,200	3	$43,200			11	4.0	Pipe Burst	$80,064	$7,433,172	Years 6-10
8	R607-R615	5	75	543	6	8	1	$8,400	6	$86,400			7	1.3	Pipe Burst	$156,384	$7,589,556	Years 6-10
8	N737-O713	4	100	323	6				1	$14,400			1	0.3	(1) Point Repair(s)	$14,400	$7,603,956	Years 6-10
8	R769-R790	4	95	256	6				2	$28,800			2	0.8	(2) Point Repair(s)	$28,800	$7,632,756	Years 6-10
8	R733-R735	4	95	327	6		2	$16,800	1	$14,400			3	0.9	(3) Point Repair(s)	$31,200	$7,663,956	Years 6-10
8	N780-N781	4	95	453	6		2	$16,800	1	$14,400	2	$28,800	5	1.1	(5) Point Repair(s)	$60,000	$7,723,956	Years 6-10
8	O928-O929	4	95	123	6				4	$57,600			4	3.3	Full CIPP	$22,140	$7,746,096	Years 6-10
8	T609-T608	4	95	276	6	8			3	$43,200	2	$28,800	5	1.8	Open Cut Replacement	$132,480	$7,878,576	Years 6-10
9	N717-N716	4	95	399	6	8			4	$57,600	6	$86,400	10	2.5	Open Cut Replacement	$191,520	$8,070,096	Years 6-10
9	O769-O768	4	95	121	6	8			2	$28,800			2	1.7	Pipe Burst	$34,848	$8,104,944	Years 6-10
9	M721-M723	4	95	169	6	8	1	$8,400	2	$28,800			3	1.8	Pipe Burst	$48,672	$8,153,616	Years 6-10
9	M750-M749	4	95	211	6	8			3	$43,200			3	1.4	Pipe Burst	$60,768	$8,214,384	Years 6-10
9	P703-P706	4	95	378	6	8	2	$16,800	28	$403,200			30	7.9	Pipe Burst	$108,864	$8,323,248	Years 6-10
9	N767-O723	4	95	396	6	8	13	$109,200	1	$14,400			14	3.5	Pipe Burst	$114,048	$8,437,296	Years 6-10
9	Q640-Q638	4	95	259	12		5	$84,000	3	$86,400			8	3.1	Pipe Burst	$111,888	$8,549,184	Years 6-10
9	P665-Q684	4	92	304	6		1	$8,400					1	0.3	(1) Point Repair(s)	$8,400	$8,557,584	Years 6-10
9	M710-M711	4	90	488	6				4	$57,600			4	0.8	(4) Point Repair(s)	$57,600	$8,615,184	Years 6-10
9	R737-R738	4	90	435	6	8	1	$8,400	5	$72,000	1	$14,400	7	1.6	Repair Sags + Pipe Burst	$139,680	$8,754,864	Years 6-10
9	N732-O710	4	87	442	6		1	$8,400	1	$14,400			2	0.5	(2) Point Repair(s)	$22,800	$8,777,664	Years 6-10
9	O798-O785	4	87	281	6				2	$28,800			2	0.7	(2) Point Repair(s)	$28,800	$8,806,464	Years 6-10
9	O657-O658	4	87	111	6	8	6	$50,400	1	$14,400	1	$14,400	8	7.2	Open Cut Replacement	$53,280	$8,859,744	Years 6-10
9	R1108-R1109	4	87	169	6	8							0	0.0	Pipe Burst	$48,672	$8,908,416	Years 6-10
10	N609-N610	4	87	375	6	8	5	$42,000	4	$57,600			9	2.4	Pipe Burst	$108,000	$9,016,416	Years 6-10
10	Q733-R705	4	87	465	6	8	1	$8,400	8	$115,200			9	1.9	Pipe Burst	$133,920	$9,150,336	Years 6-10
10	N709-N710	4	87	448	6	8	3	$25,200	4	$57,600	2	$28,800	9	2.0	Repair Sags + Pipe Burst	$157,824	$9,308,160	Years 6-10
10	O741-O743	4	85	200	6				1	$14,400			1	0.5	(1) Point Repair(s)	$14,400	$9,322,560	Years 6-10
10	O774-O773	4	85	202	6				1	$14,400			1	0.5	(1) Point Repair(s)	$14,400	$9,336,960	Years 6-10
10	P715-P716	4	85	215	6				1	$14,400			1	0.5	(1) Point Repair(s)	$14,400	$9,351,360	Years 6-10
10	N803-N804	4	85	242	8				1	$19,200			1	0.4	(1) Point Repair(s)	$19,200	$9,370,560	Years 6-10
10	N764-O718	4	85	453	6		1	$8,400	1	$14,400			2	0.4	(2) Point Repair(s)	$22,800	$9,393,360	Years 6-10
10	O6122-P666	4	85	424	6				2	$28,800			2	0.5	(2) Point Repair(s)	$28,800	$9,422,160	Years 6-10
10	P760-P761	4	85	446	6				2	$28,800			2	0.4	(2) Point Repair(s)	$28,800	$9,450,960	Years 6-10
10	Q766-Q765	4	85	216	6				2	$28,800			2	0.9	(2) Point Repair(s)	$28,800	$9,479,760	Years 6-10
10	R755-R756	4	85	345	6				2	$28,800			2	0.6	(2) Point Repair(s)	$28,800	$9,508,560	Years 6-10
10	O781-O783	4	85	399	6		1	$8,400	3	$43,200			4	1.0	(4) Point Repair(s)	$51,600	$9,560,160	Years 6-10
10	P637-P638	4	85	449	6		1	$8,400	3	$43,200			4	0.9	(4) Point Repair(s)	$51,600	$9,611,760	Years 6-10
10	Q517-Q604	4	85	431	6		1	$8,400	3	$43,200			4	0.9	(4) Point Repair(s)	$51,600	$9,663,360	Years 6-10
10	O786-O785	4	85	96	6	8			2	$28,800	4	$57,600	6	6.3	Open Cut Replacement	$46,080	$9,709,440	Years 6-10
10	O739-O741	4	85	119	6	8	1	$8,400	2	$28,800	2	$28,800	5	4.2	Open Cut Replacement	$57,120	$9,766,560	Years 6-10
10	N757-N759	4	85	151	6	8	2	$16,800	3	$43,200	3	$43,200	8	5.3	Open Cut Replacement	$72,480	$9,839,040	Years 6-10
10	M793-M791	4	85	154	6	8			4	$57,600	1	$14,400	5	3.2	Open Cut Replacement	$73,920	$9,912,960	Years 6-10
11	Q688-Q694	4	85	221	6	8			12	$172,800	2	$28,800	14	6.3	Open Cut Replacement	$106,080	$10,019,040	Years 11-15
11	S703-S702	4	85	263	6	8	5	$42,000	4	$57,600	2	$28,800	11	4.2	Open Cut Replacement	$126,240	$10,145,280	Years 11-15
11	Q782-Q718	4	85	294	6	8			1	$14,400	6	$86,400	7	2.4	Open Cut Replacement	$141,120	$10,286,400	Years 11-15
11	O660-O661	4	85	99	6	8			3	$43,200			3	3.0	Pipe Burst	$28,512	$10,314,912	Years 11-15

	Pipe Properties						Rehab/Replacement Method Analysis Input Factors									Recommended CIP			
CIP Year	PipeID	Risk	LOF	Pipe Length, LF	Exist Diameter, inches	New Diameter, inches	CIPP Patch Count	CIPP Patch Cost	Point Repair Count	Point Repair Cost	Sag Repair Count	Sag Repair Cost	Total Repair Count	No. of Repairs/ 100-LF	Rehab/Replacement Method	Rehab/ Replacement Cost	Cumulative CIP Cost	CIP Group
11	Q683-R626	4	85	131	6	8	3	$25,200	3	$43,200			6	4.6	Pipe Burst	$37,728	$10,352,640	Years 11-15
11	T644-T645	4	85	166	6	8			6	$86,400			6	3.6	Pipe Burst	$47,808	$10,400,448	Years 11-15
11	N783-N735	4	85	181	6	8	2	$16,800	6	$86,400			8	4.4	Pipe Burst	$52,128	$10,452,576	Years 11-15
11	M773-M772	4	85	183	6	8	2	$16,800	9	$129,600			11	6.0	Pipe Burst	$52,704	$10,505,280	Years 11-15
11	N722-O706	4	85	219	6	8			2	$28,800			2	0.9	Pipe Burst	$63,072	$10,568,352	Years 11-15
11	P717-P718	4	85	221	6	8	1	$8,400	2	$28,800			3	1.4	Pipe Burst	$63,648	$10,632,000	Years 11-15
11	Q691-Q692	4	85	222	6	8			20	$288,000			20	9.0	Pipe Burst	$63,936	$10,695,936	Years 11-15
11	O766-O767	4	85	223	6	8	1	$8,400	2	$28,800			3	1.3	Pipe Burst	$64,224	$10,760,160	Years 11-15
11	O701-O702	4	85	224	6	8			7	$100,800			7	3.1	Pipe Burst	$64,512	$10,824,672	Years 11-15
11	O762-O763	4	85	224	6	8			5	$72,000			5	2.2	Pipe Burst	$64,512	$10,889,184	Years 11-15
11	O767-O768	4	85	227	6	8	3	$25,200	2	$28,800			5	2.2	Pipe Burst	$65,376	$10,954,560	Years 11-15
12	P824-P826	4	85	229	6	8	2	$16,800	3	$43,200			5	2.2	Pipe Burst	$65,952	$11,020,512	Years 11-15
12	O606-O603	4	85	235	6	8							0	0.0	Pipe Burst	$67,680	$11,088,192	Years 11-15
12	Q720-Q721	4	85	262	6	8	5	$42,000	11	$158,400			16	6.1	Pipe Burst	$75,456	$11,163,648	Years 11-15
12	N612-N614	4	85	274	6	8			7	$100,800			7	2.6	Pipe Burst	$78,912	$11,242,560	Years 11-15
12	P752-P750	4	85	289	6	8			3	$43,200			3	1.0	Pipe Burst	$83,232	$11,325,792	Years 11-15
12	Q716-Q715	4	85	296	6	8			3	$43,200			3	1.0	Pipe Burst	$85,248	$11,411,040	Years 11-15
12	M723-M716	4	85	308	6	8	4	$33,600	12	$172,800			16	5.2	Pipe Burst	$88,704	$11,499,744	Years 11-15
12	N736-O712	4	85	321	6	8			12	$172,800			12	3.7	Pipe Burst	$92,448	$11,592,192	Years 11-15
12	N623-N624	4	85	324	6	8	2	$16,800	8	$115,200			10	3.1	Pipe Burst	$93,312	$11,685,504	Years 11-15
12	O760-O762	4	85	353	6	8	1	$8,400	9	$129,600			10	2.8	Pipe Burst	$101,664	$11,787,168	Years 11-15
12	N715-N716	4	85	357	6	8	1	$8,400	2	$28,800			3	0.8	Pipe Burst	$102,816	$11,889,984	Years 11-15
12	M728-M729	4	85	360	6	8	6	$50,400	3	$43,200			9	2.5	Pipe Burst	$103,680	$11,993,664	Years 11-15
13	O6117-O6118	4	85	366	6	8			6	$86,400			6	1.6	Pipe Burst	$105,408	$12,099,072	Years 11-15
13	Q673-Q674	4	85	374	6	8	3	$25,200	3	$43,200			6	1.6	Pipe Burst	$107,712	$12,206,784	Years 11-15
13	N621-N622	4	85	441	6	8	1	$8,400	6	$86,400			7	1.6	Pipe Burst	$127,008	$12,333,792	Years 11-15
13	N735-N737	4	85	451	6	8	8	$67,200	17	$244,800			25	5.5	Pipe Burst	$129,888	$12,463,680	Years 11-15
13	P672-Q6101	4	85	591	6	8	1	$8,400	36	$518,400			37	6.3	Pipe Burst	$170,208	$12,633,888	Years 11-15
13	Q627-Q608	4	84	257	10		1	$14,000					1	0.4	(1) Point Repair(s)	$14,000	$12,647,888	Years 11-15
13	O743-O744	4	84	230	6		2	$16,800	1	$14,400			3	1.3	(3) Point Repair(s)	$31,200	$12,679,088	Years 11-15
13	O6126-O606	4	84	59	6	8	1	$8,400	4	$57,600			5	8.5	Pipe Burst	$16,992	$12,696,080	Years 11-15
13	O715-O713	4	84	124	6	8			4	$57,600			4	3.2	Pipe Burst	$35,712	$12,731,792	Years 11-15
13	O603-O604	4	84	175	6	8			4	$57,600			4	2.3	Pipe Burst	$50,400	$12,782,192	Years 11-15
13	N607-N608	4	80	177	6	8			4	$57,600	4	$57,600	8	4.5	Open Cut Replacement	$84,960	$12,867,152	Years 11-15
13	P774-P781	4	79	342	6		1	$8,400			2	$28,800	3	0.9	(3) Point Repair(s)	$37,200	$12,904,352	Years 11-15
13	T610-T609	4	79	323	6		1	$8,400			2	$28,800	3	0.9	(3) Point Repair(s)	$37,200	$12,941,552	Years 11-15
14	S708-S706	4	79	261	8		4	$44,800					4	1.5	Pipe Burst	$75,168	$13,016,720	Years 11-15
14	M742-M785	4	77	232	6		1	$8,400					1	0.4	(1) Point Repair(s)	$8,400	$13,025,120	Years 11-15
14	Q687-Q686	4	77	287	6				1	$14,400			1	0.3	(1) Point Repair(s)	$14,400	$13,039,520	Years 11-15
14	T614-T612	4	77	231	6				1	$14,400			1	0.4	(1) Point Repair(s)	$14,400	$13,053,920	Years 11-15
14	O722-O726	4	77	342	6		1	$8,400	1	$14,400			2	0.6	(2) Point Repair(s)	$22,800	$13,076,720	Years 11-15
14	O758-O757	4	77	174	6		1	$8,400	1	$14,400			2	1.1	(2) Point Repair(s)	$22,800	$13,099,520	Years 11-15
14	Q692-Q693	4	77	392	6		1	$8,400	1	$14,400			2	0.5	(2) Point Repair(s)	$22,800	$13,122,320	Years 11-15
14	O780-O782	4	77	396	6				2	$28,800			2	0.5	(2) Point Repair(s)	$28,800	$13,151,120	Years 11-15
14	N762-N764	4	77	451	6		1	$8,400	2	$28,800			3	0.7	(3) Point Repair(s)	$37,200	$13,188,320	Years 11-15
14	O601-O6126	4	77	132	6	8	1	$8,400	1	$14,400	7	$100,800	9	6.8	Open Cut Replacement	$63,360	$13,251,680	Years 11-15
14	T613-T612	4	77	213	6	8	1	$8,400			2	$28,800	3	1.4	Open Cut Replacement	$102,240	$13,353,920	Years 11-15
14	T645-T646	4	77	344	6	8			13	$187,200	2	$28,800	15	4.4	Open Cut Replacement	$165,120	$13,519,040	Years 11-15
14	P619-P620	4	77	450	6	8			3	$43,200	3	$43,200	6	1.3	Open Cut Replacement	$216,000	$13,735,040	Years 11-15
14	T647-S649	4	77	129	6	8			7	$100,800			7	5.4	Pipe Burst	$37,152	$13,772,192	Years 11-15
14	Q1124-R1152	4	77	141	6	8							0	0.0	Pipe Burst	$40,608	$13,812,800	Years 11-15
14	O729-O730	4	77	157	6	8	3	$25,200	10	$144,000			13	8.3	Pipe Burst	$45,216	$13,858,016	Years 11-15
14	R539-R527	4	77	160	6	8	2	$16,800					2	1.3	Pipe Burst	$46,080	$13,904,096	Years 11-15
14	R538-R603	4	77	161	6	8			5	$72,000			5	3.1	Pipe Burst	$46,368	$13,950,464	Years 11-15
14	M725-M726	4	77	163	6	8			2	$28,800			2	1.2	Pipe Burst	$46,944	$13,997,408	Years 11-15
15	N763-N764	4	77	181	6	8	4	$33,600	2	$28,800			6	3.3	Pipe Burst	$52,128	$14,049,536	Years 11-15
15	O732-O731	4	77	208	6	8			22	$316,800			22	10.6	Pipe Burst	$59,904	$14,109,440	Years 11-15
15	O656-O657	4	77	255	6	8			2	$28,800			2	0.8	Pipe Burst	$73,440	$14,182,880	Years 11-15
15	O754-O756	4	77	364	6	8	2	$16,800	8	$115,200			10	2.7	Pipe Burst	$104,832	$14,287,712	Years 11-15
15	R780-R781	4	77	401	6	8			3	$43,200			3	0.7	Pipe Burst	$115,488	$14,403,200	Years 11-15
15	Q901-Q911	4	77	40	8		1	$11,200					1	2.5	Pipe Burst	$11,520	$14,414,720	Years 11-15
15	O710-O707	4	77	254	8		3	$33,600					3	1.2	Pipe Burst	$73,152	$14,487,872	Years 11-15
15	R527-R526	4	77	303	12		7	$117,600	1	$28,800			8	2.6	Pipe Burst	$130,896	$14,618,768	Years 11-15
15	N629-N630	4	75	228	6				1	$14,400			1	0.4	(1) Point Repair(s)	$14,400	$14,633,168	Years 11-15
15	N638-N637	4	75	249	6				1	$14,400			1	0.4	(1) Point Repair(s)	$14,400	$14,647,568	Years 11-15
15	O765-O766	4	75	206	6				1	$14,400			1	0.5	(1) Point Repair(s)	$14,400	$14,661,968	Years 11-15
15	N760-N761	4	75	446	6		1	$8,400	1	$14,400			2	0.4	(2) Point Repair(s)	$22,800	$14,684,768	Years 11-15
15	O711-O710	4	75	196	6		1	$8,400	1	$14,400			2	1.0	(2) Point Repair(s)	$22,800	$14,707,568	Years 11-15
15	N622-N623	4	75	450	6				2	$28,800			2	0.4	(2) Point Repair(s)	$28,800	$14,736,368	Years 11-15
15	P911-Q901	4	75	338	8		1	$11,200	1	$19,200			2	0.6	(2) Point Repair(s)	$30,400	$14,766,768	Years 11-15
15	O768-O770	4	75	257	6				1	$14,400	2	$28,800	3	1.2	(3) Point Repair(s)	$43,200	$14,809,968	Years 11-15
15	P701-P702	4	75	431	6				3	$43,200			3	0.7	(3) Point Repair(s)	$43,200	$14,853,168	Years 11-15
15	O672-P617	4	75	473	6				2	$28,800	2	$28,800	4	0.8	(4) Point Repair(s)	$57,600	$14,910,768	Years 11-15
15	T618-T617	4	75	53	6				1	$14,400			1	1.9	Full CIPP	$9,540	$14,920,308	Years 11-15
15	Q6151-Q657	4	75	107	6				3	$43,200			3	2.8	Full CIPP	$19,260	$14,939,568	Years 11-15
15	M778-M776	4	75	239	6				12	$172,800			12	5.0	Full CIPP	$43,020	$14,982,588	Years 11-15
16	R528-R529	4	75	150	6	8			7	$100,800	1	$14,400	8	5.3	Open Cut Replacement	$72,000	$15,054,588	Years 11-15
16	R660-R659	4	75	159	6	8			6	$86,400	1	$14,400	7	4.4	Open Cut Replacement	$76,320	$15,130,908	Years 16-20
16	M765-M742	4	75	54	6	8	6	$50,400	8	$115,200			14	25.9	Pipe Burst	$15,552	$15,146,460	Years 16-20
16	O6125-O6126	4	75	121	6	8			3	$43,200			3	2.5	Pipe Burst	$34,848	$15,181,308	Years 16-20
16	M701-M700	4	75	138	6	8			3	$43,200			3	2.2	Pipe Burst	$39,744	$15,221,052	Years 16-20
16	M700-M602	4	75	148	6	8	1	$8,400	1	$14,400			2	1.4	Pipe Burst	$42,624	$15,263,676	Years 16-20
16	N769-N771	4	75	177	6	8	2	$16,800	3	$43,200			5	2.8	Pipe Burst	$50,976	$15,314,652	Years 16-20
16	O792-O793	4	75	250	6	8			4	$57,600			4	1.6	Pipe Burst	$72,000	$15,386,652	Years 16-20
16	O787-O779	4	75	253	6	8	1	$8,400	2	$28,800			3	1.2	Pipe Burst	$72,864	$15,459,516	Years 16-20
16	M602-M781	4	75	273	6	8	1	$8,400	5	$72,000			6	2.2	Pipe Burst	$78,624	$15,538,140	Years 16-20
16	P621-P622	4	75	291	6	8	2	$16,800	9	$129,600			11	3.8	Pipe Burst	$83,808	$15,621,948	Years 16-20
16	N730-N731	4	75	295	6	8			3	$43,200			3	1.0	Pipe Burst	$84,960	$15,706,908	Years 16-20
16	N725-N726	4	75	297	6	8	1	$8,400	7	$100,800			8	2.7	Pipe Burst	$85,536	$15,792,444	Years 16-20
16	N608-N609	4	75	344	6	8	2	$16,800	4	$57,600			6	1.7	Pipe Burst	$99,072	$15,891,516	Years 16-20
17	O730-O731	4	75	453	6	8	17	$142,800	6	$86,400			23	5.1	Pipe Burst	$130,464	$16,021,980	Years 16-20
17	O654-O657	4	75	159	8		7	$78,400	3	$57,600			10	6.3	Pipe Burst	$45,792	$16,067,772	Years 16-20
17	O714-O710	4	75	243	8		2	$22,400	2	$38,400			4	1.6	Pipe Burst	$69,984	$16,137,756	Years 16-20
17	O696-O697	4	74	452	6				1	$14,400			1	0.2	(1) Point Repair(s)	$14,400	$16,152,156	Years 16-20
17	Q502-Q503	4	74	346	6				1	$14,400			1	0.3	(1) Point Repair(s)	$14,400	$16,166,556	Years 16-20
17	O691-O692	4	74	32	6	8			2	$28,800			2	6.3	Pipe Burst	$9,216	$16,175,772	Years 16-20
17	R1010-R1011	4	74	378	10								0	0.0	Pipe Burst	$136,080	$16,311,852	Years 16-20
17	P649-P650	4	73	448	8						1	$19,200	1	0.2	(1) Point Repair(s)	$19,200	$16,331,052	Years 16-20
17	R1009-R1010	4	73	354	10								0	0.0	Pipe Burst	$127,440	$16,458,492	Years 16-20
17	Q806-Q807	4	72	473	8				1	$19,200			1	0.2	(1) Point Repair(s)	$19,200	$16,477,692	Years 16-20
17	Q703-Q704	4	72	103	6	8	1	$8,400			4	$57,600	5	4.9	Open Cut Replacement	$49,440	$16,527,132	Years 16-20
17	O6105-O698	4	71	256	8						1	$19,200	1	0.4	(1) Point Repair(s)	$19,200	$16,546,332	Years 16-20
17	S610-S609	4	71	75	6				4	$57,600			4	5.3	Full CIPP	$13,500	$16,559,832	Years 16-20
17	R853-R847	4	71	148	8						2	$38,400	2	1.4	Full CIPP	$35,520	$16,595,352	Years 16-20
17	R841-R853	4	71	245	8						8	$153,600	8	3.3	Full CIPP	$58,800	$16,654,152	Years 16-20
17	R854-S802	4	71	371	8						6	$115,200	6	1.6	Full CIPP	$89,040	$16,743,192	Years 16-20
17	R805-R808	4	71	347	10						8	$192,000	8	2.3	Full CIPP	$104,100	$16,847,292	Years 16-20
17	O694-O695	4	71	300	6	8					3	$43,200	3	1.0	Open Cut Replacement	$144,000	$16,991,292	Years 16-20
18	Q710-Q783	4	71	299	6	8							0	0.0	Pipe Burst	$86,112	$17,077,404	Years 16-20
18	Q810-Q807	4	70	162	6				1	$14,400			1	0.6	(1) Point Repair(s)	$14,400	$17,091,804	Years 16-20
18	M740-M765	4	70	371	6				2	$28,800			2	0.5	(2) Point Repair(s)	$28,800	$17,120,604	Years 16-20
18	R745-R707	4	70	444	6				4	$57,600			4	0.9	(4) Point Repair(s)	$57,600	$17,178,204	Years 16-20
18	P764-P763	4	70	285	6	8	2	$16,800	20	$288,000			22	7.7	Pipe Burst	$82,080	$17,260,284	Years 16-20
18	M776-N703	4	69	200	6		1	$8,400					1	0.5	(1) Point Repair(s)	$8,400	$17,268,684	Years 16-20
18	O6136-O501	4	69	167	6				1	$14,400			1	0.6	(1) Point Repair(s)	$14,400	$17,283,084	Years 16-20
18	O678-O679	4	69	153	6				1	$14,400			1	0.7	(1) Point Repair(s)	$14,400	$17,297,484	Years 16-20
18	P602-P603	4	69	492	6				1	$14,400			1	0.2	(1) Point Repair(s)	$14,400	$17,311,884	Years 16-20
18	P814-P815	4	69	235	6				1	$14,400			1	0.4	(1) Point Repair(s)	$14,400	$17,326,284	Years 16-20
18	P815-P816	4	69	219	6				1	$14,400			1	0.5	(1) Point Repair(s)	$14,400	$17,340,684	Years 16-20
18	Q870-Q808	4	69	273	6				1	$14,400			1	0.4	(1) Point Repair(s)	$14,400	$17,355,084	Years 16-20
18	R649-R658	4	69	273	6				1	$14,400			1	0.4	(1) Point Repair(s)	$14,400	$17,369,484	Years 16-20
18	S812-S809	4	69	217	6				2	$28,800			2	0.9	(2) Point Repair(s)	$28,800	$17,398,284	Years 16-20
18	O6135-O6106	4	69	62	6				1	$14,400			1	1.6	Full CIPP	$11,160	$17,409,444	Years 16-20
18	O689-O6141	4	69	74	6				4	$57,600			4	5.4	Full CIPP	$13,320	$17,422,764	Years 16-20
18	S615-S609	4	69	301	6				3	$43,200			3	1.0	Full CIPP	$54,180	$17,476,944	Years 16-20
18	S612-S623	4	69	165	6	8			2	$28,800	1	$14,400	3	1.8	Open Cut Replacement	$79,200	$17,556,144	Years 16-20
18	R1127-R1128	4	69	174	6	8			1	$14,400	1	$14,400	2	1.1	Open Cut Replacement	$83,520	$17,639,664	Years 16-20
18	S601-CARMEl	4	69	29	6	8			2	$28,800			2	6.9	Pipe Burst	$8,352	$17,648,016	Years 16-20
18	T607-T606	4	69	82	6	8			3	$43,200			3	3.7	Pipe Burst	$23,616	$17,671,632	Years 16-20
18	O6147-O6104	4	69	121	6	8			6	$86,400			6	5.0	Pipe Burst	$34,848	$17,706,480	Years 16-20
18	O686-O687	4	69	123	6	8			6	$86,400			6	4.9	Pipe Burst	$35,424	$17,741,904	Years 16-20
18	P707-P708	4	69	126	6	8			4	$57,600			4	3.2	Pipe Burst	$36,288	$17,778,192	Years 16-20
18	O679-O680	4	69	177	6	8	1	$8,400	3	$43,200			4	2.3	Pipe Burst	$50,976	$17,829,168	Years 16-20
18	P639-O689	4	69	284	6	8			4	$57,600			4	1.4	Pipe Burst	$81,792	$17,910,960	Years 16-20
19	P747-P785	4	69	313	6	8			9	$129,600			9	2.9	Pipe Burst	$90,144	$18,001,104	Years 16-20
19	Q729-Q730	4	69	338	6	8			1	$14,400			1	0.3	Pipe Burst	$97,344	$18,098,448	Years 16-20
19	O723-O724	4	69	672	6	8	22	$184,800	5	$72,000			27	4.0	Pipe Burst	$193,536	$18,291,984	Years 16-20
19	O605-O604	4	68	214	6				1	$14,400			1	0.5	(1) Point Repair(s)	$14,400	$18,306,384	Years 16-20
19	P648-P649	4	68	450	8						1	$19,200	1	0.2	(1) Point Repair(s)	$19,200	$18,325,584	Years 16-20
19	S618-S615	4	68	182	6				4	$57,600			4	2.2	Full CIPP	$32,760	$18,358,344	Years 16-20
19	R907-R908	4	68	290	10								0	0.0	Pipe Burst	$104,400	$18,462,744	Years 16-20
19	R751-R752	4	67	193	8				1	$19,200			1	0.5	(1) Point Repair(s)	$19,200	$18,481,944	Years 16-20
19	P719-P720	4	67	221	6		2	$16,800					2	0.9	(2) Point Repair(s)	$16,800	$18,498,744	Years 16-20

	Pipe Properties						Rehab/Replacement Method Analysis Input Factors								Recommended CIP			
CIP Year	PipeID	Risk	LOF	Pipe Length, LF	Exist Diameter, inches	New Diameter, inches	CIPP Patch Count	CIPP Patch Cost	Point Repair Count	Point Repair Cost	Sag Repair Count	Sag Repair Cost	Total Repair Count	No. of Repairs/ 100-LF	Rehab/Replacement Method	Rehab/ Replacement Cost	Cumulative CIP Cost	CIP Group
19	R705-R704	4	67	521	6		1	$8,400	1	$14,400			2	0.4	(2) Point Repair(s)	$22,800	$18,521,544	Years 16-20
19	Q516-Q503	4	67	270	6				2	$28,800			2	0.7	(2) Point Repair(s)	$28,800	$18,550,344	Years 16-20
19	Q631-Q640	4	67	235	12		7	$117,600	1	$28,800	1	$28,800	9	3.8	Full CIPP	$84,600	$18,634,944	Years 16-20
19	O681-O682	4	67	60	6	8			1	$14,400	2	$28,800	3	5.0	Open Cut Replacement	$28,800	$18,663,744	Years 16-20
19	Q701-Q702	4	67	67	6	8			1	$14,400			1	1.5	Pipe Burst	$19,296	$18,683,040	Years 16-20
19	P751-P752	4	67	246	6	8	1	$8,400	1	$14,400			2	0.8	Pipe Burst	$70,848	$18,753,888	Years 16-20
19	Q732-R701	4	67	281	6	8			1	$14,400			1	0.4	Pipe Burst	$80,928	$18,834,816	Years 16-20
19	R609-R612	4	67	259	8		3	$33,600					3	1.2	Pipe Burst	$74,592	$18,909,408	Years 16-20
19	Q613-Q615	4	67	124	12		6	$100,800	3	$86,400			9	7.3	Pipe Burst	$53,568	$18,962,976	Years 16-20
20	R624-R628	4	67	372	12		5	$84,000					5	1.3	Pipe Burst	$160,704	$19,123,680	Years 16-20
20	P730-P729	4	65	104	6				1	$14,400			1	1.0	(1) Point Repair(s)	$14,400	$19,138,080	Years 16-20
20	N634-N626	4	65	260	6								0	0.0	Full CIPP	$46,800	$19,184,880	Years 16-20
20	R1001-R1002	4	65	289	8		1	$11,200	2	$38,400	6	$115,200	9	3.1	Full CIPP	$69,360	$19,254,240	Years 16-20
20	M729-M731	4	65	363	8		7	$78,400	3	$57,600	1	$19,200	11	3.0	Full CIPP	$87,120	$19,341,360	Years 16-20
20	R617-R616	4	65	165	6	8	1	$8,400	23	$331,200	1	$14,400	25	15.2	Open Cut Replacement	$79,200	$19,420,560	Years 16-20
20	S604-S603	4	65	126	6	8			9	$129,600			9	7.1	Pipe Burst	$36,288	$19,456,848	Years 16-20
20	M737-M775	4	65	211	6	8			7	$100,800			7	3.3	Pipe Burst	$60,768	$19,517,616	Years 16-20
20	O725-O728	4	65	285	6	8	8	$67,200	56	$806,400			64	22.5	Pipe Burst	$82,080	$19,599,696	Years 16-20
20	P807-P808	4	65	326	6	8	1	$8,400	2	$28,800			3	0.9	Pipe Burst	$93,888	$19,693,584	Years 16-20
20	N642-N643	4	65	408	6	8	2	$16,800	3	$43,200			5	1.2	Pipe Burst	$117,504	$19,811,088	Years 16-20
20	O744-O784	4	64	189	6	8	3	$25,200	1	$14,400	1	$14,400	5	2.6	Open Cut Replacement	$90,720	$19,901,808	Years 16-20
20	S622-S616	4	63	115	6				1	$14,400			1	0.9	Full CIPP	$20,700	$19,922,508	Years 16-20
20	O615-O616	4	63	61	8				1	$19,200			1	1.6	Pipe Burst	$17,568	$19,940,076	Years 16-20
20	M777-M784	4	63	102	8				1	$19,200			1	1.0	Pipe Burst	$29,376	$19,969,452	Years 16-20
20	N605-N606	4	62	261	6				1	$14,400			1	0.4	(1) Point Repair(s)	$14,400	$19,983,852	Years 16-20

WEST YOST ASSOCIATES