

Development of Risk Matrix

Develop likelihood of failure (LOF) and consequence of failure (COF) criteria based on the vulnerability and criticality of the asset, respectively. Calculate risk score for each pipe segment as the product of LOF and COF scores per the equation below (WEF 2007).

$$Risk = LOF \times COF$$

Likelihood of Failure

Table 1 - LOF Scoring Criteria

Likelihood Category	Negligible = 1	Unlikely = 2	Possible = 4	Likely = 7	Very Likely = 10
Years since pipe installation	< 20 years	≥ 20 years to < 30 years	≥ 30 years to < 40 years	≥ 40 years to < 50 years	≥ 50 years or unknown
Pipe material	HDPE, PVC, or PE	DIP ≤ 30 years old	Cast-iron pipe	<ul style="list-style-type: none"> DIP ≥ 30 years old/DIP without date of installation AC pipe Prestressed concrete cylinder pipe installed in the 1970s 	Unknown
Pipe break information (from 2014 through 2018)	0 breaks	Not used	No historical pipe break information available/provided from 2014 through 2018	At least one break in pipe segment	Two or more breaks in pipe segment
FM peak operating pressures	Modeled FM peak operating pressure < 60 psi	Not used	Modeled FM peak operating pressure between 60 and 100 psi	Not used	Modeled FM peak operating pressure > 100 psi
Pipe layout profile	No ARV/high point on segment	Not used	One ARV/high point on segment	Not used	Not used
Pipe maintenance	Not used	Not used	Pipe maintenance records are not available	Not used	Not used
External and internal physical factors affecting the asset/proximity to salt water intrusion	<ul style="list-style-type: none"> Pipe is above water table and outside the salt water intrusion line. PVC, HDPE, and PE are the pipe materials. 	Pipe is below the water table and outside of the salt water intrusion line.	Pipe is above water table and in salt water intrusion line.	Pipe is within groundwater and inside the salt water intrusion line or brackish.	Pipe is within groundwater and inside the salt water intrusion line.

Table 2 - LOF Category Weighting Factor

LOF Category	Weights (percent)
Years since pipe installation	16
Pipe material	17
Pipe break information (from 2014 through 2018)	23
FM peak operating pressures	16
Pipe layout profile	7
External and internal physical factors affecting the asset/proximity to salt water intrusion	14
Pipe maintenance (includes cleaning techniques, such as flushing and rodding, relief valve exercising, and previous inspections, if performed)	7

Consequence of Failure Score

Table 3 - COF Scoring Criteria

Consequence Category	Negligible = 1	Low = 4	Moderate = 7	Severe = 10
Pipe diameter	< 8 inches	≥ 8 and < 24 inches and unknown	≥ 24 and < 42 inches	≥ 42 inches
Proximity to potable water wellfield or private water wells	No well located within 1-mile radius	Well located within 0.5-mile to 1-mile radius	Well located within 0.25-mile to 0.5-mile radius	Well located within 0.25-mile radius
Residential and essential services impact	<ul style="list-style-type: none"> No essential service facility is nearby. Only low-density residential will be impacted. Proximity to waterway is greater than 1/8 mile and low-density residential. 	<ul style="list-style-type: none"> Discharge to canal or another waterway will be possible. Medium-density residential will be impacted. Proximity to waterway is within 1/8 mile and low- or medium-density residential. 	<ul style="list-style-type: none"> Moderate priority essential services, such as railway, port, and industrial area, will be impacted. High-density residential area will be impacted. Highway crossing will be impacted. Tourist and commercial areas, such as marinas, hotels, beaches, and parks, will be impacted. Proximity to waterway is within 1/8 mile and railways, ports, industrial, and/or high density residential. 	<ul style="list-style-type: none"> High-priority essential service, such as hospitals, schools, or downtown areas and convention centers, will be impacted. Proximity to waterway is within 1/8 mile and high priority essential service.
System reliability	<ul style="list-style-type: none"> Pipe has redundancy if greater than 24 inches in diameter. No sanitary sewer overflows have occurred. Rerouted average dry-weather flow is less than 2 mgd (1,400 gpm). 	<ul style="list-style-type: none"> Pipe has limited redundancy, and flow could be rerouted elsewhere in system during repair. Rerouted average dry weather flow is 2 mgd (1,400 gpm) or more and less than 4 mgd (2,800 gpm). 	<ul style="list-style-type: none"> Pipe has limited redundancy with difficulty rerouting flow elsewhere in system during repair. Rerouted average dry-weather flow is 4 mgd (2,800 gpm) or more and less than 7 mgd (4,900 gpm). 	<ul style="list-style-type: none"> Pipe has no redundancy and no ability to reroute flow elsewhere in the system during repair. Rerouted average dry-weather flow is 7 mgd (4,900 gpm) or more.
Financial impact on utility	Direct failure cost is less than \$25,000.	Direct failure cost is \$25,000 or more but less than \$50,000	Direct failure cost is 50,000 or more and less than \$100,000	Direct failure cost is \$100,000 or more.
Community impact	<ul style="list-style-type: none"> Minor disruption; no narrow streets will impede repair. 	<ul style="list-style-type: none"> Minor disruption; no narrow streets will impede repair. 	<ul style="list-style-type: none"> Substantial but short-term disruption will 	<ul style="list-style-type: none"> Long-term impact will occur.

	<ul style="list-style-type: none"> Minor service interruption; service restored without public reaction. 	<ul style="list-style-type: none"> Minor service interruption; service restored without public reaction. 	<ul style="list-style-type: none"> occur due to narrow streets. Localized impacts will occur on prominent businesses or residences. 	<ul style="list-style-type: none"> Area-wide disruption will occur. Disruptive impacts to multiple prominent businesses or residences will occur. Public will express dissatisfaction with utility services.
Environmental compliance	Volume of unauthorized discharge is less than 6,972 gal.	Volume of unauthorized discharge is 6,972 gal or more and less than 13,917 gal.	Volume of unauthorized discharge is 13,917 gal or more and less than 100,023 gal.	Volume of unauthorized discharge is 100,023 gal or more.

Notes:

gal = gallon(s)

gpm = gallon(s) per minute

mgd = million gallon(s) per day

Table 4 - COF Category Weighting Factor

COF	Weight (percent)
Pipe diameter	10
Proximity to potable water wellfield or private water wells	11
Residential and essentials services impact	17
System reliability	21
Financial impact on utility	7
Community impact	14
Environmental compliance	20

Risk Analysis

Figure 5 - Risk Score Prioritization Matrix

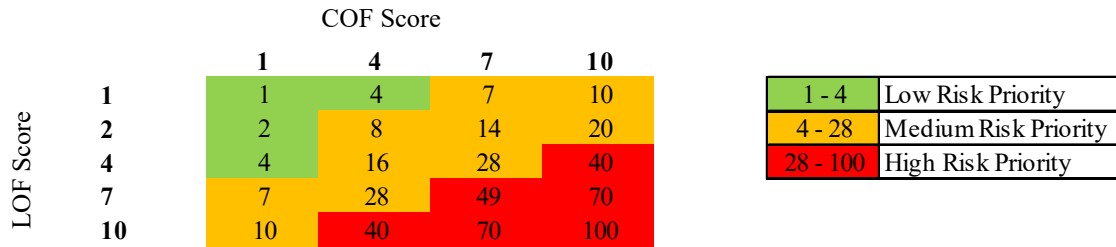


Table 5 summarizes the miles of City-owned FMs and results of the initial risk analysis. The final risk analysis results with the Tier 1 condition assessment included are presented in Section 5.

Table 5 – Summary of Risk Analysis and Implementation Plan

Item Description	Miles of FM
Total miles of active City-owned FMs	110
No further assessment – low LOF	37
No further assessment – high LOF	9
No further assessment – Phase II CO or CIP project	22
Tier 1 – Records review and field reconnaissance	42
Tier 1 – Soil survey and corrosion analysis	42