Ross Valley Sanitary District

March 2021

IAMP: MINOR PUMP STATION ASSESSMENT

Introduction

Ross Valley Sanitary District (RVSD) wishes to update their Infrastructure Asset Management Plan (IAMP), develop an inflow and infiltration (I&I) reduction plan, and meet the Cease and Desist Order No. R2-2013-0020 (CDO dated May 13, 2013 issued by the San Francisco Regional Water Quality Control Board) and new National Pollutant Discharge Elimination System (NPDES) requirements. This project, started to meet those goals, is comprised of multiple complex components. One of the main goals is reducing SSO risk, and part of achieving that goal is ensuring that the minor pump stations in the system are functioning properly. The District owns and operates 5 major pump stations and 14 minor pump or lift stations. This effort will evaluate and perform a condition assessment on the minor pump stations along with PS 10, PS 24 and PS 25, collectively referred to as Stations.

This technical memorandum presents a risk prioritization of the RVSD minor pump stations.

Acronyms and Abbreviations

LS	Lift Station
GAL	Gallons
GPM	Gallons per Minute
GPD	Gallons per Day
MGD	Million Gallons per Day
COF	Consequence of Failure
LOF	Likelihood of Failure
PCP	Pump Control Panel
PS	Pump Station
RVSD	Ross Valley Sanitary District
SSO	Sanitary Sewer Overflow

Minor Pump Stations - The minor pump stations included Lift Stations (LS), which lift the sewage by pipeline to a downstream gravity sewer and Pump Stations (PS) which pump sewage into a shared common force mains.

Background

The RVSD 2013 IAMP performed an assessment of the District's larger pump stations: PS 12, PS 13, PS 14, PS 15, PS 24, and PS 25. Due to changes to the District's pump stations over the years and to complete the assessment of the rest of the District's smaller pump station assets, this additional assessment was needed in the IAMP update.

Approach

The prioritization was developed using a risk-based approach involving likelihood of failure (LOF) and consequence of failure (COF). The LOF is an indicator of how soon a given asset is likely to fail given the present knowledge of its condition. The COF is described as the effect on levels of service resulting from an asset failure, as well as the cost of repairs, potential for property damage, community and environmental impacts, and other costs. The criteria used to develop the scores for the LOF and COF are described in the following sections.

The scores for LOF and COF are multiplied to calculate the Asset Risk Score, which is then used as a factor for prioritizing capital improvement projects for RVSD's minor pump stations.

The likelihood or consequence score of one pump station only has value in relation to the likelihood or consequence score of another pump station. For example, if Pump Station A has a likelihood of failure score of 30 and Pump Station B has a likelihood of failure score of 70, then Pump Station B is considered to be more likely to fail than Pump Station A . It would not be accurate to say, however, that a high score indicates that failure is imminent, only that failure is more likely for that pump station than for one with a lower score.

The higher the Asset Risk Score, relative to the scores of other assets, the higher the risk of failure. For example, Table 1 shows the Asset Risk Score for hypothetical Pump Station A and B. Although Pump Station B is predicted to be more likely to fail than Pump Station A, the consequence if Pump Station A fails is much greater than that of Pump Station B. Therefore, based on the overall Asset Risk Score, Pump Station A would be prioritized above Pump Station B.

Table 1: Example Asset Risk-Based Scoring

Pump Station	Likelihood of Failure	Consequence of Failure Score	Asset Risk Score
Pump Station A	5	10	50
Pump Station B	10	2	2

Prioritization Process

The process used to develop the risk model is based on guidelines found in the National Association of Clean Water Agencies (NACWA) publication "Implementing Asset Management: A Practical Guide". The analysis quantifies the risk associated with an asset (pump station) failure. Using this approach, risk scores were calculated per pump station, the scores were then be used to prioritize the improvements on the pump stations.

Once the available data were compiled, a preliminary model was developed. The compiled data are provided in Table 2. The criteria categorization, ranking and weighting will then be shared with RVSD staff and modifications can be made to get to the final risk model.

Table 2: Summary of Compiled Minor Pump Station Data

Station	Location	Pump Station Capacity gpm	Wet Well Dimensions	Wet Well Capacity	Upstream Pump Station	Pump #1 Motor and Pump	Pump #1 Capacity gpm	Pump #2 Motor and Pump	Pump #2 Capacity gpm	Station Power Primary PG&E Voltage	Station Power Backup Generator Type	Operation Hours** Dry Season	Operation Hours** Wet Season
PS 10	Landing B, 101 E Sir Francis Drake	~1,400	10'x15' 15' deep	~17,000 gal (2,250 cu. ft.)	LS 20 - Landing A	Flygt 25 hp, VFD, 480v, 3-phase	800	Flygt 25 hp, VFD, 480v, 3-phase	800	480v, 3 phase	Cummins Diesel Generator, 480v, 3 phase, 125 kw, 500 gal fuel tank, ~25 hrs operation/full tank	39.7	57.6
LS 20	Landing A, 17 E Sir Francis Drake	500	5' dia 13' deep	~1,894 gal	None, gravity inflow only	Gorman-Rupp, 5 hp, 220v, 3-phase, (operated at 208v)	250	Gorman-Rupp, 5 hp, 220v, 3-phase, (operated at 208v)	250	208v, 3-phase	Portable Generator, 230v, 3-phase, 60kw	20	22.0
LS 21	Hwy 101, 101 E Sir Francis Drake	~400	11.5'x8' 7' deep	~4,779 gal (644 cu. ft)	None, gravity inflow only	Flygt 25 hp, 230v, 3-phase	260	Flygt 25 hp, 230v, 3-phase	260	220v, 3-phase	Portable Generator, 230v, 3-phase, 60kw	9	40.0
LS 22	Cape Marin, 2 Scott Place	~225	6' dia 19' deep	~3,986 gal (537 cu. ft.)	None, gravity inflow only	Flygt 5 hp, 240v, 1-phase	150	Flygt 5 hp, 240v, 1-phase	150	240v, 1-phase	Portable Generator, 240v, 1-phase, 60kw minimum	8	16.6
LS 23	Capurro, 48 Elizabeth Circle	300	6' dia 18' deep	~3,776 gal (509 cu. ft.)	None, Local gravity influent only	Flygt 3 hp, 240v, 1-phase	150	Flygt 3 hp, 240v, 1-phase	150	240v, 1-phase	Portable Generator, 240v, 1-phase, 60kw minimum	6	6.0
LS 24	630 S Eliseo	750	13.5' x 8' 18' deep	14,424 gal (1,944 cu. ft.)	None, gravity inflow only	Flygt 25 hp, 240v, 3-phase	500	Flygt 25 hp, 240v, 3-phase	500	240v, 3-phase	Kohler 60, Natural gas powered, 240v, 3-phase, 60 kw	20.2	25.0
PS 25*	1350 S Eliseo	----	10' dia 19' deep	~11,000 gal (1,492 cu. ft.)	None, gravity influent only	Flygt 20 hp, 240v, 3-phase	500	Flygt 20 hp, 240v, 3-phase	500	240v, 3-phase	Kohler 80, Natural gas powered, 240v, 3-phase, 80 kw	8	19.0
LS 30	Heather Garden	300	6' dia 9.5' deep	~2,000 gal	None, Local gravity flow only	Flygt submersible, 5 hp, 208v, 3-phase	150	Flygt submersible, 5 hp, 208v, 3-phase	150	208v, 3-phase	Standby source: diesel generator which is maintained by Larkspur DPW, Telephone 415-927-5110	12	76.7
LS 31	1 Via La Brisa	200	5' dia 12' deep	~1,750 gal	None, gravity inflow only	3 hp, 208v, 3-phase	100	3 hp, 208v, 3-phase	100	208v, 3-phase	Portable Generator, 208v, 3-phase, 60kw minimum	19.3	28.2

LS 32	1 Corte Del Bayo	300	5' dia 12' deep	~1,750 gal	None, gravity inflow only	3 hp, 208v, 3-phase	150	3 hp, 208v, 3-phase	150	208v, 3-phase	Portable Generator, 208v, 3-phase, 60kw minimum	5.9	10.0
LS 33	415 Riviera Circle	300	6' dia 20' deep	~4,200 gal	LS-31, LS-32, LS-34, LS-35, LS-36	Flygt submersible, 5 hp, 208v, 3-phase	150	Flygt submersible, 5 hp, 208v, 3-phase	150	208v, 3-phase	Portable Generator, 208v, 3-phase, 60kw minimum	28.8	115.0
LS 34	359 Riviera Circle	300	5' dia 15' deep	~2,200 gal	LS-35, LS-36	Flygt submersible, 5 hp, (not on rails), 208v, 3-phase	150	Flygt submersible, 5 hp, (not on rails), 208v, 3-phase	150	208v, 3-phase	Portable Generator, 208v, 3-phase, 60kw minimum	7.2	32.7
LS 35	2 Corte Del Coronado	300	5' dia 9' deep	~1,300 gal	LS-36	Flygt submersible, 5 hp, (not on rails), 208v, 3-phase	150	Flygt submersible, 5 hp, (not on rails), 208v, 3-phase	150	208v, 3-phase	Portable Generator, 208v, 3-phase, 60kw minimum	8.2	32.9
LS 36	178 Riviera Circle	300	5' dia 17' deep	~2,500 gal	None, Local gravity flow only	Flygt submersible, 5 hp, (not on rails), 208v, 3-phase	150	Flygt submersible, 5 hp, (not on rails), 208v, 3-phase	150	208v, 3-phase	Portable Generator, 208v, 3-phase, 60kw minimum	3	19.3
LS 37	220 Larkspur Plaza Dr	120	6' dia 14' deep	~2,900 gal	None, Local gravity flow only	Flygt submersible, 3 hp, 240v, Single-phase	60	Flygt submersible, 3 hp, 240v, Single-phase	60	240v, single phase	Portable Generator, 240v, single-phase, 60kw minimum	25.5	33.2

* - PS 25 has three pumps - each pump is a 25 hp Flygt pump
** - 2019 Month Long Operational hours: representative dry season month = July representative wet season month = Feb

The score is calculated by calculating the COF score and LOF score per asset. The risk equation is defined as follows:

$$\text{Risk} = [(\text{COF}) \times (\text{LOF})]$$

Consequence of Failure Criteria

The COF Scoring Matrix was developed based on how a pump station failure impacts the District, the pump station operators, and the public. The goals, objectives, weighting factors, and indicators are used to determine the COF. Scores were developed based on the following criteria and are summarized in COF Scoring Matrix shown in Table 3.

- Spill Rate
- Proximity to Residents
- Sanitary Sewer Overflows (SSOs)
- Odors
- Fall Protection
- Operator Time
- Operation Cost
- Sewage Bypass Capability
- Receiving flow from other Pump Stations

The COF criteria are grouped into seven COF categories. The COF Scoring Matrix utilizes the seven categories that make up the overall COF score as shown in Table 3. Each category is weighted and the criteria are utilized to calculate the COF score for each station. Each category is weighted such that the maximum possible COF score for each station is 10. Categories that utilize multiple criteria in development of their score are calculated by a multi-parameter formula. This formula ensures that the asset receives the highest score from the associated criteria. The COF categories include:

- Environmental Impacts: impact of failure on waterways, environmentally sensitive areas
- Stakeholder/Customer Service: impact of failure on customers, partner agencies, etc.
- Regulatory Compliance: violation of regulatory requirements because of asset failure
- Health and Safety: property damage, injury to public, District staff, contractors, etc.
- Financial Impact: financial impact of failure to District or communities
- Ability to restore asset to design level of service (LOS): difficulty to restore asset to expected LOS
- Location/Critical facility impact: impact of failure on the community (e.g. open spaces vs.
- schools & hospitals)

Table 3: Consequence of Failure Criteria and Weighting Factors

Consequences of Failure					
Number	**Categories**	**Criteria**	**%**	**Indicator**	**Data**
1	Environmental Impacts	Max Spill Rate	15	Pump Capacity	Design Flow
2a	Stakeholder/Customer Service	Proximity to Residents	15	Travel Distance	Measure
2b		Odors		Operations	Historic
3	Regulatory Compliance	SSOs	20	Operations	Experience
4	Health and Safety	Fall Protection	10	Based on Assessment	Assessment
5	Financial Impact	Operator Time	20	Operations	Experience
6	Ability to Restore Asset to Design LOS	Sewage Bypass Capability	10	Based on Assessment	Assessment
7	Location/Critical Facility Impact	Receiving other PS flow	10	Emergency Bypass Plan	GIS

Environmental Impacts

Pump Stations, like the force mains they discharge into, have the potential for significant wastewater spills because they are designed to put energy in to the fluid to move the wastewater through the collection system and if this energy is uncontrolled, the wastewater can make a mess. Due to the intrinsic design of pump stations being located in low lying areas to collect wastewater, they are also located in the natural drainage confluences where surface water accumulates, so pump stations are often located very near wetlands and other sensitive water waterways. Pump stations are designed to not spill but if something failed on the discharge, the size of spill would be based on the size of pumps.

The capacity of the pumps at the pump station was chosen as a means to quantify the consequence of failure on the environment. A COF score for the capacity of the pumps was used to determine the effective Environmental Impacts COF score.

This category accounts for 15% of the overall COF Score for each pump station. The COF score for capacity of the pumps are provided in Table 4.

Table 4: Environmental Impacts COF Scores

Max. Pumping Rate (GPM)	Score
<200	2
200-450	5
451-1000	8
>1000	10

Stakeholder/Customer Service

Pump station failures can have significant impact on the residents around the pump station because of the mess and the smell related to a spill. This category determines the impact on the community by using station proximity to residences and the experience with odors at the station. The goal of this category is to minimize nuisance impacts to customers by minimizing the adjacent residents and stations with odor issues.

Mapping was used to determine the approximate distance from the primary ingress/egress of the nearest residential dwelling to the station. COF scores were assigned based on the distance ranges. Stations with odor issues were identified by district staff. COF scores were assigned based on historic odor issues at stations.

This category accounts for 15% of the overall COF Score for each pump station. The COF scores for proximity of residents and odor impacts are provided in Table 5 and Table 6.

Table 5: Service - Proximity of Residents COF Scores

Approx. Distance (FT)	Score
>250	2
101-250	3
20-100	7
<20	10

Table 6: Service - Odor COF Scores

Odors	Score
No Issues	1
Very Slight	2
Slight	3

Regulatory Compliance

Pump station failures can create a violation with regulatory requirements. The goal of this category is to reduce the potential for spills (SSOs) that violate regulatory requirements. In practice, pump stations that create violation by having SSOs when they fail have design limitations that are very specific to that pump station and thus that pump station is likely to have SSOs again if the specific conditions are met.

The SSO COF score is based on the District's operational experience with the pump stations and the issues with potential SSO at each pump station.

This category accounts for 20% of the overall COF Score for each pump station. The COF score for SSO issues are provided in Table 7.

Table 7: SSO Issues COF Scores

SSO Issues	Score
No Issues	1
Potential	2
Potentials	3
Few	6
Some	7

Health and Safety

Pump Station failure presents very little risk to the general public, but District staff who operate the pump station are much more at risk and practice extensive safety procedures to minimize these risks at all times. The understanding of the risks and the procedures/equipment to minimize these risks change over time as more is learned and technology changes. The primary risk operators experience is mitigated by fall protection measures around the vaults and the wet well. The goal of this category is to optimize the safety precautions and therefor minimize the risk to District staff operating the pump stations.

This category accounts for 10% of the overall COF Score for each station. The COF scores for Health and Safety are provided in Table 8.

Table 8: Health and Safety COF Scores

Fall Protection	Score
Great	1
Pretty Good	3
Sufficient	5
Could Be Better	7

Financial Impact

Pump stations are relatively complex facilities and represent a significant cost in a wastewater collection system to maintain. The primary cost for failure of stations of this size would be District staff time setting up and maintaining a temporary sewage bypass solution while the mode of failure at the facility addressed. The goal of this category is to minimize the time District collection system operators are required at a station asset.
To generalize for a non-specific mode of failure, the operational experience of the District staff who operate the pump station, and who know what pump stations take more time and what stations take less time, is used to estimate the cost of financial impact. The relative cost is based on the experienced maintenance times for the stations. COF scores were assigned based on the whether the station required more or less operator time than average.

This category accounts for 20% of the overall COF Score for each station. The COF scores for operator cost are provided in Table 9.

Table 9: Financial Impact COF Scores

Operator Cost	Score
Significantly Below Average	1
Below Average	3
Average	5
Above Average	7

Ability to Restore Asset to Design Level of Service

The service that the station provides is pumping wastewater and the surest contingency to restore that functionality regardless of the failure mode is with bypass pumping. The goal of this category is to determine the ability to mitigate or avoid the impacts of a failure during asset restoration by connecting a bypass pumping system.

The ease of bypass is chosen as the means to quantify the risk for large spills. The ease of bypass COF score identifies the amount of effort needed to bypass the force main during system restoration or in the event of a significant failure. This criterion is evaluated by engineering judgment which is based on the existing bypass capabilities for each station.

This category accounts for 10% of the overall COF Score for each station. The COF scores for ability to restore asset to design LOS are provided in Table 10.

Table 10: Restore Asset to LOS COF Scores

Sewage Bypass Capability	Score
Passive	1
Valve Pit Connection	2
Less Complicate	4
A Little Complicated	5
More Complicated	6
Very Complicated	8
Fittings in ROW	10

Location/Critical Facility Impact

Wastewater collection systems are gravity systems that often require a series of pumping stations to overcome gravity. When stations are in a chain, one filling the next, they impact the local service area and all the upstream stations and service areas. The goal of this category is to determine the impact of a station failure based on the other stations that rely on it.
The pump station network map and the pattern of wastewater flow through the systems was used to assign the COF score.

This category accounts for 10% of the overall COF Score for each station. The COF scores for the location/critical facility impact are provided in Table 11.

Table 11: Critical Facility COF Scores

Receiving other Station Flow	Score
0	2
1	4
2	6
>2	8

Likelihood of Failure Criteria

The LOF Scoring Matrix was developed based on industry experience and station characteristics. The data source, weighting factors, and indicators used to determine the LOF Score were developed based on the following criteria and are documented in the LOF Scoring Matrix included as Table 12.

- Physical Condition
- Wetwell Size
- Pump Size
- Pump Type
- Backup Power

The LOF criteria are grouped into six LOF categories. The LOF Scoring Matrix utilizes the six categories that make up the overall LOF score and is displayed in Table 12. Each category is weighted and the criteria are utilized to calculate the LOF score for each station. Each category is weighted such that the maximum possible LOF score for each station is 10. Categories that utilize multiple criteria in development of their score are calculated by a multiparameter formula. This formula ensures that the asset receives the highest score from any of the associated criterion. The LOF categories include:

- CDO Requirements: impact on CDO requirements if asset is not improved. N/A
- I&I Goals: impact on I&I goals if asset is not improved. N/A
- Condition: physical condition of the lift station.
- Capacity: sufficient capacity for service area needs.
- Reliability: primary component of asset.
- Functionality: difficultly maintaining asset operation, ability to pump is a strong indicator of LOF.

The following sections describe the criteria that encompass each category, the data source and indicator of each criterion, how each criterion is scored as well as the overall weight for each category.

Table 12: Likelihood of Failure Criteria and Weighting Factors

Likelihood of Failure

Number	Category	Criteria	%	Indicator
1	CDO Requirements	N/A		
2	I&I Goals	N/A		
3	Condition	Mechanical/Structural	20	Condition Assessment
		Electrical/Control		Condition Assessment
4	Capacity	Wet Well Size	20	Wetwell Volume
		Size of Pumps		Pumping Capacity
5	Reliability	Pump Type	20	Gorman-Rupp/Flygt
6	Functionality	Backup Power	40	Backup power configuration

Condition

The physical condition of the station is typically based on the condition assessment of the station which has two primary components: mechanical and structural condition and electrical and controls condition. The mechanical and structural condition assessment primarily focuses on the pumps, piping, concrete and hatches. The electrical and controls condition assessment focuses on the MCC, monitoring and control equipment and the generator.

This category accounts for 20% of the overall LOF Score for each pump station. The COF scores for the condition of the major aspects of pump stations are provided in Table 13 and Table 14.

Table 13: Mechanical/Structural Condition LOF Scores

Mechanical/Structural Condition	Score
No Issues	1
Minor Issues	2
A few Issues	3
Some Issues	4
Significant Issues	5
Overhaul	9

Table 14: Electrical and Controls Condition LOF Scores

Electrical/Controls Condition	Score
Minor Needs	2
Some Needs	5
Major Needs	7

Capacity

The capacity of a station is a factor of the size of the wetwell and the amount of pumping capacity, along with the size of the pumps. A larger wetwell allows the station to better equalize flow characteristic from the service area and larger pumps allow the station to push more wastewater through the system.

The LOF score for capacity is based on the greater of these two characteristics.

This category accounts for 20% of the overall LOF Score for each station. The LOF score for capacity are provided in Table 15 and Table 16.

Table 15: Wetwell Volume LOF Scores

Wetwell Volume (gal)	Score
>15k	1
12k - 15k	2
10k - 12k	4
4k - 5.5k	8
2k - 4k	9
<2k	10

Table 16: Pump Capacity LOF Scores

Pump Capacity (gpm)	Score
1400	2
750	3
500	4
400	5
300	6
225	7
200	8
120	9

Reliability

Pump stations are complex facilities with various equipment, and the related reliability considerations. However, the overall purpose of the station is pumping wastewater, so the reliability of the pumps is paramount. Not all pumps or pump types have the same reliability based on how they work, so the type of pump implemented at the station is used for the reliability LOF score.

This category accounts for 20% of the overall LOF Score for each station. The LOF scores for the pump types are provided in Table 17.

Table 17: Reliability LOF Scores

Pump Type	Score
Gorman-Rupp	7
Flygt	1

Functionality

Stations need power to perform their primary function, to pump wastewater, and when the power goes out, the functionality of a station is tested. Functionality is a major indicator of LOF. Stations can have a variety of different backup power configurations and the functionality of these configurations vary significantly. These configurations provide a good indication of the functionality of the station. A more robust and automated backup power configuration is more functional as staff time is precious during a power emergency.

The backup power configuration is used for the functionality LOF score.

This category accounts for 40% of the overall LOF Score for each station. The LOF scores for the backup power configuration are provided in Table 18.

Table 18: Functionality LOF Scores

Backup Power Configuration	Score
Good Generator	1
Old Generator	6
Portable Connection	7

Minor Pump Station Ranking

The following sections provide a description of the COF and LOF scoring results.

Consequence of Failure Scoring Results

The COF scores for RVSD's minor pump stations are listed in the Minor Pump Station Scoring Summary Table 19. The overall COF score was calculated by summing the weighted consequence scores from each of the categories to obtain a total COF score ranging from 1 to 10. COF scores for individual categories within the consequence scoring criteria are also listed in Table 19.

Likelihood of Failure Scoring Results

The LOF scores for RVSD's force main segments are listed in the Minor Pump Station Scoring Summary Table 19. The overall LOF score was calculated by summing the weighted likelihood scores from each of the categories to obtain a total LOF score ranging from 1 to 10. LOF scores for individual categories within the likelihood scoring criteria are also listed in this Table.

Consequence of Failure versus Likelihood of Failure Plot

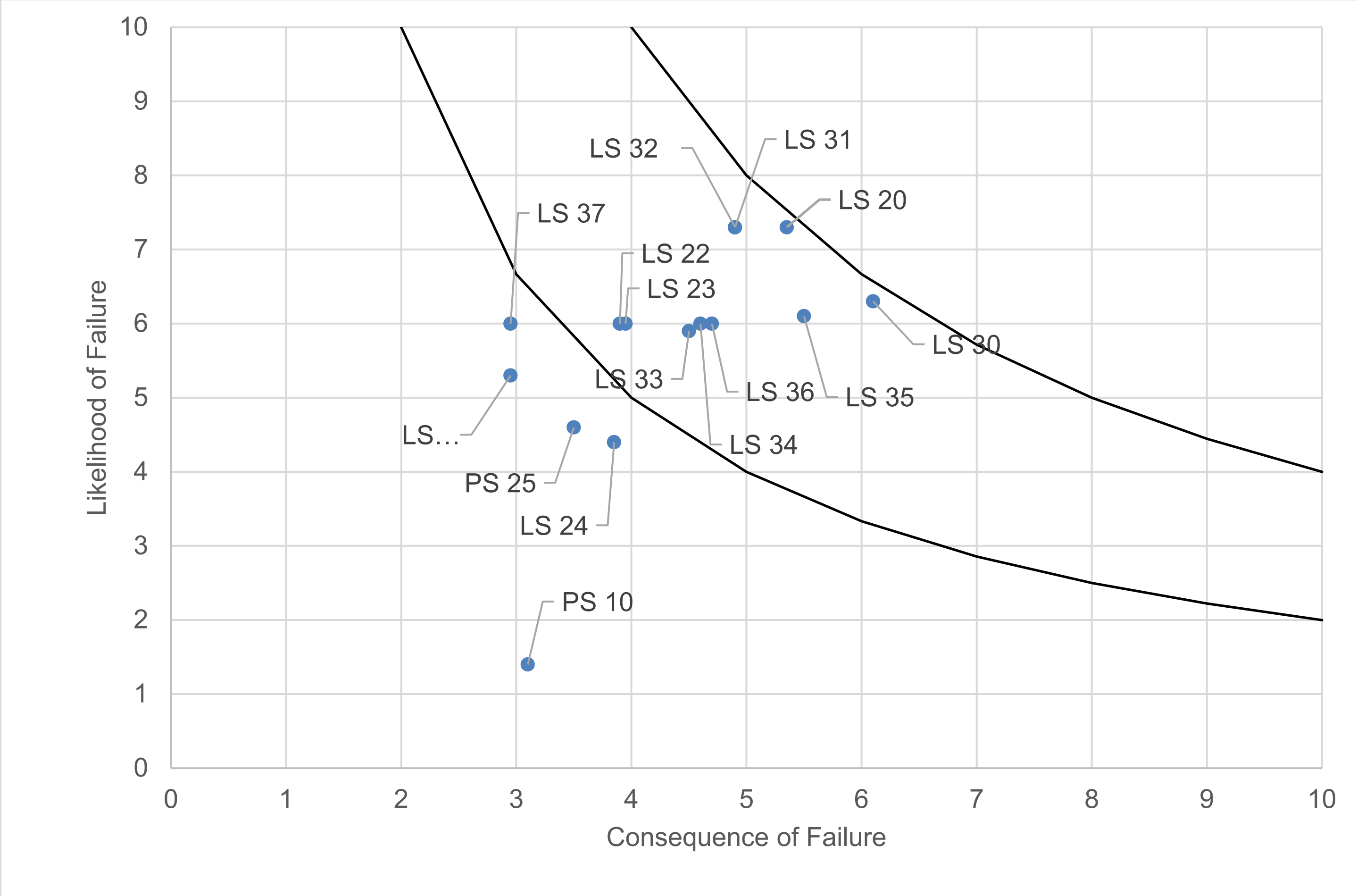

Figure 1 is a graphical representation of each force main plotted with its LOF score on the Y axis and its COF score on the X-axis. Pump stations plotted closer to the bottom left corner have a lower risk score, while pump stations plotted closer to the upper right corner have a higher risk score.

Risk Scoring Results

The total risk scores for each minor pump station within RVSD's system are listed in the Minor Pump Station Scoring Summary Table 19. The total risk score was calculated by multiplying the overall COF score by the overall LOF score for each pump station. The total risk scores can range from 1 to 100.

Table 19: Minor Pump Station Scoring Summary

Rank	Station Number	COF Score	LOF Score	Total Score
1	LS 20	5.35	7.3	39.1
2	LS 30	6.1	6.3	38.4

3	LS 31	4.9	7.3	35.8
4	LS 32	4.9	7.3	35.8
5	LS 35	5.5	6.1	33.6
6	LS 36	4.7	6	28.2
7	LS 34	4.6	6	27.6
8	LS 33	4.5	5.9	26.6
9	LS 23	3.95	6	23.7
10	LS 22	3.9	6	23.4
11	LS 37	2.95	6	17.7
12	LS 24	3.85	4.4	16.9
13	PS 25	3.5	4.6	16.1
14	LS 21	2.95	5.3	15.6
15	PS 10	3.1	1.4	4.3

The analysis shows that 5 of RVSD’s pump stations fall in the lower risk group (Overall Risk Score: <=20), 10 are within the moderate risk group (Overall Risk Score: 20-40), and 0 are in the higher risk group (Overall Risk Score: > 40).

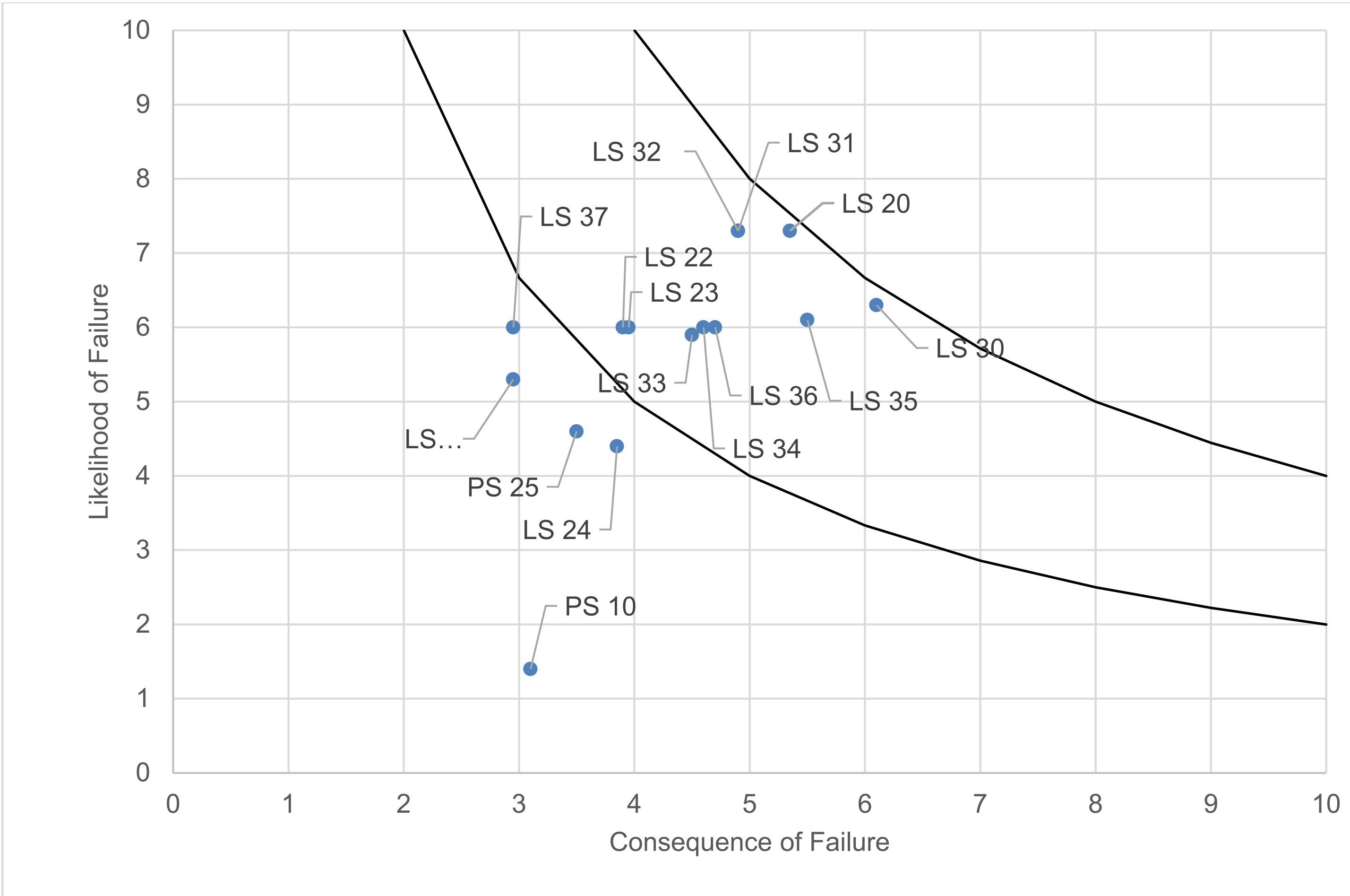

Figure 1: Minor Pump Station Scoring COF vs. LOF

Pump Station Improvement Recommendations

The District's pump station maintenance staff have provided a high level of maintenance and as needed minor upgrades for the District's minor pump stations and lift stations. However, many of the stations also have older electrical switch gear and controls, and are aged and require high maintenance attention. Replacement parts have become more difficult to obtain, particularly for older electrical controls.

The condition of the (15) Minor Pump Stations, with respect to existing electrical, control and standby power systems can be described by one of the three following categories:

- Good Condition: Pump Station PS 10 is the only observed station that falls into this category.
- Marginal Condition (i.e., 3 to 5 years of anticipated remaining service life): Lift Stations LS 21 and LS 24 and Pump Station PS 25 are the three stations that fall into this category.
- Poor Condition: All of the remaining eleven (11) Lift Stations that were observed fall into this category.

Observed conditions such as excessive equipment corrosion and obsolete control system equipment and components were found to be the two most commonly observed deficiencies for most of the inspected stations. It is anticipated that as time goes on, the older station electrical and control system equipment will exhibit more frequent component failures, some of which may lead to complete failure of a station's power and control system panel. It is expected that delaying the wholesale replacement of station electrical and control system equipment which was noted as being in "Poor Condition" will require more specialized maintenance effort to repair failed components and will heighten the risk of extended station outages required to make the necessary repairs.

Therefore, in spite of the District staff's maintenance, we recommend that several of the minor stations be considered for complete replacement, these include:

- LS 20 Landing A
- LS 30 Heather Garden
- LS 31 1 Via la Brisa at Riviera Circle
- LS 32 1 Corte del Bayo at Riviera Circle

LS 20 Landing A

This pump station serves the westerly portion of Larkspur Landing including the Golden Gate Bridge District ferry terminal. It is the old self priming type and utilizes two Gorman-Rupp pumps, similar to LS 31 and LS 32. The pump station structure is concrete and extends about two feet above grade. There is a driveway cut for access from East Sir Francis Drake Blvd. which is a busy street and it is difficult to stop in front of the pump station. Informal access is available from the parking lot of the adjacent building. It is recommended that this pump station be converted to a Flygt submersible type station.

LS 30 Heather Garden

The Heather Garden lift station was designed for a combined service as the sewage lift station shares the same building as the City of Larkspur's storm water pump station. This building is located at the intersection of Medway Road, alongside the City of Larkspur Heatherwood Park. At some time during the 1990's, the District took over the maintenance of only the sewage lift station. The actual age of the lift station is unclear, but it appears likely to be a former dry well station converted to Flygt submersible pumps at some time in its past. The station's mechanical features show considerable age and discharge piping corrosion from the occasional flooding due to malfunction of the Larkspur storm water pump station. It appears that the existing lift station could continue to operate during the construction of a new vertically buried, reinforced concrete pipe wetwell located on the west side of the existing building. The new lift station would be equipped with submersible Flygt pumps, new controls and standby generator in weather resistant enclosures. When the new station is completed, the sewers would be tied into the new wet well from the existing manhole and a new force main connection could be constructed along with a new portable bypass connection, on the existing HDPE force main.

LS 31 Via la Brisa and LS 32 Corte del Bayo at Riviera Circle

The District has continuously maintained these two conventional, self-priming Gorman-Rupp lift stations within the Greenbrae Marina Subdivision off of Riviera Circle LS 31 at 1 Via la Brisa and LS 32 at Corte del Bayo. These lift stations were originally considered "package" pump stations and the plans, pumps and controls were provided as a kit. Over the years, the District has replaced the controls for the lift stations, and these too now have nearly two decades of service and need upgraded components to meet current codes. Based on the subdivision improvement drawings, the gravity sewers from these two pump stations are connected together so that if one pump station were to fail, the sewage would flow to the other. However, this would likely surcharge the sewers and residential laterals and should only be used briefly. In 2008, District management had slated these stations, along with LS 20, for complete replacement with Flygt submersible pumps.

In the summer of 2020 these two station's wetwells were among several smaller stations the District lined with the Mainstay two part coating system. Maintaining operation of these three pump stations during construction improvements could be managed by working on one station at a time and allowing the gravity sewer intertie to function.

LS 37 - Replace Station with New Regraded Gravity Sewer

The Larkspur Isle sub-division, similar to most of the developments in this area, was constructed on areas underlain by deep bay mud which are prone to settlement of the filled areas over time, causing the gravity sewers constructed within the fill to settle and have poor grade for drainage. LS 37 was constructed to bypass the poorly draining sewer and lifts the sewage only a few feet elevation to the next downstream manhole 200 feet away. If LS 37 is not functioning, the sewage will still drain slowly by gravity to this same downstream manhole. It is recommended that a simple study be conducted to determine the sewer manhole elevations at the recently replaced 21 inch trunk sewer on Magnolia

Ave. It may be possible to replace the existing 8 inch diameter sewer with a new larger diameter regraded pipeline that is constructed with methods to minimize pipe settlement. This would eliminate the need for LS 37.

LS 21 - Replace Station with Gravity Sewer Constructed Under Highway101 by Guided Boring

Pump Station 21 serves some 50 homes on Via La Cumbre and Corte Placida in Greenbrae Subdivision 10. The pump station is located below and behind the homes on Corte Placida adjacent to the Caltrans right-of-way. The only access to the pump station is through the sound wall from the Caltrans right-of-way. Sewage is pumped uphill through a 4” diameter cast iron force main to a gravity sewer on Via La Cumbre.

In the mid-1990’s, the District hired Nute Engineering to investigate the possibility of constructing a new sewer downhill through a bored casing across Highway 101 and the old railroad right-of-way to connect to an existing sewer in Larkspur Landing. The main concern regarding this project was the possibility that rocks and boulders in the highway and railroad fill might preclude the boring of the necessary casing.

As a part of these investigations, soil borings were made in the vicinity of the proposed boring to determine, if possible, the existence of rock and boulders. Although the borings found occasional rocks in the highway fill, it was concluded that it would be feasible to bore a steel casing across the highway and railroad. The technology for accurate placement of steel casings has continued to improve since this earlier investigation and includes availability of smaller machines capable of installing the casing necessary for an 8 inch minimum gravity sewer in hard soil conditions. An allowance is recommended to cover the extra costs if such a boring should encounter rocks.

An economic evaluation showed the highway crossing to be more expensive than upgrading Pump Station 21. Based on this analysis the District chose to upgrade the pump station rather than installing a gravity sewer across the highway to Larkspur Landing as necessary to abandon the pump station.

Caltrans initially tried to push the District toward the gravity highway crossing by denying the District future access to the pump station. The District finally obtained an encroachment permit to access the pump station from the Caltrans right-of-way but the permit still retains the clause that allows Caltrans to revoke the encroachment permit on five days’ notice.

The force main from this pump station runs uphill through heavily landscaped backyard easements and is very difficult to access. Access to this pump station also remains problematic. District vehicles must pull off the right side of the southbound lanes of Highway 101 and backup through an opening between two concrete block sound walls.

At this point many years later the District is faced with the need to replace the discharge force main and provide standby power at Pump Station 21. Faced with these additional expenditures and the impediments to access and proper maintenance, the option of constructing a gravity sewer across Highway 101 should be re-analyzed.

LS 33 415 Riviera Circle - Add Permanent Standby Generator

This is the main pump station serving the Greenbrae Marina and pumps sewage from the other five pump stations in the subdivision to the main District system through the Riviera Circle force main under the Corte Madera Creek. This station was upgraded to a submersible pump station with an external valve pit in 1999.

Since this is the main pump station serving the Greenbrae Marina development it is recommended that a standby engine generator set be installed to improve its reliability. Currently, there is only a portable pump connection.

LS 34, LS 35, and LS 36 on Riviera Circle - Add External Valve Pits

These three lift stations are also part of the five stations which pump to LS 33 and are Flygt submersible type stations, but with the valves inside the wet well. The pump pit is constructed with a cone neck and two foot diameter manhole lids which make the pumps and valves very difficult to access. Confined space protections are needed every time someone enters one of these stations. These stations act as lift stations and pump the sewage from a deep sewer to a nearby shallow sewer where it flows on to the next downstream station, and finally LS 33.

It is recommended that these three lift stations be converted to submersible type stations with an external valve pit. All three of these station wetwells were coated with the two-part Mainstay coating during the summer of 2020.

LS 34 already has a functioning gravity bypass to the LS 33 collection system. However, in order to provide greater reliability, it is also recommended that a simple elevation study of the gravity sewers downstream of LS 35 and LS 36 be performed to determine how to provide a gravity sewer bypass connection to the next downstream lift station. The District has experience with replacing a gravity sewer segment just upstream of LS 33, and discovered that the sewer laterals were surprisingly over 5 foot deep within the front yards of the houses. This was probably because of a development decision to add fill over the originally constructed sewer and sewer laterals. This will have to be considered, and a gravity bypass may need to be independent of the existing collector sewer and function when the lift station surcharges to some degree.

PS 24, and PS 25 Generator Upgrade and Replacement

Currently, PS 24 and PS 25 are part of a design project for replacement of the existing natural gas fired generators with diesel generators mounted on a double contained generator base tank, and with modern sound reduction enclosures.

Pump Station Improvement Cost Estimate

To assist with planning and to help clarify the order of magnitude of recommended capital improvements, Budget level costs were developed. The budgetary costs along with a summary of the recommendations above are presented in Table 20.

Table 20: Minor Pump Station Recommendations and Cost

Station	Rehabilitation Recommendation	Budget Level Cost
PS 10	O&M PCP and Controls	$45,000
LS 20	Construct New PS	$800,000
LS 21	Upgrade PCP and Controls	$165,200
LS 22	Upgrade PCP and Controls	$165,200
LS 23	Upgrade PCP and Controls	$165,200
LS 24	Upgrade PCP, Controls and Genset	$243,600
PS 25	Upgrade PCP, Controls and Genset	$243,600
LS 30	Construct New Submersible Pump Station	$800,000
LS 31	Construct New PS	$800,000
LS 32	Construct New PS	$800,000
LS 33	Upgrade PCP, Controls and add Genset	$243,600
LS 34	Upgrade PCP and Controls, add Valve Pit	$205,000
LS 35	Upgrade PCP and Controls and add Valve Pit	$205,000
LS 36	Upgrade PCP and Controls and add Valve Pit	$205,000
LS 37	Upgrade PCP and Controls	$165,200

Pump Station O&M Recommendations

As indicated above, it is evident from the station inspections conducted for this report, that District staff have had a robust maintenance program for these lift stations, and generally stay ahead of the typical mechanical wear and tear (pumps, valves and piping).

For the existing electrical power at the stations, there are (15) Minor Pump Stations with (11) of them having portable standby power provisions (i.e., a receptacle and manual transfer switch for connecting a portable standby generator to supply power to the station when PG&E power is not available). The 2019 PGE fire season power outages tested the agency maintenance staff's ability to mobilize their portable gensets to keep up with pumping down these pump stations. It is recommended that the District maintenance staff consider which of these stations are “critical” with respect to operation during an extended PG&E outage and review their plan for portable generator equipment provisions and adequate staffing to deploy and connect portable generator equipment to each of these “critical” sites. Consideration should also be given to the amount of time that this effort will require in conjunction with collection system capacity to ensure that response time for deploying the portable generators to the “critical” sites is feasible to prevent system overflows. Based on this review, adding permanent standby generation may be possible at some of these stations (see LS 33 above).

In the interim period between now and the time in which the recommended station electrical and control system replacements are made, it is advised that the District procure used, spare components for equipment which is now obsolete and no longer commercially available as new equipment. One example that is applicable to several of the stations are the proprietary MicroMac controller modules. These are antiquated controllers which are likely only available as used equipment. Procuring spare controller units will help to minimize station downtime should one of the installed controllers fail.