PRIMARY CLARIFIER 1 – CONDITION ASSESSMENT

NOVATO SANITATION DISTRICT

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V&A

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1.0 EXECUTIVE SUMMARY

V&A Consulting Engineers, Inc. (V&A) assessed the condition of Primary Clarifier 1 at the Novato Sanitation District's (NSD) Wastewater Treatment Plant (WWTP), which included assessing the condition of the coatings and steel associated with the rake arms, skimmer arm, scum trough, and influent feed column. Condition assessment methods included pit depth measurement on exposed metal surfaces, dry film thickness (DFT) measurements, and qualitative visual evaluation. It was put in service in 2012. V&A assessed Primary Clarifier 1 on May 11, 2016.

Table 1-1 summarizes the results of the assessment and recommendations. The spiral scrapers may be pitted enough after abrasive blasting to warrant replacement at an estimated cost of $5,000 for two, which includes labor and materials. An estimate of probable construction cost is $100,000 for the removal and replacement of the protective coatings associated with the feed well, center column, center cage, rake arms, skimmer arm, scum trough, scum pipe, and spiral blades.

Table 1-1. Summary of Findings and Recommendations

Component	Conclusions	Recommendations
Rake Arms	Coating has reached the end of its design life. The steel does not require replacement.	Abrasive blast and recoat within the next year to extend the life of the rake arms.
Center Column and Feed Well	Coating has isolated spots of coating failures at edges but is in overall good condition.	Abrasive blast and recoat within the next 10 years or at the same time as the rake arms.
Underside of the Drive Mechanism	Coating and steel exhibits isolated corrosion at edges. Coating is nearing the end of its service life.	Coat within the next year to extend the life of the mechanism.
Spiral Blade Scrapers	Coating has reached the end of its design life. The steel may be pitted enough to warrant replacement.	Abrasive blast and recoat within the next year to extend the life of the scrapers.
Scum Trough	Existing coating on the topside has poor abrasion resistance and has failed. Underside is in fair condition.	Abrasive blast and recoat within the next year to extend the life of the scrapers.
Skimmer Arm	Coating has reached the end of its design life. The steel does not require replacement.	Abrasive blast and recoat within the next year to extend the life of the rake arms.
Skimmer Arm Support at Trough	Aluminum arm support exhibits corrosion and may fail within 10 years.	Consider replacing the arm support with a steel or cast iron arm coated with fusion bonded epoxy or a high solids epoxy.

2.0 INTRODUCTION

V&A Consulting Engineers, Inc. (V&A) was retained by RMC Water and Environment to assess the condition of Primary Clarifier 1 at the Novato Sanitation District's (NSD) Wastewater Treatment Plant (WWTP). The purpose of this project was to assess the condition of the coatings on the metallic components associated with the rake arms, drive mechanism, and influent feed column. Condition assessment methods included pit depth measurement on exposed metal surfaces, dry film thickness (DFT) measurements and qualitative visual evaluation. The clarifier is 100 feet in diameter and 14 feet high at the outer wall, with the floor sloping toward the central influent column and the sludge drain. It was put in service in 2012. The clarifier is covered with a flat aluminum plate roof supported by aluminum beam trusses. V&A assessed Primary Clarifier 1 on May 11, 2016. Figure 2-1 is an aerial view of the WWTP.

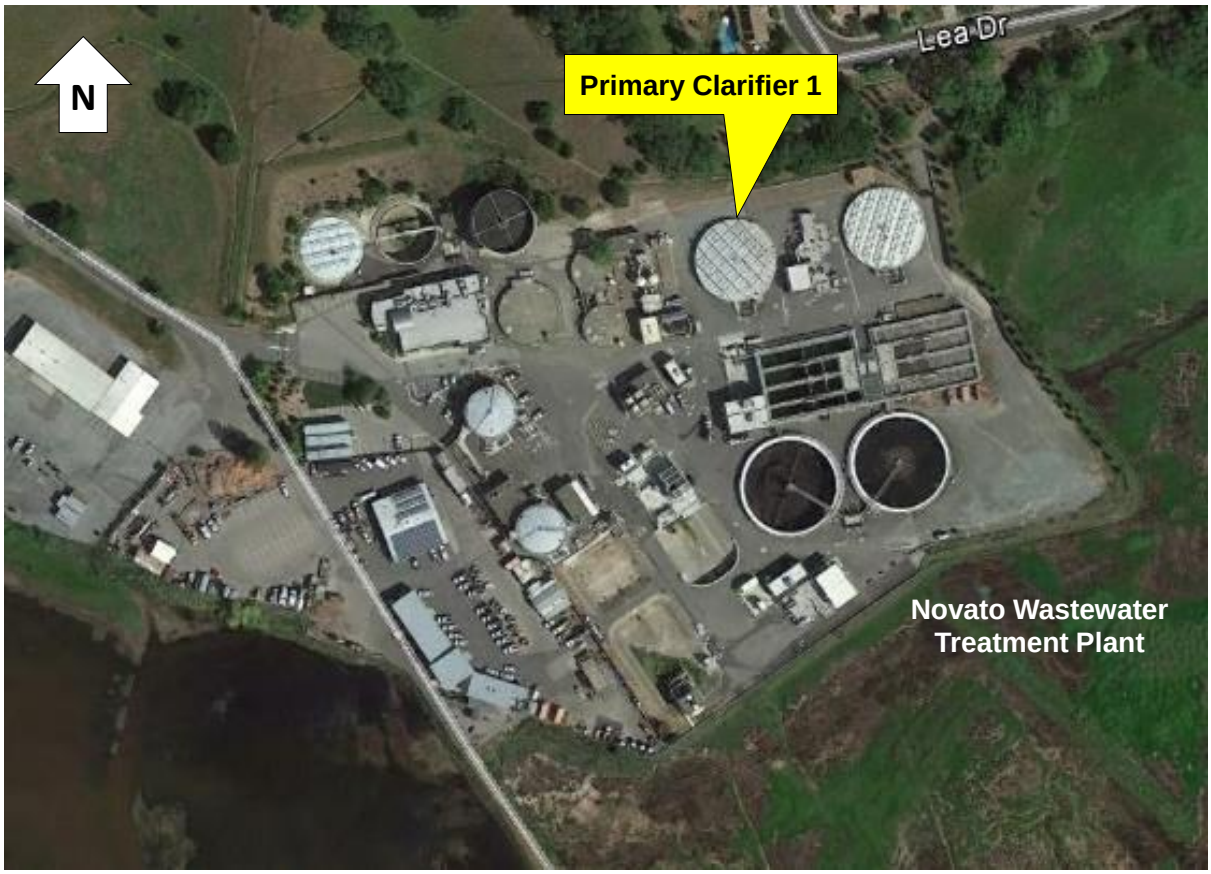

Figure 2-1. Aerial View of the Novato Wastewater Treatment Plant.

V&A conducted a confined space entry of the clarifier using a davit arm equipped with a self-retracting lifeline (SRL) for fall protection and an extension ladder secured to a topside aluminum railing. The two entrants wore hardhats, safety shoes, latex gloves, safety glasses, safety vest, and a body harness that was clipped to the SRL during descent into the clarifier. Entrants were also equipped with a 4-gas monitor that continuously sampled the clarifier atmosphere for hydrogen sulfide, carbon monoxide, LEL (flammable gas lower explosion limit), and oxygen level. Open hatches in the clarifier roof provided ventilation. Assessment tools were lowered to the Entrants by a topside Attendant.

NSD thoroughly washed down the clarifier walls, floor, rake arm assembly, and central influent column prior to V&A's entry. Entrants were aware of slipping, tripping, and fall hazards during the assessment. All valves controlling wastewater entry into the clarifier were locked out and tagged out. The SRL tagline was clipped to the lower rung of the entry ladder in the event that an evacuation of the entrants was required. Following the entry and assessment, the locks and tags were removed from the lockout/tagout (LOTO) valves and appurtenances once the entrants had exited the clarifier.

Figure 2-2 is a sectional view of the clarifier components.

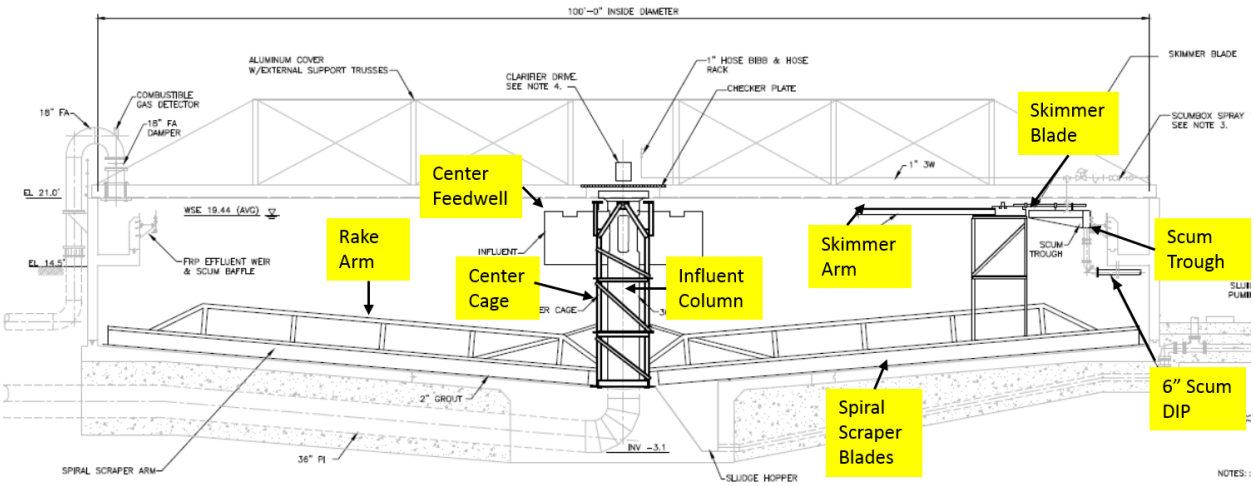

Figure 2-2. Section View Drawing of Primary Clarifier 1.

3.0 METHODS AND PROCEDURES

3.1 Pit Depth Measurement

Pitting corrosion or pitting is a form of extremely localized corrosion that creates small holes in metal. Where pits were encountered, the pit depths were measured using a pit depth gauge. If the nominal thickness of the metal is known, the percent of metal wall thickness loss can be calculated. A standard pit depth gauge is shown in Photo 3-1.

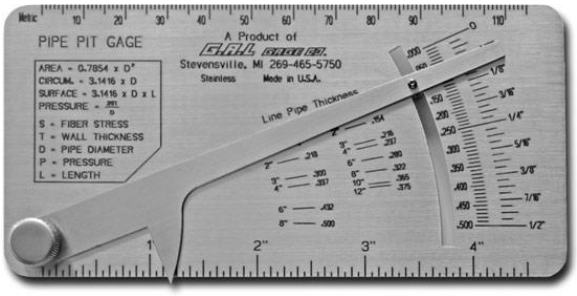

Photo 3-1. Standard Pit Depth Gauge.

3.2 Dry-Film Thickness (DFT)

V&A conducted dry-film thickness (DFT) testing on the clarifier center column, rake arms, skimmer supports, scum line and scum box supports. Up to 48 measurements were taken in Primary Clarifier 1. Dry film thickness is the thickness of a coating after it has cured. This DFT gauge uses electromagnetic induction and eddy current technology to measure the thickness of a wide variety of coatings on ferrous metal surfaces. DFT measurements on the tanks were recorded using an Elcometer® 456 Dry Film Thickness (DFT) Gauge, as shown in Photo 3-2. The gauge can measure coatings up to 60 mils in thickness. The gauge was calibrated using shims prior to collecting data.

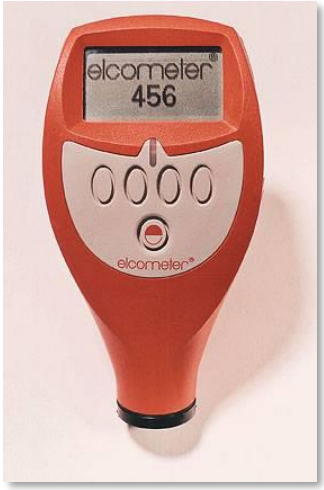

Photo 3-2. Elcometer® 456 DFT Gauge

3.3 Qualitative Visual Assessment

Qualitative visual evaluations were conducted in the clarifier during condition assessment. The visual investigation and examination was supplemented with digital photographs. The visual assessment focused on the condition of the clarifier metallic appurtenances and coatings. Defects such as metallic corrosion, pitting, exfoliation, coating blisters and coating failures were documented with digital photographs. Visual assessments are subjective in nature and are based on V&A's experience evaluating metallic structures in the water and wastewater industry.

3.4 VANDA™ Metal Condition Rating System

The VANDA® Metal Condition Index (Table 3-1) was created by V&A to provide consistent reporting of corrosion damage based on qualitative, objective criteria. Condition of ferrous metal can vary from Level 1 to Level 4 based upon visual observations and field measurements, with Level 1 indicating the best condition and Level 4 indicating severe damage. As a comparison, the ASTM D610 General Rust Grade is presented along with the VANDA Metal Condition Index.

Table 3-1. VANDA® Metal Condition Index Rating System

Condition Rating	ASTM D610 Rust Grade	Description	Representative Photograph
Level 1	**10-G to 7-G**	**Little or No Corrosion** Loss of Wall Thickness %: None Pitting Depth (as % of Wall Thickness): None to Minimal Extent (Area) of Corrosion: None	
Level 2	**6-G to 4-G**	**Minor Surface Corrosion** Loss of Wall Thickness %: < 25% Pitting Depth (as % of Wall Thickness): < 25% Extent (Area) of Corrosion: Localized	
Level 3	**3-G**	**Moderate to Significant Corrosion** Loss of Wall Thickness %: 25%-75% Pitting Depth (as % of Wall Thickness): 25%-75% Extent (Area) of Corrosion: 25%-75%	
Level 4	**2-G to 0-G**	**Severe Corrosion; Immediate Repair/Replacement Needed** Loss of Wall Thickness %: > 75% Pitting Depth (as % of Wall Thickness): 75% or More Extent (Area) of Corrosion: Affects Most or All of Surface	

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3.5 Coating Evaluation per ASTM D610

Ratings were assigned using the VANDA Metallic Condition Index and ASTM D610 General Rust Grade for painted surfaces. Figure 3-1 shows an example of general corrosion ratings. Similar rating scales are available for pinpoint and spot rusting.

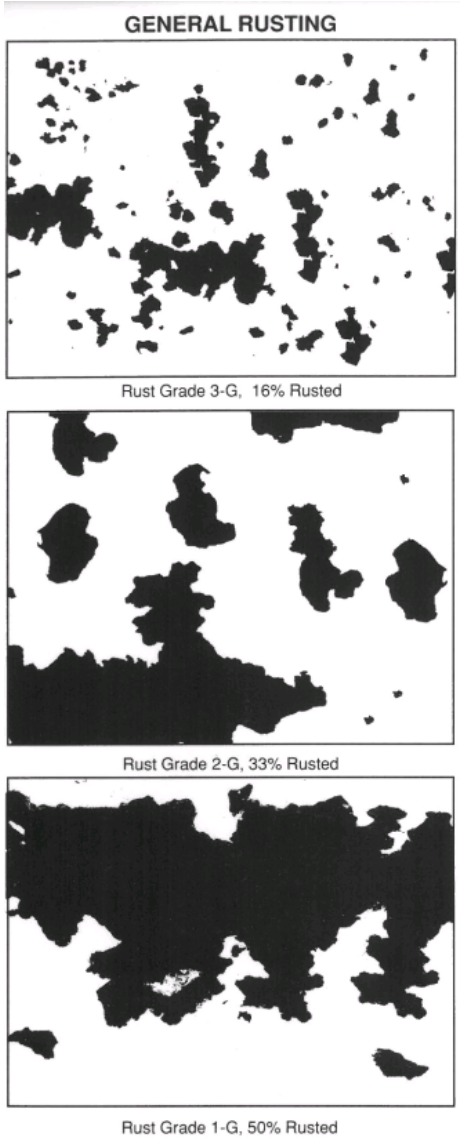

Figure 3-1. ASTM D610 Rust Grade Ratings

3.6 Observations

In many cases, the optimal method for assessing the condition of a structure is a physical investigation involving a combination of visual observations, documented with digital photographs, and substrate testing. It should be noted that much of the condition assessment data is subjective and based on V&A's experience evaluating metallic structures in the water and wastewater industry.

4.0 FINDINGS

4.1 Primary Clarifier 1

Primary Clarifier 1 is 100 feet in diameter with two rake arms and one 6-inch scum pipe. The condition assessment focused primarily on rake arms, scum skimmer, center column, center column supporting cage, scum piping, and the scum box.

4.1.1 Rake Arms

The clarifier rake arms were examined for coating integrity and metal condition where the coating had failed. The condition of welds and weld plates was assessed. Stainless steel nuts, bolts, and washers were also examined for dissimilar metal corrosion (galvanic corrosion) where they made contact with carbon steel.

Photo 4-1 shows a general view of the angle supports and cross braces of the rake arm that are in fair condition. Typical edge corrosion on an angle support is shown in Photo 4-2. Various examples of rake arm coating failure and metal corrosion are shown in Photo 4-3 through Photo 4-6. Coating delamination and metal corrosion at a rake arm weld plate are illustrated in Photo 4-7. Photo 4-8 displays the typical condition of stainless steel nuts, bolts, and washers used to fasten together the rake arm angle supports that is normally immersed. Large coating blisters on an angle iron are shown in Photo 4-9. Photo 4-10 shows no corrosion at the contact point between 316 stainless steel and coated carbon steel that is normally immersed.

Photo 4-1. Rake arms are in fair condition with isolated areas of corrosion at coating failures.

Photo 4-2. Coating failure and edge corrosion on a radial angle.

Photo 4-3. Failed coating and corroded metal of rake arm angle bracket.

Photo 4-4. Corroded rake arm angle bracket at scraper connection.

Photo 4-5. Delaminated coating on the underside of the rake arm and scraper.

Photo 4-6. Delaminated coating and VANDA Level 1 metal condition on rake arm.

Photo 4-7. Coating delamination and VANDA Level 2 metal on rake arm weld plates.

Photo 4-8. Stainless steel fasteners are intact. Minor corrosion on angle brackets above.

Photo 4-9. Blistered coating on rake arm angle bracket.

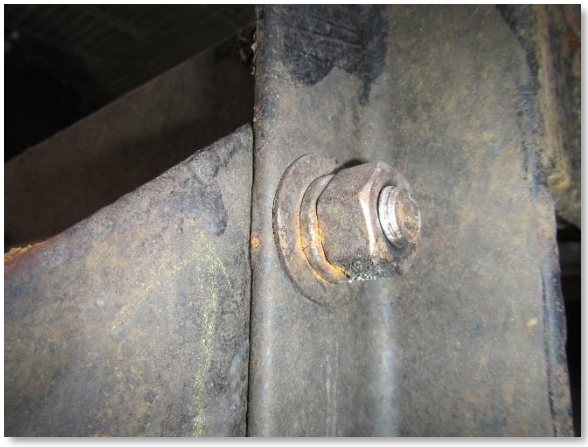

Photo 4-10. No corrosion observed on stainless bolt/carbon angle connection.

4.1.2 Center Column and Feed Well

There was approximately 1 foot of water around the center column during V&A's assessment. The bolts at the base of the column were not visible at the time. Photo 4-11 and Photo 4-12 are overall views of the exterior surfaces of the central influent column, cage, and feed well. The photos show that the central column, cage, and feed well coatings are in overall good condition. Local coating delaminations and associated corrosion on the above water surfaces of the feed well are illustrated in Photo 4-13. Photo 4-14 shows coating failure and corrosion of the exposed metal on a channel beam supporting the feed well. A bolted flange on the feed well is in VANDA Level 1 metal condition, as shown in Photo 4-15. The edges of the skimmer arm attachment to the feed well is in VANDA Level 2 metal condition as shown in Photo 4-16. No corrosion was observed on the surfaces of the center column, as shown in Photo 4-17 and Photo 4-18. Aside from the localized coating failure areas, the center influent column, cage, and feed well are in good condition.

Photo 4-11. Central influent column, cage, and feed well.

Photo 4-12. Central influent column, cage, and feed well (skirt). Coating is intact.

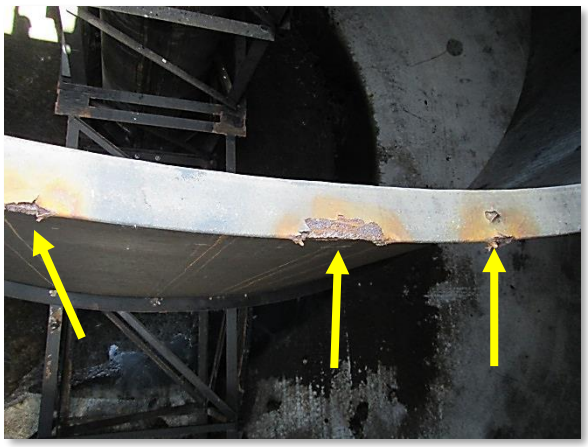

Photo 4-13. Localized coating failures and metal corrosion on the upper feed well.

Photo 4-14. Coating delamination and corrosion on the channel support.

Photo 4-15. Minor corrosion on feed well bolted flange.

Photo 4-16. Edge corrosion on feedwell/skimmer support bracket.

Photo 4-17. No corrosion was observed on the center column.

Photo 4-18. Upper surfaces of center column were in good condition.

4.1.3 Skimmer Arm, Scum Trough, and Scum Box Support

The scum box, supporting fixtures, and the scum pipe are shown in Photo 4-19. The scum pipe was constructed of plastic or fiberglass with rubber couplings, except for the ductile iron pipe spool piece that penetrates the wall. Photo 4-20 shows corrosion staining on the scum pipe flange and support bracket. Photo 4-21 and Photo 4-22 are underside views of the scum box showing minor corrosion staining on support brackets and box surfaces. Coating blisters on a scum box support plate are shown in Photo 4-23. Photo 4-24 shows VANDA Level 2 condition on the surfaces of the scum trough. The abrasion resistance of the existing coating was poor and has exposed the steel to the wastewater. Photo 4-25 and Photo 4-26 show coating blisters on the skimmer arm, which has resulted in VANDA Level 2 metal condition rating.

Overall the top side of the scum trough, skimmer arm, scum pipe, and associated structures are given a VANDA Level 2 metal condition rating.

Photo 4-19. South side of scum box, supports, and scum effluent pipe.

Photo 4-20. Corrosion stains on south side of scum pipe flange and support bracket.

Photo 4-21. The support brackets are in VANDA Level 1 metal condition.

Photo 4-22. Negligible corrosion was observed on the underside of scum trough.

Photo 4-23. Coating blisters on scum trough side plate.

Photo 4-24. Coating failure on surfaces subject to continuous abrasion.

Photo 4-25. Coating blisters and VANDA Level 1 metal condition on skimmer surface.

Photo 4-26. Coating failure and corrosion on the skimmer at the waterline.

4.1.4 Spiral Blade Scrapers

The spiral blade scrapers exhibit the most extensive coating delamination and exposed metal corrosion of the clarifier mechanism. Photo 4-27 and Photo 4-28 show blistering and delamination of coating on a spiral blade scraper. Photo 4-29 and Photo 4-30 show areas of coating loss and VANDA Level 2 metal condition on the exposed steel. It is unknown if the coating delaminations are due to excessive film buildup or insufficient steel preparation prior to the coating application. There were no holes observed in the scrapers, so scraper replacement is not warranted at this time. However, abrasive blasting of the scrapers may reveal deep pitting or perforations that may require scraper replacement. Photo 4-31 shows a 316 stainless steel nut, washer, and bolt in contact with coated steel that has not corroded in immersion service. Photo 4-32 shows a similar 316 stainless steel fastener with corrosion on the edges of the washer. It is likely that the steel around the fastener in the former photo was stripe coated well and the coating did not fail. The coating around the latter fastener was not applied correctly and dissimilar metal corrosion (galvanic corrosion) may be occurring.

Photo 4-27. Coating blistering and delamination on rake arm scraper.

Photo 4-28. VANDA Level 2 metal condition and blisters on scraper.

Photo 4-29. Coating delamination and VANDA Level 2 corrosion on backside.

Photo 4-30. VANDA Level 2 metal condition and blisters on scraper.

Photo 4-31. No corrosion observed on stainless/carbon steel bolted connection.

Photo 4-32. VANDA Level 1 metal condition at a stainless steel bolted connection.

4.1.5 Coating Dry Film Thickness (DFT) and Rake Arm Metal Thickness

Based on a review of coating records, the existing coating is likely Carboline Carboguard 890 epoxy with a recommended DFT of 12 to 18 mils for immersion service. The measured DFT for coated surfaces on the interior of Primary Clarifier 1 are presented in Table 4-1. The average, minimum, and maximum coating DFT values for the two rake arms and the scrapers are reported.

The results indicate an average coating of 17 to 20 mils on the rake arms, and twice the recommended thickness is applied on the spiral sludge scrapers. The coating on the spiral sludge scrapers may have failed due to excessive film buildup on the surfaces.

Table 4-1. Primary Clarifier 1 DFT Results

	No. of Readings	Avg. DFT (mils)*	Min. DFT (mils)*	Max. DFT (mils)	Standard Deviation (mils)	Coefficient of Variation
Rake Arm 1	24	17.5	11.8	27.4	4.0	22.7%
Rake Arm 2	25	20.2	12.1	55.8	10.3	51.2%
Scrapers	11	35.2	20.8	60.6	13.4	38.0%

* 1 mil = 0.001 inches

Cursory metal ultrasonic thickness (UT) measurements were conducted on rake arm angle braces using an Olympus 38DL Plus gauge. Thicknesses were measured on vertical, top and bottom horizontal, and cross brace angle irons. All angle pieces were 0.25 inches thick.

5.0 CONCLUSIONS

Rake Arms

1. Severe corrosion or pitting was not observed on the surfaces, and the remaining life of the rake arms is 10 to 15 years, if the coating is not replaced soon.
2. Based on the amount of coating failures observed on the rake arms, the coating is nearing the end of its design life after four years of service.
3. Sections of the rake arm have delaminated, blistered, and missing coating and are in VANDA Level 1 and Level 2 metal condition. The coatings have delaminated on flat surfaces and peeled open along rounded angle iron edges and at corners.
4. The center cage structure of the rake arms show only minor localized areas of coating failure and metal corrosion. The exposed metal areas are rated a VANDA Level 2 Condition.
5. Some stainless steel to carbon steel contact points exhibited minor corrosion, which is likely due to insufficient coating thickness on the carbon steel and not dissimilar metal contact.
6. DFT testing results on the two rake arm segments gave an average coating thickness of 18 to 20 mils.

Center Column and Feed Well

1. The coating on the interior and exterior of the feed well skirt is in good condition with a few isolated locations where the coating has failed.
2. The majority of the metal surfaces on the center column are in good condition and have a remaining life of at least 20 years.

Spiral Blade Scrapers

1. The rake arm spiral scrapers show severe coating blisters and delamination. Portions of the coating have peeled off the scraper surfaces and have exposed significant portions of the metal scraper to shallow surface corrosion and pitting. The latter, where observed, is not severe enough to warrant scraper replacement at this time.
2. Based on the amount of coating failures observed on the steel blades, the coating has reached the end of its design life after three years of service.
3. Some stainless steel to carbon steel contact points exhibited minor corrosion, which is likely due to insufficient coating thickness on the carbon steel and not dissimilar metal contact.
4. The spiral scraper coatings averaged 35.2 mils thick, which is twice the recommended thickness. The excess coating thickness or insufficient surface preparation of the steel may have caused the coating to delaminate on the spiral scrapers.

Scum Trough, Skimmer Arm, and Scum Pipe

1. The coating on the skimmer arm has reached the end of its design life after three years of service.
2. The existing coating on the topside of the scum trough has reached the end of its design life after three years in service. The abrasion resistance of the existing coating is poor.
3. The aluminum scraper arm exhibits extensive oxidation and corrosion on its surface and may lead to a failure.
4. The underside of the scum trough and its support framework is in good condition. Small isolated areas of failed coating on edges of the steel were observed, and the underlying metal was corroded to a VANDA Level 2 Condition.
5. The 6-inch scum pipe has delaminated coating at a connecting flange and exhibits corrosion of the exposed metal surface to a VANDA Level 2 Condition. The 316 stainless steel nuts, bolts, and washers are in good condition.

6.0 RECOMMENDATIONS

Based on the field observations and V&A's experience with similar wastewater treatment structures, the following recommendations are presented for the District's consideration.

Rake Arms

1. Remove and replace the coating on the center cage of the rake arm within one year to extend the life of the steel and clarifier. If the coating is not replaced soon, more extensive repairs will be required at a later time.
2. Abrasive blast all metal, including stainless steel hardware, per SSPC SP10, Near White Metal Blast Cleaning, and apply three coats of an epoxy at 4 to 6 mils per coat. The following products are recommended: Carboline Carboguard 890, International Paint Bar Rust 233H, PPG Amercoat 240, or Sherwin Williams Dura Plate UHS.
3. Coat over stainless steel hardware, if the clarifier components are not dismantled and coated separately.

Center Column and Feed Well

1. The coating on the immersed, bolted flanges and upper edges of the feedwell may be touched up and do not have to be replaced immediately. Consider excluding the complete removal and replacement of the coating on the center column and feedwell.
2. Remove and replace the blue coating on the underside of the drive mechanism as it is nearing the end of its service life.

Spiral Blade Scrapers

1. Remove and replace the coating on the steel spiral blades within 1 year to extend the life of the steel. If the coating is not replaced soon, more extensive repairs will be required at a later time.
2. Abrasive blast all metal, including stainless steel hardware, per SSPC SP10, Near White Metal Blast Cleaning, and coat with the three coats of an epoxy at 4 to 6 mils per coat. The following products are recommended: Carboline Carboguard 890, International Paint Bar Rust 233H, PPG Amercoat 240, or Sherwin Williams Dura Plate UHS.
3. Coat over stainless steel hardware, if the scraper components are not dismantled and coated separately.

Scum Trough, Skimmer Arm, and Scum Pipe

1. Replace the aluminum scraper arms with cast iron or steel coated with fusion bonded epoxy within the next 10 years. Galvanized steel with a high-solids epoxy coating would also be an acceptable replacement option.
2. Remove and replace the coating on the steel scum trough within 1 year to extend the life of the steel. If the coating is not replaced soon, more extensive repairs will be required at a later time.
3. Abrasive blast all metal per SSPC SP10, Near White Metal Blast Cleaning, and coat with one or two coats of an abrasion-resistant epoxy for a total DFT of 12 to 16 mils. The following products are recommended: Carboline Plasite 7122 VOC or Sherwin Williams Sher-Glass FF.
4. Coat over stainless steel hardware, if the scraper components are not dismantled and coated separately.

6.1 Preliminary Estimate of Probable Repair Costs

Table 6-1 summarizes the probable costs for the recommended repairs for planning purposes. Labor costs assume that the abrasive blasting and coating operations will be conducted by a contractor that is certified by the Society for Protective Coatings (formerly Steel Structures Painting Council; SSPC) QP-1 program. Currently, there are at least four certified contractors that bid projects in the Bay Area.

Table 6-1. Estimate of Probable Repair Costs for the Clarifiers

Item	Total
Primary Clarifier 1 Recoating	$100,000
Spiral Blade Scrapers (2)	$5,000
Total	$105,000

APPENDIX A

METAL THICKNESS DATA

ID No.	Remaining Thickness (inches)	Location
1	0.247	Rake Arm
2	0.250	Rake Arm
3	0.249	Rake Arm
4	0.250	Rake Arm
5	0.248	Rake Arm
6	0.248	Rake Arm
7	0.250	Rake Arm
8	0.311	vertical support for skimmer arm
9	0.248	Rake Arm
10	0.250	Rake Arm
11	0.250	Rake Arm
Average	0.250	
Min	0.247	
Max	0.311	