ECHELON ENGINEERING, INC.

Civil/Marine Consulting Engineers

INTERIOR & EXTERIOR INSPECTION OF THE AUKE LAKE WATER TANK

Juneau, Alaska

June 2001
00-2098C

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Prepared For:

City And Borough of Juneau
Public Works Department
5433 Shaune Drive
Juneau, Alaska, 99801

ATTN: Mr. Gene Rehfield, P.E.
Water Utilities Chief Resident Engineer

Prepared By:

Echelon Engineering, Inc.
3837 13th Avenue West, Suite 205
Seattle, Washington 98119

ATTN: Ms. Shelley D. Sommerfeld, P.E.
President

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ECHELON ENGINEERING, INC.
Civil/Marine Consulting Engineers

June 6, 2001

City & Borough of Juneau
Public Works Department
5433 Shaune Drive
Juneau, AK 99801

ATTN: Mr. Gene Rehfield, P.E.
Water Utilities Chief Resident Engineer

RE: FINAL REPORT – Interior and Exterior Inspection of the Auke Lake Potable Water Tank

Dear Mr. Rehfield:

This report and accompanying video are submitted to document the findings of our inspection of the Auke Lake Potable Water Storage Tank. The project was conducted to determine the existing condition of the interior and exterior of the tank. The project was carried out under the City and Borough of Juneau Contract No. RFP PW00-447.

Description Of Structure

The Auke Lake Tank is a vertical cylinder steel shell tank with a nominal capacity of 1,420,000 gallons and is a nominally 90 feet in diameter by 32 feet high. The tank is supported on a concrete ring foundation with oiled sand fill. The tank has a 30 inch diameter manhole; a 24 inch diameter manhole; a 10 inch overflow pipe on the side; and a 30 inch diameter roof vent. Additionally, a safety-caged ladder provides access to a 24 inch square access hatch located on the roof of the tank.

The roof of the tank is supported by a primary center steel pipe column and secondary steel pipe columns arranged around the perimeter of the tank. Steel I-beam rafters radiate out from the center. The tank is served by an impressed-current cathodic protection system that employs 2 anode assemblies with cast anodes mounted on semi-cylindrical beds. The cathodic protection system is powered by a rectifier that is mounted on the exterior of the tank, and controlled by an internal reference cell. The steel of the tank shell is coated inside and out with a cream-colored protective coating.

Scope Of Work – Tank Exterior

The tank exterior was subjected to a comprehensive Level I visual inspection. Damage or deterioration to the coating; tank appurtenances, the foundation ringwall, the grout joint, or to the steel structure was noted and recorded. Coating failures were located, quantified and typified. An

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estimate of the overall percentage of the tank's coating that has failed was also made. Any structural damage was similarly noted and recorded.

Additionally, sample sites were subjected to Level III ultrasonic thickness measurements and dry film thickness measurements. If significant pitting was encountered, pit depths were measured. As authorized by CBJ personnel, a cross-cut tape test was conducted and a sample of the coating material was collected from an area of coating failure. Representative photographic and video documentation of observed conditions noted on the exterior of the tank was also obtained.

Scope Of Work – Tank Interior

Investigation of the tank floor required that it be cleaned to remove light sediment deposits. Once cleaned, the interior of the tank was also subjected to a comprehensive Level I visual inspection. Damage to the structural elements of the tank and the components of the tank systems, such as the cathodic protection system, was noted and recorded. The integrity of the coating was examined for failure and deterioration. Coating failures were located, quantified and typified. An estimate of the overall percentage of the tank's coating that has failed was also made. Any structural damage was similarly noted and recorded.

Sample sites were subjected to Level III ultrasonic thickness measurements. If warranted, pit depth measurements were made. The tank electrochemical potential to a copper/copper sulfate half cell was measured to indicate the operational status of the cathodic protection system. Additionally, a sample of the coating material was collected from an area of coating failure. Representative photographic and video documentation of observed conditions noted on the interior of the tank was also obtained.

Methodologies

Inspection of the tank exterior was visually conducted from the ground, the access ladder and from the top of the tank. Suspect areas of damage in the upper inaccessible portions of the tank were viewed, as appropriate, with either a telephoto camera lens or with binoculars.

All tank interior work was conducted while the tank was in service. Inspectors utilized surface-supplied diving equipment to accomplish both the cleaning and the inspection tasks. Cleaning of the tank was conducted using a suction pump system to remove the majority of the sediment deposits such that thorough visual inspection of the floor could be conducted.

All equipment that entered the tank was disinfected in accordance with the procedures set forth in ANSI/AWWA Standard C652-92. The levels of total chlorine and free chlorine were checked to ensure appropriate amounts prior to and following all of the in-tank activity.

Locations of any damage or other items of note on the tank have been identified vertically relative to the tier of the steel tank plate to which they are associated and horizontally using analog "clock" positions. The safety access ladder was identified to be at the 12:00 position. The tank was found to have 3 plate elevations, designated Tier A, B, and C beginning at the top.

The findings of this investigation are presented within this report along with various samples and an accompanying video. Appendix A presents representative photographs of the site, of typical

conditions encountered and of various samples taken from the tank. Appendix B presents a detailed log of the video documentation prepared in conjunction with this inspection.

The accompanying video presents representative footage and specific items of note encountered during both the exterior and interior inspection of the tank. The video begins with a narrated walk-through of the exterior circumference of the tank and then documents the inspection of the exterior tank top. The variations in the audio quality of this portion of the video are due to the location of the inspector/narrator relative to the camera/microphone and the ambient wind noise experienced occasionally during the video taping. Following documentation of the exterior of the tank, the video covers the underwater and internal above water sections of the tank inspection. The quality of the underwater portion of the video is sometimes negatively impacted by the disturbance of sediment within the tank. Narration has been added to explain the components inspected.

Observed Conditions

The field investigation was carried out on November 2 and 3, 2000. Weather during the inspection was rainy and cold with temperatures in the upper 30's (°F). The underwater visibility within the tank was initially found to be good, exceeding 90 feet. Once the cleaning work commenced on the floor of the tank, visibility was reduced to approximately 5 feet due to suspended sediments. Water depth in the tank during the investigation was at the maximum level of approximately 30 feet. The water temperature was reported to be 33 °F.

The findings of the inspection are summarized in the following section:

Tank Exterior

1. Inspection showed the overall condition of the coating to be good. Visual observation and handling of coating samples, showed the material to retain some gloss indicating that material is not an epoxy or a regular alkyd paint. Based on this evaluation the coating appears to be a silicon alkyd.
2. A number of isolated areas of minor coating failure and rusting measuring were identified. The damaged areas ranged from approximately 8 inch diameter max to approximately 1.5 inch diameter, with an average of about 6 inches. This damage was found throughout the tank exterior on both the side and on the top of the structure.
3. There are no areas of concentrated coating failure. However, Tier C, the ground panel, displays the most number of areas of coating failure.
4. Several of the areas with coating failure were noted to have been treated with a maintenance application of a black colored product. This material appears to be a sprayed application of a rust converter material.
5. The access manhole at the 12:30 position was found to have rust bleeding from the bolts and crossbar.
6. A second manhole located at the 10:00 position was also noted to have coating failure and corrosion at the bolts. Additionally, a 6"diameter coating failure and several less than ½ inch

diameter coating failures with corrosion were also encountered on the hatch cover, as well as corrosion of the hinge.

7. Inspection of the tank top revealed small diameter black spots sporadically covering the entire surface. These spots were found to be lichen. When cleaned, no damage or deterioration of the underlying coating was noted.
8. A sampling of dry film thicknesses was made. Readings ranged from 15.0 mils to 32.0 mils at areas where the coating appeared smooth and flat. Readings were not attempted in areas of coating runs or areas of conspicuous heavy build.
9. Samples of the exterior coating were collected from various areas of coating damage identified on the sides and top of the tank.
10. A cross cut-tape test on the coating was not conducted due to the good visual condition of the protective coating on the exterior of the tank.
11. All structural steel joints and welds appear sound. No evidence of any deterioration or damage was identified.
12. Visual inspection of the ladder, railing, and roof access hatch show them to be sound with no evidence of significant damage or deterioration. The security plate at the bottom of the ladder appears to have been repaired. The coating on the security plate has been damaged by the repair welding and the plate was noted to be corroding.
13. The grout at the tank base was found to be broken and/or missing at various locations around the perimeter. Vegetation and moss was also noted to be growing in several of these deteriorated areas. The coating material that was applied over the grout was found to be in generally poor condition and to be peeling.
14. No pitting of measurable depth was encountered. Therefore, no pit depth measurements were obtained.
15. Representative measurements of the steel plates thicknesses were obtained using an ultrasonic thickness gauge. The results are as follows:

Location	Steel Plate Thickness Reading (Average, inches)
Tier A (Upper Panel)	0.255
Tier B (Middle Panel)	0.265
Tier C (Ground Panel)	0.388
Top of Tank	0.180

Tank Interior

1. Cleaning of the tank floor was conducted to facilitate visual inspection of the tank bottom. A uniform sediment depth of approximately 1 inch was encountered. Cleaning resulted in removal of approximately 70% of the sediment. This amount of cleaning was adequate to conduct a detailed inspection of the floor.
2. Inspection showed the overall condition of the coating to be good. Based on visual observation, the coating appears to be an epoxy applied over a red oxide prime coat.
3. Throughout the tank interior localized areas of minor coating failure and rusting were observed. Less than 1% of the tank interior surface was estimated to exhibit these isolated areas of localized coating failure.
4. The area of most concentrated coating failure was noted on the center support column at the Tier B, middle panel elevation. Measurement revealed an area of coating failure and corrosion of approximately 8 square inches.
5. Rust bleeding was noted on several of the steel roof support members. This damage was found to be associated with the corners of the members and is minor in nature at this time. No observable coating failures were identified at these sites.
6. Visual inspection showed all of the structural steel roof members, joints, welds, and bolts to be sound. No evidence of significant damage, deterioration or section loss was identified.
7. The interior portions of the roof access hatch, manholes, and pipe inlets were also found to be undamaged.
8. Inspection of the cathodic protection system identified one of the reference cells, located at the 11:50 position, to be broken. The exposed end of the cell was found to have been broken off flush with the wall mount. The tip of the reference cell was found on the floor.
9. Inspection only revealed one significant area of coating failure. The material around the edges of this damage were well adhered to the underlying steel. Therefore, no sample of interior coating material was taken.
10. No pitting of measurable size was located anywhere within the interior of the tank.
11. The electrochemical potential of the submerged steel of the tank was measured relative to a copper/copper sulfate reference half cell. The potential was –1.134 volts, indicating that the impressed cathodic protection system is operating.

Conclusions & Recommendations

Overall, the exterior coating was found to be in generally good condition. A number of small localized areas of coating failure were observed on the exterior surface of the tank that do not appear to warrant maintenance action.

The interior coating was also found to be in generally good condition, with several minor areas of coating failure. These coating failures do not appear to warrant maintenance at this time.

The cathodic protection system appears to be operating well at this time. However, the internal reference cell was found to be broken off flush with the tank wall. Inspection did not reveal any apparent cause of this damage. Further investigation by CBJ's cathodic protection consultant appears warranted to more thoroughly assess the current adequacy of the system and to develop possible repair alternatives. No other maintenance or repair of the cathodic protection system appears warranted at this time. Additionally, we recommend that the cathodic protection system routinely undergo testing and adjustment to ensure adequacy of this protection system.

Significant damage was noted to the grout material between the tank base flange and the concrete foundation ring. This damage may allow water to penetrate beneath the tank resulting in possible washout of the supporting sand fill. It is recommended that the grout be repaired.

The remaining structural elements of the tank, including the sidewall, roof, internal I-beam and knee brace roof support members were also found to be in good condition with no evidence of significant damage or deterioration. No maintenance repair of any of these members appears warranted at this time.

Finally, we recommend that tank cleaning and thorough internal and external inspection of the tank and associated components be repeated on a regular basis. Inspections of this type are typically recommended on a 3 to 5 year basis dependant upon the age of the structure and the amount of damage encountered during previous inspections. Based on the findings of this investigation, we recommend a 5 year cleaning, inspection and maintenance cycle for this tank. It has been our experience that routine re-inspections allow for the identification of trends in the damage and deterioration of various individual components and systems, as well as providing an indication of the rate of deterioration and ensuring the continued safe operation of the structure.

Probable Maintenance Costs

In summary, the overall condition of the coating system and structural tank components appear to be good. Based on the comprehensive visual inspection and random thickness testing of both the structural steel and coating, recommended maintenance and repair actions are as follows. Where provided, the probable cost of maintenance for the recommended repairs is a suggested budgetary number intended to provide an indication of the magnitude of the repair effort required. The final cost for any repairs will depend on the repair design and specific materials selected. No mobilization or demobilization costs have been included in the estimates provided.

1. **Spot Repair of Localized Damage to the Concrete Foundation Ring Grout – (Estimated Cost = $ 3,500)** Repair will require:
   a. Cleaning and surface preparation of the damaged areas.
   b. Application of appropriate cementaceous patching compound. (Epoxy grout should not be used due to the differential thermal expansion between the concrete and the grout material.)

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2. **Repair of the Cathodic Protection System Internal Reference Cell – (Estimated Cost = $ 6,000)** Repair will require:
   a. Draining of the Tank (Cost not included within the above "Estimated Cost")
   b. Installation and wiring of a new reference cell.

It has been a pleasure to assist you on this project. Should you have any questions regarding this report, or if we can be of further assistance in any way, please do not hesitate to contact our office.

Yours Truly,
Echelon Engineering, Inc.

Shelley D. Sommerfeld, P.E.
Project Manager

I have reviewed the report, samples, photos and video for the Auke Lake Potable Water Tank and I concur with the findings.

Web Chandler,
S.G. Pinney & Associates
NACE Certified Coatings Inspector

EBV:sds
Enclosures

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PHOTO No. 1: Auke Lake Tank, General View - Note the arrangement of the ladder, overflow pipe, and access man hole. The dark streaks apparent on the tank are dirt in areas of runoff. The tank coating was found to be greater than 99% intact.

PHOTO No. 2: Tier C, Ground Panel, 7:30 Position - Note the four areas of coating failures with corrosion and the otherwise good condition of the protective coating. The inspector is taking ultrasonic thickness measurements of the steel.

PHOTO No. 3: Tank Top, 1:30 Position - Note the two areas of coating failure with corrosion. Measurement showed both areas to be less than 6 inch in diameter. Note the center roof vent in the distance (top center).

PHOTO No. 4: Tank Top, 1:30 Position - A close-up of the coating failures shown in Photo No. 3 above. The circular black spots visible on the coating were found to be lichen. When these areas were cleaned, no damage to the underlying coating was noted.

PHOTO No. 5: Ringwall Foundation, 2:00 Position - Note the small section of the grout that is missing from between the bottom flange of the tank and the concrete ring foundation. This condition was found to be typical around the perimeter of the tank.

PHOTO No. 6: Tank Interior, Bottom, Tank Outlet - Note the good condition of the coating on the tank outlet and the floor of the tank. Sediment, typical of that removed from the tank can be seen to the left of the outlet pipe. Additional cleaning and sediment removal was conducted prior to inspection of the tank floor.

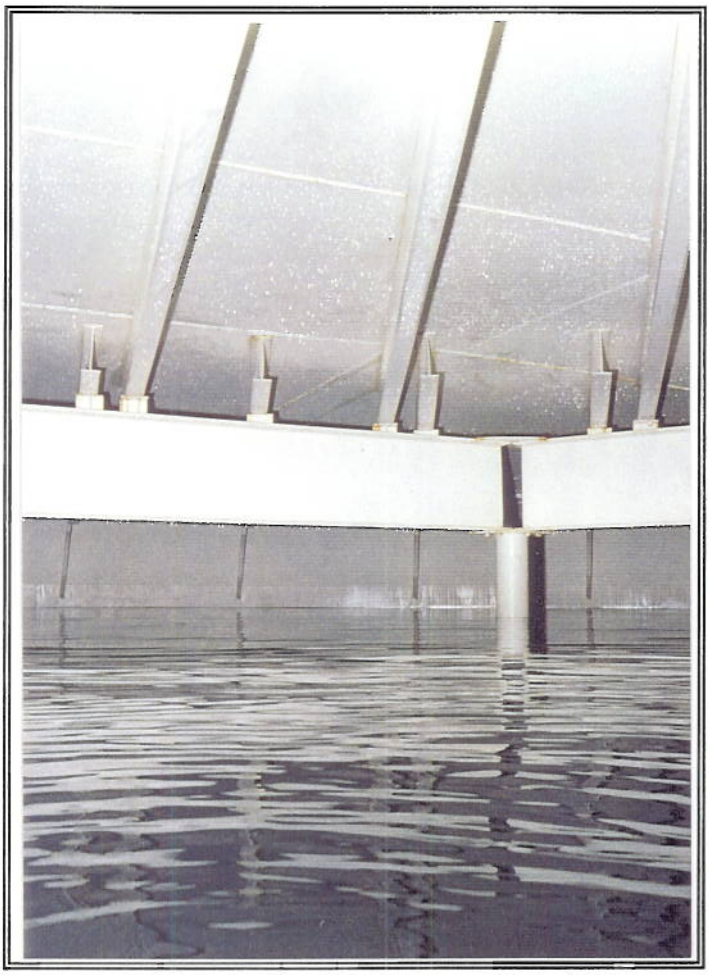

PHOTO No. 7: Tank Interior, Above Water - Note the typical good condition of the interior coating. A minor amount of rust bleeding is evident around the edges of the roof support members.

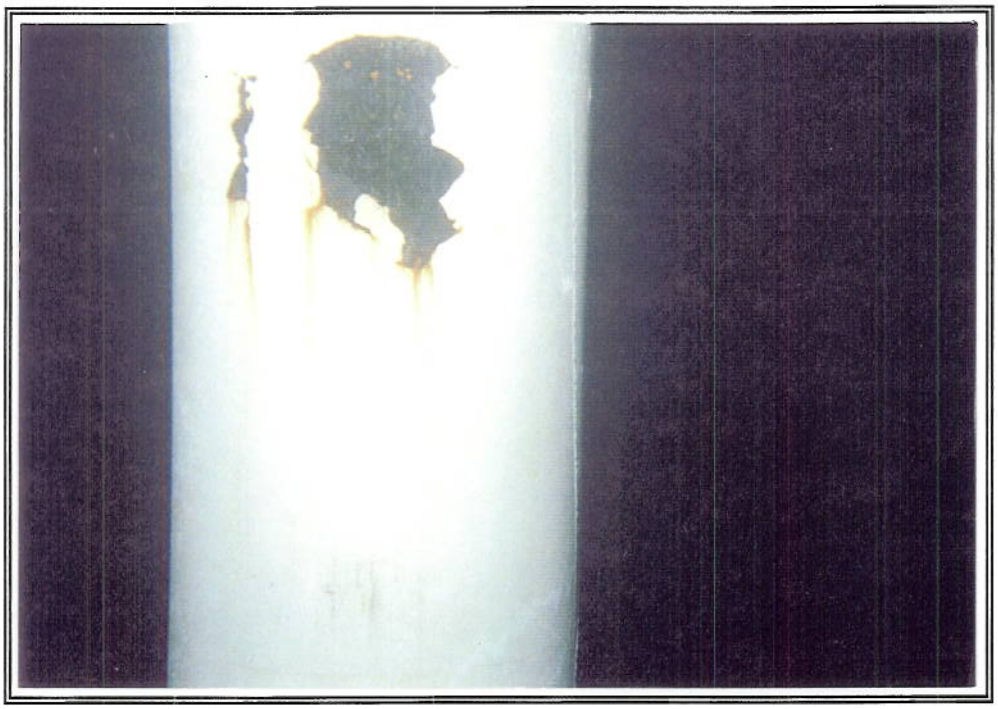

PHOTO No. 8: Tank Interior, Tier B Middle Panel - Note the area of failed coating identified at the approximate middle of the center support column. The damaged area measures approximately 8 square inches. Also note the minor amount of surface corrosion.

PHOTO No. 9: Tank Interior, Bottom - Note one of the cathodic protection system anode attached to the bottom. The anode is supported atop a semi-cylindrical PVC base. Inspection did not reveal any damage to the anodes.

PHOTO No. 10: Tank Interior, Tier C, Bottom Panel, 11:50 Position - Inspection showed the cathodic protection system reference cell to have been broken off flush with the tank wall.

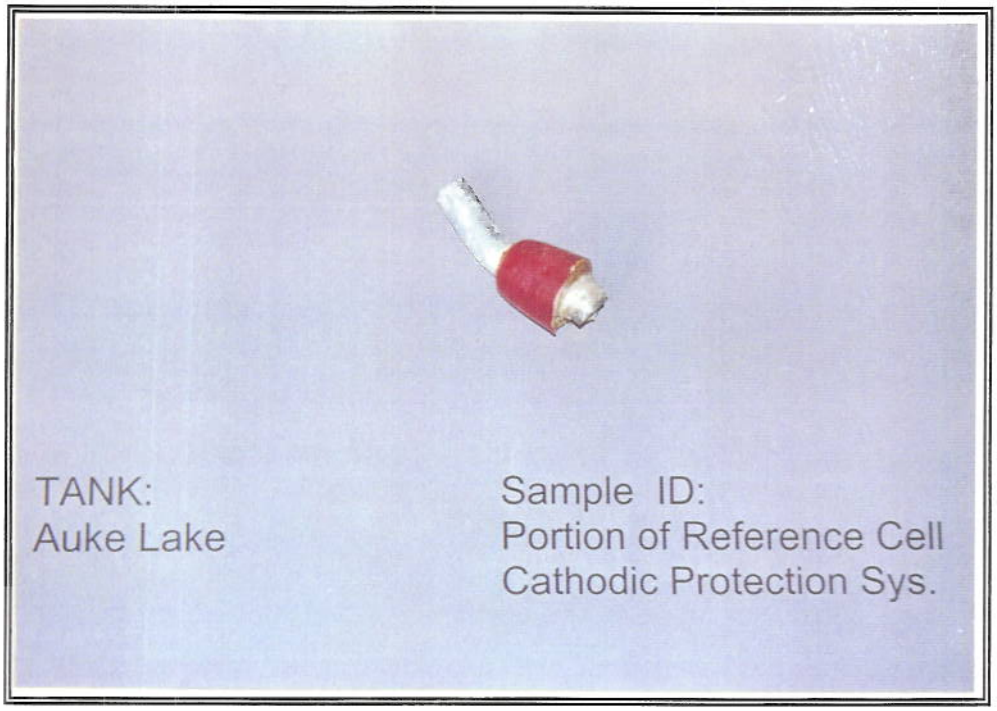

PHOTO No. 11: Cathodic Protection System, Damaged Reference Cell - This portion of the reference cell was found on the tank floor beneath the reference cell location at the Tier C, Bottom Panel, 11:50 position.

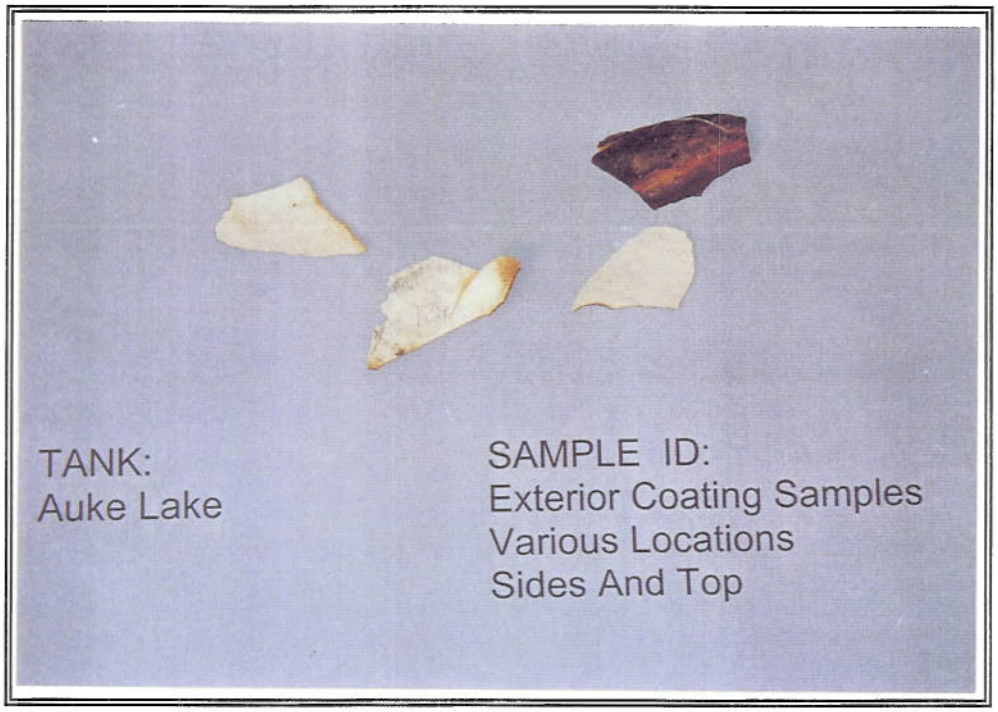

PHOTO No.12: Tank Exterior, Coating Samples - These samples were collected from various locations on both the top and the sides of the tank, where exterior coating failures were identified.

VIDEO LOG
Auke Lake Potable Water Tank Inspection

TIME/COUNTER	DESCRIPTION
0:00:00 - 0:00:10	Blank Leader
Tank Exterior	
0:00:10 - 0:00:57	Introduction
0:00:57 - 0:01:45	Ladder, Safety Cage, Hinge, And Hatch
0:01:45 - 0:02:11	Access Manhole, 1:00 Position
0:02:11 - 0:02:40	Grout And Coating Damage with Vegetation
0:02:40 - 0:03:02	Dirt On Coating
0:03:02 - 0:03:44	Grout Missing Intermittently
0:03:44 - 0:04:37	Coating Failure With Field Treatment, 3:00 Position
0:04:37 - 0:04:48	Vegetation In Grout, 3:30 To 4:00 Position
0:04:48 - 0:05:27	Coating Failures, 3:30 To 4:00 Position
0:05:27 - 0:07:18	Grout Damage
0:07:18 - 0:07:44	Dirt On Coating
0:07:44 - 0:08:44	Localized Coating Failures, 7:30 Position
0:08:44 - 0:09:27	Inspection, 9:00 To 10:00 position
0:09:27 - 0:10:56	Access Manhole And Tank Nameplate
0:10:56 - 0:11:40	Coating Failure And Scratch, 10:45 Position
0:11:40 - 0:12:10	Localized Coating Failure, 11:30 Position
0:12:10 - 0:12:38	C.P. Access Port
0:12:38 - 0:13:22	Wire Bonded To Overflow Pipe Support, 12:00 Position
0:13:22 - 0:13:42	Inspection, Tank Top
0:13:42 - 0:14:09	Tank Top Roof Vent
0:14:09 - 0:16:35	Coating Failures, 1:00-1:30, 11:30, 7:00 & 5:30 Positions
0:16:35 - 0:17:10	Lichens On Tank Top
0:17:10 - 0:17:24	Conclusion Of Exterior Inspection
0:17:24 - 0:19:06	In Tank Cleaning Operations Support
Tank Interior	
0:19:06 - 0:21:45	Typical Welds On Side Wall
0:21:45 - 0:22:05	C.P. Reference Cell, Broken
0:22:05 - 0:22:10	Wall And Floor In Uncleaned Area

VIDEO LOG

Auke Lake Potable Water Tank Inspection

TIME/COUNTER	DESCRIPTION
0:22:10 - 0:22:17	Floor And Unsupported C.P. Wire
0:22:17 - 0:22:30	Floor And Support Column Base
0:22:30 - 0:22:39	Anode Assembly
0:22:39 - 0:23:11	Inlet, Side Wall And Support Column
0:23:11 - 0:23:30	Clean/Uncleaned Floor Areas
0:23:30 - 0:23:51	Side Wall, Access Manhole, Support Column Base And Floor
0:23:51 - 0:24:26	Anode In Cleaned Floor Area
0:24:26 - 0:25:20	Floor, Support Column with Coating Failure
0:25:20 - 0:29:49	Diver And Cleaning Operation
0:29:49 - 0:31:12	Roof And Rafter Structure
0:31:12 - 0:33:48	Demobilization
0:33:48	End