Technical Memorandum

Date:	Tuesday, August 14, 2018
Project:	Task Order 7 - Aeration Basins Condition Assessment
To:	Douglas County Lake Tahoe Sewer Authority
From:	Erika Perez, EIT; Greg Mieczkowski, NACE CIPIII; Brien Clark, NACE CP-4
Subject:	**Aeration Basin Zones 1 to 8 Condition Assessment Report**

1. Introduction

HDR performed a site visit and corrosion condition assessment on aeration basins zones 1 through 8 at the Douglas County Lake Tahoe Sewer Authority's waste water treatment plant (WWTP) in Lake Tahoe, Nevada. An entry inspection was performed at basin zones 5 through 8 on April 30, 2018, and basin zones 1 through 4 on May 3, 2018, by two HDR personnel. Confined space support was provided by the plant staff.

The scope of this study was limited to conducting a corrosion condition assessment of the structures, providing photos of notable features observed during the assessment, and preparing recommendations for rehabilitation.

2. Structures

The aeration basins are below-grade concrete structures, approximately 140 feet in length. The aeration basins are split into eight zones; each basin zone is approximately 15 feet deep and 35 feet square. Each basin zone has a flat bottom that transitions to diagonal fillet walls, which in turn transitions to vertical walls. A plan view of the aeration basin zone configuration is shown in Figure 1. Each basin zone has a mechanical aerator that is vertically suspended and supported by concrete walkways that pass over the basins. The basins contain piping, mud valves, metal gates and other miscellaneous piping appurtenances. The aeration basins are open to the atmosphere.

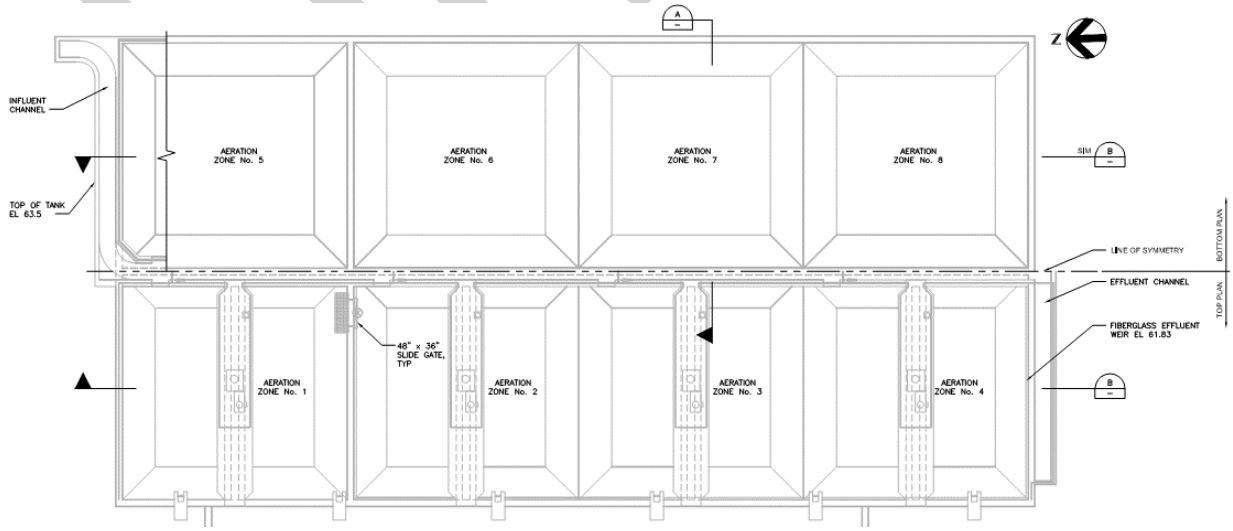

Figure 1 – Plan view drawing of aeration basins zones 1 through 8

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3. Test Methods

3.1 Visual and Photographic Inspection

Inspections and testing were performed on foot from inside the aeration basins and from the walkways above.

The concrete was visually inspected for signs of acid attack, mechanical abrasion, cracking, spalling, staining, or other forms of damage. Evaluation of the visual condition of the concrete was performed in accordance with American Concrete Institute Publication ACI 201.1R-08, *"Guide for Conducting a Visual Inspection of Concrete in Service."*

The steel was examined for signs of corrosion and metal loss. The coated steel was examined for signs of coating damage and metal loss.

3.2 Concrete Sounding

Aural testing was performed on the concrete structure to determine the location of voids and delamination. Testing was performed by tapping the concrete with a ball peen hammer and sliding a chain in multiple locations across the walls and floor, as applicable. The pitch and character of the resulting sound indicated whether the concrete was sound or was delaminated from the reinforcement or substrate. Testing was conducted in a random pattern.

3.3 Concrete pH Testing

Rainbow Indicator solution was used to test the pH of the concrete structures to determine the extent of carbonation or acid attack. Carbonation is the corrosion of concrete by carbon dioxide attack of the calcium phase in concrete whereas acid attack is the corrosion of concrete by biogenic sulfuric acid produced from H_2S in the waste stream. Both mechanisms reduce the concrete pH. Rainbow Indicator approximates the pH of the concrete by utilizing an array of colors for pH values ranging from 5 to 13, as illustrated in Figure 2. Sound concrete has a pH of 12 or higher.

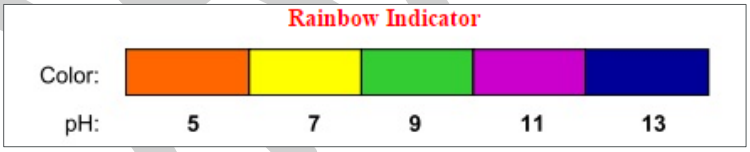

Figure 2 – Rainbow indicator color with respect to pH

At various locations a small amount of concrete was chipped away and the newly exposed surface was sprayed with the Rainbow Indicator solution. This process was repeated until a color change was observed. The approximate depth of carbonation or acid attack was measured.

4. Discussion of Observations and Test Results

Aeration basins zones 1 through 8 were observed to be in similar condition. Therefore the discussion of the observations have been grouped by structural concrete and metallic components for all aeration basin zones. The conditions are described in the sections below.

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4.1 Structural Concrete

4.1.1 INTERIOR

The aeration basins concrete floors were found to be in good to fair condition. A polyurethane coating was observed on the floors and extending up the fillets to approximately 1.5 feet in aeration basins zones 1 through 5. Those aeration basins floors were found to be in good condition with intact coating and no concrete spalls, as shown in Figure 3. Aeration basins zones 6 through 8 did not have a coating and had roughened concrete with exposed aggregate. During sounding in aeration basin zone 6 delaminated concrete was observed on the floor directly below the aerator as shown in Figure 4.



Figure 3 – Coating on the floor of aeration basin zone 4 (typical of floors in aeration basins zones 1 through 5)



Figure 4 – Roughened and delaminated concrete in aeration basin zone 6

After draining the structures, plant staff found a hole approximately 4 to 5 feet in diameter in the floor of aeration basin zone 5 directly below the aerator. The plant staff patched the hole and applied a white coating to that area of the concrete floor prior to HDR's inspection. See Figure 5.



Figure 5 – Patched concrete and coating on the floor of aeration basin zone 5

The interior zone walls and fillet walls were found to be in poor condition. Cracks approximately 1/16 to 1/8 inch wide were found on the interior zone walls and fillet walls throughout all zones, as shown in Figure 6. Typical concrete pH testing produced a color with pH 9 at a depth of 3/8 inch from the

concrete surface, though at one crack location on the fillet of zone 7 produced a color with pH 13 at a depth of less than 1/4 inch from the concrete surface as shown in Figure 7.

Concrete spalls and exposed rebar were found on the transition between the fillet and vertical walls throughout the aeration basins but most heavily concentrated on the west wall (zones 5, 6, 7, and 8) as shown in Figure 8. One location of significant prior spalling was located in basin zone 6. This area was approximately 8 feet in diameter and was directly under the aerator. This area appeared to be repaired at least twice previously. See Figure 9.



Figure 6 – Crack location on the wall of aeration basin zone 6 (typical of all)



Figure 7 – Concrete pH test on the fillet wall in aeration basin zone 7



Figure 8 – Exposed rebar on the fillet in aeration basin zone 7 (typical)



Figure 9 – Significant prior spalling and repairs in basin zone 6

Significant concrete spalling was found around most pipe penetrations, as shown in Figure 10. No voids were detected in the concrete wall by sounding. The concrete coverage over the rebar ranged from 3/16 inch (see Figure 11) to 3/4 inch. The typical rebar cover was measured at 3/8 inch.



Figure 10 – Significant concrete spalling around the pipe penetration on the north wall of zone 2 (typical)

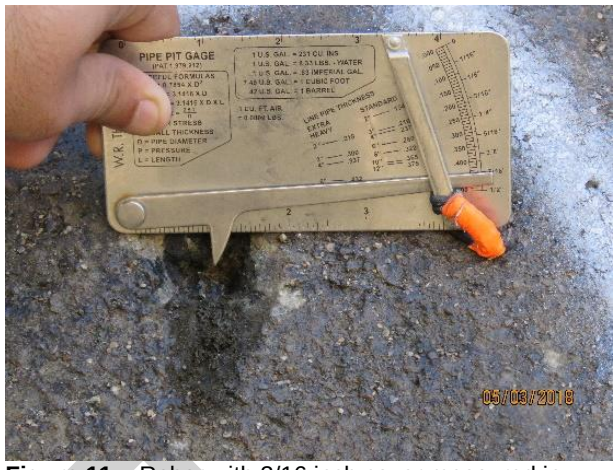

Figure 11 – Rebar with 3/16 inch cover measured in zone 2. Typical cover was 3/8 inch.

4.1.2 EXTERIOR

The exterior concrete walls were found to be in fair condition. The west exterior face of the wall from aeration basin zones 1 through 4 had 38 vertical crack locations. The crack shown in Figure 12 is representative of a typical crack. Some crack locations had exposed rebar as shown in Figure 13. Some of the crack locations were observed to have been previously patched but the patching material was found to be delaminating.



Figure 12 – Crack location along the exterior wall of aeration basins zones 1 through 4



Figure 13 – Exposed rebar at an exterior crack location with failing patch material

4.2 Metallic Components

The carbon steel components within the aeration basins were in fair condition. Some of the piping support brackets within the basins were found to have delaminated coating and surface staining and corrosion, as shown in Figure 14.

The piping in the submerged zone that runs near the top of the aeration basins was observed to have sludge staining with little to no coating degradation or surface corrosion, as shown in Figure 15. However, the same piping within the vapor space was observed to have coating degradation and general surface corrosion, also shown in Figure 15. The corrosion was mostly likely a result of

increased aeration and cyclic wetting and drying on the splash-zone piping, which tends to concentrate salts.

The aerator blades throughout the aeration basins had delaminated coating and damaged edges with minimal surface corrosion, as shown in Figure 16. The aerators likely experience mechanical abrasion during operation due to the presence of grit in the aeration basin. The drain pipes that penetrate the fillet walls were found to be collecting debris and had surface corrosion in areas where there was no coating overspray present, as shown in Figure 17. The flap gates found on the pipe shown in Figure 17 were non-operational. HDR understands the drain pipes are not used and that consideration may be given to removing or redesigning them during rehabilitation.



Figure 14 – Delaminated coating and surface corrosion on the piping support bracket



Figure 15 – Corrosion on the piping in the vapor space with little to no degradation in submerged zone

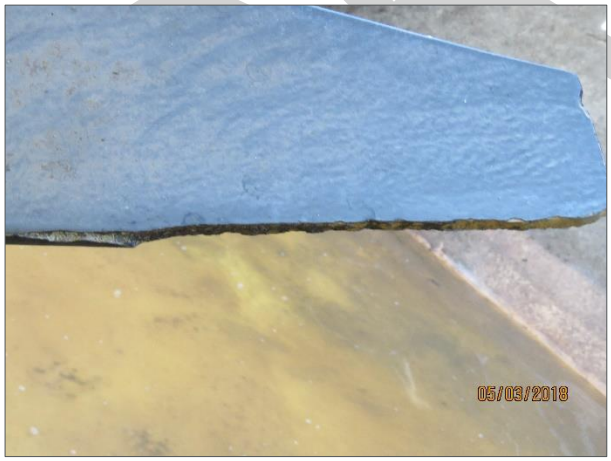

Figure 16 – Damaged aerator blade (typical of all)



Figure 17 – Surface corrosion on drain pipe (typical)

The aluminum handrails throughout the walkways were found to be in poor condition. The railing at aeration basin zone 5 walkway was found to be missing fasteners, as shown in Figure 18. The walkway support beams were found to have corroded fasteners as well as missing fasteners, as shown in Figure 19. The corrosion on the fasteners was likely a result of galvanic corrosion between the dissimilar metals.

The lower handrail stanchions were corroding as a result of overspray from the aerators. See Figure 20. Likewise the baffle at the top of the basins was corroding as a result of overspray as shown in Figure 21.



Figure 18 – Missing fasteners on the walkway railing of aeration basin zone 5



Figure 19 – Missing fasteners on walkway support beam



Figure 20 – Corroding aluminum stanchions



Figure 21 – Corrosion on bottom of baffle

5. Conclusions

- The aeration basins concrete floors were found to be in good to fair condition. The aeration basins with coated floors were found to be in good condition with intact coating and no concrete spalls. The aeration basins without a coated floor had roughened concrete with exposed aggregate. Plant staff patched a hole in the floor of aeration basin zone 5.
- The interior walls and fillet walls were found to be in poor condition. Cracks, concrete spalls and exposed rebar were found on the fillets and walls throughout the aeration basins. Significant concrete spalling was found around most pipe penetrations. The average observed concrete cover over rebar was 3/8 inch.
- The exterior concrete walls were found to be in fair condition. The west exterior face of the aeration basin wall had 38 vertical crack locations. Some crack locations had exposed rebar.
- The carbon steel components within the aeration basins were in poor condition. Some of the piping support brackets were found to have loose sections, delaminated coatings and corrosion. The piping in the submerged zone that runs near the top of the aeration basins was observed to have sludge staining with little to no coating degradation or surface

corrosion; however, the same piping within the vapor space was observed to have coating degradation and general surface corrosion. The aerator blades had delaminated coating and damaged edges with minimal surface corrosion. The drain pipes that penetrate the fillets were observed to have surface corrosion, as did the baffles at the top of the basins.

- The aluminum railing at aeration basin zone 5 walkway was found to be missing fasteners. The walkway support beams were found to have corroded and missing fasteners. The handrail stanchions were also observed to have surface corrosion. The aging walkway grating was damaged in mutiple locations.

6. Recommendations

Based on the condition of the existing concrete and metallic substrates, the following remedial actions are recommended. Recommendations are grouped by material type.

Structural Concrete

HDR recommends rehabilitation of the concrete where cracking and spalling have occurred. While no immediate repairs are necessary, rehabilitation should be performed as soon as possible to avoid further deterioration and extend the life of the structure.

1. Perform a high pressure, high solids epoxy crack injection sealing process per ACI 503.7 to all cracks in the concrete walls.
    a. Remove existing repair material on the concrete.
    b. Perform all surface preparation, epoxy application, and curing in accordance with the manufacturer's requirements.
2. Perform a rehabilitation of the concrete substrates where spalling occurred and exposed rebar was visible to improve the integrity of the concrete.
    a. Remove all degraded concrete material until a pH of 12 or higher is reached.
    b. Repair the rebar as necessary. Additional structural design may be required due to the exposed rebar. Abrasive blast the steel and apply an epoxy coating.
    c. Restore all areas to nominal thicknesses with fresh concrete. Use an appropriate concrete skim-coat material for thin application.
3. Apply a protective coating to the concrete slab in aeration basin zones 6 to 8 similar to the coatings applied to the slabs of aeration basin zones 1 through 5.
    a. Perform surface preparation and coating application following concrete rehabilitation and prior to the structure being placed back into service.
    b. Perform all surface preparation, coating, and curing in accordance with the coating manufacturer's requirements.
4. In areas where turbulent flow or high grit loads are expected, coat the concrete with a 100 percent solids aromatic polyurethane or similar abrasion-resistant coating.
5. Install stainless steel chamfers to the top of the fillets following concrete repairs.

Carbon Steel and Ductile Iron Components

OPTION 1 – REPAIR AND RECOAT EXISTING COMPONENTS

1. Replace all pipe supports.
2. Redesign drain pipes that penetrate the fillet walls so debris does not collect.
3. Remove all existing coating material on components such as piping and baffles. Replace with a new high-performance coating system.

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a. Coatings commonly used for this application include high-solids polyurethane, polyurea, and novolac epoxy systems.
b. Perform surface preparation and coating application following repair and prior to the structure being placed back into service.
c. Perform all surface preparation, coating, and curing in accordance with the coating manufacturer's requirements.

4. Replace and install dielectric shoulder washers where stainless steel fasteners are in direct contact with carbon steel.

OPTION 2 – REPLACE CARBON STEEL COMPONENTS WITH 316L STAINLESS STEEL

1. Remove and replace all submerged or non-submerged carbon steel components and replace with 316L stainless steel components.
    a. Do not coat stainless steel components.
    b. Do not install stainless steel components in direct metallic contact with non-stainless steel components.
2. Repair ductile iron components as described in option 1. Electrically isolate the ductile iron from the stainless steel components.

Aluminum and Galvanized Steel Components

1. Replace or install fasteners on the walkway support beams where fasteners are corroded or missing.
2. Install fasteners on the walkway handrails where necessary.
3. Replace all existing walkway grating.

Aerators

1. Repair or replace all damaged aerators.
2. Adjust the operation of the aerators or redesign them to limit overspray onto adjacent surfaces.

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