EVALUATION OF THE
750,000 GALLON STEEL GROUND STORAGE TANK

"GRAHAM HILL TANK"
HENDERSON, KENTUCKY

FOR

HENDERSON WATER UTILITY
HENDERSON, KENTUCKY

April 22, 2014

14.031.H1145.004
May 23, 2014

SUBJECT:

The subject of this report is the field evaluation of the 750,000 gallon steel ground storage tank in Henderson, Kentucky. The tank was owned by the Henderson Water Utility and was known as the "Graham Hill Tank." The field evaluation was performed on April 22, 2014 by Harold H. Knight, Jared C. Peyer, and Jesse Jenkins of Tank Industry Consultants. The Owner's representative on the site at the time of the field evaluation was John Thompson. The column and rafter supported roof tank was of welded steel construction. Measurements taken at the time of the field evaluation indicated the tank was approximately 60 ft 3 in. in diameter with a shell height of approximately 36 ft.

OBJECTIVE:

The purpose of this washout and evaluation was to determine the condition of the tank interior, exterior, exposed foundation, and accessories. The purpose of this report is to present the findings of the evaluation and to make recommendations for recoating, repairing, corrosion protection, and maintenance. Budget estimates for the work, anticipated life of the coating and the structure, and the replacement cost of the tank are also included.

AUTHORIZATION:

This washout, evaluation, and report were authorized in the Blanket Agreement signed by Tom Williams, P.E., General Manager dated February 10, 2014 and in Task Order Number 2014-01 also signed by Tom Williams on February 10, 2014.

EXECUTIVE SUMMARY:

The coating on the exterior of the tank appeared to be in fair overall condition as areas of topcoating failure and corrosion were observed. The exterior surfaces will likely require repainting within the next 4 years although aesthetics may dictate a quicker recoating schedule. The coating on the interior surfaces of the tank appeared to be in poor overall condition as the areas of corrosion had allowed deep metal loss to occur. Due to the extent of corrosion noted, the interior should be repainted within the next 12 months before the metal loss worsens.

An Employee-Owned Company
ANSI/OSHA and Safety-Related Deficiencies: There were OSHA and safety-related deficiencies on this tank. These deficiencies included:

♦ there was significant corrosion and metal loss on the interior ladder,
♦ the exterior and interior ladders were not equipped with safe-climbing devices (29 CFR 1910.27(d)(1)(ii)),
♦ the exterior ladder toe room was dimensionally too small (29 CFR 1910.27(c)(4)),
♦ conduit attached to the exterior ladder could interfere with the unrestricted use of the side rails by the climber (29 CFR 1910.27(b)(2)),
♦ the exterior ladder was not equipped with a vandal deterrent,
♦ the height of the existing roof safety railing handrail was dimensionally too small (29 CFR 1910.23(e)(1)),
♦ safety railing was not located at the roof’s edge adjacent to the manhole (29 CFR 1910.23(c)(1)),
♦ the access opening through the existing roof safety railing did not have closure chains (29 CFR 1910.23(a)(2)), and
♦ the existing roof safety railing was not equipped with a toe bar (29 CFR 1910.23(c)(1)).

If the Owner wishes to fully comply with OSHA and safety-related standards, it is recommended that these deficiencies be rectified.

AWWA, Sanitary, and Operational Deficiencies: There were AWWA, sanitary, and operating deficiencies on this tank as well. These deficiencies included:

♦ the roof manholes were not locked,
♦ the roof vent was not of a clog-resistant design,
♦ the size of the roof vent screening was not restrictive enough to prevent the ingress of insects into the tank,
♦ the gaps in the roof vent screening could allow the ingress of insects into the tank, and
♦ the vertically oriented roof vent could allow the ingress of wind-driven dust and debris.

These deficiencies should be corrected.

The safety-related, sanitary, and operating deficiencies listed above are not intended to be a complete list of deficiencies on this tank. The Owner should refer to the complete report text and accompanying photographs for a complete account of all observed deficiencies.

This evaluation and the reporting of the condition of this tank do not warrant the original structural condition of the tank or any of the original design for seismic loadings. Likewise, recommendations for this tank do not include modifications which may be required for compliance with present structural codes.

PHOTOGRAPHS:

Color photographs were taken of the visible portions of the foundation, the tank interior and exterior and are included as a part of this report. The significant photographs are keyed to the observations.
NOMENCLATURE:

The terms used in describing the various components of steel water tanks are unique to the industry. In fact, the terms vary from firm to firm and from person to person. In an attempt to define the terms used in this report, a sketch of the general type of tank covered is included at the end of the narrative portion of this report. Each horizontal row of steel plates on the tank is referred to as a "shell ring" or "ring." To aid in referencing the shell rings, the bottom ring is referred to as shell ring 1 and the top ring is shell ring 5. **Warning:** Some appurtenances on this tank may be referred to as erection or rigging attachments, lugs, or brackets. This does not mean that they are safe for rigging. Each attachment for each tank should be evaluated on an individual basis by a structural engineer or an experienced rigger before being used. These devices may have been intended for only the original erectors and painters to use with specialized equipment.

ADHESION TESTS:

All adhesion tests performed during this evaluation were done in general accordance with ASTM D3359. The results are reported herein using the ASTM scale. The ASTM scale is a relative scale to rate adhesion from 0 to 5 with 5 being the best. A table of adhesion test results classification is included with this report following the sketch of the tank.

HEAVY METALS TESTS:

Samples of the exterior and interior coating systems were sent to a laboratory for atomic absorption analyses. The test results were as follows:

<table>
<thead>
<tr>
<th></th>
<th>Cadmium</th>
<th>Chromium</th>
<th>Lead</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mg/kg</td>
<td>percent</td>
<td>mg/kg</td>
</tr>
<tr>
<td>Exterior</td>
<td>&lt;25</td>
<td>&lt;0.0025%</td>
<td>&lt;250</td>
</tr>
<tr>
<td>Interior</td>
<td>&lt;25</td>
<td>&lt;0.0025%</td>
<td>&lt;250</td>
</tr>
</tbody>
</table>

Tank Industry Consultants performs this test only to determine if there is lead, cadmium, or chromium present in the coating samples. To limit damage to the existing coating, only small areas were tested. The small number of samples taken and the difficulty of retrieving all primer from the steel profile may cause the tests performed to not accurately represent the total coating system. Variations in thickness, types of coatings applied, and the interim cleaning and painting operations will also affect the actual readings. The reliability of the results is also dependent on the amount of primer included in the sample. The Consumer Product Safety Commission specifies that an amount greater than 0.06% lead is considered potentially hazardous. Additional testing to determine the amount of leachable contaminants present in the spent cleaning debris will need to be performed following cleaning operations at the time of repainting. Results from the laboratory analysis are included following the adhesion tables.
ULTRASONIC THICKNESS MEASUREMENTS:

(all readings were taken through coating)

Roof Plates: 0.187 in. to 0.190 in.
Shell:
  Ring #5: 0.257 in. to 0.260 in.
  Ring #4: 0.259 in. to 0.261 in.
  Ring #3: 0.249 in. to 0.251 in.
  Ring #2: 0.389 in. to 0.392 in.
  Ring #1: 0.496 in. to 0.499 in., bottom
Bottom Plate: 0.269 in. to 0.280 in.

OBSERVATIONS:

A. Foundation and Site

SITE:
  Size: approx. 110 ft x 160 ft
  Fence:
    Type: chain link, with 3 strands of barbed wire
    Height: 6 ft
  Gates:
    Number: 2
    Southeast: 11 ft 6 in. wide
    North: 4 ft wide
    Locked: yes

Nearest Structures:
  Type: shed
  Direction: west
  Distance: approx. 33 in.
  Type: garage
  Direction: northeast
  Distance: approx. 27 ft
  Type: house
  Direction: east
  Distance: approx. 50 ft

Nearest Overhead Power Lines:
  Direction: northeast
  Distance: approx. 8 ft
FOUNDATION:
Type: concrete
Projection Above Grade:
  North: 6 in. to 9-1/2 in.
  South: 0 in. to 5 in.
  East: 0 in. to 4 in.
  West: 4-1/2 in. to 18-1/2 in.
Grout: none visible
Sealant: flexible
Fiberboard: none visible

1. **Site Location:** The tank was located between Holloway Lane and Zion Road in Henderson, Kentucky. The site was located in a residential area with the nearest residence located to the east. Overhead power lines were located just outside the northeast side of the fenced site. (See photos 3-5)

2. **Site Conditions:** The tank site was covered with grass and appeared to be graded to provide adequate drainage away from the base of the tank. The tank site was enclosed by a chain link fence which was topped with barbed wire. The fence had two locked gates on the southeast and north sides of the site. A shed with an antenna was located in close proximity to the west side of the tank. A hydrant was located on the southwest corner of the site. (See photos 1-2, 6-10)

3. **Foundation:** Numerous vertical cracks were observed in the exposed concrete foundation. A cut-out was visible in the west side of the foundation, and corrosion was noted on the piping which was visible in this area. The foundation did not exhibit the AWWA recommended 6 in. to 12 in. projection above grade in all areas. The foundation had been coated, and the coating had peeled. No grout was visible between the foundation and bottom plate projection. (See photos 11-15)

4. **Sealant:** A flexible sealant was located around the tank bottom plate-to-foundation interface. The sealant had peeled and was missing in several areas. (See photos 13-15)

B. **Exterior Surfaces**

DESCRIPTION:
  Construction: welded steel
  Diameter: approx. 60 ft 3 in.
  Shell Height: approx. 36 ft
  Shell Rings: 5
  Roof Type: column and rafter supported
ANCHOR BOLTS: none

BOTTOM PLATE PROJECTION: 1-5/8 in. to 2-3/4 in. from shell

SHELL MANHOLES:
   Number: 2
   Locations: east and west sides of shell ring #1
   Type: flanged and bolted
   Size: 24 in. diameter
   Neck: 8 in. projection x 3/8 in. thick
   Flange: 32-7/8 in. diameter x 1/2 in. thick
   Bolts:
      Number: 28
      Size: 3/4 in. diameter x 2 in. long
   Cover Plate:
      Size: 33-1/4 in. diameter x 1/2 in. thick
      Hinged: no

OVERFLOW PIPE:
   Size: 8 in. diameter
   Air Break: 38-1/2 in.
   Flap Gate: yes
   Brackets:
      Size: 4 in. x 3/8 in., flat bar
      Spacing: 8 ft to 13 ft

EXTERIOR LADDER:
   Number of Rungs: 19
   Distance From Top of Foundation to Lowest Rung: 17 ft 6 in.
   Width: 16 in.
   Side Rails: 2-1/2 in. x 3/8 in., flat bar
   Rung Size: 3/4 in. diameter
   Spacing: 12 in. on center
   Toe Room: 6-1/2 in.
   Brackets:
      Construction: welded
      Size: 3 in. x 3/8 in., flat bar x 8 in. long
      Spacing: approx. 9 ft to 11 ft
   Safe-Climbing Device: none
   Safety Cage: none
   Vandal Deterrent: none
ROOF SAFETY RAILING:
   Location: around roof manhole
   Handrail:
      Height: 37 in.
      Size: 2-1/2 in. x 3/8 in., flat bar
   Uprights: 2-1/2 in. x 3/8 in., flat bar
   Mid-Rail: 2-1/2 in. x 3/8 in., flat bar
   Toe Bar: none
   Access Opening:
      Width: 27-1/2 in.
      Closure Chains: none

ROOF OPENINGS:
   Manhole #1:
      Size: 24 in. diameter
      Type: hinged
      Curb: 4 in.
      Welded: exterior only
      Overlap: 2 in.
      Locked: no

   Manhole #2:
      Size: 24 in. diameter
      Type: flanged and bolted
      Curb: 4 in. to 8 in.
      Welded: exterior only
      Bolts:
         Number: 16
         Size: 1/2 in. diameter x 1-1/4 in. long
      Cover: 30 in. diameter x 3/16 in. thick
      Locked: no

   Roof Vent:
      Neck Diameter: 16 in.
      Neck Height: 14 in.
      Screen:
         Orientation: vertical
         Size: 4 x 4 mesh
         Cover: 30 in. diameter
# Exterior Coating and Metal Condition:

<table>
<thead>
<tr>
<th>Coating Thickness</th>
<th>Approx. % Failure to</th>
<th>Adhesion</th>
<th>Metal Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range</td>
<td>Typical</td>
<td>Underlying Coating</td>
<td>Rust</td>
</tr>
<tr>
<td>Shell</td>
<td>3 mils to 12.5 mils</td>
<td>7.5 mils</td>
<td>&lt;1%</td>
</tr>
<tr>
<td>Roof</td>
<td>-</td>
<td>-</td>
<td>2%</td>
</tr>
</tbody>
</table>

**Key to Table**
- Adhesion: 5 (very good), 4 (good), 3 (fair), 2 (poor), 1 (very poor), 0 (very poor)
- T = Topcoat to Underlying Coating
- S = Primer to Steel
- Neg. = negligible

1. **Exterior Coating Condition**: The coating on the exterior of the tank appeared to be in fair overall condition as areas of topcoating failure and corrosion were observed. The exterior coating exhibited poor adhesion to the underlying coating.

2. **Bottom Plate**: The tank bottom plate extension appeared to be in fair condition. Corrosion and pack rust were observed around the edge of the bottom plate projection. (See photos 13-15)

3. **Shell Condition**: The contour of the tank shell was irregular with peaking and banding noted. The shell plate adjacent to the overflow pipe penetration was dished. The coating appeared to be in fair condition with areas of peeled and checked coating noted. The topcoating had faded. Corrosion was observed at scratches in the coating. Runs and drips were noted in the coating. Mildew was observed, particularly in the areas behind the overflow pipe. The coating exhibited poor adhesion to the underlying coating. Abandoned bracket remains were located on the shell beneath the exterior ladder. (See photos 22-27)

4. **Shell Manholes**: The tank was equipped with two flanged and bolted circular manholes were located on the east and west sides of the shell. The shell plate around each of the manholes was equipped with a reinforcing plate. The manhole covers were not equipped with hinged support arms. Corrosion was noted on the manhole covers, hand holds, and necks. (See photos 16-18)

5. **Overflow Pipe**: The overflow pipe exited from the top shell ring and extended down the shell and slightly away from the tank before discharging above grade. The discharge end of the overflow pipe had a flap gate. The pipe was equipped with welded flat bar brackets, and the pipe and brackets appeared to be in nearly their original structural condition at the time of the field evaluation. (See photos 19-21, 26-28, 31)

6. **Exterior Ladder**: There were safety and OSHA deficiencies noted: (1) the ladder was not equipped with a safe-climbing device, (2) the 6-1/2 in. ladder toe room did not precisely meet the minimum required 7 in., (3) the ladder was not equipped with a vandal deterrent, and (4) conduit attached to the ladder could interfere with the unrestricted use of the side rails by the climber. The exterior ladder was welded to brackets which were welded to the shell. The exterior
ladder and brackets appeared to be in nearly their original structural condition at the time of this field evaluation. Conduits extended up the ladder brackets. (See photos 28-30)

7. **Roof Safety Railing:** There were safety-related and OSHA deficiencies noted: (1) the safety railing was not located adjacent to the roof’s edge, (2) the 37 in. height of the handrail did not meet the required 42 in. minimum height, (3) the safety railing was not equipped with a toe bar, and (4) the access opening did not have closure chains. Safety railing was located on either side of the roof manhole at the roof access. However, it was not located at the roof’s edge. The safety railing was constructed of welded flat bar members. No significant areas of corrosion were noted. (See photo 31)

8. **Roof Condition:** The contour of the roof was irregular as evidence of trapped water was noted on the west side of the roof. The coating appeared to be in fair overall condition with widespread areas of topcoating failure and corrosion noted. The coating had checked, faded, and chalked. Some of the corrosion was located in clusters. Corrosion was observed on a conduit which penetrated the roof adjacent to the manhole. (See photos 33, 35-38)

9. **Roof Manholes:** There was a sanitary and AWWA deficiency noted: the roof manholes were not locked. The roof was equipped with two manholes. One of the manholes was equipped with a hinged cover. The other manhole was flanged and equipped with a bolted cover. The bolted cover was not equipped with a retaining chain. The roof manholes were not locked prior to or after this evaluation. The roof manholes were welded on the exterior only. The bolts on the flanged manhole were rusty. (See photos 32-33)

10. **Roof Vent:** There were AWWA, sanitary, and operational deficiencies noted: (1) the roof vent was not of a clog-resistant design, (2) the size of the screening on the roof vent was not restrictive enough to prevent the ingress of insects into the tank, (3) the protective screening on the roof vent was not shielded from wind driven precipitation and debris, and (4) gaps were between the screen and the cover would not prevent the ingress of insects into the tank. The roof was equipped with a vent located in the approximate center of the roof. There was significant corrosion and metal loss on the roof vent. The vertically oriented screening was not shielded from wind-driven dust and debris. The size of the screening on the vent was not adequate to prevent the ingress of insects into the tank, and there were large gaps in the screening. (See photos 39-41)

### C. **Interior Surfaces**

**ROOF SUPPORT SYSTEM:**

- **Rafters:**
  - Number: 30
  - Size: 10-1/4 in. x 4 in., I-beam
  - Attachment Clips: 6 in. x 3/8 in., flat bar
  - Center Hub: 4 ft diameter x 1 in. thick
  - Center Column: 8 in. diameter

- **TOP SHELL ANGLE:**
  - Size: 3 in. x 3 in. x 1/4 in.
  - Orientation: leg in
INTERIOR LADDER:
Number of Rungs: 35
Width: 16 in.
Rung Size: 3/4 in. diameter
Spacing: 11-7/8 in. on center
Side Rails: 2-1/2 in. x 3/8 in., flat bar
Toe Room: 7 in.
Brackets:
  Construction: welded
  Size: 3 in. x 3/8 in., flat bar x 8-1/4 in. long
  Spacing: 9 ft to 11 ft
Safe-Climbing Device: none

CATHODIC PROTECTION: none

OVERFLOW:
  Inlet Type: funnel
  Location: approx. 10 in. below roof-to-shell connection

INLET/OUTLET PIPE:
  Size: 16 in. diameter
  Projection: flush w/ floor
  Protective Cover: none

INTERIOR COATING AND METAL CONDITION:

<table>
<thead>
<tr>
<th></th>
<th>Coating Thickness</th>
<th>% Failure to</th>
<th>Adhesion</th>
<th>Metal Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Range</td>
<td>Typical</td>
<td>Primer</td>
<td>Rust</td>
</tr>
<tr>
<td>Roof</td>
<td>8 mils to 13.5 mls</td>
<td>9.5 mls</td>
<td>Neg.</td>
<td>&lt;1/2%</td>
</tr>
<tr>
<td>Shell</td>
<td>11.5 mls to 27 mls</td>
<td>17 mls</td>
<td>Neg.</td>
<td>3%</td>
</tr>
<tr>
<td>Floor</td>
<td>12.5 mls to 38 mls</td>
<td>20 mls</td>
<td>Neg.</td>
<td>&lt;1/2%</td>
</tr>
</tbody>
</table>

Key to Table:
Adhesion 5 (very good) T = Topcoat to Underlying Coating
          4 (good)     S = Primer to Steel
          3 (fair)     Neg. = negligible
          2 (poor)
          1 (very poor)
          0 (very poor)

1. Interior Coating Condition: The coating on the interior surfaces of the tank appeared to be in poor overall condition as the areas of corrosion had allowed deep metal loss to occur. The coating exhibited good adhesion to the steel.

2. Roof Condition: The coating on the roof plates was in poor condition with widespread corrosion and metal loss. The interior roof support structure consisted of radial roof rafters and a center column. There was corrosion and metal loss on the rafters and center column, and the coating
on the center column had blistered. The outer ends of the rafters were welded to flat bar clips which were welded to the shell. There was extensive corrosion and metal loss in this area. There was also corrosion on the roof plates surrounding what appeared to be a sensor equipment projection. (See photos 42-50, 53)

3. **Shell Condition**: The coating on the shell interior was poor condition with corrosion and metal loss. The metal loss typically measured 1/32 in. deep, but the deepest metal loss found measured 1/8 in. deep. It appeared the coating had been touched-up previously, but the touch-up material was not well adhered. There were runs and drips in the shell coating, and the coating had blistered. A top shell angle was located around the roof-to-shell-connection, and corrosion and metal loss were observed in this area. (See photos 48-49, 51-52, 47-62)

4. **Interior Ladder**: There were safety and OSHA deficiencies noted: (1) the ladder was not equipped with a safe-climbing device, and (2) significant corrosion and metal loss were observed on the ladder brackets and rungs. The interior ladder was welded to brackets which were welded to the shell. The interior ladder and brackets appeared to be in poor structural condition with the most significant metal loss observed on the upper rungs. **It is the opinion of Tank Industry Consultants that the interior ladder should not be used for personnel access.** (See photos 54, 68)

5. **Overflow**: The overflow was equipped with a funnel-type inlet. The location of the overflow inlet was such that the top capacity level was below the roof-to-shell connection. Corrosion and metal loss were observed on the overflow pipe extension and funnel. (See photos 55-56)

6. **Bottom Plate Condition**: The coating on the tank bottom was in poor condition. Corrosion and metal loss were noted. The metal loss typically measured 1/16 in. deep with the deepest metal loss found measuring 1/4 in. deep. There were areas of peeled coating and corrosion located along the shell-to-floor connection. The floor coating had cracked in areas. (See photos 63-69)

7. **Inlet/Outlet Pipe**: The inlet/outlet pipe was flush with the floor. The pipe was not equipped with a protective cover or a mud guard. (See photo 68)

**RECOMMENDATIONS:**

**A. Foundation and Site**

1. **Site Maintenance**: The site should be regraded so that the top of the foundation projects a minimum of 6 in. to a maximum of 12 in. above grade in all areas and so that proper drainage away from the foundation continues. The gaps in the grading on the west side of the foundation should be filled.

2. **Tank and Site Security**: Water tanks have been defined by some courts under certain circumstances as attractive nuisances. As such, there may be a significant potential liability to the Owner for injury to persons on the tank and tank site, even if access is not authorized. Recent events have prompted the entire water industry to consider measures that inhibit intentional acts that could threaten the water supply. A review of the security requirements for the tank and site is recommended to confirm that the existing measures are consistent with the Owner’s security requirements for their water system. Primary tank and site security should be focused on eliminating, preventing, and
detecting unauthorized access to the tank. Such security measures might include routinely and periodically verifying all manholes and gates are locked. Other security measures might include installing site lighting, motion detectors, surveillance cameras, and arranging more frequent site visits by law enforcement agencies.

3. **Foundation:** When the tank exterior is repainted, any unsound concrete should be chipped to sound material and the concrete should be brush-off blasted. Any deteriorated areas or voids found should have a bonding agent and a vinyl emollient modified concrete patching mortar applied to build up the surface to its original contour. The concrete should then be painted with a concrete sealer.

4. **Sealant Maintenance:** When the exterior repainting is performed, the existing sealant located between the bottom plate and the foundation should be removed and replaced with a flexible polyurethane sealant.

5. **Overhead Power Lines:** All overhead power lines within 40 ft of the tank should be relocated underground in order to prevent potential electrical shock to personnel working on the tank. The relocation of the power lines should be performed in accordance with the National Electric Code (NEC) guidelines.

**B. Exterior Surfaces**

1. **Life of the Exterior Coating:** The coating on the exterior of the tank appeared to be in fair overall condition as areas of topcoating failure and corrosion were observed. The exterior surfaces will likely require repainting within the next 4 years although aesthetics may dictate a quicker recoating schedule. Due to the poor adhesion of the existing topcoating, spot cleaning and topcoating is not recommended.

2. **Coating Testing:** Prior to preparation of specifications for the cleaning and coating of the exterior of the tank, samples of the exterior coating system should be subjected to laboratory analysis to test for ingredients which may at that time be subject to regulations concerning their handling and disposal.

3. **Cleaning:** When the exterior is to be cleaned, all varieties of containment should be investigated. Containment of the wind-blown debris will be required, and containment of paint droplets may be required.

4. **Recommended Coating System:**

   a. **Complete Cleaning and Repainting:** The optimum long-life coating system presently available for this site is an epoxy-polyurethane coating system. Properly formulated and applied polyurethanes have good resistance to condensation, mildew, and chipping. The polyurethanes also have excellent color and gloss retention and the longest expected service life of any of the common exterior tank coatings. The typical life of a properly applied epoxy-polyurethane coating system is approximately 15 to 20 years. These coatings are also presently manufactured to meet current VOC requirements.
b. **Coating Application:** The entire tank exterior should be cleaned to the equivalent of an SSPC-SP 6, Commercial Blast Cleaning and have an epoxy-primed, epoxy intermediate and polyurethane finish coating system applied. However, care must be taken during the application of this particular coating system because this coating does have poor dry-fall characteristics, and potential damage to the surrounding property must be taken into consideration. The polyurethane coatings also require close monitoring of temperature and humidity during application.

5. **Effective Service Life:** Tank Industry Consultants defines the life of a coating as the amount of time before repainting becomes necessary due to coating failure and corrosion. During the coating life the Owner should expect the coating to lose its gloss, start to chalk, show signs of weathering, and possibly some rust staining. Future touch-up may be required on isolated coating failures. If aesthetics are a concern, the Owner may have to topcoat the repainted tank prior to the end of the expected service life. However, future topcoating would be less expensive than complete cleaning and recoating and could delay the next complete cleaning and repainting for many years.

6. **Other Systems:** With air emission volatile organic compounds (VOC) restrictions being put in place around the nation, alternative coating systems may become available which would be viable options for this tank. The Owner should review the available systems prior to preparing specifications for the recoating project.

7. **Coating Curing:** It would be more economical to paint the tank exterior at the same time the interior is painted, since the tank must be drained while the exterior is painted, and the applied coatings cure. This will also reduce mobilization and observation costs.

8. **Rehabilitation Schedule:** To obtain the lowest possible prices for the work outlined in the recommendations, the Owner should have the specifications prepared and the work bid in the spring, with the work scheduled to start in early summer (if possible).

9. **Grinding and Bracket Removal:** Any unused brackets or erection lugs should be removed prior to the exterior repainting. Any weld burrs, weld spatter, or erection scars should be ground off to provide a smooth surface for the application of the coating. This includes the abandoned bracket remains on the shell.

10. **Electrical Apparatus:** All unused electrical conduit, antennas, and control cabinets should be removed from the tank and tank site. All required equipment should be repaired and maintained in accordance with the National Electric Code (NEC).

11. **Existing Shell Manholes:** At the time of recoating and repairs, the gaskets for the shell manholes should be replaced. The covers should be equipped with hinged support arms located on the exterior of the tank.

12. **Exterior Ladder:** The ladder should be modified to allow adequate toe room, and the conduit should be relocated away from the side rails. The ladder should be equipped with a safe-climbing device. The exterior ladder did not include slip-resistant rungs. Slip-resistant rungs are required for all ladders constructed after March 1991 by the OSHA Construction standards. However, slip-resistant rungs are not required by the OSHA General Industry standards for ladders or by AWWA D100.
13. **Vandal Deterrent**: Installing a vandal deterrent would offer the Owner further protection from unauthorized access to the ladder and tank.

14. **Roof Safety Railing**: Additional safety railing should be installed at the edge of the roof adjacent to the roof manhole. The height of the handrail on the existing safety railing should be increased from 37 in. to 42 in., and a toe bar should be installed. The existing access opening should be equipped with removable closure chains.

15. **Existing Roof Manholes**: The roof manholes should be locked at all times to prevent unauthorized access to the tank interior. The rusty bolts on the flanged manhole should be replaced with galvanized bolts, and the cover should be equipped with a retaining chain to hold it to the manhole neck or roof when the manhole is in use.

16. **Clog-Resistant Vent**: The tank was not equipped with a clog-resistant vent. AWWA Standards recommend that all vents with screening against insects be designed to ensure "fail-safe" operation if the insect screens become occluded. Inadequate ventilation could cause a tank collapse if the tank is rapidly drained while the screen is occluded or frosted over. Therefore, a clog-resistant vent should be installed near the center of the roof. Therefore, the existing vent opening should be equipped with a large flanged opening for evaluating, cleaning, repairing, and painting the interior roof structure ends at the center. Until such time as the vent can be replaced, new, more restrictive screen should be installed immediately, and vertical shields should be installed.

C. **Interior Surfaces**

1. **Life of the Interior Coating**: The coating on the interior surfaces of the tank appeared to be in poor overall condition as the areas of corrosion had allowed deep metal loss to occur. Due to the extent of corrosion noted, the interior should be repainted within the next 12 months before the metal loss worsens. It is recommended that when the interior is completely cleaned and repainted, an epoxy coating system should be used.

2. **Coating Testing**: Prior to preparation of specifications for the cleaning and coating of the interior of the tank, samples of the interior coating system should be subjected to laboratory analysis to test for ingredients which may at that time be subject to regulations concerning their handling and disposal.

3. **Recommended Interior Coating System**:

   a. **Epoxy Coating System**: The optimum long-life coating system presently available for the interior of water tanks is a two-component epoxy coating system. A two-coat epoxy system is recommended for the interior of this tank. This coating system should meet the certification criteria of ANSI/NSF 61 and state department of health regulations.

   b. **Coating Application**: When the interior is to be repainted, the entire tank interior should be cleaned to the equivalent of an SSPC-SP 10, Near-White Blast Cleaning and an epoxy coating system applied.

   c. **Service Life**: The typical life of a properly formulated and applied epoxy coating system is approximately 12 to 15 years in immersion service. Tank Industry Consultants defines
the life of a coating as the expected service life before repainting becomes necessary due to coating failure and corrosion.

4. **Cathodic Protection**: When the tank is rehabilitated the brackets and fittings should be installed for the future installation of a cathodic protection system.

   a. **Type**: When the cathodic protection system is installed, an ice-resistant cathodic protection system which features long-life anodes, automatic potential and current control should be specified.

   b. **Scheduling**: After the interior is completely cleaned and recoated, the cathodic protection system should not be energized until after the First Anniversary Evaluation. The Owner should conduct washouts and evaluations approximately every 3 years to monitor the need for cathodic protection. As the interior coating begins to show signs of failure, the cathodic protection system should be energized to aid in minimizing corrosion below the top capacity level.

   c. **Maintenance**: Cathodic protection, if used and maintained properly, will control active corrosion below the water level and extend the useful life of a coating system. It should be noted that maintenance as recommended by the cathodic protection manufacturer is required for the cathodic protection system to work properly. Without proper monitoring, the cathodic protection system may operate too high and cause the coating to blister, or the system may operate too low and not adequately protect the exposed steel surfaces.

5. **Pit Welding and Pit Filling**: After initial cleaning, all significant pitting which is found should be welded, and all pitting with rough edges that would make the pitting difficult to coat properly should be filled with a solventless epoxy seam sealer. (It was estimated that approximately 35 square inches of pits will require welding, and approximately 2 gallons of seam sealer will be required for pit repair.)

6. **Rough Edges**: All unused brackets should be removed from the interior and exterior surfaces at the time of the next recoating. Any weld burrs, spatter, scars or rough edges in the steel should be ground smooth to provide a better surface for coating. (It was estimated that approximately 20 man-hours of grinding will be required on the interior of the tank.)

7. **Interior Ladder**: Interior ladders may be susceptible to ice damage and accelerated rates of corrosion. If the Owner decides to keep the interior ladder, the existing ladder should be replaced. The existing interior ladder did not include slip-resistant rungs. Slip-resistant rungs are required for all ladders constructed after March 1991 by the OSHA Construction standards. However, slip-resistant rungs are not required by the OSHA General Industry standards for ladders or by AWWA D100. The new ladder should be equipped with a corrosion-resistant safe-climbing device. **It is the opinion of Tank Industry Consultants that the interior ladder should not be used for personnel access.**

8. **Roof Support Structure**: After abrasive blast cleaning, the roof support structure should be carefully evaluated as metal loss repairs may be necessary at areas where metal loss was not previously visible. The specifications should be written to anticipate replacing the majority of the rafter-to-shell connections.
**ECONOMIC FACTORS:**

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
<th>Life in Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Replacement of tank with a new one</td>
<td>$ 900,000$1</td>
<td>75+</td>
</tr>
</tbody>
</table>

The following is a complete list of repairs and estimated costs for their respective recommendations found in the RECOMMENDATION section of this report.

<table>
<thead>
<tr>
<th>Item</th>
<th>Sanitary &amp; Safety</th>
<th>Scheduled Maintenance Repairs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clean and Paint Exterior:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SP 6, Complete Clean, Epoxy/Polyurethane System</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Containment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clean and Paint Interior:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SP 10, 2-Coat Epoxy System</td>
<td></td>
<td>140,000</td>
</tr>
<tr>
<td>Cathodic Protection System</td>
<td></td>
<td>10,000</td>
</tr>
<tr>
<td>Miscellaneous Chipping and Grinding</td>
<td></td>
<td>2,000</td>
</tr>
<tr>
<td>Seam Sealing</td>
<td></td>
<td>5,000</td>
</tr>
<tr>
<td>Pit Repair</td>
<td></td>
<td>4,000</td>
</tr>
<tr>
<td>Repair Foundation</td>
<td></td>
<td>2,000</td>
</tr>
<tr>
<td>Repair Sealant</td>
<td></td>
<td>1,000</td>
</tr>
<tr>
<td>Contingency for Roof Support Structure Repairs</td>
<td></td>
<td>10,000</td>
</tr>
<tr>
<td>Modify Exterior Ladder</td>
<td></td>
<td>$ 1,000</td>
</tr>
<tr>
<td>Install Exterior Ladder Safe-Climbing Device</td>
<td></td>
<td>1,500</td>
</tr>
<tr>
<td>Install Exterior Ladder Vandal Deterrent</td>
<td></td>
<td>2,000</td>
</tr>
<tr>
<td>Install Clog-Resistant Vent</td>
<td></td>
<td>8,000</td>
</tr>
<tr>
<td>Modify and Extend Roof Safety Railing</td>
<td></td>
<td>4,000</td>
</tr>
<tr>
<td>Remove Interior Ladder</td>
<td></td>
<td>1,000</td>
</tr>
<tr>
<td>Replace Interior Ladder</td>
<td></td>
<td>4,500</td>
</tr>
<tr>
<td>Install Interior Ladder Safe-Climbing Device</td>
<td></td>
<td>2,000</td>
</tr>
<tr>
<td>Contingency Items</td>
<td></td>
<td>2,000</td>
</tr>
</tbody>
</table>

Estimates are believed to be a high average of bids that would be received in 2014.

$1 The replacement estimate includes costs associated with new tank fabrication and erection, foundation, painting, and engineering. The budget estimate given does not include costs associated with tank demolition, site acquisition, and distribution interruptions.
The following economic factors include only those work items that the Engineer believes to be the minimum to properly maintain this tank from an operational standpoint. Other items related to safety and risk management should be evaluated by the Owner.

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clean and Paint Exterior:</td>
<td></td>
</tr>
<tr>
<td>SP 6, Complete Clean, Epoxy/Polyurethane System</td>
<td>$100,000</td>
</tr>
<tr>
<td>Containment</td>
<td>60,000</td>
</tr>
<tr>
<td>Clean and Paint Interior:</td>
<td></td>
</tr>
<tr>
<td>SP 10, 2-Coat Epoxy System</td>
<td>140,000</td>
</tr>
<tr>
<td>Miscellaneous Chipping and Grinding</td>
<td>2,000</td>
</tr>
<tr>
<td>Seam Sealing</td>
<td>5,000</td>
</tr>
<tr>
<td>Pit Repair</td>
<td>4,000</td>
</tr>
<tr>
<td>Repair Foundation</td>
<td>2,000</td>
</tr>
<tr>
<td>Repair Sealant</td>
<td>1,000</td>
</tr>
<tr>
<td>Contingency for Roof Support Structure Repairs</td>
<td>10,000</td>
</tr>
<tr>
<td>Modify Exterior Ladder</td>
<td>1,000</td>
</tr>
<tr>
<td>Install Exterior Ladder Safe-Climbing Device</td>
<td>1,500</td>
</tr>
<tr>
<td>Install Exterior Ladder Vandal Deterrent</td>
<td>2,000</td>
</tr>
<tr>
<td>Install Clog-Resistant Vent</td>
<td>8,000</td>
</tr>
<tr>
<td>Modify and Extend Roof Safety Railing</td>
<td>4,000</td>
</tr>
<tr>
<td>Remove Interior Ladder</td>
<td>1,000</td>
</tr>
<tr>
<td>Contingency Items</td>
<td>10,000</td>
</tr>
<tr>
<td><strong>Total of Engineer's Recommendations</strong></td>
<td><strong>$351,500</strong></td>
</tr>
</tbody>
</table>

Tank Industry Consultants has no control over the cost of labor, materials, or equipment, or over the contractors' methods of determining prices, or over competitive bidding, or the market conditions. Opinions of probable cost, as provided for herein, are to be made on the basis of our experience and qualifications and represent our best judgment as design professionals familiar with the design, maintenance, and construction of concrete and steel plate structures. However, Tank Industry Consultants cannot and does not guarantee that proposals, bids, or the construction cost will not vary from opinions of probable cost prepared for the Owner.

Due to the numerous potential scopes of work which exist, the Owner should obtain an updated budget estimate once the final scope of work has been determined. This would enable the Owner to accurately budget monies for additional mobilization costs and damaged coating rehabilitation costs.

Engineering and resident observation costs are not included in the Total of the Engineer's Recommendations because these fees are dependent upon the scope of work to be performed. Tank Industry Consultants performs all facets of the engineering services which would be required for this project. Estimated fees for engineering and resident observation will be furnished upon request.

**CLOSURE:**

**Brief Summation:** The Henderson Water Utility had a 750,000 gallon ground storage tank in Henderson, Kentucky. The coating on the exterior of the tank appeared to be in fair overall condition as areas of topcoating failure and corrosion were observed. The exterior surfaces will likely require
repainting within the next 4 years although aesthetics may dictate a quicker recoating schedule. The coating on the interior surfaces of the tank appeared to be in poor overall condition as the areas of corrosion had allowed deep metal loss to occur. Due to the extent of corrosion noted, the interior should be repainted within the next 12 months before the metal loss worsens. Proper maintenance after completing the recommendations herein would include periodic washouts and evaluations approximately every 3 to 5 years.

**Contractor Selection:** The work should be performed by a competent bonded contractor, chosen from competitive bids taken on complete and concise specifications. The coatings used should be furnished by an experienced water tank coating manufacturer, supplying the field service required for application of technical coatings.

**Standards for Repairs and Coatings:** All work done and coatings applied should be applied in accordance with NACE, ANSI/NSF Standard 61, the manufacturer's recommendation, AWWA D100 and AWWA D102 (latest revisions), and the SSPC: The Society for Protective Coatings.

**Observation of Work:** Observation of the work in progress by experienced personnel will offer additional assurance of quality protective coating application. Observations can be performed on a continuous basis or spot (critical phase) basis. The actual cost of observation may be less using spot as opposed to full-time resident observation; however, with spot observation it is often necessary for work to be redone to comply with the specifications. This somewhat lowers the quality of the finished product, lengthens the job, and is frequently a cause of conflict between the contractor, Owner, and field technician. Resident full-time observation minimizes the amount of "rework" required.

**Anniversary and Maintenance Evaluations:** An anniversary evaluation should be conducted prior to the end of the one year bonded guarantee. Washouts and coating, structural, sanitary, safety, and corrosion evaluations should be conducted not less than every three years.

**Time Frame:** If the work is not performed within the next 12 months, the structure should be reevaluated prior to the preparation of specifications and solicitation of bids.

**Specifications and Bidding Documents:** The recommendations in this report are not intended to be specifications on which a contractor can bid. Complete bidding documents must include general and special conditions, detailed technical specifications, and other information necessary for the competitive bidding process. To properly protect the interests of the Owner, Contractor, and Engineer; the initial evaluation, the technical specifications, legal portions of the contract documents, and the observation should be performed by the same firm or with close coordination of all parties involved.

**Limitations of Evaluation:** It is believed that the conditions reported herein reflect the condition of the tank as observed on the date of the evaluation, using reasonable care in making the observations, and safety in gaining access to the tank. Should latent defects be discovered during the cleaning of the structure, they should be brought to the attention of the Owner and the Engineer.
Seismic and Wind Loadings: This tank is located in or near a region of high seismic activity. This evaluation and the reporting of the condition of this tank do not warrant the structural condition of the tank or any of the original design for seismic loadings. Likewise, recommendations for this tank do not include modifications which may be required for compliance with present structural codes. It is possible the tank was erected in compliance with pre-existing industry standards which have since been replaced by more restrictive standards.

Hazardous Materials in Coatings: It should be taken into consideration that Federal, State, and local environmental agencies have placed stricter controls on the removal of lead-based and other heavy-metal based coatings from steel structures by the use of conventional abrasive blasting techniques. The paint and blast residue may be considered to be hazardous waste depending on the concentration of lead or other particles in residue.
Please contact Tank Industry Consultants if you have any questions or comments.

Respectfully submitted,

Tank Industry Consultants

Jennifer Coon, CHMM, CET

Gregory R. “Chip” Stein, P.E.
Managing Principal

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## Classification of Adhesion Test Results

### Method A – X Cut Tape Test
Approx. 1.5 in. long cuts at 30 deg. to 45 deg. apart.

<table>
<thead>
<tr>
<th>Surface</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>No peeling or removal.</td>
<td>✗</td>
</tr>
<tr>
<td>Trace peeling or removal along incisions.</td>
<td>✗</td>
</tr>
<tr>
<td>Jagged removal along incisions up to 1/16 in. (1.6mm) on either side.</td>
<td>✗</td>
</tr>
<tr>
<td>Jagged removal along most of incisions up to 1/8 in. (3.2mm) on either side.</td>
<td>✗</td>
</tr>
<tr>
<td>Removal from most of the area of the X under the tape.</td>
<td>✗</td>
</tr>
<tr>
<td>Removal beyond the area of the X.</td>
<td>✗</td>
</tr>
</tbody>
</table>

### Method B – Lattice Cut Tape Test
Six parallel cuts at 2mm apart.

<table>
<thead>
<tr>
<th>Surface</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>The edges of the cuts are completely smooth; none of the squares of the lattice are detached.</td>
<td>No Failure</td>
</tr>
<tr>
<td>Small flakes of the coating are detached at intersections; less than 5% of the lattice is affected.</td>
<td>✔</td>
</tr>
<tr>
<td>Small flakes of the coating are detached along edges and at intersections of cuts. The area affected is 5% to 15% of the lattice.</td>
<td>✔</td>
</tr>
<tr>
<td>The coating has flaked along the edges and on parts of the squares. The area affected is 15% to 35% of the lattice.</td>
<td>✔</td>
</tr>
<tr>
<td>The coating has flaked along the edges of cuts in large ribbons and whole squares have detached. The area affected is 35% to 65% of the lattice.</td>
<td>✔</td>
</tr>
<tr>
<td>Flaking and detachment worse than grade 1.</td>
<td>✔</td>
</tr>
</tbody>
</table>

ASTM 3359 Standard Test Methods for Measuring Adhesion by Tape Test

**Tank Industry Consultants**

7740 West New York Street  
Indianapolis, Indiana 46214  
Telephone – 317/271-3100  
FAX – 317/271-3300
- CERTIFICATE OF ANALYSIS -

Disp. Code: E I M S P

Client ID: TANK_INDUST
Tank Industry Consultants
7740 West New York Street
Indianapolis, Indiana 46214

Attn: Julie White

Phone: (317) 271-3100
FAX: (317) 271-3300

Our Lab # 14005389-001
Your Project # 14031.H1145.004
Your Project Name: Paint Samples
Sample Type: Paint Chips

Your Sample ID: Exterior Shell
Collection Date: 04/28/14
Collected By: Client
Receipt Date: 04/29/14 11:00

Total Metals, ICP-AES

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Analytical Method</th>
<th>Prep Method</th>
<th>Prep Date</th>
<th>By</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SW846 6010B</td>
<td>SW846 3050B</td>
<td>4/30/2014</td>
<td>amyers</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Result</th>
<th>Units</th>
<th>Quant. Limit</th>
<th>CAS #</th>
<th>Analysis Date</th>
<th>By</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cadmium, Cd</td>
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<td>mg/kg</td>
<td>25.0</td>
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<td>05/01/14</td>
<td>kfoltz</td>
</tr>
<tr>
<td>Chromium, Cr</td>
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<td>mg/kg</td>
<td>250</td>
<td>7440-47-3</td>
<td>05/01/14</td>
<td>kfoltz</td>
</tr>
<tr>
<td>Lead, Pb</td>
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<td>mg/kg</td>
<td>250</td>
<td>7439-92-1</td>
<td>05/01/14</td>
<td>kfoltz</td>
</tr>
</tbody>
</table>

Our Lab # 14005389-002
Your Project # 14031.H1145.004
Your Project Name: Paint Samples
Sample Type: Paint Chips

Your Sample ID: Interior Wet Shell
Collection Date: 04/28/14
Collected By: Client
Receipt Date: 04/29/14 11:00

Total Metals, ICP-AES

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Analytical Method</th>
<th>Prep Method</th>
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<tr>
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<td>Cadmium, Cd</td>
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<td>&lt; 250</td>
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<td>mg/kg</td>
<td>250</td>
<td>7439-92-1</td>
<td>05/01/14</td>
<td>kfoltz</td>
</tr>
</tbody>
</table>

Lab # 14005389-002
Sample ID: Interior Wet Shell

Page 1 of 2
1. Tank and site.

2. Tank.
3. Surrounding area.

4. Surrounding area.
5. Surrounding area.

6. Site.
7. Site gate.

8. Overhead power lines adjacent to site and shed on site.
9. Hydrant on site.

10. Site building and antenna.

12. Piping extending through underside of foundation.
13. Tank foundation, sealant, and corrosion on bottom plate projection.

14. Tank foundation, sealant, and projection.
15. Tank foundation, sealant, and corrosion on bottom plate projection.

16. Shell manhole.
17. Shell manhole.

18. Corrosion on shell manhole.
19. Overflow pipe and flap gate.

20. Overflow pipe along shell.
21. Overflow pipe and bracket.

22. Spot coating failures and coating adhesion tests on shell.

Henderson Water Utility

“Graham Hill Tank”

Henderson, Kentucky

14.031.H1145.004
23. Shell exterior.

24. Scratches in shell coating.
25. Topcoating failures on shell.

26. Mildew on shell adjacent to overflow pipe.
27. Mildew on shell adjacent to overflow pipe.

28. Exterior ladder, conduit, and overflow pipe.
29. Topcoating failures on shell behind exterior ladder.

30. Conduit on exterior ladder.
31. Overflow pipe penetration.

32. Roof manhole and roof safety railing.
33. Corrosion on conduit adjacent to roof manhole.

34. Roof manhole.

Henderson Water Utility

"Graham Hill Tank"
14.031.H1145.004

Henderson, Kentucky
35. Roof exterior.

36. Coating failures on roof.
37. Coating failures on roof.

38. Coating failures on roof.
39. Roof vent.

40. Corrosion on roof vent and gaps in vent screening.
41. Corrosion on roof vent and gaps in vent screening.

42. Roof interior and support structure.
43. Roof interior and support structure.

44. Roof interior and support structure.
45. Corrosion on center column, center hub, and rafters.

46. Corrosion, metal loss, and blistered coating on center column.
47. Corrosion on roof.

48. Corrosion on roof, rafter, and along roof-to-shell connection.
49. Corrosion on roof, rafter, attachment clip, and along roof-to-shell connection.

50. Corrosion and metal loss at rafter attachment clip.
51. Corrosion and metal loss along roof-to-shell connection.

52. Corrosion and metal loss along roof-to-shell connection.
53. Corrosion on roof around sensor equipment.

54. Corrosion and metal loss on interior ladder top rung.
55. Overflow inlet.

56. Corrosion and metal loss on overflow inlet.
57. Corrosion on shell.

58. Drips and runs in shell coating.
59. Corrosion and metal loss in shell.

60. Shell manhole interior.
61. Blistered shell coating.

62. Sealant along vertical seam near base of shell.
63. Peeled coating and corrosion near base of shell.

64. Floor.
65. Corrosion and metal loss in floor.

66. Corrosion and metal loss in floor.
67. Metal loss in floor.

68. Interior ladder, floor pipe opening, shell manhole interior.
69. Center column base and floor.