Hanford PUREX Tunnel 2 Stabilization

Current Status of Activities
Recent Investigations
2017 Structural Integrity Evaluation (Recap)
Updated Evaluation of Select Structural Elements
Nuclear Safety Perspective on Increased Risk
Background on Tunnel 2

August 2018
Dan Wood,
CH2M HILL Plateau Remediation Company
Chief Operating Officer
Current Status of Activities

- Grout trial batch testing and conveyance system mock-ups complete
- Road preparations complete
- Mobile grout plant set up, testing next week
- Temporary Authorization (partial) received Aug. 13
- Conveyance system installation underway
- Will be ready to grout by Sept. 6
Grout Conveyance System

Grout conveyance systems (1 of 6) to be installed in Tunnel 2, 8/16/18
2018 Investigation

- Investigation Summary
  - Opened 14 of 17 risers (inner 3” steel observation port)
  - Conducted 360 degree camera inspection
  - Collected radiological and industrial hygiene data from risers and tunnel interior
  - Removed six – 30” concrete plugs (at identified grout points)
  - Closed and restored all risers to original condition
Investigation – Railcar Placement

- Exact location of risers and railcars relative to risers confirmed

During grouting, Riser 2 will be connected to a passive HEPA filter. Risers 3, 5, 8, 11, 14, and 16 are grout insertion points, includes video cameras. Risers 4, 7, 9, 10, 12, 15 and 17 will have extra lighting installed. Risers 1, 6, and 13 not used.
Investigation - Radiological Results

• Air Sampling
  – Limited to no detectable airborne
  – No detectable hazardous vapors

• Vertical Dose Distribution
  – Includes shine from multiple cars

• Maximum Dose in each Riser (mRem/hr)

<table>
<thead>
<tr>
<th>Riser 7</th>
<th>Elevation</th>
<th>Dose (mrem/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface</td>
<td>1’</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>3’</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>6’</td>
<td>1</td>
</tr>
<tr>
<td>Top of Tunnel’</td>
<td>9’</td>
<td>2,680</td>
</tr>
<tr>
<td></td>
<td>12’</td>
<td>2,380</td>
</tr>
<tr>
<td></td>
<td>15’</td>
<td>1,720</td>
</tr>
<tr>
<td></td>
<td>18’</td>
<td>1,250</td>
</tr>
<tr>
<td></td>
<td>21’</td>
<td>1,080</td>
</tr>
<tr>
<td></td>
<td>24’</td>
<td>900</td>
</tr>
<tr>
<td></td>
<td>27’</td>
<td>570</td>
</tr>
<tr>
<td>Deck of Railcar</td>
<td>30’</td>
<td>970</td>
</tr>
<tr>
<td></td>
<td>33’</td>
<td>900</td>
</tr>
<tr>
<td>Floor</td>
<td>35’</td>
<td>630</td>
</tr>
</tbody>
</table>

Vertical dose example
Investigation – Condition of Structure (Riser 2)

- Wale Beams
- Arched Rib-beam/splice
- Arched Rib-beam/splice
- Arch Steel Ribs
Investigation – Condition of Structure (Riser 16)

- Wale Beams
- Arch Steel Ribs
- Wale Beam Anchor
Structural Evaluation - 2017 Methodology

Inputs:
- Construction drawings, photos and other files used
- As-built drawings have not been located
- Material properties, particularly soil, are not well known

Methodology:
- Based on 2012 International Building Code
- Load and resistance factor design techniques

Other Considerations:
- Current design standards are more rigorous and conservative than those used decades ago
- Older structures often exceed today’s design-to-capacity (DCR) ratios
- Tunnels contain significant quantities of radioactivity
- Personnel entries into tunnels are too hazardous

Arched Rib-beam/splice

Tunnel 2 (under construction in early 1960s)
What is a Design-to-Capacity Ratio (DCR)?

Comparison of a structure’s capacity versus the actual load

\[
\frac{\text{Load}}{\text{Capacity}} \leq 1.0
\]

**Bookshelf 1**
- Shelf Load: 40 lbs
- Shelf Capacity: 40 lbs
- DCR=1.0
  - Structure likely not to fail

**Bookshelf 2**
- Shelf Load: 60 lbs
- Shelf Capacity: 40 lbs
- DCR=1.5
  - Structure at greater risk of failing

DCR greater than 1.0 is problematic.
**Tunnel 2 Structural Evaluation Results - 2017**

<table>
<thead>
<tr>
<th>Element*</th>
<th>Max DCR</th>
</tr>
</thead>
<tbody>
<tr>
<td>A: Arched Rib-beam/splice</td>
<td>1.09</td>
</tr>
<tr>
<td>B: Concrete Arch Girders</td>
<td>0.59</td>
</tr>
<tr>
<td>C: Steel Wale Beams</td>
<td>1.12</td>
</tr>
<tr>
<td>D: Wale Beam Anchors</td>
<td>1.04</td>
</tr>
<tr>
<td>E: Concrete Footing</td>
<td>1.09</td>
</tr>
<tr>
<td>F: Foundation Soil Load</td>
<td>1.03</td>
</tr>
</tbody>
</table>

*Not all elements listed

**Loads on multiple structural members exceed building code design capacities; Tunnel 2 has a ‘potential high’ risk of collapse**
Effects of Corrosion on Structural Elements

Example: 1 3/8", Grade 2 bolt, 4 mils of surface corrosion results in a ~1,000 lb reduction in load carrying capability (Paper is typically 4 mils thick)

Stresses in the yellow and red regions are over yield strength (DCR > 1.0)

Failed Arched Rib-beam/splice, c. 1963
Tunnel 2 Structural – Updated Evaluation Results

<table>
<thead>
<tr>
<th>Element*</th>
<th>2017 Max DCR</th>
<th>Updated Max DCR</th>
</tr>
</thead>
<tbody>
<tr>
<td>A: Arched Rib-beam/splice</td>
<td>1.09</td>
<td>1.45**</td>
</tr>
<tr>
<td>B: Concrete Arch Girders</td>
<td>0.59</td>
<td>No change</td>
</tr>
<tr>
<td>C: Steel Wale Beams</td>
<td>1.12</td>
<td>Indeterminant</td>
</tr>
<tr>
<td>D: Wale Beam Anchors</td>
<td>1.04</td>
<td><strong>Suspect</strong></td>
</tr>
<tr>
<td>E: Concrete Footing</td>
<td>1.09</td>
<td>No change</td>
</tr>
<tr>
<td>F: Foundation Soil Load</td>
<td>1.03</td>
<td>No change</td>
</tr>
</tbody>
</table>

*Not all elements listed

** Based in estimated 1/32” (0.031”) loss of thickness, at 1/16” (0.063”) the DCR could exceed 1.7

Key elements are more overloaded than previously evaluated, the risk of failure is greater
Risk and the ‘zipper’ effect

Risk is composed of the likelihood of failure and the consequence. For complex structures the ‘zipper’ effect can greatly increase the consequence. Consider a steel truss bridge – if one beam or connector fails, will the bridge fail?
Two Case Studies: Actual Structural Failures

Progressive Collapse of I-35W Bridge
(August 2007, Minneapolis, MN)

The 40-year-old steel truss bridge over the Mississippi River suddenly, and without almost any noticeable warning, collapsed entirely, killing 13 and injuring over 100.

Gusset plates thinner than today’s code would allow and fatigue cracks had been noted.

Inspection reports showed the presence of corrosion on some gusset plates and adjacent areas, indicating that due to corrosion, some gusset plates and even some members may have thinned over the years and did not have the originally designed thicknesses at the time of collapse.

Structural Failures from Winter Snow
(December 2008/09, Spokane, WA)

Unusual pattern of heavy snowfall without intermittent melting caused heavy ground and roof loads.

Post-collapse evaluations were performed on 95 structures (wide variety of designs/materials).

Total collapses included one retail store with ‘zipper’ effect.

Most of the structural failures occurred prior to the roofs receiving more than the minimum basic roof snow load, thus other factors led to these failures.


Nuclear Safety Perspective on Increased Risk

- Corrosion increases likelihood of failure.
- ‘Zipper’ effect increases potential severity.

<table>
<thead>
<tr>
<th>Likelihood</th>
<th>Severity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Negligible</td>
</tr>
<tr>
<td>Anticipated</td>
<td></td>
</tr>
<tr>
<td>Unlikely</td>
<td></td>
</tr>
<tr>
<td>Extremely Unlikely</td>
<td></td>
</tr>
</tbody>
</table>

Nonreactor Nuclear Facility Documented Safety Analyses
Conclusions

- Structural failure must be anticipated
  - The time of failure—today, tomorrow or a year—is unknown.
  - Corrosion reduces the strength of the tunnel.
  - The full extent and rate of corrosion is unknown.

- Failure puts the workers, public and environs at risk from an airborne radiological release.
Background
Background - Why Tunnels?

Existing Rail Access

• Large equipment and fuel casks delivered via rail
• Rail cut below grade ~20 ft

Failed Equipment

• Too large for shielded casks
• Direct placement in ‘burial’ tunnel determined to be safest disposition

Capacities

• Tunnel 1 – 8 railcars
• Tunnel 2 – 40 railcars
• Tunnel 3 – never built
### Background - What is in the Tunnels?

#### Examples*:

<table>
<thead>
<tr>
<th>Position</th>
<th>PUREX #1 Storage Tunnel (218-E-14)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. &amp; 2.</td>
<td>HA column and miscellaneous jumpers in box placed in Tunnel #1 on 6/60 HA 4,700 Cu. Ft. Jumpers 2,190 Cu. Ft., Pb~115 Kg.</td>
</tr>
<tr>
<td>8.</td>
<td>E-F6 (2WW Waste) #3 Spare Concentrator failed 5/23/64. Placed in Tunnel #1 on 1/22/65 Flat Car 3621, 2400 Cu. Ft.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Position</th>
<th>PUREX #2 Storage Tunnel (218-E-15)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.</td>
<td>L Cell Package in a sealed steel box (H2-66012) placed in Tunnel on 12/30/70 on Car MILW 60033, 2,400 Cu. Ft.</td>
</tr>
<tr>
<td>5.</td>
<td>F2 Silver Reactor, F6 Demister, Vessel Vent Line, Steel Catwalk and Guard Rails, placed in Tunnel on 2/26/71. On Gondola Car 4610, 2,400 Cu. Ft., Ag~625 Kg</td>
</tr>
<tr>
<td>7.</td>
<td>A3 Dissolver placed in Tunnel on 12/22/71. On 9 ft. shortened Car B58, 2,400 Cu. Ft., Hg~45 Kg.</td>
</tr>
</tbody>
</table>

* from WA7890008967, Hanford Facility RCRA Permit Dangerous Waste Portion, PUREX Storage Tunnels, similar information available for all cars

---

Failed equipment (on right) being inserted into Tunnel 2

### Last Manned Entries

**Tunnel 1 - 1965**

**Tunnel 2 - 1996**
Background - Tunnel 2 Construction

• Completed in 1964
• 26’ wide, 34’ high, 1,688’ feet long
• Steel and reinforced concrete “Quonset Hut” structure
• ~ 8’ of overburden
• Shield door, storage area, and vent shaft
• Two collapses during construction followed by re-designs

Tunnel 2 under construction
Background - Tunnel 2 Construction Progress

Tunnel 2 initial construction

Tunnel 2 collapse during backfill

Re-designed with external Concrete Arches

Internal Reinforcement – Wale Beams
Diamond Wire Saw Experience

- Over 30 years of industrial experience
- Use in variety of applications world-wide
- High radiation fields require shielding to protect workers – diamond wire saw size reduction is common decommissioning technique