CHPRC-03325
Draft A

PUREX Tunnel 1 and 2 Data Quality Objectives Information Summary

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Contractor for the U.S. Department of Energy
under Contract DE-AC06-08RL14788

P.O. Box 1600
Richland, Washington 99352

Approved for Public Release;
Further Dissemination Unlimited

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APPROVED
By Julia Raymer at 4:09 pm, Aug 02, 2017

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Terms

ALARA	as low as reasonably achievable
DOE-RL	U.S. Department of Energy, Richland Operations Office
DQO	data quality objective
Ecology	Washington State Department of Ecology
FMEA	failure mode effects analysis
GPS	global positioning system
HHE	human health and environment
LIDAR	light detection and ranging
PUREX	Plutonium-Uranium Extraction (Plant)
RCRA	*Resource Conservation and Recovery Act of 1976*
S&M	surveillance and maintenance

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1 PUREX Tunnel Background

The tunnel background information presented in this section was drawn from historical documents, drawings, and photographs.

1.1 PUREX Tunnel 1

The Plutonium-Uranium Extraction (PUREX) Storage Tunnel 1 is permitted as a miscellaneous unit under WAC 173-303-680, "Dangerous Waste Regulations," "Miscellaneous Units." It is used to store mixed waste from the PUREX Plant and other onsite sources. Tunnel 1 is isolated from the railroad tunnel by a water-fillable shielding door. In general, the mixed waste stored in the tunnel is encased or contained in carbon or stainless steel plate, pipe, or vessels for shielding and to facilitate placement of the waste on railcars and ultimate storage inside the tunnel. The exterior of each tunnel is inspected annually via a visual perimeter walkdown to ensure the fences and warning signs are present and in good condition, and to identify any obvious changes to the tunnel overburden condition. No interior inspections of the tunnels are performed. No other external or internal surveillance visuals, surveys, or controls are required at this time. However, a Tunnel 1 storage area partial collapse was discovered on May 9, 2017.

The storage area extends south from the water-fillable door and has inside dimensions of 109 m (358 ft) long, 6.7 m (22 ft) high, and 5.9 m (19.3 ft) wide. The ceiling and walls are 35.6 cm (14 in.) thick, constructed of 30.5 by 35.6 cm (12 by 14 in.) creosote pressure-treated Douglas fir timbers arranged side by side. The first 30.5 m (100 ft) of the east wall is constructed of 0.9 m (3 ft) thick reinforced concrete. A 40.8 kg/m^2 (8.4 lb/ft^2) mineral surface roofing material covered the exterior surface of the treated timber roof beams and walls before placing 2.4 m (8 ft) of overburden on the storage area as protection from the elements and as shielding. The timbers forming the walls rest on reinforced concrete footings 0.9 m (3 ft) wide by 0.3 m (1 ft) thick. The floor consists of a railroad track laid on a gravel bed, with the space between the ties filled with gravel ballast. The tracks slope 1% downgrade to the south end of the tunnel. A railcar bumper is 2.4 m (8 ft) from the end of the tracks to act as a stop. Tunnel 1 is filled to capacity with eight 12.8 m (42 ft) long railcars.

Tunnel 1 was constructed in 1956 and had structural integrity evaluations in 1971, 1978, 1980, and 1991 that found it to be structurally sound, but the load-bearing capacity of the treated timbers has decreased since 1956. The 1991 evaluation summarized the past study results and recommended additional study in 2001, which was not conducted. Tunnel 1 instability could compromise its protection of the tunnel contents and human health and the environment (HHE), require facility surveillance and maintenance (S&M) updates, limit *Resource Conservation and Recovery Act of 1976* (RCRA) closure options, and accelerate closure activities. The primary concerns for Tunnel 1 are as follows:

1. The timbers and roofing materials used to construct Tunnel 1 surpassed their 50-year life expectancy in 2006.

2. The treated timbers continue to be susceptible to damage from radiation-induced decay and moisture-related decay (fungus, mildew, and mold causing wood rot), although fungus, mildew, etc., have not been documented.

3. Tunnel 1 timbers have weakened, compared to their initial capacity, based on structural evaluations (RHO-CD-1076, *Structural Evaluation of the PUREX No. 1 Burial Tunnel*; LATA, 1991, *An Evaluation of the Structural Integrity of the PUREX Storage Tunnel #1*).

4. A portion of the tunnel (6 by 6 m [20 by 20 ft]) collapsed in an area roughly 12.8 m (41.9 ft) south of the door and was discovered on May 9, 2017.

Based on the partial tunnel collapse, past study findings, Tri-Party concerns, and readily available information, a structural evaluation of Tunnel 1 is needed to establish its present stability, timber strength (structural integrity), and to determine the failure risk for the remainder of the storage area. The study results will support tunnel decisions and activities, including the following:

- S&M method-activity requirements
- Stored waste and HHE protection
- Present timber strength (structural integrity) and failure risk
- Present condition failure mode effects analysis (FMEA) model to evaluate tunnel responses to structural degradation and potentially damaging events (e.g., earthquakes, major rain events, heavy snowfall)

Additional Tunnel 1 information in the appendices and attachments for this report include the following:

- Appendix A, "PUREX Tunnel 1 Data Quality Objectives, Draft A" (May 31, 2017), including revisions per Washington State Department of Ecology (Ecology) comments on the February 27, 2017 Draft
  - Attachment 1, RHO-CD-1076, 1980, *Structural Evaluation of the PUREX No. 1 Burial Tunnel*, Rockwell Hanford Operations, Richland, Washington
  - Attachment 2, LATA, 1991, *An Evaluation of the Structural Integrity of the PUREX Storage Tunnel #1*, Los Alamos Technical Associates for Westinghouse Hanford Company, Richland, Washington
  - Attachment 3, Photographic Timeline of the PUREX Storage Tunnels
  - Attachment 4, CHPRC-03241, 2017, *PUREX Burial Tunnels*, CH2M HILL Plateau Remediation Company, Richland, Washington

1.2 PUREX Tunnel 2

PUREX Storage Tunnel 2 is permitted as a miscellaneous unit under WAC 173-303-680. It is used to store mixed waste from the PUREX Plant and other onsite sources. Tunnel 2 is isolated from the railroad tunnel by a water-fillable shielding door. In general, the mixed waste stored in the tunnel is encased or contained in carbon or stainless steel plate, pipe, or vessels for shielding and to facilitate placement of the waste on railcars and ultimate storage inside the tunnel. The exterior of each tunnel is inspected annually via a visual perimeter walkdown to ensure the fences and warning signs are present and in good condition, and to identify any obvious changes to the tunnel overburden condition. No interior inspections of the tunnels are performed. No other external or internal surveillance visuals, surveys, or controls are required at this time.

The storage area is 514.5 m (1,688 ft) long, 7.9 m (25.9 ft) high, and 10.4 m (34.1 ft) wide. Because of the arch-shaped cross-section of this tunnel and the entry clearance at the water-fillable door, the height and width of Tunnel 2 are not the same as Tunnel 1. The storage area includes a 10.4 m (34.1 ft) diameter, corrugated steel sheet (0.5 cm [0.18 in.]), semicircular roof that is supported by internal I-beams attached to external, reinforced concrete whale arches on 4.8 m (16 ft) centers. The concrete whale arches are 0.4 m (1.3 ft) thick and vary in width from 0.4 to 1.8 m (1.3 to 5.9 ft). The base on each side of the roof structure is composed of reinforced concrete beams that are about 1.8 m (5.9 ft) wide by 1.2 m (4 ft) thick and run the full length of the tunnel. The interior and exterior surfaces of the steel roof are coated with a

bituminous compound to inhibit corrosion, but have no cathodic protection. The floor consists of a railroad track laid on a gravel bed, with the space between the ties filled with gravel ballast. From the ends of the 2.4 m (8 ft) railroad ties, the earth floor slopes upward to a height of about 1.8 m (5.9 ft) above the railroad bed to the base of the sidewalls. The tracks have a 1% downgrade toward the south end of the tunnel to ensure the railcars remain in their storage positions. A railcar bumper is 2.4 m (8 ft) from the end of the tracks to act as a stop. The storage area is covered with 2.4 m (8 ft) of overburden as protection from the weather and as shielding. The capacity of the storage area is 38 to 40 railcars (each 12.8 m (42 ft] long). As of June 1996, Tunnel 2 contained 28 railcars (70% full).

Tunnel 2 construction began in early 1963 and was completed in late 1964. In January 1964, backfilling was halted when 75 linear feet of the tunnel structurally collapsed, and in the next 3 months a second, similar collapse occurred. Engineering evaluated legacy photos (Appendix B, Attachment 3, p. 6) and documents and concluded these collapses were due to a combination of weld failures, the backfilling procedure, and inadequate structural support. Between March and July 1964 efforts to "redesign" the structural supports of Tunnel 2 and modify the backfilling procedure were implemented. In the spring of 1964, efforts were focused on excavating all sections of tunnel that had been covered, installing internal I-beams along the longitudinal axis of the tunnel, installing reinforced concrete footings, and adding about 106 rib sections (whale arches) that were tied into the internal I-beams. All exposed steel surfaces were coated with a coal-tar-based bituminous solvent (per Military Specification (MIL)-C-18480) to prevent corrosion from moisture.

The primary concerns for Tunnel 2 are that the materials used to construct it surpassed their 50-year life expectancy in 2014, and its steel and concrete components continue to be susceptible to structural damage through exposure to radiation, moisture from condensation or precipitation, electrochemical corrosion, metal surface coating breakdown, dissimilar metal reactions, anchor rod corrosion, concrete weathering or cracking, and alkali-silica reactions. Tunnel 2 instability could compromise its content, HHE protection, require facility S&M updates, limit RCRA closure options, and accelerate closure activities.

Based on past study findings, Tri-Party concerns, and readily available information, a structural evaluation of Tunnel 2 is needed to establish if its structural integrity has become compromised and determine its structural strength and failure risk. The study results will support tunnel decisions and activities, including the following:

- S&M method-activity requirements
- Stored waste and HHE protectiveness
- Present structural strength (capacity) and failure risk
- Present condition FMEA model to evaluate tunnel responses to structural degradation and potentially damaging events (e.g., earthquakes, major thunderstorms, heavy snowfall)

Additional Tunnel 2 information in the appendices and attachments for this report include the following:

- Appendix B, "PUREX Tunnel 2 Data Quality Objectives, Draft A" (May 31, 2017), including revisions per Ecology comments on the February 27, 2017 Draft
  - Attachment 1, HWS-8262, 1962, *Specifications for PUREX Equipment Disposal*, General Electric Company, Richland, Washington
  - Attachment 2, Vitro, 1964, *EQUIPMENT DISPOSAL TUNNEL PUREX FACILITY INSPECTION REPORT*, Vitro Engineering Company, Richland, Washington

- Attachment 3, Photographic Timeline of the PUREX Storage Tunnels
- Attachment 4, CHPRC-03241, 20107, *PUREX Burial Tunnels*, CH2M HILL Plateau Remediation Company, Richland, Washington

2 Data Quality Objectives Methodology

The PUREX Tunnel 1 and 2 data quality objectives (DQOs) effort followed EPA/240/B-06/001, *Guidance on Systematic Planning Using the Data Quality Objectives Process*, and PRC-PRO-SMP-53095, *Data Quality Objectives Planning Process*. The tunnels were evaluated and pertinent data and information were documented in Data Quality Objectives Information Summaries (form A-6006-889 [REV 1]) for the seven DQO steps:

- Step 1: State the Problem
- Step 2: Identify the Goals of the Study
- Step 3: Identify Information Inputs
- Step 4: Define the Boundaries of the Study
- Step 5: Develop the Analytical Approach
- Step 6: Specify Performance or Acceptance Criteria
- Step 7: Develop Plan for Obtaining the Data

The CHPRC process was a modified external planning process, which included preparing a Draft A DQO Information Summary to document the seven-step DQO process with early draft DQO Information Summary briefings and reviews by the U.S. Department of Energy, Richland Operations Office (DOE-RL) and Ecology. To complete the seven-step DQO process, the following tasks were conducted:

- Ten CHPRC technical team meetings and multiple draft DQO Information Summary reviews from June 2016 to February 2017
- Three DOE-RL briefings and DQO Information Summary review-comment efforts from December 2016 to April 2017
- Two Ecology briefings (December 2016 and April 2017) and one DQO Information Summary review-comment effort

3 PUREX Tunnel Data Collection Recommendations

The data collection options presented in this section were based on reviewing the historical documents, drawings, photographs, and discussions among the DQO team while completing the DQO process.

3.1 PUREX Tunnel 1

The sampling approach and other DQO options for Tunnel 1 include the following:

Data Collection Options (external): Carefully remove the overburden from previous roof sample sites to collect 4 in. diameter coupons from the roof timbers and analyze their strength (similar to 1980 and 1991). Carefully remove the overburden from locations where critical timber density measurements can be collected with a resistance drill (timber roof to concrete wall top, timber wall to timber roof, and timber wall to concrete footings). It is anticipated that the overburden removal could allow access to multiple timbers at each site, and the data collected would be representative of the wall and roof timbers for entire Tunnel 1 structure.

Data Collection Options (internal): No human entry for internal Tunnel 1 data collection options should be seriously considered due to the May 9, 2017 partial roof collapse, structural instability, constricted walkways along the length of the tunnel, lack of readily available access points for personnel or equipment, and health and safety access restrictions.

Enhanced Surveillance Data Collection (external): Enhanced Tunnel 1 surveillance using light detection and ranging (LIDAR) and global positioning system (GPS) technologies would build on the existing overburden surface baseline (two previous surveys) that could be reevaluated at regular intervals (e.g., monthly, quarterly, or annually) to identify indications of structural failure (e.g., >5 cm overburden subsidence over a >2 m^2 area). These data could be collected using stationary, satellite, or drone-helicopter flyovers that would allow digital analyses of the entire Tunnel 1 surface (top and sides) for indications of structural failure (e.g., overburden subsidence).

3.2 PUREX Tunnel 2

The sampling approach and other DQO options for Tunnel 2 include the following:

Data Collection Options (external): Collecting Tunnel 2 corrugated steel samples for destructive assay could accelerate corrosion and decomposition of the steel. Removal of the overburden in an effort to collect samples of the corrugated steel could cause local instability and locally compromise the effectiveness of the corrugated steel and its coating. Also, limited external visual inspections would not provide sufficient information to support the structural integrity and failure risk evaluations required.

Because they are external to the storage space and several feet from the corrugated steel and its coating, overburden excavation to visually inspect the concrete whale arches and their footings would be appropriate for Tunnel 2.

Data Collection Options (internal): A Tunnel 2 internal inspection approach should be seriously considered due to the limitations identified for the external approach, the 70% full status of the tunnel (ease of movement), and available access points through the roof risers. There are 17 risers spaced every 96 ft along the north-south axis of the tunnel. The effective riser diameter is 15 ¾ in. with 36 in. diameter welded-closed manhole covers currently in place. Contingent on tunnel access safety restrictions via the risers, internal structural component visual inspections of the steel, steel coating, concrete wall foundation, welds, mechanical fasteners, etc., could be conducted via worker entry, remote control cameras, or a combination of these methods to collect photos and videos that represent the entire internal structure of the tunnel.

Worker access, if allowed, would follow as low as reasonably achievable (ALARA) principles by being limited to the tunnel door area to maximize their distance from the stored waste and could be for limited periods to minimize potential dose. Shielding would be considered. Worker entry would allow testing the structural components (e.g., weld strength, corrosion extent and depth, I-beam fastener integrity, and corrugated steel stability). This would provide better quality data and information for the tunnel structural integrity and failure risk evaluations planned.

Enhanced Surveillance Data Collection (external): Enhanced Tunnel 2 surveillance using LIDAR and GPS technologies would build on the existing overburden surface baseline (two previous surveys) that could be reevaluated at regular intervals (e.g., monthly, quarterly, or annually) to identify indications of structural failure (e.g., >5 cm overburden subsidence over a >2 m^2 area). These data could be collected using stationary, satellite, or drone-helicopter flyovers that would allow digital analyses of the entire Tunnel 2 surface (top and sides) for indications of structural failure (e.g., overburden subsidence).

4 References

CHPRC-03241, 2017, *PUREX Burial Tunnels*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington.

EPA/240/B-06/001, 2006, *Guidance on Systematic Planning Using the Data Quality Objectives Process*, EPA QA/G-4, Office of Environmental Information, U.S. Environmental Protection Agency, Washington, D.C. Available at: http://www2.epa.gov/sites/production/files/documents/guidance_systematic_planning_dqo_process.pdf.

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MIL-C-18480, *Coating, Compound, Bituminous, Solvent, Coal-Tar Base*, Military Specification, U.S. Department of Defense, Washington, D.C.

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Resource Conservation and Recovery Act of 1976, 42 USC 6901, et seq. Available at: https://elr.info/sites/default/files/docs/statutes/full/rcra.pdf.

RHO-CD-1076, 1980, *Structural Evaluation of the PUREX No. 1 Burial Tunnel*, Rockwell Hanford Operations, Richland, Washington.

Vitro, 1964, *EQUIPMENT DISPOSAL TUNNEL PUREX FACILITY INSPECTION REPORT*, Vitro Engineering Company, Richland, Washington.

WAC 173-303-680, "Dangerous Waste Regulations," "Miscellaneous Units," *Washington Administrative Code*, Olympia, Washington. Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-303-680.

5 Bibliography

40 CFR 265, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," *Code of Federal Regulations*. Available at: http://www.gpo.gov/fdsys/pkg/CFR-2010-title40-vol25/xml/CFR-2010-title40-vol25-part265.xml.

ANSI N13.1, 2011, *Sampling and Monitoring Releases of Airborne Radioactive Substances from the Stacks and Ducts of Nuclear Facilities*, Rev. 11, American National Standards Institute, New York, New York.

CP-14977, 20017, *Plutonium-Uranium Extraction Facility Documented Safety Analysis*, Rev. 9, CH2M HILL Plateau Remediation Company, Richland, Washington.[1]

[1] The PUREX ventilation system is considered "General Service" according to Section 4.1.2 of CP-14977.

HNF-11724, 2016, *CH2M Hill Plateau Remediation Company Safety Management Programs*, Rev. 13, CH2M HILL Plateau Remediation Company, Richland, Washington.

Chapter 10, "Initial Testing, In-Service Surveillance, and Maintenance."

HNF-14579, 2014, *Criticality Safety Evaluation Report CSER-03-002, Criticality Classification of PUREX Tunnels*, Rev. 1, CH2M HILL Plateau Remediation Company, Richland, Washington.

HNF-SD-CP-CR-037, 1997, *PUREX Heating, Ventilation, and Air Conditioning Consolidation Document*, Rev. 2, BWHC, Richland, Washington.

Provides a more detailed description of the HVAC system in the deactivated PUREX Facility.

WHC-SD-EN-WAP-007, 1997, *PUREX Storage Tunnels Waste Analysis Plan*, Rev. 4, Westinghouse Hanford Company, Richland, Washington.

WHC-SD-ES-003, 1991, *PUREX Storage Tunnels Disposal Alternatives Engineering Study*, Rev. 3, Westinghouse Hanford Company, Richland, Washington.

WA7890008967, *Hanford Facility Resource Conservation and Recovery Act (RCRA) Permit, Dangerous Waste Portion for the Treatment, Storage, and Disposal of Dangerous Waste*, Revision 8c, as amended, Washington State Department of Ecology. Available at: http://www.ecy.wa.gov/programs/nwp/permitting/hdwp/rev/8c/index.html.

WAC 173-303-400, "Dangerous Waste Regulations," "Interim Status Facility Standards," *Washington Administrative Code*, Olympia, Washington. Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-303-400.

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Appendix A

PUREX Tunnel 1 Data Quality Objectives, Draft A

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Appendix A – Systematic Planning Record

Characterization Data Collection Planning Record

NOTE: In cases where the requested information is not applicable, state that, and explain why it is not applicable so that it is clear that a required field has not been forgotten.

Project Summary

Project Name:	PUREX Tunnel 1 Data Quality Objectives (DRAFT A)	Date:	5-31-17
Name of Person Completing Record:	Roger Ovink/CHPRC	Position:	DQO Tech. Authority
Name of Responsible Manager:	Darin Corriell/CHPRC (Central Plateau S&M)		

Project Background (Step 1): The following information is summarized from RHO-CD-1076, 1980, *Structural Evaluation of the PUREX No. 1 Burial Tunnel*, Rockwell Hanford Operations, Richland, Washington; and LATA, 1991, *An Evaluation of the Structural Integrity of the PUREX Storage Tunnel #1*, Los Alamos Technical Associates for Westinghouse Hanford Company, Richland, Washington. The summary attachments include these reports (Attachments A and B); CHPRC, 2017, Photographic Timeline of the PUREX Storage Tunnels (Attachment C); a complete list of references (Attachment D); and CHPRC-03241, Rev. 0, *PUREX Burial Tunnels*, March 2017 (Attachment E).

PUREX Storage Tunnel 1 is permitted as a miscellaneous unit under WAC 173-303-680, "Dangerous Waste Regulations," "Miscellaneous Units." It is used to store mixed waste from the PUREX Plant and other onsite sources. Tunnel 1 is isolated from the railroad tunnel by a water-fillable shielding door. In general, the mixed waste stored in the tunnel is encased or contained in carbon or stainless steel plate, pipe, or vessels for shielding and to facilitate placement of the waste on railcars and ultimate storage inside the tunnel. The exterior of each tunnel is inspected annually via a visual perimeter walkdown to ensure the fences and warning signs are present and in good condition, and to identify any obvious changes to the tunnel overburden condition. No interior inspections of the tunnel are performed, but daily inspections of the tunnel have been required since the Tunnel 1 partial collapse was discovered on May 9, 2017.

Tunnel 1 was completed in 1956 with a water-fillable door, storage area, and vent shaft described as follows:

- The water-fillable, 1.3 cm (0.5 in.) steel plate door is located at the north end of the tunnel and separates the storage tunnel from the railroad tunnel. It is 7.5 m (24.6 ft) high, 6.6 m (21.7 ft) wide, and 2.1 m (6.9 ft) thick. The door is hollow so it can be filled with water to act as a shield when it is in the closed position. If filled with water, the door must be emptied before it can be raised. Electric hoists for opening and closing the door are located on top of a reinforced concrete structure that supports the door. After the last car was placed in the tunnel, the door was closed and filled with water, but the water was subsequently drained because the additional shielding was not required.
- The storage area extending south from the water-fillable door has inside dimensions of 109 m (358 ft) long, 6.7 m (22 ft) high, and 5.9 m (19.3 ft) wide. The ceiling and walls are 35.6 cm (14 in.) thick, constructed of 30.5 by 35.6 cm (12 by 14 in.) creosote pressure-treated Douglas fir timbers arranged side by side. The first 30.5 m (100 ft) of the east wall is constructed of 0.9 m (3 ft) thick reinforced concrete. A 40.8 kg/m^2 (8.4 lb/ft^2) mineral surface roofing material covered the exterior surface of the treated timber roof beams and walls before placing 2.4 m (8 ft) of overburden on the storage area as protection from the elements and as shielding. The timbers forming the walls rest on reinforced concrete footings 0.9 m (3 ft) wide by 0.3 m (1 ft) thick. The floor consists of a railroad track laid on a gravel bed, with the space between the ties filled with gravel ballast. The tracks slope 1% downgrade to the south end of the tunnel. A railcar bumper is 2.4 m (8 ft) from the end of the tracks to act as a stop. Tunnel 1 is filled to capacity with eight 12.8 m (42 ft) long railcars.
- There is an exhaust fan connected to a filter and vent shaft at the south end of Tunnel 1. The vent shaft is 0.28 m^2 (3 ft^2) and about 8 m (27 ft) deep and constructed of reinforced concrete and equipped with an exhaust fan. The ventilation system was deactivated in 1996, and blanks were installed at both the inlet and outlet of the fan and high-efficiency particulate air (HEPA) filter unit and abandoned in place. There are also three, 10 cm (4 in.)

Appendix A – Systematic Planning Record

Characterization Data Collection Planning Record

NOTE: In cases where the requested information is not applicable, state that, and explain why it is not applicable so that it is clear that a required field has not been forgotten.

diameter access risers that penetrate the ceiling within the first 55 m (180 ft) of the north end (door) of the tunnel (over tunnel positions 5, 7, and 8).

Construction of Tunnel 1 differs from Tunnel 2 as follows:

- A combination of steel and reinforced concrete was used in the construction of the storage area for Tunnel 2 rather than the timbers used in the Tunnel 1 walls and roof.
- Tunnel 2 is longer, with about five times the storage capacity of Tunnel 1.
- The floor of Tunnel 2, outboard of the railroad ties, slopes upward to a height of about 1.8 m (5.9 ft) above the railroad bed, while the Tunnel 1 floor is flat all the way out to the sidewalls.

Step 1: Planning Type:
(If systematic planning is not required, state the reason)

Modified External DQO Planning (includes Draft A submittal and briefing for the Washington State Department of Ecology).

Organization, Schedule, and Goal
(State the problem, requirements, schedule, PSQs, and outcomes)

Step 1: State the Problem
(Describe the reason/need for data collection and project goals/objectives)
Tunnel 1 was constructed in 1956 and had structural integrity evaluations in 1971, 1978, 1980, and 1991 that found it to be structurally sound, but the load-bearing capacity of the treated timbers has decreased since 1956. The 1991 evaluation summarized the past study results and recommended additional study in 2001, which was not conducted. Tunnel 1 instability could compromise its protection of the tunnel contents and human health and the environment (HHE), require facility surveillance and maintenance (S&M) updates, limit *Resource Conservation and Recovery Act of 1976* (RCRA) closure options, and accelerate closure activities. The primary concerns for Tunnel 1 are as follows:

1. The timbers and roofing materials used to construct Tunnel 1 surpassed their 50-year life expectancy in 2006.
2. The treated timbers continue to be susceptible to damage from radiation-induced decay and moisture-related decay (fungus, mildew, and mold causing wood rot), although fungus, mildew, etc., have not been documented.
3. Tunnel 1 timbers have weakened, compared to their initial capacity, based on structural evaluations in RHO-CD-1076 (1980) and LATA (1991).
4. A collapsed 6 by 6 m (20 by 20 ft) section of the storage area (12.8 m [41.9 ft] south of the door) was discovered on May 9, 2017.

Based on the partial tunnel collapse, past study findings, Tri-Party concerns, and readily available information, a structural evaluation of Tunnel 1 is needed to establish its present stability and timber strength (structural integrity), and to determine the failure risk for the remainder of the storage area. The study results must support tunnel decisions and activities, including the following:

- S&M method-activity requirements
- Stored waste and HHE protection
- Present timber strength (structural integrity) and failure risk

Appendix A – Systematic Planning Record

Characterization Data Collection Planning Record

NOTE: In cases where the requested information is not applicable, state that, and explain why it is not applicable so that it is clear that a required field has not been forgotten.

Step 1: State the Problem
(Describe the reason/need for data collection and project goals/objectives)

- Present condition failure mode effects analysis (FMEA) model to evaluate tunnel responses to structural degradation and potentially damaging events (e.g., earthquakes, major thunderstorms, heavy snowfall).

Principal Study Questions Step 2 *(What questions are data needed to answer?)*	**PSQ 1**	Are the following four key contact treated timber component-locations adversely affected by radiation or moisture (fungus) damage? • Roof timber to concrete wall • Roof timber to wall timber • Wall timber to concrete footing • Roof timber centers (continuation of earlier studies)	**PSQ 5**	Will the data gathered to answer PSQs 1-4 be sufficient to evaluate the strength and failure risk of Tunnel 1?
	PSQ 2	Is present Tunnel 1 treated timber condition sufficient to continue supporting the overburden (2.4 m [8 ft])?	**PSQ 6**	Will the data gathered to answer PSQs 1-4 be sufficient to conduct a FMEA model for Tunnel 1?
	PSQ 3	Is "arching" (overburden soil forming an arch, via settling, around the structure) occurring with the Tunnel 1 overburden?	**PSQ 7**	Are current surveillance practices sufficient to ensure Tunnel 1 protectiveness and structural integrity?
	PSQ 4	Is the 2.4 m (8 ft) overburden still needed to provide radiation shielding for the Tunnel 1 stored waste?	**PSQ 8**	Are current maintenance practices sufficient to ensure Tunnel 1 protectiveness and structural integrity?
Define alternative outcomes or actions that can occur upon answering PSQs. Step 2	**AA 1A**	The four Tunnel 1 key contact treated timber locations are adversely affected.	**AA 5A**	The data gathered to answer PSQs 1-4 will be sufficient to evaluate the capacity and failure risk of Tunnel 1.
	AA 1B	The four Tunnel 1 key contact treated timber locations are not adversely affected.	**AA 5B**	The data gathered to answer PSQs 1-4 will not be sufficient to evaluate the capacity and failure risk of Tunnel 1.
	AA 2A	Present Tunnel 1 treated timber condition is sufficient to continue supporting the 2.4 m (8 ft) overburden.	**AA 6A**	The data gathered to answer PSQs 1-4 will be sufficient to conduct a FMEA model for Tunnel 1.
	AA 2B	Present Tunnel 1 treated timber condition is not sufficient to continue supporting the 2.4 m (8 ft) overburden.	**AA 6B**	The data gathered to answer PSQs 1-4 will not be sufficient to conduct a FMEA model for Tunnel 1.
	AA 3A	Arching is occurring with the Tunnel 1 overburden.	**AA 7A**	Current surveillance practices are sufficient to ensure Tunnel 1 protectiveness and structural integrity.
	AA 3B	Arching is not occurring with the Tunnel 1 overburden.	**AA 7B**	Current surveillance practices are not sufficient to ensure Tunnel 1 protectiveness and structural integrity.

Appendix A – Systematic Planning Record

Characterization Data Collection Planning Record

NOTE: In cases where the requested information is not applicable, state that, and explain why it is not applicable so that it is clear that a required field has not been forgotten.

	AA 4A	The 2.4 m (8 ft) overburden is needed to provide radiation shielding for the Tunnel 1 stored waste.	**AA 8A**	Current maintenance practices are sufficient to ensure Tunnel 1 protectiveness and structural integrity.
	AA 4B	The 2.4 m (8 ft) overburden is not needed to provide radiation shielding for the Tunnel 1 stored waste.	**AA 8B**	Current maintenance practices are not sufficient to ensure Tunnel 1 protectiveness and structural integrity.

Identify the decision statements or estimation statements needed to address the PSQs. (Step 2)	**DS-1:** Tunnel 1 treated timber components-locations are/are not adversely affected by radiation or moisture (fungus) damage.
	DS-2: The present Tunnel 1 treated timber condition is/is not sufficient to continue supporting the overburden (2.4 m [8 ft]).
	DS-3: Arching is/is not occurring with the Tunnel 1 overburden.
	DS-4: The 2.4 m (8 ft) overburden is/is not still needed to provide radiation shielding for the Tunnel 1 stored waste.
	DS-5: The data gathered to answer PSQs 1-4 will/will not be sufficient to evaluate the strength and failure risk of Tunnel 1 treated timbers.
	DS-6: The data to answer PSQs 1-4 will/will not be sufficient to conduct a Tunnel 1 FMEA model to evaluate structural responses to decay and potentially damaging events (e.g., earthquakes, major thunderstorms, heavy snowfall).
	DS-7: The current surveillance practices are/are not sufficient to ensure Tunnel 1 protectiveness and structural integrity.
	DS-8: The current maintenance practices are/are not sufficient to ensure Tunnel 1 protectiveness and structural integrity.

Data Needs
(Define the spatial and temporal boundaries of the study)

Step 4: Define what constitutes a sampling unit:

All the tunnel areas where treated timbers were used (roof and walls) and the overburden. It will not be possible to collect samples from Tunnel 1 due to the structural instability of the unit.

Step 4: What is the smallest unit upon which decisions or estimates will be made?

Individual key contact treated timber areas where decay could result in failure (roof timber connections to east concrete wall, wall timber to roof timber connections, wall timber to concrete footing connections, roof timber centers, and the overburden).

Data Needs Summary Step 3
(Information inputs to answer PSQs: target population, characteristics of interest, spatial and temporal limits, scale of inference)

PSQ	Data Need	Media of Interest	Sampling Location	Sampling Approach	Action Level	Number of Samples	Practical Sampling Constraints	Analytical Approach	Potential Data Sources
PSQ 1	Outer roof timber density	Treated timbers	Near timber centers (earlier storage area study sites)	Cores and wood density drill; visual for decay (rot)	≤60% original wood strength	3+ (near earlier study sites)	Access through overburden; radiation area	Wood cores: flex test, density drill readings	Field sampling and visuals during sampling
PSQ 1	Outer roof timber density	Treated timbers	Roof timber-concrete wall interface (outer surface)	Wood density drill; visual for decay (rot)	≤60% original wood strength	3+ (adjacent beams)	Access through overburden; radiation area	Density drill field readings	Field sampling and visuals during sampling

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Characterization Data Collection Planning Record

NOTE: In cases where the requested information is not applicable, state that, and explain why it is not applicable so that it is clear that a required field has not been forgotten.

Data Needs Summary Step 3

(Information inputs to answer PSQs: target population, characteristics of interest, spatial and temporal limits, scale of inference)

PSQ	Data Need	Media of Interest	Sampling Location	Sampling Approach	Action Level	Number of Samples	Practical Sampling Constraints	Analytical Approach	Potential Data Sources
PSQ 1	Outer wall timber density	Treated timbers	Roof-wall timber interface (outer surface)	Wood density drill; visual for decay (rot)	≤60% original wood strength	3+ (adjacent beams)	Access through overburden; radiation area	Density drill field readings	Field sampling and visuals during sampling
PSQ 1	Outer wall timber density	Treated timbers	Timber wall-concrete footing joint (outer surface)	Wood density drill; visual for decay (rot)	≤60% original wood strength	3+ (adjacent beams)	Access through overburden; radiation area	Density drill field readings	Field sampling and visuals during sampling
PSQ 1	Inner wall and roof timber visuals	Treated timbers	Storage area (inner surface)	Wood density drill; visual for decay (rot)	≤60% original wood strength	10+ each (roof and timber walls)	Access (tunnel entry safety); radiation area	Density drill field readings	Field sampling and visuals during sampling
PSQ 2	Outer and inner tunnel roof and wall timber densities	Treated timbers	Storage area (inner and outer surfaces)	PSQ 1 data and information	Contingent on Tunnel 1 capacity estimated	PSQ 1 data and information	Collecting PSQ 1 data and information; radiation area	NA	PSQ 1 data and information
PSQ 3	Overburden soil "arching" potential	Overburden material (soil)	Outer storage area overburden	Overburden soil sampling (borings & test pits)	Low soil shear strength = poor arching potential	3+ locations (same areas as PSQ 1 timber density data collection)	Access through overburden; radiation area	Geotechnical testing (physical, mechanical, and arching properties)	Overburden geotechnical test results
PSQ 4	Current inner Tunnel 1 radiation estimates (or readings), decay rates, & overburden-shielding properties	Tunnel 1 stored waste and overburden	In-tunnel storage area and overburden	Current inner tunnel radiation measurements, initial waste inventory data, & information from historical waste records	Direct radiation exposure level criteria	Once for each in-tunnel area (three access risers); multiple overburden locations	Worker safety, instruments that will fit through the risers, rad inventory data availability, and historical waste records; radiation area	Radiation survey field instruments	Historical records (initial radiation inventory), decayed rad estimates, soil shielding properties, & current internal rad readings
PSQ 5	Data and information collected for PSQs 1-4	Treated timber, concrete, and overburden	See PSQs 1-4	See PSQs 1-4	See PSQs 1-4	See PSQs 1-4	See PSQs 1-4	Strength and failure risks; arching and shielding influence on overburden needs	New strength and failure risk results; new arching probability; new shielding needs
PSQ 6	Data and information collected for PSQs 1-4	Treated timber, concrete, and overburden	See PSQs 1-4	See PSQs 1-4	See PSQs 1-4	See PSQs 1-4	See PSQs 1-4	FMEA modeling	New FMEA model results
PSQ 7	Current surveillance practices, data and evaluation results from PSQs 1-6	Treated timber and overburden	Exterior of tunnel overburden surface	Light Detection and Ranging (LIDAR)	>5 cm subsidence over >2 m^2 area	Monthly to quarterly	Weather; radiation area	Digital analysis; compared flyover-to-flyover	New stationary, satellite, helicopter, or drone flyovers combined with LIDAR and global positioning system (GPS) assessment

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Characterization Data Collection Planning Record

NOTE: In cases where the requested information is not applicable, state that, and explain why it is not applicable so that it is clear that a required field has not been forgotten.

Data Needs Summary Step 3

(Information inputs to answer PSQs: target population, characteristics of interest, spatial and temporal limits, scale of inference)

PSQ	Data Need	Media of Interest	Sampling Location	Sampling Approach	Action Level	Number of Samples	Practical Sampling Constraints	Analytical Approach	Potential Data Sources
PSQ 8	Current maintenance practices, data and evaluation results from PSQs 1-6	Treated timber and overburden	Exterior of tunnel overburden surface	LIDAR	>5 cm subsidence over >2 m^2 area	Monthly to quarterly	Weather; radiation area	See PSQ 7; photo-video evaluation (if entry approved)	PSQ 7 results; new photo-video evaluation

Performance or Acceptance Criteria

(Determine the quality of data needed and analytical approach)

Decision Problem

Provide a decision rule related to the Action Level identified above that includes a clear "if…then…else" statement: Step 5: Decision rules (DRs) are related to the previously identified PSQs and decision statements in Step 2 and add applicable Action Levels that are included in clear "if…then…otherwise" statements:

DR-1: If Tunnel 1 treated timber structural component-location data show that the timber density and strength have been adversely affected by radiation or moisture (fungus) damage, then the tunnel degraded strength would be identified and a determination made if the tunnel is unstable and protection of the tunnel contents and HHE could be compromised. Otherwise, Tunnel 1 structural stability would be indicated, but enhanced S&M activities would be needed to ensure the continued protection of the stored waste and HHE.

DR-2: If the data show that the present Tunnel 1 timber strength is sufficient to continue supporting the 2.4 m (8 ft) of overburden, then no changes to the overburden is needed. Otherwise, determine how much weight the Tunnel 1 timbers can support and if reduced overburden thickness would protect the stored waste and HHE and possibly improve Tunnel 1 structural stability.

DR-3: If the geotechnical data show that arching is occurring in the Tunnel 1 overburden, then the strength (capacity) of the timbers may be sufficient to support the overburden. Otherwise, determine how much weight the Tunnel 1 timbers can support and if reduced overburden thickness would protect the stored waste and HHE and possibly improve Tunnel 1 structural stability.

DR-4: If the 2.4 m (8 ft) of overburden is required to shield the Tunnel 1 stored waste and the timber strength is sufficient to support the overburden, then no changes to the overburden thickness would be needed. Otherwise, determine how much weight the Tunnel 1 timbers can support, if the reduced overburden thickness will maintain adequate shielding, and if the overburden reduction could improve Tunnel 1 structural stability.

DR-5: If the data gathered to answer PSQs 1-4 are sufficient to evaluate the strength and failure risk of the Tunnel 1 timbers, then conduct the strength and failure risk evaluations for the tunnel. Otherwise, identify missing or inadequate data and plan to collect it so the timber strength and failure risk evaluation can be completed.

DR-6: If the data gathered to answer PSQs 1-4 are sufficient to conduct Tunnel 1 FMEA modeling, then conduct it. Otherwise, identify missing or inadequate data and plan to collect it so a FMEA modeling effort can evaluate structural responses to decay and potentially damaging events (e.g., earthquakes, major thunderstorms, heavy snowfall).

DR-7: If current surveillance practices are sufficient to ensure Tunnel 1 protectiveness and structural integrity, then continue with the current surveillance practices. Otherwise, develop updated surveillance practices that are sufficient to ensure Tunnel 1 protectiveness and structural integrity.

Appendix A – Systematic Planning Record

Characterization Data Collection Planning Record

NOTE: In cases where the requested information is not applicable, state that, and explain why it is not applicable so that it is clear that a required field has not been forgotten.

DR-8: If current maintenance practices are sufficient to ensure Tunnel 1 protectiveness and structural integrity, then continue with the current maintenance practices. Otherwise, develop updated maintenance practices that are sufficient to ensure Tunnel 1 protectiveness and structural integrity.

Step 6: Specify the population parameter *(e.g., mean, median, or percentile)*, appropriate for making decisions or estimates:

A statistical approach will not be utilized when evaluating the structural integrity of Tunnel 1. The overall empirical timber strength of the tunnel will be evaluated and modeled (FMEA) to establish the current Tunnel 1 structural integrity and failure risk using a judgmental sampling approach and a weight-of-evidence decision-making strategy.

Step 6: What are the consequences of making an incorrect decision and what is the tolerance for an incorrect decision?

To ensure the continued protection of the Tunnel 1 stored waste and HHE, incorrect decisions regarding the structural strength (capacity) and failure risk (additional collapses) should be avoided.

Thinking Tunnel 1 Is Stable When It Is Actually Unstable
Incorrectly determining that the Tunnel 1 treated timbers or concrete are not degraded, that the tunnel is stable with limited failure risk, and that current S&M practices can continue unchanged *could result in minimal actions and concern*, leading to continued degradation, tunnel failure (additional collapses), and increased HHE risk.

Thinking Tunnel 1 is Unstable when it is Actually Stable
Incorrectly determining that the Tunnel 1 treated timbers or concrete are severely degraded, that the tunnel has high failure risk, and that current S&M practices cannot continue unchanged *could result in unnecessary actions and concern*, leading to unnecessary maintenance activities and increased expenditures (labor and materials) to prevent continued degradation, tunnel failure (additional collapses), and increased HHE risk.

Step 6: Develop the specification of the estimator by combining the true value of the selected population parameter with the scale of estimation and other boundaries:

Tunnel 1 entry by workers to inspect structural conditions is not proposed. New sampling at external structural contact locations (timber-concrete [wall], timber-concrete [footing], timber-timber [roof-wall]) and at historical timber sampling locations (roof timbers near risers) would be representative of the entire tunnel timber structure.

Step 6: What are the acceptable limits on uncertainty?
The Tunnel 1 judgmental sampling approach and weight-of-evidence decision-making strategy are sufficient for establishing current Tunnel 1 structural integrity (capacity) and failure risks. The treated timbers are the construction materials of primary concern, and an important Tunnel 1 DQO assumption is that if one or more timber strength result indicates degradation to ≤60% of the original wood strength, this result would apply to all the other Tunnel 1 timbers. This assumption recognizes a low threshold for probable failure risk and minimal acceptable uncertainty in interpreting the timber strength and modeling (FMEA) modeling results.

Step 7: Plan for Obtaining the Data

(Specify the general plan of obtaining the needed data and explain where and how the information in this Planning Record will be formalized in a data collection plan)

Data Collection Options (external): Carefully remove the overburden from previous roof sample sites to collect 4 in. diameter coupons from the roof timbers and analyze their strength (similar to 1980 and 1991). Carefully remove the overburden from locations where critical timber density measurements can be collected with a resistance drill (timber roof to concrete wall top, timber wall to timber roof, and timber wall to concrete footings). It is anticipated that the

Appendix A – Systematic Planning Record

Characterization Data Collection Planning Record

NOTE: In cases where the requested information is not applicable, state that, and explain why it is not applicable so that it is clear that a required field has not been forgotten.

Step 7: Plan for Obtaining the Data

(Specify the general plan of obtaining the needed data and explain where and how the information in this Planning Record will be formalized in a data collection plan)

overburden removal could allow access to multiple timbers at each site, and the data collected would be representative of the wall and roof timbers for the entire Tunnel 1 structure.

Data Collection Options (internal): No human entry for internal Tunnel 1 data collection options should be seriously considered due to the May 9, 2017 partial roof collapse, structural instability, constricted walkways along the length of the tunnel, lack of readily available access points for personnel or equipment, and health and safety access restrictions.

Enhanced Surveillance Data Collection (external): Enhanced Tunnel 1 surveillance using LIDAR and GPS technologies would build on the existing overburden surface baseline (two previous surveys) that could be reevaluated at regular intervals (e.g., monthly, quarterly, or annually) to identify indications of structural failure (e.g., >5 cm overburden subsidence over a >2 m^2 area). These data could be collected using stationary, satellite, or drone-helicopter flyovers that would allow digital analyses of the entire Tunnel 1 surface (top and sides) for indications of structural failure (e.g., overburden subsidence).

Attachment 1

RHO-CD-1076, *Structural Evaulation of the PUREX No. 1 Burial Tunnel*

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R Purex Tunnels 905

I

AN EVALUATION OF THE STRUCTURAL INTEGRITY OF PUREX STORAGE TUNNEL #1

SUBMITTED TO
WESTINGHOUSE HANFORD COMPANY

MAY 1991

Los Alamos Technical Associates, Inc.

P. O. Box 410 / 1650 Trinity Drive / Los Alamos, NM 87544 / (505) 662-9080

An Evaluation of the Structural Integrity of PUREX Storage Tunnel # 1

May 17, 1991

by

F. R. Hand and V. J. Stephens

Los Alamos Technical Associates, Inc.

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Executive Summary

Westinghouse Hanford Company requested Los Alamos Technical Associates, Inc. (LATA) to make an independent evaluation of the structural integrity of PUREX Storage Tunnel #1 in response to questions by the State of Washington Department of Ecology as to the advisability of continuing to store dangerous waste in Tunnel #1. LATA finds that there is very low probability of any degradation of the timbers in the tunnel due to decay or insect attack. The only structural degradation that is occurring is due to the continued exposure of the timbers to the high gamma radiation field in the tunnel, and this effect is minor. In the Silvan evaluation of the tunnel (Silvan 1980), the strength of the timbers at that time was determined to be 65.4% of the original strength. Based on the same methods of calculating radiation damage effects as used in the Silvan report, it is conservatively estimated that the strength of the timbers will be 60% of original strength in the year 2001. At that time it is recommended that the structural integrity of the tunnel be reevaluated in light of tests being conducted by the United States Forest Product Laboratory and others on the resistance of treated wood to damage by decay or insect attack.

An Evaluation of the Structural Integrity of PUREX Storage Tunnel # 1

1.0 Introduction

In September, 1990, a dangerous waste permit application for the PUREX Storage Tunnels (DOE, 1990) was submitted to the Washington State Department of Ecology by the United States Department of Energy - Richland Operations Office. The PUREX Storage Tunnels are a storage unit located on the Hanford Site in the 200-East area. The unit consists of two earth-covered railroad tunnels that are used for storage of process equipment (some containing dangerous waste) removed from the PUREX Plant. The radioactively contaminated equipment is loaded on railroad cars and remotely transferred into the tunnels for long-term storage. Storage of the mixed (dangerous and radioactive) waste associated with the equipment is regulated under the *Resource Conservation and Recovery Act (RCRA) of 1976* and under the Washington Administrative Code, WAC Chapter 173-303, *Dangerous Waste Regulations* (WAC, 1989).

On February 5, 1991, the State of Washington, Department of Ecology, issued a Notice of Deficiency (NOD) for the PUREX Storage Tunnels Dangerous Waste Permit Application (Nord, 1991). In the NOD, the Department of Ecology questioned the advisability of leaving dangerous waste stored in Tunnel #1 in light of statements made by Silvan (1980) about the structural integrity of Tunnel #1 (see the Appendix for a copy of the statements in the NOD). Westinghouse Hanford Company (WHC), the operating contractor responsible for the PUREX Storage Tunnels, requested Los Alamos Technical Associates, Inc. (LATA) to make an independent evaluation of the structural integrity of PUREX Storage Tunnel #1.

2.0 Background Information

PUREX Storage Tunnel #1 is located in the southeast quadrant of the PUREX plant site (see Figure 1). The north end of the storage tunnel is near the southeast end of Building 202-A, the main process building at the PUREX site. The storage tunnel is a straight-line continuation of the north-south railroad tunnel that enters Building 202-A at the northeast corner. The storage tunnel consists of three areas: a water fillable door housed in a reinforced concrete structure that separates the storage tunnel from the PUREX railroad tunnel; the storage area proper that is 358 feet long and is constructed from wood timbers covered with earth; and a reinforced concrete vent shaft at the extreme southern end of the storage area. The area of concern is the storage area proper.

There are only two reasonable alternatives to leaving the dangerous waste in Tunnel #1, these alternatives are:

- make permanent disposition of the material; or
- move the material to another storage location.

Ultimately, permanent disposition of all of the material in both storage tunnels will have to be made; therefore, the ideal solution to the problem is to make permanent disposal of the dangerous waste in Tunnel #1 immediately. Disposal options have been evaluated by Henckel (1990). Options studied included:

- backfilling the tunnels with gravel;
- injecting the tunnels with grout;
- a combination of grout injection and backfilling;
- retrieving the equipment and disposing of it in the PUREX Plant;
- retrieving the equipment, performing size reduction procedures in the PUREX Plant, and disposing of the resulting material;
- retrieving the equipment and transporting it to the Waste Receiving and Processing (WRAP) facility (Module 2);

- retrieving the equipment and transporting it off the Hanford Site for treatment and disposal; and
- constructing a new facility for retrieving, processing, and treatment of equipment for disposal.

Based on the evaluation criteria used, three of the alternatives were closely ranked. In order of ranking, highest to lowest, the three were: retrieval and disposal in PUREX; in situ grouting; and retrieval and size reduction in PUREX. Even though it was the lowest ranking of the three, the alternative of retrieval and size reduction in PUREX was the alternative recommended because this alternative would be in compliance with RCRA regulations and is technically feasible.

Because of the interaction and dependency on other disposal actions taking place throughout the Hanford Site, none of the options studied can be accomplished in the near term. Therefore, the alternative of permanent disposal is not a viable option for the resolution of the NOD. This leaves moving to another storage location as the only reasonable alternative.

The only other storage location available for storing the dangerous waste now stored in Tunnel #1 is PUREX Storage Tunnel #2. Assuming that in-situ disposal will not be the final disposal option selected, moving the dangerous waste from Tunnel #1 to Tunnel #2 would violate the as low as reasonably achievable (ALARA) principal because operating personnel would be exposed to as much, or more, penetrating radiation during the move as during final disposition. In order to achieve exposure ALARA, it is highly desirable to leave the dangerous waste in Tunnel #1 if the structural integrity of the tunnel is acceptable. Leaving the material in Tunnel #1 has the added advantage of making more space in Tunnel #2 available for failed equipment storage during any future PUREX process operations.

3.0 Construction Features of Tunnel #1 Storage Area

Construction of Tunnel #1 was completed in 1956 as part of the PUREX Plant construction. The tunnel was designed by General Electric. Sketches of Tunnel #1 are provided in Figures 2 and 3. Copies of selected plans and sections from the original design drawings are shown in Figures 4 through 7. The original drawings for the tunnel are H-2-55586 to H-2-55595.

The tunnel is divided into three main parts - the water fillable door at the north end, the 358-foot long tunnel proper, and the reinforced concrete vent structure at the south end. Only the timber portion will be described in detail since the condition of the timbers is the essence of the NOD.

The timber portion of the tunnel is 358 feet long and is composed of two typical sections. The inside dimensions of the tunnel are 22 feet in height and 19 feet wide and are same for both typical sections. The first 103-foot length of the tunnel closest to PUREX Plant (northern part of tunnel) is composed of a 3-foot thick reinforced concrete wall on the east side and timber west wall and roof. The reinforced concrete wall section would allow for later construction of Tunnel #2 without disturbing the existing and buried Tunnel #1. The remaining 255-foot length of tunnel (south portion) is composed of two timber walls and timber roof. The same type of timbers are used in both sections.

The entire timber area of the tunnel is composed of 12-inch by 14-inch creosoted timbers arranged side by side with the 12-inch face exposed. Vertical side wall timbers were placed on a reinforced concrete footing 3-feet wide and 1-foot thick. A 9-inch high curb on the interior face of the footing restrains the timbers and resists forces imposed by the earth backfill. Continuous creosoted wood rail ties between the east and west footings carry the steel rails and permit soil loads to be transferred from one footing to the other. All timbers and rail ties are No. 1 Douglas fir.

All exterior surfaces of the timber structure were covered with mineral surfaced, 90-lb roofing. All joints in the roofing were cemented, lapped, and nailed on 3-inch centers. Cracks between timbers wider than three-quarters of an inch were covered with 26 gage galvanized steel nailed in place before the roofing was placed. The entire structure was then covered with earth fill to provide a minimum cover of 8 feet.

The materials used in and the construction of the tunnel were controlled by the original drawings and specifications (GE, 1855). These are used to expand the material descriptions given above.

Timbers - The timbers are Douglas fir No. 1 Posts and Timbers as produced and graded under the Standard Grading and Dressing Rules of the West Coast Lumberman's Association. The timbers are rough sawn to 12"x14".

The timbers are pressure treated with creosote in conformance with American Wood Preservers' Association (AWPA) Standard C2-54 for the Preservation Treatment of Lumber, Timber, Bridge Ties and Mine Ties by Pressure Process. The minimum retention is 8.0 pounds of creosote per cubic foot of wood.

All cutting, framing and drilling of holes was performed prior to pressure treating.

Roofing - Mineral surfaced roofing is asphalt saturated felt, surfaced with mineral granules and weighing at least 83 pounds per square (referred to as "90 pound roofing"). Material conforms to the requirements of ASTM Designation: D 249-50T, Specifications for Asphalt Roofing Surfaced with Mineral Granules.

Plastic roofing cement was Koppers "Flashing Cement", or approved equal.

Backfill - Heavy construction equipment was not operated over the tunnel structure

at any time. A light weight farm type tractor was permitted for finish grading over top of tunnel.

Material for non-load bearing backfill was placed in layers not to exceed 24 inches loose measurement.

Care was exercised during backfilling to prevent excessive loads on walls and to insure balanced loading on opposite walls.

Six inches of clean sand free from stones over 1 inch in diameter were placed over tunnel roofing material prior to placing embankment material.

4.0 Previous Studies and Their Evaluation

4.1 1971 Wood Sampling

The integrity of the wood in the tunnel was evaluated. Four 1½ inch steel pipes were sunk through the dirt fill down to the roof of the burial tunnel. Using a Swedish, Increment Borer four 3/16 inch diameter samples were obtained. The samples were examined visually and determined to be sound. This effort was completed in March 1971.

This 1971 study did not yield numerical test results but does indicate that the timbers are in satisfactory condition after 15 years in service.

4.2 1978 Evaluation of the Tunnel Environment

In July 1978, an evaluation of the storage tunnel environment was performed. A one-half inch tygon tube was lowered into each of the air sample and temperature probe risers and several air samples were withdrawn from the tunnel using a vacuum pump. These

samples were tested for airborne radioactivity, gaseous chemical composition and relative humidity. Temperature and radiation exposure were determined by lowering iron constantan thermocouples and thermoluminescent dosimeter chips into the tunnel. Result of these tests are shown in Table 1. No conclusions were made from these tests at that time, but it was recommended that the tunnels' wood timbers be sampled and tested to verify their structural integrity.

This 1978 study gives environmental data but no structural data. The environment data represents conditions after 22 years of service. The tunnel was sealed following placement of the last rail car in 1965. There is little reason to expect the temperature and relative humidity values to have changed between 1965 and 1978 or from 1978 to the present (1991). The temperature is a relatively cool 64 degrees and should experience little seasonal fluctuation. The relative humidity is a very dry 7-percent. This should shift slightly with changes in temperature but no major variations are expected. The Hanford climate is relatively dry and no major seasonal changes in relative humidity are expected in the tunnel due to the depth of burial.

4.3 1980 Core Sampling

Three core samples were taken from the roof of the storage tunnel to be used for static bending tests to determine the structural strength of the tunnel support timbers. The cores measured 4-1/8 inches in diameter and 13½ to 14 inches long. This size was selected because the cores would be large enough to be cut into samples for static bending tests yet small enough to prevent the timbers from which they were removed from being severely weakened. The core samples were tested by Timber Products Inspection, Inc. Two types of static tests were performed. The first test was a modified version of ASTM-D-143 using a 3/4" square specimen and a 3½" span rather than the standard 14" span. The second test was according to ASTM-D-805 using a 0.2 x 2 x 3.5 inch specimen. The test results are given in Table 2.

This 1980 study yields numerical test results and represents the condition of the timbers after 24 years in service. The test results show that the Douglas fir as tested is equal to or better than the species average for new wood even after 24 years of service. The 12 percent moisture content of the wood is in agreement with the low relative humidity value from the 1978 environmental study.

5.0 Findings

The structural integrity of the tunnel, the possibility of decay of or insect attack on the timbers, and the effect of gamma radiation on wood strength are addressed.

5.1 Structural Evaluation

A previous structural evaluation of the PUREX Storage Tunnel #1 has been made by Silvan (1980) in which it was found that the timber structure was structurally sound at the time of the study assuming the present loading conditions remain unchanged. LATA has reviewed the report, confirmed the reasonableness of the values used, and agrees with the findings regarding the structural integrity of the timber structure. No new structural calculations were performed nor are any needed. However, it was stated in the report that; "An accurate prediction of future tunnel life is not possible due to unpredictable factors that can affect timber integrity such as wood decay or insect attack." Discussions with experts on the subject of wood decay and insect attack and review of literature on the subjects reveals that it is possible to evaluate the ability of the structure to resist such attack and to make a reasonable prediction of the minimum expected time before decay or insect attack would be expected to affect the structural integrity of the creosoted timbers in the tunnel.

5.2 Wood Decay and Insect Attack

The specification for the timbers used in the tunnel (GE, 1955) required that the timbers be pressure treated with creosote solution in accordance with American Wood Preservers' Association (AWPA) Standard C2-54 for the Preservative Treatment of Lumber, Timbers, Bridge Ties and Mine Ties by Pressure Process. Experts consulted on the subject of wood decay, insect attack, and wood preservation included the staff of the AWPA, Union Pacific Railroad, and United States National Forest Products Laboratory. The AWPA staff member expressed the opinion that timbers treated per AWPA-C2-54 should last much longer in the environment of Tunnel #1 than the 35 years normally expected from timbers so treated.

In discussions with the engineering staff of Union Pacific Railroad in Omaha, Nebraska, it was stated that they experience a 50-year life for their creosote treated timber bridges. They also have a 65 to 80 year life expectancy for timber tunnel liners. They have struts in tunnels built 60 to 70 years ago and they are still in service. Specific examples are a 255 foot tunnel built in 1917 in Plaza, Idaho; a 129 foot tunnel built in 1911 in northern Idaho; a 2000 foot tunnel built in 1912 in eastern Oregon; and a tunnel built in 1909 in Barnheart, Oregon. All are still in service with original timbers. Union Pacific tunnel liners, based on experience in their 22 state service area, suffer distress due to water saturation and fault zones. The bottom end of the strut will suffer distress if it is allowed to stand in water. None of these adverse conditions are present in the PUREX storage tunnel

Staff of the United States Forest Products Laboratory (FPL) were also consulted on the subject of wood decay, insect attack, and wood preservation. They expressed the opinion that the treated Douglas fir timbers would last long beyond the typical 35-40 year life because of the dry climate at Hanford, the very dry atmosphere in the tunnel, the presence of the 90-lb roofing, the AWPA-C-2 treatment, and the low hazard area (for termite attack).

The FPL has an ongoing program of comparing wood preservatives in wood stake tests. A progress report (Forest Products Laboratory, 1989) is available that gives results of decay and termite attack on wood stakes treated with creosote and other preservatives. The report states that 2-by 4-by 18-inch pine sapwood stakes furnish an effective means for testing the protection provided against decay and termite attack by various wood preservatives. Stake tests were initiated in 1938 at Saucier, Mississippi; Madison, Wisconsin; Bogalusa, Louisiana; Jacksonville, Florida; and the Canal Zone, Panama. Wisconsin is at the same latitude as Hanford although it has a much wetter climate. Per discussion with FPL staff the Hanford site (Eastern Washington) is a low hazard area and is less prone to decay and insect attack than Madison, and that Madison is less prone to decay and insect attack than Saucier. It was judged that of all of the sites at which tests were made or are in progress, the results of tests conducted in Madison, Wisconsin would be the most nearly representative of results to be expected at the Hanford Site.

Tests with southern pine stakes (2 x 4 in. nominal x 18 in.) treated with coal-tar creosote were started at Madison Wisconsin in September 1940. Condition of the stakes in December 1985 (45+ years of service) as contained in Table 4 of the Forest Products Laboratory were as follows:

- all 10 stakes with an average retention of 0.71 pounds of creosote per cubic foot of wood (brush treatment, 2 coats) had been destroyed by decay fungi at an average life of 8.4 years;
- all 10 stakes with an average retention of 1.8 pounds of creosote per cubic foot of wood (15-minute dip at room temperature) had been destroyed by decay fungi at an average life of 12.4 years;
- all 10 stakes with an average retention of 4.3 pounds of creosote per cubic foot of wood had been destroyed by decay fungi at an average life of 37.9 years;
- 1 out 9 stakes with an average retention of 8.0 pounds of creosote per cubic foot of wood had been destroyed by decay fungi and 9 stakes were still serviceable but

showing some decay;

- all 9 stakes with an average retention of 11.8 pounds of creosote per cubic foot of wood were still serviceable with 4 in good condition and 5 showing some decay;
- all 10 stakes with an average retention of 16.4 pounds of creosote per cubic foot of wood were still serviceable with 5 in good condition and 5 showing some decay; and
- none of the creosote treated stakes showed any evidence of termite attack.

A copy of Table 4 from the report, as well as a copy of Table 6, is included in the Appendix.

The data in Table 4 and elsewhere in the FPL report indicate a ratio of average life of 1, 1½, and 3 for the Canal Zone, Saucier, and Madison sites, respectively. Applying these ratios to the Table 4 data for 4 and 8 pcf retentions, we can project a 2x4 stake average life of approximately 57 years at Madison. This is reasonable since only one of nine stakes has failed in 45+ years at Madison. Recognizing that Madison is more susceptible that Hanford, we would project an average life in excess of 60+ years for the 8 pcf creosote treated timbers.

Table 6 summarizes the results from tests with stakes of different sizes and demonstrates that for the same preservative retention, large stakes have a longer expected life than small stakes. As shown in Table 6, with average retentions of 8 pcf, the average life increases from 17.1, 23.6, to 26.6 years for ½, 1, and 1½ inch square specimens, respectively, and is not yet determined after 44½ years of service for 2x4 specimens. This would indicate that the timbers in the tunnel would be expected to last longer than the stakes.

Handbooks reviewed on the subject of decay, insect attack, and wood preservation included *Timber Construction Manual* (AITC, 1974); *Wood Handbook: Wood as an Engineering Material* (Forest Products Laboratory,1974); and *Wood Technology in the Design of Structures* (Hoyle, 1973).

The *Timber Construction Manual* has a part on design specifications which includes "Treating Standard for Structural Timber Framing," AITC 109-69, that states in part:

"**2.1 Decay.** Decay of wood is caused by low forms of plant life (fungi) that develop and grow from spores just as higher forms of plants do from seed. These microscopic pores are likely to be present wherever wood is used. The plant-like growth breaks down the wood substance, converting it into food required by the fungus for development. However, like all forms of plant life, these wood destroying fungi must have air, suitable moisture, and favorable temperatures, as well as the food if they are to develop and grow. If deprived of any of these four essentials, the spores cannot develop and the wood remains permanently sound, retaining its full strength. Wood permanently and totally submerged in water cannot decay because the necessary air is excluded. Wood will not decay when its moisture content is continuously less that 20%. Temperatures above 100° F and below 40° F will essentially stop the growth of the decay fungi. Growth will begin again each time favorable climatic conditions exist. Since rainfall and temperature conditions principally influence the rate of decay , a Southern coastal region presents a greater decay hazard that a Northern inland region.

"**2.2.1** Examples of installations where properly designed and constructed wood structural members are permanent without treatment include:

"**2.1.1.1** Enclosed buildings for which good roof coverage, proper roof maintenance, good joint details, adequate flashings to direct rain water, ventilation, and a well drained building site assure continuous moisture content of wood below 20%.

"**2.1.1.2** Arid or semi-arid regions where climatic conditions are such that the equilibrium moisture content seldom exceeds 20% and then only for short periods."

The conditions described in **2.1.1.1** existed at the time of completion of construction of the tunnel and would continue to exist as long as the mineral surfaced roofing system

installed on the roof and side walls of the tunnel was intact. *Plant Engineering Handbook* (Staniar, 1959) states that the major cause of failure of felt roofs is sunlight (Staniar, 1959). The material on the tunnel is well protected from sunlight by the 8-feet of earth cover. It is stated in the same reference that surety-bond guaranties on materials, which binds the manufacturer of the materials, are generally furnished for periods of 10, 15, and 20 years. Because of the protection provided by the earth cover, the roofing material will provide protection to the timber for much longer than 10, 15, and 20 year periods discussed above.

The conditions outlined in **2.1.1.2** are also judged to be applicable to the tunnel structure. Average annual precipitation at the Hanford Site is 6.3 inches and the average annual estimated evaporation rate is 53 inches, which essentially eliminates deep infiltration in the soil (DOE, 1982). The water table, representing the upper limit of the unconfined aquifer, ranges from 150 to 328 feet beneath the ground surface at the PUREX facilities and slopes toward the Columbia River (DOE, 1982). The temperature of the tunnel when measured in 1980 was 64°F and the relative humidity was 7% at the ceiling and 4% 5-feet below the ceiling. Under these conditions, the equilibrium moisture content of the timbers would not be expected to ever exceed 20%. This assumption is substantiated by the fact that the moisture content of the wood in 1980 was 12% (Silvan, 1980).

5.3 Gamma Radiation

Silvan (1980) stated that radiation is not expected to be a major factor in any future weakening of the tunnel timbers. This is a true statement if the assumption is made, as Silvan did, that final disposition would have been made circa 1982. However, if final disposition is delayed until the year 2001, for example (ten years from today), and the material is left in the tunnel, some further degradation of the timber can be expected.

The percent of original integrity at any year can be estimated based on the same assumptions as made by Silvan (1980) in the Appendix of his report. By the year 2001, the

percent of original integrity is estimated to be 60%. The calculations that are the basis for the estimate are as follows:

$$TE = 1 \times 10^6 (t-1) + 4.71 \times 10^7 (1-t^{1.5})$$

where: TE = total exposure (R)

When t = 2001 - 1961 = 40

$$TE = 1 \times 10^6 (40-1) + 4.71 \times 10^7 (1-40^{1.5}) = 8.59 \times 10^7$$

$$Log_{10}(8.59 \times 10^7) = 7.93$$

Percent of Original Strength = 60% (from Figure A-1 of Silvan [1980], see the appendix for a copy of Figure A-1 with the new data superimposed).

The result of this additional loss of strength would be minimal.

The amount of gamma radiation induced strength loss required to reduce the safety factor of the tunnel to zero maybe determined. This load state would correspond to the degraded tunnel just reaching its ultimate load capacity and being in a state of incipient collapse. Using the numbers and procedures in Silvan, this critical state will be reached when the standard factor of safety (which is 1.65 per Silvan) is reduced to zero. The corresponding gamma radiation degraded stress value is 0.727 of the 1980 value. Silvan calculated the degraded stress at 65.4 percent of original value. An additional reduction of 0.727 of this value, or 47.5 percent of original value, is required for the safety factor to equal zero.

6.0 Conclusions and Recommendations

Based on the results of the wood stake tests (Forest Products Laboratory, 1989) as outlined in Section 5.0, there is no evidence of termite damage to timbers treated with creosote at latitudes similar to Hanford Site, but with much greater rainfall. The tests also show no significant damage by decay fungi after 45 years of testing on wood treated with

creosote at a retention of 8.0 pounds per cubic foot, the average retention of the timbers in Tunnel #1. Further, wood in the environment that exists in the tunnel, is considered permanent except for the effects of gamma radiation. The rate of loss of strength due to gamma radiation is diminishing with time so that even by the year 2001, the timber will still have 60% of its original strength.

Therefore, it is recommended that the dangerous waste in the tunnel remain as is and that if a decision for final disposition is not made by the year 2001, that the structural integrity again be evaluated in light of any then available information including any further tests on wood preservation that may have been completed at that time. Further tests of the timbers in the tunnel, either destructive or non-destructive, are not indicated at this time.

7.0 Options for Further Study

At the option of Westinghouse Hanford Company, experts in the field of wood preservation can be retained to further validate, or invalidate, the conclusions reached by LATA which were based on a reasonable search of readily available literature.

8.0 References

American Institute of Timber Construction (AITC), "Timber Construction Manual," Second Edition, John Wiley and Sons, Inc., 1974.

Forest Products Laboratory, "Wood Handbook: Wood as an Engineering Material," Agriculture Handbook No. 72, Forest Service, U.S. Department of Agriculture, revised August 1974.

Forest Products Laboratory, "Comparison of Wood Preservatives in Stake Tests, 1987 Progress Report," Research Note FPL-RN-02, Forest Service, U.S. Department of Agriculture, revised May 1989.

General Electric Company (GE), "Specifications for Disposal Facility for Failed Equipment," HWS-5638, Project CA-513-A, Hanford Atomic Products Division, April 25, 1955.

Henckel, G. C. III, "The PUREX Storage Tunnels Engineering Study," WHC-SD-EN-ES-003, Rev. 0, Westinghouse Hanford Company, September 27, 1990. Also included in DOE/RL-90-24 (DOE, 1990) as Appendix 11A.

Hoyle, R. J., "Wood Technology in the Design of Structures," Third Edition, Second Printing, Mountain Press Publishing Company, Missoula, Montana, October 1973.

Nord, T. L. to S. H. Wisness, "Notice of Deficiency (NOD) for the PUREX Storage Tunnels," State of Washington, Department of Ecology, 9100743, February 5, 1991.

Silvan, G. R., "Structural Evaluation of the PUREX No. 1 Burial Tunnel," RHO-CD-1076, Rockwell Hanford Operations, Richland WA, September 1980.

373-2943

Staniar, W., Editor-in-Chief, "Plant Engineering Handbook," McGraw-Hill Book Company, 1959.

United States Department of Energy (DOE), "Draft Environmental Impact Statement: Operation of PUREX and Uranium Oxide Plant Facilities," DOE/EIS-0089D, Hanford Site, Richland Office, May 1982.

United States Department of Energy (DOE), "PUREX Storage Tunnels Dangerous Waste Permit Application," DOE/RL-90-24, September 1990.

Washington Administrative Code (WAC), "Dangerous Waste Regulations," Chapter 173-303 WAC, Washington State Department of Ecology, amended January 1989.

TABLE 1 RESULTS OF THE JULY 1978 EVALUATION OF THE No. 1 STORAGE TUNNEL ENVIRONMENT

Sample Location		No. 1 Air Sample and Temperature Riser						No. 2 Air Sample and Temperature Riser					
Distance Below Tunnel Ceiling at Which Sample Was Taken (ft)		-1.5	0	1.5	2	4.5	5	0	2	3	5	6	9
Tests Performed													
Airborne Radioactivity	Radon		770				770	770			770		
x 10^{-10} µCi/ml	Long-Lived Isotopes		5.5				0.022	5.5			0.022		
Air Composition[1] wt.% CO_2[2]			0.20				0.12	0.20			0.12		
Relative Humidity	% / ppm H_2O		7 / 900				4 / 750	7 / 900			4 / 750		
Temperature[3] ± 1°F			64		64		64	64	64		64		
Dose Rates[4] R/hr		0.166		121		153				17.7		30.2	37

[1] Gases other than CO_2 were at normal concentration for dry air

[2] Normal concentration of CO_2 in dry air is 0.04% wt%

[3] Temperatures were determined by lowering an iron constantan thermocouple into the tunnel

[4] Dose rates were determined by lowering thermoluminescent dosimeter chips into the tunnel

TABLE 2 RESULTS OF STATIC BEND TESTS - PUREX NO. 1 STORAGE TUNNEL CORE SAMPLES

Location Number	MODULUS OF RUPTURE (psi) Modified ASTM-D-143	ASTM-D-805	Average	Moisture Content	Specific Gravity
1	12,226	12,679	12,453	12%	0.6
2	11,325	11,312	11,319	12%	0.6
3	16,834	16,814	16,824	12%	0.6
Control (New Wood)		17,313	17,313	12%	0.58
Industry Average			12,000	12%	0.48

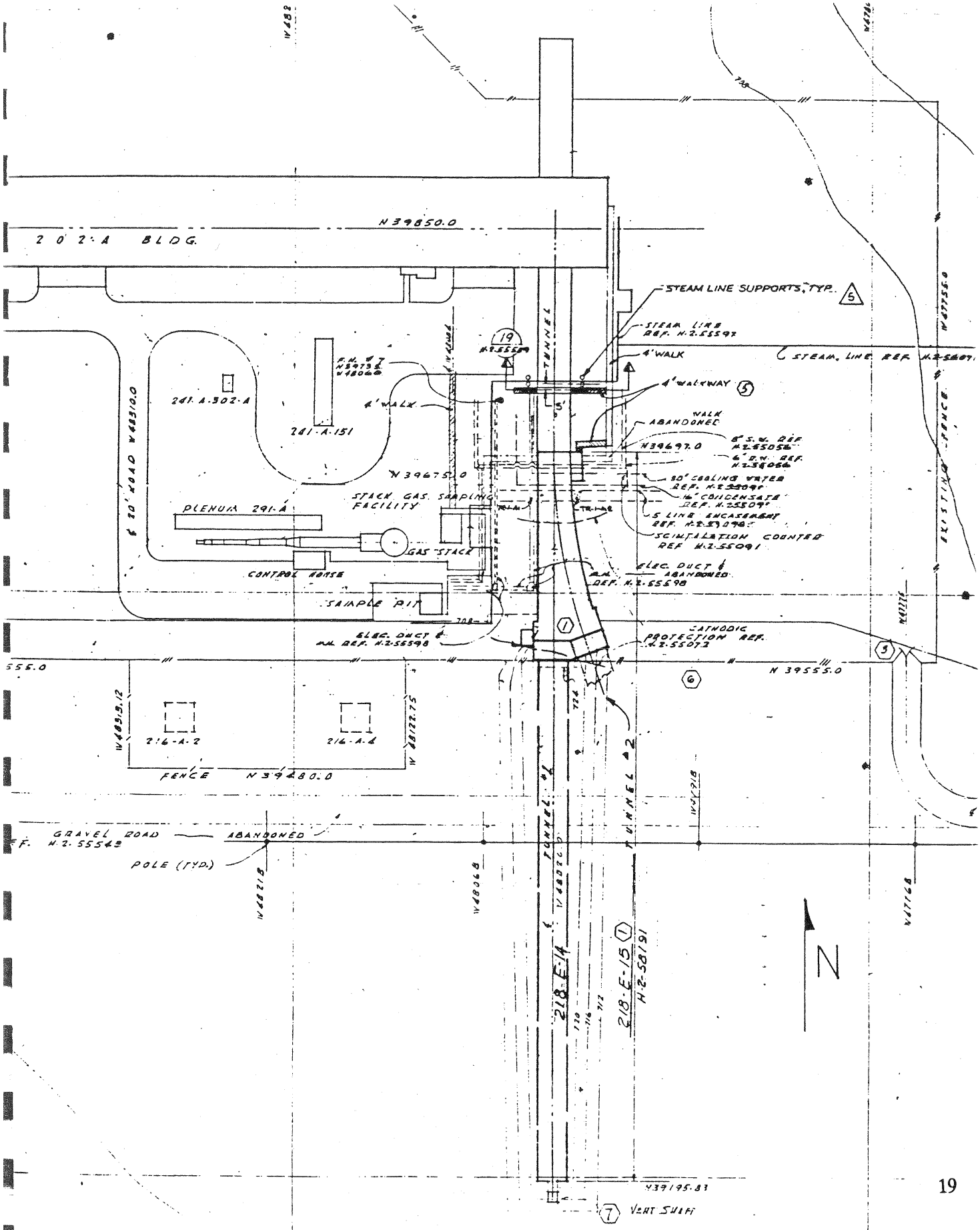


Figure 1. General Arrangement of PUREX Tunnel #1

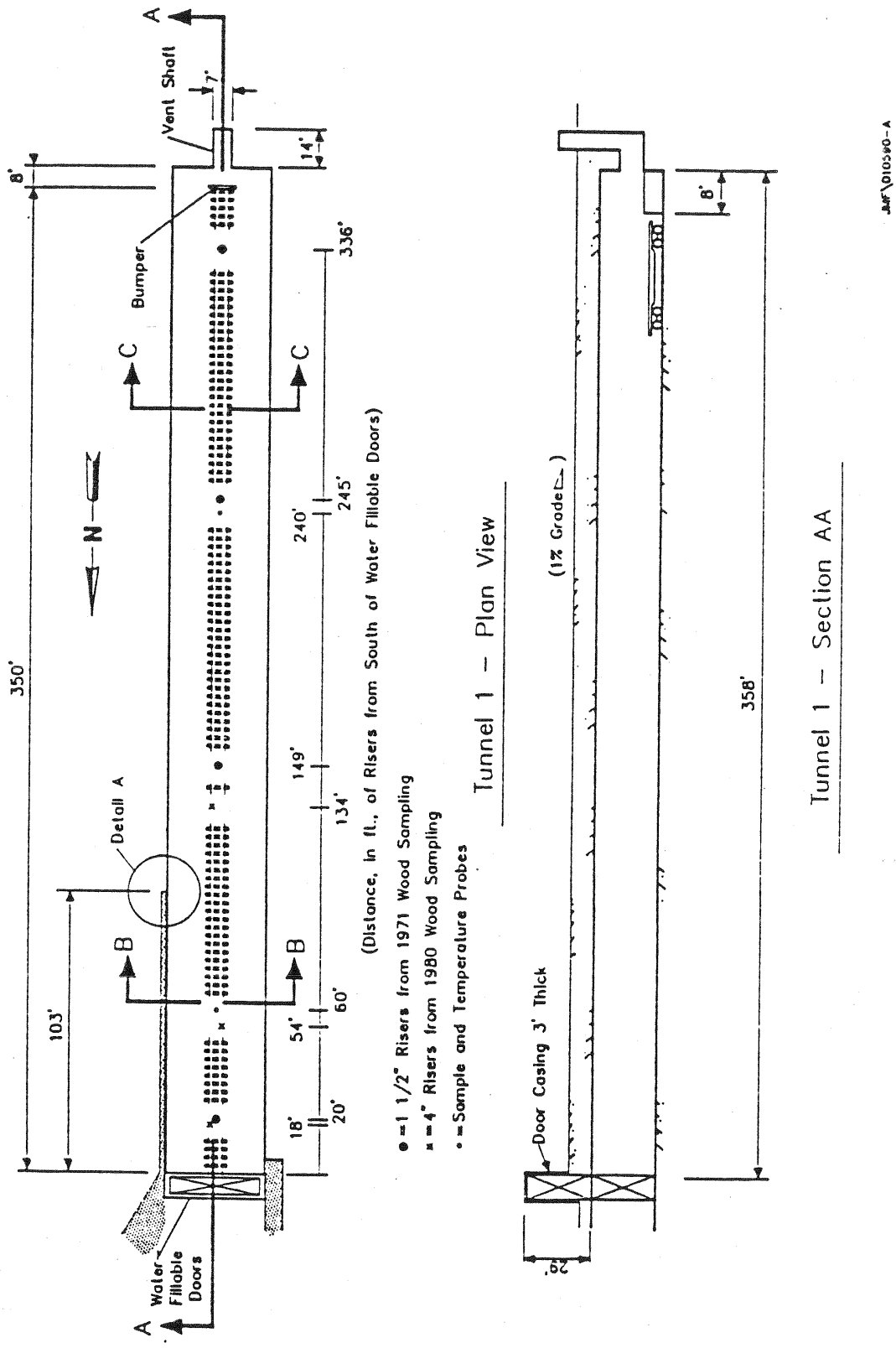


Figure 2. Sketch of PUREX Storage Tunnel 1 (218-E-14).

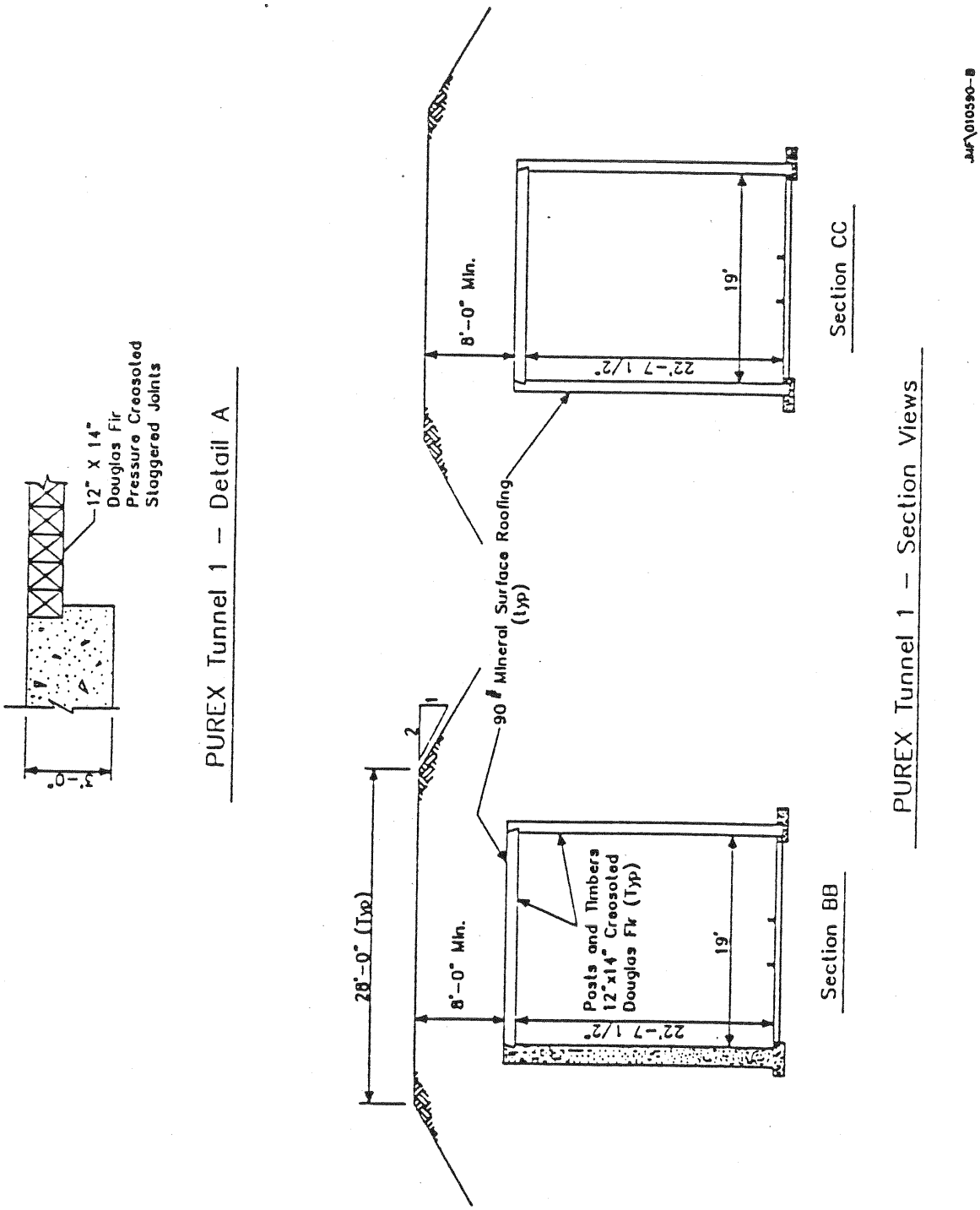
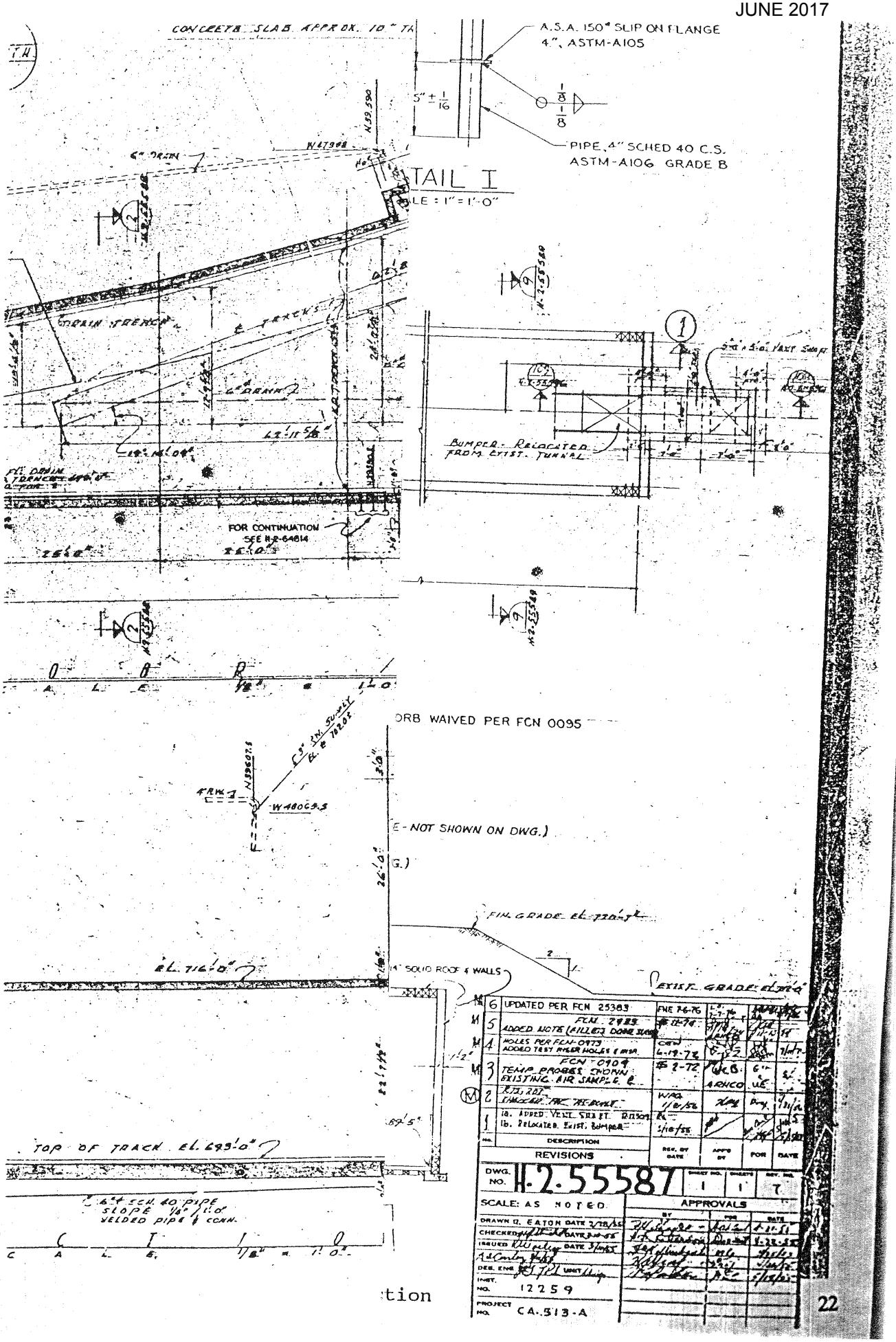


Figure 3. PUREX Storage Tunnel 1 Section Views.


CONCRETE SLAB APPROX. 10" TH
A.S.A. 150# SLIP ON FLANGE 4", ASTM-A105
PIPE, 4" SCHED 40 C.S. ASTM-A106 GRADE B
DETAIL I
SCALE: 1" = 1'-0"
DRAIN TRENCH
6" DRAIN
BUMPER - RELOCATED FROM EXIST. TUNNEL
FOR CONTINUATION SEE H-2-64814
ORB WAIVED PER FCN 0095
FIN. GRADE EL. 720'-0"
EXIST. GRADE EL. 719'-0"
EL. 716'-0"
TOP OF TRACK EL. 693'-0"
6" SCH. 40 PIPE SLOPE 1/8" / 1'-0" WELDED PIPE & CONN.
DWG. NO. H-2-55587
SCALE: AS NOTED
DRAWN G. EATON
CHECKED
ISSUED
DES. ENG.
INST. NO. 12259
PROJECT NO. CA-513-A
REVISIONS
APPROVALS
22

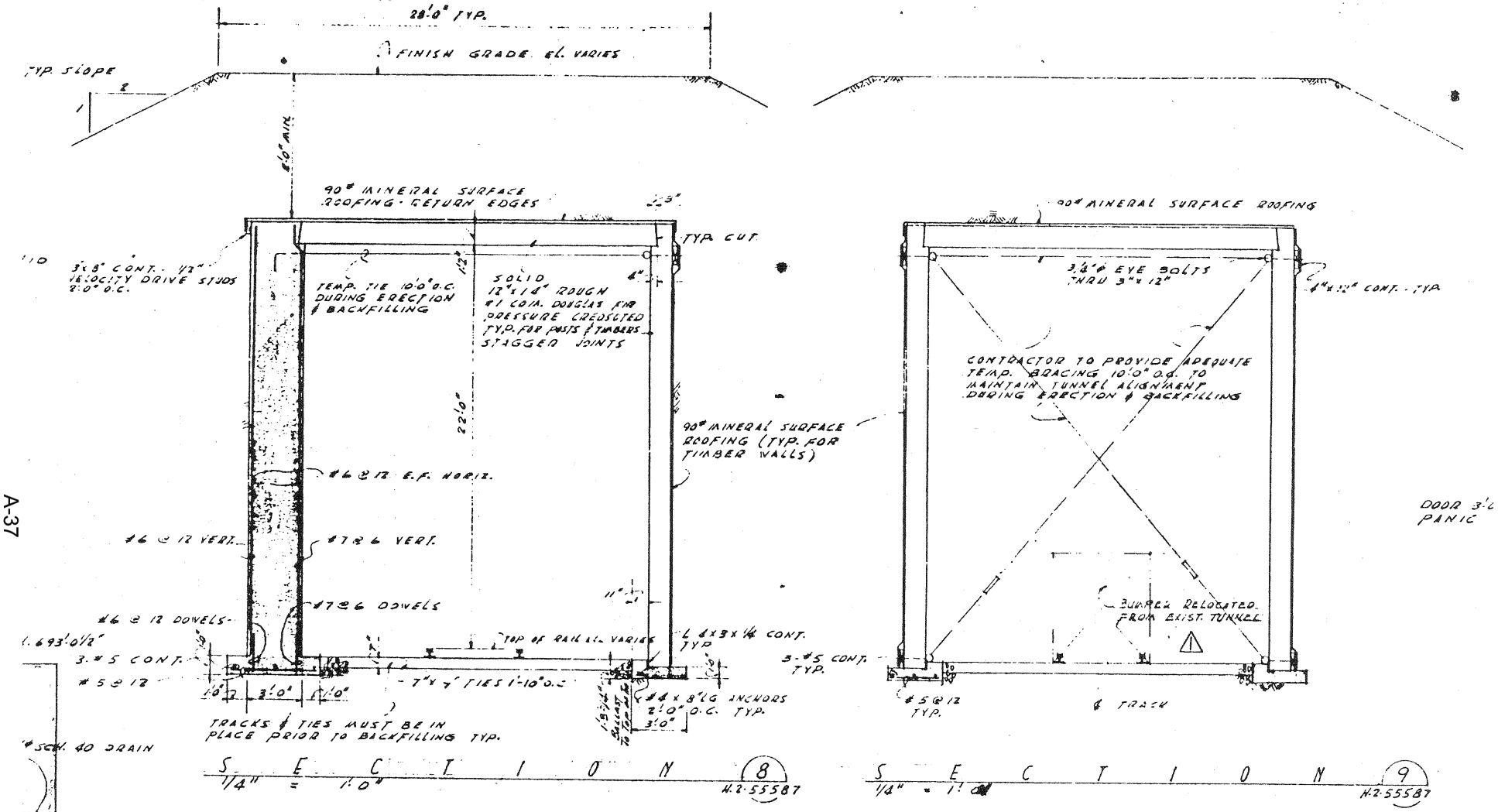


Figure 5. Tunnel Transverse Sections 8 and 9

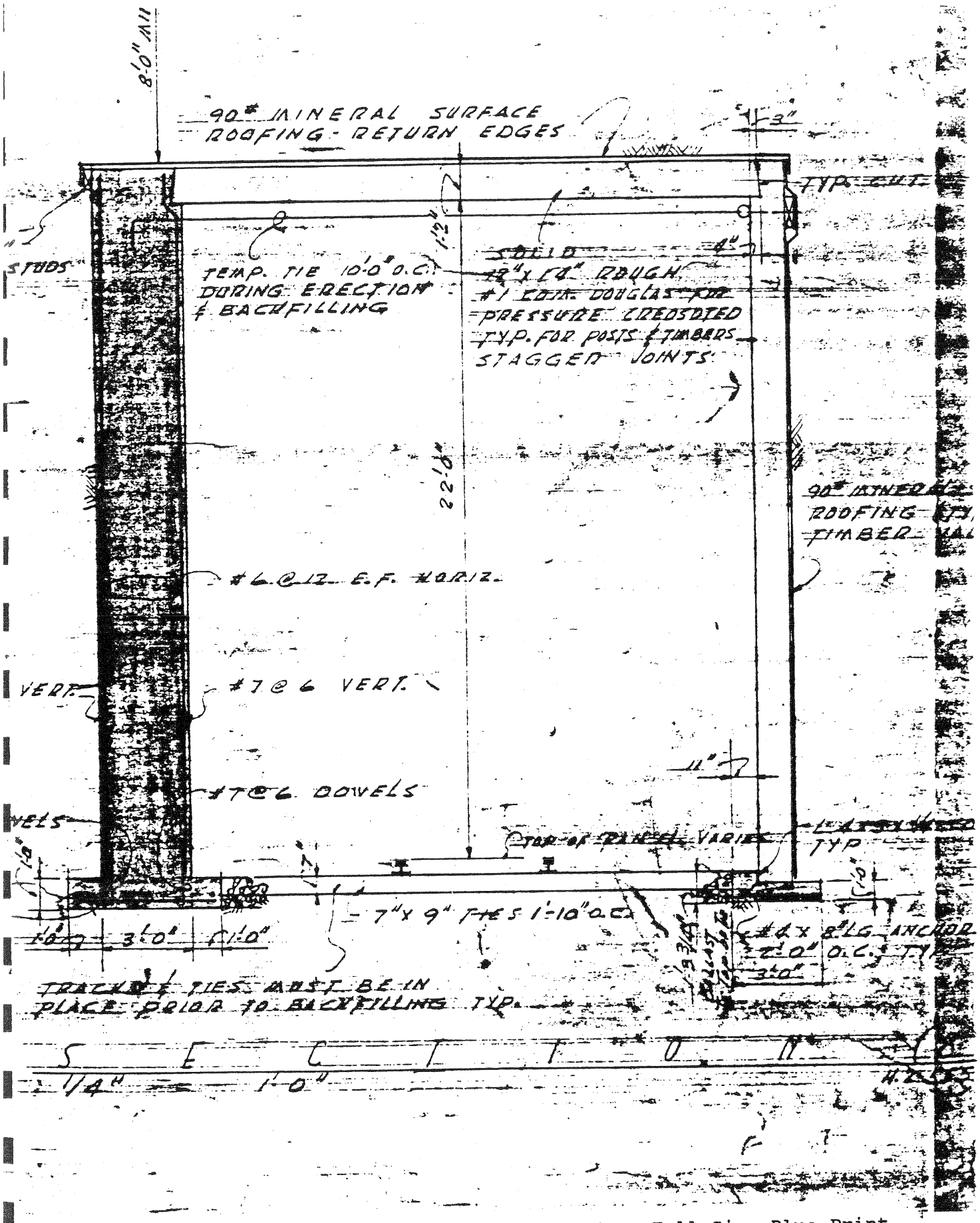


Figure 6. Tunnel Section 8 - Copy from Full Size Blue Print

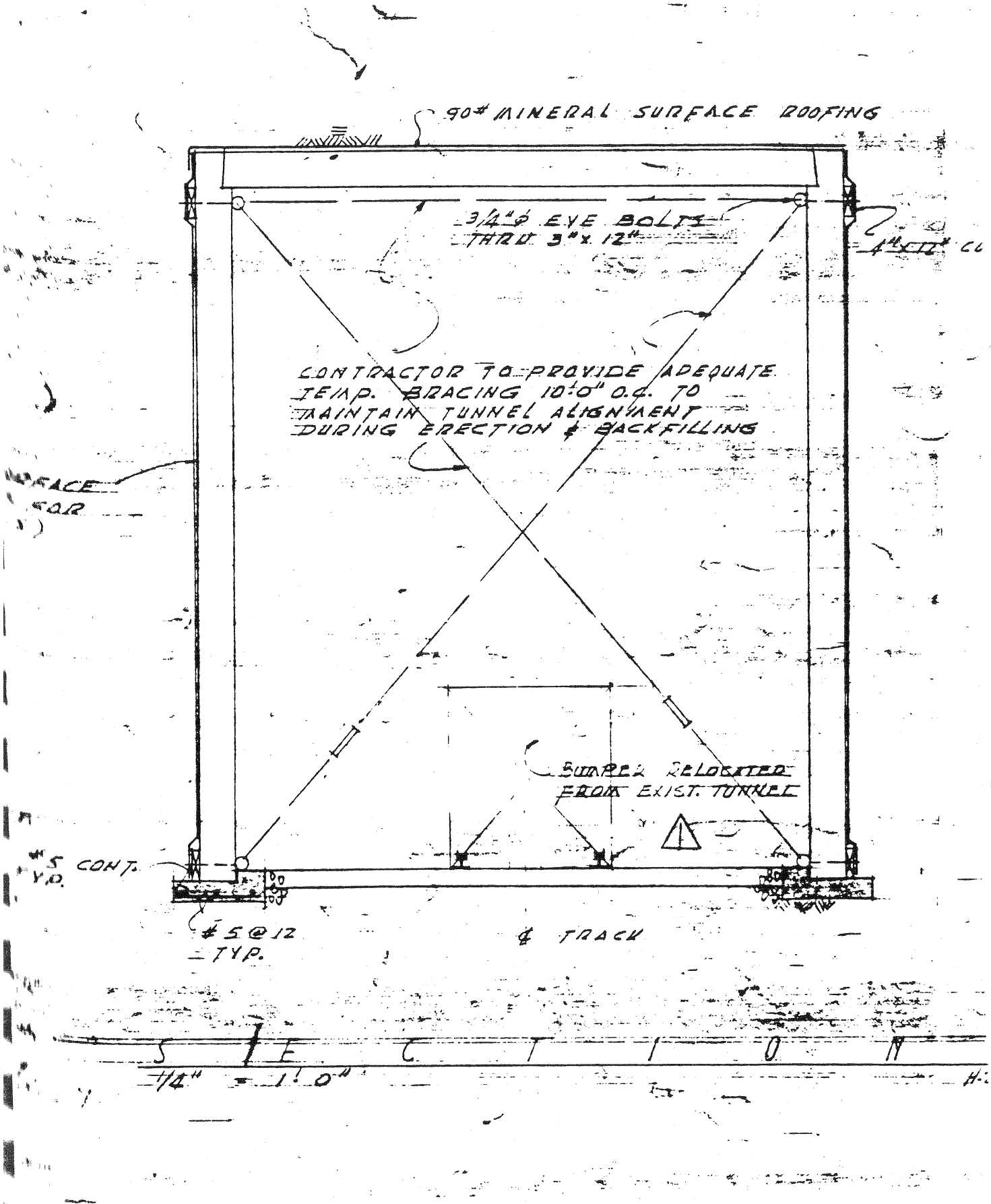


Figure 7. Tunnel Section 9 - Copy from Full Size Blue Print

APPENDIX

Reproduction of comments from the NOD (Nord, 1991) A-2
Copy of Table 4 (Forest Products Laboratory, 1989) A-3
Copy of Table 6 (Forest Products Laboratory, 1989) A-4
Copy of Figure A-1 from Silvan (1980) A-5

The two comments in the Notice of Deficiency (Nord 1991) that relate to the structural integrity of PUREX Storage Tunnel #1 are reproduced below. The original was not suitable for copying.

22. 11-4/7

Comment: The plan states, "No partial closure is anticipated for the PUREX Storage Tunnels."

Requirement: Discuss this statement with regard to the conclusion of RHO-CD-1076 (September 1980, G. R. Silvan), which states on page 33, "If the contents of the tunnel must be removed, it should be deactivated as soon as possible to ensure the tunnel is still structurally sound during the removal operation."

37. 11A-11

Comment: It is assumed that the closure activities for the PUREX Tunnels will occur in conjunction with the closure activities for the PUREX Plant. This may be appropriate for Tunnel 2, but Tunnel 1 was found to be of adequate but questionable integrity in 1980.

Requirement: Evaluate the assumption that both tunnels will be closed in conjunction with the PUREX Plant. Demonstrate that postponing closure of Tunnel 1 will not result in a more difficult closure due to failure of the timbers. Refer to the second paragraph of page 11A-16.

Table 4.--Condition of southern pine stakes (2 x 4 in. nominal x 18 in.) treated with chromated zinc arsenate (Boliden salts), zinc chloride, and coal-tar creosote after 15 to 45-1/2 years of service. Stakes placed in test at Madison, Wis., September 1940; Harrison Experimental Forest, Saucier, Miss., June 1940; and Barro Colorado Island, Canal Zone, September 1940 (Plot 4)

Preservative	Location	Average retention		Number in test	Condition of stakes December 1985[a]							Total removed		Average life
						Serviceable but showing some--			Destroyed by--					
		Oil	Dry salt[b]		Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack			
		Pcf			Pct							Number	Pct	Yr
Zinc chloride	Wis.	--	0.50 (.30)	10	--	--	--	--	100	--	--	10	100	14.8
	Miss.	--	.50 (.30)	10	--	--	--	--	60	--	40	10	100	14.2
	Canal	--	.49 (.29)	10	--	--	--	--	--	--	100	10	100	3.0
	Wis.	--	1.03 (.61)	10	--	--	--	--	100	--	--	10	100	19.8
	Miss.	--	1.02 (.61)	10	--	--	--	--	60	10	30	10	100	14.4
	Canal	--	1.01 (.60)	10	--	--	--	--	--	--	100	10	100	3.6
	Wis.	--	1.51 (.90)	10	--	--	--	--	100	--	--	10	100	22.3
	Miss.	--	1.51 (.90)	10	--	--	--	--	60	--	40	10	100	18.1
	Canal	--	1.49 (.89)	10	--	--	--	--	--	--	100	10	100	4.5
Chromated zinc arsenate (Boliden salts)[c]	Wis.	--	.33 (.22)	10	--	--	--	--	100	--	--	10	100	19.6
	Miss.	--	.33 (.22)	10	--	--	--	--	30	--	70	10	100	33.0
	Canal	--	.33 (.22)	10	--	--	--	--	--	--	100	10	100	9.2
	Wis.	--	.44 (.29)	10	--	--	--	--	100	--	--	10	100	26.1
	Miss.	--	.44 (.29)	9	--	--	--	11	11	--	78	8	89	--
	Canal	--	.44 (.29)	10	--	--	--	--	30	10	60	10	100	11.6
	Wis.	--	.60 (.40)	9	--	--	--	--	100	--	--	9	100	24.9
	Miss.	--	.58 (.38)	10	--	--	--	70	10	--	20	3	30	--
	Canal	--	.58 (.38)	10	--	--	--	--	60	40	--	10	100	14.6
	Wis.	--	.78 (.52)	10	--	--	--	--	100	--	--	10	100	34.6
	Miss.	--	.78 (.52)	10	--	--	--	100	--	--	--	--	--	--
	Canal	--	.78 (.52)	10	--	--	--	--	100	--	--	10	100	15.1
	Wis.	--	1.06 (.70)	9	--	11	--	--	89	--	--	8	89	--
	Miss.	--	1.06 (.70)	10	--	--	--	100	--	--	--	--	--	--
	Canal	--	1.05 (.69)	10	--	--	--	--	100	--	--	10	100	15.3
Coal-tar creosote	Wis.	4.3	--	10	--	--	--	--	100	--	--	10	100	37.9
	Miss.	4.2	--	10	--	--	--	--	60	--	40	10	100	17.8
	Canal	4.3	--	10	--	--	--	--	40	--	60	10	100	13.4
	Wis.	8.0	--	9	--	89	--	--	11	--	--	1	11	--
	Miss.	8.0	--	10	--	--	--	30	30	--	40	7	70	--
	Canal	8.0	--	10	--	60	--	10	30	--	--	3	30	19[d]
	Wis.	11.8	--	9	44	56	--	--	--	--	--	--	--	--
	Miss.	11.8	--	10	--	--	--	80	10	--	10	2	20	--
	Canal	11.8	--	10	--	60	--	--	40	--	--	4	40	18[d]
	Wis.	16.4	--	10	50	50	--	--	--	--	--	--	--	--
	Miss.	16.5	--	10	40	--	10	50	--	--	--	--	--	--
	Canal	16.5	--	10	--	90	--	10	--	--	--	--	--	--
	Wis.	1.8[e]	--	10	--	--	--	--	100	--	--	10	100	12.4
	Miss.	1.8[e]	--	10	--	--	--	--	10	30	60	10	100	7.7
	Canal	1.8[e]	--	10	--	--	--	--	--	80	20	10	100	4.8
	Wis.	.71[f]	--	10	--	--	--	--	100	--	--	10	100	8.4
	Miss.	.76[f]	--	10	--	--	--	--	--	50	50	10	100	4.2
	Canal	.76[f]	--	10	--	--	--	--	--	90	10	10	100	2.5
Untreated controls	Wis.	--	--	10	--	--	--	--	100	--	--	10	100	6.2
	Miss.	--	--	10	--	--	--	--	--	50	50	10	100	2.2
	Canal	--	--	10	--	--	--	--	--	90	10	10	100	1.1

[a] Final inspection at Canal Zone, January 1956.

[b] Retention values in parentheses are based on preservative oxides.

[c] Retention based upon total anhydrous salts: $ZnSO_4 + H_3AsO_4 + Na_2HAsO_4 + Na_2Cr_2O_7$.

[d] Estimate based upon percentage of stakes remaining after final inspection.

[e] 15-min dip at room temperature.

[f] Brush treatment, 2 coats.

This study was initiated by R. M. Wirka.

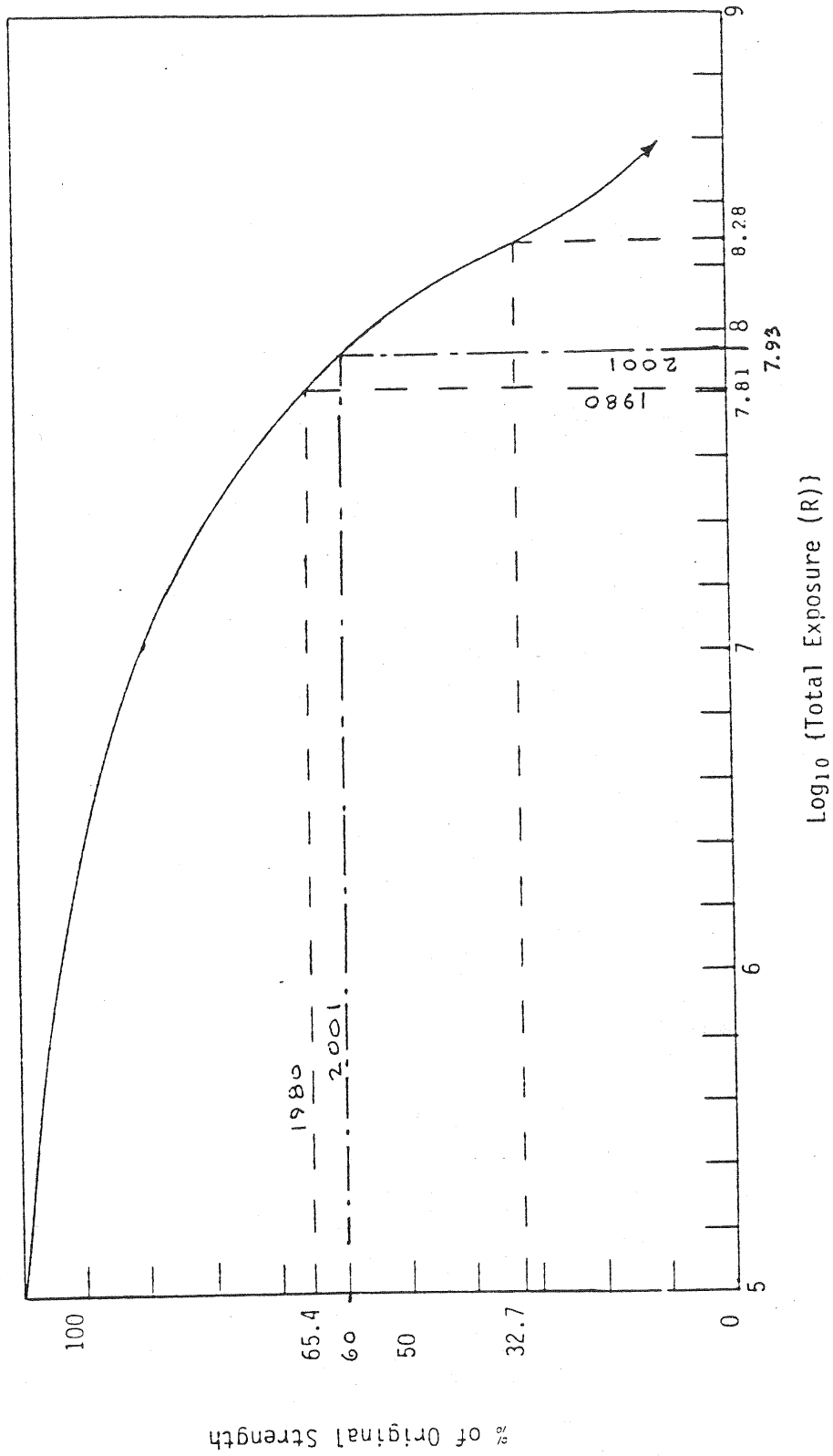
Table 6.--Condition of southern pine stakes of different sizes, treated with coal-tar creosote, toluene, and creosote-toluene mixtures, after 44-1/2 years of service. Stakes placed in test on the Harrison Experimental Forest Saucier, Miss., May 1941 (Plot 6)

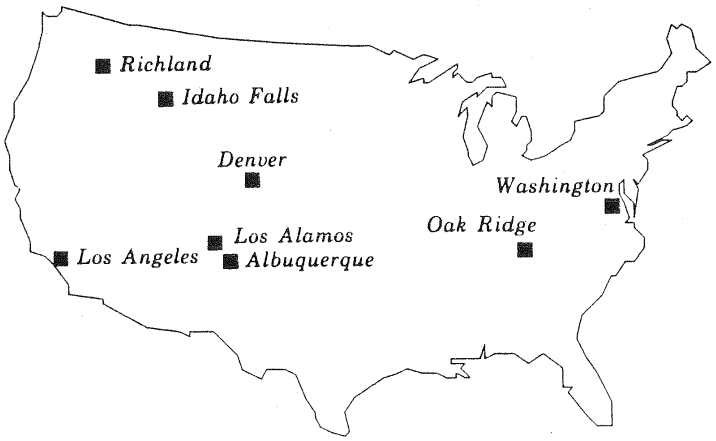
Preservative	Size of stakes	Average retention	Number in test	Condition of stakes December 1985: Good	Serviceable but showing some--: Decay	Serviceable but showing some--: Termite attack	Serviceable but showing some--: Decay and termite attack	Destroyed by--: Decay fungi	Destroyed by--: Termite attack	Destroyed by--: Decay fungi and termite attack	Total removed		Average life
	In.	Pcf		Pct							Number	Pct	Yr
Coal-tar creosote	1/2 by 1/2 by 18	7.8	8	--	--	--	--	88	--	12	8	100	17.1
	1 by 1 by 18	8.0	10	--	--	--	--	40	--	60	10	100	23.6
	1-1/2 by 1-1/2 by 18	7.9	10	--	--	--	--	50	--	50	10	100	26.6
	2 by 4 (nominal) by 18	3.3	10	--	--	--	--	10	--	90	10	100	24.9
	2 by 4 (nominal) by 18	7.8	10	--	--	--	40	20	--	40	6	60	--
	2 by 4 (nominal) by 18	13.2	10	--	--	--	80	10	--	10	2	20	--
Toluene	2 by 4 (nominal) by 18	29.5	10	--	--	--	--	--	90	10	10	100	2.2
Coal-tar creosote: 11.25 pct by weight in toluene	2 by 4 (nominal) by 18	3.4[a]	10	--	--	--	--	30	--	70	10	100	19.1
25.2 pct by weight in toluene	2 by 4 (nominal) by 18	8.1[a]	10	--	--	--	80	10	--	10	2	20	--
39.0 pct by weight in toluene	2 by 4 (nominal) by 18	12.6[a]	10	10	--	--	90	--	--	--	--	--	--

[a] Creosote only.

This study was initiated by R. M. Wirka.

FIGURE A-1: EFFECT OF GAMMA RADIATION ON WOOD BENDING STRENGTH(1)





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Attachment 2

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G. R. Silvan

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STRUCTURAL EVALUATION
OF THE
PUREX NO. 1 BURIAL TUNNEL

by

G. R. Silvan

September 1980

PHO-CD-1076

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SUMMARY

The physical integrity of the Purex number one burial tunnel has been a concern since 1971. Several surveys were performed on the tunnel but none of these surveys dealt with the actual strength of the wood by direct testing. In May, 1980, three four-inch diameter cores were cut from the roof of the tunnel and tested for strength using a static bend test. The results of these tests showed that the wood beams in the burial tunnel are within standards for present day new wood and design calculations performed on the tunnel have shown it to be within safe limits. Collapse of the tunnel is not expected at this time, but a prediction of actual tunnel life is not possible due to the many unpredictable factors affecting wood strength. Since eventual tunnel failure is certain, the manner and time of tunnel deactivation must be determined. If the tunnel contents must be removed and stored elsewhere, or buried, the tunnel should be deactivated as soon as is practical, but if the tunnel contents can be buried in place, deactivation can be deferred to a later date. It is recommended that a study on the options for deactivation be completed within two years.

DESCRIPTION

The Purex No. 1 Burial Tunnel is located at the southwest end of the Purex building and is an extension of the railroad tunnel. The burial tunnel consists of three areas: the water filled door, the storage area and the vent shaft (see figure 1).

The water filled door is at the north end of the burial tunnel and connects the burial tunnel with the railroad tunnel. The door is constructed of one-half inch steel plate and is hollow so that it can be filled with water to act as a radiation shield when it is in the down (closed) position. When in the up position, the door is surrounded by a three foot thick cement enclosure. The basic dimensions of the door are 24½ by 21½ by 7 feet. The electric hoists for raising and lowering the door are located on top of the cement enclosure, and the pumps and valves for filling and draining the door are located in a room just northwest of the enclosure. Controls for the operation of the water filled door are located on the north wall at the east end of the Pipe and Operating Gallery (P & O) in the Purex building.

The storage area is the main section of the burial tunnel. It is 358 feet long, 22 feet high and 19 feet wide. The ceiling and walls are composed of 12 by 14 inch creosote treated douglas fir timbers arranged side by side with the exception of the first one-hundred feet of the east wall which is three foot thick reinforced concrete. Ninety pound roofing material and tar were laid over the timbers and the entire structure was covered with eight foot of dirt fill. The floor consists of a railroad track laid on a gravel bed. The tracks are on a one percent downward slope to the south to prevent railroad cars from accidentally rolling out of the tunnel, and a railroad car bumper is located at the south end of the tracks to act as a stop. The capacity of the storage area is eight modified (shortened to 40 - 42 feet) railroad cars.

The vent shaft is located at the south end of the tunnel and provides a means by which a filter and fan can be connected to the storage area. The shaft is approximately three feet square and composed of reinforced concrete.

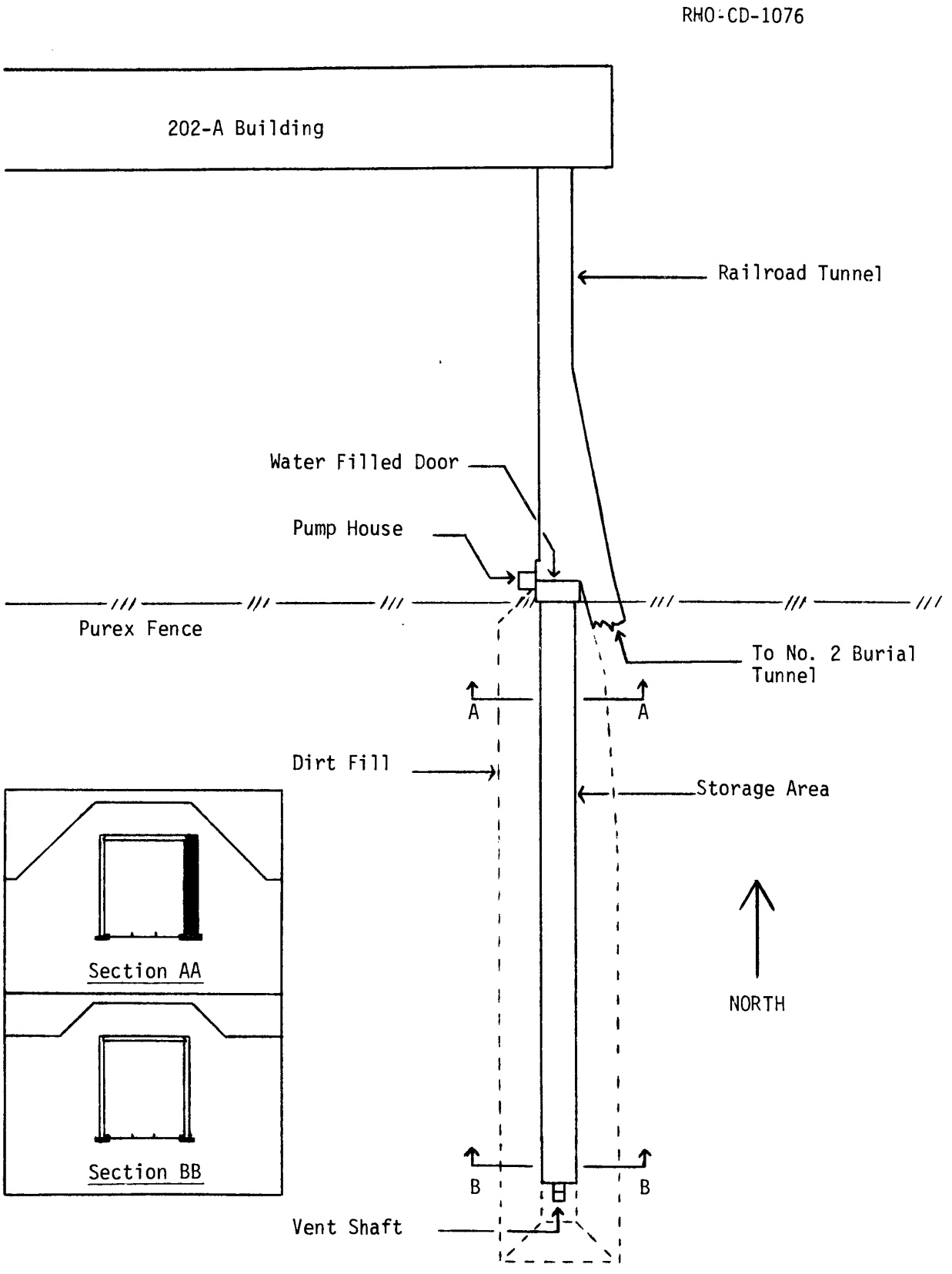

FIGURE 1: PUREX NO. 1 BURIAL TUNNEL - PLOT PLAN

HISTORY

Construction and Burials

Construction of the burial tunnel was completed in 1956 and the first two burial cars were loaded into it in June, 1960. Between this date and January, 1965, six more cars were loaded into the tunnel. Table 1 contains a list of the burial cars and their contents. During the loading of the number seven car, the burial tunnel was pressurized due to the heat given off by the contents of the car. To alleviate this problem, a blower fan and filter were connected to the vent shaft. Also, two air sample and temperature probe risers were mounted in the roof of the tunnel to allow occasional monitoring of the tunnel environment. These risers were placed at locations 60 and 240 feet south of the water filled door enclosure (see figure 2). After the last car was loaded in 1965, the water filled door was deactivated.

TABLE 1: PUREX NO. 1 BURIAL TUNNEL INVENTORY

Burial Car No.	Burial Date	Contents	Initial Dose Rate
1 & 2	6-60	HA Separations Column Box of Misc. Jumpers	5 r/hr @ 60'
3	7-24-60	E-F11, 1WW Waste Concentrator	12.5 r/hr @ 100'
4	12-24-60	G-E4 Centrifuge Two Concentrator Tube Bundles Box of Misc. Jumpers	1.5 r/hr @ 150'
5	1-4-61	E-H4, 3WB Concentrator	150 mr/hr @ 50'
6	4-21-61	E-F6, 2WW Waste Concentrator	5 r/hr @ 20'
7	2-8-61	E-F11, 1WW Waste Concentrator	25 r/h @ 150'
8	1-22-65	E-F6, 1WW Waste Concentrator	Unrecorded

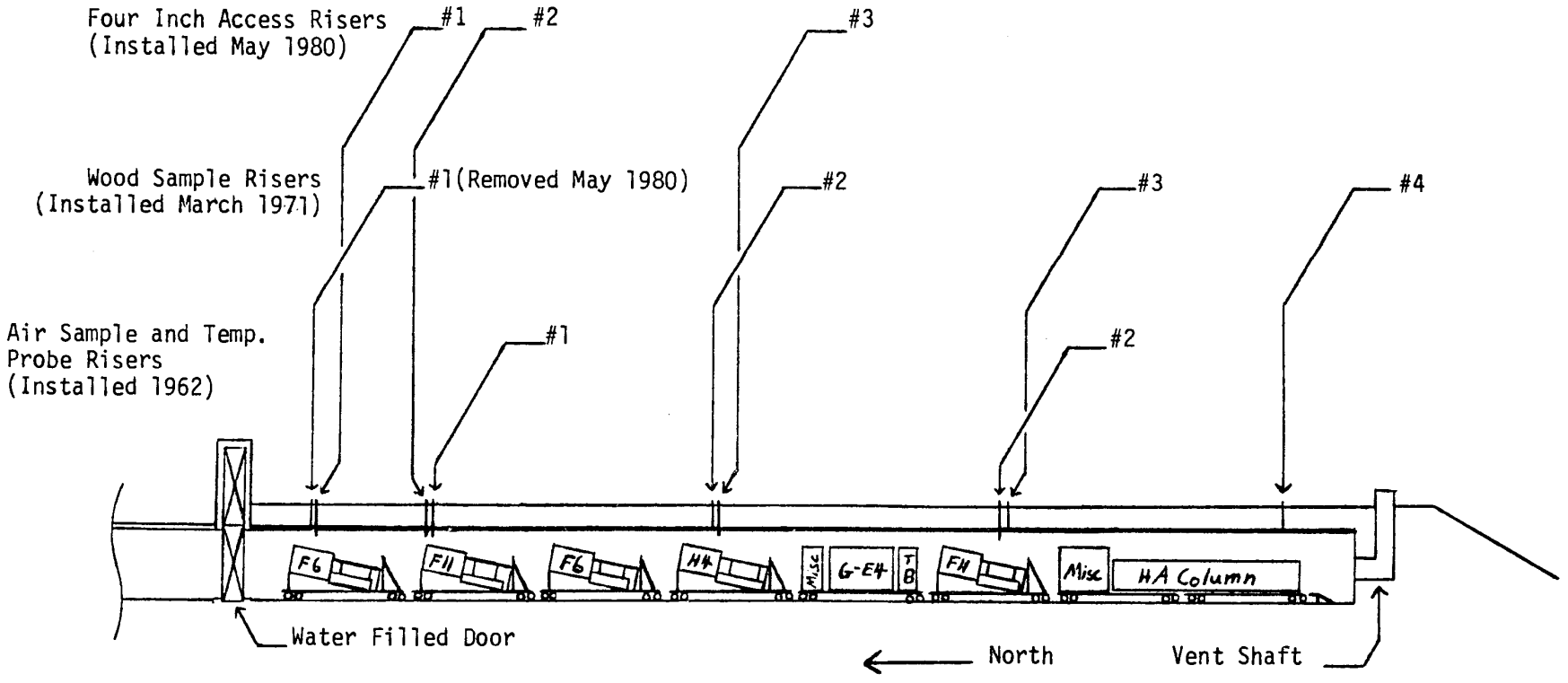

FIGURE 2: PUREX NO. 1 BURIAL TUNNEL

1971 Wood Sampling

Concern about the structural integrity of the tunnel was first raised in December, 1970. Since the wood timbers had been in place for almost fifteen years, doubts had been raised as to the condition of the wood. To determine the integrity of the wood, four 1½ inch steel pipes were sunk through the dirt fill down to the roof of the burial tunnel. These risers were located approximately 20, 149, 245 and 336 feet south of the water filled door enclosure (see figure 2). Using a Swedish, Increment Borer (see figure 3) four 3/16 inch diameter samples were obtained. The samples were examined visually and determined to be sound. This effort was completed in March 1971.

1973 Fire Hazards Study

The possibility of a fire starting in the burial tunnel by spontaneous combustion was questioned next, and in July, 1973, a fire and explosion hazard evaluation was completed by the Health and Safety Administration of the United States Department of the Interior. The report concluded that the danger of an explosion in the tunnel was non-existant, and the possibility of fire was extremely remote. However, a recommendation was made that the tunnel atmosphere be monitored for hydrocarbon content and that a sprinkler system which would be activated by a carbon monoxide monitor be installed. To date, such a system has not been installed, but an effort was made to flood the tunnel with carbon dioxide. The water filled door was caulked with a plastic sealant and the vent shaft was disconnected from the blower fan and sealed off. Six tons of carbon dioxide were then pumped into the tunnel through one of the air sample and temperature probe risers. The carbon dioxide quickly diffused through the gravel floor of the tunnel, and the attempt to create a non-combustible environment in the tunnel failed.

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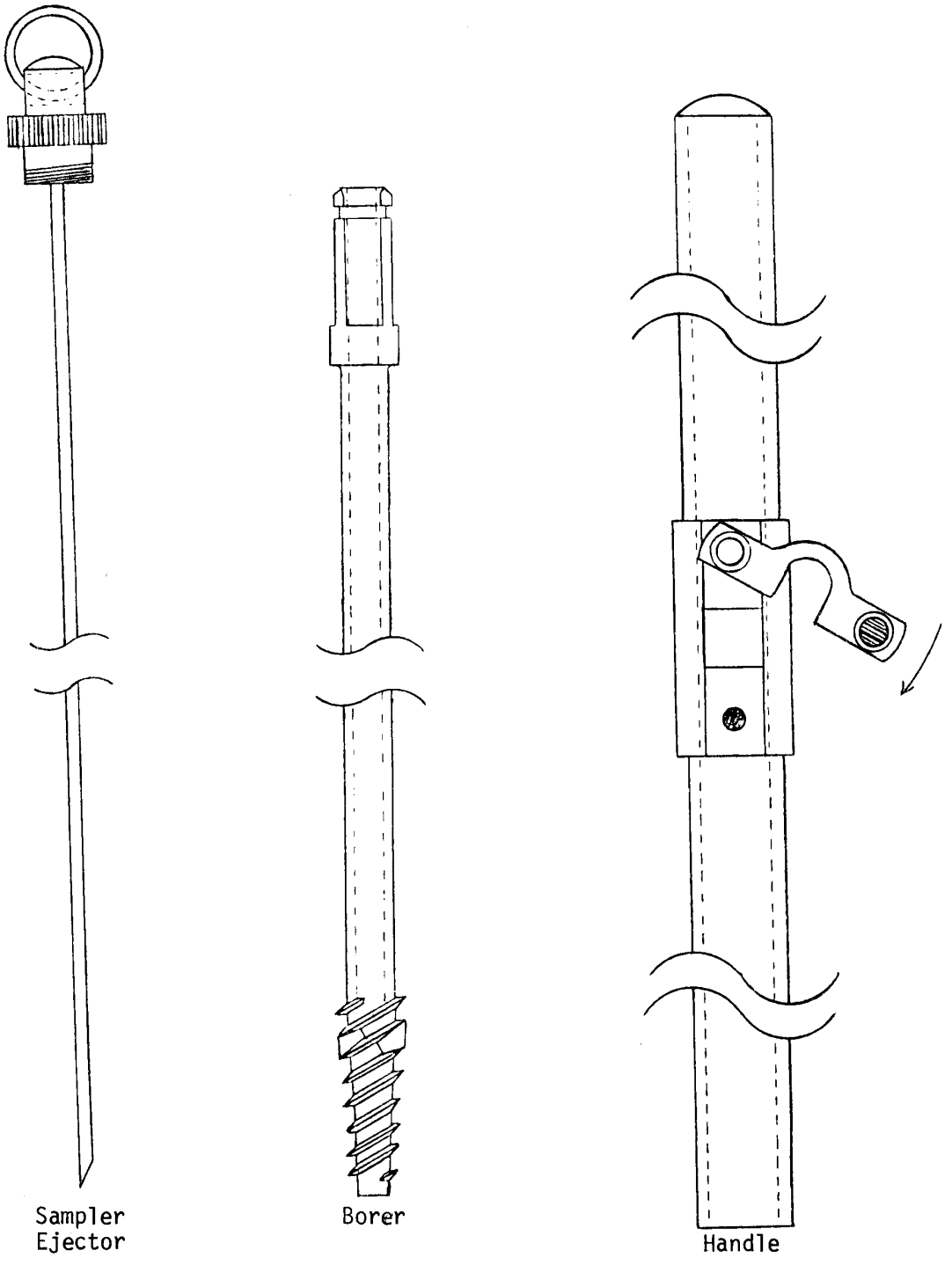

FIRGURE 3: SWEDISH INCREMENT BORER

1978 Evaluation of the Tunnel Environment

In July, 1978, an evaluation of the burial tunnel environment was performed. A one-half inch tygon tube was lowered into each of the air sample and temperature probe risers (for location, see figure 2), and several air samples were withdrawn from the tunnel using a vaccuum pump. These samples were tested for airborne radioactivity, gaseous chemical composition and relative himidity. In addition, temperature and radiation exposure were determined by lowering iron constantan thermocouples and thermoluminescent dosimeter chips into the tunnel. Results of these tests are shown in table 2. No conclusions were made from these results, but it was recommended that the tunnels' wood timbers be sampled and tested to verify their structural integrity.

1979 Wood Sampling

The wood timbers of the burial tunnel were once again sampled in June 1979 by lowering a Swedish Increment Borer (see figure 3) down the existing wood sample risers (for location see figure 2). The samples obtained, however, were of such poor quality that a visual examination could yield no usable information. A chemical analysis by Pacific Northwest Laboratories (PNL) to determine the amount of degraded cellulose in the wood also proved unsuccessful. The study concluded that the existing wood sample risers were no longer useful in obtaining samples from the tunnel and an alternate method would have to be developed.

TABLE 2: RESULTS OF THE JULY 1978 EVALUATION OF THE No. 1 BURIAL TUNNEL ENVIRONMENT

Sample Location	No. 1 Air Sample and Temperature Riser						No. 2 Air Sample and Temperature Riser					
Distance Below Tunnel Ceiling at Which Sample Was Taken (ft)	-1.5	0	1.5	2	4.5	5	0	2	3	5	6	9
Tests Performed												
Airborne Radioactivity x 10^{-10} μCi/ml — Radon		770				770	770			770		
Airborne Radioactivity x 10^{-10} μCi/ml — Long-Lived Isotopes		5.5				0.022	5.5			0.022		
Air Composition[1] wt.% CO_2[2]		0.20				0.12	0.20			0.12		
Relative Humidity % / ppm H_2O		7 / 900				4 / 750	7 / 900			4 / 750		
Temperature[3] ± 1°F		64		64		64	64	64		64		
Dose Rates[4] R/hr	0.166		121		153				17.7		30.2	37

[1] Gases other than CO_2 were at normal concentration for dry air

[2] Normal concentration of CO_2 in dry air is 0.04% wt%

[3] Temperatures were determined by lowering an iron constantan thermocouple into the tunnel

[4] Dose rates were determined by lowering thermoluminescent dosimeter chips into the tunnel

CORE SAMPLING OPERATION

Purpose and Site Locations

Three core samples were taken from the roof of the burial tunnel to be used for static bending tests to determine the structural strength of the tunnels support timbers. The cores measured 4 1/8 inch in diameter and 13 1/2 to 14 inches long. This size was selected because the cores would be large enough to be cut into samples for static bending tests yet small enough to prevent the timbers from which they were removed from being severely weakened. A structural study made by G. R. Wagenblast of Rockwell's Engineering Mechanics unit showed that as long as the cores were taken three to six feet from the tunnel centerline, the tunnel roof would not be adversely affected.[6]

The core sample locations are as follows (see fig. 2):

Location Number 1: Approximately 18 feet south of the water filled door and 4 feet east of the tunnel centerline.

Location Number 2: Approximately 54 feet south of the water filled door and 4 feet west of the centerline.

Location Number 3: Approximately 154 feet south of the door and 4 feet east of the centerline.

Locations one and two were selected because they were the areas that appeared to have received the largest amount of radiation exposure, and location number three was selected as a reference.

Method

In preparation for the core sampling, six feet of the eight foot dirt fill over each sample location was removed using a crane with a clam-shell attachment. An area sufficiently large enough for four people was dug out and the sides of the excavation were sloped at a forty five degree angle to eliminate the need for shoring. Next, a two foot square hole was dug down to the timbers using the crane, and a plywood shoring box was placed in the hole to prevent the dirt from caving in over the work area. Any remaining dirt was swept from off the timbers using a broom and a dust pan equipped with an extension

handle. Following this, the tar and roofing material on top of the timbers were chipped off using long handled wood chisels. A one foot diameter, 2½ foot long fiberglass pipe was then placed over the sample site and filled in around with dirt. Figure 4 shows a typical prepared sample site. The two inch thick lead donut shown in the figure was lowered down into the fiberglass pipe to provide additional radiation shielding.

After all three sample sites had been prepared, the cores were drilled using a specially designed hole saw. The lead donut was moved from site to site as it was needed. As each core was removed, a steel riser was placed in the newly created hole in the timber and liquid neoprene was poured around the riser to caulk it. When all three sites had been core drilled, the excavations were backfilled to their original grade. No effort was made to recover the plywood shoring boxes or the fiberglass pipes.

Equipment

Hole Saw. Since no commercially available device existed for obtaining large wood samples, a hole saw capable of obtaining a 4 1/8 inch diameter and 14 inch long core was designed and built on-site. The entire device consisted of the hole saw and four accessories: the drill cap, the starter drill, the core holder and the core holder chamber (see figure 5).

The hole saw was made from a 15 inch long piece of 4 inch stainless steel pipe into which twenty four saw teeth had been cut. The number of teeth was later reduced to twelve with carbide tips attached to each tooth. A 1/4 inch thick back plate was welded on the other end of the pipe. The back plate contained a one inch diameter hole in the center and four 1/2 inch diameter holes located equidistant from each other, and 1 5/8 inches from the center. A 4 foot long 3/4 inch steel pipe was inserted into the one inch hole and welded in place to act as a shaft. The other end of the pipe shaft was threaded with standard NPT pipe threads. Four support bars were welded to the shaft and the back plate at a forty five degree angle. The hole saw could cut

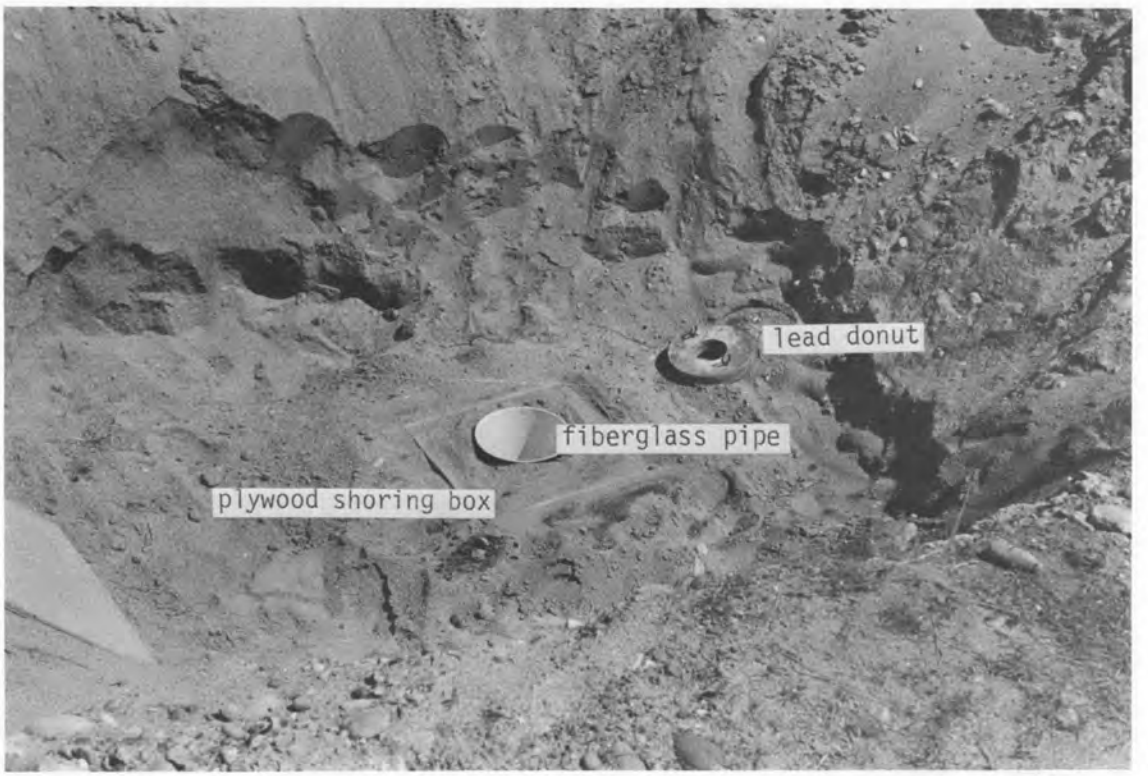

Figure 4: Typical Sample Site

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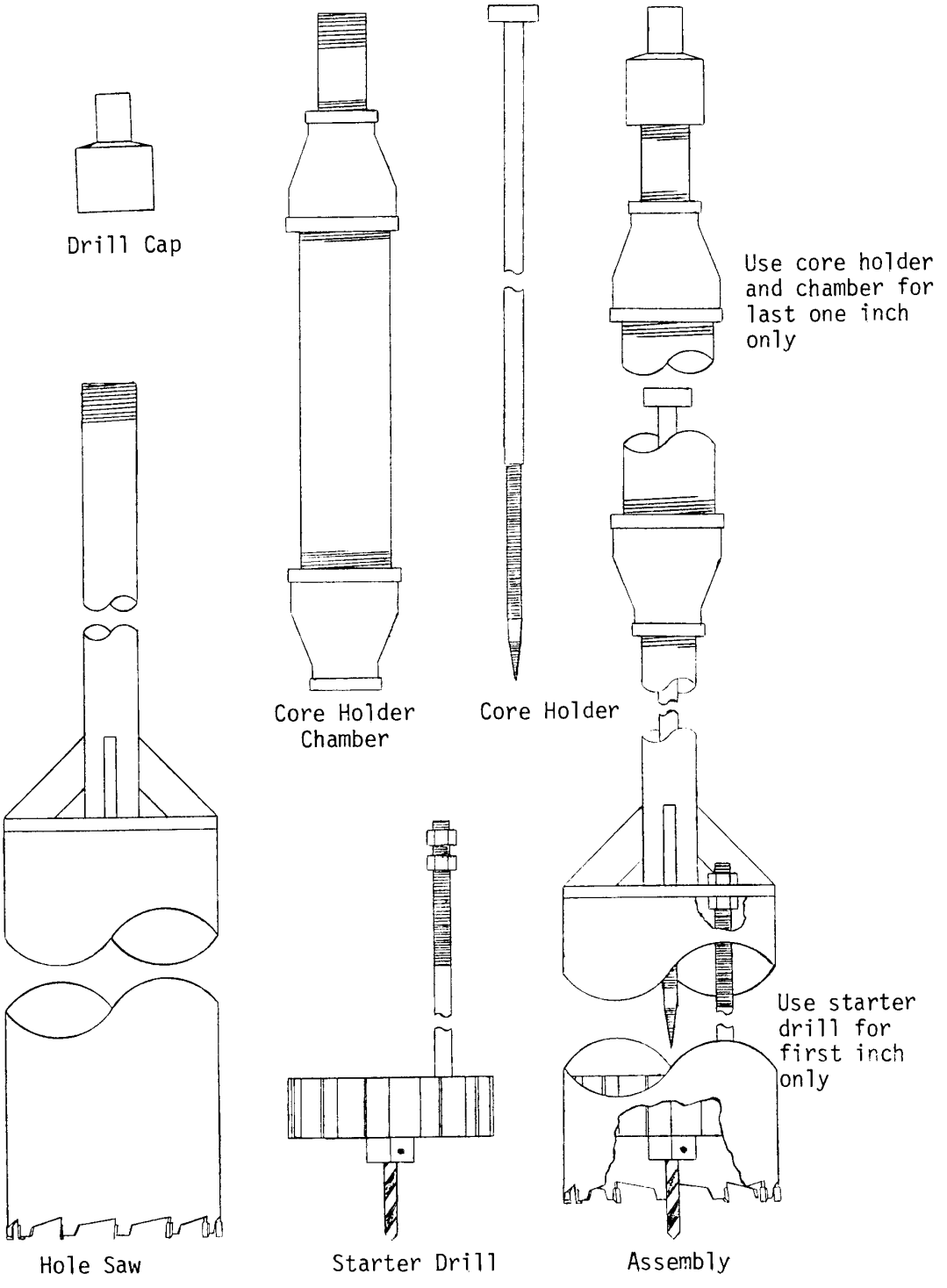


FIGURE 5: HOLE SAW - PUREX NO. 1 BURIAL TUNNEL CORE SAMPLING

a core about 4 1/8 inches in diameter and leave a 4 1/2 inch diameter hole.

The drill cap was designed to screw on top of the hole saw's shaft and fit into a three-quarter inch drill chuck. The cap was machined from a solid piece of stainless steel with one end fashioned like a pipe cap and the other like a three-quarter inch bit.

To prevent the hole saw from moving out of position when it was first cutting into a timber a starter drill was designed to be inserted into the hole saw to act as a guide. The starter drill consisted of a 3/16 inch twist drill mounted in a 1 1/4 inch thick aluminum plug. The plug was grooved on the edges to allow it to slide past the saw teeth when inserted into the hole saw. A 3/8 inch diameter threaded steel rod was attached to the other side of the aluminum plug so that when the starter drill was inserted into the hole saw, the steel rod would fit through one of the 1/2 inch holes in the hole saw's back plate. The starter drill was held in place by two hex nuts and was used only during the first inch of cutting. After that, the hole saw could guide itself.

The core holder and core holder chamber were used during the last inch of cutting to prevent the core from falling out of the hole saw and into the tunnel when the hole saw penetrated a timber. The core holder was a 5 foot long 3/8 inch steel rod with wood screw threads on one end and a one inch "T" handle on the other. The core holder chamber consisted of two 1 1/2 to 3/4 inch bell reducers, a nine inch long piece of 1 1/2 inch pipe, and a three inch long 3/4 inch pipe nipple. To attach the device, one of the bell reducers was screwed onto the hole saw shaft and the core holder was inserted into the shaft and screwed into the wood core. After that, the 1 1/2 inch pipe, the other bell reducer and the pipe nipple were screwed on in that order. The drill cap was then screwed on top of the assembly and the cutting continued until the hole saw penetrated the timber.

Drill Motor. A modified three-quarter inch portable drill was used to turn the hole saw. To allow for greater control of the hole saw and to prevent the operators from standing directly over the sample site, two extension handles were attached to the drill motor. The switch in the motor's handle was taped in the closed position and the drill was controlled by using a foot pedal switch. Figure 6 shows the drill motor in operation.

Sawdust Clearing Apparatus. Since the hole saw was not self-clearing, a method of cleaning the sawdust from the cut became necessary. This was accomplished by using an air blow. After cutting one to two inches into a timber, the hole saw was removed and the sawdust was blown from the cut with compressed air. The cutting then resumed for another one to two inches. The air blow device consisted of a ball valve connected to a four foot long 1/2 inch pipe which had been nippled down to a one inch long 1/8 inch diameter pipe on the other end. Compressed air at 90 psi was supplied to the device by a portable air compressor.

To prevent the possibly contaminated sawdust from escaping into the atmosphere, a mini hood was created using a piece of clear vinyl sheeting and a vacuum hose. Figure 7 shows the air blow device and the mini hood in use. Vacuum for the hood was supplied by a Sears sixteen gallon shop vac. which had been equipped with a 1000 CFM HEPA filter on the exhaust end (see figure 8).

Risers. In order to plug the holes created by the core drilling, three 4 inch risers were fabricated. The risers were made from four inch schedule forty steel pipe and measured ten feet three inches. Slip on flanges were welded onto the pipes fifteen inches up from the bottom to prevent the risers from slipping into the tunnel, and the areas below flanges were trimmed slightly to allow the risers to fit easily into the holes in the timbers. Standard four inch pipe caps were screwed onto the tops of the risers. Two of the three risers are shown in figure 9. After the risers were positioned and the dirt filled in around them, the tops of the risers were one foot above ground level.

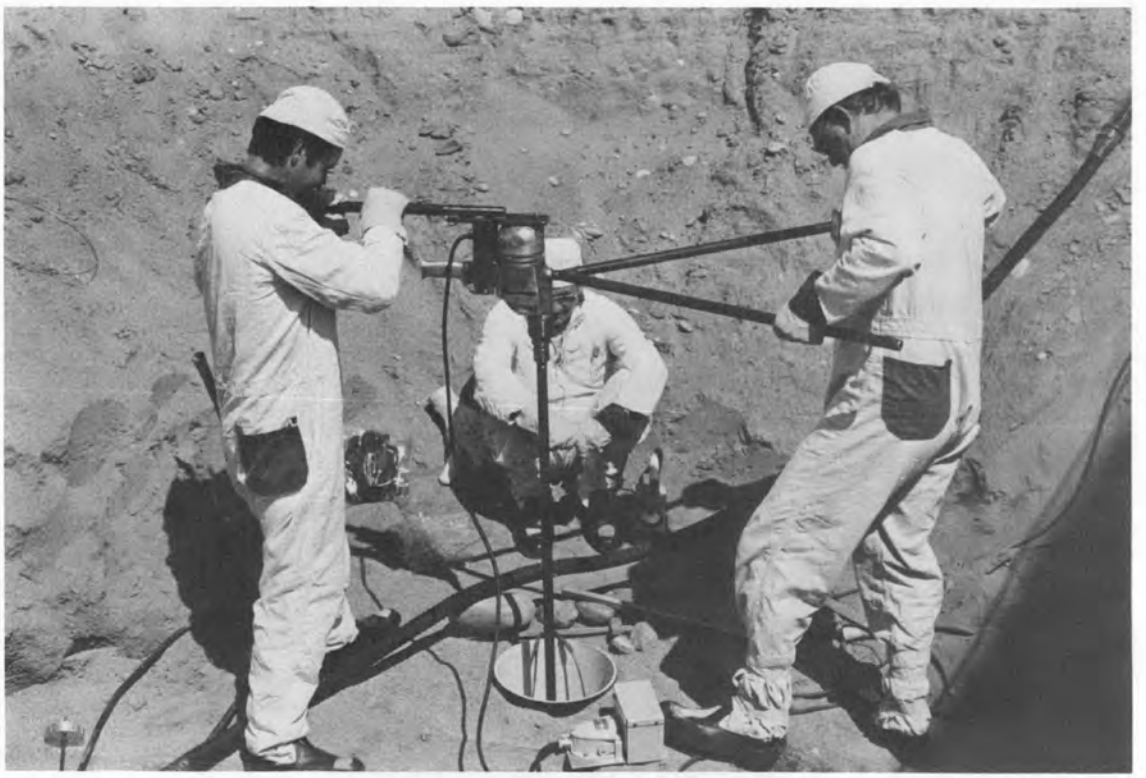


Figure 6: Drill Motor in Use

Figure 7: Sawdust Clearing Apparatus in Use

Figure 8: Vacuum Supply for the Sawdust Clearing Apparatus

Figure 9: Burial Tunnel Risers

Observations

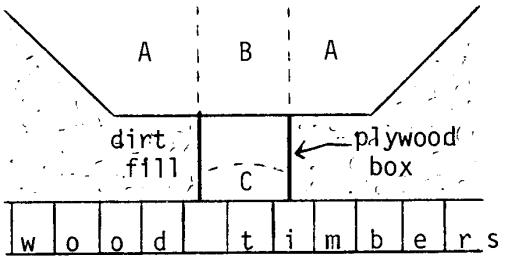
Site Preparation. Excavation of the sample sites began on Monday, May 5, 1980 and was completed with the plywood shoring boxes in place two days later. During the digging of the number one site, the number one wood sample riser (see figure 2) was struck by the clamshell and had to be removed. Exposure rates at the number one and number two locations presented a problem for the workers while they were removing the last bit of dirt and scraping the tar from off the timbers (see table 3). However, by using extension handles and by rotating personnel, radiation exposure was kept well below allowable limits. Once the fiberglass pipe was in place, the amount of exposure to personnel was cut considerably. Also, insertion of the lead donut into the fiberglass pipe just prior to core drilling further reduced the amount of exposure to well below acceptable limits. The largest dose received by any one man during the entire operation was one hundred miliroentgen. Preparation of all three sample sites was completed on Friday, May 9.

Core Drilling. Because of low radiation exposure, location number three was chosen to be sampled first and core drilling began on Tuesday, May 13. High winds and problems with the stainless steel saw teeth getting dull too fast forced the operation to be suspended for the day, and the core drilling was completed the next morning. To eliminate the need for constant sharpening, the number of saw teeth on the hole saw was cut in half, and carbide tips were attached to the reamining teeth. After the hole saw was modified, core samples from locations one and two were obtained without difficulty. All core sampling was completed on Friday, May 16. The wood cores are shown in figures 10 through 12. The cores appear blackened on the ends because the timbers had been creosote treated before use.

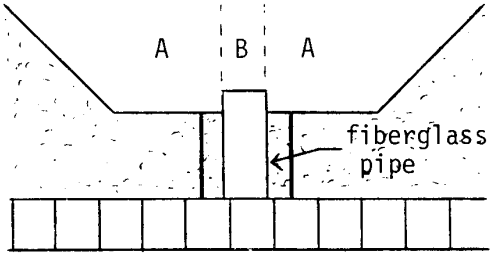
Although a release of radioactive contamination from the burial tunnel during the core drilling operation was expected, air samples taken at the time showed no sign of any contamination release. In addition, surveys of all the equipment used during the core drilling and of the work areas didn't reveal any detectable contamination. A small amount of contamination (less than one hundred fifty counts per minute) was

TABLE 3: EXPOSURE DURING CORE DRILLING OPERATION (mR/hr)

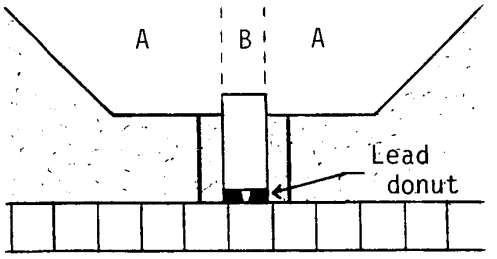
Sample Location No.	First Stage			Second Stage		Third Stage	
	Area A	Area B	Area C	Area A	Area B	Area A	Area B
1	150-200	700	2,000	20	250	8	8
2	300-500	2,000	8,000	50	450	10-15	10-15
3	0	0	15	0	0	0	0



First Stage: Plywood shoring box in place



Second Stage: Fiberglass pipe in place



Third Stage: Lead donut in place

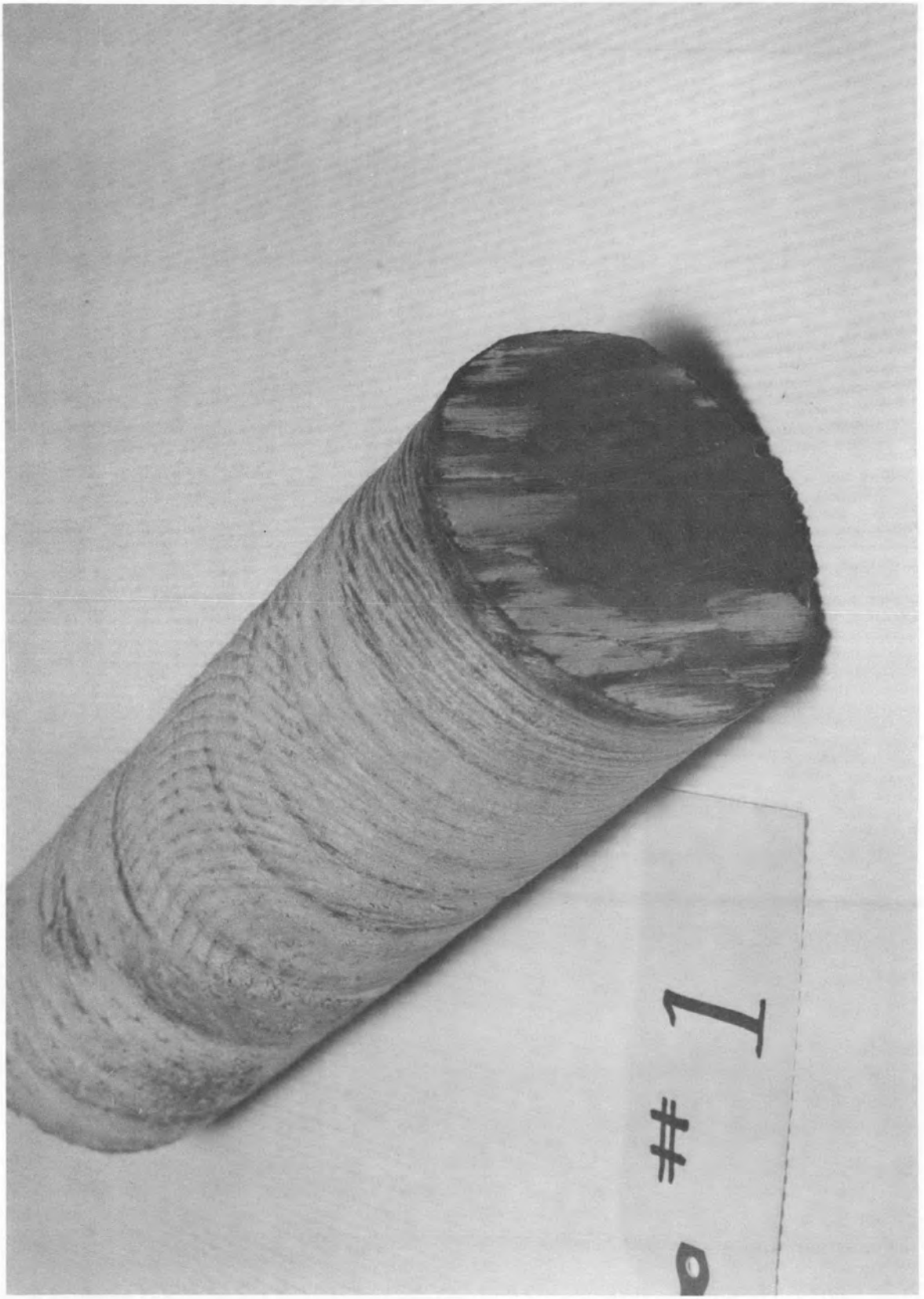


Figure 10: Core Sample, Location No. 1

Figure 11: Core Sample, Location No. 2

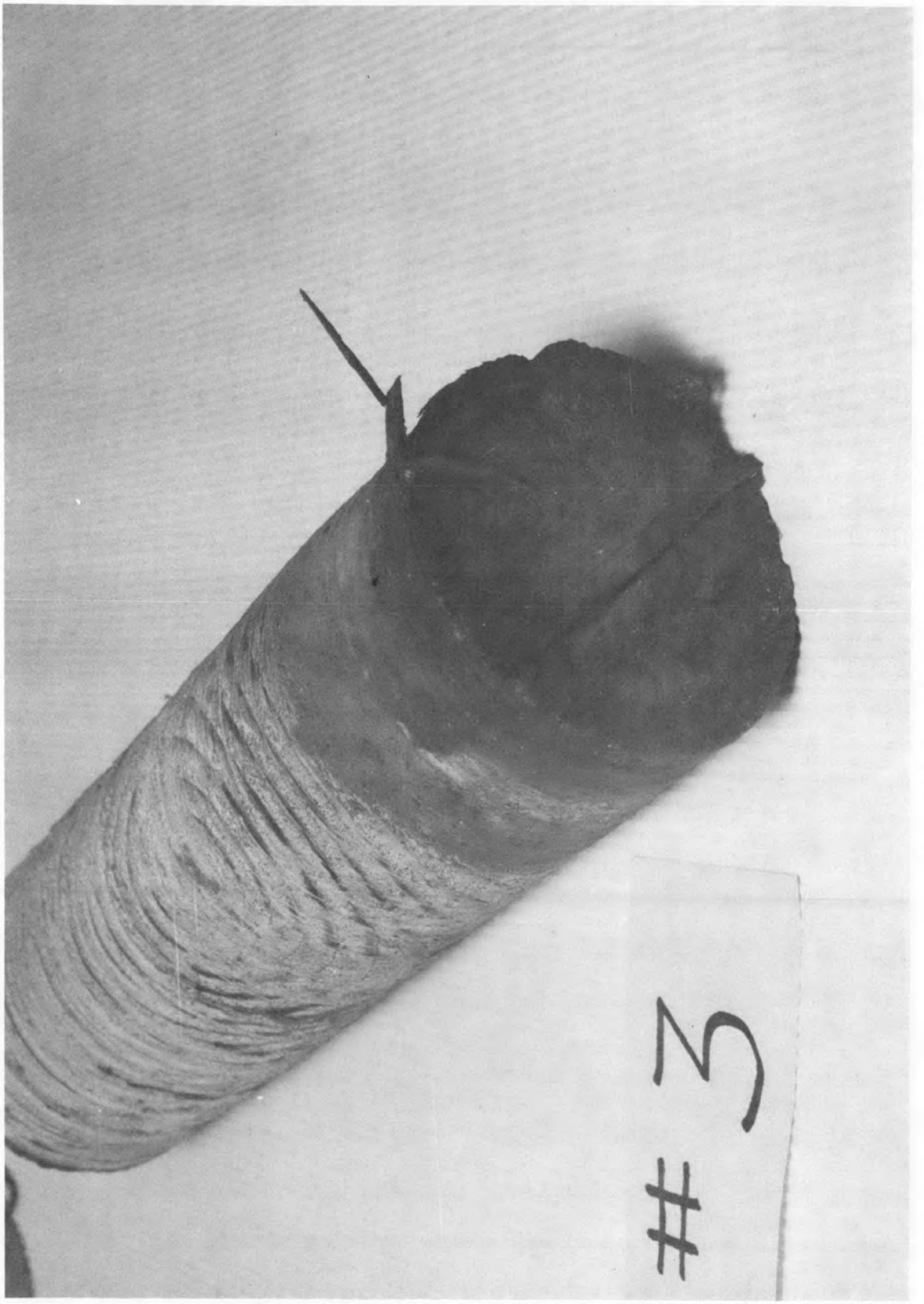


Figure 12: Core Sample, Location No. 3

found on the bottom ends of the three core samples, but this was removed by cutting the bottom one-quarter inch off of each of the cores.

Site Refilling. Refilling of the sample site was scheduled for May 19 but was delayed due to the ash fallout from the May 18 eruption of Mount Saint Helens, which necessitated cleaning and testing the crane. Filling of the sites began the following monday and was completed on Friday, May 30.

SAMPLE TESTING

Method

Two types of static bend tests were performed on the core samples. The first type was a modified version of ASTM standard number D-143. The second was according to ASTM-D-805.

In the first test, four 3/4 inch square by 3 1/2 inch long samples were cut from each of the three cores. These samples were then subjected to a center load static bend test. The results were compared with those of new wood of the same moisture content, ring count and density. The new wood was next tested using the standard three-quarter inch square and fourteen inch long sample called for in ASTM-D-143. The results of this test were used to scale up the results of the tests on the smaller samples.

The second test used samples that measured 0.2 by 2 by 3 1/2 inches. These samples were subjected to a centerload static bend across the width as specified in ASTM-D-805. This standard was meant for testing veneer but can also be used for bend tests on very short specimens.

Results

The results of the two tests are shown in Table 4:

TABLE 4: RESULTS OF STATIC BEND TESTS - PUREX NO. 1
BURIAL TUNNEL CORE SAMPLES

Location Number	MODULUS OF RUPTURE (psi) Modified ASTM-D-143	ASTM-D-805	Average	Moisture Content	Specific Gravity
1	12,226	12,679	12,453	12%	0.6
2	11,325	11,312	11,319	12%	0.6
3	16,834	16,814	16,824	12%	0.6
Control (New Wood)		17,313	17,313	12%	0.58
Industry Average			12,000	12%	0.48

All three samples have a specific gravity higher than the industrial, and since modulus of rupture is roughly proportional to specific gravity[12], they should all have a higher than average modulus of rupture. This is true with sample number three and the control sample but not true with samples number one and two, and would suggest that these timbers may have been weakened by an environmental influence. The probable cause of this loss of strength will be discussed later in greater detail. In any case, all of the samples fall within the acceptable range for modulus of rupture and the wood in the burial tunnel can be assumed to be compatible with present day douglas fir (see letter in appendix).

DISCUSSION

The Committee on Timber Structures of the American Society of Chemical Engineers Structural Division has determined that if old timbers are in good condition, they can be assigned the same working stresses as new lumber of the same grade and species.(10) The test results on the three core samples have shown that the wood in the burial tunnel is still within specie requirements, and so the present day design values can be used for evaluating the integrity of the tunnel. The grade and species of wood used in the tunnel is number one post and timber douglas fir.(15)

For the purpose of simplicity, only bending stresses will be considered in this section since the preliminary structural evaluation by G. R. Wagenblast had shown that timber failure would be by bending stresses. (6) The design value of extreme fiber in bending (F_b) for number one post and timber grade douglas fir is 1,200 psi.(9) This number is lower than the lab test value of 12,000 psi because a number of reduction factors must be applied to obtain a practical design value.

Reduction Factors

Moisture and Seasoning Effects. Green wood has a moisture content of 30%. This large amount of moisture will reduce the bending strength of the wood to a factor 1.62 (12) below the lab value for dry wood (12% moisture content). Even though this strength is gained back when the wood is dried and seasoned in the case of large timbers, it is offset by defects in the timber which form as a result of the drying and seasoning process.(7) The bending strength adjusted for moisture becomes 12,000 ÷ 1.62 = 7,410 psi.

Variability. Design strengths are based upon the average strength of a species and so most of the timbers will either be stronger or weaker than the average. To account for the weaker timbers the strength value is reduced by 25%. The bending strength adjusted for variability becomes 7,410 x 0.75 = 5,560 psi.

Duration of Load. The ability of wood to withstand a given stress decreases logarithmically with time for continuously applied loads.[12] For example, a normal bending strength test lasts about two to three minutes, and a stress of 12,000 psi is required to break the sample. However, a 8,040 psi stress applied continuously for one year will break the same sample. Similarly, a ten year 7,500 psi stress or a fifty year 7,200 psi stress will break the sample. Normal duration of load is considered to be ten years, and the bending strength is reduced by 3/8 to accommodate the loss of stress resistance during this period.[8] The corrected bending strength now is 5,560 x 5/8 = 3,475.

Natural Defects. Defects such as knots, cracks and splits in the grain will reduce the strength of a timber according to the size and type of defect. Each grade of wood is assigned a maximum reduction in strength resulting from defects. Lumber is assigned to the various grades according to number and size of defects.[13] In the case of number one grade douglas fir, the maximum loss of strength due to defects is 43%. Adjusting the bending strength for defects yields 3,475 x 0.57 = 1,980 psi.

Safety Factor. Even after applying the above reduction factors the bending strength is still a factor of 1.65 greater than the design value of 1,200 psi. This number is called the near minimum factor of safety [8] and allows for such things as accidental overloading, and public and worker safety. This factor, however, does not take into account severe overloading stresses such as those in an earthquake. It should be noted that each reduction factor contains a certain margin of safety, and when all these factors are combined the actual safety factor is usually between 2.0 and 2.5.[8]

Factors Not Included in the Design Strength

The reduction factors explained above have been determined on the basis of normal loading, construction and maintenance. When conditions go beyond these assumptions the design strength must be reduced accordingly.

Duration of Load Beyond Ten Years. As stated earlier, the normal duration of load is assumed to be ten years. If the timbers are to be loaded for longer periods of time, as in the case of the burial tunnel, the design strength must be reduced by another 10%. This will compensate for any further loss of strength due to duration of load for the entire life of the tunnel. The design strength adjusted for long term loading is 1,200 x 0.90 - 1,080 psi.

Size Factors. The design strength is only applicable for timbers up to twelve inches in depth. For larger timbers the strength must be reduced by the following equation:

$$C_F = \left(\frac{12}{d}\right)^{1/9}$$

where d is the depth of timber and C_F is the size factor. The timbers in the burial tunnel are fourteen inches deep and the design strength is reduced to 1,080 x 0.983 = 1,060 psi.

Decay and Insect Attack. The effects of decay and insect attack are so varied and hard to predict that no adjustment to the design strength is made, but the possibility of loss of timber integrity by these causes must always be kept in mind. Generally, as long as the timbers are kept dry, decay or insect attack is not likely since both need moist wood to get started.(7) In the case of the burial tunnel, the timbers were creosote treated and are kept in a very dry atmosphere (7% relative humidity - see table 2). Decay or insect attack is not considered to be a current problem. However, the possibility of decay or insect attack occurring can never be totally eliminated.

Radiation. Several locations in the tunnel have been exposed to large amounts of gamma radiation due to the presence of the failed process equipment in the tunnel. Studies have shown that large amounts of gamma radiation can lower the strength of wood.(1) The results of the core sample tests bear this out. Samples number one and two which have received large dose of radiation are noticeably weaker than sample number three even though they are similar quality wood. Fortunately, even though the wood has been weakened, it is still within allowable strength limits. A worse case radiation profile has been prepared (see appendix) and is shown in figure 13. The most severe effects

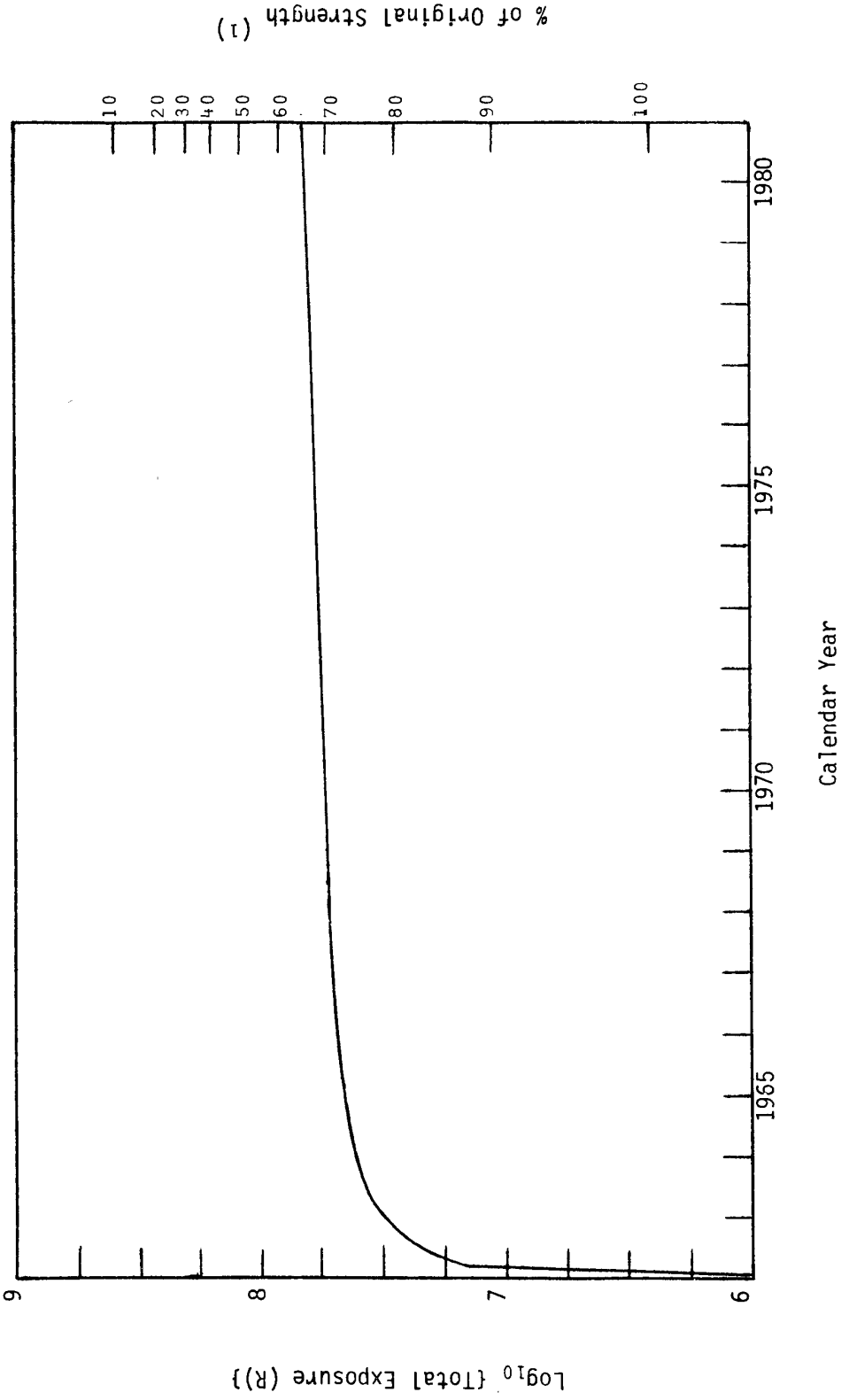


FIGURE 13: WORSE CASE EXPOSURE PROFILE

of the gamma radiation occur in the first three years and the effects gradually tapered off thereafter. Radiation is not expected to be a major factor in any future weakening of the tunnel.

Calculation of Present Tunnel Integrity

The weight a wood beam is designed to hold if loaded uniformly is given by the following equation.[7]

$$Wd = \frac{8F_b\ w\ d^2}{6\ L}$$

Where:

W_d = Design weight

F_b = Design bending stress = 1060 lb_f/in^3

w = Timber width = 12 in.

d = Timber depth = 14 in.

L = Timber length = 19 ft. = 228 in.

Substituting in the above values:

$$W = \frac{8\ (1{,}060)\ 12\ (14)^2}{6\ (228)} = 14{,}600\ lb_f$$

The weight actually held by the beam is given as follows:

$$Wa = (\rho e\ HewL + \rho w\ dwL)\ \frac{g}{gc}$$

Where:

Wa = actual weight in lb_f

ρe = density of the earth fill = 110 $\frac{lbm}{ft^3}$

H_e = height of the earth fill = 8 ft.

ρw = density of the wood beam = 37.4 $\frac{lbm}{ft^3}$

g = acceleration of gravity = 32.2 $\frac{ft.}{sec^2}$

gc = force constant = 32.2 $\frac{lbm\ ft.}{lb_f\ sec^2}$

Therefore:

$$Wa = \{(110)\ (8)\ (\tfrac{12}{12})(19) + (37.4)\ (\tfrac{14}{12})\ (\tfrac{12}{12})\ (19)\}\ \frac{32.2}{32.2}$$

$$Wa = 17{,}500\ lb_f$$

As can be seen, the actual weight on the tunnel exceeds the design

weight by 20%. Since the near minimum safety factor is 1.65, however, the tunnel can safely handle loads up to 65% in excess of design value. Therefore, even though the tunnel will not meet current design criteria, it is structurally sound and is not in danger of failure at this time, but a prediction of how long the tunnel will last is not possible due to unpredictable factors that could affect timber integrity.

Consequences of Tunnel Failure

The immediate radiological consequences of the tunnel failure are relatively minor since the contamination in the tunnel is generally well fixed and airborn activity is relatively low. Also since personnel are not normally on the tunnel, personnel safety risks are low. Public relations consequences, however, could be large due to the present attitudes regarding nuclear waste handling.

Eventually tunnel failure will occur as a few side-by-side timbers fail. The timbers will break and fall into the tunnel along with the soil that is on top of them. This will either cause a depression in the fill on top of the tunnel or open a hole to the tunnel interior. Total tunnel collapse is not expected except in a major seismic event. Should the tunnel fail, two courses of action exist: 1) bury the tunnel contents in place or 2) remove the equipment for burial or relocation. Removing the equipment after a tunnel failure could require removing the soil and timbers which had fallen into the tunnel to allow the equipment to be removed. This would be costly and could result in personnel danger and radiation exposure, depending on the degree to which the work can be accomplished remotely. Therefore, if the equipment is to be removed, it should be done while the tunnel is still structurally sound.

CONCLUSIONS

The Purex Number One Burial Tunnel is considered to be structurally sound for the present time assuming the present loading conditions remain unchanged. An accurate prediction of future tunnel life is not possible due to unpredictable factors that can affect timber integrity such as wood decay or insect attack.

Since the tunnel will eventually fail, the question is not "whether" it should be deactivated but "when" and "how" it should be deactivated. If the contents of the tunnel must be removed, it should be deactivated as soon as is practical to ensure the tunnel is still structurally sound during the removal operation. If the equipment is to be buried in place, tunnel deactivation can be deferred to a later date depending upon the burial method selected.

A deactivation study should be initiated to recommend whether the tunnel contents must be removed or whether they can be buried in place. This study should be completed within two years.

APPENDIX

CALCULATION OF
A
WORSE CASE RADIATION EXPOSURE PROFILE

Calculate percent of original integrity

$$\frac{\text{MOR of No. 2 Sample}}{\text{MOR of New Wood}} \times 100 = \frac{11,319}{17,313} \times 100 = 65.4\%$$

From Figure A-1, Total Exposure = $10^{7.81}$ = 6.46×10^7 Rads.

As derived from information in HW-75978 [6], the basic relationship for exposure from mixed gamma emitting fission products (K reactor type fuel) follows the equation:

$$E = a + bt^{-2.5} \qquad \text{(Eq.1)}$$

Where:

E = Exposure in R/yr
a & b are constants
t = time in years ($0<t\leq 20$)

The integrated form is:

$$TE = a\,(t^{-1}) + \frac{b}{1.5}\,(1 - t^{-1.5}) \qquad \text{(Eq.2)}$$

Where:

TE = Total Exposure (R)

The No. 7 car was placed in the tunnel in 1962 assuming one year aging of the fission products before burial:

$$t = Y - 1961 \qquad \text{(Eq.3)}$$

Where:

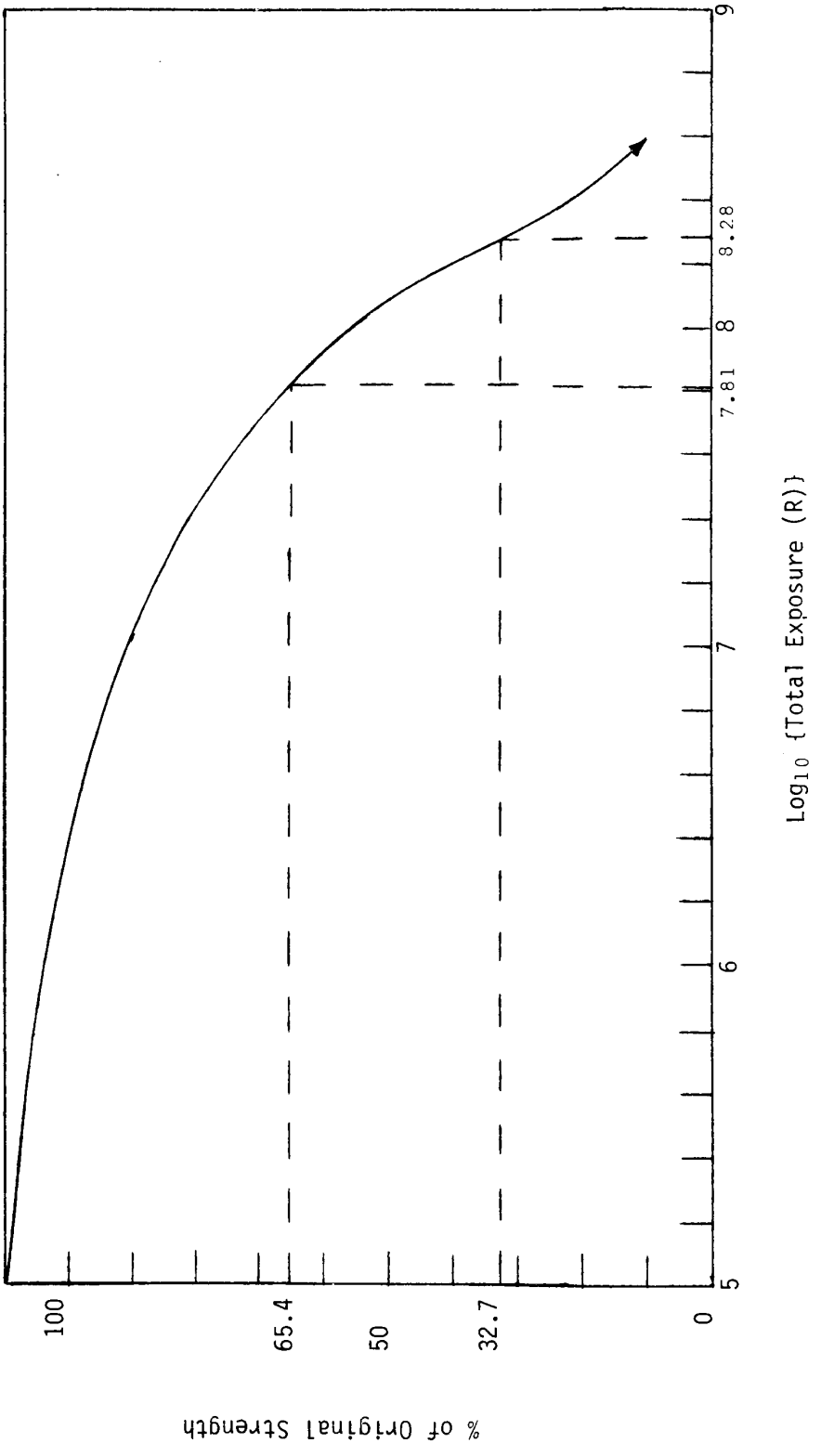
Y = Calendar Year

Two points exist:

In 1978 (t = 17) $\qquad E = 121\ ^{R}/_{hr} = 1.06 \times 10^6\ ^{R}/_{yr}$

In 1980 (t = 19) $\qquad TE = 6.46 \times 10^7$

FIGURE A-1: EFFECT OF GAMMA RADIATION ON WOOD BENDING STRENGTH(1)



Substituting into Equation 1 and 2

$$1.06 \times 10^{6} = a + b\,(17)^{-2.5} = a + 8.39 \times 10^{-4} b$$

$$6.46 \times 10^{7} = a\,(19-1) + \frac{b}{1.5}\,(1-19^{-1.5}) = 18a + 0.659b$$

Solving simultaneously

$$a = 1 \times 10^{6} \qquad b = 7.07 \times 10^{7}$$

Substituting into Equation 2

$$TE = 1 \times 10^{6}\,(t-1) + 4.71 \times 10^{7}\,(1-t^{-1.5})$$

RHO-CD-1076

TIMBER PRODUCTS INSPECTION

August 21, 1980

Rockwell Hanford Operations
Energy Systems Group
P.O. Box 800
Richland, Washington 99352

Attention: Mr. Greg Silvan

RE: 80-432 Rockwell International

Sample - 3 - Douglas Fir Wood cores, 4 in. diameter, marked #"1", #"2" and #"3".

To compare static bend tests and compare with specie averages.

SCOPE & PROCEDURES

The grain direction is across the 4 inch diameter of the sample. To determine the bending strength of the lumber it was tested in two ways.

A static bend, center load, was run on roughly 3/4 inch square specimens, 3½ inch span, four from each piece. These were compared with similar control specimens from sawn lumber of similar density, ring count, and moisture content. Static bends using official procedure for ASTM D-143, 3/4" x 3/4" - 14" span was then run on specimens from the sawn lumber. A factor between the MOR from the D-143 sample and the 3½ inch span sample was developed from the sawn lumber control and applied to the three samples from the core samples submitted by Rockwell.

Specimens were then cut from the cores in accordance with ASTM-D-805. This procedure is for testing veneer, but provides an official bend test for very short specimens.

Results of the two tests follow:

Control - 5 Rings/inch - ASTM-D-143-Static Board-Average MOR-13,886 PSI
30% Summer wood - 12% M.C.

Control - 3/4 inch square specimens, 3½ inch span - Static Board-Average MORE-7,005 PSI-.48 sp growth

RATIO - 13,886/7005=1.982

P.O. Box 919 • Conyers, GA 30207 • (404)922-8000
P.O. Box 17246 • Portland, OR 97217 • (503)285-3631
4805 University Ave., N.E. • Minneapolis, MN 55421 • (612)566-3160

ROCKWELL SAMPLES	STATIC BEND	SAME SPECIMENS	STATIC BEND-Per ASTM-D-805
Ring Count % Summer Wood	3/4" Sq. Specimen 3½" Span	Times 1.982 Calculate	.2 x 2 in. x 3.5 3½" Span

	MOR	MOR	MOR	MC	DENSITY
#1-5 Ring/In.-30%	6167 PSI	12,226 PSI	12,679 PSI	12%	.6 Spg
#2-3 Ring/In.-20-25%	5713 PSI	11,325 PSI	11,312 PSI	12%	.6 Spg
#3-5 Ring/In.-20-25%	8492 PSI	16,834 PSI	16,814 PSI	12%	.6 Spg
Control 5 Rings/In. 30%	7005 PSI		17,313 PSI	12%	.58 Spg

AVERAGE - published MOR for Douglas Fir @ 12% M.C.
.48 aver Spg - 12,000 PSI

DISCUSSION

The average clear wood value for Douglas Fir as a specie includes wood more and less dense than these samples and control. The control, and sample #1 and #3 were above average Douglas Fir density. The values for #1 and #3 and the control are above the specie average strength values, which is to be expected of clear wood above average density. Sample 2 has lower ring count and lower percentage summer wood (the brown dense layer) than the other two samples, and therefore may be expected to have lower strength than the other two samples and the control. Sample #1 and #3 appear to be very similar wood. While so small a sampling leaves some questions, there is an indication that there may have been an environmental influence on sample #1 and #2. Regardless, all three samples test within strength range for specie requirements.

The two procedures used to determine the bending strength provide substantial agreement.

Submitted - August 21, 1980
TIMBER PRODUCTS INSPECTION, INC.

Gifford L. Martin - Sr.

Gifford L. Martin-Sr. - P.E.
Technical Director

Encl.

GLM/ss

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Internal Letter

Rockwell International

Date: September 16, 1980

No. 65431-80-154

TO: (Name, Organization, Internal Address)
- G. R. Silvan
- Purex Process Control
- 202-A, 200-E

FROM: (Name, Organization, Internal Address, Phone)
- I. Kawakami
- Engineering Mechanics
- MO-043, 200-E
- 3-3242

Subject: Summary Report - Integrity of the Purex Number 1 Burial Tunnel (218-E-14)

The subject report has been reviewed; comments are as follows:

1. The ASTM-D-805 standard, used by Timber Product Inspection, Inc. for the static bending test for the Douglas Fir wood core sample, has been discontinued and replaced by ASTM-D-3499, D-3500, D-3501, D-3502, and D-3503.

   The values of Modulus of Rupture shown in the test report seem rather high compared with the average published values in ASI/ASTM D-255-78.

   The variations in the tested mechanical properties could have resulted from using testing procedures differing from those recommended.

2. An accurate prediction of the existing tunnel life is very difficult due to the various factors affecting the strength of the wood, such as knots, deviation of wood grain, shakes, and checks, all differing in their effect, depending on the kind of loading and stress to which the piece is subjected. The tunnel's life prediction will also be affected by the rate of loading and the period of time over which the load is sustained.

   Under long-time loading, timber beams have been known to fail at stresses only slightly greater than 50 per cent of the ultimate strength as given by test in which the load was applied within a few minutes. For compressive stress parallel to the grain, failure under long-time loading may occur at about the proportional limit stress obtained from short duration tests.

It is recommended that all these factors be considered for your final report.

If you have any further questions, please contact the writer.

I. Kawakami

I. Kawakami
Engineering Mechanics

IK/mmw

cc: D. L. Becker
D. E. Braden
R. D. Carrell
I. Kawakami (2)

Internal Letter

Rockwell International

Date: November 12, 1979

No. 65431-79-080

TO: (Name, Organization, Internal Address)
. G. K. Carpenter
. Purex Operations
. 202A, 200 East

FROM: (Name, Organization, Internal Address, Phone)
. G. R. Wagenblast
. Engineering Mechanics
. 2750-E/MO-043, 200 East
. 2-1047

Subject: . Evaluation of Purex No. 1 Burial Tunnel

Ref: Engineering Service Request P67-79

An evaluation of the structural integrity of the timbers in the 218-E-14 Purex number 1 railroad tunnel has been completed. The soil loads due to eight feet of earth cover were found to produce stresses in excess of current design limits. The stresses, however, are expected to be below the ultimate stress levels. The tunnel is not expected to be in any danger of collapse.

The following comments are in direct response to the questions raised in the reference ESR.

1. The amount of structural strength that may be lost before the tunnel will collapse is unknown. The current design stress limit has an average safety factor of 2.5. The actual safety factor, however, will vary from 1.25 to 5.
2. If an individual timber were to fail it would be from bending stresses. The beam would crack at mid span which would allow excessive deflection. As the beam deflects, the soil load would be transferred to the adjacent timbers. Collapse of the tunnel would not occur.
3. A four inch hole in a twelve inch wide beam will reduce its strength by one third. A hole that is located in an area of the beam that is subjected to low stresses will not adversely effect the capability of the beam to withstand the soil loads.

   Any number of four inch diameter holes will not reduce the capability of the timbers, so long as they are located a minimum of three feet and a maximum of six feet from the tunnel center line.

If you have any questions, please call me on 942-1047.

Gary R Wagenblast

G. R. Wagenblast
Engineering Mechanics

GRW/lka

cc: D. L. Becker
G. R. Silvan

54-6000-030

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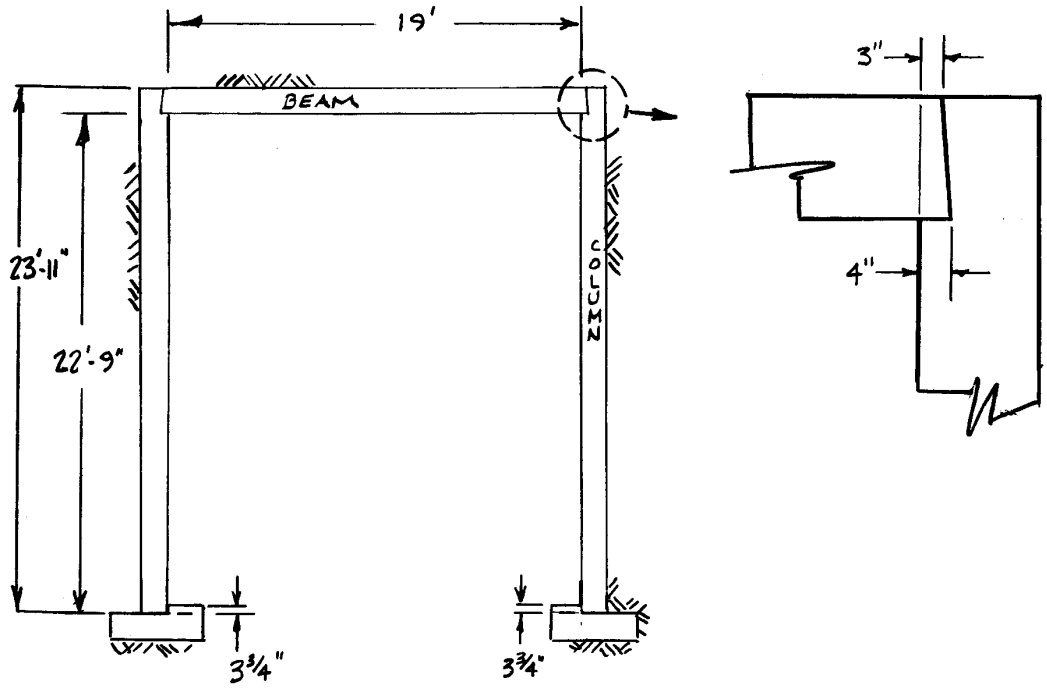

Ref. Drawings
H-2-55586
H-2-55587
H-2-55588
H-2-55589

BD-6400-060.1 (N-2-79)

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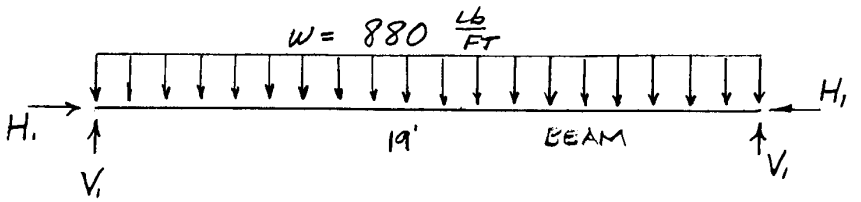


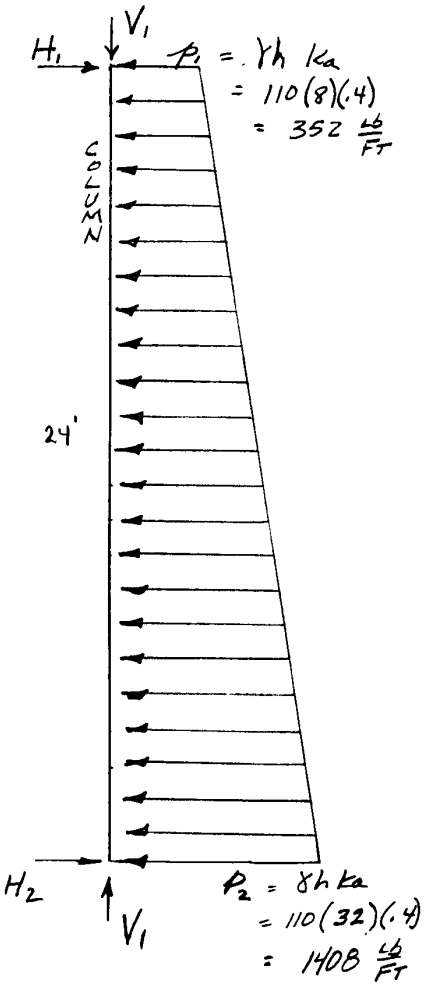
$$V_1 = \frac{1}{2}(880)19 = 8360 \text{ lb}$$

$$H_1 = \frac{1}{24}\left[352(24)\frac{24}{2} + \frac{1}{2}(1056)(24)\left(\frac{24}{3}\right)\right]$$

$$H_1 = 8448 \text{ lb}$$

$$H_2 = \frac{1}{2}(1408+352)(24) - 8448$$

$$H_2 = 12672 \text{ lb}$$



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BEAM

$$\frac{f_c}{F_c'} + \frac{f_b}{F_b - Jf_c} \leq 1$$

$$f_c = \frac{8448 \text{ lb}}{14 \times 12} = 50 \text{ psi}$$

$$F_c' = 806 \text{ psi}$$

$$f_b = \frac{6M}{bd^2}$$

$$M = \frac{wl^2}{8}$$

$$f_b = \frac{6(880 \frac{\text{lb}}{\text{ft}})(19 \text{ ft})^2 (\frac{12 \text{ in}}{\text{ft}})}{8(12 \text{ in})(14 \text{ in})^2} = 1216 \text{ psi}$$

$$F_b = 1150 \text{ psi}$$

$$J = \frac{\frac{l}{d} - 11}{K - 11} = \frac{\frac{19(12)}{14} - 11}{29.42 - 11} = .287$$

$$K = .671\sqrt{\frac{E}{F_c}} = 29.42$$

$$\frac{f_c}{F_c'} + \frac{f_b}{F_b - Jf_c} = \frac{50}{806} + \frac{1216}{1150 - .287(50)} =$$

$$= \frac{50}{806} + \frac{1216}{1135.6} = .060 + 1.071 = 1.131$$

13 % OVERSTRESSED IN COMBINED FLEXURAL & AXIAL STRESS.

BD-6400-060.1 (N-2-79)

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DESIGN ANALYSIS

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ALLOWABLE STRESSES

BENDING F_b

NOMINAL DESIGN VALUE = 1300 psi
Adjustment FOR DURATION OF LOAD = 0.90
" " SIZE FACTOR = 0.983

$F_b = 1300\,(.9)(.983) = 1150$ psi

COMPRESSION F_c

NOMINAL DESIGN VALUE = 925 psi
Adjustment FOR DURATION OF LOAD = 0.9

$F_c = 925\,(.9) = 832$ psi

COMPRESSION F_c'

$$F_c' = F_c\left[1 - \frac{1}{3}\left(\frac{\ell_d}{K}\right)^4\right] \quad \text{for} \quad 11 < \frac{\ell}{d} < K = .671\sqrt{\frac{E}{F_c}}$$

$$K = .671\sqrt{\frac{1600000}{832}} = 29.42$$

$$\ell_d = \frac{19(12)}{14} = 16.28 \quad \text{or} \quad \frac{24(12)}{14} = 20.57$$

$$F_c' = 832\left[1 - \frac{1}{3}\left(\frac{16.28}{29.42}\right)^4\right] \quad \text{or} \quad 832\left[1 - \frac{1}{3}\left(\frac{20.57}{29.42}\right)^4\right]$$

$$F_c' = 806 \text{ psi} \quad \text{or} \quad 766 \text{ psi}$$

BD-6400-060.1 (N-2-79)

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HORIZONTAL SHEAR F_v

NORMAL DESIGN VALUE = 145 psi
ADJUSTMENT FOR DURATION OF LOAD = 0.9

$F_v = 145\ (0.9) = 130.5$ psi

BEARING ON END GRAIN F_g

NORMAL DESIGN VALUE = 1480 psi
ADJUSTMENT FOR DURATION OF LOAD = 0.9

$F_g = 1480\ (0.9) = 1332$ psi.

BEARING PERPENDICULAR TO GRAIN $F_{g\perp}$

$F_{g\perp} = F_c = 832$ psi.

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check Horizontal shear

$$f_v = \frac{VQ}{Ib} = \frac{3V}{2bd}$$

$$V = \frac{w}{2}\left(1 - \frac{2d}{\ell}\right)$$

$$V = \frac{880 \frac{lb}{FT}(19 FT)}{2}\left(1 - \frac{2(14)}{19(12)}\right) = 7333 \, lb$$

$$f_v = \frac{3(V)}{2bd} = \frac{3(7333)}{2(12)(14)} = 65.5 \text{ psi}$$

F_v allowable = 130.5 psi OK

check BEARING

$F_{g\perp}$ = 832 psi allowable

$$f_{g\perp} = \frac{P}{A} = \frac{8360 \, \#}{4(12)} = 174 \text{ psi} \quad OK$$

F_g = 1332 psi allowable

$$f_g = \frac{8448}{12(14)} = 50 \text{ psi} \quad OK$$

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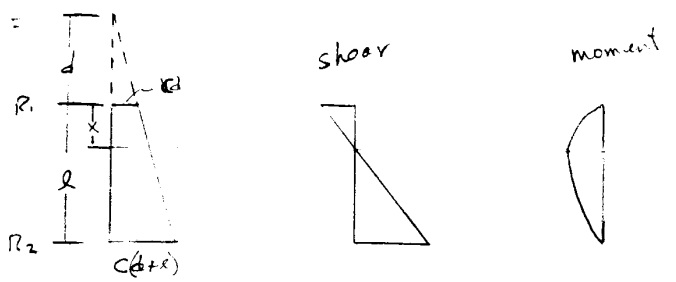
Column

M = occurs at pt of zero shear

X dist from top =



c is slope

$[\Sigma M_{R_2} = 0]$

$$l R_1 = \frac{cdl^2}{2} + \frac{cllll}{2 \cdot 3}$$

$$R_1 = \frac{cdl}{2} + \frac{cl^2}{6}$$

$[\Sigma F_x = 0]$

$$cdx + \frac{cxx}{2} = \frac{cdl}{2} + \frac{cl^2}{6}$$

$$dx + \frac{x^2}{2} = \frac{dl}{2} + \frac{l^2}{6}$$

$$2dx + x^2 = dl + \frac{l^2}{3}$$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$x = \frac{-2d \pm \sqrt{4d^2 + 4\left(dl + \frac{l^2}{3}\right)}}{2}$$

$$x = -d + \sqrt{d^2 + dl + \frac{l^2}{3}}$$

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$$M = R_1 x - \frac{c d x x}{2} - \frac{c x x x}{2 \cdot 3}$$

$$= \frac{c d \ell x}{2} + \frac{c \ell^2 x}{6} - \frac{c d x^2}{2} - \frac{c x^3}{6}$$

$$M = -\frac{cx}{6}\left(x^2 + 3dx - \ell^2 - 3d\ell\right)$$

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$$x = -d + \sqrt{d^2 + dl + \frac{l^2}{3}}$$

$$x = -8 + \sqrt{8^2 + 8(24) + \frac{24^2}{3}}$$

$$x = 13.16^{FT}$$

$$M = -\frac{cx}{6}\left(x^2 + 3dx - l^2 - 3dl\right)$$

$$c = \gamma K_a = 110(.4) = 44$$

$$M = -\frac{44(13.16)}{6}\left[(13.16)^2 + 3(8)(13.16) - 24^2 - 3(8)(24)\right]$$

$$M = 63{,}980 \text{ ft lb}$$

$$= 767{,}777 \text{ in lb.}$$

$$f_b = \frac{6M}{bd^2} = \frac{6(767777)}{12(14)(14)} = 1958 \text{ psi.}$$

$$f_c = \frac{8360}{12 \times 14} = 49.76$$

$$\frac{f_c}{F_c'} + \frac{f_b}{F_b - Jf_c} = \frac{49.76}{832} + \frac{1958}{1150 - .519(49.76)} =$$

$$= \frac{49.76}{832} + \frac{1958}{1124} = .060 + 1.74 = \underline{\underline{1.80}}$$

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check horizontal shear in Notched beam

Max V

$$V = \frac{2 F_v b d'}{3}\left(\frac{d'}{d}\right)$$

$$\frac{2(130.5)12(10)}{3}\left(\frac{10}{14}\right) = 7457^{\#}$$

design V = 8448 13% over

check Bearing area

$$f_{g\perp} = \frac{P}{A} = \frac{8448}{12(14)} = 50 \text{ psi} \quad \text{ok}$$

$$f_g = \frac{8360}{4(12)} = 174 \text{ psi} \quad \text{OK}$$

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check base of col.

horiz shear.

$$f_v = \frac{VQ}{Ib} = \frac{3V}{2bd}$$

$$V = H_2 = 12672^{\#}$$

$$f_v = \frac{12672(3)}{2(12)(14)} = 113 \text{ psi} < 130.5 \quad \underline{OK}$$

bearing area

$$f_{g\perp} = \frac{P}{A} = \frac{12672}{(3\tfrac{3}{4})12} = 281 \text{ psi} \quad \underline{OK}$$

$$F_g = \frac{8360}{12(14)} = 49 \text{ psi} \quad \underline{OK}$$

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ALLOWABLE STRESSES

BENDING F_b

NOMINAL DESIGN VALUE = 1300 psi
Adjustment FOR DURATION OF LOAD = 0.90
" " SIZE FACTOR = 0.983

$F_b = 1300(.9)(.983) = 1150$ psi

COMPRESSION F_c

NOMINAL DESIGN VALUE = 925 psi
Adjustment FOR DURATION OF LOAD = 0.9

$F_c = 925(.9) = 832$ psi

COMPRESSION F_c'

$$F_c' = F_c\left[1 - \frac{1}{3}\left(\frac{l_d}{K}\right)^4\right] \quad \text{for} \quad 11 < \frac{l}{d} < K = .671\sqrt{\frac{E}{F_c}}$$

$$K = .671\sqrt{\frac{1600000}{832}} = 29.42$$

$$l_d = \frac{19(12)}{14} = 16.28 \quad \text{or} \quad \frac{24(12)}{14} = 20.57$$

$$F_c' = 832\left[1 - \frac{1}{3}\left(\frac{16.28}{29.42}\right)^4\right] \quad \text{or} \quad 832\left[1 - \frac{1}{3}\left(\frac{20.57}{29.42}\right)^4\right]$$

$F_c' = 806$ psi ✓ or 766 psi

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HORIZONTAL SHEAR F_v

NORMAL DESIGN VALUE = 145 psi
ADJUSTMENT FOR DURATION OF LOAD = 0.9

$F_v = 145\ (0.9) = 130.5$ psi

BEARING ON END GRAIN F_g

NORMAL DESIGN VALUE = 1480 psi
ADJUSTMENT FOR DURATION OF LOAD = 0.9

$F_g = 1480\ (0.9) = 1332$ psi

BEARING PERPENDICULAR TO GRAIN $F_{g\perp}$

$F_{g\perp} = F_{c\perp} =$ ~~832~~ psi.
$F_{c\perp} = 385\ (.90) = 346$

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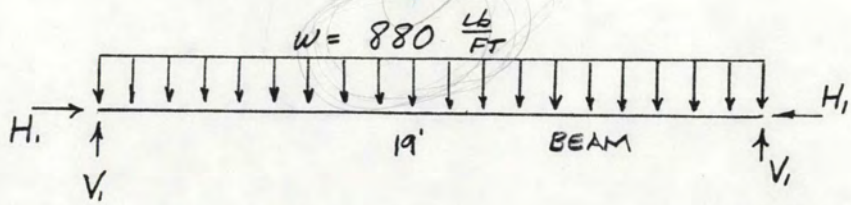


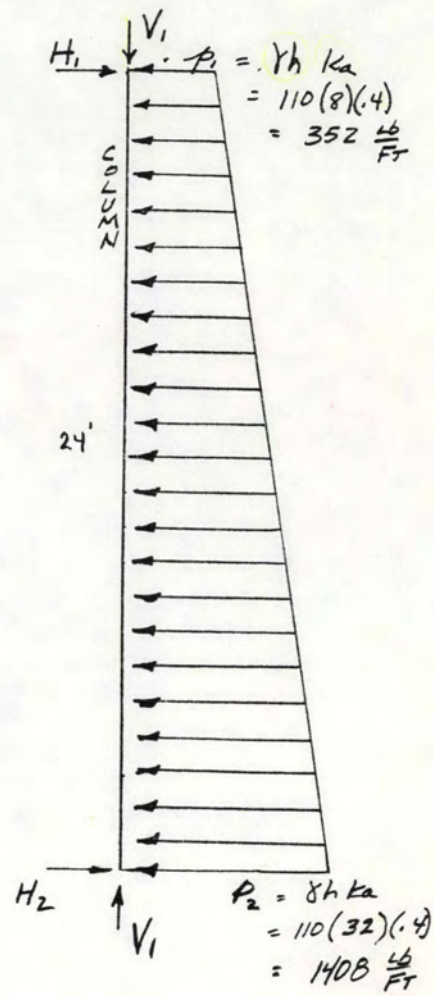
$V_1 = \frac{1}{2}(880)19 = 8360$ lb (+500, 8860)

$H_1 = \frac{1}{24}\left[352(24)\frac{24}{2} + \frac{1}{2}(056)(24)\left(\frac{24}{3}\right)\right]$

$H_1 = 8448$ lb

$H_2 = \frac{1}{2}(1408+352)(24) - 8448$

$H_2 = 12672$ lb



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BEAM

$$\frac{f_c}{F_c'} + \frac{f_b}{F_b - Jf_c} \leq 1$$

$$f_c = \frac{8448 \text{ lb}}{14 \times 12} = 50 \text{ psi}$$

$F_c' = 806$ psi or 766 psi FOR column

$$f_b = \frac{6M}{bd^2}$$

$$M = \frac{wl^2}{8} + \frac{Pl}{4}$$

$$f_b = \frac{6(880 \frac{\text{lb}}{\text{FT}})(19 \text{ FT})^2 \left(\frac{12 \text{ in}}{\text{FT}}\right)^2}{8(12 \text{ in})(14 \text{ in})^2} + \frac{Pl\,6}{4\,bd^2} = 1216 \text{ psi} + 145 = 1361$$

$F_b = 1150$ psi

$$J = \frac{\frac{l}{d} - 11}{K - 11} = \frac{\frac{19(12)}{14} - 11}{29.42 - 11} = .287$$

$$K = .671\sqrt{\frac{E}{F_c}} = 29.42$$

$$\frac{f_c}{F_c'} + \frac{f_b}{F_b - Jf_c} = \frac{50}{806} + \frac{1216}{1150 - .287(50)} = \frac{50}{806} + \frac{1216}{1135.6} = .060 + 1.071 = 1.131$$

.062 + 1.198 = 1.260

13 % OVERSTRESSED IN COMBINED FLEXURAL & AXIAL STRESS.

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check Horizontal shear

$$f_v = \frac{VQ}{Ib} = \frac{3V}{2bd}$$

$$V = \frac{w}{2}\left(1 - \frac{2d}{\ell}\right)$$

$$V = \frac{880 \frac{\#}{FT}(19 FT)}{2}\left(1 - \frac{2(14)}{19(12)}\right) = 7333 \#$$

$$f_v = \frac{3(V)}{2bd} = \frac{3(7333)}{2(12)(14)} = 65.5 \text{ psi}$$

F_v allowable $= 130.5$ psi OK

check BEARING

$F_g = \cancel{832}\ 1332$ psi allowable

$$f_g = \frac{P}{A} = \frac{8360}{4(12)} = 174 \text{ psi}$$ OK

$F_g = 1332$ psi allowable

$$f_g = \frac{8448}{12(14)} = 50 \text{ psi}$$ OK

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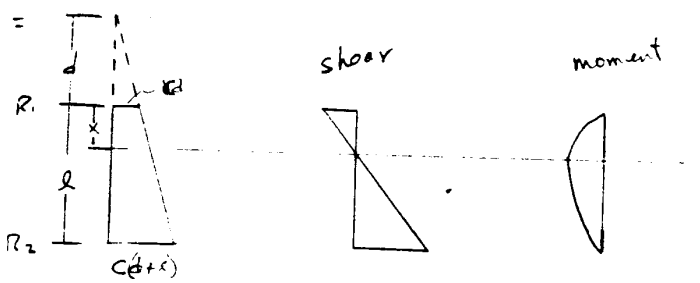
Column

M = occurs at pt of zero shear

X_{dist} from top =



c is slope

$[\Sigma M_{R_2} = 0]$

$$l R_1 = \frac{c d l^2}{2} + \frac{c l l l}{2 \cdot 3}$$

$$R_1 = \frac{c d l}{2} + \frac{c l^2}{6}$$

$[\Sigma F_x = 0]$

$$c d x + \frac{c x x}{2} = \frac{c d l}{2} + \frac{c l^2}{6}$$

$$d x + \frac{x^2}{2} = \frac{d l}{2} + \frac{l^2}{6}$$

$$2 d x + x^2 = d l + \frac{l^2}{3}$$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$x = \frac{-2d \pm \sqrt{4d^2 + 4\left(dl + \frac{l^2}{3}\right)}}{2}$$

$$x = -d + \sqrt{d^2 + dl + \frac{l^2}{3}}$$

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$$M = R_1 x - \frac{c d x x}{2} - \frac{c x x x}{2 \cdot 3}$$

$$= \frac{c d \ell x}{2} + \frac{c \ell^2 x}{6} - \frac{c d x^2}{2} - \frac{c x^3}{6}$$

$$M = -\frac{cx}{6}\left(x^2 + 3dx - \ell^2 - 3d\ell\right)$$

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$$x = -d + \sqrt{d^2 + dl + \frac{l^2}{3}}$$

$$x = -8 + \sqrt{8^2 + 8(24) + \frac{24^2}{3}}$$

$$x = 13.16^{FT}$$

$$M = -\frac{cx}{6}\left(x^2 + 3dx - l^2 - 3dl\right)$$

$$c = \gamma K_a = 110(.4) = 44$$

$$M = -\frac{44(13.16)}{6}\left[(13.16)^2 + 3(8)(13.16) - 24^2 - 3(8)(24)\right]$$

$$M = 63{,}980 \text{ ft lb}$$

$$= 767{,}777 \text{ in lb.}$$

$$f_b = \frac{6M}{bd^2} = \frac{6(767777)}{12(14)(14)} = 1958 \text{ psi}$$

$$f_c = \frac{8360}{12 \times 14} = 49.76$$

$$\frac{f_c}{F_c'} + \frac{f_b}{F_b - Jf_c} = \frac{49.76}{832} + \frac{1958}{1150 - .519(49.76)} =$$

$$= \frac{49.76}{832} + \frac{1958}{1124} = .060 + 1.74 = \underline{\underline{1.80}}$$

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check horizontal shear in Notched beam

Max V

$$V = \frac{2 F_v b d'}{3}\left(\frac{d'}{d}\right)$$

$$\frac{2(130.5)12(10)}{3}\left(\frac{10}{14}\right) = 7457^{\#}$$

design V = 8448 13% over

check Bearing area

$$f_{g\perp} = \frac{P}{A} = \frac{8448}{12(14)} = 50 \text{ psi} \quad \text{ok}$$

$$f_g = \frac{8360}{4(12)} = 174 \text{ psi} \quad \text{OK}$$

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check base of col.

horiz shear.

$$f_v = \frac{VQ}{Ib} = \frac{3V}{2bd}$$

$$V = H_2 = 12672^{\#}$$

$$f_v = \frac{12672(3)}{2(12)(14)} = 113 \text{ psi} < 130.5 \quad \underline{ok}$$

bearing area

$$f_{g\perp} = \frac{P}{A} = \frac{12672}{(3\tfrac{3}{4})12} = 281 \text{ psi} \quad \underline{ok}$$

$$F_g = \frac{8360}{12(14)} = 49 \text{ psi} \quad \underline{ok}$$

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BD 1 (N-2-79)

To: A.E. Chambers E 37247 ESR#P67-79

Rockwell Hanford Operations | ENGINEERING SERVICE REQUEST

COMPLETED BY REQUESTOR

Requestor	Organization	Cost Code	Date Approved	Date Requested
G.K. Carpenter 22830 ~~G. R. Silvan~~	65250 Purex/UO_3 Process Control	K353E E07053	10/1/79	11/2/79

Descriptive Title

Evaluation of Purex No. 1 Burial Tunnel Structural Integrety

Description of services required (including drawing or documents involved, design criteria, and special conditions) - Attach additional sheets as required.

Evaluate the structural integrety of the support timbers on the no. 1 burial tunnel to determine:

1. How much structural strenth may be lost by the wood timbers before tunnel collapse occurs.
2. How the timbers will fail when and if they do.
3. what the effect of two or three four inch holes in the tunnel roof will have on structural integrety.

Ref. Drawings: H-2-55586, 87, 88, & 89

Preliminary Contacts	Initiator Approval	Management Approval
G. R. Silvan, 21587	G.R. Silvan	[illegible]

COMPLETED BY ENGINEERING

Reviews Required

Informal Design Review ☐ Formal Design Review ☐ Hazards Review ☐

QA Level

Reviewers

Operations

Process Eng

Maintenance

Q.A.

Safety

Independent Reviewer

Other

Engineers Instructions

Document or Drawings Produced

Date Completed

Date Required

Assigned Supervisor

Assigned Engineer

Date Received

Date Assigned

Engineering Job Number

CC: [redacted]

C. Rivers

D.E. Place

A 6999 999 (1)

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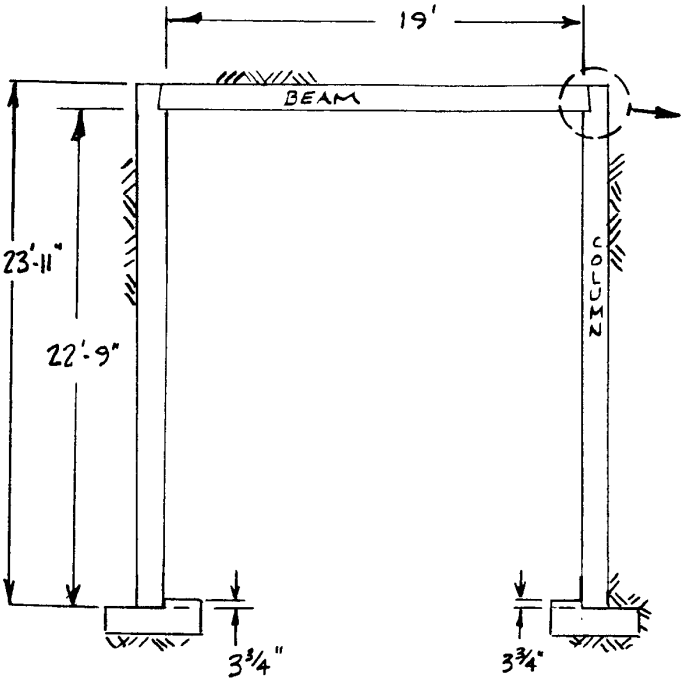

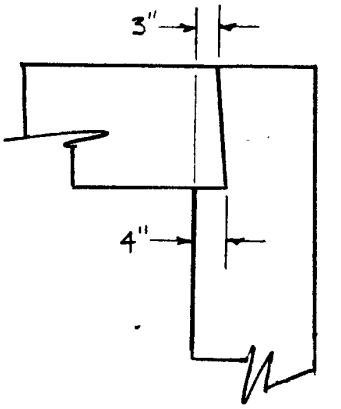

BD-6400-060.1 (N-2-79)

EM-PUREX-005

Internal Letter

Rockwell International

Date November 12, 1979

No. 65431-79-080

TO: (Name, Organization, Internal Address)
. G. K. Carpenter
. Purex Operations
. 202A, 200 East

FROM: (Name, Organization, Internal Address, Phone)
. G. R. Wagenblast
. Engineering Mechanics
. 2750-E/MO-043, 200 East
. 2-1047

Subject: . Evaluation of Purex No. 1 Burial Tunnel

Ref: Engineering Service Request P67-79

An evaluation of the structural integrity of the timbers in the 218-E-14 Purex number 1 railroad tunnel has been completed. The soil loads due to eight feet of earth cover were found to produce stresses in excess of current design limits. The stresses, however, are expected to be below the ultimate stress levels. The tunnel is not expected to be in any danger of collapse.

The following comments are in direct response to the questions raised in the reference ESR.

1. The amount of structural strength that may be lost before the tunnel will collapse is unknown. The current design stress limit has an average safety factor of 2.5. The actual safety factor, however, will vary from 1.25 to 5.
2. If an individual timber were to fail it would be from bending stresses. The beam would crack at mid span which would allow excessive deflection. As the beam deflects, the soil load would be transferred to the adjacent timbers. Collapse of the tunnel would not occur.
3. A four inch hole in a twelve inch wide beam will reduce its strength by one third. A hole that is located in an area of the beam that is subjected to low stresses will not adversely effect the capability of the beam to withstand the soil loads.

   Any number of four inch diameter holes will not reduce the capability of the timbers, so long as they are located a minimum of three feet and a maximum of six feet from the tunnel center line.

If you have any questions, please call me on 942-1047.

Gary R Wagenblast

G. R. Wagenblast
Engineering Mechanics

GRW/lka

cc: D. L. Becker
G. R. Silvan

54-6000-030

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Attachment 3

Photograhic Timeline of the PUREX Storage Tunnels

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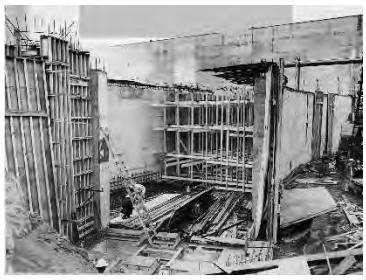
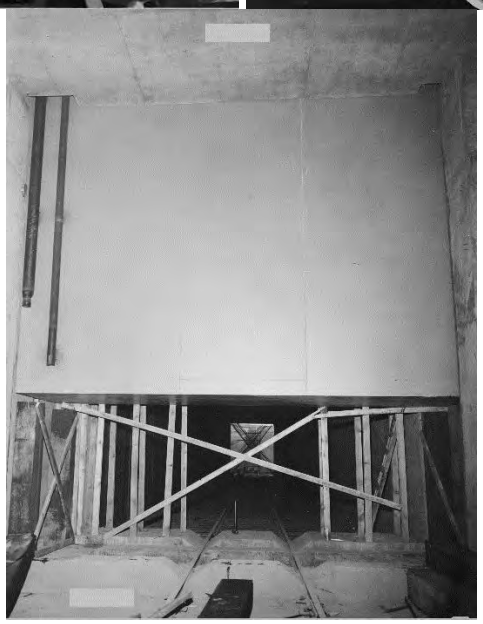
PUREX STORAGE TUNNELS

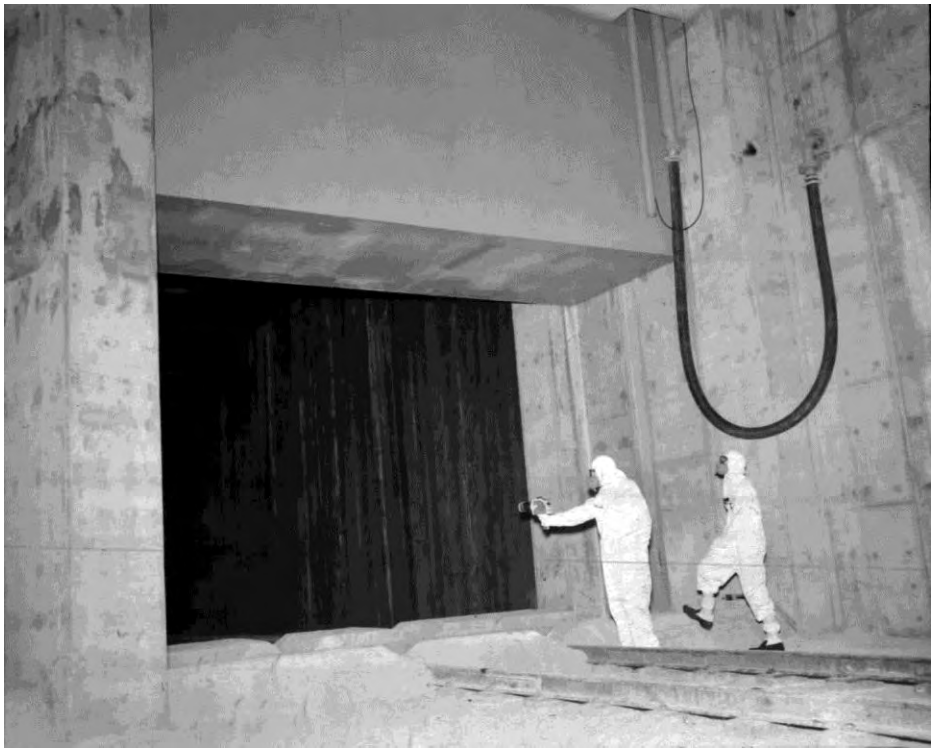
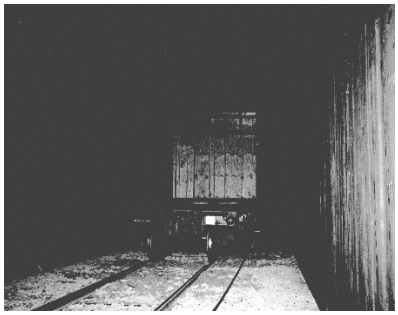
218-E-14 - TUNNEL NO. 1

218-E-15 - TUNNEL NO. 2

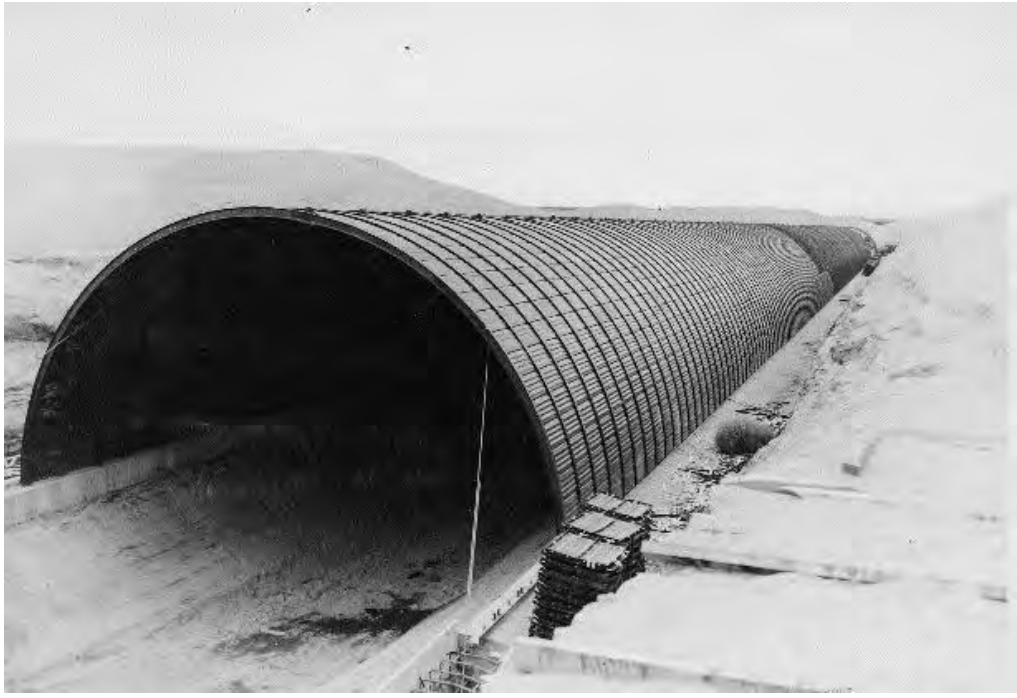
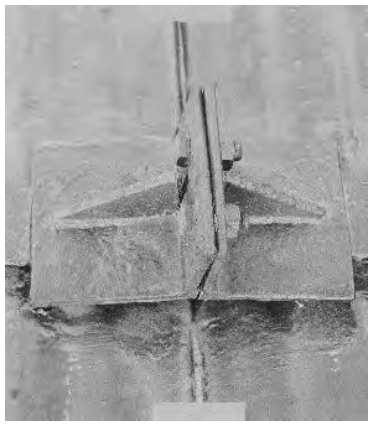
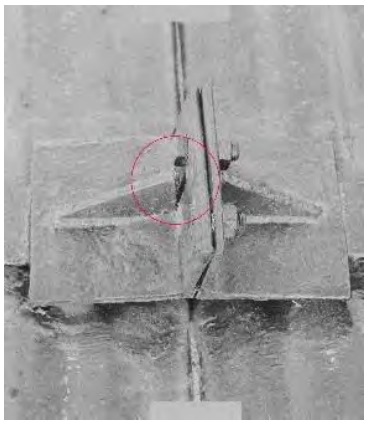
TUNNEL NO. 1

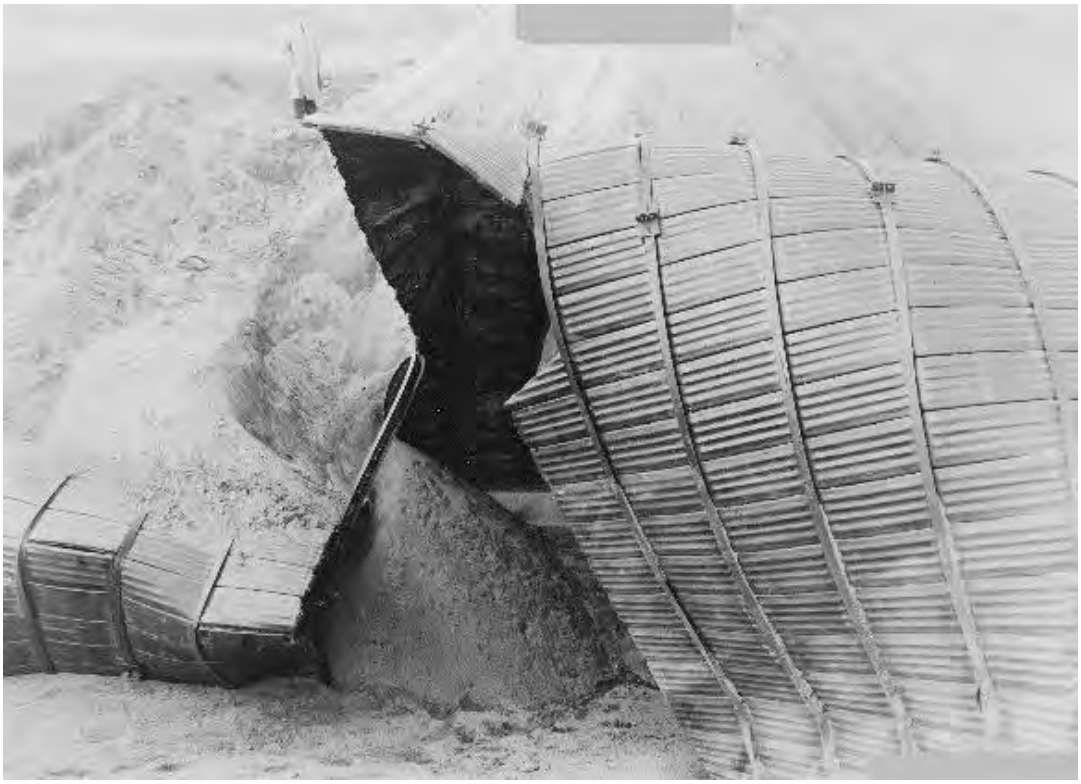
Description	Photo/Document
August, 1955 Construction proceeding.	
August, 1955	
September, 1955	
October, 1955	

November, 1955	
November, 1955	

December 1955 Construction Complete	
Assumed circa 1960 Tunnel No. 1 construction complete and in service.	
June, 1960	

TUNNEL NO. 2

Description	Photo/Document
November, 1963 Construction proceeding.	
20 January, 1964 Inspection finds 32 broken butt-angle gusset-plate welds over approximately 600 linear ft of metal arch tunnel. Prior to this inspection, objections had been raised over the manner of backfilling, using 2 D-9 Caterpillar bulldozers to push soil down on the sides of the arch tunnel, "Imposing a load on the sides of the tunnel wall(s)" with the weight of the machines projecting into the arch load zone.	 

22 January, 1964 Approximately 1030 hrs, 75 linear feet of tunnel collapsed. Sections of the arch tunnel that had been backfilled before the collapse showed flattening of the tunnel sides.	
30 January, 1964 Began removing approximately 5 feet of backfill from each side of the arch tunnel. Measurements were taken, and showed no significant recovery of the tunnel walls. Four more feet of backfill were removed; the maximum observed recovery was less than 2 inches.	

15 February, 1964 New backfill method begun. A drag-line was used to place fill on the top of the arch tunnel to distribute the load concentrically. The fill spilled down the sides of the arch. The angle of repose of the walls was reduced, and bulldozers used to push large piles of soil along the sides of the excavation were kept away from the edge. Concentric loading was observed and measured. However some deflection was still observed occurring in one portion of the tunnel after 2 days, and the backfill over that section was removed. Backfilling of the arch tunnel using this method continued.	
2 March, 1964 Approximately 1000 hrs, approximately 68 linear feet of the rib & pan portion of the tunnel collapsed. Damage was found along both east & west weldments and footings. At the time of the collapse, drag-line backfill operations were occurring some distance in "front" of the collapse section, and on one side of the tunnel. The east side collapsed first. Note – Bottom photograph includes a section of collapsed tunnel and a D9 CAT	

DWG release dates suggest a “re-design” effort had been established. Tunnel No. 2 was excavated, and internal lateral structural I-beams were installed.	H-2-58194 REV 0 Release date of 9/1962 (Approved for Construction) Photos show that in January 1964 Tunnel No. 2 is being buried without internal (I-Beam) supports H-2-58194 REV 2 Release date of 4-9-1965 PER VITRO Engineering H-2-58737 REV 0 Release date of 4-24-1964 H-2-58532, H-2-58533 Release date 6-17-1964
January thru march 1964 excavation	N/A
On July, 1964 construction of external footings to support whaler and cross member arch supports are installed	
On August thru November, 1964 construction of external whaler and cross member arch supports are installed as concrete forms are placed into position	

On August, 1964 additional internal structural I-beams and tie bars are placed into position and installed inside of Tunnel No. 2	
On November, 1964 a drag line is utilized to bury the modified Tunnel No. 2	

Assumed circa 1966 Tunnel No. 2 construction complete and in service.	

Attachment 4

CHPRC-03241, PUREX Burial Tunnels

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CHPRC-03241
Revision 0

PUREX Burial Tunnels

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Contractor for the U.S. Department of Energy
under Contract DE-AC06-08RL14788

P.O. Box 1600
Richland, Washington 99352

Approved for Public Release;
Further Dissemination Unlimited

CHPRC-03241
Revision 0

PUREX Burial Tunnels

Document Type: RPT

M. A. Maloof
CH2M HILL Plateau Remediation Company

Date Published
March 2017

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

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P.O. Box 1600
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APPROVED
By Lana Perry at 4:40 pm, Apr 20, 2017

Release Approval | Date

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PUREX BURIAL TUNNELS

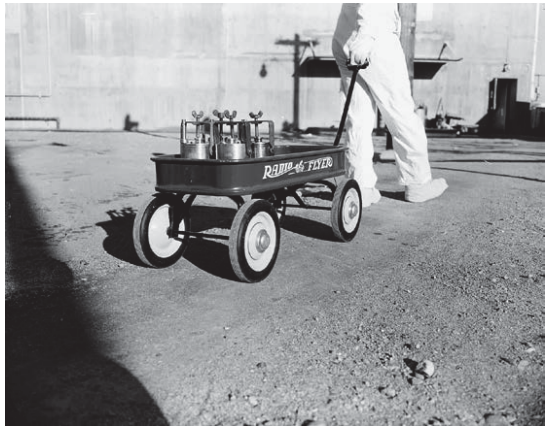
218-E-14 – TUNNEL NO. 1
(NOVEMBER, 1955)

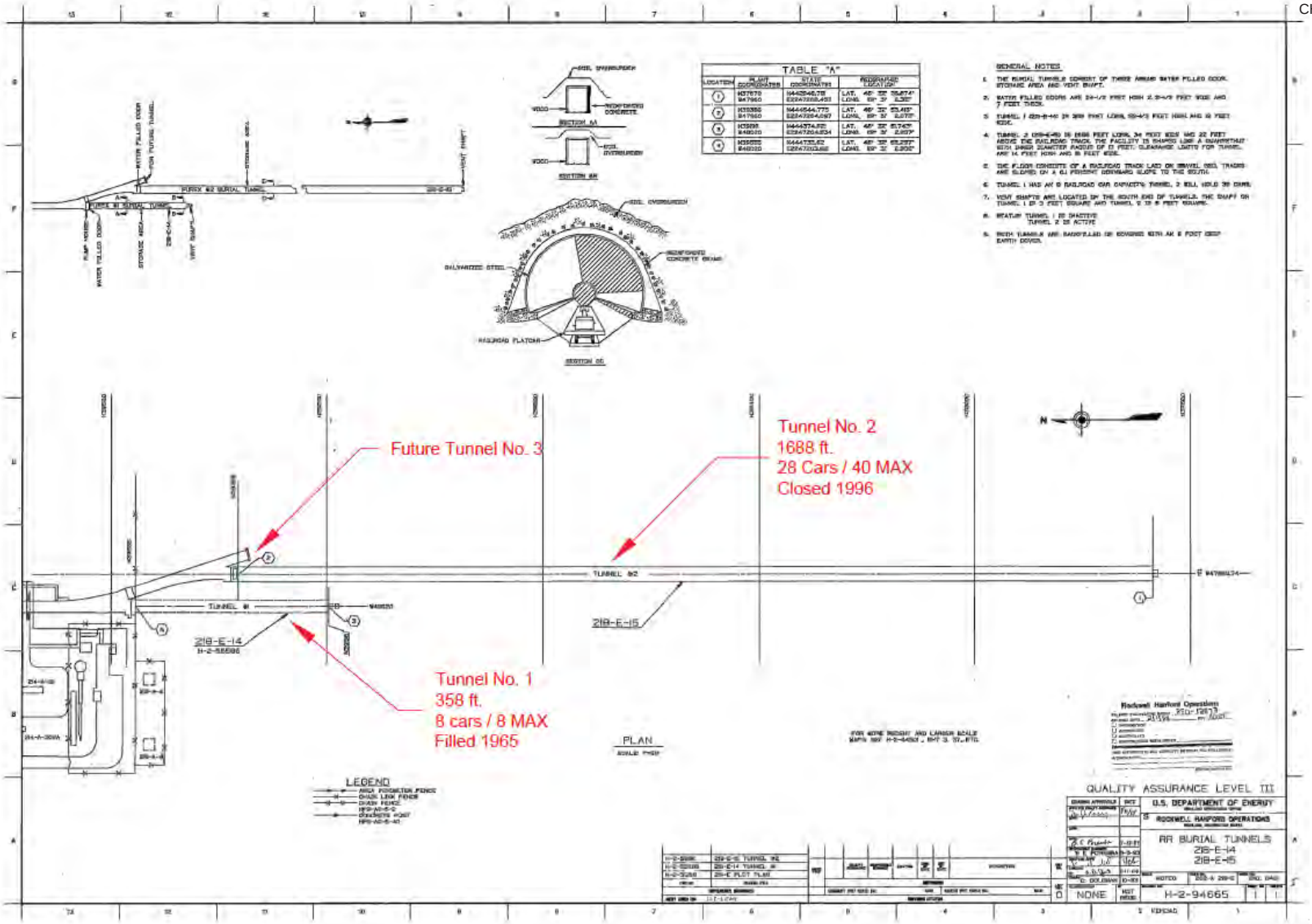
218-E-15 – TUNNEL NO. 2
(JANUARY, 1964)

CHPRC-03241, Revision 0

3

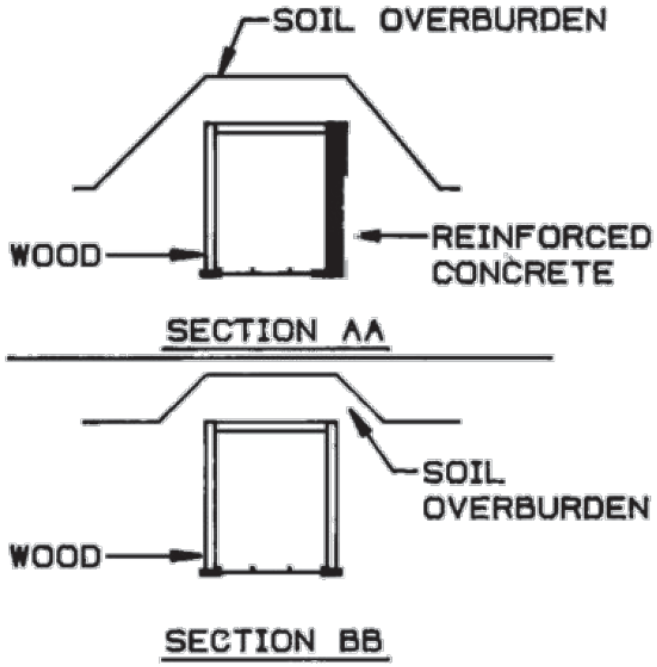
Since 1955 some things on site (at Hanford) haven't changed all that much…



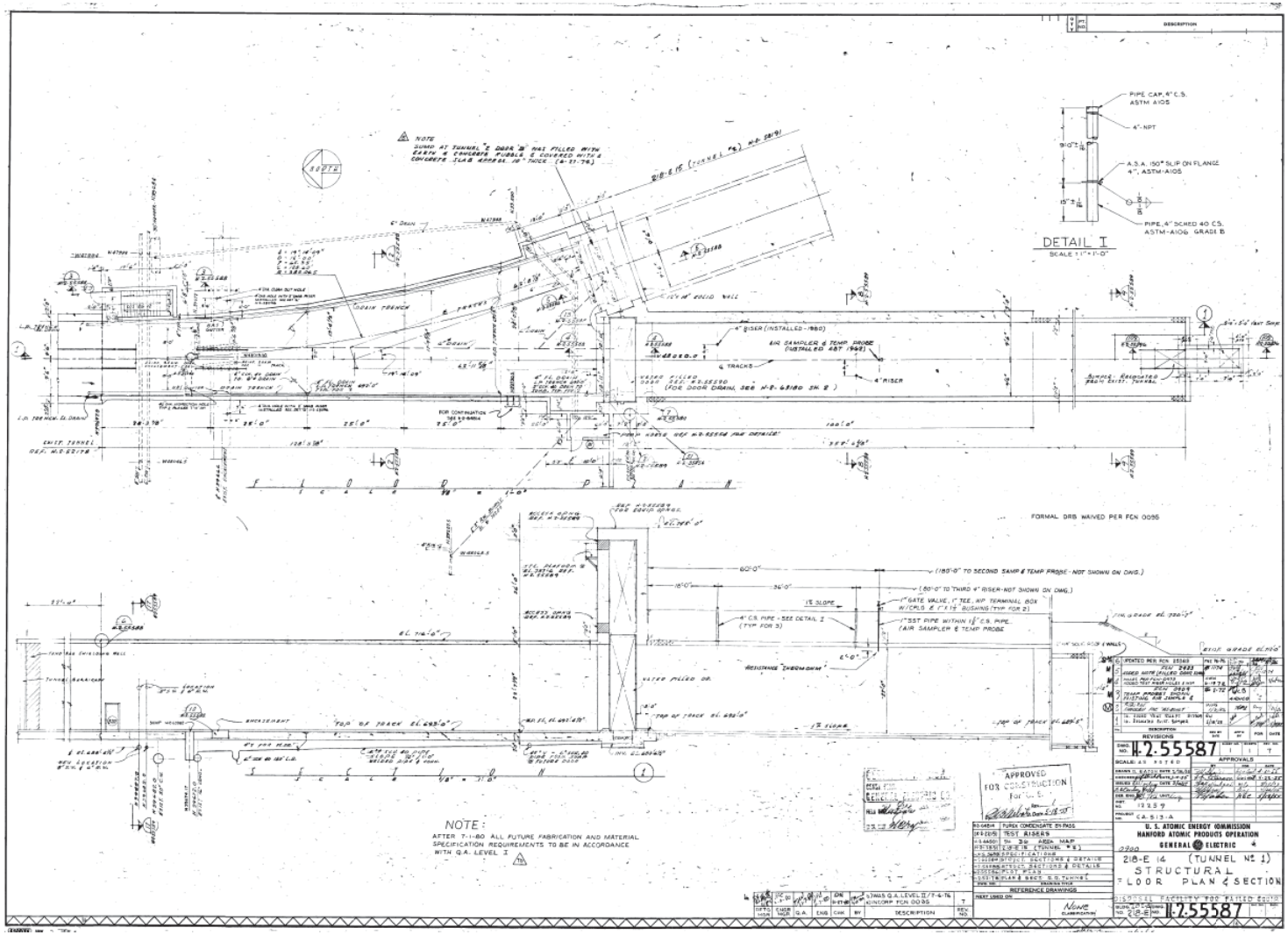

Future Tunnel No. 3
Tunnel No. 2
1688 ft.
28 Cars / 40 MAX
Closed 1996
Tunnel No. 1
358 ft.
8 cars / 8 MAX
Filled 1965
218-E-14
218-E-15
PLAN
LEGEND
TABLE "A"
GENERAL NOTES
QUALITY ASSURANCE LEVEL III
U.S. DEPARTMENT OF ENERGY
ROCKWELL HANFORD OPERATIONS
RR BURIAL TUNNELS
218-E-14
218-E-15
H-2-94665

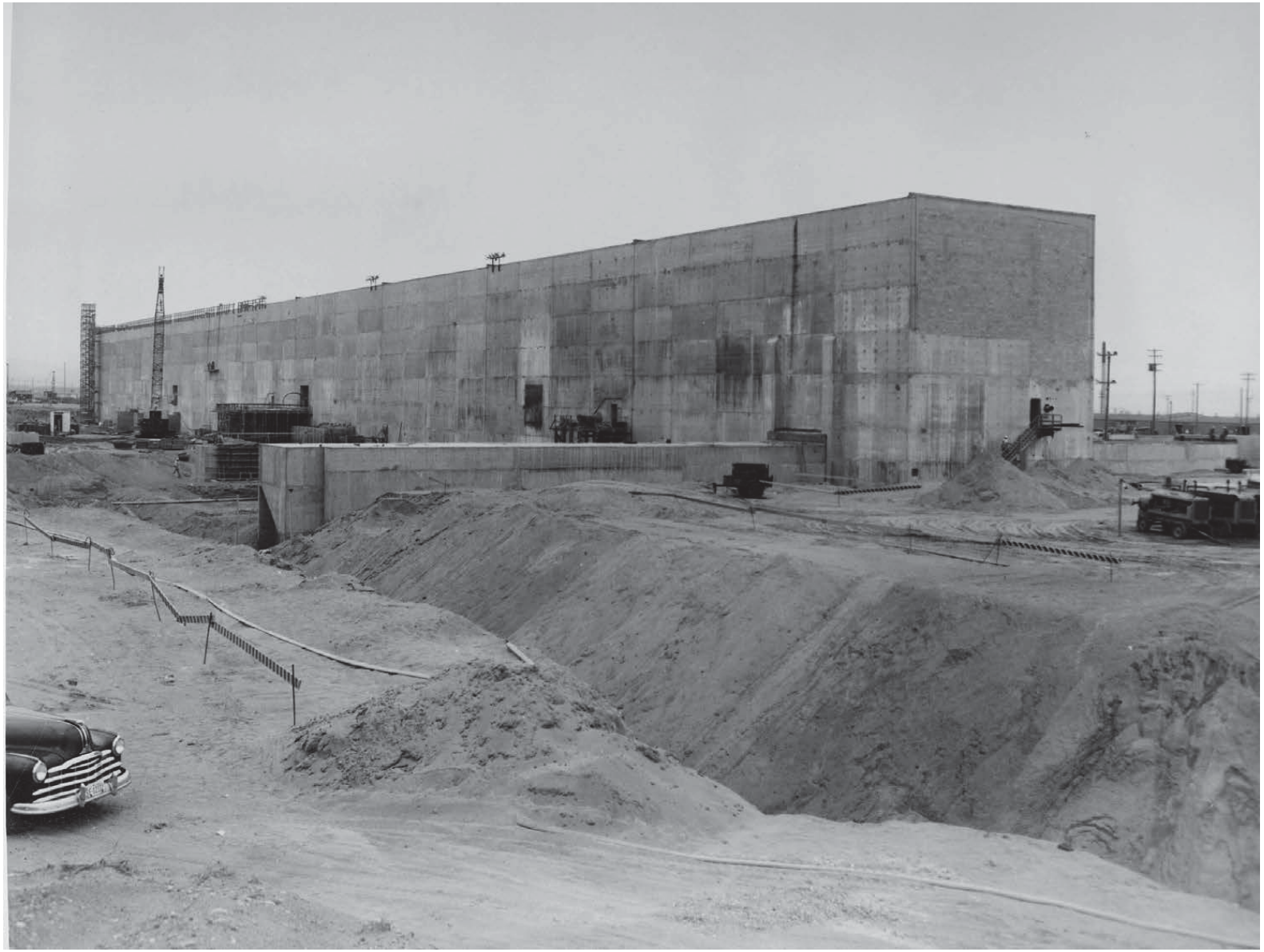
TUNNEL NO. 1 CONFIGURATION

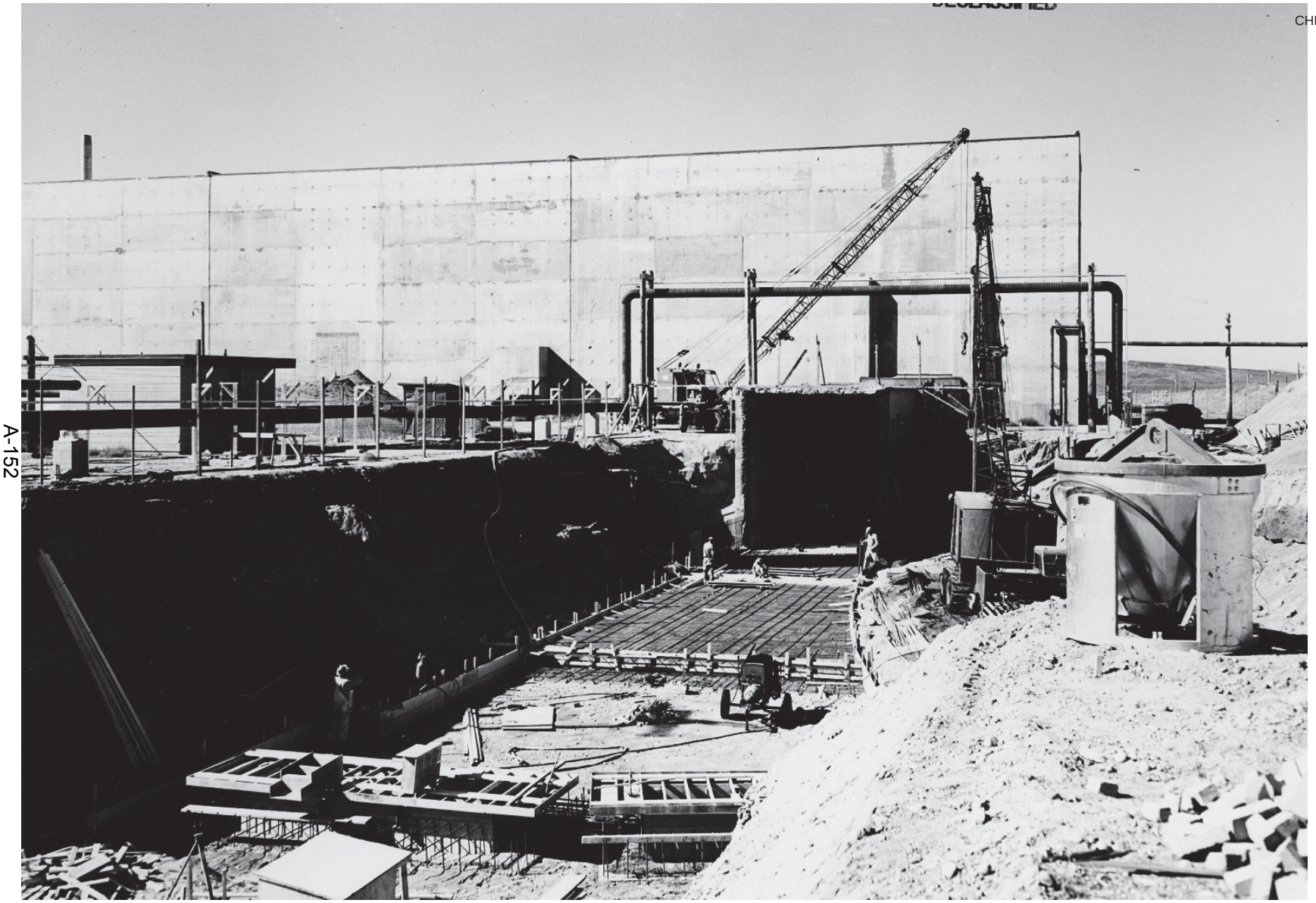
- Constructed 1954-1956
- 358 Ft. Long
- Wood Construction
- Capacity 8 RR Cars
- Service Life 1956-1965
- Filled in 1965 & CLOSED
- Ventilated till 1996

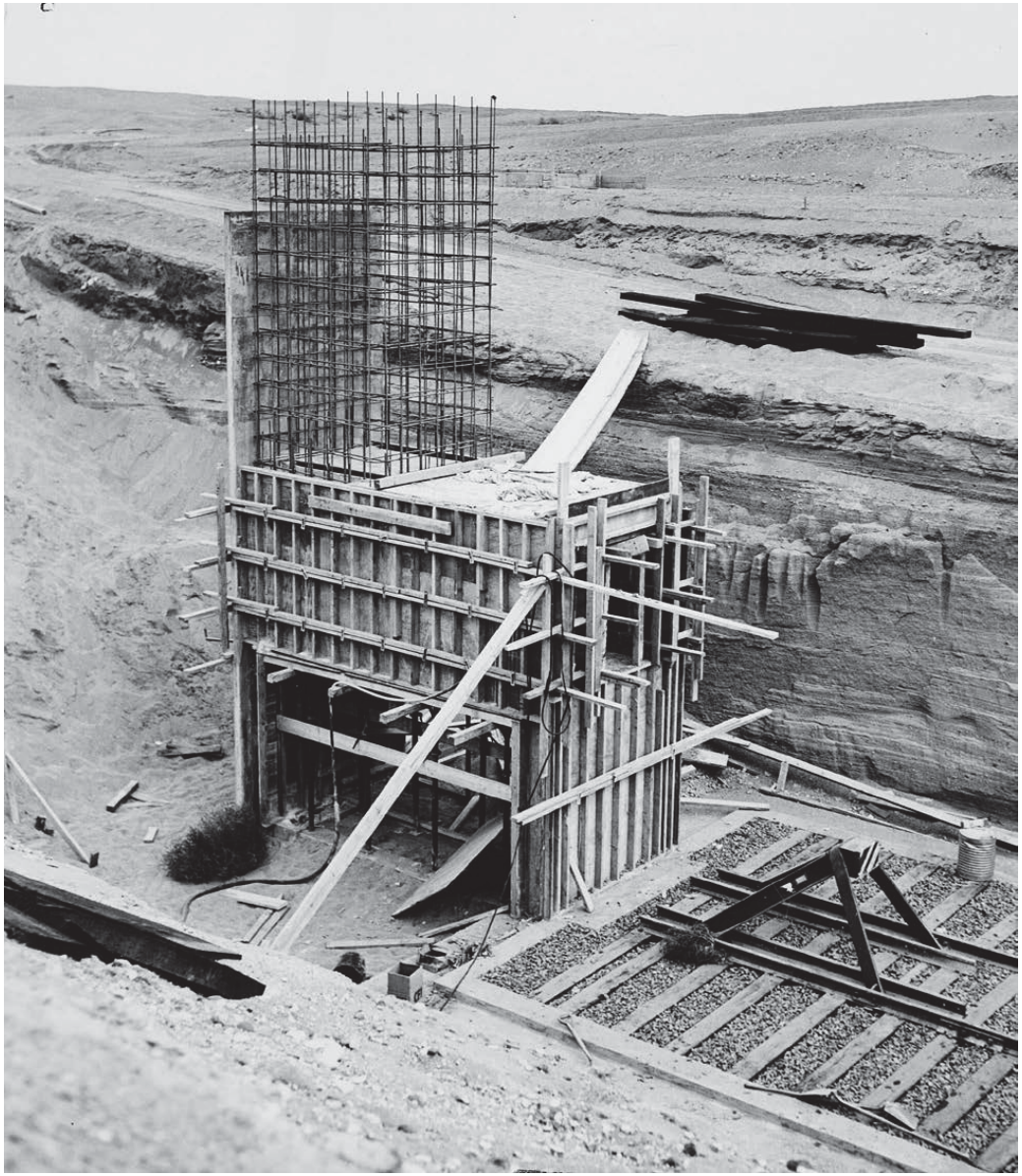


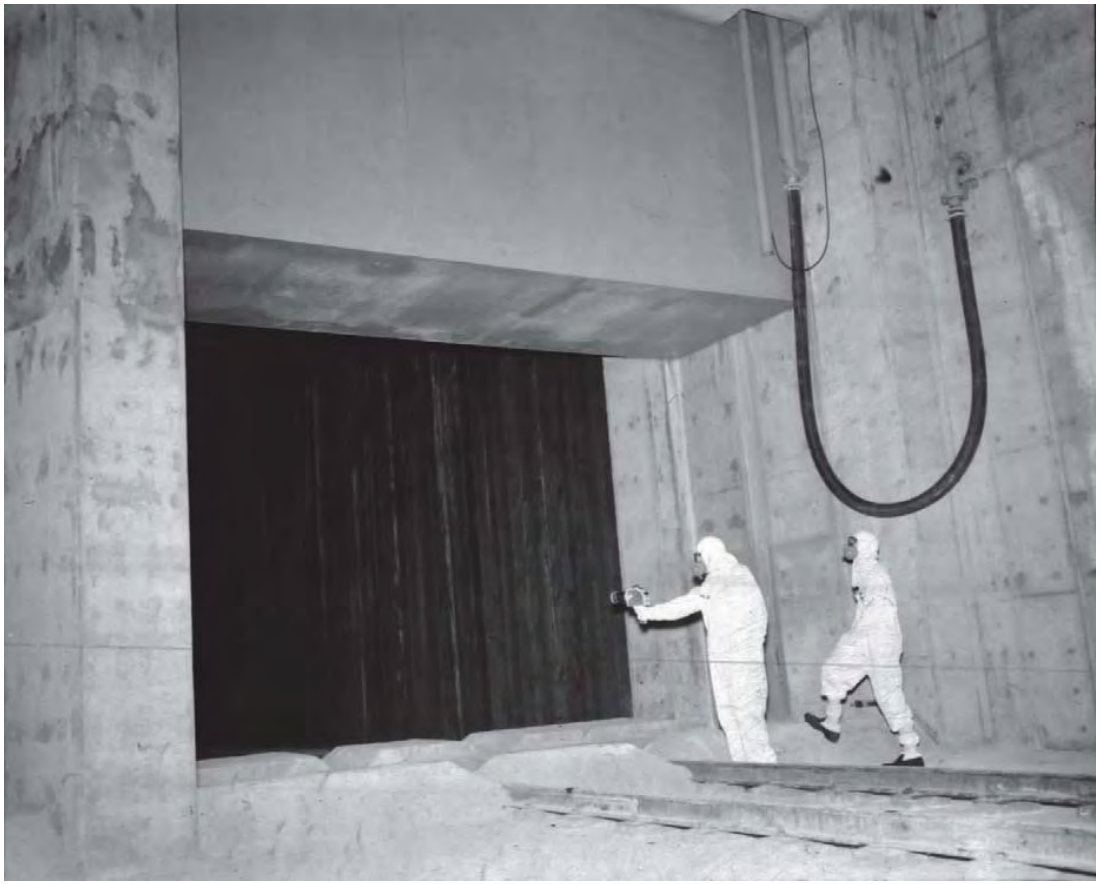
CONSTRUCTION TUNNEL NO. 1

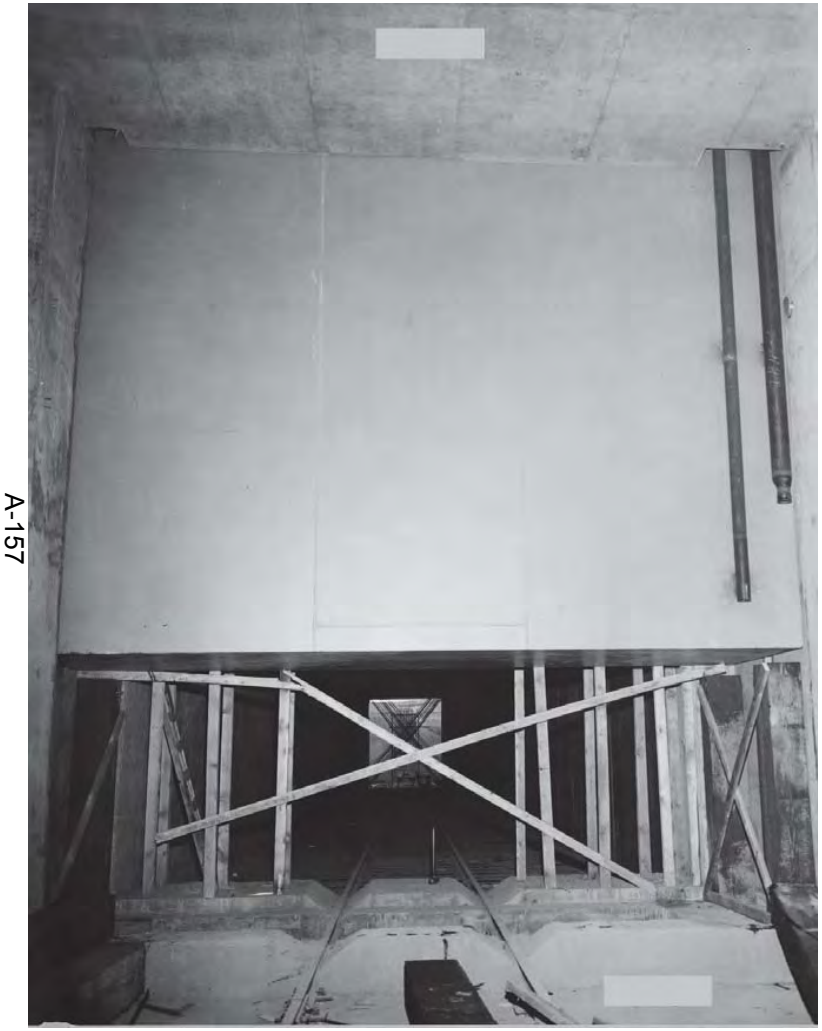


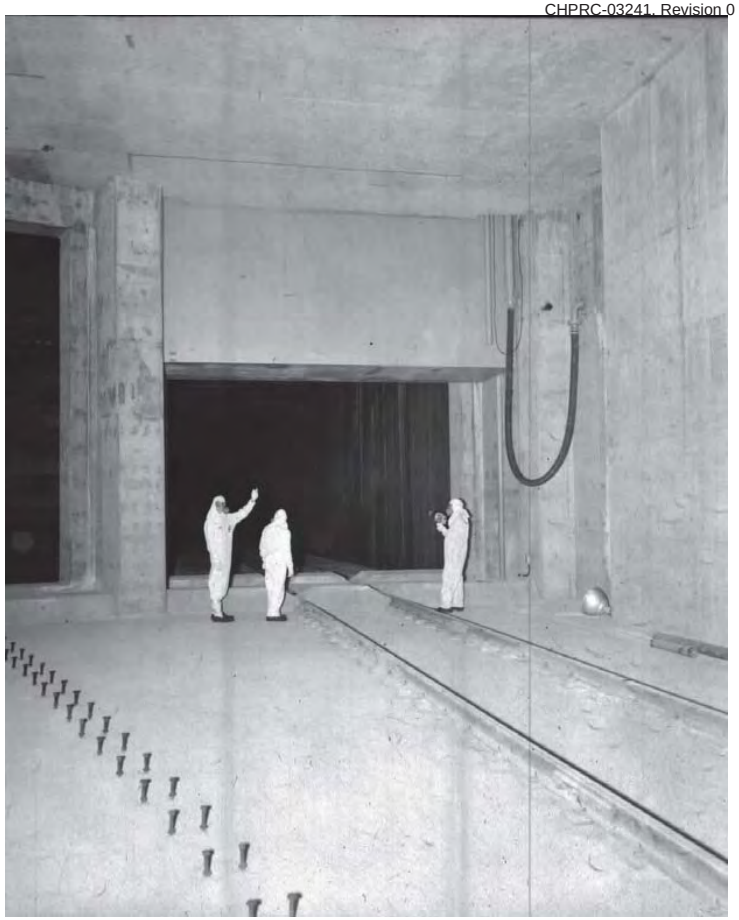


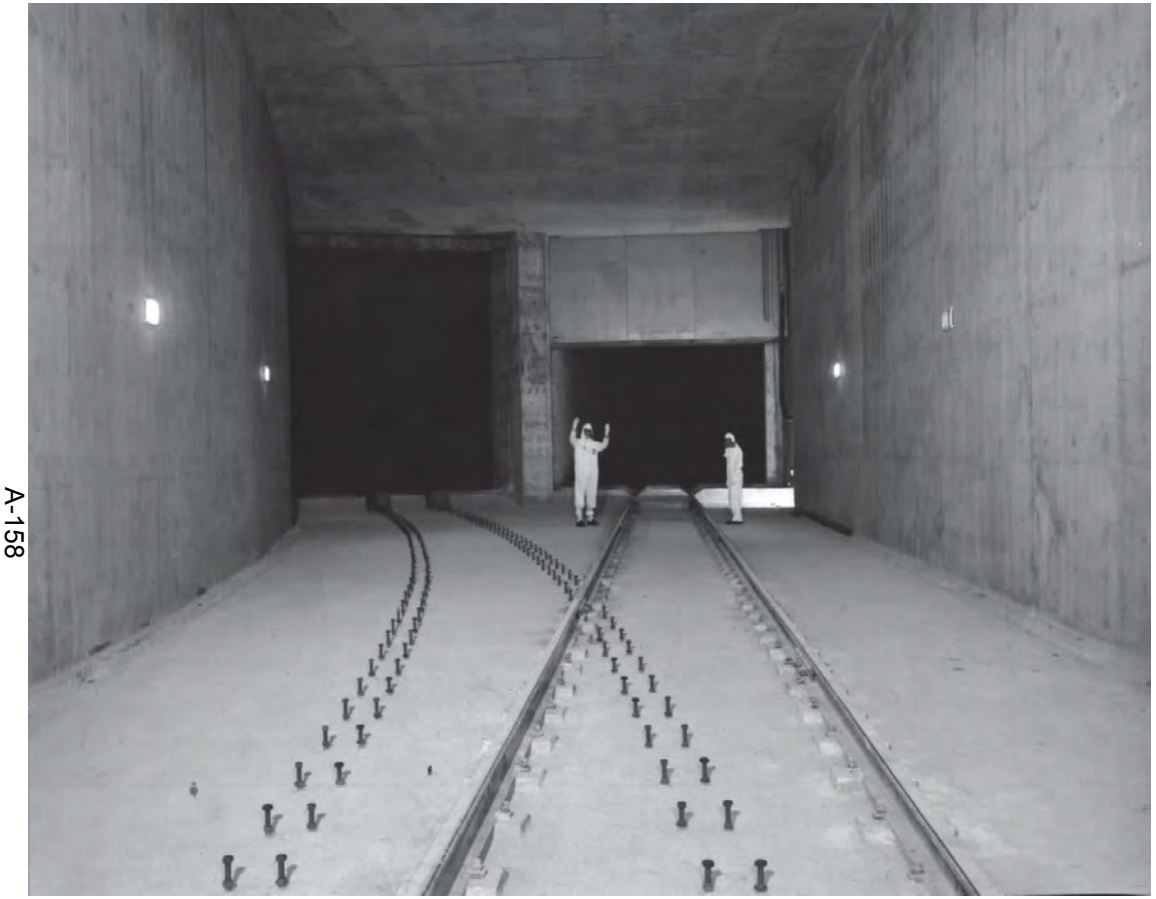












TUNNEL NO. 1 INVENTORY

Table 1: PUREX NO. 1 BURIAL TUNNEL INVENTORY

Burial Car No.	Burial Date	Contents	Initial Dose Rate
1&2	6-60	HA Separations Column Box of Misc. Jumpers	5 r/hr @ 60’
3	7-24-60	E-F11, 1WW Waste Concentrator	12.5 r/hr @ 100’
4	12-24-60	G-E4 Centrifuge Two Concentrator Tube Bundles Box of Misc. Jumpers	1.5 r/hr @ 150’
5	1-4-61	E-H4, 3WB Concentrator	150 mr/hr @ 50’
6	4-21-61	E-F6, 2WW Waste Concentrator	5 r/hr @ 20’
7	2-8-61	E-F11, 1WW Waste Concentrator	25 r/hr @ 150’
8	1-22-65	E-F6, 1WW Waste Concentrator	Unrecorded

Table 1. PUREX Storage Tunnels Inventory. (sheet 1 of 4)

PUREX #1 STORAGE TUNNEL (218-E-14)

TUNNEL IS AT ITS CAPACITY AS OF 1/22/65

PUREX #1 Storage Tunnel is located at the southeast end of the PUREX Plant and is an extention of the railroad tunnel. The storage area is approximately 109 meters long, 6.9 meters high and 5.8 meters wide. The tracks have a one percent down-grade toward the south end of the tunnel. The capacity of the Storage Tunnel is eight modified railroad cars, 12.8 meters long.

position

1. & 2. HA COLUMN AND MISC JUMPERS IN BOX
PLACED IN TUNNEL #1 ON 6/60
HA 4,700 CU. FT., 400 CURIES, 5 rem/hr. @ 60'.
JUMPRS 2,190 CU. FT., 2,000 CURIES, Pb – ~115 Kg.

3. E-F11 #1 (1WW WASTE) CONCENTRATOR FAILED 7/24/60.
PLACED IN TUNNEL #1 ON 7/29/60, 12.5 rem/hr. @ 100'.
1,900 CU. FT., 40, 000 CURIES AFTER FIFTY-FIVE MONTHS SERVICE.

4. G-E2 CENTRIFUGE, MISC JUMPERS IN BOX AND TWO TUBE BUNDLES.
PLACED IN TUNNEL #1 ON 12/24/60 (TUG SER# 782)
2,465 CU. FT., 3,000 CURIES, Pb – ~115 Kg., 1.5 rem/hr. @ 150'.

5. E-H4 (3WB) CONCENTRATOR FAILED 1/4/61.
PLACED IN TUNNEL #1 ON 1/4/61, 150 mrem/hr. @ 50'.
2,336 CU. FT., 1,000 CURIES. AFTER FIVE YEARS SERVICE.

6. E-F6 (2WW WASTE) ORIGINAL CONCENTRATOR FAILED 4/21/61.
PLACED IN TUNNEL #1 ON 4/21/61, 5 rem/hr. @ 20'.
2,336 CU. FT., 700 CURIES. AFTER FIVE YEARS FOUR MONTHS SERVICE.

7. E-F11 (1WW WASTE) #2 CONCENTRATOR FAILED 2/1/62.
PLACED IN TUNNEL #1 ON 2/8/62, 25 rem/hr. @ 150'.
2,336 CU. FT., 40,000 CURIES. AFTER EIGHTEEN MONTHS SERVICE.

8. E-F6 (2WW WASTE) #3 SPARE CONCENTRATOR FAILED 5/23/64.
PLACED IN TUNNEL #1 ON 1/22/65 FLAT CAR 3821.
2,400 CU. FT., 700 CURIES, 5 rem/hr. @ 20'.

970324.1118

T-1.1

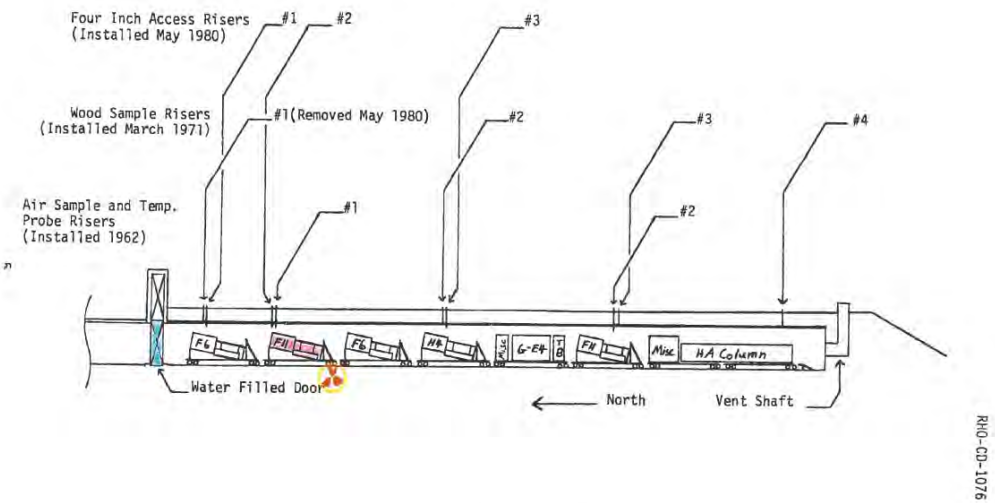


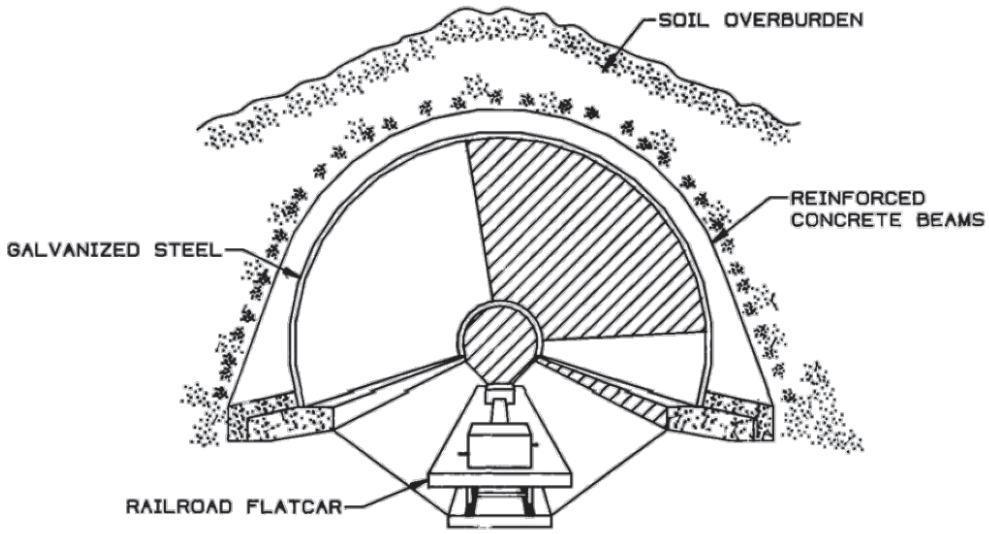
FIGURE 2: PUREX NO. 1 BURIAL TUNNEL

1996 – TUNNEL NO. 1 HVAC DEACTIVATED

2016 - TUNNEL NO. 1 HVAC STACK CURRENT CONFIGURATION

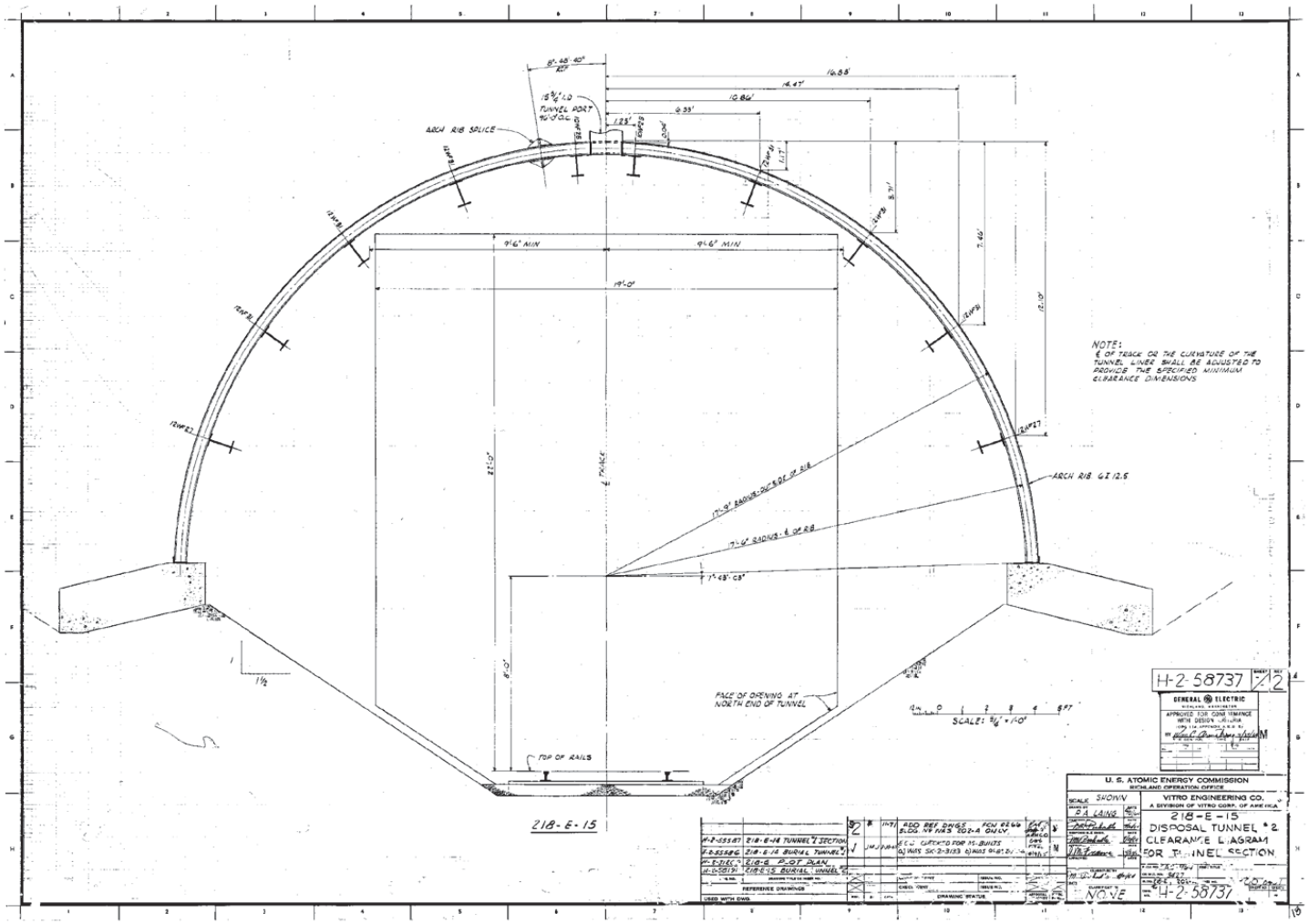
TUNNEL NO. 2 CONFIGURATION

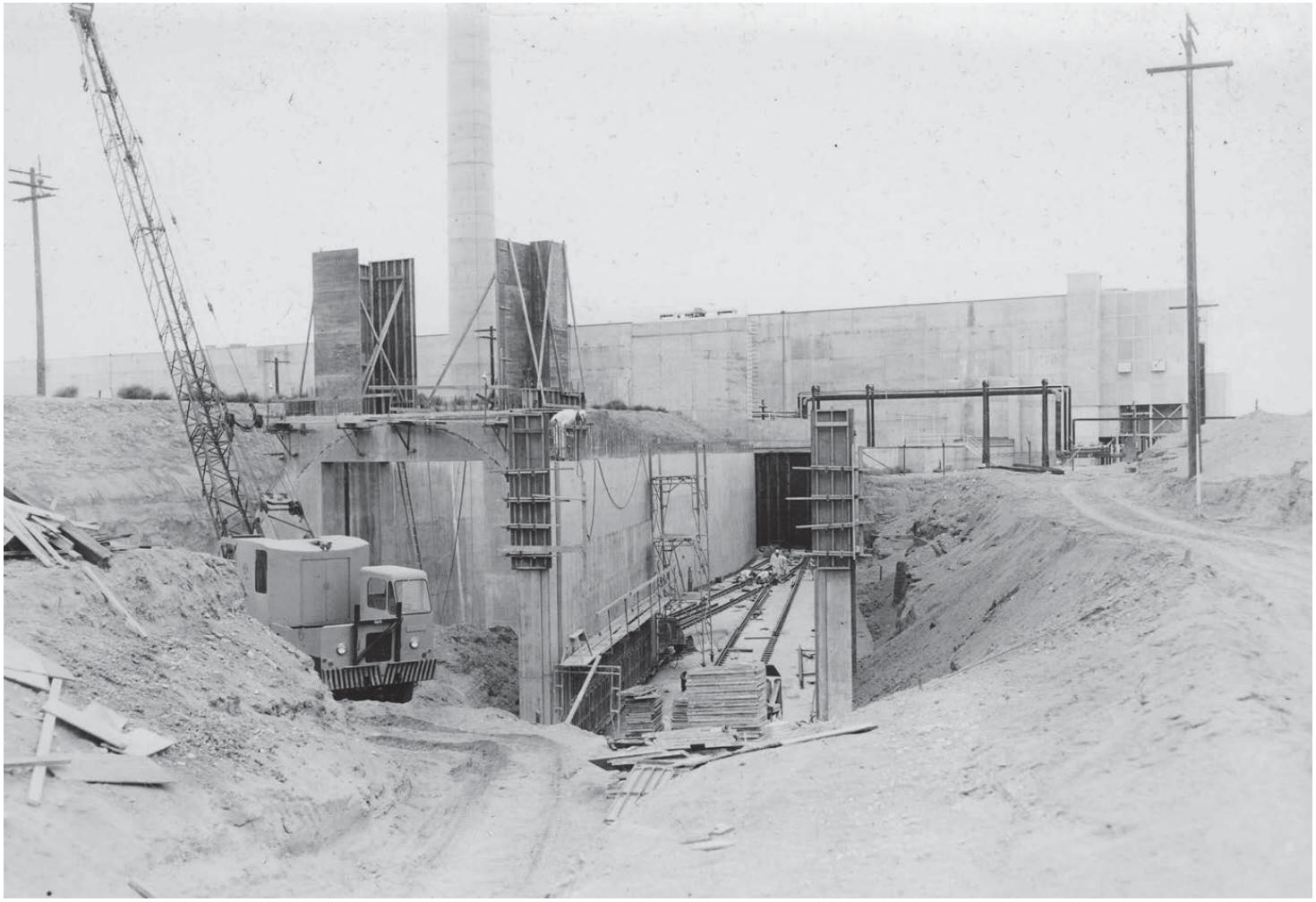
- Constructed 1964-1966
- 1688 Ft. Long
- Steel & Concrete
- Capacity 40 RR Cars
- Service Life 1966-1996 & Deactivated
- Current Inventory 28 RR Cars
- Ventilated till 1996

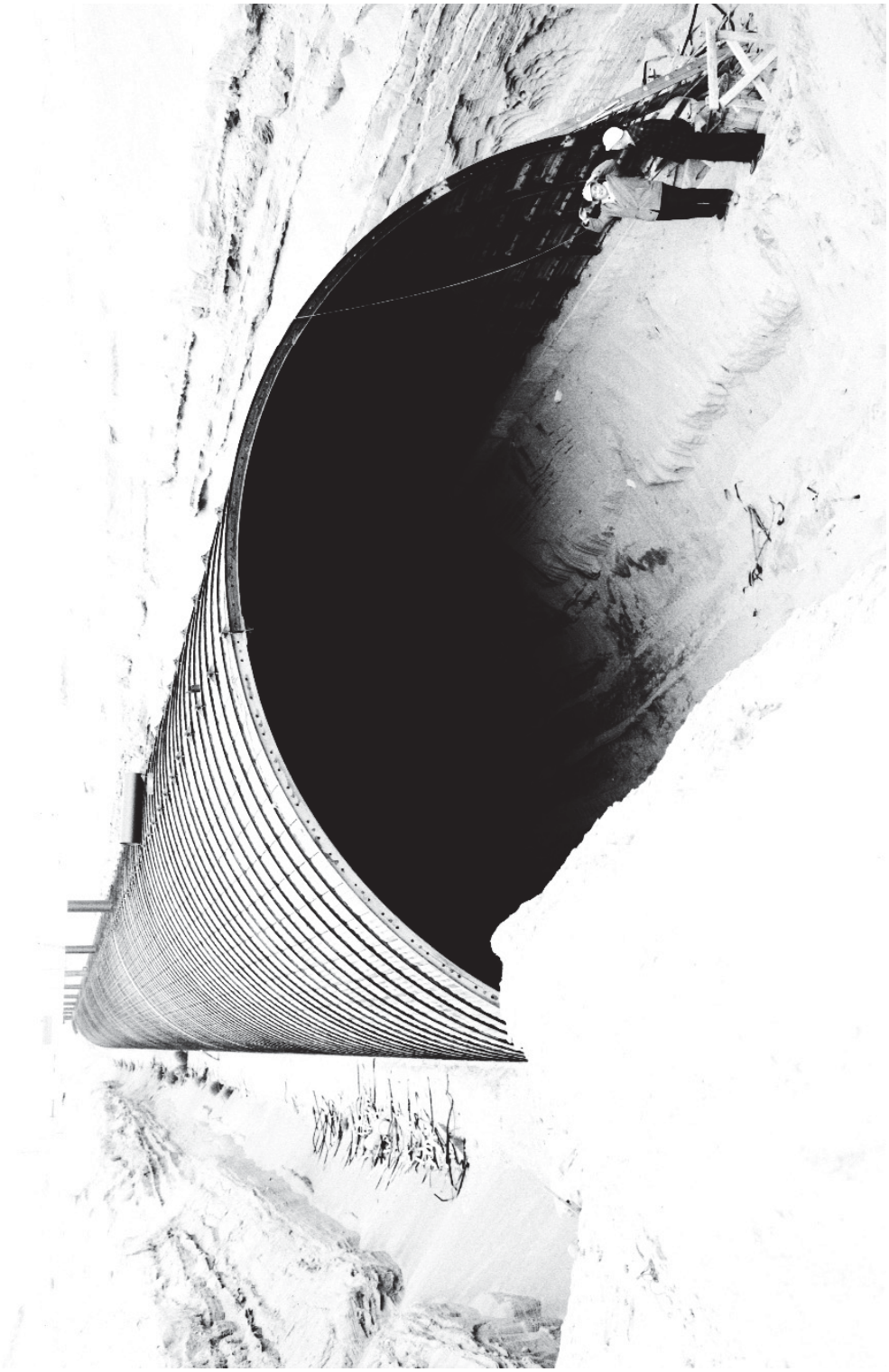


SECTION CC

CONSTRUCTION TUNNEL NO. 2

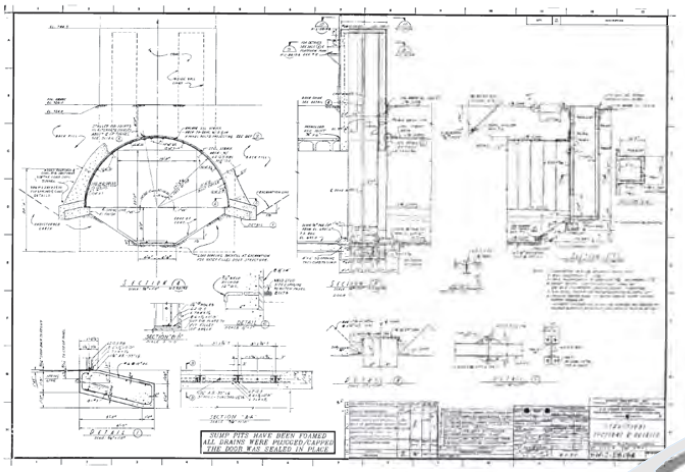


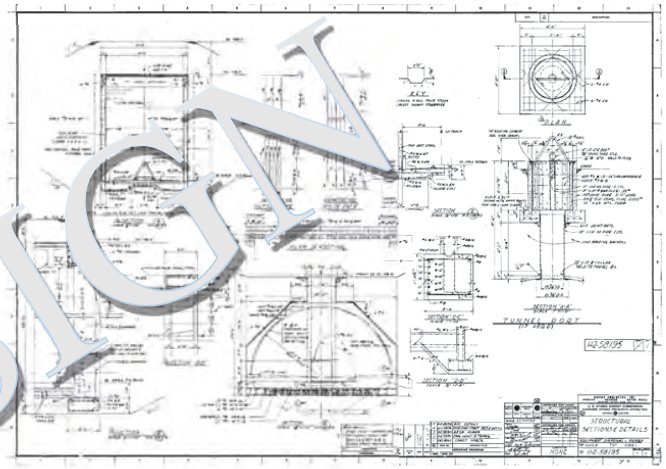


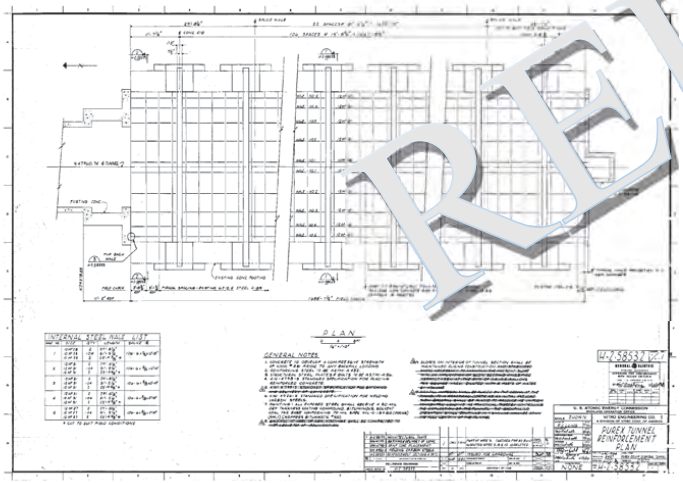


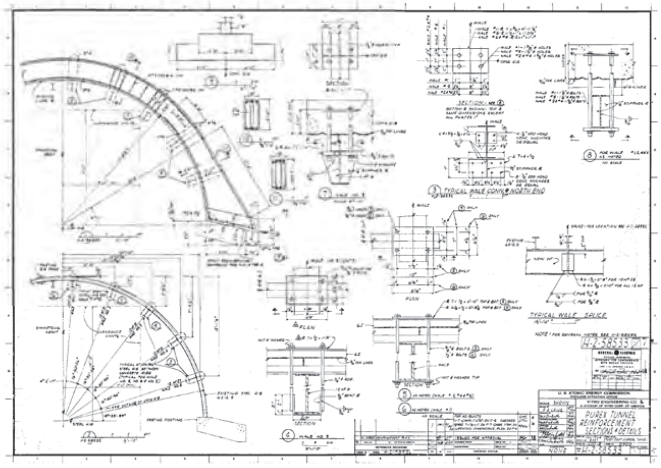
1964, JANUARY - TUNNEL COLLAPSE

1964, January to April – Tunnel No. 2 Redesign & Structural Reinforcement

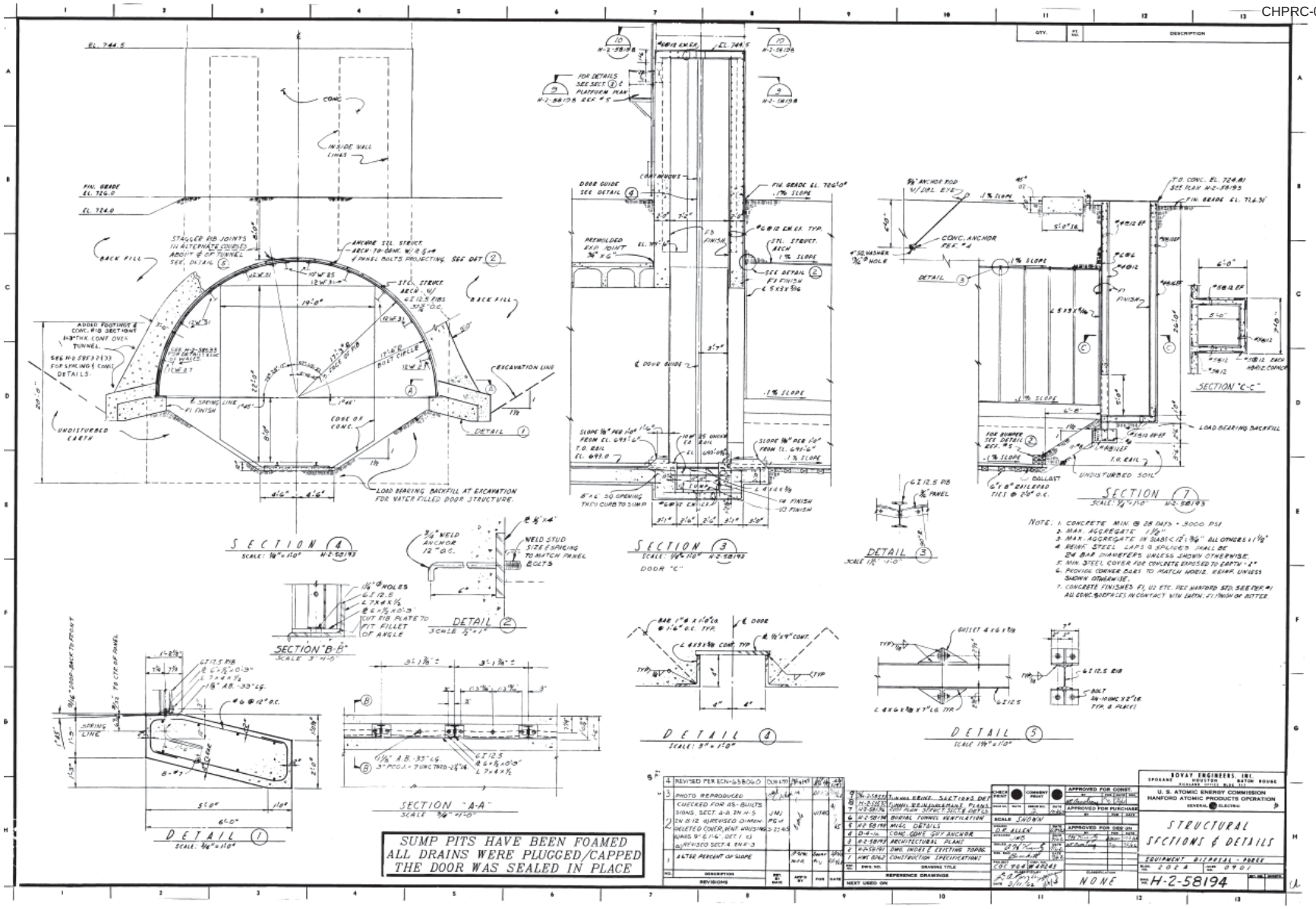


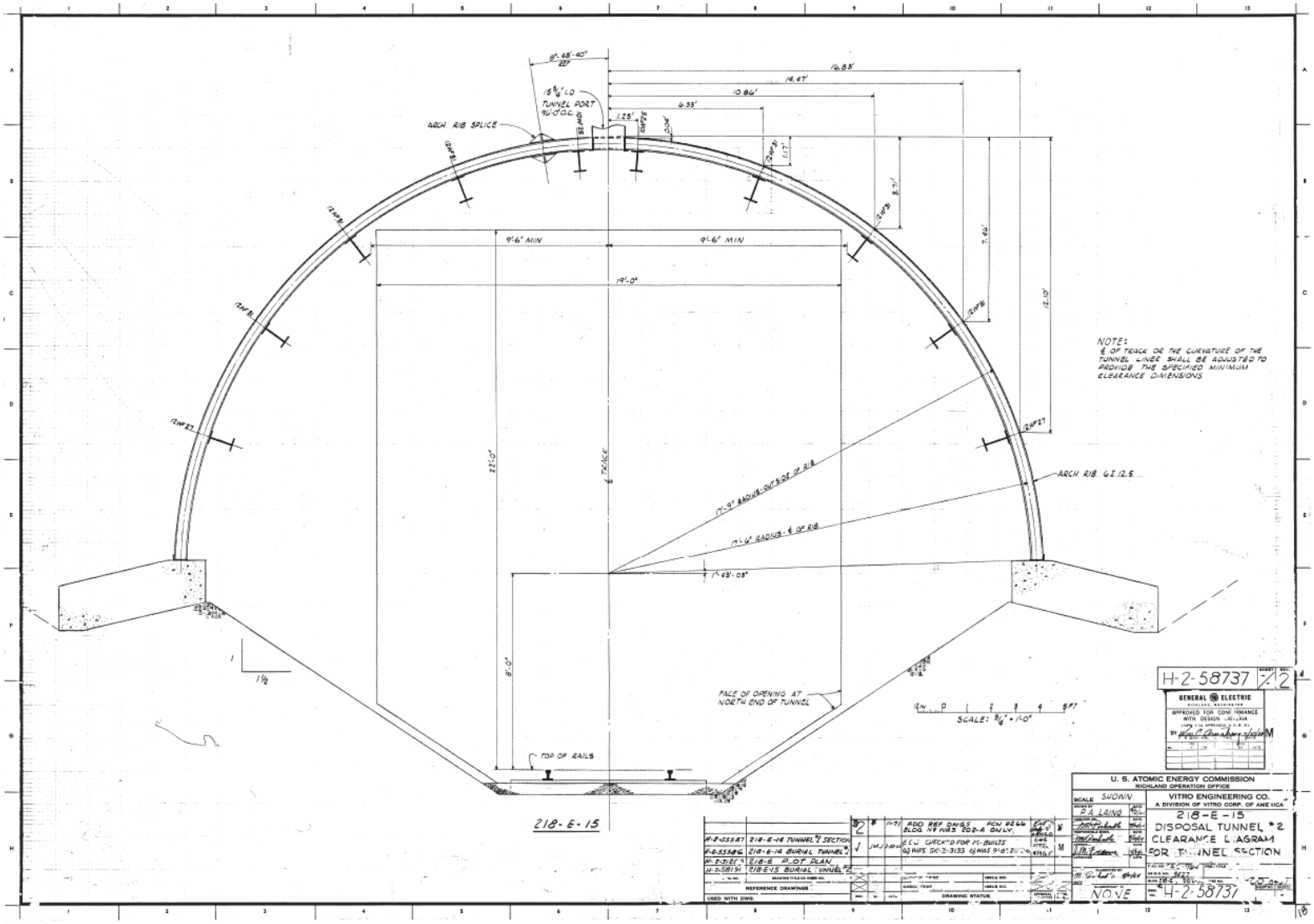




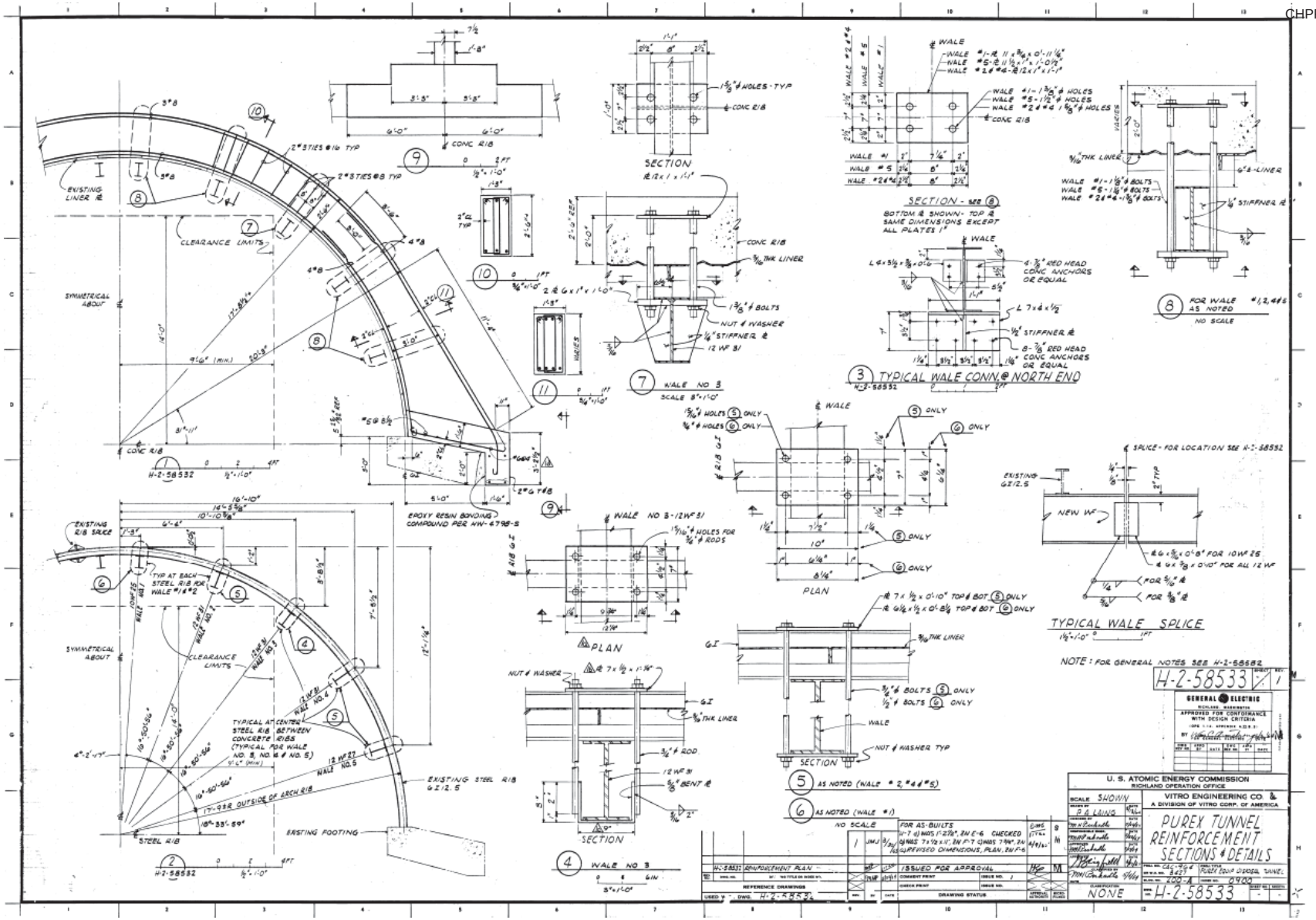


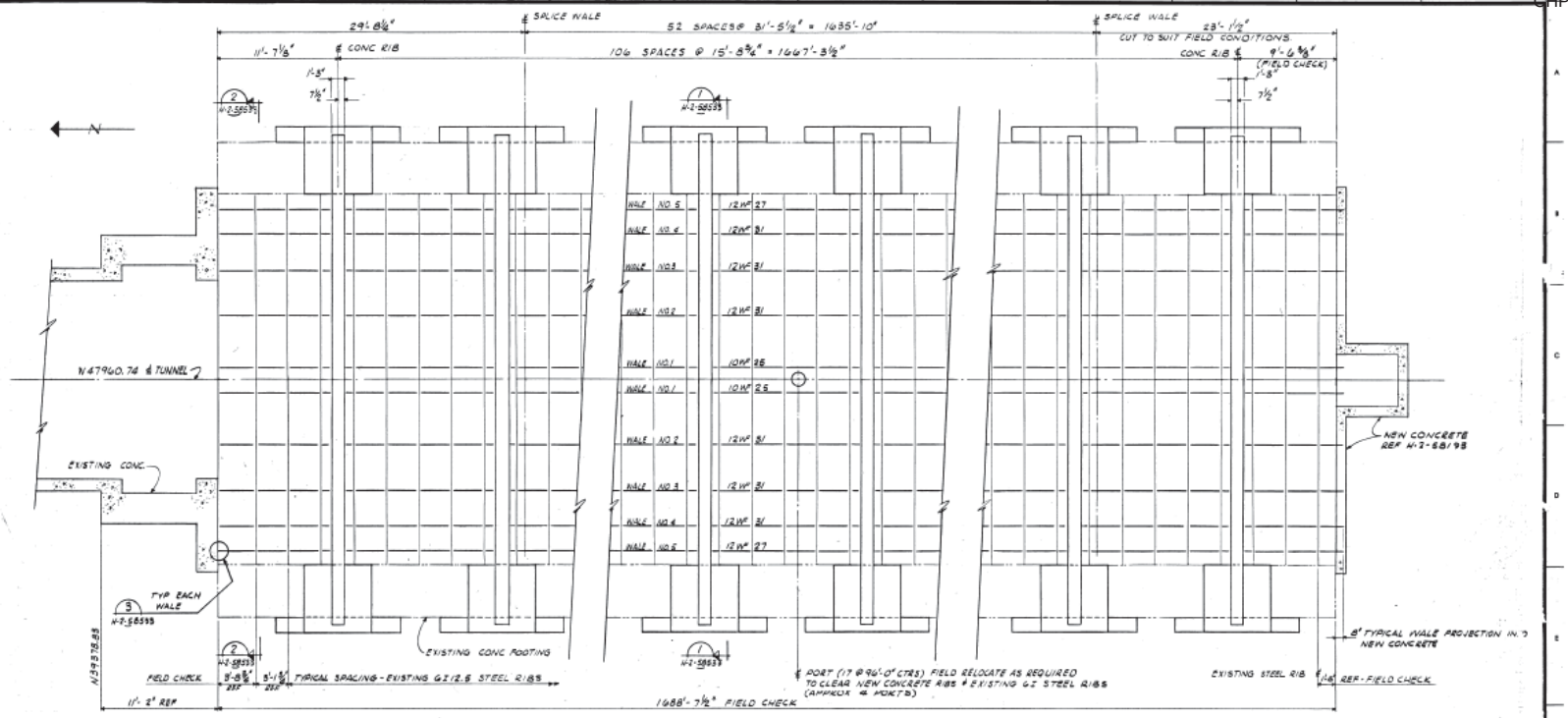
REDESIGN


SECTION 4
SCALE: 1/8"=1'-0"
H-2-58193
SECTION 3
SCALE: 1/8"=1'-0"
H-2-58193
DOOR "C"
SECTION 7
SCALE: 1/8"=1'-0"
H-2-58193
SECTION "C-C"
DETAIL 1
DETAIL 2
DETAIL 3
DETAIL 4
DETAIL 5
SECTION "B-B"
SECTION "A-A"
SUMP PITS HAVE BEEN FOAMED
ALL DRAINS WERE PLUGGED/CAPPED
THE DOOR WAS SEALED IN PLACE
NOTE: 1. CONCRETE MIN. @ 28 DAYS = 3000 PSI
2. MAX. AGGREGATE 1 1/2"
3. MAX. AGGREGATE IN SLABS < 12" 3/4" ALL OTHERS 1 1/2"
4. REINF. STEEL LAPS & SPLICES SHALL BE 24 BAR DIAMETERS UNLESS SHOWN OTHERWISE.
5. MIN. STEEL COVER FOR CONCRETE EXPOSED TO EARTH 4"
6. PROVIDE CORNER BARS TO MATCH HORIZ. REINF. UNLESS SHOWN OTHERWISE.
7. CONCRETE FINISHES F1, U1 ETC. PER HANFORD STD. SEE DWG #1
ALL CONC. SURFACES IN CONTACT WITH EARTH: F1 FINISH OR BETTER.
REVISED PER ECN-658060
PHOTO REPRODUCED
CHECKED FOR AS-BUILTS
ALTER PERCENT OF SLOPE
DESCRIPTION
REVISIONS
REFERENCE DRAWINGS
NEXT USED ON
DRAWING TITLE
BOVAY ENGINEERS, INC.
SPOKANE HOUSTON NATCHITOCHES BATON ROUGE
U. S. ATOMIC ENERGY COMMISSION
HANFORD ATOMIC PRODUCTS OPERATION
GENERAL ELECTRIC
STRUCTURAL
SECTIONS & DETAILS
EQUIPMENT BIOPREAL - PREX
NONE
H-2-58194



RELEASE DATE OF 4/21/1964


SECTION
SECTION - SEE 8
3 TYPICAL WALE CONN @ NORTH END
7 WALE NO 3
PLAN
TYPICAL WALE SPLICE
5 AS NOTED (WALE # 2, #4, #5)
6 AS NOTED (WALE #1)
4 WALE NO 3
NOTE: FOR GENERAL NOTES SEE H-2-58532
H-2-58533
GENERAL ELECTRIC
U. S. ATOMIC ENERGY COMMISSION
RICHLAND OPERATION OFFICE
VITRO ENGINEERING CO.
PUREX TUNNEL REINFORCEMENT SECTIONS & DETAILS
NONE



INTERNAL STEEL WALE LIST

WALE NO.	SIZE	QTY	LENGTH	SPLICE @
1	10WF25 10WF25 10WF25	2 104 2	29'-8 1/8" 31'-5 1/8" 23'-9 3/8" *	106'-6 x 3/8" x 0'-8"
2	12WF31 12WF31 12WF31	2 104 2	29'-8 1/8" 31'-5 1/8" 23'-9 3/8" *	106'-6 x 3/8" x 0'-10"
3	12WF31 12WF31 12WF31	2 104 2	29'-8 1/8" 31'-5 1/8" 23'-9 3/8" *	106'-6 x 3/8" x 0'-10"
4	12WF31 12WF31 12WF31	2 104 2	29'-8 1/8" 31'-5 1/8" 23'-9 3/8" *	106'-6 x 3/8" x 0'-10"
5	12WF27 12WF27 12WF27	2 104 2	29'-8 1/8" 31'-5 1/8" 23'-9 3/8" *	106'-6 x 3/8" x 0'-10"

* CUT TO SUIT FIELD CONDITIONS

PLAN

0 4 8FT
1/4" = 1'-0"

GENERAL NOTES

1. CONCRETE TO DEVELOP A COMPRESSIVE STRENGTH OF 4,000 # PSI PRIOR TO ANY BACKFILL LOADING
2. REINFORCING STEEL TO BE ASTM-A-432.
3. STRUCTURAL STEEL PLATES & BOLTS TO BE ASTM-A-36.
4. HW-47198-S STANDARD SPECIFICATION FOR PLACING REINFORCED CONCRETE.
5. ~~HW-47195-S STANDARD SPECIFICATION FOR BATCHING AND DELIVERY OF CONCRETE.~~
6. HW-49726-S STANDARD SPECIFICATION FOR WELDING CARBON STEELS.
7. PAINTING: ALL EXPOSED STEEL SHALL RECEIVE A 20 MIL DRY THICKNESS COATING COMPOUND, BITUMINOUS, SOLVENT COAL TAR BASE CONFORMING TO MIL SPEC MIL-C-184 BO (DOCKS) (AM.I) (KOPPERS BITUMASTIC #50)
8. ~~BACKFILL AT HEEL OF NEW FOOTINGS SHALL BE COMPACTED TO 100% ABOVE TOP OF FOUNDATION.~~

9. SLOPES ON INTERIOR OF TUNNEL SECTION SHALL BE MAINTAINED DURING CONSTRUCTION. ~~AND STABILIZED WHERE NECESSARY TO MAINTAIN THE REQUIRED SLOPE WITH AN APPLICATION OF SLOW SETTING EMULSIFIED ASPHALTIC SEAL AT THE RATE OF 0.4 GALS PER SQUARE YARD, DILUTED WITH 3 PARTS OF WATER BY VOLUME.~~
10. ~~BACKFILL MATERIAL SHALL BE PLACED ON THE CROWN OF THE TUNNEL TO A PRACTICAL DEPTH AS MACHINE AND LOAD. THEN BACKFILL SHALL BE PLACED TO PROVIDE AS UNIFORM CONCENTRIC LOADING AS PRACTICAL THEREBY CONTROLLING THE DEFLECTION OF THE TUNNEL. THE BACKFILLING OPERATION SHALL CONTINUE UNTIL SUFFICIENT MATERIAL COVERS THE FULL LENGTH OF THE TUNNEL.~~

1	W-2-58593	ARCHITECTURAL PLANS					
	HW-47195-S	BATCHING & DELIVERY OF CONC	1	JMJ	7-30-65	PART OF NOTE 9. CHECKED FOR AS-BUILT (4) DELETED NOTES 5, 8 & 10 (1) DELETED	Gate 4-7-65
	HW-47198-S	REINF CONC PLACEMENT					
	HW-49726-S	WELDING CARBON STEELS					
	W-2-58533	REINFORCEMENT SECTIONS & DETS				ISSUED FOR APPROVAL	
NO.	DRAWING TITLE OR INDEX NO.						

REFERENCE DRAWINGS

USED WITH D: H-2-58533

CONSENT PRINT | ISSUE NO. 1
CHECK PRINT | REV. NO.
DRAWING STATUS
APPROVAL AUTHORITY | REV. FLAG

H-2-58532 EXPERT. REV. 1

GENERAL ELECTRIC
RICHLAND, WASHINGTON
APPROVED FOR CONFORMANCE WITH DESIGN CRITERIA
OPS 1.1.16 APPENDIX A.E.B.1.
W. H. Chandler 4/14/65
FOR GENERAL ELECTRIC

REF NO.	DATE	REF NO.	DATE	REF NO.	DATE

U. S. ATOMIC ENERGY COMMISSION
RICHLAND OPERATION OFFICE

VITRO ENGINEERING CO.
A DIVISION OF VITRO CORP. OF AMERICA

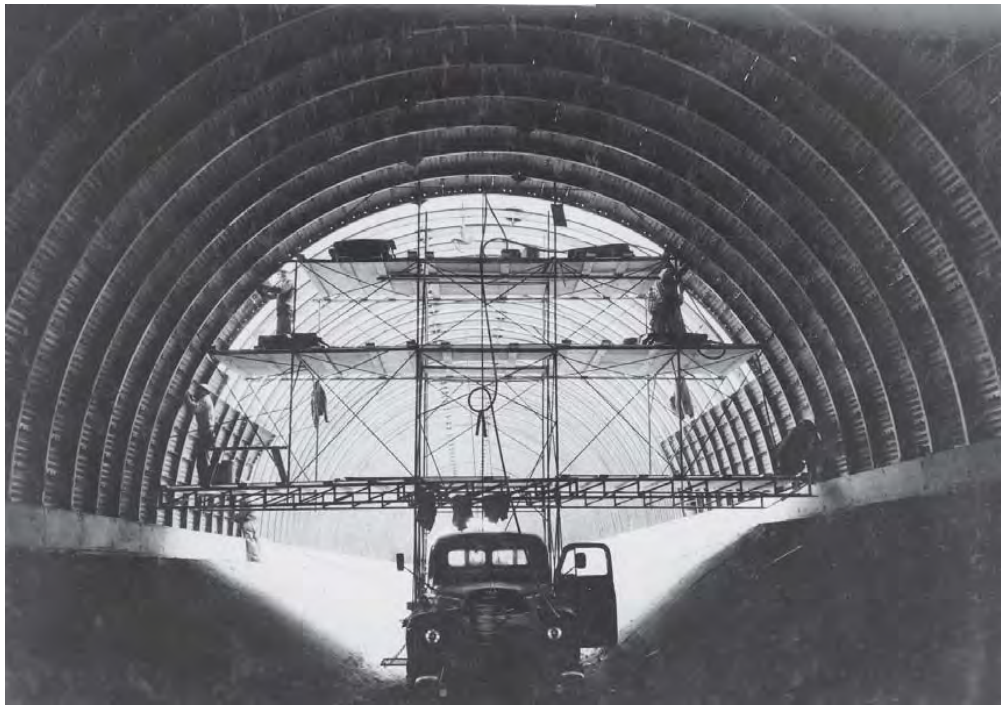
SCALE SHOWN
DESIGN BY P. A. LAING
DRAWN BY
CHECKED BY
DESIGN ENGR.
DRAWING ENGR.
DESIGN ENGR.
DRAWING ENGINEER
DESIGN ENGINEER
DRAWING ENGINEER
APPROVED BY
APPROVED BY NONE

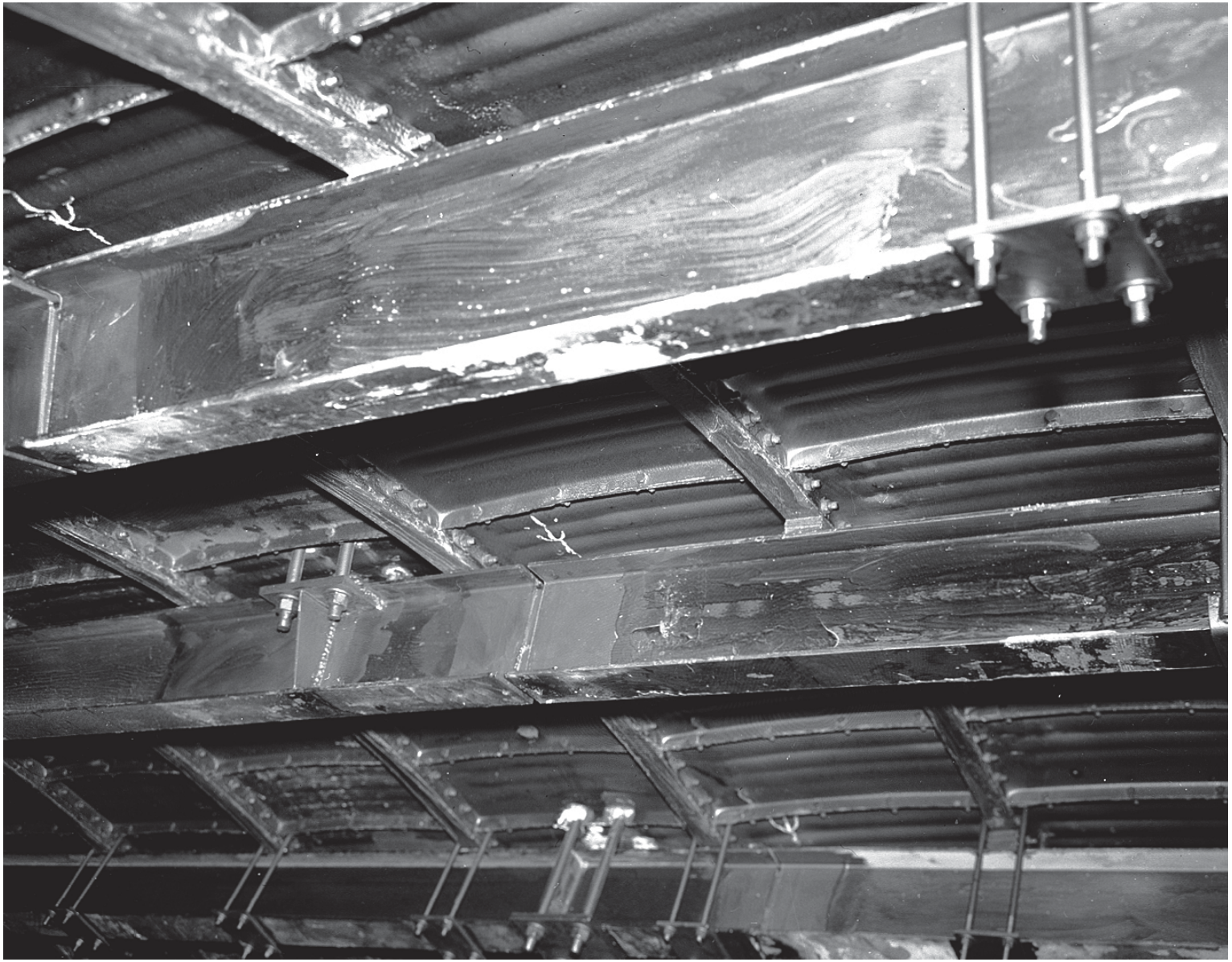
PUREX TUNNEL REINFORCEMENT PLAN

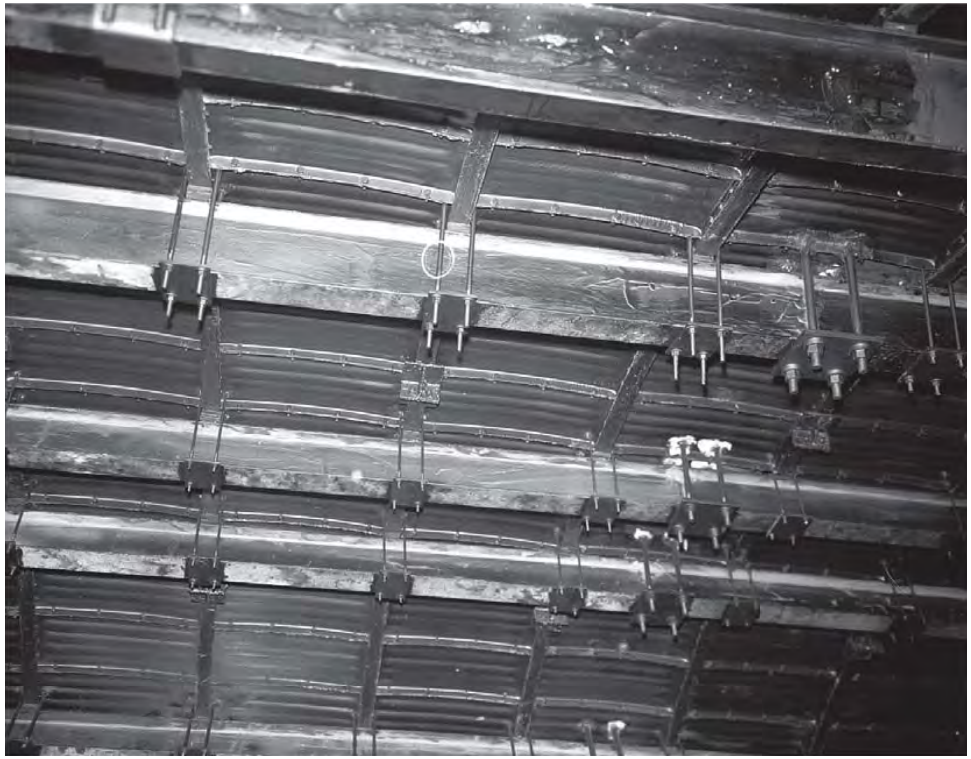
PROJ. NO. CAL-964
OR NO. 5427
BLDG. NO. 200 A
PROJ. TITLE PUREX EQUIP. DISPOSAL TUNNEL
NAME OF BLDG. 2706
DWG. NO. H-2-58532
SHEET NO. 1
SHEETS

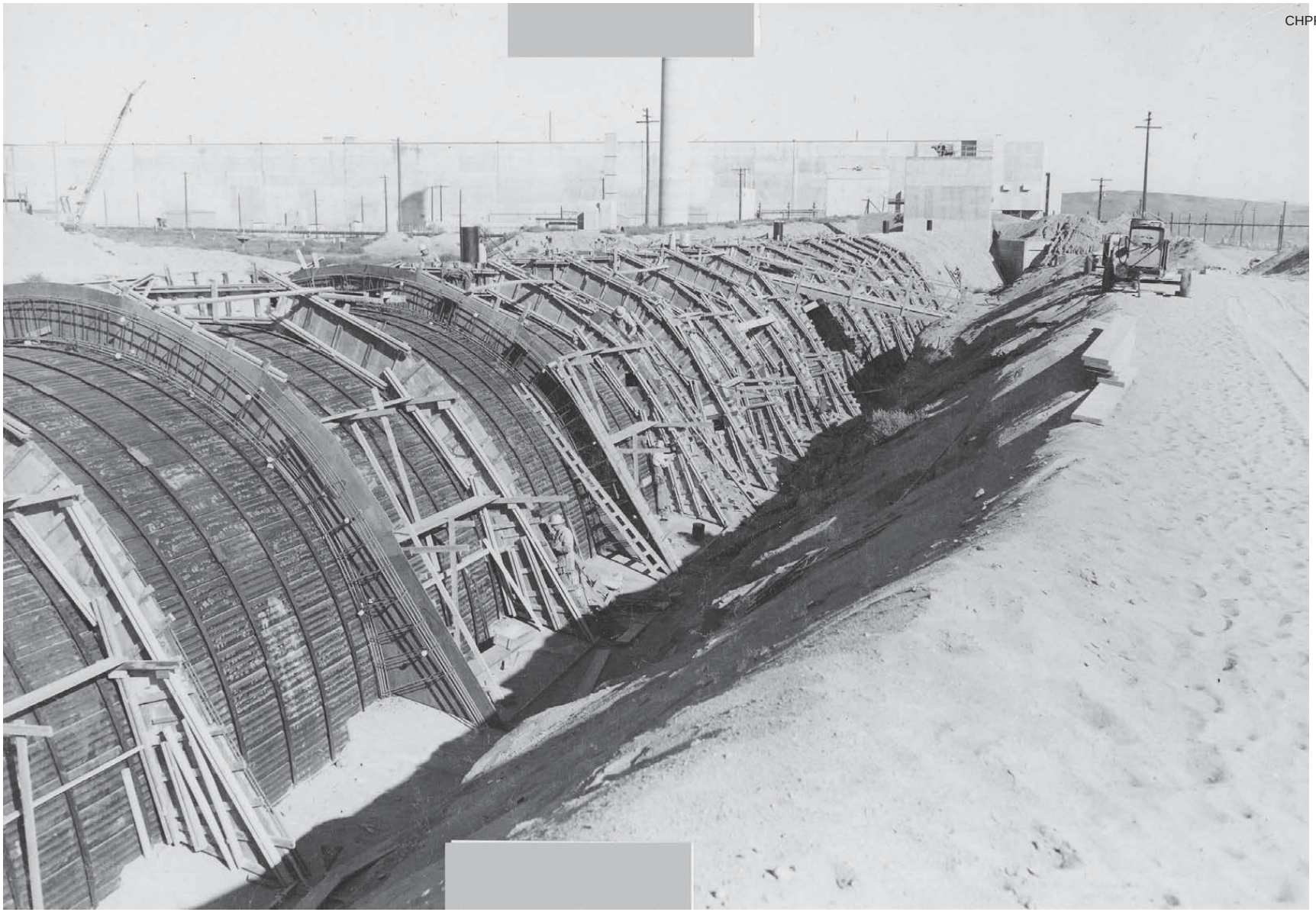
ADDITIONAL SUPPORT NOT PRESENT

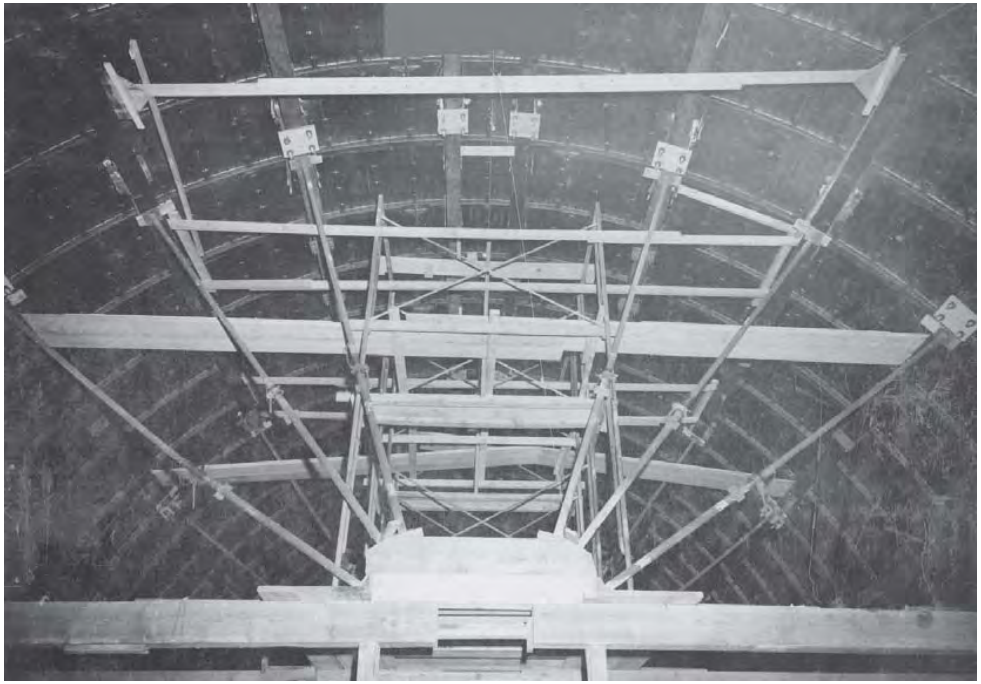
ADDITIONAL SUPPORT NOT PRESENT

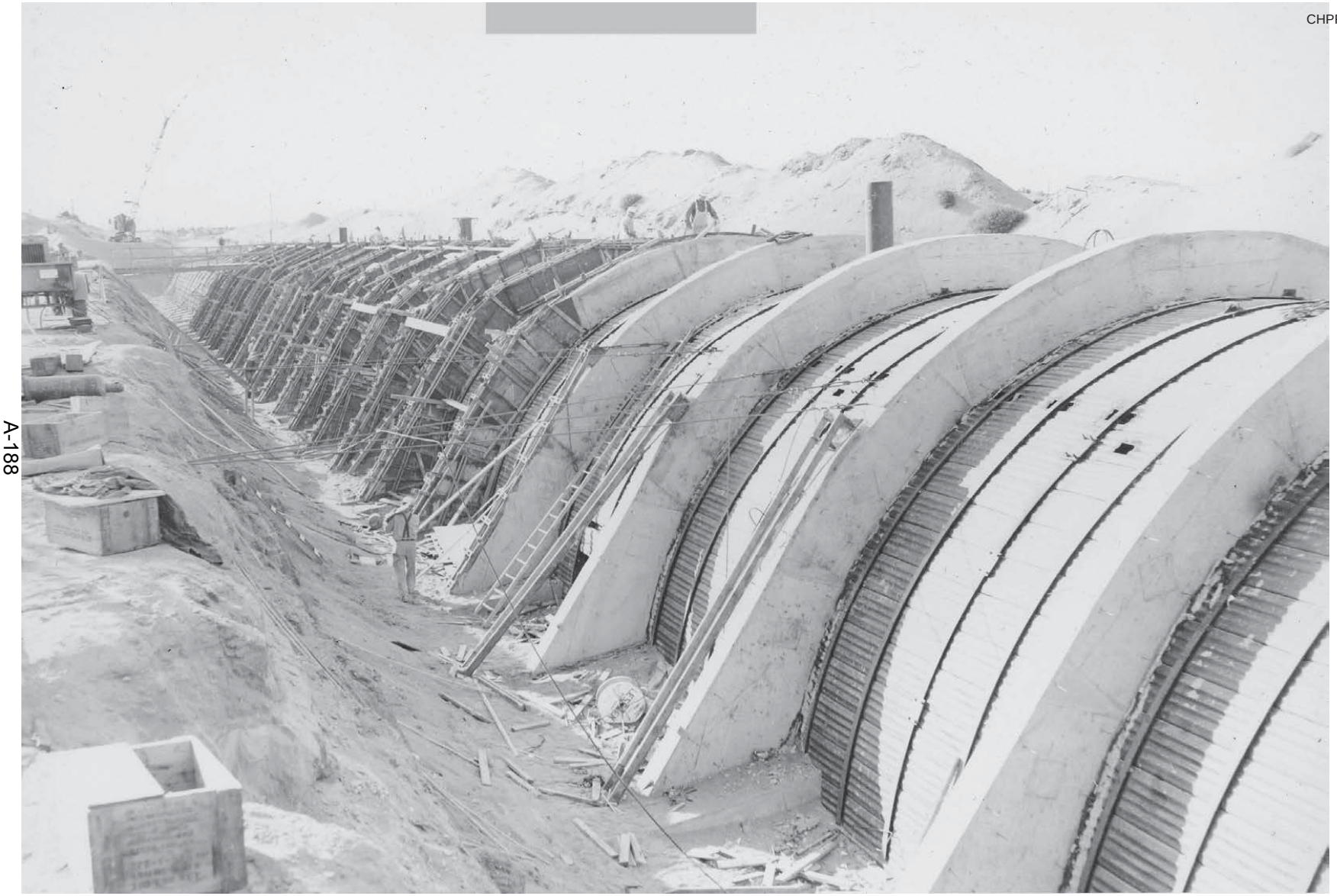




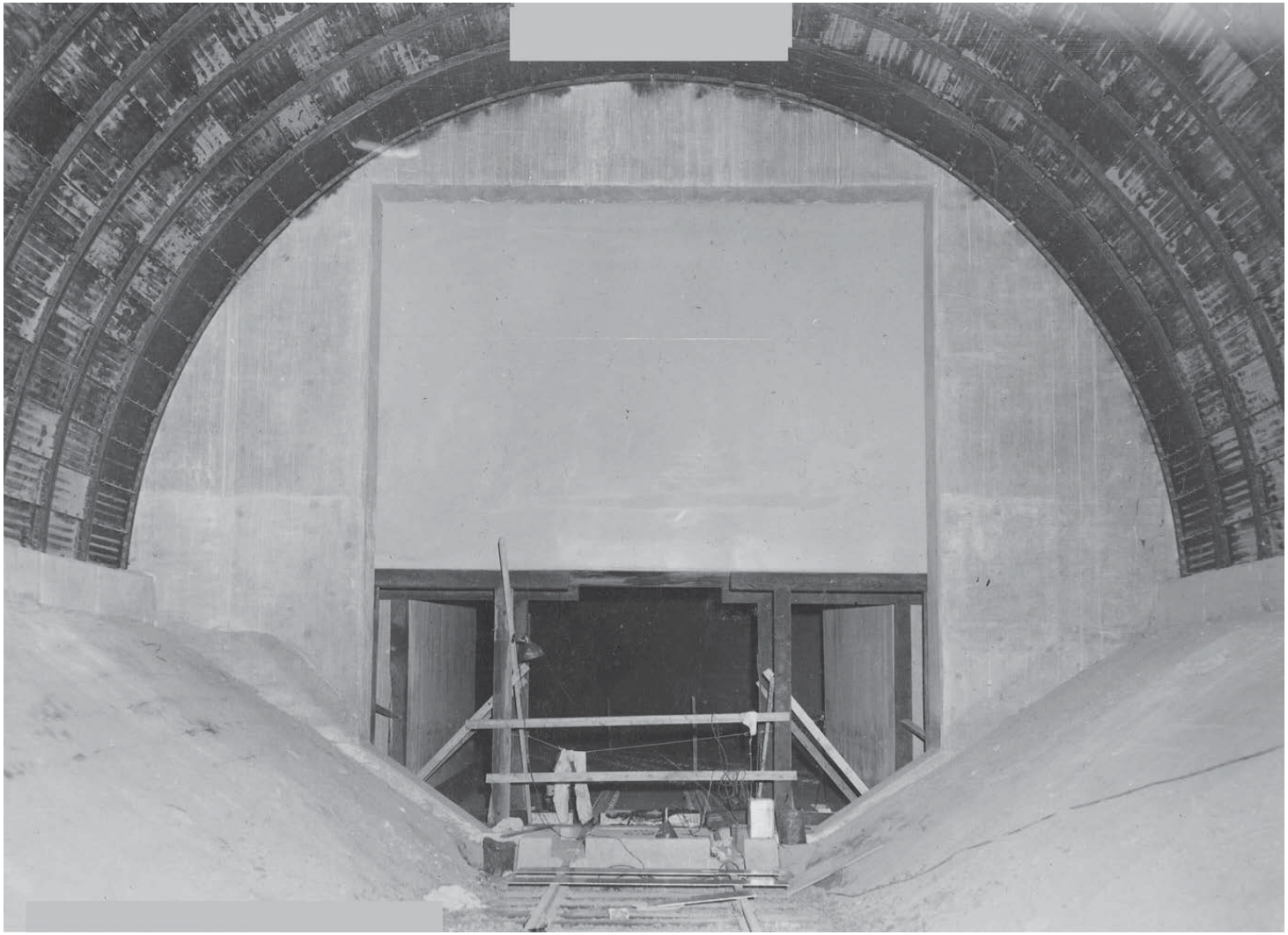








PROCESS IMPROVEMENT REGARDING BACKFILLING PROCEDURE



TUNNEL NO. 2 INVENTORY

HNF-SD-EN-WAP-007, Rev. 4

Table 1. PUREX Storage Tunnels Inventory. (sheet 2 of 4)

PUREX #2 STORAGE TUNNEL (218-E-15)

PUREX #2 Storage Tunnel is located at the southeast end of the PUREX Plant and is an extention of the railroad tunnel. The storage area is approximately 514.5 meters long, 7.9 meters high and 10.4 meters wide. The tracks have a one percent down-grade toward the south end of the tunnel. The capacity of the Storage Tunnel is 38-40 modified railroad cars, 12.8 meters long. The Tunnel contains 21 cars as of 2/95.

position

1. E-F6 # (2WW WASTE) CONCENTRATOR, TK F 15-2, ONE TUBE BUNDLE AND AGITATOR MOTORS PLACED IN TUNNEL ON 12/12/67 ON CAR 61439 2,400 CU. FT., 700 CURIES, 1.3 rem/hr. @ 100'.
2. E-F6 #5 (E-H4 3WB) CONCENTRATOR, TWO TUBE BUNDLES PLACED IN TUNNEL ON 3/28/69 ON CAR MLW 60883 2,400 CU. FT., 500 CURIES, 800 mrem/hr. @ 2'.
3. E-F6 #6 (2WW WASTE) CONCENTRATOR, TWO TUBE BUNDLES FAILED PLACED IN TUNNEL ON 3/19/70 ON CAR 3612. 2, 400 CU. FT., 700 CURIES, 500 rem/hr. @ 2'.
4. L CELL PACKAGE IN A SEALED STEEL BOX (H2-66012) PLACED IN TUNNEL ON 12/30/70 ON CAR MLW 60033 2,400 CU. FT., 500 GRMS Pu, 200 mrem/hr. @ CONTACT.
5. F2 SILVER REACTOR, F6 DEMISTER, VESSEL VENT LINE STEEL CAT-WALK AND GUARD RAILS, PLACED IN TUNNEL ON 3/26/71 ON GONDOLA CAR 4810. 2,400 CU. FT., 20 CURIES, Ag ~ ~625 Kg, 2 rem/hr. @ CONTACT.
6. MODIFIED A3-1 TOWER, SCRUBBER, LID AND VAPOR LINE PLACED IN TUNNEL ON 12/12/71 ON GONDOLA CAR <611. 2,400CU. FT., 10 CURIES, 1 rem/hr. @ CONTACT.
7. A3 DISSOLVER PLACED IN TUNNEL ON 12/22/71 ON NINE FT. SHORTENED CAR 858 2,400 CU.FT., 50 CURIES, Hg ~ ~45 Kg, 5 rem/hr. @ 5'.
8. A3W1 FUEL ENDS IN STEEL LINER BOX AND NPR FUEL HANDLING COMPT. USED WITH THE SUSPECTED CANISTERS, ON CAR 16808 PLACED IN TUNNEL ON 8/29/72. 800 CU. FT., 17,500 CURIES, 10 rem/hr. @ 150'.
9. C3 DISSOLVER PLACED IN TUNNEL ON 9/30/72 ON CAR 19811 1590 CU. FT., 50 CURIES, Hg ~ ~45 Kg., 5 rem/hr. @ 5'.
10. E-H4 (3WB) CONCENTRATOR, #61 TUBE BUNDLE, PROTOTYPE COOLING COIL AND A F-11 FILTER TANK. PLACED IN TUNNEL 8/30/83 ON CAR CCX-1. 2,400 CU. FT., 500 CURIES, 800 mrem/hr. @ 2'.
11. A3 DISSOLVER (VESSEL #10 AND HEATER VESSEL #6) PLACED IN TUNNEL ON 7/18/86 ON CAR 3613 3,960 CU. FT., 6.81 CURIES, Hg ~ ~40 Kg, Cd ~ ~43 Kg, 3 mrem/hr. @ 3'.
12. WHITE BOX (H2-56456) CONTAINING EIGHT TUBE BUNDLES (5 57, 60, 62, 64, 67, 68, 74, AND 78 PULSER (5 AND OLD HEATER DISS LID OLD STYLE DUMPING TRUNNIONS (5). PLACED IN TUNNEL ON 1/20/85 ON CAR 3611 5,438 CU. FT., 540 CURIES, 2 rem/hr. @ 3'.

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HNF-SD-EN-WAP-007, Rev. 4

Table 1. PUREX Storage Tunnels Inventory. (sheet 3 of 4)

PUREX #2 STORAGE TUNNEL (218-E-15)

position

13. JS TANK (VESSEL #20), F1 COND (VESSEL #13) AND F12-B CELL BUK. OLD FOUR-WAY DUMPER, DISS YOKE AND FLANGE PLATE, 3 rem/hr. @ 1'. PLACED IN TUNNEL ON 1/21/88 ON CAR 18806. 2,500 CU. FT., 90 CURIES.
14. L-1 PULSER, 2-COLUMN CARTRIDGES, 1-JUMPER CUTTER, 3-JUMPER ALIGNMENT TOOLS, 9-EXTERIOR DUMPING TRUNNIONS, 10-PUMPS, 3-AGITATORS, 4-TUBE BUNDLES, 2-HEAT JUMPERS AND 7-STACS. PLACED IN TUNNEL ON 11/18/87 ON CAR PX-10 (10A-19369) & RACK H2-89029.SS. 50 TONS, 3,600 CU. FT., 33,740 CURIES(REF:LETTER 12110-88-074). Pb ~ ~2540 Kg., 3, rem/hr. @ 15'.
15. SILVER REACTOR, E-F2 STEAM HEATER AND STORAGE LINER (H2-65095) FULL OF CUT UP JUMPERS PLACED IN TUNNEL ON 5/13/88 ON CAR PX-9 (10A-19809) & S/R CRADLE SK-CUR-11-2-87. 20 TONS, 2,775 CU. FT., 249 CURIES (REF: LETTER 12110-88-074). Cd ~ ~13 Kg, Ag ~ ~115 Kg, Pb ~ ~230 Kg, 20 mrem/hr. @ 20'.
16. E-J8-1 LIMITED CONCENTRATOR VESS (1 H2-52477, FAILED 3/11/89 PLACED ON STORAGE CAR H2-89908, PX-6 (10A-19028) AND INTO (2 TUNNEL 4/6/89 CHAVCYARIS. EST. 42 TONS, 6,000 CU. FT. 1.5 CURIES (REF: LETTER 12113-89-027), 0.5 mrem/hr. @ 10'.
17. NORTH STORAGE LINER H2-65095 CONTAINING SIX PUMPS, ONE AGITATOR AND CUT UP JUMPER (14 TONS). SOUTH STORAGE LINER H2-65095 CONTAINING ONE PUMP, ONE (15 TONS AND CUT UP JUMPERS (11.5 TONS). PLACED ON STORAGE CAR PX-18 (10A-19200) AND INTO (2 TUNNEL 8/9/89 DATE. EST 25.5 TONS, 2,574 CU. FT. 3.0 CURIES (REF: LETTER 12113-89-051), 80 mrem/hr. @ 1'.
18. T-75 ACID ABSORBER, E(F1-T-75/T-188713, H2-32535 AND H2-32487/489. PLACED ON STORAGE CAR PX-2 AND INTO (2 TUNNEL 4/8/94. EST 22 TONS, 835 CU. FT., 185 CURIES, 90 mrem/hr. @ CONTACT.
19. FOUR METAL LINER STORAGE BOXES H-3-65065-3/H-2-100187-9 CONTAINING FAILED JUMPERS AND MISCELLANEOUS OUTDATED CANYON EQUIPMENT ITEMS. PLACED ON STORAGE CAR PX-13 AND INTO (2 TUNNEL 8/16/94. EST 69 TONS, 4032 CU. FT., 927 CURIES, 30 mrem/hr. @ 2'.
20. E-H4-1 LIMITED CONCENTRATOR (H-2-52477/58213)(E-H4-1). PLACED IN TUNNEL ON 1/27/95 ON CAR PX-28. EST 40 TONS, 5,760 CU. FT., 3,070 CURIES, Cr ~ ~8 Kg, 1000 mrem/hr. @ 5'.
21. TANK C-3 (H-2-53232)(H-100003) CONTAINING BOX ASSEMBLY (H-2-131628)(H-2-131629-1), H4 CONCENTRATOR TOWER (H-2-58102)/ (F-223017-C3T-4), HOT SHOP COVER PLATE (H-2-52222)/(12"), TUBE BUNDLE NASH CAPSULE (H-2-56641), DISSOLVER CHARGING INSERT (H-2-75875)/ (H-2-75875-1), LIFTING YOKE (7A (H-2-100373), LIFTING YOKE (9 (H-2-52456). PLACED IN TUNNEL ON 2/8/95 ON CAR PX-3608. EST 44 TONS, 3,457 CU. FT., 28,000 CURIES, Pb ~ ~1930 Kg, 1000 mrem/hr. @ 4'.

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HNF-SD-EN-WAP-007, Rev. 4

Table 1. PUREX Storage Tunnels Inventory. (sheet 4 of 4)

PUREX #2 STORAGE TUNNEL (218-E-15)

position

22. METAL LINER BOX (H-2-65065) CONTAINING JUMPERS AND FAILED/ OBSOLETE CANYON EQUIPMENT, 4/4 MOTOR MOTOR (H-2-[illegible]), LIND STORAGE BOX (H-2-[illegible]) CONTAINING JUMPER COUNTERWEIGHTS AND MISCELLANEOUS LIND PIECES, SCRAP HOPPER (H-2-[illegible]) CONTAINING MISCELLANEOUS CANYON EQUIPMENT, CANISTER CAPPING SALVAGE (H-2-[illegible]), LIND CANISTER CONTAINING VARIOUS LOOSE OR CANYON STEEL PIPE. PLACED IN TUNNEL 3-11-96 ON CAR [illegible]. ESTIMATED WEIGHT 22 TONS, 1,112 CU. FT., 18 CURIES, Pb ~ ~[illegible] Kg, Cd ~ ~[illegible] Kg, [illegible] mrem/hr. @ 1'.
23. TWO BURIAL BOXES (H-2-100187) CONTAINING JUMPERS AND FAILED/ OBSOLETE CANYON EQUIPMENT, LIFTING CAGE (H-2-[illegible]). PLACED IN TUNNEL 3-11-96 ON CAR [illegible]. ESTIMATED WEIGHT 21 TONS, 2,114 CU. FT., 2 CURIES, 18 mrem/hr @ 1'.
24. CONCRETE BURIAL BOX (H-1-[illegible]) STORING 8 CONTAINERS OF 324 BUILDING B-CELL WASTE. FOR ADDITIONAL DETAILS, SEE PUREX WORK PLAN W-P-96-[illegible]. PLACED IN TUNNEL ON CAR (10A-[illegible]) ON JUNE 18, 1996. ESTIMATED WEIGHT 36 TONS, 1,838 CU. FT., 6 CALCULATED CURIES, ~13 mrem/hr. @ 15'. Pb ~ ~[illegible] Kg, Cd ~ ~[illegible] Kg, Cr ~ ~[illegible] Kg, Ba ~ ~[illegible] Kg, ~4 g Pu.
25. CONCRETE BURIAL BOX (H-1-[illegible]) STORING 9 CONTAINERS OF 324 AND 325 BUILDING WASTE. FOR ADDITIONAL DETAILS, SEE PUREX WORK PLAN W-P-96-[illegible]. PLACED IN TUNNEL ON CAR (10A-[illegible]) ON JUNE 18, 1996. ESTIMATED WEIGHT 45.2 TONS, 1,850 CU. FT., 2 CURIES, ~200 mrem/hr. @ 15'. Pb ~ ~[illegible] Kg, Cd ~ ~[illegible] Kg, Cr ~ ~[illegible] Kg, Ba ~ ~[illegible] Kg, Pb ~ ~[illegible] g, ~[illegible] g Pu.
26. 20,000 GALLON LIQUID WASTE TANK CAR H2-[illegible]. EMPTY FOR BURIAL. PLACED IN TUNNEL ON JUNE 18, 1996. APPROXIMATELY 20 TONS, 5 CURIES, 100 mrem/hr @ 2', ~[illegible] g Pu.
27. 20,000 GALLON LIQUID WASTE TANK CAR H2-[illegible]. EMPTY FOR BURIAL. PLACED IN TUNNEL ON JUNE 18, 1996. APPROXIMATELY 20 TONS, 5 CURIES, 200 mrem/hr @ 2', ~[illegible] g Pu.
28. 20,000 GALLON LIQUID WASTE TANK CAR H2-[illegible]. EMPTY FOR BURIAL. PLACED IN TUNNEL ON JUNE 18, 1996. APPROXIMATELY 20 TONS, 5 CURIES, 600 mrem/hr. @ 2', ~[illegible] g Pu.

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A-192

CURRENT CONFIGURATION 2016

1996 – TUNNEL NO. 2 HVAC DEACTIVATED

2016 - TUNNEL NO. 1 HVAC STACK CURRENT CONFIGURATION

- OPERATIONS VIDEO

- VIDEO PUREX 1 ~ CRANE MOVEMENT, FAILED EQUIPMENT
- VIDEO PUREX 2 ~ OPERATIONS

UNCLASSIFIED
CLASSIFICATION

DOCUMENT NO. RHO-CD-1076

DATE September 1980 COPY NO.

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Bill:
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Rockwell Hanford Operations
Richland, WA 99352

TITLE AND AUTHOR

STRUCTURAL EVALUATION OF THE PUREX NO. 1 BURIAL TUNNEL

G. R. Silvan

DISTRIBUTION

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B. F. Campbell	202A/200E	R. J. Thompson	2750E/200E
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E. N. Dodd	222U/200W		
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UNCLASSIFIED
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AN EVALUATION OF THE STRUCTURAL INTEGRITY OF PUREX STORAGE TUNNEL #1

SUBMITTED TO
WESTINGHOUSE HANFORD COMPANY

MAY 1991

Los Alamos Technical Associates, Inc.
P. O. Box 410 / 1650 Trinity Drive / Los Alamos, NM 87544 / (505) 662-9080

Appendix B

PUREX Tunnel 2 Data Quality Objectives, Draft A

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Appendix A – Systematic Planning Record

Characterization Data Collection Planning Record

NOTE: In cases where the requested information is not applicable, state that, and explain why it is not applicable so that it is clear that a required field has not been forgotten.

Project Summary

Project Name:	PUREX Tunnel 2 Data Quality Objectives (DRAFT A)	Date:	5-31-17
Name of Person Completing Record:	Roger Ovink/CHPRC	Position:	DQO Tech. Authority
Name of Responsible Manager:	Darin Corriell/CHPRC (Central Plateau S&M)		

Project Background (Step 1): **The following information is summarized from** HWS-8262, 1962, *Specifications for PUREX Equipment Disposal*, General Electric Company, Richland, Washington; and Vitro, 1964, *EQUIPMENT DISPOSAL TUNNEL PUREX FACILITY INSPECTION REPORT*, Vitro Engineering Company, Richland, Washington. The summary attachments include these reports (Attachments A and B); CHPRC, 2017, Photographic Timeline of the PUREX Storage Tunnels (Attachment C); a complete list of references (Attachment D); and CHPRC-03241, Rev. 0, *PUREX Burial Tunnels*, March 2017 (Attachment E).

PUREX Storage Tunnel 2 is permitted as a miscellaneous unit under WAC 173-303-680, "Dangerous Waste Regulations," "Miscellaneous Units." It is used to store mixed waste from the PUREX Plant and other onsite sources. Tunnel 2 is isolated from the railroad tunnel by a water-fillable shielding door. In general, the mixed waste stored in the tunnel is encased or contained in carbon or stainless steel plate, pipe, or vessels for shielding and to facilitate placement of the waste on railcars and ultimate storage inside the tunnel. The exterior of each tunnel is inspected annually via a visual perimeter walkdown to ensure the fences and warning signs are present and in good condition, and to identify any obvious changes to the tunnel overburden condition. No interior inspections of the tunnel are performed, but daily inspections of the tunnel have been required since the Tunnel 1 partial collapse was discovered on May 9, 2017.

Tunnel 2 construction began in early 1963 and was completed in late 1964. In January 1964, backfilling was halted when 75 linear feet of the tunnel structurally collapsed, and in the next 3 months a second, similar collapse occurred. Engineering evaluated legacy photos (Attachment C, page 6) and documents and concluded these collapses were due to a combination of weld failures, the backfilling procedure, and inadequate structural support. Between March and July 1964, efforts to "redesign" the structural supports of Tunnel 2 and modify the backfilling procedure were implemented. In the spring of 1964, efforts were focused on excavating all sections of tunnel that had been covered, installing internal I-beams along the longitudinal axis of the tunnel, installing reinforced concrete footings, and adding about 106 rib sections (whale arches) that were tied into the internal I-beams. All exposed steel surfaces were coated with a coal-tar-based bituminous solvent (PER MIL SPEC MIL-C-18480) to prevent corrosion from moisture. The Tunnel 2 water-fillable door, storage area, and vent shaft descriptions are as follows:

- The Tunnel 2 water-fillable door is essentially identical to the Tunnel 1 door, and since March 1997 the Tunnel 2 door has been empty because the added shielding provided by water as no longer required.
- The storage area is 514.5 m (1,688 ft) long, 7.9 m (25.9 ft) high, and 10.4 m (34.1 ft) wide. Because of the arch-shaped cross-section of this tunnel and the entry clearance at the water-fillable door, the height and width of Tunnel 2 are **not** the same as Tunnel 1. The storage area includes a 10.4 m (34.1 ft) diameter, corrugated steel sheets (0.5 cm [0.18 in.]), semicircular roof that is supported by internal I-beams attached to external, reinforced concrete whale arches on 4.8 m (16 ft) centers. The concrete whale arches are 0.4 m (1.3 ft) thick and vary in width from 0.4 to 1.8 m (1.3 to 5.9 ft). The base on each side of the roof structure is composed of reinforced concrete beams that are about 1.8 m (5.9 ft) wide by 1.2 m (4 ft) thick and run the full length of the tunnel. The interior and exterior surfaces of the steel roof are coated with a bituminous compound to inhibit corrosion, but have no cathodic protection. The floor consists of a railroad track laid on a gravel bed, with the space between the ties filled with gravel ballast. From the ends of the 2.4 m (8 ft) railroad ties, the earth floor slopes upward to a height of about 1.8 m (5.9 ft) above the railroad bed to the base of the sidewalls. The tracks have a 1% downgrade toward the south end of

Appendix A – Systematic Planning Record

Characterization Data Collection Planning Record

NOTE: In cases where the requested information is not applicable, state that, and explain why it is not applicable so that it is clear that a required field has not been forgotten.

the tunnel to ensure the railcars remain in their storage positions. A railcar bumper is 2.4 m (8 ft) from the end of the tracks to act as a stop. The storage area is covered with 2.4 m (8 ft) of overburden as protection from the weather and as shielding. The capacity of the storage area is 38 to 40 railcars (each 12.8 m (42 ft] long). As of June 1996, Tunnel 2 contained 28 railcars (70% full).

- An exhaust fan is connected to a filter and vent shaft at the south end of Tunnel 2. The reinforced concrete vent shaft is 0.46 m^2 (5 ft^2) and about 9 m (31 ft) deep. In 1996, this ventilation system was deactivated, blanked, and abandoned in place.

Construction of Tunnel 2 differs from Tunnel 1 as follows:

- A combination of steel and reinforced concrete was used in the construction of the storage area for Tunnel 2 rather than the wooden timbers used in the Tunnel 1 walls and roof.
- Tunnel 2 is longer, with about five times the storage capacity of Tunnel 1.
- The floor of Tunnel 2, outboard of the railroad ties, slopes upward to a height of about 1.8 m (5.9 ft) above the railroad bed to the base of the sidewalls, while the Tunnel 1 floor is flat all the way out to the sidewalls.

Step 1: Planning Type:
(If systematic planning is not required, state the reason)

Modified External DQO Planning (includes Draft A submittal and briefing for the Washington State Department of Ecology).

Organization, Schedule, and Goal
(State the problem, requirements, schedule, PSQs, and outcomes)

Step 1: State the Problem
(Describe the reason/need for data collection and project goals/objectives)
The initial arched roof design for Tunnel 2 was not adequate and collapsed in 1964 during overburden placement (Attachment C, pages 6 & 7; Attachment E, page 33). The tunnel structure was redesigned to add external and internal support (Attachment E, pages 34-51). However, the design basis for this re-engineering effort has not been located, so the Tunnel 2 strength (capacity) and failure risk have not been determined. Tunnel 2 has not been evaluated for structural integrity because the materials used to re-construct it included reinforced concrete whaler arches, engineered steel wide-flange beams, and 1/8 in. corrugated steel coated with a bituminous coal-tar corrosion inhibitor. The inherent nature of these materials, plus a re-engineered geometry that enhances structural integrity, provided a more robust structure.

The primary concerns for Tunnel 2 are that the materials used to construct it surpassed their 50-year life expectancy in 2014, and its steel and concrete components continue to be susceptible to structural damage through exposure to radiation, moisture from condensation or precipitation, electrochemical corrosion, metal surface coating breakdown, dissimilar metal reactions, anchor rod corrosion, concrete weathering or cracking, and alkali-silica reactions. Tunnel 2 instability could compromise its content and human health and the environment (HHE) protection, require facility surveillance and maintenance (S&M) updates, limit *Resource Conservation and Recovery Act of 1976* (RCRA) closure options, and accelerate closure activities.

Based on past study findings, Tri-Party concerns, and readily available information, a structural evaluation of Tunnel 2 is needed to establish if its structural integrity has become compromised and determine its structural strength and failure risk. The study results must support tunnel decisions and activities, including the following:

- S&M method-activity requirements
- Stored waste and HHE protectiveness

Appendix A – Systematic Planning Record

Characterization Data Collection Planning Record

NOTE: In cases where the requested information is not applicable, state that, and explain why it is not applicable so that it is clear that a required field has not been forgotten.

Step 1: State the Problem
(Describe the reason/need for data collection and project goals/objectives)

- Present structural strength (capacity) and failure risk
- Present condition failure mode effects analysis (FMEA) model to evaluate tunnel responses to structural degradation and potentially damaging events (e.g., earthquakes, major thunderstorms, heavy snowfall).

Principal Study Questions Step 2 *(What questions are data needed to answer?)*	**PSQ 1**	Is Tunnel 2 concrete and steel being degraded by moisture (e.g., concrete decay or steel corrosion) or radiation?	**PSQ 5**	Will the data gathered to answer PSQs 1-4 be sufficient to evaluate the strength and failure risk of Tunnel 2?
	PSQ 2	Is the present Tunnel 2 steel and concrete condition sufficient to continue supporting the overburden (8 ft)?	**PSQ 6**	Will the data gathered to answer PSQs 1-4 be sufficient to conduct a FMEA model for Tunnel 2?
	PSQ 3	Is "arching" (overburden soil forming an arch, via settling, around the structure) occurring with the Tunnel 2 overburden?	**PSQ 7**	Are current surveillance practices sufficient to ensure Tunnel 2 protectiveness and structural integrity?
	PSQ 4	Is the 2.4 m (8 ft) overburden still needed to provide radiation shielding for the Tunnel 2 stored waste?	**PSQ 8**	Are current maintenance practices sufficient to ensure Tunnel 2 protectiveness and structural integrity?

Define alternative outcomes or actions that can occur upon answering PSQs. Step 2	**AA 1A**	Tunnel 2 concrete and steel are being degraded by moisture (e.g., concrete decay or steel corrosion) or radiation.	**AA 5A**	The data gathered to answer PSQs 1-4 will be sufficient to evaluate the capacity and failure risk of Tunnel 2.
	AA 1B	Tunnel 2 concrete and steel are not being degraded by moisture (e.g., concrete decay or steel corrosion) or radiation.	**AA 5B**	The data gathered to answer PSQs 1-4 will not be sufficient to evaluate the capacity and failure risk of Tunnel 2.
	AA 2A	Present Tunnel 2 steel and concrete condition is sufficient to continue supporting the 2.4 m (8 ft) overburden.	**AA 6A**	The data gathered to answer PSQs 1-5 will be sufficient to conduct a FMEA model for Tunnel 2.
	AA 2B	Present Tunnel 2 steel and concrete condition is not sufficient to continue supporting the 2.4 m (8 ft) overburden.	**AA 6B**	The data gathered to answer PSQs 1-5 will not be sufficient to conduct a FMEA model for Tunnel 2.
	AA 3A	Arching is occurring with the Tunnel 2 overburden.	**AA 7A**	Current surveillance practices are sufficient to ensure Tunnel 2 protectiveness and structural integrity.
	AA 3B	Arching is not occurring with the Tunnel 2 overburden.	**AA 7B**	Current surveillance practices are not sufficient to ensure Tunnel 2 protectiveness and structural integrity.
	AA 4A	The 2.4 m (8 ft) overburden is needed to provide radiation shielding for the Tunnel 2 stored waste.	**AA 8A**	Current maintenance practices are sufficient to ensure Tunnel 2 protectiveness and structural integrity.
	AA 4B	The 2.4 m (8 ft) overburden is not needed to provide radiation shielding for the Tunnel 2 stored waste.	**AA 8B**	Current maintenance practices are not sufficient to ensure Tunnel 2 protectiveness and structural integrity.

Appendix A – Systematic Planning Record

Characterization Data Collection Planning Record

NOTE: In cases where the requested information is not applicable, state that, and explain why it is not applicable so that it is clear that a required field has not been forgotten.

Identify the decision statements or estimation statements needed to address the PSQs. (Step 2)	**DS-1:** Tunnel 2 concrete and steel are/are not being degraded by moisture (e.g., concrete decay or steel corrosion) or radiation.
	DS-2: The present Tunnel 2 steel and concrete condition is/is not sufficient to continue supporting the overburden (2.4 m [8 ft]).
	DS-3: Arching is/is not occurring with the Tunnel 2 overburden.
	DS-4: The 2.4 m (8 ft) overburden is/is not still needed to provide radiation shielding for the Tunnel 2 stored waste.
	DS-5: The data gathered to answer PSQs 1-4 will/will not be sufficient to evaluate the strength and failure risk of the Tunnel 2 steel and concrete structural components.
	DS-6: The data gathered to answer PSQs 1-4 will/will not be sufficient to conduct a Tunnel 2 FMEA model to evaluate structural responses to decay, corrosion, and potentially damaging events (e.g., earthquakes, major thunderstorms, heavy snowfall).
	DS-7: The current surveillance practices are/are not sufficient to ensure Tunnel 2 protectiveness and structural integrity.
	DS-8: The current maintenance practices are/are not sufficient to ensure Tunnel 2 protectiveness and structural integrity.

Data Needs

(Define the spatial and temporal boundaries of the study)

Step 4: Define what constitutes a sampling unit:

The entire tunnel storage area (e.g., steel and concrete structural components, corrugated steel sheets, bituminous steel sheet coating, I-beams, welds, U-bolts, whale arches, footings, and overburden). It may not be possible to collect samples from Tunnel 2 due to the structural instability of the unit.

Step 4: What is the smallest unit upon which decisions or estimates will be made?

Individual steel and concrete connections and locations where structural degradation through radiation, moisture, electrochemical corrosion, lack of metal surface coating integrity, dissimilar metal reactions, anchor rod corrosion, concrete weathering, concrete cracking, and alkali-silica reactions may be occurring.

Data Needs Summary Step 3

(Information inputs to answer PSQs: target population, characteristics of interest, spatial and temporal limits, scale of inference)

PSQ	Data Need	Media of Interest	Sampling Location	Sampling Approach	Action Level	Number of Samples	Practical Sampling Constraints	Analytical Approach	Potential Data Sources
PSQ 1	Outer tunnel structural material (steel and concrete) condition	Concrete & steel (whaler arches, foundations, and steel sheet-whaler arch joints)	Outer tunnel storage area	Visuals for corrosion (steel) or signs of decay or failure (steel and concrete)	>30% of observations are corroded (steel) or show decay or failure (steel and concrete)	3+ locations	Worker safety; overburden excavation could damage tunnel steel sheets and concrete	Visuals and photos to document steel and concrete condition	New field visuals-photos (old photos not useful for current conditions)
PSQ 1	Inner tunnel structural material condition	Steel sheet (walls & ceiling) and concrete footings	Inner tunnel storage area (risers nearest the door)	Visuals for corrosion (steel) or signs of decay or failure (steel and concrete)	>30% of observations are corroded (steel) or show decay or failure (steel and concrete)	2+ locations (2 risers nearest the door)	Access (riser cover removal, worker safety for camera and other instrument operations)	Visuals and photos to document steel and concrete condition	New field visuals and photos (old photos not useful for current conditions)

Appendix A – Systematic Planning Record

Characterization Data Collection Planning Record

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Data Needs Summary Step 3

(Information inputs to answer PSQs: target population, characteristics of interest, spatial and temporal limits, scale of inference)

PSQ	Data Need	Media of Interest	Sampling Location	Sampling Approach	Action Level	Number of Samples	Practical Sampling Constraints	Analytical Approach	Potential Data Sources
PSQ 2	Outer and inner tunnel steel & concrete condition (regarding ability to support 2.4 m [8 ft] overburden)	Concrete and steel sheet components (whaler arches, the foundations, and steel sheet-whaler arch joints)	Inner and outer storage area	Visuals for corrosion (steel) or signs of decay or failure (steel and concrete)	>30% of observations are corroded (steel) or showing signs of decay or failure (steel and concrete)	5+ (PSQ 1 & 2 locations)	Same as PSQs 1 & 2	Estimate if tunnel component strength (based on condition) can reliably support the overburden	New field visuals-photos; new estimates of structural strength; new PSQ 3 & 4 estimates of soil arching and shielding needs
PSQ 3	Overburden soil "arching" potential	Overburden material (soil)	Outer storage area overburden	Overburden soil sampling (borings and test pits)	Low soil shear strength = poor arching potential	3+ locations (same areas as PSQ 1 [outer] visual locations)	Worker safety; overburden soil sample collection restrictions	Geotechnical testing (physical, mechanical, and arching properties)	New overburden soil arching potential estimates
PSQ 4	Current inner Tunnel 2 radiation estimates, isotope decay rates, and overburden shielding properties	Tunnel 2 stored waste, storage area steel & concrete, and overburden soil	In-tunnel storage area (near the door); storage area overburden	Inner tunnel radiation dose measurements; initial waste inventory data; data and information from historical records	Direct radiation exposure level criteria	2+ locations (2 risers nearest the door)	Worker safety; tunnel access (manhole cover removal); availability of pertinent data and information from historical records	Field survey instruments for radiation dose estimates	New dose estimates; new soil shielding needs; new decay calcs; historical records (initial dose and inventory)
PSQ 5	Data and information collected for PSQs 1-4	Steel, concrete, and overburden soil	See PSQs 1-4	See PSQs 1-4	See PSQs 1-4	See PSQs 1-4	See PSQs 1-4	Strength and failure risks; arching and shielding influence on overburden needs	New strength and failure risk results; new arching probability; new shielding needs
PSQ 6	Data and information collected for PSQs 1-4	Steel, concrete, and overburden soil	See PSQs 1-4	See PSQs 1-4	See PSQs 1-4	See PSQs 1-4	See PSQs 1-4	FMEA modeling	New FMEA model results
PSQ 7	Current surveillance practices, data and evaluation results from PSQs 1-6	Steel, concrete, and overburden soil	Exterior of tunnel overburden surfaces	Light Detection And Ranging (LIDAR)	>5 cm subsidence over >2 m^2 area	Monthly to quarterly	Weather	Digital analysis; compared flyover-to-flyover	Stationary, satellite, helicopter, or drone flyovers with combined LIDAR and global positioning system assessment
PSQ 8	Current maintenance practices, data and evaluation results from PSQs 1-6	Steel, concrete, and overburden soil	Exterior of tunnel overburden surfaces; limited tunnel interior	LIDAR	>5 cm subsidence, over >2 m^2 area, steel sheet corrosion, weld failure, concrete decay, etc.	Monthly to quarterly; one-time entry	Weather; entry restrictions (S&H) and equipment	See PSQ 7; photo-video evaluation (if entry approved)	See PSQ 7; photo-video evaluation (if entry approved)

Performance or Acceptance Criteria

(Determine the quality of data needed and analytical approach)

Appendix A – Systematic Planning Record

Characterization Data Collection Planning Record

NOTE: In cases where the requested information is not applicable, state that, and explain why it is not applicable so that it is clear that a required field has not been forgotten.

Decision Problem

Provide a decision rule related to the Action Level identified above that includes a clear "if…then…else" statement: Step 5: Decision rules (DRs) are related to the previously identified PSQs and decision statements in Step 2 and add applicable Action Levels that are included in clear "if…then…otherwise" statements:

DR-1: If the data show that Tunnel 2 concrete and steel have been degraded by radiation or moisture (decay and corrosion), then the tunnel degraded capacity would be identified and a determination made if it is unstable and protection of the tunnel contents and HHE could be compromised. Otherwise, Tunnel 2 structural stability would be indicated, but enhanced S&M activities are likely needed to ensure continued stored waste and HHE protection.

DR-2: If the data show that the present Tunnel 2 steel-concrete condition is sufficient to continue supporting the overburden (2.4 m [8 ft]) , then no changes to the overburden thickness would be needed. Otherwise, determine how much weight Tunnel 2 can presently support and if reduced overburden thickness would protect the stored waste and HHE, and possibly improve Tunnel 2 structural stability.

DR-3: If the geotechnical data show that arching is occurring with the Tunnel 2 overburden, then the strength (capacity) of the tunnel may be sufficient to support the overburden. Otherwise, determine how much weight Tunnel 2 can support and if lesser overburden requirements would protect the stored waste and HHE, and possibly improve Tunnel 2 structural stability.

DR-4: If the data show that 2.4 m (8 ft) overburden is required to shield the Tunnel 2 stored waste and the tunnel strength is sufficient to support the overburden, then no changes to the overburden thickness would be evaluated. Otherwise, determine how much weight the Tunnel 2 structure can support, if the reduced overburden thickness will maintain adequate shielding, and if the overburden reduction could improve Tunnel 2 structural stability.

DR-5: If the data gathered to answer PSQs 1-4 are sufficient to evaluate the strength and failure risk of Tunnel 2, then conduct the strength and failure risk evaluations for the tunnel. Otherwise, identify missing or inadequate data and plan to collect it so the Tunnel 2 strength and failure risk evaluation can be completed.

DR-6: If the data gathered to answer PSQs 1-4 are sufficient to conduct Tunnel 2 FMEA modeling , then conduct it. Otherwise, identify missing or inadequate data and plan to collect it so a FMEA modeling effort can evaluate structural responses to decay, corrosion, and potentially damaging events (e.g., earthquakes, major thunderstorms, heavy snowfall).

DR-7: If current surveillance practices are sufficient to ensure Tunnel 2 protectiveness and structural integrity, then continue with the current surveillance practices. Otherwise, develop updated surveillance practices that are sufficient to ensure Tunnel 2 protectiveness and structural integrity.

DR-8: If current maintenance practices are sufficient to ensure Tunnel 2 protectiveness and structural integrity, then continue with the current maintenance practices. Otherwise, develop updated maintenance practices that are sufficient to ensure Tunnel 2 protectiveness and structural integrity.

Step 6: Specify the population parameter *(e.g., mean, median, or percentile)*, appropriate for making decisions or estimates:

A statistical approach will not be utilized when evaluating the structural integrity of Tunnel 2. The overall empirical steel-concrete condition of the tunnel will be evaluated and modeled (FMEA) to establish the current Tunnel 2 structural strength and failure risk using a judgmental sampling approach and a weight-of-evidence decision-making strategy.

Step 6: What are the consequences of making an incorrect decision and what is the tolerance for an incorrect decision?

Appendix A – Systematic Planning Record

Characterization Data Collection Planning Record

NOTE: In cases where the requested information is not applicable, state that, and explain why it is not applicable so that it is clear that a required field has not been forgotten.

To ensure the continued protection of the Tunnel 2 stored waste and HHE, incorrect decisions regarding the structural strength (capacity) and failure risk should be avoided.

Thinking Tunnel 2 Is Stable When It Is Actually Unstable

Incorrectly determining that the Tunnel 2 corrugated steel sheets, I-beams, welds, or concrete are not degraded, that the tunnel is stable with limited failure risk, and that current S&M practices can continue unchanged *could result in minimal actions and concern*, leading to continued degradation, tunnel failure, and increased HHE risk.

Thinking Tunnel 2 Is Unstable When It Is Actually Stable
Incorrectly determining that the Tunnel 2 corrugated steel sheets, I-beams, welds, or concrete are severely degraded, that the tunnel has high failure risk, and that current S&M practices can continue unchanged *could result in unnecessary actions and concern*, leading to unnecessary maintenance activities and increased expenditures (labor and materials) to prevent continued degradation, tunnel failure, and increased HHE risk.

Step 6: Develop the specification of the estimator by combining the true value of the selected population parameter with the scale of estimation and other boundaries:

Limited external Tunnel 2 structural component inspections are considered inadequate and could possibly compromise local tunnel structural integrity. Contingent on access restrictions via two existing manholes nearest the door, internal structural component visual inspections could be conducted via worker entry, remote control cameras, or a combination of these methods to collect data and information that represent the entire tunnel.

Step 6: What are the acceptable limits on uncertainty?
The Tunnel 2 judgmental sampling approach and weight-of-evidence decision-making strategy are sufficient for establishing current Tunnel 2 structural integrity (capacity) and failure risks. Steel and concrete are the construction materials of primary concern, and an important Tunnel 2 DQO assumption is that degradation observed via the identified accessible risers (near the door) would apply to all the other Tunnel 2 areas. This assumption recognizes a low threshold for probable failure risk and minimal acceptable uncertainty in interpreting the strength and modeling (FMEA) modeling results.

Step 7: Plan for Obtaining the Data

(Specify the general plan of obtaining the needed data and explain where and how the information in this Planning Record will be formalized in a data collection plan)

Data Collection Options (external): Collecting Tunnel 2 corrugated steel sheet samples for destructive assay is not recommended. Collecting samples could accelerate corrosion and decomposition of the steel. Removal of the overburden in an effort to collect samples of the corrugated steel sheets could cause local instability and locally compromise the effectiveness of the steel sheet and its coating. Also, limited external visual inspections would not provide sufficient information to support the structural integrity and failure risk evaluations required. Because they are external to the storage space and several feet from the corrugated steel sheet and its coating, overburden excavation to visually inspect the concrete whale arches and their footings would be appropriate for Tunnel 2.

Data Collection Options (internal): A Tunnel 2 internal inspection approach should be seriously considered due to the limitations identified for the external approach, the 70% full status of the tunnel (ease of movement), and available access points through the roof risers. There are 17 risers spaced every 29 m (96 ft) along the north-south axis of the tunnel. The effective riser diameter is 15 ¾ in. with 36 in. diameter welded-closed manhole covers currently in place. Contingent on tunnel access safety restrictions via the risers, internal structural component visual inspections of the steel, steel coating, concrete wall foundation, welds, mechanical fasteners, etc., could be conducted via worker entry, remote

Appendix A – Systematic Planning Record

Characterization Data Collection Planning Record

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Step 7: Plan for Obtaining the Data

(Specify the general plan of obtaining the needed data and explain where and how the information in this Planning Record will be formalized in a data collection plan)

control cameras, or a combination of these methods to collect photos and videos that represent the entire internal structure of the tunnel.

Worker access, if allowed, would follow as low as reasonably achievable (ALARA) principles by being limited to the tunnel door area to maximize their distance from the stored waste and could be for limited periods to minimize potential dose. Shielding would be considered. Worker entry would allow observation of the structural components (e.g., weld strength, corrosion extent and depth, I-beam fastener integrity, and corrugated steel sheet stability). This would provide better quality data and information for the tunnel structural integrity and failure risk evaluations planned.

Enhanced Surveillance Data Collection (external): Enhanced Tunnel 2 surveillance using LIDAR and GPS technologies would build on the existing overburden surface baseline (two previous surveys) that could be reevaluated at regular intervals (e.g., monthly, quarterly, or annually) to identify indications of structural failure (e.g., >5 cm overburden subsidence over a >2 m^2 area). These data could be collected using stationary, satellite, or drone-helicopter flyovers that would allow digital analyses of the entire Tunnel 2 surface (top and sides) for indications of structural failure (e.g., overburden subsidence).

Attachment 1

HWS-8262, *Specifications for PUREX Equipment Disposal*

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GENERAL ELECTRIC CO.
ENGINEERING FILES UNIT
760 BUILDING, L...
RICHLAND, WASHINGTON

HWS-8262

SPECIFICATION FOR

PUREX

EQUIPMENT DISPOSAL

PROJECT CCC 964

October 5, 1962

REFERENCE
FILE

Prepared by Bovay Engineers

Prepared by

Checked by

Approved for General Electric Company

Wm C Armstrong

10/15/62
Date

Tunnel #2

REFERENCE
FILE

GENERAL ELECTRIC CO.
ENGINEERING FILES UNIT
760 BUILDING, L...
RICHLAND, WASHINGTON

HWS-8262

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DIVISION I

EXCAVATION, BACKFILL, GRADING AND SITEWORK

GENERAL

1. SCOPE

This division covers excavation, backfill, grading and sitework.

2. WORK NOT INCLUDED

Temporary closure wall in existing tunnel will be removed by others.

3. PRECAUTIONS

Heavy construction equipment shall not be operated over tunnel structure at any time. A crawler-type tractor, not exceeding 14,000# gross weight may be used for finish grading over top of tunnel. Wheel-type equipment will not be permitted. No equipment will be permitted to operate over the metal tunnel until 24" or more of backfill has been placed.

WORKMANSHIP

4. EXCAVATION

a. Concrete tunnel section, eliptical tunnel section invert, ribbed arch footings and wall footings shall bear on undisturbed earth. No vehicl shall pass over any earth surface prepared to receive concrete. Depre ions or holes below elevations shown on the drawings shall be filled with concrete, as directed by the Commission, at the Contractor's expe

b. Excavated material shall be kept clear of buildings, roadways, fences, electric power lines, fire hydrants and other existing facilities.

c. Excavation for all buried lines shall be true to line and grade as shown on the drawings. Trenches shall be of such depth as to allow placement of not less than 4 inches of sand backfill under the pipe.

5. SHORING

a. Shoring shall be required for all excavations in which the sloughing of sides would undermine adjacent structures or would create hazardous working conditions. Shoring may be omitted wherever the sides are sloped not less than one and one-half horizontal to one vertical and where existing facilities are not endangered.

WORKMANSHIP - (Cont'd)

b. All shoring shall be removed as backfill progresses.

c. Material for shoring may be steel or timber.

6. BACKFILL, STRUCTURAL CONCRETE TUNNEL

a. Backfill around the structural concrete tunnel section shall not be commenced until 7 days after the roof slab has been poured.

b. Frozen particles, stones greater than 8 inches in any dimension, vegetable matter and trash shall not be used in any backfill. Backfill material larger than 8" may be used at least 10' away from the structure.

c. Trash shall not be allowed in spaces to be backfilled.

d. Material for structural backfill shall be placed in layers not to exceed 24 inches loose measurement and thoroughly compacted. Compaction by loaded scrapers and/or tractors will be considered adequate for non-load-bearing compaction, subject to the restrictions specified in Section 3 above.

e. Care shall be exercised during backfilling to prevent excessive loads on walls and to insure balanced loading on opposite walls.

f. Backfilling by means of sluicing or flooding will not be permitted.

7. BACKFILL, METAL TUNNEL, RIBBED ARCH DESIGN

Backfill and embankment around the ribbed arch design tunnel shall conform to Sections 6b except stone size within two feet of tunnel section shall be 3" minus.

8. BACKFILL, METAL TUNNEL, ELIPTICAL DESIGN

Backfill for the eliptical design tunnel shall conform to the following:

a. Zone 1 backfill shall consist of 3/4" minus material and shall be compacted by vibration to a density conforming to the following:

When tested in the field in accordance with AASHO (American Association of State Highway Officials) Designation T-147-49 "Field Determination of Density of Soil in Place," each layer of compacted embankment shall have a density not less than the following: (All equipment and labor for performing the tests shall be provided by the Contractor.)

(1) For clayey and silty materials - 90% of the "maximum density" as determined in accordance with AASHO Designation: T-99-49 "Standard Method of Test for the Compaction and Density of Soils." The moisture content of the material shall be uniform throughout the layer and shall be such that the specified density can be obtained. In no case shall the moisture content vary more than 3 percentage points above or below the optimum moisture content as determined by AASHO Designation T-99-49.

WORKMANSHIP (Cont'd)

(2) For cohesionless free-draining material - such as sands and gravels, 70% relative density as determined by the Standard U. S. Bureau of Reclamation relative density tests for cohesionless free-draining soils. The relative density of cohesionless free-draining soil, expressed as a percentage, is defined as its state of compactness with respect to the loosest and most compact states at which it can be placed by laboratory procedures. The relative density will be based on the following formula, wherein the maximum density is the highest unit weight of the soil, minimum density is the lowest unit weight of the soil and in-place density is the unit weight of the soil in place. Tests for moisture content are made on the materials and unit weights are expressed in terms of oven-dry weights.

$$\text{Relative density} = \frac{\text{max. den.} \times (\text{in-place den.} - \text{min. den.})}{\text{in-place den.} \times (\text{max. den.} - \text{min. den.})} \times 100$$

The particular test to be used, depending on the type of soil, shall be as determined by the Commission.

b. Zone 2 backfill shall consist of 3" minus material and shall be brought up evenly on each side of the structure in 12" lifts and shall conform to the compaction specified in Section 8a of this division.

c. Zone 3 backfill and embankment shall conform to Sections 6b, c, d and e of this Division, except that material shall be 3" minus within 2' of the tunnel.

d. Load bearing backfill shall be compacted by vibration.

9. BACKFILL, UNDERGROUND PIPING

a. Pipes shall rest on a sand cushion at least 4 inches thick.

b. After necessary line testing has been accomplished, backfill for piping shall be carefully placed around pipe. The first 12" of backfill shall be sand.

c. The remainder of the backfill shall conform to Section 6 of this division.

10. FINISH GRADING

a. Areas around and adjacent to all facilities constructed shall be bladed to provide reasonably smooth, uniform surfaces.

b. Finish grading shall be carried to elevations shown on the drawings. Surface shall consist of a 4 inch leveling course of predominantly coarse gravel to retard wind erosion. The leveling course may be formed by depositing gravel or by scarifying, dragging, raking or otherwise working to obtain the desired surface and to leave the area reasonably free of stones larger than 3 inches in diameter. Equipment for grading on top of new tunnel shall conform to Section 3 of this division. No live loads shall be imposed upon the top of the existing concrete tunnel.

DIVISION II

CONCRETE AND MASONRY

GENERAL

1. SCOPE

This division covers concrete and masonry.

MATERIALS AND WORKMANSHIP

2. CONCRETE, REINFORCING STEEL AND EMBEDDED ITEMS

a. Concrete work and reinforcing steel shall conform to Hanford Standard Specifications HW-4798-S, Placing Reinforced Concrete. Embedded items shall be as shown on the drawings.

b. Concrete shall not be placed until forms have been inspected and approved by the Commission, and pour slips have been approved by the Commission.

c. All foundations shall be poured on undisturbed soil. Areas that have been over-excavated for foundations shall be brought to proper grade with mass concrete.

d. Reinforcing steel shall be welded to existing reinforcing steel as shown on the drawings.

e. Existing dowels shall be cleaned of all rust, scale and deleterious material.

3. GROUT

Grout shall be "Embecco" as manufactured by the Master Builders, Inc., or approved equal, and shall be applied in strict conformance with the manufacturer's published instructions.

4. PRECAST CONCRETE

4.1 DESIGN

The member shall be designed in accordance with the latest recommendations of the Joint ACI-ASCE Committee 323 on prestressed concrete. The design shall be such that the camber of the precast member will provide for the deflection due to all dead loads.

MATERIALS AND WORKMANSHIP (Cont'd)

4.2 SHOP DRAWINGS

Shop drawings shall be prepared for all members and shall be submitted with complete calculations in conformance with the Special Conditions. Shop drawings and calculations shall bear the seal of a registered professional engineer.

4.3 MATERIAL

Materials shall conform to the following:

Prestressing Strands	ASTM A416-57T
Reinforcing Bars	ASTM A15-57T & A305-56T
W W Mesh	ASTM A185-56T
Aggregate: Sand and gravel (hardrock)	ASTM C33-57
Cement	ASTM C150-56

Concrete. The concrete shall have a unit weight of not greater than 150 lbs/cu ft for sand and gravel (hardrock) concrete, and the strength shall be sufficient to carry the design load.

4.4 DIMENSIONAL TOLERANCES

The size of the members shall be as shown on the plans with cross-section dimensional tolerances not to exceed ± 1/4".

Length dimensional tolerance not to exceed ± 1/4". Camber not to exceed ± 1/4" of the design camber.

4.5 FABRICATION, TRANSPORTATION AND ERECTION

a. The members shall be fabricated, transported and erected by methods which are in accordance with the PCI Standards for Prestressed Concrete Plants, STD-103-58T, Chapters 1 through 6.

b. The fabricator of the members shall have had previous experience in the construction and design of prestressed members.

5. MASONRY

5.1 MATERIAL

a. Water shall be clean and free from oil, acids, salt or injurious substances and shall be handled in clean containers.

b. Portland cement shall conform to ASTM C-150-56, Type II.

MATERIALS AND WORKMANSHIP (Cont'd)

c. Hydrated lime shall conform to ASTM C-6-49.

d. Sand shall conform to ASTM C-144-52T. 100% of the sand shall pass a No 8 sieve and not more than 30% shall pass a No 50 sieve.

e. Hollow concrete blocks of the sizes shown on the drawings, shall be Grade A blocks conforming to ASTM C-90-52. Blocks shall be damp cured for at least 7 days. Blocks shall be manufactured of sand and gravel aggregate.

f. Solid concrete blocks and concrete brick of the sizes shown on the drawings, shall be Grade A brick or blocks conforming to ASTM C-145-39. Block and brick shall be damp cured for at least 7 days and shall be manufactured of sand and gravel aggregate.

g. Mortar shall consist of 1 part portland cement and 4 parts sand tempered with 1/2 part of hydrated lime by volume.

h. Reinforcement for concrete block walls shall be of standard manufacturer designed specifically for such use.

5.2 MIXING MORTAR

a. Mortar materials shall be accurately measured by volume and thoroughly mixed in a batch mixer. Mixing shall continue for at least two minutes after all ingredients have been added.

b. Mortar shall be mixed in quantities not greater than required for immediate use.

c. Retempering of mortar will not be permitted.

d. The use of anti-freeze admixtures will not be permitted without approval of the Commission.

5.3 LAYING CONCRETE MASONRY UNITS

a. Masonry units shall be kept dry at all times. Units shall be stored on suitable dunnage or pallets and shall not be allowed to rest on the ground. Units shall be completely covered during storage to prevent absorption of water.

b. Whenever masonry laying is stopped, the tops of uncompleted walls shall be covered with suitable material to prevent the entrance of water into the units.

c. Hollow blocks shall be laid with air cells vertical and with the main bearing webs in proper relation for bearing on the webs of blocks immediately below.

d. Units shall be laid in a full bed of mortar. Courses shall be kept level.

MATERIALS AND WORKMANSHIP (Cont'd)

e. Units shall be laid in running bond pattern with vertical joints in adjacent courses staggered and vertical joints in alternate courses accurately lined up.

f. Wall reinforcement shall be placed as shown on the drawings with a minimum lap of 6" at all splices.

g. Joints shall be finished with a concave pointing tool applied so as to compact setting mortar and form a close and continuous contact with the masonry units.

h. Masonry units shall not be laid when the temperature is 35 °F or lower. If the temperature drops below 35 F during the curing of the mortar, adequate temporary heat shall be supplied to hold the temperature surrounding the walls above 35 F for a period of 7 days.

DIVISION III

STEEL TUNNEL

GENERAL

1. SCOPE

This division covers a steel tunnel. The contractor has the option of using either the ribbed arch or eliptical design, but not a combination of the two.

MATERIAL

2. RIBBED ARCH DESIGN

2.1 RIBS

Ribs shall be fabricated to the geometry shown on the drawing in conformance with the requirements of Division V of this Specification.

2.2 LINER PLATE

Liner plate shall be deformed four flange steel liner plate and having the following dimensions:

a.	Thickness	3/16"
b.	Length	37 - 11/32" (arc length)
c.	Width	16"
d.	Flanges	2"
e.	Radius	90"

The end flanges shall be bent straight, not radial. The steel shall conform to ASTM A-283-58, Grade C.

2.3 FASTENERS

Liner plates shall be fastened to the ribs with 3 - 5/8" bolts at each end. Liner plates shall be fastened to each other with 4 - 5/8" bolts. Bolts shall conform to ASTM A-325-61T.

3. ELIPTICAL DESIGN

3.1 SECTION

The section shall be constructed with No 3 gage eliptical steel corrugated sectional plate. Steel shall conform to ASTM A-283-58, Grade C. Corrugations shall have a 6" pitch and shall be 2" high.

MATERIAL (Cont'd)

3.2 FASTENERS

a. The circumferential seam shall have a lap of 4" and shall be fastened with a single row of 3/4" bolts spaced 9 19/32" on center.

b. The longitudinal seam shall have a lap of 4 3/4" and shall be fastened with 2 rows of 3/4" bolts. The 2 rows shall be 2" on center with holes staggered. The holes in each row shall be 6" on center.

c. Bolts shall conform to ASTM A 325-61T.

WORKMANSHIP

4. INSTALLATION

a. The ribs, liner plate and sectional plate shall be erected in conformance with the lines shown on the drawings.

b. On the elliptical section varying lengths of sections shall be installed so that staggered circumferential seams result.

c. No openings will be permitted large enough to permit more than fine sand seepage except for the 1" weep holes.

5. STRUTTING (Eliptical Liner Only)

Strutting shall be provided and installed during backfilling operation to prevent permanent deformation to the cross section exceeding 3% of the nominal dimensions. All strutting connections to the tunnel section shall be removed and damaged coating shall be repaired.

The contractor shall submit a sketch detailing his temporary strutting method in accordance with the provisions for Shop Drawings in the Contract Special Conditions.

DIVISION IV

RAILROAD TRACK

GENERAL

1. SCOPE

This division covers railroad track and appurtenances.

MATERIALS AND WORKMANSHIP

2. GENERAL

Railroad track, ties, ballast and appurtenances shall conform to the applicable sections of Hanford Standard Specification HWS-5722-S and Hanford Standard AC-7-4 as modified by the details on the drawings. Track clips and anchor bolts required for anchoring the track to the concrete floor shall be as detailed on the drawings.

3. COMMISSION FURNISHED MATERIAL

The Commission will furnish the following materials as stated in the Special Conditions:

a. 90# ARAA Rails
b. 72# CNW Rails
c. Ties
d. Joint bars
e. Track bolts
f. Tie plates
g. Rail anchors
h. Gage rods
i. Turnout less ties and including switchstand.
j. Ballast

All other material, including but not limited to bumper, track spikes, and rail compromise joints shall be furnished by the Contractor.

DIVISION V

STRUCTURAL AND MISCELLANEOUS STEEL

GENERAL

1. SCOPE

This division covers structural and miscellaneous steel.

2. GENERAL

The current rules and practices set forth in the Code of Standard Practice for Steel Buildings and Bridges, and the Specifications for the Design, Fabrication, and Erection of Structural Steel for Buildings of the American Institute of Steel Construction (AISC) and seismic provisions of the Uniform Building Code, Zone 2, shall govern this work, except as otherwise specified herein.

3. SHOP DRAWINGS

Fabrication shop drawings of all members shall be submitted for approval in conformance with the requirements of the Special Conditions.

MATERIALS

4. STRUCTURAL AND MISCELLANEOUS STEEL

Structural and miscellaneous steel shapes shall conform to the requirements of ASTM A7-58T unless noted otherwise on the drawings, or herein.

5. GRATING

Grating shall conform to the requirements of Federal Specification RR-G-661a, Type II. Grating shall have the bar size and spacing as shown on the drawings.

WORKMANSHIP

6. FABRICATION AND ERECTION OF STRUCTURAL AND MISCELLANEOUS STEEL

Structural and miscellaneous steel shall be fabricated and erected in conformance with the AISC Specifications for the Design, Fabrication, and Erection of Structural Steel for Buildings, and the following:

WORKMANSHIP (Cont'd)

a. The contact surfaces of connected parts shall be free from paint.

b. Connections shall be as shown on the drawings.

c. All welding shall be in accordance with the "Code of the American Welding Society for Arc and Gas Welding in Building Construction."

d. Shop holes shall be provided in members to permit connecting the work of other trades when noted on the drawings.

e. New holes required for connections to steel in the field shall only be made by drilling except by written permission of the Commission.

DIVISION VI

WATER FILLED DOOR AND HOIST

GENERAL

1. SCOPE

This division covers one water filled door and one hoist assembly.

2. SHOP DRAWINGS

Shop drawings, spare parts lists, lubrication and maintenance instructions, shall be prepared and submitted to the Commission for approval in conformance with the Special Conditions.

MATERIALS

3. CARBON STEEL AND WELDING ROD

Structural steel shapes, steel plate and filler metal for tunnel door, access platforms and other uses shall conform in all respects to the American Institute of Steel Construction (AISC) Specifications for the Design, Fabrication and Erection of Structural Steel for Buildings and shall be suitable for fusion welding.

4. TUNNEL DOOR HOIST

Tunnel door hoist shall be a standard product of an organization regularly engaged in the manufacture of hoists of this capacity and type. Hoist shall be deck mounted and shall be suitable for out of door use. Hoist shall have a rated capacity of 25 tons at a speed of not less than 8 feet per minute.. Lift travel shall be 25'. The hoist shall be driven by a 440 volt, 3 phase, 60 cycle single speed motor. The hoist shall be equipped with brakes which will prevent lowering of the load except by power of the hoisting motor or by a spring set power released brake. The load hook shall be carried by a multiple sheave block and the cable reeving shall be arranged so that the load block will travel vertically without a tendency to twist or travel laterally. If multiple cables are used, they shall be arranged so that the stresses are equallized among all load lines. All bearings shall be of the anti friction type. All gears shall be cut, totally enclosed and running in oil. The hoist shall be equipped with two limit switches each. Each limit switch shall be single pole, double throw. One limit switch shall be a slack cable limit switch and the other limit switch shall stop the travel 6" before mechanical blockage.

WORKMANSHIP

5. TUNNEL DOOR

a. Tunnel door shall be fabricated and installed in conformance with the details shown on the drawings. Unless otherwise shown on the drawings fabrication and welding shall conform to the AISC Specification for the Design, Fabrication and Erection of Structural Steel for Buildings.

b. Door shall be hydrostatically tested in place to 25 psig measured at the bottom of the door. All joints to be tested shall be painted with a mixture of powdered blue chalk and water which shall be allowed to dry prior to the application of the hydrostatic test. Leaks shall be repaired and the door shall be retested until found leak free. Upon completion of the test all chalk shall be removed. All equipment, facilities and labor for performing the hydrostatic tests shall be furnished by the Contractor.

6. INSTALLATION OF HOIST

Door hoist shall be installed as shown on the drawings and the approved shop drawings. Base plates for door hoist shall be located in conformance with the lines and elevations shown on the drawings. Grouting shall be as specified under Division II, CONCRETE AND MASONRY.

DIVISION VII

PIPING

GENERAL

1. SCOPE

This division covers piping and a pump.

2. SUBMISSION OF DATA

The following pump information shall be submitted in conformance with the Special Conditions.

a. Certified performance characteristic curve based on actual test of pu showing head in feet, efficiency and horsepower plotted against disch in U.S. gallons per minute from 0 to 200 gpm.

b. Complete pump and motor specifications including motor efficiency.

c. Complete dimensional drawings.

d. Spare parts list.

e. Installation instructions.

f. Operation, maintenance and lubrication instructions.

MATERIALS

3. PIPE AND FITTINGS

a. Pipe and fittings shall be as specified in the piping code except as noted on the drawings.

b. Pipe fittings shall conform to the requirements of the American Society for Testing Materials (ASTM), and the American Standards Association (ASA) as specified herein and in the piping code

c. Swivel joints shall be the size and style shown on the drawings as manufactured by Chicksan Company or an approved equal.

(MATERIALS - Cont.)

4. MOTORIZED VALVES

4.1 VALVE M-6

Three inch rotary bonnet, double seated, flanged end, motorized valve, Minneapolis-Honeywell Mod 2922-R, with small size motor or an approved equal. Valve shall be equipped with limit switch whose contacts close when motor field contact "B" closes. Closed contacts indicate closed valve. The valve shall operate in the following sequence:

When selector switch connects "R" to "B", motor runs, driving valve and switch cams. After the shaft has turned 30°, Contact "B" opens and Contact "R" closes. Motor continues to run until shaft has turned 180° at which time Contact "W" closes, Contact "R" opens and motor stops. When selector switch connects "R" to "W", current flows through Contact "W" to motor and similar action is repeated for second half of revolution.

4.2 VALVE M-7

Same as Valve M-6 except 4" size.

4. HOSE VALVE

Hose valve shall be as shown on the drawings.

5. HOSE

5.1 DOOR "C" HOSE

Door "C" hose shall be 2 - 50' lengths of 2 1/2" UL approved dacron filled double jacket, cotton rubber-lined hose with National Standard fire hose couplings.

6. PUMP

6.1 DESIGN CHARACTERISTICS

The pump shall be vertical deepwell turbine pump of the water lubricated type and shall deliver not less than 100 gallons per minute at 35 ft T.D.H. measured at the pump discharge assuming the water level is 1 foot above the pump suction.

MATERIALS (Cont'd)

7.2 CONSTRUCTION

a. Discharge Head - The discharge head shall be of heavy construction made of cast iron, designed for above-ground discharge with a suitable centering ring to receive a complete vertical hollow shaft motor drive. The discharge connection shall be flanged to receive a 2 1/2 discharge pipe.

b. Column shall consist of three parts; the outer column of the screwed butt joint type, the column spiders with inserted bearings, and a drive shaft of suitable strength to transmit the full horsepower required by the pump. The column shall be of Schedule 40 black steel pipe with screwed butt joint type connections, in sections not to exceed 10' in length. It shall be of 4" nominal diameter. The column spiders shall be of bronze with center hubs accurately bored to receive synthetic rubber bearings. The bearings shall be securely locked in place. The lineshaft shall be precision turned, ground and polished stainless steel not less than 1" in diameter. All threads shall be lathe cut. The ends shall be machine finished and undercut for proper butting of the shafts. Bearing intervals shall not be more than 10' center-to-center. The lineshaft shall be protected at each bearing by a sleeve.

c. Bowls shall be of heavy, close-grained cast iron, accurately machined and fitted to close tolerances, free from blow holes, sand holes, and all other faults. Outside diameter shall not exceed 6 inches.

d. Impellers shall be of bronze, semi-open type, accurately machined and finished and statically and hydraulically balanced.

e. The impeller shaft shall be of stainless steel. It shall be precision turned, ground and polished and supported by water-lubricated synthetic rubber bearings on both sides of each impeller.

f. The drive motor shall be as follows:

(1) Motor characteristics such as horsepower, rating, speed, etc. shall fit the requirements of the pump without overloading motor at any point on the pump curve. Drip-proof, ball bearing, squirrel cage induction motor, normal starting torque with non-reverse ratchet.

(2) 440 volt, 3 phase, 60 cycle AC.

(3) Motor shall conform to the latest applicable standards of the American Institute of Electrical Engineering (AIEE), the National Electric Manufacturers Association (NEMA), and the American Standards Association (ASA). The AIEE Standards shall have precedence in cases of disagreement.

WORKMANSHIP

8. PIPE WELDING

8.1 WELDER QUALIFICATION

a. All welding of carbon steel pipe shall be done by welders who have been qualified in accordance with the applicable test requirements of Hanford Standard HW-4900-S, Specifications for Qualifying Welders. A welder will be qualified only on the type of material and form of material he will weld and on the welding process which he will use to perform the work.

b. Radiographic examinations of test welds will not be required.

8.2 WELDING STANDARDS

Welding of carbon steel pipe shall be done in conformance with Hanford Standard HW-4926-S, Specification for Welding Carbon Steels. Sectioning of radiography of welds will not be required.

9. INSTALLATION OF PIPING

a. All piping shall be installed in accordance with the sizes, locations, slope and elevations shown on the drawings and the piping codes.

b. Interior of pipe, fittings and valves shall be kept free from dirt or foreign matter at all times. At all times when installation of pipe is not in progress, the open ends of pipe already laid shall be closed to prevent entry of dirt or foreign matter.

c. All joints and connections shall be water-tight at the specified test pressure.

10. HYDROSTATIC TESTING

Piping installed shall be hydrostatically tested in conformance with the following:

a. All instruments, facilities and labor required to conduct the tests shall be furnished by the Contractor.

b. Before application of the pressure, all air shall be expelled from the pipe and all joints shall be chalked in conformance with Section 5b of Division VI of this Specification.

c. Each test section of the piping shall be slowly filled with water and the specified test pressure shall be applied.

d. Duration of the test shall be at least 30 minutes without appreciable loss of pressure as determined by the Commission.

(WORKMANSHIP - Cont)

e. All piping, fittings, valves and joints shall be carefully examined during the open trench test.

f. All tests shall be made to the satisfaction and under the direction of the Commission. Any defective pipe, and wleds, fittings or valves revealed during the test shall be replaced at the Contractor's expense.

g. Test pressures shall be 125 psi.

11. PIPING CODES

Piping material, fabrication and installation shall conform strictly to the following Piping Code:

PIPING CODE

Pipe	Black steel pipe, seamless or welded per ASTM A-120-61T, Schedule 40.
Fittings	Steel butt welding per ASA B16.9-1958 150#

The exterior surface of underground pipe and fittings shall be cleaned, primed and coated with coal-tar enamel with a bonded asbestos felt wrapper. Materials and application shall conform to AWWA C204-57, together with Section A2 and A3.1 of the appendix of AWWA C204.

DIVISION VIII

VENTILATION

GENERAL

1. SCOPE

This division covers the ventilation system.

2. SUBMISSION OF DATA

The following fan information shall be submitted in conformance with the Special Conditions.

a. Certified performance characteristic curve showing static pressure, efficiency and horsepower plotted against cubic feet per minute.

b. Complete fan and motor specification including motor efficiency.

c. Complete dimensional drawings.

d. Spare parts list.

e. Installation instructions.

f. Operation, maintenance and lubrication instructions.

MATERIAL AND WORKMANSHIP

3. GENERAL

The ventilation system shall be constructed as shown on Drawing H-2-58134.

4. MOTOR

The motor shall fit the requirements of the fan without overloading the motor at any point on the fan curve. The motor shall be a TEFC, ballbearing squirrel cage induction motor rated at 440 volt, 3 phase, 60 cycle AC.

5. BELT GUARD

A belt guard conforming to Hanford Standard M-4-6 shall be installed over the fan drive.

DIVISION IX

PAINTING AND COATING

GENERAL

1. SCOPE

This division covers painting and coating.

MATERIALS

2. PAINT MATERIALS

Paint materials shall conform to the following specifications:

Identification	Type	Use
Fed Spec TT-P-86a(1)	Paint; red-lead-base, ready-mixed	Priming miscellaneous steel and field touch up and finish on water-filled door
Fed Spec TT-P-641b	Primer, paint; zinc dust-zinc oxide	Priming galvanized surfaces where required.
Fed Spec TT-E-489c	Enamel, alkyd, gloss	Finish on miscellaneous steel, identification lettering.
Sec 9.4.2 AWWA D102-55T	Red-lead, linseed with 2 pounds of dry litharage oil paint added to each gallon of paint.	Interior surfaces of water filled doors.

3. COATING MATERIALS

a. The exterior surface of water-filled door - and certain concrete surfaces shall receive coating system MV-3 conforming to Hanford Specification HWS-5961.

b. The interior and exterior surfaces of the steel tunnel shall receive a 35 mil coating of Coating Compound, Bituminous, Solvent Coal Tar Base conforming to Mil Spec MIL-C-18480 (Docks) (Am.1).

WORKMANSHIP

4. SHOP PAINTING

a. All steel, except galvanized and unless otherwise noted on the drawings or specified herein, shall be shop painted.

b. Painting shall not be done when the surrounding atmosphere is damp or dust laden or when surfaces are damp or frosty. Painting shall not be done when the ambient temperature is less than 40 F. Only thoroughly clean and dry surfaces shall be painted. A minimum of 24 hours shall elapse between coats of paint.

c. All paint materials shall be spread with care, to a uniform film thickness, showing no runs, sags, crawls, brush marks, or other defects.

5. HANDLING AND STORAGE

a. All paint shall be delivered to the job site in the manufacturer's original containers with labels intact and seals unbroken.

b. Paint shall be carefully handled and stored in a well ventilated place where it will not be exposed to excessive heat, smoke, sparks, flame, direct rays of the sun or freezing temperatures.

c. Paint shall not be mixed within 25' of stored flammable materials.

d. All necessary precautions shall be taken to prevent fires. Rags, waste, paper or other materials that have become spotted with paint, oil or solvents shall be placed in closed metal containers, and removed from the building at the close of each day's work.

6. PAINT-MIXING

a. Ready mixed oil paints, in original containers, shall be vibrated in a power-driven, vibrator type paint mixer for a period of from three to ten minutes to remove all heavy sediment from the bottom of the can. The entire quantity shall then be "boxed" and strained through a fine wire screen or cheese cloth before using.

b. Ready mixed enamels shall be thoroughly stirred in small quantities and sufficiently "boxed" for uniformity.

c. Paint shall not be mixed when the temperature of the paint or surrounding atmosphere is less than 40 F.

7. SURFACE PREPARATION

a. Surfaces to be painted shall have all rust, scale, dirt, oil, grease, old paint, and weld spatter removed by wire brushing, grinding, or scrubbing with solvents, as required.

b. Shop coats on steel items shall be "touched up" after erection but prior to application of finish coats. Touch-up paint shall be as used for shop painting.

8. PAINTING

a. All necessary precautions shall be taken to protect surfaces not to be painted from paint splash or drip.

b. Surfaces to be welded after erection shall not be painted. Any paint within a distance of 2" from the joint shall be completely removed before welding.

c. Structural steel to be encased in concrete shall not be painted.

d. After erection, bolt heads, welded joints, and all other unpainted surfaces except otherwise specified shall be painted a touch-up coat.

e. All steel shall then be given a complete field coat of primer unless otherwise specified.

f. Surfaces inaccessible for painting after erection shall be given necessary field coats of paint prior to erection.

g. Painting shall not be done when the surrounding atmosphere is damp or dust laden or when surfaces are damp or frosty. Painting shall not be done when the ambient temperature is less than 40 F. Only thoroughly clean and dry surfaces shall be painted. A minimum of 24 hours shall elapse between coats of paint.

h. All finish work shall be free from defective brushing or clogging of lines and angles. Edges of paint adjoining other colors or materials shall be clear and sharp without overlap.

i. "Wet Paint" signs shall be posted to protect newly finished surfaces from damage.

j. All paint materials shall be spread with care, to a uniform film thickness, showing no runs, sags, crawls, brush marks, or other defects.

k. Spray painting is permitted on finish coats only. Only equipment which is capable of properly applying the paint shall be used. It shall be operated as recommended by the manufacturer for the material being sprayed. The equipment shall have traps or separators to remove oil and condensed water from the air. These traps or separators shall be drained periodically during operations. The air from the spray gun impinging against the surface shall show no condensed water or oil.

9. APPLICATION OF COATING SYSTEMS

a. Surface preparation and application of coating system MV-3 - to the exterior surfaces of the water filled doors - shall conform to Hanford Specification HWS-5962.

b. Surface preparation and application of the Bituminous coating system to the interior and exterior surfaces of the steel tunnel shall conform to the coating manufacturers published instructions. The system shall be a two coat system, each coat not less than 18 mils, making a total dry film thickness of not less than 35 mils.

WORKMANSHIP (Cont'd)

10. FINISH SCHEDULE

Colors refer to Federal Standard 595.

Surfaces	Prime Coat No. Coats	Prime Coat Material	Finish Coat No. Coats	Finish Coat Material	Color
Misc steel not imbedded in concrete & not included in the following items.	1	TT-P-86a	1	TT-E-489c	14241 Gray
Ventilation unit framework	1	TT-P-86a or if galvanized TT-P-641b.	1	TT-E-489c	14241 Gray
Interior surfaces of water filled doors.	1	Sec 5.4.2 AWWA-D-102	1	Sec 5.4.2 AWWA-D-102	
Interior & exterior surfaces of steel tunnel, including ribs, curb angles and tunnel parts.		Bituminous, coal tar base, MIL-C-18480			
North face of Door "C", concrete floor of tunnel, lower 18" of interior surface of concrete tunnel wall.		System MV-3 HWS-5961 & HWS-5962			
Remainder of exterior of Door "C".	1	TT-P-86a	1	TT-E-489c	14241 Gray
Junction box and machinery numbers 1" high.			1	TT-E-489c	Black
Piping identification		per HW-5311-S			Green

DIVISION X

ELECTRICAL

GENERAL

1. SCOPE

This division covers electrical work.

2. CODES

The work shall conform to the National Electrical Code (NEC) 1962. Recommended methods and materials for installation of work as described in the above codes shall be mandatory unless otherwise specified herein or otherwise shown on the drawings or referenced Hanford Standards.

MATERIALS

3. MOTOR CONTROLLERS

Motor controllers shall be the size and type shown on the drawings or an approved equal.

4. ADDITIONS TO MOTOR CONTROL CENTER

Circuit breaker, door and operating mechanism shall match the existing motor control center. Circuit breaker shall have the rating shown on the drawings. The existing unit is a Square D Co. No. SJ-2092.8, Type CCP-2, Drawing C 3672 NW.

5. ANCHOR

Anchor shall conform to Hanford Standard D-4-1a, Concrete Cone Anchor.

6. GUY STRAND

All guy strand shall be galvanized steel as specified on Hanford Standard D-4-1d.

7. LINE HARDWARE

All line hardware for guy and anchor shall be galvanized and shall be as shown or noted on Hanford Standard D-4-1d, or approved equals.

MATERIALS (Cont'd)

8. RACEWAYS, FITTINGS AND BOXES

a. Rigid steel conduit shall be hot dipped galvanized, zinc metalized, or sherardized conduit, and shall conform to Federal Specification WW-C-581c. Conduit shall be furnished with an antifriction finish on the internal surfaces.

b. Liquid-tight flexible conduit shall be the type with a built-in ground conductor.

c. Unless shown otherwise on the drawing, the minimum size of conduit shall be 3/4 inch.

d. Boxes used in the pump house shall be aluminum, galvanized steel, cast iron or cast aluminum.

e. Boxes used in all other locations shall be cast steel or cast iron with corrosion resistant finish, threaded hubs and gasketed covers. Boxes shall conform to the Joint Industry Conference Electrical Standards for Industrial Equipment specifications for seal-tight fittings.

9. CONDUCTORS

9.1 GENERAL

Wire and cable shall be of the type specified herein. Size and number of conductors shall be as shown on the drawings.

9.2 BUILDING WIRE - 600 VOLT

a. Thermoplastic insulated wire shall conform to Hanford Standard Specifications HWS-8002-S, Thermoplastic Insulated Wire and Cable. The insulation thickness of Type TW wire shall be in accordance with the Insulated Power Cable Engineers Association (IPCEA) Standard S-19-81, Feb. 1951, Appendix I, Table I, as follows:

Size AWG or MCM	Thickness in 64th Inch
18-9	3
8	4
7-2	4

b. The minimum wire size for lighting and power circuits shall be No. 12 AWG. Unless otherwise specified, wire sizes No. 8 and larger shall be stranded and No. 10 and smaller may be solid, except that all control wire and equipment grounding conductors shall be stranded. All conductors shall be copper, unless shown otherwise on the drawings.

9.3 DIRECT BURIAL CABLE

Direct burial cable shall be Type UF and shall have the number of conductors and size shown on the drawings.

(MATERIALS - Cont)

9.4 GROUNDING CONDUCTORS

Grounding conductors shall be stranded bare copper wire of the size shown on the drawings.

10. SOLDERLESS CONNECTORS

Pressure type solderless connectors and terminal lugs for use with building wiring not exceeding 600 volts between conductors, shall be the following or approved equals:

For Conductors No. 8 AWG and Smaller	
(1) Ideal Industries, Inc.	- Ideal Set Screw Type
(2) Burndy Engineering Co.	- "Hydent"
(3) Minnesota Mining & Mfg. Co.	- "Scotchlok"

For Conductors No. 6 AWG and Larger	
(1) Burndy Engineering Co.	- "Hydent" or Screw Pressure Connectors
(2) Erico Products, Inc.	- "Cadweld" connections

WORKMANSHIP

11. INSTALLING GUY AND ANCHOR

a. Backfill around anchors shall be thoroughly compacted throughout the entire depth of the hole.

b. Down guy shall be run at an angle of 45 degrees. Guy rod set in earth shall be in line with the strand and shall have not less than 6 inches nor more than 12 inches of rod length exposed. All anchor rod shall have double thimble eyes. Down guy shall be provided with steel guy guards.

c. Guys and anchors shall be installed according to Hanford Standard D-4-1d.

WORKMANSHIP (Cont'd)

12. INSTALLING BUILDING GROUNDING SYSTEMS

12.1 UNDERGROUND ELECTRODES AND CONNECTIONS

a. Grounding shall be by means of an existing ground system, the buried tunnel liner and an underground water pipe in accordance with the drawings.

b. All grounding conductors shall be the size shown on the drawings.

c. Buried grounding cable shall be protected against all mechanical damage before and during backfill. Backfill material within one foot of the cable shall not contain rocks larger than two inches in diameter.

d. Splices and taps in grounding conductors that are to be buried in earth or concrete shall be made by the Thermite fusion process.

e. The resistance of ground system joints and taps shall not be greater than the resistance of the same length of continuous conductor.

12.2 SYSTEM AND EQUIPMENT GROUNDING

a. Grounding methods shall be according to the following Hanford Standards:

D-20-10	Basic Requirements and Conductors
D-20-10a	Services, Panels and Conduits
D-20-10b	480 and 277/480 Volt Systems

b. Soldered connections shall not be used. Cadweld or brazed ground connections are permitted.

c. In this division and the drawings, the term "equipment" shall be understood to mean all exposed metal parts of a wiring system including conduit, raceways, metal armor of cables, cabinets, motor frames, motor controllers, etc.

d. The grounding conductor shall in no case be the system neutral or any current carrying conductor.

e. All conduits, and the armor of armored cable shall be connected at each end of the grounding conductor or firmly attached at each end, with a good electrical contact, to a grounded connection box. Ground connections must be made to the grounding conductor at each box.

13. IDENTIFYING EQUIPMENT

The motor starters, junction boxes, and limit switches shall be identified after installation by means of lettering on, or by nameplates attached to such equipment. This identification shall include the designation, use, voltage and number of phases.

WORKMANSHIP (Cont'd)

14. INSTALLING CONDUITS

a. Conduits shall be run parallel to or at right angles with the lines of the building. All bends shall be made with standard conduit ells, field bends, or screwed jointed conduit fittings.

b. All conduit field bends shall be made with standard bending devices and shall have an inner edge radius not less than specified in the National Electrical Code. All bends shall be free of dents or flattening.

c. All conduit shall be cut square, reamed, burrs removed, and cleaned before the introduction of wires or cables. Immediately after installation, all conduit ends shall be plugged or capped with standard conduit accessories until wires are pulled.

d. Conduit joints shall be set up tight. Hangers and fastenings shall be secure and of a type appropriate in design and dimensions for the particular application. Maximum distance between supports shall be 7 ft for 3/4 inch conduit or smaller and 10 ft for one inch conduit and larger. Runs shall be straight and plumb. Elbows, offsets and bends shall be uniform and symmetrical.

e. Couplings, connectors and fittings shall be approved types and shall be installed to provide a rigid mechanical assembly and positive electrical conductivity.

f. Galvanized steel locknuts and bushings shall be used for attachment to enclosures unless a threaded hub is provided. In addition, ground wedges or bushings shall be installed as required by the grounding standards referenced in paragraph 13.2 "System and Equipment Grounding." Threadless fittings are not permitted. Ericson type couplings shall be used where required. Running threads are not permitted.

g. One-hole pipe straps used for supporting conduit shall be equipped with clamp-backs.

h. Conduits shall be run without moisture traps where possible. Where dips are unavoidable, a pull box or condulet with drilled hole shall be placed at each low point to provide a means of escape for moisture.

i. Liquid-tight flexible conduit is permitted in sections three feet or less to make connections to motors or other equipment where the use of rigid conduit is impractical.

15. INSTALLING CONDUCTORS

a. Wire smaller than No. 12 AWG shall not be installed unless specifically indicated on the drawings.

WORKMANSHIP (Cont'd)

b. Circuit conductor color coding shall be:

Single-Phase	Three-Phase
Hot No. 1 - Black	A Phase - Red
Hot No. 2 - Red	B Phase - Yellow or Orange
Neutral - White	C Phase - Blue or Black
Ground - Green or Bare	Neutral - White
	Ground - Green or Bare

Pressure-sensitive plastic colored tape may be used to identify the conductors in lieu of colored insulation. Tape marking shall be applied at each junction and outlet box and shall be a minimum of two inches in width. Color coding shall be maintained throughout each wiring system to the connection box at the point of utilization.

c. Powdered soapstone or other approved manufactured compounds shall be used where a lubricant is required for pulling in wire and cable.

d. All control conductor terminations shall be marked with a number to correspond to the wiring diagram. The marking shall be by means of imprinted tubular plastic wire markers.

16. INSTALLING DIRECT BURIAL CABLE

Cables, where specifically shown on the drawings as direct burial runs, shall be buried a minimum of 18 inches deep, embedded in a sand cushion, and covered with 1 by 8 inch pressure creosote-treated boards before backfilling. The sand cushion shall be a minimum of 3 inches in thickness on all sides of the cable. Underground runs shall be permanently marked with marker posts conforming to Hanford Standard D-15-48.

17. MAKING SPLICES, TAPS AND CABLE TERMINATIONS

a. Splices and taps in 600 volt building wire No. 8 AWG and smaller shall be made mechanically strong, soldered and taped except that any of the solderless connectors described under Section 10, "SOLDERLESS CONNECTORS", may be substituted. For conductors No. 6 and larger, joints shall be made with connectors, tees, lugs, etc. as described under the above paragraph.

b. Solderless connections shall be used according to the manufacturer's instructions. For connector types, which require installation tools, the proper tool made especially for the connector shall be used. Connectors without insulating covers shall be taped.

c. Plastic insulating tape made especially for electrical work shall be used for all splices and taps on circuits up to 600 volts. The thickness of insulating tape shall be at least equal to that of conductor insulation. Where a bolted splice or connection presents an irregular surface, an insulating putty, "Scotchfill" or approved equal, shall be applied to the joints before taping.

WORKMANSHIP (Cont'd)

18. LOCATION OF EQUIPMENT

Unless locations of pull boxes, switches and other equipment are dimensioned on the drawings, such locations shall be considered as approximate. The Contractor shall verify critical dimensions as shown on the drawings and shall take all field measurements necessary to prepare shop drawings as required for installation of the work. Note that the locations of all limit switches are critical.

19. INSTALLING BOXES

a. Boxes shall be sized and installed in accordance with the National Electrical Code, unless larger sizes are shown on the drawings.

b. Boxes shall have only the required openings to accommodate the conduits or cables entering the box.

20. INSPECTION AND TESTING

20.1 GENERAL

a. All electrical equipment and wiring installed under this division shall be inspected and tested by the Contractor before any attempt is made to operate the equipment. Resistance, current and voltage measurements may be made as the work progresses. The Contractor shall maintain a systematic record by using a schedule or chart of all the tests and measurements. Space shall be provided to record readings, dates, and witnesses. All tests shall be witnessed by the Commission.

b. The Contractor shall correct, to the satisfaction of the Commission, all abnormal or incorrect conditions.

20.2 MOTORS

a. All safety hazards to men and machinery shall be corrected. Frames of motors shall be grounded.

b. Voltage, frequency and number of phases of power supply shall correspond with those required for the machine.

c. The electrical connections shall be checked for tightness and proper insulation.

d. Leads to motors and power wiring shall be checked for proper numbering and color coding in accordance with drawings and specifications. Color coding shall be as follows:

Phase A - Red
Phase B - Yellow or Orange
Phase C - Blue or Black
Neutral - White
Ground - Green or Bare

WORKMANSHIP (Cont'd)

e. Bearings shall be inspected for proper lubrication.

f. The shaft end play and freedom of rotation shall be checked by hand where practical.

g. Belts shall be checked for the correct tension.

h. The voltage and current under normal operating load shall be measured and recorded.

20.3 WIRING SYSTEMS

a. All conduits and devices shall be checked for secure mountings and proper attachment.

b. Condulets and junction boxes shall be checked for loose or missing covers.

c. Conduit connections shall be checked for tightness.

d. All wiring connections shall be checked for proper installation.

e. The proper color coding for all wire and cable shall be verified. All insulated ground conductors shall be checked for green color identification.

f. All wiring and cable shall be tested phase to phase and phase to ground with a 500 volt megger. The instrument manufacturer's instruction pamphlet, accompanying the instrument, will provide the detailed instructions for methods of conducting the tests. Any device not capable of withstanding the voltage and current of a megger test (such as relays and lamps) shall be disconnected or by-passed before the test is made.

20.4 MOTOR STARTERS

a. Each starter shall be checked for proper nameplate identification.

b. Equipment and devices shall be checked with the drawings and schedules to assure that they are correctly mounted and wired. The size and rating of fuses and overload heaters shall be verified.

c. Wire tag numbers, terminal strip markings and wiring shall be checked with the drawings. Wiring shall be checked for standard color coding of phases.

d. Door fit and door handle interlocking features shall be checked to assure that door cannot be opened when unit it houses is energized. Operating handle linkages shall have a minimum of slack or play. Handle shall be lockable in either the "on" or "off" position. The switch or breaker position marker shall be checked for correct indication, i.e., switch is "open" or "closed."

(WORKMANSHIP - Cont)

e. All switch and starter mechanisms shall be checked to see that nuts and bolts are in place and tight, that no pins or keys have worked out of place and that all cotter pins have sufficient spread. Mechanism rods and moving parts shall not bind and shall be in proper working order.

f. Motor starters shall be operated several times to check for bindfree operation of moving parts, proper contact area and pressure of main and auxiliary contacts, and correct operating coil voltage.

g. Control transformers shall be checked for proper voltage ratio. Fuses for the transformers shall be removed and checked for correct size and condition. All connections and mounting bolts shall be tight.

h. Pilot light shall be checked to assure proper indication of motor operation. Push button shall be checked for connections and operability.

i. Insulation tests shall be made before energizing the control center by meggering all buses, internal cabling, breakers and starters to ground.

20.5 CONTROL SYSTEM

The control system shall be checked for proper operation of all functions of Door C.

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Attachment 2

Vitro, 1964, *Equipment Disposal Tunnel PUREX Facility Inspection Report*

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March 17, 1964

United States Atomic Energy Commission
Richland Operations Office
Richland, Washington

Attention: Mr. B. Kirz, Deputy Director
Construction Engineering Division

Subject: CAC-964 - Purex Equipment Disposal Tunnel

Gentlemen:

Attached are four copies of the inspection report on the failures of the subject tunnel.

Very truly yours,

VITRO ENGINEERING COMPANY

Original Signed By
J. M. FRAME

J. M. Frame

JMF/GK/lm

cc: A. Z. Lassila

RECEIVED
MAR 19 1964
D. R. GUSTAVSON

ORIGINAL
Do not remove from folder

VITRO ENGINEERING COMPANY
A DIVISION OF VITRO CORPORATION OF AMERICA

CONTRACT AT(45-1)-1697

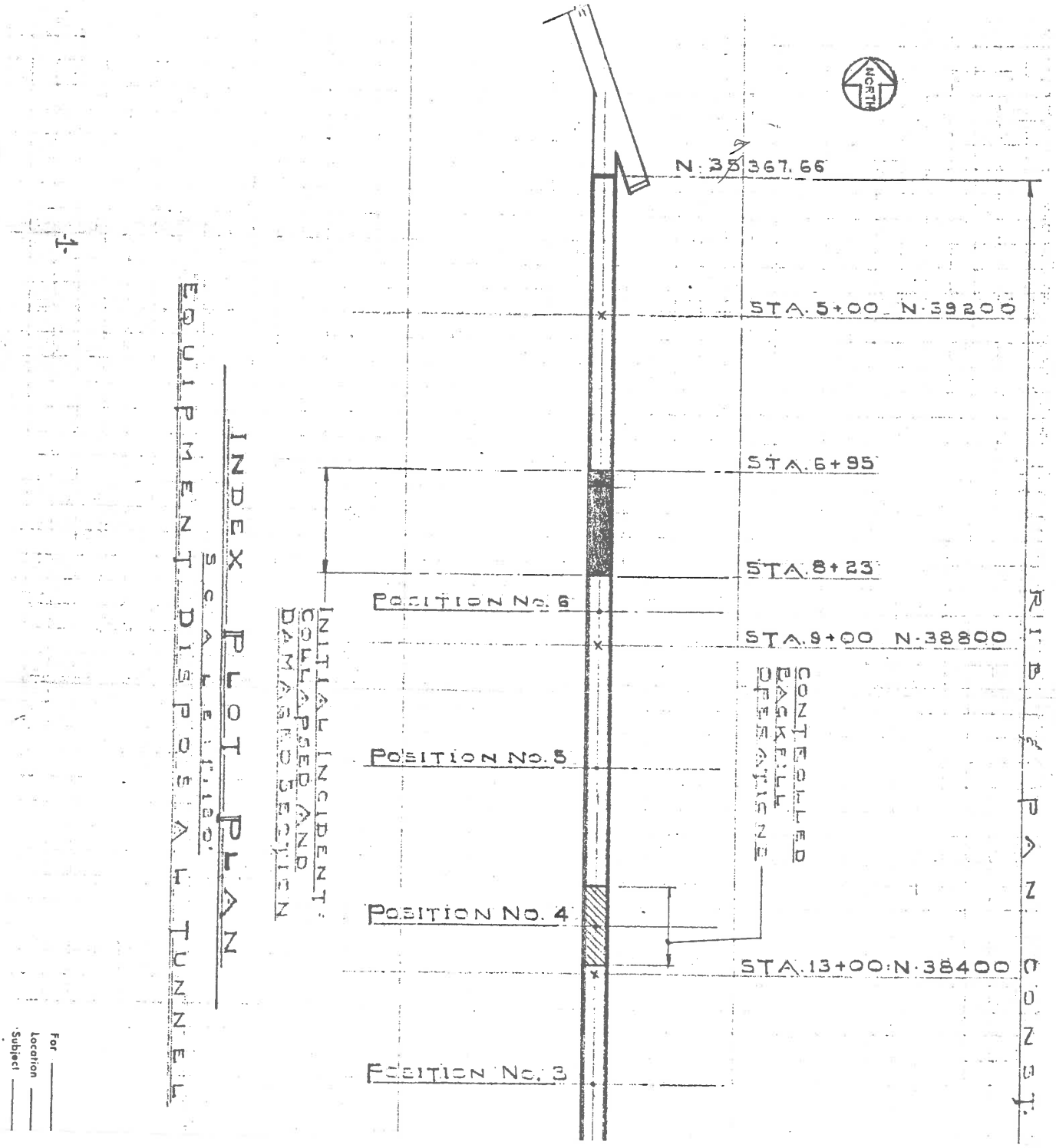
EQUIPMENT DISPOSAL TUNNEL

PUREX FACILITY

INSPECTION REPORT

This report covers and enumerates the following events:

Title	Page
Index Plot Plan	1
Observations and Reports of Initial Tunnel Backfill Operations	2
Exhibit "A"	
Backfilling Procedure	3
Events Preceeding Tunnel Collapse	4
Report of First Tunnel Collapse	5
Photographs 1 through 13	
True Tunnel Configuration as Constructed and Not Backfilled	8
Exhibit "B"	
Tunnel Deformation Due to Backfill Loading	9
Exhibit "C"	
Backfill Removal First Operation	10
Exhibit "D"	


NORTH
N 35367.66
STA. 5+00 N 39200
STA. 6+95
STA. 8+23
POSITION No. 6
STA. 9+00 N 38800
CONTROLLED BACKFILL OPERATIONS
POSITION No. 5
POSITION No. 4
STA. 13+00 N 38400
POSITION No. 3
INITIAL INCIDENT: COLLAPSED AND DAMAGED SECTION
INDEX PLOT PLAN
SCALE 1"=100'
EQUIPMENT DISPOSAL TUNNEL
RIB PAZ COZ
For
Location
Subject

Title	Page
Backfill Removal Second Operations	11
Exhibit "E"	
Controlled Backfill Operations	12
Exhibit "F"	
Partial Backfill Operations	13
Exhibit "G"	
Report of Second Tunnel Collapse	14
Photographs 1 through 4	
Summary	16

VITRO ENGINEERING COMPANY

A DIVISION OF VITRO CORPORATION OF AMERICA

CONTRACT AT(45-1)-1697

EQUIPMENT DISPOSAL TUNNEL

PUREX FACILITY

INITIAL BACKFILL INSPECTION REPORT

The following report of "Inspection of Backfilling Around Metal Arch" was submitted by our Mr. P. W. Armstrong on January 20, 1964 and is reproduced below and also attached as Exhibit "A".

"Inspection of backfilling around metal arch tunnel was made and the following conditions were found to exist.

1. The butt-angle gusset plates on the arch rib assembly have broken.

2. In an area of approximately 600 linear feet of metal arch tunnel, there are approximately 32 welds that have broken.

3. There is also some indication of cracking or stress where the butt-angle is welded to the arch rib.

4. Inspection was made from the top of the metal arch (outside).

5. It is suggested that the contractor evaluate his back-filling procedure and submit a proposed method of repair of broken gusset plates."

Phoned AZ at 1115 Cole

Equipment Engineering Tunnel
Contract AT(45-1) 1697

1-20-64

Inspection of backfilling around metal arch tunnel was made, and the following conditions were found to exist:

The butt angles, gussetts & lath nails on the arch rib assembly have broken.

In an area of approx. 600 linear feet of metal arch tunnel there are approx 32 nailed which have broken.

There is also some indication of bending or stress where the butt angle is nailed to the arch rib.

Inspection was made from the top of the metal arch (outside)

It is suggested that the contractor evaluate this page's filling procedure and submit a proposed method of repair to broken gusset & lath.

R.W. Armstrong

EXHIBIT "A"

BACKFILLING PROCEDURE

Backfilling procedure as utilized by the contractor, consisted of the use of two (2) D-9 Bulldozers, one (1) used on each side of the tunnel and grading along lines at right angles to the tunnel. Backfilling on either side being more or less equal.

Objections were extended, on several occasions, because the contractor was grading toward the tunnel on an even grade level, with the backfill level at the tunnel surface. This method transmitted unnecessary loading from the fill being moved against the sides of the tunnels. Also, it was necessary, with this method, to bring the mass of the bulldozer weight within the loading zone of the tunnel wall. Therefore, a part of the 40,000 pound weight of the bulldozer was being imposed on tunnel structure.

EVENTS PRECEEDING TUNNEL COLLAPSE

Recognization of the critical nature of these observations; and that they constituted a degree of structural failure of the tunnel construction, Mr. Armstrong was instructed to contact a representative of the contractor immediately.

These conditions were discussed with the contractor's Superintendent, Mr. Leonard Berg. He indicated that all welds would be repaired before final or top of arch backfill completion. Mr. Berg outlined the method of backfilling that he intended to use for the remainder of his backfilling operations. He stated that he planned to build up a bank of fill next to and parallel to the metal arch and tumble the fill onto the metal arch rather than push the fill against the metal arch.

These observations were reported to the Atomic Energy Commission Area Engineer, also to the General Electric Project Engineer, Mr. W. C. Armstrong.

REPORT OF FIRST TUNNEL COLLAPSE

On January 22, 1964, at about 10:30 A.M., approximately 75 linear feet section of the metal rib and pan portion of tunnel collapsed. This section is located at stations 7 plus 13 to 7 plus 98, near the north end of the tunnel. Ribs and pans were distorted beyond contract geometry for about 18' feet north and 25 feet south of these points. Structural failure occurred while backfilling operations were in progress with two (2) bulldozers.

The following points of failure are evident:

1. Extreme deformation of ribs caused complete failure of welding of gusset plates, located adjacent to and about Vertex of the arch.

2. Shear failure of weldment that attached ribs (6 I 12.5) to base plates.

3. Shear failure of base plate occurred in two (2) instances. The shear tear was longitudinal to the tunnel and across the two anchor bolt holes.

4. Detailed examination of weldment indicated they generally did not conform to design requirements. The weldment attaching ribs to the base plate were designed as one-quarter inch (1/4"). On one side of the I-Rib member they were equal to or slightly in excess of this requirement. On the opposite side, they were about one-eighth inch (1/8") to three-sixteenth inch (3/16") or less. The angle gusset plate welds were designed as one-eighth inch and were frequently less. There is

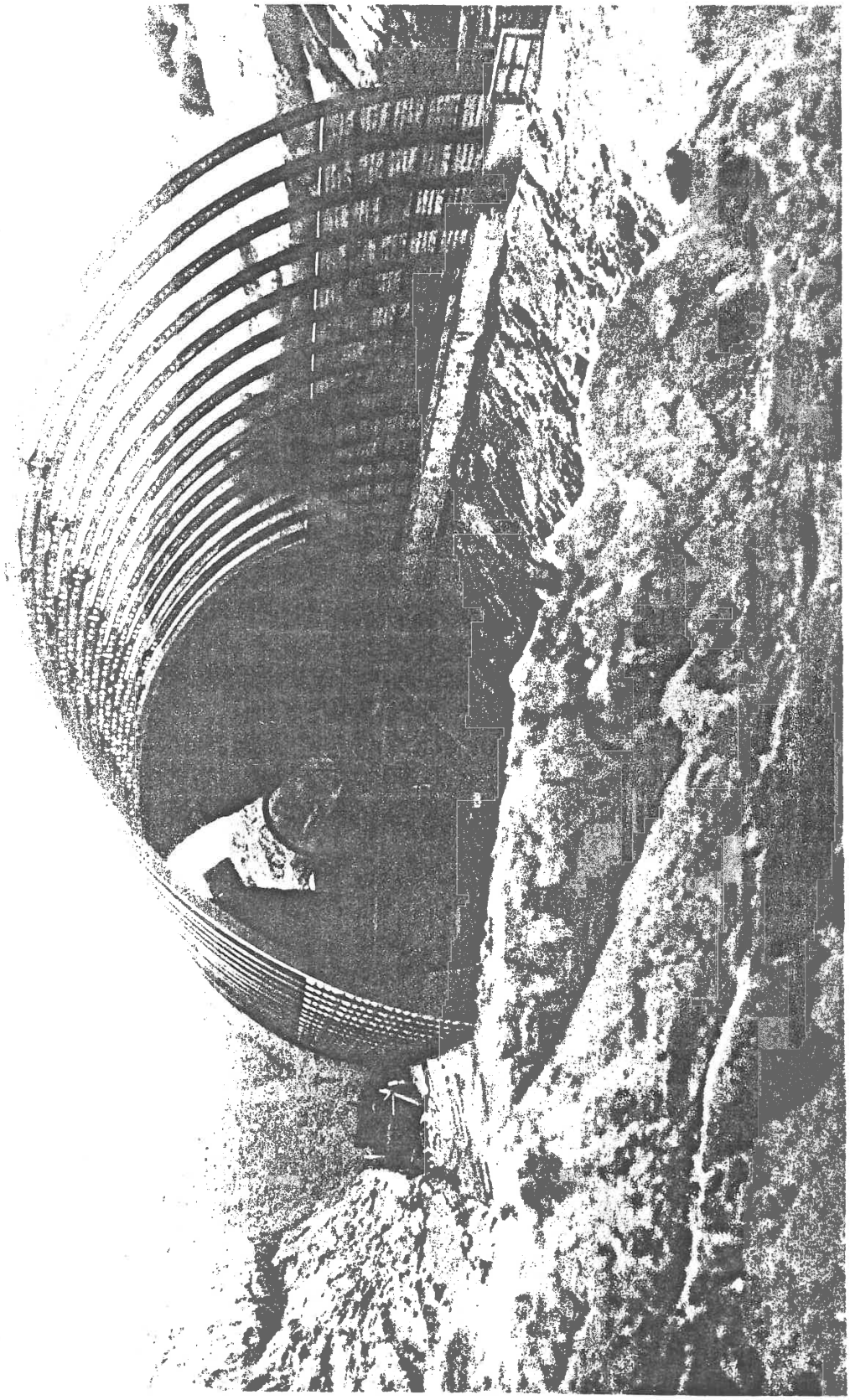
evidence that welding was performed using excessive amperage resulting in embrittlement of weldment.

PHOTOGRAPHS

The following photographs are included to establish a record of the various views of the initial tunnel collapse as enumerated.

PHOTO NO.	DESCRIPTION
1	View looking South, thru incompleted tunnel section, showing backfill drift and collapsed section.
2	View looking South, showing backfill contour and inside configuration at shear point of collapsed section.
3	View looking North, showing backfill drift over collapsed section.
4	View looking South, showing West side of collapsed section.
5	View looking South, showing backfill contour, deformation of tunnel end and backfill drift.
6	View showing structural failure of rib connector clips (about tunnel centerline or vertex).
7	View of East side concrete footing, showing rib anchor bolt damage and footing damage.

PHOTO NO.	DESCRIPTION
8	View of East side footing, showing rib anchor bolt shear and footing damage.
9	View of East side concrete footing, showing rib anchor bolt, rib base plate and footing damage.
10	View looking South, showing remaining backfill on North end of collapsed section.
11	View of West side footing, showing rib base plate deformation.
12	View looking South showing East side concrete footing as uncovered, collapsed section, and deformation of South end of collapsed section.
13	View looking East, showing backfill drift at collapsed section.



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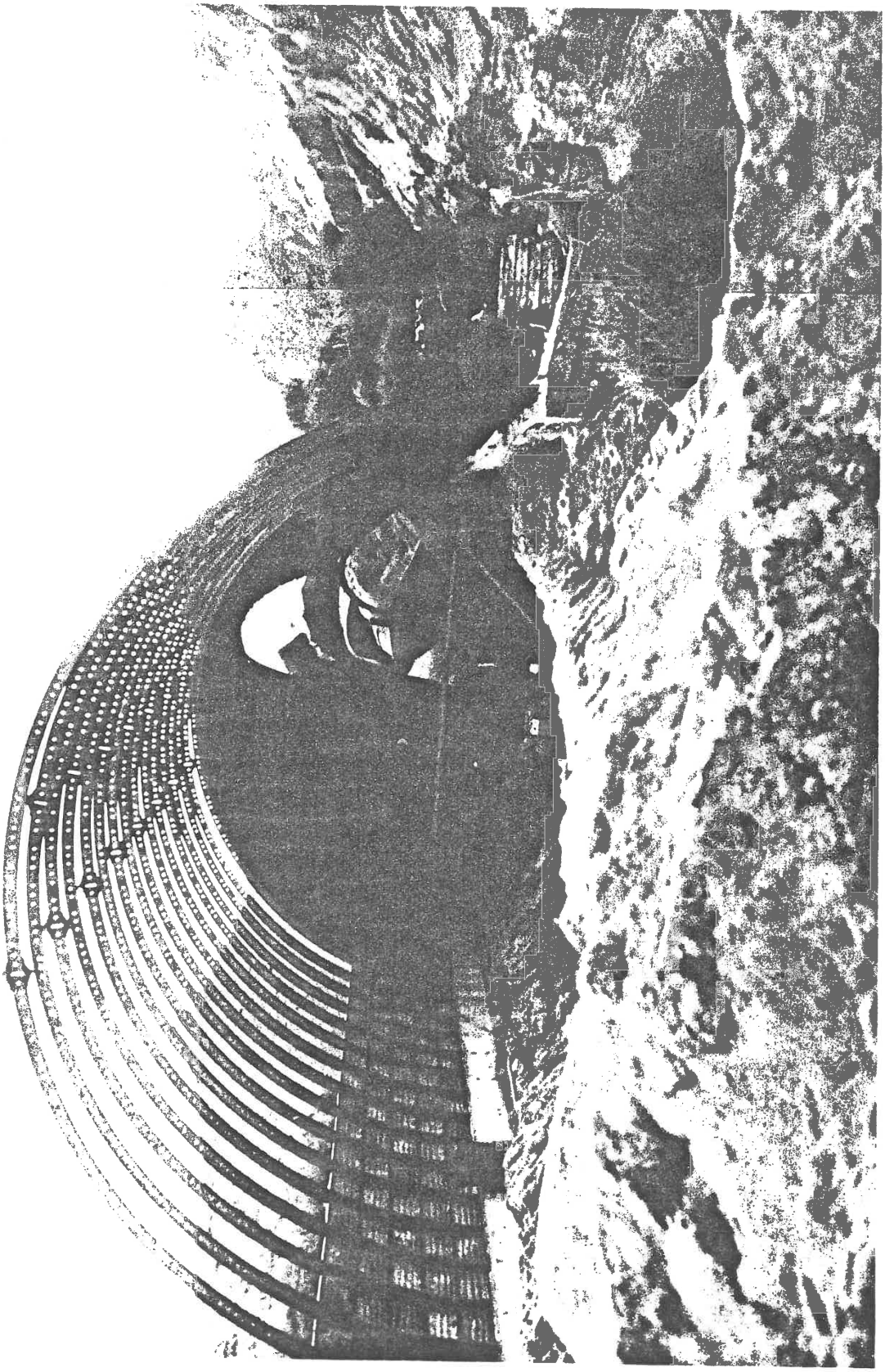

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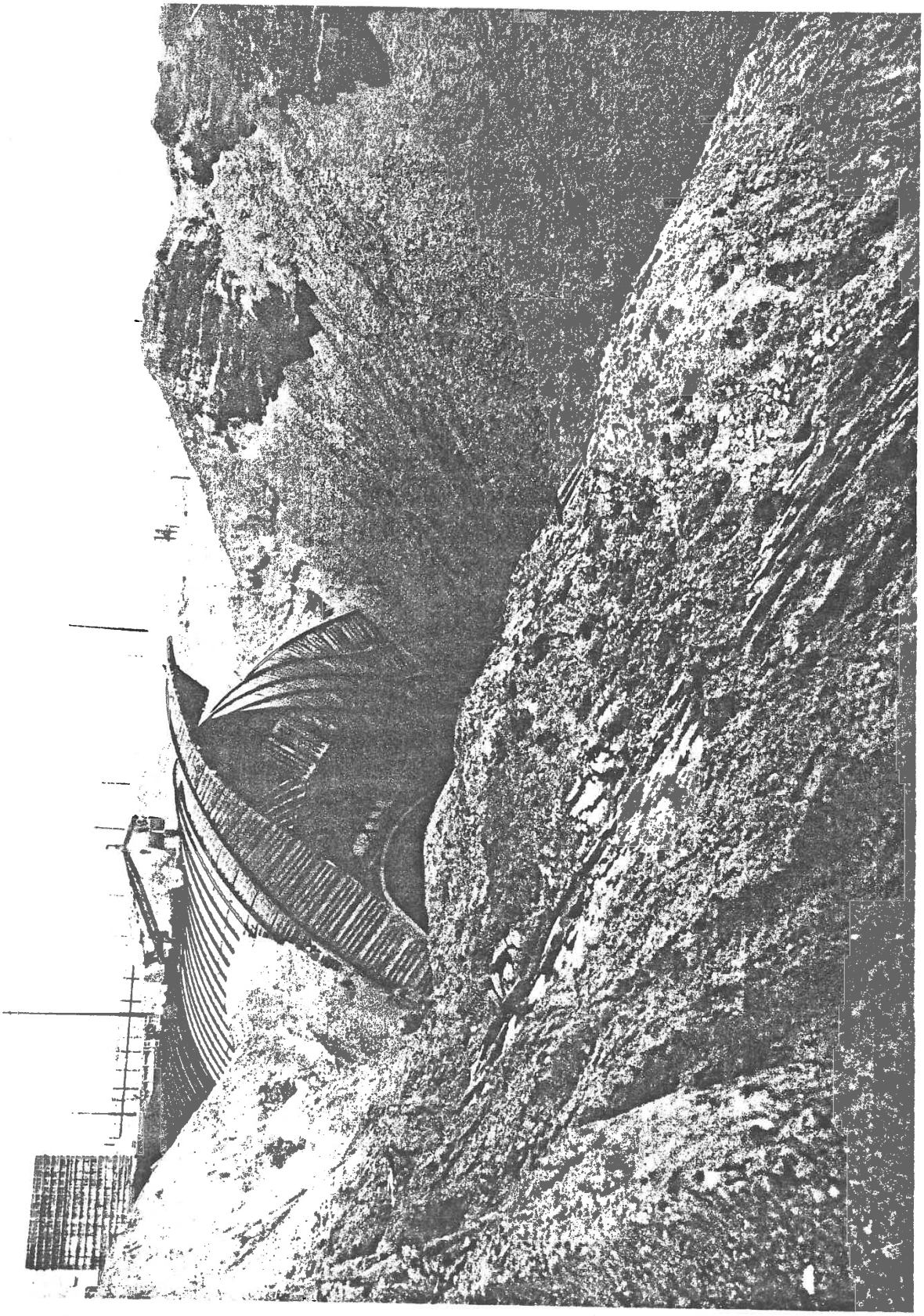

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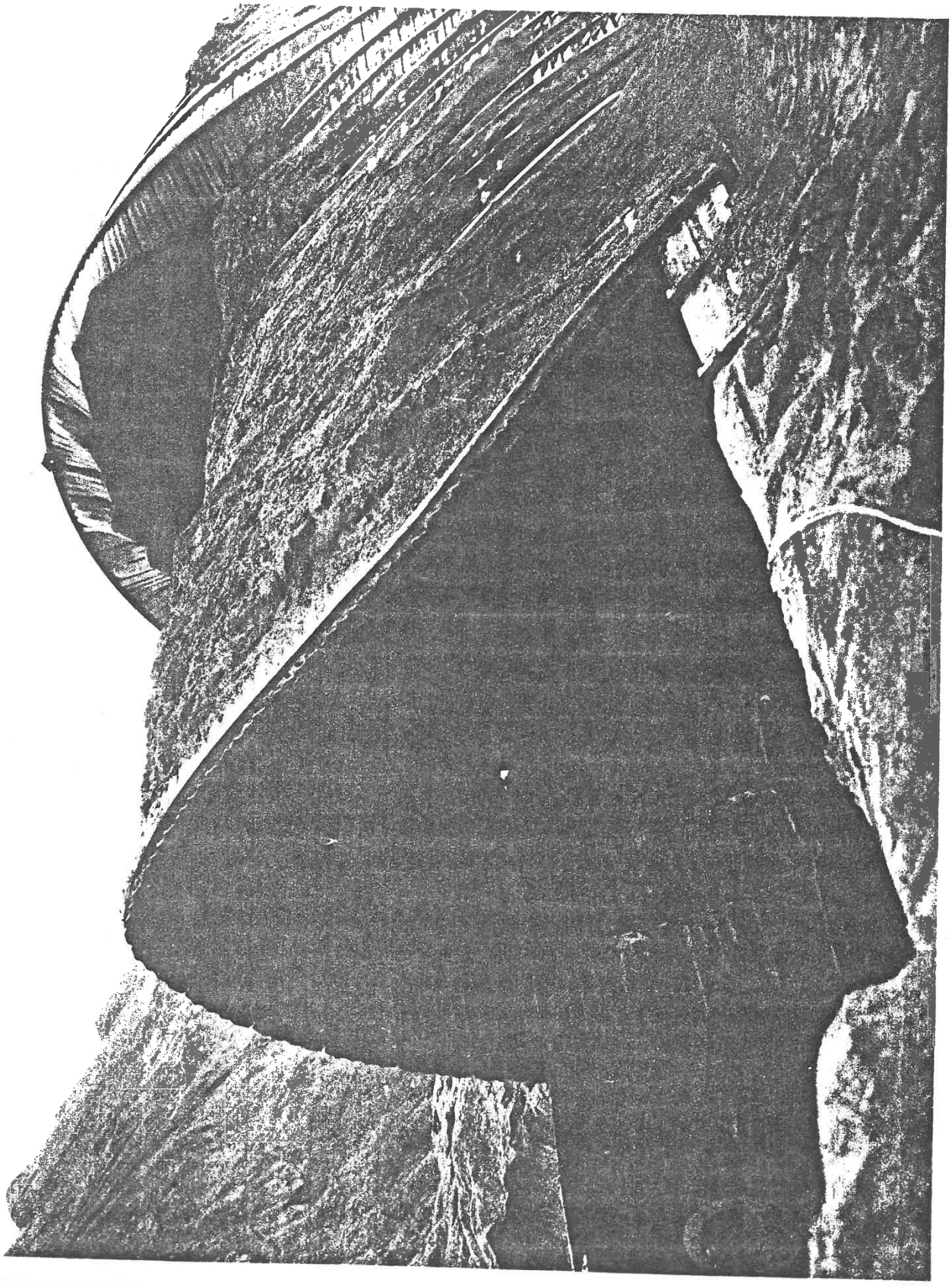

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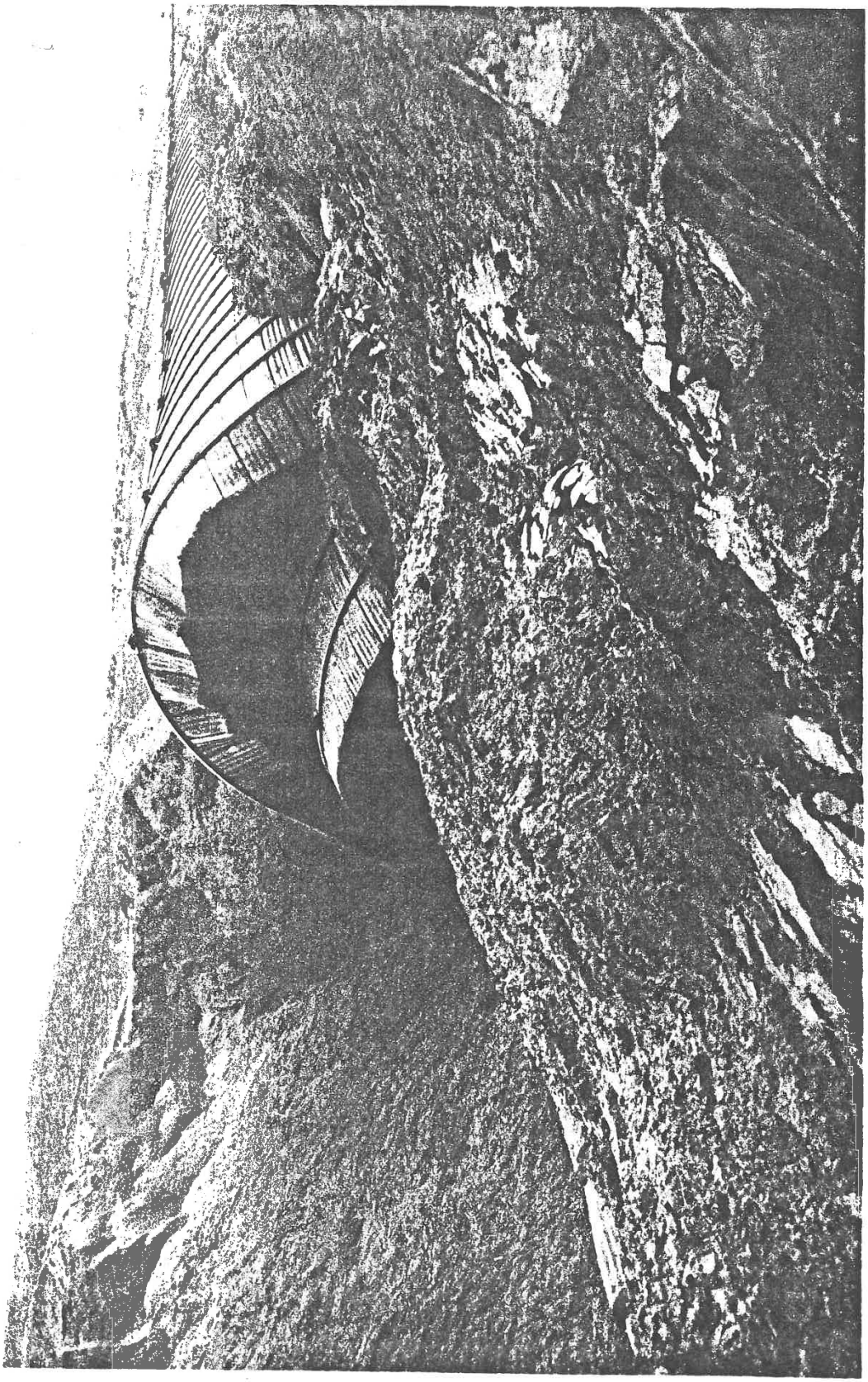

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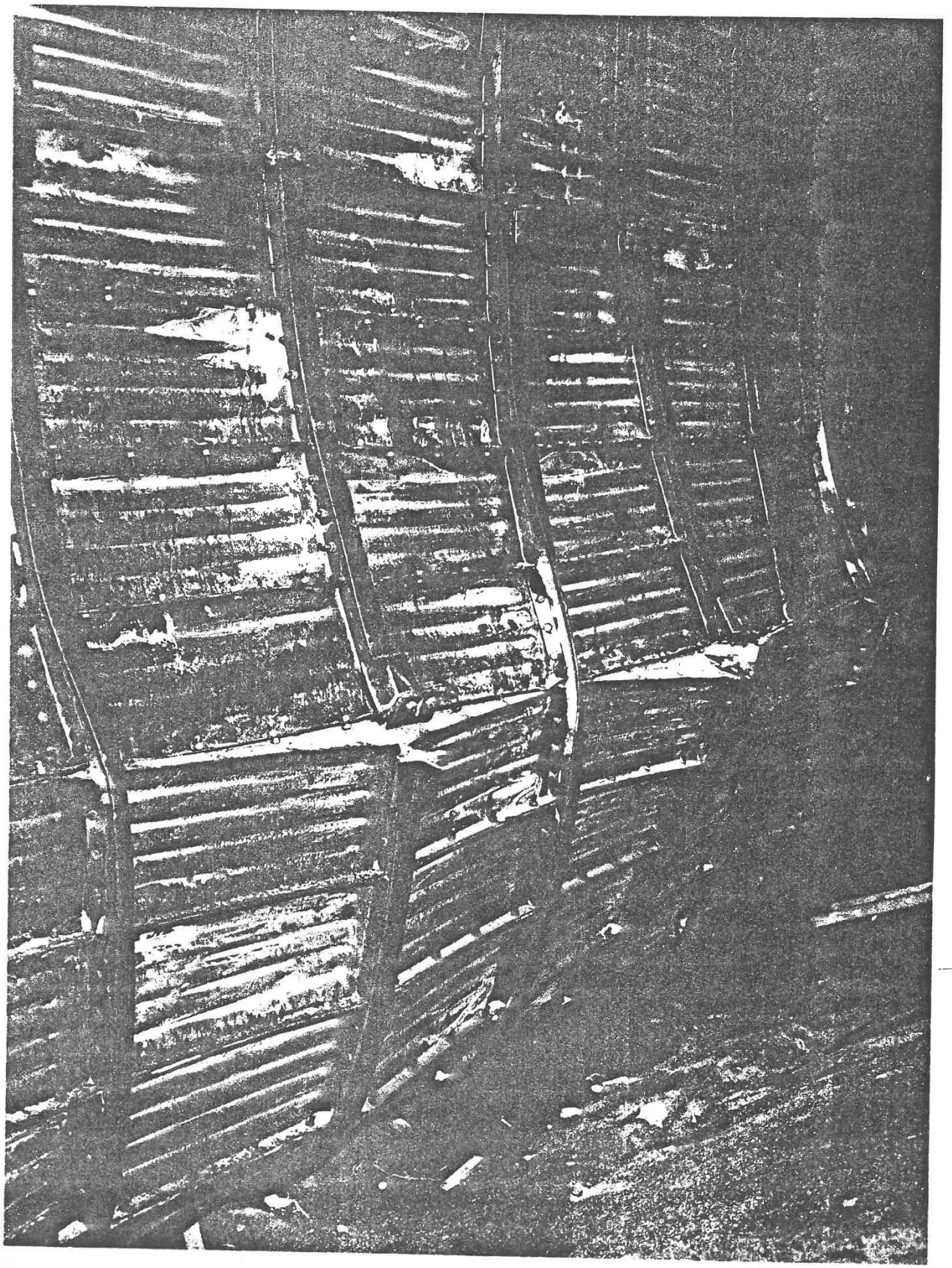

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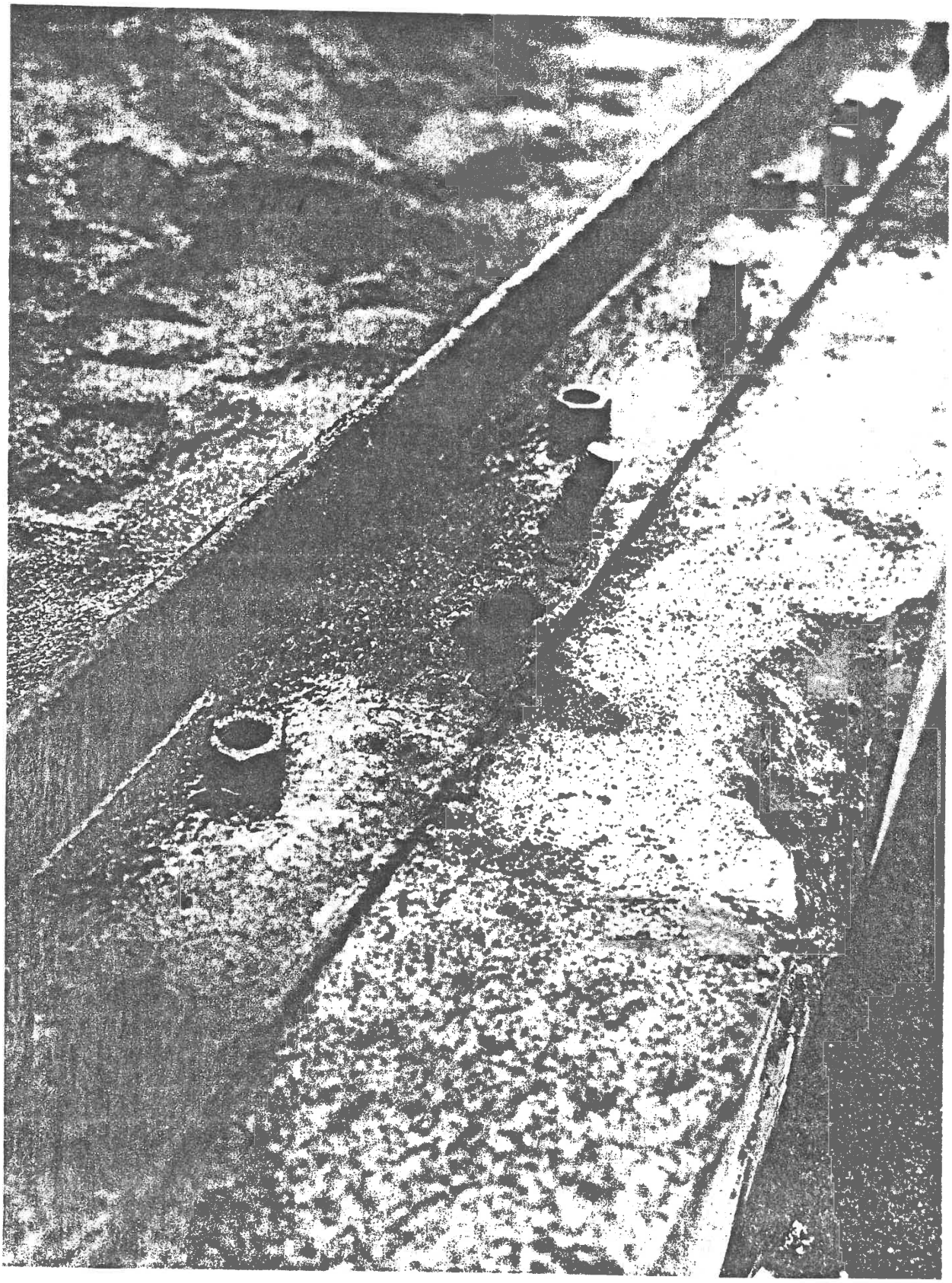

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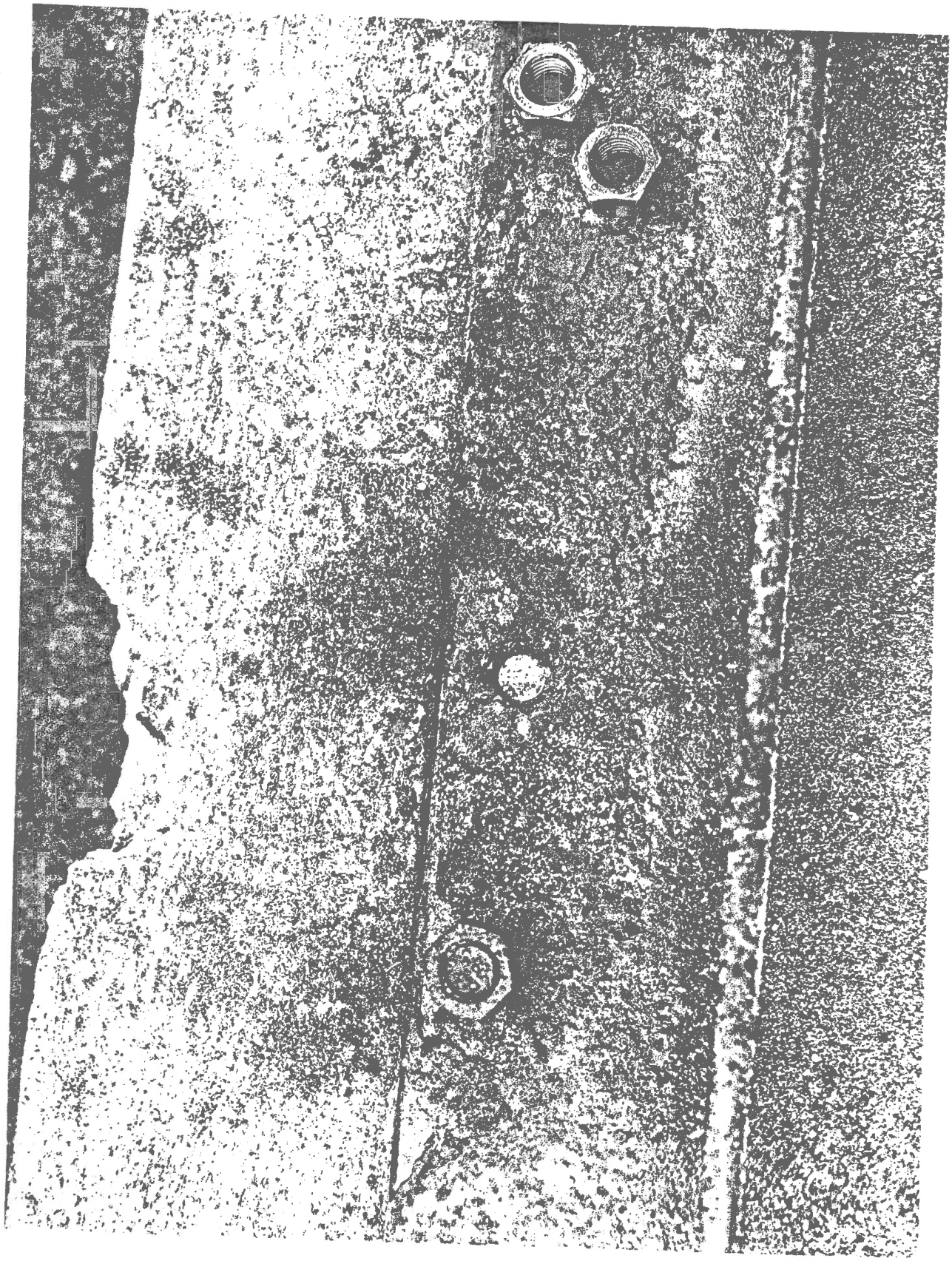

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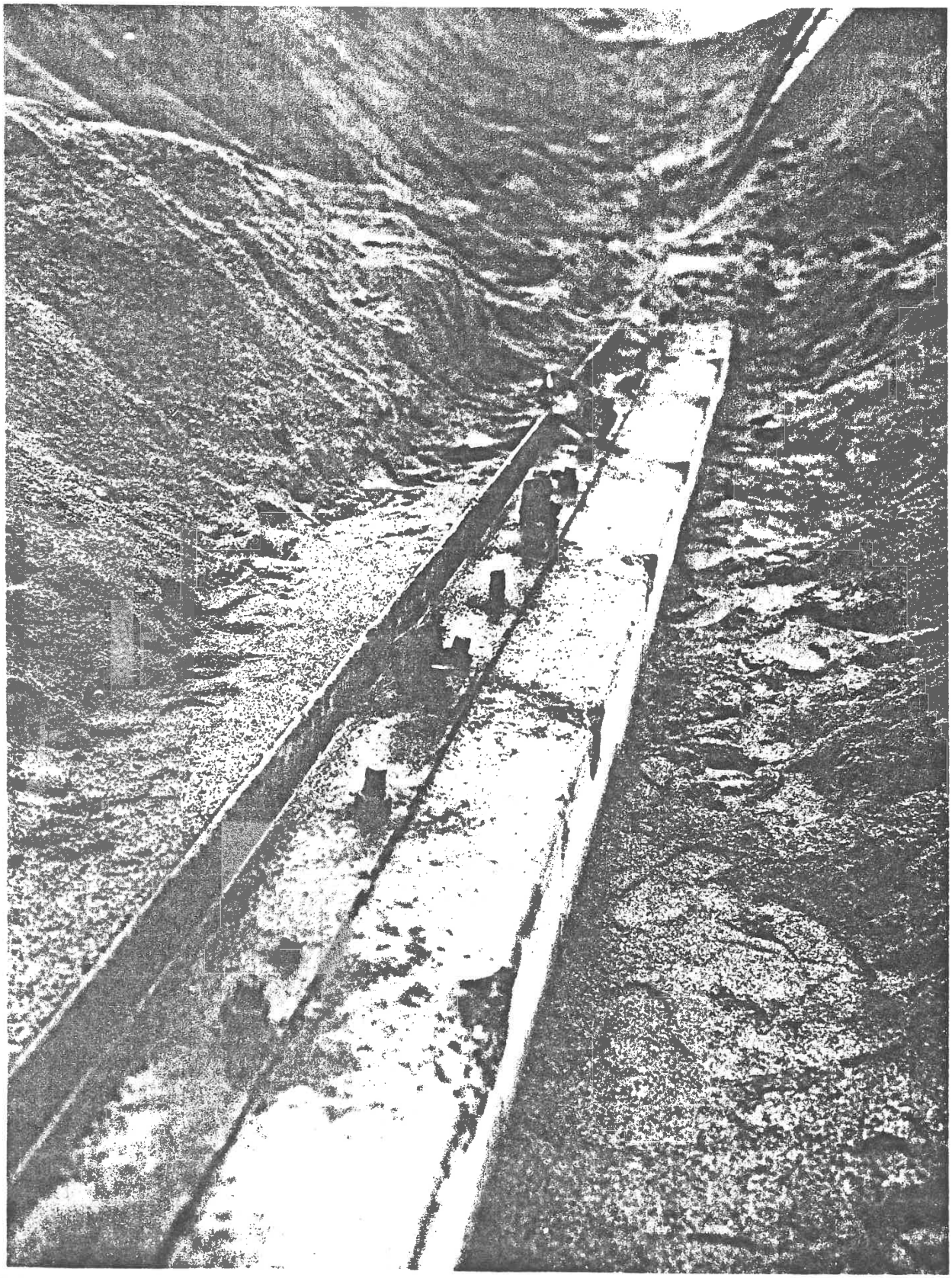

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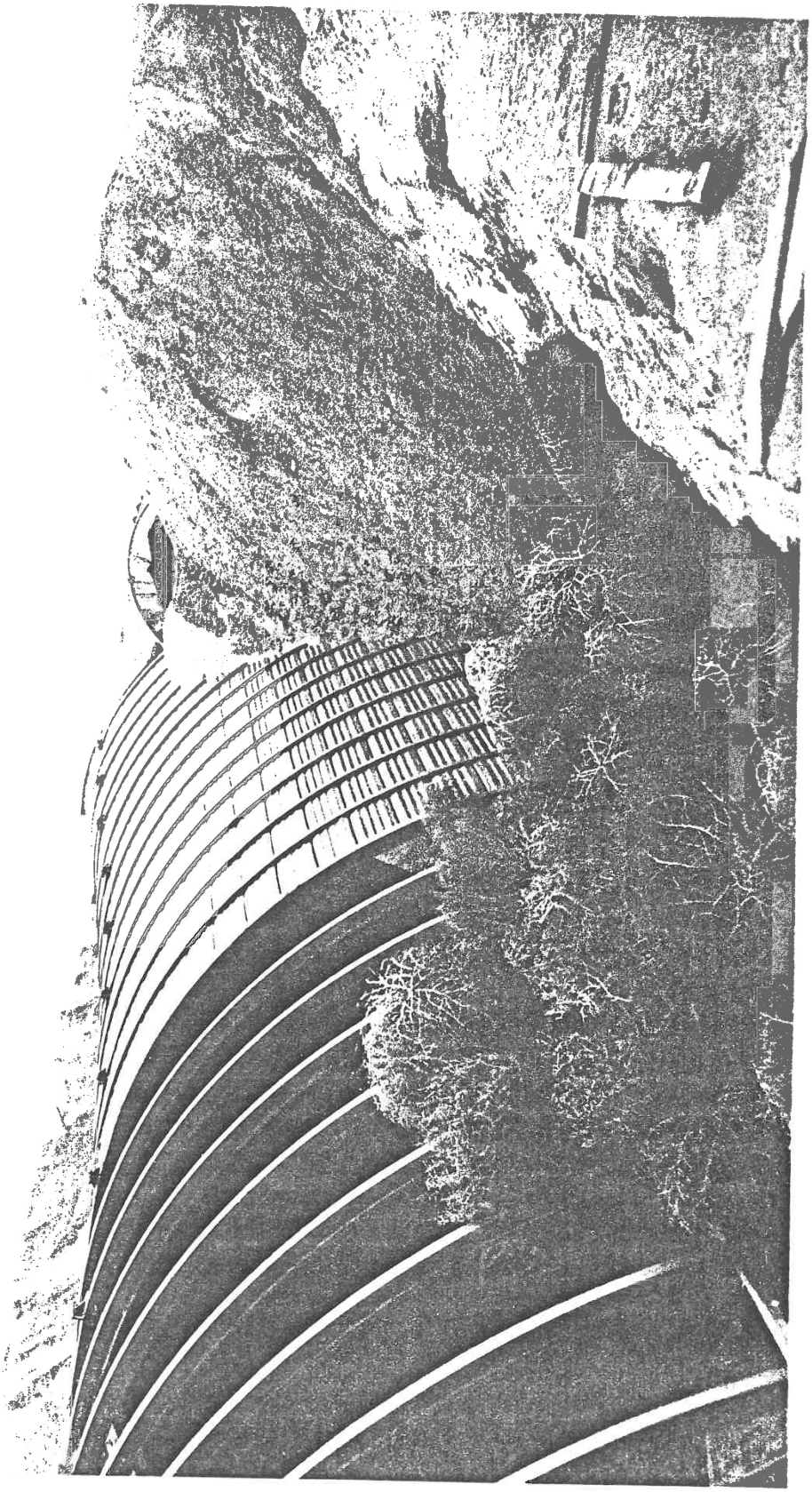

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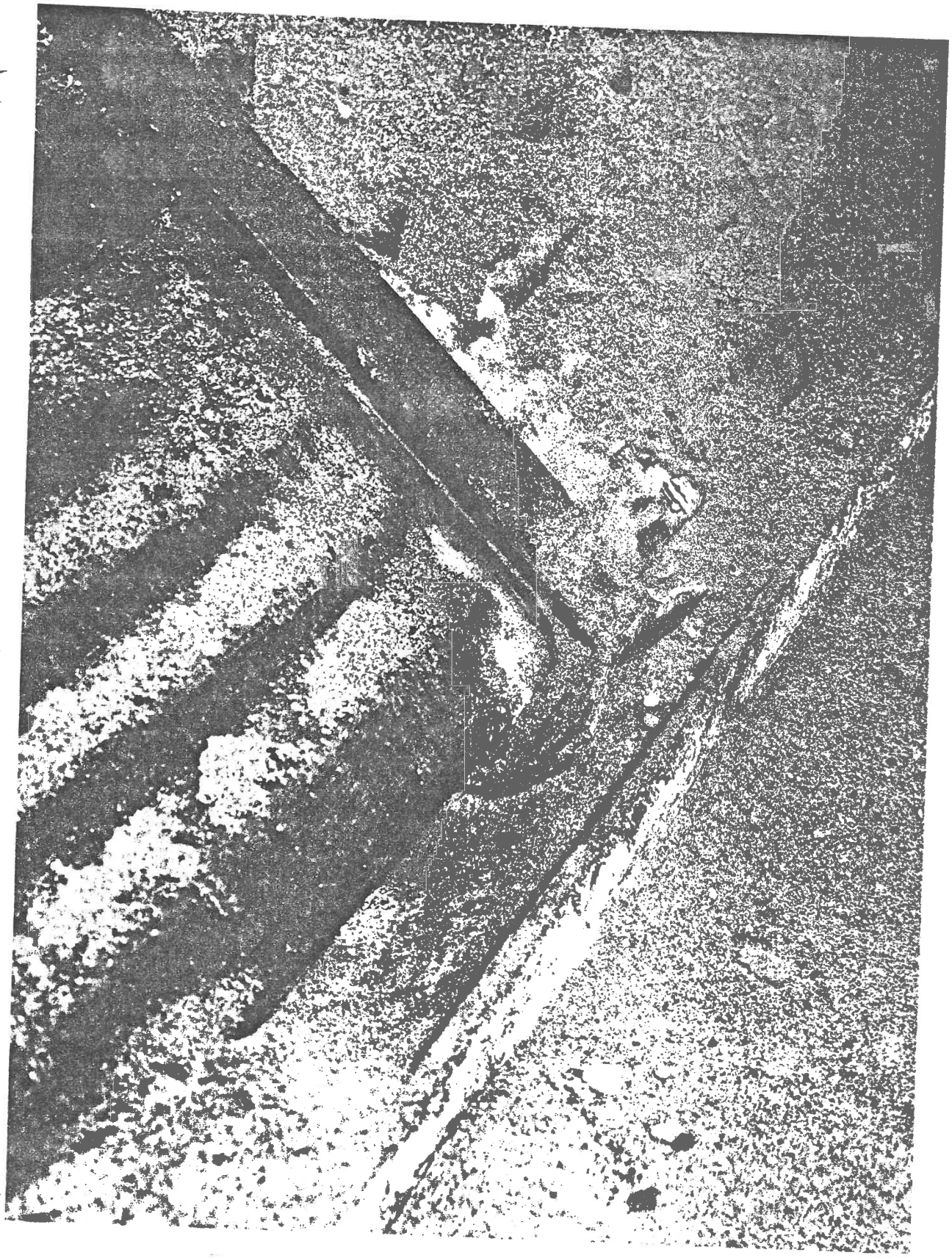

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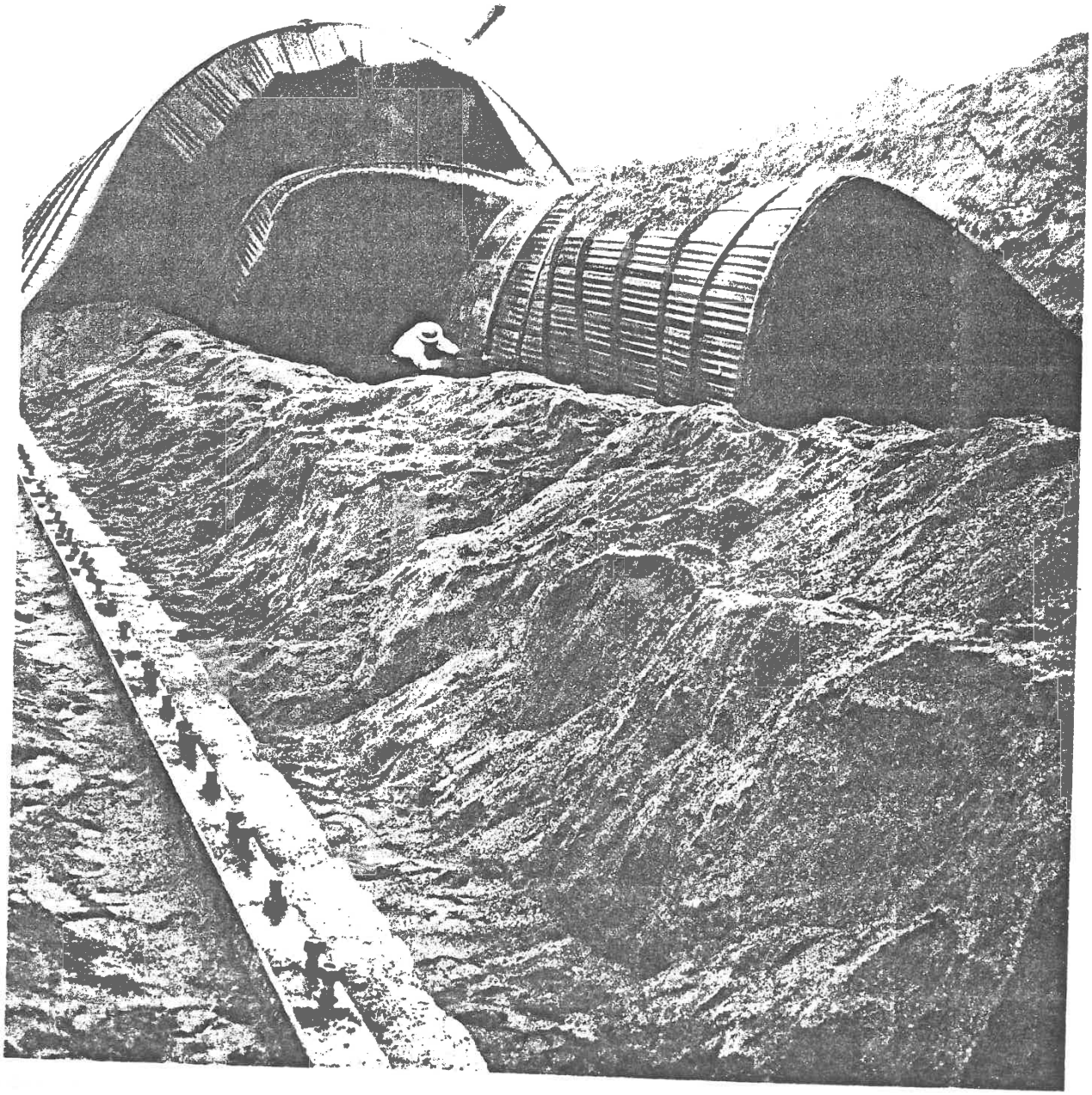

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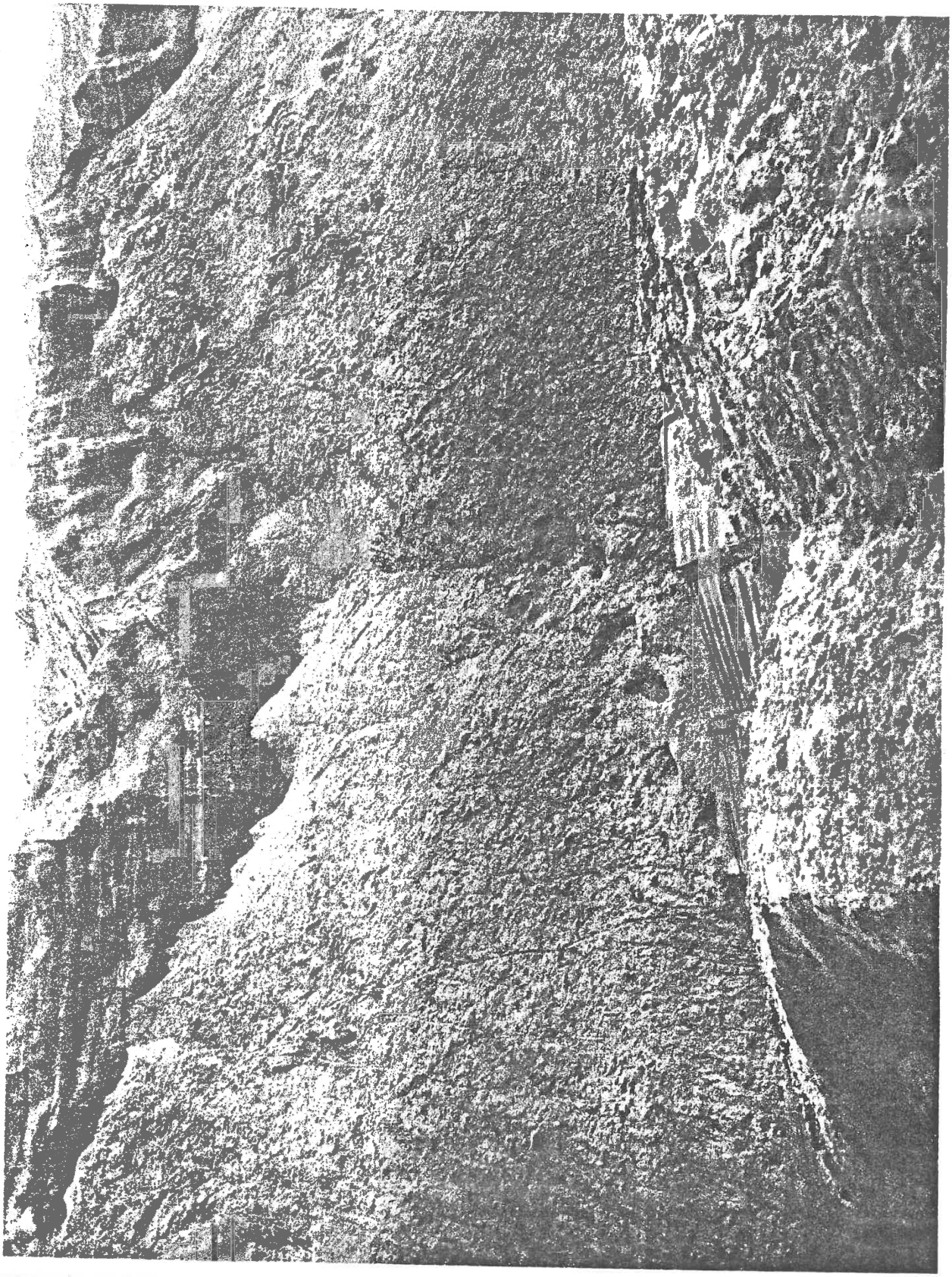


PHOTO NO. 13

TRUE TUNNEL CONFIGURATION AS CONSTRUCTED AND NOT BACKFILLED

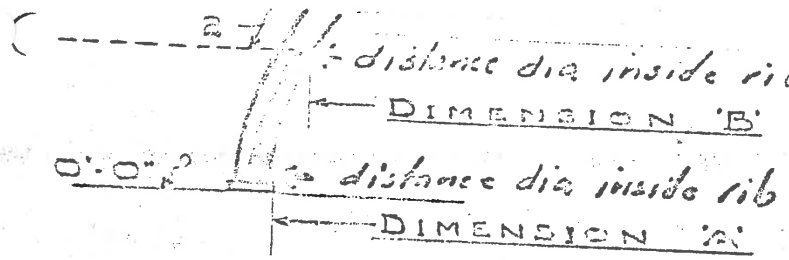
Three (3) locations were arbitrarily selected to determine datum configuration of tunnel, as constructed and unloaded.

All elevations are in feet and relative to the top of concrete footings. These reports are attached as "Exhibit B".

As a reference of datum elevations and dimensions the following appear to be representative:

Dimension B:	32'5-3/4"
Elevation 2:	5.32 Ft.
Elevation 3:	10.05 Ft.
Elevation 4:	13.79 Ft.
Elevation 5:	16.20 Ft.
Elevation 6:	17.04 Ft.
Elevation 7:	16.19 Ft.
Elevation 8:	13.78 Ft.
Elevation 9:	10.05 Ft.
Elevation 10:	5.32 Ft.

DATE 1/28/44 SUBJECT EQUIP DISPOSAL TUNNEL AT (45-1)-1697 JOB NO CAC-954



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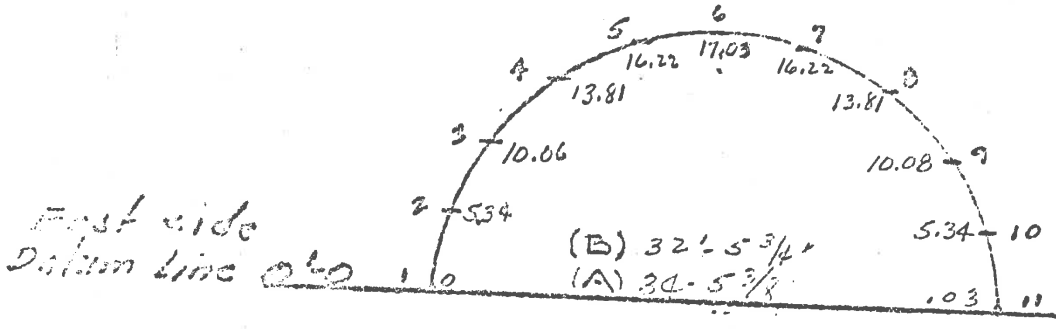
(BARE)

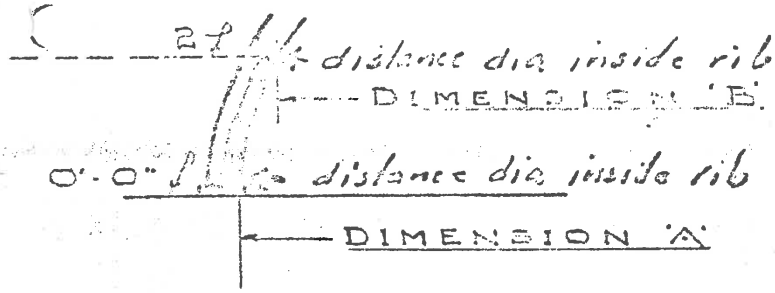


Elevation every 4 pans

6 section thru partial filled tunnel
6 sections thru tunnel no fill

EXHIBIT "B"

CHE DATE 4/20/84 SUBJECT EQUIP DISPOSAL TUNNEL ATCHISON, KANSAS SHEET NO JOB NO CAC-864



2-UNCOVERED

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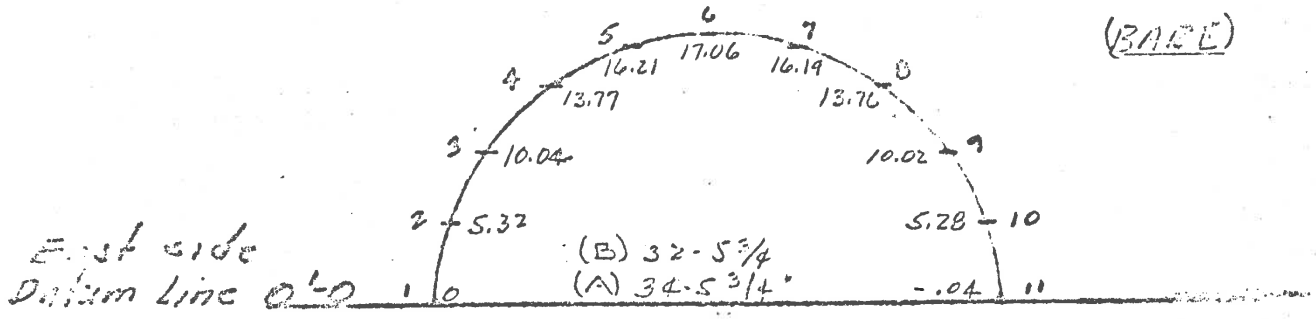
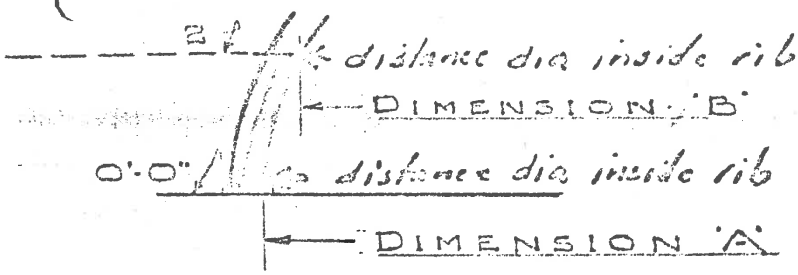


Elevation every 4 pans

6 section thru partial filled tunnel
6 sections thru tunnel no fill

EXHIBIT "B"

CWC DATE 1/31/67 SUBJECT EQUIP. DISPOSAL TUNNEL AT (45-1)-1697 SHEET NO. ___ OF ___
CHKD. BY ___ DATE ___ JOB NO. CAC-964



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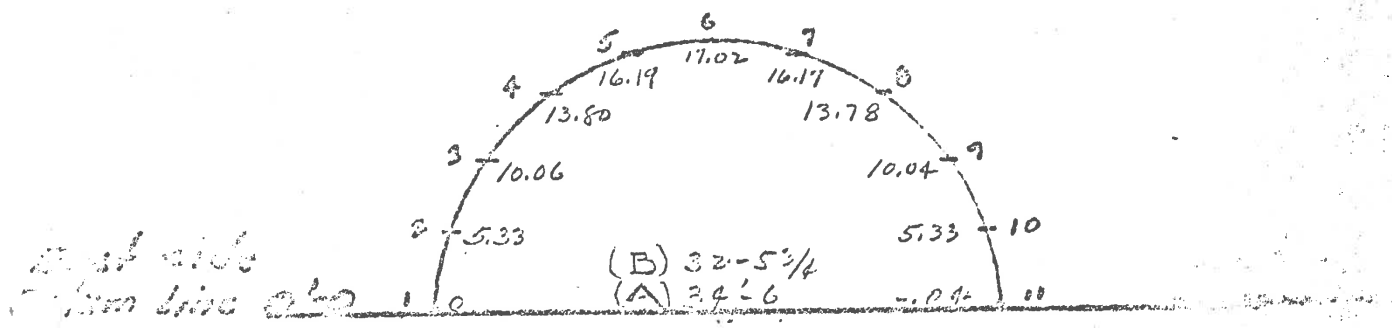
(BACE)



Elevation every 4 panel

6 section thru partial filled tunnel
6 sections thru tunnel no fill

EXHIBIT "B"

TUNNEL DEFORMATION DUE TO BACKFILL LOADING

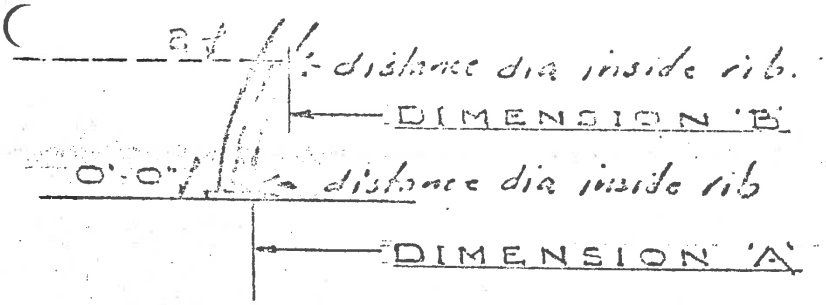
Backfilling against tunnel walls, to a depth of ten (10) to twelve (12) feet above top of footings had been completed for approximately 600 lineal feet. To accurately establish the extent of structural deformation due to backfill loading, six (6) Positions were selected for checking. These Positions were located with Position Number 1 at Station 10 plus 18 and at about two hundred (200) foot intervals southward.

Examination of these results indicate that backfilling against the side walls of tunnel and no backfilling or concentric loading of top of tunnel arch resulted in flattening or tendency toward straightening of sides. This indicates a maximum deformation (peaking) at elevation 6 of 0.40, a minimum of 0.194 and an average of 0.267 feet.

Note that the maximum deflection (shortening) at Dimension 'B' was 5-3/4" at Position Number 6.

This report is attached as Exhibit "C"

SWC [illegible] EQUIP. [illegible]
TUNNEL [illegible] CAT. [illegible]
AT(45-1)-1537



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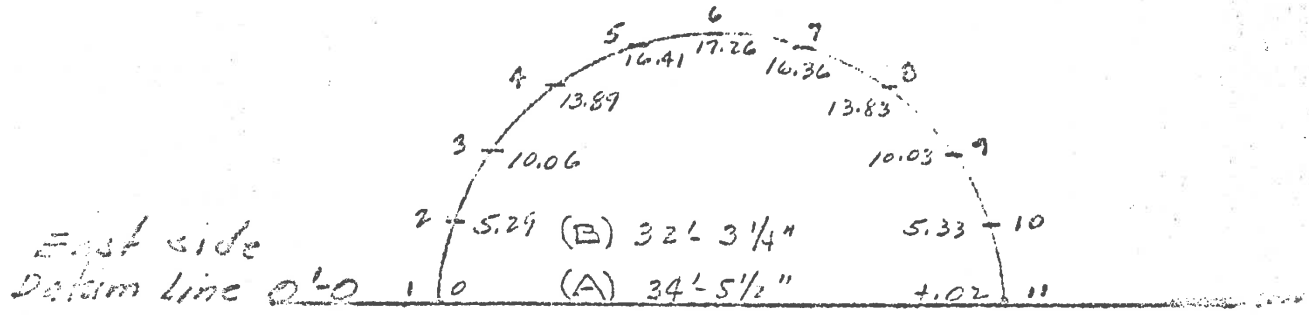
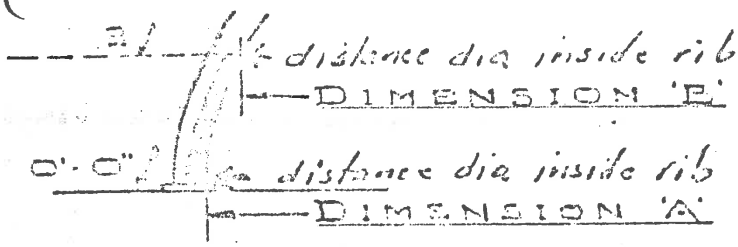


Elevation every 4 pans

6 section thru partial filled tunnel
6 sections thru tunnel no fill

EXHIBIT "C"

CWC 1/22/64 EQUIP DISPOSAL TUNNEL AT (42-1)-1697 GAC-964



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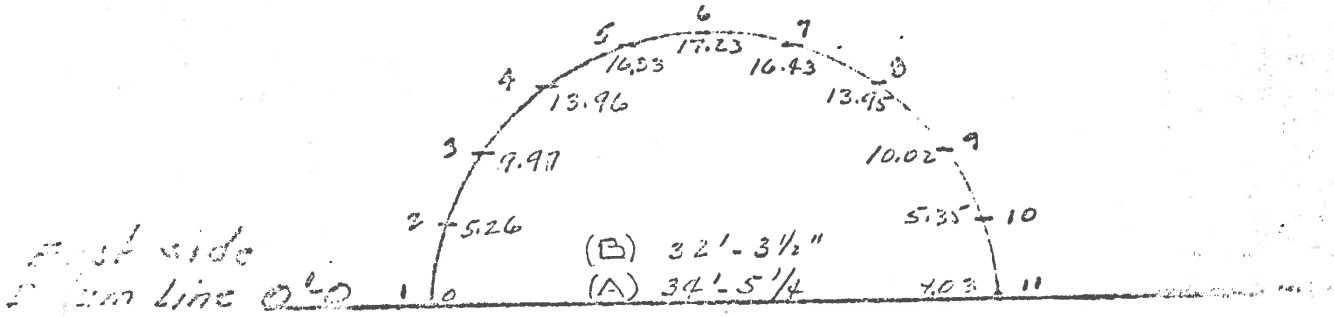

elevation every 4 panel

6 section thru partial filled tunnel
6 sections thru tunnel no fill

EXHIBIT "C"

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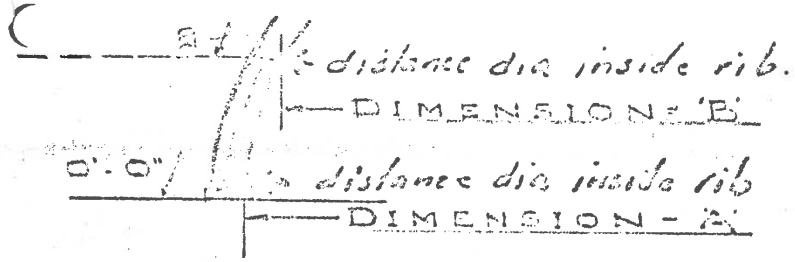
DATE TUNNEL JOB NO CAC-964
AT (15-1) 1257



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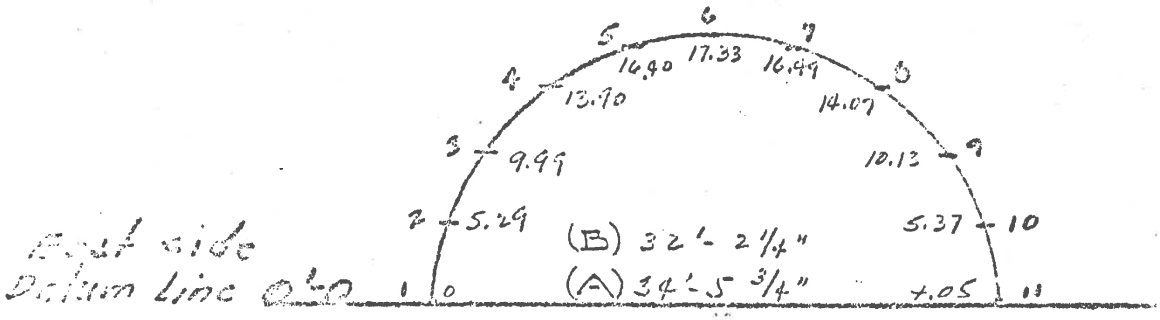
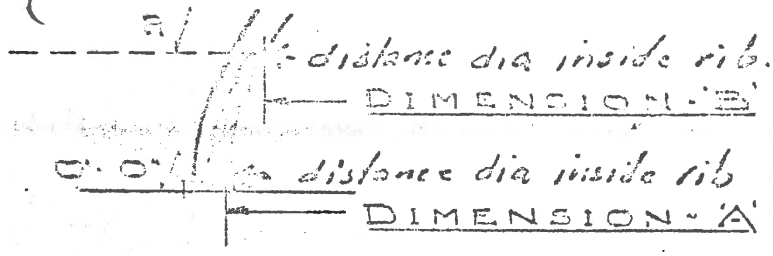


Elevation every 4 pans

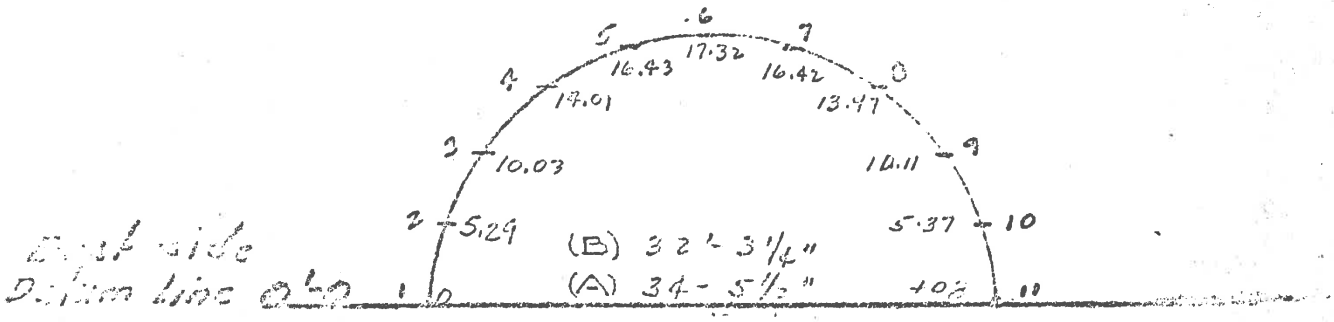
6 section thru partial filled tunnel
6 sections thru tunnel no fill

EXHIBIT "C"

EQUIP. DISPOSAL TUNNEL
AT (42-1) 1697



POSITION NO. 4

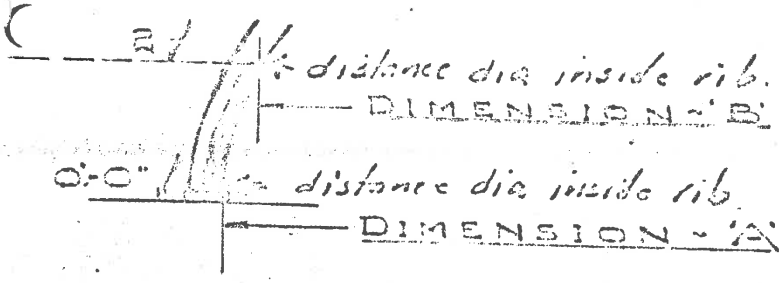


Elevation every 4 pans

6 section thru partial filled tunnel
6 sections thru tunnel no fill

EXHIBIT "C"

CWC DATE 1/24/64 SUBJECT GULF DISPOSAL TUNNEL AT (45-1)-1337 SHEET NO. JOB NO. CAC-964



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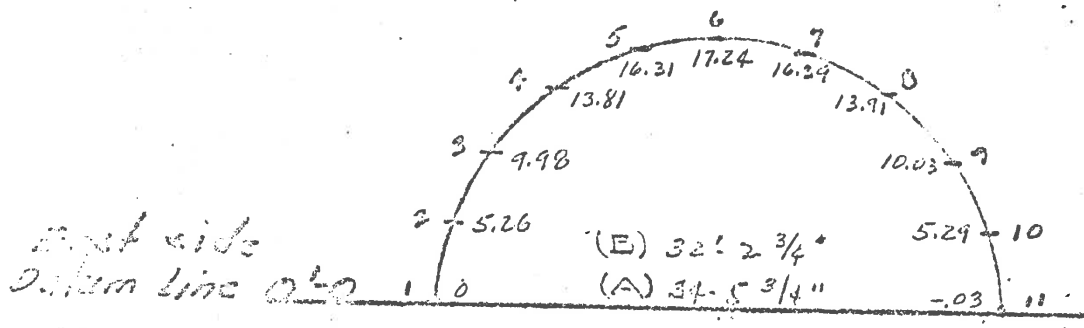
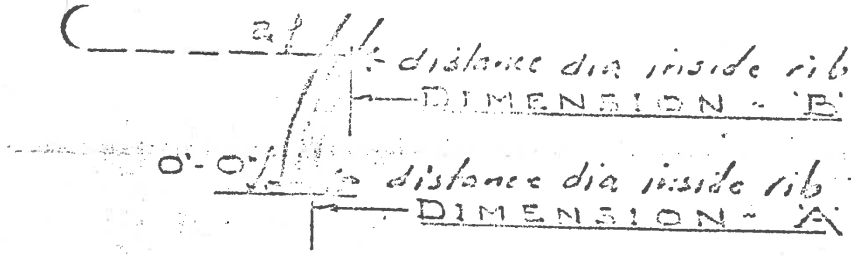


Elevation every 4 pans

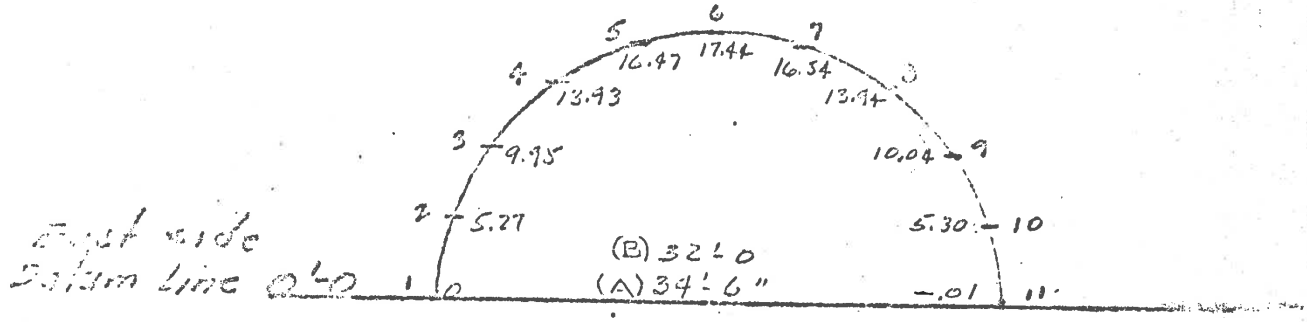
6 section thru partial filled tunnel
6 sections thru tunnel no fill

EXHIBIT "C"

EQUIPIPERAL TUNNEL
AT (45.1) 1581



POSITION NO. 6



Elevation every 4 pans

6 section thru partial filled tunnel
6 sections thru tunnel no fill

EXHIBIT "C"

BACKFILL REMOVAL FIRST OPERATION

On January 30, 1964 the Contractor started operations to partially remove the backfill and relieve the structural deformation. Approximately five (5) feet of backfill was removed from each side. To determine the extent of deformation recovery toward normal or constructed shape, we again checked dimensions and elevations at Position Numbers 1 through 6. Maximum recovery at elevation 6 was 0.12 foot at Position 4, minimum 0.04 foot at Position 2 and the average was 0.08 foot. Maximum recovery at Dimension B was 1-1/2" at Position 6.

It is evident that no significant deformation recovery was realized.

This report is attached as Exhibit "D".

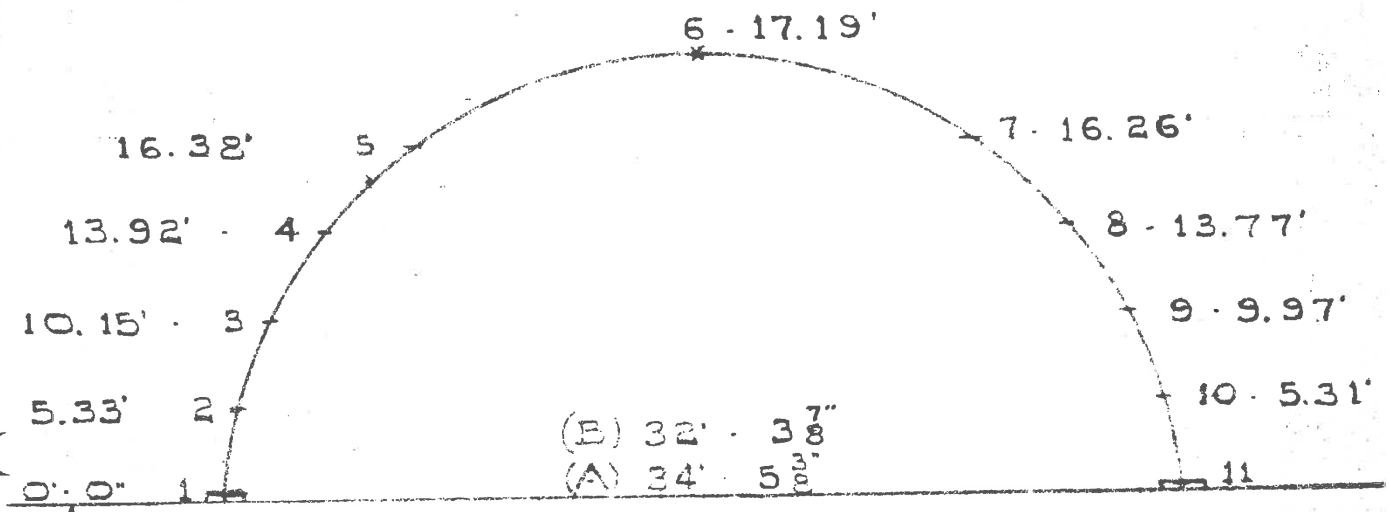
VITRO ENGINEERING COMPANY
A DIVISION OF VITRO CORPORATION OF AMERICA

CALCULATION SHEET

For 1697 (CAC 954)
Location POSITION NO. 1
Subject

Page
Job No
Date
By C.W.C

APPROX. SET BACK
FILL REMOVED.



ELEVATIONS EVERY 4 PANS

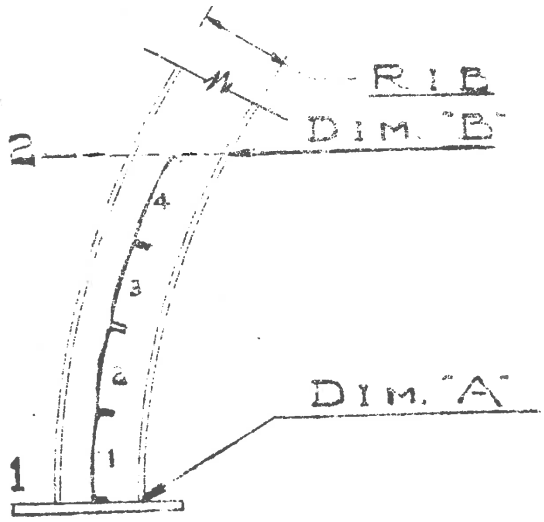


EXHIBIT "D"

VITRO ENGINEERING COMPANY
A DIVISION OF VITRO CORPORATION OF AMERICA

CALCULATION SHEET

For 1697 (CAC 964)
Location POSITION NO. 2
Subject

Page
Job No.
Date
By C.W.C

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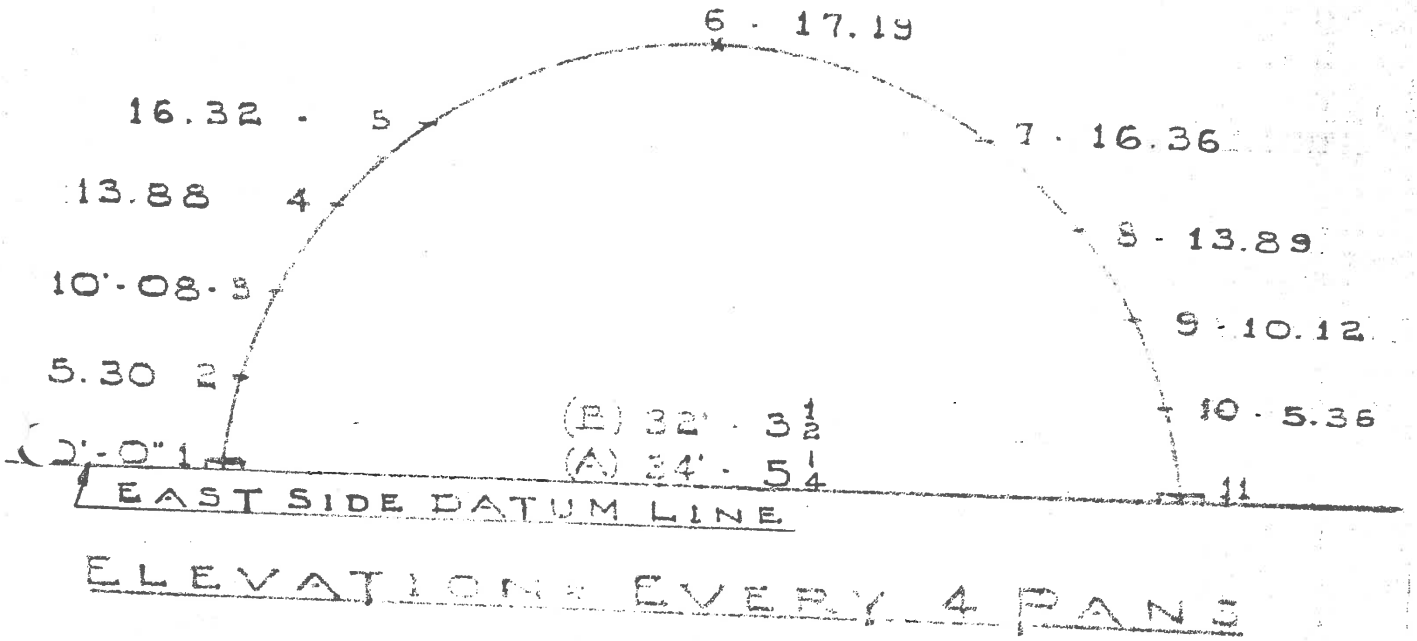

ELEVATIONS EVERY 4 PANS

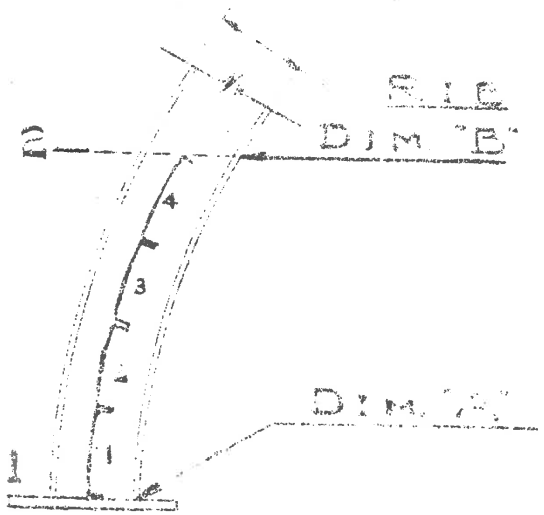

EXHIBIT "D"

VITRO ENGINEERING COMPANY
A DIVISION OF VITRO CORPORATION OF AMERICA

CALCULATION SHEET

For 1697 (CAC 964)
Location POSITION NO. 3
Subject

Page
Job No.
Date
By C.W.C

APPROX. 5 FT. BACK.
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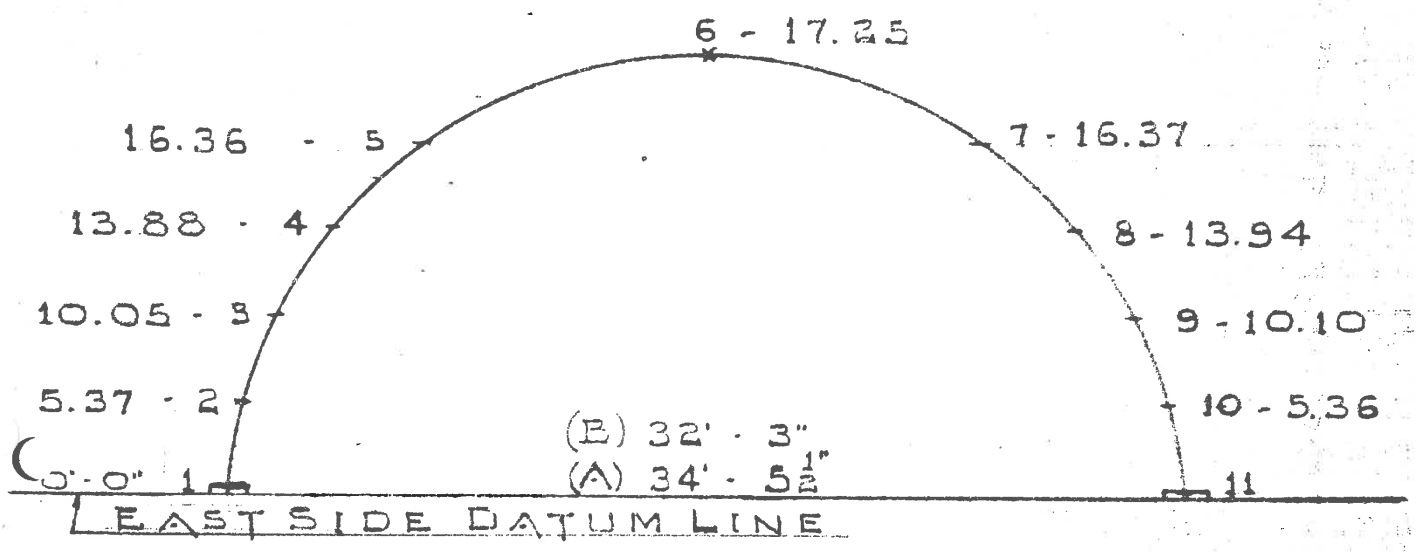


ELEVATION ≈ EVERY 4 PANS

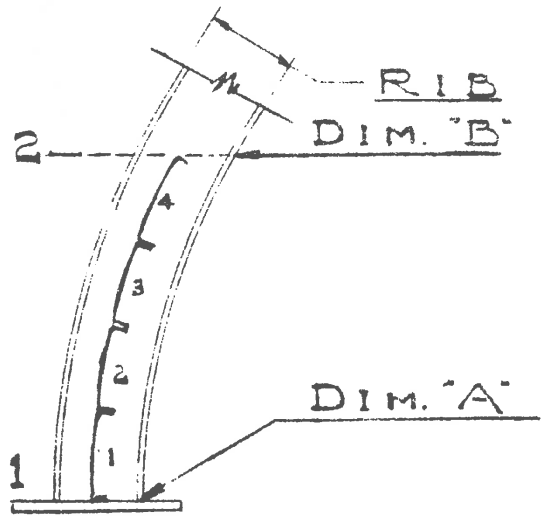


EXHIBIT "D"

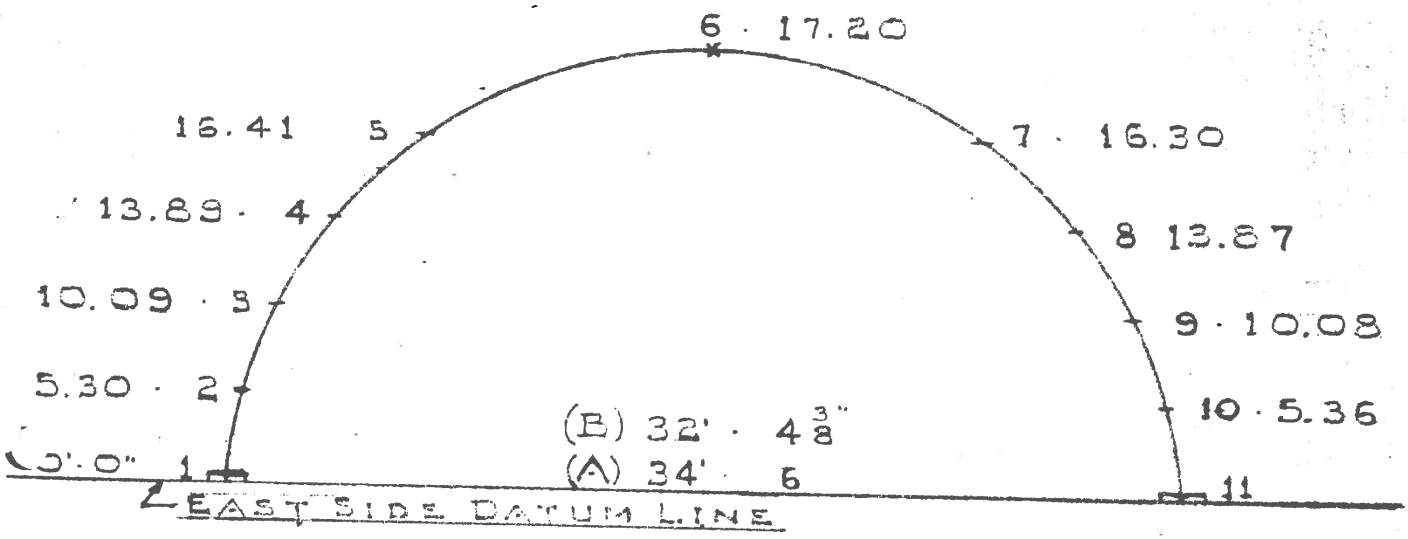
VITRO ENGINEERING COMPANY
A DIVISION OF VITRO CORPORATION OF AMERICA

CALCULATION SHEET

For 1697 (CAC 964)
Location POSITION NO. 4
Subject

Page
Job No.
Date
By C.W.C

APPROX. 5 FT. BACK.
FILL REMOVED.



ELEVATION ≈ EVERY 4 PANS

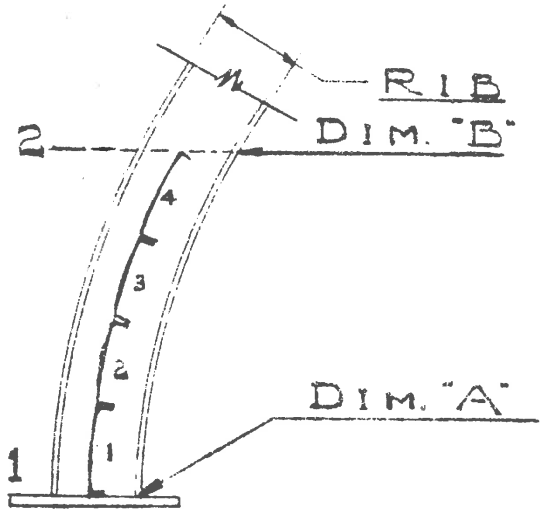


EXHIBIT "D"

VITRO ENGINEERING COMPANY
A DIVISION OF VITRO CORPORATION OF AMERICA

CALCULATION SHEET

Job 1697 (CAC 964)
Location PCF ITEM NO. 5
Subject

Page
Job No
Date
By C.W.C

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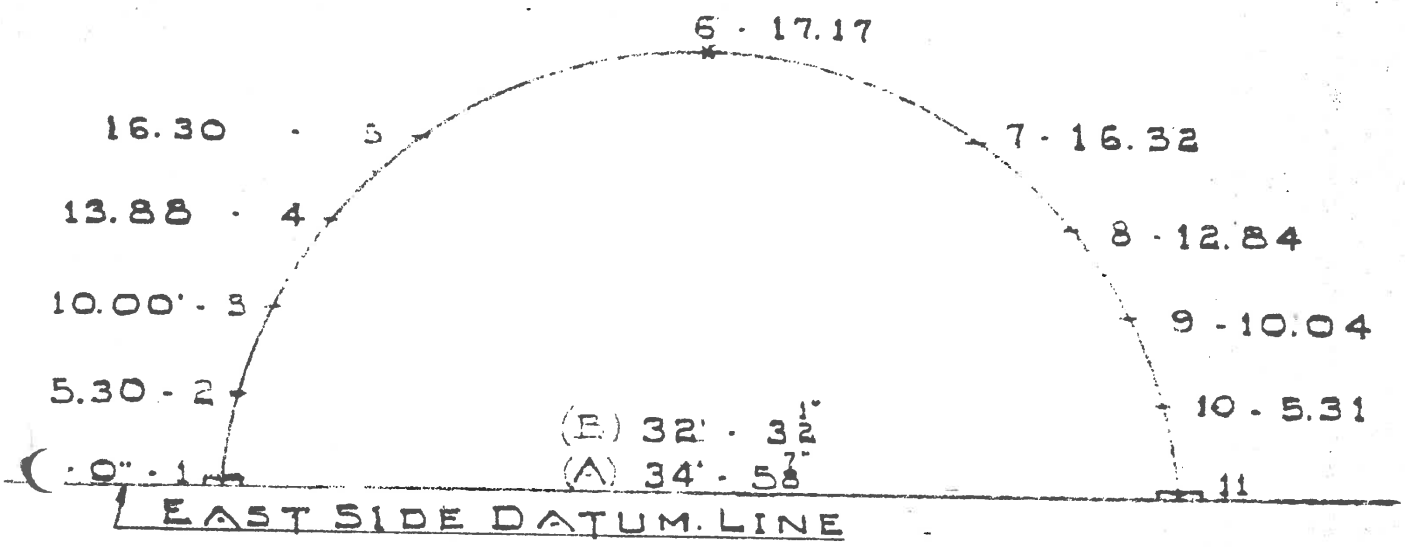

ELEVATIONS EVERY 4 PANS

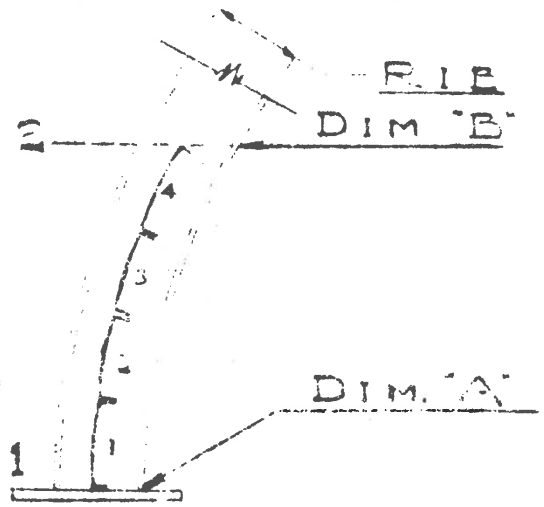

EXHIBIT "D"

VITRO ENGINEERING COMPANY
A DIVISION OF VITRO CORPORATION OF AMERICA

CALCULATION SHEET

Page
Job No. 1697 (CAC 964)
Location POSITION NO. 5
Subject
Date
By C.W.C

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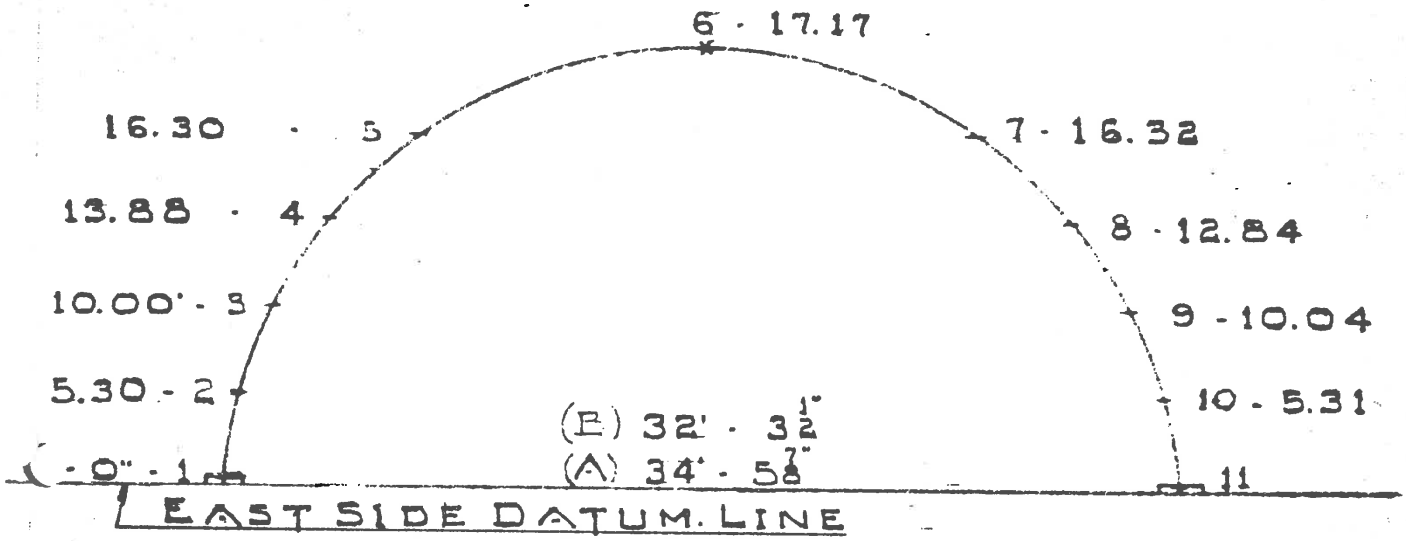

ELEVATIONS EVERY 4 PANS

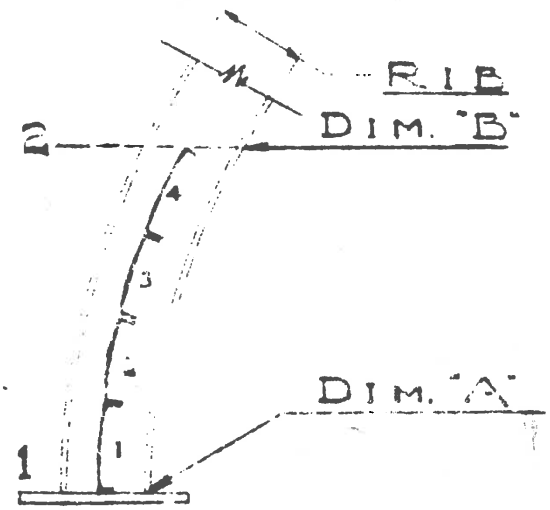

EXHIBIT "D"

VITRO ENGINEERING COMPANY
A DIVISION OF VITRO CORPORATION OF AMERICA

CALCULATION SHEET

For 1697 (C.A.C. 954)
Location PIT LINER NO. 5
Subject

Page
Job No.
Date
By C.W.C.

APPROX. SET BACK
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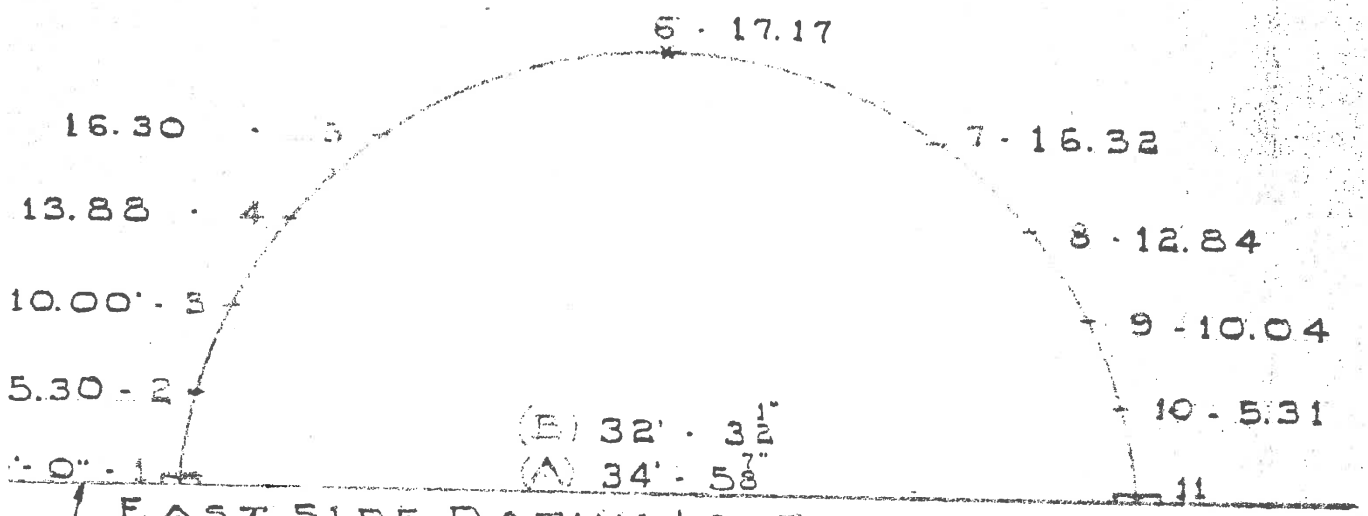

ELEVATIONS EVERY 4 PANS

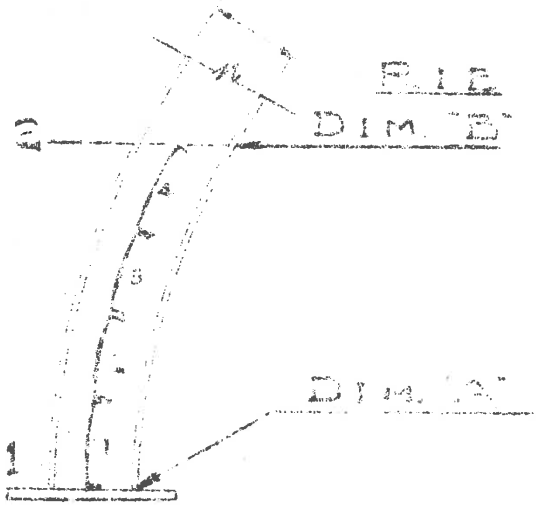

EXHIBIT "D"

VITRO ENGINEERING COMPANY
A DIVISION OF VITRO CORPORATION OF AMERICA

CALCULATION SHEET

For 1697 (CAC 964)
Location POSITION No. 6
Subject

Page
Job No.
Date
By C.W.C

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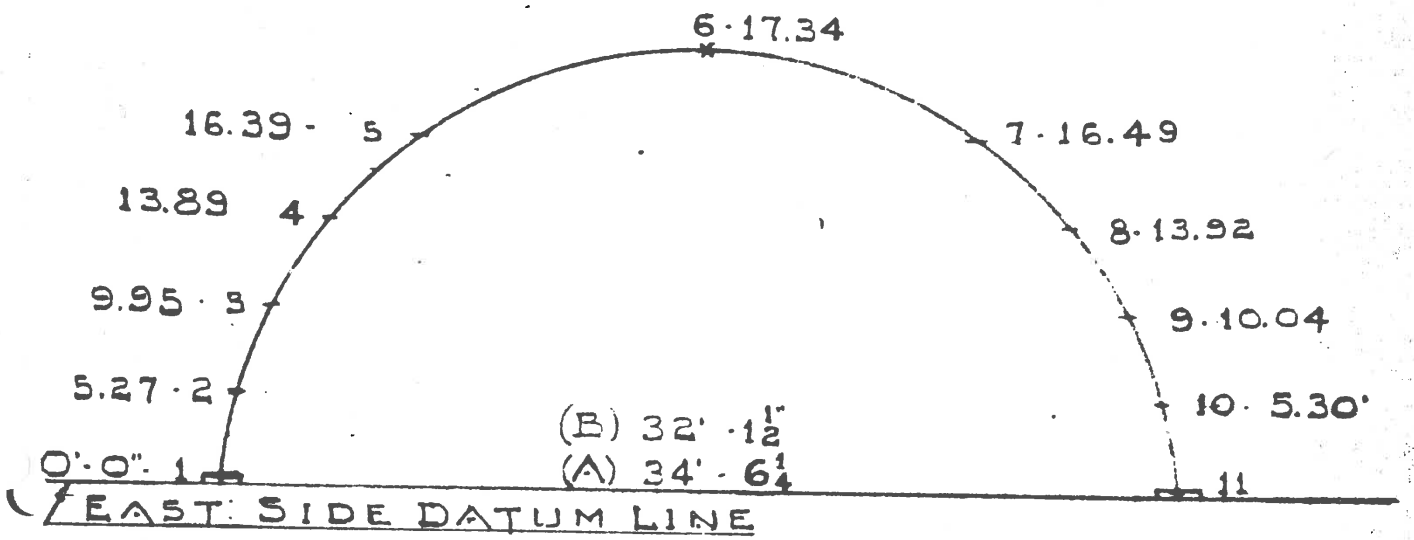

ELEVATION ≈ EVERY 4 PANS

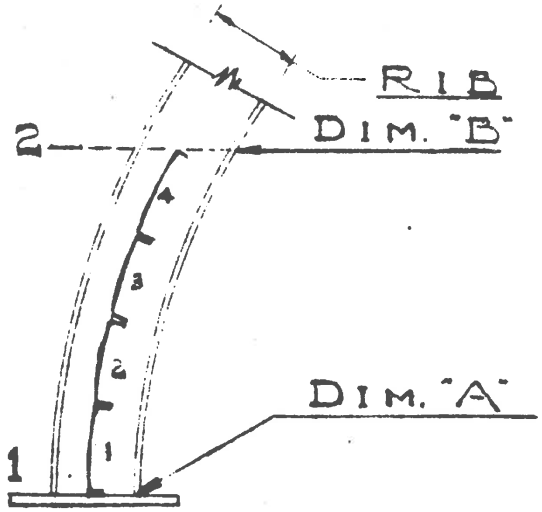

EXHIBIT "D"

VITRO ENGINEERING COMPANY
A DIVISION OF VITRO CORPORATION OF AMERICA

CALCULATION SHEET

For 1697 (CAC 964)
Location POSITION No. 6
Subject

Page
Job No.
Date
By C.W.C

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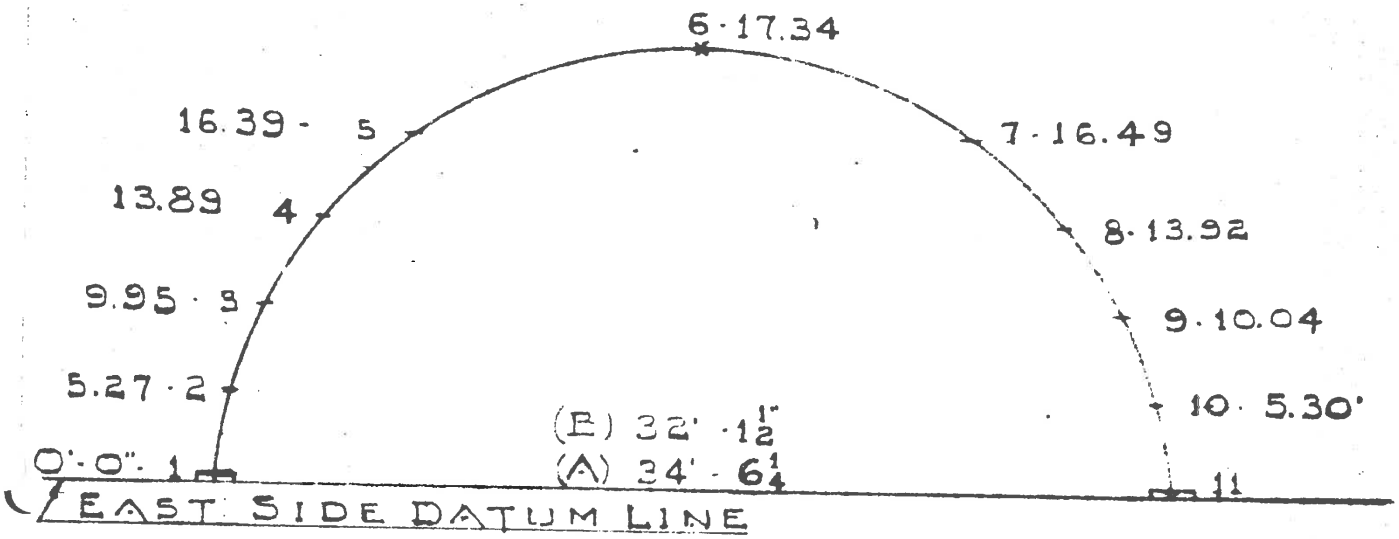
FILL REMOVED



ELEVATION ≈ EVERY 4 PANS

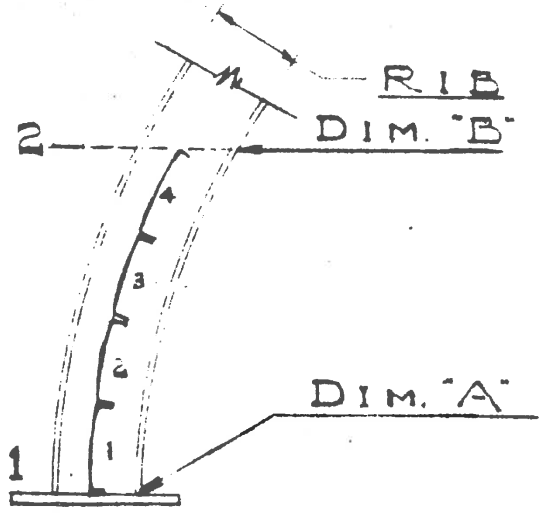


EXHIBIT "D"

VITRO ENGINEERING COMPANY
A DIVISION OF VITRO CORPORATION OF AMERICA

CALCULATION SHEET

For 1697 (CAC 964)
Location POSITION No. 6
Subject

Page
Job No.
Date
By C.W.C

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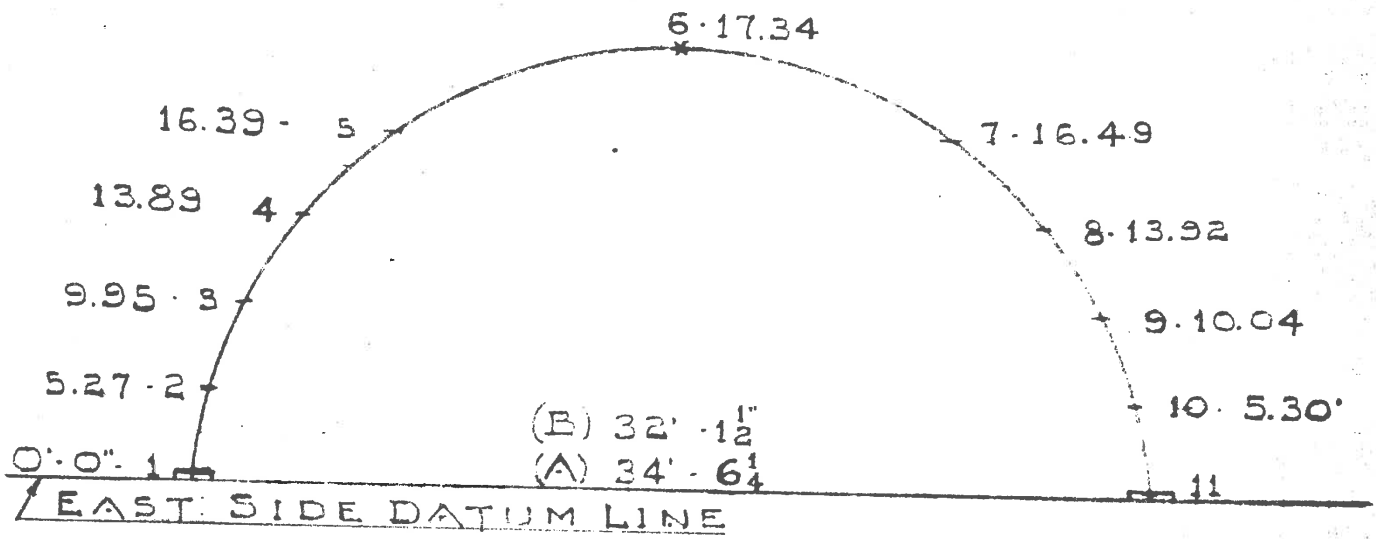
FILL REMOVED.



ELEVATION ≈ EVERY 4 PANS

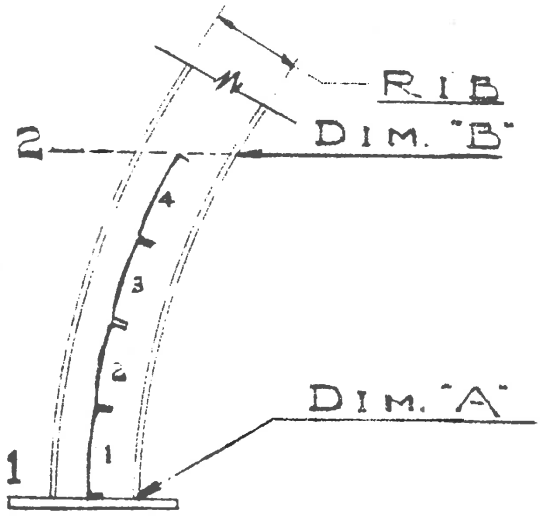


EXHIBIT "D"

BACKFILL REMOVAL SECOND OPERATIONS

In an effort to gain maximum recovery of tunnel deformation an additional four (4) feet of backfill was removed. Recheck of Positions 1 through 6 indicate that maximum recovery occurred at elevation 6, Position 4. Maximum recovery at Dimension B was 2" at Position 5.

Deformation of structure at elevation 6 averaged 1-1/2". At Dimension 'B' the average was 1-5/8".

This report is attached as Exhibit "E".

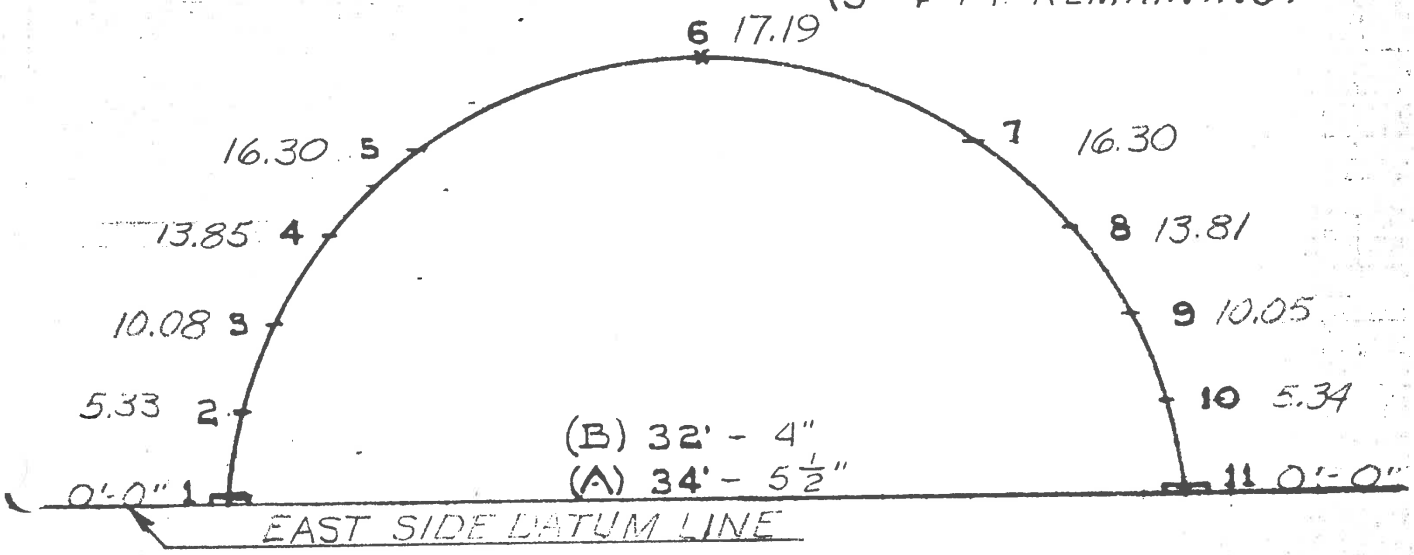
VITRO ENGINEERING COMPANY
A DIVISION OF VITRO CORPORATION OF AMERICA

CALCULATION SHEET

Page
Job No.
Date
By C.W.C

or 1697 (CAC 964)
Location POSITION NO. 1
Subject

APPROX. 9 FT. BACK FILL REMOVED.
(3'-4' FT. REMAINING)



ELEVATION ≈ EVERY 4 PANS

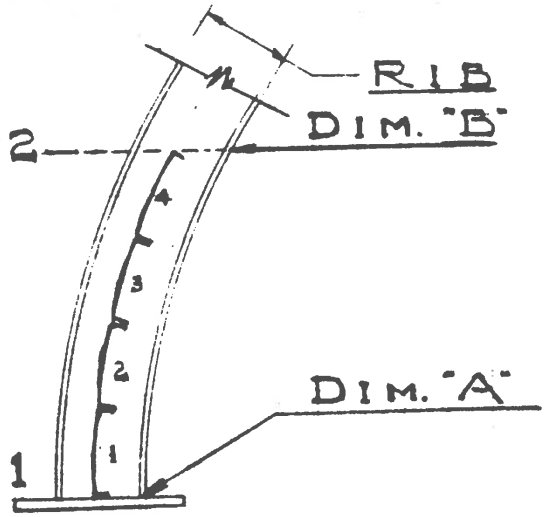


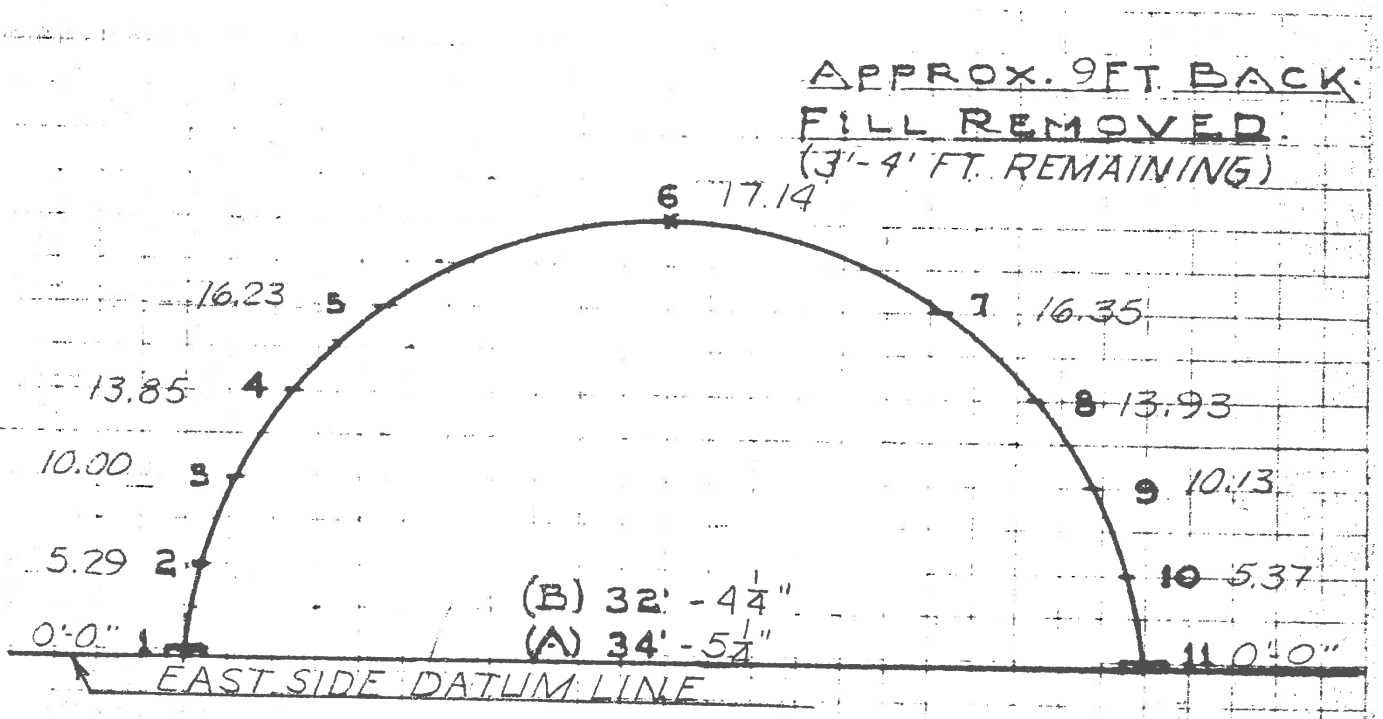
EXHIBIT "E"

VITRO ENGINEERING COMPANY
A DIVISION OF VITRO CORPORATION OF AMERICA

CALCULATION SHEET

For 1697 (CAC 964)
Location POSITION No. 2
Subject

Page
Job No.
Date
By C.W.C



ELEVATION ≈ EVERY 4 PANS

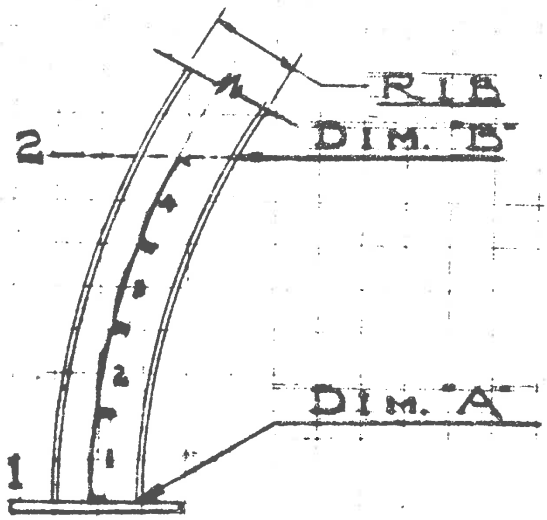


EXHIBIT "E"

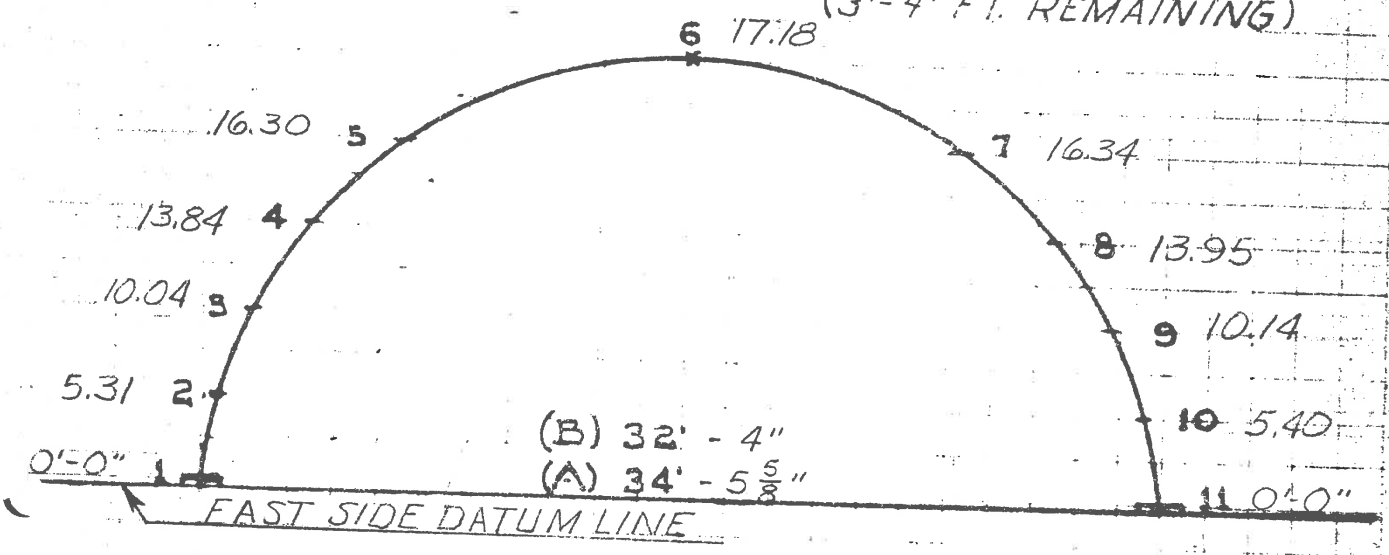
VITRO ENGINEERING COMPANY
A DIVISION OF VITRO CORPORATION OF AMERICA

CALCULATION SHEET

For 1697 (CAC 364)
Location POSITION No. 3
Subject

Page
Job No.
Date
By C.W.C

APPROX. 9 FT BACK.
FILL REMOVED.
(3'-4' FT. REMAINING)



ELEVATION ≈ EVERY 4 PANS

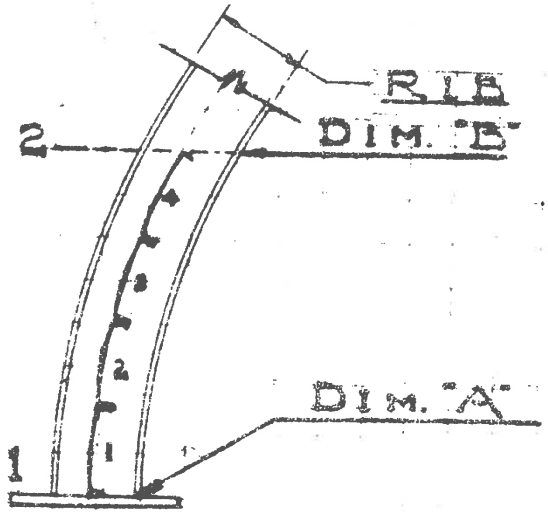


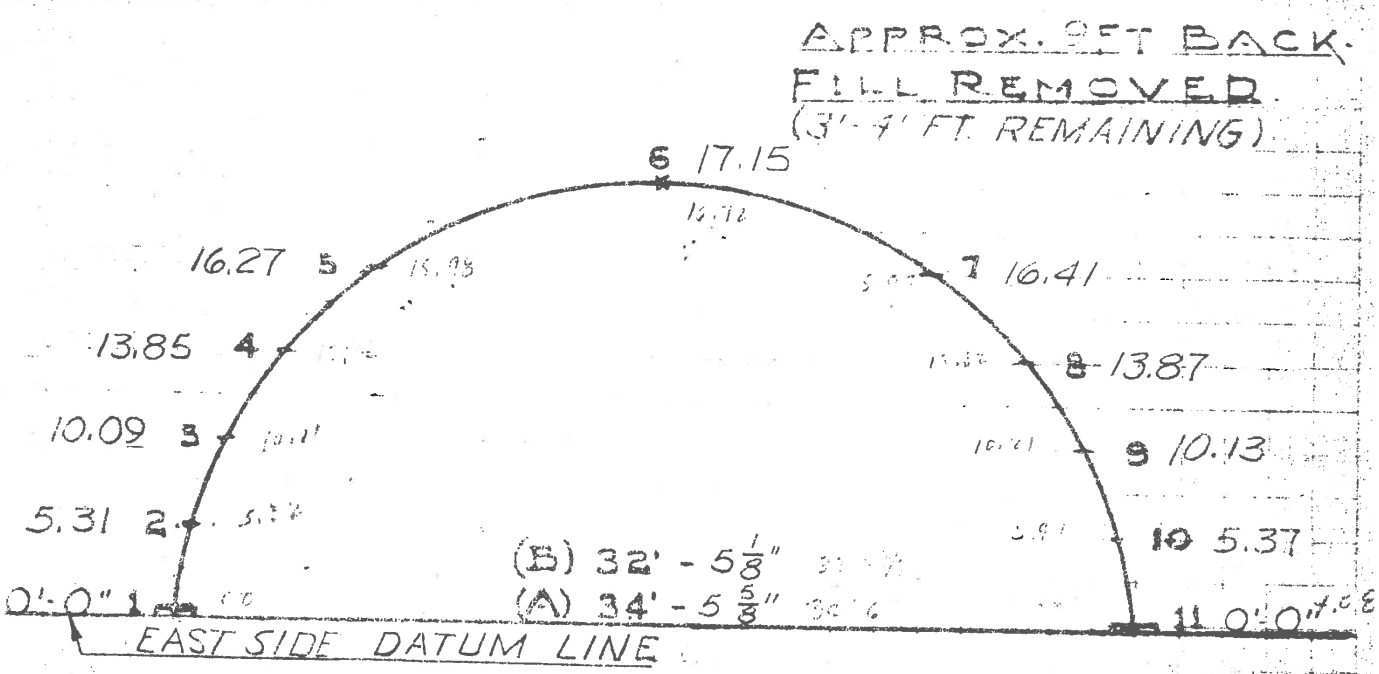
EXHIBIT "E"

VITRO ENGINEERING COMPANY
A DIVISION OF VITRO CORPORATION OF AMERICA

CALCULATION SHEET

For: 1697 (CAC 964)
Location: POSITION No. 4
Subject:

Page:
Job No.:
Date:
By: C.W.C



ELEVATION ≈ EVERY 4 PANS

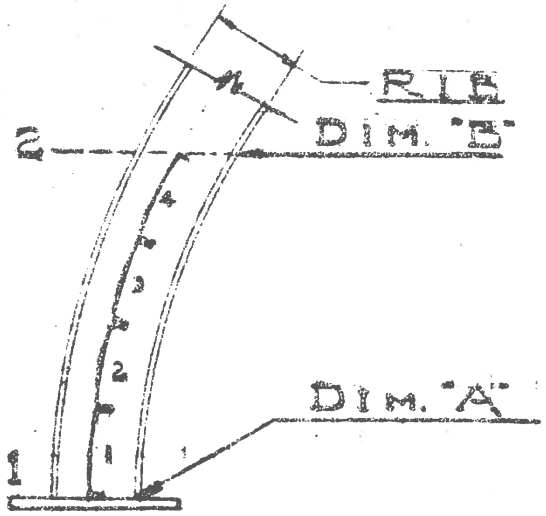


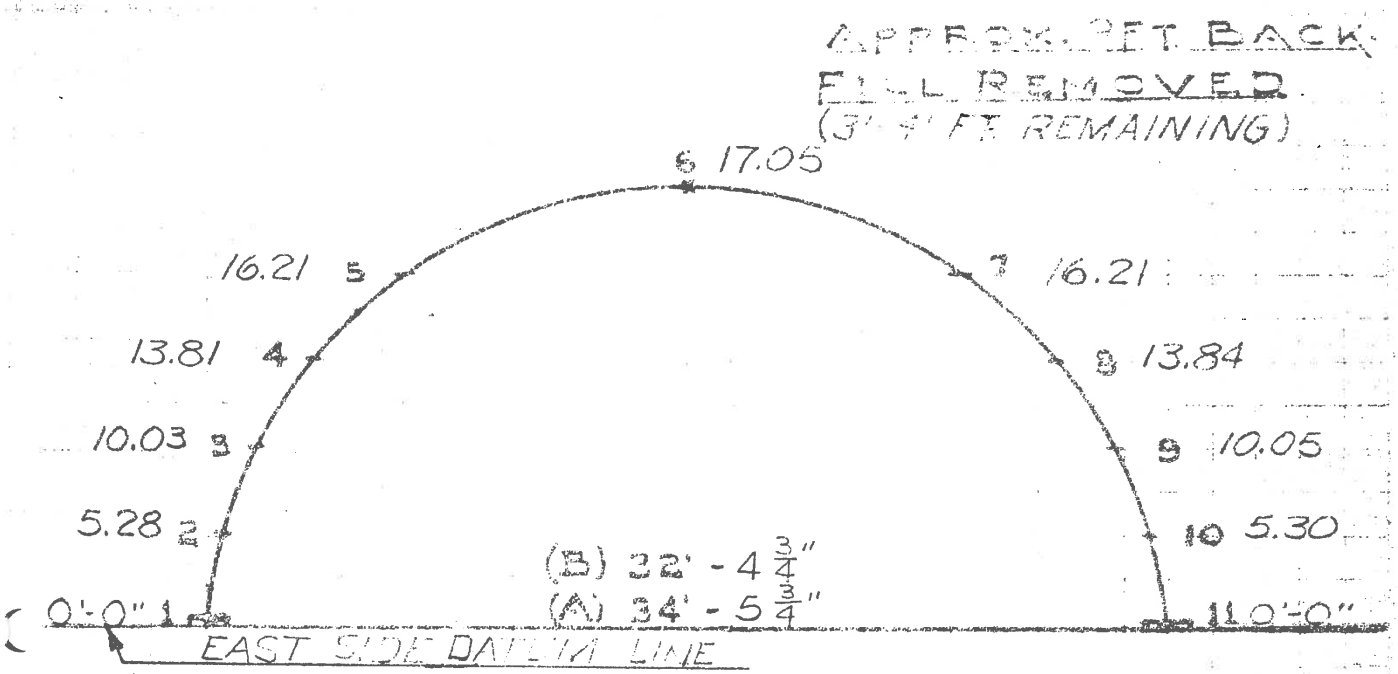
EXHIBIT "E"

VITRO ENGINEERING COMPANY
A DIVISION OF VITRO CORPORATION OF AMERICA

CALCULATION SHEET

For 1697 (CAC 964)
Location POSITION No. 5
Subject

Page
Job No.
Date
By C.W.C



ELEVATIONS EVERY 4 PANS

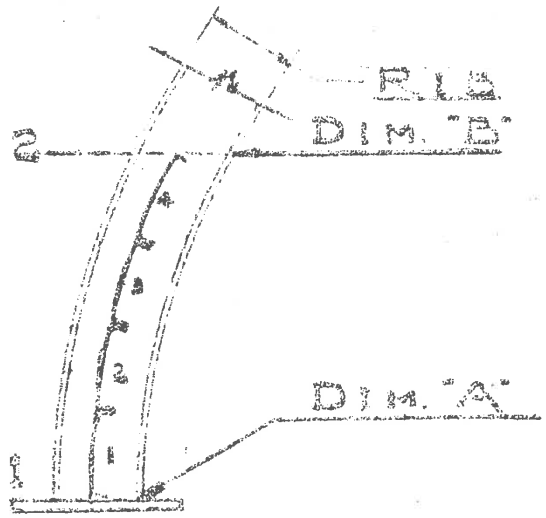


EXHIBIT "E"

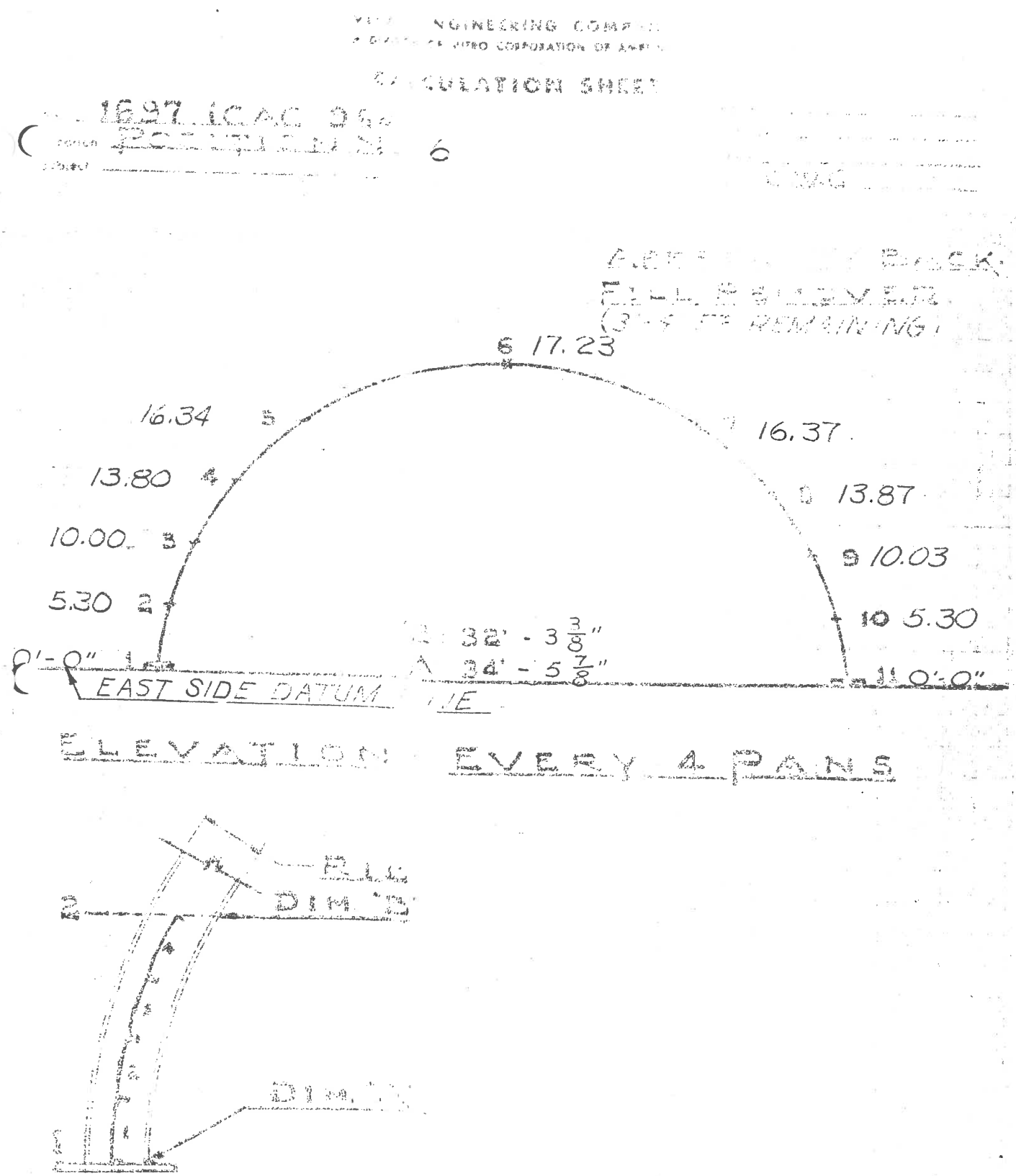

ENGINEERING COMPANY
CALCULATION SHEET
1697 ICAC
PROJECT NO. 6
BACK
FILL & BULLDOZER
(3'-4" REMAINING)
6 17.23
16.34 5
16.37
13.80 4
13.87
10.00 3
9 10.03
5.30 2
10 5.30
0'-0" 1
32' - 3 3/8"
34' - 5 7/8"
11 0'-0"
EAST SIDE DATUM LINE
ELEVATION EVERY 4 PANS
R.L.S.
DIM. "B"
2
DIM. "A"

EXHIBIT "E"

CONTROLLED BACKFILL OPERATIONS

A new backfilling procedure, designed to concentrically or radially load metal arch tunnel structure was started on February 15, 1964. A location was selected that was about Position Number 4 as previously recorded and reported. To accurately monitor the tunnel deflection during this operation, three (3) sets of uprights (story poles) were installed. Each set consisted of a vertical at the tunnel centerline or vertex, and a diagonal at about 35° to either side. Diagonals and verticals were calibrated at hundreths of a foot. Each set was spaced about eight (8) feet apart. This backfilling procedure utilized a drag-line to fill on the top of the tunnel arch first and allowed the material to spill laterally over the sides of the arch at the same time, and also assuming the natural angle of repose forward in the direction of backfilling. Concurrent with top of arch fill, the elevation of the angle of repose along the tunnel sides was decreased with D-9 equipment to build up a "heal" to support the repose. Within the limits of practicability, the concentric loading objective was accomplished. The 'tabulation' indicates the tunnel deflection, at the time intervals noted during backfilling and the report indicates the final deformation at completion of backfilling.

It is notable that the last readings taken at Elevation 6 indicated continued deflection after two (2) days. Approximately four (4) feet of this backfill was immediately removed by the contractor.

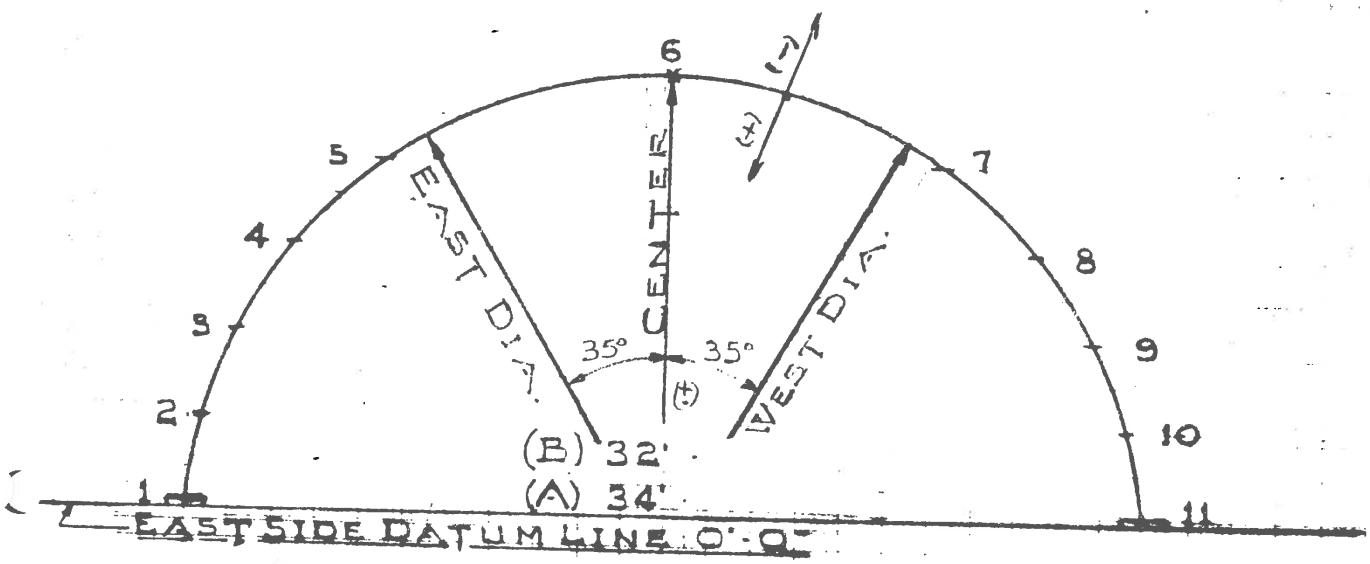
This report is attached as Exhibit "F"

VITRO ENGINEERING COMPANY
A DIVISION OF VITRO CORPORATION OF AMERICA

CALCULATION SHEET

Location 1697 (CAC 964) POSITION NO. 4 (+8 FT. N)
Subject

Page
Job No.
Date
By C.W.C



SECTION 1

TIME	EAST	CENTER	WEST
12:NOON	0.03 FT.	0.03 FT.	0.03 FT.
12:05	0.02	0.08	0.00
12:10	0.00	0.11	0.01
1:00	0.00	0.11	-0.02
1:25	-0.02	0.14	-0.04
1:35	-0.04	0.17	-0.04
2:00	-0.10	0.19	-0.03
2:15	-0.10	0.20	-0.03
2:35	-0.11	0.24	-0.07
2:55	-0.11	0.28	-0.07
3:20	-0.11	0.30	-0.09
4:30	-0.08	0.31	-0.08
2-6-64			
8:00(AM)	-0.10	0.34	-0.09
9:00	-0.07	0.35	-0.07
9:35	-0.09	0.38	-0.07
12:30	-0.08	0.40	-0.10
1:30	-0.08	0.40	-0.10
3:30	-0.08	0.40	-0.10
2-7-64			
8:45	-0.08	0.42	-0.10

EXHIBIT "F"

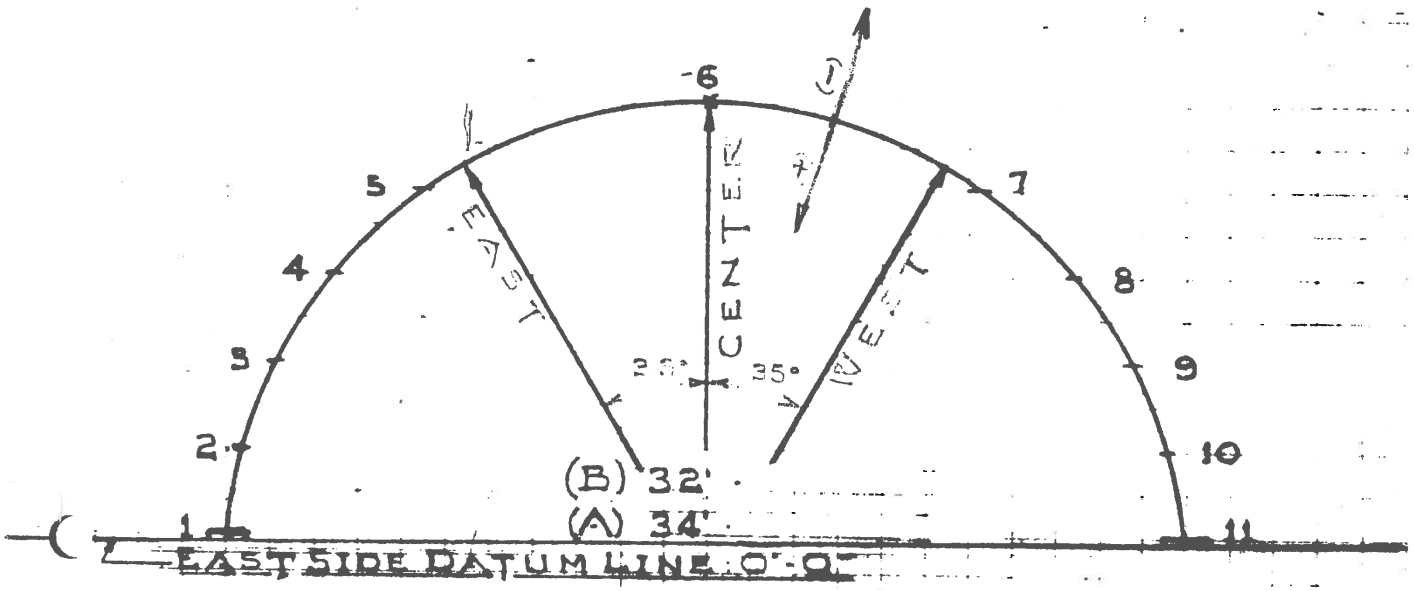
VITRO ENGINEERING COMPANY
A DIVISION OF VITRO CORPORATION OF AMERICA

CALCULATION SHEET

1697 (CAC 964)
Location POSITION NO. 4
Subject

Page
Job No.
Date
By C.W.C

EXHIBIT "F"



SETTLEMENT - 2

TIME & DT.	EAST	CENTER	WEST
2/5/64			
12:00 (NOON)	0.00 FT.	0.11 FT.	0.00 FT.
12:05	0.00	0.11	0.01
12:10	0.00	0.11	0.01
12:20	0.00	0.11	0.02
1:00	0.02	[illegible]	[illegible]
1:05	0.02	0.20	[illegible]
1:15	0.06	0.22	0.02
1:55	0.02	0.22	0.07
2:10	0.02	[illegible]	0.02
2:20	0.00	0.40	0.00
2:55	0.00	[illegible]	0.00
3:20	0.01	[illegible]	[illegible]
4:30	0.01	[illegible]	[illegible]
2/6/64			
[illegible] AM	[illegible]	0.42	[illegible]
9:00	0.01	[illegible]	[illegible]
[illegible]:20	[illegible]	[illegible]	[illegible]
9:30	[illegible]	0.44	0.02
9:35	[illegible]	[illegible]	0.04
10:00	[illegible]	[illegible]	[illegible]
10:[illegible]	[illegible]	[illegible]	[illegible]
3:30	[illegible]	[illegible]	[illegible]

VITRO ENGINEERING COMPANY
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CALCULATION SHEET

Job No. 1697 (CAC 964)
Location POSITION No. 4 (+8 FT. S)
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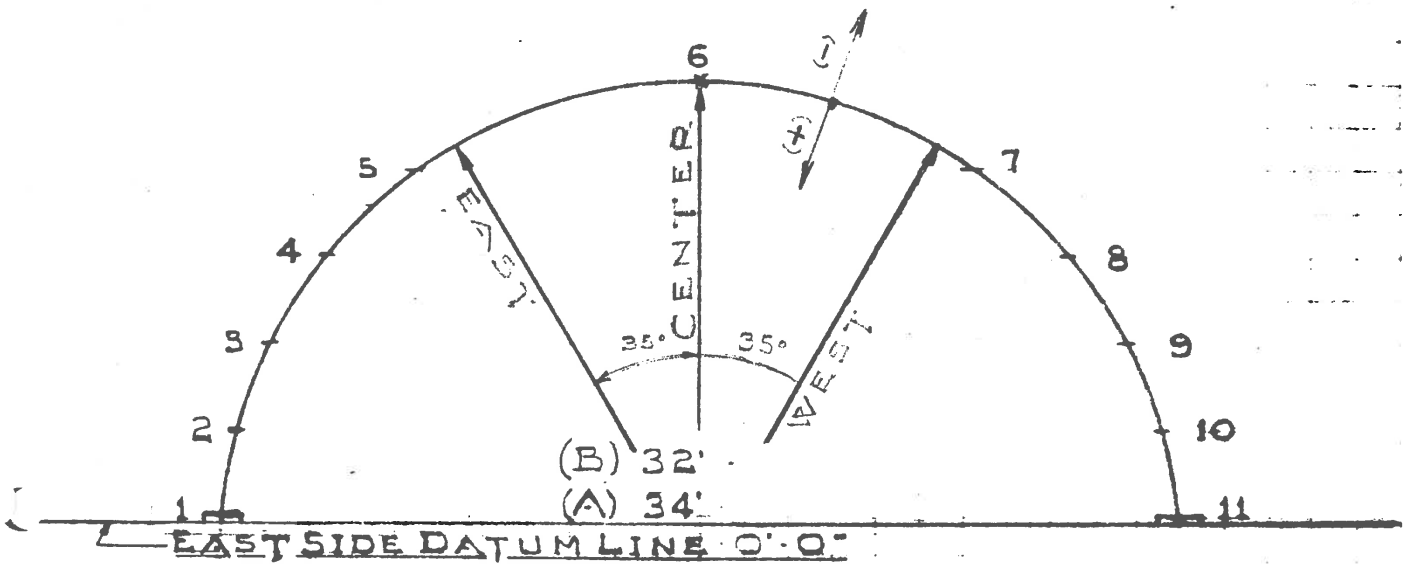

SECTION - 3

TIME / DT	EAST	CENTER	WEST
12:00 (2-5-64	0.02 FT	0.00 FT	0.00 FT
12:10	0.03	0.03	0.00
1:00	0.05	0.04	0.02
2:00	0.07	0.02	0.02
2:15	0.07	0.02	0.02
2:55	0.07	0.02	0.04
3:20	0.09	0.00	0.04
3:30	0.10	0.01	0.02
3:45	0.10	0.01	-0.01
4:00	0.10	0.02	-0.02
4:15	0.10	0.01	-0.01
4:30	0.10	0.01	-0.01
(AM) 8:00 (2-6-64	0.08	0.00	-0.02
9:00	0.01	0.00	-0.06
9:35	0.01	0.35	-0.10
10:00	0.01	0.38	-0.10
10:30	0.01	0.38	-0.10
2:30	0.01	0.40	-0.10
3:30	0.00	0.40	-0.10
2.7.64			
8:45	0.01	0.41	

EXHIBIT "F"

PARTIAL BACKFILL OPERATIONS

Backfilling operations were started to load tunnel concentrically. Backfill being placed with a combination of D-9 and drag-line equipment. The Contractor's stated intent was to backfill to a maximum of four (4) to five (5) feet. The embankments about tunnel walls were staked to limit proximity of loading equipment to tunnel.

Survey sections were selected, beginning at the South end of the tunnel, and spaced at every fifth rib or about 15'0" apart. A report of deformations at basic elevations is attached as Exhibit "G". Maximum deflection at elevation 6 is 0.36 foot downward, at Survey Sections Numbers 53 and 54. Maximum side deflection is 0.35 foot at Section 53 and at Dimension B deformed outward 4-1/8 at Section 53. Backfilling was started north of Survey Section Number 68 and had been completed south to Section Number 32, the deflection checks had been completed south to Section Number 50.

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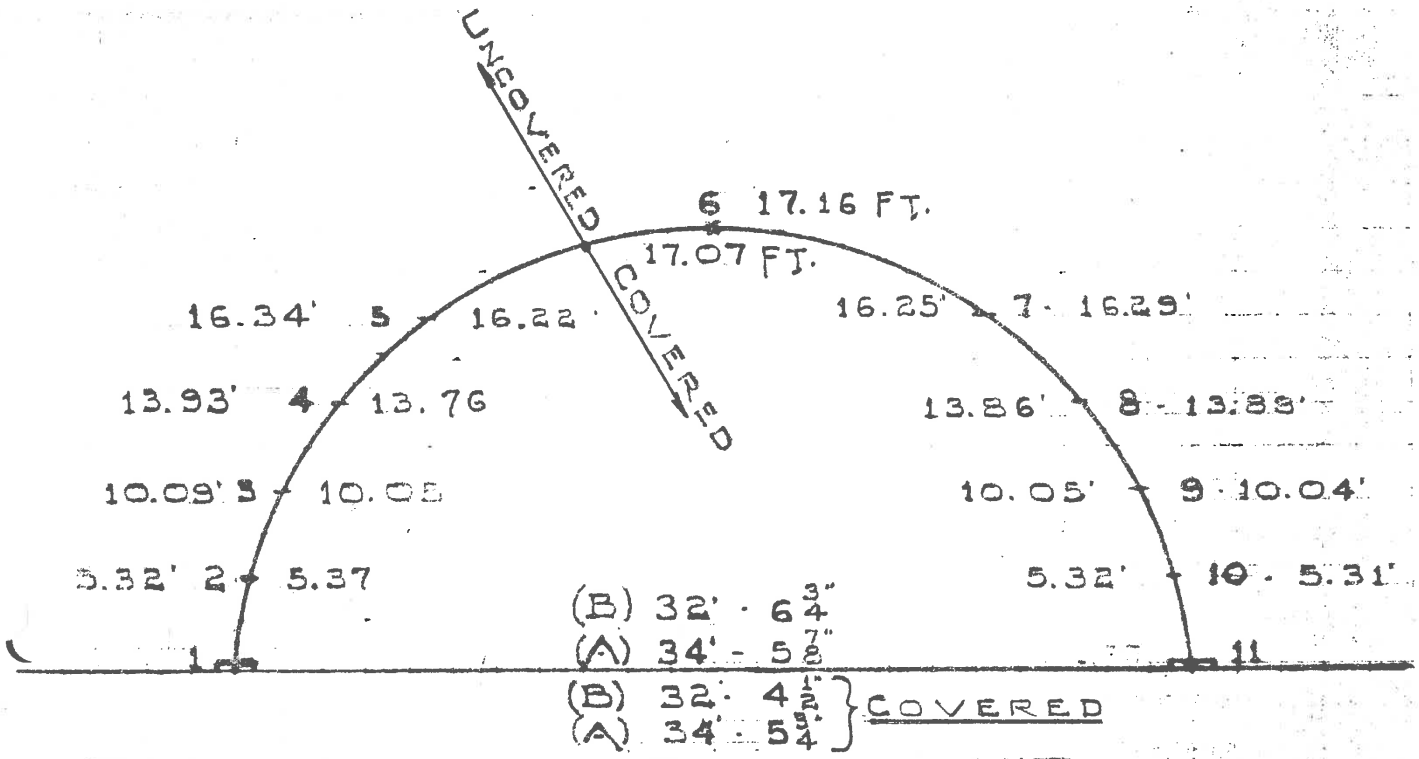
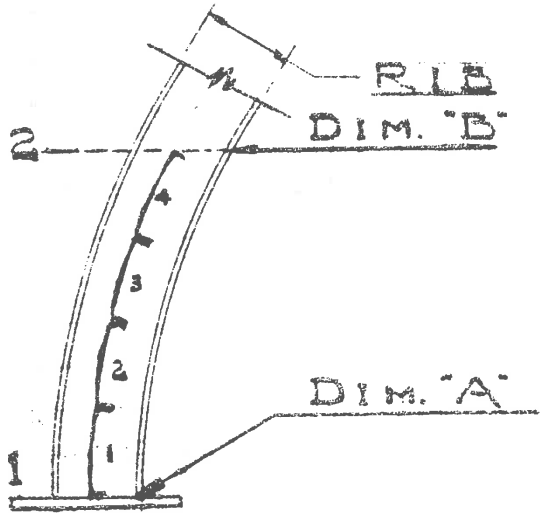


ELEVATION ≈ EVERY 4 PANS
SECTION NO. 50



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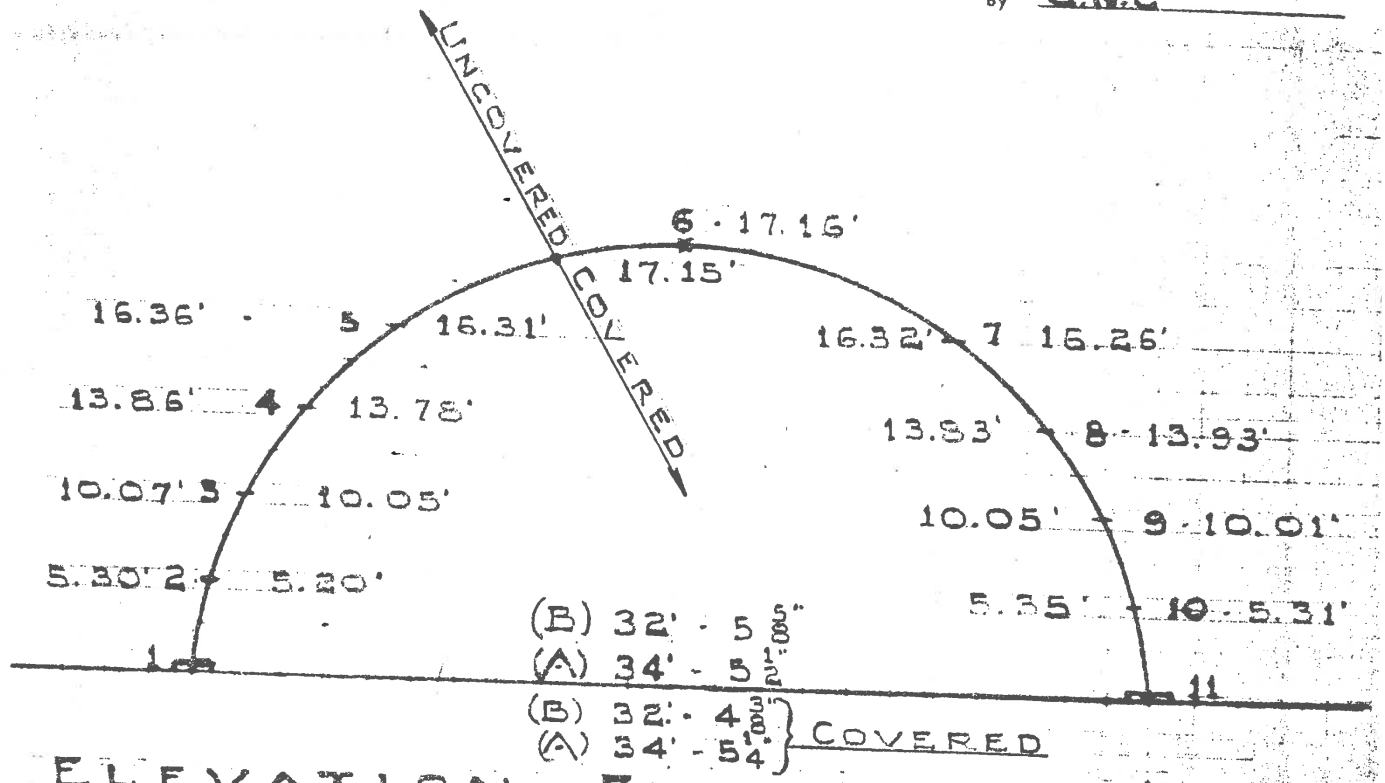
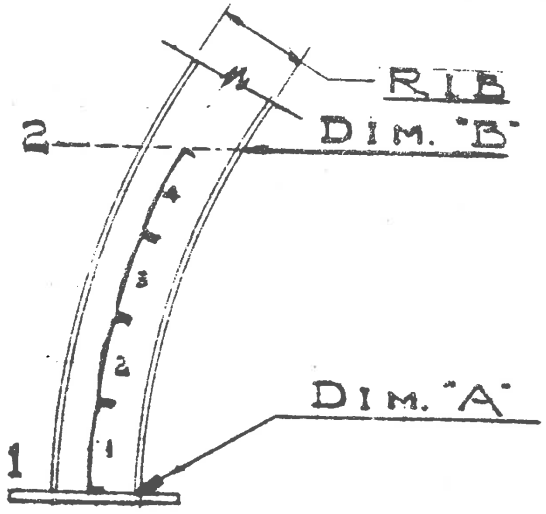


ELEVATION ≈ EVERY 4 PANS
STATION NO. 51



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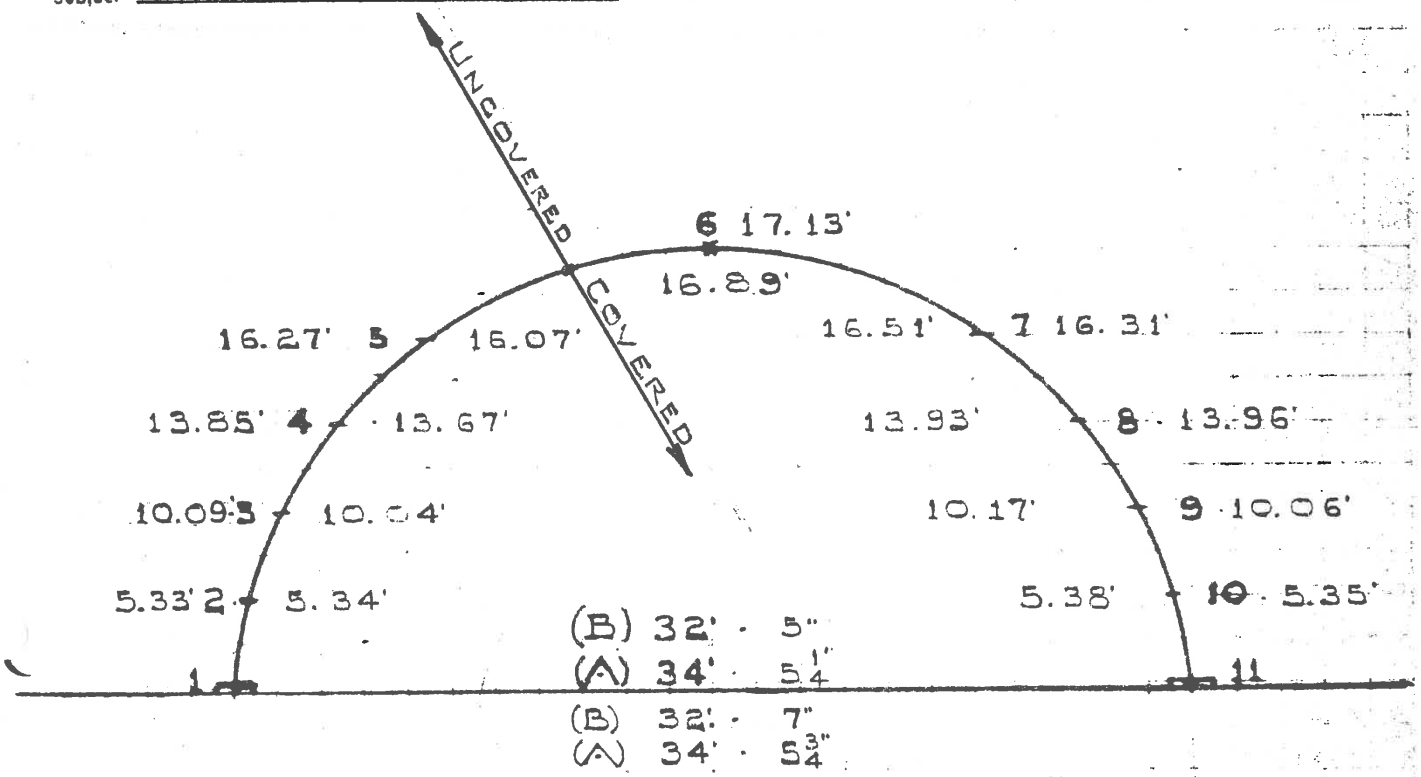
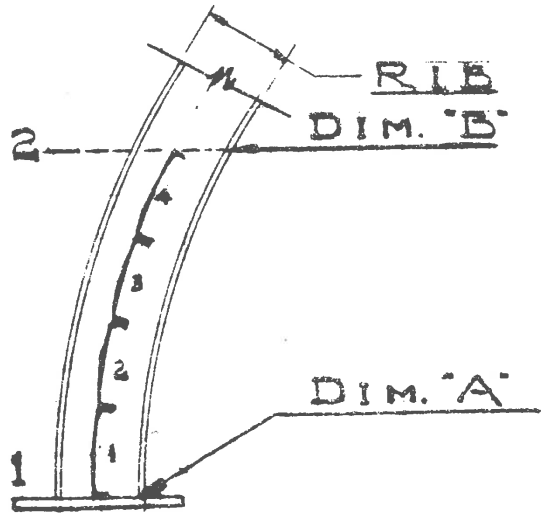


ELEVATION ≈ EVERY 4 PANS
STATION No. 52



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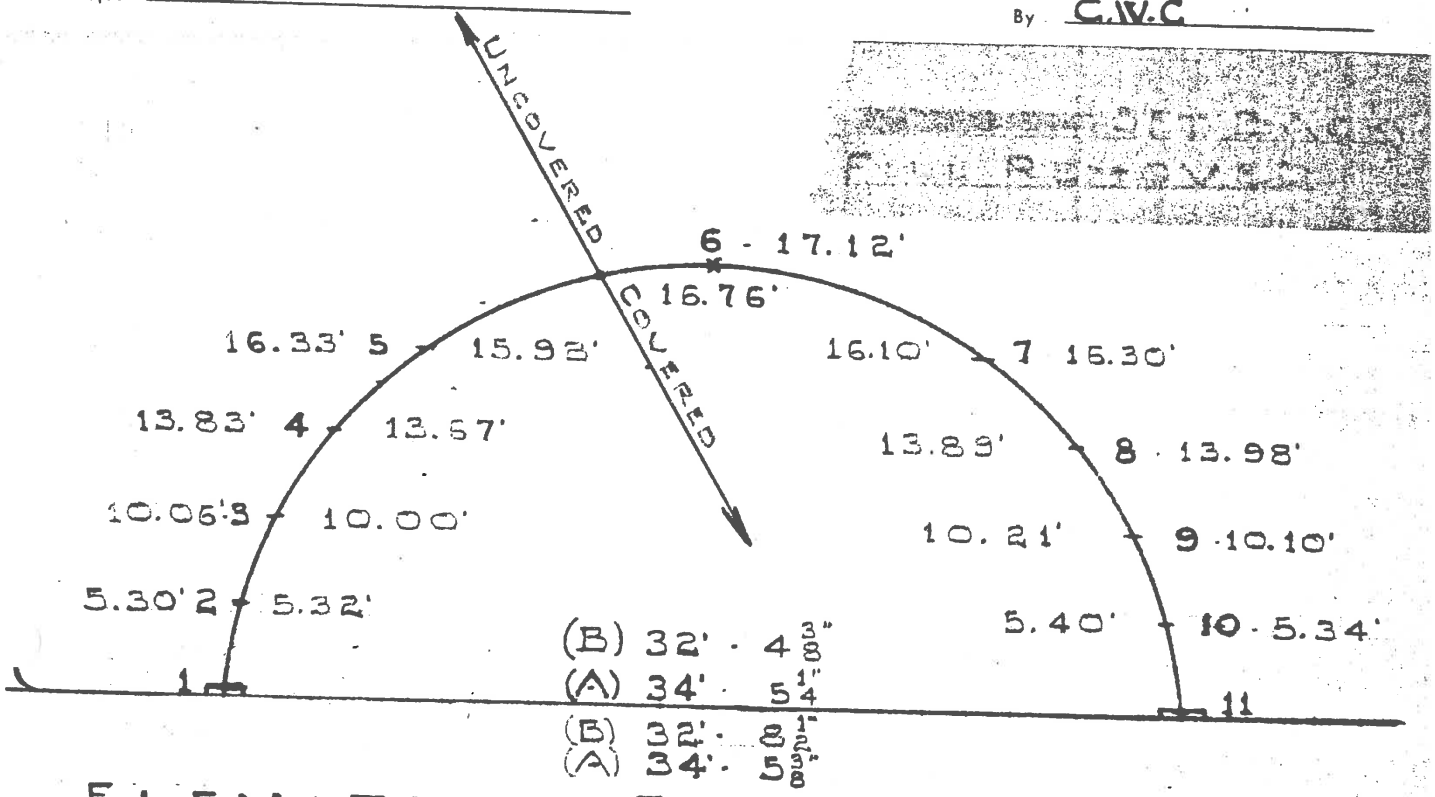
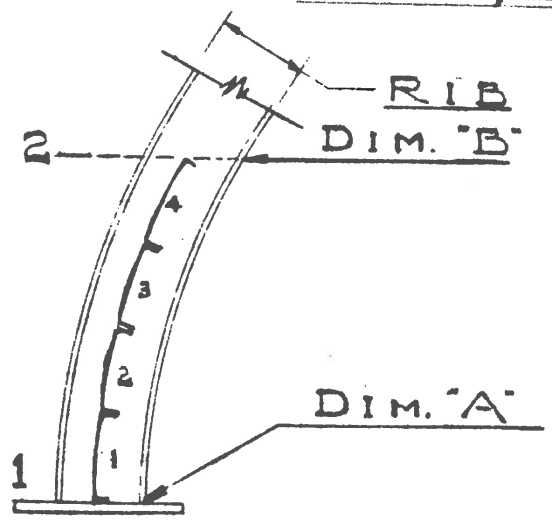


ELEVATION ≈ EVERY 4 PANS
SECTION NO. 53



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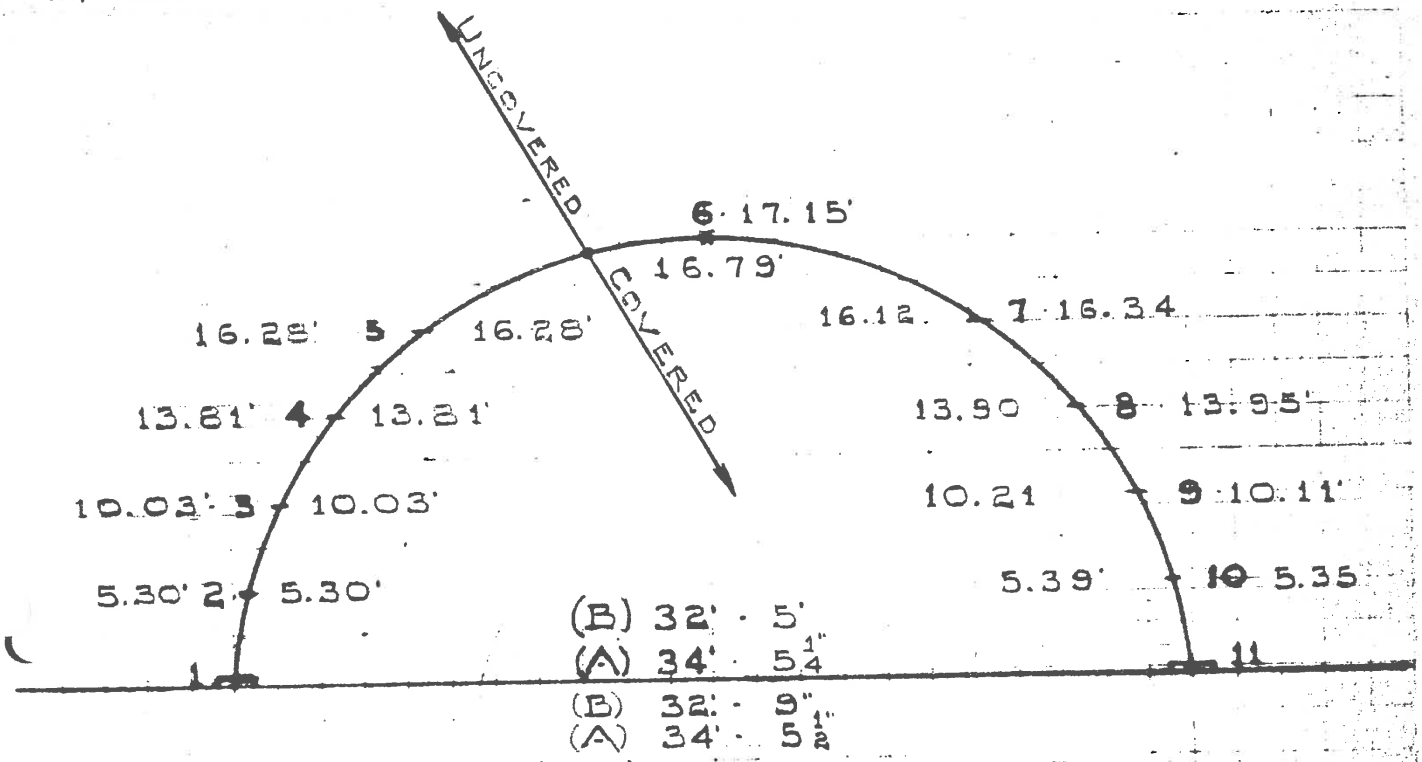
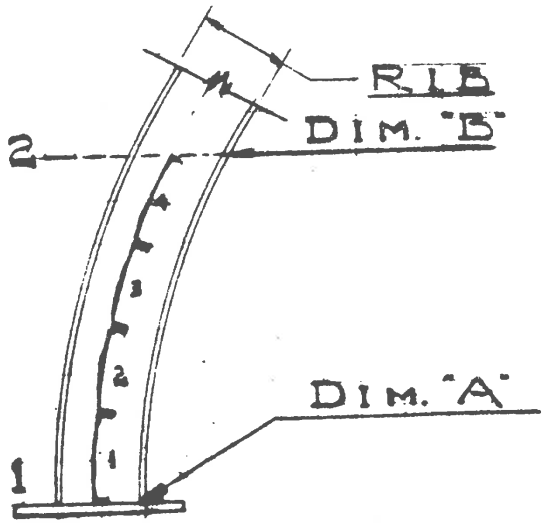


ELEVATION ≈ EVERY 4 PANS

SECTION ≈ NO. 54



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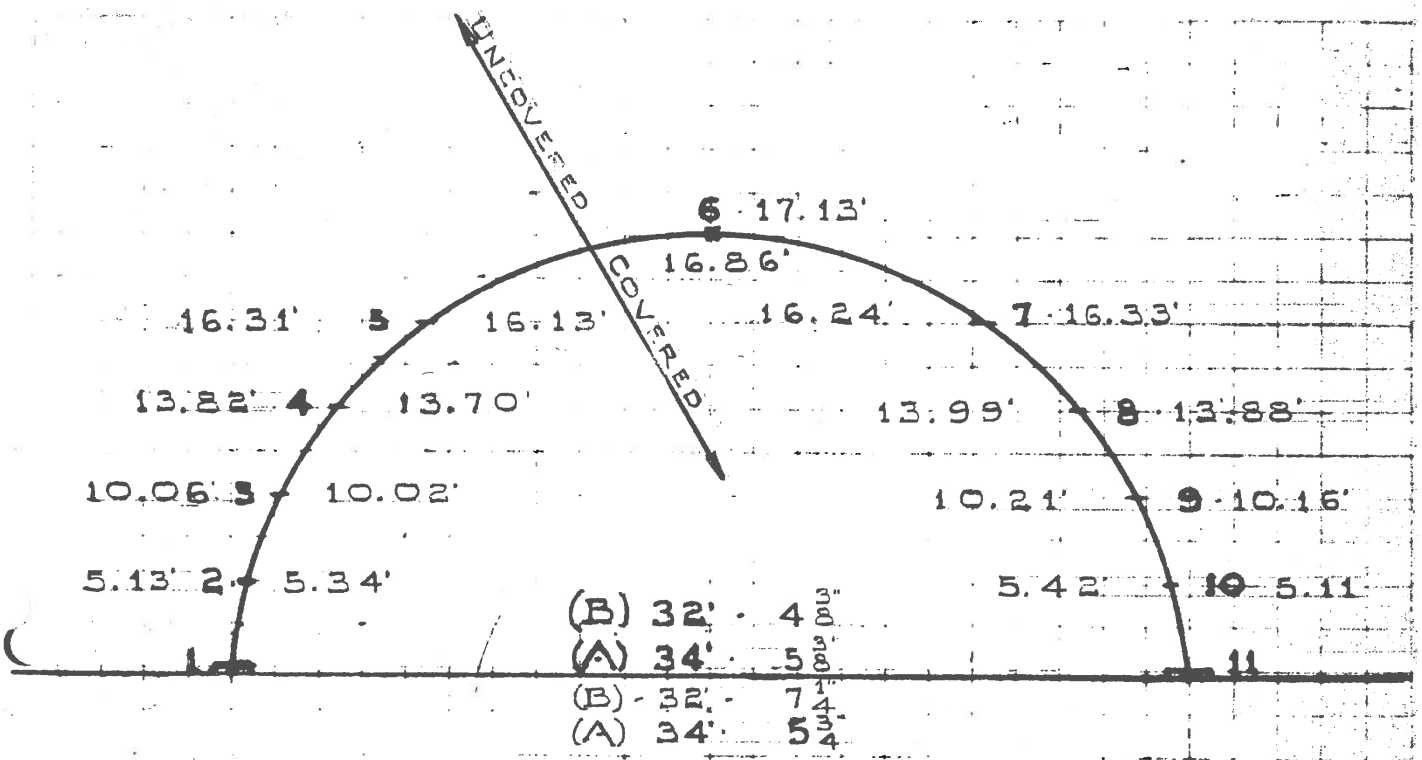
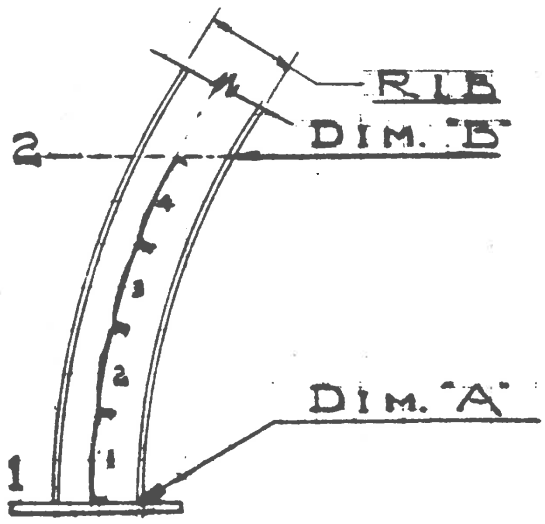


ELEVATION ≈ EVERY 4 PANS
SECTION ≈ No. 55



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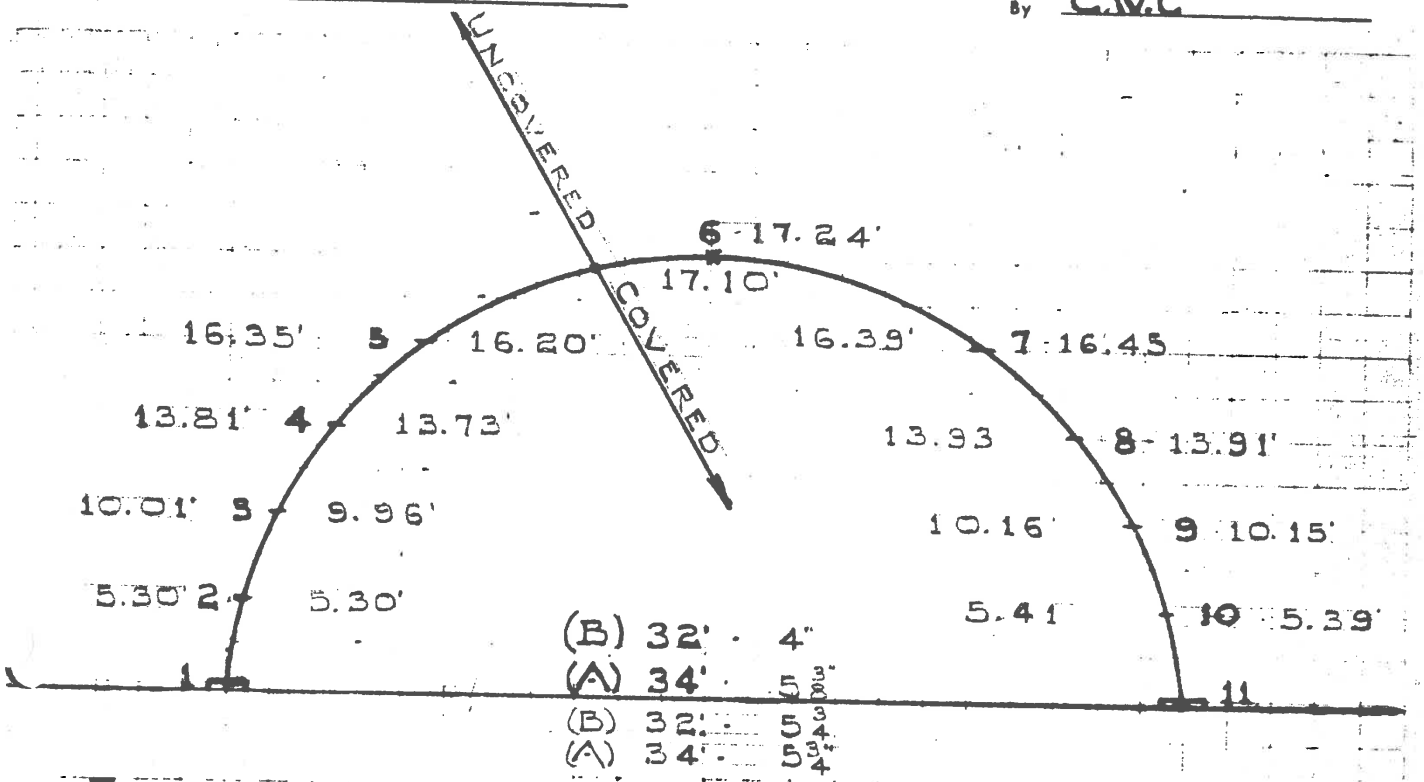

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SECTION ≈ NO. 56

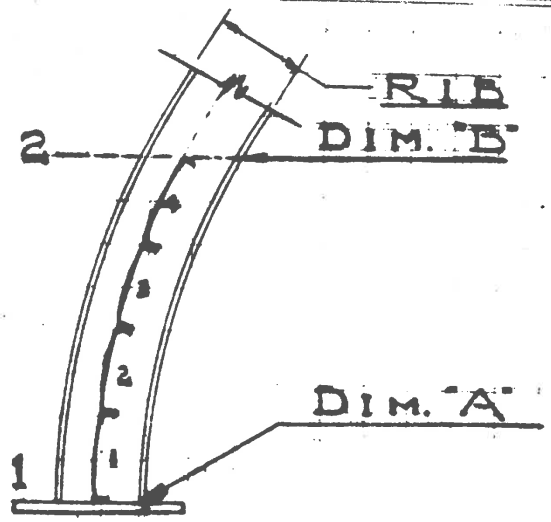
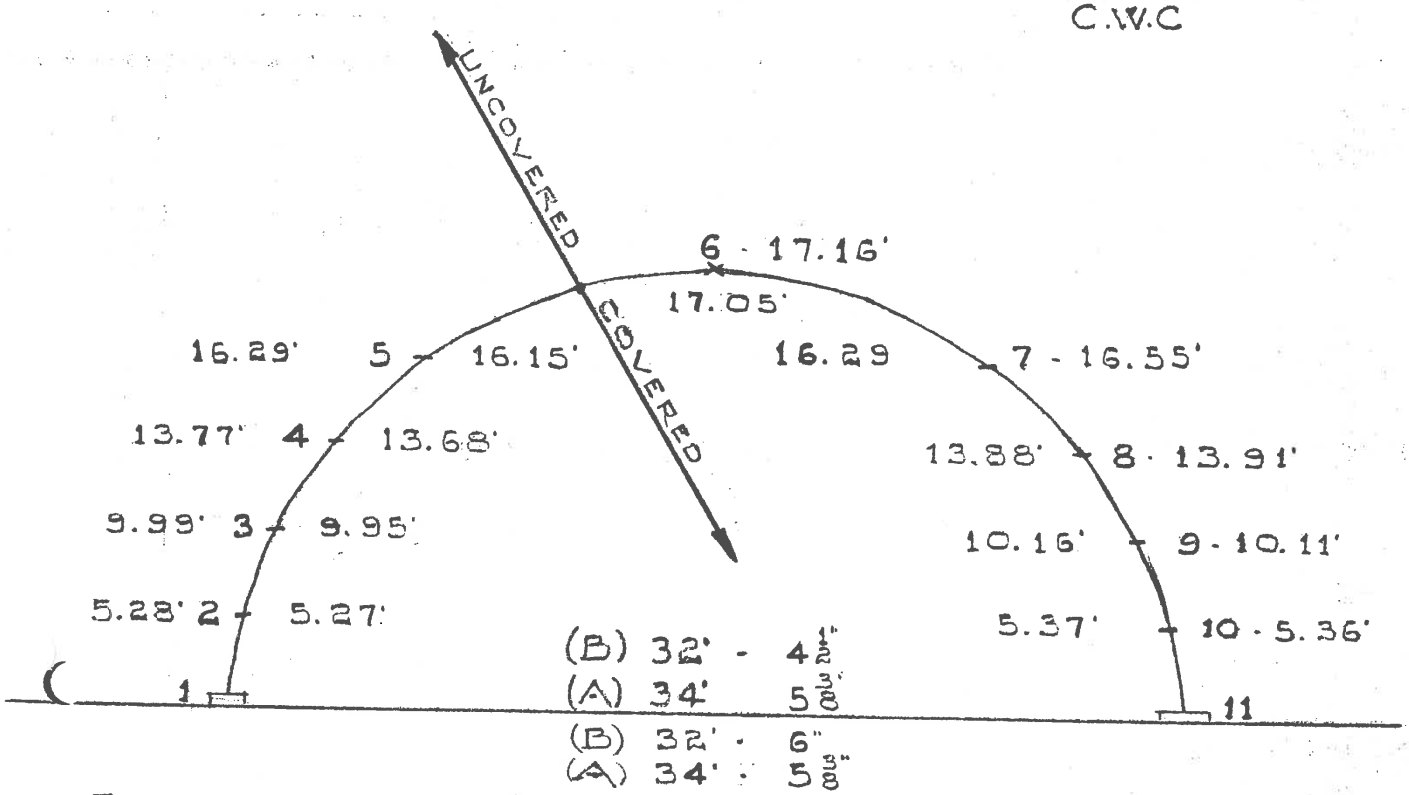


EXHIBIT "G"

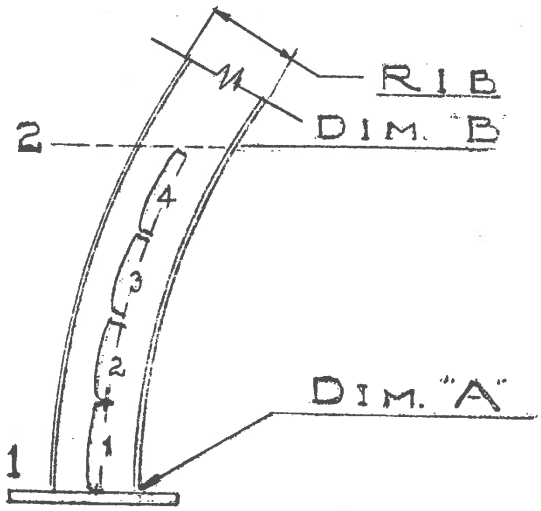
1697 (CAC 964)

C.W.C



ELEVATION - EVERY 4 PANS

SECTION - NO. 57



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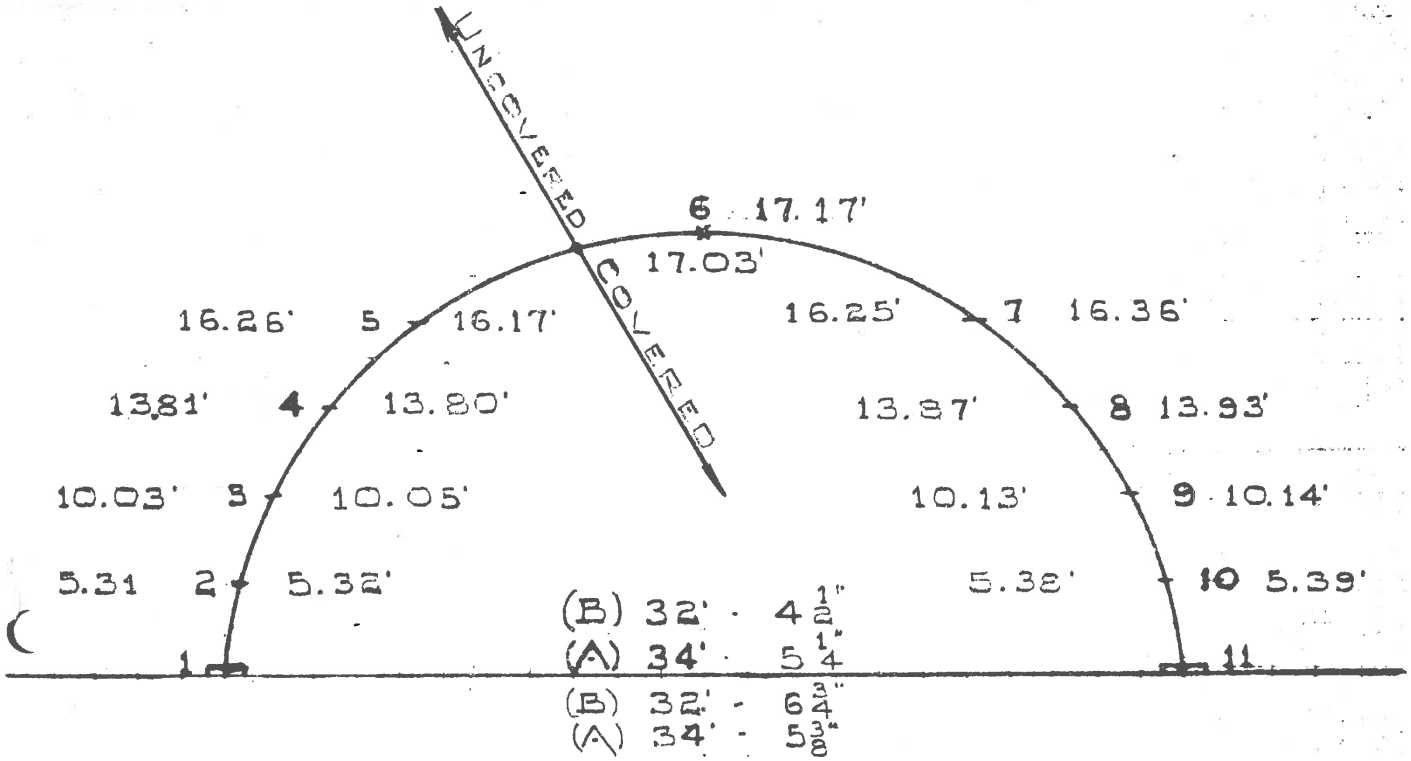

ELEVATION ~ EVERY 4 PANS

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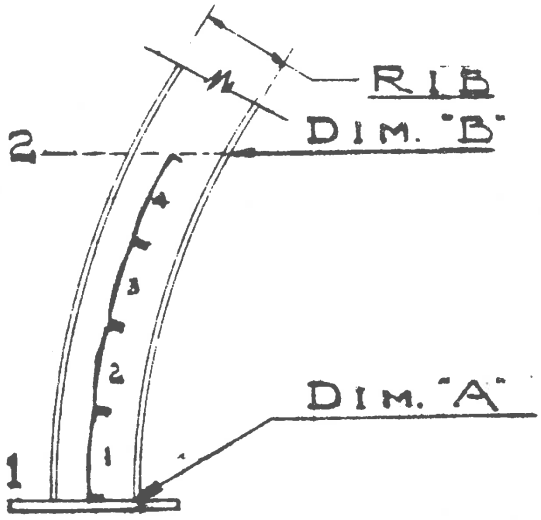

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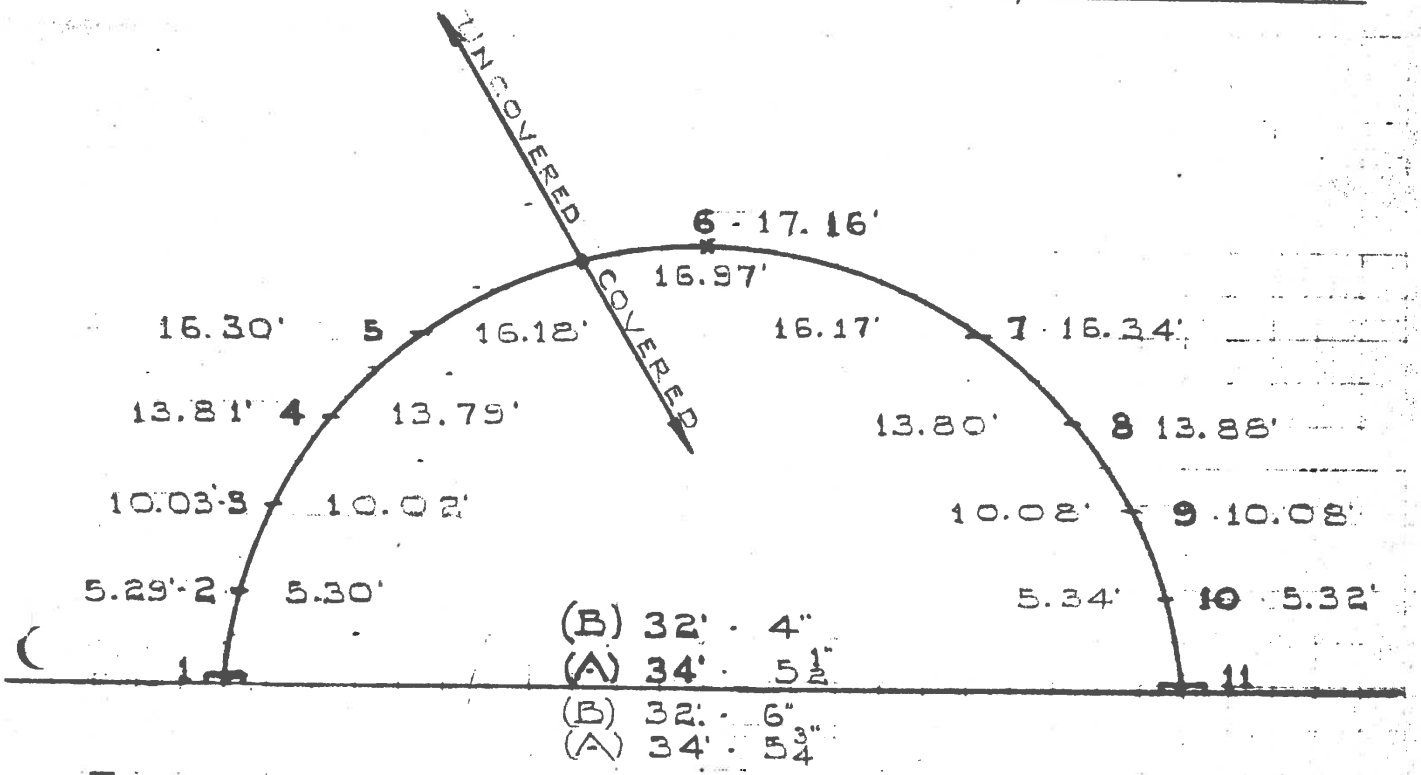

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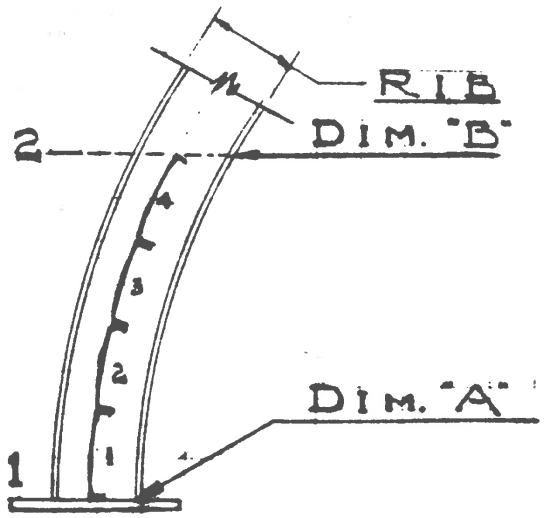

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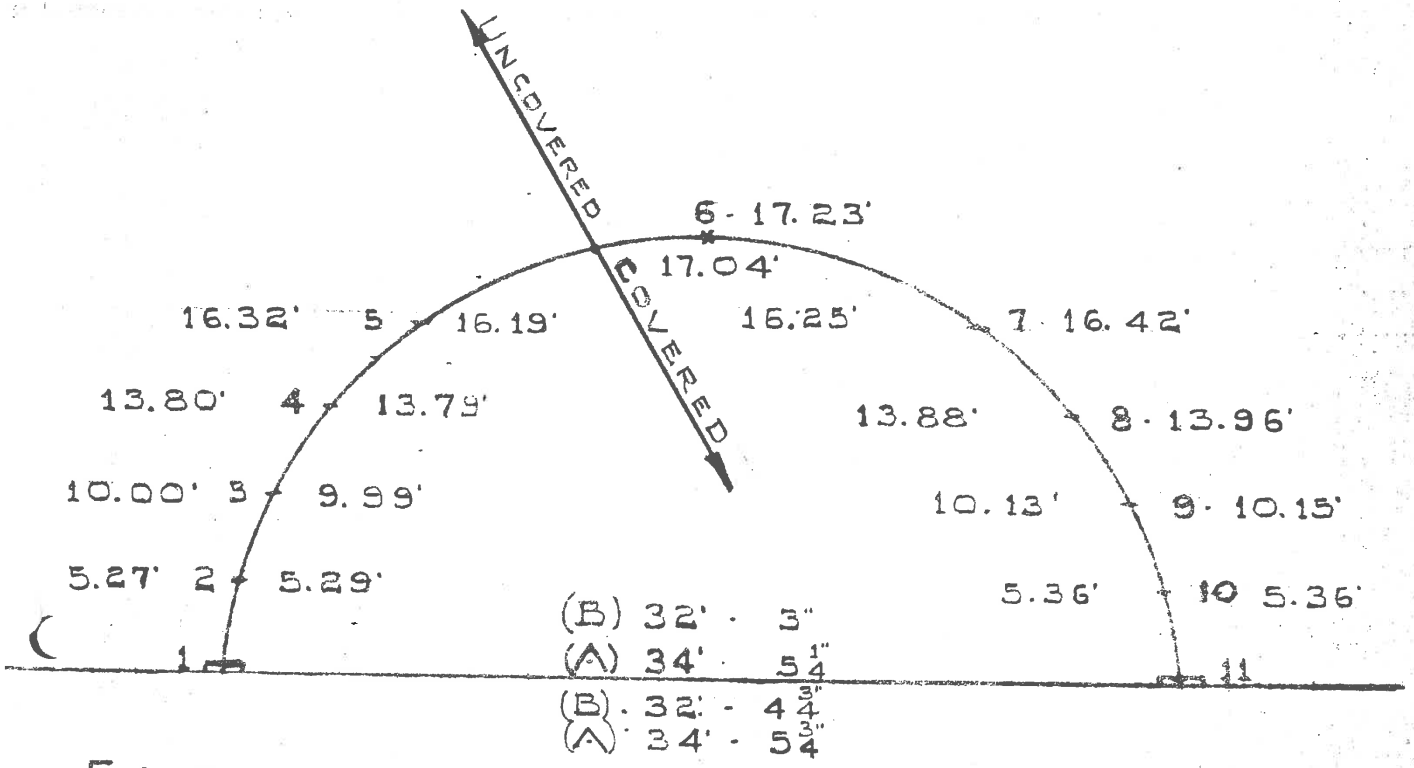
By G.W.C.



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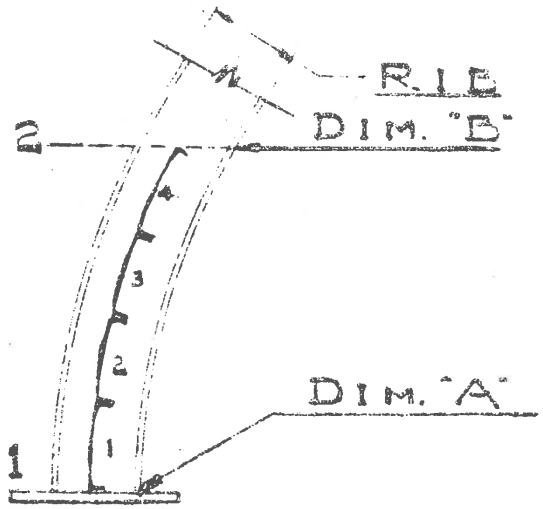

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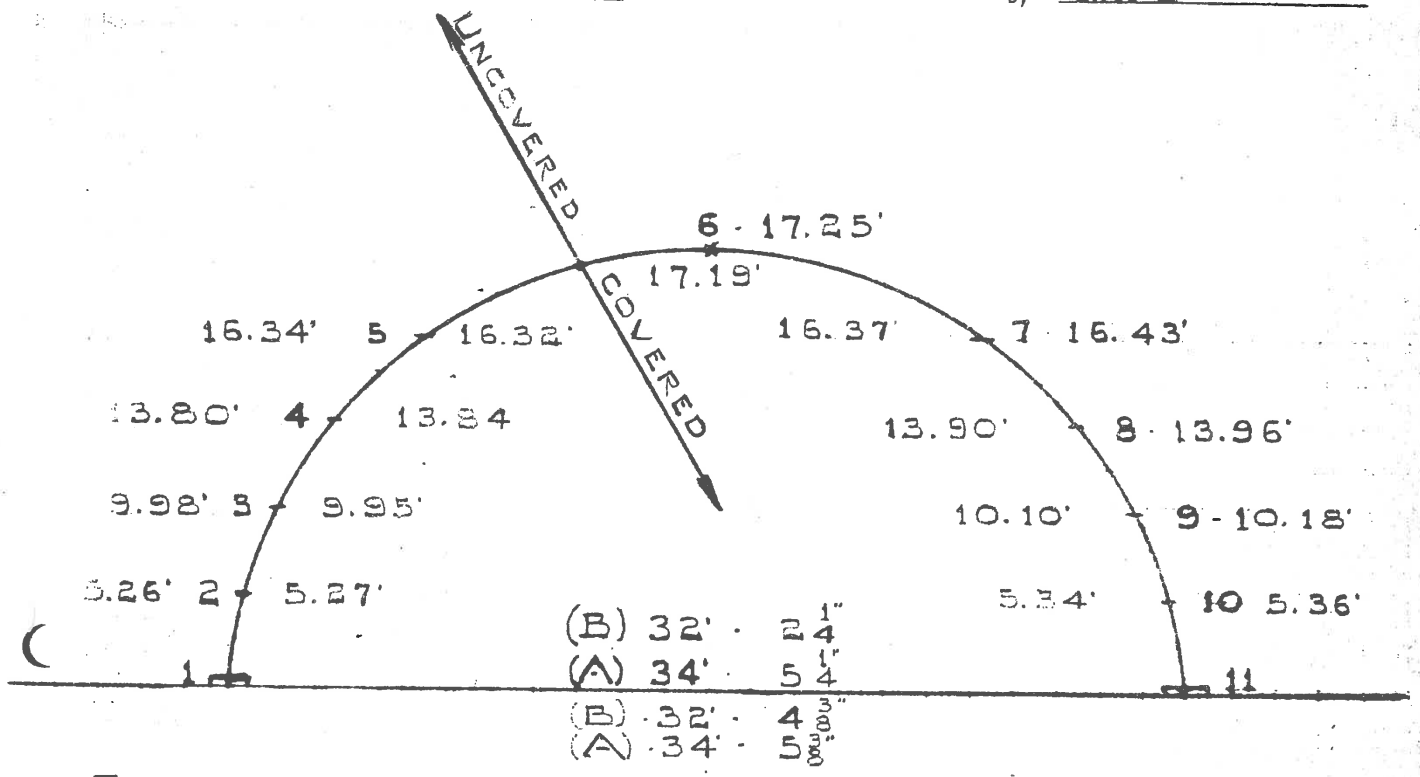

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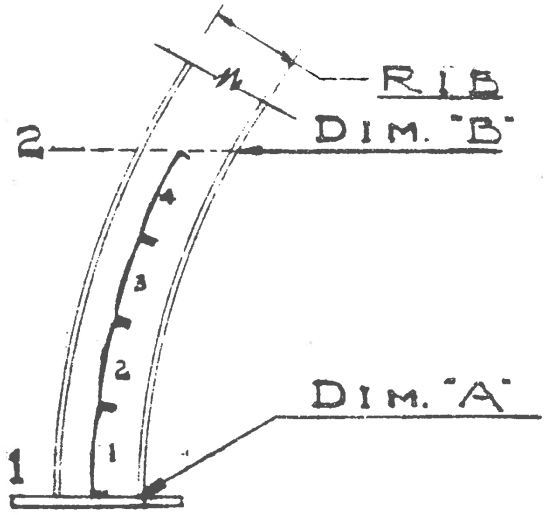

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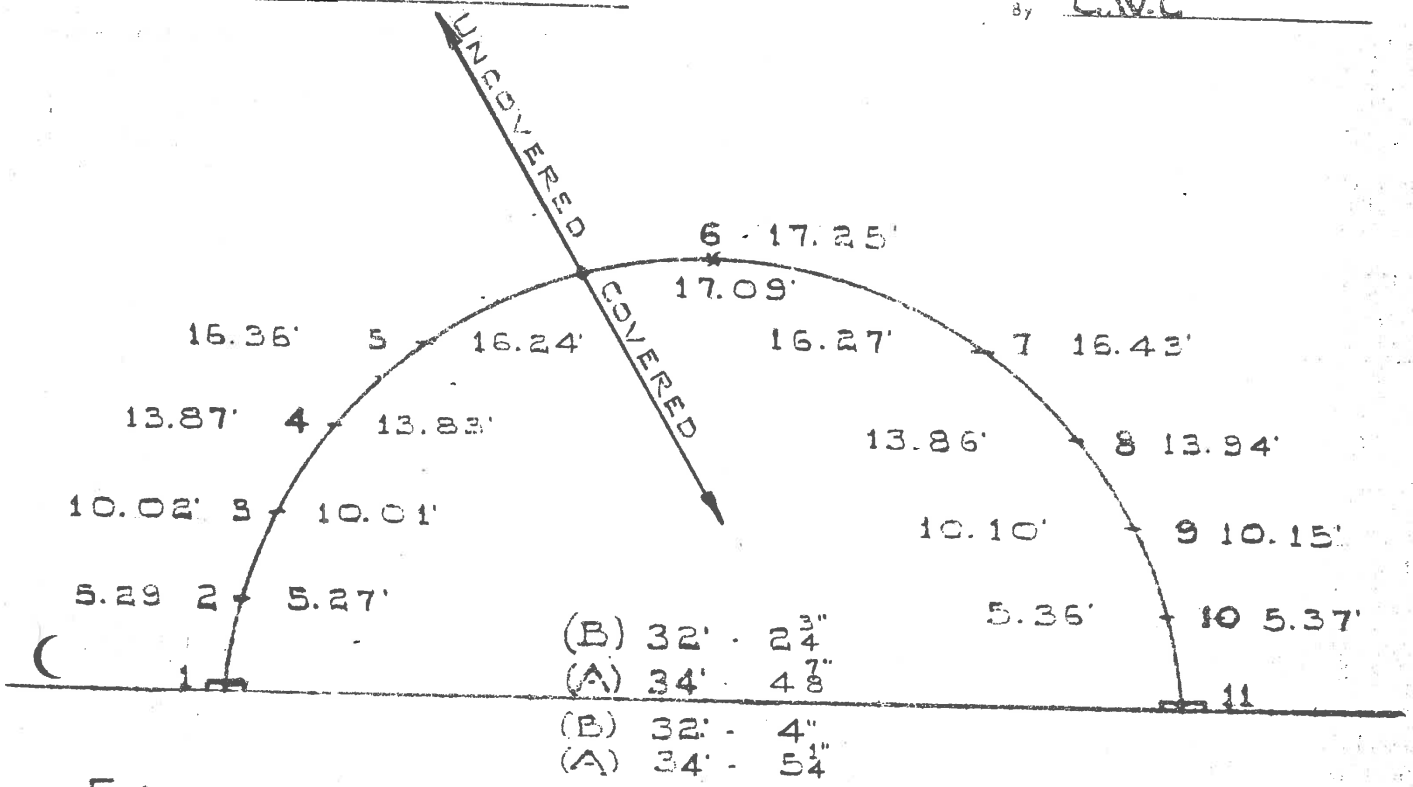

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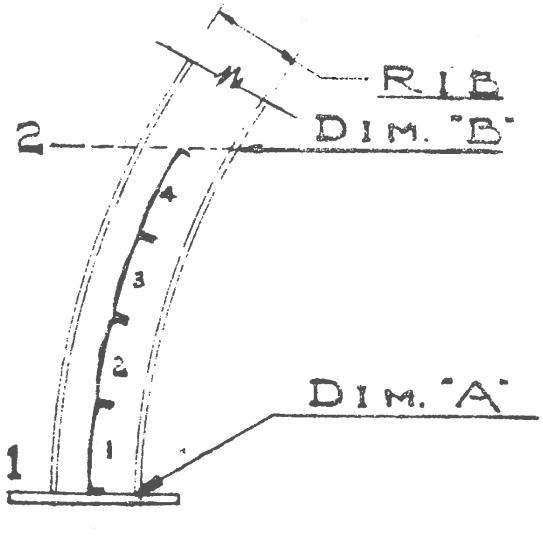

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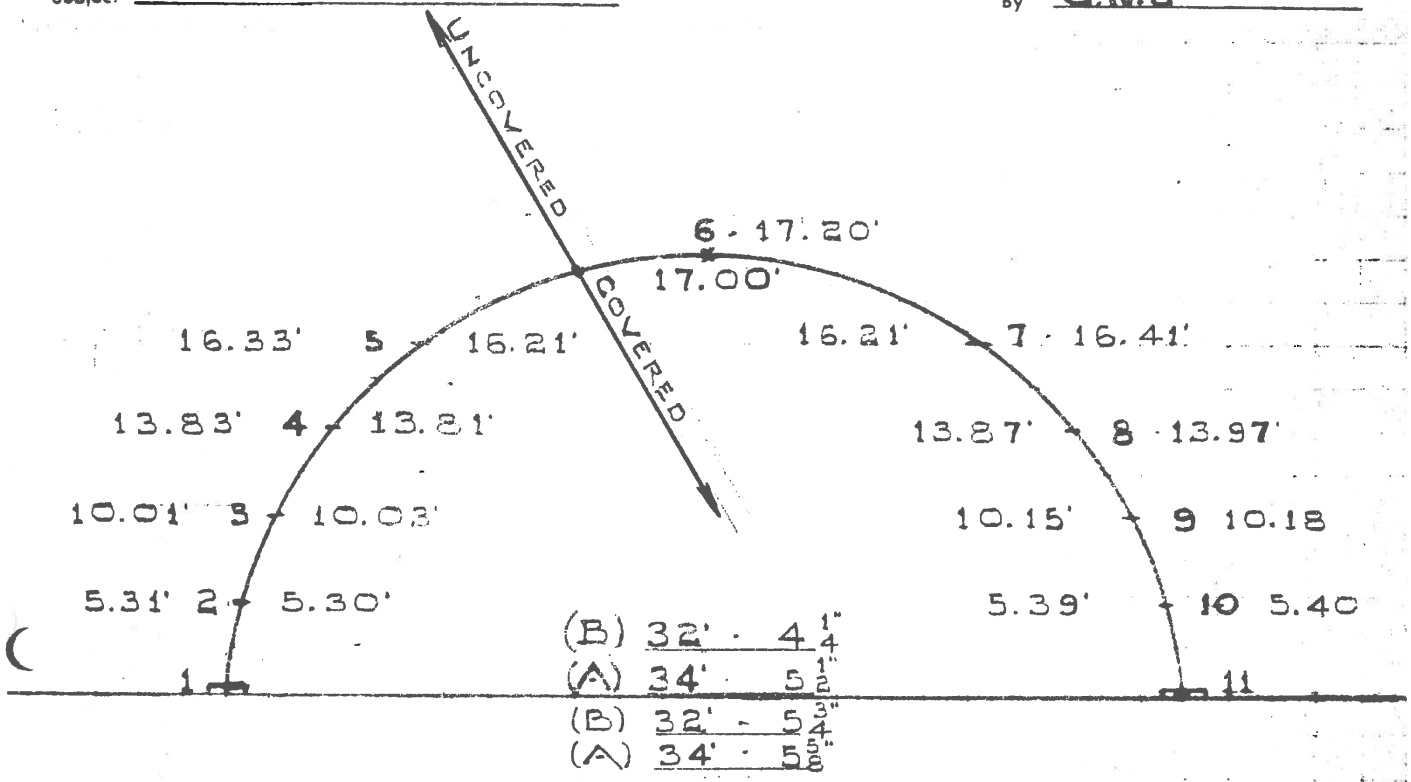

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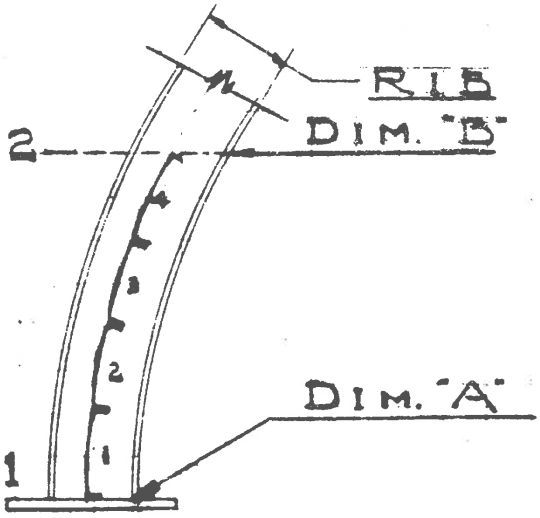

EXHIBIT "G"

VITRO ENGINEERING CO
A DIVISION OF VITRO CORPORATION

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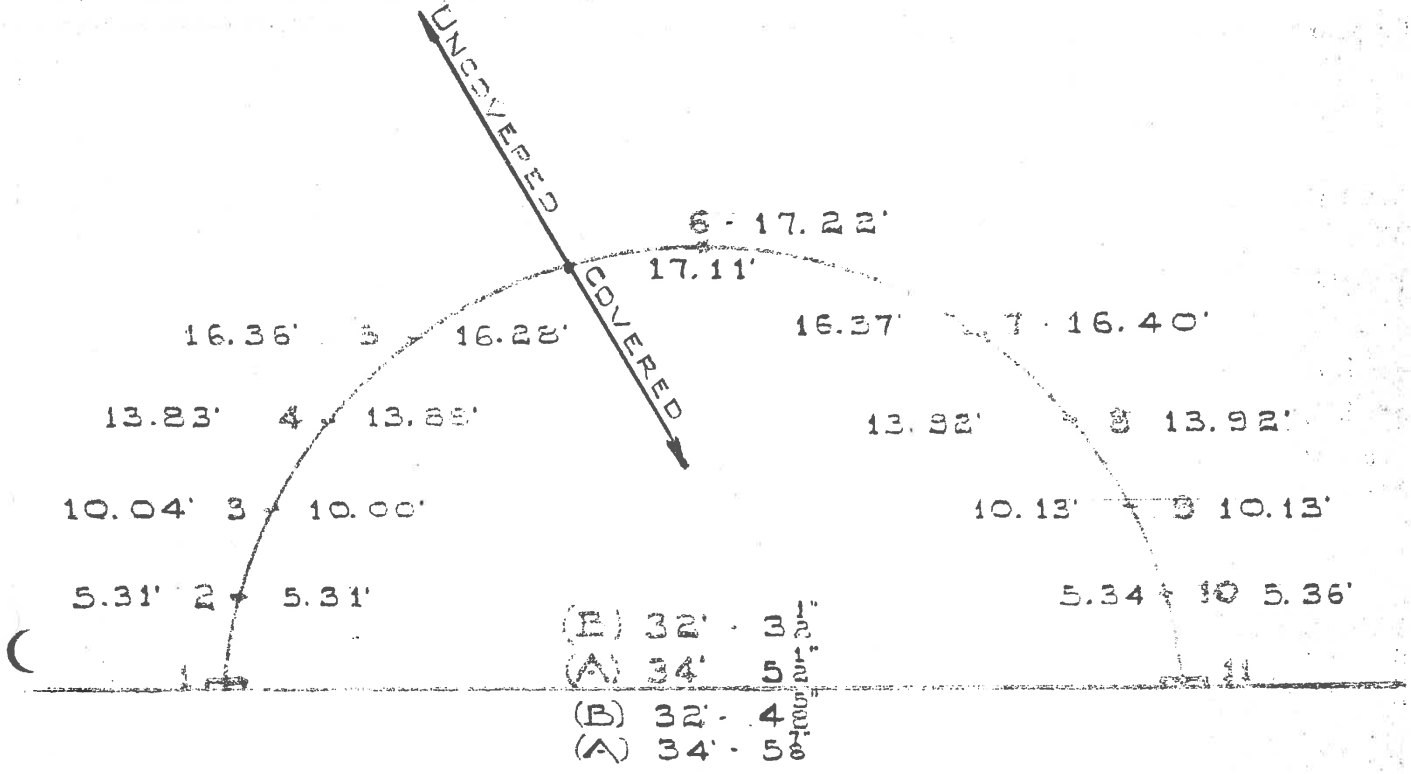
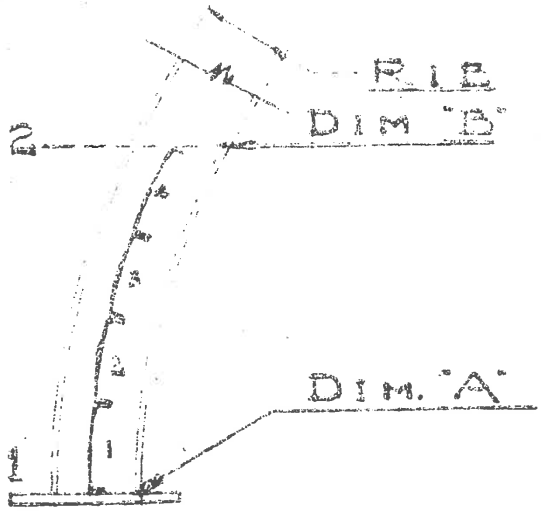


ELEVATIONS EVERY 4 PANS

SECTION NO. 64



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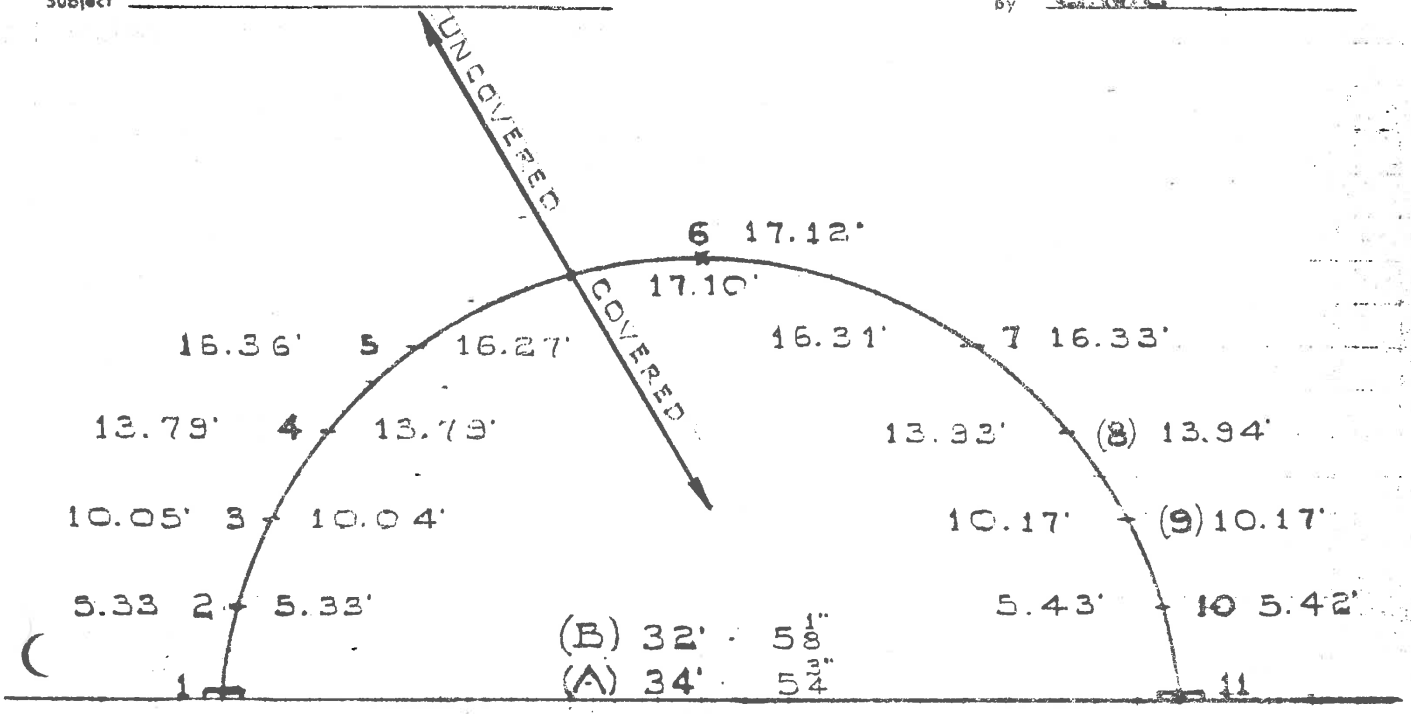

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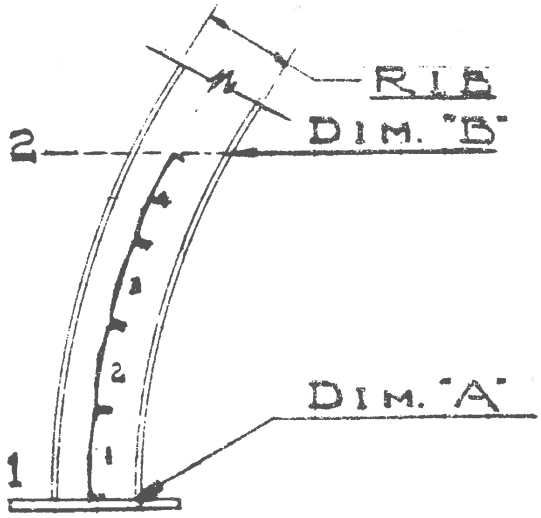

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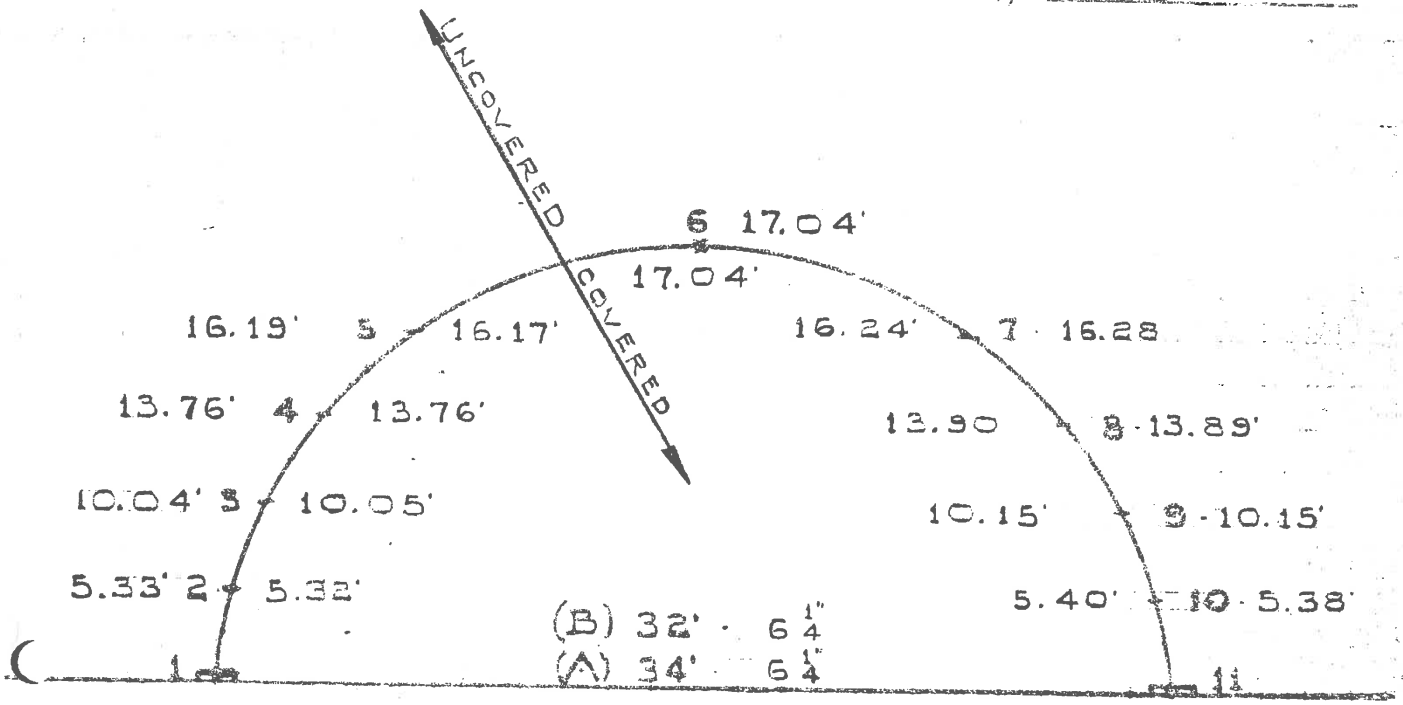

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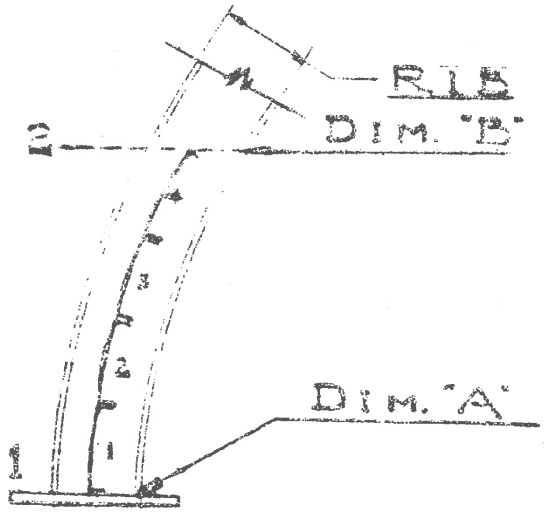
SECTION = NO. 66



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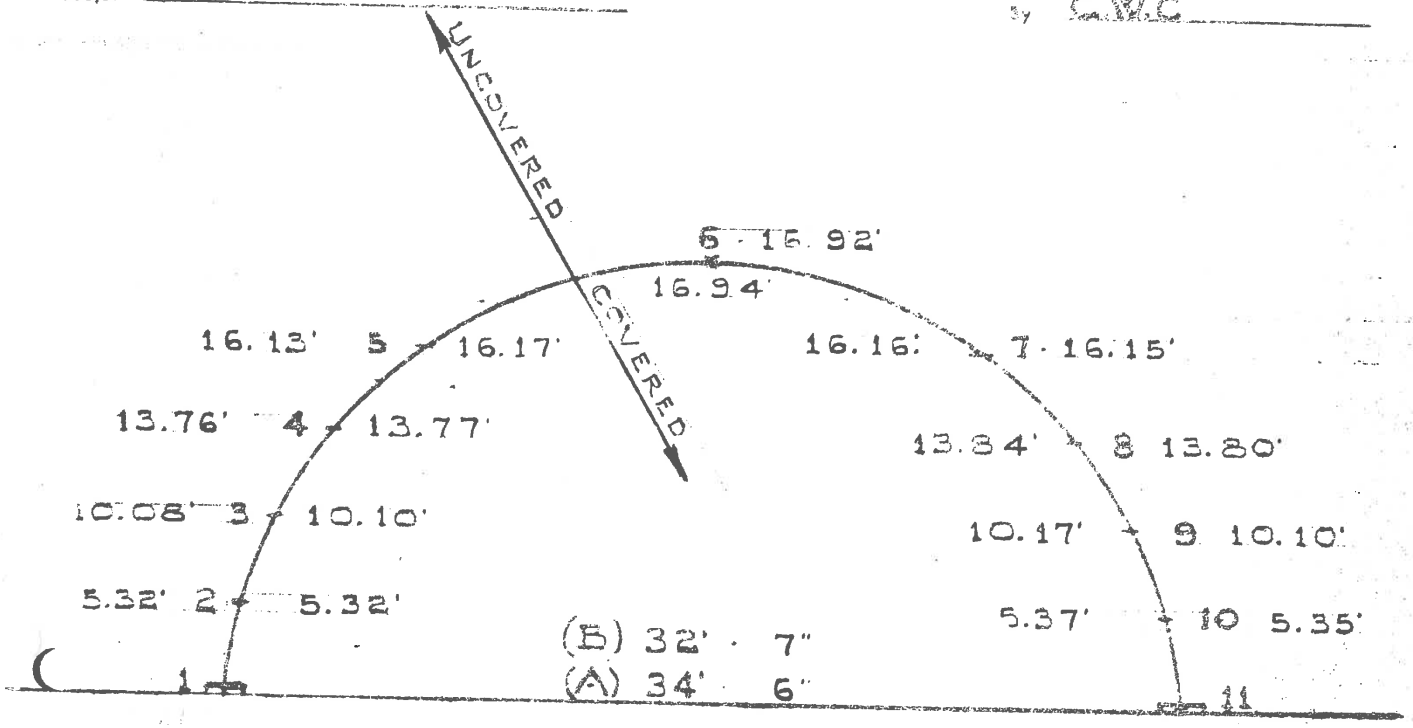

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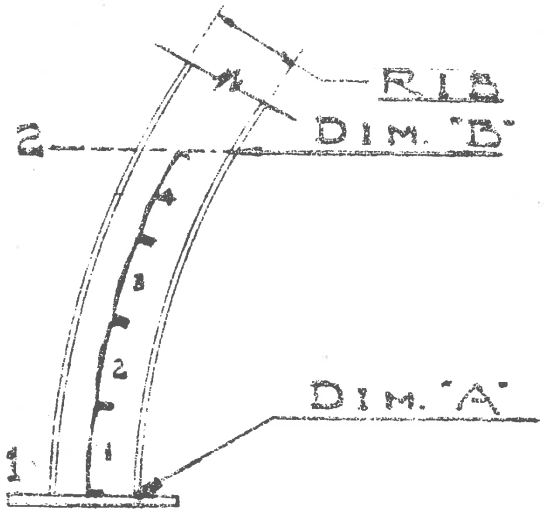
SECTION ≈ NO. 67



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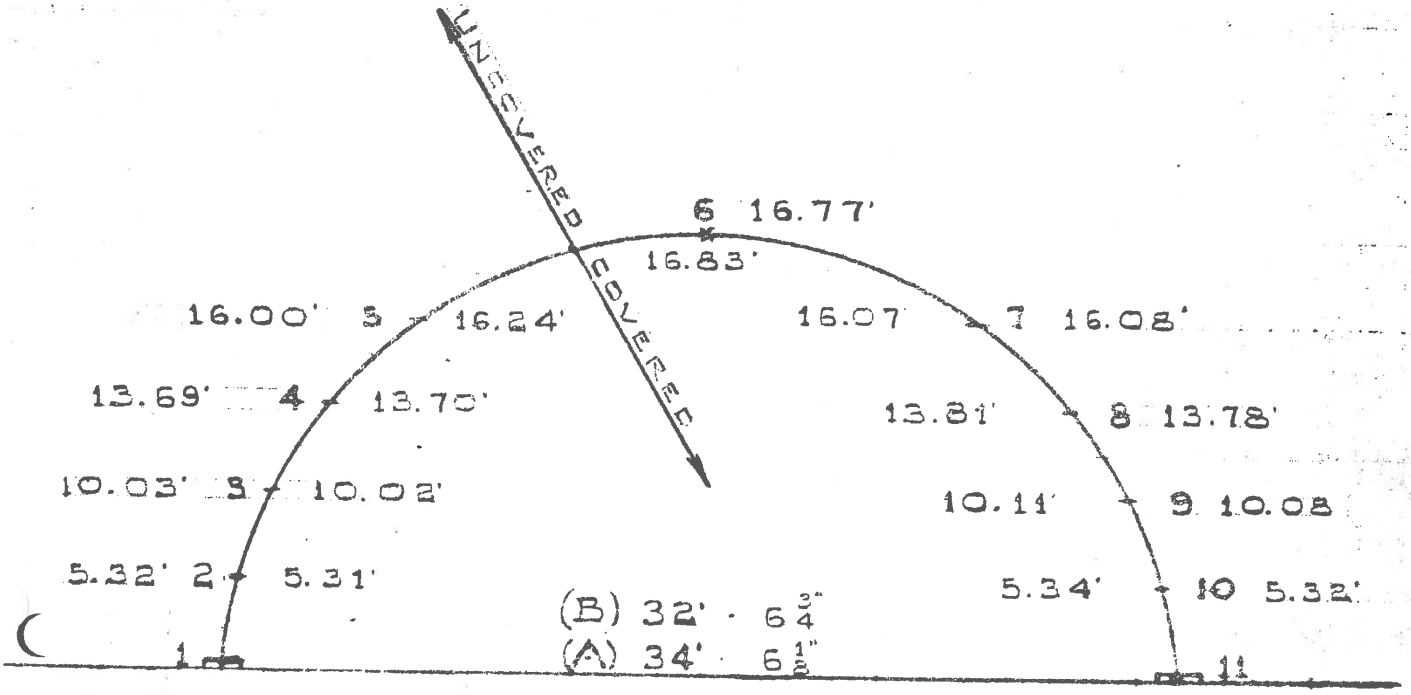


ELEVATION - EVERY 4 PANS
SECTION - NO. 68

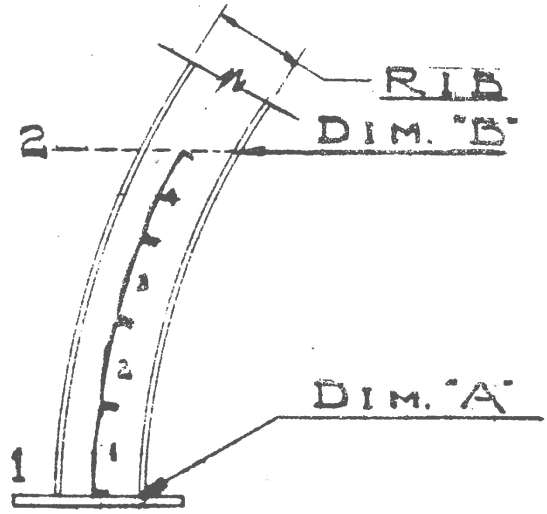


EXHIBIT "G"

REPORT OF SECOND TUNNEL COLLAPSE

On March 2, 1964 at approximately 10:00 A.M. a portion of the rib and pan portion of tunnel starting at Station 15 plus 20 and continuing to Station 15 plus 68 collapsed, while backfilling operations were in progress. Approximately 9 lineal feet of the tunnel south and 11 lineal feet north has been deformed beyond contract geometry. Additional portions of the tunnel may require replacement, depending on results of detailed measurements. Total replacement requirements appear to be approximately 68 lineal feet.

Examination of the concrete footing on the west side indicates the following:

1. A total of eleven (11) arch ribs were torn from base plates, indicating weldment failure.

2. Anchor plates were bent forward, i.e., toward tunnel centerline, one (1) anchor plate sheared across anchor bolt holes. This one (1) anchor bolt sheared off at top of footing.

Examination of the east concrete footing indicated similar damage except that the anchor plates were bent almost vertical. From this comparison it may be concluded that the east side of the tunnel was the first to collapse.

Backfill was being placed with drag-line equipment, located some distance in front of fill location. Evidence existed that backfill was being placed on one side several feet ahead of the opposite side fill. Visible deformation of tunnel ribs adjacent to collapsed section are evidence to this fact.

PHOTOGRAPHS

The following photographs are included to establish a record of the various views of the Second Tunnel Collapse as enumerated.

PHOTO NO.	DESCRIPTION
1	View looking North, showing backfill contour and deformation of sheared edge of collapsed section.
2	View of inside tunnel of collapsed section indicating footing undercut caused by backfill removal.
3	View looking North showing deformation (flattened) contour of sheared edge of collapsed section.
4	View of East footing, showing rib anchor plate deformation.

PHOTO NO. 1

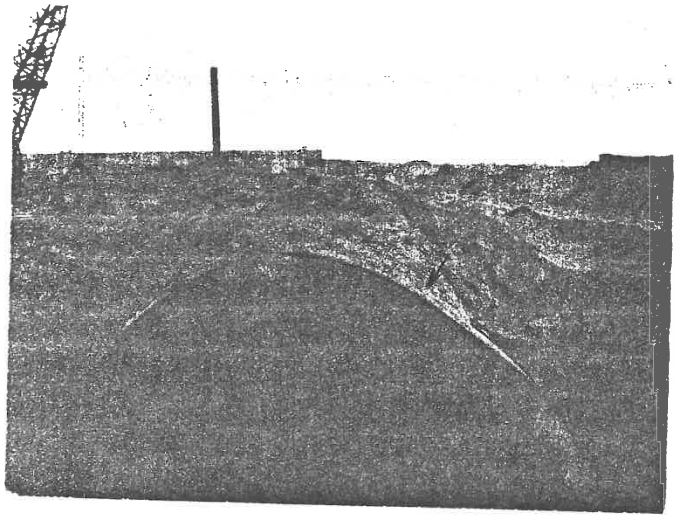


PHOTO NO. 2

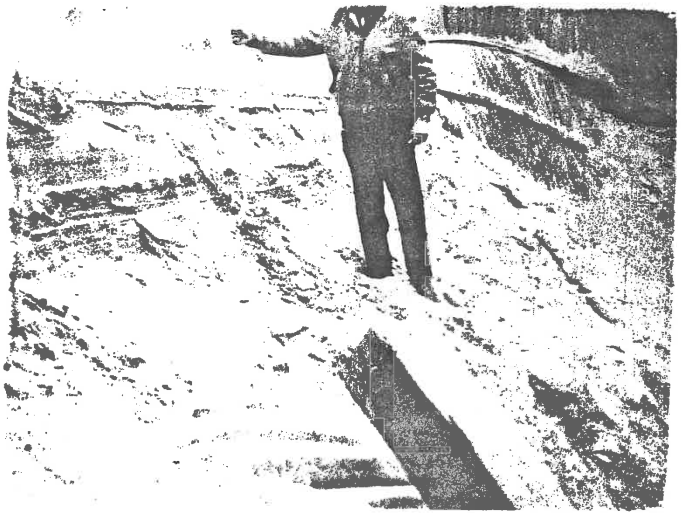


PHOTO NO. 3

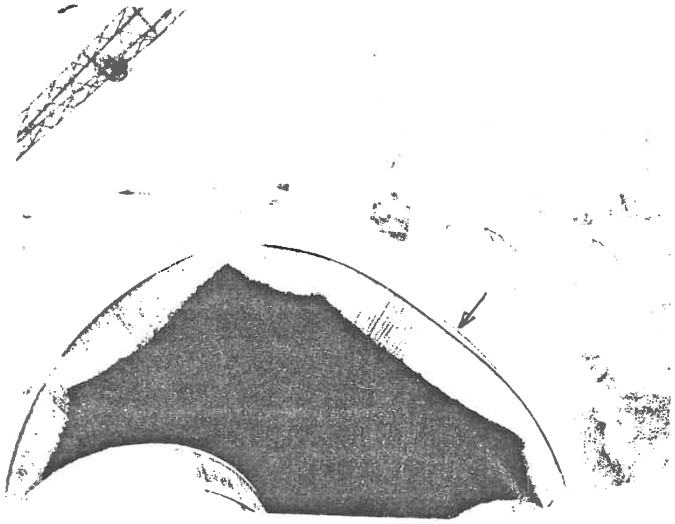
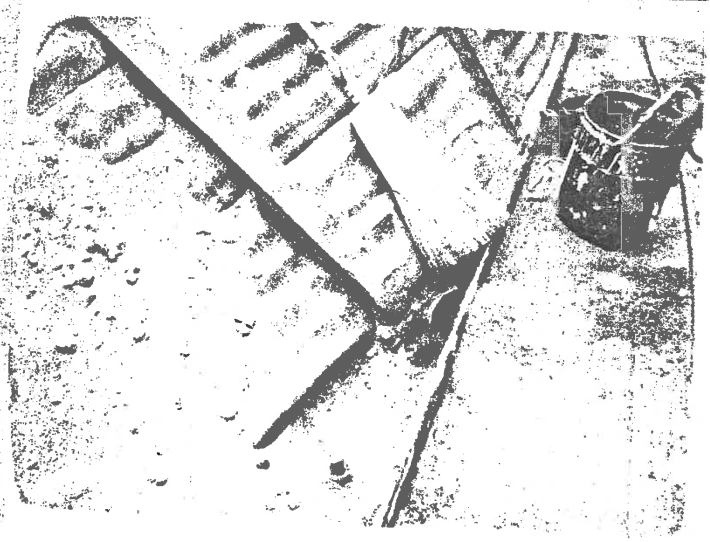


PHOTO NO. 4



SUMMARY

1. From the deflection patterns realized from backfilling of the tunnel, it is evident that deflections vary greatly, both in location and magnitude, under similar loading conditions.

2. With closely controlled and monitored backfill operations it is possible to place the specified 8'0" fill over the tunnel as demonstrated in test - Exhibit "F". The stabilization of the structure under this loading has not been demonstrated.

3. The concentrated loading of the "Inspection Port" assembly on tunnel structure should be investigated. ?

4. Additional loading of tunnel structure due to surface drift should be investigated.

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Attachment 3

Photograhic Timeline of the PUREX Storage Tunnels

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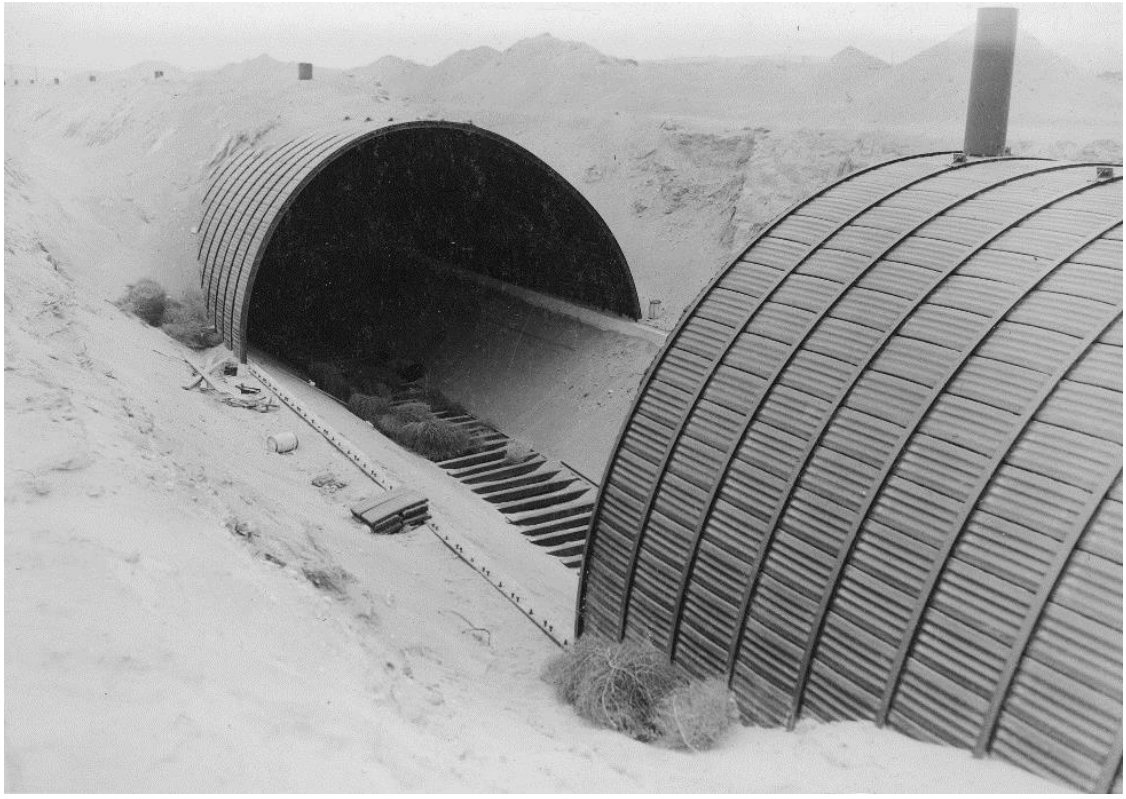
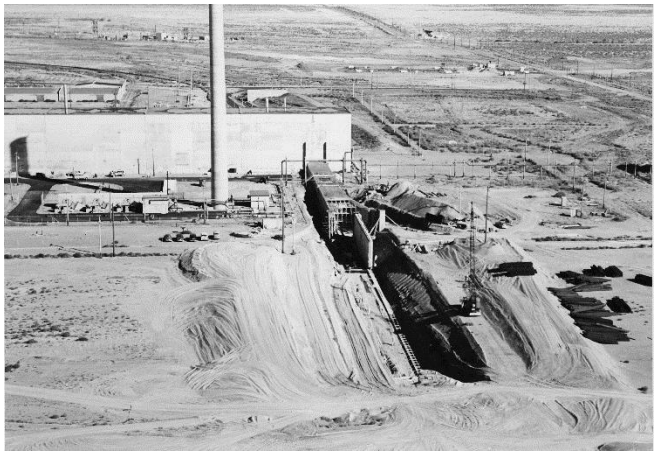
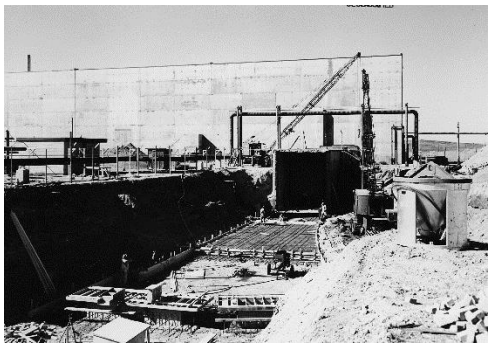
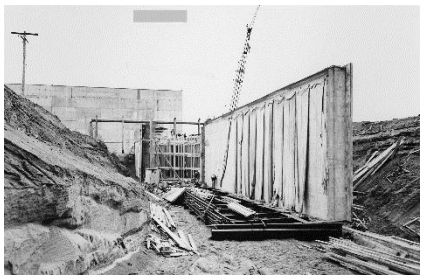
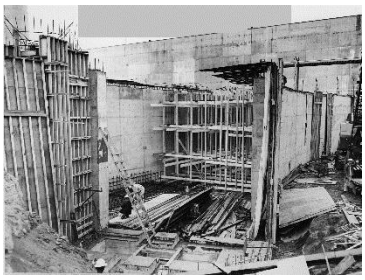
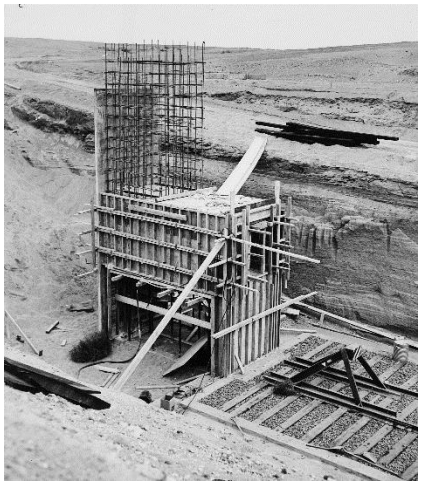
PUREX STORAGE TUNNELS

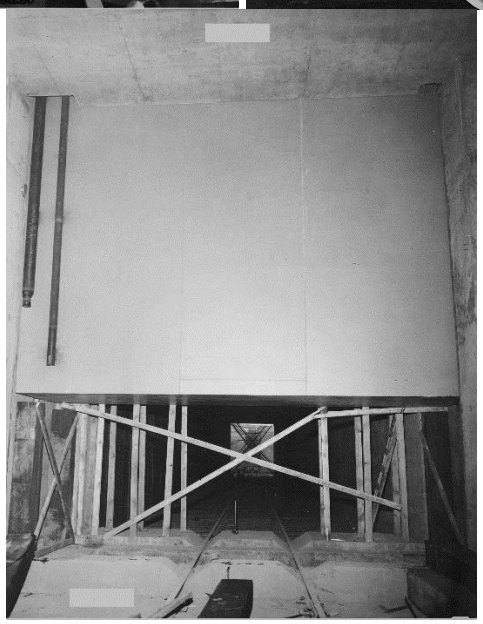
218-E-14 - TUNNEL NO. 1

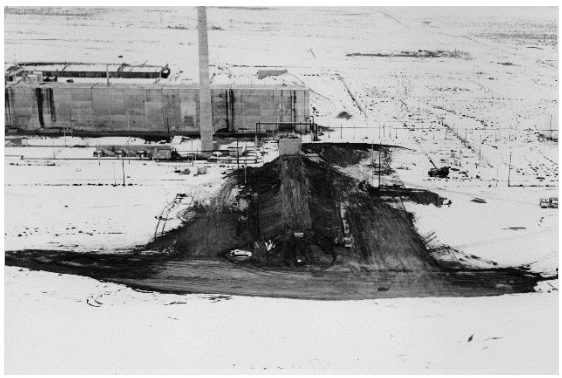
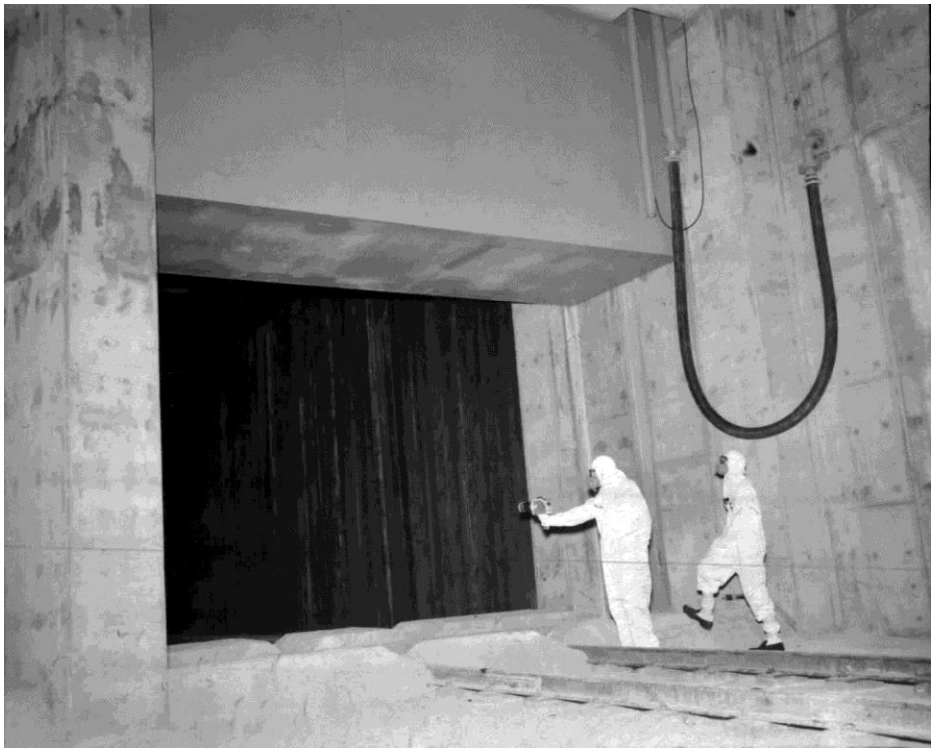
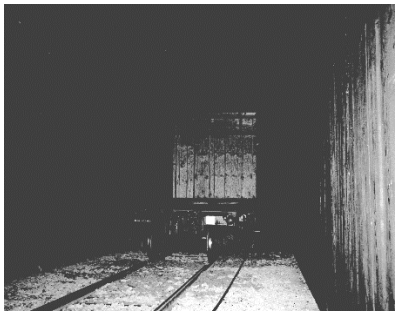
218-E-15 - TUNNEL NO. 2



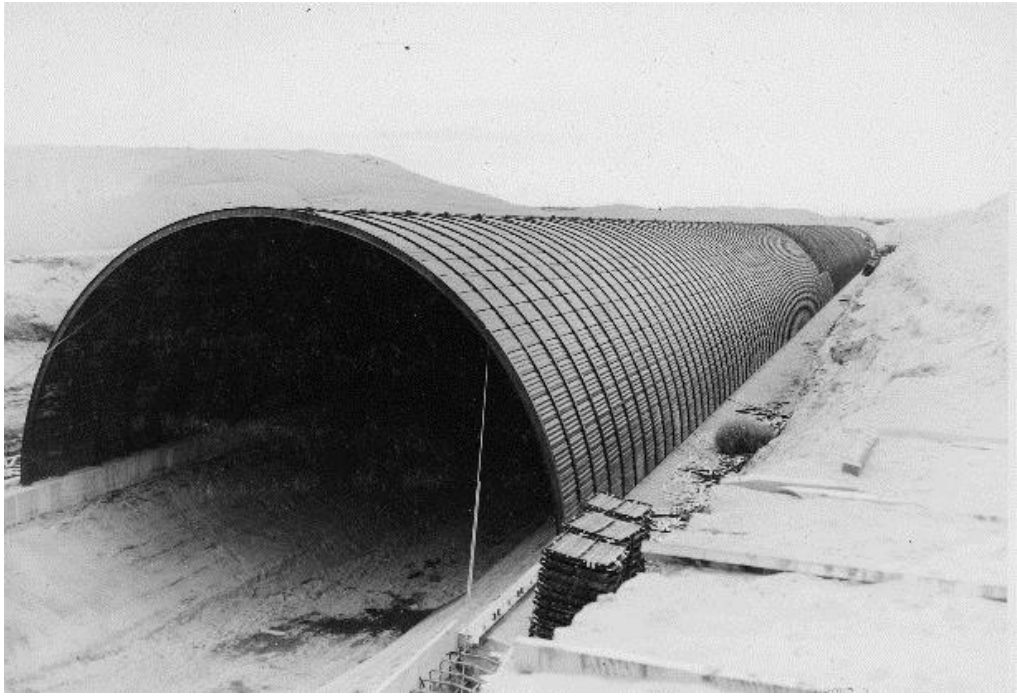
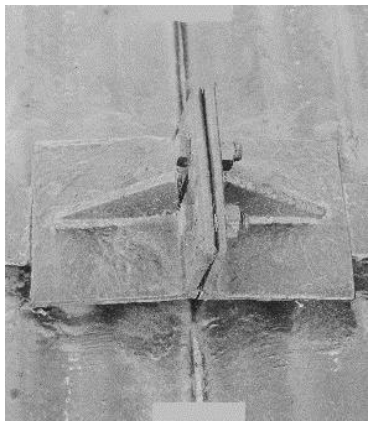
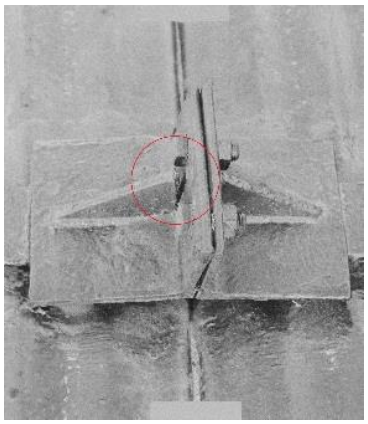
TUNNEL NO. 1

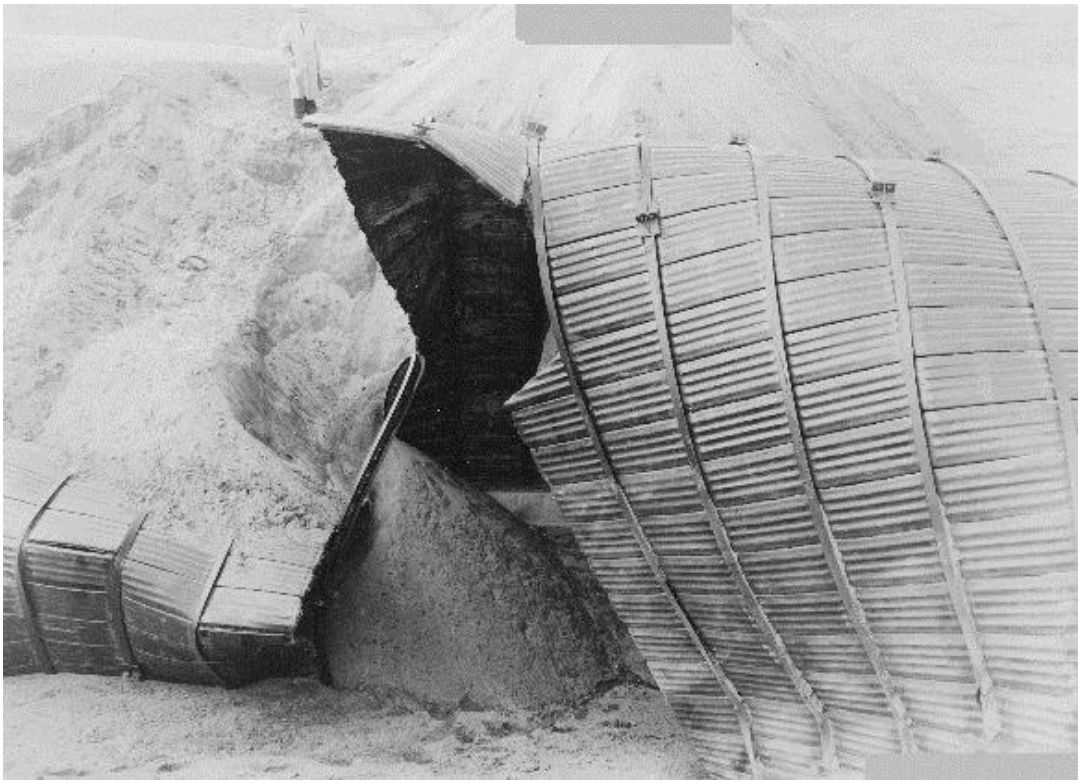
Description	Photo/Document
August, 1955 Construction proceeding.	
August, 1955	
September, 1955	 
October, 1955	

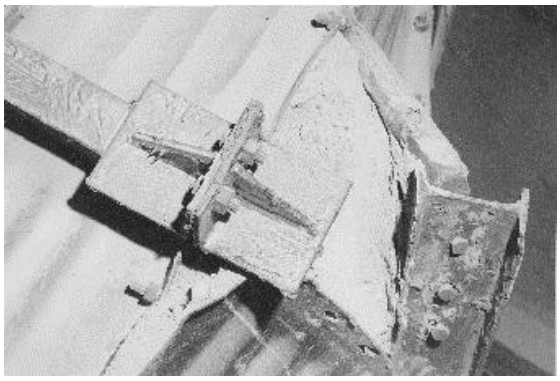
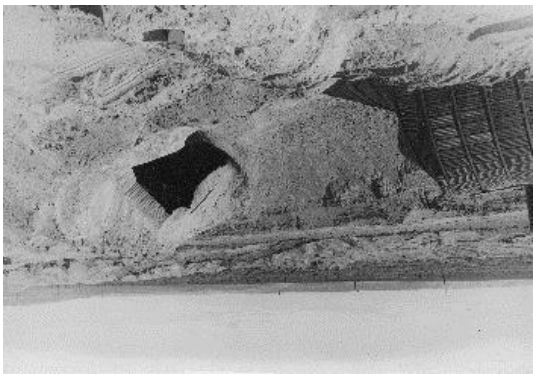
November, 1955	
November, 1955	

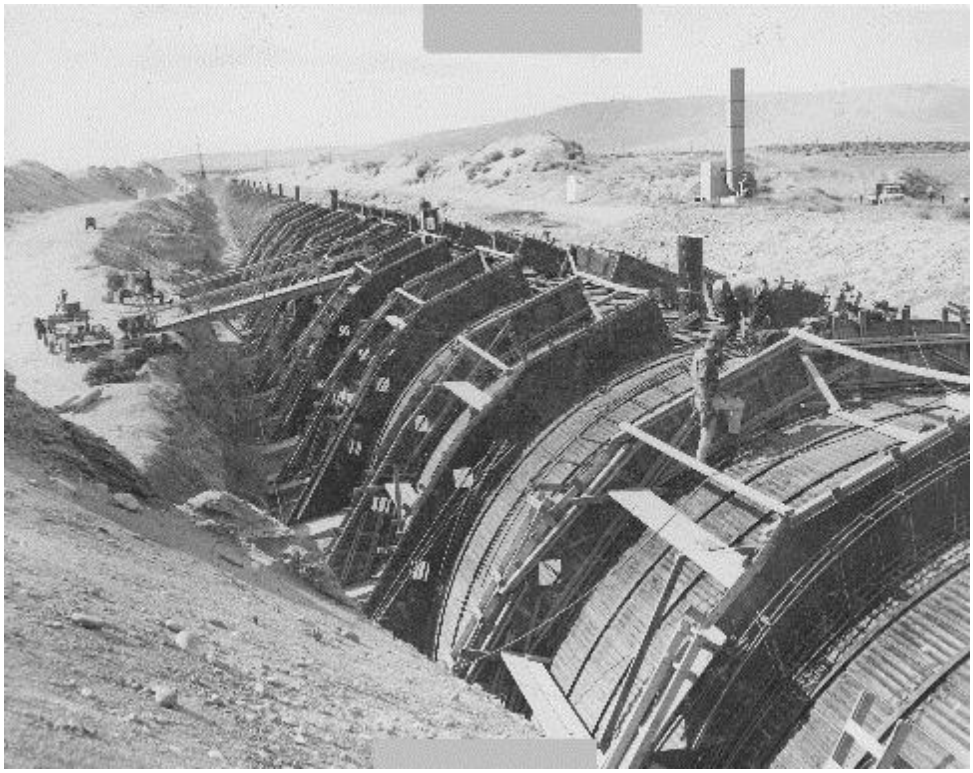
December 1955 Construction Complete	
Assumed circa 1960 Tunnel No. 1 construction complete and in service.	
June, 1960	

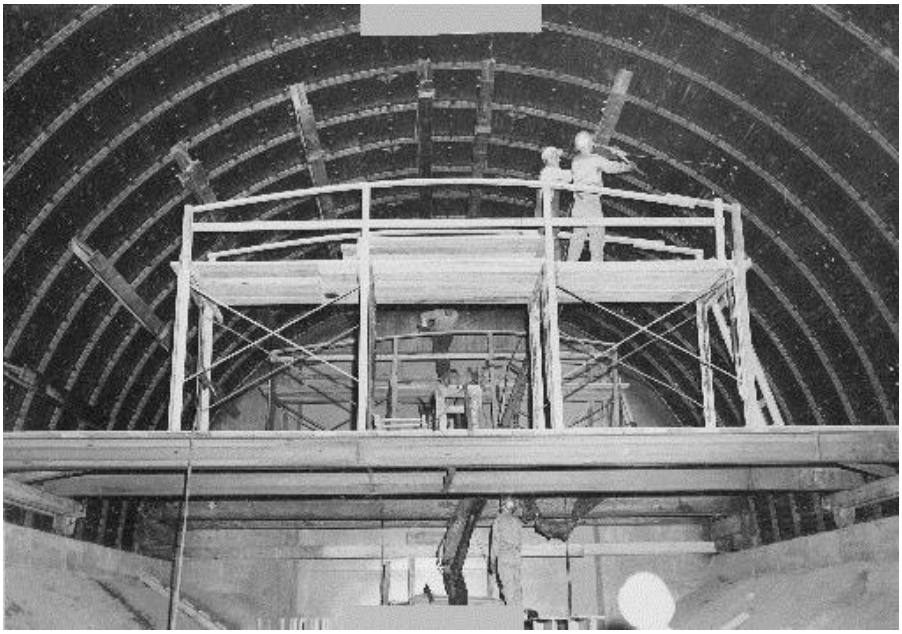
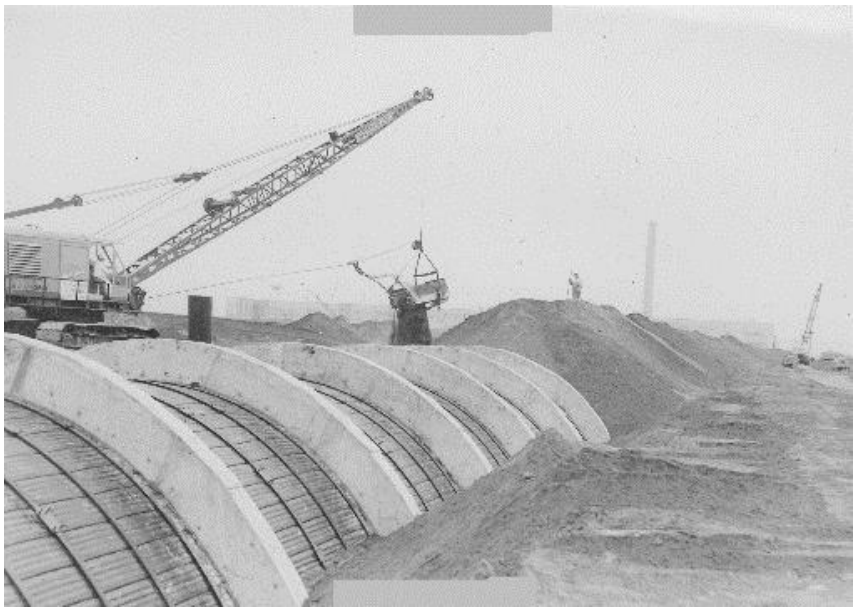
TUNNEL NO. 2

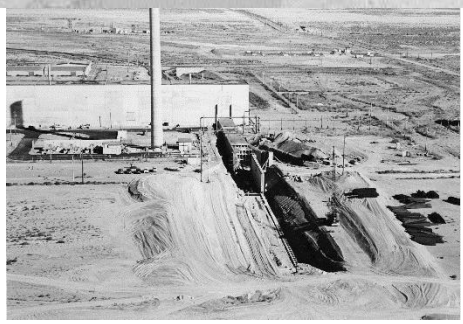
Description	Photo/Document
November, 1963 Construction proceeding.	
20 January, 1964 Inspection finds 32 broken butt-angle gusset-plate welds over approximately 600 linear ft of metal arch tunnel. Prior to this inspection, objections had been raised over the manner of backfilling, using 2 D-9 Caterpillar bulldozers to push soil down on the sides of the arch tunnel, "Imposing a load on the sides of the tunnel wall(s)" with the weight of the machines projecting into the arch load zone.	 

22 January, 1964 Approximately 1030 hrs, 75 linear feet of tunnel collapsed. Sections of the arch tunnel that had been backfilled before the collapse showed flattening of the tunnel sides.	
30 January, 1964 Began removing approximately 5 feet of backfill from each side of the arch tunnel. Measurements were taken, and showed no significant recovery of the tunnel walls. Four more feet of backfill were removed; the maximum observed recovery was less than 2 inches.	

15 February, 1964 New backfill method begun. A drag-line was used to place fill on the top of the arch tunnel to distribute the load concentrically. The fill spilled down the sides of the arch. The angle of repose of the walls was reduced, and bulldozers used to push large piles of soil along the sides of the excavation were kept away from the edge. Concentric loading was observed and measured. However some deflection was still observed occurring in one portion of the tunnel after 2 days, and the backfill over that section was removed. Backfilling of the arch tunnel using this method continued.	
2 March, 1964 Approximately 1000 hrs, approximately 68 linear feet of the rib & pan portion of the tunnel collapsed. Damage was found along both east & west weldments and footings. At the time of the collapse, drag-line backfill operations were occurring some distance in "front" of the collapse section, and on one side of the tunnel. The east side collapsed first. Note – Bottom photograph includes a section of collapsed tunnel and a D9 CAT	 

DWG release dates suggest a “re-design” effort had been established. Tunnel No. 2 was excavated, and internal lateral structural I-beams were installed.	H-2-58194 REV 0 Release date of 9/1962 (Approved for Construction) Photos show that in January 1964 Tunnel No. 2 is being buried without internal (I-Beam) supports H-2-58194 REV 2 Release date of 4-9-1965 PER VITRO Engineering H-2-58737 REV 0 Release date of 4-24-1964 H-2-58532, H-2-58533 Release date 6-17-1964
January thru march 1964 excavation	N/A
On July, 1964 construction of external footings to support whaler and cross member arch supports are installed	
On August thru November, 1964 construction of external whaler and cross member arch supports are installed as concrete forms are placed into position	

On August, 1964 additional internal structural I-beams and tie bars are placed into position and installed inside of Tunnel No. 2	
On November, 1964 a drag line is utilized to bury the modified Tunnel No. 2	

	
Assumed circa 1966 Tunnel No. 2 construction complete and in service.	

Attachment 4

CHPRC-03241, PUREX Burial Tunnels

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CHPRC-03241
Revision 0

PUREX Burial Tunnels

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Contractor for the U.S. Department of Energy
under Contract DE-AC06-08RL14788

P.O. Box 1600
Richland, Washington 99352

Approved for Public Release;
Further Dissemination Unlimited

CHPRC-03241
Revision 0

PUREX Burial Tunnels

Document Type: RPT

M. A. Maloof
CH2M HILL Plateau Remediation Company

Date Published
March 2017

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Contractor for the U.S. Department of Energy
under Contract DE-AC06-08RL14788

P.O. Box 1600
Richland, Washington 99352

APPROVED
By Lana Perry at 4:40 pm, Apr 20, 2017

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PUREX BURIAL TUNNELS

218-E-14 – TUNNEL NO. 1
(NOVEMBER, 1955)

218-E-15 – TUNNEL NO. 2
(JANUARY, 1964)

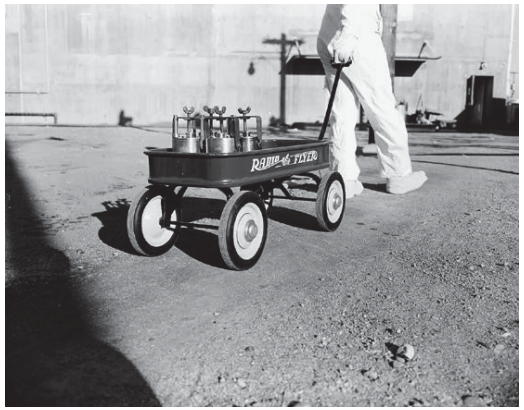
1

CHPRC-03241, Revision 0
2

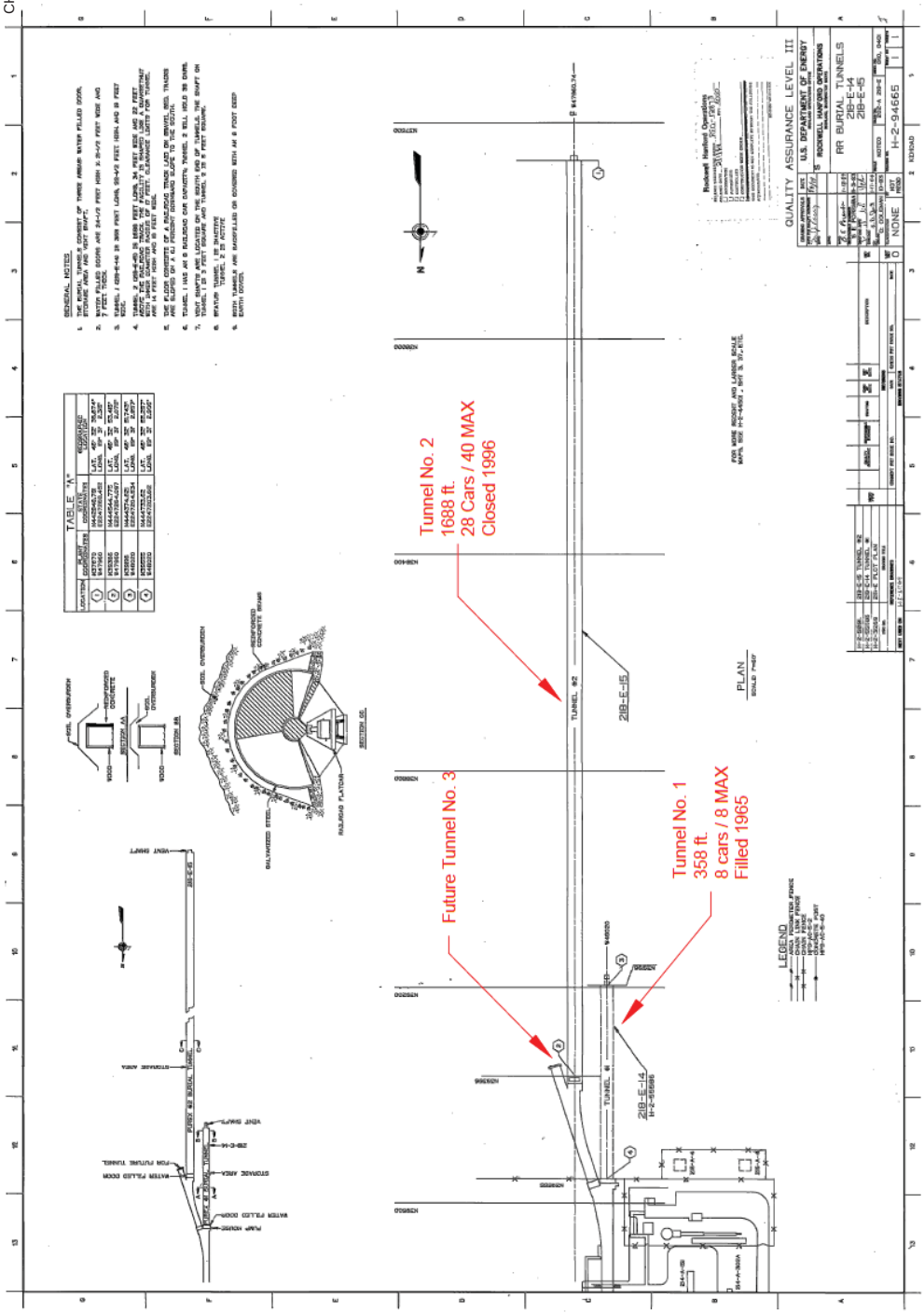
CHPRC-03241, Revision 0

3

Since 1955 some things on site (at Hanford) haven't changed all that much…

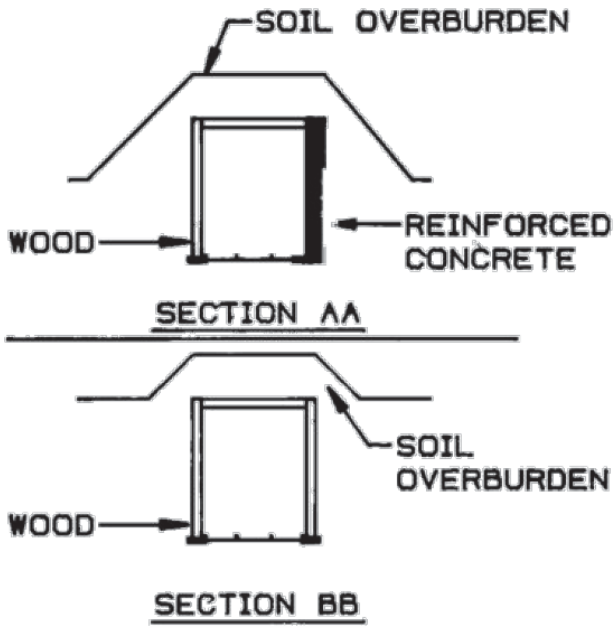


CHPRC-03241, Revision 0

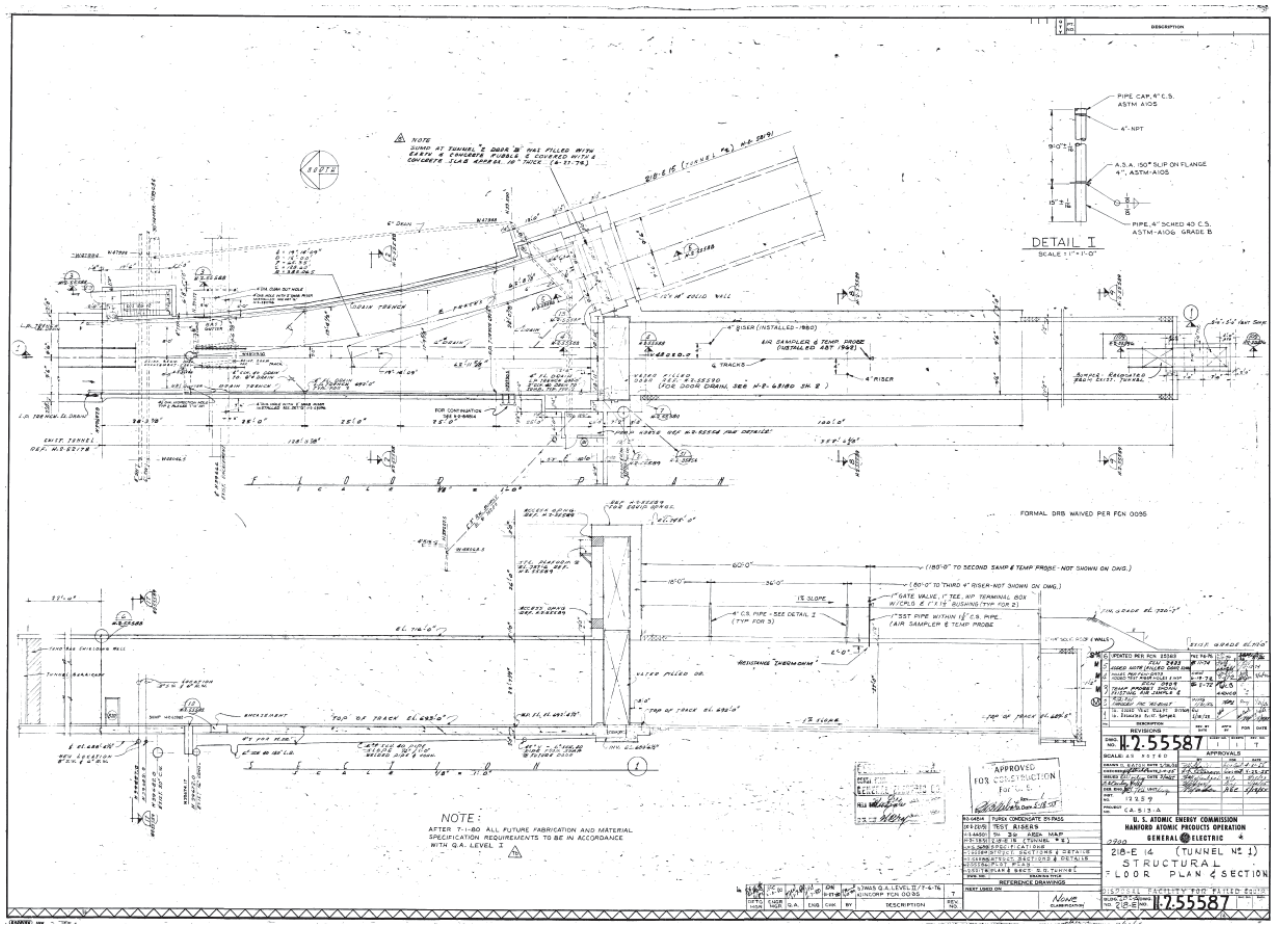


TUNNEL NO. 1 CONFIGURATION

- Constructed 1954-1956
- 358 Ft. Long
- Wood Construction
- Capacity 8 RR Cars
- Service Life 1956-1965
- Filled in 1965 & CLOSED
- Ventilated till 1996



CONSTRUCTION TUNNEL NO. 1



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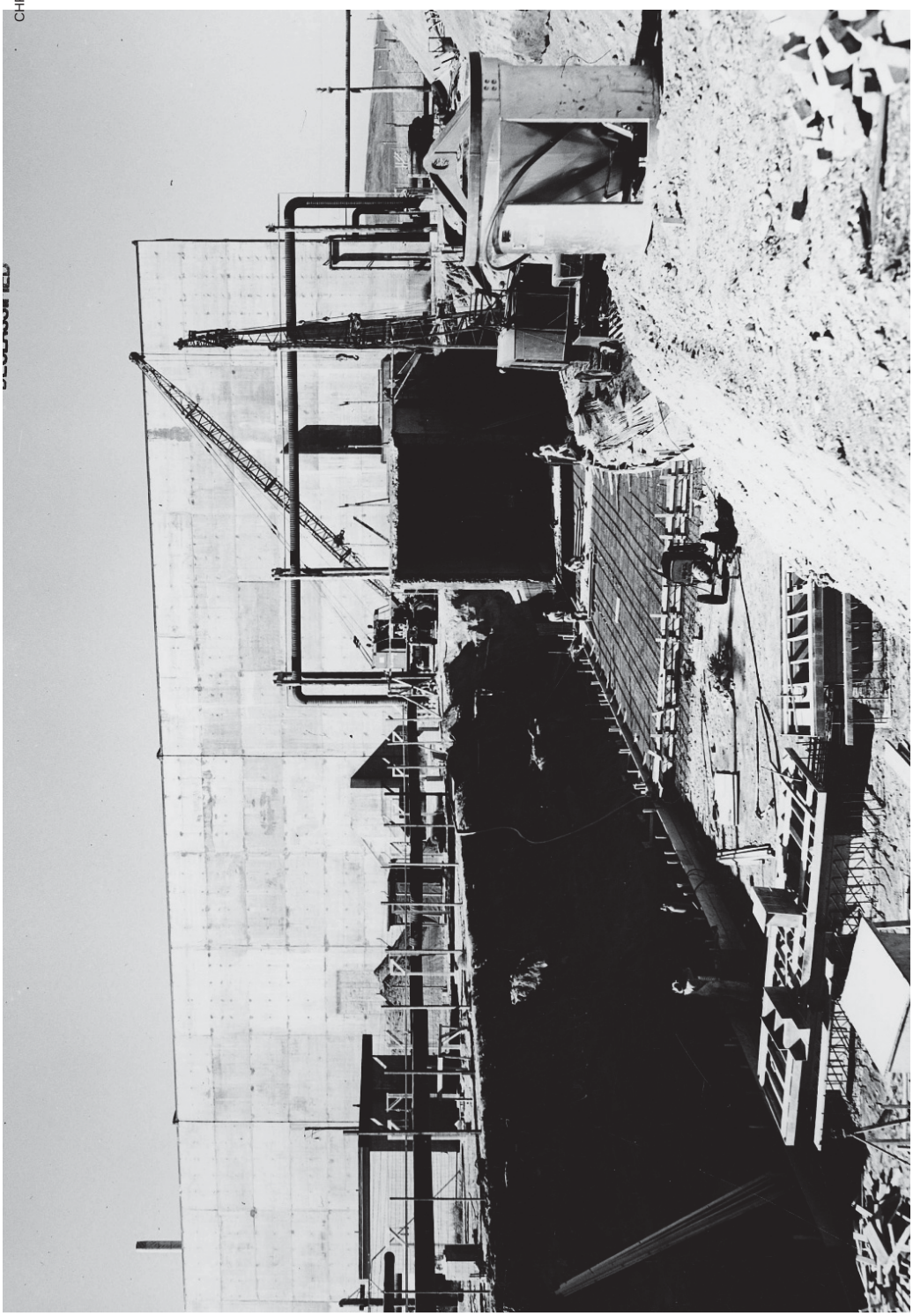

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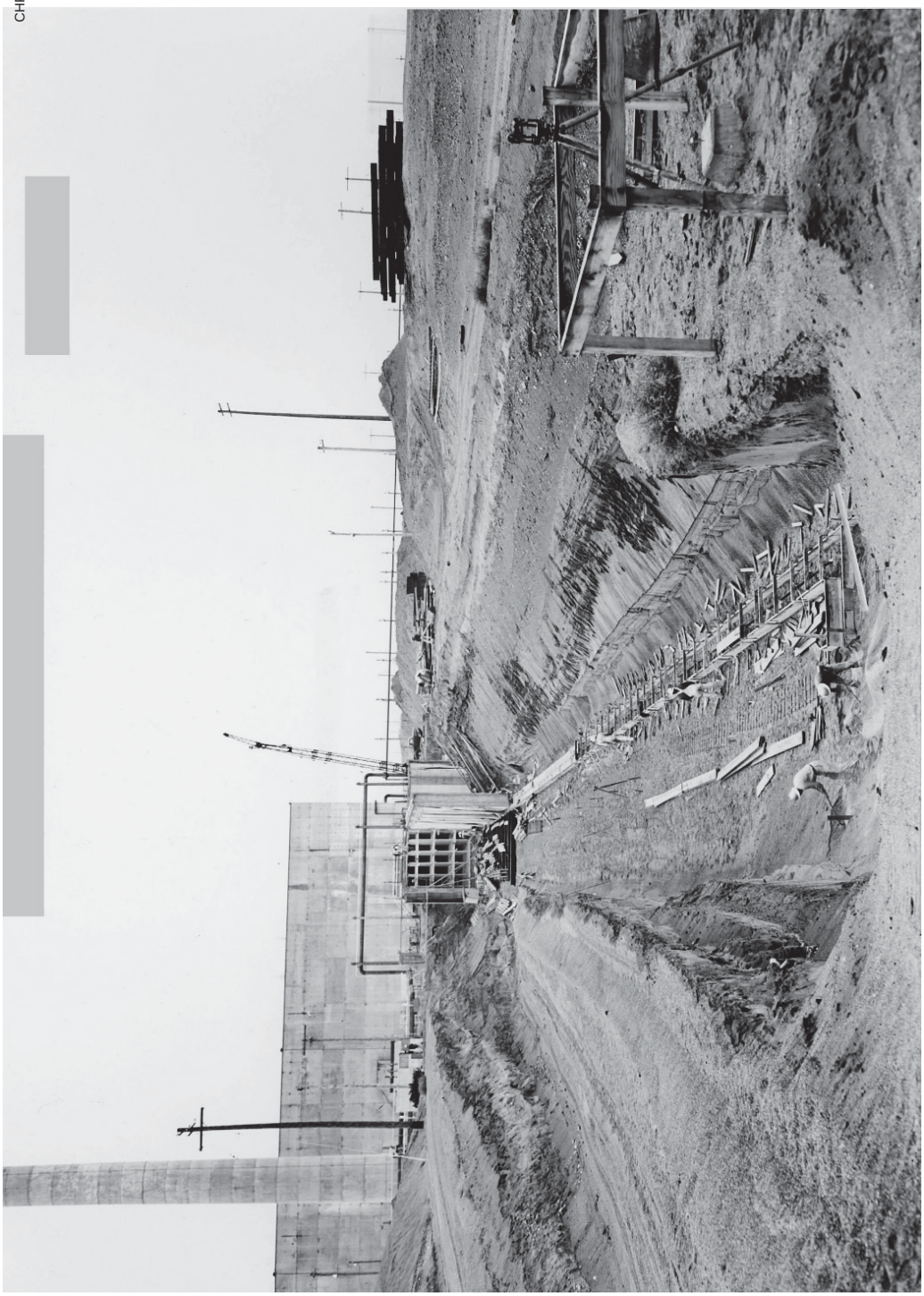

CHPRC-03241, Revision 0

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CHPRC-03241, Revision 0

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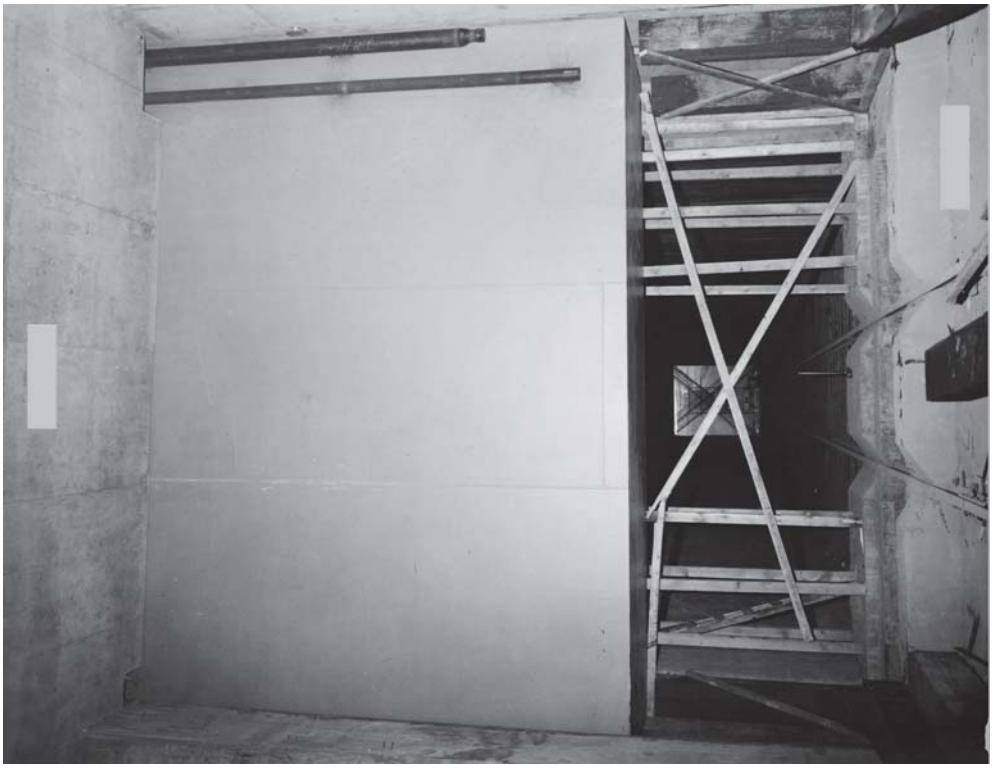
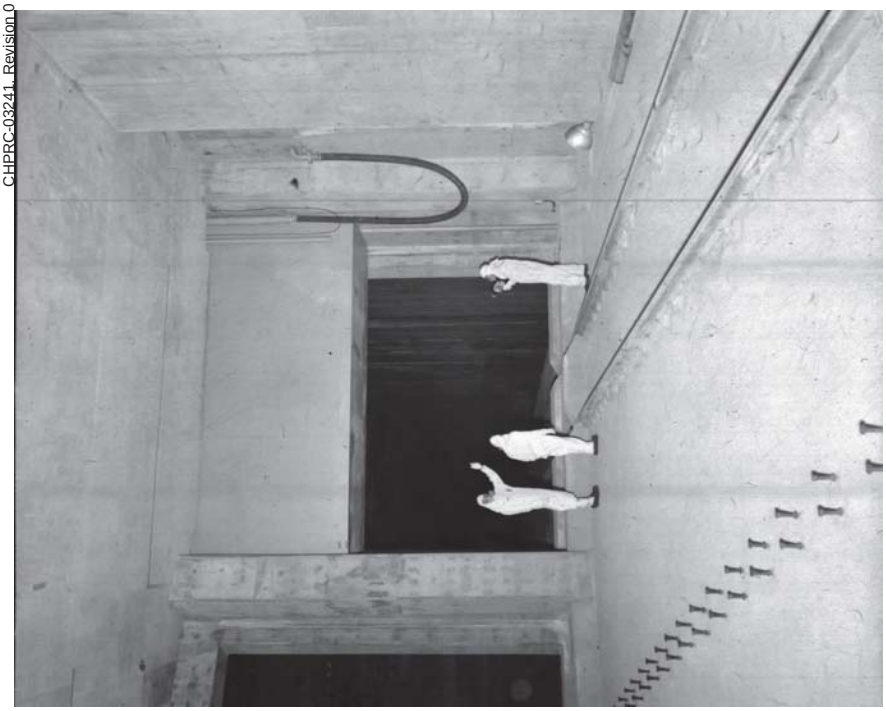
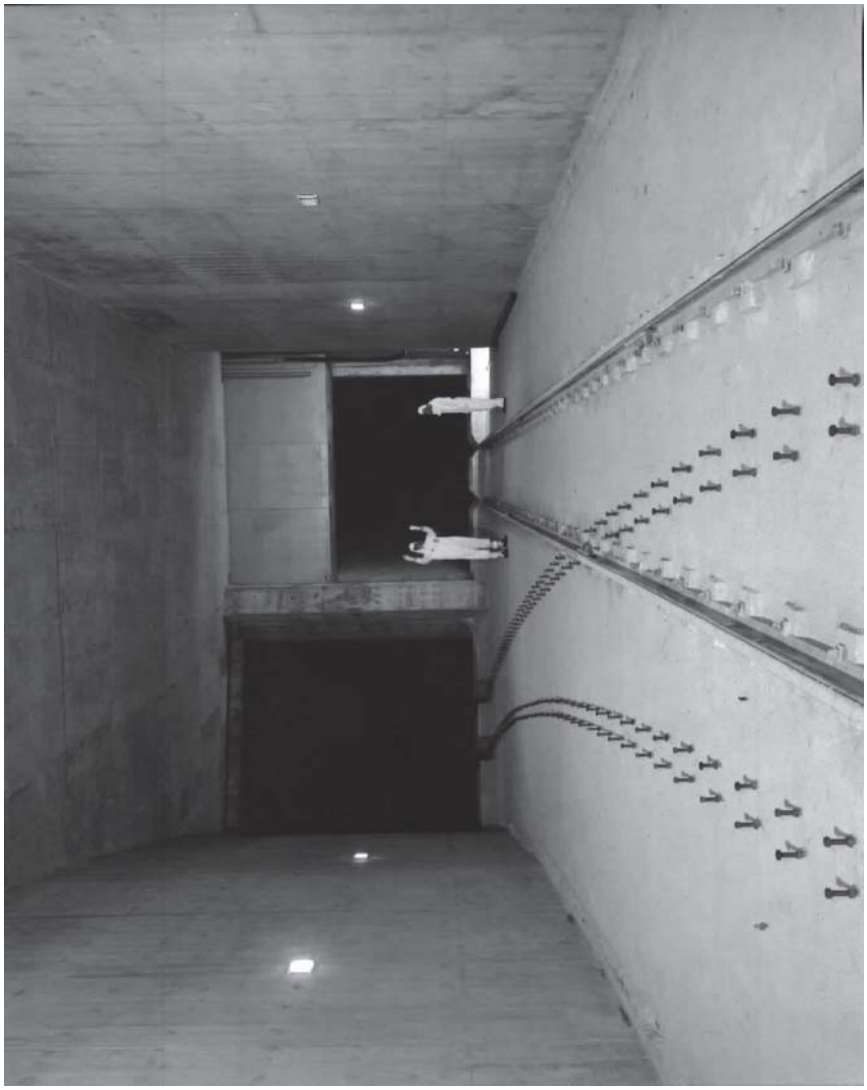




17



TUNNEL NO. 1 INVENTORY

Table 1: PUREX NO. 1 BURIAL TUNNEL INVENTORY

Burial Car No.	Burial Date	Contents	Initial Dose Rate
1&2	6-60	HA Separations Column Box of Misc. Jumpers	5 r/hr @ 60’
3	7-24-60	E-F11, 1WW Waste Concentrator	12.5 r/hr @ 100’
4	12-24-60	G-E4 Centrifuge Two Concentrator Tube Bundles Box of Misc. Jumpers	1.5 r/hr @ 150’
5	1-4-61	E-H4, 3WB Concentrator	150 mr/hr @ 50’
6	4-21-61	E-F6, 2WW Waste Concentrator	5 r/hr @ 20’
7	2-8-61	E-F11, 1WW Waste Concentrator	25 r/hr @ 150’
8	1-22-65	E-F6, 1WW Waste Concentrator	Unrecorded

Table 1. PUREX Storage Tunnels Inventory. (sheet 1 of 4)

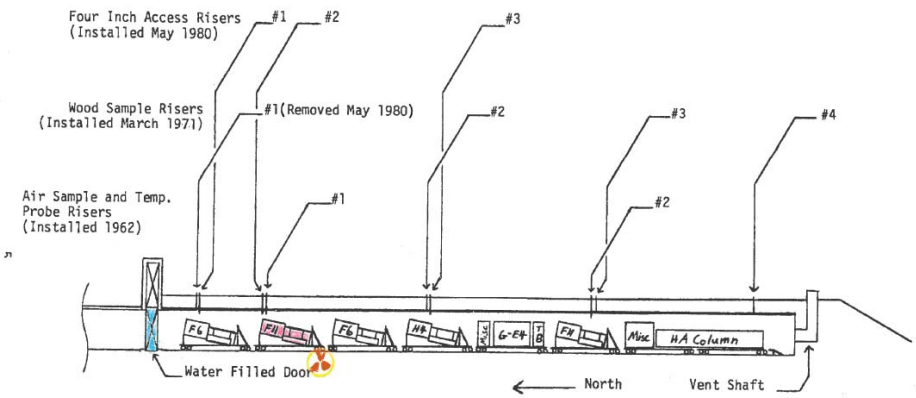
PUREX #1 STORAGE TUNNEL (218-E-14)
TUNNEL IS AT ITS CAPACITY AS OF 1/22/65

PUREX #1 Storage Tunnel is located at the southeast end of the PUREX Plant and is an extention of the railroad tunnel. The storage area is approximately 109 meters long, 6.9 meters high and 5.8 meters wide. The tracks have a one percent down-grade toward the south end of the tunnel. The capacity of the Storage Tunnel is eight modified railroad cars, 12.8 meters long.

position	
1. & 2.	HA COLUMN AND MISC JUMPERS IN BOX PLACED IN TUNNEL #1 ON 6/60 HA 4,700 CU. FT., 400 CURIES, 5 rem/hr. @ 60'. JUMPRS 2,190 CU. FT., 2,000 CURIES, Pb – ~115 Kg.
3.	E-F11 #1 (1WW WASTE) CONCENTRATOR FAILED 7/24/60. PLACED IN TUNNEL #1 ON 7/29/60, 12.5 rem/hr. @ 100'. 1,900 CU. FT., 40, 000 CURIES AFTER FIFTY-FIVE MONTHS SERVICE.
4.	G-E2 CENTRIFUGE, MISC JUMPERS IN BOX AND TWO TUBE BUNDLES. PLACED IN TUNNEL #1 ON 12/24/60 (TWO SERIE 782) 2,465 CU. FT., 3,000 CURIES, Pb – ~115 Kg., 1.5 rem/hr. @ 150'.
5.	E-H4 (3WS) CONCENTRATOR FAILED 1/4/61. PLACED IN TUNNEL #1 ON 1/4/61, 150 mrem/hr. @ 50'. 2,336 CU. FT., 1,000 CURIES. AFTER FIVE YEARS SERVICE.
6.	E-F6 (2WW WASTE) ORIGINAL CONCENTRATOR FAILED 4/21/61. PLACED IN TUNNEL #1 ON 4/21/61, 5 rem/hr. @ 20'. 2,336 CU. FT., 700 CURIES. AFTER FIVE YEARS FOUR MONTHS SERVICE.
7.	E-F11 (1WW WASTE) #2 CONCENTRATOR FAILED 2/1/62. PLACED IN TUNNEL #1 ON 2/8/62, 25 rem/hr. @ 150'. 2,336 CU. FT., 40,000 CURIES. AFTER EIGHTEEN MONTHS SERVICE.
8.	E-F6 (2WW WASTE) #3 SPARE CONCENTRATOR FAILED 5/23/64. PLACED IN TUNNEL #1 ON 1/22/65 FLAT CAR 3621. 2,400 CU. FT., 700 CURIES, 5 rem/hr. @ 20'.

970324.1118

T-1.1



RHO-CD-1076

FIGURE 2: PUREX NO. 1 BURIAL TUNNEL

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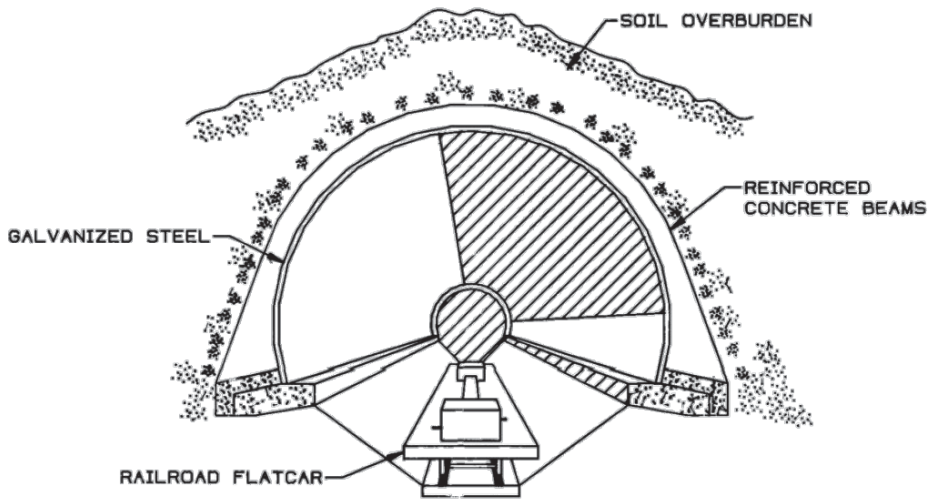
1996 – TUNNEL NO. 1 HVAC DEACTIVATED

2016 - TUNNEL NO. 1 HVAC STACK CURRENT CONFIGURATION

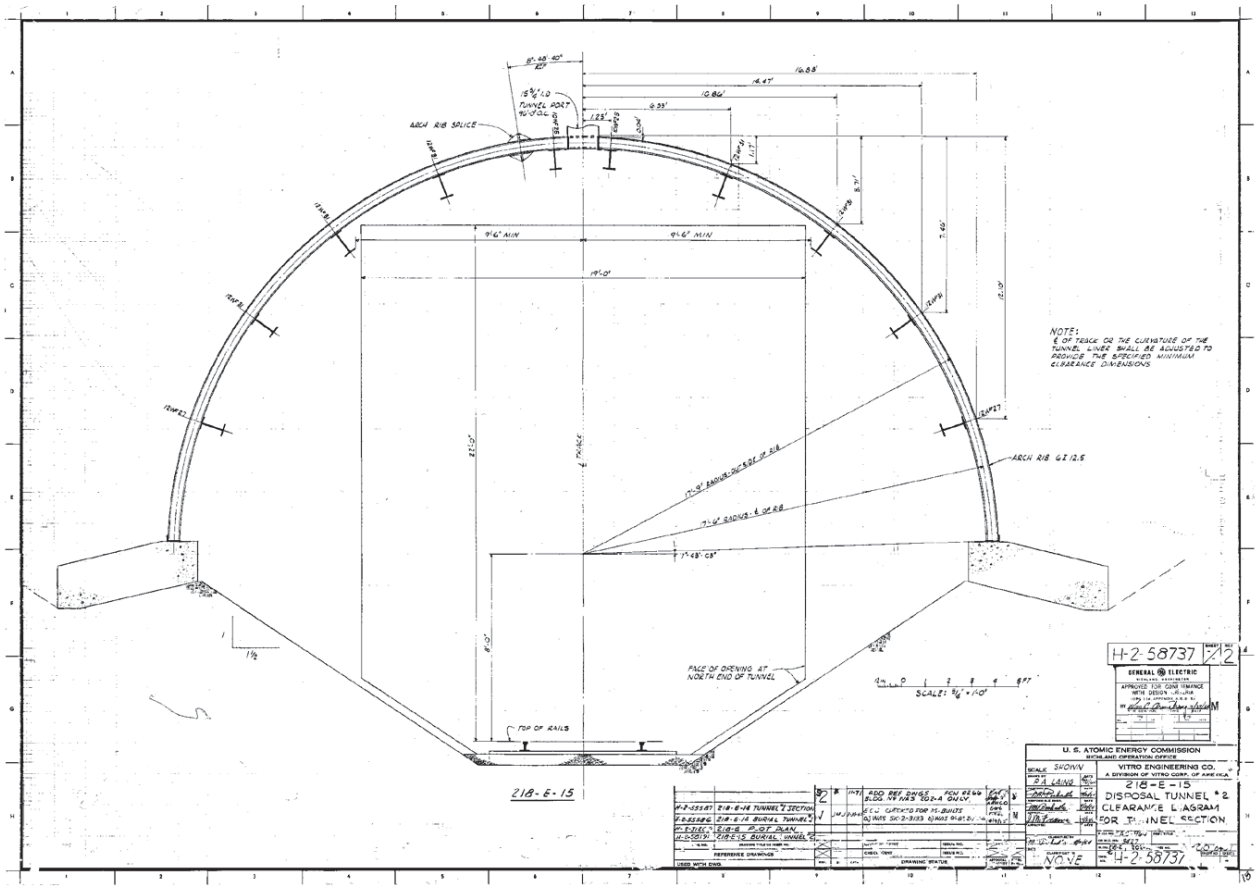
TUNNEL NO. 2 CONFIGURATION

- Constructed 1964-1966
- 1688 Ft. Long
- Steel & Concrete
- Capacity 40 RR Cars
- Service Life 1966-1996 & Deactivated
- Current Inventory 28 RR Cars
- Ventilated till 1996



SECTION CC

CONSTRUCTION TUNNEL NO. 2



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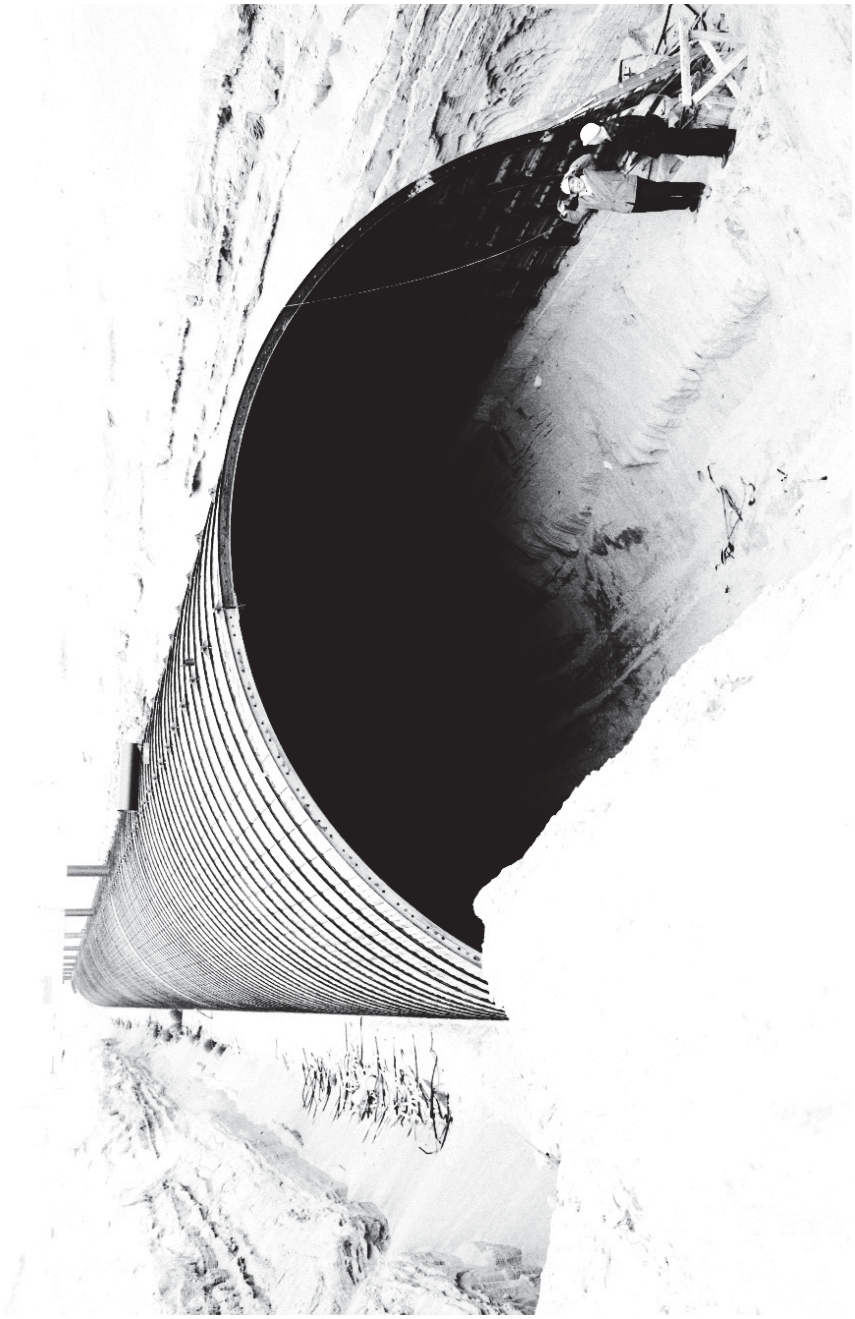

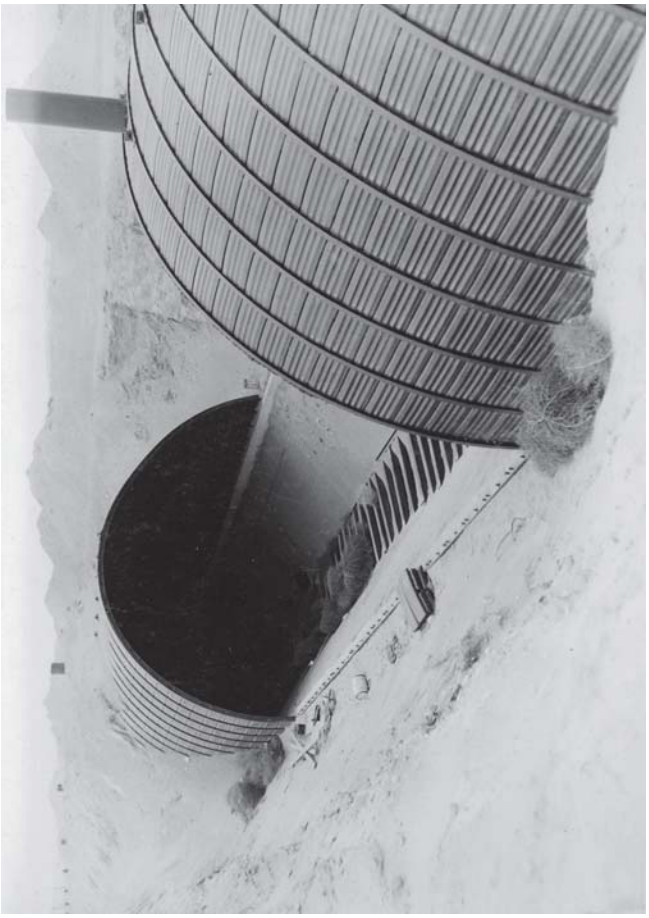

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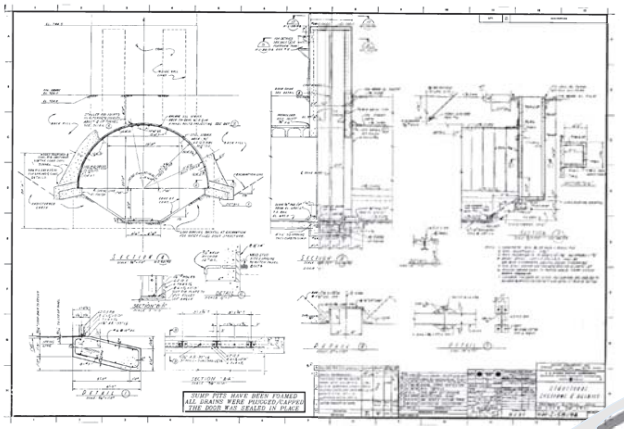
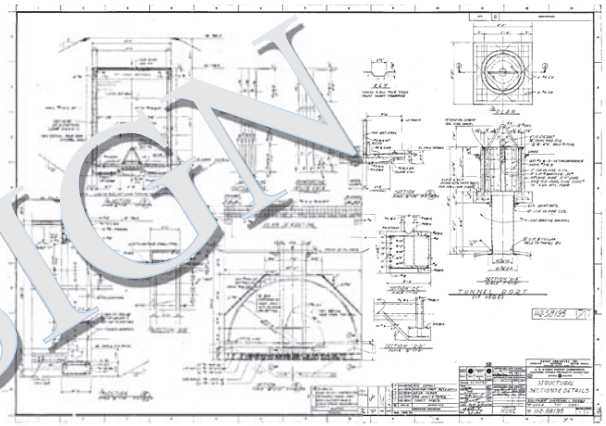
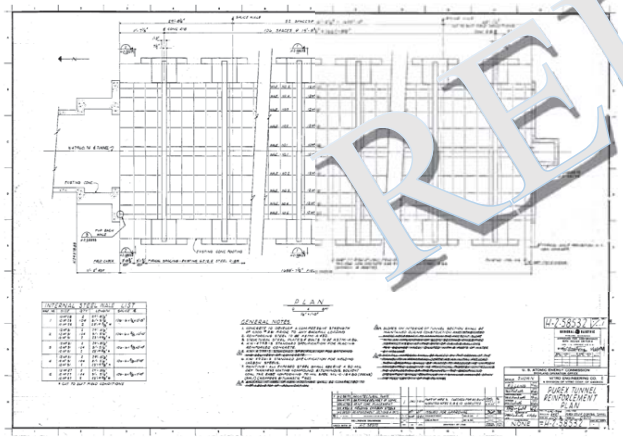
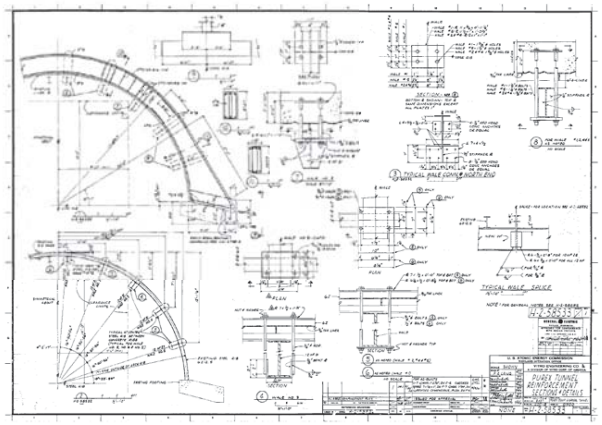
1964, JANUARY - TUNNEL COLLAPSE

1964, JANUARY TO APRIL – TUNNEL NO. 2 REDESIGN & STRUCTURAL REINFORCEMENT









REDESIGN

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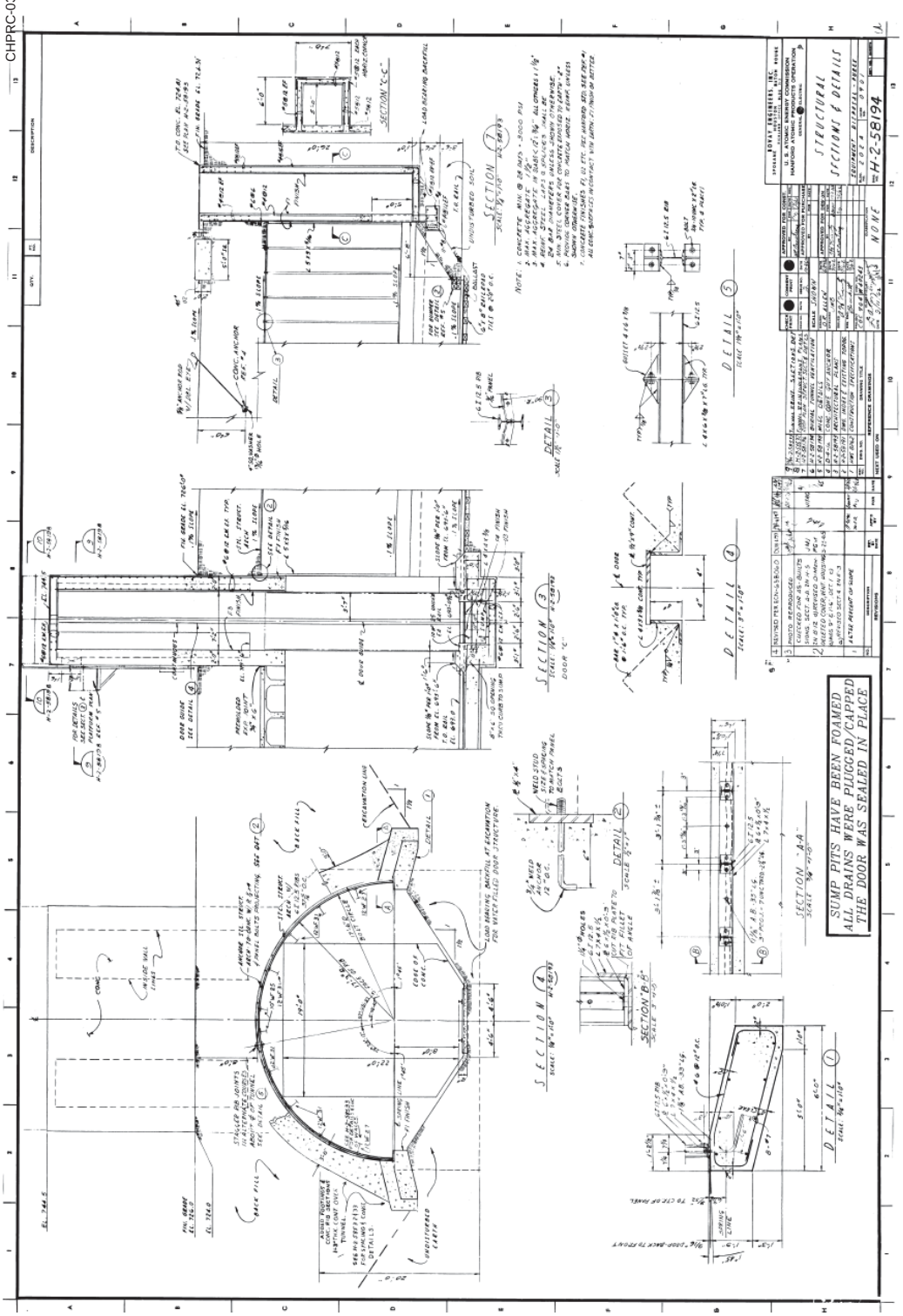
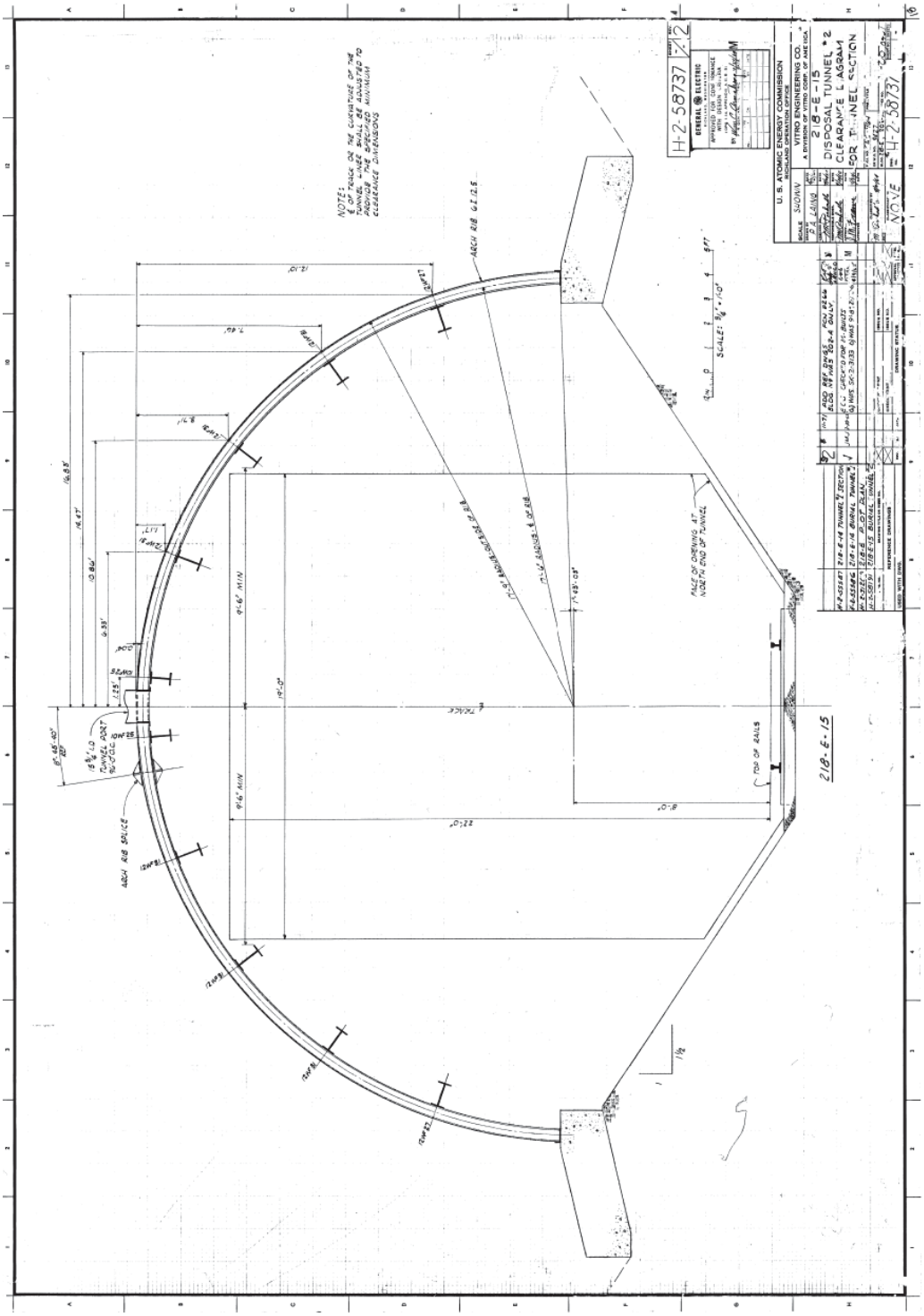
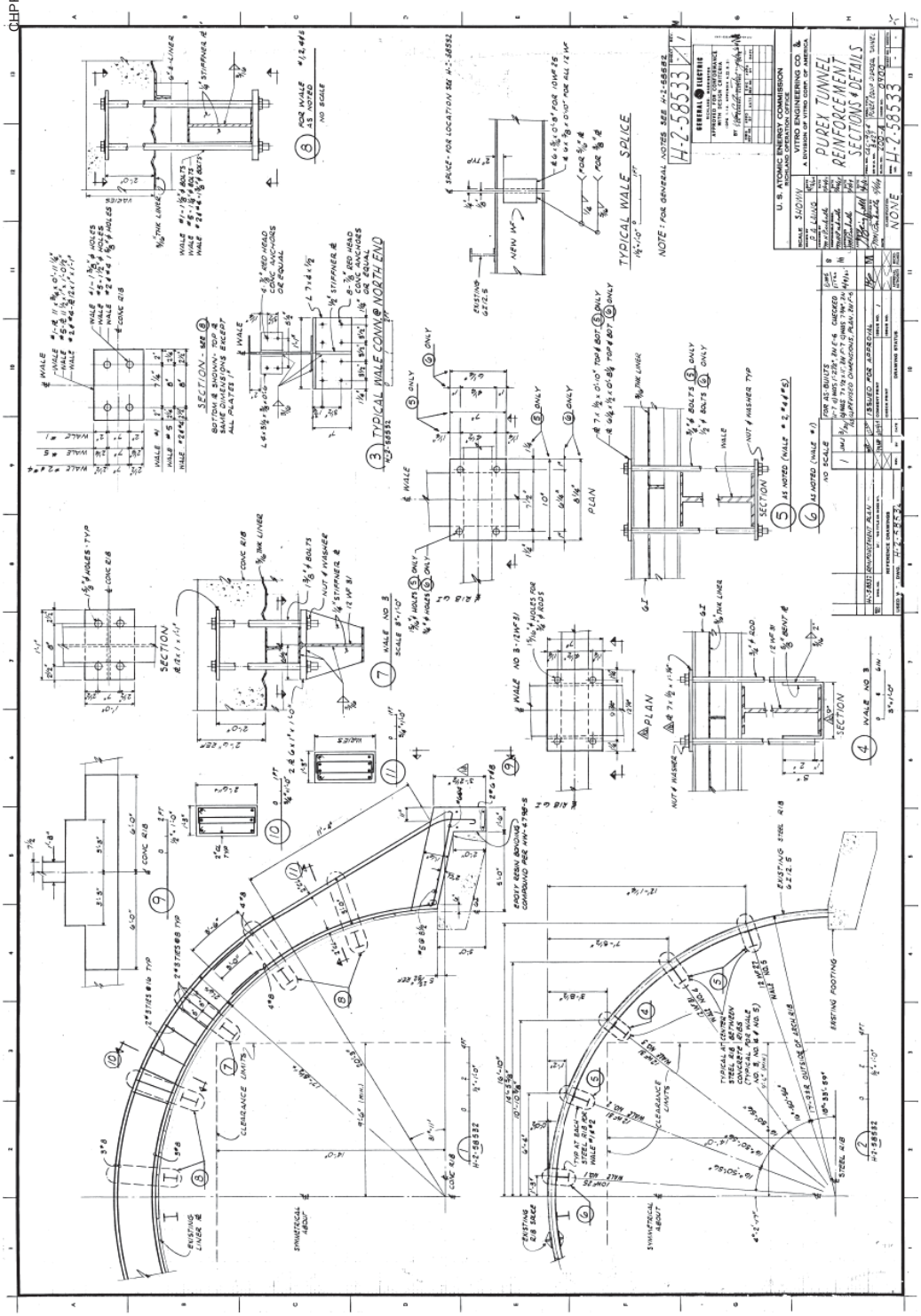
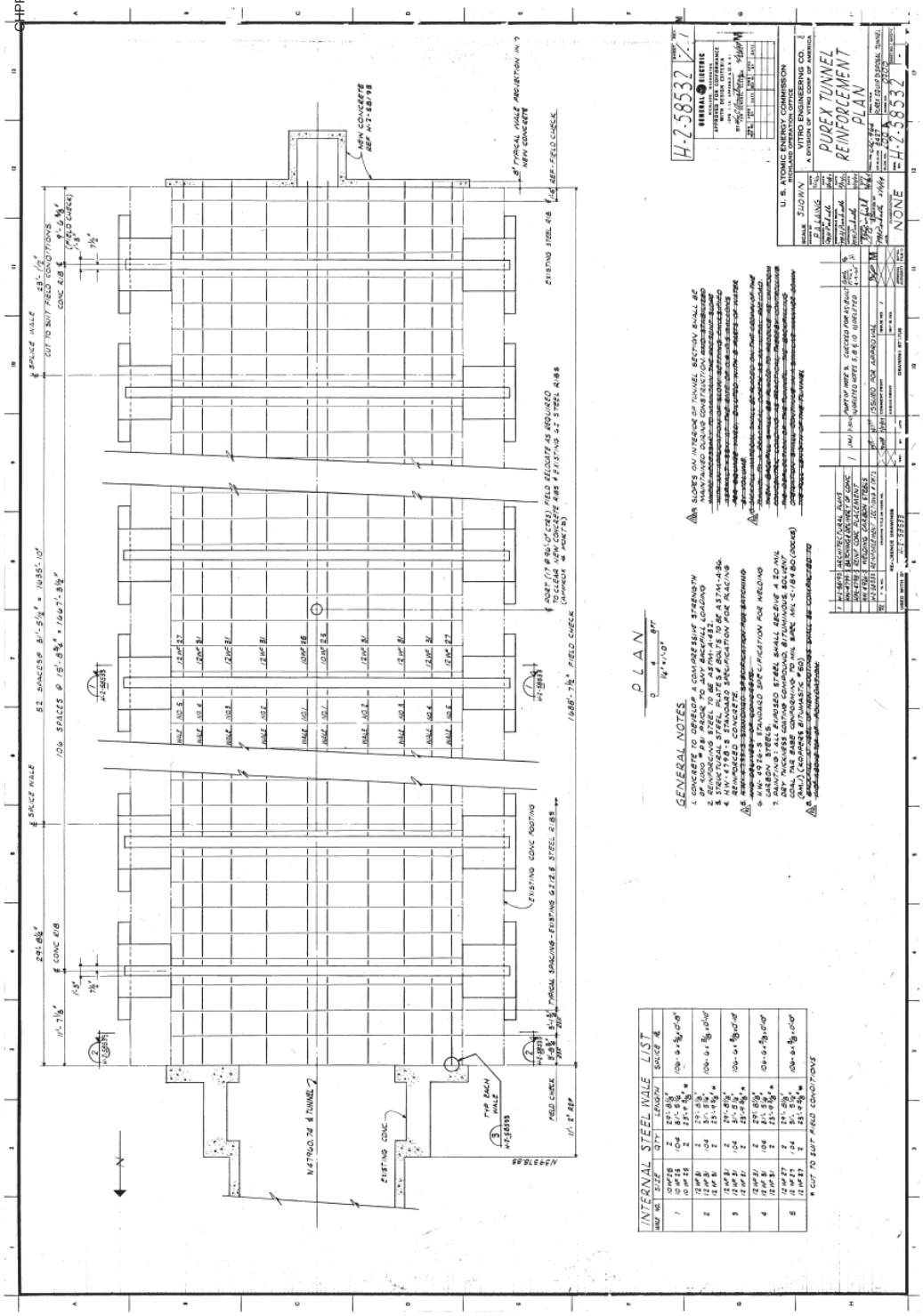


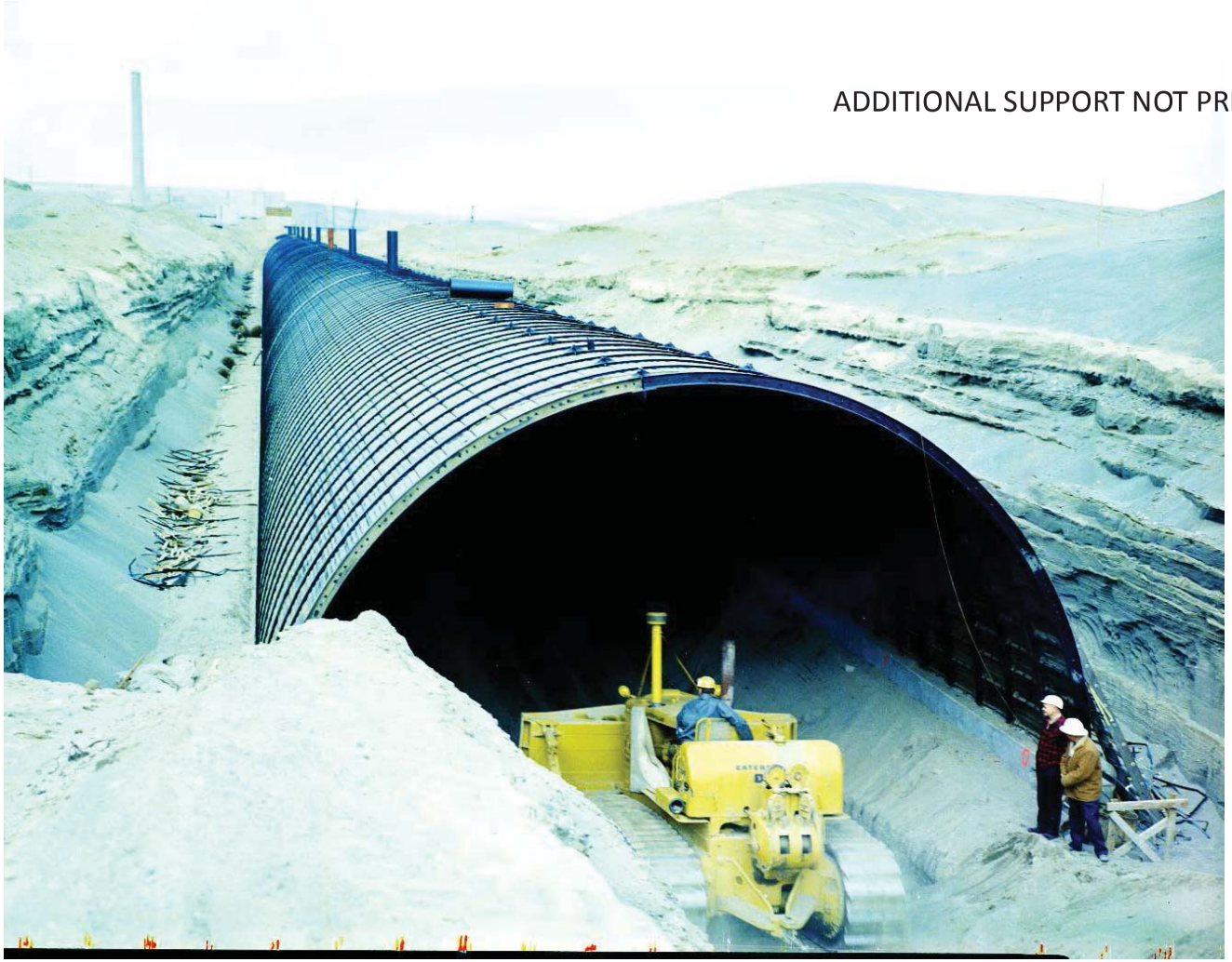
RELEASE DATE
OF 4/21/1964




U. S. ATOMIC ENERGY COMMISSION
VITRO ENGINEERING CO.
PUREX TUNNEL
REINFORCEMENT
SECTIONS & DETAILS
H-2-58533
TYPICAL WALE SPLICE
TYPICAL WALE CONN @ NORTH END
SECTION - SEE 8
BOTTOM & SHOWN: TOP & SAME DIMENSIONS EXCEPT ALL PLATES 1"
SECTION
PLAN
NOTE: FOR GENERAL NOTES SEE H-2-58532
NO SCALE
SCALE SHOWN
NONE
ISSUED FOR CONSTRUCTION
FOR AS-BUILTS
CLEARANCE LINES
SYMMETRICAL ABOUT
EXISTING FOOTING
EXISTING LINER
STEEL 4/8
CONC 4/8
TIE AT BACK OF STEEL RIB FOR WALE #1 & 2
EXISTING 2/8 SHEET
EXISTING 6/12.5
NEW WF
EPOXY RESIN BONDING COMPOUND PER HW-47908-S
WALE NO 3
WALE NO 8
WALE NO 3 - (12 WF 31)
TYPICAL ATTACHING STEEL RIB TO WALE (TYPICAL FOR WALE NO 8, NO 6 & NO 5)
TYPICAL WALE CONN @ NORTH END
TYPICAL WALE SPLICE
FOR WALE AS NOTED
FOR WALE AS NOTED (WALE #1)
AS NOTED (WALE #2, #4 & #5)
SPLICE - FOR LOCATION SEE H-2-58532
STIFFNER 8
NUT & WASHER
12 WF 31
TIE ROD
TIE BENT 8
TIE LINER
CONC 4/8
EXISTING 6/12.5
STEEL 4/8
EXISTING FOOTING


PLAN
GENERAL NOTES
INTERNAL STEEL WALE LIST
PUREX TUNNEL REINFORCEMENT PLAN
U. S. ATOMIC ENERGY COMMISSION
VITRO ENGINEERING CO.
NONE
H-2-58532

ADDITIONAL SUPPORT NOT PRESENT



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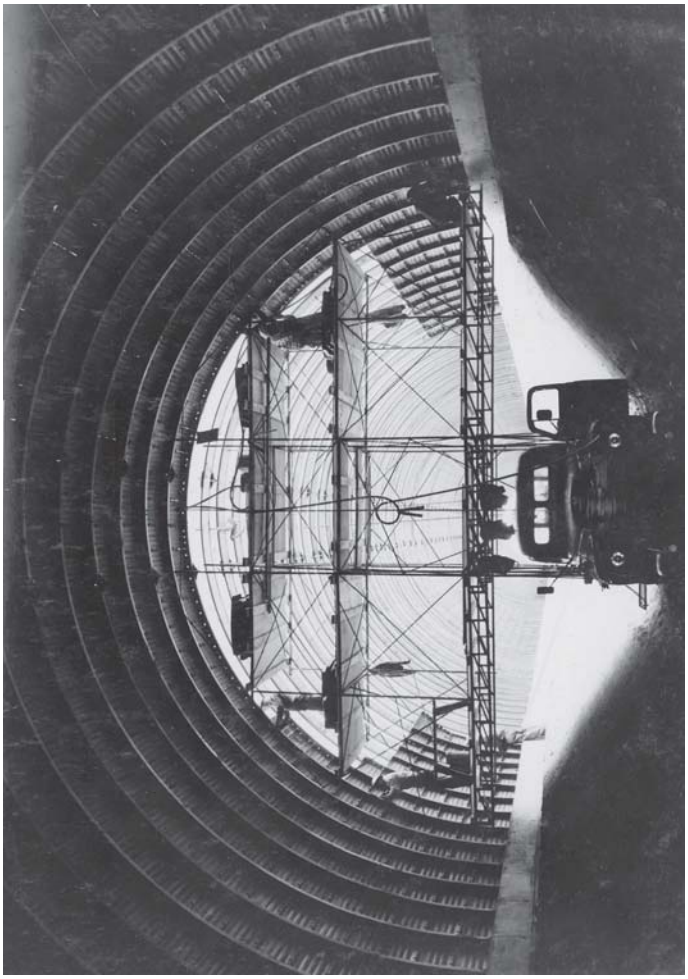
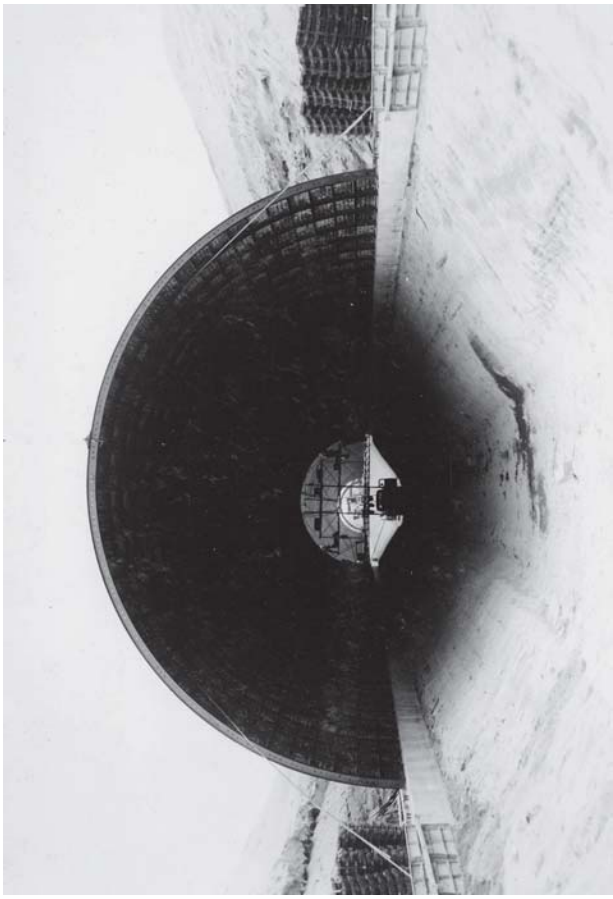
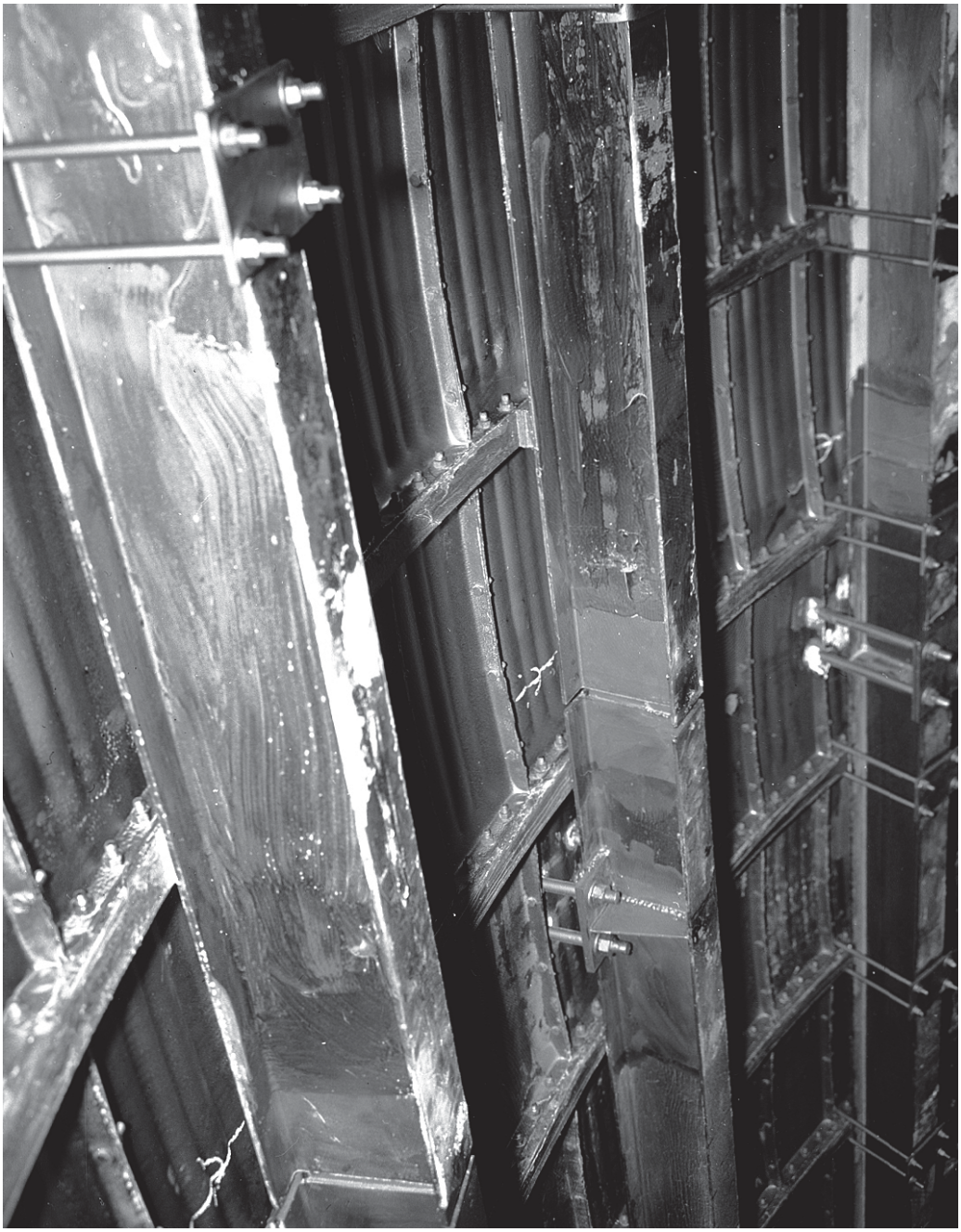
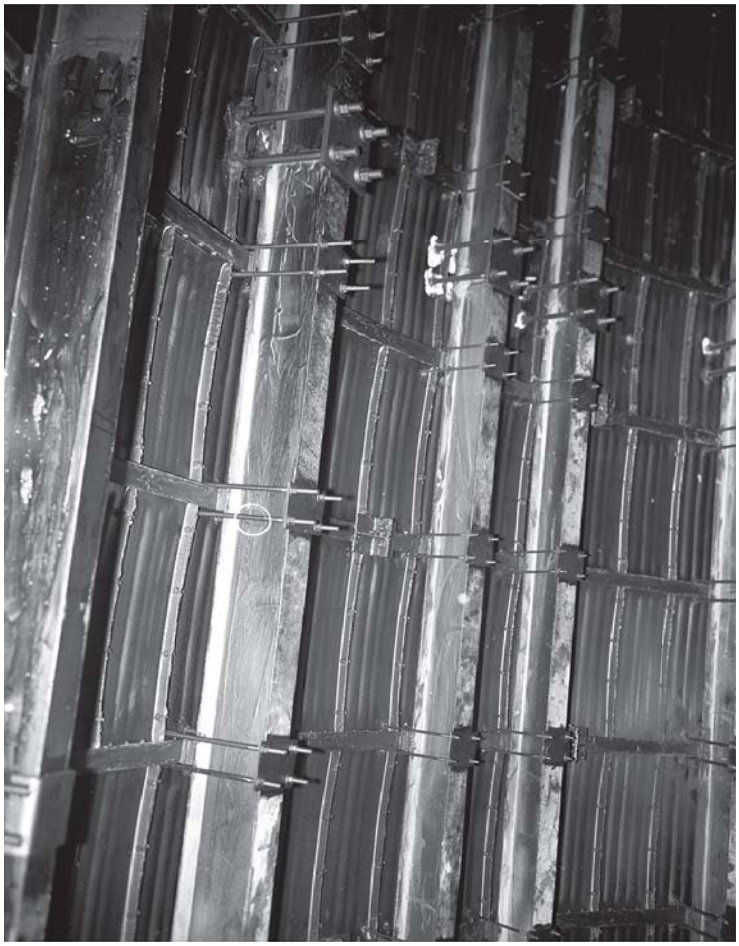
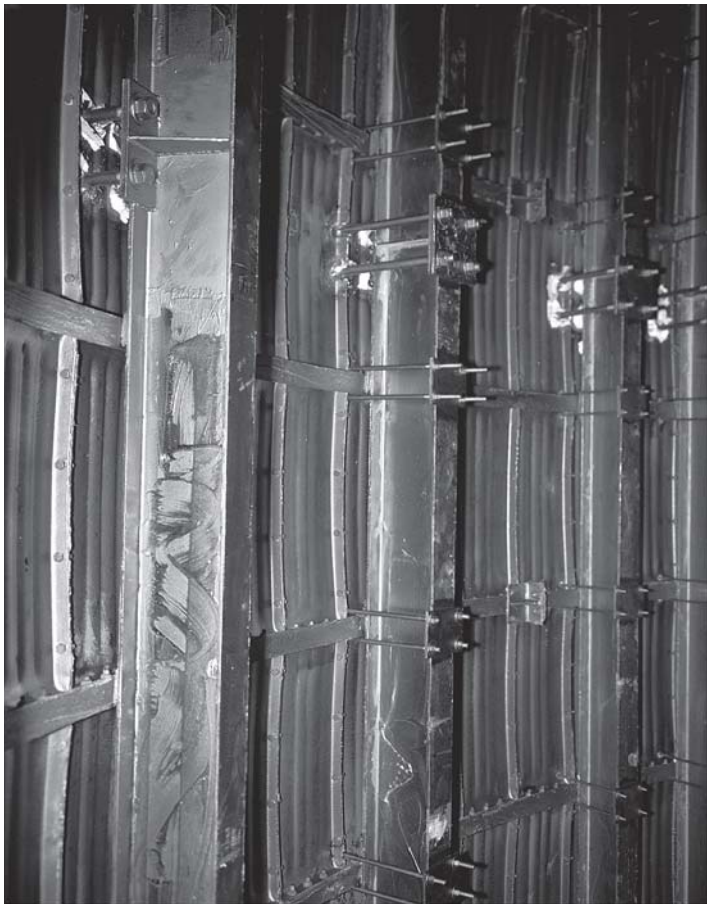
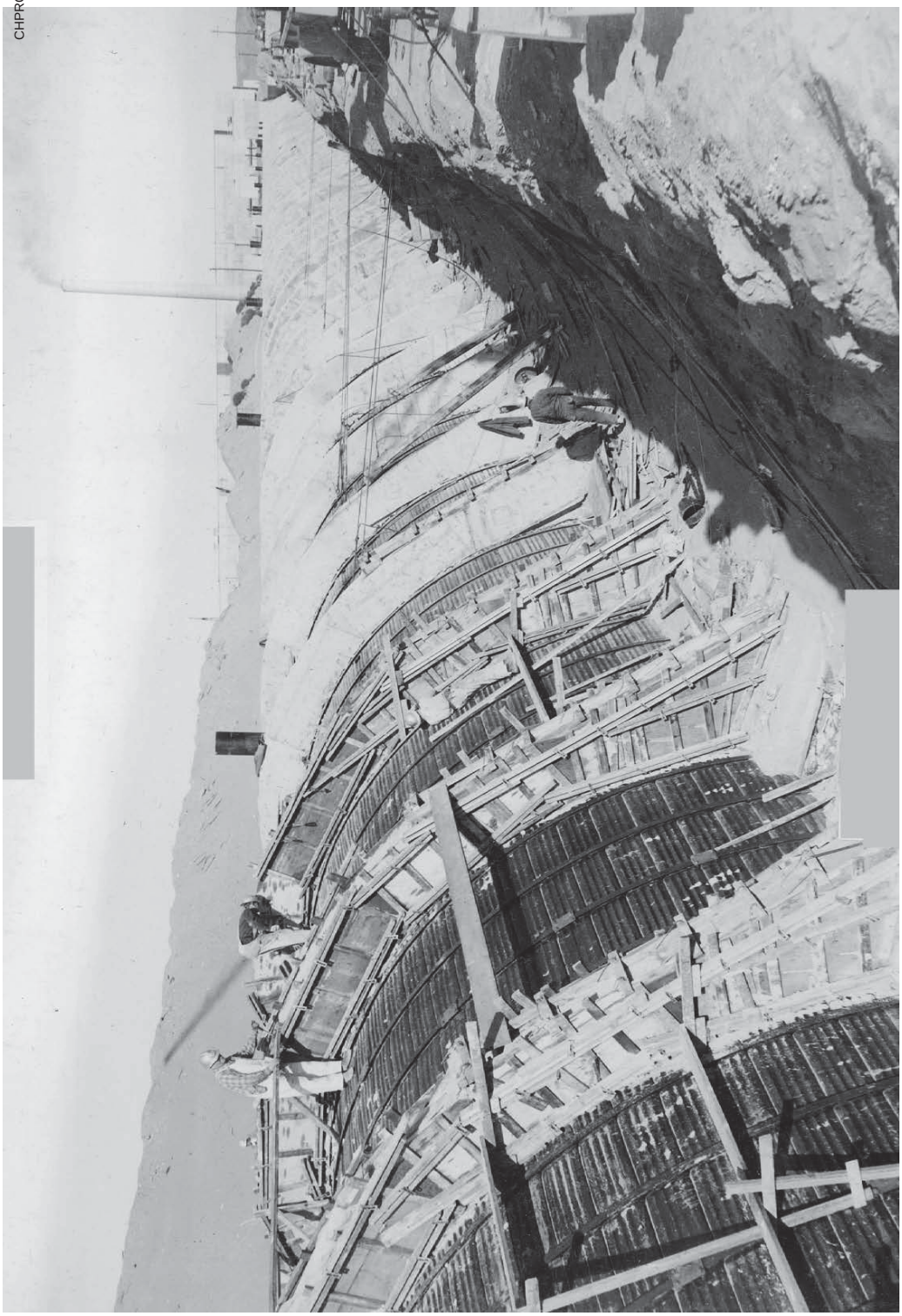


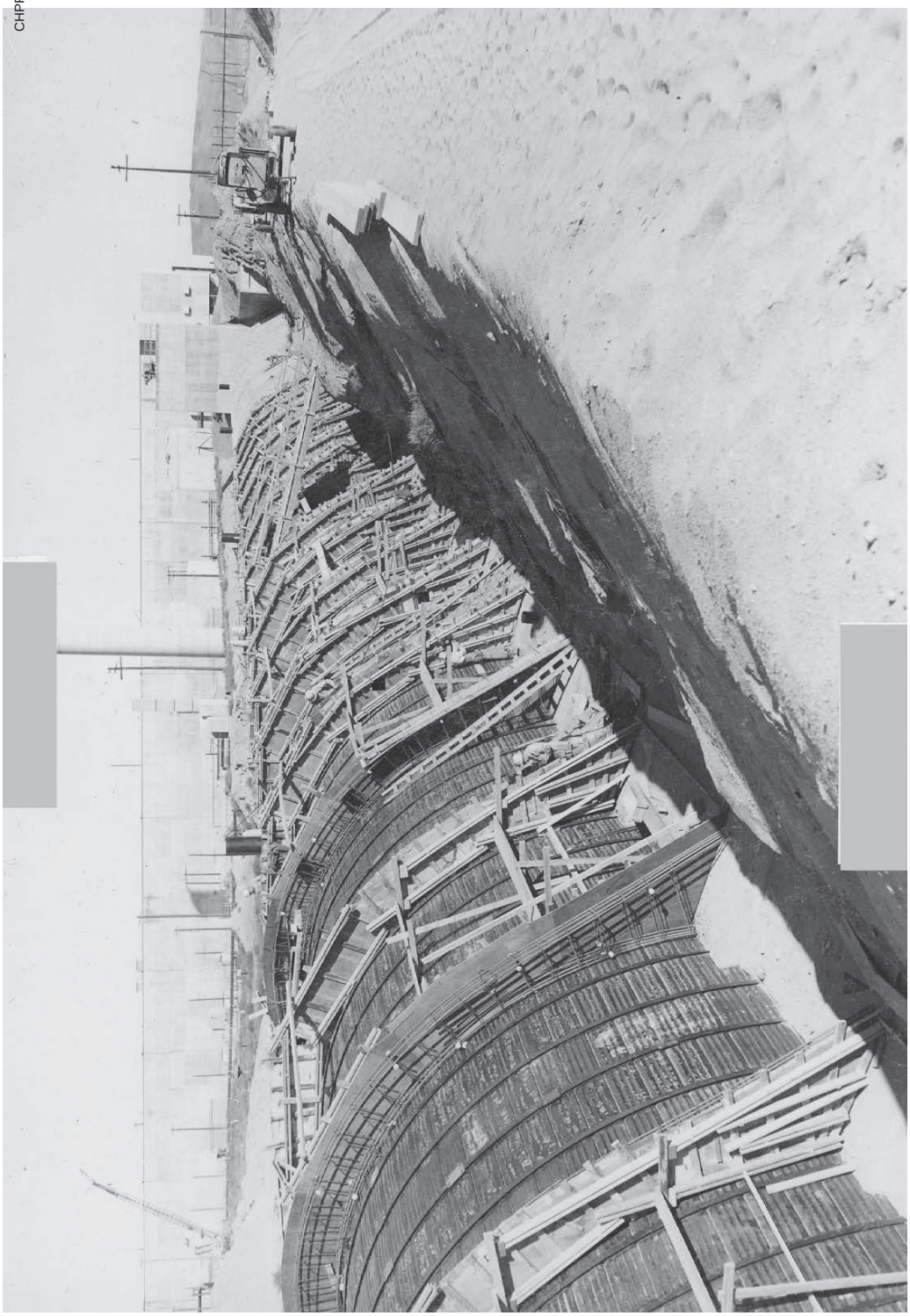


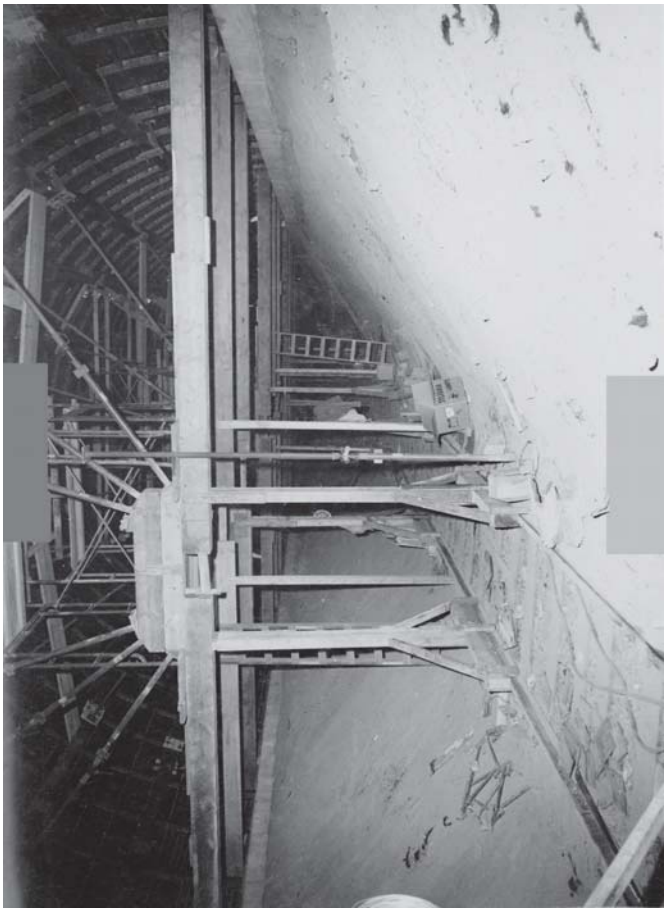


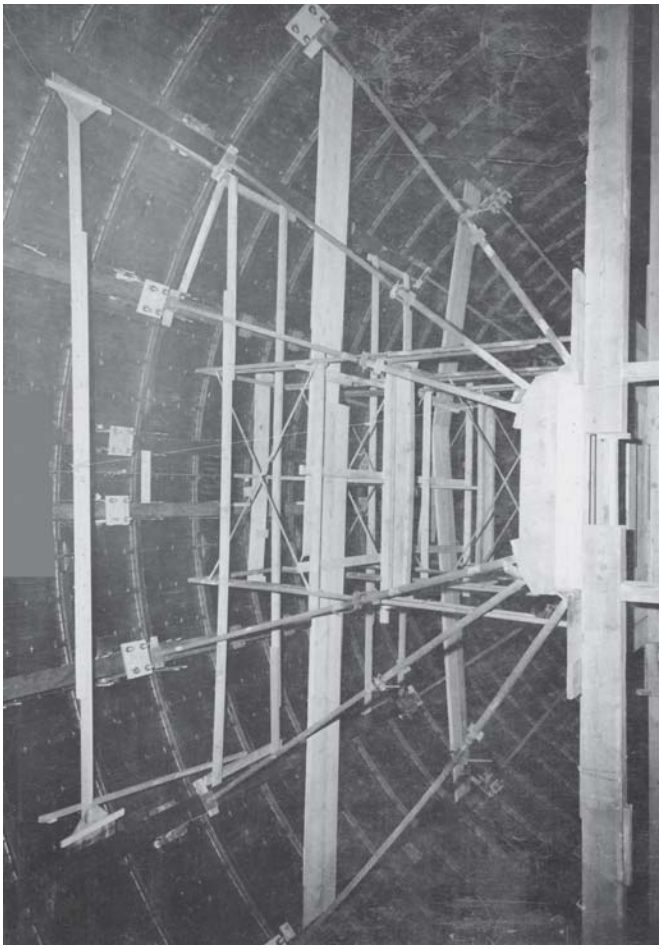








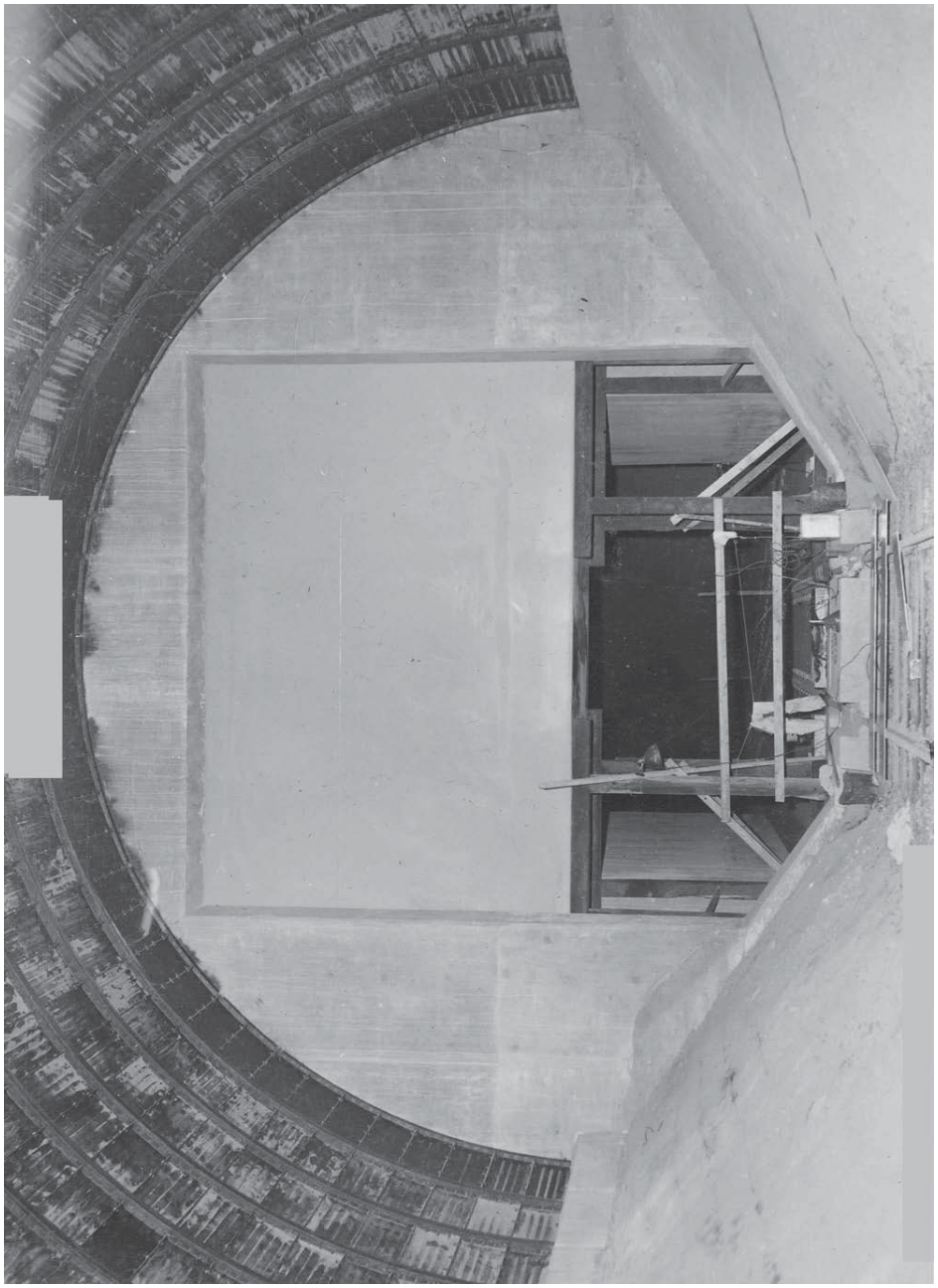




PROCESS IMPROVEMENT REGARDING BACKFILLING PROCEDURE

CHPRC-03241, Revision 0

50



TUNNEL NO. 2 INVENTORY

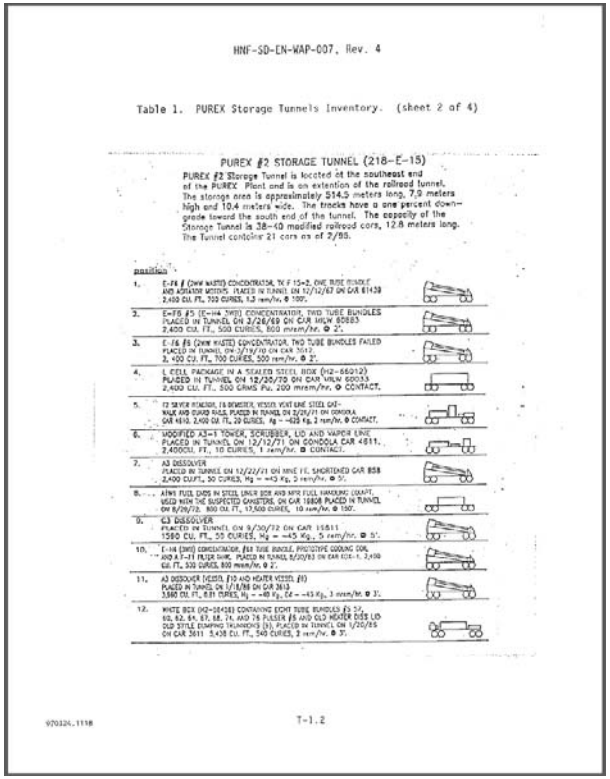


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Table 1. PUREX Storage Tunnels Inventory. (sheet 2 of 4)

PUREX #2 STORAGE TUNNEL (218-E-15)

PUREX #2 Storage Tunnel is located at the southeast end of the PUREX Plant and is an extention of the railroad tunnel. The storage area is approximately 514.5 meters long, 7.9 meters high and 10.4 meters wide. The tracks have a one percent down-grade toward the south end of the tunnel. The capacity of the Storage Tunnel is 38-40 modified railroad cars, 12.8 meters long. The Tunnel contains 21 cars as of 2/88.

position

1. E-F6 # (2WW WASTE) CONCENTRATOR, TK F 15-2, ONE TUBE BUNDLE AND AGITATOR MOTOR, PLACED IN TUNNEL ON 12/12/67 ON CAR 61438 2,400 CU. FT., 703 CURIES, 1.2 mrem/hr. @ 100'.
2. E-F6 #5 (E-H4 2WD) CONCENTRATOR, TWO TUBE BUNDLES PLACED IN TUNNEL ON 2/26/69 ON CAR HRLW 80883 2,400 CU. FT., 500 CURIES, 800 mrem/hr. @ 2'.
3. E-F6 #6 (2WW WASTE) CONCENTRATOR, TWO TUBE BUNDLES FAILED PLACED IN TUNNEL ON 3/19/70 ON CAR 3012 2, 400 CU. FT., 700 CURIES, 500 mrem/hr. @ 2'.
4. 1 CELL PACKAGE IN A SEALED STEEL BOX (H2-86012) PLACED IN TUNNEL ON 12/20/70 ON CAR HRLW 60033 2,400 CU. FT., 500 CRMS Pu, 200 mrem/hr. @ CONTACT.
5. F2 SEWER HOLDUP, F6 DEMISTER, VESSEL VENT LINE STEEL GATE-VALVE AND GUARD RAIL PLACED IN TUNNEL ON 2/26/71 ON GONDOLA CAR 4810. 2,400 CU. FT., 20 CURIES, Xg ~ -420 kg, 2 rem/hr. @ CONTACT.
6. MODIFIED A3-1 TOWER, SCRUBBER, LID AND VAPOR LINE PLACED IN TUNNEL ON 12/12/71 ON GONDOLA CAR 4811. 2,400CU. FT., 10 CURIES, 1 rem/hr. @ CONTACT.
7. A3 DISSOLVER PLACED IN TUNNEL ON 12/22/71 ON MINE FT. SHORTENED CAR 858 2,400 CU.FT., 90 CURIES, Xg ~ -43 Kg, 2 rem/hr. @ 5'.
8. ATWS FUEL DIDS IN STEEL LINER BOX AND NPR FUEL HANDING COMPT. MIXED WITH THE SUSPECTED CANISTERS, ON CAR 18808 PLACED IN TUNNEL ON 8/20/72. 800 CU. FT., 17,500 CURIES, 10 rem/hr. @ 100'.
9. A3 DISSOLVER PLACED IN TUNNEL ON 9/30/72 ON CAR 15811 1580 CU. FT., 55 CURIES, Xg ~ -45 Kg., 5 rem/hr. @ 5'.
10. E-H4 (2WD) CONCENTRATOR, #64 TUBE BUNDLE, PROTOTYPE COOLING COIL AND A7-11 FILTER SHRE. PLACED IN TUNNEL 8/20/83 ON CAR ICC-1, 2,400 CU. FT., 500 CURIES, 800 mrem/hr. @ 2'.
11. A3 DISSOLVER (VESSEL #10 AND HEATER VESSEL #9) PLACED IN TUNNEL ON 1/18/84 ON CAR 3613 3,980 CU. FT., 831 CURIES, Xg ~ -48 Kg., Cd ~ -43 Kg., 3 mrem/hr. @ 3'.
12. WASTE BOX (H2-86481) CONTAINING EIGHT TUBE BUNDLES #3 34, 50, 62, 64, 67, 68, 74, AND 76 FLUSER #5 AND OLD HEATER DISS LID OLD STYLE DUMPING TRUNNIONS (3), PLACED IN TUNNEL ON 1/20/85 ON CAR 3611 5,438 CU. FT., 540 CURIES, 2 mrem/hr. @ 3'.

970326.1118 T-1.2

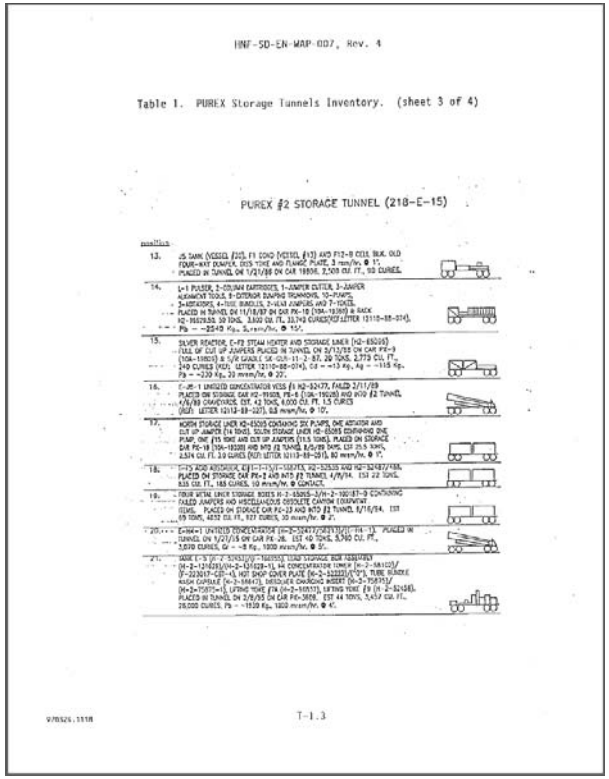

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Table 1. PUREX Storage Tunnels Inventory. (sheet 3 of 4)

PUREX #2 STORAGE TUNNEL (218-E-15)

position

13. A5 TANK (VESSEL #20), F1 COLD (VESSEL #13) AND F12-B COIL BUK. OLD FOUR-WAY DUMPER, DISS TOKE AND FLANGE PLATE. 3 mrem/hr. @ 1', PLACED IN TUNNEL ON 1/21/88 ON CAR 18898. 2,505 CU. FT., 90 CURIES.
14. E-1 FLUSER, 2-CELLULAR CANTRIDGES, 1-JUMPER CUTTER, 3-JUMPER ALIGNMENT TOOLS, 5-EXTERIOR DUMPING TRUNNIONS, 10-PUMPS, 3-ADAPTERS, 4-TOOL BUNDLES, 7-HEAT JUMPERS AND 7-TOOLS. PLACED IN TUNNEL ON 11/18/87 ON CAR PX-18 (104-19303) & RACK H2-96029.50 50 TONS. 3,600 CU. FT., 33,743 CURIES(REF LETTER 12110-88-014). Pb ~ -2540 Kg., 2.4 mrem/hr. @ 15'.
15. SILVER REMOVER, C-F2 STEAM HEATER AND STORAGE RACK (H2-85016) FULL OF CUT UP JUMPERS PLACED IN TUNNEL ON 5/13/88 ON CAR PX-9 (104-19803) & 5/8 GRADLE SK -01-11-2- 87, 20 TONS. 2,773 CU. FT., 240 CURIES (REF. LETTER 12110-88-014). Cd ~ -13 Kg, Ag ~ -115 Kg, Pb ~ -230 Kg, 20 mrem/hr. @ 20'.
16. F-JS-1 UNITIZED CONCENTRATOR VESS (H H2-92479, FAILED 2/11/89 PLACED ON STORAGE CAR H2-91928, PX-8 (104-19028) AND INTO #2 TUNNEL 4/6/89 CONVERSE. EST. 42 TONS, 6,000 CU. FT. 1.5 CURIES (REF: LETTER 12110-88-027). 0.8 mrem/hr. @ 10'.
17. NORTH STORAGE (ARE H2-85015) CONTAINING SIX PUMPS, ONE ACTUATOR AND CUT UP JUMPER (14 TONS). SOUTH STORAGE (ARE H2-85015) CONTAINING ONE PUMP, ONE (15 TONS) AND CUT UP JUMPERS (15.5 TONS), PLACED ON STORAGE CAR PX-18 (104-19028) AND INTO #2 TUNNEL 8/5/89 SWHS. EST 29.5 TONS, 2,574 CU. FT. 2.0 CURIES (REF: LETTER 12110-88-031), 80 mrem/hr. @ 1'.
18. 5-FT3 ROD ABSORBER (H2-75135)(H2-102175, H2-92520 AND H2-92487/438) PLACED ON STORAGE CAR PX-2 AND INTO #2 TUNNEL 4/8/94. 151 22 TONS. 835 CU. FT., 185 CURIES, 10 mrem/hr. @ CONTACT.
19. FOUR METAL LINER STORAGE BOXES H-2-85015-3/H-2-100187-3 CONTAINING FAILED JUMPERS AND MISCELLANEOUS OBSOLETE CANYON EQUIPMENT ITEMS. PLACED ON STORAGE CAR PX-23 AND INTO #2 TUNNEL 8/16/94. 151 69 TONS, 4032 CU. FT., 937 CURIES, 30 mrem/hr. @ 2'.
20. E-H4-1 UNITIZED PROCESS CANISTER (H-2-32417/H-2-32413/H-2-32411). PLACED IN TUNNEL ON 9/27/95 ON CAR PX-26. EST 40 TONS. 5,760 CU. FT., 2,570 CURIES, Cd ~ -8 Kg., 1000 mrem/hr. @ 5'.
21. HOOD (-3) (H-2-32433)(H-2-32432) LEAD STORAGE BOX H2-85015 (H-2-101820)(H-2-101828-1), H4 CONCENTRATOR TUNNEL (H-2-101820)/ (F-223017-CD)-1), HOT SHOP COVER PLATE (H-2-32223)(F-2), TUBE BUNDLE HEAD CAPSULE (H-2-104413), DISSOLVER CHARGING INSERT (H-2-75835)/ (H-2-75837-1), LIFTING YOKE #1A (H-2-101573), LIFTING YOKE #B (H-2-32145). PLACED IN TUNNEL ON 2/8/95 ON CAR PX-3858. EST 44 TONS, 3,457 CU. FT., 28,000 CURIES, Pb ~ -1920 Kg, 1800 mrem/hr. @ 4'.

970326.1118 T-1.3

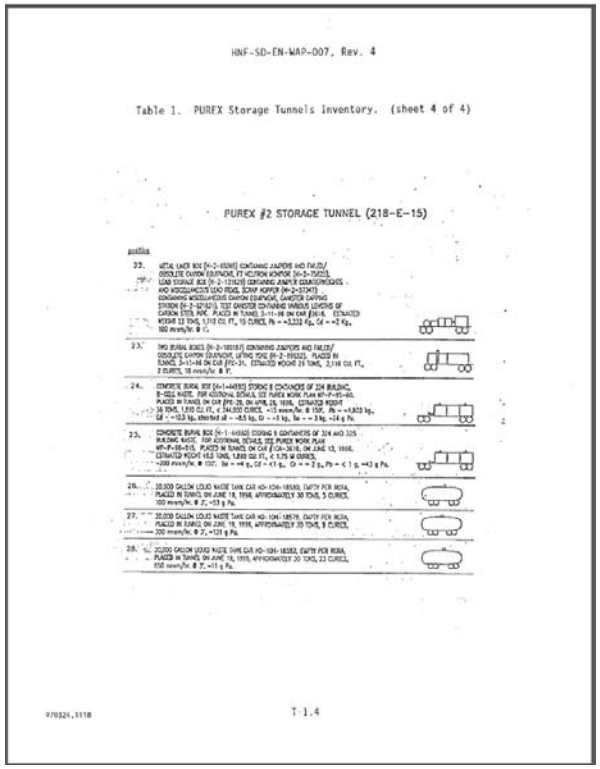

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Table 1. PUREX Storage Tunnels Inventory. (sheet 4 of 4)

PUREX #2 STORAGE TUNNEL (218-E-15)

position

22. METAL LINER BOX (H-2-85015) CONTAINING JUMPERS AND FAILED/ OBSOLETE CANYON EQUIPMENT, FT VICTORIA HOOPER (H-2-75835), LEAD STORAGE BOX (H-2-101828) CONTAINING JUMPER CONNECTORS AND MISCELLANEOUS LEAD PIECES, SCRAP HOPPER (H-2-32347) CONTAINING MISCELLANEOUS CANYON EQUIPMENT, CANISTER CAPPING STATION (H-2-32127), TEST CANISTER CONTAINING VARIOUS LENGTHS OF CARBON STEEL PIPE. PLACED IN TUNNEL 3-11-94 ON CAR #3614. ESTIMATED WEIGHT 22 TONS, 1,710 CU. FT., 15 CURIES, Pb ~ -3,222 Kg, Cd ~ -2 Kg, 100 mrem/hr. @ 1'.
23. TWO BURIAL BOXES (H-2-100187) CONTAINING JUMPERS AND FAILED/ OBSOLETE CANYON EQUIPMENT, LIFTING YOKE (H-2-101822). PLACED IN TUNNEL 3-11-94 ON CAR #72-34. ESTIMATED WEIGHT 24 TONS, 2,114 CU. FT., 2 CURIES, 18 mrem/hr. @ 1'.
24. CONCRETE BURIAL BOX (H-1-44493) STORING 8 CONTAINERS OF 324 BUILDING B-CELL WASTE. FOR ADDITIONAL DETAILS, SEE PUREX WORK PLAN WP-P-95-40. PLACED IN TUNNEL ON CAR (PX-28, ON APRIL 28, 1998. ESTIMATED WEIGHT 36 TONS, 1,850 CU. FT., < 34,000 CURIES. <15 mrem/hr. @ 100'. Pb ~ -1,832 kg, Cd ~ -103 kg, shielded Al ~ -63 kg, U ~ -1 kg, Be ~ -3 kg, -24 g Pu.
25. CONCRETE BURIAL BOX (H-1-44502) STORING 9 CONTAINERS OF 324 AND 325 BUILDING WASTE. FOR ADDITIONAL DETAILS, SEE PUREX WORK PLAN WP-P-98-015. PLACED IN TUNNEL ON CAR (CA-3618, ON JUNE 13, 1998. ESTIMATED WEIGHT 43.5 TONS, 1,850 CU. FT., < 1.75 M CURIES. <200 mrem/hr. @ 100'. Be ~ -4 g, Cd ~ -1 g, U ~ -2 g, Pb ~ < 1 g, ~43 g Pu.
26. 30,000 GALLON LIQUID WASTE TANK CAR H2-104-18589, EMPTY FOR BURIAL PLACED IN TUNNEL ON JUNE 18, 1998, APPROXIMATELY 30 TONS, 5 CURIES. 100 mrem/hr. @ 2', ~53 g Pu.
27. 30,000 GALLON LIQUID WASTE TANK CAR H2-104-18579, EMPTY FOR BURIAL PLACED IN TUNNEL ON JUNE 18, 1998, APPROXIMATELY 30 TONS, 5 CURIES. 200 mrem/hr. @ 2', ~131 g Pu.
28. 30,000 GALLON LIQUID WASTE TANK CAR H2-104-18583, EMPTY FOR BURIAL PLACED IN TUNNEL ON JUNE 18, 1998, APPROXIMATELY 30 TONS, 23 CURIES. 850 mrem/hr. @ 2', ~11 g Pu.

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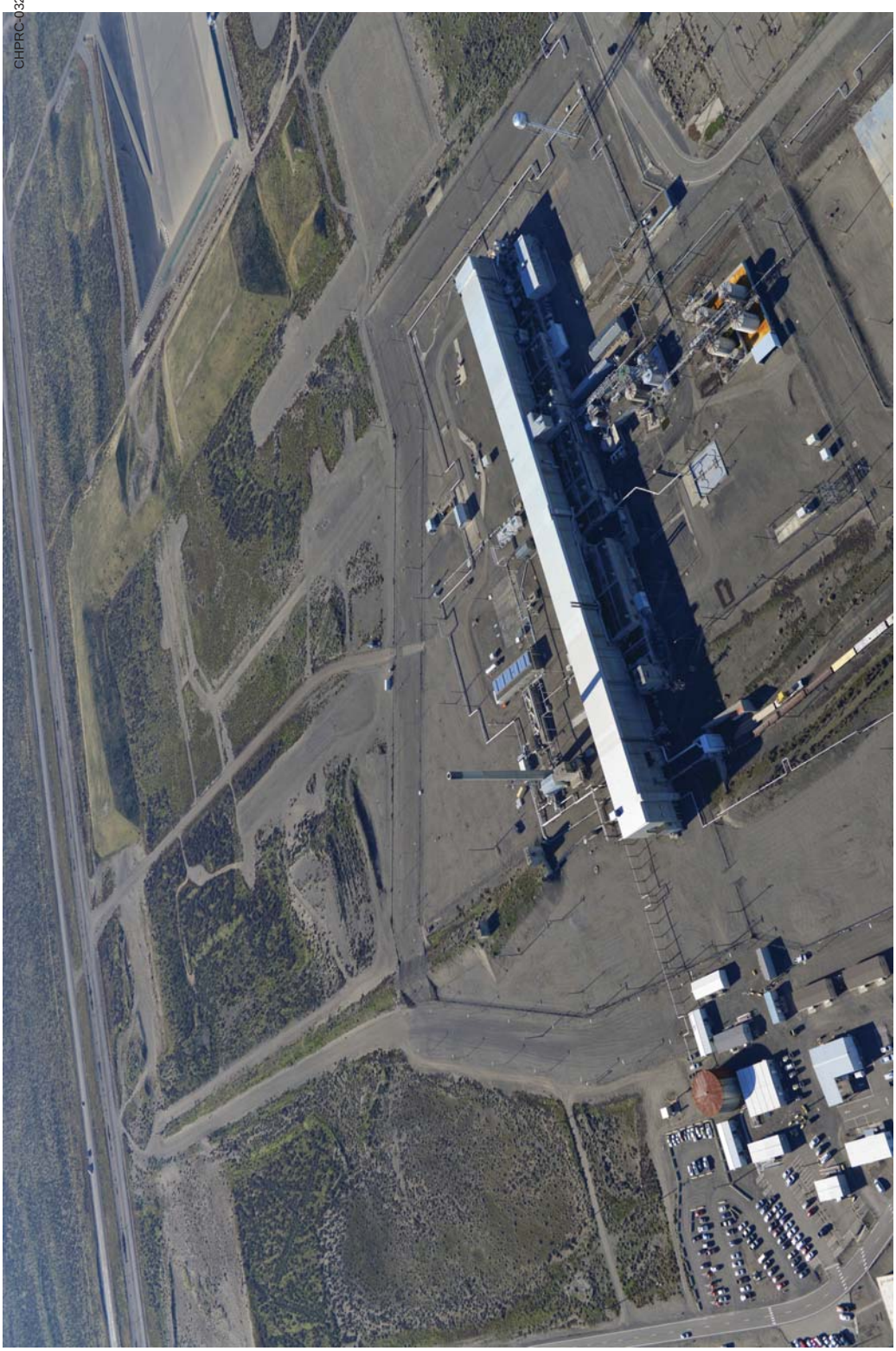
CURRENT CONFIGURATION 2016



1996 – TUNNEL NO. 2 HVAC DEACTIVATED

2016 - TUNNEL NO. 1 HVAC STACK CURRENT CONFIGURATION

- Operations Video

- Video PUREX 1 ~ Crane Movement, Failed Equipment
- Video PUREX 2 ~ Operations

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DATE September 1980 COPY NO.

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Rockwell Hanford Operations
Richland, WA 99352

TITLE AND AUTHOR

STRUCTURAL EVALUATION OF THE PUREX NO. 1 BURIAL TUNNEL

G. R. Silvan

DISTRIBUTION

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B. F. Campbell	202A/200E	R. J. Thompson	2750E/200E
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AN EVALUATION OF THE STRUCTURAL INTEGRITY OF PUREX STORAGE TUNNEL #1

SUBMITTED TO
WESTINGHOUSE HANFORD COMPANY

MAY 1991

Los Alamos Technical Associates, Inc.
P. O. Box 410 / 1650 Trinity Drive / Los Alamos, NM 87544 / (505) 662-9080