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Proposal to Cease Waste Removal Activities in Tank 16 and Enter Sampling and Analysis Phase

Presentation to DOE-SR, SCDHEC and EPA

April 1, 2013

Final Package Incorporating Comments from South Carolina Department of Health and Environmental Control and the U.S. Environmental Protection Agency

(Originally presented on March 12, 2013)

SRR-CWDA-2013-00041, Revision 1

Presentation Outline

- Meeting Objective
- Uniqueness of Tank 16
- Limited Service Life of Tank 16
- Waste Removal History and Results
- Additional Cleaning Considerations
- Request for DOE/DHEC/EPA Concurrence

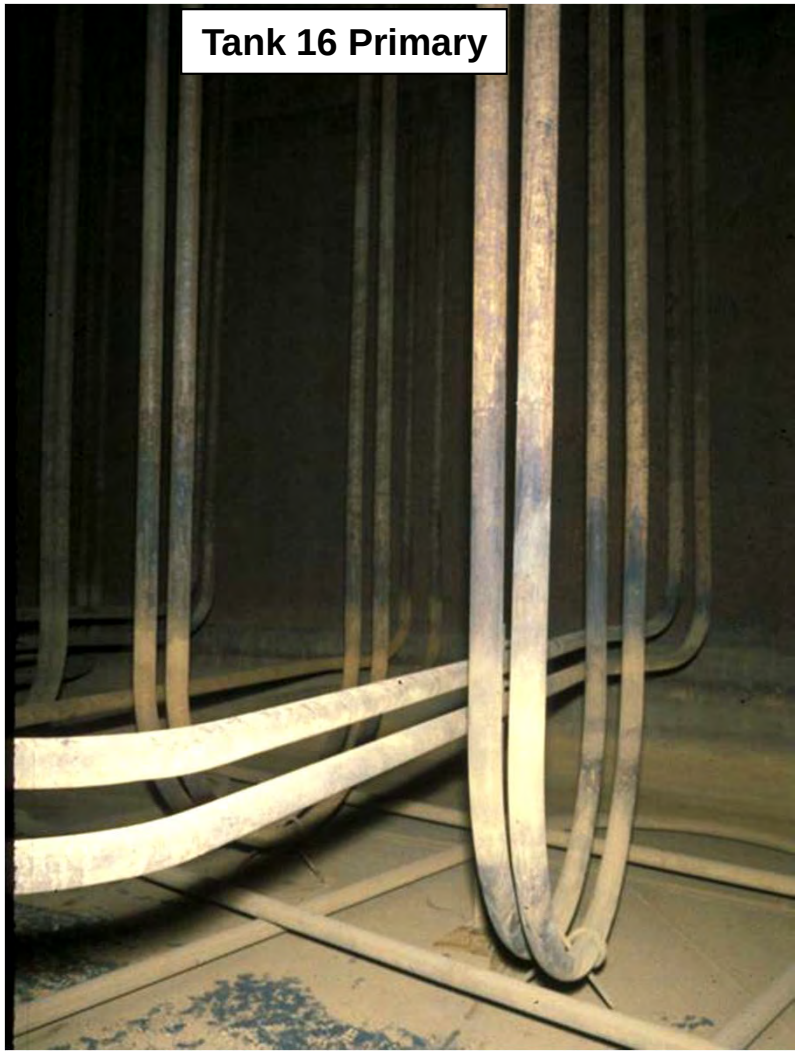
Acronyms

CSR	Chemical Sludge Removal
EOI	Expression of Interest
GCP	General Closure Plan
gpm	gallons per minute
HM	H-Modified (H-Canyon Separations Process)
HRR	Highly Radioactive Radionuclide (§3116 term)
IP	Inspection Port
MSR	Mechanical Sludge Removal
NaAlSi	Sodium Aluminosilicate (natrodavyne)
OA	Oxalic Acid
R&D	Research and Development
RFP	Request for Proposal

Purpose of Meeting

Obtain mutual agreement among SCDHEC, the EPA and the DOE to:

1. Suspend waste removal activities in Tank 16; and
2. Enter the sampling and analysis phase in Tank 16 consistent with the *Liquid Waste Tank Residuals Sampling and Analysis Plan*



Common Goals & Values

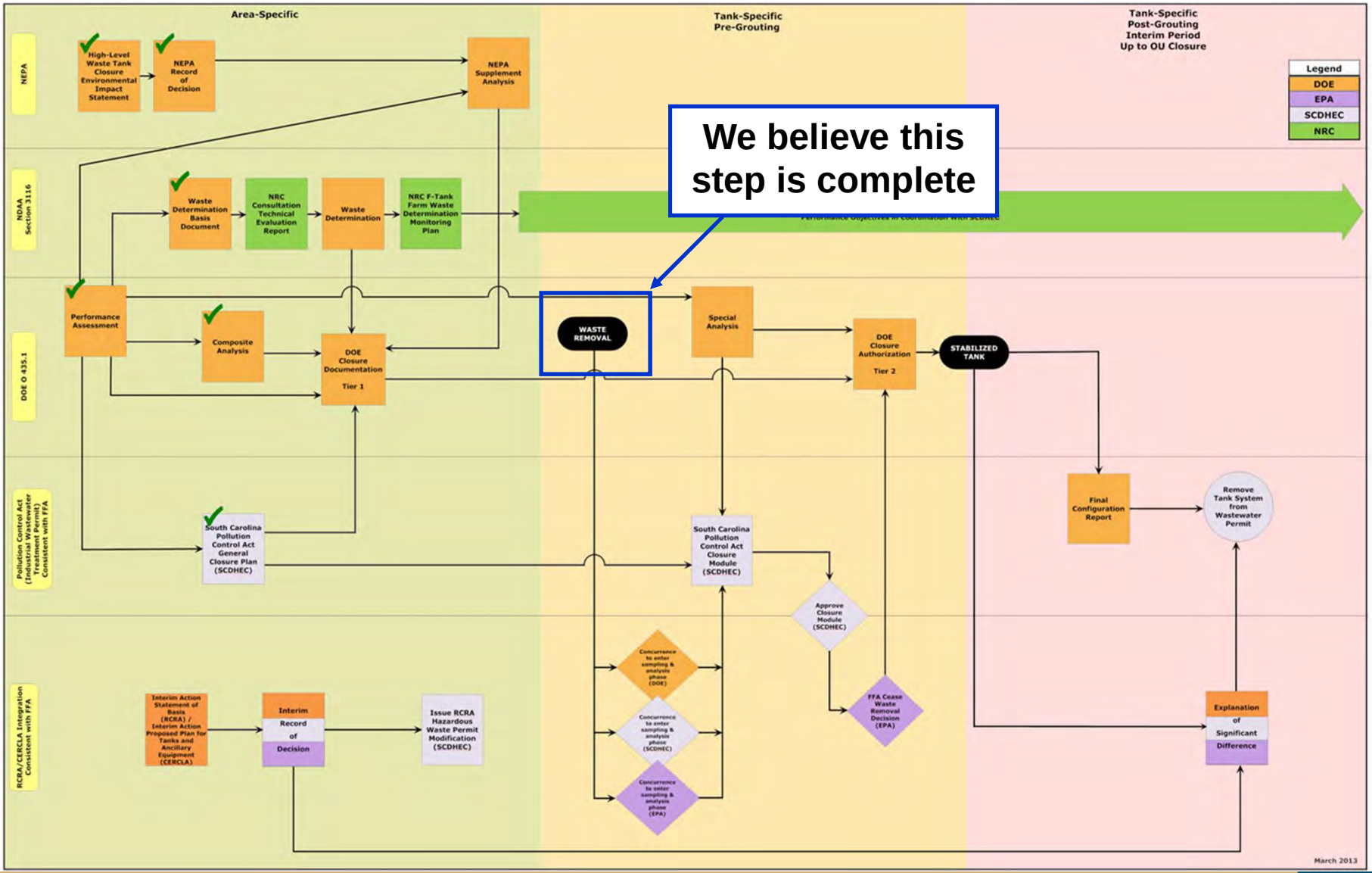
1. **Reduce operational risk and the risk of leaks to the environment by removing waste from tanks, and closing the tanks.**
2. Remove actinides from waste expeditiously since they impact on the environment most significantly if a leak occurs.
3. Maximize amount of waste ready for disposal in deep geologic repository. Make significant effort to ensure maximum amount of long lived radionuclides are disposed in a deep geologic repository.
4. Remove as much cesium as practical from salt waste and dispose in parallel with vitrified sludge.
5. Dispose of cesium as soon as practical to avoid having cesium only waste when sludge vitrification is complete.
6. Limit disposal of radioactive waste onsite at SRS so that residual radioactivity is as low as reasonably achievable.
7. Ensure DOE's strategy and plans are subject to public involvement and acceptance.

Appendix L

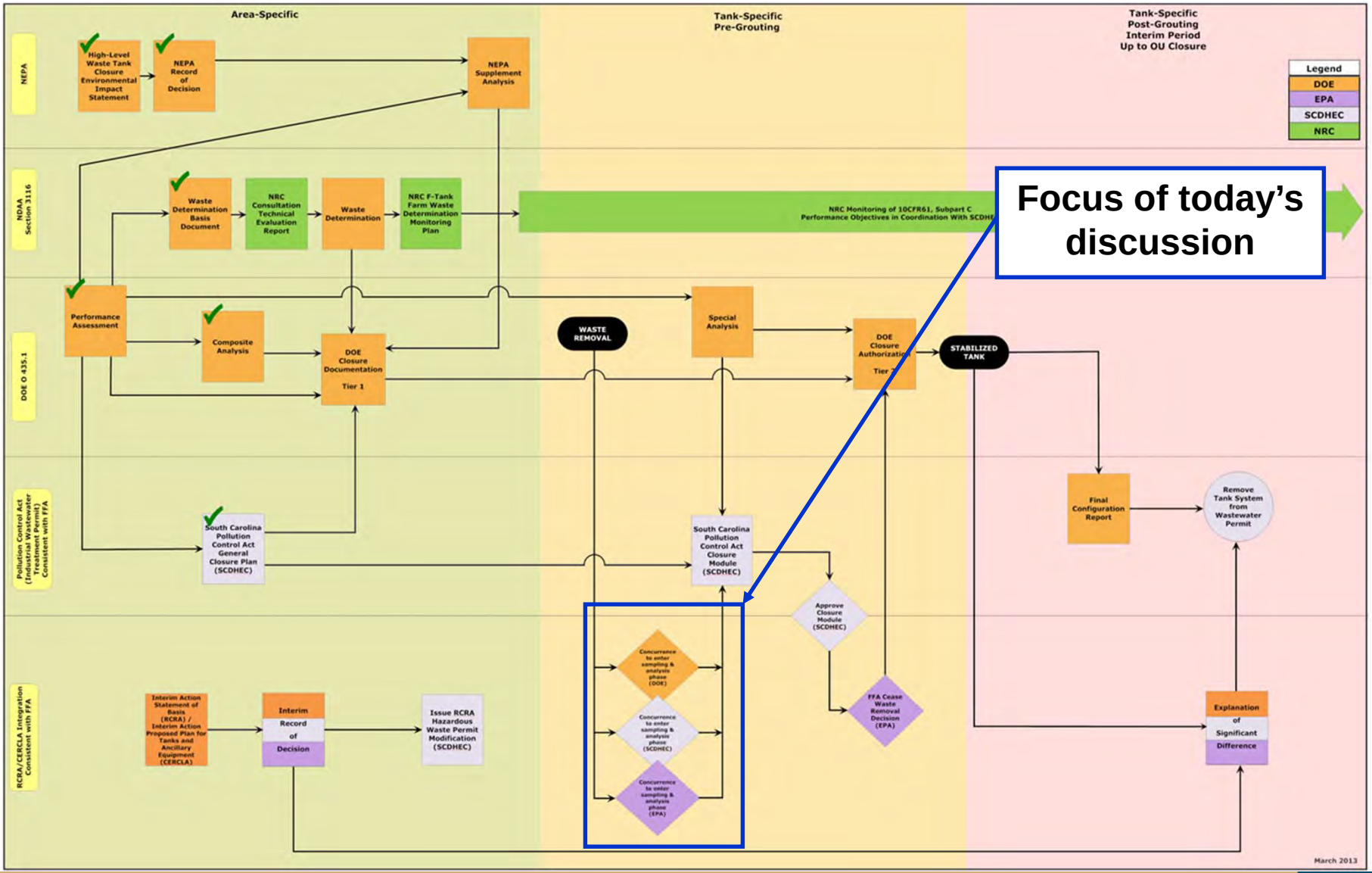
9b. When DOE considers waste removal to be complete, DOE shall notify EPA and SCDHEC and provide any supporting documentation to SCDHEC and EPA for review. DOE, SCDHEC and EPA shall mutually agree that waste removal activities may cease

*Footnote 1: Bulk waste removal activities are complete on tanks 17, 20, 18, 19, 5, 6, and **16** and are therefore not included in paragraphs 2 through 8 above. Tanks 17 and 20 are operationally closed.*

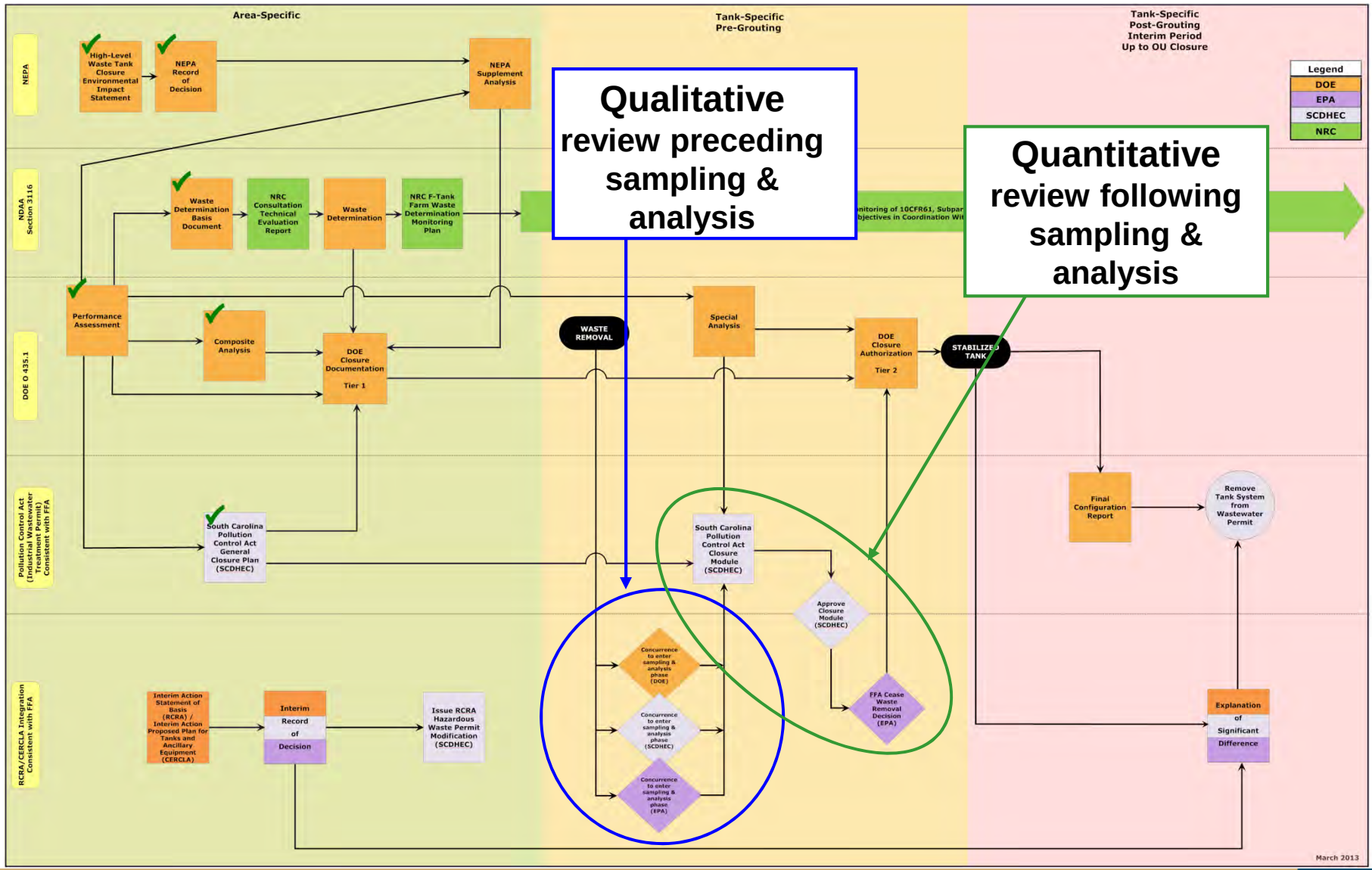
Pathway to Closure



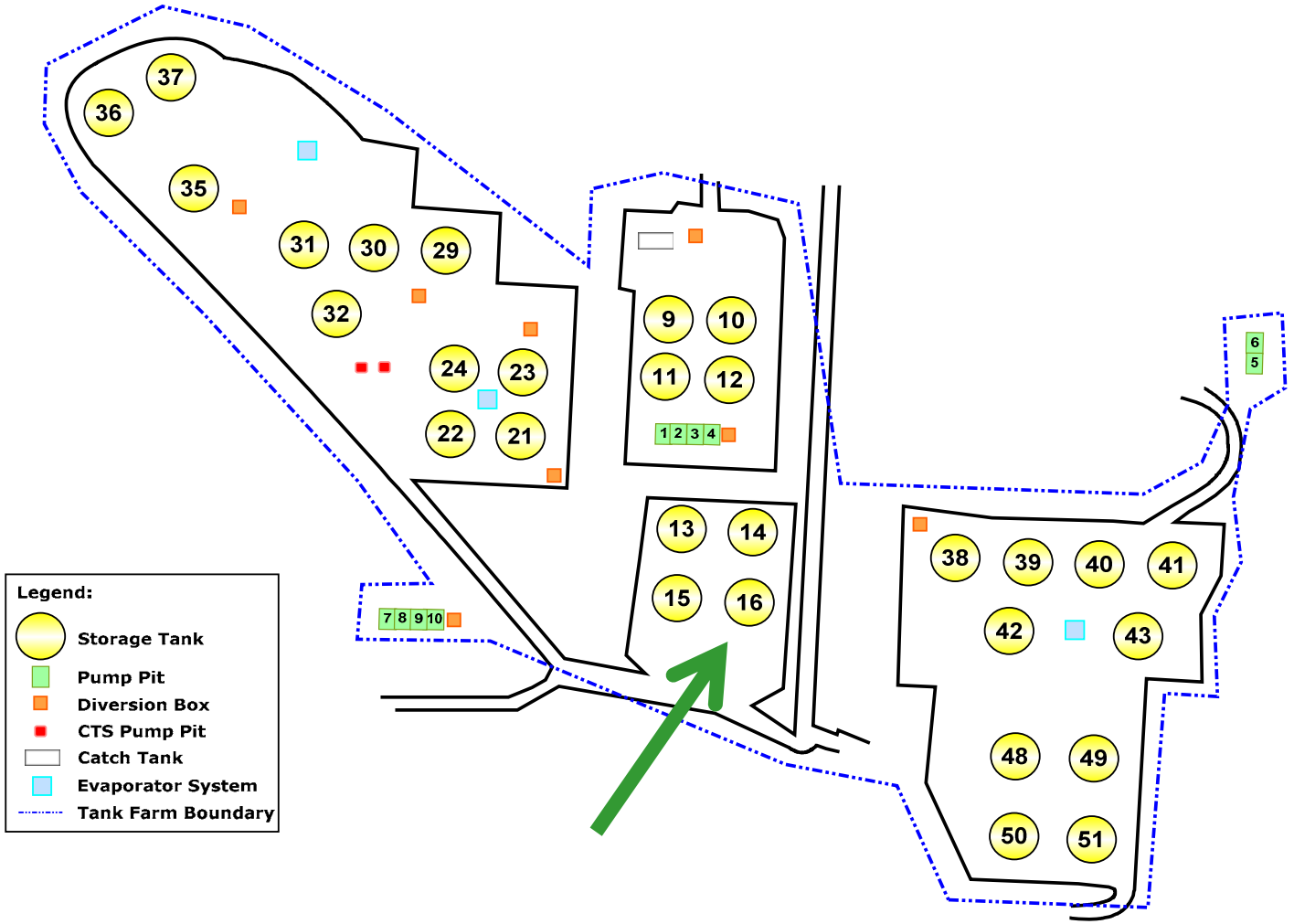
Pathway to Closure



Pathway to Closure



H-Tank Farm Layout



[NOT TO SCALE]

H-Tank Farm

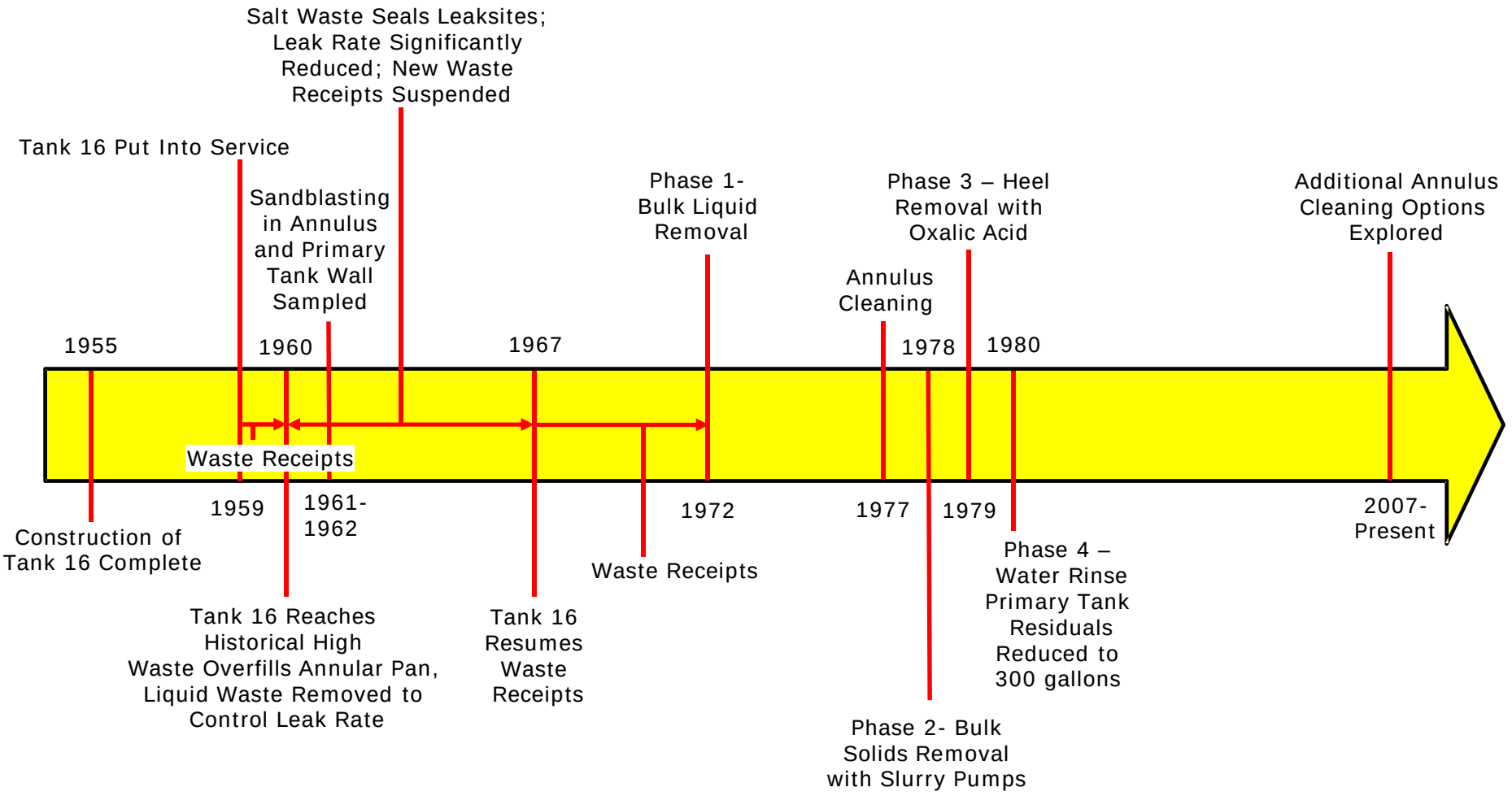
Tank 16 Tank Top Today

N

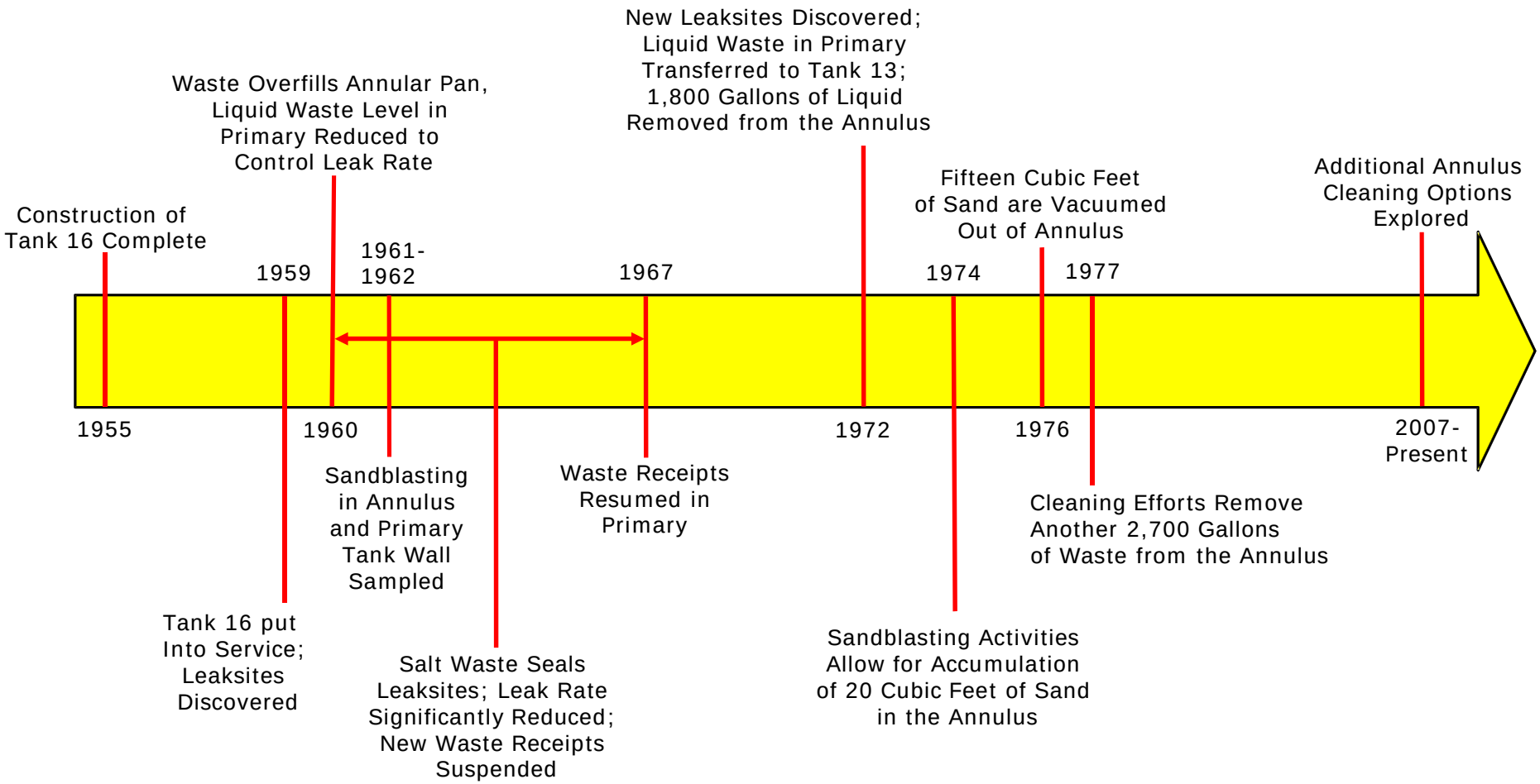
Tank 16 Is Unique

- Leakage into the annulus was discovered within six months of first receiving waste
  - Served as waste receiver tank for a single cycle; relatively small amount of sludge solids formed
- ~ 350 individual leak sites were identified on the primary walls
- Extensive examination of the tank welds was performed to understand failure mechanisms
  - Extensive sandblasting occurred in the annulus
  - Introduced over 20 ft^3 of sand into the annulus
  - Insoluble NaAlSi compounds formed in annulus

Tank 16 Timeline



Tank 16 Annulus Timeline



Tank 16 Is Unique

- Tank 16 cleaning was performed as a demonstration project
  - Introduced the use of slurry mixer pumps
  - Introduced the use of bulk oxalic acid cleaning
- Tank has been out of service for over 40 years
  - Support services never upgraded
- The current restrictions related to nuclear safety were not in place at the time

The extraordinary success seen in cleaning the primary tank and the NaAlSi compounds presented in the annular spaces of Tank 16 are unique and are not indicative of future tank conditions or likely endpoints

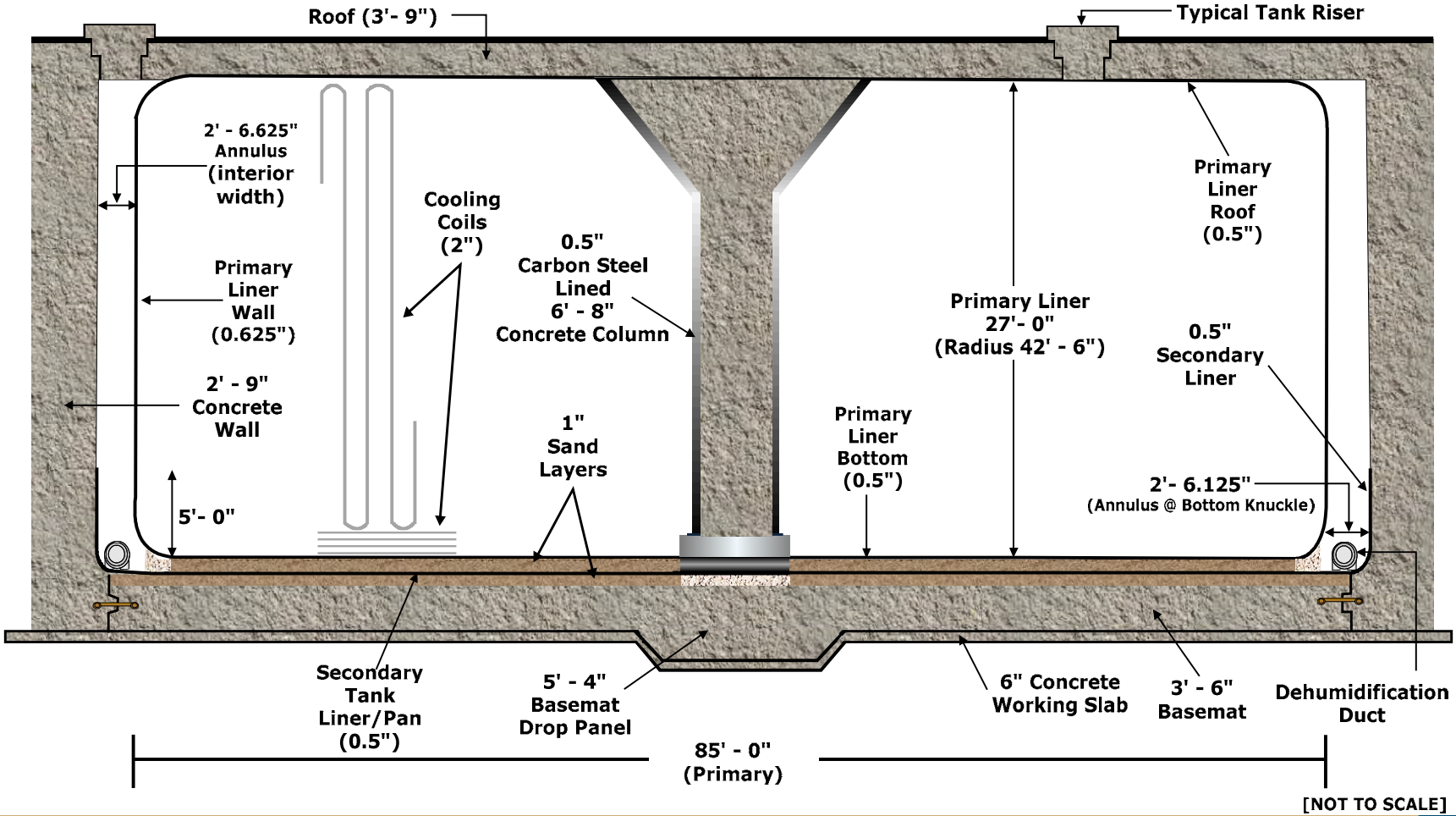
Type II Waste Tank

- Carbon steel construction; flat-bottomed tank
- Primary tank and annular pan sit on sand pads
- Nominal tank capacity: 1,030,000 gallon
- Usable tank space: 27’ high x 85’ diameter
- 90’ diameter x 5’ high annular pan
- 40 vertical cooling coils supported by roof hangers plus 4 horizontal floor coils

Tanks not designed with waste removal in mind

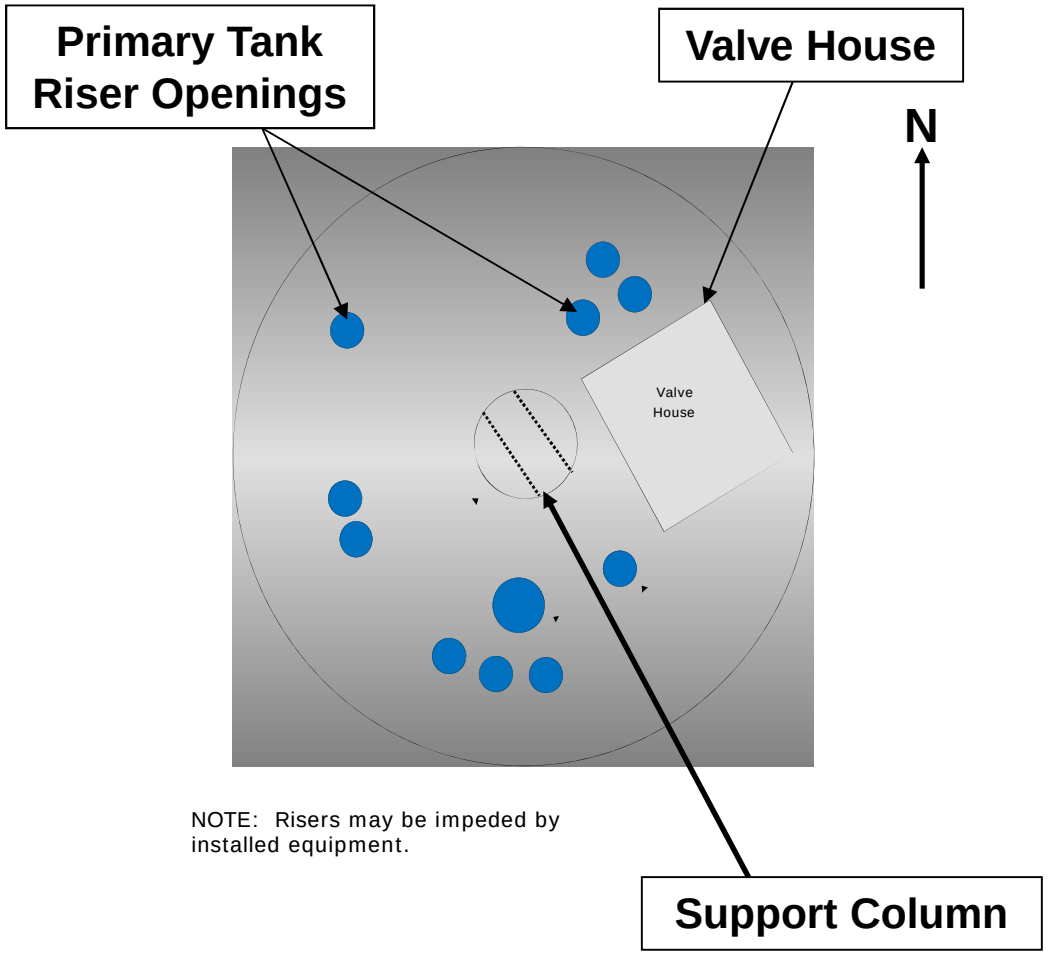
Type II Waste Tank

All four Type II tanks are located in HTF – Tanks 13 - 16



Typical Type II Tank Top Openings

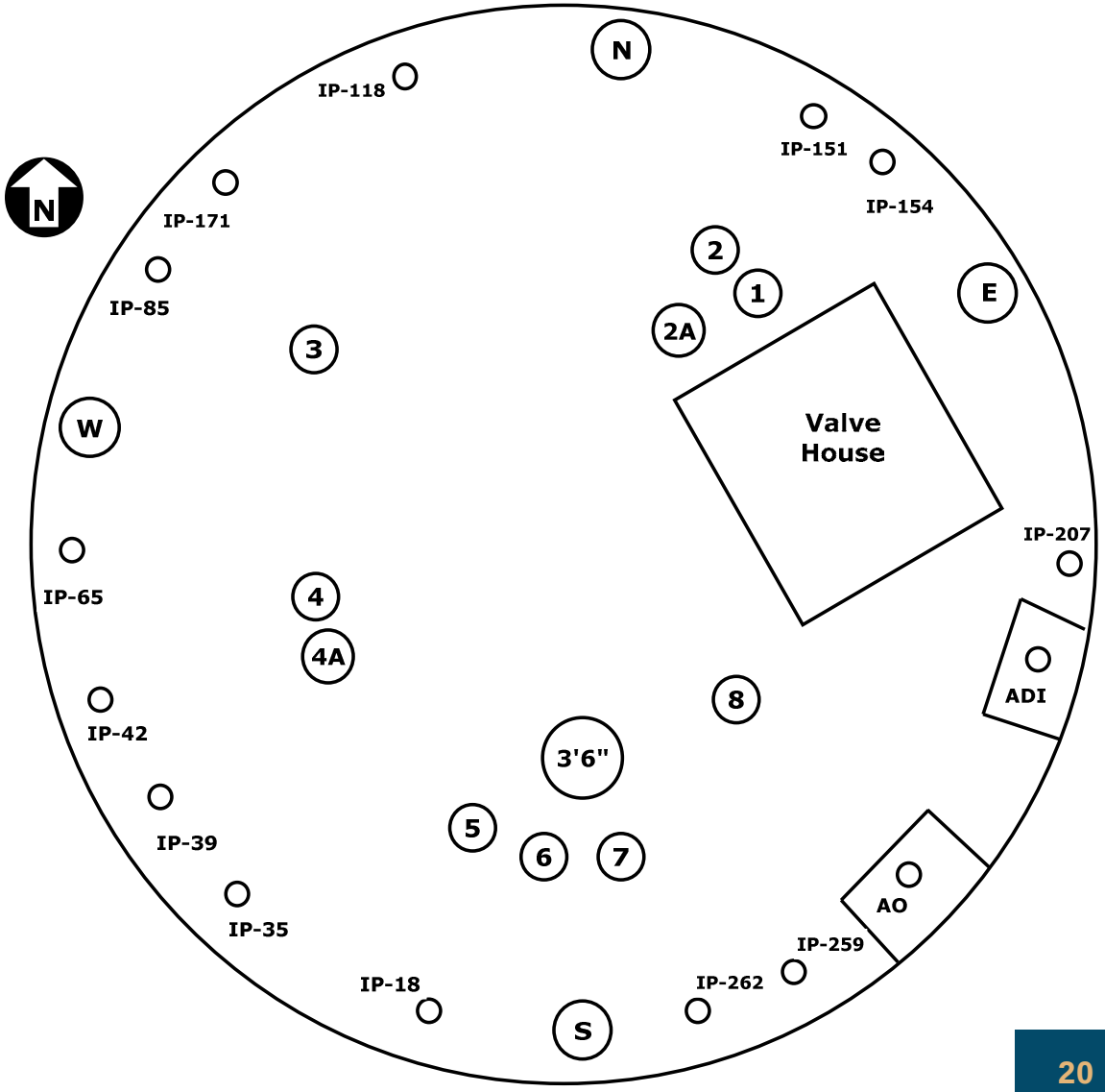
- Primary access
  - Ten 24” risers
  - One 3’6” riser
- Annulus access
  - 4 risers (24”)
- Limited riser entrances hinder
  - Pump placement
  - Cleaning operations
  - Camera viewing
  - Sampling options



NOTE: Risers may be impeded by installed equipment.

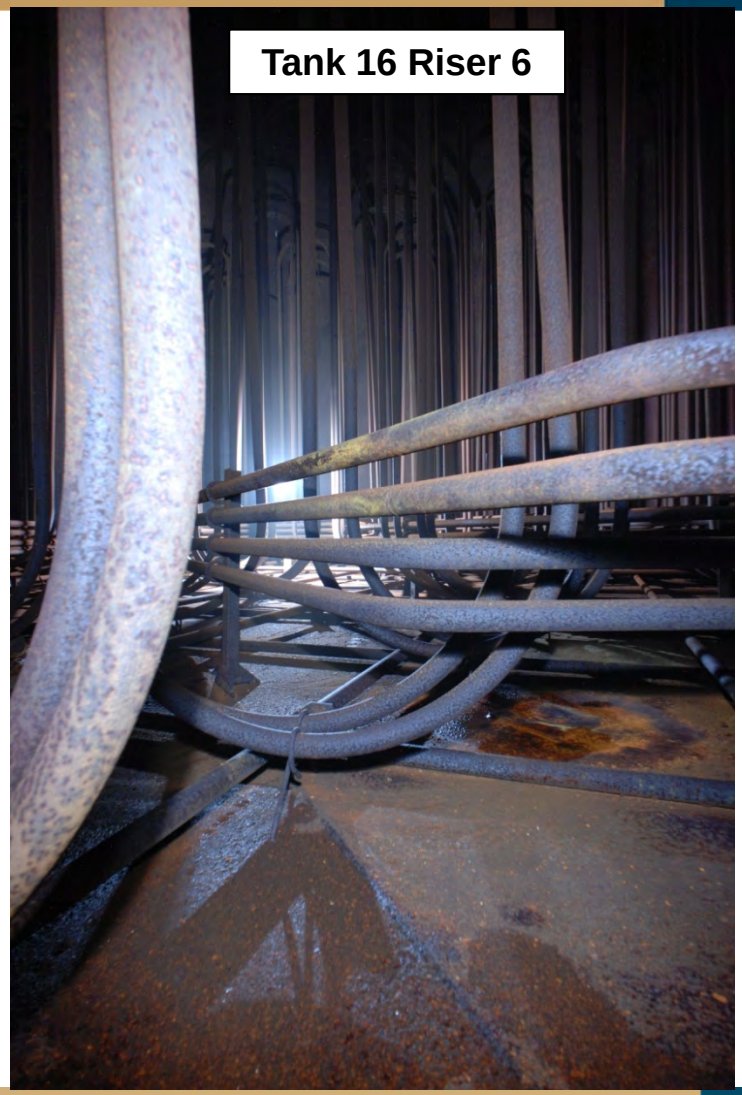
Tank 16 Tank Top Openings

Tank 16 is unique. Thirteen additional 6” diameter inspection ports (IP) were added to the annulus to permit better observation access following discovery of active leak sites.



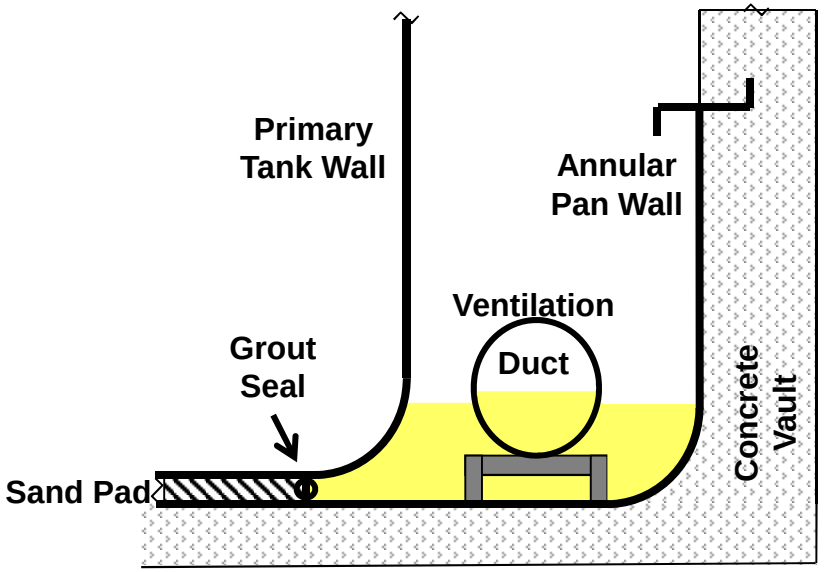
Tank 16 Cooling Coils

Type II tanks contain ~30,000 linear feet of 2-inch diameter cooling coils that run both horizontally and vertically within the tank. The installation of the coils were "field-to-fit"



Tank 16 Annular Region

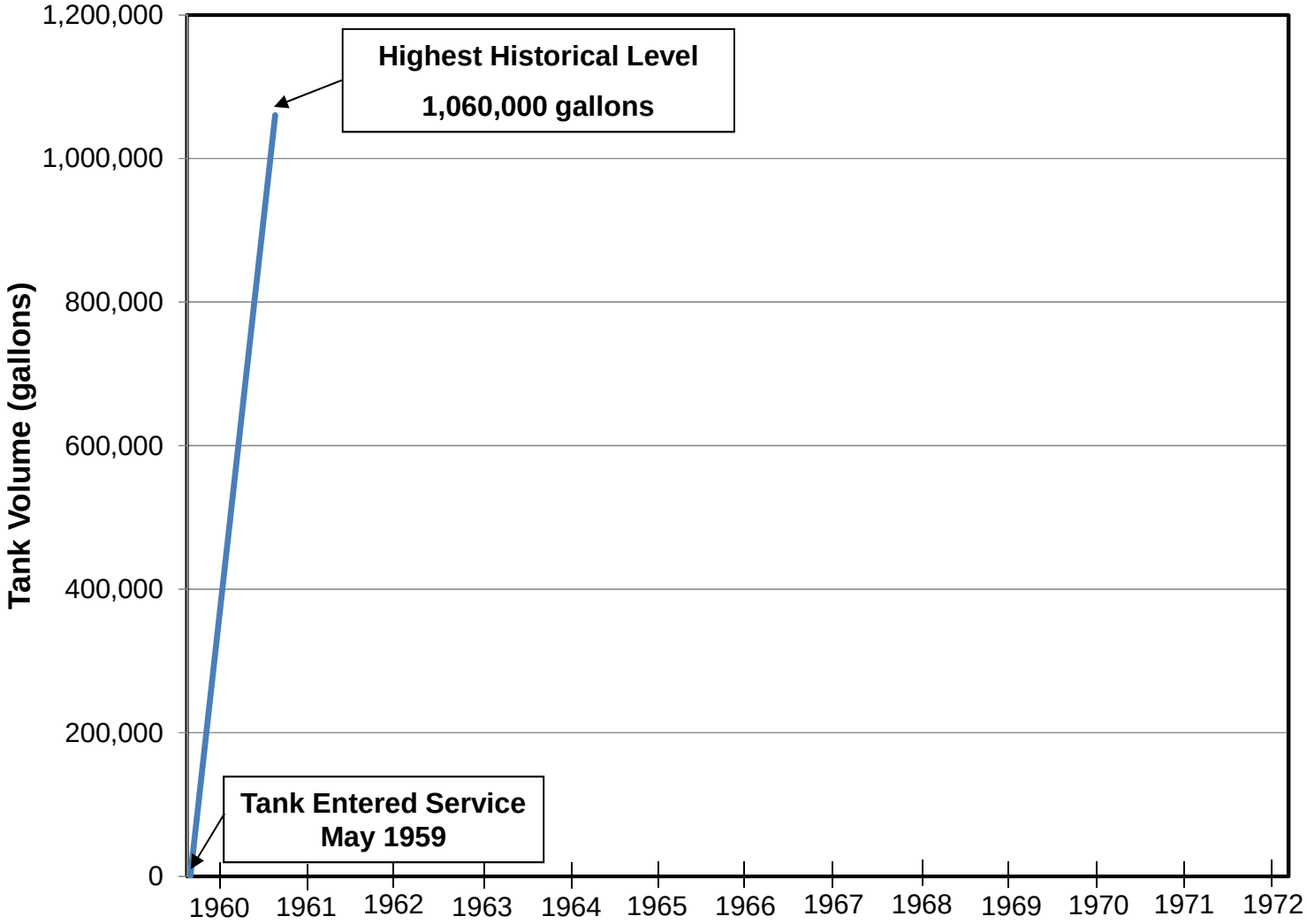
5-foot high, 90-foot diameter annular pan provides secondary containment



Tank 16 Limited Service

- 1955-56: Tanks constructed
  - One of the four Type II tanks
- May 1959: First receipt of waste
  - H Canyon high-heat waste from HM (H-Modified) process
- Nov 1959: First confirmed leak into annulus
  - Liquid below North & South risers; solids on wall
- May 1960: Tank filled to capacity (303”)

Tank 16 Limited Service



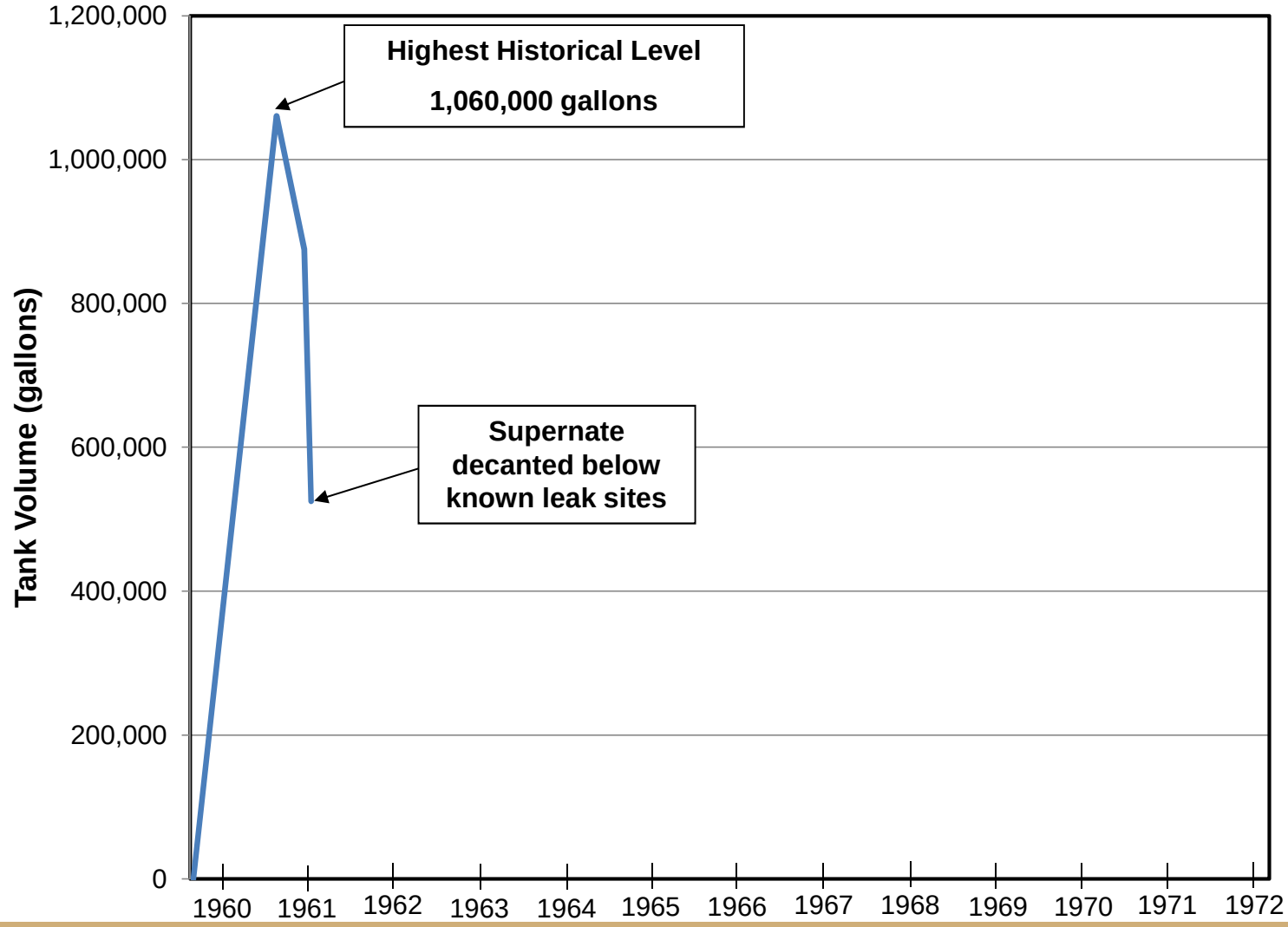
Tank 16 Limited Service

- Sept 7, 1960: Annulus found to have 4.5 feet of liquid
  - Leak rate determined to be 1.5 gallons/minute
  - Emergency actions taken to fabricate and install a transfer system
- Sept 8, 1960: Liquid level rose ~ 2" above the annulus pan
  - Estimated 700 gallons was above the annular pan for several hours
  - "A few tens of gallons" escaped the concrete vault and seeped into the surrounding soils

Tank 16 Limited Service

- Sept 9, 1960: Annulus jet was installed in Tank 16
  - Annulus liquid jetted to Tank 14
  - Leak rate peaked at 4 gallons/minute
  - Estimated 185,000 gallons had leaked in the annulus and had been transferred to Tank 14
- Oct 1960: Jet was installed in the primary and ~350,000 gallons was transferred to Tank 15
  - Leakage stopped at this time
  - Leak sites believed to be at or above 147”

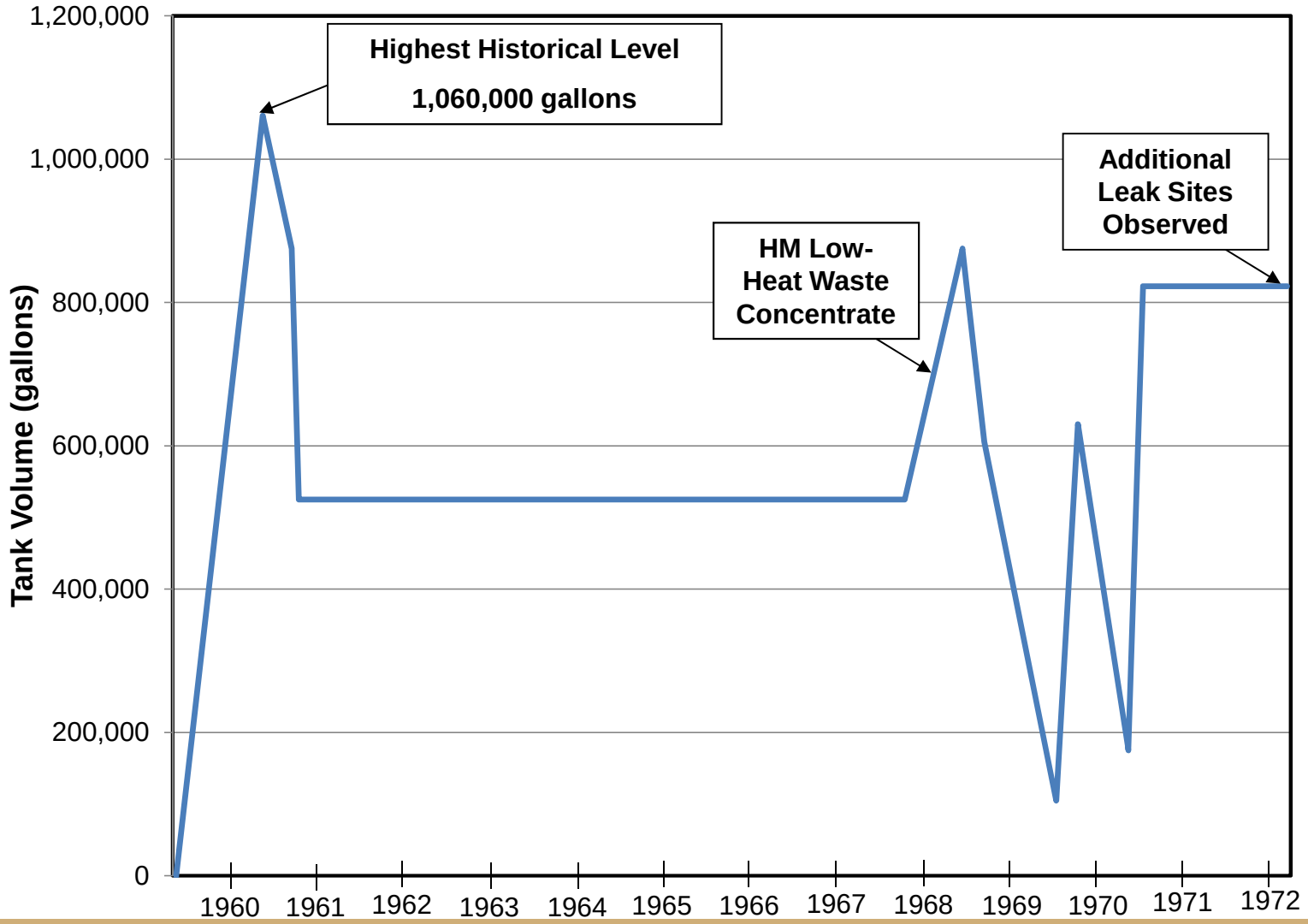
Tank 16 Limited Service



Tank 16 Limited Service

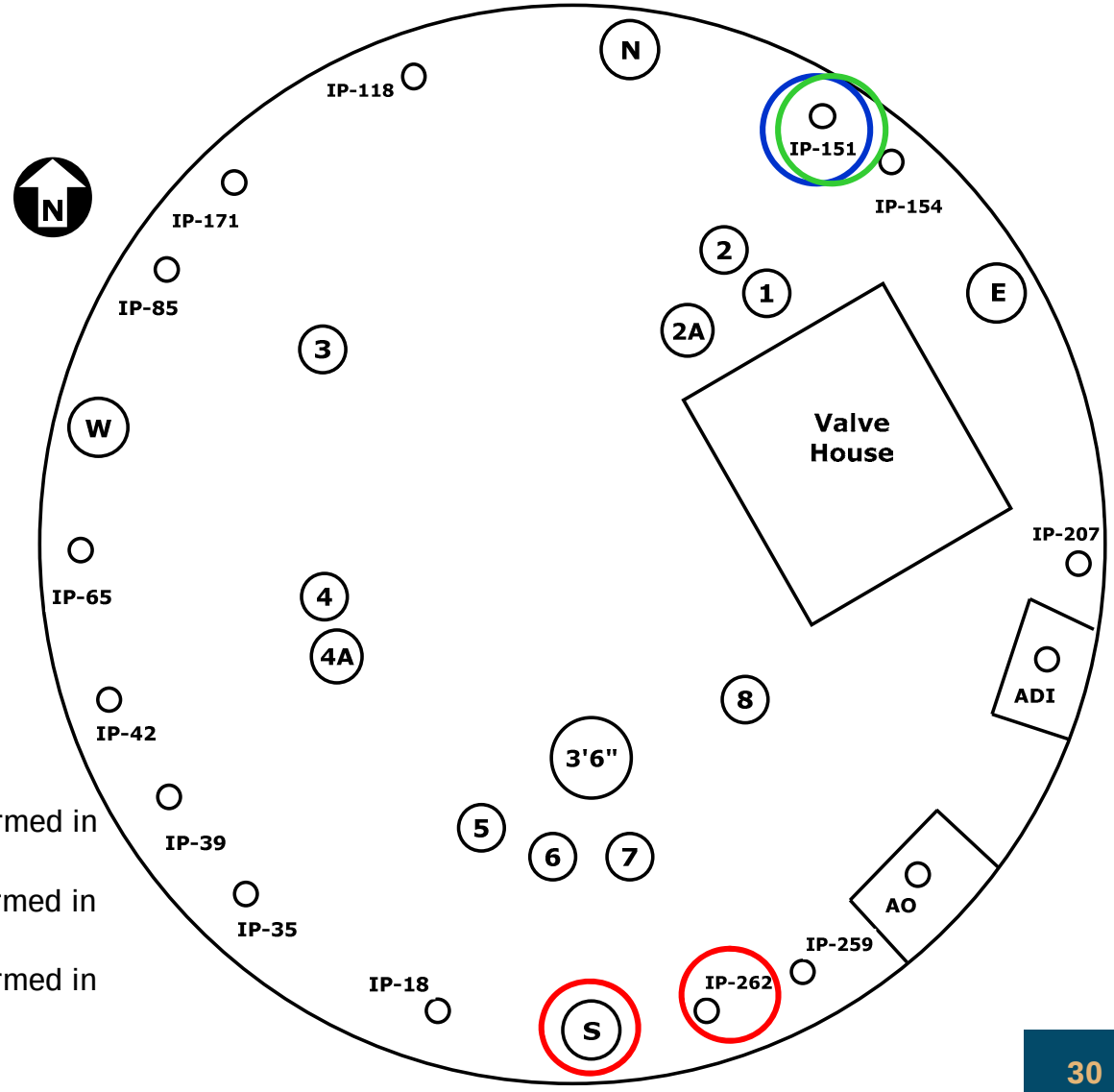
- 1961-62: Extensive testing performed
  - Thirteen annulus inspection ports added
  - Sandblasting of weld sites; introduced silica to annulus
  - Two 5¾" diameter primary tank wall samples taken
- Oct 1967: Returned tank to active service
  - Low-heat concentrated supernate transferred to tank
- 1968-70: Transfers in and out; liquid level maintained below 252"
- Jan/Feb 1972: Additional active leak sites observed

Tank 16 Limited Service



Sandblasting in Annulus

- Sandblasting was used to prepare the tank wall for inspection and cutting out 5¾ -inch diameter primary tank wall samples
- Sandblasting introduced silica to the existing salt waste in the annulus



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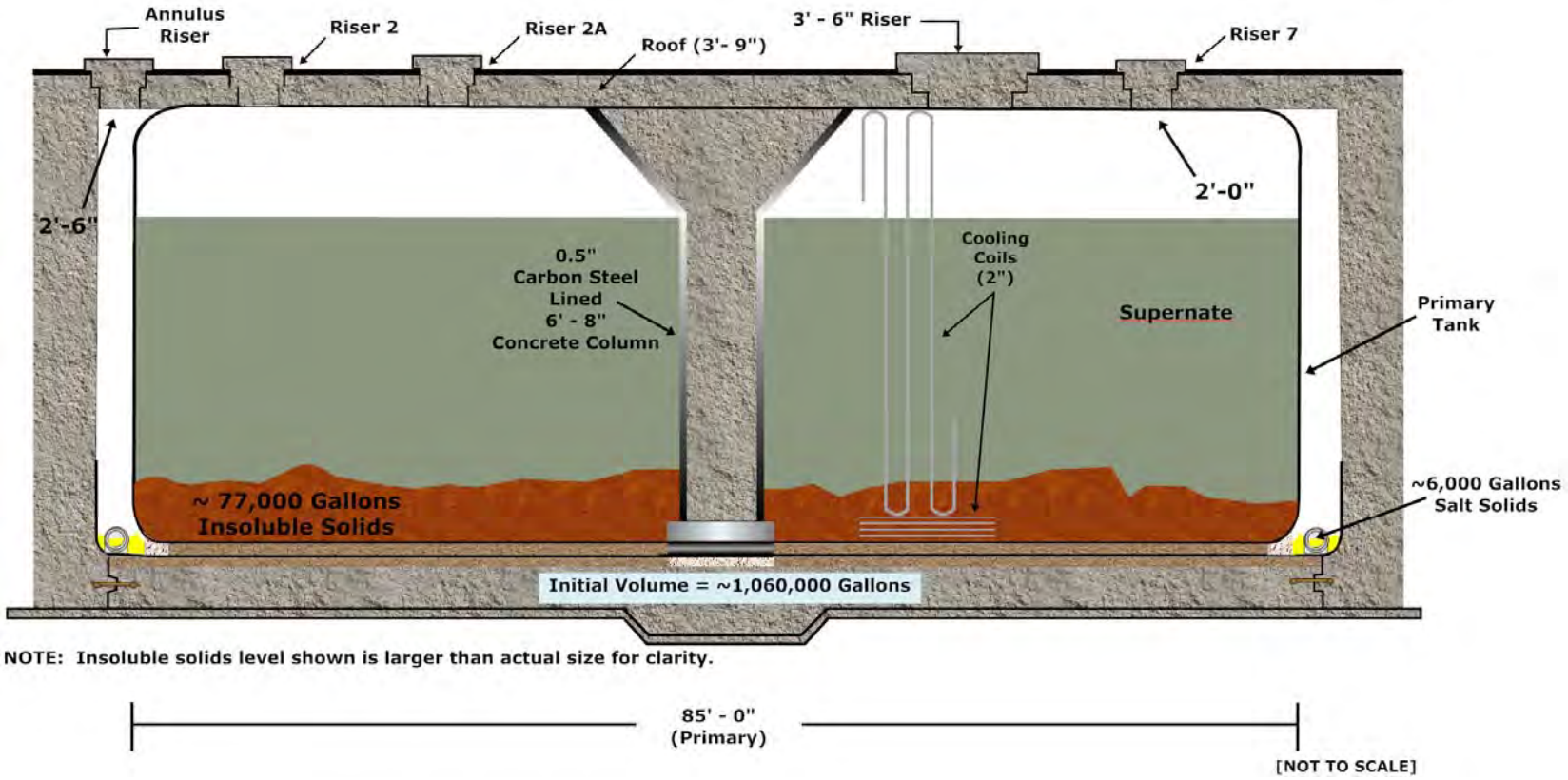
Tank 16 Waste Removal Starting Point



Prior to initiation of waste removal in March 1972:

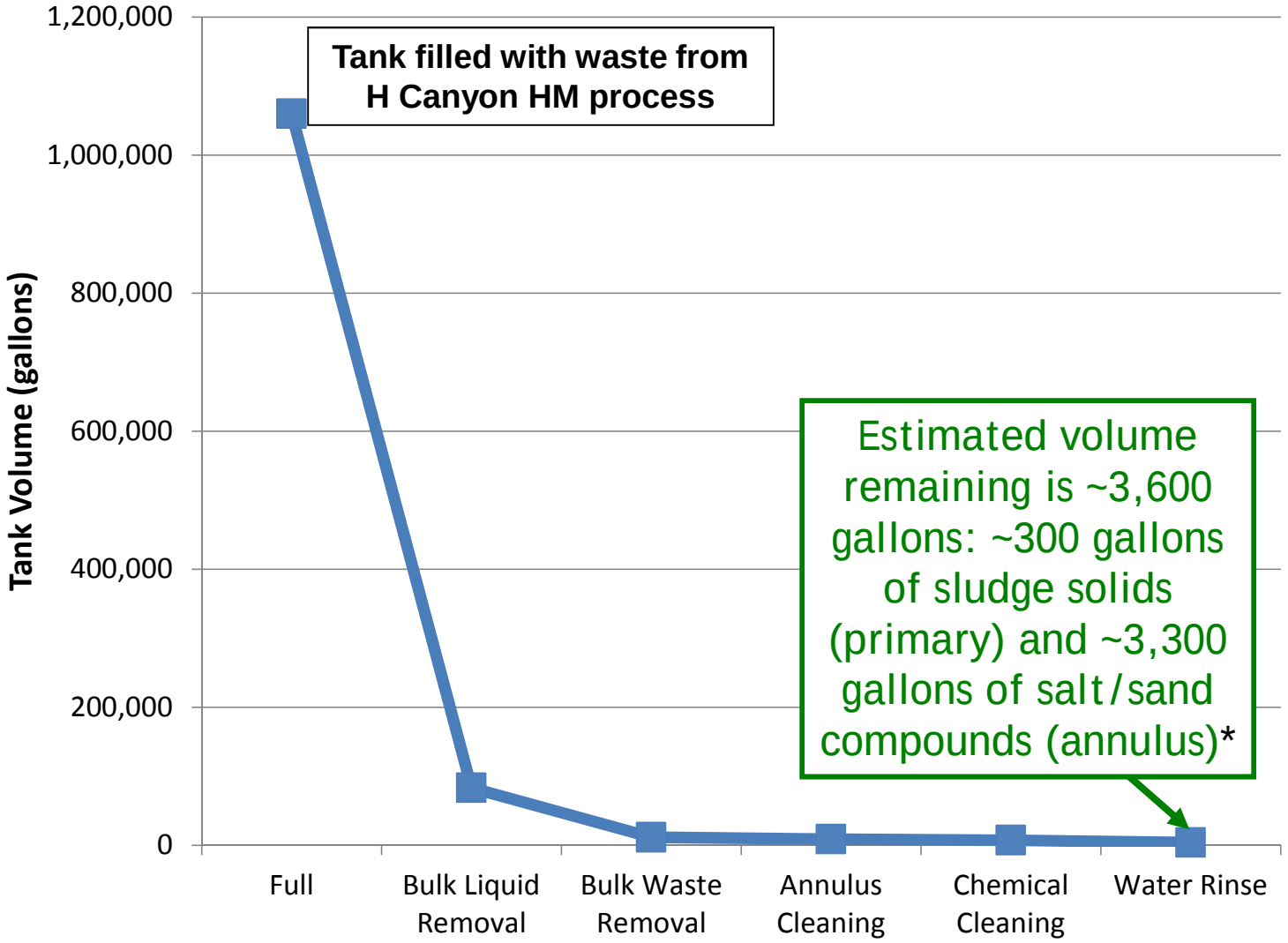
- **768,000 gallons of supernate** (primary)
- **77,000 gallons of insoluble solids** (primary)
- **6,000 gallons of salt/sand compounds** (annulus)

Cleaning Technology Selection

In the early 1970's DuPont selected the following cleaning technologies for Tank 16:

Function	Optimal Technology
Prepare bulk sludge for transfer	Slurry pumps
Prepare heel for transfer	Oxalic acid
Water wash	Spray tool
	Feed and bleed technique
Annulus Cleaning	Steam jets

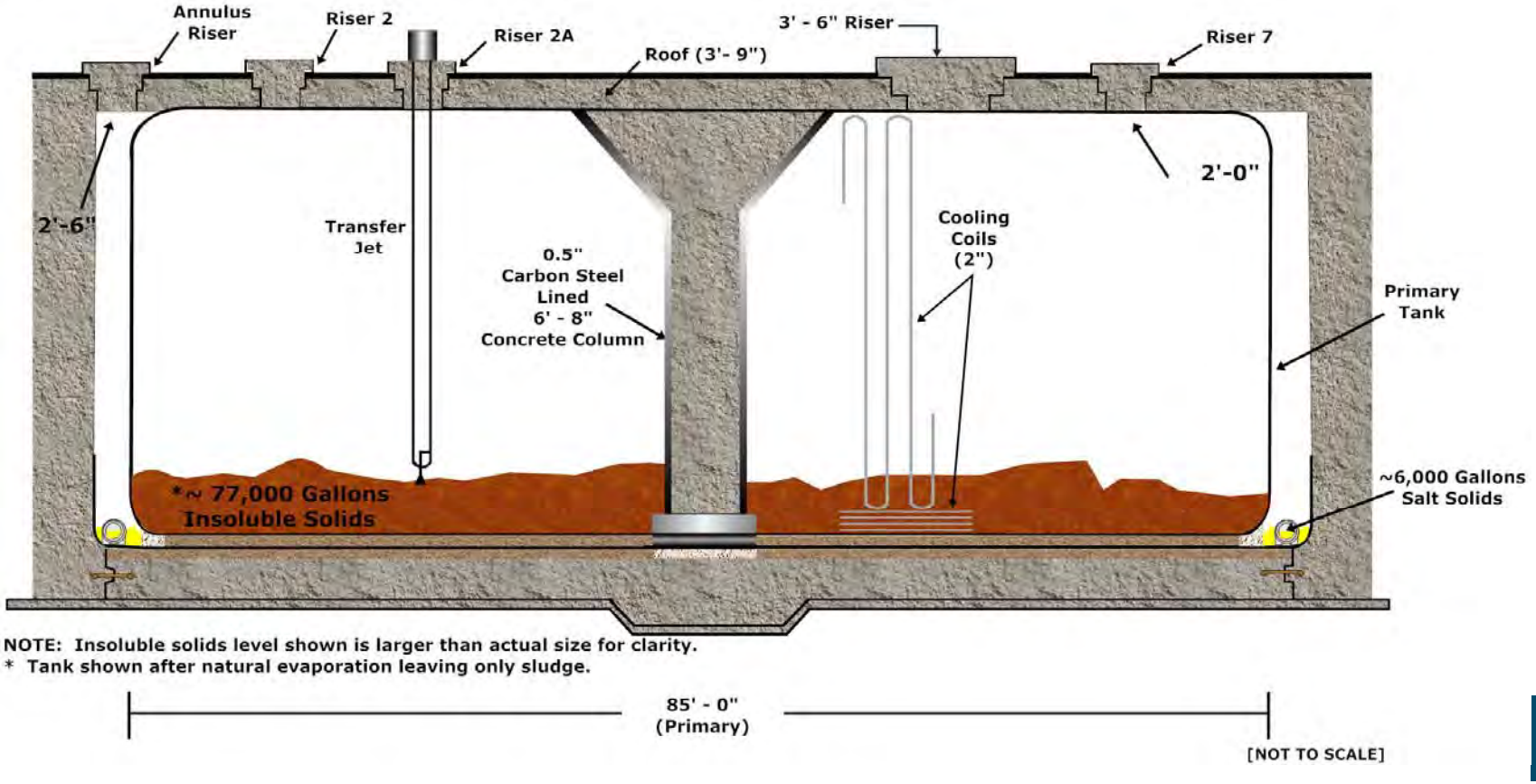
Tank 16 Cleaning History



* The final volume determination will be provided as part of the Tank 16 Closure Module.

Tank 16 Supernate Removal

- Waste removal in Tank 16 began in March 1972
- Approximately 768,000 gallons of supernate was transferred to Tank 13

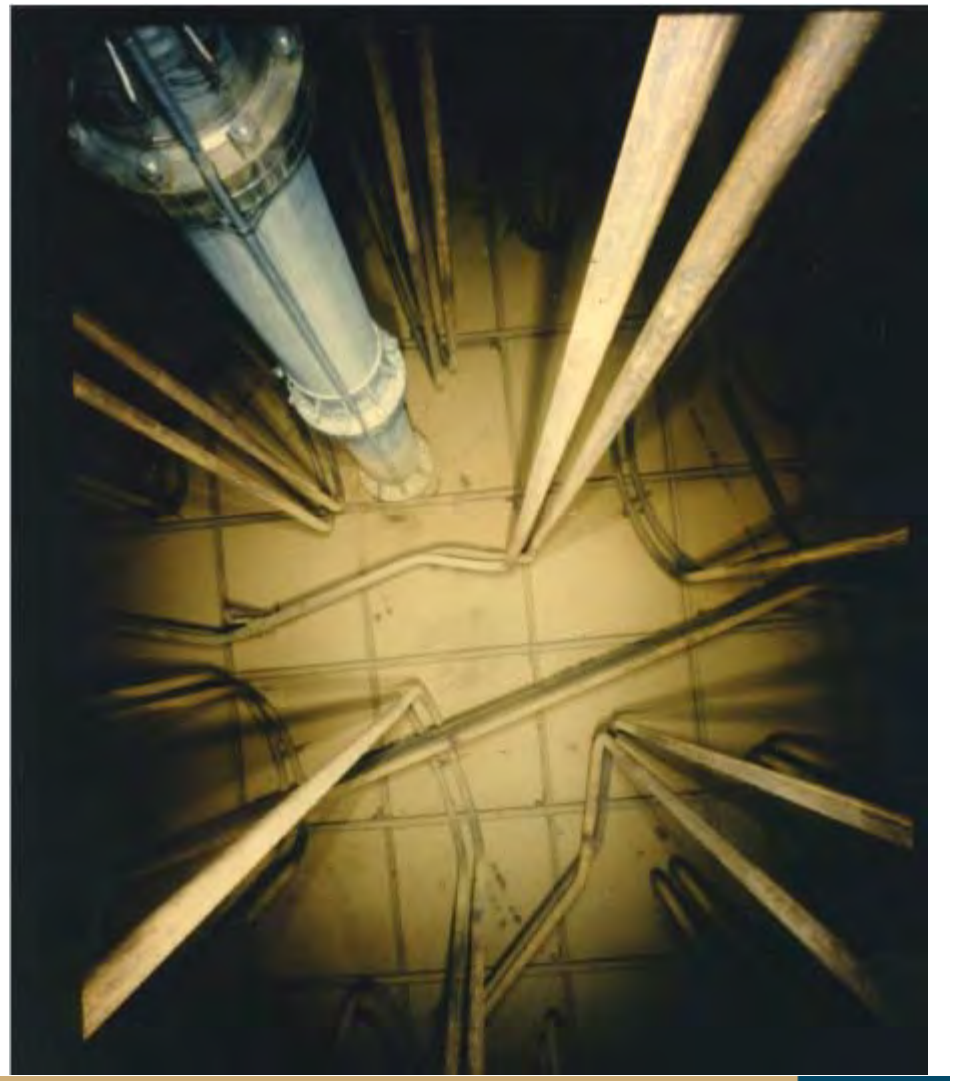


Primary Tank Campaigns

- Mechanical Sludge Removal (MSR)
  - Slurry Pumps used to suspend solids
  - Five mechanical cleaning campaigns
- Chemical Sludge Removal (CSR)
  - Oxalic acid (OA) charged to dissolve remaining solids
  - Four chemical cleaning campaigns
- Water Rinse
  - Rotary spray jets and *Feed and Bleed* process used to rinse tank

Tank 16 MSR Campaigns

- MSR campaign 1 and 2
  - First use of slurry pumps for tank cleaning
  - Single pump used
- MSR Campaigns 3
  - 3 slurry pumps operated in oscillating mode to remove bulk of sludge solids
- MSR Campaigns 4 and 5
  - 3 slurry pumps operated in indexing mode for mound obliteration



MSR Campaign Summary

- First ever application of slurry pumps for waste removal
- Success in bulk solids removal and mound obliteration

Total Starting Solids (gal)	77,000
Total Pump Run Time (hr)	1,153
Total Liquid Introduced into the Tank (gal)	277,200
Total Solids Removed (gal)	71,750
Total Solids Remaining (gal)	**5,250**

Tank 16 CSR Campaigns

- CSR Campaign 1 and 2
  - Two water washes to dissolve soluble salt deposits and to remove residual caustic in the sludge to prevent neutralization of the OA
  - First use of OA for tank cleaning
  - 3 slurry pumps operated in oscillating mode after acid addition
- CSR Campaign 3
  - OA was introduced through rotary spray jets
  - 3 slurry pumps operated in oscillating mode after acid addition
- CSR Campaign 4
  - OA was introduced through rotary spray jets
  - 3 slurry pumps operated in oscillating mode after acid addition

CSR Campaign Summary

First-of-a-kind application of OA to waste removal

Total Starting Solids (gal)	5,250
Total Pump Run Time (hr)	776
Total 4 wt % OA Introduced into the Tank (gal)	72,300
Total Liquid Introduced into the Tank (gal)*	425,300
Total Solids Removed (gal)	1,550
Total Solids Remaining (gal)	**3,700**

* Total Liquid Introduced into the tank includes the 4 weight % OA

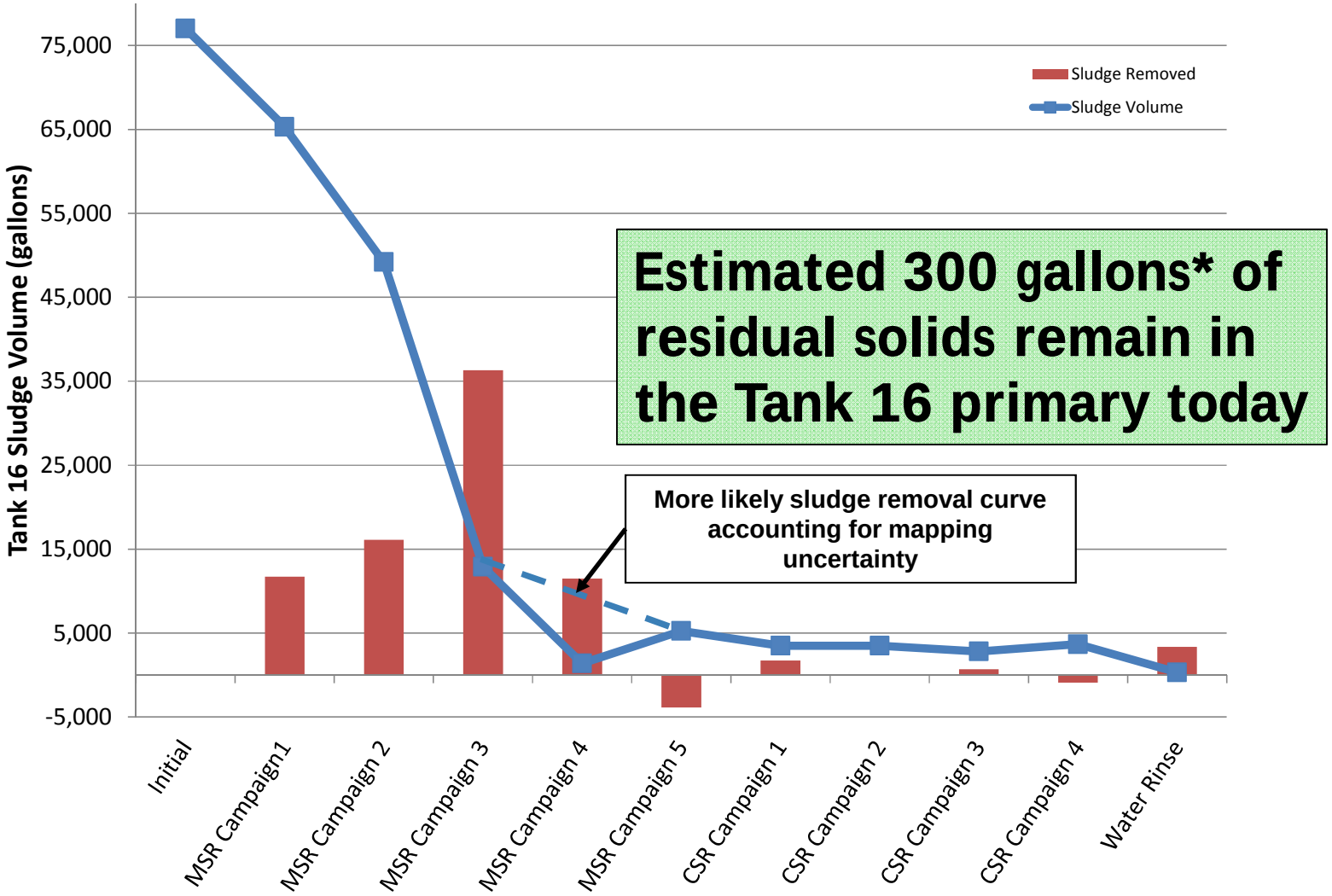
Final Water Rinse

- Two water washes were performed to suspend remaining sludge
  - Rotary spray jets were used
  - Three pumps were operated
  - Second wash was feed and bleed

Total Starting Solids (gal)	3,700
Total Pump Run Time (hr)	368
Total Liquid Introduced into the Tank (gal)	184,500
Total Solids Removed (gal)	3,400
Total Solids Remaining (gal)	**300***

* The final volume determination will be provided as part of the Tank 16 Closure Module.

Primary Tank Summary



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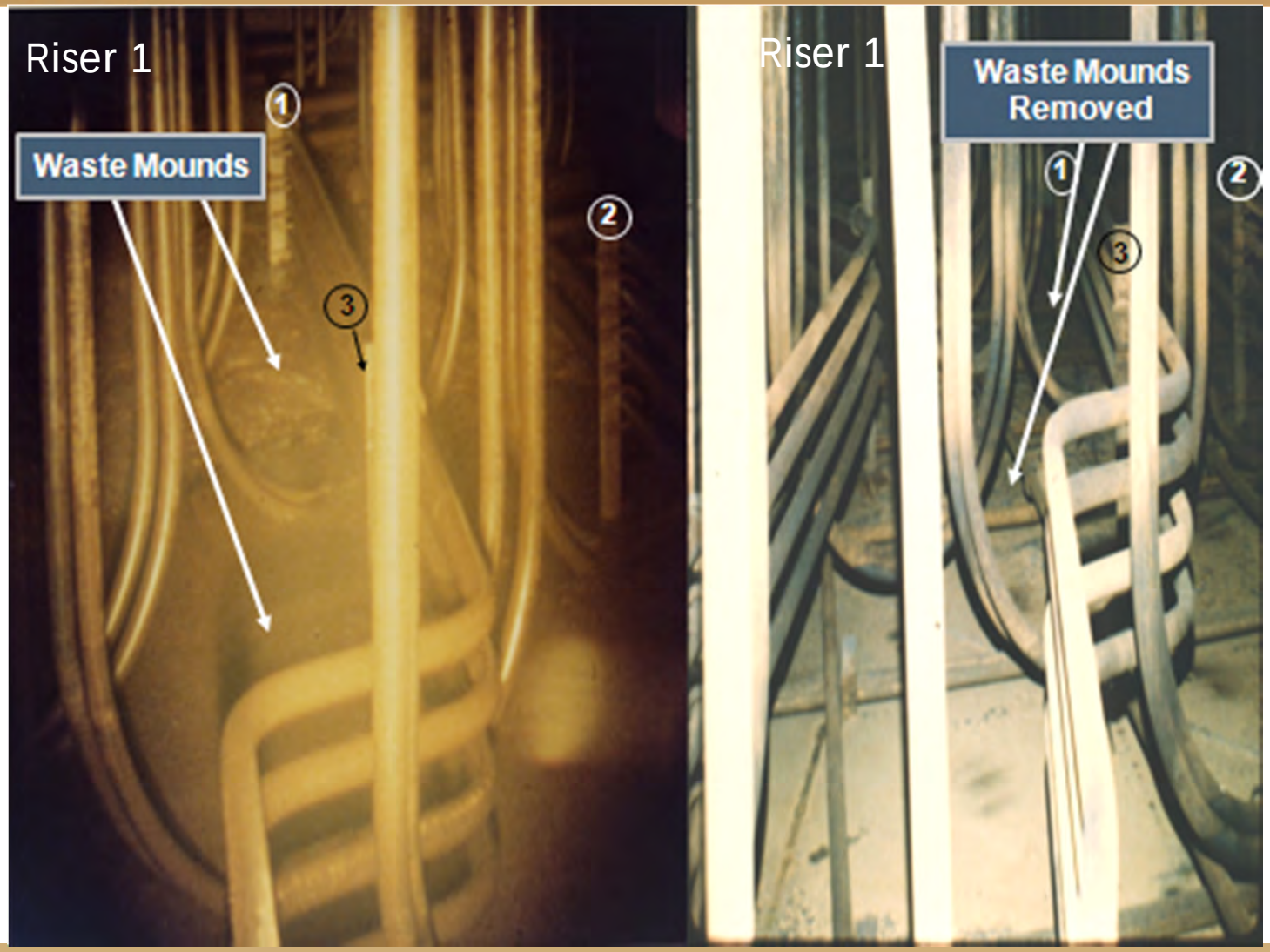
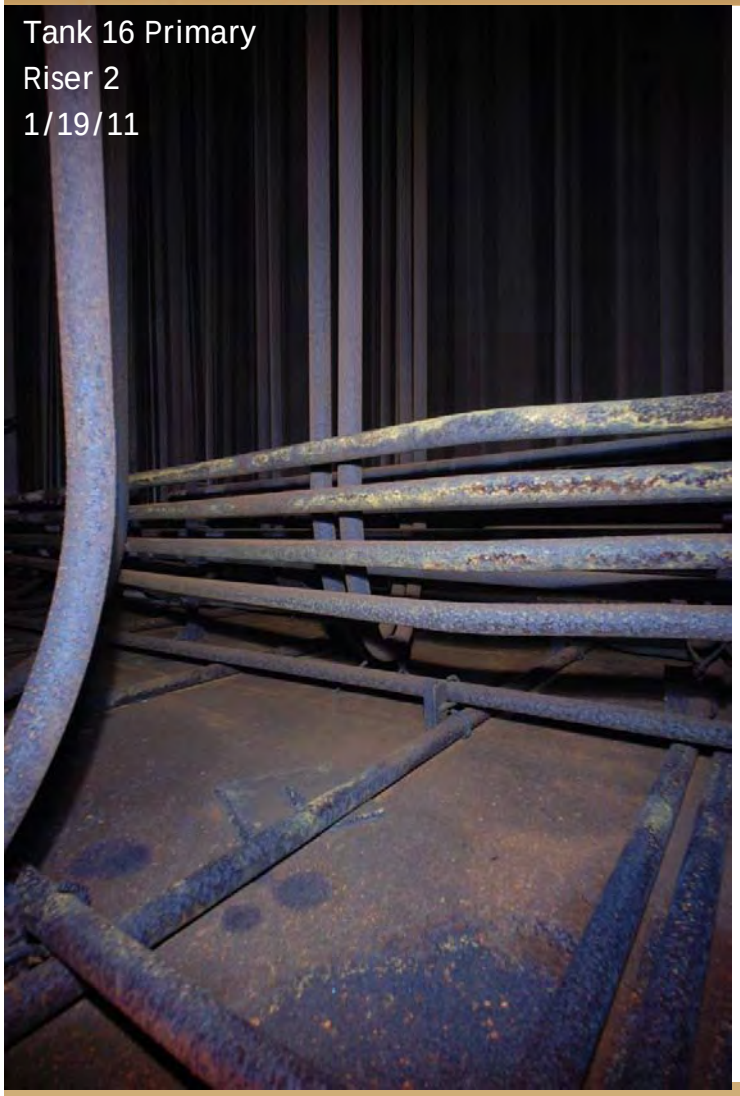
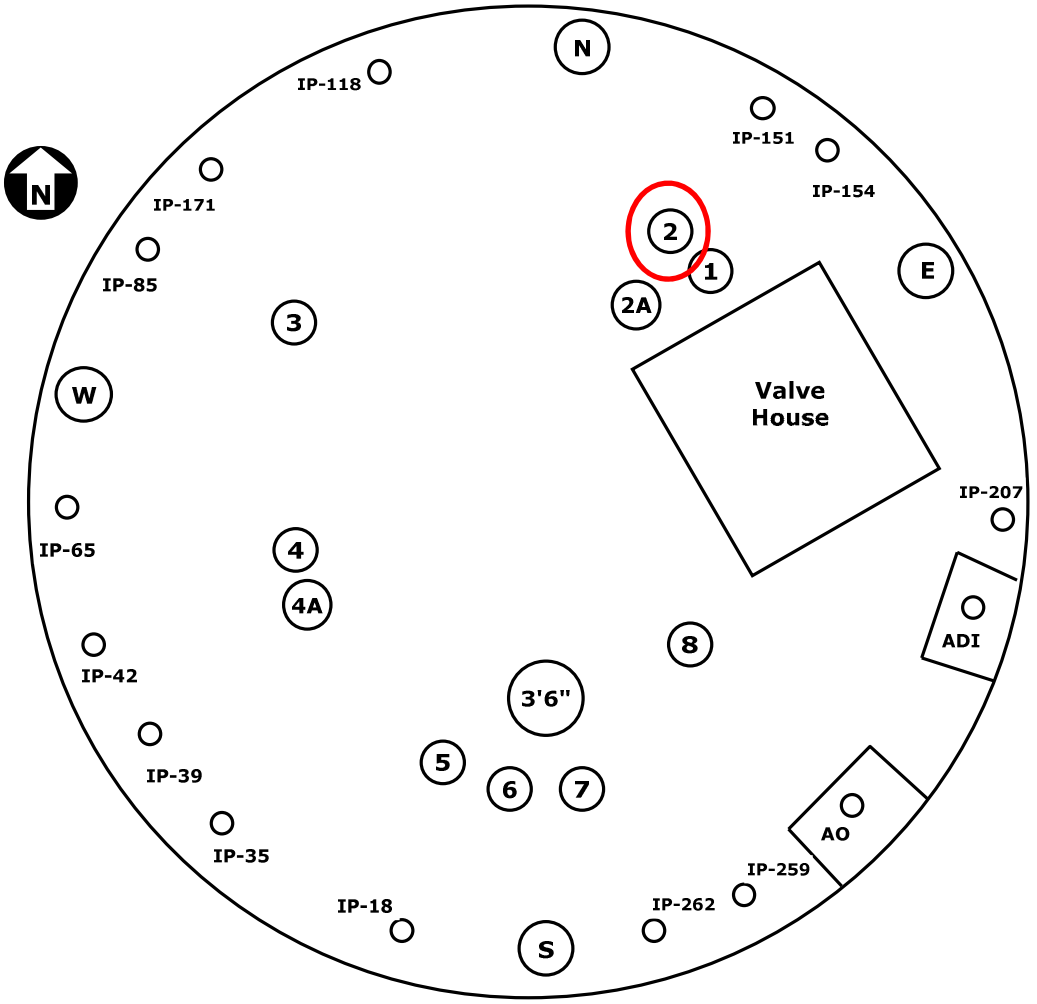
Tank 16 Before/After Cleaning

We do the right thing.

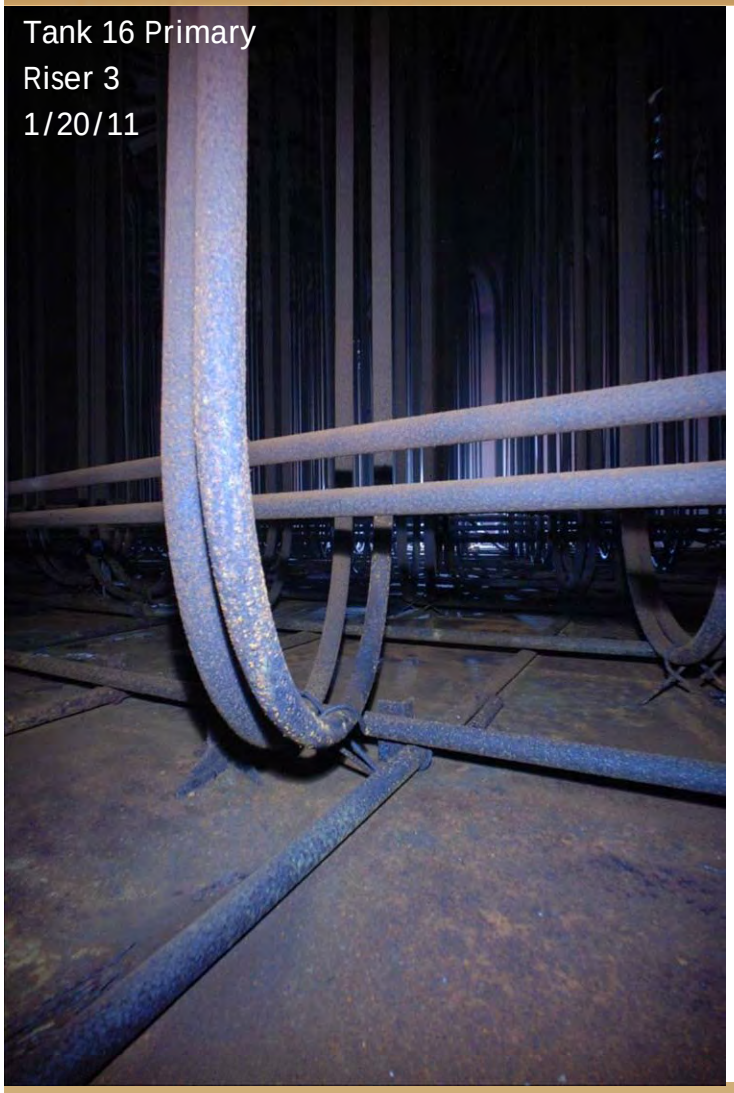


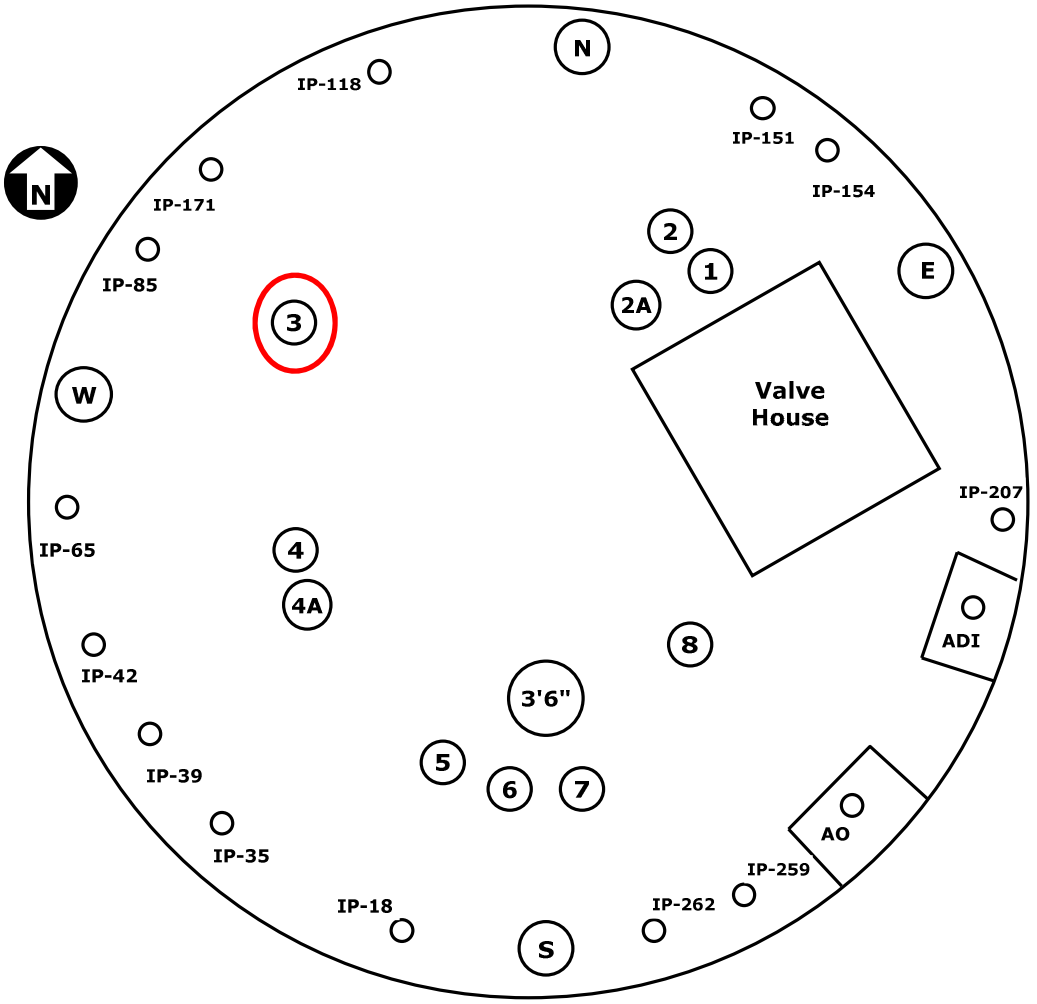
Tank 16 Primary Riser 2



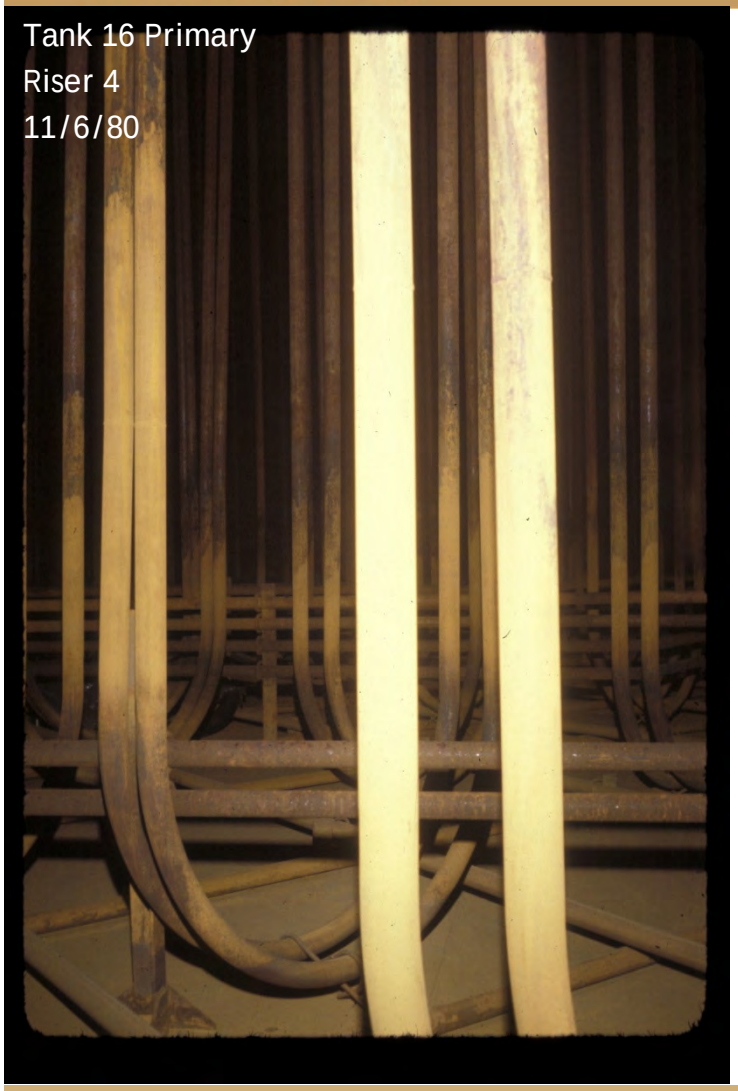


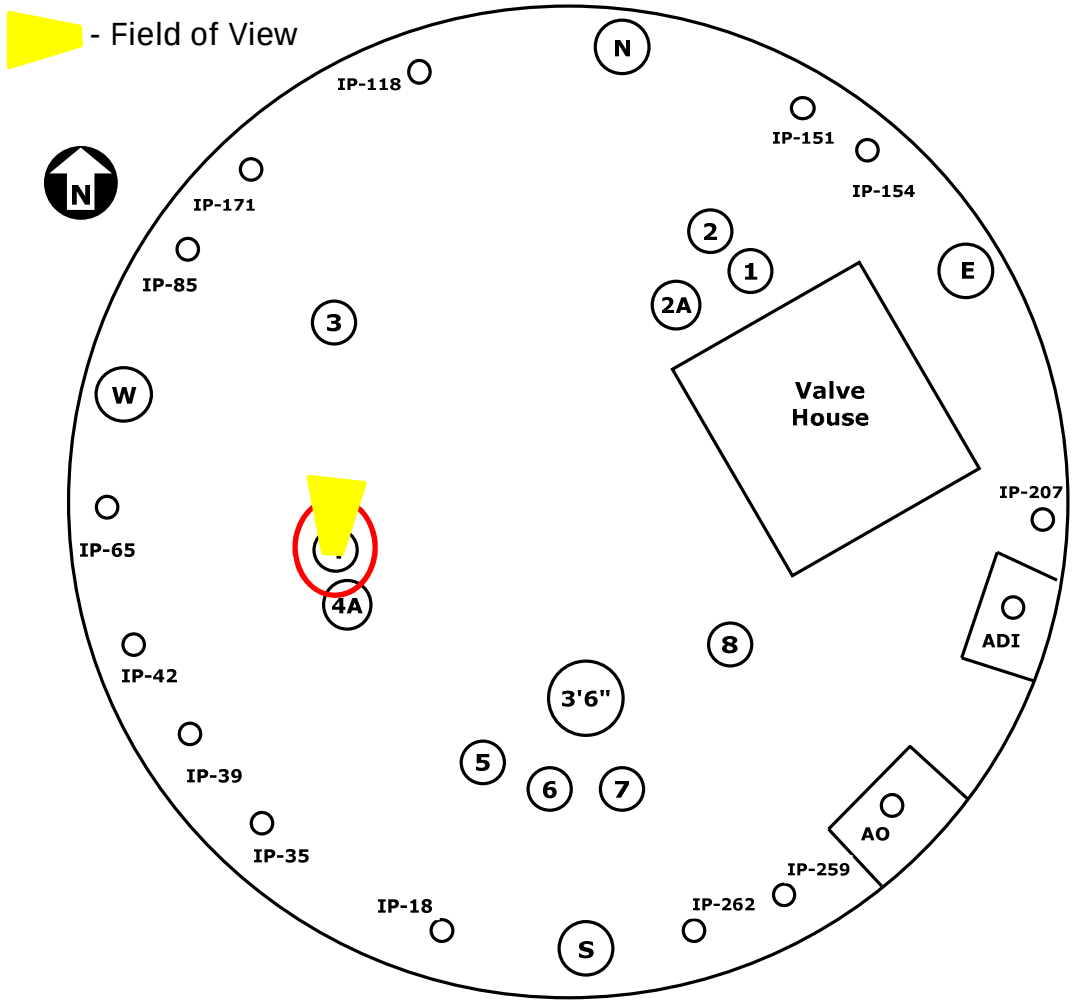
Tank 16 Primary Riser 3





Tank 16 Primary Riser 4





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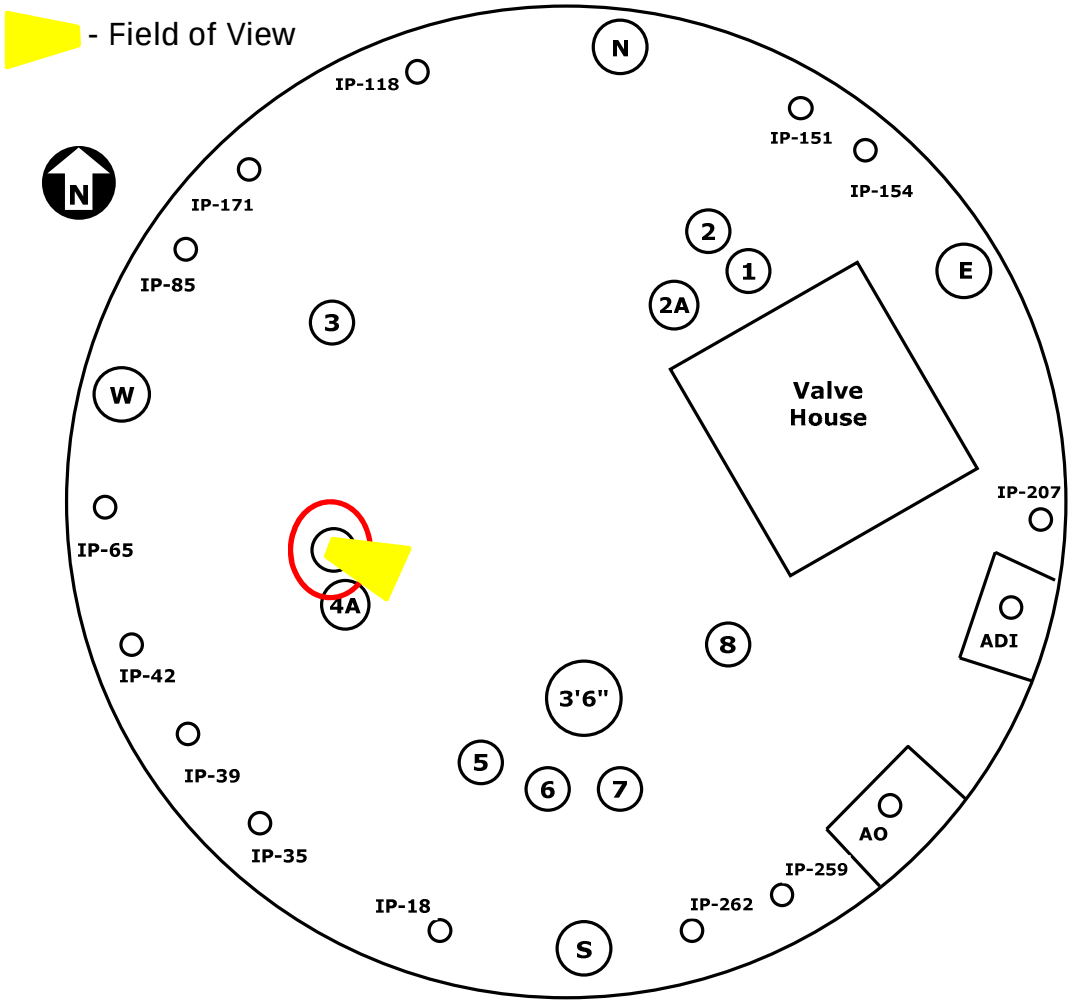

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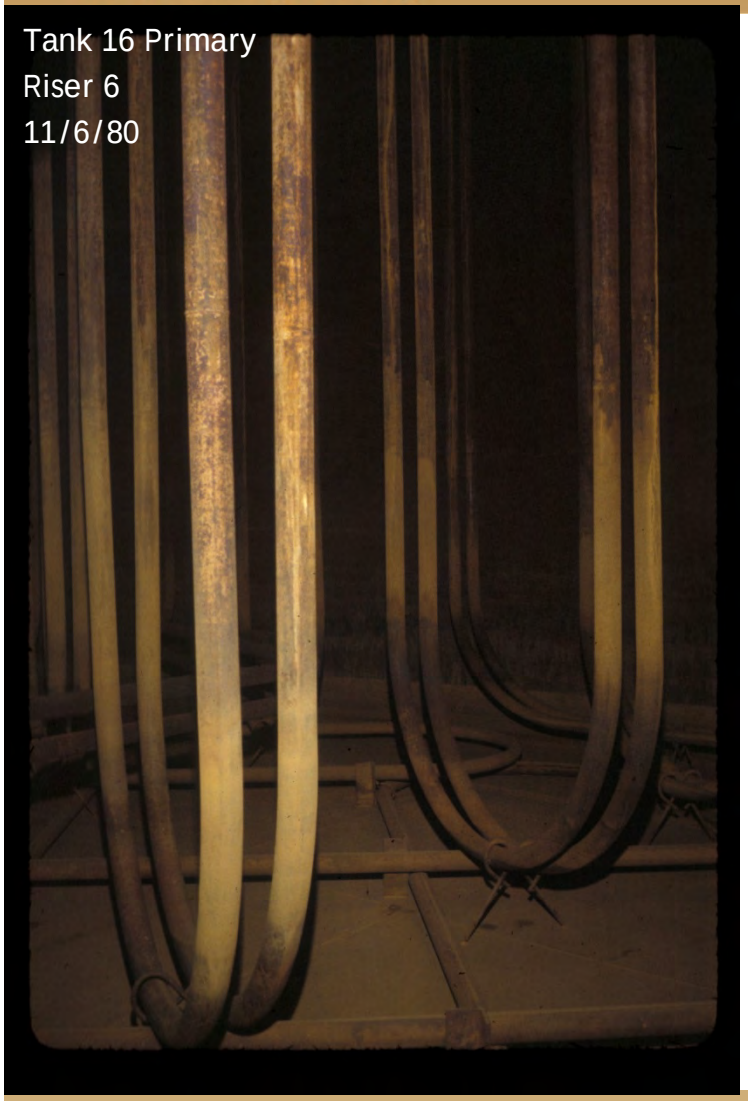
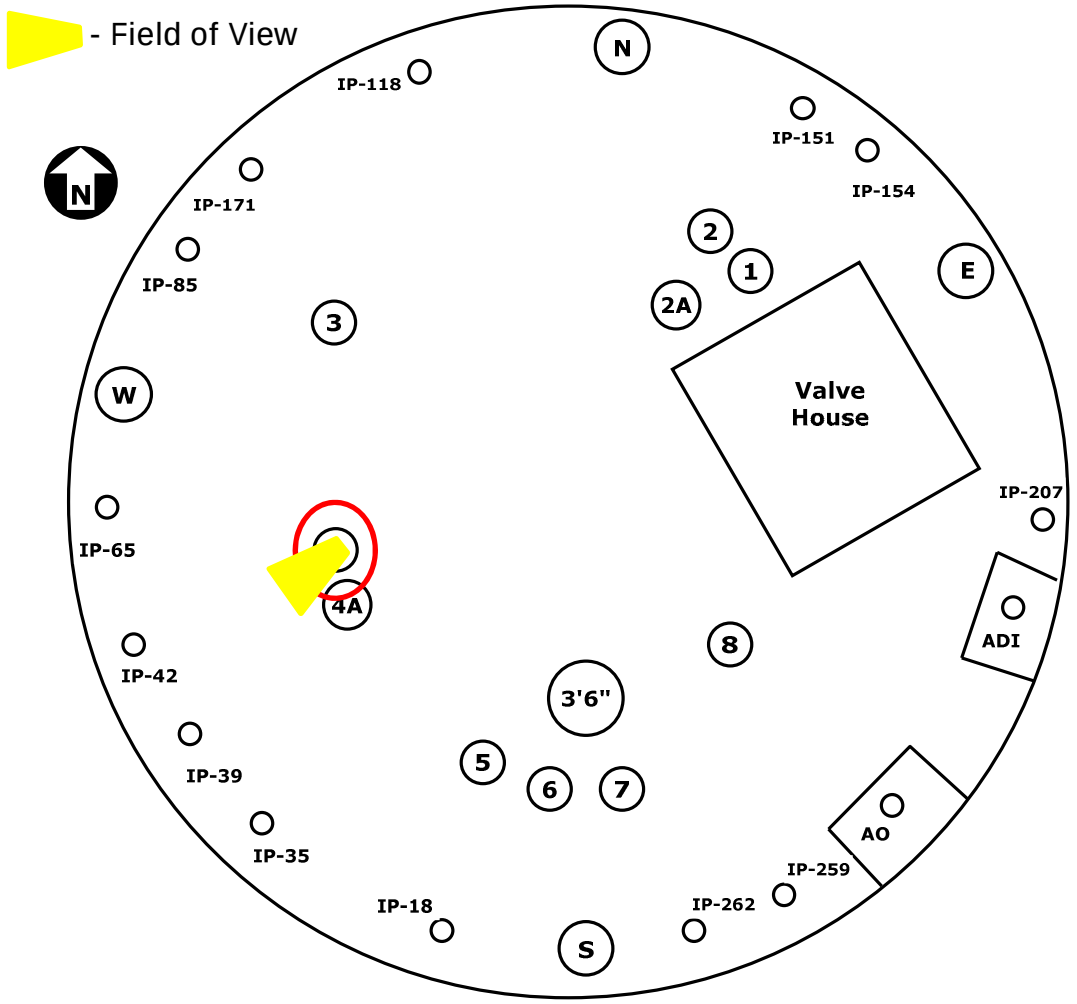
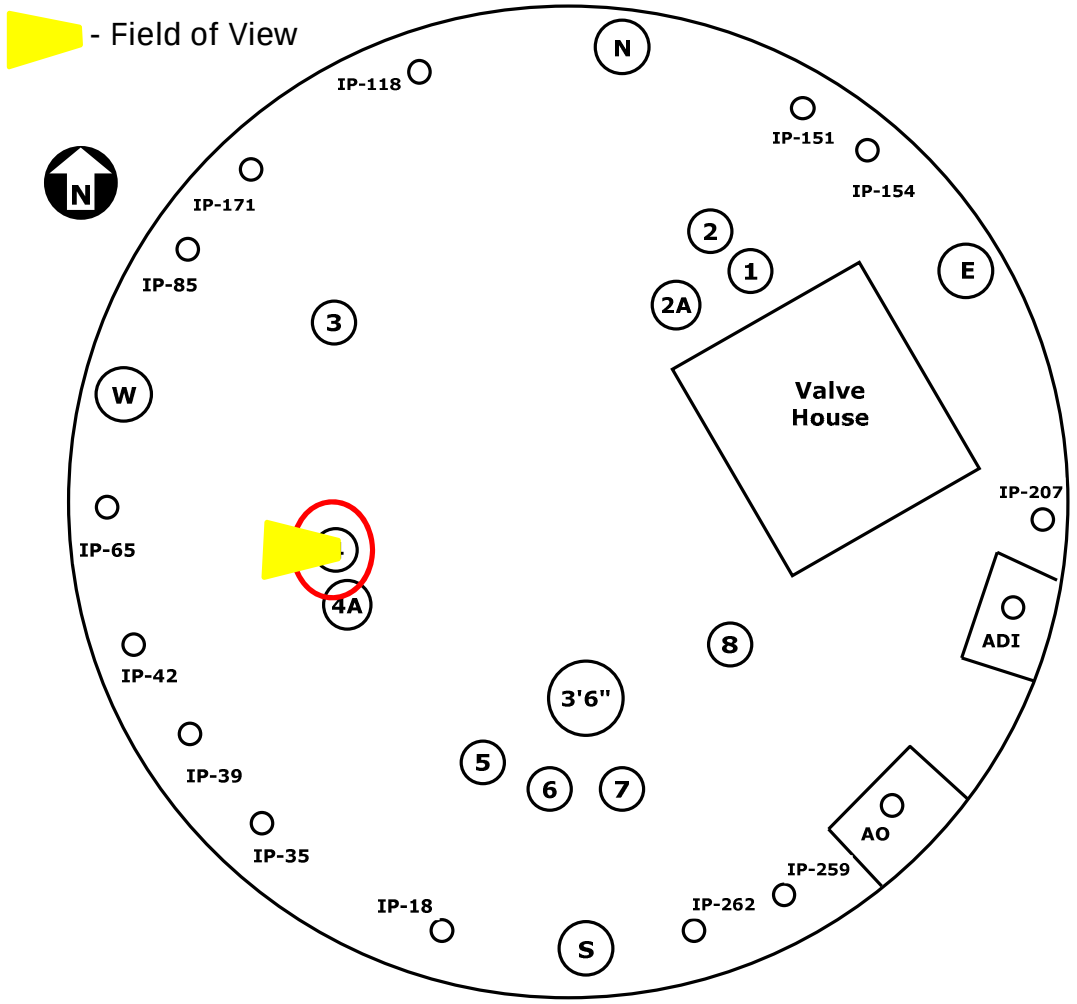
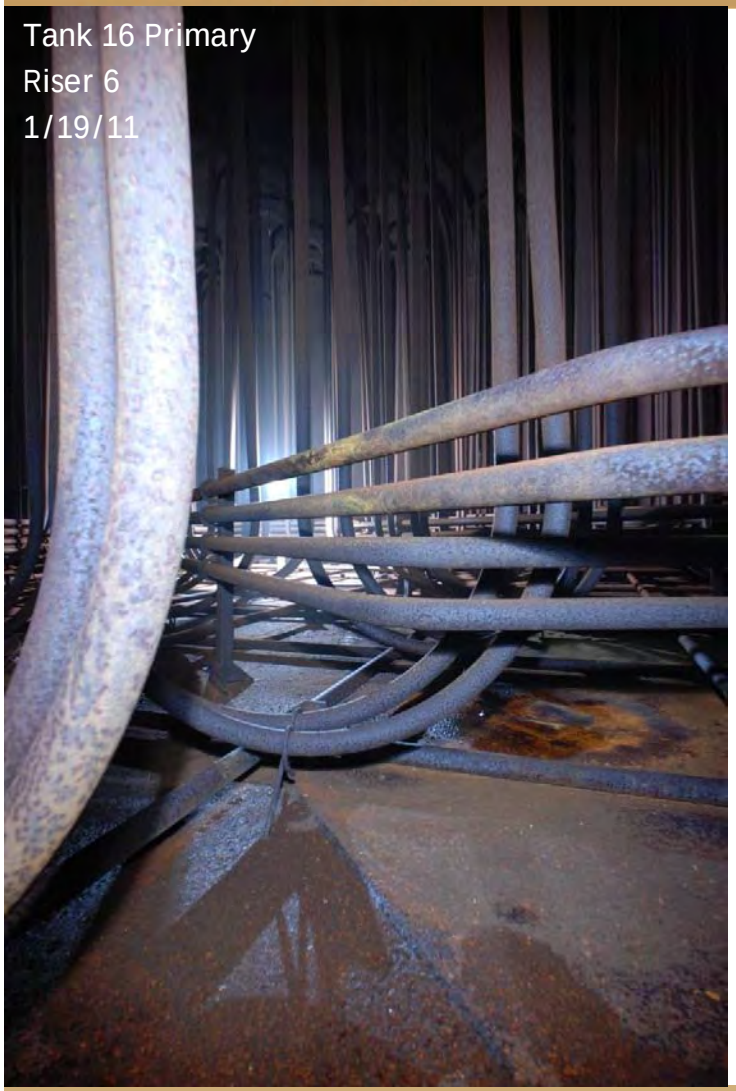


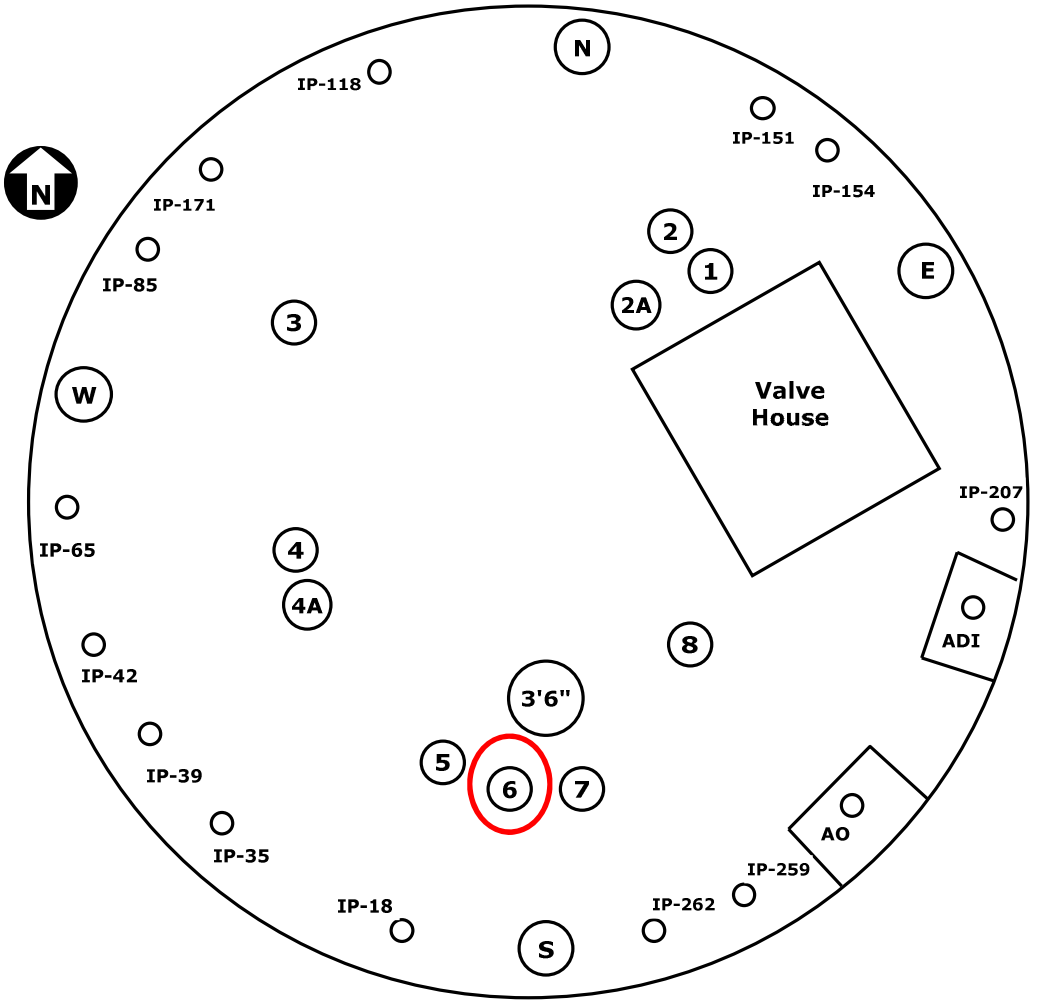


Tank 16 Primary Riser 4

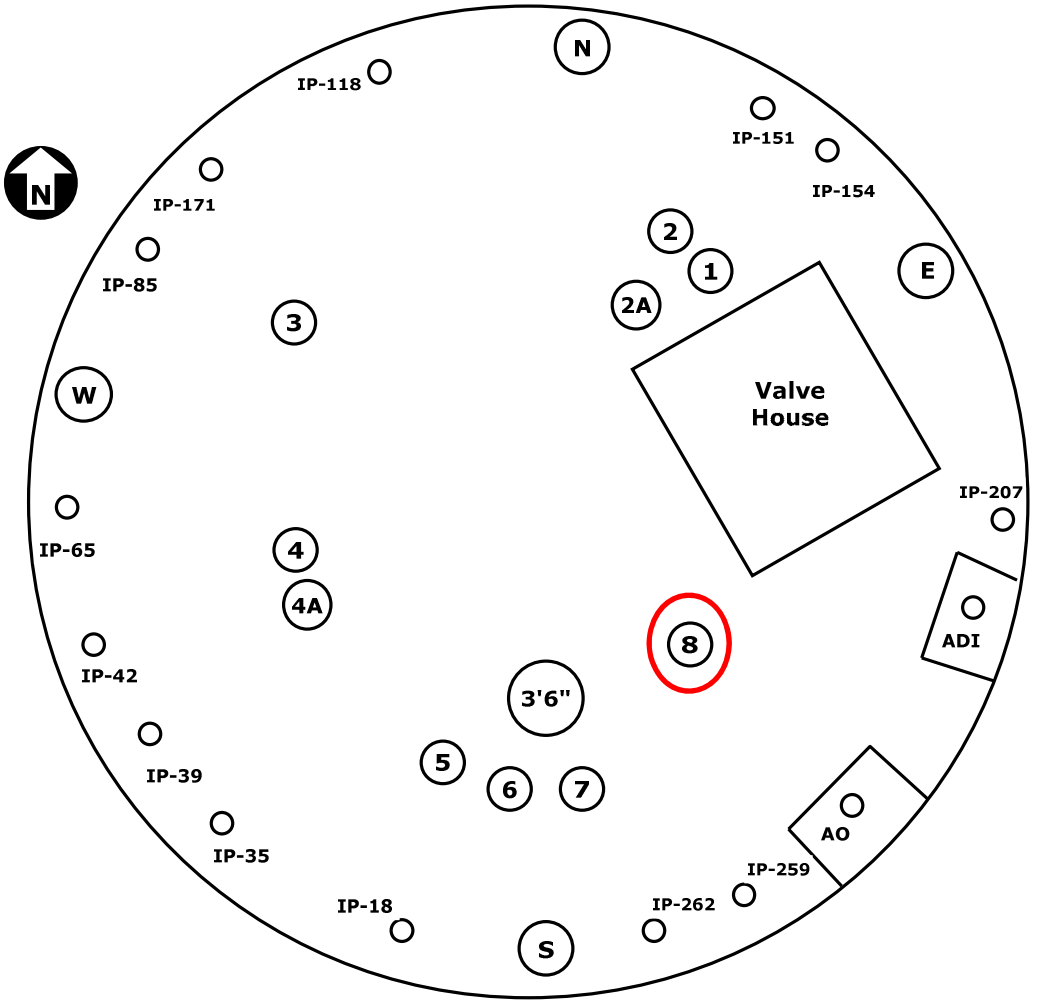


Tank 16 Primary Riser 6





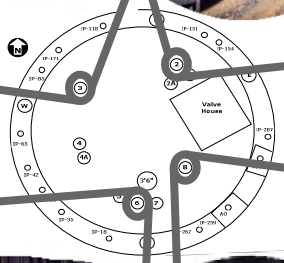
Tank 16 Primary Riser 8



Tank 16 Primary - 2011

Riser 3
360° Lower Panoramic View

Riser 2
360° Lower Panoramic View



Riser 6
360° Lower Panoramic View

Riser 8
360° Lower Panoramic View

Tank 16 Today

- An estimated **300 gallons** of residual solids remain today*
- No “significant” accumulations of solids in the primary tank

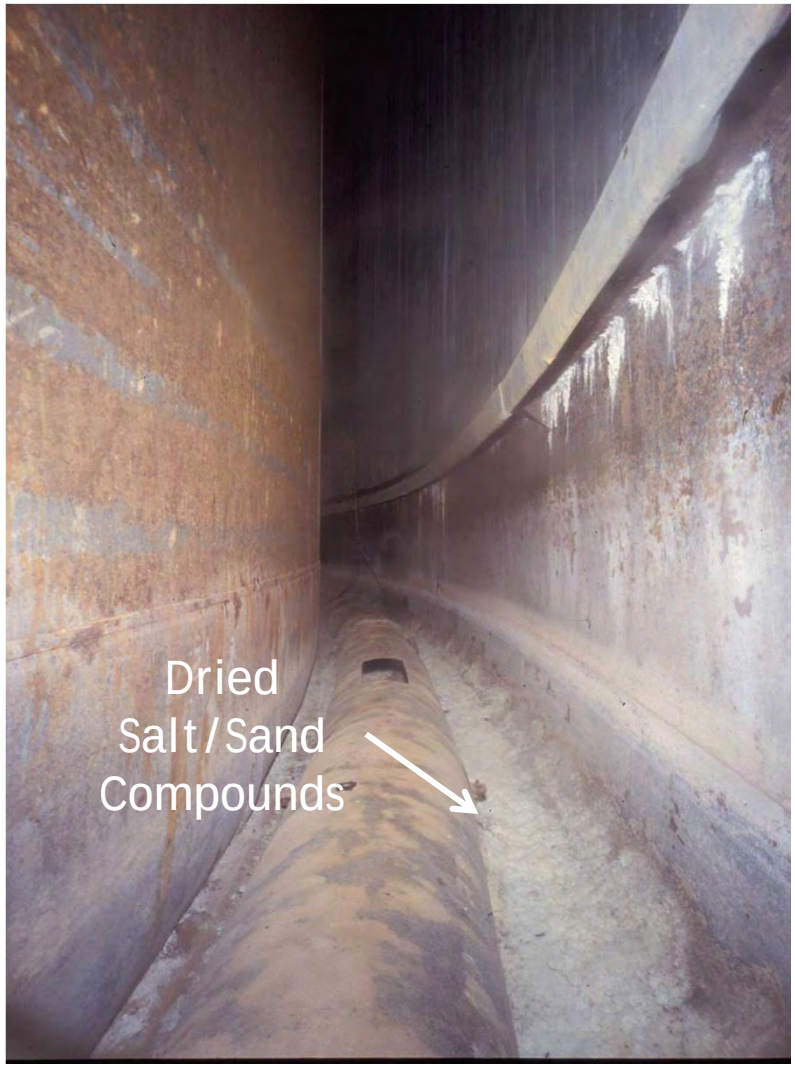
* The final volume determination will be provided as part of the Tank 16 Closure Module

Tank 16 Annulus Conditions

- Prior to 1972, over 185,000 gallons of supernate had leaked into the annulus
- In March 1972 an estimated 6,000 gallons of salt waste remained in the annulus
- Waste was a combination of crystalline salt and sand compounds with some interstitial liquid

Tank 16 Annulus Conditions

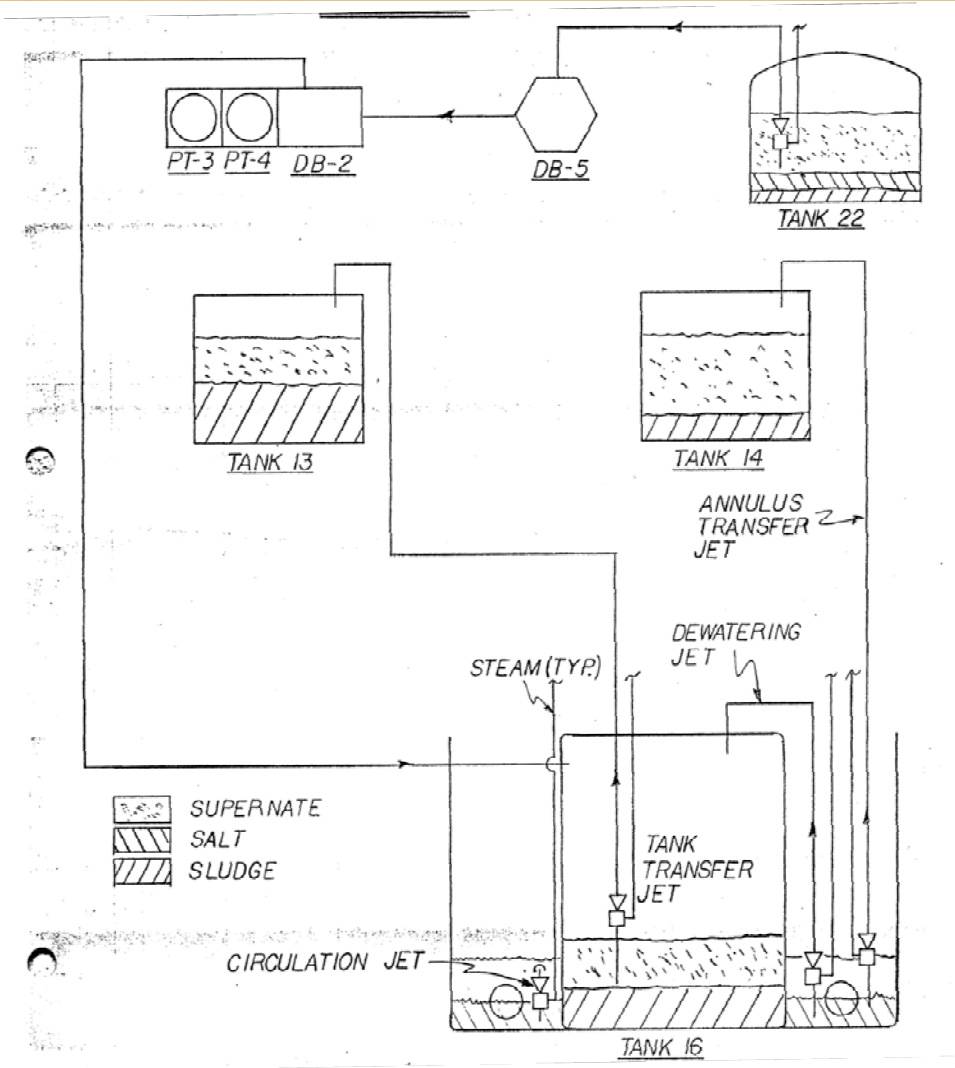
- "Dried salt/sand compounds" contained "interstitial liquid"
- As in the salt tanks, majority of radioactivity is in the interstitial liquid
- Draining the interstitial liquid removes the majority of radioactivity



Annulus Cleaning

- March 1972: 1,000 gallons of residual liquid extracted from core holes in salt crust (Phase 1)
- Sept 1972: 800 gallons jetted out (Phase 2)
- Oct 1973: 10 gpm dewatering jet, positioned 1" above annulus floor; operated for 13 days (Phase 3)
  - No appreciable waste removed
- June 1976: Estimated 15 ft^3 of dried sand below IP-151 was vacuumed out (Phase 4)

Annulus Cleaning Equipment Configuration (Phase 5)

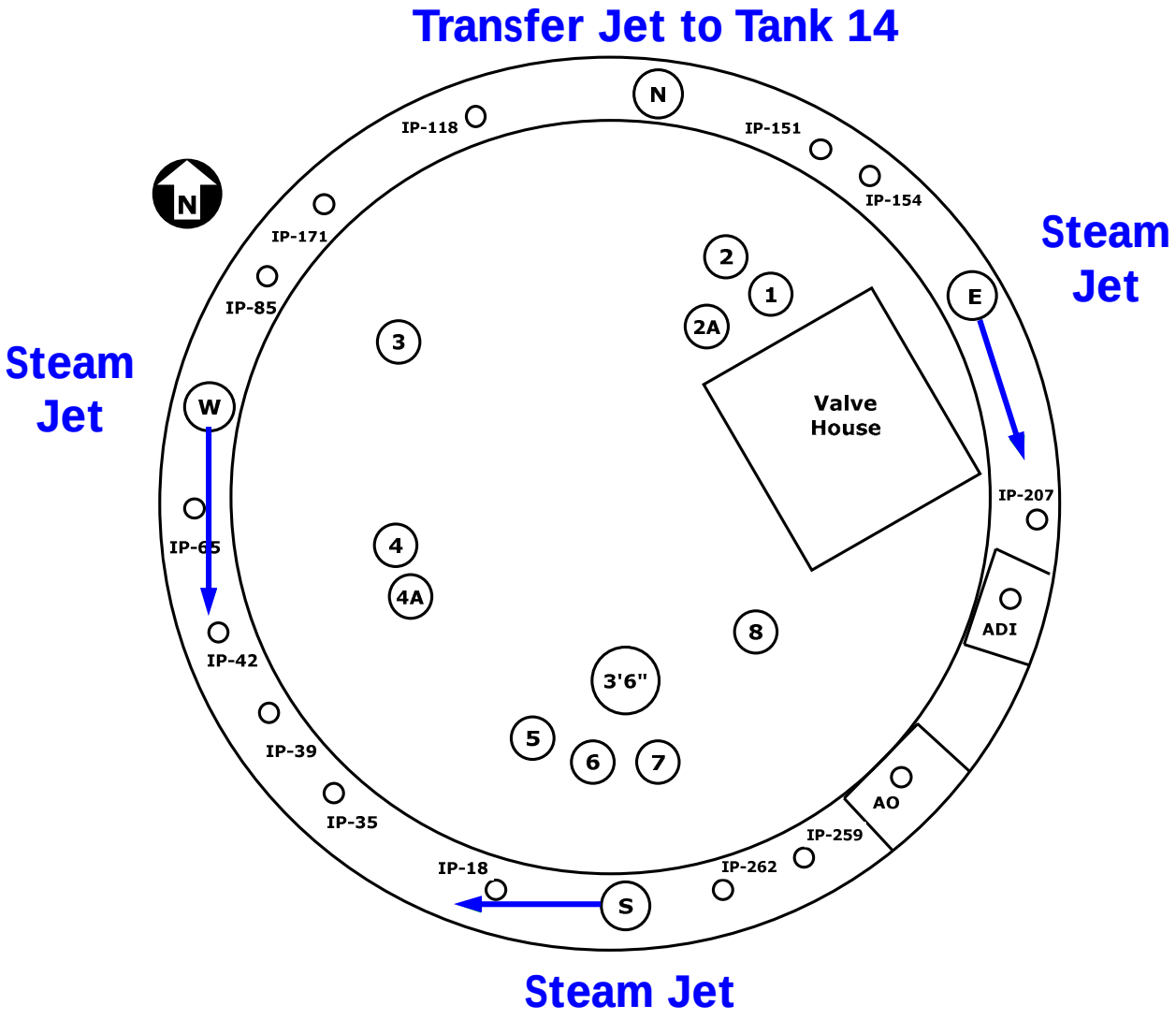


Original hand drawing depicting the transfer paths associated with Tank 16 Phase 5 annulus cleaning

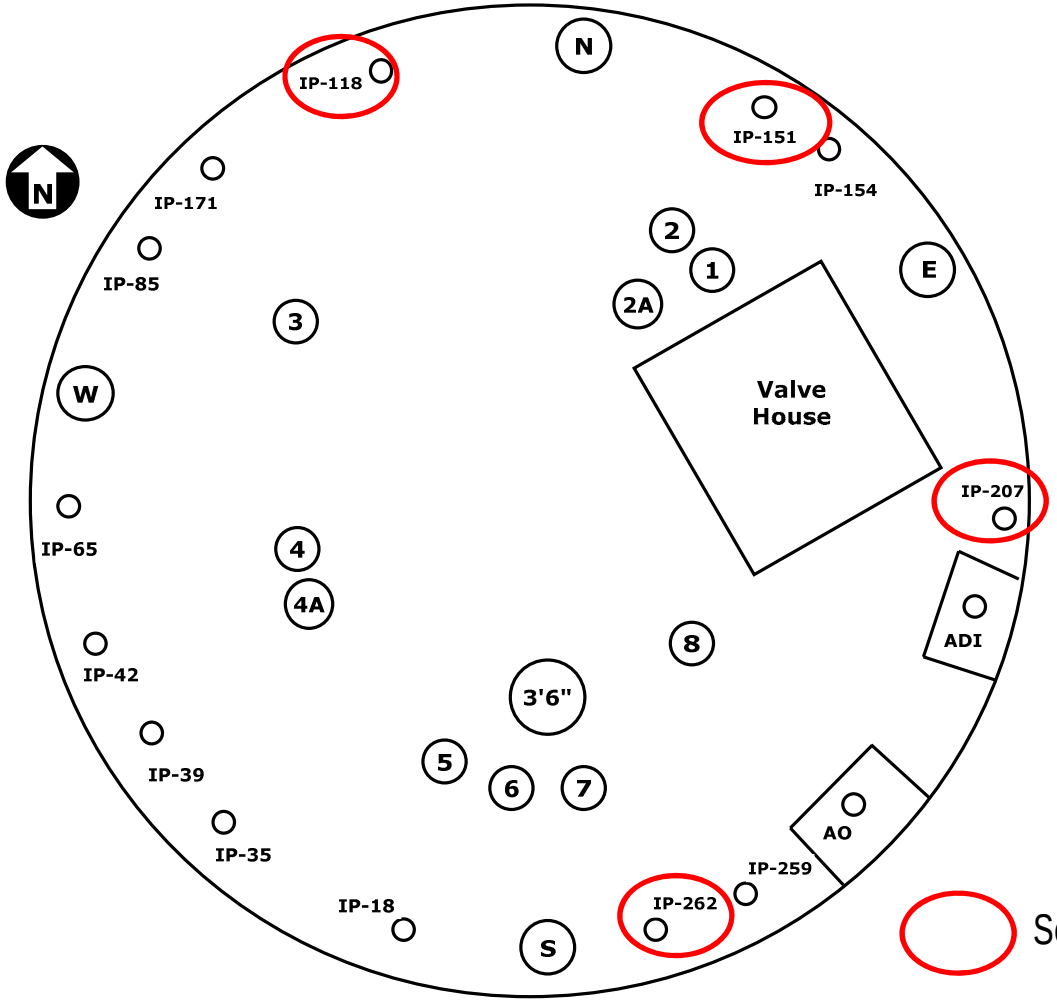
Tank 16 Annulus Cleaning Phase 5

- Supernate was added to the Tank 16 primary to prevent waste tank bottom deflection
- Process water was added to the annulus to dissolve the saltcake
  - Steam jets in the east and south risers were used to promote mixing, circulating clockwise for 190 hours
  - A third steam jet was added to the west riser and operated alternatively with the east and south riser jets to further promote dissolution
- **Estimated 2,700 gallons of additional solids were removed from the annulus**

Annulus Cleaning Equipment Configuration (Phase 5)



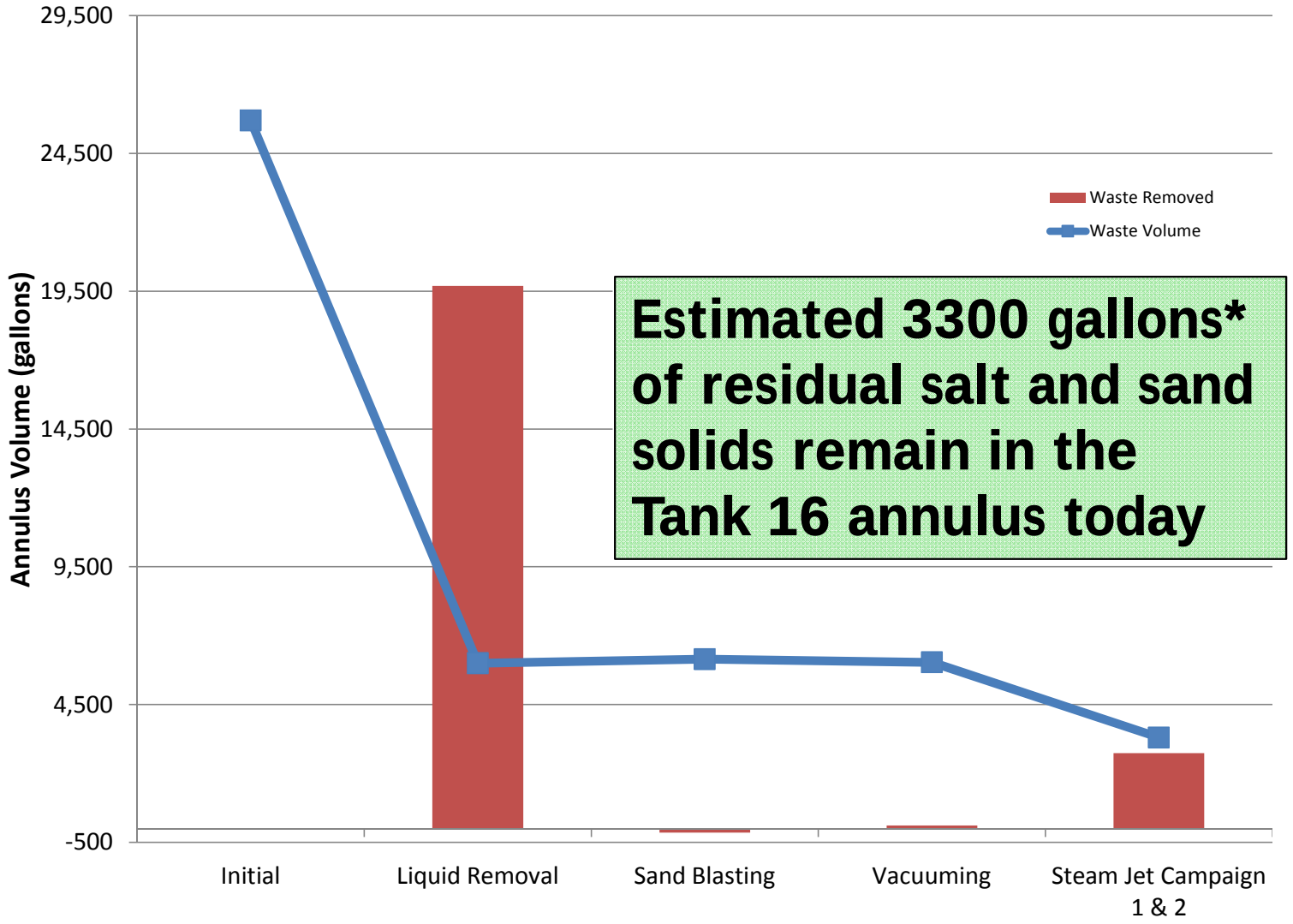
Annulus Cleaning Follow-up



- 1978: Sampling was then conducted under four IPs
- Results indicated mainly water insoluble natrodavyne (**NaAlSi**) and sand

Solid samples collected under these IPs

Annulus Cleaning Summary



Estimated 3300 gallons* of residual salt and sand solids remain in the Tank 16 annulus today

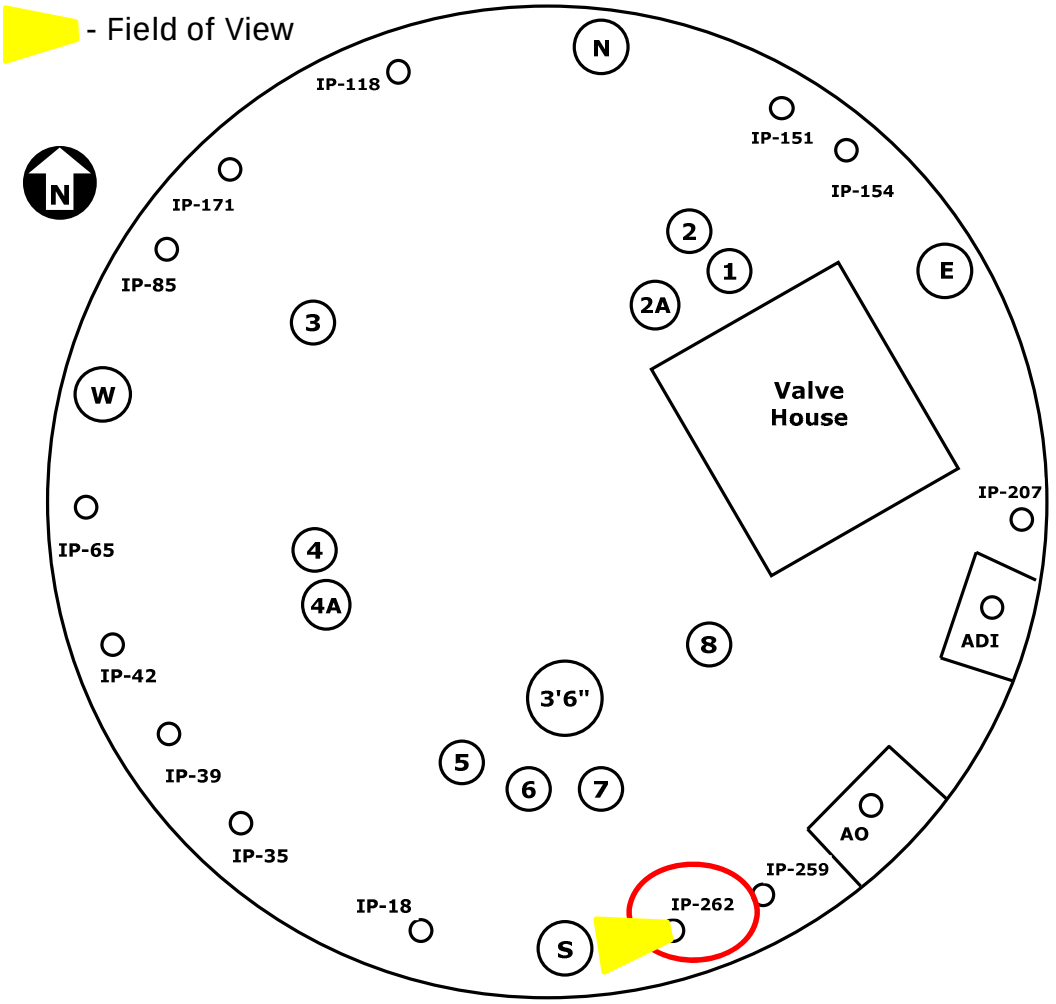
* The final volume determination will be provided as part of the Tank 16 Closure Module.

Annulus Cleaning Summary

Total Starting Solids (gal)	6,000
Total Jet Run Time (hr)	632
Total Liquid Introduced into the Annulus (gal) Approximate water addition including steam condensate	14,400
Total Solids Removed (gal)	2,700
Total Solids Remaining (gal)	**3,300***

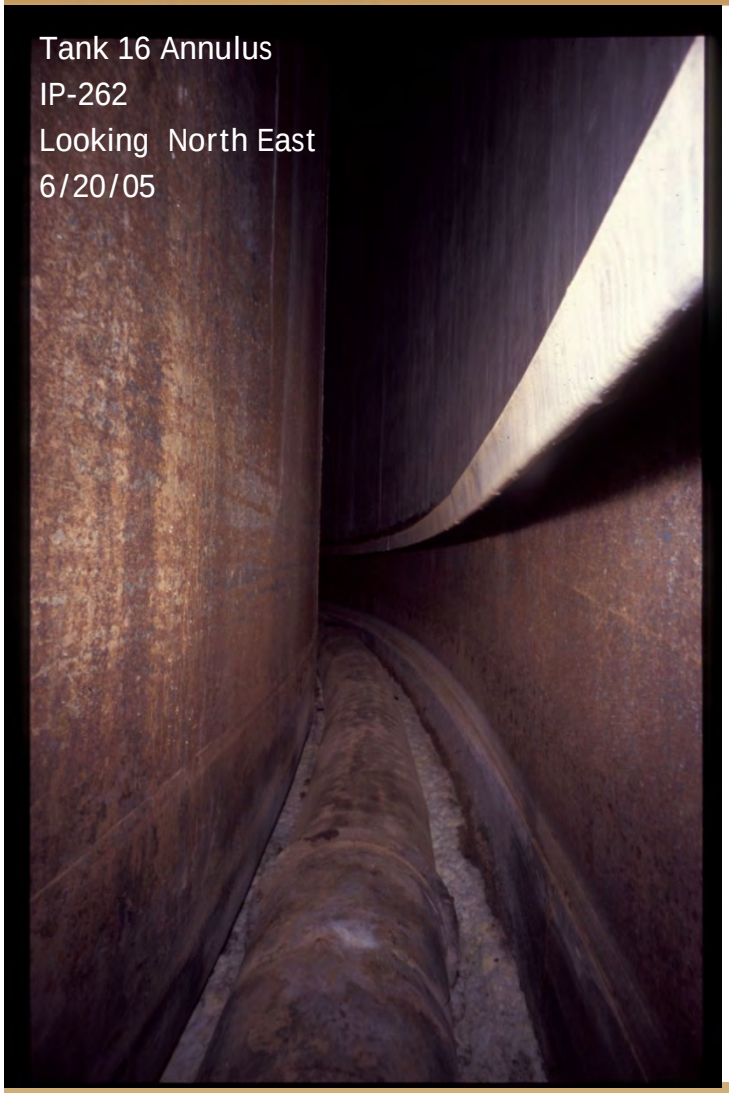
* The final volume determination will be provided as part of the Tank 16 Closure Module>

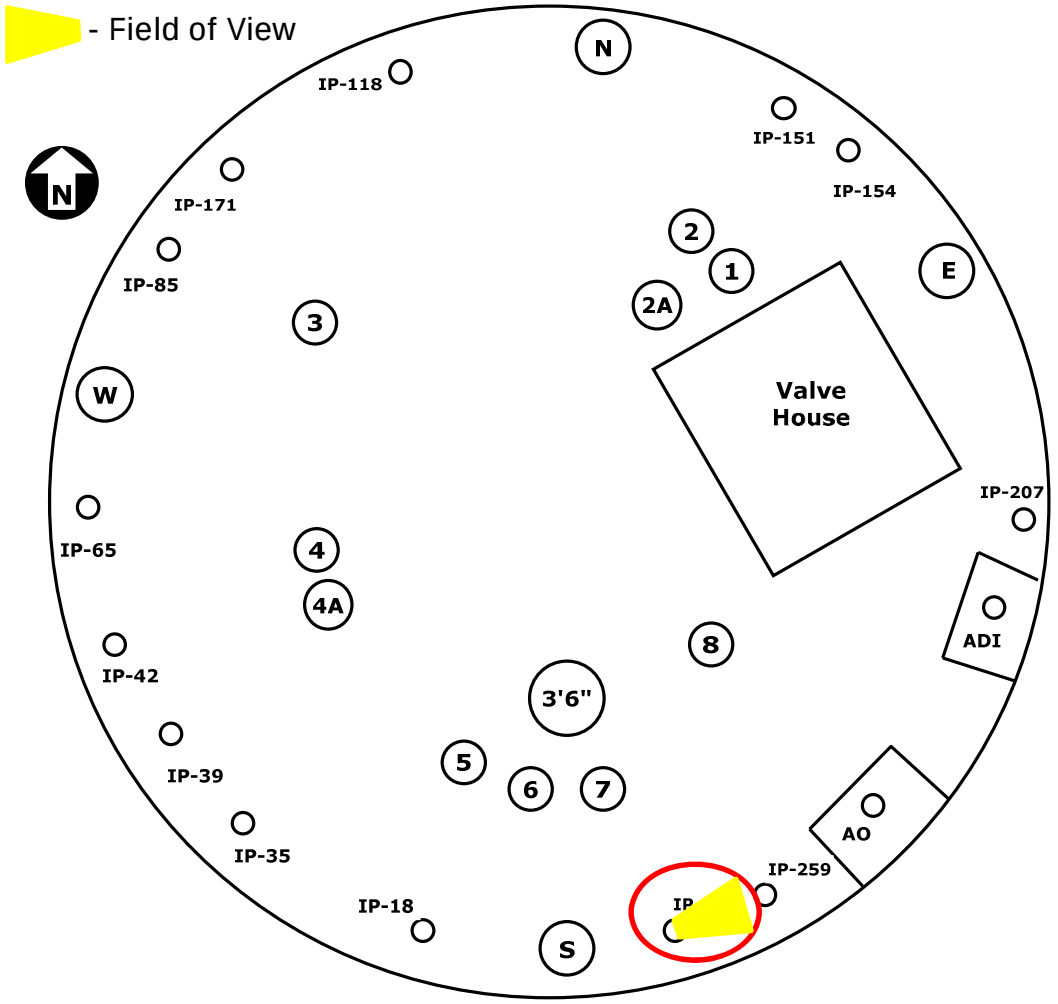
Tank 16 Annulus IP-262



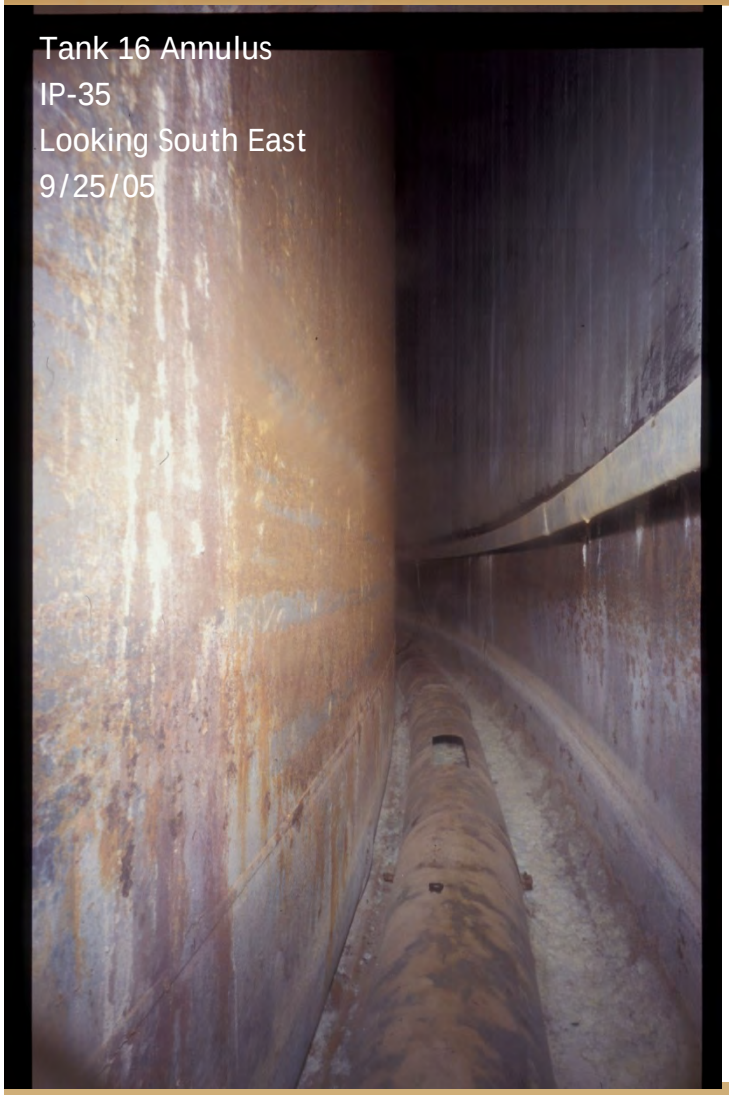
Tank 16 Annulus IP-262

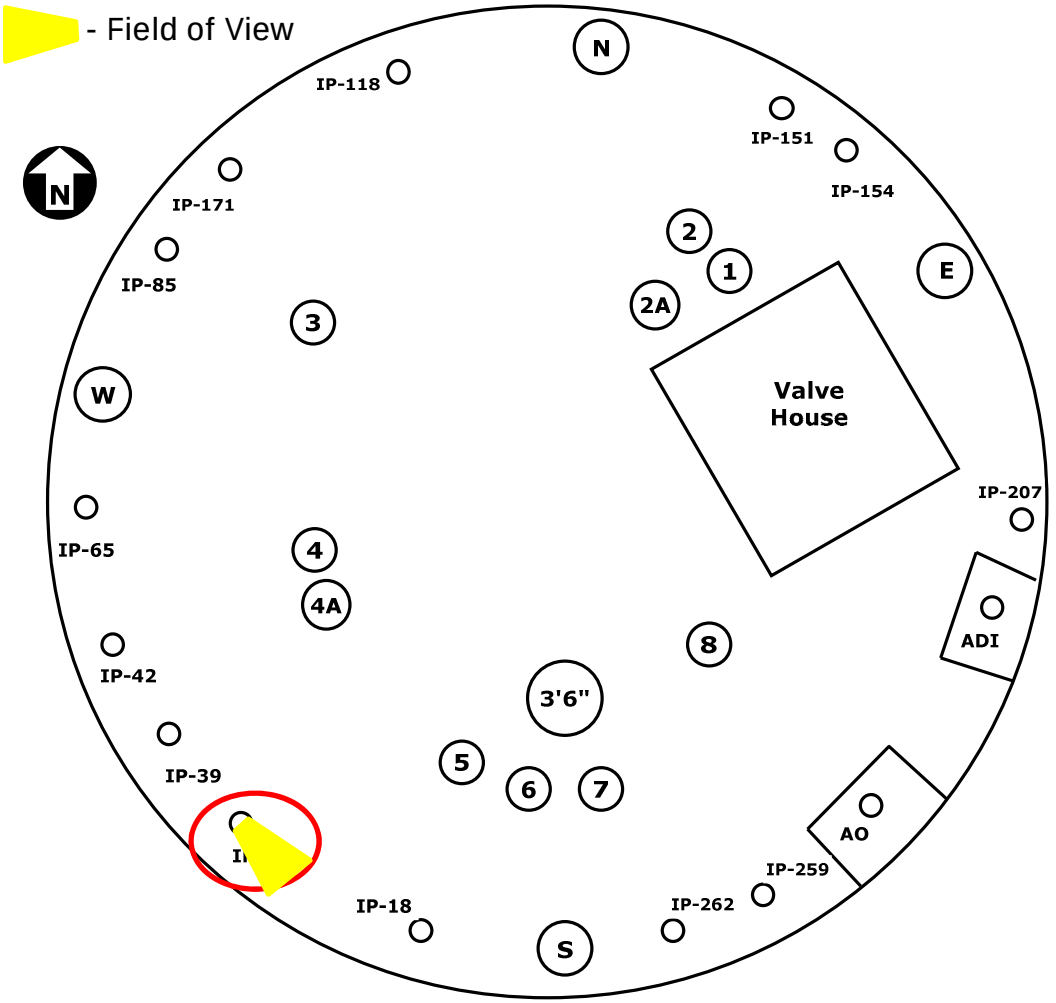
We do the right thing.



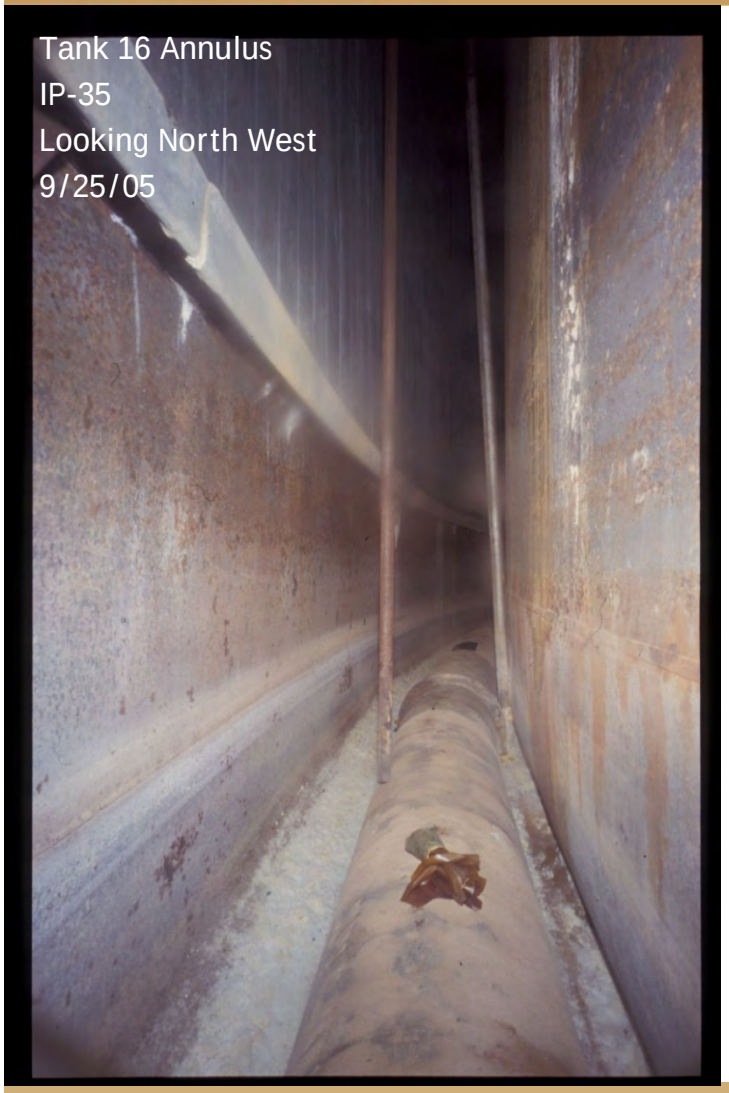


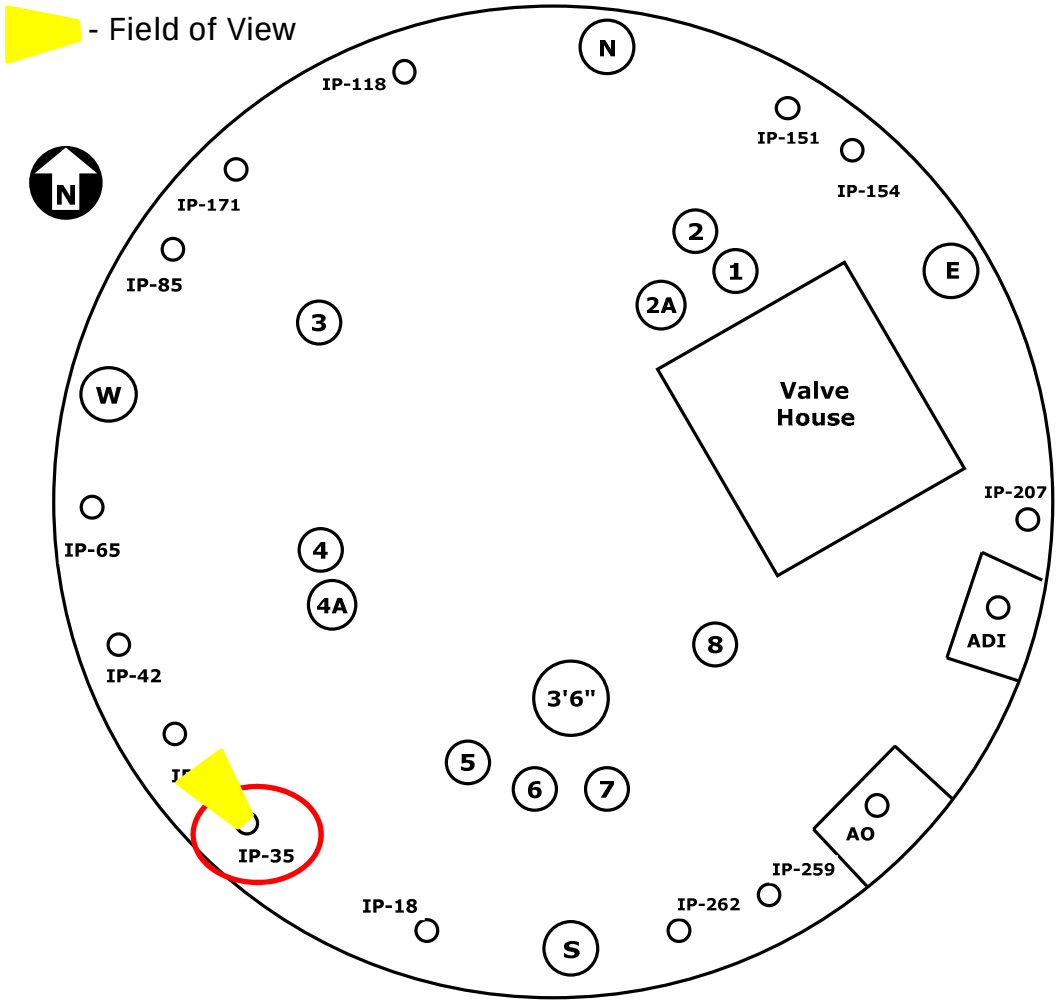
Tank 16 Annulus IP-35



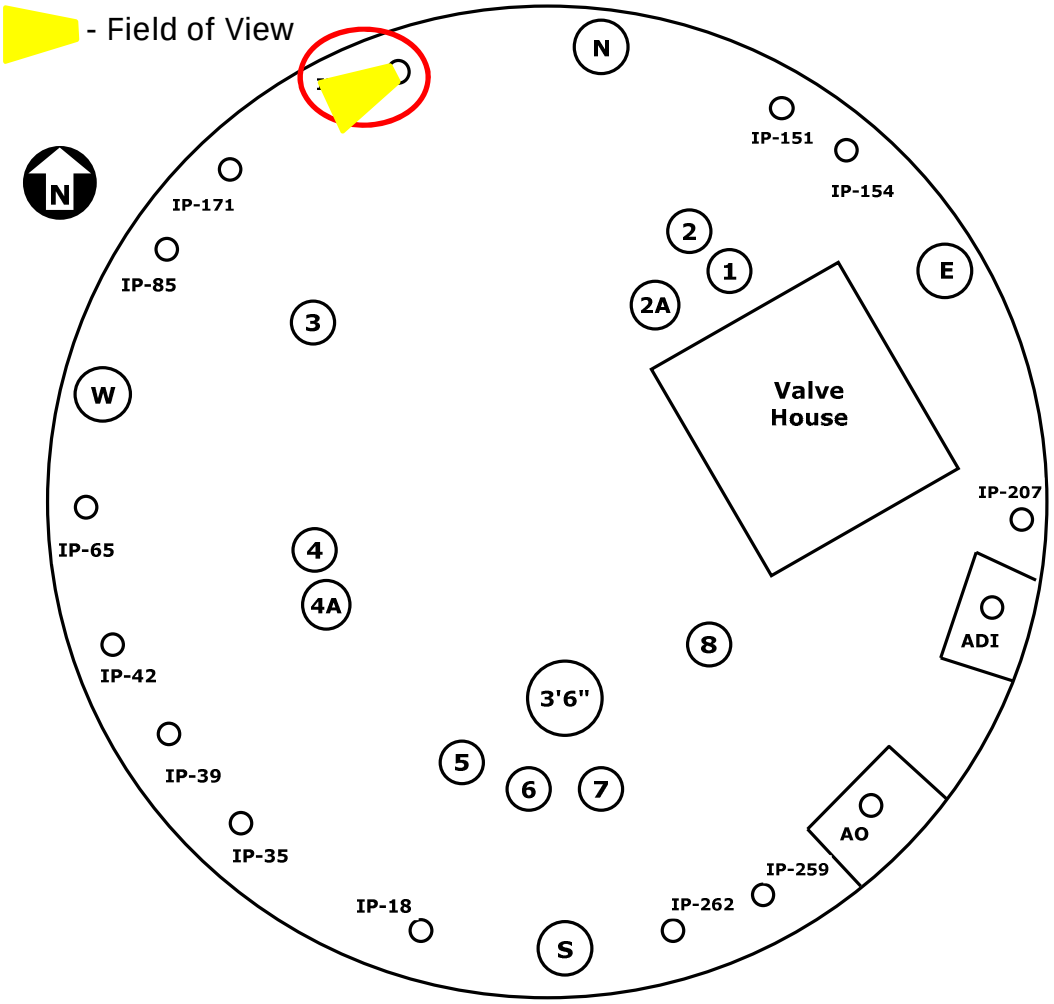


Tank 16 Annulus IP-35

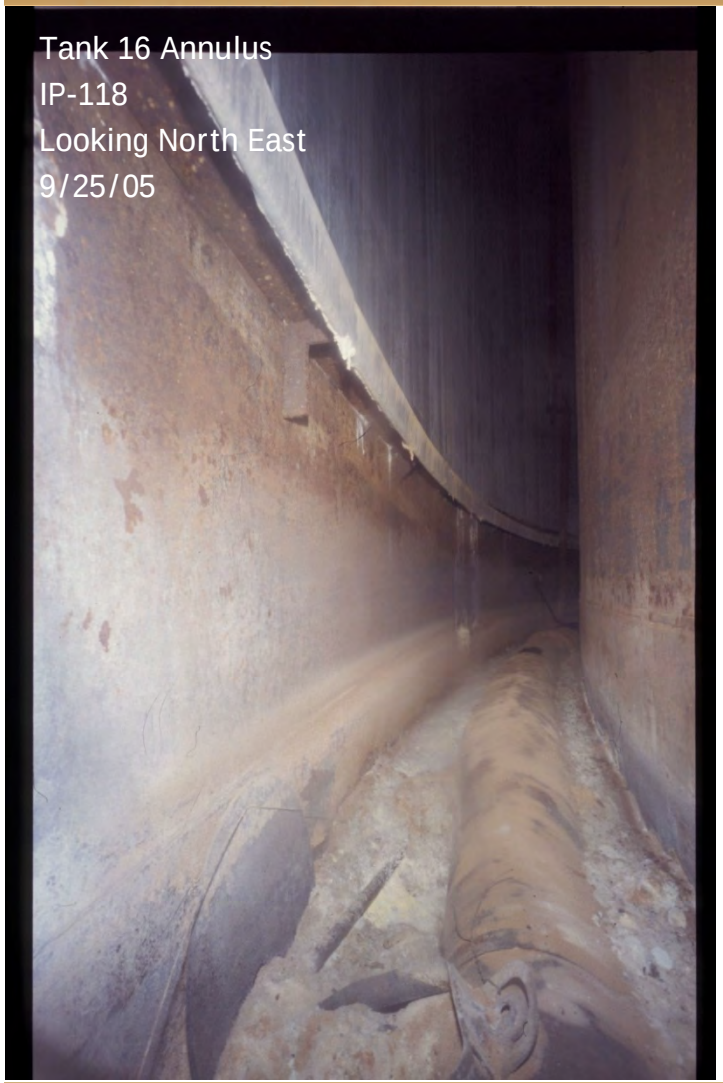


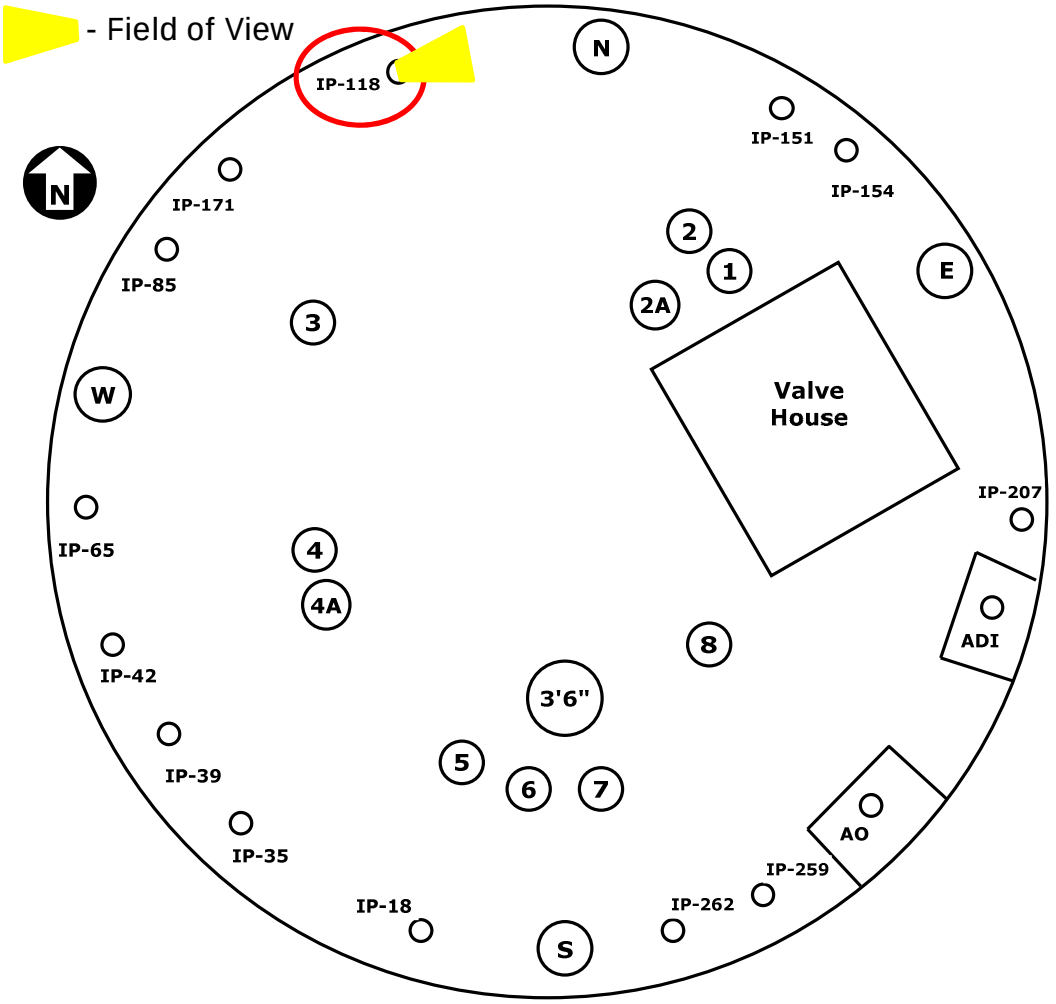


Tank 16 Annulus IP-118

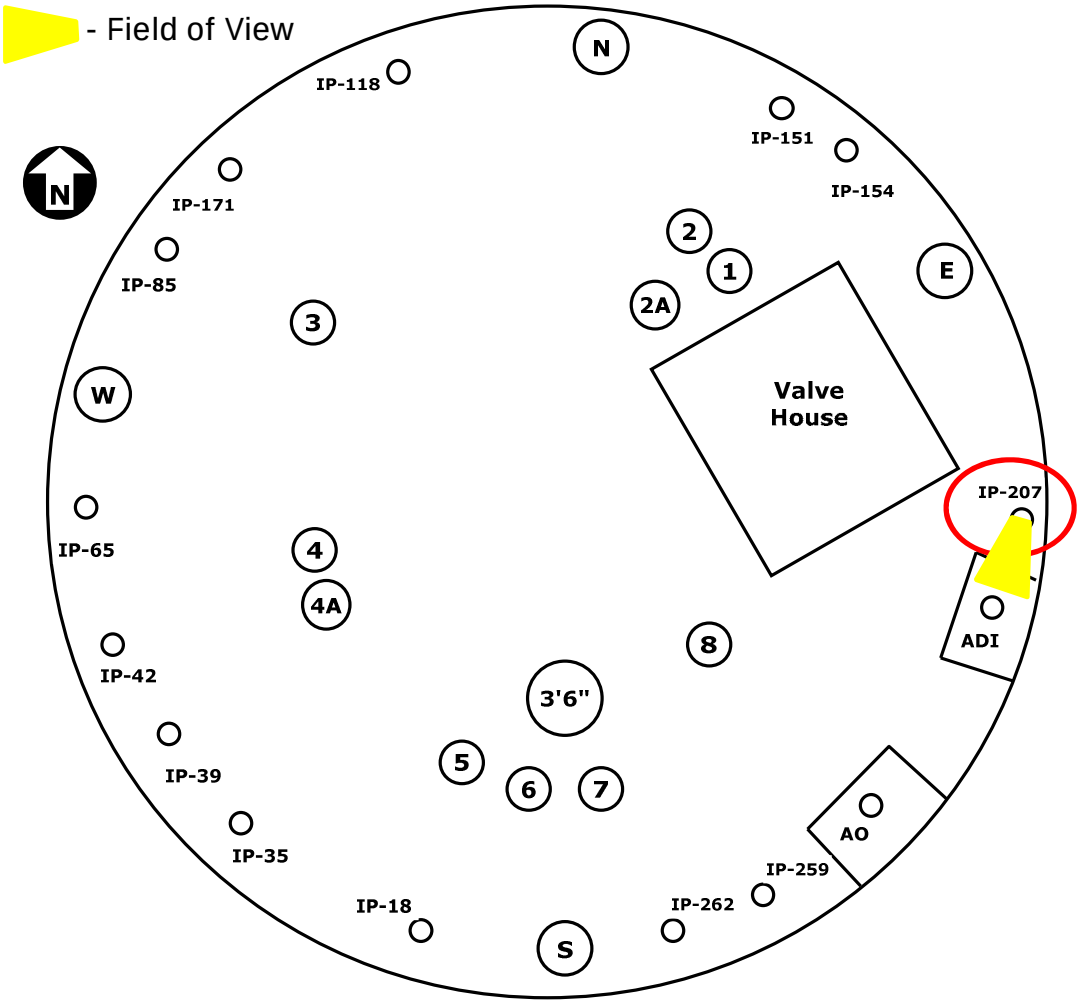


Tank 16 Annulus IP-118

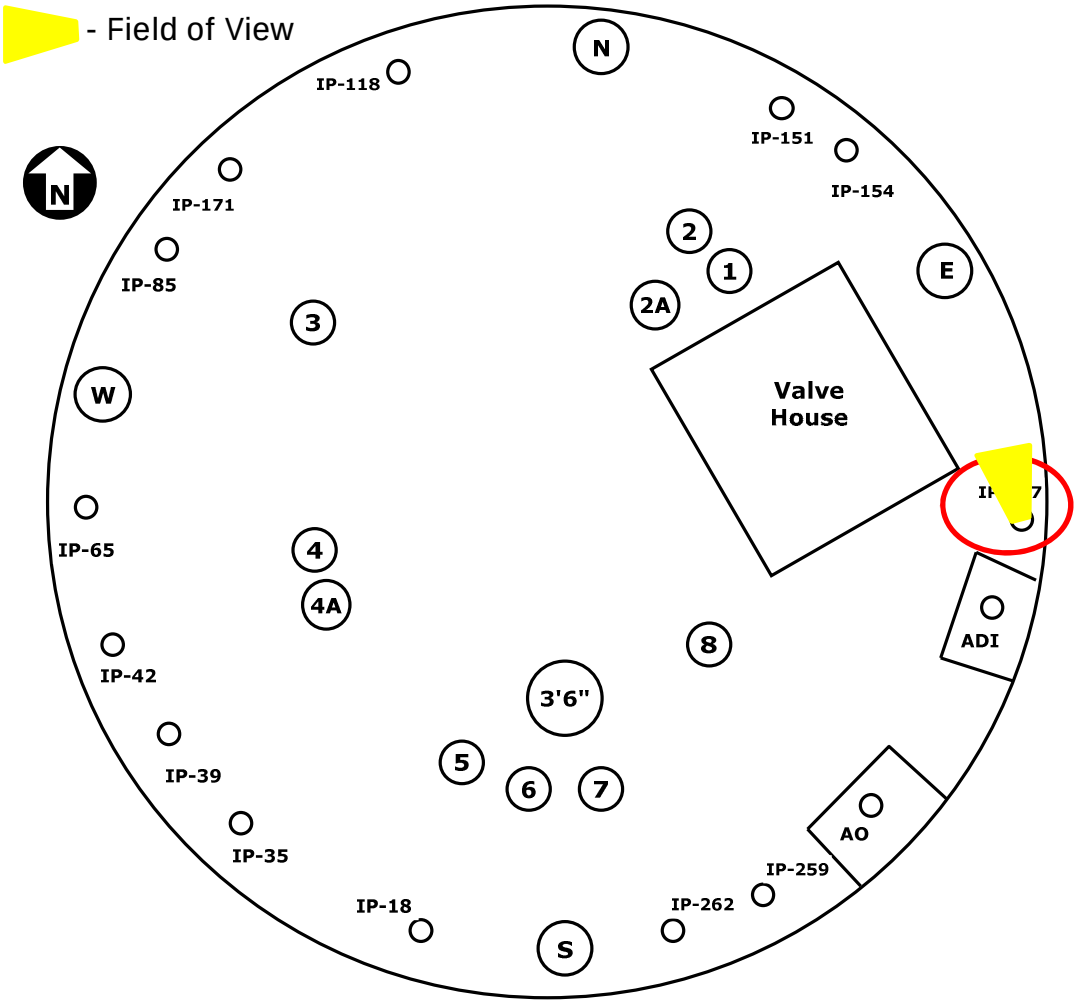




Tank 16 Annulus IP-207



Tank 16 Annulus IP-207

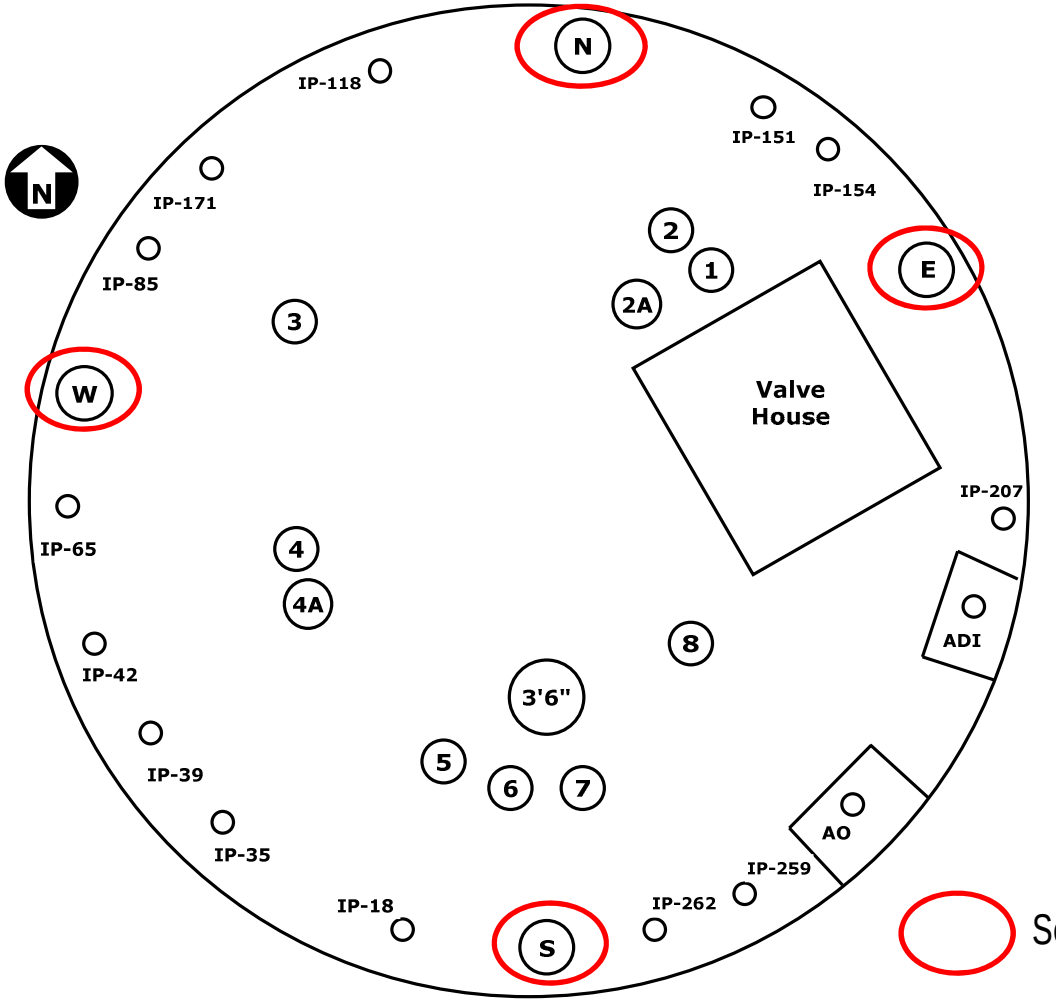


Current Status of Tank 16

	Primary	Annulus	Total
Total Starting Volume (gal)	1,060,000	25,700	**1,085,700**
Total Pump/Jet Run Time (hr)	2,297	632	**2,926**
Total Liquid Introduced into the Tank (gal)	887,000#	14,400	**901,400**
Total Solids Removed (gal)	76,700	2,700	**79,400**
Total Solids Remaining* (gal)	300^	3,300@	**3,600**
Percent of Total Volume Removed (%)	99.9	87.2	**99.7**

Based on a compilation of the total volumes used in MSR, CSR, and Final Water Rinse.
* Based on an estimate of the remaining solids. Final volume determination will be included in the Closure Module.
^ Solids have characteristics of a sludge waste inventory
@ Solids have characteristics of salt waste inventory with insoluble sodium aluminosilicates

2011 Annulus Sampling



- 2011: Sampling was conducted under four annulus risers
- Samples were collected outside of the annulus duct

Solid samples collected under these IPs

2011 Annulus Sample Results

- Four samples found to be composed primarily of Na, Al and Si
  - Predominantly sand and NaAlSi compounds
- Only 20-35% of solids dissolved after three contacts with water heated to 45°C (113°F)
  - Majority of the radionuclides were insoluble
  - ~1/3 of Tc-99 dissolved in water
- Oxalic acid at 45°C dissolved ~34-45% of solids
  - Gel-like solutions were formed

Additional Annulus Cleaning Options

- **Dry removal** technology originally pursued
  - EOI to 46 vendors, RFP to 8 vendors, 3 proposals submitted
  - Demonstrations revealed multiple challenges in development
  - Cost estimated to be > $10,000,000
- **Oxalic Acid** technology also evaluated
  - Limited effectiveness for targeted constituents
  - Processing issues due to gel-like consistency of silica solids
- **Water/steam based** technologies pursued
  - Limited effectiveness for targeted constituents
  - Nuclear safety, industrial and radiological hazards

Dry Removal Option

Deployment of a vacuum technology?

- Proven Mantis technology that was utilized in Tanks 18 and Tank 19 is not a viable alternative
  - Mantis unit too large for small annular space or within duct
  - Hard crust exists; material must be broken up into small particles
  - Duct work and shape of annulus makes similar platform unusable
- Smaller robotic platform with scabbling and vacuum capability is not mature
  - Very limited applicability at this time due to mobility around and over obstacles and associated tether management
  - Estimated > 3 years to development technology
  - Development and deployment costs estimated to be $7-10 million
  - Unknown if technology would remove significant volume of residuals

Annulus Water Sluicing Option

- Option would deploy high-pressure water nozzles in the annulus
- High-pressure spray would, in theory, break-up material exposing more surface area
  - Soluble fraction would dissolve with vigorous mixing
  - "Chunks" of insoluble fraction would have to be reduced to a particle size that could be mobilized
- Slurry that reaches transfer pump would then be transferred to a neighboring waste tank

Annulus Water Jet Demonstration

Demonstration Set-Up:

- Full scale portion of annulus with ventilation duct built in a 'sealand' container
- Residuals simulated
- Actual water jet and transfer pump used

Demonstration Results:

- Airborne hazard confirmed
- Moderate ability to move waste within spray zone
- Limited movement of solids to pump suction

Water Jet Demonstration

Risk to Today's Workers and Environment

Deployment of any cleaning technology (e.g. dry, oxalic, water sluice) into the Tank 16 annulus carries risk:

- Worker dose associated with equipment installation, operation, and maintenance
  - Equipment must be installed and operated through the annulus risers.
  - North riser dose rate: ~800 mrem/hr (Short half-life Cs-137)
  - South riser dose rate: ~500 mrem/hr (Short half-life Cs-137)
- Environmental risk associated with low frequency/high consequence events:
  - Aerosolization of sand/salt compound into airborne hazard
  - Must also consider potential event initiators (e.g. seismic, tornado) on annulus cleaning operations

H-Tank Farm General Closure Plan

Based on the characteristics and estimated volume of the solids remaining in Tank 16, the performance objectives from the HTF GCP are expected to be met.

- Anticipate that concentration values in the groundwater at the point of assessment for HTF will be **below the MCL values** for all the non-radiological inorganic constituents listed in Table 5.2-1 of the HTF GCP
- Anticipate that concentration values in the groundwater at the point of assessment for HTF will be **below the MCL values** consistent with the State Primary Drinking Water Regulations (i.e., 4 mrem/yr beta-gamma dose, 15 pCi/L total alpha concentrations, and 5 pCi/L total Ra-228 + Ra 226)

Radiation Dose Perspective

- Anticipate that the peak annual all-pathways dose from HTF will be **<0.5 mrem** during the 1,000 year period and **<5 mrem** during the 10,000-year period (versus 25 mrem performance objective)*
  - Tank 16 is not a significant contributor to the peak dose in HTF
  - For conservatism, performance assessment ignored the presence of the primary liner and the annulus pan
  - Performance assessment also assumed 1,000 gallons of sludge-like solids would remain in the annulus
- Per NCRP-160, the average dose to a person in the United States in 2006 was **620 mrem**
  - Approximately 310 mrem from naturally occurring background
  - Approximately 300 mrem from medical procedures
- A person receives approximately 0.5 mrem/hr for a cross-country flight

* Based on a preliminary estimate of the inventory. Final inventories will be included in the Closure Module

Additional Removal Considerations

- Unlikely that significant removal of key radionuclides is possible in the annulus
  - Laboratory testing under best case conditions shows low solubility of key radionuclides
  - Mineral Natrodavyne is much less soluble than typical salt waste
  - Difficult to break-up and move residuals to pump suction
  - Nuclear hazards (e.g. aerolization) would accompany mobilizing the salt/sand compounds
- Performance assessment indicates the long-term risk associated with the annulus salt/sand compounds are low
  - Salt-like radiological profile in annulus; low concentrations of long-lived actinides typically seen in sludge residuals
- The potential risk to today's workers and environment would not result in significant risk reduction to future generations

Summary

- Tank 16 represents a unique set of circumstances
- Over 99% of the waste volume in Tank 16 has been removed
- A qualitative assessment indicates that the HTF GCP performance objectives will not be challenged
- A formal "practicable" discussion will be included in the Tank 16 Closure Module

Requested Action

The three agencies agree that, based upon the described qualitative assessment, **there is reasonable assurance** that it is appropriate **to suspend waste removal activities** and enter the sampling and analysis phase of the operational closure process for Tank 16