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Revision 0

Engineered System in Waste Management Area A-AX

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

Contractor for the U.S. Department of Energy
Office of River Protection under Contract DE-AC27-08RV14800

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Engineered System in Waste Management Area A-AX

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March 22, 2017

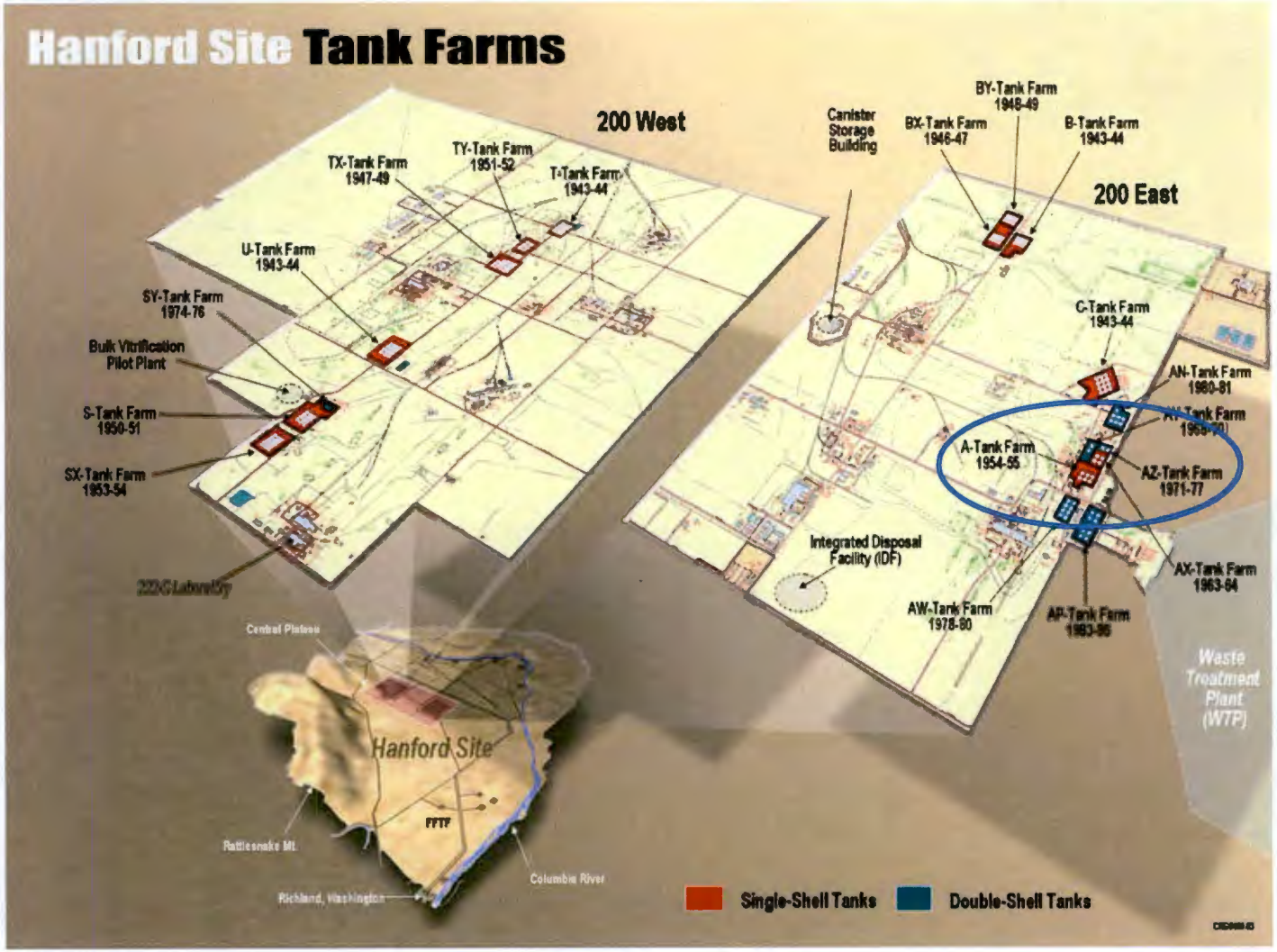
Outline

1. WMA A-AX Equipment and Nearby Facilities
2. Recharge
3. Contaminant Release Models for Residual Waste

Part 1 Outline

- Overview of WMA A-AX features and history
- Single-Shell Tanks
  - Construction
  - Excavations, backfill, and topography
- Ancillary Equipment
- Discharge facilities in or near WMA A-AX
- Post-closure system to be modeled

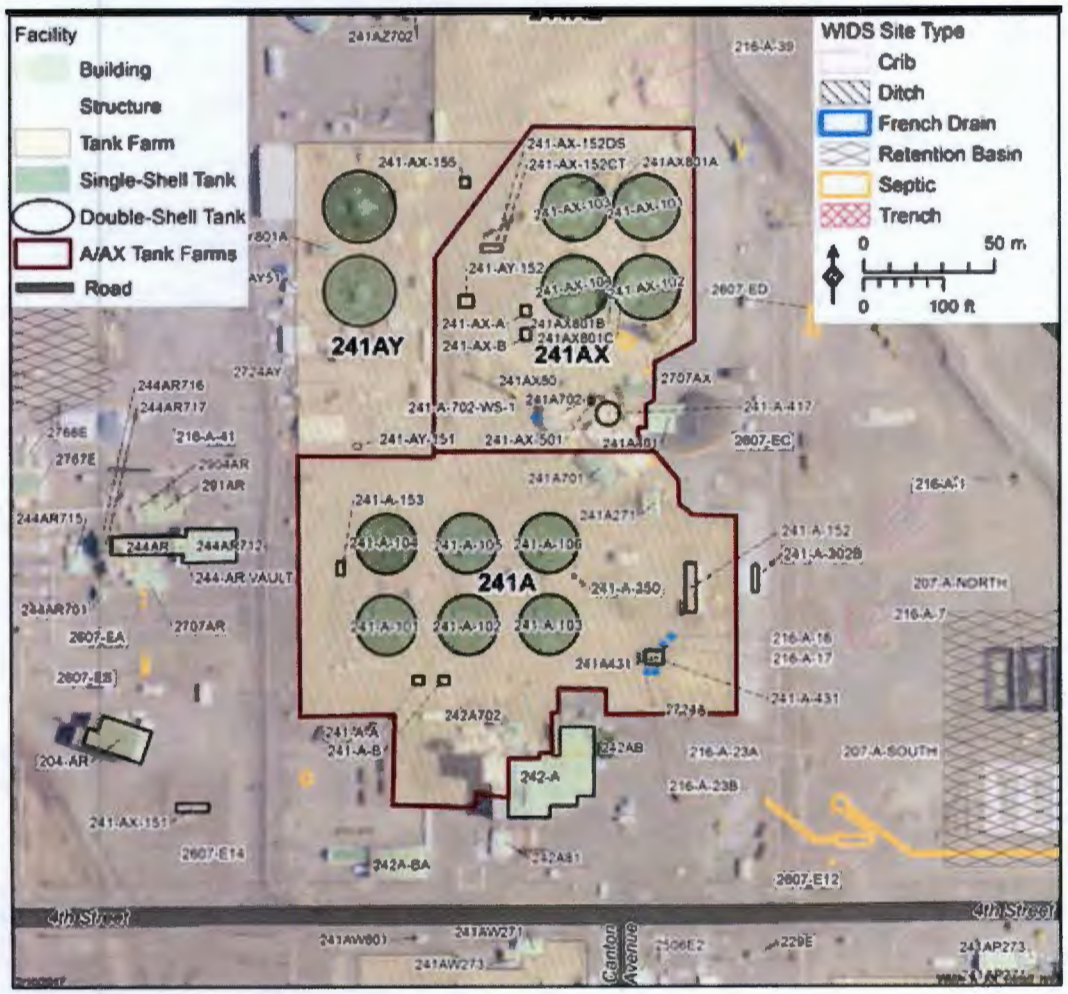
Location of WMA A-AX



WMA A-AX and Vicinity

- WMA A-AX includes the 241-A and 241-AX tank farms and associated equipment
- 244-AR Vault
- Surrounded by several other tank farms with double-shell tanks (A Complex)
- Single-shell tanks associated with WMA C (241-C) are to the northwest
- Pipelines connect to equipment in nearby farms and 202-A PUREX facility
- Numerous liquid discharge facilities used nearby at various times (cribs, trenches, ditches, septic systems, etc.)

Description of WMA A-AX

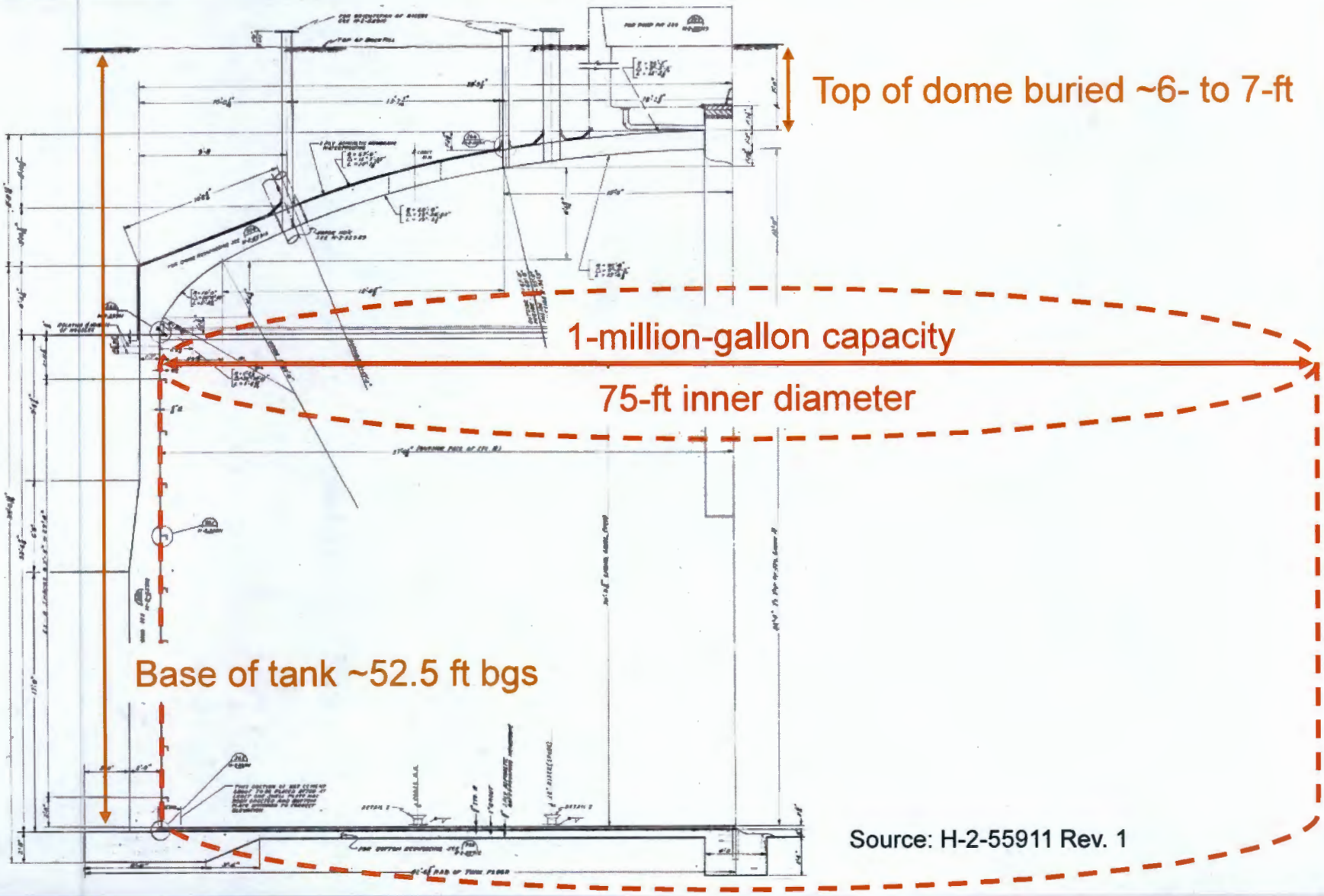


- 241-A Tank Farm (A Farm) contains six Single Shell Tanks (SSTs)
- 241-AX Tank Farm (AX Farm) contains four SSTs
- The WMA includes catch tanks, diversion boxes, valve pits, pipelines, French drains and unplanned release sites
- Losses of waste from tanks and equipment have contaminated the soil

Operations History of A and AX Farms

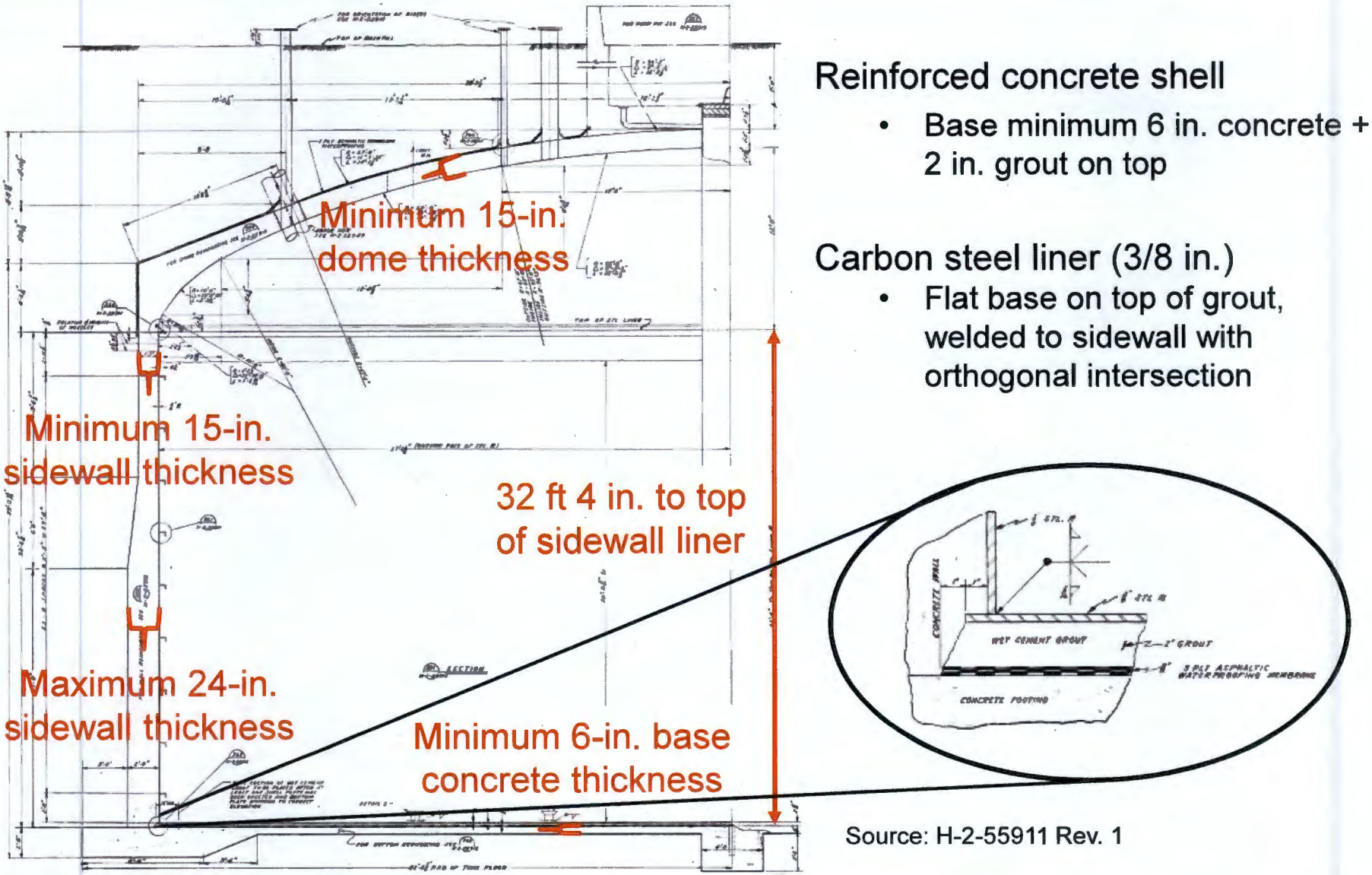
- **A Farm**
  - Constructed 1953 to 1955
  - SSTs designed to handle self-boiling PUREX waste <= 300 °F
  - Operated 1956-1980
  - Currently hold mostly saltcake and some sludge
- **AX Farm**
  - Constructed 1963 to 1965
  - SSTs designed to handle self-boiling PUREX waste <= 350 °F
  - Operated 1965-1980
  - Currently hold mostly saltcake and some sludge

A-100-Series Tank Construction



Source: H-2-55911 Rev. 1

A-100-Series Tank Construction



Reinforced concrete shell

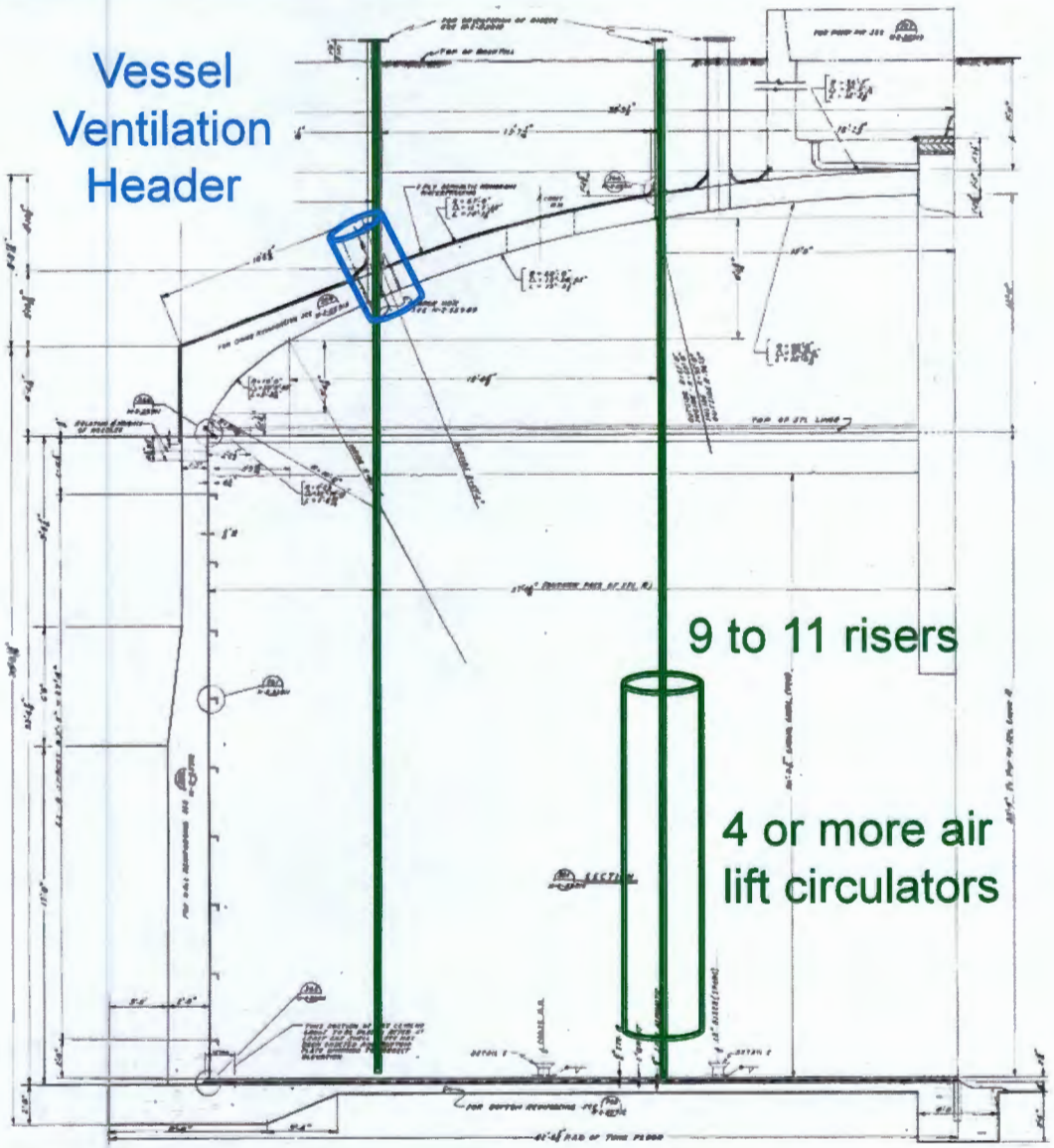
- Base minimum 6 in. concrete + 2 in. grout on top

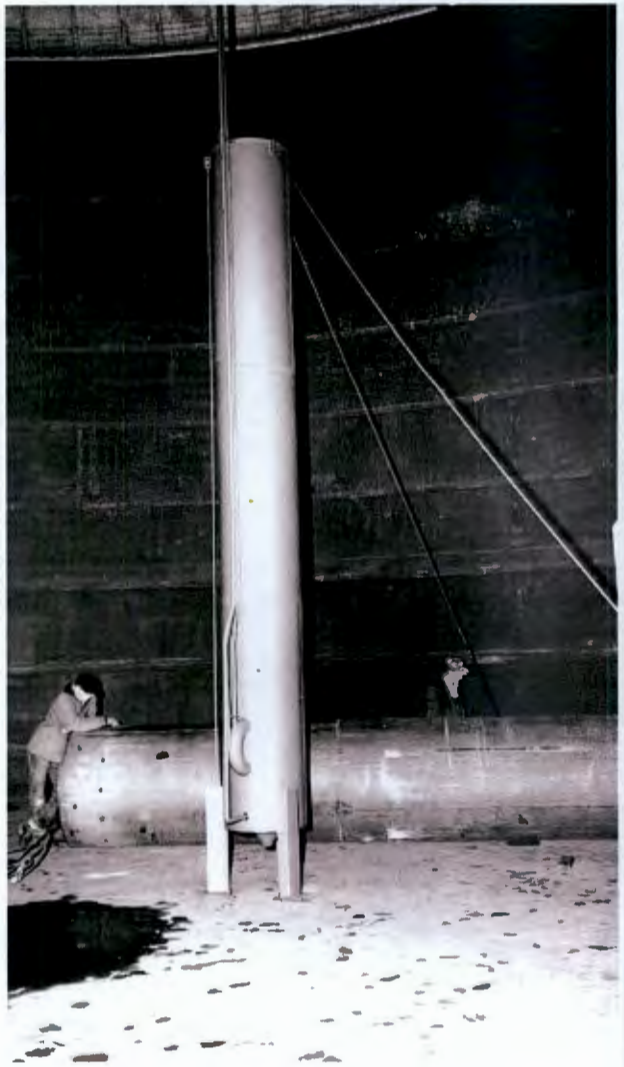
Carbon steel liner (3/8 in.)

- Flat base on top of grout, welded to sidewall with orthogonal intersection

Source: H-2-55911 Rev. 1

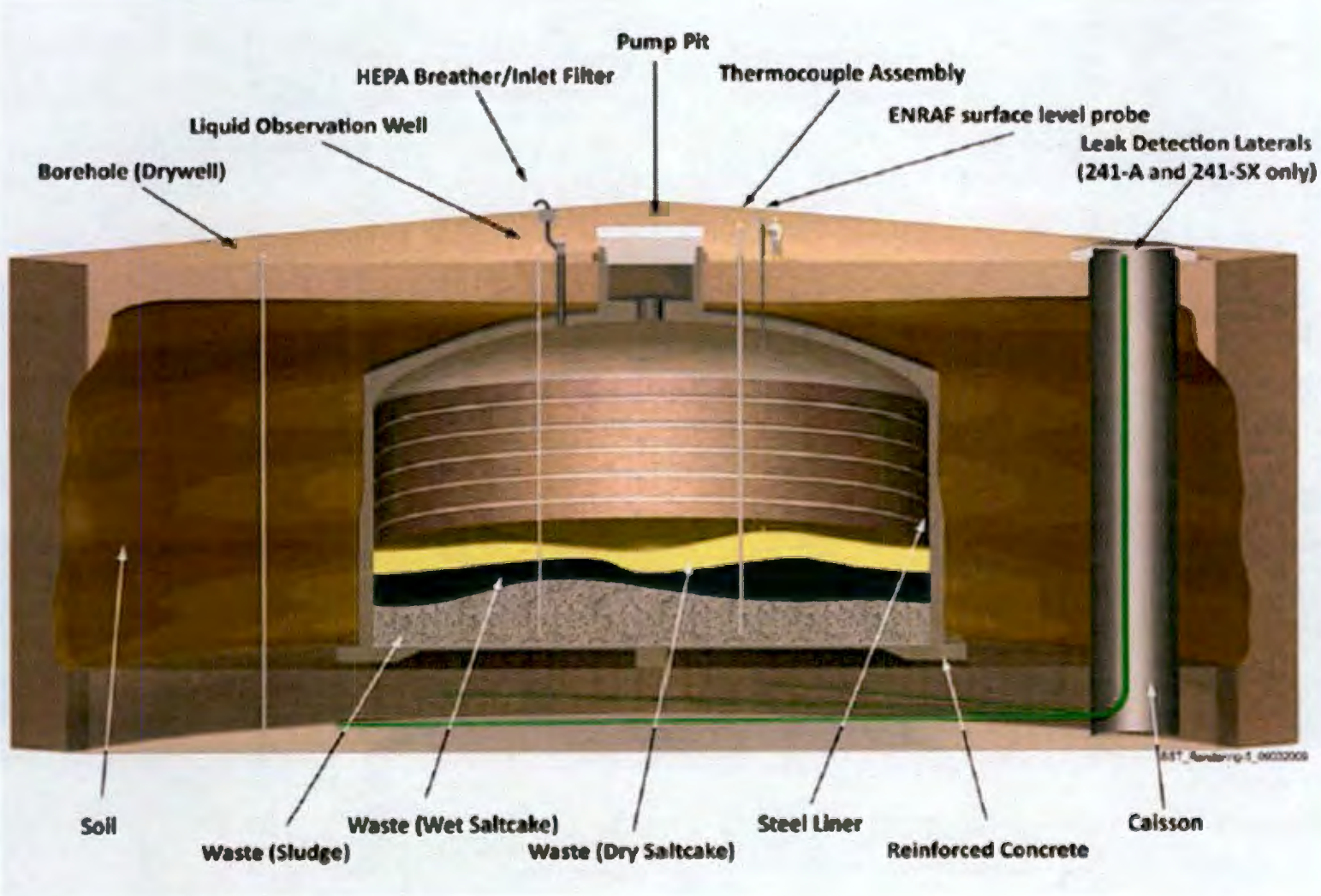
A-100-Series Tank Construction





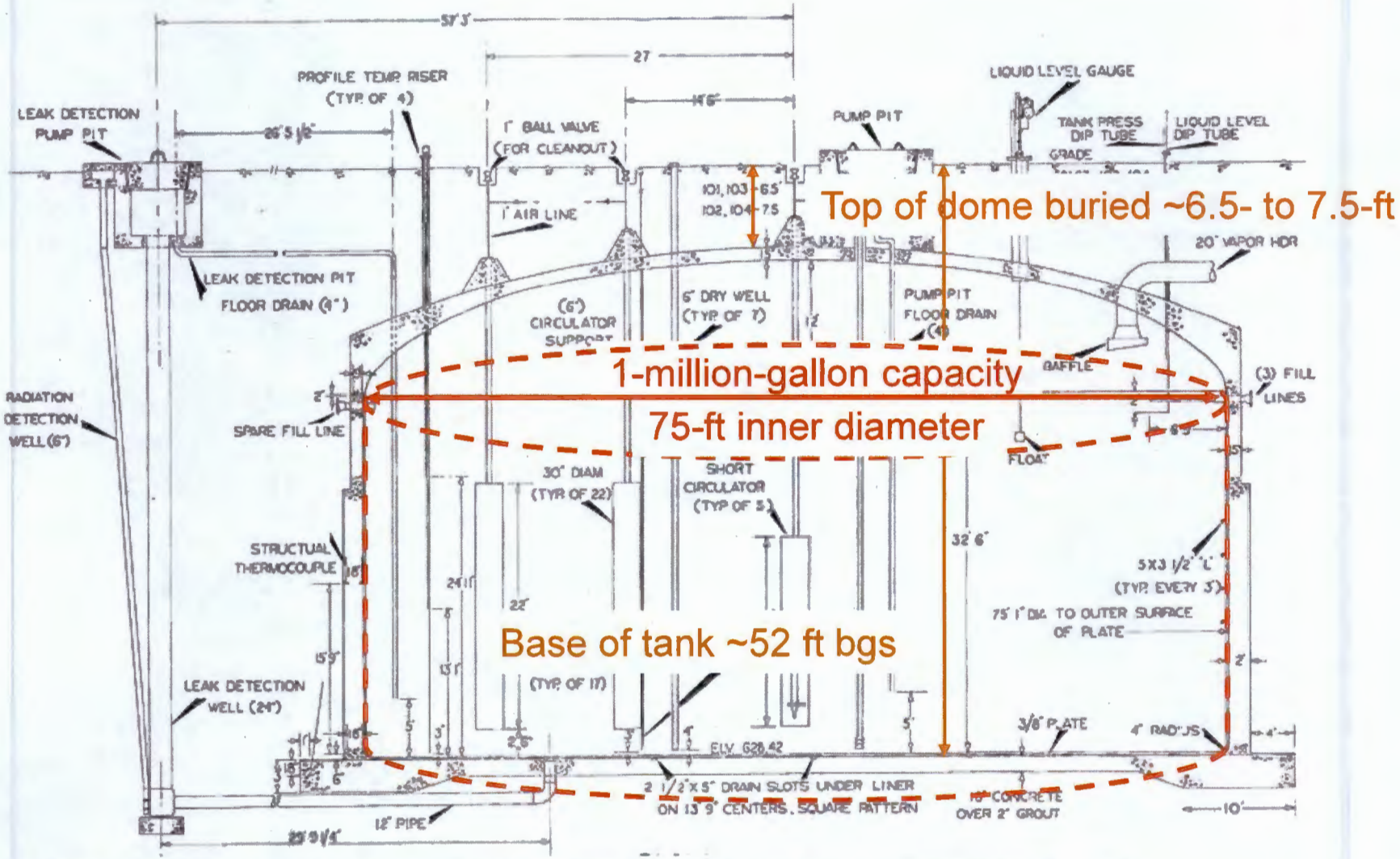
Source: H-2-55911 Rev. 1

A-100-Series Tank Schematic



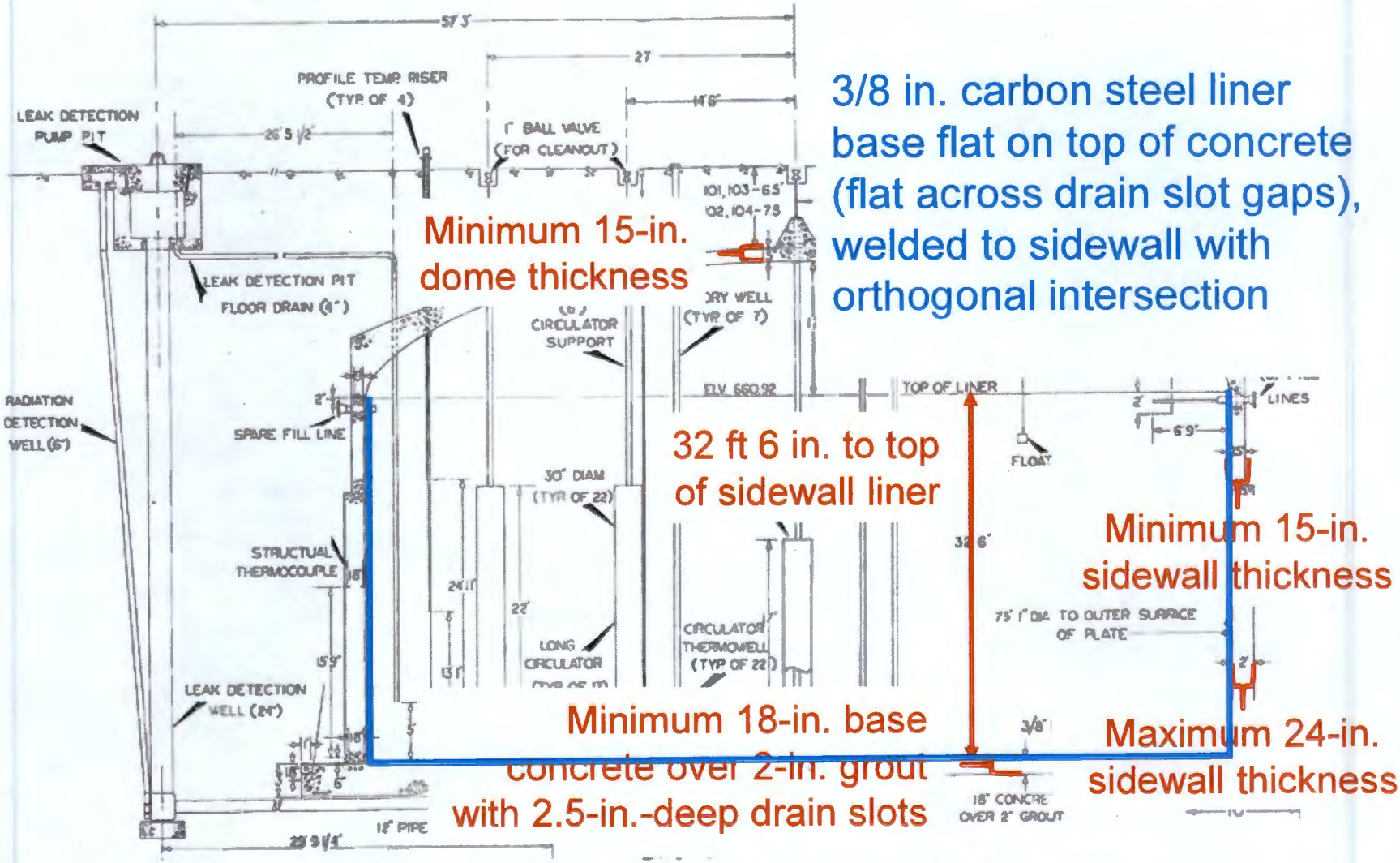
Source: HNF-EP-0182, Rev. 348

AX-100-Series Tank Composite Section



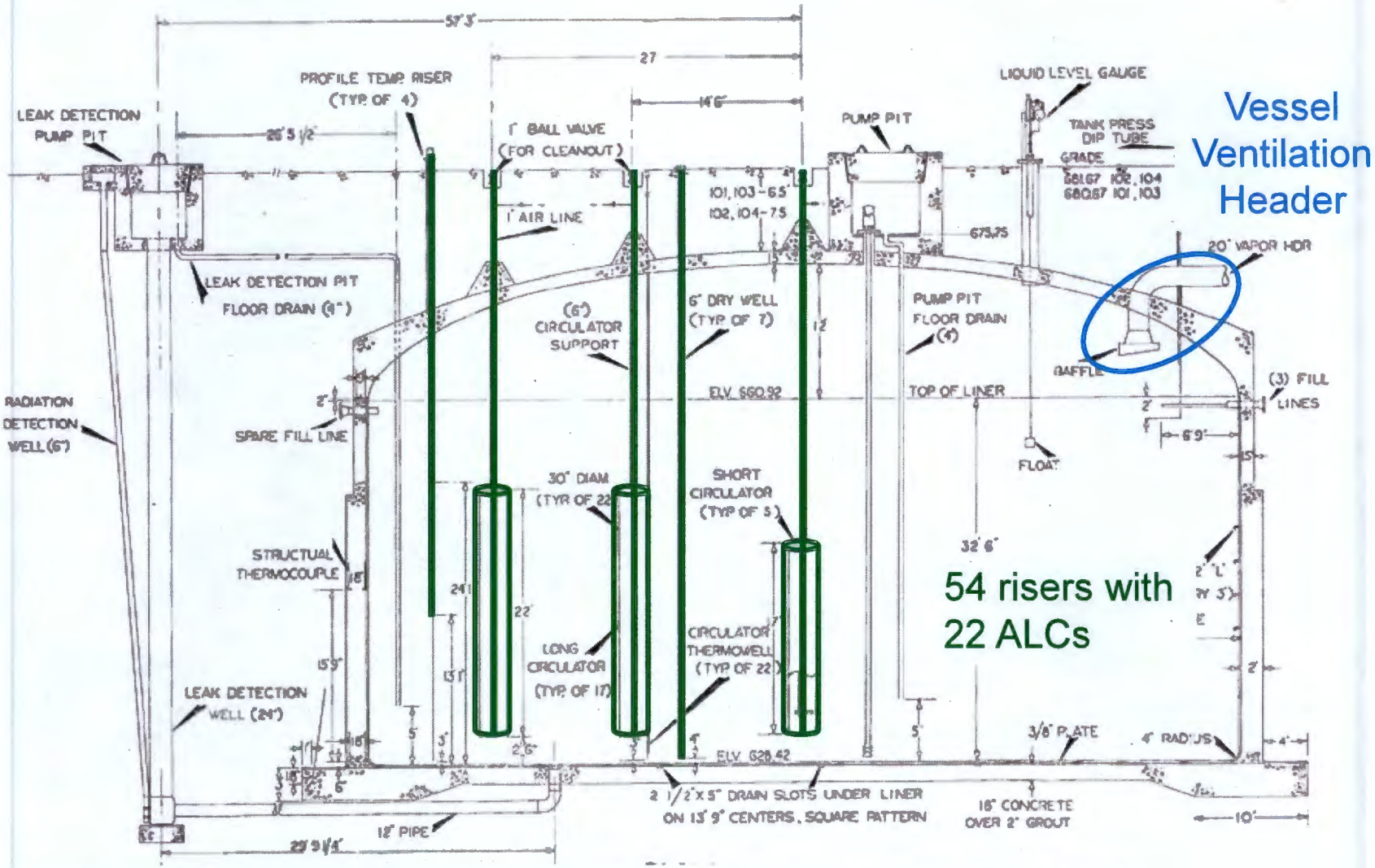
Source: RL-SEP-9, "PUREX 241-AX Tank Farm and Waste Routing System Information Manual."

AX-100-Series Tank Composite Section



Source: RL-SEP-9, "PUREX 241-AX Tank Farm and Waste Routing System Information Manual."

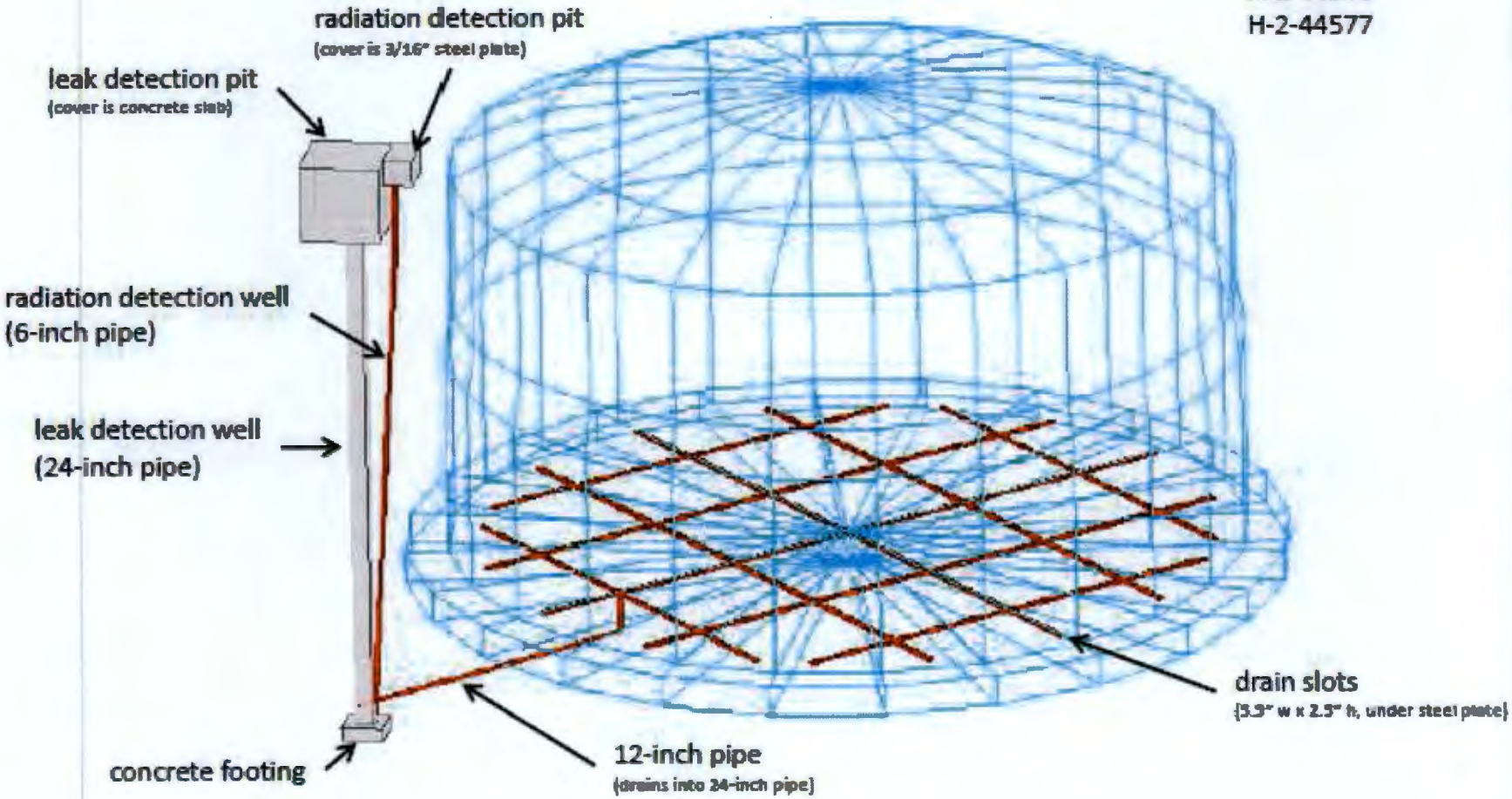
AX-100-Series Tank Composite Section



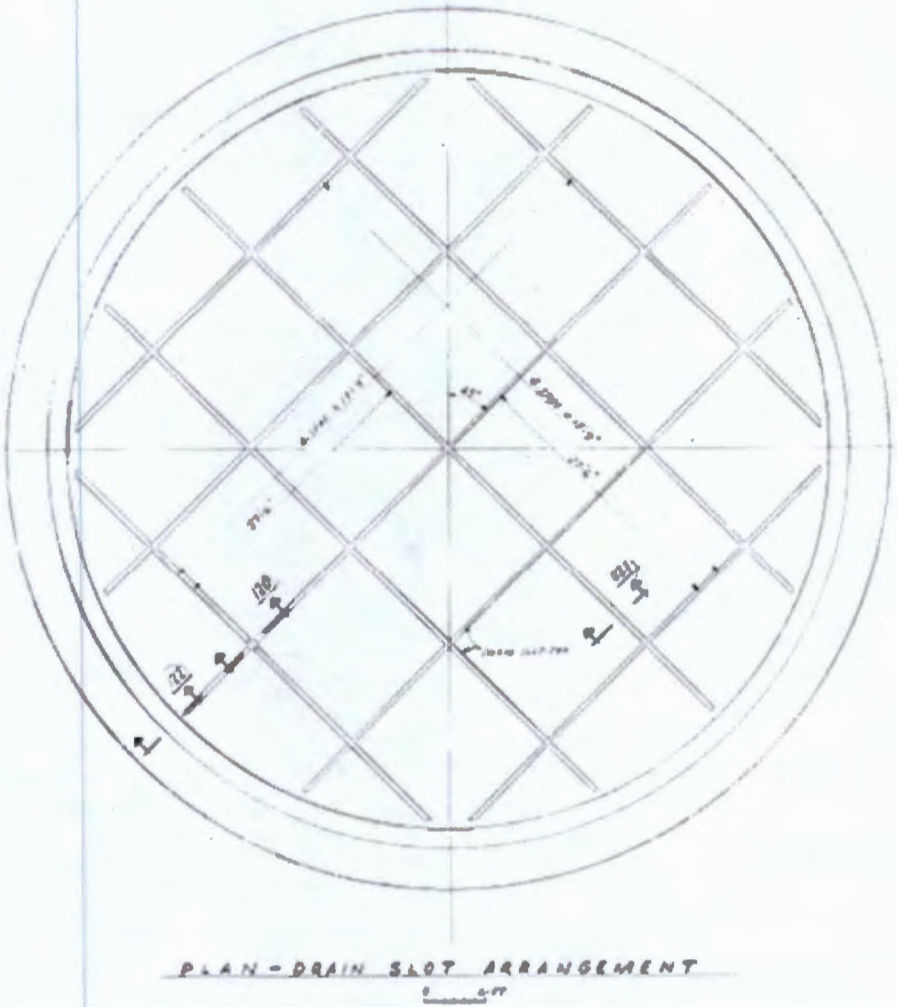
Source: RL-SEP-9, "PUREX 241-AX Tank Farm and Waste Routing System Information Manual."

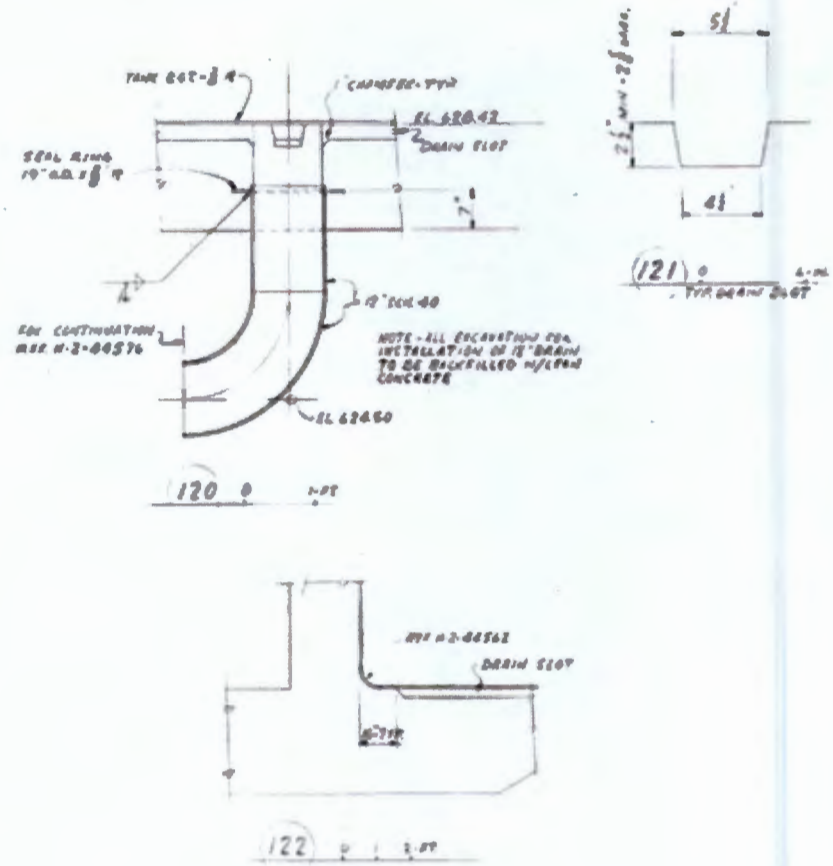
AX Farm Leak Detection Pits

Ref dwgs
H-2-44563
H-2-44575
H-2-44576
H-2-44577



AX-100-Series Drain Slot Detail





Source: H-2-44563, "Structural Waste Storage Tanks Drain Arrangement & Details 241-AX PUREX Waste Tank Farm," Rev. 2.

A Farm Construction Photos

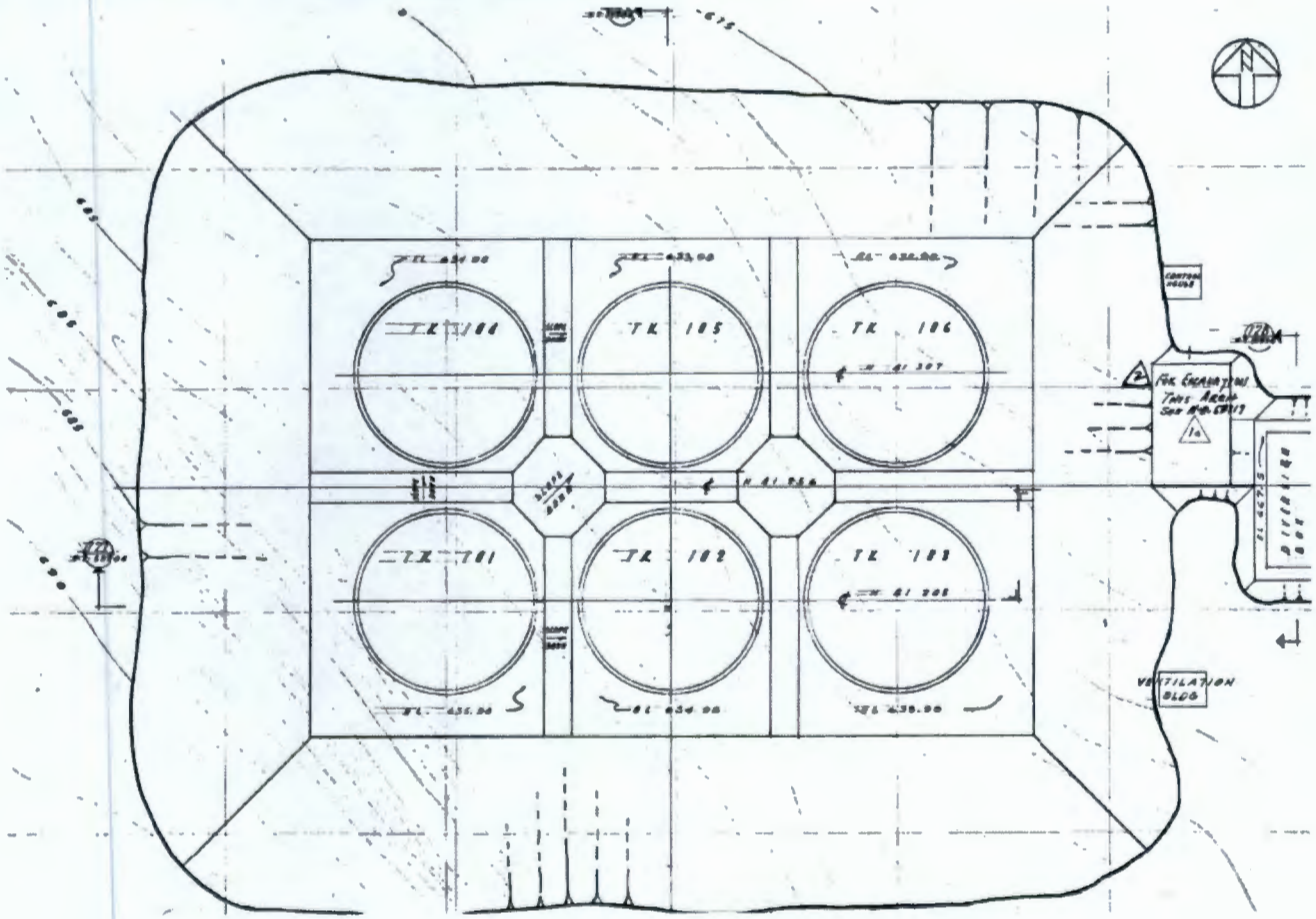
A Farm Construction Photos

A Farm Construction Photos

A Farm Construction Photos

A Farm Construction Photos

A-Farm Topography



- Ground surface slopes down ~3% to NE from 690 to 672 ft amsl NGVD29 (211.4 m to 205.9 m NAVD88)
- Tank bases at 636 to 633 ft amsl NGVD29 (194.9 m to 194.0 m NAVD88)

Ref. H-2-55904

AX-Farm Topography

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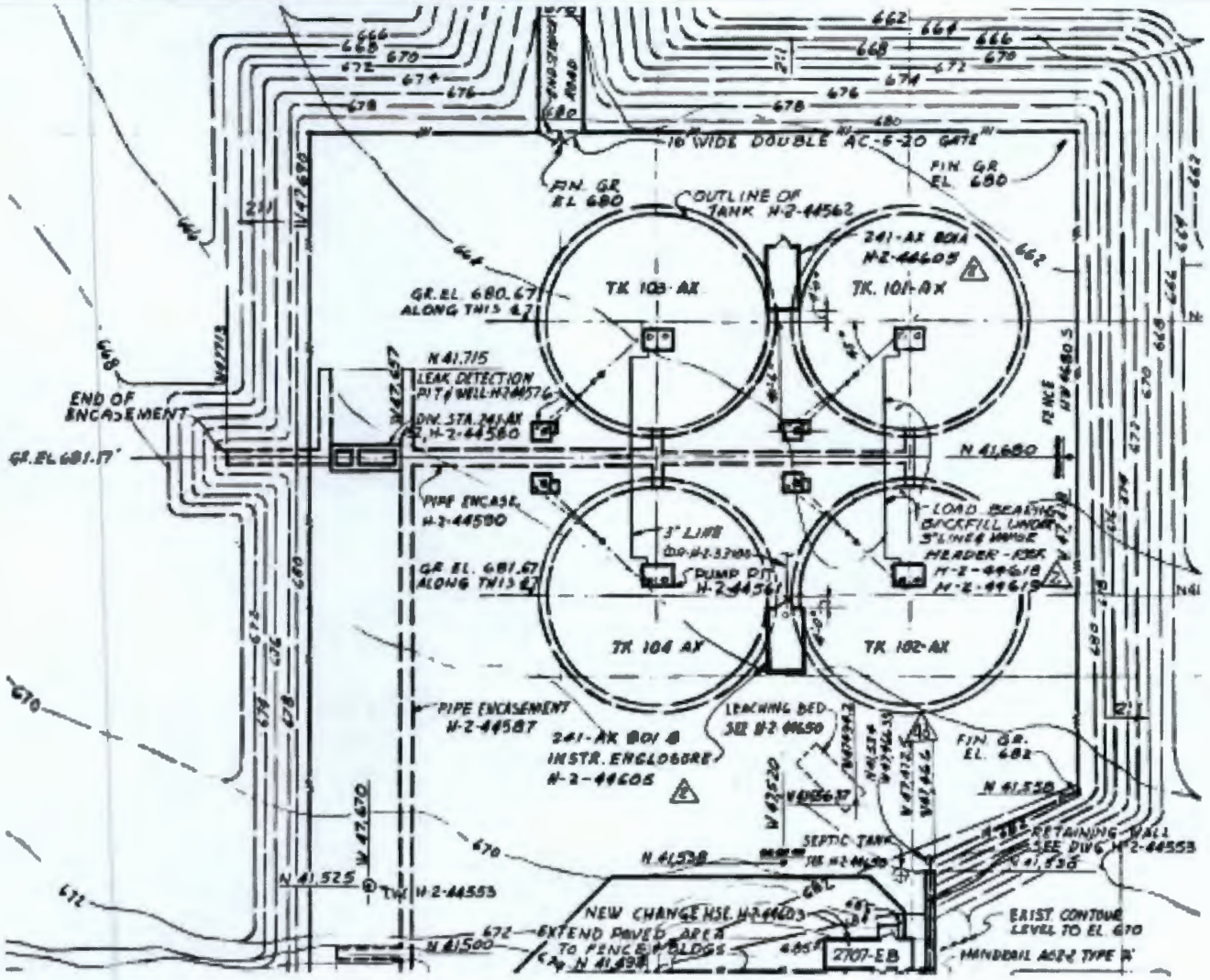


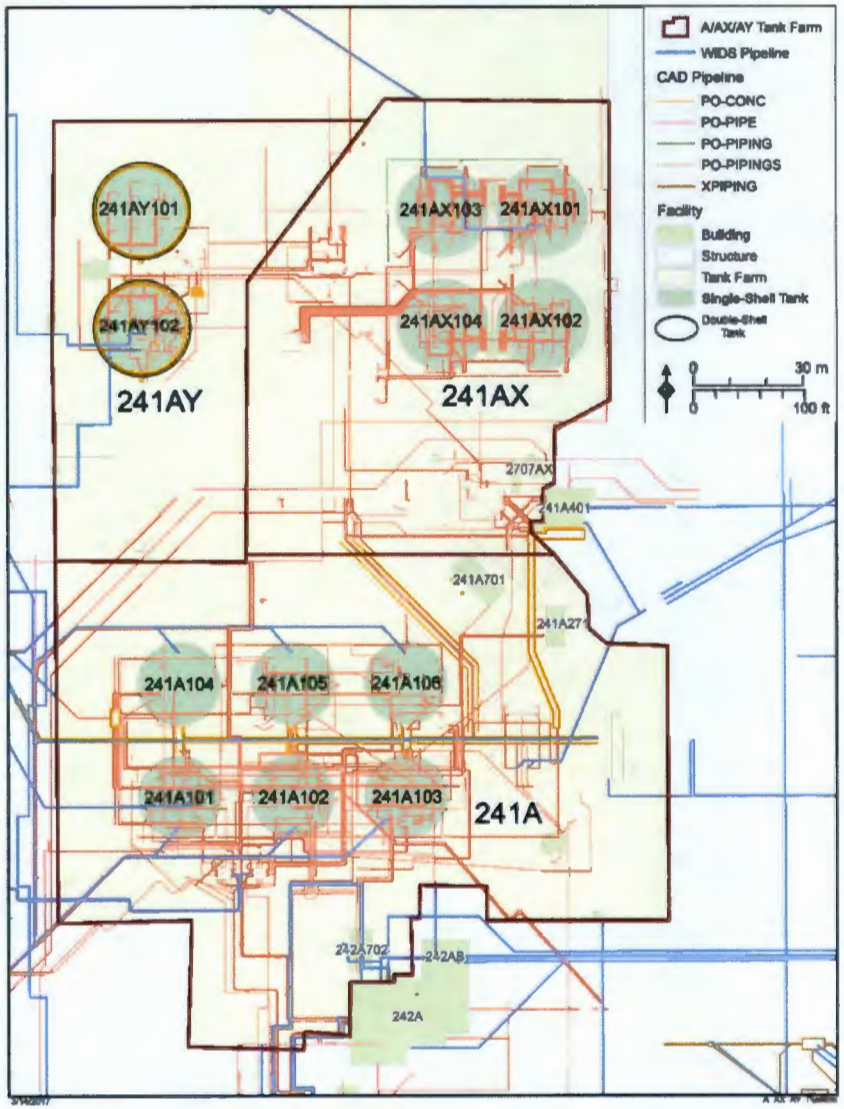
- Original ground surface sloped down to NE from 672 to 660 ft amsl NGVD29 (205.9 m to 202.2 m NAVD88)
- Tank bases ~627 ft amsl NGVD29 (192.1 m NAVD88)
- Retaining wall and farm surface built up to ~681 ft amsl NGVD29 (208.6 m NAVD88)

Ref. H-2-44552

Pipelines in Waste Management Area A-AX

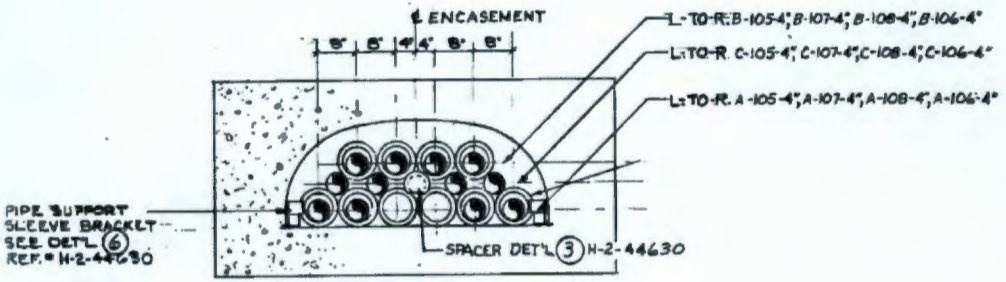
- 121 transfer pipelines (9 miles ± 3 miles) attributed to A Farm
- 119 transfer pipelines (8 miles ± 2 miles) attributed to AX Farm
- Pipelines routinely flushed after use
- Some lines in WMA A-AX became plugged in the past

For Information Only



Pipelines in Waste Management Area A-AX

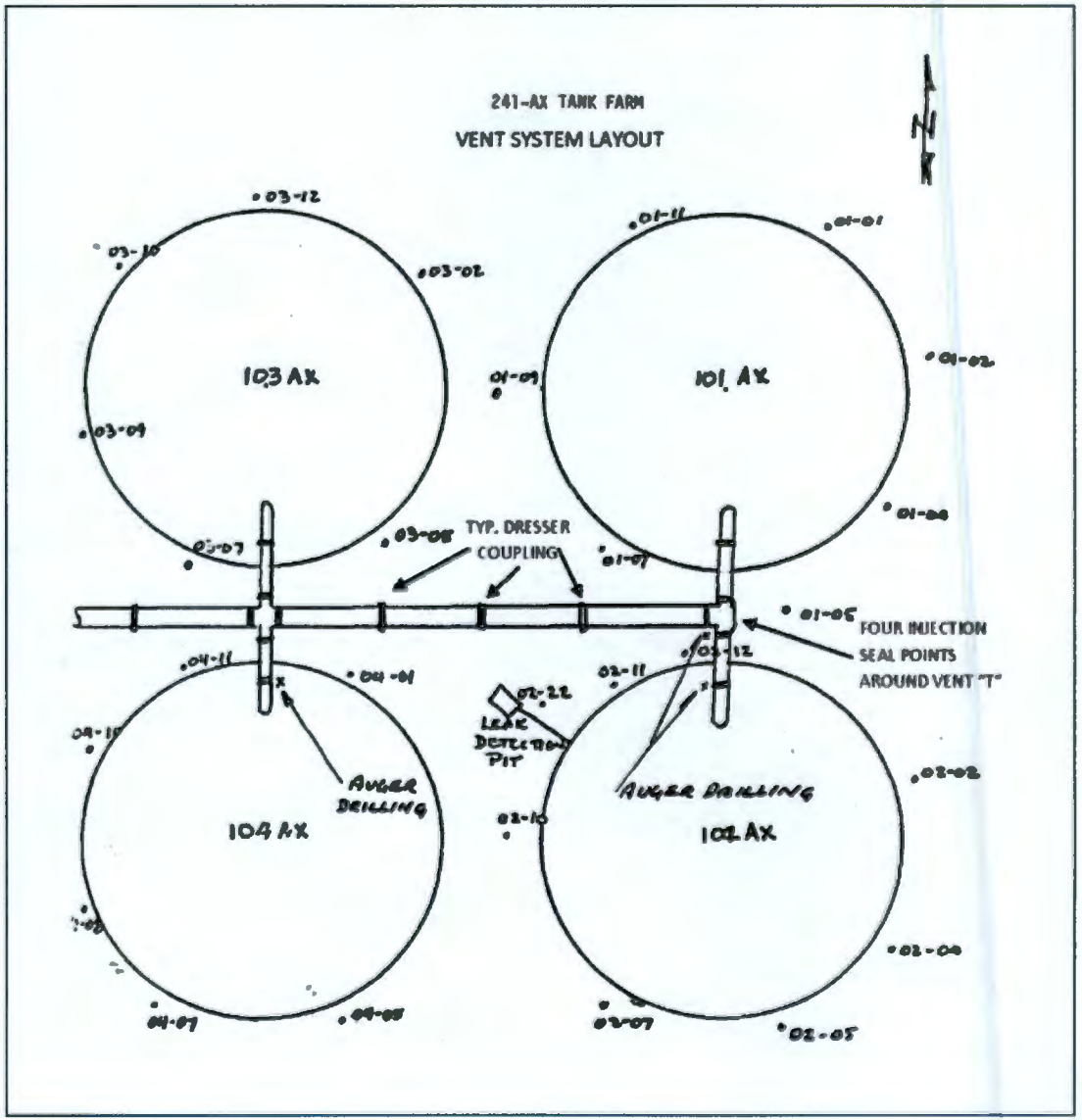
- Most carbon steel
- In general, pipelines in SST system range from 2 to 6 in. diameter (3 in. average)
- Most of length direct buried, but concrete encasements used to route within tank farms, e.g. between tanks
  - Multiple pipelines arranged in stacks within encasements using trays and/or pipe support sleeves (example below)



Source: H-2-44633

Vapor Headers in A and AX farm

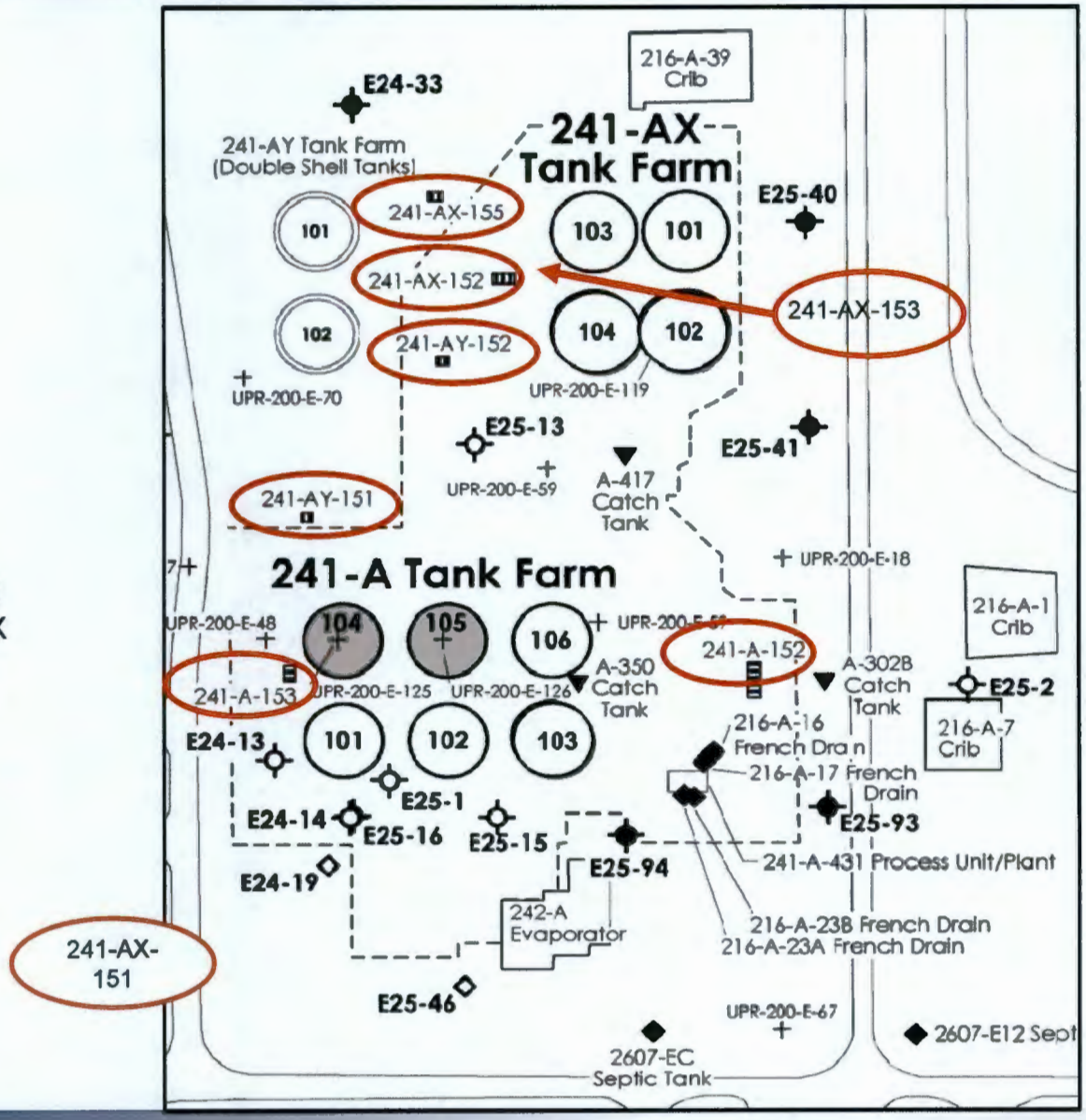
- Air and steam exit the AX Farm SSTs through 20-in. diameter pipe through dome, connects to 24-in. pipe running to AX-152 diverter station
- AX Farm vapor header slopes upward into A farm vapor header
- Header ~4 ft below grade (above waste pipeline encasements)
- Leaks attributed to Dresser couplings
- Vapor header gas to stack
- Condensate discharged back to SSTs, cribs, or French drains



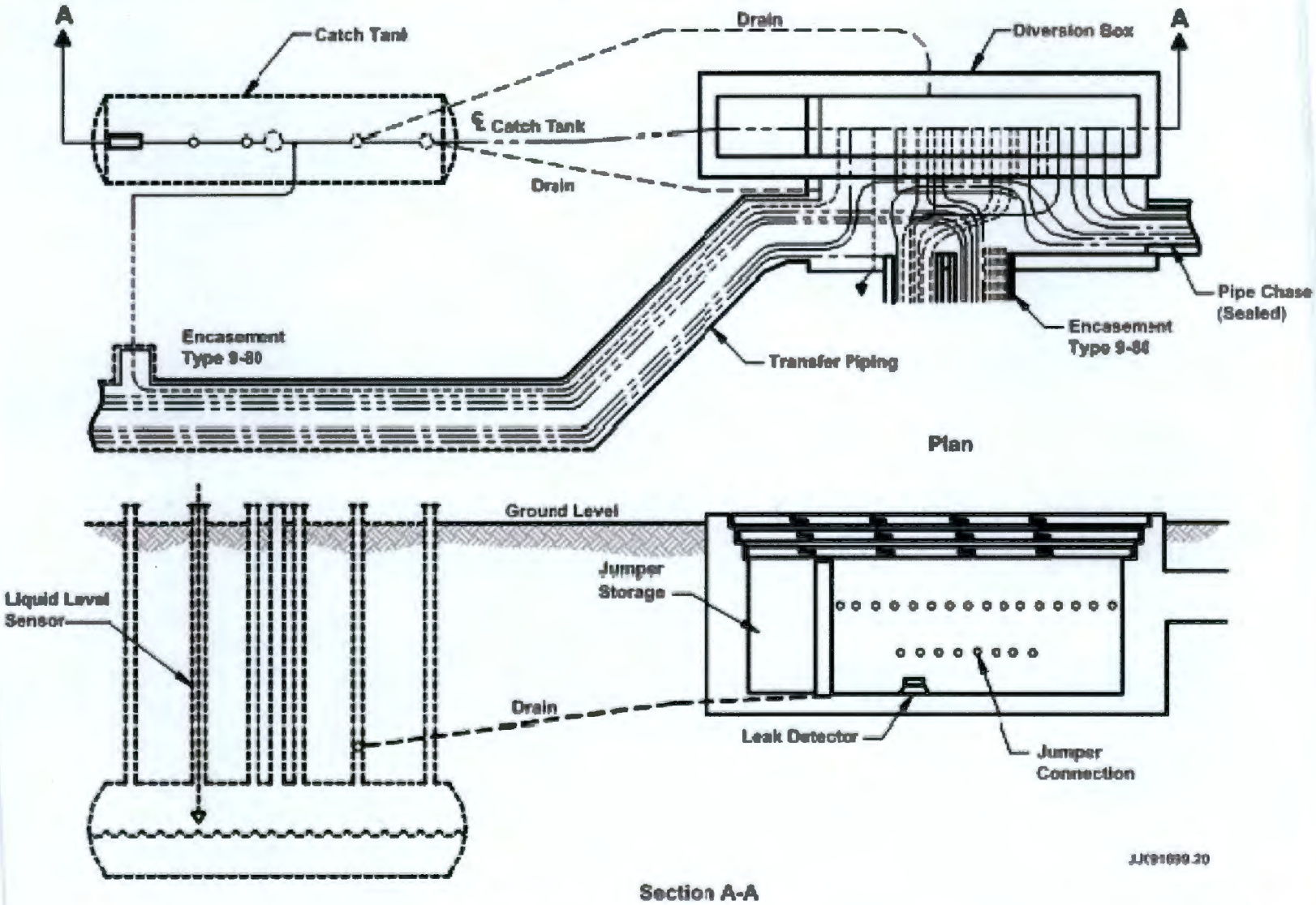
A Farm Vapor Header Construction

Diversion Boxes in or Related to Waste Management Area A-AX

241-A-151 at 202-A PUREX connects to 241-A-152



Typical Diversion Box Transfer System



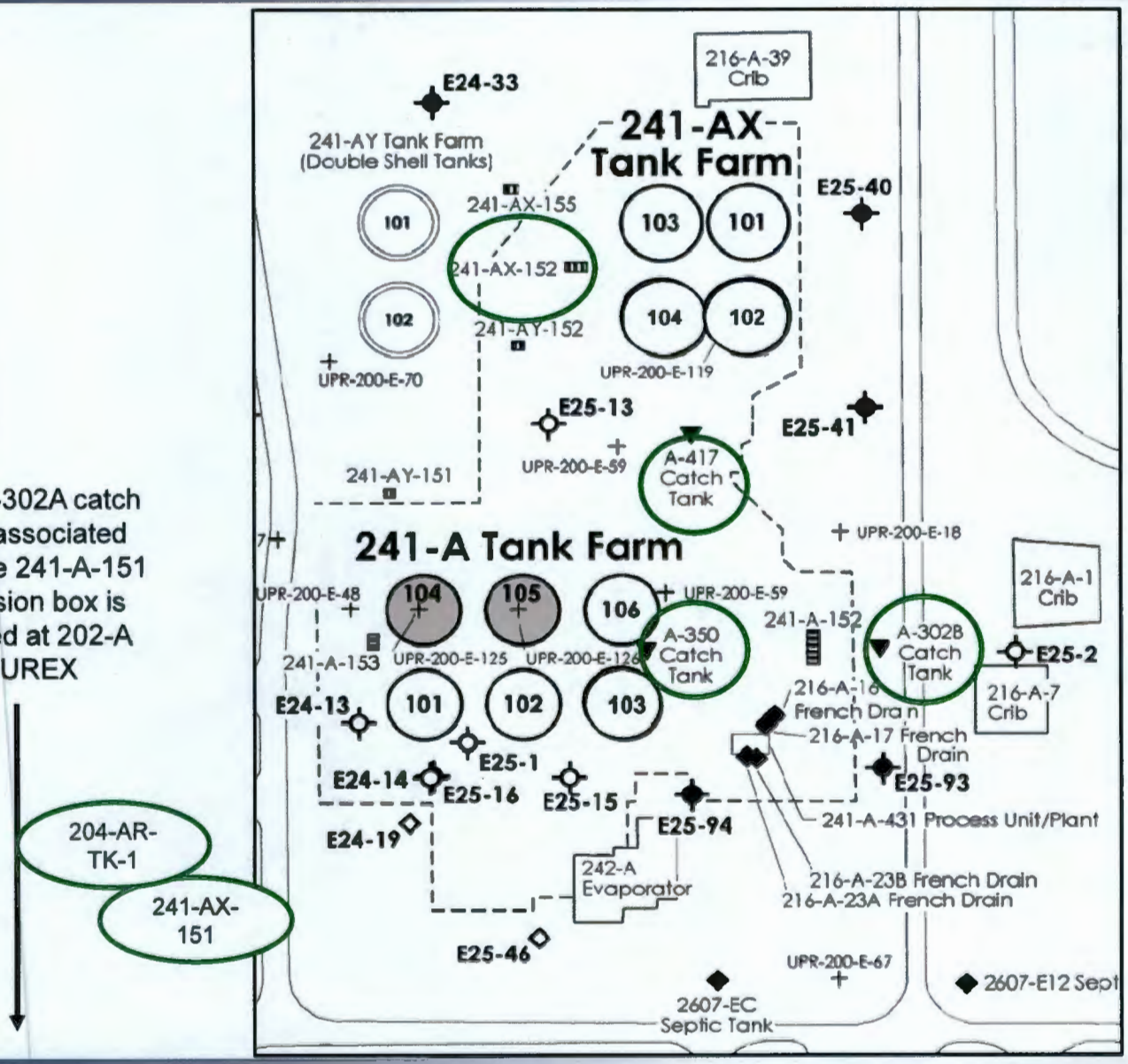
Photographs of Diversion Boxes

Historical Photograph of a Diversion Box

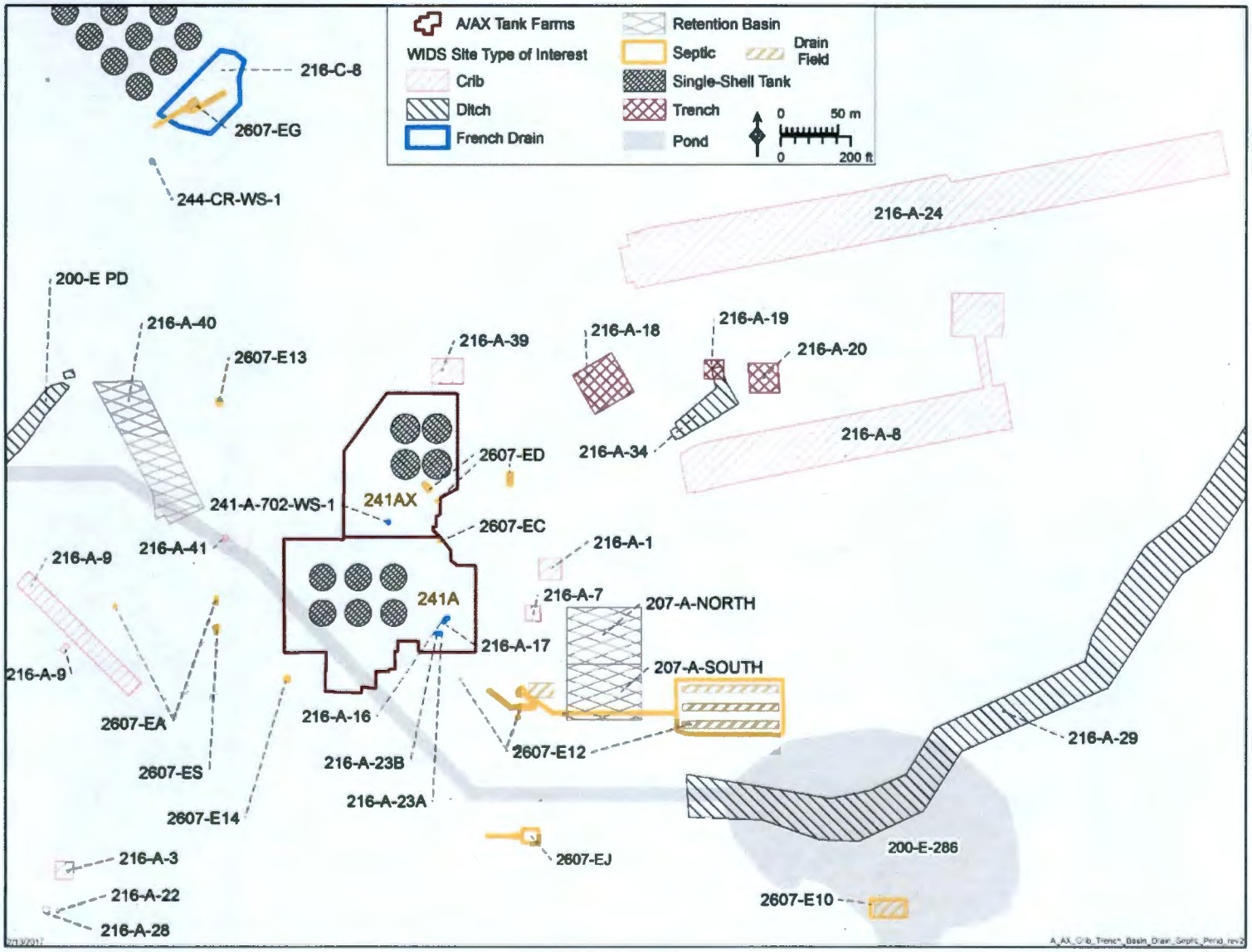
Historical Photograph 241-A Diversion Box

Catch Tanks in or Related to Waste Management Area A-AX

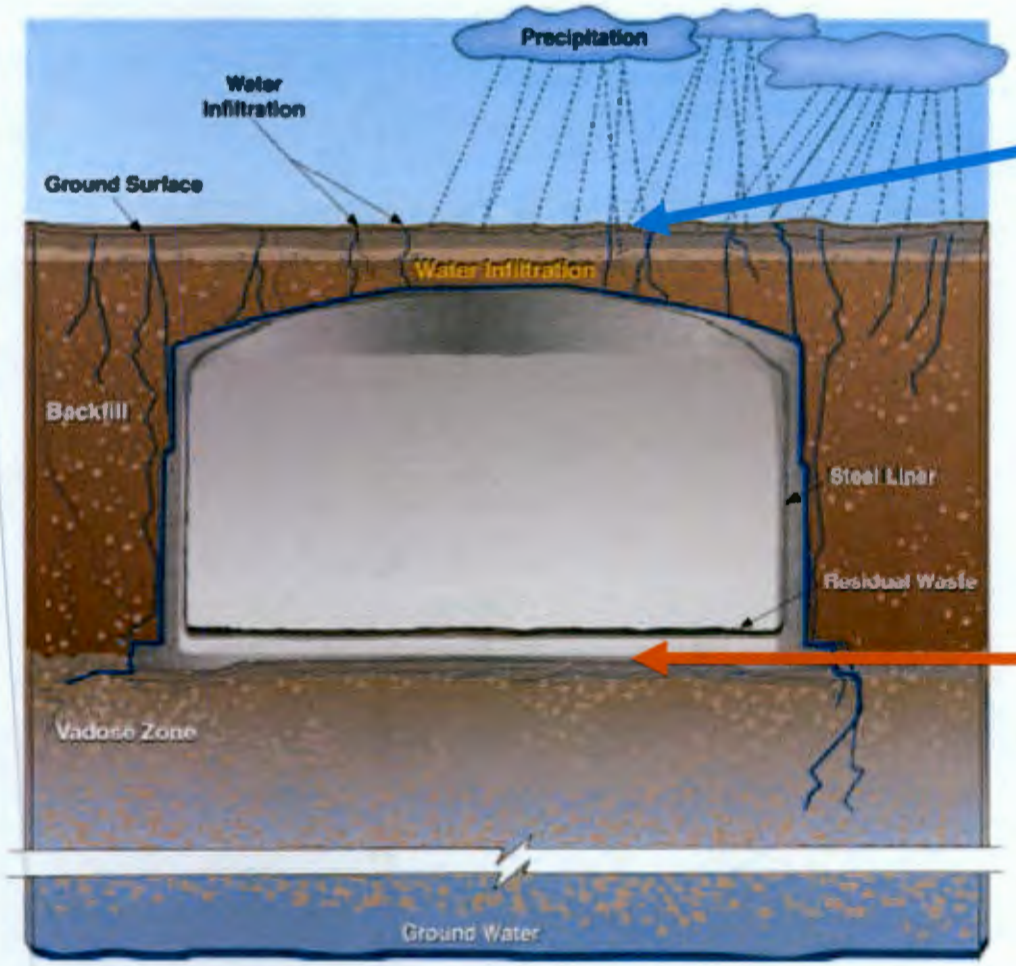
241-A-302A catch tank associated with the 241-A-151 diversion box is located at 202-A PUREX



Liquid Discharge Facilities



Post-Closure System To Be Modeled



Part 2:
Infiltration and Surface Barrier

Part 3:
Release From Grouted Residuals and Concrete to Vadose Zone

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Engineered System in Waste Management Area A-AX: Part 2 – Recharge

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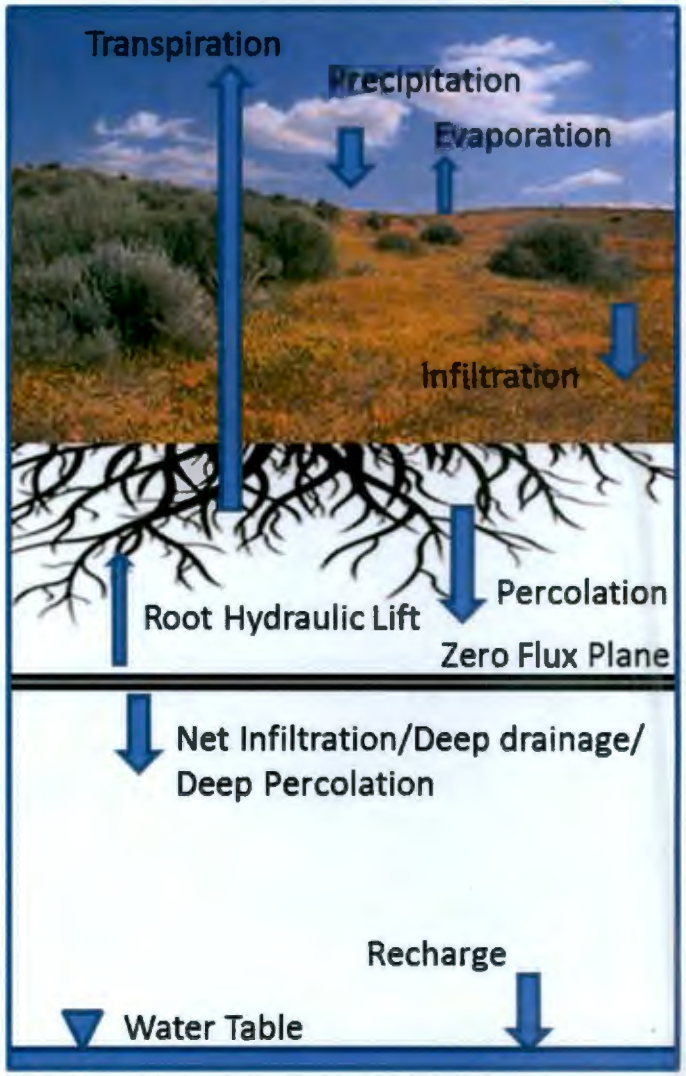
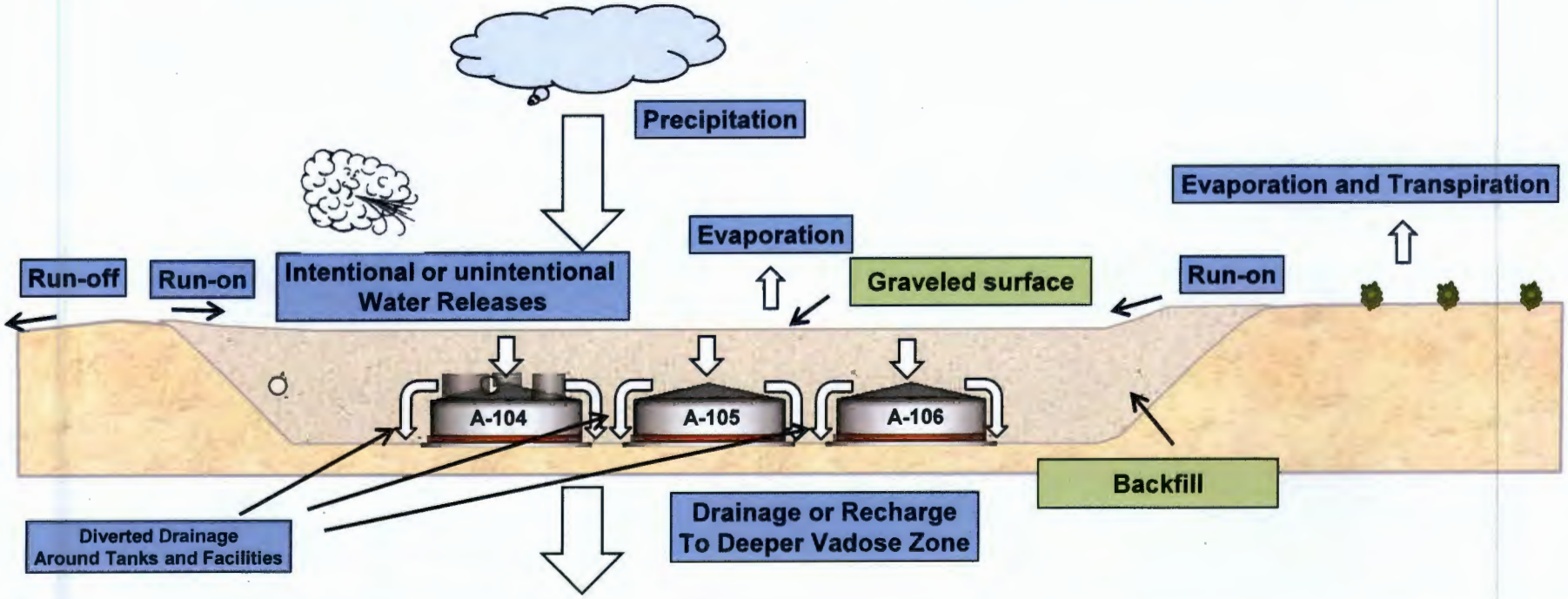
Recharge Terminology and Importance

- **Infiltration** is water that penetrates through a surface (natural or artificial).
  - Precipitation
  - Run-on
  - Ponds, trenches, ditches, cribs, firehoses
- **Net Infiltration/Deep drainage/Deep percolation** is the water flux at the base of the ET zone. This flux mobilizes and transports contaminants through the vadose zone
  - Precipitation, run-on, ponds, trenches, ditches, cribs, firehoses
  - Tank, pipeline, and ancillary equipment leaks
- **Recharge** is the water flux entering the water table. Groundwater use is (typically) the most restrictive or consequential exposure pathway in risk based analyses.



Factors That Affect Recharge

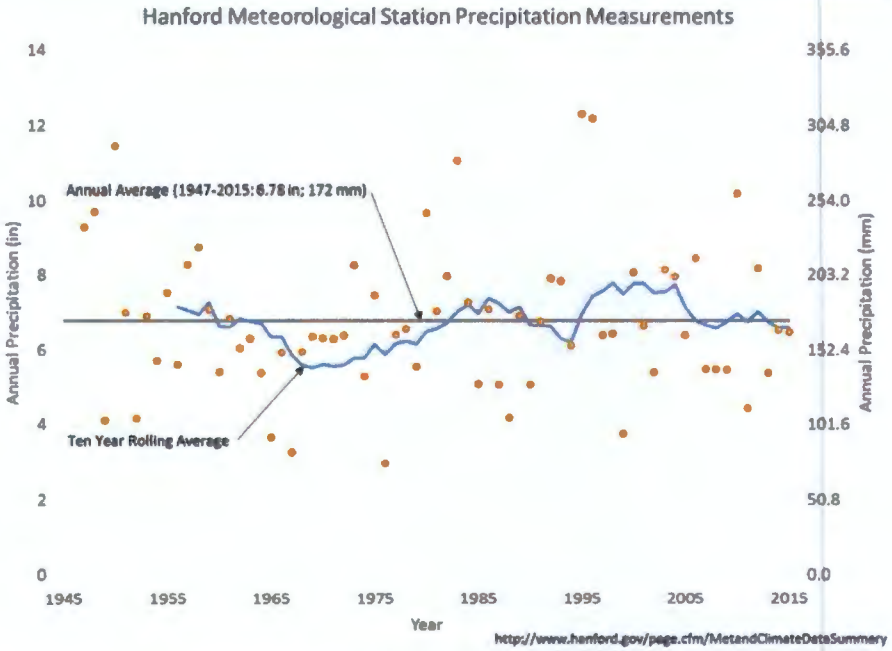
- Climate
- Soil, Vegetation, and Topography
- Sustained Surface Disturbances or Alterations
- Surface and Subsurface Discharges (Planned and Unplanned)

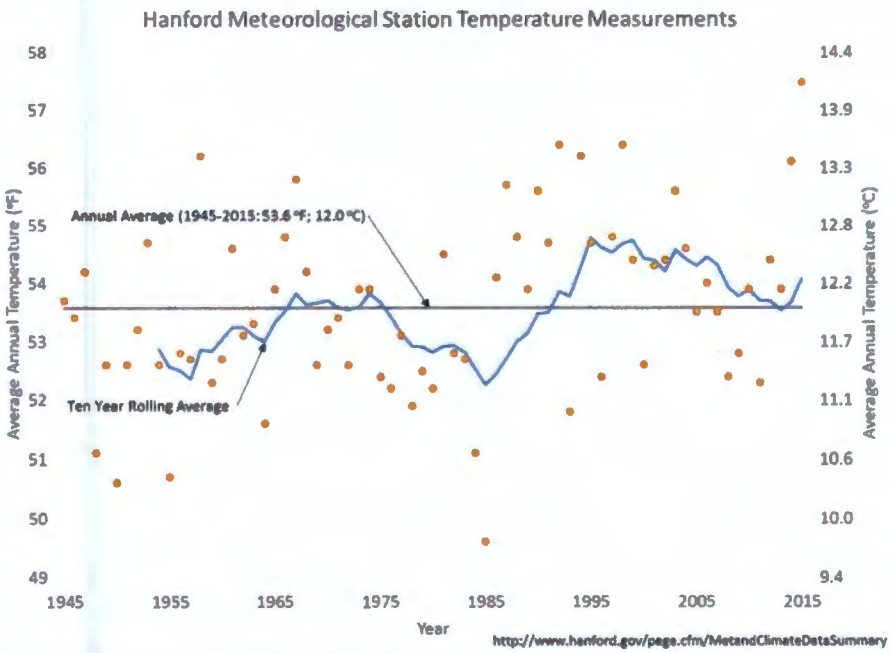


Recharge Climate Factors
Annual Temperature and Precipitation (1945-2015)

Precipitation →

Extremes:	Year	in	mm
Minimum	1976	3.0	75.9
Maximum	1995	12.3	313
Average		6.8	172





← Temperature

Extremes:	Year	°F	°C
Minimum	1985	49.6	9.8
Maximum	2015	57.5	14.2
Average		53.6	12.0

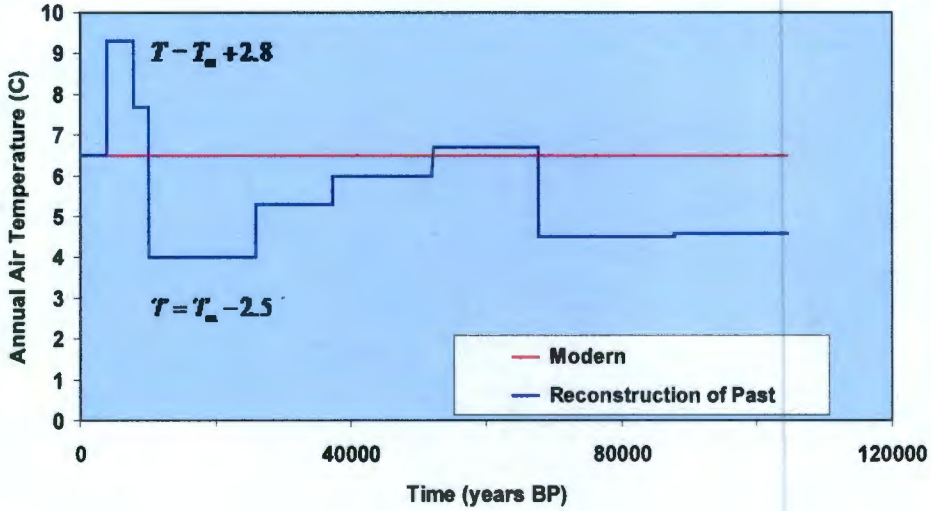
Hanford.Gov » Hanford Meteorological Station » Met and Climate Data Summary Products » Monthly and Annual Temperatures

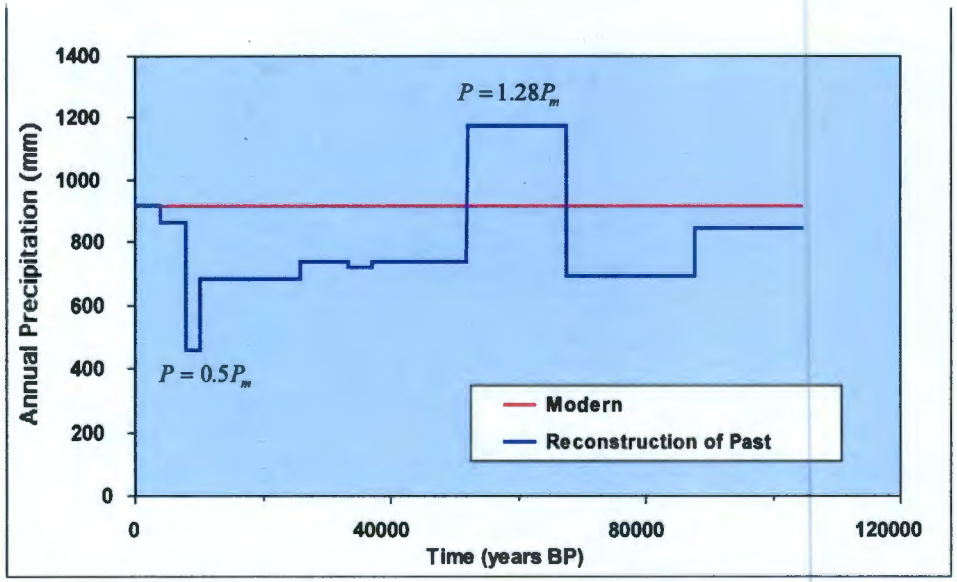
Recharge Response to Climate Change

Pollen Data Analog

In summary, for the last 100,000 years, annual precipitation ranged from 50 to 128% of modern levels and annual temperatures ranged from -2.5 to 2.8 °C (-4.5 to 5 °F) of modern levels.

BHI-00144, "Long-term Climate Change Effects Task for the Hanford Site Permanent Isolation Barrier Development Program: Final Report."





Recharge in Desert or Steppe Climate

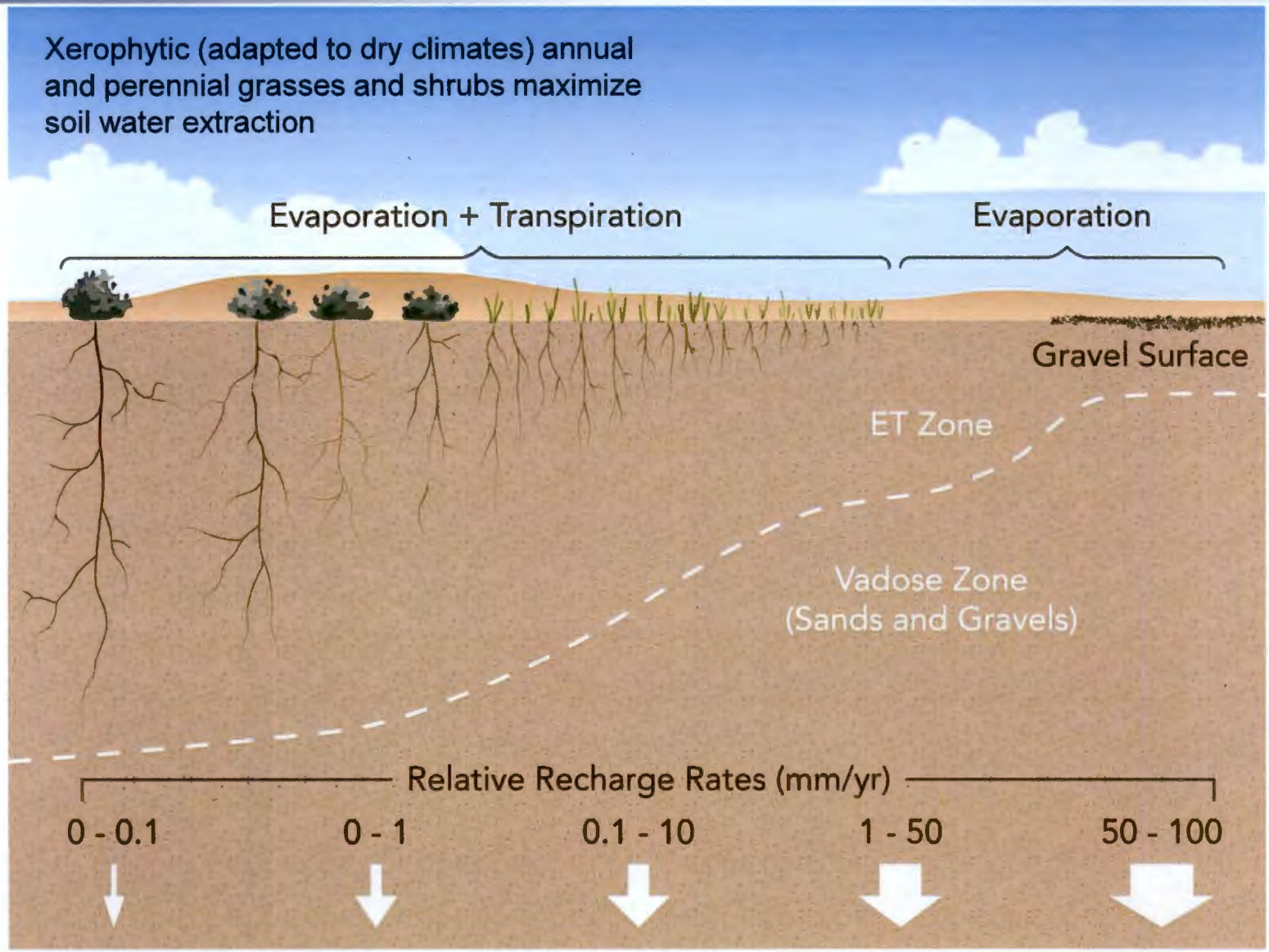
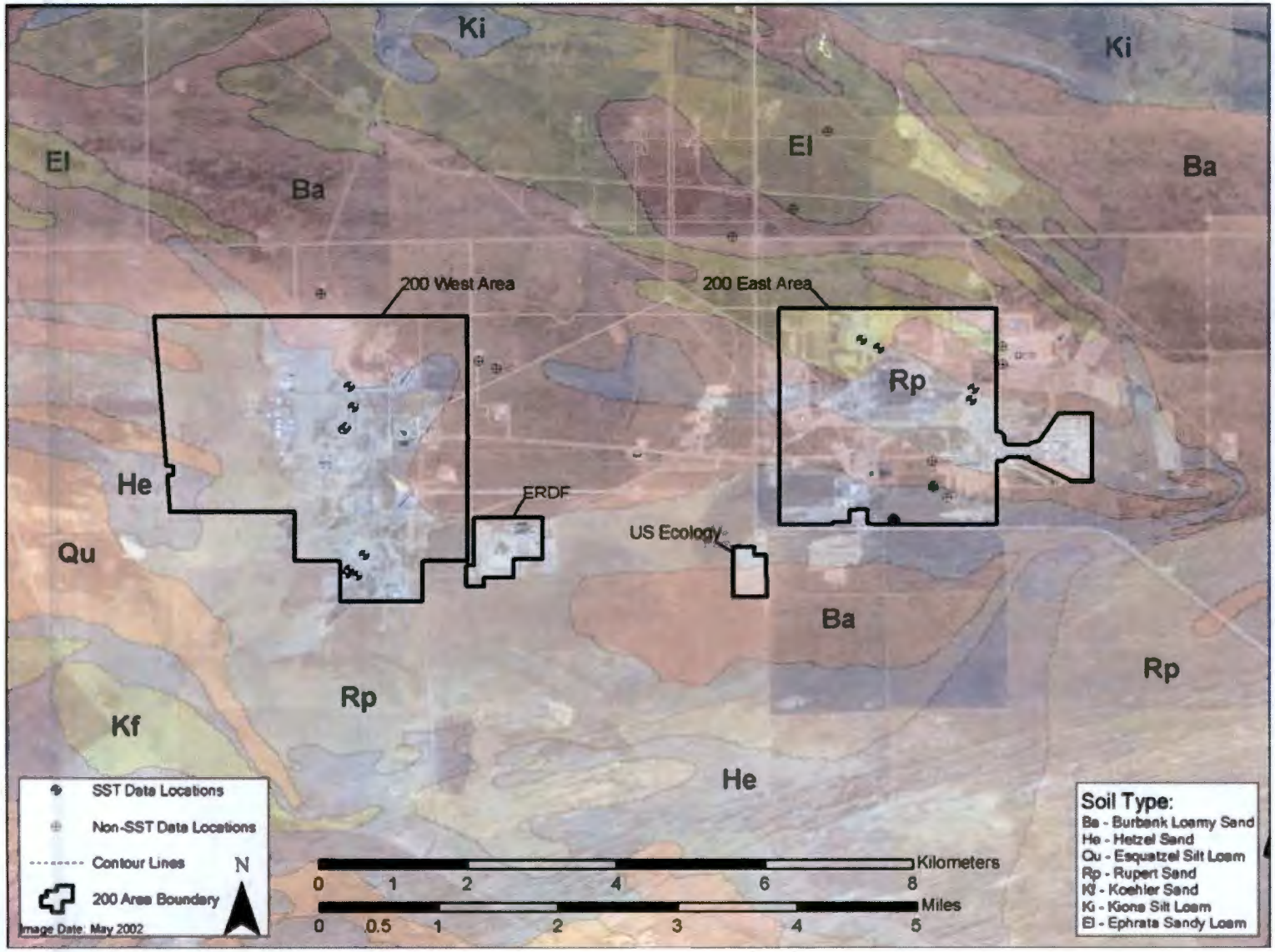


Illustration courtesy of Mike Fayer and Mark Rockhold, PNNL

Recharge Soil Factors



Rupert sand and Burbank loamy sand are coarse deposits capable of supporting shrub-steppe vegetation (PNNL-16688).

Recharge Topography

WMA A-AX is located in a local depression downhill from PUREX to allow gravity flow in the pipelines from there to the tanks. The depression also draws overland flow of rain water and snow melt, but berms and gutters installed as interim measures in 2002 now divert that water around the tank farms (DOE/ORP-2008-01).

Before Installation of the Interim Measures

A Farm

After Installation of the Interim Measures

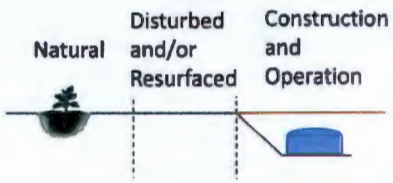
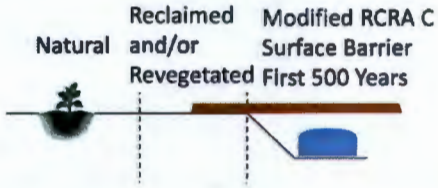
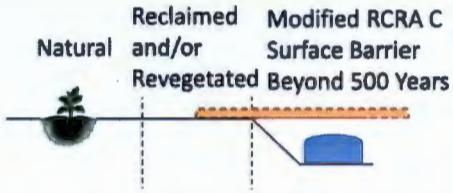
Recharge Surfaces around WMA A-AX

Disturbed Surface
(216-A-30 Crib after surface stabilization)

Tank Farm Surfaces and Resurfaced Areas, Waste Sites, and Disturbed Surfaces

Recharge Surface Evolution of WMA A-AX Sustained Surface Disturbances

Recharge Surface Evolution of WMA A-AX Sustained Surface Disturbances

Phase	Conditions	Duration	Conceptual Half Cross Section of the Waste Management Area A-AX Area
Pre-operations	Native shrub steppe	Steady-state moisture conditions representing the time before construction of Waste Management Area A-AX	
Construction and Operations	Tank Farm gravel Disturbed surfaces Resurfaced ground	1950's to closure	
Early Post-Closure	Modified RCRA C surface barrier Revegetated or reclaimed shrub steppe	500 years after closure	
Late Post-Closure	Degraded surface barrier Revegetated or reclaimed Shrub steppe	500 to 10,000 years after closure (end of sensitivity and uncertainty analysis evaluation period)	

Recharge Surface Evolution of WMA A-AX Sustained Surface Disturbances

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WMA A-AX Time Frame	Pre-Hanford Prior to Waste Management Area Construction (mm/yr)	Operational Period to Site Closure (mm/yr)	Site Closure to End of Institutional Control (100 yrs after Site Closure) (mm/yr)	End of Institutional Control to End of Barrier Design Life (500 yrs after Site Closure) (mm/yr)	End of Barrier Design Life to End of Analysis (10,000 yrs after Site Closure) (mm/yr)
Estimates	**3.5**	**100**	**0.5**	**0.5**	**3.5**
Basis for Estimate	PNNL-14702, (Within the 200 East Area, recharge estimates range between 0.9 and 3.0 mm/yr for soils with established shrub-steppe vegetation)	PNNL-14744 (Bare unvegetated gravel test at the FLTF)	WHC-EP-0673 (Design specification; PNNL-14744 recommends 0.1 mm/yr based on Hanford Barrier Testing)	WHC-EP-0673 (Design specification; PNNL-14744 recommends 0.1 mm/yr based on Hanford Barrier Testing)	PNNL-16688 (Assumed resumption of recharge as in an undisturbed area; PNNL-14744 recommends 0.1 mm/yr for Modified RCRA C and 0.9 mm/yr for Rupert Sand)

Assumed Recharge Outside of WMA A-AX Area during Operational Period (1950's to closure)

- **Disturbed Surfaces**
  - 22 mm/yr
  - Source of Estimate - PNNL-14702
- **Resurface Ground**
  - 63 mm/yr
  - Source of Estimate - PNNL-16688 (300 area lysimeter data)

Recharge Surface Barriers

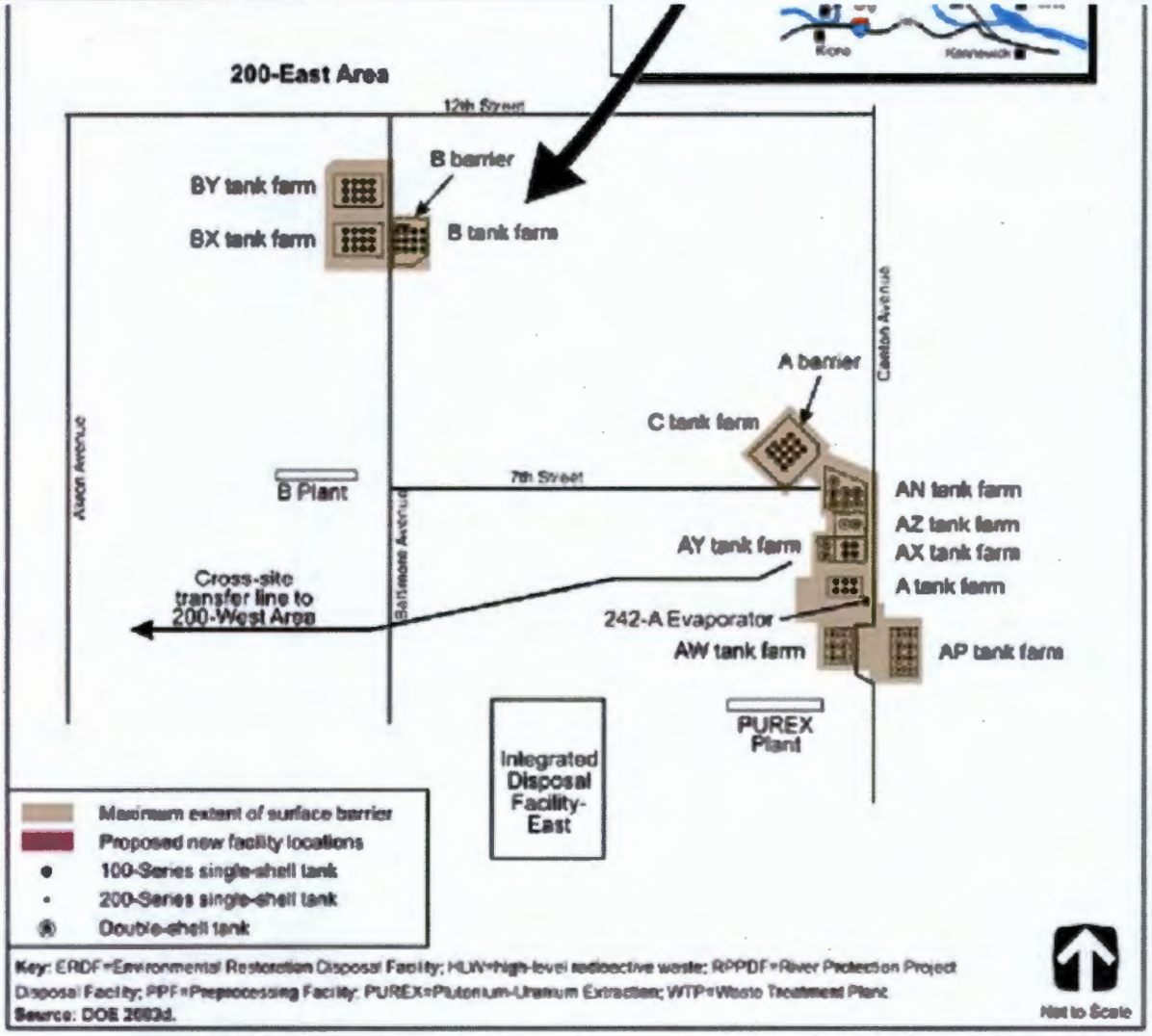
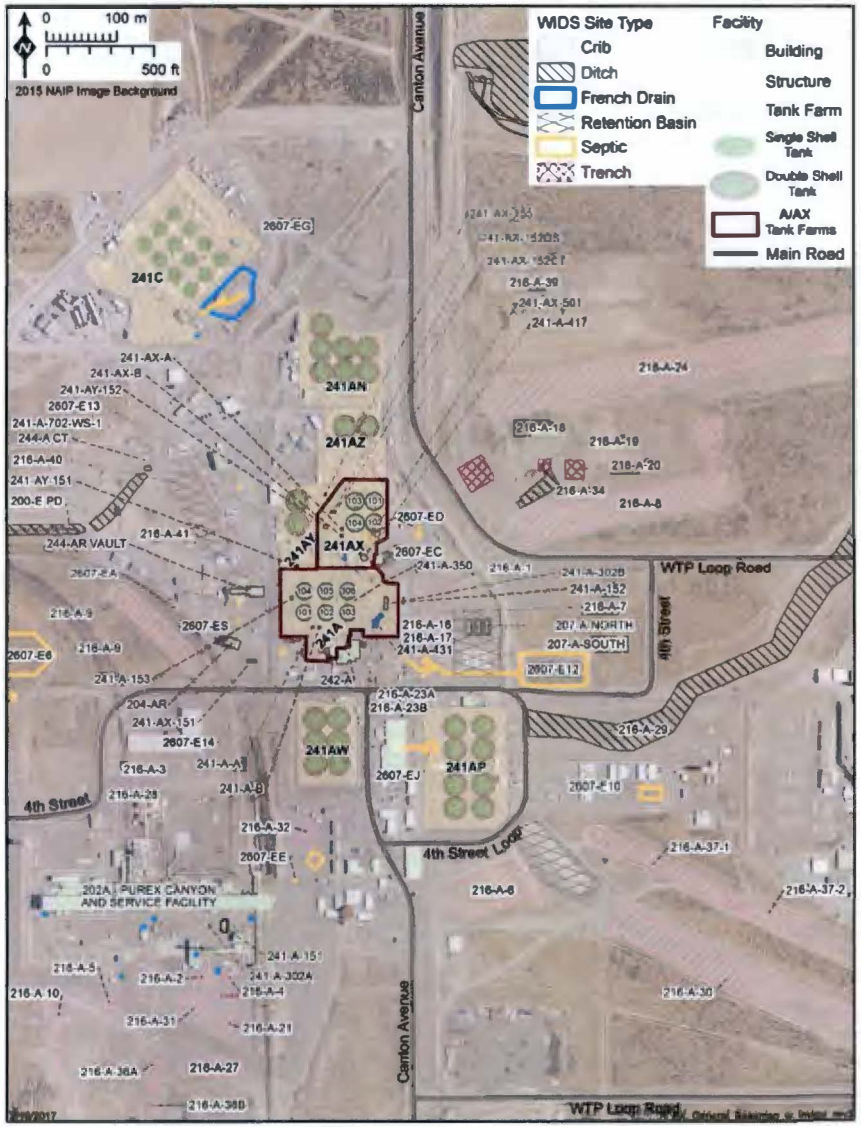


Figure E–31. Conceptualized Closure Surface Barriers in the 200-East Area

The proximity of WMA A-AX to other tank farms and waste sites will likely affect the shape and extent of the closure barrier.

Final Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington (TC & WM EIS) (DOE/EIS-0391) Appendix E "Descriptions of Facilities, Operations, and Technologies"

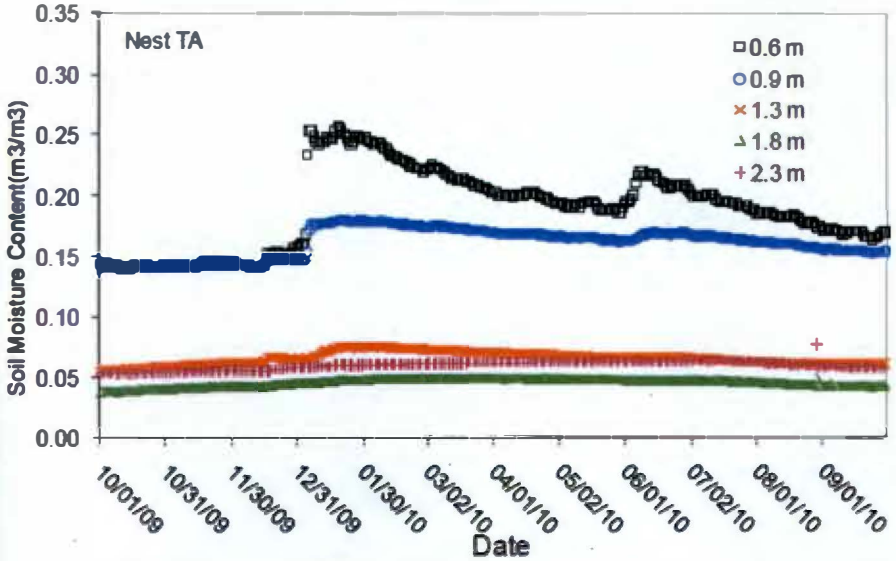
Recharge Surface Barriers

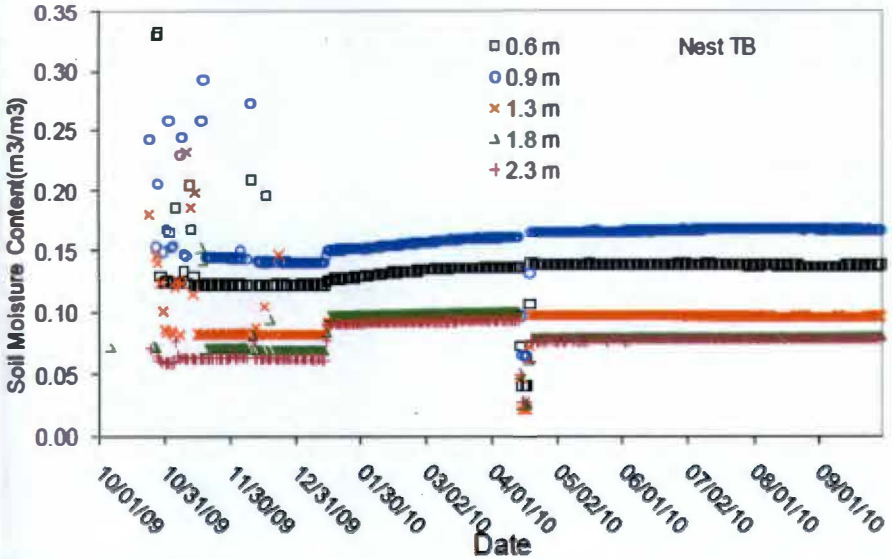


The proximity of WMA A-AX to other tank farms and waste sites will likely affect the timing of closure barrier construction and placement, and may prompt the installation of interim barriers after tank waste retrieval concludes.

TY Tank Farm Interim Barrier and Approximate Locations of Monitoring Nests TYA and TYB

Recharge T Farm Interim Barrier Monitoring

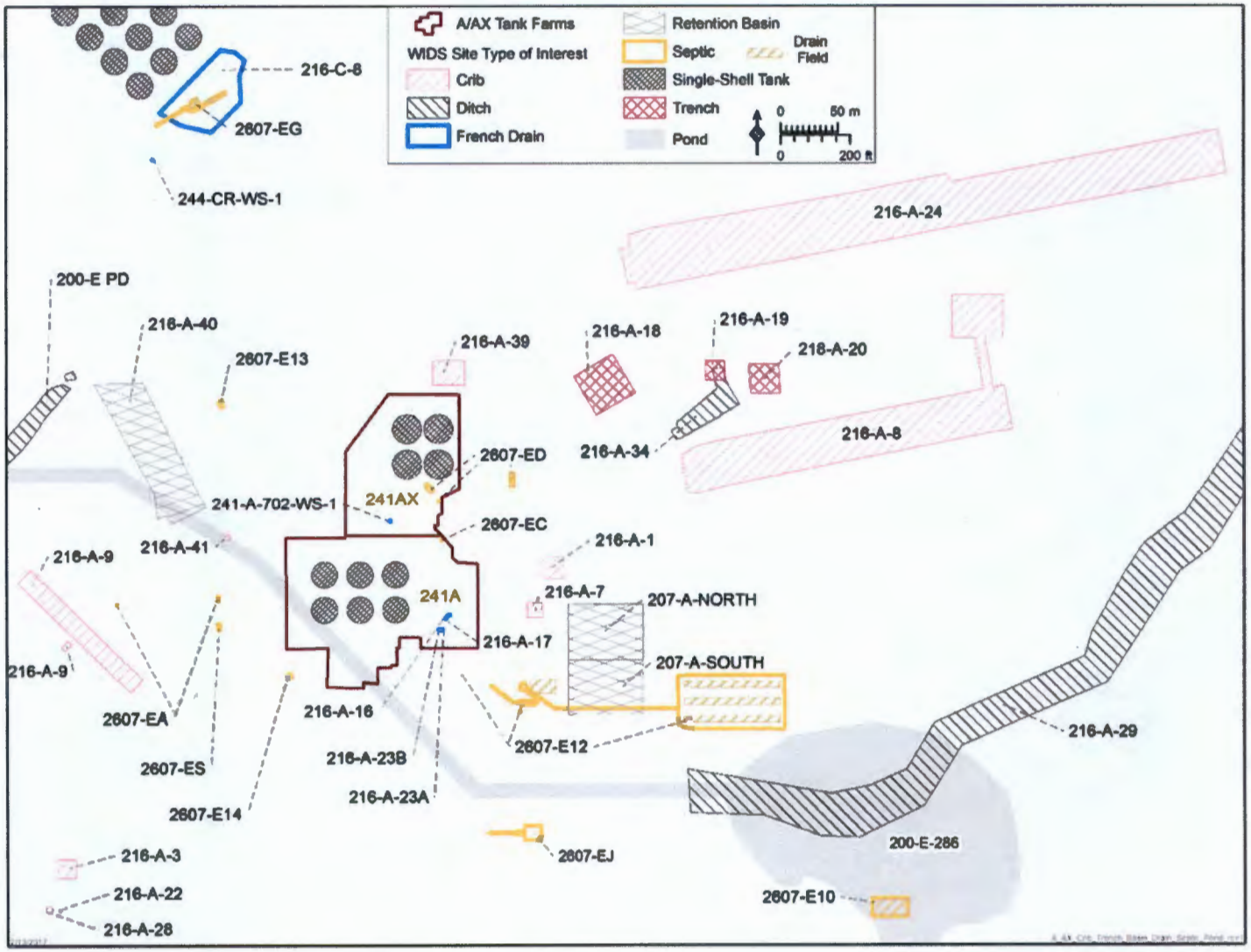




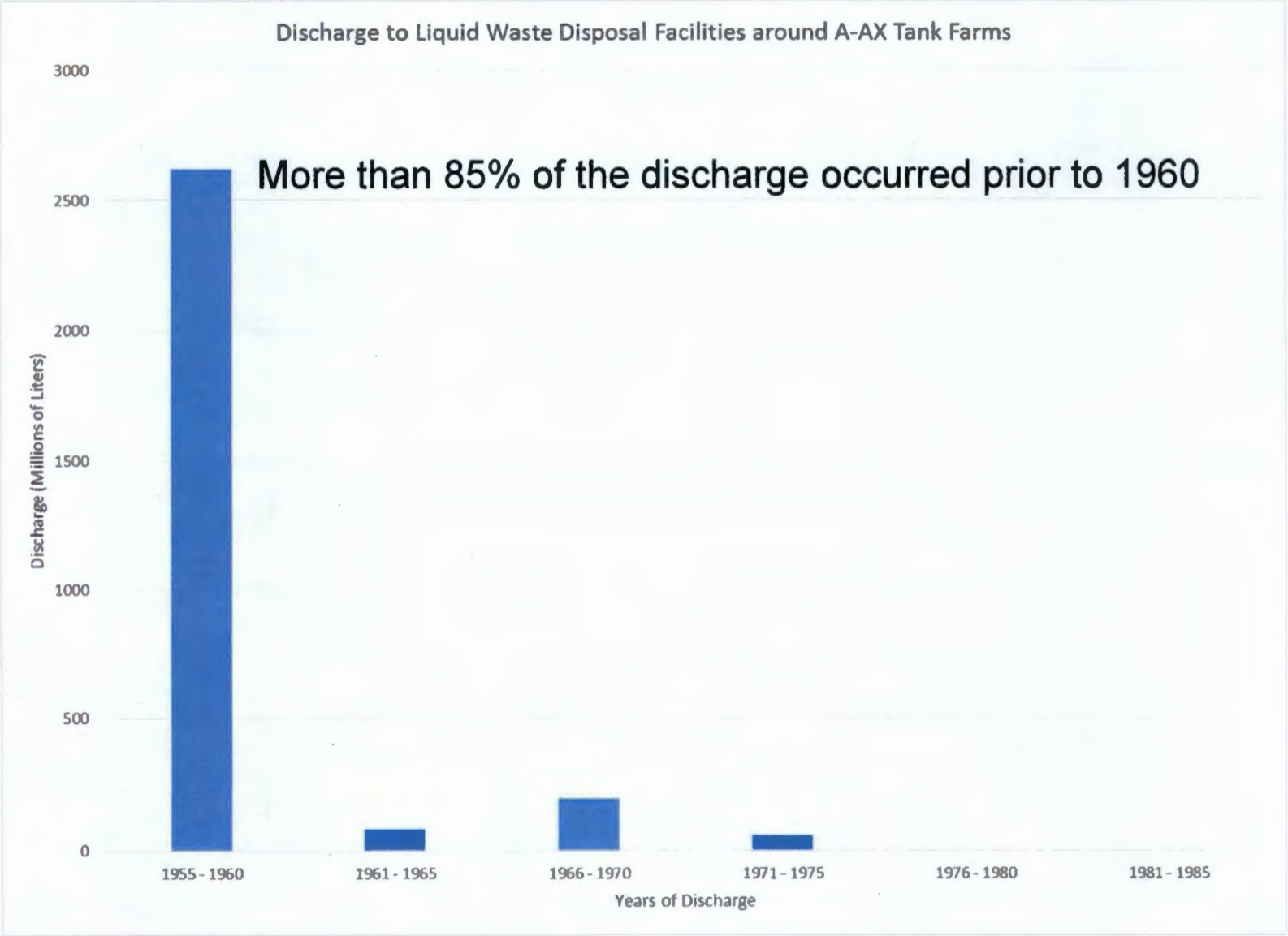
Daily Average Soil-Water Content at Five Depths Measured at 241-T Tank Farm (Figure 4.1, PNNL-20144, *T-TY Tank Farm Interim Surface Barrier Demonstration—Vadose Zone Monitoring FY10 Report*).

Nest TA is outside the barrier.
Nest TB is near the outside edge of the barrier. Equipment in Nest TB was replaced on January 14 and April 20.

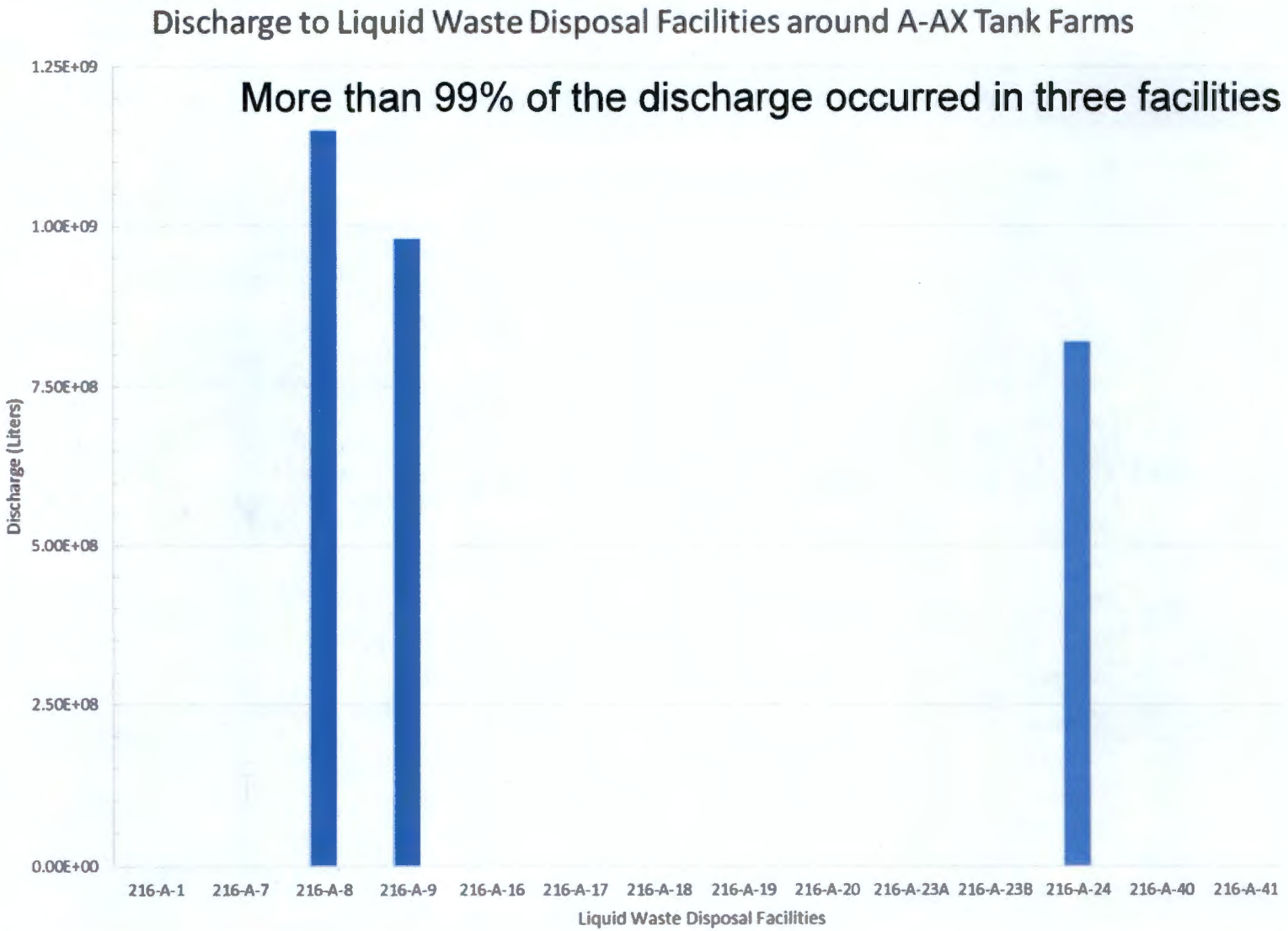
Disposal Facility and Subsurface Discharges



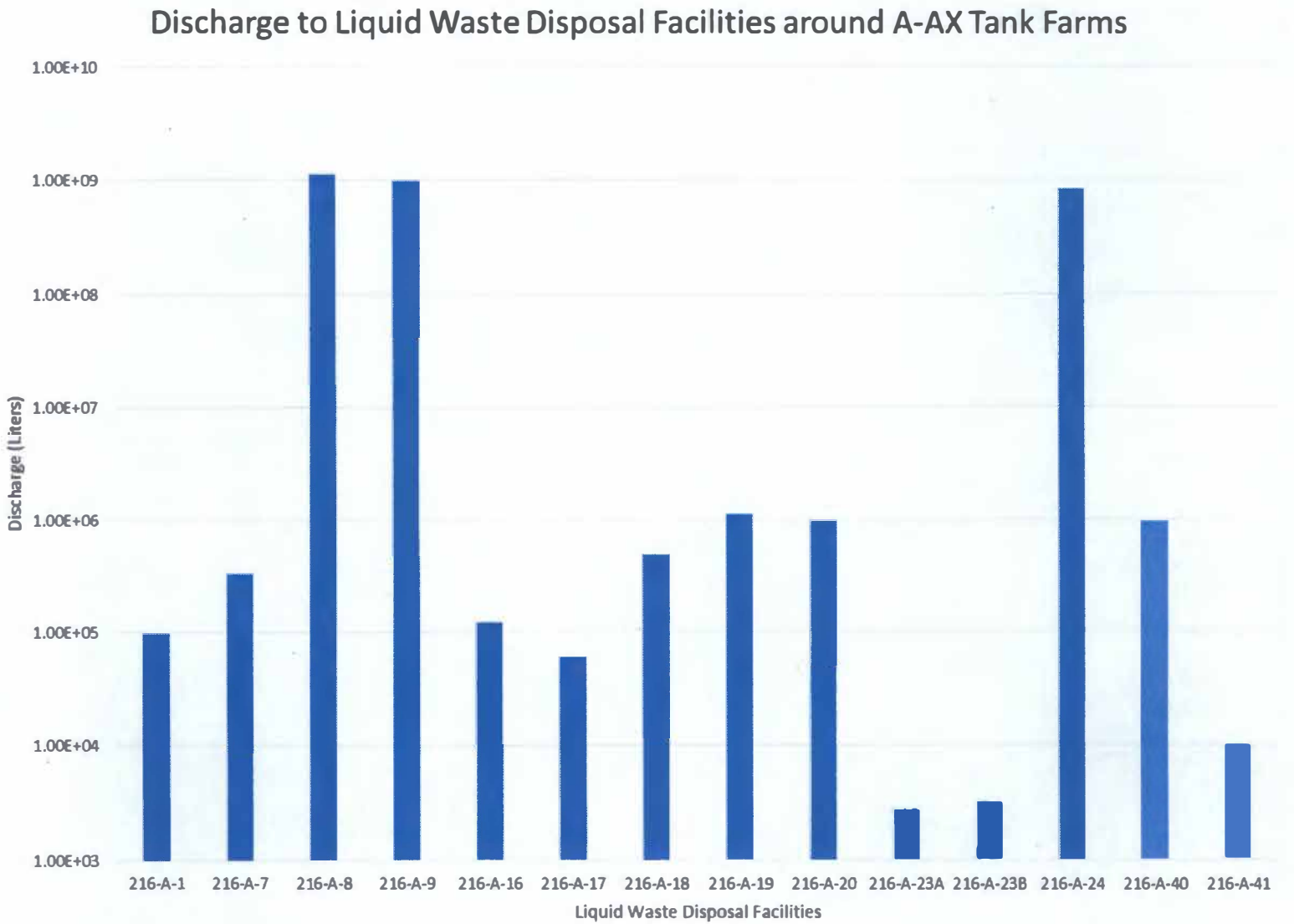
Recharge Surface and Subsurface Discharges



Recharge Surface and Subsurface Discharges



Recharge Surface and Subsurface Discharges



Recharge

Questions?

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Engineered System in Waste Management Area A-AX: Part 3 – Source Term

A.K. Wahi, S. Mehta, R. Khaleel

W.J. McMahon

M.P. Bergeron, J.G. Field

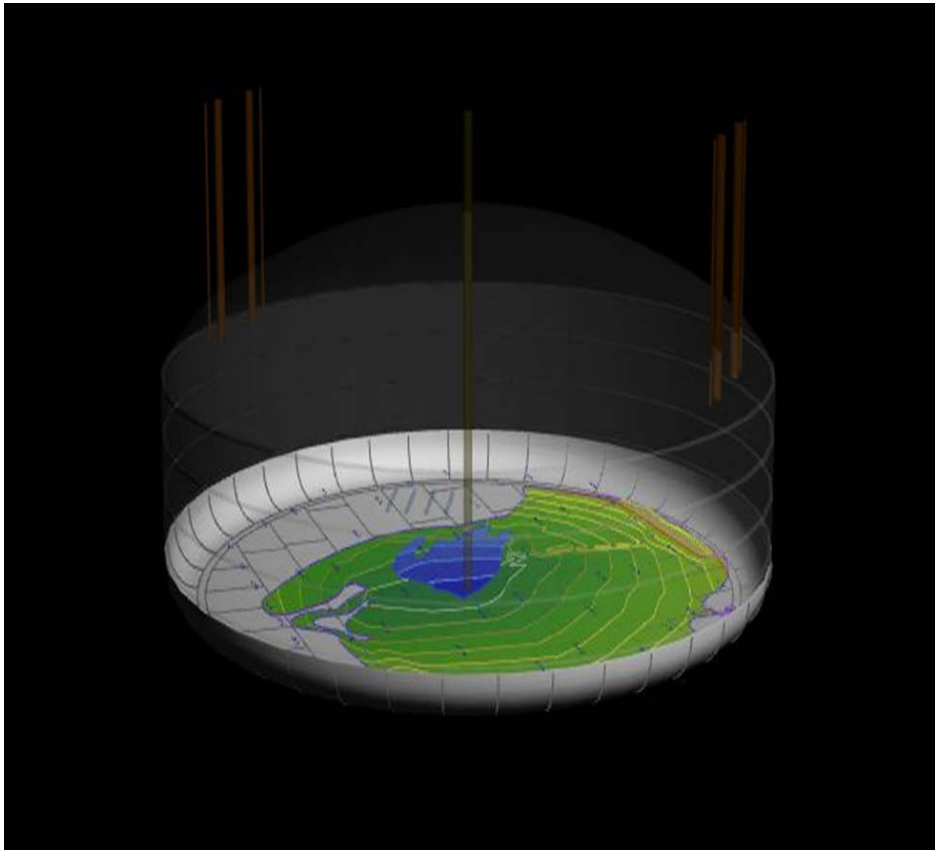
INTERA GEOSCIENCE & ENGINEERING SOLUTIONS

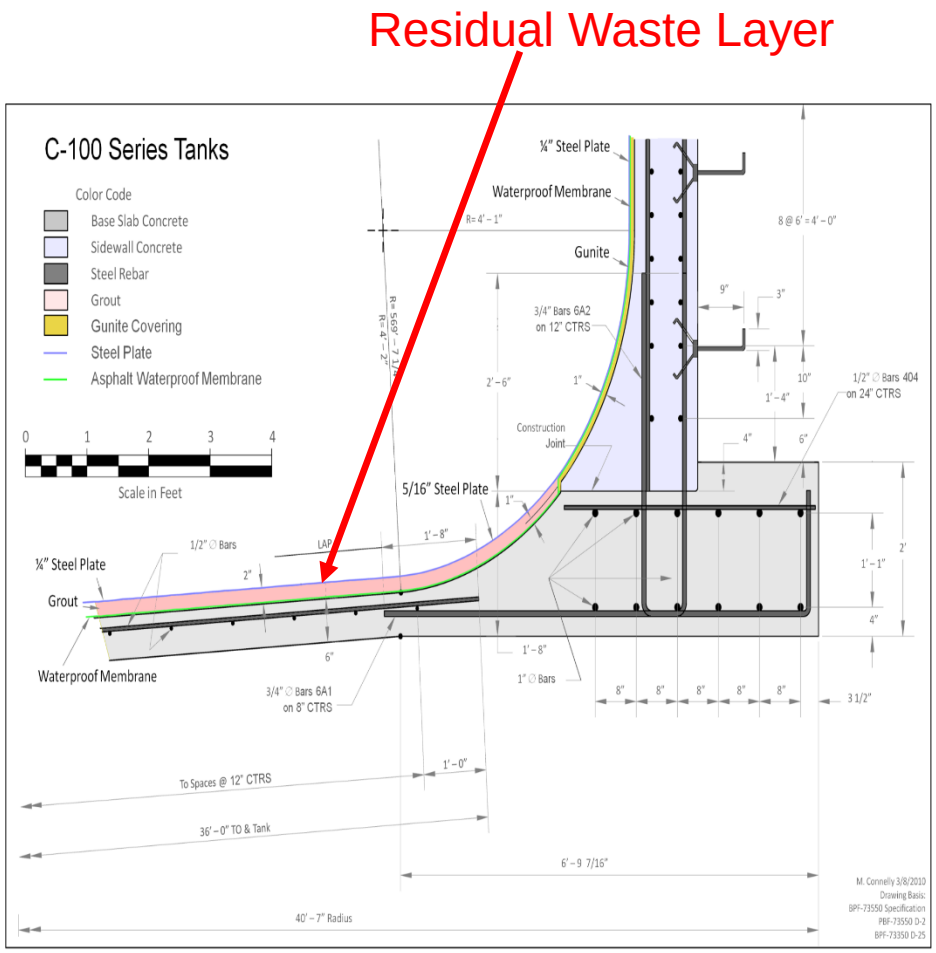
CH2MHILL Plateau Remediation Company

washington river protection solutions

March 22, 2017

Distribution of Residual Waste for a Retrieved Tank





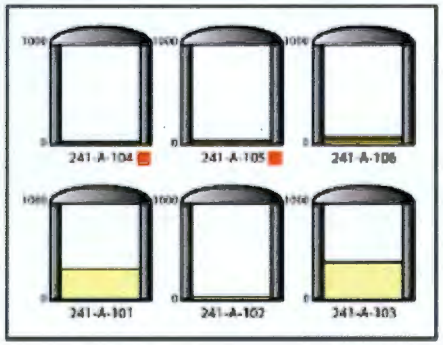
Computer-Aided Modeling Results Showing Distribution of Residual Waste for a Retrieved Tank.

Release from Tank Residuals

- The salt-cake and sludge is the primary waste phase in the WMA A/AX tanks
  - Sludge is the primary waste phase in A-105 and A-104

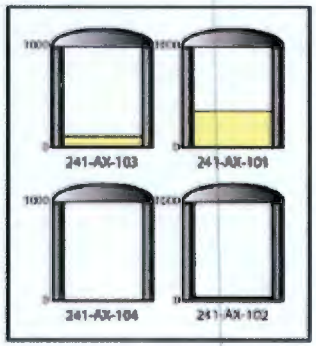
A-Tank Farm- Constructed 1953-1955
6 @ 1,000 Kgal Tank Capacity, Single-Shell

Tank	Sludge	Saltcake	Supernatant
	Kgal		
241-A-101	3	317	0
241-A-102	0	38	2
241-A-103	2	376	10
241-A-104 ■	26	0	0
241-A-105 ■	37	0	0
241-A-106	50	29	0



AX-Tank Farm- Constructed 1963-1966
4 @ 1,000 Kgal Tank Capacity, Single-Shell

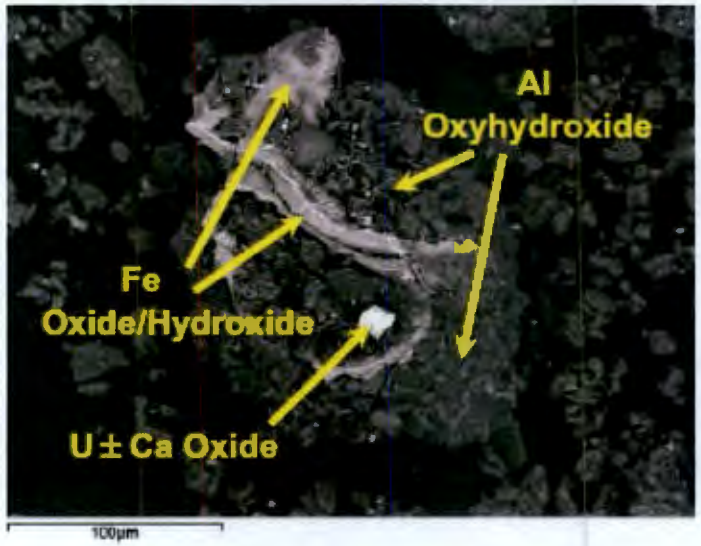
Tank	Sludge	Saltcake	Supernatant
	Kgal		
241-AX-101	3	355	0
241-AX-102	6	24	0
241-AX-103	8	99	0
241-AX-104	5	0	0



- Laboratory scale leaching experiments using waste material from WMA A/AX tanks have not been performed

Release from Tank Residuals

- Following retrieval operations, it is expected that all readily dissolvable material from the salt-cake will be removed
  - The primary residual waste will likely be similar to sludge
    - Soluble Na – NO_3/NO_2 salts will be removed
    - Al-Fe oxide/hydroxide likely to remain
  - Leach testing information from WMA C residual waste is available to evaluate the release of Uranium, Tc-99, and Chromium
    - Conservative parameter choices
  - For all other analytes—no credit is taken for waste form
    - All residual inventory available for diffusive release at the start of the simulation



Leached C-103 residual waste
Electron micrograph (collected using backscattered electron emission)

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Release of Tc-99, Uranium, and Chromium from Residual Waste for WMA C Tanks

SPFT Test: Tc-99 Release from Residual Waste

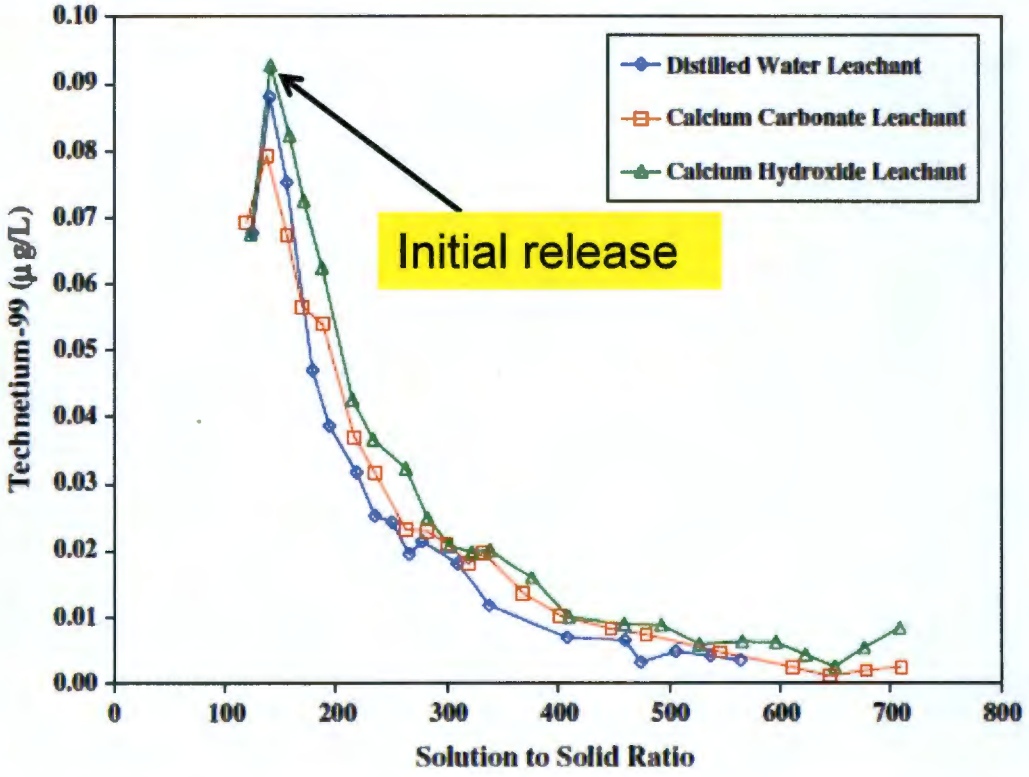
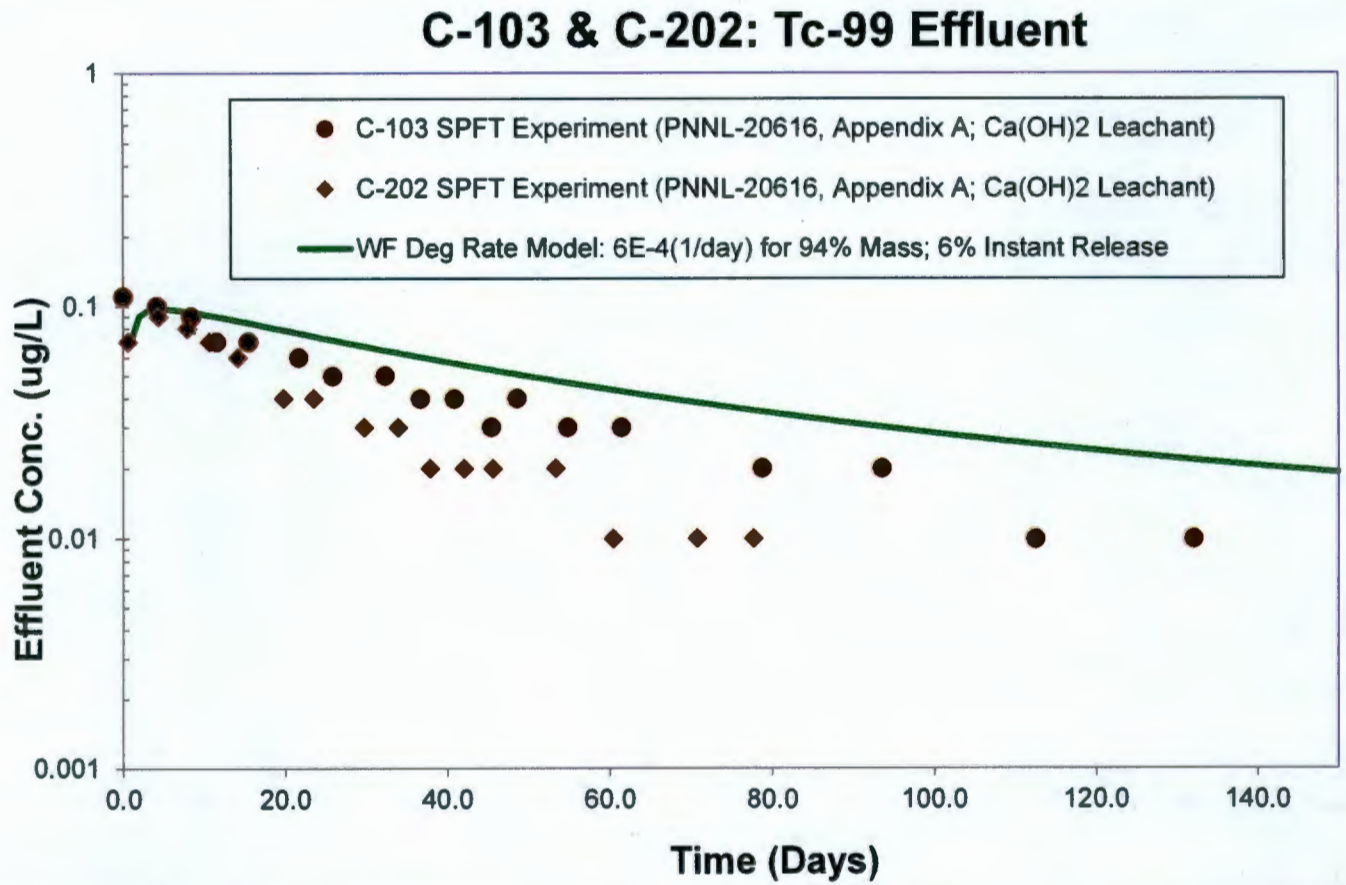


Fig. 3. Technetium concentrations in C-202 SPFT leachates as a function of the total volume of leachant that has contacted the waste in terms of leachant/solid (initial) weight ratio.

(0.1 mL/h; 120 Soln/Solid Ratio = Resident Vol)

Reference: "Single-pass flow-through test elucidation of weathering behavior and evaluation of contaminant release models for Hanford tank residual radioactive waste" (Cantrell et al. 2013).

Modeling of Tc-99 Release from Residual Waste



- WF Dissolution Model with 6% instant release fraction and empirically derived first order dissolution rate constant of 6E-4 day^{-1}.
- Uncertainty in release rate evaluated

SPFT Test: Uranium Release from Residual Waste

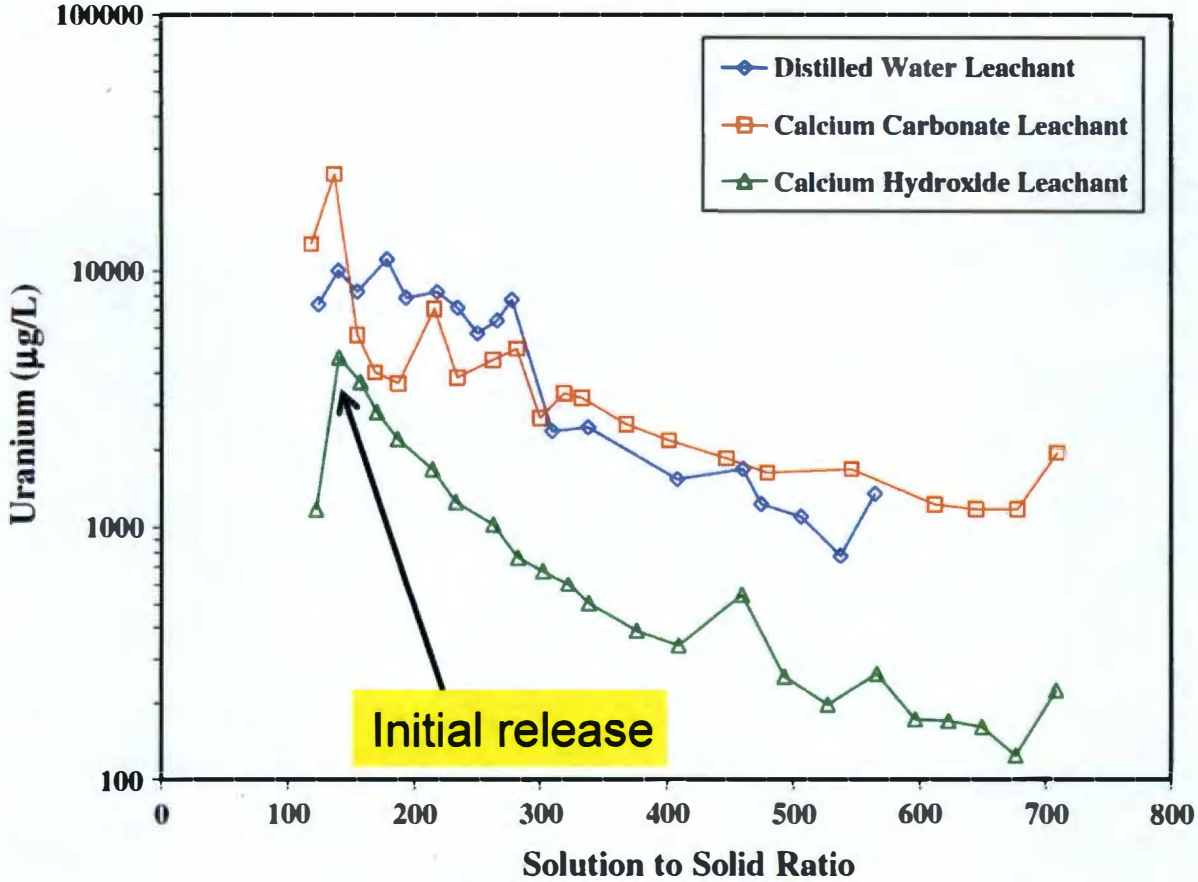


Fig. 2. Uranium concentrations in C-202 SPFT leachates as a function of the total volume of leachant that has contacted the waste in terms of leachant/solid (initial) weight ratio.

Reference: "Single-pass flow-through test elucidation of weathering behavior and evaluation of contaminant release models for Hanford tank residual radioactive waste" (Cantrell et al. 2013).

Uranium Reaction Progress Modeling

$Ca(OH)_2$ saturated

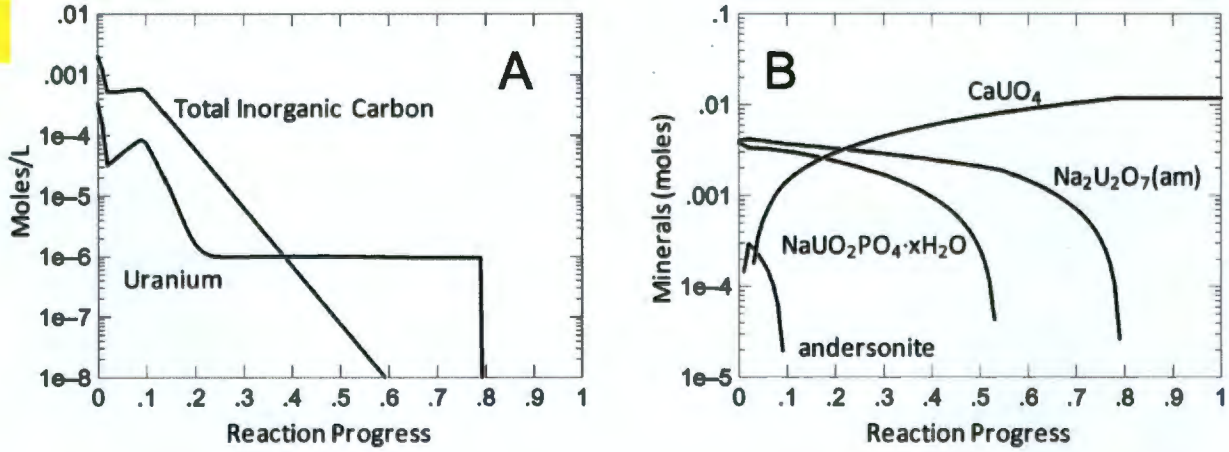


Figure 2. Uranium and TIC concentrations (A) and the paragenetic sequence of U phases present in the waste (B) as a function of reaction progress for the cement closure scenario. A reaction progress of 1 is equivalent to 10 000 years of infiltration at 1.0 mm/year.

CaCO3 saturated

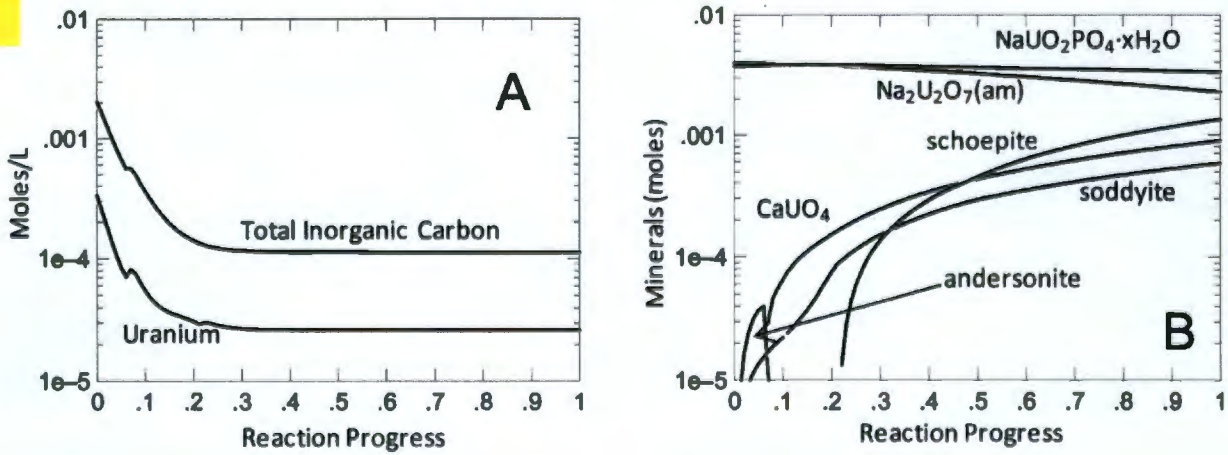


Figure 1. Uranium and TIC concentrations (A) and the paragenetic sequence of U phases present in the waste (B) as a function of reaction progress for the sediment closure scenario. A reaction progress of 1 is equivalent to 10 000 years of infiltration at 1.0 mm/year.

Uranium Solubility Model

Intact Tank Conditions

- Solubility limit of 1×10^{-4} M for 1,000 years
  - amorphous uranium mineral phases such as $Na_2U_2O_7$(am)
- After 1,000 years, apply the solubility limit of 1×10^{-6} M
  - $CaUO_4$ as the solubility-controlling mineral phase

Degraded Tank Conditions

- 1×10^{-4} M for 1,000 years; 2×10^{-5} M afterwards.
  - amorphous uranium mineral phases control release early and then solubility based on $CaCO_3$ saturated (vadose zone) water

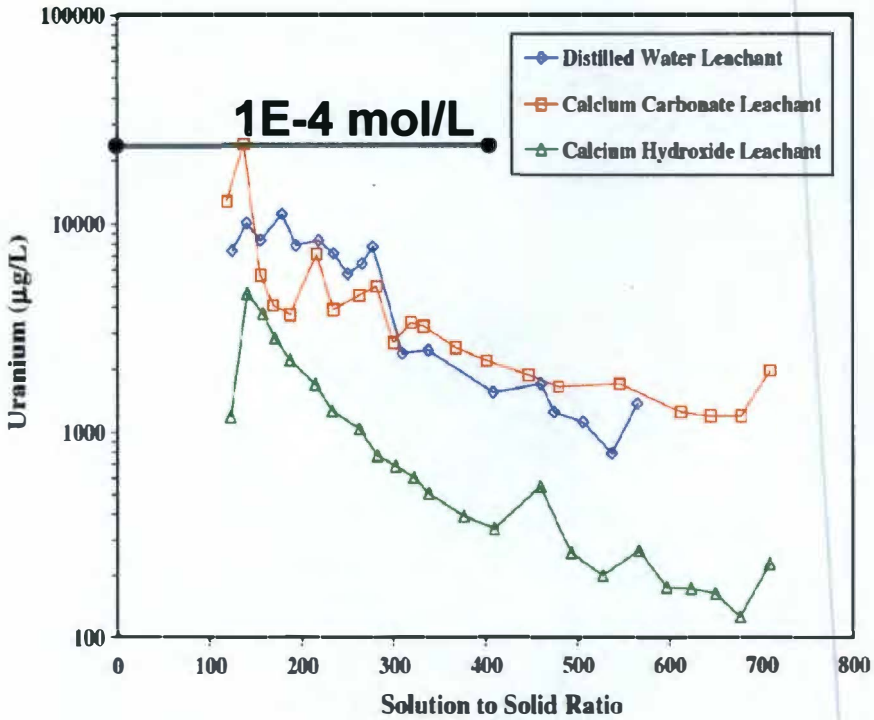


Fig. 2. Uranium concentrations in C-202 SPFT leachates as a function of the total volume of leachant that has contacted the waste in terms of leachant/solid (initial) weight ratio.

SPFT Test Results for Chromium

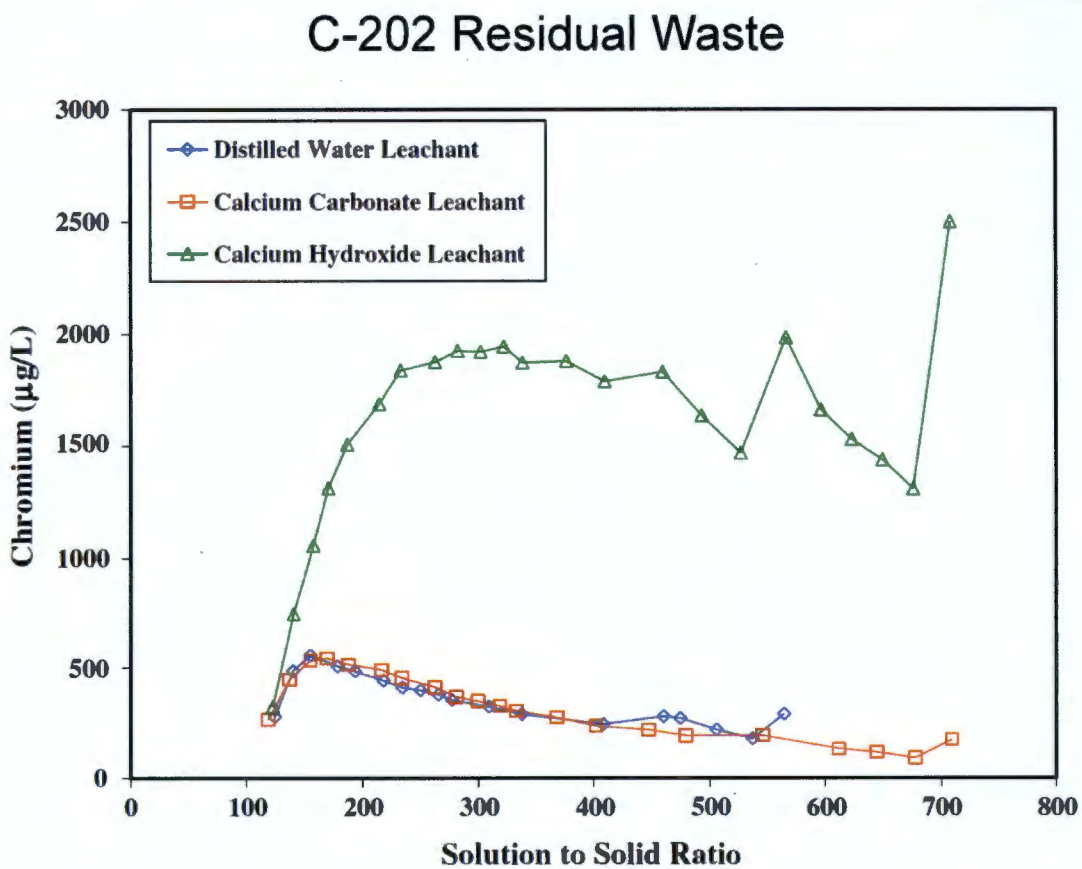


Fig. 5. Chromium concentrations in C-202 SPFT leachates as a function of the total volume of leachant that has contacted the waste in terms of leachant/solid (initial) weight ratio.

Reference: "Single-pass flow-through test elucidation of weathering behavior and evaluation of contaminant release models for Hanford tank residual radioactive waste" (Cantrell et al. 2013).

Chromium Release Model

- The Cr concentrations in C-203 and C-103 leachate were much lower than C-202 for the $Ca(OH)_2$ leachant
- The release mechanism for Cr from residual waste is unknown at this time. Some values were recommended by Cantrell et al. (2013):

Recommended chromium release concentrations along with the residual waste concentrations for tanks C-202, C-203, and C-103.

Tank	Residual waste concentration (μg/g-dry waste)	Currently recommended release concentration (μg/L)
C-202	1.0×10^4	2000
C-203	4.3×10^3	500
C-103	230	5

- For the purpose of PA, **a dissolved concentration limit of 2,000 μg/L** is proposed for all tanks (conservative but defensible).

Tank Degradation – Conceptualization

Figure 6-1. Conceptual Model of Tank Filled with Cementitious Grout Anticipated after Site Closure

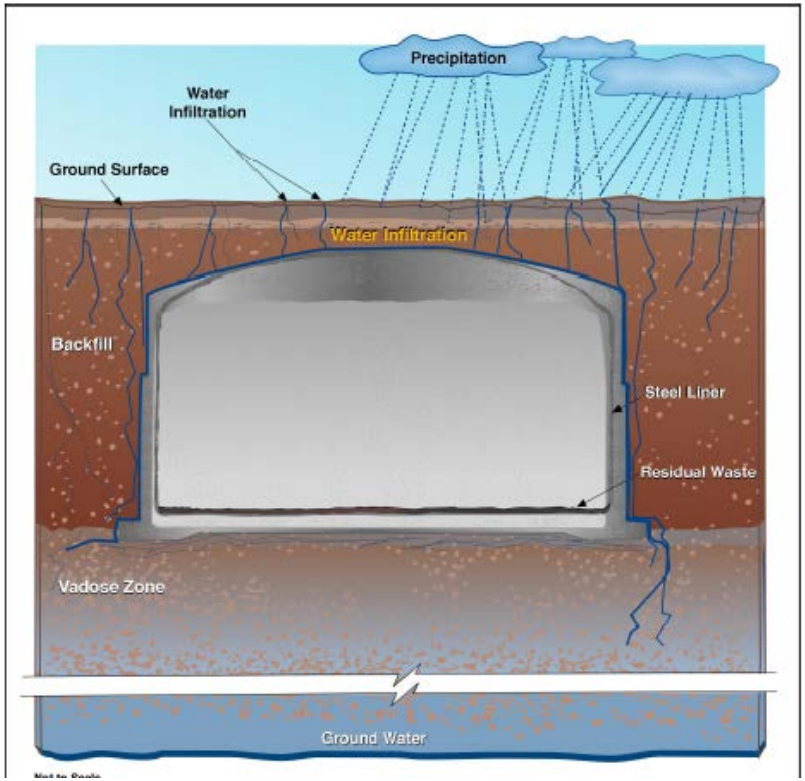
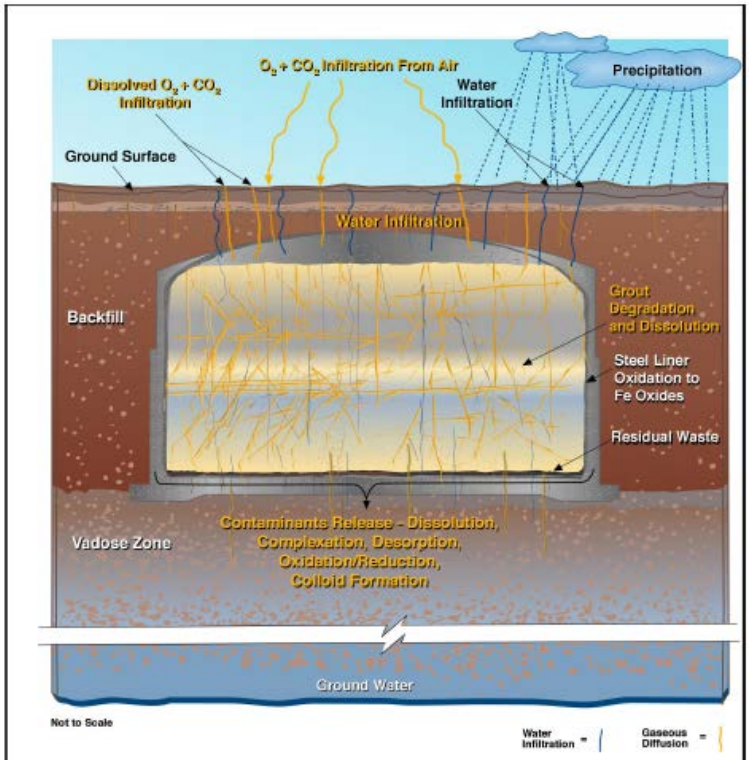


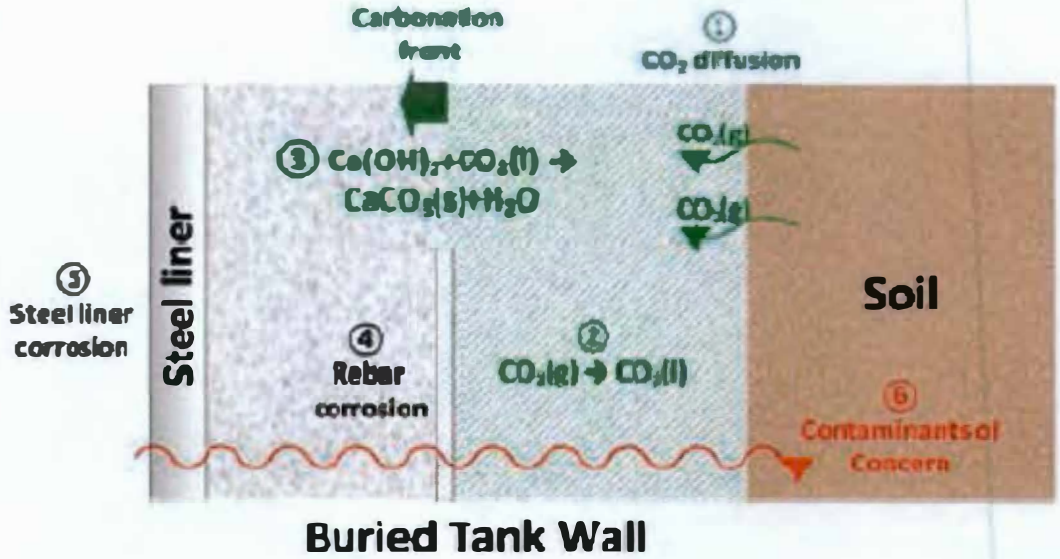
Figure 6-2. Conceptual Model of Contaminant Release from an Aged Tank Containment System Resulting from Physical and Chemical Degradation and Infiltrating of Water, Carbon Dioxide and Oxygen



RPP-RPT-46879, Rev. 2 (Corrosion and Structural Degradation within Engineered System in Waste Management Area C)

Grout/Concrete Chemical Degradation Mechanisms

- **Carbonation**
  - Not necessarily detrimental (reduces permeability; plugs pore spaces)
  - Leads to decrease in pH as $Ca(OH)_2$ dissolves

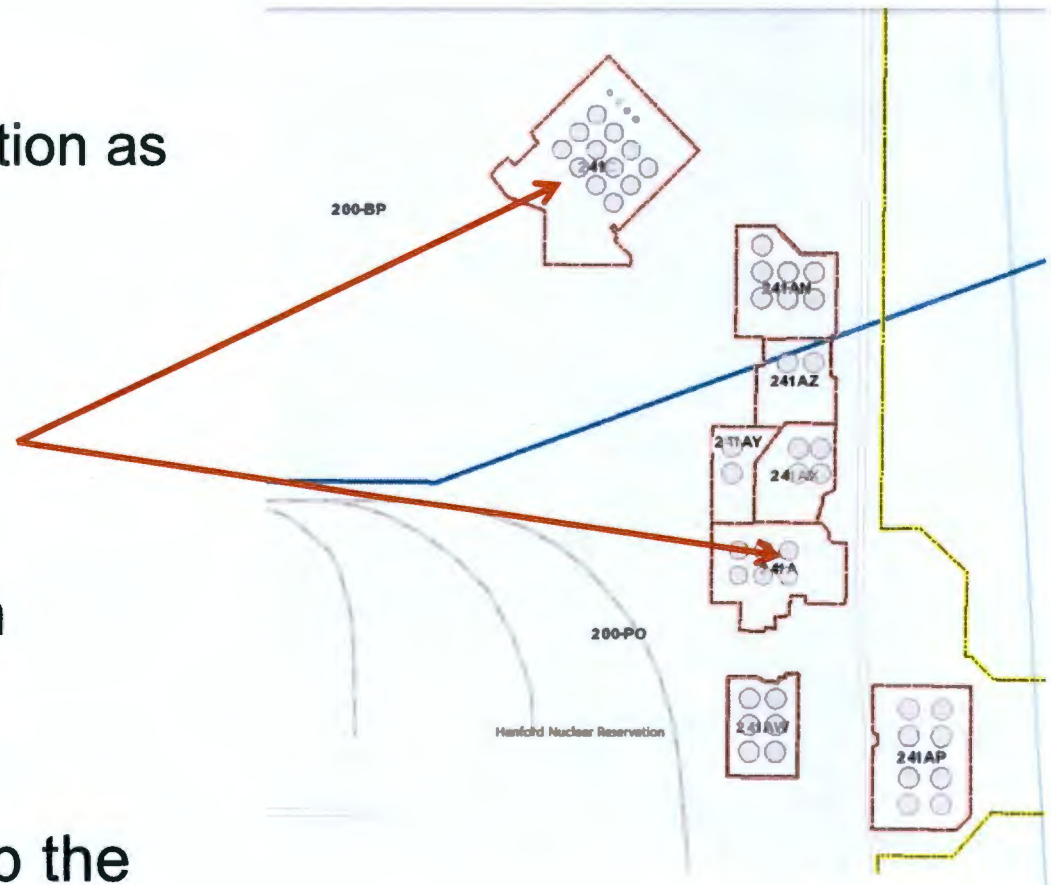


- Sulfate attack
- Alkali-aggregate attack
- Acid leaching (decalcification)

} Degradation rates expected to be lower than carbonation rates

Tank Degradation Evaluation

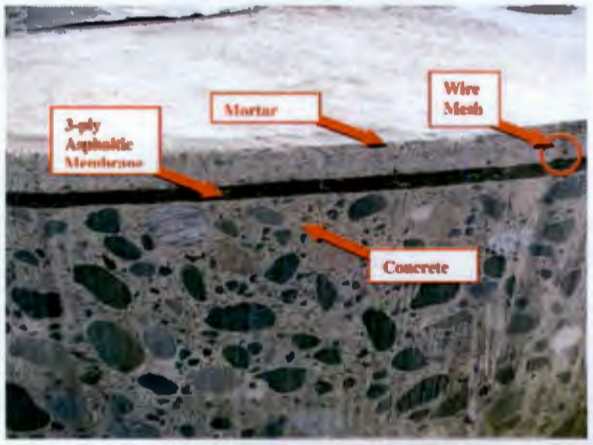
- **Tank wall** degradation evaluation
  - Use empirical information as much as possible
  - Evaluation of Hanford specific information
  - Samples from C-107 and A-106
- **In-fill grout** degradation evaluation
- Estimate timing for tank degradation and develop the modeling approach



241-C-107 Dome Plug

- 55-inch diameter reinforced concrete dome "Plug" was removed in December 2010 from C-107 (RPP-RPT-50934, 2012)
- 14 cores taken (4.2" diameter)
  - 12 cores underwent mechanical testing
  - 2 cores were sent for petrographic examination
- No cracks or large air voids were visible
- Additionally, the protective asphaltic membrane and mortar layers were present and intact.
- No evidence of chemical attack or significant alkali-aggregate reactions were observed
- **Depth of carbonation was shallow and about 1 to 2 mm from top surface**

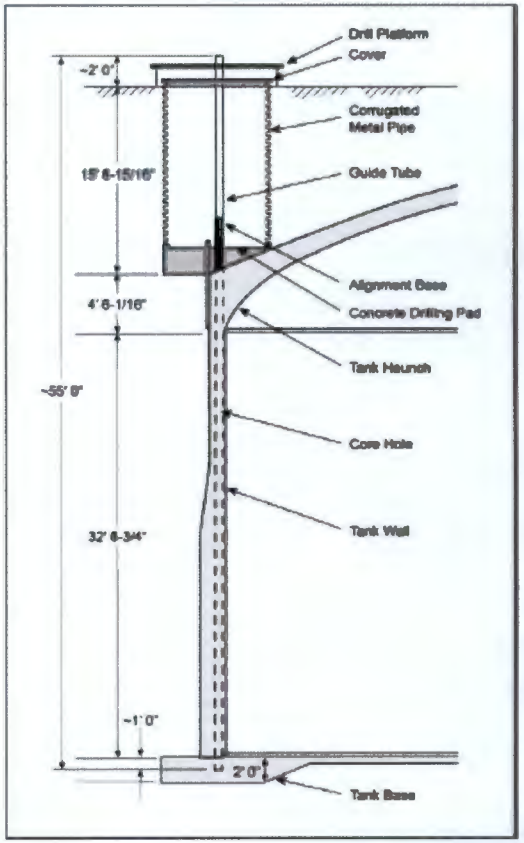
Figure 2-7. Plug Top Edge

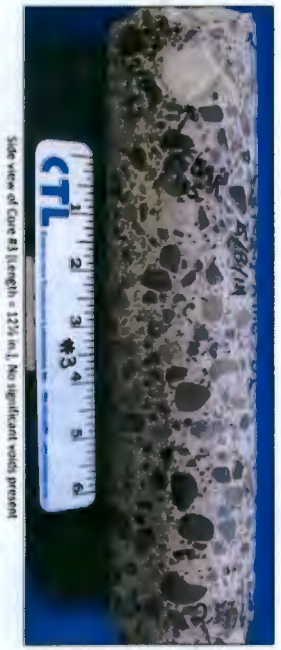


241-A-106 Sidewall Core

- Sidewall coring of 241-A-106 tank was completed in May 2014 (RPP-RPT-58254, 2014)
- Over 38 feet of concrete core removed to a depth halfway through the tank footing.
- Petrographic analyses performed (on 15 core segments)
- Concrete in overall good condition
  - Only one crack and few microcracks were observed
  - Minor degree of alkali-silica reaction (ASR) noticeable
- **Depth of carbonation was shallow and about 1 to 4 mm from outer surface**

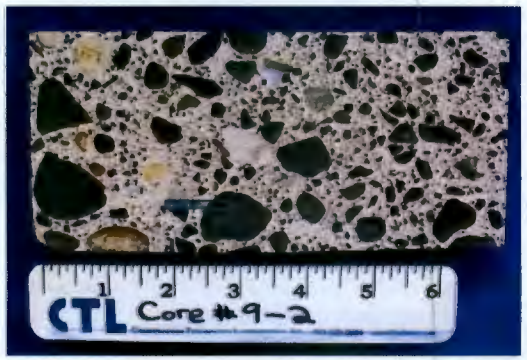
Figure 2-2. Tank A-106 Sidewall Coring Concept





Side view of Core #3 [length = 12¾ in.]. No significant voids present

of Lapped Concrete Half (Core Segment #9-2)



Key Observations

- For buried Hanford tank structure, the carbonation depths range from **1 to 4 mm**
  - Considering 60 - 70 years of burial time the carbonation rates are calculated to be 0.01 to 0.07 mm/year.
- For <u>buried tank</u> concrete at Hanford let's assume a bounding carbonation depth of 10 mm after 70 years
  - Approximately ~2x of the observed (conservative)
  - Acknowledges unknown effects that can increase carbonation

Estimating Carbonation Depth with Time

- Simplifying carbonation as a sharp moving front, simple analytical expression for the location x_c (mm) of the carbonation front when RH > 50% can be given by (Brown et al., 2013):

$$x_c = A\sqrt{t}$$

A is proportionality constant and a function of initial CO_2 concentration, effective diffusivity of CO_2, etc.
t is exposure time

- Experimental results have confirmed the relationship between the carbonation front and exposure time.
- Considering **10 mm** as depth of carbonation front over 70 year time period (a value that is over twice the observed maximum value of 4 mm):

A = 1.2 (mm per square root of time in year)

- Calculate the depth of penetration as a function of time:

Elapsed Time (yr)	Depth (mm)	Depth (inches)
1,000	37.8	1.5
5,000	84.5	3.3
10,000	119.5	4.7
20,000	169.0	6.7
50,000	267.3	10.5
100,000	378.0	14.9

Brown et al., 2013, Modeling Carbonation of High-Level Waste Tank Integrity and Closure, EPJ Web of Conferences, v. 56.

Simulation of Carbonation Front

- Brown et al. (2013) modeled carbonation front and pH change for Hanford conditions (2.4% CO_2 in the soil gas at 90% concrete saturations).
- Modeled for two different concrete materials to bracket the possible range.
- After 600 years of simulation the carbonation front (assume pH >= 9) had propagated < 5 cm
- This indicates carbonation rate of less than 8.3 cm/1000 years
- Also indicates linear relationship with square root of time.

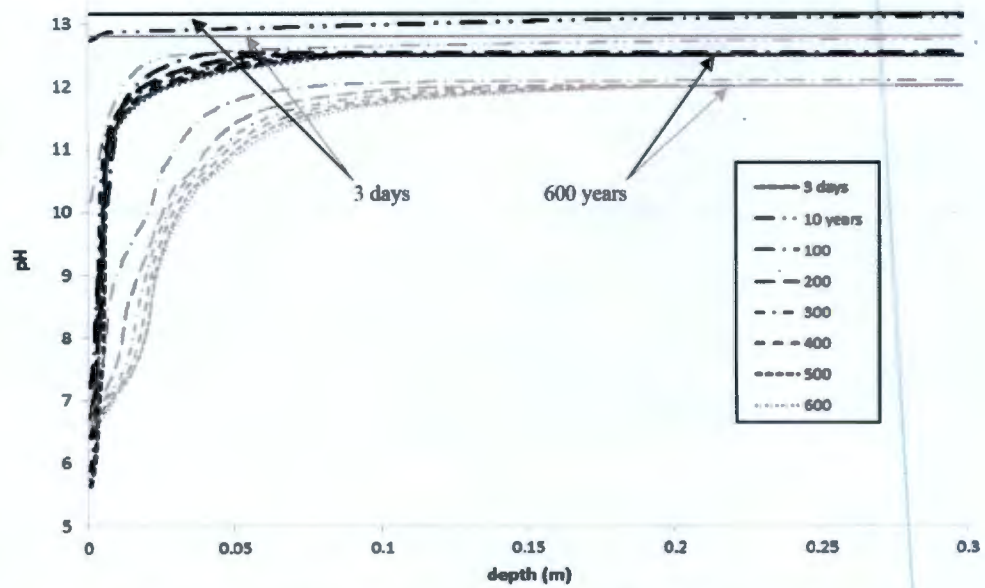


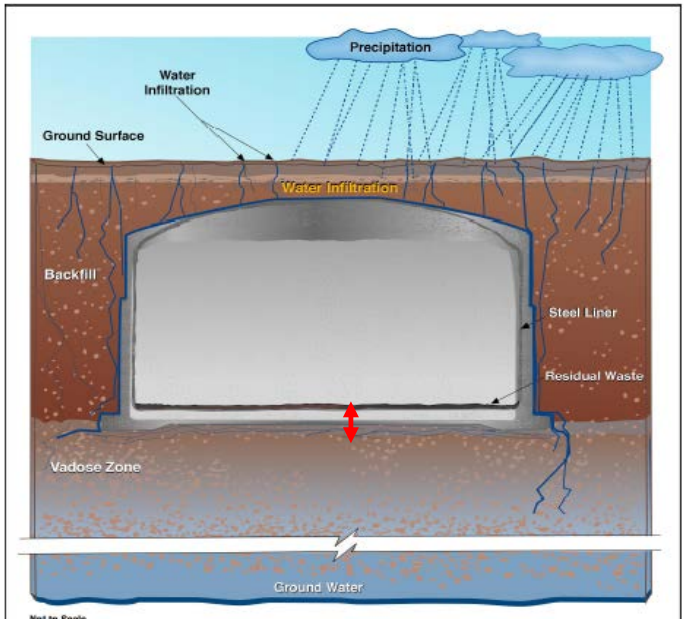
Fig. 4. Evolution of pH for HPC (black) and VCT (grey) for 2.4% Soil-Gas CO_2 and 90% Saturation.

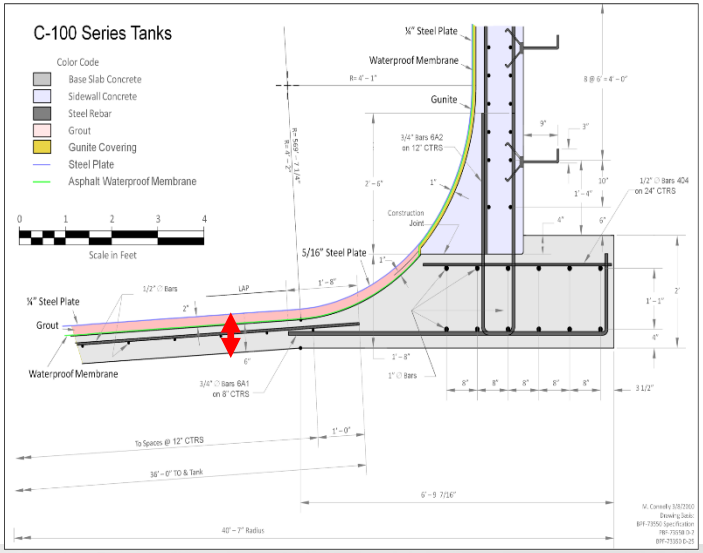
Brown et al., 2013, Modeling Carbonation of High-Level Waste Tank Integrity and Closure, EPJ Web of Conferences, v. 56.

Effective Diffusion Coefficient for Concrete

- Release to vadose zone is controlled by the diffusion of contaminants through the concrete + grout layer that forms the base of the tank (while tank is intact)
- **Effective diffusion coefficient of mobile contaminant (such as Tc-99) is considered a critical parameter for the PA**
- Evaluation of the available experimental dataset was necessary to estimate the effective diffusion coefficients
  - Focus is on estimating effective diffusion coefficient of Tc-99 from concrete under unsaturated conditions

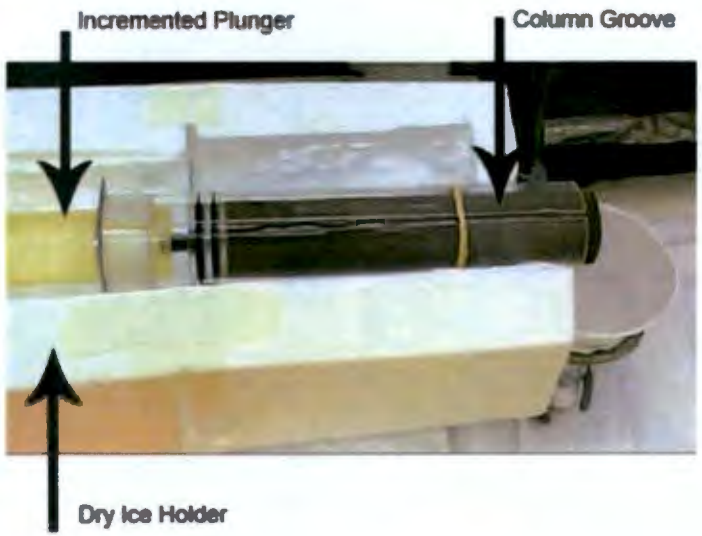
Figure 6-1. Conceptual Model of Tank Filled with Cementitious Grout Anticipated after Site Closure

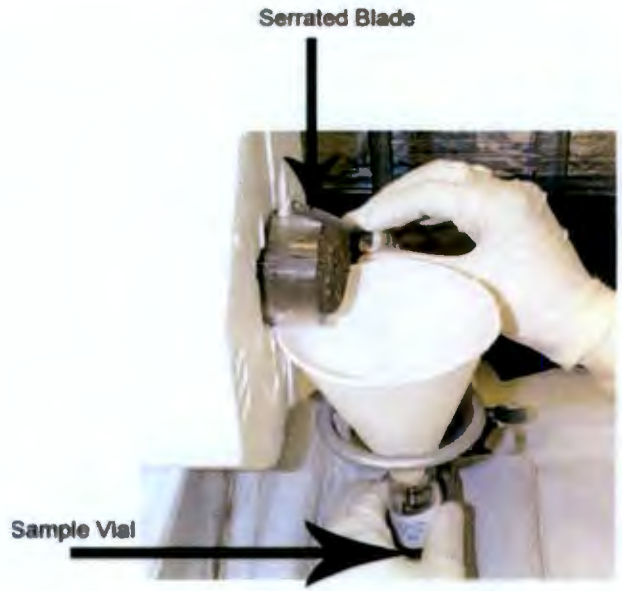




Sediment-Concrete Half-Cell Diffusion Experiments

- PNNL-23841, 2014, Radionuclide Migration through Sediment and Concrete: 16 Years of Investigations
  - Summarizes information previously published in PNNL reports, book chapters, and peer-reviewed technical publications
- Sediment-Concrete half-cell diffusion experiments conducted on Tc-99 (and Iodine)



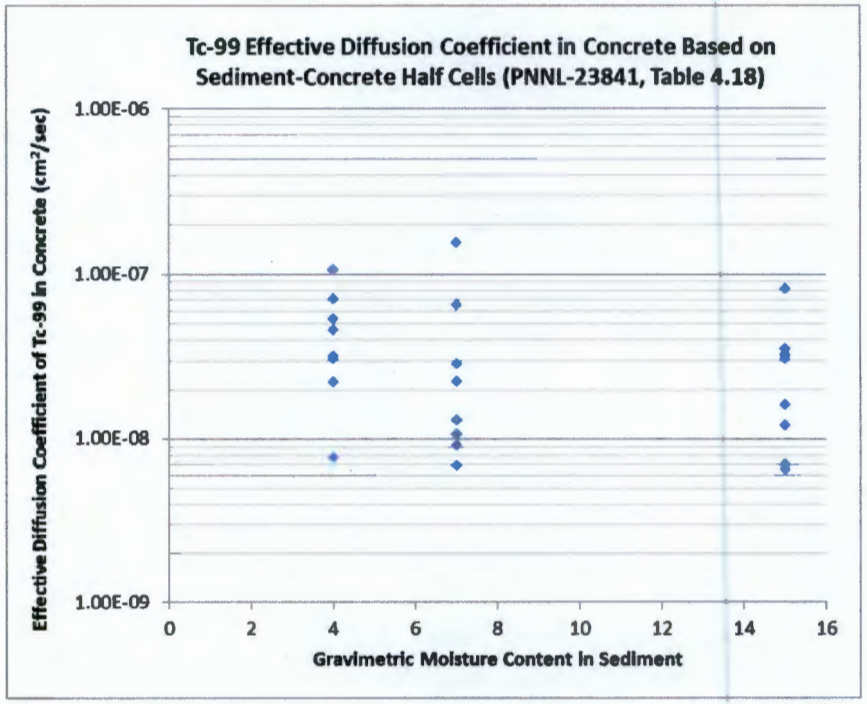


- Experiments were conducted using cylindrical cells made of Schedule 40 PVC pipe
- In the sediment-concrete half-cells, the half-cell containing the contaminated-spiked sediment was placed in contact with the non-spiked concrete monolith

Sediment-Concrete Half-Cell Experiments: Results: Tc-99 Diffusivity in Concrete

Table 4.18. Calculated Tc-99 diffusion parameters from sediment-concrete half-cell experiments

Core ID	Moisture (wt%)	Carbonated	Iron (wt%)	Tc-99 Diffusivity (cm^2/s)	Probit Slope
C-08-3-0-325	4	N	0	7.08×10^{-8}	0.4825
C-08-3-0-329	7	N	0	6.55×10^{-8}	0.5017
C-08-3-0-330	15	N	0	3.51×10^{-8}	0.6855
C-08-3-0-332	4	Y	0	2.23×10^{-8}	0.8602
C-08-3-0-333	7	Y	0	2.25×10^{-8}	0.8565
C-08-3-0-334	15	Y	0	1.22×10^{-8}	1.163
C-08-3-4-350	4	N	4	3.21×10^{-8}	0.7172
C-08-3-4-351	7	N	4	1.57×10^{-7}	0.3236
C-08-3-4-353	15	N	4	3.09×10^{-8}	0.7308
C-08-3-4-357	4	Y	4	3.09×10^{-8}	0.7302
C-08-3-4-359	7	Y	4	1.07×10^{-8}	1.2408
C-08-3-4-360	15	Y	4	3.26×10^{-8}	0.711
C-08-3-8-401	4	N	8	7.76×10^{-9}	1.4574
C-08-3-8-402	7	N	8	2.85×10^{-8}	0.7602
C-08-3-8-403	15	N	8	1.62×10^{-8}	1.0084
C-08-3-8-407	4	Y	8	5.34×10^{-8}	0.5554
C-08-3-8-409	7	Y	8	9.25×10^{-9}	1.3353
C-08-3-8-410	15	Y	8	6.61×10^{-9}	1.5788
C-08-3-12-425	4	N	12	1.07×10^{-7}	0.3927
C-08-3-12-426	7	N	12	1.31×10^{-8}	1.1205
C-08-3-12-427	15	N	12	8.21×10^{-8}	0.4481
C-08-3-12-432	4	Y	12	4.60×10^{-8}	0.5989
C-08-3-12-433	7	Y	12	6.95×10^{-9}	1.5405
C-08-3-12-435	15	Y	12	7.09×10^{-9}	1.525



Minimum Value = 6E-9 cm^2/s
Median Value = 3E-8 cm^2/s
Maximum Value = 2E-7 cm^2/s

K_d Values (mL/g) for Grout/Concrete

Element	Best	Minimum	Maximum	Reference
Ac	1.00E+05	3.00E+03	3.30E+05	NAGRA NTB 02-20
Al	0.00E+00	0.00E+00	0.00E+00	No relevant information
Am	1.00E+03	2.00E+02	5.00E+03	SKB R-05-75
B	0.00E+00	0.00E+00	0.00E+00	No relevant information
C	2.00E+02	1.00E+02	4.00E+03	SKB R-05-75
Cd	4.00E+01	2.00E+00	8.00E+02	SKB R-05-75
Cm	1.00E+03	2.00E+02	5.00E+03	SKB R-05-75
CN	0.00E+00	0.00E+00	0.00E+00	No relevant information
Co	4.00E+01	4.00E+00	4.00E+02	SKB R-05-75
Cr	0.00E+00	0.00E+00	0.00E+00	No relevant information
Cs	1.00E+00	1.00E-01	1.00E+01	SKB R-05-75
Eu	5.00E+03	1.00E+03	2.50E+04	SKB R-05-75
F	0.00E+00	0.00E+00	0.00E+00	No relevant information
Fe	0.00E+00	0.00E+00	0.00E+00	No relevant information
H	1.00E-01	7.10E-02	1.40E-01	NAGRA NTB 02-20
Hg	0.00E+00	0.00E+00	0.00E+00	No relevant information
I	3.00E+00	3.00E-01	3.00E+01	SKB R-05-75
Mn	0.00E+00	0.00E+00	0.00E+00	No relevant information
Nb	5.00E+02	1.00E+02	2.50E+04	SKB R-05-75
Ni	4.00E+01	8.00E+00	2.00E+02	SKB R-05-75
NO_2	0.00E+00	0.00E+00	0.00E+00	No relevant information
NO_3	0.00E+00	0.00E+00	0.00E+00	No relevant information
Np	1.00E+02	7.10E+01	1.40E+02	NAGRA NTB 02-20
Pa	1.00E+02	7.10E+01	1.40E+02	NAGRA NTB 02-20
Pb	5.00E+02	3.60E+02	7.10E+02	NAGRA NTB 02-20
Pu	1.00E+02	7.14E+01	1.40E+02	NAGRA NTB 02-20
Ra	5.00E+01	5.00E+00	5.00E+02	SKB R-05-75
Rn	0.00E+00	0.00E+00	0.00E+00	No relevant information
Se	6.00E+00	1.00E-01	4.00E+02	SKB R-05-75
Sm	5.00E+03	1.00E+03	2.50E+04	SKB R-05-75
Sn	5.00E+02	2.50E+01	1.00E+04	SKB R-05-75
Sr	1.00E+00	5.00E-01	5.00E+01	SKB R-05-75
Tributyl phosphate	0.00E+00	0.00E+00	0.00E+00	No relevant information
Tc	1.00E+00	7.10E-01	1.40E+00	NAGRA NTB 02-20
Th	3.00E+04	1.00E+03	1.00E+06	NIROND-TR 2008-23 E
U	2.00E+03	1.40E+03	2.80E+03	NAGRA NTB 02-20
Zr	1.00E+04	3.00E+03	3.30E+04	NAGRA NTB 02-20

(Same as used in WMA C PA)

References:
NAGRA NTB 02-20, "Cementitious Near-Field Sorption Data Base for Performance Assessment of an ILW Repository in Opalinus Clay."
NIROND-TR 2008-23 E, "Review of sorption values for the cementitious near field of a near surface radioactive waste disposal facility, Project near surface disposal of category A waste at Dessel."
PSI Bericht Nr. 95-06, "Sorption Databases for the Cementitious Near-Field of a L/ILW Repository for Performance Assessment."
SKB Rapport R-05-75, "Assessment of uncertainty intervals for sorption coefficients SFR-1 uppföljning av SAFE."

Summary

- Key engineered system features discussed
  - Liquid discharge sites around the Tank Farms (cribs, retention basins, etc.)
- Tank configuration; wall thickness; base mat thickness
- Recharge estimates for the undisturbed and disturbed areas during the operational period
- Evolution of WMA A/AX over time (surface barrier degradation)
- Release models for residual wastes that may remain following waste retrieval
  - Extensive network of transfer pipelines
- Degradation of tank concrete structure and emplaced grout
- Effective diffusion coefficient through the concrete/grout material
- Sorption within the concrete/grout material