WASHINGTON
Washington
Seattle
Spokane
Hanford Site
Tri-Cities
Vancouver
Hanford Reach National Monument
CENTRAL PLATEAU
C Tank Farm
Tank Farms
Waste Treatment Plant
200 West Area
200 East Area
Hanford Reach National Monument
Mattawa
24-SW Rd
Wahluke Branch Canal
Saddle Mountain Lake
Columbia River
Savage Island
Basin City
Road 170
Mesa
Eltopia
Glade
Glade North Rd
Taylor Flats Rd
Hanford Rd
Road L SW
Rapids Ditch
F R A N K L I N
24
243
240
241
17
395

U.S. DEPARTMENT OF ENERGY | OFFICE OF ENVIRONMENTAL MANAGEMENT

Introduction to the Draft Waste Incidental to Reprocessing (WIR) Evaluation for Waste Management Area C (WMA C)

Sherri R. Ross

U.S. Department of Energy

Environmental Management Program

Office of Regulatory Compliance

June 2018

Presentation Overview

- Answer the big picture questions:
  - What is a WIR Determination?
  - What does the WIR Determination allow DOE to do?
  - Has DOE made other Determinations?
  - How are WIR Determinations made
    - WIR Decision Process
    - WIR Criteria
  - How to submit comments

What is a WIR Determination?

A WIR Determination is a decision that waste is appropriate for management as non-high level waste.

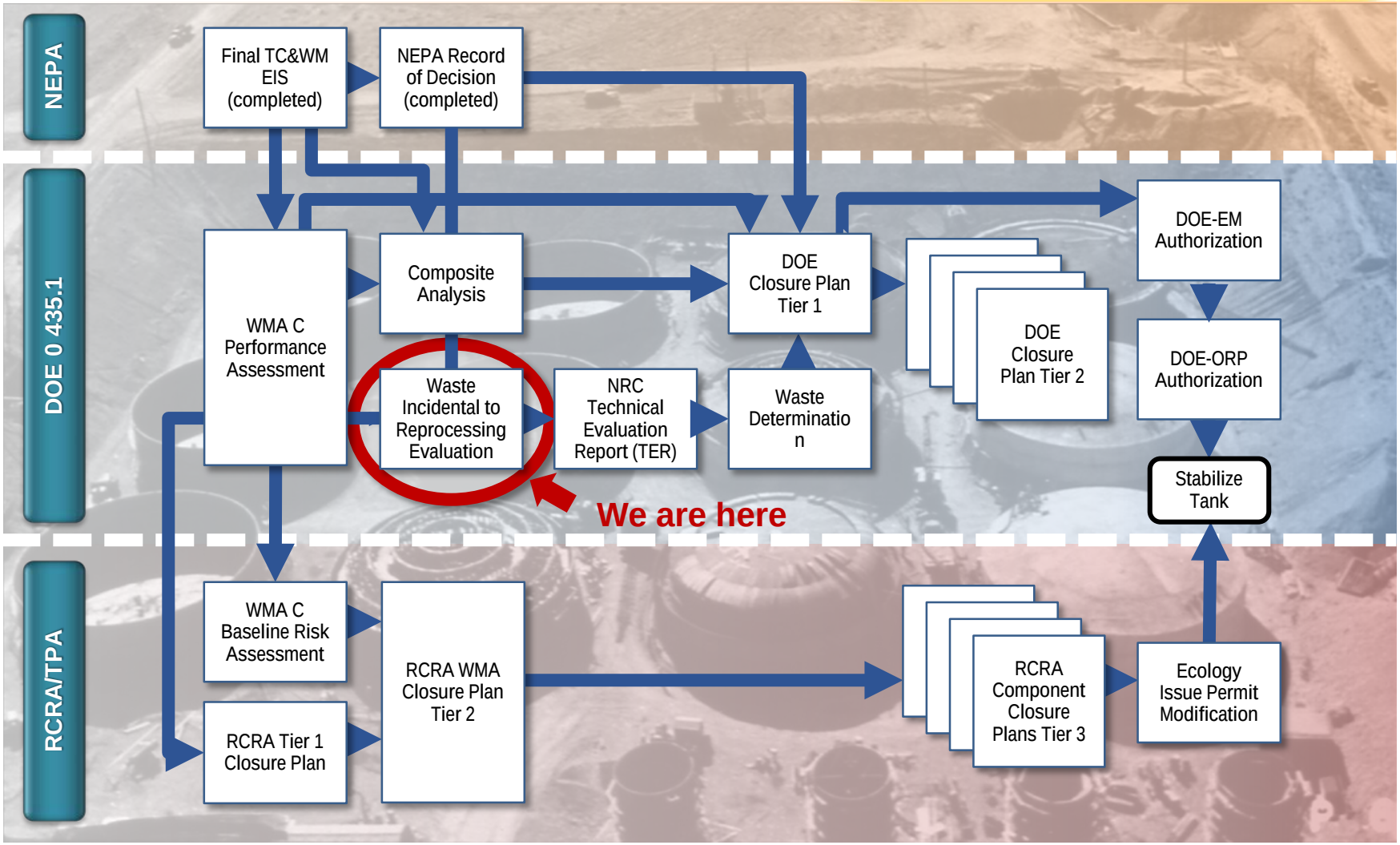
The WIR Evaluation is developed to demonstrate that the stabilized waste residuals, the waste tanks, and the ancillary structures (including integral equipment) in WMA C at the time of closure meet the WIR criteria and, therefore, are not high-level waste.

Residuals - Residual waste remaining in a waste tank or ancillary structure following completion of waste retrieval activities and removal of key radionuclides to the maximum extent that is technically and economically practical.

Stabilization - Stabilization will be carried out by filling the tanks with grout at the completion of waste retrieval activities. Ancillary structures will also be filled with an appropriate material, as necessary, to prevent subsidence.

This process is not intended to address contaminated soils or groundwater

Regulatory Processes for Tank Closure



Has DOE made other Determinations?

- *Section 3116 Determination for Salt Waste Disposal at Savannah River Site (January 2006)*
- *Section 3116 Determination for the Idaho Nuclear Technology and Engineering Center Tank Farm Facility at the Idaho National Laboratory (November 2006) – 11 Tanks Closed*
- *Section 3116 Determination for F-Tank Farm at the Savannah River Site (March 2012) – 4 Tanks Closed*
- *WIR Determination for West Valley Concentrator Feed Makeup Tank and Melter Feed Hold Tank (February 2013)*
- *Section 3116 Determination for H-Tank Farm at the Savannah River Site (December 2014) – 2 Tanks Closed*

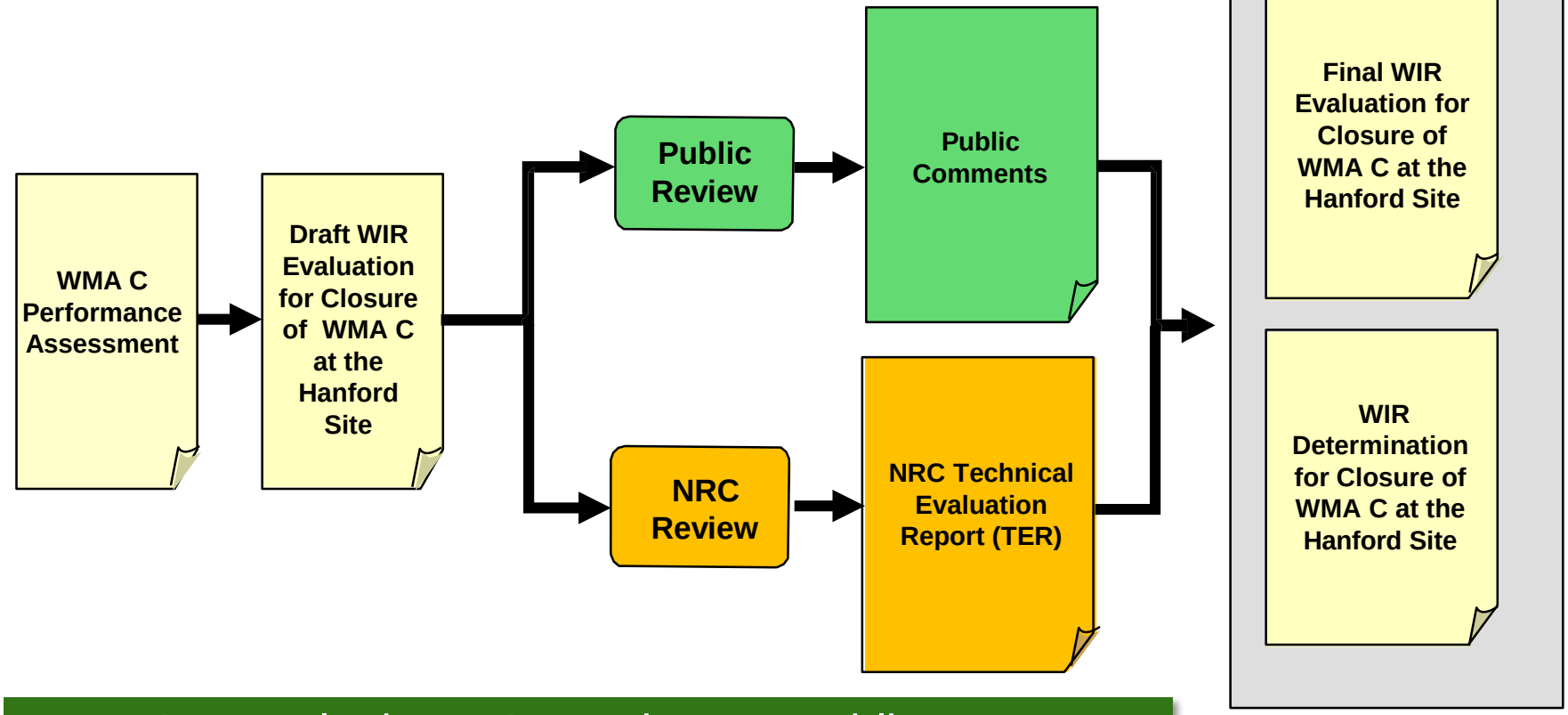
How are Determinations Made?

- Section 3116 Ronald W. Reagan National Defense Authorization Act for Fiscal Year 2005 (Public Law 108-375)
  - Applies to South Carolina and Idaho only
- DOE Order and Manual 435.1-1, Radioactive Waste Management
  - Applies to all other DOE sites
  - WMA C Draft WIR Evaluation

Same process and similar criteria used to make all determinations. Comparison between the two methods provided in Appendices A and B of the Draft WIR Evaluation.

WIR Process

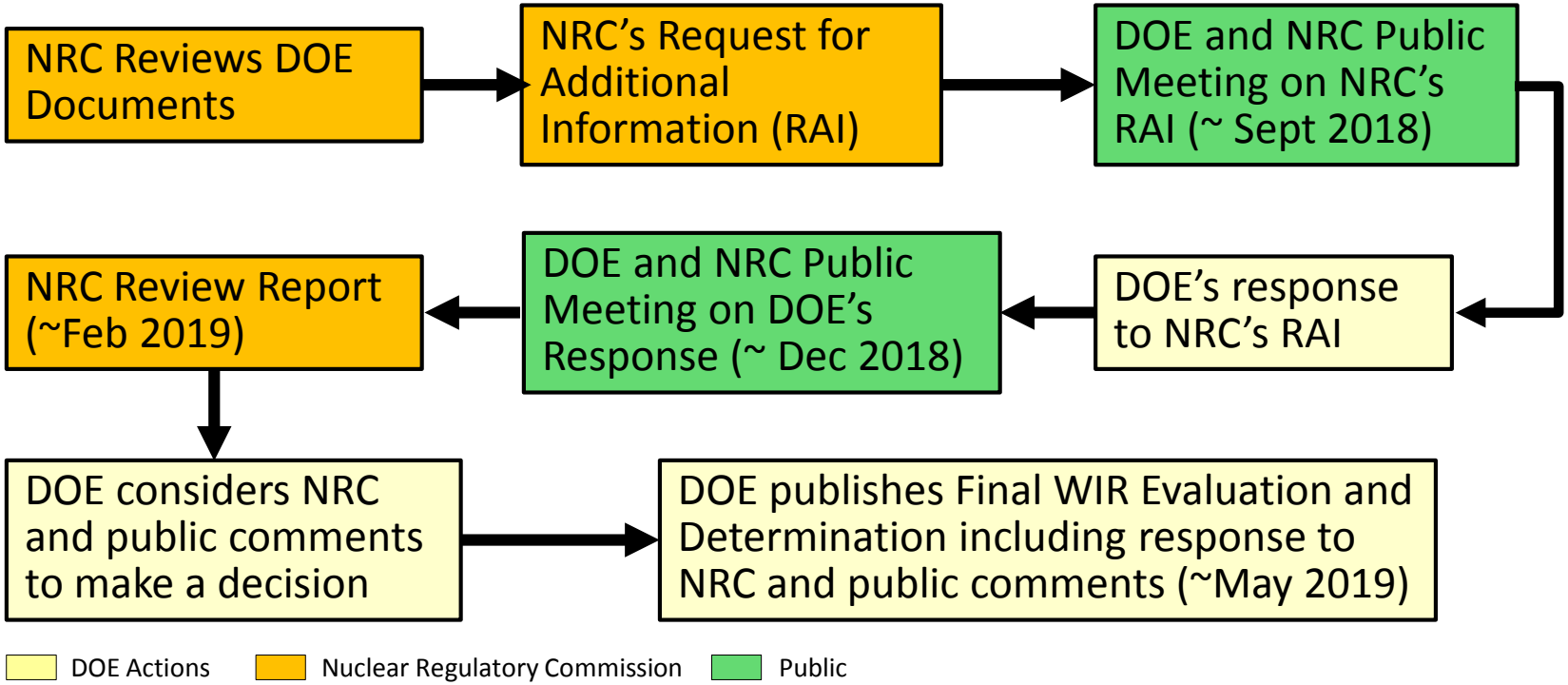
Public comment period June 4 – September 7, 2018



NRC consultation ~ 9 month open public process

DOE Actions | Nuclear Regulatory Commission | Public

NRC Review Process



All dates are estimates, subject to change. Public meetings are intended for DOE and NRC discussion with public invited to observe and comment at the end of meeting. DOE shares all public comments with NRC. DOE and NRC may, if mutually agreed, have technical staff to staff, non-decision conference calls to ask clarification type questions and if used, will post a public meeting summary.

WIR Criteria

DOE Manual 435.1-1 Chapter II, section B(2)(a) provides in pertinent part that wastes determined to be incidental to reprocessing:

1. Have been processed, or will be processed, to remove key radionuclides to the maximum extent that is technically and economically practical; and
2. Will be managed to meet safety requirements comparable to the performance objectives set out in 10 CFR 61 Subpart C…; and
3. Are to be managed, pursuant to DOE's authority under the [AEA]…, provided the waste will be incorporated in a solid physical form at a concentration that does not exceed the applicable concentration limits for Class C LLW as set out in 10 CFR 61.55…

Where is the Draft WIR Evaluation

Online: https://www.hanford.gov/page.cfm/WasteManagementAreaC

U.S. DOE Public Reading Room
1000 Independence Avenue, SW
Washington, DC 20585

Phone: (202) 586-5955

U.S. DOE Public Reading Room
2770 University Drive, Room 101L
Richland, WA 99354

Phone: (509) 372-7303

How to Submit Comments

Written comments may be submitted via email to:

WMACDRAFTWIR@rl.gov

Or postal mail to:

Mr. Jan Bovier
U.S. Department of Energy, Office of River Protection
P.O. Box 450, MSIN H6-60
Richland, WA 99354

Submit comments by Friday, September 7, 2018

Questions?

The Hanford Reach
White Bluffs Overlooking the Columbia River

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NRC's Review of the Hanford WMA-C Draft Waste Incidental to Reprocessing (WIR) Evaluation

June 18, 2018

David Esh, Maurice Heath, Hans Arlt, Lloyd Desotell
Division of Decommissioning, Uranium Recovery and Waste Programs
U.S. Nuclear Regulatory Commission

Overview

- NRC's role at Hanford
- Criteria
- Products
- Schedule

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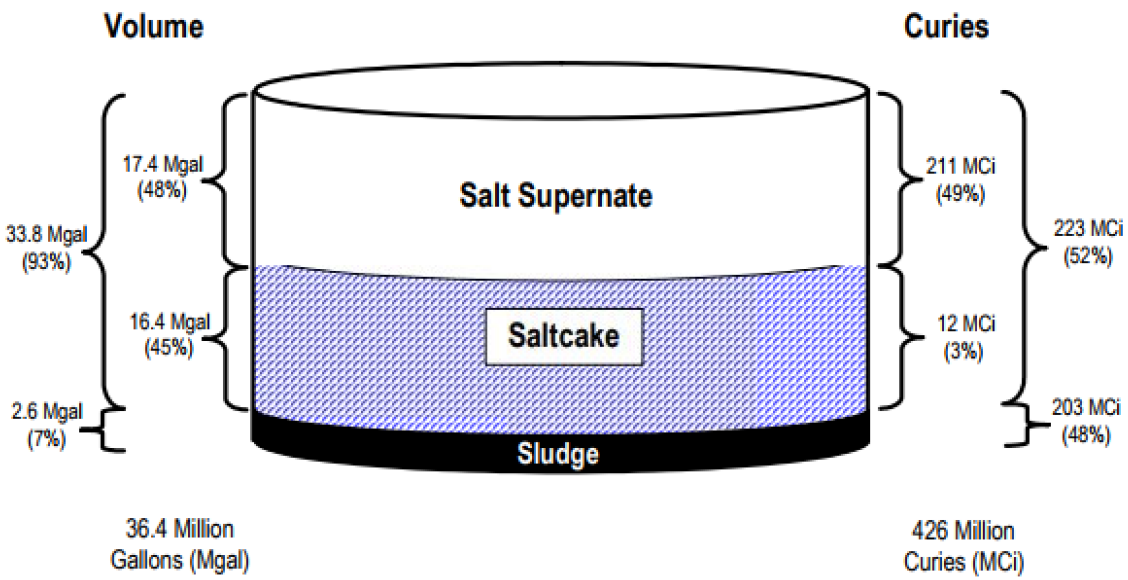
What is WIR? (theory)

WIR is waste that would be high-level waste (HLW) based on its reprocessing origin, but can be managed as low-level waste because of the lower level of risk it poses. Lower risk can result from:

- Separation and, in some cases, further decontamination of low-level fraction of waste
- Residuals of a higher-activity fraction, left in place and further stabilized



NRC's Role at Hanford

Waste Incidental to Reprocessing (WIR)

- Review of Waste Management Area C (WMA-C) waste determination
- Interagency agreement at Hanford (consultation only)
- NRC will not have a monitoring role at Hanford

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NRC's Role at Hanford

- DOE submits its draft WIR Evaluation to NRC for review. Consultation typically includes:

- Scoping meetings or technical exchanges
- Requests for Additional Information
- NRC Technical Evaluation Report (TER)

Consultation

NRC's Role at Hanford - Contacts

- Project Management (lead) – Lloyd Desotell Lloyd.Desotell@nrc.gov x5969
- Project Management – Maurice Heath Maurice.Heath@nrc.gov x3137
- Technical Review (lead) – Hans Arlt Hans.Arlt@nrc.gov x5845
- Technical Review – David Esh David.Esh@nrc.gov x6705
- Low-Level Waste Branch Chief (acting) – Richard Chang Richard.Chang@nrc.gov x5888
- Performance Assessment Branch Chief – Chris McKenney Christepher.Mckenney@nrc.gov x6663

Phone numbers take the form (301) 415 - XXXX

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Criteria for Determining Reprocessing Waste is WIR (i.e., not HLW)

- Three sets of similar criteria:
  - **Hanford – DOE Manual 435.1-1**
  - West Valley – NRC West Valley Policy Statement
  - SRS and INL – National Defense Authorization Act for 2005 (NDAA), Section 3116
- The criteria are generally consistent:
  - All require removing key radionuclides to the maximum extent practical (or "technically and economically practical")
  - All require disposal to meet the performance objectives of (or comparable to) 10 CFR Part 61 (DOE Manual 435.1-1 also has alternative requirements for waste identified as TRU)

Performance Objectives of 10 CFR Part 61, Subpart C

- §61.41 Protection of the general population from releases of radioactivity (dose limit & ALARA)
- § 61.42 Protection of individuals from inadvertent intrusion
- § 61.43 Protection of individuals during operations
- § 61.44 Stability of the disposal site after closure

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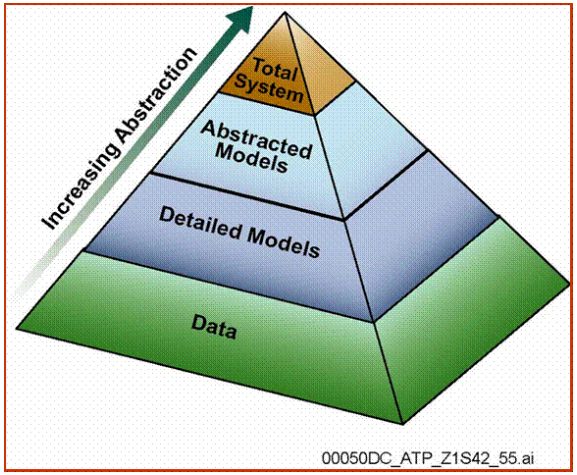
What is Reviewed

- Staff conducts completeness review of documents submitted
- Staff review the draft WIR evaluation document.
- Staff review the supporting documents (first level).
- Staff review secondary and lower level documents as needed.
- Staff review the performance assessment model, incorporated assumptions, supporting calculations, and model support.
- Staff may develop an independent model to develop risk insights.



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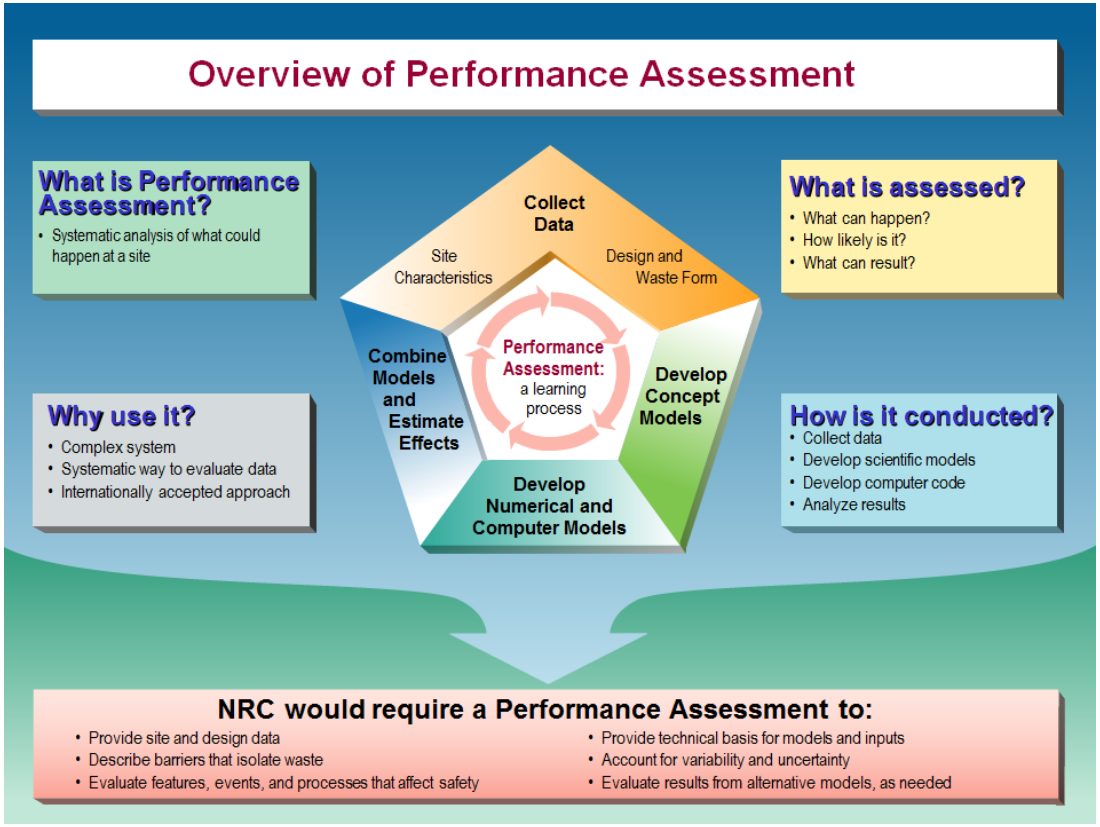
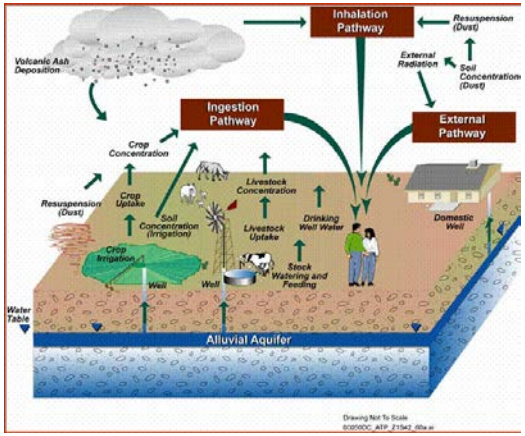
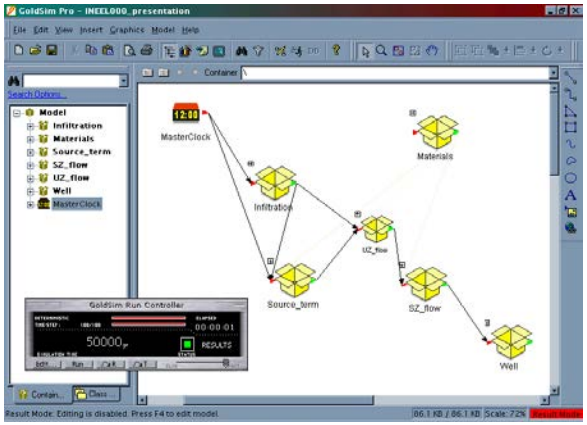
What is Reviewed







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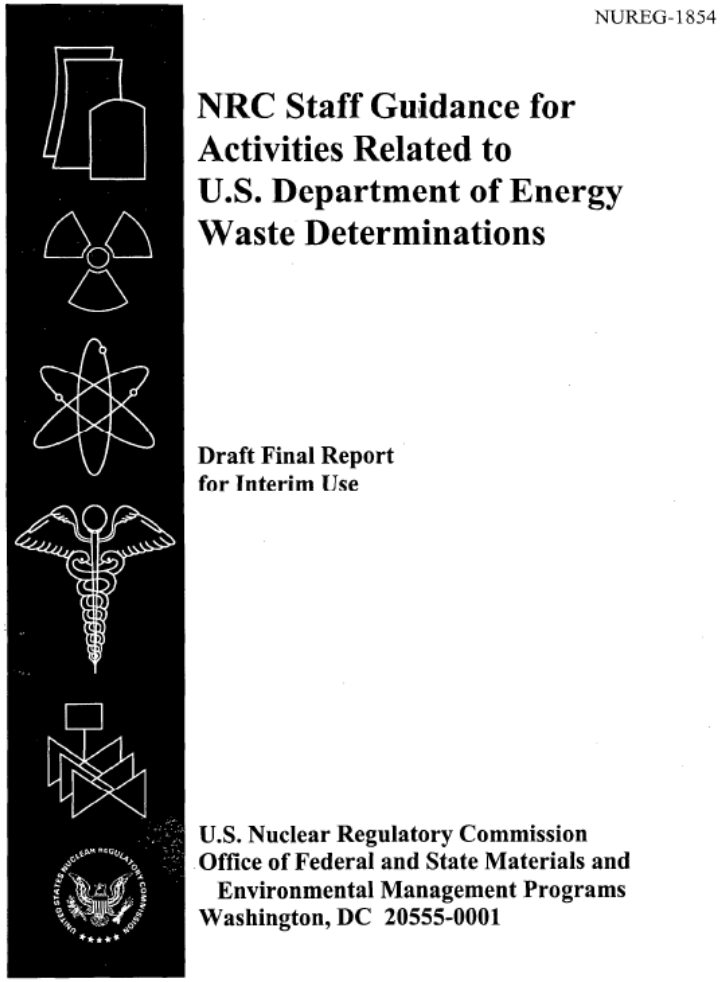
How is it Reviewed



NUREG-1854

NRC Staff Guidance for Activities Related to U.S. Department of Energy Waste Determinations

Draft Final Report for Interim Use

U.S. Nuclear Regulatory Commission
Office of Federal and State Materials and Environmental Management Programs
Washington, DC 20555-0001

- Staff uses NUREG-1854 to guide the review.
- NUREG-1854 provides areas of review and review procedures.
- ML072360184, 228 pages

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How is it Reviewed

- NRC's review is open and transparent.
- Documents are publically available.
- Basis for requests for additional information is provided.
- A report (technical evaluation report) is developed to document the results of the review.
- Documents can be accessed through ADAMS, enter docket number PROJ0736 in the search box.

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Other Considerations for the Review

- DOE indicated although the entire draft WIR evaluation is subject to consultation, DOE requested emphasis on criteria 2 (performance objectives) over criteria 1 (removal of key radionuclides).
- DOE requested that NRC determine if DOE demonstrated a reasonable expectation of compliance with the performance objectives for 1,000 years.
- Model results to 10,000 years provided to support risk-informed decision-making.

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Schedule

- Receive draft WIR evaluation – **June 4, 2018**
- NRC transmits completeness review letter – July 19, 2018
  - Note: If all the documents necessary to conduct the review are not provided, adjustments to the schedule may be needed
- NRC completes detailed technical review – September 4, 2018
- NRC issues RAIs to DOE – **October 2, 2018**
- DOE transmits RAI responses to NRC – **November 1, 2018**
  - Note: If DOE requires additional time to address RAI responses, the schedule will need to be adjusted
- NRC completes review of RAI responses – January 7, 2019
- NRC completes TER – March 1, 2019
- Teleconference with DOE to discuss findings – March 6, 2019
- NRC transmits TER to DOE – **March 11, 2019**

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Concluding Remarks

- NRC is an independent federal agency whose decision is based solely on the merits of the materials provided.
- NRC strives to provide a clear and technically-sound basis for findings.

Thank you for your time and attention

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Use of Performance Assessment to Support Decision-Making

Roger Seitz

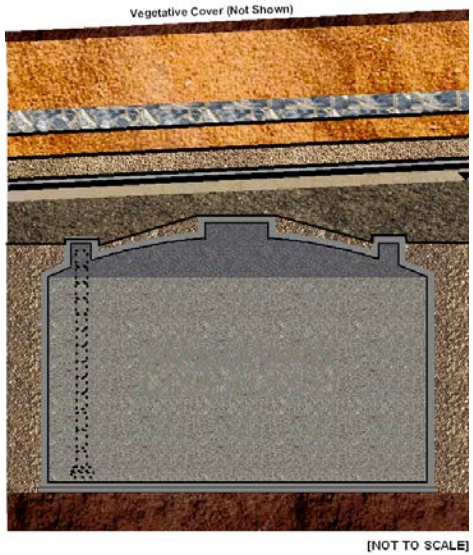
Senior Principal Consultant

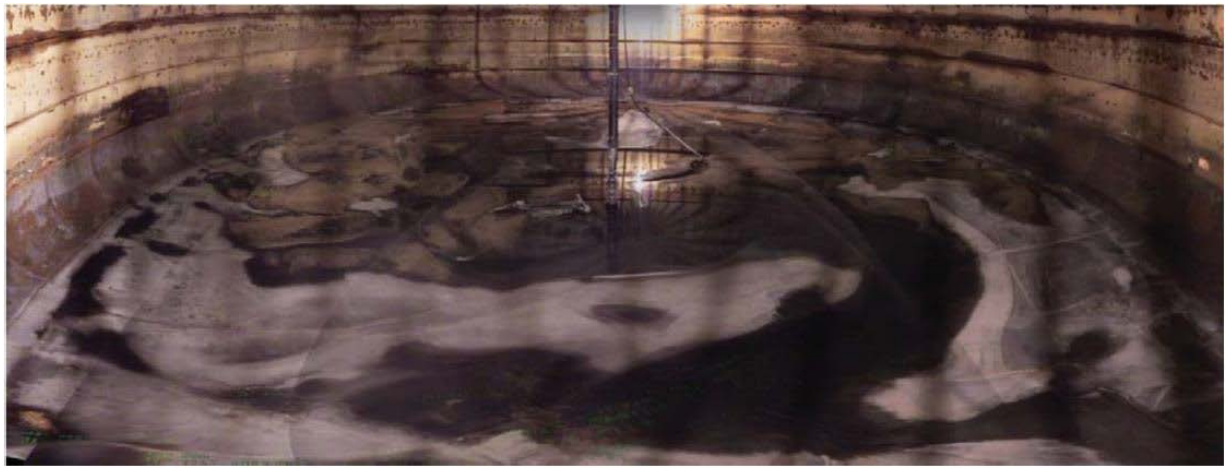
Public Meeting

June 2018

Introduction

- Important decision to determine when it is safe to leave some residual waste in tanks
- Performance assessments (PAs) with supporting “body of evidence” form the safety case
- Robust, risk-informed process based on recommendations from several organizations with layers of review and engagement with interested parties





Numerical Criteria

	DOE Manual 435.1	10 CFR Part 61
Dose Objectives	25 mrem/yr – All Pathways 10 mrem/yr – Air Pathway	25 mrem/yr – All Pathways
Inadvertent Human Intrusion	100 mrem/yr – Chronic 500 mrem – Acute	500 mrem – Acute and Chronic

Note: DOE Manual 435.1-1 also includes groundwater protection and radon flux or concentration limits for releases from the closed tanks

"Risk-Informed," Not "Risk-Based"

- DOE/NRC support a risk-informed view using PA results to support decision-making – supplemented by a full "body of evidence" to demonstrate understanding
- Recognize unknowns and uncertainties that influence implementation and interpretation of PAs – "reasonable assurance", "reasonable expectation"

"The purpose of computing is insight, not numbers"

- Richard Hamming

"A "risk-based" approach to regulatory decision-making is one in which such decision-making is solely based on the numerical results of a risk assessment." (NRC 1999)

Outline

- What is a Performance Assessment (PA)?
- International and National Standards and Recommendations
- Key Concepts

What is Performance Assessment?

- A means to address post-closure protection of human health and the environment to support a decision process
- A process to demonstrate confidence that projected doses are reasonably likely to be less than a given standard, not a prediction of actual doses
- A "learning process" to provide perspective on the significance of different site, facility and waste features in the context of the decision (demonstrate understanding of the full disposal or tank closure system)

Large Supporting Cast

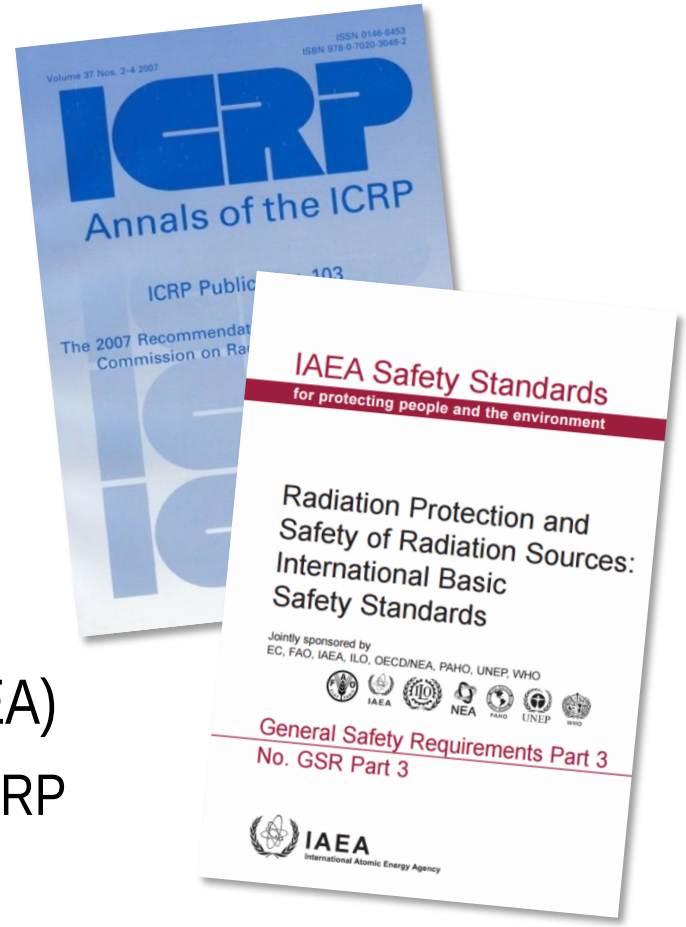
Example contributors to a PA:

- Main contractor responsible for the PA
- Regulators
- Tribal Nations
- National Laboratories
- Universities
- Consulting Firms

Involvement occurs through direct contributions to modeling, participation in workshops and providing comments on documents, and contributions to model support activities (e.g., PA Maintenance)

International Standards

- International Commission on Radiological Protection (ICRP) Publications
  - Recognized standards and recommendations
  - Dose limit of 100 mrem/yr for planned exposures
  - Concept of potential exposures
  - Time frames
  - Inadvertent intrusion
- International Atomic Energy Agency (IAEA)
  - Basic Safety Standards largely reflect ICRP



Recommendations/Experience

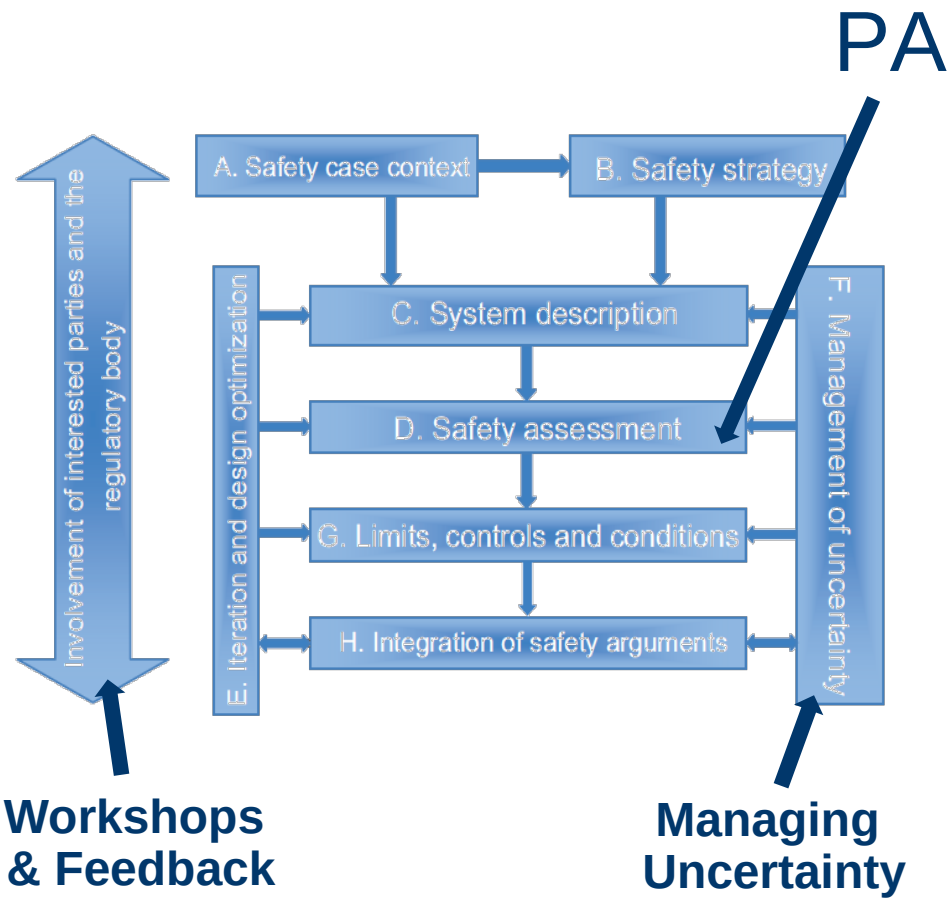
- Variety of guidance and recommendations
- IAEA
  - Requirements and Guides
- U.S. Nuclear Regulatory Commission (NRC)
  - Staff Recommendations
- National Council on Radiation Protection and Measurements (NCRP)
- Nuclear Energy Agency, European Commission

Key Concepts

- General agreement on some basic principles:
  - Safety Case and Managing Uncertainty
  - Defense-in-Depth
  - Safety Margins
  - Total System Perspective, Safety Functions
  - Complexity – Graded and Iterative Approach, Multiple Modeling Approaches
  - Sensitivity and Uncertainty Analysis
  - PA Maintenance – Integration of Modeling, Monitoring and Model Support Activities

Safety Case

- Captures the integrated approach to safety, similar to Integrated Safety Management System
- Much of the PA context and approach is focused on managing uncertainty
- Integration of multiple safety arguments to support a decision



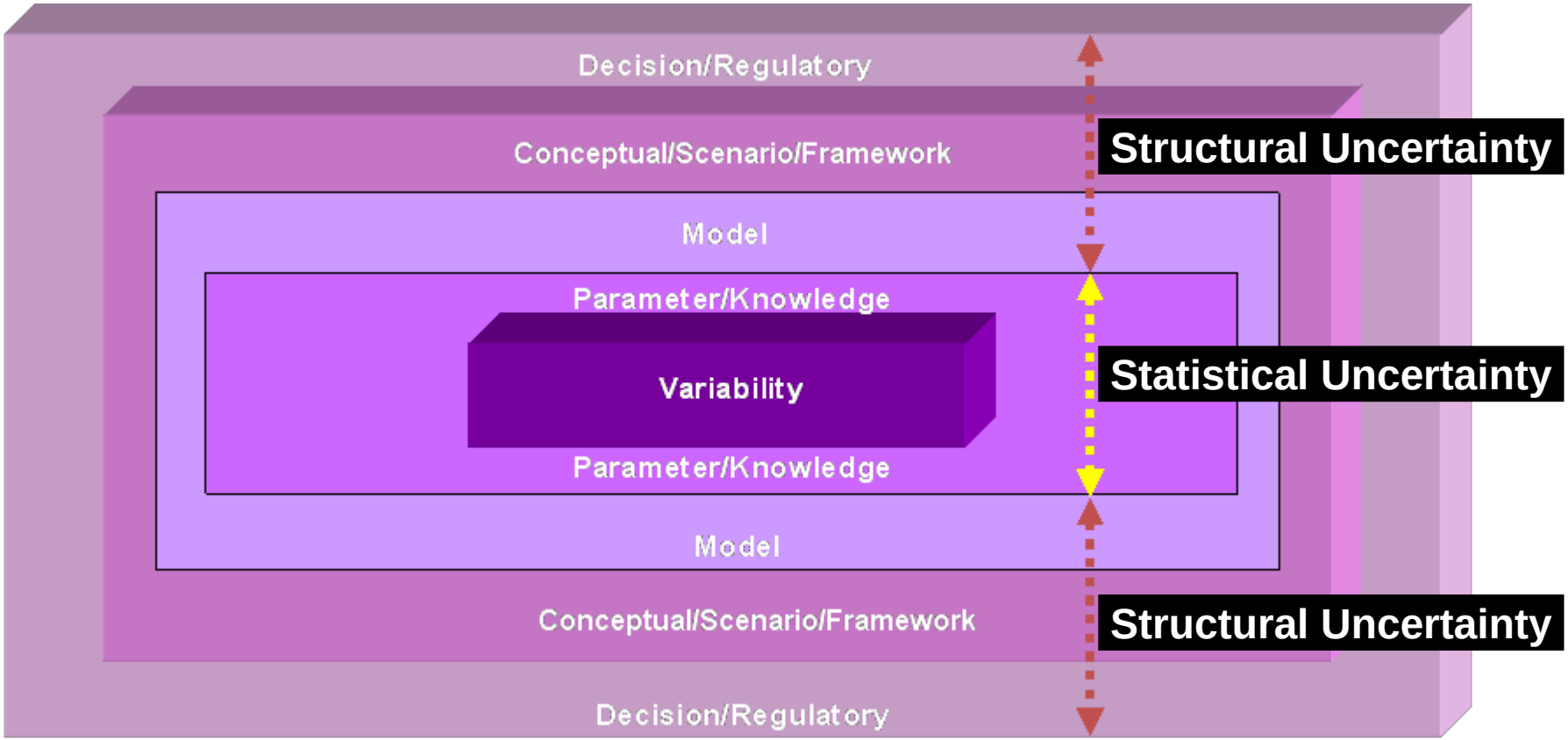
IAEA Figure

Managing Uncertainty

- Uncertainty in human habits, data and models is a fact of life for assessments, especially spanning hundreds or thousands of years
- Although the term “reducing” uncertainty is often used, typically we strive to effectively “manage” uncertainties
  1. Identify and acknowledge
  2. Prioritize importance
     (Does uncertainty impact decision?)
  3. Select approaches to manage
     (characterization, pessimistic-bias…)
  4. Quantify
- Many approaches used to manage uncertainty

DOE Photo (Hanford)

Uncertainty



Courtesy: Bruce Crowe, Nevada National Security Site

Defense-in-Depth

- Extraordinary efforts to consider potential consequences in the far future
- PAs are one part of a robust defense-in-depth approach for safety
- Multiple levels of added safety factors (e.g., dose constraints, conservative bias, inadvertent intrusion)
- Integrated total system approach (site, facility, admin/ technical controls)

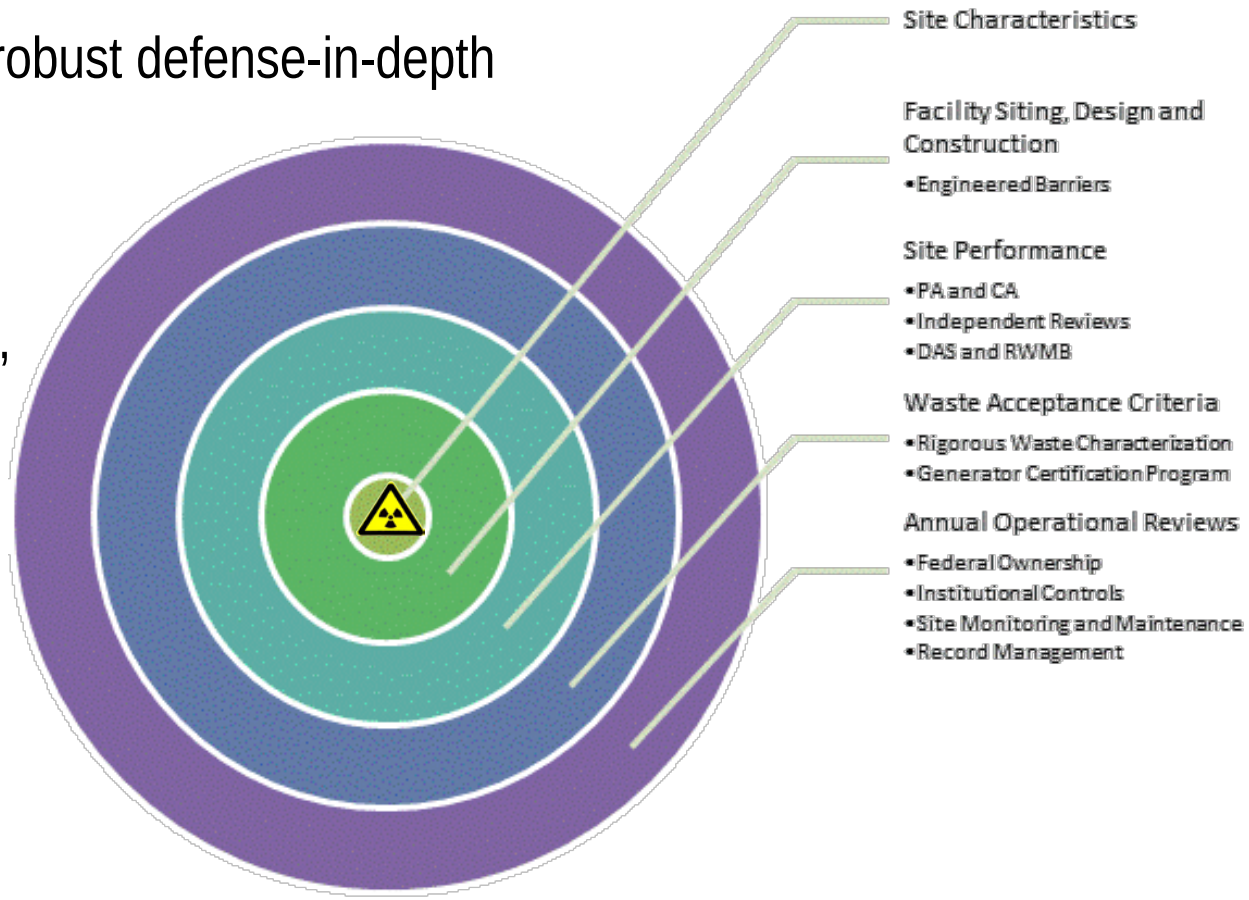


Figure: DOE Presentation to NRC ACRS – October 2013

Built-in Safety Margin for Dose Limits

620 mrem/yr – US Average dose all sources (NCRP)

In 2009, NCRP updated US Annual Average Dose from 360 to 620 mrem/yr

100 mrem/yr – All sources limit (IAEA practices, DOE)

EPA Recommended Radon Action Level of 4 pCi/L in Basements (~576 mrem/yr**)

25 mrem/yr – NRC and DOE LLW All Pathways Limit for Disposal Facilities

15 mrem/yr – EPA Radiation (40 CFR Part 191)*

10 mrem/yr – EPA Air (atmospheric) (40 CFR Part 61)

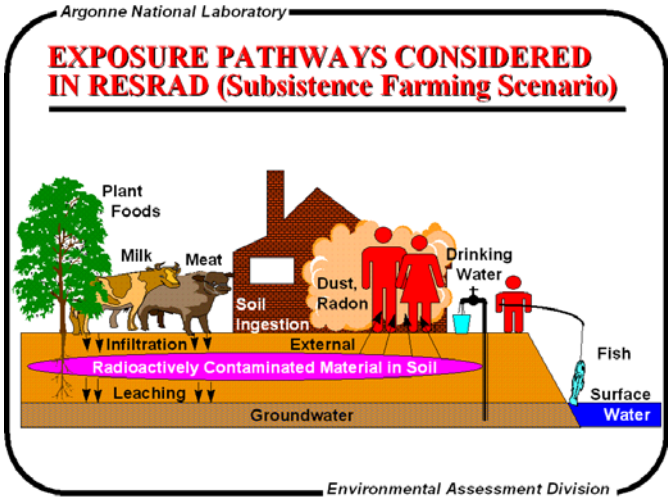
4 mrem/yr – EPA Drinking Water (40 CFR Part 141)

*EPA 540-R-012-13 (2014) has identified 12 mrem/yr as the new level for protectiveness criteria
**EPA Dose Calculator (https://www.epa.gov/radiation/calculate-your-radiation-dose)

Note: Air crew average (300 mrem/yr), from United Nations Scientific Committee on the Effects of Atomic Radiation (2000)

Safety Margin – More Highly Exposed Individuals

- Assume loss of controls and memory
- Assume exposure occurs at time and location of peak concentration
- Assume there will be a residential, subsistence farmer
- Inadvertent intrusion scenario occurs in spite of obvious signals that something is wrong

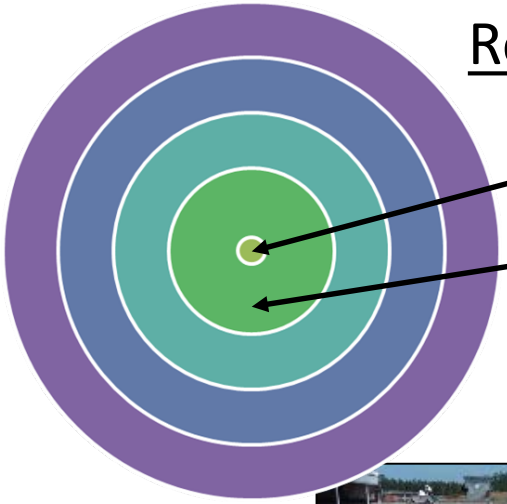


Total System Perspective – Humid and Arid

Savannah River

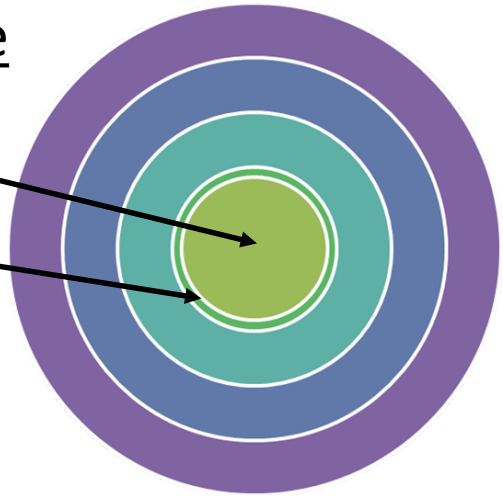
Nevada

Relative Importance



Site

Engineered Barriers



Vault

Trench

Safety Functions – What function does each feature provide?

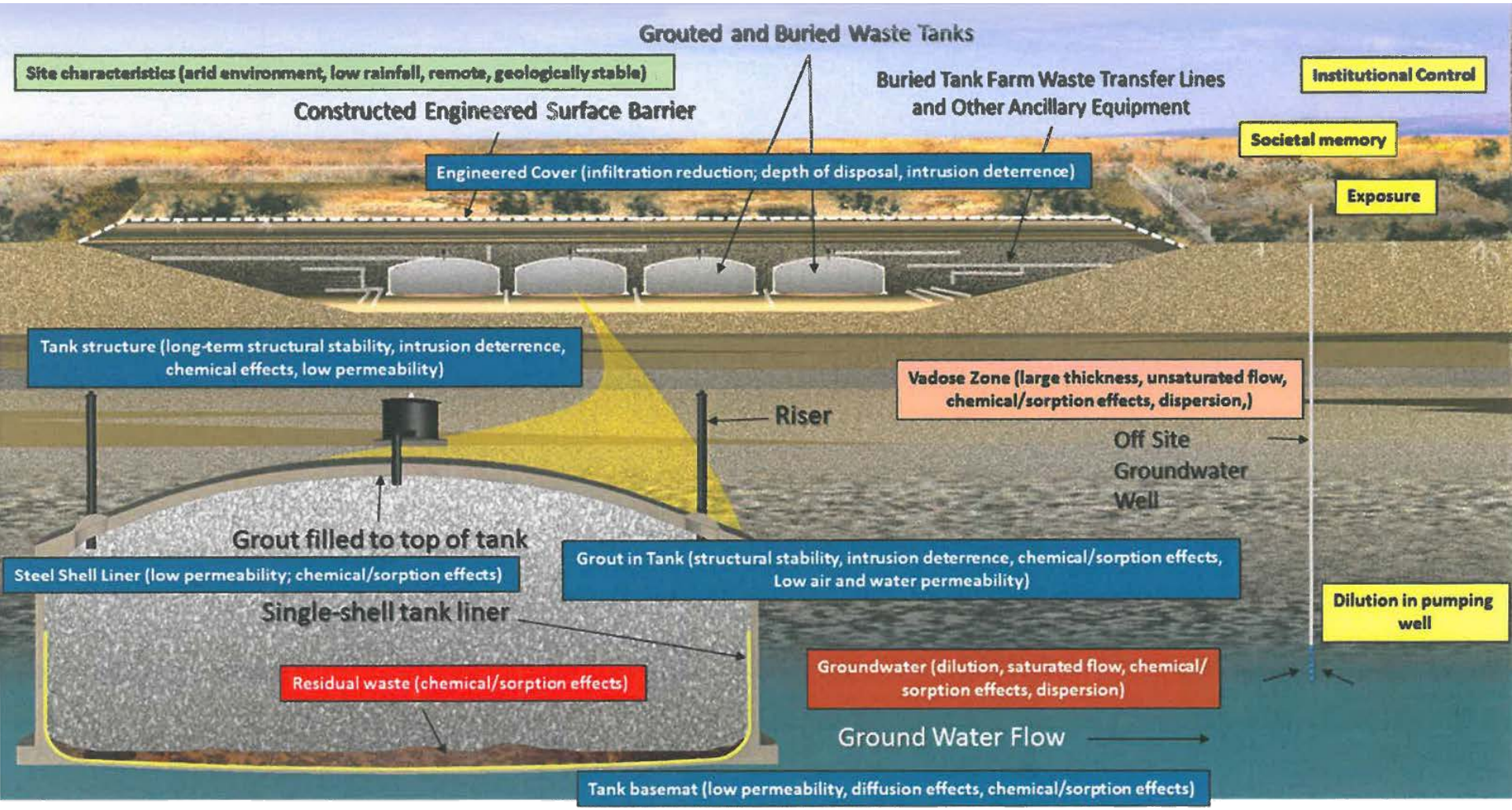


Illustration of Graded, Systems-Based Approach

Variety of Options for Priorities

Enhanced screening?

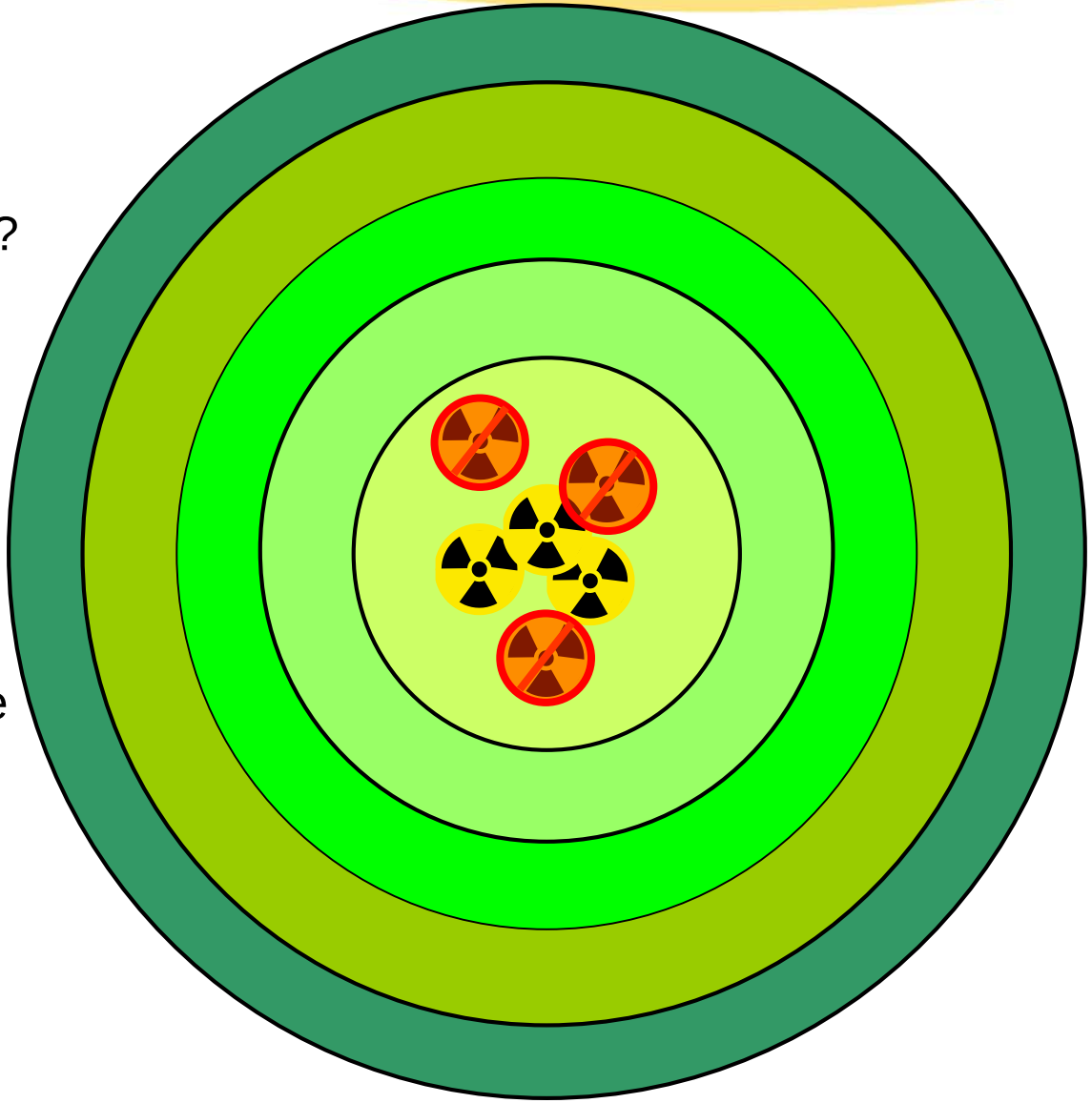
Improved cover representation?

Account for waste form (physical/chemical)?

Account for steel tank (physical/chemical)?

Account for reinforced concrete (physical/chemical)?

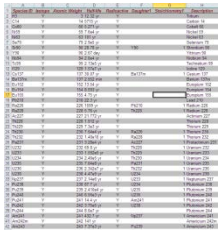
More detailed site conceptual model (physical/chemical)?

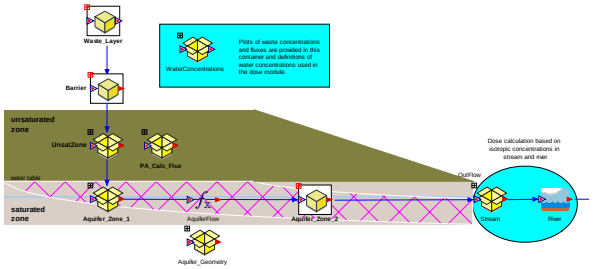


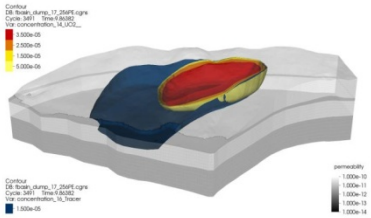
Complexity – Graded and Iterative Approach

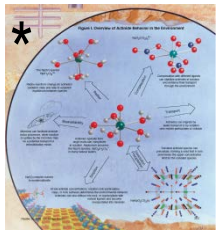
Graded and Iterative Approach

- Level of detail based on "importance" for a decision
- Multiple levels of detail typically used







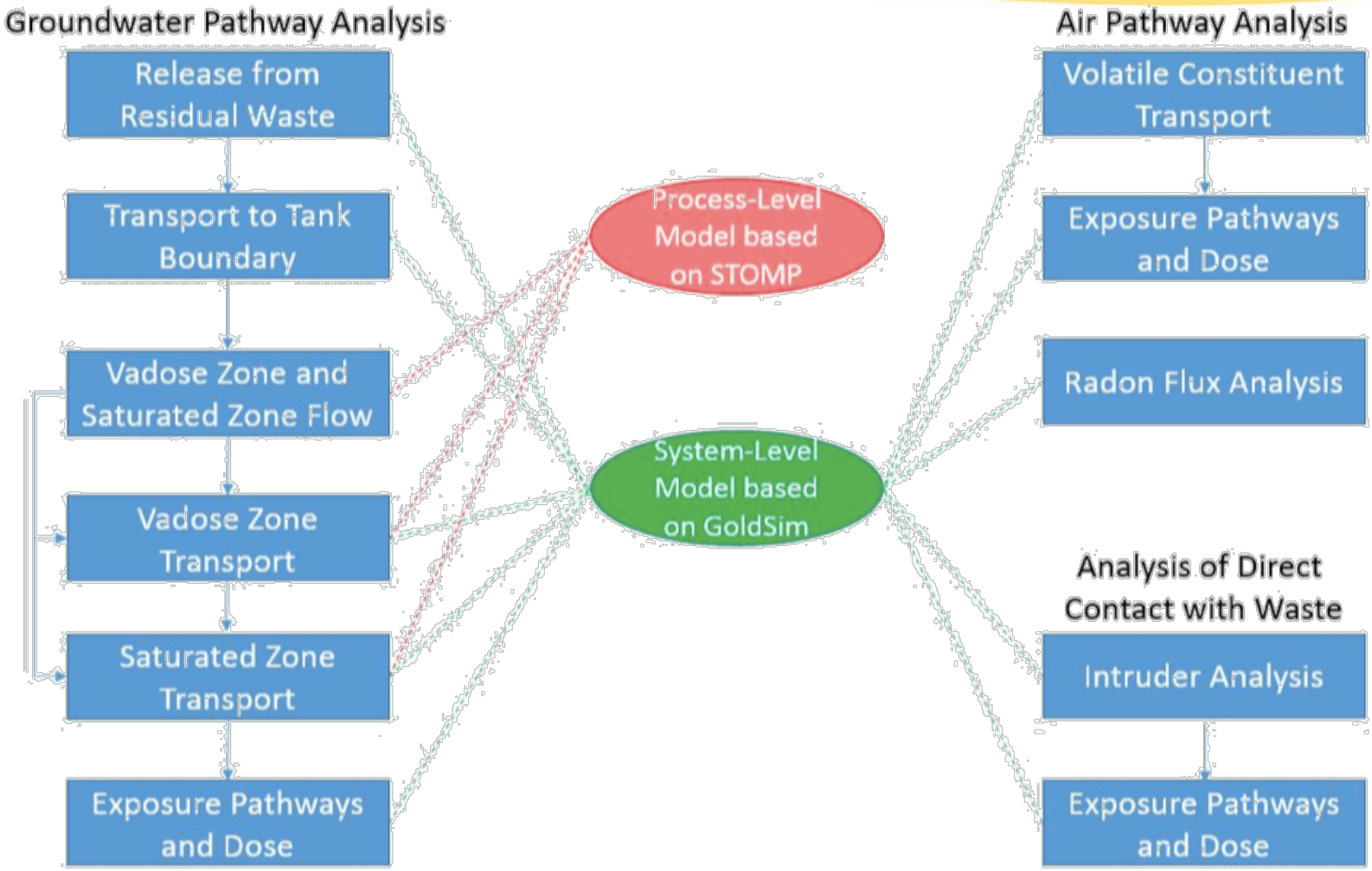


Screening → System-Level ← Process-Level

Combination of Modeling Approaches

- Probabilistic modeling using system-level models and deterministic modeling using more detailed models (multiple lines of reasoning)
- Use of multiple modeling approaches helps to improve understanding and provides additional checks and balance

Example of Model Usage



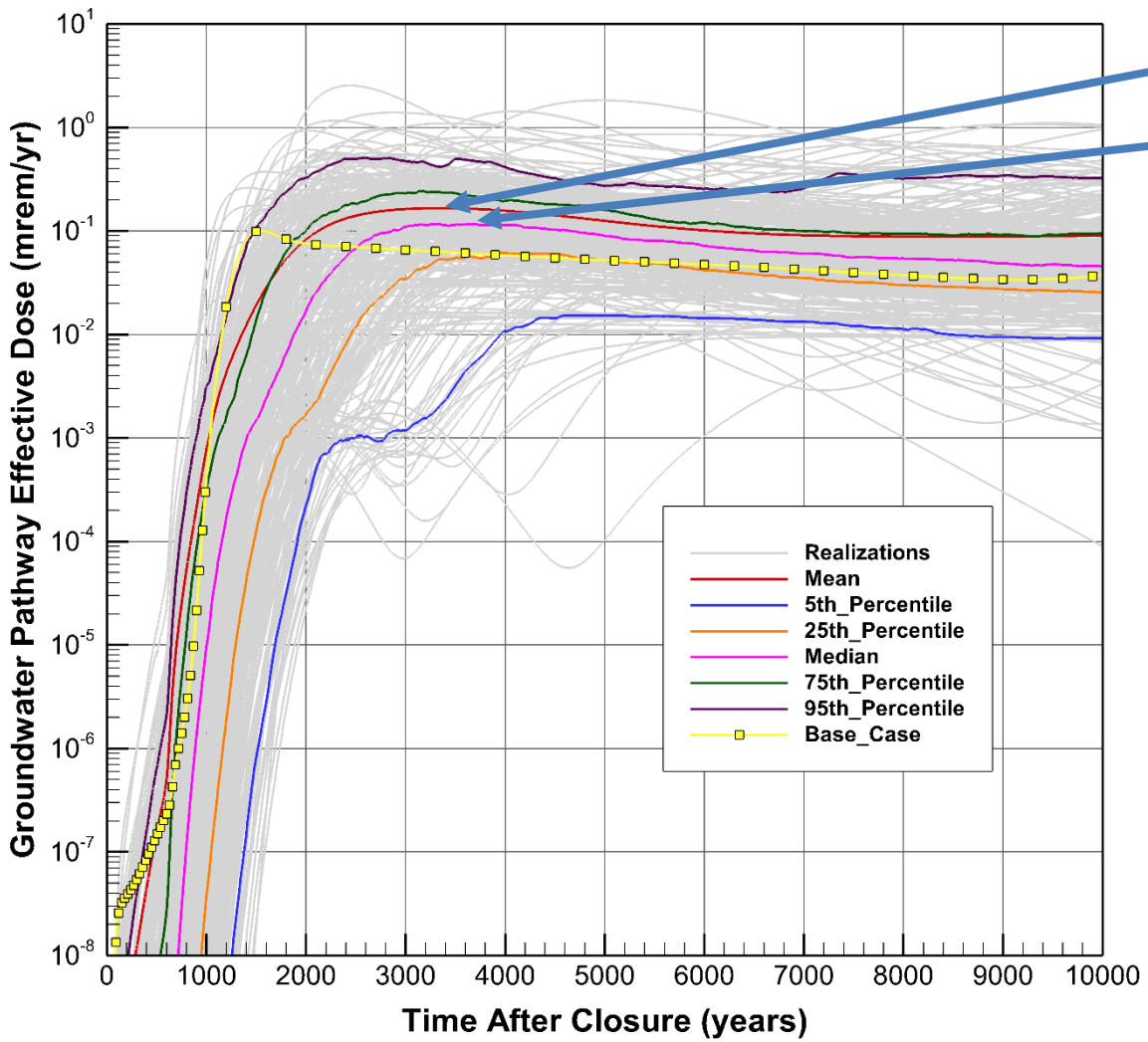
GoldSim© simulation software is copyrighted by GoldSim Technology Group LLC of Issaquah, Washington (see http://www.goldsim.com).
Subsurface Transport Over Multiple Phases (STOMP©) is copyrighted by Battelle Memorial Institute, 1996.

Sensitivity (Importance) Analysis

- Focus attention on parameters and assumptions of greatest interest for conclusions/decision
- NCRP Committee adopted the term "Importance Analysis" to reflect the application of sensitivity analysis to waste management/remediation decision making
- Individual "what-if" type cases can be run with detailed models (including barrier analyses)
- Probabilistic calculations can also be used to get statistical representations of importance
- Results guide refinements/data collection and also help guide reviewers to critical aspects

Uncertainty Analysis Results

25 mrem/yr performance objective

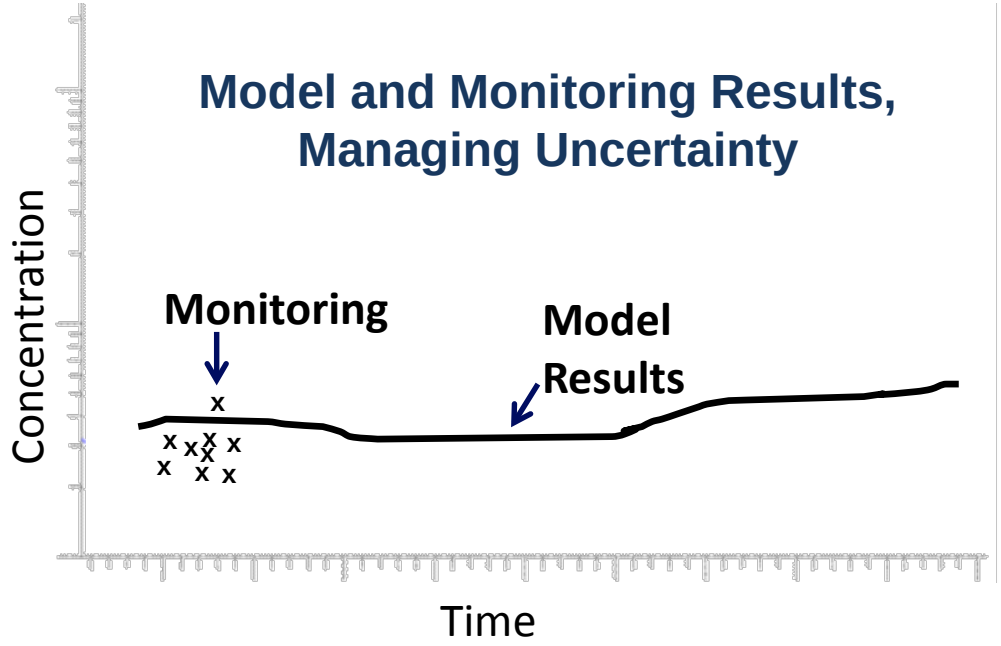


Peak of the Mean and Median less than 0.2 mrem/yr

PA Maintenance

Integrating Modeling, Monitoring and Model Support

- PA is a living document
- On-going monitoring and characterization work
- As new information is obtained, significance of any changes will be evaluated
- Special analyses can be conducted to address potentially significant changes



Key Points

- Decision to leave some residual waste in tanks needs to be carefully assessed and justified
- International and National recommendations and guidance form the basis for approaches being used for PAs
- PA is just one part of the “Safety Case” forming the body of evidence to support a decision
- Role of PA to demonstrate understanding rather than strictly calculating a number (What assumptions are important/not important? Which barriers are critical for performance? Interpreting “what-if” cases relative to compliance?)
- Managing uncertainty for key assumptions is an important focus of the PA process (safety factors, PA maintenance, graded approach)

WMA C Draft Waste Incidental to Reprocessing Evaluation

WMA C History and Waste Inventory

Jim Field

June 2018

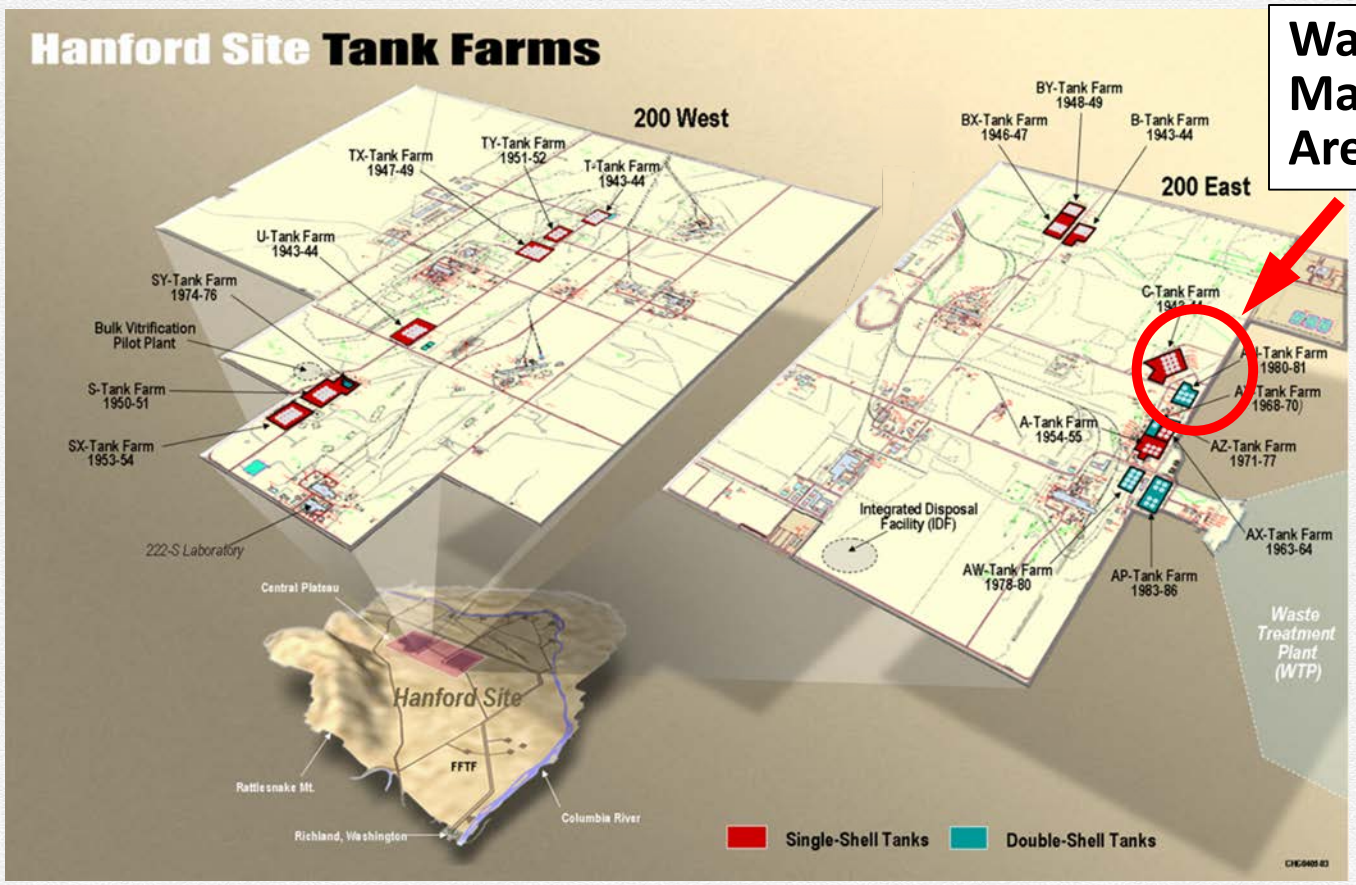
Overview

- Refer to Draft WIR Evaluation, Section 2.0
- General description of Hanford Site and WMA C
- History of WMA C tanks and ancillary structures
- Residual waste inventory in tanks
- Residual waste inventory in ancillary structures
- Inventory summary

Hanford Site

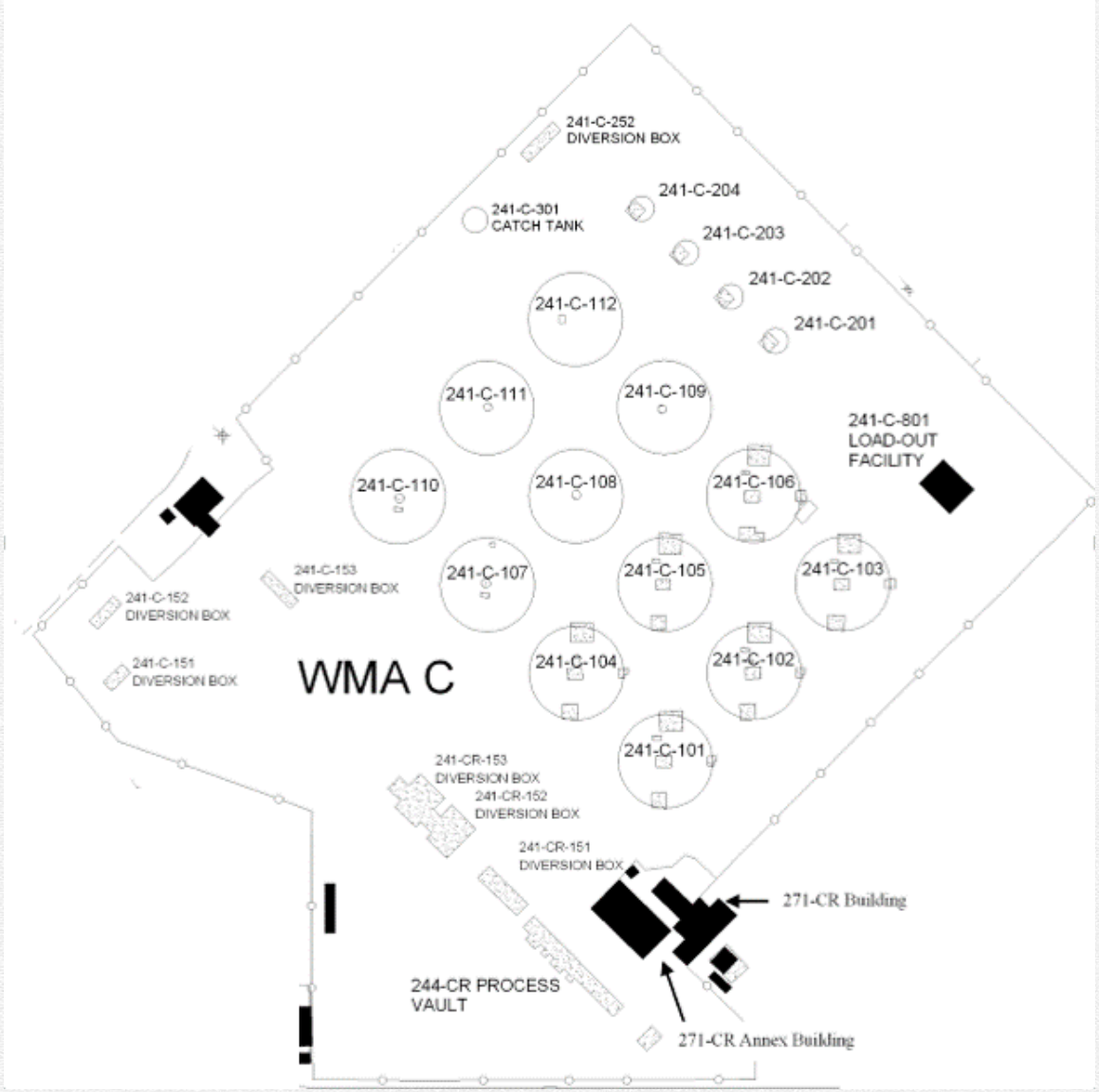
Source: Draft WIR Evaluation, Figure 2-1

200 East and West Area

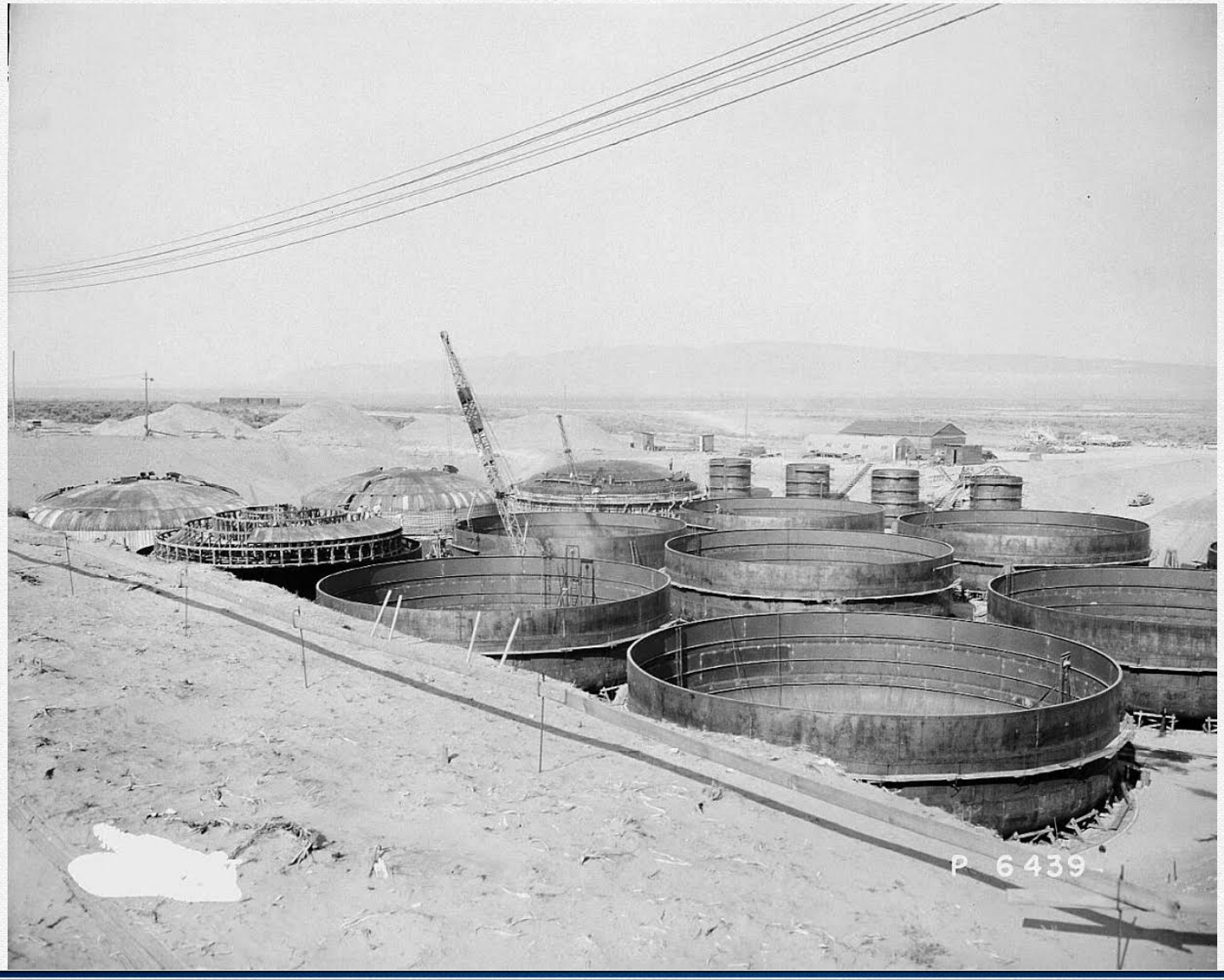


Waste Management Area C

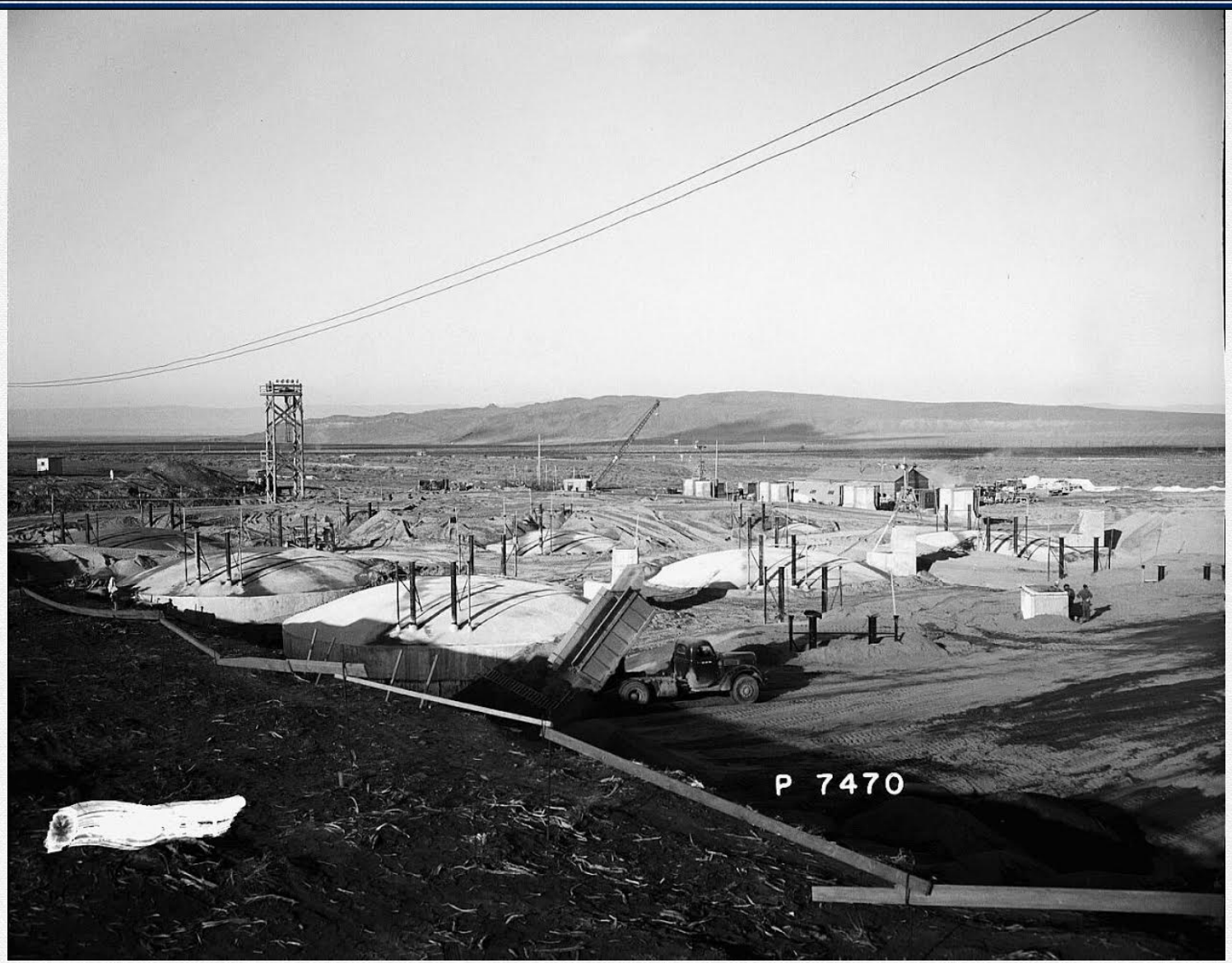
WMA C


241-C-252
DIVERSION BOX
241-C-204
241-C-301
CATCH TANK
241-C-203
241-C-202
241-C-112
241-C-201
241-C-111
241-C-109
241-C-801
LOAD-OUT
FACILITY
241-C-110
241-C-108
241-C-106
241-C-153
DIVERSION BOX
241-C-107
241-C-105
241-C-103
241-C-152
DIVERSION BOX
241-C-151
DIVERSION BOX
WMA C
241-C-104
241-C-102
241-C-101
241-CR-153
DIVERSION BOX
241-CR-152
DIVERSION BOX
241-CR-151
DIVERSION BOX
271-CR Building
244-CR PROCESS
VAULT
271-CR Annex Building

C-Farm Construction

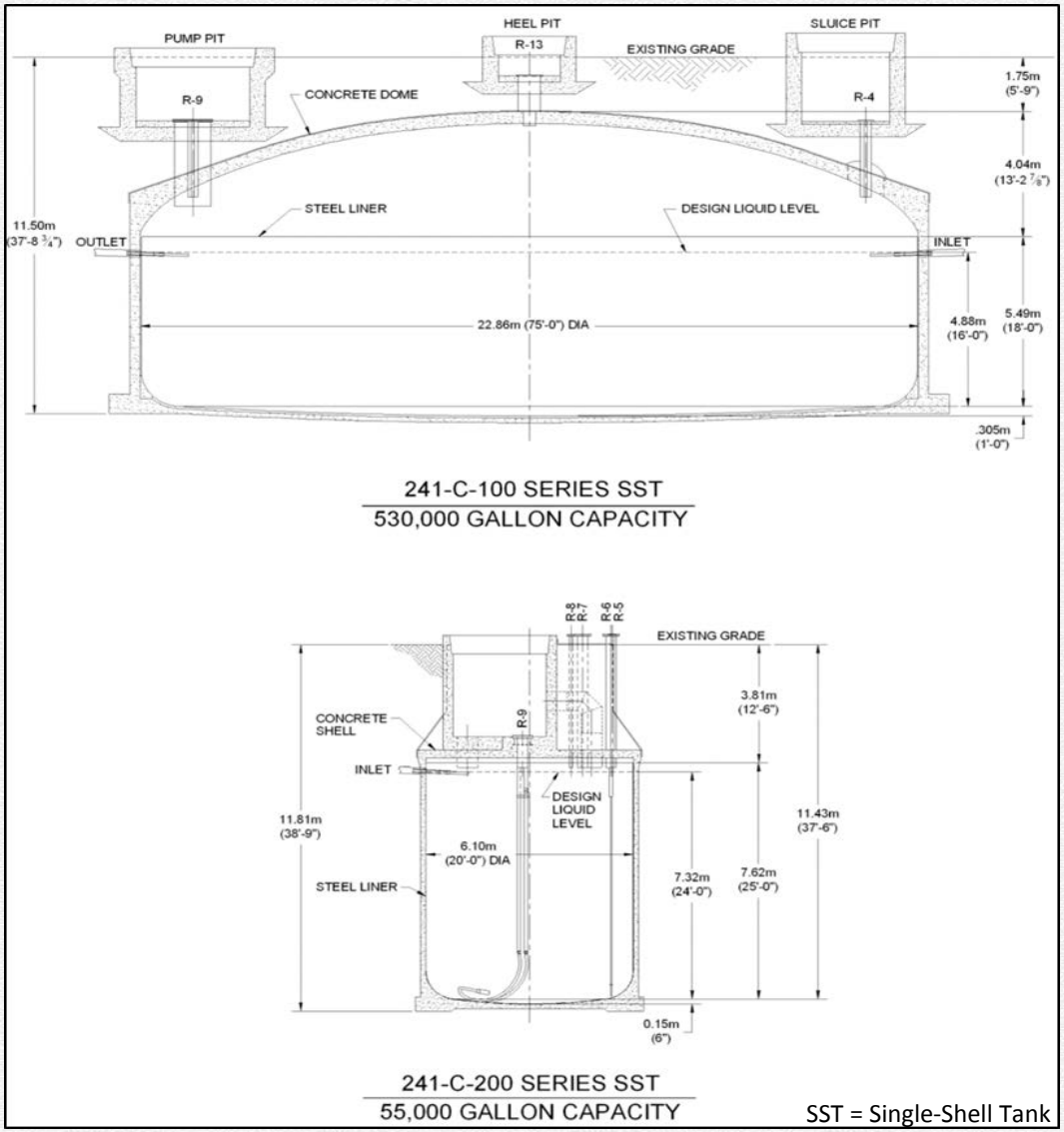


C-Farm Construction



Current C-Farm

C-Farm Tanks



SST = Single-Shell Tank

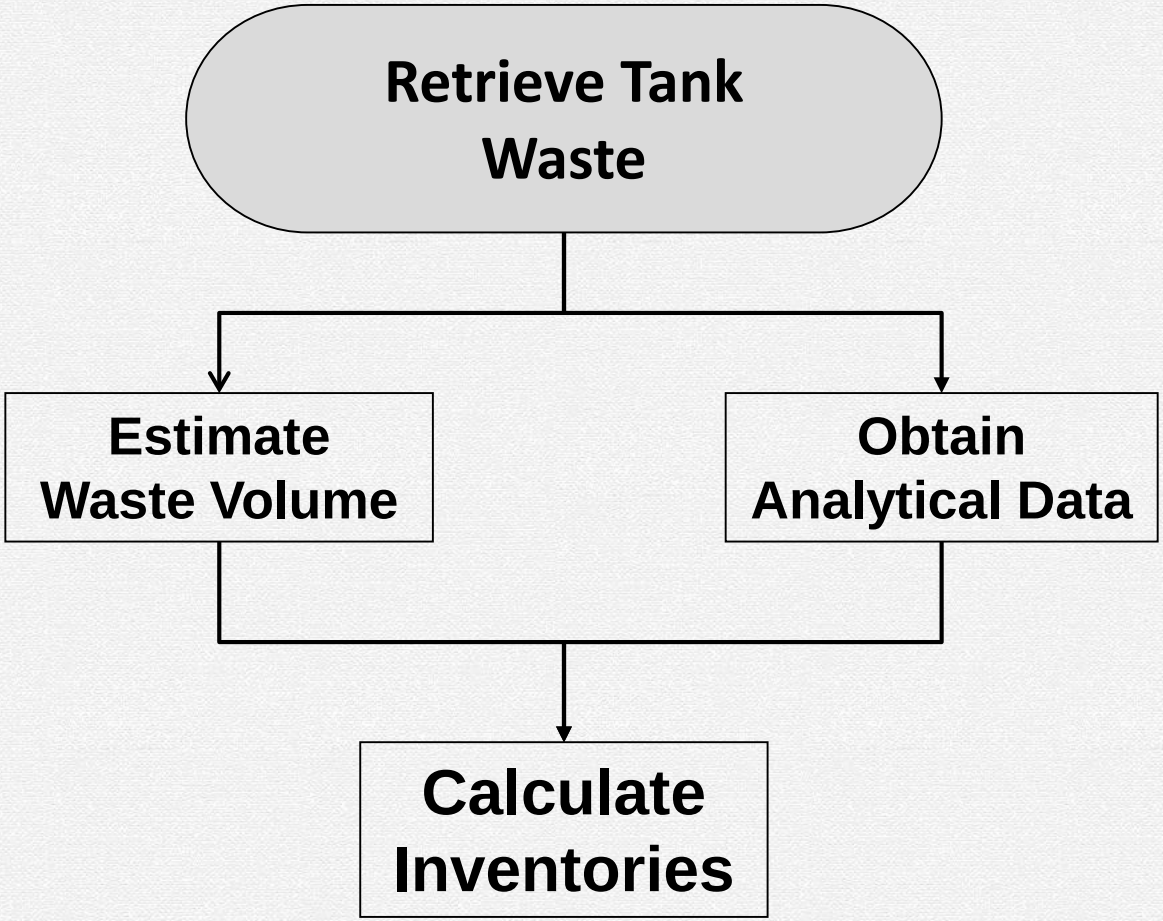
Source: Draft WIR Evaluation, Figure 2-16

WMA-C Residual Waste

Residual waste inventories were estimated for:

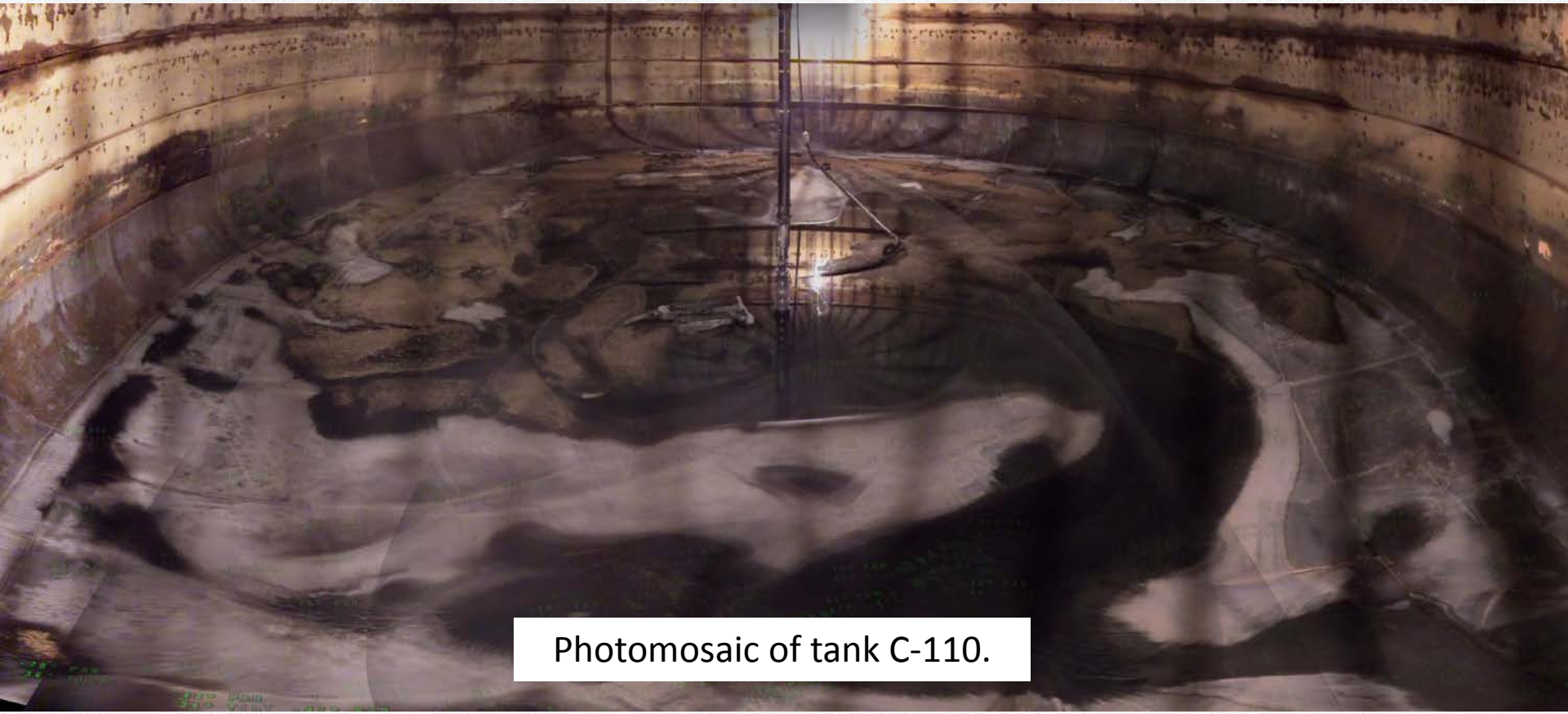
- C-Farm Tanks,
- Catch Tank and Vault,
- Pits and Diversion Boxes, and
- Pipelines.

Process to Estimate Residual Tank Waste Inventories



Estimate Waste Volume: Obtain Video

After retrieval is completed, video is obtained of the remaining residual waste in a tank.



Photomosaic of tank C-110.

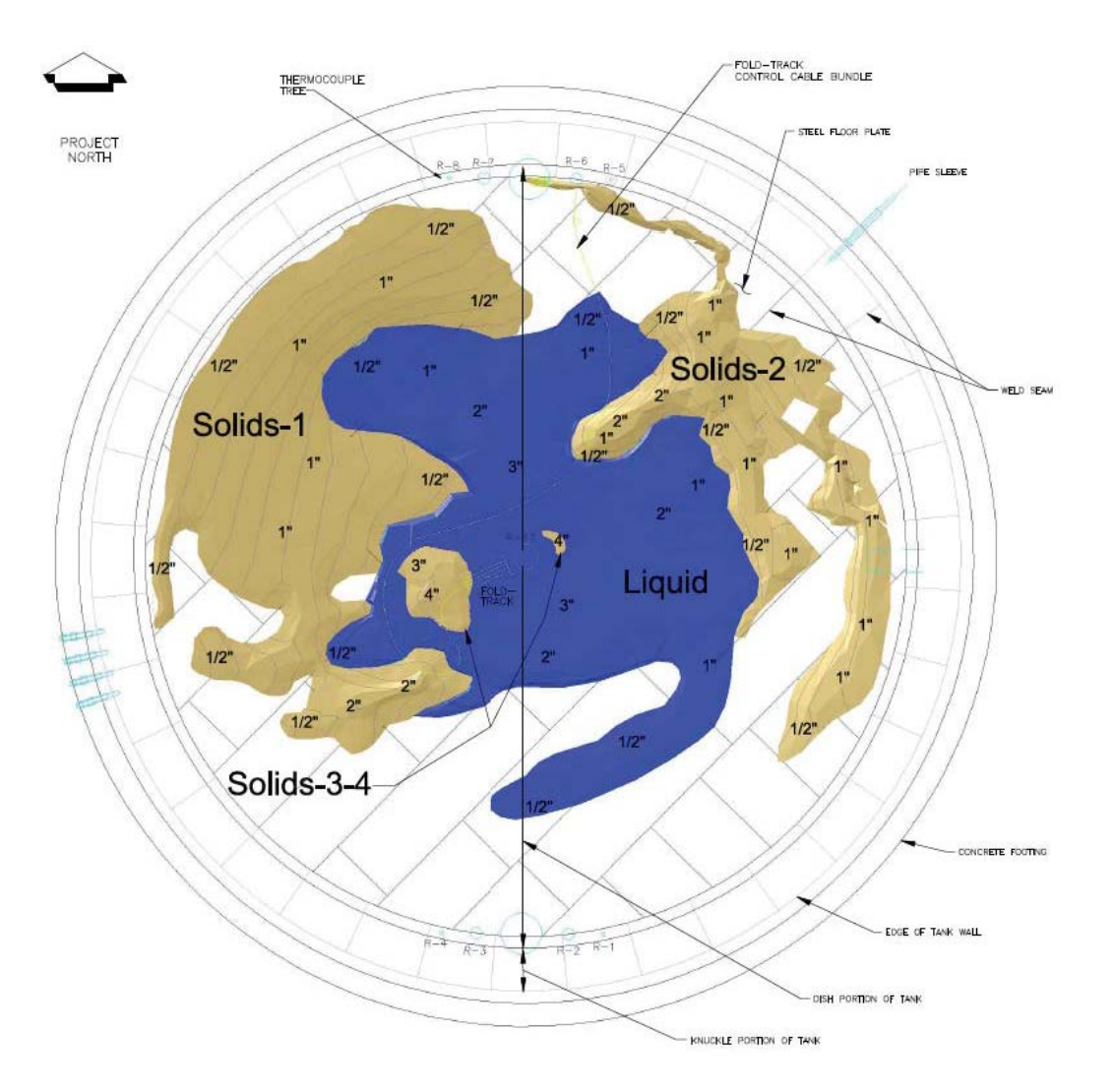
Source: Draft WIR Evaluation, Figure 4-25

Estimate Waste Volume: Review Video

Videos and video stills are reviewed to estimate location and height of waste.

Estimate Waste Volume: Create Drawing

A tank template and residual waste contour drawing is created in AutoCAD, and waste volume is calculated.



Obtain Analytical Data: Sample Tanks

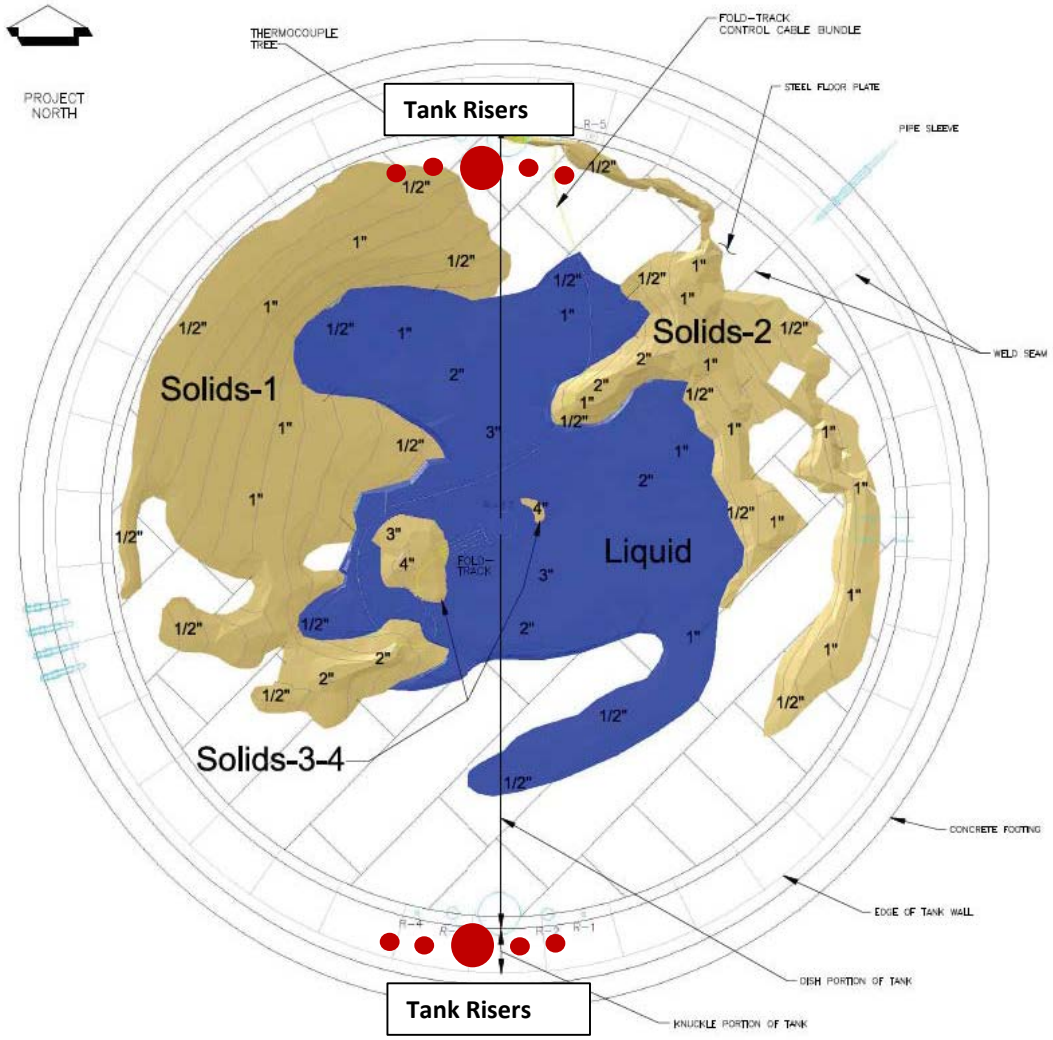
Tank residuals were sampled and analyzed in accordance with tank closure requirements determined by the Department of Energy and regulators.

Sampling Methods for Residual Waste:

- Clam Shell/ Finger Trap
- Off-Riser Sampler (ORSS)

Off-Riser Sampler

Obtain Analytical Data: Sample Access



Obtain Analytical Data: Sample Analyses

- Radionuclides
- Inorganics
- Organics
- pH
- Water Content
- Bulk Density

Primary Radionuclides		
^{137}Cs	^{99}Tc	^{238}Pu
^{60}Co	^{125}Sb	$^{239/240}Pu$
^{152}Eu	^{79}Se	^{241}Pu
^{154}Eu	^{126}Sn	^{241}Am
^{155}Eu	^{233}U	^{242}Cm
^{14}C	^{234}U	^{243}Cm
^{3}H	^{235}U	^{244}Cm
^{129}I	^{236}U	^{228}Th
^{63}Ni	^{238}U	^{230}Th
^{90}Sr	^{237}Np	^{232}Th

Ancillary Equipment Inventory Estimates

- Ancillary equipment in C-Farm:
  - One Catch Tank and One Vault
    - Measured waste volume
    - 90% retrieval assumed
  - Pits & Diversion Boxes
    - Flushed during operations
    - Small amount of waste adsorbed to surfaces.
  - Pipelines (~7 miles)
    - Most lines, 4.25 inch average diameter, assumed 5% full.
    - Cascade lines and plugged line, 3 inch diameter, assumed 100% full.
- Ancillary equipment waste concentrations are unknown.
- Assumed average composition of tank waste residual samples.

WMA-C Residual Inventories

Facility	2017 Volume (kL)	2017 Radionuclides (Ci)
C-101	20.7	2.19E+04
C-102	59	2.74E+03
C-103	9.6	1.47E+04
C-104	7.2	1.35E+04
C-105	115*	1.22E+06
C-106	10.5	1.00E+05
C-107	39	3.27E+04
C-108	12.9	2.52E+03
C-109	7.6	4.44E+03
C-110	8.0	4.90E+03
C-111	18.5	8.06E+04
C-112	37.5	1.28E+05
C-200s	2.2	1.72E+03
C-301/CR-Vault	8.1	1.37E+04
Pits/Diversion Boxes	0.4	6.00E+02
Pipelines	6.1	1.02E+04
SUM	365	1.64E+06

* In-process volume in 2017. Final volume was 5.5 kL.

Residual sample analysis is in process.

Summary

- 16 SSTs in WMA C, plus ancillary structures
- Long operational history – every tank is unique
- Tank waste retrieval is complete (next presentation)
- Residual waste inventory based on post-retrieval sampling and best available information

Questions?

The Hanford Reach
White Bluffs Overlooking the Columbia River

WMA C Draft Waste Incidental to Reprocessing Evaluation

Waste Retrieval in WMA C

Paul Rutland

June 2018

Overview

- Refer to Draft WIR Evaluation, Section 4.0
- WIR Criteria #1
- Discussion of key terms:
  - Technically Practical
  - Economically Practical
- Review of retrieval campaign in WMA C tanks

Criteria #1

DOE M 435.1-1 Chapter II, section B(2)(a) provides in pertinent part that wastes determined to be incidental to reprocessing:

(1) "Have been processed, or will be processed, to remove key radionuclides to the maximum extent that is technically and economically practical;"

Key Terminology

- Retrieval technologies are intended to remove the waste, including key radionuclides, to the extent practical.
- Waste retrieval is the only practical process to remove key radionuclides as called for in Criteria #1.
- This follows the precedent set at DOE's Idaho and Savannah River sites.

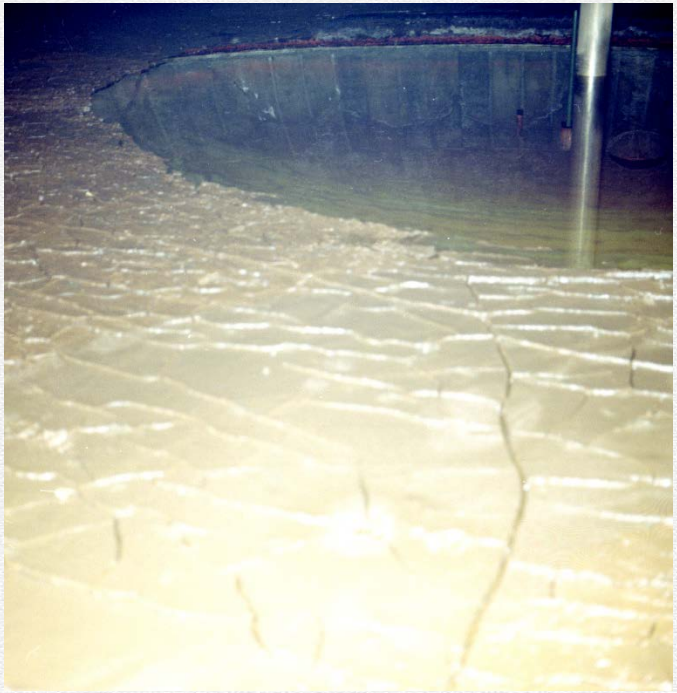
Key Terminology

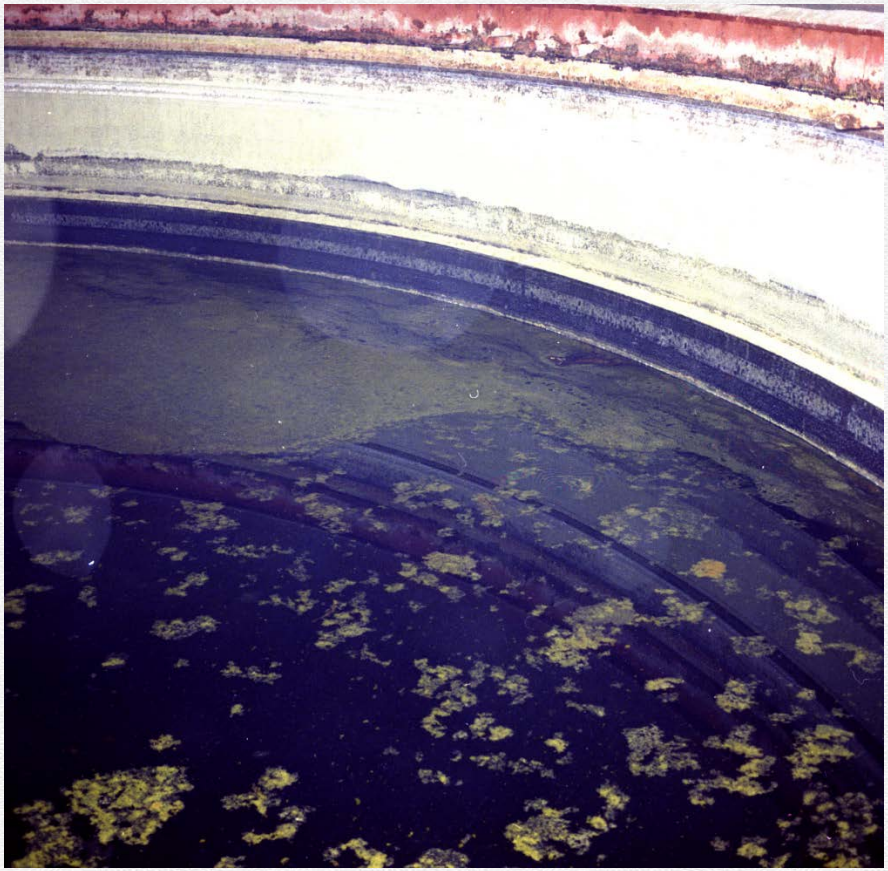
- Maximum extent that is technically practical is shown by reaching the reasonable limits of each deployed retrieval technology, on a case-by-case basis.

- Maximum extent that is economically practical considers cost/benefit analysis in determining the end point of a deployed technology, and in the decision whether to deploy or forego additional technologies.

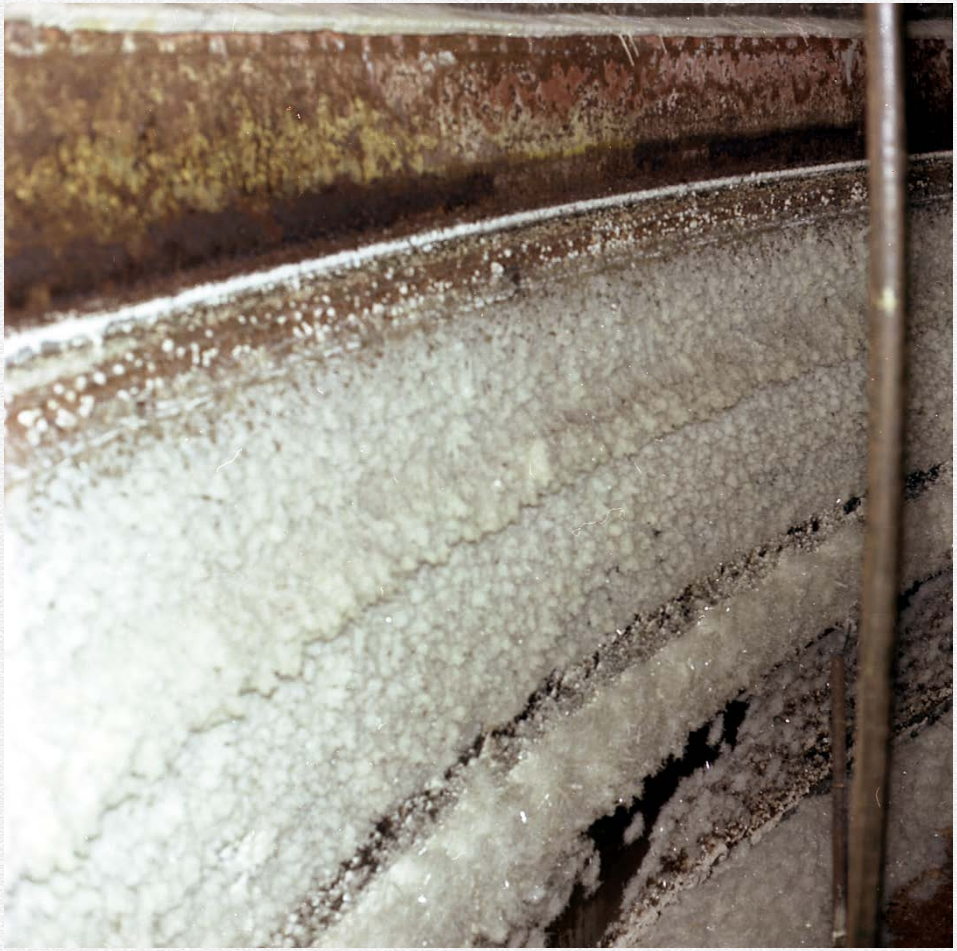
Waste Types

- Supernate

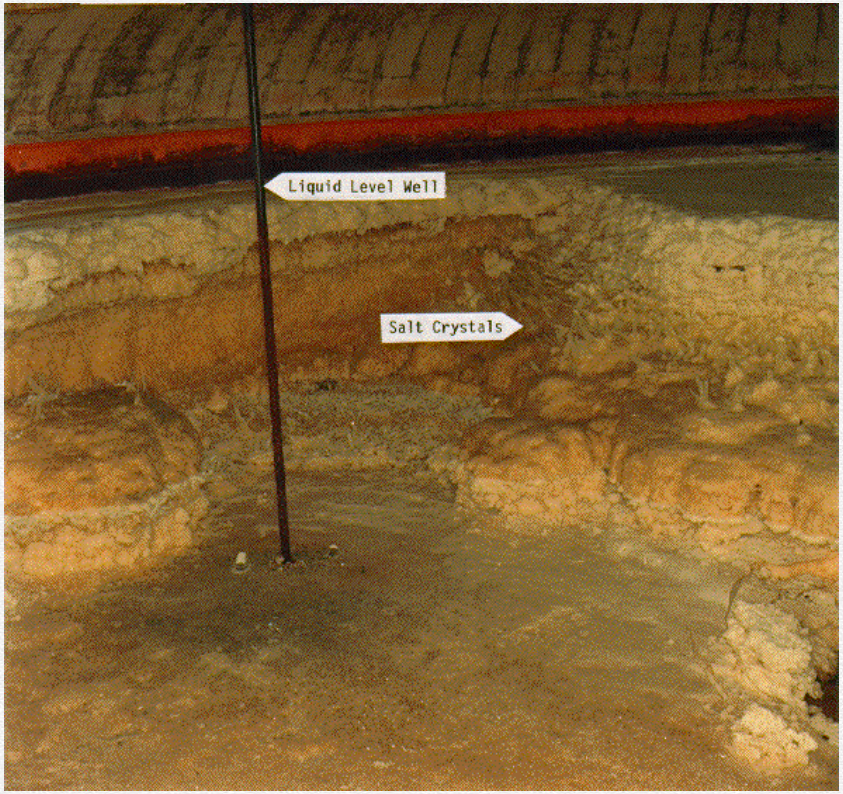




Waste Types

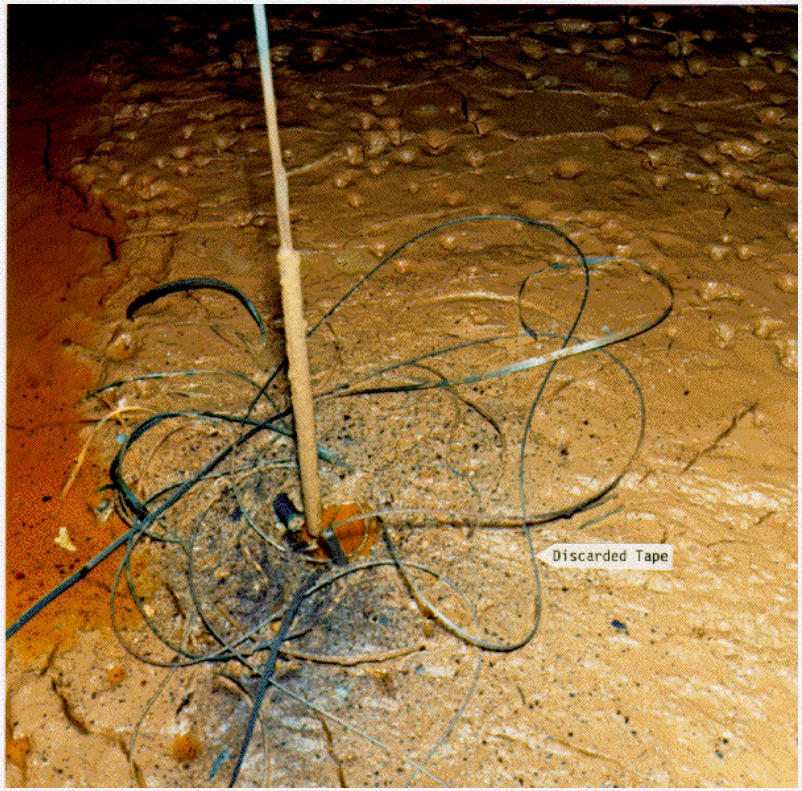


- Salt Waste



Waste Types

- Sludge



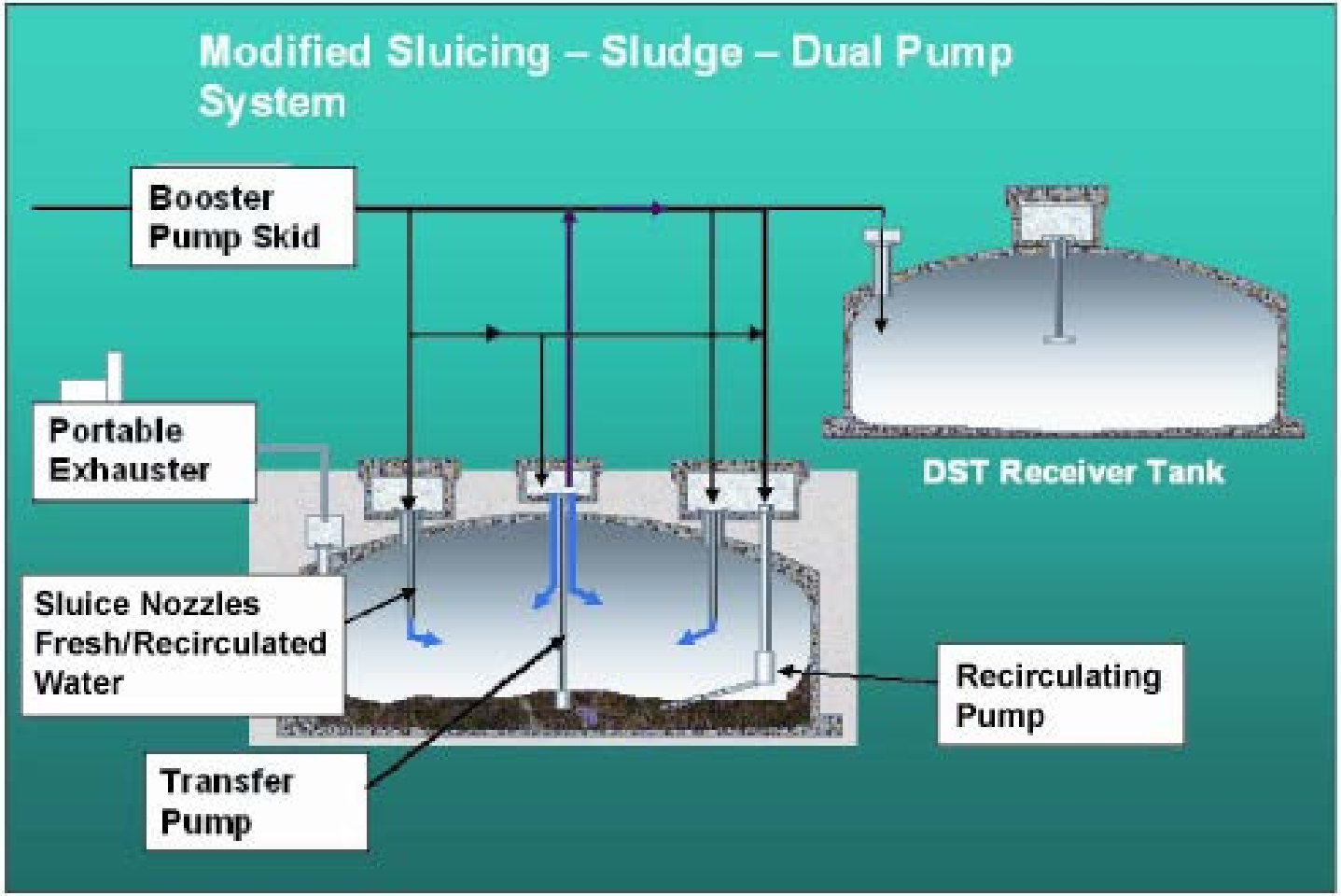
Retrieval Technologies

- Retrieval technologies selected according to individual tank chemistry and conditions:
  - Predominant Waste Type
  - Assumed Leaker vs. Sound Tank
  - Available Access to Risers
- Available Technologies – some were developed and demonstrated for the first time in WMA C

Retrieval Technologies

- Various sluicing configurations
  - Water jet vs. recirculated supernate
  - In-tank recirculation pumps
  - FoldTrack mobile retrieval tool
  - Extended Reach Sluicer System
- Mobile Arm Retrieval System
  - Sluice-mode vs. Vacuum-mode
- Chemical Heel Retrieval
  - Acid or Caustic Dissolution
- Vacuum Retrieval (200 series tanks)

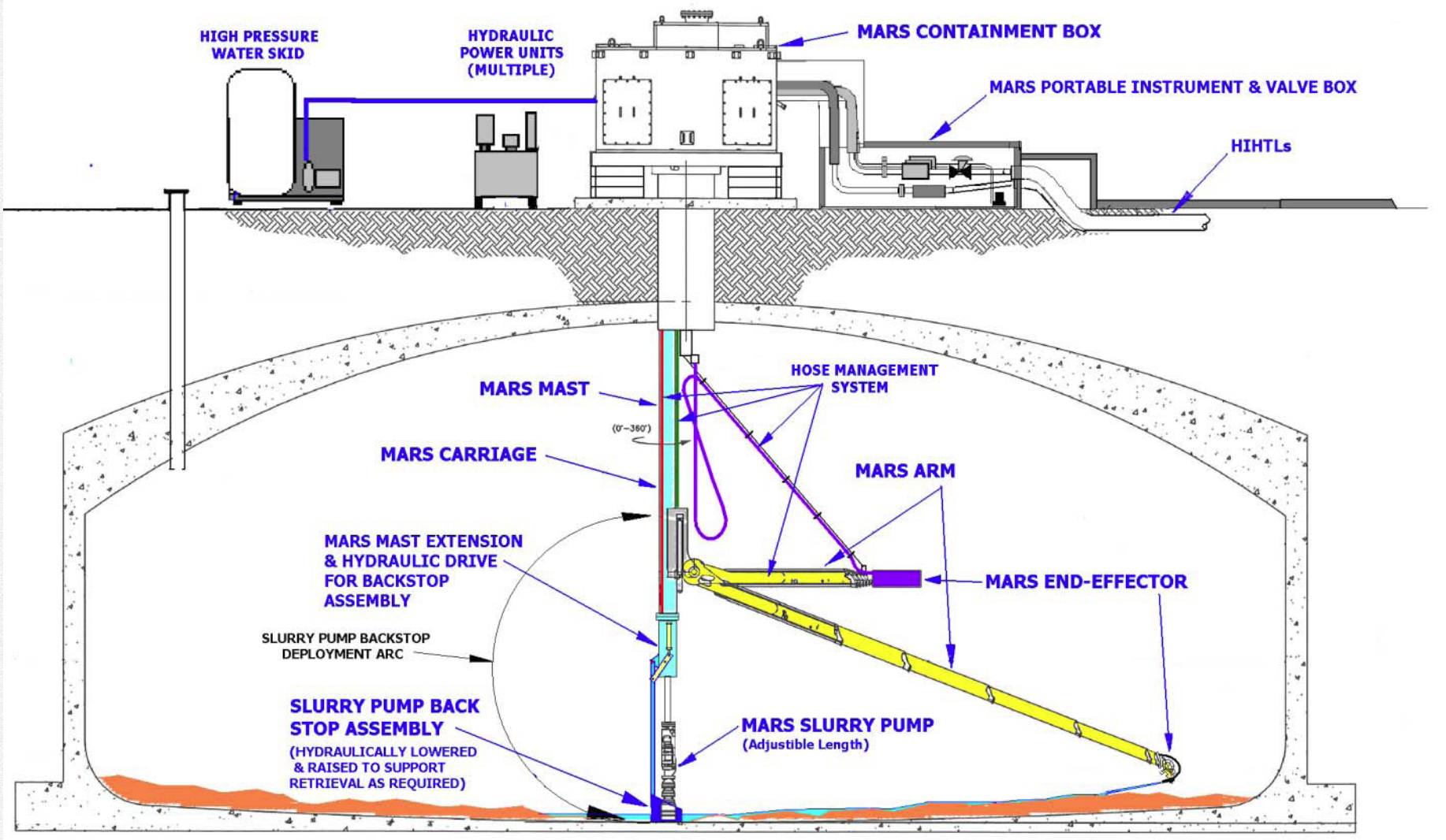
Sluicing Technologies



Sluicing Technologies

Mobile Technologies

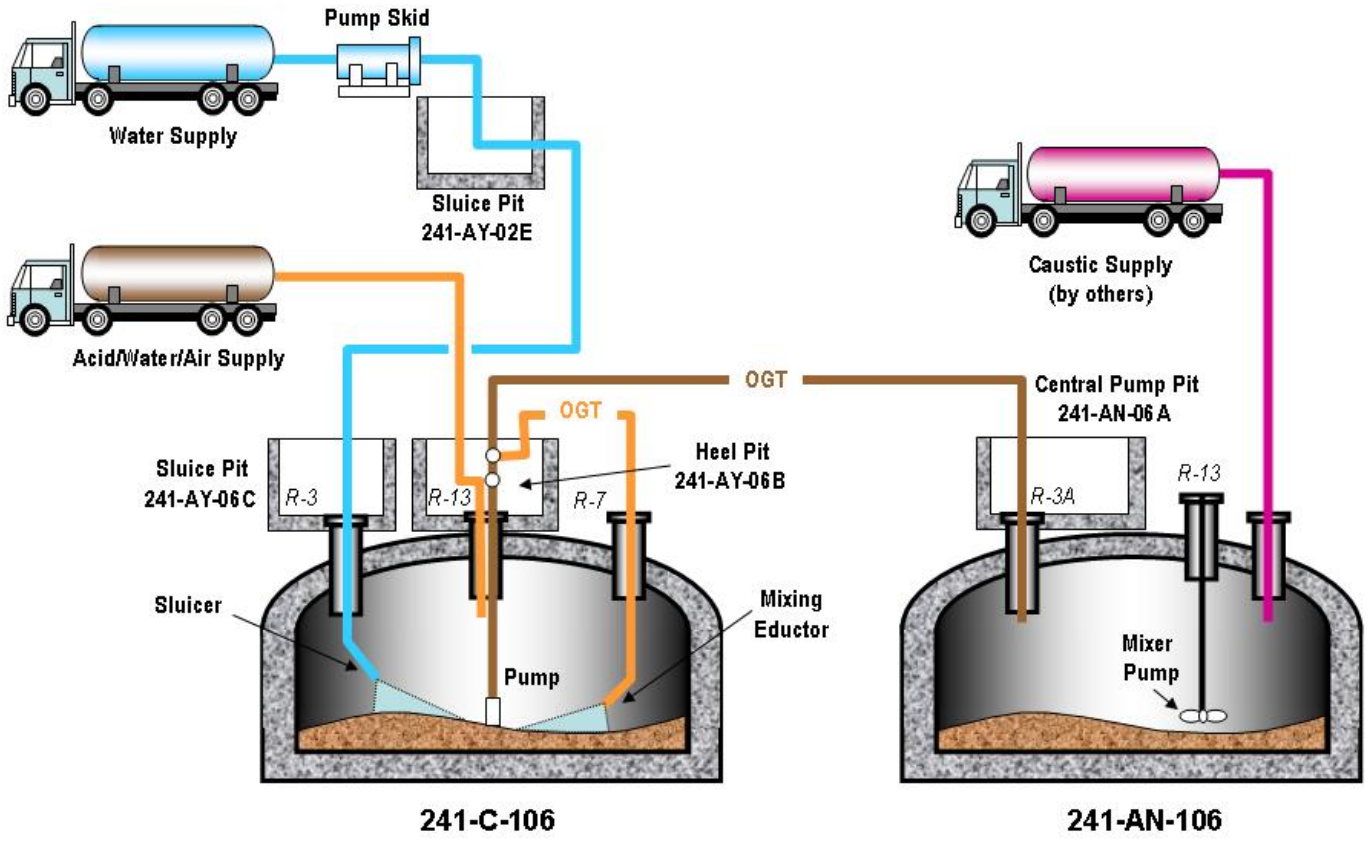
MARS Technologies



MARS Technologies

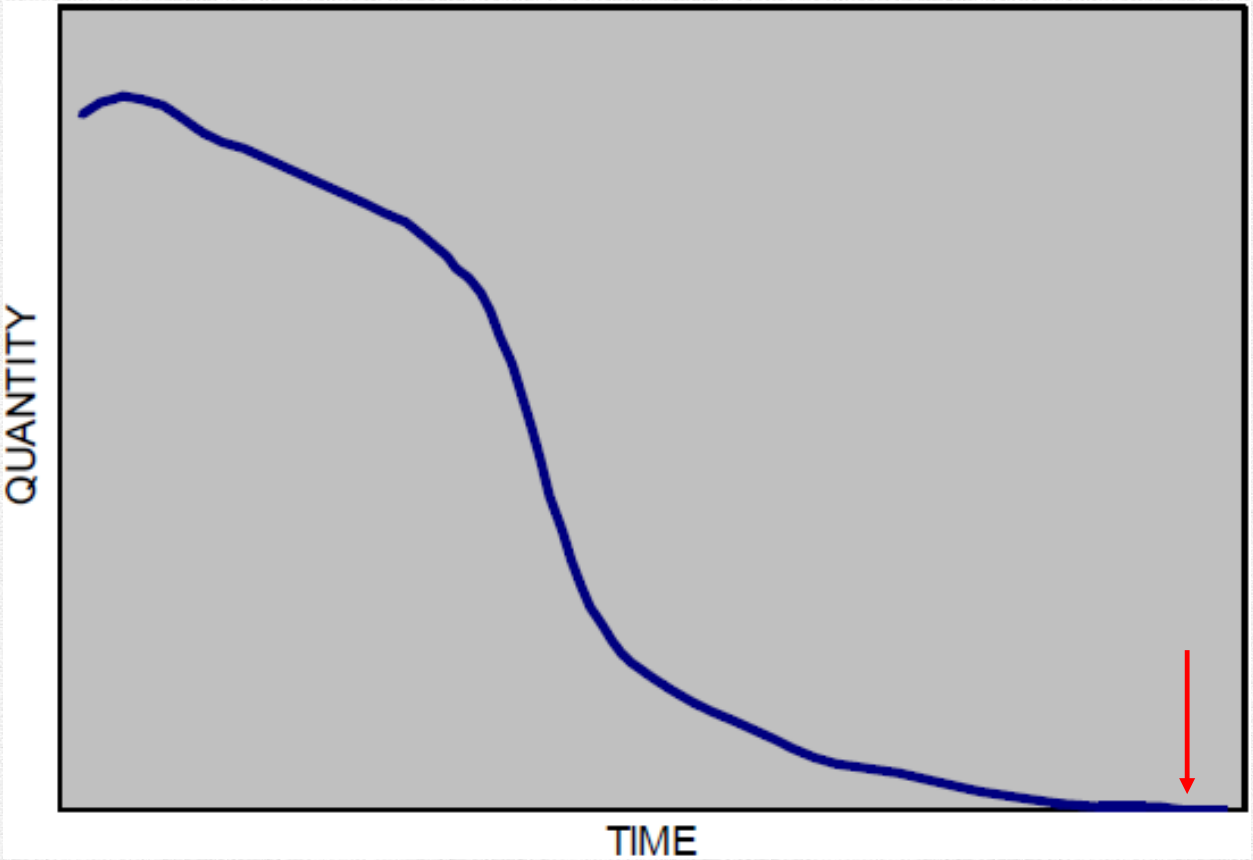
MARS testing at Columbia Energy and Environmental Services demonstration facility

Chemical Technologies



Limits of Technology

- For each retrieval technology deployed, a point of diminishing returns is reached where the amount of waste being retrieved is negligible, and increasing cost, risk, and schedule impacts make further operations impractical.



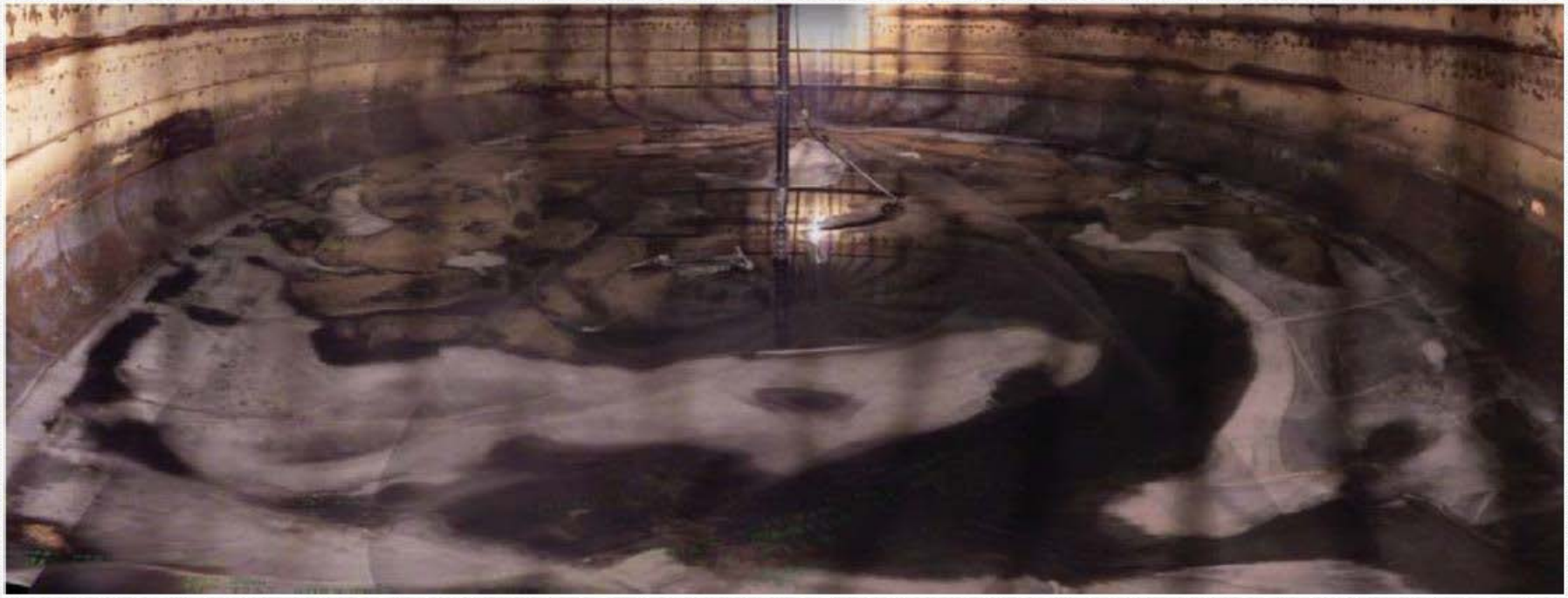
Source: Draft WIR Evaluation, Figure 4-5

Economic Practicality

- Depends on a cost / benefit analysis:
  - Considers monetary costs, schedule delays, worker dose and other hazards, and system impacts.
  - Considers such benefits as reduction in future public/intruder dose, reduced cost in other areas, and environmental impacts.
- Draft WIR Evaluation, Section 4.4 demonstrates that in reaching the limits of technical practicality, DOE has gone well beyond the limits of economic practicality.

Results of Retrieval

- Post-Retrieval Photomosaic of Tank C-110



Source: Draft WIR Evaluation, Figure 4-25

Current Tank Status

- Approximately 96% of the waste, and 96% of the key radionuclides, have been removed from the tanks in WMA C

Tank	Waste Volume Pre-Retrieval gal (ft^3)	Waste Volume Retrieved gal (ft^3)	Residual Waste Remaining gal (ft^3)
C-101	77,500 (10,360)	72,505 (9,693)	4,995 (667)
C-102	316,000 (42,200)	295,500 (39,500)	20,500 (2,700)
C-103	77,800 (10,400)	75,269 (10,062)	2,531 (338)
C-104	259,000 (34,600)	257,400 (34,380)	1,600 (220)
C-105	132,000 (17,646)	~117,000 (15,640) *	~4800 (650) *
C-106	230,000 (30,746)	227,230 (30,376)	2,770 (370)
C-107	247,000 (33,000)	236,600(31,610)	10,400 (1,390)
C-108	66,000 (8,823)	63,030 (8,426)	2,970 (397)
C-109	63,400 (8,480)	61,680 (8,250)	1,720 (230)
C-110	178,000 (23,800)	176,227 (23,563)	1,773 (237)
C-111	34,900 (4,670)	30,010 (4,016)	4,890 (654)
C-112	104,000 (13,900)	93,900 (12,552)	10,100 (1,348)
C-201	860 (115)	717 (95.8)	144 (19.2)
C-202	1,400 (187)	1,253 (167)	147 (19.7)
C-203	2,640 (353)	2,501 (334)	138 (18.5)
C-204	1,489 (199)	1,346 (180)	137 (18.3)

* Updated final estimate for C-105 is ~1,500 gallons remaining

Source: Draft WIR Evaluation, Tables 4-7 and 4-8

Summary

- WIR Criteria #1 has been met by waste retrieval to the maximum extent technically and economically practical
- “Technically Practical” was reached for each tank and deployed technology
- “Economically Practical” is determined by cost/benefit analysis – see Section 4.4 of Draft WIR Evaluation
- Results – 96% of all waste – including key radionuclides – have been removed

Questions?

The Hanford Reach
White Bluffs Overlooking the Columbia River

WMA C Draft Waste Incidental to Reprocessing Evaluation

Disposal Safety Requirements

Marcel Bergeron

June 2018

Presentation Overview

- Refer to Draft WIR Evaluation, Section 5.0
- WIR Criteria #2
- Demonstration of compliance with WIR Criteria #2
  - All-pathways dose results from WMA C PA
  - Intruder dose results from WMA C PA
  - Radiological safety during operations
  - Long-term site stability

WIR Criteria #2

DOE M 435.1-1 Chapter II, section B(2)(a) provides in pertinent part that wastes determined to be incidental to reprocessing:

(2) Will be managed to meet safety requirements comparable to the performance objectives set out in 10 CFR Part 61, Subpart C, Performance Objectives;

10 CFR 61, Subpart C

10 CFR 61.40 — General requirement.

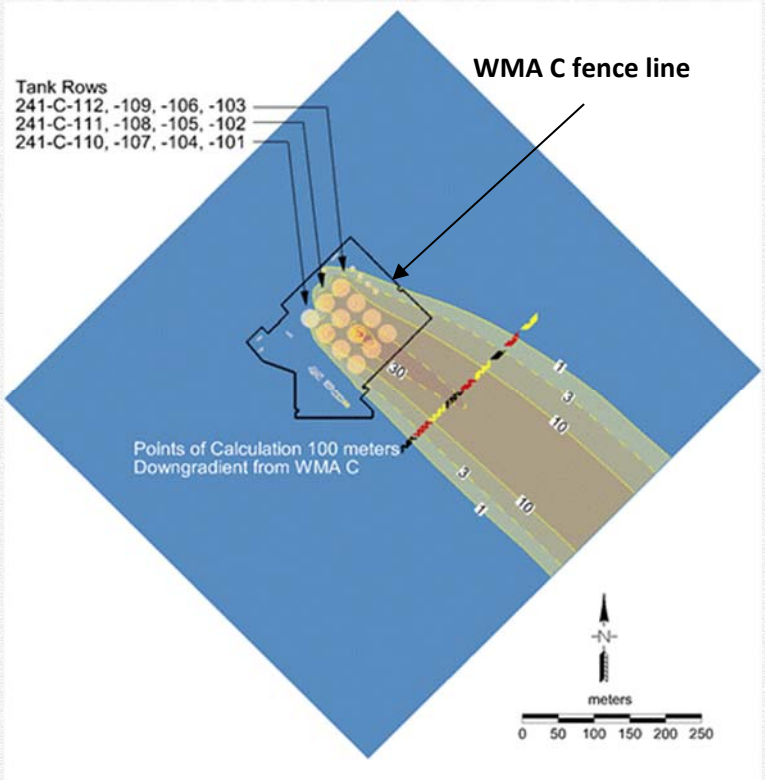
Land disposal facilities must be sited, designed, operated, closed, and controlled after closure so that reasonable assurance exists that exposures to humans are within the limits established in the performance objectives in §§61.41 through 61.44.

Performance Assessment (PA)

- The WMA C PA provides the technical basis and results demonstrating that the performance objectives/measures will be met for:
  - Potential radiological doses to a hypothetical member of the public (10 CFR 61.41)
  - Potential radiological doses to a hypothetical inadvertent intruder (10 CFR 61.42)

Performance Assessment (PA)

- WMA C BOUNDARY:
  - WMA C boundary is a line of demarcation enclosing the WMA C waste tanks currently defined by the WMA fence line.
- ALL PATHWAYS DOSE EVALUATION:
  - Hypothetical future member of the public assumed to be exposed to air and groundwater pathway concentrations
  - Calculated at ~100 meters downgradient from the WMA C boundary
- INADVERTENT INTRUDER DOSE EVALUATION:
  - Hypothetical inadvertent intruder assumed to drill a well right on top of tank farm facilities
  - Doses are from exposure to drill cuttings for a variety of acute and chronic exposure scenarios



Source: WMA C PA, Figure 7-24

Performance Assessment (PA)

- Institutional Control Period:
  - For purposes of analysis, PA assumes an Institutional Control Period is limited to first 100 years following final closure activities.
- Compliance Period:
  - Comparison of PA results with performance objectives/measures are performed during a Compliance Period which is the first 1,000 years following final closure activities.

Performance Assessment (PA)

- Post-Compliance Period:
  - WMA C PA also evaluated periods beyond 1,000 years to assess when peaks might occur.
- Uncertainty and Sensitivity Analyses:
  - WMA C PA also evaluates ranges of safety function failures, model parameters and modeling assumptions to further inform closure decisions.

All-Pathways Dose Evaluation Requirements

10 CFR 61.41 — Protection of general population from releases of radioactivity.

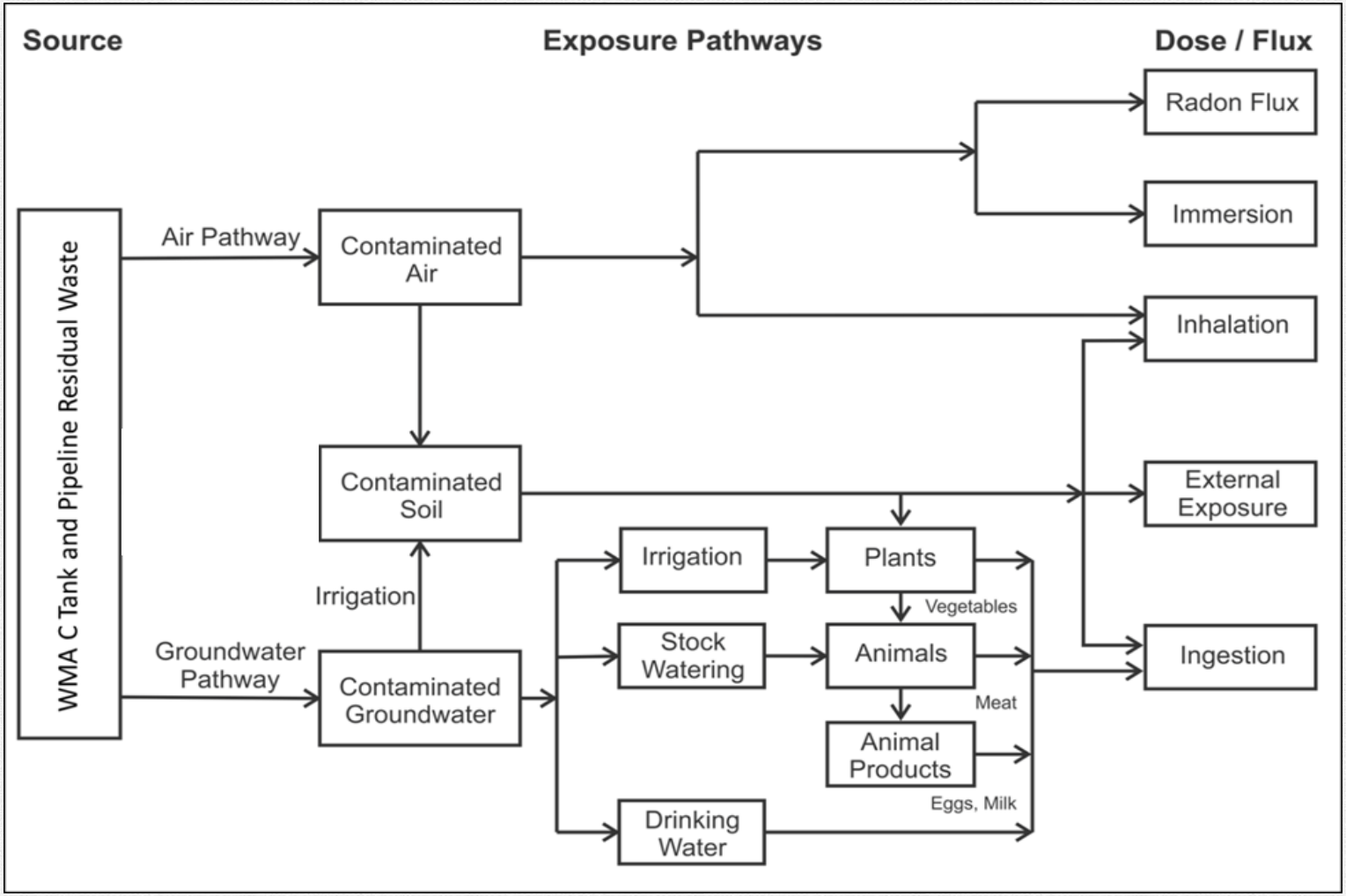
- *Concentrations of radioactive material which may be released to the general environment in ground water, surface water, air, soil, plants, or animals must not result in an annual dose exceeding an equivalent of 25 millirems to the whole body, 75 millirems to the thyroid, and 25 millirems to any other organ of any member of the public. Reasonable effort should be made to maintain releases of radioactivity in effluents to the general environment as low as is reasonably achievable (ALARA).*

A comparison of NRC and DOE performance objectives for LLW Disposal is provided in the Draft WIR Evaluation, Appendix B

All-Pathways Scenario

- In the Draft WIR Evaluation, peak all-pathways dose is used to demonstrate compliance with 10 CFR 61.41 performance objective
  - All-Pathways Dose – 25 mrem/yr
- Projected dose is determined utilizing the DOE Manual 435.1-1 Performance Assessment process

Exposure Pathways Associated with All Pathways Dose Evaluation



Source: Draft WIR Evaluation, Figure 5-1

All-Pathways Dose Results

Exposure Scenarios (Performance Objectives)	Compliance Period (<1,000 yrs)		Post-Compliance Period (> 1,000 yrs)	
	Peak Dose (mrem/yr)	Time of Peak (years after closure)	Peak Dose (mrem/yr)	Time of Peak (years after closure)
Air Pathway (10 mrem/yr)	0.004	10	0.00002	1,000
GW Pathway (4 mrem/yr)	0.0004	1000	~0.3	~15,000
All Pathways (25 mrem/yr)	0.004	10	~0.3	~15,000

Source: Data summarized from WMA C PA

Inadvertent Intruder Dose Evaluation Requirements

10 CFR 61.42 — Protection of individuals from inadvertent intrusion.

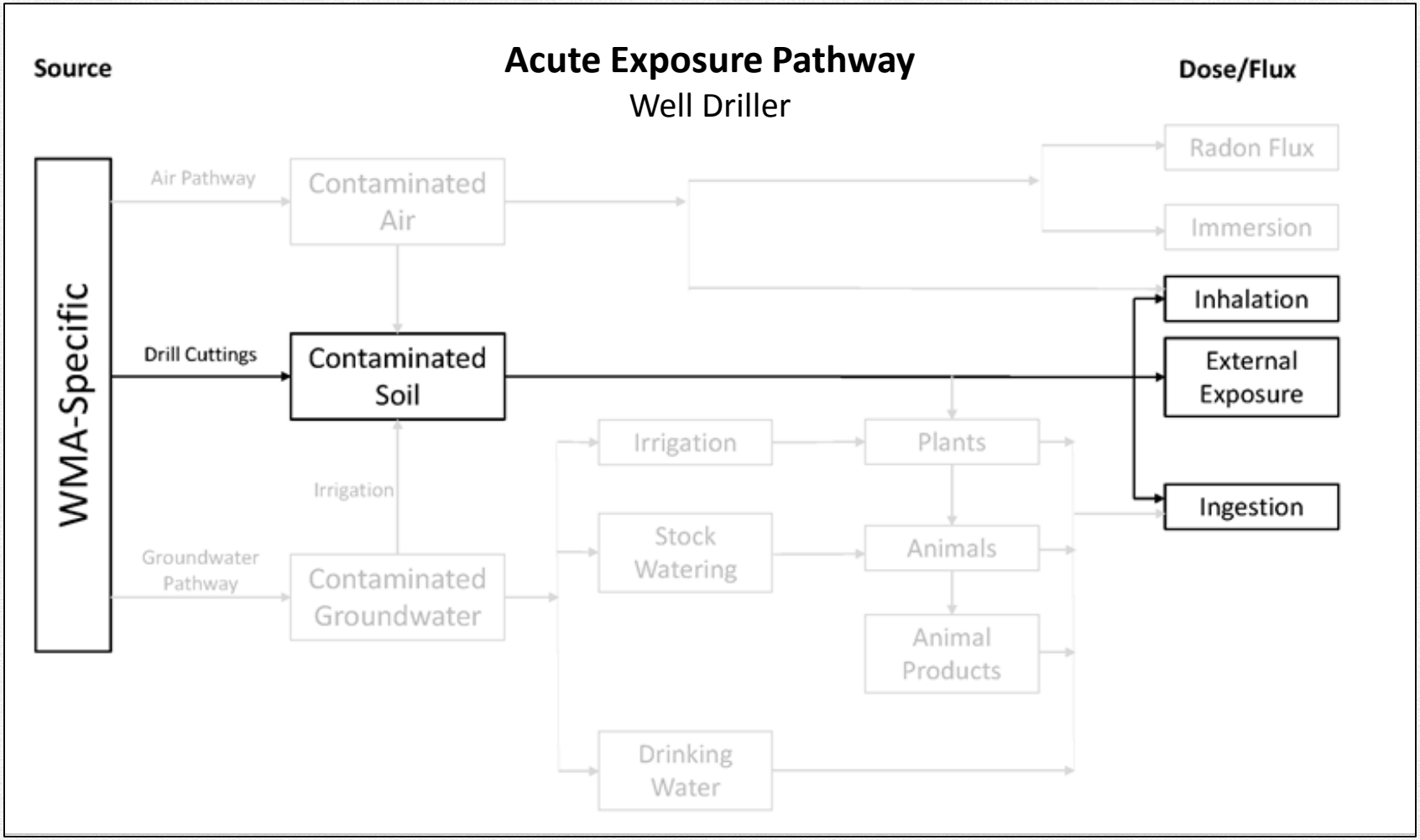
- *Design, operation, and closure of the land disposal facility must ensure protection of any individual inadvertently intruding into the disposal site and occupying the site or contacting the waste at any time after active institutional controls over the disposal site are removed.*

A comparison of NRC and DOE performance measures for LLW Disposal is provided in the Draft WIR Evaluation, Appendix B

Inadvertent Intruder Scenario

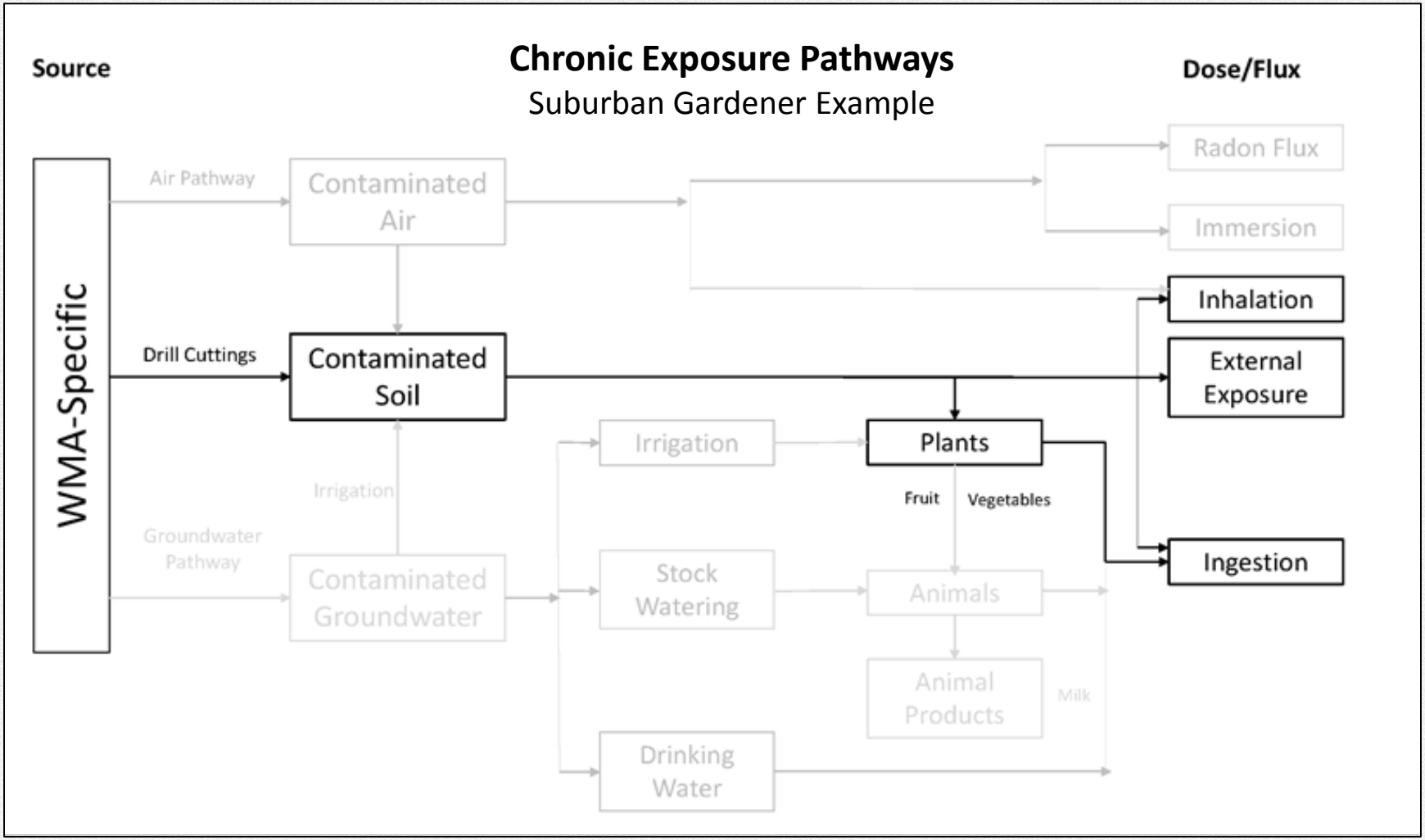
- In the Draft WIR Evaluation, peak acute and chronic inadvertent intruder doses are used to demonstrate compliance with NRC and DOE performance measures
  - Acute Exposure Intruder Dose – 500 mrem
  - Chronic Exposure Intruder Dose – 500 mrem/yr (NRC), 100 mrem/yr (DOE)
- Projected dose is determined utilizing the DOE Manual 435.1-1 Performance Assessment process
- Bounding cases involve drilling into waste transfer pipeline:
  - Acute exposure to drill cuttings with a well driller scenario
  - Chronic exposure to drill cuttings with a rural pasture scenario

Exposure Pathways Associated with Acute Inadvertent Intruder



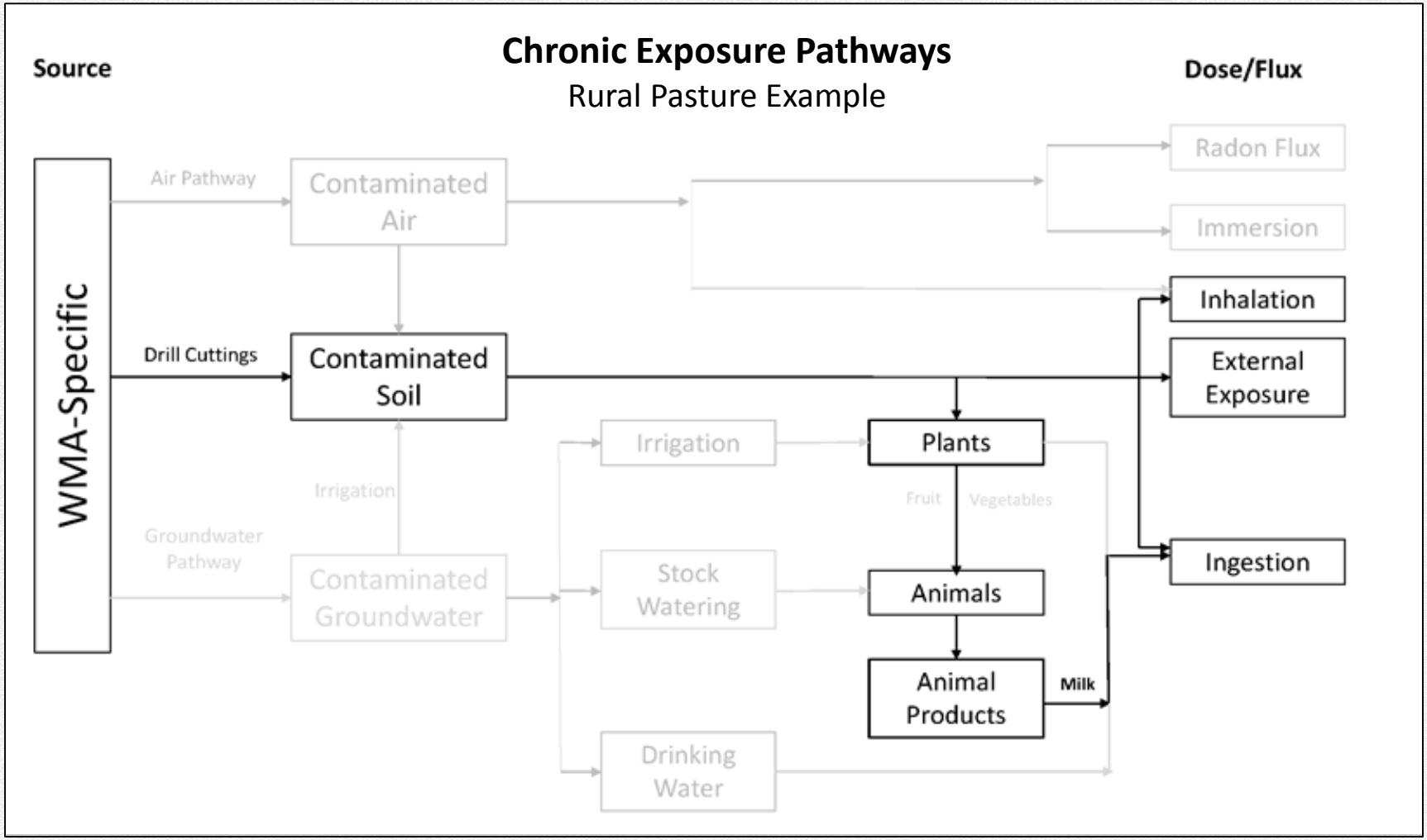
Source: DOE Order 435.1 PA, Figure 9-2

Exposure Pathways Associated with Chronic Inadvertent Intruder



Source: DOE Order 435.1 PA, Figure 9-4

Exposure Pathways Associated with Chronic Inadvertent Intruder



Source: DOE Order 435.1 PA, Figure 9-3

Inadvertent Intruder Results

Exposure Scenarios (Performance Measure)	Compliance Period (<1,000 yr)	
	Peak Dose (mrem/yr)	**Time of Peak** (years after closure)
Acute inadvertent intruder (500 mrem)	36.0	100
Chronic inadvertent intruder (500 / 100 mrem/yr)	8.2	100

Source: Draft WIR Evaluation, Figure 5-3

PA Results Summary

- WMA C PA provides reasonable assurance that performance objectives/measures in 10CFR 61.41 and 10CFR 61.42 will be met.
- Results of the WMA C PA analysis
  - WMA C PA dose results values should not be considered limits
  - Uncertainty and sensitivity analyses provide a robust set of analyses exploring a range of safety function failures and other parameter changes to better inform and support decision-making.

Radiological Safety Requirements

- 10 CFR 61.43 — Protection of Individuals During Operation.
  - Operations at the land disposal facility must be conducted in compliance with the standards for radiation protection set out in Part 20 of this chapter.
  - Every reasonable effort shall be made to maintain radiation exposures as low as is reasonably achievable (ALARA).
- NRC and DOE have comparable requirements for Radiological Safety during Operations

Radiological Safety for NRC and DOE

- NRC requirements in10 CFR 61.43 reference 10 CFR 20, which contains radiological protection standards for workers and the public.

- DOE requirements for occupational radiological protection are provided in 10 CFR 835 and those for radiological protection of the public and the environment are provided in DOE Order 458.1.

- These requirements are met by the existing Hanford Site Radiological Protection Programs, as described in the Draft WIR Evaluation, Section 5.4.

ALARA Considerations

- Measures that provide reasonable assurance that WMA C closure operations will comply with the ALARA provisions:
  - Radiation Protection Program
  - Documented Safety Analysis
  - Radiological Design Procedure
  - Regulatory and Contractual Enforcement
  - Access Controls, Training, and Dosimetry
  - History of Effective Radiological Control Performance

Site Stability Requirements

10 CFR 61.44 — Stability of the disposal site after closure.

- *The disposal facility must be sited, designed, used, operated, and closed to achieve long-term stability of the disposal site and to eliminate to the extent practicable the need for ongoing active maintenance of the disposal site following closure so that only surveillance, monitoring, or minor custodial care are required.*

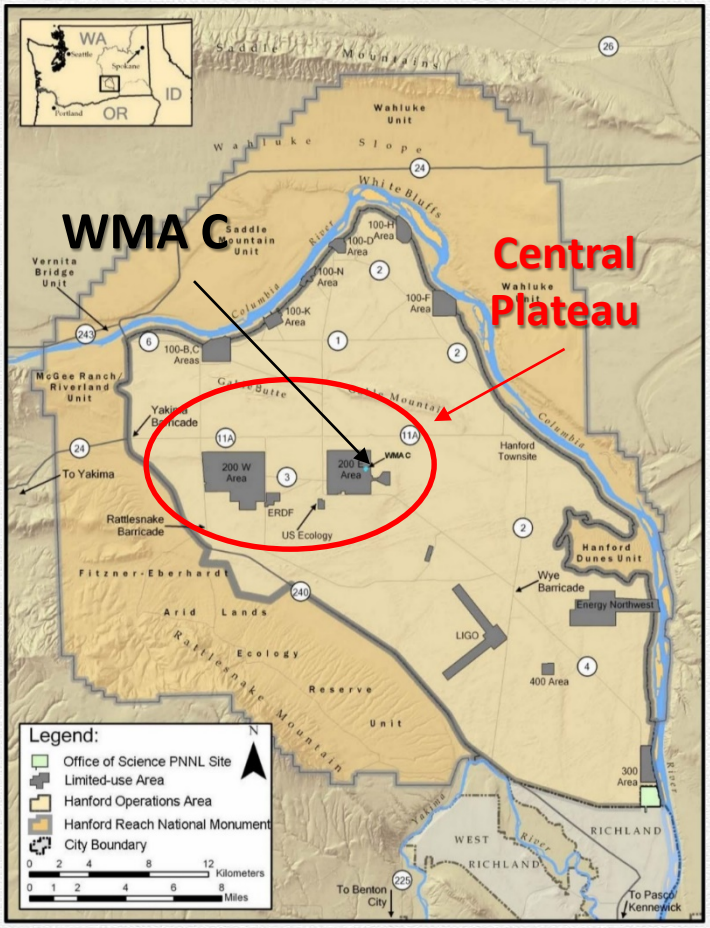
NRC and DOE have comparable requirements for Site Stability

Site Stability

- Compliance with 10 CFR 61.44 are demonstrated by the physical characteristics of WMA C and plans for closure which provide long-term stability:
  - Siting
  - Closure Design
  - Operations During Closure / Institutional Control
  - Final Engineered Surface Barrier System

Siting Requirements

- WMA C siting features which enhance long-term stability:
  - Arid climate
  - Relatively deep water table
  - Seismic considerations
  - Volcanic activity
  - Flooding potential
- Refer to Draft WIR Evaluation, Section 5.5.1, and WMA C PA for detailed discussions of these features.



Source: Draft WIR Evaluation, Figure 2-1

Closure Design

- Elements of Closure Design:
  - Existing Structure of Waste Tanks and Ancillary Structures
  - Stabilization with Grout
  - Combined Use of Engineered and Intruder Barriers

- See Draft WIR Evaluation, Section 5.5.2, and WMA C PA for detailed discussion of these elements.

Operations / Institutional Control

- Operational Programs in place prior to closure which promote long-term stability (see Draft WIR Evaluation, Section 5.5.3):
  - Corrosion Control
  - Structural Integrity
  - Leak Detection
  - Groundwater Protection
- Institutional Control Period
  - DOE is currently required and expects to maintain control of site indefinitely
  - Assumed to be 100 years after facility closure for purposes of PA calculations

Engineered Surface Barrier at Closure

- DOE expects to install a multi-layer RCRA-compliant engineered surface barrier over the entire WMA C Facility at closure that will:
  - Reduce water infiltration through the closed facility
  - Prevent intrusion into residual wastes contained within closed facility
- Specific details and placement of final engineered surface barrier will be designed as a part of the WMA C closure process

Compliance with Disposal Safety Requirements

- Demonstration of Compliance with Disposal Safety Requirements comparable to 10 CFR 61 Subpart C (WIR Criteria #2)
  - 61.41: All-Pathways dose results from WMA C PA are well below NRC (and DOE) performance objectives for closed LLW disposal facilities
  - 61.42: Intruder dose results from WMA C PA are well below NRC (and DOE) performance measures for closed LLW disposal facilities
  - 61.43: Existing Hanford Site radiological protection programs meet NRC (and DOE) requirements for Radiological Safety during LLW disposal facility operations
  - 61.44: Physical features of WMA C and anticipated plans for closure meet NRC (and DOE) requirements for long-term site stability required for closed LLW disposal facilities

Questions?

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WMA C Draft Waste Incidental to Reprocessing Evaluation

Key Radionuclide Concentrations

David Thorne

June 2018

Overview

- Identifying the Key Radionuclides (WIR Criteria #1)
  - Refer to Draft WIR Evaluation, Section 4.2
- Concentration Limits (WIR Criteria #3)
  - Refer to Draft WIR Evaluation, Section 6.0

Key Radionuclides

As discussed earlier, DOE M 435.1-1 Chapter II, section B(2)(a) provides in pertinent part that wastes determined to be incidental to reprocessing:

(1) "Have been processed, or will be processed, to remove key radionuclides to the maximum extent that is technically and economically practical;"

- What are the key radionuclides?

Key Radionuclides

DOE Guide 435.1-1 provides that:

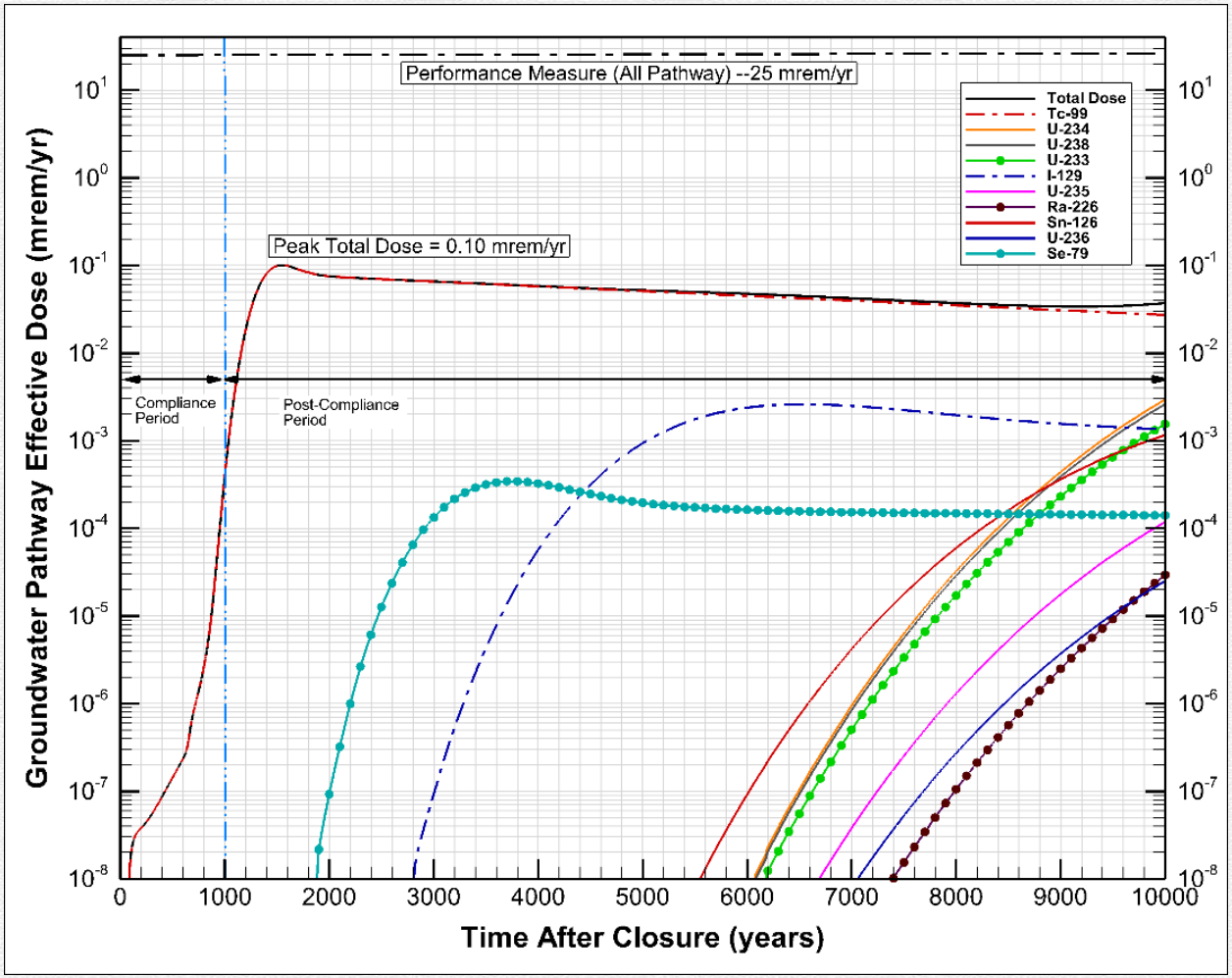
- "It is generally understood that "key radionuclides" applies to those radionuclides that are controlled by concentration limits in 10 CFR 61.55. Specifically these are: long-lived radionuclides (C-14, Ni-59, Nb-94, Tc-99, I-129, Pu-241, Cm-242) and alpha emitting transuranic nuclides with half-lives greater than five years; and short-lived radionuclides (H-3, Co-60, Ni-63, Sr-90, and Cs-137). In addition, key radionuclides are those that are important to satisfying the performance objectives of 10 CFR Part 61, Subpart C."

Key Radionuclides

- Key radionuclides important to the performance objectives in 10 CFR Part 61, Subpart C are those which contribute significantly to the projected future dose.
- The WMA C Performance Assessment identifies those radionuclides which contribute significantly to dose for:
  - Protection of the General Population:
    - Groundwater pathway
    - Air pathway
  - Protection of the Inadvertent Intruder

Key Radionuclides

WMA C PA Groundwater Exposure Pathway Results



Source: Draft WIR Evaluation, Figure 4-1

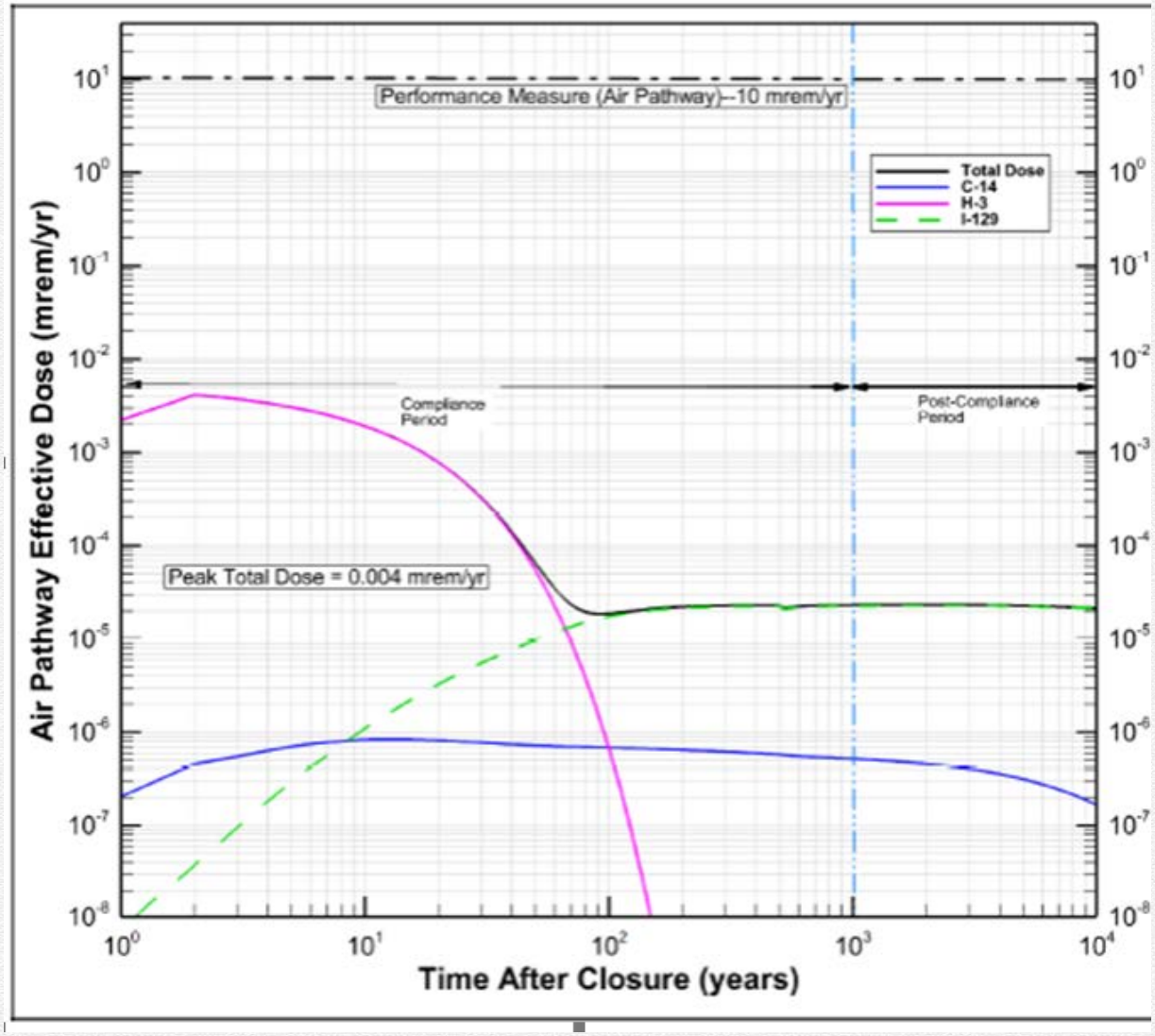
Key Radionuclides

Key Radionuclides Based on the WMA C PA Groundwater Exposure Pathway

- ^{99}Tc, ^{234}U, ^{238}U and ^{129}I contribute 95% of the dose from the groundwater exposure pathway and are identified as a key radionuclides.

Key Radionuclides

WMA C PA Air Exposure Pathway Results

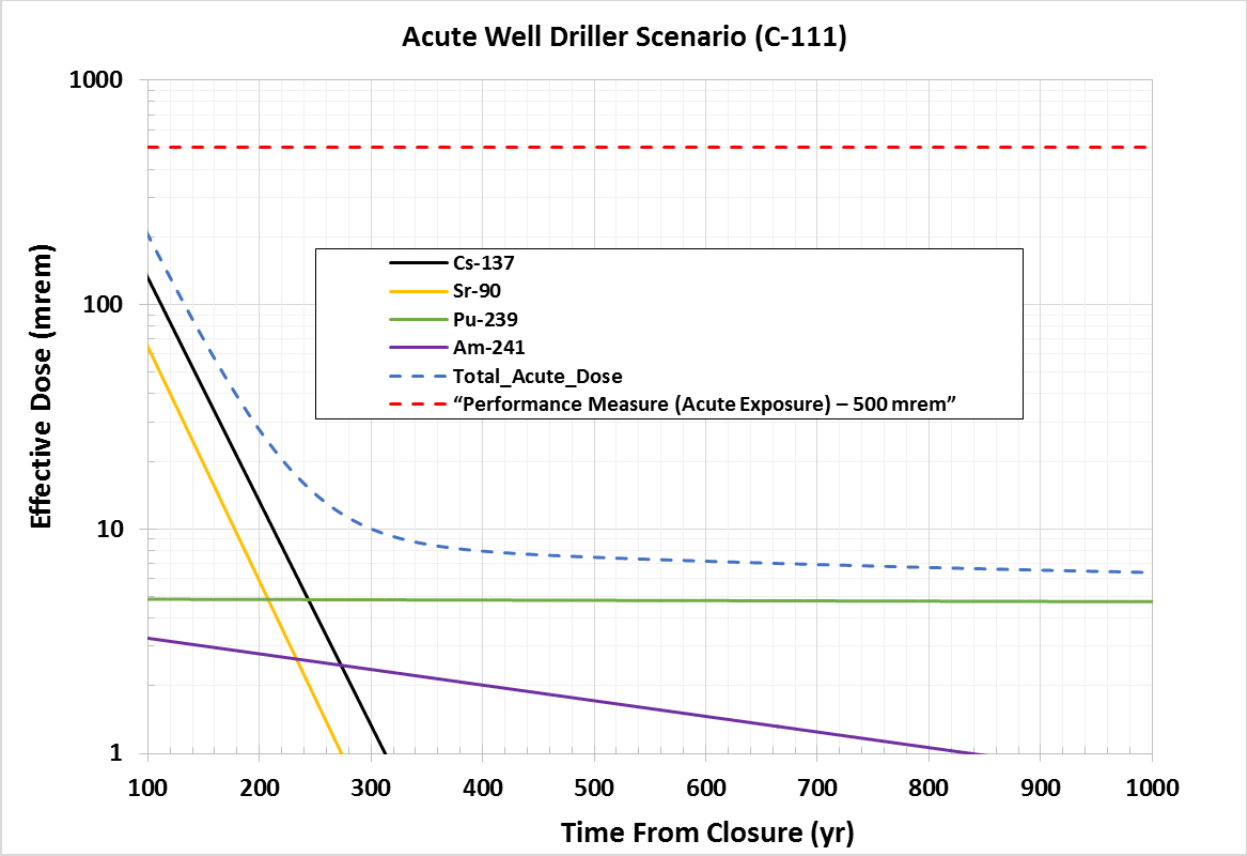


Source: WMA C PA, Figure 7-32

Key Radionuclides

- Key Radionuclides Based on the WMA C PA Air Exposure Pathway:
  - Due to the very low doses predicted for the air exposure pathway, no key radionuclides were identified.
  - H-3, C-14 and I-129 were already selected as key radionuclides from 10 CFR 61.55.

WMA C PA Intruder Exposure Pathway Results



Source: WMA C PA, Figure 9-7a

Key Radionuclides

- Key Radionuclides Based on the WMA C PA Intruder Exposure Pathway:
  - ^{137}Cs, ^{90}Sr, ^{239}Pu, ^{241}Am and ^{240}Pu contributed 95% of the intruder dose and were identified as key radionuclides.

Summary of Key Radionuclides

Key Radionuclide[a]	10 CFR 61.55 Long-Lived Radionuclides	10 CFR 61.55 Short-Lived Radionuclides	Radionuclides Important to Performance Assessment
^{3}H		X	
^{14}C	X		
^{60}Co		X	
^{59}Ni	X		
^{63}Ni		X	
^{90}Sr		X	X
^{99}Tc	X		X
^{129}I	X		X
^{137}Cs		X	X
^{234}U			X
^{238}U			X
^{237}Np	X		
^{238}Pu	X		
^{239}Pu	X		X
^{240}Pu	X		X
^{241}Pu	X		
^{242}Pu	X		
^{241}Am	X		X
^{243}Am	X		
^{243}Cm	X		
^{244}Cm	X		

Source: Draft WIR Evaluation, Table 4-3

WIR Criteria #3

DOE M 435.1-1 Chapter II, section B(2)(a) provides in pertinent part that wastes determined to be incidental to reprocessing:

- *(3) Will be incorporated in a solid physical form at a concentration that does not exceed the applicable concentration limits for Class C low level waste as set out in 10 Code of Federal Regulations 61.55…*

Class C Calculations

10 CFR 61.55 Class C Table 1 Concentration Limits

Radionuclides (Long-lived)	Class C Concentration (Ci/m^3)
^{14}C	8
^{14}C in activated metal	80
^{59}Ni in activated metal	220
^{94}Nb in activated metal	0.2
^{99}Tc	3
^{129}I	0.08
Alpha Emitting Transuranic nuclides with half-life greater than five years	[1]100
^{241}Pu	[1]3,500
^{242}Cm	[1]20,000

[1] Units are in nanocuries per gram.

Class C Calculations

10 CFR 61.55 Class C Table 2 Concentration Limits

Radionuclides (Short-lived)	Class C Concentration (Ci/m^3)
Total of all nuclides with less than 5 year half-life	([1])
^{3}H	([1])
^{60}Co	([1])
^{63}Ni	700
^{63}Ni in activated metal	7000
^{90}Sr	7000
^{137}Cs	4600

[1] There are no limits established for these radionuclides in Class C wastes

Class C Calculations

- WMA C WIR Class C Limits:
  - Based on the acute drilling scenario, since this scenario resulted in the maximum intruder doses in the WMA C PA.
  - The Class C calculations are based on the assumption that each radionuclide would provide an intruder dose of 500 mrem. Therefore, the sum-of-fractions is used to evaluate the Class C limits.
  - If the sum-of-fractions **(SOF) ≤ 1**, then the waste concentrations do not exceed the Class C limits.

Class C Calculations

- Results of the WMA C Draft WIR Class C Limit Calculations:
  - Tank C-107 exhibited the highest Class C – Sum of Fractions for tanks, at 0.03
  - C-301 Catch Tank exhibited the highest Class C – Sum of Fractions for all ancillary structures, at 0.04
  - Pipelines exhibited a Class C – Sum of Fractions of 0.05

Class C Calculations

Table 1 Radionuclide	Fraction of Class C Concentration Limit		
	C-107	C-301	Pipelines
^{14}C	8.24E-10	1.11E-09	6.48E-10
^{59}Ni	5.51E-12	2.77E-08	1.54E-08
^{99}Tc	1.52E-07	3.70E-08	2.06E-08
^{129}I	3.33E-07	2.40E-08	1.34E-08
^{237}Np	9.84E-06	6.86E-05	3.81E-05
^{238}Pu	1.46E-06	1.94E-05	2.53E-04
^{239}Pu	1.32E-02	3.11E-02	1.75E-02
^{240}Pu	1.39E-03	6.45E-03	3.74E-03
^{241}Pu	6.62E-16	1.09E-14	1.43E-06
^{242}Pu	1.93E-08	1.82E-06	1.01E-06
^{241}Am	1.51E-02	3.47E-03	3.66E-03
^{243}Am	6.67E-06	3.38E-06	1.95E-06
^{243}Cm	4.29E-13	6.66E-11	5.03E-07
^{244}Cm	2.40E-15	3.43E-13	8.32E-07
SOF	***0.03***	***0.04***	***0.03***

Table 2 Radionuclide	Fraction of Class C Concentration Limit		
	C-107	C-301	Pipelines
^{63}Ni	5.44E-11	5.12E-08	4.53E-07
^{90}Sr	6.68E-07	1.24E-06	1.03E-02
^{137}Cs	8.61E-06	6.57E-06	3.56E-02
SOF	***0.00001***	***0.00001***	***0.05***

Sum of Fractions (SOF) limit ≤ 1

Summary

- "Key Radionuclides" are those listed in 10 CFR 61.55 Tables 1 & 2, as well as those identified in the WMA C PA as contributing significantly to dose.

- The waste will be stabilized with grout, meeting the Criteria #3 requirement that the waste be incorporated in a solid physical form.

- Concentration calculations demonstrate that none of the stabilized residuals at WMA C will exceed the 10 CFR 61.55 Class C concentration limits.

Questions?

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