PUBLIC EDUCATIONAL FORUM
ON
PERFORMANCE ASSESSMENTS

Aiken Technical College Amphitheater
Aiken, SC

May 18, 2010

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Aiken Technical College Amphitheater, Aiken, SC

9:00	Welcome and Introductions (Sherri Ross, Mike Simmons – Department of Energy – Savannah River (DOE-SR))
9:10	Opening Remarks (Shelly Wilson – South Carolina Department of Health and Environmental Control Rob Pope – Environmental Protection Agency)
9:20	DOE Perspectives (Sherri Ross – DOE-SR)
9:50	Performance Assessment (PA) History at SRS (Sonny Goldston – Savannah River Nuclear Solutions)
10:15	Break
10:45	Overview of Performance Assessment – Exercise 1 (Roger Seitz – Savannah River National Laboratory (SRNL))
12:00	Lunch
1:00	Composite Analysis and Supporting Activities – Exercise 2 (Mark Phifer – SRNL)
2:15	Break
2:45	Saltstone and F Tank Farm PA Revisions (Steve Thomas – Savannah River Remediation)
4:00	NRC Perspectives (Nishka Devaser – US Nuclear Regulatory Commission)
4:30	Close-out (Sherri Ross, Mike Simmons)
5:00	End of Educational Forum

Acronyms

- 1-D – One dimensional
- 3-D – Three dimensional
- ACP – Area Closure Program
- AP – Assessment Period
- BGE – Burial Ground Expansion
- BWIP – Basalt Waste Isolation Project
- CA – Composite Analysis
- CAB – Citizens Advisory Board
- CAP88 – Clean Air Act Assessment Package, 1988
- CDP – Cellulose degradation products
- CERCLA – Comprehensive Environmental Response, Compensation and Liability Act
- CFR – Code of Federal Regulations
- Ci – curie
- D&D – Deactivation and Decommissioning
- DAS – Disposal Authorization Statement
- DNFSB – Defense Nuclear Facilities Safety Board
- DOE 435.1 – DOE Order, Manual, and Guide "Radioactive Waste Management"
- DOE – Department of Energy
- DOE HQ – DOE Headquarters
- DOE SR – DOE Savannah River
- EAV – E-Area Vaults
- EDE – Effective Dose Equivalent
- EIS – Environmental Impact Statement
- ELLT – Engineered Low-Level Trench
- ELLWF – E Area Low Level Waste Facility
- EPA – Environmental Protection Agency
- ER – Environmental Restoration
- FACT – Subsurface Flow and Contaminant Transport model
- FAMS – F-Area Materials Storage (Facility)
- FEP – Features, Events, and Processes
- FFA – Federal Facilities Agreement
- FMB – Four Mile Branch
- ft – foot
- FTF – F-Area Tank Farm
- g – gram
- GCD – Greater Confinement Disposal
- GOLDSIM™ – Probabilistic modeling code
- GSA – General Separations Area
- HDPE High density polyethylene
- HELP – Hydrologic Evaluation of Landfill Performance
- HTF – H-Area Tank Farm
- HLW – High Level Waste
- IAEA – International Atomic Energy Agency
- ICRP – International Commission on Radiological Protection
- IOU – Integrator Operable Unit
- INL – Idaho National Laboratory
- INEEL – Idaho National Engineering Laboratory
- ISAM – Coordinated Research Project on Improvement of Safety Assessment Methodologies for Near Surface Waste Disposal Facilities
- ISO – International standards organizations
- Kd – distribution coefficient
- Kg – kilogram
- L – liter
- L3RC – Lower Three Runs Creek
- LFRG – Low-Level Waste Disposal Facility Federal Review Group

Acronyms, continued

- LLW – Low Level Waste
- M – meter
- m^2 – square meters
- m^3 – cubic meters
- MCL – Maximum Contaminant Level
- mL – milli Liter
- MEPAS – Multimedia Environmental Pollutant Assessment System
- MODFLOW – USGS modular groundwater flow model
- mrem/year – millirem per year
- NDAA – National Defense Authorization Act
- NRC – Nuclear Regulatory Commission
- NCRP – National Council on Radiation Protection and Measurements
- NORM – Naturally Occurring Radioactive Material
- NRCDA – Naval Reactor Components Disposal Area
- ORNL – Oak Ridge National Laboratory
- ORWBG – Old Radioactive Waste Burial Ground
- PA – Performance Assessment
- pCi – pico (1x10-12) Curie
- PDE – Partial Differential Equation
- POA – Point of Assessment
- POC – Point of Compliance
- PORFLOW – Groundwater modeling code
- PNNL – Pacific Northwest National Laboratory
- PRP – Peer Review Panel
- QA – Quality Assurance
- Rev – Revision
- RESRAD – Residual Radioactive Material (environmental analysis code)
- ROD – Record of Decision
- RWMC – Radioactive Waste Management Complex
- Rx - Reactor
- SA – Special Analysis
- SC – Steel Creek
- SCDHEC – South Carolina Department of Health and Environmental Control
- sec – second
- SDF – Saltstone Disposal Facility
- SLB – Shallow Land Burial
- SR – Savannah river
- SREL – Savannah River Ecology Laboratory
- SRNL – Savannah River National Laboratory
- SRNS – Savannah River Nuclear Solutions
- SRR – Savannah River Remediation
- SRS – Savannah River Site
- ST – Slit Trench Disposal Unit
- TRU – Transuranic
- U3RC – Upper Three Runs Creek
- UDQ – Unreviewed Disposal Question
- UDQE – Unreviewed Disposal Question Evaluation
- US – United States of America
- USGS – United States Geological Survey
- USQ – Unreviewed Safety Question
- UTR – Upper Three Runs
- yr - year

Overview of
DOE's Regulatory Compliance Process for Approval of Performance Assessments

Sherri R. Ross
Low-Level Waste Disposal Facility Federal Review Group
DOE-SR Alternate Representative

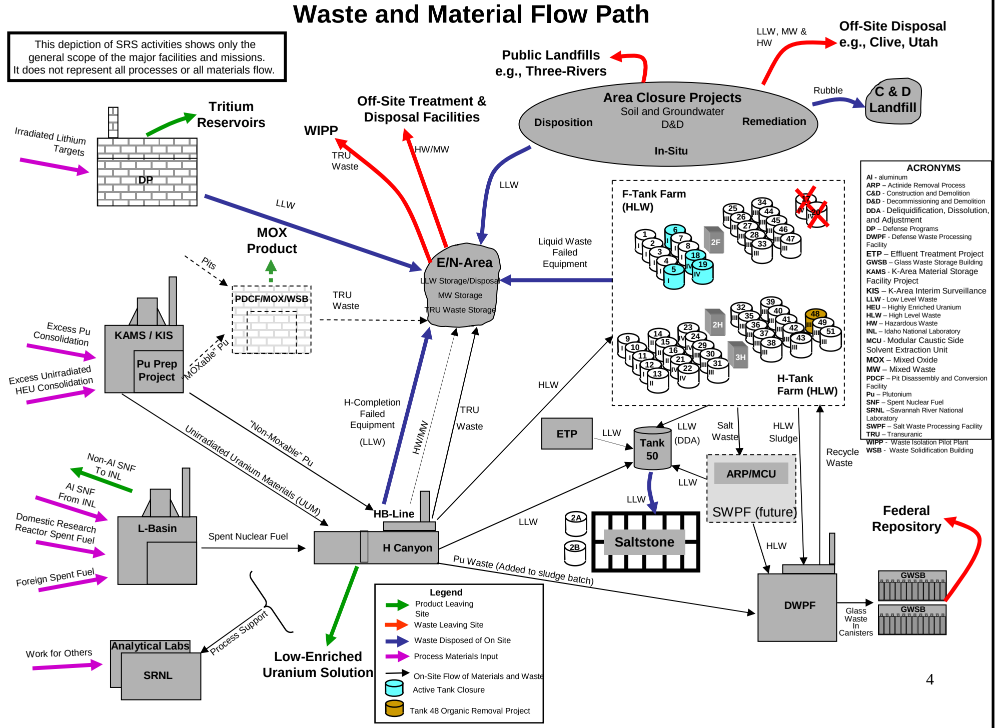
Acronyms

- CA – Composite Analysis
- DAS – Sisposal Authorization Statement
- DNFSB – Defense Nuclear Facility Safety Board
- DOE – Department of Energy
- EM – Environmental Management
- LFRG – Low Level Waste Facility Federal Review Group
- LLW – Low Level Waste
- PA – Performance Assessment

Purpose

- Explain DOE's authority for management of radioactive waste
- Explain DOE's regulations for management of radioactive waste
  - Focus on performance assessment requirements
  - Review and approval process of performance assessments
- Explain ongoing efforts to update DOE's regulations for management of radioactive waste

Savannah River Site Waste and Material Flow Path



Self-Regulatory Authority under the Atomic Energy Act

- Establish by rule, regulation, or order, such standards and instructions to govern the possession and use of special nuclear material, source material, and byproduct material as the Commission* may deem necessary or desirable to promote the common defense and security or to protect health or to minimize danger to life or property.

  * In this context "Commission" refers to the Atomic Energy Commission which later evolved into the Energy Research and Development Administration and then the Department of Energy (for promotion of uses of nuclear energy) and the Nuclear Regulatory Commission (for regulation of commercial nuclear energy uses).

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Energy Reorganization Action of 1974

- There are hereby transferred to and vested in the Administrator [of the Energy Research and Development Administration] all functions of the Atomic Energy Commission, the Chairman and members of the Commission, and the officers and components of the Commission, except as otherwise provided in this Act.

- The Administrator is authorized to prescribe such policies, standards, criteria, procedures, rules, and regulations as he may deem to be necessary or appropriate to perform functions now or hereafter vested in him.

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DOE's Self-Regulation of Radioactive Waste Disposal

- Self-regulation does not mean everyone gets to do whatever they want
- Responsibilities and authorities under the Atomic Energy Act implemented through directives and orders.
- Legal requirement to protect members of the public from all sources of radiation, not to exceed 100 mrem.

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History and Background of DOE Order 435.1

- DOE Order 5820.2A issued September 1988
- DNFSB Recommendation 94-2
  - LLW forecasting and capacity planning inadequate
  - Characterization of LLW ineffective
  - LLW with no identified path to disposal in storage indefinitely
  - Storage conditions for LLW inadequate
  - Some LLW generated with no path for disposition
  - Performance Assessments unapproved and lacking adequate requirements
- DNFSB 94-2 required DOE to conduct a complex-wide review
  - Complex-Wide Review identified 6 complex-wide vulnerabilities which echoed DNFSB findings (May 1996)
  - Input into DOE Order 435.1 development

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How DOE Order 435.1 was created

- Began Order writing process September 1996
- Four teams of Headquarters and Field staff
  - High Level Waste
  - Transuranic Waste
  - Low Level Waste/Mixed Low Level Waste
  - General Requirements
- Structured process of workshops and steps
- July 9, 1999 issued Order, Manual, Guidance, Technical Basis, and training program

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DOE Order 435.1, Radioactive Waste Management

- Effective implementation date July 2000
- Establishes DOE HQ/Site responsibilities
  - Low-Level Waste Disposal Facility Federal Review Group (LFRG)
- Establishes Performance Objective and Requirements governing disposal actions:
  - 25 mrem all pathways dose
  - 10 mrem air pathway
  - 20 pCi/m^2/second radon flux
  - Intruder Scenario

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LFRG Framework and Processes

- LFRG Manual
- LFRG Program Management Plan
- Format and Content Guide for Performance Assessments and Composite Analyses
- Closure Guide
- Maintenance Guide
- Monitoring Guidance

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LFRG Composition

- Martin J. Letourneau, Chair, EM Office of Compliance
- Dave Adler, Oak Ridge Operations Office
- Frank DiSanza, Nevada Site Office
- Doug Hildebrand, Richland Operations Office
- Bob Lober, Office of River Protection
- Barry Parks, Office of Science
- Mike Simmons (Primary), Savannah River Operations Office
- Sherri Ross (Alternate), Savannah River Operations Office
- Andy Wallo, Office of Health, Safety and Security
- Mary Willcox, Idaho Operations Office
- Alice Williams, National Nuclear Security Administration

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Authorization Requirements

- Approved Disposal Authorization Statement (DAS)
- Approved Performance Assessment (PA)
- Approved Composite Analysis (CA)
- Preliminary Closure Plan
- Monitoring Plan
- PA/CA Maintenance Plan
- Annual Summaries
- Radioactive Waste Management Basis

LFRG Roles and Responsibilities

- Track and report preparation of compliance documentation
- Develop and conduct formal review processes
- Review compliance documentation submitted by sites in support of disposal authorization statements
- Provide LFRG recommendations to EM senior managers
- Prepare disposal authorization statements for disposal facilities
- Conduct other reviews and assessments as directed by EM senior management (e.g., waste determinations and transuranic waste disposal performance assessments)

LFRG Review Topics and Review Criteria for PAs & CAs

- Site and Facility Characteristics -- 7 criteria
- Radioactive Sources and Release Mechanisms -- 6 criteria
- Performance Objectives and Measures -- 8 criteria
- Point of Assessment -- 6 criteria
- Conceptual Model -- 5 criteria
- Mathematical Models -- 13 criteria
- Assumptions -- 2 criteria
- Exposure Pathways and Dose Analysis -- 14 criteria
- Sensitivity and Uncertainty -- 7 criteria
- ALARA and Options Analysis -- 3 criteria
- Results Integration -- 11 criteria
- Quality Assurance -- 2 criteria

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LFRG Review Process (Overall)

- Site Representative submits PA/CA
- LFRG determines suitability for review
- LFRG appoints review team leader and team members
- Review team prepares review plan and LFRG approves
- Team performs review and prepares draft report
- Site provides factual accuracy review
- Team edits and submits report to the LFRG
- LFRG approves PA, develops Compliance Evaluation and Disposal Authorization Statement (DAS) and provides recommendation to the Deputy Assistant Secretary
- Deputy Assistant Secretary approves DAS

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LFRG Review Process (Review Team)

- Review team identifies issues and classifies them as key issues, secondary issues, or opportunities for improvement
- Criteria with associated key or secondary issues are "not satisfied"
- Criteria with no associated key or secondary issues are "satisfied"
- Key issues must be resolved for the team to recommend acceptance of the PA/CA
- Secondary issues must also be resolved but may be addressed through the PA/CA maintenance plan
- Opportunities for improvement may be addressed at the discretion of site personnel
- Issues requiring resolution may be documented with conditions imposed via the DAS

Unreviewed Disposal Question Evaluation

A disciplined, graded approach to ensure evaluation of proposed changes and discoveries for the purpose of maintaining disposal operations within the approved performance envelope. Preliminary screening identifies changes/discoveries to be subjected to full evaluation and possible need for a Special Analysis.

Evaluation Criteria

a. Is the proposed activity or new information outside the bounds of the approved PA/CA?

b. Does the proposed activity or new information cause the PA/CA performance measures to be exceeded?

c. Would the radionuclide disposal limits in the approved PA need to be changed to implement the proposed activity?

d. Does the new information involve a change in the radionuclide disposal limits in the approved PA?

e. Does the proposed activity or new information involve a change to the DAS?

Waste Incidental to Reprocessing and Section 3116 Determinations

Waste previously associated with high-level waste processing but not requiring isolation in a geologic repository may, in certain cases, be managed as low-level waste or transuranic waste. Two similar approaches have been developed.

Waste Incidental to Reprocessing (DOE Manual 435.1-1, Radioactive Waste Management) is applicable at all DOE sites and may employ the citation process or the evaluation process.

Section 3116 Determination (National Defense Authorization Act of 2005) is applicable at DOE facilities in South Carolina and Idaho.

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Path Forward for DOE Order 435.1

- Complex-Wide Review initiated late 2008
  - More than 10 years since first Complex-Wide Review (1996)
  - 10 years experience implementing DOE Order 435.1
  - Opportunity to re-assess and evaluate DOE's progress
  - Consistent with feedback and continuous improvement step of Integrated Safety Management System
  - Good first step for evaluating DOE Order 435.1 update needs
- Final Complex-Wide Review Report under preparation
- DOE Order 435.1 Update underway and anticipated to complete late 2012
  - Will include a public review and comment period

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History of Performance Assessment Development at SRS

Sonny Goldston and Elmer Wilhite

Savannah River Site

May 18, 2010

Performance Assessment Educational Forum

SRNL-STI-2010-00288

Evolution of LLW Disposal & PA Developments

Timeline

National Developments

- 1960 - 1970: Five Commercial Disposal Facilities Open
- 1971: Barnwell Burial Ground Opens
- 1975 - 1978: Burial Ground Closures, West Valley, Sheffield Maxey Flats

1960 — **1970** — **1980**

SRS Developments

- 1953: 76-Acre Burial Ground Opens
- 1956: Burial Ground Perimeter Wells Installed
- 1970: 119-Acre Burial Ground Opens
- 1972: 76-Acre Burial Ground closes
- 1973 – 1980s: Development and use of DOSTOMAN PA Code Elmer Wilhite
- 1965 – 1980s: Intensive Study of Shallow-Land Burial
  - Subsurface Monitoring
  - Lysimeters
  - Exhumation of waste – Perry Holcomb
  - Vegetative uptake
  - Cover stabilization
  - Pre-SRS use of Burial Ground
  - Pathways Analysis – Elmer Wilhite

Evolution of LLW Disposal & PA Developments

Timeline - continued

1980

1982
NRC Issues 10CFR61

1983 - 1984
- B-25 Box disposal
- ELLT
- GCD Demonstrations
- Initiate BGE Project

1984
ORNL Withdraws EIS for SLB

1986
Nuclear Waste Policy Act
(Regional Compacts)
Draft EPA LLW Rule
(40CFR193 Groundwater Protection required)

1986
235-H Compactor opens

1986
- Saltstone assumed leaching Mechanism proven false
- Intensive effort to understand and model mechanism
- Modeling showed that vaults instead of trenches were needed – Elmer Wilhite

1987
DOE-HQ issues letter requiring separation of waste from environment based on SRS Saltstone

1987
Ed Albenesius detailed to DOE-HQ to prepare 5820.2A
Jim Cook and Elmer Wilhite on LLW team

1988
DOE Issues 5820.2A
Requiring PA for first time;
Peer Review Panel Formed
Elmer Wilhite Chairman

1988
WM EIS ROD

1989
- E-Area Vault Design Complete
- Cease SLB of Rx Deionizers Tritium Crucibles

1990

Savannah River Nuclear Solutions, LLC

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Evolution of LLW Disposal & PA Developments

Timeline - continued

1990

1990
Performance Assessment Task Team Formed
Jim Cook SRS member
Roger Seitz INEL member

1990
Saltstone Startup;
Begin Saltstone PA
Jim Cook
Elmer Wilhite
Roger Seitz

1991
Begin EAV PA
Jim Cook
Elmer Wilhite
Roger Seitz

1993
Saltstone PA approved by PRP

1993
E-Area Vault Construction Complete

1994
EAV PA approved
Startup EAV

1994
DNFSB 94-2

1995
Elmer Wilhite asked to Lead Radiological Assessments part of DOE response to DNFSB 94-2

1995-1997
SRS HLW Tank closure
Jim Cook
Jeff Newman

1996
94-2 Revised
Implementation Plan Issued
Marty Letourneau Led effort
CA now required

1997
LFRG established
Jim Cook & Elmer Wilhite Participate in most reviews

1997
SRS CA Completed
Jim Cook
Elmer Wilhite
Sonny Goldston

1999
DOE 435.1
Sonny Goldston
Elmer Wilhite

1999
SRS DAS Issued

1999
With CAB support, Expanded use of Trenches
Saved $63 million

2000

Savannah River Nuclear Solutions, LLC

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Evolution of LLW Disposal & PA Developments

Timeline - continued

2000

2010

2000
ELLWF PA Revision
J. Cook
S. Goldston
E. Wilhite

2000
UDQ Procedure
S. Goldston
J. Cook
E. Wilhite

2002
Saltstone SA
J. Cook
S. Goldston
E. Wilhite

2004
NDAA
Section 3116
Reclassification
Of HLW residues

2005
INEEL
HLW Tank
Farm PA

2005
Saltstone SA
J. Cook
S. Goldston
E. Wilhite

Saltstone WD
G. Dickert, et al
J. Cook
E. Wilhite

2006
Modeling
Consistency
Team
E. Wilhite
S. Goldston
K. Rosenberger

2007
ELLWF
PA Revision
J. Cook
S. Goldston
E. Wilhite

FTF PA
K. Rosenberger,
et al

2008
Revised DAS
for E-Area

2009
Saltstone PA issued to
NRC & DHEC for review

2010
CA under
DOE-HQ
review

FTF PA Rev. 1
issued to NRC,
DHEC & EPA
for review

HTF PA under
development

Summary

- SRS has been involved in PA development since the early 1970s
- SRS has influenced PA development around the DOE Complex
- SRS is leading the DOE Complex in efforts to ensure consistency in PA development
- Summary of Conclusions

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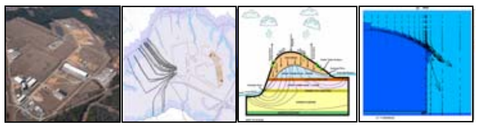
SAVANNAH RIVER NATIONAL LABORATORY
Operated by Savannah River Nuclear Solutions, LLC
We Put Science To Work

Performance Assessment (PA) Overview

Roger Seitz

18 May 2010



PA Educational Forum

SRNL-MS-2010-00089

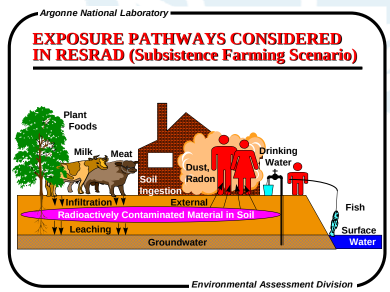
EM Office of Environmental Management
safety • performance • cleanup • closure

Radiation Concepts

- **Curie (Ci) or Becquerel (Bq) – amount of radioactivity**
  - 1 Ci is equivalent to 37 billion Bq
  - 1 Bq = 1 disintegration per second
- **Half-Life – time required for the amount of radioactivity to decay to ½ starting value**
  - Cs-137 has a ~30 yr half-life, if we start with 2 Ci, there will be 1 Ci remaining after 30 yr
- **Effective Dose (millirem (mrem) or milliSievert (mSv)) is a measure of impact of radioactivity**
  - 100 mrem is equivalent to 1 mSv

Regulatory Standards

- Regulations include specific criteria that must be met (performance objectives)
- DOE Order 435.1 and 10 CFR Part 61 include all pathways dose standards (25 mrem/yr)
- DOE Order 435.1 also includes composite analysis, groundwater protection and radon release standards
- NRC and DOE have performance measures for inadvertent intruder protection



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Dose Perspectives

100,000 mrem – Dose leading to ~5% chance of Fatal Cancer (UNSCEAR)

10,000 mrem/yr – IAEA mandatory intervention

5,000 mrem/yr – Worker dose standard (DOE)

1,000 mrem/yr – IAEA reference level for intervention for cleanup situations

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

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

25 mrem/yr – NRC and DOE LLW

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

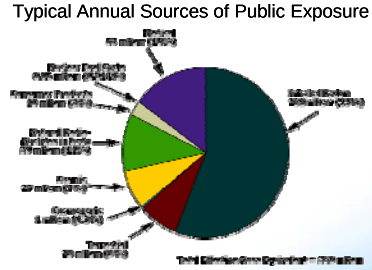
10 mrem/yr – Air (atmospheric) (40 CFR 61)

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

1 mrem/yr – IAEA Exemption/Clearance

Note: Air crew average (300 mrem/yr)
From UNSCEAR (2000)

Typical Annual Sources of Public Exposure



Graphics from NCRP Report No. 93

SRNL

Objectives for this Presentation

- Provide perspective regarding how performance assessments are conducted
- Introduce fundamental concepts associated with performance assessments
- Summarize basic terminology

SRNL

Contents

What is PA?

How are PAs conducted?

Key Concepts and Terminology

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What is PA?

Performance Assessment Applications

- **Development of Waste Acceptance Criteria for disposal facilities – waste forms, radionuclide content, etc.**
- **Estimate health effects associated with leaving different amounts of waste in tanks or different levels of contamination in facilities**
- **Evaluation of health effects associated with different options for remediation or D&D**
  - PA provides capability to be able to distinguish benefits of specific features

Performance Assessment

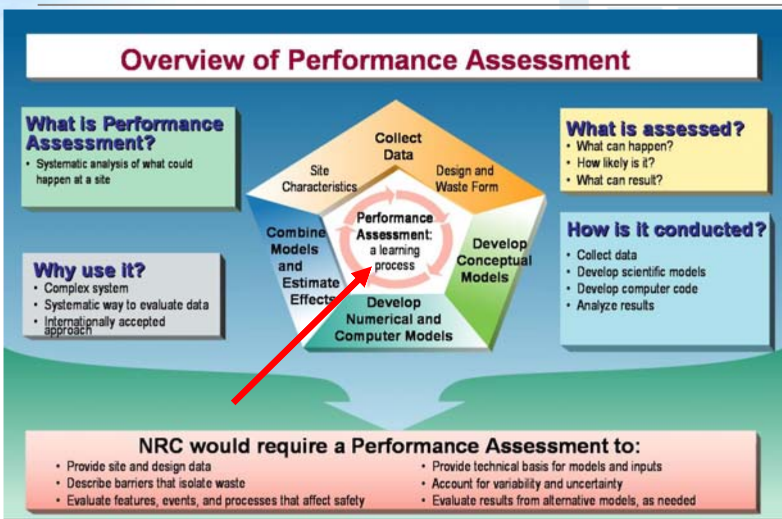
IS…

- A means to address post-closure protection of human health in a decision process
- A process to build confidence that projected doses are reasonably likely to be less than a given standard
- A means to provide perspective on the significance of different site, facility and waste features relative to protection of human health (demonstrate understanding of the system)

IS NOT…

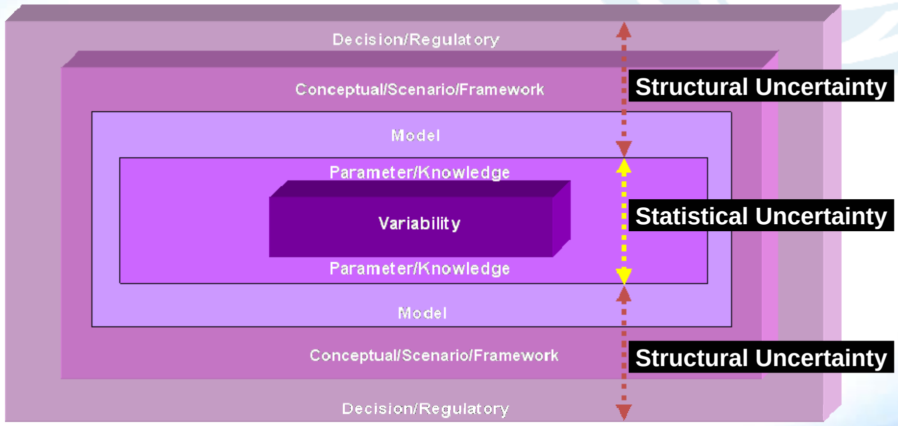
- A "prediction" of doses to real people, it is assumed that someone will live and use water at a specific location at some point in the future
- Safety analysis for worker and public protection during pre-closure operations
- An assessment of worst case scenarios

Performance Assessment (NRC View)



Courtesy: David Esh, US NRC

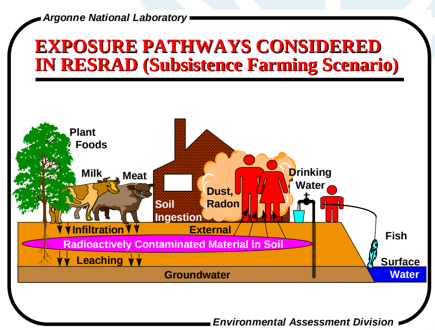
Uncertainty



Courtesy: Bruce Crowe, Nevada Test Site

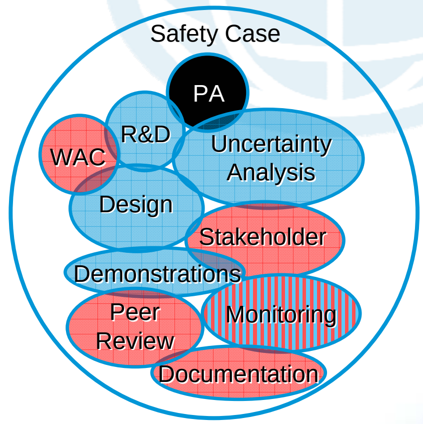
Exposure Scenarios in Context (Structural Uncertainty)

- **Assume complete loss of institutional memory of DOE Site**
- **Resident drills a well at point of peak concentration in aquifer (outside buffer zone)**
- **Resident farmer with beef and milk cows, garden for consumption**
- **Intruder digs basement and drills well immediately above the waste (hypothetical, not a performance objective)**



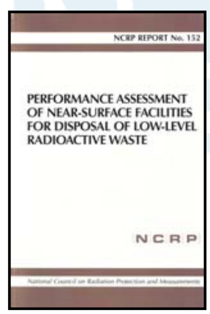
Managing Uncertainties – International Concept of "Safety Case"

- **IAEA, Nuclear Energy Agency and others**
- **Reflects use of performance assessment as only one part of a package used to support decisions**
  - *"The purpose of computing is insight, not numbers"* – Richard Hamming
- **Similar concept to the Radioactive Waste Management Basis in the DOE System**



Other Organizations

- **National Council on Radiation Protection and Measurements (NCRP) Report No. 152**
  - Merits of deterministic, probabilistic and combined approaches
  - "Importance Analysis"
- **International Atomic Energy Agency**
  - Decades of global experience on assessments
  - Develop Safety Standards for waste management activities
  - PRISM project looking at practical application of safety case concept


NCRP REPORT No. 152

PERFORMANCE ASSESSMENT OF NEAR-SURFACE FACILITIES FOR DISPOSAL OF LOW-LEVEL RADIOACTIVE WASTE

NCRP

National Council on Radiation Protection and Measurements


IAEA SAFETY STANDARDS SERIES

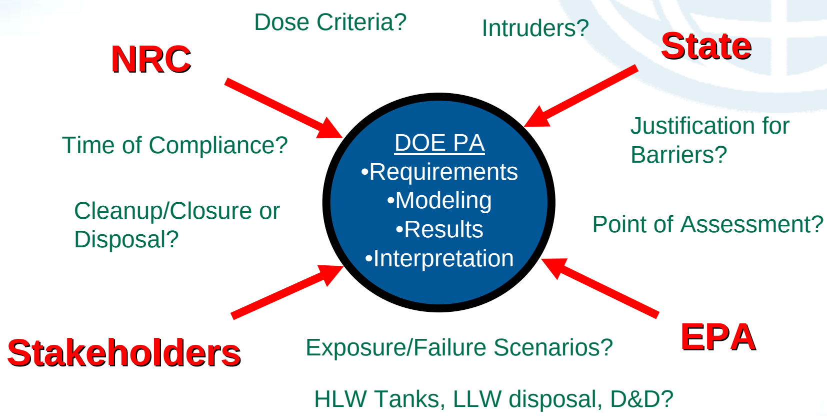
The Safety Case and Safety Assessment for Radioactive Waste Disposal

DRAFT SAFETY GUIDE

No. DS 355

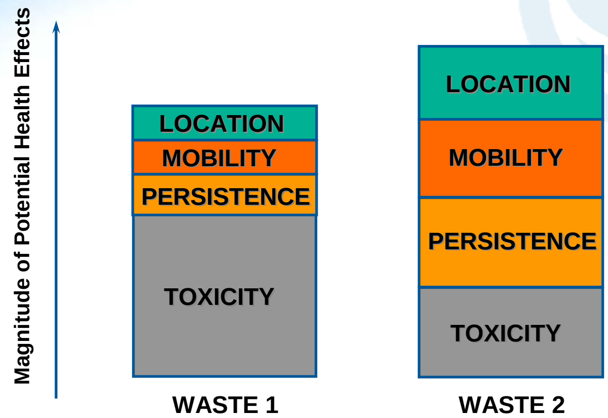
IAEA

Performance Assessment Reality



Factors Influencing Performance

Factors Contributing to Impacts



Toxicity includes amount and inherent toxicity
Mobility includes site properties and barriers/waste form
Location includes pathways and distance to receptor

"Toxicity"

- **Represented by Dose Factors (e.g., mrem/Ci)**
- **More activity generally leads to greater toxicity**
- **Different radionuclides have different toxicity**
- **Toxicity also depends on the pathway of exposure (ingestion, inhalation, external exposure)**

Persistence (short-lived isotope, physical barriers)

- Cs-137 source removed from teletherapy device by junk dealer in Goiânia, Brazil
- Extensive contamination (3,500 m^3 of waste)
- Concrete vault provides hundreds of years of isolation to protect nearby community

Initial Inventory	30 yr	100 yr	200 yr	300 yr	500 yr
~1400 Ci	700 Ci	139 Ci	14 Ci	1.4 Ci	0.01 Ci
0.4 Ci/m^3	0.2 Ci/m^3	0.04 Ci/m^3	0.004 Ci/m^3	0.0004 Ci/m^3	0.000004 Ci/m^3

Persistence (Short-and Long-lived Isotopes)

- Mixture of contamination and activated metals
- Much of activity levels within metal matrix, grouted
- Chemical (grout) and physical barriers (vessel, metals)
- Total Inventory ~60,000 Ci

	Half-Life	Initial Ci	100 yr	500 yr	1000 yr	10,000 yr
H-3	12.3 yr	32,900	118	0.00000002	-	-
C-14	5,730 yr	13.3	13.1	12.5	11.8	4
Co-60	5 yr	1,970	0.002	-	-	-
Ni-59	76,000 yr	132	131.9	131.4	130.8	120.5
Ni-63	100 yr	24,200	12,100	760	24	-
Cs-137	30 yr	2.7	0.3	0.00003	-	-

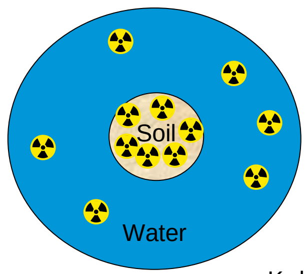
"-" < 1E-9 Ci

Chemical Mobility – Retardation and Distribution Coefficient, K_d

$$K_d \text{ (ml/g)} = \frac{\text{mass of solute on the solid phase per unit mass of solid phase, g/g}}{\text{concentration of solute in solution, g/ml}^3}$$

Retardation Coefficient

$$R_d = 1 + \frac{\rho_b K_d}{n_e}$$



K_d = 0, all activity in water

K_d large, most activity on solid

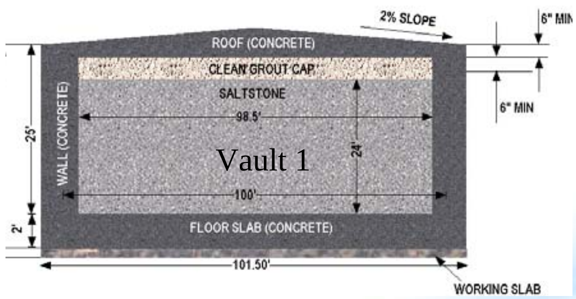
Persistence, Toxicity, and Mobility

	Half-Life (yr)	Dose Factors (mrem/pCi)		External Dose (mrem/yr)/(pCi/g)	K_d (mL/g)	
		Ingestion	Inhalation		Sandy	Clayey
H-3	12.3	6.4E-08	6.4E-08	0	0	0
C-14	5730	2.1E-06	2.1E-06	1.3E-05	10	400
Ni-59	76,000	2.1E-07	2.7E-06	0	7	30
Ni-63	100	5.8E-07	6.3E-06	0	7	30
Co-60	5	2.7E-05	2.2E-04	16	7	30
Tc-99	211,100	1.5E-06	8.3E-06	1.3E-04	0.6	1.8
Cs-137	30	5.0E-05	3.2E-05	3.6 (Ba-137m)	10	50
Np-237	2,140,000	4.4E-03	0.54	0.08	3	9
Pu-239	24,110	3.5E-03	0.43	2.9E-04	290	5,950

Most limiting Ingestion and Inhalation dose factors shown here,
External Dose Factor is for a source of infinite thickness
K_d = Distribution Coefficient (soil and water partitioning) – SRS values

Design Controls for Mobility

- **Chemistry**
  - Partitioning (K_d)
  - Solubility
- **Waste Form**
  - Grout
  - Activated metals
- **Containers**
- **Barriers**
  - Concrete
  - Steel

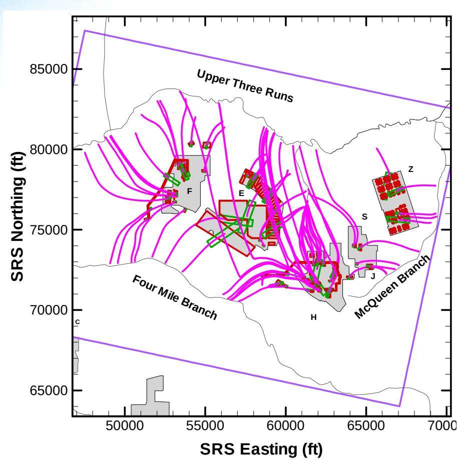


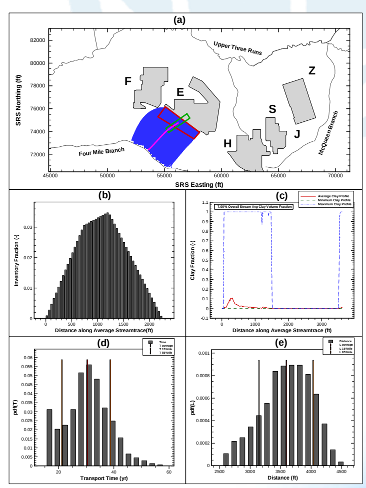
Receptor and Exposure Considerations (Location)

- **Dose is dependent on location and habits of the receptor**
- **Point of compliance is a critical consideration (increased distance is generally equivalent to increased dilution and time for decay)**
- **Exposures are more significant through different pathways for different radionuclides (e.g., I-129 in milk, Tc-99 in leafy vegetables, C-14 in fish, Cs-137 for external exposure)**

Technical Approaches

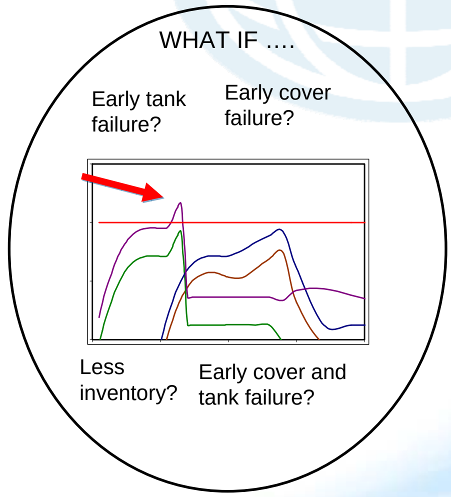
Abstraction & Dimensionality





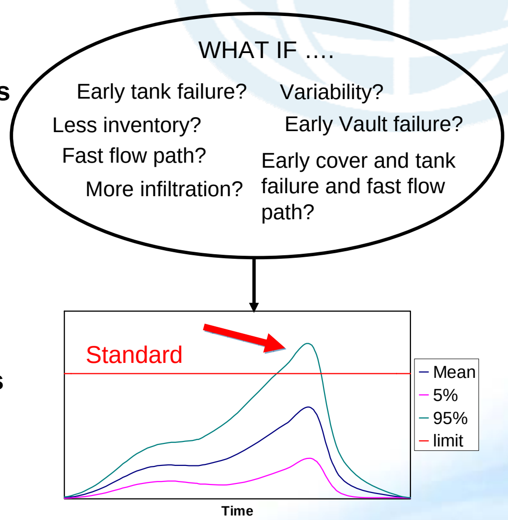
Deterministic "Importance" Analysis

- **Traditional, deterministic standards (Idaho Tank PA, many existing PAs for LLW disposal)**
- **Demonstrate dose is less than standard**
- **Add sensitivity cases to address "what-if" type questions**
- **How do you interpret "what-if" cases that may exceed the standard?**



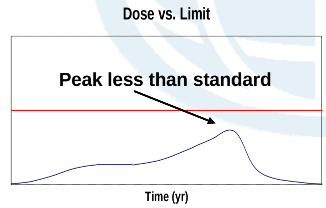
Probabilistic "Importance" Analysis

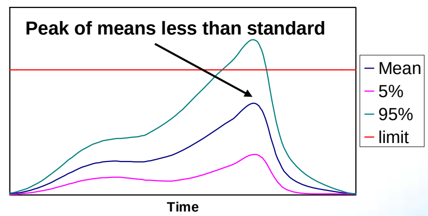
- **Becoming expected, risk-informed**
- **Demonstrate peak of means or median is less than deterministic standard**
- **"What-if" and uncertainty analysis implicitly included**
- **Relative likelihood of extreme cases is specifically represented**
- **How do we interpret results at extremes?**



Hybrid Approach

- Agree on deterministic baseline case(s) to compare with deterministic standard (add sensitivity "what-if" cases)
- Use probabilistic approach to capture "what-if" questions and uncertainty analysis
  - Multiple lines of reasoning
  - Models check each other

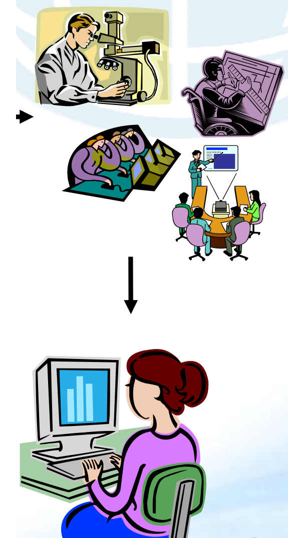




Key Concepts

Multi-Disciplinary Team Approach

PA



Source Term

Drives the PA Process

Facility Description

- Dimensions
- Barriers (concrete, metal)
- Initial condition and degradation of barriers

Contaminant Inventory

- Chemical/physical form

SRS P Reactor Area

Material Composition

container lifetime? resins?

concrete? enhanced mobility?

activated metal? solubility?

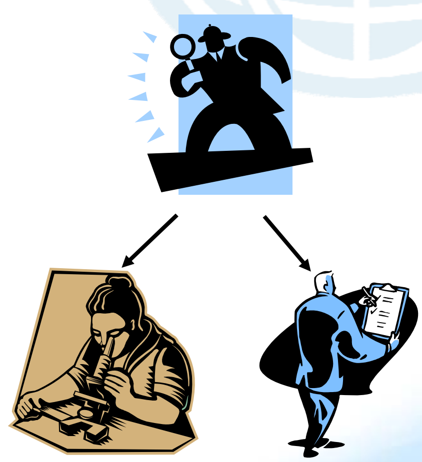
gaseous release?

Graded and Iterative

- Start simple, more complex as necessary
- Models commensurate with quantity and quality of data
- Each successive iteration should be focused on critical aspects
- Contaminant-specific, focus on those contaminants of concern
- Take credit for specific barriers or processes as necessary, defend assumptions as necessary

Sensitivity (Importance) Analysis

- Focus attention on parameters of greatest interest for conclusions (not just model)
- NCRP Committee adopted the term "Importance Analysis"
- Guide reviewers and also identify areas where continued work can build confidence in conclusions



Graded Implementation (Barrier Analysis)

Enhanced screening?

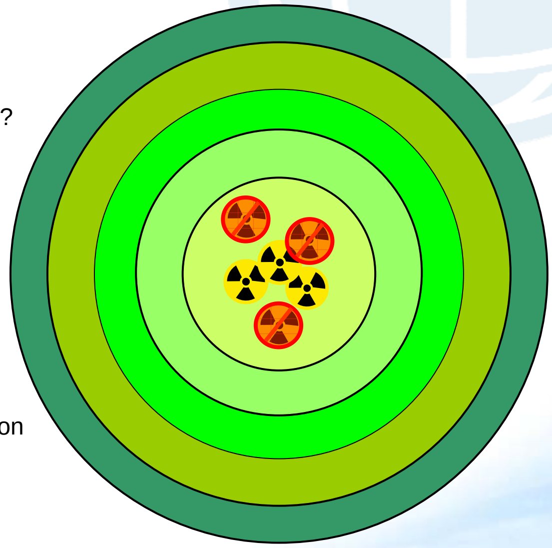
Improved cover representation?

Account for waste form (physical/chemical)?

Account for container (physical/chemical)?

Account for barriers (physical/chemical)?

More detailed site representation (physical/chemical)?



PA Maintenance

- **DOE approach to longer-term iterative process**
- **Importance analyses and results of reviews used to prioritize work**
- **Special analyses**
- **Laboratory/field studies, model development or model refinement to reduce conservatism, address key assumptions**
  - C-14 column experiment at Idaho
  - SRNL waste-form specific K_d studies for I-129

Integrate and Interpret Results

- Demonstrate understanding of the system?
- What are the critical assumptions, design features and barriers, radionuclides, etc.?
- Which options/barriers are effective and ineffective?
- "Robustness" test
- Do the results provide reasonable assurance that all radionuclides can be disposed of safely in given quantities?

Summary and Review

- LLW is regulated to a strict standard relative to everyday radiation exposures
- PA is used to help make decisions (demonstrate understanding) – many supporting activities in addition to modeling
- Persistence (time), Mobility, Toxicity and Location
- Deterministic and Probabilistic approaches are used
- Several decades of continually evolving experience on PAs (US and International) – extensive reviews are important
- Key Concepts
  - Multi-disciplinary
  - Iterative and graded process, barrier analysis
  - Source term
  - Sensitivity and Uncertainty
  - Integration and interpretation
  - PA Maintenance

Exercise 1 - Rank each category

- On the following slide, rank the different values in each column from smallest to largest
- Identify radionuclides with long half-lives (circle 3)
- Identify radionuclides with highest dose factors for each pathway (circle 3)
- Identify radionuclides that are most mobile in each soil type (low value) (circle 4 for sandy, 3 for clayey)
- Identify radionuclides that have a significant difference in mobility in sandy and clayey soil

Persistence, Toxicity, and Mobility

	Half-Life (yr)	Dose Factors (mrem/pCi)		External Dose (mrem/yr)/(pCi/g)	K_d (mL/g)	
		Ingestion	Inhalation		Sandy	Clayey
H-3	12.3	6.4E-08	6.4E-08	0	0	0
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Most limiting Ingestion and Inhalation dose factors shown here,
External Dose Factor is for a source of infinite thickness
K_d = Distribution Coefficient (soil and water partitioning) – SRS values

Exercise 2 – Persistence, Mobility, and Toxicity

- **Identify long-lived radionuclides (>30 yr)**

  Use exercise 1 slide to help with these questions
- **Discuss which dose factors are most significant for those nuclides (Is external dose important?) – use slide for exercise 1**
- **How mobile are the "key" radionuclides? – use exercise 1**
- **Would a different type of soil reduce mobility for any nuclides?**
- **Discuss management considerations for the different radionuclides**

Note that this is a simplified example for illustration, a more detailed evaluation would be conducted in practice.

Persistence (Short-and Long-lived Isotopes)

	Half-Life	Initial Ci	100 yr	500 yr	1000 yr	10,000 yr
H-3	12.3 yr	32,900	118	0.00000002	-	-
C-14	5,730 yr	13.3	13.1	12.5	11.8	4
Co-60	5 yr	1,970	0.002	-	-	-
Ni-59	76,000 yr	132	131.9	131.4	130.8	120.5
Ni-63	100 yr	24,200	12,100	760	24	-
Cs-137	30 yr	2.7	0.3	0.00003	-	-

"-" < 1E-9 Ci

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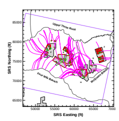
We Put Science To Work

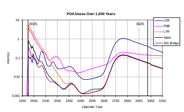
SRS DOE 435.1 Composite Analysis

Mark Phifer

Senior Fellow Engineer

May 18, 2010





Performance Assessment Educational Forum

SRNL-STI-2010-00281

Why are Both a PA and a CA Needed?

- **Performance Assessment:**
  - An analysis of **a single** radioactive waste disposal facility
  - Conducted to demonstrate there is a reasonable expectation that performance objectives established for the long-term protection of the public and the environment will not be exceeded following closure of the facility.
- **Composite Analysis**
  - An analysis that accounts for **all sources** of radioactive material that may contribute to the long-term dose projected to a hypothetical member of the public from an active or planned low-level waste disposal facility.
  - The analysis is a planning tool intended to provide a reasonable expectation that current low-level waste disposal activities will not result in the need for future corrective or remedial actions to ensure protection of the public and the environment.

SRS Composite Analysis (CA): What is it?

The SRS CA is an end state, public dose projection (to provide reasonable expectation of public radiological protection), required by DOE 435.1:

- **Cumulative effects of interaction of all radioactive sources anticipated to remain at SRS's projected end state:**
  - PA Facilities (LLW disposal, tank closure, and TRU disposal)
  - In combination with all other actions that would result in end state residual radioactive material (e.g., CERCLA, RCRA, and D&D)
- **Evaluated at site boundary points of assessment (POA) over minimum 1,000 year assessment period (AP)**
- **Performance measures:**
  - 100 mrem/year primary dose limit
  - 30 mrem/year administrative dose constraint

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SRS Performance Assessment Facilities

SRS Performance Assessment (PA) Facilities:

- **E-Area Low-Level Waste Facility (ELLWF)**
- **Saltstone Disposal Facility (SDF)**
- **F-Tank Farm (FTF)**
- **H-Tank Farm (HTF)**

Potential SRS PA Facilities (based on final disposition):

- **TRU Pad 1 – Pu-238 waste from Mound and LANL**
- **Building 235-F (FAMS) – Production of Pu-238 heat sources**

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SRS CA Quick Facts

- 152 source units modeled
- ~ 1,300 pages long
- 26 month effort
- 24 member CA Core Team to provide oversight (DOE-SR, SRNL, SRR, RI&BM, SWM, ACP (ER and D&D))
- 37 preparers (SRNL, SRR, ACP, SREL)
- 24 supporting CA reports
- Over 450 references
- 3 separate reviews (CA Core Team, DOE-SR, and DOE-HQ LFRG)

CA Summary

- Disciplined, well documented implementation
- Significant oversight and review
- Deterministic (base case and sensitivity) and probabilistic (uncertainty) analyses
- Maximum deterministic SRS end state dose to public is 3 mrem/year (i.e., 10% of the 30 mrem/year dose constraint)
- Sensitivity and uncertainty analyses provide great confidence that dose constraint will not be exceeded
- Provides a risk-based management tool

CA Implementation

- **CA Planning and Implementation Documents:**
  - Program Plan (defined tasks)
  - Execution Plan (defined method of implementation)
  - Quality Assurance Plan (defined QA controls)
  - Composite Analysis Criteria and Comments Matrices (defined applicable criteria)
- **CA Steering Team (7 members):**
  - CA policy and strategic issues
  - Review and approval
  - Interface with DOE-SR and the DOE LFRG

CA Implementation (continued)

- **CA Core Team (24 members):**
  - Recommendations on CA policy and strategic issues
  - Technical oversight, direction, and review
  - Radionuclide source custodial organization representation (Representatives for solid waste, environmental restoration, deactivation and decommissioning, liquid waste, and DOE-SR)
- **CA Task Teams (37 preparers):**
  - Implement and document (i.e. task report) each CA task
  - Report to the CA Core Team

CA Quality Assurance Controls

- Organization
- Document Control
- Software Quality Assurance
- Radionuclide Source Locations and Inventory QA
- Technical Design Check Process
- CA Archive

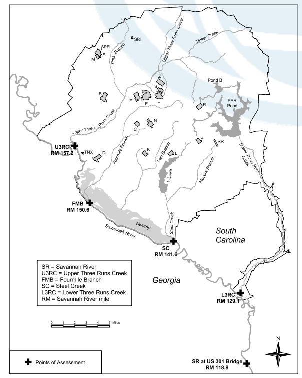
SRS Quick Facts

- 310 square miles
- 5% of area developed
- 16 operating areas
- 95% of area undeveloped
- Five major watersheds draining into the Savannah River
- Public exposure location: Stream mouths and Savannah River

SRS Land Use Plans and CA POAs

SRS Land Use Plan

(End State Vision; SRS Comprehensive Plan/Ten Year Site Plan)



SRS CA Points of Assessment

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Primary Screening Analyses

- **Transport Pathways Screening: 50 pathways screened to 2 primary pathways: 1) Source leaching and 2) groundwater transport to surface streams**
- **Exposure Scenario Screening: Recreational and residential bound exposures, since exposure due to contact with, and use of, contaminated surface water**
- **Radionuclide Screening: 849 radionuclides considered reduced to 49 parents to be modeled**
- **D&D Facility Screening: D&Ded Facilities with radionuclide concentrations less than MCL directly beneath them screened out (31 facilities)**

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Inventory Development

Extensive custodial organization (solid waste, environmental restoration, deactivation and decommissioning, liquid waste, and DOE-SR representatives) involvement to:

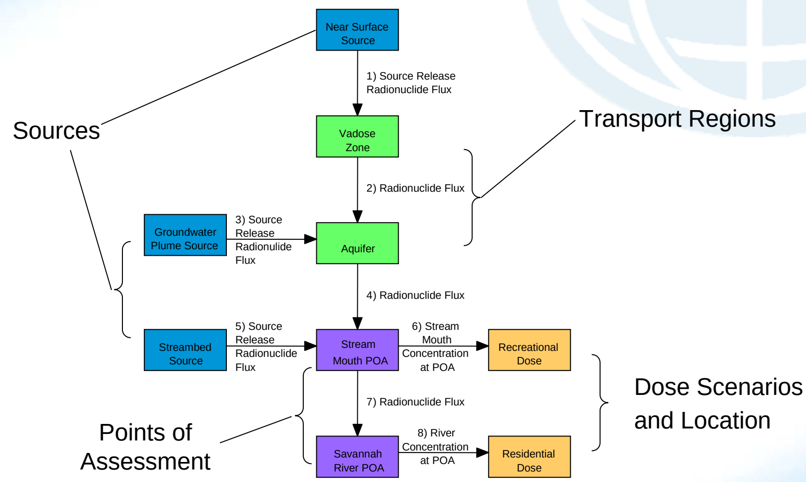
- **Identify facilities and waste sites with projected end state radionuclide inventories**
- **Quantify end state inventories**

Inventory Development (continued)

Inventory Estimate Hierarchy:

- **Existing documented inventories**
- **Developed from existing sampling and analysis data**
- **Developed from inventories of similar facilities/waste sites**
- **Developed from SAR operational inventories**

CA Conceptual Model

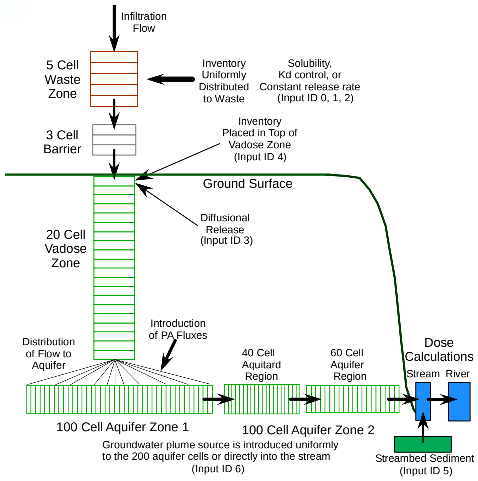


CA Modeling Approach

- **1-D abstraction from 3-D flow models**
- **Graded approach**
- **Hybrid modeling approach using GoldSim™ for both transport and dose modeling (152 sources) :**
  - Reasonably-conservative best estimate deterministic base case:
    - Generic Release Model
    - Source Release Modeling
  - Deterministic sensitivity cases and probabilistic (uncertainty) modeling to aid in the interpretation of the deterministic base case results

CA Transport Module

Schematic Representation of CA GoldSim™ Transport Module



Generic Release (108 sources):

- **Inventory on top of vadose zone**

Source Release (44 sources):

- **Source with generic release >0.1 mrem/yr**
- **More accurately account for radionuclide release mechanism**

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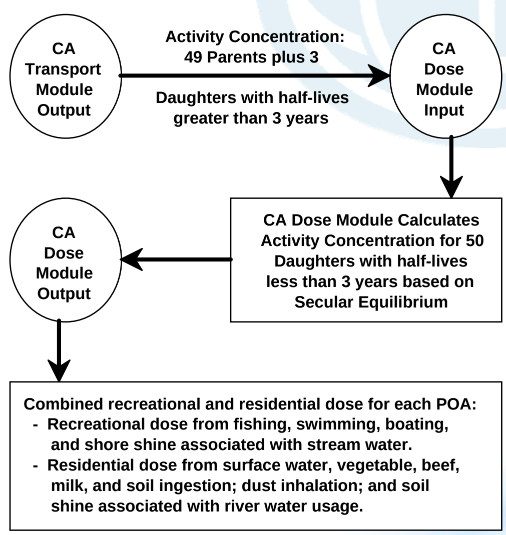
CA Dose Module

GoldSim™ Dose Module calculates a combined recreational and residential dose for each POA.



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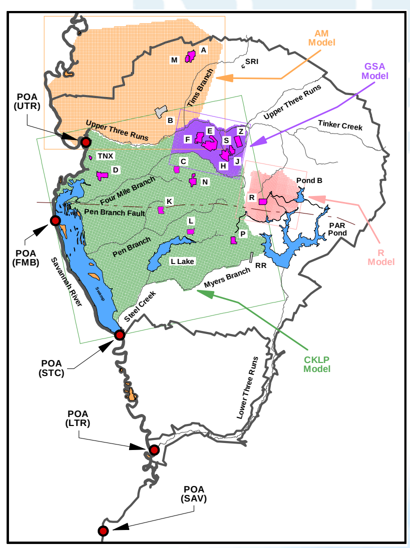
Input Data

- Inventories
- Infiltration and distribution
- Porosity, density, tortuosity and saturation and distribution
- K_d and distributions and CDP correction factors
- Vadose zone thickness and lithology
- Aquifer flow path length, clay length, flow velocity, and flow velocity distribution
- Average stream and river flow and distributions
- Radionuclide decay chains, branching fractions, half lives and molecular weights
- Bioaccumulation (transfer factors) and dose conversion factors
- Human exposure parameters and consumption rates and distributions

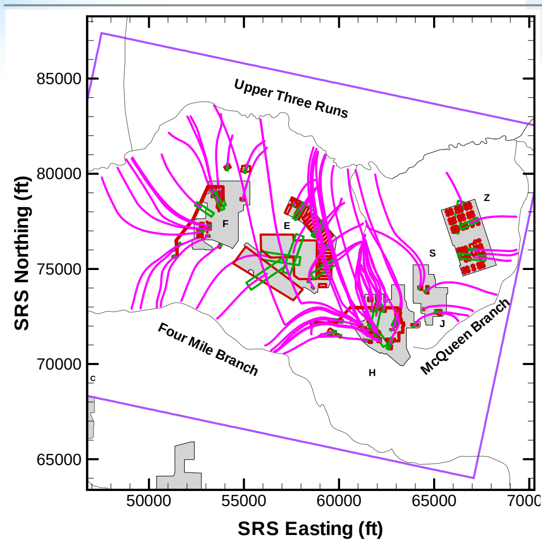
Input Data: Aquifer Flow Path Parameters

Existing 3D Flow Models Utilized

Area Flow Model	Code
AM	MODFLOW
CKLP	FACT
GSA	PORFLOW (FACT based)
R	FACT



Input Data: Aquifer Flow Path Parameters

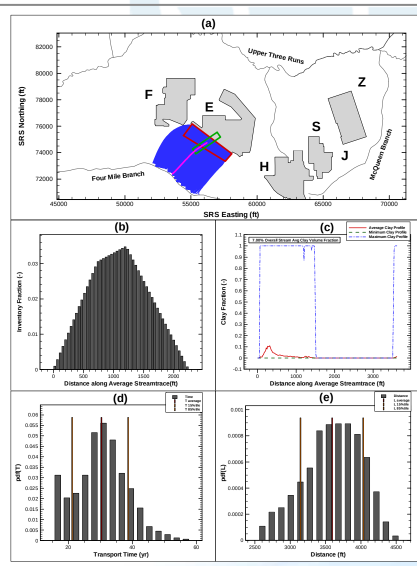


1-D abstraction from 3-D GSA PORFLOW flow model for GSA sources

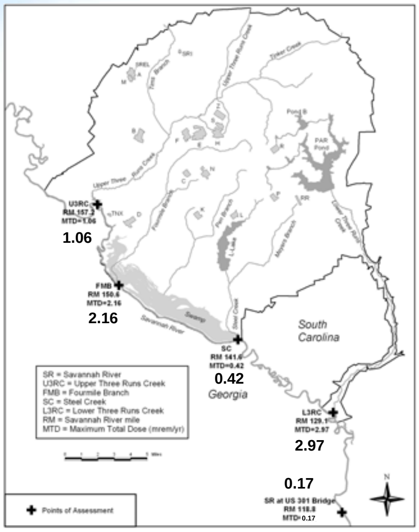
Input Data: Aquifer Flow Path Parameters (continued)

Example: Old Radioactive Waste Burial Ground (ORWBG):

a) **Streamtrace plot (~1000)**
b) **Inventory distribution (area projection)**
c) **Clay in flow path (~27 ft)**
d) **Transport time (~30 years)**
e) **Distance (~3600 ft)**



Deterministic Base Case Results



- **SRS Radionuclide Source Interaction:**
  - **81 Sources at U3RC**
  - **118 Sources at FMB**
  - **141 Sources at SC**
  - **152 Sources at L3RC**
  - **152 Sources at Savannah River (Highway 301 Bridge)**
- **Maximum of 3 mrem/year at L3RC**

Deterministic Base Case Results (continued)

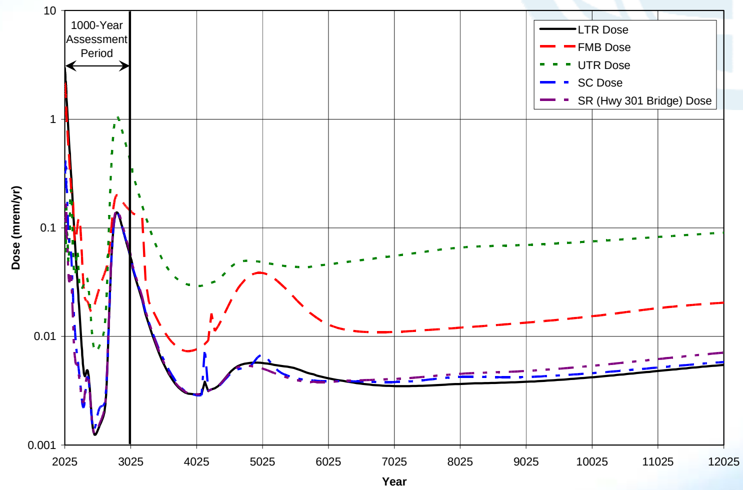
Maximum Cumulative* Dose at each POA

Point of Assessment	1000-Year Maximum Cumulative Dose mrem/yr	Next 9000-Year Maximum Cumulative Dose mrem/yr	Major Contributing Source	Major Contributing Radionuclide	Major Exposure Scenario/Pathway
Upper Three Runs	1.06	0.40	H-Canyon	Np237	Recreational / Fish Ingestion
Fourmile Branch	2.16	0.14	FMB IOU	Cs137	Recreational / Fish Ingestion
Steel Creek/Pen Branch	0.42	0.05	SC IOU	Cs137	Recreational / Fish Ingestion
Lower Three Runs	2.97	0.05	LTR IOU	Cs137	Recreational / Fish Ingestion
Savannah River	0.17	0.05	LTR IOU	Cs137	Residential / Vegetable Ingestion

* Cumulative dose includes contribution from upstream sources

Deterministic Base Case Results (continued)

Total Cumulative Dose at POAs for Extended 10,000 Year Analysis Period



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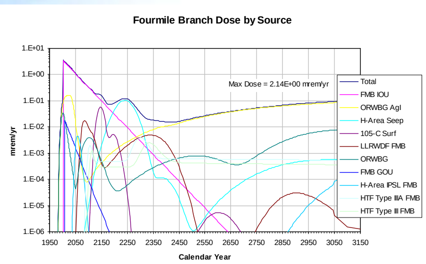
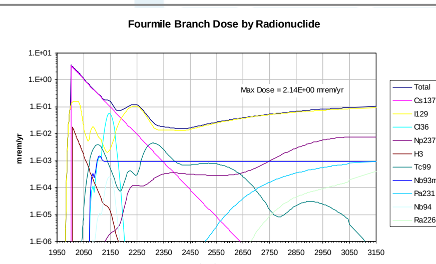
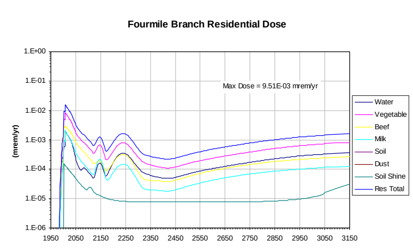
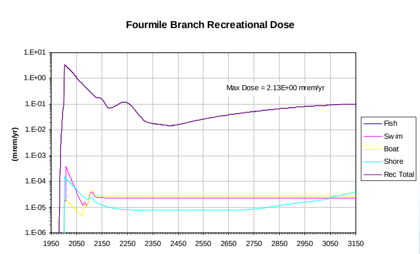
Deterministic Base Case Results (continued)









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Sensitivity Results

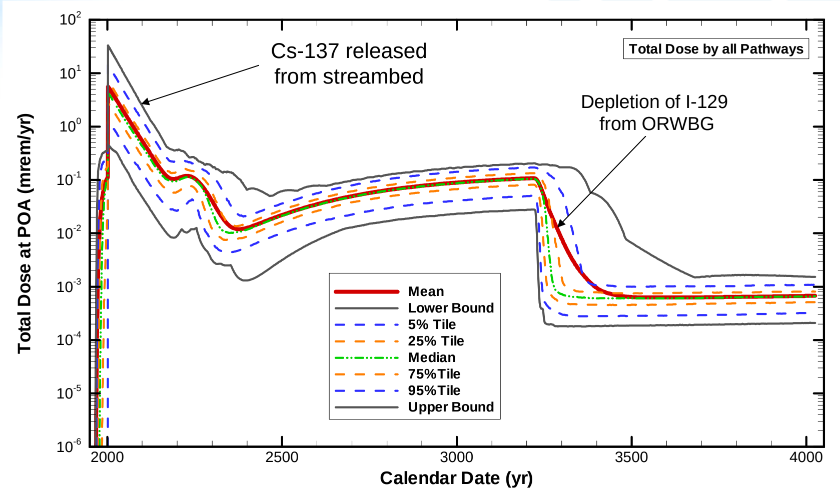
Principal Results of Sensitivity Cases

Sensitivity Case	Principal Result
Stream and River Flow	Maximum at 7Q10 (Low) Flow = 10.1 mrem/yr (LTR POA) versus 3.0 mrem/yr base case
Alternative POA	Maximum dose of 9.7 mrem/yr for Fourmile Branch POA at the edge of the SRS industrial core versus 2.2 mrem/yr base case
Source Inventory	Inventory multiplier to reach 30 mrem/yr at POAs: 10 at LTR (IOU); 14 at FMB (IOU); 28 at UTR (H-Canyon); 75 at SC/PB (IOU); and 950 in SR
Groundwater Divide	Maximum Dose Increase Factor to FMB = 42.2 (HTF dose increased from 3.3E-04 to 1.4E-02 mrem/yr with groundwater flow direction change from UTR to FMB)
Alternative End State Date	Changing the End State Date from 2025 to 2050 results in either no change or a reduction in dose at each POA
C14 Bioaccumulation Factor	Changing the C14 bioaccumulation factor from 3 L/kg to 4,500 and 50,000 L/kg had no effect on dose during 1000-yr CA assessment period
Aquifer Clay	Increase in dose without clay ranged from a factor of 0.9 to 2.8 with an average of 1.4
Maximum Dose over 100,000 years	16 significant sources have maximum doses outside the 1,000-year assessment period. The highest dose over 100,000 years is 3.6E-01 mrem/yr from the NRCDA (part 6) versus 3.7E-03 mrem/yr base case

Probabilistic Uncertainty Analysis

- **Consider sources contributing greater than 0.05 mrem/yr for each POA (17 sources)**
- **Distributions for 73 parameters:**
  - Background and engineered barrier infiltration rates
  - Material property values (porosity, density, tortuosity, and saturation)
  - Distribution coefficients (Kds)
  - Concrete aging
  - Aquifer flow velocity
  - Stream and river flow rates
  - Human exposure parameters and consumption rates

Probabilistic Uncertainty Results – FMB Example



FMB sources representing 98% of maximum base case dose

Key CA Operations Assumptions

- **Unrestricted public access and residential land use over the entire site will be prohibited in perpetuity per current SRS land use plan (DOE 2000; DOE 2005). Due to these land use controls the first publicly accessible location where radionuclide contaminated media originating from SRS can be contacted is at the mouth of the SRS streams.**
- **End states will be consistent with SRS End State Vision (DOE 2005) and Federal Facilities Agreement (FFA) for the Savannah River Site (FFA 1993).**
- **End state inventories will be consistent with CA Appendix A inventory tables.**

CA Conclusions

- **Maximum deterministic dose is 3 mrem/year (i.e., 10% of the 30 mrem/year dose constraint)**
- **Sensitivity and uncertainty analyses provide great confidence that dose constraint will not be exceeded**
- **Major contributors to the dose are Np237 from H-Canyon and Cs137 from the FMB, SC, and LTR Integrator Operable Units (IOUs)**
- **Recreation (fishing) within creek mouths is the major exposure scenario/pathway contributor to dose**

CA Conclusions (continued)

- **The CA provides management a risk based tool to help prioritize and select source actions relative to radiological protection of the public:**
  - e.g. D&D of H-Canyon should include significant removal of Np237
  - Many sources are of no significant concern relative to the public

Major Revisions from 1997 SRS CA

1997 SRS CA	2010 SRS CA Revision
GSA end state inventory	Entire SRS end state inventory
POAs: • Upper Three Runs • Fourmile Branch • Savannah River	POAs: • Upper Three Runs • Fourmile Branch • Steel Creek • Lower Three Runs • Savannah River
Exposure scenarios: • Creek mouth recreation • Savannah River recreation plus drinking water	Base case exposure scenarios: • Creek mouth recreation plus Savannah River residential • Savannah River recreation plus residential
Base case and sensitivity analyses performed.	Base case, sensitivity, and uncertainty (probabilistic) analyses performed.

CA Status

- November 1997 first SRS CA issued to LFRG in support of ELLWF and SDF
- October 2007 work initiated on revised SRS CA
- August 28, 2009 SRS CA Rev A issued to SRS CA Core Team for review
- September 28, 2009 SRS CA Rev B issued to DOE-SR for review
- January 14, 2010 SRS CA Rev 0 issued to LFRG for review
- April 20, 2010 SRS CA Review Report issued by LFRG Review Team recommending LFRG approval of the CA
- May 13, 2010 SRS CA and Review Report presented to LFRG
- June 10, 2010 LFRG to vote on SRS CA approval

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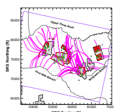
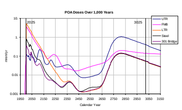
Operated by Savannah River Nuclear Solutions, LLC
We Put Science To Work

SRNL Supporting Activities

Mark Phifer
Senior Fellow Engineer

May 18, 2010



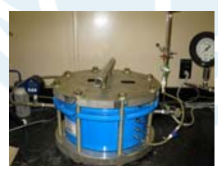


Performance Assessment Educational Forum

SRNL-STI-2010-00287

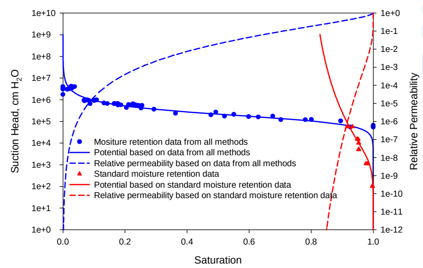
Saltstone Moisture Retention Analysis

- **Standard pressure extraction methods**
  - Used for wet end of retention curve
  - Range is from 0 to 15 bar
  - Samples are cut into wafers which are placed in contact with ceramic plates
  - Minimal drainage from cementitious samples in 0 to 15 bar pressure range
  - Long equilibrium times
- **Measured vapor pressure (chilled mirror humidity sensor)**
  - Used mainly for drier end of retention curve
  - Range is from 0 to 3000 bar
  - Sample is pulverized for analysis. In drier samples, moisture potential is controlled more by adsorption than capillarity
  - Measures the total moisture potential of sample based on relative humidity in temperature controlled chamber
  - Analysis times of 20 minutes or less
- **Controlled vapor pressure**
  - Used mainly for dry end of retention curve
  - Pulverized sample placed in sealed container above saturated salt solution
  - Sample allowed to reach vapor equilibrium with relative humidity in the head space above the salt solution
  - Requires multiple salt solutions and lengthy equilibrium times



Saltstone Moisture Retention Analysis

- **Substantially different characteristic curves obtained by using data from dry end of moisture retention curve**
- **Relative permeability curve similar to literature curves for cementitious materials when dry range is included**



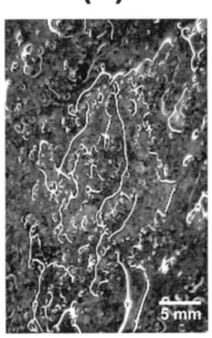
Effective Hydraulic Properties of Cracked Concrete

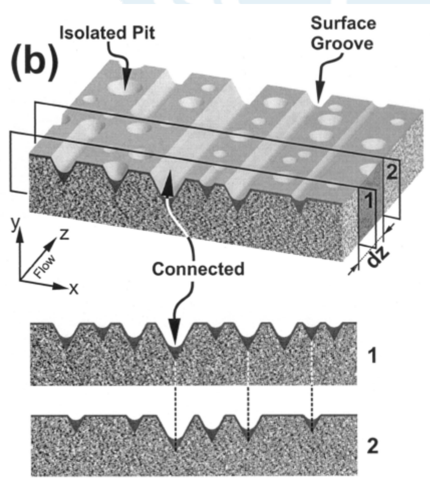
Or and Tuller (2000):

a) Wet fracture surface of Apache Leap Tuff (Arizona)

b) Idealized geometry

(a)





WATER RESOURCES RESEARCH, VOL. 36, NO. 5, PAGES 1165–1177

Effective Hydraulic Properties of Cracked Concrete

Three flow regimes:

Saturated flow

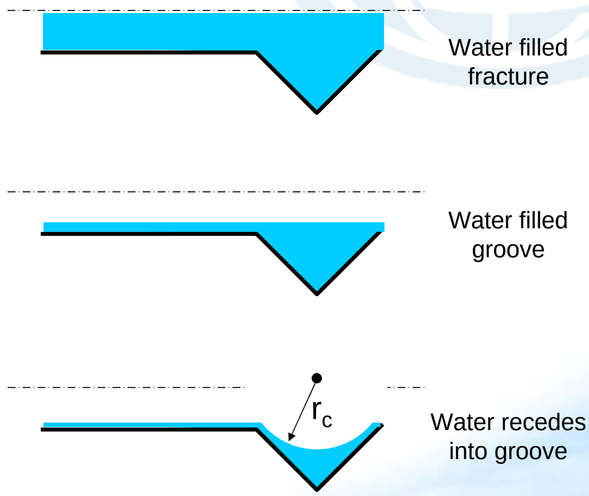
$$P > -\frac{2\sigma}{b}$$

Thick film flow

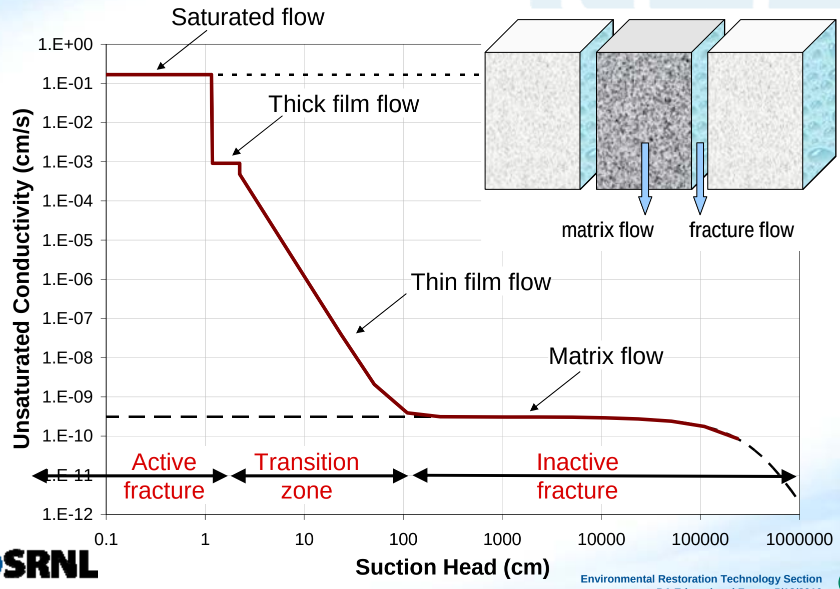
$$-\frac{\sigma}{r_c} < P < -\frac{2\sigma}{b}$$

Thin film flow

$$P < -\frac{\sigma}{r_c}$$



Effective Hydraulic Properties of Cracked Concrete



SRS Liquid Waste Program Performance Assessment Process

May 18, 2010

Virginia Dickert
Manager, Closure & Waste Disposal Authority

Acronym List

ARP	Actinide Removal Process
DWPF	Defense Waste Processing Facility
GWSB	Glass Waste Storage Building
LFRG	Low Level Waste Federal Review Group
MCU	Modular Caustic Side Solvent Extraction Unit
MST	MonoSodium Titanate
PA	Performance Assessment
SPF	Saltstone Production Facility

Savannah River Remediation

We do the right thing.

Background

- Savannah River Remediation (SRR) assumed responsibility for the Liquid Waste Contract on July 1, 2009
- SRR's mission is to operationally close **all** 22 of the old-style tanks within eight years
- The associated regulatory closure requirements are a key focus of this mission
- Liquid Waste Performance Assessments are a key tool supporting **risk-informed decision making**

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Savannah River Remediation

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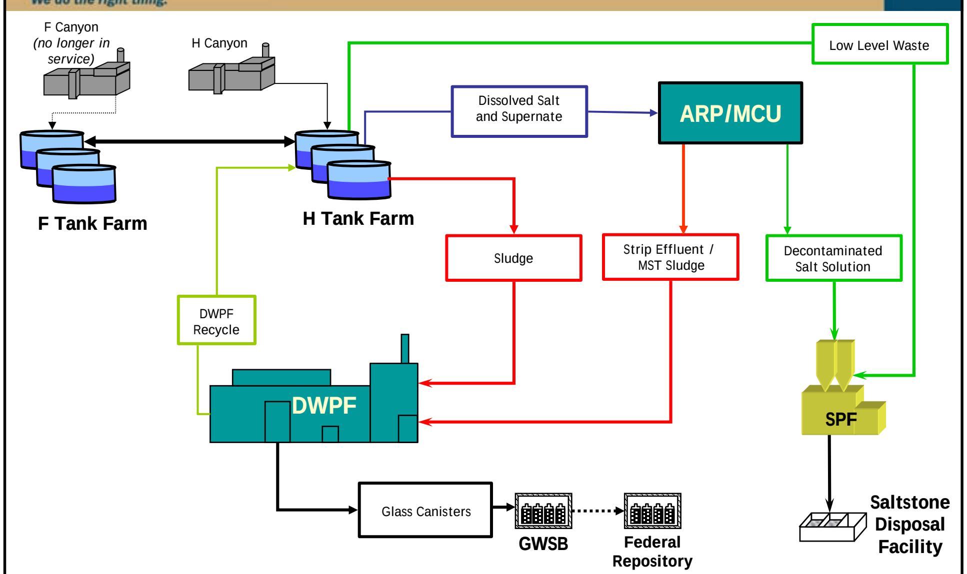
Liquid Waste System



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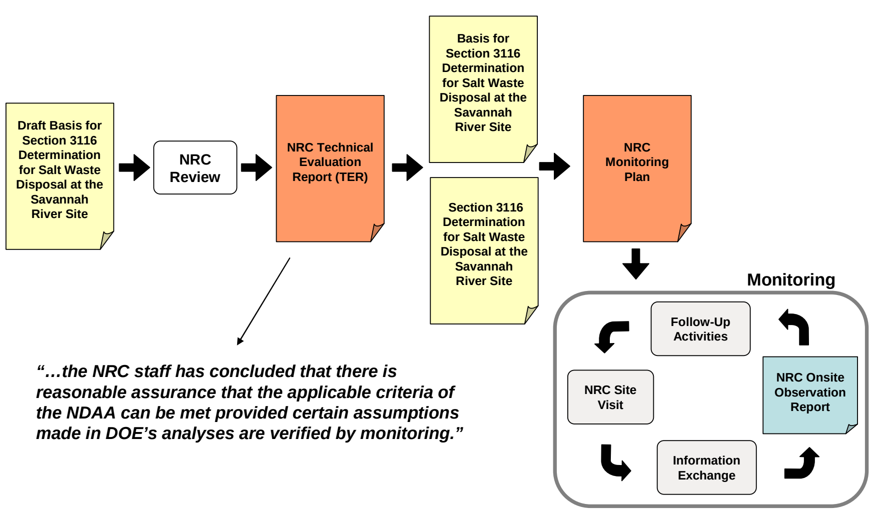
Unique Requirements

FY 2005 Ronald W. Reagan National Defense Authorization Act, Section 3116 (NDAA §3116) legislation
- Requires NRC involvement
- Review occurs in Consultation phase if prior to issuance of §3116 Waste Determination
- Review occurs during NRC Monitoring phase if after issuance of §3116 Waste Determination

NDAA §3116 Process



SRR Savannah River Remediation

We do the right thing.

PA Preparation & Approval

- Special Group within SRR dedicated to preparation of complex closure and waste disposal documentation including PAs
- Scoping meeting process used to gain early input from DOE, SCDHEC, EPA, NRC and other stakeholders
- PAs are reviewed and approved by DOE-HQ through the LFRG process

SRR Savannah River Remediation

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PA Review

- PAs are also provided to following groups for review and comment:
  - South Carolina Department of Health and Environmental Control
  - U.S. Environmental Protection Agency
  - SRS Citizens Advisory Board
- Also posted for public access

SRR Savannah River Remediation

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Summary

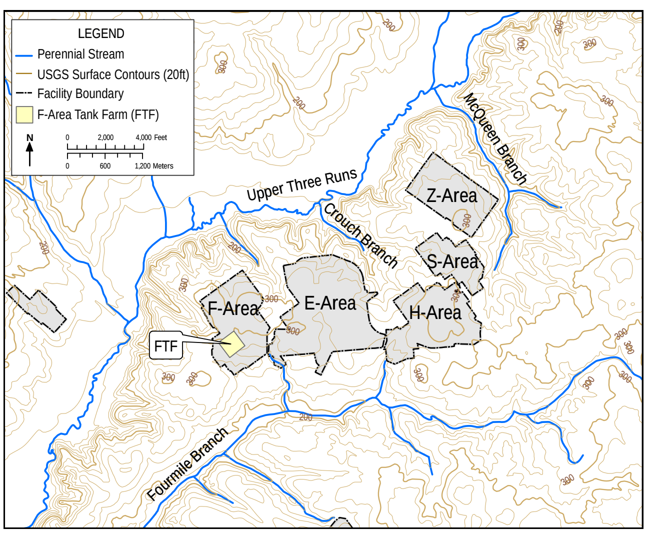
- SRR is currently in various stages of production for three PAs:
  - F-Tank Farm PA
  - Saltstone Disposal Facility PA
  - H-Tank Farm PA
- Prior to implementation, each of these PAs will have been provided to outside agencies for review and comment prior to final DOE approval and contractor implementation

Liquid Waste Performance Assessments Overview

Tom Robinson
Savannah River Remediation
Manager, Closure and Disposal Assessment
May 18, 2010

SRR-CWDA-2010-00056

General Separations Area

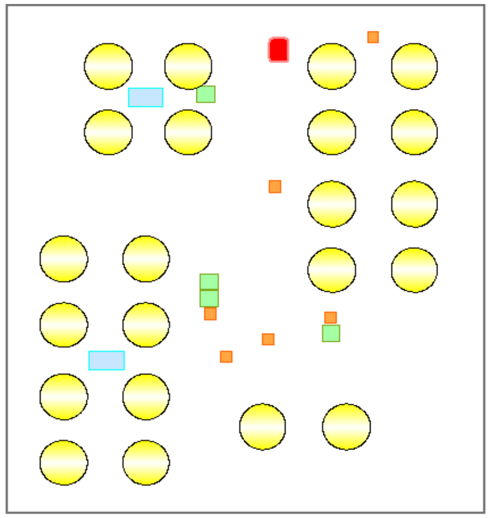


FTF Facility

F-Tank Farm is approximately 22 acres in size

F-Tank Farm PA considers:

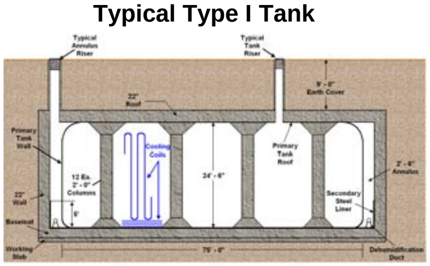
- 22 underground liquid waste storage tanks
- 2 Evaporator systems
- 6 Diversion boxes
- 3 Pump tanks
- 1 Catch tank
- 1 Concentrate Transfer Tank
- ~45,000 feet of transfer lines



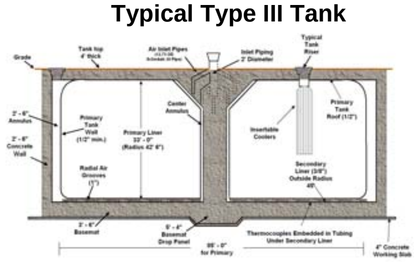
[NOT TO SCALE]

FTF Tank Types

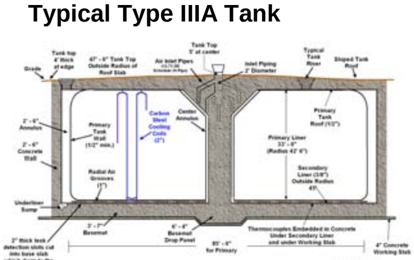
Typical Type I Tank



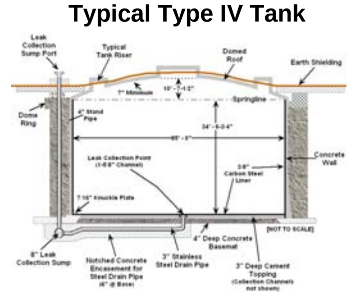
Typical Type III Tank



Typical Type IIIA Tank



Typical Type IV Tank



Groundwater Modeling Flow Paths

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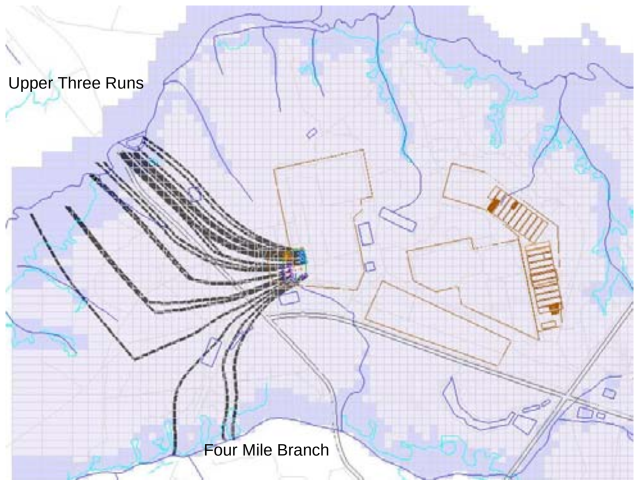

FTF Flow Path-Close-In View

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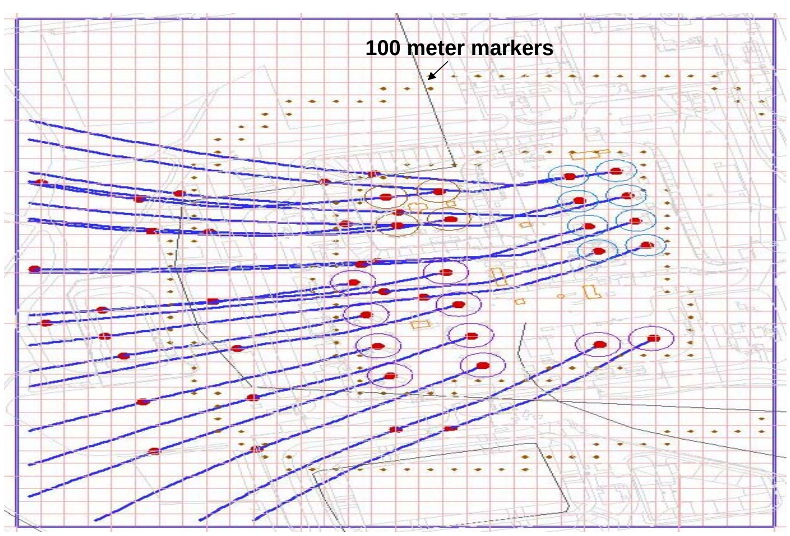

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FTF Modeling Approach

- Used Hybrid modeling approach
- Deterministic evaluation used to assess base case and perform sensitivity analyses including barrier analysis
- Stochastic evaluation used for Uncertainty Analysis and Sensitivity Analysis
  - Included analysis of highest individual realizations from Uncertainty Analysis
- Hybrid approach supported more comprehensive and flexible assessment
  - Also allows for benchmarking of two models

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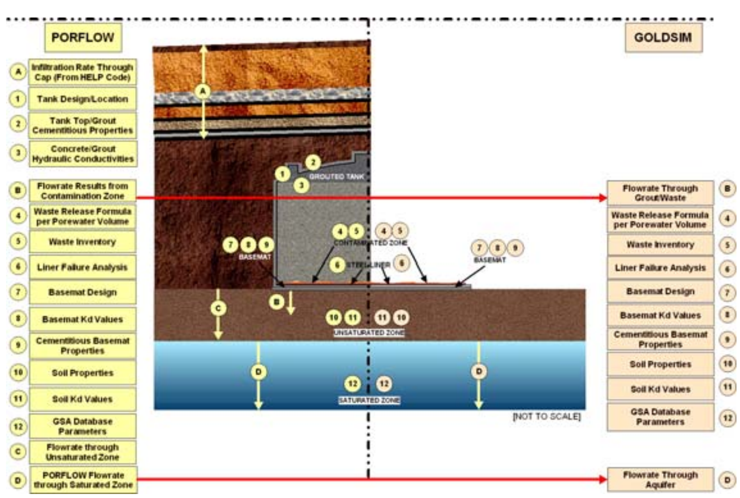
FTF Conceptual Model Inputs



MOP at 100m Peak Groundwater Pathway Dose Results within 10,000 Years

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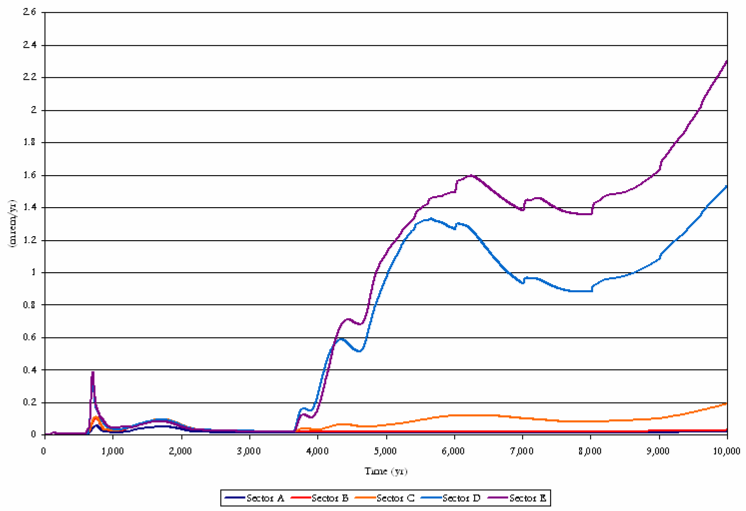
Performance Objective is 25 mrem peak dose in 10,000 years



MOP at 100m Peak Groundwater Pathway Dose Results within 20,000 Years

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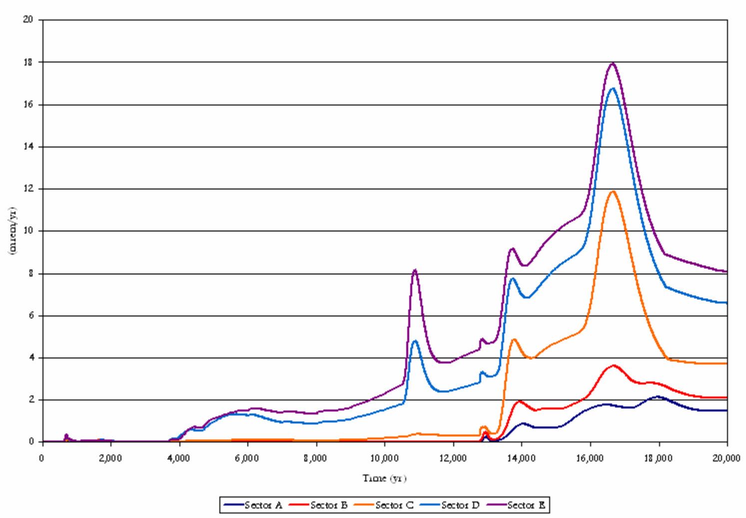

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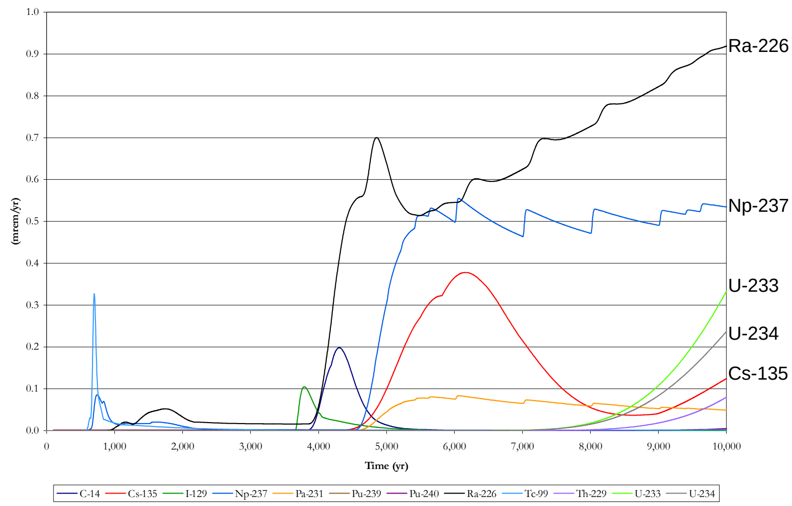
Individual Radionuclide Contributors to the Sector E, 100m Peak Groundwater Pathway Dose, 10,000 years



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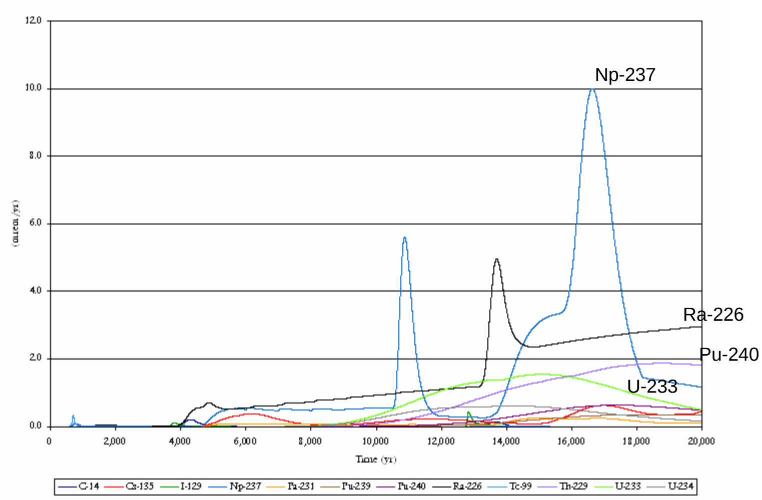
Individual Radionuclide Contributors to Sector E, 100m Peak Groundwater Pathway Dose, 20k yrs



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Barrier Analysis

- Comprehensive barrier analysis performed using PORFLOW deterministic model
- Provides information about the contribution of individual barriers
  - Non-mechanistic evaluation of 15 cases
  - Evaluated three tank types and eight radionuclides
  - Included closure cap, grout, contamination zone, liner and tank concrete
  - Included evaluation of nominal, partially degraded and fully degraded conditions for materials

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Barrier Analysis Insights

- Impact of individual barrier can vary significantly based on radionuclide involved
- Closure cap has minimal effect in 10,000 years
- Contamination zone as a barrier can be significant depending on radionuclide but is less dependent on tank type
- Liner as a independent barrier has variable impact depending on tank type and radionuclide
- Grout impact as an independent barrier less dependent on tank type or radionuclide

FTF PA Summary

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- Significant benefit from hybrid approach and performance of different analyses to provide understanding of importance of individual system features
- FTF PA Rev. 1 is currently undergoing external review
- Analysis shows planned FTF closure activities result in peak doses/concentrations well below regulatory requirements

H Tank Farm PA Status

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- H Tank Farm PA is under development
- HTF PA scoping meeting was held 4/20-21
- HTF PA Rev. 0 will be issued for review and comments 3/31/2011

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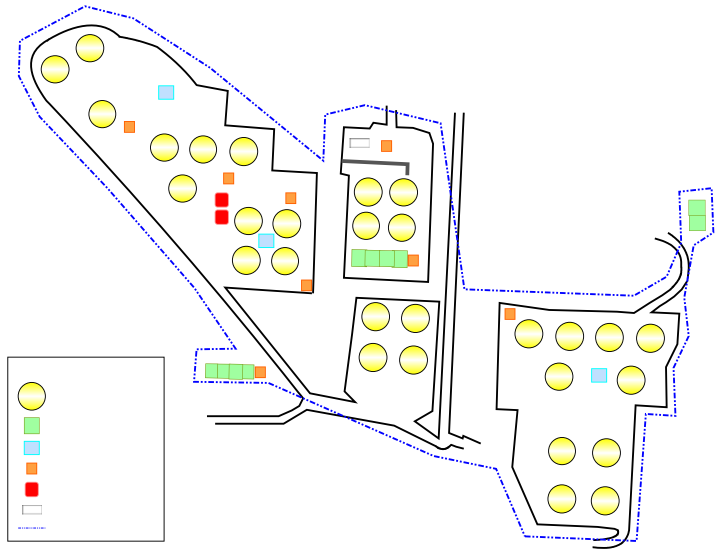
H-Tank Farm Layout



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H-Tank Farm Aerial Photo

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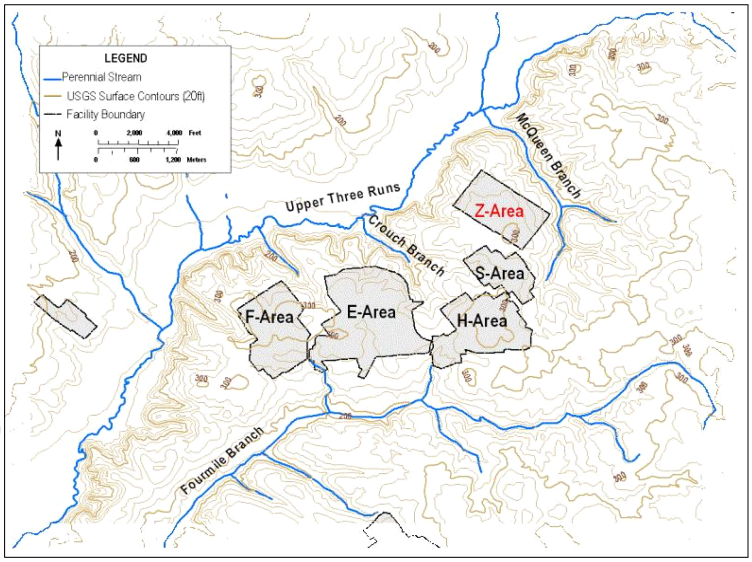
General Separations Area



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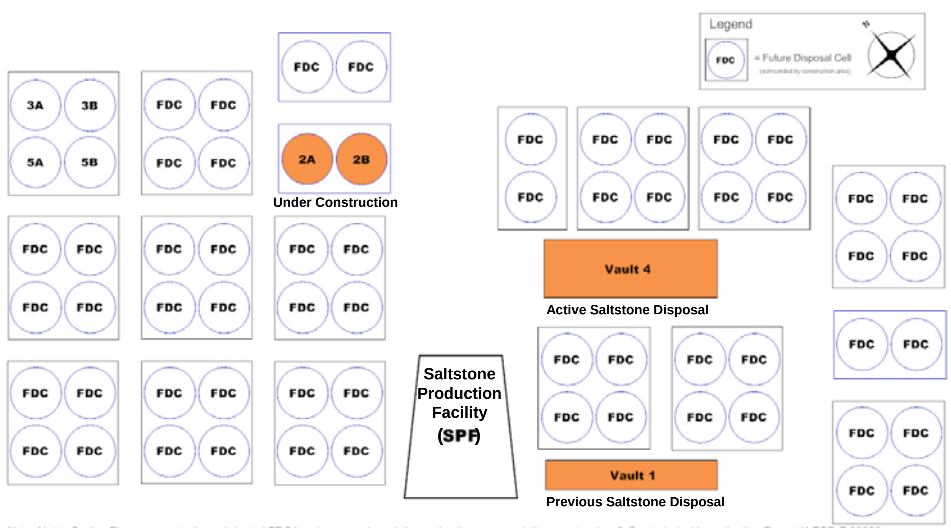
Saltstone Disposal Facility (SDF)



Note: Not to Scale - Figure presents the anticipated FDC locations, numbered disposal units are per existing construction & Geotechnical Investigation Report K-ESR-Z-00002

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Existing Disposal Units

Vault 1
Six 100'x100' cells
Approximately 25' high

Vault 4
Twelve 100'x100' cells
Approximately 26' high

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Vault 2–Future Disposal Cells

SRR Savannah River Remediation

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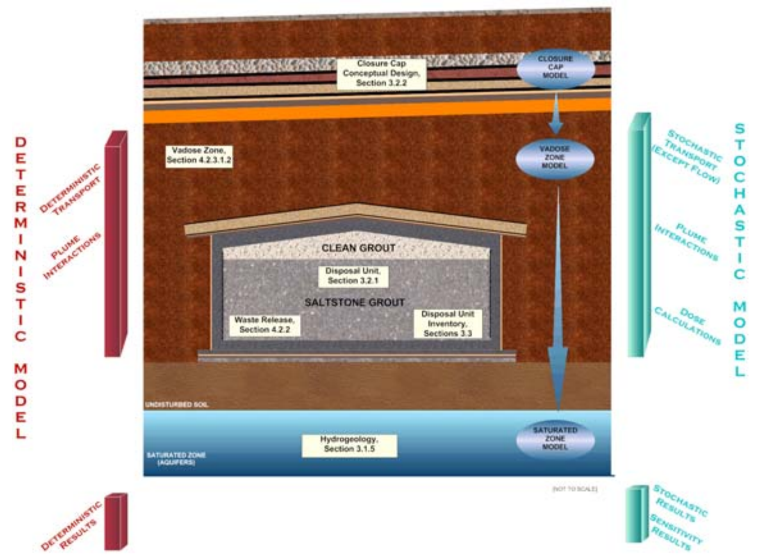
SPF Conceptual Model



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Model Example: Closure Cap

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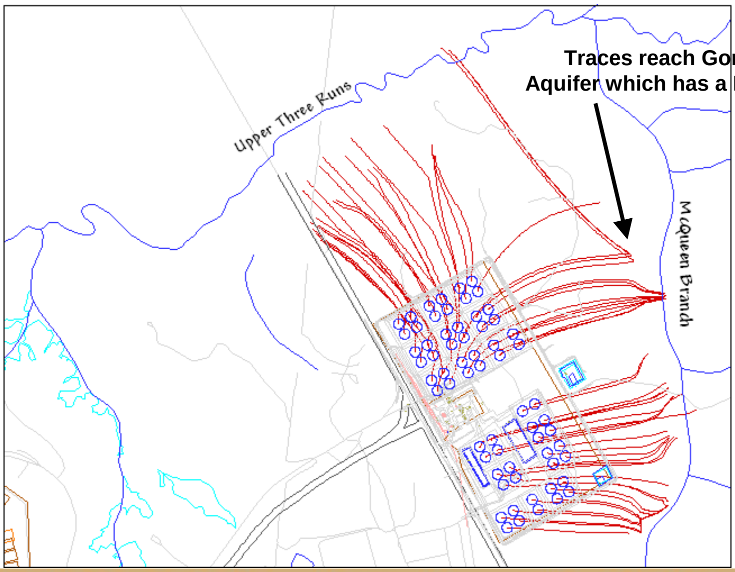
Far-Field Flow Path lines



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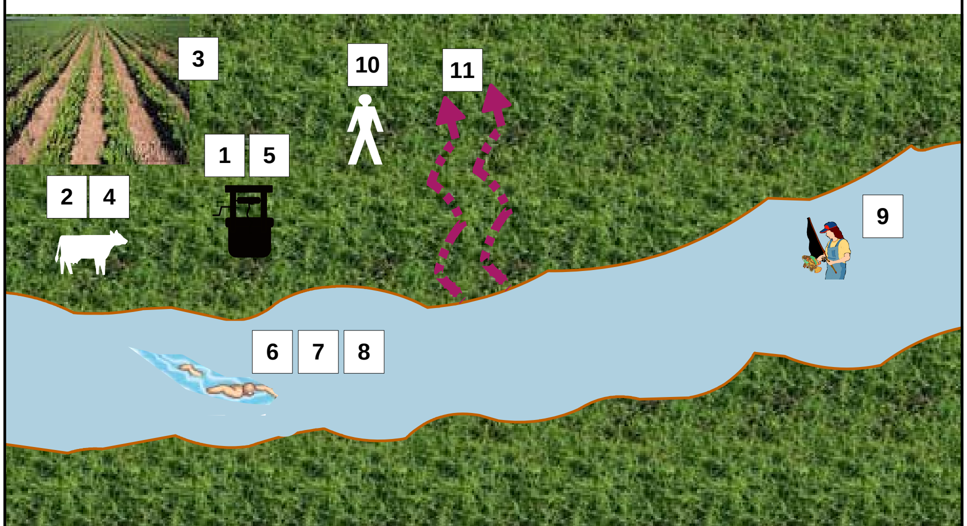
Member of Public Exposure Pathways



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SDF PA Results

Performance Measure		Limit	Result
DOE O 435.1-1	**All-Pathways Dose**	**25 mrem/yr**	**1.4 mrem/yr**
DOE O 435.1-1	**Intruder Dose**	**500 mrem acute** **100 mrem/yr chronic**	**N/A – acute** **1.9 mrem/yr - chronic**
DOE O 435.1-1	**Air Pathways Dose**	**10 mrem/yr**	**<4E-09 mrem/yr**
DOE O 435.1-1	**Radon Flux**	**20 $pCi/m^2/s$** **At ground surface**	**2.0E-13 $pCi/m^2/s$**
DOE O 435.1-1 And Safe Drinking Water Act	**Groundwater Protection - Maximum Contaminant Levels**	**Total β/γ 4 mrem/yr** **Total α 15 pCi/L** **Total U 30 mg/L** **Total Ra 5 pCi/L**	**1.16 mrem/yr** **1.9 pCi/L** **8.0E-9 mg/L** **1.9 pCi/L**
10 CFR 61.41	**All-Pathways Dose**	**25 mrem/yr**	**1.4 mrem/yr**
10 CFR 61.42	**Intruder Dose**	**500 mrem/yr**	**1.9 mrem/yr**

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SDF PA Conclusions

- SDF PA has been completed and is currently in the external review process
- Planned SDF disposal activities result in peak year doses / concentrations well below regulatory requirements

Saltstone Disposal Facility Performance Assessment

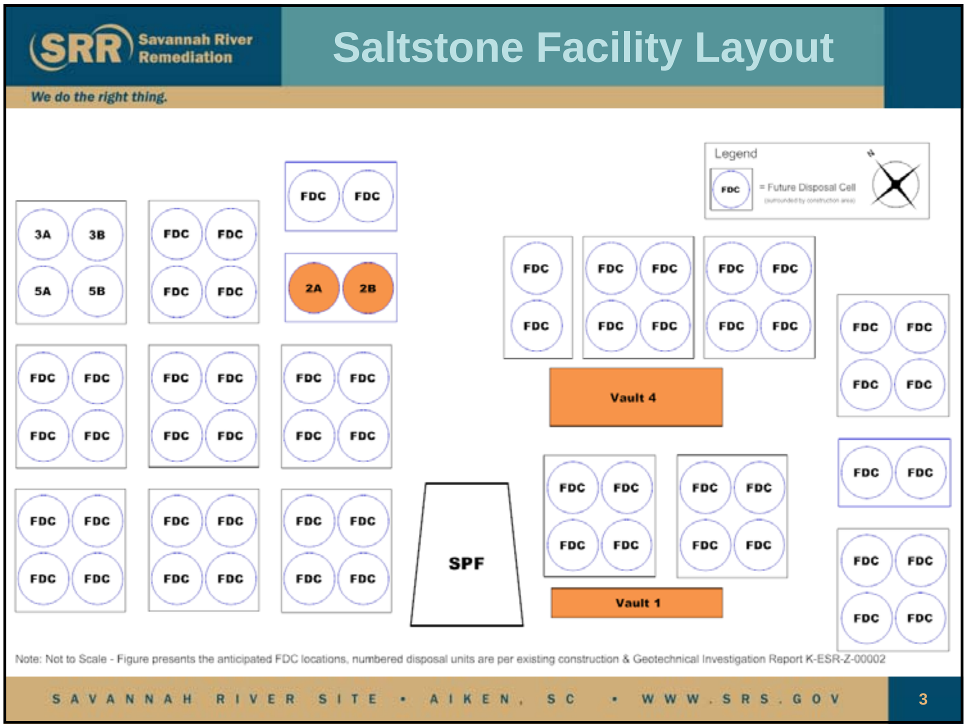
Example of PA Concepts

Kent Rosenberger
Savannah River Remediation
Closure and Waste Disposal Assessment
May 18, 2010

SRR-CWDA-2010-00055

Saltstone Disposal Facility PA

- Influences on SDF PA results:
  - Natural processes – plume interactions
  - Engineered barriers – concrete disposal units, closure cap
  - Waste form – reducing grout
  - Chemistry – distribution coefficients (K_d)
  - Degradation processes – grout chemistry, grout/concrete physical properties, closure cap infiltration


SRR Savannah River Remediation
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Saltstone Facility Layout
Legend
FDC = Future Disposal Cell
N
3A
3B
5A
5B
2A
2B
FDC
Vault 4
Vault 1
SPF
Note: Not to Scale - Figure presents the anticipated FDC locations, numbered disposal units are per existing construction & Geotechnical Investigation Report K-ESR-Z-00002
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3


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Saltstone Facility Layout
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4

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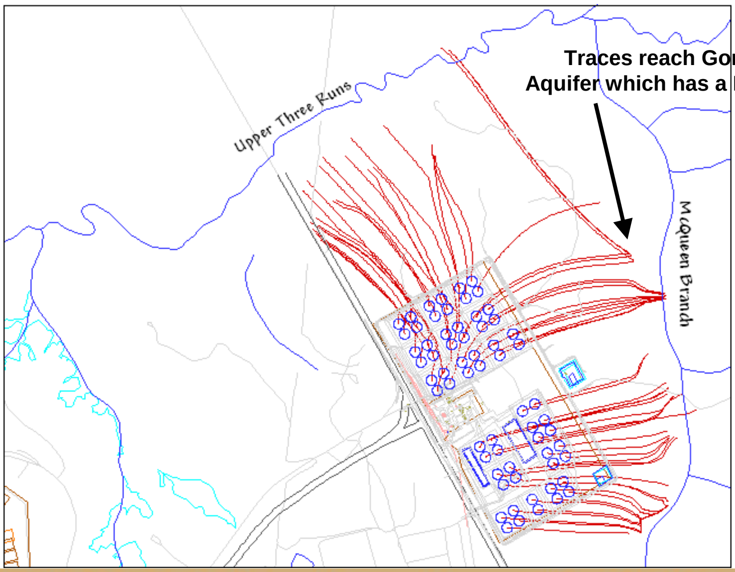
Plume Interactions & Timing



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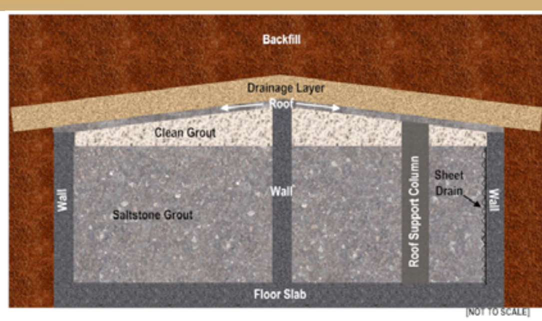
Engineering Barriers - Vault 4



Model Zone	*Thickness*	*Modeled Material*
Backfill Layer	**24 feet (min)**	**Backfill**
Drainage Layer	**2 feet**	**Sand**
Roof (2 % slope)	**4 inches**	**Ordinary Concrete**
Clean Grout Cap	**17.4 inches (min)**	**Saltstone**
Saltstone	**24.75 feet**	**Saltstone**
Floor Slab	**2 feet**	**High Quality Concrete**
Wall	**18 inches**	**High Quality Concrete**

Savannah River Remediation

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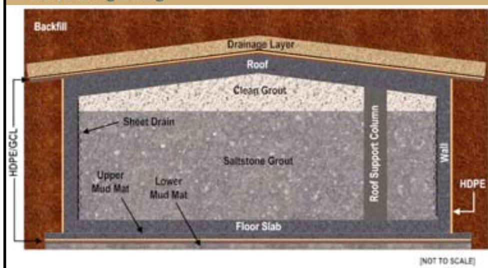
Engineered Barriers – Future Disposal Cells



Model Zone	*Thickness*	*Modeled Material*
Backfill Layer	7 feet (min)	Backfill
Drainage Layer	2 feet	Sand
HDPE-GCL	1 inch	HDPE-GCL
Roof (2 % slope)	8 inches	High Quality Concrete
Clean Grout Cap	2 feet (min)	Saltstone
Saltstone	20 feet	Saltstone
Floor Slab	8 inches	High Quality Concrete
Upper Mud Mat	4 inches (min)	High Quality Concrete
HDPE-GCL	1 inch	HDPE-GCL
Lower Mud Mat	4 inches	Low Quality Concrete
Radial Orientation		
Wall	8 inches	High Quality Concrete
Shotcrete	6 inches	Backfill
HDPE	1 inch	HDPE

Savannah River Remediation

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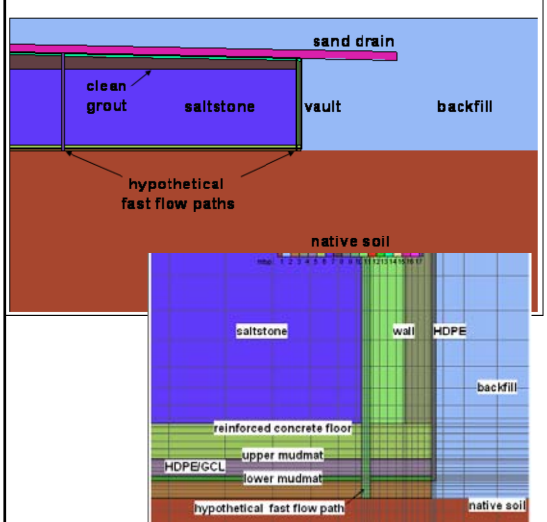
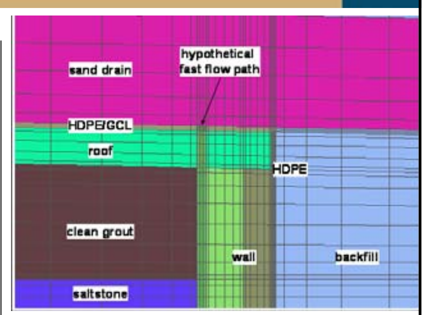
Engineered Barrier Modeling



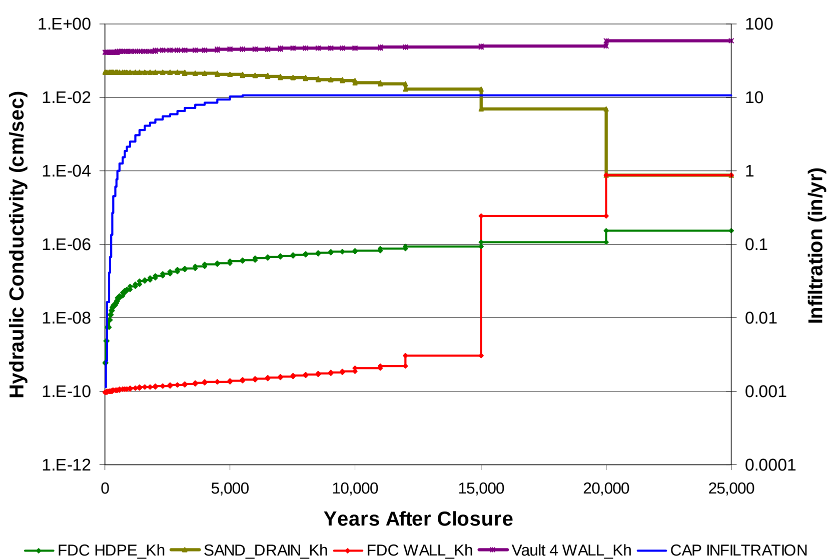


Waste Form & Chemistry

- **Reducing capacity and high pH of cement-impacted pore water has an influence on mobility of many radionuclides (cementitious material K_d values in mL/g)**

Radionuclide	Reducing high pH	Oxidizing high pH	Oxidizing low pH
Tc-99	5,000	0.8	0.5
I-129	9	15	4
Ra-226	3	100	70
Pu-239	10,000	10,000	1,000

Degradation of Barriers



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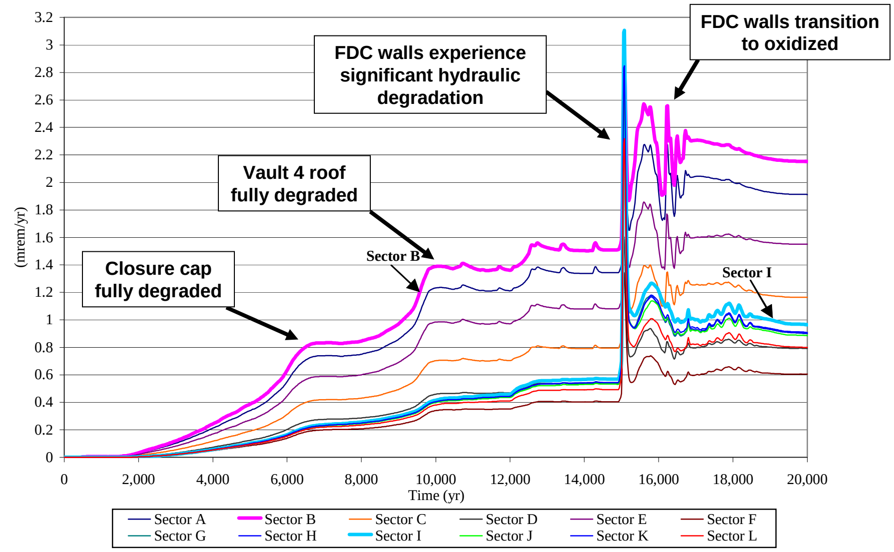
Modeling Results 20,000 yr



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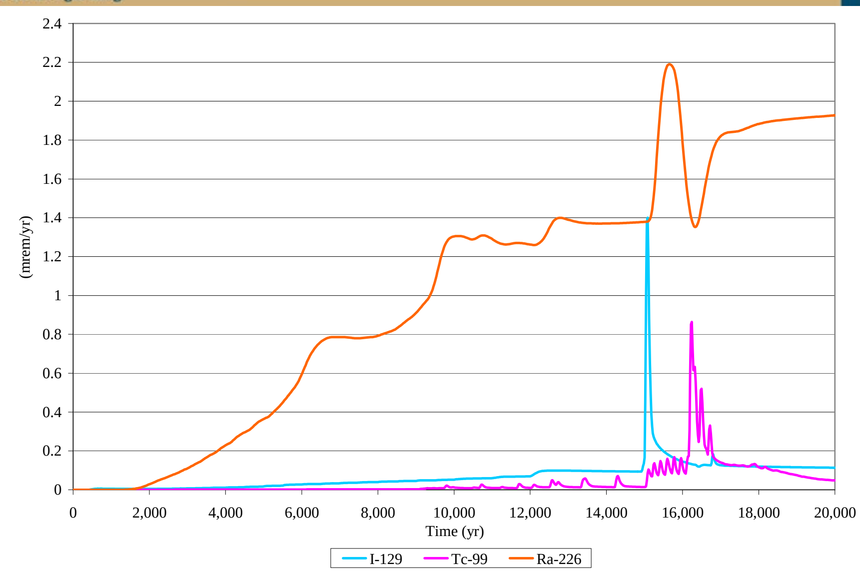
Modeling Results-Sector B



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Conclusions

- SDF PA incorporates many of the concepts discussed during today's presentations
- PA results are influenced by many factors including inventory interactions, engineered barriers, waste form, and chemistry
- Due to temporal and spatial influences PA results are complex
- By examining all of the factors the results can be understood and provide a valuable resource

NRC Perspective on Performance Assessment

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May 18, 2010

Performance Assessment

- **IS…**
  - A tool for understanding how a site's natural and engineered features retain radioactive materials.
- **IS NOT…**
  - A subjective process to produce a result supporting a pre-determined decision (e.g., "the site is safe")
  - A substitute for a lack of key data

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A PA should be used:

- To estimate radionuclide release and transport, and potential radiation dose to an average member of a critical group;
- To evaluate the effects of uncertainty and variability; and
- To provide information to decision makers.

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Objectives for NRC PA Reviews

- The primary objectives of NRC's PA review are to:
  - Identify risk-significant matters;
  - Explore parameter and model uncertainty;
  - Perform a risk-informed review of DOE's PA model.
- NRC will base decisions on DOE's PA model

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NDAA Criteria

1. Does not require permanent isolation in a deep geologic repository
2. Highly radioactive radionuclides are removed to the maximum extent practical
3. ***Meets 10 CFR Part 61, Subpart C performance objectives***
   – NRC's review of a DOE PA is generally focused on this last criterion

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10 CFR Part 61, Subpart C

Performance Objectives

- 61.40 General requirements
- ***61.41 Protection of the general population from releases of radioactivity***
- ***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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10 CFR 61.41

Protection of the general population from releases of radioactivity

- Some areas of NRC review include:
  - How radioactive material might be released in the future
  - How future populations may be exposed to radioactive material
  - Understanding how site features and environmental processes influence future human doses

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10 CFR 61.42

Protection of individuals from inadvertent intrusion

- NRC staff review:
  - The behavior of hypothetical intruders, timing and dose pathways assumed.
  - The operations, procedures, materials, barriers, and structures designed to provide protection.

10 CFR 61.44

Stability of the disposal site after closure

- Stability of waste and the site is important to ensure disruptive processes like erosion, flooding, and seismicity, are considered in siting, design, use, operation, and closure of the disposal facility.

PA Review Procedures

NUREG-1854 – NRC Staff Guidance

- Scenario Selection and Receptor Groups
- Computational Models and Computer Codes
- Uncertainty/Sensitivity Analysis for Overall PA
- Evaluation of Model Results
- ALARA Analysis
- Inadvertent Intrusion

NRC Review Procedures

Examples

- Under “Specific Technical Review Procedures,” are review procedures for Climate and Infiltration
- Within the Climate review area, NRC staff would, for example, confirm that precipitation estimates are based on long-term precipitation data for the disposal facility

NRC Review Procedures

Examples

- Under “Computational Models and Computer Codes,” is a review area on Modeling Approach: Probabilistic or Deterministic.
- Within this area, NRC examines DOE’s choice of either a deterministic or probabilistic approach to compliance with the performance objectives

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NRC PA review

Results

- Through the PA review, NRC staff develops an understanding of factors that are important to NRC staff's finding of reasonable assurance that the 10 CFR Part 61 performance objectives are being (or will be) met.
- These risk-significant factors, called "key monitoring areas," are identified in NRC's Technical Evaluation Report.

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NRC Monitoring

- Once DOE issues a final waste determination, NRC will:
  - Prepare a monitoring plan in coordination with the covered State; and
  - Monitor DOE disposal actions, focusing on key monitoring areas that NRC identified during the PA review.
- NRC will also review routine updates of DOE's PAs as they become available.

Regulatory Perspective on Performance Assessment

Questions?