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NDAA 3134 Supplemental Low Activity Waste FFRDC Team Study Overview

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NAS Committee Meeting #1
December 12 & 13, 2017

Pre-Decisional

FFRDC Task Overview

- 2017 NDAA Section 3134 Analysis of Approaches for Supplemental Treatment of Low Activity Waste at Hanford Nuclear Reservation
  - Analyze Treatment Approaches
    - *Further Removal of long lived constituents (i.e. ^{99}Tc, ^{129}I)*
    - *Vitrification, Grouting, Steam Reforming and Other identified alternatives*
  - Further Analysis
    - *Risks*
    - *Cost/Benefit/Estimate/Schedule*
    - *Regulatory Compliance*
    - *Obstacles inhibiting pursuit of options*

FFRDC Team Overview

- FFRDC – Federally Funded Research and Development Center
  - 42 in the US (see National Science Foundation (NSF) website)
  - Defined per 49 CFR 35.017
    - *Recertified and Approved by Secretary of Energy at least every 5 years*
  - "FFRDCs, such as DOE's National Laboratories, are sponsored and funded by the United States Government to meet special long-term research or development needs that cannot be met effectively in-house or by contractors."
  - "Required to conduct its business in a manner befitting its special relationship with the Government, to operate in the public interest with objectivity and independence, to be free from organizational conflicts of interest, and to have full disclosure of its affairs to the sponsoring agency."
- EMNLN – Environmental Management National Laboratory Network
  - Sponsored/Chartered by EM National Lab Policy Office and EM-1
  - SRNL – Savannah River National Laboratory
  - PNNL – Pacific Northwest National Laboratory
  - ORNL – Oak Ridge National Laboratory
  - INL – Idaho National Laboratory
  - LANL – Los Alamos National Laboratory
  - SNL – Sandia National Laboratories

FFRDC Team Organization and Work Breakdown Structure (WBS)

FFRDC/ LAW Analysis Team Lead
Project Integration/Coordination
WBS 1.0
Bill Bates - SRNL

Sr. Technical Advisor
Michael Stone - SRNL

Office of River Protection
SRNL POC
Connie Herman - SRNL

LAW Analysis Support (SRNL)
Project Management/Estimating
Frank Sinclair
Communications/Document Control
Sheryl Bush
Contracts/Funds Management
Rick Pelfrey
Scheduling
Cindy Franklin
Administrative Assistant
Debbie Gibbons

Repository Reach-back
Paul Shoemaker - SNL

Regulatory Lead
Thomas Brouns - PNNL

Wasteform Lead
Christine Langton – SRNL

Assessment Area
Pre-Treatment
WBS 2.0
Robert Jubin - ORNL

Assessment Area
Vitrification
WBS 3.0
Alex Cozzi - SRNL

Assessment Area
Steam Reforming
WBS 4.0
Nick Soelberg - INL

Assessment Area
Grout
WBS 5.0
George Guthrie - LANL

Assessment Area
“Other Options”
WBS 6.0
Thomas Brouns - PNNL

FFRDC/LAW Analysis Technical Team Profiles: Cross-cutting Functions

Team Lead
Bill Bates – SRNL
- Deputy Associate Laboratory Director,
  Nuclear Materials Management Programs
- 30 years nuclear experience
- Nuclear Facility Engineering and Facility Management
- BS, Electrical Engineering, Lehigh University

Regulatory Lead
Thomas Brouns – PNNL
- Market Sector Manager,
  Energy & Environment
- 30 years nuclear experience
- Hanford low-activity waste supplemental treatment technology evaluation and down-selection program
- MS, BS, Chemical Engineering, Washington State University

Office of River Protection SRNL POC
Connie Herman – SRNL
- Director, Wasteform Processing Technologies,
  Environmental Stewardship
- 27 years nuclear experience
- Technical Consultant to ORP - WTP
- Fellow, American Ceramic Society
- B.S., Ceramic Engineering, University of Missouri

Senior Technical Advisor
Michael Stone – SRNL
- Senior Fellow Engineer,
  Wasteform Processing Technologies, Environmental Stewardship
- 25 years nuclear experience
- ORP Pretreatment Professional Proposal Technical Review Team
- BS, Chemical Engineering, Clemson University

Wasteform Lead
Christine Langton – SRNL
- Senior Advisory Scientist,
  Wasteform Processing Technologies, Environmental Stewardship
- 30+ years nuclear experience
- Internationally recognized Expert on Cementitious Applications
- PhD, Materials Science & Engineering; MS, Geochemistry; BS, Geoscience: Pennsylvania State University

Repository Reach-back
Paul Shoemaker – SNL
- Senior Manager, Sandia National Laboratories/Carlsbad
- 28 years nuclear experience
- SNL Lead, WIPP Technical Assessment Team
- MPAff, Lyndon B. Johnson School of Public Affairs, University of Texas; B.S., Physics, New Mexico Institute of Mining and Technology

FFRDC/LAW Analysis Technical Team Member Profiles: Assessment Areas

Pre-Treatment Assessment Area Lead
Robert Jubin – ORNL

- Project Manager, Nuclear Technology Research & Development Material Recovery and Waste Forms
- 40+ years nuclear experience
- Extended assignment with French Atomic Energy Commission developing DIAMEX separation process
- Fellow of American Institute of Chemical Engineers; PhD, Chemical Engineering, & MS, Engineering Management, University of Tennessee; BS, Chemical Engineering, University of Akron

Vitrification Assessment Area Lead
Alex Cozzi – SRNL

- Manager, Immobilization Technologies, Wasteform Processing Technologies, Environmental Stewardship
- 20 years nuclear experience
- Hanford Supplemental Immobilization of LAW grout team
- PhD, Materials Science and Engineering, University of Florida; BS, Ceramic Engineering, Alfred University

Steam Reforming Assessment Area Lead
Nick Soelberg – INL

- Chemical Engineer Level 5, Environmental and Geological Engineering
- 35 years nuclear experience
- Integrated Waste Treatment Unit (IWTU) Technical Review Group
- MS, BS, Chemical Engineering, Brigham Young University

Grout Assessment Area Lead
George Guthrie – LANL

- Program Manager for Fossil and Geothermal Energies
- 29 years experience
- Technical Director and Chair for National Risk Assessment Partnership
- PhD, MS, Mineralogy and Crystallography, The Johns Hopkins University; A.B., Geology, Harvard University

Program Plan

Hanford LAW Analysis Team (LAT) Mission

Evaluate existing technologies and plans for pretreatment of Hanford tank waste, supplemental processing to immobilize the low activity waste (LAW), and disposal of the immobilized LAW.

LAT Coordination And Interface

- SRNL responsible for coordination and direction of LAT activities
  - Interface with ORP, NAS, and laboratories supporting effort
- Utilize EM National Laboratory Network (EMNLN) to establish LAT team members
  - National Lab personnel expertise and experience in disciplines pertinent to LAT's charter
  - Enable reach-back to member laboratories and reach out to other National Laboratories
  - Provide technical rigor needed to ensure credibility of analysis activities
- Weekly updates to ORP
- Team visits to site
  - May 23-24, 2017
  - 2018 TBD
- Weekly team conference calls and/or VTCs throughout performance of analysis
- Draft report to ORP by mid-CY2018

Program Plan - continued

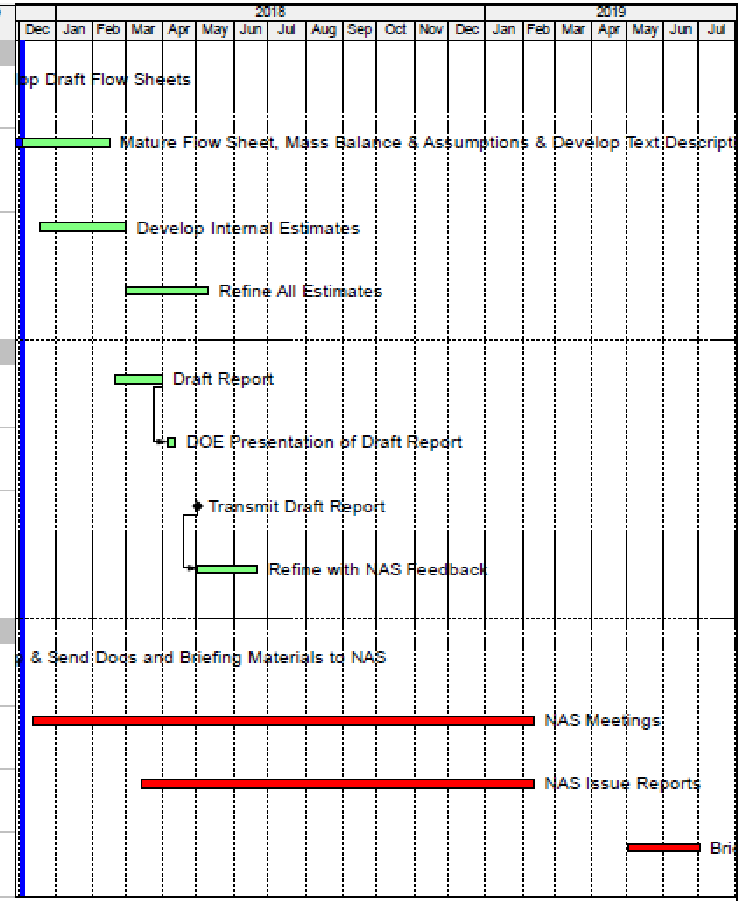
Conducting the Analysis

- Follow well-vetted guidance
  - GAO Best Practices for the Analysis of Alternatives
  - SRNL-led Special Technical Assessments: Good Practices
    - WIPP Technical Assessment, Hanford Tank Vapors Assessment
- Major steps in analysis process:

1. Utilize the EMNLN to assemble the team
2. Define the scope of the analysis based on NDAA requirements and ORP guidance
3. Review the current baseline cradle-to-disposal flow sheet
4. Define assessment areas for the review
5. Establish lines of inquiry (LOI) for each assessment area
6. Pursue the lines of inquiry using appropriate methods, such as document reviews, personnel interviews, facility tours, and observations of work
7. Report the findings in each assessment area to the team
8. Compare the alternatives against the baseline and one another
9. Present results

Schedule (Level 1)

Activit Line #	Activity ID	Activity Name	Start	Finish	Rem Dur	% Comp
Phase II - Work Execution			08/15/17 A	05/10/18	86	
01	LAW-1151	Develop Draft Flow Sheets	08/15/17 A	10/12/17 A	0	100%
02	LAW-1171	Mature Flow Sheet, Mass Balance & Assumptions & Develop Text Descriptions, Risks, etc.	11/13/17 A	02/15/18	40	0%
03	LAW-1181	Develop Internal Estimates	12/18/17*	03/01/18	39	0%
04	LAW-992	Refine All Estimates	03/01/18	05/10/18	40	0%
Phase III - Deliverables			02/21/18	06/21/18	68	
05	LAW-241	Draft Report	02/21/18*	04/01/18	38	0%
06	LAW-281	DOE Presentation of Draft Report	04/05/18	04/12/18	5	0%
07	LAW-311	Transmit Draft Report		05/01/18*	0	0%
08	LAW-312	Refine with NAS Feedback	05/01/18	06/21/18	30	0%
NAS			10/10/17 A	07/01/19	567	
09	LAW-0574	Prep & Send Docs and Briefing Materials to NAS	10/10/17 A	10/24/17 A	0	100%
10	LAW-1191	NAS Meetings	12/12/17*	02/10/19	426	0%
11	LAW-1201	NAS Issue Reports	03/15/18*	02/10/19	333	0%
12	LAW-1210	Briefings to Congress, State, DOE, etc...	05/01/19*	07/01/19	62	0%



Hanford LAW-Analysis of Approaches C.S. Franklin	Supplemental Treatment of Hanford LAW Analysis of Approaches Page 1 of 1	Pre-Decisional DRAFT - For Internal Use Only Layout: LAW1 Data Date: 12/04/17

Draft Table of Contents Report Outline

1.0 EXECUTIVE SUMMARY
2.0 BACKGROUND

- Description of Baseline
- Recognition of other possible scenarios
- Feed Vector Overview

3.0 ANALYSIS STRATEGY AND METHODOLOGY
4.0 REGULATORY COMPLIANCE AND RISK OVERVIEW
5.0 ASSESSMENT AREA SUMMARIES (including high-level flow-sheet cartoon in each)
5.1 PRE-TREATMENT APPROACH
5.2 VITRIFICATION

5.2.1 Description of Flowsheet(s)
5.2.2 Assumptions
5.2.3 Risks
5.2.4 Benefits and Cost Estimate (Project and Lifecycle)
5.2.5 Schedule
5.2.6 Regulatory Compliance (Process, Transport, Disposal/Waste form)
5.2.7 Obstacles

5.3 STEAM REFORMING
5.4 GROUT
5.5 OTHER APPROACHES
6.0 DISPOSAL SITE CONSIDERATIONS
7.0 TRANSPORATION
8.0 COMPARATIVE SUMMARY OF ALL APPROACHES (table)

APPENDIX A. EXPANDED DISCUSSION – PRETREATMENT
APPENDIX B. EXPANDED DISCUSSION – VITRIFICATION
APPENDIX E. EXPANDED DISCUSSION – STEAM REFORMING
APPENDIX F. EXPANDED DISCUSSION – GROUT
APPENDIX G. EXPANDED DISCUSSION – OTHER APPROACHES
APPENDIX H. EXPANDED DISCUSSION – REGULATORY COMPLIANCE
APPENDIX I . FEED VECTOR DISCUSSION

ATTACHMENT 1. TEAM BIOs
ATTACHMENT 2. *NATIONAL DEFENSE AUTHORIZATION ACT FOR FISCAL YEAR 2017*, SECTION 3134, "ANALYSIS OF APPROACHES FOR SUPPLEMENTAL TREATMENT OF LOW-ACTIVITY WASTE AT HANFORD NUCLEAR RESERVATION"
ATTACHMENT 3. *PROGRAM PLAN FOR ANALYSIS OF APPROACHES TO SUPPLEMENTAL TREATMENT OF LOW-ACTIVITY WASTE AT THE HANFORD NUCLEAR RESERVATION*

Approach to Assess Technologies

- Lines of Inquiry (LOI)
- Team Met and Toured Hanford
- Briefed by DOE-ORP and Contractors
- Developed LOIs for each Option Developed
  - Will address options against these parameters in report appendices

Supplemental LAW Options and Areas of Consideration

OPTIONS Pre-Treatment Waste, Disposition Technology, & Disposal Location	TRL & Complexity	Safety	Robust Operational Flexibility (ability to handle wide variety of waste feed streams)	Cost LC & Annual	Schedule	Risks and Opportunities	Waste form Performance	Secondary Wastes	Regulatory Considerations (Includes waste form & packaging)			End State Decommissioning
									Processing	Shipment	Disposal	
- Option Description - High Level Flowsheet a. Sub-option 1 b. Sub-option 2 c.	- TRL - Review prior documents assessing TRL - Assess qualitatively as a team - Use EM TRL guide - Complexity - Number of unit ops - Type unit ops - Secondary wastes generated (minimal, moderate, high) - Difficulty handling off-spec waste products - Major equipment replacement challenges (i.e. melters, etc.)	- Nuclear Safety - Chemical Safety - Accident/Hazard Analysis - Number of Hazards requiring controls (evaluate qualitatively, focus on active controls) - Address - Pretreatment - Immobilization - Packaging - Transport - Disposal	- Number of challenging feed streams or constituents - Impact to Pretreatment Needs - Fraction of feed streams not compatible	- Project Cost - Operations Cost - Annual Cost - Pedigree & method/reference for estimate - Comparison to "baseline" EM liability cost profile - Include Disposal & Transport Costs - Use Net Present Value or consistent "Dollars"	- Comparison to "baseline" - Options for Acceleration	- Project Risks - Operational Execution Risks - TRL related risks with technology maturation - Opportunities to accelerate schedule or reduce LC cost	- Comparison to Disposal Site WACs - Physical Performance Summary - Max Release Rate per radionuclide - TCLP Leaching - Compressive Strength - Rad Tolerance - Thermal Tolerance - Other	- Quantity - Contribution to the Environment Assessment (EA) - Disposal Pathways - Evaluation against LAW criteria	- NEPA - Long Term Environmental Impacts - Env. Permits	- DOT & NRC shipping compliance - Road vs. Rail considerations - Onsite shipping compliance - NEPA - Long Term Environmental Impacts - Env. Permits - Address concentration (Ci/cm^3) - Total volume - Inventory per container	- NEPA - Long Term Environmental Impacts - Env. Permits - Address concentration (Ci/cm^3) - Total volume - Inventory per container - PA compliance	- Decon - Removal - Entombment

Options - Pre-Treatment Waste, Disposition Technology, and Disposal Location

- Pretreatment
  - Baseline (Per System Plan 8)
    - *Solids filtration*
    - *Cesium removal*
      - Spherical Resorcinol Formaldehyde (sRF) Ion Exchange (IX)
  - Other needs as defined by disposition technology
- Disposition Technology
  - Vitrification
    - *Melter*
    - *Bulk*
  - Grout
    - *Containerized*
    - *Large vaults*
  - Steam Reforming
    - *Containerized as powder*
    - *Containerized as monolith*
  - Other
- Disposal Location
  - Hanford Integrated Disposal Facility (IDF) (Richland, WA)
  - Offsite commercial LLW disposal facility

TRL and Complexity

- Technology Readiness Level (TRL)
  - Assess whether the disposition option requires additional development prior to deployment
    - *Past assessments of TRL for each technology will be reviewed*
    - *Utilize EM guide to determine a TRL level for each disposition technology*
- Complexity
  - Assess the level of difficulty in operating and maintaining required facilities and unit operations for each disposition technology
    - *Number and type of unit operations*
    - *Expected life of processing equipment*
    - *Secondary waste generation / disposition*
    - *Packaging operations*
    - *Ability to handle process upsets (such as off-spec products)*

Safety

- Assess the relative safety of the process to disposition the waste for each proposed disposition technology
  - Nuclear safety
    - *Criticality control, radionuclide containment, worker dose, etc.*
  - Process safety
    - *Hazardous chemical handling, pressurized systems, high temperatures, etc.*
  - Number of controls required
  - Processes considered
    - *Pretreatment*
    - *Immobilization*
    - *Packaging*
    - *Transportation*
    - *Disposal*

Robust Operational Flexibility

- Assess ability of disposition technology to handle entire range of feeds to be processed as well as variability of feed and uncertainty in composition/physical properties
  - Number of stream components that challenge disposition technologies
    - *e.g. sulfur and chromium for glass; organics and ammonia for grout*
  - Percentage of feeds that challenge limits of the disposition technology
    - *i.e. fraction of feed vector not compatible*
  - Ability to handle turndown in feed flowrates
  - Impact on Pretreatment Requirements
    - *Any additional treatment required beyond filtration/cesium removal*

Cost Lifecycle and Annual

- Assess cost of each disposition technology
  - Capital project cost
  - Operation/Maintenance cost
    - *Facility operations*
    - *Disposal cost*
    - *Transportation cost*
  - Total cost and annual costs considered
- Will review previous estimates for each disposition technology
  - Evaluate previous methods and assumptions
- Compare to current EM baseline liability cost profile
- Utilize net present value for cost estimates

Schedule

- Assess the time needed to implement each disposition technology
  - Compare against current baseline assumptions
  - Evaluate opportunities to improve schedule with each option
- Will review previous estimates for each disposition technology
  - Evaluate previous methods and assumptions

Risks and Opportunities

- Assess the risks and opportunities associated with each disposition technology
  - Regulatory risks
    - *Could the disposition technology fail to meet a regulatory commitment?*
  - Schedule risks
    - *Can the disposition technology accelerate the baseline schedule?*
    - *How likely is meeting the estimated schedule?*
  - Cost risks
    - *Could the disposition technology be less costly than the baseline?*
    - *How likely are cost overruns?*
  - Safety risks
    - *Will the process be safer than the baseline*
    - *Could the process result in excessive worker dose?*
  - Process risks
    - *Could the process fail to make acceptable immobilized product?*
      - Product out of specification
    - *Throughput not met*
    - *Generation of excessive secondary wastes*

Regulatory Considerations – Disposal

- Radioactive Waste Management (DOE O 435.1)
  - Waste incidental to reprocessing
  - Solid physical waste form not exceeding Class C LLW limits
  - Meet safety requirements comparable to performance objectives in 10 CFR Part 61, Subpart C
- RCRA/TSCA (40 CFR 261 & 268/40 CFR 761 and WAC 173-303)
  - Hanford tank waste is a radioactive mixed waste (non-wastewater) subject to land disposal restrictions (LDR)
  - Disposal requires compliance with State and Federal regulations including meeting applicable treatment standards for metals and organics
    - *D001-D043 Characteristic Wastes*
    - *F001-F005 Solvents*
    - *Underlying Hazardous Constituents (UHCs)*

Waste Form Performance

- Waste form must meet disposal site's Waste Acceptance Criteria (WAC)
  - Radiological criteria – waste classification and dose
    - *Limits on specific activity (Ci/m^3 and nCi/gram for transuranics)*
    - *"Summed contributions of each nuclide" needed to classify waste for disposal (e.g., as Class C) and many nuclides in ILAW*
  - Waste package requirements – e.g., compressive strength
  - Waste form chemical and physical criteria
    - *e.g. RCRA, LDR compliance*
- Disposal Site-specific considerations
  - Off-site disposal: Compliance with established disposal site WAC
  - On-site disposal: Compliance with draft IDF WAC

Waste Form Performance for On-Site Disposal

Hanford Integrated Disposal Facility (IDF)

- IDF WAC not finalized
  - Draft criteria mostly comparable to offsite disposal site WAC
  - Draft WAC contains a “release rate limit (Ci/yr)” for LAW waste forms informed by past IDF performance assessment (PA) analysis
- Study will employ a risk assessment approach (“mini” PA) to directly compare alternative waste forms
  - Verify waste form meets long-term performance objectives (groundwater benchmarks)
  - Waste form-specific radionuclide release mechanisms, rates, and transport to groundwater
  - Reference analysis
    - *2003 Supplemental Treatment Risk Assessment*
    - *2012 Final Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington (TC & WM EIS) (DOE/EIS-0391)*
    - *2017 DRAFT Integrated Disposal Facility Performance Assessment*

Secondary Wastes Impacts for On-Site Disposal - Previous Studies

- 2003 SLAW Risk Assessment; 2014 Tank Closure & Waste Management EIS
- Thermal treatment may drive volatile nuclides such as technetium and iodine to secondary wastes
- Long-lived radionuclides ^{99}Tc, ^{129}I in *secondary wastes were primary risk drivers* to IDF performance predictions
- Secondary wastes include:
  - Liquid effluents from LAW and HLW processing (e.g., off-gas condensates)
  - Solid secondary wastes (e.g., spent HEPA filters)
- Consideration of both primary and secondary waste forms important to overall risk assessment

TC&WM EIS (2014)

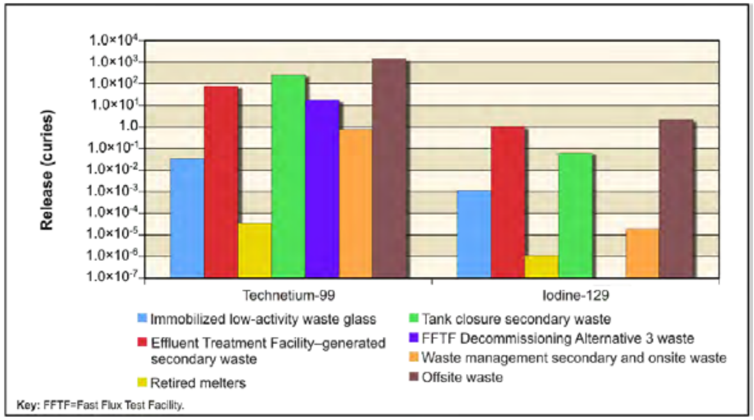


Figure 5–383. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Radionuclide Releases from 200-East Area Integrated Disposal Facility to Groundwater

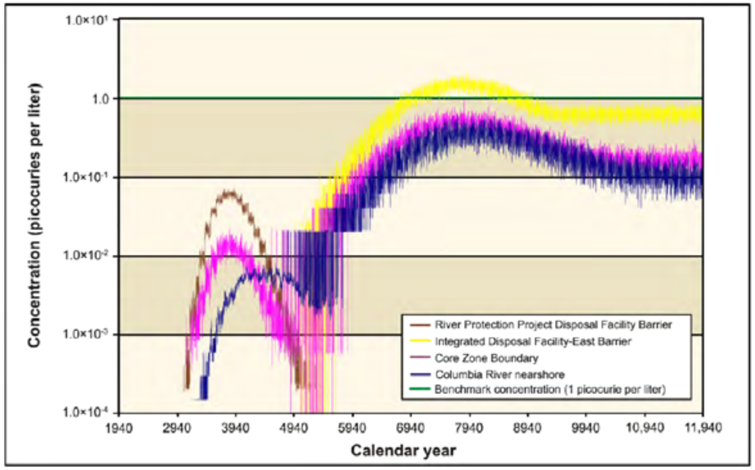


Figure 5–393. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Iodine-129 Concentration Versus Time

Regulatory Considerations – Processing

- RCRA/LDR Requirements
  - Treatment Standards for Hazardous Wastes – technology, total waste, or waste extract standards, as applicable.
  - Determination of Equivalent Treatment or Alternate Treatment Standards (variance)
- Air Emissions
  - Controls for New Sources of Toxic Air Pollutants (WAC 173-460) – e.g., Volatile Organic Compounds (VOCs), nitrogen oxides (NOx), mercury
- Secondary Effluents and Solid Wastes
  - Liquid LLW from processing (e.g., off-gas scrubber, process condensate)
  - Solid waste (e.g., spent HEPA filters, resins or sorbents)
- RCRA TSD licensing
- Material Balance – Splits of contaminants of concern between waste form, secondary waste, air emissions
  - Long-lived radionuclides – e.g., volatile species into waste form, off-gas filters, off-gas scrubber
  - Volatile metals

Regulatory Considerations – Shipping Off-Site

- 10 CFR 71 Packaging and Transportation Of Radioactive Material
  - Additional DOE requirements for shipping
- Type A or Type B shipping containers?
  - Exact shipping container – e.g., B-12 box for Type A shipping
- Over-the-road or railroad?
- Large volumes, over 30 years, long distances
  - NEPA requirements