U.S. DEPARTMENT OF ENERGY

Tank Waste Processing (EM-31) Research and Development Program

Briefing for Workshop on DOE Used Nuclear Fuel & High Level Waste

September 15, 2010

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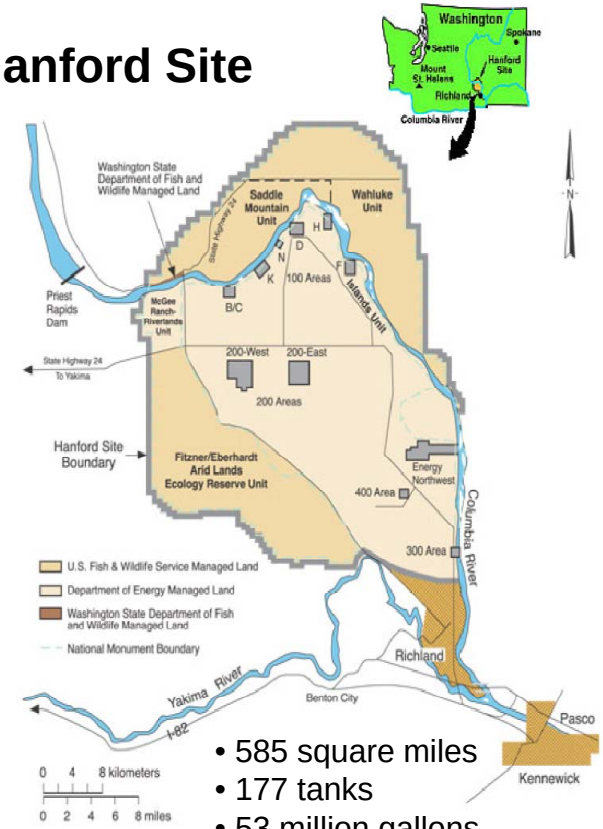
Office of Technology Innovation and Development
Office of Environmental Management

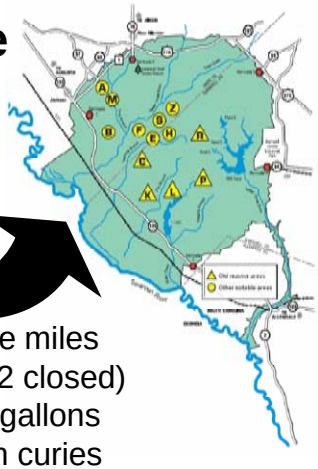
Active Tank Waste Sites

Hanford Site



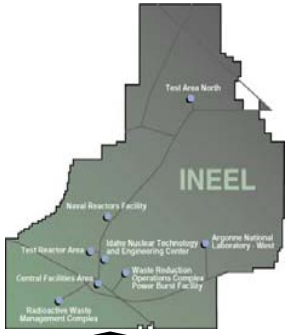
- 585 square miles
- 177 tanks
- 53 million gallons
- 194 million curies

Savannah River Site



- 310 square miles
- 51 tanks (2 closed)
- 33 million gallons
- 416 million curies

Idaho Site



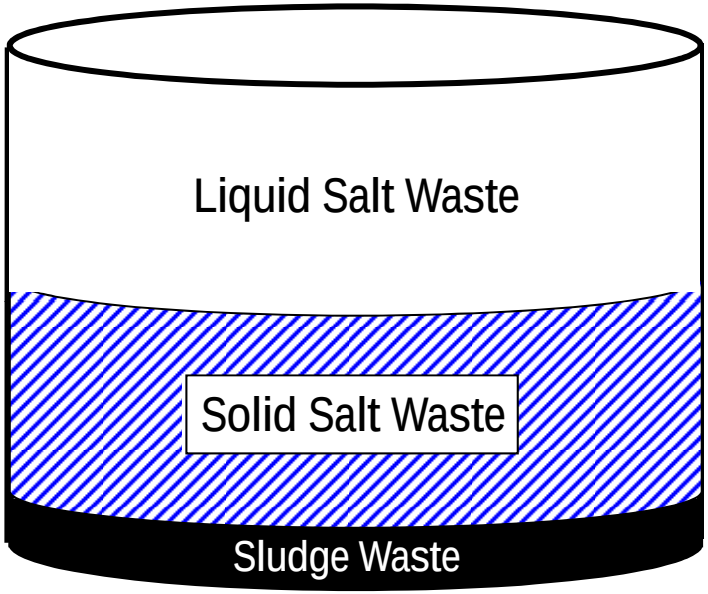
- 890 square miles
- 11 tanks (7 closed)
- 0.9 million gallons
- 0.5 million curies

Note: West Valley is also a HLW Site (tank waste processing complete)

Environmental Management

safety ❖ performance ❖ cleanup ❖ closure

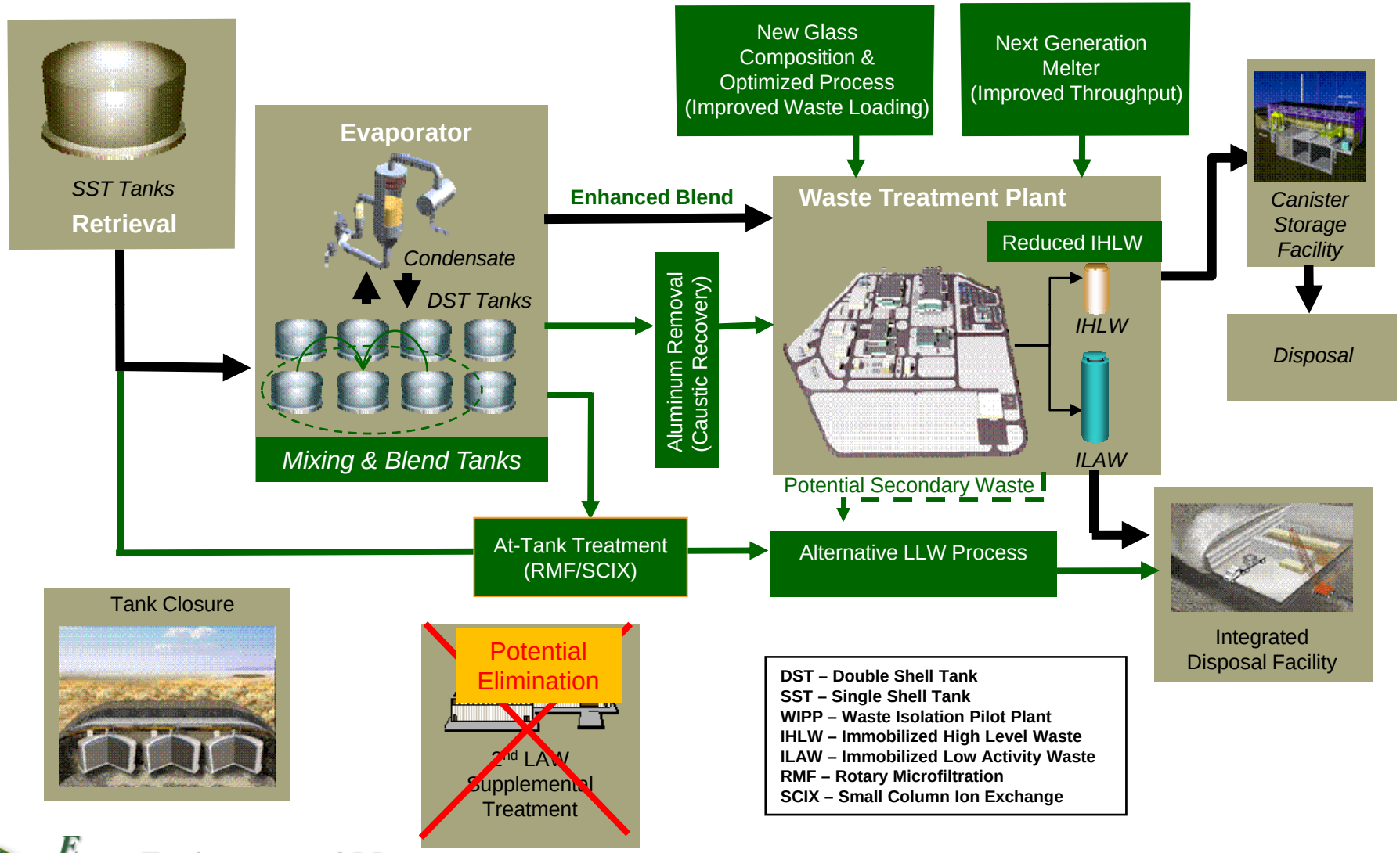
Tank Waste



- Challenges
  - Tank Integrity
  - Retrieval
  - Treatment
  - Final Waste Forms (HLW & LAW)
  - Closure

Optimized Hanford Strategies

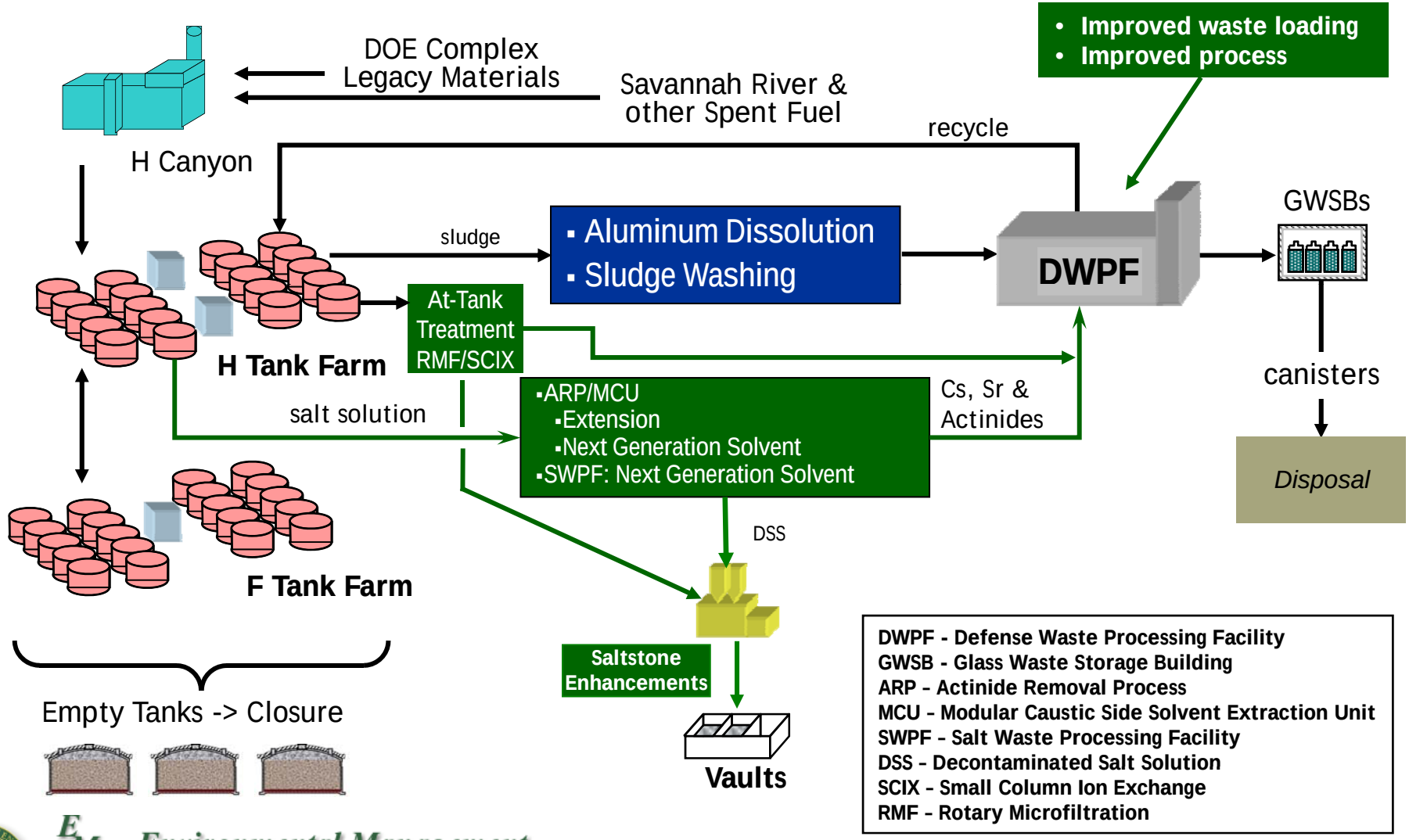
Potential Transformational Changes to RPP Flow Sheet



DST – Double Shell Tank
SST – Single Shell Tank
WIPP – Waste Isolation Pilot Plant
IHLW – Immobilized High Level Waste
ILAW – Immobilized Low Activity Waste
RMF – Rotary Microfiltration
SCIX – Small Column Ion Exchange

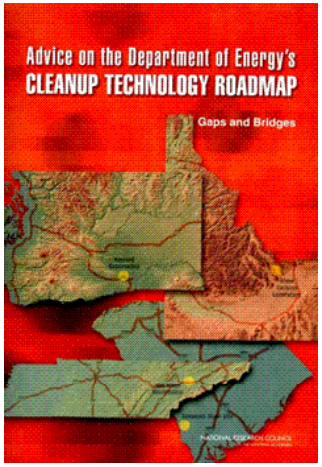
Optimized Savannah River Strategies

Potential Transformational Changes to SRS Flow Sheet

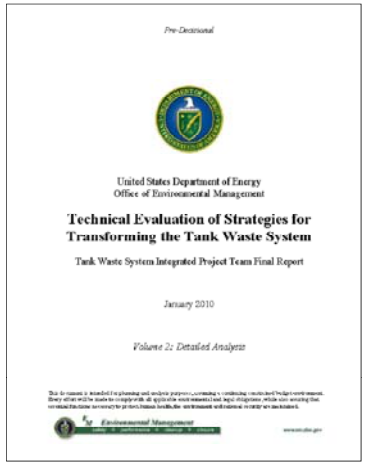


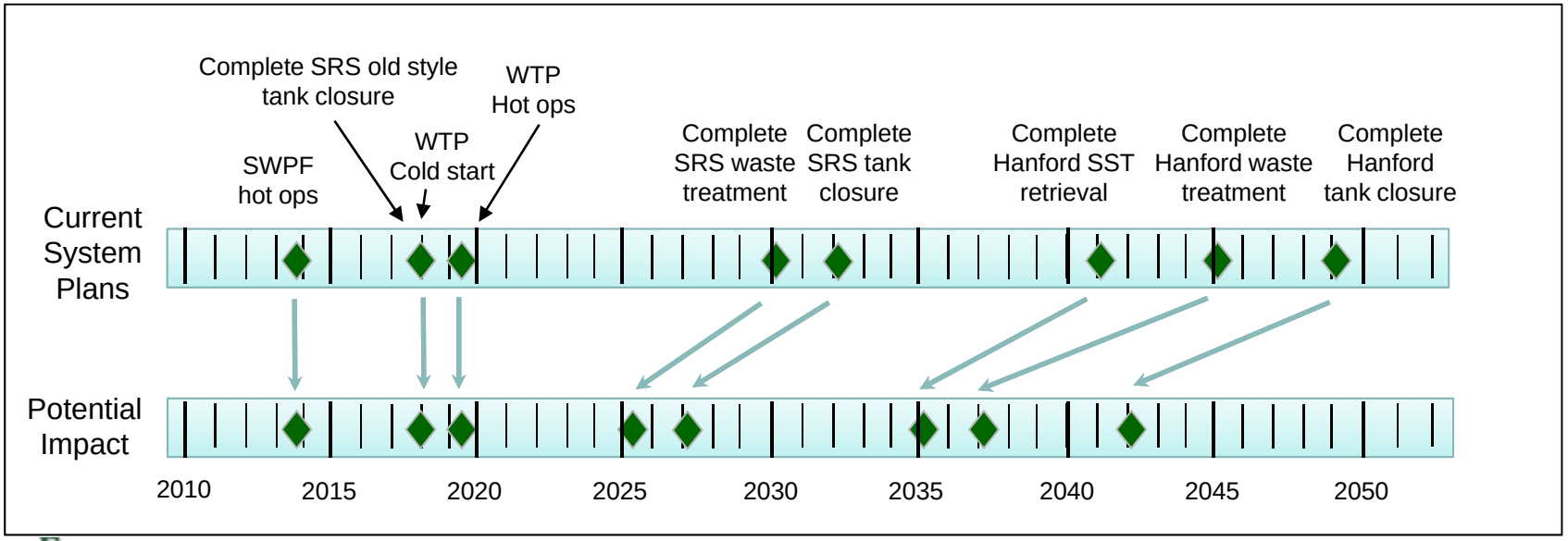
DWPF - Defense Waste Processing Facility
GWSB - Glass Waste Storage Building
ARP – Actinide Removal Process
MCU – Modular Caustic Side Solvent Extraction Unit
SWPF – Salt Waste Processing Facility
DSS – Decontaminated Salt Solution
SCIX – Small Column Ion Exchange
RMF – Rotary Microfiltration

Tank Waste R&D Plan and Impacts



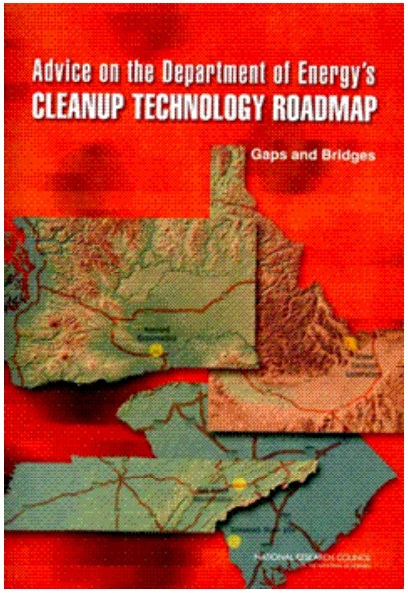
- Basis for Tank Waste R&D Plan
  - Engineering and Technology Roadmap
  - NAS Recommendation on Roadmap (Gaps)
  - Technical Evaluation of Strategies for Transforming the Tank Waste System
  - Site System Plans
  - Support Enhanced Strategies for Hanford & SRS





NAS Identified Gaps – Waste Processing

National Academy of Sciences Reviewed and Validated the EM Technology Program in “Advice on the Department of Energy’s Cleanup Technology Roadmap: Gaps and Bridges” – February 2009



NAS Technology Gaps for Waste Processing (WP)		NAS Priority
WP-1	Substantial amounts of waste may be left in tanks/bins after their cleanout—especially in tanks with obstructions, compromised integrity, or associated piping.	High
WP-2	Low-activity streams from tank waste processing could contain substantial amounts of radionuclides.	Medium
WP-3	New facility designs, processes, and operations usually rely on pilot-scale testing with simulated rather than actual wastes.	Medium
WP-4	Increased vitrification capacity may be needed to meet schedule requirements of EM’s high-level waste programs.	High
WP-5	The baseline tank waste vitrification process significantly increases the volume of high-level waste to be disposed.	Medium
WP-6	A variety of wastes and nuclear materials do not yet have a disposition path.	Low

WP-1: Waste Retrieval and Closure Technologies

NAS: "Substantial amounts of waste may be left in tanks/bins after their cleanout – especially in tanks with obstructions, compromised integrity, or associated piping"

Need

- Increase capability to remove tank waste material
- Reduce waste volume
- Capability to assess environmental safety of grouted tanks

Proposed Solutions

- Develop alternative chemical cleaning methods
- Develop improved throughout waste reduction technologies
- Develop in-tank settling technologies to separate radionuclides
- Evaluate and assess cementitious materials for tank closure

Potential Benefits

- Reduce retrieval time and improve efficiency
- Reduce further environmental impact when retrieving from unsound tanks
- Reduce waste volume to maximize available tank space
- Provide predictive modeling and materials for tank closure decisions

FY2010 Program Topics

- Alternative Chemical Cleaning
- High-Throughput Waste Reduction
- Sludge Differential Settling
- Improved Cementitious Materials

Waste Retrieval and Closure Technologies Portfolio

R&D Initiatives	Description	Tasks
Alternative Chemical Cleaning	Develop improved methods to control the chemistry of tank heels	- Alternative Chemical Cleaning - Gas Retention
High-Throughput Waste Reduction Technologies	Improve methods of tank waste handling and tank space usage	- Wipe Film Evaporator - Plugging Issues Resolution
Sludge Differential Settling	Develop selective separation methods for in-tank elutriation of high radiological risk sludge components to separate constituents during retrieval	- In-Tank Elutriation
Determine Long-term Performance of Cementitious Materials	Improve the tools used in performance assessments by providing support to the Cementitious Barriers Partnership	- Cementitious Barriers Partnership

WP-2: Alternative Waste Pretreatment

NAS: "Low activity streams from tank waste processing could contain substantial amounts of radionuclides"

Need

- Accelerate tank waste treatment by using small, at-tank or in-tank systems
- Increase incorporation of long-lived radionuclides in immobilized waste forms
- Remove glass-limiting, non-hazardous chemicals from waste to reduce plant operating lifetimes
- Obtain reliable data without physical sampling

Proposed Solutions

- Develop At-Tank/In-Tank treatment solutions to accelerate salt and sludge processing
- Develop approaches for managing Technetium during processing
- Develop advanced separation technologies to address key waste constituents
- Develop in-situ tank characterization technologies

Potential Benefits

- Decrease WTP mission duration
- Reduce environmental risk from mobile radionuclides
- Increase WTP and SWPF efficiency
- Reduce amount of glass produced, thus reducing disposal costs
- Reduce worker exposure and provide real-time data for process control

FY2010 Program Topics

- At-Tank/In-Tank Treatment Solutions to Accelerate Salt and Sludge Processing
- Approaches for Managing Technetium Issues
- Advanced Separation Technologies to Address Key Waste Constituents
- Develop In-Situ Tank Characterization Technologies

Alternative Waste Pretreatment Portfolio

R&D Initiatives	Description	Tasks
At-tank/In-tank Solutions	Develop at-tank treatment capability in the tank farms to supplement the main treatment facility	-Improved Strontium and Actinide Separations -Continuous Sludge Leaching -Phosphate Management
Next Generation Solvent	Develop new solvent for Caustic-Side Solvent Extraction (CSSX)	**-Mature solvent for Modular CSSX Unit (MCU) application** -Application for SWPF and Hanford
Rotary Microfilter (RMF)	Mature RMF to improve filtration of HLW	**-Small Column IX prefiltering for Hanford** -Sludge Washing at SRS
Small Column Ion Exchange (SCIX)	Develop SCIX for Cs removal	-Testing with sRF for SRS **-Non-acid eluent for Hanford**
Technetium Management	Develop immobilization methods for key LAW risk-driver (Tc)	- Improved Retention of Tc in LAW -Tc Removal using Goethite Precipitation -Improved Retention in Low Temperature Waste Forms for off-gas streams
Advanced Separations	Develop technology for separation and removal of aluminum, sodium, sulfate, and solids	-Aluminum Solubility -Electrochemical Caustic Recycle -Sulfate Removal -Alternative Sodium Technologies -Filtration
In-Situ Characterization	Develop understanding of residual tank waste to assist retrieval and closure strategy	-Raman Spectroscopy -Radiometric Characterization

Bold = enhanced strategy component

WP-3: Advanced Unit Operations and Scaling

NAS: "New facility designs, processes and operations rely on pilot-testing with simulated rather than actual wastes"

Need

- Develop a computational capability to predict the behavior of actual solids in waste slurries, reducing the risk in unit operations involving mixing, transport, and processing
- Develop simulants to enable design verification
- Enable implementation of improved process simulation tools

Proposed Solutions

- Implement new mathematical algorithms to better simulate multi-phase flow phenomena
- Improve Hanford and SRS "best-estimates" of physical/chemical properties
- Evaluate methods to modify rheology so that solids loading can be increased
- Adoption of common nuclear waste material properties

Potential Benefits

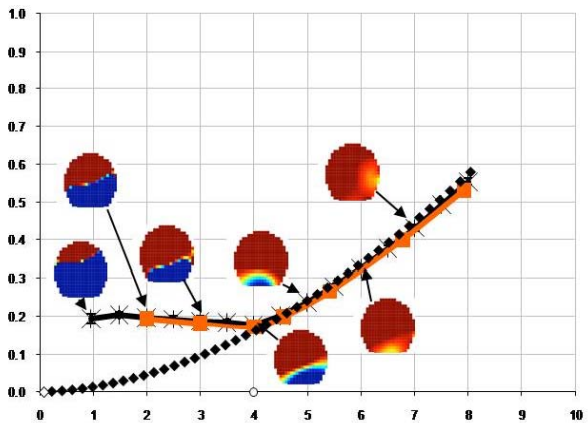
- Better flow models and waste characterization increases confidence that plant processes will work as intended as unit operations are moved from bench to full-scale
- Increased solids loading reduces the amount of glass produced, thus reducing disposal costs

FY2010 Program Topics

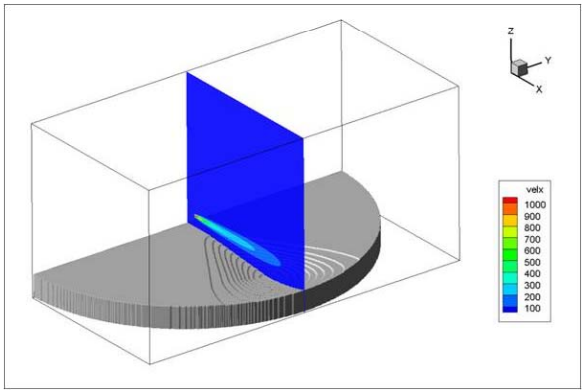
- Advanced Multi-Phase Mixing and Suspension Methods
- Development of Simulants to Enable Design Verification

Advanced Unit Operations and Scaling Portfolio

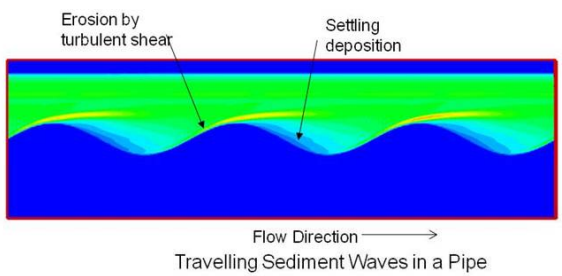
R&D Initiatives	Description	Tasks
Advanced Multi-Phase Mixing and Suspension Methods	Develop and demonstrate computational code to predict the behavior of solids in waste slurries, reduce risk in unit operations involving mixing, transport and processing.	- Waste Feed Delivery - Advanced Multi-Phase Mixing
Develop Simulants to Enable Design Verification	Develop mechanisms to improve waste processing predictions with effective simulants and improve process simulating tool predictions by comparing with historical process data.	- Actual Waste Testing to Determine Key Physical and Chemical Properties -Scaled Validation Testing/Modeling of Transformational Solutions



Critical velocity



Tank Jet modeling



Pipe Flow modeling

WP-4: Increased Waste Loading

NAS: "The baseline tank waste vitrification process significantly increases the volumes of HLW to be disposed"

Need

- Reduce total amount of glass by increasing waste loaded into the glass
- Develop treatment options for broader range of wastes, including selected LAW's

Proposed Solutions

- Increase waste loading to reduce the total amount of glass produced
- Develop alternative treatment and disposal processes to reduce the amount of waste requiring vitrification, thereby reducing glass volume and treatment schedule

Potential Benefits

- Increase WTP efficiency by increasing waste loading into glass without effecting melt rates
- Reduce the amount of additional LAW capacity needed
- Provide other waste forms for immobilizing waste to reduce cost and schedule

FY2010 Program Topics

- Advanced Glass Formulations to Increase Waste Loading and Melt Rate
- Alternative Treatment and Disposal Processes using Advanced Waste Forms

Increased Waste Loading Portfolio

R&D Initiatives	Description	Tasks
Advanced Glass Formulations to Increase Waste Loading and Melt Rate	Develop improved glass formulation for increased waste loading that may substantially reduce the volume of glass produced, stored, transported, and disposed.	- Phosphate Glass -**Advanced Silicate Glass** -Joint EM-NE International Study of Glass Behavior over Geologic Time -Low Temperature Waste Forms
Fluidized Bed Steam Reformer Low-Level Waste Form Qualification	Demonstrate the capability of the Fluidized Bed Steam Reforming technology to process lower-activity waste into a final waste form suitable for onsite disposal at the Hanford site.	-**Hanford LAW FBSR waste form development and qualification**

Bold = enhanced strategy component

Laboratory glass pour

DWPF canisters

Engineering scale FBSR

WP-5: Improved Vitrification Capacity

NAS: "Increased vitrification capacity may be needed to meet schedule requirements of EM's high-level waste programs"

Need

- Next generation melters are needed to increase WTP throughput
- Develop understanding of process tools for maintaining cold cap on melt surface

Proposed Solutions

- Develop next-generation melters, such as advanced joule-heated melter and cold crucible induction melter
- Develop advanced process understanding of cold-cap chemistry

Potential Benefits

- Increase WTP efficiency by increasing melter throughput and increasing waste loading
- Increase steady state operations by reducing process upsets

FY2010 Program Topics

- Develop Next-Generation Melters
- Advanced Process Understanding and Predictive Tools for Melter Cold Cap Chemistry

Improved Vitrification Capacity Portfolio

R&D Initiatives	Description	Tasks
Advanced Melters to Enhance Waste Throughput and Loading into Glass	Develop next generation melters with higher throughput rate to shorten cleanup mission.	- Next Generation Waste Glass Melter Workshop -Glass Formulation for Next Generation Melters -Next Generation Induction-heated and Advanced Joule-heated Melter Bench Scale Testing - Next Generation Melter Development and Engineering - Design, Fabrication and Installation of Next Generation Test Melter System -Next Generation Melter Testing and component improvement -Next Generation Melter Diagnostic Development and Demonstration
Melter Cold Cap Chemistry	Develop sufficient chemical understanding of the complex reactions that convert melter feed into the glass melt and the physical parameters known to influence melting behavior such as heat transfer to and within the cold cap.	-Bench Scale Testing of Cold-cap Processes -Cold-cap Reaction Simulation Code Development

Waste Retrieval and Closure R&D

R&D Initiatives	R&D Activity	FY10	FY11	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	Comments
Develop Alternative Chemical Cleaning Techniques to Reduce Downstream Impacts and Conservatism	Develop alternative oxalate destruction method											Insert oxalate destruction alternatives into SRS and Hanford flowsheets to reduce downstream volume and oxalate impacts from baseline cleaning and reduce gas model conservatism based on actual waste test in 2012, with annual flowsheet updates.
	Perform oxalate destruction alternative bench-scale testing with real waste											
	Determine gas release mechanism for sludge											
	Perform gas release scale testing and demonstration with real waste											
	Validate models / simulants for for waste specific flowsheet insertions											
Develop High-Throughput Waste Reduction Technologies to Expedite Tank Retrievals	Determine alternative technology options to increase throughput											2013 insertion for implementation on first WFE deployment campaign with pipeline transport parameters.
	Perform scale testing with actual waste using Agitated Thin-Film Evaporator											
	Determine operational parameters to correlate with pipeline transport											
Develop Sludge Differential Settling to Separate Constituents during Retrieval	Perform simulant and real waste studies of elutriation concept											Evaluate initial scoping results and feed into system planning for characterization and real waste testing with 2016 insertion based on succesful demostration.
	Perform actual waste test and pilot scale demonstration of elutriation											
	Characterize mixing/settling of Pu particles using Hanford sludge sample											
	Develop/validate elutriation and criticality parameters and flowsheet											
Determine Long-term Performance of Cementitous Materials	Develop predictive models based on experimental program data and documentation											Data insertion into ASCEM models 2011-2015 and apply knowledge to PA community on an ongoing basis.
	Modeling development - integration with ASCEM											

DOE Decision
Complete actual waste test
Complete pilot scale demo
Technology Insertion

Completed Work
Planned Work

Environmental Management
safety ❖ performance ❖ cleanup ❖ closure

Alternative Waste Pretreatment R&D

R&D Initiative	R&D Activity	FY10	FY11	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	Comments
At-Tank/In-Tank Treatment Solutions	Develop Advanced Sorbent for Sr/Tru Separations											Varied Approaches with Insertions Dependent on availability of immobilization technology or to support WTP
	Continuous Sludge Leaching											
	Phosphate Management											
Rotary Microfiltration	Develop Rotary Microfiltration for SRS											
	Develop Rotary Microfiltration for Hanford											
SCIX	Develop Small Column Ion Exchange with sRF resin											
Next Generation Solvent for Cs	Next Generation Cesium Solvent for MCU											
	Next Generation Cesium Solvent for SWPF											
Determine Tc Behavior in Waste Processing Unit Operations	Improve Tc Retention in LAW - Cold Cap Proc.											Hanford insertion to support Effluent Treatment Facility upgrade or thereafter in processing
	Develop Tc Removal with Goethite											
	Determine Tc Retention in Low Temperature Forms											
Advanced Separations for Key Constituents (Na, Al, S)	Refine Aluminum Solubility											Insertion would support WTP immobilization, or an at-tank treatment at Hanford
	Develop Electrochemical Caustic Recovery											
	Explore Alternative Sodium Recovery											
	Investigate Sulfate Removal											
	Improve Filtration Performance											
In-Situ Characterization	Develop Raman Spectroscopy (of Tank Residues)											Can be used any time during retrieval and closure campaign
	Develop Radiometric Characterization (in Tank)											

Complete actual waste test
Complete pilot scale demo
Technology Insertion

Completed Work
Planned Work

Environmental Management
safety ❖ performance ❖ cleanup ❖ closure

Advanced Unit Operations R&D

R&D Initiative	R&D Activity	FY10	FY11	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	Comments
Develop Advanced Multi-Phase Mixing and Suspension Methods	Model WTP Waste Feed Delivery											Multi-phase mixing deployment is ongoing. Insertion depends on success of model development.
	Develop Advanced Multi-Phase Mixing											
Develop Simulants to Enable Design Verification	Waste Design Basis Determination											Actual waste testing, will extend beyond WTP startup in 2019.
	Adoption of Common Nuclear Waste Material Properties											
	Develop Rheological Modifiers for Higher Waste Throughput											
	Complete Develoment of Improved Anti-Foam Agent											
	Identify Gibbsite Inhibitors											
	Uncertainty Quantification and Error Propagation Management in Waste Processing Systems											

DOE Decision
Complete actual waste test
Complete pilot scale demo
Technology Insertion

Completed Work
Planned Work

Increased Waste Loading R&D

R&D Initiative	R&D Activity	FY10	FY11	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	Comments
Phosphate glass development and demonstration	Develop phosphate glass waste form, perform cost benefit analysis, and qualify waste form											Transfer to site 2018 Implement on WTP first melter changeout 2024
Advanced silicate glass development and demonstration	Develop advanced crystal tolerant glasses and advanced glasses for difficult waste types, e.g. high alumina, high sulfur, bismuth phosphate along with necessary predictive models											Use in system planning by annual update, Implementation at WTP startup 2019
Joint EM-NE-International Study of Glass Corrosion Behavior Over Geologic Time	Determine glass waste form corrosion over geologic times scales in multiple disposal environments											Transfer performance of glass in multiple geologic environments in 2013.
Low-temperature Waste Forms for Low-level Wastes and Off-gas Recycles	Develop Duralith waste form for LAW											Transfer data in 2011 for waste form selection. Final data and model to support PA model in 2013
	Develop Ceramacrete waste form for LAW											
	Develop alternative waste forms											
	Waste form development and qualification											
Fluidized Bed Steam Reformer Low-Level Waste Form Qualification	Hanford LAW FBSR waste form development and qualificaiton											Transfer data in 2011 for waste form selection. Final data and model to support PA model in 2013

DOE Decision
Complete actual waste test
Complete pilot scale demo
Technology Insertion

Completed Work

Planned Work

Environmental Management
safety ❖ performance ❖ cleanup ❖ closure

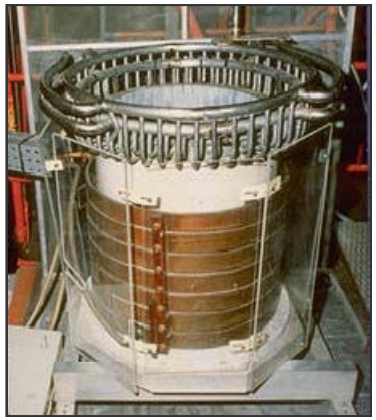
Improved Vitrification Capacity R&D

R&D Initiative	R&D Activity	FY10	FY11	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	Comments
Advanced Melters to Enhance Waste Throughput and Loading into Glass	Develop Next Generation Waste Glass Melters and Flowsheets											Down selection of next generation melter technology 2013. Transfer melter technology at TRL 6 in 2016 to support first scheduled WTP melter changeout in 2024.
Develop Advanced Process Understanding and Predictive Tools for Melter Feed Cold Cap Chemistry	Understand, Model, and Control Reaction Rate of Melter Feed Conversion to Glass to Improve Throughput											Implementation for DWPF is in 2012 at the melter changeout. Hanford implementation is in 2017 in time to validate during cold commissioning
	Improvement of existing DWPF melting rate model											

DOE Decision
Complete actual waste test
Complete pilot scale demo
Technology Insertion

Completed Work

Planned Work



Cold Crucible Induction Melter

U.S. DEPARTMENT OF ENERGY

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Back-up Information

Tank Waste Summary Chart

Site	Tanks	Gallons (thousands)	Curies (thousands)	Major Radiochemical separations facilities/ flowsheets	Major Constituents
Hanford	149 Single Shell Tank 28 Double Shell Tank	53,000	194,000	T, B BiPO4 U Uranium recovery S REDOX A PUREX Z Pu Prod/ Fab/Recovery B Cs/Sr Sep./Encap.	Widely varied waste from multiple processes: Na, K, Al, Ba, Fe, Bi, Cr, Mg, Zr, Cd, Ti, Ni, Pb, Ag, Sr, Cs, Tc, U, Th, Ru, Nitrate/Nitrite. Sulfate, Hydroxide, Phosphate
Savannah River	51 Tanks (2 closed)	33,100	416,000	F PUREX/Pu Production H PUREX/Pu-238 Production	similar constituents to Hanford, but less variability because waste derived from fewer processe, and higher curie content because Cs & Sr were not separated
Idaho	11 Tanks (7 closed)	900	539	ICPP- Idaho Chemical Processing Plant (Uranium Recovery)	waste derived primarily from one process: sodium nitrate Cs-137, Sr-90 Pu-241/Pu-238
	43 Bins of calcine in 6 Bin Sets	1,000	31,600		waste derieved from one process: alumina (Al_2O_3), zirconia (ZrO_2), CaF_2, B, metal oxides/carbonates and nitrates: Na, K, Cr, Fe, Mg, Pb, Hg

What is High Level Waste?

- High-level radioactive waste (HLW) is defined by the Nuclear Waste Policy Act (NWPA) as:
  - A) the highly radioactive material resulting from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid material derived from such liquid waste that contains fission products in sufficient concentrations; and
  - B) other highly radioactive material that the (Nuclear Regulatory) Commission, consistent with existing law, determines by rule requires permanent isolation.
- High-level radioactive waste is defined in 10CFR60.2 as:
  - A) irradiated reactor fuel,
  - B) liquid wastes resulting from the operation of the first cycle solvent extraction system, or equivalent, and the concentrated wastes from subsequent extraction cycles, or equivalent, in a facility for reprocessing irradiated reactor fuel, and
  - C) solids into which such liquid wastes have been converted.
- The definition of HLW is source-based under both the NWPA and 10CFR60, and classification requires knowledge of the processing history.
- The definition is not based on chemical composition, curie content, risk or other analytic factors; therefore a waste of unknown or mingled process history does not have a straightforward classification.
- Hanford tank waste has not been formally classified, although it has been managed as HLW.

What is DOE's basis to exit the definition of HLW in producing a LAW fraction for on-site disposal ?

- DOE has consulted with the NRC for decades regarding criteria, processes and approaches that can be used to make credible waste determinations.

- DOE has a provisional agreement with the NRC*, in considering DOE plans for treatment of Hanford tank waste to separate radionuclides and segregate the largest practical amount of the total site inventory attributable to "first-cycle solvent extraction, or equivalent" for disposal as HLW, leaving behind only a small fraction of moderately radioactive material.

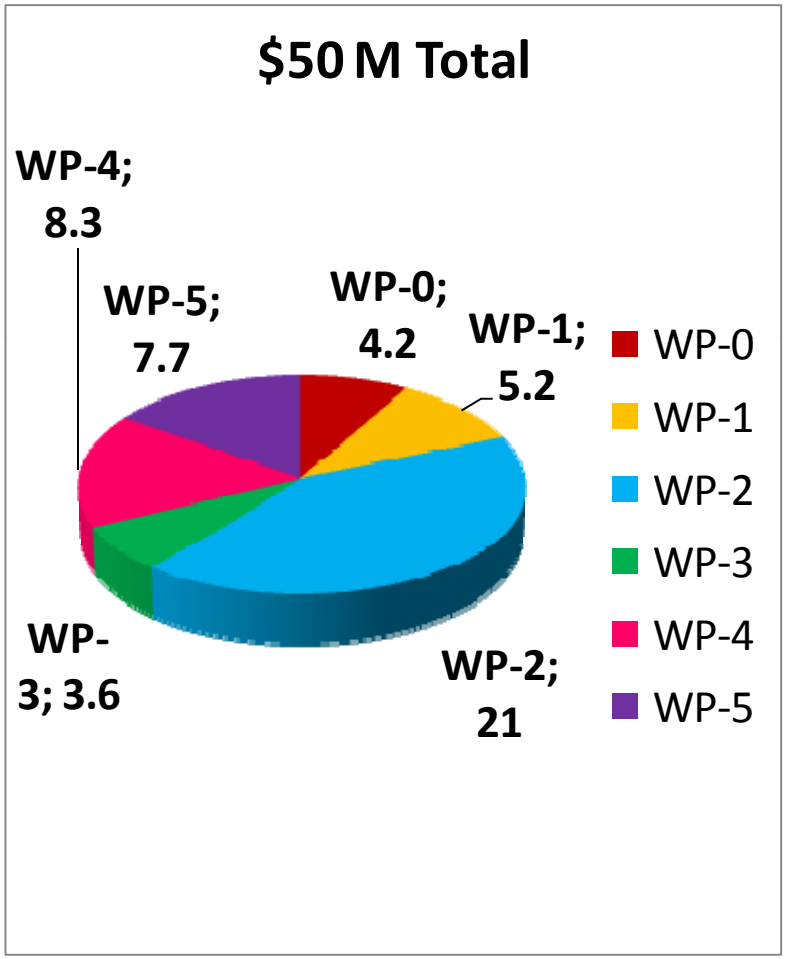
- If treated as described by DOE, the Commission would regard the residual fraction as "incidental" waste and would not be subject to NRC licensing authority, based on the Commission's understanding that DOE will assure that the waste:
  - (1) has been processed (or will be further processed) to remove key radionuclides to the maximum extent that is technically and economically practical;
  - (2) will be incorporated in a solid physical form at a concentration that does not exceed the applicable concentration limits for Class C low-level waste as set out in 10CFR Part 61; and
  - (3) will be managed, pursuant to the Atomic Energy Act, so that safety requirements comparable to the performance objectives set out in 10CFR Part 61 are satisfied.

*1993 Correspondence; R.Bernero (U.S.NRC) to J.Lytle (U.S.DOE)

Tank Farm Comparison

Tank Specification	Hanford Site	Savannah River Site	Idaho National Laboratory	
			Sodium Bearing Waste	Calcine
Number of tanks / Areas to Close / Volume of Waste	177 Tanks 18 Tank Farms 56.5 Mgal Waste	51 Tanks 2 Tank Farms 36.5 Mgal Waste	11 Tanks 1 Tank Farm ~900, 000 gal	7 Calcine Bin Sets 1 Area 1 Mgal (liquid vol.)
Tank Types	2 (149 SSTs and 28 DSTs)	4 (Type I, II, III, and IV)	1	2 (annular and cylindrical bins)
Construction Period	SSTs: 1943-1964 DSTs: 1968-1986	Type I: 1954-1965 Type II: 1956-1960 Type III: 1971-1992 Type IV: 1959-1965	1953-1966	1960"s
Tank Size	55,000 gal - 1.16 Mgal	750,000 gal – 1.3 Mgal	30,000 – 318,000 gal	60,000 – 471,000 gal
Const. Material	Carbon Steel	Carbon Steel	Stainless Steel	Stainless Steel
Waste Types	Viscous, concentrated alkaline liquid, sludge, and saltcake	Viscous, concentrated alkaline liquid, sludge, and saltcake	Acidic, liquid sodium waste, and small amount of sludge	Calcined solids
Extent of obstructions in tank	Abandoned equipment and debris	Severe obstructions, vertical cooling coils in most tanks	Little or none; cooling coils on bottom and walls	Limited access
Tank Conditions	67 Confirmed or assumed leakers with est. of 1 Mgal to soil	11 Leakers, 1 to soil	No Leakers	No Leakers
Tank Depth relative to water table	Well Above; ~180'	Some tanks are in water table	Well above; >200'	Bins above surface

FY 2010 Tank Waste Technology Funding



Technology Gaps for Tank Waste Processing		Priority
WP-0	Technical Planning, Integration and Risk Management	N/A
WP-1	Waste Retrieval and Closure – Substantial amounts of waste may be left in tanks after cleanout – especially in tanks with obstructions.	High
WP-2	Alternative Waste Pretreatment – Low-activity streams from tank waste processing could contain substantial amounts of radionuclides.	Medium
WP-3	Advanced Unit Operations – New facility designs and processes usually rely on pilot-scale testing with simulated rather than actual wastes.	Medium
WP-4	Improved Vitrification Capacity – Increased Vitrification Capacity may be needed to meet schedule requirements.	High
WP-5	Increased Waste Loading – The baseline tank waste vitrification process significantly increases the HLW volume.	Medium

WP-1: Waste Retrieval and Closure Technologies

WBS	Activity Area Description	Funding Proposed for WP-2	Description
WP 1.1	Alternative Chemical Cleaning	$ 1.5 M	On-going task to develop improved methods to control the chemistry of tank heels: • Chemical Cleaning: removes iron and aluminum in sludge and lightens the burden on downstream processing. ($1.0 M) • Gas Retention: reduces the possibility of high concentrations of radiolytically generated hydrogen and allows greater usage of available tank space. ($0.5 M)
WP 1.2	High-Throughput Waste Reduction	$ 2.2 M	Improved methods of tank waste handling and tank space usage: • Wiped Film Evaporator: provides auxiliary evaporative capacity, can be done at tank, and would free up more usable tank space. ($1.4M) • Plugging Issue Resolution: Facilitates tank operations by eliminating or reducing transfer line plugs and possibly allowing a higher solids content to be transferred. ($0.8M)
WP 1.3	Sludge Differential Settling	$ 0.5 M	Selective separation by in-tank elutriation of high radiological risk sludge components to control rheology and criticality: • In-Tank Elutriation: Could lead to preferential separation of certain radionuclides of interest (Pu, Cm, Sr, Cs) from tank heels and allow a larger tank heel to remain due to reduced risk ($0.5 M)
WP 1.4	Improve Cementitious Materials	$ 1.0 M	Continuation of the on-going effort to improve the tools used in performance assessments • Provides support to the Cementitious Barriers Partnership
Total		**$5.2 M**	

WP-2: Alternative Waste Pretreatment

WBS	Activity Area Description	Funding Proposed for WP-2	Description
WP 2.1	At-tank/In-tank solutions	$ 6.2 M	Waste treatment in the tank farms to supplement the main treatment plant or facility: • Sorbent for Improved Strontium and Actinide Separations: Develops material that will be used in conjunction with Cs removal (by ion exchange) to enable separation of Cs, Sr and Actinides in a single unit.(0.7 M) • Rotary Microfiltration: Concentrates slurries in a unit near a tank. ($ 1.0 M) • Small Column Ion Exchange: Matures use of Spherical Resourcinol Formaldehyde (sRF) resin for ion-exchange at either Hanford or SRS. ($ 0.8 M) • Continuous Sludge Leaching (with Near Tank Treatment System): Project develops an approach for dissolution and removal of aluminum boehmite in tank farms (S/SX high Al tanks). ($ 1 M) • Phosphate Management: Phosphate removal mitigates a risk of gelation and plugging. ($1.3 M) • Next Generation Cesium Solvent: – would extend the life of the Modular Caustic Side Solvent Extraction Unit (MCU) and throughput of SWPF, could make solvent extraction feasible for use at Hanford with greater selectivity. ($1.4 M)
WP 2.2	Technetium Management	$ 2.9 M	Immobilization of key LAW risk-driver (Tc): • Improved Retention of Tc in LAW: Manage cold-cap chemistry in melter to retain Tc. ($ 0.2 M) • Tc Removal using Goethite Precipitation: Precipitation of Tc/Fe hydroxide (goethite) from LAW off-gas scrubber to divert to HLW stream ($ 1.1 M) • Improved Retention in Secondary Wastes – Develop a non-mobile Tc compound to reduce release from non-glass waste (cementitious, steam reforming product). ($1.6 M)
WP 2.3	Advanced Separations	$ 10.8 M	Technology for separation and removal of aluminum, sodium, sulfate, and solids: • Aluminum Solubility: Real waste testing to demonstrate Al solubility for WTP and tank farm conditions. ($1.0 M) • Electrochemical Caustic Recycle: Electrochemical recycle of sodium hydroxide used for aluminum leaching. ($ 1.6 M) • Lithium Hydrotalcite (LiHT) (Precipitation for Caustic Recycle): Precipitation of dissolved aluminum using lithium and magnesium salts to a mineral form to recycle hydroxide and minimize sodium use. ($4.8M) • Alternative Sodium Technologies: Explores destruction of nitrates near tank; also leaching at high temperature and concentration. ($ 1 M) • Sulfate Removal: Survey and explore candidates to remove melter-limiting sulfate salts and evaluate the impact on downstream processes. ($ 0.7 M) • Filtration: Predictive model & testing of cross-flow filtration fouling, cleaning, and operational strategy. ($ 1.6 M)
WP 2.4	In-Situ Characterization	$ 0.9 M	Understanding of residual tank waste to assist retrieval and closure strategy: • Raman Spectroscopy - Identification of tank waste compounds through Raman spectra. ($ 0.475 M) • Radiometric Characterization - In-tank measurement of x-ray emissions to measure relative concentrations of radioactive elements. ($ 0.475 M)
Total		**$20.8 M**	

WP-3: Advanced Unit Operations and Scaling

WBS	Activity Area Description	Funding Proposed for WP-3	Description
WP 3.1	Develop Advanced Multi-Phase Mixing and Suspension Methods	$ 500 K	**Advanced Multi-Phase Mixing and Suspension Methods: Develop a computational code to predict the behavior of actual solids in waste slurries, reducing the risk in unit operations involving mixing, transport and processing:** • **Waste Feed Delivery: Provide guidance for the design of waste feed extraction based on Paraflow CFD simulations. ($ 0.35 M)** • **Advanced Multi-Phase Mixing: Model (Paraflow CFD) of DWPF feed tanks and issue guidance on jet pump operation time. ($ 0.15 M)**
WP 3.2	Develop Simulants to Enable Design Verification	$ 3,100K	**Develop Simulants to Enable Design Verification, Improve Process Simulation Tools:** • **Actual Waste Testing to Determine Key Physical and Chemical Properties (1.35 M)** • **Scaled Validation Testing/Modeling of Transformational Solutions (Rheological Modifiers, Improved Anti-Foam Agent, Gibbsite Inhibitor) ($1.75M)**
Total		**$3.6 M**	

WP-4: Improved Vitrification Capacity

WBS	Activity Area Description	Funding Proposed for WP-4	Description
WP 4.1	Develop Next Generation Melters	$7,555 K	The rate of glass production and loading of waste in glass is strongly dependent on glass melter design and operation. • Next Generation Waste Glass Melter Workshop and Needs Definition ($ 0.2 M) • Glass Formulation for Next Generation Melters ($1.1 M) • Next Generation Induction-heated and Advanced Joule-heated Melter Bench Scale Testing ($ 2.0 M) • Next Generation Melter Development and Engineering: Advanced glass contact materials and crystal tolerance in AJHM and large scaling of melter for CCIM. ($ 3.0 M) • Design, Fabrication, and Installation of Next Generation Test Melter System ($1.2 M) • Next Generation Melter Testing and Component Improvement ($0 M starts in 2011) • Next Generation Melter Technology Innovation Call Issue call for innovative concepts in melters and associated systems to improve performance and reliability. Call in FY10, start funding in FY11. ($0 M) • Next Generation Melter Diagnostic Development and Demonstration: Develop melter and system diagnostic tools. ($0 M starts in 2011)
WP 4.2	Advanced Processes Understanding and Predictive Tools for Melter Cold Cap Chemistry	$925 K	Develop sufficient chemical understanding of the complex reactions that convert melter feed into the glass melt and the physical parameters known to influence melting behavior such as heat transfer to and within the cold cap. • Bench Scale Testing of Cold-cap Processes: Perform experimental studies to better understand cold-cap processes. ($ 0.5 M) • Cold-cap Reaction Simulation Code Development: Develop heat-mass reactive transport code capable of predicting the behavior of melter cold-caps. ($ 0.3 M) • Improvement of Existing DWPF Melting Rate Model ($ 0.2 M)
Total		**$8,480 K**	

WP-5: Increased Waste Loading

WBS	Activity Area Description	Funding Proposed for WP-5	Description
WP 5.1	Advanced Glass Formulations to Increase Waste Loading and Melt Rate	$5,000 K	Glass formulation improvements for increased waste loading to reduce the volume of glass produced, stored, transported, and disposed. • Phosphate Glass Development and Demonstration ($3.0 M) • Advanced Silicate Glass Development and Demonstration (glass-ceramics, low-silicate glasses, and other silicate based waste forms for existing melters) ($2.0 M)
WP 5.2	Alternative Treatment and Disposal Processes using Advanced Waste Forms	$2,750 K	Develop treatment options for a broader range of secondary low-level wastes (LLW), and selected LAW's, and other orphan wastes by processes other than vitrification. • Fluidized Bed Steam Reformer Low-Level Waste Form Qualification: ($0.6 M) • Joint EM-NE-International Study of Glass Behavior Over Geologic Time Scales for international consensus on rate laws in various environments: Co-funded partnership and agreement with DOE-NE, France, Belgium, Japan, and the U.K ($0.55 M) • Low-temperature Waste Forms for Low-level Wastes and Off-gas Recycles (alternatives to cement with better performance and pretreatment options to stabilize Tc in cement waste forms) ($1.6 M)
Total		**$7,750 K**	