DOCUMENT RELEASE AND CHANGE FORM

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River Protection Project Technology And Innovation Roadmap

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U.S. Department of Energy Contract DE-AC27-08RV14800

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Abstract: The Technology and Innovation Roadmap is a planning tool for WRPS management, DOE ORP, DOE EM, and others to understand the risks and technology gaps associated with the RPP mission. The roadmap identifies and prioritizes technical areas that require technology solutions and underscores where timely and appropriate technology development can have the greatest impact to reduce those risks and uncertainties. The roadmap also serves as a tool for determining allocation of resources.

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EXECUTIVE SUMMARY

The Technology and Innovation Roadmap presents a comprehensive, integrated assessment of the technology-related advances needed to achieve successful completion of the Hanford Site tank waste cleanup mission. Key near-term U.S. Department of Energy (DOE), Office of River Protection (ORP) River Protection Project (RPP) mission needs with respect to the next 10 years are identified and prioritized. The Technology and Innovation Roadmap will be used to assist with planning near-term scope to address technology priorities and will be updated periodically.[1] The Technology and Innovation Roadmap is consistent with the ORP priorities presented in Letter 17-WSC-0016[2] and is also in alignment with other Hanford Site technical initiatives and policy and planning documents.

ES.1 DEVELOPMENT METHODOLOGY AND TECHNOLOGY PRIORITIZATION

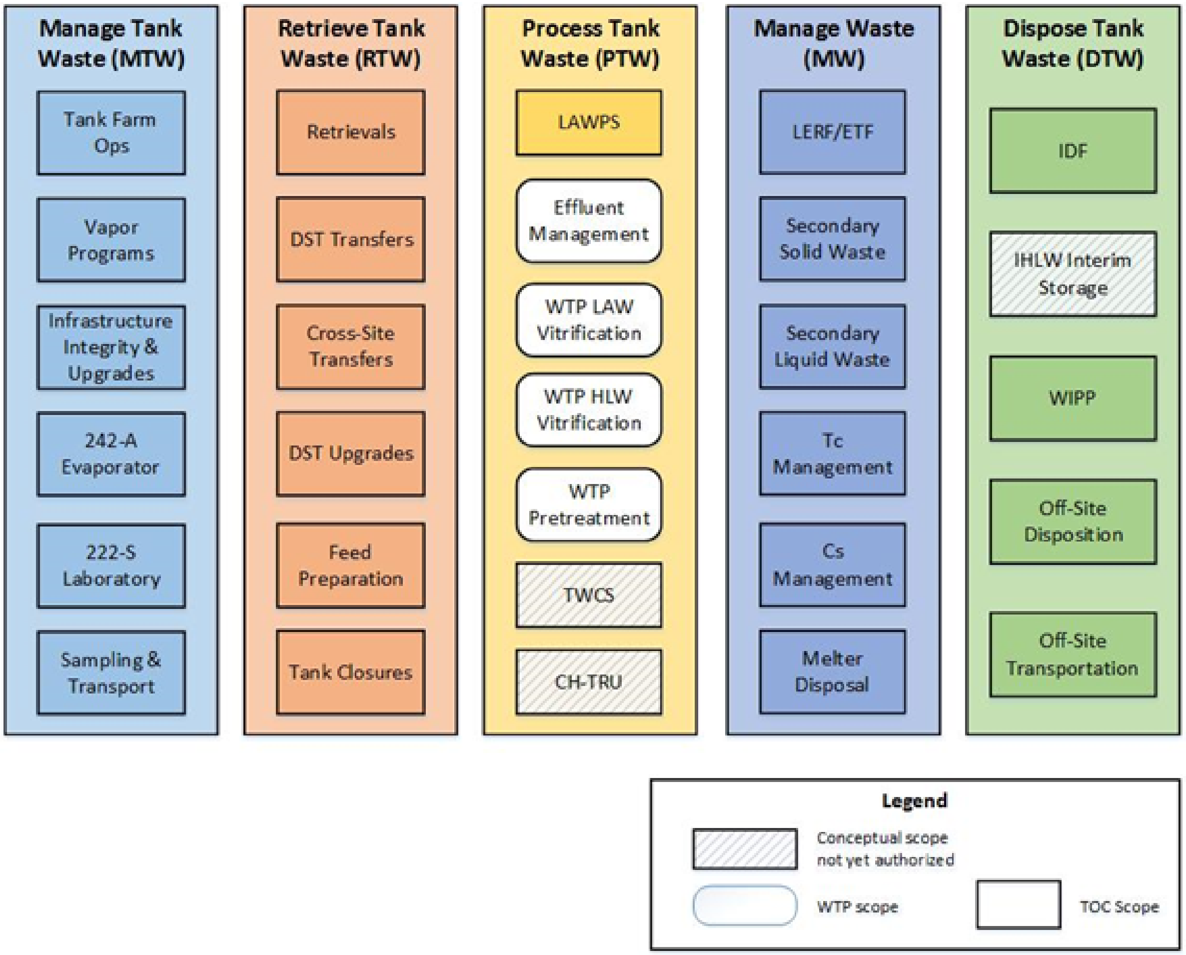
This Technology and Innovation Roadmap is primarily a planning tool used to assist with near-term scope allocations to address ORP priorities and will be revised on a regular basis. This document focuses on identifying and connecting technology needs to high-priority, near-term mission objectives and also considers longer-term gaps and pending programmatic decisions that require technology support. The technology evaluation includes prioritizing those needs to ensure that they are addressed to support the RPP mission.

The RPP functional areas were identified and defined in terms of their role in the mission and in alignment with the Tank Operations Contract (TOC) work breakdown structure. Subject matter experts for each functional area were identified and consulted. These experts provided consolidated input regarding technology needs for each functional area using standardized pro forma worksheets. The pro forma worksheet is a tool that enables direct comparison of provided input. Figure ES-1 illustrates the functional and sub-functional area "bins."

Note that routine process operations support is not included as part of the Technology and Innovation Roadmap. Process technology support activities (e.g., waste compatibility evaluations) are ongoing programs that will permanently support operations. Waste Treatment and Immobilization Plant (WTP) technology needs are identified in Figure ES-2 as functional groups under Process Tank Waste. The WTP project has advanced to the detailed design and construction phases; therefore, no specific needs for identifying, selecting, and advancing technologies has occurred. Before the design and construction of some WTP facilities can be completed, a number of technical issues that require resolution must be addressed. The goal of future revisions of this planning document is to capture specific WTP technology needs. Ongoing WTP technical issue resolution is also a Hanford Site high-priority but does not require "technology needs" (besides technical issue resolution, see Section 7.0 of this report) to warrant inclusion in the Technology and Innovation Roadmap.

[1] The period between revisions has not been finalized. Ideally, the document will be revised annually to help facilitate project planning.

[2] 17-WSC-0016, 2017, "Contract Number DE-AC27-08RV14800 – Fiscal Year 2018 Preliminary Budget Guidance for Technology Roadmap and Chief Technology Office" (Letter from G.D. Trenchard to K.A. Downing of Washington River Protection Solutions, LLC, May 11), U.S. Department of Energy, Office of River Protection, Richland, Washington.

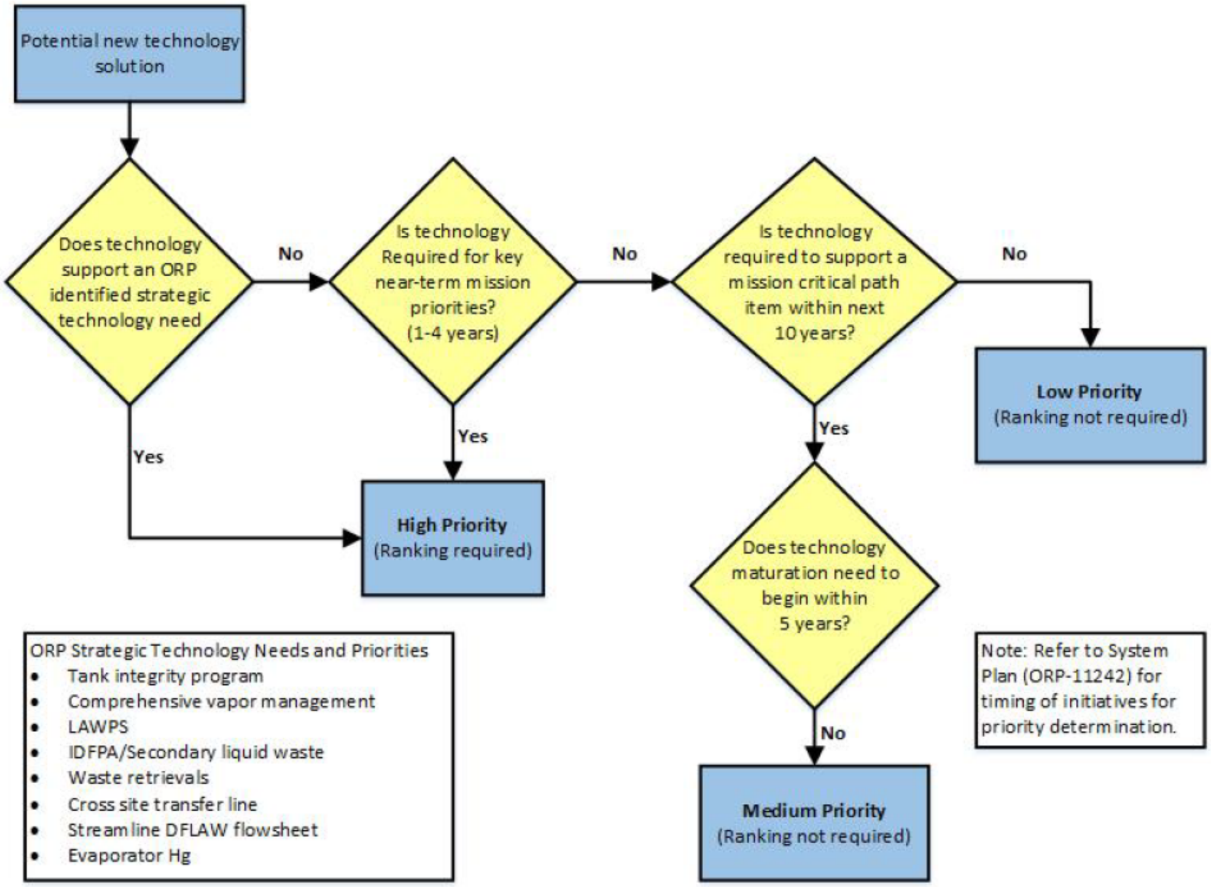


CH-TRU	=	contact-handled transuranic.	ETF	=	Effluent Treatment Facility.	LERF	=	Liquid Effluent Retention Facility.
Cs	=	cesium.	HLW	=	immobilized high-level waste.	Tc	=	technetium.
DFLAW	=	direct-feed low-activity waste.	LAW	=	low-activity waste.	WIPP	=	Waste Isolation Pilot Plant.
DST	=	double-shell tank.	LAWPS	=	low-activity waste pretreatment system.	WTP	=	Waste Treatment and Immobilization Plant.

Figure ES-1. Functional Area Summary.

The key performance parameters relating to fiscal year 2018 ORP strategic initiatives are specified in Letter 17-WSC-0016.[3] In support of those initiatives, a council consisting of the functional area subject matter experts, independent reviewers, and ORP developed the prioritization criteria and scored the technologies versus the criteria. The priority ranking council was enhanced in 2017 to include performance measurement baseline and life-cycle baseline representatives. Figure ES-2 illustrates the general logic for screening and prioritizing technology items evaluated by the prioritization council. This basic diagram is used to guide the prioritization process throughout the Technology and Innovation Roadmap. The technologies were first prescreened against the mission goals outlined in the Letter 17-WSC-0016 and the key ORP near-term mission needs.

[3] 17-WSC-0016, 2017, "Contract Number DE-AC27-08RV14800 – Fiscal Year 2018 Preliminary Budget Guidance for Technology Roadmap and Chief Technology Office" (Letter from G.D. Trenchard to K.A. Downing of Washington River Protection Solutions, LLC, May 11), U.S. Department of Energy, Office of River Protection, Richland, Washington.



ORP-11242, 2014, *River Protection Project System Plan*, Rev. 7, U.S. Department of Energy, Office of River Protection, Richland, Washington.

DFLAW	=	direct-feed low-activity waste.	LAWPS	=	low-activity waste pretreatment system.
Hg	=	mercury.	ORP	=	U.S. Department of Energy, Office of River Protection.
IDF	=	Integrated Disposal Facility.	PA	=	performance assessment.

Figure ES-2. Mission-Driven Technology Activity Prioritization Logic.

Table ES-1 summarizes the evaluation criteria and scoring protocol used to prioritize technology needs. The evaluation criteria are divided into high, medium, and low weighting categories. High weighting is attributed to those technologies that impact safety and compliance with DOE requirements and commitments. Medium weighting is attributed to technologies that mitigate risk, positively impact schedule, and provide technology benefits beyond the identified application. Low weighting is attributed to implementation complexity and mission enhancement potential.

As part of the overall priority evaluation, additional incremental scoring based on the level and extent of the impact for each criterion was also taken into account. The final priority value is scored according to the summation of the weighted high, medium, and low attributes.

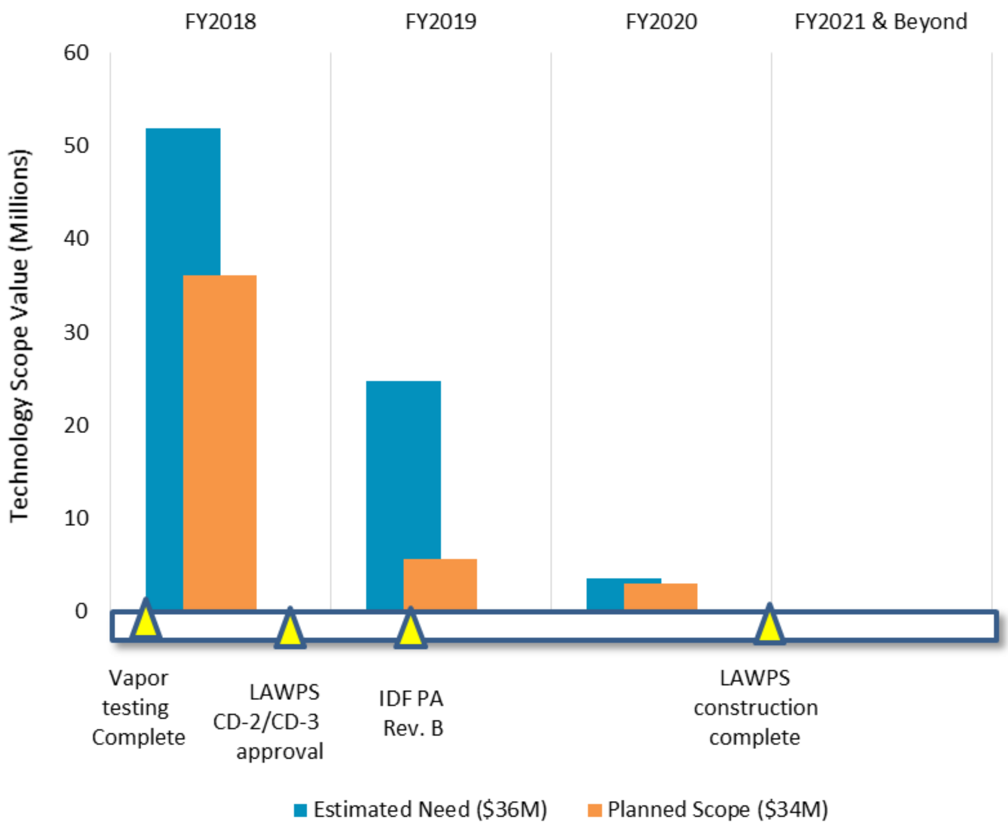
Table ES-1. Scoring Protocols for Priority Determination.

Evaluation Criteria	High (3x weight)			Medium (2x weight)			Low (1x weight)	
	Safety	DOE Commitment	Strategic Initiative	Risk Mitigation	Schedule Impact	Technology Impact	Implementation Complexity	Mission Enhancement
Gauge for relative criteria score	Reduce specifically identified safety risk?	Contribute to DOE commitment or milestone completion?	Support ORP identified Strategic Initiative?	Reduce RPP mission or WRPS program and project risk?	Impact near-term schedule?	Multiple applications?	Change existing operating protocols or extend schedule?	Improve or accelerate the mission?
3	Yes	Needed for Consent Decree or DFLAW	Yes, directly supports initiative	Supports mitigation or impacts RPP mission risks	Needed to maintain or recover key RPP mission objectives schedule	Benefits other WRPS projects or DOE sites	No, within scope with no delays expected	Implements a specific opportunity that improves mission efficiency
2	Potentially	Needed for TPA, DOE HQ or public commitment	Enhances an initiative but not critical path	Supports risk items that don't impact RPP mission risks	Needed to accelerate key mission objective schedule	Benefits other Hanford projects	Extra time and more schedule activities may be needed	Improves likelihood of mission efficiencies
1	No	No direct impact	No direct impact	N/A or acceptable risk	No impact to key RPP mission objective schedules	Project-specific, WRPS application only	Extra time and more schedule activities will be needed	None identified
Total = 3∑(high criteria scores) + 2∑(medium criteria scores) + 1∑(low criteria scores)								

DFLAW = direct-feed low-activity waste.
DOE = U.S. Department of Energy.
HQ = Headquarters.
N/A = not applicable.
RPP = River Protection Project.
TPA = Tri-Party Agreement.
WRPS = Washington River Protection Solutions, LLC.

Figure ES-3 summarizes the near-term, high-priority scope needs and presents rough order of magnitude estimates from pro forma input.

For purposes of the scope profile charts, "Planned scope" includes activities that are part of the TOC or ORP life-cycle planning basis, and activities that are included in the TOC fiscal year 2017/2018 contract proposal provided to ORP. "Estimated need" includes all technology scope identified on the pro forma worksheets regardless of associated planning status. To date, no high-priority pro formas related to WTP scope have been received. The charts presented in this Executive Summary only reflect the high-priority items that impact key near-term mission priorities. Medium- and low-priority items are addressed in Section 7.0 of this document.



FY	=	fiscal year.	IDF PA	=	Integrated Disposal Facility Performance Assessment.
LAWPS	=	low-activity waste pretreatment system.			

Figure ES-3. High-Priority Technology Scope Profile.

ES.2 TECHNOLOGY NEEDS

For purposes of this evaluation, technology selection refers to the identification of new technologies that are not included in current baseline designs or project planning. Table ES-2 presents a summary of the high-priority needs that were scored by the prioritization council, with a focus on the overall *ORP Strategic Technology Needs & Priorities*. These results were obtained as part of the Technology and Innovation Roadmap development process and grouped to be consistent with project planning. The ranking results from the prioritization process and a planned path forward to describe the next steps to address technology maturation needs are also considered.

The left hand column of Table ES-2 shows the ranking of the high-priority pro forma. The lowest number corresponds to the highest priority. For example, the rank of "1.0" is the highest possible priority and 2.1 is higher than 2.2.

Table ES-2. Summary of High-Priority Needs. (2 pages)

Rank	Pro Forma #	Title	ORP Strategic Technology Needs and Priorities
1.0	PTW-48	LAWPS Cs IX column	LAWPS
2.1	PTW-19	LAWPS TE-3 IX using sRF	LAWPS
2.2	PTW-17	LAWPS integrated scale test (before CD-2)	LAWPS
3.1	RTW-55	Hanford waste end effecter	Waste Retrievals
3.2	MTW-23	Provide technology/methods to mitigate selected active/passive tank farm vapor sources	Vapors
4.1	PTW-21	LAWPS TE-8 resin handling system-resin replacement and disposal	LAWPS
4.2	PTW-18	LAWPS TE-2 cross-flow filtration (return to AP-107)	LAWPS
4.3	MTW-9	Automated DST annulus camera system	Tank Integrity Program
5.1	MTW-24	Implement recommended Tank Farm vapor monitoring/detection equipment/predictive modeling software	Vapors
5.2	MTW-69	Personal ammonia monitor that reports ammonia concentrations to the Central Shift Office in real-time.	Vapors
6.0	PTW-31	Maturation of the DFLAW feed qualification processes	Streamline DFLAW Flowsheet
7.1	MTW-49	Corrosion control DFLAW bounding	Tank Integrity Program
7.2	DTW-3	Characterize ILAW glass to support the IDF PA update and future maintenance	IDF PA/Secondary Liquid Waste
7.3	RTW-24	Two-step characterization of the 241-C-301 catch tank contents	Waste Retrievals
7.4	RTW-8	Develop in-tank mechanical waste gathering system	Waste Retrievals
8	DTW-7	Development and maturation of a technology for solidification/stabilization of solid secondary waste	IDF PA/Secondary Liquid Waste
9.1	PTW-49	Study to examine feasibility of removing nitrates from the LAW feed stream prior to vitrification.	LAWPS
9.2	MTW-68	Mass spectrometer (PTR-MS) mounted in a mobile analytical laboratory	Vapors
9.3	MTW-59	Zeolites for reducing exposure to nitrosamines from tank vapors	Vapors
9.4	MTW-56	Evaluate and establish inventory of DFLAW organic COPCs	Streamline DFLAW Flowsheet
10.1	MW-2	Liquid secondary waste grout ammonia vapor	Vapors
10.2	MTW-66	Treat NDMA in the tank headspace or tank-side, where there is >48 hours of residence time	Vapors
11.1	RTW-54	Tank waste modular treatment study	Waste Retrievals
11.2	MTW-41	Analytical method development at the 222-S Laboratory	Vapors
11.3	PTW-40	HLW direct vitrification	LAWPS

Table ES-2. Summary of High-Priority Needs. (2 pages)

Rank	Pro Forma #	Title	ORP Strategic Technology Needs and Priorities
12.1	RTW-39	Develop a strategy and basis for anticipating and predicting residual waste volumes and properties	Waste Retrievals
12.2	MTW-20	Acquire and test an upgraded still and video camera system for DST and SST inspections	Tank Integrity Program
13.1	MTW-11	Volumetric inspection of DST primary tank bottoms	Tank Integrity Program
13.2	MTW-15	Visual inspection of DST air slots using a robotic crawler	Tank Integrity Program
13.3	MTW-40	Improved sampling methods for headspace particulate analysis	Vapors
14	PTW-44	Technical basis for sRF storage - life expectancy and Cs-removal efficiency over time and method	LAWPS

COPC = constituent of potential concern.
Cs = cesium.
DFLAW = direct-feed low-activity waste.
DST = double-shell tank.
DTW = dispose tank waste.
FY = fiscal year.
HLW = high-level waste.
IDF = Integrated Disposal Facility.
ILAW = immobilized low-activity waste.
IX = ion exchange.
LAWPS = low-activity waste pretreatment system.
MTW = manage tank waste.
NDMA = N-nitrosodimethylamine
ORP = U.S. Department of Energy, Office of River Protection.
PA = performance assessment.
PTR-MS = proton transfer reaction – mass spectrometer.
PTW = process tank waste.
RTW = retrieve tank waste.
sRF = spherical resorcinol formaldehyde.
SST = single-shell tank.

ES.3 TECHNOLOGY SUMMARY

The Technology and Innovation Roadmap is intended to serve multiple functions, including the following:

- Highlight existing technology gaps through pro forma submittals
- Promote initiation of appropriate technology development or maturation actions
- Anticipate emerging technology needs
- Provide a basis for mission planning by identifying opportunities to use national laboratory resources to mitigate RPP mission risks
- Identify integration opportunities
- Serve as a tool for fiscal year planning with stakeholders and technology development customers and providers
- Communicate tank farm mission technology priorities to ORP
- Understand and facilitate implementation of ORP strategic initiatives (Section 2.4).

These functions are summarized in charts that represent the resources that will be required by each project as a function of time. The estimated needs and planned scope are provided as rough order of magnitude estimates. Several milestone dates are also reflected for reference. Note that not all out-year planning is reflected, as only high-priority needs are represented. Because urgency factors into assessing priority, needs will change and progress over time.

This report summarizes the high-priority technology needs that directly impact the near-term RPP mission objectives. All identified technology needs, and a more detailed look at national laboratory support in addressing these needs, are discussed in Sections 4.0 and 7.2, respectively.

The key elements of the RPP mission require the application of technology to achieve mission success. A comprehensive list of technology needs has been identified, screened, and prioritized to ensure that the technology needs are included in baseline planning. The high-priority technology needs that support near-term mission priorities (fiscal year 2017-2018) approach $88 million in annual scope. Of this scope, 80% (approximately $68 million) is included in planned baseline scope in the fiscal year 2018 contract proposal that has been provided to ORP. There is an approximately $20 million deficit indicated for fiscal year 2018 proposed work, which may be considered during fiscal year 2018 planning.

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LIST OF TERMS

Acronyms and Abbreviations

BBI	best-basis inventory
CD	Critical Decision
CFF	cross-flow filtration
CH-TRU	contact-handled transuranic
COPC	constituent of potential concern
Cs	cesium
CSST	cross-site slurry transfer
CTO	Chief Technology Office
CWC	Central Waste Complex
DFLAW	direct-feed low-activity waste
DOE	U.S. Department of Energy
DST	double-shell tank
DTW	dispose tank waste
EM	U.S. Department of Energy, Office of Environmental Management
ETF	Effluent Treatment Facility
FY	fiscal year
HDW	Hanford Defined Waste
HLW	high-level waste
HQ	U.S. Department of Energy, Headquarters
I	iodine
IDF	Integrated Disposal Facility
IHLW	immobilized high-level waste
ILAW	immobilized low-activity waste
IMUST	inactive miscellaneous underground storage tank
IX	ion exchange
LAW	low-activity waste
LAWPS	low-activity waste pretreatment system
LERF	Liquid Effluent Retention Facility
LLW	low-level waste
MARS	mobile arm retrieval system
MTW	manage tank waste
MUST	miscellaneous underground storage tank
MW	manage generated wastes and excess facilities
NDMA	N-Nitrosodimethylamine
ORP	U.S. Department of Energy, Office of River Protection
PA	performance assessment
PJM	pulse jet mixer
PMB	performance measurement baseline
PPE	personal protective equipment
PT	pretreatment
PTR-MS	proton transfer reaction – mass spectrometer
PTW	process tank waste

RCRA	*Resource Conservation and Recovery Act of 1976*
RPP	River Protection Project
RTW	retrieve tank waste
SBS	submerged bed scrubber
SLW	secondary liquid waste
sRF	spherical resorcinol formaldehyde
SST	single-shell tank
SSW	secondary solid waste
System Plan	River Protection Project System Plan (ORP-11242)
Tc	technetium
TC&WM EIS	Tank Closure and Waste Management Environmental Impact Statement (DOE/EIS-0391)
TOC	Tank Operations Contract
TPA	Tri-Party Agreement (Ecology et al. 1989)
TRL	technology readiness level
TRU	transuranic
TWCS	tank waste characterization and staging
VMDS	vapor monitoring and detection system
WFAQ	waste feed acceptance and qualification
WIPP	Waste Isolation Pilot Plant
WRF	Waste Receiving Facility
WRPS	Washington River Protection Solutions, LLC
WTP	Hanford Tank Waste Treatment and Immobilization Plant

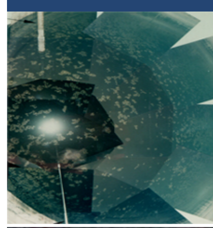
Units

Ci	curie
ft	foot
ft^3	cubic foot
gal	gallon
hr	hour
in.	inch
kgal	thousand gallons
Mgal	million gallons
min	minute
MTG	metric tons of glass
R	roentgen
wt%	weight percent

1.0 INTRODUCTION

An estimated 54 million gallons[1] (Mgal) of radioactive waste are stored in 177 underground tanks at the Hanford Site, located in southeastern Washington State. This waste resulted from plutonium production for the nation's nuclear defense program. There are 149 single-shell tanks (SST), which were constructed between 1943 and 1964. Sixty-six SSTs are located in the 200 East Area and 83 SSTs are located in the 200 West Area. The SSTs are currently only used for storage and have had nearly all of the free liquid removed as part of the Interim Stabilization Program. Current SST waste inventories are primarily sludges, salt cake, and supernate. The 28 double-shell tanks (DST) at the Hanford Site were constructed between 1968 and 1986. Three DSTs are located in the 200 West Area, and 25 DSTs are located in the 200 East Area. The waste tanks contain a complex and diverse mix of radioactive and chemical waste in the form of sludge, salts, and liquids, necessitating a variety of unique waste retrieval, treatment, and disposition methods. Descriptions and volumes of these waste fractions for SSTs and DSTs are provided in Figure 1-1.

What is in the Hanford Tanks?



Supernate: 19 Mgal
Liquid above the solids or in large liquid pools in waste storage tanks.

Saltcake: 24 Mgal
Soluble salts in waste storage tanks formed by the evaporation of liquid waste from nuclear reactor fuels reprocessing, and is characterized by high porosity, interstitial liquid drainability, and crystalline texture.

Sludge: 11 Mgal
Insoluble hydrated metal oxides and fission products in waste storage tanks from nuclear reactor fuels reprocessing, and is characterized by low porosity, reduced interstitial liquid drainability, and mud-like texture.

Figure 1-1. Hanford Tank Waste Description.

In 1989, the U.S. Department of Energy (DOE), U.S. Environmental Protection Agency, and Washington State Department of Ecology entered into an enforceable compliance agreement, the *Hanford Federal Facility Agreement and Consent Order–Tri-Party Agreement* (TPA) (Ecology et al. 1989)[2], setting forth milestones for tank waste retrievals and tank closures. DOE, the regulatory agencies, and stakeholders all view tank waste cleanup as a top long-term priority. The tank waste must be retrieved, treated, immobilized, and permanently disposed to conform to the TPA provisions. The project tasked with managing this program is the River Protection Project (RPP). The RPP mission is to accomplish the following:

- Safeguard and safely manage an estimated 54 Mgal of nuclear waste stored in the Hanford Site tanks
- Treat the waste in the Waste Treatment and Immobilization Plant (WTP)
- Achieve safe waste disposition to protect the Columbia River and the environment.

[1] Waste volumes fluctuate as a function of tank retrievals and other tank farms operations. The separate waste form volumes that total 54.1 Mgal (figure 1-1) were derived from HNF-EP-0182, *Waste Tank Summary Report for Month Ending May 31, 2017*, Rev. 353, Washington River Protection Solutions, LLC, Richland, Washington.

[2] This reference includes all applicable amendments of the TPA.

The responsibility of the Tank Operations Contractor is to safely store, maintain, and retrieve the tank waste. Future responsibility includes delivery of the waste to treatment facilities for immobilization, and assuming responsibility for the immobilized waste forms. In addition, the Tank Operations Contractor is responsible for final cleanup and closure of the now-emptied waste tanks and the associated waste management areas.[3].

In accordance with guidance provided inLetter 17-WSC-0016[4], the DOE Office of River Protection (ORP) plans to pursue alternative approaches to further the RPP mission. To facilitate progress of the mission, the One System organization, comprised of Washington River Protection Solutions, LLC (WRPS) and Bechtel National, Inc. staff, is working to begin operations of the WTP Low-Activity Waste (LAW) Vitrification Facility using an alternate LAW pretreatment system (LAWPS) to provide LAW feed to the glass melter(s). The WTP LAW Vitrification Facility will be started up using LAWPS feed. This mode of operations is called direct-feed LAW (DFLAW).

The purpose of this Technology and Innovation Roadmap is to present a comprehensive, integrated assessment of the technology-related advances needed to achieve successful completion of the tank waste cleanup mission and to also identify and prioritize the current, most critical needs.

The Technology and Innovation Roadmap is primarily a planning tool used to assist with near-term scope allocations to address WRPS priorities and will be revised on a regular basis. The Technology and Innovation Roadmap is consistent with the priorities presented in the Letter 17-WSC-0016 and WRPS strategic and operational planning documents and is in alignment with other Hanford Site technical initiatives and policy documents, such as RPP-RPT-57991, *One System River Protection Project Integrated Flowsheet*. This document also includes potential technology improvements provided as a result of the ORP Grand Challenges initiative. The Grand Challenges provides input solicited by ORP throughout the DOE complex and from tribes, stakeholders, and academia regarding potential technology solutions. This information is summarized in Section 4.5.

The RPP is tasked with managing this program, with an overall mission to accomplish the following:

- Safeguard and safely manage an estimated 54 Mgal of nuclear waste stored in the Hanford tanks
- Treat the waste using the WTP
- Achieve safe waste disposition to protect the Columbia River and the environment.

The approach to permanent disposition of the waste as described in RPP-RPT-56516, *One System River Protection Project Mission Analysis Report*, is as follows:

- Perform SST waste retrievals into a DSTs and/or Waste Receiving Facility (WRF)

[3] This reference includes all applicable amendments of the TPA.

[4] 17-WSC-0016, 2017, “Contract Number DE-AC27-08RV14800 – Fiscal Year 2018 Preliminary Budget Guidance for Technology Roadmap and Chief Technology Office” (Letter from G.D. Trenchard to K.A. Downing of Washington River Protection Solutions, LLC, May 11), U.S. Department of Energy, Office of River Protection, Richland, Washington.

- Perform DST to DST transfers, including WRFs to DSTs, to support waste delivery to treatment facilities.
- Perform liquid waste transfers to LAWPS and to WTP pretreatment (PT) as well as slurry transfers to TWCS.
- Construct and operate the WTP to separate tank wastes into LAW and high-level waste (HLW) fractions and vitrify the resultant feeds into durable glass waste forms.
- Develop and deploy supplemental treatment capacity to treat the LAW fraction that cannot be immobilized by the WTP LAW Vitrification Facility.
  - Develop and deploy treatment and packaging capability for potential transuranic (TRU) tank waste at a supplemental TRU treatment facility, then store onsite at the Central Waste Complex (CWC) until final disposition has been determined (e.g. WIPP)
  - Deploy interim storage capacity for the immobilized HLW (IHLW), pending determination of the final disposal pathway
  - Close the SST and DST farms, ancillary facilities, and associated waste management areas.

The Letter 17-WSC-0016 allows for tank waste immobilization to begin as early as practicable without waiting for completion of work to resolve the technical issues associated with the WTP Pretreatment Facility and HLW Vitrification Facility. The Letter 17-WSC-0016 focuses on implementing DFLAW, which will facilitate the start of tank waste immobilization and provide additional flexibility to the tank waste treatment system.

The complexity of the RPP mission predicates the use of technology to resolve necessary technical gaps, reduce risks/uncertainties, and exploit opportunities. This document summarizes the process, results, and potential mission impacts of development, maturation, and deployment of the high-priority technologies.

The WTP is under construction and has experienced some technical difficulties resulting in delays, which in turn impact the schedule for the overall RPP mission. The tank farms infrastructure, originally built during the Cold War era, continues to age. Almost all of the underground storage tanks (and other tank farms facilities) have outlived their original engineered design lives. DOE is legally bound by the TPA and Revised Consent Decree to retrieve SSTs into DSTs. There are many challenges facing the mission, including:

- Aging Hanford Site infrastructure
- Management of DST space to support RPP Mission Objectives
- Health protection concerns regarding tank vapor emissions
- Legal obligations that drive ORP priorities (TPA)
- Delays in WTP availability.

2.0 BACKGROUND AND TECHNOLOGY AND INNOVATION ROADMAP DEVELOPMENT METHODOLOGY

In early 2007, the DOE Office of Environmental Management (EM) prepared a congressionally requested engineering and technology roadmap to support the complex cleanup effort. The National Academy of Sciences reviewed the EM Engineering and Technology Roadmap and issued a report in 2009 documenting their gap analysis on the current state of the DOE Hanford Site cleanup effort.

The initial version of this Technology and Innovation Roadmap (Revision 0), was released in May 2010 in response to the National Academy of Sciences report and was in alignment with the philosophy of the Assistant Secretary for EM[8] of leveraging existing technology, using lessons-learned across the complex, and incorporating “transformational technologies” to improve the mission. The scope for Revision 1 was to identify technology gaps, prioritize technology needs and advocate the use of national laboratories to provide technical support, with an end goal of completing the RPP mission. The scope for Revision 2 was the same; however, the content was updated to incorporate interim progress and changing mission priorities. The scope for Revision 3 is the same as the other revisions. However Revision 3 improvements include addressing integration of ORP Grand Challenge technologies and updated technology prioritization and ranking process. .

This Technology and Innovation Roadmap does not explicitly address issues that are the responsibility of the WTP Contractor, except for those that are integral to One System functions (e.g., DFLAW). This document will be revised on a regular basis and used as a tool to help prioritize and direct technology scope, particularly with respect to national laboratory work contracted to support technical needs and funding priorities. This Technology and Innovation Roadmap will not impact existing needed scope for continued baseline operations.

This Technology and Innovation Roadmap adapts the basic RPP mission functions[9] presented in Figure 2-1 as a framework to comprehensively capture mission scope.

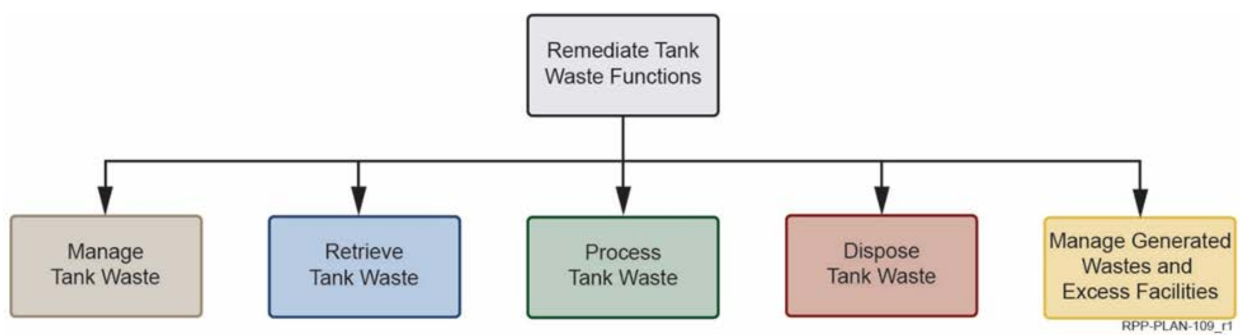
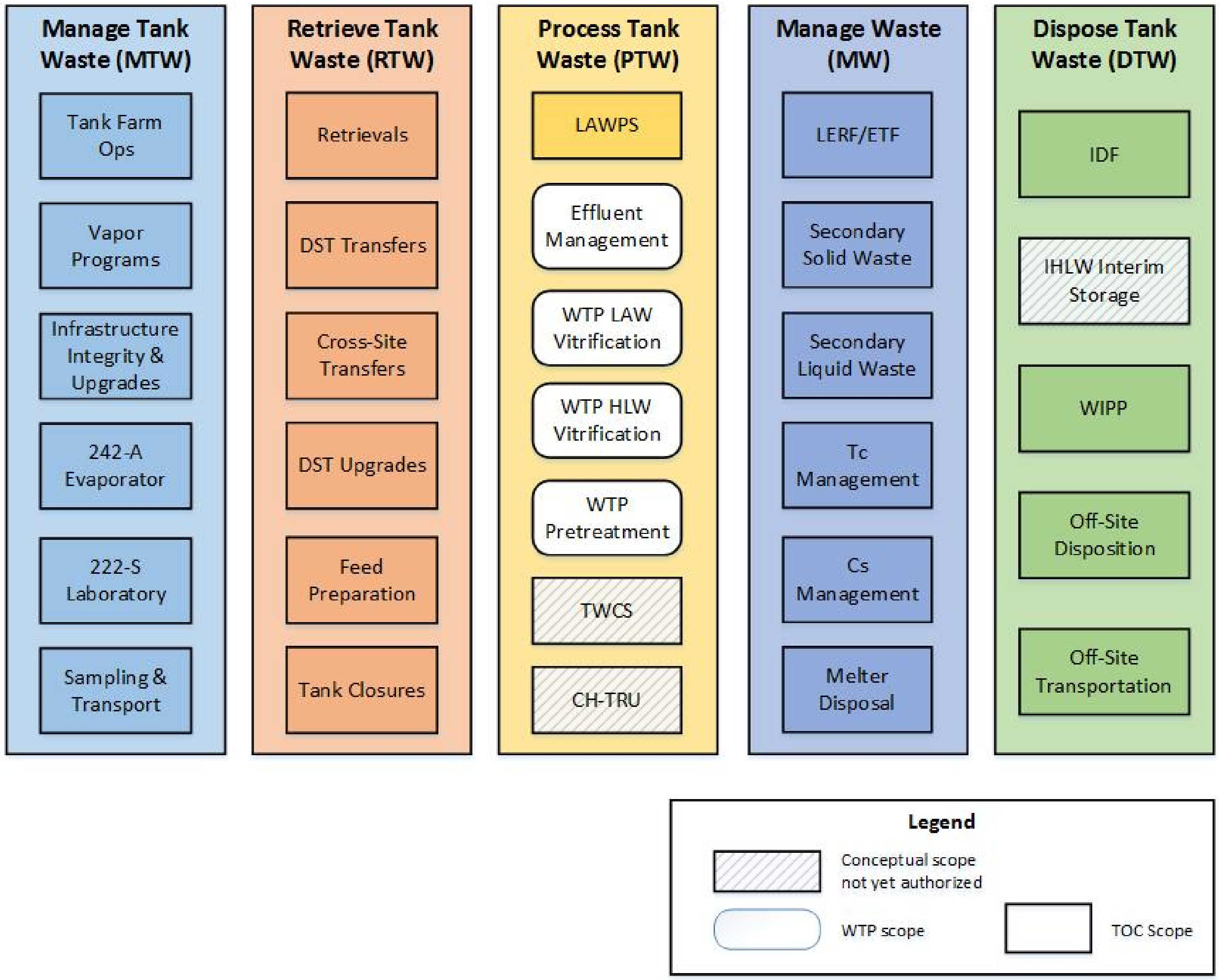


Figure 2-1. River Protection Project Mission Functional Areas.

[8] This position was held by Dr. Ines Triay at that time.

[9] The RPP mission functional areas are in alignment with the DE-AC27-08RV14800, *Tank Operations Contract,* work breakdown structure and are discussed further in RPP-51303, *River Protection Project Functions and Requirements*, and RPP-RPT-56516.

The basic functional "bins" are used to ensure that all of the RPP mission requirements have coverage in the Technology and Innovation Roadmap. The adapted functional structure is depicted in Figure 2-2.



CH-TRU = contact-handled transuranic.
Cs = cesium.
DST = double-shell tank.
ETF = Effluent Treatment Facility.
IHLW = immobilized high-level waste.
LAW = low-activity waste.
LAWPS = low-activity waste pretreatment system.
LERF = Liquid Effluent Retention Facility.
Tc = technetium.
TWCS = tank waste characterization and staging.
WIPP = Waste Isolation Pilot Plant.
WTP = Waste Treatment and Immobilization Plant.

Figure 2-2. Tank Operations Contractor Functional Scope.

To ensure that the technology needs and gaps are comprehensively captured, the WRPS Chief Technology Office (CTO) assembled a team with extensive experience in Hanford Site tank farms operations spanning all of the functional areas depicted in Figure 2-2. Direct technology input was solicited from the team members (and their designees) on pro forma worksheets. Existing pro formas were updated, and additional new ones were provided to address new technologies. The pro forma worksheet is a standardized tool that enables direct comparison of provided input. The pro forma worksheets include the following information:

- Technology description
- Functional area
- Technology need/driver/linkage
- Priority and type of activity
- Programmatic interfaces
- Risk register integration
- Scope and schedule
- National laboratory (yes or no?)
- Needs/preferences
- Points of contact.

This information was used to create a comprehensive spreadsheet of technology needs (see Appendix A). From this information, a council of representatives met to prioritize the technology items identified, both within and across functional areas. This information is used to guide technical and scope priorities for the RPP mission. The process and methodology used to develop the Technology and Innovation Roadmap are depicted in Figure 2-3.

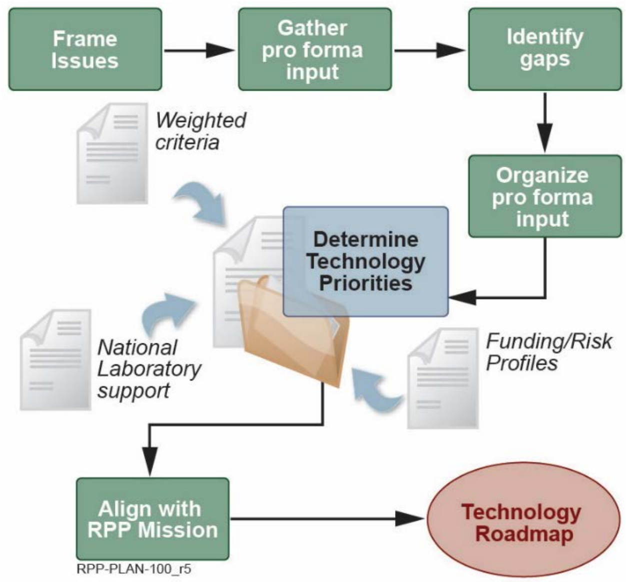


Figure 2-3. Technology and Innovation Roadmap Development Methodology.

2.1 OBJECTIVES

A primary objective of the Technology and Innovation Roadmap is to identify existing technology gaps, issues, and needs and then develop technology solutions to address them. Technology solutions may require support from the national laboratories. These technology solutions must be approached from a strategic perspective according to mission planning and integrated with overall RPP mission goals. The program must also be responsive to emerging issues as they arise. In an environment of limited resources, scope will be allocated according to mission priority. The Technology and Innovation Roadmap prioritization process is described in Section 2.3.

The RPP mission is interconnected with other functional flowsheet areas such that it is often difficult to isolate technology solutions to a single functional area. The Technology and Innovation Roadmap is intended to cross-cut functional areas and identify integration opportunities where appropriate. The document also serves as an internal planning tool for WRPS and a communication tool for stakeholders and technology customers and providers.

2.2 TECHNOLOGY IDENTIFICATION

Technology and technology needs identification are provided directly by the personnel most knowledgeable of the area of interest. The CTO directly solicited input from management and subject matter expert representatives from the various functional areas. The points of contact provided pro forma worksheets documenting technology needs within their areas of expertise. In some cases this was updated input, in others it was new input. This information is consolidated into a spreadsheet that is provided in Appendix A. A collection of the raw pro forma worksheet input is provided in Appendix B. An overview and narrative description of the technology needs for each functional area are provided separately as part of this Technology and Innovation Roadmap. High-priority items are also identified. Relative priority of individual pro forma input was evaluated and scored by a representative technical council. The pro forma prioritization process is described in Section 2.3.

2.3 TECHNOLOGY PRIORITIZATION

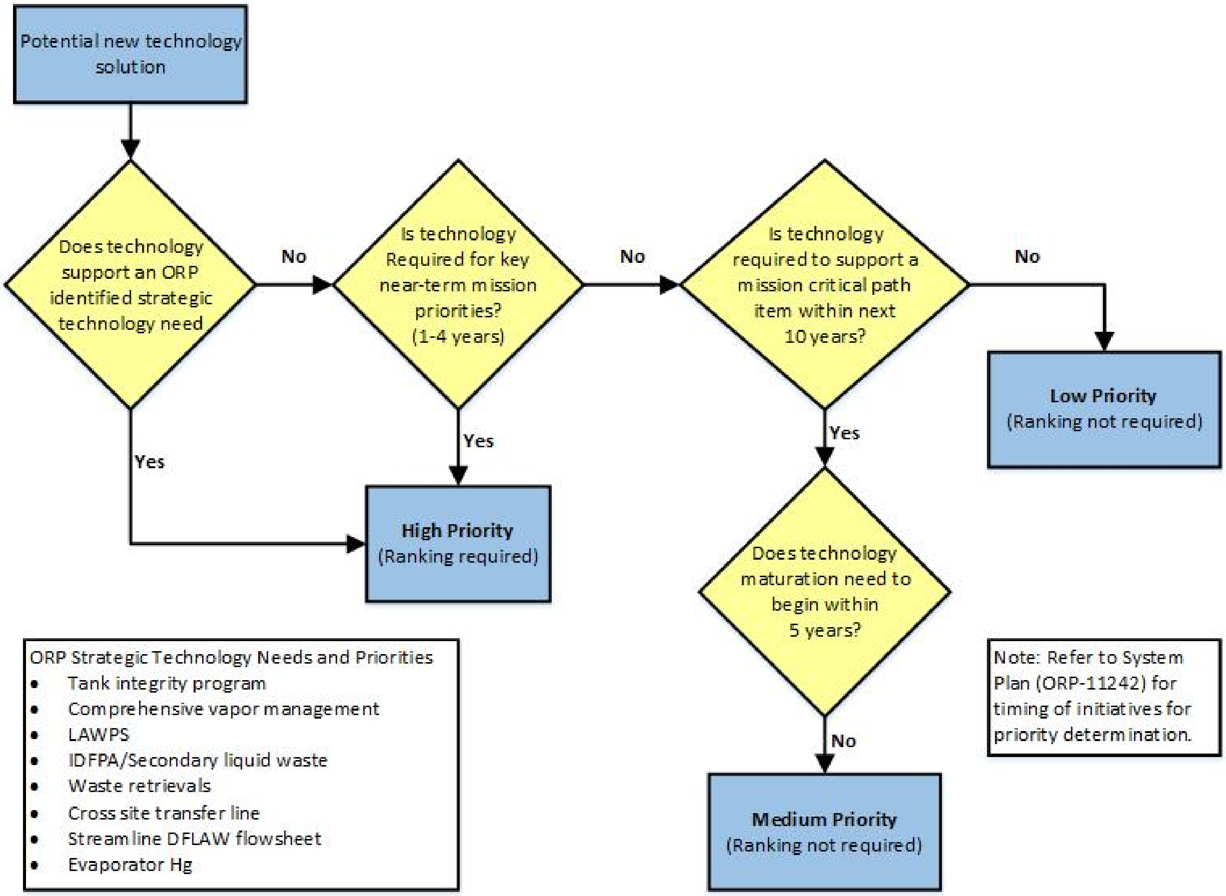
Given limitations of funding and that some tasks require development of predecessor tasks prior to implementation, not all identified technology tasks can be performed concurrently. Therefore, a method was established to prioritize the various technology actions.

The ranking/comparison system takes into account the urgency of the need and the potential benefit of the proposed technology solution. The urgency of a technology need is related to timing, while the benefit of the solution is related to the magnitude of its contribution to overall mission success.

Determining the benefit of a technology solution involves ascertaining if the solution addresses a "need-to-have" imperative or a "nice-to-have" addition to support the progress of the RPP mission. In other words, does the technology provide a solution that does not yet exist, but is required to allow completion of the mission? Or, does the technology offer incremental improvement resulting in greater efficiency, cost avoidance, or other benefit? The ORP strategic technology needs and priorities provided by ORP in letter 17-WSC-0016, "Contract Number DE-AC27-08RV14800 – Fiscal Year 2018 Preliminary Budget Guidance for Technology Roadmap and Chief Technology Office," (identified in the lower left-hand box of Figure 2-4) are considered "need to haves." Figure 2-4 also illustrates the general logic for prescreening and prioritizing technology actions used by the prioritization council. This basic diagram guides the prioritization process.

The prioritization methodology measured the technology activities against a predetermined set of criteria defined by technology and subject matter expert representatives from each functional area. The prioritization council comprises one expert representative of each functional area, plus five additional impartial members who are familiar with the RPP mission scope to facilitate the process. For this effort, the impartial council members represented ORP, the CTO, One System Mission Planning, Performance Measurement Baseline, and Life-Cycle Baseline.

Each pro forma worksheet is prescreened to determine the technology needs that are the considered high priority. Only these prescreened pro formas are brought before the prioritization council to further prioritize mission-critical technologies. A set of evaluation criteria and a scoring protocol are defined to determine relative priority for purposes of guiding out-year technology scope decisions. Results are validated by the functional area leads.



ORP = U.S. Department of Energy, Office of River Protection.
LAW = low-activity waste pretreatment system.
IDF = Integrated Disposal Facility.
PA = performance assessment.
DFLAW = direct-feed low-activity waste.

Figure 2-4. Mission-Driven Technology Activity Prioritization Logic.

The evaluation criteria are divided into high, medium, and low weighting categories. High weighting is attributed to those technologies that impact safety and compliance with DOE requirements and commitments. Medium weighting is attributed to technologies that mitigate risk, positively impact schedule, and provide technology benefits beyond the identified application. Low weighting is attributed to technologies with technical and mission enhancement impacts.

As part of the overall priority evaluation, additional incremental scoring based on the level and extent of the impact for each criterion was also taken into account. The final priority value is scored according to the summation of the weighted high, medium, and low attributes. This process is summarized in Table 2-1.

The ranking process results in a weighted raw score and a whole number ranking for each item. Some items resulted in the same weighted score and were assigned the same whole number priority. A sub-ranking process was applied that further differentiated rank according to category weight by adding a relative decimal value. To discriminate between the tie scores, first, an evaluation of the high medium and low categories was performed, then, if needed their subcategories (e.g., Safety, DOE Commitment, and Strategic Initiative in highest to lowest priority order) was performed.

Table 2-1. Scoring Protocols for Priority Determination.

Evaluation Criteria	High (3x weight)			Medium (2x weight)			Low (1x weight)	
	Safety	DOE Commitment	Strategic Initiative	Risk Mitigation	Schedule Impact	Technology Impact	Implementation Complexity	Mission Enhancement
Gauge for relative criteria score	Reduce specifically identified safety risk?	Contribute to DOE commitment or milestone completion?	Support ORP identified Strategic Initiative?	Reduce RPP mission or WRPS program and project risk?	Impact near-term schedule?	Multiple applications?	Change existing operating protocols or extend schedule?	Improve or accelerate the mission?
3	Yes	Needed for Consent Decree or DFLAW	Yes, directly supports initiative	Supports mitigation or impacts RPP mission risks	Needed to maintain or recover key RPP mission objectives schedule	Benefits other WRPS projects or DOE sites	No, within scope with no delays expected	Implements a specific opportunity that improves mission efficiency
2	Potentially	Needed for TPA, DOE HQ or public commitment	Enhances an initiative but not critical path	Supports risk items that don't impact RPP mission risks	Needed to accelerate key mission objective schedule	Benefits other Hanford projects	Extra time and more schedule activities may be needed	Improves likelihood of mission efficiencies
1	No	No direct impact	No direct impact	N/A or acceptable risk	No impact to key RPP mission objective schedules	Project-specific, WRPS application only	Extra time and more schedule activities will be needed	None identified
Total = 3∑(high criteria scores) + 2∑(medium criteria scores) + 1∑(low criteria scores)								

Consent Decree, 2010, *State of Washington v. DOE,* Case No. 08-5085-FVS (October 25), Eastern District of Washington.

DFLAW	=	direct-feed low-activity waste.	RPP	=	River Protection Project.
DOE	=	U.S. Department of Energy.	TPA	=	Tri-Party Agreement.
HQ	=	Headquarters.	WRPS	=	Washington River Protection Solutions, LLC.
N/A	=	not applicable.			

The priority ranking results are provided in Appendix C with expanded descriptions of the weighting criteria.

Each technology item that is determined to be high priority will be called out in the text and described using a sliding scale graphic that depicts the relative ranking of all the high-priority items scored. Figure 2-5 is an example of the sliding scale metric. The number in the orange circular field on the metric depicts the numerical ranking. The sliding scale metric reflects the priority scoring protocols described in Table 2-1. The Safety, DOE Commitment, and Strategic Initiative scales parallel the high-weighted priority categories and the score is averaged and reported as high weighting. The medium-weighted categories – risk mitigation,

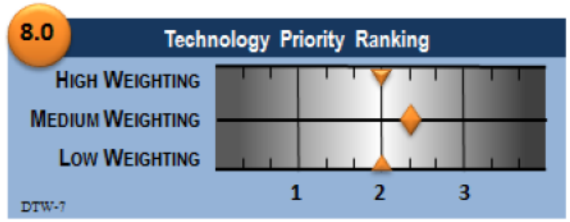


Figure 2-5. Technology Priority Sliding Scale Metric.

schedule impact, and technology impact – are averaged and reported as medium weighting. Finally, the low-weighted categories – implementation complexity and mission efficiencies – are averaged and reported as low weighting. The numerical value across the bottom shows the average score for each category. Activities that are ranked as high priority, but are currently unfunded for fiscal year (FY) 2017, are similarly depicted with an orange background field.

The raw scoring values are used to determine position on the sliding scale. The metric graphic provides an immediate visual check regarding how high the technology was ranked and which attributes influenced the ranking. High-priority items are listed in the text and have an alphanumeric identifier that corresponds to functional area (for configuration control, the unique technology identifier is in the lower left corner of the metric). The prefixes used for the identification numbers are as follows:

- MTW – Manage tank waste
- RTW – Retrieve tank waste
- PTW – Process tank waste
- MW – Manage generated wastes and excess facilities
- DTW – Dispose tank waste.

A complete list (high, medium, and low priorities) of active pro forma worksheet activities is provided in Appendix A, Table A-1. Appendix A, Table A-2, lists all retired pro forma. Pro forma are retired for the following reasons:

- Work is completed
- Deemed as not technology development
- Merged with another pro forma
- Technology is no longer needed.

2.4 OFFICE OF RIVER PROTECTION STRAGETIC TECHNOLOGY NEEDS AND PRIORITIES

The key performance parameters relating to FY 2018 ORP strategic initiatives are specified in letter 17-WSC-0016. Not all ORP strategic initiatives identified in the letter have been assigned a high-priority pro forma at this time. It is anticipated that the next revision of this roadmap will address these gaps.

For purposes of the scope profile charts, planned scope includes activities that are in the WRPS performance measurement baseline or the ORP life-cycle baseline and activities that are included in a contract proposal provided to ORP. In particular, this scope includes the TOC contract proposal for the FY 2017/2018 extension period. Estimated need includes all technology scope identified on the pro forma worksheets regardless of the associated baseline or planning status. See Section 7.0 for an explanation of the logic used to differentiate between planned scope and estimated need.

2.4.1 Tank Integrity Program

The goals of the tank integrity program are six-fold:

- Prevent water intrusion into leak detection pits
- Apply corrosion inhibitors to DST liner via leak detection pits
- Investigate remote liquid observation well system to minimize SST quarterly entries

- Upgrade annulus and DST video/camera systems
- Research guided wave solids measurement system for DST integrity
- Improve inspection technology to support effectiveness of proactive measures.

2.4.1.1 Project Priorities

In FY 2017 $2.4 million was funded for the high-priority tank integrity program pro forma. This work included the following pro forma:

- MTW-11, Volumetric inspection of DST primary tank bottoms
- MTW-15, Visual inspection of DST air slots using a robotic crawler
- MTW-49, Corrosion control DFLAW bounding.

Figure 2-6 illustrates the monetary scope of these needs as a function of FY.

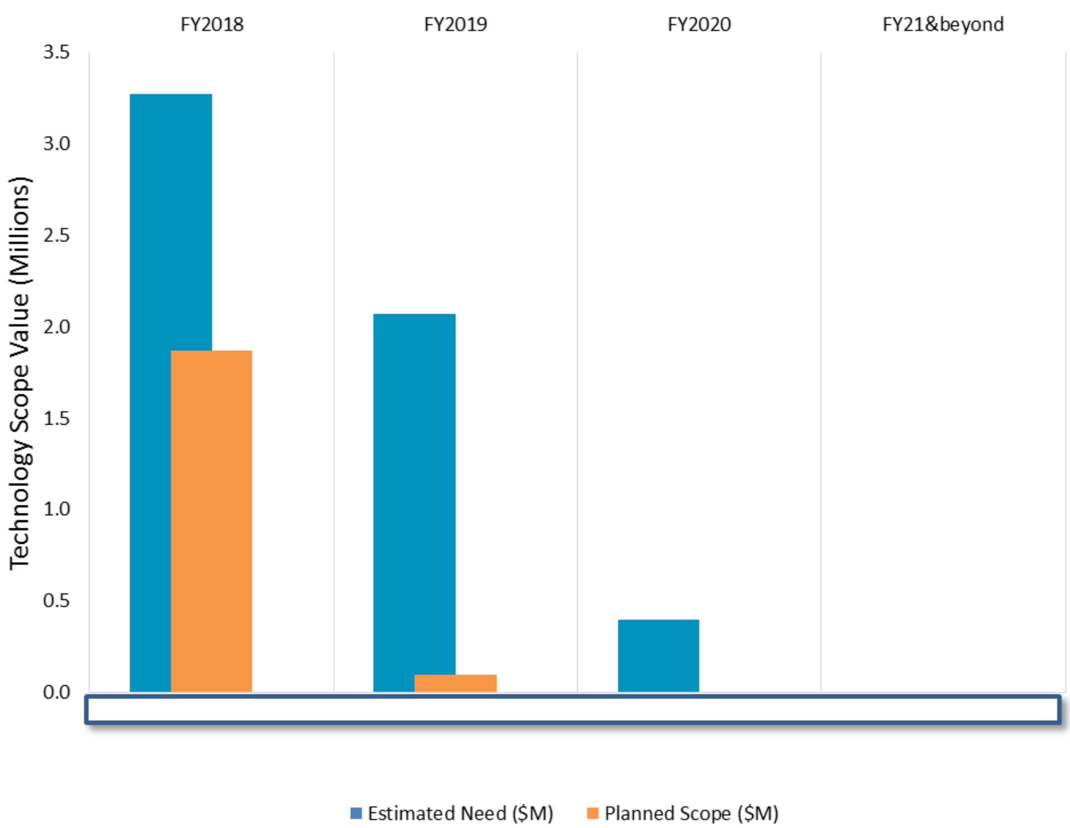


Figure 2-6. Tank Integrity Program High-Priority Needs.

2.4.2 Vapors

The key performance parameters relating to vapors are the following:[10]

- Establish a comprehensive vapor management communication plan, engagement processes, and effectiveness measurements.

[10] This information is a good representation of performance objectives which will be finalized in other programmatic documents.

- Maintain industrial hygiene chemical vapor technical basis and constituents of potential concern (COPC). Institutionalize process for updates, including new scientific findings and enhanced understandings of potential exposures.
- Maintain industrial hygiene program and institutionalize vapor program requirements, best practices and program parity, and complete necessary training to support full implementation by FY 2018.
- Complete engineering control concept demonstrations for Strobic Tri Stack and NUCON International Inc. thermal combustion in support of unrestricted work boundaries.
- Define unrestricted work boundaries and implement monitoring on active stack ventilation and unrestricted work boundaries in the 241-A and 241-AX Tank Farms to provide defense in depth.
- Institutionalize a tank operations stewardship program that minimizes required tank farm personnel entries, and establishes parameters for locating ancillary personnel and offices.
- Provide options to promote the hierarchy of controls for chemical vapor respiratory protection beyond current use of self-contained breathing apparatus.
- Support medical program enhancements in conjunction with responsible Hanford Site organizations and update WRPS process/procedures as required.

2.4.2.1 Project Priorities

In FY 2017 $7.8 million was funded for the high-priority vapors pro forma. This work included the following pro forma:

- MTW-23, Provide technology/methods to mitigate selected active/passive tank farm vapor sources
- MTW-24, Implement recommended tank farm vapor monitoring/detection equipment/predictive modeling software
- MTW-41, Analytical method development at the 222-S Laboratory
- MTW-68, Mass spectrometer mounted in a mobile analytical laboratory
- MTW-69, Personal ammonia monitor that reports ammonia concentrations to the Central Shift Office in real-time.

Figure 2-6 illustrates the monetary scope of these needs as a function of FY.

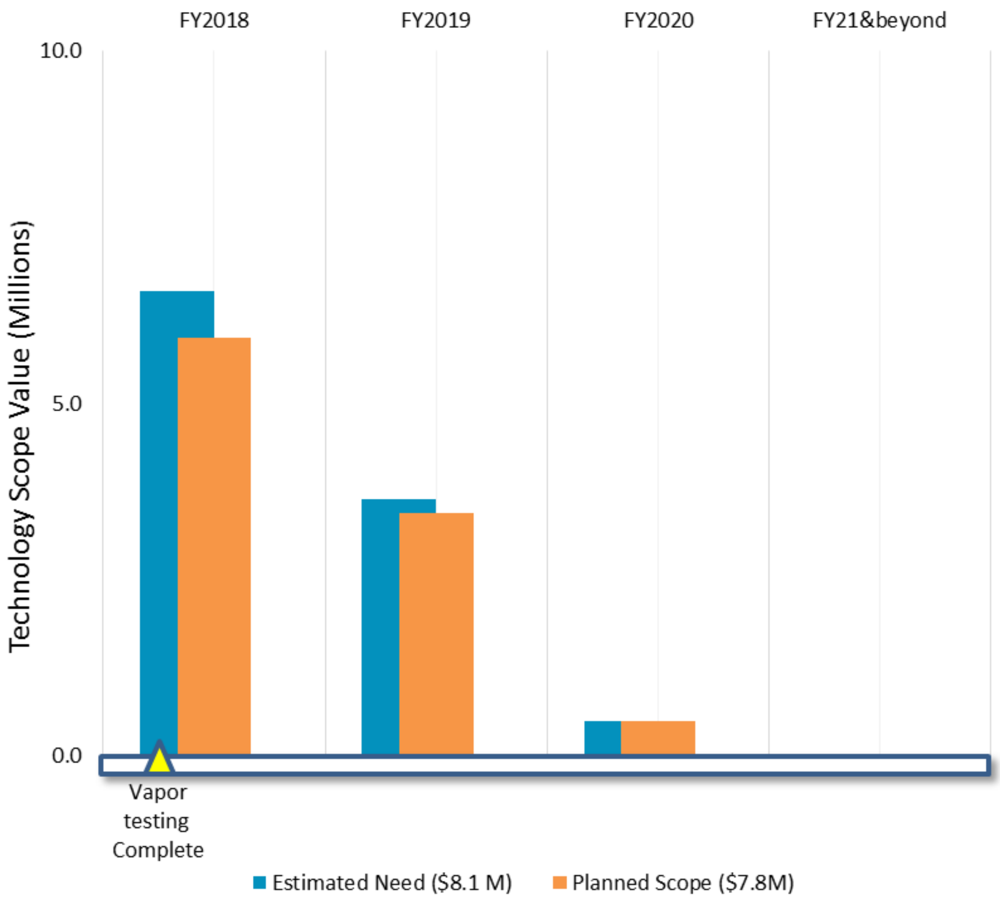


Figure 2-7. Vapors High-Priority Needs.

2.4.3 LAWPS

The LAWPS supporting technology development is needed to advance the project technology maturation plan, to meet project schedule, specifically the following:

- Ion exchange (IX) equipment maturation (gas mitigation)
- Cross-flow filtration (CFF) equipment maturation
- Integrated system functionality
- DFLAW feed qualification, with involvement by the One System Division
- IX eluate neutralization
- IX resin replacement and disposal.

2.4.3.1 Project Priorities

In FY 2017 $16.95 million was funded for the high-priority LAWPS pro forma. This work included the following pro forma:

- PTW-17, LAWPS integrated system test (before [Critical Decision] CD-2)
- PTW-18, LAWPS TE-2 CFF (return to tank 241-AP-107)
- PTW-19, LAWPS TE-3 IX using spherical resorcinol formaldehyde (sRF)

- PTW-21, LAWPS TE-8 resin handling system-resin replacement and disposal
- PTW-31, Maturation of the DFLAW feed qualification processes.

The LAWPS project requires the maturation of critical technology element unit operations, integrated system testing, definition of production parameters, and definition of a qualification program. These activities encompass IX and filtration operations, LAWPS effluent management, and integrated system testing. Figure 2-8 illustrates the monetary scope of these needs as a function of FY.

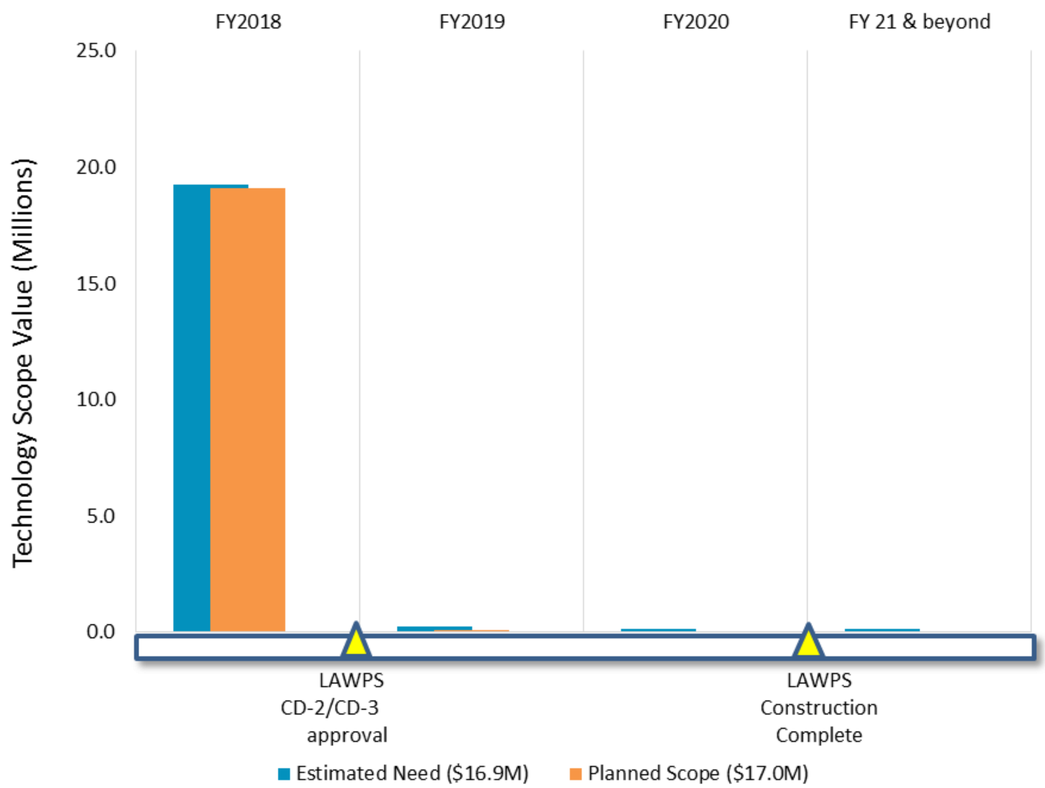


Figure 2-8. LAWPS High-Priority Needs.

2.4.4 IDF PA and SLW

The Integrated Disposal Facility (IDF) performance assessment (PA), RPP-RPT-59958, and secondary liquid waste (SLW) supporting work continues to focus on areas highlighted by model sensitivity analyses to ensure project schedule needs are met for future PA updates. Development of the PA maintenance and monitoring plan is needed to define work to support future updates. The plan must be reviewed by Low-Level Waste (LLW) Disposal Facility Review Group and approved by ORP and the DOE Richland Operations Office by the end of FY 2018.

2.4.4.1 Project Priorities

In FY 2017 $4.8 million was funded for the high-priority IDF PA and SLW pro forma. This work included the following pro forma:

- DTW-3, Characterize ILAW glass to support the IDF PA update and future maintenance
- DTW-7, Development and maturation of a technology for solidification/stabilization of solid secondary waste.

Secondary liquid waste disposition and the IDF PA are required to support DFLAW operations. High-priority activities encompass technology to immobilize SLW, provide a supplemental LAW treatment capability, and conduct performance testing characterizing the identified waste forms. Figure 2-9 illustrates the monetary scope of these needs as a function of FY.

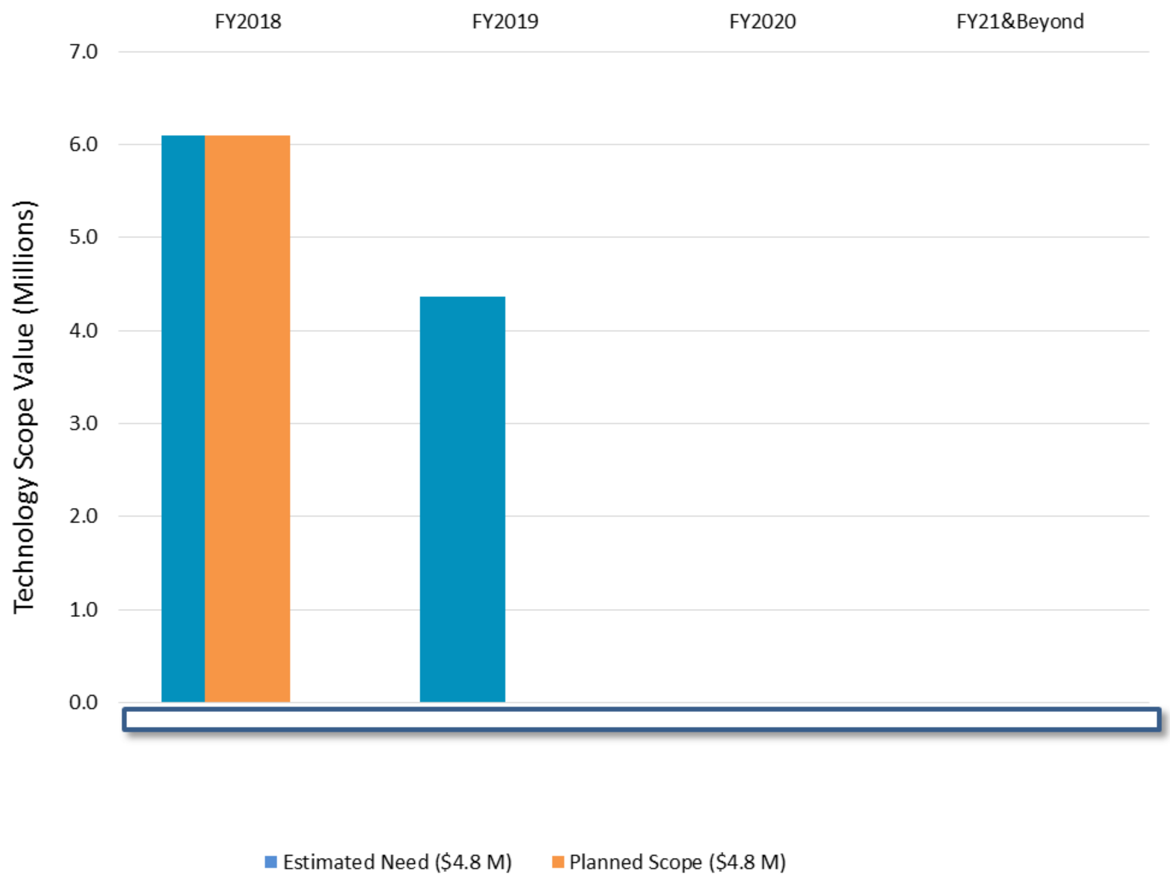


Figure 2-9. IDF PA and SLW High-Priority Needs.

2.4.5 Waste Retrieval

The waste retrieval effort includes evaluating evaporator erosion/corrosion design margin and the corrosion control program. This includes ensuring Savannah River Site lessons learned regarding evaporator vessel erosion are included. With continued innovation, retrieval technologies will minimize the risk of leakage to the environment and maximize waste retrieval efficiency.

2.4.6 Cross-Site Transfer Line

A cross-site transfer line integrity evaluation will be conducted and recommendations will be provided. Technology necessary for the integrity evaluation and the line recovery and restart will be investigated and developed.

2.4.7 Streamline DFLAW Flowsheet

A study of ideas to simplify or streamline the DFLAW flowsheet is needed. Ideas such as evaporation and nitrate removal prior to LAW feed will be considered.

2.4.7.1 Project Priorities

In FY 2017 $1.02 million was funded for the high-priority Tank Farm Vapors pro forma. This work included the following pro forma:

- PTW-31, Maturation of the DFLAW feed qualification processes.

Figure 2-10 illustrates the monetary scope of these needs as a function of FY.

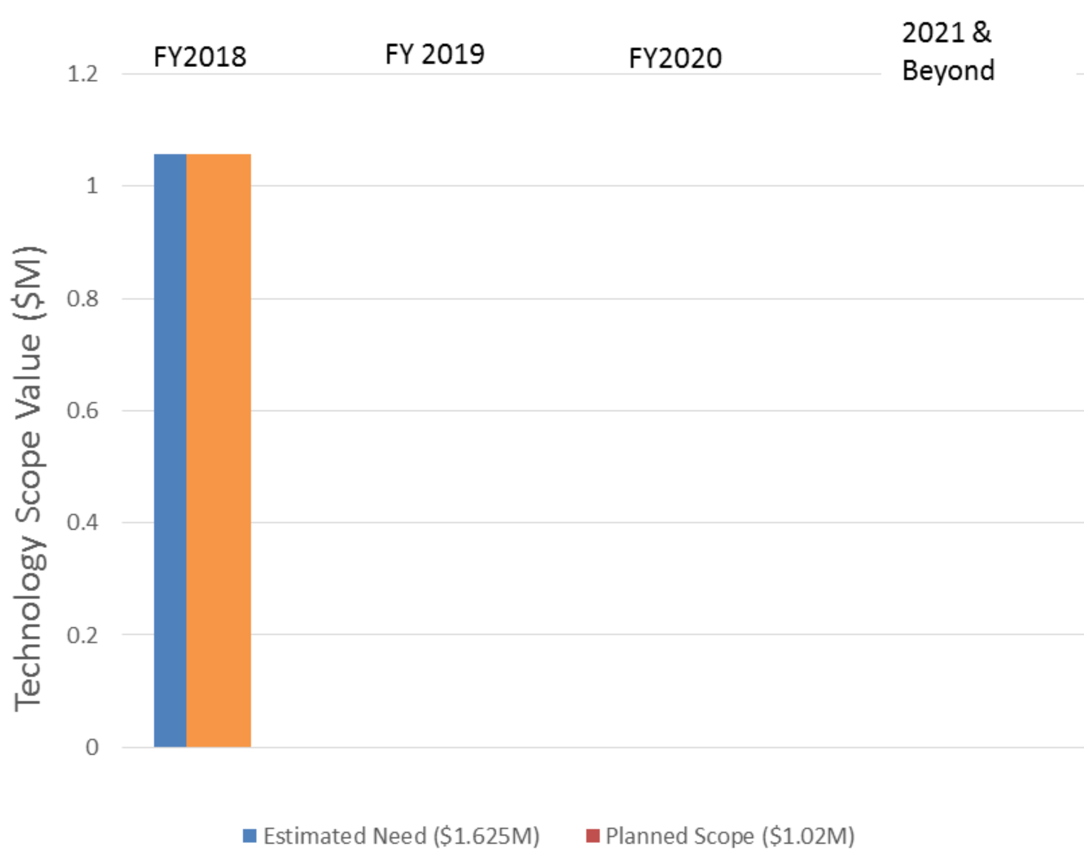


Figure 2-10. Streamline DFLAW Flowsheet High-Priority Needs.

2.4.8 Evaporator Mercury

A basis for predicting the behavior and impact of mercury in the evaporator is needed. Technology necessary for making these predictions will be investigated and developed.

3.0 TECHNOLOGY MATURITY

The level of technology maturity comes into play when determining whether technology items merit high priority. For the purposes of this Technology and Innovation Roadmap, maturation of technology activities required to support development of DFLAW in general, and LAWPS in particular, are evaluated to have high priority. DOE has established technology development protocols for maturing technologies integral to capital assets projects as described in DOE O 413.3B, *Program and Project Management for the Acquisition of Capital Assets*. Overall technology maturation refers to the advancement and progression of selected technologies, culminating with the level appropriate for system startup and operations (i.e., technology readiness level [TRL] 9). Typically technology development begins with a TRL value of 4 or 5, as described in DOE-EM 2013, *Technology Readiness Assessment (TRA) / Technology Maturation Plan (TMP) Process Implementation Guide*. Technology demonstration occurs at TRL 6. Earlier stages of technology maturation include bench scale testing (i.e., TRLs 1 through 3) and are also captured through the technology maturation process.

Although this level of rigor is not required for all technologies described in the Technology and Innovation Roadmap, the guidance is a useful tool to achieve alignment with DOE reasoning regarding technology maturation and deployment. Some technologies described in this Technology and Innovation Roadmap (e.g., those supporting LAWPS) are subject to the requirements of DOE O 413.3B.

Implementation of DOE O 413.3B requirements is detailed in DOE-EM 2013. This Technology and Innovation Roadmap does not present results of any technology readiness assessments conducted for any of the technologies discussed.

Those technologies bound by DOE O 413.3B requirements[11,12] must have technology maturation plans developed to detail the current levels of technical maturity and to map out plans to mature the critical technology elements[13] sufficiently to enable deployment. DOE-EM 2013 expands on the DOE O 413.3B guidance to include operating activities and suggests that technology readiness self-assessments be conducted to achieve planning and project robustness.

This overall practice is intended to safeguard against prematurely deploying expensive technologies without systematic, relevant testing at engineering scale. Most of the technologies described in this Technology and Innovation Roadmap do not require DOE O 413.3B compliance. Those that do (e.g., LAWPS) are flagged accordingly. Items that require technology development are procedurally guided at the Tank Farms Contractor level by TFC-PLN-90, *Technology Maturation Management Plan.* DOE terminology and technology maturity protocols notwithstanding, WRPS is focused on differentiating between mission-critical programs and projects. For example, the DFLAW initiative is a program. The LAWPS is a project that supports the DFLAW program. Both programs and projects can require technology

[11] DOE O 413.3B requires capital assets projects greater than $750 million to complete a technology readiness assessment prior to CD-2 and CD-3 and to develop a technology management plan.

[12] Because the WTP project has advanced to the detailed design and construction phases, there are no specific needs for identifying, selecting, and advancing technologies.

[13] A critical technology element is described in DOE-EM 2013 as "an element that is new or novel or being used in a new or novel way is critical if it is necessary to achieve the successful development of a system, its acquisition, or its operational utility."

maturity. The associated development activities are discussed in this Technology and Innovation Roadmap even if they fall outside of typical DOE O 413.3B guidance.

3.1 INTEGRATION WITH MISSION NEEDS

The Technology and Innovation Roadmap relies on input from pro forma worksheets but also draws information from other Hanford Site planning documents to present cohesive, consistent communication regarding technology work to support the RPP mission. This approach is used to ensure that the planning and strategic initiatives agree. The applicable Hanford Site planning documents include the following:

- RPP-RPT-57991, *One System River Protection Project Integrated Flowsheet*
- RPP-PLAN-58003, *One System River Protection Project Integrated Flowsheet Maturation Plan*
- Letter 17-WSC-0016RPP-RPT-44139, *Hard Heel Waste Retrieval Technology Review and Roadmap*
- RPP-40149, *Integrated Waste Feed Delivery Plan*.
- RPP-RPT-60656, Execution Plan for the Hanford Tank Farm Vapor Monitoring, Detection, and Remediation Project (OP163)
- RPP-PLAN-57181, Technology Maturatio*n Plan for the Low-Activity Waste* Pretreatment System Project (T5L01)
- RPP-PLAN-59972, Technology Maturation Plan for the Tank Farm Vapors Monitoring and Detection System

This Technology and Innovation Roadmap provides a clear and consistent message to DOE regarding RPP mission goals and frames the information found in other Hanford Site documents into a task-specific, mission-driven priority list that provides specific guidance regarding the path forward. In particular, this Technology and Innovation Roadmap highlights specific technology support provided by the national laboratories (and other DOE complex affiliates, such as the Vitreous State Laboratory at the Catholic University of America).

3.2 MISSION GAPS, RISKS, AND OPPORTUNITIES

Emerging issues and a delayed WTP start date are impacting the baseline flowsheet, as reported in ORP-11242, *River Protection Project System Plan* (hereinafter System Plan). Consequently the flowsheet now initiates waste processing with DFLAW for a period of time until the remaining facilities at WTP become available.

The current WRPS performance measurement baseline risk assessment model contains risks and opportunities that can impact schedule and scope. Risk modeling can be applied that helps predict the scope and schedule impact as a function of risk level. Uncertainty is also a dominant factor when evaluating risk.

The life-cycle cost of tank waste cleanup is influenced by the WTP operating duration. A rule of thumb is that each year the WTP operates will cost taxpayers approximately $1 billion in today's dollars, which is a strong incentive to shorten the mission. Therefore, a significant life-cycle cost incentive exists to complete tank waste treatment processing at the earliest practicable date. Risks can often provide the potential for alternative solutions and may be viewed as opportunities. For example, the LAWPS will enable startup of the WTP LAW Vitrification Facility without requiring resolution of outstanding technical issues with the WTP PT Facility. This phased startup of LAW vitrification (i.e., DFLAW) will provide a platform for determining operating parameters that will be used later for full LAW vitrification operations (e.g., melter feed certification, process control, procedural controls). This approach will also provide an opportunity for training personnel and identifying methods of optimizing future production parameters. The DFLAW initiative is facilitated by the One System organization. Follow-on, staged startup using a direct-feed HLW approach could further shorten the mission by decoupling LAW and HLW vitrification operations. Following the baseline approach, the operations are interdependent with each other and WTP pretreatment, and drives mission duration.

Many planned and future architectural decisions will drive the technology needs (and vice versa). However, additional unforeseen issues will likely continue to arise, at which time the RPP mission will adapt and approaches will be developed to address them.

3.3 NATIONAL LABORATORY AND UNIVERSITY ROLES

The development and maturation of technology is often assigned to ORP-directed national laboratory work. National laboratory work is identified based on technology needs to fill gaps and buy-down risk. The WRPS CTO has established an internal process through project controls for tracking and reporting national laboratory work to WRPS upper management and ORP. All national laboratory work is routed through the CTO, with work performance reported monthly and used to produce standardized metrics for cost and schedule. This management system enables accurate tracking of cost and schedule performance and also provides familiarity with the individual national laboratory technical strengths for consideration when directing new work.

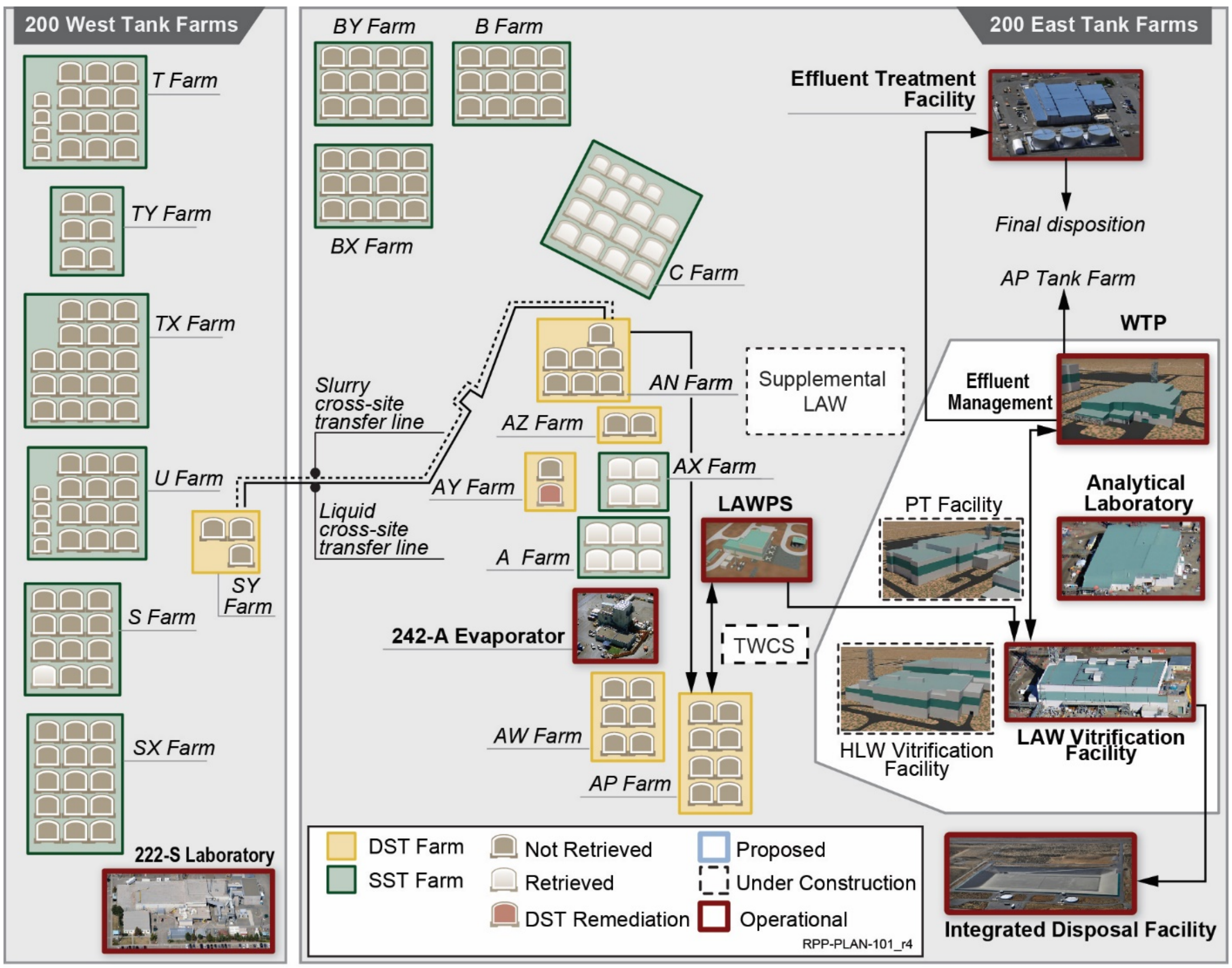
The national laboratories can provide a combination of technical expertise and analytical capabilities and services that are not available within WRPS or WTP. In some instances, the national laboratories are also called on to spearhead technical review groups or provide nationally-recognized experts to consult regarding specific problems. The national laboratories may also be engaged to provide lessons learned regarding cross-cutting work (e.g., waste feed qualification or tank closure). Updates to the Technology and Innovation Roadmap will assist with out-year planning and distribution of technology work to the national laboratories, as appropriate. Section 7.2 provides additional details regarding the national laboratories in support of WRPS technology needs.

It should be noted that in some areas of technology maturation WRPS and ORP have partnered with several Universities to provide technical expertise and laboratory services. Examples of academia involvement include support for glass formulation, nondestructive examination of double shell tanks, and treatment options.

4.0 BASELINE MISSION TECHNOLOGY AND INNOVATION NEEDS

While the RPP mission includes all aspects of the Hanford Site mission (culminating with closure), the near-term One System focus is on safely managing the underground waste tanks and providing acceptable waste feed to the WTP as part of the DFLAW initiative. Later in the mission, once the WTP is fully operational, the Tank Operations Contractor will also be responsible for waste form storage and/or disposal and for SST and DST closure. Additionally, TOC will be responsible for providing acceptable waste feed to all waste treatment facilities.

Figure 4-1 depicts the RPP mission progress projected over the next 10 years.[14] This progress includes construction and startup of LAWPS, commencement of DFLAW operations, mitigation of tank farm vapor issues, and continued SST retrieval and infrastructure upgrades. Technology development and maturation activities are procedurally covered by TFC-PLN-90.



DST	=	double-shell tank.	PT	=	pretreatment.
HLW	=	high-level waste.	SST	=	single-shell tank.
LAW	=	low-activity waste.	TWCS	=	tank waste characterization and staging.
LAWPS	=	low-activity waste pretreatment system.	WTP	=	Hanford Tank Waste Treatment and Immobilization Plant.

Figure 4-1. Projected Status – DFLAW Startup.

[14] Figure 4-1 is a simplified overview of the projected mission status 10 years from now. More detailed information about effluent management is provided in Figure 4-10.

As depicted in Figure 4-1, effluent management, a process currently identified within the WTP balance of facilities, manages LAW effluents. Effluent management is a process under development as a potential mission improvement initiative (discussed in Section 4.3.2).

A placeholder for TWCS is also shown on Figure 4-1. The TWCS will provide additional high level waste staging/conditioning capability and serve as an interface between the tank farms and WTP to enable waste feed qualification and process control. The authorization to proceed with TWCS has not yet been provided, and development of the functions and requirements for TWCS is currently on hold.

The Technology and Innovation Roadmap addresses key functional areas and technology elements, as depicted in Figure 2-2. The content of the Technology and Innovation Roadmap will continue to evolve in response to emerging issues and changes in the overall mission, such as the technology, timing, and configuration of supplemental treatment capacity.

Table 4-1 presents a summary of all the high-priority technology needs that were scored by the prioritization council. The weighted score is the raw score each item received and is used to determine overall rank. The ranking is the relative score of each high-priority item (Section 2.3 describes the prioritization methodology, and Appendix C provides more scoring and ranking details). The table also identifies which items are expected to include national laboratory support. Those activities that do not identify the need for national laboratory support will be developed internally by WRPS or acquired commercially as directed by WRPS.

The following sections describe the high-level technology needs in more detail and are aligned with each functional area.

Table 4-1. High-Priority Technology Needs Summary (2 pages)

Functional Area	ID #	Item Description	Weighted Score	Ranking	National Laboratory?
Manage Tank Waste	MTW-9	Automated DST annulus camera system	41	4.3	-
	MTW-11	Guided wave system across tank diameter	27	13.1	Yes
	MTW-15	Visual Inspection of DST Primary Tank Bottoms	27	13.2	-
	MTW-20	Upgrade DST and SST video and still camera systems	32	12.2	-
	MTW-23	Vapor mitigation	42	3.2	Yes
	MTW-24	Monitoring-detection of vapors	40	5.1	Yes
	MTW-40	Improved sampling for headspace particulate analysis	27	13.3	-
	MTW-41	Analytical method development at 222-S Laboratory	33	11.2	-
	MTW-49	Corrosion control DFLAW bounding	37	7.1	Yes
	MTW-56	Evaluate and establish inventory of DFLAW organic COPCs	35	9.4	Yes
	MTW-59	Zeolites for reducing exposure to nitrosamines from tank vapors	35	9.3	Yes
	MTW-66	Treat NDMA in the tank headspace or side	34	10.2	Yes

Table 4-1. High-Priority Technology Needs Summary (2 pages)

Functional Area	ID #	Item Description	Weighted Score	Ranking	National Laboratory?
	MTW-68	Evaluate the utility of using a PTR-MS mounted in a mobile analytical laboratory	35	9.2	-
	MTW-69	Develop a personal ammonia monitor that reports ammonia concentrations to the central shift office in real-time	40	5.2	-
Retrieve Tank Waste	RTW-8	Develop in-tank mechanical waste gathering system	37	7.4	-
	RTW-24	Two-step characterization of the 241-C-301 catch tank contents	37	7.3	-
	RTW-39	Develop a strategy and basis for anticipating and predicting residual waste volumes and properties	32	12.1	Yes
	RTW-54	Tank waste modular treatment study	33	11.1	Yes
	RTW-55	Hanford waste end effector	42	3.1	Yes
Process Tank Waste	PTW-17	LAWPS integrated system test (before CD-2)	43	2.2	-
	PTW-18	LAWPS CFF (return to tank 241-AP-107)	41	4.2	Yes
	PTW-19	LAWPS TE-3 IX using sRF	43	2.1	Yes
	PTW-21	LAWPS TE-8 resin handling system-resin replacement and disposal	41	4.1	Yes
	PTW-31	Maturation of the DFLAW feed qualification processes	39	6	Yes
	PTW-40	HLW direct vitrification	33	11.3	Yes
	PTW-44	Technical basis for sRF storage – life expectancy and Cs-removal efficiency over time and method	22	14.0	-
	PTW-48	LAWPS Cs IX column	45	1.0	Yes
	PTW-49	Study to examine feasibility of removing nitrates from the LAW feed stream prior to vitrification.	35	9.1	Yes
Dispose Tank Waste	DTW-3	Characterize ILAW glass to support the IDF PA update and future maintenance	37	7.2	Yes
	DTW-7	Development and maturation of a technology for solidification/stabilization of solid secondary waste	36	8.0	Yes
Manage Waste	MW-2	Liquid secondary waste grout ammonia vapor	34	10.1	Yes

CD = critical decision.
CFF = cross-flow filtration.
COPC = constituent of potential concern.
Cs = cesium.
DFLAW = direct-feed low-activity waste.
DST = double-shell tank.
IDF = Integrated Disposal Facility.
ILAW = immobilized-low activity waste.
IX = ion exchange.
LAW = low-activity waste.
LAWPS = low-activity waste pretreatment system.
ORP = Office of River Protection.
PA = performance assessment.
sRF = spherical resorcinol formaldehyde.
SST = single-shell tank.

4.1 MANAGE TANK WASTE

A total of 177 underground tanks store Hanford Site radioactive wastes. The tanks are strategically located in groups, called farms, containing 2 to 18 tanks each. Each tank is constructed of reinforced concrete with a mild steel liner covering the bottom and sidewalls. The tanks are grouped as SSTs and DSTs, as shown in Figure 4-1. Most of the tanks are 75 ft in diameter and are constructed to hold from 15 ft to more than 30 ft of liquid level for a nominal capacity of 530 to 1.16 Mgal. Sixteen of the tanks are smaller units of the same basic design built to contain 55 kgal each. All of the tanks have a minimum of 7 ft of earth covering for shielding purposes. In addition, there are two other sets of tanks designated as inactive miscellaneous underground storage tanks (IMUST) managed by the Tank Operations Contractor and active miscellaneous underground storage tanks (MUST) managed by other Hanford Site contractors. These tanks are either associated with tank farms or facilities.

Tank farms management requires that the radioactive waste liquids, salts, and sludges be maintained in a safe, regulatory-compliant manner (pursuant to TPA requirements). This includes safeguarding the overall integrity of the tanks and tank infrastructure and safely managing the waste contents. Tank farms management involves monitoring the tank contents and surrounding soil, upgrading aging infrastructure and equipment (as required), providing contingency storage in the event of a tank failure, and remediating vadose zones where waste has historically leaked to the environment. Most of the tanks have already exceeded their engineered design life; therefore, continued monitoring of overall waste tank integrity (e.g., steel liner, concrete shell) is essential.

The tank farms infrastructure must also be upgraded to support the DFLAW initiative, which will require upgrades to utilities, transfer lines, and support facilities to bypass the WTP PT Facility and deliver LAW feed directly to the WTP LAW Vitrification Facility. Actions are being taken to support an initiative that promotes modernizing and automating tank farms equipment and infrastructure to protect tank farms workers from exposure to tank vapors. Continued analytical support services from the 222-S Laboratory and operational support services from the 242-A Evaporator and Liquid Effluent Retention Facility (LERF) / Effluent Treatment Facility (ETF) are required to achieve continued safe operations of the tank farms. In the event WTP experiences continued delays, there may also be construction of new DST-type space required to support continued operations of the tank farms. This new tank space can be tailored with engineering features to meet current technology needs (e.g., instrumentation, monitoring, mixing, detection, greater access, temperature control).

4.1.1 Tank Farms Operations

Major tank farms operations include waste transfers, waste characterization, chemical adjustments, and waste concentration. Waste transfer operations include the following:

- SST retrieval and transfer to a DST and/or WRF
- WRF transfer to DST
- DST-to-DST waste transfers to support 242-A Evaporator campaigns
- DST-to-DST waste transfers to meet DST space management objectives
- DST waste transfers (feed) to the 242-A Evaporator
- DST waste transfers to support LAWPS and subsequently TWCS (slurry) as well as directly to WTP PT (supernate).

- DST-to-DST waste transfers to support waste receipt from the 242-A Evaporator and the 222-S Laboratory.

Waste concentration (i.e., the removal of water to increase the available storage volume in the DSTs) is conducted in the 242-A Evaporator which is operated by the Tank Operations Contractor but has an independent documented safety analysis (HNF-14755, *242-A Evaporator Documented Safety Analysis*). However, the transfer of waste to and receipt of waste from the 242-A Evaporator is included within the scope of this Technology and Innovation Roadmap. The Tank Operations Contractor also operates four less hazardous than Hazard Category 3 liquid waste processing facilities: ETF, LERF, Treated Effluent Disposal Facility, and the State Approved Land Disposal Site.

4.1.1.1 High-Priority Pro Forma

MTW-49 is a high-priority pro forma that is already identified in Section 4.1.3. This cross-cutting pro forma addresses corrosion mitigation for the evaporator.

4.1.2 Tank Farm Vapor Programs

The Vapor Monitoring, Detection and Remediation Project (Project OP163) has been established to address Hanford Site tank farms chemical vapors. Prompted by concerns regarding potential workplace vapor exposures, a Chemical Vapors Solutions Team is chartered to investigate methods to determine the nature and extent of potential chemical vapor exposure in the workplace and to propose potential solutions. The initial response to these industrial hygiene concerns led to more stringent personal protective equipment (PPE) requirements for tank farm workers. The enhanced PPE requirements (e.g., self-contained breathing apparatus) limits the amount of time workers can effectively spend performing tasks, hampers mobility, and can cause tripping hazards and other safety concerns.

A comprehensive, real-time tank farms vapor monitoring and detection system (VMDS) that can predict when, where, and under what conditions chemical vapors may be present is under development. The VMDS is working to identify chemical compounds, called leading indicators, with adequate detection levels and correlations to chemicals of potential concern, to estimate the concentrations of other chemical compounds. For example, if chemical compound “X” is detected at a certain concentration then chemical compound “Y” can be assumed to be at an established safety threshold and appropriate actions taken. This information could be correlated with historical information (e.g., location, weather conditions, time of day) to guide planned work activities and PPE requirements.

The VMDS will include existing equipment and instrumentation as well as the new equipment and instrumentation recommended by the Chemical Vapors Solutions Team. An initial down-select of viable vapor monitoring and sensor equipment has been performed, and a recommended path forward has been developed and documented in RPP-RPT-60656, *Execution Plan for the Hanford Tank Farm Vapor Monitoring, Detection, and Remediation Project (OP163)*. Some of the equipment is intended for general screening of workplace environments prior to sending workers into the field. Other equipment is intended to provide more detailed vapor information from known and/or potential vapor sources (e.g., waste tank stacks). The VMDS will potentially provide three fundamental working functions:

- Real-time tank farm monitoring sensors

- Data interpretation capability
- Human interaction and decision-making.

The fully integrated VMDS is envisioned to use commercially available equipment, sensors, and monitors working together as part of a comprehensive system to model Hanford airspace characteristics for a particular working environment. RPP-RPT-PLAN-59972, *Technology Maturation Plan for the Tank Farm Vapors Monitoring and Detection System*, has been developed for the VMDS. Several critical technology elements have been identified for technology maturation, along with other needed technology improvements to implement Project OP163.

Sources of vapors that are identified by the VDMS will be evaluated to determine if viable mitigation methods or technologies may be deployed to further reduce exposure.

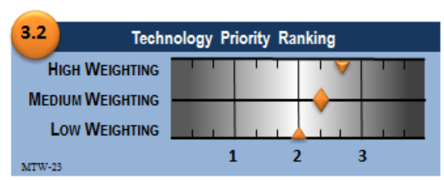
The VMDS will require the purchase and testing of new monitoring and detection equipment. The VMDS will also require integration with a software control system that provides real-time feedback regarding tank farms environmental conditions. An integrated bench-scale test is complete, and pilot-scale testing of the VMDS is under way. In addition to the VMDS, a parallel project is under way to modernize and automate tank farms systems and infrastructure to minimize the collective time Hanford Site personnel must spend in the tank farms.

Some equipment employed for pilot-scale testing will remain in place and reporting until final field implementation (FY 2017/2018) is complete.

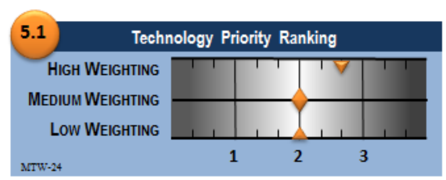
4.1.2.1 High-Priority Pro Forma

High-priority pro forma that have been identified to support tank farms chemical vapor issues include the following, which are ranked in order of descending priority.

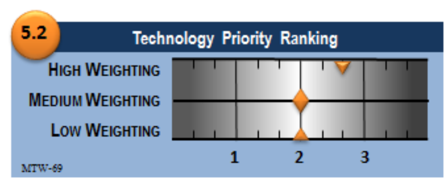
MTW-23: Determine mitigation/technology methods to mitigate selected active or passive tank vapor sources. This activity is part of the VMDS and may require national laboratory support.



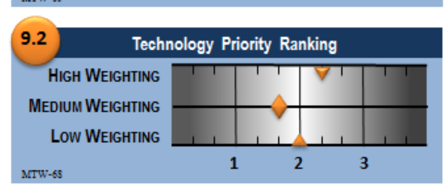
MTW-24: Implement tank farms monitoring/detection equipment, including predictive software. This activity is part of the VMDS. 222-S Laboratory upgrades will be required to analyze whole air samples.



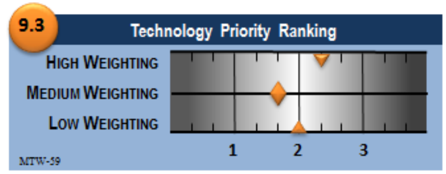
MTW-69: Develop a personal ammonia monitor that reports ammonia concentrations to the central shift office in real-time.



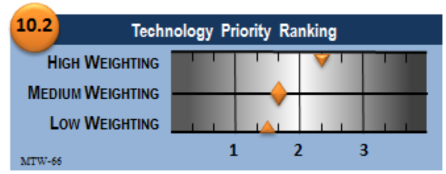
MTW-68: Evaluate the utility of using a proton transfer reaction – mass spectrometer (PTR-MS) mounted in a mobile analytical laboratory.



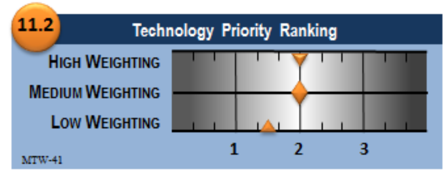
MTW-59: Zeolites for reducing exposure to nitrosamines from tank vapors.



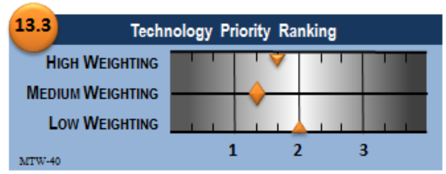
MTW-66: Treat N-Nitrosodimethylamine (NDMA) in the tank headspace or side.



MTW-41: Develop analytical methods at 222-S Laboratory to characterize vapors and other chemical species of interest in support of DFLAW.



MTW-40: Provide improved sampling for headspace particulate analysis to support tank vapors characterization and mitigation.



Note: Although there are many needs and gaps identified in the discussions above, not all related active pro forma were ranked as high due to expected mission need dates.

4.1.3 Infrastructure Integrity and Upgrades

The SSTs store mixed chemical and radioactive wastes. Some of the SSTs are designated as sound; however, some of the SSTs are known leakers and others are assumed leakers. Confidence in the tank-by-tank knowledge of structural tank integrity is essential to plan waste retrieval activities accordingly. SST integrity centers on knowing the condition of the tank steel liner, and concrete shell, as well as associated piping, offgas systems, and support facilities. Understanding the SST chemical and radiological waste constituents and how they interact with the tank and supporting infrastructure comprise additional important waste storage parameters. Confidence in the known "state" of each SST will become even more important over time, as the tanks will be in use for at least another 30 years.

The SST waste will ultimately be retrieved and sent to the WTP (or other treatment facility)[15] for processing and disposal. In the meantime, the waste storage facilities and infrastructure must be monitored and controlled. There are gaps and needs associated with SST integrity within tank farms management. Some of the key items include the following:

- Perform improvements to the tank leak and intrusion detection systems
- Evaluate the tank steel liner with inspection tools that can provide definitive information on the liner condition
- Monitor and predict steel liner corrosion

[15] Contact-handled transuranic (CH-TRU) waste will not be treated at the WTP.

- Conduct tank concrete shell monitoring such that an integrity evaluation can be projected into the future
- Perform waste sampling to characterize long-term storage conditions, support waste mixing requirements, and retrieval technology selection.
- Improve monitoring and testing of piping systems (metallic and nonmetallic)
- Use the 222-S Laboratory to conduct SST integrity testing using the electrochemical test stand for corrosion and tank integrity studies
- Protect tank farms workers from tank vapor exposures
- Upgrade infrastructure.

The aging tanks and support infrastructure require continued improvements to achieve a safe and reliable system. Some of the monitoring, sampling, and testing systems, techniques, and components are either obsolete or nearing obsolescence and are not up to current standards and capabilities.

SST integrity needs and gaps have been assessed as a function of RPP mission timeframe and prioritized with respect to their importance and urgency for long-term confidence in SST storage capability.

The Hanford DSTs and WRFs are essential to the RPP mission. The DSTs have been the receiver tanks for waste retrieved from the SSTs. In the future WRFs and DSTs are anticipated to be used as receiver tanks and also the platform for delivering waste feed to the WTP for immobilization. Current assumptions would allow for some waste to be pretreated in LAWPS and sent to Supplemental Immobilization without going to WTP.

Understanding DST integrity involves knowing the condition of the primary and secondary tank steel liners, the concrete shell, and the associated piping, offgas systems, and support facilities. The chemical and radiological waste constituents and how they interact with the tank and supporting infrastructure comprise the additional important parameters for waste storage. DSTs play a fundamental role in the overall waste retrieval process. DSTs receive tank wastes retrieved from the SSTs and will receive line flushes and process effluents from LAWPS and DFLAW operations. The DST system relies heavily on the 242-A Evaporator to concentrate the waste and help mitigate the shortage of DST space. The following primary monitoring activities are needed to evaluate DST integrity parameters:

- Leak detection
- Examination and testing of the primary containment (e.g., tanks, piping)
- Sampling.

The aging DSTs and supporting infrastructure require continued improvements to achieve a safe and compliant tank system. Some of the monitoring, sampling, and testing systems, techniques, and components are either obsolete or nearing obsolescence and are not up to current standards and capabilities. Some of the technology needs listed for SSTs may also be applied to DSTs.

The tank farms infrastructure will be required to operate for decades past the engineered lifetime. While continuing to age, the tank farms equipment becomes more vulnerable to failing systems and obsolescence that makes maintenance and repair of existing systems more difficult. In addition to required continuing improvement, the existing tank farms infrastructure must also be adapted and upgraded to support the DFLAW initiative. This initiative will require upgrades to utilities, transfer lines, and support facilities to deliver LAW directly to the LAWPS, followed by delivery of pretreated LAW directly to the WTP LAW Vitrification Facility. Actions are being taken to support an initiative that promotes modernizing and automating tank farms equipment and infrastructure to protect tank farms workers from exposure to tank vapors. Continued analytical support services from the 222-S Laboratory and operational support services from the 242-A Evaporator are required to achieve continued safe operations of the tank farms. If the WTP experiences continued delays, construction of new, specialized (i.e., instrumented) DST-type space may also be required to support continued operations of the tank farms.

Required tank farms infrastructure upgrades currently identified include the following:

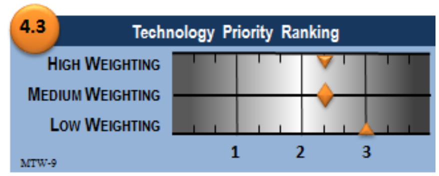
- Tank farms projects
- 242-A Evaporator projects
- 222-S Laboratory projects
- Facilities projects
- Utilities projects
- Critical spare parts program.

The need for upgraded infrastructure cross-cuts all of the RPP functional areas; however, the identified upgrades are most prevalent in the areas of MTW and RTW for retrofit of existing systems.

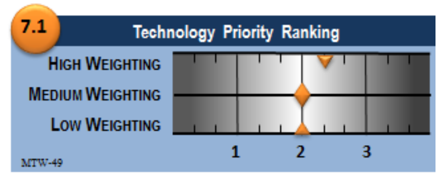
4.1.3.1 High-Priority Pro Forma

High-priority pro forma that have been identified to support infrastructure integrity and upgrade issues include the following, which are ranked in order of descending priority.

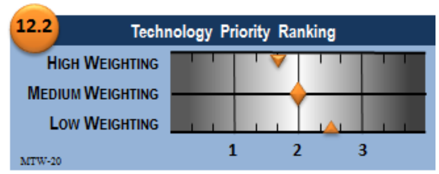
MTW-9: Automated DST annulus camera system.



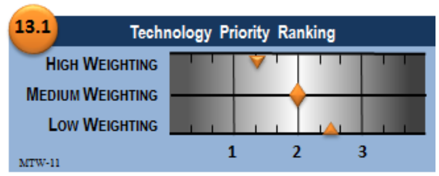
MTW-49: Perform carbon steel corrosion tests with bounding simulated waste compositions for DFLAW.



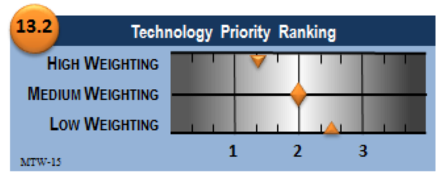
MTW-20: Acquire and test an upgraded still and video camera system for DST and SST inspections.



MTW-11: Conduct staged, long-range guided wave ultrasonic testing to evaluate DST bottom conditions.



MTW-15: Visual inspection of DST primary tank bottoms.



Note: Although there are many needs and gaps identified in the discussions above, not all related active pro forma were ranked as high due to expected mission need dates.

4.1.4 242-A Evaporator

The 242-A Evaporator is an essential component for continued tank farms operations. Figure 4-2 depicts how the 242-A Evaporator is used. The 242-A Evaporator currently provides the only available evaporative capability on the Hanford Site. The evaporator is beyond its engineered lifetime and represents a potential single-point failure that could impact continued tank farms operations. There is heightened awareness regarding safeguarding the 242-A Evaporator due to premature evaporator failure that has occurred elsewhere in the DOE complex.

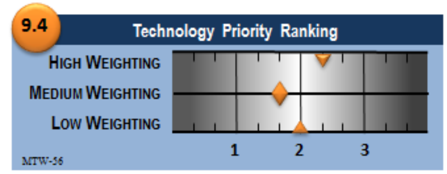
The 242-A Evaporator is integrated with the tank farms and the ETF and is needed to recover DST space for tank farms operations. The 222-S Laboratory provides support for 242-A Evaporator operations by using the electrochemical test stand for corrosion and tank integrity studies and the boil-down apparatus for preparation for evaporator runs. The existing 242-A Evaporator must be maintained in good repair (including the acquisition of spare parts), and any potential technical issues that could endanger continued operations of the evaporator must be mitigated.

Figure 4-2. 242-A Evaporator Overview.

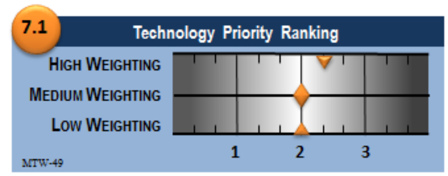
4.1.4.1 High-Priority Pro Forma

High-priority pro forma that have been identified to support 242-A Evaporator issues include the following, which are ranked in order of descending priority.

MTW-56: Evaluate the current DFLAW organic COPCs list. Develop a methodology for establishing the organic inventory and evaluating organic emissions limits from the 242-A Evaporator vessel vent system.



MTW-49: Perform 304L stainless steel corrosion tests with bounding simulated waste compositions for DFLAW.



Note: Although there are many needs and gaps identified in the discussions above, not all related active pro forma were ranked as high due to expected mission need dates.

4.1.5 222-S Laboratory

The 222-S Laboratory is an analytical and information management service organization. This laboratory provides tank waste characterization services and analytical and laboratory support for the following:

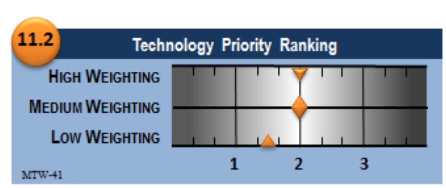
- Waste retrievals, waste transfers, and tank integrity
- Tank farms chemical vapors
- Tank waste processing
- Waste feed delivery and qualification
- Alternative waste forms.

The 222-S Laboratory has the capability to handle radioactive samples and to provide some integrated laboratory-scale testing but is in need of general infrastructure upgrades. 222-S Laboratory support for DFLAW will require characterization and some analysis of real waste.

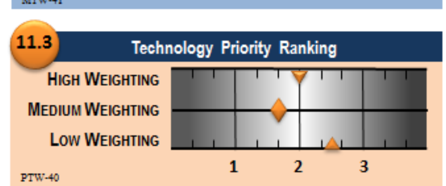
4.1.5.1 High-Priority Pro Forma

High-priority pro forma that have been identified to support the 222-S Laboratory issues include the following, which are ranked in order of descending priority.

MTW-41: Develop analytical methods at 222-S Laboratory to characterize vapors and other chemical species of interest in support of DFLAW.



MTW-40 Provide improved sampling for headspace particulate analysis to support tank vapors characterization and mitigation.



Note: Although there are many needs and gaps identified in the discussions above, not all related active pro forma were ranked as high due to expected mission need dates.

4.1.6 Sampling and Transport

When the Hanford Site was built, the mission was to manufacture nuclear materials in support of the national defense program. Due to the political climate of the Cold War, there was urgency to manufacture as much weapons material as possible, as quickly as possible. The waste tank system was constructed to contain the waste byproducts generated from weapons production. Tank waste management was not the focus of that early mission, but instead was a necessary support function. As a result, there is a lack of information regarding the nature of waste in the tanks. The best-basis inventory (BBI)[16] is the official database for tank waste inventory estimates at the Hanford Site. Estimates are based on the "best" available information to describe in-tank waste contents, not including vapors. This includes sample-based information (when available), process knowledge calculations, waste type templates based on sample data, and Hanford Defined Waste (HDW) Model estimates (RPP-19822, *Hanford Defined Waste Model*). Because representative waste samples are very difficult and expensive to collect and analyze, much of the information in the BBI is based on historical process knowledge rather than from actual sample data, particularly for SSTs.

The focus of the Hanford RPP mission is tank waste cleanup and environmental restoration. Waste tank inventory sampling and characterization are needed to understand the scope and magnitude of the RPP mission. This information is essential to fill in the data gaps regarding the individual tank contents to support associated retrieval and immobilization efforts. Systematic and representative samples of the waste tanks need to be collected and characterized. WRPS also needs accurate characterization data to facilitate waste feed delivery and efficiently plan waste staging to the WTP. There are gaps and needs associated with waste tank inventory and sampling that stem from the difficulty and high cost associated with tank sampling and characterization.

Approaches to address these items are currently being considered and will likely involve additional testing, analysis, and technology development requirements. The sampling and characterization program projects and prioritizes samples identified for the operation of the Tank Farms and to support planning for future waste treatment activities. Input is solicited from SST Retrieval and Closure, Closure and Corrective Measures, Tank Farm Projects, Sampling Operations, One System, and Process Engineering Analysis technical staff. Additional sampling events are anticipated to support WTP feed requirements and to support ongoing and potential future projects, such as DFLAW.

Waste tank inventory sampling and characterization needs and gaps have been assessed as a function of mission timeframe and prioritized with respect to their importance and urgency for tank farm operations. The current top priority in this functional area is characterization of tank vapors, which is discussed in Section 4.1.2. BBI is anticipating the incorporation of vapor data but is currently not addressing vapors. Subsequent revisions to this document will address incorporation of vapor data into BBI as warranted.

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[16] https://twins.labworks.org/twinsdata/Forms/About.aspx

Samples collected for tank waste characterization are handled as a Hazardous Material and are transported pursuant to tank farm procedures. Technology development for sample containers has previously been documented in one pro forma but none generated concerning transportation modes. Currently there is an ongoing effort to review sampling and transportation mission needs (i.e. tank integrity, waste feed qualification, and DFLAW radioactive waste test platform) that may lead to technology development activities.

4.1.6.1 High-Priority Pro Forma

No current high-priority pro forma are associated with this sub-functional category.

4.2 RETRIEVE TANK WASTE

Waste retrieval is required to remove most of the waste to close the tanks per regulatory requirements. Retrieval efficiency is based on knowledge of the tank contents for both the extraction of the waste with effective tools, the transfers downstream, and the mixing and blending for delivery of feed to the WTP that meets waste form qualification requirements. Across all aspects of the waste retrieval process, there is a need to know overall waste composition and chemical and physical characteristics. Remote in situ monitoring of these parameters would enhance and improve retrieval operations. Waste retrieval can also include special processes such as those envisioned for contact-handled TRU (CH-TRU) waste[17] and mitigation of selected DSTs.

Figure 4-3. Primary Hanford SST Waste Retrieval Technologies.

The various methods of waste retrieval are described in RPP-RPT-44139. Figure 4-3 shows the primary retrieval technologies used for the Hanford Site SSTs. Modified sluicing or salt cake dissolution is typically used to retrieve the majority of the waste volume from the SSTs; however, these methods are typically insufficient to reach the established residual waste volume goal of 360 ft^3 or less for 100 series SSTs, and 30 ft^3 or less for 200 series SSTs as mandated by the TPA. This residual waste is typically characterized as a hard heel of insoluble material that requires more aggressive methods to mobilize and remove from the tank. The Tank Operations Contractor also uses mechanical and chemical technologies for hard heel removal subsequent to waste retrieval operations using modified sluicing.

Implementing these technologies can require tank modifications in the form of new and or larger tank penetrations to accommodate waste retrieval equipment. This equipment includes the mobile arm retrieval system, as shown in Figure 4-4, and various robots and tank crawlers used to mechanically break up the waste and move it to the center of the tank for easier access by the waste retrieval equipment.

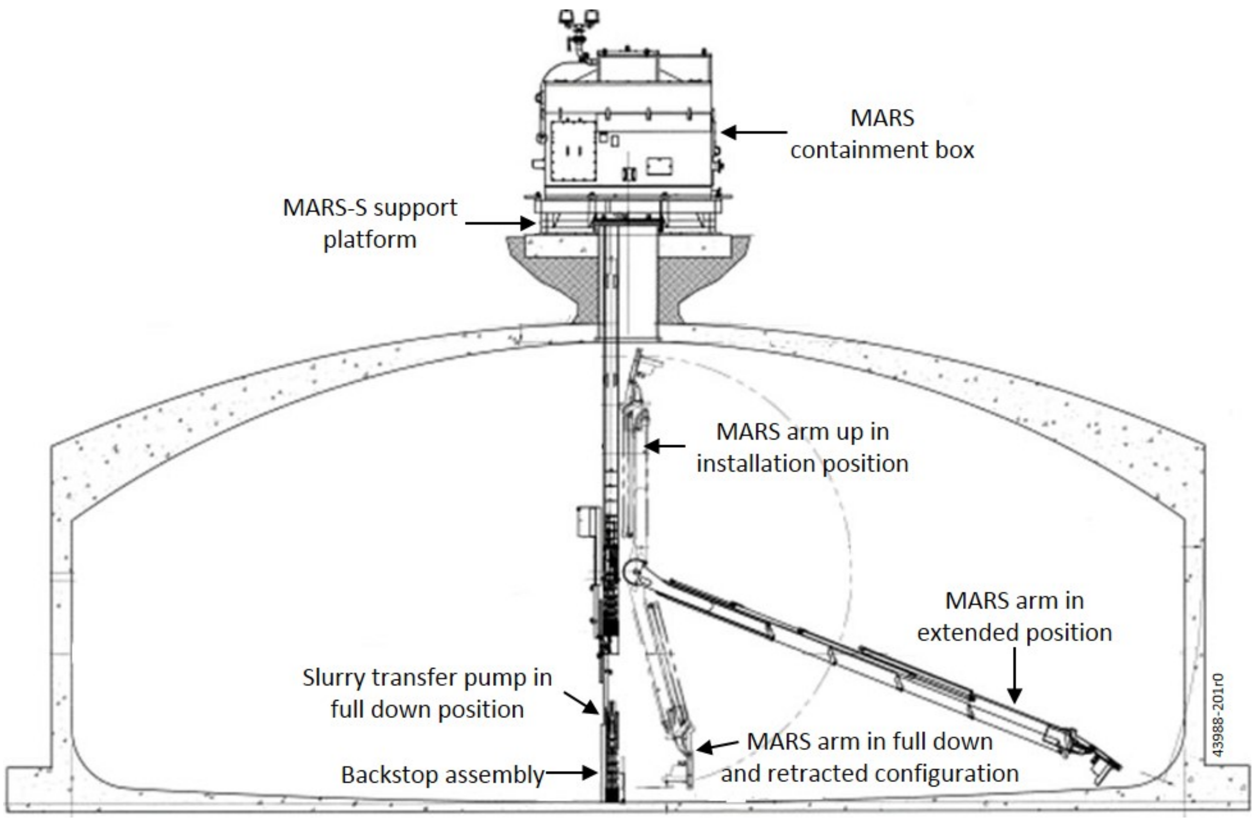
[17] CH-TRU waste retrieval technologies should be developed in advance of CH-TRU waste processing to achieve mission objectives.

4.2.1 Waste Retrievals

Characterization of the SST waste is a first step in successful mobilization and retrieval of the waste in these tanks. Some of the SSTs have not been sampled, and much of the tank sampling that has occurred was performed years ago. For these tanks, natural long-term chemical or physical reactions have likely occurred that could change waste characteristics and affect projected waste retrieval efficiency. Valid sample information is needed prior to initiating a tank waste retrieval.

In addition, in situ real-time waste characterization and monitoring would increase waste retrieval efficiency as retrieval in a tank progresses. Improved residual waste characterization could reduce the time required for tank closure declaration. No specific high-priority pro forma worksheets are addressed regarding these activities because they represent longer-term needs; however, this discussion is included to highlight important future RPP mission needs.

Multiple techniques are required to mobilize and retrieve the SST waste to the level needed for ultimate closure of that tank and the associated waste management area.



MARS = mobile arm retrieval system.

Figure 4-4. Schematic of the Mobile Arm Retrieval System.

The same methods used for monitoring and retrieval of SSTs may also be used for DSTs; however, the current focus of the RPP mission has been to retrieve waste from SSTs into DSTs. Important considerations include the following:

- Waste is adequately characterized to support efficient waste retrieval and delivery to LAWPS

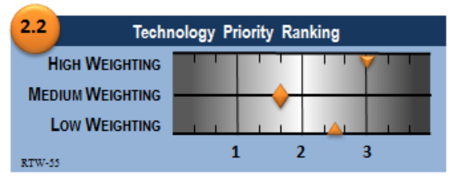
- Waste mobilization/retrieval techniques are available in time for in-tank use
- Waste transfer capability is available and properly controlled
- Waste tank residual heel evaluation is optimized
- Waste is adequately blended by mixer pumps.

Most technology development needs for SST waste retrieval deal with improving the efficiency and reliability of the process. This approach is particularly important for FY 2018 as retrieval operations shift from 241-C Tank Farm to the 241-A and 241-AX Tank Farms, presenting a new set of challenges. SST waste retrieval needs and gaps have been assessed and prioritized with respect to their importance and urgency in support of TPA milestones, LAWPS, and DFLAW.

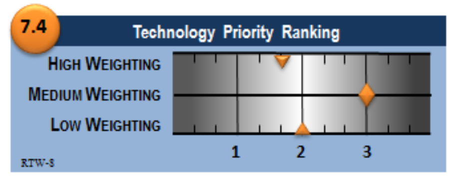
4.2.1.1 High-Priority Pro Forma

High-priority pro forma that have been identified to support waste retrievals include the following, which are ranked in order of descending priority.

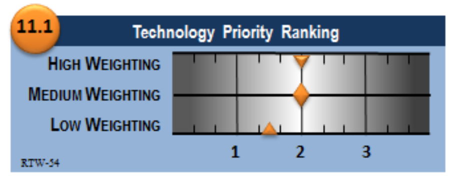
RTW-55: The Hanford Site waste end effecter is needed to facilitate waste retrieval in leaking tanks via a confined sluicing process.



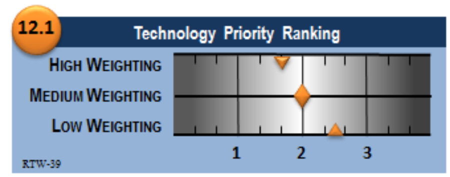
RTW-8: Develop an in-tank mechanical waste gathering system. This activity supports risk mitigation of “wet” retrievals of structurally compromised waste tanks (e.g., tank 241-A-105) and is currently unfunded for FY 2017.



RTW-54: Conduct a study of all modular treatment methods to determine if modular treatment is an option for ORP under Hanford Site permitting and nuclear safety restrictions, and if so, which modular treatment options would be best to pursue to improve mission efficiency and reduce time to stabilize waste and empty tanks.



RTW-39: Develop a strategy and basis for predicting residual waste volumes and properties, and to develop effective retrieval options for each SST or type of waste in SSTs.



Note: Although there are many needs and gaps identified in the discussions above, not all related active pro forma were ranked as high due to expected mission need dates.

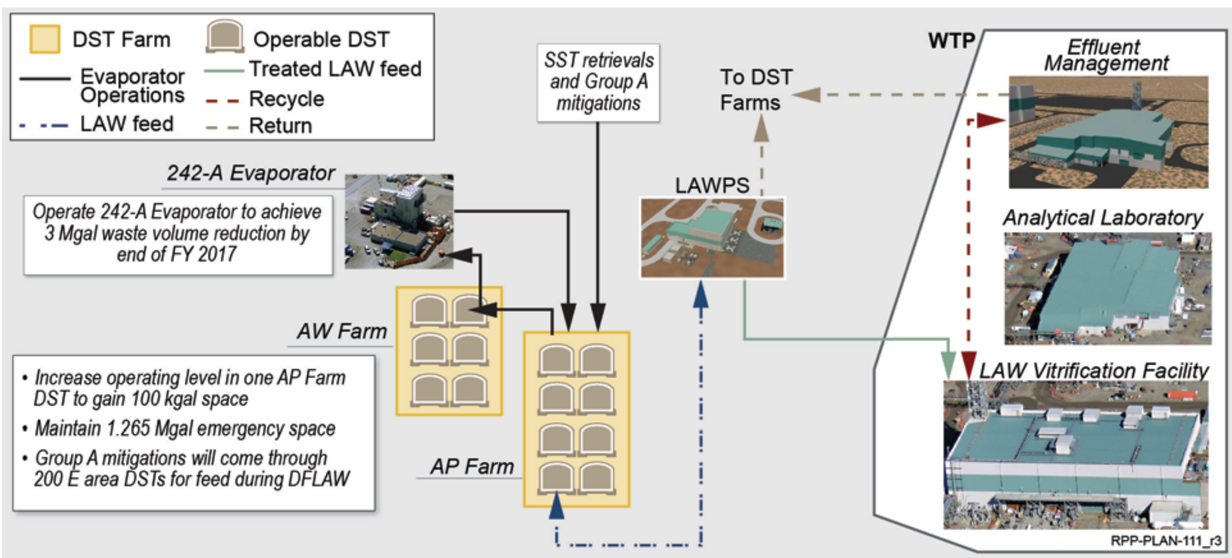
4.2.2 Double-Shell Tank Waste Transfers

The DST waste transfer system is a critical, interdependent system within the RPP that relies on the ability to continually retrieve, treat (as necessary), and transfer tank waste to the LAWPS, WTP, and various waste treatment facilities. The near-term DST waste transfer strategy focuses on the following:

- Startup, commissioning, and initial operation of LAWPS
- Waste volume management
- Modeling of waste blending and staging strategies.

The DST system will continue to (1) receive new waste generated by miscellaneous Hanford Site facilities and waste retrieved from the SSTs and (2) stage waste for delivery to pretreatment and treatment facilities. Waste retrieval from the 27 active DSTs is required to supply continuous feed to WTP. The DSTs require upgrades to support waste retrieval and delivery. The use of mixing pumps to mobilize tank waste (not saltcake) has been demonstrated, but recent changes that increased limits of allowable sludge depth in the DSTs will require further testing of deep sludge retrieval.

Tank farms waste retrieval operations must be coordinated and timed such that the DST system is not overwhelmed with respect to waste volume. A key challenge in supporting the RPP mission is to efficiently manage the use of the DSTs and the rest of the DST waste transfer system. In the near-term, the DST waste transfer system is also in need of infrastructure upgrades to enable LAWPS and DFLAW operations. Figure 4-5 depicts the steps that must occur (excluding upgrades) to deliver feed to the LAWPS in support of DFLAW.



NOTE: Effluent management transfers to DST farms are only performed during evaporator outages.

DST =	double-shell tank.	LAWPS =	low-activity waste pretreatment system.
LAW =	low-activity waste.	WTP =	Waste Treatment and Immobilization Plant.

Figure 4-5. Preparation and Delivery of Feed to the LAWPS.

There are gaps and needs associated with WFD. Many of these needs stem from the interdependence of the ability to retrieve waste from the SSTs and DSTs, transfer the waste to various treatment facilities (as necessary), blend the waste appropriately, and deliver the waste to the WTP (e.g., via LAWPS).

A fundamental long-term challenge of waste feed delivery is whether in-tank mixing will operate with enough efficiency, sufficiency, and longevity to support the mission. An ongoing effort seeks to improve the DST transfer system infrastructure to support WTP operations. In addition, the DSTs contain relic equipment (e.g., airlift circulators) that further hinder the ability of mixing equipment to reach, mobilize, mix, and suspend in-tank waste. The impact of the mixing operation on the DSTs (i.e., erosion and corrosion) is also not known and cannot be predicted with current information, particularly for those DSTs that store large volumes of HLW sludge. A solution to this problem considers the use of TWCS (see Section 4.3.6 for further details).

The deteriorating conditions of the aging DSTs are anticipated to exacerbate the technically complicated re-tasking of the DSTs for waste transfer operations. This is evidenced by the failure of the tank 241-AY-102 liner and the ongoing evaluation of like-era DSTs. Important technology considerations[18] for DST waste transfers include the following:

- Accounting for the transport of tank samples for analysis
- Characterizing in-farm soil samples.

4.2.2.1 High-Priority Pro Forma

No current high-priority pro forma are associated with this sub-functional category.

4.2.3 Cross-Site Transfers

Cross-site transfer line WT-SNL-3150 is currently the only path for supernate from the 200 West Area tank farms to reach the 200 East Area tank farms and, subsequently, the LAWPS Facility. As of 2006, the primary piping, encasement, encasement drain line, and test riser assemblies were compliant (RPP-7846, *241-AN Transfer Line SNL-3150 Acceptance Test Report*). However, SNL-3150 has not been used in the interim. Pneumatic encasement testing must be performed on all fit-for-service transfer lines either every 10 years or prior the next use, whichever is longer as required in RPP-RPT-52206, *Tank Farms Waste Transfer System Fitness-for-Service Requirements and Recommendations*. Given that the last pressure test was in 2006 documented by RPP-7846, SNL-3150 must pass a pneumatic encasement test prior to next use. If SNL-3150 was scheduled for and passed the pneumatic encasement test as soon as FY 2017, the results would still be valid when the transfer line is needed for DFLAW purposes in 2025 and would mitigate a risk of the transfer line being unfit for service when it is needed (RPP-RPT-40149, Volume 3).

Cross-site slurry transfer (CSST) line WT-SLL-3160 requires separate approval from DOE before commencement of slurry transfer operations. DOE has not approved use of the CSST line. In order to authorize use of the CSST system to transfer slurry waste, an authorization basis amendment needs to be performed per procedure TFC-ENG-SB-C-01, *Safety Basis Issuance and Maintenance*. Criteria that are suspected to impact accident analyses are the higher pressures and flow rates that will be produced by the 6241-A diversion box booster pumps, the effect of slurry wastes upon postulated leak dose rates, and the potential impacts of the CSST system upon raw water systems. One of the recommendations of this gap analysis is that a flush system be installed that would automatically activate to flush the transfer line WT-SLL-3160 upon loss of pressure from a 241-SY DST transfer pump in order to prevent plugging of transfer line WT-SLL-3160.

Important technology considerations for Cross-Site transfer lines are as follows:

- Leak detection capability
- Line plugging detection and clearing capability

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[18] These specific needs were not screened as high priority because they did not fit the urgency of the 5-year timeframe; however, they merit noting as they affect waste transfers to WTP.

- Critical velocity measurement.

4.2.3.1 High-Priority Pro Forma

No current high-priority pro forma are associated with this sub-functional category.

4.2.4 Double-Shell Tank Upgrades

A primary objective of DST upgrades is to ensure that the Hanford tank farms are able to provide optimized, continuous, and reliable feed to the WTP or new supplemental treatment systems. Important technology considerations for DST upgrades are as follows:

- Enhanced online monitoring capability
- Enhanced in-tank mixing, sampling, and blending capability (i.e., TWCS).

4.2.4.1 High-Priority Pro Forma

No current high-priority pro-forma are associated with this sub-functional category.

4.2.5 Feed Preparation

The primary goal of feed preparation is to ensure that qualified waste feed batches are readily available for WTP and secondary treatment system campaigns. TWCS has an approved mission need (CD-0). It has previously been described as having a potential capability of supporting feed to the PTF and/or HLW facility. TOPSim assumes that a LAW transfer system will be installed to feed WTP PT. Important technology considerations for feed preparation are as follows:

- Particle segregation process.

4.2.5.1 High-Priority Pro Forma

No current high-priority pro forma are associated with this sub-functional category.

4.2.6 Tank Closures

The ultimate RPP mission goal is to close the waste tanks and associated waste management areas. Prior to tank closure, the Tank Operations Contractor must demonstrate that the waste has been sufficiently retrieved to meet DOE and Washington State Department of Ecology requirements. In addition, the soil environment surrounding the waste tanks must be characterized and monitored for evidence of tank leaks and waste plumes in the vadose zone.

Closure will include backfilling the empty waste tanks with stabilizing grout and/or filler, and capping off the tank farm with an impermeable liner material to prevent moisture from migrating down through the soil to the underground waste tanks. Because water in-leakage is a natural pathway for soluble radionuclides to the groundwater, the waste management areas must be sealed off with a monitored moisture barrier. Tank closure activities at other DOE sites will be evaluated for potential leveraging of technology, equipment, and methods.

Closure activities will address a group of small (less than 50,000 gal), radioactively contaminated, inactive, underground storage tanks that are collectively termed the IMUSTs. These tanks are located throughout the 200 East and 200 West Areas and are described in RPP-13329, *Tank Farm Facility Hazard Categorization*. Currently, a total 44 IMUSTs, 20 in the 200 West Area and 24 in the 200 East Area, are managed by the TOC as identified in RPP-

13033, *Tank Farm Documented Safety Analysis*. In addition, there are two categories of radioactively contaminated, active waste storage tanks that are collectively termed MUSTs as identified in RPP-13033; catch tanks and double-contained receiver tanks. The TOC manages 14 catch tanks and 4 double-contained receiver tanks for a total of 18 MUSTs. These numbers are subject to change based on regulatory status. Additionally, IMUST/MUSTs owned by other contractors are intentionally not identified in this document because this Technology and Innovation Roadmap focuses primarily tank farm issues. However the disposal of IMUST/MUST waste has an added dimension that will require contractor coordination and integration where the disposal plans managed by different Hanford contractors merge. There is also the aspect of internal tank farms integration of the IMUST/MUST waste with the ongoing retrieval, mixing, sampling, and blending of waste to be processed at the WTP.

Although MUST and IMUST retrieval is not a high priority and will be deferred until later in the mission, ongoing monitoring and detection activities will continue (quarterly if leak detection monitoring is required, or annually if only intrusion monitoring is required).

Important technology considerations for MUSTs and IMUSTs are as follows:

- Tank waste characterization techniques to support risk based closure (RTW-24)
- Highly flowable grout formulation and pipe encasement sealing techniques to support closure (RTW-25).

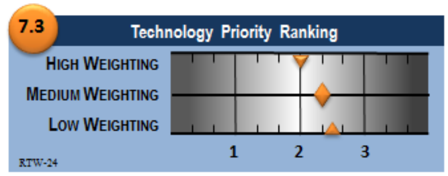
The 222-S Laboratory currently receives soil cores from vadose sampling in the tank farms. A state-licensed WRPS geologist extracts photographs and describes the soils, makes a composite from each depth, and determines percent moisture. The composites are turned over to the 222-S Laboratory for selected standard analyses.

Expanded capability for the analysis of vadose zone soil samples is desirable. The determination of saturated hydraulic conductivity, particle size distribution, partitioning of toxics between solid and liquid, and other analytical capabilities have been discussed. If this determination is left to routine upgrade activities, the needed capabilities will not be evenly expanded and will mainly be planned as part of other TOC projects.

4.2.6.1 High-Priority Pro Forma

High-priority pro forma that have been identified to support SST closure includes the following:

RTW-24: Perform direct-push coring, a waste characterization technique for in-farm soil sampling adapted for use with catch tank contents (e.g., tank 241-C-301) and to model and plan large tank retrievals and support 241-C Tank Farm closure.



Note: Although there are many needs and gaps identified in the discussions above, not all related active pro forma were ranked as high due to expected mission need dates.

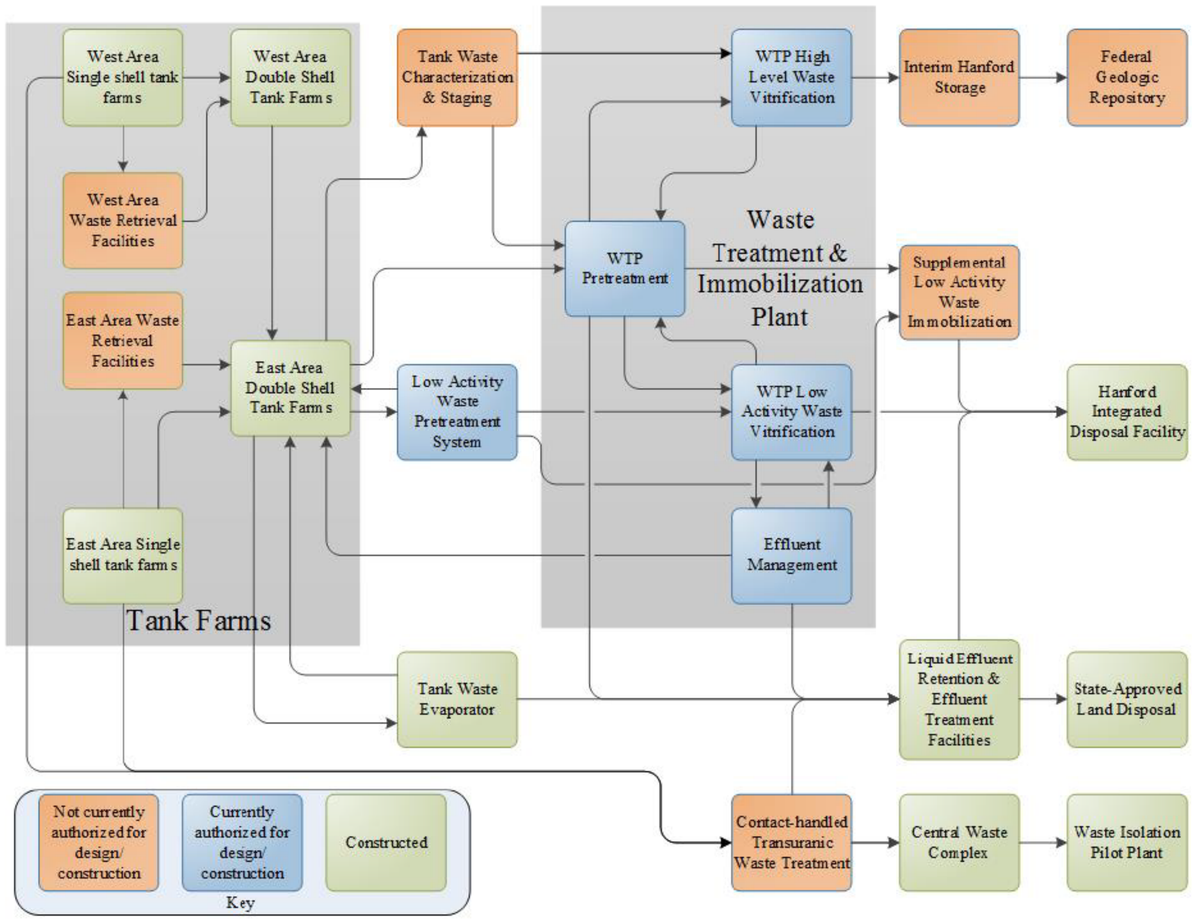
4.3 PROCESS TANK WASTE

Hanford Site tank wastes must be retrieved from the tank farms and safely immobilized into stable waste forms. The baseline method for Hanford Site waste immobilization is vitrification.

As part of the WTP design basis, the retrieved waste will be separated into LAW and HLW fractions at the WTP PT Facility. Some of the LAW waste will be vitrified into borosilicate glass at the WTP LAW Vitrification Facility. The HLW fraction of the waste will be vitrified into borosilicate glass at the WTP HLW Vitrification Facility. The WTP LAW Vitrification Facility alone was never intended to treat the entire inventory of Hanford LAW in the same period as the HLW can be treated. Supplemental immobilization was always envisioned to treat part of the LAW waste (System Plan). Technologies that have been considered for immobilization include joule-heated melter vitrification (similar to WTP), grout (cast stone), fluidized bed steam reforming, and bulk vitrification. Milestone M-062-40 used to include a requirement for a Hanford Tank Waste Supplemental Treatment Technologies Report if a tank waste supplemental treatment technology was proposed other than a 2nd LAW vitrification facility. However, as of this time, the scope of the supplemental immobilization and treatment projects have been deferred until a date yet to be determined.

The Tank Operations Contractor is committed to providing support for startup of the WTP LAW Vitrification Facility by designing and deploying LAWPS, which will enable early facility startup.

As the RPP mission transitions from managing/retrieving tank farms to waste treatment operations by the WTP, the need exists to understand the flowsheet interactions that will occur and to anticipate the implications this interconnectedness will cause with respect to chemical interactions, process flows, unit operations, and effluent management. The One System examines the RPP mission holistically to develop integrated process flowsheets from the individual process flowsheets that comprise each aspect of the RPP mission. The portions of RPP-RPT-57991 that are of greatest importance for the scope of the Technology and Innovation Roadmap are those that directly impact the tank farms and support DFLAW. A simplified version the integrated flowsheet is provided in Figure 4-6.



Source: RPP-RPT-57991, 2015, *One System River Protection Project Integrated Flowsheet*, Rev. 1, Washington River Protection Solutions, LLC, Richland, Washington.

Figure 4-6. Simplified Integrated Flowsheet.

RPP Integrated Flowsheet activities include developing plans to address process flowsheet gaps and opportunities associated with the DFLAW phase of the RPP mission (RPP-PLAN-58003). Revisions to the flowsheet roadmaps are under development to evaluate emerging issues associated with the following:

- SST waste retrievals (e.g., salt-cake dissolution, hard heel management)
- Material transfers between facilities (e.g., critical velocity and flushing requirements)
- DFLAW (e.g., mercury and ammonia behavior).

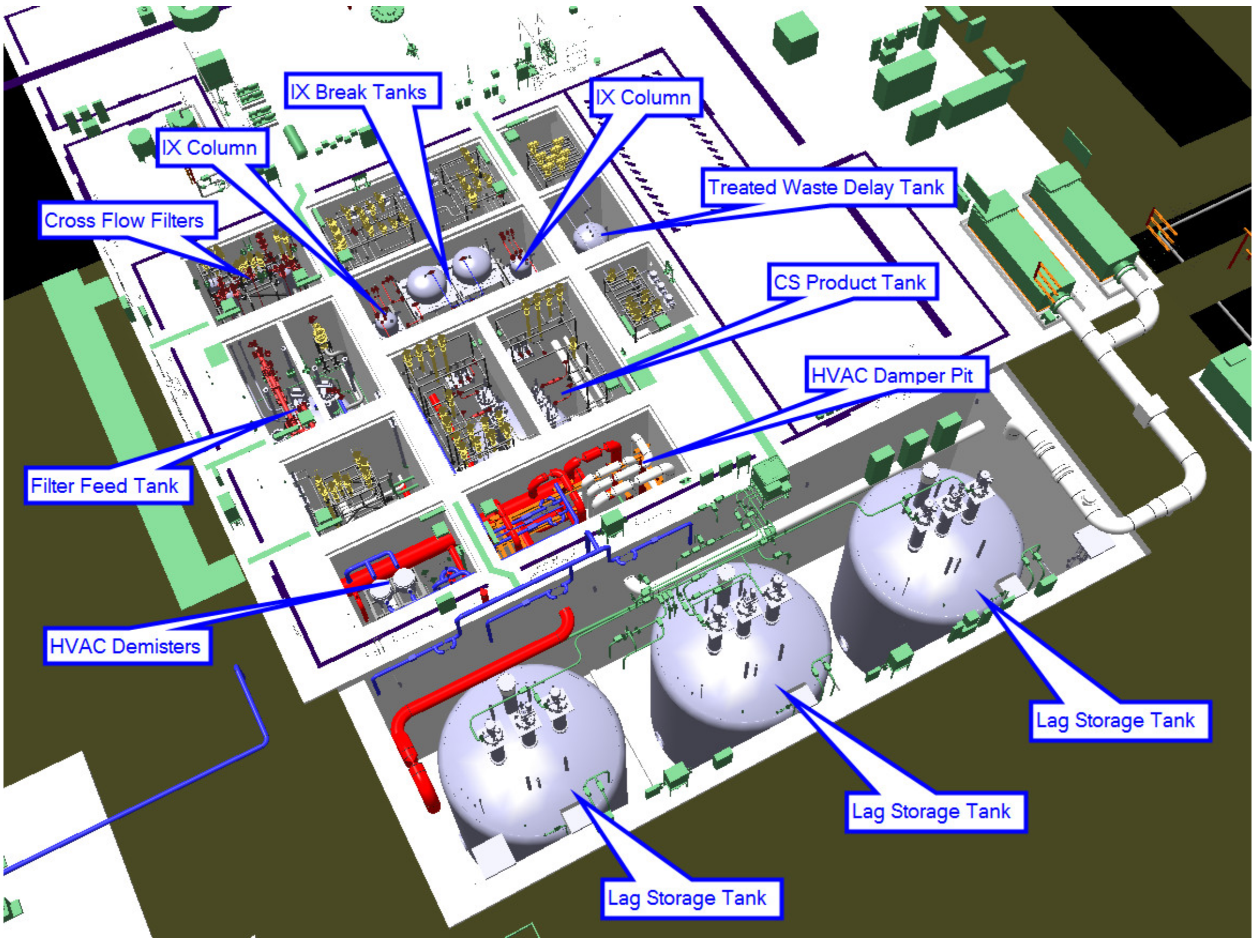
4.3.1 LAWPS

Under the original System Plan the WTP PT Facility is the linchpin system[19] that precedes all other WTP operations. The Tank Operations Contractor transfers waste from the waste tanks to the WTP PT Facility to chemically treat and separate the wastes into LAW and HLW fractions. PT Facility operations prepare the waste feed for vitrification. However, the WTP PT Facility

[19] The WTP PT Facility is described as a "linchpin system" because, according to the System Plan baseline flowsheet, most material must be processed through the PT Facility before the waste can be immobilized by downstream operations.

will not be available for operations in the near-term. To facilitate DFLAW, WRPS is designing a LAWPS facility that will provide pretreated LAW suitable for vitrification. The LAWPS is undergoing the DOE CD process. As a capital assets project, the system is also subject to DOE O 413.3B.

The LAWPS will support DFLAW operations, ramping up to an average treatment capacity of 21 MTG/day using two melters (assumed maximum capacity of 30 MTG/day). The LAWPS, shown in Figure 4-7, is a permanent facility that is described in RPP-PLAN-57181, *Technology Maturation Plan for the Low-Activity Waste Pretreatment System Project (T5L01).*

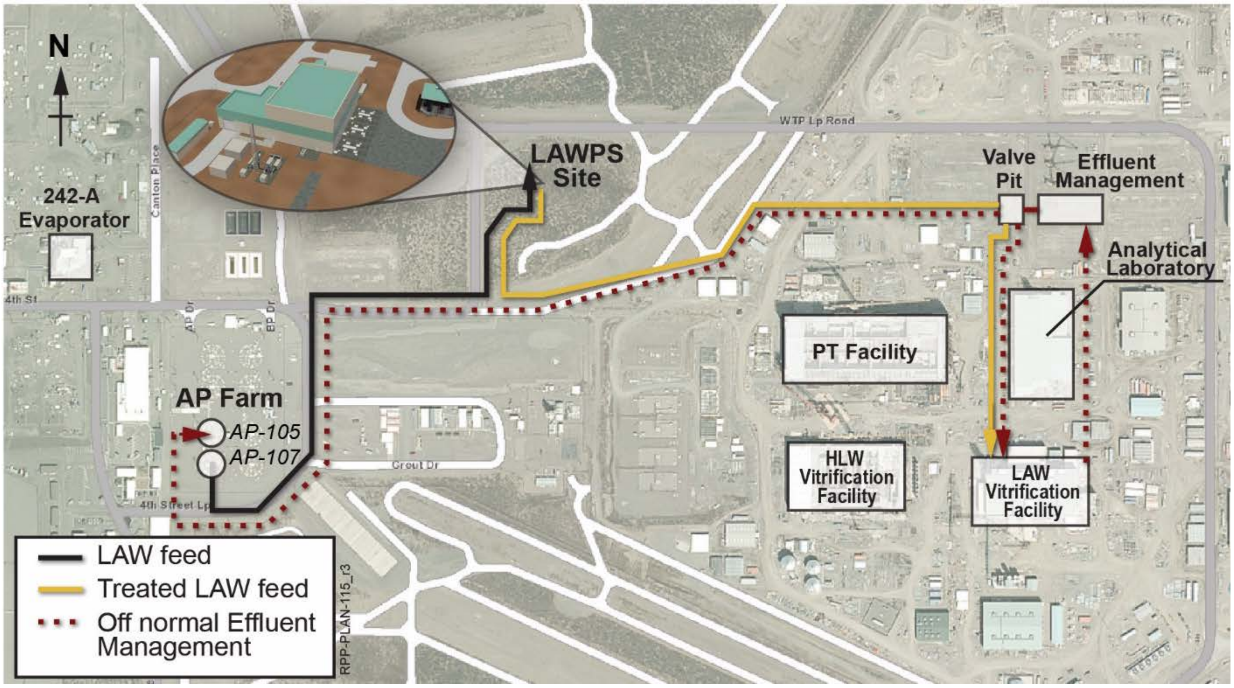


CS = cesium.
HVAC = heating, ventilation, and air conditioning.
IX = ion exchange.

Figure 4-7. LAWPS Facility Concept.

The LAWPS uses CFF to remove suspended solids containing alpha-emitting TRU nuclides and highly radioactive ^{90}Sr, and IX using sRF resin to remove ^{137}Cs from supernatant tank waste. The resultant LAW feed is immobilized at the WTP LAW Vitrification Facility using the DFLAW operating flowsheet. Starting up LAW immobilization operations in advance of WTP completion enables RPP mission progress in a phased WTP startup scenario.

This approach also offers the opportunity to respond to technical issues that may arise in the tank farms while supporting WTP operations. The planned location of the LAWPS with respect to the location of the WTP and the 241-AP Tank Farm DSTs is shown in Figure 4-8.



HLW	=	high-level waste.	LAWPS	=	low-activity waste pretreatment system.
LAW	=	low-activity waste.	PT	=	pretreatment.

Figure 4-8. Location of the LAWPS.

The LAWPS must be designed and constructed in time to support DFLAW. The auxiliary infrastructure (e.g., transfer lines, utilities) must also be in place to deliver feed to the WTP LAW Vitrification Facility. The challenge is for the Tank Operations Contractor to deliver supernatant waste material to the LAWPS that is within acceptable processing limits. In addition, all of the other DFLAW operations are interdependent with the LAWPS. Without pretreated feed, there can be no LAW immobilization.

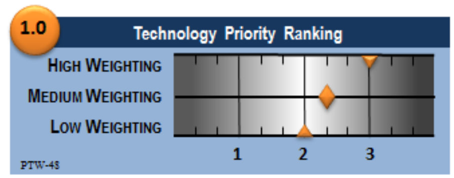
RPP-PLAN-57181 identifies four critical technology elements associated with LAWPS:

- CFF
- IX system
- IX eluate neutralization
- IX resin replacement, treatment, and disposal.

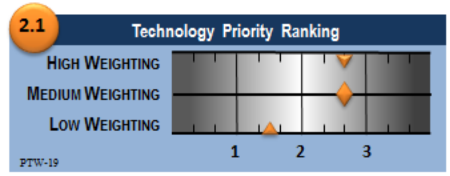
4.3.1.1 High-Priority Pro Forma

LAWPS needs and gaps have been assessed as a function of mission timeframe and prioritized with respect to their importance and urgency for DFLAW startup. High-priority pro forma that have been identified to support LAWPS include the following, which are ranked in order of descending priority.

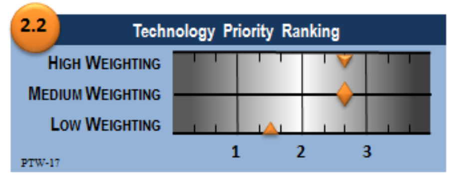
PTW-48: LAWPS Cs IX column.



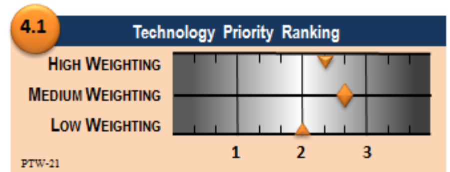
PTW-19: Mature the IX system to demonstrate expanded operating range using sRF IX resin, including sodium molarity and temperature requirements. This activity may require national laboratory support.



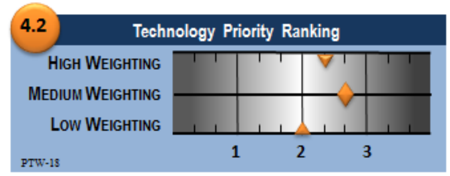
PTW-17: Perform the LAWPS engineering-scale integrated test (before CD-2). The integrated system test is required to mature the technology to TRL 6.



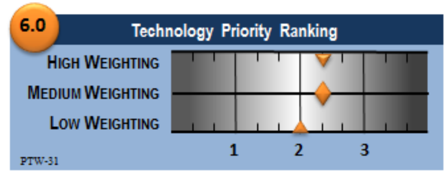
PTW-21: Mature the sRF handling systems (i.e., storage, transfer, and the removal and disposition of spent IX resin and replacement with fresh IX resin), as identified by the technology maturation plan. This activity may require national laboratory support.



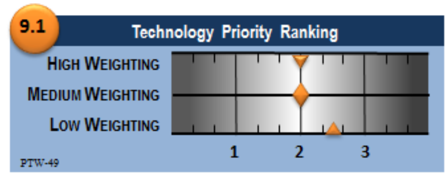
PTW-18: Qualify CFF for use with tank 241-AP-107 waste (and filtrate returns), including cleaning protocols for LAWPS application. This activity may require national laboratory support.



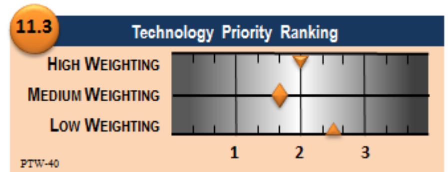
PTW-31: Maturation of the DFLAW qualification processes. Determine the appropriate level of LAWPS unit operations feed qualification to demonstrate the DFLAW feed can be processed through LAWPS in a safe and environmentally compliant manner.



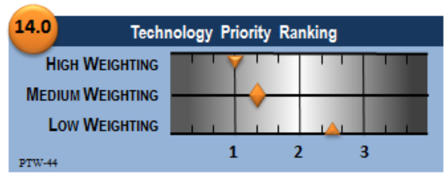
PTW-49: Conduct a study to examine feasibility of removing nitrates from the LAW feed stream prior to vitrification.



PTW-40: HLW direct vitrification – builds off of proposed DOE Framework phased approach enabling processing HLW solids in the absence of the WTP PT Facility.



PTW-44: Establish technical basis for sRF storage conditions, life expectancy, and cesium removal efficiency over time and method.



Note: Although there are many needs and gaps identified in the discussions above, not all related active pro forma were ranked as high due to expected mission need dates.

4.3.2 Effluent Management

To achieve the DFLAW mission, a method of managing LAW melter condensate and other effluent returns that are not compatible with the current ETF is required. Effluent management will include evaporative capability and appropriate routing of effluent returns. Additionally, it will include receipt and treatment of LAW melter condensate and other incidental waste streams from the WTP LAW Vitrification Facility. The low radioactivity SLW output stream (evaporator overheads) will be transferred to the LERF for treatment at ETF.

A majority of the concentrated liquid waste output (evaporator bottoms) will be recycled through the WTP LAW Vitrification Facility. A small fraction might be returned back to the tank farms during off-normal operations (i.e., effluent management evaporator outages). One System flowsheet integration has established the split between the returned and recycled effluent.

Evaporator Condensate Disposal. The WTP LAW Vitrification Facility will generate a substantial volume (i.e., millions of gallons per year) of SLW in the offgas treatment system. In particular, wastes generated in the LAW melter submerged bed scrubber (SBS) and wet electrostatic precipitator are expected to contain significant amounts of ^{99}Tc, ^{129}I, halides, and sulfates from the LAW melter feed stream.

The current RPP baseline approach is to recycle the SBS condensate following concentration by effluent management.[20] SBS condensate will also be generated using the DFLAW flowsheet. Secondary radioactive liquid waste from the LAW Vitrification Facility offgas systems, with the exception of the caustic scrubber waste stream, will be routed to effluent management for evaporation. The effluent management design includes flexibility to route the effluent management evaporator concentrate (also referred to as effluent management evaporator bottoms) as follows:

- Recycle back to the LAW Vitrification Facility for blending with incoming LAWPS feed
- Return back to the Hanford Site DST farms
- Purge via a tanker truck load-out station for direct disposal.

The ability to purge or selectively treat the effluent management evaporator concentrate to remove chlorides and sulfates provides a means to increase future operational flexibility and also provides an outlet to address potential upset or off-normal conditions during the DFLAW mission. Alternatives being investigated include various permutations of onsite or offsite treatment (or selective treatment), and onsite or offsite disposal. Key considerations regarding the effluent management SLW are as follows.

- ^{99}Tc volatility/entrainment may not be constant, reducing the capture fraction and causing ^{99}Tc buildup in the recycle.
- SBS condensates accumulate halides and sulfates, which adversely impact LAW glass production, performance, and waste loading. Halides and sulfates are also corrosive, which reduces equipment life.

[20] In the baseline full WTP flowsheet, recycling the LAW melter condensate includes concentrating in the WTP PT Facility, combining with new incoming LAW feed, and feeding the enriched LAW feed back to the LAW melters. For the DFLAW flowsheet, the effluent management concentrate will be recycled to the LAW facility, returned to the DSTs during effluent management evaporator outages, or disposed offsite.

- During DFLAW, the SBS condensates are planned to be routed to effluent management to provide evaporative capability and appropriate routing of effluent returns. The DST system has limited space for effluent returns.

Successful effluent management SLW offsite treatment/disposal will mitigate processing and equipment risks inherent in the LAW Vitrification Facility recycle flowsheet by removing a significant portion of ^{99}Tc and halides from the flowsheet through offsite disposal. This approach will directly facilitate technetium management, mitigate DFLAW processing risks, reduce the ^{99}Tc inventory stored at the IDF, and assist with minimizing waste volumes returned to the tank farms system. Because this initiative will require a business decision to proceed, and is not part of the near-term priority list provided by ORP in letter 17-WSC-0016, effluent management SLW offsite treatment/disposal will not be discussed further as part of the Technology and Innovation Roadmap.

Direct-Feed Low-Activity Waste Vitrification. The WTP LAW Vitrification Facility is part of the PTW functional area. The LAW Vitrification Facility has been designed to vitrify LAW into borosilicate waste glass using a joule-heated, ceramic-lined melter system. LAW feed, provided by LAWPS, is mixed with glass-forming chemicals and fed to the melter in a slurry form. The melter feed is introduced through the top of the melter directly onto the molten LAW glass pool. The liquid fraction evaporates, and the offgases are processed through the melter offgas system.

The offgas condensates are recycled back to the LAW melter to enhance ^{99}Tc (and other volatile constituents) retention. A cold cap of liquid waste and glass-forming chemicals forms on top of the melt pool and is gradually incorporated into the glass melt. This cold cap assists in radionuclide retention in the melt.

Continuous feeding of the melter maintains the cold cap. The molten glass is poured directly from the melter into a stainless steel container. The stainless steel containerized waste form is allowed to cool at a controlled rate to mitigate glass crystallization. After cooling, the container is sealed, and the container surface is decontaminated. The container may then be transported to the IDF. Note that the IDF must be available to receive LAW forms in time to support DFLAW startup.

DFLAW is an operational method that allows phased startup of the WTP Vitrification Facility using LAW feed provided by LAWPS, prior to the WTP PT Facility being available for operations. Figure 4-9 represents the DFLAW flowsheet. DFLAW requires the following:

- Feed provided by LAWPS
- Modifications to the tank farms that provide the required utilities and support infrastructure to deliver feed to the WTP LAW Vitrification Facility
- An operational WTP Analytical Laboratory and balance of facilities[21]
- The capability to handle process effluents
- The IDF available to accept LAW forms for disposal.

[21] The balance of facilities includes fire protection, process steam and process water supplies, electrical power switchgear, emergency power, cooling water, and glass-former chemicals.

The DFLAW operating flowsheet integrates with the tanks farms (providing LAW and receiving effluents), LAWPS, WTP LAW Vitrification Facility, and IDF. DFLAW also relies on services from the 242-A Evaporator and 222-S Laboratory.

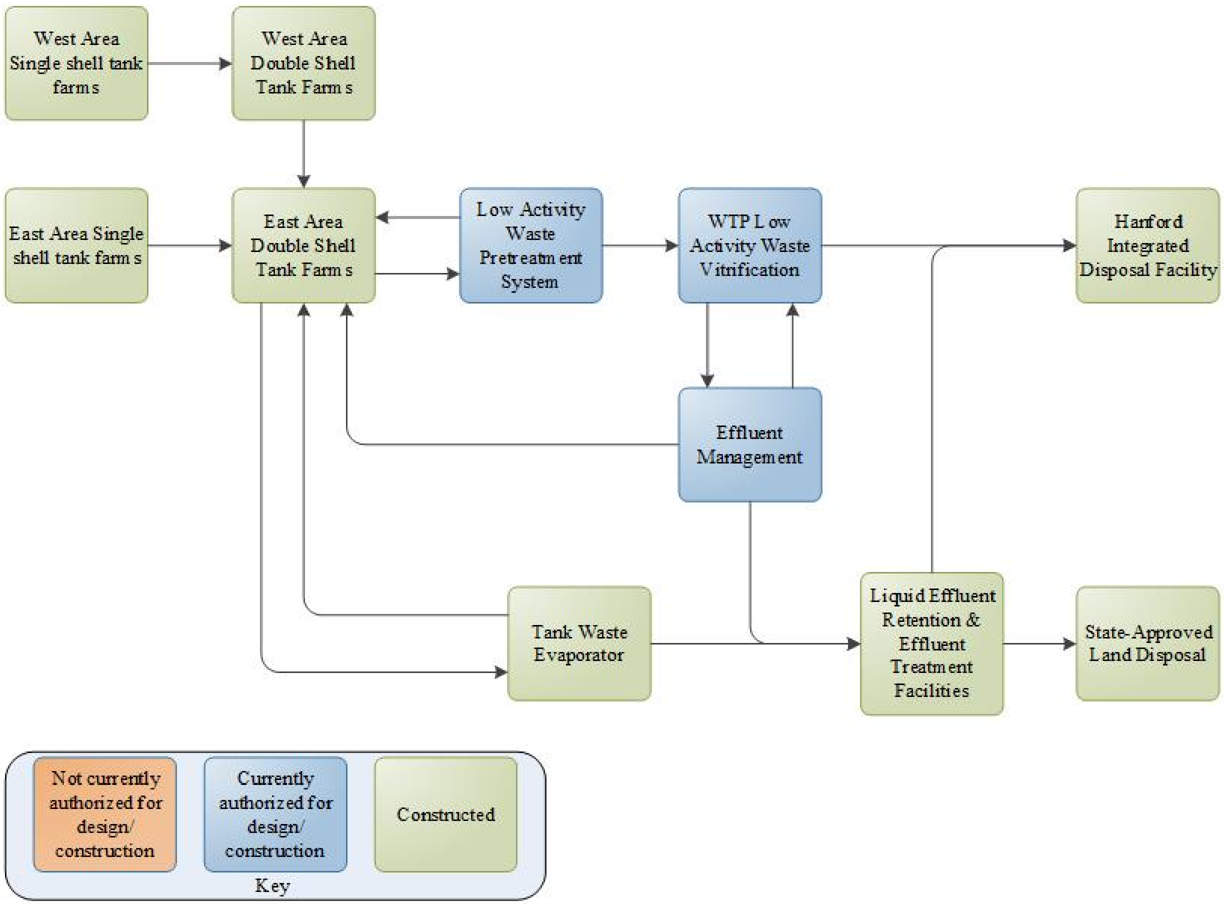


Figure 4-9. Simplified RPP DFLAW Integrated Flow Diagram.

DFLAW needs and gaps have been assessed as a function of mission timeframe and prioritized with respect to importance and urgency for startup. Solids formation avoidance is a cross-cutting issue with all waste handling and process activities. Important technology considerations for DFLAW include the following:

- MTW-56 – Evaluate COPC list and develop methodology for establishing the organic inventory
- PTW-31 – Mature DFLAW feed qualification process.

4.3.3 WTP LAW Vitrification

The WTP LAW Vitrification Facility is part of the PTW functional area. The WTP LAW Vitrification Facility performs the same function as described in Section 4.3.2.2. Feed will come from DFLAW for a limited time and from PT for the balance of the mission.

4.3.3.1 High-Priority Pro Forma

No current high-priority pro forma are associated with this sub-functional category.

4.3.4 WTP HLW Vitrification

The WTP HLW Vitrification Facility is part of the PTW functional area. Due to the interdependent nature of the overall WTP design, the facility is also reliant on upstream functions such as tank farms management, waste retrieval, and feed pretreatment, and is supported by secondary waste disposition and mission support services (e.g., WTP Analytical Laboratory). In addition, sub-tier systems such as HLW feed preparation, glass-former additions, and offgas handling are important to HLW vitrification.

Similar to the LAW Vitrification Facility, the HLW Vitrification Facility has been designed to vitrify HLW into borosilicate waste glass using a joule-heated, ceramic melter system. HLW feed is mixed with glass-forming chemicals tailored to be compatible with the melter and to produce acceptable glass. The molten glass is poured directly from the melter into a stainless steel canister. The stainless steel canistered waste form is allowed to cool. After cooling, the canister is sealed, and the surface is decontaminated using a cerium acid wash.[22] The canister may then be transported to an interim storage facility. The ultimate disposal path is an as-yet undetermined geologic repository disposal site.

HLW vitrification relies on HLW feed that is to be provided by the WTP PT Facility. The WTP Analytical Laboratory supports HLW operations by generating analytical data on process samples that are used to direct and control waste glass production.

Direct-feed HLW options, similar to the method used at Savannah River Site for the Defense Waste Processing Facility, may be viable for vitrification of Hanford HLW if the WTP PT Facility is further delayed. Certain waste streams problematic to the WTP PT Facility could also potentially be prepared in-tank using the Savannah River approach. This mission improvement initiative was included as part of the DOE Framework. However, this option is not currently being considered, as the initiative is not part of the near-term priority list provided by ORP in letter 17-WSC-0016.

4.3.4.1 High-Priority Pro Forma

No current high-priority pro forma are associated with this sub-functional category.

4.3.5 WTP Pretreatment

The WTP PT Facility is part of the PTW functional area. The PT Facility will receive waste from the tank farms (supernate) and TWCS (HLW slurry). It is designed to separate tank waste into HLW and LAW fractions via filtration and IX for subsequent feed to the respective vitrification facilities. The PT Facility also handles recycle of all vitrification off gas effluents.

4.3.5.1 High-Priority Pro Forma

No current high-priority pro forma are associated with this sub-functional category.

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[22] Lessons learned from the Defense Waste Processing Facility HLW vitrification operation at the Savannah River Site should be reviewed to leverage technology and identify potential issues.

4.3.6 Tank Waste Characterization and Staging

A TWCS capability has potential to improve or support the waste feed delivery process, waste feed acceptance criteria compliance, and waste feed qualification process control, TWCS may also help mitigate criticality safety concerns with particulate plutonium inventories.

The TWCS will provide a compatibility bridge between sludge wastes stored in the tank farms and the WTP receipt systems to ensure delivered waste is within the WTP waste acceptance criteria. While one fundamental need is to meet the WTP PT Facility particle size waste criterion, other sampling and DST space needs may become significant considerations in the design. This mission improvement initiative is in the preconceptual design phase and has not yet been authorized by DOE. However, the process could offer considerable mitigation capability to various RPP mission issues. Because TWCS is preconceptual, the capability does not meet the priority prescreening requirements to "support mission critical path" and does not have any high-priority technology items highlighted. However, relevant activities that TWCS supports include the following:

- Waste feed qualification strategy
- Particle size segregation and size-reduction technologies
- Direct-feed HLW vitrification initiative.

4.3.6.1 High-Priority Pro Forma

No current high-priority pro forma are associated with this sub-functional category.

4.3.7 Contact-Handled Transuranic Waste

The Tank Operations Contractor has evaluated 20 tanks (17 SSTs and 3 DSTs) as potentially containing TRU waste. Of the 20 tanks identified, 11 SSTs contain CH-TRU waste.[23] The System Plan Baseline Case assumes that 11 SSTs containing CH-TRU tank waste will be treated at a supplemental TRU treatment facility and then stored onsite at the CWC until the final disposition is determined.

The design of the potential TRU tank waste packaging system was essentially completed, and several pieces of long-lead fabrication equipment were procured and fabricated in the early 2000s timeframe. The project has been in standby mode since 2005, and is not currently authorized. DOE/EIS 0391, *Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington* (hereinafter TC&WM EIS), provides *National Environmental Policy Act of 1969* coverage for the project. However, a Record of Decision amendment is required to formalize the waste disposition decision to send CH-TRU waste to the Waste Isolation Pilot Plant (WIPP) in New Mexico, if this project is pursued.

4.3.7.1 High-Priority Pro Forma

No current high-priority pro forma are associated with this sub-functional category, however it is recognized that technology maturation for CH-TRU is considered an ORP mission need under the Grand Challenge competition. Refer to Section 5.0 for a general discussion of the Grand Challenge competition.

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[23] DOE has not taken steps to formally designate the waste as non-HLW, but has issued their preferred alternative to disposition potential CH-TRU tank waste to WIPP.

4.4 MANAGE GENERATED WASTES AND EXCESS FACILITIES

Hanford Site waste immobilization processes will generate secondary waste byproducts in addition to canistered waste forms. Safe, effective disposal paths must be provided for these secondary waste byproducts. The appropriate disposal path will be determined based on the nature of the waste type (i.e., SLW or secondary solid waste [SSW]).

SSW will be disposed using a variety of different methods, depending on the type, size, and level of contamination of the waste.

4.4.1 Secondary Solid Waste

SSWs (i.e., radioactive solid wastes) are non-liquid waste debris and byproducts of Hanford Site operations. The different SSW types include miscellaneous failed equipment, filters, debris, spent IX media, failed LAW melters, LAW melter consumables (e.g., bubblers, thermocouples), and glass residues, among others. Some SSW may be treated on or offsite and will primarily be disposed of at the IDF.

For purposes of updates to the IDF PA, a waste form release model for SSW must be developed that identifies the transport mechanisms and projected partitioning of the key waste form constituents of concern for those wastes to be disposed at IDF.

During tank farm and WTP operations, several capabilities will be required onsite for successful and efficient management of SSW. The interface for the removal of packaged waste from the WTP is principally governed by 24590-WTP-ICD-MG-01-003, *ICD 03 – Interface Control Document for Radioactive Solid Waste*.

The primary SSW needs and gaps fall into one of the following categories:

- Packaging, staging, and storage
- Waste characterization designation, which determines required treatment methods
- Waste incidental to reprocessing determination for the ILAW
- Waste disposal location
- Transportation
- IDF operations.

The WTP LAW Vitrification Facility was not designed with sufficient capacity to process the entire volume of retrieved Hanford LAW; therefore, a supplemental LAW immobilization facility will be required. Up to two-thirds of the retrieved LAW will be processed in a supplemental LAW facility. Supplemental LAW immobilization also requires a source of pretreated feed.

The TC&WM EIS assumes supplemental operations from a second LAW vitrification facility, and an opportunity exists to select an alternative waste form. Regardless of the supplemental LAW immobilization technology that is selected, the resultant waste forms will be disposed at IDF. However, the IDF waste acceptance criteria have not yet been established. The IDF must be available to receive LAW waste forms in time to support WTP startup.

Due to the interdependent nature of the overall WTP design, supplemental LAW processing is also reliant on upstream functional areas such as tank farms management, waste retrieval, and feed pretreatment, and is supported by secondary waste disposition and mission support services (e.g., the WTP Analytical Laboratory). This facility is also directly impacted by the LAW

Vitrification Facility because its vitrification efficiency and throughput define how much supplemental capacity is required. In addition, sub-tier systems such as LAW feed preparation, glass-former additions, and offgas condensate recycle (with respect to ^{99}Tc management and halide and sulfate considerations) are important to supplemental LAW immobilization. Offgas condensate recycle is important for the supplemental LAW facility, as the facility is currently modeled as an effective purge path, or "relief valve," for undesirable byproducts of the LAW Vitrification Facility.

While the supplemental LAW facility is an essential component of the overall RPP mission, identification of the supplemental LAW technology has been delayed, and construction of a supplemental LAW facility has not begun. Because the supplemental LAW facility is not within WRPS scope and is not part of the near-term priority list, the facility will not be discussed further as part of the Technology and Innovation Roadmap.

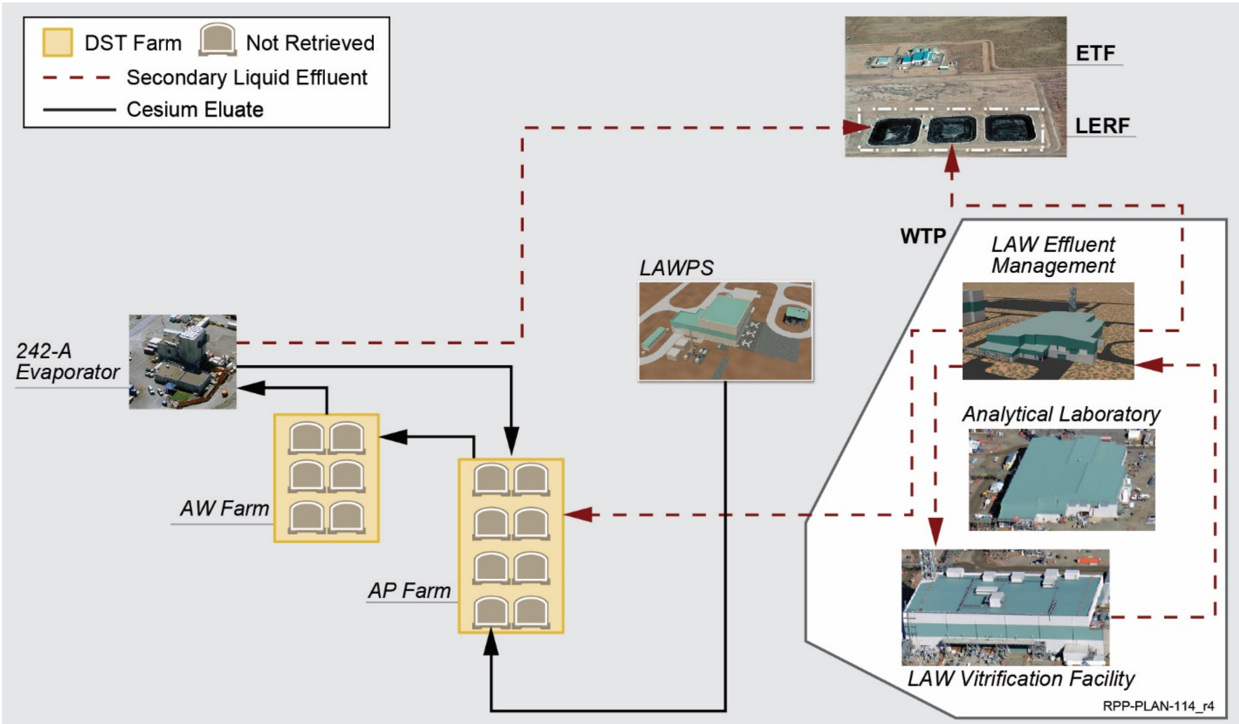
There are no high-priority technology needs associated with SSW.

4.4.2 Secondary Liquid Waste

The WTP HLW and LAW Vitrification Facilities will convert radioactive wastes into glass. Vitrification is a high-temperature process. As a result of WTP vitrification, a portion of the volatile species in the waste (e.g., fluorides, chlorides, some radionuclides [technetium[24]]) will partition to the offgas system and become part of the SLW streams instead of becoming fully incorporated into the waste glass. Subsequently, offgas scrubber solutions and evaporator condensates containing these volatile species can become part of the SLW streams. In the DFLAW configuration, multiple SLW streams from the WTP LAW Vitrification Facility are transferred to effluent management for processing. See Section 4.3.2 for additional details regarding effluent management.

Alternatives for handling, treating, and dispositioning concentrated and dilute effluents have been developed and are being evaluated. Figure 4-10 depicts the baseline SLW handling options evaluated for DFLAW.

[24] Technetium, a long-lived highly mobile radionuclide, has been identified as a major dose contributor in the IDF PA. Getters are being evaluated to improve waste form performance with respect to technetium release (discussed in Section 4.4.3).



DST	=	double-shell tank.	LAWPS	=	low-activity waste pretreatment system.
ETF	=	Effluent Treatment Facility.	LERF	=	Liquid Effluent Retention Facility.
LAW	=	low-activity waste.	WTP	=	Waste Treatment and Immobilization Plant.

Figure 4-10. DFLAW Secondary Liquid Waste Handling.

The actual chemical compositions of SLW cannot be precisely known until DFLAW vitrification operations commence. However, the ETF currently treats wastes from a number of sources on the Hanford Site. SLW feed streams will include the following:

- Environmental Restoration and Disposal Facility leachates
- Mixed-waste disposal trench leachate
- IDF leachates
- 242-A Evaporator condensates
- Laboratory wastewaters and other miscellaneous minor aqueous streams
- WTP PT evaporator overheads, caustic scrubber solutions, and other miscellaneous SLW.

The treatment method for ETF brine may be cast stone. Cementitious waste forms are used worldwide for the stabilization of LLW streams; therefore, the developmental history of cementitious waste forms is extensive. There are numerous gaps and needs associated with Hanford-specific SLW immobilization. Some identified key items include the following:

- Defining the SLW waste feed envelope, including key feed vectors and source terms
- Developing representative simulants to facilitate accurate waste form development
- Optimizing waste form performance with respect to processing parameters and product requirements (e.g., radionuclide retention)
- Establishing process control through engineering- and pilot-scale testing

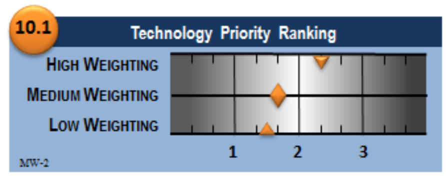
- Conducting SLW cast stone waste form qualification in accordance with IDF waste acceptance criteria
- Safeguarding ETF process equipment from corrosion and contact with unacceptable waste streams
- Providing 222-S Laboratory and WTP Analytical Laboratory chemical and radiological analyses that support SLW operations
- Updating the IDF PA to enable disposal of SLW generated by DFLAW.

If a cast stone waste form is selected for ETF brine, infrastructure to facilitate SLW treatment (either onsite at an upgraded/enhanced ETF or trucked offsite) must be implemented. If another treatment method is identified, the process must be available to support DFLAW.

4.4.2.1 High-Priority Pro Forma

The primary focus for SLW is to complete activities required to develop methods and/or waste forms acceptable for IDF disposal. The high-priority pro forma that has been identified to support SLW is the following.

MW-2: Investigate potential unit operations (e.g., precipitation, complexation) to provide possible solutions to ammonia vapor release that can occur with some liquid secondary waste grout formulations.



4.4.3 Technetium Management

Technetium management is necessary to facilitate SLW disposal. Long-lived radionuclide ^{99}Tc is a fission product from nuclear reactors. Approximately 26,000 Ci of predominantly soluble technetium remains within the tank farms that will be processed as LAW. The primary chemical form of ^{99}Tc found in LAW is the pertechnetate anion (TcO_4^-), with a +7 oxidation state. Pertechnetate will not be removed from the aqueous waste during PT. The compound will be immobilized in the LAW glass (though volatile at high temperatures), secondary effluents, or in macro encapsulated SSW, all of which will be disposed at the IDF. Due to a long half-life and high mobility, ^{99}Tc has the potential to be a major dose contributor in the IDF PA. While the impact of ^{99}Tc on IDF performance will not be known until completion of updates to the PA, sufficient risk to satisfying the performance standards may warrant a technetium management program.

The technetium management effort evaluates and guides the options for reducing the amount of secondary waste ^{99}Tc disposed at the IDF including the following:

- Evaluating the benefits of ^{99}Tc removal
- Identifying process points in the flowsheet where ^{99}Tc removal is most feasible
- Identifying ^{99}Tc removal technology options
- Characterizing the ^{99}Tc quantity and speciation projected for the Hanford Site tank waste inventory, in addition to the baseline option of offgas condensate recycle back to the LAW melter.

The technetium management effort may also include evaluating the viability of low melting temperature glasses for technetium retention.

Needs and gaps identified for ^{99}Tc management are centered on preventing mobilization of long-lived ^{99}Tc in the groundwater and protecting the Columbia River.

Other technetium management activities include the following:

- Field testing a prototype beta detection probe for in situ detection of soil contamination
- Field testing a prototype electrical conductivity probe designed for in situ testing of pore water
- Developing technetium removal (e.g., IX) and management technologies (e.g., getters)
- Evaluating low-melting temperature glasses for immobilizing and retaining technetium in a disposal environment.

There are no high-priority technology needs associated with technetium management.

4.4.4 Cesium Management

The treatment of LAW must provide for the removal of Cesium. The baseline strategy will remove Cesium by ion exchange that will be eluted back to the DST system for storage until a HLW treatment facility is operational.

There are no current high-priority technology needs associated with cesium management.

4.4.5 Melter Disposal

The final disposition of spent LAW and HLW melters has not yet been determined (System Plan). The alternatives evaluated in the TC&WM EIS assume that the spent HLW melters will be packaged in an overpack and stored at the Interim Hanford Storage area until they can be removed for disposition and final disposal. For planning purposes, the final disposition of the LAW melters is assumed to be at the IDF to maintain consistency with the current performance measurement baseline.

There are no current high-priority technology needs associated with melter disposal.

4.5 DISPOSE TANK WASTE

Disposal is the ultimate goal for Hanford Site tank waste. The method of treatment, final waste form characteristics, and type of waste form will determine how and where the waste can be disposed.

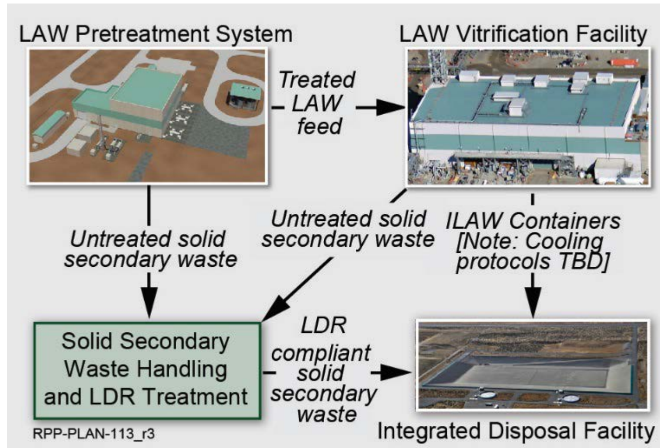
Secondary liquid waste effluents may be treated at ETF and disposed at a permitted land disposal site. ETF secondary solid waste may be disposed at IDF. Immobilized LAW (ILAW) and supplemental LAW will be disposed at IDF. IHLW will be interim-stored onsite and ultimately disposed at an as-yet undetermined geologic repository. CH-TRU waste is planned to be disposed at WIPP. There are other relatively benign wastes (e.g., submerged bed scrubber condensates) that may be treated offsite and disposed at commercial waste disposal facilities.

The following subsections address waste disposal.

4.5.1 Integrated Disposal Facility

The IDF is located on the Hanford Site in 200 East Area and is the designated disposal location for ILAW. The facility consists of a single landfill with two expandable cells for extra capacity. The cells use a double-lined system with leachate collection, detection, and removal capability.

Cell 1 is permitted as a RCRA Subtitle C Landfill system designed in accordance with WAC 173-303, "Dangerous Waste Regulations." Cell 1 may receive dangerous and/or hazardous waste (specifically mixed LLW) which includes all ILAW (e.g., DFLAW glass containers, spent melters, and ETF secondary solid waste). Cell 2 is currently reserved for LLW only. Figure 4-11 depicts the waste treatment and disposal pathways that lead to IDF.



LDR = land disposal restriction. LAW = low-activity waste.
ILAW = immobilized low-activity waste.

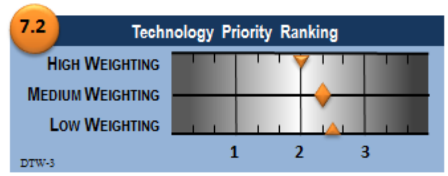
Figure 4-11. Handling ILAW and SSW.

The IDF is constructed, but cannot accept waste until revised waste acceptance criteria are generated for the anticipated waste forms, the *Resource Conservation and Recovery Act of 1976* (RCRA) permit is modified accordingly, and DOE issues a new Disposal Authorization Statement. All these activities are dependent on the completion of a new IDF PA.

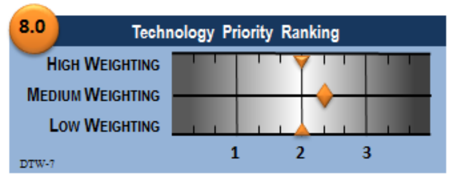
4.5.1.1 High-Priority Pro Forma

High-priority pro forma that have been identified to support the IDF include the following, which are ranked in order of descending priority.

DTW-3: Perform engineering tests to characterize LAW glass in support of DFLAW and the IDF PA. This activity may require national laboratory support.



DTW-7: Development and maturation of a technology for the solidification and stabilization of SSW form by macro or micro-encapsulation with grout.



4.5.2 IHLW Interim Storage

To facilitate the RPP mission, the ORP has implemented a process to acquire Hanford Site tank waste treatment and immobilization services by construction and operation of the WTP. The primary product from the WTP will be IHLW. In accordance with the planned approach, the Waste Disposal Program will furnish interim storage and disposal services for the products from the WTP. In general, these services consist of onsite transportation of IHLW to interim storage, long-term isolation of IHLW in a safe and environmentally compliant manner, and retrieval of

IHLW from interim storage for subsequent disposal. A more detailed description of the IHLW Interim Hanford Storage and its functional components is provided in Section 3.0.

The path forward for IHLW interim storage entails sequential construction of potentially several modular facilities. One or more facilities will be provided as necessary to furnish IHLW interim storage capacity. The IHLW canisters will be retrieved from the interim storage facilities and transferred to the Hanford Shipping Facility for shipment to the national repository. The interim storage facility and the future shipping facility may be located adjacent to each other such that some IHLW canister handling functions can be shared, eliminating the need for cask transport between two separate facilities (RPP-23674, *Immobilized High-Level Waste Interim Hanford Storage System Specification*).

4.5.3 Waste Isolation Pilot Plant

The WIPP is the nation's underground disposal facility for DOE TRU solid waste. The repository disposes of waste in underground salt layers. TRU containers are lowered approximately 2,000 ft below the surface, and walled off in separate wings, where eventual salt creep from the walls and ceiling will entomb the waste containers. Further facility facts may be gathered from its website: http://www.wipp.energy.gov/wipprecovery/fact_sheets.html.

Hanford ships legacy TRU waste to WIPP as part of the CH2MHILL Plateau Remediation Company program to disposition solid waste landfills. The Tank Operations Contractor plans to ship TRU waste to WIPP from 11 underground SSTs, after building and operating specific retrieval, treatment, and packaging systems. This TOC effort is expected to produce material for shipment to WIPP after 2030; current specific planning dates are documented in the System Plan.

4.5.4 Offsite Disposition

Offsite disposition refers to both offsite treatment and disposal of Hanford tank liquid and/or related solid waste. Currently, PermaFix Northwest of Richland, Washington, provides offsite treatment capability for some Hanford tank-contacted solid waste. Small amounts of Hanford tank-contacted solid waste have also been treated at the PermaFix Diversified Scientific Services, Inc. incinerator treatment facility in Tennessee, and then disposed offsite. This topic involves developing additional treatment and packaging technologies to allow shipment of waste to other treatment and disposal facilities. There are no current plans or budgeted scope for this additional waste disposition; this concept remains a strategic planning option.

4.5.5 Offsite Transportation

Offsite transportation refers to future transportation systems needed for shipping Hanford waste (liquid and/or solid) to offsite treatment and/or disposal facilities. This effort supports offsite disposition by developing shipping transportation systems for material transport. There are likewise no current plans or budgeted scope for this additional waste disposition; this concept remains a strategic planning option. One potential unique transportation system that may need development is for the shipping of a spent high-level waste melter. This is a low probability, unless the final spent melter waste package cannot be qualified as LLW.

5.0 OFFICE OF RIVER PROTECTION GRAND CHALLENGES

ORP is hosting its Fifth Annual Grand Challenge competition in September 2017. The competition provides a forum where creative ideas that can make a significant difference in the ORP mission can be presented, evaluated, and potentially selected for implementation. The goal of the competition is to identify ideas that enhance ORP mission efficiency by creating cost savings of at least $250 million, while improving safety and reducing worker exposure. All contractors, federal employees, national laboratory employees, Tribal Nations, faculty and students of universities and stakeholders can bring forward their innovative ideas for consideration and discussion in a collegial environment.

Since its inception five years ago, the challenge has grown in scale and received notice from outside Washington State, most recently being recognized as a DOE Best Practice for Leadership and Organizational Transformation.

Through the competition, 10 finalists are selected to present their idea at the workshop, generally held in September. At the end of the workshop, judges representing ORP, prime contractors, DOE headquarters, national laboratories, and select universities select a winning idea. Judges consider a variety of factors, including: technical viability and risks; whether ideas are achievable within a timeframe to meet mission needs; if they can be executed within existing safety basis requirements; and whether they provide cost avoidance, cost savings, or process efficiencies.

This year's winner is expected to be announced the last day of the workshop. The winning idea, and potentially other high-scoring ideas, will be studied for possible implementation at ORP.

The Grand Challenge brings together members of DOE, the national laboratories, academia, and contractors. Each year great ideas are presented, and DOE works throughout the year to implement high scoring ideas via the Technology and Innovation Roadmap process. Grand Challenge and the Technology and Innovation Roadmap together encourage a culture of continuous improvement in safety and mission efficiency and engage our internal workforce and the external scientific community in the process of overcoming our biggest challenges.

FY17 high-priority Grand Challenge pro forma include the following:

- MTW-23, Provide technology/methods to mitigate selected active/passive tank farm vapor sources
- RTW-54, Conduct a study of all modular treatment methods to determine if modular treatment is an option for ORP under Hanford Site permitting and nuclear safety restrictions and, if so, which modular treatment options would be best to pursue to improve mission efficiency and reduce time to stabilize waste and empty tanks.
- PTW-49, Conduct a study to examine feasibility of removing nitrates from the LAW feed stream prior to vitrification.

5.1 PREVIOUS GRAND CHALLENGE WINNERS

The ORP Grand Challenge initiative has generated a number of cost and schedule saving initiatives, as well as ideas for resolving technical challenges associated with the RPP mission. Many of the Grand Challenge winners are highlighted as high ranking pro formas as described throughout the Technology and Innovation Roadmap. The winner of the 2013 competition was the "Ownership and Operation of the RPP Flowsheet." Since then the RPP Integrated Flow Sheet program[25] was established to identify the major Hanford facilities as groups of process unit operations and their interconnections required to complete the RPP's mission to retrieve, treat and dispose of Hanford's tank waste. The RPP Integrated Flowsheet should serve as the basis for all reference RPP Mission operating plans and lower tier flowsheets. The RPP Integrated Flowsheet transcends contractor boundaries in that it describes the elements for completing the entire RPP mission, including the Tank Operations Contractor (TOC), Washington River Protection Solutions, LLC (WRPS); the WTP contractor, Bechtel National, Inc. (BNI); and the Plateau Remediation Contractor (PRC), CH2M Hill Plateau Remediation Co. (CHPRC)[26].

The 2014 winner was "Destruction of Noxious Vapors with Ultraviolet Light." This idea is generically captured in MTW-23 and proposed the use of UV photo-oxidation for the decomposition of VOCs present in the Hanford waste tanks and emanating through the ventilation stacks to alleviate the hazardous occupational exposure. . MTW-23, looks at technology / methods to mitigate selected vapor sources, and laboratory testing was funded in 2016 to evaluate the feasibility of UV destruction of ammonia.

The 2015 Grand Challenge winner HLW Direct Vitrification was captured in PTW-40. This proposed idea builds off of the proposed DOE Framework phased approach enabling processing HLW solids in the absence of the WTP PT Facility. PTW-40 priority was ranked as a medium due to the timing need of this proposal. In order to support the current planned startup of DFHLW, this activity will elevate in priority in FY18.

The 2016 winning idea, "Control of Vapors From Hanford Storage Tanks" (NUCON vapors abatement skid captured in MTW-23), was tested at the manufacturer this spring, and additional proof-of-concept / bench-scale testing of the prototype skid will be conducted in FY18 at an offsite vendor location near Hanford.

Additionally, many other submittals are actively being pursued to advance the RPP mission. The third place entry from 2016, submitted from the University of Utah focusing on studying engineered aerogels that could be used to capture technetium and iodine in the melter offgas system, has also been implemented. The WTP project is funding a research project regarding in-line monitoring, that includes elements of five 2015 Grand Challenge proposals. These are just a few of the many ideas that have been implemented since 2014. Of the 2016 proposals eleven submittals were endorsed by ORP for outside funding opportunities, and 34 were included in technology roadmap process as potential technologies to pursue with project or Technology Development funding.

[25] TFC-PLN-139, 2015, River Protection Project Integrated Flowsheet Configuration Management Plan,

[26] TFC-PLN-139, 2015, River Protection Project Integrated Flowsheet Configuration Management Plan

6.0 HANFORD TANK WASTE TREATMENT AND IMMOBILIZATION PLANT TECHNOLOGY NEEDS

The One System organization is an integration of the Tank Operations Contractor and WTP Contractor to bridge the gap between managing and treating tank waste. The WTP has a more definitive mission than many of the WRPS program elements requiring technology development and maturation. As such, the WTP need for technology solutions follows a different path forward than the Tank Operations Contractor. Because the WTP project has advanced to the detailed design and construction phases, there are no specific needs for identifying, selecting, and advancing technologies; however, there are a number of technical issues that require resolution before the design and construction of some WTP facilities can be completed. The resolution of these technical issues involves a complex mix of testing technologies and design solutions. As a fundamental component of the RPP mission, the WTP technical issues being addressed are listed in Table 6-1. By late 2016, DOE and the WTP contractor resolved three of the eight outstanding technical issues:

- (T1) Hydrogen Gas in Vessels
- (T2) Criticality in PT Facility Vessels
- (T3) Hydrogen in Piping and Ancillary Vessels.

While not considered to be in the same category as WRPS technology development and maturation, this work does involve national laboratory resources and warrants inclusion in this document. The WTP technical issue resolution is directly tied to the TOC from a One System perspective, and the interfaces necessary to complete the PTW functional area scope are applicable (see Section 4.3). WTP lessons learned from technical issue resolution can potentially be applied to WRPS technology needs identified in this document. Table 6-1 lists the WTP technical issue resolution areas.

Table 6-1. WTP Technical Issues.

Design Completion Team	Technical Issue Title
T4	PJM vessel mixing and control
T5	Erosion/corrosion in piping and vessels
T6	Design redundancy/in service inspection
T7	Black cell vessel/equipment structural integrity

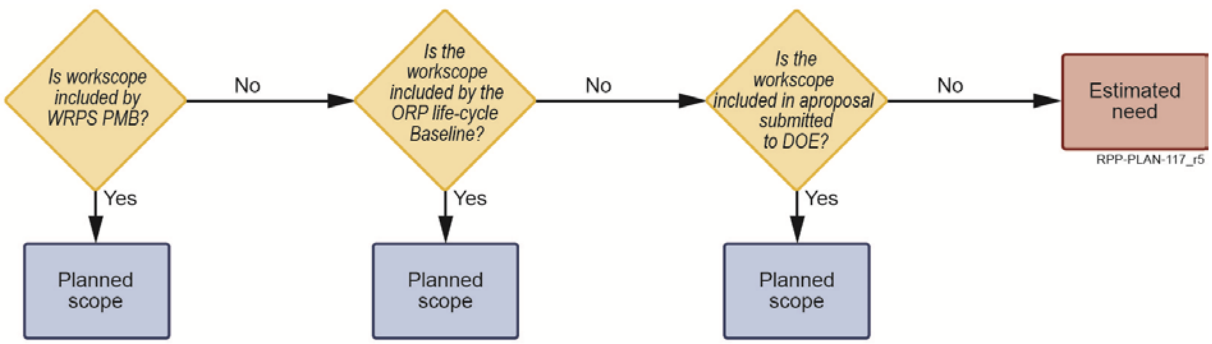
Source: Hamel, W., et al., 2017, "Resolution of Technical Issues at the Waste Treatment and Immobilization Plant Pretreatment Facility - 17281," *Waste Management Symposia 2017*, U.S. Department of Energy, Office of River Protection, Richland, Washington.

PJM = pulse jet mixer.

7.0 FISCAL YEAR PLANNING

A primary goal of the Technology and Innovation Roadmap is to serve as a tool for the FY planning process to ensure that the needed technologies are identified and accounted for. This planning has two major components: the WRPS planning process, and the national laboratory planning process. This section provides the tools that roll up the pro forma information supporting both near-term and long-term planned and needed scope activities.

For purposes of the scope profile charts, planned scope includes activities that are in the WRPS performance measurement baseline or the ORP life-cycle baseline and activities that are included in a contract proposal provided to ORP. In particular, this scope includes the TOC proposal for the FY 2017/2018 extension period. Estimated need includes all technology scope identified on the pro forma worksheets regardless of the associated baseline or planning status. The logic used to differentiate between planned scope and estimated need is presented in Figure 7-1.



Note: ORP life-cycle baseline may be superseded by ORP letter 17-WSC-0016, 2017, "Contract Number DE-AC27-08RV14800 – Fiscal Year 2018 Preliminary Budget Guidance for Technology Roadmap and Chief Technology Office" (Letter from G.D. Trenchard to K.A. Downing of Washington River Protection Solutions, LLC, May 11), U.S. Department of Energy, Office of River Protection, Richland, Washington.

DOE = U.S. Department of Energy.
ORP = U.S. Department of Energy, Office of River Protection.
PMB = performance measurement baseline.
WRPS = Washington River Protection Solutions, LLC.

Figure 7-1. Determination Logic for Technology Scope Status.

7.1 SCOPE PLANNING

The WRPS FY planning process has three major timeframes to consider the following:

1. **Next fiscal year** – The annual budget process includes detailed planning to support prioritization and authorization of activities that fall within the projected budget for the following fiscal year. The scope and priority summary presented in this section provides planning tools to ensure that the high-priority items are included in the next fiscal year planned baseline scope and that the medium- and low-priority items may be identified for inclusion on the efficiencies buy-back list.
2. **Near-term planning** – The scope and priority summary presented in this section provides planning tools to ensure that the high-priority items are included as part of the FY 2018 planning scope details and that the medium- and low-priority items are identified by FY preference.
3. **Life-cycle planning –** This Technology and Innovation Roadmap includes items that are necessary for the success of future projects and mission objectives that extend well beyond FY 2018. The scope and priority summary presented in this section provides an

essential link between mission needs and ensures that high-priority items are identified and carried forward in the out-year planning process.

The priority screening process identified high-priority technology activities that support key Tank Operations Contractor near-term work priorities and critical path needs for longer-term mission objectives. Based on this criteria, all high-priority items should be included in baseline planning. Planned scope, as used here, means the activity is included in the WRPS performance measurement baseline or the DOE life-cycle baseline. While not all high-priority items are currently in the baseline scope, this information can be used to support necessary baseline changes to ensure that mission critical-path items are added to the baseline. The following information can also be used to target those medium- and low-priority technology items for consideration as buy-back list items or for inclusion in future life-cycle baseline adjustments.

Technology scope profiles are presented here by functional area. The charts show the estimated technology need (need column) and planned scope (plan column) for each FY, color-coded by priority. The plan column identifies the activities that are currently included in the approved baselines. These activities are also color-coded by priority and aligned to the beginning position for the estimated "need" data so the amount of unplanned scope for each priority can be visualized. The accuracy of the estimated needs varies from rough conceptual estimates for work that has not yet been fully planned to certified cost estimate levels for those items that have been accepted as WRPS performance measurement baseline scope. Following the plots is a brief description of the FY 2018 high-priority planning shortfalls.

7.1.1 Manage Tank Waste

Figure 7-2 summarizes the MTW estimated needs and planned scope as a function of FY.

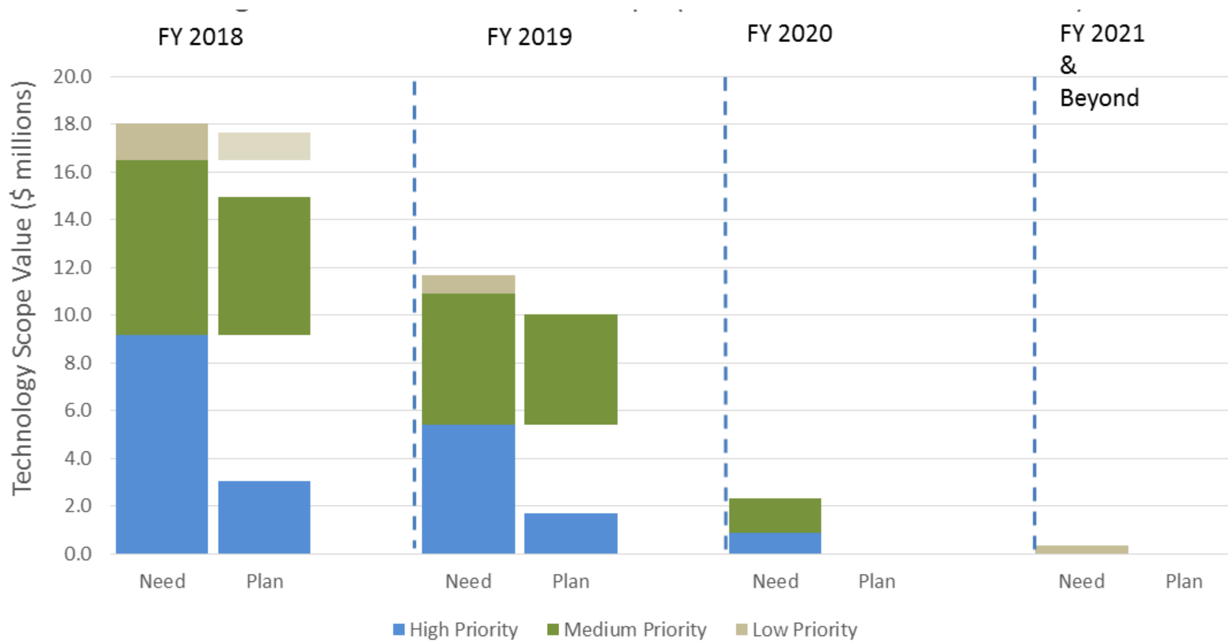


Figure 7-2. MTW Estimated Needs and Planned Scope by Fiscal Year.

High-priority MTW planning shortfalls for FY 2017 include the following:

- MTW-9, Automated DST annulus camera system

- MTW-11, Guided wave system across tank diameter
- MTW-13, Improved liquid observation well data acquisition and analysis
- MTW-15, Visual Inspection of DST primary tank bottoms
- MTW-41, Analytical method development at 222-S Laboratory
- MTW-57, Develop basis for predicting the behavior and impact of mercury on the evaporator.

Deferring these technology needs was determined based on relative priority as a function of available resources. However, all of these activities are important to managing, monitoring, maintaining, and characterizing the condition of the Hanford tank farms system.

7.1.2 Retrieve Tank Waste

Figure 7-3 summarizes the RTW estimated needs and planned scope as a function of FY.

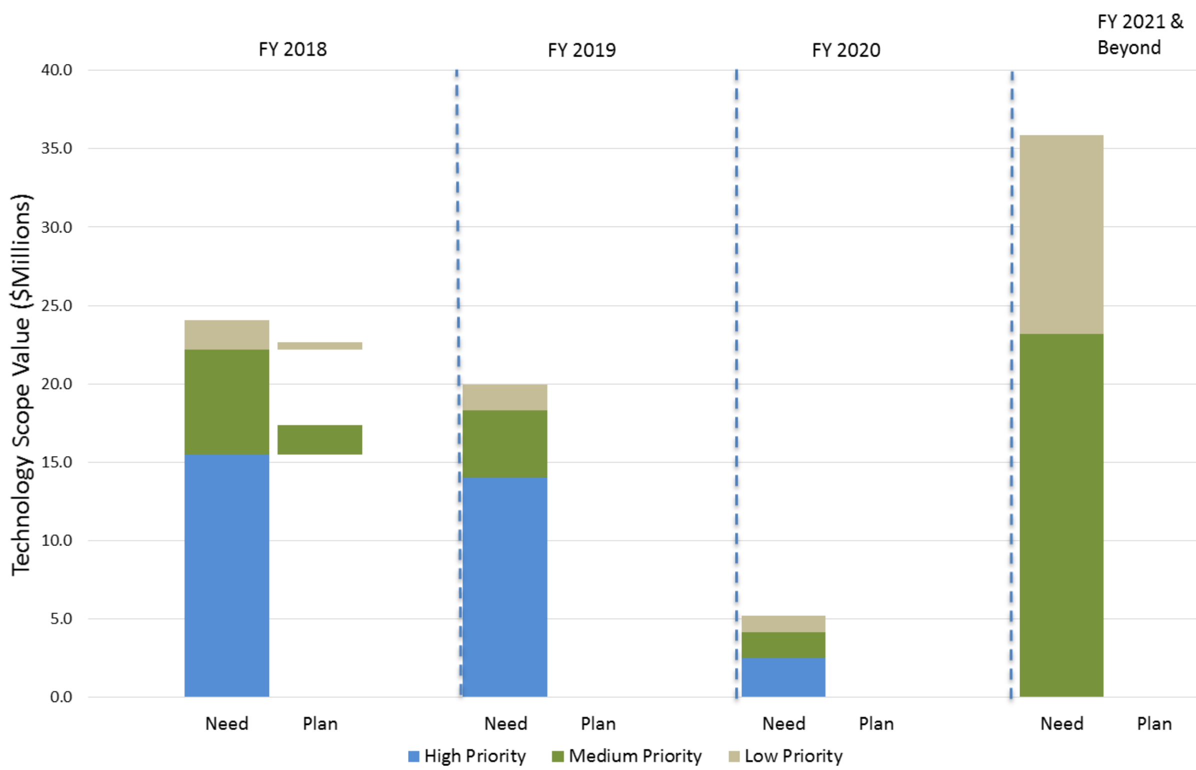


Figure 7-3. RTW Estimated Needs and Planned Scope by Fiscal Year.

High-priority RTW planning shortfalls for FY 2017 include the following:

- RTW-3, Tank farms remote inspection
- RTW-8, Mechanical waste gathering system.

Deferring these technology needs was determined based on relative priority as a function of available resources. However; all of these activities are important to tank farm waste retrievals.

7.1.3 Process Tank Waste

Figure 7-4 summarizes the PTW estimated needs and planned scope as a function of FY.

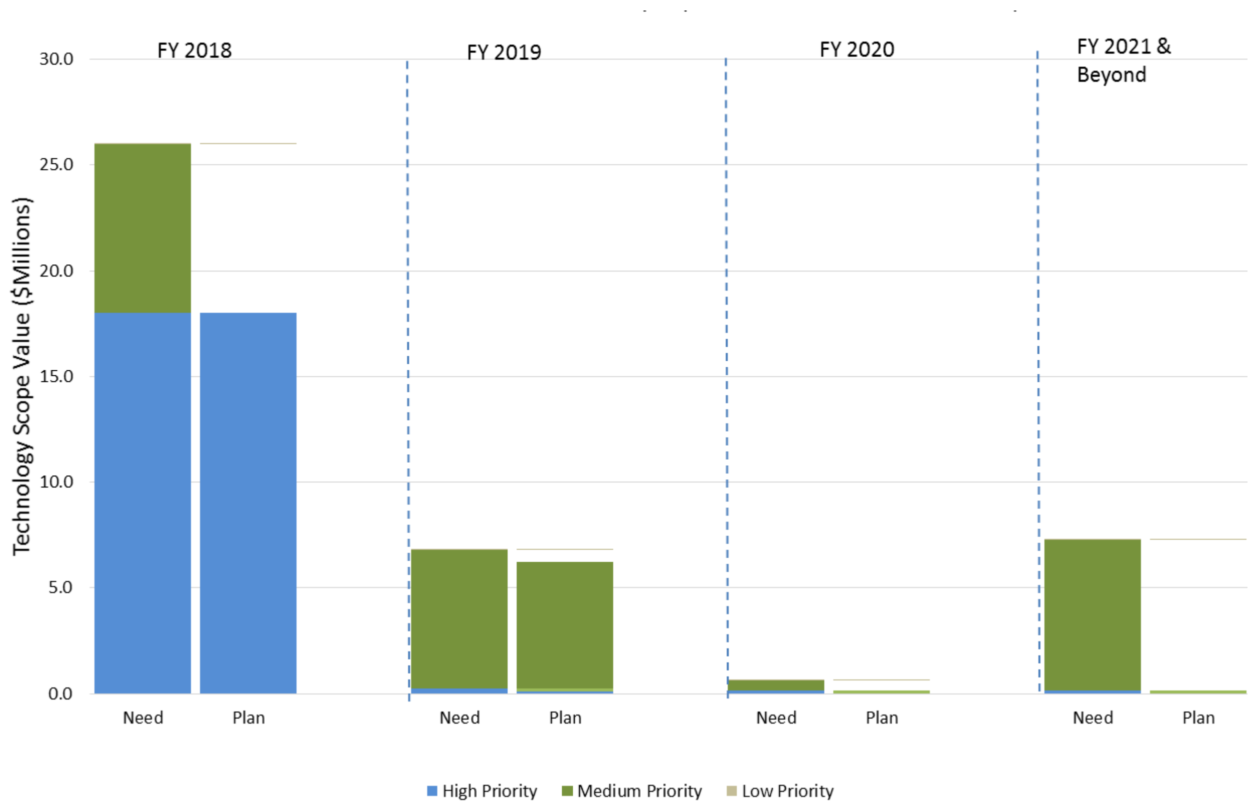


Figure 7-4. PTW Estimated Needs and Planned Scope by Fiscal Year.

High-priority PTW planning shortfalls for FY 2017 include the following:

- PTW-43, Multiple cycle testing of sRF resin in a radiation field.

7.1.4 Dispose Tank Waste

Figure 7-5 summarizes the DTW estimated needs and planned scope as a function of FY. There are currently no high-priority for DTW activities planning shortfalls for FY 2017.

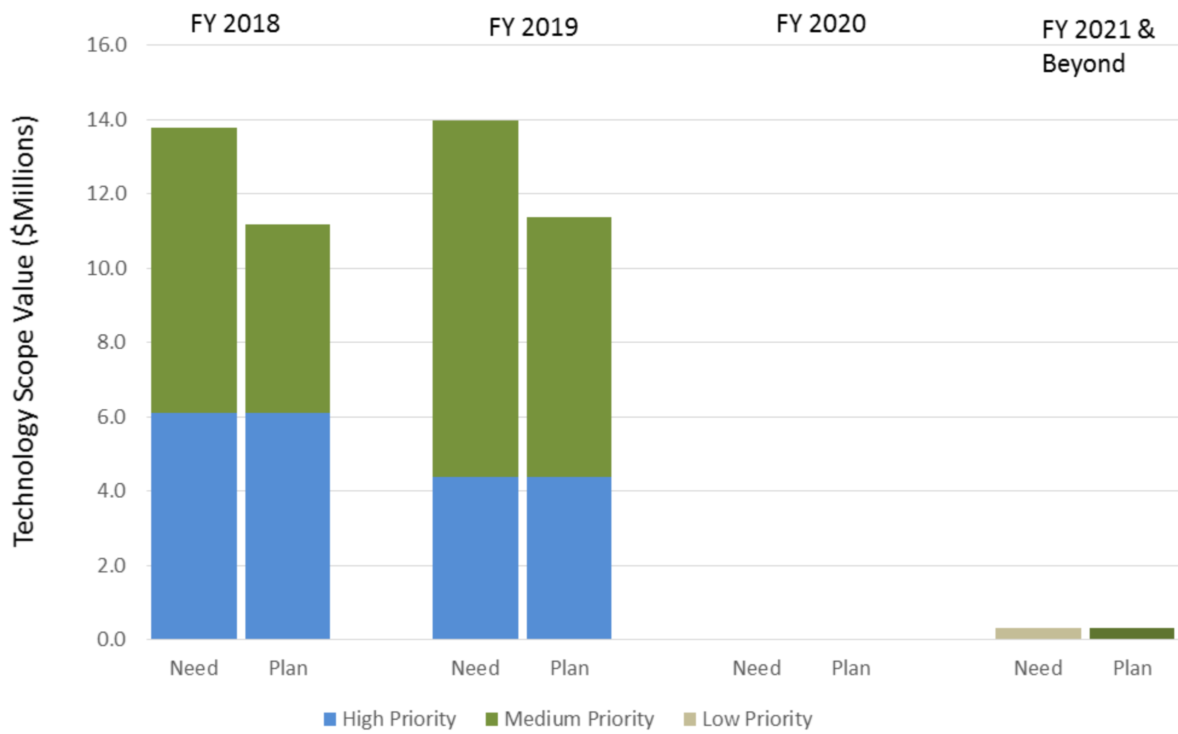


Figure 7-5. DTW Estimated Needs and Planned Scope by Fiscal Year.

7.1.5 Manage Generated Wastes and Excess Facilities

Figure 7-6 summarizes the MW estimated needs and planned scope as a function of FY.

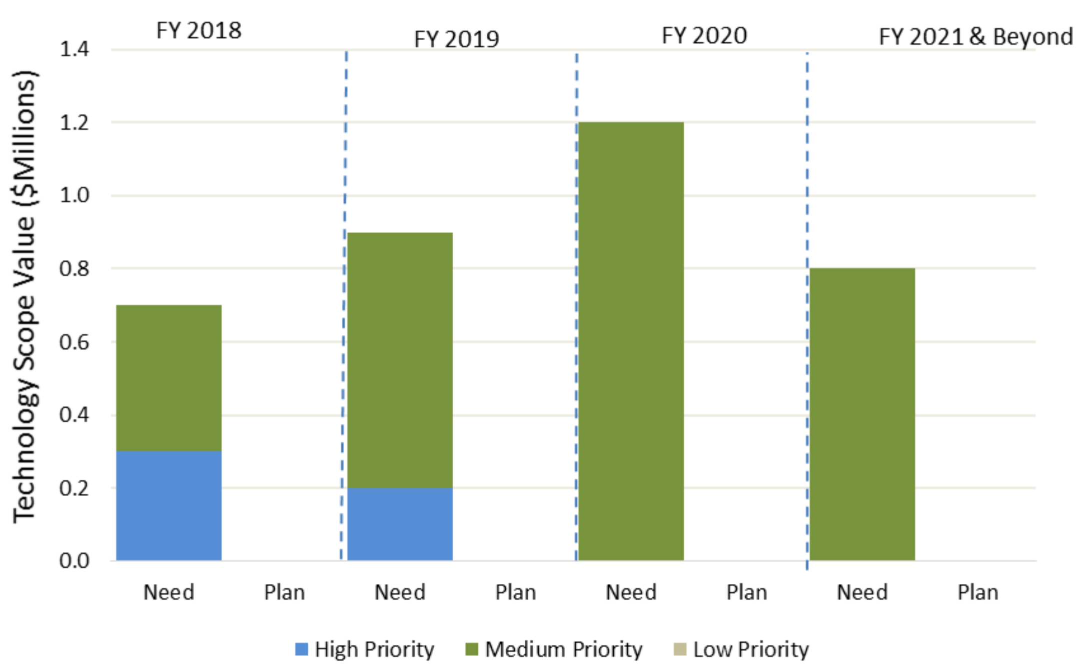


Figure 7-6. MW Estimated Needs and Planned Scope by Fiscal Year.

High-priority MW scope needs include the following:

- MW-2, SLW ammonia vapor
- MW-14, DFLAW melter offgas condensate disposition.

7.2 NATIONAL LABORATORY PLANNING

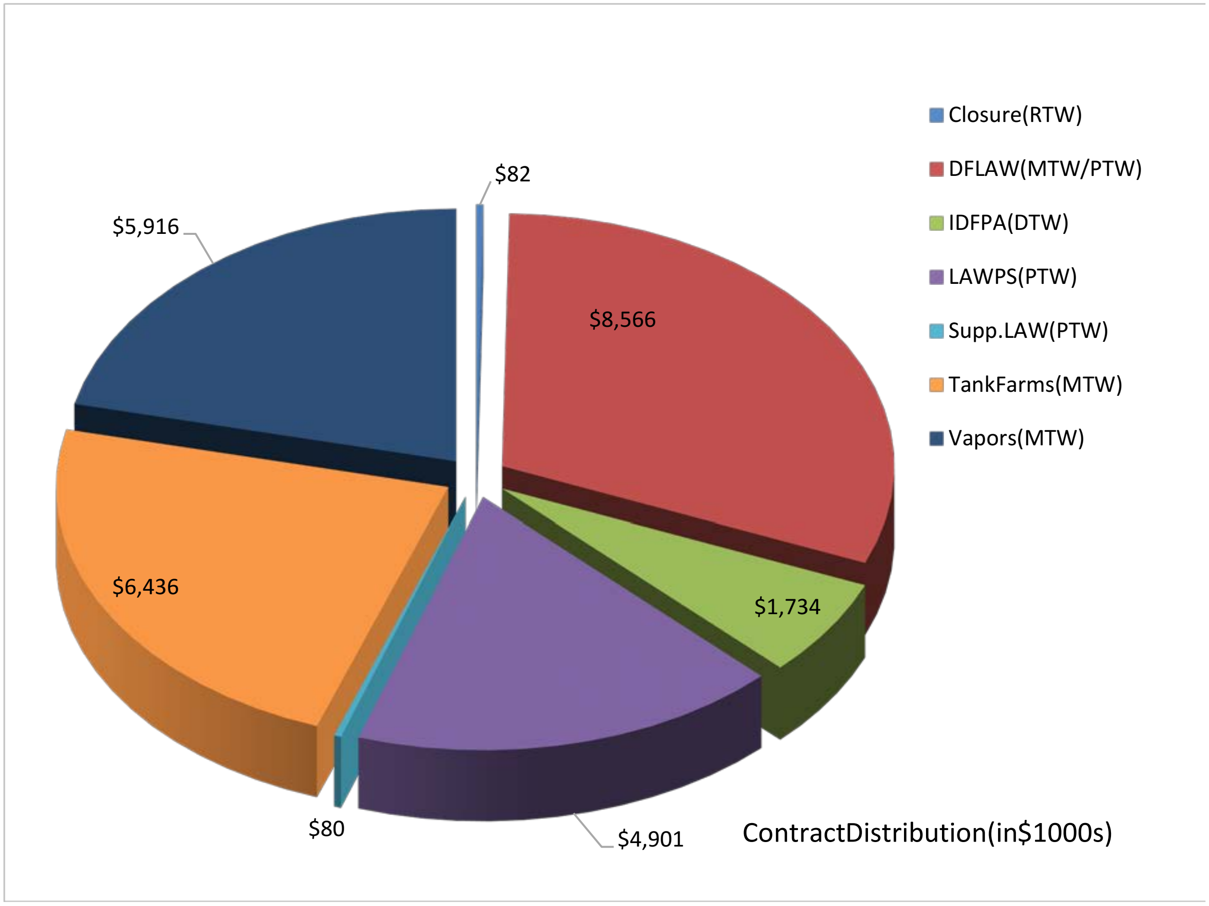
Several of the high-priority items identified in the Technology and Innovation Roadmap may involve support from the national laboratories. The development of technology is often assigned to directed national laboratory work. This work is identified based on technology needs to fill gaps and buy-down risk. The WRPS CTO has established a work management program for tracking and reporting national laboratory work to One System upper management and ORP. All national laboratory work is routed through the CTO, with work performance reported monthly and used to produce standardized metrics for cost and schedule. This management system enables accurate tracking of cost and schedule performance and also provides familiarity with the individual national laboratory technical strengths that are considered when directing new work.

The national laboratories can provide a combination of technical expertise and analytical capabilities and services that are not available within WRPS or WTP. In some instances, the national laboratories are also called on to lead technical review groups or provide nationally recognized experts to consult regarding specific problems. The national laboratories may also be engaged to provide lessons learned regarding cross-cutting work (e.g., waste feed qualification or tank closure). The Technology and Innovation Roadmap will assist with out-year planning and effective allocation of technology work to the national laboratories, as appropriate.

Integration of the DOE national laboratories with the TOC work scope is essential to the success of the RPP mission. A long partnership history joins the unique capabilities of the national laboratories with the engineering, operating, and project management capabilities of WRPS. While the scope planning process includes planning assumptions for national laboratory participation, the process does not specifically highlight which activities involve national laboratory participation or which national laboratory is preferred to perform the work. To support the national laboratory FY planning process, the level of anticipated national laboratory support needs is identified in this section.

Figure 7-7 is a pie chart that indicates the amount of laboratory funding allotted for the different FY 2017 technology development activities that include participation from the National Laboratory.

The technology scope profiles are presented by functional area (see Figure 7-8 through Figure 7-12). The charts show the estimated technology need scope ("need" columns) for each FY, color-coded by priority. The lab column identifies those activities that are currently expected to include national laboratory work. These activities are also color-coded by priority and aligned to the beginning position for the estimated need data, so that laboratory participation for each priority can be visualized. The scope value represents the total work scope and is not reflective of the scope intended to be specifically assigned through national laboratory contracts. Following the plots, there is a short description of the high-priority planning shortfalls. National laboratory participation in medium- and low-priority activities is identified in the comprehensive spreadsheet (Appendix A) and the individual pro forma sheets (Appendix B). This information is intended to be used as a guide to ensure national laboratory planning is aligned with technology needs.



DFLAW	=	direct-feed low-activity waste.	LAWPS	=	low-activity waste pretreatment system.
FY	=	fiscal year.	PA	=	performance assessment.
IDF	=	Integrated Disposal Facility.			

Figure 7-7. Fiscal Year 2017 Performance Budget for National Laboratories.

7.2.1 Manage Tank Waste

Figure 7-8 summarizes potential national laboratory participation in MTW technology work. This work is identified but not necessarily planned.

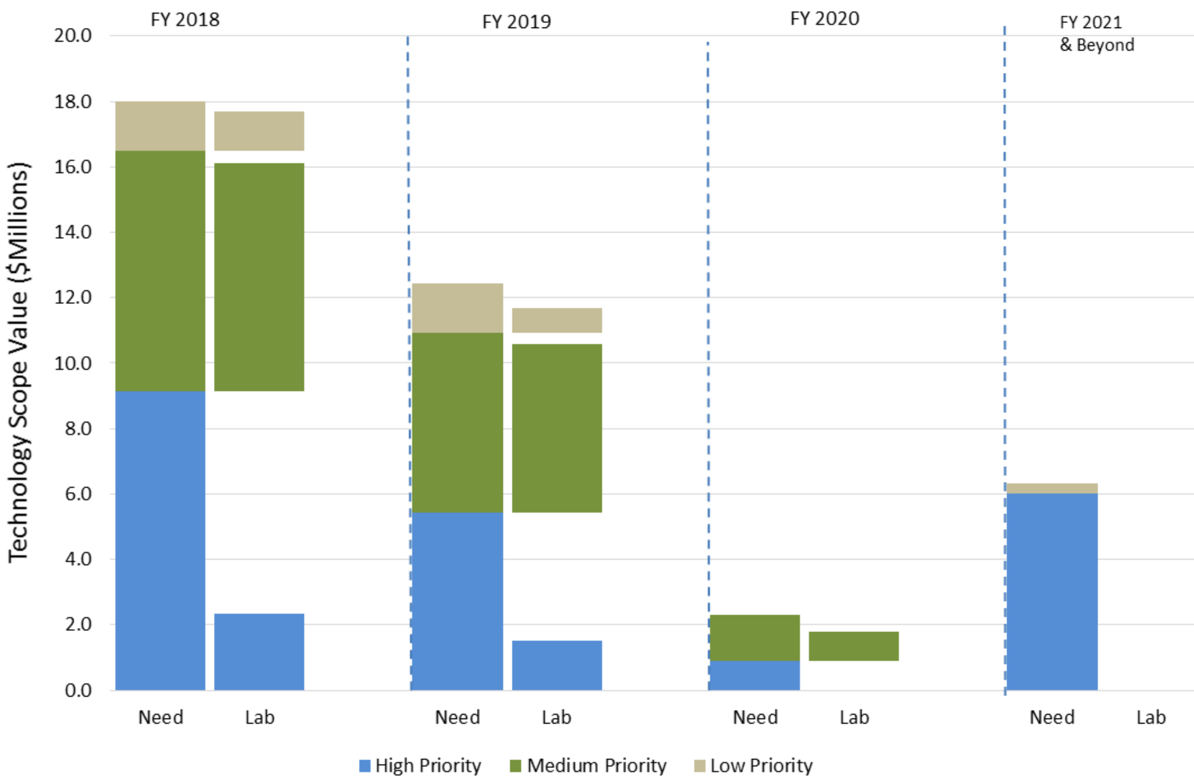


Figure 7-8. MTW National Laboratory Work.

High-priority MTW technology tasks potentially involving national laboratories include the following:

- MTW-11, Volumetric inspection of DST primary tank bottoms
- MTW-24, Monitoring and detection of vapors
- MTW-49, Corrosion control
- MTW-56, Evaluate DFLAW COPC list
- MTW-59, Zeolites for reducing exposure to nitrosamines from tank vapors
- MTW-66, Treat N-Nitrosodimethylamine (NDMA) in the tank headspace or side.

These activities are important to managing and monitoring the Hanford Site tank farms system (particularly with respect to tank vapors issues) and have been identified to potentially rely on national laboratory support. Working with the national laboratories requires collaboration and scheduling considerations to ensure that the appropriate technical resources are available for project support.

7.2.2 Retrieve Tank Waste

Figure 7-9 summarizes potential national laboratory participation in RTW technology work.

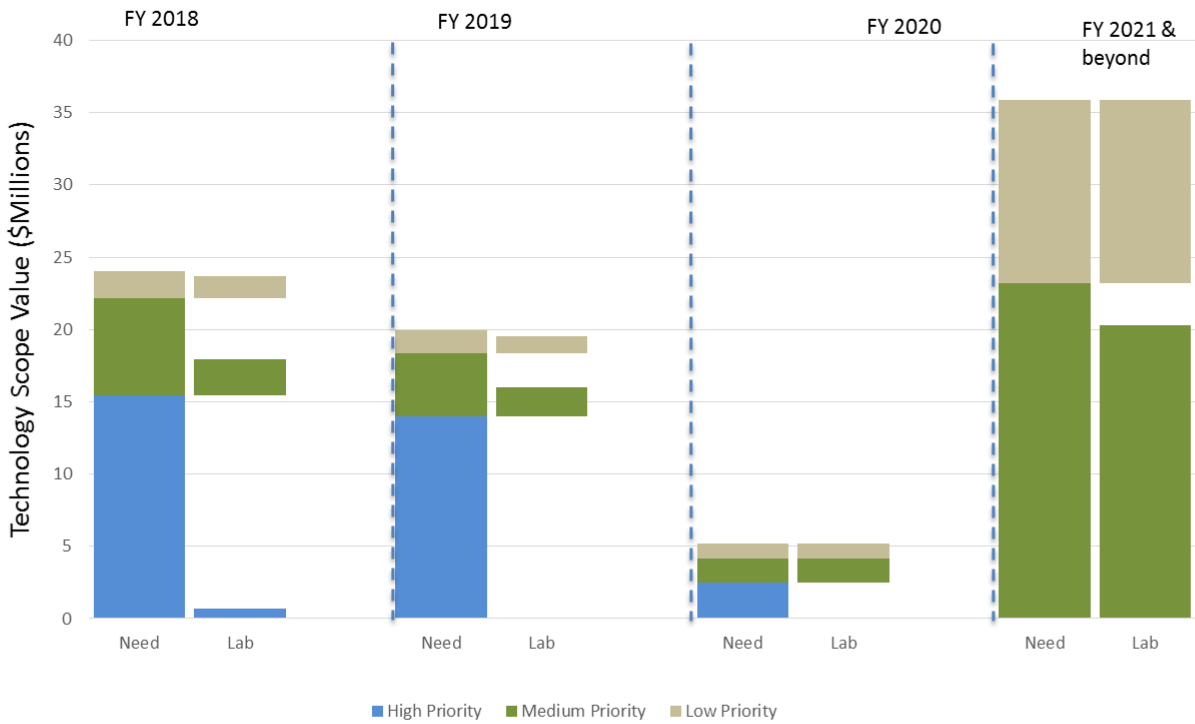


Figure 7-9. RTW National Laboratory Work.

High-priority RTW technology tasks potentially involving national laboratories include the following:

- RTW-39, Predictive tank residual model
- RTW-54, Tank waste modular treatment study
- RTW-55, Hanford waste end effector.

These activities are important to Hanford Site tank waste retrieval efforts and DFLAW support.

7.2.3 Process Tank Waste

Figure 7-10 summarizes potential national laboratory participation in PTW technology work.

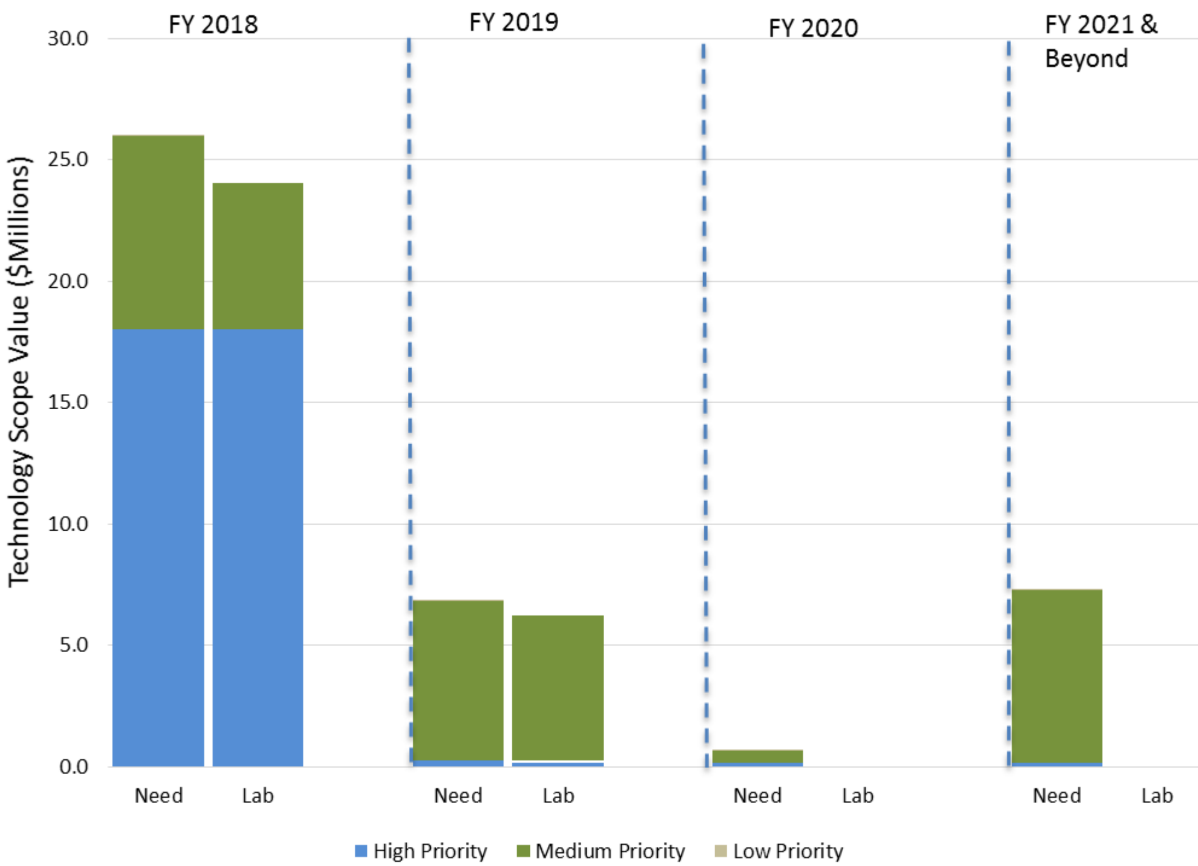


Figure 7-10. PTW National Laboratory Work.

High-priority PTW technology tasks potentially involving national laboratories include the following:

- PTW-17, LAWPS integrated scale test (before CD-2)
- PTW-18, LAWPS TE-2 CFF
- PTW-19, LAWPS TE-3 IX
- PTW-21, LAWPS TE-8 resin replacement and disposal
- PTW-40, HLW direct vitrification
- PTW-49, Study to examine feasibility of removing nitrates from the LAW feed stream prior to vitrification.

The Tank Operations Contractor will collaborate with the national laboratories to resolve technology issues associated with the LAWPS project.

7.2.4 Dispose Tank Waste

Figure 7-11 summarizes potential national laboratory participation in DTW technology work.

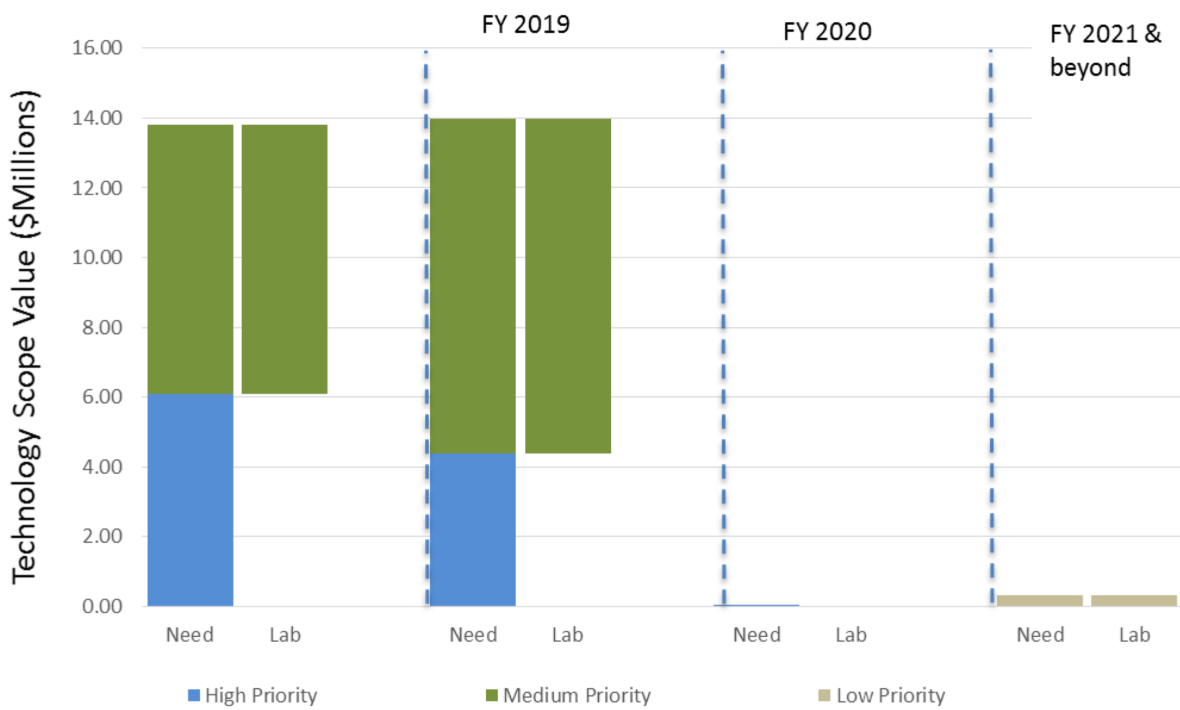


Figure 7-11. DTW National Laboratory Work.

High-priority DTW technology tasks potentially involving national laboratories include the following:

- DTW-3, Perform engineering and laboratory tests to characterize ILAW
- DTW-7, Development and maturation of a technology for solidification/stabilization of SSW.

7.2.5 Manage Generated Wastes and Excess Facilities

Figure 7-12 summarizes potential national laboratory participation in MW technology work.

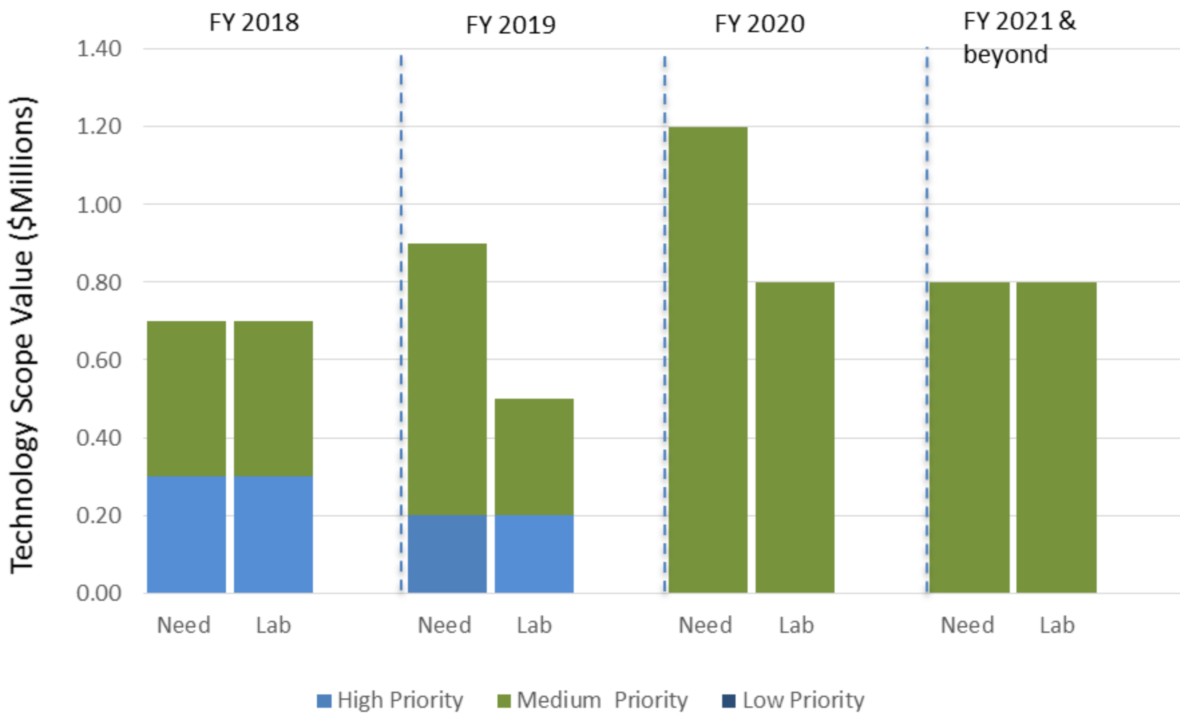


Figure 7-12. MW National Laboratory Work.

High-priority MW technology tasks potentially involving national laboratories include the following:

- MW-2, SLW grout ammonia vapor.

8.0 SUMMARY AND CONCLUSIONS

ORP is responsible for managing and completing the RPP mission, which comprises both the Hanford Site tank farms operations and the WTP. The RPP mission is to accomplish the following:

- Safeguard and safely manage over 54 Mgal of nuclear waste stored in Hanford tanks
- Treat the waste
- Achieve safe waste disposition to protect the Columbia River and the environment.

The life-cycle cost of tank waste cleanup is strongly influenced by the WTP operating duration. Each year the RPP mission continues beyond the forecasted end date costs taxpayers approximately $1 billion in 2017 dollars. Therefore, there is a significant life-cycle cost incentive to complete tank waste treatment processing at the earliest practicable date.

This Technology and Innovation Roadmap was developed in a systematic manner to facilitate sound strategic, programmatic, and fiscal planning regarding existing technology gaps in the RPP mission. Expert personnel were solicited for input from each functional area of the RPP flowsheet. Input was provided in standardized pro forma worksheets to ensure parallelism of reporting. Based on pro forma input, the technology needs were tied to the actual projects. As the RPP mission consists of many interwoven, interdependent unit operations, a technology gap or need in an upstream unit operation can cause a ripple effect of downstream impacts throughout many functional areas.

A prioritization process, described in Section 2.3, differentiated high-priority needs from medium- or low-priority needs by applying logic based on necessity, urgency, and stakeholder requirements. A prioritization council evaluated prescreened high-priority technology activities. Weighting criteria were applied to determine relative ranking among the high-priority items. Table 4-1 provides a summary of the high-priority technology needs as ranked by the priority ranking process and identifies those activities where national laboratory involvement is anticipated. Appendix C provides additional information regarding the ranking process.

The Technology and Innovation Roadmap highlights the current estimated technology needs and identifies where planning shortfalls exist and where national laboratory participation is needed. This information is intended to support the FY planning and national laboratory contracting processes to ensure that technology needs are supported as necessary to complete the RPP mission. In addition to supporting the RPP baseline mission, the Technology and Innovation Roadmap provides a basis for strategic planning by identifying opportunities to use technology solutions to enhance mission efficiency.

Figure 8-1 summarizes the costs associated with the pro forma worksheets (Appendix B). There is a planned funding deficit starting in FY 2018 and continues in the out years. The planned costs beyond FY2018 lose resolution because the life-cycle baseline is under development and not all technology needs are known (those that are known are outlined in the pro forma worksheets). Moreover, for many future technologies the costs are not easily estimated or only have rough order of magnitude estimates. For these reasons, cost estimate totals in the future should only be used for planning purposes, as they may not be considered reliable projections of actual cost. A primary function of the Technology and Innovation Roadmap is to identify and integrate needed technologies as a function of timeframe. Figure 8-1 illustrates the overall mission benefit of proactively identifying and planning for both forecasted and emerging needs.

This plot identifies the overall high-, medium-, and low-priority monetary scopes and indicates funding deficiencies.

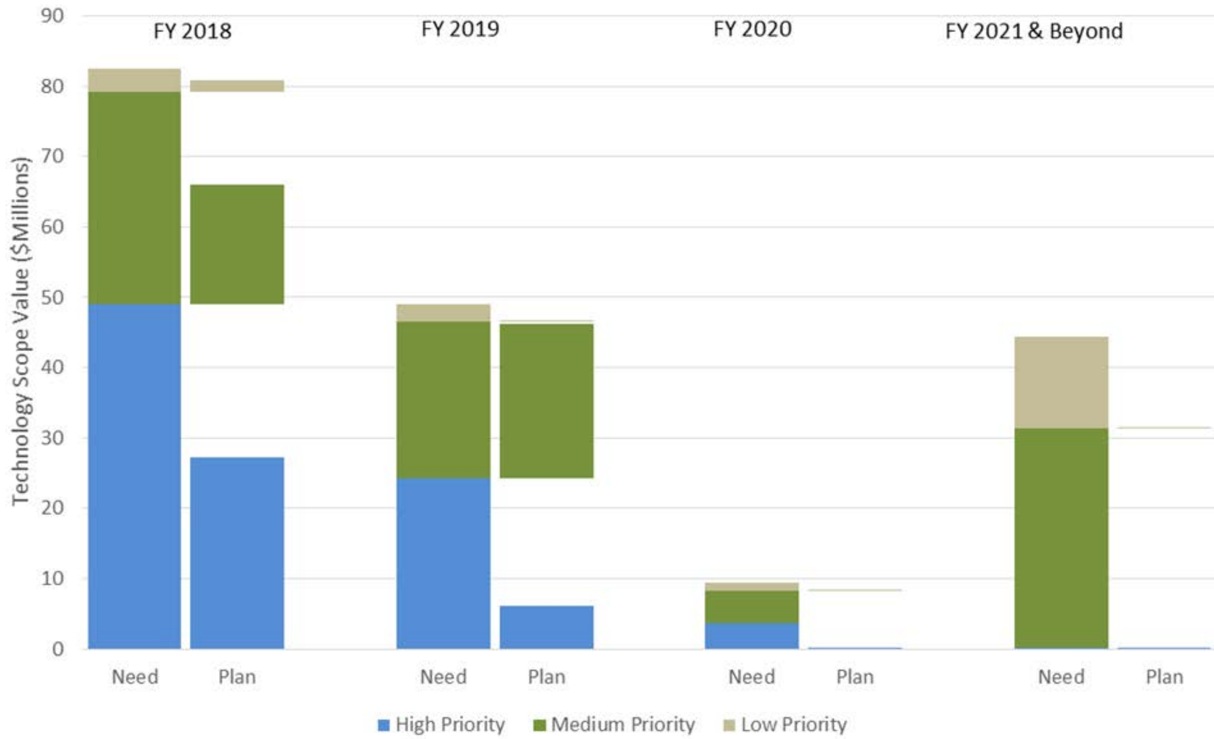


Figure 8-1. Comprehensive Technology and Innovation Roadmap Activity Costs as a Function of Time.

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APPENDIX A

TECHNOLOGY ROADMAP COMPREHENSIVE PRO FORMA SPREADSHEET

Table A-1. Active Pro Forma. (8 pages)

Pro Forma ID	ORP POC	Contractor POC	Title	Priority (High, Medium, Low)	Ranking Value
MTW-1	T Nirider	S Arm	Evaluate size segregation and grinding technologies for use in the proposed Tank Waste Characterization and Staging (TWCS) facility	Low	N/A
MTW-5	T Nirider	J Reynolds	Develop technically based operating limits and/or schemes for potentially challenging chemical species for the 242-A Evaporator.	Medium	N/A
MTW-8	D Stewart	Boomer	Evaluate additional nondestructive examination (flash thermography).	Low	N/A
MTW-9	D Stewart	E Wilson	Automated DST annulus camera system.	High	4.3
MTW-10	D Stewart	J Gunter	Develop electromagnetic acoustic transducer and phased array.	Medium	N/A
MTW-11	D Stewart	J Gunter	Volumetric inspection of DST primary tank bottoms.	High	13.1
MTW-12	D Stewart	J Rice	Improve annulus air monitoring.	Low	N/A
MTW-13	J Johnson	T Venetz	Improve LOW data acquisition.	Medium	N/A
MTW-15	D Stewart	J Gunter	Visual inspection of DST air slots using a robotic crawler.	High	13.2
MTW-18	D Stewart	J Rice	Synthetic and tandem synthetic aperture focusing techniques (SAFT and T-SAFT).	Low	N/A
MTW-20	J Johnson, D Stewart	A Kim	Acquire and test an upgraded video camera system for DST and SST inspections.	High	12.2
MTW-22	J Cheadle	C Peoples, B Orth	Re-engineer the ORSS car to allow for new technology to be introduced into the sampling arena.	Medium	N/A
MTW-23	J Lynch	R Calmus	Vapor mitigation.	High	3.2
MTW-24	J Lynch	R Calmus	Monitoring-detection of vapors.	High	5.1
MTW-33	D Stewart, J Johnson	R Mendoza	Develop a suite of tools/methods to evaluate SST and DST leaks and structural integrity to continue safely storing waste in the tanks.	Low	N/A
MTW-36	J Cheadle	G Cooke	Slurry properties.	Medium	N/A
MTW-37	J Cheadle	G Cooke	Solid phase characterization.	Medium	N/A
MTW-40	J Lynch	G Cooke	Improved sampling methods for headspace particulate analysis.	High	13.3
MTW-41	J Cheadle, J Lynch	G Cooke	Analytical method development at the 222-S Laboratory.	High	11.2
MTW-49	T Nirider	J Reynolds	Perform carbon steel corrosion tests with bounding simulated waste compositions for DFLAW.	High	7.1

Table A-1. Active Pro Forma. (8 pages)

Pro Forma ID	ORP POC	Contractor POC	Title	Priority (High, Medium, Low)	Ranking Value
MTW-50	D Stewart, J Johnson	M Landon	Development of new tank(s) or tank system for use in continued SST waste retrieval missions and risk reductions of aging SSTs.	Medium	N/A
MTW-56	T Nirider	J Reynolds	Evaluate and establish inventory of DFLAW organic COPCs.	High	9.4
MTW-57	T Nirider	J Reynolds	Perform modeling to develop the basis for predicting the behavior and impact of mercury on the evaporator.	Medium	N/A
MTW-59	J Lynch	J Vitali	Zeolites for reducing exposure to nitrosamines from tank vapors.	High	9.3
MTW-66	J Lynch, E Diaz	J Vitali	Treat NDMA in the tank headspace or side.	High	10.2
MTW-67	J Johnson	K Boomer	Adapt surgical steerable needle robotics technology to access refractory channels beneath primary tank in Hanford DSTs for the purpose of inspection and tank integrity.	Medium	N/A
MTW-68	J Lynch	G Weeks	Evaluate the utility of using a PTR-MS mounted in a mobile analytical laboratory.	High	9.2
MTW-69	J Lynch	G Weeks	Develop a personal ammonia monitor that reports ammonia concentrations to the Central Shift Office in real-time.	High	5.2
MTW-70	J Christensen	J Reynolds	Characterization of plutonium and synthesis of Pu-Bi species.	Medium	N/A
MTW-71	E Diaz	T Sams	Improve the interface used for best-basis updates and data access within the TWINS database.	Medium	N/A
RTW-1	J Rambo	M Allen	Development of the next generation ORSS capable of sampling hard heel material in support of tank closure.	Low	N/A
RTW-2	J Rambo	M Allen	Waste volume measurement and tank bottom classification technique.	Low	N/A
RTW-3	J Rambo	M Allen	Remote tank farm above ground inspections	Medium	N/A
RTW-4	J Rambo	P Rutland	Field test a prototype beta detection probe designed for in-situ detection of beta-emitting soil contamination (e.g., technetium).	Medium	N/A
RTW-7	J Johnson	P Rutland	This is a placeholder for technology needs expected to be identified upon completion of the initial revision of the WMA C PA are reviewed	Low	N/A
RTW-8	J Rambo	M Allen	Development of in-tank mechanical waste gathering system.	High	7.4

Table A-1. Active Pro Forma. (8 pages)

Pro Forma ID	ORP POC	Contractor POC	Title	Priority (High, Medium, Low)	Ranking Value
RTW-10	J Rambo	M Allen	Development and Testing of High Radiation Hose Materials	Low	N/A
RTW-11	J Rambo	M Allen	Development of in-line radiation monitoring system.	Medium	N/A
RTW-12	J Rambo	M Allen	Development of rotary core 30 in. riser installation system.	Medium	N/A
RTW-15	K Burnett	S Kelly	Evaluate back up options for HLW delivery from the tank farms as a contingency for when the proposed TWCS facility is not available to provide feed to the WTP.	Medium	N/A
RTW-16	A Kruger	S Kelly	Develop an integrated HLW feed qualification plan.	Low	N/A
RTW-17	J Rambo	S Kelly	Assess deep sludge pump reliability for DST mixer and transfer pumps.	Medium	N/A
RTW-18	D Stewart	S Kelly	Improved heat removal for 241-AW and 241-AN Tank Farms tanks TSR heat limits.	Low	N/A
RTW-19	D Stewart	S Kelly	In DST ^{90}Sr and TRU precipitation presents an opportunity to increase mission efficiency by performing this step in the tank farms rather than in the WTP PT Facility.	Low	N/A
RTW-21	T Nirider	Q Ho	ESP – a thermodynamic modeling program.	Low	N/A
RTW-23	J Johnson	R Mendoza	Waste transfer pipe unplugging.	Low	N/A
RTW-24	J Bovier	D Parker	Two-step characterization of the 241-C-301 catch tank contents.	High	
RTW-25	J Bovier	D Parker	Development and demonstration of a highly-flowable grout formula and pipe encasement sealing techniques are required to support WMA C closure.	Low	N/A
RTW-27	T Nirider	M Britton	Improved solubility modeling of aluminum is required.	Low	N/A
RTW-28	T Nirider	M Britton	Improved solubility modeling of oxalate, fluoride, and other simple mixtures is required	Low	N/A
RTW-29	T Nirider	M Britton	Improved solubility modeling of phosphate is required.	Low	N/A
RTW-31	D Stewart	K Bader	In-tank sampling technologies for plutonium particulates required to meet waste feed acceptance limits.	Low	N/A

Table A-1. Active Pro Forma. (8 pages)

Pro Forma ID	ORP POC	Contractor POC	Title	Priority (High, Medium, Low)	Ranking Value
RTW-32	J Christensen	J Meacham	Retrievals are prohibited in the seven Hanford tanks until the criticality concerns are addressed. One potential solution is to introduce soluble neutron absorbers into the tanks and ensure the criticality poisons remain with the Pu particles during retrieval operations.	Medium	N/A
RTW-33	J Christensen	D Losey	Instrumentation for detecting the presence of plutonium accumulations.	Low	N/A
RTW-34	J Rambo	M Allen	The simplified sluicer would provide a technology for waste retrieval from tanks that have shallow sludge depths and no in-tank obstructions.	Medium	N/A
RTW-37	J Rambo	M Allen	Tank waste residual volume measurement system.	Medium	N/A
RTW-39	T Nirider	J Reynolds	Develop a strategy and basis for predicting residual waste volumes and properties, and to develop effective retrieval options for each SST tank or type of waste in SSTs.	High	12.1
RTW-40	T Nirider	J Reynolds	A better understanding of the impacts of formation of solids and gels and predictive tools are needed to improve tank retrievals, avoid pipeline plugging, and minimize the volume of waste that must be stored.	Medium	N/A
RTW-42	K Burnett, E Diaz	J Vitali	By using scaled versions of mining equipment, that may fit through a tank riser penetration (or larger opening such as used for the MARS), material could be removed from the tank with minimal introduction of water.	Medium	N/A
RTW-43	C Kemp, E Diaz	J Vitali	Develop similar forms of task analysis, metrics, and a computer simulator for the training and operational benefit of tank farm retrieval operators as those used for measuring and modelling robotic surgical skills.	Medium	N/A
RTW-44	J Rambo	J Vitali	Use of sonar and ultrasound to quantify solids in DSTs.	Medium	N/A
RTW-46	J Rambo, E Diaz	J Vitali	MARS-V alternative and dry method for waste gathering.	Medium	N/A
RTW-47	J Rambo	J Vitali	Implement enhancements to MARS-V that will allow it to be used effectively in waste retrieval of tanks 241-A-104 and 241-A-105, and other leaking tanks.	Medium	N/A

Table A-1. Active Pro Forma. (8 pages)

Pro Forma ID	ORP POC	Contractor POC	Title	Priority (High, Medium, Low)	Ranking Value
RTW-50	J Rambo	M Allen	Evaluate SLIMS and cone penetrometers for SST waste retrievals.	Medium	N/A
RTW-52	J Rambo	M Allen	Perform barrier technology research.	Medium	N/A
RTW-53	C Kemp, E Diaz	J Vitali	3-dimensional flash LIDAR to map waste tanks.	Medium	N/A
RTW-54	K Burnett, E Diaz	J Vitali	Tank waste modular treatment study.	High	11.1
RTW-55	J Rambo	S Kelly	Hanford waste end effector.	High	3.1
PTW-17	J Diediker	R Russell	LAWPS integrated system test (before CD-2).	High	2.2
PTW-18	J Diediker	R Russell	LAWPS cross-flow filtration (return to tank 241-AP-107).	High	4.2
PTW-19	S Smith, S Pfaff	R Russell	LAWPS – TE-3 Mature technology for IX system utilizing sRF including resin regeneration system.	High	2.1
PTW-21	J Diediker	R Russell	LAWPS TE-8 resin handling system-resin replacement and disposal.	High	4.1
PTW-23	K Burnett	R Mabrouki	Development and maturation of technetium removal and management technologies is required to support various alternate flowsheets being developed by WRPS.	Medium	N/A
PTW-24	K Burnett	J Fleming	Design and develop an advanced dynamic simulation modeling platform, to replace the G2 platform (upon which HTWOS, TOPSim, and the WTP G2 model are built).	Medium	N/A
PTW-26	J Rambo	M Aurah	Deploy high to mid fidelity consolidated OTS in TOC for process monitoring and controls.	Medium	N/A
PTW-28	E Mattlin	M Aurah	Provide a common set of productivity and analysis tools which gather together data from a variety of sources and transforms it into real time, reliable information for tank farm decision makers.	Medium	N/A
PTW-31	T Nirider	J Reynolds	Maturation of the DFLAW feed qualification processes.	High	6.0
PTW-32	T Nirider	J Reynolds	Evaluate the comprehensive impact of the IX regeneration process on secondary liquid waste volume reduction.	Medium	N/A
PTW-38	K Burnett	K Colosi	Develop radioactive waste test platform that will provide bench-scale unit operations for DFLAW.	Medium	N/A

Table A-1. Active Pro Forma. (8 pages)

Pro Forma ID	ORP POC	Contractor POC	Title	Priority (High, Medium, Low)	Ranking Value
PTW-39	B Mauss, E Diaz	J Vitali	Virtual workbench for waste processing grand challenge proposal.	Medium	N/A
PTW-40	E Diaz, A Kruger	J Vitali	HLW direct vitrification.	High	11.3
PTW-41	E Diaz	J Vitali	Cesium removal and interim storage of Cs containing resin in support of direct feed low-activity waste (DFLAW) immobilization. Conceptual overview of methods to safely remove, store and dispose of Cs using a modular, skid based ion exchange system to allow treatment of the decontaminated LAW.	Low	N/A
PTW-42	E Diaz, A Kruger	J Vitali	Investigate new glass for HLW direct vitrification.	Medium	N/A
PTW-43	S Smith	J Reynolds	Multiple cycle testing of sRF resin in a radiation field.	Low	N/A
PTW-44	S Smith	J Vitali	Technical basis for sRF storage - life expectancy and Cs-removal efficiency over time and method.	High	14
PTW-45	A Kruger	D Swanberg	Demonstrate a novel method of selectively sequestering the pertechnetate (Tc (VII)) ion (TcO_4^-) from radioactive liquid waste by absorbing the water-soluble ^{99}Tc isotope into porous organic frameworks.	Medium	N/A
PTW-46	K Burnett	R Tedeschi	Advance CH-TRU tank waste treatment technologies.	Medium	N/A
PTW-47	S Smith	R Russell	The LAWPS Cs IX column elution process was developed based on eluting a single column at a time. LAWPS plans to elute two IX columns in series. Due to a lack of information on the efficiencies in chemical use when eluting two columns in series, LAWPS is conservatively being designed for two times the single elution process. There is opportunity to define an optimized in series elution process to minimize chemical usage during elution.	Low	N/A
PTW-48	S Smith	R Russell	LAWPS Cs IX column.	High	1.0
PTW-49	K Burnett, E Diaz	J Vitali	Study to examine feasibility of removing nitrates from the LAW feed stream prior to vitrification.	High	
PTW-50	D Alexander	J Vitali	Hydrocyclones applied in TWCS, PT, and DFHLW applications to segregate solids into batches by particle size.	Medium	N/A

Table A-1. Active Pro Forma. (8 pages)

Pro Forma ID	ORP POC	Contractor POC	Title	Priority (High, Medium, Low)	Ranking Value
MW-2	K Burnett	D Swanberg	Liquid secondary waste grout ammonia vapor.	High	10.1
MW-4	K Burnett	D Darling	HLW melter disposal.	Low	N/A
MW-8	R Valle	D Halgren	A complete organic constituent characterization of the WTP secondary liquid waste going to the ETF and potentially a subsequent technology to replace the current ETF organic destruction unit.	Medium	N/A
MW-9	R Valle	D Halgren	A technology to replace the ETF peroxide destruction unit operation.	Medium	N/A
MW-10	R Valle	D Halgren	A means is needed to clean the ETF process tanks interior walls and roofs (up to 15 ft wide × 20 ft high) without manned entry.	Medium	N/A
MW-12	G Triner	D Swensen	Upgrade of the site wide waste tracking program (SWITS). SWITS will need to be upgraded to handle the waste generated by the WTP.	Medium	N/A
MW-13	TBD	D Swensen	Ensure that transportation requirements are addressed in the development of new equipment. Any equipment developed will at some point need to be replaced and disposed. Need to ensure there is an appropriate package to transport these items for disposal. Also sampling need to be considered to ensure the proper packaging is developed so that the samples can be transported per applicable regulations.	Medium	N/A
DTW-1	G Pyles	D Swanberg	Development and maturation of a technology for the low temperature cementitious waste Form for the solidification and stabilization of liquid secondary wastes from the ETF.	Medium	N/A
DTW-2	G Pyles	D Swanberg	Develop a low temperature waste form (cast stone) for supplemental immobilization of Hanford LAW.	Medium	N/A
DTW-3	G Pyles	D Swanberg	Perform engineering and laboratory tests to characterize immobilized LAW, glass, to support the IDF PA update and future maintenance.	High	7.2

Table A-1. Active Pro Forma. (8 pages)

Pro Forma ID	ORP POC	Contractor POC	Title	Priority (High, Medium, Low)	Ranking Value
DTW-4	G Pyles	P Rutland	This is a placeholder for technology needs expected to be identified when the initial modeling results of the IDF PA are reviewed. This review will identify areas where new information will supplement the IDF PA. Technology needs will be identified in the 2017 time frame. They will lead to development of new information to be integrated into revision 1 of the IDF PA for future operation.	Medium	N/A
DTW-6	K Burnett	R Tedeschi	Advance Offsite Transportation Capability	Low	N/A
DTW-7	G Pyles	D Swanberg, E Brown	Development and maturation of a technology for the solidification and stabilization of SSW form by macro- or micro-encapsulation with grout.	High	8.0

CD = critical decision.
CH-TRU = contact-handled transuranic.
COPC = constituent of potential concern.
Cs = cesium.
DFLAW = direct-feed low-activity waste.
DFHLW = direct-feed high-level waste.
DOE = U.S. Department of Energy.
DST = double-shell tank.
ESP = Environmental Simulation Program.
ETF = Effluent Treatment Facility.
HLW = high-level waste.
HTWOS = Hanford Tank Waste Operations Simulator.
IDF = Integrated Disposal Facility.
IX = ion exchange.
LAW = low-activity waste.
LAWPS = low-activity waste pretreatment system.
LIDAR = light detection and ranging.
LOW = liquid observation well.
MARS = mobile arm retrieval system.
MARS-V = mobile arm retrieval system vacuum.
N/A = not applicable.
NDMA =
ORP = U.S. Department of Energy, Office of River Protection.
ORSS = off-riser sampling system.
OTS = operators training simulator.
PA = performance assessment.
POC = point of contact.
PT = pretreatment.
PTR-MS = proton transfer reaction – mass spectrometer.
SLIMS = solid/liquid interface monitoring system.
sRF = spherical resourcinol-formaldehyde.
SST = single-shell tank.
SSW = solid secondary waste.
TOC = Tank Operations Contract.
TRU = transuranic.
TSR = Technical Safety Requirement.
TWCS = tank waste characterization and staging.
TWINS = Tank Waste Information Network System.
WMA = waste management area.
WTP = Waste Treatment and Immobilization Plant.

Table A-2. Retired Pro Forma. (18 pages)

Pro Forma ID	Contractor POC	Title	Ranking (High, Medium, Low)	Reason Retired
MTW-1	S Arm	Evaluate size segregation and grinding technologies for use in the proposed TWCS facility.	Low	Reclassified as non-technology development.
MTW-2	S Arm	Evaluate and document technical basis and operating margin during 242-A Evaporator operations. Recommend changes if warranted.	N/A	Reclassified as non-technology development.
MTW-3	S Arm	Evaluate the 242-A Evaporator feed qualification process to determine methods to reduce qualification time.	N/A	Reclassified as non-technology development.
MTW-4	S Arm	Develop a process development plan identifying the objectives and plans for technology development activities to address the 242-A Evaporator evaporation of HLW condensates.	N/A	Reclassified as non-technology development.
MTW-6	N Kirch	Increasing supernatant specific gravity, and possibly to the production of saltcake solids may save significant volume, especially in 241-AP Tank Farm which is primarily storing supernatant waste.	Medium	Retired because increasing spG could cause BDGRE events
MTW-7	J Garfield	Investigate and utilize software (like WRIKE) for open source collaboration with DST Integrity Project.	N/A	Retired; overcome by events
MTW-14	K Boomer	Improved DST exhaust systems (241-SY and 241-AP Tank Farms).	N/A	Reclassified as non-technology development.
MTW-16	K Boomer	Robotic crawler – guided wave in air slots.	Medium	Retired and replaced by MTW-15
MTW-17	K Boomer	Robotic annulus air supply pipe inspections.	Medium	
MTW-19	Amie Kim	Acquire and test an upgraded still camera system for DST and SST inspections.	High	Combined with MTW-20.
MTW-21	K Boomer D Baide	Forensic examination of the primary tank bottom in tank 241-AY-102.	High	Retired used steel taken from other tanks to perform forensics
MTW-22	B Orth	Re-engineering the ORSS car allows for new technology to be introduced into the sampling arena. The current design has been in place for over 15 years and has not been updated.		Combined with RTW-1.
MTW-25	P Gagnon	Perform an analysis for the potential of chemical vapors from tank headspaces to plate out on exhauster and vent stack components and determine whether those chemicals can later dissolve in condensate and reappear in vapor or particulate form during heating of the metal components from sun exposure.	High	Technology no longer needed (P Gagnon email 3/21/17).

Table A-2. Retired Pro Forma. (18 pages)

Pro Forma ID	Contractor POC	Title	Ranking (High, Medium, Low)	Reason Retired
MTW-26	P Gagnon	Develop a system to be deployed on a tank riser to pull headspace samples from the tank. The sampling device should be able to acquire samples from various depths within the tank headspace.	High	Technology no longer needed (P Gagnon email 3/21/17).
MTW-27	P Gagnon	Perform testing of MOVs to document the effectiveness/accuracy of their ability to fully open and fully close the valves via remote operations from a central control room. The motor-operated mechanism needs to be evaluated for its ability to open and close the valves under high torque conditions. The evaluation should include testing and down-selecting pneumatic vs. hydraulic vs. electric motors.	High	Retired telephone discussion with Paul on 7/18/17 deferred to a later date.
MTW-28	P Gagnon	Perform a toxicological study of tank chemical mixtures and perform an evaluation of potential research of the epidemiological effects of tank vapors.	High	This was a DOE only task
MTW-29	N Kirch	The current maximum fill height for most DSTs is 422 in. Four tanks in the 241-AP Tank Farm have been increased to 458 in. and the remaining four 241-AP Tank Farm tanks are planned to be raised. The fill height in 241-AN, 241-AW, and 241-SY Tank Farms could potentially be raised by expanding the structural analysis to these farms and successful leak testing by moving supernatant material into the subject tanks.	High	Reclassified as non-technology development.
MTW-31	T Sams	Develops and tests Raman spectroscopy and radiometric characterization tools to characterize residual wastes left in the tanks after retrieval.	Low	No longer needed-email per D Baide 3/21/17.
MTW-32	T Sams	Methods to identify phosphate compounds in HLW sludge are being examined to devise a technology to separate phosphate from HLW prior to transfer to the WTP.	Low	No longer needed-email per D Baide 3/21/17.
MTW-34	M Allan	Waste volume measurement and tank bottom classification technique.	N/A	Retired replaced by MTW-11
MTW-35	M Allan	Remote tank farm above ground inspections.	High	Duplicate of RTW-3
MTW-38	G Cooke	Sample archive upgrades.	Medium	
MTW-39	G Cooke	Improved technology and redundancy for key analytical tasks (boil down and electrochemical analysis).	Medium	Not technology development
MTW-42	G Cooke	Investigation of surrogate method for detecting tank vapors.	High	Not technology development

Table A-2. Retired Pro Forma. (18 pages)

Pro Forma ID	Contractor POC	Title	Ranking (High, Medium, Low)	Reason Retired
MTW-43	G Cooke	Radionuclides in tank vapors.	High	Absorbed by MTW-40.
MTW-44	G Cooke	Real-time monitoring of airborne toxics in tank farms (rolled into MTW-24).	High	Absorbed by MTW 24
MTW-45	G Cooke	Method development for WFD certification.	Low	Duplicate of PTW-29 so is retired.
MTW-46	G Cooke	Laboratory selection and capacity versus mission(s).	N/A	Reclassified as non-technology development.
MTW-47	G Cooke	Alternative waste forms.	Low	
MTW-48	G Cooke	222-S Laboratory support for tank farm closure: vadose support.	Low	Handled by other pro forma
MTW-51	R Calmus	OP-FTIR spectrometer.	High	No longer needed- email from R Calmus 3/15/17.
MTW-52	R Calmus	Gas imaging camera – The gas imaging camera is a forward-looking infrared radiation camera that converts infrared radiation originating from gases and vapors to an identifiable image.	High	No longer needed because it was pilot tested and is to be transitioned to engineering for deployment - email from R Calmus 3/15/17.
MTW-53	R Calmus	UV-DOAS and FTIR spectrometer stack monitor.	High	No longer needed because it was pilot tested and is to be transitioned to engineering for deployment - email from R Calmus 3/15/17.
MTW-54	R Calmus	Design a real-time VMDS that can detect when, where, and under what conditions chemical vapors are present.	High	No longer needed because it was pilot tested and is to be transitioned to engineering for deployment - email from R Calmus 3/15/17.
MTW-55	J Vitali	Structural analysis to justify increasing the allowable waste levels in the DST farms.	High	ORP email 3/30/17. Delete because already implementing.
MTW-58	A Ramsey	The VMDS integration software package is: SAFER Real-Time by SAFER Systems.	High	Redundant to MTW-54. Retired.
MTW-60	A Ramsey	Remote wireless video monitoring for reduced worker exposure.	High	Redundant to MTW-61
MTW-61	J Vitali	Remote wireless video monitoring for reduced worker exposure.	High	ORP email 3/30/17 : Recommend deleting because already implementing. This is also being considered under the suite of TF Automation updates.

Table A-2. Retired Pro Forma. (18 pages)

Pro Forma ID	Contractor POC	Title	Ranking (High, Medium, Low)	Reason Retired
MTW-62	J Vitali	Method to eliminate nuisance tank farms odors at the source or for individual PPE that can be used to help solve the tank farm vapor issue(s).	High	ORP email 3/30/17. Recommend deleting and replacing with UV NDMA treatment study by SRNL.
MTW-63	J Vitali	Rapid routine real-time mobile COPC monitoring to ensure worker health and safety at Hanford.	High	ORP email 3/30/17. Delete because already implementing.
MTW-64	J Vitali	Vapor detection via portable positive ion sensor.	High	ORP email 3/30/17. Delete WRPS will provide viability assessments of the current pilot scale equipment in 241-AP Tank Farm and move from there to field operations turnover and tailoring for the other tank farms.
MTW-65	J Vitali	Mobile and portable multiple-wavelength differential absorption LIDAR (DIAL) for real-time detection and reporting of gases and vapors from the tank farms at Hanford.	High	ORP email 3/30/17. Delete WRPS will provide viability assessments of the current pilot-scale equipment in 241-AP Tank Farm and move from there to field operations turnover and tailoring for the other tank farms.
RTW-5	P Rutland	Field test a prototype electrical conductivity probe designed for in-situ detection of increased porewater conductivity indicative of waste releases.	Medium	Retired because subject technology will become obsolete by the time it is needed.
RTW-6	S Eberlein	Prepare an interactive tank model that allows for soil property estimations and infiltration effects, to evaluate various release scenarios on an as needed basis.	Medium	Reclassified as non-technology development
RTW-9	V Magnus	Development of the next generation slurry pump. Develop and test modifications to the AGI slurry turbine pump, Model 12HTSP100-1 to reduce the pump drawdown capability to less than 1 in.	High	Work has been completed, pump has already been designed.
RTW-13	C Burke / V Magnus	Development of in-line temperature monitoring system.	High	Have other means of determining temperature
RTW-14	Harlow	241-SY Tank Farm waste staging.	Medium	Replaced by TWCS and WRFs

Table A-2. Retired Pro Forma. (18 pages)

Pro Forma ID	Contractor POC	Title	Ranking (High, Medium, Low)	Reason Retired
RTW-20	T Waldo	Develop a waste certification strategy for feed batches, to WTP, that eliminates the current feed batch hold time assumption of 180 – 210 days.	Medium	Work completed.
RTW-30	C Burke / V Magnus	Development of radiation hardened camera system.	High	Included in MTW-20
RTW-35	M Allen	MARS 42-in. development – Phase 2.	High	This technology no longer being pursued. Email from M Allen 3/21/17.
RTW-36	M Allen	Remove/shorten 42-in. risers.	High	This technology no longer being pursued. Email from M Allen 3/21/17.
RTW-38	S Arm	Define the potential settling and settled layer conditions relative to a gravity settling and decant method to provide DFLAW feed that meets the desired concentration.	High	PNNL completed this work in FY16. Email from J Reynolds 3/20/17.
RTW-41	J Vitali	Alternative system to MARS-V for SST retrieval that minimizes the use of liquid.	High	Delete because already being implemented (HWEE)
RTW-45	A Ramsey	Phased deployment of NitroJet technology with MARS for Hanford HLW tank hard heel removal.	Medium	ORP email 3/30/17. Delete: NitroJet with MARS-FIU.
RTW-48	J Vitali	Raman spectroscopy and turbidity sensors for in-line, real-time monitoring of WTP process streams.	Low	ORP email 3/30/17. Delete WTP is already implemented.
RTW-51	M Allen	Evaluate mixer pumps for SST waste retrievals.	Medium	Reclassified as non-technology development.
PTW-1	S Arm	Define the potential settling and settled layer conditions relative to gravity settling and decant method to meet target solids concentration for DFHLW feed and conduct bench-scale testing with simulants to address uncertainty of scale-up to tank conditions. If it is determined that a fraction of the waste will likely not meet acceptable parameters and time requirements within the uncertainty of the data, actual waste testing will be required to confirm definitions of wastes that meet feed specifications.	Low	Reclassified as non-technology development.
PTW-2	S Arm	Evaluate initial DFHLW feed campaigns to assess impact of leaching and washing endpoint on the waste disposition process, identify necessary future testing, and recommend washing strategy improvements.	Low	Reclassified as non-technology development.

Table A-2. Retired Pro Forma. (18 pages)

Pro Forma ID	Contractor POC	Title	Ranking (High, Medium, Low)	Reason Retired
PTW-3	S Arm	Develop critical velocity model(s) to provide design and operating boundaries for Hanford waste slurry transfers.	Low	Reclassified as non-technology development.
PTW-4	S Arm	Identify and evaluate potential impacts of the proposed DFHLW flowsheet on the HLW vitrification process and provide recommendations for operations optimization and risk mitigation as well as future testing needs.	Low	Reclassified as non-technology development.
PTW-5	S Arm	Evaluate water usage and provide recommendations for optimization and recycle volume reductions in LAWPS. Bench-scale and/or pilot-scale testing to confirm the recommendations using nonradioactive simulants.	High	Reclassified as non-technology development.
PTW-6	S Arm	Evaluate the LAW melter off-gas system operation (and any proposed changes) to provide operational and technology development recommendations for reducing water usage without compromising the design and emissions goals.	High	Reclassified as non-technology development.
PTW-7	S Arm	Evaluate and model the LAW melter off-gas condensate and the existing tank waste to predict the resulting chemical interactions.	High	Reclassified as non-technology development.
PTW-8	S Arm	Evaluate LAW melter off-gas condensates impact on DST corrosion control program and recommend both operational and technological strategies to mitigate impacts to DST space, chemical additions, and process incompatibilities.	High	Reclassified as non-technology development.
PTW-9	S Arm	Evaluate DFLAW streams for potential solids precipitation throughout the process, develop predictive tools for solubility, establish process recovery methods, and establish a solids precipitation mitigation strategy for DFLAW based on experimental results.	High	Reclassified as non-technology development.
PTW-10	S Arm	Identify and evaluate potential impacts of the proposed LAWPS flowsheet on the LAW melter process and provide recommendations for operations optimization and risk mitigation.	Medium	Reclassified as non-technology development.
PTW-11	S Arm	Evaluate the WTP LAW melter off-gas system to assess the impact of the changes in melter feed from the "direct feed" flowsheet options versus that tested during VSL evaluations and provide recommendations for melter off-gas operations and any necessary testing to mitigate risk.	High	Reclassified as non-technology development.

Table A-2. Retired Pro Forma. (18 pages)

Pro Forma ID	Contractor POC	Title	Ranking (High, Medium, Low)	Reason Retired
PTW-12	S Arm	Evaluate DFLAW flowsheet and propose an integrated DFLAW WFAQ strategy.	High	Reclassified as non-technology development.
PTW-13	S Arm	Establish a validated technical basis for the LAWPS CFF performance, filter cleaning and back pulsing operations when processing a decanted supernatant feed stream with less than 0.5wt% solids content.	High	Retired because it was found to be redundant with PTW-17.
PTW-14	S Arm	Conduct pilot–scale testing with CFF and IX to verify and optimize operational parameters as well as determining LAWPS operating margin.	High	Retired because it was found to be redundant with PTW-17.
PTW-15	S Arm	Evaluation, modeling, and bench-scale experimental IX work to identify, mitigate, and recover from solids precipitation (column fouling) risk in LAWPS while also establishing performance trade-offs based on sodium concentration, temperature, solids precipitation, and other ions as well as secondary waste volume reduction and WTP-LAW melter production considerations.	High	Retired because it was found to be redundant with PTW-17.
PTW-16	K Ard	An understanding of flammable gas generation rates, gas retention and release rates and design approaches to maintain build-up of flammable gas to below the required concentration require testing.	High	Combined with PTW-17.
PTW-20	R Russell	LAWPS – TE-4 The IX eluate neutralization and preparation for return to the DSTs consists of collecting the slightly acidic cesium eluate and neutralizing it for return to the DST system.	High	Retired not needed at this time-overcome by events
PTW-22	T Waldo	Develop an operating strategy/flowsheet that eliminates the recycles, of LAW vitrification, returning to tank farms, during DFLAW operations.	Medium	Retired work completed
PTW-25	M Aurah	Deploy central control room (full Phase 2) in TOC for process monitoring and control for all TOC facilities from a common location.	Medium	Retired work completed
PTW-27	M Aurah	This plan adopts the vision of a seamless waste processing stream from the tank farm, through the WFD process, and on to the WTP.	Medium	
PTW-29	G Cooke	Method development for WFD certification.	Low	
PTW-30	G Cooke	Laboratory selection and capacity versus mission(s).	Low	Reclassified as non-technology
PTW-33	S Arm	This task will improve prediction of the volume and nature of these streams to better plan for their management.	High	Reclassified as non-technology development.

Table A-2. Retired Pro Forma. (18 pages)

Pro Forma ID	Contractor POC	Title	Ranking (High, Medium, Low)	Reason Retired
PTW-34	S Arm	This task will develop alternative approaches to using simple split factors, perform and document a scientific-based review of the HTWOS/TOPSIM model assumptions, and validate that the model output matches test results.	High	Reclassified as non-technology development.
PTW-35	S Arm	Establish and evaluate technical bases and defensibility in predicting flowsheet speciation, solubility, and partitioning.	N/A	Reclassified as non-technology development
PTW-36	J Reynolds	Establish and implement an improved liquid viscosity model for accurate predictions by expanding and improving the experimental and theoretical basis underlying the correlation documented in RPP-RPT-51652.	Medium	Reclassified as non-technology development
PTW-37	S Arm	Establish estimates of BBI uncertainty, identify gaps and recommend improvements, and test the impact of BBI inventory uncertainty estimates on flowsheet model predicted DFLAW operations and LAWPS staged feed acceptance.	Medium	PNNL completed the tasks in FY2016. Email from J Reynolds 3/20/17.
PTW-44	J Vitali	This work establishes a technical basis for sRF storage conditions, life expectancy, and cesium removal efficiency as a function of storage degradation.		Determined to be unnecessary.
DTW-5	P Rutland	Perform laboratory release rate testing on tank waste residuals to provide technical information to use in modeling of long term risk associated with the closed tank farms (PA).	Medium	Release rates obtained from C-farm tanks came back so far below standards that there is no need to pursue this.
MW-1	S Arm	Evaluation, modeling, and bench-scale experimental IX work to identify, mitigate, and recover from solids precipitation (column fouling) risk in LAWPS while also establishing performance trade-offs based on sodium concentration, temperature, solids precipitation, and other ions as well as secondary waste volume reduction and WTP-LAW melter production considerations.	Medium	Overcome by events
MW-3	D Swanberg	Develop and qualify a low temperature waste form (cast stone) for solidification and stabilization of liquid secondary waste from the Hanford ETF.	High	Waste form was addressed ammonia issue addressed in MW-2
MW-5	D Darling	Cooling of ILAW canisters during transport to IDF.	High	Alternate technology chosen.

Table A-2. Retired Pro Forma. (18 pages)

Pro Forma ID	Contractor POC	Title	Ranking (High, Medium, Low)	Reason Retired
MW-6	D Halgren	Perform LERF cover inspection/surveillance utilizing a drone. The inspection will look for cover damages and dirt/water accumulation over the 340 ft by 280 ft covers. ETF has three covered basins with varying degree of contaminations on the covers. Currently the inspection is done from around the basin parameter. A thorough inspection of the cover is not possible for the majority of the cover. With a drone, a close up view can be obtained for the entire cover with minimal manpower resources. Photos can be taken to assist in the evaluation and documentation of the cover condition. The results will facilitate planning for cover cleaning and eventual cover replacement.	Low	Retired due to cover replacement
MW-7	M Teats, P Haig, P Sabin	Provide secured HLAN connection to ETF MCS, and upgrade MCS HMI to allow technical staff to access MCS data from office locations. PLCs would not require upgrade.	Medium	
MW-11	D Halgren	Use technologies to develop criteria for halide concentration under various process conditions that will support long term service of the ETF secondary treatment train process vessels.	Medium	Email from D Halgren 2/2/16. This is being pursued directly and no development support is needed.
MW-14	S Arm	DFLAW melter off-gas condensate disposition.	High	No longer sending solids from the WTP off-gas system back to tank farms.

Note: Pro forma numbers are uniquely assigned and not reused.
RPP-RPT-51652, 2012, *One System Evaluation of Waste Transferred to the Waste Treatment Plant*, Rev. 0.

Table A-2. Retired Pro Forma. (18 pages)

Pro Forma ID	Contractor POC	Title	Ranking (High, Medium, Low)	Reason Retired

BBI	=	best basis inventory.
CFF	=	cross-flow filtration.
COPC	=	constituent of potential concern.
DFHLW	=	direct-feed high-level waste.
DFLAW	=	direct-feed low-activity waste.
DIAL	=	differential absorption LIDAR
DOE	=	U.S. Department of Energy.
ETF	=	Effluent Treatment Facility.
HLAN	=	Hanford Local Area Network.
HLW	=	high-level waste.
HTWOS	=	Hanford Tank Waste Operations Simulator.
HWEE	=	Hanford Waste End Effector
IDF	=	Integrated Disposal Facility.
IX	=	ion exchange.
LAW	=	low-activity waste.
LAWPS	=	low-activity waste pretreatment system.
LERF	=	Liquid Effluent Retention Facility.
LIDAR	=	light detection and ranging.
MARS	=	mobile arm retrieval system.
MARS-V	=	mobile arm retrieval system vacuum.
MCS	=	monitor and control system.
N/A	=	not applicable.
NDMA	=	N-Nitrosodimethylamine
OP-FTIR	=	open path Fourier transform infrared.
ORP	=	U.S. Department of Energy, Office of River Protection.
ORSS	=	off-riser sampling system.
PA	=	performance assessment.
PLC	=	programmable logic controller.
PNNL	=	Pacific Northwest National Laboratory.
POC	=	point of cotact
PPE	=	personal protective equipment.
sRF	=	spherical resourcinol-formaldehyde.
SRNL	=	Savannah River National Laboratory.
SST	=	single-shell tank.
SWITS	=	Solid Waste Information and Tracking System
TOC	=	Tank Operations Contract.
TWCS	=	tank waste characterization and staging.
UV	=	ultraviolet.
UV-DOAS	=	ultraviolet differential optical absorption system.
VDMS	=	vapor monitoring and detection system.
WFAQ	=	waste feed acceptance and qualification.
WFD	=	waste feed delivery.
WRPS	=	Washington River Protection Solutions, LLC.
WTP	=	Waste Treatment and Immobilization Plant.

APPENDIX B
PRO FORMA WORKSHEETS

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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Grand Challenge topic 7, Vapors Engineered Controls

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Study feasibility					
Bench Scale Test					
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

APPENDIX C
PRIORITY RANKING RESULTS

Question (score)	HighWeighting			MediumWeighting(Risk/ImpactCategory)			LowWeighting(EnhancementCategory)	
	Safety	**DOECommitment**	**StrategicInitiative**	**RiskMitigation**	**ScheduleImpact**	**TechnologyImpact**	**ImplementationComplexity**	**MissionEfficiencies**
	Doestheitemreduce asafetyrisk?	Doestheitem contributeto completionofa DOEcommitment ormilestone?	Doestheitemsupport anORPidentified strategicinitiative?	Doesthisitemcontributeto RPPMissionorTOCProgram andProjectriskreduction?	Willtheitemimpactkey RPPmissionobjectives ?	Willthisitemhave technology implicationsbeyond identifiedTOCuse?	Willtechnologyimplementation involvechangingexisting operatingprotocols,authorization basisrequirements,orpermitting conditionsthataddsignificant scheduleuncertainty?	Doesthisitemrepresentand opportunitytoimproveor acceleratetheRPPMission?
3	Supportsmitigationof aspecifically identifiedsafety issue.	Neededto completeaConsent Decree commitmentor startDFLAW Operations.	Technologyneededto directlysupportaDOE identifiedstrategic inititatve	Supportsmitigationand handlingstrategiesofRPP MissionriskitemsorTOC ProgramorProjectriskitems thatcouldimpactRPPMission risks.	Neededtomaintainor recoverschedulefor keyRPPmission objectives.	Technologyhas applicationatother TOCprojectsorother DOEsites.	Technologyimplementationis expectedtofallwithintheexisting operatingprotocols,authorizations basis,andregulatorypermit conditionssuchthatadditional scheduledelaysarenotexpected.	Implementsaspecifically identifiedmission,program,or projectopportunitythatresults inimprovedperformanceor moreefficientuseofresources.
2	Potentialforreducing asafetyriskthatmay ormaynotbe specificallyidentified.	Neededto completeaTPA, DOEHQorhigh profilepublic commitment.	EnhancesaDOE identifiedstrategic initiativebutnot neededforbasic functionality	Supportsmitigationand handlingstrategiesofTOC ProgramorProjectriskitems thatdon'timpactRPPmission riskitems.	Acceleratesscheduleto createadditionalfloat forreachingkeyRPP missionobjectives.	Technologyhas applicationatother Hanfordprojects.	Thereisapotentialthatadditional criticalpathimplementation scheduleactivitiesandtimewillbe neededtoaccommodatechanges tooperatingprotocols, authorizationbasis,and/or regulatorypermitconditions.	Providesanopportunityto increasethelikelihoodof meetingcommitmentsor providesformoreefficientuse ofresources.
1	Nocontributionto reducingsafetyrisk.	NoimpactonDOE commitments.	NoimpacttoORP identifiedStrategic Initiave	Notrelatedtoanidentified riskitemorisrelatedtoan acceptedrisk.	Nolikelyschedule impactforkeyRPP missionobjectives.	Technologyisspecific todesignatedTOC applicationonly.	Itisexpectedthatadditional criticalpathimplementation scheduleactivitiesandtimewillbe neededtoaccommodatechanges tooperatingprotocols, authorizationbasis,and/or regulatorypermitconditions.	Nomissionenhancement potentialidentified.

WeightingFactors	
HighFactor	**3**
Medium Factor	**2**
LowFactor	**1**

31	<<<TOTAL		D	E	F	G	H	I	J	K				
ID#	Title	FINAL RANK	SafetyScore	DOECommitment Score	StrategicInitiative Score	RiskMitigation Score	Schedule ImpactScore	Technology ImpactScore	Implementation ComplexityScore	Mission EfficienciesScore	Unweighted Score(add)	Weighted Score(add)	Sub Rankings	FINAL RANK
	MaxScore>>>		3	3	3	3	3	3	3	3	24	51		
PTW-48	LAWPSCsIXcolumn	**1.0**	3	3	3	2	3	2	2	2	20	45		**1.0**
PTW-19	LAWPSTE-3ion-exchangeusingsRF	**2.1**	2	3	3	3	3	2	1	2	19	43	a	**2.1**
PTW-17	LAWPSintegratedscaletest(beforeCD-2)	**2.2**	2	3	3	3	3	2	1	2	19	43	b	**2.2**
RTW-55	HanfordWasteEndEffecter	**3.1**	3	3	3	3	1	1	2	3	19	42	a	**3.1**
MTW-23	Providetechnology/methodstomitigateselectedactive/passiveTankFarm (TF)vaporsources.	**3.2**	3	2	3	3	3	1	2	2	19	42	b	**3.2**
PTW-21	LAWPSTE-8ResinHandlingSystem-resinreplacementanddisposal	**4.1**	1	3	3	3	3	2	2	2	19	41	a	**4.1**
PTW-18	LAWPSTE-2cross-flowfiltration(returntoAP-107)	**4.2**	1	3	3	3	3	2	2	2	19	41	b	**4.2**
MTW-9	AutomatedDSTAnnulusCameraSystem	**4.3**	1	3	3	3	1	3	3	3	20	41	c	**4.3**
MTW-24	ImplementrecommendedTankFarmvapormonitoring/detection equipment/predictivemodelingsoftware	**5.1**	3	2	3	2	3	1	2	2	18	40	a	**5.1**
MTW-69	Personalammoniamonitorthatreportsammoniaconcentrationstothe CentralShiftOfficeinreal-time.	**5.2**	3	2	3	2	2	2	2	2	18	40	b	**5.2**
PTW-31	MaturationoftheDFLAWfeedqualificationprocesses	**6.0**	1	3	3	2	3	2	3	1	18	39		**6.0**
MTW-49	CorrosioncontrolDFLAWbounding	**7.1**	1	3	3	3	1	2	2	2	17	37	a	**7.1**
DTW-3	CharacterizeILAWglasstosupporttheIDFPAupdateandfuture maintenance	**7.2**	1	2	3	3	3	1	3	2	18	37	b	**7.2**
RTW-24	Two-stepcharacterizationofthe241-C-301CatchTankcontents	**7.3**	1	3	2	2	3	2	2	3	18	37	c	**7.3**
RTW-8	DevelopIn-tankMechanicalWasteGatheringSystem	**7.4**	1	2	2	3	3	3	2	2	18	37	d	**7.4**
DTW-7	Development&maturationofatechnologyforsolidification/stabilizationof solidsecondarywaste	**8.0**	1	3	2	3	3	1	2	2	17	36		**8.0**
PTW-49	StudytoexaminefeasibilityofremovingnitratesfromtheLAWfeedstream priortovitrification.	**9.1**	3	1	2	2	2	2	3	2	17	35	a	**9.1**
MTW-68	MassSpectrometer(PTR-MS)mountedinamobileanalyticallaboratory (MobileLab)	**9.2**	2	2	3	2	2	1	3	1	16	35	b	**9.2**
MTW-59	ZeolitesforReducingExposuretoNitrosaminesfromTankVapors	**9.3**	2	2	3	2	2	1	2	2	16	35	c	**9.3**
MTW-56	Evaluate&establishinventoryofDirectFeedLowActivityWaste(DFLAW) organicCOPCs	**9.4**	1	3	3	1	2	2	2	2	16	35	d	**9.4**
MW-2	LiquidSecondaryWasteGroutAmmoniaVapor	**10.1**	3	2	2	3	1	1	2	1	15	34	a	**10.1**
MTW-66	TreatNDMAinthetankheadspaceortank-side,wherethereis>48hoursof residencetime	**10.2**	3	1	3	2	2	1	1	2	15	34	b	**10.2**
RTW-54	TankWasteModularTreatmentStudy	**11.1**	1	2	3	3	2	1	1	2	15	33	a	**11.1**
MTW-41	Analyticalmethoddevelopmentatthe222-SLaboratory	**11.2**	1	2	3	2	1	3	2	1	15	33	b	**11.2**
PTW-40	HLWDirectVitrification	**11.3**	1	2	3	3	1	1	3	2	16	33	c	**11.3**
RTW-39	Developastrategyandbasisforanticipatingandpredictingresidualwaste volumesandproperties	**12.1**	1	2	2	3	2	1	3	2	16	32	a	**12.1**
MTW-20	AcquireandtestanupgradedstillandvideocamerasystemforDSTandSST inspections.	**12.2**	1	2	2	2	1	3	3	2	16	32	b	**12.2**
MTW-11	VolumetricInspectionofDSTPrimaryTankBottoms	**13.1**	1	2	1	2	1	3	1	2	13	27	a	**13.1**
MTW-15	VisualInspectionofDSTAirSlotsUsingaRoboticCrawler	**13.2**	1	2	1	2	1	3	1	2	13	27	b	**13.2**
MTW-40	Improvedsamplingmethodsforheadspaceparticulateanalysis	**13.3**	1	1	3	2	1	1	3	1	13	27	c	**13.3**
PTW-44	TechnicalbasisforsRFstorage-lifeexpectancyandCs-removalefficiency overtimeandmethod	**14.0**	1	1	1	2	1	1	3	2	12	22		**14.0**

INFORMATION CLEARANCE REVIEW AND RELEASE APPROVAL

Part I: Background Information

Title: River Protection Project Technology And Innovation Roadmap	Information Category: ☐ Abstract ☐ Journal Article ☐ Summary ☐ Internet ☐ Visual Aid ☐ Software ☐ Full Paper ☐ Report ☑ Other Administrative Document
Publish to OSTI? ☑ Yes ☐ No	

	Yes	NA
Trademark/Copyright "Right to Use" Information or Permission Documentation	☐	☑

Document Number: RPP-PLAN-43988 Revision 3	Date: August 2017
Author: Doug Reid	

Part II: External/Public Presentation Information

Conference Name:	
Sponsoring Organization(s): WRPS Chief Technology Office	
Date of Conference:	Conference Location:
Will Material be Handed Out? ☐ Yes ☑ No	Will Information be Published? ☐ Yes ☑ No *(If Yes, attach copy of Conference format instructions/guidance.)*

Part III: WRPS Document Originator Checklist

Description	*Yes*	*N/A*	*Print/Sign/Date*
Information Product meets requirements in TFC-BSM-AD-C-01?	☐	☑	
Document Release Criteria in TFC-ENG-DESIGN-C-25 completed? (Attach checklist)	☐	☑	
If product contains pictures, safety review completed?	☐	☑	

Part IV: WRPS Internal Review

Function	*Organization*	*Date*	*Print Name/Signature/Date*
Subject Matter Expert	WRPS	01/25/2018	Doug Reid IDMS Data File att.
Responsible Manager	WRPS	08/09/2017	Kayle Boomer IDMS Data File att.
Other:			

Part V: IRM Clearance Services Review

Description	*Yes*	*No*	*Print Name/Signature*
Document Contains Classified Information?	☐	☒	If Answer is "Yes," ADC Approval Required Print Name/Signature/Date
Document Contains Information Restricted by DOE Operational Security Guidelines?	☐	☒	Reviewer Signature: Print Name/Signature/Date
Document is Subject to Release Restrictions? *If the answer is "Yes," please mark category at right and describe limitation or responsible organization below:*	☐	☒	Document contains: ☐ Applied Technology ☐ Protected CRADA ☐ Personal/Private ☐ Export Controlled ☐ Proprietary ☐ Procurement – Sensitive ☐ Patentable Info. ☐ OUO ☐ Predecisional Info. ☐ UCNI ☐ Restricted by Operational Security Guidelines ☐ Other (Specify)
Additional Comments from Information Clearance Specialist Review?	☐	☒	Information Clearance Specialist Approval APPROVED By Janis Aardal at 10:36 am, Feb 05, 2018 Print Name/Signature/Date

When IRM Clearance Review is Complete – Return to WRPS Originator for Final Signature Routing (Part VI)

INFORMATION CLEARANCE REVIEW AND RELEASE APPROVAL

Part VI: Final Review and Approvals

Description	Approved for Release		Print Name/Signature
	Yes	N/A	
WRPS External Affairs	☒	☐	IDMS Data File att. Holloway, Jerry N
WRPS Office of Chief Counsel	☒	☐	IDMS Data File att. Cherry, Steve
DOE – ORP Public Affairs/Communications	☒	☐	IDMS Data File att. Marshall, Richard
Other: ORP SME	☒	☐	IDMS Data File att. Jaschke, Naomi M/Peschong, Jon C
Other: DOE OCC	☒	☐	IDMS Data File att. Stubblebine Scott D/Silberstein, Mark D

Comments Required for WRPS-Indicate Purpose of Document:

The Technology and Innovation Roadmap is a planning tool for WRPS management, DOE ORP, DOE EM, and others to understand the risks and technology gaps associated with the RPP mission. The roadmap identifies and prioritizes technical areas that require technology solutions and underscores where timely and appropriate technology development can have the greatest impact to reduce those risks and uncertainties. The roadmap also serves as a tool for determining allocation of resources.

APPROVED
By Janis Aardal at 10:36 am, Feb 05, 2018

Approved for Public Release;
Further Dissemination Unlimited

Information Release Station

Was/Is Information Product Approved for Release? ☒ Yes ☐ No

If Yes, what is the Level of Releaser? ☑ Public/Unrestricted ☐ Other (Specify) ______

Date Information Product Stamped/Marked for Release: 02/05/2018

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</task>
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- <task name="Doc Owner Clearance Review" id="13" date-due="20170831T0826" date-done="20170905T1220" performer="Douglas J Reid" performer-id="212973731" username="h7908872" disposition="Send On" authentication="true">
<comments>Stephen Cherry discussed the WRPS Legal comment previously with Scott Stubblebine, and also agreed with Ted Wooley that the comment could be incorporated at Rev. 4 since the Rev. 3 deliverable has already been released in SPF/IDMS.</comments>
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<task name="Milestone 1" id="24" date-done="20170905T1221" />
- <task name="ORP Document Reviewer1" id="57" date-due="20170907T1220" date-done="20180118T1523" performer="Richard A Marshall" performer-id="203862915" username="h4535783" disposition="Public Release" authentication="true">
<reviewer performer="Naomi M Jaschke" performer-id="68788398" username="h6764369" />
<reviewer performer="Jon C Peschong" performer-id="12728199" username="h0073309" />
<reviewer performer="Mark D Silberstein" performer-id="158207236" username="h5490246" />
<reviewer performer="Scott D Stubblebine" performer-id="1860658" username="h0022172" />
<reviewer performer="Naomi M Jaschke" performer-id="68788398" username="h6764369" />
<comments>Reviewer's Comments Date: 09/19/2017 07:39 AM Step Name: RPP-PLAN-43988 R3 River Protection Project Technology and Innovation Roadmap Performer: Aardal, Janis (h0090683) Workflow returned, per Richard Marshall (ORP-CIM) 9/19/17 - JD Aardal, Info. Clearance Reviewer's Comments Date: 09/29/2017 03:43 PM Step Name: RPP-PLAN-43988 R3 River Protection Project Technology and Innovation Roadmap Performer: Silberstein, Mark (h5490246) approve Reviewer's Comments Date: 1/17/2018 03:53 PM Step Name: RPP-PLAN-43988 R3 River Protection Project Technology and Innovation Roadmap Performer: Stubblebine, Scott (h0022172) Accept.</comments>

</task>
<task name="Doc Owner Reviews ORP Comments" id="61" date-due="20180119T1547" date-done="20180125T0930" performer="Douglas J Reid" performer-id="212973731" username="h7908872" disposition="Send On" authentication="true" />
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