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Federally Funded Research and Development Center (FFRDC) Team Overview and Approach

Bill Bates
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FFRDC Team Lead

2021 NDAA-3125 Meeting #3

October 20-21, 2021

SRNL-STI-2021-00541

The information in this briefing represents the preliminary draft professional opinions of the FFRDC team, provided for review by the National Academies.

U.S. DEPARTMENT OF ENERGY

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FFRDC Team Status

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- **Matured Description of Alternatives**
- **Developed Framework of Criteria for Comparison of Alternatives**
  - Some Measure of Effectiveness (MOE) still being developed/ refined
  - Cross-walked to ensure consistency with 2021 NDAA-3125
- **Completed Assessment of First Alternative Against Criteria**
  - Some Measures of Effectiveness (MOE) and details being developed
- **Developed Questions for Washington State Department of Ecology**
  - Transmitted on 10/8/21
- **Work in Progress**
  - Continuing Assessment of Alternatives vs. Criteria
  - Developing Cost Estimates
  - Defining Risks and Uncertainties related to technologies and waste form behaviors
  - Drafting some initial sections of report (e.g., alternative descriptions)
  - Addressing Final 2020 NAS Report (2017 NDAA-3134)

The FFRDC Team is sharing preliminary DRAFT information in the interest of stimulating open discussion and to maximize feedback from the NAS Committee.

FFRDC Team Structure

The information in this briefing represents the preliminary draft professional opinions of the FFRDC team, provided for review by the National Academies.

Site Technology Liaison and ORP Decision Framework

Delmar Noyes

Team Leader

Bill Bates †
SRNL

Executive Review Team (ERT)

David Kosson, CRESP
Ken Picha, TechSource

Senior Technical Advisors

Paul Dixon, LANL
Tom Brouns †, PNNL

Grout Team

Matt Asmussen *
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Christine Langton †
SRNL
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Estimating

Gene Ramsey †*
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Alternatives Evaluation Team

Dan McCabe *, SRNL
Pre-Treatment Technologies
David Herman, SRNL
Treatment Alternatives
Mike Stone †, SRNL
Flowsheet & Waste SME
Jim Silk, IDA
Treatment Alternatives
Kevin Brown
CRESP

Decision Framework & Analysis

David Tate *
IDA
Matt Champagney
Parsons

Transport & Offsite Disposal

Paul Shoemaker †*
SNL

RCRA Legal & Regulatory SME

Stephanie Johansen *
PNNL
Jane Stewart
CRESP

†Member of 2017 NDAA-3134 FFRDC Team

*Assessment Area Lead

Added an ERT Member and many "reachback" staff are now engaged

Order of Presentations

The information in this briefing represents the preliminary draft professional opinions of the FFRDC team, provided for review by the National Academies.

- **Bill Bates (SRNL)** — Overview & Status/Intro
- **Michael Stone (SRNL)** — Process Overview
- **Stephanie Johansen (PNNL)** — Regulatory Considerations
- **David Tate (IDA)** — Decision Framework Overview
- **Matt Champagney (Parsons)** — Assumptions & GAO Best Practices
- **Dan McCabe (SRNL)** — Alternative Descriptions & Initial Assessment Status
- **Matt Asmussen (PNNL)** — Long-lived Radionuclide & Contaminant Behaviors in Grout Waste Forms at Hanford
- **William Ramsey (SRNL)** — Cost Estimating Bases and Description
- **Bill Bates (SRNL)** — FFRDC Team Schedule & Wrap Up

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Process Overview

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Alternatives Evaluation Team

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What is Supplemental LAW?

- **Treatment Facility for Treated Supernate from Hanford Tank Waste**
  - Treats LAW when feed rate exceeds the capacity of the WTP-LAW facility
    - *Prevents slowing down HLW treatment due to lack of capacity for LAW treatment*
  - Complete treatment facility (no returns to any sending facility)
    - *Includes any additional pretreatment needed for Supplemental LAW process*
      - LDR Organics
      - Tc-99
      - I-129
    - *Includes processing liquid secondary waste to allow recycle and/or treatment at the Hanford Liquid Effluent Retention Facility / Effluent Treatment Facility (LERF-ETF)*
- **Purely a Conceptual System at the Moment**
  - Many aspects are still TBD
    - *Immobilized waste form*
    - *Capacity*
    - *Location*

WTP-LAW: Two LAW melters
Design Capacity: 15 MT (glass)/day each

Footprint – 330 ft x 240 ft x 90 ft
Concrete – 28,500 cubic yards
Structural Steel – 6,200 tons
Craft hours to build: 2,337,000

Overall Tank Waste Treatment Flowsheet

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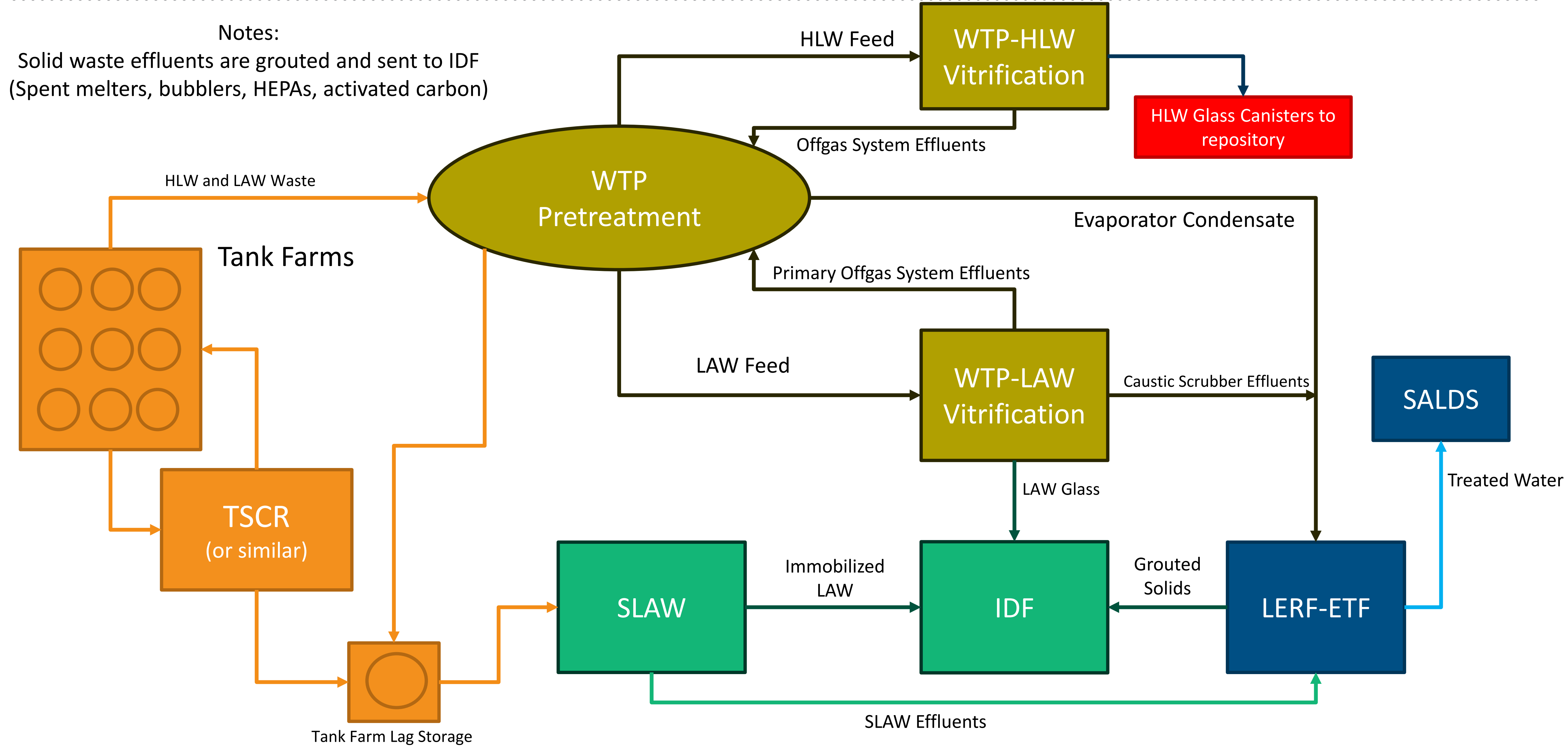

Common View of Mission Progress: SP9 Treatment Progress

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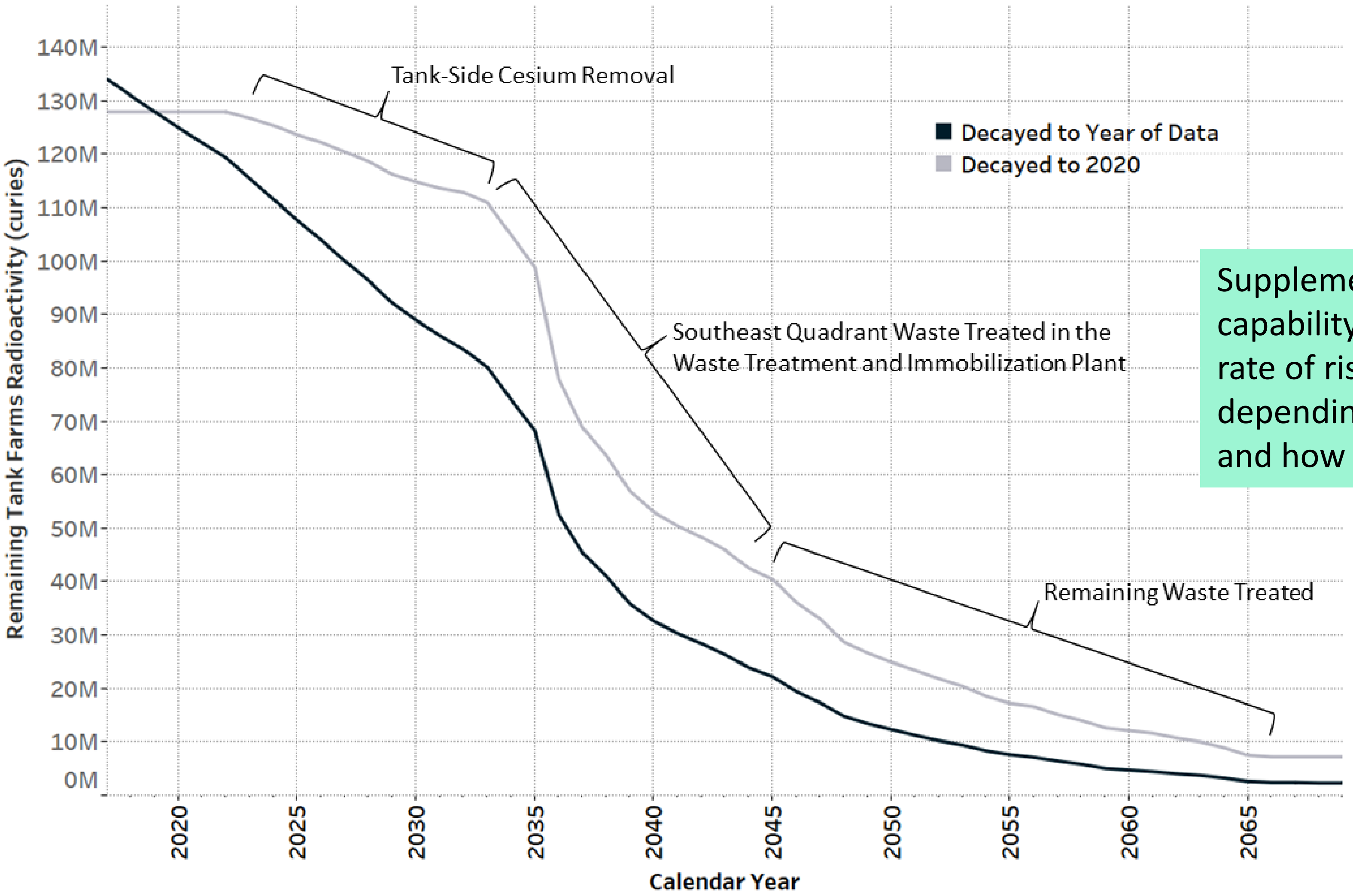
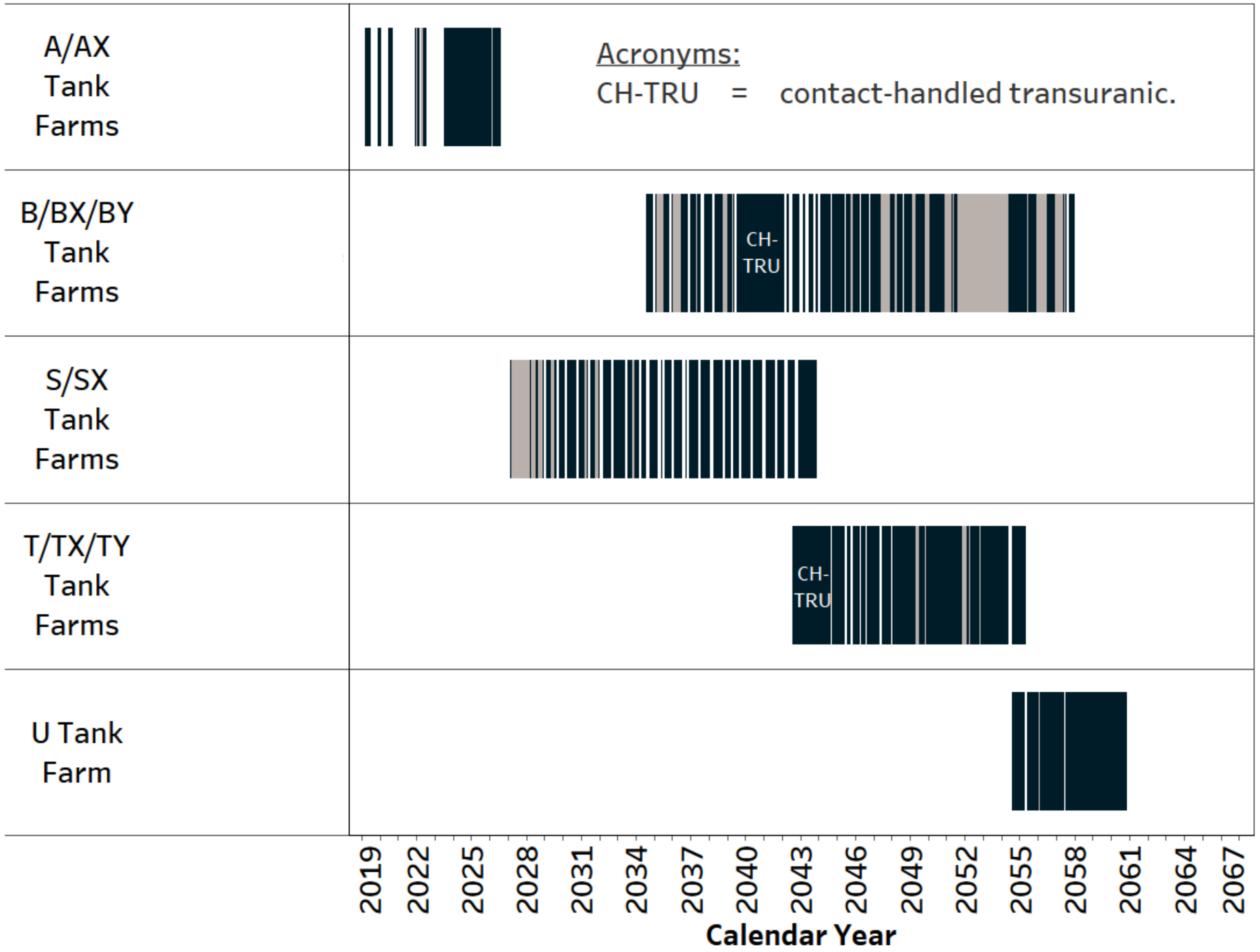


Provided by WRPS System Planning

Supplemental LAW capability impacts rate of risk reduction, depending on when and how employed

Common View of Mission Progress: SP9 Timing of SST Retrievals



Provided by WRPS System Planning

This is a measure of progress as function of retrievals, geography, and feed delivery. Supplemental LAW alternatives will be formed and analyzed as regards cost and progress.

Flowsheet Overview: Significant Changes from 2017 NDAA Evaluation of SLAW

- **Process based on System Plan 9 (assumes vitrification)**
  - Previous study used System Plan 8
- **AP tank farm tank used to stage and deliver LAW and SLAW feed**
- **Total Operating Efficiency (TOE)**
  - System Plan 8 and 9 assume 70%
  - Some recent studies of the WTP flowsheet have assumed 50% or 40%
    - *Based on TOE of comparable facilities*
      - Defense Waste Processing Facility, West Valley Demonstration Project, others
    - *Increases number of melters needed for SLAW for vitrification option*
      - Four assumed in System Plan 8 and 9
      - Seven SLAW melters required at 40%
- **ETF**
  - Capacity of LERF-ETF exceeded by SLAW effluents
    - New LERF-ETF required
  - Existing LERF-ETF assumed adequate in previous study

- **I-129 in Glass**
  - Increased uncertainty of iodine capture of in glass
    - *Estimates of glass capture range from <20% to 96%*
    - *Single pass capture is expected to be low*
    - *The high uncertainty results in differences in the assumed I-129 capture in the primary offgas system*
      - Condensate from the primary offgas system is evaporated and recycled to the melter feed
  - The caustic scrubber in secondary offgas treatment system is expected to capture most of the iodine not captured in glass
    - *Some I-129 capture could occur in other unit operations*
    - *Uncertainty in iodine capture in secondary offgas system also has high uncertainty*
    - *The baseline assumes the material is transferred directly to LERF/ETF for treatment*
      - ETF can treat the I-129, but inventory limits for I-129 could be exceeded in ETF
      - I-129 will be sent to IDF in grouted solids from the ETF
  - Operation of WTP-LAW will reduce the uncertainty for a SLAW vitrification process
  - Potential mitigation measures to address
    - *Recycle the caustic scrubber effluents to the SLAW feed with the primary offgas condensate*
    - *Sodium in the scrubber effluent would reduce the amount of waste sodium in glass*
    - *Evaluate ferrous oxalate as a glass forming chemical to increase I-129 capture in glass*
    - *Evaluate changes needed to allow the LERF-ETF process to treat the I-129 in the caustic scrubber effluents*

SLAW Treatment Capacity

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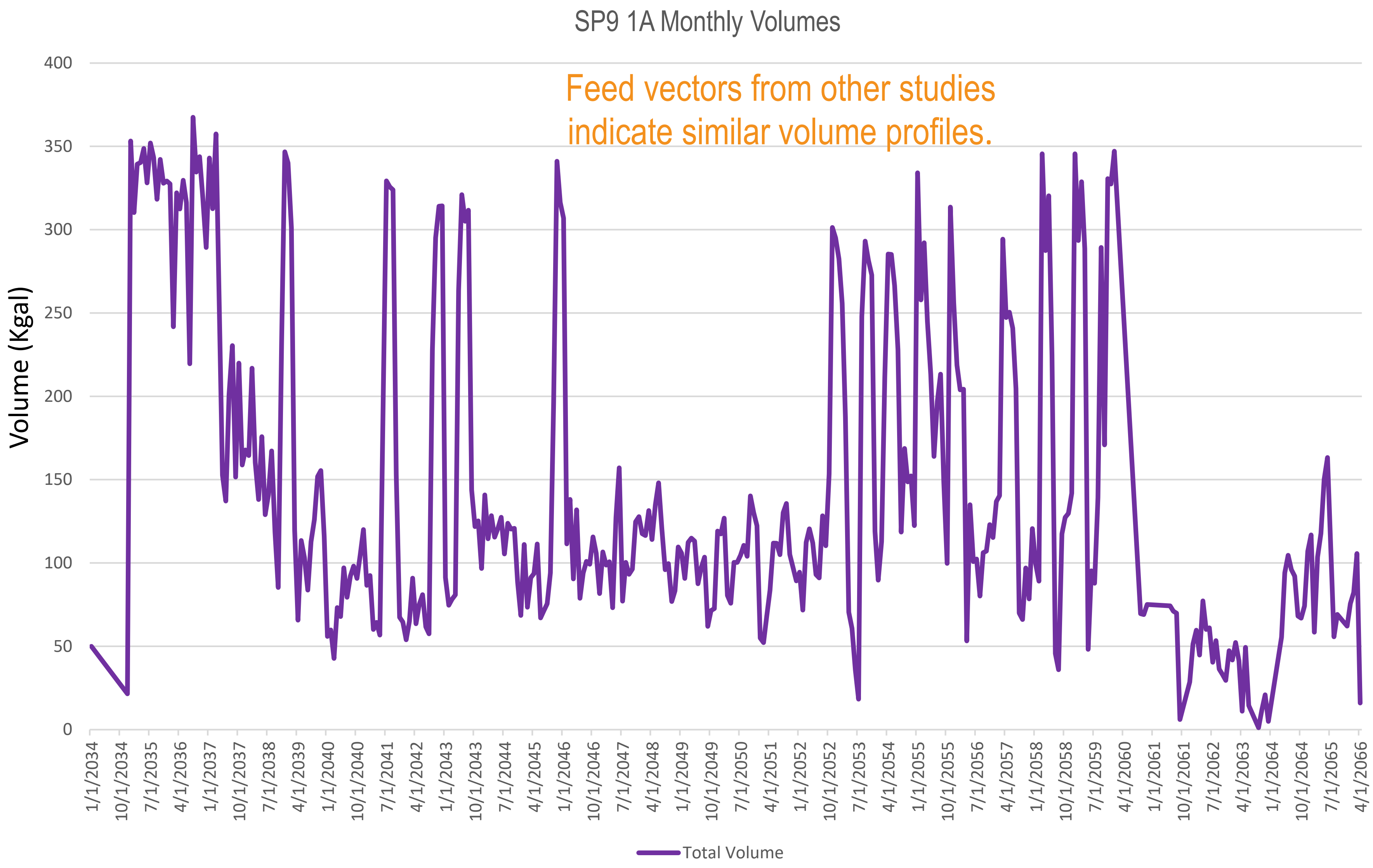

Overall waste volume determines needed capacity for grout facility

System Plan 8
Max: 370,000 gal/month
Ave: 160,000 gal/month
Min: 7,200 gal/month
Total: 54,000,000 gallons
Turndown: 50:1

System Plan 9 1A
Max: 367,000 gal/month
Ave: 145,000 gal/month
Min: 1,100 gal/month
Total: 52,000,000 gallons
Turndown: 300:1

System Plan 9 1B
Max: 264,000 gal/month
Ave: 114,000 gal/month
Min: 700 gal/month
Total: 57,000,000 gallons
Turndown: 370:1

SLAW Treatment Capacity

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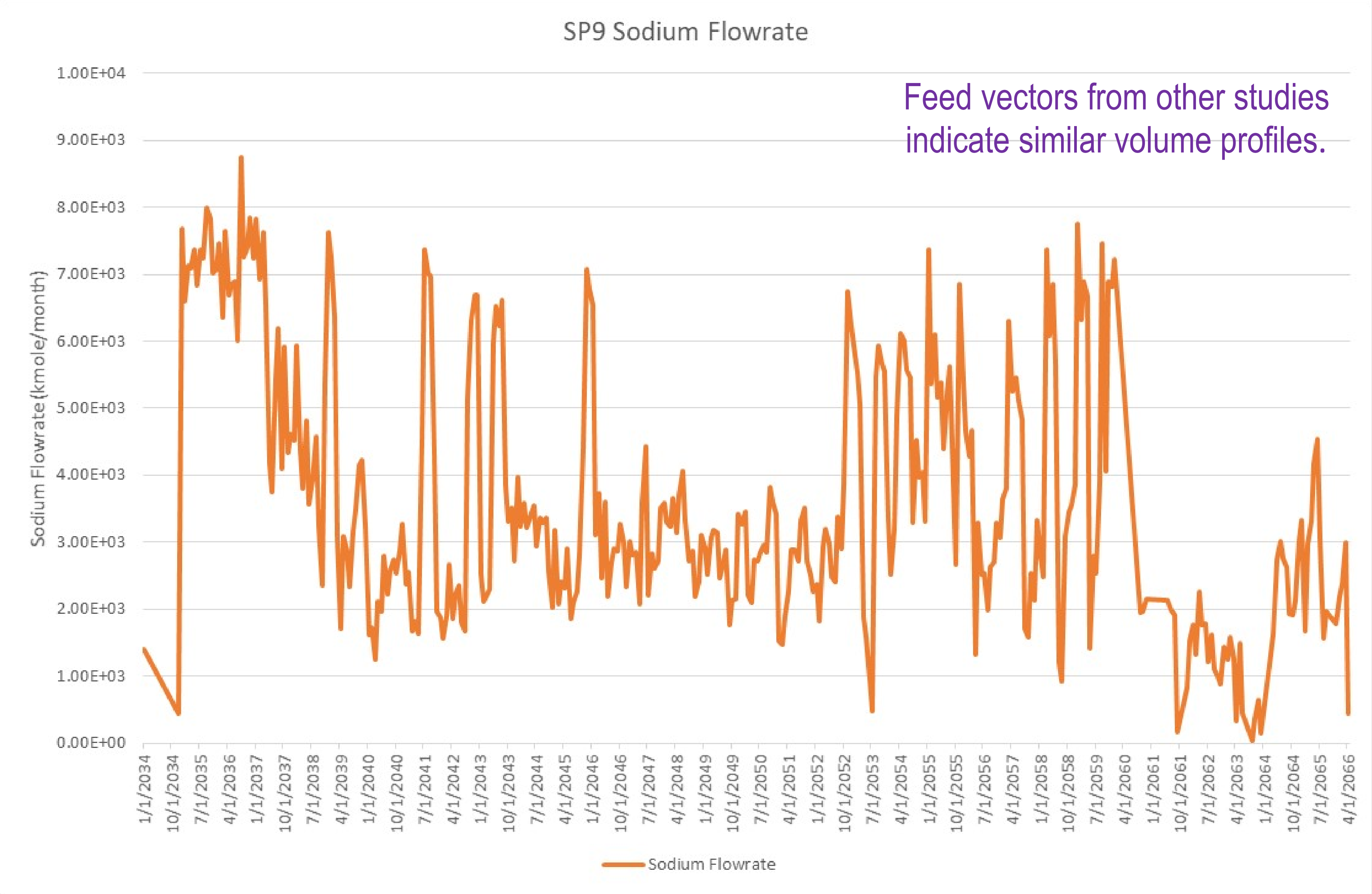
- Waste sodium determines needed capacity for vitrification process
- One melter can treat 40 to 80 MT of sodium/day depending on waste loading and operating efficiency

System Plan 8
Max: 296 MT/month
Ave: 138 MT/month
Min: 8 MT/month
Total: 47,000 MT

System Plan 9 1A
Max: 271 MT/month
Ave: 113 MT/month
Min: 1 MT/month
Total: 40,000 MT

System Plan 9 1B
Max: 195 MT/month
Ave: 87 MT/month
Min: 1 MT/month
Total: 43,000 MT



Radionuclides of Concern in SLAW

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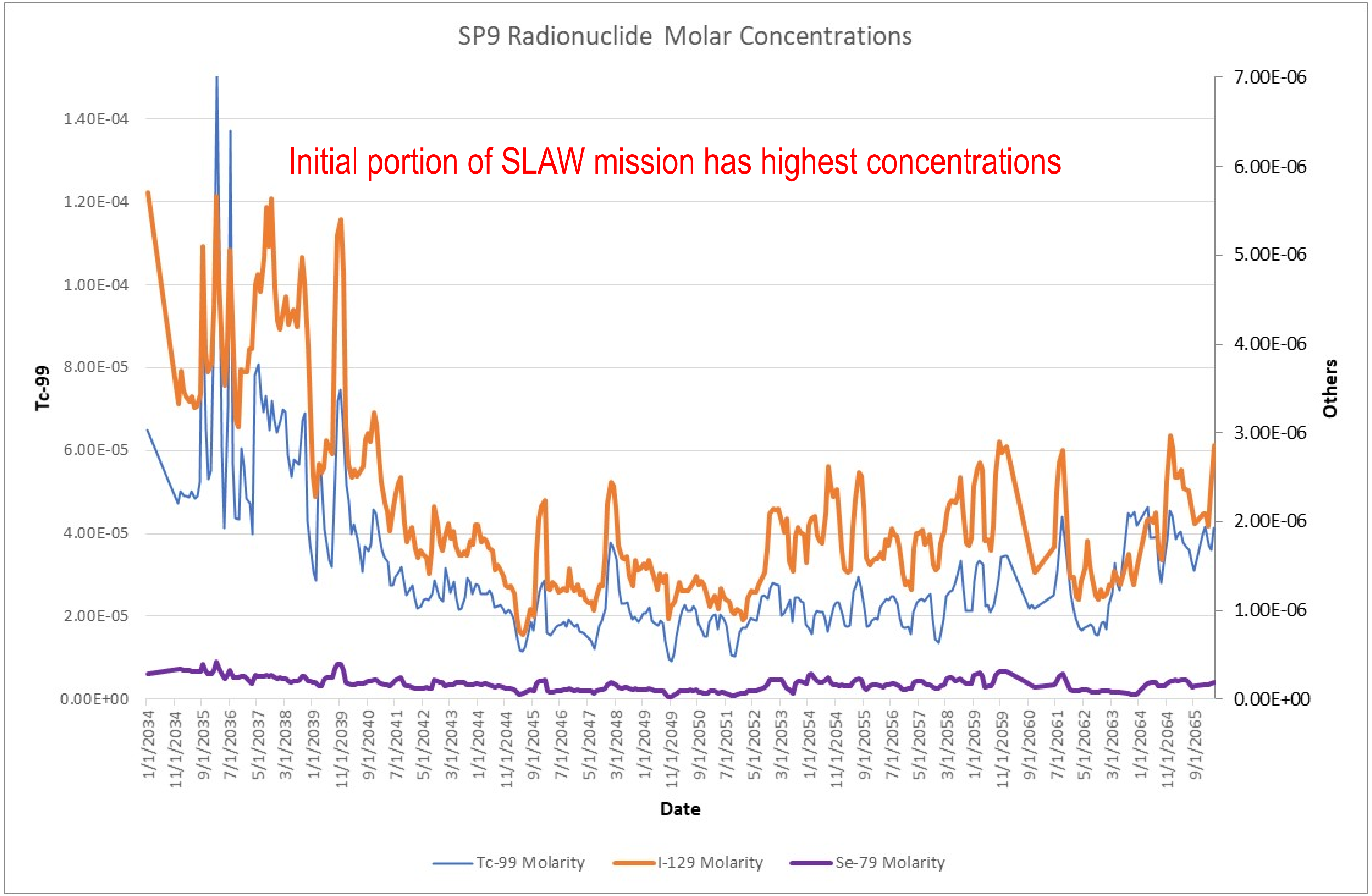
- The IDF Performance Assessment identified Tc-99 and I-129 as the constituents that were most likely to challenge groundwater protection performance standards
- Se-79 also included on chart based on comments received on 2017 evaluation of SLAW



Feed vectors from other studies indicate similar profiles.

Vitrification Flow Diagram

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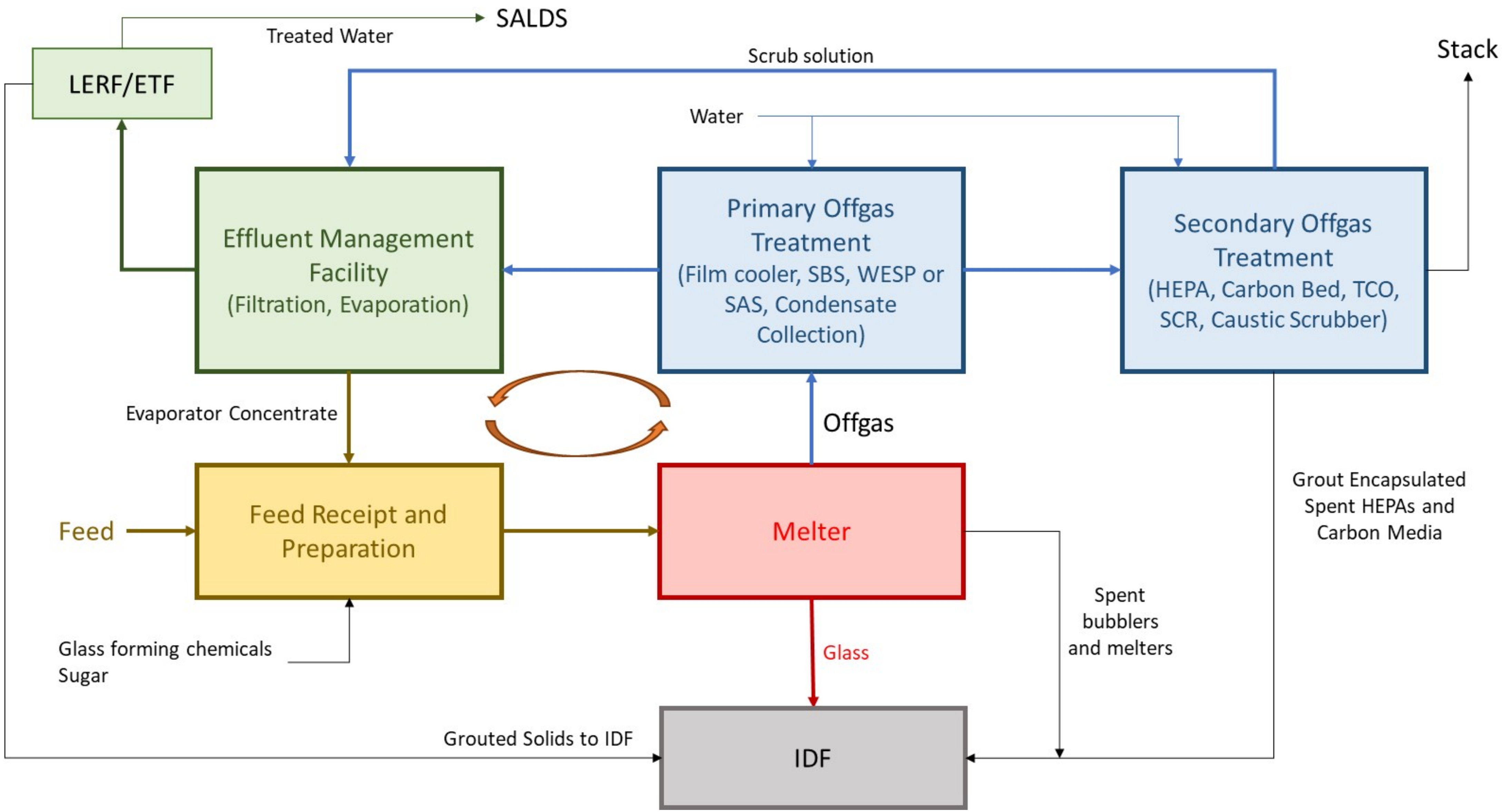

Semi-volatile Flywheel in Combined WTP-LAW/SLAW Operations

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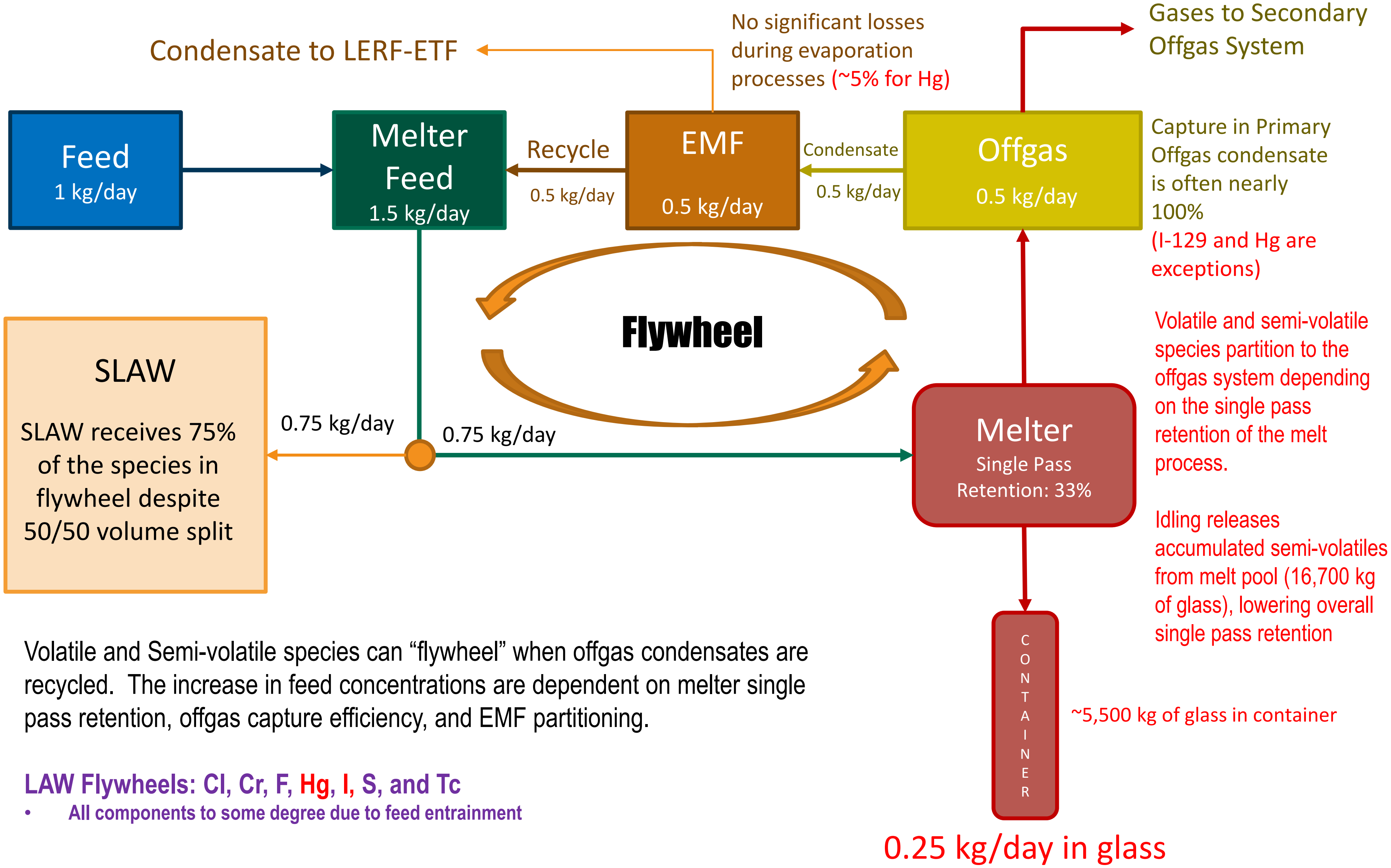
Graphic illustrates the path through the process for 1 kg of a semi-volatile component, such as Tc, in the feed.

WTP-LAW flywheel is intentional to force Tc-99 into glass



Volatile and Semi-volatile species can "flywheel" when offgas condensates are recycled. The increase in feed concentrations are dependent on melter single pass retention, offgas capture efficiency, and EMF partitioning.

LAW Flywheels: Cl, Cr, F, Hg, I, S, and Tc

- All components to some degree due to feed entrainment

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Regulatory Considerations

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FFRDC Approach

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Activity	Previously included in 3134 scope	In process	Future Action
Identify Applicable Regulations	X	X	
Consult with Interested Parties		X	
Identify Current Regulatory Framework	X	X	
Evaluate Regulatory Aspects that the 3134 Study Identified as a Significant Factor	X	X	
Develop strategies to move alternatives forward	X		X

Underlying Principles:

- **Address regulatory landscape and potential approaches**
- **Not make compliance determinations**

Regulatory Context

- **Tank Waste is Mixed Radioactive Waste Regulated Under the Resource Conservation and Recovery Act (RCRA) as well as the Atomic Energy Act (as Implemented by Department of Energy Orders 435.1, Radioactive Waste Management).**
- **The Washington Department of Ecology is Granted Authority from EPA to Implement the RCRA Regulations in Washington.**
- **The Tri Party Agreement (TPA) is a Comprehensive Cleanup and Compliance Agreement Between DOE, EPA, and Ecology that Defines and Ranks CERCLA and RCRA Cleanup Commitments and Establishes Enforceable Schedule Milestones.**
  - The TPA is also known as the Hanford FFCA – Federal Facility Agreement and Consent Order.
- **Storage and Treatment of Hanford Tank Waste is Conducted Onsite at Treatment, Storage, and Disposal Facilities (TSDFs) that have RCRA Permits Issued by Ecology.**

Consultations with Interested Parties

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- **Met with DOE and Hanford Site Contractors**
  - Discussions regarding current regulatory framework for the Waste Treatment Plant and Test Bed Initiative
- **Met with EPA HQ**
  - Discussions regarding Land Disposal Restrictions
- **Provided Written Questions to WA Department of Ecology**
  - Asked for Ecology position on various issues related to treatment of Supplemental Low Activity Waste

Applicable Regulations

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Regulation	Lead Regulatory Agency	Listed in 3125 via reference from 3134	3134 Study Identified as a Significant Factor
Resource Conservation and Recovery Act of 1976 (RCRA) (including Land Disposal Restrictions) *(42 U.S.C. 6901 et seq.)*	Ecology	Yes	Yes
Tri Party Agreement (TPA) - *Hanford Federal Facility Agreement and Consent Order*	Ecology/EPA/DOE	No	Yes
National Primary Drinking Water Regulations (*40 CFR Part 141*) (adopted in WAC 246-290, "Group A Public Water Supplies")	EPA	No	Yes
Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) *(42 U.S.C. 9601 et seq.)*	EPA/Ecology	Yes	No
Clean Air Act *(42 U.S.C. 7401 et seq.)*	Ecology/WDOH	Yes	No

Applicable Regulations, cont'd

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Regulation	Lead Regulatory Agency	Listed in 3125 via reference from 3134	3134 Study Identified as a Significant Factor
Clean Water Act *(33 U.S.C. 1251 et seq.)*	Ecology	Yes	No
Atomic Energy Act/DOE Order 435.1	DOE	No	No
US. Department of Transportation Regulations for Class 7 (Radioactive) Materials (*49 CFR 173 Subpart I*)	DOT	No	No
Licensing Requirements For Land Disposal Of Radioactive Waste (*10 CFR 61*) (applies to commercial disposal facilities)	NRC	No	No
Commercial Disposal Facility Permit Requirements and Waste Acceptance Criteria	Various	No	No

Current RCRA Regulatory Framework for Onsite Treatment

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- **Vitrification**
  - LAW currently permitted for treatment at WTP
  - Vitrified waste forms permitted for disposal onsite at IDF
  - Permit modification request for IDF disposal of WTP secondary waste is in process
    - *Ecology's Draft Permit is out for Public comment*

Current RCRA Regulatory Framework for Onsite Treatment– cont'd

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- **Grouting – ORP's Test Bed Initiative**
  - Phase 1
    - *Conducted in 2017*
    - *Pre-treated 3 gallons of tank waste onsite under a **RCRA Treatability Study**;*
    - *Grouting was conducted offsite at a permitted TSDF*
    - *The grouted waste form was disposed offsite at a permitted TSDF*
  - Phase 2
    - *Planned future work*
    - *Plan to pre-treat 2,000 gallons of tank waste using an **RD&D permit**;*
    - *Plan to grout waste offsite at a permitted TSDF*
    - *Plan to dispose of the grouted waste form offsite at a permitted TSDF*

Current RCRA Regulatory Framework for Onsite Treatment– cont'd

- **Disposal of Grouted Waste Forms**
  - Permit modification request for IDF disposal of secondary solid waste in a cementitious (grouted) waste form from ETF is in process. (Ecology's Draft Permit is out for Public comment 09/13/21-10/28/21)
- **Applicability of HLVIT Land Disposal Restrictions (LDR) Treatment Standard**
  - DOE stated their position regarding applicability of HLVIT to Hanford tank waste processed through the vit plant in the transmittal letter (07/21/17) for the LDR Treatability Variance Petition for Hanford Tank Waste (https://pdw.hanford.gov/document/0069108H)
  - Ecology has recently stated their position regarding applicability of HLVIT to Hanford tank waste in comments (09/03/21) on the draft Environmental Assessment for TBI (https://pdw.hanford.gov/document/AR-15639)

Current TPA Framework (https://www.hanford.gov/files.cfm/HFFACO.pdf)

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- **Vitrification**
  - M-062 milestone series reflects vitrification of SLAW, also includes M-062-45 for selection of supplemental treatment.
- **Steam Reforming and Grouting**
  - M-062-45 item 3 requires the parties to negotiate "Supplemental treatment selection (a one-time selection to be made not later than April 30, 2015) and milestones, which must be consistent with M-062-00 as established by M-062-45 item #5. A 2nd LAW Vitrification Facility must be considered as one of the options."

    (Ecology and DOE have not reached agreement on this milestone, and are following Article VIII of the TPA, "Resolution of Disputes")

- **Disposal of Grouted Waste Forms**
  - IDF Performance Assessment indicates that all predicted results from the deterministic models are well below the Maximum Contaminant Levels (MCLs) for the 1,000-year compliance period
  - IDF Performance Assessment indicates a potential for exceedance of MCLs in the post-compliance period (1,000-10,000 years after closure) due to contributions from secondary waste
  - For the study, the team plans to address this in the context of long-term impacts

Other Regulations

Regulation	Discussion
Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) *(42 U.S.C. 9601 et seq.)*	Tank waste is regulated under RCRA; CERCLA is not applicable to treatment and disposal operations.
Clean Air Act *(42 U.S.C. 7401 et seq.)*	Abated radioactive and toxic air emissions associated with proposed alternatives are similar to those already permitted on the Hanford site.
Clean Water Act (CWA) *(33 U.S.C. 1251 et seq.)*	Wastewater sources associated with the proposed alternatives are similar to those already permitted on the Hanford site.
Atomic Energy Act/DOE Order 435.1	All waste forms associated with the proposed alternatives are expected to meet WIR criteria and meet DOE performance requirements. Aspects of long-term waste form performance and uncertainty are addressed in the context of long-term impact.

Other Regulations Cont'd

Regulation	Discussion
US. Department of Transportation Regulations for Class 7 (Radioactive) Materials (*49 CFR 173 Subpart I*)	Radioactive waste that would be transported offsite is similar to waste that is routinely transported from DOE facilities to disposal sites.
Licensing Requirements For Land Disposal Of Radioactive Waste (*10 CFR 61*)	Alternatives consider offsite disposal facilities that have existing licenses.
Disposal Facility Waste Acceptance Criteria	Proposed waste forms for the alternatives comply with existing Waste Acceptance Criteria for offsite disposal facilities.

Future Actions

- **For Alternatives that are Evaluated Favorably by the FFRDC Team, Assess Potential Regulatory Pathways to Support Implementation. Elements that may be Considered Include:**
  - Permitting (including supporting documentation such as Determination of Equivalent Treatment, site-specific treatability variance, or no-migration petition)
  - Rulemaking
  - Changes to the TPA

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Decision Framework Overview

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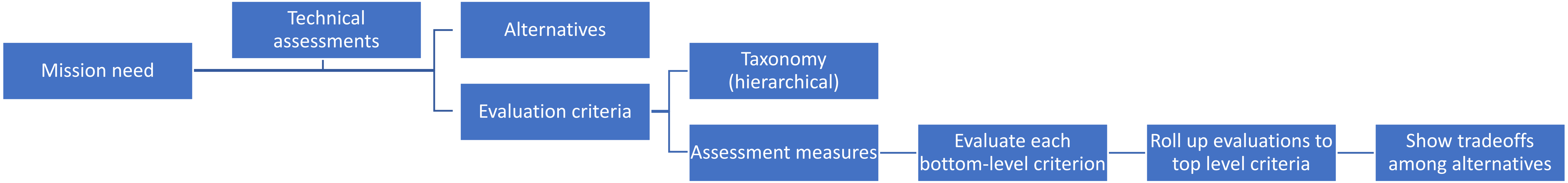
Decision Framework

- **Overall Goal: "…to Provide Decisionmakers with the Ability to Make a Direct Comparison Between Approaches for the Supplemental Treatment of Low-Activity Waste […] Based on Criteria that are Relevant to Decision-Making and Most Clearly Differentiate Between Approaches." (FY21 NDAA, Section 3125 (B))**
- **Analytical Approach: Hierarchical Decomposition and Recomposition**
  - Identify technically feasible alternatives
  - Choose top-level decision criteria to be directly compared
  - Analyze hierarchy of underlying factors affecting these criteria
  - Establish measures of effectiveness (MOE) for fundamental factors
  - Evaluate each fundamental factor according to its MOE for each alternative
  - Roll up low-level evaluations to higher-level assessments
  - Show explicit criterion tradeoffs among alternatives



Hierarchical Taxonomy of Decision Criteria

- **Intended to Capture All Factors of Potential Relevance to Decision Makers in a Way that Makes the High-Level Tradeoffs Between Alternatives as Clear as Possible**
- **Incorporates All Statutory Factors from Section 3134 (2017) and Section 3125 (2021)**
  - Some explicitly, some implicitly – crosswalk will be included in the final report
- **Includes both Technical and Non-technical Factors**
- **Includes Both Assessment of Designed Performance and Assessment of Shortfall Risks**
- **Top Level Criteria are Patterned After NEPA / RCRA / CERCLA / AEA (DOE 435.1) Decision Factors**
  - Familiar to decision makers
  - Already similar to NDAA-specified list of factors to consider
  - Explicitly cited as information of interest in FY2017 Section 3134 language
  - Show key tradeoffs (e.g., performance vs. implementability) at the top level

Level 1 and 2 Taxonomy of Criteria to Be Assessed for Each Alternative

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1. **Long-Term Effectiveness if Successful**
    1. Residual threat to health and environment upon successful completion
    2. Long-term risks upon successful completion
2. **Short-Term Effectiveness and Risk**
    1. Risks to humans during execution
    2. Risks to the environment during execution
    3. Time needed to execute (including risk of delay)
3. **Implementability**
    1. Likelihood and consequences of failure to succeed due to technical problems
    2. Likelihood and consequences of failure to succeed due to resource shortfall
    3. Likelihood and consequences of failure to succeed due to external factors
4. **Life Cycle Costs**
    1. Capital project costs, commissioning, Hanford operations, offsite operations, decommissioning and disposal
5. **Community / Public acceptance**

Examples of Lowest-Level Criteria and Associated Measures

- **1.1.2.1.1: Mobility of Iodine to a Groundwater Source at Disposal Site, Given Successful Completion**
  Measure: Estimated Peak Concentration and Approximate Time to Reach Peak
- **1.2.1.4.1: Confidence in Estimated Residual Toxicity of Mercury in the Wasteform**
  Measure: Half-Width of Error Bars in Model Estimate vs. Margin Under Current Health/Regulatory Standard
- **3.1.1.1.5: Process Complexity**
  Measure: Count of Unit Operations with SME-Assessed Complexity (Scale Of 1-10) for Each
- **3.2.2 Risk of Unaffordability Due to Peak Spending Level Required**
  Measure: Peak Estimated Annual Cost vs. Assumed Annual Budget

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Assumptions & GAO Best Practices

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Decision Framework & Analysis SME

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Assumptions for Analysis

- **All Alternatives are Defined to Achieve a Minimum SLAW Treatment Rate of 375 Kgal/Month and Total Volume of 57mgal**
- **All Alternatives will Address Permanent Disposition of All SLAW**
- **Low Activity Waste (LAW) is Pretreated in Tank Farm Pretreatment (TFPT) (~TSCR)**
  - To remove ^{137}Cs to WTP equivalent (<3.18E-5 Ci/Mole Na^+)
  - Does not preclude treatment in WTP Pretreatment Facility
  - Spent CST columns are stored onsite in interim storage and assumed vitrified in the HLW Facility.
- **TFPT Treatment Removes ^{90}Sr to Class A (<0.04 Ci/m^3 and Pu To <100 nCi/g) For Most (~90%) LAW Feed**
  - Treatment in WTP pretreatment facility would not reach these limits
- **LAW is Retrieved and Staged for Pretreatment in a Double Shell Tank (DST) (Except for Alternatives Grout 4 and 5)**
- **LAW is Sampled and Analyzed/Tested to Ensure a Compliant Waste Form will be Produced**
- **Pretreated LAW will be Evaporated to Reach Optimum Na^+ Concentration**
- **Land Disposal Restriction (LDR) Organics will be Removed from LAW by Evaporation (and Oxidation, if Needed) to Beneath Regulatory Levels or Waste will be Sent for Vitrification**
- **All Debris/Solid Waste is Disposed Onsite in the IDF Except Alternatives Grout 5A and B**

Assumptions for Analysis, cont'd

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- **Funding will be Constrained to an Annual Budget**
- **All Alternatives will Include Necessary Transfer, Storage, Processing, and Disposition Facilities And Projects**
- **For Grout Alternatives, "Getters" for ^{129}I (and perhaps ^{99}Tc) are Included in Grout Formulations for Alternatives Grout 1-5 but are not Needed for Offsite Disposal**
- **LAW Immobilized by Grouting or Steam Reforming can be Disposed of On Site in the IDF**
  - Enabling assumption to avoid restrictive screening of alternatives
- **LAW Immobilized by Grouting or Steam Reforming can be Disposed of Offsite Provided the WAC for Those Locations is Met**
- **Off-Site Grout Facilities will have Adequate Capacity for Treatment (Grouting) of LAW within 6 Months of start of HLW Treatment**
  - Applies to Alternatives Grout 5A and 5B only
- **All Alternatives that Include Offsite Shipment Assume DOT Compliant Shipping Containers are Utilized**
- **Permits can be Obtained in a Timely Fashion to Meet the Schedule**
- **The IDF can be Expanded to Accommodate the Needed Volume of Immobilized LAW; Costs and Risks of IDF Expansion will be Assessed Where Applicable**

GAO Best Practices for Analysis of Alternatives

Step	Phase I: Initialize the AoA Process
1	Define mission need. The customer defines the mission need without a predetermined solution.
2	Define functional requirements. The customer defines functional requirements based on mission need without a predetermined solution.
3	Develop AoA time frame. The customer provides the team conducting the analysis enough time to complete the AoA to ensure a robust and complete analysis.
4	Establish AoA Team. This team consists of members with a variety of necessary skill sets, specific knowledge, and abilities to successfully execute the study.
5	Define selection criteria. The AoA Team or the decision maker defines selection criteria based on the mission need. The defined criteria are based on mission needs and are independent of a particular capital asset or technological solution.
6	Weight selection criteria. The AoA Team or the decision maker weights the selection criteria to reflect the relative importance of each criterion.
7	Develop AoA process plan. The AoA Team creates a plan to include proposed methodologies for identifying, analyzing, and selecting alternatives prior to beginning the AoA process.

GAO Best Practices for Analysis of Alternatives, cont'd

The information in this briefing represents the preliminary draft professional opinions of the FFRDC team, provided for review by the National Academies.

Step	Phase II: Initialize the AoA Process
8	Develop list of alternatives. The AoA Team identifies and considers a diverse range of alternatives to meet the mission need.
9	Describe alternatives. The AoA Team describes alternatives in enough detail to allow robust analysis.
10	Include baseline alternative. The AoA Team includes one alternative to represent the status quo to provide a basis of comparison among alternatives.
11	Assess alternatives' viability. The AoA Team screens the list of alternatives to eliminate those alternatives that are not viable, and it documents the reasons for eliminating any alternatives.

GAO Best Practices for Analysis of Alternatives, cont'd

Step	Phase III: Analyze Alternatives
12	Identify significant risks and mitigation strategies. The AoA Team identifies and documents the significant risks and mitigation strategies for each alternative.
13	Determine and quantify benefits/effectiveness. The AoA Team uses a standard process to document the benefits and effectiveness of each alternative.
14	Tie benefits/effectiveness to mission need. The AoA Team explains how each measure of effectiveness supports the mission need.
15	Develop life-cycle cost estimates (LCCEs). The AoA Team develops an LCCE for each alternative, including all costs from inception of the project through design, development, operation, maintenance, and disposal.
16	Include confidence interval or range for LCCEs. The AoA Team presents the LCCE for each alternative with a confidence interval or range, and not solely as a point estimate.
17	Perform sensitivity analysis. The AoA Team tests and documents the sensitivity of the cost and benefit and effectiveness estimates for each alternative to risks and changes in key assumptions.

GAO Best Practices for Analysis of Alternatives, cont'd

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Step	Phase IV: Document & Review the AoA
18	Document AoA process in a single document. The AoA Team documents all steps taken to identify, analyze, and select alternatives in a single document.
19	Document assumptions and constraints. The AoA Team documents and justifies all assumptions and constraints used in the AoA process.
20	Ensure AoA process is impartial. The AoA Team conducts the analysis without a predetermined solution. The AoA process informs the decision-making process rather than reflecting the validation of a predetermined solution.
21	Perform an independent review. An entity independent of the AOA process reviews the extent to which all best practices have been followed.
22	Compare alternatives. The AoA Team or the decision maker compares the alternatives using PV, if possible, to select a preferred alternative.

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Alternative Descriptions & Initial Assessment Status

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Alternatives Evaluation Team Lead

SRNL-STI-2021-00541

2021 NDAA-3125 Meeting #3

October 20-21, 2021

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- **Identified Technically Feasible Alternatives**
  - Generally extended/expanded on alternatives in NDAA17 report
  - Drafted flowsheet schematics and descriptions
  - Descriptions contain sufficient detail for scoring along with auxiliary information
  - Obtain input from Subject Matter Experts, as needed
  - Identified variants (~minor modification of major alternatives)
    - *may evolve into alternatives*
- **Identified Underlying Factors for Taxonomy**
- **Identified Measures of Effectiveness (MOEs) for Differentiating Factors**
  - Refine MOEs as needed
- **Obtain Information From Existing/Developing Documents**
- **Team Assess *("Scores")* Each Factor with Justification/Explanation**

Current Alternatives

The information in this briefing represents the preliminary draft professional opinions of the FFRDC team, provided for review by the National Academies.

Alternative	Brief Description	Cross-site transfer required for alternatives	Utilize existing DSTs	Disposal	Container
Vitrification	Vitrification	X	X	Onsite	X
Fluidized Bed Steam Ref-A	Steam Reform	X	X	Onsite	X
Fluidized Bed Steam Ref-B	Steam Reform	X	X	Offsite	X
Grout-1	Single plant	X	X	Onsite	X
Grout-2	Single plant	X	X	Offsite	X
Grout-3A	Separate plants East-West		X	Onsite	X
Grout-3B	Separate plants East-West		X	Offsite	X
Grout-4A	Individual plants (farms/tanks)			Onsite	X
Grout-4B	Individual plants (farms/tanks)			Offsite	X
Grout-5A	Offsite vendor			Onsite	X
Grout-5B	Offsite vendor			Offsite	X
Grout-6	Onsite monolith	X	X	Onsite	
Variant Grout-1B.	Grout 1 + Tc/I removal	NA	NA	Onsite	X
Variant Grout 3C	Grout 3 + Tc/I removal		X	Onsite	X
Variant Grout 1C	Grout 1 + Sample Tc/I/send offsite/onsite	X	X	Onsite	X
Variant Grout 3D	Grout 3 + Sample Tc/I/send offsite/onsite		X	Onsite	X

Preliminary Alternative Vitrification (onsite) Flowsheet

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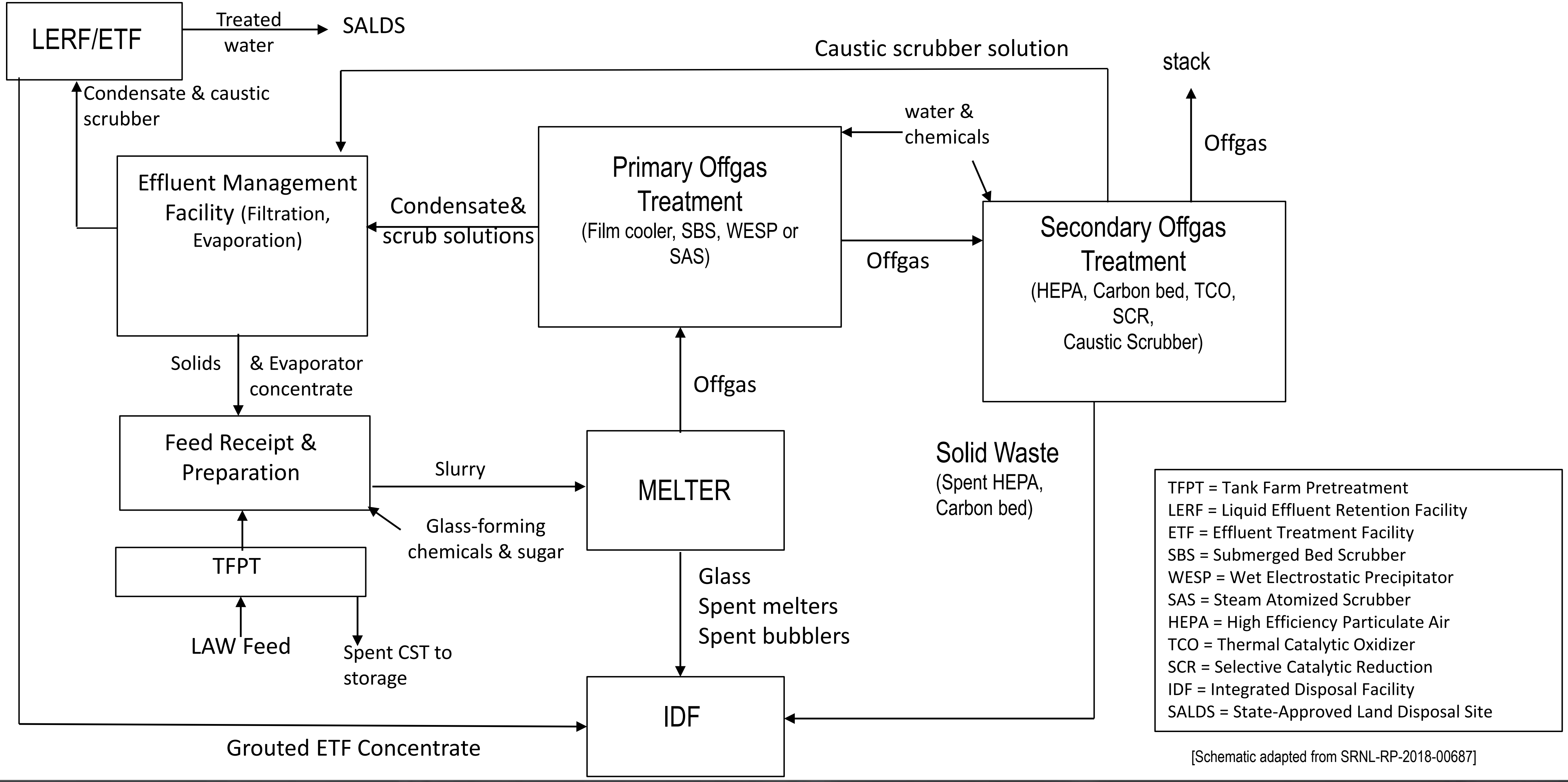

[Schematic adapted from SRNL-RP-2018-00687]

Preliminary Simplified Alternative FBSR 1A (onsite) Flowsheet

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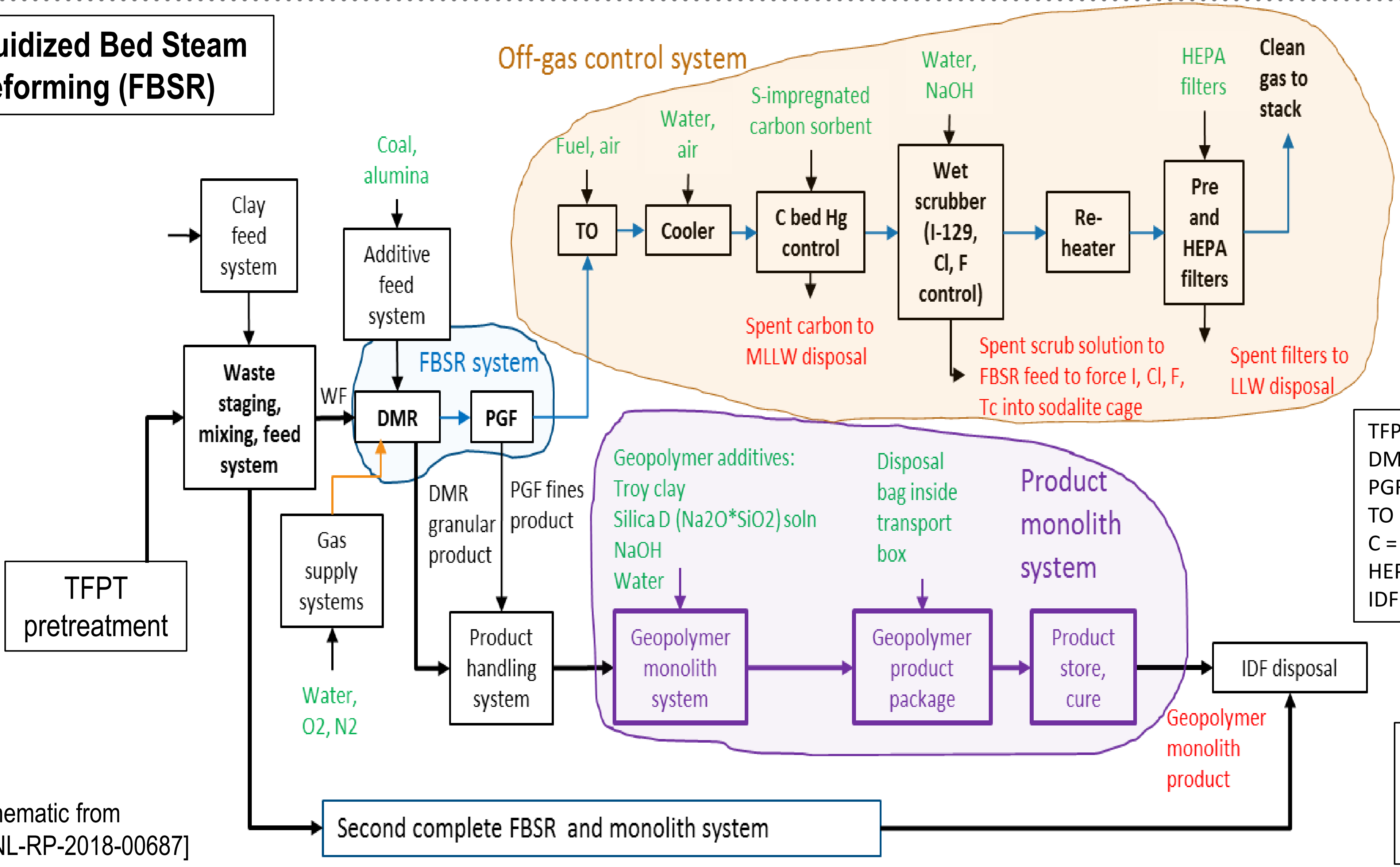
Fluidized Bed Steam Reforming (FBSR)



TFPT = Tank Farm Pretreatment
DMR = Denitration & Mineralizing Reformer
PGF = Process Gas Filter
TO = Thermal Oxidizer
C = Carbon
HEPA = High Efficiency Particulate Air
IDF = Integrated Disposal Facility

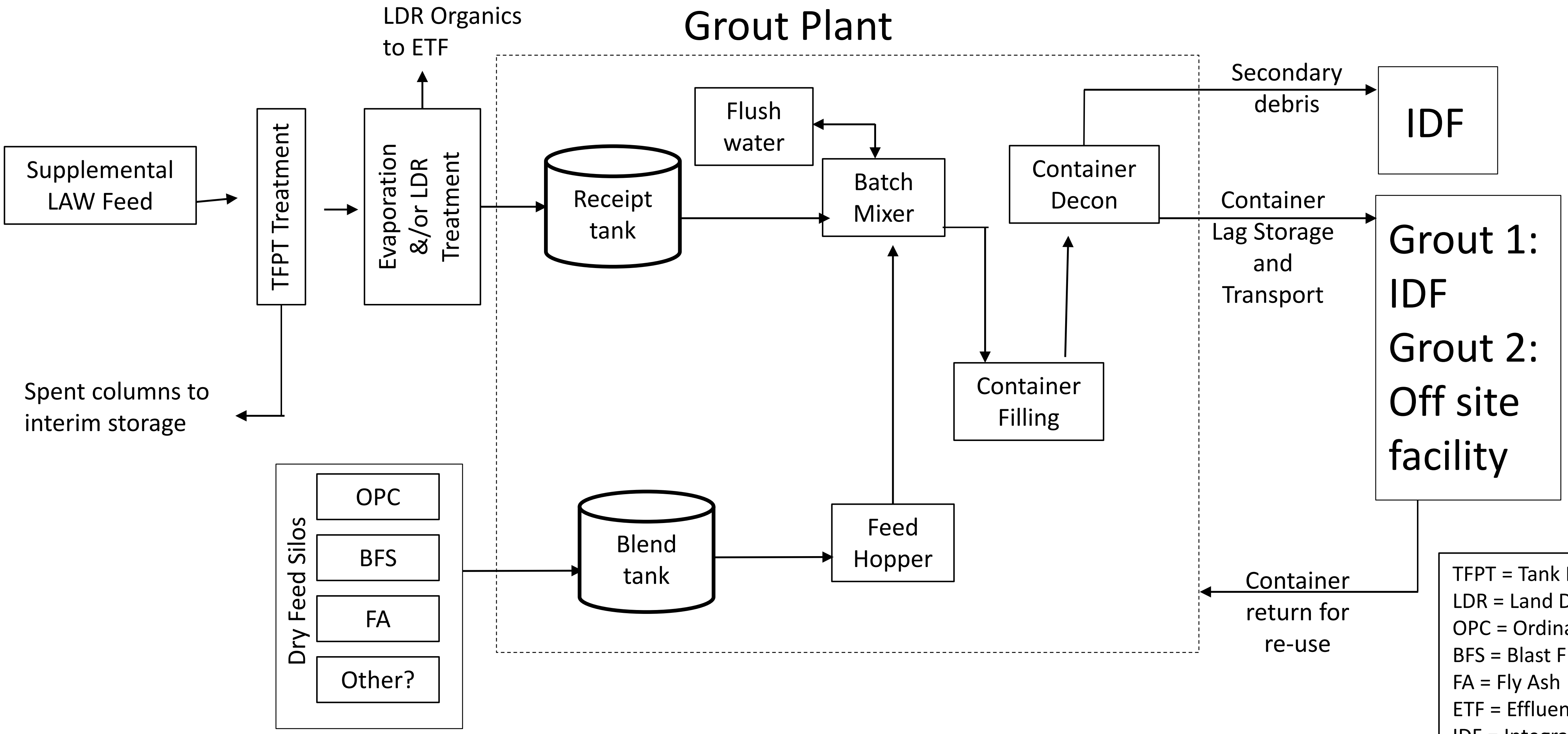
FBSR 1B would be offsite disposal and excludes geopolymer step

[Schematic from SRNL-RP-2018-00687]

Preliminary Simplified Alternative Grout 1 and Grout 2 Flowsheet

The information in this briefing represents the preliminary draft professional opinions of the FFRDC team, provided for review by the National Academies.

Grout 1: Single SLAW Grout Plant – On Site Disposal
Grout 2: Single SLAW Grout Plant – Offsite Disposal

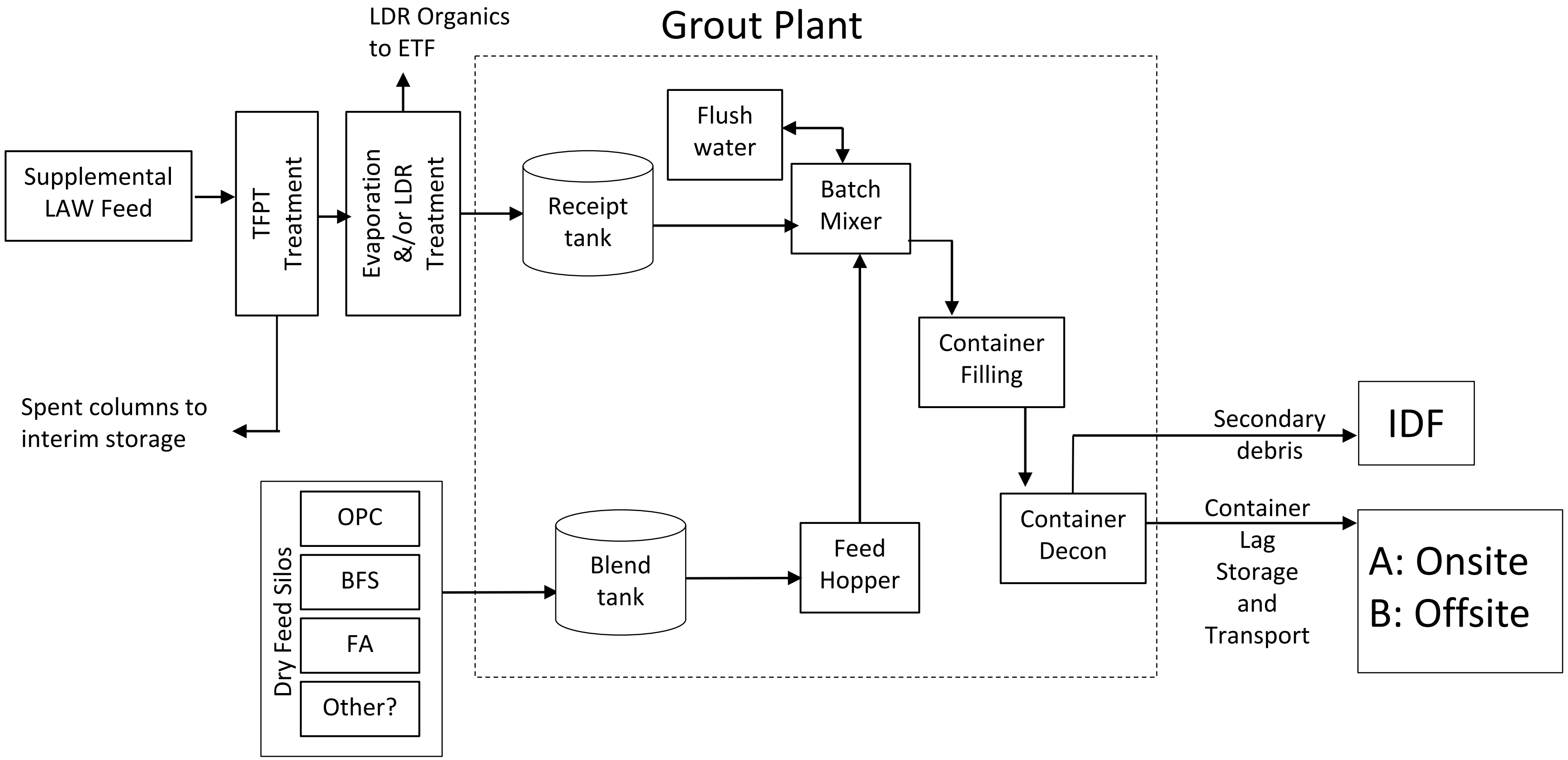


TFPT = Tank Farm Pretreatment
LDR = Land Disposal Restriction
OPC = Ordinary Portland Cement
BFS = Blast Furnace Slag
FA = Fly Ash
ETF = Effluent Treatment Facility
IDF = Integrated Disposal Facility

Preliminary Simplified Alternative Grout 3-4 Flowsheet

The information in this briefing represents the preliminary draft professional opinions of the FFRDC team, provided for review by the National Academies.

- **Grout 3A – Separate Grout Plants East-West; Onsite Disposal**
- **Grout 3B – Separate Grout Plants East-west; Offsite Disposal**
- **Grout 4A – Individual Grout Plants; Onsite Disposal**
- **Grout 4B – Individual Grout Plants; Offsite Disposal**



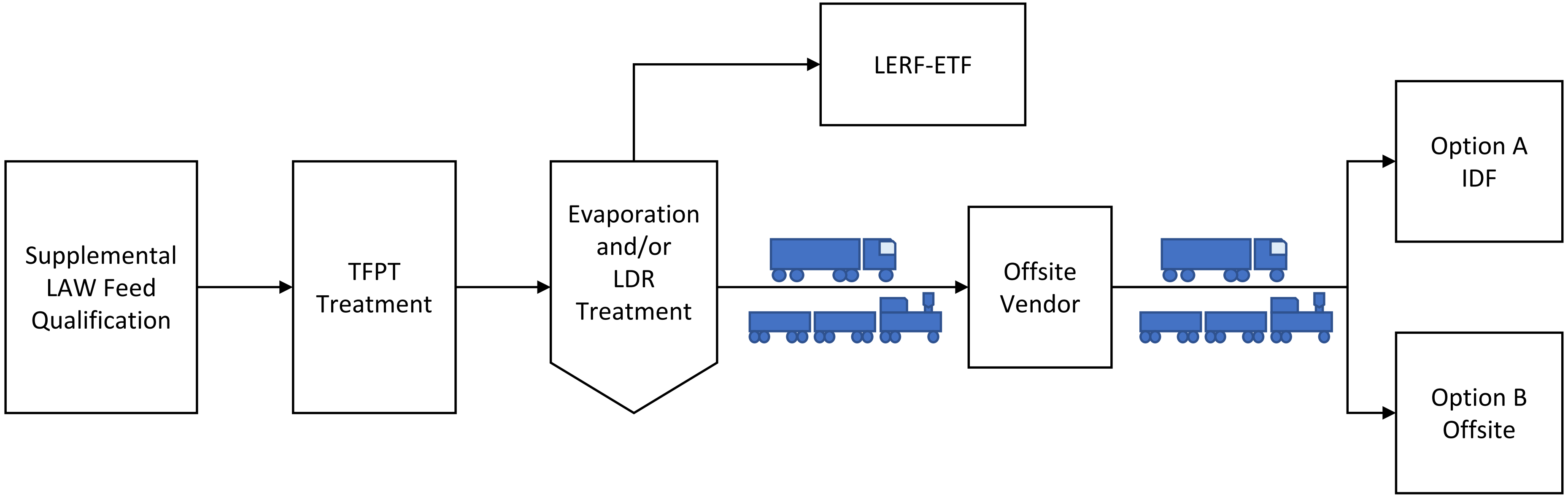
Preliminary Simplified Alternative Grout 5 Flowsheet

The information in this briefing represents the preliminary draft professional opinions of the FFRDC team, provided for review by the National Academies.

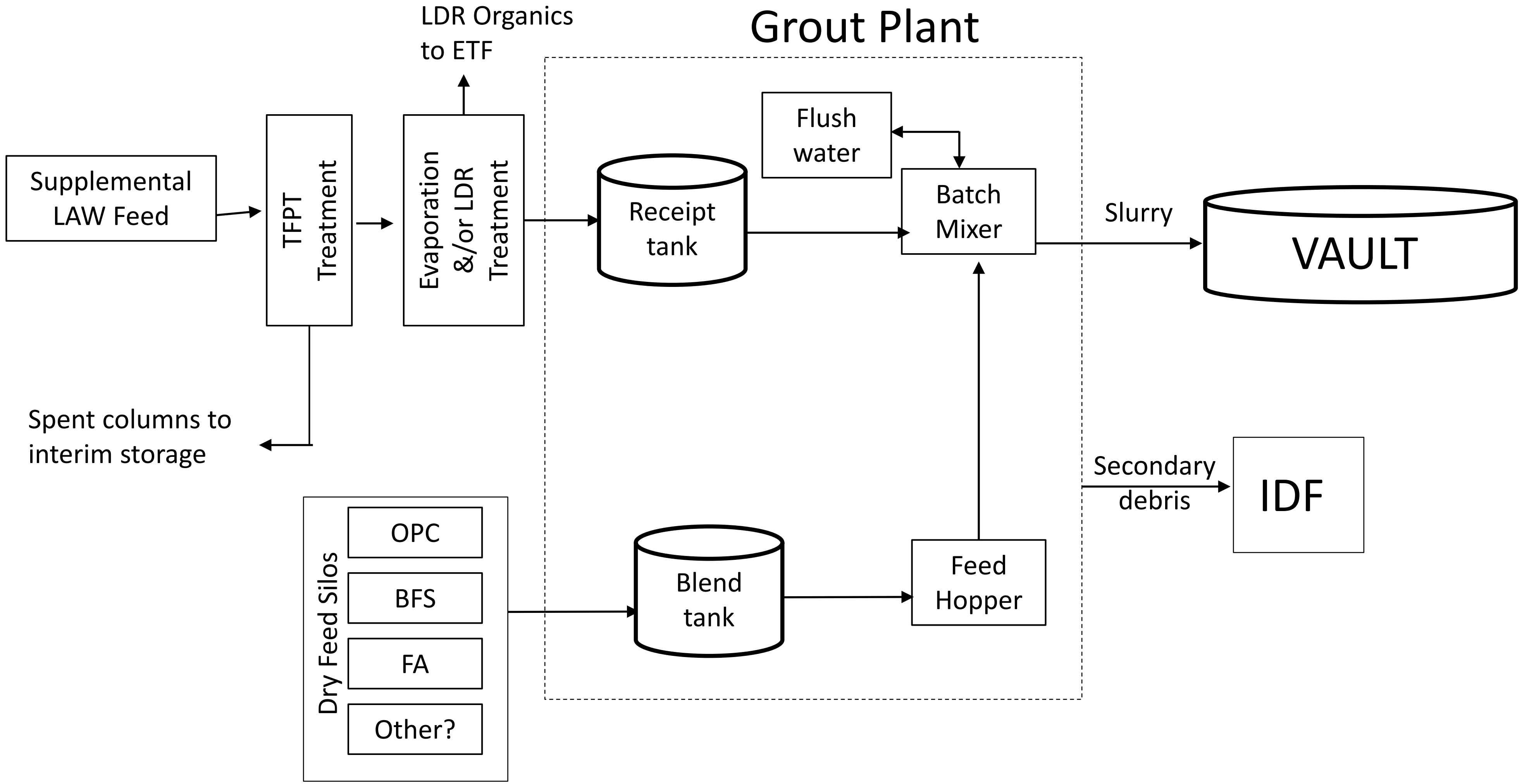
Off-site Vendor For Grouting

Grout 5A – Offsite Vendor; Onsite Disposal

Grout 5B – Offsite Vendor; Offsite Disposal



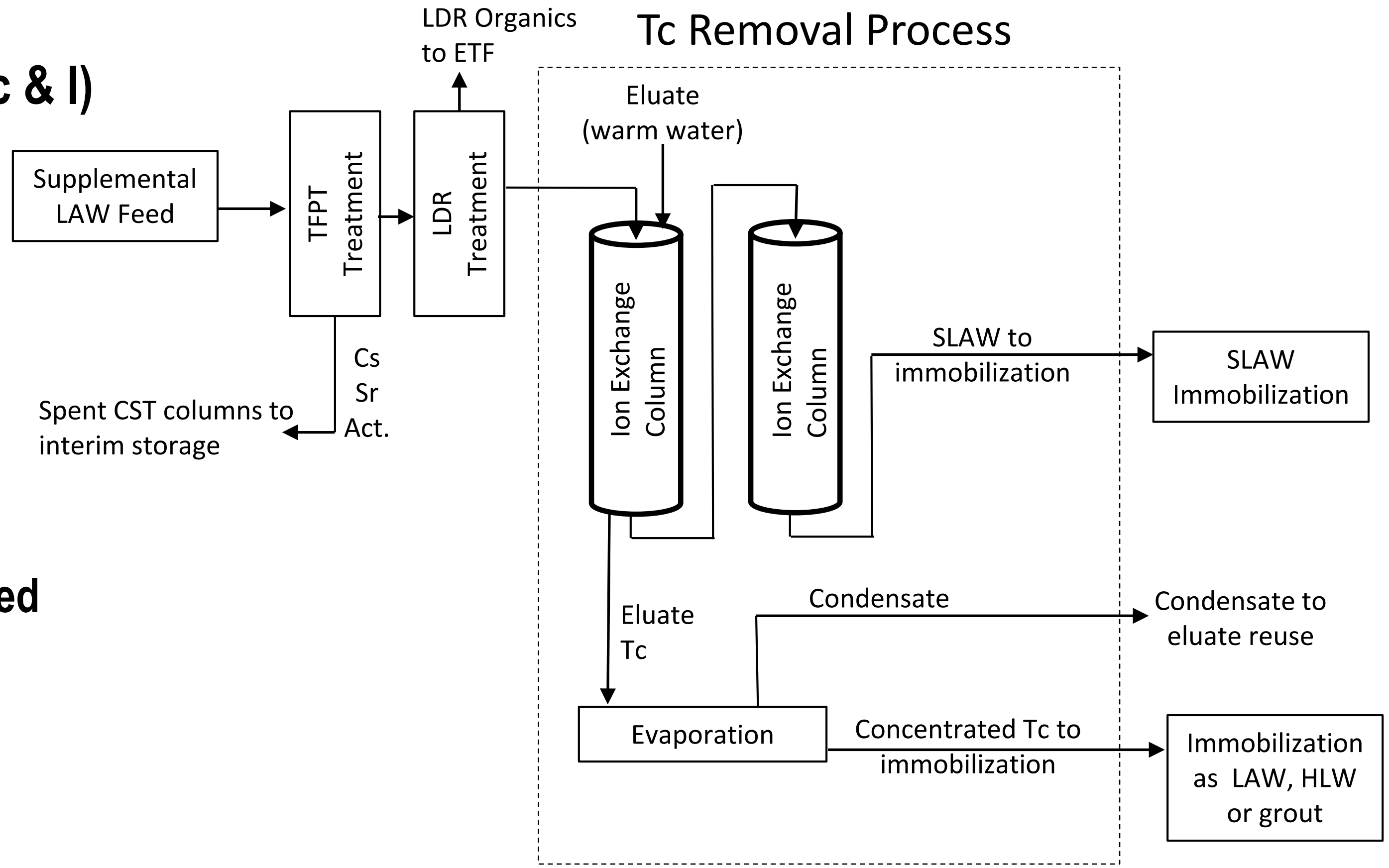
Onsite Disposal Improvement – Similar to Grout 1 with Disposal as Large Monolith and Vault with Engineered Liners



Preliminary Grout Alternative Variants

The information in this briefing represents the preliminary draft professional opinions of the FFRDC team, provided for review by the National Academies.

- **Variant Grout 1B: Grout 1 with Tc* & Iodine Removal**
- **Variant Grout 3C: Grout 3 with Tc & Iodine Removal**
- **Variant Grout 1C: Grout 1 + Sample (Measure Tc & I) Send Offsite/Onsite**
- **Variant Grout 3D: Grout 3 + Sample (Measure Tc & I) Send Offsite/Onsite**



***Tc removal assumes only TcO_4^- is removed**

Disposal of separated Tc and Iodine are to be determined

Alternative Description and Initial Assessments Status

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- **Alternative Descriptions are Drafted (Short Version)**
  - Flow-sheet schematics for each alternative are complete
- **Alternative Comparison Table is Drafted**
  - 47 points of comparison
  - More may be added to detail cost basis comparison
- **Alternative Selection Criteria Evaluations are in Progress**
  - Grout 1 has been evaluated by team – gaps remain
    - *Need details from other documents*
    - *Cost estimates*
  - Vitrification is partially complete – gaps remain
    - *Draft completed by SME*
    - *Team review underway*

Grout 1 Alternative Selection Evaluation has been Completed – Gaps Remain, Costs Not Yet Assessed

1. **Long-Term Effectiveness if Successful**
   1. Residual threat to health and environment upon successful completion
      - *Uncertainty in I-129 getter effectiveness, retention of all forms of Tc and nitrates, effectiveness of organics removal; waste volume increased*
2. **Short-Term Effectiveness and Risk**
   1. Risks to humans during execution
      - *Minimal risks to workers, public, or environment; minimal risk of delay to startup*
3. **Implementability**
   1. Likelihood and consequences of failure to succeed due to technical problems
      - *Uncertainty in Iodine getter effectiveness at scale and organics removal/destruction; low process and equipment complexity; robust process*
   2. Likelihood and consequences of failure to succeed due to resource shortfall
      - *Low likelihood of failure, relatively low cost*
   3. Likelihood and consequences of failure to succeed due to external factors
      - *Materials and equipment generally available, risk of inability to obtain permission to dispose in IDF*
4. **Life Cycle Costs -TBD**
5. **Community / Public acceptance - TBD**

Vitrification Selection Criteria Evaluation Underway

1. **Long-Term Effectiveness if Successful**
   1. Residual threat to health and environment upon successful completion
      - *Nitrates and waste organics destroyed, NH_3 and organics produced, most Tc sequestered in glass, most NH_3, Hg, I-129 in secondary wastes*
   2. Long-term risks upon successful completion
      - *Uncertainty in fate of secondary species and in partitioning of Hg, I-129, to secondary wastes, impact of melter idling on Tc fate*
2. **Short-Term Effectiveness and Risk**

   TBD
3. **Implementability**

   TBD
4. **Life Cycle Costs**

   TBD
5. **Community / Public Acceptance**

   TBD

➢ **Changes to All Documents are to be Expected**

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Long-lived Radionuclide & Contaminant Behaviors in Grout Waste Forms at Hanford

Matt Asmussen
Scientist, Principal Investigator
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Grout Team Lead

SRNL-STI-2021-00541

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October 20-21, 2021

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Information Format

The information in this briefing represents the preliminary draft professional opinions of the FFRDC team, provided for review by the National Academies.

- **State in Tank Waste**
  – Provides general understanding of the state (soluble/insoluble) and chemical form (cation/anion) of the species within the Hanford tank waste and the total inventory
- **Behavior in Grout**
  – Defines information about contaminant and radionuclide speciation in different grout and leachate chemistries (reducing/oxidizing)
    - *Reducing chemistry is achieved through the inclusion of blast furnace slag*
    - *Oxidizing chemistry is characteristic of slag-free formulations and aged specimens where oxidation has depleted the reductants*
- **Approaches to Improve Retention/Waste Acceptance**
  – Presents general approaches to improve retention or reduce concentration of the species to support Waste Acceptance Criteria of the final waste form
- **Uncertainty with On-site Disposal**
  – Describes the main unknowns when wastes are disposed at the Hanford Integrated Disposal Facility (IDF), which is a shallow land disposal with a pathway to groundwater
- **Uncertainty with Off-site Disposal**
  – Describes the main unknowns when wastes are disposed at a permitted, off-site Federal (DOE) facility with no ground water pathway

Technetium

The information in this briefing represents the preliminary draft professional opinions of the FFRDC team, provided for review by the National Academies.

- **State in Tank Waste**
  - Majority as soluble pertechnetate anion [$Tc(VII)O_4^-$]
  - Fraction as poorly-quantified soluble non-pertechnetate species (i.e., Tc(I))[1]
  - Maximum Tc concentration ~ 10 mg/L
- **Behavior in Grout**
  - Reducing grout chemistry – precipitated as low solubility Tc(IV) phases (e.g., TcO_2)
  - Oxidizing grout chemistry – mobile as Tc(VII) pertechnetate
  - Behavior of non-pertechnetates unknown
- **Approaches to Improve Retention**
  - Add reductants (e.g.; slag, sulfide) to control redox conditions
    - *Interactions between getters with different targets requires further investigation*
  - Reduce potential for oxidation via containment or isolation in disposal environment
- **Uncertainty with On-site Disposal**
  - Long-lived isotope ($\lambda \approx$ 211,000 y) results in temporal uncertainty
  - Susceptible to oxidization and subsequent release with possibility of groundwater contamination
- **Uncertainty with Off-site Disposal**
  - Solubility and release not issues for disposal in engineered facilities with no groundwater pathway

Total Tank Inventory (Solid and Liquids)

Constituent	Inventory
Technetium-99	1,500 kg (25,300 Ci)
Current as of 7/2015 decay date in Best Basis Inventory (twins.Hanford.gov)	

1 – Serne RJ, BM Rapko, IL Pegg. 2014. Technetium Inventory, Distribution and Speciation in Hanford Tanks. PNNL-23319. Rev. 1

Iodine

- **State in Tank Waste**
  - Majority as soluble iodide (I^-) and a mixture of non-radiological (e.g., I-127) and radiological (e.g., I-129)
  - Fraction as poorly-quantified iodate (IO_3^-), organo-iodine, precipitated iodide in the sludge (e.g., AgI)[1]
  - Iodine concentration ~ 5 mg/L
- **Behavior in Grout**
  - Reducing grout chemistry – mobile as iodide, iodate or other organo-iodine
  - Oxidizing grout chemistry – mobile as iodide, iodate or other organo-iodine
- **Approaches to Improve Retention**
  - Precipitate as a low solubility iodide phase (e.g.; producing AgI using a getter)
    - *Interactions between getters with different targets requires further investigation*
  - Reduce potential for release using containment or isolation in disposal environment
- **Uncertainty with On-site Disposal**
  - Long-lived isotope ($\lambda \approx$ 15,800,000 y) results in temporal uncertainty
  - Stability of low solubility phase in disposal environment
    - *Compatibility with competing anions and grout chemistry*
- **Uncertainty with Off-site Disposal**
  - Solubility and release not an issue for disposal in engineered facilities with no groundwater pathway

Total Tank Inventory (Solid and Liquids)

Constituent	Inventory
Iodine-129	165 kg (29.2 Ci)
Current as of 7/2015 decay date in Best Basis Inventory (twins.Hanford.gov)	

1 – Reynolds, JG et al. 2020. Silver-iodine Association in Hanford Nuclear Waste. *J. Radioanalytical Chemistry*. 326, 737

Nitrate/Nitrite

The information in this briefing represents the preliminary draft professional opinions of the FFRDC team, provided for review by the National Academies.

- **State in Tank Waste**
  - Soluble nitrate (NO_3^-) and nitrite (NO_2^-)
  - Concentration varies by tank
- **Behavior in Grout**
  - Reducing grout chemistry – mobile as nitrate/nitrite
  - Oxidizing grout chemistry – mobile as nitrate/nitrite
- **Approaches to Improve Retention**
  - Porosity reduction to lower release pathways for soluble ions
  - Reduce potential for release using containment or isolation in disposal environment
- **Uncertainty with On-site Disposal**
  - Subsurface transport of nitrate/nitrite
  - Quantification of inventory and distribution in the IDF
  - Contribution to Columbia River from existing plumes and other sources
- **Uncertainty with Off-site Disposal**
  - Solubility and release not an issue for disposal in engineered facilities with no groundwater pathway

Total Tank Inventory (Solid and Liquids)

Constituent	Inventory
NO_3	50,900,000 kg
NO_2	11,900,000 kg
Current as of 7/2015 decay date in Best Basis Inventory (twins.Hanford.gov)	

RCRA Metals

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- **State in Tank Waste**
  - Not well characterized in the waste, depends on tank chemistry
  - Predominantly insoluble oxides/hydroxides in alkaline conditions (e.g.; Ba, Cd)
  - Chromium largely as soluble chromate (CrO_4^{2-}) in supernatant liquid
  - Oxyanions likely present in soluble form (e.g.; SeO_4^{2-}, $AsO_4^{2-/3}$)
  - Organic complexes are possible in some tank chemistries
- **Behavior in Grout**
  - Reducing chemistry – Most will exist in low solubility state (e.g.; oxides, sulfides, precipitates) that are dependent on oxidation state
  - Oxidizing chemistry – Cr, As, Se, Hg likely as mobile form
  - Expected to meet non-hazardous waste disposal requirements based on TCLP
- **Approaches to Improve Retention**
  - Long-term maintenance of reducing chemistry and disposal site
  - No "catch all" approach
- **Uncertainty with On-site Disposal**
  - Chemical stabilization and limited subsurface transport mitigates long-term groundwater contamination
- **Uncertainty with Off-site Disposal**
  - Solubility and release are not issues for disposal in engineered facilities with no groundwater pathway

Total Tank Inventory (Solid and Liquids)

Constituent	Inventory
Cr	547,000 kg
Pb	73,100 kg
Ba	4,170 kg
As	3,750 kg
Cd	3,580 kg
Ag	3,000 kg
Hg	1,820 kg
Se *Se-79*	3,700 kg *1.6 kg (114 Ci)*
Current as of 7/2015 decay date in Best Basis Inventory (twins.Hanford.gov)	

LDR Organics

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- **State in Tank Waste**
  - 114 known or suspected LDR organic compounds in Hanford tank wastes
  - Present in liquid, solid, or vapor depending on specific chemical and tank chemistry
  - Can be pure form or complexed
  - Limited characterization and quantification available
    - *Complex tank chemistries and analytical capabilities are problematic*
    - *Process history at Hanford can be used as a screening indicator for consideration in tanks*
    - *Ongoing efforts to assess LDR organic content and subsequent treatment needs*
- **Behavior in Grout**
  - Reducing and oxidizing chemistry: minimal chemical stabilization of organic compounds
  - Impact to environment assessed against regulatory concentrations
- **Approaches to Improve Waste Acceptance**
  - Improved quantification of organics present in waste to be grouted
  - Pretreatment to reduce inventory of organics (e.g.; evaporation, oxidation)
  - Target grouting of tank wastes that can comply with LDR requirements
- **Uncertainty with On-site Disposal**
  - Quantification uncertainty in waste may limit grout options
- **Uncertainty with Off-site Disposal**
  - Quantification uncertainty in waste may limit grout options

LDR Organics Estimated in Exceedance of Waste Standards in Tank Waste based on Vapor Data

(Table 4 From 3134 study, List being updated in ongoing work outside FFRDC effort)

Compound
Pyridine
Methanol
Acetic acid ethyl ester
Propanenitrile
Acetonitrile
2-methyl-1-propanol
Dichloromethane
4-methyl-2-pentanone
9H-fluorene
2-propenol
N-nitroso-n-propyl-1-propanamine

Compound
2-nitropropane
Phenol
1,2-benzenedicarboxylic acid
1-phenylethanone
2-methylphenol
1,2-benzenedicarboxylic acid diethyl ester
N-nitrosomorpholine
2-propanone
N-methyl-N-nitrosomethanamine
2-butanone
1-butanol

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Cost Estimating Bases and Description

William G. Ramsey, PhD
Technical Advisor, Environmental and Legacy Mgmt., SRNL
Estimating Lead

2021 NDAA-3125 Meeting #3

October 20-21, 2021

SRNL-STI-2021-00541

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U.S. DEPARTMENT OF ENERGY

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As Part of the Program, Cost Estimating will be Performed for Selected Process Alternatives.

Considerations

- **The Total Project Cost Thru Completion of Hanford Tank Waste Processing has been Estimated Dozens of Times**
- **These Estimates have been Developed for Various Reasons**
  - Determinations regarding integrated mission schedule
  - Impact of start dates (often a function of supporting project costs)
  - Description of required site integration (Tank Farms, WTP, Disposal, Secondary Waste, etc.)
- **Hanford Site - System Planning – Provides One Common, Referenced, and Integrated Source for Cost Estimating**
  - Based on a site-specific software maintained and updated in configuration control by the Tank Operations Contractor for ORP
  - Model run data is downloaded delivered to a life-cycle cost estimating tool
- **Many (Most) Alternative Studies can be Traced Back to Said System Planning Tool**
  - SMEs evaluate particular facets (may vary technology performance or substitute techniques)
  - Project SMEs determine probability of start dates as function of construction (i.e. WTP) completion
- **There are Several Advantages and Requirements for Using a System Planning Model Run**
  - Large amount of data and supporting graphics available that are familiar to stakeholders, decision makers, SME’s, etc.
  - Provides a common basis for evaluating risk reduction, site integration, technology impact
  - The totality of mission completion (especially LAW and HLW) will be reflected

Common View of Hanford Project Costs

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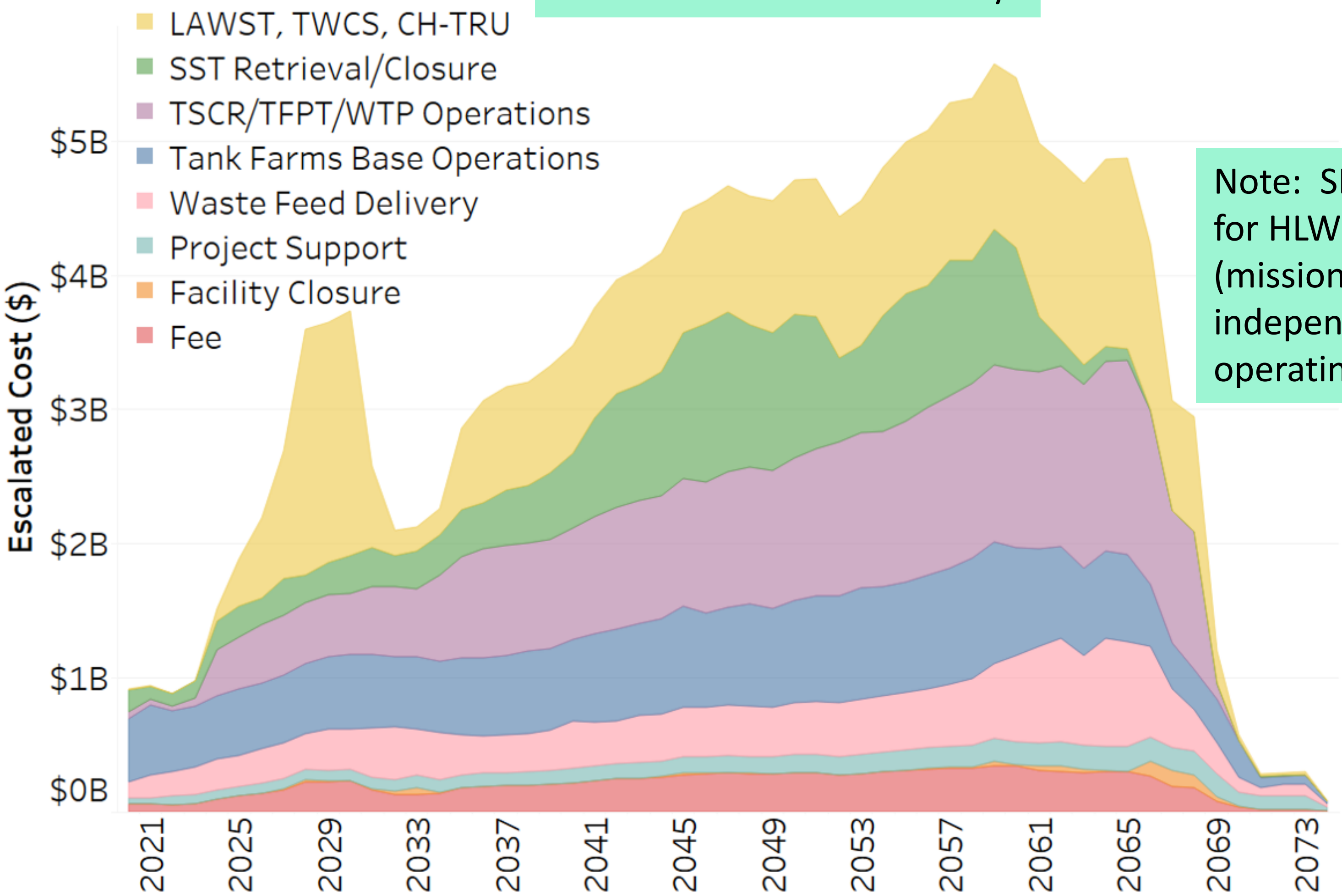
Supplemental LAW will be shown discrete for this study.



Note: SLAW is required for HLW throughput (mission driver) but cost independent through operating mission

Provided by WRPS System Planning

Common View of Hanford Costs

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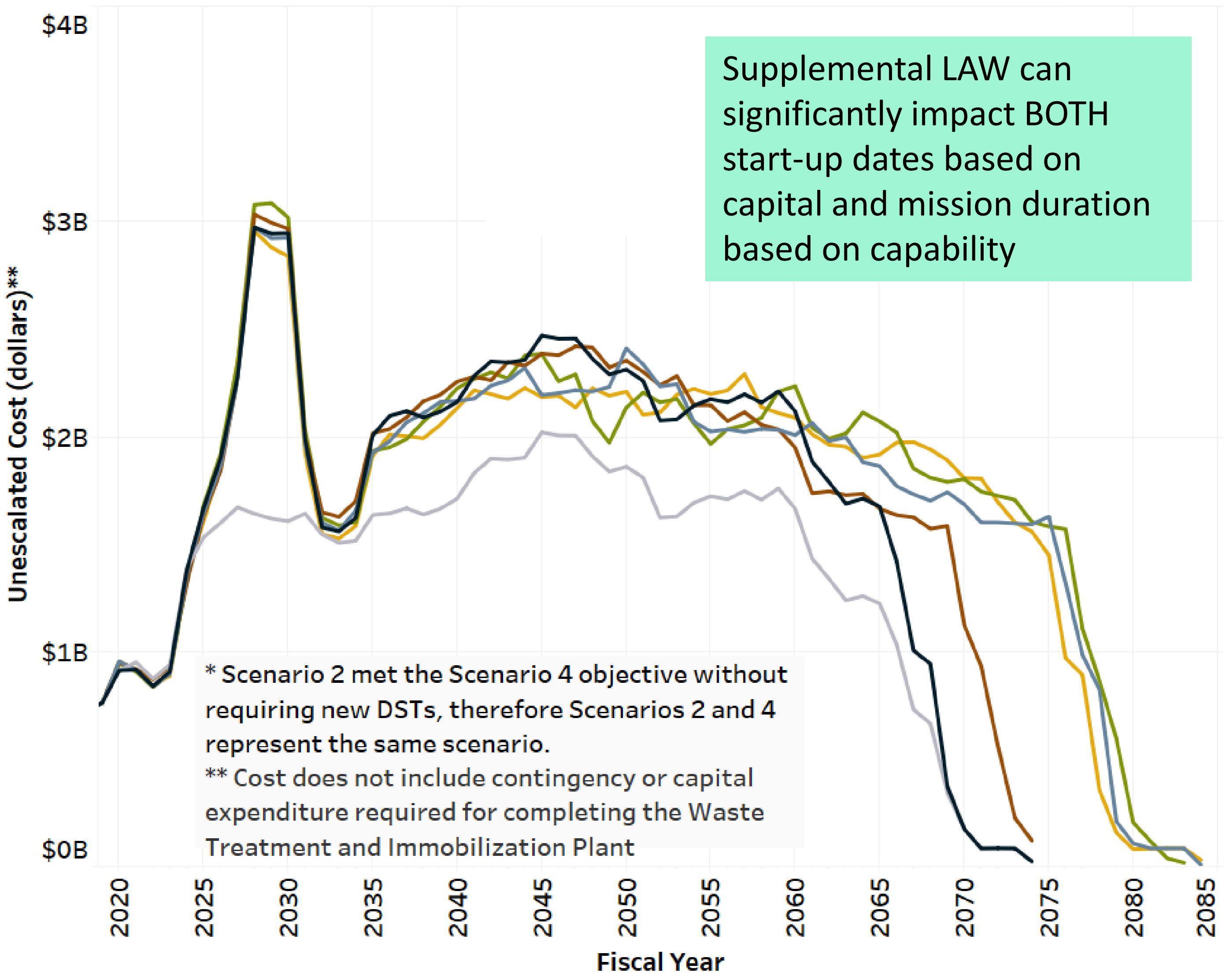

Provided by WRPS System Planning

Common View of Mission Progress

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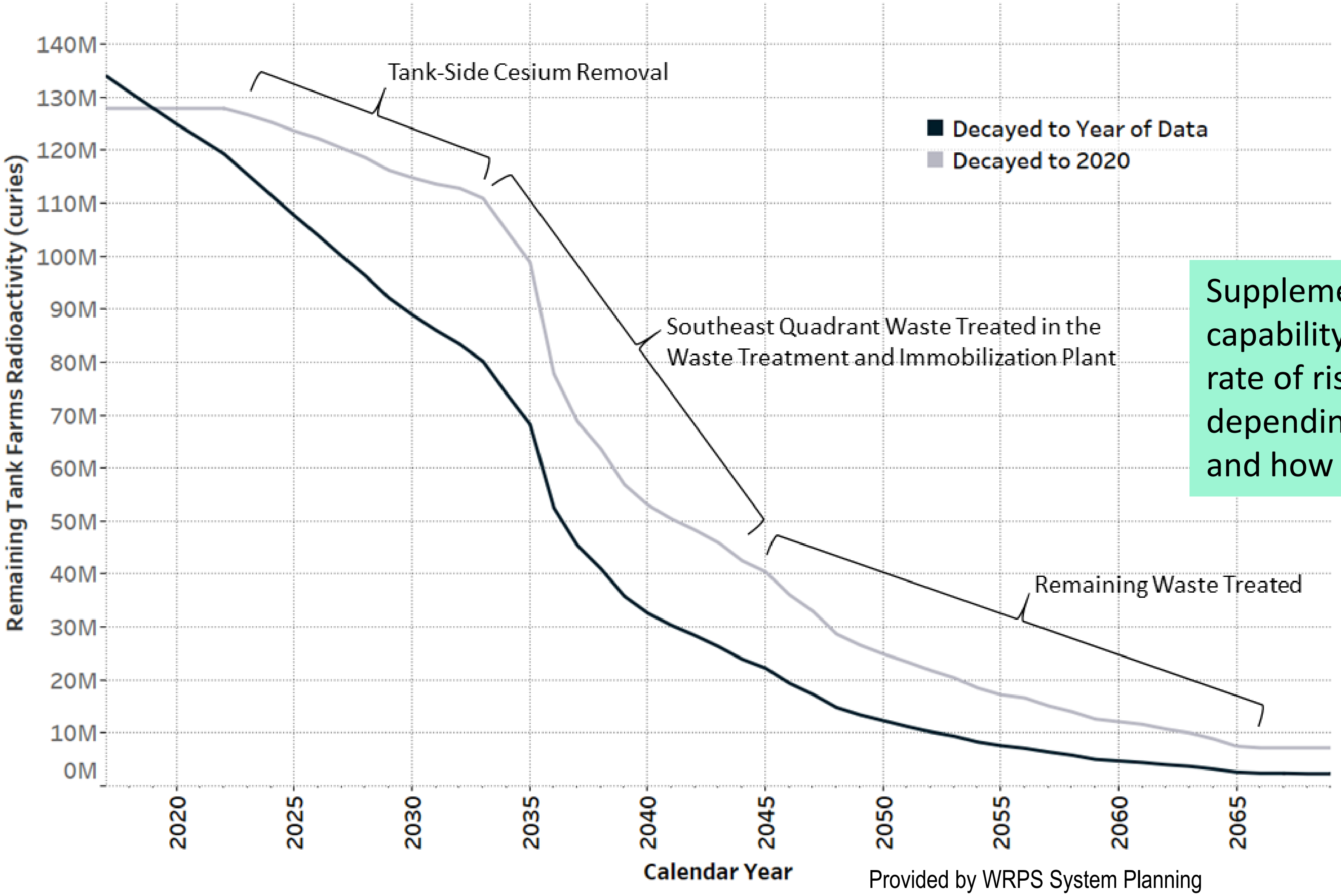

Provided by WRPS System Planning

Supplemental LAW capability impacts rate of risk reduction, depending on when and how employed

Common View of Mission Progress

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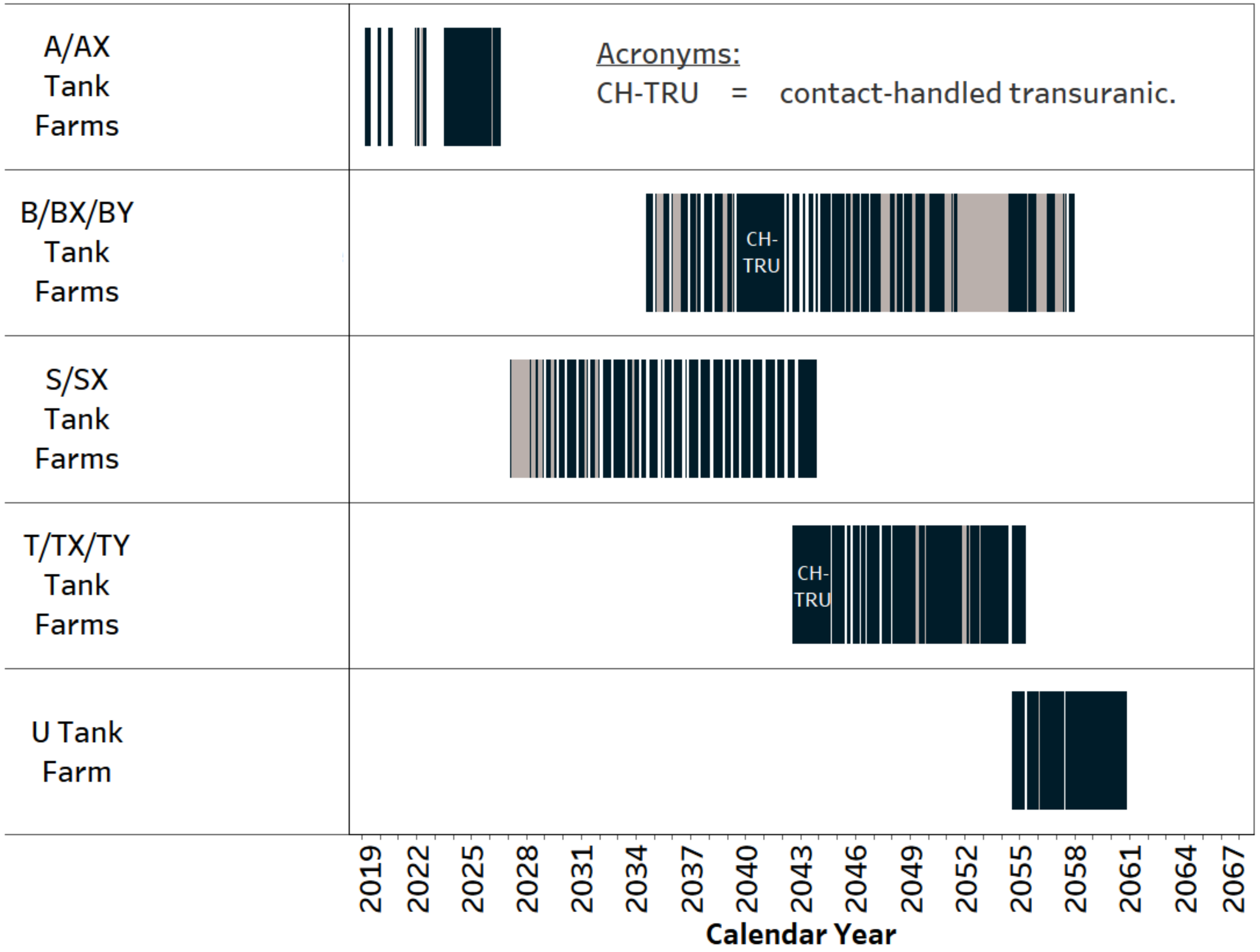

Provided by WRPS System Planning

This is a measure of progress as function of retrievals, geography, and feed delivery. Supplemental LAW alternatives will be formed and analyzed as regards cost <u>and</u> progress.

View of Mission Progress: If Offsite Disposition is Employed

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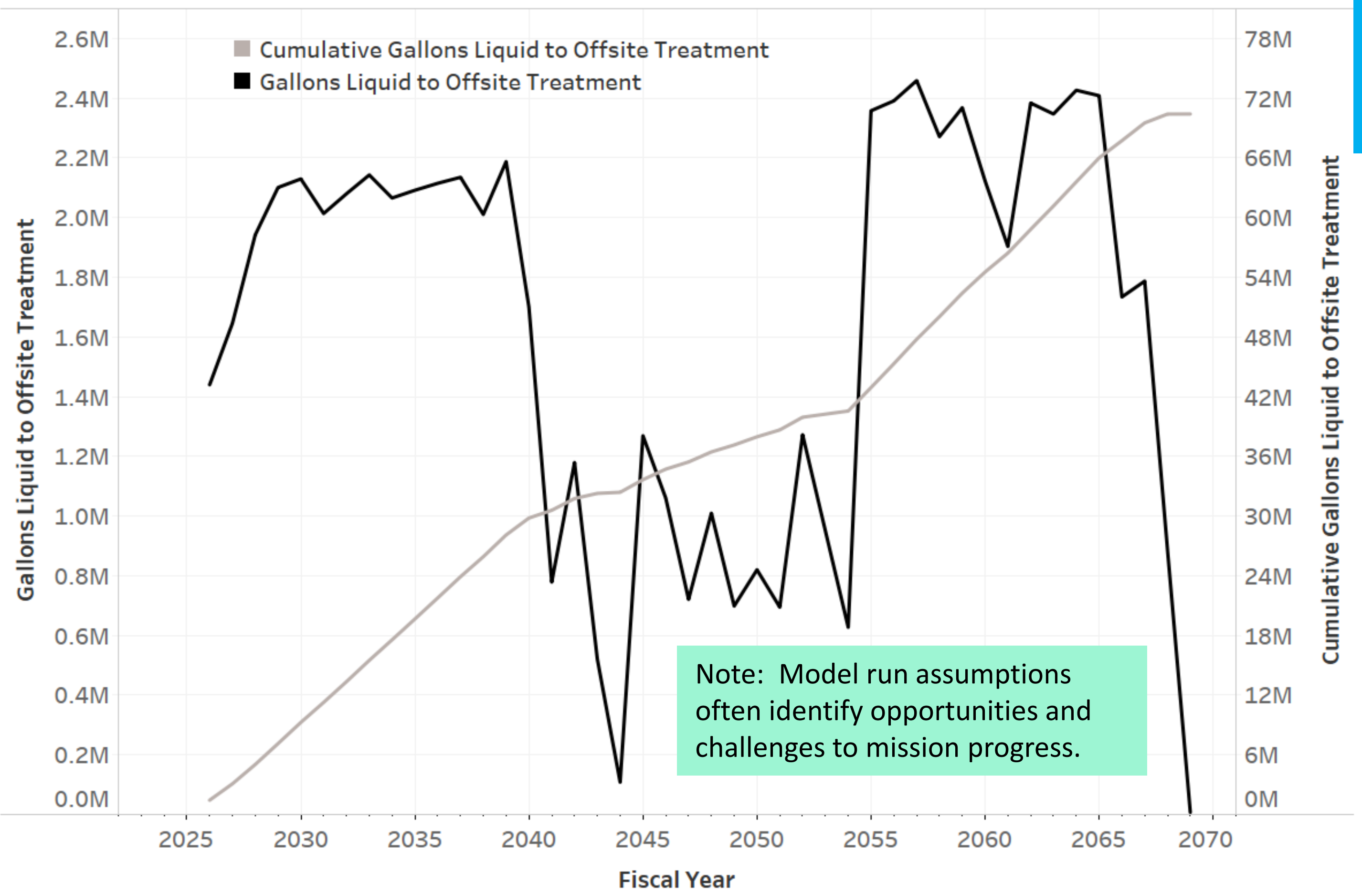
This graphic is for reference only – does not reflect System Plan scenario data



Iterative approach may be employed to better "level load" mission progress, cost and/or feed vector as applicable

Approach

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Cost Estimating for this Project will Employ a System Planning / Life Cycle Cost Model Approach

- **Alternatives Selected for Analysis will be Evaluated Using the System Planning Software**
  - Full mission profile will be evaluated with the selected LAW Supplemental Treatment methodology applied
  - Life cycle cost estimates will be developed and parsed with regards to LAW Supplemental Treatment
  - System Plan 9 will be used as a basis for reference
- **Cost Estimate Points**
  - These are intended as Class 5 estimates and where possible, in accordance with previous studies
  - GAO Best Practices to extent possible and applicable
  - Base year for estimate will be FY 2022 (may require re-run of SP 9 Case)
  - Escalation
    - *Capital Costs: 4% per year*
    - *Operating Costs: 2.4% per year*
  - Discount Rate: Latest guidance has this near zero
  - Work Breakdown as per System Plan (amended as necessary)
  - Unconstrained and flat funding scenario (with sensitivity) to be employed for LAW Supplemental Treatment (as possible)
  - Where practicable, capital facility estimates will be consistent with SP9, previous NDAA, and recent Corp's of Engineers study
- **Costs Reflected as Net Present Value Plus Annual Projections Across WBS**
- **Cost Estimating will Attempt to Focus on Discrete Facets of LAW Supplemental Treatment Per the Mission**
  - Will evaluate cost versus risk reduction rate
  - Will evaluate cost versus Tank Farm progress (retrievals, etc.)

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FFRDC Team Schedule & Wrap Up

Bill Bates
Dep. Associate Laboratory Director,
Environmental and Legacy Mgt., SRNL
FFRDC Team Lead

SRNL-STI-2021-00541

2021 NDAA-3125 Public Meeting #2

October 20-21, 2021

The information in this briefing represents the preliminary draft professional opinions of the FFRDC team, provided for review by the National Academies.

FFRDC Preliminary Team Schedule

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Actual dates are subject to change as NAS schedules and Public Meetings are coordinated.