Project W-551 Interim Pretreatment System Technology Selection Summary Decision Report and Recommendation

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Abstract: This report provides the conclusions of the tank farm interim pretreatment technology decision process. It documents the methodology, data, and results of the selection of cross-flow filtration and ion exchange technologies for implementation in project W-551, Interim Pretreatment System. This selection resulted from the evaluation of specific scope criteria using quantitative and qualitative analyses, group workshops, and technical expert personnel.

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EXECUTIVE SUMMARY

This report documents the evaluation and recommendation to the Office of River Protection (ORP) for a new Interim Pretreatment System (IPS) in the Hanford tank farms to provide early feed to the Waste Treatment Plant, Low Activity Waste (LAW) vitrification facility. The recommended technologies are comprised of Cross-flow Filtration (CFF) for entrained solids removal and Ion Exchange for cesium separation, using spherical resorcinol-formaldehyde resin (IX-sRF). Additionally, it is recommended that limited testing of Fractional Crystallization (FC) be continued to ensure an alternate cesium removal technology for reducing the risk of cost-effectively providing a waste feed supply to the Waste Treatment Plant. These recommendations are the product of a formal review process of the candidate technologies by CH2M HILL and involving ORP, and other stakeholders.

The recommendation of CFF over Rotary Micro-filtration (RMF) was based on two considerations: 1) that construction and installation of the CFF units will be performed in non-radioactive conditions (green field), while RMF would require modification of an existing double shell tank (DST) pit and installation within a nuclear facility; and 2) that there is a high likelihood the RMF units will need to be replaced during the 5-year IPS mission.

The recommendation of IX-sRF over Caustic-side Solvent Extraction (CSSX) and FC was based on the consideration that the earliest possible deployment of IPS could be achieved with the IX-sRF technology. Implementation schedules showed that IPS could be implemented approximately one year earlier if the IX-sRF technology was selected over FC and approximately two years earlier if IX-sRF was selected over CSSX. Further, the IX-sRF capital and life cycle costs were estimated to be significantly lower than the other two technologies.

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List of Terms

ALARA	As low as reasonably achievable
Board	IPS Decision Support Board
CH2M HILL	CH2M HILL Hanford Group, Inc.
CFF	Cross-flow Filtration
Cs	Cesium
CSSX	Caustic-side Solvent Extraction
D&D	Decontamination & Decommissioning
DOE	U. S. Department of Energy
DST	Double-shell tank
ERP	Expert Review Panel
ETF	Effluent Treatment Facility
FC	Fractional Crystallization
IPS	Interim Pretreatment System
IX	Ion Exchange
LAW	Low-activity waste
MAR	Materials at risk
Mgal	Million gallons
Na	Sodium
NEPA	National Environmental Policy Act
ORP	Office of River Protection
RMF	Rotary Micro-filtration
RPP	River Protection Project
SEPA	State Environmental Policy Act
SME	Subject matter expert
sRF	Spherical resorcinol-formaldehyde
SST	Single Shell Tank
STP	Supplemental Treatment Project
SU&T	Start Up & Testing
TBD	To be determined or developed
TPA	Tri-Party Agreement
TRA	Technology Readiness Assessment
TRL	Technology Readiness Level
ULD	Unit liter dose
WTP	Waste Treatment Plant
WDOE	Washington State Department of Ecology

1.0 INTRODUCTION

This technology selection summary documents the basis for selection of cross-flow filtration (CFF) and ion-exchange using spherical resorcinol-formaldehyde (IX-sRF) resin as the recommended technologies for the two early Low Activity Waste (LAW) pretreatment functions (entrained solids removal and cesium separation, respectively) and provides the rationales for their respective selections.

1.1 BACKGROUND AND SCOPE

The Waste Treatment Plant (WTP) LAW Vitrification facility is currently scheduled for completion several years prior to completion of the WTP Pretreatment facility. The Office of River Protection (ORP) is evaluating the early start up and operation of the WTP LAW Vitrification facility along with supplemental treatment alternatives. To generate feed for LAW treatment, entrained solids removal and cesium separations (i.e., pretreatment) will be required (External letter, CH2M-0800043 R1 (CH2M HILL 2008a)). Early pretreatment is anticipated to be done in a new facility called Interim Pretreatment System (IPS). The IPS is envisioned to be a moderately-sized system which will filter entrained solids and separate cesium from several selected batches of Hanford tank waste. The IPS is expected to be operational several years prior to the hot startup of the WTP Pretreatment facility, thereby allowing accelerated processing of tank waste. However, the IPS is not intended to replace the WTP Pretreatment Facility, since the IPS will not have the full functionality or capacity of the WTP Pretreatment Facility.

A decision was required regarding which technologies for each of the two major technical objectives would be carried forward into the conceptual design of IPS. The selected technologies will necessarily undergo additional testing and further technology development for maturation prior to their deployment and implementation. To facilitate this selection process, ORP directed a study to evaluate and recommend processing options for Interim Pretreatment of LAW (External letter, 08-AMD-050 (ORP 2008a)). The results of that evaluation are summarized in this report.

The candidate technologies that were evaluated for the entrained solids removal function were:

- Rotary micro-filtration (RMF) and
- Cross-flow filtration (CFF)

The candidate technologies that were evaluated for the cesium separation function were:

- Fractional crystallization (FC),
- Caustic side solvent extraction (CSSX) and
- Ion-exchange using spherical resorcinol-formaldehyde (IX-sRF) resin

2.0 DECISION ANALYSIS METHODOLOGY (PROCESS AND APPROACH)

The approach used to select the solids filtration and cesium separation technology was based on a tiered data development and assessment as shown in Figure 2-1 and described below.

Figure 2-1 - Decision Process Flowchart

2.1 DECISION PLANNING

The decision planning process consisted of the development of the RPP-PLAN-37558, *Decision Plan: Selection of Early LAW Interim Pretreatment System Process for Removal of Entrained Solids and Cesium* (CH2M HILL 2008b) Decision Plan that defined and documents the scope, objectives, roles, responsibilities, decision strategy and decision criteria. The decision statement from the Plan is:

> *Select one entrained solids filtration technology and one cesium separation technology that can be used for the pre-conceptual design of the interim pretreatment system*

The Decision Maker and members of the Decision Support Board (Board) were also identified in the Decision Plan (CH2M HILL 2008b).

Decision maker: Ben Harp, Federal Project Director, ORP

Decision Support Board members (biographical information included in Attachment E):

- Jim Honeyman (Chairman)
- Jim Badden (operations)
- Kris Colosi (project)
- Beth Conrad (project)
- Felix Miera (regulatory policy)
- Rick Raymond (technology/ engineering)
- PK Brockman (senior management representative and alternate Chairman)

Measures and definitions were developed for each criterion with input provided by Decision Support Board (Board) members, subject matter experts and stakeholders during a workshop in April 2008 and formed the basis for the multi-attribute decision analysis performed to select the recommended technologies. Finally, weights were assigned to the criteria and measures based on the values from the participants.

The major criteria used to assess the technologies and the assigned weights are:

- Safety (25%),
- Regulatory/Stakeholder Acceptance (20%),
- Technical Maturity (20%),
- Operability and Maintainability (15%), and
- Programmatic Aspects (20%)

Further detail the development of the Criteria, Measure and Definitions and respective weights is documented in the Decision Plan.

2.2 TECHNOLOGY SCOPING

In parallel with the decision planning, technology scoping activities were undertaken for the candidate technologies to develop technical descriptions that included flowsheets, facility and equipment layouts. Existing tests and reports for each of the technologies were reviewed, additional testing and modeling was conducted and supporting calculations were performed to provide the foundation for the technical descriptions. The technology descriptions are documented in RPP-RPT-37551, *Project W-551 Interim Pretreatment System Pre-Conceptual Candidate Technology Descriptions* (CH2M HILL 2008c).

2.3 COMPARATIVE DATA DEVELOPMENT

Each of the definitions developed for the criteria and measures were then assessed by the SMEs assigned to each criterion. The SMEs reviewed and analyzed the technical scoping information using sub-teams, workshops and subcontractor experts and developed both quantitative and qualitative assessments of each of the candidate technologies. Cost and schedule estimates were also developed for each of the 6 technology pairs (i.e., each of the 2 solids separation technologies pairs with one of 3 Cs separations technologies). The results of these assessments were documented in Assessment Summary Forms that were compiled by technology in RPP-RPT-37741, *Project W-551 Determination Data for Early LAW Interim Pretreatment Selection* (CH2M HILL 2008d). The data by technology was then compiled into cross cutting summaries that showed the evaluation data by criteria/measure/definition in order to facilitate the final assessment by the Board in RPP-RPT-37740, *Project W-551 Summary Information for Early LAW Interim Pretreatment System Selection*, (CH2M HILL 2008e)

2.4 DECISION MAKING

The activities and documents described above provided a framework and served as the basis for evaluating and selecting pretreatment processes during the Technology Selection Workshops. The Workshops were conducted over 4 days in June 2008 and attended by the Board members and observers from ORP and Washington State Department of Ecology (W-DOE) staff. The Board performed their evaluation of the technologies using the technical and comparative data discussed above, discussion with the SMEs, and taking into account stakeholder comments and observations. Some minor changes were made to the Assessment forms and summary document as a result (CH2M HILL 2008d and CH2M HILL 2008e). A scoring calculator was developed to record the raw scores and calculate the final weighted rankings for each technology (SVF-1520, *IPS Decision Calculator Rev 1 with Workshop Data 6-18-08.xls* (CH2M HILL 2008e)). The Board assigned ranks to the 71 Definitions in the following manner:

- The ranking scores were generally assigned around a raw score of 5 (on a scale of 1 to 10) as being acceptable performance for the IPS mission; raw scores above or below 5 indicated the degree that a technology performed *relative to the other technologies, rather than on an absolute scale.*

- If a Definition was deemed to be a non-discriminator, all technologies were assigned a ranking score of 5.

- In a few instances, if the Definition was determined to be redundant or of lesser importance relative to other Definitions within a Measure, the ranking scores were lowered to minimize the importance of the Definition,

- If a Definition or Measure was determined to be not applicable, then a score of 0 was assigned and the points redistributed within the Measure or Criterion to compensate.

The results from the Board evaluation are discussed in Section 3.0.

2.5 INDEPENDENT REVIEW

The initial draft of this document and the process used by the Board was reviewed in early July 2008 by an independent Expert Review Panel (ERP). The comments and observations from the ERP are summarized in Section 4.0.

3.0 RESULTS OF DECISION ANALYSIS

The following two sections provide a discussion of the results by criterion for the entrained solids filtration technologies and cesium separation technologies, respectively.

3.1 SOLIDS FILTRATION DISCUSSION

This section summarizes the evaluations of the two entrained solids filtration technologies (cross-flow filtration and rotary micro-filtration) and their respective rankings. The summary weighted results are shown in Table 3-1 and the detailed evaluation information is provided in Attachment A.

Table 3-1 – Solids Filtration Evaluation Results

Criteria	Criterion Weight	Weighted Results	
		CFF	RMF
Safety	25%	12	12
Regulatory & Stakeholder Acceptance	20%	10	11
Technical Maturity/Flexibility	20%	12	11
Operability and Maintainability	15%	8	7
Programmatic Aspects	20%	12	8
Total		**54**	**49**

3.1.1 Safety

The Safety criterion was divided into 3 Measures – process safety (further evaluated by 8 Definitions), criticality safety, and industrial safety and hygiene. Under the Safety criterion, Industrial Health and Safety and Criticality Safety criteria were non-discriminators between the 2 technologies with identical scores; the process safety ranking differential between the two technologies was less than 1 point. The only noted comment from the Board meetings was the concern of performing in tank nitric acid cleaning on the RMF housing/disks. Neither of the technologies introduces a new or unique hazard that has not been encountered previously at the Hanford. Also neither technology represents any unusual or significant barriers to implementation from a safety systems design or licensing perspective.

A comparison of the Safety aspects of respective technologies is provided in Table 3-2.

Table 3-2 – Comparison of Safety Aspects for Solids Filtration

Safety Pros & Cons	CFF	RMF
Pros	♦ Fewer moving parts ♦ Green field construction ♦ Potentially less contact maintenance required	♦ Lower flow rate pump ♦ Less solids holdup
Cons	♦ Higher flow rate pump ♦ Greater solids holdup	♦ More moving parts Potentially more contact maintenance ♦ Nitric acid wash solutions are used for filter cleaning – in tank impacts require evaluation ♦ Seal life will require that units be replaced at least once during 5 year mission ♦ Construction in radiological zone

3.1.2 Regulatory and Stakeholder Acceptance

The Regulatory and Stakeholder Acceptance criterion was divided into 2 Measures – achieve Tribal Nations/stakeholder acceptance (further evaluated by 2 Definitions) and achieve regulator acceptance (4 Definitions).

No discrimination could be made between the solid/liquid separation technologies with respect to regulatory compliance (Definition 2.2.1), secondary waste (Definition 2.2.3), or impacts to other permitted facilities (Definition 2.2.4).

3.1.3 Technical Maturity/Flexibility

The Technical Maturity/Flexibility criterion was divided into 2 Measures – Technology Readiness Level (further evaluated by 3 Definitions) and process flexibility and robustness (6 Definitions).

Overall, the ranking differential between the two technologies was less than 1 point overall. The CFF technology readiness level score was slightly higher due to the shorter time schedule to mature the technology (Definition 3.1.2), while RMF was slightly better in the flexibility/robustness measure. CFF also scored higher because it is currently being used at several DOE sites and is planned for use at the WTP Pretreatment facility.

A comparison of the technical aspects of respective technologies is provided in Table 3-4.

Table 3-3 – Comparison of Technical Aspects for Solids Filtration

Technical Pros & Cons	CFF	RMF
Pros	♦ Slightly cheaper to mature ♦ Easier to startup and shutdown ♦ Easier recovery out of spec product	♦ More flexibility to adjust process rates
Cons	♦ Less flexibility to adjust process rates	♦ Slightly more expensive to mature ♦ Harder to startup and shutdown ♦ Easier recovery out of spec product

3.1.4 Operability/Maintainability

The Operability and Maintainability criterion was divided into 6 Measures – ease of process control (further evaluated by 10 definitions), ALARA, reliability (2 definitions), ease and frequency of maintenance (5 definitions), ease of implementation (3 definitions), and liquid/solid secondary waste (2 definitions).

Overall, the ranking differential between the two technologies was less than 1 point.. Ease of process control (Measure 4.1), Ease of implementation (Measure 4.5), and Secondary waste (Measure 4.6) were deemed to be non-discriminators between the technologies.

ALARA (Measure 4.2), Reliability (Measure 4.3), and Ease and frequency of maintenance (Measure 4.4) favored the CFF technology. This was primarily due to the extra rotating parts for the RMF and the service life of the rotating disk seals. The service life of the RMF seals becomes more of an issue if the FC process were to be selected as the cesium separation technology, since the number of RMF components increases by a factor of 3.

3.1.5 Programmatic Aspects

The Programmatic Aspects criterion was divided into 6 Measures – cost impact (further evaluated by 3 Definitions), schedule impact (4 Definitions), DST space (2 Definitions), impacts to WTP/ Supplemental Treatment project (STP) (8 Definitions), impacts to other facilities (4 Definitions), and resources and materials (2 Definitions).

The majority of the (weighted) differences in the overall solid/liquid technologies were identified under this criterion. The cost evaluation was performed using paired costs, i.e., a solids removal technology paired with a Cs separation technology (see Section 2.2.5 for Cost Estimate Summaries). The RMF consistently cost more to build (capital) because of the need to install the equipment in a radiologically-contaminated zone (i.e., the DST feed tank). The operating costs are also higher because of the projected need to change out the RMF units at least once in the 5-year IPS mission.

The other difference in the programmatic scoring was Schedule Impact (Measure 5.2) where the DOE complex experience with operating CFF systems increased the rating for the CFF technology.

The other measures, DST space, impact on WTP, impacts on other facilities, and resource and material were deemed to be either non-discriminators or not applicable.

3.1.6 Solids Filtration Conclusion

In summary, the Board selected CFF as recommended filtration technology for entrained solids removal, based on construction and installation in a non-radioactive field conditions and the high probability that the RMF units would require replacement at least once during the 5 year IPS mission period.

3.2 CESIUM SEPARATION DISCUSSION

This section summarizes the evaluations of the three cesium separations technologies (caustic-side solvent extraction, fractional crystallization, and ion exchange using spherical Resorcinol-Formaldehyde resin) and their respective rankings. The summary weighted results are shown in Table 3-4 and the detailed evaluation information is provided in Attachment B.

The following sections discuss the salient points that lead to the weighted rankings for each of the Criterion.

Table 3-4 – Cs Separation Evaluation Results

Criteria	Criterion Weight	Weighted Results		
		FC	CSSX	IX-sRF
Safety	25%	13	11	11
Regulatory & Stakeholder Acceptance	20%	11	9	11
Technical Maturity/Flexibility	20%	9	7	9
Operability and Maintainability	15%	8	6	8
Programmatic Aspects	20%	11	8	11
Total		**51**	**41**	**50**

3.2.1 Safety

The Safety criterion was divided into 3 Measures – process safety (further evaluated by 8 Definitions), criticality safety, and industrial safety and hygiene.

The quantity of MAR (Definition 1.1.1), dispersive energy (Definition 1.1.4), and criticality safety (Definition 1.2.1) were deemed to be non-discriminators among the 3 technologies. Additionally none of the technologies will create new, or exacerbate any existing, Tank Farm hazards (Definition 1.1.6). However, a comparison of the three Cs separation technologies did rank the FC process somewhat higher overall for both the Process Safety and Industrial Safety & Hygiene measures than either CSSX or IX-sRF, primarily because FC does not introduce any additional chemicals (e.g., solvents, resins) into the process (Definitions 1.1.8 and 1.3.1). In addition, the IX-sRF process rated lower than either FC or CSSX with regard to dispersabilty during a fire accident, because the Cs becomes concentrated over time on the resin column bed (Definition 1.1.3). Finally, because of the potential for a solvent-fueled fire, the CSSX process rated lower than either FC or IX-sRF (Definition 1.1.7).

Fractional crystallization (FC) received the highest weighted ranking, primarily because it uses no additional chemicals. The only area where FC received the lowest ranking was in the material at risk (MAR) concentration (Definition 1.1.2).

Caustic side solvent extraction (CSSX) received a weighted ranking slightly better than ion exchange (IX-sRF). In all but one case (MAR concentration), CSSX ranked equal to or lower than FC and only showed better performance than IX with respect to ease of shutdown. Additionally, CSSX was ranked the lowest on fire hazard (Definition 1.1.7).

For ion exchange, the quantity and type of chemicals (resin, caustic, and nitric acid) resulted in lower ranking than FC in the areas of fire hazard (Definition 1.1.7), reactive chemicals (Definition 1.1.8), and the industrial safety and hygiene measure (Definition 1.3.1). In the case of MAR dispersabilty (Definition 1.1.3) and process stability (Definition 1.1.5), IX was ranked the lowest of the three technologies, primarily due to concerns with the potential for hydrogen gas buildup in the IX columns if loaded with Cs.

Overall, the ranking differential among the three technologies was less than 2 points (i.e., FC – 13; CSSX – 11; IX – 11). The Board noted that with regard to process safety, the toxicological doses are driven by the chemicals within the DST waste, not by the additional chemicals used by either CSSX or IX. None of the technologies introduce a new or unique hazard that has not been encountered previously at the Hanford site and successfully managed and controlled, nor do any of them represent any unusual or significant barriers to implementation from a safety systems design or licensing perspective.

A comparison of the safety aspects of respective technologies is provided in Table 3-5.

Table 3-5 – Comparison of Safety Aspects for Cesium Separation

Safety Pros & Cons	FC	CSSX	IX-sRF
Pros	♦ No additional chemicals required ♦ No combustibles ♦ Easy shutdown ♦ Moderate contact maintenance	♦ Continuous Operation ♦ Easy shutdown	♦ Low system complexity ♦ Low contact maintenance
Cons	♦ Steam system provides dispersive energy ♦ Unit liter dose slightly higher ♦ Potential for solids formation in return stream to Tank Farms ♦ Moderate system complexity	♦ Organic solvent has low flash point and is a potential fire hazard ♦ Requires nitric acid and NaOH ♦ High system complexity ♦ Significant number of moving parts/rotating equipment requiring contact maintenance	♦ Requires column venting to preclude H_2 buildup ♦ Decay heat on loaded column increase fire potential ♦ Requires eluting to remove Cs source term during shutdowns ♦ Requires nitric acid and NaOH

3.2.2 Regulatory and Stakeholder Acceptance

The Regulatory and Stakeholder Acceptance criterion was divided into 2 Measures – achieve Tribal Nations/stakeholder acceptance (further evaluated by 2 Definitions) and achieve regulator acceptance (4 Definitions).

No discrimination could be made between the solid/liquid separation technologies with respect to regulatory compliance (Definition 2.2.1), secondary waste (Definition 2.2.3), or impacts to other permitted facilities (Definition 2.2.4).

Ion exchange received the highest ranking under this criterion, primarily because of the earliest enabling of LAW treatment (Definition 2.1.1), which included an assessed 'tried and true' technology based on stakeholder interactions and land usage (Definition 2.1.2) due to the smallest footprint for the facility. It ranked equally with CSSX with regard to disposal system performance (Definition 2.2.2); both were ranked significantly lower than FC in this area.

Fractional crystallization ranked second, driven essentially by the removal of technetium (Tc) from the LAW product stream (Definition 2.2.3). It ranked higher than CSSX with respect to enabling early LAW treatment but equally with regard to land usage.

Finally, CSSX received the lowest ranking, basically due to land usage, and longer implementation schedule for enabling early LAW treatment.

Overall, the ranking differential among the three technologies was 2 points. Based on these results, there was no meaningful difference among the technologies and none of the technologies represent any unusual or significant barriers from a regulatory or stakeholder perspective to implementation. Moreover, while the Tc removal by FC is of major benefit, it should be noted that Tc management is a significant regulatory issue, not just limited to early LAW, but one that requires a more systematic site-wide resolution. A separate effort is underway to resolve the Tc issue and is outside the scope of this assessment.

3.2.3 Technical Maturity/Flexibility

The Technical Maturity/Flexibility criterion was divided into 2 Measures – Technology Readiness Level (TRL) (further evaluated by 3 Definitions) and process flexibility and robustness (6 Definitions).

With respect to the technical maturity measurements, FC and IX-sRF were ranked equally on TRL (Measure 3.1) with CSSX slightly lower. The rankings were based on review of the previous EM-20 technical readiness assessments (TRA) for FC and IX-sRF and assessment of CSSX for application at Hanford by a senior technical team using the EM-20 methodology. Generally, FC and IX-sRF were deemed to have equivalent TRLs for application to IPS, even though FC had previously received a higher TRL during its assessment for application to Supplement Treatment. This determination was based on the demonstration of IX-sRF on real DST waste, while the FC work to date has been focused on SST salt cake feeds, rather than the DST supernate feeds for IPS.

CSSX has been well demonstrated for application at Savannah River (SR) and has been formally reviewed by DOE-SR. However, there are enough differences in the compositions between Hanford and SR waste that without testing with actual wastes on a laboratory scale and simulants at the pilot scale, a higher ranking on technical maturity could not be justified.

A rough order-of-magnitude estimate of the cost and schedule to mature the three technologies to a TRL of Level 6 (Definition 3.1.2) for the IPS application was also performed, in addition to an assessment of the probability of success (Definition 3.1.3). In all cases, facilities and equipment are available for laboratory and pilot testing, but given the recent testing of the pilot scale FC on Hanford SST salt cake feed simulants, it was deemed to have the least cost and most favorable schedule of the three technologies, with IX-sRF a close second.

If the technical maturity cost and schedule estimates are considered in light of the overall project costs, the maturation costs would not be a discriminator (i.e., costs ranged from ~\$3M to ~\$4.5M), nor would the 30 to 36-month maturation schedule likely impact the IPS project critical path. A more detailed analysis of cost and schedule to mature the selected technologies will be documented in the upcoming IPS Technology Maturation Plan.

When considering the process flexibility and robustness measure, IX-sRF scored more favorably than either FC or CSSX overall. IX-sRF is considered to be able to handle greater variety of DST feeds (Definition 3.2.1), while FC ranked higher in turn up/turn down (Definition 3.2.2) and flexibility to modify the LAW product (Definition 3.2.3). CSSX was judged to be slightly less robust in this area, primarily due to uncertainty on ability to handle feed variability and ability to expand, if needed, post construction (Definition 3.2.4). No discrimination could be made among the cesium separation technologies with respect to recovery from out-of-specification product (Definition 3.2.5).

The rankings for the three technologies using this criterion were 9, 9, and 7 for FC, IX, and CSSX, respectively. Development work remains to ensure that the selected technology can process the candidate IPS feed vectors, e.g., issues such as phosphate solids for FC and Al solubility for IX-sRF and CSSX, albeit to a lesser extent with IX-sRF, due to the previous demonstration on real DST waste.

A comparison of the technical aspects of respective technologies is provided in Table 3-6

Table 3-6 – Comparison of Technical Aspects for Cesium Separation

Technical Pros & Cons	FC	CSSX	IX-sRF
Pros	♦ Has been demonstrated on SST simulants in a 1/5 scale pilot ♦ Removes Tc from feed to WTP LAW	♦ Demonstrated at SRS and has a pilot scale facility available for further demonstration and testing	♦ Well developed technology used previously at Hanford ♦ Has been tested on DST feeds ♦ Would provide a hot pilot to WTP pretreatment
Cons	♦ Requires testing on DST feeds ♦ Sensitive to sulfate and phosphate content in feed ♦ Na recovery for DST feeds averages 40 – 45% ♦ Requires feed from 16 tanks to provide feed for 5 year mission (3+ full tank to tank transfers a year)	♦ Requires testing on DST feeds ♦ Process sensitive to potassium content in the feed ♦ Based on conservative Al solubility model, requires significant addition of cold NaOH to process	♦ Based on conservative Al solubility model, requires significant addition of cold NaOH to process

3.2.4 Operability/Maintainability

The Operability and Maintainability criterion was divided into 6 Measures – ease of process control (further evaluated by 10 definitions), ALARA, reliability (2 definitions), ease and frequency of maintenance (5 definitions), ease of implementation (3 definitions), and liquid/solid secondary waste (2 definitions).

In five of the 6 Measures under this Criterion (process control, ALARA, reliability, maintenance, and implementation) IX-sRF scored the highest, followed by FC. In the sixth measure (secondary waste) FC scored the best, primarily because of the periodic need to dispose of spent solvent and resin for the CSSX and IX-sRF processes, respectively. No discrimination could be made between the cesium separation technologies with respect to operating crew size (Definition 4.1.2), complexity of transfers between Tank Farms and IPS (Definition 4.1.10), or reliability of analogous systems (Definition 4.3.2).

The rankings in this criterion for the three technologies were 8, 8, and 6 for IX, FC, and CSSX, respectively. All of the technologies would benefit from optimization and most of the operability and maintainability concerns associated with any of the technologies would be addressed by working closely with operations staff during the design phase of the project.

3.2.5 Programmatic Aspects

The Programmatic Aspects criterion was divided into 6 Measures – cost impact (further evaluated by 3 Definitions), schedule impact (4 Definitions), DST space (2 Definitions), impacts to WTP/STP (8 Definitions), impacts to other facilities (4 Definitions), and resources and materials (2 Definitions).

The rankings in this criterion for the three technologies were 11, 11, and 8 for IX, FC, and CSSX, respectively.

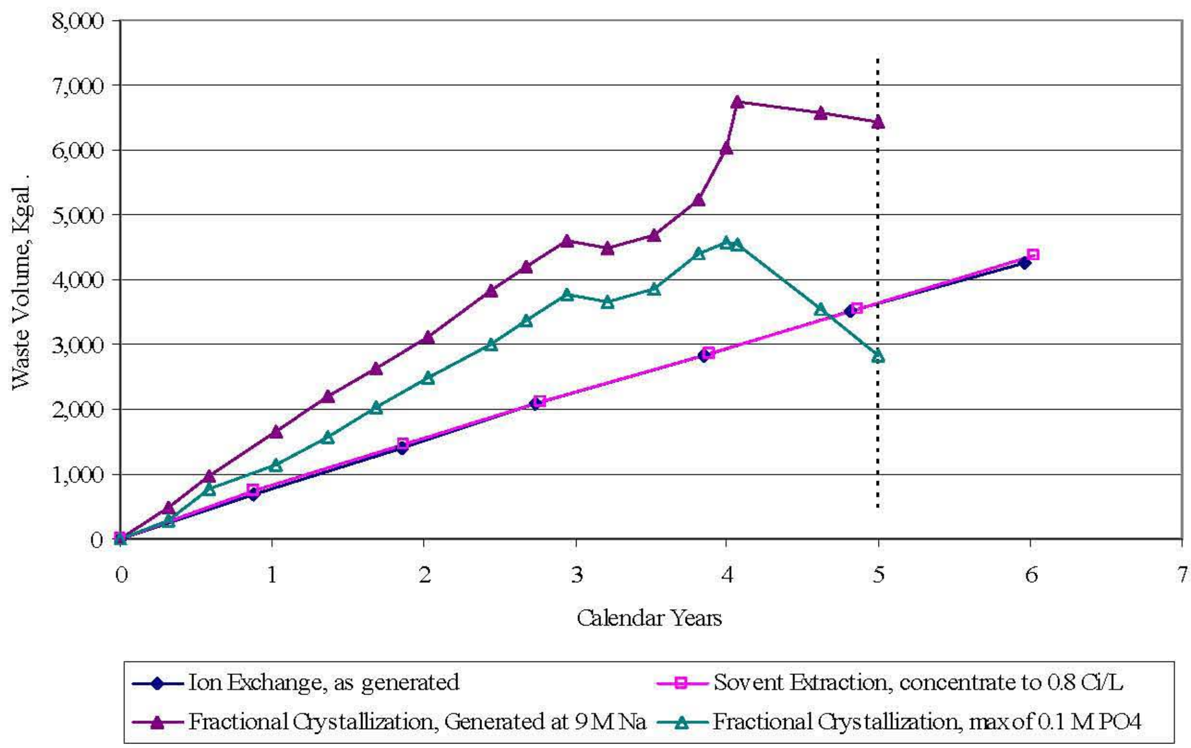
No distinction could be made between the cesium separation technologies with respect to the permitting, licensing, and D&D schedules (Definitions 5.2.2, 5.2.3, and 5.2.4), overall WTP production rate (Definition 5.4.1) or mission duration (Definition 5.4.2), WTP waste packages (Definition 5.4.3), impacts to other Hanford facilities (Measure 5.5), or stability of critical resource pricing (Definition 5.6.2).

With respect to cost and schedule impacts (Measures 5.1 and 5.2), IX-sRF scored the best, followed by FC and CSSX, based on no consideration of the additional incremental implementation costs required to supply additional feed to FC. Detail on the cost and schedule estimates can be found in Attachment C.

With respect to DST space generation (Measure 5.3), the initial assessment shows FC generates space faster due to the higher processing rates associated with its operation and the amount of feed from each DST that is returned to the Tank Farms due to its lower Na recovery rate. Additionally, both the IX and CSSX process flowsheets used a very conservative aluminum (Al) solubility model that had a net effect of slowing the process rate and thus, decreasing the rate that is DST space generated. The estimated amount of space gained by FC ranges from 6.4 to 2.8 Mgal, depending on whether the waste is assumed to be transferred to Tank Farms as generated at 9 M Na, or whether it is limited to 0.1 M phosphate, respectively. The 0.1 M phosphate limit triggers boil down evaluations to ensure that phosphate solids formation does not occur as a result of concentrated waste. In comparison, the estimated amount of space gained by IX is 3.7 Mgal and CSSX is 2.6 Mgal (with the potential to increase to 3.6 Mgal if concentrated to 0.8 Ci Cs in the 242-A Evaporator). Since there was significant uncertainty of the phosphate impact and the impact is a function of the feed tanks chosen, FC was favorably credited with about 4.5 Mgal of space gained over the 5 year mission by the Board.

Further discussion of the DST space recovered occurred later in the Board deliberations. As stated above, FC was favorably credited with 4.5 Mgal of DST space recovered over the 5 year period, by neglecting the impact from processing the high phosphate SST wastes in Year 5 (coincidentally, it is also approximately the average between the maximum value of 6.4 Mgal and the minimum estimate of 2.8 Mgal). Conversely, the worst case volume of DST space recovered was used for both IX-sRF and CSSX. The Board determined that further discussion of the technical issues and uncertainties for all technologies in order to maximize the DST space recovered for the amount of waste processed was warranted.

Figure 3-1 – Comparison of Net Change in Available DST Waste Storage Space For Alternative Cesium Separation Technologies



FC would have to process 14.9 Mgal of feed from 16 feed tanks in order to meet the WTP/supplemental treatment requirement of 5875 MT Na for the 5 year mission. Because of the amount of waste returned to the Tank Farms (i.e., 57% of the Na is returned in the Cs return stream), the estimated amount of space recovered from processing the 14.9 Mgal of feed through FC ranges from 6.4 to 2.8 Mgal, depending on whether the waste is assumed to be transferred to Tank Farms as generated at 9 M Na, or whether it is limited to 0.1 M phosphate, respectively. Because the concern with phosphate precipitation and the potential to plug waste transfer lines, the acceptable concentration of phosphates will need to be determined on a batch-by-batch basis, using the "boil down" procedure prior to its transfer from IPS to the DST system. As such, there is significant uncertainty regarding the amount of tank space that could be recovered. Further, if the results from the boil-down test are not favorable, an alternative would be a cost/benefit analysis of the addition of a phosphate removal step to IPS versus the additional tank space recovered.

In comparison, the worst case Al solubility model was applied during the development of both the IX-sRF and CSSX flowsheets. The DST feeds selected for this evaluation contain concentrated aluminum in solution. Neither IX-sRF nor CSSX are tolerant of solids precipitating with the process as the waste chemistry changes during processing. To protect the processes, both the CSSX and IX-sRF processes assumed that the Na molarity of the incoming waste feed must first be adjusted to 6M sodium, if the WTP solubility curves for aluminum are used. This adjustment requires the addition of ~30% cold (non-radioactive waste) sodium. Based on the worst case model, the amount of space gained by IX-sRF is 3.7 Mgal and CSSX is 2.6 Mgal (with the potential to increase to 3.6 Mgal if concentrated to 0.8 Ci Cs in the 242-A Evaporator). If the Al solubility issue is resolved, the additional NaOH required by the process flowsheets evaluated for IX-sRF and CSSX would be greatly reduced. The impact would be to increase the amount of feed processed 9.1 Mgal and would result in the recovery of 6.2 Mgal of DST space for IX-sRF and up to 6 Mgal of space for CSSX with the use of the 242-A Evaporator. Resolving the aluminum solubility issue also benefits the WTP by reducing the estimated Na processed from 90,000 MT to 60,000 MT. Because of the significant impact of the Al solubility on waste volume, an EM-20 initiative is underway to update the Al solubility model.

For all the technologies, the maximum DST space recovered in the best case is estimated at between 6 – 6.4 Mgal, if the respective technical issues can be resolved. However, to put it in a different perspective, the DST space recovered is shown as a "return on investment" (i.e., space recovered for the amount of waste processed) in Figure 3-2 and Table 3-7. As an interesting note, IX-sRF has a 68% "return" even under the worst case compared to range of 19% to 43% for FC, and 48% to 67% for CSSX.

Figure 3-2 – Comparison of DST Space Recovered For the Amount of Waste Processed

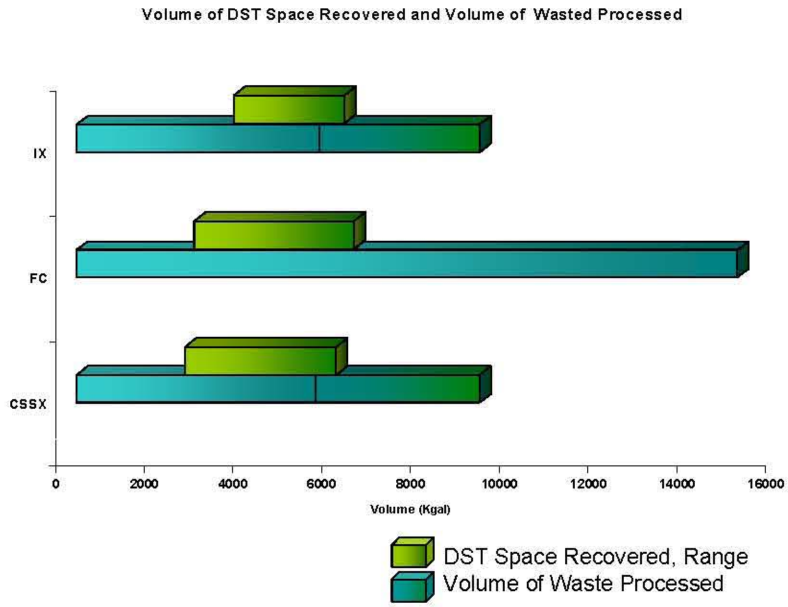


Table 3-7 – Project Feed Volume and DST Space Recovered Over 5 Year IPS Mission

	Fractional Crystallization[1]		Ion Exchange[2]		Caustic Side Solvent Extraction[3]	
	Worst Case	Best Case	Worst Case	Best Case	Worst Case	Best Case
Feed Volume Processed, Mgal	14.9	14.9	5.5	9.1	5.4	9.1
DST Space Recovered, Mgal	2.8	6.4	3.7	6.2	2.6 – 3.6	3.6 – 6.0
% Return (DST Space recovered/ Feed volume processed)	19%	43%	68%	68%	48 – 67%	55 – 66%

[1] The comparison for Fractional Crystallization is based conservatively on whether phosphate is a factor (worst case) or the whether the waste is concentrated to 9 M Na (best case).

[2] The comparison for Ion Exchange is based on the added Na (worst case) to address the conservative Al solubility curves or whether the more liberal (e.g., Barney solubility data [ARH-ST-133] is used (best case).

[3] The comparison for Caustic Side Solvent Extraction is based on the same worst case/best case Al assumptions shown for Ion Exchange, with a range provided to account for the space gained from concentrating the Cs return stream in 242-A evaporator to 0.8 Ci/L.

Regarding impacts to WTP and Supplemental Treatment (Measure 5.4), IX-sRF and FC were ranked equally, followed by CSSX. FC would provide alternative evaporator capacity and a potential for using grout for immobilization of Tc-free LAW. IX-sRF provides potential cost reduction benefits by combining IPS and WTP IX technology deployment activities, as well as possible benefits for future Tc removal. Additionally, the WTP pretreatment process development, operation and maintenance would benefit from the lessons learned by deployment of IX-sRF in IPS. During the assessment, no ancillary programmatic benefits were identified for CSSX. Finally FC was rated higher than either IX-sRF or CSSX for availability of key skill, critical materials, and qualified vendors (Definition 5.6.1), due to the single vendor for CSSX centrifugal contactors and the current lack of a long-term supply strategy for the IX-sRF resin.

3.2.6 Additional Assessment

Because the results were so close between FC and IX-sRF, the Board determined that further evaluation was necessary in order to make the final recommendation for a cesium separation technology. The need for additional evaluation was anticipated in the Decision Plan (CH2M HILL 2008b0

... Some additional work may be required prior to the final assignment of rating or the selection of the preferred technology.

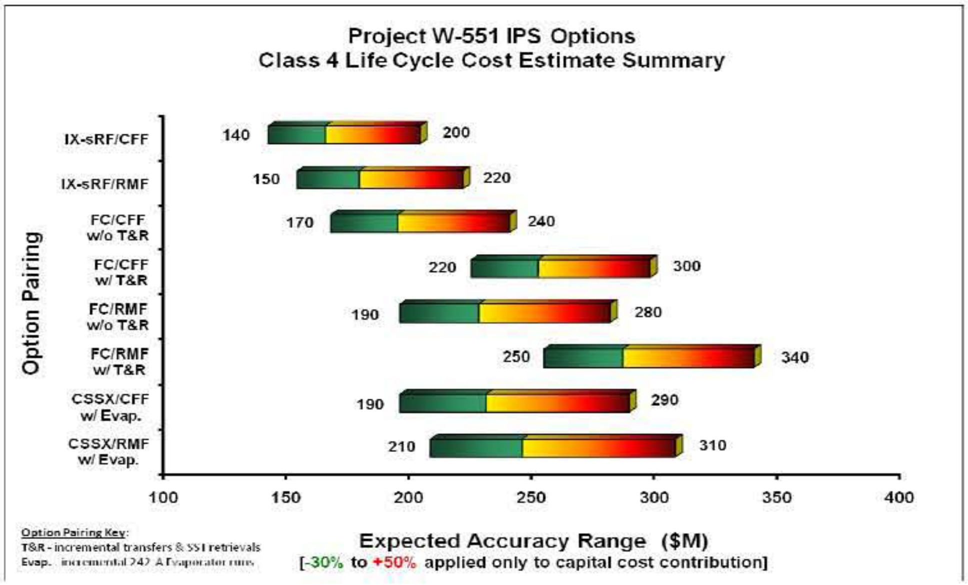
Mindful of the DOE goal of the IPS Project as articulated by the ORP Decision Maker, "*Deliver five years of pretreated feed to the Waste Treatment Plant's Low-Activity Waste Vitrification facility as early as possible and for the least cost to the government,*" the Board decided re-examine the implementation costs and implementation schedule aspects of the two technologies as the basis for making the final selection between the two technologies.

3.2.6.1 Implementation Costs

As noted in the discussion under the cost impacts, the incremental implementation costs, including baseline costs that would have to be accelerated into the mission period were not considered in the initial assessment by the Board. Because FC returns approximately 57% of the Na from the tank waste back to the Tank Farms with the Cs, a total of 16 feed tanks (14.9 Mgal) is required in order to supply sufficient Na to meet the WTP/supplemental treatment annual requirement of 1175 MT Na/year over the 5 year mission. Based on the tanks chosen by the FC SME (and discussions with technical staff knowledgeable about Na loading and tank composition) to supplement the initially identified feed candidate DSTs, this requires an incremental 16 tank to tank transfers, 2 SST retrievals and 3 cross-site transfers above and beyond the tank to tank transfers required for either IX-sRF or CSSX, increasing the life cycle costs for FC by an estimated \$50 – 60M during the mission period. This is shown in the cost ranges labeled *FC/CFF w/T&R and FC/RMF w/T&R* in Figure 3-3.

While an argument was considered that retrievals would have to be done eventually, would only be moved forward in time and/or substituted for other planned retrievals that would be ongoing during this mission period, ORP-11242, *River Protection Project System Plan*, (ORP 2008a) shows that no SST retrievals are planned or funded for the mission period. Further, while optimization of the feed tanks selected for FC could have reduced these costs somewhat, to allow such 'cherry-picking' of the feed tanks that would be best suited for FC would potentially have unfairly biased the evaluation, unless an equal feed optimization endeavor was undertaken for IX-sRF and CSSX.

Figure 3-3 – Life-Cycle Cost Estimate Summary (for comparative purposes only)

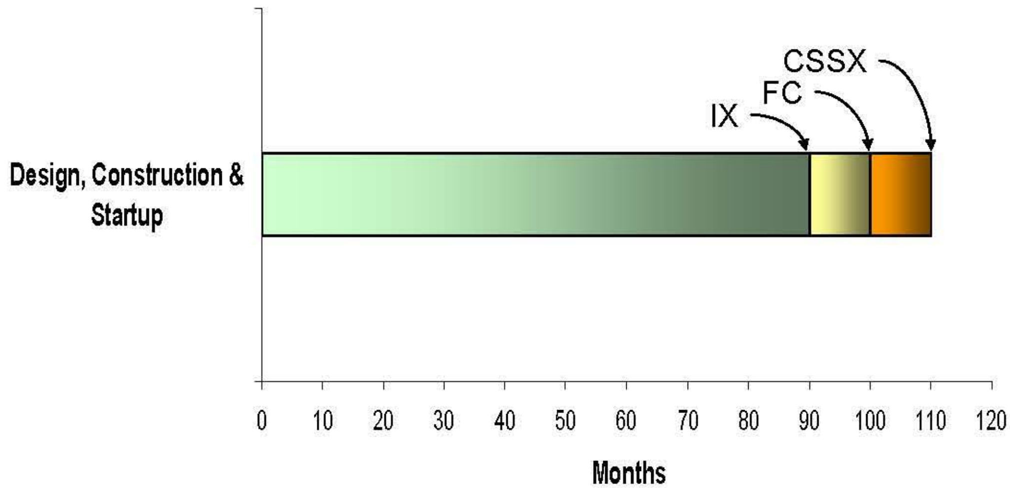


While IX-sRF did receive the highest ranking in the initial evaluation, consideration of these additional incremental implementation costs led the Board to conclude that IX-sRF is clearly the more cost effective choice.

3.2.6.2 Implementation Schedules

The initial schedule assessment did show that IX-sRF had the best implementation schedule of the three cesium technologies. Further review and discussion between the Board and knowledgeable project management staff upheld the determination that the deployment of IX-sRF technology also represented the least schedule risk to IPS project.

Figure 3-4 – Implementation Schedule Duration Comparison



Estimated duration from date of authorization to proceed

[Schedule estimates are for comparative purposes between the technologies only & DO NOT reflect the total IPS project schedule]

3.2.7 Conclusion – Cesium Separation

In summary, while by FC and IX-sRF are both viable technologies for cesium separation, the further examination of FC and IX-sRF with respect to the incremental implementation costs, including baseline costs that would have to be accelerated into the mission period, and implementation schedule duration and risk clearly favors IX-sRF:

- Implementation costs for IX-sRF are estimated at $80M less than FC, and
- The earliest possible deployment of IPS could be achieved with the IX-sRF technology.

4.0 EXPERT REVIEW PANEL

The Expert Review Panel (ERP) assessed the technology selection process in early July 2008 as part of its scope. Based on the initial draft of this summary report, the ERP concluded that sufficient technical information was available to make a selection and that an objection multi-attribute decision process had been used to make the technology selection. The ERP had a number of observations and suggestions to clarify the documentation of the technology selection process.

Several elements of the selection process were closely examined by the ERP, including the tight clustering of the raw ranking scores around 5, the assignment of the weights for the all elements under selection criteria and inclusion of safety related elements within other criterion besides safety (the ERP suggestion was to bin all Safety elements under a single Safety Criterion). During the July 2008 meetings, as an exercise, the ERP performed an abbreviated assessment of the cesium separation technologies with adjustments to the elements noted above. While the ERP's weighted scores for the three technologies were more widely spread, the conclusion was the same – IX-sRF is the preferable technology for cesium separation (See Table 4-1).

Table 4-1 – Comparison of Decision Board versus ERP Cs Separation Evaluation Weighted Results

Criteria	Original Decision Board			Expert Review Panel		
	FC	CSSX	IX-sRF	FC	CSSX	IX-sRF
Safety	13	11	11	20	7	13
Regulatory & Stakeholder Acceptance	11	9	11	12	8	13
Technical Maturity/Flexibility	9	7	9	12	5	15
Operability and Maintainability	8	6	8	11	3	12
Programmatic Aspects	11	8	11	11	8	15
Total	**51**	**41**	**50**	**65**	**32**	**68**

5.0 RECOMMENDATIONS

After the additional review of the implementation costs and schedule for the cesium separation technologies, the Board made the following unanimous recommendations:

- Proceed with project effort to construct and start up a new interim pretreatment system in the Hanford tank farms comprised of cross-flow filtration for entrained solids removal, and ion exchange for cesium separation, using spherical resorcinol-formaldehyde resin.

- Continue limited testing of fractional crystallization to ensure an alternate cesium removal technology for reducing the risk of cost-effectively providing a waste feed supply to the Waste Treatment Plant. Testing scope shall be defined in the follow-up Technical Maturation Plan.

The recommendation of CFF over RM was based on two considerations: 1) that construction and installation of the CFF units will be performed in non-radioactive conditions (green field), while RMF would require modification of an existing DST pit and installation within a nuclear facility; and 2) that there is a high likelihood the RMF units will need to be replaced during the 5-year IPS mission.

The recommendation of IX-sRF over CSSX and FC was based on the consideration that the earliest possible deployment of IPS could be achieved with the IX-sRF technology. Implementation schedules showed that IPS could be implemented approximately one year earlier if the IX-sRF technology was selected over FC and approximately two years earlier if IX-sRF was selected over CSSX. Additionally, the IX-sRF capital and life cycle costs were estimated to be significantly lower than the other two technologies and represent the best "return" on recovered DST space.

As an ancillary benefit, selection of CFF and IX-sRF as the recommended technologies provides potential cost reduction benefits by combining IPS and Waste Treatment Plant (WTP) technology deployment activities. Additionally, the WTP pretreatment process development, operation and maintenance would benefit from the lessons learned by deployment of CCF and IX in IPS.

6.0 REFERENCES

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CH2M HILL 2008b, May, T. H. et al, *Decision Plan: Selection of Early LAW Interim Pretreatment System Processes for Removal of Entrained Solids and Cesium,* Rev. 0, RPP-PLAN-37558, May 5, 2008, CH2M HILL Hanford Group Inc., Richland, Washington.

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ORP 2008b, Certa, P. J., *River Protection Project System Plan,* Rev. 3, ORP-11242, May 2008, U. S. Department of Energy, Office of River Protection, Richland, Washington.

ATTACHMENT A. SOLIDS FILTRATION TECHNOLOGY DECISION SUPPORT BOARD ASSESSMENT

Table A-1 – Solids Filtration Technology Assessment Matrix Summary

Criteria	Measures and Definitions	Cross-flow Filtration (CFF)	Rotary Micro-filtration (RMF)
1 SAFETY *1.1 Process Safety*	1.1.1 Quantity of material at risk (MAR) – radiological and chemical – less is better	• The CFF system does have a larger hold up (volume) then the RMFs. The quantity waste in the system is several thousand gallons. An individual flush of the CFF system also would use a larger volume of chemical. This technology therefore has a higher quantity of MAR.	• Each RMF unit has a hold up of about 40 gallons or about 160 gallons total for the CSSX and IX-sRF options (4 RMF units) and about 500 gallons total (12 RMF units) for the FC option. Each RMF unit has less MAR then the CFF unit.
	1.1.2 Concentration of radiological and chemical MAR - less is better	• Since the feed vector does not have a solids component there is no change in the concentration of radiological and chemical MAR. The solids in the 8 feed tanks have a MAR similar to the liquid. While the MAR could change with a different feed, any changes would be similar for both CFF and RMF	• Since the feed vector does not have a solids component there is no change in the concentration of radiological and chemical MAR. The solids in the 8 feed tanks have a MAR similar to the liquid. While the MAR could change with a different feed, any changes would be similar for both CFF and RMF
	1.1.3 Dispersability of the MAR – less dispersible form is better (e.g., solids over liquids over powders over gases)	• The MAR is a liquid with entrained solids.	• The MAR is a liquid with entrained solids..
	1.1.4 Dispersive energy, e.g., heat, off gassing, pressure, etc. inherent in the process – less dispersive energy is better	• CFF uses a high capacity recirculation pump (1,100-3,300 gpm). In the event of a recirculation pump component failure (e.g. large pipe break accident), dispersive energy would be significant due to the high supply flow rate.	• RMF system has significantly lower flow rates then CFF. However, the rotational energy of the spinning disks will have to be evaluated as part of a housing failure accident.
	1.1.5 Process Stability - including ease of process control/shutdown -- easier/faster process shutdown is better	• Quick shutdown can be achieved by shutting of the system pumps.	• Quick shutdown can be achieved by shutting of the pumps and filter motors.
	1.1.6 Process that does not create a new or exacerbate an existing Tank Farm hazard is preferred to one that does	• Potential exists for one tank farm hazard accidental scenario - mixing of incompatible chemicals.	• Potential exists for one tank farm hazard accidental scenario - mixing of incompatible chemicals.

Table A-1 – Solids Filtration Technology Assessment Matrix Summary

Criteria	Measures and Definitions	Cross-flow Filtration (CFF)	Rotary Micro-filtration (RMF)
	1.1.7 Less fire hazard (e.g. less quantity of combustibles, including flammable gas, less flammable combustibles, etc.)	• The CFF will have to be evaluated for flammable gas retention and release due to solids in the system during shutdown and start up. The solids hold up is larger in the CFF system.	• The RMF will have to be evaluated for flammable gas retention and release due to solids in the system during shutdown and start up. The solids hold up is larger in the CFF system.
	1.1.8 Reactive Chemicals - Process with less reactive chemicals (reactivity) is better	• Caustic and nitric acid wash solutions are used for filter cleaning. These would have to be /treated/neutralized in the CFF system to meet DST specifications.	• Caustic and nitric acid wash solutions are used for filter cleaning. Since nitric acid potentially will be used for cleaning and since in two configurations the RMFs are in the DST, further evaluation and changes to the TF DSA may be required
1.2 Criticality Safety	1.2.1 A Process that is inherently sub-critical is preferred over a process that relies on criticality controls	• CFF process is sub-critical under expected conditions as it does not hold up enough volume to approach the critical mass limit with the projected feed vector. A review of BBI data for the source tanks also shows that even if sludge was transferred the above statement is still true. • Criticality is not credible because the fissile material concentration will always remain too low and the neutron absorbers are too abundant. • CFF does not change the result of tank farm DSA evaluation.	• RMF process is sub-critical under expected conditions as it does not hold up enough volume to approach the critical mass limit with the projected feed vector A review of BBI data for the source tanks also shows that even if sludge was transferred the above statement is still true. • Criticality is not credible because the fissile material concentration will always remain too low and the neutron absorbers are too abundant. • RMF does not change the result of tank farm DSA evaluation.
1.3 Industrial Safety and Hygiene	1.3.1 Less hazards/less severe hazardous is better (e.g., less hazardous chemicals, less noise, less hot surfaces, less rotating equipment, less confined spaces, etc.)	• Located in a below grade area within the IPS facility, considered to be a confined space in radiation zone. • Low shear high capacity circulation pump may have some noise hazards with routine maintenance requirements. • Does not use hazardous (severe) chemicals.	• RMF equipment mounted at grade on an existing DST riser and a vault for the FC option. • Uses rotating disks (with adjustable speed) in a pressurized module. • Modular design approach for filter pack. • Minimal noise hazards. • Does not use hazardous (severe) chemicals.
2 REGULATORY / STAKEHOLDER ACCEPTANCE ***2.1 Achieve Tribal Nations / stakeholders' acceptance***	2.1.1 Early waste treatment enabled	• Early waste pretreatment schedule can be met. Technological maturity assessment is needed to confirm this. • Can be permitted in 28 – 33 months with some additional process demonstration work.	• Early waste pretreatment schedule can be met. Technological maturity assessment is needed to confirm this. • Can be permitted in 28 – 33 months with some additional process demonstration work. • RMF system requires a re-design to fit into a 42-inch diameter DST riser.

Table A-1 – Solids Filtration Technology Assessment Matrix Summary

Criteria	Measures and Definitions	Cross-flow Filtration (CFF)	Rotary Micro-filtration (RMF)
	2.1.2 Land usage (more contaminated ground)	• 400-600 ft² module space will be needed within the cesium separation facility depending on the processing system.	• RMF system is mounted on a DST riser and so generally requires no additional land. • If FC is selected as a cesium separation technology, a 500 ft² area will be needed to house larger capacity RMF system and will be co-located with the FC equipment.
2.2 Achieve regulators' acceptance	2.2.1 Compliance with applicable regulations (RCRA, NEPA/SEPA, NESHAPS, NPDES, CAA, DOE Orders)	• Depends on TC&WM EIS and ROD completion by January 2010. • RCRA Part B Application required. • Three notices of construction required.	• Depends on TC&WM EIS and ROD completion by January 2010. • RCRA Part B Application required. • Three notices of construction required. • May require 2 permitting actions, one for in-tank equipment and one for equipment in IPS • 2 permits required – one for IPS and one for DST modification
	2.2.2 Impact to Disposal System Performance	• Items such as PPE, failed equipment, etc. are commonly disposed of during Tank Farms operations. • COPC are not applicable.	• Items such as PPE, failed equipment, etc. are commonly disposed of during Tank Farms operations. • COPC are not applicable.
	2.2.3 Secondary Waste Form and Quantity	• Does not produce secondary waste requiring new disposal form.	• Does not produce secondary waste requiring new disposal form.
	2.2.4 Potential impacts to other permitted facilities	• The current WTP Project commissioning approach will support commissioning and operation of the LAW processing facility,	• The current WTP Project commissioning approach will support commissioning and operation of the LAW processing facility,
3 TECHNICAL MATURITY / FLEXIBILITY *3.1 Technology Readiness Level*	3.1.1 TRL Number	• TRL number is 3.	• TRL number is 3.
	3.1.2 Effort to mature technology (cost and schedule)	• ROM cost and schedule to mature technology is $2.0M over 30 months.	• ROM cost and schedule to mature technology is $2.5M over 36 months.(additional 6 months of time is for run-time reliability)
	3.1.3 Probability of Success	• Probability of success for maturing technology is *"High"*.	• Probability of success for maturing technology is *"High"*.

Table A-1 – Solids Filtration Technology Assessment Matrix Summary

Criteria	Measures and Definitions	Cross-flow Filtration (CFF)	Rotary Micro-filtration (RMF)
3.2 Process Flexibility and robustness	3.2.1 Ability to process a variety of feeds	• Demonstrates "***Medium***" level of flexibility to process variety of Hanford tank waste feeds.	• Demonstrates "***High***" level of flexibility to process variety of Hanford tank waste feeds.
	3.2.2 Ability to adjust process rate (turn up/turn down)	• Demonstrates "***High***" level of flexibility to adjust process rates. • Rated slightly lower because only pump rate can be adjusted	• Demonstrates "***High***" level of flexibility to adjust process rates. • Rated slightly higher because rotational speed can also be adjusted
	3.2.3 Flexibility to modify product	• "***Medium***" filtration product flexibility with 9 degrees of freedom.	• "***Medium***" filtration product flexibility with 10 degrees of freedom.
	3.2.4 Ability to expand	• Sized to meet required throughput for IPS mission	• Sized to meet required throughput for IPS mission
	3.2.5 Recover from out of spec product	• "***Medium***" flexibility to recover from out of specification product.	• "***Low***" flexibility to recover from out of specification product.
	3.2.6 Technology applicability to other DOE complex projects	• "***High***" applicability to other DOE complex projects.	• "***Medium***" applicability to other DOE complex projects.
4 OPERABILITY & MAINTAINABILITY ***4.1 Ease of Process control and operation***	4.1.1 Minimize number and frequency of surveillances	• At least 22 process parameters are to be monitored and it is comparable to current waste transfer operation.	• With CSSX and IX-sRF, at least 35 process parameters are to be monitored and it is comparable to current waste transfer operation. • With FC, a total of 71 process parameters are to be monitored due to increased number of filter modules.
	4.1.2 Minimize number of people to operate	• Operation requires at least six people.	• Operation requires at least five people for CSSX and IX-sRF and six when used with the FC.
	4.1.3 Ease of startup and shutdown	• Easy to startup and shutdown based on a small number of moving components (2) and a simplified process.	• Easy to startup and shutdown based on few (6) moving components when used with CSSX and IX-sRF. • More complex due to higher number of moving components (14) and multiple locations when used with FC.
	4.1.4 Minimize system complexity	• No more complex than any of the existing waste transfer systems currently used in the tank farms.	• No more complex than any of the existing waste transfer systems currently used in the tank farms.
	4.1.5 Minimize number of chemicals needed	• Process uses modest quantities of basic chemicals, sodium hydroxide and nitric acid for filter flush.	• Process uses modest quantities of basic chemicals, sodium hydroxide and nitric acid for filter flush.

Table A-1 – Solids Filtration Technology Assessment Matrix Summary

Criteria	Measures and Definitions	Cross-flow Filtration (CFF)	Rotary Micro-filtration (RMF)
	4.1.6 Minimize number of process and regulatory samples	• Process sampling requirements are minimum (2) with no requirements for regulatory samples. • Detailed design may identify more parameters for measurements.	• Process sampling requirements are minimum (2) with no requirements for regulatory samples. • Detailed design may identify more parameters for measurements.
	4.1.7 Batch versus continuous	• Routinely used as a continuous process for each campaign.	• Routinely used as a continuous process for each campaign.
	4.1.8 Ease of entry and exit from standby	• System shutdown and restart is easy.	• System shutdown and restart is easy.
	4.1.9 Wide operating margin	• System has an acceptable operating range for the majority of Hanford tank waste.	• System has an acceptable operating range for the majority of Hanford tank waste.
	4.1.10 Complexity of transfers to, from and within Tank Farms	• System does not impose any complex tank waste transfer requirements to the Tank Farms.	• System does not impose any complex tank waste transfer requirements to the Tank Farms.
4.2 ALARA	4.2.1 Less required contact maintenance is better, etc.	• Potentially less contact maintenance is required. Most maintenance activities will be done at the IPS (except for the feed pump). • ALARA must be implemented during the design phase to assure maximum benefits. Contaminated components will be flushed and decontaminated to the extent possible prior to maintenance. • Waste transfer and feed pumps, transfer piping, and filter tube bundle will require contact maintenance. • Design will include remote replacement and maintenance to the extent possible. • Instrumentation and control systems will invoke work in radiation area (valve pit) or the IPS facility, but exposure can be minimized. • Initial installation is in "green field" conditions	• May require maintenance activities to be performed in a DST pit or components may have to be removed from the tank for repair or replacement. • ALARA must be implemented during the design phase to assure maximum benefits. Contaminated components will be flushed and decontaminated to the extent possible prior to maintenance. • Waste transfer and feed pumps, transfer line and filter assemblies will require contact maintenance. • Design will include remote replacement and maintenance to the extent possible. • Instrumentation and control systems will invoke work in radiation area (valve pit) or the IPS facility, but exposure can be minimized. • Replacement of seals will likely be required during 5-year mission

Table A-1 – Solids Filtration Technology Assessment Matrix Summary

Criteria	Measures and Definitions	Cross-flow Filtration (CFF)	Rotary Micro-filtration (RMF)
4.3 Reliability	4.3.1 Number of active components	• Three active components (waste feed/transfer pumps, and the filter back-flush system).	• More (6 – 13) active components (waste feed/transfer pump motors and RMF shaft motors).
	4.3.2 Reliability of analogous systems	• Large shell and tube filter systems have not been used at Hanford. • Single element metal filters have been used at Hanford. • Apparent potential for single point failure with current design • Extensive application of technology • The reliability of the CFF system should be outstanding.	• No documented use of RMF at Hanford Site or similar system at the site. • There is a limited historical data for the reliability of the filters and rotational motor. • Apparent redundancy with current design • The reliability of the RMF system should be good.
4.4 Ease and frequency of maintenance	4.4.1 Minimize number of support systems	• For operation five services- power, air, water, NaOH and HNO_3 are required.	• For operation five services- power, instrument air, water, NaOH and HNO_3 are required.
	4.4.2 Minimize number and frequency of PM's (includes calibrations)	• Preventive maintenance activities are anticipated to be routine with some entry into radiation zone areas.	• Preventive maintenance activities are anticipated to be routine with some entry into radiation zone areas. Due to higher number of RMF units, number of activities will be higher. • If used with FC, number of RMF units will be 12, increasing number of maintenance activities.
	4.4.3 Minimize maintenance in-zone entries	• Routine zone entry required once every five year for repair/replacement of filter tube bundle.	• Zone entry is needed every 2 years for repair/replacement of mechanical seals. • Frequency of replacement potentially impacted by start/stop mode of operation • Seal reliability impacted by planned start/stop operation.
	4.4.4 Minimize specialized equipment and parts	• CFF is a commercial technology which is adapted to radioactive operation. Adequate spare parts are needed.	• RMF assembly is specialized equipment but is based on commercial technology which is modified for a radioactive operation. Adequate spare parts will be needed.
	4.4.5 Minimize tank entries	• Routine waste transfer through pipes per tank farm procedures requiring no special DST tank entry. Installation of feed pump in the valve pit is also considered a "DST tank entry". • Some maintenance activities on feed pump will require a DST tank entry.	• Requires a DST entry to install filtration equipment on AP-104 riser and some maintenance activities.

Table A-1 – Solids Filtration Technology Assessment Matrix Summary

Criteria	Measures and Definitions	Cross-flow Filtration (CFF)	Rotary Micro-filtration (RMF)
4.5 Ease of Implementation	4.5.1 Ease of training	• CFF is a passive unit with an uncomplicated operating principles leading to non-complex training needs.	• RMF is a compact design with basic control and configured for ease of assembly and maintenance, eliminating complex training needs.
	4.5.2 Complexity of procedures	• No complexity for O&M procedure is anticipated.	• No complexity for O&M procedure is anticipated.
	4.5.3 Similar to other process facilities on Hanford site	• Similar technology is not in use at Hanford Site	• Similar technology is not in use at Hanford Site
4.6 Liquid/solid secondary waste-	4.6.1 Waste handling compatible with existing systems as defined by DOE Order 420.1B – N/A	• N/A.	• N/A
	4.6.2 Minimize operational impacts associated with hazardous (generated) waste handling – N/A	• The technology is suited for continuous normal operation, with no impact for handling of secondary waste. • Operation requires suspension once in 5 yr for replacement of filter tube bundles and disposal of failed equipment.	• The technology is suited for continuous normal operation, with no impact for handling of secondary waste. • Operation requires suspension every 2 year for replacement of mechanical seals and disposal of failed equipment.
5 PROGRAM-MATIC ASPECTS ***5.1 Cost Impact***	5.1.1 Capital costs (for comparative purposes only)	• With expected accuracy range of -30% to +50%: CFF - FC capital costs = $64M to $140M, CFF - CSSX capital costs = $82M to $180M, CFF - IX capital costs = $54M to $120M.	• With expected accuracy range of -30% to +50%: RMF - FC capital costs = $75M to $160M, RMF - CSSX capital costs = $87M to $190M, RMF - IX capital costs = $59M to $130M.
	5.1.2 Life cycle costs (for comparative purposes only)	• With expected accuracy range of -30% to +50% (applied to capital cost contribution): CFF - FC life cycle costs (w/o T&R) = $170M to $240M, CFF - CSSX life cycle costs (w/ evap) = $190M to $290M, CFF - IX life cycle costs = $140M to $200M.	• With expected accuracy range of -30% to +50% (applied to capital cost contribution): RMF - FC life cycle costs (w/o T&R) = $190M to $280M, RMF - CSSX life cycle costs (w/ evap) = $210M to $310M, RMF - IX life cycle costs = $150M to $220M.
	5.1.3 Cost profile (for comparative purposes only)	• Both the lowest capital cost and the lowest life cycle cost result from pairing CFF with IX-sRF. (for comparative purposes only)	• Both the highest capital cost and highest life cycle cost result from pairing RMF with CSSX. (for comparative purposes only)

Table A-1 – Solids Filtration Technology Assessment Matrix Summary

Criteria	Measures and Definitions	Cross-flow Filtration (CFF)	Rotary Micro-filtration (RMF)
5.2 Schedule Impact	5.2.1 Overall schedule (confidence) - for comparative purposes only	• Scheduling of "green field" activities has a lower degree of uncertainty.	• Scheduling of work in tank farms has a higher degree of uncertainty..
	5.2.2 Licensing	• Due to considerable experience with this technology at various DOE sites (including WTP), its safety analysis should not impact overall schedule.	• Due to lack of enough design and process information, safety analysis will require additional efforts and time.
	5.2.3 Permitting	• Does not impact RCRA part B permitting schedule as it is the first step of the total pretreatment process and does not produce any secondary waste.	• Does not impact RCRA part B permitting schedule as it is the first step of the total pretreatment process and does not produce any secondary waste.
	5.2.4 D&D	• Considerations for D&D will be accommodated during the IPS design. Negligible impact on IPS schedule.	• Considerations for D&D will be accommodated during the IPS design. Negligible impact on IPS schedule.
5.3 DST Space	5.3.1 How fast DST space is made available – N/A	• Does not directly impact rate of freed up DST space.	• Does not directly impact rate of freed up DST space.
	5.3.2 Amount of DST space – N/A	• Generates a total of 200,000 gals of 20 wt% entrained solids waiting to be processed as HLW feed. • Larger CFF system volume and higher filter cleaning frequency will generate neutralized wash solution volumes significantly (10+ times) greater than RMF.	• Generates a total of 200,000 gals of 20% entrained solids waiting to be processed as HLW feed. • Smaller RMF system volume and lower filter cleaning frequency will generate neutralized wash solution volumes significantly less than CFF. • Neutralized wash solution volumes for FC will be ~2-3 times than those for CSSX or IX-sRF due to increased number of filters.

Table A-1 – Solids Filtration Technology Assessment Matrix Summary

Criteria	Measures and Definitions	Cross-flow Filtration (CFF)	Rotary Micro-filtration (RMF)
5.4 Impacts to WTP & Supplemental Treatment	5.4.1 Production rate impact - N/A	• No production rate impact to WTP (HLW and LAW) or supplemental Treatment Plant.	• No production rate impact to WTP (HLW and LAW) or supplemental Treatment Plant.
	5.4.2 Mission duration – N/ A	• No impact to overall WTP primary mission duration.	• No impact to overall WTP primary mission duration.
	5.4.3 Number of high and low level packages – N/A	• No impact on high or low level waste packages to be produced by WTP or supplemental treatment plants.	• No impact on high or low level waste packages to be produced by WTP or supplemental treatment plants.
	5.4.4 Lessons Learned benefits for WTP pretreatment	• IPS CFF deployment, start up and operational experience will provide lessons learned feedback to the WTP pretreatment facility.	• RMF process does not provide lessons learned for WTP.
	5.4.5 Technology transfer to WTP	• Does not provide technology transfer for WTP.	• RMF can provide technology transfer to WTP if for any reason CFF did not perform in the WTP. RMF can also provide filtration support to WTP if needed.
	5.4.6 ALARA - N/A	• No ALARA impact to WTP.	• No ALARA impact to WTP.
	5.4.7 Diversity of technology	• CFF does not provide technology diversity.	• RMF provides technology diversity for waste filtration needs at Hanford. This technology can be adapted to other tanks in tank farms.
	5.4.8 Positive programmatic impacts and opportunities	• Provide potential cost reduction through shared development costs and reduced WTP startup costs and reduces technical and schedule risk through lessons learned.	• No programmatic opportunities are identified yet.
5.5 Impacts to other facilities e.g., ETF, LAB	5.5.1 Analytical equipment, methods, and capacity – N/A	• No impact to analytical laboratories (in-line measurement of solids concentration).	• No impact to analytical laboratories (solids are returned directly to feed tank AP-104).
	5.5.2 Compliance to ETF WAC – N/A	• Does not impact ETF operation.	• Does not impact ETF operation.
	5.5.3 ALARA	• Because CFF included as part of new IPS facility, ALARA will be more easily incorporated into its process design. • Initial installation is under "green field" conditions	• Because RMF is being installed in an existing DST, ALARA will be more difficult to incorporate into its process design.
	5.5.4 Number of Evaporator campaigns – N/A	• Does not directly impact 242-A Evaporator campaigns.	• Does not directly impact 242-A Evaporator campaigns.

Table A-1 – Solids Filtration Technology Assessment Matrix Summary

Criteria	Measures and Definitions	Cross-flow Filtration (CFF)	Rotary Micro-filtration (RMF)
5.6 Resources and materials	5.6.1 Availability of Key Skills, Critical Materials, Qualified Vendors	• CFF unit can be assembled by multiple experienced vendors with limited technical oversight. • CFF requires very high capacity recirculation pump. • German supplier provides best quality filter material, but not seen as sole source	• RMF will require some technological development resources to support re-engineering of the system for Hanford tank specific design. • Only a single vendor has been identified who is capable of assembling these modules and the vendor will require strong participation of technology experts from the DOE sites.
	5.6.2 Stability of Critical Resource Pricing	• Does not require any special or unusual material of construction. • No specific critical material pricing risk is anticipated.	• Does not require any special or unusual material of construction. • Due to a single source vendor, may be subjected to some pricing risk.

Table A-2 – Solids Filtration Technology Assessment Decision Calculator Results
(extracted from CH2M HILL 2008f)

#	RPP-PLAN-37558 DECISION PLAN CRITERIA	Weight (%)	CFF		RM	
			Raw Ranking	Weighted Value	Raw Ranking	Weighted Value
1.0	**Safety**	**25**				
1.1	**Process Safety**					
1.1.1	Quantity of material at risk (MAR) – radiological and chemical – less is better		5	0.94	5	0.94
1.1.2	Concentration of radiological and chemical MAR - less is better		5	0.94	5	0.94
1.1.3	Dispersability of the MAR – less dispersible form is better (e.g., solids over liquids over powders over gases)		5	0.94	5	0.94
1.1.4	Dispersive energy, e.g., heat, off gassing, pressure, etc. inherent in the process – less dispersive energy is better		4	0.75	5	0.94
1.1.5	Process Stability - including ease of process control/shutdown -- easier/faster process shutdown is better		5	0.94	5	0.94
1.1.6	Process that does not create a new or exacerbate an existing Tank Farm hazard is preferred to one that does		5	0.94	5	0.94
1.1.7	Less fire hazard (e.g. less quantity of combustibles, including flammable gas, less flammable combustibles, etc.)		4	0.75	5	0.94
1.1.8	Reactive Chemicals - Process with less reactive chemicals (reactivity) is better		5	0.94	4	0.75
1.2	**Criticality Safety**					
1.2.1	A Process that is inherently sub critical is preferred over a process that relies on criticality controls		5	1.25	5	1.25
1.3	**Industrial Safety and Hygiene**					
1.3.1	Less hazards/less severe hazardous is better (e.g.,…)		5	3.75	5	3.75
			Subtotals	**12**		**12**
2.0	**Regulator and Stakeholder Acceptance**	**20**				
2.1	**Achieve Tribal Nations / stakeholders' acceptance**					
2.1.1	Early waste treatment enabled		5	2.00	5	2.00
2.1.2	Land usage (more contaminated ground)		6	2.40	7	2.80

Table A-2 – Solids Filtration Technology Assessment Decision Calculator Results
(extracted from CH2M HILL 2008f)

#	RPP-PLAN-37558 DECISION PLAN CRITERIA	Weight (%)	CFF		RM	
			Raw Ranking	Weighted Value	Raw Ranking	Weighted Value
2.2	**Achieve regulators' acceptance**					
2.2.1	Compliance with applicable regulations (RCRA, CAA, NESHAPS, NEPA/SEPA, NPDES, DOE Orders)		5	1.50	4	1.20
2.2.2	Impact to Disposal System Performance		5	1.50	5	1.50
2.2.3	Secondary Waste Form and Quantity		5	1.50	5	1.50
2.2.4	Potential impacts to other permitted facilities		5	1.50	5	1.50
			Subtotals	**10**		**11**
3.0	**Technical Maturity/Flexibility**	**20**				
3.1	**Technology Readiness Level**					
3.1.1	Technology Readines Level Number		5	2.00	5	2.00
3.1.2	Effort to mature technology		6	2.40	4	1.60
3.1.3	Probability of success		8	3.20	8	3.20
3.2	**Process Flexibility and robustness**					
3.2.1	Ability to process a variety of feeds		5	0.80	5	0.80
3.2.2	Ability to adjust process rate		5	0.80	6	0.96
3.2.3	Flexibility to modify product		5	0.80	5	0.80
3.2.4	Ability to expand		0	0.00	0	0.00
3.2.5	Recover from out of spec product		5	0.80	4	0.64
3.2.6	Technology applicability to other DOE complex projects		5	0.80	6	0.96
			Subtotals	**12**		**11**
4.0	**Operability and Maintainability**	**15**				
4.1	**Ease of Process control and operation**					
4.1.1	Minimize number and frequency of surveillances		5	0.19	5	0.19
4.1.2	Minimize number of people to operate		5	0.19	5	0.19
4.1.3	Ease of startup and shutdown		6	0.23	5	0.19
4.1.4	Minimize system complexity		5	0.19	5	0.19
4.1.5	Minimize number of chemicals needed		5	0.19	5	0.19
4.1.6	Minimize number of process and regulatory samples		5	0.19	5	0.19
4.1.7	Batch verses continuous		5	0.19	5	0.19
4.1.8	Ease of entry and exit from standby		5	0.19	5	0.19

Table A-2 – Solids Filtration Technology Assessment Decision Calculator Results
(extracted from CH2M HILL 2008f)

#	RPP-PLAN-37558 DECISION PLAN CRITERIA	Weight (%)	CFF		RM	
			Raw Ranking	Weighted Value	Raw Ranking	Weighted Value
4.1.9	Wide operating margin		5	0.19	5	0.19
4.1.10	Complexity of transfers to, from and within Tank Farms		5	0.19	5	0.19
4.2	ALARA					
4.2.1	Less required contact maintenance is better, etc. (rad and tox)		5	1.50	4	1.20
4.3	**Reliability**					
4.3.1	Number of active components		6	1.04	5	0.86
4.3.2	Reliability of analogous systems		5	0.86	5	0.86
4.4	**Ease and frequency of maintenance**					
4.4.1	Minimize number of support systems		5	0.30	5	0.30
4.4.2	Minimize number and frequency of PM's		5	0.30	4	0.24
4.4.3	Minimize maintenance in zone entries		6	0.36	4	0.24
4.4.4	Minimize specialized equipment and parts		5	0.30	5	0.30
4.4.5	Minimize tank entries		5	0.30	5	0.30
4.5	**Ease of Implementation**					
4.5.1	Ease of training		5	0.30	5	0.30
4.5.2	Complexity of procedures		5	0.30	5	0.30
4.5.3	Similar to other process facilities on site		5	0.30	5	0.30
4.6	**Liquid/solid secondary waste**					
4.6.1	Waste handling compatible with existing systems as defined by DOE Order 420.1B		0		0	
4.6.2	Minimize operational impacts associated with hazardous (generated) waste handling		0		0	
			Subtotals	**8**		**7**
5.0	**Programmatic Aspects**	**20**				
5.1	**Cost Impacts**					
5.1.1	Capital costs		8	2.13	5	1.33
5.1.2	Life cycle costs		8	2.13	4	1.07
5.1.3	Cost profile		8	2.13	4	1.07
5.2	**Schedule Impact**					
5.2.1	Overall schedule (confidence)		7	1.23	5	0.88

Table A-2 – Solids Filtration Technology Assessment Decision Calculator Results
(extracted from CH2M HILL 2008f)

#	RPP-PLAN-37558 DECISION PLAN CRITERIA	Weight (%)	CFF		RM	
			Raw Ranking	Weighted Value	Raw Ranking	Weighted Value
5.2.2	Licensing		6	1.05	5	0.88
5.2.3	Permitting		5	0.88	5	0.88
5.2.4	D&D		5	0.88	5	0.88
5.3	**DST Space**					
5.3.1	How fast DST space is made available		0		0	
5.3.2	Amount of DST space		0		0	
5.4	**Impacts to WTP and Supplemental Treatment, positive and negative**					
5.4.1	Production rate impact		0		0	
5.4.2	Mission duration		0		0	
5.4.3	Number of high and low level packages		0		0	
5.4.4	Lessons Learned benefits for WTP pretreatment		3	0.23	2	0.15
5.4.5	Technology transfer to WTP		1	0.08	2	0.15
5.4.6	ALARA		0		0	
5.4.7	Diversity of technology		1	0.08	2	0.15
5.4.8	Positive programmatic impacts and opportunities		2	0.15	1	0.08
5.5	**Impacts to other facilities e.g., ETF, LAB**					
5.5.1	Analytical equipment, methods, and capacity		0		0	
5.5.2	Compliance to ETF WAC		0		0	
5.5.3	ALARA		5	0.50	4	0.40
5.5.4	Number of Evaporator campaigns		0		0	
5.6	**Resources and materials**					
5.6.1	Availability of Key Skills, Critical Materials, Qualified Vendors		6	0.30	4	0.20
5.6.2	Stability of Critical Resource Pricing		5	0.25	5	0.25
			Subtotals	**12**		**8**
	TOTALS		**301**	**54**	**278**	**49**

ATTACHMENT B. CESIUM SEPARATION TECHNOLOGY DECISION SUPPORT BOARD ASSESSMENT

Table B-1 – Cesium Separation Technology Assessment Summary Matrix

Criteria	Measures and Definitions	Fractional Crystallization (FC)	Caustic-Side Solvent Extraction (CSSX)	Ion Exchange with sRF (IX-sRF)
1 SAFETY *1.1 Process Safety*	1.1.1 Quantity of material at risk (MAR) – radiological and chemical – less is better	• The radionuclide (Ci) MAR quantity ranges are E+04 to E+05 for feed receipt tank. Since FC has the larger feed tank it has larger quantity of MAR. • The radionuclide (Ci) MAR quantity ranges are E+04 to E+05 for Cs Product tank. • The radionuclide (Ci) MAR quantity ranges are 8.65 E+01 to 4.46 E+02 for LAW Product tank. • Toxicological doses are driven by the chemicals in the DST wastes.	• The radionuclide (Ci) MAR quantity ranges are E+04 to E+05 for feed receipt tank. • The radionuclide (Ci) MAR quantity ranges are E+04 for Cs Product tank. • The LAW Product tank MAR is similar to the IX technology. • Toxicological doses are driven by the chemicals in the DST wastes and not process chemicals.	• The radionuclide (Ci) MAR quantity ranges are E+04 to E+05 for feed receipt tank. • The radionuclide (Ci) MAR quantity ranges are E+04 for Cs Product tank. • The radionuclide (Ci) MAR quantity ranges are 2.17 E+02 to 1.15 E+03 for LAW Product tank. • Toxicological doses are driven by the chemicals in the DST wastes and not process chemicals.
	1.1.2 Concentration of radiological and chemical MAR - less is better – focused on toxicological over radiological	• ULDs of the LAW (0.5 to 2.8) to the WTP is very low (similar for all three technologies). ULDs range for Cs return stream is 99.2 to 515.6.	• ULDs of the LAW (1.3 to 6.7) to the WTP are very low. ULDs range for Cs return stream is 33.2 to 278.2. The strip solution has ULD values up to 700.	• ULDs of the LAW (1.3 to 6.7) to the WTP are very low. ULDs range for Cs return stream is 155.4 to 342.0.
	1.1.3 Dispersability of the MAR – less dispersible form is better (e.g., solids over liquids over powders over gases)	• Minimal dispersability as MAR remains in a liquid phase. • Some of the MAR can be entrained in the vapor phase.	• Minimal dispersability as MAR always remains in a liquid phase in non-fire type accidents. • The MAR is mixed with the solvent.	• Minimal dispersability as MAR remains in a liquid phase. • Dispersibility of MAR for resin column could be problematic in a fire accident when IX column is loaded with Cs
	1.1.4 Dispersive energy, e.g., heat, off gassing, pressure, etc. inherent in the process – less dispersive energy is better	• Dispersion energy comes mainly from kinetic energy from transfer pumps and process steam and gravitational energy from tanks and vessels. • The FC recirculation pumps are rated for over 5000 gpm. • Rotational speed of centrifuge is 1200 rpm	• Dispersive energy comes from rotational kinetic energy, reactive chemical energy, organic solvents (fires), and gravitational energy from tanks and vessels.	• Dispersive energy can be kinetic energy (pumps), reactive chemical energy, H2 gassing, and gravitational energy from tanks and vessels. • Decay heat on resin column accounted for in 1.1.7

Table B-1 – Cesium Separation Technology Assessment Summary Matrix

Criteria	Measures and Definitions	Fractional Crystallization (FC)	Caustic-Side Solvent Extraction (CSSX)	Ion Exchange with sRF (IX-sRF)
	1.1.5 Process Stability - including ease of process control/shutdown -- easier/faster process shutdown is better	• The FC does operate at a slightly evaluated temperature. Boiling can be easy stopped by reducing the vacuum. Long term shut down requires dumping or flushing of the solution to minimize further solids formation.	• Turning off the pumps and contactors achieves a quick shutdown. But stripping of the Cs from the organic would take several hours for a long term shutdown. • Stripping of Cs may need to be performed as part of a shutdown operation	• Simple turning off the pumps achieves the quick shutdown, but rinse and elution of ^{137}Cs from resin columns maybe required for long term shutdown • Elution of Cs may need to be performed as part of a shutdown operation
	1.1.6 Process that does not create a new or exacerbate an existing Tank Farm hazard is preferred to one that does	• The potential for solids in the FC return stream (or in the tank as the solution cools) will need further evaluation. No other potential were identified which exacerbate tank farm hazard accidental scenarios.	• Potential exists for one tank farm hazard accidental scenarios - mixing of incompatible chemicals.	• Potential exists for one tank farm hazard accidental scenarios - mixing of incompatible chemicals.
	1.1.7 Less fire hazard (e.g. less quantity of combustibles, including flammable gas, less flammable combustibles, etc.)	• Does not use combustible material. • Process is susceptible to forming hydrogen gas due to radiolysis.	• Use of organic solvents with a low flash point of 62 °C (Isopar L) elevates fire safety concern. • Organic susceptible to forming hydrogen gas due to radiolysis – postulated accident	• Process is susceptible to forming hydrogen gas due to radiolysis. • Various chemicals used in the process may generate heat if mixed improperly. • Decay heat on resin column increases potential for fire, but water-cooled jacket will be integrated into IX column design
	1.1.8 Reactive Chemicals - Process with less reactive chemicals (reactivity) is better	• Only chemical that may be used is nitric acid (low concentration) for cleaning. • Lowest chemical reactivity.	• Uses caustic, nitric acid and 4 different organic solvents components. Organic solvents have negligible or no chemical reactivity. • Interactions of nitric acid with caustic solutions and strong acids with organic solvents should be carefully monitored and controlled. • More concentration and higher quantity of hazardous chemicals, e.g., nitric acid in IPS	• Uses caustic, nitric acid and sRF organic resins. • Interactions of nitric acid with caustic solutions should be carefully monitored and controlled. • More concentration and higher quantity of hazardous chemicals, e.g., nitric acid in IPS

Table B-1 – Cesium Separation Technology Assessment Summary Matrix

Criteria	Measures and Definitions	Fractional Crystallization (FC)	Caustic-Side Solvent Extraction (CSSX)	Ion Exchange with sRF (IX-sRF)
1.2 Criticality Safety	1.2.1 A Process that is inherently sub- critical is preferred over a process that relies on criticality controls	• FC process is sub-critical under expected conditions as it does not hold up enough feed volume to approach the critical mass limit in any condition. • FC does not change the result of tank farm DSA evaluation.	• CSSX process is sub-critical under expected conditions as it does not hold up enough feed volume to approach the critical mass limit in any condition. • CSSX does not change the result of tank farm DSA evaluation.	• IX-sRF process is sub-critical under expected conditions as it does not hold up enough feed volume to approach the critical mass limit in any condition. • IX-sRF does not change the result of tank farm DSA evaluation.
1.3 Industrial Safety and Hygiene	1.3.1 Less hazards/less severe hazardous is better (e.g., less hazardous chemicals, less noise, less hot surfaces, less rotating equipment, less confined spaces, etc.)	• Large product tanks (8,600 – 32,000 gals) along with pumps, heat exchangers, reboilers, and condensers are located in below-grade areas of confined space in a radiation zone. • Two crystallizers are tall (30 ft) requiring a ladder and elevated walkways for access. • Does not add chemicals for processing.	• Large product tanks (11,500-45,000 gas) along with contactors and associated pumps and heat exchangers are located below grade areas of confined space in a radiation zone. • Uses organic solvent, NaOH, $NaNO_2$ and HNO_3 requiring chemical area and handling.	• Large product tanks (11,500-45,000 gas) along with contactors and associated pumps and heat exchangers are located below grade areas of confined space in a radiation zone. • Uses ion exchange resin, NaOH, NaNO2 and HNO3 requiring chemical area and handling.
2 REGULATORY / STAKEHOLDER ACCEPTANCE *2.1 Achieve Tribal Nations / stakeholders' acceptance*	2.1.1 Early waste treatment enabled	• Early waste pretreatment schedule expectation can be met. Technological maturity assessment is needed to confirm this. • Some additional demonstration and verification work is required for Hanford use. • Based on familiarity with evaporator technology - stakeholders are less likely to support implementation of a somewhat analogous technology	• Early waste pretreatment schedule expectation can be met. Technological maturity assessment is needed to confirm this. • Some additional demonstration and verification work is required for Hanford use. • New technology to Hanford - stakeholders are least likely to support implementation of a less familiar technology	• Early waste pretreatment schedule expectation can be met. Technological maturity assessment is needed to confirm this. • Limited demonstration and verification work is required. • Based on familiarity with past Hanford separations and WTP based technology –stakeholders are most likely to support implementation of a more familiar technology
	2.1.2 Land usage (more contaminated ground)	• Process Vault/Building footprint is 5699 ft^2 (with RMF) and 5963 ft^2 (with CFF).	• Process Vault/Building footprint is 6016 ft^2 (with RMF) and 6628 ft^2 (with CFF).	• Process Vault/Building footprint is 4032 ft^2 (with RMF) and 4610 ft^2 (with CFF).

Table B-1 – Cesium Separation Technology Assessment Summary Matrix

Criteria	Measures and Definitions	Fractional Crystallization (FC)	Caustic-Side Solvent Extraction (CSSX)	Ion Exchange with sRF (IX-sRF)
2.2 Achieve regulators' acceptance	2.2.1 Compliance with applicable regulations (RCRA, NEPA/SEPA, NESHAPS, NPDES, CAA, DOE Orders)	• Can be permitted in 28-33 months with some additional process demonstration work. • Depends on TC&WM EIS and ROD being completed by January 2010. • RCRA Part B Application required. • Three notices of construction required.	• Can be permitted in 28 – 33 months with some additional process demonstration work. • Depends on TC&WM EIS and ROD being completed by January 2010. • RCRA Part B Application required. • Three notices of construction required.	• Can be permitted in 28 – 33 months with some additional process demonstration work. • Depends on TC&WM EIS and ROD being completed by January 2010. • RCRA Part B Application required. Three notices of construction required.
	2.2.2 Impact to Disposal System Performance	• Further investigation of potential COPC concern for secondary waste disposal system is required. • The current WTP Project commissioning approach will support commissioning and operation of the LAW processing facility, without the support of the Pretreatment facility. • FC will remove Tc from LAW feed; a substantial positive for FC	• Further investigation of potential COPC concern for secondary waste disposal system is required. • The current WTP Project commissioning approach will support commissioning and operation of the LAW processing facility, without the support of the Pretreatment facility.	• Further investigation of potential COPC concern for secondary waste disposal system is required. • The current WTP Project commissioning approach will support commissioning and operation of the LAW processing facility, without the support of the Pretreatment facility.
	2.2.3 Secondary Waste Form and Quantity	• Generates 7,256,143 L (1.9 million gallons) of liquid effluent for disposal at ETF.	• Generates 680 -1,475 L (180 – 390 gallons) of liquid organic solvent per year for disposal.	• Generates 4,535 kg (10,000 lbs) of spent resin for disposal.

Table B-1 – Cesium Separation Technology Assessment Summary Matrix

Criteria	Measures and Definitions	Fractional Crystallization (FC)	Caustic-Side Solvent Extraction (CSSX)	Ion Exchange with sRF (IX-sRF)
	2.2.4 Potential impacts to other permitted facilities	• Secondary waste to ETF will meet Waste Acceptance Criteria. • Permit modification for IDF will be needed sooner than anticipated (allows disposal of LAW glass)	• Does not generate secondary waste for ETF. • Permafix is the permitted facility for disposal of organic. If it is determined that their permit needs to be modified to accept other waste codes, it would likely be a class 2 or class 3 modification of the permit and require a minimum of 6 months and up to 2 years for a class 3. • The WTP permit does not prohibits organics (only D001 & D003 waste codes are called out in the permit). The extent to which destruction of organics occurs and how they would impact the DRE (destructive removal efficiency) would need to be determined. • Permit modification for IDF will be needed sooner than anticipated (allows disposal of LAW glass)	• Does not generate secondary waste for ETF. • Permit mod for IDF to accept spent resins • Permit modification for IDF will be needed sooner than anticipated (allows disposal of LAW glass)
3 TECHNICAL MATURITY / FLEXIBILITY *3.1 Technology Readiness Level*	3.1.1 TRL Number	• TRL number is 4 – this TRL number is based on the technical and programmatic work that was done in support of SST wastes in 200W. May 2008 review of original assessment found that original work was sufficiently valid to maintain TRL # of 4. • Original assessment was based on SST saltcake feeds, rather than DST supernate feeds identified for IPS	• TRL number is 3 • Lab testing with simulants and modeling needed • Potassium could be an issue	• TRL number is 3 • Cs separation demonstrated with real waste • Equipment optimization is primarily need (engineering, not development)
	3.1.2 Effort to mature technology (cost and schedule)	• ROM cost and schedule to mature technology is \$3.0M over 30 months.	• ROM cost and schedule to mature technology is \$4.5M over 36 months.	• ROM cost and schedule to mature technology is \$3.5M over 33 months.

Table B-1 – Cesium Separation Technology Assessment Summary Matrix

Criteria	Measures and Definitions	Fractional Crystallization (FC)	Caustic-Side Solvent Extraction (CSSX)	Ion Exchange with sRF (IX-sRF)
	3.1.3 Probability of Success	• Probability of success for maturing technology is "***High***".	• Probability of success for maturing technology is "***Medium***".(waste foaming issue was rated as a High risk, even though it had marginal probability of occurring; entrainment could also be an issue)	• Probability of success for maturing technology is "***High***".
3.2 Process Flexibility and robustness	3.2.1 Ability to process a variety of feeds	• Highly sensitive to analytes in waste feed • Sensitive to a variety of physical parameters	• Process is potentially sensitive to potassium content of IPS candidate feeds	• Selected resin has been demonstrated to meet Cs removal rates for IPS candidate feeds
	3.2.2 Ability to adjust process rate – turn up/ turn down	• Demonstrates "***High***" level of flexibility to adjust process rates.	• Demonstrates "***Medium***" level of flexibility to adjust process rates.	• Demonstrates "***Medium***" level of flexibility to adjust process rates.
	3.2.3 Flexibility to modify product	• "***High***" product flexibility with 15 degrees of freedom. -2stages +	• "***Medium***" product flexibility with 10 degrees of freedom.	• "***Medium***" product flexibility with 10 degrees of freedom.
	3.2.4 Ability to expand	• Capacity increase would require significant equipment size increases and footprint modifications	• Practical volume increases would require resizing of contactors or installation of parallel lines	• Capacity increase would require moderate size increases and footprint modifications
	3.2.5 Recover from out of spec product –	• System would require minor tank storage changes to handle out-of-spec product while recycling	• Installation of recycle piping would be required at an ROM cost of <\$5M	• System would require minor tank storage changes to handle out-of-spec product while recycling
	3.2.6 Technology applicability to other DOE complex projects – revisit in programmatic aspects evaluation	• "***No***" applicability to other DOE complex projects.	• "***High***" applicability to other DOE complex projects.	• "***High***" applicability to other DOE complex projects.
4 OPERABILITY AND MAINTAINABILITY ***4.1 Ease of Process control and operation***	4.1.1 Minimize number and frequency of surveillances	• 58 process parameters and 11 sump leak detectors requiring routine measurements and recordings.	• 38 process parameters, 20 sump leak detectors and 98 other equipment related data points requiring routine measurements and recordings.	• 26 process parameters and 18 sump leak detectors requiring routine measurements and recordings.
	4.1.2 Minimize number of people to operate	• Estimated 10 people to operate.	• Estimated 11 people to operate.	• Estimated 10 people to operate.

Table B-1 – Cesium Separation Technology Assessment Summary Matrix

Criteria	Measures and Definitions	Fractional Crystallization (FC)	Caustic-Side Solvent Extraction (CSSX)	Ion Exchange with sRF (IX-sRF)
	4.1.3 Ease of startup and shutdown	• Startup and shut down has medium complexity among these three systems.	• Startup and shut down is the most time consuming and complex among these three systems.	• Startup and shut down is relatively simple with the lowest complexity among these three systems.
	4.1.4 Minimize system complexity	• System complexity is moderate due to basic evaporation equipment with specialized control functions.	• System complexity is very high with 85 active components with associated instrumentation. System and process flow sheets are highly complex with potential for more process upsets.	• System complexity is considered to be low based on passive nature of resin columns.
	4.1.5 Minimize number of chemicals needed	• No chemicals used in the basic system operation.	• In addition to $NaOH$, $NaNO_2$, and HNO_3, four other organic chemicals are used in the process.	• Three chemicals, $NaOH$, $NaNO_2$, and HNO_3 are used in the process.
	4.1.6 Minimize number of process and regulatory samples	• Process sampling needs include feed and product streams and steam condensate. Batch sampling of liquid effluent stream going to ETF will be required.	• Process sampling needs is anticipated for feed and product streams. In addition, aqueous and organic streams from contactors, process chemicals will be required on a regular basis. Spent solvent will be sampled on a batch basis to meet regulatory disposal requirements.	• Process sampling needs is anticipated for feed and product streams. Aqueous make ups should be sampled on a regular basis. Spent resin sampling will be required on a batch basis to assure disposal requirement conformance.
	4.1.7 Batch versus continuous	• Operates on a semi-continuous or campaign basis.	• Operates on a continuous basis.	• Operates only on a batch basis.
	4.1.8 Ease of entry and exit from standby	• Minor impact for standby restart activities.	• Significant operational impacts for any shutdown or standby condition to restart activities.	• Minimal impacts for a short time standby restart activities.
	4.1.9 Wide operating margin	• Can be applied to wide range of feed containing various chemicals. • Relatively tight range of temperature and pressure required for crystal formation	• Does not have a wide operating range for most flow sheet parameters with the exception of the washing and scrubbing functions. • Aqueous/organic ratio is critical and needs to be tightly controlled	• Narrow range of application, based on Na concentration • Relatively forgiving process based on temperature range.
	4.1.10 Complexity of transfers to, from and within Tank Farms	• Effluent stream transfer to ETF for final disposal. • Return stream to DSTs	• Standard tank farm transfers (requires no special equipment or processes to transfers). • Return stream to DSTs	• No special or additional tank waste transfer anticipated. • Return stream to DSTs

Table B-1 – Cesium Separation Technology Assessment Summary Matrix

Criteria	Measures and Definitions	Fractional Crystallization (FC)	Caustic-Side Solvent Extraction (CSSX)	Ion Exchange with sRF (IX-sRF)
4.2 ALARA	4.2.1 Less required contact maintenance is better, etc.	• Estimated process related components requiring hands-on or contact maintenance are: One waste feed pump, 2 centrifuges, 15 process pumps, undetermined numbers of flow meters, and flow control valves. • Has medium number of components that may require contact maintenance.	• Estimated process related components requiring hands-on or contact maintenance are: One waste feed pump, 41 contactors; 7 primary process pumps, undetermined numbers of flow meters, and flow control valves; seven transfer pumps associated with aqueous chemical make up area. • Has highest number of components that may require contact maintenance.	• Estimated process related components requiring hands-on or contact maintenance are: One waste feed pump, 2 ion exchange columns; 13 process pumps, undetermined numbers of flow meters, and flow control valves. • Has lowest number of components that may require contact maintenance.
4.3 Reliability	4.3.1 Number of active components	• System has 21 active components consisting of pumps, centrifuges, chilled water skids, and building ventilation system.	• System has 60 active components consisting of pumps and centrifugal contactors, and building ventilation system.	• System has 14 active components consisting of pumps and building ventilation system.
	4.3.2 Reliability of analogous systems	• 242-A Evaporators provides strong analogous reliability data support.	• The use of centrifugal contactors has been successful at SRS. • .	• Ion exchange operation does provide some improved reliability, but sRF resin reliability data is not available. • Large-scale IX has been operated successfully at Hanford for many years, e.g., B-Plant separations of Cs and Sr
4.4 Ease and frequency of maintenance	4.4.1 Minimize number of support systems	• Requires 3 standard services of air, water, and cooling water. • Requires steam to be provided • Requires 1 chemical support service.	• Requires 3 standard services of air, water and cooling water. • Requires six chemical support services.	• Requires 3 standard services of air, water and cooling water. • Requires five chemical support services.
	4.4.2 Minimize number and frequency of PM's	• Moderate level of PMs required due to the large number of rotating components, and necessary piping and control system.	• Extensive level of PMs required due to the large number of rotating components, and necessary piping and control system.	• Minimal level of PMs required due to the passive operation of a majority of the technology, and low number of process components required.
	4.4.3 Minimize maintenance in zone entries	• Moderate amount of equipment requiring maintenance in-zone.	• Extensive amount of equipment requiring maintenance in-zone.	• Moderate amount of equipment requiring maintenance in-zone. • Fewer in-zone maintenance items; most of equipment, e.g., pumps, are located in cold chemical area

Table B-1 – Cesium Separation Technology Assessment Summary Matrix

Criteria	Measures and Definitions	Fractional Crystallization (FC)	Caustic-Side Solvent Extraction (CSSX)	Ion Exchange with sRF (IX-sRF)
	4.4.4 Minimize specialized equipment and parts	• Uses commercially available components	• Uses specialized components which may limit the availability of components and parts.	• Uses commercially available components • Assumes external jacketed cooling to IX column
	4.4.5 Minimize tank entries - N/A	• No tank entries are required for this technology.	• No tank entries are required for this technology.	• No tank entries are required for this technology.
4.5 Ease of Implementation	4.5.1 Ease of training	• Above average amount of training is anticipated due to large number of components and complex process control.	• Extensive amount of training is anticipated due to large number of components and complex process control.	• Nominal amount of training is anticipated due to small number of components and simpler process control.
	4.5.2 Complexity of procedures	• Above average complexity in procedures.	• Extensive complexity in procedures.	• Nominal complex procedures.
	4.5.3 Similar to other process facilities on site	• Technology is similar to evaporator system with familiarity at Hanford.	• Technology is not used at Hanford, but is being implemented at SRS.	• Technology is similar to other ion exchange systems used at Hanford and will be implemented at pretreatment facility of the WTP project.
4.6 Liquid/solid secondary waste	4.6.1 Waste handling compatible with existing systems as defined by DOE Order 420.1B –	• Can be designed to be compliant with DOE-Order 420.1B, • Not a significant issue	• Can be designed to be compliant with DOE-Order 420.1B. • Not a significant issue	• Can be designed to be compliant with DOE-Order 420.1B. • Not a significant issue
	4.6.2 Minimize operational impacts associated with hazardous (generated) waste handling	• Suited for continuous operation. • Secondary waste is routed to ETF with no abnormal operational impact.	• Suited for continuous operation. • Cs product requiring volume reduction is routed to evaporator with no abnormal operational impact. • Disposal of spent organics	• Suited for continuous operation with planned shutdown for resin change outs. • Used resin requires special handling and disposal as LLW. This can be designed in the facility to minimize operational waste handling impacts.
5 PROGRAMMATIC ASPECTS *5.1 Cost Impact*	5.1.1 Capital costs(for comparative purposes only)	• With expected accuracy range of -30% to +50%: FC – CFF capital costs = \$64M to \$140M, FC - RMF capital costs = \$75M to \$160M.	• With expected accuracy range of -30% to +50%: CSSX – CFF capital costs = \$82M to \$180M, CSSX- RMF capital costs = \$87M to \$190M.	• With expected accuracy range of -30% to +50%: IX – CFF capital costs = \$54M to \$120M, IX - RMF capital costs = \$59M to \$130M.

Table B-1 – Cesium Separation Technology Assessment Summary Matrix

Criteria	Measures and Definitions	Fractional Crystallization (FC)	Caustic-Side Solvent Extraction (CSSX)	Ion Exchange with sRF (IX-sRF)
	5.1.2 Project life cycle costs for W-551 (for comparative purposes only)	• With expected accuracy range of -30% to +50% (applied to capital cost contribution): FC - CFF life cycle costs (w/o T&Rs) = $180M to $250M, FC - RMF life cycle costs (w/o T&Rs) = $210M to $290M. • 2 SST retrievals add $50M of non-project cost in 4th year of mission (FY-08); these are accelerated (not new) costs	• With expected accuracy range of -30% to +50% (applied to capital cost contribution): CSSX - CFF life cycle costs (w/ evap) = $190M to $290M, CSSX - RMF life cycle costs (w/ evap) = $210M to $310M.	• With expected accuracy range of -30% to +50% (applied to capital cost contribution): IX - CFF life cycle costs = $140M to $200M, IX - RMF life cycle costs = $150M to $220M.
	5.1.3 Cost profile (for comparative purposes only)	• Both the highest capital cost and highest life cycle (comparative) cost result from pairing FC with RMF.	• Lowest project capital (comparative) cost is offered by pairing CSSX with CFF.	• Lowest life cycle (comparative) cost is offered by pairing IX-sRF with CFF.
5.2 Schedule Impact	5.2.1 Implementation schedule (confidence) – for comparative purposes only	• At 50% of probability of on-time completion the estimated schedule duration is **100** months (8.5 years), from CD-1 to Startup completion.	• At 50% of probability of on-time completion the estimated schedule duration is **110** months (9 years), from CD-1 to Startup completion.	• At 50% of probability of on-time completion the estimated schedule duration is **90** months (7.5 years), from CD-1 to Startup completion.
	5.2.2 Licensing	• Due to existing knowledge and experience licensing activities should not adversely impact.	• Due to lack of Hanford specific performance knowledge, CSSX will require additional efforts and time to support licensing activities.	• Due to existing knowledge and experience licensing activities should not be adversely impact.
	5.2.3 Permitting	• Assuming timely completion of TC&WM EIS and 32 months permitting process per Tri-Party Agreement, RCRA part B permitting for FC will not impact start of Construction.	• Assuming timely completion of TC&WM EIS and 32 months permitting process per Tri-Party Agreement, RCRA part B permitting for CSSX will not impact start of Construction.	• Assuming timely completion of TC&WM EIS and 32 months permitting process per Tri-Party Agreement, RCRA part B permitting for IX-sRF will not impact start of Construction.
	5.2.4 D&D	• Considerations for D&D will be accommodated during the IPS design. Negligible impact on IPS schedule.	• Considerations for D&D will be accommodated during the IPS design. Negligible impact on IPS schedule.	• Considerations for D&D will be accommodated during the IPS design. Negligible impact on IPS schedule.

Table B-1 – Cesium Separation Technology Assessment Summary Matrix

Criteria	Measures and Definitions	Fractional Crystallization (FC)	Caustic-Side Solvent Extraction (CSSX)	Ion Exchange with sRF (IX-sRF)
5.3 DST Space	5.3.1 How fast DST space is made available	• Recovers DST space at a rate of 1.1 – 1.8 M gal/yr for the 13 batches from retrieved from DSTs over 4 years (assumes 70% TOE). • Rate of DST space recovery depends on the extent to which the phosphate concentration needs to be kept below 0.1 M • Waste is retrieved from SSTs in 5th year, so that DST space is consumed.	• Recovers DST space at a rate of 600K gal/yr (assumes 70% TOE over 5-year IPS mission, plus one additional year to complete evaporation).	• Recovers DST space at a rate of 725K gal/yr (assumes 70% TOE).
	5.3.2 Amount of DST space	• Recovers between 2.8 and 6.4M gallons of DST space, depending on the extent to which the phosphate concentration needs to be kept below 0.1 M	• Recovers 3.7M gallons of DST space. (including evaporation)	• Recovers 3.7M gallons of DST space, but no additional evaporation is required.
5.4 Impacts to WTP and Supplemental Treatment, positive and negative	5.4.1 Production rate impact	• Will provide required feed rate of 0.192 MT Na/hr to meet WTP/supplemental treatment production requirements. • Sulfate concentration in FC feed may adversely impact the production rate. • Potentially will have to add Na to Cs-loaded stream to maintain proper feed solubility to WTP Pretreatment (based upon WTP Al solubility curves).	• Will provide required feed rate of 0.192 MT Na/hr to meet WTP/supplemental treatment production requirements. • Impact of feed chemical composition need to be made. • Approximately 1/3 of Na is cold chemical addition to maintain Al solubility (based upon WTP Al solubility curves)	• Will provide required feed rate of 0.192 MT Na/hr to meet WTP/supplemental treatment production requirements. • Impact of feed chemical composition needs to be assessed • Has a NaOH load same as WTP ion exchange system. • Approximately 1/3 of Na is cold chemical addition to maintain Al solubility (based upon WTP Al solubility curves)
	5.4.2 Mission duration	• No impact	• No impact	• No impact

Table B-1 – Cesium Separation Technology Assessment Summary Matrix

Criteria	Measures and Definitions	Fractional Crystallization (FC)	Caustic-Side Solvent Extraction (CSSX)	Ion Exchange with sRF (IX-sRF)
	5.4.3 Number of high and low level packages (need to revise for 5-year mission)	• Produces 7,800 ILAW canisters based on Na inventory of the LAW feed. • Number of canisters of ILAW would increase if sulfate cannot be sufficiently removed. • Additional canisters of IHLW may be produced in WTP depending on the chemical composition of the Cs-loaded waste stream.	• Produces 7,800 ILAW canisters based on Na inventory of the LAW feed. • No additional HLW canisters are produced.	• Produces 7,800 ILAW canisters based on Na inventory of the LAW feed. • No additional HLW canisters are produced.
	5.4.4 Lessons Learned benefits for WTP pretreatment	• There will not be "lessons learned" from the operations and maintenance of FC equipment in IPS.	• There will not be "lessons learned" from the operations and maintenance of CSSX equipment in IPS.	• Provides lessons learned benefits to WTP ion exchange process development, operation and maintenance activities.
	5.4.5 Technology transfer to WTP and/or Supplemental Treatment	• Not applicable	• Not applicable	• Not applicable.
	5.4.6 ALARA	• No ALARA impact to WTP LAW facility.	• No ALARA impact to WTP LAW facility.	• No ALARA impact to WTP LAW facility.
	5.4.7 Diversity of technology	• Provides diversity of technology for use at Hanford.	• Provides diversity of technology for use at Hanford.	• No new technology for use at Hanford.
	5.4.8 Positive programmatic impacts and opportunities	• Provides alternative evaporator capability • Provides possibility of using grout for immobilizing TC-free LAW	• No programmatic benefits have been identified yet.	• Provides potential cost reduction benefits by combining IPS and WTP sRF technology deployment activities. • Potential use of IX for Tc removal
5.5 Impacts to other facilities e.g., ETF, LAB, IDF (see regulatory assessment for IDF impacts)	5.5.1 Analytical equipment, methods, and capacity	• WTP LAW feed stream (cesium-depleted product) will be analyzed at WTP lab; Cesium-rich product analyzed at 222-S lab; process control analyses performed on-line at IPS. • Amount of lag storage for product batches may require adjustment based on laboratory analysis turn around time.	• WTP LAW feed stream (cesium-depleted product) will be analyzed at WTP lab; Cesium-rich product analyzed at 222-S lab; process control analyses performed on-line at IPS. • Amount of lag storage for product batches may require adjustment based on laboratory analysis turn around time.	• WTP LAW feed stream (cesium-depleted product) will be analyzed at WTP lab; Cesium-rich product analyzed at 222-S lab; process control analyses performed on-line at IPS. • Amount of lag storage for product batches may require adjustment based on laboratory analysis turn around time.

Table B-1 – Cesium Separation Technology Assessment Summary Matrix

Criteria	Measures and Definitions	Fractional Crystallization (FC)	Caustic-Side Solvent Extraction (CSSX)	Ion Exchange with sRF (IX-sRF)
	5.5.2 Compliance to ETF WAC – N/A	• Process condensates from FC meet ETF's WAC.	• No impact to ETF.	• No impact to ETF.
	5.5.3 ALARA	• Because FC is being included as part of the new IPS facility, ALARA will be incorporated into its process design.	• Because CSSX is being included as part of the new IPS facility, ALARA will be incorporated into its process design.	• Because IX-sRF is being included as part of the new IPS facility, ALARA will be incorporated into its process design.
	5.5.4 Number of Evaporator campaigns	• No evaporator campaigns required because cesium-loaded stream meets DST density and Na molarity specifications.	• Using the 0.8 Ci/liter operating limit for the 242-A Evaporator, five (5) evaporator campaigns will provide an additional 1.0M gal of DST space.	• No evaporator campaigns are required because cesium-loaded waste streams are near or exceed the 0.8 Ci/liter operating limit for 242-A Evaporator.
5.6 Resources and materials	5.6.1 Availability of Key Skills, Critical Materials, Qualified Vendors	• Does not use any specialty chemicals or material. • Uses engineered equipment to be designed and fabricated by experienced vendors.	• Costner Industries Nevada Corp. is the experienced commercial company who is experienced with supplying centrifugal contractors, due to their working partnership with SRNL. Other basic commercial suppliers do exist. • Solvents used are proprietary: such as BOB CalixC6, TOA and Cs-7SB. Suppliers are single source and may have to pay premium price to obtain these chemicals. – verify that these are proprietary (check with Parsons)	• Two resin manufacturing facilities have been identified and prepared product tested. • Long term supply strategy for resin must be developed.
	5.6.2 Stability of Critical Resource Pricing	• Qualified fabricators may be difficult to find	• Qualified fabricators may be difficult to find	• Qualified fabricators may be difficult to find

Table B-2 – Cesium Separation Technology Assessment Decision Calculator
(extracted from CH2M HILL 2008f)

#	RPP-PLAN-37558 DECISION PLAN CRITERIA	Weight (%)	FC		CSSX		IX	
			Raw Ranking	Weighted Value	Raw Ranking	Weighted Value	Raw Ranking	Weighted Value
1.0	**Safety**	25.00						
1.1	**Process Safety**							
1.1.1	Quantity of material at risk (MAR) – radiological and chemical – less is better		5	0.94	5	0.94	5	0.94
1.1.2	Concentration of radiological and chemical MAR - less is better		4	0.75	5	0.94	5	0.94
1.1.3	Dispersability of the MAR – less dispersible form is better (e.g., solids over liquids over powders over gases)		5	0.94	5	0.94	3	0.56
1.1.4	Dispersive energy, e.g., heat, off gassing, pressure, etc. inherent in the process – less dispersive energy is better		5	0.94	5	0.94	5	0.94
1.1.5	Process Stability - including ease of process control/shutdown -- easier/faster process shutdown is better		6	1.13	5	0.94	4	0.75
1.1.6	Process that does not create a new or exacerbate an existing Tank Farm hazard is preferred to one that does		5	0.94	5	0.94	5	0.94
1.1.7	Less fire hazard (e.g. less quantity of combustibles, including flammable gas, less flammable combustibles, etc.)		6	1.13	2	0.38	4	0.75
1.1.8	Reactive Chemicals - Process with less reactive chemicals (reactivity) is better		6	1.13	4	0.75	4	0.75
1.2	**Criticality Safety**							
1.2.1	A Process that is inherently sub critical is preferred over a process that relies on criticality controls		5	1.25	5	1.25	5	1.25
1.3	**Industrial Safety and Hygiene**							
1.3.1	Less hazards/less severe hazardous is better (e.g.,…)		5	3.75	4	3.00	4	3.00
			Subtotals	**13**		**11**		**11**
2.0	**Regulator and Stakeholder Acceptance**	20.00						
2.1	**Achieve Tribal Nations / stakeholders' acceptance**							
2.1.1	Early waste treatment enabled		5	2.00	4	1.60	7	2.80
2.1.2	Land usage (more contaminated ground)		4	1.60	4	1.60	6	2.40
2.2	**Achieve regulators' acceptance**							
2.2.1	Compliance with applicable regulations (RCRA, CAA, NESHAPS, NEPA/SEPA, NPDES, DOE Orders)		5	1.50	5	1.50	5	1.50
2.2.2	Impact to Disposal System Performance		10	3.00	5	1.50	5	1.50

Table B-2 – Cesium Separation Technology Assessment Decision Calculator
(extracted from CH2M HILL 2008f)

#	RPP-PLAN-37558 DECISION PLAN CRITERIA	Weight (%)	FC		CSSX		IX	
			Raw Ranking	Weighted Value	Raw Ranking	Weighted Value	Raw Ranking	Weighted Value
2.2.3	Secondary Waste Form and Quantity		5	1.50	5	1.50	5	1.50
2.2.4	Potential impacts to other permitted facilities		5	1.50	5	1.50	5	1.50
			Subtotals	11		9		11
3.0	**Technical Maturity/Flexibility**	20.00						
3.1	**Technology Readiness Level**							
3.1.1	Technology Readines Level Number		5	2.00	4	1.60	5	2.00
3.1.2	Effort to mature technology		6	2.40	4	1.60	5	2.00
3.1.3	Probability of success		5	2.00	4	1.60	5	2.00
3.2	**Process Flexibility and robustness**							
3.2.1	Ability to process a variety of feeds		4	0.53	4	0.53	6	0.80
3.2.2	Ability to adjust process rate		5	0.67	4	0.53	4	0.53
3.2.3	Flexibility to modify product		3	0.40	2	0.27	2	0.27
3.2.4	Ability to expand		2	0.27	1	0.13	2	0.27
3.2.5	Recover from out of spec product		5	0.67	5	0.67	5	0.67
3.2.6	Technology applicability to other DOE complex projects		2	0.27	3	0.40	3	0.40
			Subtotals	**9**		**7**		**9**
4.0	**Operability and Maintainability**	15.00						
4.1	**Ease of Process control and operation**							
4.1.1	Minimize number and frequency of surveillances		5	0.15	4	0.12	6	0.18
4.1.2	Minimize number of people to operate		5	0.15	5	0.15	5	0.15
4.1.3	Ease of startup and shutdown		5	0.15	4	0.12	7	0.21
4.1.4	Minimize system complexity		5	0.15	3	0.09	7	0.21
4.1.5	Minimize number of chemicals needed		7	0.21	3	0.09	5	0.15
4.1.6	Minimize number of process and regulatory samples		6	0.18	3	0.09	5	0.15
4.1.7	Batch verses continuous		5	0.15	5	0.15	4	0.12
4.1.8	Ease of entry and exit from standby		5	0.15	4	0.12	5	0.15
4.1.9	Wide operating margin		5	0.15	3	0.09	6	0.18
4.1.10	Complexity of transfers to, from and within Tank Farms		5	0.15	5	0.15	5	0.15
4.2	**ALARA**							
4.2.1	Less required contact maintenance is better, etc. (rad and tox)		5	1.50	4	1.20	6	1.80

Table B-2 – Cesium Separation Technology Assessment Decision Calculator
(extracted from CH2M HILL 2008f)

#	RPP-PLAN-37558 DECISION PLAN CRITERIA	Weight (%)	FC		CSSX		IX	
			Raw Ranking	Weighted Value	Raw Ranking	Weighted Value	Raw Ranking	Weighted Value
4.3	**Reliability**							
4.3.1	Number of active components		5	0.68	3	0.41	6	0.81
4.3.2	Reliability of analogous systems		5	0.68	5	0.68	5	0.68
4.4	**Ease and frequency of maintenance**							
4.4.1	Minimize number of support systems		4	0.30	5	0.38	5	0.38
4.4.2	Minimize number and frequency of PM's		5	0.38	4	0.30	6	0.45
4.4.3	Minimize maintenance in zone entries		5	0.38	4	0.30	6	0.45
4.4.4	Minimize specialized equipment and parts		5	0.38	3	0.23	5	0.38
4.4.5	Minimize tank entries		0		0		0	
4.5	**Ease of Implementation**							
4.5.1	Ease of training		5	0.30	4	0.24	6	0.36
4.5.2	Complexity of procedures		5	0.30	4	0.24	6	0.36
4.5.3	Similar to other process facilities on site		5	0.30	3	0.18	5	0.30
4.6	**Liquid/solid secondary waste**							
4.6.1	Waste handling compatible with existing systems as defined by DOE Order 420.1B		0		0		0	
4.6.2	Minimize operational impacts associated with hazardous (generated) waste handling		6	0.90	4	0.60	4	0.60
			Subtotals	**8**		**6**		**8**
5.0	**Programmatic Aspects**	20.00						
5.1	**Cost Impacts**							
5.1.1	Capital costs		5	0.83	3	0.50	7	1.17
5.1.2	Life cycle costs		4	0.67	4	0.67	7	1.17
5.1.3	Cost profile		5	0.83	4	0.67	6	1.00
5.2	**Schedule Impact**							
5.2.1	Overall schedule (confidence)		5	0.63	4	0.50	6	0.75
5.2.2	Licensing		5	0.63	3	0.38	5	0.63
5.2.3	Permitting		5	0.63	5	0.63	5	0.63
5.2.4	D&D		5	0.63	5	0.63	5	0.63
5.3	**DST Space**							
5.3.1	How fast DST space is made available		8	2.00	4	1.00	5	1.25

Table B-2 – Cesium Separation Technology Assessment Decision Calculator
(extracted from CH2M HILL 2008f)

#	RPP-PLAN-37558 DECISION PLAN CRITERIA	Weight (%)	FC		CSSX		IX	
			Raw Ranking	Weighted Value	Raw Ranking	Weighted Value	Raw Ranking	Weighted Value
5.3.2	Amount of DST space		6	1.50	4	1.00	5	1.25
5.4	**Impacts to WTP and Supplemental Treatment, positive and negative**							
5.4.1	Production rate impact		5	0.21	5	0.21	5	0.21
5.4.2	Mission duration		5	0.21	5	0.21	5	0.21
5.4.3	Number of high and low level packages		5	0.21	5	0.21	5	0.21
5.4.4	Lessons Learned benefits for WTP pretreatment		2	0.09	2	0.09	8	0.34
5.4.5	Technology transfer to WTP		0		0		0	
5.4.6	ALARA		3	0.13	1	0.04	1	0.04
5.4.7	Diversity of technology		3	0.13	2	0.09	1	0.04
5.4.8	Positive programmatic impacts and opportunities		6	0.26	2	0.09	4	0.17
5.5	**Impacts to other facilities e.g., ETF, LAB**							
5.5.1	Analytical equipment, methods, and capacity		5	0.17	5	0.17	5	0.17
5.5.2	Compliance to ETF WAC		5	0.17	5	0.17	5	0.17
5.5.3	ALARA		5	0.17	5	0.17	5	0.17
5.5.4	Number of Evaporator campaigns		0		0		0	
5.6	**Resources and materials**							
5.6.1	Availability of Key Skills, Critical Materials, Qualified Vendors		6	0.30	4	0.20	4	0.20
5.6.2	Stability of Critical Resource Pricing		5	0.25	5	0.25	5	0.25
			Subtotals	**11**		**8**		**11**
	TOTALS		**334**	**51**	**268**	**41**	**333**	**50**

ATTACHMENT C. COST PROFILES AND SUMMARY SCHEDULES

C.1. COST ESTIMATES

Cost estimates were prepared for each of the six possible combinations of entrained solids filtration and cesium separations technologies, namely for FC/CFF, FC/RMF, CSSX/CFF, CSSX/RMF, IX-sRF/CFF, and IX-sRF/RMF. As required by the Decision Plan, three types of cost estimates were prepared, capital cost for design and construction, and life-cycle costs for the 5-year IPS mission duration (including capital costs and a sixth year for decommissioning), and a year-by-year cost profile for the IPS life-cycle.

When paired with any of the 3 Cs separation technologies, cross-flow filtration (CFF) was consistently estimated to have a lower capital and life-cycle cost than the rotary micro-filtration system. This difference was primarily attributed to the installation and operation of the RMF in a potentially contaminated work zone, i.e. in a DST riser and its associated pump pit, for the IX-sRF and CSSX processing options and the higher cost of the RMF units. Because of its significantly larger throughput, the FC processing option required a larger number of RMF units that could not be accommodated in the available DST riser, so they were relocated to the IPS facility. However, this relocation also required a facility footprint that was larger than that required for the CFF units.

Both capital and life-cycle cost estimates for the IX-sRF process were lower than either the CSSX or FC processes, regardless of which filtration process it was paired with. While the estimated capital cost of FC was lower than that for CSSX, regardless of the selected filtration process, the total life-cycle costs for both FC and CSSX were estimated to be approximately the same.

A limited review of the cost drivers was performed using the CFF pairs to determine what the major drivers were for the differences in capital and life cycle costs. IX-sRF costs were used as the basis for comparison, as it was consistently the lowest cost option in all categories.

The major differences in cost between FC/CFF and IX-sRF/CFF were in the following areas.

- First, the technology specific equipment required for FC/CFF is significantly larger than for IX-sRF/CFF resulting in equipment costs that were 2.7 times more expensive. The major FC/CFF cost items were the Reboiler, Crystallizer, and Chilled Water System. Furthermore, because the flow rates required by FC are about 3 times that for IX-sRF, the size and cost of the CFF to support the process is greater by a factor of 3 as well. The capital construction and startup costs were approximately 20% greater for FC, primarily again due to the facility footprint and equipment size.

- Secondly, consumables required to support FC Operations is more than double that for IX-sRF, driven mainly by the fuel costs to generate steam. This, plus the above account for approximately $30M of the cost difference

- Finally the last major cost difference is in the incremental implementation costs required to provide the additional feed required by FC over the 5 year mission, as discussed in Section 0. This additional feed requires an incremental 16 tank to tank transfers, 2 SST retrievals and 3 cross-site transfers above and beyond the tank to tank transfers required for either IX-sRF or CSSX, increasing the life cycle costs for FC by an estimated $50 – 60M during the mission period.

The major differences in cost between CSSX/CFF and IX-sRF/CFF are:

- The cost for the technology specific equipment required for CSSX/CFF is about 5.7 times that for IX-sRF and driven by the cost of the 43 centrifugal contactors (the centrifugal contactors are about 80% of the technology specific equipment procurement costs). Overall the capital construction and startup costs were over 50% greater for CSSX compared to IX-sRF, primarily due to the facility footprint, equipment costs and more complex process startup.

- The above increase in capital costs also translates to a comparable increase in the D&D costs for the CSSX facility.

- Finally, the last major cost difference is in the incremental implementation costs are those for 242-Evaporator operation in order to recover as much DST space as possible, as discussed in Section 3.2.5. The cost for the 242-Evaporator operation in support of CSSX over the mission period is estimated at just over $10M.

Since the cost profiles for construction were developed without optimizing or level loading, no conclusion regarding cost outlay with time can be reliably assessed at this time. The operating costs are essentially the same as all technologies would require equivalent crew size to operate. The exception to that is spike in the fourth year of IPS operation due to the anticipated need to change out the RMF units. However, it should be noted that no attempt has been made to optimize the cost profiles, i.e. to minimize cost spikes such as those that typically occurred in the last year of construction.
Capital and life-cycle costs for each of the six combinations of entrained solids filtration and Cs separation technologies are summarized in Figure C-1 and Figure C-2. Cost profiles for each of the technology combinations are shown in Figure C-3 through Figure C-8. It should be noted that these are Class 4 estimate per the Association for the Advancement of Cost Engineering (AACE) International definitions. A Class 4 estimate has an expected accuracy range from a minus 30% to a plus 50%. Furthermore the cost estimates do not reflect a total project as they do not contain costs for common systems required by all technologies (e.g., control systems, fire protection systems, etc) and were used only for the purpose of comparing the respective technology pairs.

Figure C-1 – Capital Cost Estimate Summary (For Technology comparison purposes only)

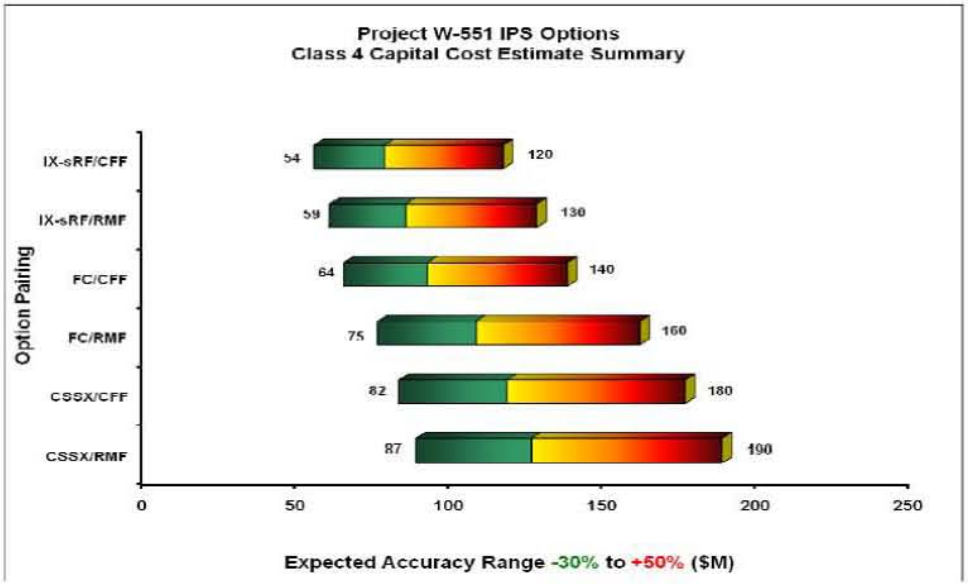
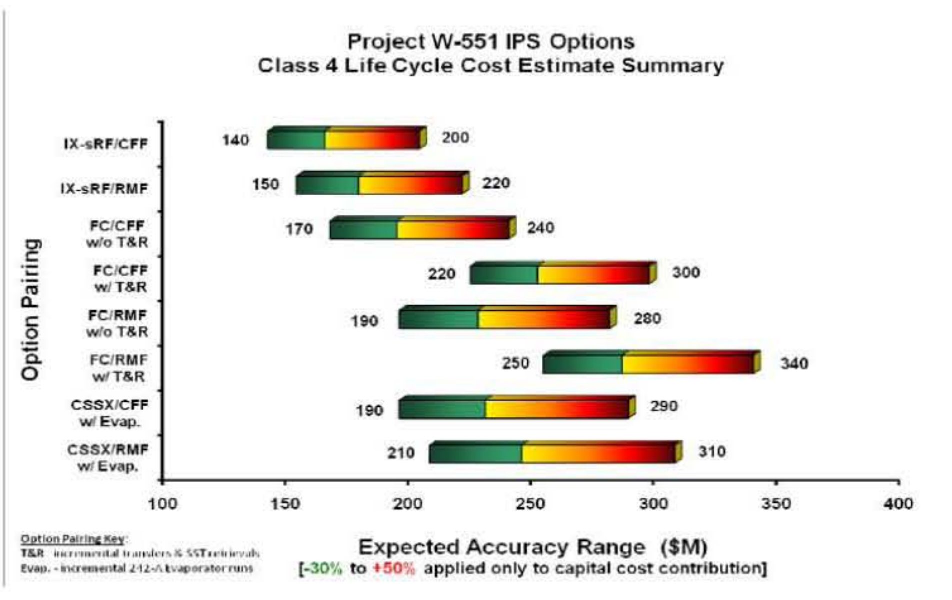


Figure C-2 – Life Cycle Cost Estimate Summary (For Technology comparison purposes only)



[Costs estimates are for comparative purposes between the technologies only & DO NOT reflect the total IPS project cost]

Figure C-3 – Cost Profile for IX-SRF/CFF Technology Pair

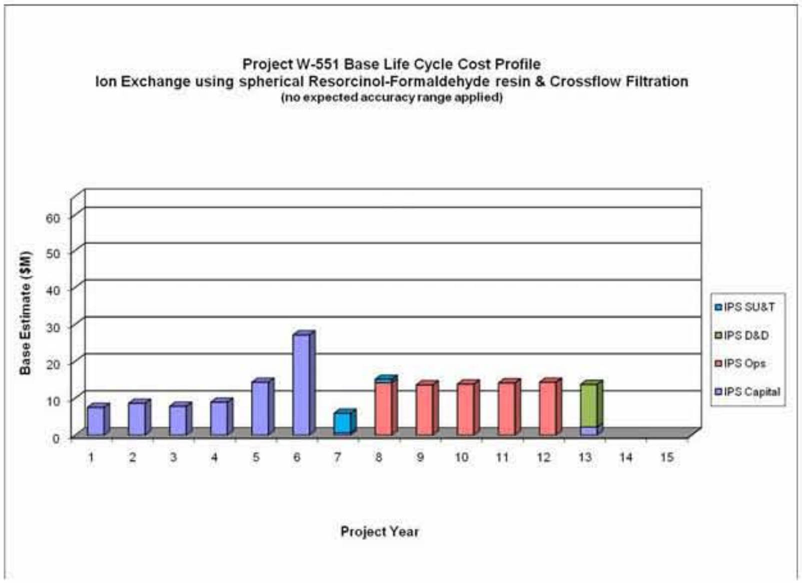
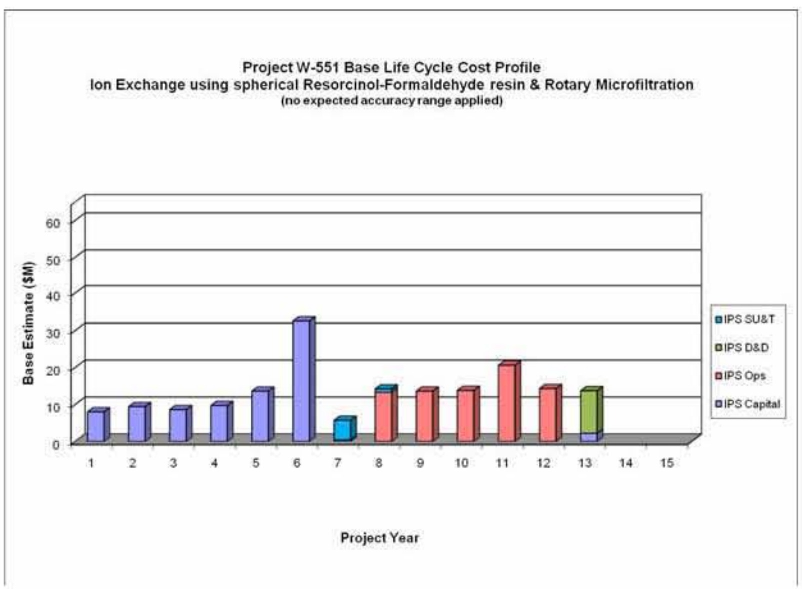


Figure C-4 – Cost Profile for IX-SRF/RMF Technology Pair



SU&T – Start Up & Testing
D&D – Decontamination & Decommissioning

[Costs estimates are for comparative purposes between the technologies only & DO NOT reflect the total IPS project cost]

Figure C-5 – Cost Profile for FC/CFF Technology Pair

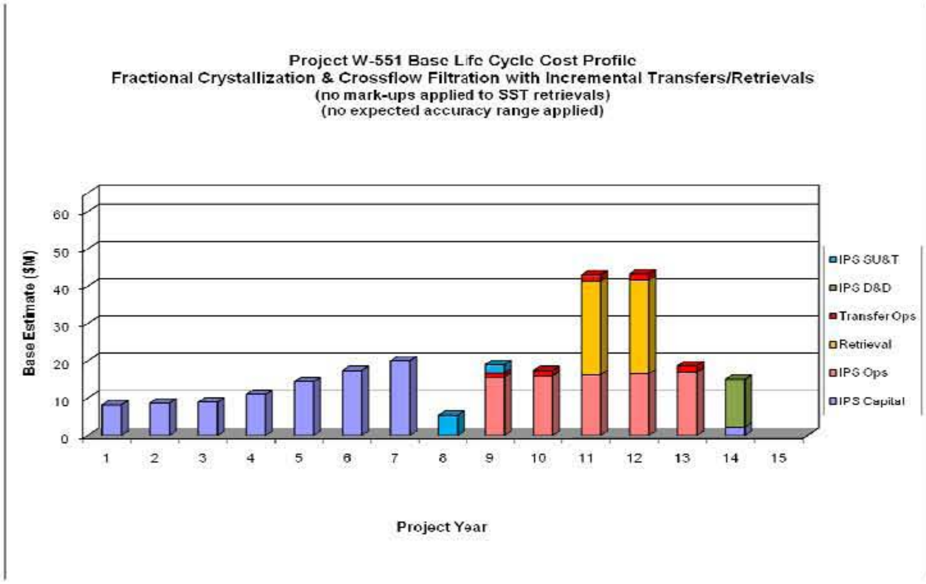
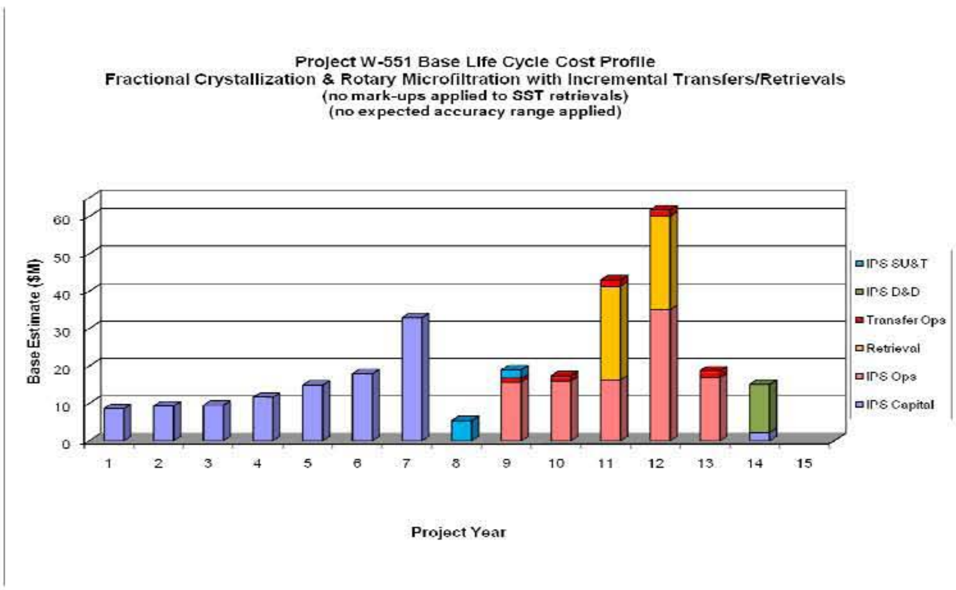


Figure C-6 – Cost Profile for FC/RMF Technology Pair



SU&T – Start Up & Testing
D&D – Decontamination & Decommissioning

[Costs estimates are for comparative purposes between the technologies only & DO NOT reflect the total IPS project cost]

Figure C-7 – Cost Profile for CSSX/CFF Technology Pair

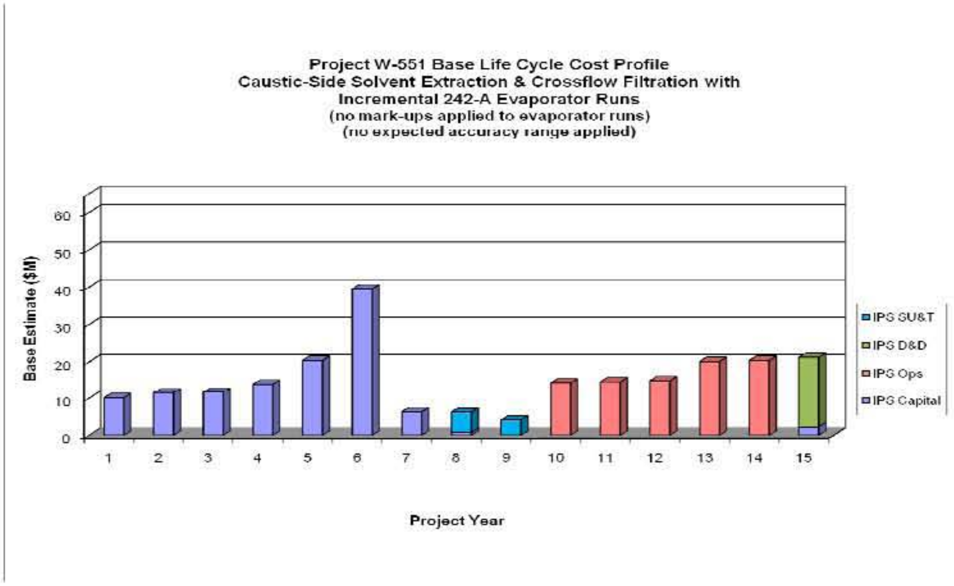
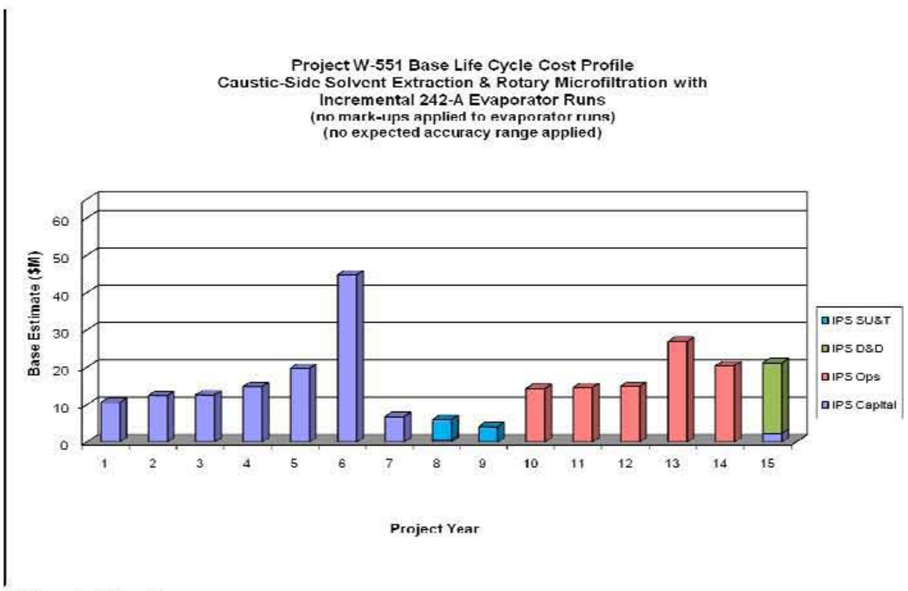


Figure C-8 – Cost Profile for CSSX/RMF Technology Pair



SU&T – Start Up & Testing
D&D – Decontamination & Decommissioning

[Costs estimates are for comparative purposes between the technologies only & DO NOT reflect the total IPS project cost]

C.2. SCHEDULE ESTIMATES

Based on the estimated durations for each of the major activities as provided by Subject Matter Experts (SMEs), implementation schedules (conceptual design through operational readiness) were developed for each of the Cs separation technologies. The major activities that were included in the three implementation schedules were: design, technology development, permitting, licensing, construction (including long-lead procurement), and construction. Duration estimates for each of these major activities were provided by SMEs. The SMEs provided optimistic (<25% probability of on-time completion), most probable (50% probability of on-time completion) and pessimistic (>75% probability of on-time completion) schedule durations for overall design, testing, permitting, safety and licensing, construction and startup schedule activities.

Because it was assumed that both the permitting and licensing activities were driven by design (and not vice versa), the critical path in all cases was through design, construction, and start up activities.

In all cases the overall design duration of 44 months was assumed to be adequate for all alternatives and thus, was not a discriminator.

Additionally, because the IPS mission was defined as being 5 years of operations and one year for D&D (i.e., the same for all technologies), the operations and decommissioning durations were not included.

The construction durations for each option were based on total craft labor hours from the cost estimate and an assumed crew size, resulting in the following durations for each technology pair:

- IX-sRF/RMF: 26 month
- IX-sRF/CFF: 27 months
- FC/RMF: 32 months
- FC/CFF: 32 months
- CSSX/RMF: 39 months
- CSSX/CFF: 40 months

The startup and testing durations were estimated with help from Operations SMEs as

- IX alternatives: 14 months
- FC alternatives: 17 months
- CSSX alternatives: 21 months

As there did not appear to be a significant difference in the construction duration estimates based on the filtration technologies, it was decided to develop individual implementation schedules for each of the three Cs separation technologies, rather than for each combination of filtration and separation technologies.

Using these duration estimates, a simplified Monte Carlo simulation was run for each of the Cs separation technologies using the duration estimates from the SMEs described above. The resulting S-curves showed that at a 50/50 probability of on-time completion, implementation of the IX-sRF process, i.e., completion of hot start up activities, would require approximately 90 months (7-1/2 years) from the start of conceptual design. Similarly for the FC process, the duration of the implementation phase was approximately 100 months (almost 8-1/2 years) and for CSSX approximately 110 months (over 9 years). The primary differences in these schedule estimates occurred in the construction and start up phases and were attributed to the relatively increasing complexity of the FC- and CSSX-based systems.

The set of S-curves for the Cs separation technologies that was generated by the Monte Carlo simulation are shown in Figure C-9. These curves were developed for comparative purposes only.

The implementation schedules for the Cs separation technologies are shown in Figure C-10 through Figure C-12.

Figure C-9 – S-Curves for Cs Separation Technologies

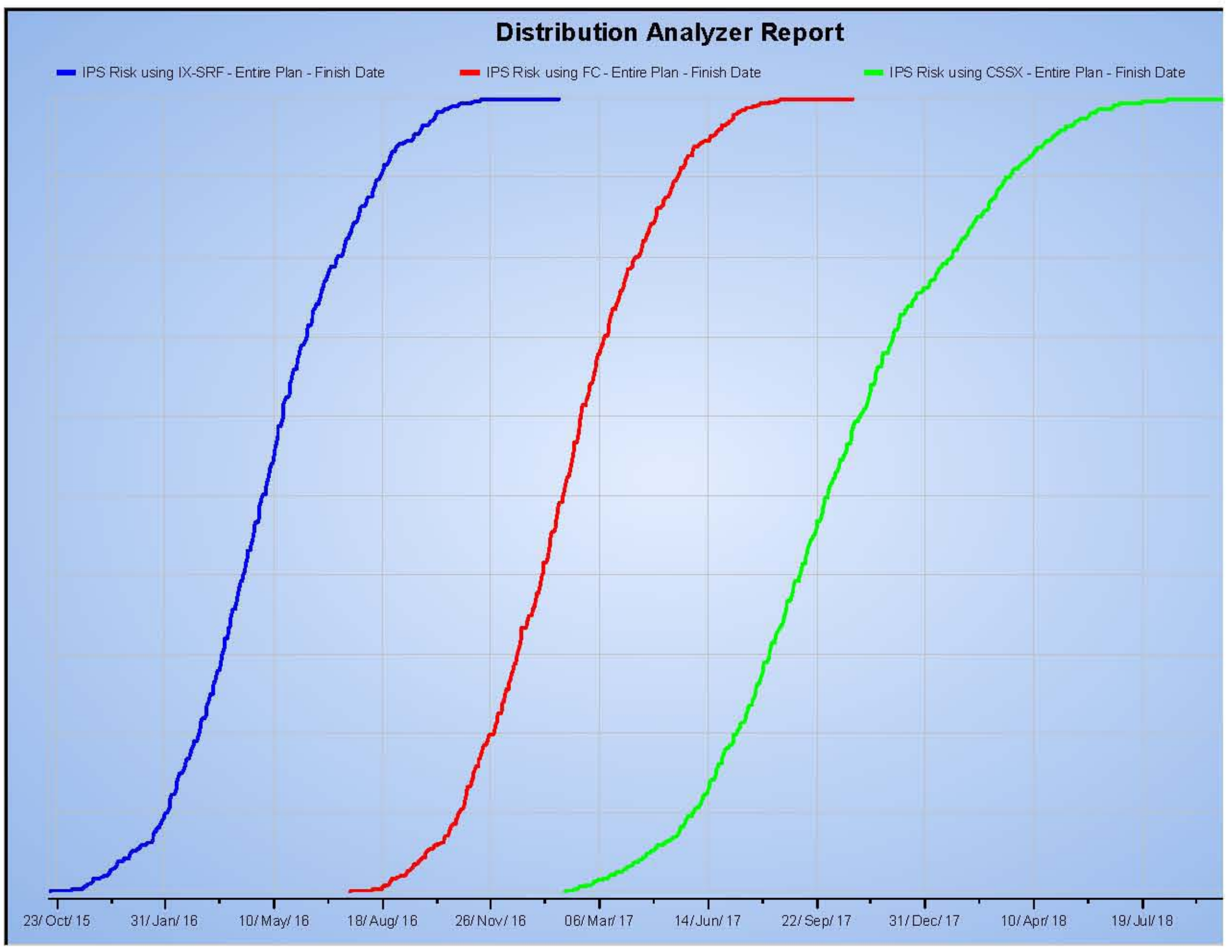
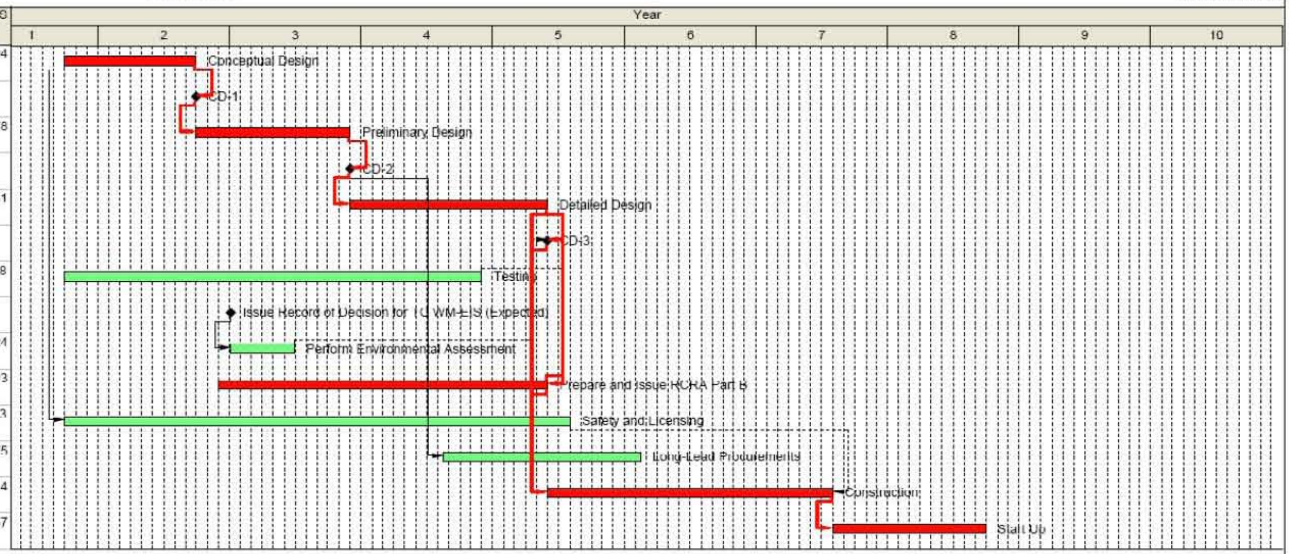


Figure C-10 – Implementation Schedule for IX-SRF

IPS Risk using IX-SRF — Calendar Years — 17-Jun-08 15:34

Activity ID	Activity Name	Original Duration	MOST	OPTD	PESS
IPRETEC010	Conceptual Design	252	252	252	294
IPRETEC020	CD-1	0			
IPRETEC030	Preliminary Design	293	293	330	378
IPRETEC040	CD-2	0			
IPRETEC050	Detailed Design	370	370	370	441
IPRETEC060	CD 3	0			
IPRETEC100	Testing	708	708	756	1008
IPRETEC200	Issue Record of Decision for TC WM-EIS (Expected)	0			
IPRETEC300	Perform Environmental Assessment	124	124	124	124
IPRETEC400	Prepare and Issue RCRA Part B	629	629	588	693
IPRETEC500	Safety and Licensing	966	966	966	1113
IPRETEC600	Long-Lead Procurements	375	375	375	375
IPRETEC700	Construction	546	546	525	714
IPRETEC800	Start Up	294	294	231	357



◆ Milestone
Early Bar
Critical Remaining Work
Progress Bar
Remaining Level of Effort
Actual Level of Effort

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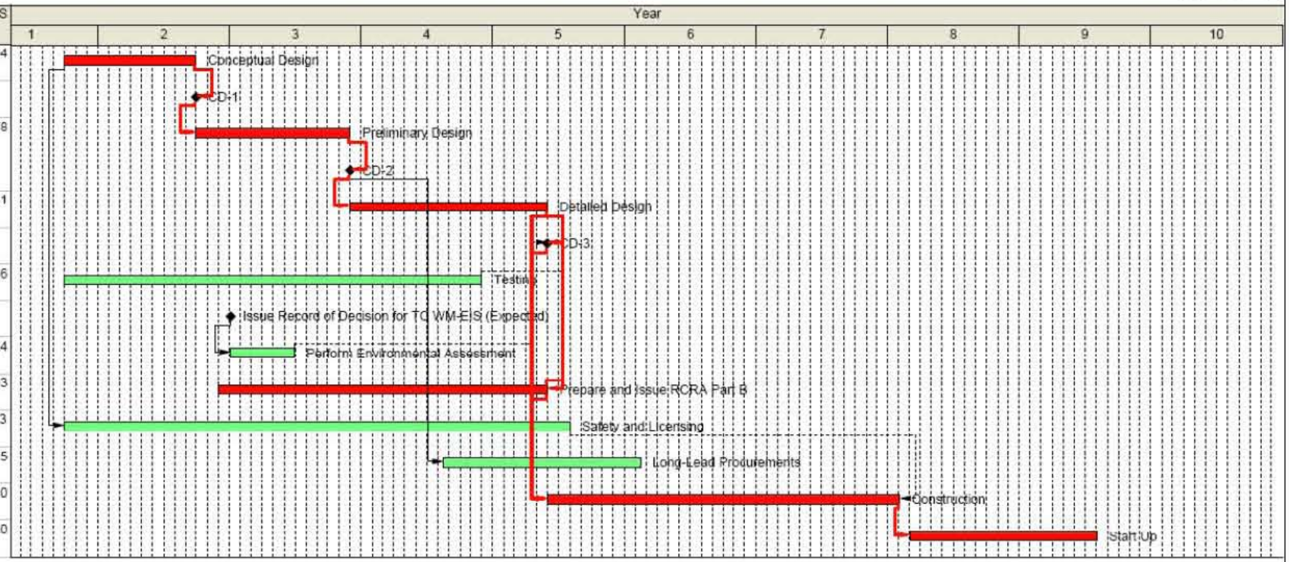
IPS Risk using IX-SRF

Figure C-11 – Implementation Schedule for FC

IPS Risk using FC | Calendar Years | 17-Jun-08 15:27

Activity ID	Activity Name	Original Duration	MOST	OPTD	PESS
IPRETEC010	Conceptual Design	252	252	252	294
IPRETEC020	CD-1	0			
IPRETEC030	Preliminary Design	203	203	336	378
IPRETEC040	CD-2	0			
IPRETEC050	Detailed Design	378	378	378	441
IPRETEC060	CD-3	0			
IPRETEC100	Testing	798	798	504	966
IPRETEC200	Issue Record of Decision for TC WM-EIS (Expected)	0			
IPRETEC300	Perform Environmental Assessment	124	124	124	124
IPRETEC400	Prepare and Issue RCRA Part B	629	629	588	693
IPRETEC500	Safety and Licensing	966	966	966	1113
IPRETEC600	Long-Lead Procurements	375	375	375	375
IPRETEC700	Construction	672	672	651	840
IPRETEC800	Start Up	357	357	294	420



◆ Milestone | Progress Bar
Early Bar | Remaining Level of Effort
Critical Remaining Work | Actual Level of Effort

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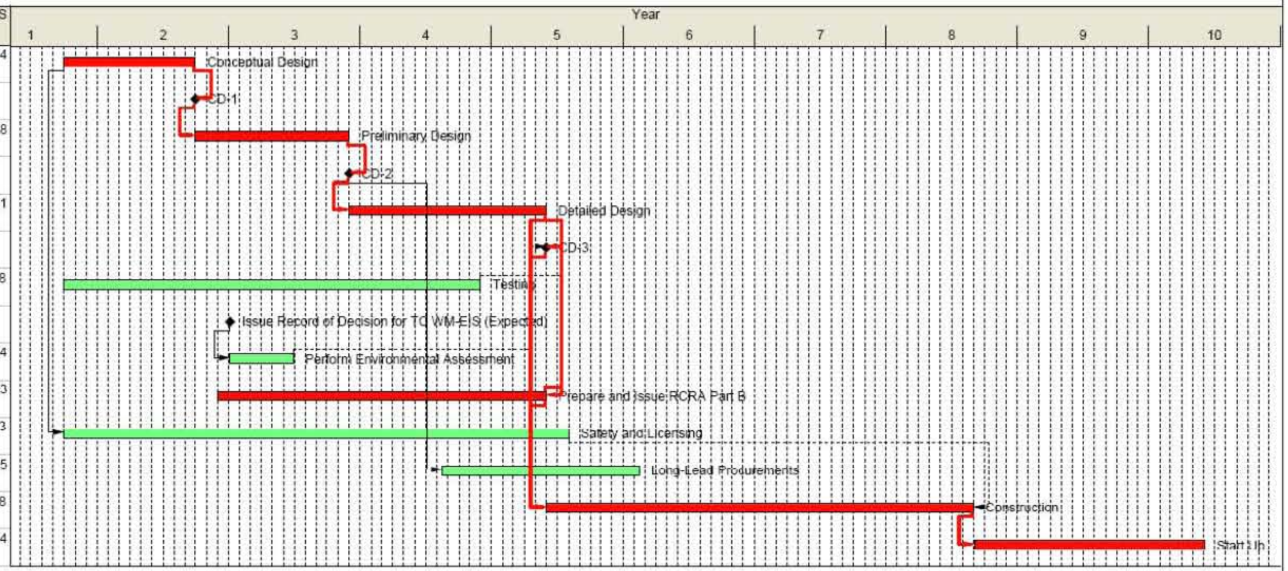
IPS Risk using FC

Figure C-12 – Implementation Schedule for CSSX

IPS Risk using CSSX — Calendar Years — 17-Jun-08 15:41

Activity ID	Activity Name	Original Duration	MOST	OPTD	PESS
IPRETEC010	Conceptual Design	252	252	252	294
IPRETEC020	CD-1	0			
IPRETEC030	Preliminary Design	293	293	336	378
IPRETEC040	CD-2	0			
IPRETEC050	Detailed Design	378	378	378	441
IPRETEC060	CD-3	0			
IPRETEC100	Testing	798	798	672	1008
IPRETEC200	Issue Record of Decision for TC WM-EIS (Expected)	0			
IPRETEC300	Perform Environmental Assessment	124	124	124	124
IPRETEC400	Prepare and Issue RCRA Part B	629	629	500	693
IPRETEC500	Safety and Licensing	966	966	966	1113
IPRETEC600	Long-Lead Procurements	375	375	375	375
IPRETEC700	Construction	820	820	693	1008
IPRETEC800	Start Up	441	441	357	504



◆ Milestone
Early Bar
Critical Remaining Work
Progress Bar
Remaining Level of Effort
Actual Level of Effort

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IPS Risk using CSSX

ATTACHMENT D. SENSITIVITY ANALYSIS

Limited sensitivity analysis was performed for both the solids filtration and cesium separation assessments to determine the impact of changing the point spread of the raw scores. The results of the sensitivity analysis are shown in Table D-1 and Table D-2. As can be seen from the tables, unless you apply a wide spread to the raw scores, there is no appreciable change in the results. While applying a wider spread (i.e., 1, 5, 10) to the raw scoring makes the results more distinctive, at issue is the implication that the score for the best is 10 times better than the worst and 2 times better than the middle ranking technology.

Table D-1 – Sensitivity Analysis for Solids Filtration Technologies

SOLIDS SEPARATION			*Sensitivity Changes for Unequal Scores*			
	Original		Increasing Delta on Each Score by 1 (Lowest Down, Highest Up)		Changing Low Score to 1 and High Score to 10	
	Base CFF	**Base RM**	**CFF +/-1**	**RM +/-1**	**CFF 1-10**	**RM 1-10**
Safety	12	12	12	13	11	14
Regulatory	10	11	10	11	10	11
Technical Maturity	12	11	12	11	13	11
Operations	8	7	8	7	10	5
Programmatic	12	8	13	7	17	5
Total	54	49	56	47	61	46

Table D-2 – Sensitivity Analysis for Cs Separation Technologies

CESIUM SEPARATION				*Sensitivity Changes for Unequal Scores*					
	Original			Increasing Delta on Lowest and Highest Score by 1 (Lowest & next lowest down 1 and Highest Up 1, Duplicates same action)			Changing Range for all Scores (Lowest to 1, Middle to 5, Highest to 10, Duplicates same action)		
	Base FC	**Base CSSX**	**Base IX**	**FC +/-1**	**CSSX +/-1**	**IX +/-1**	**FC 1-10**	**CSSX 1-10**	**IX 1-10**
Safety	13	11	11	14	10	10	19	10	8
Regulatory	11	9	11	10	8	12	10	6	13
Technical Maturity	9	7	9	11	6	9	17	5	15
Operations	8	6	8	7	5	9	9	3	12
Programmatic	11	8	11	11	6	11	13	4	13
Total	51	41	50	53	35	51	68	28	61

ATTACHMENT E. DECISION SUPPORT BOARD BIOGRAPHICAL SUMMARIES

Jim Honeyman, Chairman

Jim Honeyman has over 33 years of experience within the DOE weapons complex, encompassing a wide range of strategic and tactical planning, process design and development, program management, program alternative evaluation, contingency planning for both weapons material processing and environmental clean up. Mr. Honeyman is skilled in chemical engineering process design and analysis, new venture feasibility assessment, technology implementation, NEPA processes, regulatory compliance, and stakeholder involvement. He also has experience across a broad range of program areas that includes DOE complex-wide nuclear materials production, DOE Site Cleanup technology and planning, recovery and waste management; weapons fabrication technologies and compliance issues; startup planning for contingency capabilities. Mr. Honeyman has participated in numerous project validation and review efforts conduct by DOE and its predecessor agencies, and has extensive experience in what is required to be successful in these reviews. Highlights of Mr. Honeyman's accomplishments include:

- Developed the first integrated cleanup plan for the Hanford site (Hanford Site Mission Plan) that serves as a blueprint for cleanup today
- Led the initial competitive demonstration of vitrification of Hanford LAW wastes
- Led the negotiation of the technical basis for the Interim Stabilization Consent Order, and led the development of the implementation plan
- VP for interim design of the Waste Treatment Plant after BNFL termination, responsible for operations planning, Research and Technology, AB, and flowsheet validation
- Led the development of the first of a kind Tank Farm Industrial Hygiene Technical Basis
- Led the development of the LAW first concepts for early treatment of Hanford Tank Wastes

Jim Badden

Jim Badden has over 30 years of experience in the nuclear industry to include 26 years of management experience. In addition, he has six years of commercial project management experience. This encompasses construction projects, commercial reactor refueling outages, commercial reactor upgrades, nuclear waste management facility designs, nuclear waste management planning and scheduling, nuclear waste management operations, and safety analysis development. Mr. Badden's professional accomplishments include maintaining, operating, and upgrading the single and DSTs for transition to interim closure; providing direction regarding status of equipment operability and compliance with operational safety requirements and operational safety documents related to the safe storage of waste in the 200E and 200W Tank Farms. He also provided direction in writing the functional design criteria for the Dry Materials Grout Facility, the initial Grout Vault conceptual design report. Mr. Badden was also the operation manager during the AP Farm initial start up and Operational Readiness Reviews for the 242-A Evaporator and the New Cross-Site Transfer line.

P. K. Brockman (alternate)

P.K. Brockman has over 25 years of Operations, Business Development, and Program and Project Management experience in radioactive waste stabilization and treatment, environmental engineering, nuclear waste management, remediation planning, site characterization and construction related project activities. Mr. Brockman has been responsible for the management and direction of a multi functional engineering consulting services operation with over 200 professional engineering and scientific staff with an annual budget in excess of $50M. Mr. Brockman was responsible for the oversight and performance of a previous company's largest single project with revenues in excess of $110M. Currently Mr. Brockman provides senior leadership to the Hanford Tank Farms Project Delivery organization which provides supplemental treatment options for the final disposal of tank farm wastes, management of tank farm construction projects and management of tanks farm start up and testing readiness activities in a highly regulated and visible public arena.

Kris Colosi,

Kris Colosi is a project manager with over 20 years in project management and engineering. Ms. Colosi's background includes successful management of design, construction and startup of primary tank waste ventilation systems for the aging waste tanks, cross site transfer system, K-basin water treatment system for spent fuel retrieval, high level waste storage facility and low level disposal landfill at the Hanford Reservation. Prior to working at the Hanford Reservation, Ms. Colosi worked on five commercial nuclear reactor facilities providing engineering support during construction and operations. She has a bachelor's degree in mechanical engineering and master's n engineering and technology management.

Beth Conrad

Beth Conrad has over 25 years of experience in nuclear materials management, processing, safety and operations at Hanford, Rocky Flats, and in the UK. Ms. Conrad recently returned to the Hanford site after a 2 year assignment supporting the United Kingdom Atomic Energy Authority (UKAEA) in the management and disposition of nuclear material and waste, primarily at the Dounreay Site. Her professional background includes the successful return to Dounreay of thorium nitrate material located in Peru, analysis, direction and strategy development on technical and safety issues associated with the storage, stabilization, and shipment of Rocky Flats plutonium metal, oxide and residues and technical support to DOE-HQ, DOE-Albuquerque and DOE-Rocky Flats ranging from plutonium production to nuclear and criticality safety oversight to the establishment of the DOE Facility Representative qualification requirements for Sandia Explosive Components Facility.

Felix Miera

Felix Miera is a Senior Environmental Manager for CH2M HILL, with over 30 years experience developing and managing complex multi-disciplinary radioactive and hazardous waste environmental cleanup projects. His experience includes tenures with State governments as a manager and regulator, and with the federal government and private industry as a compliance specialist and project manager. Mr. Miera's project experience includes the development of innovative strategies for mitigating releases of radioactive mixed waste, implementing selected alternatives for cleanup of radioactive mixed waste, and the development and negotiation of innovative approaches to obtain environmental regulatory permits in a timely manner.

Rick Raymond

Mr. Richard E Raymond is currently the Director of Technology Development and the Director of Engineering Standards. In this position, he manages the development and deployment of new technologies and he manages the development of engineering procedures and senior technical support for all Tank Farm operations. In his previous position of Vice President of Projects he was responsible for full service project management of multi-disciplined, multi-year capital line item and expense projects, including engineering, construction, procurement, quality, safety, environmental compliance, and start-up/testing. Other assignments include a variety of engineering, operations, and program/project management roles, including Plant Manager for the Hanford N-Reactor, Director of Reactor Engineering, Director of Plant Engineering, Chief Engineer for the Hanford Tank Farms, and Reactor Engineer with U.S. Department of Energy on the Headquarters staff of Admiral H. G Rickover in the Division of Naval Reactors. He has a Bachelor of Science from the University of Washington in Electrical Engineering, Masters Degree in Nuclear Engineering, and has completed advanced nuclear reactor operational training with the U.S. Navy. Mr. Raymond also serves as an adjunct member of the faculty and Chairman of the Advisory Board of the Walla Walla College of Engineering, and Chairman of the Advisory Board for the Applied Research Center for Florida International University.