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Feasibility Study for the Lower Three Runs Integrator Operable Unit (U)

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EXECUTIVE SUMMARY

This Feasibility Study (FS) has been developed for the Lower Three Runs (LTR) Integrator Operable Unit (IOU) located at the Savannah River Site (SRS) in South Carolina. The LTR IOU is listed as a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Unit in Appendix C, Resource Conservation and Recovery Act/CERCLA Units, of the SRS Federal Facility Agreement.

The SRS encompasses 803 square kilometers (km^2 [310 square miles {mi^2}]) of South Carolina coastal plain along the Savannah River in Aiken, Barnwell, and Allendale counties. The LTR IOU is one of six IOUs that correspond to the respective watersheds associated with the stream systems located on the SRS (Upper Three Runs, Fourmile Branch, Pen Branch, Steel Creek, and Lower Three Runs), and the Savannah River that establishes the northwestern boundary of the SRS. The SRS IOUs are defined as surface water bodies (e.g., stream, lakes, and ponds) and associated wetlands/floodplains, including surface water, sediment/soil (sediment and floodplain/wetland soils), and related biota.

The LTR watershed is located in the southeastern portion of SRS. LTR is a large blackwater stream that originates in the northeast portion of SRS and follows a southerly direction for approximately (~) 40 kilometers (km [24.5 miles {mi}]), discharging into the Savannah River. The LTR watershed drains about 460 km^2 (180 mi^2) and includes two main industrial operable units: P-Area Operable Unit including P-Reactor, and R-Area Operable Unit including R-Reactor. The LTR IOU was predominately contaminated with cesium-137 (Cs-137) from historical releases associated with reactor operations in P Area and R Area.

The LTR IOU is delineated into Upper, Middle, and Lower subunits. The Upper subunit of the LTR IOU is located upgradient of the PAR Pond Dam and includes PAR Pond and the pre-cooler ponds and canal system. The Middle and Lower subunits are located below the PAR Pond Dam. The Lower subunit bounds the LTR stream system by a narrow buffer of United States Department of Energy property, an area referred to as the "tail portion" of the LTR IOU. The remedial action for the Middle and Lower subunits was previously addressed and documented in the *Explanation of Significant Differences (ESD) for the Revision 0 Interim Action Record of Decision Remedial*

Alternative Selection: PAR Pond Unit (U); Lower Three Runs Integrator Operable Unit Tail Portion (Middle and Lower Subunits) (U). As documented in the ESD, no additional data collection, risk assessment, or response evaluation is necessary for the Lower and Middle subunits, and the approved final remedial action for the tail portion of the LTR IOU is complete.

The Upper subunit of the LTR IOU is the subject of this FS. Past characterization efforts have shown that Cs-137 is the major contaminant in the LTR IOU. In 2009/2010, extensive sampling of the Upper subunit was undertaken to augment previously collected data to support the risk evaluation. The sampling was performed as outlined in approved Sampling and Analysis Plans and included sampling of sediment/soil, surface water, and biological data (primarily fish) in the canals, pre-cooler ponds, PAR Pond. Stream channel/floodplain sediment and floodplain/wetland soil (i.e., sediment/soil) are combined as a single media and referred to as "sediment/soil".

For the Upper subunit of the LTR IOU, the IOU on-site worker was selected as the most likely receptor. The IOU on-site worker scenario is based on an SRS researcher and is also protective of an adolescent trespasser. Because it is known that some contaminants could bio-accumulate in fish, the recreational fisherman was chosen as the most likely receptor for the ingestion of contaminated fish tissue. The recreational fisherman scenario was determined to only be viable in locations that can sustain populations of consumable fish.

For evaluation purposes, the Upper subunit of the LTR IOU is segregated into nine individual exposure areas (EAs) as follows:

- EA1: Pond A – Including R-Area Discharge Canal
- EA2: Canal from Pond A to Pond B
- EA3: Pond B – Including canal to Pond C
- EA4: Canal from Pond B to North Arm of PAR Pond
- EA5: Joyce Branch (Old Discharge Canal)
- EA6: PAR Pond
- EA7: Canal from P-Area to Ponds 4 and 5 – Including Pond 2
- EA8: Ponds 4 and 5 – Including canal from Ponds 4 and 5 to Pond C
- EA9: Pond C

Remedial Action Objectives

The contaminants considered for remedial action for the Upper subunit of the LTR IOU are identified as refined constituents of concern (RCOCs) for each EA. The primary RCOCs are Cs-137 and cobolt-60 (Co-60) in sediment/soil that could result in an unacceptable risk to the IOU on-site worker. Because Co-60 was collocated with Cs-137, any remedial action selected for Cs-137 in sediment/soil will also address the Co-60 contamination. Cs-137 and Co-60 are RCOCs for the IOU on-site worker in sediment/soil in EA1, EA5, EA6, EA7, and EA9. Cs-137 only is identified as a RCOC for the IOU on-site worker in EA2, EA3, EA4, and EA8. With respect to the recreational fisherman scenario, Cs-137 and mercury were identified as RCOCs in fish tissue in EA3, EA6, and EA9. Although mercury was identified as a RCOC (for fish tissue), its presence is the result of atmospheric deposition (i.e., regional issue/problem) and from the use of the elevated levels of mercury in Savannah River water as part of the river water distribution system. Therefore, mercury was introduced into the LTR system not as a result of site operations but rather a combination of atmospheric deposition and the use of Savannah River water. No RCOCs were identified for the surface water media or for ecological receptors.

Based on human health and ecological risk evaluation documented in the *Remedial Investigation/ Baseline Risk Assessment for the Lower Three Runs Integrator Operable Unit (U),* remedial action objectives (RAOs) identified for the Upper subunit of the LTR IOU are as follows:

- Protect IOU on-site workers from exposure to Cs-137 and Co-60 in sediment/soil that exceed 1E-06 risk threshold or background levels. The primary exposure route of concern is the external radiation pathway.
- Protect the recreational fisherman from exposure to Cs-137 and mercury in fish tissue. The primary route of exposure is the ingestion of fish pathway.

Table ES-1 lists the RAOs for each individual EA.

Summary of Feasibility Study

Potential remedial alternatives are based on general response actions (i.e., No Action, Land Use Controls (LUCs), Containment, Excavation) and remedial technologies initially screened with respect to effectiveness, implementability, and cost. The general response action and technologies most applicable to contaminants identified for the Upper subunit of the LTR IOU are assembled into functional alternatives to address EA-specific factors and satisfy the RAOs.

Seven alternatives were identified to address contaminated media in the Upper subunit of the LTR IOU.

- Alternative 1 (A-1) – No Action
- Alternative 2 (A-2) – LUCs with Monitored Natural Recovery (MNR)
- Alternative 3 (A-3) – In Situ Capping on Principle Threat Source Material (PTSM) Sediment/Soil (Including Consideration of a Hybrid Cap)
- Alternative 4 (A-4) – Broadcast of Amendments to Limit Bioavailability
- Alternative 5 (A-5) – Excavation and Disposal of PTSM Sediment/Soil
- Alternative 6 (A-6) – Maintain Water in Ponds
- Alternative 7 (A-7) – Excavation and Disposal of All Contaminated Sediment/Soil

The National Contingency Plan requires that potential remedial alternatives undergo detailed analysis using relevant criteria that will be used by decision makers to select a final remedy. The seven alternatives were initially screened with respect to effectiveness, implementability, and cost. Except for Alternatives A-4 and A-7 that were not retained for further consideration, the remaining five alternatives were subjected to the detailed evaluation and comparative analysis based on nine criteria established by United States Environmental Protection Agency (USEPA) under CERCLA. The results of the detailed analysis are examined to compare alternatives and identify key tradeoffs among alternatives. The results of this assessment will be used to determine the appropriate remedial response for each EA. Table ES-2 provides a comparative analysis summary and provides the cost of the appropriate alternatives for each EA.

Although a comparative analysis of remedial alternatives is provided in the FS, this document does not propose a preferred alternative. The preferred alternative is presented in the Proposed Plan basin on information contained in this report and on comments received from the USEPA, South Carolina Department of Health and Environmental Control, and the public prior to finalization of the Record of Decision.

Table ES-1. Summary of the RAOs for Individual EAs

Upper Exposure Area	RAOs
1. Pond A – Including R Discharge Canal	Protect IOU on-site workers from exposure to Cs-137 and Co-60 in sediment/soil that exceed 1E-06 risk threshold or background levels. The primary route of exposure is the external radiation pathway.
2. Canal from Pond A to Pond B	Protect IOU on-site workers from exposure to Cs-137 in sediment/soil that exceed 1E-06 risk threshold or background levels. The primary route of exposure is the external radiation pathway.
3. Pond B	Protect IOU on-site workers from exposure to Cs-137 in sediment/soil that exceed 1E-06 risk threshold or background levels. The primary route of exposure is the external radiation pathway. Protect the recreational fisherman from exposure to Cs-137 and mercury in fish tissue. The primary route of exposure is the ingestion of fish pathway.
4. Canal from Pond B to North Arm of PAR Pond	Protect IOU on-site workers from exposure to Cs-137 in sediment/soil that exceed 1E-06 risk threshold or background levels. The primary route of exposure is the external radiation pathway.
5. Joyce Branch (Old Discharge Canal)	Protect IOU on-site workers from exposure to Cs-137 and Co-60 in sediment/soil that exceed 1E-06 risk threshold or background levels. The primary route of exposure is the external radiation pathway.
6. PAR Pond	Protect IOU on-site workers from exposure to Cs-137 and Co-60 in sediment/soil that exceed 1E-06 risk threshold or background levels. The primary route of exposure is the external radiation pathway. Protect the recreational fisherman from exposure to Cs-137 and mercury in fish tissue. The primary route of exposure is the ingestion of fish pathway.
7. Canal from P-Area to Ponds 4 and 5 – Including Pond 2	Protect IOU on-site workers from exposure to Cs-137 and Co-60 in sediment/soil that exceed 1E-06 risk threshold or background levels. The primary route of exposure is the external radiation pathway.
8. Ponds 4 and 5 – Including Canal from Ponds 4 and 5 to Pond C	Protect IOU on-site workers from exposure to Cs-137 in sediment/soil that exceed 1E-06 risk threshold or background levels. The primary route of exposure is the external radiation pathway.
9. Pond C	Protect IOU on-site workers from exposure to Cs-137 and Co-60 in sediment/soil that exceed 1E-06 risk threshold or background levels. The primary route of exposure is the external radiation pathway. Protect the recreational fisherman from exposure to Cs-137 and mercury in fish tissue. The primary route of exposure is the ingestion of fish pathway.

Table ES-2. Summary of the Comparative Analysis

Technology Alternative	Description	Cost
Alternative (A-1) – No Action	This alternative will not achieve RAOs. Alternative A-1 is not effective in reducing exposure of IOU on-site worker to contaminated media. The time to reach remedial goal options (RGOs) for the entire Upper Subunit of the LTR IOU is 290 years.	None
Alternative (A-2) – LUCs with MNR	This alternative will achieve RAOs. Alternative A-2 reduces exposure of IOU on-site worker to contaminated media by limiting access through administrative and engineering controls. The time to reach RGOs is not reduced by this remedy.	Upper subunit - $17.3 M
Alternative (A-3) – In Situ Capping on PTSM Sediment/Soil (Including Consideration of a Hybrid Cap)	This alternative includes LUCs with MNR as part of the remedy; therefore, RAOs would be achieved. Alternative A-3 reduces exposure of IOU on-site worker to PTSM sediment/soil by placing a barrier over the PTSM locations. The evaluation of a hybrid cap is considered and would include adding in situ amendments in addition to the barrier on PTSM sediment/soil. The addition of in situ amendments would reduce the bio-availability of Cs-137 for fish and subsequently human receptors who may eat the fish. The use of an amendment in the cap is a treatment method that will reduce the mobility of the PTSM sediment/soil. The time to reach RGOs is not reduced by this remedy.	EA1 - $417 K EA3 - $2.7 M EA5 - $805 K
Alternative (A-5) – Excavation and Disposal of PTSM Sediment/Soil	This alternative includes LUCs with MNR as part of the remedy; therefore, RAOs would be achieved. Alternative A-5 reduces exposure of IOU on-site worker to PTSM sediment/soil by removing the contaminated media through excavation or dredging. The use of a drying agent will treat the PTSM sediment/soil by reducing mobilization during transportation and disposal. ~~This alternative eliminates the exposure, toxicity, and mobility of PTSM sediment/soil at the known locations.~~ The time to reach RGOs is reduced to 220 years for EA1 and EA5 and to 230 years for EA3.	EA1 - $486 K EA3 - $2.0 M EA5 - $796 K
Alternative (A-6) – Maintain Water in Ponds	This alternative includes LUCs with MNR as part of the remedy; therefore, RAOs would be achieved. Alternative A-6 reduces exposure of IOU on-site worker to contaminated media by shielding sediment/soil with water. This alternative is accomplished through the continuance of annual inspections that are already in place along with periodic maintenance of the physical attributes (i.e., dams, weirs, control gates, etc.) that make water retention viable. The time to reach RGOs is not reduced by this remedy.	EA3 - $2.1 M EA6 - $2.8 M EA9 - $591 K

Note:
K = thousand
M= million

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LIST OF ABBREVIATIONS AND ACRONYMS

~	approximate, approximately
<, ≤	less than, less than or equal to
>, ≥	greater than, greater than or equal to
ac	acre
ARAR	applicable or relevant and appropriate requirement
B	billion
BRA	Baseline Risk Assessment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
Ci	curies
CSM	conceptual site model
EA	exposure area
LLWF	Low Level Waste Facility
ECODS	Early Construction Operation Disposal Site
EPC	exposure point concentration
ERA	ecological risk assessment
ESD	Explanation of Significant Difference
FERC	Federal Energy Regulatory Commission
FFA	Federal Facility Agreement
FONSI	finding of no significant impact
FS	Feasibility Study
ft	feet
ft^3	cubic feet
ha	hectare
HHRA	human health risk assessment
IOU	Integrated Operable Unit
IROD	Interim Record of Decision
K	thousand
km	kilometer
km^2	square kilometers
LTR	Lower Three Runs
LUCs	land use controls
LUCIP	Land Use Control Implementation Plan
m	meter
m^2	square meters
m^3	cubic meters
M	million
mg/kg	milligrams per kilogram
mi	mile
mi^2	square miles
MNR	monitored natural recovery
msl	mean sea level

LIST OF ABBREVIATIONS AND ACRONYMS *(Continued/End)*

NA	not applicable
NBN	no building number
NCP	National Oil and Hazardous Substances Contingency Plan
NEPA	National Environmental Policy Act
NFA	No Further Action
NPDES	National Pollutant Discharge Elimination System
O&M	operations and maintenance
OU	operable unit
pCi/g	picocuries per gram
PAOU	P-Area Operable Unit
PRG	preliminary remediation goal
PTSM	principal threat source material
PP	Proposed Plan
RAO	remedial action objective
RAOU	R-Area Operable Unit
RCOC	refined constituent of concern
RCRA	Resource Conservation and Recovery Act
RG	remedial goal
RGO	remedial goal option
RI	Remedial Investigation
ROD	Record of Decision
RSL	regional screening level
SCDHEC	South Carolina Department of Health and Environmental Control
sec	second
SEMS	Superfund Enterprise Management Systems
SRARP	Savannah River Archaeological Research Program
SRNS	Savannah River Nuclear Solutions, LLC
SRS	Savannah River Site
TBC	to be considered
TCR	total cumulative risk
USDOE	U.S. Department of Energy
USEPA	U.S. Environmental Protection Agency
WSRC	Washington Savannah River Company, LLC
yd^2	square yards
yd^3	cubic yards

1.0 INTRODUCTION

This Feasibility Study (FS) has been developed for the Lower Three Runs (LTR) Integrator Operable Unit (IOU) located at the Savannah River Site (SRS) in South Carolina (Figure 1-1). The LTR IOU is listed as a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Unit in Appendix C, Resource Conservation and Recovery Act (RCRA)/CERCLA Units, of the SRS Federal Facility Agreement (FFA).

The SRS encompasses 803 square kilometers (km^2 [310 square miles {mi^2}]) of South Carolina coastal plain along the Savannah River in Aiken, Barnwell, and Allendale counties. The LTR IOU is one of six IOUs that correspond to the respective watersheds associated with the stream systems located on the SRS (Upper Three Runs, Fourmile Branch, Pen Branch, Steel Creek, and Lower Three Runs), and the Savannah River that establishes the northwestern boundary of the SRS. The SRS IOUs are defined as surface water bodies (e.g., stream, lakes, and ponds) and associated wetlands/floodplains, including surface water, sediment/soil (sediment and floodplain/wetland soils), and related biota.

For administrative purposes, the LTR IOU is delineated into Upper, Middle, and Lower subunits (Figure 1-2). The Upper subunit of the LTR IOU is the subject of this FS and consists of the canal and pond/reservoir system located upgradient of the PAR Pond Dam. The Middle and Lower subunits are located below the PAR Pond Dam. The Lower subunit bounds the LTR stream system by a narrow buffer of United States Department of Energy (USDOE) property, an area referred to as the "tail portion" of the LTR IOU. An early remedial action for the Middle and Lower subunits was previously addressed and documented in the *Explanation of Significant Differences (ESD) for the Revision 0 Interim Action Record of Decision Remedial Alternative Selection: PAR Pond Unit (U); Lower Three Runs Integrator Operable Unit Tail Portion (Middle and Lower Subunit*s) *(U)* (SRNS 2012). As documented in the ESD, no additional data collection, risk assessment, or response evaluation is necessary for the Lower and Middle subunits, and the approved final remedial action for the tail portion of the LTR IOU is complete.

The primary sources of contamination to the LTR IOU were liquid releases from past reactor operations and include process leaks, reactor disassembly basin purges, and thermal discharges which contained tritium, metallic contaminants, and other radiological contaminants. Table 1-1 provides the status of the potential sources of contamination to the LTR IOU. Remedial actions for source units at R-Area Operable Unit (RAOU) and P-Area Operable Unit (PAOU) have been completed, and all other potential sources to the LTR IOU have been mitigated or determined to require No Further Action (NFA). Two units originally identified in the LTR IOU Work Plan, Dunbarton Railroad Yard and P-Area Groundwater, have subsequently been re-evaluated and administratively transferred to the Steel Creek watershed.

1.1 Purpose and Organization of Report

The purpose of this FS is to provide a detailed evaluation of the remedial alternatives for contaminated media in the Upper subunit of the LTR IOU. This evaluation provides sufficient information to support the preferred remedial action to be documented in the Proposed Plan (PP) and selection of the final remedial action to be documented in the Record of Decision (ROD) for completion of remedial activities at the LTR IOU.

This FS is organized into five chapters including Chapter 1.0 – Introduction, Chapter 2.0 – Identification and Screening of Technologies, Chapter 3.0 – Development and Screening of Alternatives, Chapter 4.0 – Detailed Analysis of Alternatives, Chapter 5.0 – References. Chapter 1.0 broadly discusses the purpose and organization of the report, regulatory background and unit descriptions. Chapter 2.0 discusses general response actions and potential technology types applicable to the LTR IOU, remedial action objectives (RAOs), and applicable and relevant or appropriate requirements (ARARs). Chapter 3.0 presents the development and screening of the potential remedial alternatives. Chapter 4.0 presents a detailed analysis of the remedial alternatives. Chapter 5.0 provides the references cited in this report.

For evaluation purposes, the Upper subunit of the LTR IOU is segregated into the following nine individual exposure areas (EAs) (Figure 1-3):

- EA1: Pond A – Including R-Area Discharge Canal
- EA2: Canal from Pond A to Pond B

- EA3: Pond B – Including canal to Pond C
- EA4: Canal from Pond B to North Arm of PAR Pond
- EA5: Joyce Branch (Old Discharge Canal)
- EA6: PAR Pond
- EA7: Canal from P-Area to Ponds 4 and 5 – Including Pond 2
- EA8: Ponds 4 and 5 – Including canal from Ponds 4 and 5 to Pond C
- EA9: Pond C

1.2 Unit Background

The LTR watershed is located in the southeastern portion of SRS. LTR is a large blackwater stream that originates in the northeast portion of SRS and follows a southerly direction for approximately (~) 40 kilometers (km [24.5 miles {mi}]), discharging into the Savannah River. R-Reactor and P-Reactor, which historically produced special nuclear materials for national defense, released reactor effluent, known as "thermal discharges," into the LTR watershed. The LTR IOU reactor effluent pathway is shown in Figure 1-3.

R-Reactor began operations in 1953 and was followed by P-Reactor in 1954. Both received cooling water from the Savannah River via the river water distribution system. R-Reactor discharged reactor effluent directly into Joyce Branch, while P-Reactor discharged reactor effluent directly into Steel Creek. In 1958, PAR Pond and a series of pre-cooler ponds and a canal system were constructed to address the cooling water requirements of both P- and R-Reactors. Effluent from R-Reactor was routed to the R-Area Discharge Canal and pre-cooler Pond B where it discharged into what was identified as the north arm of PAR Pond (Figure 1-3). This effluent pathway was used for R-Reactor discharge from 1961 until the reactor was shut down in 1964. Since the shutdown of R-Reactor, R-Area Discharge Canal and Pond B have remained essentially undisturbed.

PAR Pond also served as a heat exchange/cooling reservoir for P-Reactor until 1988. Heated water was released through a series of man-made canals and smaller impoundments into the pre-cooler Pond C and released into PAR Pond. Effluent discharges from P-Reactor ceased in 1987. As with the R-Area Discharge Canal, the associated canal system and pre-cooler ponds have remained essentially undisturbed since the termination of P-Reactor discharges to PAR Pond.

During an inspection of the PAR Pond Dam in March 1991, a small surface depression was noted on the downstream face which necessitated a detailed structural investigation and initiated a precautionary drawdown of the reservoir. From June through September 1991, the level of PAR Pond was lowered from 60-meters (m) to 54-m (200-feet [ft]) to 181-ft) mean sea level (msl) to reduce the risk and consequences of an unlikely event of dam failure. A CERCLA interim ROD (IROD) for PAR Pond was issued in 1995 to address potential exposure to the contaminated sediment/soil that was exposed following water level drawdown of the PAR Pond reservoir during repair of the PAR Pond dam (SRNS 1995). The interim remedy was to prevent exposure of contaminated shoreline sediment/soil until a National Environmental Policy Act (NEPA) evaluation could be conducted. The NEPA Environmental Impact Statement for the *Shutdown of the River Water System at the Savannah River Site* was used as the basis for the selection of the alternative (USDOE 1997). The IROD, issued in 1995, documented the preferred interim alternative of refilling PAR Pond to the 60.9+0.3-m (200+1-ft) level to prevent exposure of contaminated sediment/soil (SRNS 1995). Under severe drought conditions, and if necessary, the River Water System could be used to maintain PAR Pond water levels. The *Finding of No Significant Impact Natural Fluctuation of Water Level in Par Pond and Reduced Water Flow in Steel Creek Below L-Lake at the Savannah River Site* allows the PAR Pond reservoir water levels to naturally fluctuate between 59-m and 60-m (195-ft and 200-ft) above msl (USDOE 1995). In 2009, a revised Finding of No Significant Impact (FONSI) reduced the base flow requirements from 0.28 cubic meters (m^3)/second (sec) to 0.14 m^3/sec (10 cubic ft (ft^3)/second (sec) to 5.0 ft^3/sec for the PAR Pond dam (USDOE 2009). The effectiveness of this remedy is evaluated in the Fifth Five-Year Remedy Review Report (SRNS 2015). The next Five-Year Remedy Review Report for the PAR Pond IROD is scheduled for issuance in 2020.

Liquid releases before and after the construction of PAR Pond and the pre-cooler ponds and canal system included process leaks, reactor disassembly basin purges, and thermal discharges that contained tritium, metallic contaminants, and other radiological contaminants. Cesium-137 (Cs-137), present in sediment/soil in the pre-cooler ponds and PAR Pond, is the primary contaminant in the PAR Pond/canal system. Extensive sampling of the IOU was undertaken to augment existing data and ensure sufficient information would be available for evaluating risks to human and ecological receptors. Characterization was performed in accordance with approved Sampling and Analysis Plans (SRNS 2009 and SRNS 2016) and included sampling within the canals, pre-cooler ponds, PAR Pond, and the stream channel/floodplain. With the exception of the larger ponds, the sampling plan design was based on evenly spaced transects. Field gamma measurements were augmented by sediment, sediment/soil, and surface water samples collected for laboratory analyses. Biological data (primarily fish) were collected from LTR subunits. Background samples were collected for all media.

The Upper subunit of the LTR IOU is used as a research site and is part of the National Environmental Research Park. The primary entities that conduct research within the Upper subunit are the Savannah River Ecology Laboratory and the Savannah River National Laboratory. Emphasis in recent years has primarily been associated with aspects of radioecology in the Pond A, Pond B, and PAR Pond systems.

1.3 Unit Description

A brief summary of each EA is provided in Section 1.3.1 through Section 1.3.9 and shown in Figure 1-3. A complete history for each EA is documented in the Remedial Investigation/ Baseline Risk Assessment (RI/BRA) for the LTR IOU (SRNS 2017).

For the Upper subunit of the LTR IOU, the IOU on-site worker was selected as the most likely receptor for exposure to contaminated sediment/soil. The IOU on-site worker is based on an SRS researcher scenario and is also protective of an adolescent trespasser. The IOU on-site worker scenario is applicable to the entire Upper subunit. Because it is known that some contaminants could bio-accumulate in fish and fish are a mobile medium, the hypothetical recreational fisherman was chosen as the most likely receptor for the ingestion of contaminated fish tissue. The recreational fisherman scenario was determined to only be viable to EAs that can sustain populations of consumable fish, specifically EA3, EA6, and EA9.

A summary of the risk and identified refined constituents of concern (RCOCs) for each individual EA is described in the sections below and identified in Table 1-2. RCOCs were only identified if concentrations exceeded risk based screening levels. For purposes of the RI/BRA and the FS, sediment and floodplain/wetland soils (i.e., sediment/soil) were combined as a single media and referred to as "sediment/soil".

1.3.1 Exposure Area 1: Pond A – Including R-Area Discharge Canal

EA1 includes Pond A and the R-Area Discharge Canal. Pond A is ~2.6 hectare (ha [6.4 acres {ac}]) and received water from the R-Area Discharge Canal and subsequently discharged to Pond B via a canal (EA2, see Section 1.3.2). Prior to construction of PAR Pond, the effluent flowed into LTR via Joyce Branch (refer to Section 1.3.5). Water levels in Pond A fluctuate from year to year. Storm water runoff and high groundwater elevation provides a constant shallow water level throughout the year in the R-Area Discharge Canal. The canal from R-Reactor to Pond A is ~645-m (2,116-ft) long. The canal from the R-Area Discharge Canal to Joyce Branch is 233-m (764.4-ft) long. The canal flow area is ~3.0-m (9.8-ft) across the base of the canal.

As documented in the RI/BRA (SRNS 2017), Cs-137 and Co-60 were identified as human health RCOCs in EA1 sediment/soil for the IOU on-site worker receptor. Concentrations pose a Total Cumulative Risk (TCR) of 8.2E-04 to the IOU on-site worker (decay corrected to 6.4E-04)[1]. Cs-137: (Exposure Point Concentration [EPC] = 148 pCi/g; risk to the IOU on-site worker = 8.2E-04; decay corrected to 6.4E-04). Co-60: (EPC = 0.144 pCi/g; risk to the IOU on-site worker = 1.7E-06; decay corrected to <1E-06).

Results of the principal threat source material (PTSM) screening for EA1 indicate that using maximum concentrations and maximum activity concentrations of detected constituents, the only constituent that exceeds the PTSM threshold (i.e., risk ≥1E-03) established in the RI/BRA is Cs-137. Although Cs-137 exceeded the sediment/soil threshold, the subsequent refinement/ uncertainty evaluation presented in the RI/BRA (SRNS 2017) determined there are no PTSM RCOCs identified for EA1. However, one submerged location (R-Area Downstream of R-1) had

[1] Contaminant concentrations were decay adjusted to January 1, 2017 to establish a decay corrected risk estimate.

five separate samples above the PTSM threshold for the IOU on-site worker and was taken into consideration for the remedial alternative evaluation.

Radioactive decay is a known process of the degradation of radioactivity. All sampling records have been decay adjusted and through degradation, the estimated time for EA1 to reach levels below the PTSM threshold (144 pCi/g) is 50 years.[2] The estimated time for EA1 to reach the Cs-137 remedial goal option (RGO) of 0.68 pCi/g is 290 years. The SRS Land Use Control Assurance Plan (WSRC 1999) ensures that LUCs will be maintained for as long as necessary to keep the selected remedy fully protective of human health and the environment.

1.3.2 Exposure Area 2: Canal from Pond A to Pond B

EA2 includes the canal from Pond A to Pond B which is ~2,837-m (9,308-ft) long. It received water from Pond A which flowed to and discharged into Pond B. Water levels in the canal fluctuate from year to year based on precipitation amounts. The canal flow area is ~3.0-m (9.8-ft) across the base of the canal.

As documented in the RI/BRA (SRNS 2017), Cs-137 was identified as a human health RCOC in sediment/soil for the IOU on-site worker receptor. Cs-137 in sediment/soil (EPC = 48.8 pCi/g) poses a 2.7E-04 risk to the IOU on-site worker (decay corrected to 2.3E-04).

Results of the PTSM evaluation for EA2 indicate that using maximum concentrations and activity concentrations of detected constituents, the only constituent that equates to the PTSM threshold level (i.e., risk ≥1E-03) is Cs-137. Based on the subsequent refinement/uncertainty evaluation presented in the RI/BRA (SRNS 2017), there are no PTSM RCOCs identified for EA2. However, it is recognized that there is one location in EA2 (RDC-007-001) where the measured activity of Cs-137 (in 2010) equaled the PTSM threshold for the IOU on-site worker.

Considering the radiological half-life of Cs-137 (30.2 years), the decay-corrected maximum (~155 pCi/g) is expected to be below the PTSM threshold at the time any remedial decision is implemented. Therefore, location RDC-007-001 is not considered a PTSM location for this FS.

[2] Cs-137 PTSM threshold (144 pCi/g) is based on the 2017 update to the USEPA Radionuclide Preliminary Remediation Goals for Superfund.

Through degradation, the estimated time for EA2 to reach the Cs-137 RGO of 0.68 pCi/g is 235 years. The SRS Land Use Control Assurance Plan (WSRC 1999) ensures that LUCs will be maintained for as long as necessary to keep the selected remedy fully protective of human health and the environment.

1.3.3 Exposure Area 3: Pond B – Including Canal to Pond C

EA3 includes Pond B and the spillway outlet structure connecting Pond B to Pond C. Pond B is ~82.1 ha (202.8 ac) and received water from Pond A and subsequently discharged to the North Arm of PAR Pond. Pond B generally maintains its water level from year to year. The canal from Pond B to Pond C is ~547-m (1,795-ft) long. The canal flow area is ~3.0-m (9.8-ft) across the base of the canal.

As documented in the RI/BRA (SRNS 2017), Cs-137 was identified as a human health RCOC in sediment/soil for the IOU on-site worker receptor. Cs-137 in sediment/soil (EPC = 98.3 pCi/g) poses a 5.5E-04 risk to the IOU on-site worker (decay corrected to 3.3E-04).

Cs-137 and mercury were identified as human health RCOCs in fish tissue for the recreational fisherman receptor. Cs-137 in fish tissue (maximum concentration [max] = 113 pCi/g; preliminary remedial goal [PRG] = 0.054 pCi/g) and mercury (max = 1.83 mg/kg; regional screening level [RSL] = 0.154 mg/kg) exceeds risk based screening levels for the recreational fisherman.

Based on results of the PTSM screening for EA3 and the subsequent refinement/uncertainty evaluation, there are no PTSM RCOCs identified for EA3. However, two locations (SCB-29 and SCB-34) had sample results above the PTSM threshold for the IOU on-site worker and were taken into consideration for the remedial alternative evaluation.

All sampling records have been decay adjusted and through degradation, the estimated time for EA3 to reach levels below the PTSM threshold is 25 years. The estimated time for EA3 to reach the RGO of 0.68 pCi/g is 260 years. The SRS Land Use Control Assurance Plan (WSRC 1999) ensures that LUCs will be maintained for as long as necessary to keep the selected remedy fully protective of human health and the environment.

1.3.4 Exposure Area 4: Canal from Pond B to North Arm of PAR Pond

EA4 includes the canal from Pond B to the North Arm of PAR Pond and is ~2,305-m (7,562-ft) long. The canal flow area is ~3.0-m (9.8-ft) across the base of the canal. The canal received water from Pond B which flowed to and discharged into the North Arm of PAR Pond. Water levels within the canal fluctuate from year to year based on precipitation amounts.

Based on the RI/BRA (SRNS 2017), Cs-137 was identified as a human health RCOC in sediment/soil for the IOU on-site worker receptor. Cs-137 in sediment/soil (EPC = 18.3 pCi/g) poses a 1.0E-04 risk to the IOU on-site worker (decay corrected to 8.8E-05).

Results of the PTSM evaluation for EA4 indicated no PTSM RCOCs were present. All sampling records have been decay adjusted and through degradation, the estimated time for EA4 to reach the Cs-137 RGO of 0.68 pCi/g is 180 years. The SRS Land Use Control Assurance Plan (WSRC 1999) ensures that LUCs will be maintained for as long as necessary to keep the selected remedy fully protective of human health and the environment.

1.3.5 Exposure Area 5: Joyce Branch (Old Discharge Canal)

EA5 includes the remnant of the natural stream (i.e., Joyce Branch) that flows into Pond C which was initially used to convey reactor discharge water from R Reactor directly to the LTR stream system prior to the construction of the canal system to Pond B. Water levels in EA5 fluctuate throughout the year and certain areas may become dry during instances of low rainfall. Joyce Branch is ~2,53-m (8,310-ft) long. The flow area is ~3.0-m (9.8-ft) across the base of the stream bed.

Cs-137 and Co-60 were identified as human health RCOCs in sediment/soil for the IOU on-site worker receptor in the RI/BRA (SRNS 2017). Concentrations pose a TCR of 1.3E-03 to the IOU on-site worker (decay corrected to 9.4E-04); Cs-137: (EPC = 228 pCi/g; risk to IOU on-site worker = 1.3E-03; decay corrected to 9.4E-04). Co-60: (EPC = 0.76 pCi/g; risk to IOU on-site worker = 9.1E-06; decay corrected to 1.7E-06).

Results of the PTSM evaluation for EA5 indicate that using maximum concentrations and activity concentrations of detected constituents, the only constituent that exceeds the PTSM threshold level (i.e., risk ≥1E-03) is Cs-137. Based on the subsequent refinement/uncertainty evaluation, no PTSM RCOCs were identified for EA5 (SRNS 2017). However, two locations (LTR-02 and LTR-04) had sample results above the PTSM threshold for the IOU on-site worker and were taken into consideration for the remedial alternative evaluation.

All sampling records have been decay adjusted and the estimated time for EA5 to reach levels below the PTSM threshold is 30 years. The estimated time for EA5 to reach the Cs-137 RGO of 0.68 pCi/g is 265 years. The SRS Land Use Control Assurance Plan (WSRC 1999) ensures that LUCs will be maintained for as long as necessary to keep the selected remedy fully protective of human health and the environment.

1.3.6 Exposure Area 6: PAR Pond

EA6 includes PAR Pond. PAR Pond is a ~1,068-ha (2,640-ac) cooling water reservoir that historically received thermal discharges from R Reactor and P Reactor. Following a necessary drawdown in 1991 to conduct repairs on the PAR Pond dam, a CERCLA IROD was issued in 1995 (SRNS 1995). The IROD selected refilling and maintaining the PAR Pond reservoir at the 61- +/- 0.3-m (200- +/- 1-ft msl) water level as an interim remedy, along with a commitment to evaluate the environmental impacts of natural water level fluctuations in a NEPA document. The interim remedy also included land use controls (LUCs) to manage exposure to contaminated sediment/soil.

In 1995, a *Finding of No Significant Impact (FONSI) for the Natural Fluctuation of Water Level in Par Pond and Reduced Water Flow in Steel Creek Below L-Lake at the Savannah River Site* documented that there were no significant environmental impacts from the natural fluctuation of water levels in PAR Pond (USDOE 1995). The 1995 FONSI supported the selected alternative in the 1998 NEPA ROD for the *Shutdown of the River Water System at the SRS* (USDOE 1997) to continue to operate the River Water System to maintain the water level in L-Lake and allow PAR Pond to naturally fluctuate between 59- and 61-m (195- and 200-ft) msl. Under severe drought conditions, and if necessary, the River Water System could be used to maintain PAR Pond water levels. In 2009, a revised FONSI determined that a minimum outflow of 0.14 m^3/sec

(5 ft^3/sec) from PAR Pond is sufficient to support downstream balanced biological aquatic communities (USDOE 2009).

The RI/BRA identified Cs-137 and Co-60 as human health RCOCs in sediment/soil for the IOU on-site worker receptor (SRNS 2017). Concentrations pose a TCR of 5.0E-05 to the IOU on-site worker (decay corrected to 2.9E-05); Cs-137:(EPC = 8.82 pCi/g; risk to IOU on-site worker = 4.9E-05; decay corrected to 2.9E-05). Co-60: (EPC = 0.097 pCi/g; risk to IOU on-site worker = 1.2E-06; decay corrected to <1E-06).

Cs-137 and mercury were identified as human health RCOCs in fish tissue for the recreational fisherman receptor. Cs-137 (max = 18.4 pCi/g; PRG = 0.054 pCi/g) and mercury (max = 3.18 mg/kg; RSL = 0.154 mg/kg) in fish tissue exceeds risk based screening levels for the recreational fisherman.

Results of the PTSM evaluation for EA6 indicated no PTSM RCOCs were present. All sampling records have been decay adjusted and through degradation, the estimated time for EA6 to reach the RGO of 0.68 pCi/g is 205 years. The SRS Land Use Control Assurance Plan (WSRC 1999) ensures that LUCs will be maintained for as long as necessary to keep the selected remedy fully protective of human health and the environment.

1.3.7 Exposure Area 7: Canal from P-Area to Ponds 4 and 5 – Including Pond 2

EA7 includes the canal from P-Area to Pond 2 and the canal to Ponds 4 and 5. Pond 2 is ~7.9 ha (20 ac) and received water from the canal leading out of P-Area. Pond 2 discharged water into a canal that emptied into Ponds 4 and 5. The canal from P-Area is ~3,582-m (11,752-ft) long. The canal from Pond 2 to Ponds 4 and 5 is ~2,081-m (6,827-ft) long. The canal flow area is ~3.0-m (9.8-ft) across the base of the canal. Water levels fluctuate from year to year in Pond 2 and the canal system based on precipitation amounts.

Cs-137 and Co-60 were identified as human health RCOCs in sediment/soil for the IOU on-site worker receptor as documented in the RI/BRA (SRNS 2017). Concentrations pose a TCR of 7.8E-04 to the IOU on-site worker (decay corrected = 4.5E-04); Cs-137: (EPC = 139 pCi/g; risk to IOU on-site worker = 7.7E-04; decay corrected to 4.5E-04). Co-60: (EPC = 0.802 pCi/g; risk to IOU on-site worker = 9.6E-06; decay corrected to 1.0E-06).

Results of the PTSM evaluation for EA7 indicated no PTSM RCOCs were present. All sampling records have been decay adjusted and through degradation, the estimated time for EA7 to reach the RGO of 0.68 pCi/g is 220 years. The SRS Land Use Control Assurance Plan (WSRC 1999) ensures that LUCs will be maintained for as long as necessary to keep the selected remedy fully protective of human health and the environment.

1.3.8 Exposure Area 8: Ponds 4 and 5 – Including Canal from Ponds 4 and 5 to Pond C

EA8 includes Ponds 4 and 5 and the canal from Pond 5 to Pond C. Pond 4 is ~14.3 ha (35 ac) and received water from Pond 2 and subsequently discharged to Pond 5. Pond 5 is ~4.0 ha (10 ac), received water from Pond 4 and subsequently discharged to Pond C via a 1,887-m (6,191-ft) long canal. The canal flow area is ~3.0-m (9.8-ft) across the base of the canal. Water levels fluctuate from year to year in Pond 4, Pond 5, and the canal.

The RI/BRA identified Cs-137 as a human health RCOC in sediment/soil for the IOU on-site worker receptor (SRNS 2017). Cs-137 in sediment/soil (EPC = 50.3 pCi/g) poses a 2.8E-04 risk to the IOU on-site worker (decay corrected to 1.9E-04).

Results of the PTSM evaluation for EA8 indicated no PTSM RCOCs were present. All sampling records have been decay adjusted and through degradation, the estimated time for EA8 to reach the Cs-137 RGO of 0.68 pCi/g is 220 years. The SRS Land Use Control Assurance Plan (WSRC 1999) ensures that LUCs will be maintained for as long as necessary to keep the selected remedy fully protective of human health and the environment.

1.3.9 Exposure Area 9: Pond C

EA9 includes Pond C. Pond C is a ~53.5 ha (132.4 ac) pre-cooler pond that received water from R Reactor and P Reactor. Pond C maintains its water level from year to year and is connected to PAR Pond through a bubble-up conveyance at the Pond C dam that allows water to flow from Pond C into PAR Pond. The bubble-up conveyance uses hydraulic pressure to stabilize water elevation between the two ponds.

Cs-137 and Co-60 were identified as human health RCOCs in sediment/soil for the IOU on-site worker receptor as documented in the RI/BRA (SRNS 2017). Concentrations pose a TCR of 1.2E-04 to the IOU on-site worker (decay corrected = 6.7E-05); Cs-137: (EPC = 20.9 pCi/g; risk to IOU on-site worker = 1.2E-04; decay corrected to 6.7E-05). Co-60: (EPC=0.114 pCi/g; risk to IOU on-site worker =1.4E-06; decay corrected to <1E-06).

Cs-137 and mercury were identified as human health RCOCs in fish tissue for the recreational fisherman receptor. Cs-137 (max = 42.5 pCi/g; PRG = 0.054 pCi/g) and mercury (max = 0.214 mg/kg; RSL = 0.154 mg/kg) in fish tissue exceeds risk based screening levels for the recreational fisherman.

Results of the PTSM evaluation for EA9 indicated no PTSM RCOCs were present. All sampling records have been decay adjusted and through degradation, the estimated time for EA9 to reach the Cs-137 RGO of 0.68 pCi/g is 200 years. The SRS Land Use Control Assurance Plan (WSRC 1999) ensures that LUCs will be maintained for as long as necessary to keep the selected remedy fully protective of human health and the environment.

1.3.10 Nature and Extent

A conceptual site model (CSM) was created for the Upper subunit of the LTR IOU to evaluate potential exposure pathways for human and ecological receptors. The CSM was revised to identify the RCOCs associated with the complete exposure pathways of concern based on the evaluation presented in the RI/BRA (Figure 1-4). The mobility of Cs-137 from contaminated sediment/soil within the Upper subunit is variable for each EA (pond/canal) but general aspects abide in all. In both aquatic and terrestrial environments, strong binding of Cs-137 to sediment and soil reduces both the mobility of Cs-137 and assimilation by humans and other biota. Sorption is a naturally-occurring process in which one substance is bound to another by some physical or chemical means. Sorption causes Cs-137 to bind to the sediment/soil within the system, which in turn limits the mobility of contaminated media. The binding to clay minerals is so strong it is nearly irreversible (Evans et al., 1983). In general, mobility of sediment/soil in the system is restricted by the inlet and outlet structures such as those in the R-Area Discharge Canal, the diversion box for Joyce Branch, the inlet/outlet structures for the pre-cooler ponds, and Pond B, Pond C, and

PAR Pond dam infrastructures. Also, since high reactor cooling-related flows are no longer occurring, the canals serve as a sink with limited pooling and movement that is now facilitated only by precipitation events. As a gravity-fed system, overall movement within the canal system would be toward PAR Pond. In situations where dams and weirs are present, the infrastructure serves as a sedimentation barrier for sediment/soil transport. These sedimentation barriers maintain the depositional environment within each EA. Deposition, a naturally-occurring process in which material is deposited over time, is ongoing and enhanced in the highly productive (in terms of flora and fauna) ponds systems. As a result, contaminated media, over time, is covered as a natural capping effect is created. Whicker et al. stated that deposition of radionuclides is affected by the depth of water with the deposition in the pond system more effective than in the canals (Whicker et al. 1990).

During times of drought or low water levels for normally inundated sediment/soil, erosion can contribute to localized mobilization along the edges of the ponds/reservoirs and other exposed areas. Surface water runoff is another contributing factor that allows for the resuspension and remobilization of Cs-137 within the IOU around the shallow edges of the reservoirs/ponds and other exposed areas.

Co-60 was also identified as a RCOC in EA1, EA5, EA6, EA7, and EA9 and is present, to a much lesser degree than Cs-137, in sediment/soil. Co-60 has a short radioactive half-life (5.3 years) and is generally collocated with Cs-137. When radioactive decay-corrected activities are considered, Co-60 has a minimal contribution to the total cumulative risk (<1E-06). Because Co-60 was collocated with Cs-137, any remedial action selected for Cs-137 in sediment/soil will also address the Co-60 contamination.

Although mercury was identified as a RCOC (for fish tissue), its presence is the result of atmospheric deposition (i.e., regional issue/problem) and from the use of the elevated levels of mercury in Savannah River water as part of the river water distribution system. Therefore, mercury was introduced into the LTR system not as a result of site operations but rather a combination of atmospheric deposition and the use of Savannah River water. No RCOCs were identified for the surface water media or for ecological receptors.

1.3.11 Estimated Volumes of Contaminated Media at the LTR IOU

Volumes of contamination were estimated based on characterization data provided in the RI/BRA (SRNS 2017). Table 1-3 summarizes the estimated volumes for each EA.

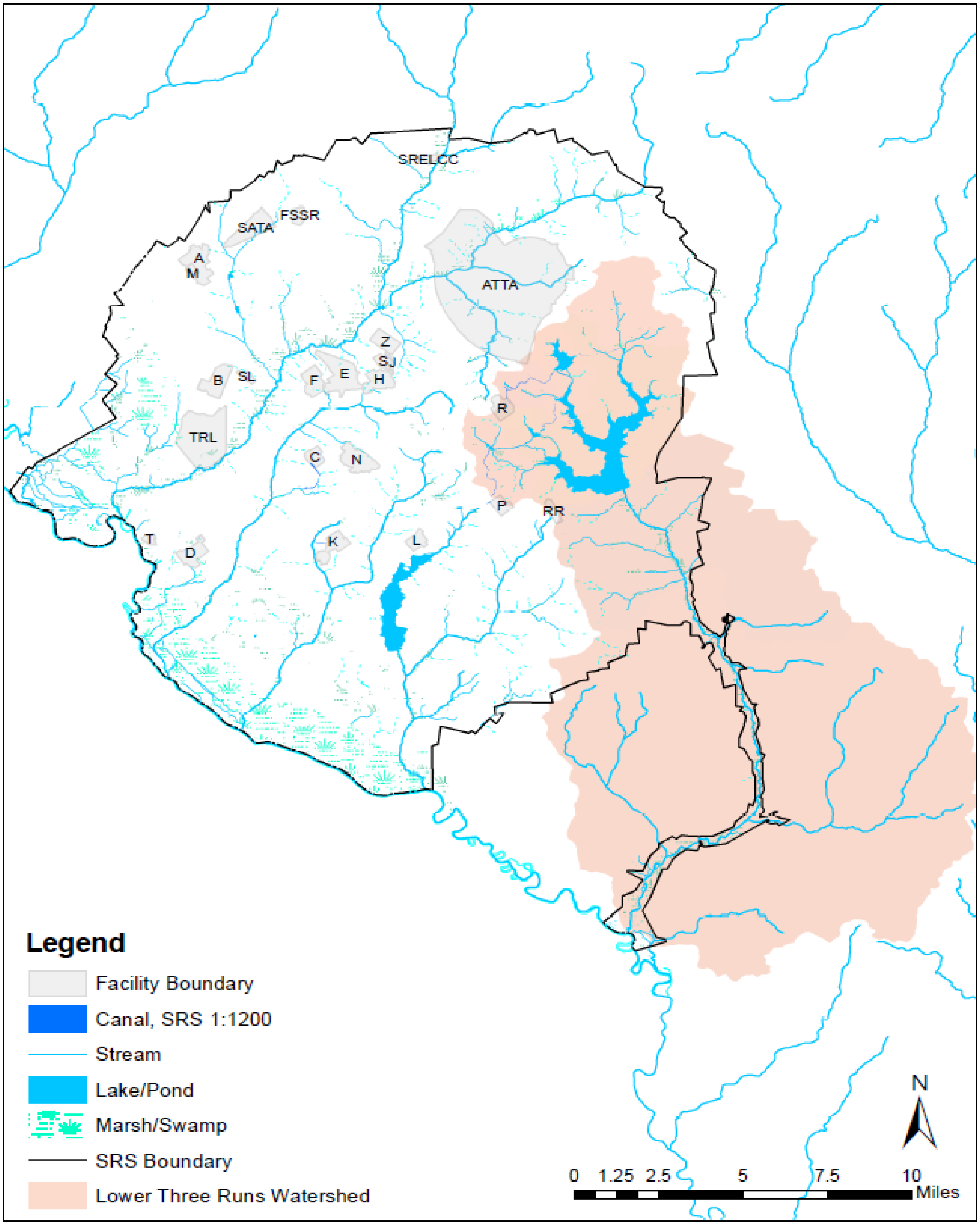


Figure 1-1. Location of the LTR IOU within the Savannah River Site

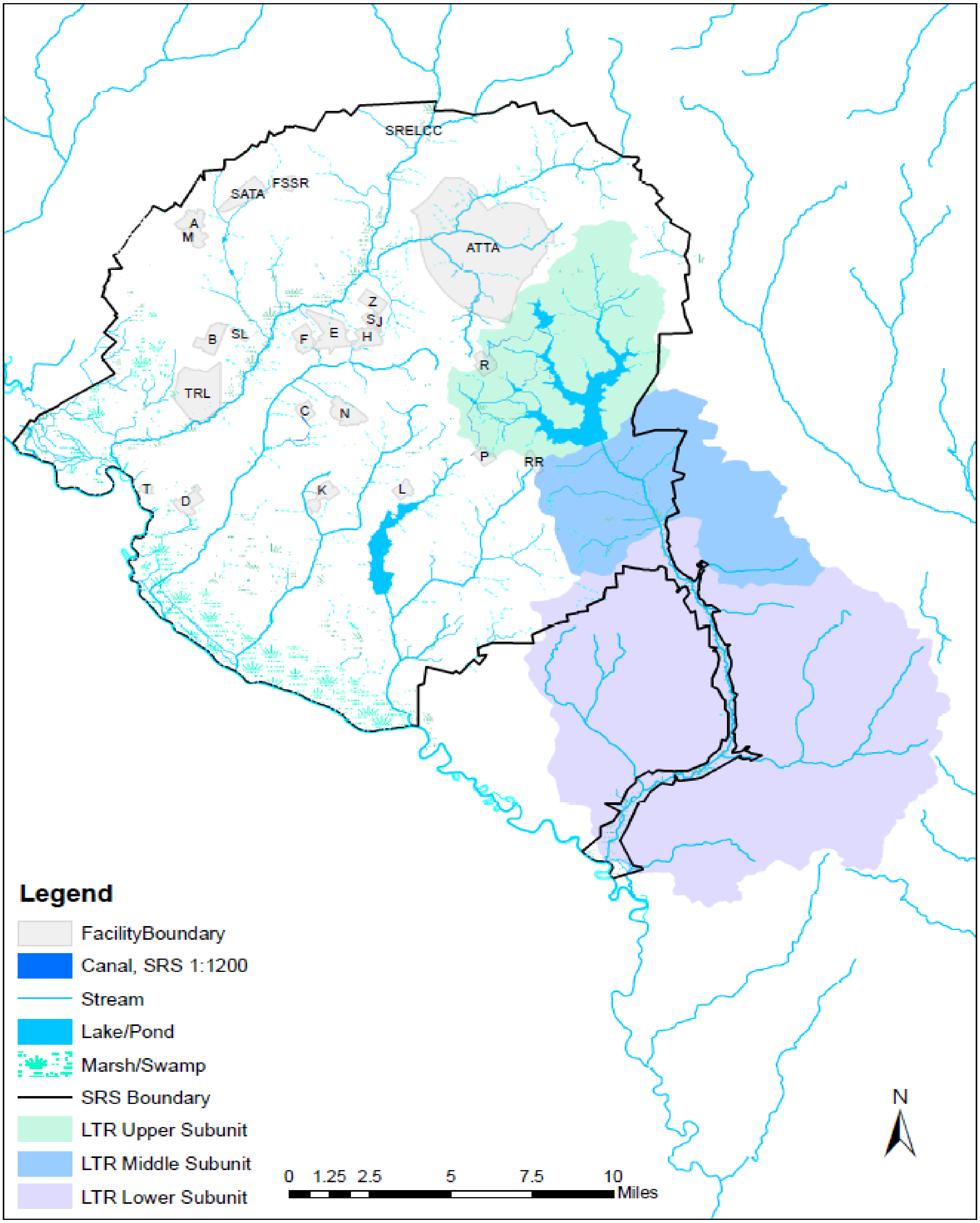


Figure 1-2. LTR IOU Subunits

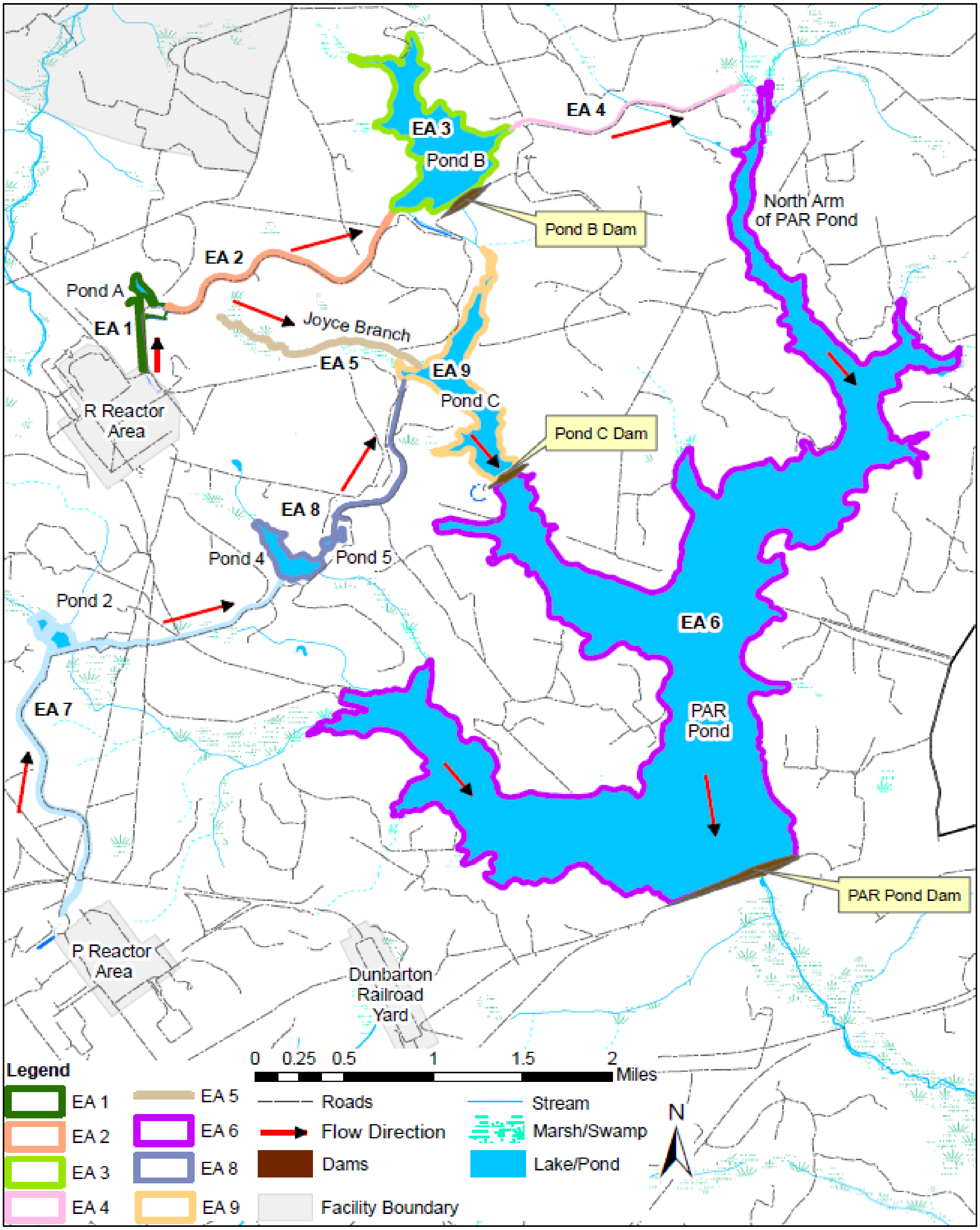
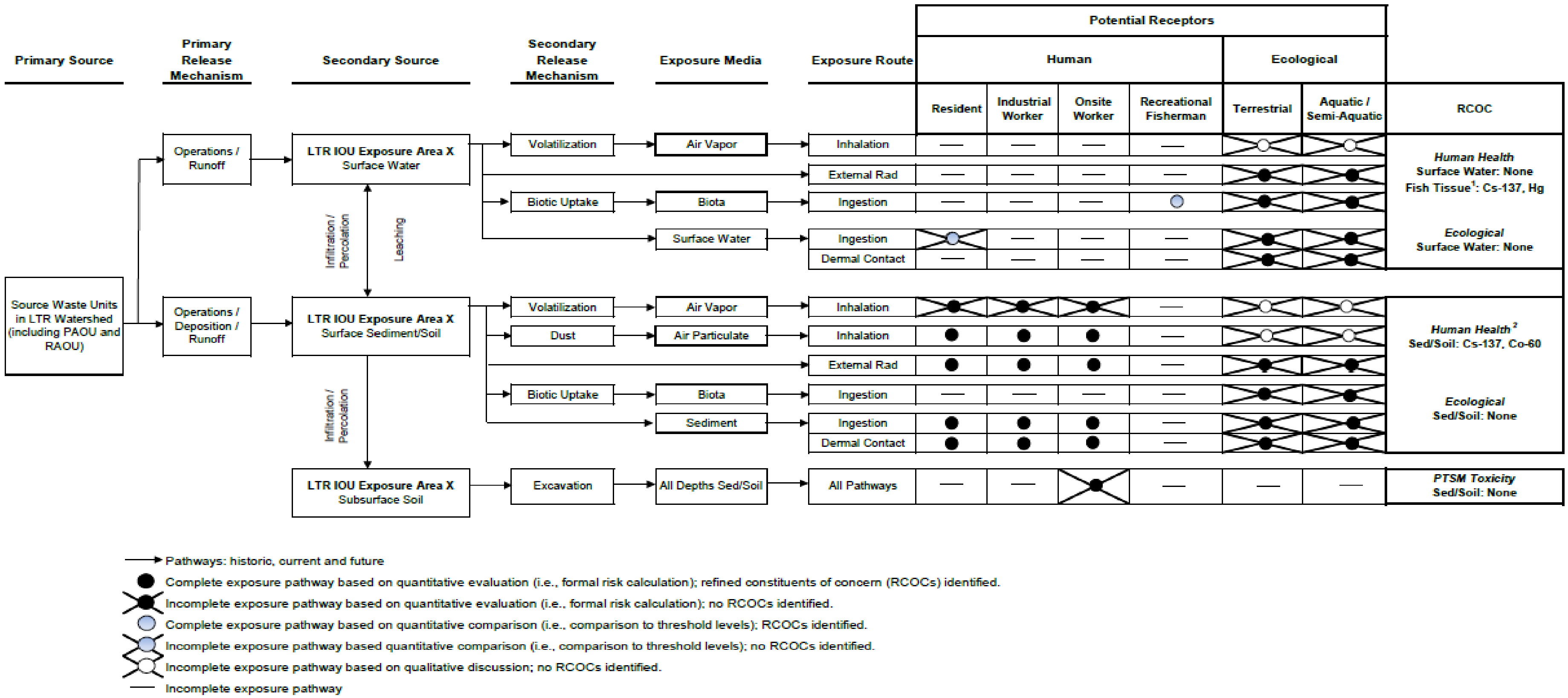


Figure 1-3 Upper Subunit of the LTR IOU Exposure Areas



1 Cs-137 and Hg identified as human health RCOCs in fish tissue for recreational fisherman scenario in EA3, EA6 and EA9.

2 Cs-137 and Co-60 identified as human health RCOCs in sediment/soil for resident, industrial worker and onsite worker scenarios. RCOCs/ risk levels associated with onsite worker scenario for each EA identified below:

EA1 Cs-137 risk = 8.2E-04 (decay corrected risk = 6.4E-04); Co-60 risk = 1.7E-06 (decay corrected risk = 3.8E-07); total cumulative risk (TCR) = 8.2E-04 (decay corrected TCR = 6.4E-04)
EA2 Cs-137 risk = 2.7E-04 (decay corrected risk = 2.3E-04)
EA3 Cs-137 risk = 5.5E-04 (decay corrected risk = 3.3E-04)
EA4 Cs-137 risk = 1.0E-04 (decay corrected risk = 8.8E-05)
EA5 Cs-137 risk = 1.3E-03 (decay corrected risk = 9.4E-04); Co-60 risk = 9.1E-06 (decay corrected risk = 1.7E-06); TCR = 1.3E-03 (decay corrected TCR = 9.4E-04)
EA6 Cs-137 risk = 4.9E-05 (decay corrected risk = 2.9E-05); Co-60 risk = 1.2E-06 (decay corrected risk = 7.2E-08); TCR = 5.0E-05 (decay corrected TCR = 2.9E-05)
EA7 Cs-137 risk = 7.7E-04 (decay corrected risk = 4.5E-04); Co-60 risk = 9.6E-06 (decay corrected risk = 1.0E-06); TCR = 7.8E-04 (decay corrected TCR = 4.5E-04)
EA8 Cs-137 risk = 2.8E-04 (decay corrected risk = 1.9E-04)
EA9 Cs-137 risk = 1.2E-04 (decay corrected risk = 6.7E-05); Co-60 risk = 1.4E-06 (decay corrected risk = 9.6E-08); TCR = 1.2E-04 (decay corrected TCR = 6.7E-05)

Figure 1-4. Conceptual Site Model for the Upper Subunit of the LTR IOU

Table 1-1 Summary of Disposition of LTR IOU Source Waste Sites

Area	Unit ID	Unit Name	Unit Status	Response Selected/ Implemented
G	39	Gunsite 218 Rubble Pile, 631-23G	ROD (No Action) issued November 3, 2010	Yes
G	110	PAR Pond (Including The Pre-Cooler Ponds and Canals), 685-G	Part of the LTR IOU	No
G	111	PAR Pond Sludge Land Application Site, 761-5G	No Action Approved	Yes
G	152	Second PAR Pond Site, 761-8G	No Further Action (NFA) Approved	Yes
G	163	Gunsite 012 Rubble Pile, no building number (NBN)	Combined with Early Construction Operation Disposal Site (ECODS) G-3, Rubble Pile across from Gunsite 012. ROD for LUCs, Land Use Controls Implementation Plan (LUCIP) approved by South Carolina Department of Health and Environmental Control (SCDHEC) 8/2011 & U.S. Environmental Protection Agency (USEPA) 9/2011.	Yes
G	172	Miscellaneous Rubble Pile at Dunbarton, NBN	NFA Approved	Yes
G	173	Miscellaneous Trash at Snapp, NBN	NFA Approved	Yes
G	177	Pond B Dam Rubble Pile, NBN	NFA Approved	Yes
G	321	Patterson Mill Road Rubble Pile, NBN	NFA Approved	Yes
G	337	Rubble Pile across from Gunsite 012, NBN	Combined with ECODS G-3, Gunsite 012 Rubble Pile. ROD for LUCs, LUCIP approved by SCDHEC Aug 2011 & USEPA Sept 2011.	Yes
G	455	Stadia Lights With Poles, NBN	NFA Approved	Yes
G	505	LTR IOU	Phase III of the IOU program.	No
G	544	ECODS G-3 (Adjacent to Gunsite 012, NBN)	Combined with Rubble Pile Across from Gunsite 012, Gunsite 012 Rubble Pile. ROD for LUCs, LUCIP approved by SCDHEC Aug 2011 and USEPA Sept 2011.	Yes
G		General Area Outfalls GS-012	Deactivated as part of Gunsite 12 Project	Yes
G		PAR Pond Outfalls PP-1, PP-2	Outfalls retired, no longer discharging.	Yes
G	546	Dunbarton Railroad Yard, NBN; Outfalls Y-003 and Y-004	FFA Field Start/Site Evaluation Report date of December 2035. Part of the Steel Creek IOU.	No
P	17	P-Area Acid/Caustic Basin, 904-78G	NFA Approved	Yes
P	107	P-Area Bingham Pump Outage Pit, 643-4G	NFA Approved	Yes
P	143	P-Area Groundwater	RCRA/CERCLA unit, March 2020 FFA ROD Issuance. Part of the Steel Creek IOU	No

Table 1-1. Summary of Disposition of LTR IOU Source Waste Sites *(Continued)*

Area	Unit ID	Unit Name	Unit Status	Response Selected/ Implemented
P	221	Sandblast Area CMP-003	NFA Approved	Yes
P	259	Combined Spills from 183-2P, NBN	NFA Approved	Yes
P	287	P-Area Acid/Caustic Basin (Groundwater)	NFA Approved	Yes
P	314	Potential Release from P-Area Disassembly Basin, 105-P	ROD issued 7/22/2011 for PAOU with LUCs, remediation complete.	Yes
P	316	Potential Release from the P-Area Reactor Cooling Water System, 186/190-P	ROD issued 7/22/2011 for PAOU with LUCs, remediation complete.	Yes
P	428	Spill on 05/24/82 of 10 gal of 31.5% Acid from 183-P, NBN	NFA Approved	Yes
P	439	Spill on 06/26/86 of 1 gal of Tritiated Waste Oil from 110-P, NBN	NFA Approved	Yes
P	477	P Reactor Area: P-Area Reactor Area Cask Car Railroad Tracks As Abandoned, NBN	ROD issued 7/22/2011 for PAOU with LUCs; remediation complete.	Yes
P	498	Sandblast Area CMP-002, NBN	NFA Approved	Yes
P	557	P-Area Process Sewer Lines As Abandoned, NBN	ROD issued 7/22/2011 for PAOU with LUCs, remediation complete.	Yes
P	587	PAOU	ROD issued 7/22/2011 for PAOU with LUCs; remediation complete, except PSA-3A and PSA-3B ongoing soil vapor extraction. April 2013 Performance Evaluation Report documented completion of soil vapor extraction.	Yes
P		P-Area Production Area Incidents and Unplanned Releases	All potential sources address under PAOU Completion.	Yes
P		P-Area Outfalls P-1, P-2, P-3, P-4, P-19, P-14	Outfalls retired. All potential sources address under PAOU completion.	Yes
R	42	108-4R Overflow Basin, 108-4R	NFA Approved	Yes
R	112	R-Area Acid/Caustic Basin, 904-77G	NFA Approved	Yes
R	113	R-Area Bingham Pump Outage Pits, 643-10G	Final Remediation Report Approved, LUCs	Yes
R	114	R-Area Bingham Pump Outage Pits, 643-8G	Final Remediation Report Approved, LUCs	Yes
R	115	R-Area Bingham Pump Outage Pits, 643-9G	Final Remediation Report Approved, LUCs	Yes
R	116	R-Area Burning/Rubble Pits, 131-1R	ROD Submittal 5/1/04 /RA Complete/ LUCs	Yes
R	117	R-Area Burning/Rubble Pits, 131-R	ROD Submittal 5/1/04 /RA Complete/ Continue Post-Closure Maintenance Activities	Yes

Table 1-1. Summary of Disposition of LTR IOU Source Waste Sites *(Continued)*

Area	Unit ID	Unit Name	Unit Status	Response Selected/ Implemented
R	118	R-Area Rubble Pile, 631-25G	ROD Submittal 5/1/04 /RA Complete/ Continue Post-Closure Maintenance Activities	Yes
R	119	R-Area Reactor Seepage Basins, 904-103G	Biennial Groundwater Mixing Zone Reporting/ RA Complete	Yes
R	120	R-Area Reactor Seepage Basins, 904-104G	Biennial Groundwater Mixing Zone Reporting/ RA Complete	Yes
R	121	R-Area Reactor Seepage Basins, 904-57G	Biennial Groundwater Mixing Zone Reporting/ RA Complete	Yes
R	122	R-Area Reactor Seepage Basins, 904-58G	Biennial Groundwater Mixing Zone Reporting/ RA Complete	Yes
R	123	R-Area Reactor Seepage Basins, 904-59G	Biennial Groundwater Mixing Zone Reporting/ RA Complete	Yes
R	124	R-Area Reactor Seepage Basins, 904-60G	Biennial Groundwater Mixing Zone Reporting/ RA Complete	Yes
R	178	R-Area Asbestos Pit, 080-01R	NFA Approved	Yes
R	179	R-Area Rubble Pit, 131-2R	NFA Approved	Yes
R	230	Potential Release from the R-Area Concrete Lake, 183-1R/186R	NFA Approved	Yes
R	231	Area on the North Side of Building 105-R, NBN	ROD issued for RAOU 4/10/2011 with LUCs; remediation complete	Yes
R	233	Laydown Area North of 105-R, NBN	ROD issued for RAOU 4/10/2011 with LUCs; remediation complete	Yes
R	271	Cooling Water Effluent Sump, 107-R	ROD issued for RAOU 4/10/2011 with LUCs; remediation complete	Yes
R	288	R-Area Groundwater, NBN	ROD issued for RAOU 4/10/2011 with LUCs; MNA for Groundwater	Yes
R	312	Old R-Area Discharge Canal, NBN	Part of the LTR IOU. Also known as Joyce Branch.	No
R	324	Potential Release of $NaOH/H_2SO_4$ from 183-2R, NBN	ROD issued for RAOU 4/10/2011 with LUCs; remediation complete	Yes
R	328	Purge Water Storage Basin, 109-R	D&D Unit #1924 – part of RAOU – no longer a source.	Yes
R	329	R-Area Ash Basin, 188-0R	ROD issued for RAOU 4/10/2011 with LUCs; remediation complete	Yes
R	330	Potential Release from R-Area Disassembly Basin, 105-R	ROD issued for RAOU 4/10/2011 with LUCs; remediation complete	Yes
R	478	R Reactor Area: R-Area Reactor Area Cask Car Railroad Tracks As Abandoned, NBN	ROD issued for RAOU 4/10/2011 with LUCs; remediation complete	Yes
R	513	Release from the Decontamination of R-Area Reactor Disassembly Basin, NBN	ROD issued for RAOU 4/10/2011 with LUCs; remediation complete	Yes
R	517	Combined Spills North of Building 105-R, NBN	ROD issued for RAOU 4/10/2011 with LUCs; remediation complete	Yes

Table 1-1. Summary of Disposition of LTR IOU Source Waste Sites *(Continued/End)*

Area	Unit ID	Unit Name	Unit Status	Response Selected/ Implemented
R	540	ECODS R-1A, -1B, -1C (East of R Reactor)	Corrective Measures Implementation Report/ Remedial Action Completion Report documenting completion of RA for closure approved by USEPA (4/13/2011) and SCDHEC (3/30/2011)	Yes
R	550	R-Area Unknown Pit #1 (Runk-1), NBN	ROD Approved	Yes
R	551	R-Area Unknown Pit #2 (Runk-2), NBN	ROD Approved	Yes
R	552	R-Area Unknown Pit #3 (Runk-3), NBN	ROD Approved	Yes
R	556	R-Area Process Sewer Lines As Abandoned, NBN	ROD issued for RAOU 4/10/2011 with LUCs; remediation complete	Yes
R	588	R-Area Operable Unit	ROD issued for RAOU 4/10/2011 with LUCs; remediation complete	Yes
R		R-Area Incidents and Unplanned Releases	All potential sources addressed under RAOU completion.	Yes
R		R-Area Outfalls R-1 through R-4	Outfalls retired. R-4 has no discharge (basin is capped).	Yes

Table 1-2. Risk Summary and Identified RCOCs

Upper Exposure Area	Human Health IOU On-Site Worker	Human Health Recreational Fisherman
1. Pond A – Including R-Area Discharge Canal	Sediment /Soil Cs-137(+D) = 8.2E-04 (Decayed = 6.4E-04) Co-60 = 1.7E-06 (Decayed = 3.8E-07) Total Cumulative Risk (TCR) = 8.2E-04 (Decayed = 6.4E-04)	Fish Tissue Not Applicable
2. Canal from Pond A to Pond B	Sediment /Soil Cs-137(+D) = 2.7E-04 Decayed = 2.3E-04	Fish Tissue Not Applicable
3. Pond B	Sediment /Soil Cs-137(+D) = 5.5E-04 (Decayed = 3.3E-04)	Fish Tissue Cs-137(+D) Mercury
4. Canal from Pond B to North Arm of PAR Pond	Sediment /Soil Cs-137(+D) = 1.0E-04 (Decayed = 8.8E-05)	Fish Tissue Not Applicable
5. Joyce Branch (Old Discharge Canal)	Sediment /Soil Cs-137(+D) = 1.3E-03 (Decayed = 9.4E-04) Co-60 = 9.1E-06 (Decayed = 1.7E-06) TCR = 1.3E-03 (Decayed = 9.4E-04)	Fish Tissue Not Applicable
6. PAR Pond	Sediment /Soil Cs-137(+D) = 4.9E-05 (Decayed = 2.9E-05) Co-60 = 1.2E-06 (Decayed = 7.2E-08) TCR = 5.0E-05 (Decayed = 2.9E-05)	Fish Tissue Cs-137(+D) Mercury
7. Canal from P-Area to Ponds 4 and 5 – Including Pond 2	Sediment /Soil Cs-137(+D) = 7.7E-04 (Decayed = 4.5E-04) Co-60 = 9.6E-06 (Decayed = 1.0E-06) TCR = 7.8E-04 (Decayed = 4.5E-04)	Fish Tissue Not Applicable
8. Ponds 4 and 5 – Including Canal from Ponds 4 and 5 to Pond C	Sediment /Soil Cs-137(+D) = 2.8E-04 (Decayed = 1.9E-04)	Fish Tissue Not Applicable
9. Pond C	Sediment /Soil Cs-137(+D) = 1.2E-04 (Decayed = 6.7E-05) Co-60 = 1.4E-06 (Decayed = 9.6E-08) TCR = 1.2E-04 (Decayed = 6.7E-05)	Fish Tissue Cs-137(+D) Mercury

Table 1-3. Estimated Volumes of Contaminated Media

Upper Exposure Area	Human Health IOU Onsite Worker	Human Health Recreational Fisherman
1. Pond A – Including R Area Discharge Canal	Assuming 0.3 m (1.0 ft) depth of contaminated sediment/soil and 3.0-m (9.8-ft) canal flow area, the maximum volume of contaminated sediment/soil in the canal system would be 658 m^3 (1,034 cubic yards [yd^3]). Contaminated sediment/soil below the water surface in Pond A covers an area of ~25,900 square meters (m^2 [30,976 square yards {yd^2}]). Assuming a 0.3-m (1.0-ft) depth of contaminated sediment/soil, the maximum volume of contaminated sediment/soil in Pond A would be 7,770 m^3 (10,163 yd^3). Approximately 10-m^3 (13-yd^3) sediment/soil > PTSM threshold	Not Applicable
2. Canal from Pond A to Pond B	Assuming 0.3-m (1.0*ft) depth of contaminated sediment/soil and 3.0-m (9.8-ft) canal flow area, the maximum volume of contaminated sediment/soil in the canal system would be 2,553 m^3 (3,339 yd^3).	Not Applicable
3. Pond B	Assuming 0.3-m (1.0-ft) depth of contaminated sediment/soil and 3.0-m (9.8-ft) canal flow area, the maximum volume of contaminated sediment/soil in the canal system would be 492 m^3 (644 yd^3). Contaminated sediment/soil below the water surface in Pond B covers an area of ~820,703 m^2 (981,533 yd^2). Assuming a 0.3-m (1.0-ft) depth of contaminated sediment/soil, the maximum volume of contaminated sediment/soil in Pond B would be 246,211 m^3 (322,032 yd^3). Approximately 200-m^3 (260-yd^3) sediment/soil > PTSM threshold	Contaminated fish have been detected in Pond B.
4. Canal from Pond B to North Arm of PAR Pond	Assuming 0.3 m (1.0 ft) depth of contaminated sediment/soil and 3.0 m (9.8 ft) canal flow area, the maximum volume of contaminated sediment/soil in the canal system would be 2,075 m^3 (2,714 yd^3)	Not Applicable
5. Joyce Branch (Old Discharge Canal)	Assuming 0.3-m (1.0-ft) depth of contaminated sediment/soil and 3.0-m (9.8-ft) canal flow area, the maximum volume of contaminated sediment/soil in the canal system would be 2,280 m^3 (2,982 yd^3). Approximately 20-m^3 (26-yd^3) sediment/soil > PTSM threshold	Not Applicable
6. PAR Pond	Contaminated sediment/soil below the water surface in PAR Pond covers an area of ~10,680,000 m^2 (12,773,000 yd^2). Assuming 0.3 m (1.0 ft) depth of contaminated sediment/soil the maximum volume of contaminated sediment/soil under water in PAR Pond would be 3,257,400 m^3 (4,261,000 yd^3).	Contaminated fish have been detected in PAR Pond.

Table 1-3. Estimated volumes of contaminated media *(Continued/End)*

Upper Exposure Area	Human Health IOU Onsite Worker	Human Health Recreational Fisherman
7. Canal from P-Area to Ponds 4 and 5 – Including Pond 2	Assuming 0.3-m (1.0-ft) depth of contaminated sediment/soil and 3.0-m (9.8-ft) canal flow area, the maximum volume of contaminated sediment/soil in the canal system would be 5,097 m^3 (6,667 yd^3). Contaminated sediment/soil below the water surface in Pond 2 covers an area of ~79,318 m^2 (94,864 yd^2). Assuming a 0.3-m (1.0-ft) depth of contaminated sediment/soil, the maximum volume of contaminated sediment/soil in Pond 2 would be 23,796 m^3 (31,124 yd^3).	Not Applicable
8. Ponds 4 and 5 – Including Canal from Ponds 4 and 5 to Pond C	Assuming 0.3-m (1.0-ft) depth of contaminated surface sediment/soil and 3.0-m (9.8-ft) canal flow area, the maximum volume of contaminated sediment/soil in the canal system would be 1,698 m^3 (2,221 yd^3). Contaminated sediment/soil below the water surface in Pond 4 and 5 covers a combined area of ~182,918 m^2 (218,768 yd^2). Assuming 0.3-m (1.0-ft) depth of contaminated sediment/soil the maximum volume of contaminated sediment/soil under water in Ponds 4 and 5 combined would be 54,875 m^3 (71,774 yd^3).	Not Applicable
9. Pond C	Contaminated sediment/soil below the water surface in Pond C covers a combined area of ~535,800 m^2 (640,800 yd^2). Assuming 0.3-m (1.0-ft) depth of contaminated sediment/soil the maximum volume of contaminated sediment/soil under water in Pond C would be 163,419 m^3 (213,700 yd^3).	Contaminated fish have been detected in Pond C.

2.0 IDENTIFICATION AND SCREENING OF TECHNOLOGIES

This chapter discusses the RAOs and RGOs identified in the RI/BRA for each EA (SRNS 2017). This chapter also describes the General Response Actions for the Upper subunit of the LTR IOU, identifies potential remedial technologies for each general response actions, and screens remedial technologies with respect to implementability, effectiveness, and cost. The initial list of technologies applicable to the Upper subunit is drawn from similar remedial actions and guidelines available for common remediation technologies.

2.1 Remedial Action Objectives

RAOs are media-specific or site-specific objectives for protection of human health and the environment. RAOs usually specify the RCOCs for the potential receptors, media of concern, and exposure pathways. RAOs describe what the remediation must accomplish and are used as framework for developing remedial alternatives for the FS. For the Upper subunit of the LTR IOU, the IOU On-Site Worker was determined to be the most likely receptor for risks associated with the ponds and canal system in the Upper subunit. The IOU on-site worker is based on an SRS wetland researcher scenario (20 years, 150 days/year, 8 hours/day) and is also protective of the IOU Adolescent Trespasser (10 years, 90 days/year, 18 hours/day). Because it is known that some contaminants have the potential to bio-accumulate in fish, and fish are a mobile media, the evaluation of human exposure for the Upper subunit also includes a recreational fisherman scenario (26 years, 350 days/year, 54 grams/day). The RAOs for the LTR IOU are identified in Section 2.1.1.

2.1.1 Contaminants of Interest

The contaminants of interest considered for remedial action for the Upper subunit of the LTR IOU are identified as RCOCs for each EA. The primary RCOCs are Cs-137 and Co-60 in sediment/soil. Co-60 has a short half-life with minimal contribution to the overall risk for the IOU on-site worker. Because Co-60 was collocated with Cs-137, any remedial action selected for Cs-137 in sediment/soil will also address the Co-60 contamination. Cs-137 and Co-60 are RCOCs in sediment/soil in EA1, EA5, EA6, EA7, and EA9. Cs-137 only is identified as a RCOC in sediment/soil in EA2, EA3, EA4, and EA8. With respect to the recreational fisherman scenario, Cs-137 and mercury were identified as RCOCs in fish tissue in EA3, EA6, and EA9. Although mercury was identified as a RCOC (for fish tissue), its presence is the result of atmospheric deposition (i.e., regional issue/problem) and from the use of the elevated levels of mercury in Savannah River water as part of the river water distribution system. Therefore, mercury was introduced into the LTR system not as a result of Site operations but rather a combination of atmospheric deposition and the use of Savannah River water. No RCOCs were identified for the surface water media or for ecological receptors.

RAOs identified for the Upper subunit of the LTR IOU are based on the results of the human health risk assessment (HHRA), ecological risk assessment (ERA) and PTSM evaluation and are as follows:

- Protect IOU on-site workers from exposure to Cs-137 and Co-60 in sediment/soil that exceed 1E-06 risk threshold or background levels. The primary exposure route of concern is the external radiation pathway.
- Protect the recreational fisherman from exposure to Cs-137 and mercury in fish tissue. The primary route of exposure is the ingestion of fish pathway.

Table 2-1 lists the RAOs for each individual EA.

2.1.2 Allowable Exposure Based on Risk Assessment

<u>Target Risk Range</u>

The risk for the Upper subunit of the LTR IOU was identified in the HHRA and ERA conducted in the RI/BRA (SRNS 2017). RCOCs were identified for EAs with constituents that pose an exposure risk (i.e., ≥1.0E-06) to the IOU on-site worker and the recreational fisherman.

<u>ARARs</u>

Section 121(d) of CERCLA (1980), as amended by the Superfund Amendments and Reauthorization Act (1986), requires that remedial actions comply with requirements or standards set forth under Federal and State environmental laws (i.e., ARARs), as well as, non-promulgated advisories, guidance, or proposed standards that are not legally binding but provide useful approaches or recommendations (called "to-be-considered" [TBC] requirements). Such information is required to be considered when developing remedial goals (RGs).

ARARs and TBCs include action-specific, location-specific, and chemical-specific requirements that are to be achieved unless a waiver is invoked. In addition, the National Oil and Hazardous Substances Contingency Plan (NCP) requires the development of health-based, site-specific levels for constituents (i.e., risk-based levels) where such promulgated limits do not exist and where there is a concern with their potential health or environmental effects.

- Action-specific ARARs control or restrict the design, performance, and other aspects of implementation of specific remedial activities.
- Location-specific ARARs reflect the physiographic and environmental characteristics of the unit or the immediate area and may restrict or preclude remedial actions depending on the location or characteristics of the unit.
- Chemical-specific ARARs are media-specific concentration limits promulgated under federal or state law. The NCP requires the development of health-based, site-specific levels for chemicals where such limits do not exist and where there is a concern with their potential health or environmental effects.

ARARs for the Upper subunit of the LTR IOU are discussed in Chapter 4.

2.1.3 Development of Remediation Goals

RGOs serve to provide a range of cleanup goals for each RCOC and are typically identified along with the RAOs. RGOs can be qualitative statements or numerical values often expressed as concentrations in soil and groundwater or actions (e.g., installation of engineered barriers, placement of caps and covers, etc.) that achieve the RAO. Following public comment and approval of the PP, the RGOs for the selected remedy are documented as final cleanup goals or RGs in the ROD.

A range of RGOs were developed for each medium in which RCOCs were identified to provide a basis for selecting the final RGs. The media of concern includes sediment/soil and fish tissue. RGOs were based on the IOU on-site worker scenario for sediment/soil and the recreational fisherman scenario for fish tissue. The selection of final RGOs is subject to approval by the USDOE, SCDHEC, and USEPA. The RGOs for the LTR IOU are listed in Table 2-2.

Risk-based RGOs for the IOU onsite worker for sediment/soil media and recreational fisherman for fish tissue media correspond to a risk of 1E-06 for carcinogens (i.e., Cs-137 and Co-60) and an HQ of 1 for noncarcinogens (i.e., Hg). The IOU onsite worker scenario is based on the most likely human receptor for the Upper Subunit: an SRS worker/researcher (20 years, 150 days/year, 8 hours/day). Because it is known that some contaminants could bio-accumulate in fish, and fish are a mobile media, the evaluation of human exposure also included a hypothetical recreational fisherman scenario for the ingestion of fish (26 years, 350 days/year, 54 g/day). The risk-based RGOs were obtained using the calculator function available at the USEPA Preliminary Remediation Goals website (USEPA 2018a) for the radiological constituents and the USEPA Regional Screening Levels website (USEPA 2018b) for mercury.

The most likely RGOs also consider a comparison to background levels. Because of the inherently conservative nature of the risk assessment and RGO calculations, it is possible for the risk-based RGO to be less than what occurs naturally in background soil. In this case, the RGO defaults to the background concentration to be technically practical to achieve. Background levels presented in Table 2-2 are based on the SRS Background Soils Statistical Summary Report (WSRC 2006) and the IOU Background Dataset (SRNS 2017), as available.

The SRS soil background two times (2x) the 95th percentile concentration is identified as the most likely RGO for Cs-137 in sediment/soil media for the onsite worker since this is the generally accepted concentration for “typical” anthropogenic fallout, and has been accepted as the RG for other SRS projects, specifically the SRS Wetland Area at Dunbarton Bay In Support of Steel Creek Integrator Operable Unit (SRNS 2018).

2.2 General Response Actions

General Response Actions are unit-specific actions that achieve RAOs and satisfy the requirements of the NCP. General Response Actions relate to basic methods of protection such as treatment or containment and are further refined during the development of remedial alternatives. Four General Response Actions have been identified for the LTR IOU and include No Action, LUCs, Containment, and Excavation and Disposal.

2.2.1 No Action

No Action provides a baseline for comparison against other remedial technologies and is required by the NCP. In this scenario, no action would be taken to monitor, remove, treat, or otherwise mitigate potential contaminant migration from the Upper subunit of the LTR IOU. No cost would be associated with the selection of this option. The acceptability of the No Action response was evaluated in relation to the assessment of known site risks and by comparison with other remedial technologies.

2.2.2 Land Use Controls

LUCs include actions to limit inadvertent human exposure to contaminants by restricting access to contaminated areas using engineering controls (i.e., fencing and warning signs) and/or institutional controls (i.e., worker protection program, deed restrictions). LUCs may be implemented as a stand-alone remedy or in conjunction with other technologies where appropriate.

Monitoring of environmental media is commonly used in conjunction with LUCs to evaluate the chemical or physical properties of contaminated media over time. Monitored Natural Recovery (MNR) is a remedy that uses ongoing, naturally-occurring processes to contain, destroy, or reduce the bioavailability or toxicity of contaminants in sediment/soil (USEPA 2005). The Upper subunit of the LTR IOU is conducive to the MNR remedy because natural recovery processes of radioactive decay and continued sediment/soil deposition will reduce bioavailability.

2.2.3 Containment

Containment technologies such as capping, shielding, and immobilization (i.e., amendments) minimize or eliminate human and ecological exposure to contaminants by the use of engineered or physical barriers (i.e., covers, caps). Containment technologies do not treat or remove contaminants but serve to minimize leaching, erosion, or bio-uptake of contaminated media.

2.2.4 Excavation and Disposal

Excavation and disposal methods involve the excavation, transportation, storage and disposal of contaminated media using conventional earth-moving equipment. Excavation can be accomplished by scraping, cutting, digging, scooping, dredging, or some other method of removal.

2.3 Screening of Technology and Process Options

Various technologies and approaches exist for implementing the General Response Actions for the Upper subunit of the LTR IOU. The NCP requires an initial screening process of the potential technologies based on effectiveness, implementability, and relative cost.

- <u>Effectiveness</u>: An effective technology must achieve specified RAOs, be compatible with contaminant characteristics and waste unit conditions, and be protective of human health and the environment in both short-term and long-term scenarios. Technologies that do not meet RAOs, are significantly less effective than comparable approaches, or have not been demonstrated successfully at a similarly contaminated site are eliminated from further consideration.

- <u>Implementability</u>: Technologies are evaluated based on the technical feasibility, availability of resources and equipment, and the administrative or institutional feasibility of implementation. Implementable technologies are those that can be readily installed in a cost-effective and timely fashion and that will not elicit substantial public concern from the surrounding community. Mobilization and permitting requirements must be workable and must have been previously demonstrated at similar projects. Consideration is also given to regulatory constraints such as waste handling, disposal, and treatment requirements that would affect the implementation of a technology.

- <u>Cost</u>: A qualitative cost evaluation is provided so that comparisons can be made among the alternatives. Qualitative evaluations take into consideration capital costs and operation and maintenance (O&M) costs. For screening purposes, the costs of technologies are typically described as high, medium, or low relative to others in the same general category.

General Response Actions that pass the initial screening process for effectiveness, implementability, and cost are retained and carried forward for consideration in the development of remedial alternatives in Chapter 3. Table 2-3 provides detailed results of this initial screening and are summarized below.

2.3.1 No Action

This response would take no action to monitor, remove, treat, or otherwise mitigate the existence or potential spread of contaminants from the LTR IOU. The No Action response requires no implementation and no cost would be associated with the selection of this option. Contaminant reduction would be achieved only through natural decay and is unrestrictive of any type of human exposure. Although the No Action response is ineffective at achieving RAOs, it is required by the NCP and is retained as a baseline for comparison with other remedial actions. Therefore, No Action is retained for further consideration in the development of alternatives.

2.3.2 Land Use Controls

LUCs leave hazardous substances in place that present a potential exposure risk to human receptors. LUCS, including both engineering and institutional controls, would prevent unlimited exposure of potential human receptors to contaminants by limiting access to the land or resource use. LUCS are effective in achieving RAOs in the Upper subunit of the LTR IOU and are readily implementable and relatively inexpensive to implement. The SRS Land Use Control Assurance Plan (WSRC 1999) ensures that LUCs will be maintained for as long as necessary to keep the selected remedy fully protective of human health and the environment.

Engineering Controls

Engineering controls (access controls) use temporary or permanent physical restrictions to prevent or reduce human exposure to contaminants. Access controls may include, but are not limited to signs, fencing, barricades, or exclusion devices. Engineering controls are retained for further consideration in the development of remedial alternatives.

Institutional Controls

Institutional controls (administrative controls) prevent or reduce future human exposure to contaminants remaining on the site. These controls include worker protection controls such as site use permits and radiological worker protection program. Administrative controls are retained for further consideration in the development of remedial alternatives.

Monitoring

Environmental monitoring is used to measure the chemical or physical properties of environmental media. Monitoring determines the need for continuance of remedial alternatives or the need for further action. Monitoring is retained for further consideration in the development of remedial alternatives.

2.3.3 Containment

Containment technologies involve the use of engineered or physical limitations to isolate contaminated media. Properly constructed and maintained containments prevent direct exposure to contaminants and minimize leaching, erosion, mobility, and bio-uptake. Various containment technologies would be effective in achieving RAOs for applicable EAs within the Upper subunit of the LTR IOU. Cost and implementability of these technologies depend on the size and location the technology is being applied.

Capping

Various capping materials and designs are available depending on the nature of the contaminated media, local climate and hydrogeology, availability of materials, and intended use of the capped area. Capping reduces infiltration and subsequent contaminant migration, as well as provides a protective barrier to prevent worker or ecological exposure. Capping is retained for further consideration in the development of remedial alternatives.

Shielding

Shielding of contaminated media prevents exposure to contaminated sediment/soil. Engineered barriers such as dams can be used to maintain water levels to provide shielding from contaminated sediment/soil as well as serve as an impediment to human access. Shielding is retained for further consideration in the development of remedial alternatives.

Immobilization

In-situ immobilization would be achieved by applying amendments that would limit the bioavailability of contaminants. Immobilization involving the addition of amendments to sediment/soil has not been demonstrated at SRS and would require a site-specific treatability study before full scale implementation. Immobilization is retained for further consideration in the development of remedial alternatives.

2.3.4 Excavation and Disposal

Excavation and disposal of contaminated media is one of the most aggressive approaches to remediation. Excavation and disposal methods involve processes such as the excavation, transportation, storage and disposal of contaminated media using conventional earth-moving equipment. Various excavation and disposal technologies would be effective in achieving RAOs for applicable EAs within the Upper subunit of the LTR IOU. Cost and implementability of these technologies depend on the size and location the technology is being applied.

Dredging

Dredging uses specialized machinery and attachments to permanently remove sediment/soil by using both mechanical and/or hydraulic methods. Dredged sediment/soil would require de-watering prior to disposal. Dredging (removal and disposal) is retained for further consideration in the development of remedial alternatives.

Excavation

Excavation is the permanent removal of contaminated media with conventional earth moving equipment. Excavation (removal and disposal) is retained for further consideration in the development of remedial alternatives.

Table 2-1. Summary of the RAOs for Individual EAs

Upper Exposure Area	RAOs
1. Pond A – Including R-Area Discharge Canal	Protect IOU on-site workers from exposure to Cs-137 and Co-60 in sediment/soil that exceed 1E-06 risk threshold or background levels. The primary route of exposure is the external radiation pathway.
2. Canal from Pond A to Pond B	Protect IOU on-site workers from exposure to Cs-137 in sediment/soil that exceed 1E-06 risk threshold or background levels. The primary route of exposure is the external radiation pathway.
3. Pond B	Protect IOU on-site workers from exposure to Cs-137 in sediment/soil that exceed 1E-06 risk threshold or background levels. The primary route of exposure is the external radiation pathway. Protect the recreational fisherman from exposure to Cs-137 and mercury in fish tissue. The primary route of exposure is the ingestion of fish pathway.
4. Canal from Pond B to North Arm of PAR Pond	Protect IOU on-site workers from exposure to Cs-137 in sediment/soil that exceed 1E-06 risk threshold or background levels. The primary route of exposure is the external radiation pathway.
5. Joyce Branch (Old Discharge Canal)	Protect IOU on-site workers from exposure to Cs-137 and Co-60 in sediment/soil that exceed 1E-06 risk threshold or background levels. The primary route of exposure is the external radiation pathway.
6. PAR Pond	Protect IOU on-site workers from exposure to Cs-137 and Co-60 in sediment/soil that exceed 1E-06 risk threshold or background levels. The primary route of exposure is the external radiation pathway. Protect the recreational fisherman from exposure to Cs-137 and mercury in fish tissue. The primary route of exposure is the ingestion of fish pathway.
7. Canal from P-Area to Ponds 4 and 5 – Including Pond 2	Protect IOU on-site workers from exposure to Cs-137 and Co-60 in sediment/soil that exceed 1E-06 risk threshold or background levels. The primary route of exposure is the external radiation pathway.
8. Ponds 4 and 5 – Including Canal from Ponds 4 and 5 to Pond C	Protect IOU on-site workers from exposure to Cs-137 in sediment/soil that exceed 1E-06 risk threshold or background levels. The primary route of exposure is the external radiation pathway.
9. Pond C	Protect IOU on-site workers from exposure to Cs-137 and Co-60 in sediment/soil that exceed 1E-06 risk threshold or background levels. The primary route of exposure is the external radiation pathway. Protect the recreational fisherman from exposure to Cs-137 and mercury in fish tissue. The primary route of exposure is the ingestion of fish pathway.

Table 2-2. Summary of the RGOs for the Upper Subunit of the LTR IOU

Media	RCOC	Units	IOU Onsite Worker RGO[1]	Recreational Fisherman RGO[1]	SRS BKGRD 95th %tile[2]	2X SRS BKGRD 95th %tile[2]	SRS BKGRD Max[2]	IOU BKGRD Max[3]	Most Likely RGO
Sediment/ Soil	Cesium-137 (+D)	pCi/g	0.144	NA	0.34	*0.68*	3.3	0.623	0.68
	Cobalt-60	pCi/g	*0.0295*	NA	NA	NA	NA	0.011	0.0295
Fish Tissue	Cesium-137 (+D)	pCi/g	NA	*0.0544*	NA	NA	NA	0.488	0.0544
	Mercury	mg/kg	NA	*0.154*	NA	NA	NA	0.24	0.154

Sources of the most likely RGO are italicized
NA = not applicable
1 – Risk-based RGOs obtained using the calculator function available at the USEPA Preliminary Remediation Goals website (USEPA 2018a) for the radiological constituents and the USEPA Regional Screening Levels website (USEPA 2018b) for mercury.
2 – SRS background concentrations obtained from the *Background Soils Statistical Summary Report for the Savannah River Site*, Table B-1 (WSRC 2006).
3 - IOU Background maximum concentrations from the *Remedial Investigation/Baseline Risk Assessment for the Lower Three Runs Integrator Operable Unit* (SRNS 2017).

Table 2-3. Summary of the Screening of Technologies

General Response Action	Technology	Screening of Technologies			Technology Status
		Effectiveness	Implementability	Cost	
No Action	None	Does not achieve RAOs for any EA within the Upper subunit of the LTR IOU. Short-term and long-term exposure to contaminated sediment/soil is not eliminated through the implementation of this technology.	Requires no implementation.	None.	Retained
Land Use Controls (LUCs) and Monitoring	Engineering Controls	Engineering controls (access controls) are effective in using temporary or permanent physical restrictions to prevent or reduce human exposure to all contaminated media. Engineering controls can be used to prevent vandalism of on-site remedial equipment or disturbance of contaminated systems. Access controls may include, but are not limited to signs, fencing, barricades, or exclusion devices. Short-term exposure is limited to worker construction and implementation. Long-term exposure to workers is limited to the length of inspections, monitoring, and maintenance of access controls.	Readily implemented. Regular inspections, monitoring, and maintenance of access controls must be implemented for this technology to effectively deter site entry.	Low.	Retained
	Institutional Controls	Institutional controls (administrative controls) are effective in preventing or reducing future human exposure to all contaminated media remaining on the site. These controls include worker protection controls such as site use permits and radiological worker protection program. Administrative controls can include controls such as excavation permit restrictions used to permanently prohibit excavation or subsurface construction. Administrative controls also can be temporary measures used while other remedial actions are taking place. Short-term and long-term exposure to contaminated media is eliminated with the implementation of this technology.	Readily implemented. Compliance with the various controls and programs must be enforced for this technology to effectively deter site entry.	Low.	Retained

Table 2-3. Summary of the Screening of Technologies *(Continued)*

General Response Action	Technology	Screening of Technologies			Technology Status
		Effectiveness	Implementability	Cost	
Land Use Controls (LUCs) and Monitoring *(cont'd)*	MNR	Environmental monitoring is effective in measuring the chemical or physical properties of environmental media and monitoring radiological decay. Monitoring determines the need for continuance of remedial alternatives or the need for further action. Short-term exposure to contaminated sediment/soil is eliminated. Long-term exposure to workers is limited to the length of sampling and monitoring activities.	Monitoring can be readily implemented and includes several different methods (traditional monitoring, remote sensing, etc.). Long-term sampling and monitoring of contaminant concentrations in sediment/soil and fish tissue will continue to demonstrate decay processes.	Medium. Cost is dependent of the type and frequency of monitoring.	Retained
Containment	Capping	Capping would effectively limit or prevent direct exposure to PTSM sediment/soil. Variable degrees of isolation and protection are offered by different types of capping materials. Resuspension of contaminated media and exposure to workers during construction would limit short-term exposure. Long-term exposure depends upon placement, materials, and hydraulic setting.	The placement of capping would require a planned design and confirmation of placement of the cap. The design of the cap would vary depending upon the site-specific conditions at each PTSM location.	Medium. The cost of capping is dependent on the area being treated.	Retained
	Shielding	Shielding of contaminated media is effective in preventing exposure to all contaminated sediment/soil. Engineered barriers such as dams can be used to maintain water levels to provide shielding from all contaminated sediment/soil as well as serve as an impediment to human access. Short-term and exposure is eliminated through the implementation of this technology. Long-term exposure to contaminated sediment/soil would be limited to the length of worker inspections and maintenance.	Shielding would require retaining water over all the contaminated sediment/soil within the applicable pond systems by maintaining dam/weir structures that are currently maintaining water/shielding.	Medium.	Retained

Table 2-3. Summary of the Screening of Technologies *(Continued)*

General Response Action	Technology	Screening of Technologies			Technology Status
		Effectiveness	**Implementability**	**Cost**	
Containment *(cont'd)*	Immobilization	Amendments are considered in addition to the capping system as an additional feature to stabilize and/or sequester the PTSM sediment/soil into a more stable media below a cover. This technology would be effective for contaminated sediment/soil. Resuspension of contaminated media and exposure to workers during construction would limit short-term exposure. Long-term exposure depends upon placement, materials, and hydraulic setting.	In-situ immobilization would be achieved by applying amendments such as illite, organoclay, Aquablok™ or other suitable material that would limit bioavailability of contaminants. Controlled placement of amendments is difficult to implement, especially in inundated conditions. Amendments can be broadcast on the surface water and allowed to settle on the PTSM sediment/soil or spread directly on the surface of the contaminated sediment/soil as a thin layer or within other capping materials such as sand. Treatments involving the addition of amendments to sediment/soil have been demonstrated at SRS for small scale applications only. Larger scale application of amendments would require a site-specific treatability study before full scale implementation.	High. The cost of amendments is dependent on the treatment application and the area being treated.	Retained

Table 2-3. Summary of the Screening of Technologies *(Continued/End))*

General Response Action	Technology	Screening of Technologies			Technology Status
		Effectiveness	Implementability	Cost	
Excavation and Disposal	Dredging	Dredging would be effective in eliminating exposure to PTSM sediment/soil. Resuspension of contaminated media and exposure to workers during construction would limit short-term exposure. Permanent removal of contaminated sediment/soil effectively eliminates long-term exposure.	Difficult to implement. Dredging uses specialized machinery and attachments to permanently remove sediment/soil by using both mechanical (i.e. intrusive) methods such as digging in or dragging with heavy equipment and hydraulic (i.e., non-intrusive) methods such as centrifugal or tornado-motion pump removal of a sediment/soil slurry. Mechanical methods are typically bank or barge-mounted, while hydraulic methods can be operated by boat, barge or hand. Dredged sediment/soil would require de-watering prior to disposal.	High. The cost could be substantial based upon the volume of contaminated media and the distance the sediment/soil must be hauled to an approved waste disposal facility.	Retained
	Excavation	Excavation would be effective in eliminating exposure to all contaminated sediment/soil or PTSM sediment/soil alone. Resuspension of contaminated sediment/soil and exposure to workers during construction would limit short-term effectiveness. Permanent removal of contaminated sediment/soil effectiveness eliminates long-term exposure.	Difficult to implement. Conventional excavation with heavy, long-reach equipment from the stream bank or pond shore to permanently remove contaminated sediment/soil in shallow water conditions. Excavated sediment/soil would require de-watering prior to disposal.	High. The cost could be substantial based on the volume of contaminated media and the distance the sediment/soil must be hauled to an approved waste disposal facility.	Retained

3.0 DEVELOPMENT AND SCREENING OF ALTERNATIVES

Potential alternatives have been developed to address the contaminated media in the LTR IOU. In accordance with the NCP, it is desirable to offer a range of diverse alternatives to compare during the detailed analysis. The range of alternatives includes options that 1) reduce the contaminant volume and need for long-term management; or 2) limit future exposure to contaminated media. As required by the NCP, the No Action alternative is provided as a baseline for comparison.

3.1 Development of Alternatives

Based on the RAOs for the Upper subunit of the LTR IOU and the technology screening in Chapter 2, seven remedial alternatives have been developed for evaluation and are listed below according to the appropriate General Response Action category. Each remedial alternative is described in more detail in Section 3.1.1 through Section 3.1.7.

General Response Action – No Action

- Alternative 1 (A-1) – No Action

General Response Action – Land Use Controls

- Alternative 2 (A-2) – LUCS with MNR

General Response Action – Containment

- Alternative 3 (A-3) – In Situ Capping on PTSM Sediment/Soil (Including Consideration of a Hybrid Cap)
- Alternative 4 (A-4) – Broadcast of Amendments to Limit Bioavailability
- Alternative 6 (A-6) – Maintain Water in Ponds

General Response Action – Excavation

- Alternative 5 (A-5) – Excavation and Disposal of PTSM Sediment/Soil
- Alternative 7 (A-7) – Excavation and Disposal of All Contaminated Sediment/Soil

To aid in the process of screening, certain remedial alternatives are applicable to the entire Upper subunit of the LTR IOU while other remedial alternatives are EA specific. Alternatives A-1, A-2, and A-7 are applicable to the entire Upper subunit. Alternatives A-3 and A-5 are evaluated for

EAs 1, 3, and 5. Alternatives A-4 and A-6 are evaluated for EAs 3, 6, and 9. Figure 3-1 schematically identifies all the alternative options.

3.1.1 Alternative A-1: No Action

Alternative A-1 is required by the NCP to serve as a baseline for comparison with other remedial alternatives. The No Action alternative is considered for the entire Upper subunit of the LTR IOU. Under this alternative, no effort would be made to control access, limit exposure, or reduce toxicity, mobility, or volume of constituents of concern at the LTR IOU. This alternative would leave the Upper subunit in its current condition with no additional controls. This alternative does not include five-year remedy reviews.

3.1.2 Alternative A-2: Land Use Controls with Monitored Natural Recovery

Alternative A-2 involves the use of LUCs to limit access to the Upper subunit of the LTR IOU and MNR to monitor decay of Cs-137 at all nine EAs.

LUCs include engineering controls (i.e., signs, fences) and institutional controls (i.e., deed restrictions, worker protective programs) to limit inadvertent human exposure by restricting and controlling access to contaminated areas. LUCs would be implemented at each EA by posting warning and no trespassing signs at access points, ensuring compliance with the Site Use Program and other associated procedures, and deed restrictions in the event the property is ever sold. LUCs and MNR would be effective in achieving RAOs for the Upper subunit of the LTR IOU.

MNR was identified to address the long-term monitoring component of LUCs. MNR is a remedy that uses ongoing, naturally-occurring processes to contain, destroy, or reduce the bioavailability or toxicity of contaminants in sediment/soil (USEPA 2005). The Upper subunit of the LTR IOU is conducive to the MNR remedy because natural recovery processes of decay and continued sediment/soil deposition will reduce bioavailability. ~~These natural processes have a high degree of certainty to continue within an acceptable time frame.~~ In addition, the anticipated land uses for the LTR IOU is compatible with natural recovery.

Long-term monitoring, a component of the MNR remedy, includes consideration of sampling methods such as remote sensing (remote gamma surveys) and ground truthing (sediment/soil sampling) to document the decay of Cs-137 in the Upper subunit of the LTR IOU. As technology advances, new innovative sampling techniques will be employed. The MNR remedy would include a single comprehensive monitoring plan for all nine EAs that would be subject to USEPA and SCDHEC review and approval. Monitoring data would be presented in the five-year remedy reviews and would be used to document the effectiveness of a remedial action or evaluate the need for further actions. The need for continued monitoring would be re-evaluated after Cs-137 concentrations in the Upper subunit decay below the PTSM threshold.

Alternative A-2, LUCs with MNR is an appropriate remedy to be considered in the detailed analysis for the entire Upper subunit of the LTR IOU. This alternative may be an appropriate remedy to reduce risk ~~within an acceptable time~~ for some EAs~~,~~ or may be implemented in combination with more active alternatives that target PTSM or maintain water levels to mitigate sediment/soil migration as identified in Alternatives A-3 through A-6.

3.1.3 Alternative A-3: In Situ Capping on PTSM Sediment/Soil (Including Consideration of a Hybrid Cap)

Alternative A-3 consists of placing a defined barrier (cap) over the identified subaqueous (or floodplain sediment/soil) PTSM sediment/soil identified at EA1, EA3 and EA5. Caps are generally constructed of sand and/or gravel; however, a more complex cap design could include the addition of an amendment. The cap would be designed to reduce risk through the following primary functions:

- Physical isolation of the Cs-137 contaminated sediment/soil, sufficient to reduce exposure due to direct contact and to reduce the ability of burrowing organisms to move contaminants to the surface;
- Stabilization of contaminated sediment/soil and erosion protection of sediment/soil and cap, sufficient to reduce resuspension and transport; and/or
- Sequestration of Cs-137 through the use of an amendment added to the cap material to reduce bioavailability.

In-situ capping can quickly reduce exposure to contaminants and requires minimal exposure to contaminated sediment/soil during placement. A cap often provides a clean substrate for recolonization by bottom-dwelling or riparian organisms. Resuspension of contaminated sediment/soil is minimal during cap placement. Erosion protection for in-situ caps in shallow water bodies or floodplain/wetland environments may require the use of a stone armor, essentially a layer of rubble used to provide a barrier of protection.

Cap placement in shallow water would be placed from the shore using conventional equipment such as a clamshell or front-end loader. During placement, silt curtains would be installed to reduce sediment/soil migration. Placement of an in-situ cap in deeper water will require a bathymetric survey prior to installation to determine slope and cap material dispersion during placement. A barge with a surface release mechanism such as a tremie or bottom placement using conventional equipment such as clamshells, would be required to place the in-situ cap in deeper water.

The performance objective of the in-situ cap is to provide sufficient physical isolation and stabilization of the Cs-137 contaminated sediment/soil until concentrations are reduced below the PTSM thresholds which would require long-term monitoring. Inspections and maintenance activities would be implemented to ensure that there is no erosion or other physical disturbance of the cap. Prior to implementation, this alternative would require sampling to define the extent of PTSM in the identified EAs and a cap design that considers the unique site characteristics at each location. The cap design would consider the use of an amendment to reduce bioavailability. Amended caps have the potential to reduce the thickness of traditional caps and improve the resistance to erosional events and advective transport of Cs-137. Implementation of this alternative would involve significant mobilization and demobilization of heavy equipment and materials, clearing of vegetation, radiological controls, and a post installation verification to ensure the placement and thickness of the cap. This alternative will include LUCs with MNR (as detailed in A-2) and will require five-year remedy reviews as part of the entire Upper subunit remedy.

3.1.4 Alternative A-4: Broadcast of Amendments to Limit Bioavailability

Alternative A-4 involves the broadcasting of a reactive material into applicable pond systems to bind contaminants and limit the bioavailability. This alternative was selected to limit subsequent risk based on a recreational fisherman scenario. This alternative is only applicable to EA3, EA6, and EA9, which can sustain a population of consumable fish and the only EAs identified with a potential risk to the recreational fisherman.

Studies have shown that illite clay has been proven to effectively bind with Cs-137 (Hinton, et al., 2006). Activated carbon is generally used to bind mercury. Alternative A-4 involves the bulk application of amendments directly on the surface of the water and is intended to be mixed with the underlying sediment/soil through natural processes. The intent is direct application to change the native sediment/soil geochemistry to reduce contaminant bioavailability without creating a new surface layer or cap. Long-term monitoring to ensure the alternatives effectiveness would be required. There is difficulty in accurately placing bulk amendments via broadcast methods in surface water due to the potential for entrainment on surface vegetation and movement with the water column. Delivery systems for bulk delivery of amendments, such as SediMite™ and AquaBlok™ have not been used with illite. A delivery system for the specific amendment would need to be developed. In addition, implementation of this alternative would require a full-scale site treatability study. Although previous studies have shown effectiveness, this technology has not been proven on large-scale aquatic systems such as those within the Upper subunit of the LTR IOU. This alternative requires the mobilization and demobilization of specialized equipment (i.e., barges, spreader) and materials, broadcasting of the amendment, and sampling verification to ensure the effectiveness of the amendment. This alternative will require five-year remedy reviews.

3.1.5 Alternative A-5: Excavation and Disposal of PTSM Sediment/Soil

Alternative A-5 involves the excavation and disposal of known PTSM sediment/soil to reduce exposure, mobility, and toxicity of the overall risk. This alternative is only applicable to EA1, EA3, and EA5 that contain sediment/soil above the PTSM threshold. Implementation of this alternative will involve the excavation of PTSM in shallow water bodies/floodplain sediment/soil and dredging of PTSM sediment/soil from deeper ponds (EA3). Migration of suspended contaminated sediment/soil that will result from subaqueous excavation/dredging will be controlled by installing silt curtains. Excavation of shallow PTSM sediment/soil will require the use of standard commercial equipment (i.e., mini-excavator, skidsteer, dump truck) which will require special access control provisions for the remote floodplain conditions. PTSM sediment/soil located in deep water will require the use of a barge and dredging equipment. Significant mobilization will be required to transport and launch the barge as there is currently no significant infrastructure to support large vessels. Sediment/soil will be placed into large disposal bags or containers and dewatered before being transported to an approved waste disposal facility (e.g., E-Area Low Level Waste Facility [LLWF]). A post excavation sampling survey to ensure the effectiveness of the remedy will be required.

This action includes sampling to define the extent of PTSM in the unit, mobilization and demobilization of heavy equipment and materials, the scanning and clearing of vegetation, dewatering, installation of sediment/soil control features, sediment/soil excavation, and a post excavation sampling survey. This alternative will include LUCS with MNR (as detailed in A-2) and will require five-year remedy reviews as part of the entire Upper subunit remedy.

3.1.6 Alternative A-6: Maintain Water in Ponds

Alternative A-6 consists of maintaining dam structures to sustain water levels. This alternative minimizes access and limits exposure to submerged, contaminated sediment/soil within the pond. This action is only applicable to EAs that contain infrastructure to retain water and have historically maintained consistent water levels (EA3, EA6, and EA9). The dams will retain water to act as a shield to submerged contamination and prevent exposure to receptors. These physical structures also act as sedimentation barriers to prevent contaminant mobilization to prevent harm to receptors and the public. Inspections and maintenance of the water retaining structures would be required.

The dam structure for Pond B (EA3) was constructed in 1960 as a simple earthen dam with a sand toe drain system, with no spillway discharge system or monitoring devices. O&M of the dam currently includes routine inspections and repairs as needed.

The dam structure for PAR Pond (EA6) dam was constructed in 1958. O&M of the dam currently includes routine inspections and repairs as needed.

The dam and bubble-up structure for Pond C (EA9) were completed in the early 1960's. The bubble-up structure allows water to flow from Pond C into PAR Pond. The bubble-up uses hydraulic pressure to stabilize water elevation between the two ponds. O&M of the dam currently includes routine inspections and repairs as needed.

Alternative A-6 includes the monitoring of dam structures and water levels, annual inspections, and periodic maintenance of physical attributes that make water retention viable. Should future conditions warrant, the capability to provide water to PAR Pond currently exists through other site services and is expected to continue. Inspection and maintenance activities will be re-evaluated after Cs-137 concentrations drop below PTSM levels. Also, if an inspection or maintenance activity identifies structural inadequacies with the dams, the appropriate regulatory path will be pursued. This alternative will include LUCs with MNR (as detailed in A-2) and will require ~~a~~ five-year remedy reviews as part of the entire Upper subunit remedy.

3.1.7 Alternative A-7: Excavation and Disposal of All Contaminated Sediment/Soil

Alternative A-7 entails the excavation and disposal of all Cs-137 contaminated sediment/soil exceeding a 1.0E-06 risk to the IOU on-site worker. Alternative A-7 applies to all nine EAs. Heavy equipment (i.e, excavator, skidsteer, dump truck) will be used to excavate and dispose of contaminated media. Long-term monitoring would not be required as no risk would remain after the completion of the remedial action. Dewatering of the excavated sediment/soil for the entire Upper subunit of the LTR IOU would be required prior to disposal. Contaminated media would be transported to an approved waste disposal facility (e.g., E-Area LLWF). This alternative includes mobilization and demobilization of heavy equipment and materials, dewatering, sediment/soil excavation, disposal of the contaminated media, and a post excavation sampling survey. This alternative will not require five-year remedy reviews because no contaminants would remain following completion of the remedial action.

3.2 Screening of Alternatives

The seven alternatives defined for the Upper subunit of the LTR IOU are evaluated against the three CERCLA criteria of effectiveness, implementability, and cost. The purpose of this screening evaluation is to reduce the number of alternatives that will undergo a more through and detailed analysis in Section 4.0.

For an alternative to be effective, it must achieve specified objectives, must be compatible with the contaminant characteristics and unit conditions, and must be protective of human health and the environment in the long-term. The alternative must also be effective in reducing the risk to human health and the environment in the short term (during construction and construction execution). In addition, each alternative should be effective in decreasing the inherent threats or risks associated with hazardous substances or media by reducing their toxicity, mobility, or volume through treatment. Permanence of the action is also considered. Alternatives that do not provide adequate protection of human health and the welfare of the environment or that do so to a much lesser extent than a comparable alternative are screened out and not considered during the detailed analysis.

Implementability addresses both the technical and institutional feasibility of applying a technology. Under this criterion, technologies are evaluated based on the technical feasibility to construct, reliably operate, and meet technology-specific regulations for the particular treatment operation, maintenance, and monitoring of technical components of the alternative, if required, after the remedial action is complete. Institutional feasibility of an alternative refers to the ability to obtain necessary approvals and the availability of treatment, storage, and disposal services and capacity, as needed, as well as availability of specific equipment, technical specialists, and other related components.

The nature of the alternative should be such that it can be implemented in a cost effective and timely manner. In addition, the implementation of the technology should not elicit substantial public concerns in the community. Site accessibility, available area, and potential future use of the property may affect the implementation of a specific technology. Mobilization and permitting or approval requirements must be workable and previously demonstrated at similar projects.

Preliminary consideration is also given to regulatory constraints such as waste handling, disposal, and treatment requirements that would affect the implementation of a technology. These considerations will be evaluated further during the detailed analysis.

A qualitative cost evaluation is provided so that cost comparisons can be made among the alternatives. Remedial alternative costs are estimated for screening purposes as relative to other technologies in the same general response action category. Qualitative evaluations take into consideration capital costs and O&M costs. These estimates are based on prior estimates, previous experience, and engineering judgment. Alternatives demonstrating comparable levels of applicability, effectiveness, and implementability but at a significantly greater cost will be rejected. Otherwise, cost will not be used as a criterion to screen technologies at this point in the FS process.

The seven proposed remedial alternatives for the Upper subunit of the LTR IOU were evaluated against the initial screening criteria of effectiveness, implementability, and cost. The results of the evaluation are presented in the following sections and summarized in Table 3-1.

3.2.1 Alternative A-1 No Action

The No Action alternative was considered for the entire Upper subunit of the LTR IOU. The No Action alternative is not appropriate for the Upper subunit as it does not meet the RAOs defined in Section 2.1.1. However, in accordance with the NCP, this alternative is carried forward to serve as a baseline for comparison with other remedial alternatives.

3.2.2 Alternative A-2 Land Use Controls with Monitored Natural Recovery

The LUCs with MNR alternative was evaluated for the entire Upper subunit of the LTR IOU. LUCs with MNR provides a high degree of protection of human health, and is relatively simple to implement. All contaminated sediment/soil present would be protected through the implementation of this alternative. These actions would prevent further damage to the LTR IOU caused by earth moving activities from more aggressive removal technologies. MNR has never been implemented at SRS but is a similar process to monitored natural attenuation, which has been effectively implemented at SRS. LUCs are typically lower in cost but are dependent of the size of the unit and the length and frequency of monitoring required. Due to the vast size of the Upper subunit and the estimated duration periods for monitoring (50 years) and LUCs (300 years), the cost was determined to be relatively inexpensive when given that LUCs would be applied to the Upper subunit as a whole. The cost of this alternative is estimated at 17.3 million (M) dollars ($). LUCs with MNR can be implemented as a standalone remedy or as a component of Alternatives A-3 through A-6. LUCs with MNR is retained for further evaluation in the detailed analysis of alternatives.

3.2.3 Alternative A-3 In Situ Capping on PTSM Sediment/Soil (Including Consideration of a Hybrid Cap)

The In Situ Capping on PTSM Sediment/Soil (including consideration of a Hybrid Cap) alternative was considered for EA1, EA3, and EA5. In situ capping on PTSM sediment/soil is effective in protecting the IOU on-site worker by limiting exposure and mobility to contaminated sediment/soil until PTSM is no longer present. This alternative is relatively simple to implement on exposed sediment/soil or in shallow waters but will become more difficult with water depth and area accessibility considerations.

This alternative considers a hybrid cap that would include the addition of in situ amendments to the barrier over the PTSM sediment/soil. This would be effective due to the sequestering of contaminated sediment/soil to reduce mobility until the PTSM threshold is reached. This action has been implemented at other Superfund sites, although large scale application of amendments below water has not been demonstrated at SRS. Implementation of this alternative would require a design including bench scale testing to determine the appropriate composition of cap materials including the use of an amendment.

The cost for this alternative is estimated at $417 thousand (K) for EA1, $2.7 M for EA3, and $805 K for EA5. In Situ Capping on PTSM Sediment/Soil (Including Consideration of a Hybrid Cap) is retained for further evaluation in the detailed analysis of alternatives.

3.2.4 Alternative A-4 Broadcast of Amendments to Limit Bioavailability

The Broadcast of Amendments to Limit Bioavailability alternative was considered for EA3, EA6, and EA9. This alternative is perceived to be effective in reducing the bioavailability of Cs-137 and mercury to prevent uptake by the recreational fisherman. This alternative would be applied to all contaminated sediment/soil within the applicable EAs. However, overall effectiveness is uncertain due to the availability of limited studies coupled with difficulties in monitoring bioavailability. Studies pertaining to the effectiveness of such amendments have not been demonstrated on a unit this size. A treatability study would be required before large scale implementation in the Upper subunit of the LTR IOU. This alternative would be very difficult to implement due to the vast size of the pond systems. Entrainment and dispersion of amendments could even become detrimental to ecological resources. Further research would be required to determine the best application method. The minimum estimated cost of this action for each of the three EAs is estimated at $33 M for EA3, $428 M for EA6, and $22 M for EA9. This cost is based on a unit cost for a broadcast application of AquaBlok™ (USDOD 2017), which was considered to be representative of costs associated with the appropriate amendment material. A treatment study, development of delivery products using illite, and site-specific factors are likely to drive these costs higher. Due to the uncertainty with the implementation and effectiveness of this alternative and the cost of execution, the Broadcast of Amendments to Limit Bioavailability alternative is not retained for further evaluation in the detailed analysis of alternatives.

3.2.5 Alternative A-5 Excavation and Disposal of PTSM Sediment/Soil

The Excavation and Disposal of PTSM Sediment/Soil alternative is considered for EA1, EA3, and EA5 that contain PTSM sediment/soil. This alternative is effective in reducing risk to the IOU on-site worker due to the removal and disposal of the PTSM sediment/soil to eliminate the exposure, toxicity, and mobility of the contaminated media. The implementation of this alternative in shallow water bodies will be relatively easy. Areas that contain PTSM sediment/soil in deeper water will require a higher degree of implementation due to the need for specialized equipment and area accessibility. Dewatering of excavated sediment/soil may be necessary prior to disposal. The cost for this alternative is estimated at $486 K for EA1, $2 M for EA3, and $796 K for EA5. The Excavation and Disposal of PTSM Sediment/Soil alternative is retained for further evaluation in the detailed analysis of alternatives.

3.2.6 Alternative A-6 Maintain Water in Ponds

The Maintain Water in Ponds alternative is considered for EA3, EA6, and EA9. This alternative is effective in protecting the IOU on-site worker by shielding contaminated sediment/soil with the presence of water to reduce exposure risk. This alternative would address all contaminated sediment/soil within the applicable EAs. This alternative is readily implementable through the continuance of annual inspections and periodic maintenance of the physical attributes (i.e., dams, weirs, control gates) that make water retention viable. The estimated cost for this option is $2.1 M for EA3, $2.8 M for EA6, and $591 K for EA9. The Maintain Water in Ponds alternative is retained for further evaluation in the detailed analysis of alternatives.

3.2.7 Alternative A-7 Excavation and Disposal of All Contaminated Sediment/Soil

The Excavation and Disposal of All Contaminated Sediment/Soil alternative was considered for the entire Upper subunit of the LTR IOU. This alternative is effective in achieving RAOs by removing all contaminated media. This action eliminates the exposure, toxicity, and mobility of all contaminated media. However, Alternative A-7 is very difficult to implement. Due to the sheer volume of contaminated sediment/soil within the entire Upper subunit (estimated at nearly 4 M m^3 [5 M yd^3]), this alternative would take years to complete. In addition, damage to the environment and ecological habitat that would be incurred if this alternative was to proceed is of great concern. Furthermore, the cost of this response is estimated to be greater than $1 billion (B). Due to the extremely difficult implementation and excessive cost and unfavorable environmental consequences, the Excavation and Disposal of All Contaminated Sediment/Soil alternative is not retained for further evaluation in the detailed analysis of alternatives.

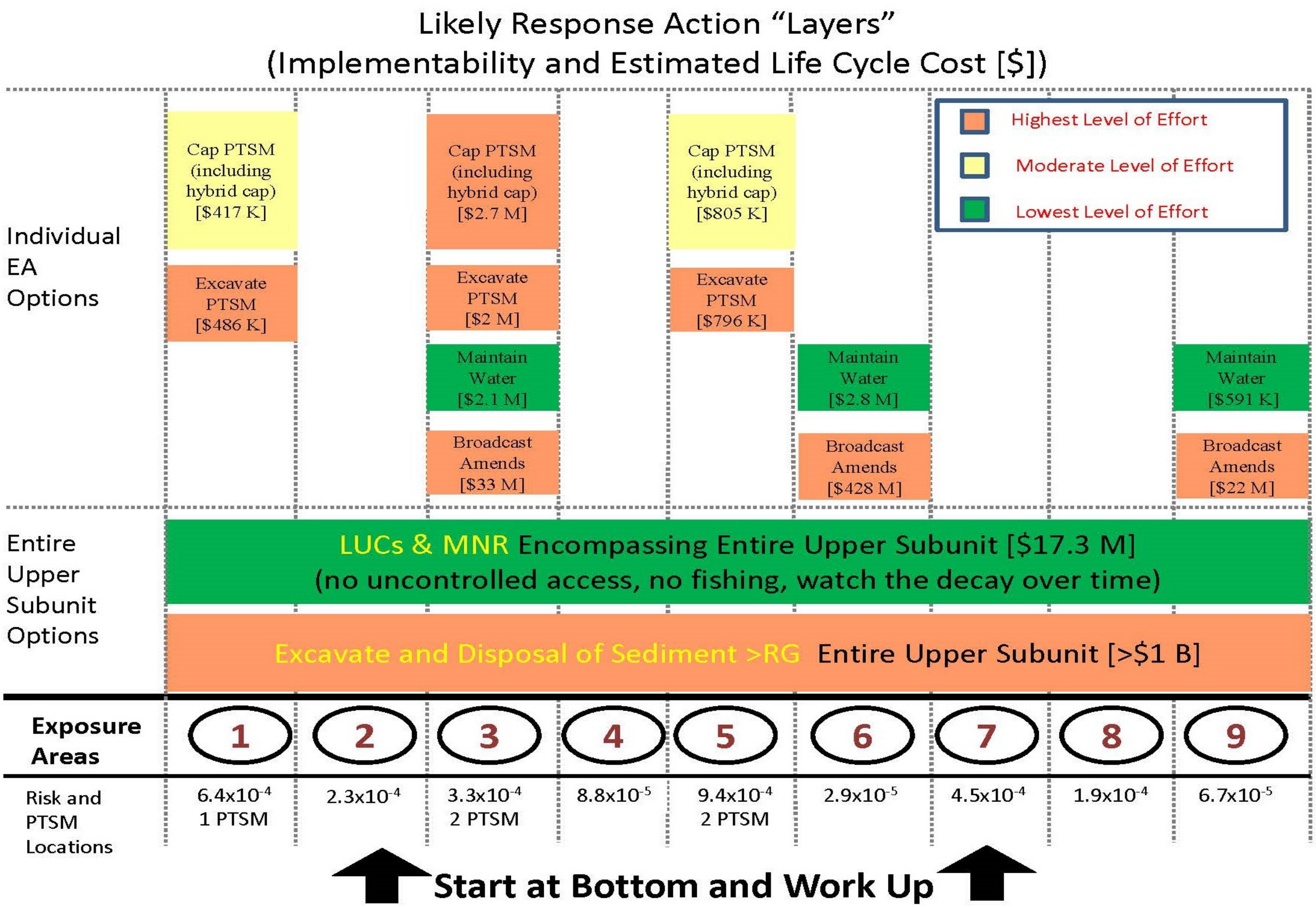


Figure 3-1. Summary of the Likely Response Action Layers

Table 3-1. Summary of the Screening of Alternatives

Alternative	Effectiveness	Implementability	Approximate Cost	Retained for Detailed Analysis	Applicable EA s
A-1: No Action	Not effective in reducing exposure of IOU on-site worker to contaminated media. Alternative does not reduce toxicity, mobility or volume.	Not Applicable (N/A)	None	Yes	EA1 through EA9
A-2: LUCs with MNR	This alternative is effective in reducing exposure of IOU on-site worker to all contaminated media by limiting access. LUCs are very effective in the short-term due to the remote locations and public unavailability of the exposure areas. Long-term monitoring of natural decay processes will ensure that exposure to PTSM levels will be eliminated after ~50 years. Alternative does not reduce toxicity, mobility, or volume.	The installation of warning signs and site inspections are readily implementable activities that are routinely performed at SRS. Sediment/soil and fish sampling are also readily implementable at SRS; however, due to the vast size, the MNR portion of this remedy is considered to be moderately implementable. Monitoring technology may change over time allowing for efficiencies in monitoring.	$17.3 M	Yes	EA1 through EA9
A-3: In Situ Capping on PTSM Sediment/Soil (Including Consideration of a Hybrid Cap)	This alternative is only considered for EA1, EA3, and EA5 that have PTSM sediment/soil. This alternative is effective in reducing exposure of IOU on-site worker to PTSM sediment/soil. The evaluation of a hybrid cap is considered and would include adding in situ amendments in addition to the barrier on PTSM sediment/soil. This is effective due to the binding of sediment/soil beneath the barrier to reduce mobility until the PTSM threshold is reached.	This action has been implemented at other Superfund sites, although large scale application of amendments below water has not been demonstrated at SRS. Implementation is considered moderately difficult and would include bench scale testing to determine the appropriate composition of cap materials, as well as the use of an amendment.	EA1 - $417 K EA3 - $2.7 M EA5 - $805 K	Yes	EA1, EA3, and EA5

Table 3-1. Summary of the Screening of Alternatives *(Continued)*

Alternative	Effectiveness	Implementability	Approximate Cost	Retained for Detailed Analysis	Applicable EA s
A-4: Broadcast of Amendments to Limit Bioavailability	This alternative is only considered for EA3, EA6, and EA9. The effectiveness of this action is assumed to be long-term due to the expected binding of Cs-137 and mercury sediment/soil in the system onto the amendments. The process of binding contaminated sediment/soil would reduce bioavailability and prevent uptake by the recreational fisherman. This alternative addresses all contaminated sediment/soil within the applicable EAs. Overall effectiveness is uncertain due to the lack of studies on broadcasting amendments coupled with expected difficulties in monitoring uptake and quantifying reduction in bioavailability. Studies containing the effectiveness of elite clay for Cs-137 and activated carbon for Mercury have not been demonstrated on this large of a scale. A treatability study would be required before large scale implementation within the Upper subunit of the LTR IOU.	This alternative will be very difficult to implement due to the vast size of the pond systems. The likelihood of amendments dispersing evenly throughout the water column is highly unlikely. Broadcast of amendments could cause more harm to the ecology in the pond systems rather than becoming beneficial. A treatability study will also be required to determine the best application method.	EA3 - $33 M EA6 - $428 M EA9 - $22 M	No	EA3, EA6, and EA9
A-5: Excavation and Disposal of PTSM Sediment/Soil	This alternative was considered for EA1, EA3, and EA5 that have PTSM sediment/soil. Excavation and disposal of PTSM sediment/soil is effective in the long-term due to the removal and disposal of the PTSM sediment/soil. This alternative eliminates the exposure, toxicity, and mobility of PTSM sediment/soil at the known locations.	The process to excavate sediment/soil from below the water surface is expected to be more difficult than stream bank excavations, and may require specialized equipment. Dewatering may be necessary at certain EAs which will increase the difficulty of implementation at those locations.	EA1 - $486 K EA3 - $2 M EA5 - $796 K	Yes	EA1, EA3, and EA5
A-6: Maintain Water in Ponds	This alternative is effective in the long-term due to the shielding of all contaminated sediment/soil.	This action is readily implementable through the continuance of annual inspections that are already in place and periodic maintenance of the physical attributes (i.e., dams, weirs, control gates, etc.) that make water retention viable.	EA3 - $2.1 M EA6 - $2.8 M EA9 - $591 K	Yes	EA3, EA6, and EA9

Table 3-1. Summary of the Screening of Alternatives *(Continued/End)*

Alternative	Effectiveness	Implementability	Approximate Cost	Retained for Detailed Analysis	Applicable EA s
A-7: Excavation and Disposal of All Contaminated Sediment/Soil	This alternative was considered for the entire Upper subunit of the LTR IOU. This alternative is effective in the long-term due to the removal of all contaminated media above the RG. This action eliminates the exposure, toxicity, and mobility of all contaminated media. However, this alternative is difficult to implement due to the sheer size of the entire Upper subunit estimated volume of contaminated sediment/soil (~4 M m^3 [5 M yd^3]).	This action is implementable though extreme in the planning and actual execution of the excavation of all contaminated sediment/soil.	> $1 B	No	EA1 through EA9

4.0 DETAILED ANALYSIS OF ALTERNATIVES

The NCP [40 CFR 300.430(e) (91)] requires that potential remedial alternatives undergo detailed analysis using relevant criteria that will be used by decision makers to select a final remedy. The results of the detailed analysis are then examined to compare alternatives and identify key tradeoffs among alternatives.

Although a comparative analysis of alternatives is provided in this FS report, this document does not propose a preferred alternative. The preferred alternative will be presented in the PP. The preferred alternative will be based on information contained in this report and comments received from the USEPA, SCDHEC, and the public prior to finalization of the ROD.

Based upon the screening processes and the RAOs for the Upper subunit of the LTR IOU, five alternatives are being carried forward for a detailed analysis against the CERCLA criteria listed in the NCP. Alternatives A-4 Broadcast of Amendments to Limit Bioavailability and A-7 Excavation and Disposal of All Contaminated Sediment/Soil were not retained for the detailed analysis. Under CERCLA, the statutory requirements that guide the evaluation of the remedial alternatives carried forward from the initial screening state that a remedial action must:

- Be protective of human health and the environment;
- Attain ARARs or define criteria for invoking a waiver;
- Be cost effective; and
- Use permanent solutions to the maximum extent.

USEPA has established nine evaluation criteria to address these statutory requirements under CERCLA. These criteria fall into the categories of threshold criteria, primary balancing criteria, and modifying criteria. Modifying criteria (i.e., State or support agency acceptance and community acceptance) will be evaluated after the public comment period on the PP and are not considered in the detailed analysis.

4.1 Individual Analysis of Alternatives

Threshold Criteria

Each alternative must meet the following threshold criteria to be selected as a permanent remedy under CERCLA:

- **Overall protection of human health and the environment** – The overall protection of human health and the environment is evaluated for each alternative. The criterion assesses how the alternative reduces the risk of exposure to contaminants from potential exposure pathways.

- **Compliance with ARARs** – Remedial actions under CERCLA must attain all ARARs. ARARs are cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under Federal, State, or Local environmental law that specifically addresses a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site.

Primary Balancing Criteria

Primary balancing criteria are factors that identify key tradeoffs among alternatives.

- **Long-term Effectiveness and Permanence** – Long-term effectiveness and permanence are evaluated for each alternative based on the magnitude of residual risk and the adequacy and reliability of controls used to manage contaminated media. Alternatives that offer long-term effectiveness and permanence mitigate or halt any potential for offsite contaminant transport and minimize the need for future engineered controls.

- **Reduction of Mobility, Toxicity, or Volume through Treatment** – The statutory preference is to select a remedial action that employs treatment to reduce the toxicity, mobility, or volume of hazardous substances. The degree to which alternatives employ recycling or treatment is assessed, including how treatment is used to address the principal threats posed by the waste unit.

- **Short-term Effectiveness** – Evaluation of alternatives for short-term effectiveness considers protection of remedial workers, members of the community, and the environment during implementation of the remedial action and the time required to achieve RAOs/RGOs. Schedule estimates are based on projected availability of materials and labor and may have to be updated at the time of remediation.

- **Implementability** – Each alternative is evaluated with respect to the technical and administrative feasibility of implementing the alternatives as well as the availability of necessary equipment and services. This criterion includes the ability to obtain services, capacities, equipment, and specialists necessary to construct components of the alternative; the ability to operate the technologies and monitor their performance and effectiveness; and the ability to obtain necessary approvals from other agencies.

- **Cost** – Accuracy of present-worth costs is +50/-30% according to USEPA guidance. Detailed cost estimates are derived from current information including vendor quotes, conventional cost estimating guides, and costs associated with serial costs, site conditions, competitive market conditions, final project scope, and implementation schedule at the time that the remedial activities are initiated. Real interest rates on U.S. Treasury notes and bonds of specific maturity were used to estimate present-worth costs. Present worth costs for review of the site remedy every five years are given for each alternative for which residuals remain at the site. Present-worth costs for these items are based on an estimated time frame of operation.

Modifying Criteria

Modifying criteria (i.e., State or support agency acceptance, community acceptance) will be considered during final remedy selection.

- **State or Support Agency Acceptance** – The preferred alternative should be acceptable to State and support agencies. The State acceptance criterion is evaluated based on scoping meetings held between the USDOE, USEPA, and SCDHEC, and based on comments received on this FS, which are addressed in the final PP document.

- **Community Acceptance** – The concerns of the community should also be considered in presenting alternatives that would be acceptable to the community. Community acceptance is evaluated based on comments on the PP received during the public comment period. These comments are considered in the final remedy selection for the ROD.

4.1.1 Alternatives Applicable to the Entire Upper Subunit of the LTR IOU

Two alternatives (i.e., A-1 and A-2) that were retained following the initial screening process are applicable to all nine of the EAs and are described in the following subsections. Alternatives that were carried through to the detailed analysis are evaluated with respect to the threshold and primary balancing criterion in Table 4-1 through 4-9.

4.1.1.1 Alternative A-1: No Action

The No Action alternative was carried forward as required by the NCP to serve as a baseline for comparison with other remedial alternatives. This option consists of performing no action to address contamination at the LTR IOU. Contaminated media would remain in place and no LUCs or active remediation would be conducted to control current and/or future potential risk; to treat or remove contaminated media; or to reduce toxicity, mobility, or volume of the contaminated media. Alternative A-1, No Action, is evaluated for each EA in Table 4-1 through Table 4-10.

4.1.1.2 Alternative A-2: LUCs with MNR

LUCs with MNR was carried forward for detailed analysis. This option consists of using engineering controls and institutional controls to prevent access of the IOU on-site worker or recreational fisherman from exposure to Cs-137 and mercury, as well as implementing a form of monitoring to document the decay of radionuclides for the entire Upper subunit of the LTR IOU. Alternative A-2 addresses all contaminated sediment/soil within the Upper Subunit. This alternative includes a single LUC implementation plan, compliance with Site Use Program and other associated procedures, posting of warning signs and fishing advisories, deed restrictions, a monitoring plan, and data sampling, analysis, and reporting.

More specifically warning signs will be posted in at each EA at current and potential access points. For estimating purposes, a total of ~107 signs were assumed adequate. Fishing advisories will be placed around viable surface water bodies (Ponds B, C, and PAR) that are able to maintain fish populations.

MNR will include initial and periodic monitoring of sediment/soil at four locations within each individual EA, fish samples collected in the fish sustainable ponds (Pond B, Pond C and PAR Pond), and deposition samples from each pre-cooler pond (i.e., Ponds A, B, C, 4, 5, and PAR). For cost estimating purposes, MNR monitoring of sediment/soil and biota is planned to be sampled at a five-year frequency until decayed below PTSM value (~50 years). Monitoring data will be summarized and reported every five years. The monitoring reports will include recommendations for continued sampling using ~~technology~~technological advances in remote sensing. Remote sensing includes acquiring data from such technologies as aerial gamma surveys. It is anticipated that costs can be reduced by alternating remote sensing and ground truthing surveys at five-year intervals. Ground truthing includes field surveys using hand-held monitoring devices or collection of physical samples for laboratory analyses. The detailed cost estimate was based solely on the physical sample collection and analysis of sediment and biota. LUCS will be applied to the entire LTR IOU until the RG is met. Five-year remedy reviews are also included in the cost summary. Alternative A-2, LUCs with MNR is evaluated for the entire Upper subunit of the LTR IOU and is presented within each EA in Table 4-1 through Table 4-10. A detailed cost estimate, representative of an order of magnitude estimate with an assumed accuracy in the range of +50/-30%, is presented in Appendix A.

4.1.2 EA by EA Evaluations

In addition to Alternatives A-1 and A-2 that are applicable to the entire Upper subunit of the LTR IOU, three alternatives (i.e., Alternatives A-3, A-5, and A-6) that were retained following the initial screening process are applicable to specific EAs. The detailed analysis for these three alternatives are discussed in the following subsections for the applicable EAs. All three alternatives are described as specific to the individual EAs however each alternative will include LUCs with MNR as part of the entire Upper subunit remedy. Alternatives that were carried through to the detailed analysis are evaluated with respect to the threshold and primary balancing criterion in Table 4-1 through 4-9, as appropriate.

4.1.2.1. EA1: R-Area Discharge Canal and Pond A

Alternative A-3: In Situ Capping on PTSM Sediment/Soil (including consideration of a hybrid cap)

Alternative A-3 was retained for detailed analysis. PTSM sediment/soil is located within the R-Area Discharge Canal (see Figure 4-2) at a relatively shallow depth below the water surface. It is anticipated that placement of an in situ cap could be achieved with conventional construction equipment operated from the bank of the canal. This alternative includes sampling to define the extent of PTSM in the unit, mobilization and demobilization of heavy equipment and materials, clearing of vegetation, implementation of radiological controls, the placement of a cap (or hybrid cap), and a post installation verification to ensure the placement and thickness of the cap. Cap inspection and maintenance is assumed to be required every five years. This alternative will require five-year remedy reviews.

Access will be via the access road that routes along the R-Area Discharge Canal. An area of ~10 m^2 (12 yd^2) will require removal of vegetation and tree debris prior to the placement of the cap. A cap design will be required based on site-specific conditions and the results of the PTSM extent sampling. Based on a literature review, a sand cap thickness over the subaqueous contaminated sediment/soil, for low flow environments with minimal expected disturbance, such as the R-Area Discharge Canal, should be ~1-m (3-ft) thick. Due to the shallow depth of the subaqueous sediment/soil, an aggregate cover to prevent erosion and to protect the cap from potential wading animals is also assumed in the design. The use of an amendment will bind Cs-137 to the clay to reduce mobilization and, when used in conjunction with other materials, can reduce the cap thickness. Application of the amendment, AquaBlok™, at other waste units is typically applied at a thickness of 0.15 m (0.5 ft), with an additional sand layer to assist with recolonization of the benthic community. For estimating purposes, the cap design is assumed to be 0.3-m (1-ft) thick and containing a mixture of sand and an amendment (AquaBlok™) with and additional aggregate armor cover. The results of the bench scale testing will determine the amendment material and may result in increased costs. Figure 4-3 provides a conceptual rendering of a cap over the PTSM sediment/soil. A silt curtain will be installed prior to the placement of the cap to help reduce turbidity from construction activities.

Alternative A-3 is evaluated for EA1 in Table 4-1. A detailed cost estimate, representative of an order of magnitude estimate with an assumed accuracy in the range of +50/-30%, is presented in Appendix A.

Alternative A-5: Excavation and Disposal of PTSM Sediment/Soil

Alternative A-5 was carried forward for detailed analysis. This option proposes to remove PTSM sediment/soil from the R-Area Discharge Canal. The sediment/soil will be disposed of in an approved waste disposal facility (e.g., E-Area LLWF). This action requires sampling to define the extent of PTSM in the unit, clearing of vegetation, heavy equipment and material mobilization and demobilization, improvements to the access road to accommodate truck traffic for waste disposal staging and hauling, and a post excavation sampling survey. This alternative will require 5-year remedy reviews.

Access will be through the un-named gravel road off SRS Road 6 that routes along the R-Area Discharge Canal. Laydown areas will require clearing to provide temporary storage for waste containers and equipment. The limit of disturbance will be ~0.20 ha (0.5 ac).

Excavation will be completed using standard earth moving equipment. Initially an estimated 10 m^3 (13 yd^3) of waste will be generated during excavation. ~~and directly~~ The excavated sediment/soil will be treated with a drying agent to reduce mobility during transportation and disposal. Contaminated media will be loaded into roll-off containers with appropriate containers/bags and staged at the site. Representative sediment/soil samples will be collected and analyzed for waste characterization and post-excavation confirmation sampling. This alternative assumes that the wastes will ultimately be hauled to an approved disposal facility. Figure 4-4 provides photos of similar excavation techniques that were performed in the Lower subunit of LTR IOU.

Alternative A-5 is evaluated for EA1 in Table 4-1. A detailed cost estimate, representative of an order of magnitude estimate with an assumed accuracy in the range of +50/-30%, is presented in Appendix A.

4.1.2.2 EA3: Pond B – Including Canal to Pond C

Alternative A-3: In Situ Capping on PTSM Sediment/Soil (including consideration of a hybrid cap)

Alternative A-3 was retained for detailed analysis. PTSM sediment/soil is located at two locations within Pond B at depths of ~5-m (17-ft) and 9-m (30-ft) below the water surface. Figure 4-2 shows the location of the PTSM sediment/soil in Pond B. An engineering design and implementation plan for the caps would take into consideration the extent of PTSM, the slope and presence of any vegetation/stumps, the potential for erosion, hydraulic properties, habitat alterations, and sediment/soil characteristics. A bathymetry survey will need to be done prior to the placement of the cap. For cost estimation purposes, it is estimated that two caps would be installed, each with an area of ~100 m^2 (120 yd^2). The design would include bench scale testing to determine the appropriate composition of cap materials including the use of an amendment to reduce mobility of the PTSM. For estimating purposes, the use of an amendment (similar to AquaBlok™) combined with a 0.15-m (0.5-ft) sand layer and an aggregate cover to prevent erosion and support aquatic habitat was assumed.

Specific activities associated with this alternative include: sampling to define the extent of PTSM in the unit, development of engineering design documents, mobilization and demobilization of heavy equipment and materials, a bathymetry survey, the placement of a (hybrid) cap, and a post installation verification to ensure the placement and thickness of the cap.

Access will be via the unnamed access road off SRS Road 6, that routes along the Pond B dam. It is assumed that placement of an in-situ cap at each of these locations would require a barge. There is no existing infrastructure to launch large water vessels/barges that would be required, therefore, mobilization costs are anticipated to be significant. A silt curtain will be installed prior to the placement of the cap to help reduce turbidity from construction activities. Figure 4-3 provides a conceptual rendering of a cap over the PTSM sediment/soil in Pond B.

This alternative will require five-year remedy reviews. It is assumed that a cap inspection and minor amounts of replenishment would be required every five years.

Alternative A-3 is evaluated for EA3 in Table 4-3. A detailed cost estimate, representative of an order of magnitude estimate with an assumed accuracy in the range of +50/-30%, is presented in Appendix A.

Alternative A-5: Excavation and Disposal of PTSM Sediment/Soil

Alternative A-5 was carried forward for detailed analysis. This option proposes to remove PTSM sediment/soil at two locations within Pond B which are ~5-m (17-ft) and 9-m (30-ft) below the water surface. Sediment/soil would require de-watering and disposal at an approved waste disposal facility (e.g., E-Area LLWF). This action requires sampling to define the extent of PTSM in the unit, a bathymetry survey and survey of stumps and debris, clearing to allow equipment access, heavy equipment mobilization and demobilization, waste disposal staging and hauling, and a post excavation sampling survey. Access will be the un-named gravel road off SRS Road 6 that routes along the Pond B dam. There is no existing infrastructure to launch large water vessels/barges that would be required; therefore, mobilization costs are anticipated to be significant. This alternative will require five-year remedy reviews.

Excavation will be completed using specialized dredging equipment to access the PTSM sediment/soil below water. Initially an estimated 200 m^3 (260 yd^3) of waste will be generated during excavation. Dewatering of sediment/soil will be required., and the sediments will be treated with a drying agent to reduce mobility of the PTSM during transport and disposal. Waste will be loaded into roll-off containers with appropriate containers/bags and staged at the site. Representative sediment/soil samples will be collected and analyzed for waste characterization and post-excavation confirmation sampling.

A laydown area will be required for dewatering and staging of excavated sediment/soil. The limit of disturbance will be ~0.20 ha (0.5 ac) of the LTR IOU to be cleared. Figure 4-4 provides a conceptual rendering of activities associated with excavation PTSM sediment/soil in Pond B.

This alternative will remove the PTSM sediment/soil, but contaminated sediment/soil above the 1E-06 risk threshold will remain in place. Five-year remedy reviews will be required for Alternative 5.

Alternative A-5 is evaluated for EA3 in Table 4-3. A detailed cost estimate, representative of an order of magnitude estimate with an assumed accuracy in the range of +50/-30%, is presented in Appendix A.

Alternative A-6: Maintain Water in Ponds

Alternative A-6 was retained for detailed analysis. This alternative will maintain water in Pond B to limit inadvertent exposure to all contaminated media. Controls are in place and will remain in place to ensure that the dam will allow for an adequate water cover over contaminated sediment/soil to provide shielding and to prevent migration. This option does not include any physical activities and only includes the scheduled maintenance, inspections, and repairs of the Pond B dam structure. This alternative will require five-year remedy reviews.

The existing Pond B dam will continue to be maintained, inspected, and repaired per SRS procedures.

Alternative A-6 is evaluated for EA3 in Table 4-3. A detailed cost estimate, representative of an order of magnitude estimate with an assumed accuracy in the range of +50/-30%, is presented in Appendix A.

4.1.2.3 EA5: Joyce Branch

Alternative A-3: In Situ Capping on PTSM Sediment/Soil (including consideration of a hybrid cap)

Alternative A-3 was retained for detailed analysis. PTSM sediment/soil is located within or adjacent to Joyce Branch (see Figure 4-2) at a relatively shallow depth below the water surface or within the adjoining stream bank. It is anticipated that placement of an in-situ cap at each PTSM location could be achieved with conventional construction equipment operated from the bank of Joyce Branch. This alternative includes sampling to define the extent of PTSM in the unit, mobilization and demobilization of heavy equipment and materials, clearing of vegetation, implementation of radiological controls, the placement of a (hybrid) cap, and a post installation verification to ensure the placement and thickness of the cap. The topography surrounding Joyce Branch is relatively steep. This could cause erosion issues after the placement of the cap. PTSM sediment/soil in Joyce Branch may be intermittently covered with water. The cap design would take into consideration erosion effects and potential exposure to terrestrial animals due to fluctuations in water level. Cap inspection and maintenance is assumed to be required every five years. This alternative will require five-year remedy reviews.

Access paths would have to be constructed for equipment to enter the Joyce Branch at each PTSM location. Vegetation and tree debris will need to be removed prior to the placement of the cap. A cap design will be required based on site-specific conditions and the results of the PTSM extent sampling. Based on a literature review, a sand cap thickness over the contaminated sediment/soil, for low flow environments with minimal expected disturbance, should be ~1-m (3-ft) thick. Due to the shallow depth of the sediment/soil, an aggregate cover to prevent erosion and to protect the cap from animals is also assumed in the design. The use of an amendment, a hybrid cap, will bind Cs-137 to the clay to reduce mobilization and, when used in conjunction with other materials, can reduce the cap thickness. Application of the amendment, AquaBlok™, at other waste units is typically applied at a thickness of 0.15 m (0.5 ft), with a thin sand layer to assist with recolonization of the benthic community. For estimating purposes, the cap design is assumed to be 0.3-m (1-ft) thick and containing a mixture of sand and an amendment (AquaBlok™) with and additional aggregate armor cover. The results of the bench scale testing will determine the amendment material and may result in increased costs. Figure 4-3 provides a conceptual rendering of a cap over the PTSM sediment/soil. A silt curtain will be installed prior to the placement of the cap to help reduce the turbidity from the construction activities.

Alternative A-3 is evaluated for EA5 in Table 4-3. A detailed cost estimate, representative of an order of magnitude estimate with an assumed accuracy in the range of +50/-30%, is presented in Appendix A.

Alternative A-5: Excavation and Disposal of PTSM Sediment/soil

Alternative A-5 was carried forward for detailed analysis. This option proposes to remove PTSM sediment/soil from two locations within Joyce Branch. The contaminated sediment/soil would be disposed of in an approved waste disposal facility (e.g. E-Area LLWF). This action requires sampling to define the extent of PTSM in the unit, clearing of vegetation for a roll off pan laydown yard, creation of access paths to Joyce Branch, improvements to the access road to accommodate truck traffic for waste disposal staging and hauling, improvements to the access road to accommodate truck traffic for waste disposal staging and hauling, heavy equipment and material mobilization and demobilization, and a post excavation sampling survey. This alternative will require five-year remedy reviews.

Access will be the un-named gravel road off SRS Road 6 that routes along the R-Area Discharge Canal and then along Joyce Branch. Laydown areas will require clearing to provide temporary storage of waste containers and equipment. The limit of disturbance will be ~0.2 ha (0.5 ac).

Excavation will be completed using standard earth moving equipment. Initially, an estimated 20 m^3 (26 yd^3) of waste will be generated during excavation. The excavated sediment/soil will be treated with a drying agent to reduce mobility during transportation and disposal. Contaminated sediment/soil will ~~likely require dewatering and will~~ be loaded into roll-off containers with appropriate containers/bags and staged at the site. Figure 4-4 provides photos of similar excavation techniques that were performed in the lower subunit of LTR. Representative sediment/soil samples will be collected and analyzed for waste characterization and post-excavation confirmation sampling. This alternative assumes that the wastes will ultimately be hauled to the E-Area LLWF.

Alternative A-5 is evaluated for EA5 in Table 4-3. A detailed cost estimate, representative of an order of magnitude estimate with an assumed accuracy in the range of +50/-30%, is presented in Appendix A.

4.1.2.4 EA6: PAR Pond

Alternative A-6: Maintain Water in Ponds

Alternative A-6 was retained for detailed analysis. This alternative will maintain water in PAR Pond to limit inadvertent exposure to all contaminated media. This option does not include any physical activities and only includes the scheduled maintenance, inspections, and repairs of the PAR Pond dam structure. This alternative will require five-year remedy reviews.

The existing PAR Pond dam will continue to be maintained, inspected, and repaired per SRS procedures.

Alternative A-6 is evaluated for EA6 in Table 4-3. A detailed cost estimate, representative of an order of magnitude estimate with an assumed accuracy in the range of +50/-30%, is presented in Appendix A.

4.1.2.5 EA9: Pond C

Alternative A-6: Maintain Water in Ponds

Alternative A-6 was retained for detailed analysis. This alternative will maintain water in Pond C to limit inadvertent exposure to all contaminated media. This option does not include any physical activities and only includes the scheduled maintenance, inspections, and repairs to the Pond C dam. This alternative will require five-year remedy reviews.

The existing Pond C dam will continue to be maintained, inspected, and repaired per SRS procedures.

Alternative A-6 is evaluated for EA9 in Table 4-3. A detailed cost estimate, representative of an order of magnitude estimate with an assumed accuracy in the range of +50/-30%, is presented in Appendix A.

4.2 Comparative Analyses

Once the alternatives have been described and individually assessed against the criteria, a comparative analysis is conducted to evaluate the relative performance of each alterative in relation to each specific evaluation criterion. This contrasts with the preceding analysis in which each alternative was analyzed independently without a consideration of other alternatives. This section identifies key advantages and disadvantages of each alternative relative to one another in relation to the evaluation criteria. The comparative analysis is presented in tabular format in Table 4-11 to reduce repetitive narrative discussion of the nine EAs. Each alternative is ranked with respect to the other alternatives for the evaluation criteria.

A summary of the performance of each alternative relative to one another is discussed below for each criterion. No RCOCs were identified for the surface water media or for ecological receptors, so the comparative analysis will focus on risks to human health associated with contaminated sediment/soil.

<u>Overall Protection of Human Health and the Environment</u>

Alternative A-1 would not be protective of human health or the environment. All other alternatives (A-2, A-3, A-5, and A-6) are protective of human health and the environment. Alternative A-2, will prevent human exposure to all contaminated sediment/soil. Contaminated sediment/soil would be left in place, but exposure pathways will be broken. LUCs will ensure that the people will not be exposed to contaminated sediment/soil (exposure pathways will remain broken). MNR will ensure that any unexpected changes to the system that would allow for human exposure to contaminated sediment/soil would be identified and mitigated.

Alternatives A-3, A-5, and A-6 each include LUCs with MNR as part of the remedy. These alternatives include additional actions. Alternative A-3 will install an integrated soil amendment/physical capping system over PTSM level contaminated sediment/soil. This will reduce the bioavailability of cesium-137 for fish and subsequently human receptors who may eat the fish. This offers no further level of protection as opposed to LUCs with MNR. This is because LUCs will effectively protect human receptors from eating any contaminated fish. Alternative A-5 prescribes excavation of sediment/soil that exceed PTSM levels. This will remove the most highly contaminated sediment/soil from the unit, but will not provide a further level of protection as opposed to LUCs with MNR. This is because exposure to the sediment/soil is effectively cut off by LUCs and MNR. Alternative A-6 calls for maintaining the water levels in the ponds to preserve the existing barrier to human exposure posed by the depth of water over all contaminated sediment/soil. This will likely be achieved through continued maintenance of the existing dams, but will not provide a further level of protection as opposed to LUCs with MNR. This is because exposure to the sediment/soil is effectively cut off by LUCs and MNR. Based on this logic, the overall protectiveness of each of the remedial alternatives A-2, A-3, A-5, and A-6 have been rated the same in Table 4.11

Compliance with ARARs

The list of applicable and relevant ARARs and TBC Criteria for the Upper Subunit of the LTR IOU are presented in Table 4-10. There are no ARARs associated with Alternative A-1. Alternatives A-2, A-3, A-5, and A-6 are expected to comply with the identified ARARs as shown in the comparative analysis evaluation in Table 4-11.

Long-Term Effectiveness

Alternative A-1 does not provide long-term effectiveness. Alternative A-2 provides excellent long-term effectiveness. LUCs with MNR will remain in place until the contaminated sediment/soil reaches RGs. LUCs will ensure that the exposure pathways remain broken. MNR will identify any unexpected long-term changes not proceeding as predicted to allow for an evaluation of change in protection of human exposure to contaminated sediment/soil. Alternatives A-3, A-5 and A-6 each include LUCs with MNR as part of the remedy. Alternatives A-3 and A-6 provide additional barriers to exposure but do not shorten the time-frame for reaching RGs. Alternative A-5 will remove sediment/soil with the highest concentrations of contamination and thereby effectively shorten the time-frame for the radioactive decay mechanism to reach RGs. However, the reduction in time to meet RGs is relatively small. Based on this logic, the long-term effectiveness of each of the remedial alternatives A-2, A-3, A-5, and A-6 have been rated the same in Table 4.11

Reduction of Toxicity, Mobility, or Volume Through Treatment

~~None~~ Two of the alternatives (A-3 and A-5) apply a treatment technology. ~~Therefore, no~~ A reduction of ~~toxicity,~~ mobility~~, or volume through treatment~~ is accomplished ~~from any~~ via the use of an amendment within the hybrid cap (A-3), and with the use of a drying agent for the excavated sediment/soil (A-5) to allow safe transport and disposal. No other alternatives evaluated for the Upper subunit of the LTR IOU~~.~~ provide a reduction of toxicity, mobility, or volume through treatment. Based on this logic, the Reduction of Toxicity, Mobility, or Volume Through Treatment of each of the remedial alternatives A-1, A-2, ~~A-3, A-5,~~ and A-6 have been identified as 'none' in Table 4.11

Short-Term Effectiveness

Short-term effectiveness considers whether an alternative will disturb, mitigate, increase or cause injury to a natural resource. Alternative A-1 will not implement an action. Therefore, no disturbance to a natural resource will occur. Alternative A-2 will consist of administrative controls, signs, and long-term monitoring. These activities are minimally invasive and will result in no injury to a natural resource. Alternative A-3 consists of applying a cap of sand and soil amendments and is expected to create minimal disturbance. Alternative A-6 consists of maintaining the existing dams and is also likely to impose minimal disturbance. Alternative A-5 will be the most disruptive of the alternatives. Based on this logic, the alternatives are ranked as either high or medium for short term effectiveness on the individual exposure areas in Table 4-11.

Implementability

The implementability of alternatives is determined by factors such as the ease of access to the unit, availability of materials and equipment, ability to construct and operate, technology, and ability to obtain the proper permits and approvals. All of the alternatives evaluated are implementable, the relative level of difficulty for each is identified in Table 4-11.

Alternative A-1 does not require implementation. Alternative A-2 will consist of administrative controls, signs, and long-term monitoring. Alternative A-6 consists of maintaining the existing dams. Most activities associated with these remedies are currently ongoing. Therefore, Alternatives A-2 and A-6 are rated as is highly implementable on Table 4-11.

Alternative A-3 will require mobilization of heavy equipment and installation of a sand/soil amendment type cap system over contaminated sediment/soil. Alternative A-5 will require mobilization of heavy equipment, excavation of sediment/soil, drying of sediment/soil, transport, and disposal of contaminated sediment/soil. The relative difficulty of implementation of these alternatives varies depending on the site-specific conditions. Alternatives A-3 and A-5 are identified as either difficult or of medium difficulty for individual exposure areas in Table 4-11.

Cost

A total present worth cost for each alternative was calculated for each applicable EA, and presented in Table 4-11. The cost estimates include capital and annual O&M costs. Capital costs include direct costs, such as construction, equipment, materials, labor, mobilization, pilot studies, disposal fees, etc., as well as indirect costs such as engineering, health and safety, project management, overhead, contingency, etc. Capital costs were derived from SRS experience, review of cost studies performed for similar technologies at other sites, consultation from vendors, volume estimates based on RI data, etc. O&M direct costs primarily consist of labor for inspections, labor and material for maintenance, and costs of periodic (every 5 years) reviews. Indirect O&M costs also include project management, health and safety, overhead and contingency. O&M costs were primarily derived from experience at SRS and recent maintenance costs from the SRS site infrastructure (SI) organization. A present worth analysis is performed for both Capital and O&M costs. The level of detail is representative of an order of magnitude estimate with an assumed accuracy of +50%/-30%.

Cost associated with Alternative A-2 ~~are~~is identified for the Upper subunit of the LTR IOU in its entirety. The total estimated cost of A-2 for the Upper subunit which includes all nine exposure areas (EA1 thru EA9) is ~$17 M. The cost of this alternative is in addition to any additional remedy selected for any individual EA.

Costs associated with Alternatives A-3, A-5, and A-6 are provided by individual EAs on Table 4-11. In general, costs associated with Alternatives A-3, A-5, and A-6 are in the same range at a specific exposure area, but they vary widely across exposure areas. Estimated costs of these alternatives range from ~$500 K to $2.5 M depending on the EA. Costs are presented for each alternative at each exposure area in Table 4-11. A detailed cost estimate, representative of an order of magnitude estimate with an assumed accuracy in the range of +50/-30%, ~~for each~~ is presented in Appendix A.

State or Support Agency Acceptance

This criterion will be addressed in the ROD.

<u>Community Acceptance</u>

This criterion will be addressed in the ROD.

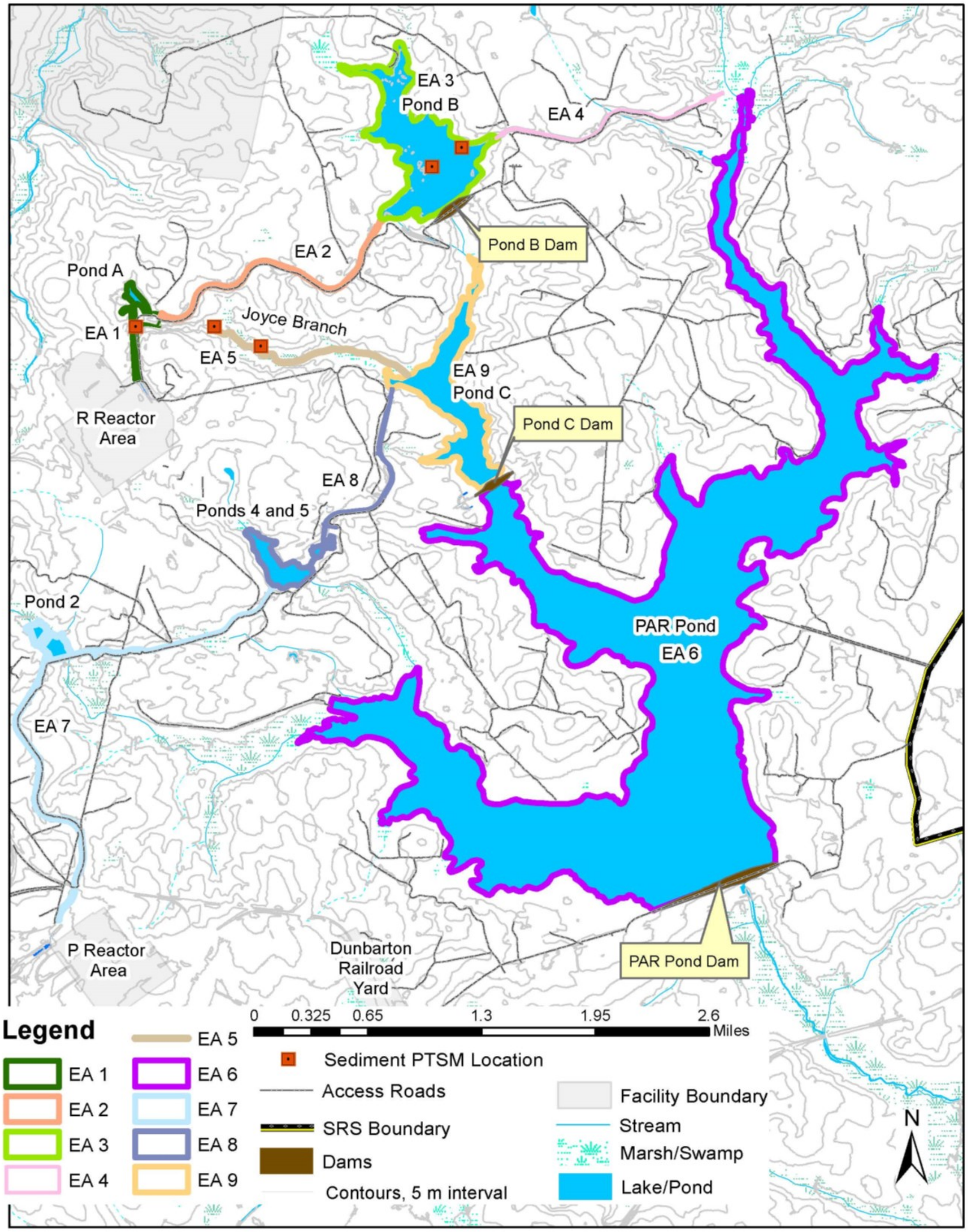


Figure 4-1. Location of Nine EAs Within the Upper Subunit of the LTR IOU

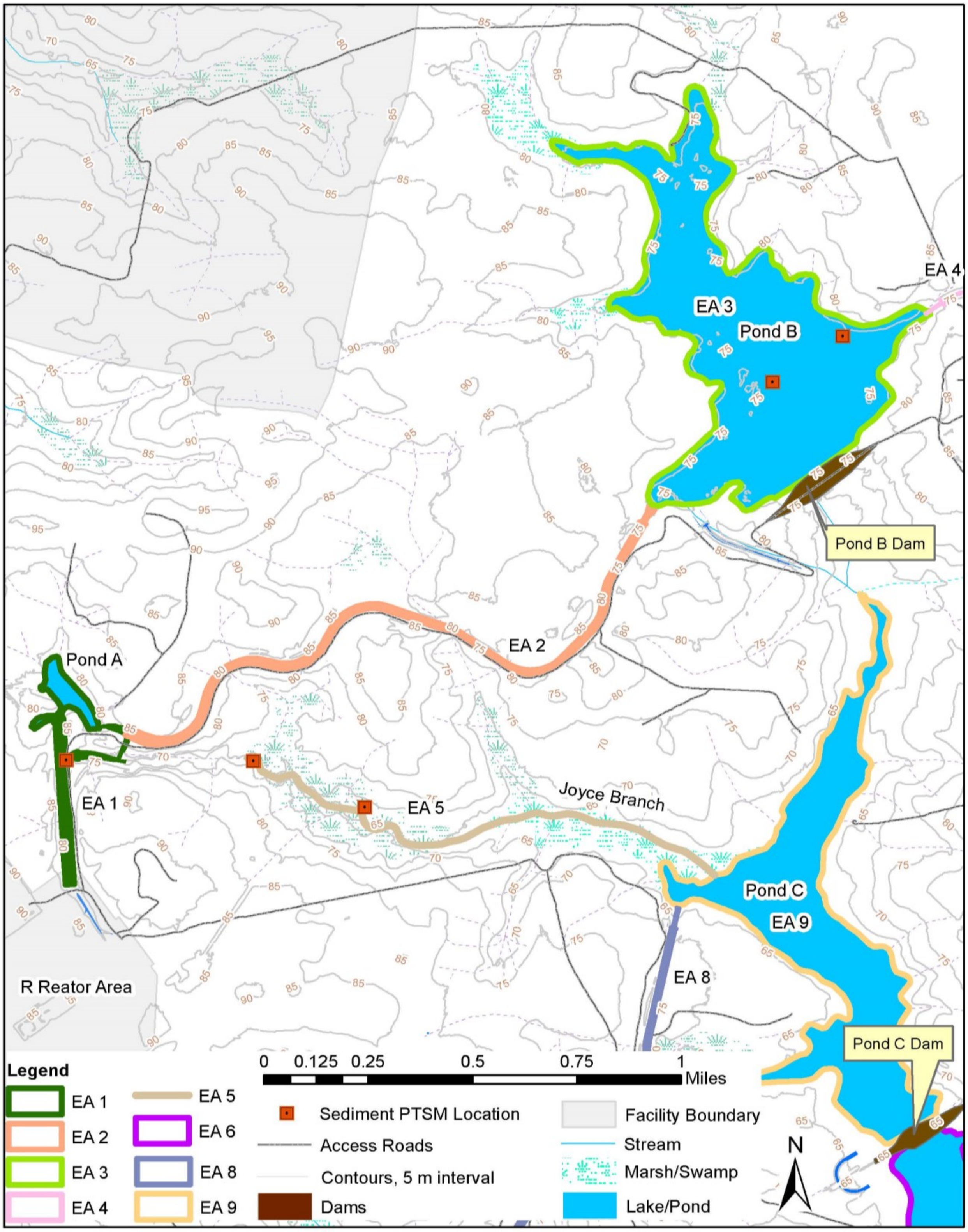


Figure 4-2. Location of PTSM Sediment/Soil Within the Upper Subunit of the LTR IOU

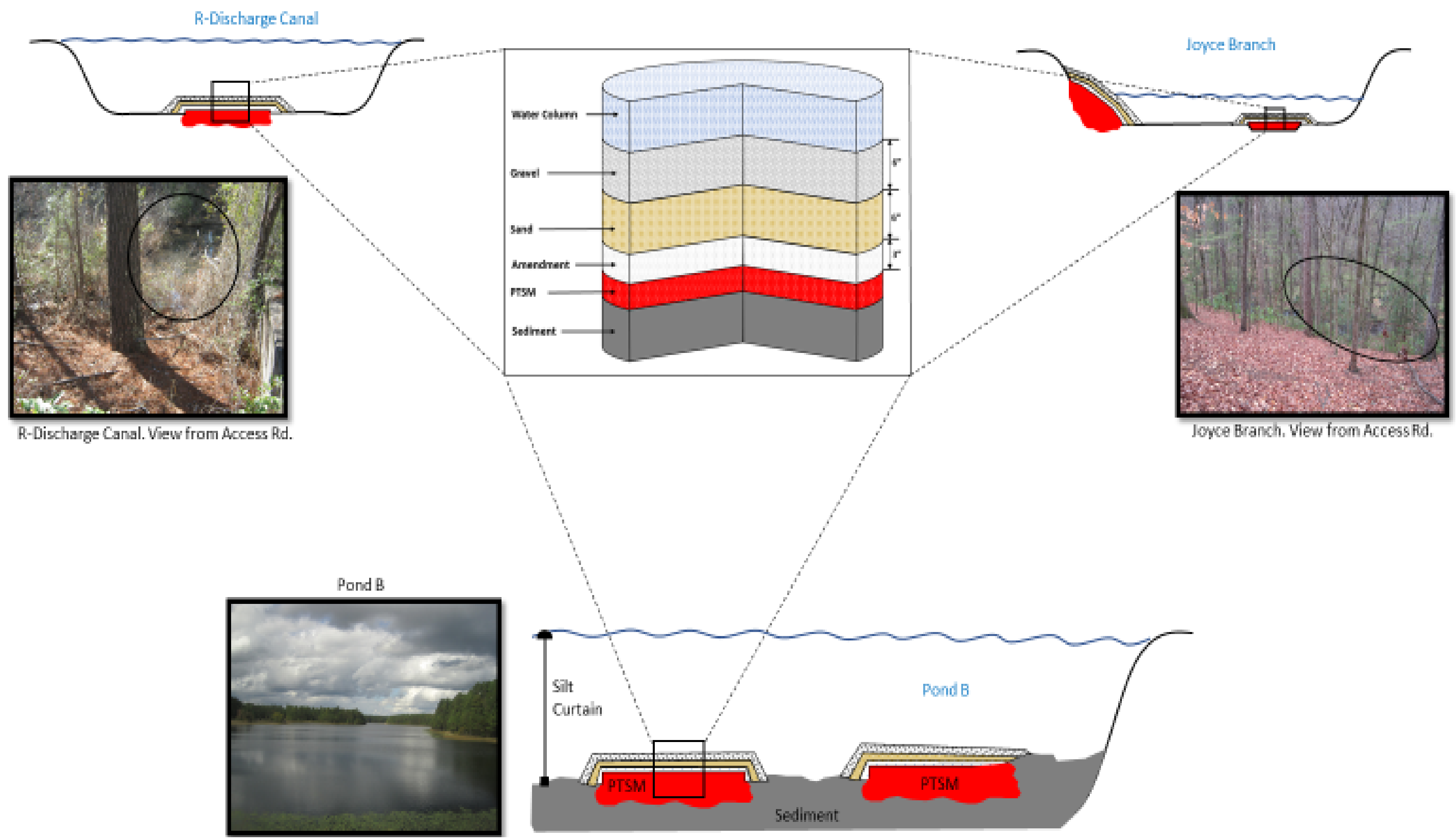
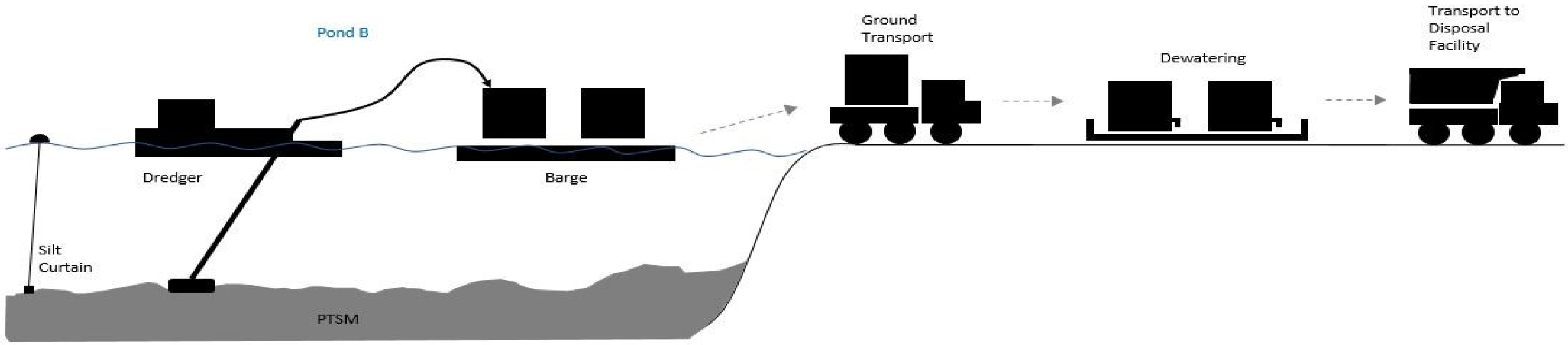


Figure 4-3. Conceptual Rendering of Alternative 3 In-Situ Capping on PTSM Sediment/Soil (Including Consideration of a Hybrid Cap)



Representation of Alternative 5 Excavation and Disposal of PTSM Sediment/Soil in EA3 Pond B

Photos of excavation in the lower subunit of LTR as a representation of Alternative 5 Excavation and Disposal of PTSM Sediment/Soil in EA1 and EA5

Figure 4-4. Conceptual Rendering of Alternative 5 Excavation and Disposal of PTSM Sediment/Soil

Table 4-1. Detailed Analysis of EA1 R-Area Discharge Canal and Pond A

Alternatives[(a)]	A-1	A-2[(b)]	A-3	A-5	A-6
Criterion	**No Action**	**LUCs with MNR**	**In Situ Capping on PTSM Sediment/Soil (Including Consideration of a Hybrid Cap)**	**Excavation and Disposal of PTSM Sediment/Soil**	**Maintain Water in Ponds by Maintaining Dam Structures**
Overall Protection of Human Health and the Environment					
Human Health	Does not address risk to IOU on-site worker.	Protective of human health and the environment by restricting access to all contaminated sediment/soil.	Prevents human exposure to and fish and biota uptake of subaqueous sediment/soil that is contaminated above the PTSM thresholds, but does not address sediment/soil contaminated at levels exceeding the 1E-06 risk threshold. The use of a hybrid cap would decrease mobility of PTSM sediment/soil through the sequestration of Cs-137 with the introduction of amendments.	Prevents human exposure to and fish and biota uptake of subaqueous sediment/soil that is contaminated above the PTSM thresholds, but does not address sediment/soil contaminated at levels exceeding the 1E-06 risk threshold.	NA
Environment	No ecological risks were identified.	No ecological risks were identified.	No ecological risks were identified. The use of a hybrid cap would decrease mobility of PTSM sediment/soil through the sequestration of Cs-137 with the introduction of amendments.	No ecological risks were identified. Excavation eliminates the mobility of PTSM sediment/soil.	NA
Compliance with ARARs					
Requirements/ Potential and TBC	NA	Yes, Potential and TBC ARARs, refer to Table 4-10.	Yes, Potential and TBC ARARs, refer to Table 4-10.	Yes, Potential and TBC ARARs, refer to Table 4-10.	NA

Table 4-1. Detailed Analysis of EA1 R-Area Discharge Canal and Pond A *(Continued)*

Alternatives[(a)]	A-1	A-2[(b)]	A-3	A-5	A-6
Criterion	**No Action**	**LUCs with MNR**	**In Situ Capping on PTSM Sediment/Soil (Including Consideration of a Hybrid Cap)**	**Excavation and Disposal of PTSM Sediment/Soil**	**Maintain Water in Ponds by Maintaining Dam Structures**
Long-Term Effectiveness and Permanence					
Magnitude of Residual Human Health Risk	Sediment/soil contaminated at concentrations above PTSM and residual contamination will remain in place until Cs-137 decays below the 1E-06 risk threshold.	Area requiring LUCs: Pond A: – 2.8 ha (7 ac) – includes R-Area Discharge Canal Controls will remain in place until Cs-137 decays to concentrations below the 1E-06 threshold or background level.	Area of residual risk: Pond A: – 2.8 ha (7 ac) – includes R-Area Discharge Canal A cap area of ~10 m^2 (12 yd^2) will cover and contain the location in the R-Area Discharge Canal where PTSM sediment/soil was identified; however, residual contamination would remain untreated in the subaqueous sediment/soil at levels above the 1E-06 risk threshold.	Area of residual risk: Pond A: – 2.8 ha (7 ac) – includes R-Area Discharge Canal Although ~10 m^3 of PTSM sediment/soil would be removed from R-Area Discharge Canal, residual contamination would remain untreated in the subaqueous sediment/soil at levels above the 1E-06 risk threshold.	NA
Adequacy of Controls	NA	Periodic monitoring and inspections of the signs (every five years) will ensure that the controls are effective and that Cs-137 concentrations are diminishing.	Periodic cap inspection and maintenance (every five years) would be required to adequately maintain effectiveness. Due to the shallow depth of the canal (<2 m [6 ft] deep) this cap is subject to disturbance by wading animals. As a stand-alone remedy, controls are not adequate for residual contamination in the subaqueous sediment/soil at levels above the 1E-06 risk threshold.	Post excavation sampling would be required to ensure that sediment/soil contaminated above PTSM thresholds is excavated. As a stand-alone remedy, controls are not adequate for residual contamination in the subaqueous sediment/soil at levels above the 1E-06 risk threshold.	NA

Table 4-1. Detailed Analysis of EA1 R-Area Discharge Canal and Pond A *(Continued)*

Alternatives[a]	A-1	A-2[b]	A-3	A-5	A-6
Criterion	**No Action**	**LUCs with MNR**	**In Situ Capping on PTSM Sediment/Soil (Including Consideration of a Hybrid Cap)**	**Excavation and Disposal of PTSM Sediment/Soil**	**Maintain Water in Ponds by Maintaining Dam Structures**
Long-Term Effectiveness and Permanence *(cont'd)*					
Permanence	Time to meet RGOs: 290 years.	Time to meet RGOs: 290 years. Monitoring will be performed by traditional sampling and analyses methods and will employ remote sensing technology. Remote sensing technology advances will likely reduce costs of long-term monitoring. Concentrations are reduced through radioactive decay. Requires Five-Year Remedy Reviews.	Time to meet RGOs: 290 years. Cap replenishment is assumed to be required every five years. PTSM sediment/soil would be contained via the placement of a cap or sequestered within a hybrid cap. Sediment/soil concentration would be reduced via radioactive decay. Requires Five-Year Remedy Reviews.	Time to meet RGOs: 220 years. Excavation will permanently remove PTSM sediment/soil, but residual contamination will remain at levels above the 1E-06 risk threshold. Approximately 10 m^3 (13 yd^3) of contaminated sediment/soil would be removed from the R-Area Discharge Canal and transported to an approved disposal facility. Additional vegetation would also need to be removed and disposed of as low level radioactive waste. Requires Five-Year Remedy Reviews.	NA
Reduction of Toxicity, Mobility, or Volume Through Treatment					
Degree of Expected Reduction in Toxicity, Mobility or Volume Through Treatment	No active treatment.	No active treatment.	~~No active treatment.~~The use of an amendment in the cap is a treatment method that will reduce the mobility of the PTSM sediment/soil.	~~No active treatment.~~The use of a drying agent will treat the PTSM sediment/soil by reducing mobilization during transportation and disposal.	NA

Table 4-1. Detailed Analysis of EA1 R-Area Discharge Canal and Pond A *(Continued)*

Alternatives[a]	A-1	A-2[b]	A-3	A-5	A-6
Criterion	**No Action**	**LUCs with MNR**	**In Situ Capping on PTSM Sediment/Soil (Including Consideration of a Hybrid Cap)**	**Excavation and Disposal of PTSM Sediment/Soil**	**Maintain Water in Ponds by Maintaining Dam Structures**
Short-term Effectiveness					
Risk to Remedial Worker	NA	No risk to the worker from exposure to contaminated sediment/soil is expected during installation of access controls. Worker exposure during monitoring of sediment/soil is minimal and will be mitigated using radiological controls and health and safety procedures.	Exposure to contaminated sediment/soil during construction would be greatest during the clearing, staging, and disposal of contaminated vegetation during construction. Placement of the hybrid cap is assumed to be accomplished with long reach construction equipment operated from the canal bank. Field activities for construction are assumed to be accomplished within one month. Health and safety procedures would be implemented to mitigate potential exposures to remediation workers when installing and inspecting the cap.	Worker exposure to contaminated sediment/soil may be significant due to dewatering, staging, and transportation of excavated sediment/soil to an on-site disposal area.	NA
Risk to Community	NA	Risk to the community is negligible as LUCs and MNR include minimal disturbance of sediment/soil.	Sediment/soil disturbance would be limited to the area immediately surrounding the PTSM. Risk to the community would be mitigated by the use of a silt curtain during cap construction to control sediment/soil migration.	Risk to the community from sediment/soil migration would be mitigated by the use of a silt curtain during excavation.	NA
Risk to Environment	NA	There would be no disruption to the environment and no additional impacts/injuries to natural resources due to implementation of this remedy.	Sediment/soil migration would be controlled with the use a silt curtain. This alternative would not produce additional impacts/injuries to natural resources during remediation.	Sediment/soil disturbance would be limited to the area immediately surrounding the PTSM and migration of the disturbed sediment/soil would be mitigated by the use a silt curtain. This alternative would not produce additional impacts/injuries to natural resources during remediation.	NA

Table 4-1. Detailed Analysis of EA1 R-Area Discharge Canal and Pond A *(Continued)*

Alternatives[a]	A-1	A-2[b]	A-3	A-5	A-6
Criterion	**No Action**	**LUCs with MNR**	**In Situ Capping on PTSM Sediment/Soil (Including Consideration of a Hybrid Cap)**	**Excavation and Disposal of PTSM Sediment/Soil**	**Maintain Water in Ponds by Maintaining Dam Structures**
Short-term Effectiveness *(cont'd)*					
Time to Implement remedy and Achieve RAO	NA	8 months (approx.) Installation of signs and initial monitoring can be accomplished with SRS personnel.	18 months (approx.) Will require sampling to delineate extent, preparation of a bench scale study and design, and subcontract for services.	12 months (approx.) Will require sampling to delineate extent, design, and subcontract for services.	NA
Implementability					
Availability of Materials, Equipment, Contractors	NA	Requires no unique materials or equipment and contractors are readily available for the installation of signs and for monitoring sediment/soil. Development of technology for remote sensing is anticipated to allow for more efficient monitoring.	Construction of the cap in the R-Area Discharge Canal is anticipated to be performed from the bank using readily available construction equipment and general construction contractors.	Excavation of the PTSM sediment/soil in the R-Area Discharge Canal is anticipated to be performed mostly from the bank using readily available construction equipment and general construction contractors. Post excavation sampling would be required to ensure that PTSM sediment/soil was removed.	NA
Ability to Construct and Operate Technology	NA	Access controls and monitoring are frequently implemented at SRS.	Subaqueous cap construction is a unique technology for SRS.	SRS has experience in excavation in wetland areas (e.g., Lower subunit of LTR IOU).	NA
Ability to Obtain Permits/Approval from Other Agencies		Permits and approvals for the installation of signs and operation of monitoring equipment is easily achieved.	Permit requirements for the installation of a subaqueous cap would have to be determined as part of the cap design.	Permit requirements for subaqueous sediment/soil excavation and dewatering would have to be determined as part of the design.	NA

Table 4-1. Detailed Analysis of EA1 R-Area Discharge Canal and Pond A *(Continued/End)*

Alternatives[a]	**A-1**	**A-2[b]**	**A-3**	**A-5**	**A-6**
Criterion	**No Action**	**LUCs with MNR**	**In Situ Capping on PTSM Sediment/Soil (Including Consideration of a Hybrid Cap)**	**Excavation and Disposal of PTSM Sediment/Soil**	**Maintain Water in Ponds by Maintaining Dam Structures**
Estimated Capital Cost[b]					
Total Capital Cost	$0	$696,168	$325,311	$485,968	NA
Present Worth O&M	$0	$16,624,973	$1,266	$0	NA
Total Cost	$0	$17,321,141	$416,566	$485,986	NA

Notes:

(a) Alternatives A-4 (Broadcast of Amendments to Limit Bioavailability) and A-7 (Excavation and Disposal of all Contaminated Sediment/Soil) were not carried through for detailed analysis. Alternative A-6 Maintain Water by Maintaining Dam Structures does not apply to EA1.

(b) Costs associated with LUCs with MNR are for the entire Upper subunit of the LTR IOU and include the costs for Five-Year Remedy Reviews.

Table 4-2. Detailed Analysis of EA2 Canal from Pond A to Pond B

Alternatives[a]	A-1	A-2[b]
Criterion	**No Action**	**LUCs with MNR**
Overall Protection of Human Health and the Environment		
Human Health	Does not address risk to IOU on-site worker	Protective of human health and the environment by restricting access to all contaminated sediment/soil.
Environment	No ecological risks were identified.	No ecological risks were identified.
Compliance with ARARs		
Requirements/Potential and TBC	NA	Yes, Potential and TBC ARARS, refer to Table 4-10.
Long-Term Effectiveness and Permanence		
Magnitude of Residual Human Health Risk	Residual contamination will remain in place until Cs-137 decays below the 1E-06 risk threshold.	Area requiring LUCs: 0.9 ha (2 ac) Controls will remain in place until Cs-137 decays to concentrations below the 1E-06 threshold.
Adequacy of Controls	NA	Periodic monitoring and inspections of the signs (every five years) will ensure that the controls are effective and that Cs-137 concentrations are diminishing.
Permanence	Time to meet RGOs: 235 years.	Time to meet RGOs: 235 years. Monitoring will be performed by traditional sampling and analyses methods and will employ remote sensing technology. Remote sensing technology advances will likely reduce costs of long-term monitoring. Concentrations are reduced through radioactive decay. Requires Five-Year Remedy Reviews.
Reduction of Toxicity, Mobility, or Volume Through Treatment		
Degree of Expected Reduction in Toxicity, Mobility or Volume Through Treatment	No active treatment.	No active treatment.

Table 4-2. Detailed Analysis of EA2 Canal from Pond A to Pond B *(Continued/End)*

Alternatives[a]	A-1	A-2[b]
Criterion	**No Action**	**LUCs with MNR**
Short-term Effectiveness		
Risk to Remedial Worker	NA	No risk to the worker from exposure to contaminated sediment/soil is expected during the installation of access controls. Worker exposure during monitoring of sediment/soil is minimal and will be mitigated using radiological controls and health and safety procedures.
Risk to Community	NA	There would be no disruption to the environment and no additional impacts/injuries to natural resources due to implementation of this remedy.
Risk to Environment	NA	There would be no disruption to the environment and no additional impacts/injuries to natural resources due to implementation of this remedy.
Time to Implement remedy and Achieve RAO	NA	8 months (approx.) Installation of signs and initial monitoring can be accomplished with SRS personnel.
Implementability		
Availability of Materials, Equipment, Contractors	NA	Requires no unique materials or equipment and contractors are readily available for the installation of signs and for monitoring sediment/soil. Development of technology for remote sensing is anticipated to allow for more efficient monitoring.
Ability to Construct and Operate Technology	NA	Access controls and monitoring are frequently implemented at SRS.
Ability to Obtain Permits/Approval from Other Agencies		Permits and approvals for the installation of signs and operation of monitoring equipment is easily achieved.
Estimated Capital Cost[b]		
Total Capital Cost	$0	$696,168
Present Worth O&M	$0	$16,624,973
Total Cost	$0	$17,321,141

Notes:

(a) Alternatives A-4 (Broadcast of Amendments to Limit Bioavailability) and A-7 (Excavation and Disposal of all Contaminated Sediment/Soil) were not carried through for detailed analysis. Alternatives A-3 (In-situ Capping of PTSM Sediment/Soil), A-5 (Excavation of PTSM Sediment/Soil), and A-6 Maintain Water by Maintaining Dam Structures do not apply to EA2.

(b) Costs associated with LUCS with MNR are for the entire Upper subunit of the LTR IOU and include cost for Five-Year Remedy Reviews.

Table 4-3. Detailed Analysis of EA3 Pond B Including Canal to Pond C

Alternatives[a]	A-1	A-2 [b]	A-3	A-5	A-6[c]
Criterion	**No Action**	**LUCs with MNR**	**In Situ Capping on PTSM Sediment/Soil (Including Consideration of a Hybrid Cap)**	**Excavation and Disposal of PTSM Sediment/Soil**	**Maintain Water in Ponds by Maintaining Dam Structures**
Overall Protection of Human Health and the Environment					
Human Health	Does not address risk to IOU on-site worker	Protective of human health and the environment by restricting access to all contaminated sediment/soil.	Prevents human exposure to and fish and biota uptake of subaqueous sediment/soil that is contaminated above the PTSM thresholds, but does not address sediment/soil contaminated at levels exceeding the 1E-06 risk threshold. The use of a hybrid cap would decrease mobility of PTSM sediment/soil through the sequestration of Cs-137 with the introduction of amendments.	Prevents human exposure to and fish and biota uptake of subaqueous sediment/soil that is contaminated above the PTSM thresholds. Does not address sediment/soil contaminated at levels exceeding the 1E-06 risk threshold.	Provides shielding for direct exposure to all contaminated sediment/soil.
Environment	No ecological risks were identified.	No ecological risks were identified.	No ecological risks were identified. The use of a hybrid cap would decrease mobility of PTSM sediment/soil through the sequestration of Cs-137 with the introduction of amendments.	No ecological risks were identified. Excavation eliminates the mobility of PTSM sediment/soil.	No ecological risks were identified. Maintaining the water level mitigates migration of contaminated sediment/soil.
Compliance with ARARs					
Requirements/ Potential and TBC	NA	Yes, Potential and TBC ARARS, refer to Table 4-10.	Yes, Potential and TBC ARARS, refer to Table 4-10.	Yes, Potential and TBC ARARS, refer to Table 4-10.	Yes, Potential and TBC ARARS, refer to Table 4-10.

Table 4-3. Detailed Analysis of EA3 Pond B Including Canal to Pond C *(Continued)*

Alternatives[a]	A-1	A-2 [b]	A-3	A-5	A-6[c]
Criterion	**No Action**	**LUCs with MNR**	**In Situ Capping on PTSM Sediment/Soil (Including Consideration of a Hybrid Cap)**	**Excavation and Disposal of PTSM Sediment/Soil**	**Maintain Water in Ponds by Maintaining Dam Structures**
Long-Term Effectiveness and Permanence					
Magnitude of Residual Human Health Risk	NA	Area requiring LUCs: ~82.1 ha (203 ac) Controls will remain in place until Cs-137 decays to concentrations below the 1E-06 threshold.	Area of residual risk: ~82.1 ha (203 ac) Two caps, each ~100 m^2 (120 yd^2) each will cover and contain the two locations where PTSM sediment/ soil was identified; however, residual contamination would remain untreated in the subaqueous sediment/soil at levels above the 1E-06 risk threshold.	Area of residual risk: ~82.1 ha (203 ac) Although ~200 m^3 (262 yd^3) of PTSM sediment/soil would be removed from Pond B, residual contamination would remain untreated in the subaqueous sediment/soil at levels above the 1E-06 risk threshold.	Area of PTSM and residual risk: ~82.1 ha (203 ac) The magnitude of residual risk is reduced by providing shielding over all radiologically contaminated sediment/soil. Sediment/soil contaminated at concentrations above PTSM and residual contamination exceeding 1E-06 risk threshold will remain in place.
Adequacy of Controls	NA	Periodic monitoring and inspections of the signs (every five years) will ensure that the controls are effective and that Cs-137 concentrations are diminishing.	Periodic cap inspection and maintenance (every five years) would be required to adequately maintain effectiveness of PTSM sediment/soil. As a stand-alone remedy, controls are not adequate for residual contamination in the subaqueous sediment/soil at levels above the 1E-06 risk threshold.	Post excavation sampling would be required to ensure that sediment/soil contaminated above PTSM thresholds was excavated. As a stand-alone remedy, controls are not adequate for residual contamination in the subaqueous sediment/soil at levels above the 1E-06 risk threshold.	Monitoring of dams will continue to be monitored per the SRS procedures and in accordance with the Federal Energy Regulatory Commission (FERC) guidelines. The existing dams will continue to provide adequate water over contaminated sediment/soil to shield radiological contamination and mitigate migration. As a stand-alone remedy, controls are not adequate for residual contamination in the subaqueous sediment/soil at levels above the 1E-06 risk threshold.

Table 4-3. Detailed Analysis of EA3 Pond B Including Canal to Pond C *(Continued)*

Alternatives[(a)]	A-1	A-2 [(b)]	A-3	A-5	A-6[(c)]
Criterion	**No Action**	**LUCs with MNR**	**In Situ Capping on PTSM Sediment/Soil (Including Consideration of a Hybrid Cap)**	**Excavation and Disposal of PTSM Sediment/Soil**	**Maintain Water in Ponds by Maintaining Dam Structures**
Long-Term Effectiveness and Permanence *(cont'd)*					
Permanence	Time to meet RGOs: 260 years.	Time to meet RGOs: 260 years. Monitoring will be performed by traditional sampling and analyses methods and will employ remote sensing technology. Remote sensing technology advances will likely reduce costs of long-term monitoring. Concentrations are reduced through radioactive decay. Requires Five-Year Remedy Reviews.	Time to meet RGOs: 260 years. Cap replenishment is assumed to be required every five years. PTSM sediment/soil would be contained via the placement of a cap or sequestered within a hybrid cap sediment/soil concentrations would be reduced via radioactive decay. Requires Five-Year Remedy Reviews.	Time to meet RGOs: 230 years. Excavation will permanently remove PTSM sediment/soil, but residual contamination will remain at levels above the 1E-06 risk threshold. Approximately 200 m^3 (262 yd^3) of contaminated sediment/soil would be removed from the Pond B and transported to an on-site disposal area. Requires Five-Year Remedy Reviews.	Time to meet RGOs: 260 years. Dam maintenance and repairs are anticipated. Concentrations are reduced through radioactive decay. Requires Five-Year Remedy Reviews.
Reduction of Toxicity, Mobility, or Volume Through Treatment					
Degree of Expected Reduction in Toxicity, Mobility or Volume Through Treatment	NA	No active treatment.	~~No active treatment.~~ The use of an amendment in the cap is a treatment method that will reduce the mobility of the PTSM sediment/soil.	~~No active treatment.~~ The use of a drying agent will treat the PTSM sediment/soil by reducing mobilization during transportation and disposal.	No active treatment.

Table 4-3. Detailed Analysis of EA3 Pond B Including Canal to Pond C *(Continued)*

Alternatives[(a)]	A-1	A-2 [(b)]	A-3	A-5	A-6[(c)]
Criterion	**No Action**	**LUCs with MNR**	**In Situ Capping on PTSM Sediment/Soil (Including Consideration of a Hybrid Cap)**	**Excavation and Disposal of PTSM Sediment/Soil**	**Maintain Water in Ponds by Maintaining Dam Structures**
Short-term Effectiveness					
Risk to Remedial Worker	NA	No risk to the worker from exposure to contaminated sediment/soil is expected during installation of access controls. Worker exposure during monitoring of sediment/soil is minimal and will be mitigated using radiological controls and health and safety procedures.	Worker exposure to contaminated sediment/soil will be minimal as the cap will be installed from a barge or vessel from the surface of the water.	Worker exposure to contaminated sediment/soil may be significant due to dewatering, staging, and transportation of excavated sediment/soil to an on-site disposal area.	Workers who perform the dam inspections and maintenance are not likely to come in contact with subaqueous contaminated sediment/soil.
Risk to Community	NA	Risk to the community is negligible as LUCs and MNR include minimal disturbance of sediment/soil.	Risk to the community would be mitigated by the use of a silt curtain during cap construction to control sediment/soil migration.	Risk to the community from sediment/soil migration would be mitigated by the use of a silt curtain during excavation.	Continued maintenance of the dam protects the community by preventing migration of contaminated sediment/soil.
Risk to Environment	NA	There would be no disruption to the environment and no additional impacts/injuries to natural resources due to implementation of this remedy.	Sediment/soil disturbance would be moderate and handled with the use a silt curtain. This alternative would not produce additional impacts/injuries to natural resources during remediation.	Sediment/soil disturbance would be limited to the area immediately surrounding the PTSM and migration of the disturbed sediment/soil would be mitigated by the use a silt curtain. This alternative would not produce additional impacts/injuries to natural resources during remediation.	Continued maintenance of the dam protects the community by preventing migration of contaminated sediment/soil. Maintaining water levels in Pond B does not prevent contaminant uptake by fish or biota, but does support continued habitat for aquatic organisms. This alternative would not produce additional impacts/injuries to natural resources.

Table 4-3. Detailed Analysis of EA3 Pond B Including Canal to Pond C *(Continued)*

Alternatives[(a)]	A-1	A-2 [(b)]	A-3	A-5	A-6[(c)]
Criterion	**No Action**	**LUCs with MNR**	**In Situ Capping on PTSM Sediment/Soil (Including Consideration of a Hybrid Cap)**	**Excavation and Disposal of PTSM Sediment/Soil**	**Maintain Water in Ponds by Maintaining Dam Structures**
Short-term Effectiveness *(cont'd)*					
Time to Implement remedy and Achieve RAO	NA	8 months (approx.) Installation of signs and initial monitoring can be accomplished with SRS personnel.	24 months (approx.) Will require a bench scale study and design and subcontract for services.	18 months (approx.) Will require sampling to delineate extent, design, and subcontract for services.	4 months (approx.) Existing infrastructure and procedures are currently in place; however, some administrative changes would be required to ensure the procedures reflect the CERCLA requirements.
Implementability					
Availability of Materials, Equipment, Contractors	NA	Requires no unique materials or equipment and contractors are readily available for the installation of signs and for monitoring sediment/soil. Development of technology for remote sensing is anticipated to allow for more efficient monitoring.	~~Mobilization~~Availability of specialized equipment/contractors and mobilization of a barge to this interior pond within a remote area may ~~hinder availability of equipment and contractors~~be difficult.	~~Mobilization~~Availability of specialized equipment/contractors and mobilization to this remote area may ~~hinder availability of equipment and contractors~~be difficult.	This action is implemented with pre-existing site infrastructure.
Ability to Construct and Operate Technology	NA	Access controls and monitoring are frequently implemented at SRS.	Subaqueous cap construction is a unique technology for SRS.	Subaqueous excavation in Ponds is a unique technology for SRS.	Available operators and procedures are in place to implement this activity.

Table 4-3. Detailed Analysis of EA3 Pond B Including Canal to Pond C *(Continued/End)*

Alternatives[(a)]	A-1	A-2 [(b)]	A-3	A-5	A-6[(c)]
Criterion	**No Action**	**LUCs with MNR**	**In Situ Capping on PTSM Sediment/Soil (Including Consideration of a Hybrid Cap)**	**Excavation and Disposal of PTSM Sediment/Soil**	**Maintain Water in Ponds by Maintaining Dam Structures**
Ability to Obtain Permits/Approval from Other Agencies	NA	Permits and approvals for the installation of signs and operation of monitoring equipment are easily achieved.	Permit requirements for the installation of a subaqueous cap would be determined as part of the design bench scale testing. CERCLA activities are exempt from USACOE 404 Permitting.	Permit requirements for subaqueous sediment/soil excavation and dewatering would be determined as part of the design. CERCLA activities are exempt from USACOE 404 Permitting.	Existing procedures are in place that comply with the inspection FERC guidelines and requirements.
Estimated Capital Cost[(a)/(c)]					
Total Capital Cost	$0	$696,168	$2,536,200	$1,990,626	$18,500
Present Worth O&M	$0	$16,624,973	$92,500	$0	$2,064,116
Total Cost	$0	$17,321,141	$2,678,700	$1,989,737	$2,082,616

Notes:
(a) Alternatives A-4 (Broadcast of Amendments to Limit Bioavailability) and A-7 (Excavation and Disposal of all Contaminated Sediment/Soil) were not carried through for detailed analysis.
(b) Costs associated with LUCS with MNR are for the entire Upper subunit of the LTR IOU and include the cost for Five-Year Remedy Reviews.
(c) Dam maintenance is anticipated to continue until Cs-137 concentrations have decayed below the PTSM thresholds (~50 years).

Table 4-4. Detailed Analysis of EA4 Canal from Pond B to North Arm of PAR Pond

Alternatives[a]	A-1	A-2[b]
Criterion	**No Action**	**LUCs with MNR**
Overall Protection of Human Health and the Environment		
Human Health	Does not address risk to IOU on-site worker	Protective of human health and the environment by restricting access to all contaminated sediment/soil.
Environment	No ecological risks were identified.	No ecological risks were identified.
Compliance with ARARs		
Requirements/Potential and TBC	NA	Yes, Potential and TBC ARARS, refer to Table 4-10.
Long-Term Effectiveness and Permanence		
Magnitude of Residual Human Health Risk	Residual contamination will remain in place until Cs-137 decays below the 1E-06 risk threshold.	Area requiring LUCs: 0.7 ha (1.7 ac) Controls will remain in place until Cs-137 decays to concentrations below the 1E-06 threshold.
Adequacy of Controls	NA	Periodic monitoring and inspections of the signs (every five years) will ensure that the controls are effective and that Cs-137 concentrations are diminishing.
Permanence	Time to meet RGOs: 180 years.	Time to meet RGOs: 180 years. Monitoring will be performed by traditional sampling and analyses methods and will employ remote sensing technology. Remote sensing technology advances will likely reduce costs of long-term monitoring. Concentrations are reduced through radioactive decay. Requires Five-Year Remedy Reviews.
Reduction of Toxicity, Mobility, or Volume Through Treatment		
Degree of Expected Reduction in Toxicity, Mobility or Volume Through Treatment	No active treatment.	No active treatment.

Table 4-4. Detailed Analysis of EA4 Canal from Pond B to North Arm of PAR Pond *(Continued/End)*

Alternatives[a]	A-1	A-2[b]
Criterion	**No Action**	**LUCs with MNR**
Short-term Effectiveness		
Risk to Remedial Worker	NA	No risk to the worker from exposure to contaminated sediment/soil is expected during the installation of access controls. Worker exposure during monitoring of sediment/soil is minimal and will be mitigated using radiological controls and health and safety procedures.
Risk to Community	NA	There would be no disruption to the environment and no additional impacts/injuries to natural resources due to implementation of this remedy.
Risk to Environment	NA	There would be no disruption to the environment and no additional impacts/injuries to natural resources due to implementation of this remedy.
Time to Implement remedy and Achieve RAO	NA	8 months (approx.) Installation of signs and initial monitoring can be accomplished with SRS personnel.
Implementability		
Availability of Materials, Equipment, Contractors	NA	Requires no unique materials or equipment and contractors are readily available for the installation of signs and for monitoring sediment/soil. Development of technology for remote sensing is anticipated to allow for more efficient monitoring.
Ability to Construct and Operate Technology	NA	Access controls and monitoring are frequently implemented at SRS.
Ability to Obtain Permits/Approval from Other Agencies		Permits and approvals for the installation of signs and operation of monitoring equipment is easily achieved.
Estimated Capital Cost[b]		
Total Capital Cost	$0	$696,168
Present Worth O&M	$0	$16,624,973
Total Cost	$0	$17,321,141

Notes:
(a) Alternatives A-4 (Broadcast of Amendments to Limit Bioavailability) and A-7 (Excavation and Disposal of all Contaminated Sediment/Soil) were not carried through for detailed analysis. Alternatives A-3 (In-situ Capping of PTSM Sediment/Soil), A-5 (Excavation of PTSM Sediment/Soil), and A-6 Maintain Water by Maintaining Dam Structures do not apply to EA4.
(b) Costs associated with LUCS with MNR are for the entire Upper subunit of the LTR IOU and include cost for Five-Year Remedy Reviews.

Table 4-5. Detailed Analysis of EA5 Joyce Branch

Alternatives[a]	A-1	A-2[b]	A-3	A-5	A-6
Criterion	**No Action**	**LUCs with MNR**	**In Situ Capping on PTSM Sediment/Soil (Including Consideration of a Hybrid Cap)**	**Excavation and Disposal of PTSM Sediment/Soil**	**Maintain Water in Ponds by Maintaining Dam Structures**
Overall Protection of Human Health and the Environment					
Human Health	Does not address risk to IOU on-site worker.	Protective of human health and the environment by restricting access to all contaminated sediment/soil.	Prevents human exposure to and fish and biota uptake of sediment/soil that is contaminated above the PTSM thresholds, but does not address sediment/soil contaminated at levels exceeding the 1E-06 risk threshold. The use of a hybrid cap would decrease mobility of PTSM sediment/soil through the sequestration of Cs-137 with the introduction of amendments.	Prevents human exposure to and fish and biota uptake of sediment/soil that are contaminated above the PTSM thresholds, but does not address sediment/soil contaminated at levels exceeding the 1E-06 risk threshold.	NA
Environment	No ecological risks were identified.	No ecological risks were identified.	No ecological risks were identified. The use of a hybrid cap would decrease mobility of PTSM sediment/soil through the sequestration of Cs-137 with the introduction of amendments.	No ecological risks were identified. Excavation eliminates the mobility of PTSM sediment/soil.	NA
Compliance with ARARs					
Requirements/ Potential and TBC	NA	Yes, Potential and TBC ARARS, refer to Table 4-10.	Yes, Potential and TBC ARARS, refer to Table 4-10.	Yes, Potential and TBC ARARS, refer to Table 4-10.	NA

Table 4-5. Detailed Analysis of EA5 Joyce Branch *(Continued)*

Alternatives[a]	A-1	A-2[b]	A-3	A-5	A-6
Criterion	**No Action**	**LUCs with MNR**	**In Situ Capping on PTSM Sediment/Soil (Including Consideration of a Hybrid Cap)**	**Excavation and Disposal of PTSM Sediment/Soil**	**Maintain Water in Ponds by Maintaining Dam Structures**
Long-Term Effectiveness and Permanence					
Magnitude of Residual Human Health Risk	Sediment/soil contaminated at concentrations above PTSM and residual contamination will remain in place until Cs-137 decays below the 1E-06 risk threshold.	Area requiring LUCs: 0.8 ha (1.9 ac) Controls will remain in place until Cs-137 decays to concentrations below the 1E-06 threshold or background level.	Area of residual risk: 0.8 ha (1.9 ac) Two caps; each of an area of ~10 m^2 (12 yd^2) will cover and contain the locations in Joyce Branch where PTSM sediment/soil was identified; however, residual contamination would remain untreated in the sediment/soil at levels above the 1E-06 risk threshold.	Area of residual risk: 0.8 ha (1.9 ac) Although ~20 m^3 (26 yd^3) of PTSM sediment/soil would be removed from Joyce Branch, residual contamination would remain untreated in the sediment/soil at levels above the 1E-06 risk threshold.	NA
Adequacy of Controls	NA	Periodic monitoring and inspections of the signs (every five years) will ensure that the controls are effective and that Cs-137 concentrations are diminishing.	Periodic cap inspection and maintenance (every five years) would be required to adequately maintain effectiveness. Due to the shallow depth of the canal (<1 m [3 ft] deep), this cap is subject to disturbance by wading animals. As a stand-alone remedy, controls are not adequate for residual contamination in the sediment/soil at levels above the 1E-06 risk threshold.	Post excavation sampling would be required to ensure that sediment/soil contaminated above PTSM thresholds were excavated. As a stand-alone remedy, controls are not adequate for residual contamination in the sediment/soil at levels above the 1E-06 risk threshold.	NA

Table 4-5. Detailed Analysis of EA5 Joyce Branch *(Continued)*

Alternatives[a]	A-1	A-2[b]	A-3	A-5	A-6
Criterion	**No Action**	**LUCs with MNR**	**In Situ Capping on PTSM Sediment/Soil (Including Consideration of a Hybrid Cap)**	**Excavation and Disposal of PTSM Sediment/Soil**	**Maintain Water in Ponds by Maintaining Dam Structures**
Long-Term Effectiveness and Permanence *(cont'd)*					
Permanence	Time to meet RGOs: 265 years.	Time to meet RGOs: 265 years. Monitoring will be performed by traditional sampling and analyses methods and will employ remote sensing technology. Remote sensing technology advances will likely reduce costs of long-term monitoring. Concentrations are reduced through radioactive decay. Requires Five-Year Remedy Reviews.	Time to meet RGOs: 265 years. PTSM sediment/soil would be contained via the placement of a cap or sequestered within a hybrid cap. Sediment/soil concentrations would be reduced via radioactive decay. The topography surrounding Joyce Branch is relatively steep. This could cause erosion issues after the placement of the cap. Cap replenishment is assumed to be required every five years. Requires Five-Year Remedy Reviews.	Time to meet RGOs: 220 years. Excavation will permanently remove PTSM sediment/soil, but residual contamination will remain at levels above the 1E-06 risk threshold. Approximately 20 m^3 (26 yd^3) of contaminated sediment/soil would be removed from Joyce Branch and transported to an approved disposal facility. Additional vegetation would also need to be removed and disposed of as low level radioactive waste. Requires Five-Year Remedy Reviews.	NA
Reduction of Toxicity, Mobility, or Volume Through Treatment					
Degree of Expected Reduction in Toxicity, Mobility or Volume Through Treatment	No active treatment.	No active treatment.	~~No active treatment.~~The use of an amendment in the cap is a treatment method that will reduce the mobility of the PTSM sediment/soil.	~~No active treatment.~~The use of a drying agent will treat the PTSM sediment/soil by reducing mobilization during transportation and disposal.	NA

Table 4-5. Detailed Analysis of EA5 Joyce Branch *(Continued)*

Alternatives[a]	A-1	A-2[b]	A-3	A-5	A-6
Criterion	**No Action**	**LUCs with MNR**	**In Situ Capping on PTSM Sediment/Soil (Including Consideration of a Hybrid Cap)**	**Excavation and Disposal of PTSM Sediment/Soil**	**Maintain Water in Ponds by Maintaining Dam Structures**
Short-term Effectiveness					
Risk to Remedial Worker	NA	No risk to the worker from exposure to contaminated sediment/soil is expected during the installation of access controls. Worker exposure during monitoring of sediment/soil is minimal and will be mitigated using radiological controls and health and safety procedures.	Exposure to contaminated sediment/soil during construction would be greatest during the clearing, staging, and disposal of contaminated vegetation during construction. Placement of the hybrid cap is assumed to be accomplished with long reach construction equipment operated from the canal bank. Field activities for construction are assumed to be accomplished within two months. Health and safety procedures would be implemented to mitigate potential exposures to remediation workers when installing and inspecting the cap.	Worker exposure to contaminated sediment/soil may be significant due to dewatering, staging, and transportation of excavated sediment/soil to an on-site disposal area.	NA
Risk to Community	NA	Risk to the community is negligible as LUCs and MNR include minimal disturbance of sediment/soil.	Sediment/soil disturbance would be limited to the area immediately surrounding the PTSM. Risk to the community would be mitigated by the use of a silt curtain during cap construction to control sediment/soil migration.	Risk to the community from sediment/soil migration would be mitigated by the use of a silt curtain during excavation.	NA

Table 4-5. Detailed Analysis of EA5 Joyce Branch *(Continued)*

Alternatives[a]	A-1	A-2[b]	A-3	A-5	A-6
Criterion	**No Action**	**LUCs with MNR**	**In Situ Capping on PTSM Sediment/Soil (Including Consideration of a Hybrid Cap)**	**Excavation and Disposal of PTSM Sediment/Soil**	**Maintain Water in Ponds by Maintaining Dam Structures**
Short-term Effectiveness *(cont'd)*					
Risk to Environment	NA	There would be no disruption to the environment and no additional impacts/injuries to natural resources due to implementation of this remedy.	Sediment/soil migration would be controlled with the use a silt curtain. This alternative would not produce additional impacts/injuries to natural resources during remediation.	Sediment/soil disturbance would be limited to the area immediately surrounding the PTSM and migration of the disturbed sediment/soil would be mitigated by the use a silt curtain. This alternative would not produce additional impacts/injuries to natural resources during remediation.	NA
Time to Implement remedy and Achieve RAO	NA	8 months (approx.) Installation of signs and initial monitoring can be accomplished with SRS personnel.	22 months (approx.) Will require sampling to delineate extent, preparation of a bench scale study and design, and subcontract for services.	16 months (approx.) Will require sampling to delineate extent, design, and subcontract for services.	NA

Table 4-5. Detailed Analysis of EA5 Joyce Branch *(Continued)*

Alternatives[a]	A-1	A-2[b]	A-3	A-5	A-6
Criterion	**No Action**	**LUCs with MNR**	**In Situ Capping on PTSM Sediment/Soil (Including Consideration of a Hybrid Cap)**	**Excavation and Disposal of PTSM Sediment/Soil**	**Maintain Water in Ponds by Maintaining Dam Structures**
Implementability					
Availability of Materials, Equipment, Contractors	NA	Requires no unique materials or equipment and contractors are readily available for the installation of signs and for monitoring sediment/soil. Development of technology for remote sensing is anticipated to allow for more efficient monitoring.	Construction of the caps in Joyce Branch will require clearing and construction of access roads. The steep terrain adjacent to the PTSM locations may require specialized equipment; however, this equipment is anticipated readily available. SRS has experience in construction within remote areas (e.g., lower subunit of LTR IOU) and general construction contractors were available.	Excavation of the PTSM sediment/soil in Joyce Branch will require clearing and construction of access roads. The steep terrain adjacent to the PTSM locations may require specialized equipment; however, this equipment is anticipated readily available. SRS has experience in excavation within remote areas (e.g. lower subunit of LTR IOU) and general construction contractors were available. Post excavation sampling would be required to ensure that PTSM sediment/soil was removed.	NA
Ability to Construct and Operate Technology	NA	Access controls and monitoring are frequently implemented at SRS.	PTSM locations in Joyce Branch may require the construction of a cap on a relatively steep slope. The top of the cap will be likely to be intermittently above the water level depending on rainfall. This type of design will be unique to SRS.	SRS has experience in excavation in wetland areas (e.g., Lower subunit of LTR IOU).	NA

Table 4-5. Detailed Analysis of EA5 Joyce Branch *(Continued/End)*

Alternatives[(a)]	A-1	A-2[(b)]	A-3	A-5	A-6
Criterion	**No Action**	**LUCs with MNR**	**In Situ Capping on PTSM Sediment/Soil (Including Consideration of a Hybrid Cap)**	**Excavation and Disposal of PTSM Sediment/Soil**	**Maintain Water in Ponds by Maintaining Dam Structures**
Implementability *(cont'd)*					
Ability to Obtain Permits/Approval from Other Agencies		Permits and approvals for the installation of signs and operation of monitoring equipment is easily achieved.	Permit requirements for the installation of a cap would have to be determined as part of the cap design.	Permit requirements for sediment/soil excavation and dewatering would have to be determined as part of the design.	NA
Estimated Capital Cost[(b)]					
Total Capital Cost	$0	$696,168	$662,690	$795,537	NA
Present Worth O&M	$0	$16,624,973	$142,500	$0	NA
Total Cost	$0	$17,321,141	$805,190	$795,537	NA

Notes:

(a) Alternatives A-4 (Broadcast of Amendments to Limit Bioavailability) and A-7 (Excavation and Disposal of all Contaminated Sediment/Soil) were not carried through for detailed analysis. Alternative A-6 Maintain Water by Maintaining Dam Structures does not apply to EA1.

(b) Costs associated with LUCS with MNR are for the entire Upper subunit of the LTR IOU and include the costs for Five-Year Remedy Reviews.

Table 4-6. Detailed Analysis of EA6 PAR Pond

Alternatives[(a)]	A-1	A-2[(b)]	A-6[(c)]
Criterion	**No Action**	**LUCs with MNR**	**Maintain Water in Ponds by Maintaining Dam Structures**
Overall Protection of Human Health and the Environment			
Human Health	Does not address risk to IOU on-site worker.	Protective of human health and the environment by restricting access to all contaminated sediment/soil.	Provides shielding for direct exposure to all contaminated sediment/soil.
Environment	No ecological risks were identified.	No ecological risks were identified.	No ecological risks were identified. Maintaining the water level mitigates migration of contaminated sediment/soil.
Compliance with ARARs			
Requirements/Potential and TBC	NA	Yes, Potential and TBC ARARs, refer to Table 4-10.	Yes, Potential and TBC ARARs, refer to Table 4-10.
Long-Term Effectiveness and Permanence			
Magnitude of Residual Human Health Risk	NA	Area requiring LUCs: ~1,068 ha (2,640 ac) Controls will remain in place until Cs-137 decays to concentrations below the 1E-06 threshold.	Area of residual risk: ~1,068 ha (2,640 ac) The magnitude of residual risk is reduced by providing shielding over radiologically contaminated sediment/soil. Residual contamination exceeding the 1E-06 risk threshold will remain in place.
Adequacy of Controls	NA	Periodic monitoring and inspections of the signs (every five years) will ensure that the controls are effective and that Cs-137 concentrations are diminishing.	Monitoring of dams will continue to be monitored per the SRS procedures and in accordance with the FERC guidelines. The existing dams will continue to provide adequate water over all contaminated sediment/soil to shield radiological contamination and mitigate migration. As a standalone remedy, controls are not adequate for residual contamination in the subaqueous sediment/soil at levels above the 1E-06 risk threshold.

Table 4-6. Detailed Analysis of EA6 PAR Pond *(Continued)*

Alternatives[a]	A-1	A-2[b]	A-6[c]
Criterion	**No Action**	**LUCs with MNR**	**Maintain Water in Ponds by Maintaining Dam Structures**
Long-Term Effectiveness and Permanence *(cont'd)*			
Permanence	Time to meet RGOs: 205 years.	Time to meet RGOs: 205 years. Monitoring will be performed by traditional sampling and analyses methods and will employ remote sensing technology. Remote sensing technology advances will likely reduce costs of long-term monitoring. Concentrations are reduced through radioactive decay. Requires Five-Year Remedy Reviews.	Time to meet RGOs: 205 years. Concentrations are reduced through radioactive decay. Requires Five-Year Remedy Reviews.
Reduction of Toxicity, Mobility, or Volume Through Treatment			
Degree of Expected Reduction in Toxicity, Mobility or Volume Through Treatment	NA	No active treatment.	No active treatment.
Short-term Effectiveness			
Risk to Remedial Worker	NA	No risk to the worker from exposure to contaminated sediment/soil is expected during installation of access controls. Worker exposure during monitoring of sediment/soil is minimal and will be mitigated using radiological controls and health and safety procedures.	Workers who perform the dam inspections and maintenance are not likely to come in contact with subaqueous contaminated sediment/soil.

Table 4-6. Detailed Analysis of EA6 PAR Pond *(Continued)*

Alternatives[(a)]	A-1	A-2[(b)]	A-6[(c)]
Criterion	**No Action**	**LUCs with MNR**	**Maintain Water in Ponds by Maintaining Dam Structures**
Short-term Effectiveness *(cont'd)*			
Risk to Community	NA	Risk to the community is negligible as LUCs and MNR include minimal disturbance of sediment/soil.	Continued maintenance of the dam protects the community by preventing migration of contaminated sediment/soil.
Risk to Environment	NA	There would be no disruption to the environment and no additional impacts/injuries to natural resources due to implementation of this remedy.	Maintaining water levels in PAR Pond does not prevent contaminant uptake by fish or biota, but does support continued habitat for aquatic organisms. This alternative would not produce additional impacts/injuries to natural resources.
Time to Implement Remedy and Achieve RAO	NA	8 months (approx.) Installation of signs and initial monitoring can be accomplished with SRS personnel.	4 months (approx.) Existing infrastructure and procedures are currently in place; however, some administrative changes would be required to ensure the procedures reflect the CERCLA requirements.
Implementability			
Availability of Materials, Equipment, Contractors	NA	Requires no unique materials or equipment and contractors are readily available for the installation of signs and for monitoring sediment/soil. Development of technology for remote sensing is anticipated to allow for more efficient monitoring.	This action is implemented with pre-existing site infrastructure.
Ability to Construct and Operate Technology	NA	Access controls and monitoring are frequently implemented at SRS.	Available operators and procedures are in place to implement this activity.
Ability to Obtain Permits/Approval from Other Agencies	NA	Permits and approvals for the installation of signs and operation of monitoring equipment are easily achieved.	Existing procedures are in place that comply with the inspection FERC guidelines and requirements.

Table 4-6. Detailed Analysis of EA6 PAR Pond *(Continued/End)*

Alternatives[(a)]	A-1	A-2[(b)]	A-6[(c)]
Criterion	**No Action**	**LUCs with MNR**	**Maintain Water in Ponds by Maintaining Dam Structures**
Estimated Capital Cost[(a)/(c)]			
Total Capital Cost	$0	$696,168	$18,500
Present Worth O&M	$0	$16,624,973	$2,817,422
Total Cost	$0	$17,321,141	$2,835,922

(a) Alternatives A-4 (Broadcast of Amendments to Limit Bioavailability) and A-7 (Excavation and Disposal of all Contaminated Sediment/Soil) were not carried through for detailed analysis. Alternatives A-3 (In-situ Capping of PTSM Sediment/Soil), and A-5 (Excavation of PTSM Sediment/Soil) do not apply to EA6.
(b) Costs associated with LUCS with MNR are for the entire Upper subunit of the LTR IOU and include the cost for Five-Year Remedy Reviews.
(c) Dam maintenance is anticipated to continue until Cs-137 concentrations in the entire upper subunit have decayed below the PTSM thresholds (~50 years).

Table 4-7. Detailed Analysis of EA7 Canal from P-Area to Ponds 4 and 5 – Including Pond 2

Alternatives[a]	A-1	A-2[b]
Criterion	**No Action**	**LUCs with MNR**
Overall Protection of Human Health and the Environment		
Human Health	Does not address risk to IOU on-site worker.	Protective of human health and the environment by restricting access to all contaminated sediment/soil.
Environment	No ecological risks were identified.	No ecological risks were identified.
Compliance with ARARs		
Requirements/Potential and TBC	NA	Yes, Potential and TBC ARARs, refer to Table 4-10.
Long-Term Effectiveness and Permanence		
Magnitude of Residual Human Health Risk	Residual contamination will remain in place until Cs-137 decays below the 1E-06 risk threshold.	Area requiring LUCs: 9.6 ha (23.8 ac) Controls will remain in place until Cs-137 decays to concentrations below the 1E-06 threshold.
Adequacy of Controls	NA	Periodic monitoring and inspections of the signs (every five years) will ensure that the controls are effective and that Cs-137 concentrations are diminishing.
Permanence	Time to meet RGOs: 220 years.	Time to meet RGOs: 220 years. Monitoring will be performed by traditional sampling and analyses methods and will employ remote sensing technology. Remote sensing technology advances will likely reduce costs of long-term monitoring. Concentrations are reduced through radioactive decay. Requires Five-Year Remedy Reviews.
Reduction of Toxicity, Mobility, or Volume Through Treatment		
Degree of Expected Reduction in Toxicity, Mobility or Volume Through Treatment	No active treatment.	No active treatment.

Table 4-7. Detailed Analysis of EA7 Canal from P-Area to Ponds 4 and 5 – Including Pond 2 *(Continued/End)*

Alternatives[(a)]	A-1	A-2[(b)]
Criterion	**No Action**	**LUCs with MNR**
Short-term Effectiveness		
Risk to Remedial Worker	NA	No risk to the worker from exposure to contaminated sediment/soil is expected during the installation of access controls. Worker exposure during monitoring of sediment/soil is minimal and will be mitigated using radiological controls and health and safety procedures.
Risk to Community	NA	There would be no disruption to the environment and no additional impacts/injuries to natural resources due to implementation of this remedy.
Risk to Environment	NA	There would be no disruption to the environment and no additional impacts/injuries to natural resources due to implementation of this remedy.
Time to Implement remedy and Achieve RAO	NA	8 months (approx.) Installation of signs and initial monitoring can be accomplished with SRS personnel.
Implementability		
Availability of Materials, Equipment, Contractors	NA	Requires no unique materials or equipment and contractors are readily available for the installation of signs and for monitoring sediment/soil. Development of technology for remote sensing is anticipated to allow for more efficient monitoring.
Ability to Construct and Operate Technology	NA	Access controls and monitoring are frequently implemented at SRS.
Ability to Obtain Permits/Approval from Other Agencies		Permits and approvals for the installation of signs and operation of monitoring equipment is easily achieved.
Estimated Capital Cost[(b)]		
Total Capital Cost	$0	$696,168
Present Worth O&M	$0	$16,624,973
Total Cost	$0	$17,321,141

Notes:

(a) Alternatives A-4 (Broadcast of Amendments to Limit Bioavailability) and A-7 (Excavation and Disposal of all Contaminated Sediment/Soil) were not carried through for detailed analysis. Alternatives A-3 (In-situ Capping of PTSM Sediment/Soil), A-5 (Excavation of PTSM Sediment/Soil), and A-6 Maintain Water by Maintaining Dam Structures do not apply to EA7.

(b) Costs associated with LUCS with MNR are for the entire Upper subunit of the LTR IOU and include cost for Five-Year Remedy Reviews.

Table 4-8. Detailed Analysis of EA8 Ponds 4 and 5 – Including Canal from Ponds 4 and 5 to Pond C

Alternatives[a]	A-1	A-2[b]
Criterion	**No Action**	**LUCs with MNR**
Overall Protection of Human Health and the Environment		
Human Health	Does not address risk to IOU on-site worker	Protective of human health and the environment by restricting access to all contaminated sediment/soil.
Environment	No ecological risks were identified.	No ecological risks were identified.
Compliance with ARARs		
Requirements/Potential and TBC	NA	Yes, Potential and TBC ARARs, refer to Table 4-10.
Long-Term Effectiveness and Permanence		
Magnitude of Residual Human Health Risk	Residual contamination will remain in place until Cs-137 decays below the 1E-06 risk threshold.	Area requiring LUCs: 18.9 ha (46.6 ac) Controls will remain in place until Cs-137 decays to concentrations below the 1E-06 threshold.
Adequacy of Controls	NA	Periodic monitoring and inspections of the signs (every five years) will ensure that the controls are effective and that Cs-137 concentrations are diminishing.
Permanence	Time to meet RGOs: 210 years.	Time to meet RGOs: 210 years. Monitoring will be performed by traditional sampling and analyses methods and will employ remote sensing technology. Remote sensing technology advances will likely reduce costs of long-term monitoring. Concentrations are reduced through radioactive decay. Requires Five-Year Remedy Reviews.
Reduction of Toxicity, Mobility, or Volume Through Treatment		
Degree of Expected Reduction in Toxicity, Mobility or Volume Through Treatment	No active treatment.	No active treatment.

Table 4-8. Detailed Analysis of EA8 Ponds 4 and 5 – Including Canal from Ponds 4 and 5 to Pond C *(Continued)*

Alternatives[a]	A-1	A-2[b]
Criterion	**No Action**	**LUCs with MNR**
Short-term Effectiveness		
Risk to Remedial Worker	NA	No risk to the worker from exposure to contaminated sediment/soil is expected during the installation of access controls. Worker exposure during monitoring of sediment/soil is minimal and will be mitigated using radiological controls and health and safety procedures.
Risk to Community	NA	There would be no disruption to the environment and no additional impacts/injuries to natural resources due to implementation of this remedy.
Risk to Environment	NA	There would be no disruption to the environment and no additional impacts/injuries to natural resources due to implementation of this remedy.
Time to Implement Remedy and Achieve RAO	NA	8 months (approx.) Installation of signs and initial monitoring can be accomplished with SRS personnel.
Implementability		
Availability of Materials, Equipment, Contractors	NA	Requires no unique materials or equipment and contractors are readily available for the installation of signs and for monitoring sediment/soil. Development of technology for remote sensing is anticipated to allow for more efficient monitoring.
Ability to Construct and Operate Technology	NA	Access controls and monitoring are frequently implemented at SRS.
Ability to Obtain Permits/Approval from Other Agencies		Permits and approvals for the installation of signs and operation of monitoring equipment is easily achieved.

Table 4-8. Detailed Analysis of EA8 Ponds 4 and 5 – Including Canal from Ponds 4 and 5 to Pond C *(Continued/End)*

Alternatives[a]	A-1	A-2[b]
Criterion	**No Action**	**LUCs with MNR**
Estimated Capital Cost[b]		
Total Capital Cost	$0	$696,168
Present Worth O&M	$0	$16,624,973
Total Cost	$0	$17,321,141

Notes:

(a) Alternatives A-4 (Broadcast of Amendments to Limit Bioavailability) and A-7 (Excavation and Disposal of all Contaminated Sediment/Soil) were not carried through for detailed analysis. Alternatives A-3 (In-situ Capping of PTSM Sediment/Soil), A-5 (Excavation of PTSM Sediment/Soil), and A-6 Maintain Water by Maintaining Dam Structures do not apply to EA8.

(b) Costs associated with LUCS with MNR are for the entire Upper subunit of the LTR IOU and include cost for Five-Year Remedy Reviews.

Table 4-9. Detailed Analysis of EA9 Pond C

Alternatives[(a)]	A-1	A-2 [(b)]	A-6[(c)]
Criterion	**No Action**	**LUCs with MNR**	**Maintain Water in Ponds by Maintaining Dam Structures**
Overall Protection of Human Health and the Environment			
Human Health	Does not address risk to IOU on-site worker.	Protective of human health and the environment by restricting access to all contaminated sediment/soil.	Provides shielding for direct exposure to all contaminated sediment/soil.
Environment	No ecological risks were identified.	No ecological risks were identified.	No ecological risks were identified. Maintaining the water level mitigates migration of contaminated sediment/soil.
Compliance with ARARs			
Requirements/Potential and TBC	NA	Yes, Potential and TBC ARARs, refer to Table 4-10.	Yes, Potential and TBC ARARs, refer to Table 4-10.
Long-Term Effectiveness and Permanence			
Magnitude of Residual Human Health Risk	NA	Area requiring LUCs: ~53.5 ha (132 ac) Controls will remain in place until Cs-137 decays to concentrations below the 1E-06 threshold.	Area of residual risk: ~53.5 ha (132 ac) The magnitude of residual risk is reduced by providing shielding over radiologically contaminated sediment/soil. Residual contamination exceeding the 1E-06 risk threshold will remain in place.
Adequacy of Controls	NA	Periodic monitoring and inspections of the signs (every five years) will ensure that the controls are effective and that Cs-137 concentrations are diminishing.	Monitoring of dams will continue to be monitored per the SRS procedures and in accordance with the FERC guidelines. The existing dams will continue to provide adequate water over contaminated sediment/soil to shield radiological contamination and mitigate migration. As a stand-alone remedy, controls are not adequate for residual contamination in the subaqueous sediment/soil at levels above the 1E-06 risk threshold.

Table 4-9. Detailed Analysis of EA9 Pond C *(Continued)*

Alternatives[a]	A-1	A-2 [b]	A-6[c]
Criterion	**No Action**	**LUCs with MNR**	**Maintain Water in Ponds by Maintaining Dam Structures**
Long-Term Effectiveness and Permanence *(cont'd)*			
Permanence	Time to meet RGOs: 200 years.	Time to meet RGOs: 200 years. Monitoring will be performed by traditional sampling and analyses methods and will employ remote sensing technology. Remote sensing technology advances will likely reduce costs of long-term monitoring. Concentrations are reduced through radioactive decay. Requires Five-Year Remedy Reviews.	Time to meet RGOs: 200 years. Concentrations are reduced through radioactive decay. Requires Five-Year Remedy Reviews.
Reduction of Toxicity, Mobility, or Volume Through Treatment			
Degree of Expected Reduction in Toxicity, Mobility or Volume Through Treatment	NA	No active treatment.	No active treatment.
Short-term Effectiveness			
Risk to Remedial Worker	NA	No risk to the worker from exposure to contaminated sediment/soil is expected during installation of access controls. Worker exposure during monitoring of sediment/soil is minimal and will be mitigated using radiological controls and health and safety procedures.	Workers who perform the dam inspections and maintenance are not likely to come in contact with subaqueous contaminated sediment/soil.
Risk to Community	NA	Risk to the community is negligible as LUCs and MNR include minimal disturbance of sediment/soil.	Continued maintenance of the dam protects the community by preventing migration of contaminated sediment/soil.

Table 4-9. Detailed Analysis of EA9 Pond C *(Continued)*

Alternatives[a]	A-1	A-2 [b]	A-6[c]
Criterion	**No Action**	**LUCs with MNR**	**Maintain Water in Ponds by Maintaining Dam Structures**
Short-term Effectiveness *(cont'd)*			
Risk to Environment	NA	There would be no disruption to the environment and no additional impacts/injuries to natural resources due to implementation of this remedy.	Maintaining water levels in PAR Pond does not prevent contaminant uptake by fish or biota, but does support continued habitat for aquatic organisms. This alternative would not produce additional impacts/injuries to natural resources.
Time to Implement Remedy and Achieve RAO	NA	8 months (approx.) Installation of signs and initial monitoring can be accomplished with SRS personnel.	4 months (approx.) Existing infrastructure and procedures are currently in place; however, some administrative changes would be required to ensure the procedures reflect the CERCLA requirements.
Implementability			
Availability of Materials, Equipment, Contractors	NA	Requires no unique materials or equipment and contractors are readily available for the installation of signs and for monitoring sediment/soil. Development of technology for remote sensing is anticipated to allow for more efficient monitoring.	This action is implemented with pre-existing site infrastructure.
Ability to Construct and Operate Technology	NA	Access controls and monitoring are frequently implemented at SRS.	Available operators and procedures are in place to implement this activity.
Ability to Obtain Permits/Approval from Other Agencies	NA	Permits and approvals for the installation of signs and operation of monitoring equipment are easily achieved.	Existing procedures are in place that comply with the inspection FERC guidelines and requirements.

Table 4-9. Detailed Analysis of EA9 Pond C *(Continued/End)*

Alternatives[a]	A-1	A-2 [b]	A-6[c]
Criterion	**No Action**	**LUCs with MNR**	**Maintain Water in Ponds by Maintaining Dam Structures**
Estimated Capital Cost[a]/[c]			
Total Capital Cost	$0	$696,168	$18,500
Present Worth O&M	$0	$16,624,973	$572,676
Total Cost	$0	$17,321,141	$591,176

(a) Alternatives A-4 (Broadcast of Amendments to Limit Bioavailability) and A-7 (Excavation and Disposal of all Contaminated Sediment/Soil) were not carried through for detailed analysis. Alternatives A-3 (In-situ Capping of PTSM Sediment/Soil), and A-5 (Excavation of PTSM Sediment/Soil) do not apply to EA9.
(b) Costs associated with LUCS with MNR are for the entire Upper subunit of the LTR IOU and include the cost for Five-Year Remedy Reviews.
(c) Dam maintenance is anticipated to continue until Cs-137 concentrations in the entire upper subunit have decayed below the PTSM thresholds (~50 years).

Table 4-10. Potential ARARs and TBC Criteria for the Lower Three Runs IOU Feasibility Study

LOCATION-SPECIFIC ARARs/TBC			
Location Characteristics	**Requirements**	**Prerequisite**	**Citation**
Floodplains and Wetlands			
Presence of Wetlands as Defined in 10 *CFR* 1022.4	Avoid, to the extent possible, the long- and short-term adverse effects associated with destruction, occupancy, and modification of wetlands and floodplains.	DOE actions that involve potential impacts to, or take place within, wetlands – applicable.	10 *CFR* 1022.3(a)
	Take action, to extent practicable, to minimize destruction, loss, or degradation of wetlands and to preserve and enhance the natural and beneficial values of wetlands.		10 *CFR* 1022.3(a)(7) and (8)
	Undertake a careful evaluation of the potential effects of any new construction in wetlands. Identify, evaluate, and as appropriate, implement alternative actions that may avoid or mitigate adverse impacts on wetlands.		10 *CFR* 1022.3(b) and (d)
	Measures that mitigate the adverse effects of actions in a wetland including, but not limited to, minimum grading requirements, runoff controls, design and construction constraints, and protection of ecologically-sensitive areas.		10 *CFR* 1022.13(a)(3)
	If no practicable alternative to locating or conducting the action in the wetland is available, then before taking action, design or modify the action in order to minimize potential harm to or within the wetland, consistent with the policies set forth in E.O. 11990.		10 *CFR* 1022.14(a)

Table 4-10. Potential ARARs and TBC Criteria for the Lower Three Runs IOU Feasibility Study *(Continued)*

LOCATION-SPECIFIC ARARs/TBC *(cont'd)*			
Location Characteristics	**Requirements**	**Prerequisite**	**Citation**
Floodplains and Wetlands *(cont'd)*			
Location Encompassing Aquatic Ecosystem as Defined in 40 *CFR* 230.3(c)	Except as provided under section CWA 404(b)(2), no discharge of dredged or fill material is permitted if there is a practicable alternative that would have less adverse impact on the aquatic ecosystem or if it will cause or contribute to significant degradation of the waters of the United States. Except as provided under section CWA 404(b)(2), no discharge of dredged or fill material shall be permitted unless appropriate and practicable steps have been taken that will minimize potential adverse impacts of the discharge on the aquatic ecosystem. 40 CFR 230.70 *et seq*. identifies such possible steps.	Action that involves the discharge of dredged or fill material into *waters of the United States* including jurisdictional wetlands – relevant and appropriate.	40 *CFR* 230.10(a) and (c) 40 *CFR* 230.10(d)
Nationwide Permit Program	Must comply with the substantive requirements of the NWP 38, General Conditions, as appropriate.	Discharge of dredged or fill material into *waters of the United States*, including jurisdictional wetlands – relevant and appropriate.	Nationwide Permit (38) – Cleanup of Hazardous and Toxic Waste 33 *CFR* 323.3(b)
Presence of Wetlands	Requires Federal agencies to evaluate action to minimize the destruction, loss or degradation of wetlands and to preserve and enhance beneficial values of wetlands.	Actions that involve potential impacts to, or take place within, wetlands – TBC.	Executive Order 11990 – *Protection of Wetlands* – Section 1(a)
Presence of Floodplains	Shall consider alternatives to avoid, to the extent possible adverse effects and incompatible development in the floodplain.	Federal actions that involve potential impacts to, or take place within, floodplains –TBC.	Executive Order 11988 – Floodplain Management – Section 2(a)(2)
Endangered, Threatened or Rare Species			
Presence of Migratory Birds and Their Habitats	No person may take, possess, import, export, transport, sell, purchaser, barter or offer for sale, purchase or barter, any migratory bird, or the parts, nests, or eggs of such bird except as may be permitted under the terms of a valid permit.	If action is likely to impact migratory birds – applicable.	16 *USC* 703-704 – Migratory Bird Treaty Act

Table 4-10. Potential ARARs and TBC Criteria for the Lower Three Runs IOU Feasibility Study *(Continued)*

LOCATION-SPECIFIC ARARs/TBC *(cont'd)*			
Location Characteristics	**Requirements**	**Prerequisite**	**Citation**
Historical, Archeological or Cultural Resources			
Presence of Archeological or Cultural Artifacts	No person may excavate, remove, damage, or otherwise alter or deface, or attempt to excavate, remove, damage, or otherwise alter or deface any archaeological resource located on public lands unless such activity is pursuant to a permit issued under § 7.8 or exempted by § 7.5(b) of this part. Note: Prior to removal activities existing Site Use process requires approval by the Savannah River Archaeological Research Program (SRARP). The SRARP is a division of the South Carolina Institute of Archaeology and Anthropology at the University of South Carolina. The SRARP manages the archaeological and other historic resources for the USDOE.	Excavation and/or removal of archaeological resources from public lands – applicable.	43 *CFR* Part 7 – implementing the Archaeological Resources Protection Act of 1979.
Presence of Historically Significant Resources	Federal agencies must take into account the effects of their projects on historic and culturally significant properties. USDOE must determine whether the proposed action is an "undertaking" as defined in 36 *CFR* 800.16(y) and, if so, whether it is a type of activity that has the potential to cause effects on historic properties. If such potential effects exist, USDOE must comply with the further obligations under this Part.	Potential presence of historical or cultural resources – applicable.	36 *CFR* Part 800 – implementing the National Historic Preservation Act of 1966, as amended.

Table 4-10. Potential ARARs and TBC Criteria for the Lower Three Runs IOU Feasibility Study *(Continued)*

LOCATION-SPECIFIC ARARs/TBC *(cont'd/end)*			
Location Characteristics	**Requirements**	**Prerequisite**	**Citation**
Location Encompassing Navigable Waters	Activities shall not block or obstruct navigation or the flow of any waters unless specifically authorized herein. No spoil, dredged material, or any other fill material shall be placed below the mean high water or ordinary highwater elevation, unless specifically authorized herein. Shall make every reasonable effort to perform the authorized work in a manner to minimize adverse impact on fish, wildlife, or water quality.	Actions that involve any dredging, filling, or construction or alteration activity in, on, or over a navigable water, as defined in R.19-450.2.C, or in, or on the bed under navigable waters, or in, or on lands or waters subject to a public navigational servitude under Article 14 Section 4 of the South Carolina Constitution and 49-1-10 of the 1976 S.C. Code of Laws including submerged lands under the navigable waters of the state, or for any activity significantly affecting the flow of any navigable water – relevant and appropriate.	SCDHEC R. 19-450.4(7) SCDHEC R. 19-450.4(8)
ACTION-SPECIFIC ARARs/TBC			
Action	**Requirements**	**Prerequisite**	**Citation**
All Land-disturbing Activities (i.e., excavation, clearing, grading, etc.)			
Managing storm water runoff from land-disturbing activities	Must comply with the substantive requirements for stormwater management and sediment/soil control of *NPDES General Permit No. SCR100000*.	Large and small construction activities (as defined in R. 61-9) of >1 ac of land – applicable.	SCDHEC R. 61-9.122.41 NPDES General Permit No. SCR100000
	The stormwater management and sediment/soil control plan shall contain at a minimum the information provided in the following subsections:	Activities involving >2 ac and <5 ac of actual land disturbance which are not part of a larger common plan of development or sale – applicable.	SCDHEC R. 72-307 I. – South Carolina Storm Water Management and sediment/soil Reduction Regulations

Table 4-10. Potential ARARs and TBC Criteria for the Lower Three Runs IOU Feasibility Study *(Continued)*

ACTION -SPECIFIC ARARs/TBC *(cont'd)*			
Action	**Requirements**	**Prerequisite**	**Citation**
All Land-disturbing Activities (i.e., excavation, clearing, grading, etc.) *(cont'd)*			
	A plan for temporary and permanent vegetative and structural erosion and sediment/soil control measures which specify the erosion and sediment/soil control measures to be used during all phases of the land disturbing activity and a description of their proposed operation;		SCDHEC R. 72-307 I.(3)(d)
	Provisions for stormwater runoff control during the land disturbing activity and during the life of the facility meeting the following requirements of subsections (e)1 and 2.		SCDHEC R. 72-307 I.(3)(e)
Managing fugitive dust emissions from land disturbing activities	Emissions of fugitive particulate matter shall be controlled in such a manner and to the degree that it does not create an undesirable level of air pollution.	Activities that will generate fugitive particulate matter (Statewide) – applicable.	SCDHEC R. 61-62.6 Section III(a)- Control of Fugitive Particulate Matter Statewide
Excavation activities causing radionuclide emissions	Emissions of radionuclides to ambient air from USDOE facilities shall not exceed amounts that would cause any member of the public to receive an effective dose equivalent of 10 millirem/year. (Excavation of cesium-contaminated soil may cause airborne contamination).	Radionuclide emissions at a USDOE facility – applicable.	40 *CFR* 61.92
	~~The exposure of members of the public to radiation sources as a consequence of all USDOE activities, including remedial actions, shall not cause a total effective dose exceeding 100 millirem/year from all sources of ionizing radiation and exposure pathways that could contribute significantly to the total dose, except as otherwise provided in 458.1(4)(b) or (c). The ALARA process in para. 4.d. of this order shall be implemented for all USDOE activities and facilities that cause public doses.~~	~~Dose received from all sources of radionuclides – TBC.~~	~~DOE Order 458.1(4)(b)(1) and (2)~~

Table 4-10. Potential ARARs and TBC Criteria for the Lower Three Runs IOU Feasibility Study *(Continued)*

ACTION -SPECIFIC ARARs/TBC *(cont'd)*			
Action	**Requirements**	**Prerequisite**	**Citation**
Waste Characterization and Storage — (e.g., excavated contaminated sediment/soil)			
Characterization of solid waste	Must determine if the solid waste is excluded from regulation under 40 *CFR* 261.4.	Generation of solid waste as defined in 40 *CFR* 261.2 – applicable.	40 *CFR* 262.11(a) SCDHEC R. 61-79 262.11*(a)*
	Must determine if waste is listed as hazardous waste in subpart D of 40 *CFR* Part 261.	Generation of solid waste which is not excluded under 40 *CFR* 261.4(a) – applicable.	40 *CFR* 262.11(b) SCDHEC R. 61-79 262.11*(b)*
	Must determine whether the waste is identified in subpart C of 40 *CFR* Part 261 by using prescribed testing methods or applying generator knowledge based on information regarding material or processes used.	Generation of solid waste that is not listed in subpart D of 40 *CFR* Part 261 and not excluded under 40 *CFR* 261.4 – applicable.	40 *CFR* 262.11(c) SCDHEC R. 61-79 262.11*(c)*
Characterization of LLW	Shall be characterized using direct or indirect methods and the characterization documented in sufficient detail to ensure safe management and compliance with the WAC of the receiving facility.	Generation of USDOE LLW – TBC.	USDOE M 435.1-1(IV)(I)
	Characterization data shall, at a minimum, include the following information relevant to management of the waste: • physical and chemical characteristics; • volume, including the waste and any stabilization or absorbent media; • weight of the container and contents; • identifies, activities, and concentration of major radionuclides; • characterization date; • generating source; and • any other information needed to prepare and maintain the disposal facility performance assessment, or demonstrate compliance with performance objectives.		USDOE M 435.1-1(IV)(I)(2)(a)-(g)

Table 4-10. Potential ARARs and TBC Criteria for the Lower Three Runs IOU Feasibility Study *(Continued/End)*

ACTION -SPECIFIC ARARs/TBC *(cont'd)*			
Action	**Requirements**	**Prerequisite**	**Citation**
Waste Treatment and Disposal — (e.g., excavated contaminated sediment/soil, debris)			
Disposal of solid waste	Shall ultimately dispose of solid waste at facilities and/or sites permitted or registered by the Department for processing or disposal of that waste stream.	Generation of solid waste intended for off-site disposal – relevant and appropriate.	SCDHEC R. 61-107.5(D)(3)
CHEMICAL-SPECIFIC ARARs			
Action/Media Characteristics	**Requirements**	**Prerequisite**	**Citation**
Removal of radionuclide-contaminated sediment/soil	Cleanups of radioactive contamination outside the risk range (in general, exceeding 12 millirem/year effective dose equivalent which equates to ~3E-04 increased lifetime cancer risk) are not protective.	Requires use of a risk range for developing cleanup standards for radioactive contamination – TBC.	USEPA OSWER Directive 9200.4-40

ALARA = As Low As Reasonably Achievable
OSWER = U.S. Environmental Protection Agency Office of Solid Waste and Emergency Response
ARAR = applicable or relevant and appropriate requirement
SCDHEC = South Carolina Department of Health and Environmental Control
CFR = Code of Federal Regulations
TBC = to be considered
CWA = Clean Water Act
USEPA = U.S. Environmental Protection Agency
NPDES = National Pollutant Discharge Elimination System

Table 4-11. Summary of the Comparative Analyses of the Alternatives

LTR IOU Alternatives	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-term Effectiveness	Reduction of Toxicity, Mobility, and Volume through Treatment	Short-term Effectiveness	Implementability	Cost
Alternatives That Apply to Entire Upper Subunit of the LTR IOU (EA1 thru EA9)							
A-1: No Action	None	No	None	None	None	None	$0
A-2: LUCs with MNR	High	Yes	High	None	High	Low Level of Effort	$17,321,141
EA by EA evaluation							
EA1: Pond A – Including R-Area Discharge Canal							
A-1: No Action	None	No	None	None	None	None	$0
A-2: LUCs with MNR	High	Yes	High	None	High	Low Level of Effort	*see Upper subunit
A-3: Capping of PTSM Sediment/Soil[1]	High	Yes	High	~~None~~ Yes	High	Moderate Level of Effort	$416,566
A-5: Excavation of PTSM Sediment/Soil[1]	High	Yes	High	~~None~~ Yes	Medium	High Level of Effort	$485,986
EA2: Canal from Pond A to Pond B							
A-1: No Action	None	No	None	None	None	None	$0
A-2: LUCs with MNR	High	Yes	High	None	High	Low Level of Effort	*see Upper subunit

Table 4-11. Summary of the Comparative Analyses of the Alternatives *(Continued)*

LTR IOU Alternatives	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-term Effectiveness	Reduction of Toxicity, Mobility, and Volume through Treatment	Short-term Effectiveness	Implementability	Cost
EA3: Pond B – Including Canal to Pond C							
A-1: No Action	None	No	None	None	None	None	$0
A-2: LUCs with MNR	High	Yes	High	None	High	Low Level of Effort	*see Upper subunit
A-3: Capping of PTSM Sediment/Soil[1]	High	Yes	High	~~None~~ Yes	High	High Level of Effort	$2,678,707
A-5: Excavation of PTSM Sediment/Soil[1]	High	Yes	High	~~None~~ Yes	Medium	High Level of Effort	$1,990,626
A-6: Maintain Pond Level[1]	High	Yes	High	None	High	Low Level of Effort	2,082,616
EA4: Canal from Pond B to North Arm of PAR Pond							
A-1: No Action	None	No	None	None	None	None	$0
A-2: LUCs with MNR	High	Yes	High	None	High	Low Level of Effort	*see Upper subunit
EA5: Joyce Branch (Old Discharge Canal)							
A-1: No Action	None	No	None	None	None	None	$0
A-2: LUCs with MNR[1]	High	Yes	High	None	High	Low Level of Effort	*see Upper subunit
A-3: Capping of PTSM Sediment/Soil[1]	High	Yes	High	~~None~~ Yes	High	Moderate Level of Effort	$805,190
A-5: Excavation of PTSM Sediment/Soil[1]	High	Yes	High	~~None~~ Yes	Medium	High Level of Effort	$795,537

Table 4-11. Summary of the Comparative Analyses of the Alternatives *(Continued/End)*

LTR IOU Alternatives	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-term Effectiveness	Reduction of Toxicity, Mobility, and Volume through Treatment	Short-term Effectiveness	Implementability	Cost
EA6: PAR Pond							
A-1: No Action	None	No	None	None	None	None	$0
A-2: LUCs with MNR	High	Yes	High	None	High	Low Level of Effort	*see Upper subunit
A-6: Maintain Pond Level[1]	High	Yes	High	None	High	Low Level of Effort	$2,835,922
EA7: Canal from P-Area to Ponds 4 and 5 – Including Pond 2							
A-1: No Action	None	No	None	None	None	None	$0
A-2: LUCs with MNR	High	Yes	High	None	High	Low Level of Effort	*see Upper subunit
EA8: Ponds 4 and 5 – Including Canal from Ponds 4 and 5 to Pond C							
A-1: No Action	None	No	None	None	None	None	$0
A-2: LUCs with MNR	High	Yes	High	None	High	Low Level of Effort	*see Upper subunit
EA9: Pond C							
A-1: No Action	None	No	None	None	None	None	$0
A-2: LUCs with MNR	High	Yes	High	None	High	Low Level of Effort	*see Upper subunit
A-6: Maintain Pond Level[1]	High	Yes	High	None	High	Low Level of Effort	$591,176

[1] Alternative is evaluated with under the condition that LUCs with MNR is also applied.
Note: Range is Low to High, where Low = worst and High = best.
ARAR = applicable or relevant and appropriate requirement.

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APPENDIX A

Detailed Cost Estimates

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Lower Three Runs — Integrator Operable Unit - Upper Section
A-2: Land Use Controls and Monitored Natural Recovery

Item	Quantity	Units	Unit Cost	Total Cost	
Direct Capital Costs					
Land Use Controls					
Posting of Warning Signs EA1	5	ea	$200	$1,000	At access points - approximately 5 per EA except where noted differently
Posting of Warning Signs EA2	5	ea	$200	$1,000	At access points - approximately 5 per EA except where noted differently
Posting of Warning Signs EA3	5	ea	$200	$1,000	At access points - approximately 5 per EA except where noted differently
Posting of Warning Signs EA4	5	ea	$200	$1,000	At access points - approximately 5 per EA except where noted differently
Posting of Warning Signs EA5	5	ea	$200	$1,000	At access points - approximately 5 per EA except where noted differently
Posting of Warning Signs EA6	50	ea	$200	$10,000	At access points - estimated and reviewed with JK
Posting of Warning Signs EA7	15	ea	$200	$3,000	At access points - estimated and reviewed with JK
Posting of Warning Signs EA8	7	ea	$200	$1,400	At access points - estimated and reviewed with JK
Posting of Warning Signs EA9	10	ea	$200	$2,000	At access points - estimated and reviewed with JK
Land Use Control Implementation Plan	1	ea	$30,000	$30,000	3 times the normal cost due to the number of exposure areas
Deed Restrictions	1	lf	$40,000	$40,000	A little more than 5 times the normal cost due to fish advisories and number of Eas
Monitoring - Initial					
Development of Monitoring Plan	1	ea	$40,000	$40,000	Reference Nobis Engineering NH-2423-2010 Table 12-2
Initial monitoring - Sediment sampling & analyses	36	ea	$1,000	$36,000	4 Locations per EA
Initial monitoring -Fish Sampling and Analyses	12	ea	$1,000	$12,000	4 samples per fishable Pond (B, C, and Par)
Initial monitoring - Deposition measurements	20	ea	$500	$10,000	4 samples per Pond (A, B, C, and Par, 4 &5)
Data analysis & Reporting	1	ea	$45,000	$45,000	Reference Nobis Engineering NH-2423-2010 Table 12-2
					Total number of signs is
Subtotal - Direct Capital Cost				$234,400	
Mobilization/Demobilization	10%	of subtotal direct capital		$23,440	Includes submittals, badging and training as well.
Site Preparation/Site Restoration	55%	of subtotal direct capital		$128,920	Includes GPR, site preparation, minor access roads, path clearing, boat usage, sample mobilizationetc.(See backup sheet).
Total Direct Capital Cost	(sum of * items)			**$386,760**	
Indirect Capital Costs					
Engineering & Design	15%	of direct capital		$58,014	Estimating Guideline Range 14-26%. Includes SU/SC sketches, placement sketches, workplan support (see backup sheet)
Project/Construction Management	5%	of direct capital		$19,338	Standard
Health & Safety	10%	of direct capital		$38,676	Increased percentage because of remote locations.
Overhead	30%	of direct capital		$116,028	Standard
Contingency	20%	of direct capital		$77,352	Standard
Total Indirect Capital Cost				**$309,408**	
Total Estimated Capital Cost				**$696,168**	
Direct O&M Costs					
Annual Costs (during implementation)	0.7%	discount rate for costs > 30 years duration[1]			
Access Controls	1	yr	$6,750	$6,750	Standard cost of $750 was ultiplied by 9 to account for the Eas
Subtotal - Annual Costs				$6,750	
Present Worth Annual Costs (-0.5% Discount Rate)				**$6,784**	
Annual Costs (Land Use Controls)	290 years O&M				Land Use Controls will last 290 years - until decay reaches 2x background
Access Controls	1	ea	$6,750	$6,750	Standard cost of $750 was ultiplied by 9 to account for the Eas
Subtotal - Annual Costs				$6,750	
Present Worth Annual Costs (0.7% Discount Rate)				**$830,925**	
Five Year Costs	58				
Inspections / Reporting (1 every 5 years)	1	ea	$13,500	$13,500	Assume 2 inspectors ($45/hr) for 15 days/10 hr days (Big ponds assume 3 days each, other Eas 1 day each)
Path Maintenance /Vegetation Removal for Access	1	ea	$13,500	$13,500	Assume 2 workers for 15 days/10 hr days (Big ponds assume 3 days each, other Eas 1 day each)
Sign Maintenance / Repairs (1 per year) Allowance	1	ea	$13,500	$13,500	Assume 2 workers to accompany inspectors for 15 days/10 hr days
Remedy Review	1	ea	$100,000	$100,000	Standard remedy review cost of $20,000 multiplied by 5 to account for large number of EA s and review of MNR data
Subtotal - Five Year O&M Costs				$140,500	
Present Worth Annual Costs (0.7% Discount Rate)				**$6,632,276**	
MNR Costs (every 5 years for 50 years)	10				
Review/revise Monitoring Plan	1	ea	$25,000	$25,000	Engineering review/revision of monitoring plan - assume slightly more than half of development cost ($40k)
Sediment sampling & analyses	36	ea	$1,000	$36,000	Costs are estimated for sediment sampling, however gamma overflight data may be used in lieu of sampling.
Fish Sampling and Analyses	12	ea	$1,000	$12,000	Sampling costs include transportation to site, sample collection, sample analyses, boat costs, radcon support
Deposition measurements	20	ea	$500	$10,000	Deposition measurements can be collected during sediment and fish sampling
Data evaluation & Reporting	1	ea	$45,000	$45,000	Reporting assumed to be in addition to 5-yr remedy review
				$128,000	
Present Worth Five Year Costs				$1,280,000	
Total Present Worth Direct O&M Cost				**$8,749,986**	
Indirect O&M Costs					
Project/Admin Management	25%	of direct O&M		$2,187,496	0.05 FTE/YEAR $75 PER HR 2500 HR/YR $2,718,750 Approximate
Health & Safety	20%	of direct O&M		$1,749,997	0.05 FTE/YEAR $45 PER HR 2500 HR/YR $1,631,250 Approximate
Overhead	30%	of direct O&M		$2,624,996	
Contingency	15%	of direct O&M		$1,312,498	
Total Estimated Present Worth Indirect O&M Cost				**$7,874,987**	
Total Estimated Present Worth O&M Cost				**$16,624,973**	
TOTAL ESTIMATED COST				**$17,321,141**	

1. Interest rate from OMB Cirular No A-94 (December 12, 2016)

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Lower Three Runs — Integrator Operable Unit - Upper Section
A-3: In Situ Capping on PTSM Sediments (Hybrid Cap Design)
EA-1 Pond A — Including R Discharge Canal

Item	Quantity	Units	Unit Cost	Total Cost	Notes
Direct Capital Costs					
Sampling to define extent of PTSM in R-Canal					
Sample Analysis	20	ea	$1,500	$30,000	Approximately 1 sample every 30 meters
Labor for sampling	4	days	$2,250	$9,000	2 samplers, 2 radcon, 1 health and safety for 10 hours per day = ($45/hr x 5 people x 10 hr /day) = $2250/day
Cap Design/Treatability Study to determine Amendment	1	ea	$75,000	$75,000	Research has been done by SRNL, so this should just be a report to establish the dose and spec the material
Mobilization/Demobilization	1	ea	$4,000	$4,000	Includes bringing in mini excavator, two bobcats/backhoes, staging sand & aggregate material, removing & disposal of silt curtain
Clear/stage/ship vegetation (rad waste)	108	ft^2			Removal of vegetation tree debris required prior to cap placement.
Mini - excavator with long reach & clam shell	1	week	$1,000	$1,000	assume that a mini excavator with long reach clamshell can operate from dry land
Labor - operator	30	hrs	$100	$3,000	Assume one operator for 30 hours per week. 1 day to mobilize & prejob brief, on day to remove vegetation, one day to decon & demobilize
General Laborer	60	hrs	$45	$2,700	Two laborers required to set up staging, dewatering for vegetation, place in roll off with burrito bags
Truck driver	10	hrs	$50	$500	Vegetation is assumed to require 2 roll off pans with two trips to E-Area (3 hr round trip includes wait time)
Radcon	60	hrs	$75	$4,500	2 radcon assumed for support of vegetation removeal and burrito bag preparation for shipping
Amendment Material and Placement	108	ft^2	$11	$1,210.68	Unit cost is for a 1 acre site from NAVFAC cost estimate ER-201131
Sand Material Cost	54	ft^3	$2	$108	0.5 ft of sand assumed to be adequate (price includes shipping)
Aggregate Material Cost	54	ft^3	$3	$176	0.5 ft of aggregate assumed to be adequate (price includes shipping)
Equipment Cost	3	days	$400	$1,200	Bobcat front end loader may be sufficient
Placement Cost	3	days	$4,400	$13,200	(2 operators x $50/hr + 1 superintendent $100/hr +2 radcon $75/hr + 2 laborers $45/hr) x 10 hr/day = $4,400/day
Install silt curtain	25	ft	$17	$413	Per "The Balance" turbidity barrier material and installtion costs are 8.25/lf - double based on SRS factor and small area
Post installation verification/survey thickness verification	1	ea	$2,300	$2,300	Survey cost based on Seth's estimate for project 01293250
Subtotal - Direct Capital Cost				$148,307	
Mobilization/Demobilization	5%	of subtotal direct capital		$7,415	Includes laydown preparation, badging, radworker training
Site Preparation/Site Restoration	2%	of subtotal direct capital		$2,966	Includes submittals, workpackage development, acceptance walkdowns
Total Direct Capital Cost		(sum of * items)		**$158,688**	
Indirect Capital Costs					
Engineering & Design	20%	of direct capital		$31,738	Estimating Guideline Range 14-26%. Includes engineering review and development of maintenance criteria
Project/Construction Management	25%	of direct capital		$39,672	Standard
Health & Safety	10%	of direct capital		$15,869	Health and safety review and sign off on procedures
Overhead	30%	of direct capital		$47,606	Standard
Contingency	20%	of direct capital		$31,738	Standard
Total Indirect Capital Cost				**$166,623**	
Total Estimated Capital Cost				**$325,311**	
Direct O&M Costs (over 290 years)					
Annual Costs (yearly costs over 290 years) - None. See Five Year Costs.	0.7%	discount rate for costs > 30 years duration[1]			
	50	Years O&M			
Subtotal - Annual Costs				$0	
Present Worth Annual Costs (0.7% Discount Rate)				**$0**	
Subtotal - Annual Costs				$0	
Five Year Costs	10				
Cap inspection/Maintenance (LUCs & remedy reviews are in A-2 costs)	1	ea	$5,000	$5,000	Cap inspection includes measuring the the thickness of the cap. Maintenance includes adding additional sand or stone
Subtotal - Five Year O&M Costs				$5,000	Cap inspection and maintenance is outside of MNR scope
Present Worth Five Year Costs				$41,480	
Total Present Worth Direct O&M Cost				**$41,480**	
Indirect O&M Costs					
Project/Admin Management	45%	of direct O&M		$18,666	0.02 FTE/YR $75 PER HR 1250 HR/YR $18,750 Approximate
Health & Safety	30%	of direct O&M		$12,444	0.02 FTE/YR $45 PER HR 1250 HR/YR $11,250 Approximate
Overhead	30%	of direct O&M		$12,444	
Contingency	15%	of direct O&M		$6,222	
Total Estimated Present Worth Indirect O&M Cost				**$49,776**	
Total Estimated Present Worth O&M Cost				**$91,256**	
TOTAL ESTIMATED COST				**$416,566**	

1. Interest rate from OMB Circular No. A-94 (December 12, 2016)
2. In addition to costs associated with this alternative, LUCs with MNR and five-year remedy reviews for the entire Upper subunit is estimated at ~$17 M (refer to details in Alternative A-2)

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Lower Three Runs — Integrator Operable Unit - Upper Section
A-5: Excavation of PTSM Sediments
EA-1 Pond A — Including R Discharge Canal

Item	Quantity	Units	Unit Cost	Total Cost	
Direct Capital Costs					
Regulatory Documents and Work Planning	1	ea	$50,000	$50,000	Develop RAIP, sampling plan, workpackages
Sampling to define extent of PTSM in R-Canal					
Sample Analysis	20	ea	$1,500	$30,000	Approximately 1 sample every 30 meters
Labor for sampling	4	days	$2,250	$9,000	2 samplers, 2 radcon, 1 health and safety for 10 hours per day = ($45/hr x 5 people x 10 hr /day) = $2250/day
Mobilization/Demobilization	1	ea	$3,500	$3,500	Includes bringing in mini excavator, two bobcats/backhoes, removing & disposal of silt curtain
Clearing for roll off pan laydown yard	0.5	acre	$4,197	$2,099	Unit cost for clearing and grubbining from 488-1D estimate
Site Prep for roll of pan laydown yard	0.5	acre	$14,000	$7,000	grade to provided containment bem, lay crusher run, etc... (crusher run volume = 202 cy - cost $6722
Access road improvements - widening	1750	ft	$34	$58,958	From GOSB estimate for access road improvments (cost includes canal prep for equipment access and temporary bridge for equipment)
Clear/stage/ship vegetation (rad waste)	108	ft^2			Removal of vegetation tree debris required prior to cap placement.
Mini - excavator with long reach & clam shell	1	week	$1,000	$1,000	assume that a mini excavator with long reach clamshell can operate from dry land
Labor - operator	30	hrs	$100	$3,000	Assume one operator for 30 hours per week. 1 day to mobilize & prejob brief, on day to remove vegetation, one day to decon & demobilize
General Laborer	60	hrs	$45	$2,700	Two laborers required to set up staging, dewatering for vegetation, place in roll off with burrito bags
Truck driver	5	hrs	$50	$250	Vegetation is assumed to require 2 roll off pans with two trips to E-Area (3 hr round trip includes wait time)
Radcon	60	hrs	$75	$4,500	2 radcon assumed for support of vegetation removeal and burrito bag preparation for shipping
Equipment Cost- Sediment Excavation					
Excavator Rental	1	week	$1,500	$1,500	3 days to include mobilization, excavation and decontamination
Roll Off pan	2	ea	$400	$800	
truck contaminated sediments to E-Area	13	cy	$220	$2,860	20 mile round trip ((1.5 hrs x $45/hr)*1 turck + truck rental $500/day x 2 days) x 2 radcon@$45/hr x 20 hrs = $2868
Dewater roll offs - burrito wrap for transport	2	ea	$2,700	$5,400	Assume 2 radcon $45/hr and 2 laborers $45/hr all for 30 hours
Install silt curtain	25	ft	$17	$413	Per "The Balance" turbidity barrier material and installtion costs are 8.25/ff - double based on SRS factor and small area
Post excavation sampling/surveying	1	ea	$2,300	$2,300	Survey cost based on Seth's estimate for project 01293250
Subtotal - Direct Capital Cost				$185,279	
Mobilization/Demobilization	12%	of subtotal direct capital		$22,233	Includes badging, radworker training
Site Preparation/Site Restoration	10%	of subtotal direct capital		$18,528	Includes submittals, workpackage development, acceptance walkdowns
Total Direct Capital Cost		(sum of * items)		**$226,040**	
Indirect Capital Costs					
Engineering & Design	25%	of direct capital		$56,510	Estimating Guideline Range 14-26%. Includes engineering review and development of maintenance criteria
Project/Construction Management	25%	of direct capital		$56,510	Standard
Health & Safety	15%	of direct capital		$33,906	Health and safety review and sign off on procedures
Overhead	30%	of direct capital		$67,812	Standard
Contingency	20%	of direct capital		$45,208	Standard
Total Indirect Capital Cost				**$259,946**	
Total Estimated Capital Cost				**$485,986**	
Direct O&M Costs (over 290 years)					
Annual Costs (yearly costs over 290 years)	0.7%	discount rate for costs > 30 years duration [1]			
Subtotal - Annual Costs				$0	
Five Year Costs	10				
LUCs and remedy reviews are included in A-2		ea		$0	
Present Worth Five Year Costs				$0	
Total Present Worth Direct O&M Cost				**$0**	
Indirect O&M Costs					
Project/Admin Management	90%	of direct O&M		$0	0.05 FTE/YEAR $75 PER HR 1250 HR/YR $46,875 Approximal doubled this due to huge dam construction project
Health & Safety	50%	of direct O&M		$0	0.05 FTE/YEAR $45 PER HR 1250 HR/YR $28,125 Approximal doubled this due to huge dam construction project
Overhead	30%	of direct O&M		$0	
Contingency	15%	of direct O&M		$0	
Total Estimated Present Worth O&M Cost				**$0**	
TOTAL ESTIMATED COST				**$485,986**	

1. Interest rate from OMB Circular No. A-94 (December 12, 2016)
2. <u>In addition to costs associated with this alternative, LUCs with MNR and five-year remedy reviews for the entire Upper subunit is estimated at ~$17 M (refer to details in Alternative A-2)</u>

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Lower Three Runs — Integrator Operable Unit - Upper Section
A-3: In Situ Capping on PTSM Sediments (Hybrid Cap Design)
EA-3 Pond B

Item	Quantity	Units	Unit Cost	Total Cost	
Direct Capital Costs					
Sampling to define extent of PTSM in R-Canal					
Sample Analysis	40	ea	$1,500	$60,000	Approximately 1 sample every 30 meters
Labor for sampling	8	days	$2,250	$18,000	2 samplers, 2 radcon, 1 health and safety for 10 hours per day = ($45/hr x 5 people x 10 hr /day) = $2250/day
Boat/equipment	14	days	$300	$4,200	Assume use of SRS boat. Costs include gass/maintenance and inspection during use.
Bathymetry survey - survey of stumps debris - design of cap	2152	ft^2	$50	$107,600	Use underwater camera, survey instrumentation to define subsurface conditions prior to cap construction, develop cap design
Cap Design/Treatability Study to determine Amendment	1	ea	$100,000	$100,000	Research has been done by SRNL, so this should just be a report to establish the dose and spec the material. Increased cost due to 30 ft depth
Mobilization/Demobilization	1	ea	$500,000	$500,000	Cost from papers range from $300,000 (2004 in LA) to ($600,000 in 2010 in MA)
Amendment Material and Placement	2152	ft^2	$11	$24,124	Unit cost is for a 1 acre site from NAVFAC cost estimate ER-201131
Sand Material Cost	1076	ft^3	$2	$2,152	0.5 ft of sand assumed to be adequate (price includes shipping)
Aggregate Material Cost	1076	ft^3	$3	$3,497	0.5 ft of aggregate assumed to be adequate (price includes shipping)
Equipment Cost Barge	4	weeks	$20,000	$80,000	One barge for crane (cost is estimated using NH-2423-2010 Table 12-5)
Equipment Cost Front End Loader	4	weeks	$1,050	$4,200	Front end loader to load sand cost is estimated using NH-2423-2010 Table 12-5)
Equipment Cost Crane	4	weeks	$3,000	$12,000	Crane with clam shell to place sand cost is estimated using NH-2423-2010 Table 12-5)
Labor costs					
Crane Operator	4	weeks	$4,000	$16,000	Assume $100/hr 40 hr/week cost is estimated using NH-2423-2010 Table 12-5)
Front end loader operator	4	weeks	$2,400	$9,600	Assume $60/hr 40 hr/week cost is estimated using NH-2423-2010 Table 12-5)
work boat operator	4	weeks	$4,000	$16,000	Assume $100/hr 40 hr/week cost is estimated using NH-2423-2010 Table 12-5)
general laborors	20	days	$2,990	$59,800	(4 laborors x $45/hr + 1 manager $75/hr +2 radcon $45/hr) x 10 hr/day = $2,550/day
Placement Cost	20	days	$4,400	$88,000	(2 operators x $50/hr + 1 superintendent $100/hr +2 radcon $75/hr + 2 laborers $45/hr) x 10 hr/day = $4,400/day
Install silt curtain	800	ft	$26	$20,800	Per "The Balance" turbidity barrier material and installtion costs are 8.25/lf - double based on SRS factor and small area
Post Installation Confirmation Sampling	10	ea	$500	$5,000	
Subtotal - Direct Capital Cost				$1,130,973	
Mobilization/Demobilization	10%	of subtotal direct capital		$113,097	Includes laydown preparation, badging, radworker training
Site Preparation/Site Restoration	5%	of subtotal direct capital		$56,549	Includes submittals, workpackage development, acceptance walkdowns
Total Direct Capital Cost		(sum of * items)		**$1,300,619**	
Indirect Capital Costs					
Engineering & Design	15%	of direct capital		$195,093	Estimating Guideline Range 14-26%. Includes engineering review and development of maintenance criteria
Project/Construction Management	25%	of direct capital		$325,155	Standard
Health & Safety	5%	of direct capital		$65,031	Health and safety review and sign off on procedures
Overhead	30%	of direct capital		$390,186	Standard
Contingency	20%	of direct capital		$260,124	Standard
Total Indirect Capital Cost				**$1,235,588**	
Total Estimated Capital Cost				**$2,536,207**	
Direct O&M Costs (over 290 years)					
Annual Costs (yearly costs over 290 years)	0.7%	discount rate for costs > 30 years duration[1]			
	50	Years O&M			
Subtotal - Annual Costs				$0	
Present Worth Annual Costs (0.7% Discount Rate)				**$0**	
Subtotal - Annual Costs				$0	
Five Year Costs	10				
Cap inspection/Maintenance (LUCs and remedy review included in A-2)	1	ea	$5,000	$5,000	Cap inspection includes measuring the the thickness of the cap. Maintenance includes adding additional sand or stone
Subtotal - Five Year O&M Costs				$5,000	Cap inspection and maintenance is outside of MNR scope
Present Worth Five Year Costs				$50,000	
Total Present Worth Direct O&M Cost				**$50,000**	
Indirect O&M Costs					
Project/Admin Management	90%	of direct O&M		$45,000	0.05 FTE/YR $75 PER HR 1250 HR/YR $46,875 Approximate
Health & Safety	50%	of direct O&M		$25,000	0.05 FTE/YR $45 PER HR 1250 HR/YR $28,125 Approximate
Overhead	30%	of direct O&M		$15,000	
Contingency	15%	of direct O&M		$7,500	
Total Estimated Present Worth O&M Cost				**$92,500**	

1. Interest rate from OMB Circular No. A-94 (December 12, 2016)
2. In addition to costs associated with this alternative, LUCs with MNR and five-year remedy reviews for the entire Upper subunit is estimated at ~$17 M (refer to details in Alternative A-2)

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Lower Three Runs — Integrator Operable Unit - Upper Section
A-5: Excavation of PTSM Sediments
EA-3 Pond B

Item	Quantity	Units	Unit Cost	Total Cost		Notes
Direct Capital Costs						
Regulatory Documents and Work Planning	1		$50,000	$50,000		Develop RAIP, sampling plan, workpackages
Sampling to define extent of PTSM in Pond B						
Sample Analysis	40	ea	$1,500	$60,000		Approximately 1 sample every 30 meters
Labor for sampling	8	days	$2,250	$18,000		2 samplers, 2 radcon, 1 health and safety for 10 hours per day = ($45/hr x 5 people x 10 hr /day) = $2250/day
Boat/equipment	14	days	$300	$4,200		
Bathymetry survey - survey of stumps debris -	2152	ft^2	$25	$53,800	100 m^2	Use underwater camera, survey instrumentation to define subsurface conditions prior to cap construction, develop cap design
Clearing for roll off pan laydown yard	0.5	acre	$4,197	$2,098.50		Unit cost for clearing and grubbining from 488-1D estimate
Site Prep for roll of pan laydown yard	0.5	acre	$14,000	$7,000		grade to provided containment berm, lay crusher run, etc... (crusher run volume = 202 cy - cost $6722
Mobilization/demobilization for Dredging Equipment	1	ea	$600,000	$600,000		Used cost in Nyanza Chemical Waste Dump Table 12-7 OF NH-2423-2010 - cost will be significant since it is overland vs. shore transportation
Sediment Dredging	262	cy	$44	$11,528		Used cost in Nyanza Chemical Waste Dump Table 12-7 OF NH-2423-2010 - doubled estimate due to economy of scale
Sediment Dewatering	262	cy	$100	$26,200		Used cost in Nyanza Chemical Waste Dump Table 12-7 OF NH-2423-2010 - doubled estimate due to rad waste
Sediment dredging support	262	cy	$36	$9,432		Used cost in Nyanza Chemical Waste Dump Table 12-7 OF NH-2423-2010 - doubled estimate due to rad waste
Dredge material disposal Labor costs						
Haul roll offs to E-Area	1	weeks	$7,800	$7,800		20 mile round trip ((1.5 hrs x $45/hr)*17 + truck rental $500/day x 6 days) x 2 radcon@$45/hr x 40 hrs = $7750
work boat operator	1	weeks	$4,000	$4,000		Assume $100/hr 40 hr/week cost is estimated using NH-2423-2010 Table 12-5)
general laborors	14	days	$2,990	$41,860		(4 laborors x $45/hr + 1 manager $75/hr +2 radcon $45/hr) x 10 hr/day = $2,550/day
Install silt curtain	800	ft	$26	$20,800		Per email from Bill Adams on 030718 Enviro-USA, price is $25.84/lf. Increased lf of curtain to allow for equipment maneuvering.
Dewater roll offs - burrito wrap for transport	17	ea	$750	$12,750		Assume 2 radcon $45/hr and 2 laborers $45/hr all for 4 hours per roll off
Excavation Verification Sampling	4	ea	$4,000	$16,000		Sampling cost is combination of detailed sampling costs to define extent.
Subtotal - Direct Capital Cost				$895,469		
Mobilization/Demobilization	10%	of subtotal direct capital		$89,547		Includes badging, radworker training
Site Preparation/Site Restoration	7%	of subtotal direct capital		$62,683		Includes submittals, workpackage development, acceptance walkdowns
Total Direct Capital Cost		(sum of * items)		**$1,047,698**		
Indirect Capital Costs						
Engineering & Design	15%	of direct capital		$157,155		Estimating Guideline Range 14-26%. Includes engineering review and development of maintenance criteria - Dredging permits may be required- SWPPP?
Project/Construction Management	15%	of direct capital		$157,155		Reduced - estimated to be 0.4 FTE X 2500 HR/YR X 2 YR X $75/HR
Health & Safety	10%	of direct capital		$104,770		Health and safety review and sign off on procedures
Overhead	30%	of direct capital		$314,309		Standard
Contingency	20%	of direct capital		$209,540		Standard
Total Indirect Capital Cost				**$942,928**		
Total Estimated Capital Cost				**$1,990,626**		
Direct O&M Costs (over 290 years)						
Annual Costs (yearly costs over 290 years)	0.7%	discount rate for costs > 30 years duration [1]				
	50	Years O&M				
Subtotal - Annual Costs				$0		
Present Worth Annual Costs (0.7% Discount Rate)				**$0**		
Subtotal - Annual Costs				$0		
Five Year Costs	10					
LUCs and remedy reviews are included in A-2		ea		$0		Cap inspection includes measuring the the thickness of the cap. Maintenance includes adding additional sand or stone
Subtotal - Five Year O&M Costs				$0		Cap inspection and maintenance is outside of MNR scope
Present Worth Five Year Costs				$0		
Total Present Worth Direct O&M Cost				**$0**		
Indirect O&M Costs						
Total Estimated Present Worth O&M Cost				**$0**		
TOTAL ESTIMATED COST				**$1,990,626**		

1. Interest rate from OMB Circular No. A-94 (December 12, 2016)
2. In addition to costs associated with this alternative, LUCs with MNR and five-year remedy reviews for the entire Upper subunit is estimated at ~$17 M (refer to details in Alternative A-2)

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Lower Three Runs — Integrator Operable Unit - Upper Section
A-6: Maintain Water in Ponds for EA-3 – Pond B

Item	Quantity	Units	Unit Cost	Total Cost	
Direct Capital Costs					
No physical activites					
Establish Procedures MOU to concur with ROD requirements	1	ea	$10,000	$10,000	Establish formal internal documents to ensure dam maintenance complies with ROD
	1	ea	$0	$0	
Subtotal - Direct Capital Cost				$10,000	
Mobilization/Demobilization	0%	of subtotal direct capital		$0	
Site Preparation/Site Restoration	0%	of subtotal direct capital		$0	
Total Direct Capital Cost		(sum of * items)		**$10,000**	
Indirect Capital Costs					
Engineering & Design	15%	of direct capital		$1,500	Estimating Guideline Range 14-26%. Includes engineering review and development of maintenance criteria
Project/Construction Management	15%	of direct capital		$1,500	Standard
Health & Safety	5%	of direct capital		$500	Health and safety review and sign off on procedures
Overhead	30%	of direct capital		$3,000	Standard
Contingency	20%	of direct capital		$2,000	Standard
Total Indirect Capital Cost				**$8,500**	
Total Estimated Capital Cost				**$18,500**	
Direct O&M Costs (over 290 years)					
Annual Costs (yearly costs over 290 years)	0.7%	discount rate for costs > 30 years duration[1]			
	50	Years O&M			
Baseline Dam Program & Minor Maintainance Pond B	1	yr	$37,050	$37,050	Average of costs provided by SI for FY15-FY17 (SEE WORKSHEET FROM SI)
Assume one signifcant repair per year between both dams	1	yr	$62,000	$62,000	Average of costs provided by SI for FY15-FY17 (SEE WORKSHEET FROM SI)
Subtotal - Annual Costs				$99,050	
Present Worth Annual Costs (0.7% Discount Rate)				**$1,366,964**	
Five Year Costs					
Remedy Review (Included in A-2 LUCs and MNA)	0	ea	$0	$0	
Subtotal - Five Year O&M Costs				$0	
Present Worth Five Year Costs				$0	
Total Present Worth Direct O&M Cost				**$1,366,964**	
Indirect O&M Costs					
Project/Admin Management	4%	of direct O&M		$54,679	0.005 FTE/YR $75 PER HR 2500 HR/YR $46,875 Approximate
Health & Safety	2%	of direct O&M		$27,339	0.005 FTE/YR $45 PER HR 2500 HR/YR $28,125 Approximate
Overhead	30%	of direct O&M		$410,089	
Contingency	15%	of direct O&M		$205,045	
Total Estimated Present Worth Indirect O&M Cost				**$697,152**	
Total Estimated Present Worth O&M Cost				**$2,064,116**	
TOTAL ESTIMATED COST				**$2,082,616**	

1. Interest rate from OMB Circular No. A-94 (December 12, 2016)
2. <u>In addition to costs associated with this alternative, LUCs with MNR and five-year remedy reviews for the entire Upper subunit is estimated at ~$17 M (refer to details in Alternative A-2)</u>

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Lower Three Runs — Integrator Operable Unit - Upper Section
A-3: In Situ Capping on PTSM Sediments (Hybrid Cap Design)
EA-5 Joyce Branch

Item	Quantity	Units	Unit Cost	Total Cost	
Direct Capital Costs					
Sampling to define extent of PTSM in R-Canal					
Sample Analysis	20	ea	$1,500	$30,000	Approximately 1 sample every 30 meters
Labor for sampling	4	days	$2,250	$9,000	2 samplers, 2 radcon, 1 health and safety for 10 hours per day = ($45/hr x 5 people x 10 hr /day) = $2250/day
Mobilization/Demobilization	1	ea	$4,000	$4,000	Includes bringing in mini excavator, two bobcats/backhoes, staging sand & aggregate material, removing & disposal of silt curtain
Create epuipment access path to Joyce Branch	400	ft	$300	$120,000	Clearing, crane mat for path stability, placement of temporary bridge similar to LTR tail excavation. (used $300/ft due to crane mat cost - $450 per mat to buy but can rent/sell back. Each mat is about 2 ft long)
Cap Design/Treatability Study to determine Amendment	1	ea	$75,000	$75,000	Research has been done by SRNL, so this should just be a report to establish the dose and spec the material
Clear/stage/ship vegetation (rad waste)	216	ft^2			
Mini - excavator with long reach & clam shell	2	week	$1,000	$2,000	assume that a mini excavator with long reach clamshell can operate from dry land
Labor - operator	60	hrs	$100	$6,000	Assume one operator for 30 hours per week. 1 day to mobilize & prejob brief, on day to remove vegetation, one day to decon & demobilize
General Laborer	120	hrs	$45	$5,400	Two laborers required to set up staging, dewatering for vegetation, place in roll off with burrito bags
Truck driver	10	hrs	$50	$500	Vegetation is assumed to require 2 roll off pans with two trips to E-Area (3 hr round trip includes wait time)
Radcon	120	hrs	$75	$9,000	2 radcon assumed for support of vegetation removeal and burrito bag preparation for shipping
Amendment Material and Placement	216	ft^2	$11	$2,421	Unit cost is for a 1 acre site from NAVFAC cost estimate ER-201131
Sand Material Cost	108	ft^3	$2	$216	0.5 ft of sand assumed to be adequate (price includes shipping)
Aggregate Material Cost	108	ft^3	$3	$351	0.5 ft of aggregate assumed to be adequate (price includes shipping)
Equipment Cost	12	days	$800	$9,600	Assume two bobcats/front end loaders to place sand/aggregate $400/day each
Placement Cost	12	days	$2,550	$30,600	(2 operators x $45/hr + 1 manager $75/hr +2 radcon $45/hr) x 10 hr/day = $2,550/day
Install silt curtain	25	ft	$17	$413	Per "The Balance" turbidity barrier material and installtion costs are 8.25/lf - double based on SRS factor and small area
Post installation verification/survey thickness verification	1	ea	$2,300	$2,300	Survey cost based on Seth's estimate for project 01293250
Subtotal - Direct Capital Cost				$306,801	
Mobilization/Demobilization	5%	of subtotal direct capital		$15,340	Includes laydown preparation, badging, radworker training
Site Preparation/Site Restoration	3%	of subtotal direct capital		$9,204	Includes submittals, workpackage development, acceptance walkdowns
Total Direct Capital Cost		(sum of * items)		**$331,345**	
Indirect Capital Costs					
Engineering & Design	15%	of direct capital		$49,702	Estimating Guideline Range 14-26%. Includes engineering review and development of maintenance criteria
Project/Construction Management	25%	of direct capital		$82,836	Standard
Health & Safety	10%	of direct capital		$33,134	Health and safety review and sign off on procedures
Overhead	30%	of direct capital		$99,403	Standard
Contingency	20%	of direct capital		$66,269	Standard
Total Indirect Capital Cost				**$331,345**	
Total Estimated Capital Cost				**$662,690**	
Direct O&M Costs (over 290 years)					
Annual Costs (yearly costs over 290 years)	0.7%	discount rate for costs > 30 years duration[1]			
	50	Years O&M			
Subtotal - Annual Costs				$0	
Present Worth Annual Costs (0.7% Discount Rate)				**$0**	
Subtotal - Annual Costs				$0	
Five Year Costs	10				
Cap inspection/Maintenance (LUCs and remedy review included in A-2)	1	ea	$5,000	$5,000	Cap inspection includes measuring the the thickness of the cap. Maintenance includes adding additional sand or stone
Subtotal - Five Year O&M Costs				$5,000	Cap inspection and maintenance is outside of MNR scope
Present Worth Five Year Costs				$50,000	
Total Present Worth Direct O&M Cost				**$50,000**	
Indirect O&M Costs					
Project/Admin Management	90%	of direct O&M		$45,000	0.05 FTE/YR $75 PER HR 1250 HR/YR $46,875 Approximate
Health & Safety	50%	of direct O&M		$25,000	0.05 FTE/YR $45 PER HR 1250 HR/YR $28,125 Approximate
Overhead	30%	of direct O&M		$15,000	
Contingency	15%	of direct O&M		$7,500	
Total Estimated Present Worth Indirect O&M Cost				**$92,500**	
Total Estimated Present Worth O&M Cost				**$142,500**	
TOTAL ESTIMATED COST				**$805,190**	

1. Interest rate from OMB Circular No. A-94 (December 12, 2016)
2. In addition to costs associated with this alternative, LUCs with MNR and five-year remedy reviews for the entire Upper subunit is estimated at ~$17 M (refer to details in Alternative A-2)

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Lower Three Runs — Integrator Operable Unit - Upper Section
A-5: Excavation of PTSM Sediments
EA-5 Joyce Branch

Item	Quantity	Units	Unit Cost	Total Cost	
Direct Capital Costs					
Regulatory Documents and Work Planning	1		$50,000	$50,000	Develop RAIP, sampling plan, workpackages
Sampling to define extent of PTSM in Joyce Branch					
Sample Analysis	20	ea	$1,500	$30,000	Approximately 1 sample every 30 meters
Labor for sampling	4	days	$2,250	$9,000	2 samplers, 2 radcon, 1 health and safety for 10 hours per day = ($45/hr x 5 people x 10 hr /day) = $2250/day
Mobilization/Demobilization	1	ea	$3,500	$3,500	Includes bringing in mini excavator, two bobcats/backhoes, removing & disposal of silt curtain
Create epuipment access path to Joyce Branch	400	ft	$300	$120,000	Clearing, crane mat for path stability, placement of temporary bridge similar to LTR tail excavation
Clearing for roll off pan laydown yard	0.5	acre	$4,197	$2,099	Unit cost for clearing and grubbining from 488-1D estimate
Site Prep for roll of pan laydown yard	0.5	acre	$14,000	$7,000	grade to provided containment berm, lay crusher run, etc... (crusher run volume = 202 cy - cost $6722
Access road improvements - widening	2700	ft	$34	$90,963	From GOSB estimate for access road improvments (cost includes canal prep for equipment access and temporary bridge for equipment)
Clear/stage/ship vegetation (rad waste)	216	ft^2			Area of PTSM is assumed to be 20 square meters = 215 sq ft
Mini - excavator with long reach & clam shell	2	week	$1,000	$2,000	assume that a mini excavator with long reach clamshell can operate from dry land
Labor - operator	60	hrs	$100	$6,000	Assume one operator for 30 hours per week. 1 day to mobilize & prejob brief, on day to remove vegetation, one day to decon & demobilize
General Laborer	120	hrs	$45	$5,400	Two laborers required to set up staging, dewatering for vegetation, place in roll off with burrito bags
Truck driver	10	hrs	$50	$500	Vegetation is assumed to require 2 roll off pans with two trips to E-Area (3 hr round trip includes wait time)
Radcon	120	hrs	$75	$9,000	2 radcon assumed for support of vegetation removeal and burrito bag preparation for shipping
Equipment Cost (sediment excavation)					
Excavator Rental	2	week	$1,500	$3,000	3 days to include mobilization, excavation and decontamination
Roll Off pan	2	ea	$400	$800	Roll off pans - assume 15 cy each
truck contaminated sediments to E-Area	26	cy	$180	$4,680	20 mile round trip ((1.5 hrs x $45/hr)*2 + truck rental $500/day x 3 days) x 2 radcon@$45/hr x 30 hrs = $4335 total
Dewater roll offs - burrito wrap for transport	4	ea	$2,700	$10,800	Assume 2 radcon $45/hr and 2 laborers $45/hr all for 30 hours
Install silt curtain	50	ft	$17	$825	Per "The Balance" turbidity barrier material and installtion costs are 8.25/lf - double based on SRS factor and small area
Post excavation sampling/surveying	1	ea	$2,300	$2,300	Survey cost based on Seth's estimate for project 01293250
Subtotal - Direct Capital Cost				$357,867	
Mobilization/Demobilization	10%	of subtotal direct capital		$35,787	Includes badging, radworker training
Site Preparation/Site Restoration	7%	of subtotal direct capital		$25,051	Includes submittals, workpackage development, acceptance walkdowns
Total Direct Capital Cost		(sum of * items)		**$418,704**	
Indirect Capital Costs					
Engineering & Design	15%	of direct capital		$62,806	Estimating Guideline Range 14-26%. Includes engineering review and development of maintenance criteria - SWPPP prep
Project/Construction Management	15%	of direct capital		$62,806	Reduced due to similar costs associated with EA-1
Health & Safety	10%	of direct capital		$41,870	Health and safety review and sign off on procedures
Overhead	30%	of direct capital		$125,611	Standard
Contingency	20%	of direct capital		$83,741	Standard
Total Indirect Capital Cost				**$376,833**	
Total Estimated Capital Cost				**$795,537**	
Direct O&M Costs (over 290 years)					
Annual Costs (yearly costs over 290 years)	0.7%	discount rate for costs > 30 years duration [1]			
	50	Years O&M			
Subtotal - Annual Costs				$0	
Present Worth Annual Costs (0.7% Discount Rate)				**$0**	
Subtotal - Annual Costs				$0	
Five Year Costs	10				
LUCs and remedy reviews are included in A-2		ea		$0	Cap inspection includes measuring the the thickness of the cap. Maintenance includes adding additional sand or stone
Subtotal - Five Year O&M Costs				$0	Cap inspection and maintenance is outside of MNR scope
Present Worth Five Year Costs				$0	
Total Present Worth Direct O&M Cost				**$0**	
Indirect O&M Costs					
Total Estimated Present Worth O&M Cost				**$0**	
TOTAL ESTIMATED COST				**$795,537**	

1. Interest rate from OMB Circular No. A-94 (December 12, 2016)
2. In addition to costs associated with this alternative, LUCs with MNR and five-year remedy reviews for the entire Upper subunit is estimated at ~$17 M (refer to details in Alternative A-2)

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Lower Three Runs — Integrator Operable Unit - Upper Section
A-6: Maintain Water in Ponds for EA-6 PAR Pond

Item	Quantity	Units	Unit Cost	Total Cost	
Direct Capital Costs					
No physical activites					
Establish Procedures MOU to concur with ROD requirements	1	ea	$10,000	$10,000	Establish formal internal documents to ensure dam maintenance complies with ROI
	1	ea	$0	$0	
Subtotal - Direct Capital Cost				$10,000	
Mobilization/Demobilization	0%	of subtotal direct capital		$0	
Site Preparation/Site Restoration	0%	of subtotal direct capital		$0	
Total Direct Capital Cost		(sum of * items)		**$10,000**	
Indirect Capital Costs					
Engineering & Design	15%	of direct capital		$1,500	Estimating Guideline Range 14-26%. Includes engineering review and developmen
Project/Construction Management	15%	of direct capital		$1,500	Standard
Health & Safety	5%	of direct capital		$500	Health and safety review and sign off on procedures
Overhead	30%	of direct capital		$3,000	Standard
Contingency	20%	of direct capital		$2,000	Standard
Total Indirect Capital Cost				**$8,500**	
Total Estimated Capital Cost				**$18,500**	
Direct O&M Costs (over 290 years)					
Annual Costs (yearly costs over 290 years)	0.7%	discount rate for costs > 30 years duration[1]			
	50	Years O&M			
Baseline Dam Program & Minor Maintainance Pond PAR	1	yr	$74,100	$74,100	Average of for FY15-FY17
	1	yr	$62,000	$62,000	
Subtotal - Annual Costs				$136,100	
Present Worth Annual Costs (0.7% Discount Rate)				**$1,878,282**	
Five Year Costs					
Remedy Review (Included in A-2 LUCs and MNA)	0	ea	$0	$0	
Subtotal - Five Year O&M Costs				$0	
Present Worth Five Year Costs				$0	
Total Present Worth Direct O&M Cost				**$1,878,282**	
Indirect O&M Costs					
Project/Admin Management	3%	of direct O&M		$56,348	0.006 FTE/YR $75 PER HR 2500 HR/YR $56,250 Approximate
Health & Safety	2%	of direct O&M		$37,566	0.005 FTE/YR $45 PER HR 2500 HR/YR $28,125 Approximate
Overhead	30%	of direct O&M		$563,484	
Contingency	15%	of direct O&M		$281,742	
Total Estimated Present Worth Indirect O&M Cost				**$939,141**	
Total Estimated Present Worth O&M Cost				**$2,817,422**	
TOTAL ESTIMATED COST				**$2,835,922**	

1. Interest rate from OMB Circular No. A-94 (December 12, 2016)
2. In addition to costs associated with this alternative, LUCs with MNR and five-year remedy reviews for the entire Upper subunit is estimated at ~$17 M (refer to details in Alternative A-2)

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Lower Three Runs — Integrator Operable Unit - Upper Section
A-6: Maintain Water in Ponds for EA-9 – Pond C

Item	Quantity	Units	Unit Cost	Total Cost	
Direct Capital Costs					
No physical activites					
Establish Procedures MOU to concur with ROD requirements	1	ea	$10,000	$10,000	Establish formal internal documents to ensure dam maintenance complies with ROD
	1	ea	$0	$0	
Subtotal - Direct Capital Cost				$10,000	
Mobilization/Demobilization	0%	of subtotal direct capital		$0	
Site Preparation/Site Restoration	0%	of subtotal direct capital		$0	
Total Direct Capital Cost		(sum of * items)		**$10,000**	
Indirect Capital Costs					
Engineering & Design	15%	of direct capital		$1,500	Estimating Guideline Range 14-26%. Includes engineering review and development of maintenan
Project/Construction Management	15%	of direct capital		$1,500	Standard
Health & Safety	5%	of direct capital		$500	Health and safety review and sign off on procedures
Overhead	30%	of direct capital		$3,000	Standard
Contingency	20%	of direct capital		$2,000	Standard
Total Indirect Capital Cost				**$8,500**	
Total Estimated Capital Cost				**$18,500**	
Direct O&M Costs (over 290 years)					
Annual Costs (yearly costs over 290 years)	0.7%	discount rate for costs > 30 years duration[1]			
	50	Years O&M			
Baseline Dam Program & Minor Maintainance Pond C	1	yr	$24,700	$24,700	Average of costs provided by SI for FY15-FY17 (SEE WORKSHEET FROM SI)
Subtotal - Annual Costs				$24,700	
Present Worth Annual Costs (0.7% Discount Rate)				**$340,878**	
Five Year Costs					
Remedy Review (Included in A-2 LUCs and MNA)	0	ea	$0	$0	
Subtotal - Five Year O&M Costs				$0	
Present Worth Five Year Costs					
Indirect O&M Costs					
Project/Admin Management	15%	of direct O&M		$51,132	0.005 FTE/YEAR $75 PER HR 2500 HR/YR $46,875 Approximate
Health & Safety	8%	of direct O&M		$27,270	0.005 FTE/YEAR $45 PER HR 2500 HR/YR $28,125 Approximate
Overhead	30%	of direct O&M		$102,264	
Contingency	15%	of direct O&M		$51,132	
Total Estimated Present Worth Indirect O&M Cost				**$231,797**	
Total Estimated Present Worth O&M Cost				$572,676	
TOTAL ESTIMATED COST				**$591,176**	

1. Interest rate from OMB Circular No. A-94 (December 12, 2016)
2. In addition to costs associated with this alternative, LUCs with MNR and five-year remedy reviews for the entire Upper subunit is estimated at ~$17 M (refer to details in Alternative A-2)

Site Infrastructure Worksheet for Alternative A-6						
FY	**Speed Chart**	**Description**	**Pond B 15%**	**PAR 30%**	**Other P&R Ponds 10%**	***ALL P&R Related Baseline 55%**
FY 17	07ILDAMMNT	Baseline Dam Program & Maintenance	$ 31,523	$ 63,045	$ 21,015	$ 115,583
FY 16	07ILDAMMNT	Baseline Dam Program & Maintenance	$ 34,096	$ 68,193	$ 22,731	$ 125,020
FY 15	07ILDAMMNT	Baseline Dam Program & Maintenance	$ 45,533	$ 91,065	$ 30,355	$ 166,953

FY	Speed Chart	Description	Pond B Project	PAR Repair		TOTAL P&R Projects
FY 17	07J74G4113	Correct Erosion of Face of Pond B Dam	$ 69.030			$ 69.030
FY 15	07ILPARBCP	Repair Valve Guide Interior of Dam		$ 54,548		$ 54,548

Total Cost – P&R Related Dams		
FY17		$ 184,613
FY 16		$ 125,020
FY 15		$ 221,501

***Remaining 45% of Baseline is related to Non-P&R Related Dams**