

elevation between the two ponds. Therefore, the water level in Pond C (EA9) will be maintained through implementation of Alternative A-6 at PAR Pond (EA6).

This remedy includes the monitoring of dam structures and water levels, annual inspections, and periodic maintenance of physical attributes that make water retention viable. This remedy is combined with Alternative A-2, *LUCs with MNR* to achieve the remedial action objectives.

Statutory Determinations

Based on the unit Remedial Investigation/Baseline Risk Assessment (BRA) (SRNS 2017), the LTR IOU poses a threat to human health and the environment. Therefore, Alternative A-2, *LUCs with MNR* for all nine EAs (EA1 through EA9); Alternative A-5, *Excavation, Treatment and Disposal of PTSM Sediment/Soil* in EA1; and Alternative A-6, *Maintain Water in Ponds* for EA3 and EA6 have been selected as the remedy for the LTR IOU. As part of the selected remedy, the future land use for the LTR IOU will be non-residential and primarily used for environmental/ecological research with USDOE maintaining control of the land.

Because hazardous substances will remain at the site above levels that allow for unlimited exposure and unrestricted use, the USDOE will review the remedial action no less than every five years per CERCLA Section 121(c) and the NCP at 40 CFR 300.430(f)(4)(ii) until the levels of refined constituents of concern (RCOC) allow for unrestricted use and unlimited exposure of sediment/soil. If results of the five-year reviews reveal that remedy integrity is compromised and protection of human health and the environment is insufficient, then additional remedial actions will be evaluated by the USDOE, USEPA, and SCDHEC.

The selected remedy is protective of human health and the environment, complies with Federal and State requirements that are legally applicable or relevant and appropriate to the remedial action (unless justified by a waiver), is cost-effective, and utilizes permanent solutions and alternative treatment (or resource recovery) technologies to the maximum extent practicable. ~~This~~ The remedy also satisfies the statutory preference for treatment as a principal element of the remedy (i.e., reduce the toxicity, mobility, or volume of materials comprising principal threats through treatment) for EA1.

Operable Unit Operational and Compliance History

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, LTR), and the Savannah River, the receiving body for the onsite stream systems, 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 (stream channel/floodplain sediment and floodplain/wetland soil), and related biota. The LTR IOU is listed as a CERCLA unit in Appendix C, RCRA/CERCLA Units, of the SRS FFA (FFA 1993).

The LTR watershed is located in the southeastern portion of SRS (Figure 2). LTR is a large₂ blackwater stream that originates in the northeast portion of SRS and follows a southerly direction for ~40-km (24.5-mi), discharging into the Savannah River. The LTR watershed drains about 460 km² (180 mi²). LTR is classified as Waters of the State for South Carolina.

For administrative purposes, the LTR IOU is delineated into Upper, Middle, and Lower subunits (Figure 3). The Upper subunit is located upgradient of the PAR Pond Dam, while the Middle and Lower subunits are located below the PAR Pond Dam that includes an area with a narrow land buffer referred to as the “tail” section of the LTR IOU.

The LTR IOU includes two main industrial SRS operable units (OUs): P-Area Operable Unit (PAOU) including P-Reactor, and R-Area Operable Unit (RAOU) including R-Reactor. In 1953, R-Reactor began operations, followed by P-Reactor in 1954. Both P- and R-Reactors received cooling water from the Savannah River via the river water distribution system. Prior to construction of the PAR Pond canal system, thermal reactor effluent from R-Reactor was discharged directly into Joyce Branch (R-Area Old Discharge Canal), a tributary of LTR. P-Reactor initially discharged to Steel Creek. In 1958, PAR Pond was created by constructing an earthen dam across the widened LTR stream corridor and the pre-cooler ponds/canal system was constructed. In 1963, P-Reactor began discharging into the LTR system via PAR Pond that was built to augment the cooling water available to both P- and R-Reactors. Effluent from R-Reactor was routed through the

If any of these elements is missing, the pathway is incomplete, and it not considered further in a quantitative risk assessment. A pathway is complete when all five components are present to permit potential exposure of a receptor to a source of contamination. Exposure analysis is conceptually important in terms of identifying all the potentially complete exposure routes, understanding the nature and extent (as well as fate and transport) of contamination, and developing preliminary remedial alternatives. In a complete pathway, exposure occurs at exposure points that may represent only a small portion of the entire exposure route. If there is no exposure point, then there is no exposure, and the pathway is considered incomplete.

Due to the variability of environmental conditions and large scale of the LTR IOU, the Upper subunit is segregated into the following nine individual exposure areas (EAs) (Figure 5).

- EA1 includes Pond A and the R-Area Discharge Canal. Pond A, is ~2.6 hectare (ha [6.4 acre {ac}]), and received water from the R-Area Discharge Canal that subsequently discharged to Pond B. The canal from R-Reactor to Pond A is ~645-m (2,116.1-ft) long. The canal from the R-Discharge Canal to Joyce Branch is 233-m (764.4-ft) long.
- EA2 consists of the section of the canal system between Pond A and Pond B and is ~2,837-m (9,307.7-ft) long. The canal flow area (i.e., where contaminants most likely have been deposited) is ~3.0-m (9.8-ft) across the base of the canal.
- EA3 includes Pond B and the overflow canal connecting Pond B to Pond C. Pond B is ~82.1 ha (202.8 ac) and received water from the R-Area which subsequently discharged to PAR Pond. Pond B generally maintains its water level from year to year. The over flow canal from Pond B is ~547-m (1,794.6-ft) long. ~~The canal flow area (i.e., where contaminants most likely have been deposited) is ~3 m (9.8 ft) across the base of the canal.~~

Exposure Area 9 (Pond C)

Twelve (12) sediment/soil samples and three sediment samples were collected from EA9 during the 2009/2010 sampling event. Pond C sample locations were determined by the established transect lines. Two samples were taken at each end of the transect line in dry soil ~0.91-m (3-ft) away from the water line. One sample was collected from 0- to 0.3-m (0- to 1-ft) bgs, and the second was taken from 0.3- to 1.2-m (1- to 4-ft) bgs. Also, one manually collected sediment sample was obtained from 0- to 0.15-m (0- to 0.5-ft) bgs for each transect line.

Two surface water samples were taken at Pond C during the 2009/2010 sampling event. Pond C surface water samples were collected at the transect location where the sediment/soil sample required a full analytical suite with one water sample being filtered and the other unfiltered.

Biota samples (i.e., fish tissue) were collected at Pond C during the 2009/2010 sampling event. Figure 15 shows the sample locations for EA9.

Media Assessment Results

The characterization data was used to perform a human health risk assessment (HHRA), an ecological risk assessment (ERA), and a PTSM evaluation (SRNS 2017). Sediment/soil media was compared to USEPA regional screening levels (RSLs) for non-radionuclides and USEPA preliminary remediation goals (PRGs) for radionuclides, while surface water was compared to USEPA maximum contaminant levels (MCLs), SCDHEC ambient water quality criteria, RSLs, or PRGs as appropriate. For the HHRA, an IOU onsite worker (wetland researcher) is selected as the most likely receptor scenario for the Upper LTR IOU. A recreational fisherman scenario is also considered for EAs that can sustain populations of consumable fish. Table 2 summarizes the results of these evaluations and identifies refined constituents of concern (RCOCs) for each EA. RCOCs are those constituents that were retained following a weight-of-evidence evaluation and require remedial action. The details of the risk assessments, including references to the tables that present the screening criteria, is provide in Section VII Summary of Site Risks.

Surface water sampling was conducted as part of the RI and metals and radionuclides were detected in surface water. Several metals including mercury exceeded the SCDHEC ambient water quality criteria, while the highest detected concentration of Cs-137 in surface water was below the surface water MCL. Based on the conceptual site model considerations of the high affinity of Cs-137 for sediment/soil and low solubility in water, it was determined that Cs-137 contamination is predominantly located in sediment/soil, as is mercury; therefore, surface water was determined to not be a media of concern and is not being directly addressed with the final remedial action. Instead, actions are proposed to address the sediment/soil as the “source” of the contamination (excavation/dredging, LUCs to reduce the chance of direct contact for humans and terrestrial ecological organisms by keeping the sediment/soil covered by water, restricting access, posting signs, restricting fishing on USDOE property, and MNR).

In summary, all EAs (EA1 through EA9) present a problem warranting remedial action. Cs-137 (+D), and to a lesser extent, Co-60 present in sediment/soil in the canals and ponds may pose a threat to human health and the environment.

In addition, for EAs that can sustain populations of consumable fish (EA3, EA6, and EA9), where the recreational fisherman scenario was determined viable, Cs-137(+D) and Hg are present in fish tissue that presents a problem warranting action.

Surface water was determined to not be a media of concern and did not pose an unacceptable risk.

A brief description of the media assessment results for each EA is provided below.

Exposure Area 1 (Pond A Including R-Area Discharge Canal)

The characterization data revealed Cs-137(+D) and Co-60, to a lesser extent, were present in the sediment/soil and may potentially pose a threat to human health and the environment. No fish samples were collected in EA1. There were no problems warranting action identified for surface water for EA1.

Cs-137(+D) The majority of historic data for Cs-137(+D) from Pond B were obtained from incremental analyses of two-centimeter intervals from cores collected from discrete sampling locations. To obtain an activity for Cs-137 from a discrete sampling location, the activities were combined and averaged for the results from the 0- to 0.3-m (0- to 1-ft) interval and the 0.3- to 1.22-m (1- to 4-ft) interval. Cs-137(+D) was detected in 44 out of 44 sediment/soil samples, with none being an estimated value (i.e., “J” qualified). Concentrations ranged from 0.093 pCi/g to 456.8 pCi/g with the highest concentration detected at location Main Body near Heron Island: SCB-34 on 9/14/1994. The maximum centimeter incremental activity in Pond B was 930 pCi/g from the Main Body near Mouth of Outlet Bay: SCB-29-0 location collected from the 14- to 15-centimeter (5.5- to 5.9-inches) depth interval on 9/20/1994 (Figure 9). Problems warranting action for EA3 include Cs-137(+D) for the sediment/soil medium for the onsite worker.

Cs-137(+D) was detected in all 54 fish samples collected from Pond B. Concentrations ranged from 9.35 pCi/g to 113 pCi/g. Sample Pond B 28054 had the highest concentration, which was collected on 3/4/1998 (Figure 9). Cs-137(+D) in fish tissue were identified as a problem warranting action for the recreational fisherman receptor.

Mercury in fish was detected in 77 out of 81 samples with one result being estimated (i.e., “J” qualified). Concentrations ranged from ND to 1.83 mg/kg with the highest detected concentration collected at location Pond B-32081 on 1/1/1998 (Figure 9). Mercury in fish tissue were identified as a problem warranting action for the recreational fisherman receptor.

Exposure Area 4 (Canal from Pond B to North Arm of PAR Pond)

Constituents that pose a potential threat to human health and the environment include Cs-137(+D) for the onsite worker for EA4. No fish samples were collected in EA4. There were no problems warranting action identified for surface water for EA4.

Cs-137(+D) was detected in 24 out of 36 samples in EA4 with five of these being an estimated value (i.e., “J” qualified). Concentrations ranged from ND to 50 pCi/g, with the highest detected concentration collected at location RDC015-001 on 4/20/2010

(Figure 10). Cs-137(+D) in sediment/soil were identified as a problem warranting action for the IOU onsite worker.

Exposure Area 5 (Joyce Branch [Old Discharge Canal])

Constituents that pose a potential threat to human health and the environment include Cs-137(+D) and Co-60 in sediment/soil for EA5. No fish samples were collected in EA5. There was no problem warranting action for surface water for EA5.

Cs-137(+D) was detected in 17 out of 17 sediment/soil samples with none of these results being an estimated value (i.e., “J” qualified). Concentrations ranged from 1.7 pCi/g to 405 pCi/g, with the highest detected concentration collected at location LTR Environmental Restoration Data Management System (ERDMS) IOULTR2 Sampling Event: LTROU-02 on 4/28/2004 (Figure 11). Cs-137(+D) in sediment/soil was identified as a problem warranting action for the IOU onsite worker.

Co-60 was detected in 6 out of 17 sediment/soil samples with no results being estimated values (i.e., “J” qualified). Concentrations ranged from ND to 1.83 pCi/g, with the highest detected concentration collected at location LTR ERDMS IOULTR2 Sampling Event: LTROU-02 on 4/28/2004 (Figure 11). Co-60 was identified as a problem warranting action in sediment/soil for the IOU onsite worker for EA5.

Exposure Area 6 (PAR Pond)

Constituents that pose a potential threat to human health and the environment include Cs-137(+D) and Co-60 in sediment/soil, and Cs-137(+D) and Hg for fish tissue for EA6. There were no problems warranting action identified for surface water for EA6.

Cs-137(+D) was detected in 510 out of 540 sediment/soil samples, with one of these results being an estimated value (i.e., “J” qualified). Concentrations ranged from ND to 124 pCi/g. Sample location PAR Pond Sediment Fish: PF3-5 had the highest detected concentration and was collected on 9/16/1995 (Figure 12). Cs-137(+D) was identified as a problem warranting action in sediment/soil for the IOU onsite worker for EA6.

activity concentration at Pond 2 P25-007-01 on 3/9/2000 (Figure 13). Co-60 was identified as a problem warranting action in sediment/soil for the IOU onsite worker for EA7.

Exposure Area 8 (Ponds 4 and 5 Including Canal from Ponds 4 and 5 to Pond C)

Constituents that pose a potential threat to human health and the environment include Cs-137(+D) and Co-60 in sediment/soil for EA8. Although fish samples were collected in Ponds 4 and 5, this pond system is not considered viable for fishable fish populations. There were no problems warranting action identified for surface water for EA8.

Cs-137(+D) was detected in 59 out of 71 sediment/soil samples with four of these results being estimated (i.e., “J” qualified). Activity concentrations ranged from ND to 125.6 pCi/g, with the highest activity concentration at location Pond 5 P25-042-01 on 3/27/2000 (Figure 14). Cs-137(+D) was identified as a problem warranting action for sediment/soil for the onsite worker for EA8.

Co-60 was detected in 5 out of 73 sediment/soil samples with one result being estimated (i.e., “J” qualified). Activity concentrations ranged from ND to 0.586 pCi/g with the highest activity concentration at Pond 4 (P25-022-01) on 3/2/2000 (Figure 14). Co-60 was identified as a problem warranting action in sediment/soil for the IOU onsite worker for EA8.

Exposure Area 9 (Pond C)

Constituents that pose a potential threat to human health and the environment include Cs-137(+D) and Co-60 in sediment/soil, and Cs-137 (+D) and Hg in fish for EA9. No problem warranting action was identified for EA9 based on surface water data.

Cs-137(+D) was detected in 51 out of 54 sediment/soil samples with four of these results being estimated (i.e., “J” qualified). Activity concentrations ranged from ND to 116.5 pCi/g, with the highest activity concentration at location Pond C Site No. 3 Elevation 59.5 m (195 ft) on 7/30/1991 (Figure 15). Cs-137(+D) was identified as a problem warranting action for sediment/soil for the onsite worker for EA9.

Cs-137(+D) was detected in 2 out of 2 fish samples with no result being estimated (i.e., “J” qualified). Concentrations ranged from 1.18 pCi/g to 42.5 pCi/g. Sample LTR-PC had the highest activity concentration and was collected on 4/14/2010 (Figure 15). Cs-137(+D) in fish tissue was identified as a problem warranting action for the recreational fisherman for EA9.

Co-60 was detected in 4 out of 24 sediment/soil samples with none of these results being estimated (i.e., “J” qualified). Activity concentrations ranged from ND to 0.448 pCi/g (Figure 15). The maximum, 0.448 pCi/g was from location Pond C SED-12, Pond C SED-~~2028~~. Co-60 was identified as a problem warranting action for sediment/soil for the onsite worker for EA9.

Mercury was detected in 2 out of 2 fish samples with one result being estimated (i.e., “J” qualified). Concentrations ranged from 0.0206 mg/kg to 0.244 mg/kg. Sample LTR-PC had the maximum detected fish concentration and was collected on 4/14/2010 (Figure 15). Mercury in fish tissue was identified as a problem warranting action for the recreational fisherman for EA9.

Site-Specific Factors

The entire SRS became the nation’s first National Environmental Research Park (NERP) in 1972. The LTR IOU, wetlands and pond systems have been actively studied as part of the NERP for various investigative purposes. The primary onsite entities that conduct research within the LTR IOU are the Savannah River Ecology Laboratory (SREL [University of Georgia]) and the Savannah River National Laboratory (SRNL). The emphasis in recent years has primarily been on aspects of radioecology in the Pond A, Pond B, and PAR Pond systems. The LTR IOU also contains a USDOE Research Set-Aside Program reserve area that provides a reference site for investigating human impacts on the environment. The SREL administers the Set-Aside program and coordinates activities to maintain the natural state of the area. The Boiling Springs Natural Area is a set-aside located in the Lower subunit of the LTR IOU adjacent to the LTR stream corridor. It is the only known intact old-growth (over 200 years) beech-magnolia-pine association climax

Conclusions

In summary, analysis of all data and weight-of-evidence indicates that problems warranting action only exist for human health receptors from exposure to the sediment/soil media and ingestion of fish tissue. No problems warranting action were identified for ecological receptors. As previously discussed, the HHRA evaluated multiple receptors for risk management purposes; however, problems warranting action are based on the IOU onsite worker receptor scenario which was selected as the most appropriate receptor for the LTR IOU.

Surface water was determined to not be a media of concern and did not pose an unacceptable risk to human or ecological receptors. Surface water sampling was conducted as part of the RI and metals and radionuclides were detected in surface water. Several metals including mercury exceeded the SCDHEC ambient water quality criteria, while the highest detected concentration of Cs-137 in surface water was below the surface water MCL. Based on the conceptual site model considerations of the high affinity of Cs-137 for sediment/soil and low solubility in water, it was determined that Cs-137 contamination is predominantly located in sediment/soil, as is mercury; therefore, surface water was determined to not be a media of concern and is not being directly addressed with the final remedial action.

In December 2016, the USEPA PRG website announced a revision to the approach for calculating PRG thresholds. The primary change was that the plus daughters (+D) option had been removed from the selection list and secular equilibrium PRGs became the preferred (default) option. The revised Cs-137 secular equilibrium PRG is 0.144 pCi/g for the IOU onsite worker. This activity corresponds to a 1.0E-06 risk; 144 pCi/g corresponds to a 1.0E-03 risk and PTSM threshold. Risks presented in the BRA were not recalculated using the secular equilibrium PRGs. However, the PTSM threshold for Cs-137 evaluated in the FS phase of the project was based on the secular equilibrium PRG, and the risk-based range of PRG concentrations were established using the updated secular equilibrium PRGs.

VIII. REMEDIAL ACTION OBJECTIVES AND CLEANUP LEVELS

This section discusses the remedial action objectives (RAOs) and cleanup levels for the Upper subunit of the LTR IOU. The goals of the remedial actions are to protect human health and the environment and mitigate the effects of contamination.

Remedial Action Objectives

RAOs are media- or IOU-specific objectives for protecting human health and the environment. RAOs usually specify potential receptors and exposure pathways and are identified during project scoping once the CSM is understood. RAOs describe what the remediation must accomplish and are used as a framework for developing remedial alternatives. The RAOs are based on the nature and extent of contamination, threatened resources, and the potential for human and environmental exposure. The following RAOs are identified for the Upper subunit of the LTR IOU and are protective of the onsite worker:

- Protect IOU onsite workers from exposure to Cs-137 and Co-60 in sediment/soil that exceed 1.0E-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 Hg in fish tissue that exceed risks of 1E-06 and HQ of 1, respectively. The primary route of exposure is the ingestion of fish pathway.

Cleanup Levels

PRGs (previously referred to as remedial goal options in earlier documentation) serve to provide a range of cleanup levels for each RCOC and are typically identified along with the RAOs. Following public comment and approval of the PP, the final cleanup levels for the selected remedy are chosen from the PRGs and documented in the ROD. Cleanup levels were previously referred to as remedial goals in earlier documentation.

Cleanup levels can be qualitative statements or numerical values often expressed as concentrations in soil and groundwater, or actions (installation of engineered barriers, placement of caps and covers, etc.) that achieve the RAO. These cleanup levels are either

Table 13. Land Use Controls for the Lower ~~Three~~ Three Runs IOU (Continued/End)

Type of Control	Purpose of Control	Duration	Implementation	Affected Areas ^a
5. Physical Access Controls ^f (e.g., fences, gates, portals)	Control and restrict access to workers and the public to prevent unauthorized access.	Until the concentration of hazardous substances associated with the unit have been reduced to levels that allow for unlimited exposure and unrestricted use.	Controls maintained by USDOE.	Security is provided at site boundaries in accordance with SRS procedures. Gates will be installed at access points to Joyce Branch. Signs will be placed at road access points leading to the LTR IOU.
6. Warning Signs ^g	Provide notice or warning to prevent unauthorized uses.	Until the concentration of hazardous substances associated with the unit have been reduced to levels that allow for unlimited exposure and unrestricted use.	Signage maintained by USDOE.	Warning signs will be posted in accordance with applicable site procedures and will be placed at access roads leading to the LTR IOU.
7. Security Surveillance Measures	Control and monitor access by workers/public.	Until the concentration of hazardous substances associated with the unit have been reduced to levels that allow for unlimited exposure and unrestricted use.	Established and maintained by USDOE Necessity of patrols evaluated upon completion of remedial actions or property transfer.	Patrol of LTR IOU as identified in this ROD, will be conducted as necessary.

^aAffected areas – Specific locations identified in the OU-specific LUCIP or subsequent post-ROD documents.

^bProperty Record Notices – Refers to any non-enforceable, purely informational document recorded along with the original property acquisition records of USDOE and its predecessor agencies that alerts anyone searching property records to important information about residual contamination; waste disposal areas in the property.

^cProperty Record Restrictions – Includes conditions and/or covenants that restrict or prohibit certain uses of real property and are recorded along with original property acquisition records of USDOE and its predecessor agencies.

^dOther Notices – Includes information on the location of waste disposal areas and residual contamination depicted on a survey plat, which is provided to a zoning authority (i.e., city planning commission) for consideration in appropriate zoning decisions for non-USDOE property.

^eSite Use Program – Refers to the internal USDOE/USDOE contractor administrative program(s) that requires the permit requestor to obtain authorization, usually in the form of a permit, before beginning any excavation/penetration activity (e.g., well drilling) for the purpose of ensuring that the proposed activity will not affect underground utilities/structures, or in the case contaminated soil or groundwater, will not disturb the affected areas without the appropriate precautions and safeguards.

^fPhysical Access Controls – Physical barriers or restrictions to entry.

^gSigns – Posted command, warning or direction.

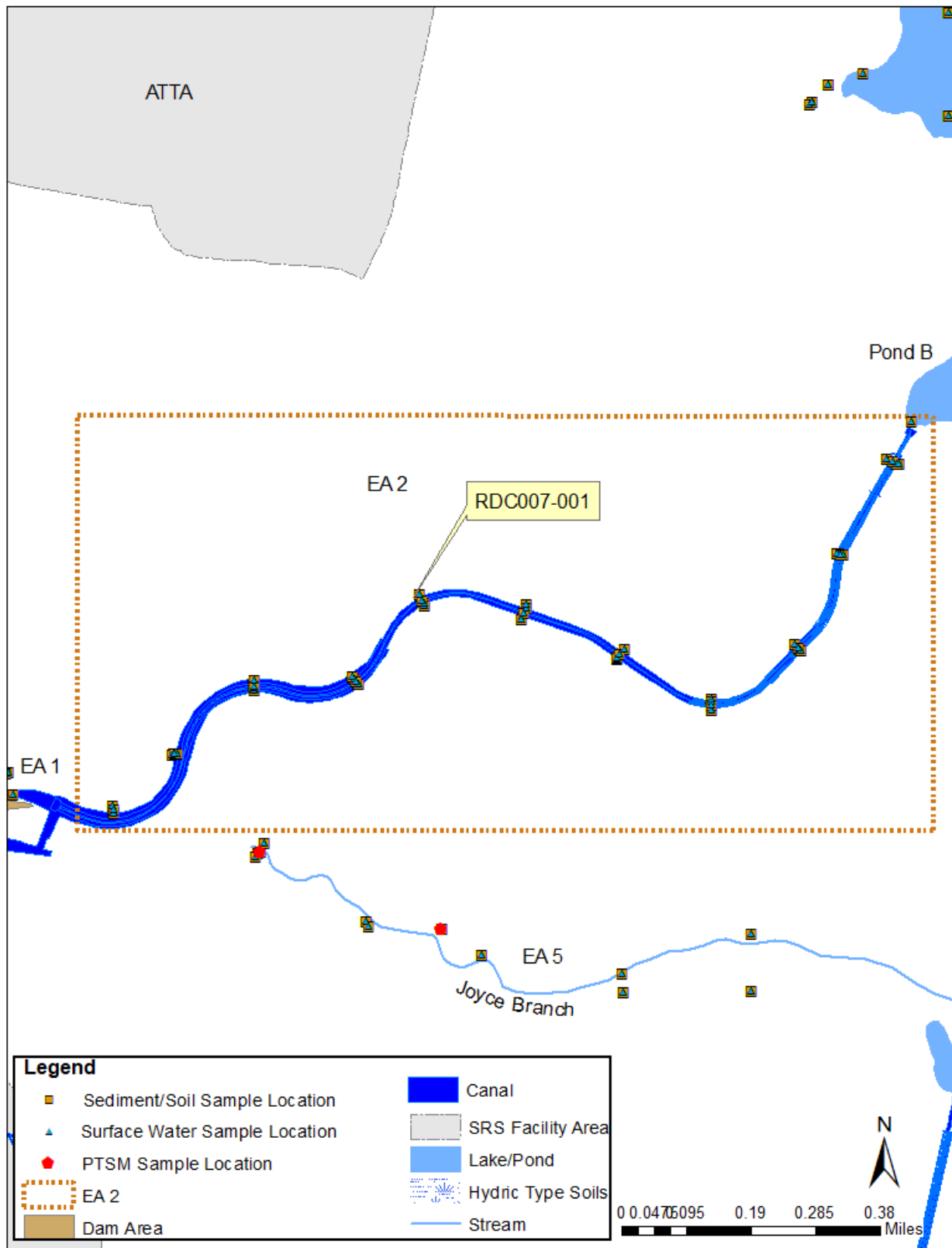


Figure 8. Sample Locations for EA2 in the Upper Subunit of the LTR IOU

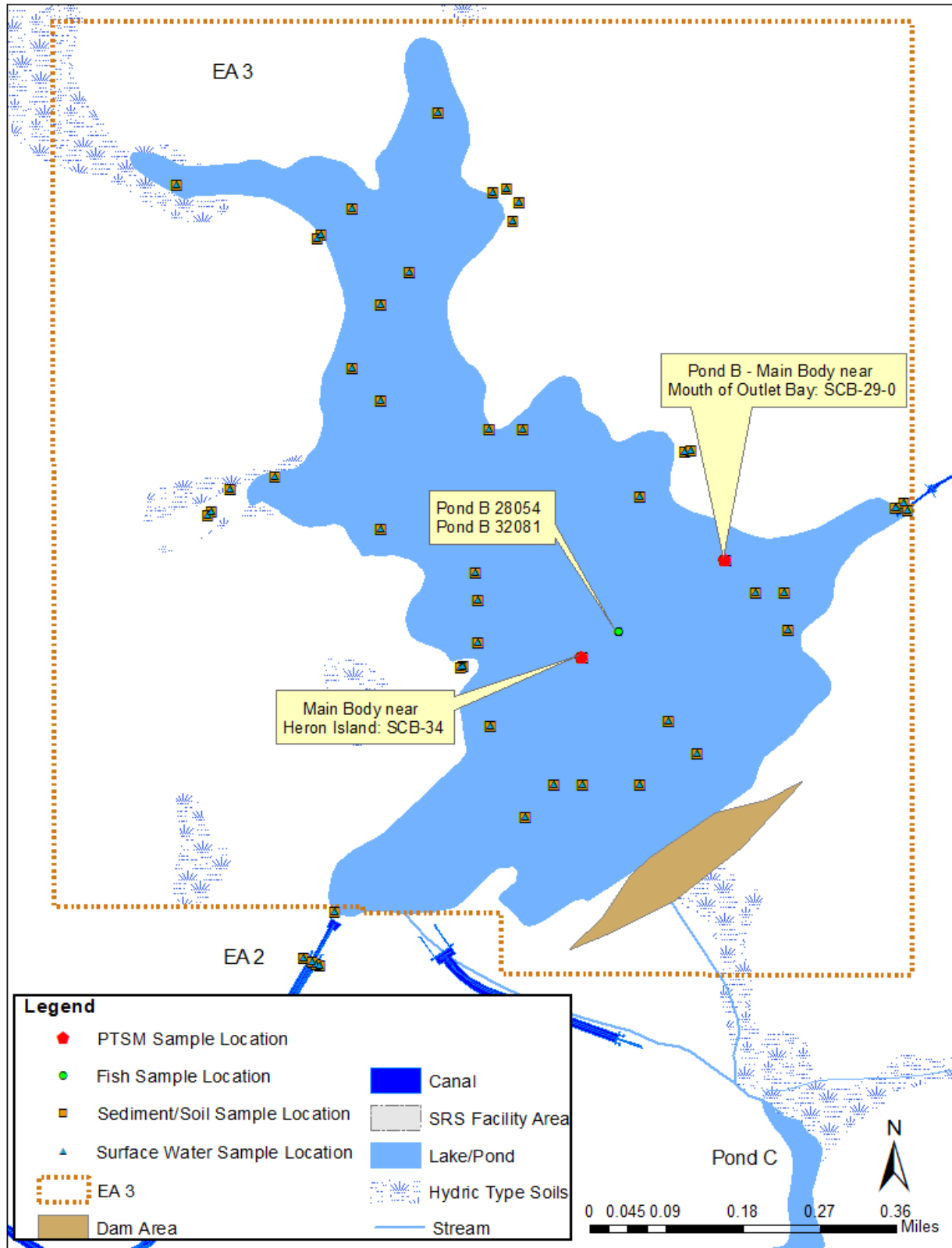


Figure 9. Sample Locations for EA3 in the Upper Subunit of the LTR IOU

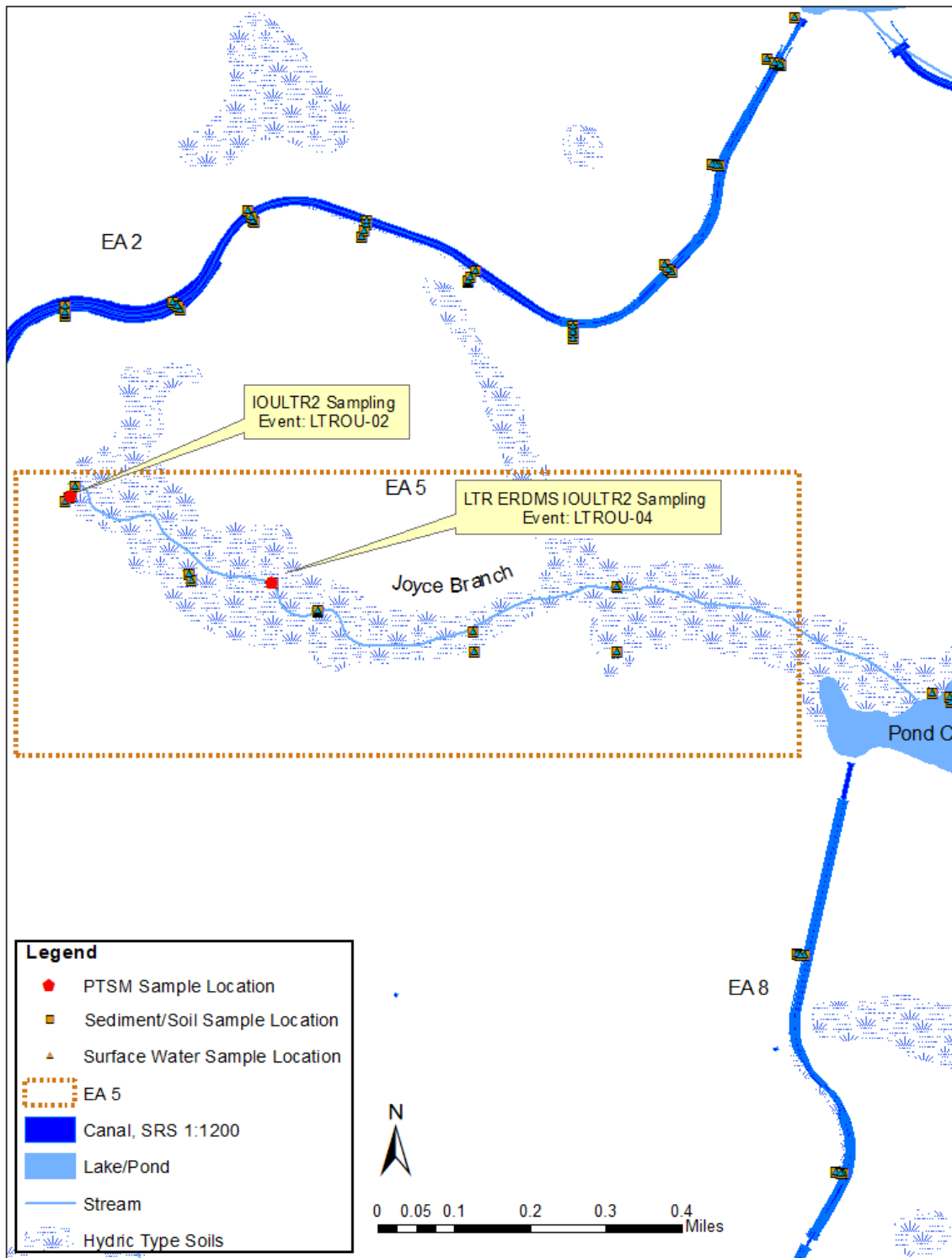


Figure 11. Sample Locations for EA5 in the Upper Subunit of the LTR IOU

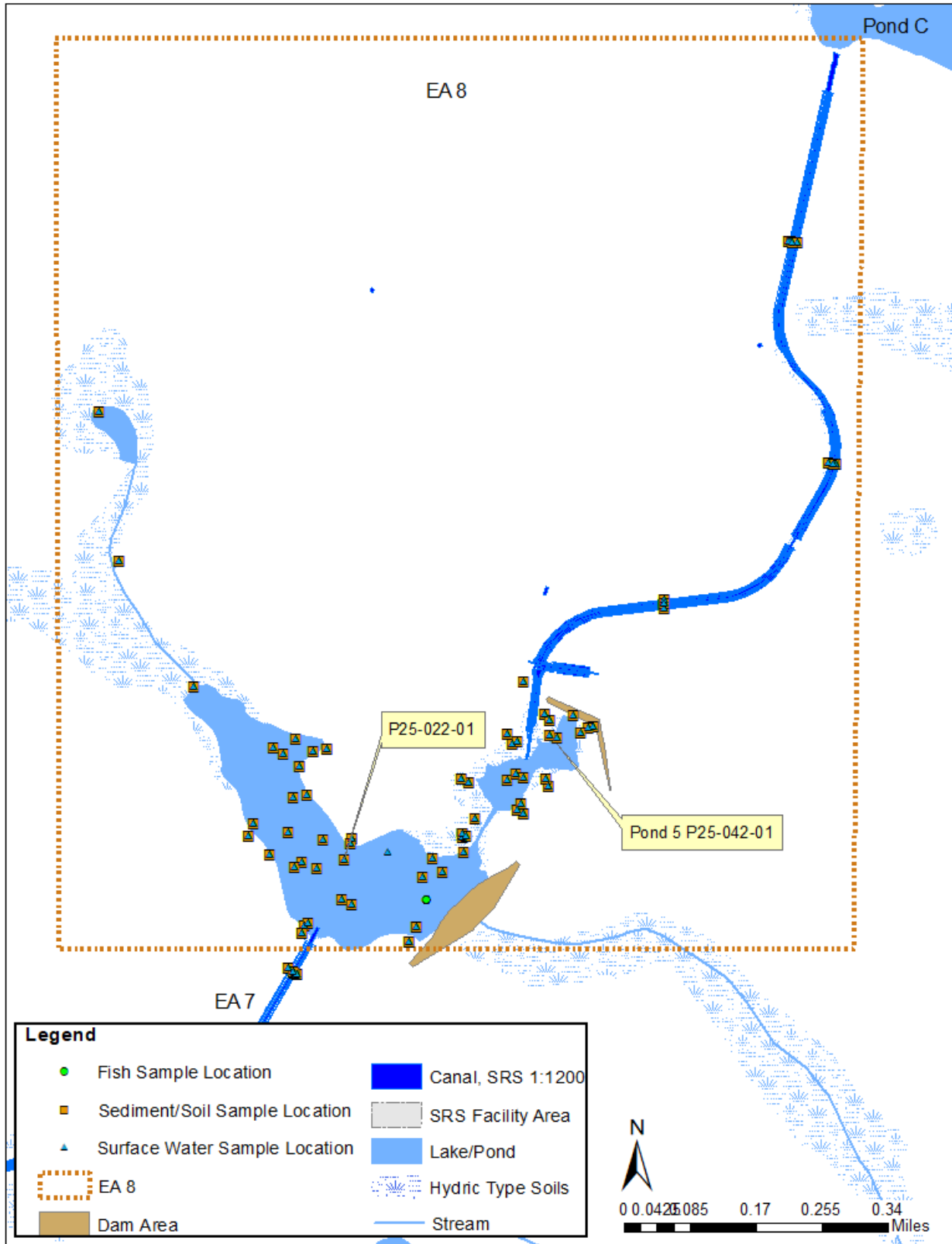


Figure 14. Sample Locations for EA8 in the Upper Subunit of the LTR IOU