Savannah River NUCLEAR SOLUTIONS℠

Focused Corrective Measures Study/Feasibility Study for D-Area Ash Basin Wetlands (NBN) in Support of the Savannah River Floodplain Swamp Integrator Operable Unit (U)

SEMS Numbers: 69

SRNS-RP-2024-01034

Revision 1

May 2025

SAVANNAH RIVER SITE • AIKEN, SOUTH CAROLINA

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Aiken, South Carolina

CERTIFICATION

Focused Corrective Measures Study/Feasibility Study for D-Area Ash Basin Wetlands (NBN) in Support of the Savannah River and Floodplain Swamp Integrator Operable Unit (U)

SEMS Number(s): 69
SRNS-RP-2024-01034, Revision 1, May 2025

[REF: 40CFR270.11 (d)(1)]

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EXECUTIVE SUMMARY

The purpose of this Focused Corrective Measures Study/Feasibility Study is to support a remedial decision for the D-Area Ash Basin Wetlands located at the Savannah River Site. The D-Area Ash Basin Wetlands is listed as a Resource Conservation and Recovery Act/ Comprehensive Environmental Response, Compensation, and Liability Act Unit in Appendix C of the Savannah River Site Federal Facility Agreement (FFA 1993).

In 2022, the United States Department of Energy proposed a holistic remedial approach to the U.S. Environmental Protection Agency and South Carolina Department of Environmental Services for the remaining coal ash and coal fines operable units at the Savannah River Site. The proposed strategy was documented in the *Preferred Remedial Action and Regulatory Strategy for Remaining Savannah River Site's Coal Ash and Coal Fines Operable Units (U)* (SRNS 2022a) and submitted to the regulatory agencies for review and approval in July 2022. The U.S. Environmental Protection Agency and South Carolina Department of Environmental Services approved the remedial strategy for the remaining seven coal ash and coal fines operable units (including the D-Area Ash Basin Wetlands) on August 11, 2022, and September 22, 2022, respectively.

The D-Area Ash Basin Wetlands was investigated as part of the approved *Resource Conservation and Recovery Act (RCRA) Facility Investigation/Remedial Investigation/Baseline Risk Assessment (RFI/RI/BRA) for the D-Area Expanded Operable Unit (DEXOU)* (WSRC 2002a). The 2002 remedial investigation/baseline risk assessment evaluation concluded that there were no contaminant migration or principle threat source material problems warranting action for the D-Area Ash Basin Wetlands. However, arsenic and coal-related radionuclides (i.e., potassium-40, thorium-232 series, and uranium-238 series) that pose an unacceptable risk for human receptors were present in surface ash/soils and were identified as human health refined constituents of concern. Although the 2002 risk assessment concluded that there were no ecological contaminants of concern, the regulatory agencies determined that additional ecological study of the wetland area was needed to support a final remedial action. For this reason, the D-Area Ash Basin Wetlands was separated from the D-Area Expanded Operable Unit in 2003 and administratively transferred to the Savannah River Floodplain Swamp Integrator Operable Unit to allow for additional ecological study.

During the July 2024 regulatory strategy scoping meeting for the remaining coal ash and coal fines operable units at the Savannah River Site, the U.S. Department of Energy, U.S. Environmental Protection Agency, and the South Carolina Department of Environmental Services agreed that the data and conclusions for the D-Area Ash Basin Wetlands, as documented in the *Resource Conservation and Recovery Act (RCRA) Facility Investigation/Remedial Investigation/Baseline Risk Assessment (RFI/RI/BRA) for the D-Area Expanded Operable Unit (DEXOU),* could be used to support a Focused Corrective Measures Study/Feasibility Study report.

This Focused Corrective Measures Study/Feasibility Study report for the D-Area Ash Basin Wetlands verifies the conclusions of the 2002 remedial investigation/baseline risk assessment evaluation through implementation of the most currently approved technical protocols documented in the *Savannah River Site Environmental Compliance and Area Completion Projects Regulatory Document Handbook* (SRNS 2023b). The D-Area Ash Basin Wetlands is located in an area that precludes any residential (unrestricted) or industrial land use in the future. Therefore, the most likely human health receptor scenario is the Integrator Operable Unit onsite worker (i.e., Savannah River Ecology Laboratory researcher). However, in order to support risk management decision making, the standard hypothetical resident (i.e., unrestricted land use) and the industrial worker scenarios were also evaluated. The updated human health risk evaluation confirms that arsenic and coal-related radionuclides (i.e., potassium-40, thorium-232, and uranium-238) exceed the 1E-06 risk threshold for the Integrator Operable Unit onsite worker (total cumulative risk of 1.7 E-04), the industrial worker (total cumulative risk of 3.4E-04), and the hypothetical resident (total cumulative risk of 5.8E-04), and are identified as refined constituents of concern.

This report also includes an updated ecological risk assessment that incorporates the 2022-2024 site-specific ecological study. Overall, the site-specific ecological data show species composition and other environmental variables at the D-Area Ash Basin Wetlands are reflective of a typical southeastern floodplain forest, and a remedial action based on the ecological concerns is not warranted.

Therefore, there are no ecological, principal threat source material, or contaminant migration refined constituents of concern identified for the D-Area Ash Basin Wetlands. The remedial action objective for the D-Area Ash Basin Wetlands, based on the most likely receptor, is as follows:

- Prevent the Integrator Operable Unit onsite worker from exposure to contaminants in surface ash/soil at concentrations exceeding 1E-06 risk or SRS background levels.

The three remedial alternatives evaluated in this Focused Corrective Measures Study/Feasibility Study against the nine Comprehensive Environmental Response, Compensation, and Liability Act criteria listed in the National Oil and Hazardous Substances Contingency Plan include the following:

- Alternative A-1: No Action
- Alternative A-2: Land Use Controls
- Alternative A-3: Excavation and Disposal

Alternative A-1 proposes no remedial efforts to be taken to control risk, treat, or remove contaminated media and is required by the National Oil and Hazardous Substances Contingency Plan to serve as a baseline for comparison with other remedial alternatives. Alternative A-2 proposes placing administrative and engineering controls at the D-Area Ash Basin Wetlands to prevent exposure to human receptors. Alternative A-3 proposes excavating the ash/soil for disposal at an approved offsite disposal facility to eliminate exposure to human receptors. Under Alternative A-3, the D-Area Ash Basin Wetlands would be restored to pre-ash deposition conditions.

The comparative analysis of remedial alternatives presented in this document does not propose a preferred alternative. Rather, the preferred alternatives will be presented in the Statement of Basis/Proposed Plan document to be submitted to the regulatory agencies following approval of this Focused Corrective Measures Study/Feasibility Study. A subsequent Record of Decision documenting the selected remedial action for the D-Area Ash Basin Wetlands is scheduled for issuance in March 2027.

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LIST OF ABBREVIATIONS AND ACRONYMS

~	approximately
ac	acre(s)
amsl	above mean sea level
ARAR	Applicable or Relevant and Appropriate Requirements
BRA	Baseline Risk Assessment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CM	Contaminant Migration
CMS/FS	Corrective Measures Study/Feasibility Study
CSM	Conceptual Site Model
DEXOU	D-Area Expanded Operable Unit
EC&ACP	Environmental Compliance and Area Completion Projects
ERA	Ecological Risk Assessment
FCMS/FS	Focused Corrective Measures Study/Feasibility Study
FFA	Federal Facility Agreement
ft	foot/feet
GCU	Gordon Confining Unit
ha	hectare(s)
HH	Human Health
HHRA	Human Health Risk Assessment
km	kilometer(s)
km^2	square kilometer(s)
LUC	Land Use Controls
m	meter(s)
m^3	cubic meter(s)
mi / mi^2	mile(s) / square mile(s)
NCP	National Oil and Hazardous Substances Contingency Plan

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

NRIE	Natural Resource Injury Evaluation
O&M	Operation & Maintenance
OU	operable unit
PRG	Preliminary Remedial Goal, Preliminary Remediation Goal
PTSM	Principal Threat Source Material
RAO	Remedial Action Objective
RCOC	Refined Constituents Of Concern
RCRA	Resource Conservation and Recovery Act
RFI/RI	RCRA Facility Investigation/Remedial Investigation
ROD	Record of Decision
SAP	Sampling and Analysis Plan
SARA	Superfund Amendments and Reauthorization Act
SB/PP	Statement of Basis/Proposed Plan
SCDES	South Carolina Department of Environmental Services[1]
SEMS	Superfund Enterprise Management System
SRFS IOU	Savannah River and Floodplain Swamp Integrator Operable Unit
SRNS	Savannah River Nuclear Solutions, LLC
SRS	Savannah River Site
SWPPP	Stormwater Pollution Prevention Plan
TBC	to-be-considered
TCR	Total Cumulative Risk
TES	threatened, endangered, and sensitive
USDOE	U.S. Department of Energy
USEPA	U.S. Environmental Protection Agency
UTRA	Upper Three Runs Aquifer
WSRC	Washington Savannah River Company, LLC
yd / yd^3	yard(s) / cubic yard(s)

[1] SCDES was known as the South Carolina Department of Health and Environmental Control prior to July 1, 2024.

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1.0 INTRODUCTION

This Focused Corrective Measures Study/Feasibility Study (FCMS/FS) discusses remedial action objectives (RAOs) and preliminary remedial goals (PRGs) for the D-Area Ash Basin Wetlands (DABW) in support of the Savannah River and Floodplain Swamp Integrator Operable Unit (SRFS IOU). The DABW was investigated as part of the approved *Resource Conservation and Recovery Act (RCRA) Facility Investigation/Remedial Investigation/Baseline Risk Assessment (RFI/RI/BRA) for the D-Area Expanded Operable Unit (DEXOU)* (WSRC 2002a). In 2003, the DABW was separated from the DEXOU and administratively transferred to the SRFS IOU to allow for additional ecological study of the area. The DABW is listed as a RCRA/ Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) unit in Appendix C of the Savannah River Site (SRS) Federal Facility Agreement (FFA) (FFA 1993).

The goal of the remedial actions evaluated in this FCMS/FS is to protect human health and the environment from coal-related contaminants. The United States Environmental Protection Agency (USEPA) has established a structured process to identify and evaluate technologies for remedial applications. This process involves developing and screening a range of appropriate remedial options and selecting the most suitable approach(es) for corrective measures and remedial actions. As agreed to during project scoping in July 2024, the remedial alternatives evaluated in this report are focused on the most likely remedies for the DABW.

1.1 Purpose and Organization of Report

The purpose of this FCMS/FS is to assess the remedial alternatives for the DABW at the SRS. This FCMS/FS was developed in accordance with CERCLA guidance. The general approach to evaluating potential remedial actions in the FCMS/FS is based on U.S. Department of Energy (USDOE) guidance, USEPA guidance, and Core Team agreements. The Core Team are representatives from the USDOE, USEPA, and South Carolina Department of Environmental Services (SCDES) who are the remedial decision makers for the project.

The FCMS/FS provides discussion to:

- Summarize the results of the ash characterization.
- Define the RAOs for the media of interest.
- Identify general response actions for the media of concern.
- Identify remedial technologies that are applicable.
- Identify remedial alternatives that meet the RAOs.
- Conduct a detailed analysis of remedial alternatives based on National Oil and Hazardous Substances Contingency Plan (NCP) criteria.
- Conduct a comparative analysis of these remedial alternatives.

The terms "corrective measures" and "remedial actions" are terms used under RCRA and CERCLA to refer to potential cleanup activities. The preferred alternative for the DABW will be presented in the Statement of Basis/Proposed Plan (SB/PP) to be submitted after approval of this FCMS/FS.

Supporting information includes the following: investigation data table (Appendix A); human health risk assessment (HHRA) (Appendix B); ecological risk assessment (ERA) (Appendix C); risk based cleanup level calculations (Appendix D); natural resource injury evaluation (NRIE) checklist (Appendix E); and detailed cost estimates (Appendix F). All are pertinent to supporting the conclusions in this document.

1.2 Unit Background

The SRS comprises an area of approximately (~) 803 square kilometers (km^2) (310 square miles [mi^2]) located in Aiken, Barnwell, and Allendale counties and ~32 km (20 mi) south of Aiken, South Carolina (Figure 1). The USDOE owns SRS while Savannah River Nuclear Services, LLC (SRNS) provides management and operating services for the environmental cleanup program. Since its creation in 1951, SRS has historically produced tritium, plutonium, and other special nuclear materials for national defense. SRS has also provided nuclear materials for the space program and for medical, industrial, and research efforts. Chemical and radioactive wastes are byproducts of the nuclear material production processes. Hazardous substances as defined by

CERCLA and hazardous waste as defined by RCRA (40 Code of Federal Regulations [CFR] 261.20) (USEPA 2024) are currently present in the environment at SRS. On December 21, 1989, SRS was placed on the CERCLA National Priority List (NPL). In accordance with Section 120 of CERCLA, USDOE has entered into a FFA with SCDES and USEPA to coordinate cleanup activities at SRS under one comprehensive strategy that fulfills RCRA and CERCLA assessment, investigation, and response action requirements.

Early infrastructure development of the SRS between 1951 and 1955 included the use of coal-fired powerhouses to generate steam and electricity. These powerhouses were located in each industrial/administrative area of the SRS with coal ash (coal combustion products) produced as a waste as a result of boiler operations. For D Area, the coal ash was sluiced from the D-Area Powerhouse into nearby ash basins. The D-Area Powerhouse was the longest running coal-fired powerhouse on SRS, operating from 1952 until 2012. Overflow from operations, prior to closure of the D Area ash basins, accounts for the presence of ash within the DABW. Several SRS ash basins, coal pile runoff basins, and one ash pile have been remediated/certified closed with a final Record of Decision (ROD) in four SRS areas (A, D, P, and R) (Washington Savannah River Company, LLC [WSRC] 2004, WSRC 2007, SRNS 2009, SRNS 2010, SRNS 2020). The remedial actions for these operable units (OUs) were implemented to meet regulatory requirements due primarily to elevated levels of arsenic (As) and coal-related radionuclides that result in unacceptable long-term risks to a future resident or industrial worker from direct exposure to the material.

In 2022, SRS proposed a comprehensive remedial approach for the remaining coal ash and coal fines OUs, including the DABW. The SRS proposed regulatory strategy for the remaining coal ash and coal fines OUs was presented at a Core Team meeting held on April 19, 2022, with a follow-up meeting held on May 23, 2022. As a result of these meetings, SRS submitted the *Preferred Remedial Action and Regulatory Strategy for Remaining Savannah River Site's Coal Ash and Coal Fines Operable Units (U)* (SRNS 2022a) in July 2022 to the USEPA and SCDES for regulatory review and approval. SCDES provided comments on the strategy, and SRS provided responses to the comments on September 15, 2022. USEPA and SCDES approved the regulatory strategy and associated comment responses in their letters dated August 11, 2022, and September 22, 2022,

respectively. The proposed remedy of No Action or Land Use Controls [LUCs] was identified as the likely remedial alternative for the DABW.

1.2.1 Unit Description

The DABW is discussed in the following subsections based on physical description, habitats/ecological setting, hydrogeology, surface topography, and unit history.

Physical Description

The DABW is located in the SRFS IOU downgradient of D Area (Figure 1). The DABW is a forested mixed compositional bottomland wetland that received overflow ash from the D Area ash basins. The DABW ash depositional area has an estimated area of ~36 hectares (ha) (90 acres [ac]) with an estimated volume of ~739,000 cubic yards (yd^3) (565,006 cubic meters [m^3]) of ash. The area has a gentle relief that slopes toward the Savannah River.

Habitats and Ecological Setting

The DABW is located outside of the boundary of any industrial or general SRS support area. The DABW is downgradient, southwest of the 488-D Ash Basin, and a portion of the southeastern boundary of the DABW is adjacent to Beaver Dam Creek (Figure 2). The DABW bottomland forest habitats range from more frequently flooded areas, to areas of open canopy, to a climax swamp forest approaching the Savannah River. Depending on precipitation events, river flood levels, and groundwater table fluctuations, portions of the DABW hold water seasonally/periodically.

Threatened, endangered and sensitive (TES) species surveys were conducted in June and July 1993/1994 for the DEXOU and included the eastern portion of the DABW. No TES plants or animals were identified during the surveys. There was a sighting of a transient bald eagle flying within the vicinity of the DEXOU; the nearest known nesting site is along Pen Branch ~ 9.6 km (6 mi) east-southeast. No bald eagle nesting sites were observed in the DEXOU survey area. The mature bottomland hardwood habitat associated with the Savannah River provides suitable habitat for several protected/rare plants including southern dutchman's pipe (*Aristochia tomentosa*),

collins' sedge (*Carex collinsii*), and large-whorled pogonia (*Isotria verticillata*), among others. Habitat in the TES survey area could also potentially support the little brown bat (*Myotis lucifugs),* southeastern myotis (*Myotis austroriparius*), southern big-eared bat (*Corynorhinus rafinesquii*), star-nosed moles (*Condylura cristata*), swamp rabbit (*Sylvilagus aquaticus*), osprey (*Pandion haliaetus*), and green water snake (*Nerodia cyclopion*). The eastern wood rat (*Neotoma floridana*) could also occur in the upland slopes. The swallow-tailed kite (*Elanoides forficatus*) could potentially visit the area during flyovers. More detailed information regarding species that may be found within habitats represented at the DEXOU area are discussed in the RFI/RI/BRA for the DEXOU (WSRC 2002a).

Groundwater Hydrogeology

Regional hydrostratigraphic and hydrogeological descriptions of the SRS can be found in *Hydrogeologic Framework of West-Central South Carolina* (Aadland et al. 1995). The hydrogeologic units of interest to the DABW are contained within the Southeastern Coastal Plain hydrogeologic province, which consists of unconsolidated Coastal Plain sediments of Late Cretaceous and Tertiary age (Figure 3). A generalized correlation between stratigraphy and hydrostratigraphic units is provided in Figure 4.

The SRS is underlain by Atlantic Coastal Plain sediments that thicken to the southeast. Sediments range in age from Late Cretaceous to recent and are ~270 m (900 feet [ft]) thick at SRS (Aadland et al. 1995, Fallaw and Price 1995). The pertinent lithostratigraphy beneath D Area, in ascending order, is the Snapp, Fourmile Branch, Congaree, Warley Hill, Tinker/Santee, and Clinchfield Formations (Aadland et al. 1995). The shallow aquifer system at D Area includes a semi-confined and an unconfined aquifer system. The semi-confined Gordon Aquifer is a 15-m (50-ft) thick sequence of fine to medium-grained sand that is overlain by the Gordon Confining Unit (GCU); the GCU can be up to a 3-m (10 ft) thick clay layer or consist of silty/sandy clays to silty sands. The GCU is overlain by the Upper Three Runs Aquifer (UTRA), which is an unconfined series of interbedded and laterally discontinuous sand, silt, and clay beds ranging in thickness from 12 m (40 ft) to 18 m (60 ft) beneath D Area. In D Area, the UTRA has been partially eroded and the tan clay confining zone is not present; therefore, the UTRA in D Area is not defined by upper and lower zones separated by a confining layer as often seen at other units at SRS. A schematic of the

lithostratigraphy and hydrostratigraphy generally observed at SRS is provided in Figure 4. The depth to groundwater is ~0 m (0 ft) (wetland/floodplain) to 4.6 m (15 ft) below ground surface.

Surface Topography

SRS lies within the Savannah River drainage basin with the Savannah River forming the southwestern boundary of the SRS. D Area is situated on an erosional terrace formed by the ancestral movement of the Savannah River. The erosional terrace is broad and relatively flat with ~6.1 m (20 ft) of topographic relief over the lateral distance (northeast to southwest) of 3.05 km (1.90 mi). Elevations along the western extent of the erosional terrace (in the vicinity of the 488-D Ash Basin) are ~8.5 m (28 ft) above the elevation of the Savannah River (28 m [92 ft]) above mean sea level (amsl). The modern floodplain represents a southwest migration of the river. The DABW is located within the modern Savannah River floodplain downgradient of the erosional terrace. The land surface within the DABW slopes gradually down-gradient toward the Savannah River and is relatively flat with an elevation range of ~28 m (95 ft) amsl along the Savannah River and 30 m (100 ft) amsl along the upgradient eastern boundary. The western boundary of the DABW is ~600 m (1,979 ft) from the Savannah River.

Unit History

The DABW is the result of ash overflow from the D Area ash basins. The D Area ash basins received ash from the coal fired D-Area Powerhouse via a wet sluice line. Ash is believed to have been deposited in the DABW via an upgradient drainage ditch. The upgradient ditch, identified as the 488-D Drainage, was addressed in the remedial action for the DEXOU where ash was excavated for inclusion under a geosynthetic cover. The area no longer presents a source to the DABW. The location of the former drainage ditch is shown on Figure 2. The D-Area Powerhouse was the longest running coal fired powerhouse, operating from 1952 until 2012.

The D Area ash basins, and DABW specifically, have been the subject of decades of ecological investigations. In 2022-2024, the DABW was the focus of study to provide critical information supporting the ecological assessment for the DABW. The 2022-2024 study was based on results of previous studies and the approach/findings associated with the Wetland Area at Dunbarton Bay,

another wetland-related ash depositional area (in this case, a Carolina bay) that supported final action determination from an ecological perspective.

Previous Actions

No previous CERCLA regulatory actions have been implemented for the DABW. However, the DABW was investigated as part of the approved *Resource Conservation and Recovery Act (RCRA) Facility Investigation/Remedial Investigation/Baseline Risk Assessment (RFI/RI/BRA) for the D-Area Expanded Operable Unit (DEXOU)* in 2002 (WSRC 2002a). The DEXOU RFI/RI/BRA concluded that there was a risk for exposure of human receptors to coal-related contaminants in surface ash/soil at the DABW subunit, but there was no ecological, principal threat source material (PTSM), and contaminant migration (CM) problems warranting actions. Although the DEXOU RFI/RI/BRA concluded that there were no ecological contaminants of concern for the DABW subunit, the regulatory agencies determined that additional ecological study of the wetland area was needed to support a final remedial action. A Core Team Problem Identification meeting was held in October 2002, and the DABW was administratively transferred to the SRFS IOU to allow for additional ecological data to support a final remedial decision for the DABW. The DEXOU RFI/RI/BRA was approved by the USEPA and SCDES on July 17, 2003, and July 21, 2003, respectively.

As previously noted, site-specific studies have been conducted to evaluate ecological impacts of ash disposition at the DABW. The strategy for this DABW FCMS/FS document was to use the information and conclusions of the DEXOU RFI/RI/BRA for the HHRA, PTSM evaluation, CM analysis, and the results of the 2022-2024 site-specific ecological study to support the ERA conclusion. The conclusions of the DEXOU RFI/RI/BRA for the DABW (WSRC 2002a) were verified, as appropriate, through implementation of the approved technical protocols documented in the *Environmental Compliance & Area Completion Projects (EC&ACP) Regulatory Document Handbook* (SRNS 2023b).

Data Evaluation

Data used to support the risk evaluations for the DEXOU wetlands subunit (i.e., 488-D Wetland) is presented in the 2002 RFI/RI/BRA (WSRC 2002a) and includes the following:

- 1997 pre-characterization data consisting of surface water sampling and a wetland survey consisting of 44 water samples (DSW1 through 18, DSW21 through 42, DSW46, DSW47, and DSW49) along with pH and conductivity readings,

- DEXOU Phase I sampling conducted from 1998-1999 resulting in eight (8) sediment/soil samples (DAB-31 through -38) from 0.0 to 0.3 m (0 to 1 ft) and seven (7) surface water samples (DAB-32 through -38); two (2) background samples (BGSM-1 and BGSM-2) were also taken from 0.0 to 0.3 m (0 to 1 ft) and later determined to be used as part of the DABW risk evaluation,

- DEXOU Phase II sampling conducted in 2001, a Work Plan Addendum for DEXOU that resulted in 16 paired sediment/soil (DAB-50 through -62, DAB-74, DAB-75, and DAB-76) from 0.0 to 0.3 m (0 to 1 ft), 0.3 to 0.6 m (1 to 2 ft), 0.6 to 0.9 m (2 to 3 ft), and 0.9 to 1.2 m (3 to 4 ft) and 13 surface water samples (DAB-50 through -62), and

- Summer 2002 field sampling resulting in four (4) sediment/soil samples (DAB-88 through -91) to identify the 0.0 to 0.3 m (0 to 1 ft) extent of contamination.

Data from the DEXOU used to support the risk evaluations in the FCMS/FS for the DABW included 25 sediment/soil samples (DAB-31, DAB-33 through DAB-38, DAB-50 through 62, DAB-74, -75, and -76, BGSM-1, and BGSM-2) from the 0.0 to 0.3 m (0 to 1 ft) interval (Table 1). Locations DAB-88 through -91 were not used in the risk evaluation and only used to define the extent of ash.

Figure 5 shows the sampling locations used to support the DABW FCMS/FS.

1.2.2 Nature and Extent of Contamination

The DABW is represented by the ash deposition area shown in Figure 2. This area was referred to as the ash plume or ash deposition area in earlier documentation. The extent of ash was determined in 2002 based on a review of historical aerial photographs, field observations (i.e., visual verification of ash and field measurements of ash depth), and analytical sampling collected as part of the DEXOU RFI/RI/BRA characterization (WSRC 2002a). The area of ash is ~36 ha (90 ac).

The approximate volume of soil/ash within the boundary is 565,006 m^3 (739,000 yds^3). Field measurements from the *Ecological Sampling and Analysis Plan for the D-Area Wetlands Operable Unit* indicate an ash depth up to ~1.3 m (4.3 ft) in portions of the DABW (WSRC 2002b).

1.2.3 Conceptual Site Model

The conceptual site model (CSM) is an objective framework for assessing data pertinent to the investigation. The CSM identifies and evaluates suspected sources of contamination, contaminant release mechanisms, potentially affected media (secondary sources of contamination), potential exposure pathways, and potential human and ecological receptors.

Exposure pathways describe the course a chemical or physical agent takes from the source to the exposed receptor. The following five (5) components make up an exposure pathway:

- Source (facility operations, spill, etc.)
- Exposure media (soil, groundwater, etc.)
- Exposure point (drinking water well, etc.)
- Exposure route (external radiation, ingestion, dermal contact, inhalation, etc.)
- Receptor (resident, industrial, IOU onsite worker, wildlife, etc.)

If any of these elements is missing, the pathway is incomplete and is not considered further in the 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 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.

The DABW is located in an area that precludes any residential (unrestricted) or industrial land use in the future. Therefore, the most likely receptor scenario is the IOU onsite worker (i.e., Savannah River Ecology Laboratory [SREL] researcher). However, in order to support risk management decision making, a variety of hypothetical receptors are evaluated in the HHRA. These include the standard hypothetical resident (i.e., unrestricted land use) and the industrial worker scenarios. The primary exposure pathways for evaluation relative to human receptors include:

- Exposure to surface media 0 to 0.3 m (0 to 1 ft) via incidental ingestion, dermal contact, inhalation of windblown dust, inhalation of volatile constituents, and external exposure from radionuclides.

From an ecological risk perspective, the habitats of the DABW primarily support terrestrial receptors. Aquatic/semi-aquatic habitats also exist, on a temporary basis, within the forested ecosystem. In general, terrestrial receptors include soil invertebrates (earthworms, etc.), reptiles (lizards, turtles, etc.), small mammals (moles, shrews, etc.), insectivorous/omnivorous/herbivorous birds such as the American robin, and carnivorous mammals/top predators such as gray foxes. Aquatic/semi-aquatic organisms include various amphibians (frogs/toads, salamanders), reptiles (turtles, snakes, etc.), birds (such as kingfishers, heron, and egrets), and various small/large mammals (raccoons, etc.).

The preliminary CSM for the DABW is presented in Figure 6.

1.2.4 Baseline Risk Assessment

1.2.4.1 Summary of the Human Health Risk Assessment

The HHRA is presented in Appendix B of this document. As stated above in Section 1.2.1, the DABW has been previously investigated under the RI/FS process in 2002 and documented in a DEXOU RFI/RI/BRA (WSRC 2003a). The complete HHRA is provided in the DEXOU RFI/RI/BRA report in Section 7.0 and appendices H, I, J, K, L, and M. The results of the DEXOU HHRA for the DABW identified the following human health (HH) RCOCs in the 0 to 0.3 m (0 to 1 ft) surface ash/soil interval: one metal (As), and eight radionuclides (potassium-40 [K-40], radium-228 [Ra-228], thorium-228 [Th-228], thallium-208 [Tl-208], thorium-232 [Th-232],

radium-226 [Ra-226], bismuth-214 [Bi-214], and uranium-238 [U-238]). Ra-228, Th-228, and Tl-208 are daughter products of the Th-232 decay series, and Ra-226 and Bi-214 are daughter products of the U-238 decay series. These daughter products will be managed under the cleanup level established for the entire decay series. There were no RCOCs identified in surface water media.

The conclusions of the 2002 HHRA for the DABW were reprocessed in accordance with the approved EC&ACP protocols and exposure assumptions (SRNS 2023b) to verify that the original risk assessment conclusions were still valid (Appendix B). The results indicate that the potential risk to the three human receptor scenarios evaluated in the HHRA (residential, industrial worker, and IOU onsite worker) exceeds 1E-06 for exposure to As and coal-related radionuclides (K-40, Th-232, and U-238) from the 0 to 0.3 m (0 to 1 ft) surface ash/soil interval. The risk estimates for each of the RCOCs for each receptor scenario are summarized below. RCOCs are defined as constituents that have undergone an uncertainty evaluation and require a remedial action.

Residential scenario, 0 to 0.3 m (0 to 1 ft) surface ash/soil interval: HH RCOCs include As (risk = 6.0E-05), K-40 (risk = 1.2E-04), Th-232 (risk = 2.1E-04), and U-238 (risk = 1.8E-04); the total cumulative risk (TCR) is 5.8E-04.

Industrial worker scenario, 0 to 0.3 m (0 to 1 ft) surface ash/soil interval: HH RCOCs include As (risk = 1.4E-05), K-40 (risk = 8.0E-04), Th-232 (risk = 1.4E-04), and U-238 (risk = 1.1E-04); the TCR is 3.4E-04.

IOU onsite worker scenario, 0 to 0.3 m (0 to 1 ft) surface ash/soil interval: HH RCOCs include As (risk = 6.5E-06), K-40 (risk = 3.8E-05), Th-232 (risk = 6.6E-05), and U-238 (risk = 5.5E-05); the TCR is 1.7E-04.

1.2.4.2 Summary of the Ecological Risk Assessment

The ERA for the DABW is presented in Appendix C of this document. The ERA concluded that ecological risks associated with the DABW are negligible, and the data are sufficient to make a remedial decision recommendation for the protection of ecological receptors. Site-specific ecological/biological studies have been conducted on various ash units at the SRS including ash

depositional areas in sensitive environments such as a Carolina bay (i.e., Wetland Area at Dunbarton Bay) and the DABW (located within floodplain habitat).

Despite finding elevated concentrations of trace elements within soil and biota, there is little evidence that ash-associated contaminants are impacting the ecological community using various community measures such as species richness, species diversity, and dissimilarity in species composition. The site-specific ecological data are the final determining factor in assessing whether remedial action is required for the protection of ecological resources. These recolonized/recovered areas appear healthy and diverse when compared to similar uncontaminated areas, and it is reasonable to conclude, from an ecological perspective, that the DABW does not pose a deleterious threat to ecological receptors. Overall, the site-specific ecological data show species composition, as well as other environmental variables at the DABW, is reflective of a typical southeastern floodplain forest, and a remedial action, based on the ecological concerns, is not warranted.

1.2.4.3 Summary of Contaminant Fate and Transport and Principal Threat Source Material Evaluations

No PTSM or CM RCOCs were identified for the DABW based on the DEXOU RFI/RI/BRA evaluations (WSRC 2002a). The PTSM evaluation conducted in the DEXOU RFI/RI/BRA was based on a toxicity and mobility assessment and evaluated the DEXOU from a holistic approach, i.e., all subunits within the DEXOU were evaluated. The toxicity evaluation concluded that the DEXOU unit-wide sediment for noncarcinogens and carcinogens were below the allowable PTSM threshold. The mobility evaluation that was conducted as part of the PTSM assessment was derived from the results of the contaminant migration assessment and determined that the only subunit with a mobility concern was the 488-D Ash Basin. The DEXOU RFI/RI/BRA concluded that a separate CM analysis was not warranted for the DABW because there was no primary source material identified, and that the DABW is a discharge area located within a floodplain that is at, or near, the water table (Figure 7).

Since publication of the 2002 DEXOU RFI/RI/BRA, a more extensive groundwater monitoring network is available in D Area to evaluate the impact of coal/ash surface units on groundwater. As

part of D-Area Groundwater (DAG) OU monitoring, seven shallow wells exist at the perimeter of the DABW (Figure 8). These empirical groundwater results can be used to evaluate the CM potential from the coal-related contaminants in DABW ash/soil. Arsenic is a common ash unit COC with a robust data set and can be used as an indicator of contamination associated with ash units. The groundwater results from the second quarter of 2023 showed no exceedances of the As maximum contaminant level (MCL) (10 micrograms per liter [ug/L]) in the seven shallow wells (Figure 8). For the 2023 second quarter sampling event, the practical quantitation limit for arsenic was 30 ug/L and the method detection limit (MDL) was 5 ug/L. The MDL is below the MCL for arsenic. Table 2 provides a summary of groundwater data collected to support the DAG OU monitoring at the seven DABW shallow wells. Arsenic, barium, beryllium, and uranium are common constituents related to ash units at SRS. As shown in Table 2, the only detections above MCLs in the last 16 years were from samples that also had elevated turbidity values (greater than 140 nephelometric turbidity units [NTU]). Review of groundwater monitoring data supports the conclusions of the DEXOU RFI/RI/BRA, that ash located in the DABW floodplain is not a CM concern to groundwater. Therefore, the conclusions of the DEXOU RFI/RI/BRA were carried forward and no further CM analysis was needed.

1.2.4.4 Conclusion

Results of the evaluations for DABW indicate that there are no CM, ecological, or PTSM RCOCs. The potential risk to human receptor scenarios (residential, industrial worker, and IOU onsite worker) evaluated in the HHRA exceeds 1E-06 for exposure to As and coal-related radionuclides (K-40, Th-232, and U-238) in surface ash/soils. A summary of the RCOCs is provided in Table 3. Based on these conclusions, the preliminary CSM has been revised and is now presented as the refined CSM as shown in Figure 9.

1.2.5 Problems Warranting Action

The problems warranting action include As and coal-related radionuclides (K-40, Th-232, and U-238) that are present in surface ash/soils that pose an unacceptable risk for the IOU onsite worker (with a total cumulative risk [TCR] = 1.7E-04). The most likely cleanup levels for As and the coal-related radionuclides are based on SRS background concentrations (Table 4). Figures 10 and 11

present sampling results for As, K-40, Th-232, and U-238 which represent the highest reasonable maximum exposure concentrations from the HH RCOC parent and daughter products from the DEXOU dataset. The sampling points identify levels that are above 95th percentile background concentrations representing the likely cleanup level for the constituent shown. A proposed LUC boundary is depicted in Figure 12 based on the ash extent and HH RCOC concentrations above the SRS Background 95th percentile, represented by As (8.2 mg/kg). Arsenic was used to determine the LUC boundary due to its robust data set and because it is a significant contaminant associated with ash. Other radiological COCs are naturally occurring and comparable to SRS background levels making it difficult to distinguish between natural background and process related contamination. There are no ecological, CM, or PTSM RCOCs for the DABW.

The following problem warranting action exists for the DABW:

- Arsenic and coal-related radionuclides (K-40, Th-232, and U-238) are present in the 0.0 to 0.3 m (0 to 1 ft) ash/soil interval that pose an unacceptable risk to the IOU onsite worker (TCR = 1.7E-04).

2.0 IDENTIFICATION AND SCREENING OF TECHNOLOGIES

This section summarizes the technology screening for the DABW and the RAOs for ash/soil contamination in relation to the PRGs which have been developed. Identified technologies are screened using the NCP criteria: effectiveness, implementability, and cost. Technologies that pass this screening are retained and carried forward into the development of remedial action alternatives.

2.1 Remedial Action Objectives

RAOs are site-specific goals defining the extent of cleanup required to achieve protection of human health and the environment. RAOs specify RCOCs, media of concern, protected receptors, potential pathways, target cleanup goals, and Applicable, or Relevant and Appropriate Requirements (ARARs). RAOs are based on the nature and extent of contamination, threatened resources, and the potential for human and environmental exposure. They provide a framework for developing remedial alternatives in the FCMS/FS.

The RAO for the DABW is to:

- Prevent the IOU onsite worker from exposure to contaminants in surface ash/soil at concentrations exceeding 1E-06 risk or SRS background levels.

2.1.1 Allowable Exposure Based on Risk Assessment

Section 121(d) of CERCLA (CERCLA 1980), as amended by Superfund Amendments and Reauthorization Act (SARA), (SARA 1986), requires that remedial action comply with requirements or standards set forth under Federal and State environmental laws. These are considered ARARs and include action-specific, location-specific, and chemical-specific requirements. SARA requires that the remedial action for a site meet all ARARs unless a waiver is invoked for one of the following reasons:

1. The remedial action is an interim measure where potential final actions will attain the ARAR upon completion.

2. Compliance will result in greater risk to human health and the environment than other options.

3. Compliance is technically impracticable.

4. The remedial action will attain the equivalent of an ARAR.

5. The State has not consistently applied the requirement in similar circumstances.

6. SARA Section 121(e) exempts any federal, on-site remedial action from administrative requirements for Federal, State, and/or local permits. However, on-site actions still must comply with the substantive, technical aspects of these requirements.

Potential ARARs are classified as either applicable or relevant and appropriate. Applicable requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under Federal or State law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location or other circumstance at a CERCLA site. Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under Federal or State law that do not specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, but nonetheless are well suited to the particular site.

In general, relevant and appropriate requirements involve comparing a number of site-specific factors with those addressed in the statutory or regulatory requirement. Site-specific factors include the characteristics of a remedial action, hazardous substances present at the site, or physical circumstances of the site. In some cases, a requirement can be relevant but not appropriate based on site-specific circumstances and thus may not be selected as an ARAR for the site. Therefore, it is not an ARAR for the site. There is additional flexibility in the determination of relevant and appropriate requirements. It is possible for only part of a requirement to be considered relevant and appropriate in a given case. When the analysis results in a determination that a requirement is

both relevant and appropriate, such a requirement must be complied with to the same degree as if it were applicable.

In addition to ARARs, many Federal and State environmental and public health programs include criteria, guidance, and proposed standards that are not legally binding but provide useful approaches or recommendations. These "To-be-considered" (TBC) requirements are non-promulgated advisories or guidance issued by Federal or State government that are not legally binding and do not have the status of potential ARARs. However, TBC requirements can be considered, along with ARARs in determining the level of cleanup for protection of human health and the environment.

Three categories of ARARs were defined to clarify how to identify and comply with environmental requirements. They include action-specific, location-specific, and chemical-specific requirements. 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 or the immediate area. 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 promulgated limits for the particular contaminant and/or media do not exist and where there is concern with their potential health or environmental effects.

Table 5 summarizes potential ARARs for the DABW.

2.1.2 Development of Preliminary Remedial Goals

PRGs represent the preliminary media-specific goals and serve as a standard by which to measure whether a selected remedial action has met its RAO. PRGs can be qualitative statements (e.g., indirect actions that prevent receptor contact), numerical values often expressed as concentrations in media (e.g., risk-based soil or sediment concentrations) or specific actions to eliminate contact with contaminated media (e.g., installation of engineered barriers, placement of caps and covers, etc.) that achieve the RAO. PRGs become finalized as cleanup levels following public comment

and approval of the SB/PP. The PRGs for the selected remedy are documented as cleanup levels in the ROD. Numerical PRGs consist of a range of risk-based concentrations for RCOCs that provide a basis for selecting the final remedial action to achieve such values. Risk-based clean-up level calculations for the DABW are provided in Appendix D and summarized in Table 4.

The selection of final cleanup levels is made by the Core Team. The Core Team members are the key decision makers and include representatives of the USDOE, SCDES, and USEPA.

Risk-based PRGs for the HH RCOCs are identified for the DABW. No ecological RCOCs, CM RCOCs, or PTSM RCOCs have been identified. The development of PRGs for the DABW is described below.

The HHRA is presented in Appendix B. HH RCOCs were identified for the surface ash/soil medium for the residential, industrial worker, and IOU site worker receptor scenarios that were evaluated in the HHRA, and PRGs are provided for each as appropriate. Human health risk-based PRGs are developed in accordance with the *Human Health Preliminary Remedial Goal Options* protocol (SRNS 2023b). Risk-based PRGs are calculated for the future resident, future industrial worker, and the IOU onsite worker at various target risk levels (1E-06, 1E-05, and 1E-04). The HH PRGs for surface ash/soil media for the DABW are provided in Table 4.

2.1.3 Most Restrictive and Most Likely PRGs

The most restrictive PRG for the HH RCOCs are identified as the lowest of the PRGs and are summarized in Table 4.

In contrast to the most restrictive PRGs, the most likely PRGs also considers a comparison to background levels. Because of the inherently conservative nature of the risk assessment and PRG calculations, it is possible for the risk-based PRG to be less than what occurs naturally in unimpacted background soil at the SRS. In this case, the PRG defaults to the SRS background concentration to be technically practical to achieve. The background concentration is set as the 95th percentile for unimpacted SRS-wide soil.

The most restrictive PRGs and most likely PRGs presented in Table 4 are an appropriate starting point for developing remedial alternatives. Final cleanup levels will be agreed upon by USDOE, SCDES, and USEPA concurrent with selection of a remedial action. Final cleanup levels will be documented in the ROD.

2.2 General Response Actions

General response actions are unit-specific actions that achieve RAOs and satisfy the requirements of the NCP. The following general response actions have been identified for the DABW.

1. No Action
2. LUCs
3. Excavation and Disposal

These response actions may be implemented individually or in combination.

2.2.1 No Action

The No Action response is not a technology but is required by the NCP as a baseline for comparison with other remedial actions. In this scenario, no efforts would be taken to monitor, remove, treat, or otherwise mitigate the potential spread of contaminants from the DABW. Contaminant reduction would be achieved only through any natural attenuation that may occur.

2.2.2 LUCs

LUCs include engineering controls (i.e., access controls) and institutional controls (i.e., administrative measures) that minimize the potential for human exposure to contaminants. Generally, LUCs are retained for use, if necessary, in conjunction with other remedial alternative(s) selected at the area or as a stand-alone alternative. In this case LUCs are being considered as a stand-alone alternative. LUCs already exist at SRS and can be implemented at the DABW.

Access controls involve temporary or permanent physical restrictions to prevent or reduce human exposure to contaminants. Controls also can be used to prevent vandalism of on-site remedial

equipment or disturbance of contaminated media. Regular monitoring and maintenance of access controls are required for this technology to effectively deter site entry. Access controls may include, but are not limited to, signs, fencing, barricades, or exclusion devices.

Access controls that are effective in minimizing the potential for human exposure from direct contact with contaminated media are relatively easy to implement and low in cost when compared to other technologies. Access controls are retained to deter intruders and will be part of all alternatives in which contaminated media are left on the unit at risk levels that prohibit unrestricted use.

Administrative controls can be used to prevent or reduce future human exposure to contaminants remaining on the site. For example, excavation permit restrictions can be used to permanently prohibit excavation or subsurface construction. Administrative controls also can be temporary measures used while other remedial actions are taking place.

In the long-term, if the property is ever transferred to nonfederal ownership, the U.S. Government would, in compliance with Section 120(h) of CERCLA, create a deed for the new property owner. The deed would include notification disclosing the former waste management and disposal activities as well as remedial actions taken onsite and any continuing groundwater monitoring commitments.

2.2.3 Excavation and Disposal

Excavation (or removal) can be accomplished by scraping, cutting, digging, scooping, and vacuuming, with heavy earth moving equipment and using conventional construction methods. Excavation is both effective and permanent since wastes are removed from the unit. Because the contaminated media is both removed and then isolated by sending to an approved disposal site, this alternative is effective and reliable at eliminating human and ecological exposure to contaminants. It also prevents direct radiation exposure, reduces mobility, and reduces bio-uptake of contaminated media. The ash would be consolidated and excavated with heavy earth moving equipment and transported to an approved off-SRS disposal facility.

2.3 Identification and Evaluation of Technology Types and Process Options

Various technologies and approaches exist for implementing the three general response actions for the DABW. The NCP requires these potential technologies be screened against the criteria of effectiveness, implementability, and cost. All the technology types suitable for this project are conventional and reliable. Table 6 summarizes the general response actions, remedial technologies, relative costs, and a synopsis of the screening.

Effectiveness: An effective technology must achieve the specified RAOs, must be compatible with the contaminant characteristics and waste unit conditions, and must 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. Technologies that have not been demonstrated successfully at similarly contaminated waste units are eliminated from further consideration.

Implementability: 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.

Cost: A qualitative cost evaluation is provided so that comparisons can be made between general response actions. 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.

2.3.1 No Action (Retained)

This response action would not require the deployment of any technology to reduce the toxicity, mobility, or volume through treatment of the ash or otherwise mitigate the potential spread of contaminants from the ash. The No Action response action could be readily implemented and would have no cost. There would be no reduction in risk and the RAO would not be attained. Five-year remedy reviews under CERCLA would not be required. The No Action alternative is implementable and is the least costly response action, but it is not effective.

2.3.2 Land Use Controls (Retained)

This response action leaves hazardous substances in place that present a potential risk to the IOU onsite worker. LUCs would be required to remain in place as long as the ash within the DABW is present. Both administrative and engineering controls would prevent exposure of potential human receptors to contaminants by limiting access to the land or resource use. LUCs are relatively simple and inexpensive to implement and may be retained as an independent alternative or in conjunction with another remedial alternative(s). LUCs may also be used to implement engineering controls to ensure their continued effectiveness. Engineering controls such as warning or no trespassing signs, fencing, and barricades can prevent human access to contaminated media. Five-year remedy reviews under CERCLA would be required.

LUCs are relatively low in cost, provide a high degree of protection of human health, and are relatively simple to implement. LUCs would prevent further damage to the area caused by earth moving activities from more aggressive removal technologies. LUCs are retained for further consideration in the detailed analysis.

2.3.3 Excavation and Disposal (Retained)

Excavation of contaminated soil media is one of the most aggressive approaches to implement remediation. Contaminated ash media could be excavated and hauled to an approved off-SRS disposal facility. Excavation is typically readily implementable, and the earthwork required for excavating the contaminated ash media is standard construction practice.

The cost of excavation could be substantial based upon the volume of contaminated media and the transportation costs of the ash. Removing contaminated ash media from the DABW would lower risk levels for the IOU on-site worker scenario by permanently removing and disposing the ash in an approved off-SRS waste disposal facility.

The earthwork required for excavating the ash media will be challenging due to implementation in a wetland environment. The cost of this action could be substantial based upon the volume of contaminated media and the distance the ash must be hauled to an approved waste disposal facility. Due to its effectiveness, excavation and disposal is retained for further consideration in the detailed analysis.

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3.0 DEVELOPMENT AND SCREENING OF ALTERNATIVES

This section provides the development of alternatives and a screening analysis of the remedial alternatives for the DABW based on the general technologies retained from Section 2.3.

3.1 Development of Alternatives

Three remedial alternatives (No Action, LUCs, and Excavation and Disposal) have been developed for the DABW and are discussed in detail below.

3.1.1 Alternative A-1: No Action

Alternative A-1 proposes no remedial efforts to be taken to control risk, treat, or remove contaminated media and is required by the National Oil and Hazardous Substances Contingency Plan to serve as a baseline for comparison with other remedial alternatives. This alternative would leave the DABW in its current condition with no additional controls. This alternative would not include five-year remedy reviews.

3.1.2 Alternative A-2: LUCs

Alternative A-2 involves the use of administrative and engineering controls to limit access to the DABW. LUCs have been implemented successfully within SRS and are fully employed in all areas of the SRS to limit access at the site boundary and on-site facilities. LUCs will include both administrative and engineering controls. Administrative measures include use of the SRS Site Use/Site Clearance Program to require authorization before beginning work activities at the site (e.g. no excavation). Other administrative measures include property record notices and deed restrictions if the property is ever transferred to non-federal ownership to disclose former waste management and disposal activities, as well as remedial actions taken at the ash sites.

Engineering controls would be implemented at the DABW through the use of warning and no trespassing signs at likely ingress locations. The LUCs will be described in detail in a Land Use Control Implementation Plan (LUCIP). Five-year remedy reviews would be required under this alternative. LUCs would be applied to the entire area of contaminated media, ~36 ha (90 ac).

Proposed LUC boundaries are provided in Figure 12. A buffer zone to either the nearest sample location below the SRS Background 95th percentile for arsenic or 100 feet outside the ash deposition area was used to bound the extent.

3.1.3 Alternative A-3: Excavation and Disposal

Alternative A-3 would include excavation of all ash to an average depth of 5 feet with an estimated volume of ~565,006 m^3 (739,000 yd^3**)**. Prior to excavation activities, additional delineation would be required to bound the extent of contamination that exists outside of the estimated ash plume. After excavating, the ash would be dried to meet the acceptance criteria of the receiving permitted receiving disposal facility. The ash would then be hauled to disposal facility. Excavation work would be performed in accordance with an approved stormwater pollution prevention plan (SWPPP). Verification sampling would be performed per an approved sampling and analysis plan (SAP) to ensure all ash is removed. After ash removal, DABW would be contoured with clean fill and topsoil for proper drainage and the wetland restored. This alternative would not require five-year remedy reviews.

3.2 Screening of Alternatives

In this section, the proposed remedial alternatives for the DABW are evaluated against the CERCLA criteria of effectiveness, implementability, and cost. (See Table 7) The retained alternatives will be analyzed in detail 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, to the extent practicable, each alternative should be effective in decreasing the inherent threats or risks associated with hazardous substances or media by reducing 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 action-specific regulations for the particular treatment. Operation, maintenance, and monitoring of technical components of the alternative, if required after the remedial action is complete, are also considered. 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 for retained alternatives when action-specific ARARs are developed. Screened out alternatives will not be considered during the detailed analysis.

A qualitative cost evaluation is provided so that cost comparisons can be made among the alternatives. Remedial alternative costs are described as high, medium, or low 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 effectiveness and implementability, but a significantly greater cost, will be rejected. Otherwise, cost will not be used as a criterion to screen the technologies at this point in the FCMS/FS process.

The proposed remedial alternatives for the DABW were evaluated and screened using the three criteria of effectiveness, implementability, and cost. The results of the evaluation are described in the following sections. Table 7 summarizes the results of this screening.

3.2.1 Alternative A-1: No Action

Under the No Action alternative, no remedial efforts would be taken to control risk, treat or remove contaminated media. This alternative is not effective in achieving the RAO. Implementability is not a consideration since no action would be implemented. There is no capital construction or system O&M costs for the No Action alternative. 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: LUCs

Alternative A-2 proposes placing administrative and engineering controls at DABW to prevent exposure to human receptors. Human health would be protected in the long term through O&M of the LUCs, as well as in the short term due to no worker exposure to contaminated media (ash/soil) during implementation. Because there are no ECO RCOCs, CM RCOCs, or PTSM identified for the DABW, no additional physical controls are needed for protection of the environment to prevent ecological exposure to contamination or to control migration of contaminants through environmental media. There is no reduction in toxicity, mobility, or volume through treatment of the contaminated media with this alternative. The unit-specific LUCs for the DABW will be included in the ROD.

Alternative A-2 is readily implementable, as demonstrated by the previously successful implementation of LUCs at other locations on the SRS. The cost of this alternative is considered low because the costs include inspections, signage, a LUCIP, mandatory five-year remedy reviews, and any necessary deed restrictions. This alternative is determined to be effective and is retained for detailed analysis.

3.2.3 Alternative A-3: Excavation and Disposal

Alternative A-3 consists of excavating contaminated media (ash/soil) from the DABW and disposal offsite. The DABW would be restored by backfilling with clean soil and vegetated.

Human health and the environment would be protected in the long term due to the permanence of removing the contaminated media, and in the short term through the use of best management construction practices and strict adherence to the project-specific health and safety plan. There is no reduction in toxicity, mobility, or volume through treatment of the contaminated media with this alternative.

Although alternative A-3 is determined to be implementable due to SRS's previous experience with the common construction methods and equipment used to implement this type of alternative, the earthwork required for excavating the ash media will be challenging due to implementation in a wetland environment. This alternative is considered to have a higher cost due to special permits, worker requirements, and work controls that must be put in place for the excavation of contaminated media, loading and hauling to an approved off-site disposal facility, disposal fees, and restoration of the area with clean fill and vegetated. This alternative is determined to be effective and is retained for detailed analysis.

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4.0 DETAILED ANALYSIS OF ALTERNATIVES

This section discusses the relative strengths and weaknesses of the three alternatives retained from the screening analysis in Section 3.2 with respect to each of the nine CERCLA evaluation criteria. 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.

The NRIE Checklist and supporting descriptions are provided in Appendix E. The purpose of the NRIE Checklist is to identify potential natural resource injuries associated with CERCLA remedial activities. Based on the NRIE Checklist, natural resources in the locale have been impacted by hazardous substances from the unit. Remedial alternatives under consideration may or may not address injuries to the natural resources. Remedial alternatives considered may cause additional injury based on the scope of the action. No irreversible or irretrievable resource losses are known to exist.

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

4.1 Individual Analysis of Alternatives

The statutory requirements that guide the evaluation of remedial alternatives under CERCLA 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,
- Use permanent solutions to the maximum extent.

USEPA has established nine evaluation criteria to address these statutory requirements under CERCLA. The 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 SB/PP. Evaluation criteria categories and the nine evaluation criteria are listed and explained in the following sections.

A detailed analysis of each alternative is provided for each of the following evaluation criteria:

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 on the basis of how the alternative reduces the risk of exposure to contaminants from potential exposure pathways through engineered barriers or LUCs. Each alternative is examined as to whether it creates any unacceptable short-term risks to human health. In addition, the RCRA criterion specifying control of source releases is evaluated.

- **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. Three types of ARARs (chemical-, action-, and location-specific) have been developed to simplify identification and compliance with environmental requirements. Location-specific ARARs were evaluated to determine applicability to the combined report. The summary of potential ARARs is provided in Table 5.

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 on the basis of the magnitude of residual risk and the adequacy and reliability of controls used to manage contaminated media that remain after response objectives have been achieved. Alternatives that offer long-term effectiveness and permanence halt or otherwise mitigate any potential for offsite contaminant transport and minimize the need for future engineered controls. The degree of uncertainty with regard to treatment effectiveness is also evaluated.

- **Reduction of toxicity, mobility, 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 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 and cleanup levels. 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 percent according to USEPA guidance. Detailed cost estimates are derived from current information including vendor quotes, conventional cost estimating guides (e.g., Mean Site Work Cost Data), 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. Cost estimates are presented in Appendix F.

Modifying Criteria

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

- **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 SB/PP received during the public comment period. These comments are considered in the final remedy selection for the ROD and the issuance of a RCRA permit modification.

- **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 USDOE, USEPA, and SCDES, and based on comments received on this FCMS/FS and are addressed in the SB/PP document.

The retained alternatives are evaluated against the seven CERCLA threshold and balancing criteria that provide the basis for evaluating the alternatives and selecting a remedy. The purpose of this section is to identify key advantages and disadvantages of each alternative. The remaining two modifying criteria will be evaluated in the SB/PP.

4.1.1 Individual Analyses of the Alternatives for the DABW

A comparison of DABW alternatives to the threshold, primary balancing, and modifying criteria are discussed in Sections 4.1.1.1 through 4.1.1.3 and summarized in Table 8.

4.1.1.1 Alternative A-1 - No Action

Alternative A-1 was carried forward as required by the NCP to serve as a baseline for comparison with other remedial alternatives.

Overall Protection of Human Health and the Environment

The No Action alternative would not address potential risk to the human receptors from exposure to the contaminated media at the DABW. This alternative would not achieve the RAO and would not be protective of human health or the environment. No additional injury to natural resources would be encountered under this alternative.

Compliance with ARARs

Table 5 lists the potential ARARs applicable to the DABW. Specific ARARs applicable to the alternative are listed below.

- *Chemical-Specific ARARs*: No chemical-specific ARARs are associated with the No Action alternative.
- *Location–Specific ARARs*: No location-specific ARARs are associated with the No Action alternative.
- *Action-Specific ARARs*: No action-specific ARARs are associated with the No Action alternative.

Long-Term Effectiveness and Permanence

Potential future exposure to human health from contaminated media at the DABW would remain unchanged under the No Action alternative. This alternative does not provide for long-term effectiveness or permanence.

Reduction of Toxicity, Mobility, or Volume through Treatment

There is no reduction in the toxicity, mobility, or volume through treatment of contaminated media associated with the No Action alternative.

Short-Term Effectiveness

The No Action alternative would not endanger the surrounding communities or remedial workers or adversely affect the environment during implementation; however, the RAO would not be achieved. Under this alternative, hazardous contaminants would remain in place.

Implementability

Since this alternative requires no action, implementability is not a consideration.

Cost

There is no present-worth cost estimated for the No Action alternative since there is no action implemented and no five-year remedy review. Detailed cost estimates are provided in Appendix F. A summary of the estimated cost is below.

Total Present-Worth Cost $0

4.1.1.2 Alternative A-2 – LUCs

Alternative A-2 consists of LUCs to prevent or reduce human exposure to contaminants remaining in place at the DABW.

LUCs will include administrative access controls and warning/no trespassing signs to alert IOU onsite workers to the presence of hazardous substances and to prevent unknowing entry and unrestricted use. Alternative A-2 would require ongoing five-year remedy reviews as contaminants will remain in place.

Overall Protection of Human Health and the Environment

The exposure pathway to human receptors is broken by controlling access and prohibiting unrestricted use of the contaminated media and is thereby protective of human health. Because there are no ECO RCOCs, CM RCOCs, or PTSM identified for the DABW, no additional physical controls are needed for protection of the environment to prevent ecological exposure to contamination or to control migration of contaminants through environmental media. Alternative A-2 would achieve the RAO and is therefore determined to be protective of human health and the environment. Alternative A-2 would not cause additional natural resource injury.

Compliance with ARARs

Table 5 lists the potential ARARs applicable to the DABW. Specific ARARs applicable to the alternative are listed below.

Chemical-Specific ARARs: No chemical-specific ARARs are associated with Alternative A-2.

Location-Specific ARARs: No location-specific ARARs are associated with Alternative A-2.

Action-Specific ARARs: No action-specific ARARs are associated with Alternative A-2.

Long-Term Effectiveness and Permanence

The long-term effectiveness for protecting human health can be achieved under Alternative A-2 as long as unit-specific LUCs are maintained. LUCs will be maintained until the concentration of hazardous substances in the ash/soil is at such levels to allow for unrestricted use and exposure. The timeframe for LUCs is assumed for 30 years of duration as a basis for a cost estimate. The actual time requirement would likely be longer as As and coal-related radionuclides are stable and do not decay rapidly. Remedy reviews will be performed every 5 years. Annual inspections will be performed to ensure warning and no trespassing signs are in place and no encroachment onto the controlled area is occurring. Signs will be replaced and/or repaired as needed and records for site use/site control permits will be maintained within the SRS infrastructure.

A LUCIP will be prepared by the USDOE that describes the implementation of LUCs and maintenance actions for the remedial action, including periodic inspections. The USDOE is responsible for implementing, maintaining, monitoring, reporting upon, and enforcing the LUCs. The LUCIP will remain in effect unless and until modifications are approved by the USEPA and SCDES as needed to be protective of human health and the environment. LUCIP modification will only occur through another CERCLA document.

Reduction of Toxicity, Mobility, or Volume Through Treatment

There is no reduction in the toxicity, mobility or volume through treatment of contaminated media associated with the Alternative A-2.

Short-Term Effectiveness

This alternative poses no risk to remedial workers or the community because no work will be performed which disturbs the ash/soil in the DABW. All of the ash and contaminated soil media are within an area with restricted access (site boundary); therefore, it is not accessible to members of the public or community. DABW is located in the southwest quadrant of SRS approximately (~) 0.9-km (3,000-ft) east of the nearest site boundary, the Savannah River (Figure 1). There is no hazard to nearby communities since there are none in proximity.

Implementability

LUCs are currently active in all areas of SRS. LUCs have been implemented at many waste units at SRS. The implementation of LUCs presents no technical or administrative impediments.

Cost

The cost of Alternative A-2 for LUCs are considered low. Costs associated with this alternative include posting warning signs at areas of access to the unit where the ash/soil is located. SRS would control access to and prohibit excavation of the subunit through the Site Use/Site Control permit system. A review of the remedy will be performed every five years over an assumed 30-year duration. A summary of the estimated cost is presented below:

Total Capital Cost	*$61,391*
Present-Worth O&M Cost	*$1,642,528*
Total Estimated Cost	*$1,703,918*

4.1.1.3 Alternative A-3 – Excavation and Disposal

Alternative A-3 consists of removing all ash from the estimated ash depositional area of ~36 ha (90 ac) at DABW and disposal of contaminated ash/soil to prevent human and ecological exposure to contaminants at the DABW. After the ash/soil is excavated and transported to an approved offsite disposal facility, the DABW will be clean closed.

Overall Protection of Human Health and the Environment

By removing all contaminated media from the DABW, exposure to human and ecological receptors is eliminated. Because there are no ECO RCOCs, CM RCOCs, or PTSM identified for the DABW, no additional physical controls are needed for protection of the environment to prevent ecological exposure to contamination or to control migration of contaminants through environmental media. Alternative A-3 is determined to be protective of human health and the environment and therefore achieves the RAO. Alternative A-3 would not cause additional natural resource injury.

Compliance with ARARs

Chemical-Specific ARARs: No chemical-specific ARARs are associated with Alternative A-3.

Location-Specific ARARs: Compliance with location-specific ARARs are associated with Alternative A-3. There is a probability that location-specific ARARs will be associated with the excavation of the ash/soil media. Any excavation within any wetland area may require restoration upon completion of the excavation to comply with the applicable ARARs in 10 CFR 1023 (see Table 5). Action will need to be taken to avoid, minimize, or mitigate the destruction, loss, or degradation of wetlands.

Action-Specific ARARs: Compliance with action-specific ARARs is associated with Alternative A-3. In order to minimize erosion of sediment and manage storm water runoff that may occur during the during excavation and removal activities, a storm water management plan would be required to comply with SC R. 61-9.122.41. To minimize erosion and manage storm water runoff that may occur during the remedial action, best management practices (BMPs) would be employed. In addition, the disposal and transportation of waste generated from Alternative A-3 would be handled in accordance with Federal and State regulations 40 CFR 262.11(b) and South Carolina Regulation 61-107.5(D)(3). Coal ash is excluded as hazardous, solid waste per 40 CFR 261.4(b)(4)(i) and (ii).

Long-Term Effectiveness and Permanence

The long-term effectiveness for protecting human health can be achieved under this alternative after excavation of ash/soil material to unrestricted use levels, disposal, and the site is restored. This alternative will be protective in the long-term.

Reduction of Toxicity, Mobility, or Volume Through Treatment

There is no reduction in the toxicity, mobility, or volume through treatment of contaminated media associated with the Alternative A-3.

Short-Term Effectiveness

This alternative is expected to take a considerable amount of time to complete but would pose no significant risk to the community during execution. Remedial workers would have the greatest risk of exposure during excavation activities. Use of BMPs during excavation and strict adherence to the project specific health and safety plan would prevent worker exposure to hazardous material and would minimize any risk to surrounding communities while excavation activities are performed. All of the ash and contaminated soil media are within an area with restricted access; therefore, it is not accessible to members of the public or community. There is no hazard to nearby communities since there are none in proximity.

Implementability

Alternative A-3 includes excavation and hauling of contaminated ash/soil to an approved off-site disposal facility. Although excavation and disposal are typically readily implemented with standard earth-moving equipment, materials, and conventional construction methods; the implementation of this large-scale removal in a wetland environment would be very challenging. Specialized equipment and/or site preparation will likely be necessary to execute the work safely. Ash drying would be required to meet acceptance criteria of the receiving disposal facility. There are several waste units at SRS where this practice has been implemented safely and effectively. The implementation of excavation and disposal presents no administrative impediments.

Cost

The cost of Alternative A-3 could be substantial based upon the excavation volume of contaminated media and the transportation costs. There is no O&M cost associated with Alternative A-3 because the DABW is expected to be clean closed following excavation of the contaminated ash/soil material. A summary of the estimated cost is presented below:

Total Capital Cost	*$80,421,391*
Present-Worth O&M Cost	*$0*
Total Estimated Cost	*$80,421,391*

4.2 Comparative Analyses

This section identifies key advantages and disadvantages of each alternative in relation to the evaluation criteria. Table 9 provides a summary of the comparative ranking analysis. Each alternative is ranked with respect to the other alternatives for the evaluation criteria.

4.2.1 Overall Protection of Human Health and the Environment

Alternative A-1 would not be protective of human health or the environment. Alternatives A-2 and A-3 are protective of human health and the environment. Alternative A-2 limits human exposure

to contaminated ash/soil through the implementation of LUCs. Contaminated ash/soil would be left in place, but exposure pathways will be broken. Alternative A-3 will prevent human exposure to all contaminated ash/soil via excavation and removal which permanently breaks the exposure pathway.

4.2.2 Compliance with ARARs

There are no chemical-specific ARARs for any of the alternatives. Location-specific ARARs associated with the excavation of the ash/soil media in the wetland area are considered for Alternative A-3. Alternative A-3 achieves the location-specific ARARs by avoiding, minimizing, or mitigating the destruction, loss, or degradation of wetlands. Excavation within any wetland area may require restoration upon completion of the excavation to comply with the applicable ARARs in 10 CFR 1023 (see Table 5). Action-specific ARARs associated with Alternative A-3 are achieved by employing BMPs to minimize erosion of ash/soil and management of storm water runoff during excavation activities.

4.2.3 Long-term Effectiveness

Alternative A-1 does not provide long-term effectiveness. Alternatives A-2 and A-3 provide excellent long-term effectiveness. For Alternative A-2, LUCs will remain in place until hazard risk levels no longer require controls. LUCs will ensure that the exposure pathways remain broken. For Alternative A-3, after the ash is excavated and removed to an approved offsite disposal facility and the DABW is clean closed, the exposure pathway will be eliminated. While both Alternatives A-2 and A-3 provided long-term effectiveness, Alternative A-3 is ranked higher because the contaminated media is permanently removed.

4.2.4 Reduction of Toxicity, Mobility, or Volume through Treatment

None of the alternatives employ any treatment to reduce the toxicity, mobility, or volume of the contaminated media. As such, all alternatives are given an equally low ranking.

4.2.5 Short-term Effectiveness

Alternative A-1 is not effective in the short-term since exposure is not prevented and therefore, ranked lowest of all the alternatives. Alternative A-2 poses no risk to the IOU onsite worker or surrounding community during implementation of the remedial action. These activities are minimally invasive and will result in no injury to a natural resource. Under Alternative A-3, remedial workers would have the greatest risk of exposure during excavation activities. The time to implement Alternative 2 is less than 6 months. In comparison, Alternative A-3 would take a significantly longer time to implement (approximately 18 months). For these reasons, Alternative A-3 is ranked lower than Alternative A-2 for short-term effectiveness.

4.2.6 Implementability

No implementation is required of Alternative A-1; therefore, this alternative was ranked highest. Alternative A-2, LUCs have been implemented successfully at other waste units within SRS. There are no administrative or technical impediments for implementing LUCs at SRS. Alternative A-3 can also be readily implemented using standard construction techniques for excavation and hauling the contaminated ash/soil and contaminated soil to an approved offsite disposal facility. However, there will likely be difficulty associated with the construction because of working in the wetlands (groundwater table is near the ground surface), more controls required to minimize damage from construction, and more work needed to restore damage caused by the construction. Permitting for Alternative A-3 may be difficult and costly to obtain. For these reasons, Alternative A-3 is ranked lower than Alternatives A-1 and A-2 for implementability.

4.2.7 Cost

A total present worth cost for each alternative was calculated for each remaining ash unit and presented in Appendix F. The cost estimates include capital and annual O&M costs. Capital costs include direct costs, such as construction, equipment, materials, labor, mobilization, as well as indirect costs such as engineering, health and safety, project management, overhead, contingency, etc. Capital costs were derived from SRS experience, 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. 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%.

Alternative A-3 has high cost due mainly to excavating ash in a wetland, drying the ash, hauling to a landfill and disposal tipping fees. Alternative A-2 requires minimal work, warning sign installation and access controls. Alternative A-1 has no cost. For these reasons, Alternative A-3 is ranked lower than Alternatives A-1 and A-2 for cost.

4.2.8 Summary

Alternative A-1 does not meet threshold criteria. Alternative A-3 is rated slightly higher than Alternative A-2 for long-term effectiveness. Alternative A-2 is rated slightly higher than Alternative A-3 for Short-Term Effectiveness, and significantly higher for Implementability. Overall, for criteria with numerical values, the Alternative A-2 is ranked the highest. In addition, Alternative A-2 has a significantly lower cost of $1.7M versus $80.4M for Alternative A-3. Alternative A-2 cost is nearly all O&M costs, while Alternative A-3 cost is all capital costs.

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6.0 FIGURES AND TABLES

Figures and tables cited in text are found on the following pages.

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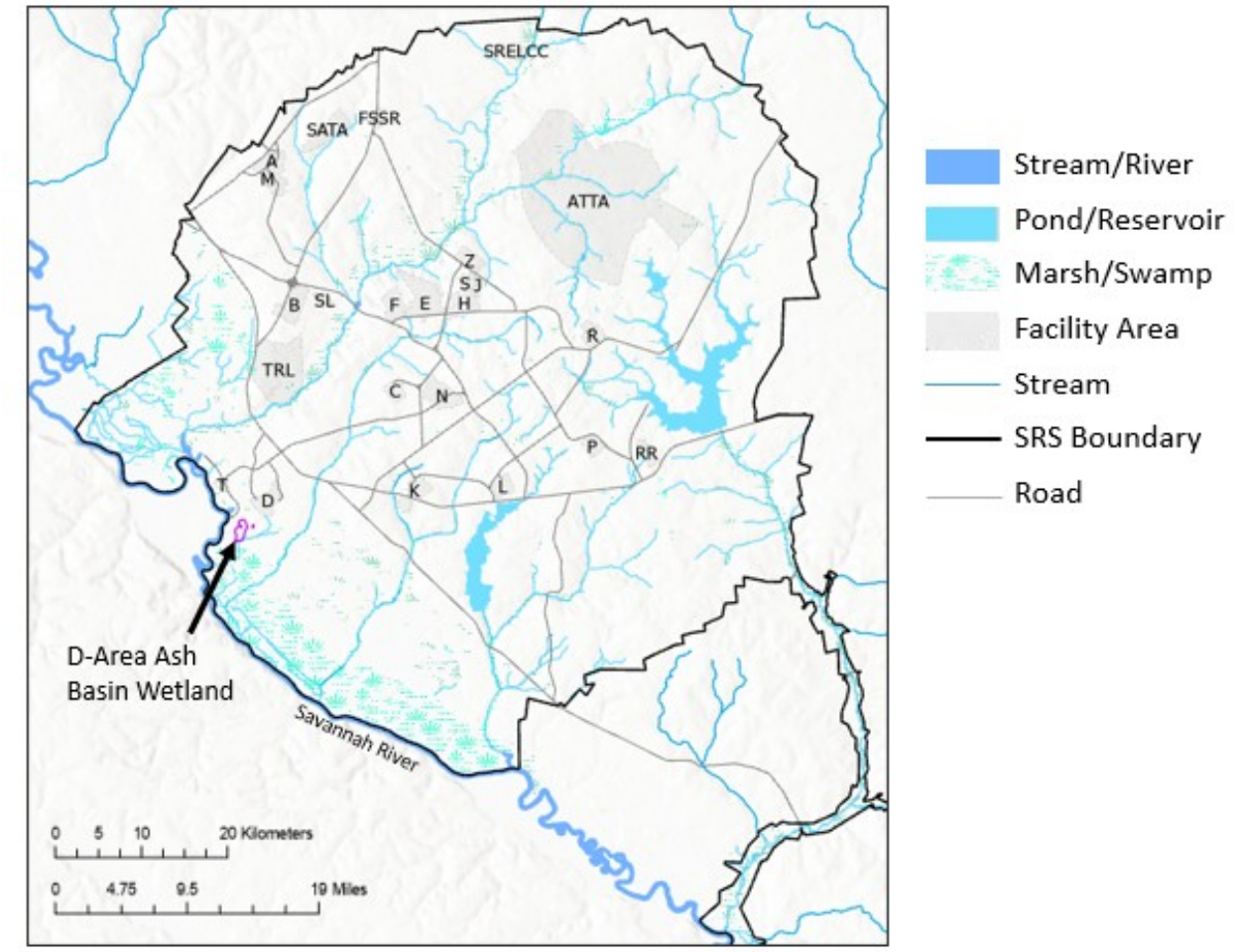


Figure 1. Location of the D-Area Ash Basin Wetlands within the Savannah River Site

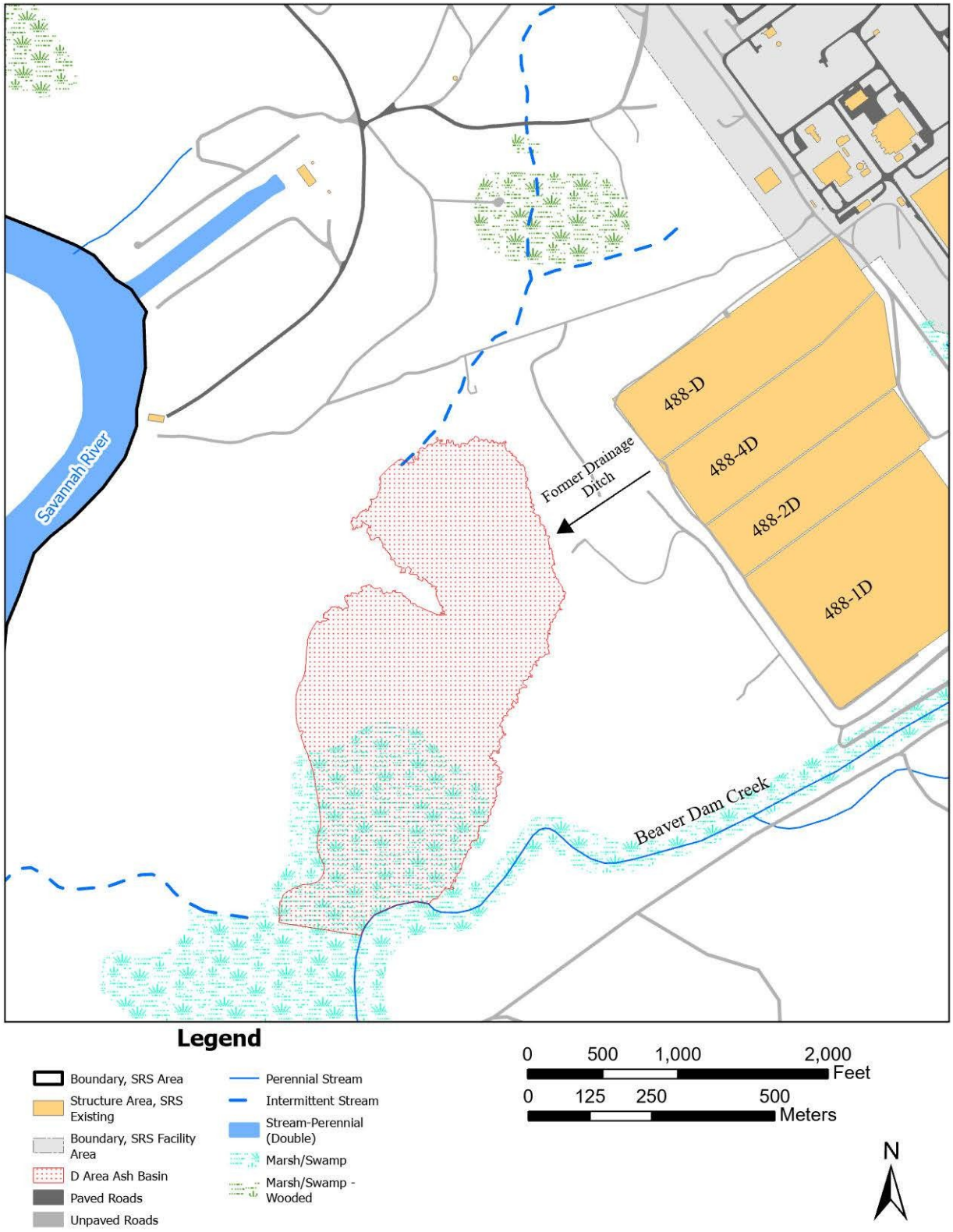


Figure 2. Layout of the D-Area Ash Basin Wetlands

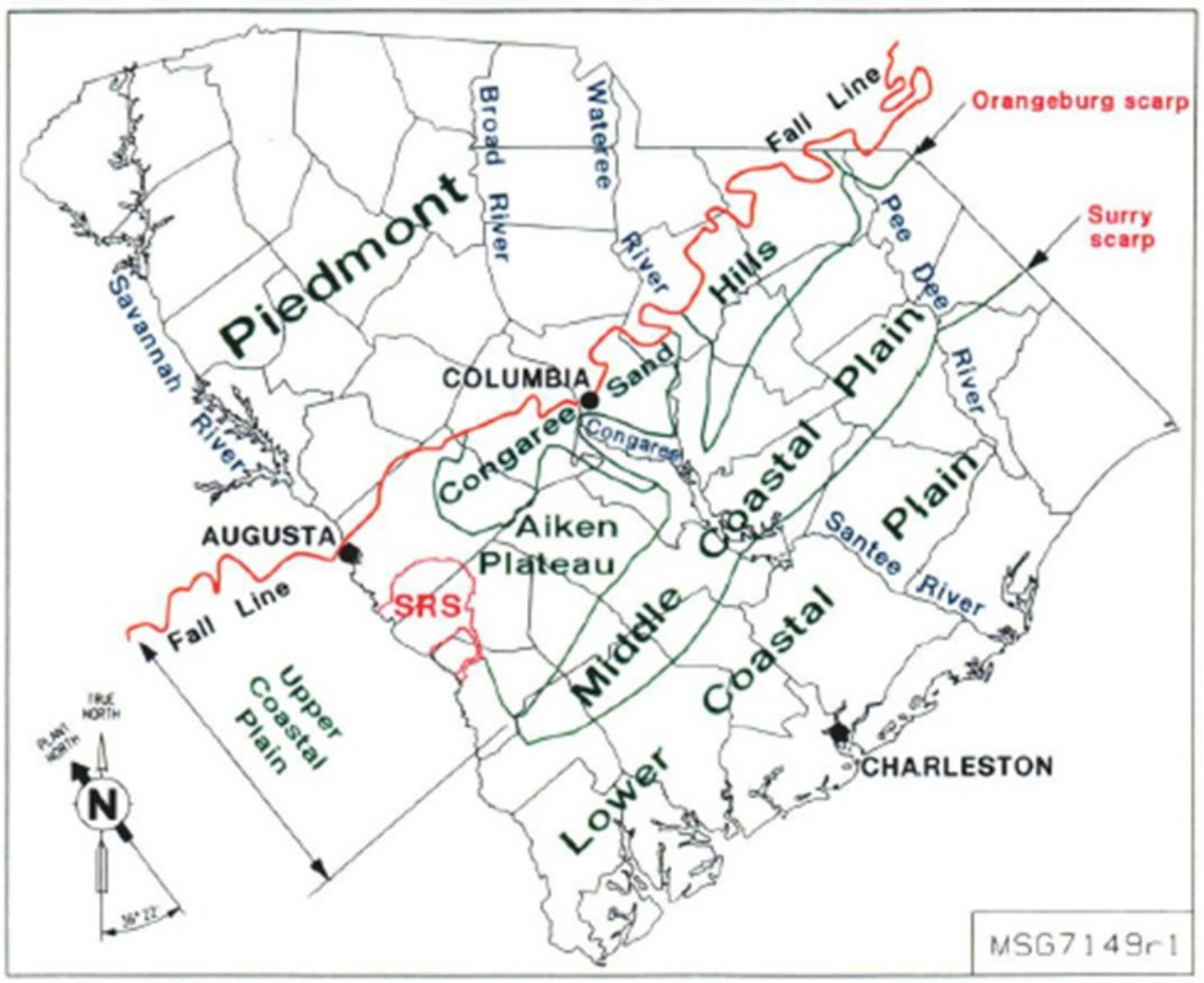


Figure 3. Physiographic Sub-Provinces of the South Carolina Coastal Plain

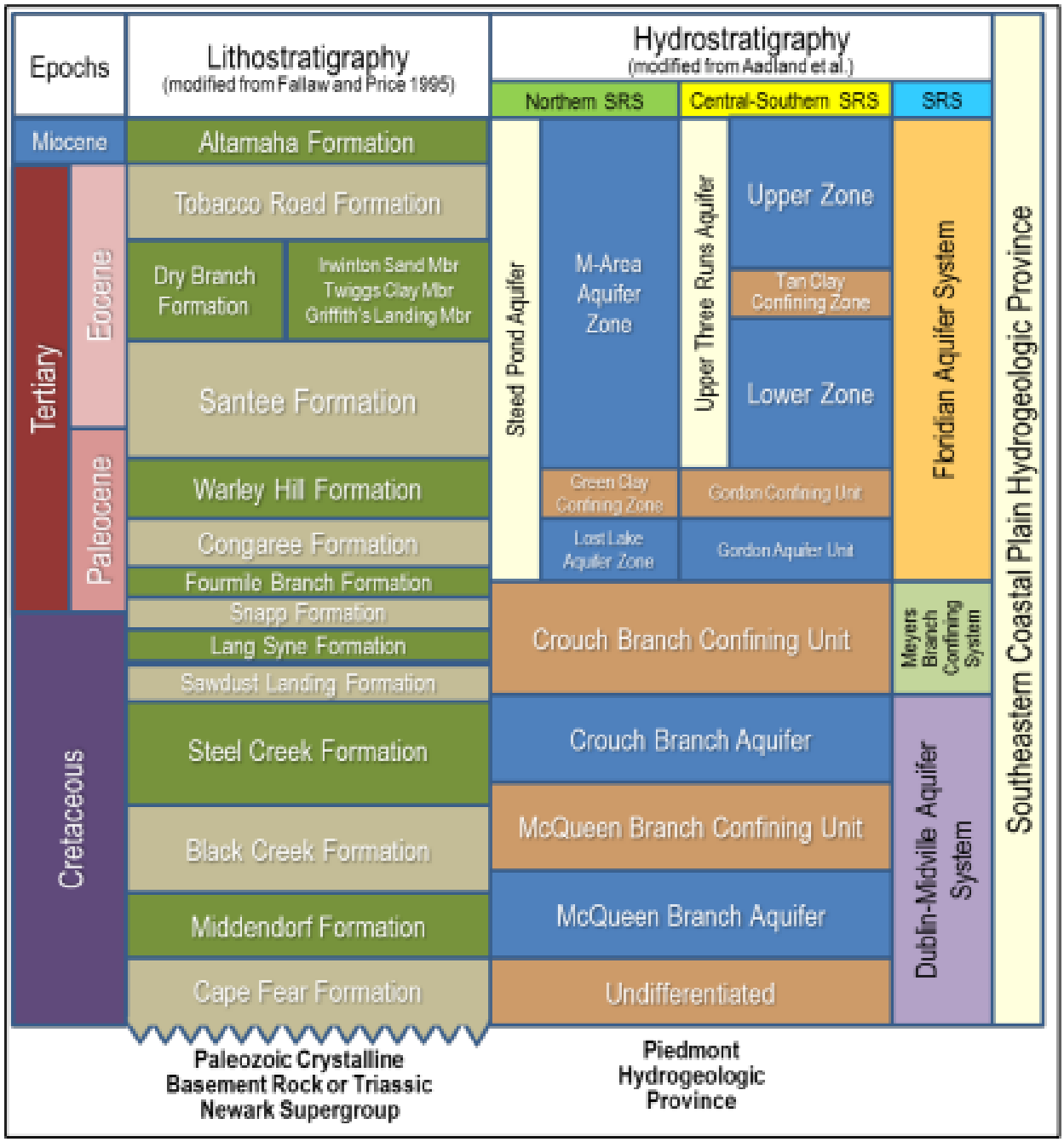


Figure 4. Lithostratigraphic and Hydrostratigraphic Units at SRS

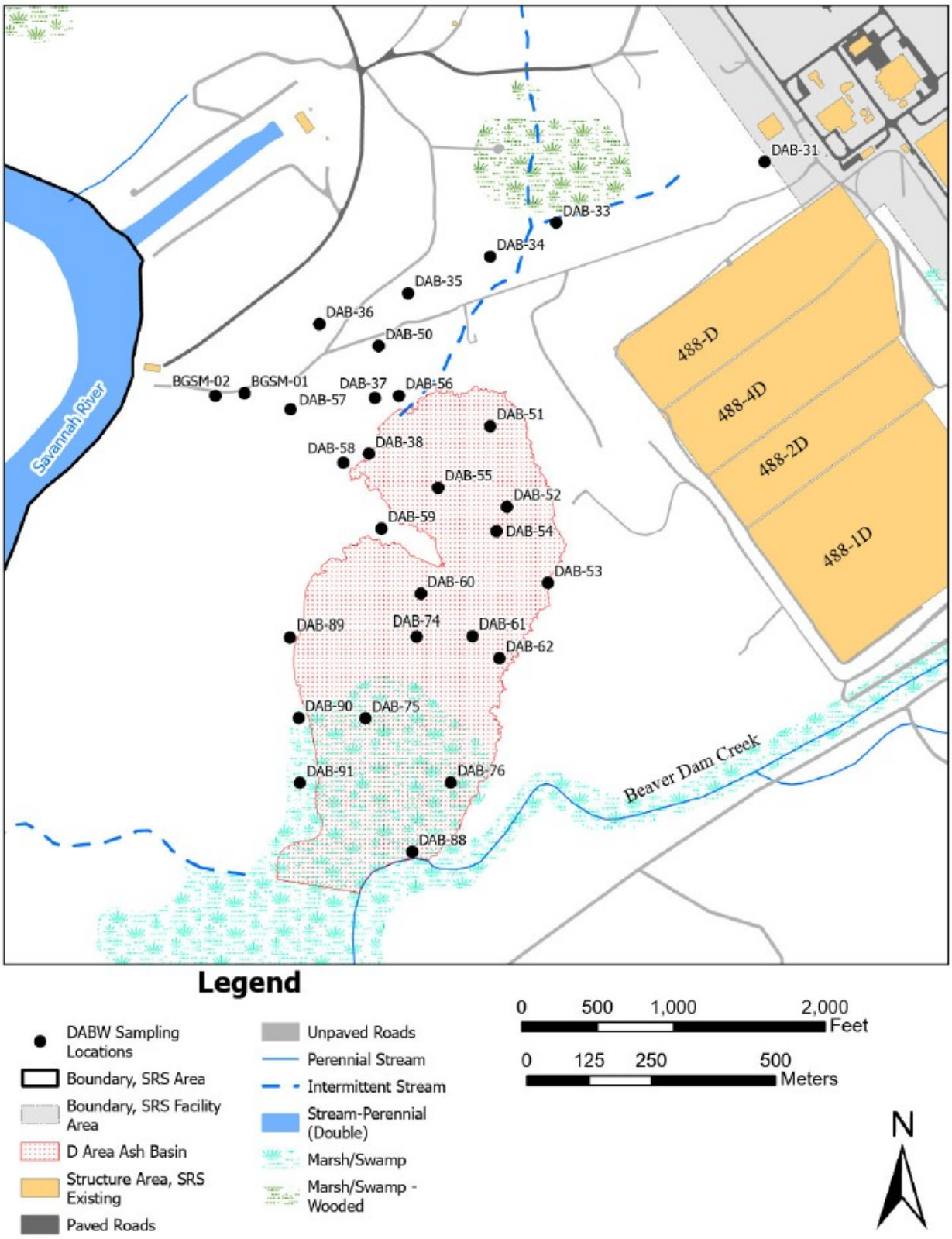


Figure 5. D-Area Ash Basin Wetlands Sampling Locations

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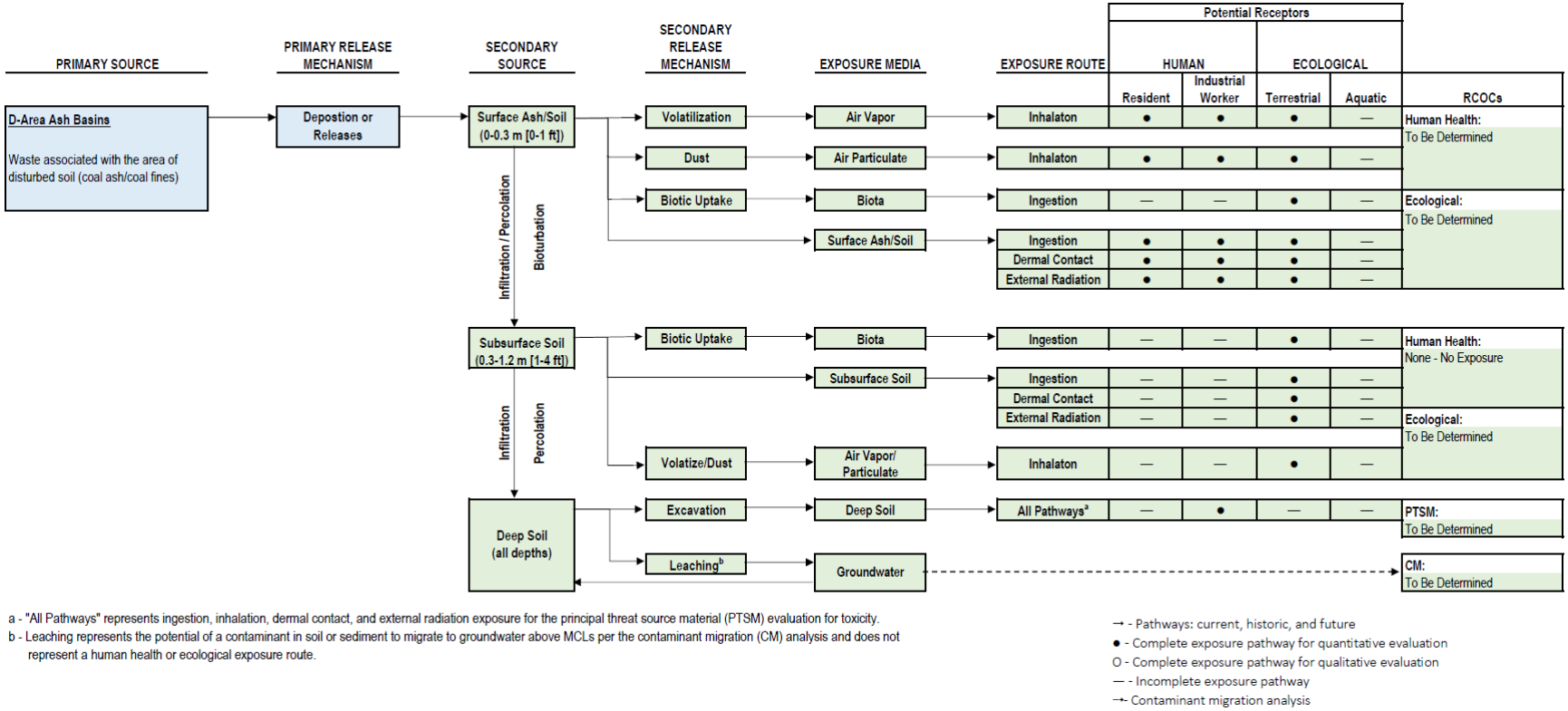


Figure 6. Preliminary CSM for the D-Area Ash Basin Wetlands

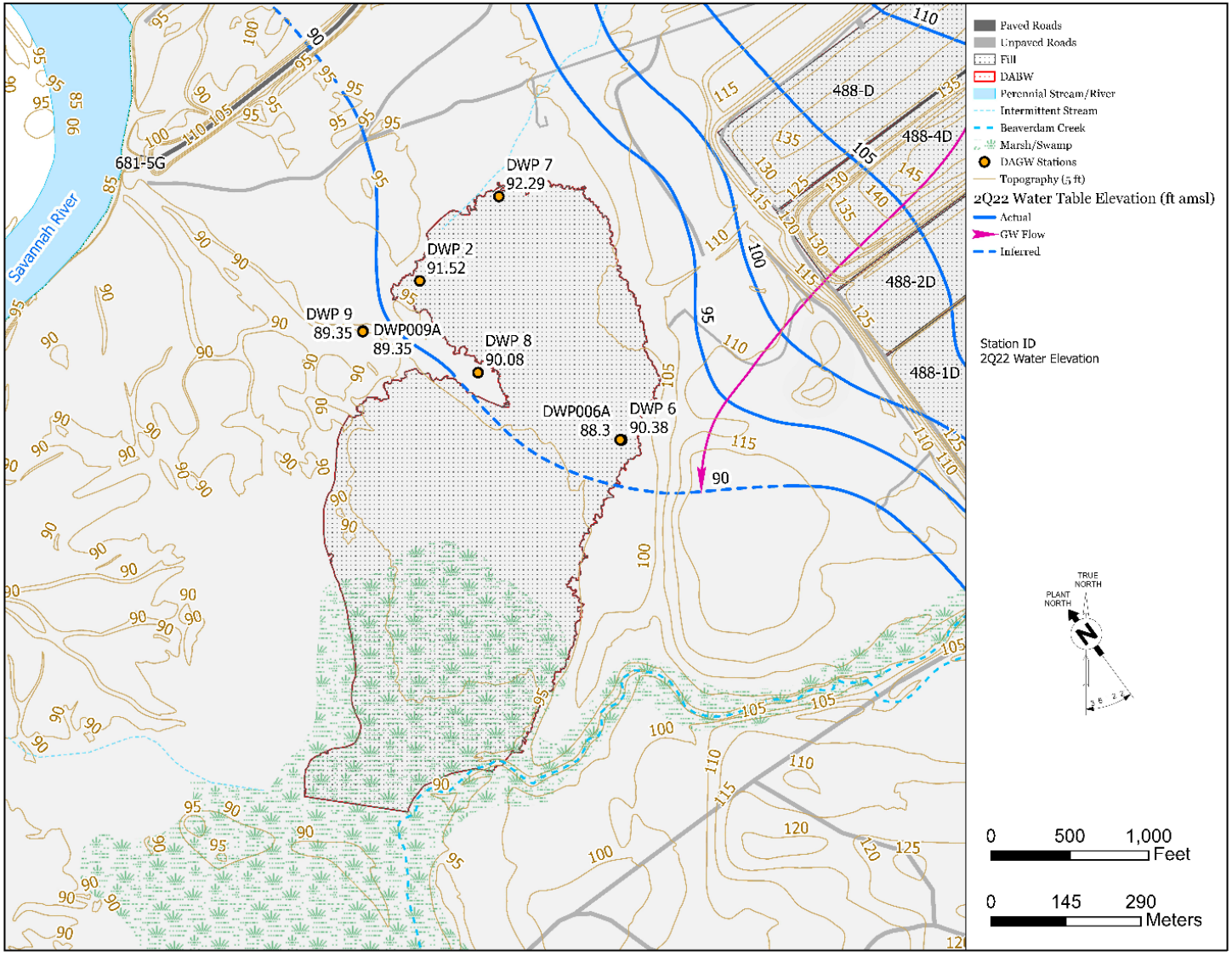


Figure 7. D-Area Ash Basin Wetlands Topography and Water Table Contours

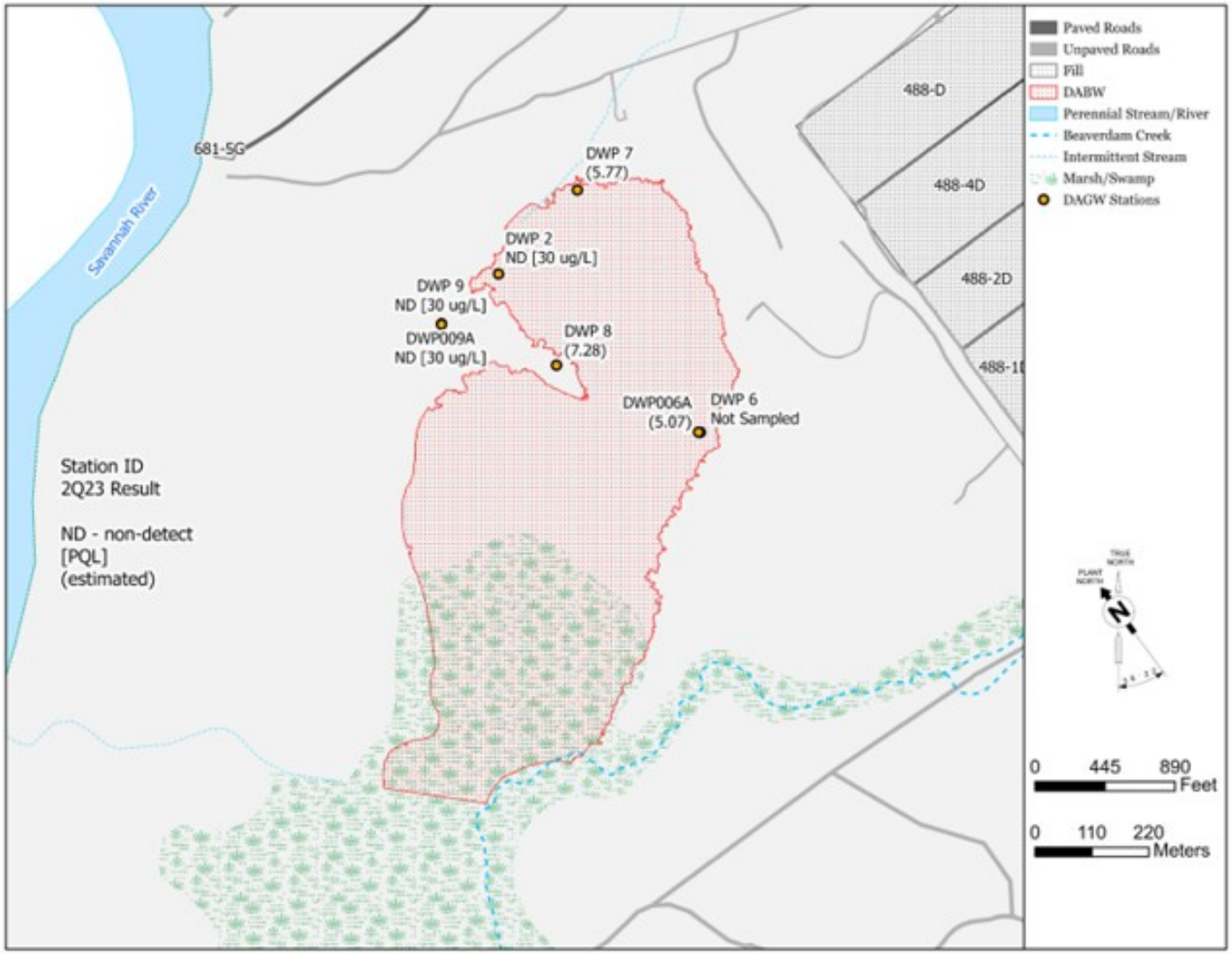


Figure 8. D-Area Ash Basin Arsenic Results for Groundwater (2q23)

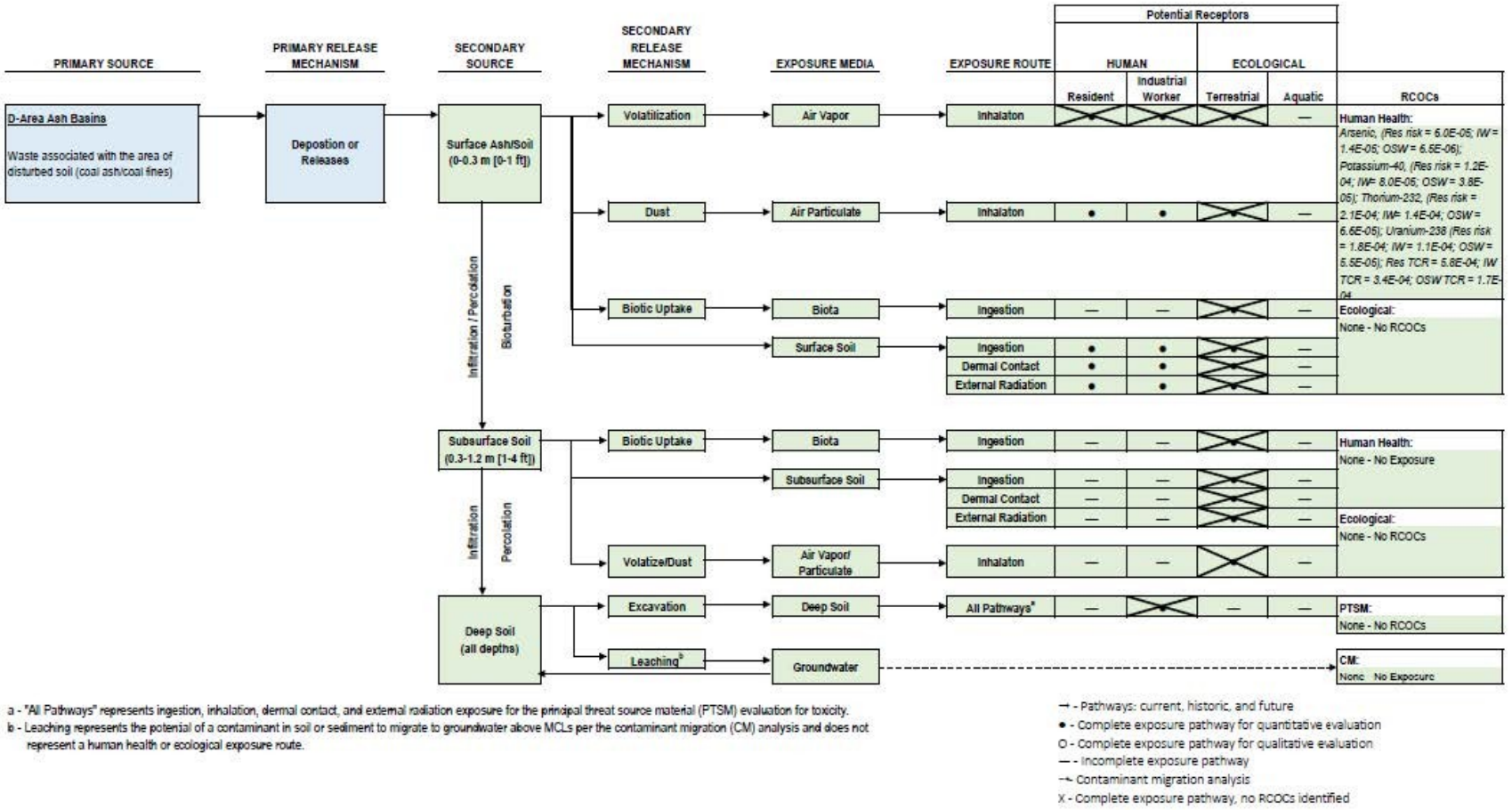


Figure 9. Refined CSM for the D-Area Ash Basin Wetlands

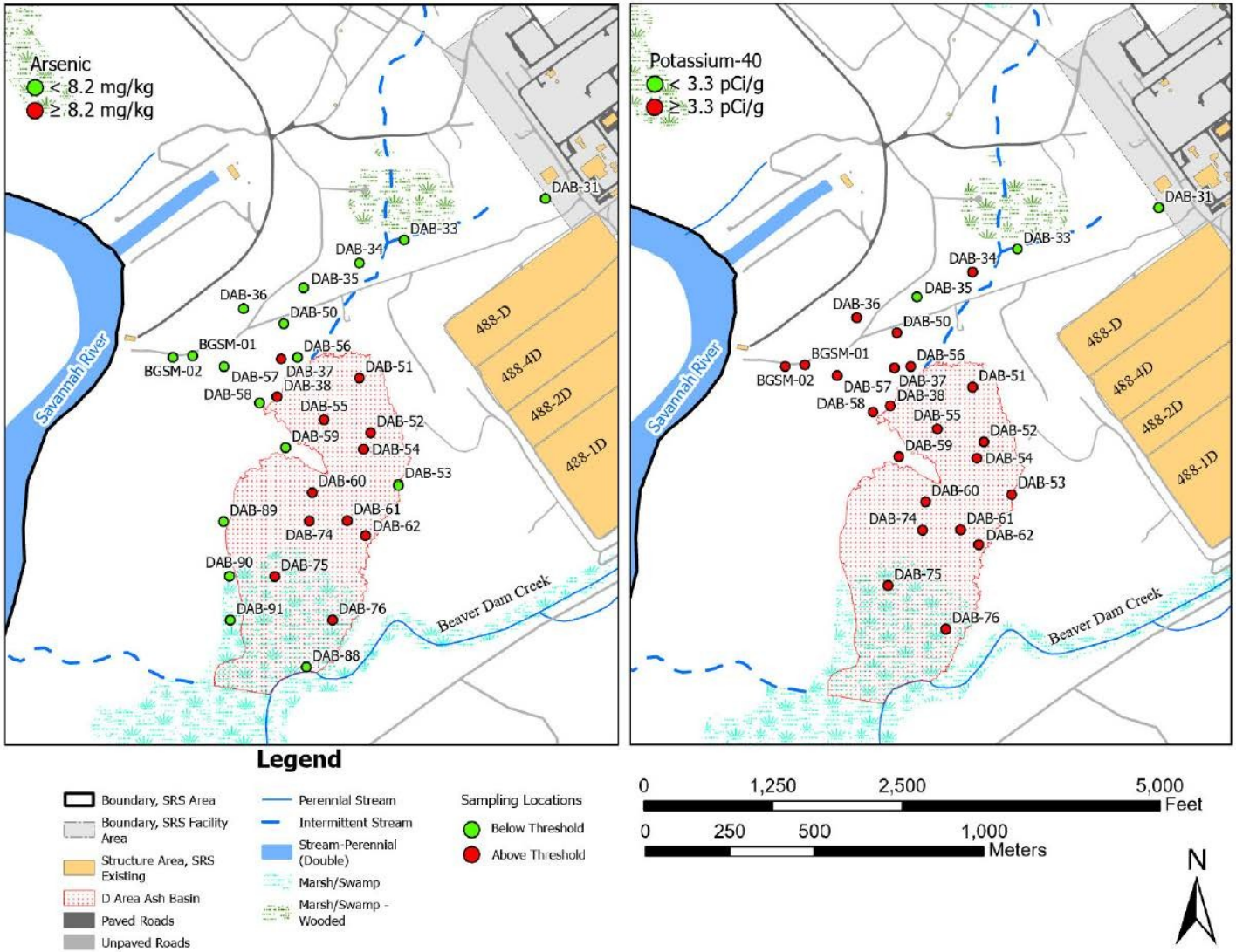


Figure 10. Arsenic and Potassium-40 Levels in Sediment/Soil within the 0-1ft Depth Intervals

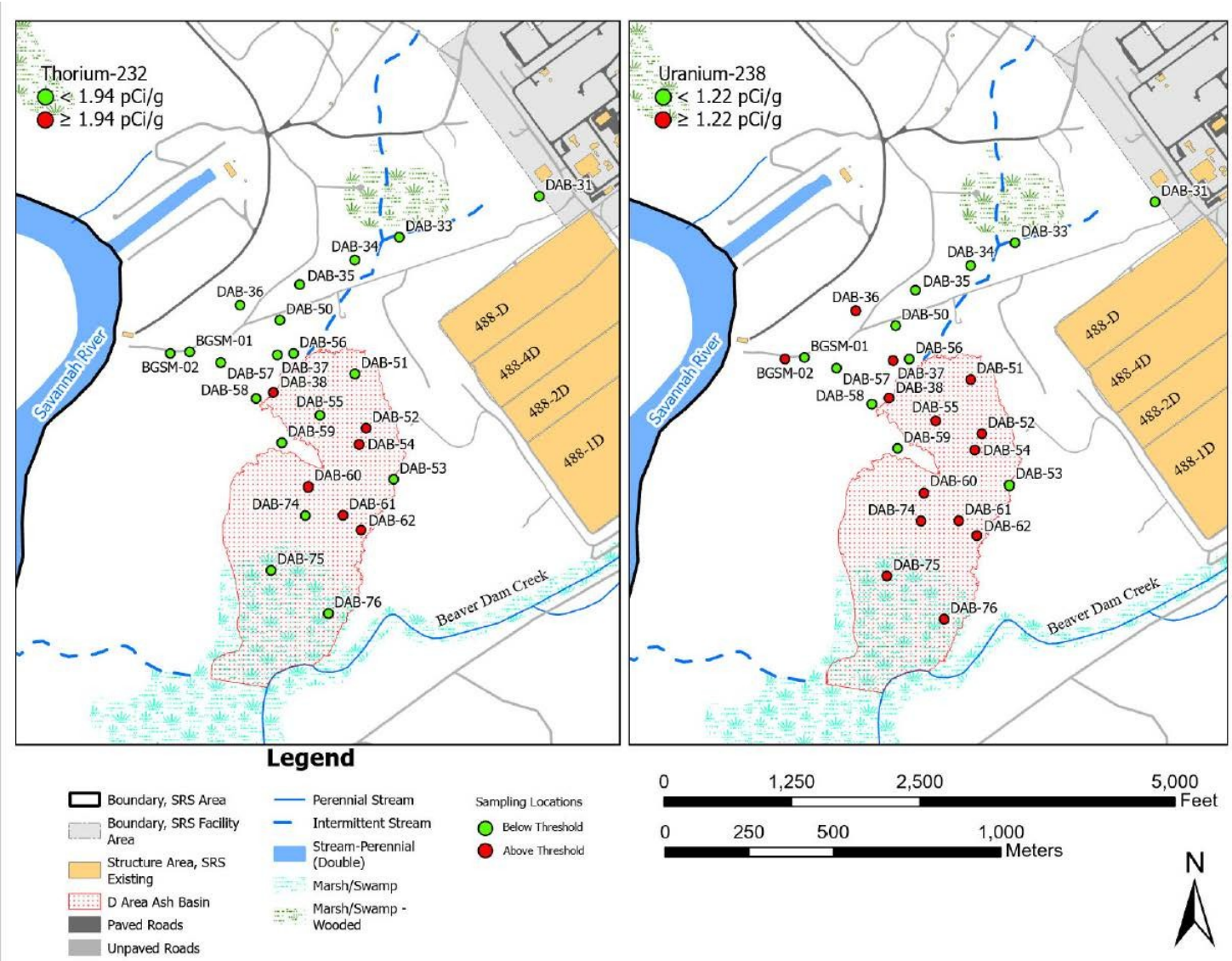


Figure 11. Thorium-232 and Uranium-238 Levels in Sediment/Soil within the 0-1ft Depth Intervals

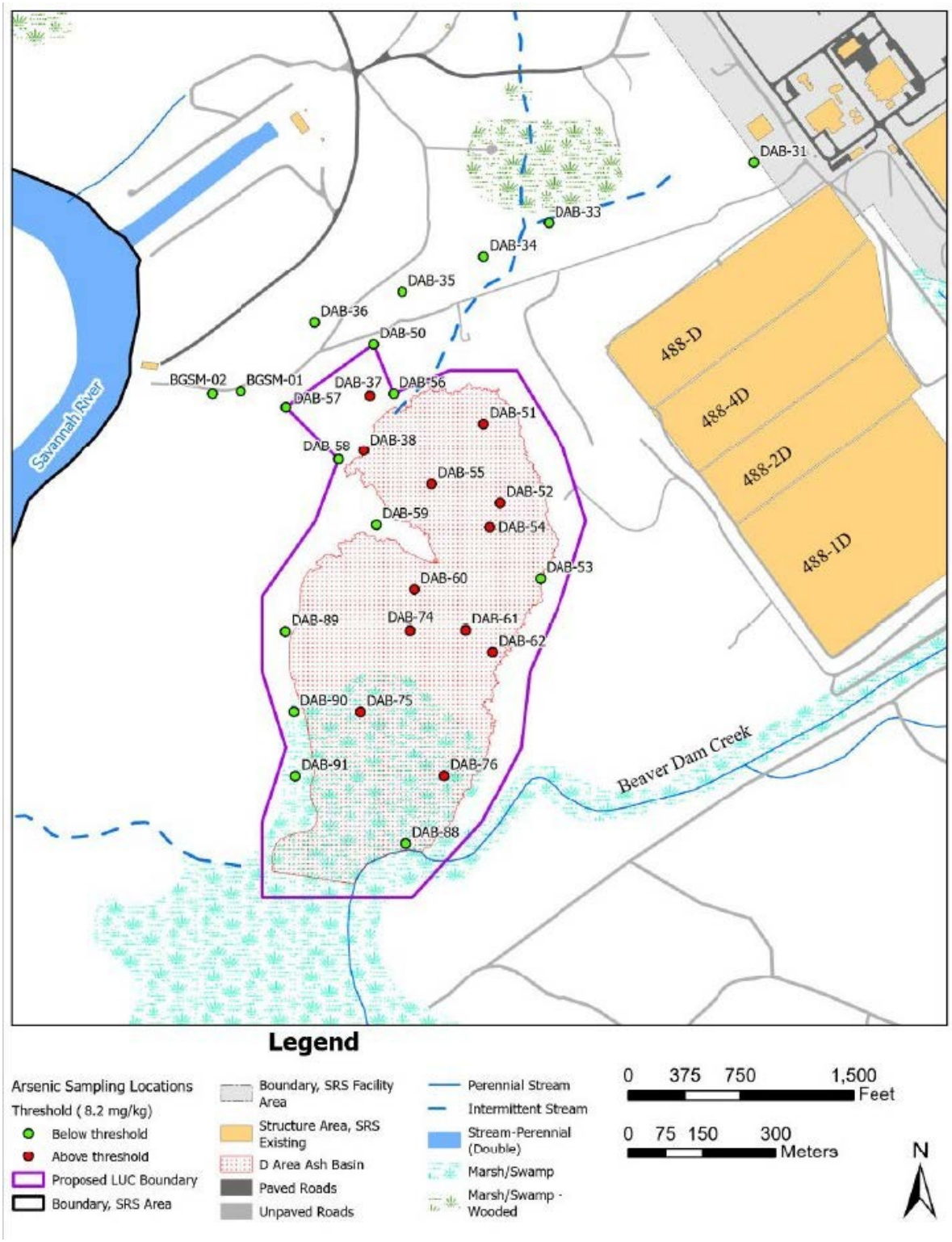


Figure 12. Proposed Land Use Control Boundary Based on Ash Extent (represented by As and background cleanup level of 8.2 mg/kg)

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Table 1. Sampling Stations for the DABW presented in the RFI/RI/BRA for the DEXOU

Exposure Group	Media	Sampling Stations	Notes
488-DAB (Interior)	Soil	DAB-07 through -16, DAB-43 and DAB-44	Includes borings through waste, berm, and 488-D Pooled Basin.
488-DAB (Exterior)	Soil	DAB-17 through –24	
DRP	Soil	DRP-01 through -51	
Background	Soil	BGFA-01, BGFA-02	Background dataset for all soil exposure groups.
Background	Soil	BGCH-01, BGCH-02	For information only (See Section 4.3).
Background	Soil	BGUO-01, BGUO-02	For information only (See Section 4.3).
488-D Pooled Basin	SW	DAB-43 and DAB-44	Data group for surface water only. DAB-43 and DAB-44 sediment samples are evaluated as soil under 488-DAB (Interior).
488-D Drainage	SW/SED	DAB-39, -40, -45, -46	
Dead and Stressed Vegetation Area	SW/SED	DAB-27, -28, -41, -41R, -42	DAB-41: Sediment only.
488-D Wetland	SW/SED	DAB-31, DAB-33 through -38; DAB-50 through -62; and DAB-74, -75, and -76 and BGSM-01 and BGSM-02.	
DRP Stream Boundary	SW/SED	DRP-S2, -S3, and -S4; DAB-32	
DRP Stream Boundary Background	SW/SED	DRP-S1	For information only (See Section 4.3).
Background	SW/SED	SSBG-01, SSBG-02, SSBG-03	For use as background for all SW/SED exposure groups, including DRP.

Note: Samples from locations DAB-88 through -91 were taken as part of a characterization effort in 2002 to define the extent of ash. Analytical results from these locations were not evaluated as part of the risk assessments.

Table 2. Summary of the Groundwater Data from the Seven DABW Shallow Wells

Calendar Year [A]	Arsenic				Barium				Beryllium				Uranium			
	Detects/ Samples	Max	Station of Max	# Above MCL[B]	Detects/ Samples	Max	Station of Max	# Above MCL[B]	# of Samples	Max	Station of Max	# Above MCL[B]	# of Samples	Max	Station of Max	# Above MCL[B]
2023	5/8	58[C]	DWP-008	1	8/8	103	DWP-007	0	7/8	10[C]	DWP-008	1	-	-	-	-
2022	2/7	7.77	DWP-008	0	7/7	125	DWP-009-A	0	4/7	2.07	DWP-008	0	-	-	-	-
2021	5/10	27.9[C]	DWP-008	1	10/10	127	DWP-006-A	0	2/10	1.11	DWP-006-A	0	-	-	-	-
2020	4/7	6.77	DWP-008	0	7/7	81.2	DWP-002	0	5/7	0.714	DWP-009-A	0	-	-	-	-
2019	4/6	6.47	DWP-008	0	6/6	47.4	DWP-007	0	6/6	0.946	DWP-009-A	0	0/6	-	-	-
2018	5/6	7.5	DWP-009-A	0	6/6	109	DWP-009-A	0	5/6	3.04	DWP-009	0	2/6	0.185	DWP-007	0
2017	4/5	5.97	DWP-008	0	5/5	142	DWP-009-A	0	5/5	1.54	DWP-009	0	-	-	-	-
2016	6/8	7.92	DWP-006	0	8/8	185	DWP-006	0	5/8	2.75	DWP-006	0	1/8	2.92	DWP-006	0
2015	4/7	5.97	DWP-009-A	0	7/7	68	DWP-008	0	5/7	0.944	DWP-008	0	0/7	-	-	-
2014	3/6	3.9	DWP-009-A	0	6/6	140	DWP-009-A	0	5/6	0.68	DWP-002	0	-	-	-	-
2013	2/5	6.2	DWP-008	0	5/5	82.8	DWP-009-A	0	5/5	0.896	DWP-002	0	-	-	-	-
2012	4/4	7.63	DWP-009-A	0	4/4	156	DWP-007	0	4/4	1.29	DWP-002	0	0/3	-	-	-
2011	2/6	6.4	DWP-008	0	6/6	92.8	DWP-009-A	0	4/6	0.66	DWP-002	0	-	-	-	-
2010	3/7	9.3	DWP-008	0	7/7	118	DWP-009-A	0	2/7	0.45	DWP-002	0	-	-	-	-
2009	3/7	5.8	DWP-008	0	7/7	90	DWP-009-A	0	7/7	1.6	DWP-009	0	1/7	0.327	DWP-008	0
2008	0/6	-	-	-	6/6	135	DWP-008	0	2/6	1.87	DWP-009	0	0/6	-	-	-
2007	2/7	16.2	DWP-008	1	7/7	131	DWP-008	0	6/7	2	DWP-009	0	-	-	-	-
2006	3/7	10.1	DWP-008	1	7/7	195	DWP-009-A	0	7/7	1	DWP-009	0	-	-	-	-
2005	2/5	10.7	DWP-008	1	5/5	81.9	DWP-008	0	3/5	2.1	DWP-009	0	0/5	-	-	-
2004	3/5	13.9	DWP-008	1	5/5	87.9	DWP-008	0	2/5	5	DWP-008	1	-	-	-	-
2003	2/6	7.29	DWP-008	0	6/6	67	DWP-008	0	12/12	3.48	DWP-009	0	-	-	-	-

Red shaded results exceed the MCL

A – Number of sampling events vary in each calendar year. Sampling performed in accordance with the *Monitoring Work Plan for the D-Area Groundwater Operable Unit (U)* (WSRC-RP-2003-4150).

B – November 2023 USEPA MCLs; Arsenic - 10 ug/L, Barium - 2,000 ug/L, Beryllium - 4 ug/L, Uranium - 30 ug/L

C – Sample had high turbidity (>140 NTU)

Table 3. Summary of the RCOCs for the DABW

Subunit	RCOCs						
			HHRA				
	ARAR	CM	Residential	Industrial	IOU Worker	ERA	PTSM
DABW	Ash / Soil None	Ash / Soil None	Ash / Soil *Arsenic = 5.99E-05* *Potassium-40 = 1.22E-04* *Thorium-232 =2.12E-04* *Uranium-238 = 1.82E-04* **TCR = 5.75E-04**	Ash / Soil *Arsenic = 1.36E-05* *Potassium-40 = 7.99E-05* *Thorium-232 = 1.37E-04* *Uranium-238 = 1.14E-04* **TCR = 3.44E-04**	Ash / Soil *Arsenic = 6.52E-06* *Potassium-40 = 3.84E-05* *Thorium-232 = 6.57E-05* *Uranium-238 = 5.46E-05* **TCR = 1.65E-04**	Ash / Soil None	Ash / Soil None

ARAR = applicable or relevant and appropriate requirement
CM = contaminant migration
DABW = D-Area Ash Basin Wetlands
ERA = ecological risk assessment
HHRA = human health risk assessment
IOU = Integrator Operable Unit
PTSM = principal threat source material
RCOCs = refined constituents of concern from RFI/RI/BRA
TCR = total cumulative risk

Table 4. Summary of the D-Area Ash Basin Wetlands PRGs

Unit (media)	RCOC	Units	ARAR	CM	HH Residential[1]	HH Industrial[1]	HH IOU Worker[1]	ERA	PTSM	Most Restrictive Cleanup Level	SRS Background Maximum[2]	SRS Background 95th Percentile	Most Likely PRG[3]
DABW (ash)	Arsenic	mg/kg	---	---	0.68	3.0	6.24	---	---	0.68	22.9	*8.2*	8.2
	Potassium-40	pCi/g	---	---	0.144	0.219	0.446	---	---	0.144	8.53	*3.3*	3.3
	Thorium-232	pCi/g	---	---	0.00985	0.0153	0.0318	---	---	0.00985	2.79	*1.94*	1.94
	Uranium-238	pCi/g	---	---	0.0125	0.020	0.0416	---	---	0.0125	1.9	*1.22*	1.22

[1] Resident, Industrial Worker and IOU Onsite Worker 1E-06 regional screening level or PRG from Appendix B, Table B-1.
[2] SRS Background concentrations from the *Background Soils Statistical Summary Report for the Savannah River Site* (ERD-EN-2005-0223) (WSRC 2006).
[3] Most likely PRG is the lesser of the risk-based levels or the SRS 95th percentile background concentration. Source of the most likely cleanup level is identified in italics.

ARAR = applicable or relevant and appropriate requirement
CM = contaminant migration
DABW = D-Area Ash Basin Wetlands
ERA = ecological risk assessment
HH = human health
IOU = Integrator Operable Unit
PTSM = principal threat source material
RCOC = refined constituents of concern from RFI/RI/BRA

Table 5. Potential ARARs and TBC Criteria for the D-Area Ash Basin Wetlands

LOCATION-SPECIFIC ARARs/TBC					
Location Characteristics	**Requirements**	**Prerequisite**	**Citation**	**Alt -2**	**Alt-3**
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)		✓
	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)		✓
Location encompassing *aquatic ecosystem* as defined in 40 CFR 230.3(c)	No discharge of dredged or fill material into an aquatic ecosystem is permitted if there is a practicable alternative that would have less adverse impact. No discharge of dredged or fill material shall be permitted unless appropriate and practicable steps in accordance with 40 CFR 230.70 *et seq.* have been taken that will minimize potential adverse impacts of the discharge on the aquatic ecosystem.	Action that involves the discharge of dredged or fill material into waters of the United States, including jurisdictional wetlands – **applicable.**	40 CFR 230.10(a) 40 CFR 230.10(d)		✓

Table 5. Potential ARARs and TBC Criteria for the D-Area Ash Basin Wetlands *(Continued)*

LOCATION-SPECIFIC ARARs/TBC					
Location Characteristics	**Requirements**	**Prerequisite**	**Citation**	**Alt -2**	**Alt-3**
Floodplains and Wetlands					
Location encompassing *aquatic ecosystem* as defined in 40 CFR 230.3(c)	No discharge of dredged or fill material into an aquatic ecosystem is permitted if there is a practicable alternative that would have less adverse impact. No discharge of dredged or fill material shall be permitted unless appropriate and practicable steps in accordance with 40 CFR 230.70 *et seq.* have been taken that will minimize potential adverse impacts of the discharge on the aquatic ecosystem.	Action that involves the discharge of dredged or fill material into waters of the United States, including jurisdictional wetlands – **applicable.**	40 CFR 230.10(a) 40 CFR 230.10(d)		✓
	Must comply with the substantive requirements of the NWP 38, General Conditions, as appropriate, any regional or case-specific conditions recommended by the Corps District Engineer, after consultation. <u>Note</u>: Despite that consultation may be considered an administrative requirement, it should be performed to ensure activities are in compliance with substantive provisions of the permit.	On-site CERCLA action conducted by Federal agency that involves 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 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 5. Potential ARARs and TBC Criteria for the D-Area Ash Basin Wetlands *(Continued)*

LOCATION-SPECIFIC ARARs/TBC					
Location Characteristics	**Requirements**	**Prerequisite**	**Citation**	**Alt-2**	**Alt-3**
Floodplains and Wetlands					
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. The SRARP is a division of the South Carolina Institute of Archaeology and Anthropology (SCIAA) at the University of South Carolina. The SRARP manages the archaeological and other historic resources for the U.S. Department of Energy.*	Excavation and/or removal of archaeological resources from public lands – **applicable**.	43 *CFR* Part 7 – implementing the Archaeological Resources Protection Act of 1979.		✓

Table 5. Potential ARARs and TBC Criteria for the D-Area Ash Basin Wetlands *(Continued)*

ACTION SPECIFIC ARARs/TBC					
Action	**Requirements**	**Prerequisite**	**Citation**	**Alt-2**	**Alt-3**
General Construction Standards — All Land-disturbing Activities (i.e., excavation, clearing, grading, etc.)					
Managing storm water run-off from land-disturbing activities	Must comply with the substantive requirements for stormwater management and sediment control of *NPDES General Permit No. SCR100000.*	Large and small construction activities (as defined in R.61-9) of more than 1 acre of land – **applicable**	SC R.61-9.122.26(c) NPDES General Permit No. SCR100000		✓
	The requirements of R.72-305 and R.72-307 will apply.	For land disturbing activities disturbing more than five (5) acres – **applicable**	SC R.72-305.B.(3)		✓
	The stormwater management and sediment control plan shall contain at a minimum the information provided in the following subsections:	Activities involving more than two (2) acres and less than five (5) acres of actual land disturbance which are not part of a larger common plan of development or sale – **applicable**	SC R.72-307 I. – *South Carolina Storm Water Management and Sediment Reduction Regulations*		✓
	A plan for temporary and permanent vegetative and structural erosion and sediment control measures which specify the erosion and sediment control measures to be used during all phases of the land disturbing activity and a description of their proposed operation.		SC R.72-307 I.(3)(d)		✓

Table 5. Potential ARARs and TBC Criteria for the D-Area Ash Basin Wetlands *(Continued)*

ACTION SPECIFIC ARARs/TBC					
Action	**Requirements**	**Prerequisite**	**Citation**	**Alt-2**	**Alt-3**
General Construction Standards — All Land-disturbing Activities (i.e., excavation, clearing, grading, etc.)					
Managing storm water run-off from land-disturbing activities (*continued*)	Provisions for stormwater runoff control during the land disturbing activity and during the life of the facility meeting the following requirements: 1. Post-development peak discharge rates shall not exceed pre-development discharge rates for the 2- and 10-year frequency 24-hour duration storm event. Implementing agencies may utilize a less frequent storm event (e.g. 25-year, 24-hour) to address existing or future stormwater quantity or quality problems. 2. Discharge velocities shall be reduced to provide a non-erosive velocity flow from a structure, channel, or other control measure or the velocity of the 10-year, 24-hour storm runoff in the receiving waterway prior to the land disturbing activity, whichever is greater.		SC R.72-307 I.(3)(e)		✓

Table 5. Potential ARARs and TBC Criteria for the D-Area Ash Basin Wetlands *(Continued)*

Action	Requirements	Prerequisite	Citation	Alt-2	Alt-3
General Construction Standards — All Land-disturbing Activities (i.e., excavation, clearing, grading, etc.*(cont'd)*					
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. Volatile organic compounds shall not be used for dust control purposes. Oil treatment is also prohibited.	Activities that will generate fugitive particulate matter (Statewide) – **applicable**	SC R.61-62.6 Section III(a)- *Control of Fugitive Particulate Matter Statewide* SC R.61-62.6 Section III(d)		✓
Waste Characterization and Storage — (e.g., wastewaters, excavated ash, coal fines, contaminated soils/sediments, vegetation, debris)					
Characterization of *solid* waste	Must determine if solid waste is a hazardous waste using the following method: Should first determine if waste is excluded from regulation under 40 CFR 261.4; and	Generation of solid waste as defined in 40 CFR 261.2 – **applicable**	40 CFR 262.11(a) SC R.61-79 262.11*(a)*		✓
	Must determine if waste is listed as hazardous waste under 40 CFR Part 261.	Generation of solid waste which is not excluded under 40 CFR 261.4(a) – **applicable**	40 CFR 262.11(b) SC R.61-79 262.11*(b)*		✓
	Must determine whether the waste is (characteristic waste) identified in subpart C of 40 CFR Part 261 by either: 1. Testing the waste according to the methods set forth in subpart C of 40 CFR part 261, or according to an equivalent method approved by the Administrator under 40 CFR 260.21; or 2. Applying knowledge of the hazard characteristic of the waste in light of the materials or the processes used.	Generation of solid waste which is not excluded under 40 CFR 261.4(a) – **applicable**	40 CFR 262.11(c) SC R.61-79 262.11*(c)*		✓
	Must refer to Parts 261, 262, 264, 265, 266, 268, and 273 of Chapter 40 for possible exclusions or restrictions pertaining to management of the specific waste.	Generation of solid waste which is determined to be *hazardous* waste – **applicable**	40 CFR 262.11(d) SC R.61-79 262.11*(d)*		✓

Table 5. Potential ARARs and TBC Criteria for the D-Area Ash Basin Wetlands *(Continued)*

Action	Requirements	Prerequisite	Citation	Alt-2	Alt-3
Waste Characterization and Storage — (e.g., wastewaters, excavated ash, coal fines, contaminated soils/sediments, vegetation, debris) *(cont'd)*					
Determinations for management of *hazardous* waste [1]	Must determine each EPA Hazardous Waste Number (waste code) applicable to the waste in order to determine the applicable treatment standards under 40 CFR 268 *et seq.* *Note:* This determination may be made concurrently with the hazardous waste determination required in Sec. 262.11 of this chapter.	Generation of hazardous waste for storage, treatment or disposal – **applicable**	40 CFR 268.9(a) SC R.61-79 268.9*(a)*		✓
	Must determine the underlying hazardous constituents [as defined in 40 CFR 268.2(i)] in the characteristic waste.	Generation of RCRA characteristic hazardous waste (and is not D001 non-wastewaters treated by CMBST, RORGS, or POLYM of Section 268.42 Table 1) for storage, treatment, or disposal – **applicable**	40 CFR 268.9(a) SC R.61-79 268.9*(a)*		✓
	Must determine if the hazardous waste meets the treatment standards in 40 CFR 268.40, 268.45, or 268.49 by testing in accordance with prescribed methods or use of generator knowledge of waste. *Note:* This determination can be made concurrently with the hazardous waste determination required in 40 CFR 262.11.	Generation of hazardous waste for storage, treatment or disposal – **applicable**	40 CFR 268.7(a) SC R.61-79 268.7 *(a)* (1)		✓
Temporary Storage of Solid Waste	Shall be conducted in a manner to: a. Inhibit the harborage of flies, rodents, and other vectors; b. Prevent conditions for transmission of diseases to man or animals; c. Prevent blowing debris and particulates so as not to be injurious to human health and the environment; d. Prevent water pollution and prevent the escape of solid waste or leachate to waters of the State; and Minimize objectionable odors, dust, unsightliness, and aesthetically objectionable conditions, and prevent the accumulation of materials in an untidy and unsafe manner so as to become a fire and safety hazard.	Generation of solid waste for temporary storage prior to processing, disposal of that waste – **relevant and appropriate**	SC R.61-107.5(C)(1)		✓

Table 5. Potential ARARs and TBC Criteria for the D-Area Ash Basin Wetlands *(Continued)*

Action	Requirements	Prerequisite	Citation	Alt-2	Alt-3
Disposal of Wastes Off-Site (e.g., ash, coal fines, contaminated soils/sediments, vegetation, debris)					
Off-Site 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**	SC R.61-107.5(D)(3)		✓
Off-site Disposal of RCRA-*Hazardous* Waste in a Land-Based Unit [1]	May be land disposed if it meets the requirements in the table "Treatment Standards for Hazardous Waste" at 40 CFR 268.40 before land disposal.	Land disposal, as defined in 40 CFR 268.2, of restricted RCRA waste – **applicable**	40 CFR §268.40(a) SC R.61-79 268.40*(a)*		✓
	All underlying hazardous constituents [as defined in 40 CFR 268.2(i)] must meet the Universal Treatment Standards (UTSs), found in 40 CFR 268.48 Table UTS prior to land disposal.	Land disposal of restricted RCRA characteristic wastes (D001-D043) not managed in a wastewater treatment system regulated under the Clean Water Act (CWA), that is CWA equivalent, or that is injected into a Class I nonhazardous injection well – **applicable**	40 CFR §268.40(e) SC R.61-79 268.40*(e)*		✓
	Must be treated according to the alternative treatment standards of 40 CFR 268.49(c) or Must be treated according to the UTSs [specified in 40 CFR 268.48 Table UTS] applicable to the listed and/or characteristic waste contaminating the soil prior to land disposal.	Land disposal, as defined in 40 CFR 268.2, of restricted hazardous soils –**applicable**	40 CFR §268.49(b) SC R.61-79 268.49*(b)*		✓

Table 5. Potential ARARs and TBC Criteria for the D-Area Ash Basin Wetlands *(Continued)*

Action	Requirements	Prerequisite	Citation	Alt-2	Alt-3
Disposal of Wastes Off-Site (e.g., ash, coal fines, contaminated soils/sediments, vegetation, debris)					
Off-site Disposal of RCRA-*Hazardous* Waste in a Land-Based Unit [1] *(continued)*	To determine whether a hazardous waste identified in this section exceeds the applicable treatment standards of 40 CFR 268.40, the initial generator must test a sample of the waste extract or the entire waste, depending on whether the treatment standards are expressed as concentration in the waste extract or waste, or the generator may use knowledge of the waste. If the waste contains constituents (including underlying hazardous constituents [UHCs] in the characteristic wastes) in excess of the applicable UTS levels in 40 CFR 268.48, the waste is prohibited from land disposal, and all requirements of Part 268 are applicable, except as otherwise specified.	Land disposal of RCRA toxicity characteristic wastes (D004-D011) that are newly identified – **applicable**	40 CFR 268.34(f) SC R.61-79 268.34*(f)*		✓

Table 5. Potential ARARs and TBC Criteria for the D-Area Ash Basin Wetlands *(Continued)*

Action	Requirements	Prerequisite	Citation	Alt-2	Alt-3
Dewatering of Ash Area During Removal (If Necessary)					
Discharge to Surface Water	Any discharge into waters of the State must be permitted by the Department and receive a degree of treatment and/or control which shall produce an effluent which is consistent with the Act, the Clean Water Act (P.L. 92-500, 95-217, 97-117, 100-4), this regulation, and related regulations. *Note:* Under CERCLA Section 121(e) permits are not required for on-site response actions. Instead, SRS must meet any applicable effluent limits in its existing NPDES discharge permit or other substantive requirements, including the numeric water quality criteria for the protection and maintenance of the appropriate class of surface waters as adopted in SC R.61-68 and listed in Sections E, G, and the appendix therein.	Discharge of pollutants (including toxic substances) into waters of the State of South Carolina – **applicable**	SC R.61-68E.4.a SC R.61-68 E.14		✓
	Site-specific permit effluent limitations and alternate criteria less stringent than those derived in accordance with the requirements in SC R.61-68 E.14.c. may be derived where it is demonstrated that such limits and criteria shall maintain the existing and classified uses.		SC R.61-68 E.14.c.(7)		✓
	Discharge of garbage, cinders, ashes, oils, sludges, or other refuse is not allowed.	Quality Standards for Waters of the State of South Carolina (classified as FW as provided in SC R.61-68G.10) – **applicable**	SC R.61-68G.10.a		✓
	Treated wastes, toxic wastes, deleterious substances in sufficient amounts to make the waters unsafe or unsuitable for primary contact recreation or to impair the waters for any other best usage are not allowed.		SC R.61-68G.10.b		✓
	Discharge of toxic pollutants is not allowed except as prescribed in Section E of SC R.61-68.		SC R.61-68G.10.c		✓
	Stormwater, and other nonpoint source runoff is allowed if water quality necessary for existing and classified uses shall be maintained and protected consistent with anti-degradation rules.		SC R.61-68G.10.d		✓

Table 5. Potential ARARs and TBC Criteria for the D-Area Ash Basin Wetlands *(Continued/End)*

Action	Requirements	Prerequisite	Citation	Alt-2	Alt-3
Dewatering of Ash Area During Removal (If Necessary					
	Dissolved oxygen – daily average not less than 5.0 mg/L with a low of 4.0 mg/L		SC R.61-68G.10.e		✓
	pH between 6.0 and 8.5		SC R.61-68G.10.g		✓
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. Volatile organic compounds shall not be used for dust control purposes. Oil treatment is also prohibited.	Activities that will generate fugitive particulate matter (Statewide) – Applicable	SC R. 61-62.6 Section III(a)-Control of Fugitive Particulate Matter Statewide SC R. 61-62.6 Section III(d)		✓

1- The requirements from 40 CFR Part 268 contained in this table will be triggered if any generated wastes, including coal ash, coal fines, soil, sediments, and/or groundwater are characterized as RCRA *hazardous* wastes.

Alt	=	Alternative	NPDES	=	National Pollutant Discharge Elimination System
ARAR	=	applicable or relevant and appropriate requirement	POLYM	=	Polymerization
CFR	=	*Code of Federal Regulations*	RCRA	=	Resource Conservation and Recovery Act of 1976
CMBST	=	Combustion	RORGS	=	Recovery of organics
CWA	=	Clean Water Act of 1972	SC	=	South Carolina
DEACT	=	deactivation	TCLP	=	Toxicity Characteristic Leaching Procedure
DOT	=	U.S. Department of Transportation	UHC	=	underlying hazardous constituents
EPA	=	U.S. Environmental Protection Agency	UTS	=	Universal Treatment Standard
LDR	=	Land Disposal Restrictions	WWTU	=	Wastewater Treatment Unit

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Table 6. Summary of the Screening of Technologies for the DABW

General Response Action	Remedial Technology	Effectiveness	Implementability	Cost	Technology Status
No Action	None	No action is required by the NCP to serve as a baseline against other technologies and alternatives. Not effective in meeting RAOs.	Requires no implementation. No efforts would be taken to monitor, remove, treat, or otherwise mitigate the potential spread of contaminants	None	Retained
Land Use Controls	Institutional Controls (i.e., Administrative Controls)	Administrative controls provided by SRS Site Use/Site Clearance procedures; work controls; mandatory worker use of health and safety plans; SRS access controls including security procedures; 24-hour surveillance; controlled entry systems; and warning signs at SRS boundary.	Readily implemented. Compliance with the various controls and programs must be enforced for this technology to effectively deter site entry.	Low	Retained
	Engineering Controls (i.e., Access Controls)	Engineering controls - Installation of barriers and signs for access control. Effective in restricting land use.	Readily implemented. Regular inspections, monitoring, and maintenance of access controls must be implemented for this technology to effectively deter site entry	Low	Retained
Excavation and offsite disposal	Excavation	Removing contaminated ash/soil media would eliminate exposure of human receptors to contaminants in soil. Short-term exposure is limited to worker construction and implementation. Long term exposure is eliminated by removal of contaminated ash/soil.	Although excavation and disposal are typically readily implemented with standard earth-moving equipment, materials, and conventional construction methods; the implementation of this large-scale removal in a wetland environment would be very challenging. Specialized equipment and/or site preparation will likely be necessary to execute the work safely.	High	Retained

Table 7. Summary of the Screening of Alternatives for the DABW

Alternatives	Effectiveness	Implementability	Cost	Status	Comments
A-1 – No Action	Not effective in preventing exposure to IOU onsite worker to contaminated media. Alternative does not treat waste	Not applicable	None	Required	Alternative is required by NCP
A-2 - LUCs	Effective for achieving RAO; prevents exposure to IOU onsite worker. Does not reduce toxicity, mobility, or volume of waste.	Already implemented at SRS; additional measures to be incorporated into Site Use/Site Clearance permits, SSHASPs to protect IOU onsite worker	Low	Retained	Effective; implementation would allow contaminated media to remain in place where exposure scenarios are prevented. Requires five-year remedy reviews.
A-3 – Excavation and Disposal	Effective for achieving RAO; eliminates exposure to IOU onsite worker. Permanently removes volume, toxicity and mobility of ash.	Although excavation and disposal are typically readily implemented with standard earth-moving equipment, materials, and conventional construction methods; the implementation of this large-scale removal in a wetland environment would be very challenging. Specialized equipment and/or site preparation will likely be necessary to execute the work safely.	High	Retained	Protective of human health; all ash would be removed from DABW eliminating risk, volume, toxicity, and mobility. Even though the distance to the nearest permitted landfill with adequate storage capacity is in the vicinity, hauling costs very high. Does not require five-year remedy reviews.

Table 8. Comparison of Alternatives to CERCLA Criteria for the DABW

	A-1	A-2	A-3
Criterion	No Action	LUCs	Excavation and Disposal
Overall Protection			
Human Health	Not protective of the IOU onsite worker because there are no controls or remediation.	Meets the requirement by limiting exposure of IOU onsite worker to the contaminated media through the use of administrative and engineering controls.	More protective of IOU on-site worker because contaminated media is removed.
Environment	Not protective because contaminants remain in place	Protective of the environment because no ECO/CM/PTSM RCOCs	Protective of the environment because no ECO/CM/PTSM RCOCs
Compliance with ARARs			
Chemical-Specific	No ARARs exist	No ARARs exist	No ARARs exist
Location-Specific	No ARARs exist	No ARARs exist	Various federal and South Carolina regulations are applicable for protection and mitigation of damage to wetlands
Action-Specific	No ARARs exist	No ARARs exist	ARARs for control of the minimization of sediment erosion, management of storm water and transportation of solid waste can be achieved.
Long-Term Effectiveness and Performance			
Magnitude of Residual Human Health Risk	Residual human health risk remains above 1E-06 or SRS background concentrations	Residual human health risk remains above 1E-06 or SRS background concentrations; five-year remedy reviews and LUCs required.	No residual human health risk because contaminated media removed.
Adequacy of Controls	None	Effective in preventing exposure to human receptors and breaking the exposure pathway. Leaves contaminants in place. LUCs required as long as contaminants are present.	No controls are required because contaminated media removed.
Permanence	Not permanent.	LUCs are permanent as long as LUCs are maintained.	Excavation of contaminated media will be permanent.

Table 8. Comparison of Alternatives to CERCLA Criteria for the DABW
(Continued/End)

	A-1	A-2	A-3
Criterion	No Action	LUCs	Excavation and Disposal
Reduction of Mobility, Toxicity, or Volume Through Treatment			
Type of Reduction	No reduction	No reduction	No reduction
Degree of Expected Reduction in Toxicity, Mobility, or Volume	No reduction via treatment	No reduction via treatment	No reduction via treatment
Short-Term Effectiveness and Performance			
Amount of Hazardous Material Destroyed or Treated	No reduction	No reduction	No reduction
Risk to Remedial Worker	None	None	Minimal; Health and Safety Plan will be implemented to protect remedial workers
Risk to Community	None	None	None
Risk to Environment	None	None	None
Time to Implement and achieve RAO	Never	6 months	18 months
Implementability			
Availability of Materials, Equipment, Contractors	Not Applicable	Readily Available	Readily Available
Ability to Construct and Operate the Technology	Not Applicable	Proven technology at SRS	The implementation of this large-scale removal in a wetland environment would be very challenging. Typically, not performed at SRS.
Ability to Obtain Permits/Approvals from Other Agencies	Not Applicable	Prior history with similar permits/approvals at SRS	Prior history with similar permits/approvals at SRS
Estimated Cost*			
Total Capital Cost	$0	$61,391	$ 80,421,391
Present Worth O&M Cost	$0	$1,642,528	$0
Total Cost	$0	**$1,703,918**	**$** 80,421,391

*-for itemized costs see Appendix F.

Table 9. Summary of the Comparative Ranking Analysis

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	Overall Ranking
Alternative A-1	No	NA	1	1	1	5	$0	8
Alternative A-2 Total	Yes	NA	4	1	5	4	$1,703,918	14
Alternative A-3 Total	Yes	Yes	5	1	4	2	$80,421,391	13

Note: Numeric range 1 through 5, where 1= worst and 5 = best

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APPENDIX A

DATA SUMMARY TABLE

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LIST OF ACRONYMS AND ABBREVIATIONS

DABW	D-Area Ash Basin Wetlands
DEXOU	D-Area Expanded Operable Unit
FCMS	Focused Corrective Measures Study
FS	Feasibility Study
ft	foot
HH	human health
m	meter
RCOC	Refined constituent of concern
RFI	Facility Investigation
RI/BRA	Remedial Investigation/Baseline Risk Assessment
SW	surface water
WP	Work Plan

A-1. INTRODUCTION

The D-Area Ash Basin Wetlands (DABW) was investigated as part of the approved *RCRA Facility Investigation (RFI) Remedial Investigation/Baseline Risk Assessment (RI/BRA) for the D-Area Expanded Operable Unit (DEXOU)* in 2002 (WSRC 2002). Data supporting the 2002 DEXOU RFI/RI/BRA included the following:

- 1997 pre-Work Plan (WP) characterization data consisting of surface water (SW) sampling and a wetland survey consisting of 39 water samples along with pH and conductivity readings,
- DEXOU Phase I sampling conducted from 1998-1999 resulting in eight (8) sediment/soil and seven (7) SW samples,
- DEXOU Phase II sampling conducted in 2001,
- a WP Addendum for DEXOU that resulted in 16 paired sediment/soil and SW samples, and
- June 2002 field sampling conducted to identify the 0.0 to 0.3 meters (m) (0 to 1 foot [ft]) extent of contamination and collection of four (4) sediment/soil samples.

As documented in the DEXOU RFI/RI/BRA, the data evaluation concluded that there were no ecological, contaminant migration, or principal threat source material refined contaminants of concern (RCOCs) for the DABW. There were also no human health (HH) RCOCs identified for the DABW. However, arsenic and ash-related radionuclides (i.e., potassium-40, thorium-232 series, and uranium-238 series) were present in surface ash/soil that pose an unacceptable risk for the Integrator Operable Unit onsite worker and were identified as Human Health Refined Constituents of Concern (HH RCOCs). The complete data set that supported the 2002 evaluation is published in the DEXOU RFI/RI/BRA (WSRC 2002).

As agreed to by the Core Team during project scoping in 2024, the strategy for the DABW OU Focused Corrective Measures Study/Feasibility Study (FCMS/FS) document is to use the information and conclusions of the DEXOU RFI/RI/BRA to support the FCMS/FS. Since only HH RCOCs were identified in the DEXOU RFI/RI/BRA, the data that supported the risk assessment was extracted from the DEXOU dataset and presented in Table A-1. The data summary

table includes the HH RCOCs identified in the DEXOU RFI/RI/BRA and provides all of the necessary information to update the HH risk calculation in Appendix B per the approved Environmental Compliance and Area Completion Protocols (SRNS 2023). The ProUCL (USEPA 2022) software package was used to calculate the 95% upper confidence limit (UCL) on the arithmetic mean. The data distribution and recommended 95% UCL, as determined by ProUCL for each constituent, are presented as footnotes to Table A-1. Non-detected constituent concentrations were processed in accordance with the ProUCL User's Guide. Rather than including the output from the ProUCL software (v 5.2) in this appendix due to volume of files generated for each analyte, the results are summarized in Table A-1.

The ecological risk assessment is presented in Appendix C.

A-2. REFERENCES

SRNS, 2023. *Environmental Compliance and Area Completion Projects Regulatory Document Handbook*, SRNS-RP-2022-00330, Revision 0, June 2023, Savannah River Nuclear Solutions, LLC, Savannah River Site, Aiken, SC.

USEPA, 2022. *Statistical Software ProUCL v5.2 for Environmental Applications for Data Sets With and Without Nondetect Observations*, United States Environmental Protection Agency

WSRC, 2002. *Resource Conservation and Recovery Act (RCRA) Facility Investigation/Remedial Investigation/Baseline Risk Assessment (RFI/RI/BRA) for the D-Area Expanded Operable Unit*, WSRC-RP-2001-4162, Revision 1, Washington Savannah River Company, Savannah River Site, Aiken, SC

Table A-1. Data Summary Table for Surface Ash/Soil (0 to 0.3 m [0 to 1 ft])

HH RCOC	Units	Samples	ND	Det	J- Qual	Dist	UCL Method	Mean	95%UCL	Max	Min	RME	Max Loc
Arsenic	mg/kg	25	1	24	9	2	95%UCL-N	28.4	40.7	152	0.321	40.7	DAB-60
Potassium-40	pCi/g	25	0	25	2	2	95%UCL-N	14.8	17.5	26.1	2.73	17.5	DAB-52
Thorium-232	pCi/g	25	0	25	5	3	95%UCL-N	1.48	1.7	2.58	0.567	1.7	DAB-38
Radium-228	pCi/g	25	3	22	5	1	95%UCL-T	1.65	2.03	3.1	0.9	2.03	DAB-38
Thorium-228	pCi/g	25	0	25	4	1	95%UCL-T	1.66	2.09	3.17	0.56	2.09	DAB-52
Thallium-208	pCi/g	16	0	16	0	2	95%UCL-N	0.586	0.678	0.836	0.281	0.678	DAB-75
Uranium-238	pCi/g	25	6	19	2	2	95%UCL-N	1.39	1.74	2.79	0.53	1.74	DAB-60
Radium-226	pCi/g	25	0	25	1	2	95%UCL-N	1.64	1.9	2.66	0.54	1.9	DAB-54
Bismuth-214	pCi/g	16	0	16	0	2	95%UCL-N	1.95	2.27	2.66	0.797	2.27	DAB-54

HH RCOCs = As, K40, Ra228, Th228, Tl208, Ra226, Bi214. Th232 and U238 (in italics) shown for Th and U series data comparison.

Data Summary Table populated from RFI/RI/BRA for the DEXOU, Table 4.2-12, p. 4-242 and Table 5.1-11, p. 5-38

Det = Detect; Dist = Distribution; J-Qual = J-qualified (estimated) result; Max = Maximum; Max Loc = sample location with maximum; Min = Minimum; ND = non detect; RME = Reasonable Maximum Exposure; UCL = Upper Confidence Limit.
Distribution:

1 - Log-normal distribution per Shapiro-Wilkes W test.
2 - The distribution was indeterminant per the Shapiro-Wilkes W test. It was assumed as normal for determination of EPC.
3 - Normal distribution per the Shapiro-Wilkes W test.

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APPENDIX B

HUMAN HEALTH RISK ASSESSMENT

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LIST OF ABBREVIATIONS AND ACRONYMS

BRA	baseline risk assessment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability
COC	constituent of concern
DABW	D-Area Ash Basin Wetlands
DEXOU	D-Area Expanded Operable Unit
EC&ACP	Environmental Compliance & Area Completion Projects
EPC	exposure point concentration
FCMS/FS	Focused Corrective Measures Study/Feasibility Study
ft	feet
HH	human health
HHRA	human health risk assessment
IOU	Integrator Operable Unit
m	meter
MCL	maximum contaminant level
pCi/g	picocuries per gram
PRG	preliminary remediation goal
RCOC	refined constituent of concern
RCRA	Resource Conservation and Recovery Act
RFI	RCRA facility investigation
RI	remedial investigation
RME	reasonable maximum exposure
RSL	regional screening level
SCDES[1]	South Carolina Department of Environmental Services
SRFS	Savannah River and Floodplain Swamp
SRS	Savannah River Site
UCL	upper confidence limit
USEPA	U.S. Environmental Protection Agency

[1] SCDES was known as the South Carolina Department of Health and Environmental Control prior to July 1, 2024.

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B-1. INTRODUCTION

The human health risk assessment (HHRA) in support of the Focused Corrective Measures Study/Feasibility Study (FCMS/FS) for the D-Area Ash Basin Wetlands (DABW) is presented in this appendix. The evaluation contained herein assesses the risks of contamination to human receptors to identify the problems warranting action from a human health (HH) standpoint to support subsequent remediation as deemed necessary.

The DABW is located within the Savannah River and Floodplain Swamp (SRFS) Integrator Operable Unit (IOU) and is outside of the boundary of any industrial or general support area (Figure B-1). The DABW is listed in Appendix C of the FFA and will receive final disposition as a remedial action under the Savannah River Site (SRS) Resource Conservation and Recovery Act (RCRA)/ Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) program.

No current or future development of the remaining DABW is planned. Nevertheless, to support risk management decision-making, the residential (unrestricted), industrial worker, and IOU onsite worker scenarios are evaluated.

No previous CERCLA regulatory actions have been implemented for the DABW. However, the DABW was investigated as part of the approved RCRA Facility Investigation (RFI) Remedial Investigation (RI)/Baseline Risk Assessment (BRA) for the D-Area Expanded Operable Unit (DEXOU) in 2002 (WSRC 2002). As agreed to by the Core Team (i.e., United States Department of Energy, US Environmental Protection Agency [USEPA], and the South Carolina Department of Environmental Services [SCDES[1]]) at the July 2024 FCMS/FS scoping meeting, the strategy for the DABW FCMS/FS document is to use the information and conclusions of the DEXOU RFI/RI/BRA for this HHRA. The DEXOU RFI/RI/BRA concluded that arsenic (As) and coal-related radionuclides in sediment media were constituents of concern (COCs) for human receptors. The conclusions will be verified, as appropriate, through implementation of the most current approved technical protocols documented in the Environmental Compliance & Area Completion Projects (EC&ACP) Regulatory Document Handbook (SRNS 2023).

[1] SCDES was known as the South Carolina Department of Health and Environmental Control prior to July 1, 2024.

B-1.1 Background

The DABW is located in the SRFS IOU downgradient of D Area (Figure B-1). The DABW is downgradient, southwest of the 488-D Ash Basin, and a portion of the southern boundary of the DABW is adjacent to Beaver Dam Creek (Figure B-2). The area is a mixed compositional bottomland forest that ranges from more frequently flooded areas to areas of open canopy, to a climax swamp forest approaching the Savannah River. Depending on precipitation events, river flood levels, groundwater table fluctuations, portions of the DABW hold water. The ash depositional area has an estimated acreage of approximately (~) 36 hectares (90 acres) with an estimated volume of ~739,000 cubic yards (565,006 cubic meters) of ash. The depth to groundwater is ~ 0 to 15 feet (ft) below ground surface.

B-1.2 Data

The DABW was investigated as part of the approved RFI/RI/BRA for the DEXOU (WSRC 2002). Characterization activities for the DABW are described in Section 1.2.1 and summarized in Table 1 of this FCMS/FS.

The previous RFI/RI/BRA was conducted using a comprehensive set of risk evaluation tables that were required at the time of document preparation. Current streamlining agreements have reduced the complexity (and volume) of these documents. Therefore, a Data Summary Table that provides all of the information per the approved EC&ACP protocols has been populated and presented in Appendix A, Table A-1, of this FCMS/FS. The ProUCL (USEPA 2022) software package was used to calculate the 95% upper confidence limit (UCL) on the arithmetic mean that are presented in Appendix A. The data distribution and recommended 95% UCL as determined by ProUCL for each constituent are presented as footnotes to the tables in Appendix A. Non-detected constituent concentrations were processed in accordance with the ProUCL User's Guide.

Groundwater media is not part of the DABW and will be addressed under the D-Area Groundwater Operable Unit.

B-1.3 Receptors and Exposure Scenarios

The purpose of the HHRA is to evaluate the potential for adverse effects associated with exposure to constituents present in the DABW. The assessment estimates the risk potential in the absence of any remedial action and provides a basis for determining whether remedial actions are necessary to reduce or eliminate risks to HH.

Previously, the HHRA presented in the DEXOU RFI/RI/BRA was based on the residential scenario only. This hypothetical scenario was based on the assumption that a resident does not live in the wetland proper but has access and utilizes it for recreational purposes. The exposure assumptions were 30 years (24 years adult; 6 years child), 50 days per year, and 2 hours per day. Onsite Worker and Industrial Worker scenarios were deemed not likely and therefore were not evaluated in the DEXOU RFI/RI/BRA. In addition, an adolescent trespasser scenario (10 years, 50 days/year, 2 hours (hours)/day) was evaluated to determine if an early action (EA) was warranted (the EA benchmark > 1E-04 risk and/or Hazard Index > 3) (WSRC 2002). These exposure assumptions are outdated and do not align with the EC&ACP currently accepted exposure assumptions. Therefore, a streamlined approach that considers both standard USEPA receptors (i.e., future industrial worker, future resident) and site-specific receptors (i.e., IOU onsite worker) has been used for this HHRA evaluation. A description of each is outlined below.

The *future resident* receptor scenario is a standard USEPA exposure scenario which evaluates long-term risks to individuals assumed to have unrestricted use of the area. This scenario considers residents (adults and children) that hypothetically live on-unit and are exposed chronically, both indoors and outdoors, to the contaminants present. The standard exposure assumptions are 26 years, 350 days per year, and 24 hours per day. Exposure routes associated with soil include inhalation of particulates and vapors, external exposure to radiation, dermal absorption, and incidental ingestion.

The *future industrial worker* scenario is a standard USEPA exposure scenario which addresses long-term risks to workers who are exposed to the on-unit contaminants within an industrial setting. The standard exposure assumptions are 25 years, 250 days per year, and 8 hours per day. This receptor is referred to as “composite worker” by USEPA and is analogous to the term

"industrial worker" used herein. The future industrial worker scenario considers an adult who hypothetically works on-unit in an outdoor setting for the majority of time. Exposure routes include inhalation, external exposure to radiation, dermal absorption, and incidental ingestion to soil.

The *IOU onsite worker* receptor scenario is site-specific and describes a worker who is performing maintenance, collecting site samples, or conducting research within the IOU. The exposure assumptions for the onsite worker are 20 years, 150 days/year, and 8 hours per day. These site-specific assumptions are based on input provided by the Savanna River Ecology Laboratory (SREL) and describes a typical wetlands researcher. Exposure routes include inhalation, external exposure to radiation, dermal absorption, and incidental ingestion. This receptor, which is quantitatively evaluated, is routinely evaluated in the IOU program risk screening exercises (i.e., benchmark comparisons) performed by the EC&ACP. This is the most likely receptor exposure scenario for this wetland/floodplain environment and is consistent with recent BRAs with similar ecological settings (e.g., Lower Three Runs IOU, Wetland Area at Dunbarton Bay).

B-1.4 Sources of Risk-Based Threshold Values

The USEPA publishes regional screening levels (RSLs) for nonradiological constituents and preliminary remediation goals (PRGs) for radiological constituents that are risk-based concentrations (or activity concentrations) that can be used to evaluate potentially contaminated waste sites. Both RSLs and PRGs combine current USEPA toxicity values with standard exposure factors that represent reasonable maximum exposure (RME) conditions to estimate contaminant concentrations in exposure media that the agency considers protective of humans over a lifetime. The concentrations are based on direct exposure pathways for which generally accepted methods, models, and assumptions have been developed for specific land use conditions.

The USEPA RSLs website (USEPA 2024a) is the source of risk-based threshold values for nonradiological constituents used in this evaluation. The website was accessed in July 2024. The default resident and industrial worker RSLs are provided in Attachment B-1. The site-specific IOU onsite worker RSLs were obtained by using the website calculator function to derive site-specific RSLs. The RSLs were calculated by selecting the composite worker receptor and adjusting the

exposure assumptions. The site-specific IOU onsite worker RSLs are provided in Attachment B-2.

The USEPA Superfund Radionuclide PRGs for Superfund website (USEPA 2024b) is the source of the radionuclide threshold values used in this evaluation. The website was accessed in July 2024. The PRGs for a residential scenario were obtained by using the website calculator function to derive site-specific peak PRGs. These site-specific PRGs are calculated by eliminating the fruit and vegetable consumption pathways and using all other default parameters. The site specific residential PRGs are provided in Attachment B-3. The peak PRGs for the industrial worker assume all default exposure parameters and are provided in Attachment B-4. The site-specific IOU onsite worker PRGs were obtained by using the website calculator function to derive site-specific peak PRGs. The PRGs were calculated by selecting the composite worker receptor and adjusting the exposure assumptions. The site-specific IOU onsite worker PRGs are provided in Attachment B-5.

B-2. HUMAN HEALTH RISK ASSESSMENT PROCESS

The strategy for the HHRA portion of this FCMS/FS is to recalculate the risk for the HH refined constituents of concern (RCOCs) identified in the previous DEXOU RFI/RI/BRA (WSRC 2002) using the currently accepted exposure assumptions for the future resident, industrial worker, and IOU onsite worker scenarios.

B-2.1 Surface Water Media

Based on the results of the DEXOU RFI/RI/BRA, no HH RCOCs were identified for surface water media at the DABW (WSRC 2002). Therefore, a reevaluation of surface water data was not conducted as part of this HHRA, and the conclusions of the previous RFI/RI/BRA are still relevant.

B-2.2 Surface Ash/Soil Media

Based on the results of the DEXOU RFI/RI/BRA, As, potassium-40 (K-40), radium-228 (Ra-228), thorium-228 (Th-228) and thallium-208 (Tl-208), radium-226 (Ra-226) and bismuth-214 (Bi-214) were identified as HH RCOCs for sediment media at the DABW (WSRC 2002). Sediment was

identified as the medium of concern in the DEXOU RFI/RI/BRA; however, after further evaluation of the area, the media will more descriptively be referred to as surface ash/soil for the purposes of this HHRA.

In addition, the risk assessment conducted in the DEXOU RFI/RI/BRA calculated a separate risk for each isotope in the decay chain which is now considered an outdated methodology. Therefore, the HH risk was re-calculated by applying the most recent USEPA Peak PRGs. Peak PRGS are the preferred, default risk-based thresholds. For both the Th-232 and U-238 decay series, secular equilibrium is assumed, and the risk is calculated using the highest exposure point concentration (EPC) for all the daughter products in the series. Previously identified HH RCOCs Ra-228, Th-228, and Tl-208 are included in the Th-232 series PRG. Ra-226 and Bi-214 are included in the U-238 series PRG. The risk is calculated for the entire decay series, not individual isotopes.

The primary dataset used for this HH screening and risk/hazard calculations is the 0 to 0.3 meters (m) (0 to 1 ft) depth sample interval for surface ash/soil media. Concentrations of detected constituents in the 0 to 0.3 m (0 to 1 ft) depth interval include both the maximum and the 95% UCL on the mean concentration for screening and risk/hazard calculations, respectively.

A summary of the processes undertaken to evaluate HH associated with the surface ash/soil is described below.

B-2.2.1 Risk Calculation

The process to recalculate the risk for the future resident, industrial worker, and IOU onsite worker is described below. Risk estimate calculations are based on a RME EPC, which is the lesser of the maximum detected concentration and the 95% UCL on the mean concentration. Appendix A, Table A-1 provides the EPCs for each of the constituents.

The risk estimates are calculated using the following equation:

$$risk\ estimate = \left(\frac{[EPC]}{[RSL\ or\ PRG]}\right) \times 1E\text{-}06$$

The risk estimates by constituent grouping (i.e., inorganic, organic, and radionuclide) are then summed to provide the total cumulative risk (TCR). The total TCR is the sum of the total groupings. Constituents with an individual cancer risk greater than 1E-06 are identified as COCs and are further evaluated in the refinement of COCs step (Section B-2.2.2).

B-2.2.2 Results/Refinement of Constituents of Concern

Table B-1 presents the TCR (5.8E-04) for the resident exposure scenario and the associated COCs: As, K-40, Th-232, and U-238.

Table B-1 presents the TCR (3.4E-04) for the industrial worker exposure scenario and the associated COCs: As, K-40, Th-232, and U-238.

Table B-1 presents the TCR (1.7E-04) for the IOU onsite worker exposure scenario and the associated COCs: As, K-40, Th-232, and U-238.

The refinement/uncertainty evaluation is presented for each of these COCs.

Arsenic is identified as a COC for the resident (risk = 6.0E-05), the industrial worker (risk = 1.4E-05), and the IOU onsite worker (risk = 6.5E-06) scenarios. It was detected in 24/25 samples, with nine results being estimated values. Concentrations range from 0.3 mg/kg to 152.0 mg/kg, with a mean concentration of 28.4 mg/kg. The EPC used in the risk calculations was 40.7 mg/kg.

Arsenic is a naturally occurring constituent that is common in the environment. Arsenic is widely distributed in the earth's crust, being present in soil and minerals. The maximum detected concentration in the SRS soil background dataset is 22.9 mg/kg (WSRC 2006). Surface ash/soil concentrations from this subunit are above the range of concentrations found in background soil at SRS. Arsenic, naturally present in coal, may be concentrated in coal ash because it is not lost during combustion; thus, it is expected to be present at the DABW due to the ash material that has been deposited.

Arsenic is recommended for further remedial evaluation as a HH RCOC in surface ash/soil for any of the receptor scenarios based on the following lines of evidence:

- The resident, industrial worker, and IOU onsite worker risk is >1E-06;
- Unit concentrations are above the SRS background soil concentration range; and
- Its presence is consistent with the historical use of the unit.

Potassium-40 is a COC for the resident (risk = 1.2E-04), the industrial worker (risk = 8.0E-05), and the IOU onsite worker (risk = 3.8E-05) scenarios. Potassium-40 was detected in 25/25 samples, with two results being estimated values. Concentrations range from 2.7 picocuries/gram (pCi/g) to 26.1 pCi/g, with a mean concentration of 14.8 pCI/g. The EPC used in the risk calculations was 17.5 pCi/g.

Potassium-40 is a naturally occurring constituent that is common in the environment. The SRS background maximum activity concentration is 8.5 pCi/g. Surface ash/soil concentrations from this subunit are above the range of concentrations found in background soil at SRS.

Potassium-40, naturally present in coal, is concentrated in coal ash because it is not lost during combustion; thus, it is expected to be present at the DABW due to the ash material deposited.

Potassium-40 is recommended for further remedial evaluation as a HH RCOC in surface ash/soil for any of the receptor scenarios based on the following lines of evidence.

- The resident, industrial worker, and IOU onsite worker risk is >1E-06;
- Unit concentrations are above the SRS background soil concentration range; and
- Its presence is consistent with the historical use of the unit.

Thorium-232 is a COC for the resident (risk = 2.1E-04), the industrial worker (risk = 1.4E-04), and the IOU onsite worker (risk = 6.6E-05) scenarios. The Thorium Series (Th-232) evaluation includes not only the measured activity concentration of Th-232 specifically but also considers any analytical results from its daughter products (e.g., Ra-228, Th-228, and Tl-208) since these isotopes are assumed to be present in secular equilibrium. Concentrations from the entire series range from 0.6 pCi/g to 3.2 pCi/g. The risk calculations were performed using the highest EPC of

the entire decay series as represented by 2.1 pCi/g for thorium-228. The daughter products are not evaluated individually since they are considered in the thorium-232 peak PRG.

Background comparisons for the thorium-232 series includes consideration of the range of activity concentrations for the entire decay chain (i.e., includes daughter products). The SRS soil background maximum detected activity concentration is 6.75 pCi/g, based on the Ra-228 result (WSRC 2006). Surface ash/soil concentrations from this subunit are below the range of concentrations found in background soil at SRS.

Thorium-232, naturally present in coal, is concentrated in coal ash because it is not lost during combustion; thus, it is expected to be present at the DABW due to the ash material deposited.

Thorium-232 is recommended for further remedial evaluation as HH RCOC in surface ash/soil for any of the receptor scenarios based on the following lines of evidence:

- The resident, industrial worker, and IOU onsite worker risk is >1E-06; and
- Its presence is consistent with the historical use of the unit.

Uranium-238 is a COC for the resident (risk = 1.8E-04), the industrial worker (risk = 1.1E-04), and the IOU onsite worker (risk = 5.5E-05) scenarios. The Uranium Series (U-238) evaluation includes not only the measured activity concentration of U-238, but also considers any analytical results from its daughter products (e.g., Ra-226 and Bi-214) since these isotopes are assumed to be in secular equilibrium. Concentrations from the entire series range from 0.5 pCi/g to 2.8 pCi/g. The risk calculations were performed using the highest EPC (2.3 pCi/g for Bi-214) for the entire series. The daughter products are not evaluated individually since they are considered in the U-238 peak PRG.

Uranium is a naturally occurring constituent that is common in the environment. The maximum detected activity concentration for the U-238 decay chain in the SRS soil background data set is 2.8 pCi/g (for Th-230). Surface ash/soil activity concentrations from this subunit are above the activity range found in background soil at SRS.

Uranium-238, naturally present in coal, is concentrated in coal ash because it is not lost during combustion; thus, it is expected to be present at the DABW due to the ash material deposited.

Uranium-238 is recommended for further remedial evaluation as a HH RCOC in surface ash/soil for any receptor scenario based on the following lines of evidence:

- The resident, industrial worker, and IOU onsite worker risk is >1E-06;
- Unit activity concentrations are above the SRS soil background activity concentration range; and
- Its presence is consistent with the historical use of the unit.

B-2.2.3 HHRA Conclusion for the DABW

As previously discussed, there were no HH RCOCs identified for surface water media at the DABW (WSRC 2002). RCOCs were identified for in surface ash/soil media for all HH receptors evaluated as follows:

Resident scenario: As, K-40, Th-232, U-238.

Industrial Worker scenario: As, K-40, Th-232, U-238.

IOU onsite worker scenario: As, K-40, Th-232, U-238.

B-3. SUMMARY/CONCLUSION OF THE HUMAN HEALTH RISK ASSESSMENT

The table presented below shows the overall summary of the HHRA. The refined conceptual site models based on the results of this HHRA are presented in Chapter 3 (Figure 9).

Summary of the DABW Human Health Risk Assessment

Unit	HH Residential RCOCs	HH Industrial Worker RCOCs	HH IOU Onsite Worker RCOCs
DABW	Surface Ash/Soil (0-0.3 m [0-1 ft]) As, (risk = 6.0E-05) K-40, (risk = 1.2E-04) Th-232, (risk = 2.1E-04) U-238 (risk = 1.8E-04) **TCR = 5.8E-04**	Surface Ash/Soil (0-0.3 m [0-1 ft]) As, (risk = 1.4E-05) K-40, (risk = 8.0E-05) Th-232, (risk = 1.4E-04) U-238 (risk = 1.1E-04) **TCR = 3.4E-04**	Surface Ash/Soil (0-0.3 m [0-1 ft]) As, (risk = 6.5E-06) K-40, (risk = 3.8E-05) Th-232, (risk = 6.6E-05) U-238 (risk = 5.5E-05) **TCR = 1.7E-04**

B-4. REFERENCES

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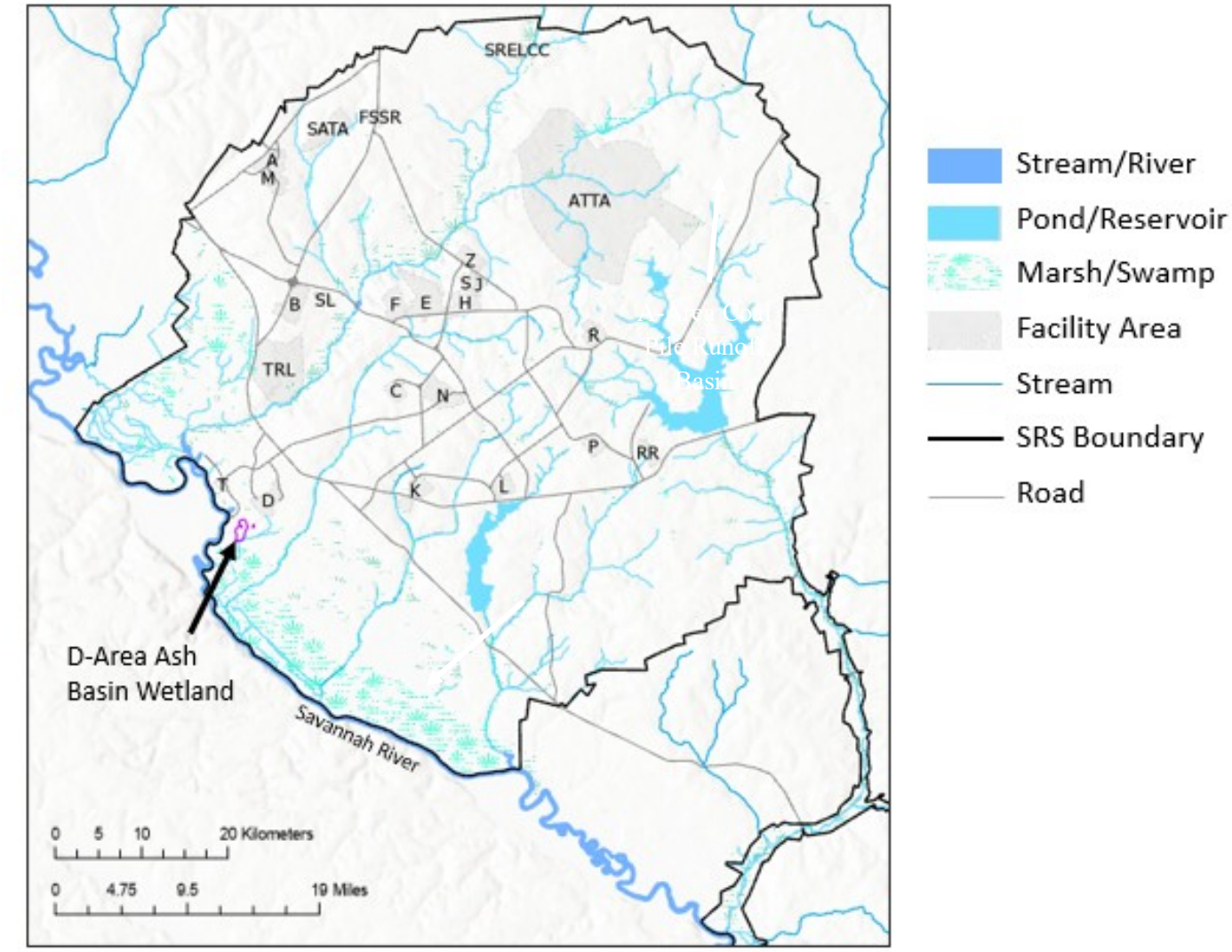


Figure B-1. Location of DABW within the SRS

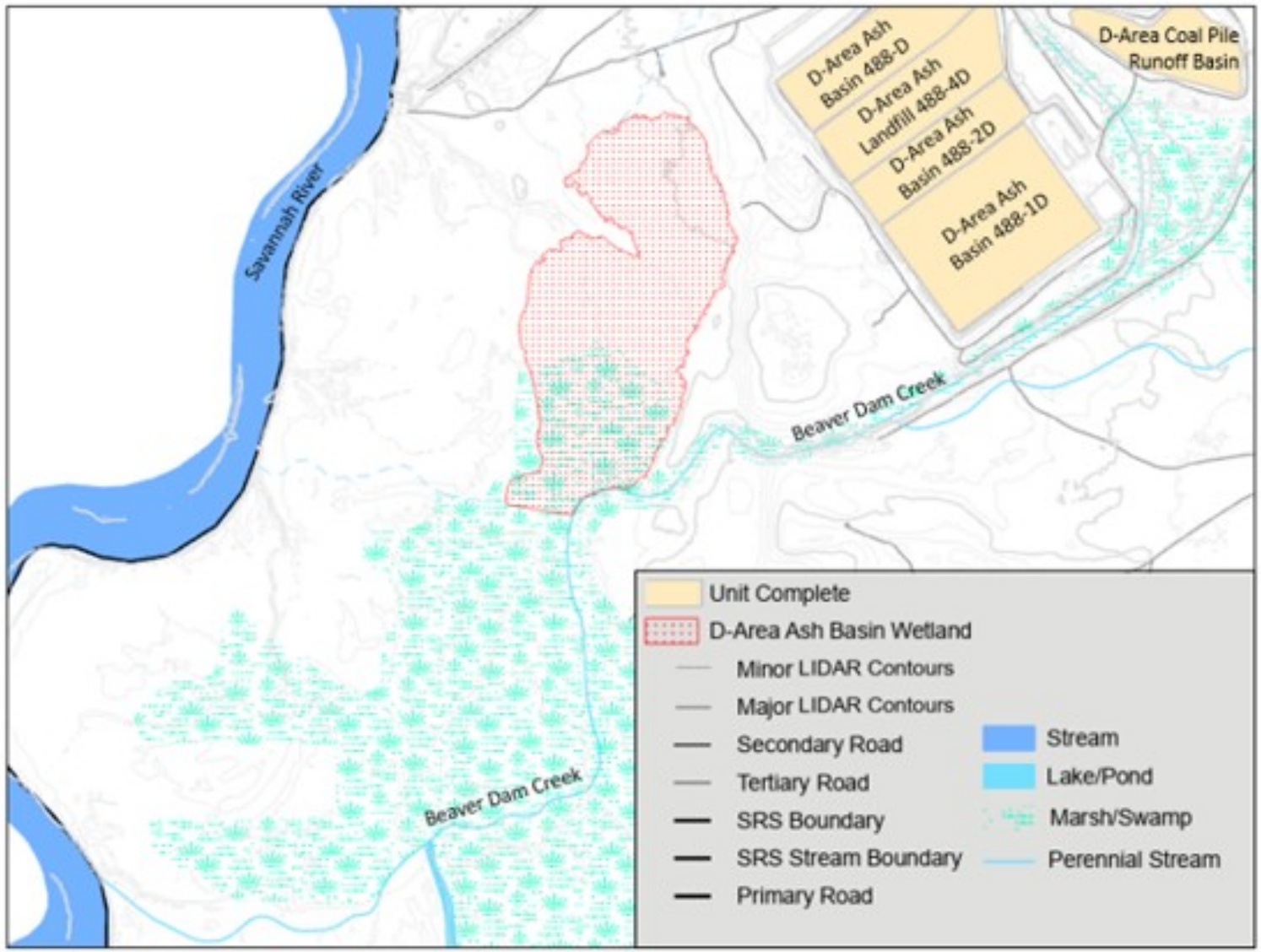


Figure B-2. DABW

Table B-1. Human Health Risk Recalculation Using Current RSLs/PRGs

HH RCOC[1]	EPC[2] (mg/kg or pCi/g)	Resident RSL/PRG[3]	Industrial RSL/PRG[3]	IOU Onsite Worker RSL/PRG[3]	Residential Risk Estimate[4]	Industrial Risk Estimate[4]	IOU Onsite Worker Risk Estimate[4]
As	4.07E+01	6.80E-01	3.00E+00	6.24E+00	5.99E-05	1.36E-05	6.52E-06
K-40	1.75E+01	1.44E-01	2.19E-01	4.56E-01	1.22E-04	7.99E-05	3.84E-05
Th-232 (Th-228)	2.09E+00	9.85E-03	1.53E-02	3.18E-02	2.12E-04	1.37E-04	6.57E-05
U-238 (Bi-214)	2.27E+00	1.25E-02	2.00E-02	4.16E-02	1.82E-04	1.14E-04	5.46E-05
			TCR =		**5.75E-04**	**3.44E-04**	**1.65E-04**

1 - HH RCOCs = As, K-40, Ra-228, Th-228, Tl-208, Ra-226, Bi-214. For radionuclides within a decay chain (i.e., Th-232 and U-238) the most conservative EPC (highest activity) within each series is used to estimate the risk. Risk is calculated using the parent PRG for the entire series. For the Th-232 series, the Th-228 EPC was used; for the U-238 series, the Bi-214 EPC was used.
2 - EPC = reasonable maximum exposure (RME) exposure point concentration (EPC) from Appendix A, Table A-1.
3 - RSLs for nonradiological constituents obtained from the USEPA Regional Screening Levels website (accessed July 2024). PRGs for radiological constituents obtained from the Preliminary Remedial Goals website (accessed July 2024).
4 - Risk estimate = (EPC/[RSL or PRG])x1E-06

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Attachment B-1
USEPA Regional Screening Levels Table
RSLs for Default Resident and Default Industrial Worker Scenarios

Website accessed July 2024

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USEPA Regional Screening Levels Table *RSLs for Default Resident and Default Industrial Worker Scenarios*

SFO $(mg/kg\text{-}day)^{-1}$	key	IUR $(ug/m^3)^{-1}$	key	RfD_o (mg/kg-day)	key	RfC_i (mg/m^3)	key	VOC	Analyte	CAS No.	Resident Soil (mg/kg)	key	Industrial Soil (mg/kg)	key	Tap Water (ug/L)	key	MCL (ug/L)
Inorganics																	
1.5E+00	I	4.3E-03	I	3.0E-04	I	1.5E-05	C		Arsenic, Inorganic	7440-38-2	6.8E-01	c*G	3.0E+00	cG	5.2E-02	c	1.0E+01

Note: This table was generated from the May 2024 Regional Screening Level Summary Table found on the USEPA RSL website (USEPA 2024a)

C = California EPA
G = User's Guide
I = Integrated Risk Information System (IRIS)
MCL= maximum contaminant level
P = Provisional Peer-Reviewed Toxicity Values
VOC = volatile organic compound
c = cancer
* = where: n SL < 100X c SL

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Attachment B-2
USEPA Regional Screening Levels Table
RSLs for Site-Specific IOU Onsite Worker Scenario

(Website accessed July 2024)

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Site-Specific IOU Onsite Worker Equation Inputs for Soil

Variable	Site-Specific Value	Variable	Site-Specific Value
A (PEF Dispersion Constant)	16.2302	ED_{com} (exposure duration - composite worker) yr	20
A (VF Dispersion Constant)	11.911	EF_{com} (exposure frequency - composite worker) day/yr	150
A (VF Dispersion Constant - mass limit)	11.911	ET_{com} (exposure time - composite worker) hr	8
B (PEF Dispersion Constant)	18.7762	THQ (target hazard quotient) unitless	1
B (VF Dispersion Constant)	18.4385	IRS_{com} (soil ingestion rate - composite worker) mg/day	100
B (VF Dispersion Constant - mass limit)	18.4385	LT (lifetime) yr	70
City (PEF Climate Zone) Selection	Default	SA_{com} (surface area - composite worker) cm^2/day	3527
City (VF Climate Zone) Selection	Default	TR (target risk) unitless	0.000001
C (PEF Dispersion Constant)	216.108	T_w (groundwater temperature) Celsius	25
C (VF Dispersion Constant)	209.7845	$Theta_a$ (air-filled soil porosity) L_{air}/L_{soil}	0.28396
C (VF Dispersion Constant - mass limit)	209.7845	$Theta_w$ (water-filled soil porosity) L_{water}/L_{soil}	0.15
foc (fraction organic carbon in soil) g/g	0.006	T (exposure interval) s	819936000
F(x) (function dependent on U_m/U_t) unitless	0.194	T (exposure interval) yr	26
n (total soil porosity) L_{pore}/L_{soil}	0.43396	U_m (mean annual wind speed) m/s	4.69
p_b (dry soil bulk density) g/cm^3	1.5	U_t (equivalent threshold value)	11.32
PEF (particulate emission factor) m^3/kg	1359344438	V (fraction of vegetative cover) unitless	0.5
p_s (soil particle density) g/cm^3	2.65		
Q/C_{wind} (g/m^2-s per kg/m^3)	93.77		
Q/C_{vol} (g/m^2-s per kg/m^3)	68.18		
Q/C_{vol} (g/m^2-s per kg/m^3 - mass limit)	68.18		
A_s (PEF acres)	0.5		
A_s (VF acres)	0.5		
A_s (VF mass-limit acres)	0.5		
AF_{com} (skin adherence factor - composite worker) mg/cm^2	0.12		
AT_{com} (averaging time - composite worker)	365		
BW_{com} (body weight - composite worker)	80		

Site-Specific IOU Onsite Worker RSLs for Soil

Constituent	Ingestion SL TR=1E-06 (mg/kg)	Dermal SL TR=1E-06 (mg/kg)	Inhalation SL TR=1E-06 (mg/kg)	Carcinogenic SL TR=1E-06 (mg/kg)
Arsenic, Inorganic	7.57E+00	3.58E+01	8.08E+03	6.24E+00

Attachment B-3
USEPA Radionuclide Preliminary Remediation Goals Website
Site-Specific PRGs for Resident Scenario

(Website accessed July 2024)

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Site-Specific Resident Equation Inputs for Soil

Variable	Site-Specific Value	Variable	Site-Specific Value
A (PEF Dispersion Constant)	16.2302	ET_{res-i} (soil exposure time - indoor resident) hr/day	16.416
B (PEF Dispersion Constant)	18.7762	ET_{res-o} (soil exposure time - outdoor resident) hr/day	1.752
City (Climate Zone)	Default	GSF_i (gamma shielding factor - indoor) unitless	0.4
C (PEF Dispersion Constant)	216.108	$IFA_{res-adj}$ (age-adjusted soil inhalation factor - resident) m^3	161000
Cover thickness for GSF_o (gamma shielding factor) cm	0 cm	$IFS_{res-adj}$ (age-adjusted soil ingestion factor - resident) mg	1120000
Cover thickness for GSF_b (gamma shielding factor) cm	0 cm	IRA_{res-a} (soil inhalation rate - resident adult) m^3/day	20
$CF_{res-produce}$ (contaminated plant fraction) unitless	0	IRA_{res-c} (soil inhalation rate - resident child) m^3/day	10
ED_{res-a} (produce exposure duration - resident adult) yr	0	IRS_{res-a} (soil intake rate - resident adult) mg/day	100
ED_{res-c} (produce exposure duration - resident child) yr	0	IRS_{res-c} (soil intake rate - resident child) mg/day	200
EF_{res-a} (produce exposure frequency - resident adult) day/yr	0	t_{res} (time - resident) yr	26
EF_{res-c} (produce exposure frequency - resident child) day/yr	0	TR (target cancer risk) unitless	0.000001
TR (produce target cancer risk) unitless	0.000001	Soil type	Default
F(x) (function dependent on U_m/U_t) unitless	0.194	U_m (mean annual wind speed) m/s	4.69
PEF (particulate emission factor) m^3/kg	1359344438	U_t (equivalent threshold value)	11.32
Q/C_{wind} (g/m^2-s per kg/m^3)	93.77	V (fraction of vegetative cover) unitless	0.5
A_s (acres)	0.5		
Site area for ACF (area correction factor) m^2	1000000 m^2		
ED_{res} (soil exposure duration - resident) yr	26		
ED_{res-a} (soil exposure duration - resident adult) yr	20		
ED_{res-c} (soil exposure duration - resident child) yr	6		
EF_{res} (soil exposure frequency - resident) day/yr	350		
EF_{res-a} (soil exposure frequency - resident adult) day/yr	350		
EF_{res-c} (soil exposure frequency - resident child) day/yr	350		
ET_{res} (soil exposure time - resident) hr/day	24		
ET_{res-a} (soil exposure time - resident adult) hr/day	24		
ET_{res-c} (soil exposure time - resident child) hr/day	24		

Site-Specific Resident PRGs for Soil

Isotope	Ingestion PRG *(pCi/g)*	Inhalation PRG *(pCi/g)*	External Exposure PRG *(pCi/g)*	Total PRG *(pCi/g)*
Peak PRG for K-40	1.53E+01	3.80E+04	1.45E-01	1.44E-01
Peak PRG for Th-232	3.08E-01	3.65E+01	1.02E-02	9.85E-03
Peak PRG for U-238	1.44E-01	5.84E+01	1.36E-02	1.25E-02

PRG = preliminary remediation goal

Attachment B-4
USEPA Radionuclide Preliminary Remediation Goals for Superfund Table: Default PRGs for Industrial Worker Scenario

(Website accessed June 2024)

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Default Industrial Worker Equation Inputs for Soil

Radionuclide		Isotope-specific Information		PRG
Element (Atomic Number)	Isotope	Lambda (1/yr)	Half-life (yr)	Composite Worker Soil Total PRG TR=1E-06 (pCi/g)
Potassium (19)	K-40	5.54E-10	1.25E+09	2.19E-01
Thorium (90)	Th-232	4.93E-11	1.41E+10	1.53E-02
Uranium (92)	U-238	1.55E-10	4.47E+09	2.00E-02

PRG = preliminary remediation goal

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Attachment B-5
USEPA Radionuclide Preliminary Remediation Goals Website
Site-Specific PRGs for IOU Onsite Worker Scenario

(Website accessed July 2024)

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Site-Specific Resident Equation Inputs for Soil

Variable	Site-Specific Value
A (PEF Dispersion Constant)	16.2302
B (PEF Dispersion Constant)	18.7762
City (Climate Zone)	Default
C (PEF Dispersion Constant)	216.108
Cover thickness for GSF_o (gamma shielding factor) cm	0 cm
F(x) (function dependent on U_m/U_t) unitless	0.194
PEF (particulate emission factor) m^3/kg	1359344438
Q/C_{wind} (g/m^2-s per kg/m^3)	93.77
A_s (acres)	0.5
Site area for ACF (area correction factor) m^2	1000000 m^2
ED_{com} (exposure duration - composite worker) yr	20
EF_{com} (exposure frequency - composite worker) day/yr	150
ET_{com-i} (exposure time - indoor composite worker) hr/day	0
ET_{com-o} (exposure time - outdoor composite worker) hr/day	8
GSF_i (gamma shielding factor - indoor) unitless	0.4
IRA_{com} (inhalation rate - composite worker) m^3/day	60
IRS_{com} (soil intake rate - composite worker) mg/day	100
t_{com} (time - composite worker) yr	20
TR (target cancer risk) unitless	0.000001
U_m (mean annual wind speed) m/s	4.69
U_t (equivalent threshold value)	11.32
V (fraction of vegetative cover) unitless	0.5

Site-Specific Resident PRGs for Soil

Isotope	Ingestion PRG *(pCi/g)*	Inhalation PRG *(pCi/g)*	External Exposure PRG *(pCi/g)*	Total PRG *(pCi/g)*
Peak PRG for K-40	2.21E+02	1.02E+05	4.57E-01	4.56E-01
Peak PRG for Th-232	3.63E+00	9.79E+01	3.21E-02	3.18E-02
Peak PRG for U-238	1.32E+00	1.57E+02	4.30E-02	4.16E-02

PRG = preliminary remediation goal

APPENDIX C

ECOLOGICAL RISK ASSESSMENT

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LIST OF ABBREVIATIONS AND ACRONYMS

BRA	Baseline Risk Assessment
CMS	Corrective Measures Study
COPC	constituent of potential concern
CSM	Conceptual Site Model
DABW	D-Area Ash Basin Wetlands
ERA	Ecological Risk Assessment
ESV	ecological screening value
FCMS	Focused Corrective Measures Study
FS	Feasibility Study
ft	feet
IOU	Integrator Operable Unit
m	meter
NOAEL	No Observed Adverse Effect Level
OU	operable unit
RCOC	refined constituent of concern
RCRA	Resource Conservation and Recovery Act
RFI	RCRA facility investigation
RI	remedial investigation
SCDES	South Carolina Department of Environmental Services (previously known as the South Carolina Department of Health and Environmental Control)
SRS	Savannah River Site
SW	surface water
USEPA	United States Environmental Protection Agency

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C-1. INTRODUCTION

The ecological risk assessment (ERA) in this appendix is in support of the Focused Corrective Measures Study/Feasibility Study (FCMS/FS) for the D-Area Ash Basin Wetlands (DABW). The ERA supports the wholistic remedial approach that addresses remaining coal ash and coal fines units at the Savannah River Site (SRS) that includes the DABW. The SRS proposed regulatory strategy for the remaining coal ash and coal fines units was presented at a Core Team meeting held on April 19, 2022, with a follow-up meeting held on May 23, 2022. As a result of these meetings, SRS submitted the *Preferred Remedial Action and Regulatory Strategy for Remaining Savannah River Site's Coal Ash and Coal Fines Operable Units (U)* (IACD-22-166) in July 2022 to the United States Environmental Protection Agency (USEPA) and South Carolina Department of Environmental Services (SCDES) for regulatory review and approval. SCDES provided comments on the strategy, and SRS provided responses to the comments on September 15, 2022. USEPA and SCDES approved the regulatory strategy and associated comment responses in their letters dated August 11, 2022, and September 22, 2022, respectively. The proposed remedies of No Action or Land Use Controls (LUCs) were identified as the most likely remedial alternatives for the DABW.

No previous Comprehensive Environmental Response, Compensation, and Liability Act regulatory actions have been implemented for the DABW. However, the DABW was investigated as part of the approved *Resource Conservation and Recovery Act (RCRA) Facility Investigation/Remedial Investigation/Baseline Risk Assessment (RFI/RI/BRA) for the D-Area Expanded Operable Unit* (DEXOU) in 2002 (WSRC 2002a). As agreed to by the Core Team (i.e., United States Department of Energy, USEPA, and SCDES) at the July 2024 CMS/FS scoping meeting, the strategy for the DABW FCMS/FS is to use the information and conclusions of the DEXOU RFI/RI/BRA for this ERA with the addition of the results of the ecological evaluation that was recently completed assessing the ecological health of the DABW.

C-1.1 Background

The DABW is located within the floodplain of the Savannah River downgradient of D Area and is within the Savannah River and Floodplain Swamp (SRFS) Integrator Operable Unit (IOU) (Figure C-1). The DABW is located outside of the boundary of any industrial or general SRS

support area and is downgradient, southwest, of the 488-D Ash Basin. A portion of the southeastern boundary of the DABW is adjacent to Beaver Dam Creek (Figure C-2). The DABW ash depositional area has an estimated acreage of approximately (~) 36 hectares (ha) (90 acres [ac]) with an estimated volume of ~565,006 cubic meters (m^3) (739,000 cubic yards [yd^3]) of ash.

The DABW was investigated as part of the approved RFI/RI/BRA for the DEXOU in 2002 (WSRC 2002a). A Problem Identification meeting was held in October 2002 that resulted in the DABW subunit of the DEXOU being administratively transferred to the SRFS IOU due to the need for additional ecological data to support a final remedial decision for the DABW. The DEXOU RFI/RI/BRA was approved by the USEPA and SCDES on July 17, 2003, and July 21, 2003, respectively.

The ERA for the DABW is conducted in accordance with the conceptual site model (CSM). The CSM is a graphical depiction of the known and suspected sources of contamination, the types of contaminants and potentially affected media, known and potential routes of migration, and potential ecological receptors. The concentrations of constituents present in environmental media (in this case, ash/soil) are screened in a multi-step process against ecological thresholds to determine the potential impact to ecological receptors. This screening was conducted and documented in the RFI/RI/BRA for the DEXOU (WSRC 2002a). No ecological refined constituents of concern (RCOCs) were identified at the DABW (previously referred to as the 488-D Wetland). The conclusion of the ERA documented continuation of the ERA process, specifically, with collection of unit-specific ecological data.

Since development of the DEXOU RFI/RI/BRA (WSRC 2002a), site-specific ecological studies have been conducted to evaluate potential ecological impacts of ash disposition at the DABW, and previously, at the Wetland Area at Dunbarton Bay (WADB). The ERA herein supports the FCMS/FS by drawing on the information and conclusions of the DEXOU RFI/RI/BRA, and the results of ecological studies, particularly the 2022-2024 DABW study, to support the conclusion of the ERA.

C-1.2 Data

The data supporting the investigation of the DABW is presented in the DEXOU RFI/RI/BRA (WSRC 2002a), and characterization activities for ash/soil media for the DABW are described in Section 1.2.1 of this FCMS/FS. As depicted in Table C-1, the data from the RFI/RI/BRA included the following:

- 1997 pre-characterization data consisting of surface water (SW) sampling and a wetland survey consisting of 39 water samples along with pH and conductivity readings,
- DEXOU Phase I sampling conducted from 1998-1999 resulting in eight (8) sediment/soil and seven (7) SW samples,
- DEXOU Phase II sampling conducted in 2001,
- a WP Addendum for DEXOU that resulted in 16 paired sediment/soil and SW samples, and
- June 2002 field sampling conducted to identify the 0.0 to 0.3 meters (m) (0 to 1 foot [ft]) extent of contamination and collection of four (4) sediment/soil samples.

Figure C-3 shows the sampling locations associated with the DABW. These data were not re-evaluated in this ERA. Instead, results of the ERA described in the DEXOU RFI/RI/BRA (WSRC 2002a) are summarized, and the ERA process continues, herein, with the incorporation of ecological studies that support final remedial decision for the DABW.

The D Area ash basins (which are now closed) and the DABW have been the subject of decades of ecological investigations. In 2022-2024, the DABW was the focus of an ecological investigation to provide critical information supporting the ERA to support a final remedial decision for the DABW. The most recent study was conducted based on results of previous studies and the approach/findings associated with the WADB, another wetland-related ash depositional area (in this case, a Carolina bay), that supports the final action determination from an ecological perspective.

Groundwater is not part of the DABW and will be addressed under the D-Area Groundwater Operable Unit (OU).

C-1.3 Habitats/Receptors/Assessment Endpoints

The DABW is a mixed compositional bottomland hardwood forest that ranges from more frequently flooded areas to areas of open canopy, to a climax swamp forest approaching the Savannah River. Depending on precipitation events, river flood levels, and groundwater table fluctuations, portions the DABW hold water seasonally/periodically. Photos of the DABW are presented in Attachment C-1. Information on threatened, endangered, and sensitive (TES) species surveys are provided in Section 1.2.1 of this FCMS/FS. More detailed information regarding species that may be found within habitats represented at the DEXOU area, including the DABW, are discussed in the DEXOU RFI/RI/BRA (WSRC 2002a).

Assessment endpoints are tailored to groups of organisms with similar feeding strategies and/or exposure scenarios appropriate for the DABW. Assessment endpoints from the RFI/RI/BRA for the DEXOU (WSRC 2002a), applicable to the DABW, include those listed below. This information is provided to highlight the types of organisms with potential exposure to DABW contaminants. Constituent screening values used in the DEXOU RFI/RI/BRA were based on thresholds applicable to these types of receptors for the ecological screening that was conducted in the DEXOU ERA:

- Protection of soil-dwelling invertebrate communities to maintain species diversity and nutrient cycling. Soil-dwelling invertebrate communities are selected because they are ecologically important, are susceptible to constituents in soil, and may be exposed at the DABW. The soil-dwelling invertebrate community is essential for decomposition of detritus, contributes to energy and nutrient cycling, and is an important component of the diet of insectivorous mammals and birds.

- Protection of herbivorous mammal communities to ensure that exposure of contaminants in forage and soils does not have a negative impact on growth, survival, and reproduction. Herbivorous mammals are ecologically important because they provide a food base for higher trophic level receptors and are susceptible to soil constituents.

- Protection of insectivorous mammal communities to ensure that exposure of contaminants in prey, forage, and soils does not have a negative impact on growth or survival. Insectivorous

mammals are ecologically important because they help to control the size of the terrestrial invertebrate population that might otherwise damage populations of plant primary producers. They also are susceptible to soil constituents within the DABW.

- Protection of amphibian communities from contaminants in abiotic media in order to maintain species diversity and to ensure there is not negative impact on growth, survival and reproduction. The amphibian community is ecologically important as it serves as prey items for mammals, reptiles, birds, and fish. Amphibians are particularly susceptible to constituents in SW since embryonic/larval life stages are exclusively in the aquatic environment and are more sensitive than adult life stages.

The ERA process is conducted in accordance with the preliminary CSM. The CSM is a graphical depiction of the known and suspected sources of contamination, the types of contaminants and potentially affected media, the known and potential routes of contaminant migration, and the potential ecological receptors. Concentrations of constituents present in environmental media are screened in a multi-step process against ecological thresholds to determine the potential contaminants to access potential threats to ecological receptors. The preliminary CSM for the DABW in presented in Section 1.2.3 and depicted in Figure 6 of this FCMS/FS.

C-2. Ecological Risk Assessment Process

The ERA consists of steps designed to provide a scientifically based and defensible assessment of exposure and hazard assessment for ecological receptors that will support a risk management decision for the DABW. The ERA begins with a screening-level ecological effects evaluation in which maximum constituent concentrations in environmental media are compared to conservative and relevant ecological screening values (ESVs). The screening level ecological effects evaluation for the DABW was conducted and documented in the ERA for the DEXOU RFI/RI/BRA (WSRC 2002a) following the established/approved SRS ERA protocols at the time. The ESVs, media- and receptor-specific literature-based thresholds, were used to evaluate (i.e., screen) soil, sediment, and SW data from the DABW. The thresholds used in the DEXOU RFI/RI/BRA (WSRC 2002a) were derived from several sources and were used to screen potential contaminants based on No Observed Adverse Effect Level (NOAEL) for this initial screening. Constituents that failed the

screening (with hazard quotients > 1.0), or constituents with no available ESVs, were carried forward for further evaluation.

The refinement screening step included a comparison to background. Average and maximum unit values were compared to two times the average unit background level, bioaccumulation potential was assessed, and toxicity reference value comparisons was conducted, representing measurement endpoints derived from the assessment endpoints for the DEXOU ERA (WSRC 2002a). For radionuclides, a dose comparison was conducted based on findings from the International Atomic Energy Agency in E*ffects of Ionizing Radiation on Plants and Animals at Levels Implied by Current Radiation Standards* (IAEA 1992) that reports chronic dose rates of 0.1 rad/day and 1.0 rad/day, or less, do not appear likely to cause observable changes in terrestrial and aquatic animal populations, respectively. The radiological screening thresholds used in the DEXOU RFI/RI/BRA ERA were divided by 10 to provide an additional protective safety factor. Other lines of evidence were also utilized including frequency of detection, pattern of detection, and an overall uncertainty evaluation that included a review of existing ecological data available at the time the DEXOU RFI/RI/BRA was prepared.

The ERA for the DABW, as documented in the DEXOU RFI/RI/BRA ERA (WSRC 2002a), did not identify final ecological RCOCs. The conclusion of the ERA referred to the uncertainty surrounding the selection of final RCOCs and deferred to continuance of the ecological assessment process for collection of site-specific ecological data to support the remedial decision.

This ERA continues the ERA process by applying site-specific ecological data to determine if final RCOCs are identified for the DABW. If final RCOCs are identified, then final action consideration would be warranted.

C-2.1 Results of the DEXOU Ecological Risk Assessment for the D-Area Ash Basin Wetlands

For the DABW ERA in the DEXOU (DEXOU RFI/RI/BRA, WSRC 2002a), the environmental media screened included sediment, soil, and SW.

The Constituents of Potential Concern (COPCs) identified through the ecological screening process included the following:

Sediment

- Arsenic – due to potential effects on benthic organisms and aquatic predators,
- Selenium and vanadium – due to potential effects of aquatic predators.

Soil

- Arsenic, selenium, and vanadium – due to potential effects of terrestrial receptors.

Surface Water

For SW, there were several inorganics that exceeded threshold screening, but all were associated with samples having usually high total suspended solids (TSS) and/or turbidity. Samples with low TSS/turbidly were similar to background. Therefore, no COPCs were identified for the SW medium. Also, based on the results of the uncertainty evaluation, the results of the ERA identified the following as *final* COPCs (for all media):

- Arsenic, selenium, and vanadium (for sediment/soil).

The ERA for the DEXOU concluded with identification of COPCs for the DABW.

C-2.2. Summary of the DEXOU Ecological Risk Assessment for the DABW

Results of the ERA for the DABW documented in the DEXOU RFI/RI/BRA (WSRC 2002a) did not complete the ERA process and identify ecological RCOCs or state that no RCOCs were identified. Instead, the conclusion of the ERA referred to the uncertainty surrounding the final RCOCs and deferred to continuance of the ecological assessment process for collection of site-specific ecological data to support the remedial decision.

The overall conclusion of the ERA (DEXOU) also stated that it is uncertain if the ecological problems warranting action are significant enough to warrant removal of contaminated sediment/soil within the wetland due to the significant ecological impacts of the action itself.

The ERA process for the DABW continues below with inclusion of ecological data that were collected based on the COPCs identified in the ERA from the DEXOU (WSRC 2002a), and other relevant ecological studies.

C.2.3 Refinement of Constituents of Concern – Inclusion of Ecological Data

Results of the DABW RFI/RI/BRA ERA deferred to continuance of the ecological assessment process for collection of site-specific ecological data to support the remedial decision. In support of this decision point, an ecological Sampling and Analysis Plan (SAP) was developed and submitted with the Revision 0 DEXOU RFI/RI/BRA (WSRC 2002b). Comments from SCDES were received and discussed in a follow up scoping meeting. The DABW was administratively transferred from the DEXOU to the SRFS IOU to allow for additional ecological study. Based on the development of the draft SAP, initial studies were conducted by the University of Georgia's Savannah River Ecology Laboratory (SREL) and the Savannah River National Laboratory including, but not limited to, earthworm toxicity testing, trace element distribution and speciation, assessment of plant and animal communities, contaminant inventories, and body burdens assessments.

Following on the results of these initial studies and the ERA approach used for the approved *Focused Corrective Measures Study/Feasibility Study Report for the Wetland Area at Dunbarton Bay* (SRNS 2013), the SREL began a final investigation of the DABW in 2022. The study, *Bioaccumulation and Community Composition of Small Terrestrial Biota Exposed to Coal Combustion Residual Contaminants* (K. Holland 2024), was completed in April 2024. The results of this work are summarized in the following paragraphs (Holland 2024).

The 2022-2024 DABW study included several aspects including biota collections for body burden analyses that also included collection of ash/soil samples within the DABW and reference areas (Figure C-4) to assess contaminant levels within biota and ash/soil. Sampling arrays constructed and utilized for the body burden biota collections are shown in Figure C-5. Examples of organisms collected/surveyed, either for body burden analyses or community surveys, are shown in Figure C-6.

As expected, the ecological investigation found trace element concentrations were higher in ash-contaminated sediment/soil (ash/soil) than reference sediment/soil (Figure C-7). Also, as expected, target biota assessed for contaminant body burdens had elevated levels of arsenic, selenium, and strontium when compared to reference samples (Figure C-8). Data comparisons also showed similar concentrations in ash/soil from 2003 to 2022 suggesting no observable natural attenuation based on the data/locations collected for the study (Figure C-9).

In order to determine if elevated levels in ash/soils and/or biota were impacting inhabiting wildlife, a more robust survey was conducted to assess community-level metrics. The community matrices primarily included species richness and diversity of small vertebrates as well as collection of environmental data to assess environmental parameter variability. The sampling locations are shown Figure C-10, and the sampling design for the community assessment is shown in Figure C-11. This sampling consisted of passive camera surveys, active pit traps and drift fences, funnel traps oriented along the arms of the Y-oriented sampling array drift fence, and Sherman traps dispersed around the sampling array, which also allowed for live captures. Comparisons were made based on location within the interior of the DABW (Interior ash locations), Intermediate locations (along the boundary of the DABW to assess marginal ash exposure), and Reference areas located with the floodplain.

The Mark-Recapture sampling resulted in 837 captures of 34 species including 15 reptile,15 amphibian, and 4 small mammal species with 22 species at the Ash site (Interior), 16 from the Intermediate site, and 11-21 species from the three Reference sites. Camera Trapping included detection events from 12,400 photos of biota including 3570 photos of non-target species (i.e., birds, mesomammals, and invertebrates), and 610 photos for which species could not be identified. Target species and repeat detections included 3026 individual captures of 31 species including 19 reptile, 7 amphibian, and 5 small mammal species. Figure C-12 provides an example of the camera data collected during the study. A total of 14 of 31 detected species were found in the Ash, Intermediate, and at least one Reference site. Cameras detected a significantly higher number of species than Mark-Recapture. Significantly more species were recorded from arrays in the Ash site compared to arrays in the Reference sites.

For species richness, rarified richness was calculated rather than raw richness to account for uneven sampling period among sites. Rarefaction calculates species richness based on a random subsample of individuals (a "sample"). Typically, the sample number used would be less than the total community size, or number of species detected within the sampling period. The rarefaction was based on 5 samples, 5 species within the community, a low but robust enough number for calculations for most arrays. Rarified richness values for the Reference sites were aggregated. To calculate diversity, the Inverse Simpson's Index was used which considers species richness and evenness but is less sensitive to presence of rare species than other indices.

Results of the community assessment show that environmental variables varied minimally among contaminated (Ash and Intermediate sites) and Reference sites. Although elevation and ground cover differed between sites, there was no evidence that the environmental variables measured affected species richness or diversity.

Species of small vertebrates documented were reflective of a typical southeastern floodplain forest. Elevation and ground cover differed between sites, but there was no evidence that any environmental variables affected species richness or diversity. Interestingly, ground cover was greater for the DABW sites, which may be attributed to the enriched availability of essential trace elements for plants growing within the ash plume area. This could be viewed as being similar to biochar additions which are known to enhance plant growth providing elemental nutrients to agricultural or forested ecosystems.

C-3. Refinement of Constituents of Concern – Ecological Data

Despite finding elevated concentrations of trace elements within soil and biota, there is little evidence that ash-associated contaminants are impacting diversity measures such as species richness and diversity (Figures C-13 and C-14). Findings also suggest beta diversity (measured by dissimilarity in species composition) could be altered by ash, but there are environmental differences between sites that offered an explanation, and overall, there is broad overlap in species composition among Reference and Ash-contaminated sites. Dissimilarity based on camera trap data was driven by both species and environmental variables; driven by abundant species like cotton mice in the Ash site, eastern woodrats (*Neotoma floridana*) in the Reference sites, and green

anoles (*Anolis carolinensis*) in Ash and Reference sites (as shown in Figure C-15). The main environmental parameters driving dissimilarity among sites was elevation and ground cover (Figure C-14), and as mentioned previously, ground cover was greater at Ash sampling locations. Overall, species composition at the DABW is reflective of a typical southeastern floodplain forest.

Overall, the Holland (2024) study also showed that using active live traps, including pitfalls and funnels, was more effective for amphibian captures, and the adapted camera traps (passive technique) was more effective for reptiles, specifically squamate and small mammal detections.

The DABW has not received additional ash inputs in over five decades. During that timeframe, ecological research on ash units accelerated at SRS. Ecological data is the pillar of the ERA process. Threshold screening provides one level of evaluation, but site-specific data determines if threshold exceedances may be eliciting adverse effects negatively impacting ecological resources.

Amphibians have been a focus of many ash-related ecological studies since they are ideally suited for investigating chronic level affects due to their heightened skin permeability and contaminant susceptibility in both terrestrial and aquatic systems, and initial studies were conducted in ash basins that served as aquatic habitat. Previous SRS studies have documented contaminant bioaccumulation, with incidences of accompanying individual-level effects in some studies (e.g., altered behavior, increased deformities , reduced growth) and population-level effects (e.g., reduced recruitment and offspring viability) in some species, with deleterious effects being associated with the highest level of contaminants within ash slurry settling basins (Row et al. 1996, 1998, 2006; Hopkins et al. 1997, 1999, 2000; Snodgrass et al. 2004). The basins where the past impacts were identified are now closed and, therefore, no longer pose a potential threat to ecological receptors.

Related SREL research in ash depositional areas continued as well, including investigations at the DABW and WADB. Both of these units had historic deposition that ceased decades ago (>35 years). Both depositional areas are now revegetated with a mature mixed hardwood/floodplain community and an organic soil layer has developed. Conditions within these ash depositional areas present similar conditions.

Research associated with the WADB included additional lines of evidence with site-specific Toxicity Characteristic Leaching Procedure extractable contaminant evaluations for ash impacted soils showing no clear trends within the ash disposition zone in Dunbarton Bay (SRNS 2013).

SREL collected and analyzed both biotic and abiotic samples within the WADB (SRNS 2013). The findings showed overall levels of arsenic, selenium, and strontium, as well as uranium, copper, and nickel in tissue were elevated in Dunbarton Bay when compared to the reference site (a nearby Carolina bay). However, no population- level effects related to elevated body burdens were observed. Instead, the number of herpetofauna species in Dunbarton Bay were comparable to the nearby reference bay indicating that the elevated levels of metals are not adversely impacting the biodiversity of herpetofauna within Dunbarton Bay. The results of the site-specific studies at the WADB indicate, overall, that the ash media at Dunbarton Bay does not represent a significant risk to populations/communities of ecological receptors. The results for WADB are comparable to the DABW. These aged depositional environments have not been shown to negatively impact residing ecological receptors.

Other lines of evidence utilized for the WADB ecological assessment included trophic-level modeling using the site-specific data that was collected and analyzed by SREL. The trophic modeling effort addressed the uncertainty associated with relying strictly on literature-base toxicity values and exposure assumptions. The results showed only aluminum exceeded toxicity reference values for the raccoon and great blue heron in both the WADB and the reference site (Bay 100) (SRNS 2013). Aluminum is known to be elevated across the SRS due to naturally high aluminum in soils at the SRS, and its presence in the reference bay indicates the elevated levels are not due to contributions from the ash deposits. This is also observed by the data collected that showed levels in the reference bay (Bay 100) were higher than the Dunbarton Bay system. The trophic-level modeling report did not indicate any other ash-related contaminants of issue associated with the WADB and was included as Attachment C-3 in the FCMS/FS for the WADB (SRNS 2013).

A multiple lines-of-evidence approach was followed to determine whether the SRS ash units, DABW in this case, have the potential to pose a significant risk to wildlife receptors. Overall,

these lines-of-evidence have included chemical analysis of the impacted medium, literature-based risk screening, bioaccumulation and field-based biota tissue surveys, trophic level modeling, population/community evaluations, and toxicity testing to make an assessment on ecological health of ash units. The results of these evaluations show no clear evidence that the DABW negatively impacts ecological receptors. These recovered ecological systems appear healthy and diverse ecosystems when compared to similar reference areas that are not contaminated. For further information, Attachment C-2 includes a list of selected publications relating to the ecological studies conducted at SRS ash OUs as well as an annotated bibliography of D Area ash-related studies that was prepared as part of the DABW SREL study (Holland 2024).

C-3. SUMMARY/CONCLUSION OF THE ECOLOGICAL RISK ASSESSMENT

The conclusion of the ERA process leads to the following three possible decisions upon completion of the assessment:

- There are adequate data to conclude that ecological risks are negligible, therefore, there is no need for remediation on the basis of ecological risk.
- The information indicates a potential for adverse ecological effects and a more thorough assessment is warranted.
- The information is not adequate to make a decision at this point and the ERA process will continue to address data gaps.

The ecological evaluation for the DABW indicates that the data are adequate to conclude that ecological risks are negligible, and a remedial decision for the protection of ecological receptors is not needed. Site-specific ecological/biological studies have been conducted on various ash units at the SRS, primarily associated with ash depositional areas in sensitive environments such as Carolina bays (i.e., WADB) and in this instance, within a floodplain habitat (i.e., DABW). The ecological investigations are the final determining factor in assessing whether remedial action is required for the protection of ecological resources. These recolonized/recovered areas appear healthy and diverse as compared to similar uncontaminated areas, and it is reasonable to

conclude that from an ecological perspective, the DABW has become integrated within the natural landscape, and does not pose a deleterious threat to ecological receptors.

The following table presents the overall summary of the ERA based on media.

OU	ERA Soil 0.0 to 0.3 m (0 to 1 ft) RCOCs	ERA Sediment 0.0 to 0.3 m (0-to 1 ft) RCOCs	ERA SW RCOCs
DABW	None	None	None

The refined CSM is presented in Section 1.2.3 of this FCMS/FS.

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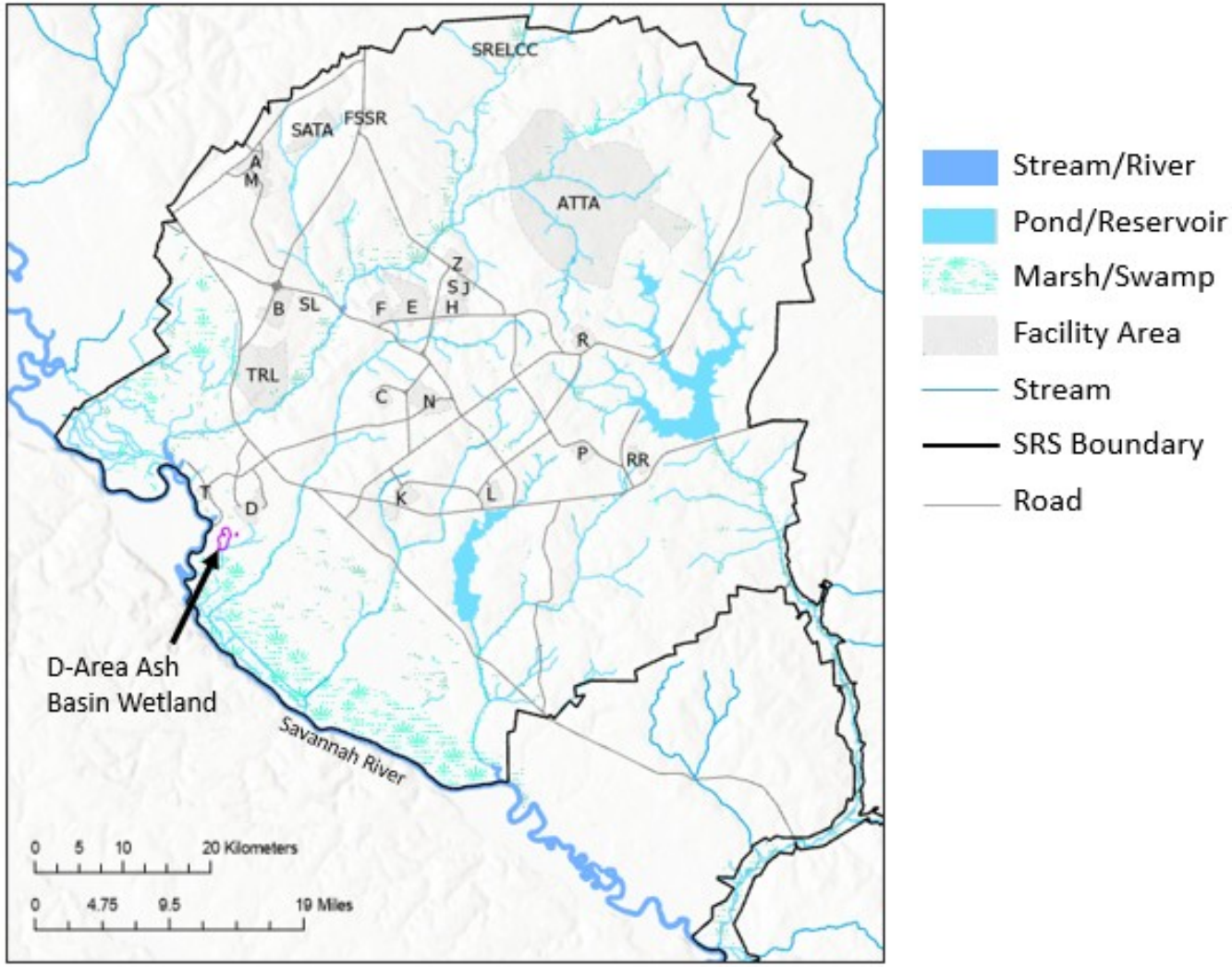


Figure C-1. Location of the D-Area Ash Basin Wetlands

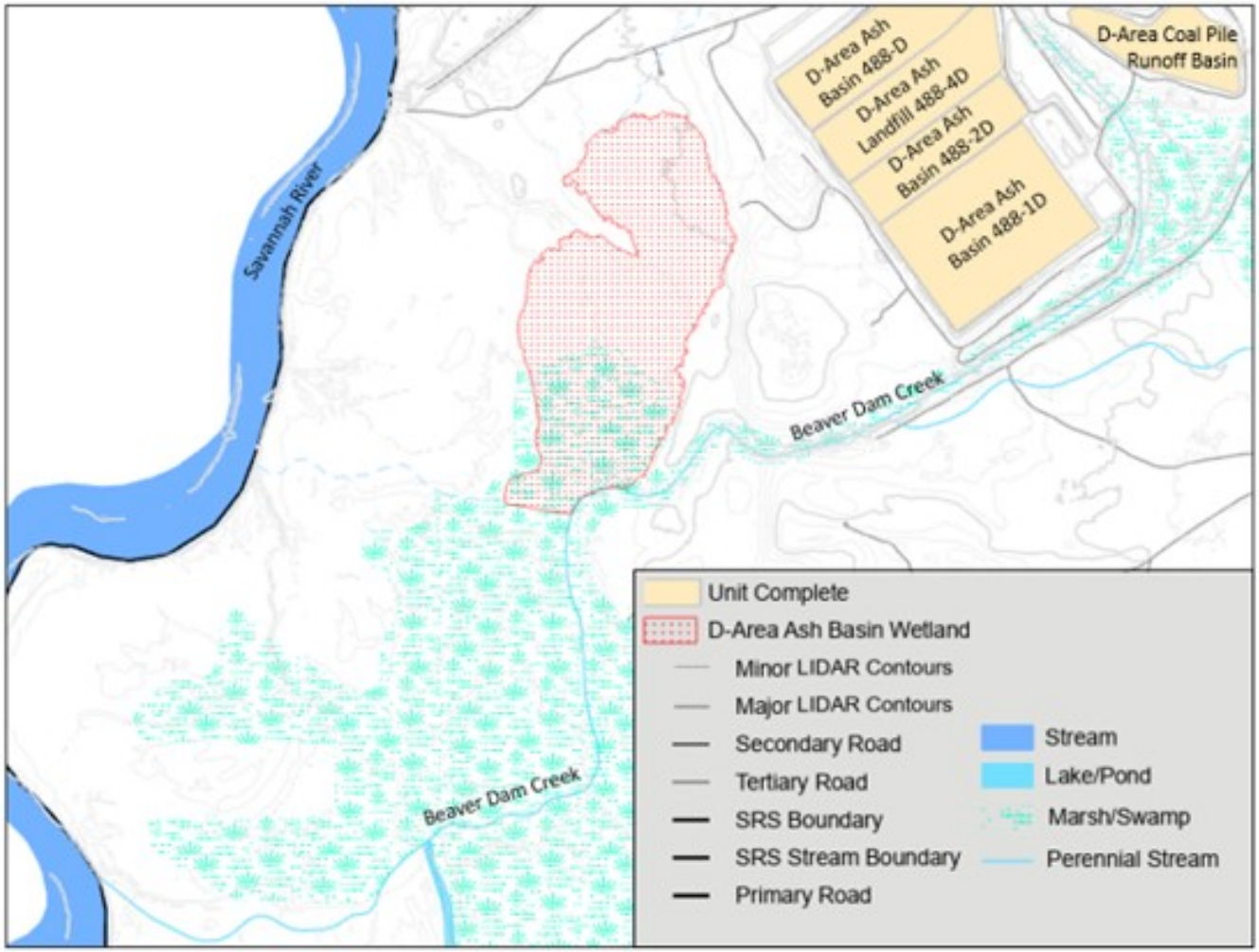


Figure C-2. D-Area Ash Basin Wetlands

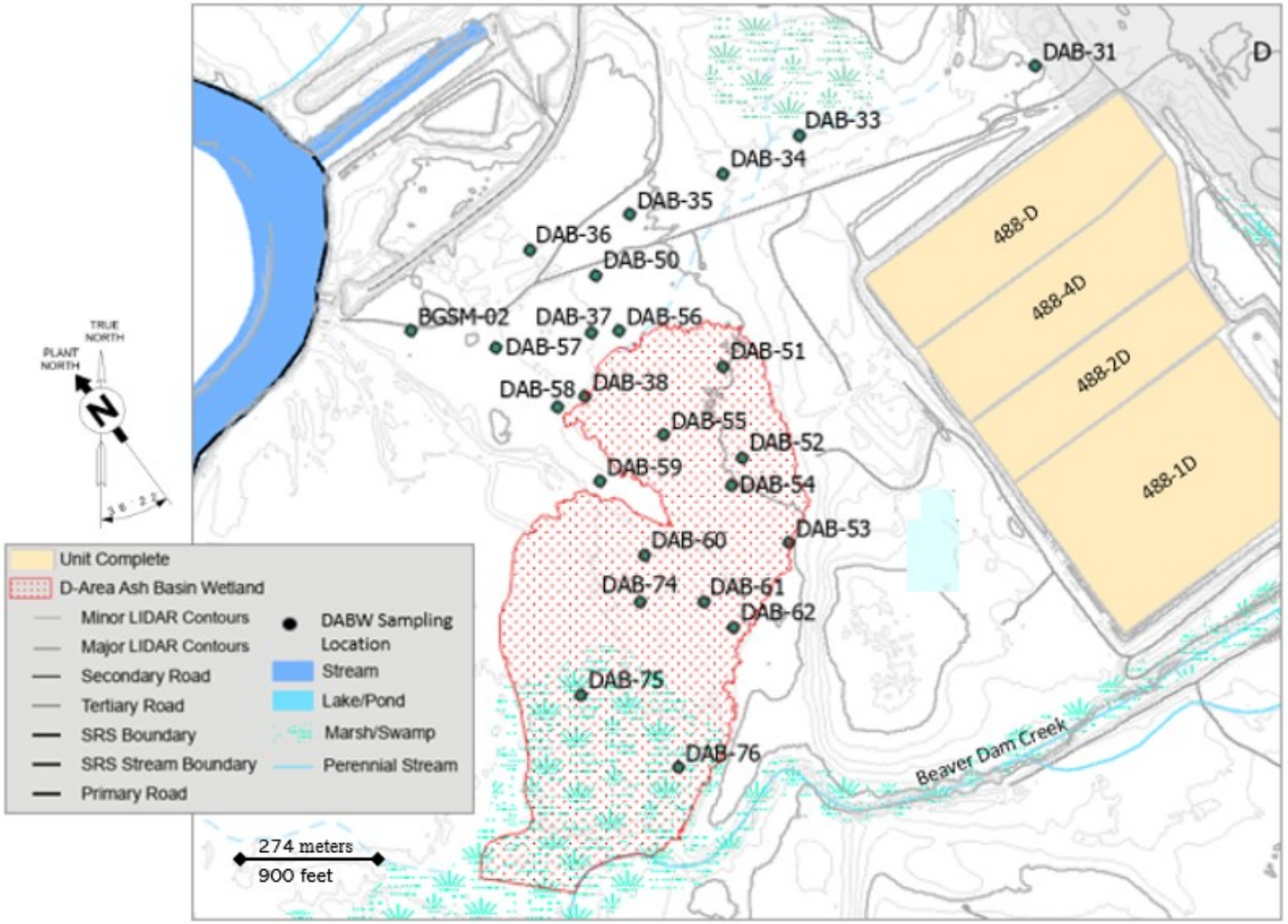
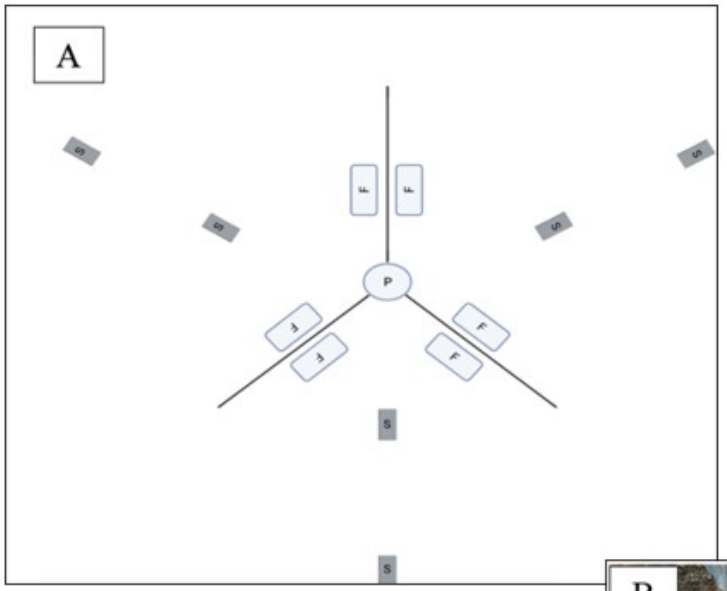


Figure C-3. D-Area Ash Basin Wetlands Sampling Locations from the RFI/RI/BRA for the DEXOU



DABW Biota Collection Arrays C1, C2 and C3 and Reference Area Arrays C4 and C5. Five soil cores were also taken approximately every 100 m using a soil core sampler.

Figure C-4. D-Area Ash Basin Wetlands Biota and Soil Sampling Locations (From Holland, 2024)



Array layout used to collect biota samples between August 2022 and November 2023. Arrays were made of three 7.5 m drift fence arms of aluminum flashing with a central pitfall trap (P), 6 funnel traps (F) on each side, and 2 Sherman traps (S) 5 and 10 m away from the pitfall between each drift fence arm for a total of 6

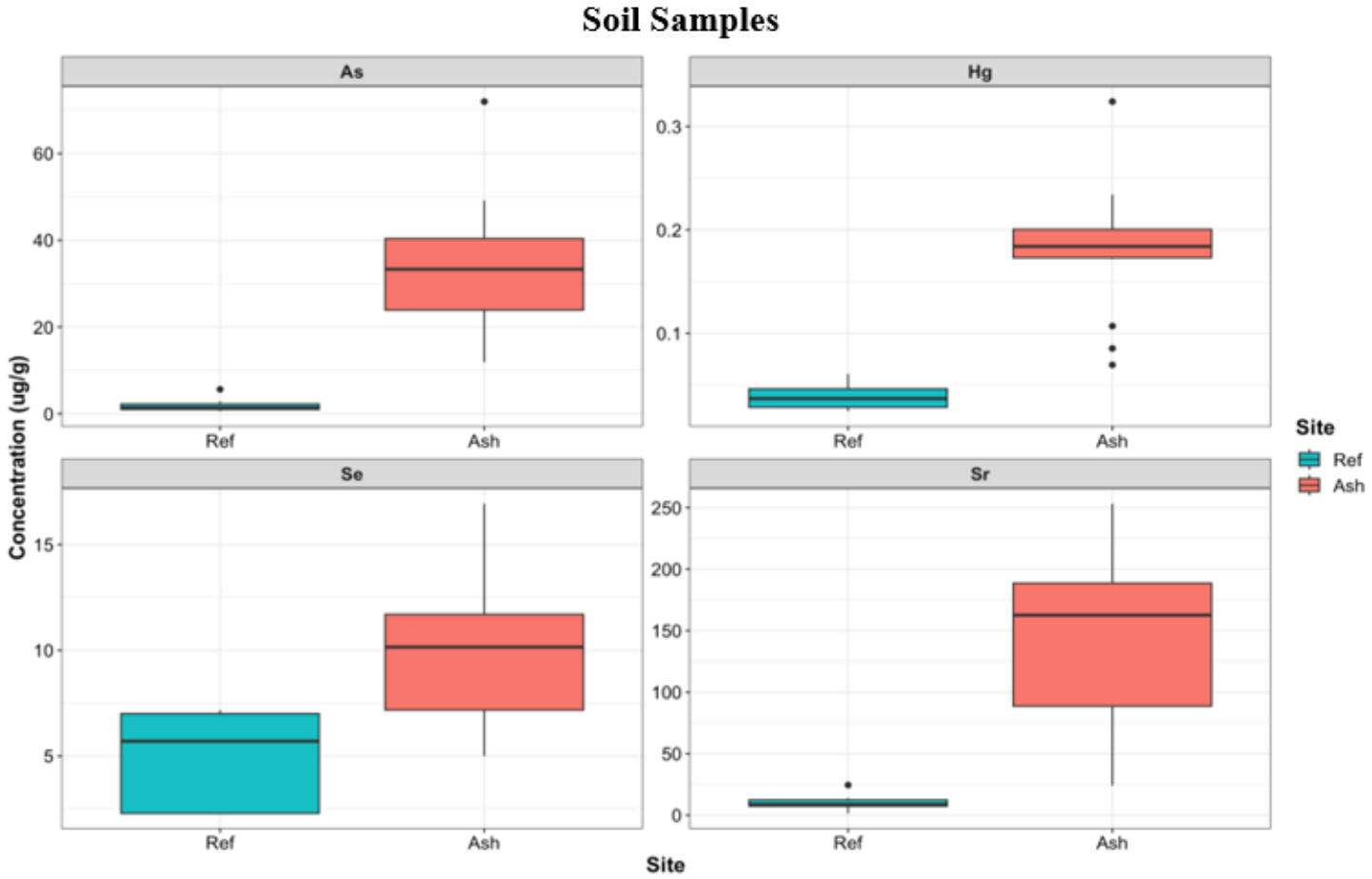


Photos of a collection array with associated traps (left to right: closed pitfall, funnel, Sherman trap, drift fence) in the field.

Figure C-5. Biota Collection Array Sampling Design (From Holland, 2024)

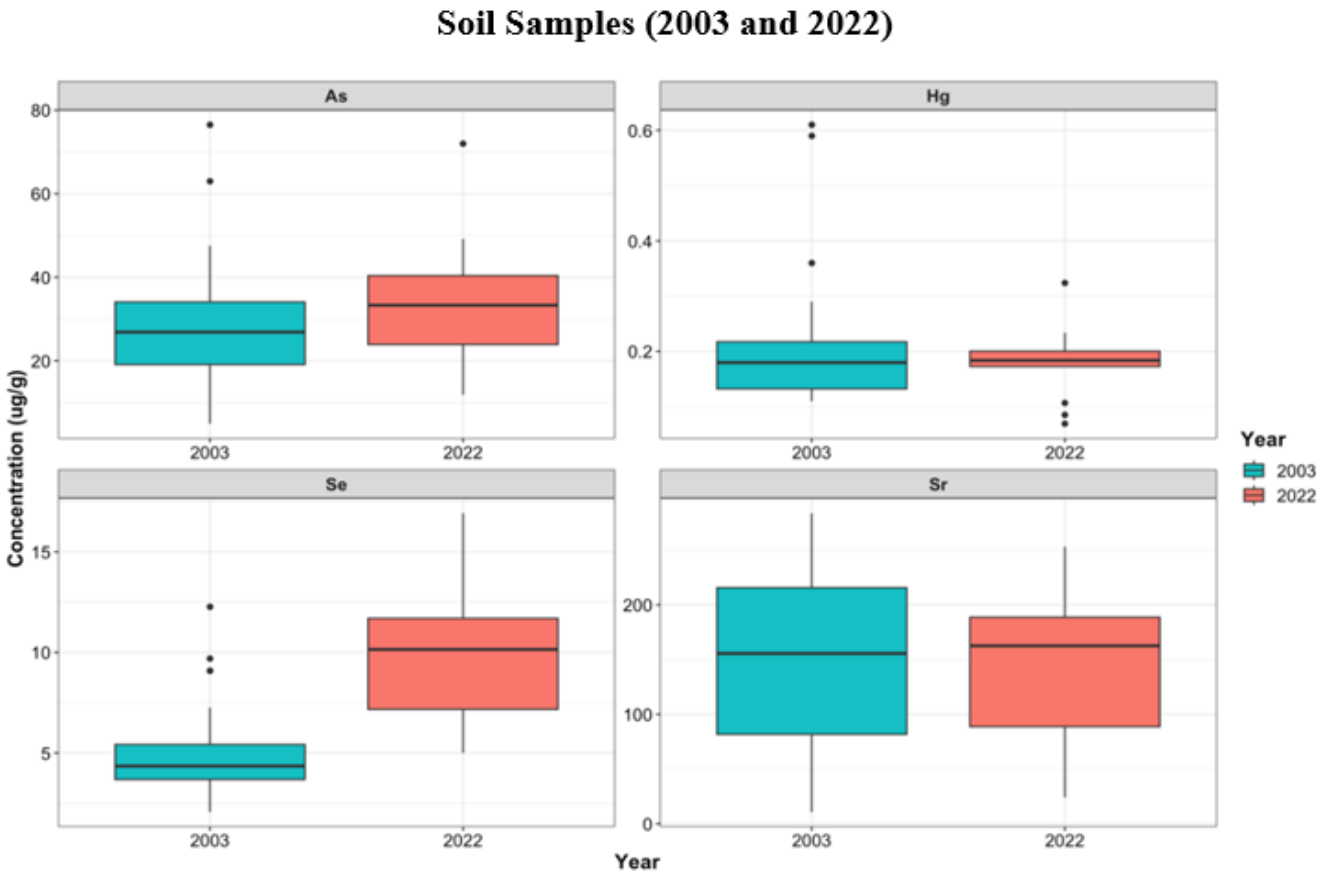


Figure C-6. Example of Biota Surveys: Woodrat (left); funnel trap (middle); incidental box turtle.



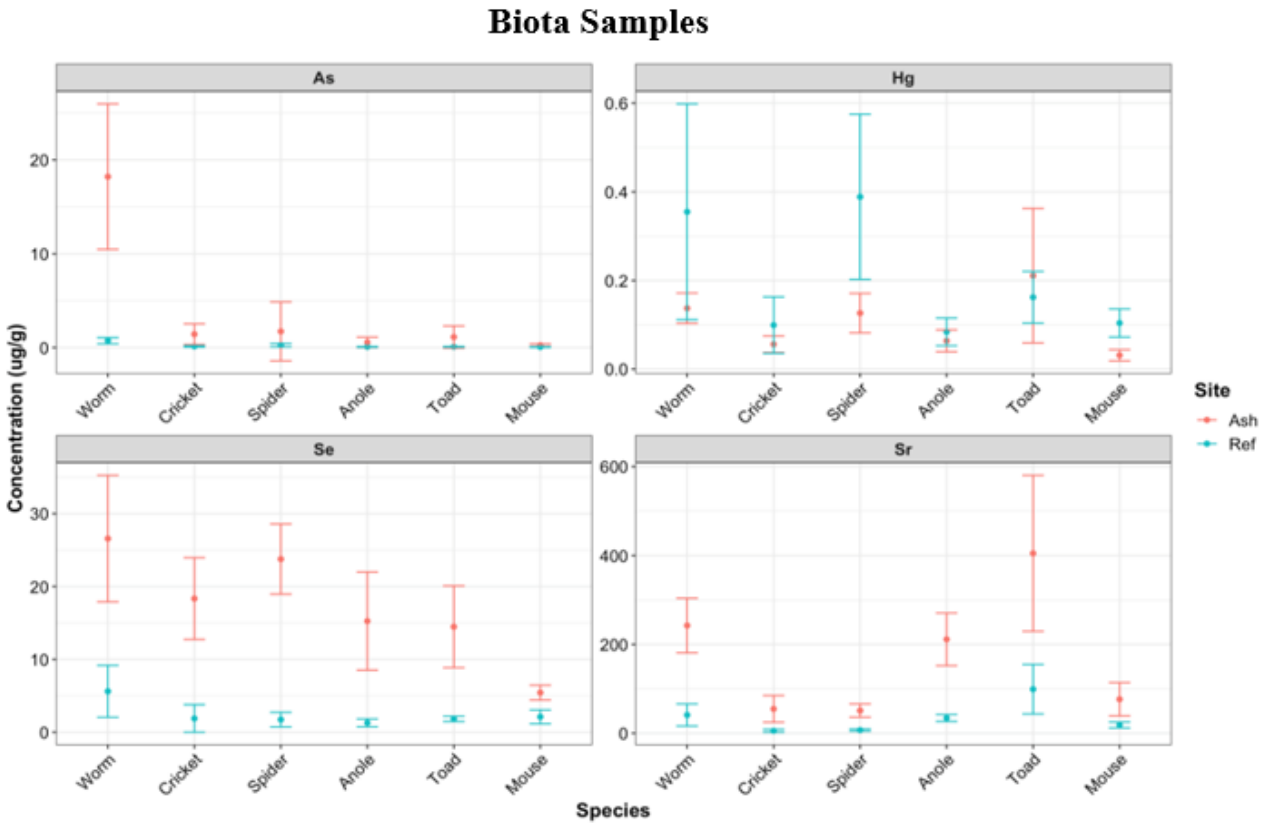
Trace element (As, Hg, Se, and Sr) concentration (µg/g dry weight) comparisons in **soil samples** collected from the DABW(Ash, *n*=15) and a reference site (Ref, *n*=8). All samples were collected in October 2022.

Figure C-7. Soil Sampling Results (From Holland, 2024)



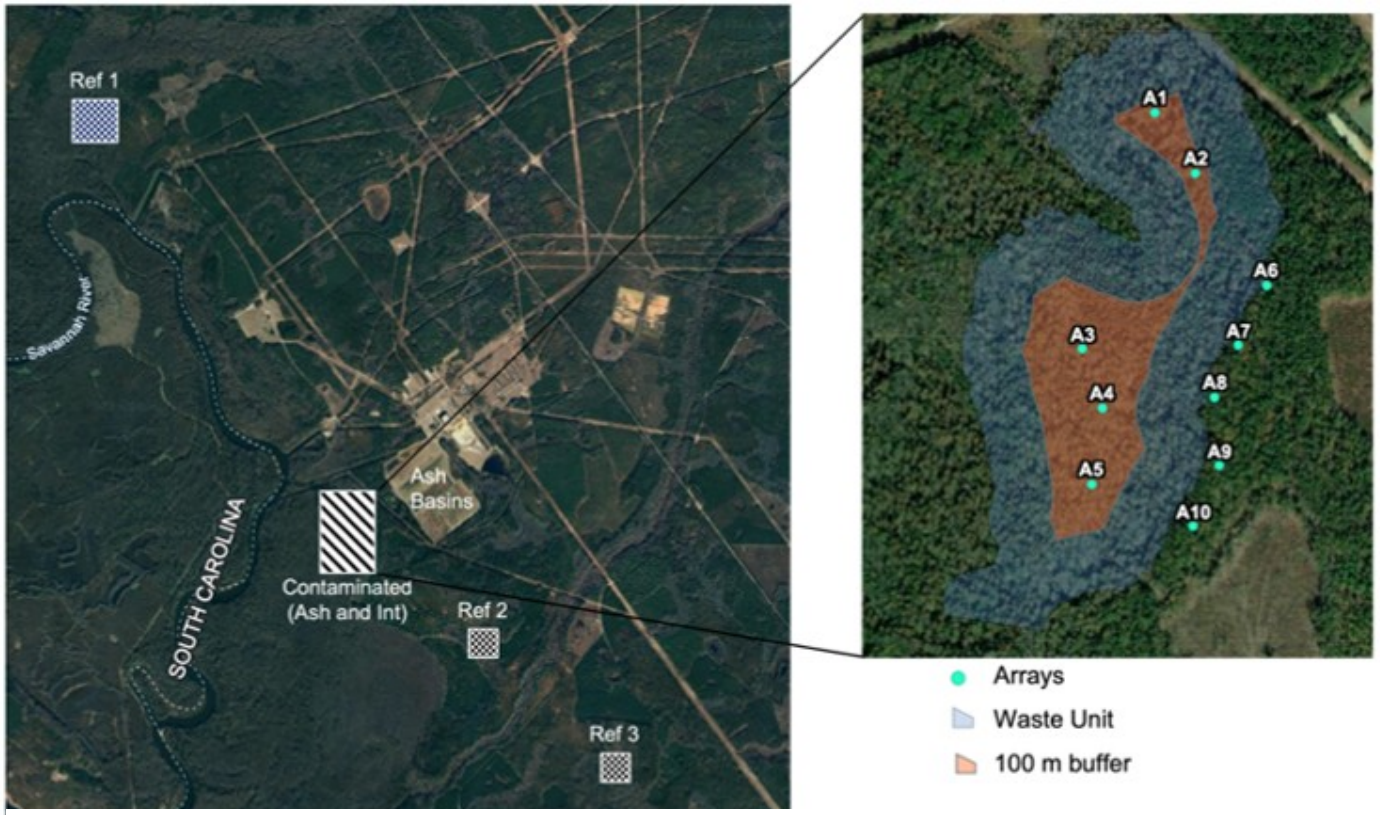
Comparison of trace element (As, Hg, Se, and Sr) concentrations (µg/g dry weight) quantified from **soil samples** taken in 2003 (*n*=36) and 2022 (*n*=15) in the DABW

Figure C-8. Biota Sampling Results (From Holland, 2024)



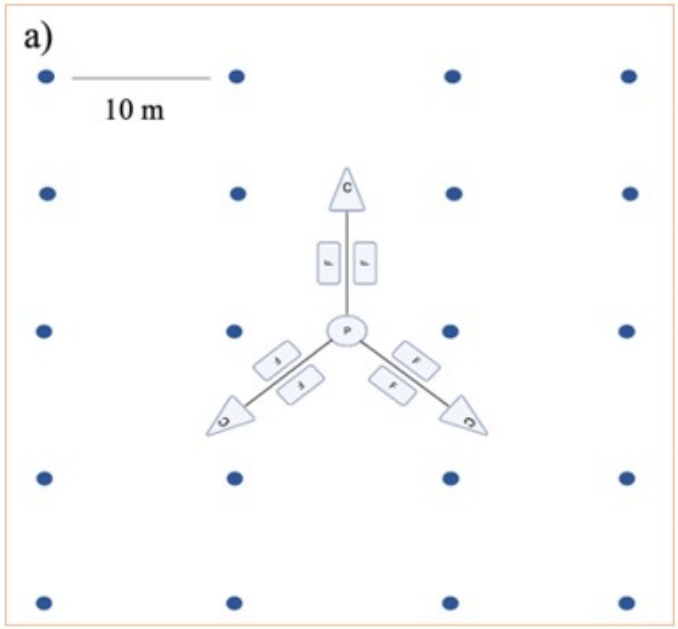
Map of all sites (Ash, Intermediate, Reference 1, Ref 2, and Ref 3) where community sampling occurred. Zoomed in map (right) of the contaminated area shows the outline of the D-Area Ash Basin Wetlands, a 100 m buffer from the edge designating the ash plume core containing ash arrays (A1-A5), and intermediate arrays (A6-A10) within 50 m of the edge of the plume.

Figure C-9. Soil Sampling Results from 2003 and 2022 (From Holland, 2024)



Average concentrations (µg/g dry weight) of trace elements (As, Hg, Se, and Sr) with standard deviations (± 1 SD) in six species collected from the DABW (Ash) and a reference site (Ref) within the Savannah River Site, South Carolina. Invertebrate species included Oligochaetes (Worm), *Ceuthophilus uhleri* (Camel Cricket), and *Tigrosa georgicola* (Wolf Spider). Vertebrate species included *Anolis carolinensis* (Green Anole), *Anaxyrus terrestris* (So Toad), and *Peromyscus gossypinus* (Cotton Mouse).

Figure C-10. Community Sampling Array Locations

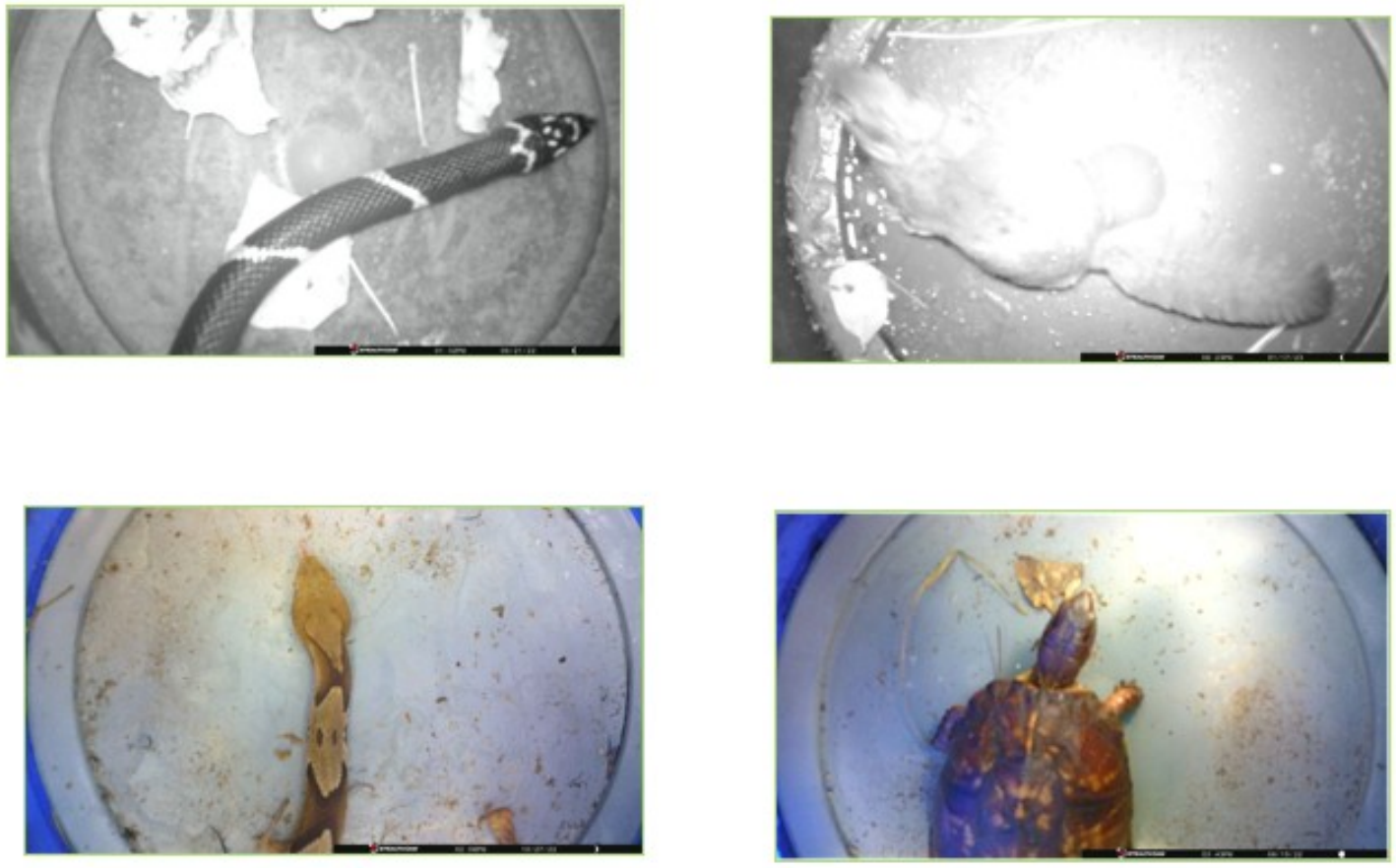


a) Diagram of sampling array layout with trap placement; C = camera traps, F = funnel traps, P = pitfall trap, dot = 5 x 4 Sherman trap grid spaced 10 m apart.



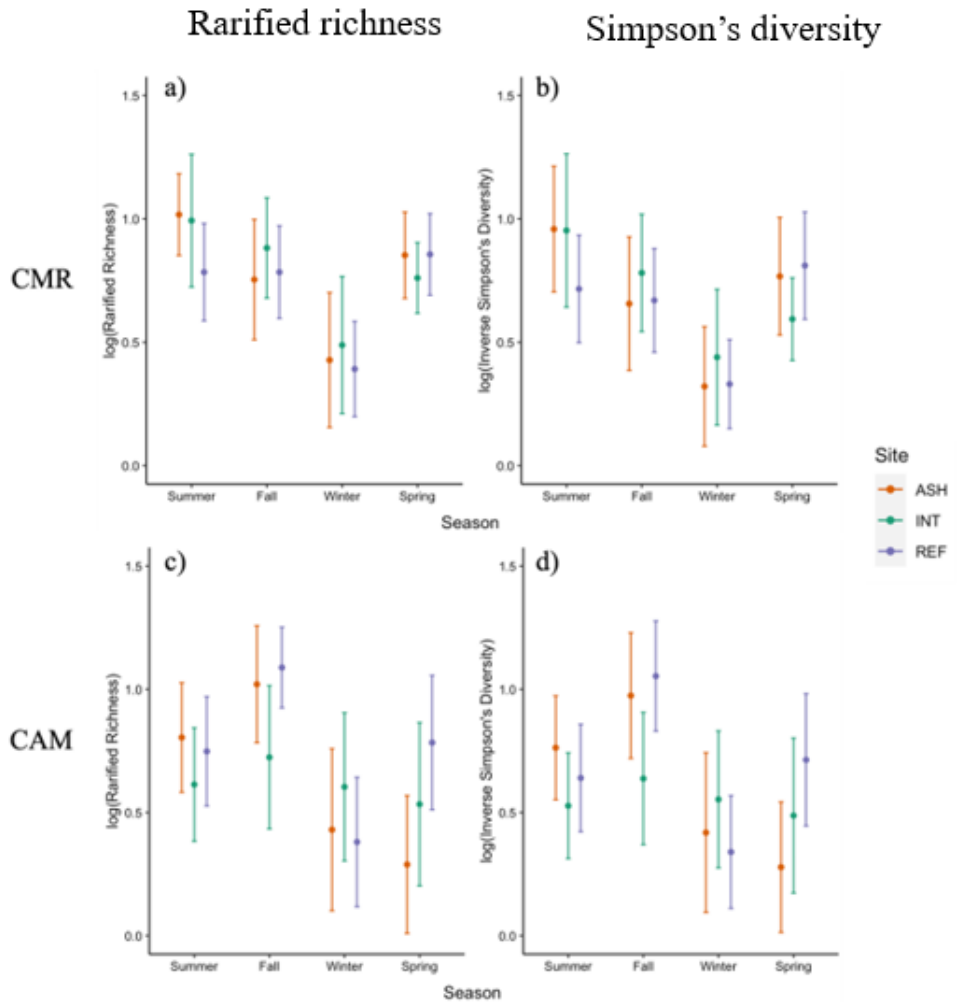
b) Photos of traps included in sampling arrays; left to right: inactive pitfall trap with lid, modified bucket camera trap, wire mesh funnel trap, and Sherman live trap in situ.

Figure C-11. Community Collection Sampling Design (From Holland, 2024)



Photos Left (top to bottom) then Right: Eastern Kingsnake, Copperhead, Flying Squirrel, Box Turtle

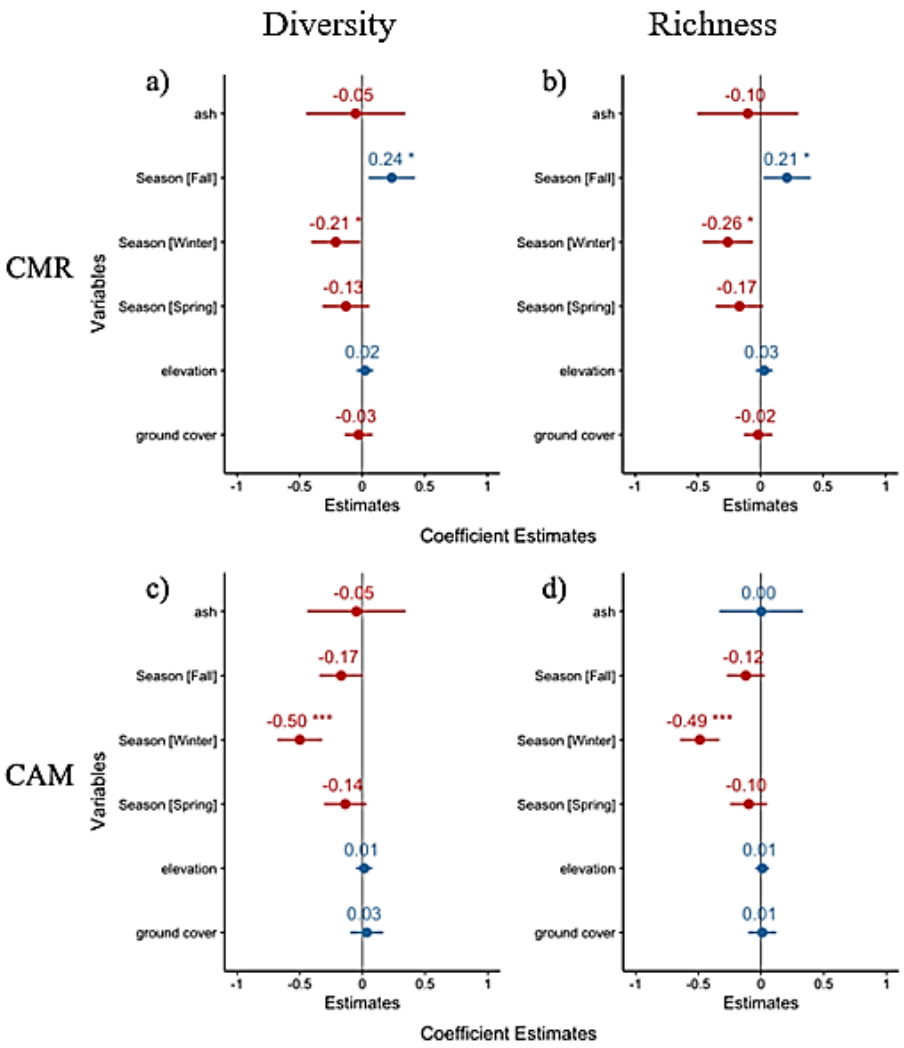
Figure C-12. Passive Sampling Camera Trap Photos (From K. Holland, 2024)



Small vertebrate log transformed **richness and diversity** values from mark-recapture (CMR) (top) and camera traps (CAM) (bottom).

Rarified richness (left) and inverse Simpson's diversity averages (right) plotted with 95% confidence intervals for each site by season.
ASH = Ash site
INT = Intermediate site
REF = Reference sites

Figure C-13. Species Richness and Diversity Results (From K. Holland, 2024)



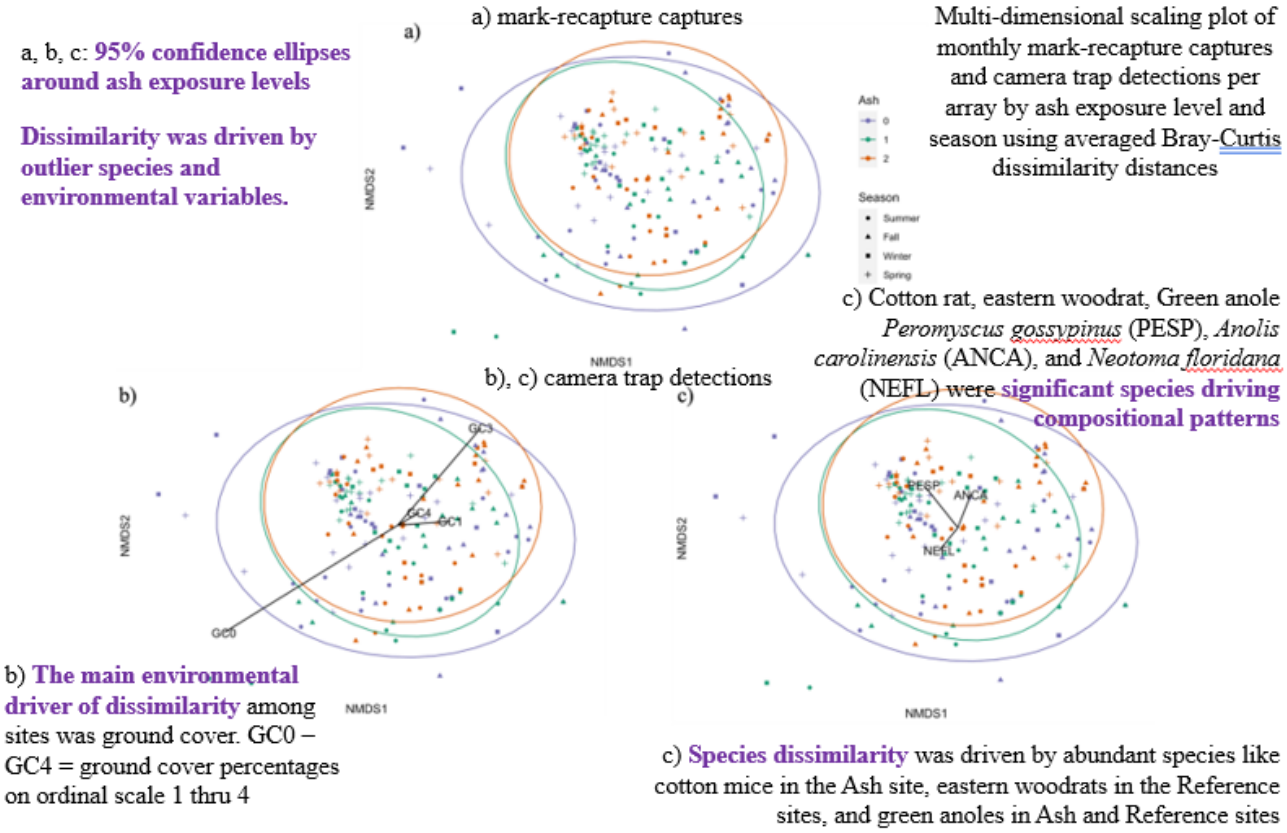
Coefficient estimates of fixed variables including **ash exposure, season, and environmental variables (elevation and ground cover)** on richness (right) and inverse Simpson's diversity values (left) derived from mark-recapture captures (CMR) and camera trap detections (CAM).

Asterisks (*) depict significance.

Winter had a significant negative effect on richness and diversity for both capture methods.

Fall had a significant positive effect on richness and diversity while no significant effect was detected, ash exposure coefficient estimates had wide CI ranges.

Figure C-14. Species Richness and Diversity Coefficient Estimates (From K. Holland, 2024)



Non-metric multi-dimensional scaling plot of monthly a) mark-recapture captures and b-c) camera trap detections per array by ash exposure level (Ash = 2, Intermediate = 1, Reference = 0) and season using averaged Bray-Curtis dissimilarity distances. 95% confidence ellipses around ash exposure levels.

Figure C-15. Non-Metric Multi-Dimensional Scaling Plot. (From K. Holland, 2024)

Table C-1. Exposure Groups and Sampling Stations for the DABW (488-D Wetland) (from the RFI/RI/BRA for the DEXOU)

Exposure Group	Media	Sampling Stations	Notes
488-DAB (Interior)	Soil	DAB-07 through -16, DAB-43 and DAB-44	Includes borings through waste, berm, and 488-D Pooled Basin.
488-DAB (Exterior)	Soil	DAB-17 through –24	
DRP	Soil	DRP-01 through -51	
Background	Soil	BGFA-01, BGFA-02	Background dataset for all soil exposure groups.
Background	Soil	BGCH-01, BGCH-02	For information only (See Section 4.3).
Background	Soil	BGUO-01, BGUO-02	For information only (See Section 4.3).
488-D Pooled Basin	SW	DAB-43 and DAB-44	Data group for surface water only. DAB-43 and DAB-44 sediment samples are evaluated as soil under 488-DAB (Interior).
488-D Drainage	SW/SED	DAB-39, -40, -45, -46	
Dead and Stressed Vegetation Area	SW/SED	DAB-27, -28, -41, -41R, -42	DAB-41: Sediment only.
488-D Wetland	SW/SED	DAB-31, DAB-33 through -38; DAB-50 through -62; and DAB-74, -75, and -76 and BGSM-01 and BGSM-02.	
DRP Stream Boundary	SW/SED	DRP-S2, -S3, and -S4; DAB-32	
DRP Stream Boundary Background	SW/SED	DRP-S1	For information only (See Section 4.3).
Background	SW/SED	SSBG-01, SSBG-02, SSBG-03	For use as background for all SW/SED exposure groups, including DRP.

Attachment C-1
Photos of D-Area Ash Basin Wetlands

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Aerial (drone view) of D-Area Basin Wetlands showing powerline boundary line and the Savannah River in the distance (May 29, 2024)



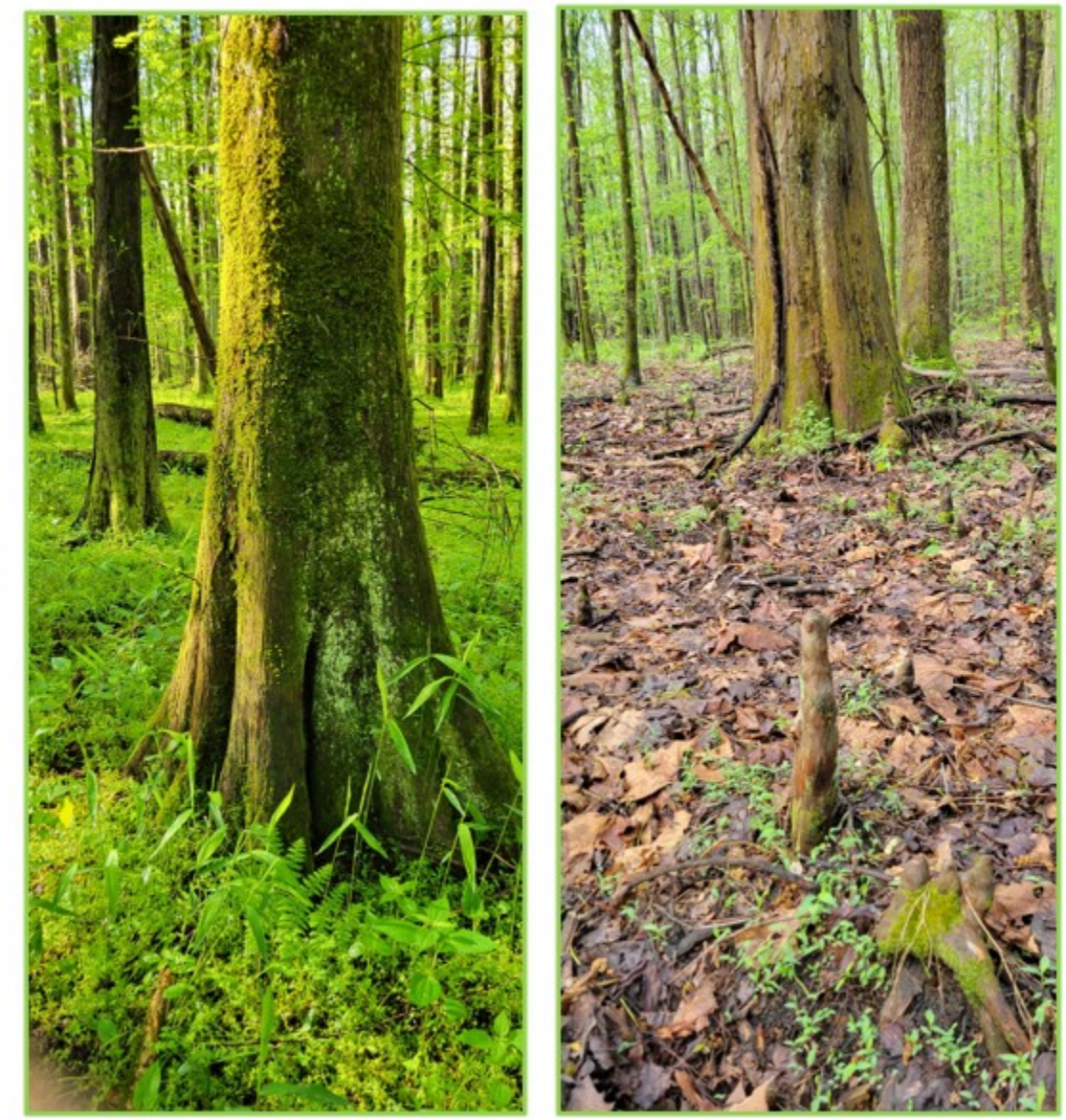
Aerial (drone view) of D-Area Basin Wetlands from mid-powerline boundary (May 29, 2024).



D-Area Ash Basin Wetlands from March 28, 2023 field visit showing hardwoods from ground level (left) and tree canopy (right).



D-Area Ash Basin Wetlands from March 28, 2023, field visit showing hardwoods, ground cover, and mayapple (right) along the forest floor.



D-Area Ash Basin Wetlands from March 28, 2023, field visit showing cypress buttressing and ground cover (left), and cypress knee among the leaf litter (right).



D-Area Ash Basin Wetlands from March 28, 2023, field visit showing seasonal flooding (top) and evidence of recent high-water line based on pollen signatures (bottom).

Attachment C-2
Selected Ecological Studies Relating to Ash Units at the SRS

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SREL CCW Publications

SREL Reprint # proceeds the citation.

0572 Adriano, D.C., T.A. Woodford, and T.G. Ciravolo. 1978. Growth and elemental composition of corn and bean seedlings as influenced by soil application of coal ash. Journal of Environmental Quality 7:416-421.

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1574 Carlson, C.L. and D.C. Adriano. 1991. Growth and elemental content of two tree species growing on abandoned coal fly ash basins. Journal of Environmental Quality 20:581-587

1576 Sandhu, S.S. and G.L. Mills. 1991. Chapter 17. Mechanisms of mobilization and attenuation of inorganic contaminants in coal ash basins. p. 342-364. In Emerging Technologies in Hazardous Waste Management II, edited by D.W. Tedder and F.G. Pohland. American Chemical Society. Atlantic City, NJ.

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1764 Menon, M.P., K.S. Sajwan, G.S. Ghuman, J. James, and K. Chandra. 1993. Chapter 12. Elements in coal and coal ash residues and their potential for agricultural crops. In Trace Elements in Coal and Coal Combustion Residues, edited by R.F. Keefer and K.S. Sajwan. p. 259-287. Lewis Publishers, Inc. Boca Raton, FL.

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1764 Menon, M.P., K.S. Sajwan, G.S. Ghuman, J. James, and K. Chandra. 1993. Chapter 12. Elements in coal and coal ash residues and their potential for agricultural crops. In Trace Elements in Coal and Coal Combustion Residues, edited by R.F. Keefer and K.S. Sajwan. p. 259-287. Lewis Publishers, Inc. Boca Raton, FL.

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Annotated Bibliography for the Savannah River Site's D-Area

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Borchert, E. J., J. C. Leaphart, A. L. Bryan Jr., and J. C. Beasley. 2019. Ecotoxicoparasitology of mercury and trace elements in semi-aquatic mammals and their endoparasite communities. Science of the Total Environment 679(2019): 307-316.

Hepatic trace element concentrations with focus on mercury (Hg) were quantified for three species of semi-aquatic mammals of varying assumed trophic levels. North American river otters (*Lontra canadensis*), raccoons (*Procyon lotor*), and North American beavers (*Castor canadensis*) were collected from known contaminated sites within the SRS and compared to individuals collected throughout GA and SC to examine any relationship between trace element concentrations and endoparasite loads. Hg demonstrated biomagnification corresponding to assumed trophic levels but there was no clear pattern of elevated concentrations among SRS collected individuals. The study also found possible links between hepatic elements and endoparasite diversity/abundance in raccoons.

Bryan, J., A.L., W. A. Hopkins, J. H. Parikh, B. P. Jackson, and J. M. Unrine. 2012. Coal fly ash basins as an attractive nuisance to birds: Parental provisioning exposes nestlings to harmful trace elements. Environmental Pollution 161(2012): 170-177.

Trace element concentrations were analyzed in the diet and tissues of nestling Common Grackles (*Quiscalus quiscala*) collected around D-Area settling basins and a reference site. As, Cd, and Se concentrations were significantly elevated in ash basin nestling diets. Those elements with the addition of Sr were also significantly higher in ash basin nestling tissues. Se concentrations in some individuals met or exceeded reported levels of concern. There was a strong positive relationship between feather, liver, and carcass concentrations supporting the use of feathers as a non-destructive indicator of exposure for As, Se, and Sr.

Cochran, J. P., N. A. Eady, M. A. Pilgrim, T. D. Tuberville, and D. L. Haskins. 2012. Influence of coal ash contamination on metabolic rates of eastern mud turtles (*Kinosternon subrubrum*). Oral presentation at the Annual SC Upstate Research Symposium; printed proceedings, Spartanburg, SC.

A proceeding presenting similar results as the Cochran et al. 2018 study but focused solely on metabolic rates (MR). MRs of mud turtles increased with increased temperature. When accounting for mass differences, there was no significant effect of exposure to contaminants on MR.

Cochran, J. P., D. L. Haskins, N. A. Eady, M. T. Hamilton, M. A. Pilgrim, and T. D. Tuberville. 2018. Coal combustion residues and their effects on trace element accumulation and health indices of eastern mud turtles (*Kinosternon subrubrum*). Environmental Pollution 243: 346-353.

This study compared a collection of 30 eastern mud turtles (*Kinosternon subrubrum*) exposed to coal combustion residues (CCR) and 17 unexposed turtles to assess their

physiology. This assessment included CCR accumulation in claws and blood, immune response, red blood cell parasite loads, and metabolic rates. Se and Sr were significantly elevated in both claw and blood samples and As was additionally elevated in claw samples of exposed individuals. CCR did not negatively impact immune status or parasite load, however the latter was positively correlated with size. Temperature was significantly positively correlated with metabolic rate for both groups, but exposed turtles tended to have a lower metabolic rate.

Finger Jr., J. W., M. T. Hamilton, B. S. Metts, T. C. Glenn, and T. D. Tuberville. 2016. Chronic ingestion of coal fly-ash contaminated prey and its effects on health and immune parameters in juvenile American alligators (*Alligator mississippiensis*). Archives of Environmental Contamination and Toxicology 71(3): 347-358.

A lab experiment raising juvenile American alligators for two years in a controlled environment and fed one of four dietary treatments with varying levels of contamination from coal combustions wastes (CCW). Then numerous tests of immune function were performed including inflammatory response, bacterial killing assays, plasma biochemistry, splenic mass, morphometry, and an overall kidney and liver trace-element analysis. Although the alligators accumulated substantial concentrations of contaminants, there was no significant effect of dietary treatment on any of these health parameters. This is the first study to implement certain ecoimmunology techniques (i.e PHA injection) on this species.

Fletcher, D. E., A. H. Lindell, G. K. Stillings, G. L. Mills, S. A. Blas, and J. V. McArthur. 2014. Spatial and taxonomic variation in trace element bioaccumulation in two herbivores from a coal combustion waste contaminated stream. Ecotoxicology and Environmental Safety 101(2014): 196-204.

A comparison study of bioaccumulation patterns of two aquatic invertebrate herbivores, Asiatic clams (*Corbicula fluminea*) and Mayfly nymphs (*Maccaffertium modestum*) and their potential as biomonitors in CCW contaminated stream systems. Trace element and stable isotope analyses were conducted on specimens collected from Beaver Dam Creek. Variation in stable isotope signatures and bioaccumulation were found between and among species and sites. However, both species bioaccumulated some elements, particularly Se, over reported risk thresholds. Due to these variations the study suggests using a suite of aquatic biota ranging in habitat and feeding behavior to assess bioavailability of contaminants.

Fletcher, D. E., A. H. Lindell, G. K. Stillings, G. L. Mills, S. A. Blas, and J. V. McArthur. 2014. Variation in trace-element accumulation in predatory fishes from a stream contaminated by coal combustion waste. Archives of Environmental Contamination and Toxicology 66(3): 341-360.

This study compared bioaccumulation of trace elements in 4 predatory fish (largemouth bass, *Micropterus salmoides;* channel catfish, *Ictalurus punctatus*; longnose gar, *Lepisosteus osseus*; and bowfin, *Amia calva*) and 2 aquatic invertebrate species (Asiatic

clam, *Corbicula fluminea* and heptagniid mayfly, *Maccaffertium modestum*) within Beaver Dam Creek. Tissue samples underwent trace element and stable isotope analysis to assess bioaccumulation and trophic position. V, Cd, Ba, Ni, and Pb bioaccumulated in invertebrate species but not in fish muscle while Se, Sr, Zn, Cr, Cu, and As did accumulate in fish muscle but to a lesser extent than invertebrate species. Liver tissues analyzed contained higher concentrations than muscle tissue. Hg and Cs were found to biomagnify within fish species as concentrations had a positive relationship with trophic position. Hg concentrations in bowfin and longnose gar exceeded USEPA human health guidelines, posing potential human health risks.

Fletcher, D. E., A. H. Lindell, G. K. Stillings, G. L. Mills, S. A. Blas, and J. V. McArthur. 2015. Trophic variation in coastal plain stream predatory fishes. Southeastern Naturalist 14(2): 373-396.

A study looking at the relationship between size and trophic level using stable isotopes analysis in 4 large predatory fish species. Trophic level of largemouth bass (*Micropterus salmoides*) and longnose gar (*Lepisosteus osseus*) had a positive linear relationship with size. The channel catfish (*Ictalurus punctatus*) was the largest-bodied but lowest trophic position fish with no linear relationship detected.

Fletcher, D. E., A. H. Lindell, G. K. Stillings, S. A. Blas, and J. V. McArthur. 2017. Trace element accumulation in lotic dragonfly nymphs: Genus matters. PLos ONE 12(2): 1-27.

This study investigated trophic hierarchies and trace element accumulation in dragonfly nymphs within a narrow δ15N range. Trophic position was minimally influenced by size, and its impact on trace element accumulation varied within and among genera. Higher trace element concentrations were observed in upstream samples which were closer to the contaminant source. However, differences among genera within a site were often more significant than differences between sites. The study highlighted the importance of separating dragonfly genera for accurate comparisons in contaminant accumulation. It emphasized the need for continued exploration of factors influencing variation in accumulation among and within aquatic insect genera to aid in improving stream assessments.

Flynn, R. W., C. N. Love, A. Coleman, and S. L. Lance. 2019. Variation in metal tolerance associated with population exposure history in Southern toads (*Anaxyrus terrestris*). Aquatic Toxicology 207(2019): 163-169.

Southern toads (*Anaxyrus terrestris*) were collected from 3 coal combustion waste (CCW) contaminated wetlands and 3 reference wetlands and induced in a laboratory setting. Egg clutches were collected and raised to larval stage and then exposed to a Cu (50 ppb) treatment or kept as a control. Cu tolerance was measured by larvae time to death. Larvae produced by exposed populations were no more tolerant to Cu treatment than reference populations. However, larvae from one recently constructed wetland

Leaphart, J. C., R. E. Oldenkamp, A. L. Bryan Jr., R. A. Kennamer, and J. C. Beasley. 2020. Patterns of trace element accumulation in waterfowl restricted to impoundments holding coal combustion waste. Environmental Toxicology and Chemistry 39(5): 1052-1059.

Male ring-necked ducks (*Aythya collaris*) from a control site were experimentally restricted to a coal combustion waste (CCW) settling basin. After known periods of exposure (between 3 and 92 days) blood, muscle, and liver tissue samples were collected to quantify trace element burdens. With focus on As, Se, and Hg, models were created to help predict bioaccumulation and muscle/liver burdens based on blood concentrations. Se concentration increased over time in all three tissue samples while As and Hg showed no pattern of accumulation. Blood may be a viable non-destructive sampling alternative for As and Se muscle/liver concentrations.

Lindell, A. H., R. C. Tuckfield, and J. V. McArthur. 2016. Differences in the effect of coal pile runoff (low pH, high metal concentration) versus natural Carolina Bay water (low pH, low metal concentration) on plant condition and associated bacterial epiphytes of Salvinia minima. Bulletin of Environmental Contamination and Toxicology 96(5): 602-607.

In a controlled mesocosm study, the effects of water with different pH and metal concentration levels were observed in aquatic macrophyte *Salvinia minima*. Water samples were collected from a D-Area ash basin (lowest pH, high metal concentration) and two natural Carolina Bays (low pH, low metal concentration) within SRS. Both natural and pH adjusted mesocosms were used. Plant condition was measured by chlorophyll α concentration in leaves and epiphytic bacteria communities were measured by functional diversity. Low pH and high metal concentrations had significant negative impact on both parameters. The driving force of epiphyte function appeared to be metal concentration levels and when pH was adjusted, metal uptake was significantly higher in D-Area *S. minima*.

Metts, B. S., K. A. Buhlmann, D. E. Scott, T. D. Tuberville, and W. A. Hopkins. 2012. Interactive effects of maternal and environmental exposure to coal combustion wastes decrease survival of larval southern toads (*Bufo terrestris*). Environmental Pollution 164(2012): 211-218.

Through the creation of mesocosms representing the D-Area ash basins, ash plume wetland and a control, this study assessed southern toad larval survival in relation to maternal exposure to coal combustion wastes (CCW). Exposure reduced larval survival by 57% compared to unexposed females. A combination of maternal exposure and larval exposure reduced survival by 85%. Effects of exposure to CCW were correlated to age of the sediments suggesting natural attenuation of contaminants in the environment may alleviate these effects over time.

Metts, B. S., K. A. Buhlmann, T. D. Tuberville, D. E. Scott, and W. A. Hopkins. 2013. Maternal transfer of contaminants and reduced reproductive success of southern toads (*Bufo [Anaxyrus] terrestris*) exposed to coal combustion waste. Environmental Science and Technology 2013(47): 2846-2853.

Southern toads were collected from D-Area ash basins and associated wetlands and a reference site. In a controlled laboratory environment toads from the same collection area were allowed to breed and a subsample of eggs from each clutch was reared to hatching. Both females and remaining eggs were used for elemental analysis. Hatch success, viability, and maternal reproductive success were measured for each clutch and compared to reference clutches. For contaminated clutches all were reduced by 22%, 23%, and 27%, respectively. Females from contaminated sites had elevated Ni, Se, and Sr levels and transferred elevated Cu, Pb, Se, and Sr levels to their eggs. Se was negatively correlated with both viability and reproductive success while Ni was negatively correlated with viability and Cu was negatively correlated with reproductive success.

Oldenkamp, R. E., A. L. Bryan Jr., R. A. Kennamer, J. C. Leaphart, S. C. Webster, and J. C. Beasley. 2017. Trace elements and radiocesium in game species near contaminated sites. Journal of Wildlife Management 81(8): 1338-1350.

An assessment of trace element and radiocesium concentrations in common game species found in the SRS (feral hog, gray squirrel, and waterfowl) from contaminated and uncontaminated habitats. The species collected from the ash basins had elevated concentrations, particularly of Se and some above the level considered toxic for waterfowl. Radiocesium concentrations were also elevated but within limits for human consumption.

Silva, A. E., B. F. Barnes, D. R. Coyle, E. F. Abernethy, K. L. Turner, O. E. Rhodes Jr., J. C. Beasley, and K. J.K. Gandhi. 2020. Effects of industrial disturbances on biodiversity of carrion-associated beetles. Science of the Total Environment 709(2020): 135-158.

A comparison of communities of carrion-associated beetles along a habitat gradient and between uncontaminated and contaminated sites. Abundance and diversity were typically higher at contaminated sites and primarily consisted of scavenger species while predator species were highly variable in abundance and diversity between sites. Species composition differed between sites, but habitat seemed to be a stronger influence, particular edge habitat.

Tannenbaum, L. V., and J. C. Beasley. 2016. Validating mammalian resistance to stressor-mediated reproductive impact using rodent sperm analysis. Ecotoxicology 25(3): 584-593.

Cotton mice were collected from three contaminated and one reference site to assess reproductive parameters and validate the use of rodent sperm analysis (RSA) in ecological risk assessments of contaminated areas. The study quantified sperm counts and morphology, ovarian follicle counts, and weights of organs. Sperm counts were

nominally higher at two contaminated sites in comparison to the reference site but none of the sites exceeded the threshold-for-effect. It was concluded that there was no reproductive impact of contaminants on SRS cotton mice.

Thomas IV, J. C., A. Oladeinde, T. J. Kieran, J. W. Finger Jr., N. J. Bayona-Vásquez, J. C. Cartee, J. C. Beasley, J. C. Seaman, J. V. McArthur, O. E. Rhodes Jr., and T. C. Glenn. 2020. Co-occurrence of antibiotic, biocide, and heavy metal resistance genes in bacteria from metal and radionuclide contaminated soils at the Savannah River Site. Microbial Biotechnology 13(4): 1179-1200.

A study assessing structure and diversity of bacterial communities with varying contaminant exposure. Soils were collected from heavy metal, radionuclide, and both heavy metal and radionuclide contaminated areas in addition to a reference site. While structure was similar among sites, contaminated areas had less bacterial diversity in comparison to the reference site. Antibiotic resistant genes and metal resistant genes were found in all site soils but, the relative abundance and diversity was significantly higher at Tim's Branch, a site with both types of contamination.

Thomas IV, J. C., T. J. Kieran, J. W. Finger Jr., N. J. Bayona-Vásquez, A. Oladeinde, J. C. Beasley, J. C. Seaman, J. V. McArthur, O. E. Rhodes Jr., and T. C. Glenn. 2021. Unveiling the gut microbiota and resistome of wild cotton mice, Peromyscus gossypinus, from heavy metal-and radionuclide-contaminated sites in the southeastern United States. Microbiology Spectrum 9(1).

A study looking at how heavy metal and radionuclide contamination affect the gut microbial community (GMC) and antibiotic and metal resistant genes (ARGs and MRGs) in cotton mice (*Peromyscus gossypinus*). Although individuals captured in both contaminated and uncontaminated areas shared a core microbiome, those within contaminated areas had lowered GMC diversity. Co-occurring resistance genes were found in mice from all sites but the proportion of co-occurring ARGs and MRGs were highest in radionuclide contaminated sites.

Tisdale, C. A., J. C. Leaphart, J. C. Beasley, and J. A Martin. 2021. Accumulation of contaminants by wild turkeys and potential for consumer exposure. Environmental Toxicology and Chemistry 40(4): 1222-1231.

Trace element accumulation was assessed in muscle, liver, feather, and blood samples of wild turkey (*Meleagris gallopavo*) inhabiting both a heavy metal contaminated and reference site. Turkeys from contaminated areas had elevated Hg and Se in comparison to reference turkeys but all elements were below Center for Disease Control and Prevention's reference limits for safe consumption. There was a positive correlation between muscle and feather Hg concentrations, suggesting feathers as a non-lethal sampling method for elemental accumulation.

Tuberville, T. D., D. E. Scott, B. S. Metts, J. W. Finger Jr., and M. T. Hamilton. 2016. Hepatic and renal trace element concentrations in American alligators (*Alligator mississippiensis*) following chronic dietary exposure to coal fly ash contaiminated prey. Environmental Pollution 214(2016): 680-689.

A novel study assessing bioaccumulation of trace element contaminants in juvenile alligators (*Alligator mississippiensis*) after chronic dietary exposure through CCW-contaminated or reference prey items and the effect on growth. Although no significant effect on size or growth was found, alligators significantly accumulated trace elements, particularly As, Cd, and Se. Concentration levels were consistently higher in kidney tissue analyzed than liver tissue.

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APPENDIX D

RISK-BASED CLEANUP LEVEL CALCULATIONS

PRELIMINARY REMEDIATION GOALS

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Table D-1. Human Health Risk-Based Preliminary Remediation Goals for the DABW D-7

LIST OF ABBREVIATIONS AND ACRONYMS

ARAR	applicable or relevant and appropriate requirement
CM	contaminant migration
DABW	D-Area Ash Basin Wetlands
FCMS	Focused Corrective Measures Study
FS	Feasibility Study
HH	human health
IOU	Integrator Operable Unit
PRG	preliminary remediation goal
PTSM	principal threat source material
RCOC	refined constituent of concern
USEPA	U. S. Environmental Protection Agency

D-1. INTRODUCTION

Risk-based cleanup levels, i.e., preliminary remediation goals (PRGs) for the Focused Corrective Measures Study /Feasibility Study (FCMS/FS) for the D-Area Ash Basin Wetlands (DABW) are presented in this appendix.

D-2. APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS PRGS

As presented in the Remedial Investigation (Chapter 3), there are no applicable or relevant and appropriate requirements (ARARs) refined constituents of concern (RCOCs) identified for the DABW. Therefore, no ARAR PRGs are presented in this appendix.

D-3. CONTAMINANT MIGRATION PRGS

As stated in Section 1.2.4.3, no Contaminant Migration (CM) RCOCs were identified for the DABW. Therefore, CM PRGs were not developed in this appendix.

D-4. HUMAN HEALTH PRGS

The human health (HH) risk assessment is presented in Appendix B of this document. HH RCOCs were identified for the DABW ash/soil for arsenic, and naturally occurring radionuclides (potassium-40, thorium-232, and uranium-238). No HH RCOCs were identified for surface water.

Risk-based PRGs are based on the regional screening levels presented in Appendix B and are calculated for the residential, industrial worker, and integrator operable unit (IOU) worker exposure scenarios at various target risk levels (1E-06, 1E-05, 1E-04) for carcinogenic effects. The HH PRGs for the DABW ash/soil medium are provided in Table D-1.

D-5. ECOLOGICAL PRGS

The ecological risk assessment is presented in Appendix C of this document. No ecological RCOCs were identified for the DABW. Therefore, ecological PRGs were not developed in this appendix.

D-6. PRINCIPAL THREAT SOURCE MATERIAL PRGS

As discussed in Section 1.2.4.3, no principal threat source material (PTSM) RCOCs were identified for the DABW. Therefore, no PTSM PRGs are presented in this appendix.

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Table D-1. Human Health Risk-Based Preliminary Remediation Goals for the DABW

RCOC	Units	Resident 1E-06	Resident 1E-05	Resident 1E-04	Industrial Worker 1E-06	Industrial Worker 1E-05	Industrial Worker 1E-04	IOU Onsite Worker 1E-06	IOU Onsite Worker 1E-05	IOU Onsite Worker 1E-04
Arsenic	mg/kg	6.8E-01	6.8E+00	6.8E+01	3.0E+00	3.0E+01	3.0E+02	6.24E+00	6.24E+01	6.24E+02
K40	pCi/g	1.44E-01	1.44E+00	1.44E+01	2.19E-01	2.19E+00	2.19E+01	4.46E-01	4.46E+00	4.46E+01
Th232	pCi/g	9.85E-03	9.85E-02	9.85E-01	1.53E-02	1.53E-01	1.53E+00	3.18E-02	3.18E-01	3.18E+00
U238	pCi/g	1.25E-02	1.25E-01	1.25E+00	2.00E-02	2.00E-01	2.00E+00	4.16E-02	4.16E-01	4.16E+00

RCOC refined constituent of concern
Note: Risk-based PRGs are based on the Regional Screening Levels (RSLs) (1E-06) from the U.S. Environmental Protection Agency (USEPA) RSLs website for nonradiological constituents and Preliminary Remediation Goals (PRGs) (1E-06) from the USEPA PRG website for radiological constituents that are provided in Appendix B.

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APPENDIX E

Natural Resource Injury Evaluation

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LIST OF ABBREVIATIONS AND ACRONYMS

CERCLA	Comprehensive Environmental Response, Compensation, and Liability
CMS	corrective measures study
DABW	D-Area Ash Basin Wetlands
FCMS/FS	Focused Corrective Measures Study/Feasibility Study
RCOC	refined constituent of concern
RCRA	Resource Conservation and Recovery Act

NATURAL RESOURCE INJURY EVALUATION CHECKLIST

The purpose of the Natural Resource Injury Evaluation (NRIE) checklist is to identify potential natural resource injuries associated with Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)/Resource Conservation and Recovery Act (RCRA) remedial activities. This checklist is provided to assist project teams in determining the potential for natural resource injuries in the conduct and planning of remedial activities. For the most part, the questions only require a simple "yes/no" or "to be determined" response. Some require a short answer or explanation. However, it is in the best interest of the project team to be as complete as possible and add any relevant information.

If potential injuries are identified, consideration is given as to whether or not trustee involvement is needed. The checklist is a starting point in potential injury identification and is not intended to be all-inclusive. The checklist has been designed as a series of questions to help identify the potential for natural resource injuries and what resources may be affected. It is based on the pre-assessment screen in Title 43 *Code of Federal Regulations* Part 11.13.

The intent of the checklist is to prevent potential injuries to natural resources that can occur as the result of remediation activities and to mitigate, to the extent practical, any injuries that have already occurred. Trustees are consulted early in the scoping process so they can provide effective input for decisions regarding natural resources.

Five main areas are being evaluated, as follows:

- Are there potential natural resource injuries and what do they consist of?
- What are the potential impacts from implementing the remedial alternatives?
- Are there potential residual injuries that will not be addressed by the alternative?
- Would implementation of the alternative cause additional injuries?
- What potential irreversible and irretrievable resource losses may be identified?

The checklist may be re-visited and revised as CERCLA activities continue and additional information from the D-Area Ash Basin Wetlands (DABW) become available.

1. Has a release of a hazardous substance occurred?

Yes. OU-related constituents (arsenic, potassium-40, thorium-232, and uranium-238) were identified as refined constituents of concern (RCOCs) based on a human health residential, industrial, and Integrator Operable Unit onsite worker scenarios for the surface ash/soil medium.

2a. Have natural resources for which Federal or State agencies (or Indian Tribes) may assert trusteeship under CERCLA been or are likely to have been adversely affected by the release?

Yes. Natural resources are defined by Section 101(16) of CERCLA as "land, fish, wildlife, biota, air, water, groundwater, drinking water supplies, and other such resources." The National Oil and Hazardous Substances Pollution Contingency Plan Section 300.600(b) indicates that natural resources may include not only the environmental organisms and abiotic resources, but the "supporting ecosystems associated with the biotic resources" as well. Resources are categorized into five groups: 1) surface water resources, 2) groundwater resources, 3) air resources, 4) geologic resources, and 5) biological resources. Resources can also be classified as direct use (i.e., drinking water, hunting, etc.) or nonuse (i.e., aesthetic value or existence). Nonuse services do not require physical or visual contact between people and the resource. Nonuse resources include resources that provide well-being for people (or other flora/fauna) because they exist (e.g., nesting sites, threatened and endangered species, natural areas, etc.).

While RCOCs are associated with surface ash/soil media, there is no indication that constituents present in these media have migrated to surrounding soil or to underlying groundwater.

2b. List the potentially affected resources (e.g., ground water, waterfowl, etc.).

Localized soil.

3. Is the amount of hazardous substance released sufficient to potentially cause a natural resource injury?

Yes. The RCOCs previously identified in checklist item #1 will likely prevent unrestricted use of the land at the DABW.

4. Will the remedial alternatives being considered, or action already taken, sufficiently address the injuries to natural resources (including residual injuries)?

Remedial alternatives are identified and evaluated in the Focused Corrective Measures Study/Feasibility Study (FCMS/FS) (Sections 3 and 4). Each alternative is evaluated as to whether it would be protective of human health and the environment.

5. Will the remedial alternatives being considered produce additional impacts to natural resources during remediation?

Remedial alternatives are identified and evaluated in the FCMS/FS (Sections 3 and 4). Each alternative is evaluated as to whether it would impact surrounding natural resources during and after implementation.

The potential costs for addressing resource injuries during remedial action implementation will be taken into consideration when selecting a remedial alternative. The liability (damage) associated with resource injuries could drive the cost of the intended best or lowest cost alternative.

6. Identify any irreversible and/or irretrievable resource losses in the appropriate documentation.

No irreversible and/or irretrievable resource losses are known to exist associated with the remedial action options developed for the DABW.

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Table E-1. Savannah River Site Natural Resource Trustees and Their Responsibilities

U.S. Department of Energy, Savannah River Operations Office *All natural resources located on, over, or under land administrated by the USDOE*
South Carolina Office of the Governor *All natural resources of the state of South Carolina*
South Carolina Department of Environmental Services Bureau of Land and Waste Management *Geologic resources including soil* *Groundwater resources including drinking water sources* *Air resources* *Surface water resources*
U.S. Department of the Interior *Threatened and endangered species (includes the Red-Cockaded Woodpecker, Bald Eagle, Wood Stork, American Alligator, Shortnose Sturgeon, and Smooth Coneflower)* *Migratory birds* *Anadromous species* *National Park Service land - Fort Pulaski National Monument* *Fish and Wildlife Service land - Savannah River National Wildlife Refuge, Tybee Island National Wildlife Refuge, and Orangeburg National Fish Hatchery*
South Carolina Department of Natural Resources *Commercial species* *Game and nongame species* *State sensitive species*
Georgia Department of Natural Resources *Savannah River resources* *Groundwater resources* *Air resources* *Surface water resources*
U.S. Department of Commerce, National Oceanic and Atmospheric Administration *Living and nonliving natural resources in coastal and marine areas including:* – *All life stages, wherever they occur, of fishery resources on the Exclusive Economic Zone and continental shelf* – *Anadromous and catadromous species throughout their ranges* – *Rivers and tributaries to rivers which historically or presently support the above species* – *Federally endangered and threatened species, including designated critical habitat and marine mammals for which NOAA has assigned responsibility* – *Tidal wetlands, salt marshes, estuaries, and all other habitats supporting all fishery and marine resources listed above* – *Living and nonliving resources of National Marine Sanctuaries and National Estuarine Reserves*
U.S. Army Corps of Engineers, Charleston, South Carolina District Savannah, Georgia District *Savannah River resources* *Navigable waters resources* *Waters of the United States resources*

APPENDIX F

Cost Estimates

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Abbreviations for Cost Estimates

Abbreviation	Definition
ac	acre
ea	each
ft	feet
gal	gallon
IWT	Industrial Wastewater Treatment
lf	linear feet
ls	lump sum
O&M	Operations and Maintenance
PP	Proposed Plan
ROD	Record of Decision
SER	Site Evaluation Report
yd^2	square yards
yd^3	cubic yard

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No Action Estimate
Alternative A-1
D-Area Ash Basin Wetlands

Item	Quantity	Units	Unit Cost	Total Cost
Direct Capital Costs				
No Action				
Subtotal - Direct Capital Cost				$0
Mobilization/Demobilization	9%	of subtotal direct capital		$0
Site Preparation/Site Restoration	9%	of subtotal direct capital		$0
Total Direct Capital Cost				**$0**
Indirect Capital Costs				
Engineering & Design	14%	of direct capital		$0
Project/Construction Management	25%	of direct capital		$0
Health & Safety	6%	of direct capital		$0
Overhead	30%	of direct capital + indirect capital		$0
Contingency	26%	of direct capital + indirect capital		$0
Total Indirect Capital Cost				**$0**
Total Estimated Capital Cost				**$0**
Direct O&M Costs	2.5%	30 Year Discount Rate1		
Annual Costs	30	years O&M		*Years 2029-2058*
Subtotal - 30 Year Annual Costs				**$0**
Present Value Cost				**$0**
Five Year Costs	0			
Remedy Review	0	ea	$15,000	$0
Subtotal - Five Year O&M Costs				$0
Present Value Cost				**$0**
Total Present Value Direct O&M Cost				**$0**
Indirect O&M Costs				
Project/Admin Management	146%	of direct O&M		$0
Health & Safety	19%	of direct O&M		$0
Overhead	30%	of direct O&M + indirect O&M		$0
Contingency	20%	of direct O&M + indirect O&M		$0
Total Present Worth Indirect O&M Cost				$0
Total Estimated Present Worth O&M Cost				**$0**
TOTAL ESTIMATED COST				**$0**

Interest rates for costs with 3-year and 30-year durations are based on SRNS Technical Memorandum ERTEC-2017-00002.
Real Interest Rates for OMB Circular No. A-94 (12/28/23)
Treasury Notes and Bonds of Specified Maturities

Institutional Controls Estimate

Alternative A-2

D-Area Ash Basin Wetlands

Item	Quantity	Units	Unit Cost	Total Cost
Direct Capital Costs				
DABW				
Institutional Controls				
Posting of Warning Signs	26	ea	$500	$13,000
Land Use Control Implementation Plan	1	ea	$5,000	$5,000
Deed Restrictions	1	ea	$5,000	$5,000
Subtotal - Direct Capital Cost				$23,000
Mobilization/Demobilization	9%	of subtotal direct capital		$2,070
Site Preparation/Site Restoration	9%	of subtotal direct capital		$2,070
Total Direct Capital Cost				**$27,140**
Indirect Capital Costs				
Engineering & Design	14%	of direct capital		$3,800
Project/Construction Management	25%	of direct capital		$6,785
Health & Safety	6%	of direct capital		$1,628
Overhead	30%	of direct capital + indirect capital		$11,806
Contingency	26%	of direct capital + indirect capital		$10,232
Total Indirect Capital Cost				**$34,251**
Total Estimated Capital Cost				**$61,391**
Direct O&M Costs	2.2%	3 Year Discount Rate [1]		
Annual Costs (Existing System during Post-ROD Design & Const)	2	years O&M		*Years 2027-2028*
Access Controls	1	ea	$500	$500
Maintenance	1	ea	$36,248	$36,248
Subtotal - Annual Costs				$36,748
Present Value Cost				**$71,140**
	2.5%	30 Year Discount Rate [1]		
Annual Costs	30	years O&M		*Years 2028-2057*
Access Controls	1	ea	$500	$500
Annual Inspection/Maintenance	1	ea	$36,248	$36,248
Subtotal - 30 Year Annual Costs				$36,748
Present Value Cost				**$769,146**
Five Year Costs	6			
Remedy Review	1	ea	$15,000	$15,000
Subtotal - Five Year O&M Costs				$15,000
Present Value Cost				**$59,729**
Total Present Value Direct O&M Cost				**$900,015**

Institutional Controls Estimate

Alternative A-2

D-Area Ash Basin Wetlands

Indirect O&M Costs

Project/Admin Management	14% of direct O&M	$126,002
Health & Safety	19% of direct O&M	$171,003
Overhead	30% of direct O&M + indirect O&M	$270,005
Contingency	20% of direct O&M + indirect O&M	$175,503
Total Present Worth Indirect O&M Cost		$742,512
Total Estimated Present Worth O&M Cost		**$1,642,528**
TOTAL ESTIMATED COST		**$1,703,918**

[1] Interest rates for costs with 3-year and 30-year durations are based on SRNS Technical Memorandum ERTEC-2017-00002.

Real Interest Rates for OMB Circular No. A-94 (12/28/23)
Treasury Notes and Bonds of Specified Maturities

Excavate and Haul to 3 Rivers Landfill Estimate

Alternative A-3
D-Area Ash Basin Wetlands

Item	Quantity	Units	Unit Cost	Total Cost
Direct Capital Costs				
3RLF				
Landfill Disposal Fees				
DABW	739,000	yd^3	$65.00	$48,035,000
DABW				
Clearing and Grubbing				
Clear Vegetation and Debris, Stockpile at Site Perimeter	108.0	ac	$2,600	$280,800
Clear Trees and Grub Stumps, Stockpile at Site Perimeter	108.0	ac	$4,500	$486,000
Access Road	1,320	lf	$12	$15,840
Basin Content Treatment				
Surface Water Initial Testing - Allowance	1	ls	$5,000	$5,000
pH Adjustment - Allowance	1	ls	$15,000	$15,000
Surface Water pH Adjustment Testing - Allowance	1	ls	$5,000	$5,000
Flocculate Metals For Water Discharging - Allowance	1	ls	$15,000	$15,000
Surface Water Flocculate Testing - Allowance	1	ls	$5,000	$5,000
Dewater Basin / Discharge to Ground	1,400,000	gals	$0.005	$7,000
Dry Ash	886,800	yd3	$2	$1,773,600
Off-Unit Disposal				
Excavate & Load Contaminated Soil for Hauling	739,000	yd3	$3.59	$2,653,010
Truck Haul Contaminated Soil to Disposal Site	886,800	yd3	$12.36	$10,960,848
Backfill / Compact Soil at Disposal Site	886,800	yd3	$3.59	$3,183,612
Confirmation Sampling / Analysis	540	ea	$1,000	$540,000
Stormwater Management	7,920	lf	$25	$198,000
Site Restoration				
Equipment mobilization	1	ea	$30,240	$30,240
Contour Site After Contaminated Soil Removal	90.0	ac	$1,700	$153,000
Common Backfill (8 Inches)	116,160	yd3	$13	$1,510,080
Topsoil (4 Inches)	58,080	yd3	$35	$2,032,800
Fertilizer, Lime, Seed & Mulch	435,600	yd2	$1	$326,700
Backfill Sampling / Analysis	71	ea	$1,200	$85,200
Wetland Restoration	1	ls	$200,000	$200,000
		Subtotal - Direct Capital Cost		$24,481,730
		Mobilization/Demobilization	2% of subtotal direct capital	$489,635
		Site Preparation/Site Restoration	2% of subtotal direct capital	$489,635
		Total Direct Capital Cost		**$25,460,999**
Indirect Capital Costs				
Engineering & Design		2%	of direct capital	$509,220
Project/Construction Management		2%	of direct capital	$509,220
Health & Safety		2%	of direct capital	$509,220
Overhead		5%	of direct capital + indirect capital	$1,349,433
Contingency		15%	of direct capital + indirect capital	$4,048,299
		Total Indirect Capital Cost		**$6,925,392**
		Total Estimated Capital Cost		**$80,421,391**

Excavate and Haul to 3 Rivers Landfill Estimate

Alternative A-3

D-Area Ash Basin Wetlands

Direct O&M Costs

O&M Costs at Ash Basins for Site Restoration		2.2%	3 Year Discount Rate [1]		
Annual Costs (Existing System during Post-ROD Design & Const)		2	years O&M		*Years 2027-2028*
Access Controls		0	ea	$500	$0
Maintenance		0	ea	$36,248	$0
	Subtotal - Annual Costs				$0
	Present Value Cost				**$0**
		2.5%	30 Year Discount Rate [1]		
Annual Costs		30	years O&M		*Years 2028-2057*
Access Controls		0	ea	$500	$0
Annual Inspection/Maintenance		0	ea	$36,248	$0
	Subtotal - 30 Year Annual Costs				$0
	Present Value Cost				**$0**
Five Year Costs		0			
Remedy Review		0	ea	$15,000	$0
Subtotal - Five Year O&M Costs					$0
	Present Value Cost				**$0**
	Total Present Value Direct O&M Cost				**$0**

Indirect O&M Costs

Project/Admin Management	14%	of direct O&M	$0
Health & Safety	19%	of direct O&M	$0
Overhead	30%	of direct O&M + indirect O&M	$0
Contingency	20%	of direct O&M + indirect O&M	$0
Total Present Worth Indirect O&M Cost			$0
Total Estimated Present Worth O&M Cost			**$0**
TOTAL ESTIMATED COST			**$80,421,391**

[1] Interest rates for costs with 3-year and 30-year durations are based on SRNS Technical Memorandum ERTEC-2017-00002.
Real Interest Rates for OMB Circular No. A-94 (12/28/23)
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