United States Department of Energy

Savannah River Site

Environmental Compliance and Area Completion Projects Regulatory Document Handbook

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Prepared by:
Savannah River Nuclear Solutions, LLC
Savannah River Site
Aiken, SC 29808

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For Savannah River Site Use Only

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Approved

T. F. Gaughan 6/21/2012

Thomas F. Gaughan **Date**
Environmental Compliance and Area Completion Projects
Engineering & Technology Manager

[a]P.10.1 is no longer referenced by USEPA-Region 4 pending revision of OSWER 9380.3-06FS guidance (November 1991) regarding principal threat and low level threat waste.

SITE EVALUATION REPORT FORMAT

1.0 INTRODUCTION

Site Evaluation Reports are prepared in accordance with Section 300.410 and 300.420 of the National Contingency Plan (NCP). They are mandated by the Savannah River Site Federal Facility Agreement (FFA), Section X, Site Evaluations. The [official *FFA title (Bldg # or NBN if no Bldg. # is specified] is* listed in Appendix G. 1, Areas To Be Investigated, of the FFA.

The purpose of this investigation was to obtain sufficient information concerning conditions at *(insert official FFA title)* to assess the threat, if any, posed to human health and the environment and to determine the need for additional action under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) or other appropriate action. The scope of the investigation included a review of the files and historical data, site visits, soil sampling (if applicable), interviews, a Radiological Control Survey, and [state *others as required to describe briefly what was done]*.

2.0 AREA DESCRIPTION, OPERATIONAL HISTORY, AND WASTE CHARACTERISTICS

2.1 Location

The Savannah River Site (SRS) occupies an area of approximately 300 square miles adjacent to the Savannah River, principally in the Aiken and Barnwell Counties of South Carolina. The Site is approximately 25 miles south of Aiken, SC. The Site Evaluation Area is located in the *(briefly state where the SEA is located within the SRS)* of the SRS. Also, mention the distance from the SEA to the nearest SRS boundary.

Give directions to the Site Evaluation Area (SEA); start at either SC Route 125 or SC 19, whichever is closest. At entrances to SRS include some statement like "To travel on Road C past the barricade (identify barricade #), visitors must have an SRS badge or be escorted." If the Site Evaluation Area lies within the "fenced" portion of a facility (i.e. Reactors, F/H-Areas, etc.) state that only government or other authorized vehicles are permitted to enter the fenced portion of the facility and all private vehicles must park in the lot outside the facility. Continue directions to the SEA upon reaching the perimeter fence. Include the general SRS site map as Appendix A, showing the location of the SEA and a specific (detailed) SEA map as Appendix B. The SEA should be noted on the map. Include the SRS coordinates of the northeast comer or the center of the SEA and the longitude and latitude (in decimal degrees) of the SEA.

2.2 Area Description

Physically describe the SEA: (draw a picture with words) i.e.: mature pine trees with some undergrowth of blackberry vines, grassy, etc. Does the SEA appear well-drained? What are the physical boundaries -Road C-to north, unnamed stream to south, mixed trees to east... etc. ? Include "historical" picture and/or a recent color photograph(s) as Appendix C. (In certain instances, photos may not be available due to security restrictions. If so, state this fact in the Report).

Include location of Threatened and Endangered Species and/or sensitive habitats, if within 1/2 mile (otherwise make statement that no Threatened and Endangered Species/habitats are within this area ,if that is the case). Include map, showing these habitats, if applicable, as Appendix D, Figure D. 1. The SEA is located within the Watershed. *Include map showing the location of the SEA within the Watershed. Label as Appendix D, Figure D.2 or D. 1, if no T&E habitat map is necessary.*

Include location of the nearest RCRA/CERCLA unit and closest SEA (in two separate paragraphs), particularly if up-or side-gradient of the SEA). Include a map of these units/areas as Appendix E, Figures E. 1. (If not already shown in Appendix B). Describe the status of this unit/area. List dates of approved reports and numbers, decisions by the EPA/SCDHEC, recommended actions, and dates of decisions, etc.

Use the following for SEAS inside fenced areas: These SEAS have been identified with alphanumeric codes. These identifiers are from the Savannah River Site Plan for Performing Maintenance in Federal Facility Agreement Areas (O&M Plan) (U) (WSRC-RP-96-45) (12/15/96). In that document, most Site Evaluation Areas located within the facility perimeter fences or adjacent to that facility have been assigned a discrete number. These identifiers help to ensure that these Site Evaluation Areas do not get overlooked while assessments for adjacent areas are being conducted. *(Identify these alphanumeric codes for the adjacent SEAS). (Note: SEAS that are spill events may not be identified with an alphanumeric code. The above paragraph may be eliminated if this is the case). For SEAs that have numerous adjacent Site Evaluation Areas and RFI/RI units (i.e. F-Area, H-Area, M-Area, etc.), state the number of SEAs/Units in the vicinity, and then list only the closest one. The only exception to this would be f there were a SEA/Unit that was not the closest but would have an impact. Appropriate data* would *be included for the mentioned SEAs/Units only.*

2.3 Operational History and Waste Characteristics

Describe the history of the SEA, as best we know it; what happened here, when did the SEA open, when did it close? What was dumped/stored/spilled here? Include spill reports, if available, as an appendix. If a spill report is not available then insert the following: The (*insert name of the SEA*) occurred at or within (*insert details*), according to the SRS SID (Site

Incident Databank) (See Appendix _). [NOTE: Information obtained in the SID is not for public dissemination and has not been included in this Report]. *On the Appendix cover sheet insert the following statement:* [NOTE: Information obtained in SID is not for public dissemination and has not been included in this Report. The following pages show user information and query instructions for the Databank].

[Do not be concerned that many of our past operations & waste practices would now be considered illegal, or at best questionable. We will NOT be fined, chastised, etc. by the regulators; the important point now is to try to discover what got dumped/spilled, and what are we going to do about it or what we did].

3.0 SAMPLING/MONITORING DATA HISTORY

3.1 Sampling Data

[NOTE: Even when field sampling is <u>not</u> required, a Radiological Control Survey must be performed, unless the SEA is inside a building or is located within a Rad area, or has routine RCO surveys performed, as part of a facility. State this fact, inapplicable.]

A Radiological Control Survey of the Site Evaluation Area was conducted on *(insert date)* to support the development of the Health and Safety Plan and to ensure the protection of workers during the soil sampling activities. This survey consisted of measuring background radiation levels, probing the surface for possible contamination, and collecting random soil samples (0-6 inches below the ground surface) for analysis in a radiological counting facility. *If true, state: No* radiological contamination was found during this survey, and the SEA was designated as a "Clean Area" on the RCO Survey sheet. *(A copy of this Survey is not included within an appendix). If contamination was found, discuss this, i.e. speciation, etc.) Include a map showing the bounds of the radiological survey as Appendix F, Figure F. 1.* Appendix F also presents the results from a radiological screening for alpha and non-volatile beta for two sample locations *(Insert the sample identification numbers here)* taken from within the Site Evaluation Area. These screening operations were performed by the SRS Analytical Laboratories Group. *If true, state:* The two samples were below the screening value of 50 pCi/g for non-volatile beta and below the screening value of 20 pCi/g for gross alpha. *[NOTE: for those SEAs that have been designated as an archaeological/historical site use the following regarding the RCO survey:* On (*insert date*) a Radiological Control Survey was conducted to ensure that this area poses no threat to the environment (See Appendix __, Figure __). This survey consisted of measuring background radiation levels and probing the surface for possible contamination. Due to this area being considered an archaeological/historical site and therefore should not be disturbed, no random soil samples were taken as part of this survey. *State if the area was designated as a "Clean Area" or if contamination was found, discuss this, i.e. speciation, etc.*

Next paragraph: Note when soil or other samples were collected; briefly describe analysis

(TAL, TCL, rads., BTEX, etc.); number of samples; particularly depth of samples; describe labeling of samples depths/letter designations, etc., discuss results, (mention by family i.e. TALs, PCB 's, TCLS, etc., any hits above the detection/reporting limit but less than the RBC'S and any hits above the RBC'S. This includes both man-made and natural substances out of the ordinary). A table of any identified constituents above the EPA Region III residential and/or industrial soil ingestion limits must be included as part of the text. Make sure that the most recent EPA limits are used. At this time 5/99), EPA RBC limits dated April 12, 1999, are in effect. Should a constituent be above the residential and/or industrial RBCs, then the constituent's level may be compared with twice the mean for that same constituent from the background locations and at the same depth interval. For any background samples labeled with a "u" qualifier, use the MDL in calculating the mean. Mention the SCDHEC Bureau of Land and Waste Management levels for lead (400 ppm residential and 895 ppm industrial). Compare any levels, above the EPA Region III RBCS, to twice the site specific background limit for that particular constituent, as SCDHEC allows us to state that the concentrations are below twice the background. Discuss quality control and any discrepancies in the laboratory analyses Case Narratives. Also, note that these discrepancies are detailed in Appendix G. Indicate the sampling results that were not used in the site evaluation, and why, and whether this would impact the conclusions of the site evaluation. Mention, however, that these samples were used as estimates in the site evaluation process. If there are no discrepancies, state such. Include sample location map, Soil Sample Table, Case Narrative, sample analysis results, chain-of-custody forms, field notes (if applicable), as Appendix G. Note, that some Site Evaluation Areas do not require soil sampling. If this is the case, then this paragraph regarding soil sampling will be eliminated. However, you must justify why no sampling was necessary.

3.2 Monitoring History

If no monitoring has been done at the SEA, use this statement, "Since there is no history of hazardous waste, hazardous constituents, or radiological materials being deposited at the *(name of the SEA),* no monitoring has occurred or is required." *Mention nearest monitoring and production wells and sampling history, if available. Check status of production wells. If monitoring is taking or has taken place describe such and what was the purpose of this monitoring.*

4.0 GROUDNWATER PATHWAYS

4.1 Hydrogeological Setting

"The Savannah River Site (SRS) is located on the Upper Atlantic Coastal Plain, approximately 20 miles southeast of the Fall Line, which separates the Piedmont and Coastal Plain Physiographic Provinces. The SRS is on the Aiken Plateau, a relatively flat area that slopes southeast and is dissected by several tributaries of the Savannah River. The SRS is underlain by a 700 to 1,200 foot-thick, seaward-thickening wedge of Coastal Plain sediment

composed of unconsolidated sand, clayey sands, sandy clays, and less amounts of calcareous sediment. These layers are underlain by dense crystalline igneous and metamorphic or younger consolidated sediments of the Triassic Period. Within the Coastal Plain sediments, the sandy strata are generally porous and permeable and may form aquifers." A standard cross-section of soils, with major streams noted, is presented in Appendix H, Figure H. 1. (Appendix *H is the drawing showing the standard cross-section of soils with major streams at the SRS).*

State the watershed that the SEA is located and reference the previous appendix, where the location map can be found. Mention the elevation above mean sea level (msl) and the depth to groundwater and predicted groundwater flow. Include groundwater information, if available. Include location of the nearest monitoring well(s) (do not include all monitoring wells within a 4 mile radius) and nearest production/domestic well(s) (within a 4 mile radius of the SEA) and distance from the SEA. State whether wells are side, down, or upgradient of the SEA. This is the place to expand upon well monitoring results if appropriate. Have constituents of concern from the SEA shown up in the well(s)? Could there be other units that also may impact that well. Discuss such, if applicable. A map showing the SEA in relation to monitoring, production/domestic wells (typically from the SRS EPD/EMS Well Inventory Book, ESH-EMS-980590, July 1998) and appropriate well testing data should be included as Appendix I. Identify potential seepage points to nearest surface waters. Include adjacent wetlands as groundwater targets. If domestic water distribution system is present at the SEA, mention such. This will usually be the case within Facility Areas (A, B, C, F, H, etc.)

Any other information regarding the particular soil type found at the SEA should be included, if available; do not perform a special study to gather this information(Use the "Soil Survey of the SRP Area, of Aiken, Barnwell, and Allendale Counties, SC, as published by the USDA, SCS, June 1990). This information can also be placed in Section 5.1.

4.2 Groundwater Targets

These targets are defined as drinking water supply wells (domestic/production) within 4 miles of the SEA; is groundwater used for purposes other than drinking water (irrigation, food preparation, etc. ?) Describe as appropriate; if the SEA does not impact any potential water supply source, state where the nearest supply wells are and their relationship to the SEA, i.e : up-gradient, down-gradient, side-gradient. Include information on drinking water wells, if appropriate, i.e. sampling results, etc., also in Appendix I).

4.3 Groundwater Conclusions

What are your conclusions? Why? If there are no impacts on groundwater, state the following: "There is no history of hazardous waste, hazardous constituents, or radioactive materials being disposed at the *(insert the SEA title).* Considering the history, location, soil sample results, the DOE believes that the Site Evaluation Area has not impacted the

groundwater."

5.0 SURFACE WATER PATHWAY

5.1 Hydrologic Setting

Discuss surface water drainage, which direction, closest surface water(s) (wetlands are considered surface waters) that maybe impacted by the SEA. Range of concern is 2 miles. If appropriate, include area drainage/outfall maps as Appendix J. Identify probable point of entry of surface water into stream, creek, wetlands, etc. If the area is located in a facility area, then the report needs to include applicable NPDES maps, in Appendix J. State the watershed that the SEA belongs to and reference back to the previous Appendix showing such. You can place information regarding the soil type(s), present at the SEA, in a separate paragraph. Mention if drainage gullies *are present and ~ pending of water is noted after rainfall events.*

5.2 Surface Water Targets

What targets exist within 2 miles of units? Targets here are fisheries, Threatened and Endangered Species (Reference appropriate Appendix that contains the location map, if applicable), wetlands (Use the National Wetlands Inventory Maps, as published by the USFWS, 1993, for wetland locations), intake(s) for drinking water, other human-related consumption (i.e. farming, livestock, etc.), State that: "No fishing is permitted within the SRS."

5.3 Surface Water Conclusions

What are your conclusions? Why? If there are no impacts to surface waters, state the following: "Due to the history, location, operational characteristics, the DOE believes that the *(Insert the SEA name)* has not impacted the surface water or the Threatened and Endangered Species Habitats *(If applicable).*

6.0 SOIL EXPOSURE AND AIR PATHWAYS

6.1 Physical Conditions

Briefly re-describe the physical description of the SEA, especially ground surface conditions. Mention the nearest active/occupied facilities/buildings, etc. State that: "Long-term entry control procedures for access to the SRS have made casual access to this SEA very difficult. "

Research has shown that there is no prevailing wind at the SRS, which is typical of the lower

midlands of South Carolina. This SEA is located approximately *(Insert m*iles)-miles from the nearest SRS boundary.

6.2 Soil and Air Targets

Soil/Air Targets via air pathways are defined as within 4 miles (radius)(Facilities, buildings, residences, etc.) and 1/2 mile for sensitive environments. Are there any targets? Mention Threatened and Endangered Species Habitats, if applicable, and describe & analyze, as appropriate.

6.3 Soil Exposure and Air Pathway Conclusions

What are your conclusions? Why? If there are no impacts due to soil exposure or air pathways, state the following: "The DOE believes that limited personnel access to the Site Evaluation Area, lack of prevailing winds, and a stable ground surface that impedes wind erosion/dusting, do not present a threat to human health and/or the environment and to the Threatened and Endangered Species Habitats *(If applicable),* due to soil exposure or air pathways from the *(Insert the name of the SEA)."*

7.0 SUMMARY AND CONCLUSION

State the title of the Site Evaluation Area from Appendix G. 1 (with building No. or NBN) and briefly describe any impacts to the environment and/or to human health from the Site Evaluation Area. Briefly review the findings (sampling results, constituents present, and levels above or versus residential/industrial RBC's, twice site specific background levels, etc.) State; "No radiological contamination was found during the Radiological Control Survey."

(You MUST make a CLEAR Conclusion, and there are four possible conclusions:)

1) For Transfers of Site Evaluation Areas to Appendix C RCRA/CERCLA Units, include justification (i.e. efficiency [combining units], benchmarks exceeded [e.g. RBCs)

Include the following: "Based on the information gathered for this report, past operational history, and (describe environmental *impacts),* it is recommended that a more complete and formal investigation of this Site Evaluation Area be undertaken. Therefore, it is recommended that the *(Title of SEA from Appendix G.1 with building No. or NBN)* be further evaluated under the RFI/RI Program and that this Site Evaluation Area be deleted from Appendix G. 1 and placed on Appendix C (RCRA/CERCLA List) of the FFA.

2) If *the SEA is recommended for inclusion in the D&D program (this must be negotiated/approved by the DOE/SR prior to them reviewing this report), use the following statement:* "It is recommended that the *(Title of the SEA from Appendix G. 1 with building No. or*

NBN) remain on Appendix G. 1, Areas To Be Investigated of the FFA and be evaluated after the Decontamination and Decommissioning of the surrounding facilities."

3) If a removal action is necessary (requires public involvement, costs less than $2 million and less than 1 year to complete [this must be negotiated/approved by the DOE/SR prior to review of the report]).

4) If a NFA designation is recommended, then the following statement is required: "In accordance with 300.420(b)(1)(i) of the NCP, *(Title of the SEA from Appendix G. 1 with building No. or NBN)* poses no threat to human health or the environment. It is recommended that *(Insert the SEA Name)* be removed from Appendix G. 1, (Areas to Be Investigated) and placed on Appendix G.2, (Areas Determined to Require No Further Response Action) of the SRS Federal Facility Agreement."

Additional housekeeping may be required before an NFA is appropriate. In this situation, the following should be added to the end of the above statement: "after housekeeping is completed at the Site Evaluation Area."

(General Note: Additional Appendices (i.e. copies of spill reports, etc.) may be needed and the sequence of Appendices' labeling may be adjusted to include for these additions.) Also, note that all maps, pictures, drawings, etc. contained in the Appendices must be labeled with a title and figure number, SER#, and Appendix label. Figure numbers should be used in references in body of SER. For example, Figure F. 1, F. 2, etc. Refer to Appendix format sheets at the end of this template.

REFERENCES

(List all references, maps, reports, personal communications, etc. used in the SER and number in sequence 1, 2, 3, 4, etc. Use the WSRC Style Guide for formatting the reference section of the SER)

APPENDIX A, B, C, D, E, F, G, H, I, J, etc

(Insert Title of Appendix in Caps., Font 12 and center)

(Note, the Appendix containing the soil analyses data will, most likely, be the largest Appendix, and it must contain the following items: Soil Sampling Location Map, Soil Sampling Table, if you feel such is necessary, as this is usually discussed in the text, Discussion of the Analyses Data [QA/QC, etc.], Definition of Terms, Abbreviations, and Laboratory Codes, Data Summary Screening Report, Case Narrative, and Chain-of-Custody Forms. The Data Screening Summary Report will be in the computerized format previously set-up between the ERD and the EMS)

Appendix ____ SRNS-RP-XX-YYYY

This page shows the general header and footer format for an Appendix sheet layout. In some cases, an Appendix may not be a figure, map, photo, etc. In this case, you do not need to enter a title in the Footer, just a page #(s). For example, a Spill Report, etc.

Figure A.1 (*Insert Title of Figure*)
Page 1 of #

RFI/RI WORK PLAN FORMAT

Executive Summary
Table Of Contents
List Of Figures
List Of Tables
List Of Acronyms

1.0 INTRODUCTION

The purpose of the work plan is to present the following information: 1) the initial evaluation of the existing unit data; 2) relevant background information; 3) the regulatory framework for the unit investigation; 4) the evaluations and decisions made during the scoping process; and 5) the scope and objectives of the planned RI/FS activities.

1.1 RFI/RI Work Plan Organization

Provides a description of the organization of the report.

1.2 Regulatory Background

1.2.1 RCRA Facility Investigation (RFI) Program

Provides a description of the regulatory background for the application of RCRA 3004(u) at SRS and for unit specific issues.

1.2.2 CERCLA Remedial Investigation (RI) Program

Provides a description of the regulatory background for the application of CERCLA at SRS and for unit specific issues.

1.2.3 Summary of Unit Description

Provides a brief, summary description of the unit history, characteristics, and setting. Unit setting includes physical location, ecological setting, geological setting, hydrological setting, demographics, and infrastructure description.

2.0 PRELIMINARY UNIT EVALUATION

The purpose of this section is to provide the reader with a summary description of the existing information available for the unit.

2.1 Introduction

Provides a brief introduction of preliminary unit evaluation topics.

2.2 Unit Characteristics

Provides a discussion of the background information on the characteristics of the waste unit such as unit-specific geologic and hydrogeologic properties, climatic conditions, physical setting, waste composition (as appropriate), and history of the unit.

2.3 Existing/Previous Investigations

Provides a discussion of the history, chronology, and results of previous investigations.

2.4 Unit Evaluation Conclusions

Provides a discussion, based on the information from Sections 2.2 and 2.3, of whether or not the unit and surrounding media have been impacted in a general sense.

2.5 Operable Unit Strategy

Provides the preliminary anticipated operable unit strategy based on the current understanding of the CSM utilizing process history and existing data. The strategy will outline the entire RI/FS process for the operable unit.

2.6 Potential ARARs and TBC Criteria

Provides a preliminary list of the applicable or relevant and appropriate requirements (legally binding laws and regulations) and "to-be-considered" factors (criteria, guidance, and proposed standards) for the unit. These are to be used to establish preliminary remediation objectives (e.g., cleanup goals) early in the RCRA/CERCLA process.

2.7 Potential Corrective Measures Study/Feasibility Study Options

Provides a preliminary list of corrective measures and/or feasibility study options that may be applicable to the unit.

2.7.1 Innovative Remedial Technologies

Provides a listing and a discussion of treatability study options that may be considered for the unit.

2.8 Potential Early and/or Interim Remedial Actions

Provides a discussion and a preliminary list of early and/or interim remedial actions that may be applied at the unit.

2.8.1 Early Action Strategy

Provides the justification for selecting an early action for a portion or entire operable unit. Includes the Early Action Strategy flowchart and discussion of its utilization.

3.0 DATA QUALITY OBJECTIVES (DQO)

The purpose of this section is to provide a discussion of DQOs. DQOs are quantitative and qualitative descriptions of the information required to achieve project goals. They apply to all unit remediation activities including, but not limited to, scoping for potential contamination, verifying contamination, characterizing the extent and concentration of contamination, risk assessment, evaluation and design of alternative clean-up remedies, and monitoring cleanup. The focus of the DQO development process is effective and efficient planning for data collection. The DQO process is participatory, encouraging input and consensus from all data users. The process is intended to encourage effective, efficient thinking about key data planning issues, thus bringing increased understanding and acceptance of project goals. The DQO process is a series of planning steps based on the Scientific Method (see 3.1.2 to 3.1.8 below) and are detailed in EPA540-R-93-071, "Data Quality Objectives Process for Superfund". The DQO process provides a systematic, flexible approach to decision-making. The steps are portrayed sequentially, but the DQO process is iterative.

3.1 DQO Evaluation

3.1.1 Conceptual Site Model (CSM)

Presents the known and suspected sources of contamination, the types of contaminants and potentially affected media, the known and potential routes of migration, and the known or potential human and environmental receptors. In addition to assisting in identifying locations where sampling is, or is not (based on existing data) necessary, the CSM also assists in the identification of potential remedial technologies.

3.1.1.1 Exposure/Physical Attributes of (CSM)

Provides an expanded discussion and/or details of the physical and exposure attributes as presented in the CSM.

3.1.2 State the Problem

Provides a summary statement of the problem that will require new environmental data, and identifies the resources to resolve the problem.

3.1.3 Identify the Decisions

Provides a discussion of the decisions that require new environmental data to address the problem.

3.1.4 Identify the Inputs to the Decisions

Provides a discussion of the information needed to support the decision, and specifies which inputs require new environmental measurements.

3.1.5 Define the Boundaries of the Study

Provides a discussion of the spatial and temporal aspects of the problem that the data must represent to support the decision.

3.1.6 Develop Decision Rules

Provide the logical statements that define the conditions that would cause the decision maker to choose among alternative actions. These decision rules encompass the entire RCRA/CERCLA process.

3.1.7 Specify the Limits on Decision Errors

Provides a discussion of the specifics for the decision maker's acceptable limits on decision errors, which are used to establish performance goals for limiting uncertainty in the data.

3.1.8 Optimize Design for Obtaining Data

Provides a discussion of the most resource-effective sampling and analysis design for generating the data that are expected to satisfy the DQO process needs.

3.2 Summary of DQO Evaluation

Provides a summary discussion of the information developed in support of the DQO process.

4.0 UNIT ASSESSMENT

4.1 Objectives

Provides a discussion of the unit characterization objectives as they address the CSM and meet the DQO process needs.

4.2 Primary Source Characterization

Provides a discussion of the specific investigation activities to be implemented and the analytical parameters to be obtained in order to characterize the primary source(s) of contamination as depicted by the CSM and as required by DQO process needs.

4.3 Secondary Source Characterization

Provides a discussion of the specific investigation activities to be implemented and the analytical parameters to be obtained to characterize the secondary sources as depicted by the CSM and as required by DQO process needs.

4.4 Exposure Media Characterization

Provides a discussion of the specific investigation activities to be implemented and the analytical parameters to be obtained to characterize the exposure media impacted as depicted by the CSM and as required by DQO process needs**.**

4.5 Physical Characteristics

Provides a discussion of the specific investigation activities to be implemented and the physical/analytical parameters to be obtained to provide the data needed to accommodate the CSM and as required by DQO process needs. (The DQO process will ensure feasibility and treatability study data needs are met.)

5.0 SCHEDULE

Provides an explanation of the implementation schedule.

6.0 SAFETY, HEALTH, AND EMERGENCY RESPONSE PLAN

Provides a statement informing the reader that a unit specific health and safety plan, in accordance with 29 CFR 1910.120 and SRS health and safety requirements, will be generated for the specific characterization activities detailed in the Unit Assessment section.

7.0 QUALITY ASSURANCE/QUALITY CONTROL PLAN

Provides a reference to the existing quality assurance/quality control documents that are in place and in use (e.g., WSRC 1Q).

8.0 DATA MANAGEMENT PLAN

Provides a reference to the existing data management documents that are in place and in use (e.g., FFA Appendix J, Data Management Plan).

REFERENCES

Provides a list of references used for the preparation of the document.

DATA USABILITY REPORT FORMAT

1.0 PROJECT SUMMARY

This report presents analytical data verification, validation and usability assessment results for sampling at the (*Sampling Event Name*). The project generated *(# of)* regular field samples and (*# of*) field duplicate samples, collected at (*# of*) locations, and (*# of*) trip blanks. The samples, along with the requested analytical analyses, are listed in Table 1.

Table 1. Sample Identification (ID) Summary

Station ID	Sample ID	Sample Type	Sample Date	Sample Time	Matrix	Interval	Analysis Requested
A-ASHPILE-01	A-ASHPILE0049	REG	26-Aug-09	2:30 PM	ASH	0 - 1 ft	1, 2, 3, 4, 8, 9, 10, 11
A-ASHPILE-01	A-ASHPILE0050	REG	26-Aug-09	2:40 PM	ASH	1 - 4 ft	1, 2, 3, 4, 8, 9, 10, 11
A-ASHPILE-01	A-ASHPILE0051	REG	26-Aug-09	3:00 PM	ASH	8 - 10 ft	1, 2, 3, 4, 8, 9, 10, 11
A-ASHPILE-01	A-ASHPILE0052	REG	26-Aug-09	3:30 PM	ASH	20 - 22 ft	1, 2, 3, 4, 8, 9, 10, 11
A-ASHPILE-01	A-ASHPILE0029	REG	26-Aug-09	3:40 PM	SOIL	22 - 23 ft	1, 2, 3, 4, 8, 9, 10, 11
A013-01	A013-00000008	REG	14-Jan-10	10:00 AM	SOIL	0 - 1 ft	1, 8, 9*, 11
A013-01	A013-00000009	REG	14-Jan-10	10:10 AM	SOIL	1 - 4 ft	1, 8, 9*, 11
A013-02	A013-00000006	REG	20-Jan-10	9:25 AM	SOIL	0 - 1 ft	1, 8, 9*, 11
A013-02	A013-00000007	REG	20-Jan-10	9:50 AM	SOIL	1 - 4 ft	1, 8, 9*, 11
A013-03	A013-00000004	REG	20-Jan-10	11:40 AM	SOIL	0 - 1 ft	1, 8, 9*, 11
A013-03	A013-00000001	FD	20-Jan-10	11:40 AM	SOIL	0 - 1 ft	1, 8, 9*, 11
A013-03	A013-00000005	REG	20-Jan-10	12:00 PM	SOIL	1 - 4 ft	1, 8, 9*, 11
A013-04	A013-00000002	REG	20-Jan-10	10:40 AM	SOIL	0 - 1 ft	1, 8, 9*, 11
A013-04	A013-00000003	REG	20-Jan-10	10:50 AM	SOIL	1 - 4 ft	1, 8, 9*, 11
TRIP BLANK	AOUTFALL00001	TB	14-Jan-10	10:00 AM	WATER		12
TRIP BLANK	AOUTFALL00002	TB	20-Jan-10	9:25 AM	WATER		12

Analyses Requested

1. TAL Metals/TCL (VOC, SVOC, Pest, PCB)
2. Alkalinity
3. Sulfate
4. pH
5. TSS, TDS
6. Total Phosphates
7. Tritium
8. GA/NVB
9. Alpha Spec (U, Th)
10. Ra-226, Ra-228
11. Gamma PHA
12. TCL VOA

*****Radiological speciation only performed on samples when Gross Alpha >/=20 pCi/g or Non-Volatile Beta >/=50 pCi/g.

The total of (*# of*) analytical records were produced consisting of (*# of*) regular sample records and (*# of*) field quality control (QC) records as shown in Table 2.

Table 2. Total Number of Records

Number of Records	Chemical	Radiochemical	Totals
Analytical	13625	3603	17228
Field QC	2182	415	2597
Totals	15807	4018	19825

The verification process was conducted to review completeness of the sampling and analytical requirements. Validation has been performed to assess compliance with methods, procedures, and contracts and to assess a comparison with measurement performance criteria (MPC) in the ER-SOP-033. A usability assessment will provide the data user with an assessment of whether the process execution and resulting data meet project quality objectives in the Sampling and Analysis Plan (SAP) and Quality Assurance Project Plan (QAPP). These processes involve examination of the SAP, electronic data files, the field data, analytical data, and laboratory records. Computer programs are used to verify that samples were properly preserved and were analyzed within the required holding time, that QC results were within specified acceptable ranges, and that the appropriate detection limits were employed by the laboratories. Additionally, manual reviews of field data and laboratory records are conducted to ensure the quality of these items. Validation summaries for holding time, preservation, calibration, analyte identification, and analyte quantitation can be found in subsections 3.1, *Holding Times*; 3.2, *Preservation*; and 3.3, *Calibration, Identification, and Quantitation*.

The data were validated to determine if the records conform to the technical criteria associated with definitive data per ER-SOP-033. Table 3 provides a brief validation summary for the project. Review qualifiers are assigned by a data validator internal to SRS and external to the analytical laboratory. Environmental records include regular sample and field duplicate records.

Table 3. Environmental Record Review Qualifier Summary

	Detects		Non-detects		Rejected	
Method Code	**# NULL Qualifiers**	**# J Qualifiers**	**# U Qualifiers**	**# UJ Qualifiers**	**# R Qualifiers**	**Total**
A-01-RMOD	209	29	63	0	0	301
EPA300.0	25	18	0	0	0	43
EPA365.4	30	5	0	0	0	35
EPA6010C	561	147	169	79	13	969
EPA6020A	690	163	93	0	0	946
Total	2468	737	15417	219	23	19078
% of Total	13%	4%	81%	1%	1%	100%

2.0 ASSESSMENT OF PRECISION, ACCURACY, REPRESENTATIVENESS, COMPARABILITY, and COMPLETENESS DATA QUALITY INDICATORS (DQIs) AND MEASUREMENT PERFORMANCE CRITERIA (MPCs)

This section discusses the analytical data in terms of the following indicators of data quality: precision, accuracy, representativeness, comparability, and completeness. Precision is determined from the field and laboratory duplicate analyses and indicates the consistency of field and laboratory techniques. Accuracy is determined from the laboratory control samples (LCS), matrix spikes (MS), and the results of the method, field, trip, and rinsate blanks; it indicates the ability of the laboratory to generate correct results. Comparability expresses the confidence with which data from different laboratories are considered to be equivalent. Completeness measures the amount of data resulting from the data collection activity.

2.1 Precision

Precision is the degree to which a set of observations or measurements of the same property, obtained under similar conditions, conform to themselves. Field duplicates measure the repeatability of the sampling and analytical techniques, and laboratory duplicates measure the ability of the laboratory to reproduce a result. Low precision can be caused by poor instrument performance, poor operator technique, inconsistent application of method protocols, laboratory environment, time between analyses, or by a difficult, heterogeneous sample matrix. Precision is especially important when the action limit approaches the quantification limit. At least 5% of the samples were collected in duplicate for this project. The laboratory performs duplicate analyses on at least 5% of the samples received.

Precision is expressed in terms of the relative percent differences (RPD) as follows:

$$\text{RPD} = \frac{|x - y|}{\left(\frac{x + y}{2}\right)} \times 100$$

where x is the original sample result and y is the duplicate sample result. When one result of a duplicate pair is below the MDL, the ssEQL is used for that result in the calculation. When both results are below the MDL, the RPD is not calculated.

The RPD should be less than 20% for water samples and less than 35% for solid samples when results are greater than the ssEQL. In the case where results are between the ssEQL and the MDL, the RPD should be less than 100% for water samples and less than 200% for soil samples. In the event analytical precision goals are not met, a determination of the usability of that information is made through the environmental data assessment process.

[*Input number*] records were rejected due to precision issues. Details for this project can be found in Sections 3.6, *Laboratory Duplicate RPD*; and 3.7, *Field Duplicate RPD*.

2.2 Accuracy

Accuracy is defined as the closeness of agreement between an observed value and an accepted reference value. Accuracy is especially important when the concentration of concern approaches the detection limit and/or the action limit. When the concentration is underestimated near the detection limit, the analyte may be present but reported as not detected. When the concentration is underestimated near the action limit, the analyte may be at a concentration that would require remediation, but the remediation would not be performed. When the concentration is overestimated near the detection limit, the analyte may not be present but reported as detected. When the concentration is overestimated near the action limit, the analyte may not be at a concentration that would require remediation, but the remediation would be performed. The sample types used to evaluate accuracy are performance evaluation studies, laboratory control samples (LCSs), surrogate spikes, matrix spikes (MSs), method blanks, trip blanks, and rinsate blanks

LCSs monitor the performance of all steps in the analytical process, including sample preparation, and are used to identify problems with the analytical procedure. LCSs are deionized water that is spiked with the target analyte, digested, and analyzed with the regular samples. The

LCS spiking solution is obtained from the EPA, a third-party supplier, or is prepared in the laboratory using chemical from a different source than the calibration standards.

The LCS percent recovery is calculated as follows:

$$\% \text{ Recovery} = \frac{\text{Blank spike concentration}}{\text{Spike concentration}} \times 100$$

One hundred percent recovery is equivalent to 100% accuracy. Values less than 100% or greater than 100% may indicate a sample matrix effect and a false reading. A periodic program of sample spiking is required (e.g., one MS and one MS duplicate per 20 samples). In the event that analytical accuracy goals are not met, a determination is made through the environmental data assessment process relative to the usability of that information.

[*Input number of records and identify constituents*] were rejected because the matrix spike was outside limits. Details for this project can be found in subsections 3.4, *Trip Blanks*; 3.5, *Method Blanks*; 3.8, *Matrix Spike Recovery*; 3.9, *LCS Recovery*; and 3.10, *Surrogate/Tracer Recovery*.

2.3 Representativeness

Representativeness is a measure of the degree to which data accurately and precisely represent a characteristic of a population, a parameter variation at a sampling point, a process condition, or an environmental condition. The representativeness of samples collected is controlled by adhering to the detailed descriptions of sampling procedures. The objective of this assessment is to accurately represent the concentrations of target analytes or compounds. Representative samples for this investigation will be required by implementing approved sampling and analytical procedures that will generate data representative of the sampling point location and will be maintained. Analytical methods are selected that will most accurately represent the true concentration of the parameter of interest. The accumulation of QC procedures and information (i.e., RPD values, blank QC concentrations, MS percent recoveries, etc.) employed for a given analysis combine to exhibit the representativeness of the data generated.

The goal for representative sample data will therefore be met by properly documenting field and analytical protocols. In the event these procedures and methods are not able to be implemented, the appropriate corrective action documentation should encompass the impact on the representativeness of the information. When review of the data and documentation determines the data to be non-representative, the information is qualified in its use or is not used by the project.

[*Example:* All samples were collected and analyzed per established procedures.]

2.4 Comparability

Comparability is the degree to which different methods, data sets, and decisions agree or can be represented as similar. The comparability of the data from the laboratories is based on the results of the split samples and on confirmation that the laboratories used the same standardized procedures for sample analysis, the same reporting unit, and obtained similar quantitation limits. Comparability of the data produced for this investigation may be obtained by implementing the identified protocols for sampling and analysis of samples. Implementation of traceable reference materials such as laboratory standards, expression of results in standard concentration units, and successful participation by the laboratories in external performance evaluation programs will enable the information produced through this investigation to be compared with future data sets, if required. For at least 5% of the sample locations, a split sample is collected and sent to the designated QC laboratory.

[*Example:* No split samples were collected per the scoping summary.]

2.5 Completeness

Completeness is a measure of the amount of valid data obtained from a measurement system compared with the amount that was expected to be obtained under correct, normal circumstances. . The Quality Assurance (QA) completeness objective for RFI/RI projects is to obtain valid field and laboratory analytical results for at least 90% of the samples collected

during the project. This implies that completeness of sample collection (i.e., the number of samples collected compared to the number of samples planned) must be virtually 100% to allow for some loss of data during the laboratory analytical process. Accountability of samples collected, from field to final disposal, must be 100%.

Completeness is a measure of the amount of data obtained from a measurement process that achieves the project goals as compared to the amount of data planned to be obtained by the project. Completeness is affected by unexpected conditions during the data collection process that reduce the usable data achieved relative to the data planned.

When review of the data and documentation determines the data to be incomplete, the impact relative to the project objective will be assessed and documented.

The following are measures of completeness:

Sample Collection:

$$\text{Completeness} = \frac{\text{Number of Sample Points Sampled}}{\text{Number of Sample Points Planned}} \times 100$$

Field Measurement:

$$\text{Completeness} = \frac{\text{Number of Valid Measurements Made}}{\text{Number of Measurements Planned}} \times 100$$

Laboratory Analysis:

$$\text{Completeness} = \frac{\text{Number of Valid Data Points}}{\text{Number of Data Points Planned}} \times 100$$

The completeness numbers for this project are listed below:

Sample Collection Completeness	99%
Field Measurement Completeness	100%
Laboratory Analysis Completeness	99%

3.0 VALIDATION FINDINGS

3.1 Holding Times

Table 4. Holding Time (HT) Review Qualifier Summary

Method Code	Total # of Records	# of Records Qualified for HT	Associated Samples Qualified
EPA300.0	43	15	A-ASHPILE0021, A-ASHPILE0022, A-ASHPILE0023, A-ASHPILE0033, A-ASHPILE0034, A-ASHPILE0035, A-ASHPILE0036, A-ASHPILE0037, A-ASHPILE0038, A-ASHPILE0039, A-ASHPILE0040, A-ASHPILE0041, A-ASHPILE0042, A-ASHPILE0043, A-ASHPILE0044

All holding times for the reported analyses were within the recommended limits. No qualification was required. [*Or add a statement on what was observed in the data*.]

3.2 Preservation

Table 5. Preservation Review Qualifier Summary

Method Code	Total # of Records	# of Records Qualified for Preservation	Associated Samples Qualified
A-01-RMOD	301	0	
EPA300.0	43	0	
EPA365.4	35	0	
EPA6010C	969	0	
EPA6020A	946	0	
EPA7470A	3	0	
EPA7471B	84	0	
EPA8081B	1723	0	
EPA8081BSCNPDES	60	0	
EPA8082A	609	0	

All chemical and physical preservation for the reported analyses were properly applied. No qualification was required. [*Or add a statement on what was observed in the data*].

3.3 Calibration, Identification, and Quantitation

Table 6. Calibration (CAL), Identification (ID), and Quantitation Review Summary

Method Code	Total # of Records	# of Records Qualified for CAL, ID and Quantitation	Associated Samples Qualified
EPA6010C	969	142	ACPRB00000001, ACPRB00000002, ACPRB00000003, ACPRB00000004, ACPRB00000005, ACPRB00000006, ACPRB00000007, ACPRB00000008, ACPRB00000009, ACPRB00000010, ACPRB00000011, ACPRB00000012, ACPRB00000013, ACPRB00000014, ACPRB00000015, ACPRB00000016, ACPRB00000017, ACPRB00000018, ACPRB00000019, ACPRB00000020, ACPRB00000021, ACPRB00000022, ACPRB00000029, ACPRB00000030,

All calibration, identification and quantitation criteria for the reported analyses were within the recommended limits. No qualification was required. [*Or add a statement on what was observed in the data*].

3.4 Trip Blanks

Table 7. Trip Blank (TB) Review Qualifier Summary

Method Code	Total # of TB Records	# of TB Records Qualified	Associated Samples Qualified
EPA8260B	618	5	A013-00000009

All trip blanks for the reported analyses were within the recommended limits. No qualification was required. [*Or add a statement on what was observed in the data*.]

3.5 Method Blanks

Table 8. Method Blank (MB) Review Qualifier Summary

Method Code	Total # of MB Records	# of MB Records Qualified	Associated Samples Qualified
A-01-RMOD	36	22	A-ASHPILE0017, A-ASHPILE0028, A-ASHPILE0029, A-ASHPILE0032, A-ASHPILE0039, A-ASHPILE0040

All method blanks for the reported analyses were within the recommended limits. No qualification was required. [*Or add a statement on what was observed in the data*.]

3.6 Laboratory Duplicate RPD

Table 9. Laboratory Duplicate Qualifier Summary

Method Code	Total # of Duplicate Records	# of Duplicate Records Qualified	Associated Samples Qualified
A-01-RMOD	33	3	A-ASHPILE0018, A-ASHPILE0021, A-ASHPILE0022

All laboratory duplicates for the reported analyses were within the recommended limits. No qualification was required. [*Or add a statement on what was observed in the data*.]

3.7 Field Duplicate RPD

Table 10. Field Duplicate Qualifier Summary

Method Code	Total # of Field Duplicate Records	# of Duplicate Records Qualified	Associated Samples Qualified
EPA300.0	4	1	A-ASHPILE0027, A-ASHPILE0054

All field duplicates for the reported analyses were within the recommended limits. No qualification was required. [*Or add a statement on what was observed in the data*.]

3.8 Matrix Spike Recovery

Table 11. Matrix Spike (MS) Recovery Qualifier Summary

Method Code	Total # of MS/MSD Records	# of MS/MSD Records Qualified	Associated Samples Qualified
EPA365.4	12	4	ACPRB00000033, ACPRB00000037

All matrix spike recovery for the reported analyses were within the recommended limits. No qualification was required. [*Or add a statement on what was observed in the data*.]

3.9 LCS Recovery

Table 12. LCS Qualifier Summary

Method Code	Total # of LCS Records	# of LCS Records Qualified	Associated Samples Qualified
EPA903.0MOD	5	1	A-ASHPILE0037, A-ASHPILE0041

All LCS recovery criteria for the reported analyses were within the recommended limits. No qualification was required. [*Or add a statement on what was observed in the data*.]

3.10 Surrogate/Tracer Recovery

Table 13. Surrogate/Tracer Recovery Qualifier Summary

Method Code	Total # of Surrogate/ Tracer Records	# of Surrogate/Tracer Records Qualified	Associated Samples Qualified
EPA903.0MOD	43	3	A-ASHPILE0011, A-ASHPILE0033, A-ASHPILE0041

All surrogate/tracer recovery criteria for the reported analyses were within the recommended limits. No qualification was required. [*Or add a statement on what was observed in the data*.]

4.0 DATA USABILITY

[*Include a statement that indicates whether the data meets DQOs for the applicable project (Ex: The analytical data from this project are considered usable for purposes outlined in the A-Area Waste Units Scoping Summary.)]*

[Include a statement of data limitations. (Ex: Two hundred and thirty-seven environmental sample records (1% of total) were rejected. The rejected data should not be used. A significant number of europium-155 (54%) and tin-126 (97%) records were rejected and these analytes should be evaluated for additional actions. The qualifier "J" indicates that the analyte was detected but the result is approximate.)] Qualification details are found in Section 3.0, *Validation Findings.*

RFI/RI/BRA Format

EXECUTIVE SUMMARY

The purpose of the Executive Summary is to provide the results in a very concise overview manner for the reader who does not wish to be weighed down by the details of the analyses. The Executive Summary will support the key decisions agreed to by the Core Team during the development of the RI/BRA report, and will prepare the Core Team for validating key conclusions. The Executive Summary will be consistent with the RI/BRA scoping summary.

The following sections should be summarized in the Executive Summary:

Background
RFI / RI Investigation (Conceptual Site Model)
Nature and Extent
Fate and Transport
Risk Assessment
RGOs

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

LIST OF ACRONYMS

GENERAL NOTE: When a protocol is used, refer to it by title, revision number, and date. Figures and Tables are to be grouped together and placed at the back of each chapter, unless otherwise noted.

CHAPTER 1. INTRODUCTION

The purpose of following sections is to provide the reader with a discussion of the purpose and layout of the document and to provide the reader with basic information about the unit.

1.1 Report Organization

Provides a description of the report organization for the reader.

1.2 Regulatory Background

1.2.1 RCRA Facility Investigation Program

Provides a description of the RCRA status of the unit, if applicable. This section is not needed for a CERCLA only unit.

1.2.2 CERCLA Remedial Investigation Program

Provides a description of the CERCLA status of the unit.

1.2.3 Natural Resource Injury Evaluation

This section provides a discussion of potential natural resource injuries that are suspected or known. The potential injuries are documented by completion of the Natural Resource Injury Checklist. Natural resource injury evaluations are based on the SRS Natural Resource Trustee Responsibilities list of trust resources.

Each of the following should be discussed, as appropriate:

Surface water resources
Groundwater resources
Air resources
Geological resources
Biological resources

1.3 Unit Description

Provides a description of the unit history, location, and setting. This information is available from the workplan and updated, as necessary. Appropriate maps showing the unit will be included.

1.4 RFI/RI/BRA Protocol Implementation

Discusses the fact that the document was prepared according to a set of agreed upon protocols and refers the reader to the appendix containing the list of protocols used.

CHAPTER 2. CONCEPTUAL SITE MODEL AND STUDY AREA INVESTIGATION

The purpose of following sections is to provide the reader with a discussion of the conceptual site model (CSM) for the unit. This includes a discussion of the known and suspected sources of contamination, identification of those sources, the types of contaminants and potentially affected media, the known and potential routes of migration, and the known or potential human and ecological receptors. The CSM and unit investigation will be consistent with the key decisions agreed to by the Core Team at the Post Characterization RI/BRA Scoping Meeting prior to the implementation of RFI/RI/BRA protocols.

2.1 Conceptual Site Model

Provides a discussion of the waste unit as represented by the CSM. Specifically identifies all sources, exposure routes, and media applicable to the exposure unit.

2.1.1 Primary Sources of Contamination
2.1.2 Primary Sources Environmental Release Mechanisms
2.1.3 Secondary Sources of Contamination
2.1.4 Secondary Sources Environmental Release Mechanisms
2.1.5 Exposure Media
2.1.6 Exposure Routes
2.1.7 Receptors (Human and Ecological)

2.2 Investigation Objectives

Provides a discussion of the objectives of the investigation as it is addressed by the CSM. This will include a summary of the objectives identified through the use of the DQO process evaluations as detailed in the workplan. Based on the results of the investigation, a revised CSM may be presented.

2.3 Unit Assessment Investigation

Provides a detailed description of the unit-specific assessment investigation activities. The following subsections will include information about the number of samples and the type of sampling and analysis conducted to characterize CSM sources and exposure media. The information in the subsections will also describe unit assessment activities per appropriate exposure units.

2.3.1 Background Investigation

Provides a discussion of the unit-specific background investigation activities that were conducted in order to establish baseline concentrations for the evaluation of unit contaminant information. Information and data from the background investigation will be presented, as needed, by specific exposure groups to accommodate the CSM and the DQO process.

2.3.2 Primary Source Investigation

Provides a discussion of the unit-specific investigation activities conducted in order to characterize the primary source(s) of contamination as identified by the CSM and the DQO process.

2.3.3 Secondary Source Investigation

Provides a discussion of the unit-specific investigation activities conducted in order to characterize the secondary source(s) of contamination as identified by the CSM and the DQO process.

2.3.4 Exposure Media Investigations

Provides a discussion of the specific investigation activities conducted in order to characterize exposure media as identified by the CSM and the DQO process. This section will include, as appropriate, a discussion of all potentially contaminated exposure media, including soil, groundwater, surface water, sediments, biota, and air. It will not duplicate any discussions presented in the source investigation sections.

2.3.5 Physical Characteristics Investigation

Provides a discussion of the specific investigation activities conducted in order to obtain physical (geotechnical) parameters that were used to accommodate the physical data needs of the CSM.

2.3.6 Receptors (Human and Ecological)

Provides a discussion of the specific investigation activities conducted and reasoning applied in order to determine the receptors that were selected to be used in the CSM.

CHAPTER 3. PHYSICAL CHARACTERIZATION OF STUDY AREA

The purpose of the following sections is to provide the reader with a discussion of the physical attributes of the waste unit as well as a discussion relating the unit to the regional physical framework. Historical data and the data results from the unit assessment activities to ascertain physical characteristics investigation activities are presented in the appropriate subsection for which the activity was conducted. For example, geologic data gathered via cone penetrometer technology and/or coring operations will be utilized to augment the Unit Specific Geology subsection.

3.1 Surface Features

Provides a description of the setting of the waste unit with respect to surface features (e.g., topography).

3.2 Meteorology

Provides a description of the typical weather conditions for the waste unit. A reference to existing sources that summarize SRS weather conditions can be used instead of a detailed discussion.

3.3 Surface Water Hydrology

Provides a description of the surface water hydrologic characteristics for the waste unit including wetlands, streams, etc. This section is to include a figure depicting the waste unit in its respective integrator/watershed operable unit along with any other waste units identified in the watershed. All of the known groundwater plumes within the study area will be included on the map.

3.4 Unit Soils

Provides a description of the soil characteristics associated with the waste unit that has been investigated.

3.5 Geology

3.5.1 Regional Geology

Provides a reference to the workplan (or appropriate Administrative Record source) for regional geology description, unless revised based on investigation.

3.5.2 Unit-Specific Geology

Provides a brief description of the unit-specific geology. This section is to include historical data as well as data obtained during investigation.

3.6 Hydrogeology

3.6.1 Regional Hydrogeology

Provides a reference to the workplan (or appropriate Administrative Record source) for regional hydrogeology description, unless revised based on investigation.

3.6.2 Unit-Specific Hydrogeology

Provides a description of the unit-specific hydrogeology. This section is to include historical data as well as data obtained during investigation.

3.7 Demography and Land Use

3.7.1 Demographics

Provides a reference to an appropriate source of information in the Administrative Record or a discussion of the appropriate data.

3.7.2 Land Use

Provides a description of the proposed/accepted land use for the area occupied by the waste unit. Include figures as needed.

CHAPTER 4. NATURE AND EXTENT OF CONTAMINATION

The purpose of the following sections is to provide the reader with a discussion of the results of the unit investigation. This is best achieved using tables, illustrations, and interpretive discussion of the type and extent of contamination for all environmental media that are present as a result of the operable unit. Both the horizontal and vertical extent of contamination are to be discussed.

Based on professional judgment, prepare planar maps, cross-sectional plots, or other illustrations for each USC in each exposure group, which will be useful in illustrating the nature and extent of contamination at the unit. It is expected that data for all preliminary COCs will be interpreted. In addition to plotting and/or tabulating contaminant data, other data will also be provided (i.e., non-detects, not analyzed, less than detection limit, etc.).

Contouring of concentration isopleths will be provided when appropriate. The inability to contour will also be explained (e.g., constituent ubiquitous throughout the unit, lack of data, etc.). The nature and extent of contamination summary and conclusions will provide the method of managing uncertainty where interpretation is not possible based on inadequate data quality or quantity. The conclusions of the nature and extent evaluation will be consistent with the key decisions agreed to by the Core Team at the Post Characterization RI/BRA Scoping Meeting.

4.1 Overview of Sampling and Analysis Plan

This section provides an overview of the sampling and analysis plan, which was executed, for the unit.

4.2 Unit-Source Data Presentation

Provides a presentation and interpretation of the data collected during the investigation along with appropriate process history and existing data in order to depict the nature and extent of contamination for the media at the waste unit.

At a minimum, all preliminary COCs will be illustrated in a planar and vertical manner. Based on best professional judgment, other constituents/parameters that will aid in the interpretation of the operable unit in terms of the CSM will also be illustrated, as needed.

Follow Unit-Source Data Processing Protocol, latest revision.

Primary Source(s)
Secondary Source(s) / Exposure Media
Soils (0 to 1 ft)
Soils (0 to 4 ft) [if applicable]
Soils (0 to X ft) [where X represents the deepest level in the vadose zone which was investigated]
Sediments (if applicable)
Surface Water (if applicable)
Aquifer(s) (if applicable)
Biota (if applicable)

4.3 Unit-Background Data Presentation

Provides a presentation and interpretation of the data collected during the investigation along with appropriate process history and existing data in order to depict background concentrations in the media at the waste unit. Presentation (e.g., maps and cross-sections) of unit-background data may best be provided along with unit-source data. . Follow Unit-Background Data Processing Protocol, latest revision.

Soils (0 to 1 ft)
Soils (0 to 4 ft) [if applicable]
Soils (0 to X ft) [where X represents the deepest level in the vadose zone which was investigated]
Sediments (if applicable)
Surface Water (if applicable)
Aquifer(s) (if applicable)
Biota (if applicable)

4.4 Unit-Specific Constituents (USC) Determination

Provides documentation of the determination of USCs. Follow USCs Protocol, latest revision.

4.5 Preliminary Applicable or Relevant and Appropriate Requirements (ARAR) COCs

Provides documentation of the constituents that exceed ARARs. ARAR COCs Protocol, latest revision for preliminary ARAR COC determination.

4.6 Nature and Extent of COCs

Provides a discussion of the nature and extent of contamination limited to those USCs that are identified as COCs in the chapters of the document that address ARARs, fate and transport, and human health and ecological risk assessments.

4.7 Principal Threat Source Material (PTSM) Evaluation

Provides a discussion of the operable unit source(s) that may pose a threat to human health or the environment if left unaddressed.

4.7.1 PTSM Description

Provides a definition of PTSM and low level threat source material (LLTSM) and explains the criteria used to identify potential source material as PTSM or LLTSM. Also includes a discussion of the future land use for the operable unit.

4.7.2 PTSM Evaluation Process

Provides a discussion of the process used to evaluate the operable unit for determination of PTSM and a discussion of the data evaluated. Tables are provided for the toxicity and mobility evaluations.

4.7.2.1 PTSM Toxicity Aspect

Provides a discussion of the toxicity screen used to evaluate the operable unit for PTSM. Includes a discussion of the constituents that exceed the toxicity threshold.

4.7.2.2 PTSM Mobility Aspect

Provides a discussion of the contaminant migration analysis to determine if the media evaluated meet the mobility criteria for PTSM.

4.8 Nature and Extent Uncertainty Analysis

Provides a discussion focusing on the uncertainty associated with the nature and extent of contamination and includes a recommendation of how to manage this

uncertainty. The adequacy of the operable unit-specific data set's quality and quantity will be evaluated. Contamination detected in method blanks, analytical interference, counting error, sample acquisition anomalies, measurement anomalies, etc., if significant and appropriate will be discussed and the ramifications upon the data provided.

CHAPTER 5. SCREENING AND EXPOSURE POINT CONCENTRATIONS

The purpose of the following sections is to provide the reader with a tabular list of the screening and exposure point concentrations (EPC) for contaminants at the unit. This information will be used in the technical analyses (fate & transport, human health risk, ecological risk) performed in the following chapters. Note that some screening (for USCs and ARAR COPCs) has already been performed and discussed in the previous chapter. Selected exposure groups and receptors will be consistent with the key decisions agreed to by the Core Team at the Post Characterization RI/BRA Scoping Meeting.

5.1 Unit-Source Exposure Group Exposure Point Concentrations

Tabular presentation of the needed information. Follow Unit-Source Data Processing Protocol, latest revision.

5.2 Unit-Background Exposure Group Exposure Point Concentrations

Tabular presentation of the needed information. Follow Unit-Background Data Processing, latest revision.

5.3 Uncertainty Discussion

Provides a discussion focusing on uncertainty associated with the determination of the exposure point concentration.

CHAPTER 6. CONTAMINANT FATE AND TRANSPORT

The purpose of this chapter is to provide the reader with a discussion of the expected fate of the unit contaminants in the soil and groundwater. The analysis of the contaminant migration through the soil to groundwater is described in detail within this chapter with the end result being a list of preliminary contaminant migration constituents of concern (CMCOCs). For groundwater contaminants that have exceeded the MCLs and for which groundwater modeling has been determined to be appropriate a summary discussion of the groundwater modeling is provided in this Chapter. A separate appendix documenting the details of the groundwater modeling will be provided. Results of the contaminant fate and transport analysis and final CMCOCs will be discussed with the Core Team at the Problem ID Scoping Meeting.

6.0 Introduction

This section describes the types of contaminant migration analyses and the rationale for providing those analyses. For example the soil USCs identified in Chapter 4 are analyzed using the contaminant migration analysis protocols for their potential to pose a threat to groundwater contamination in the future. Documentation of this analysis is provided in this Chapter. Constituents that were shown in Chapter 4 to constitute a discernable plume at concentrations above the MCL are considered for groundwater modeling. A summarization of the groundwater modeling is provided in this chapter, while the detailed documentation of the modeling effort is provided in an appendix to the RFI/RI/BRA.

6.1 Physical and Chemical Properties of Contaminants

The USCs and groundwater contaminants exceeding MCLs shall be identified by the general contaminant class (e.g. metals, VOCs, radionuclides, etc.). Provide the justification for including or not including groundwater constituents that exceed an MCL in the groundwater modeling. Physical and chemical properties that control the behavior of the appropriate contaminant classes in the environment shall be discussed. This will include a narrative discussion of the general mobility of the contaminant class within the environment as well as the pertinent physical constants affecting contaminant transport such as K_{oc}, K_{ow}, TOC, K_ds, half-lives, solubility, density, vapor pressure, Henry's Law and constants.

6.2 Fate and Transport of Soil USCs

6.2.1 Vadose Zone Conceptual Site Model

Provides a discussion of the potential sources of contamination, migration pathways, release mechanisms, and receptor locations. Significant findings of the RI that would affect migration of contaminants (e.g. the presence of NAPLs) should be discussed. In addition, a discussion of the generic factors affecting contaminant migration should be included. The logic of analyzing the contamination migration potential using either combined units or individual units will be presented.

6.2.2 Soil Leachability Screening

In this section the contaminant migration constituents of potential concern (CM COPCs) are determined using the computer spreadsheet, VZCOMML. Follow CM COPCs Protocol, latest revision.

6.2.3 Modeling (If used for analysis in the report)

Provides a discussion of the modeling used to derive the Tier 2 CM COPCs (using VZCOMML) and the detailed unit-specific fate and transport model(s) for the vadose zone to be developed for any resulting CM COPCs.

6.2.3.1 Model Input Data and Assumptions

Provides a discussion of the rationale for the selection of K_ds, exposure pathways, geotechnical parameters, and other assumptions and the model's sensitivity to them.

6.2.3.2 Model Application

Provides a discussion of the methods utilized in the unit-specific model.

6.2.3.3 Model Results

Provides a discussion of the results of the unit-specific modeling.

6.2.4 Identification of Preliminary Contaminant Migration COCs

In this section, the preliminary contaminant migration constituents of concern (CM COCs) are determined based on the results obtained from the modeling. Apply the CM COCs Protocol, latest revision in order to determine which constituents are to be identified.

6.2.5 Soil Contaminant Migration Analysis Uncertainty Discussion

Provides a discussion of the uncertainty inherently associated with the contaminant migration analysis.

6.3 Fate and Transport of Groundwater Contaminants

Information provided in this section is supplied by the executive summary of the corresponding groundwater modeling report.

6.3.1 Hydrogeologic Conceptual Model

The Hydrogeologic Conceptual Model (HCM) is a simplified presentation of the groundwater flow system used to simplify the field problem. This section includes summary information regarding descriptions of the geologic setting, hydrostratigraphic units, hydraulic parameters, and system boundaries such as external boundaries, wells, and sources/sinks. Also, a description of the source and geometry of contaminant plumes is included. A figure of the HCM is required for Chapter 6.

6.3.2 Summary of Flow Modeling

In this section, the major assumptions, input parameters, and result that were used in the flow model are discussed. Also, a brief description of the data points used for calibration targets and the results of, the overall calibration are included. A comparison of the calculated head distribution with head distribution figures presented in earlier chapters of the RFI/RI/BRA (most likely Chapter 3) shall be made with any discrepancies explained. A figure(s) of predicted hydraulic head for each aquifer unit modeled will be presented with Chapter 6 figures.

6.3.3 Summary of Particle Tracking (if applicable)

Describe the rationale for performing particle tracking (e.g. to evaluate potential monitoring well placement, to evaluate potential source terms, etc.) . Provide a summary of the seed locations and results from forward and backward particle tracking in this section.

6.3.4. Summary of Contaminant Transport Modeling (if applicable)

Identify the model used to estimate contaminant transport. Include a summary of the transport mechanisms modeled (e.g. advection, dispersion, biodegradation, decay, etc.). List the significant assumptions used in for the modeling, discuss model calibration, and summarize the conclusions in the report. Figures depicting the hydrogeologic conceptual model, predicted hydraulic head(for each aquifer zone), and the contaminant plume configuration will be included for appropriate time intervals.

6.3.5 Uncertainty Discussion

Provide a discussion of uncertainty resulting from the deviation between model predictions due to incomplete knowledge about head distribution, aquifer parameters, source term conditions, and hydrologic stresses. The categories (sources) of uncertainty that should be discussed include:

1) Conceptual uncertainty – unsure of the processes occurring
2) Model uncertainty - using a simplified representation of reality
3) Parameter uncertainty – unsure of parameter values used in the model (assessed during calibration sensitivity analysis)

In addition, the significance of the uncertainty should be explained with respect to the remedial action objectives of the OU.

CHAPTER 7. HUMAN HEALTH BASELINE RISK ASSESSMENT

The purpose of this chapter is to provide documentation of the analysis of the potential for adverse human health effects associated with exposure to contaminants likely to be present at the unit. Baseline human health risks are those risks to human health that can be anticipated to be present in the absence of any remedial efforts or institutional controls for the unit. Exposure groups and receptors evaluated will be consistent with the key decisions agreed to by the Core Team at the Post Characterization Scoping Meeting prior to the implementation of RFI/RI/BRA protocols. Results of the risk assessment will be presented to the Core Team at the Problem ID Scoping Meeting

For the detailed human health risk assessment format, refer to the Environmental Restoration Division Regulatory Handbook, Manual ERD-AG-003, Part I, RCRA/CERCLA Document Format, F-16 Human Health Risk Assessment Template.

7.1 Description of the Human Health Risk Assessment Process

7.1.1 Overview

Provides a brief explanation of the purpose of the BRA and discusses the organization of the human health BRA chapter. Provides an introductory discussion of the fundamental concepts pertinent to the human health risk assessment process.

7.1.2 Receptors and Exposure Scenarios

Identifies the receptors and exposure scenarios, which will be evaluated in the assessment. The risk assessment evaluates both known and hypothetical land uses. At a minimum, includes the following based on the Human Health Receptors and Scenarios Protocol, latest revision:

- *Known On-Unit SRS Worker*
- *Hypothetical On-Unit Industrial Worker*
- *Hypothetical On-Unit Resident (Adult/Child)*

Exposure Parameters for these scenarios are based on Human Health Exposure Parameters Protocols, latest revisions.

7.1.3 Exposure Routes

Identifies the exposure routes which are applicable and includes the following:

Ingestion (of soil, water, etc.)
Inhalation (of particles and vapors)
Dermal exposure
External Radiation

These are discussed in detail in the Human Health Receptors and Scenarios Protocol, latest revision.

7.1.4 Exposure Groups

Provides a discussion of how the data will be grouped and used. In the risk assessment, consideration will be given to a variety of receptor/media/route combinations. Exposure groups (EGs) will be identified, which will be used to represent exposure, point concentrations in the risk assessment. It is important to note that EGs are developed for each unit under investigation and are tailored to the needs of the risk assessment for that unit. Additional EGs may be developed, as needed. If an overall exposure unit is to be evaluated, then this section should also include a discussion on the combined data groups.

The following are based on the Development of Exposure Groups Protocol, latest revision. For human health risk assessment purposes, typical exposure groups are the following:

Unit-Source

- *Soil from 0 to 1 foot, over the area of the unit.*
- *Soil from 0 to 4 feet, over the area of the unit (if appropriate).*
- *Groundwater in a designated aquifer system (may be in the highly concentrated area of the plume, if appropriate).*
- *Surface Water in a nearby water system.*
- *Sediments / soils in nearby drainage areas.*

Unit-Background

- *Soil from 0 to 1 foot*
- *Soil from 0 to 4 feet (if appropriate)*
- *Soil from 0 to X feet, where X represents the depth of the vadose zone investigated.*
- *Groundwater in a designated aquifer system.*
- *Surface Water in a nearby water system.*

- *Sediments / soils in nearby drainage areas.*

7.1.5 Exposure Pathways

Provides a review of the unit CSM and discusses the application for risk assessment. This section includes a discussion of exposure pathways. Based on the Exposure Pathways Protocol, latest revision, an exposure pathway describes the course a contaminant takes from its origin at the source to the exposed individual. It consists of five elements, as follows:

source (landfill, spill, etc.);
exposure media (groundwater, air, etc.);
exposure point (drinking water well, shower, etc.);
exposure route (ingestion, inhalation, dermal absorption, etc.); and
receptor (resident, worker, etc.).

7.2 Human Health Constituents of Potential Concern

In this section, HH COPCs are selected using the established protocol

7.2.1 COPC Selection Process Description

Provides a discussion of how the human health constituents of potential concern (HH COPC) for the unit are identified for each exposure group and how the COPC process is conducted. This is based on the Human Health Constituents of Potential Concern Protocol, latest revision.

7.2.2 COPC Screening Results for Unit-Source Data

Refers to the results in the tables containing the HH COPC screening process.

7.2.3 COPC Screening Results for Unit-Background Data

Refers to the tables containing the results of the HH COPC screening process.

7.2.4 COPC Screening Results Summary

Refers to the summary tables containing the results of the HH COPC screening process.

7.3 Exposure Assessment

Provides a description of the type and magnitude of the potential human exposures to COPCs. For a given receptor group, this result is an estimate of chronic daily intake or dose that may occur from exposure to the COPCs in the various environmental media within each exposure group.

7.3.1 Exposure Point Concentrations

Refers back to the tables in Chapter 5 and the RME concentrations, which were determined for each exposure group.

7.3.2 Development of Constituent Intakes

Provides information concerning the equations and exposure factors (i.e., assumptions) used to calculate constituent intakes for both RME exposure parameters and CTE exposure parameters.

7.3.3 Exposure Factors

Describes the exposure factors that are combined with the exposure point concentrations in order to calculate intake or dose.

7.3.4 Exposure Equations

Provides a description of the intake estimates developed for each COPC using corresponding exposure point concentrations. The risk assessment uses intake equations developed and applied in accordance to regulatory risk assessment guidance.

7.4 Toxicity Assessment

The objectives of the toxicity assessment discussion are to evaluate the inherent toxicity of the substances under investigation and to identify and to select toxicity values for use in the risk characterization.

7.4.1 Chemical and Radionuclide Toxicity

Provides a description of the data to be used to characterize the toxicity of the individual constituents for carcinogenicity and for chronic effects.

7.4.2 Lead

The toxicity assessment process used for lead is described.

7.4.3 Provisional Values

The treatment of constituents with provisional values is described.

7.4.4 Constituents for which No EPA Toxicity Values are Available

The toxicity assessment process is complicated by the fact that toxicity values are not readily available for all constituents or all exposure routes. In this section, a discussion of those constituents is presented. This section also includes a discussion of the use of surrogates when available.

7.4.5 Exposure to VOC During Showering

This section discusses the use of the drinking water ingestion intake to estimate intake due to inhalation and dermal contact with VOCs while showering.

7.5 Human Health Risk Estimation

The risk estimate spreadsheets are presented in tabular format in the appendices. The text refers the reader to the appropriate set of appendices.

7.6 Human Health Risk Assessment Results

The results of the risk characterization are presented.

7.6.1 Human Health Summary of Receptor Risks and Hazards

The results of the risk and hazard estimates are presented here.

7.6.2 Human Health Risk Assessment Summary

The total cumulative risk determined for each receptor is presented here.

7.6.3 Human Health *Preliminary* Constituents of Concern

Provides a listing and discussion of all of the preliminary Constituents of Concern.

7.6.4 Human Health Risk Assessment Uncertainty Discussion

Provides a discussion of the uncertainty that is inherent in the selection of key input parameters and in every step of the risk assessment process. The results of risk assessment may be understood only in light of the assumptions and methods used in the evaluation.

CHAPTER 8. ECOLOGICAL BASELINE RISK ASSESSMENT

This section has been removed. For BRAs see Environmental Restoration Division Regulatory Handbook, Manual ERD-AG-003, Part I, RCRA/CERCLA Document Format, F-14 Ecological Risk Assessment Process Annotated Outline for the ecological risk assessment format. Exposure groups and receptors evaluated will be consistent with the key decisions agreed to by the Core Team at the Post Characterization Scoping Meeting prior to the implementation of RFI/RI/BRA protocols. Results of the risk assessment will be presented to the Core Team at the RI/BRA scoping meeting.

CHAPTER 9. SELECTION OF REFINED CONSTITUENTS OF CONCERN (RCOCs) and REVISED CONCEPTUAL SITE MODEL

The purpose of this chapter is to provide documentation of the review of the refined constituents of concern (RCOCs) identified as a result of the application of characterization, contaminant migration, human health risk, and ecological risk protocols to the unit data in the preceding chapters. The selection of RCOCs and revision of the Conceptual Site Model (CSM) will be based on key conclusions determined by the Core Team during the Problem ID Scoping Meeting.

The purpose of the review is to determine which of these RCOCs are to be rejected as unsuitable for retention for the next phase of the remedial investigation process which involves the development of remedial goal options (RGOs). The review is conducted by examining each set of preliminary COCs - ARAR, Contaminant Migration, Human Health, and Ecological Health. The selection is performed by applying the 'COC Refinement Process' Protocol, latest revision.

9.1 COC RETENTION ANALYSIS

9.1.1 ARAR Based COCs

Provides a discussion of the uncertainty associated with each of the preliminary ARAR COCs. Based on the review of the uncertainties, the discussion finishes with recommendations as to which preliminary COCs should become refined ARAR COCs.

9.1.2 Contaminant Migration Based COCs

Provides a discussion of the uncertainty associated with each of the preliminary CM COCs. Based on the review of the uncertainties, the discussion finishes with recommendations as to which preliminary COCs should become refined CM COCs. This will usually involve referring back to the modeling performed in a previous chapter.

9.1.3 Human Health Based COCs

Provides a discussion of the uncertainty associated with each of the preliminary HH COCs. Based on the review of the uncertainties, the discussion finishes with recommendations as to which refined COCs should become final HH COCs.

9.1.4 Ecologically Based COCs

Provides a discussion of the uncertainty associated with each of the preliminary ECO COCs. Based on the review of the uncertainties, the

discussion finishes with recommendations as to which preliminary COCs should become refined ECO COCs.

9.1.5 Source Material COCs: PTSM COCs and LLTSM COCs

Provides a discussion of the uncertainty associated with the inherent toxicity, physical state, and potential mobility of source material identified as PTSM or LLTSM.

9.2 RCOC LIST

Presentation of the list of refined COCs.

9.3 REVISED CONCEPTUAL SITE MODEL

Presentation and discussion of the revised conceptual site model. The CSM is revised based on the new understanding of the unit, which has been the result of the preceding technical analysis and uncertainty analysis.

CHAPTER 10. DEVELOPMENT OF REMEDIAL GOAL OPTIONS (RGOs)

The purpose of this chapter is to provide documentation on the development of remedial goal options (RGOs). The revised COCs (RCOCs) and RGOs will be based on key conclusions determined by the Core Team during the Problem ID Scoping Meeting.

10.1 Description of Remedial Action Objectives for the Unit

Presents a discussion of the specific objectives for remediation of the unit. The remedial action objectives will be used to determine whether or not RGOs need to be developed for each revised COC.

10.2 Remedial Goal Option Development

10.2.1 ARAR Based RGOs

Provides a detailed discussion of the development of remedial goal options for the purpose of compliance with ARARs. Follow ARAR Remedial Goal Options Protocol, latest revision. . In addition, figures are provided illustrating the locations where each of the preliminary RGOs are presently exceeded at the unit.

10.2.2 Contaminant Migration Based RGOs

Provides a detailed discussion of the development of remedial goal options for protection of groundwater. These options will apply to remediation of the vadose zone soils associated with the unit. Follow Contaminant Migration Remedial Goal Options Protocol, latest revision. . In addition, figures are provided illustrating the locations where each of the preliminary RGOs are presently exceeded at the unit.

10.2.3 Human Health Based RGOs

Provides a detailed discussion of the development of remedial goal options for the protection of human health. These will apply to the various media associated with the unit. Follow Human Health Remedial Goal Options Protocol, latest revision. . In addition, figures are provided illustrating the locations where each of the preliminary RGOs are presently exceeded at the unit.

10.2.4 Ecologically Based RGOs

Provides a detailed discussion of the development of remedial goal options for the protection of ecological receptors in the environment. These will apply to the various media associated with the unit. In addition, figures are provided illustrating the locations where each of the preliminary RGOs are presently exceeded at the unit.

10.2.5 Most Restrictive RGOs for each Media

Provides a tabular listing, by media, of the preliminary RGOs based on ARARs, as well as contaminant migration, human health, and ecological analysis. Average background values for each media are included. From this table, the final RGO(s) for each media are determined based on the lowest RGO derived from the ARAR, contaminant migration, human health, and ecological RGO.

CHAPTER 11. SUMMARY OF RESULTS

The purpose of the Summary chapter is to provide the results in a relatively concise manner consistent with the RI/BRA scoping summary. This will assist the reader who wishes to have a detailed understanding of the results of the assessment but does not wish to review all of the details of the characterization, contaminant migration, human health risk, and ecological risk analyses. Summary information provided in this section will support key decisions agreed to by the Core Team during the Problem ID Scoping Meeting.

11.1 RFI/RI/BRA Process

Provides a summary discussion of the RI/BRA process and brief explanation and result from each chapter.

11.2 Primary Source Investigation Results

Provide a summary discussion of the major findings of the primary source investigation. Refers to the presentation and interpretation of the results from earlier chapters of the document, rather than repeating them here.

11.3 Secondary Sources Investigation Results

Provide a summary discussion of the major findings of the secondary source(s) investigation. Refers to the presentation and interpretation of the results from earlier chapters of the document, rather than repeating them here. Each relevant media will be discussed -

soils - 0 to 1 ft, 0 to 4 ft, 0 to X ft [where X represents the deepest level in the vadose zone which was investigated]
sediments
surface water
aquifer(s)
biota (if available)
air (if available)

11.4 Natural Resource Injury Evaluation Results

This section provides a discussion of potential natural resource injuries that are suspected or known.

11.5 Applicable or Relevant and Appropriate Requirement (ARAR) Technical Analysis Results

Provides a summary discussion of the major findings from the ARAR analysis. Refers to the presentation and interpretation of the results from earlier chapters of the document. Includes the results of the uncertainty assessment and a list of the refined ARAR COCs.

11.6 Principal Threat Source Material Technical Analysis Results

Provides a summary discussion of the major findings from the PTSM analysis. Refers to the presentation and interpretation of the results from earlier chapters of the document.

11.7 Contaminant Migration Technical Analysis Results

Provide a summary discussion of the major findings of the contaminant migration analysis. Refers to the presentation and interpretation of the results from earlier chapters of the document. Includes the results of the uncertainty assessment and a list of the refined CM COCs.

11.8 Human Health Risk Assessment Results

Presents a summary of the results of the human health risk assessment. Refers to the detailed analysis from earlier chapters and the appendices. Includes the results of the uncertainty assessment and a list of the refined HH COCs.

11.9 Ecological Risk Assessment Results

Presents a summary of the results of the ecological risk assessment. Refers to the detailed analysis from earlier chapters and the appendices. Includes the results of the uncertainty assessment and a list of the refined ECO COCs.

11.10 Most Likely RGOs for Each Media

Provides a tabular listing, by media, of the most likely RGOs with consideration for ARARs, contaminant migration, human health, and ecological analysis, and background values. The most likely RGOs will consider the land use and likely response actions as determined by the Core Team and may differ from the most restrictive RGOs presented in Chapter 10.

11.11 Conclusion

The purpose of this section is to provide a final succinct conclusion representative of key decisions agreed to by the Core Team during the Problem ID scoping meeting. The conclusion section will summarize the problems warranting actions, remedial action objectives, and uncertainties by subunit as presented in the operable unit scoping summary document. The intent of this section is to summarize the conclusions of the scoping summary document in support of the operable unit strategy.

11.11.1 Problem Warranting Action

Presents the problem statement by subunit as presented in the operable unit scoping summary.

11.11.2 Remedial Action Objectives

Presents the RAOs defined specifically for the problem to which they apply. The RAOS will be presented by subunit and specify the exposure pathway to be mitigated and the receptor to be protected.

11.11.3 Uncertainties

Presents the key uncertainties specific to the remedial decisions identified for each subunit.

11.12 Operable Unit Strategy

Identifies key management strategies related to achieving overall operable unit remediation. Key components of the strategy warranting discussion may include the identification of early actions, integration with other operable units, segregation of operable unit components, and modifications to project schedules and milestones based on changes in technical understanding.

CHAPTER 12. BIBLIOGRAPHY

APPENDICES

APPENDIX	CONTENT
A	Protocol Matrix
B	Reserved for additional Nature and Extent Drawings, if needed
C	Data Summary Report
D	Reserved for use, if needed
E	Contaminant Migration Modeling (if performed)
F	Toxicological Profiles
G	Reserved for use, if needed
H	Human Health Risk Calculations - Non-Cancer Hazard, RME
I	Human Health Risk Calculations - Cancer Risk, RME
J	Human Health Risk Calculations – Radionuclide Dose, RME
K	Human Health Risk Calculations - Non-Cancer Hazard, CT
L	Human Health Risk Calculations - Cancer Risk, CT
M	Human Health Risk Calculations - Radionuclide Dose, CT
N	Lead Modeling
O	Ecological Risk Calculations
P	RGO Calculations - Contaminant Migration
Q	RGO Calculations - Human Health Risk
R	RGO Calculations - Ecological Risk
S	Natural Resources Injury Evaluation

ATTACHMENT 1 FIGURES AND TABLES FOR RFI/RI/BRA REPORT

CHAPTER 1 - FIGURES AND TABLES

Required Figures

Fig 1.3-1 **SRS Site Map Showing Unit Location**

Fig 1.3-2 **Close Up Map of Unit**

Fig 1.3-3 **Aerial Photograph of Unit**

Fig 1.3-4 **IOU with all OUs identified and OU under investigation highlighted.**

Required Tables

Table 1.2-1 **Savannah River Site Natural Resource Trustees and Their Responsibilities**

Table 1.3-1 **History of Environmental Activities Performed at the Unit**

CHAPTER 2 - FIGURES AND TABLES

Required Figures

Fig 2.1-1 **Conceptual Site Model**

Fig 2.3-X **Map(s) Depicting Investigation Activities/Locations**

Required Tables

None.

CHAPTER 3 - FIGURES AND TABLES

Required Figures

Fig. 3.3-1 IOU with OUs, potentiometric surface, groundwater flow directions, and all known plumes identified.

Fig. 3.5.1-1 Lithographic Nomenclature Used At SRS

Fig. 3.5.2-1 Unit-Specific Geologic Section

Fig 3.6.1-1 Comparison of Lithographic and Hydrologic Nomenclatures

Fig. 3.6.2-1 Unit-Specific Hydrogeologic Section

Fig 3.7.2-1 Proposed SRS Future Land Use

CHAPTER 4 - FIGURES AND TABLES

Required Figures

Figure 4.2.1 Schematic Summary of Exposure Media Nomenclature

Fig 4.2.X Planar Maps and Vertical Cross-sections Showing Concentrations of all preliminary COCs and any other constituents or parameters that may aid in the interpretation of the operable unit data.

Required Tables

Tables 4.2.1.X Unit-Source Data *(at a minimum to include the headers below)*:

Constituent	Frequency of Detects	Method Detection Limit	Range of Method Detection Limit	Maximum	Minimum	Average	Two Times Average Bkgrd*	USC (Y/N)*

** The last two columns are only used for those data groups that are evaluated for USC determination (e.g., 0-X soils, sediments, surface water, each aquifer, others as appropriate). The last two columns may be omitted if not applicable for a specific data group.*

Table 4.2.1.1 Constituents Detected in 0-1 Soils
Table 4.2.1.2 Constituents Detected in 0-4 Soils
Table 4.2.1.3 Constituents Detected in 0-X Soils

Table 4.2.1.4 Constituents Detected in Sediments
Table 4.2.1.5 Constituents Detected in Surface Waters
Table 4.2.1.6 Constituents Detected in Water Table Aquifer
Table 4.2.1.7+x Constituents Detected in each additional aquifer

Tables 4.3.1.X Unit-Background Data *(at a minimum to include the headers below)*:

Constituent	Frequency of Detects	Method Detection Limit	Range of Method Detection Limit	Maximum	Minimum	Average	Two Times Average

Table 4.3.1.1 Constituents Detected in 0-1 Soils
Table 4.3.1.2 Constituents Detected in 0-4 Soils
Table 4.3.1.3 Constituents Detected in 0-X Soils
Table 4.3.1.4 Constituents Detected in Sediments
Table 4.3.1.5 Constituents Detected in Surface Waters
Table 4.3.1.6 Constituents Detected in Water Table Aquifer
Table 4.3.1.7+x Constituents Detected in each additional aquifer.

Tables 4.5.X Preliminary ARAR COCs
Prepare using the instructions in the established protocol. The table will include the following headings, at a minimum.

Constituent	Frequency of Detects	Method Detection Limit	Range of Method Detection Limit	Maximum	Minimum	Average	ARAR	ARAR COC

Table 4.5.1 Soil ARAR COCs
Table 4.5.2 Sediment ARAR COCs
Table 4.5.3 Surface Water ARAR COCs
Table 4.5.4 Water Table Aquifer ARAR COCs
Table 4.5.5 Each Additional Aquifer ARAR COCs

Table 4.7.2-X PTSM Evaluation – Toxicity Aspect
Prepare using the instructions in the established protocol. The table will include the following headings, at a minimum.

	Maximum Concentrations			Noncarcinogens			Carcinogens		
USC	Exposure Group X	Exposure Group X	OU (Unit Max)	PTSM Criteria	PTSM Criteria Source	Index	PTSM Criteria	PTSM Criteria Source	Index

Total Noncarcinogenic Index PTSM (Y/N)	(value) (Y/N)	Total Carcinogenic Index PTSM (Y/N)	(value) (Y/N)

Table 4.7.2-X PTSM Evaluation – Mobility Aspect
Prepare using the instructions in the established protocol. The table will include the following headings, at a minimum.

Constituent	Predicted Time To Max Groundwater Concentration (years)	Index Concentration	PTSM Criteria	PTSM Source	Arrival Time < 10 years (Y/N)	Index Concentration > Criteria (Y/N)	Currently GW Contaminant (Y/N)	PTSM (Y/N)

CHAPTER 5 - FIGURES AND TABLES

Table 5.1.X Unit-Source Exposure Group Data
(RAGS- Part D - Standard Table 3)
Prepare using the instructions in the established protocol. The table will include the following headings.

Detected Analyte	Units	Arithmetic Mean	95% UCL of Normal Data	Maximum Detected Concentration	Maximum Qualifier

(continuation of headings from above)

EPC Units	Reasonable Maximum Exposure			Central Tendency		
	Medium EPC Value	Medium EPC Statistic	Medium EPC Rationale	Medium EPC Value	Medium EPC Statistic	Medium EPC Rationale

Table 5.1.1 Values for 0-1' Soils
Table 5.1.2 Values for 0-4' Soils
Table 5.1.3 Values for 0-X' Soils
Table 5.1.4 Values for Sediments
Table 5.1.5 Values for Surface Waters
*Table 5.1.6 Values for Water Table Aquifer**
*Table 5.1.X Values for each additional Aquifer**

Table 5.2.X Unit-Background Exposure Group Data
Prepare using the instructions in the established protocol. The table will include the following headings.

Detected Analyte	Units	Arithmetic Mean	95% UCL of Normal	Maximum Detected	Maximum Qualifier	EPC Units

			Data	Concentration		

(continuation of headings from above)

Reasonable Maximum Exposure			Central Tendency		
Medium EPC Value	Medium EPC Statistic	Medium EPC Rationale	Medium EPC Value	Medium EPC Statistic	Medium EPC Rationale

Table 5.2.1 Values for 0-1' Soils
Table 5.2.2 Values for 0-4' Soils
Table 5.2.3 Values for 0-X' Soils
Table 5.2.4 Values for Sediments
Table 5.2.5 Values for Surface Waters
*Table 5.2.6 Values for Water Table Aquifer**
*Table 5.2.x Values for each additional Aquifer**

** For aquifers, the average concentrations from the highly concentrated area of plumes will be utilized to calculate RMEs.*

CHAPTER 6 - FIGURES AND TABLES

Required Figures

Figure 6.2.1-1 Vadose Zone Contaminant Migration Conceptual Model

Figure 6.3.1-1 Hydrogeologic Conceptual Model

Figure 6.3.2-1 Calculated Hydraulic Head Distribution from Model

Figure 6.3.3-1 Results from Particle Tracking (if applicable)

Figure 6.3.4-x Modeled Plume Position at Applicable Intervals (may require several figures)

Required Tables

Table 6.1-1 Physical and Chemical Properties of Contaminants
Table 6.2.2-1 Contaminant Migration Constituents of Potential Concern – Tier 1

Prepare using the instructions in the established protocol. The table will include the following headings.

USC	Maximum Concentration	Kd	MCL/RBC/ RBA	Henry's Law Constant H'	Standard SSL (S-SSL)	Average Source Depth ds	Mass Limit SSL (MLSSL)

(continuation of headings from above)

Unit Specific SSL (USSSL) *(Greater of S-SSL & MLSSL)*	CM COPC (*If USC > USSSL, list by analyte name*.)

Table 6.2.2-2 Contaminant Migration Constituents of Potential Concern – Tier 2

CM COPC	Maximum Concentration	Retardation Factor R	Time of Maximum Groundwater Concentration T_{max}	Calculated Groundwater Concentration C_w	MCL /RBC /RBA	CM COPC* (*If Cw > MCL/RBC/RBA & Tmax < 1000 yrs, list by analyte name*)

Table 6.2.3-1 Modeling Input and Assumptions

Table 6.2.4-1 Preliminary CM COCs

CHAPTER 7 - FIGURES AND TABLES

Required Figures

Fig. 7.1.1-1 Flowchart Illustrating Human Health Risk Assessment Process
Fig. 7.1.5-1 Pictorial Representation of Receptors and Exposure Scenarios
Fig. 7.1.5-2 Conceptual Site Model (human health receptors only)

Fig. 7.2.1-1 Flowchart of the Human Health COPC Selection Process

Required Tables

Table 7.1.5-1 Selection of Exposure Pathways
(RAGS- Part D - Standard Table 1)

Scenario Time frame	Medium	Exposure Medium	Exposure Point	Receptor Population	Receptor Age	Exposure Route	On-Site / Off-Site

(continuation of headings from above)

Type of Analysis	Rationale for Selection or Exclusion of Exposure Pathway

Tables 7.2.2-X Occurrence, Distribution and Selection of Chemicals of Potential Concern (Human Health)

(RAGS- Part D - Standard Table 2.1)

The table will include the following:

INFO BOX:

Scenario Time frame: xxxxxxx Medium: xxxxxxx Exposure Medium: xxxxxxxx Exposure Point: xxxxxx

COLUMN HEADINGS:

CAS Number	Chemical	Minimum Concentration	Minimum Qualifier	Maximum Concentration	Maximum Qualifier	Units	Location of Maximum Concentration

(continuation of headings from above)

Detection Frequency	Range of Detection Limits	Concentration Used for Screening	Background Value	Screening Toxicity Value	Potential ARAR/ TBC Value	COPC Flag	Rationale for Contaminant Deletion or Selection

Table 7.2.2-1 Unit-Source Surface Soil
Table 7.2.2-2 Unit-Source Subsurface Soil (if appropriate)
Table 7.2.2-3 Unit-Source Groundwater
Table 7.2.2-4 Unit-Source Surface Water
Table 7.2.2-5 Unit-Source Sediment
Table 7.2.2-6 Unit-Background Surface Soil
Table 7.2.2-7 Unit-Background Subsurface Soil (if appropriate
Table 7.2.2-8 Unit-Background Groundwater
Table 7.2.2-9 Unit-Background Surface Water
Table 7.2.2-10 Unit-Background Sediment

Tables 7.2.4-X Summary of HH COPC Screening

The table will include the following headings.

Analyte	Exposure Unit X	Exposure Unit X	Exposure Unit X	Exposure Unit X

Table 7.2.4-1 Surface Soil
Table 7.2.4-2 Subsurface Soil (if appropriate)
Table 7.2.4-3 Groundwater
Table 7.2.4-4 Surface Water

Table 7.2.4-5 Sediment

Table 7.3.2-1 Values Used For Daily Intake Calculations

(RAGS- Part D - Standard Table 4)

The table will include the following:

INFO BOX:

Scenario Time frame: xxxxxxx Medium: xxxxxxx Exposure Medium: xxxxxxxx Exposure Point: xxxxxx Receptor Population: xxxxxx Receptor Age: xxxxxxx

COLUMN HEADINGS:

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rational/ Reference	CT Value

(continuation of headings from above)

CT Rationale/Reference	Intake Equation / Model Name

Table 7.4.1-1 Non-Cancer Toxicity Data--Oral / Dermal

(RAGS- Part D - Standard Table 5)

The table will include the following:

COLUMN HEADINGS:

Chemical of Potential Concern	Chronic / Subchronic	Oral RfD Value	Oral to Dermal Adjustment Factor	Adjusted Dermal RfD	Units	Primary Target Organ

(continuation of headings from above)

Combined Uncertainty / Modifying Factors	Sources of RfD : Target Organ	Dates of RfD: Target Organ

Table 7.4.1-2 Non-Cancer Toxicity Data--Inhalation

(RAGS- Part D - Standard Table 5)

The table will include the following:

COLUMN HEADINGS:

Chemical of Potential Concern	Chronic / Subchronic	Value Inhalation RfC	Units	Adjusted Inhalation RfD	Units	Primary Target Organ

(continuation of headings from above)

Combined Uncertainty / Modifying Factors	Sources of RfC:RfD : Target Organ	Dates

Table 7.4.1-3 Non-Cancer Toxicity Data--Special Case Chemicals

(RAGS- Part D - Standard Table 5)

The table will include the following:

COLUMN HEADINGS:

Chemical of Potential Concern	Chronic / Subchronic	Value	Units	Primary Target Organ	Combined Uncertainty / Modifying Factors

(continuation of headings from above)

Sources of Toxicity : Primary Target Organ	Date

Table 7.4.1-4 Cancer Toxicity Data--Oral / Dermal

(RAGS- Part D - Standard Table 6)

The table will include the following:

COLUMN HEADINGS:

Chemical of Potential Concern	Oral Cancer Slope Factor	Oral to Dermal Adjustment Factor	Adjusted Dermal Cancer Slope Factor	Units

(continuation of headings from above)

Weight of Evidence / Cancer Guideline Description	Source	Date

Table 7.4.1-5 Cancer Toxicity Data--Inhalation

(RAGS- Part D - Standard Table 6)

The table will include the following:

COLUMN HEADINGS:

Chemical of Potential Concern	Unit Risk	Units	Adjustment	Inhalation Cancer Slope Fact	Units

(continuation of headings from above)

Weight of Evidence / Cancer Guideline Description	Source	Date

Table 7.4.1-6 Cancer Toxicity Data--Special Case Chemicals

(RAGS- Part D - Standard Table 6.3)

The table will include the following:

COLUMN HEADINGS:

Chemical of Potential Concern	Value	Units	Source	Date

Tables 7.6.1-X Summary of Receptor Risks and Hazards for COPCs

(RAGS- Part D - Standard Table 9)

The table will include the following:

INFO BOX:

Scenario Time frame: xxxxxxx Receptor Population: xxxxxx Receptor Age: xxxxxxx

COLUMN HEADINGS:

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk			
				Ingestion	Inhalation	Dermal	Exposure Routes Total

(continuation of headings from above)

Chemical	Non-Carcinogenic Hazard Quotient			
	Ingestion	Inhalation	Dermal	Exposure Routes Total

Tables 7.6.2-X Risk Assessment Summary

(RAGS- Part D - Standard Table 10)

The table will include the following:

INFO BOX:

Scenario Time frame: xxxxxxx Receptor Population: xxxxxx Receptor Age: xxxxxxx

COLUMN HEADINGS:

Medium	Exposure	Exposure Point	Chemical	Carcinogenic Risk

Medium				
	Ingestion	Inhalation	Dermal	Exposure Routes Total

(continuation of headings from above)

Chemical	Non-Carcinogenic Hazard Quotient			
	Ingestion	Inhalation	Dermal	Exposure Routes Total

CHAPTER 8 - ECOLOGICAL BASELINE RISK ASSESSMENT: FIGURES AND TABLES

This section has been removed. For BRAs see Reference ERD-AG-003 Part I, RCRA/CERCLA Document Format, F-14 Ecological Risk Assessment Process Annotated Outline for the ecological risk assessment format.

CHAPTER 9 - FIGURES AND TABLES

Required Figures

Figure 9.1-1. Revised Conceptual Site Model

Required Tables

Table 9.1.1-1 *Refined* ARAR COCs
Table 9.1.2-1 *Refined* CM COCs
Table 9.1.3-1 *Refined* HH COCs
Table 9.1.4-1 *Refined* ECO COCs

CHAPTER 10 - FIGURES AND TABLES

Required Figures

Figure 10.2.1-1 ARAR RGO Exceedences

Figure 10.2.2-1 CM RGO Exceedences

Figure 10.2.3-1 HH RGO Exceedences

Figure 10.2.4-1 ECO RGO Exceedences

Required Tables

Table 10.2.1-1 ARAR RGOs

Table 10.2.2-1 CM RGOs

Table 10.2.3-1 HH RGOs

Table 10.2.4-1 ECO RGOs

Table 10.2.5-1 Summary of Media RGOs

CHAPTER 11 - FIGURES AND TABLES

Required Figures

Figures 11.7.2-X	**Figure(s) Depicting Impacted Media of Concern with RGO Contour or Equivalent Concentrations Highlighted.**
Figure 11.11-X	**Simplified CSM and Refined COCs**

Required Tables

Table 11.1-X Overview of the COC Process

Table 11.7.1-1 Summary of Refined COCs and RGOs

CHAPTER 12 - FIGURES AND TABLES

As needed, none required.

APPENDIX A – PROTOCOL MATRIX

Table A-1. Protocol Matrix

APPENDIX E – CONTAMINANT MIGRATION MODELING

Table E. X Modeling Input and Assumptions

APPENDIX F – TOXICOLOGICAL PROFILES

Table F-1. Toxicological Profiles

APPENDIX G – Reserved for use, if needed

APPENDIX H – Human Health Risk Calculations – Non-Cancer Hazard, RME

Required Tables -

TABLE H-XXX.XXX.XXX Calculation of Non-Cancer Hazards

(RAGS- Part D - Standard Table 7)

The table will include the following:

INFO BOX:

Scenario Time frame: xxxxxxx Medium: xxxxxxx Exposure Medium: xxxxxxxx Exposure Point: xxxxxx Receptor Population: xxxxx Receptor Age: xxxxx

COLUMN HEADINGS:

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Hazard Calculation

(continuation of headings from above)

Intake (Non-Cancer)	Intake (Non-Cancer) Units	Reference Dose	Reference Dose Units	Reference Concentration	Reference Concentration Units	Hazard Quotient

Table H -Unit-Source RME – SRS Worker
Table H -Unit-Source RME – Industrial Worker
Table H -Unit-Source RME – Adult Resident
Table H -Unit-Source RME – Child Resident

Table H -Unit-Source RME – other receptors as appropriate

APPENDIX I – Human Health Risk Calculations – Cancer Risk, RME

TABLE I-XXX.XXX.XXX Calculation of Cancer Risk

(RAGS- Part D - Standard Table 8)

The table will include the following:

INFO BOX:

Scenario Time frame: xxxxxxx Medium: xxxxxxx Exposure Medium: xxxxxxxx Exposure Point: xxxxxx Receptor Population: xxxxx Receptor Age: xxxxx

COLUMN HEADINGS:

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Risk Calculation

(continuation of headings from above)

Intake (Cancer)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Factor Units	Cancer Risk

Table I -Unit-Source RME – SRS Worker
Table I -Unit-Source RME – Industrial Worker
Table I -Unit-Source RME – Adult/Child Resident
Table I -Unit-Source RME – other receptors as appropriate

APPENDIX J – Human Health Risk Calculations – Radionuclide Dose, RME

Required Figures - None.

Required Tables -

TABLE J-XXX.XXX.XXX Calculation of Radionuclide Dose

The table will include the following:

INFO BOX:

Scenario Time frame: xxxxxxx Medium: xxxxxxx Exposure Medium: xxxxxxxx Exposure Point: xxxxxx Receptor Population: xxxxx Receptor Age: xxxxx

COLUMN HEADINGS:

Exposure Route	Radionuclide	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Dose Calculation

(continuation of headings from above)

Dose Conversion Factor	Dose

Table J -Unit-Source RME – SRS Worker
Table J -Unit-Source RME – Industrial Worker
Table J -Unit-Source RME – Adult/Child Resident
Table J -Unit-Source RME – other receptors as appropriate

APPENDIX K – Human Health Risk Calculations – Non-Cancer Hazard, CT

Required Figures - None.

Required Tables -

TABLE K-XXX.XXX.XXX Calculation of Non-Cancer Hazards
(RAGS- Part D - Standard Table 7)

The table will include the following:

INFO BOX:

Scenario Time frame: xxxxxxx
Medium: xxxxxxx
Exposure Medium: xxxxxxxx
Exposure Point: xxxxxx
Receptor Population: xxxxx
Receptor Age: xxxxx

COLUMN HEADINGS:

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Hazard Calculation

(continuation of headings from above)

Intake (Non-Cancer)	Intake (Non-Cancer) Units	Reference Dose	Reference Dose Units	Reference Concentration	Reference Concentration Units	Hazard Quotient

Table K -Unit-Source RME – SRS Worker
Table K -Unit-Source RME – Industrial Worker
Table K -Unit-Source RME – Adult Resident
Table K - Unit-Source RME – Child Resident
Table K -Unit-Source RME – other receptors as appropriate

APPENDIX L – Human Health Risk Calculations – Cancer Risk, CT

Required Figures - None.

Required Tables -

TABLE L-XXX.XXX.XXX Calculation of Cancer Risk

(RAGS- Part D - Standard Table 8)

The table will include the following:

INFO BOX:

Scenario Time frame: xxxxxxx Medium: xxxxxxx Exposure Medium: xxxxxxxx Exposure Point: xxxxxx Receptor Population: xxxxx Receptor Age: xxxxx

COLUMN HEADINGS:

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Risk Calculation

(continuation of headings from above)

Intake (Cancer)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Factor Units	Cancer Risk

Table L -Unit-Source RME – SRS Worker
Table L -Unit-Source RME – Industrial Worker
Table L -Unit-Source RME – Adult/Child Resident
Table L - Unit-Source RME – Child Resident

APPENDIX M – Human Health Risk Calculations – Radionuclide Dose, CT

Required Figures - None.

Required Tables -

TABLE M-XXX.XXX.XXX Calculation of Radionuclide Dose

The table will include the following:

INFO BOX:

Scenario Time frame: xxxxxxx Medium: xxxxxxx Exposure Medium: xxxxxxxx Exposure Point: xxxxxx Receptor Population: xxxxx Receptor Age: xxxxx

COLUMN HEADINGS:

Exposure Route	Radionuclide	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Dose Calculation

(continuation of headings from above)

Dose Conversion Factor	Dose

Table M -Unit-Source RME – SRS Worker
Table M -Unit-Source RME – Industrial Worker
Table M -Unit-Source RME – Adult/Child Resident
Table M -Unit-Source RME – other receptors as appropriate

APPENDIX S. NATURAL INJURY RESOURCE EVALUATION

Table S.1 Natural Resource Trustee Responsibility List

Table S.2 Natural Resource Injury Checklist

CORRECTIVE MEASURES STUDY/FEASIBILITY STUDY FORMAT

1.0 INTRODUCTION

The purpose of this section is to provide the reader with information that can be used to develop a basic understanding of the unit. This basic information includes the unit's history and the nature and extent of contamination that has resulted from activities at the unit. This section also provides a description of the organization of the documentation of the analysis of alternatives.

1.1 Purpose and Organization of Report

Provides a description of the purpose of the CMS/FS report and of the organization of the report for readers who may be unfamiliar with this type of document. A reference that directs the reader to the more extensive information available in the RFI/RI/BRA report should be included.

1.2 Background Information

Provides a summary of the information available about the unit in order to give the reader a basic understanding of the history of the unit and the nature and extent of contamination that has resulted from activities at the unit.

1.2.1 Unit Description

Provides a brief description of the unit, including its location, size, geography, and environmental setting. Reference Figures 1 and 2 in description.

Figure 1. Location of the Unit Acronym within the Savannah River Site

Figure 2. Layout of the Unit Acronym

1.2.2 Unit History

Provides the reader with a brief description of the activities that have taken place at the unit.

1.2.3 Nature and Extent of Contamination

Provides a discussion of the contamination that has resulted from the unit activities. Reference Figure 3, Schematic Cross Section. This figure should be available from the Scoping Summary.

1.2.4 Constituent Fate and Transport

Provides a discussion of the mobility, in-growth, and decay of the unit contaminants. Reference Figure 4, Conceptual Site Model. May require CSM for each subunit, if applicable.

1.2.5 Baseline Risk Assessment

Provides a summary of the results of the analysis performed and documented in the baseline risk assessment.

Figure 3. Schematic Cross Section of the Unit Acronym

Figure 4. Conceptual Site Model for the Unit Acronym

2.0 IDENTIFICATION AND SCREENING OF TECHNOLOGIES

The purpose of this section is to provide the reader with a description of the remedial technologies that are available and reasonably expected to be suitable for use at the unit. Note that this section will be significantly streamlined for focused CMS/FS reports.

2.1 Introduction

Provides an introduction to the reader of the type of technologies that have been identified for consideration in the CMS/FS.

2.2 Remedial Action Objectives

This section provides a description of the range of objectives that will be considered. The following sections address the concerns for each medium of interest. Reference table of potential ARARs (Table 1). The table should include a specific citation, a synopsis of the requirement, and how it is considered in the CMS/FS.

2.2.1 Contaminants of Interest

Provides a list and description of the contaminants that are being considered for remedial action. Reference table of COCs (Table 2) (for each subunit, if applicable).

2.2.2 Allowable Exposure Based on Risk Assessment

Provides a summary of the regulatory guidelines governing the development of risk-based contaminant levels.

Table 1. Summary of the Potential ARARs

Table 2. Summary of the COCs for the Unit Acronym

2.2.3 Development of Remediation Goals

Provides a list of the remediation goals for the unit. Reference table of RGOs (Table 3) (for each subunit if applicable).

2.3 General Response Actions

Provides a discussion of the actions that could be used to address contaminants at the unit. For each medium of interest, a description of the estimate of the area or volume to which treatment, containment, or exposure technologies may be applied.

2.4 Identification of Screening of Technology Types and Process Options

Provides a description of the universe of potentially applicable technology types and process options.

2.4.1 Identification and Screening of Technologies

Provides a discussion of the technology types that are suitable for use at the unit as well as a discussion of the viable process options. Reference the technology screening table (Table 4.)

2.4.2 Evaluation of Technologies and Selection of Representative Technologies

Provides an evaluation of how reasonable the use of the technologies will be at the site using the broad categories of effectiveness, implementability, and cost as criteria. Describes the technologies that have been selected to represent the suitable technology types.

Table 3. Summary of the Unit Acronym RGOs

Table 4. Summary of the Screening of Technologies

3.0 DEVELOPMENT AND SCREENING OF ALTERNATIVES

The purpose of this section is to provide the reader with a description of the range of alternatives under consideration and the documentation of the evaluation of each alternative using broad categories of effectiveness, implementability, and cost as criteria. Note that this section will be significantly streamlined for focused CMS/FS reports.

Present worth costs should include a statement listing the basis for those costs. The discount rate (2.1% for 1 to 3 years, 2.8% for 4 to 5 years, 3.0% for 6 to 7 years, 3.1% for 8 to 10 years, and 3.9% for 11 years or longer) and the length of time used for O&M costs must be stated. Use the actual expected length of time in the calculations. If the costs are expected to continue beyond 30 years; but, the time is indefinite use 200 years.

3.1 Development of Alternatives

Provides a description of the alternatives developed by assembling combinations of technologies and the media to which they apply. A minimum of 3 alternatives must be evaluated. For example, if a No Action Alternative and a Land Use Control Alternative are under consideration, a third alternative that reduces the toxicity, mobility, or volume of the hazardous substances, pollutants, or contaminants must also be included. (Reference 40 CFR 300.430(e)(3) for more information).

3.2 Screening of Alternatives

Provides a description of the alternatives (Table 5) and evaluates them for use at the unit in question.

3.2.1 Introduction

Provides any relevant introductory information.

3.2.2 Alternative 1

3.2.2.1 Description

Provides a description of the alternative

3.2.2.2 Evaluation

Provides an evaluation of how reasonable the use of the alternative will be for the unit.

3.2.3 Alternative 2

3.2.3.1 Description

Repeat from above for each alternative developed.

3.2.3.2 Evaluation

Repeat from above for each alternative developed.

3.2.4 Alternative 3

3.2.4.1 Description

Repeat from above for each alternative developed.

3.2.4.2

Repeat from above for each alternative developed.

Table 5. Summary of the Screening of Alternatives

4.0 DETAILED ANALYSIS OF ALTERNATIVES

The purpose of this section is to provide the reader with a discussion of the detailed analyses and evaluations performed in order to evaluate each alternative.

4.1 Introduction

Provides any introductory information needed.

4.2 Individual Analysis of Alternatives

Provides a detailed analysis of each alternative for each of the following evaluation criteria:

- Overall protection of human health and the environment
- Compliance with ARARs
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume through treatment
- Short-term effectiveness
- Implementability
- Cost
- Community acceptance
- State acceptance

4.2.1 Alternative 1

4.2.1.1 Description

Provides the description of alternative 1.

4.2.1.2 Assessment

Provides the description of the assessment of alternative 1

4.2.2 Alternative 2

4.2.2.1 Description

Repeat from above for each alternative developed.

4.2.2.2 Assessment

Repeat from above for each alternative developed.

4.2.3 Alternative 3

4.2.3.1 Description

Repeat from above for each alternative developed.

4.2.3.2 Assessment

Repeat from above for each alternative developed.

4.3 Comparative Analyses

Provides a discussion of the relative strengths and weaknesses of the alternatives with respect to each of the evaluation criteria (Tables 6 and 7).

Table 6. Comparison of the Alternatives to the Nine Criteria

Table 7. Summary of the Present Value Costs of the Alternatives

5.0 REFERENCES

Provide a list of the resources used to develop the CMS/FS report.

SAMPLING AND ANALYSIS PLAN FORMAT

1.0 INTRODUCTION

This Sampling and Analysis Plan (SAP) was prepared in accordance with the United States Environmental Protection Agency (USEPA) *Uniform Federal Policy for Quality Assurance Project Plans* (USEPA, et al, 2005) and the *Area Completion Projects Programmatic Quality Assurance Project Plan for Environmental Data Collection and Management* (SRNS 2012). Project or task specific information for the waste unit is documented in the SAP and refers to the program level Quality Assurance Program Plan (QAPP) (SRNS 2012) for the program level quality objectives, standard operating procedures, and quality assurance/quality control procedures.

1.1 Sampling Unit Name and Purpose for Sampling

This section of the SAP is to present the following information: 1) reason/purpose for sampling, 2) relevant background information; 3) the regulatory framework for the unit investigation; 4) and any evaluations and decisions made during the scoping process.

1.2 Sampling Unit Location

This section provides a brief description of where the sampling unit is located at SRS and with respect to the larger area operable unit, if any. Figure 1 should also be provided to illustrate the sampling area location.

1.3 Statement of Broad Objectives for the Sampling

This section presents the project-specific objectives for conducting the sampling event. This is a general description of the media to be sampled and specific uses for the data. The level of detail in individual SAP documents will vary according to the work being performed and the intended us of the data. For this reason, a graded approach should be used for establishing the project requirements according to the intended use of the results and the

degree of confidence needed in the quality of the results. The degree of documentation, level of effort, and detail will vary based on the scope, complexity, and cost of the project.

2.0 SAMPLING UNIT BACKGROUND

2.1 Sampling Area Physical and Geographical Description

This section presents background information about the physical characteristics of the sampling unit such as unit-specific geologic and hydrogeologic description (if available), climatic conditions, physical setting, waste composition, history, and size and/or volume.

2.2 Operational History

This section presents any operational knowledge about the sampling unit such as history of contamination, type of contaminants, nature of contamination, and any details concerning process knowledge.

2.3 Previous Investigations/Regulatory Actions

Provides a brief discussion of the regulatory history, previous sampling results, chronology, and outcome of previous investigations and any remedial, removal, or interim actions previously completed (reference any parent document(s).

2.4 Summary of Existing Data Compared to Risk-Based Thresholds

Tables 1 and 2 summarize detected waste unit contaminant concentrations by media/waste unit and compare them to risk-based thresholds or Maximum Contaminant Levels (MCLs). Risk-based thresholds include USEPA Regional Screening Levels (RSLs) for soil, sediment, and tap water. MCLs are risk-based drinking water concentrations that have been determined based upon consideration of the limits of detection, available treatment technologies, and cost and are compared to groundwater concentrations. Contaminant concentrations are also compared to Preliminary Remediation Goals (PRGs) for concrete and all radiological contaminated media.

3.0 PROJECT DATA QUALITY OBJECTIVES (DQOs)

The Data Quality Objective (DQO) process is a series of logical steps that guides managers or staff to a plan for the resource-effective acquisition of environmental data. It is both flexible and iterative, and applies to both decision-making (e.g., compliance/non-compliance with a standard) and estimation (e.g., ascertaining the mean concentration level of a contaminant). The DQO process is used to establish performance and acceptance criteria, which serve as the basis for designing a plan for collecting data of sufficient quality and quantity to support the goals of the study. Use of the DQO process leads to efficient and effective expenditure of resources; consensus on the type, and quantity of data needed to meet the project goal; and the full documentation of actions taken during the development of the project. The DQO process is a series of seven planning steps based on the scientific method (Sections 3.1.1 to 3.1.7 below) and is detailed in United States Environmental Protection Agency (USEPA) Guidance (USEPA 2006).

3.1 Subunit 1/Media 1 **(Listed by either subunit or media)**

3.1.1 State the Problem

This is a concise and detailed statement(s) of the problem(s) which will be resolved with the data being collected. This section should describe the problem, develop a conceptual model of the environmental hazard(s) (Figure 2) to be investigated, identify the general type of data needed, discuss alternative approaches to the investigation and solving the problem, and identify any constraints associated with data collection and data assessment.

3.1.2 Identify Goals of the Study

This section presents the study questions, alternative outcomes, and decision statements of the study. This section should identify principal study questions and define alternative actions based on possible outcomes which result from answering the study questions, use the study question(s) and alternative actions to make a decision statement, and organize multiple decisions into an order of priority.

3.1.3 Identify Information Inputs

This section will identify the sources of information that will be used to answer decision statements and the basis for what will be used to guide the choices to be made later. This section should identify the types of and potential sources of information, information basis for specifying performance or acceptance criteria, and the availability of appropriate sampling and analysis methods. USEPA RSL, MCL, radiological PRG, and concrete PRG tables will be used as the basis to guide decisions and screening. Tables 1 and 2 should be completed using site-specific data to help develop inputs.

3.1.4 Define the Boundaries of the Study

This section defines the spatial and/or temporal boundaries of the study area. This section should define the target population, determine any spatial or temporal boundaries, identify practical constraints, and define the scale of inference (decision unit). Define a decision unit and the scale on which decisions will be made.

3.1.5 Develop the Analytical Approach

This section specifies the population parameters for making decisions and develops "If-Then-Else" decision rules for the project. This section should specify the parameters considered to be important to make inferences about the target population, choose an RSL/PRG/MCL (from Section 3.1.3) that sets the boundary between one outcome of the decision process and an alternative and verify that there exists sampling and analysis methods that have detection limits below the risk-based threshold, construct an "If – Then" decision rule by using the risk-based threshold; determine the scale of decision making, and the alternative action(s).

3.1.6 Specify Performance or Acceptance Criteria

Most SAPs at SRS will use a biased sampling design. Please use the below paragraphs to justify the rationale for a biased sampling design.

According to USEPA guidance (USEPA 2006), "The USEPA has developed the Data Quality Objectives (DQO) Process as the Agency's recommended planning process when environmental data are used to select between two or more alternatives or to derive an estimate of contamination. The DQO process is a seven step method designed to ensure that the appropriate type, quantity, and quality of environmental data are collected for the intended application. SW-846 methods are analytical procedures for sample analyses and are presented in the Analytical Plan, Section 5, Analytical Plan. Section 4 presents DQO worksheets developed for each subunit and/or media and specifies the quantity, type, and quality, of data as well as ensuring representative data is collected for each sampling population.

Total study error is the additive impact of two main sources of error: 1) sampling error and 2) measurement error, with sampling error being responsible for the vast majority of the total error. "As much as 90% or more of the uncertainty in environmental data sets is due to sampling variability as a direct consequence of the heterogeneity of the environmental matrices" (Crumbling 2001). The method best suited to reduce sampling error is to gather representative samples (Crumbling 2001).

It is incorrect to assume that randomly collected, non-representative samples, plus perfect analytical chemistry will always lead risk managers to correct risk management decisions. In order to avoid incorrect risk management decisions, it is more important to develop Decision Quality Data (DQD). DQD is defined as "Data of known quality that can logically be demonstrated to be effective for making the specified decision because both the sampling and analytical uncertainties are managed to the degree necessary to meet clearly defined and stated data needs (Crumbling 2001). Therefore, it is more important for the risk managers to use decision quality data, emphasizing representative sampling with a specified percentage of definitive data, in order to make a correct decision and should not be confused by emphasizing analytical data quality which does not necessarily equate to a correct risk management decision.

Because the Savannah River Site (SRS) possesses significant process and historical knowledge and in most instances has preliminary or survey data results for the majority of its waste units, this sampling plan will largely control sampling error (the cause of greatest total error) and set tolerable limits on decision errors by gathering data by judgmental, judgmental-stratified, and systematic sampling designs based on process knowledge, existing data, historical information/data, survey data, and institutional knowledge to generate decision quality data. This is the method SRS will use to control decision errors, since sample collection will be focused in areas of known contamination rather than using a sampling design intended to randomly search for contamination. Judgmental sampling provides a very conservative and certain method for collecting data with a high likelihood for detecting worst-case contaminant concentrations while reducing total study error.

The (DQOs) for the (operable unit name) represent the type and level of analytical quality needed for characterization at this unit and can be found in Sections 4 and 5 of this SAP.

If a statistical-based sample design is required such as for confirmation sampling then this section should specify the decision rule(s) as a statistical hypothesis test and determine the acceptable limits on decision errors. In this section the decision rule should be specified as a statistical hypothesis test that examines the consequences of making an incorrect decision from the test, and place acceptable limits on the likelihood of making decision errors. If developing a statistically controlled sampling design, either the USEPA Decision Error Feasibility Trial software (DEFT) or the Visual Sampling Plan (VSP) is recommended to develop acceptance criteria to control decision errors.

3.1.7 *Develop the Plan for Obtaining the Data (Project Quality Objectives)*

This section documents the selected sampling design that will yield data that will best attain the quality objectives for the project. This section should summarize all the information from the previous steps, apply this information to identify alternative sampling designs that are appropriate for use, and document a sampling design that will yield the data that best answers the study questions plus obtains sufficient data quality. Clearly stated Project

Quality Objectives (PQOs) should be included in this section in order for the developers of the Data Usability Report (DUR) to assess whether the SAP has achieved its quality objectives for the collected data to be qualified for project decision-making. PQOs are qualitative and quantitative statements derived from the DQO process that clarify study objectives the measurement performance critieria which define the appropriate types of data and acceptance limits for data. PQOs are used as the basis for establishing the quality and quantity of data needed to support decisions.

Examples of PQO statements in terms of measurement performance criteria statements are as follows:

- RPD (relative percent difference) < 20% between regular groundwater sample and field duplicate when result >= ssEQL for precision data quality indicator
- RPD < 35% between regular soil sample and field duplicate when result >= ssEQL for precision data quality indicator
- RPD < 100% when groundwater sample result >= MDL but < ssEQL for precision data quality indicator
- RPD < 200% when soil sample result >= MDL but < ssEQL for accuracy/bias for precision data quality indicator
- Percent Recovery from Matrix Spike (MS) and Matrix Spike Duplicates (MSD) are generally >= 135% or < 30% for accuracy/bias data quality indicator. MS recovery windows may be tighter than those listed. Refer to the Measurement Performance Criteria Tables in the QAPP (SRNS 2012) for analyte and media-specific recovery percentages.
- No target compound >= ssEQL for equipment blank, field blanks, method blanks, or instrument blanks for accuracy data quality indicator
- ssEQL < MCL, RSL, or PRG for sensitivity data quality indicator
- Split sample result will have an RPD = 100% for groundwater samples and 200% for soil samples.
- 5% of the samples will be split samples for the comparability data quality indicator.

- 95% of samples sent to laboratory have useable (non-rejected) results for completeness data quality indicator
- 90% of planned samples are collected and their data are useable for completeness data quality indicator
- The objective for the representativeness data quality indicator is qualitative and will be met by properly documenting field and analytical protocols. In the event these procedures and methods are not able to be implemented, the appropriate corrective action documentation should encompass the impact on the representativeness of the information. When review of the data and documentation determines the data to be nonrepresentative, the information is qualified for use or is not used by the project.

4.0 SAMPLING DESIGN AND RATIONALE

Implementation of the SAP to obtain decision quality data for each subunit/media is documented in the remaining sections of this sampling and analysis plan. The following section describes how the plan is implemented to collect the physical data to meet the criteria developed during the DQO process.

4.1 Rationale for Subunit 1/Media 1

This section presents a description outlining the rationale for the sampling design/strategy using the conceptual site model. This section is also a comprehensive description discussing sample collection and how it integrates with the sample design/strategy. These are detailed statements of how the number of samples, the analytical analyses, sample locations, analytical data quality, and sampling design achieve the performance and acceptance criteria. There should be a rationale for each subunit/media described in separate sections (Section 4.2, 4.3, etc.) for each subunit/media.

The rationale and details of the sampling design/strategy are summarized in the DQO Worksheets for each subunit and/or sampling media. Example DQO worksheets are found in Tables 3 (soil), 4 (groundwater), and 5 (surface water).

5.0 ANALYTICAL PLAN

This section describes the data quality levels for each type of data being collected. All data collected under this SAP will follow the *Area Completion Projects Quality Assurance Project Plan for Environmental Data Collection* and *Management* (QAPP) (SRNS 2012). The data quality level is determined by the intended use of the data.

5.1 Data Quality Levels for Subunit/Media

A) Subunit 1/Media 1 data quality level should be defined here

B) Subunit 1/Media 2 data quality level should be defined here

Table 6 or parts of Table 6 may be used to illustrate analytical data quality levels and its correlated quality assurance/quality control field samples. To provide assistance in determining appropriate data quality levels, the Uniform Federal Policy (UFP) (USEPA, et al, 2005) states:

> **Screening data** are analytical data that are of sufficient quality to support an intermediate or preliminary decision but must eventually be supported by definitive data before a project is complete.
>
> **Definitive data** are analytical data that are suitable for final decision-making which includes data used for human health risk assessment, PTSM determination, contaminant migration, and ecological risk assessment. Please refer to the UFP for more information.

5.2 Field Analytical Sampling Quality Assurance/Quality Control

Provide a table with the type and number of regular (soils, sediments, surface water, and groundwater) and field QC samples required for collection in the sampling plan. Refer to example Table 11. The number and type of field samples can be variable depending upon the needs of the project. *If there are no field QA/QC samples collected, the data is of unknown quality and will not be validated or used for remedial decision making.

Field Quality Control/Quality Control Samples

A) Field Duplicates
B) Rinsate/Equipment Blanks
C) Field Blanks
D) Trip Blanks
E) Split Samples

Field quality assurance/quality control will be maintained through the use of quality control/quality (QA/QC) samples and methods as described below:

1. Field Duplicate (co-located) Samples: Two or more independent samples collected from side-by-side locations at the same point in time and space so as to be considered identical. These separate samples are intended to represent the same population and are carried through all steps of the sampling and analytical procedures in an identical manner. These samples are used to assess precision of the total method, including sampling, analysis, and site heterogeneity. Field duplicate samples are planned at a combined minimum rate of 5% according to ER-SOP-043, or typically 1 per 20 samples and analyzed for the same parameters as the associated samples.

2. Equipment Blank: A sample of water free of measurable contaminants poured over or through decontaminated field sampling equipment that is considered ready to collect or process an additional sample. The purpose of this blank is to assess the adequacy of the decontamination process. Also called rinse blank or rinsate blank. Equipment blanks are typically planned at a rate of 1 blank per 40 samples.

3. Field Blank: A blank used to provide information about contaminants that may be introduced during sample collection, storage, and transport; also a clean sample exposed to sampling conditions, transported to the laboratory, and treated as an environmental sample. Field blanks are optional and may be collected when contamination from external environmental sources is anticipated by the project

team. Typically field blanks, when used, are planned at a rate of 1 blank per 40 samples.

4. Trip Blank: A clean sample of water free of measurable contaminants that is taken to the sampling site and transported to the laboratory for analysis without having been exposed to sampling procedures. Trip blanks are analyzed to assess whether contamination was introduced during sample shipment (typically analyzed for volatile organic compounds only). A blank consists of distilled-deionized water provided by the laboratory to be placed in every cooler with VOC samples typically at the rate of 1 trip blank per cooler.

5. Split Samples: Two or more representative portions from a sample in the field, analyzed by at least two different laboratories and/or methods. Prior to splitting, a sample is mixed (except volatiles, oil and grease, or when otherwise determined) to minimize sample heterogeneity. These are quality control samples used to assess precision, variability, and data comparability between laboratories. Split samples are planned at a combined minimum rate of 5% or typically 1 per 20 samples and analyzed for the same parameters as the associated samples.

5.3 Sample Matrix Table

Develop a Sampling Matrix Table to include all the below information. Refer to Table 11 for a comprehensive example.

A) Sample Count
B) Coordinates*
C) Sample ID
D) Sample Number
E) Field Quality Control Samples
F) Sample Collection Method
G) Media
H) Sample Depth (depth below ground surface)
I) Subunit Location
J) Analytical Suites

*Proposed coordinates may change as necessary due to field conditions.

The sample matrix table or text should provide a summary of the number of each type of sample collected.

5.4 Sample Location Map

Develop a figure (Figure 3) that illustrates the proposed locations of samples to be collected for all matrices. Contingency sample locations should be included.

6.0 FIELD IMPLEMENTATION

6.1 List of Sampling/Collection Equipment

This section lists type of sampling/collection equipment needed to execute the Field Implementation Plan. Examples include:

- Hand augers
- Hand scoops
- Organic Vapor Analyzer (OVA) meter
- Portable/hand-held pH meter
- Portable/hand-held Conductivity meter
- Lanthanum-Bromide (La-Br) gamma detector
- Global Positioning System (GPS) Unit
- KIJ-5 Radio

- Sample bottles with preservatives
- Coolers

6.2 Investigation Derived Waste

Investigation Dervied Waste (IDW) will be managed according to the site-specific IDW management plan developed for the project.

REFERENCES

1. Crumbling, Deana M. et. al, 2001. "*Managing Uncertainty in Environmental Decisions*", Environmental Science & Technology, 2001, American Chemical Society, October 1, 2001, pages 405A-409A.

2. SRNS, 2012. *Area Completion Projects Programmatic Quality Assurance Project Plan for Environmental Data Collection and Management*, ERD-AG-2005-00001, Revision 5, Savannah River Site, Aiken, SC 2009.

3. USEPA, USDOD, USDOE, 2005. *Uniform Federal Policy for Quality Assurance Project Plans*, EPA:-505-B-04-900A, Version 1 Final, March 2005.

4. USEPA, 2006. *Guidance on Systematic Planning Using the Data Quality Objectives Process*, EPA QA/G-4, EPA/240/B-06/001, February 2006.

5. USEPA, Various Updates. *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846,* Third Edition Basic Manual with Updates.

Figure 1 Location of the Sampling Unit

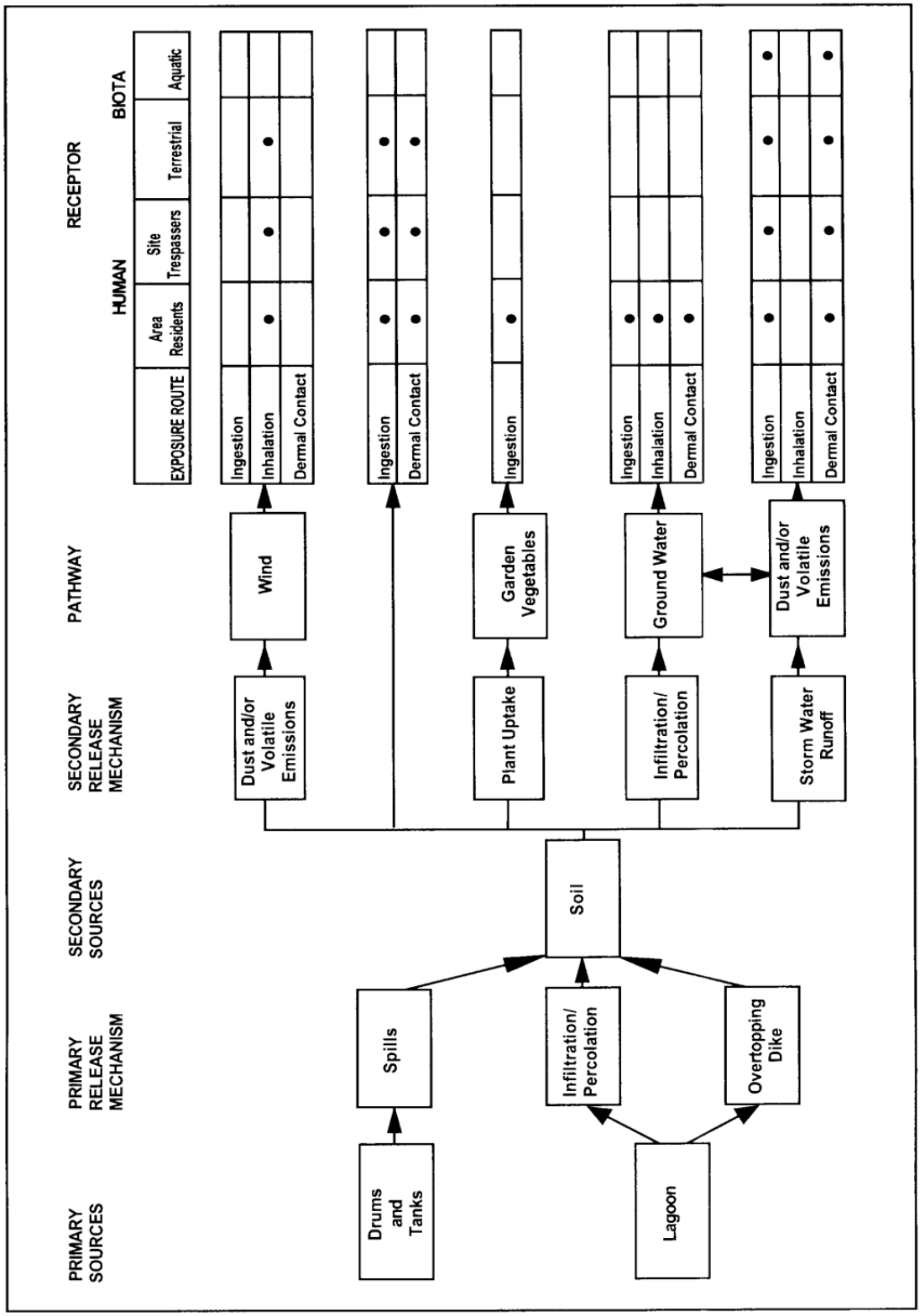


Figure 2 Conceptual Site Model for Contaminated Soil

Figure 3 Map Illustrating Sampling Location for All Media

TABLES

Table 1 Soil Analyte Concentrations Compared to Regional Screening Levels

Table 2 Water Analyte Concentrations Compared to Regional Screening Levels and/or Maximum Contaminant Levels

Table 3 Example of Data Quality Objectives Worksheet for Soil Media

Pathway (Media)	Probable Conditions	Exposure Pathway and/or Release Mechanisms	Data Needs and DQOs Including Engineering/Physical Processes	Field Activities Including Removal and Characterization	Parameters	Potential Remedial Action Alternatives
Surface soil, subsurface soil, deep soil	Radiological contamination of gravel and/or soil from overflows and spills from radioactive water from the cask cars Infiltration/percolation of contaminated water through onto gravel and/or surface and subsurface soils	Ingestion, inhalation, absorption, or direct exposure with soil	Use Background Soils Study for background soil concentrations Determine the nature and vertical and horizontal extent of contamination Qualitative and quantitative concentration data of soil contaminants Determine surficial risk (COCs) due to direct exposure with rad contaminated gravel or soils Determine contaminant migration (CMCOCs) potential through contaminant migration analysis Determine PTSM through evaluation of data Determine geotechnical properties of soil media If soil is determined to be contaminated, then continue to move contingency samples outward in a radial direction from the last sample station until the deepest sample screens clean with the Canberra 1000	Perform radiological survey with Canberra 1000 of rail road track, cross-ties, and up to 6 feet on either side of the rail road bed in order to detect the presence of radiological contaminants above background levels Use ISOCS and/or lanthanum-bromide portable detectors to in-situ quantify activities of “Hot Spots” in gravel. Soil samples from “hot spots” to quantify activity in soil. Soil samples will be collected at all areas identified above background. Soil samples should be from interface of gravel-soil. Step-outs will be planned at 3 foot intervals, if contamination is not bounded, to determine both the vertical and horizontal extent.	90% Screening–level data quality 10% definitive-level data quality Full TAL/TCL suite with alpha/beta radiological indicators and gamma PHA suite. Speciate samples if radiological 20/50 trigger levels are exceeded. Hydraulic conductivity, total porosity, effective porosity, grain size analysis, bulk density, moisture content	Institutional Controls Excavation of contaminated gravel and or soils Cover System

Table 4 Example of Data Quality Objectives Worksheet for Groundwater Media

Pathway (Media)	Probable Conditions	Exposure Pathway and/or Release Mechanisms	Data Needs and DQOs Including Engineering/Physical Processes	Field Activities Including Removal and Characterization	Parameters	Potential Remedial Action Alternatives
Groundwater	Contamination of groundwater from leaching and spills from primary sources	Ingestion or dermal contact with groundwater, showering (includes inhalation and dermal), or inhalation of vapor from groundwater	Determine groundwater background concentrations using up-gradient CPT groundwater samples Define the nature, vertical, horizontal extent, and 3-D geometry of any detected groundwater plumes Qualitative and quantitative concentration data of groundwater contaminants Attempt to identify the source zone of groundwater contamination by tracing the plume back to the source zone Trace the groundwater plume to discharge zones in surface water Collect hydr0geologic and lithologic data of subsurface to provide data for unsaturated and saturated zone modeling Determine if the groundwater plume has migrated beneath XYZ Branch Creek Determine if next deepest aquifer has been contaminated to bound the plume vertically	First, perform CPT geophysical logging of all sample locations including tip pressure, sleeve friction, pore-pressure, and resistivity Push continues until tool refusal Use the geophysical logs to select multiple depth-discrete groundwater sampling locations Collect groundwater samples and analyze for TCL VOCs and tritium Use real time analytical data and CPT logs to locate the next sampling stations If groundwater contaminant concentrations at any sample station exceed the MCL, then continue groundwater sampling both parallel and perpendicular to the longitudinal axis of the of the plume(s), until the groundwater concentrations are less than the MCL or lead to a groundwater discharge zone	90% Screening–level data quality 10% definitive-level data quality TCL VOC suite and tritium Hydraulic conductivity, total porosity, effective porosity, grain size analysis, bulk density collected from geotechnical samples in the saturated zone	Institutional Controls Monitored Natural Attenuation Remedy ZVI recirculation wells Phyto-remediation

Table 5 Example of Data Quality Objectives Worksheet for Surface Water and Sediment Media

Pathway (Media)	Probable Conditions	Exposure Pathway and/or Release Mechanisms	Data Needs and DQOs Including Engineering/Physical Processes	Field Activities Including Removal and Characterization	Parameters	Potential Remedial Action Alternatives
Surface water and sediment	Surface water and sediment may be contaminated from groundwater discharging to local creeks	Ingestion, inhalation, or dermal contact with contaminated surface water or sediment in creeks	Qualitative and quantitative concentration data of surface water contaminants and co-located sediment samples to determine impact to potential receptors from the contaminated groundwater discharge Determine the linear extent of impacted surface water and sediment Determine best long-term monitoring locations for surface water Bound the extent of impacted stream discharge zones	Surface water and sediment sampling to be conducted after the groundwater plume discharge zone(s) have been identified and the area of discharge has been determined Use linear-judgmental sampling design to collect surface water samples Use trowel method for sediment sample collection in the same location as the surface water sample Collect surface water and sediment samples working from down-gradient to up-gradient so subsequent samples will not be contaminated from stream flow	90% Screening–level data quality 10% definitive-level data quality TCL VOC suite and tritium	Institutional Controls Monitored Natural Attenuation Remedy None based on existing data

Table 6 Minimum Field Quality Control/Quality Assurance Sampling Requirements

Data Quality Level	Field Quality Control/Quality Assurance Samples	Frequency of Field Quality Control/ Quality Assurance Sample
UU	None	
VU	None	
VV	Co-located Field Duplicate	Minimum 5%[1]
	Trip Blank	Minimum 1 per cooler
	Equipment Blank	1 per 40 samples[2]
	Field Blank	Optional; 1 per 40 samples[3]
	Split Sample	Minimum 5%
SD	Co-located Field Duplicate	Minimum 5%[1]
	Trip Blank	1 per cooler
	Equipment Blank	1 per 40 samples[2]
	Field Blank	Optional; 1 per 40 samples[3]
	Split Sample	Minimum 5%
D	Co-located Field Duplicate	Minimum 5%[1]
	Trip Blank	1 per cooler
	Equipment Blank	1 per 40 samples[2]
	Field Blank	Optional; 1 per 40 samples[3]
	Split Sample	Minimum 5%

Data Quality Levels

UU Data **Unverified and Unvalidated Data (no errors from ERDMs database loading screens)**
VU Data **Verified and Unvalidated Data (includes missing data checks)**
VV Data **Verified and Validated Data (validated to automated criteria; equivalent to USEPA Screening Level Data)**
SD Data **USEPA Screening Level Data with 10% Definitive Confirmation**
D Data **USEPA Definitive Level Data**

Footnotes:
1. **Minimum frequency established per ER-SOP-043**
2. **Typical frequency**
3. **Recommended based on project needs; typical frequency**

Table 7 Laboratory Analytical Specifications Table TAL/TCL Analytes for Soil and Sediment Media

Analyte	Analyte ID	Preparation [B] Method	EPA [B] Method	CRDL [A] (mg/kg)
Target Analyte List				
Cyanide				
Cyanide	57-12-5		EPA9012B	3.0
Metals				
Aluminum	7429-90-5	3051A,3052	EPA6010C	1.9
Antimony	7440-36-0	3051A,3052	EPA6010C	0.35
Arsenic	7440-38-2	3051A,3052	EPA6010C	0.312
Barium	7440-39-3	3051A,3052	EPA6010C	0.021
Beryllium	7440-41-7	3051A,3052	EPA6010C	0.0311
Cadmium	7440-43-9	3051A,3052	EPA6010C	0.04
Calcium	7440-70-2	3051A,3052	EPA6010C	0.069
Chromium	7440-47-3	3051A,3052	EPA6010C	0.09
Cobalt	7440-48-4	3051A,3052	EPA6010C	0.08
Copper	7440-50-8	3051A,3052	EPA6010C	0.1
Iron	7439-89-6	3051A,3052	EPA6010C	2.19
Lead	7439-92-1	3051A,3052	EPA6010C	0.59
Magnesium	7439-95-4	3051A,3052	EPA6010C	0.0141
Manganese	7439-96-5	3051A,3052	EPA6010C	0.0885
Mercury	7439-97-6	3051A,3052	EPA7471B	0.0152
Nickel	7440-02-0	3051A,3052	EPA6010C	0.088
Potassium	7440-09-7	3051A,3052	EPA6010C	0.08
Selenium	7782-49-2	3051A,3052	EPA6010C	0.0057
Silver	7440-22-4	3051A,3052	EPA6010C	0.101
Sodium	7440-23-5	3051A,3052	EPA6010C	0.298
Thallium	7440-28-0	3051A,3052	EPA6010C	0.16
Vanadium	7440-62-2	3051A,3052	EPA6010C	0.074
Zinc	7440-66-6	3051A,3052	EPA6010C	0.0043
Special Analysis				
Hexavalent chromium (Cr^{+6})	1333-82-0	3060A	EPA7196A/7199	TBD
Target Compound List				
PCBs				
AROCLOR 1016	12674-11-2	3540C,3541,3545A	EPA8082A	0.0032
AROCLOR 1221	11104-28-2	3540C,3541,3545A	EPA8082A	0.00022
AROCLOR 1232	11141-16-5	3540C,3541,3545A	EPA8082A	0.00022
AROCLOR 1242	53469-21-9	3540C,3541,3545A	EPA8082A	0.00022
AROCLOR 1248	12672-29-6	3540C,3541,3545A	EPA8082A	0.00022
AROCLOR 1254	11097-69-1	3540C,3541,3545A	EPA8082A	0.00022
AROCLOR 1260	11096-82-5	3540C,3541,3545A	EPA8082A	0.00022
Pesticides				
Aldrin	309-00-2	3540C,3541,3545A,3550C	EPA8081B	0.000029
alpha-Benzene hexachloride	319-84-6	3540C,3541,3545A,3550C	EPA8081B	0.000066
alpha-Chlordane	5103-71-9	3540C,3541,3545A,3550C	EPA8081B	0.000021

Analyte	Analyte ID	Preparation [B] Method	EPA [B] Method	CRDL [A] (mg/kg)
beta-Benzene hexachloride	319-85-7	3540C,3541,3545A,3550C	EPA8081B	0.00032
DDD	72-54-8	3540C,3541,3545A,3550C	EPA8081B	0.0024
DDE	72-55-9	3540C,3541,3545A,3550C	EPA8081B	0.0017
DDT	50-29-3	3540C,3541,3545A,3550C	EPA8081B	0.00101
delta-Benzene hexachloride	319-86-8	3540C,3541,3545A,3550C	EPA8081B	0.000066
Dieldrin	60-57-1	3540C,3541,3545A,3550C	EPA8081B	0.00003
Endosulfan I	959-98-8	3540C,3541,3545A,3550C	EPA8081B	0.000066
Endosulfan II	33213-65-9	3540C,3541,3545A,3550C	EPA8081B	0.00013
Endosulfan sulfate	1031-07-8	3540C,3541,3545A,3550C	EPA8081B	0.00013
Endrin	72-20-8	3540C,3541,3545A,3550C	EPA8081B	0.00013
Endrin aldehyde	7421-93-4	3540C,3541,3545A,3550C	EPA8081B	0.00013
Endrin ketone	53494-70-5	3540C,3541,3545A,3550C	EPA8081B	0.00034
gamma-Chlordane	5103-74-2	3540C,3541,3545A,3550C	EPA8081B	C
Heptachlor	76-44-8	3540C,3541,3545A,3550C	EPA8081B	0.00044
Heptachlor epoxide	1024-57-3	3540C,3541,3545A,3550C	EPA8081B	0.00059
Lindane	58-89-9	3540C,3541,3545A,3550C	EPA8081B	0.000066
Methoxychlor	72-43-5	3540C,3541,3545A,3550C	EPA8081B	0.00113
Toxaphene	8001-35-2	3540C,3541,3545A,3550C	EPA8081B	0.0187
Semi-volatiles				
2,4,5-Trichlorophenol	95-95-4	3540C,3541,3545A,3550C	EPA8270D	0.0074
2,4,6-Trichlorophenol	88-06-2	3540C,3541,3545A,3550C	EPA8270D	0.0074
2,4-Dichlorophenol	120-83-2	3540C,3541,3545A,3550C	EPA8270D	0.014
2,4-Dimethylphenol	105-67-9	3540C,3541,3545A,3550C	EPA8270D	0.014
2,4-Dinitrophenol	51-28-5	3540C,3541,3545A,3550C	EPA8270D	0.12
2-Chlorophenol	95-57-8	3540C,3541,3545A,3550C	EPA8270D	0.0057
2-Methyl-4,6-dinitrophenol	534-52-1	3540C,3541,3545A,3550C	EPA8270D	0.0078
2-Nitrophenol	88-75-5	3540C,3541,3545A,3550C	EPA8270D	0.013
4-Chloro-m-cresol	59-50-7	3540C,3541,3545A,3550C	EPA8270D	0.0555
4-Nitrophenol	100-02-7	3540C,3541,3545A,3550C	EPA8270D	0.156
m/p-Cresol	1319-77-3	3540C,3541,3545A,3550C	EPA8270D	0.096
o-Cresol (2-Methylphenol)	95-48-7	3540C,3541,3545A,3550C	EPA8270D	0.0056
Pentachlorophenol	87-86-5	3540C,3541,3545A,3550C	EPA8270D	0.003
Phenol	108-95-2	3540C,3541,3545A,3550C	EPA8270D	0.0062
1,2,4,5-Tetrachlorobenzene	95-94-3	3540C,3541,3545A,3550C	EPA8270D	0.17
2,3,4,6-Tetrachlorophenol	58-90-2	3540C,3541,3545A,3550C	EPA8270D	0.17
1,1'-Biphenyl	92-52-4	3540C,3541,3545A,3550C	EPA8270D	0.35
2,4-Dinitrotoluene	121-14-2	3540C,3541,3545A,3550C	EPA8270D	0.0446
2,6-Dinitrotoluene	606-20-2	3540C,3541,3545A,3550C	EPA8270D	0.028
2-Chloronaphthalene	91-58-7	3540C,3541,3545A,3550C	EPA8270D	0.0056
2-Methylnaphthalene	91-57-6	3540C,3541,3545A,3550C	EPA8270D	0.05
2-Nitroaniline	88-74-4	3540C,3541,3545A,3550C	EPA8270D	0.0035
3,3'-Dichlorobenzidine	91-94-1	3540C,3541,3545A,3550C	EPA8270D	0.143
4-Bromophenyl phenyl ether	101-55-3	3540C,3541,3545A,3550C	EPA8270D	0.015
4-Chloroaniline	106-47-8	3540C,3541,3545A,3550C	EPA8270D	0.016
4-Chlorophenyl phenyl ether	7005-72-3	3540C,3541,3545A,3550C	EPA8270D	0.0409
Acenaphthene	83-32-9	3540C,3541,3545A,3550C	EPA8270D	0.0352

Analyte	Analyte ID	Preparation [B] Method	EPA [B] Method	CRDL [A] (mg/kg)
Acenaphthylene	208-96-8	3540C,3541,3545A,3550C	EPA8270D	0.035
Acetophenone	98-86-2	3540C,3541,3545A,3550C	EPA8270D	0.00049
Anthracene	120-12-7	3540C,3541,3545A,3550C	EPA8270D	0.0445
Atrazine	1912-24-9	3540C,3541,3545A,3550C	EPA8270D	0.0022
Benzaldehyde	100-52-7	3540C,3541,3545A,3550C	EPA8270D	6.1
Benzo[a]anthracene	56-55-3	3540C,3541,3545A,3550C	EPA8270D	0.0294
Benzo[a]pyrene	50-32-8	3540C,3541,3545A,3550C	EPA8270D	0.0255
Benzo[b]fluoranthene	205-99-2	3540C,3541,3545A,3550C	EPA8270D	0.0553
Benzo[g,h,i]perylene	191-24-2	3540C,3541,3545A,3550C	EPA8270D	0.0296
Benzo[k]fluoranthene	207-08-9	3540C,3541,3545A,3550C	EPA8270D	0.0588
Bis(2-chloro-1-methylethyl)ether	108-60-1	3540C,3541,3545A,3550C	EPA8270D	0.0541
Bis(2-chloroethoxy) methane	111-91-1	3540C,3541,3545A,3550C	EPA8270D	0.0072
Bis(2-chloroethyl) ether	111-44-4	3540C,3541,3545A,3550C	EPA8270D	0.0695
Bis(2-ethylhexyl) phthalate	117-81-7	3540C,3541,3545A,3550C	EPA8270D	0.035
Butylbenzyl phthalate	85-68-7	3540C,3541,3545A,3550C	EPA8270D	0.028
Caprolactam	105-60-2	3540C,3541,3545A,3550C	EPA8270D	0.0463
Carbazole	86-74-8	3540C,3541,3545A,3550C	EPA8270D	0.024
Chrysene	218-01-9	3540C,3541,3545A,3550C	EPA8270D	0.0329
Dibenz[a,h]anthracene	53-70-3	3540C,3541,3545A,3550C	EPA8270D	0.0332
Dibenzofuran	132-64-9	3540C,3541,3545A,3550C	EPA8270D	0.0389
Dibutyl phthalate	84-74-2	3540C,3541,3545A,3550C	EPA8270D	0.028
Diethyl phthalate	84-66-2	3540C,3541,3545A,3550C	EPA8270D	0.028
Dimethyl phthalate	131-11-3	3540C,3541,3545A,3550C	EPA8270D	0.028
Di-n-octyl phthalate	117-84-0	3540C,3541,3545A,3550C	EPA8270D	0.028
Fluoranthene	206-44-0	3540C,3541,3545A,3550C	EPA8270D	0.0034
Fluorene	86-73-7	3540C,3541,3545A,3550C	EPA8270D	0.0379
Hexachlorobenzene	118-74-1	3540C,3541,3545A,3550C	EPA8270D	0.0322
Hexachlorobutadiene	87-68-3	3540C,3541,3545A,3550C	EPA8270D	0.0056
Hexachlorocyclopentadiene	77-47-4	3540C,3541,3545A,3550C	EPA8270D	0.0024
Hexachloroethane	67-72-1	3540C,3541,3545A,3550C	EPA8270D	0.03
Indeno[1,2,3-c,d]pyrene	193-39-5	3540C,3541,3545A,3550C	EPA8270D	0.03
Isophorone	78-59-1	3540C,3541,3545A,3550C	EPA8270D	0.044
m-Nitroaniline	99-09-2	3540C,3541,3545A,3550C	EPA8270D	0.164
Naphthalene	91-20-3	3540C,3541,3545A,3550C	EPA8270D	0.0056
Nitrobenzene	98-95-3	3540C,3541,3545A,3550C	EPA8270D	0.014
N-Nitrosodiphenylamine	86-30-6	3540C,3541,3545A,3550C	EPA8270D	0.013
N-Nitrosodipropylamine	621-64-7	3540C,3541,3545A,3550C	EPA8270D	0.0559
Phenanthrene	85-01-8	3540C,3541,3545A,3550C	EPA8270D	0.0335
p-Nitroaniline	100-01-6	3540C,3541,3545A,3550C	EPA8270D	0.028
Pyrene	129-00-0	3540C,3541,3545A,3550C	EPA8270D	0.0082
Volatiles				
1,1,1-Trichloroethane	71-55-6	5035A	EPA8260B	0.00118
1,1,2,2-Tetrachloroethane	79-34-5	5035A	EPA8260B	0.00133
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	5035A	EPA8260B	C
1,1,2-Trichloroethane	79-00-5	5035A	EPA8260B	0.00085

Analyte	Analyte ID	Preparation [B] Method	EPA [B] Method	CRDL [A] (mg/kg)
1,1-Dichloroethane	75-34-3	5035A	EPA8260B	0.00115
1,1-Dichloroethylene	75-35-4	5035A	EPA8260B	0.000054
1,2,4-Trichlorobenzene	120-82-1	5035A	EPA8260B	0.000423
1,2-Dibromo-3-chloropropane	96-12-8	5035A	EPA8260B	0.00045
1,2-Dibromoethane	106-93-4	5035A	EPA8260B	6.9E-06
1,2-Dichlorobenzene	95-50-1	5035A	EPA8260B	C
1,2-Dichloroethane (EDC)	107-06-2	5035A	EPA8260B	0.00035
1,2-Dichloropropane	78-87-5	5035A	EPA8260B	0.00035
1,3-Dichlorobenzene	541-73-1	5035A	EPA8260B	C
1,4-Dichlorobenzene	106-46-7	5035A	EPA8260B	C
2-Hexanone	591-78-6	5035A	EPA8260B	0.00286
Acetone	67-64-1	5035A	EPA8260B	0.00703
Benzene	71-43-2	5035A	EPA8260B	0.000823
Bromodichloromethane	75-27-4	5035A	EPA8260B	0.001
Bromoform (Tribromomethane)	75-25-2	5035A	EPA8260B	0.00115
Bromomethane (Methyl bromide)	74-83-9	5035A	EPA8260B	0.00256
Carbon disulfide	75-15-0	5035A	EPA8260B	0.000988
Carbon tetrachloride	56-23-5	5035A	EPA8260B	0.00122
Chlorobenzene	108-90-7	5035A	EPA8260B	0.000987
Chloroethane	75-00-3	5035A	EPA8260B	0.00269
Chloroethene (Vinyl chloride)	75-01-4	5035A	EPA8260B	0.00015
Chloroform	67-66-3	5035A	EPA8260B	0.00142
Chloromethane (Methyl chloride)	74-87-3	5035A	EPA8260B	0.0012
cis-1,2-Dichloroethylene	156-59-2	5035A	EPA8260B	C
cis-1,3-Dichloropropene	10061-01-5	5035A	EPA8260B	0.00131
Cyclohexane	110-82-7	5035A	EPA8260B	0.00008
Dibromochloromethane	124-48-1	5035A	EPA8260B	0.00103
Dichlorodifluoromethane	75-71-8	5035A	EPA8260B	0.004
Dichloromethane (Methylene chloride)	75-09-2	5035A	EPA8260B	0.00165
Ethylbenzene	100-41-4	5035A	EPA8260B	0.00107
Cumene (Isopropylbenzene)	98-82-8	5035A	EPA8260B	0.000254
Methyl acetate	79-20-9	5035A	EPA8260B	22
Methyl ethyl ketone	78-93-3	5035A	EPA8260B	0.00468
Methyl isobutyl ketone	108-10-1	5035A	EPA8260B	0.00262
Methyl tertiary butyl ether (MTBE)	1634-04-4	5035A	EPA8260B	0.000107
Methylcyclohexane	108-87-2	5035A	EPA8260B	2.6
Styrene	100-42-5	5035A	EPA8260B	0.00072
Tetrachloroethylene (PCE)	127-18-4	5035A	EPA8260B	0.00142
Toluene	108-88-3	5035A	EPA8260B	0.00107
trans-1,2-Dichloroethylene	156-60-5	5035A	EPA8260B	0.002
trans-1,3-Dichloropropene	10061-02-6	5035A	EPA8260B	0.00113
Trichloroethylene (TCE)	79-01-6	5035A	EPA8260B	0.00137
Trichlorofluoromethane	75-69-4	5035A	EPA8260B	0.002
o-Xylene	95-47-6	5035A	EPA8260B	0.00311
m,p-Xylene	MPXYL	5035A	EPA8260B	0.005

Analyte	Analyte ID	Preparation [B] Method	EPA [B] Method	CRDL [A] (mg/kg)
Bromochloromethane	74-97-5	5035A	EPA8260B	0.005
1,4-Dioxane	123-91-1	5035A	EPA8260B	0.1
1,2-Dichlorobenzene	95-50-1	5035A	EPA8260B	.005
1,2,3-Trichlorobenzene	87-61-6	5035A	EPA8260B	.005

A) CRDL is the Contract Required Detection Limit and is not always attainable.
B) Extraction and preparation methods differ depending upon media, concentration, instrument, laboratory, and analytical method. Preparation methods will also influence detection limits.
C) Laboratory instructed to obtain the lowest possible method detection limit.

Table 8 Laboratory Analytical Specifications Table for TAL/TCL Analytes for Surface or Groundwater Media

Analyte	Analyte ID	Preparation [B] Method	Analytical [B] Method	CRDL [A] (µg/L)
Target Analyte List				
Cyanide				
Cyanide	57-12-5	NA	EPA9012B	4.0
Metals				
Aluminum	7429-90-5	3005A,3015A	EPA6010C	2.0
Antimony	7440-36-0	3005A,3015A	EPA6010C	2.0
Arsenic	7440-38-2	3005A,3015A	EPA6010C	2.0
Barium	7440-39-3	3005A,3015A	EPA6010C	1.0
Beryllium	7440-41-7	3005A,3015A	EPA6010C	2.0
Cadmium	7440-43-9	3005A,3015A	EPA6010C	2.0
Calcium	7440-70-2	3005A,3015A	EPA6010C	2.0
Chromium	7440-47-3	3005A,3015A	EPA6010C	2.0
Cobalt	7440-48-4	3005A,3015A	EPA6010C	2.0
Copper	7440-50-8	3005A,3015A	EPA6010C	2.0
Iron	7439-89-6	3005A,3015A	EPA6010C	13.0
Lead	7439-92-1	3005A,3015A	EPA6010C	3.4
Magnesium	7439-95-4	3005A,3015A	EPA6010C	2.0
Manganese	7439-96-5	3005A,3015A	EPA6010C	2.0
Mercury	7439-97-6	3005A,3015A	EPA7471B	2.0
Nickel	7440-02-0	3005A,3015A	EPA6010C	2.0
Potassium	7440-09-7	3005A,3015A	EPA6010C	2.0
Selenium	7782-49-2	3005A,3015A	EPA6010C	10.0
Silver	7440-22-4	3005A,3015A	EPA6010C	2.0
Sodium	7440-23-5	3005A,3015A	EPA6010C	2.0
Thallium	7440-28-0	3005A,3015A	EPA6010C	2.0
Vanadium	7440-62-2	3005A,3015A	EPA6010C	10.0
Zinc	7440-66-6	3005A,3015A	EPA6010C	2.0
Special Analysis				
Hexavalent Chromium (Cr^{+6})		NA	EPA7196A	TBD
Target Compound List				
PCBs				
Aroclor 1016	12674-11-2	3510C,3520C,3535A	EPA8082A	0.01
Aroclor 1221	11104-28-2	3510C,3520C,3535A	EPA8082A	0.5
Aroclor 1232	11141-16-5	3510C,3520C,3535A	EPA8082A	0.5
Aroclor 1242	53469-21-9	3510C,3520C,3535A	EPA8082A	5.7
Aroclor 1248	12672-29-6	3510C,3520C,3535A	EPA8082A	0.056
Aroclor 1254	11097-69-1	3510C,3520C,3535A	EPA8082A	TBD
Aroclor 1260	11096-82-5	3510C,3520C,3535A	EPA8082A	4.0
Pesticides				
Aldrin	309-00-2	3510C,3520C,3535A	EPA8081B	2.0
alpha-Benzene hexachloride	319-84-6	3510C,3520C,3535A	EPA8081B	10.0
alpha-Chlordane	5103-71-9	3510C,3520C,3535A	EPA8081B	1.0
beta-Benzene hexachloride	319-85-7	3510C,3520C,3535A	EPA8081B	2.0
delta-Benzene hexachloride	319-86-8	3510C,3520C,3535A	EPA8081B	4.0

Analyte	Analyte ID	Preparation [B] Method	Analytical [B] Method	CRDL [A] (µg/L)
Dieldrin	60-57-1	3510C,3520C,3535A	EPA8081B	2.0
Endosulfan I	959-98-8	3510C,3520C,3535A	EPA8081B	1.0
Endosulfan II	33213-65-9	3510C,3520C,3535A	EPA8081B	10.0
Endosulfan sulfate	1031-07-8	3510C,3520C,3535A	EPA8081B	14.0
Endrin	72-20-8	3510C,3520C,3535A	EPA8081B	2.0
Endrin aldehyde	7421-93-4	3510C,3520C,3535A	EPA8081B	2.0
Endrin ketone	53494-70-5	3510C,3520C,3535A	EPA8081B	2.0
gamma-Chlordane	5103-74-2	3510C,3520C,3535A	EPA8081B	2.0
Heptachlor	76-44-8	3510C,3520C,3535A	EPA8081B	1.0
Heptachlor epoxide	1024-57-3	3510C,3520C,3535A	EPA8081B	14.0
Lindane	58-89-9	3510C,3520C,3535A	EPA8081B	2.0
Methoxychlor	72-43-5	3510C,3520C,3535A	EPA8081B	2.0
DDD	72-54-8	3510C,3520C,3535A	EPA8081B	2.0
DDE	72-55-9	3510C,3520C,3535A	EPA8081B	2.0
DDT	50-29-3	3510C,3520C,3535A	EPA8081B	2.0
Toxaphene	8001-35-2	3510C,3520C,3535A	EPA8081B	1.0
Semi-volatiles				
2,4,5-Trichlorophenol	95-95-4	3510C, 3520C	EPA8270D	1.0
2,4,6-Trichlorophenol	88-06-2	3510C, 3520C	EPA8270D	1.0
2,4-Dichlorophenol	120-83-2	3510C, 3520C	EPA8270D	0.12
2,4-Dimethylphenol	105-67-9	3510C, 3520C	EPA8270D	4.0
2,4-Dinitrophenol	51-28-5	3510C, 3520C	EPA8270D	5.0
2-Chlorophenol	95-57-8	3510C, 3520C	EPA8270D	1.0
2-Methyl-4,6-dinitrophenol	534-52-1	3510C, 3520C	EPA8270D	5.0
2-Nitrophenol	88-75-5	3510C, 3520C	EPA8270D	1.0
4-Chloro-m-cresol	59-50-7	3510C, 3520C	EPA8270D	2.0
4-Nitrophenol	100-02-7	3510C, 3520C	EPA8270D	20.0
m/p-Cresol	1319-77-3	3510C, 3520C	EPA8270D	0.062
o-Cresol (2-Methylphenol)	95-48-7	3510C, 3520C	EPA8270D	1.0
Pentachlorophenol	87-86-5	3510C, 3520C	EPA8270D	1.0
Phenol	108-95-2	3510C, 3520C	EPA8270D	1.0
1,2,4,5-Tetrachlorobenzene	95-94-3	3510C, 3520C	EPA8270D	1.0
2,3,4,6-Tetrachlorophenol	58-90-2	3510C, 3520C	EPA8270D	4.0
1,1'-Biphenyl	92-52-4	3510C, 3520C	EPA8270D	10.0
2,4-Dinitrotoluene	121-14-2	3510C, 3520C	EPA8270D	0.14
2,6-Dinitrotoluene	606-20-2	3510C, 3520C	EPA8270D	2.0
2-Chloronaphthalene	91-58-7	3510C, 3520C	EPA8270D	10.0
2-Methylnaphthalene	91-57-6	3510C, 3520C	EPA8270D	20.0
2-Nitroaniline	88-74-4	3510C, 3520C	EPA8270D	1.0
3,3'-Dichlorobenzidine	91-94-1	3510C, 3520C	EPA8270D	10.0
4-Bromophenyl phenyl ether	101-55-3	3510C, 3520C	EPA8270D	10.0
4-Chloroaniline	106-47-8	3510C, 3520C	EPA8270D	2.0
4-Chlorophenyl phenyl ether	7005-72-3	3510C, 3520C	EPA8270D	0.2
Acenaphthene	83-32-9	3510C, 3520C	EPA8270D	1.0
Acenaphthylene	208-96-8	3510C, 3520C	EPA8270D	2.0
Acetophenone	98-86-2	3510C, 3520C	EPA8270D	100.0
Anthracene	120-12-7	3510C, 3520C	EPA8270D	2.0

Analyte	Analyte ID	Preparation [B] Method	Analytical [B] Method	CRDL [A] (µg/L)
Atrazine	1912-24-9	3510C, 3520C	EPA8270D	2.0
Benzaldehyde	100-52-7	3510C, 3520C	EPA8270D	4.0
Benzo[*a*]anthracene	56-55-3	3510C, 3520C	EPA8270D	10.0
Benzo[*a*]pyrene	50-32-8	3510C, 3520C	EPA8270D	2.0
Benzo[*b*]fluoranthene	205-99-2	3510C, 3520C	EPA8270D	2.0
Benzo[*g,h,i*]perylene	191-24-2	3510C, 3520C	EPA8270D	0.055
Benzo[*k*]fluoranthene	207-08-9	3510C, 3520C	EPA8270D	2.0
Bis(2-chloro-1-methylethyl)ether	108-60-1	3510C, 3520C	EPA8270D	87.0
Bis(2-chloroethoxy) methane	111-91-1	3510C, 3520C	EPA8270D	0.5
Bis(2-chloroethyl) ether	111-44-4	3510C, 3520C	EPA8270D	0.5
Bis(2-ethylhexyl) phthalate	117-81-7	3510C, 3520C	EPA8270D	0.5
Butylbenzyl phthalate	85-68-7	3510C, 3520C	EPA8270D	1.0
Caprolactam	105-60-2	3510C, 3520C	EPA8270D	12.0
Carbazole	86-74-8	3510C, 3520C	EPA8270D	1.0
Chrysene	218-01-9	3510C, 3520C	EPA8270D	10.0
Dibenz[*a,h*]anthracene	53-70-3	3510C, 3520C	EPA8270D	2.0
Dibenzofuran	132-64-9	3510C, 3520C	EPA8270D	0.064
Dibutyl phthalate	84-74-2	3510C, 3520C	EPA8270D	2.0
Diethyl phthalate	84-66-2	3510C, 3520C	EPA8270D	1.0
Dimethyl phthalate	131-11-3	3510C, 3520C	EPA8270D	2.0
Di-n-octyl phthalate	117-84-0	3510C, 3520C	EPA8270D	0.5
Fluoranthene	206-44-0	3510C, 3520C	EPA8270D	2.0
Fluorene	86-73-7	3510C, 3520C	EPA8270D	1.0
Hexachlorobenzene	118-74-1	3510C, 3520C	EPA8270D	0.5
Hexachlorobutadiene	87-68-3	3510C, 3520C	EPA8270D	1.0
Hexachlorocyclopentadiene	77-47-4	3510C, 3520C	EPA8270D	1.0
Hexachloroethane	67-72-1	3510C, 3520C	EPA8270D	2.0
Indeno[1,2,3-*c,d*]pyrene	193-39-5	3510C, 3520C	EPA8270D	2.0
Isophorone	78-59-1	3510C, 3520C	EPA8270D	10.0
m-Nitroaniline	99-09-2	3510C, 3520C	EPA8270D	1.0
Naphthalene	91-20-3	3510C, 3520C	EPA8270D	10.0
Nitrobenzene	98-95-3	3510C, 3520C	EPA8270D	1.0
N-Nitrosodiphenylamine	86-30-6	3510C, 3520C	EPA8270D	1.5
N-Nitrosodipropylamine	621-64-7	3510C, 3520C	EPA8270D	2.0
Phenanthrene	85-01-8	3510C, 3520C	EPA8270D	2.0
p-Nitroaniline	100-01-6	3510C, 3520C	EPA8270D	8.0
Pyrene	129-00-0	3510C, 3520C	EPA8270D	2.0
Volatiles				
1,1,1-Trichloroethane	71-55-6	5021A,5030C,5031,5032	EPA8260B	2.0
1,1,2,2-Tetrachloroethane	79-34-5	5021A,5030C,5031,5032	EPA8260B	2.0
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	5021A,5030C,5031,5032	EPA8260B	10.0
1,1,2-Trichloroethane	79-00-5	5021A,5030C,5031,5032	EPA8260B	1.0
1,1-Dichloroethane	75-34-3	5021A,5030C,5031,5032	EPA8260B	1.0
1,1-Dichloroethylene	75-35-4	5021A,5030C,5031,5032	EPA8260B	19.0
1,2,4-Trichlorobenzene	120-82-1	5021A,5030C,5031,5032	EPA8260B	0.14

Analyte	Analyte ID	Preparation [B] Method	Analytical [B] Method	CRDL [A] (µg/L)
1,2-Dibromo-3-chloropropane	96-12-8	5021A,5030C,5031,5032	EPA8260B	1.0
1,2-Dibromoethane	106-93-4	5021A,5030C,5031,5032	EPA8260B	2.0
1,2-Dichlorobenzene	95-50-1	5021A,5030C,5031,5032	EPA8260B	1.0
1,2-Dichloroethane (EDC)	107-06-2	5021A,5030C,5031,5032	EPA8260B	0.4
1,2-Dichloropropane	78-87-5	5021A,5030C,5031,5032	EPA8260B	10.0
1,3-Dichlorobenzene	541-73-1	5021A,5030C,5031,5032	EPA8260B	2.0
1,4-Dichlorobenzene	106-46-7	5021A,5030C,5031,5032	EPA8260B	8.0
2-Hexanone	591-78-6	5021A,5030C,5031,5032	EPA8260B	2.0
Acetone	67-64-1	5021A,5030C,5031,5032	EPA8260B	2.0
Benzene	71-43-2	5021A,5030C,5031,5032	EPA8260B	2.0
Bromodichloromethane	75-27-4	5021A,5030C,5031,5032	EPA8260B	1.0
Bromoform (Tribromomethane)	75-25-2	5021A,5030C,5031,5032	EPA8260B	1.0
Bromomethane (Methyl bromide)	74-83-9	5021A,5030C,5031,5032	EPA8260B	0.0096
Carbon disulfide	75-15-0	5021A,5030C,5031,5032	EPA8260B	C
Carbon tetrachloride	56-23-5	5021A,5030C,5031,5032	EPA8260B	2.0
Chlorobenzene	108-90-7	5021A,5030C,5031,5032	EPA8260B	10.0
Chloroethane	75-00-3	5021A,5030C,5031,5032	EPA8260B	2.0
Chloroethene (Vinyl chloride)	75-01-4	5021A,5030C,5031,5032	EPA8260B	1.0
Chloroform	67-66-3	5021A,5030C,5031,5032	EPA8260B	6.5
Chloromethane (Methyl chloride)	74-87-3	5021A,5030C,5031,5032	EPA8260B	2.0
cis-1,2-Dichloroethylene	156-59-2	5021A,5030C,5031,5032	EPA8260B	0.2
cis-1,3-Dichloropropene	10061-01-5	5021A,5030C,5031,5032	EPA8260B	0.6
Cumene (Isopropylbenzene)	98-82-8	5021A,5030C,5031,5032	EPA8260B	1.0
Cyclohexane	110-82-7	5021A,5030C,5031,5032	EPA8260B	15.0
Dibromochloromethane	124-48-1	5021A,5030C,5031,5032	EPA8260B	2.0
Dichlorodifluoromethane	75-71-8	5021A,5030C,5031,5032	EPA8260B	0.00075
Dichloromethane (Methylene chloride)	75-09-2	5021A,5030C,5031,5032	EPA8260B	1.0
Ethylbenzene	100-41-4	5021A,5030C,5031,5032	EPA8260B	6.0
Methyl acetate	79-20-9	5021A,5030C,5031,5032	EPA8260B	1.0
Methyl ethyl ketone	78-93-3	5021A,5030C,5031,5032	EPA8260B	20.0
Methyl isobutyl ketone	108-10-1	5021A,5030C,5031,5032	EPA8260B	10.0
Methyl tertiary butyl ether (MTBE)	1634-04-4	5021A,5030C,5031,5032	EPA8260B	2.0
Methylcyclohexane	108-87-2	5021A,5030C,5031,5032	EPA8260B	150.0
Styrene	100-42-5	5021A,5030C,5031,5032	EPA8260B	50.0
Tetrachloroethylene (PCE)	127-18-4	5021A,5030C,5031,5032	EPA8260B	2.0
Toluene	108-88-3	5021A,5030C,5031,5032	EPA8260B	10.0
trans-1,2-Dichloroethylene	156-60-5	5021A,5030C,5031,5032	EPA8260B	0.2
trans-1,3-Dichloropropene	10061-02-6	5021A,5030C,5031,5032	EPA8260B	8.0
Trichloroethylene (TCE)	79-01-6	5021A,5030C,5031,5032	EPA8260B	1
Trichlorofluoromethane	75-69-4	5021A,5030C,5031,5032	EPA8260B	0.2
o-Xylenes	95-47-6	5021A,5030C,5031,5032	EPA8260B	1.0
m,p-Xylene	MPXYL	5021A,5030C,5031,5032	EPA8260B	0.4
Bromochloromethane	74-97-5	5021A,5030C,5031,5032	EPA8260B	10.0

Analyte	Analyte ID	Preparation [B] Method	Analytical [B] Method	CRDL [A] (µg/L)
1,4-Dioxane	123-91-1	5021A,5030C,5031,5032	EPA8260B	6.0
1,2-Dichlorobenzene	95-50-1	5021A,5030C,5031,5032	EPA8260B	1.0
1,2,3-Trichlorobenzene	87-61-6	5021A,5030C,5031,5032	EPA8260B	0.88

A) CRDL is the Contract Required Detection Limit and is not always attainable.
B) Extraction and preparation methods differ depending upon media, concentration, instrument, laboratory, and analytical method. Preparation methods will also influence detection limits.
C) Laboratory instructed to obtain the lowest possible method detection limit

Table 9 Laboratory Analytical Specifications Table for Radiological Analytes in Soil, Sediment, Surface, and Groundwater Media

Radionuclides

Isotope	Typical Soil MDAs	Typical Water MDAs	Analytical Method [b]
Alpha Spectroscopy			
Americium-241	0.50	0.40	NNS
Americium-243	0.50	0.462	NNS
Curium-243/244	0.351	0.503	NNS
Curium-245/246	0.416	0.458	NNS
Neptunium-237	0.07	0.771	NNS
Plutonium-238	0.50	0.35	NNS
Plutonium-239/240	0.50	0.353	NNS
Plutonium-242	0.50	0.372	NNS
Thorium-228	0.50	0.445	NNS
Thorium-230	0.50	0.523	NNS
Thorium-232	0.50	0.45	NNS
Uranium-233/234	0.50	0.663	NNS
Uranium-235	0.206	0.684	NNS
Uranium 238	0.50	0.744	NNS
Gamma Pulse Height Analyses			
Actinium-228	0.30	25.00	NNS
Cesium-137	0.15	5.0	NNS
Cobalt-60	0.03	10.00	NNS
Lead-214	0.25	20.00	NNS
Potassium-40	1.00	75.00	NNS
Rad Indicators			
Gross Alpha	3.000	3.00	EPA900.0MOD
Nonvolatile beta	4.000	4.00	EPA900.0MOD
Individual Analyses			
Carbon-14	2.00	10.00	NNS
Iodine-129	2.00	1.00	NNS
Nickel-59	3.38	20.00	NNS
Nickel-63	4.00	10.00	NNS
Promethium-147	10.00	10.00	NNS
Radium-226	0.895	0.30	EPA903.0MOD
Radium-228	1.29	0.50	EPA903.0MOD
Strontium-90	2.00	0.852	NNS
Technetium-99	5.00	17.3	NNS
Tritium	6.00	0.50	EPA906.0MOD

Note: All MDAs are sample-specific. The MDAs represented above are typical MDAs as reported by the subcontract laboratories but are not always achievable.
NNS = No National Standard

Table 10 Preservatives, Holding Times, and Sample Containers

	Preservatives		Holding Time		Containers	
Parameter	**Aqueous**	**Solid**	**Aqueous**	**Solid**	**Aqueous**	**Solid**
Volatile Organics Compounds (VOCs) Including: 8260- VOCs, 8021 – Aromatic VOCs, 8021 Halogenated VOCs, 8015 – Nonhalogenated VOCs, 8032 - Acrylamide	No Residual Chlorine Adjust pH to <2 with H_2SO_4, HCL, or solid sodium bisulfate ($NaHSO_4$). Cool to 4° C	Low-level soil Add ~5 g soil to 40 mL VOA vial preserved with 1 g of $NaHSO_4$/5 mL water	14 days	Low/High Level 14 days`	3x40 mL glass VOC vial, PTFE septa cap	3x40 (or 60) mL glass VOA vial (with stir bar for low-level soil), PTFE septa cap
8033 – Acetonitrile, 8315 – Carbonyl Compounds Prepped by: 5030 – Purge and trap (aqueous) 5035 – Closed system purge and trap (solid)	Residual Chlorine Present Collect sample in a 125 mL container, preserved with 4 drops of 10% sodium thiosulfate (Na2S2O3) solution. Gently swirl to mix and transfer to 40 mL VOC vials. Adjust pH to <2 with H2SO4, HCL, or solid NaHSO4. Cool to 4° C, no headspace	High-Level Soil Add ~5 g soil to 40 (or 60) ML VOC vial preserved with 10 mL methanol	14 days	Low/High Level 14 days`	3x40 mL glass VOC vial, PTFE septa cap	3x40 (or 60) mL glass VOA vial (with stir bar for low-level soil), PTFE septa cap
Prepared by: 5021 – Automated Headspace	NA	Soil Only Add ~2 g soil to 22 mL soil vial. Cool to 4° C. Soil/Matrix Modifier Add ~2 g soil to 22 mL soil vial preserved with 10 mL matrix modifier. Cool to 4° C. Soil/Water Add ~2 g soil to 22 mL soil vial preserved with	NA	14 days	NA	2 x 22 mL glass soil headspace vial, PTFE-lined septa with crimp or screw–top cap

	Preservatives		Holding Time		Containers	
Parameter	**Aqueous**	**Solid**	**Aqueous**	**Solid**	**Aqueous**	**Solid**
		10 mL water. Cool to 4° C.				
Prepared by: 5032 – Vacuum Distillation	Same as VOC – purge and trap	Cool to 4° C. No headspace	14 days	14 days	2 x 40 mL glass vial, PTFE septa cap	2 x 125 mL clear wide-mouth glass jars with PTFE – lined lids (CWM)
Nonpurgeable Water-Soluble VOCs Prepared by: 5031 - Azeotropic Distillation	Same as VOC – purge and trap	Cool to 4° C. No headspace	14 days	14 days	2 x 40 mL glass vial, PTFE septa cap	2 x 2125 mL CWM
VOCs Prepared by: 3585 – Solvent Dilution	NA	Oily Waste Cool to 4° C.	NA	14 days	NA	125 mL CWM
VOCs Including: 8031 – Acrylonitrile, 8316 – Acrolein, Acrylamide, Acrylonitrile	Adjust pH to 4-5 with H_2SO_4, HCL, or solid $NaHSO_4$. Cool to4° C.	NA	14 days	NA	2 x 40 mL glass vial, PTFE septa cap	250 mL CWM
Extractable Organics Including: 8270 – Semivolatile Organics 8041 - Phenols	No Residual Chlorine Cool to 4° C.	Cool to 4° C.	7 days until extraction/analyzed within 40 days after extraction	14 days until extraction/analyzed within 40 days after extraction	2 x 1 L amber glass bottle per chemical parameter	250 mL CWM
8061 – Phthalate Esters 8070 – Nitrosamines 8081 – Organochlorine Pesticides	Residual Chlorine Present Add 1 mL 10% sodium thiosulfate ($Na_2S_2O_3$) solution per liter of water. Cool to4° C. Extracts must be stored at 4°C and in the dark until analysis Extracts must be stored at 4°C and in the dark until analysis	Cool to 4° C.	7 days until extraction/analyzed within 40 days after extraction	14 days until extraction/analyzed within 40 days after extraction	2 x 1 L amber glass bottle per chemical parameter	250 mL CWM

	Preservatives		Holding Time		Containers	
Parameter	**Aqueous**	**Solid**	**Aqueous**	**Solid**	**Aqueous**	**Solid**
8082 – Polychlorinated Biphenyls	Extracts must be stored at 4°C and in the dark until analysis					
8091 – Nitroaromatics /Cyclic Ketones	Extracts must be stored at 4°C and in the dark until analysis					
8100 – Polycyclic Aromatic Hydrocarbons	Extracts must be stored at 4°C and in the dark until analysis					
8111 – Haloethers	Extracts must be stored at 4°C and in the dark until analysis					
8121 – Chlorinated Hydrocarbons						
8151 – Chlorinated Herbicides						
8310 – Polycyclic Aromatic Hydrocarbons						
8321 – Nonvolatile Organics						
8325 - Nonvolatile Organics	Extracts must be stored at -10C and in the dark					
8330 – Nitroaromatics and Nitramines	Extracts must be stored at 4°C and in the dark until analysis					
8331 – Tetrazene	Extracts must be stored at 4°C and in the dark until analysis					
8332 - Nitroglycerine						
8141 – Organophosphate Pesticides	Adjust to 5<pH<9 with H_2SO_4 or NaOH. Cool to 4° C.	Cool to 4° C.	7 days until extraction/analyzed within 40 days after extraction	14 days until extraction/analyzed within 40 days after extraction	2 x 1 L amber glass bottle per chemical parameter	250 mL CWM
8318 – N-Methyl carbamates	Adjust pH to 4-5 with 0.1 N chloroacetic	Cool to 4° C. Store in dark.	7 days until extraction/analyzed within 40	14 days until extraction/analyzed within 40	2 x 1 L amber glass bottle per chemical	250 mL CWM

	Preservatives		Holding Time		Containers	
Parameter	**Aqueous**	**Solid**	**Aqueous**	**Solid**	**Aqueous**	**Solid**
	acid. Cool to 4° C. Store in dark.		days after extraction	days after extraction	parameter	
8280–Dioxins/Furans	No Residual Chlorine If sample pH is greater than 9, adjust to pH 7-9 with sulfuric acid (H_2SO_4). Cool to 4° C. Store in dark.	Cool to 4° C. Store in dark.	30 days until extraction/analyzed within 45 days after extraction	30 days until extraction/analyzed within 45 days after extraction	2 x 1 L amber glass bottle per chemical parameter	250 mL CWM
8290-Dioxins/Furans	Residual Chlorine Present Add 80 mg sodium thiosulfate ($Na_2S_2O_3$) per liter of water. If sample pH is greater than 9, adjust to pH 7-9 with sulfuric acid (H_2SO_4). Cool to 4° C. Store in dark.	Cool to 4° C. Store in dark.	30 days until extraction/analyzed within 45 days after extraction	30 days until extraction/analyzed within 45 days after extraction	2 x 1 L amber glass bottle per chemical parameter	250 mL CWM
8131-Analine/selected derivatives	No Residual Chlorine Present Adjust pH to 6-8 with H_2SO_4 or NaOH. Cool to 4° C. Residual Chlorine Present Add 35 mg sodium thiosulfate ($Na_2S_2O_3$) per ppm chlorine per liter water. Adjust pH to 6-8 with H_2SO_4 or NaOH. Cool to 4° C.					
Metals (except Chromium (VI) & Mercury)	HNO_3 to pH < 2	Cool to 4° C.	6 months	6 months	1 L HDPE	250 mL CWM (metals and cyanide may be collected in the same container for soils)
Mercury	HNO_3 to pH < 2	Cool to 4° C.	28 days	28 days	250 mL HDPE or glass	250 mL CWM
Chromium (VI)	Cool to 4° C.	Cool to 4° C.	24 hours	24 hours	250 mL HDPE	250 mL CWM
Miscellaneous						
Acidity	Cool to 4° C.	NA	48 hours	NA	250 mL HDPE	NA
Alkalinity	Cool to 4° C.	NA	48 hours	NA	250 mL HDPE	NA
Ammonia	Cool to 4° C. H_2SO_4 to pH < 2.	NA	14 days	NA	1 L HDPE	NA
Chloride	NA	NA	28 days	28 days	125 mL HDPE	125 mL CWM
Chloride (total residual)	NA	NA	ASAP	NA	500 mL HDPE	NA

	Preservatives		Holding Time		Containers	
Parameter	**Aqueous**	**Solid**	**Aqueous**	**Solid**	**Aqueous**	**Solid**
Common Ions	Cool to 4° C.	Cool to 4° C.	28 days	28 days	1 L glass	250 mL CWM
Cyanide (total & amenable)	Cool to 4° C and adjust pH >12 with 50% NaOH. If oxidizing agents are present: Cool to 4° C. Add 5 mL 0.1 N $NaAsO_2$ per liter water or 0.06 g ascorbic acid per liter water. Adjust pH > 12 with 50% NaOH.					
Hardness	HNO_3 or H_2SO_4 to pH < 2.	NA	6 months	NA	250 mL HDPE	NA
Hydrogen Ion (pH)	None	Cool to 4° C.	24 hours	ASAP	60 mL HDPE	125 mL CWM
Kjeldahl and Organic Nitrogen	Cool to 4° C. H_2SO_4 to pH < 2.	NA	28 days	NA	1 L HDPE	NA
Nitrate	Cool to 4° C.	Cool to 4° C.	48 hours	48 hours	250 mL HDPE	250 mL CWM
Nitrate-Nitrite	Cool to 4° C. H_2SO_4 to pH < 2.	Cool to 4° C.	28 days	28 days	250 mL HDPE	250 mL CWM
Nitrite	Cool to 4° C.	NA	48 hours	NA	125 mL HDPE	NA
Oil & Grease	Cool to 4° C and add 5 mL 1:1 HCL.	Cool to 4° C.	28 days	28 days	2- 1 L glass	250 mL CWM
Organic Carbon, Total	Adjust pH to < 2 with H_2SO_4, HCL, or solid $NaSO_4$. Cool to 4° C and store in dark.	Cool to 4° C.	28 days	28 days	125 mL HDPE	125 mL CWM
Phosphorus (elemental)	Cool to 4° C.	NA	48 hours	NA	1 L BR	NA
Phosphorus (Total)	Cool to 4° C. H_2SO_4 to pH < 2.	NA	28 days	NA	125 mL HDPE	NA
Radiological Test Gross Alpha	HNO_3 to pH <2.	Cool to 4° C.	6 months	6 months	2 L HDPE	250 mL HDPE
Radiological Test Nonvolatile Beta	HNO_3 to pH <2.	Cool to 4° C.	6 months	6 months	2 L HDPE	250 mL HDPE
Radium Total	HNO_3 to pH <2.	Cool to 4° C.	6 months	6 months	2 L HDPE	250 mL HDPE
Tritium	None Cool 0 to 6 C	None Cool 0 to 6 C	180 days	180 days	250 Amber Glass	250 HDPE or 4 oz Amber Glass
Sulfate	Cool to 4° C.	Cool to 4° C.	28 days	28 days	125 mL HDPE	125 mL CWM
Sulfide	Cool to 4° C and add 4 drops zinc acetate and NaOH to pH > 9.	Add 2 N zinc acetate until moistened and cool to 4° C.	7 days	7 days	1 L HDPE	250 mL CWM
Sulfite	Cool to 4° C.	NA	ASAP	NA	125 mL HDPE	NA
Total Organic Halogens (TOX)	Cool to 4° C add H_2SO_4 to pH <2.	Cool to 4° C.	28 days	28 days	16 ounce BR	125 mL CWM

	Preservatives		Holding Time		Containers	
Parameter	**Aqueous**	**Solid**	**Aqueous**	**Solid**	**Aqueous**	**Solid**

Abbreviations used in Table:
H_2SO_4 – Sulfuric acid
HCL – Hydrochloric acid
$NaHSO_4$ – Sodium bisulfate
PTFE – Teflon lined seals
$Na_2S_2O_3$ – Sodium Thiosulfate
CWM – Clear Wide-Mouth Glass Jar
AG – Amber Glass Jar
HNO_3 – Nitric acid
HDPE – High-Density Polyethylene plastic bottle
BR – Boston Round bottle

Table 11 Example Sampling Matrix Table

Sample Count	Subunit Location	Sample Station	Sample Number	Top Depth	Bottom Depth	Sample Type	Sample Media	Collection Method	Analyte Code	Proposed Sample Coordinates	
										North	East
1.	186-01P	1861P-01	01	0	1	REG	Surface Soil	Hand auger	3,5	3679309.288	437173.848
2.	186-01P	1861P-01	01RB	0	1	RB			1,3	3679309.288	437173.848
3.	186-01P	1861P-01	02	1	4	REG	Subsurface Soil	Hand auger	3,5	3679309.288	437173.848
4.	186-01P	1861P-01	03	8	10	REG	Deep Soil	DPT	3,5	3679309.288	437173.848
5.	186-01P	1861P-01	04	18	20	REG	Deep Soil	DPT	3,5	3679309.288	437173.848
6.	186-01P	1861P-01	05	28	30	REG	Deep Soil	DPT	3,5	3679309.288	437173.848
7.	186-01P	1861P-01	06	38	40	REG	Deep Soil	DPT	3,5	3679309.288	437173.848
8.	186-01P	1861P-01	07	48	50	REG	Deep Soil	DPT	3,5	3679309.288	437173.848
9.	186-01P	1861P-01	08	58	60	REG	Deep Soil	DPT	3,5	3679309.288	437173.848
10.	186-01P	1861P-01	09	68	70	REG	Deep Soil	DPT	3,5	3679309.288	437173.848
11.	186-01P	1861P-02	01	0	1	REG	Surface Soil	Hand auger	3,5	3679232.782	437226.718
12.	186-01P	1861P-02	02	1	4	REG	Subsurface Soil	Hand auger	3,5	3679232.782	437226.718
13.	186-01P	1861P-02	03	8	10	REG	Deep Soil	DPT	3,5	3679232.782	437226.718
14.	186-01P	1861P-02	04	18	20	REG	Deep Soil	DPT	3,5	3679232.782	437226.718
15.	186-01P	1861P-02	05	28	30	REG	Deep Soil	DPT	3,5	3679232.782	437226.718
16.	186-01P	1861P-02	06	38	40	REG	Deep Soil	DPT	3,5	3679232.782	437226.718
17..	186-01P	1861P-02	07	48	50	REG	Deep Soil	DPT	3,5	3679232.782	437226.718
18.	186-01P	1861P-02	08	58	60	REG	Deep Soil	DPT	3,5	3679232.782	437226.718
19.	186-01P	1861P-02	09	68	70	REG	Deep Soil	DPT	3,5	3679232.782	437226.718
20.	186-01P	1861P-03	01	0	1	REG	Surface Soil	Hand auger	3,5	3678820.09	437382.11
21.	186-01P	1861P-03	01FD	0	1	FD	Surface Soil	Hand auger	3,5	3678820.09	437382.11
22.	186-01P	1861P-03	01SPL	0	1	SPL	Surface Soil	Hand auger	3,5	3678820.09	437382.11
23.	186-01P	1861P-03	02	2	4	REG	Subsurface Soil	Hand auger	3,5	3678820.09	437382.11
24.	186-01P	1861P-03	03	8	10	REG	Deep Soil	DPT	3,5	3678820.09	437382.11
25.	186-01P	1861P-03	04	18	20	REG	Deep Soil	DPT	3,5	3678820.09	437382.11
26.	186-01P	1861P-03	05	28	30	REG	Deep Soil	DPT	3,5	3678820.09	437382.11
27.	186-01P	1861P-03	06	38	40	REG	Deep Soil	DPT	3,5	3678820.09	437382.11
28.	186-01P	1861P-03	07	48	50	REG	Deep Soil	DPT	3,5	3678820.09	437382.11
29.	186-01P	1861P-03	08	58	60	REG	Deep Soil	DPT	3,5	3678820.09	437382.11
30.	186-01P	1861P-03	09	68	70	REG	Deep Soil	DPT	3,5	3678820.09	437382.11
31/	186-01P	1861P-04	01	0	1	REG	Surface Soil	Hand auger	3,5	3678802.074	437358.812
32.	186-01P	1861P-04	01FB	0	1	FB	Surface Soil	Hand auger	1	3678802.074	437358.812
33.	186-01P	1861P-04	01FD	0	1	FD	Surface Soil	Hand auger	3,5	3678802.074	437358.812
34.	186-01P	1861P-04	01SPL	0	1	SPL	Surface Soil	Hand auger	3,5	3678802.074	437358.812
35.	186-01P	1861P-04	02	1	4	REG	Subsurface Soil	Hand auger	3,5	3678802.074	437358.812
36.	186-01P	1861P-04	03	8	10	REG	Deep Soil	DPT	3,5	3678802.074	437358.812
37/	186-01P	1861P-04	04	18	20	REG	Deep Soil	DPT	3,5	3678802.074	437358.812
38.	186-01P	1861P-04	05	28	30	REG	Deep Soil	DPT	3,5	3678802.074	437358.812
39.	186-01P	1861P-04	06	38	40	REG	Deep Soil	DPT	3,5	3678802.074	437358.812
40.	186-01P	1861P-04	07	48	50	REG	Deep Soil	DPT	3,5	3678802.074	437358.812
41.	186-01P	1861P-04	08	58	60	REG	Deep Soil	DPT	3,5	3678802.074	437358.812
42.	186-01P	1861P-04	09	68	70	REG	Deep Soil	DPT	3,5	3678802.074	437358.812
43.	246-01P	2461P-01	01	75	80	REG	Groundwater	DPT	2	3678932.522	436777.266
44.	246-01P	2461P-01	01RB	75	80	RB			1	3678932.522	436777.266
45.	246-01P	2461P-01	02	85	95	REG	Groundwater	DPT	2	3678932.522	436777.266
46.	246-01P	2461P-01	03	100	105	REG	Groundwater	DPT	2	3678932.522	436777.266
47.	246-01P	2461P-01	04	110	115	REG	Groundwater	DPT	2	3678932.522	436777.266
48.	246-01P	2461P-01	05	120	125	REG	Groundwater	DPT	2	3678932.522	436777.266
49.	246-01P	2461P-01	06	135	140	REG	Groundwater	DPT	2	3678932.522	436777.266

Sample Count	Subunit Location	Sample Station	Sample Number	Top Depth	Bottom Depth	Sample Type	Sample Media	Collection Method	Analyte Code	Proposed Sample Coordinates North	East
50.	246-01P	2461P-01	07	145	150	REG	Groundwater	DPT	2	3678932.522	436777.266
51.	246-01P	2461P-01	08	160	165	REG	Groundwater	DPT	2	3678932.522	436777.266
52.	246-01P	2461P-01	09	170	175	REG	Groundwater	DPT	2	3678932.522	436777.266
53.	246-01P	2461P-01	10	185	190	REG	Groundwater	DPT	2	3678932.522	436777.266
54.	246-01P	2461P-01	10FD	185	190	FD	Groundwater	DPT	2	3678932.522	436777.266
55.	246-01P	2461P-01	10SPL	185	190	SPL	Groundwater	DPT	2	3678932.522	436777.266
56.	CCSS-01	CCSW-01	01	Surface	Surface	REG	Surface Water	Dip/Grab	2	3678820.09	437382.11
57.	CCSS-01	CCSW-01	01FB	Surface	Surface	FB			1	3678820.09	437382.11
58.	CCSS-01	CCSS-01	01	0	1	REG	Sediment	Dredge/Grab	2	3678820.09	437382.11
59.	CCSS-01	CCSS-01	01FD	0	1	FD	Sediment	Dredge/Grab	2	3678820.09	437382.11
60.	CCSS-01	CCSS-01	01SPL	0	1	SPL	Sediment	Dredge/Grab	2	3678820.09	437382.11
61.	Outfall	P007-01	01	0	1	REG	Soil	Hand scoop	2	3679309.288	437173.848
62.	Outfall	P007-01RB	01RB	0	1	RB			1	3679309.288	437173.848
63.	Outfall	P007-02	02	1	4	REG	Soil	Hand auger	2	3679309.288	437173.848
64.	Outfall	P007-02	03	4	6	REG	Soil	Hand auger	2	3679309.288	437173.848
65.	Outfall	P007-03	01	0	1	REG	Soil	Hand scoop	2	3678953.974	436759.55
66.	Outfall	P007-03	02	1	4	REG	Soil	Hand auger	2	3678953.974	436759.55
67.	Outfall	P007-03	03	4	6	REG	Soil	Hand auger	2	3678953.974	436759.55
68.	Outfall	P007-04	01	0	1	REG	Soil	Hand scoop	2	3678953.974	436759.55
69.	Outfall	P007-04	02	1	4	REG	Soil	Hand scoop	2	3678953.974	436759.55
70.	Outfall	P007-04	03	4	6	REG	Soil	Hand scoop	2	3678953.974	436759.55
71.	Outfall	P007-05	01	0	1	REG	Soil	Hand scoop	2	3679000.962	436796.806
72.	Outfall	P007-05	02	1	4	REG	Soil	Hand auger	2	3679000.962	436796.806
73.	Outfall	P007-05	03	4	6	REG	Soil	Hand auger	2	3679000.962	436796.806
74.	Outfall	P007-06	01	0	1	REG	Soil	Hand auger	2	3678973.904	436815.448
75.	Outfall	P007-07	01FD	0	1	FD	Soil	Hand auger	2	3678973.904	436815.448
76.	Outfall	P007-07	01SPL	0	1	SPL	Soil	Hand auger	2	3678973.904	436815.448
77.	Outfall	P007-07	02	1	4	REG	Soil	Hand auger	2	3678973.904	436815.448
78.	Outfall	P007-07	03	4	6	REG	Soil	Hand auger	2	3678973.904	436815.448
79.		Trip Blank							1		
80.		Trip Blank							1		
81.		Trip Blank							1		
82.		Trip Blank							1		

Regular and QA Sample Summary	
Regular Samples	**61**
Field Duplicates	**6**
Split Samples	**6**
Rinsate Blanks	**3**
Field Blanks	**2**
Trip Blanks	**1 per shipment***
Total Samples	**78**

***Not included in total.**

Analytical Suites

1. TCL VOCs
2. TCL Organic Compounds (VOCs, SVOCs, Pesticides/PCBs)
3. TAL Inorganics
4. TCL PAHs
5. Gross alpha, nonvolatile beta
6. Gross alpha, nonvolatile beta, select gamma emitters

POST-CONSTRUCTION REPORT FORMAT

1.0 INTRODUCTION

1.1 Purpose and Scope

This Post-Construction Report (PCR) [for Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) projects] documents the completion of the construction of the remedial action (RA) for the closure of the *Operable Unit Name* operable unit (OU). It summarizes construction activities performed to implement the RA requirements in the *Operable Unit Name* Record of Decision (ROD) in accordance with the approved Corrective Measures Implementation (CMI)/Remedial Action Implementation Report (RAIP) (SRNS XXXX).

The future completion of the RA and other post-construction activities (see Section 7.0) will be reported in the Removal Action Completion Report (RACR) in accordance with the Federal Facility Agreement (FFA).

This report includes the following items:

A brief description of the OU background including RA requirements and objectives

A chronology of completed events related to remediation of the OU

A summary of construction activities performed

Deviations from the original design per the approved CMI/RAIP

Performance standards and quality control inspections, including a summary of performance test results documenting verification of compliance with the acceptance criteria in the CMI/RAIP

Verification of construction completion

As-built drawings

Forecasts of post-construction activities (e.g., startup tests, operation and maintenance) per the CMI/RAIP and the ROD (as appropriate)

Project costs [including RA capital costs incurred to date, forecast RA operating costs, post-RA annual Operations and Maintenance (O&M) costs and total present worth (PW) costs.]

1.1.1 Document Format

[Typically addresses the document format used, including the basis for the format. This section should include specific details regarding any deviation from the generic description as well as the basis of the deviation.]

This report was prepared in accordance with the requirements for submittal of regulatory documents as identified in the FFA (1993) and the latest format for the PCR in the Regulatory Document Handbook (SRNS 2012). This format was developed in accordance with the resolution of regulatory comments on required contents for PCRs and United States Environmental Protection Agency (USEPA) guidelines (USEPA 2011).

The *Operable Unit Name* source OU will require long-term RA (i.e., the final RA will require long-term operation of the constructed equipment for treatment of contaminants in the source unit or in the groundwater). Therefore, a CMIR/RACR will be submitted upon completion of RA and this PCR is being submitted upon completion of the construction of operating equipment.

1.2 Operable Unit Background

The *Operable Unit Name* source OU is listed as a Resource Conservation Recovery Act (RCRA) 3004(u) Solid Waste Management Unit/Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Unit in Appendix C of the FFA for Savannah River Site (SRS).

[Since earlier documents have provided the same information in detail, the PCR provides a brief description of the OU with emphasis on RA requirements, including whether the OU is a RCRA and/or CERCLA unit. Reference Figure 1.]

Figure 1. ***Operable Unit Name*** **Location on SRS Map**

1.3 Remedial Action Requirements and Objectives

1.3.1 Remedial Action Objectives

As stated in the ROD (SRNS XXXX), the remedial action objectives (RAOs) for the *Operable Unit Name* are as follows:

[Provide text from ROD]

1.3.2 Selected Remedial Action

As stated in the ROD (SRNS XXXX), the selected RA for the *Operable Unit Name* included the following elements:

[Provide text from ROD]

1.4 Chronology of Events

[A tabular summary (reference Table 1) that lists major milestones and dates related to the RA for the OU, starting with ROD signature, (e.g., RA start/mobilization, site preparation, stabilization, soil cover installation, final inspection [regulatory walk down], etc.), any major changes from the approved CMI/RAIP (change in technology, change in RA, etc.) where it was necessary to get regulatory/core team approval, demobilization and final inspection of completed construction. For future post-construction activities (like start-up, operation and/or maintenance, effectiveness monitoring activities as applicable) and the RACR, the PCR refers to the RA implementation schedule and the discussion in Section 7.0 of this PCR.]

Table 1. Chronology of Events

Description of Activity	Start Date

2.0 CONSTRUCTION ACTIVITIES

[Provides a summary of construction activities performed during the construction phase in accordance with the approved CMI/RAIP. The first numbered section, which should be titled "OU Construction Team," briefly describes names and roles of prime subcontractors associated with the RA. The next numbered sections will provide a brief narrative following the sequence of activities listed in Section 1.4. The narrative will describe any treatment process required to implement the remedial design, materials and equipment used, successes and problems encountered during construction and resolution of problems (including innovative solutions, if any), and causes for delay. These sections also include brief discussions of unexpected conditions encountered in the field, particularly those that affected the scope or schedule of the construction work.

The last numbered section, which should be titled "Secondary Waste Disposal," provides the specific details of the unit's waste management plan and the CMI/RAIP waste section. Describe the waste types, waste volumes, methods, consistent with SRS procedures, that were used for waste characterization (e.g., testing methods), disposal (include location such as onsite, offsite at SRS, off SRS at XYZ facility) and transportation (include contaminant limits) during construction, as applicable to the selected RA].

3.0 DEVIATIONS FROM ORIGINAL DESIGN

[Identifies design changes from the approved CMI/RAIP required during construction as well as the technical basis for those changes. The discussion includes all changes made during construction, regardless of whether those changes were previously communicated to South Carolina Department of Health and Environmental Control (SCDHEC) and United States Environmental Protection Agency (USEPA). The process and scope of design change notifications are discussed in the CMI/RAIP.]

Several design and construction changes were needed during construction to resolve construction problems. The project team reviewed all changes prior to implementation to ensure compliance with regulatory requirements in the ROD and the CMI/RAIP. Consistent with the CMI/RAIP, notifications were made to USEPA and SCDHEC as appropriate. Table 2 provides a summary of all such changes.

The basis and resolution of deviations from the original design are detailed below. Where applicable, a statement is provided on whether the deviation still meets a performance criterion.

Table 2. Summary of Design Changes

Item	Change	Reason
1		
2		
3		

4.0 VERIFICATION SAMPLING, TESTING AND ANALYSIS, PERFORMANCE STANDARDS, AND CONSTRUCTION QUALITY CONTROL

[Cites appropriate reference to the performance requirements (acceptance criteria) as required per the CMI/RAIP which are derived from the RAOs in the ROD for the remedial action and the construction quality control requirements in the specification. Provides a brief discussion of collection of test samples, a comparison of test results with

those acceptance criteria, and a description of how those criteria were met. It also provides discussion on non-conforming conditions identified during the quality control inspection and how those non-conformances were resolved to meet the specified performance criteria.]

5.0 VERIFICATION OF CONSTRUCTION COMPLETION AND FINAL INSPECTION

5.1 Verification of Construction Completion

[Provides text stating that as detailed in Section 4.0, construction activities required for the RA have met the acceptance criteria established in the approved CMI/RAIP. The results of the analytical sampling and testing have been documented and the records are on file at SRS Area Completion Projects (ACP) Document Control in the project file.]

5.2 Final Inspection

The final walkdown inspection with participation of USEPA and SCDHEC [as applicable] was performed [provide date].

6.0 AS-BUILT DRAWINGS

6.1 As-Built Drawings

[Provides the as-built drawings for the project, which are updated drawings provided in the approved CMI/RAIP and are included in Appendix X of this PCR.]

6.2 Well Modifications

[This section provides a summary or attaches a report of any well modifications (e.g., well abandonment, well extension or protection).]

See Appendix X of this PCR for attached reports.

7.0 POST-CONSTRUCTION ACTIVITIES

[Provides a forecast schedule and refers to the approved CMI/RAIP for discussion of scope and content. As explained in Section 1.0, the PCR also refers to the subsequent Post-ROD documents (e.g., the RACR) to report completion of post-construction activities required by long-term remedial actions for the final closure of the OU. Such activities included (when required per the CMI/RAIP and the unit specific ROD) start-up testing, operations, and effectiveness monitoring report. Maintenance and institutional controls per the Land Use Control Implementation Plan (LUCIP) will be reported during the five-year review of the remedy.]

8.0 PROJECT COSTS

[Provides in a table format (reference Table 3) a cost comparison of the final costs to the original ROD cost estimate of the remedial action activities completed in the construction phase. Cost deviations, beyond –30% or +50%, from the ROD cost estimate are discussed.

The cost breakdown is limited to that which was presented in the ROD. As an example, the combined remedial action construction costs are as follows.]

Table 3. Project Cost Comparison

Project Construction Cost Comparison (Example)			
	ROD Construction Cost ($K)	Incurred Construction Cost ($K)	Delta Cost (%)
Soil Cover Construction	175	157	(10%)

[If applicable, separate into equipment, non-equipment, and O&M categories.]

9.0 REFERENCES

[Provide a list of reports or other documents referenced in the body of the PCR. Examples are shown below.]

FFA, 1993. Federal Facility Agreement for the Savannah River Site, Administrative Docket No. 89-05-FF (Effective Date: August 16, 1993)

SRNS, 2012. *Regulatory Document Handbook (U),* Protocol F.11, "Post-Construction Report Format", ERD-AG-003, Revision 17, Savannah River Nuclear Solutions, Aiken, SC (June).

USEPA, 2011. *Close Out Procedures for National Priorities List Sites*, USEPA OSWER Directive 9320.2-22, Office of Superfund Remediation and Technology Innovation, Washington, D.C.

Appendix X Significant Reference Documents

[Examples: As-Built Drawings, RA Start Notification Letter, USEPA/SCDHEC Walkdown Memo, Well Abandonment Reports]

Attachment X

As-Built Drawings

CORRECTIVE MEASURES IMPLEMENTATION REPORT/ REMEDIAL ACTION COMPLETION REPORT FORMAT

1.0 GENERAL DESCRIPTION

1.1 Purpose and Scope

This Corrective Measures Implementation Report/Remedial Action Completion Report (CMIR/RACR) documents the completion of the remedial action (RA) for the closure of the *Operable Unit Name* operable unit (OU). The previously submitted Post-Construction Report (PCR) (SRNS 200X) summarized construction activities performed to implement the RA requirements in the Record of Decision (ROD) (SRS XXXX) in accordance with the approved Corrective Measures Implementation/Remedial Action Implementation Report (CMI/RAIP) (SRNS XXXX). The *Operable Unit Name (acronym)* entered a period of long-term operation of the constructed equipment for treatment of contaminants in the source unit or in the groundwater. This operations period has ended and this CMIR/RACR reports on operations and documents the completion of all RA activities for this OU. [Note: Delete CMIR and CMI from this document if the OU is CERCLA only.]

This CMIR/RACR was completed after final inspection of operations and a determination that the RA is complete. The Savannah River Site (SRS) notified U.S. Environmental Protection Agency (USEPA) Region 4 and South Carolina Department of Health and Environmental Control (SCDHEC) regarding completion of the aforementioned final operation and function determination. This CMIR/RACR is submitted to USEPA and SCDHEC for approval in accordance with Federal Facility Agreement (FFA) requirements.

This report includes the following items:

- A brief description of the OU background, including a brief statement on RA requirements and objectives in the ROD
- A chronology of completed events related to remediation of the OU
- A summary of reference to the PCR document which summarizes construction activities performed
- A summary of operations activities performed subsequent to the PCR
- Deviations from the original design of the approved CMI/RAIP (SRNS XXXX) or PCR (SRNS XXXX)
- Maps depicting source unit and groundwater COCs both before and after the RA completion
- Performance standards and quality control inspections, including a summary of performance test results documenting verification of compliance with the acceptance criteria in the CMI/RAIP (SRNS XXXX) or PCR (SRNS XXXX)
- Final inspection and verification of OU Closure
- As-built drawings
- Land Use Controls
- Total Project costs includes total RA capital costs, total annual operations and maintenance (O&M) costs and total present worth (PW) costs from RA start date through completion

1.1.1 Document Format

[Typically addresses the document format used, including the basis for the format. This section should include specific details regarding any deviation from the generic description as well as the basis of the deviation.]

This report has been prepared in accordance with the requirements for submittal of regulatory documents as identified in the FFA (1993) and the latest format for the CMIR/RACR in the Regulatory Document Handbook (SRNS 2012). This format was developed in accordance with the resolution of regulatory comments on required contents for CMIR/RACRs and USEPA latest guidelines (USEPA 2011).

The *Operable Unit Name* source OU required long-term RA (i.e., the final RA required long-term operation of the constructed equipment for treatment of contaminants in the source unit or in the groundwater). Therefore a PCR was submitted upon construction completion, on (date) (SRNS XXXX) and this CMIR/RACR is now being submitted upon completion of operation of the constructed equipment.

1.2 Operable Unit Background

The *Operable Unit Name* source OU is listed as a RCRA 3004(u) Solid Waste Management Unit/CERCLA unit in Appendix C of the FFA for SRS.

[Copy an abbreviated description of the waste unit from the ROD. Include only those components that are addressed by the RA. The description should include location, size, and the background operational history of the unit requirements including whether the OU is a RCRA and/or CERCLA unit. The section may also include a short paragraph identifying the predecessor documents related to the construction of the RA (e.g., PCR). Provide figures showing RA location at SRS (Figure 1) and a pre-RA site layout (Figure 2).

Previous community involvement activities should be summarized. A very condensed presentation of information for this section since the same information has been covered

in greater detail in previous documents required by the FFA process; however, this document is supposed to be a standalone document presenting all aspects of the RA. Since earlier documents have provided the same information in detail, the CMIR/RACR provides a brief description of the OU with emphasis on RA. This section should also state whether the OU is a RCRA and/or CERCLA unit.]

Figure 1. ***Operable Unit Name*** **Location on SRS Map**

Figure 2. ***Operable Unit Name*** **Pre-Remedial Action Site Plan**

1.2.1 General Description and Location of Operable Unit Name

The *Operable Unit Name* (Figure 1) is located within the SRS, approximately TBD feet south of the (e.g., C, K, L, P, or R-Area Reactor) perimeter fence and XX feet north of [add location description].

1.2.2 Pre-Remedial Action Completion Nature and Extent of Contamination in Operable Unit Name Soils (Source Unit)

[Briefly identifies the source unit constituents of concern (COCs) and principal threat source materials (PTSMs) copied from the ROD (table may be used) that were considered for RA, and the associated risks, specific components of the unit requiring remediation and locations of COCs and PTSMs with respect to the zone of remediation (areas and depths). Because the information is covered in greater detail in previous FFA documents, a condensed presentation (synopsis or summary) is appropriate for this section. Provide or reference figures or maps for the design clarification of data already provided in the ROD to illustrate the nature and horizontal and vertical extent of COCs and PTSMs (Figure 3).]

1.2.3 Pre Remedial Action Completion Nature and Extent of Contamination in Operable Unit Name Groundwater

[Briefly identifies the groundwater source unit constituents of concern (COCs) and principal threat source materials (PTSM) copied from the ROD (table may be used) that were considered for RA and the associated risks, specific components of the unit requiring remediation and locations of COCs and PTSM with respect to the zone of remediation (areas and depths). Because the information is covered in greater detail in

Figure 3. Pre-Remedial Action Completion Nature and Horizontal and Vertical Extent of COCs in the Source Unit

previous FFA documents, a condensed presentation (synopsis or summary) is appropriate for this section. Provide or reference figures or maps for the design clarification of data already provided in the ROD to illustrate the nature and horizontal and vertical extent of COCs and PTSMs (Figure 4).]

1.3 Remedial Action Requirements and Objectives

1.3.1 Remedial Action Objectives

As detailed in the ROD, the remedial action objectives (RAOs) for the *Operable Unit Name* are as follows:

[Copy RAO text from the ROD for OU.]

Per the ROD, the RAOs for this RA would be achieved by implementing the below RA.

1.3.2 Selected Remedial Action

As stated in the ROD (SRNS XXXX), the selected RA for the *Operable Unit Name* source OU soils included the following key elements:

[Copy RA description text from the ROD for the OU. May include a schematic illustration of the selected remedy from the ROD or a reference to the Land Use Control Implementation Plan (LUCIP) figure number if the conceptual site model (CSM) is contained therein.]

Figure 4. Pre-Remedial Action Completion Nature and Horizontal and Vertical Extent of COCs in the Groundwater Source Unit

Figure 5. Conceptual Site Model

1.4 Chronology of Events

[Copy from the PCR, the tabular summary (reference Table 1) of activities performed during the construction phase in accordance with the approved CMI/RAIP. Reference the PCR. Add to the tabular summary (reference Table 1) the additional post PCR major milestones and dates related to the RA for the OU, PCR approval, major operations verification sampling and performance testing, inspections, identification and resolution of non-conformances (if any), demobilization and final inspection (regulatory walkdown) of completed operations.]

Table 1. Chronology of Events

Description of Activity	Start Date

2.0 OPERATIONS ACTIVITIES

[Provides a summary of operations activities performed during the operations phase in accordance with the approved PCR. The summary will be a brief narrative following the sequence of activities listed in Section 1.4. This section also briefly describes materials and equipment used, name and roles of the prime subcontractor(s), with description of any treatment process required to implement the RA, a description of operating permits, successes and problems encountered during operations and resolutions of problems (including innovative solutions, if any) and causes for any delay. This section also includes a brief discussion of unexpected conditions encountered in the field, particularly those that affected the scope or schedule of the operations phase of the RA.]

2.1 Performance Reports

[State (if applicable): The effectiveness of the action in meeting the performance criteria of the groundwater RAOs was assessed through periodic Effectiveness Monitoring Reports (EMRs), Corrective Action Plans (CAPs), etc. This section provides a brief description of all EMRs, CAPs, etc. Summaries should include discussions and graphs of operations durations, pounds of materials treated, pounds of COC removed, COC concentrations in groundwater, vadose and or source units, as well as discussions of significant downtimes and mass or concentration spikes or rebounds. Hydrogeological conditions throughout the plume and the impact of the RAs may also be included. Enhancement recommendations and implementation results along with system effectiveness in meeting the RAOs should also be highlighted.]

2.2 Equipment D&D

[Describe the treatment system waste (e.g., sludge, filters, purge water, etc.) Describe the decontamination and decommissioning (D&D) of all equipment (e.g., treatment systems) not permanently required for the RA and subsequently disposed.]

2.3 Secondary/Job Control Waste Disposal

[This section provides the specific details of the unit's waste management plan. Describe the waste type, waste volume, and method, consistent with SRS procedures, that were used for waste characterization (e.g., testing methods), disposal (include location such as onsite, offsite at SRS, off SRS at XYZ facility) and transportation (include contaminant limits) during operations, as applicable to the selected RA. An example follows.]

[Example: Waste management (handling, disposal, and transportation of operations-generated wastes) and de-watering met the requirements of applicable SRS manuals and procedures (e.g., SRS 3Q Manual, *Environmental Compliance Manual;* SRS 1S Manual, *Waste Acceptance Criteria*; SRS C1 Manual, *Environmental Restoration Administrative*

Procedures). Primary remediation waste was stabilized by in situ stabilization/solidification (S/S). Aqueous secondary remediation waste, which includes decontamination rinsates and the excess water from de-watering was…….. Excess (unused) rainwater was sampled, analyzed, and compared to the *Investigation-Derived Waste Management Plan*, Rev 9, Appendix A (WSRC 1994) limits. The contamination in the water was below those liwsmits, and water was discharged on the ground.]

3.0 DEVIATIONS FROM ORIGINAL DESIGN

[Identifies design changes required during operations as well as the technical basis for those changes. The discussion includes all changes made during operation, regardless of whether those changes were previously communicated to SCDHEC and USEPA.]

Several design and construction changes were needed during operations to resolve problems. The project team reviewed all changes prior to implementation to ensure compliance with regulatory requirements in the ROD, CMI/RAIP and the PCR. Consistent with the PCR, notifications were made to USEPA and SCDHEC prior to implementation, as appropriate. Table 2 provides a summary of all such changes.

The basis and resolution of deviations from the original design are detailed below. Where applicable, a statement is provided on whether the deviation still meets a performance criterion.

Table 2. Summary of Design Changes

Item	Change	Reason
1		
2		
3		

4.0 VERIFICATION SAMPLING, TESTING, ANALYSIS, PERFORMANCE STANDARDS, AND OPERATIONS QUALITY CONTROL

4.1 Performance Requirements/Standards

[For each RA component verified in the PCR (e.g., cover, soil treatment, soil disposal, etc.), copy a summary of the PCR verification. For all remaining components (e.g., long-term operating equipment), subsections of Section 4.0 will cite appropriate references to the performance requirements (acceptance criteria) as required per the PCR and/or CMI/RAIP for the RA and the operation quality control requirements. Provide a brief discussion and table of test samples, and a comparison of test results with PCR and/or CMI/RAIP acceptance criteria performance requirement and/or process control parameters broken down by type of media evaluated (groundwater, vadose, air emission, etc.) Copy from the PCR and/or the CMI/RAIP. Include a description of how those criteria were met but with allowances for deviations outlined in Section 3.0. It also provides discussion on other non-conforming conditions identified during the quality control inspection and how those non-conformances were resolved to meet the specified performance criteria.

A summary table is suggested which lists the specific attributes required and the specific tests or monitoring for each attribute. If numerous tests or monitoring is conducted, a minimum, maximum, average summary is suggested along with footnotes for entries not meeting RAOs, shutdown criteria, or other compliance points. Summarize cover inspection and maintenance actions.]

4.2 Operations Quality Control

[Provides a summary of operations quality assurance (QA) and quality control procedures that were implemented to ensure successful implementation of the RA. It also includes any special or unit-specific strategy applicable to the RA.]

5.0 VERIFICATION OF REMEDIAL ACTION COMPLETION AND FINAL INSPECTION

[Note: If the waste unit is being released for unrestricted land use (e.g., no land use controls), use the term "OU Closure" instead of "Remedial Action Completion" in the title. Provides the text stating that:]

(1) As detailed in Section 4.0, the operations activities required for the RA have met the acceptance criteria established in the approved CMI/RAIP and/or PCR, but with allowances for deviations outlined in Section 3.0. (2) As detailed in Section 5.1, the RA is verified as complete and that operations were in accordance with the ROD RAOs. Section 5.1's verification is typically based upon the result of performance tests and quality control inspections provided in the verification of Section 4.0. (3) As outlined in Section 5.2, the final walkdown inspection with participation of USEPA and SCDHEC (as applicable) has been performed and issues have been closed out.

[Note: For each RA component inspected and verified as complete in the PCR (e.g., typically all non-operation components like the cover, soil treatment, disposal, etc.), summarize Section 5.0 of the PCR (Verification of Construction Completion and Final Inspection.)]

5.1 Verification of Remedial Action Completion

[List the primary RA components and include a verification statement on which and how each applicable RAO was met. Each RAO should be copied from the ROD. Provide assurance that the implemented remedy (or no action decision) achieves the degree of cleanup or protection specified in the ROD(s) for all pathways of exposure described in the CSM and that no further RCRA/CERCLA response is needed to protect human health and the environment.]

[This section provides the verification that RAOs established in the ROD have been met through field implementation of the RA per the approved CMI/RAIP (SRNS XXXX).] The verification is based on the Section 5.2 walkdown and successful achievement of the RAOs per discussion above. It is concluded that the *Operable Unit Name* closure has been completed satisfactorily and the RA is complete in accordance with the requirements of the *Operable Unit Name* ROD. The results of any analytical sampling and testing have been documented and the records are on file at SRS ACP Document Control in the project file. In accordance with the ROD, applicable post-closure activities (e.g., land use control, 5-year remedy reviews, etc.) will be performed as described in Section 7.0 of this CMIR/RACR. [Also include a summary of and reference for the PCR verification section for RA components not verified herein.]

5.2 Final Inspection for Acceptance of *Operable Unit Name* Closure

A final joint walkdown was performed on month/day/year by the *Operable Unit Name* closure Project Team, SCDHEC and USEPA. No further outstanding issues resulted from the walkdown. A summary and participants of the USEPA/SCDHEC inspection are provided in Appendix X. [Also include a summary of and reference for the PCR inspection section.]

6.0 AS-BUILT DOCUMENTATION

6.1 As-Built Drawings

[This section provides as-built drawings, which are updated PCR construction drawings and as-built operations drawings for the completed project and are included in Appendix X of this CMIR/RACR. Drawings should reflect the RA completion configuration. RA components no longer needed (e.g., operating equipment) should be deleted or shown as abandoned in place. Post-CMIR/RACR RA components needed (e.g., cover, fencing, etc. needed per the LUCIP) should also be as-built.]

6.2 Well Modifications

[This section provides a summary or attaches a report of any well modifications (e.g., well abandonment, well extension or protection).]

7.0 POST-CMIR/RACR ACTIVITIES AND LAND USE CONTROL

[For post-CMIR/RACR activities, see the OU specific LUCIP required for the RA. Maintenance and land use controls per the LUCIP (if applicable) will be reported during the five-year review of the remedy. [Provide assurance that a LUCIP is in place and is sufficient to maintain the protectiveness of the remedy. The LUCIP for this section should describe redevelopment potential at the site or any planned or ongoing redevelopment work. State whether a five-year review is appropriate, and if so, the type of review (statutory or policy) and the schedule for the review. Provide a summary of any five-year reviews already completed.]

8.0 PROJECT COSTS

[Provides in a table format (reference Table 3) a cost comparison of the final costs for the RA to the original ROD cost estimate. Cost deviations, beyond –30% and +50%, from the ROD cost estimate are discussed. The cost breakdown is limited to that which was presented in the ROD (e.g., limited to the soil cover total capital and total O&M costs and the soil vapor extraction (SVE)/Air Spurging (AS) total capital and total 5-year O&M costs.) As an example, the combined RA comparative capital costs and O&M costs for a soil cover and a SVE/AS system are as follows:]

Table 3. Project Cost Comparison

Project Cost Comparison (Example)			
	ROD Cost ($K)	Incurred Cost ($K)	Delta Cost (%)
Soil Cover Capital AS/SVE Capital	175 800	157 690	(10%) (14%)
Soil Cover O&M AS/SVE O&M	20 1200	25 2735*	+25% +228%**

[If applicable, separate costs into equipment, non-equipment and O&M categories.]

9.0 REFERENCES

[Provide a list of documents referenced in the body of the CMIR/RACR document. Examples are shown below.]

FFA, 1993. *Federal Facility Agreement for the Savannah River Site,* Administrative Docket No. 89-05-FF (Effective Date: August 16, 1993)

SRNS, XXXX. *Record of Decision, Remedial Alternative Selection for the Operable Unit Name*

SRNS, XXXX. *Corrective Measures Implementation Plan/Post Construction Report for the Operable Unit Name*

SRNS, 2012. *Regulatory Document Handbook (U),* Protocol F.12, "Corrective Measures Implementation Report/Removal Action Completion Report Format", ERD-AG-003, Revision 17, Savannah River Nuclear Solutions, Aiken, SC (June).

SRS, 1994a. SRS E7 Manual, *Conduct of Engineering and Technical Support (U), Rev. 7,* Westinghouse Savannah River Company, Savannah River Site, Aiken, SC

SRS, 1994b. SRS Procedure Manual 1Q, *Quality Assurance (U), Rev. 0,* Westinghouse Savannah River Company, Savannah River Site, Aiken, SC

USEPA, 2011. *Close Out Procedures for National Priorities List Sites*, USEPA OSWER Directive 9320.2-22, Office of Superfund Remediation and Technology Innovation, Washington, D.C.

WSRC, 1994. *Investigation-Derived Waste Management Plan (U)* WSRC-RP-94-1227, Rev. 9, Westinghouse Savannah River Company, Savannah River Site, Aiken, SC

Appendix X

[Examples: As-Built Drawings, RA Start Notification Letter, Fact Sheet, USEPA/SCDHEC Walkdown Memo, Well Abandonment Reports]

FORMAT FOR RESPONSE TO REGULATORY COMMENTS

Instructions for preparing written responses to EPA and SCDHEC comments on regulatory reviewed documents are provided below. A separate set of responses is prepared for EPA and SCDHEC.

Comment Response Header

- Header will include the subject line from the EPA or SCDHEC comment submittal.
- If initial responses are submitted electronically, add the words "DRAFT SRS Responses to" before the EPA or SCDHEC subject line.
- Following regulatory agreement on the responses, replace "DRAFT SRS Responses to" with "Final SRS Responses to" if submitted electronically.
- Include the date comments were officially received.
- Include page numbers (i.e., Page X of Y).

Comment Response Format

- Repeat the regulator comments verbatim as received.
- Following the comment, add a Response line followed by "Agree", "Disagree", or "Clarification". The SRS response should be in bold font.
- Provide a brief, factual, and technically supported explanation to support the response.
- If no change to the document is needed, state "No change to the document is proposed" in the response.
- If changes to the document are needed, identify the location in the text where the change will be made by section and paragraph. (Do not identify by page number as text will shift with revisions.) Repeat the revised text in the response as it will appear in the document. Identify deleted text with strikethrough and new text with underline.
- Attach new or revised figures and tables with the comment responses.
- Identify the Responsible Party by name, phone number, and email address.

Refer to the format example for preparing responses to regulatory comments.

EXAMPLE

DRAFT SRS Responses to U.S. Environmental Protection Agency
Comments on the
Post Construction Report (PCR) for the
R-Area Operable Unit (U)
SRNS-RP-2011-01574, Revision 0, December 2011, CERCLIS Number: 95
Savannah River Site NPL Site, South Carolina
Page 1 of 2

Comments Received 4/9/12

SPECIFIC COMMENTS

1. Page 8, Section 1.2.2, Nature and Extent of Contamination: The discussion of the R-Area Ash Basin (188-P) Subunit on Page 8 of 28 of the PCR describes the ash thickness in the basin tapered from 4.9 meters (16 feet) at the point the coal ash was sluiced into the basin in the north. However, according to Figure 5, Layout of the R-Area Ash Basin (Page 12 of 28), the ash thickness at the north of the basin is 20 plus feet. To promote clarity and consistency between the text and figures, revise the PCR to correct the discrepancy in the reported thickness of the ash located at the north end of the ash basin.

   Response: Agree

   Section 1.2.2, R-Area Ash Basin (188-P) Subunit will be revised to read "Ash thickness in the basin tapers from <u>greater than 6.1 m (20 ft)</u> ~~4.9 m (16 ft)~~ at the point ……"

   Responsible Party: John Doe, (803) 952-9594, john.doe@srs.gov

2. Page 12, Section 1.3.2 Selected Removal Action, bullet one: "Removal of the contaminated media (soil and railroad bed gravel) to a removal action goal of 10 pCi/g for cesium-137 (+D) to an estimated depth of 0.61 to 0.91m (2 to 3 ft)." Unclear if there is an inconsistency between this statement and the statements shown on Figures E-3 and E-4 regarding the depth of soil removal. Figure E-3 states: "Proposed RRCC Excavation Limit (Area 1) – Excavate to minimum depth of 1-ft below the gravel layer. Area shown in shade shall be excavated to minimum depth of 2-ft below the existing ballast materials. Additional excavation may be required based on confirmation sampling. Figure E-4 states: "Proposed RRCC Excavation Limit (Area 2) – Excavate area to minimum depth of 1-foot. Additional excavation may be required based on confirmatory sampling."

   Response: Clarification

   The rail ballast was approximately 0.3 m (1 ft) in depth. The excavation depth(s) as stated in Figures E-3 and E-4 are presented in terms of 0.3 to 0.61m (1 to 2 ft) below the ballast layer. As noted in the confirmatory sampling results in Table E-2, all results were below 1.0 pCi/g, significantly less than the 10 pCi/g removal action goal. No change to the document is proposed.

   Responsible Party: John Doe, (803) 952-9594, john.doe@srs.gov

PROTOCOL

ECOLOGICAL RISK ASSESSMENT PROCESS ANNOTATED OUTLINE

The purpose of the annotated outline is to provide a consistent format for ecological risk assessments (ERAs) at the Savannah River Site (SRS) following the "Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments" (USEPA 1997) guidance document. This outline applies to both work plans and baseline risk assessments (BRAs) depending on their current state of development. All new work plans will start at Step 1 of the process provided adequate abiotic data are available for evaluation. Work plans with adequate biological data will contain a minimum of Steps 1 and 2 (screening-level ERA) and may contain Steps 3 and 4 depending on the results of the screening-level ERA. If adequate data are not available, Step 1 will be initiated and documented in the next document submittal (e.g., subsequent work plan phase or in the BRA) once adequate data have been collected. BRAs will begin at Step 1 of the process and will either (1) summarize the steps already conducted in the work plan, (2) initiate the process if not previously conducted in the work plan, or (3) if new data become available after completion of Steps 1 and 2, determine the impact of the data and modify the results of Steps 1 and 2 accordingly.

The prefixes in the section numbering will vary depending on which document this report is contained (e.g., in a BRA, the numbering will be 8.1.2 for the screening-level problem formulation).

Introduction

Provide an introduction including the purpose, scope, scale, and status of the ERA process for the unit under evaluation.

SCREENING-LEVEL PROBLEM FORMULATION AND ECOLOGICAL EFFECTS EVALUATION (Process Step 1)

1.1 INTRODUCTION

The screening-level problem formulation and ecological effects evaluation is part of the initial ecological risk screening assessment. Section 1.2 describes the screening-level problem formulation and Section 1.3 describes the screening-level ecological effects evaluation.

1.1.1 Unit History

Provide a brief history of the unit including its current status, emphasizing those aspects that are important to the ecological risk assessment.

1.2 SCREENING-LEVEL PROBLEM FORMULATION

The screening-level problem formulation requires the development of a brief and preliminary conceptual site model (CSM) that addresses the following four issues:

- Environmental setting and contaminants known or suspected to exist at the waste unit (Section 1.2.1);
- Contaminant fate and transport mechanisms that might exist at the unit (Section 1.2.2);
- A brief discussion of the mechanisms of ecotoxicity associated with broad classes of contaminants (Section 1.2.3); and
- Potentially complete exposure pathways (Section 1.2.4).

1.2.1 Environmental Setting and Contaminants at the Site

The discussion of the ecological characterization of the unit, including the results of habitat mapping, field reconnaissance, and any previously conducted ecological studies. The results of the checklist for ecological assessment/sampling for the unit is also discussed here and the checklist is provided as an attachment. This includes a description of physical features such as surface water drainage pathways (both current and historic), soil type(s), vegetative communities, wildlife, threatened or endangered species, and the general categories of contaminants present at the unit.

1.2.2 Contaminant Fate and Transport

Based on the CSM, the potential pathways for the migration of unit-related contaminants are discussed.

1.2.3 Ecotoxicity and Potential Receptors

Given the types of constituents detected at the unit as discussed in Section 1.2.1, toxic mechanisms of the constituents are generically discussed by constituent category (organics, inorganics, and radionuclides).

1.2.4 Complete Exposure Pathways

Potential exposure pathways at the unit are also discussed in Section 1.2.2. For ecological receptors present at the unit, the potentially complete exposure pathways are discussed as well as the routes through

which exposure to these pathways may occur.

1.3 SCREENING-LEVEL ECOLOGICAL EFFECTS EVALUATION

The ecological effects evaluation identifies the potential for adverse ecological effects based on conservative assumptions. Ecological screening values (ESVs) are used as the screening -level effects levels. ESVs are abiotic media (surface water, sediment, and soil) concentrations associated with the low risk (approaching the threshold of acceptable/ unacceptable risks) to ecological receptors. The uncertainty associated with the screening-level assessment is unidirectional, with a low probability of not identifying contaminants which pose unacceptable risks to ecological receptors.

1.3.1 Preferred Toxicity Data

The preferred toxicity data for the screening-level ecological effects evaluation are the ecological screening values (ESVs) as identified in the "Ecological Screening Values (ESVs)" protocol (WSRC 1999e) and subsequent revisions.

1.3.2 Dose Conversions

The use of any dose conversions in the "Ecological Screening Values (ESVs)" protocol (WSRC 1999e) will be identified in this section.

1.3.3 Uncertainty Assessment

The generic uncertainties associated with the ESVs and the assumptions made in Step 1 of the process will be identified.

1.4 SUMMARY

A brief summary of the information provided in Sections 1 will be provided.

SCREENING-LEVEL EXPOSURE ESTIMATE AND RISK CALCULATION (Process Step 2)

2.1 INTRODUCTION

This step includes estimating exposure levels and screening for ecological risks.

2.2 SCREENING-LEVEL EXPOSURE ESTIMATES

2.2.1 Exposure Parameters

The exposure parameters used, if any, are identified in the "Ecological Screening Values (ESVs)" protocol (WSRC 1999e).

2.2.2 Uncertainty Assessment

The generic uncertainties associated with the ESVs and the assumptions made in Step 2 of the process will be identified.

2.3 SCREENING-LEVEL RISK CALCULATION

The screening-level risk calculation is performed per Steps A and B of the "Ecological Constituents of Potential Concern Selection Process" protocol (WSRC 1999d). Constituents identified as having the potential to bioaccumulate/bioconcentrate per the "Bioaccumulation and Bioconcentration Screening" protocol (WSRC 1999c) will be retained for further evaluation per Step D of the "Ecological Constituents of Potential Concern Selection Process" protocol (WSRC 1999d).

2.4 SCIENTIFIC/MANAGEMENT DECISION POINT (SMDP)

The selection of one of the following three decisions is made:

(1) There is adequate data to conclude that ecological risks are negligible and therefore no need for remediation on the basis of ecological risk;
(2) The information is not adequate to make a decision at this point, and the ecological risk assessment process will continue to Step 3; or
(3) The information indicates a potential for adverse ecological effects, and a more thorough assessment is warranted.

This SMDP will be addressed through a meeting (e.g., conference call) with EPA and SCDHEC for the initial waste units utilizing this outline.

2.5 SUMMARY

A brief summary of the information provided in Section 2 will be provided.

BASELINE RISK ASSESSMENT PROBLEM FORMULATION (Process Step 3)

Step 3 of the process initiates the problem-formulation phase of the baseline ecological risk assessment. Step 3 refines the screening-level problem formulation and, with input from stakeholders and other involved parties, expands on the ecological issues that are of concern at the particular site. Steps 3 through 7 are required only for sites for which the

screening-level assessment indicated a need for further ecological risk evaluation.

3.1 THE PROBLEM-FORMULATION PROCESS

Problem formulation establishes the goals, breadth, and focus of the baseline ecological risk assessment and establishes the assessment. The questions and issues that need to be addressed in the baseline ecological risk assessment are defined based on potentially complete exposure pathways and ecological effects. The conceptual model of the site is refined and includes questions about the assessment endpoints and the relationship between exposure and effects.

3.2 REFINEMENT OF PRELIMINARY CONTAMINANTS OF CONCERN

The results of the screening-level risk assessment (Steps 1 and 2) should have indicated which contaminants found at the site could be eliminated from further consideration and which should be evaluated further. Because of the conservative assumptions used during the risk screen, some of the contaminants retained for Step 3 might also pose acceptable levels of risk. At this stage, the remaining constituents are further evaluated based on the following considerations per the "Ecological Constituents of Potential Concern Selection Process" protocol (WSRC 1999d):

(1) Comparison to unit background /reference (Section 3.2.1);
(2) Evaluation-level hazard quotient (HQ) development (Section 3.2.2);
(3) Lines-of-evidence (Section 3.2.3).

3.2.1 Comparison to Unit Background/Reference

Per Step C of the "Ecological Constituents of Potential Concern Selection Process" protocol (WSRC 1999d), constituents are identified for which background/reference media concentrations can be used to eliminate them from further consideration. Remaining constituents are further evaluated in Section 3.2.2.

3.2.2 Evaluation-Level Hazard Quotient Development

Per Steps E and F of the "Ecological Constituents of Potential Concern Selection Process" protocol (WSRC 1999d), evaluation-level HQs are based on exposure doses that are calculated based on receptor-specific input parameters and average concentrations. Receptors to be considered at this step of the process are determined using the "Assessment and Measurement Endpoint Selection Process" protocol (WSRC 1999b). Terrestrial toxicity reference values (TRVs) are identified based on the terrestrial TRVs protocol (WSRC 1999f). Aquatic TRVs are identified

based on the aquatic TRVs protocol (WSRC 1999a). Remaining constituents are further evaluated in Section 3.2.3.

3.2.3 Lines-of-Evidence

Per Steps F and G of the "Ecological Constituents of Potential Concern Selection Process" protocol (WSRC 1999d), constituents with an evaluation-level HQ greater than one are further evaluated based on the following lines-of-evidence: preliminary assessments involving alternate toxicity reference values (e.g., no observed versus lowest observed adverse effects level comparisons), frequency of detections (i.e., analytical qualifier evaluation), and patterns of detections (i.e., pattern of hits indicating contamination migration from a source). This evaluation is based on an interpretation of the available data, interpretation of the available information, and professional judgement. Information from previous ecological studies, if available, should also be evaluated in this step as additional lines of evidence for retaining or eliminating constituents. Constituents remaining upon completion of this evaluation are identified as final COPCs.

3.3 LITERATURE SEARCH ON KNOWN ECOLOGICAL EFFECTS

The initial literature search conducted in Steps 1 and 2 should be expanded to obtain the information needed for the more detailed problem formulation phase of the baseline ecological risk assessment. The literature search should identify NOAELs, LOAELs, exposure-response functions, and the mechanisms of toxic responses (presented in toxicological profiles for each final COPC either within Section 3.3 or as an appendix for contaminants for which those data were not collected in Steps 1 and 2.

3.4 CONTAMINANT FATE AND TRANSPORT, ECOSYSTEMS POTENTIALLY AT RISK, AND COMPLETE EXPOSURE PATHWAYS

The contaminant fate and transport, ecosystems potentially at risk, and complete exposure pathways identified in the screening ecological risk assessment should be reevaluated and refined as necessary in this step.

3.4.1 Contaminant Fate and Transport

Information on how the final COPCs will or could be transported or transformed in the environment physically, chemically, and biologically are presented and used to identify the exposure pathways that might lead to significant ecological effects.

3.4.2 Ecosystems Potentially at Risk

The ecosystems or habitats potentially at risk should be identified based on information gathered and refined from Steps 1 and 2 of the process.

3.4.3 Complete Exposure Pathways

The potentially complete exposure pathways identified in Steps 1 and 2 are described in more detail on the basis of the refined contaminant fate and transport evaluations (Section 3.4.1) and evaluation of potential ecological receptors (Section 3.4.2).

3.5 SELECTION OF ASSESSMENT ENDPOINTS

Assessment endpoints are selected and identified here based on the "Assessment and Measurement Endpoint Selection Process" protocol (WSRC 1999b).

3.6 THE CONCEPTUAL MODEL AND RISK QUESTIONS

The conceptual site model from Section 1.2 is refined, if necessary, and presented here to establish the complete exposure pathways that will be evaluated in the ecological risk assessment and the relationship of the contaminants to the assessment endpoints. In the conceptual model, the possible exposure pathways are depicted in an exposure pathway diagram and are directly linked to the assessment endpoints identified in Section 3.5. Developing the conceptual site model and risk questions are described in Sections 3.6.1 and 3.6.2, respectively.

3.6.1 Conceptual Model

The CSM developed in Step 1 is refined based on knowledge of the contaminants present, exposure pathways, and the assessment endpoints.

3.6.2 Risk Questions

Ecological risk questions are developed to address the questions about the relationships among assessment endpoints and their predicted responses when exposed to unit contaminants. The risk questions are based on the assessment endpoints and provide a basis for developing the study design (Step 4) and for evaluating the results of the site investigation in the analysis phase (Step 6) and during risk characterization (Step 7). An evaluation as to if and how these risk questions should be addressed must be completed at this step. This is a critical step since additional studies should only be performed if necessary to reduce critical uncertainty in the

unit evaluation. Two circumstances may eliminate or reduce the need for additional data collection for ecological purposes. First, if the clean up levels for the remaining ecological COPCs are known to be higher than those required based on human health concerns (through surficial exposure or contaminant fate and transport), additional data collection to reduce the uncertainties surrounding the ecological COPCs may not be warranted and the ERA process may be suspended (if the anticipated human health remedial action is not implemented , the ERA process would continue) . Second, if clean up remedies are limited at the unit and will result in the elimination of the ecological exposure pathways of concern, additional data collection to reduce the uncertainties surrounding the ecological COPCs may not be warranted.

3.7 SCIENTIFIC/MANAGEMENT DECISION POINT (SMDP)

The SMDP consists of agreement on four items: constituents of potential concern (final COPCs), assessment endpoints, exposure pathways, and risk questions. These items will be proposed in the report and approval of the document by EPA and SCDHEC will indicate agreement of this SMDP.

3.8 SUMMARY

The information presented in Step 3 will be briefly summarized here.

STUDY DESIGN AND DATA QUALITY OBJECTIVE PROCESS (Process Step 4)

Step 4 will establish the measurement endpoints (Section 4.1) and study design (Section 4.2), if needed for a given unit.

4.1 ESTABLISHING MEASUREMENT ENDPOINTS

Measurement endpoints are selected based on the assessment endpoints selected using the "Assessment and Measurement Endpoint Selection Process" protocol (WSRC 1999b).

4.1.1 Species/Community/Habitat Considerations

Considerations of the species, communities, and habitat present at the unit that impact the selection of measurement endpoints and their relationship to the assessment endpoints will be discussed here.

4.1.2 Relationship of the Measurement Endpoints to the Constituents of Potential Concern

The inherent properties (such as the physiology or behavioral characteristics of the species) or life history parameters that make a species useful in evaluating the effects of site-specific contaminants will be discussed here.

4.1.3 Mechanisms of Ecotoxicity

The mechanisms of ecotoxicity for the final COPCs that may influence the selection of measurement endpoints will be discussed here.

4.2 STUDY DESIGN

The lines of evidence to be used in addressing the risk questions posed in Section 3.6.2 will be identified in this section.

4.2.1 Bioaccumulation and Field Tissue Residue Studies

The appropriateness of bioaccumulation and field tissue residue studies for the waste unit will be discussed here and detailed as necessary. The justification for the parameter values which will be used in the food web analysis will be given and the variables identified. The interpretation of the results of the modeling will be discussed and the unacceptable risk levels will be defined. The appropriateness of detection levels of COPCs will be verified by the contaminant levels associated with unacceptable risks.

4.2.2 Population/Community Evaluations

The appropriateness of population/community evaluations for the waste unit will be discussed here and detailed as necessary. The interpretation of the results of population and community evaluations will be discussed including defining acceptable and unacceptable results.

4.2.3 Toxicity Testing

The appropriateness of toxicity testing for the waste unit will be discussed here and detailed as necessary. The interpretation of the toxicity tests will be discussed including the defining of acceptable and unacceptable effects.

4.3 DATA QUALITY OBJECTIVES AND STATISTICAL CONSIDERATIONS

The concept of data quality objectives (DQOs) and statistical considerations will

be briefly introduced here.

4.3.1 Data Quality Objectives

The specific DQOs for the unit will be identified here.

4.3.2 Statistical Considerations

Statistical considerations that must be addressed for the unit will be identified here.

4.4 CONTENTS OF WORK PLAN AND SAMPLING AND ANALYSIS PLAN

A brief introduction as to the contents of the ecological work plan and sampling and analysis plan (SAP) sections and how they relate to other sections of the Remedial Investigation (RI) work plan will be discussed here.

4.4.1 Work Plan

The critical decisions and evaluations made during problem formulation will be identified here as well as additional investigative tasks needed to complete the evaluation of risks to ecological receptors. Information detailed in other reports will only be summarized and the reader directed to the appropriate report for details.

4.4.2 Sampling and Analysis Plan

Details of the ecological SAP will be discussed here. The quality assurance project plan (QAPP) will reference the existing QAPP for the unit and provide supplemental information only when not included in the existing QAPP.

4.4.3 Field Verification of Sampling Plan and Contingency Plans

To the extent possible, field verification of the SAP will be performed and contingency plans developed and documented here.

4.5 SCIENTIFIC/MANAGEMENT DECISION POINT (SMDP)

This SMDP consists of agreement on the study design, work plan, and SAP. These items will be proposed in the report and approval of the document by EPA and SCDHEC will indicate agreement of this SMDP.

4.6 SUMMARY

The key elements of Step 4 will be discussed here.

FIELD VERIFICATION OF SAMPLING DESIGN (Process Step 5)

5.1 PURPOSE

The purpose of field verification of the sampling design will be discussed here.

5.2 DETERMINING SAMPLING FEASIBILITY

Field verification of the sampling design will be performed, as possible, and documented here.

5.3 SCIENTIFIC/MANAGEMENT DECISION POINT (SMDP)

This SMDP consists of agreement on sampling feasibility. These items will be proposed in the report and approval of the document by EPA and SCDHEC will indicate agreement of this SMDP. If schedules do not permit the verification of sampling feasibility, a separate letter will be sent to EPA and SCDHEC subsequent to the work plan submittal documenting the conclusions of the field verification.

5.4 SUMMARY

The key elements of Step 5 will be discussed here.

SITE INVESTIGATION AND ANALYSIS PHASE (Process Step 6)

6.1 INTRODUCTION

A brief overview of the concept of site investigation and analysis phase will be discussed here. In the event that significant changes to the ecological SAP occur during field implementation or during analyses of the data, EPA and SCDHEC will be notified and briefed on the impact of the changes and the recommended course of action.

6.2 SITE INVESTIGATION

The site investigation should be a direct implementation of the ecological SAP. If changes to the SAP occurred, they should be documented in this section.

6.2.1 Changing Field Conditions

Changing field conditions resulting in the modification of the ecological SAP will be identified.

6.2.2 Unexpected Nature or Extent of Contamination

Any unexpected findings in regards to nature and extent of contamination and its impact to the implementation of the ecological SAP will be evaluated and an appropriate course of action will be developed.

6.3 ANALYSIS OF ECOLOGICAL EXPOSURES AND EFFECTS

An overview of the intent of the analysis phase will be discussed here.

6.3.1 Characterizing Exposures

An exposure profile and a description of associated uncertainties and assumptions will be discussed here.

6.3.2 Characterizing Ecological Effects

Evidence for existing and potential adverse effects on the unit's assessment endpoints is discussed here.

6.4 SCIENTIFIC/MANAGEMENT DECISION POINT (SMDP)

This SMDP is only required if alterations to the ecological SAP were necessary. Any significant changes to the SAP will have been communicated to EPA and SCDHEC.

6.5 SUMMARY

The key elements of Step 6 will be discussed here.

RISK CHARACTERIZATION (Process Step 7)

7.1 INTRODUCTION

An overview of risk characterization will be discussed here.

7.2 RISK ESTIMATION

Documentation of the risk estimates will be discussed here.

7.3 RISK DESCRIPTION

The intent of the risk description is discussed here.

7.3.1 Threshold for Effects on Assessment Endpoints

Contaminant media concentrations representing the threshold(s) at which environmental effects may occur will be discussed here. However, clean up levels for the final ecological constituents of concern will be identified in Chapter 10 where ARAR, human health, contaminant migration, and ecological clean up levels are identified.

7.3.2 Likelihood of Risk

A qualitative or quantitative evaluation of the likelihood of risk will be discussed in this section.

7.3.3 Additional Risk Information

Other factors influencing the potential risk at the unit will be discussed here.

7.4 UNCERTAINTY ANALYSIS

An overview of the uncertainty analysis process will be discussed here. It should be noted that an additional uncertainty analysis will be performed in conjunction with human health, contaminant migration, and ARAR considerations in Chapter 9 of the RI/BRA report. This additional uncertainty analysis may result in a modification of the final list of ecological constituents of concern identified in the ERA.

7.4.1 Categories of Uncertainty

The possible categories of uncertainty for the waste unit evaluation will be discussed here.

7.4.2 Tracking Uncertainties

Documentation of the method for tracking uncertainties, to have been

agreed to in Step 4 of the process, will be discussed here.

7.5 SUMMARY

The key elements of Step 7 are discussed here.

RISK MANAGEMENT (Process Step 8)

Step 8, risk management, of the ERA process is acknowledged as a distinctly different process from risk assessment and encompasses a broader range of considerations and potential documents (e.g., Feasibility Studies, etc.). Therefore, this step is not included in the outline for the ERA process for development of work plans and BRAs.

References

USEPA. 1997. Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments. Interim Final. EPA 540-R-97-006. June 1997.

WSRC. 1999a. Aquatic Toxicity Reference Values (TRVs). Draft, November 1999, Westinghouse Savannah River Company, Savannah River Site, Aiken, SC.

WSRC. 1999b. Assessment and Measurement Endpoint Selection Process. April 1999, Westinghouse Savannah River Company, Savannah River Site, Aiken, SC.

WSRC. 1999c. Bioaccumulation and Bioconcentration Screening. April 1999, Westinghouse Savannah River Company, Savannah River Site, Aiken, SC.

WSRC. 1999d. Ecological Constituents of Potential Concern Selection Process. April 1999, Westinghouse Savannah River Company, Savannah River Site, Aiken, SC.

WSRC. 1999e. Ecological Screening Values (ESVs). April 1999, WSRC-TR-98-00110, Westinghouse Savannah River Company, Savannah River Site, Aiken, SC.

WSRC. 1999f. Terrestrial Toxicity Reference Values (TRVs). April 1999, Westinghouse Savannah River Company, Savannah River Site, Aiken, SC.

CORRECTIVE MEASURES IMPLEMENTATION (CMI)/ REMEDIAL ACTION IMPLEMENTATION PLAN (RAIP) FORMAT

1.0 GENERAL DESCRIPTION

1.1 Purpose and Scope

This post-Record of Decision (ROD) document provides the following items for the implementation of the selected remedial action (RA) established in the ROD (SRNS XXXX) for the operable unit name (OU):

- A general description of the location and history of the site, description of the constituents of concern (COC) to be remedied and an overview of the selected RA
- A summary of any associated study (if applicable) and the application of its results in the remedial design
- An outline of the necessary design tasks
- A design summary highlighting the results of each of the design tasks performed to accomplish the objectives of the selected RA
- A summary of the construction strategy addressing critical components of construction activities required to implement the remedial design
- Requirements for health and safety, waste management, contamination control, decontamination, quality assurance, quality control inspections, performance verifications (sampling, testing/analysis, when applicable), post-construction operations, maintenance and land use, project closeout, post-construction monitoring and a forecast schedule for implementation of the RA
- A forecast schedule and brief discussion of the contents of the upcoming post-ROD documents required by the Federal Facility Agreement (FFA) for the Savannah River Site (SRS)

1.2 General Description and History of the Unit

[Briefly describes the waste unit. The description should include location, size, and the background operational history of the unit. The section may also include a short paragraph identifying the predecessor documents related to the selection of the RA. Provide figures showing the RA location at SRS and a RA site layout. A very condensed presentation of information is appropriate for this section since the same information has been covered in greater detail in previous documents required by the FFA process.]

1.3 Nature and Extent of Contamination

[Briefly identifies the COCs (table may be used) identified in the ROD that are considered for RA, and the associated risks, specific components of the unit requiring remediation and locations of COCs with respect to the zone of remediation (areas and depths). Because the information is covered in greater detail in previous FFA documents, a condensed presentation (synopsis or summary) is appropriate for this section. Provide figures or maps for the design clarification of data already provided in the ROD to illustrate the nature and horizontal and vertical extent of COCs within the respective media of concern and area(s) targeted/goals for the RA.]

1.4 Document Format

1.4.1 Format of CMI/RAIP

[Typically addresses the document format used, including the basis for the format. This section should include specific details regarding any deviation from the generic description as well as the basis for the deviation.]

This report has been prepared in accordance with the requirements for submittal of regulatory documents as identified in the FFA (1993) and the latest format for the CMI/RAIP in the Regulatory Document Handbook (SRNS 2012). This format was developed in accordance with the resolution of regulatory comments on required contents for CMI/RAIP documents.

[Note: CMI is used in the title when the waste unit is a Resource Conservation and Recovery Act (RCRA) unit. RAIP is used in the title when the waste unit is a Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) unit])

1.5 Remedial Action

As stated in the ROD, the selected RA for the *Operable Unit Name* included the following elements:

[Provide text from ROD. The discussion will also include the rationale (e.g., brief explanation of link between RAs and remedial action objectives (RAOs), industrial land use or ecological concern) for selection of the RA objectives and remedial goals. Table 1 in Section 2.5 lists ARARs associated with the RA.]

[A conceptual site model (CSM) (Figure 2) illustrates how implementation of the RA breaks the exposure pathways.]

Figure 1. Title of Figure (Shows location of waste unit)

1.6 Remedial Action Objectives

As stated in the ROD (SRNS XXXX), the RAOs for the *Operable Unit Name* are as follows:

[Provide text from ROD.]

1.7 Remedial Action Implementation Schedule

[Provides the unit-specific RA implementation schedule as Figure 3.]

1.8 Community Relations

[Provides a brief summary of public involvement activities related to the subject waste unit, including applicable resolutions of public comments by appropriate references to the sections in the ROD. A very condensed presentation of information is appropriate for this section because this information is presented in greater detail in previous documents required by the FFA process.]

[In addition, this section includes any unit-specific item that was identified for the resolution of public comments, related to the selected RA. In accordance with USEPA's "Community Relations Handbook" (#EPA/540 R-92/009, January 1992), upon completion of the final engineering design the agency must issue a "FACT SHEET" and provide a public briefing, as appropriate prior to beginning remedial action. A fact sheet on the RA is attached as Appendix A to inform interested parties about activities related to the RA and that an opportunity for a public briefing will be held before initiation of the RA.]

2.0 REMEDIAL DESIGN

2.1 Design Strategy

[Provides brief description of the remedial design strategy (e.g., identification of definitive design, performance-based design, vendor supplied design, multi-phased design, etc.).]

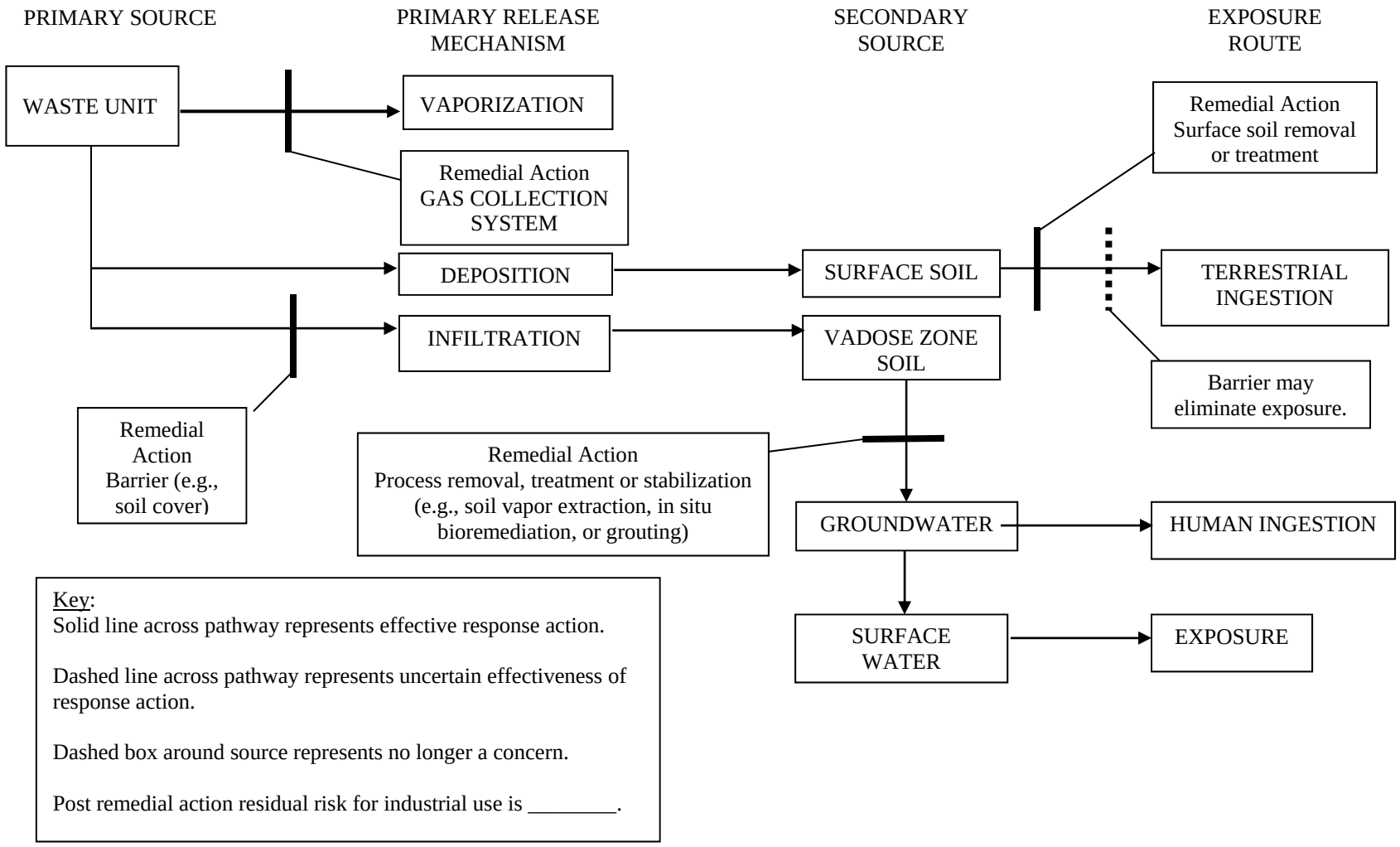
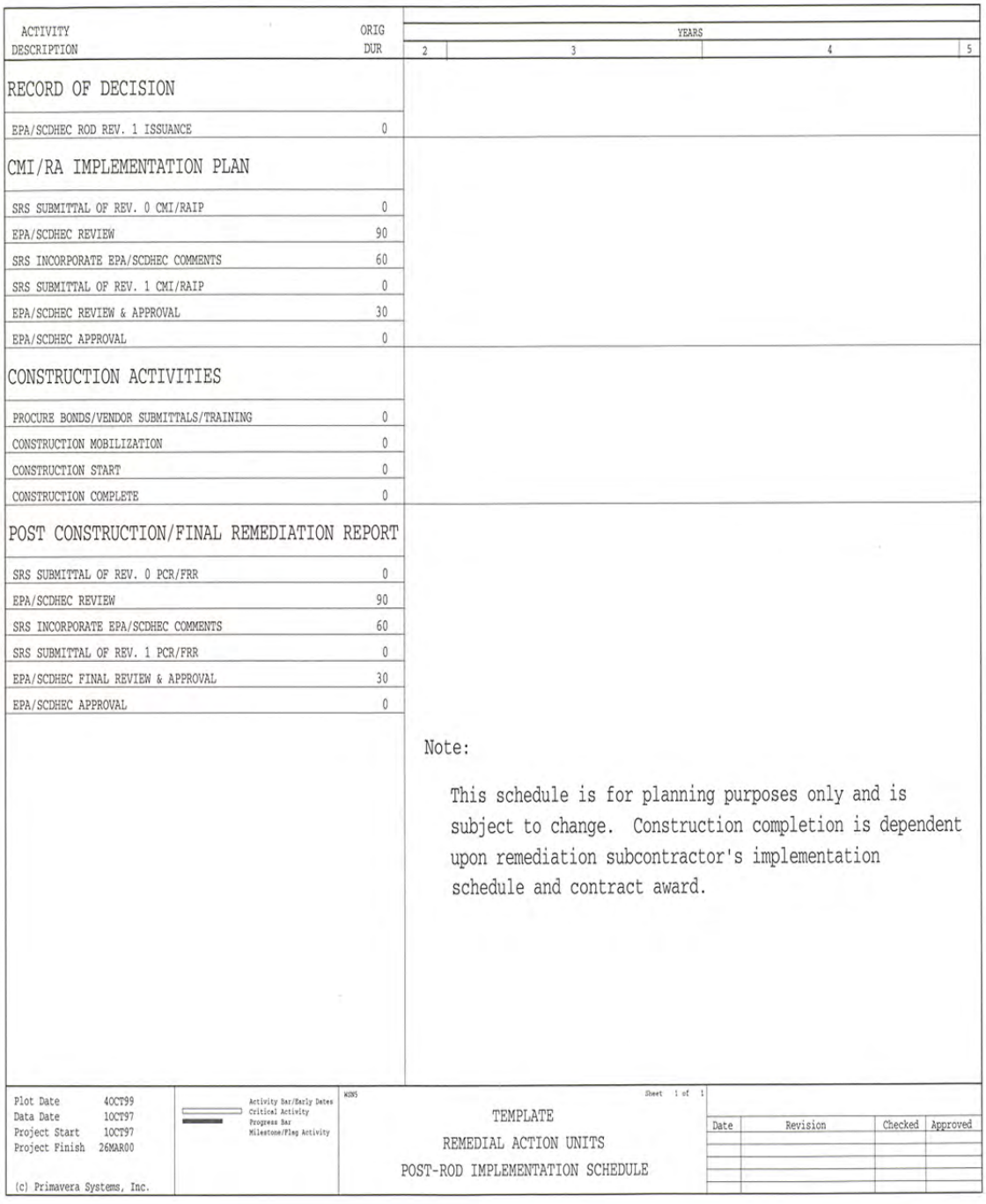


Figure 2. Post-Remedial Action Conceptual Site Model for [Name of Unit]



ACTIVITY DESCRIPTION	ORIG DUR
RECORD OF DECISION	
EPA/SCDHEC ROD REV. 1 ISSUANCE	0
CMI/RA IMPLEMENTATION PLAN	
SRS SUBMITTAL OF REV. 0 CMI/RAIP	0
EPA/SCDHEC REVIEW	90
SRS INCORPORATE EPA/SCDHEC COMMENTS	60
SRS SUBMITTAL OF REV. 1 CMI/RAIP	0
EPA/SCDHEC REVIEW & APPROVAL	30
EPA/SCDHEC APPROVAL	0
CONSTRUCTION ACTIVITIES	
PROCURE BONDS/VENDOR SUBMITTALS/TRAINING	0
CONSTRUCTION MOBILIZATION	0
CONSTRUCTION START	0
CONSTRUCTION COMPLETE	0
POST CONSTRUCTION/FINAL REMEDIATION REPORT	
SRS SUBMITTAL OF REV. 0 PCR/FRR	0
EPA/SCDHEC REVIEW	90
SRS INCORPORATE EPA/SCDHEC COMMENTS	60
SRS SUBMITTAL OF REV. 1 PCR/FRR	0
EPA/SCDHEC FINAL REVIEW & APPROVAL	30
EPA/SCDHEC APPROVAL	0

Figure 3. Remedial Action Units Post-ROD Implementation Schedule Design Deliverables

2.2 Design Activities

[Provides a list of design tasks, including development of the permit applications required to implement the selected RA. This section should also include any design activity that was performed to complete the definitive design, e.g., treatability studies, bench-scale grout mix design, etc.]

2.3 Design Deliverable

[Provides a list of the design deliverables for this RA, including the required permit documents. The list includes design drawings, design technical information, permit documents, applicable sampling, analysis, and test plans, etc., which are necessary to verify that the RA objectives have been met.]

2.4 Results of Data Acquisition

2.4.1 Evaluation of Studies

[Provides a summary level description of any study performed, including the application of the results and conclusion from the study to the remedial design. If no treatability study was performed, a statement should be included to indicate that none was required.]

2.4.2 Other Design Data

[Provides results of any data gathered to support the remedial design (e.g., sampling, topographic, or other surveys). References to all applicable and related reports should also be included.]

2.5 Design Criteria

[Provides functional requirements and design criteria based on USDOE Orders, national consensus standards, SRS and regulatory requirements needed to ensure the design meets RA objectives and goals per the ROD document. Provides a table of applicable or relevant and appropriate requirements (ARARs) (i.e., Table 1) which includes the ARAR type, citation, status, a brief descriptive summary of what the ARAR requires and a brief explanation for inclusion of the ARAR. The list of ARARs will include those in the ROD that are related to the selected remedy and also any additional ARARs identified during the remedial design process.]

Table 1. Compliance with ARARs for the Selected Remedial Action *(example)*

	Citations (S)	Status	Requirement Summary	Reason for Inclusion
A)	**Chemical Specific ARAR**			
	40 CFR 263 and SC 4.61-79.263 Standards Applicable to Transporters of Hazardous Waste (For example)	Applicable	Identifies transporter requirements including manifests, record keeping, and actions for accidental waste discharges.	Applicable to offsite transportation of RCRA hazardous waste.
B)	**Location Specific ARAR**			
	Executive Order 11990 (For example)	Applicable	The remedial action must minimize the destruction, loss, or degradation of wetlands.	Wetlands are located in the vicinity of the waste unit; however, they will be unaffected by this action.
C)	**Action Specific ARARs**			
	SC R.72-300 Standards for Stormwater Management and Sediment Reduction (For example)	Applicable	Stormwater management and sediment control plan for land disturbances.	Excavation activities will require an erosion control plan.
	29 CFR 1910 Occupational Worker Safety (OSHA) (For example)	Applicable	Identifies health and safety requirements for remediation workers.	Worker activities involving hazardous materials must be conducted according to a project health and safety plan.

2.6 Drawings

[Provides a list and brief description of the design drawings developed during the remedial design.]

2.7 Design Technical Information

[Provides a summary of the construction specifications developed during the remedial design.]

3.0 PERMITTING REQUIREMENTS

[Identifies and describes all permitting activities required for the selected RA. The related schedule for each applicable regulatory permit submittal is also included. A copy of permit documents, which are approved by other departments or authorized representatives of USEPA or SCDHEC (e.g., Stormwater Management and Sediment Reduction Plans, Monitoring Well Program Plans, Air Quality Control Permits) may be provided for reference. However, do not include them as an attachment. Add a statement on the cover sheet of the document that reads "Reference - for Information Only."]

4.0 CONSTRUCTION

4.1 Construction Strategy

[Provides a brief description of the construction strategy (e.g., discussion of construction in phases, construction by subcontractor, construction using new technology, etc.) for implementation of the remedial design.]

4.2 Construction Activities

[Provides a summary of the conceptual construction activities that are critical for implementation of the RA. Unless such activities have been concurred with by the constructor, at this stage they will be considered conceptual (anticipated based on past experiences).]

4.3 Remedial Design Change Control

[Provides a standard procedure for documenting and reporting changes to the remedial design after the remedial design document has been approved by USEPA and SCDHEC. This section will be included in the generic document. The following statement (or similar words with the same intent) should be included in this section. "USDOE will notify USEPA and SCDHEC, within a reasonable time frame, when significant problems arise with any aspect of the Remedial Design/RA process. In particular, scheduling, budget and implementability/technical issues should be brought to the attention of the

regulators as soon as they are identified. Notifications will follow established protocols for major and minor changes during construction." If the change is considered major, NCP Section 300.435(c)(2)(i) or (ii) will be followed for public participation requirements. Section 300.435(c)(2)(i) applies to ESD for RODs and (ii) applies to ROD amendments.]

4.4 Waste Disposal and Transport

[Describes the specific details consistent with the unit's waste management plan, that will be used for waste characterization (e.g., testing methods), disposal (include location such as onsite, off-site at SRS, off SRS at XYZ facility) and transportation (include contaminant limits) during construction, as applicable to the selected RA. It also includes the status of any permit required for handling, disposing and transporting wastes.]

4.5 Quality Assurance

[Provides a summary of quality assurance (QA) and quality control procedures that will be implemented to ensure successful implementation of the remedial action. It also includes any special or unit-specific strategy applicable to the remedial action.]

4.6 Non-Conformances

[Provides the anticipated steps and procedures that will be used to resolve construction non-conformances with respect to the required acceptance criteria in the specifications. This section also provides a description of the contingency plan to be used during this construction phase if construction activities cannot be completed as designed.]

4.7 Health and Safety Plan (HASP)

[This section provides health and safety requirements, consistent with SRS procedures, that will be implemented during the RA. The section includes any special or unit-specific requirements for worker safety during construction. Except for unit- specific items, this section will be included in the generic document. The HASP may be included with the post-ROD document package for reference only; it should not be used as an attachment to the CMI/RAIP. If this is the case, add a statement on the cover sheet of the document that reads "Reference – For Information Only".]

A Site-Specific HASP will be prepared in accordance with 29 CFR, Part 1910, Section 120, Occupational Safety and Health Administration (OSHA) and will be implemented by the construction team. The HASP will be approved in accordance with SRS procedures, and a copy will be available at the jobsite at all times. A copy of the HASP will also be available in the ACP project file.

The plan will describe the following:

- Dust suppression requirements related to 40 CFR 50.6 and South Carolina Regulation 61-62.6
- Required actions by the facility personnel in case of fires, explosions, or any unplanned releases of hazardous waste
- Arrangements with onsite security, fire department, medical facility, and emergency response teams to coordinate emergency services
- Names, addresses, and phone numbers (office and home) of all persons qualified to act as emergency coordinators
- Emergency equipment available at the facility
- Evacuation plan for facility personnel

5.0 POST CONSTRUCTION

5.1 Post-Construction Monitoring

[Provides the long- and short-term (including type of sampling, sampling frequency, criteria, and reporting information) to monitor the effectiveness of the implemented RA (e.g., monitoring of groundwater affected by the remediated unit). Includes maps showing the location of remediation and zone of influence. Map should show general grid coordinates but not exact coordinates of remediation actions. Also, provides criteria for turnover to the next remedial phase (e.g., startup to operation phase).]

Figure 4. Map(s) for Section 5.1

5.2 Contingency Plan Implementation Strategy

[This section provides for contingencies after completion of construction, including any special or unit-specific responses and actions to be taken if the implemented RA fails to perform.]

5.3 Operations, Maintenance, and Institutional Control

[Describes start-up and operational procedures for equipment and process systems required by the selected RA. The section also provides maintenance and institutional control information. In addition, it includes any special or unit-specific requirements applicable to the selected RA. For RODs requiring land use controls, a LUCIP will be issued. The duration of land use controls will be specified. Standard maintenance and institutional control requirements will be identified in the LUCIP.]

5.4 Requirements for Project Closeout

[Provides field data collection and performance verification requirements (including sampling, analysis, and testing plans, when applicable) and procedures to verify that the RA objectives have been met. It also addresses updating the design documents as required for configuration management to incorporate design changes during construction.]

5.5 Schedule for Federal Facility Agreement Deliverables

[Provides submittal schedule for the next post-ROD documents [Post-Construction Report (PCR) and the Remedial Action Completion Report (RACR)] required by the FFA. For waste sites not requiring an extended operational equipment RA, the PCR and RACR may be combined into a single document.]

6.0 REFERENCES

[Provides a list of documents referenced in the body of the CMI/RAIP document. Examples are shown below.]

FFA, 1993. *Federal Facility Agreement for the Savannah River Site,* Administrative Docket No. 89-05-FF (Effective Date: August 16, 1993)

SRNS, XXXX. *Record of Decision, Remedial Alternative Selection for the Operable Unit Name*

SRNS, 2012. *Regulatory Document Handbook (U)*, Protocol F.15, "Corrective Measures Implementation Plan/Removal Action Implementation Plan Format", ERD-AG-003, Revision 17, Savannah River Nuclear Solutions, Aiken, SC (June).

7.0 APPENDICES

Appendix X [Provides the unit-specific fact sheet.]

8.0 ATTACHMENTS

[Attach design drawings and plans referenced in the body of the CMI/RAIP. Include engineering design drawings and plans and vendor-supplied design drawings and plans. Documents such as construction and fabrication documents need not be included since they are not design documents.]

Attachment X List of Drawings

APPENDIX X

FACT SHEET

[Remedial Action Title Fact Sheet]

Location

[Briefly describes the waste unit. The description should include location and size of the unit.]

History

[Briefly describes the waste unit's history. The description should include operation of the facility, the duration of use and the type of contamination deposited.]

Remedial Action

[Briefly describes the RA selected in the ROD, the broken pathways and the remaining risks associated with the operable unit after implementation of the remedy. Also, describes the land use controls and specifies its duration.]

ATTACHMENT X

LIST OF DRAWINGS

[Provides lists of attachments that contain the design drawings and plans related to this CMI/RAIP.]

INTERNAL SRS PROTOCOL

Conceptual Site Model Development

Introduction

The following protocol has been developed in order to support the Savannah River Site (SRS) Environmental Restoration (ER) program. This protocol provides instructions for the development of conceptual site models (CSMs) used in the Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) and Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Remedial Investigation (RI) process. This process is commonly referred to as the RFI/RI process. The protocol is intended to provide guidance promoting consistency in the presentation of CSMs provided in regulatory documents across ER project teams. A simplified CSM has been identified as in integral part of the Operating Unit (OU) summary.

The development of the CSM is an iterative process that begins during the pre-workplan investigation, sampling and analysis planning phase and is continually refined throughout the RFI/RI/Baseline Risk Assessment (BRA) process. The final CSM presented in Chapter 10 of the RI/BRA represents the understanding of the unit based on the remedial investigation data evaluation and the risk assessment calculations. The Remedial Goal Options (RGOs) presented in Chapter 11 of the RI/BRA are developed for the particular media and receptors remaining with contaminants of concern (COCs) after the refinement of COCs in Chapter 9 of the RI/BRA. These refined COCs (RCOCs) become the basis for the Feasibility Study (FS) and the contaminated media identified in the final CSM is the focus of the FS analysis. The proposed plan (PP) and record of decision (ROD) will reflect the findings of the entire process as represented by the final CSM and the FS analysis.

Initially, the CSM provides a representation of the source of contamination and how it was released into the environment based on historical information. It also includes potential release mechanisms and exposure routes based on the existing understanding of the nature and extent of contamination. In addition, potential human and ecological receptors are identified within the CSM based on the location of the unit with respect to potential authorized and unauthorized access and surrounding habitats.

The release mechanisms and exposure routes are modified as data are collected and evaluated. Within the BRA, the human health and ecological CSMs may be revised separately to identify the complete exposure pathways for the appropriate receptors and to identify pathways that will be quantitatively or qualitatively evaluated using available data. Once the BRA is completed, the human health and ecological CSMs are combined to illustrate the significant pathways and receptors that are potentially at risk.

Figure 1 provides an example of a CSM that has been prepared after initial data evaluation for a typical operable unit (OU). CSMs used to support the RFI/RI/BRA should have the following headings: Primary Source, Primary Release Mechanism, Secondary Source, Secondary Release Mechanism, Exposure Media, Exposure Route, and Potential Receptors. Each portion of the CSM is described in the sections below. An example of a focused ecological CSM prepared only for the ecological portion of the BRA is provided in Figure 2. For the human health BRA, the ecological receptors are not shown on the focused CSM and minor variations are usually made to the exposure route determinations. Therefore, an example of a focused human health CSM is not provided. Figure 3 is an example of a refined CSM that has been prepared after the constituents of concern (COCs) have been identified.

Details

Primary Source

The primary source contains a brief description of the waste(s) initially disposed within the OUs. The primary source is usually known or assessed from review of historical documentation. Some examples include: liquid discharged into a basin, debris buried in a pit, solvents spilled on the ground, liquid effluents released from an outfall, etc. If an operable unit has more than one primary source, or the areas of disposal of the primary source are being investigated independently, then separate CSMs should be prepared for each. For example, if an operable unit contains a burning rubble pit and an ash basin, then separate CSMs should be prepared for each disposal area. Similarly, a basin and it's associated pipeline should be represented on separate CSMs. Separate CSMs prepared for each primary source or source area will aid in presenting the conclusions of the BRA for the refined CSMs.

In some cases, additional primary sources may be identified by field activities associated with the sampling and analysis plan. Such discoveries will be included in subsequent CSM revisions.

Principal threat source material (PTSM) or low level threat waste (LLTW), as defined by non-quantitative risk criteria (e.g., Lead concentrations >4,000 mg/kg, PCB concentrations >50 mg/kg, total carcinogens $>10^{-3}$ risk and noncarcinogens hazard quotient [HQ] >100) should be identified under the Primary Source category, if it is known to exist at the waste unit. An example of PTSM would be a buried drum of highly toxic source material.

Primary Release Mechanism

The primary release mechanism describes how contaminants from the primary source enter the environment or impact secondary sources. Some examples include deposition directly from the primary source as in the case of a liquid release to a basin, runoff, leakage from deteriorating drums, leakage from pipeline joints, etc.

Secondary Source

The secondary source includes the environmental media contaminated by the release of the primary source. Initially, the secondary source is assumed to include soil beneath and/or adjacent to the primary source material and surface water (if appropriate). For ease of representation, the secondary sources are typically divided into exposure groups (surface soil [0-1 ft/0-0.3 m], subsurface soil [0-4 ft/0-1.2 m], deep soil [>4 ft/>1.2 m], and surface water). If direct runoff from the primary source to a surface water body is not appropriate, then surface water should not be shown as a secondary source. Additionally, the method of transport between soil exposure groups is labeled (e.g., infiltration/percolation).

Secondary Release Mechanism

Secondary release mechanisms should include processes that in the past, currently, or may in the future, release contaminants for exposure to potential receptors. Secondary release mechanisms typically used include: fugitive dust generation, volatilization, biotic uptake, radiation emissions, leaching, and excavation (usually applied to 0-4 ft soil interval). Direct contact is not considered a release mechanism (as some previously developed CSMs have shown). For direct ingestion or dermal contact with soil, the secondary release mechanism should be left blank.

Exposure Media

All media that could potentially be contaminated should be listed beneath the exposure media category. The media should be listed separately for each different exposure group (i.e., surface soil and subsurface soil should be listed separately).

Exposure Route

The exposure route identifies the method of entry into the receptor (e.g., inhalation, ingestion, dermal contact, external radiation). For the groundwater pathway, inhalation and dermal contact (both from showering) should be listed together because the risk/hazard calculations for these routes are combined in the human health risk assessment. For ecological representations, a foodweb may be developed to communicate biotransfer mechanisms for cases where groundwater is available for exposure (e.g., groundwater seeps). This can assist in focusing and selecting assessment and/or measurement endpoints.

Potential Receptors

Human and ecological receptors are identified on the same CSM, as appropriate, in the data collection work plan and early stages of the RI processes. In the BRA, however, human and ecological receptors are separately addressed for the focused CSMs. Following the completion of the BRA, the CSMs are combined again (in the summary and conclusions section of the RFI/RI/BRA) to summarize the potential risks/hazards for each receptor by exposure routes.

Human Health

For the human health CSMs, the receptor for the current exposure scenario is represented by an on-unit worker. Potential future exposure scenarios are represented by an industrial worker, an on-unit resident adult, and an on-unit resident child. Depending on the location of the waste unit with respect to the SRS boundary and access control, a current or future trespasser may also be considered as a potential receptor.

Ecological

Ecological receptors are defined as plant and animal populations and communities, habitats, and sensitive environments. (EPA, 1997). The receptors depicted in the CSM are selected based on the results of the screening-level ecological risk assessment (Steps 1 and 2 of the ecological risk assessment [ERA] process) and are further refined to establish the complete exposure pathways evaluated in the ERA based on the relationship of the contaminants to the assessment endpoints. A foodweb diagram may be developed to communicate biotransfer mechanisms associated with ecological receptors. This may also assist in refining the assessment and measurement endpoints that dictate which receptors will be presented in the CSM.

Refined CSMs

Refined CSMs presented in the summary chapter of the RFI/RI/BRA should provide a summary of the results of the risks/hazards calculated in the BRA. This summary should coincide with the symbols listed in the following section.

For the ecological component, the CSM is refined and is presented to establish the complete exposure pathways evaluated in the ERA and the relationship of the contaminants to the assessment endpoints selected. In the refined CSM, the possible exposure pathways are depicted in an exposure pathway diagram and are directly linked to the assessment endpoints.

This refinement is based on knowledge of the contaminants present, exposure pathways, and the assessment endpoints. Ecological risk questions are developed to address the questions about the relationships among assessment endpoints and their predicted responses when exposed to unit contaminants.

Symbols

For each receptor, the exposure routes quantitatively addressed in the BRA should be designated with a darkened circle. Exposure routes being addressed qualitatively should be designated with an open circle. If contact with a particular media is not anticipated for a receptor then the associated exposure route should be identified with a dash indicating that the exposure route is incomplete for that receptor. Pathways should not be marked as incomplete only because data was not collected (e.g., the pathway is being

addressed under another OU). Appropriate footnotes or visual designations should be provided for unit specific circumstances.

Other symbols as presented below are intended to provide a visual summarization of the results of the BRA. There is no significance to the symbols except to standardize them for application for each BRA.

Incomplete pathway	--
Quantitative evaluation	
Qualitative evaluation	
No Constituents of Potential Concerns identified (COPCs)	
No final COPCs identified (applicable to ERA only)	
No preliminary Constituents of Potential Concerns identified (pCOCs)	
No refined Constituent of Concerns (COCs)	
Refined COCs exist	Provide specific risk/hazard value

References

US EPA, 1997. *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments*. Interim Final. Environmental Response Team, Edison, NJ, June 5, 1997.

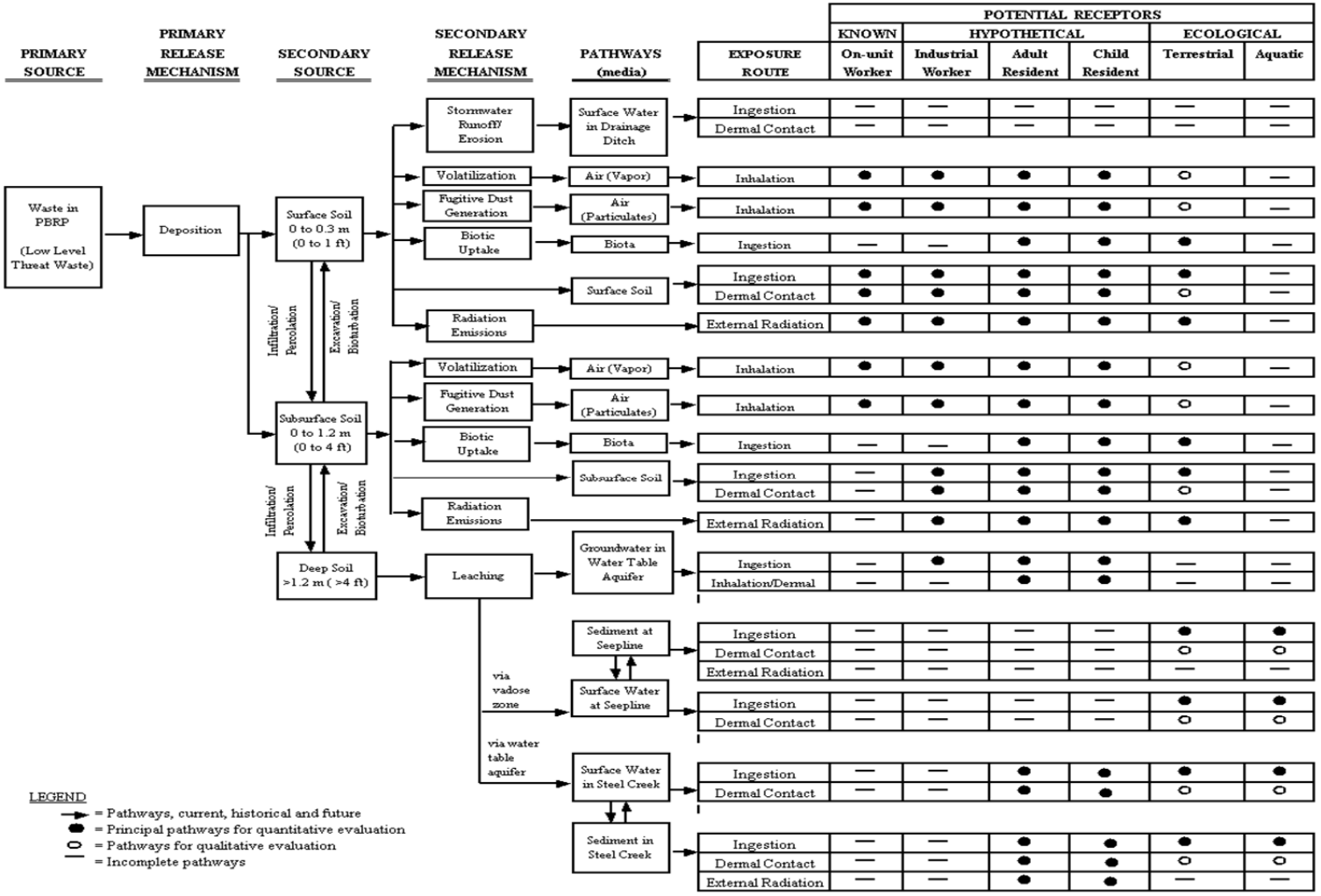


Figure 1. Example of Initial Pre-Workplan/Workplan CSM

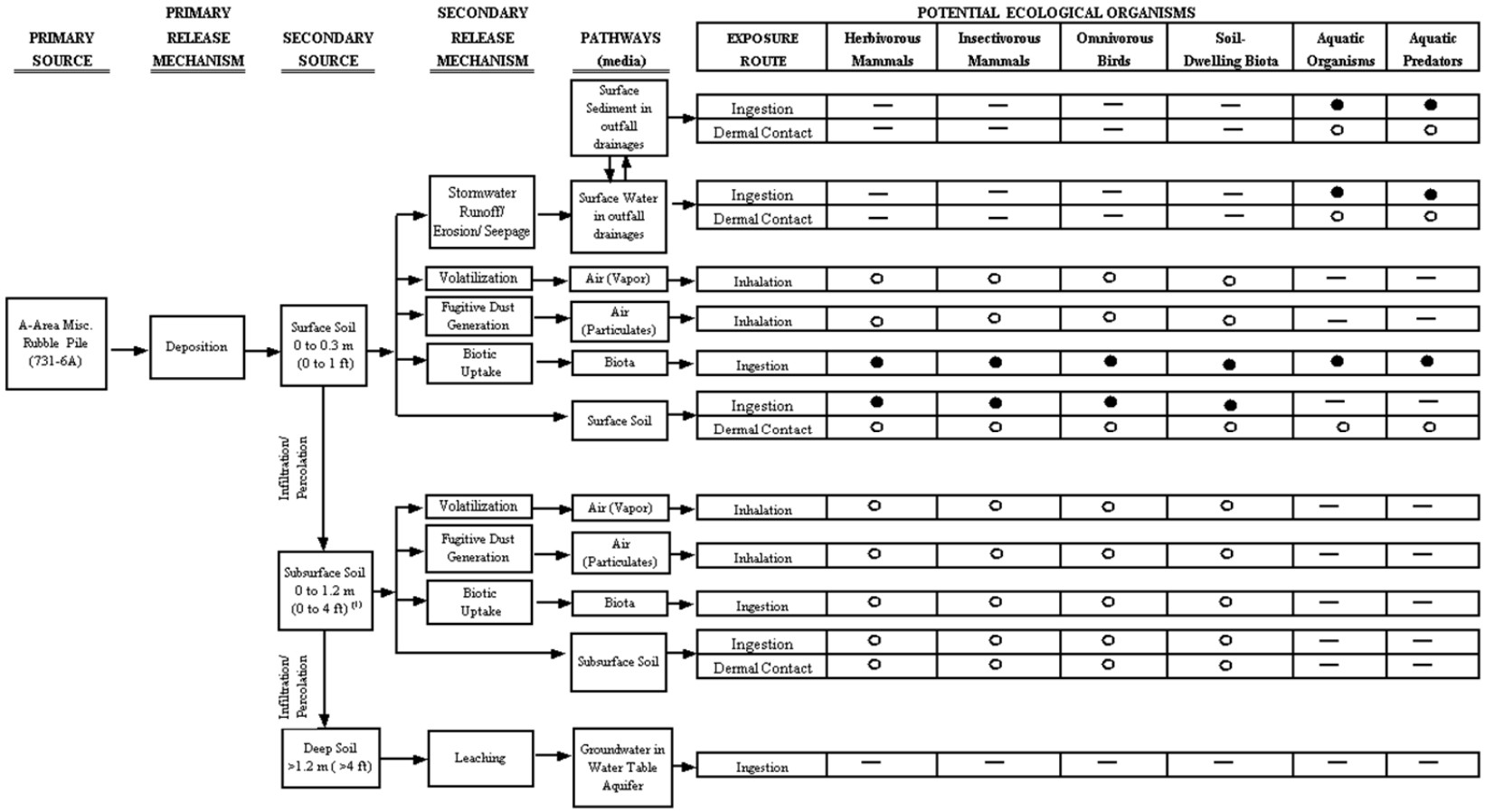


Figure 2. Example Figure of an Ecological Focused CSM

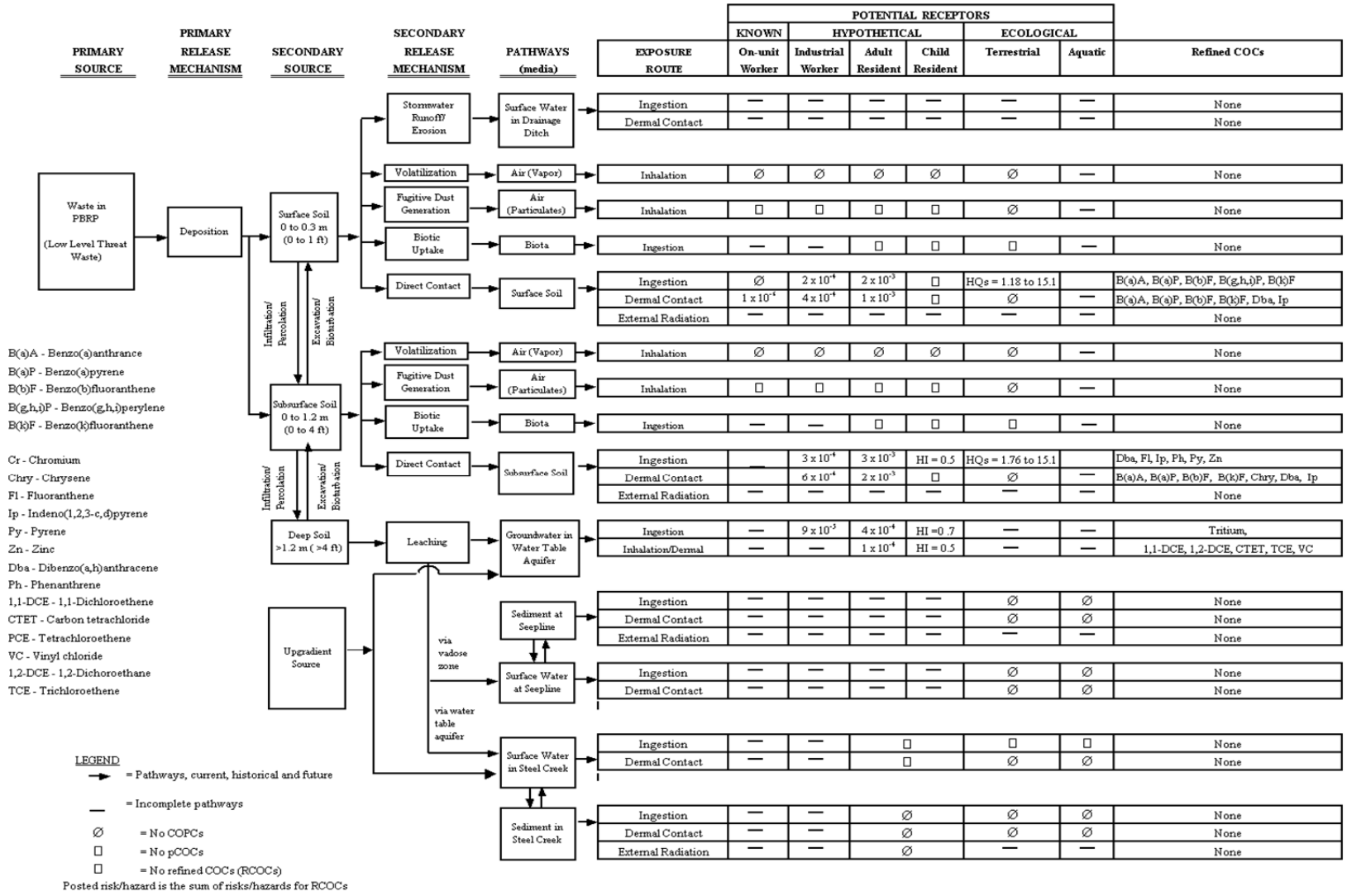


Figure 3. Example of Refined CSM

I. INTRODUCTION AND BACKGROUND

Introduction

This Statement of Basis/Proposed Plan (SB/PP) [or Interim Action Proposed Plan (IAPP)] is being issued by the United States Department of Energy (USDOE), which functions as the lead agency for Savannah River Site (SRS) remedial activities, with concurrence by the United States Environmental Protection Agency (USEPA) and the South Carolina Department of Health and Environmental Control (SCDHEC). The purpose of this SB/PP is to describe the preferred remedial alternative(s) for the operable unit name (Bldg. No.) Operable Unit (OU) (unit acronym), and to provide for public involvement in the decision-making process.

SRS occupies approximately 310 square miles of land adjacent to the Savannah River, principally in Aiken and Barnwell counties of South Carolina. SRS is located approximately 25 miles southeast of Augusta, Georgia, and 20 miles south of Aiken, South Carolina.

SRS is owned by the USDOE. Management and operating services are provided by Savannah River Nuclear Solutions (SRNS). SRS has historically produced tritium, plutonium, and other special nuclear materials for national defense. Chemical and radioactive wastes are byproducts of nuclear material production processes. Hazardous substances, as defined by the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), are currently present in the environment at SRS.

The unit acronym is located at the SRS in Aiken or Barnwell County, South Carolina (see Figures 1 and 2). A remedial action is needed at the unit acronym because [list contaminants] are present in [list media, i.e., soil, sediment, surface water, and/or groundwater] that may pose a threat to human health and the environment. The preferred remedial alternative for the unit acronym is [identify preferred alternative] which was selected because [explain the most compelling reason(s) for the preference. As part of the selected remedy, the future land use for the unit acronym will be industrial or unrestricted.

SRS Compliance History

SRS manages certain waste materials that are regulated under the Resource Conservation and Recovery Act (RCRA), a comprehensive law requiring responsible management of hazardous waste. The unit acronym is a solid waste management unit under RCRA Section 3004(u). SRS received a RCRA hazardous waste permit from the SCDHEC, which was most recently renewed on September 30, 2003 (SC1 890 008 989). Module VIII of the Hazardous and Solid Waste Amendments portion of the RCRA permit mandates corrective action requirements for non-regulated solid waste management units subject to RCRA 3004(u).

On December 21, 1989, SRS was included on the National Priorities List (NPL). The inclusion created a need to integrate the established RCRA Facility Investigation (RFI) program with CERCLA requirements to provide for a focused environmental program. In accordance with Section 120 of CERCLA 42 U.S.C. § 9620, USDOE has negotiated a Federal Facility Agreement (FFA) (FFA 1993) with

the USEPA and SCDHEC to coordinate remedial activities at SRS into one comprehensive strategy which fulfills these dual regulatory requirements. The FFA lists the unit acronym as a RCRA/CERCLA unit requiring further evaluation using an investigation/assessment process that integrates and combines the RFI process with the CERCLA Remedial Investigation (RI) process to determine the actual or potential impact to human health and the environment of releases of hazardous substances to the environment.

Both RCRA and CERCLA require the public to be given an opportunity to review and comment on the draft RCRA permit modification and proposed remedial alternatives. Public participation requirements are listed in South Carolina Hazardous Waste Management Regulations (SCHWMR) R.61-79.124 and Sections 113 and 117 of CERCLA 42 U.S.C. § 9613 and 9617. These requirements include establishment of an Administrative Record File that documents the investigation and selection of remedial alternatives and allows for review and comment by the public regarding those alternatives (See Section II). The Administrative Record File must be established at or near the facility at issue. The SRS FFA Community Involvement Plan (WSRC 2011a) is designed to facilitate public involvement in the decision-making process for permitting, closure, and the selection of remedial alternatives. SCHWMR R.61-79.124 and Section 117(a) of CERCLA, as amended, require the advertisement of the draft permit modification and notice of any proposed remedial action and provide the public an opportunity to participate in the selection of the remedial action. [Insert these sentences if there is a final action component to the interim action: Because this is an interim action for the (insert applicable media) for this OU, a RCRA permit modification is not required for this media. However, a permit modification is required for the (insert applicable media) because the action for this media is considered to be a final action. **OR** Insert this sentence if this is an interim action for all applicable media: Because this is an interim action for all media associated with this OU, a RCRA permit modification is not required.]

SCHWMR R.61-79.124 requires that a brief description and response to all significant comments be made available to the public as part of the RCRA Administrative Record. Community involvement in consideration of this evaluation of alternatives for the unit acronym is strongly encouraged. All submitted comments will be reviewed and considered. Following the public comment period, a Responsiveness Summary will be prepared to address issues raised during the public comment period. The Responsiveness Summary will be made available with the final RCRA permit modification and the Record of Decision (ROD). [Replace the previous sentence with these sentences if any media in the interim action has a final remedial action and there is a final action component to the interim action: The Responsiveness Summary will be made available with the final RCRA permit modification and the Interim Record of Decision (IROD) for those media whose remedial action is final. **OR** Replace the previous sentence with these sentences if this is an interim action for all applicable media: The Responsiveness Summary will be made available with the IROD. A RCRA permit modification will not be issued since this is an interim action.]

The final remedial decision will be made only after the public comment period has ended and all the comments have been received and considered. The final remedial decision under RCRA will be in the form of a final permit modification, which is made by SCDHEC. Selection of the remedial alternative that will satisfy the FFA requirements will be made by USDOE, in consultation with USEPA and SCDHEC. It is important to note that the final action(s) may be different from the preferred alternative discussed in this plan depending on new information or public comments. The alternative chosen will be protective of human health and the environment and comply with all federal and state laws.

[Note: Delete reference to RCRA if a CERCLA only unit.]

II. COMMUNITY PARTICIPATION

The FFA Administrative Record File, which contains the information pertaining to the selection of the response action, is available at the following locations:

US Department of Energy
Public Reading Room
Gregg-Graniteville Library
University of South Carolina – Aiken
171 University Parkway
Aiken, South Carolina 29801
(803) 641-3465

Thomas Cooper Library
Government Documents Department
University of South Carolina
Columbia, South Carolina 29208
(803) 777-4866

Hard copies of the SB/PP (or IAPP) are available at the following locations:

Reese Library
Government Information Section
Augusta State University
2500 Walton Way
Augusta, Georgia 30910
(706) 737-1744

Asa H. Gordon Library
Savannah State University
Tompkins Road
Savannah, Georgia 31404
(912) 356-2183

The RCRA Administrative Record File for SCDHEC is available for review by the public at the following locations:

The South Carolina Department of Health and Environmental Control
Bureau of Land and Waste Management
8911 Farrow Road
Columbia, South Carolina 29203
(803) 896-4000

The South Carolina Department of Health and Environmental Control – Region 5
Aiken Environmental Quality Control Office
206 Beaufort Street, Northeast
Aiken, South Carolina 29801
(803) 641-7670

The public will be notified of the public comment period through mailings of the SRS Environmental Bulletin, a newsletter sent to citizens in South Carolina and Georgia, and through notices in the *Aiken Standard*, the *Allendale Citizen Leader*, the *Augusta Chronicle*, the *Barnwell People-Sentinel*, and *The State* newspapers. The public comment period will also be announced on local radio stations.

USDOE will provide an opportunity for a public meeting during the public comment period if significant interest is expressed. The public will be notified of the date, time, and location. At the

meetings, the proposed action will be discussed, and questions about the action will be answered.

To request a public meeting during the public comment period, to obtain more information concerning this document, or to submit written comments, contact one of the following:

Paul Sauerborn
Savannah River Nuclear Solutions, LLC
Public Involvement
Savannah River Site
Building 730-1B
Aiken, South Carolina 29808
1-803-952-6658
paul.sauerborn@srs.gov

The South Carolina Department of Health and Environmental Control
Attn: Richard Haynes, P.E., Director
Division of Waste Management
Bureau of Land and Waste Management
2600 Bull Street
Columbia, South Carolina 29201
(803) 896-4000

Following the public comment period, a ROD will be signed, and a final decision for the SRS RCRA permit will be issued. The ROD and RCRA permit will detail the remedial alternative chosen for this operable unit and include responses to oral and written comments received during the public comment period in the Responsiveness Summary. [Insert the following sentence if the remedial action is an interim action for only a particular media: Since this is an interim action for (insert the applicable media), a RCRA permit modification is not required for that media. **OR** Insert the following sentence where the remedial decision for all media associated with the OU is an interim action: Since this is an interim action, a RCRA permit modification is not required.]

If there were any SRS Citizens Advisory Board (CAB) activities or recommendations regarding the OU, include a summary in this section.

For a CERCLA only unit, delete references to RCRA.

III. OPERABLE UNIT BACKGROUND

Briefly describe site history including:

- History of waste generation or disposal that led to current problems
- History of Federal, State, and local site investigations
- Identification of contaminated media at the site (e.g., soil, air, groundwater, and surface water)
- Description of removal or previous remedial actions conducted under CERCLA or other authorities
- Briefly describe site characteristics including: Geographical or topographical factors that had a major impact on remedy selection (e.g., resources affected or threatened by site contamination such as current or potential drinking water sources or wetlands)
- Type of contamination and its vertical and lateral extent
- A site map that shows location of roads, buildings, drinking water wells and other characteristics that are important to understanding why the remedial objectives and preferred alternative are appropriate for the site
- Principal and low-level threat wastes (e.g., location of mobile/high toxicity/high

concentration source material and immobile/low toxicity/low concentration source material)

– A schematic cross section (Figure 3) drawing (from the Scoping Summary) depicting subunits, constituents of concern (COCs), principal threat source material (PTSM), migration route, etc.

IV. SCOPE AND ROLE OF OPERABLE UNIT OR RESPONSE ACTION

This section of the Proposed Plan should summarize the lead agency's overall strategy for remediating the site and describe how the action being considered in the Proposed Plan fits into the overall strategy. This section should:

– Summarize the overall cleanup strategy for SRS and how the action being considered in the Proposed Plan fits into the overall site strategy

Due to the complexity and size of multiple waste units located in different areas of the SRS, the site is divided into watersheds for the purpose of managing a comprehensive cleanup strategy. The SRS is segregated into six watersheds: Upper Three Runs, Lower Three Runs, Fourmile Branch, Steel Creek, Pen Branch, and the Savannah River and Floodplain Swamp. In addition, the SRS also identifies six Integrator Operable Units (IOUs) which are the surface water bodies and associated wetlands that correspond to the six respective watersheds. Waste units within a watershed may be evaluated and remediated individually or grouped with other waste units and evaluated as part of a larger Area OU. Upon disposition of all the waste units within a watershed, a final comprehensive ROD for the corresponding IOU (i.e., surface water and associated wetlands) will be pursued with additional public involvement. The unit acronym is located within the watershed name watershed. [Reference map (Figure 1)].

[In addition to the previous paragraph, insert the following text if this PP also addresses an Area OU]. In 2003, a new completion strategy for environmental restoration at SRS was developed to accelerate cleanup completion. A key component of the plan is to implement an area-by-area remediation strategy. Through the sequencing of environmental restoration and decommissioning activities, environmental cleanup can be completed for entire areas of the SRS. In [month year], the USDOE, USEPA, and SCDHEC convened and agreed that using the Area OU strategy to manage surface units at the unit acronym was appropriate and the waste units and facilities in the area were consolidated to form a single Area OU.

– Describe the purpose of the Proposed Plan for the OU. If multiple subunits are present, describe the purpose for each subunit and its respective media.

– Any prior or planned removal actions, interim actions, or early actions should be discussed

– Identify how the response action addresses source materials constituting principal threat(s).

V. SUMMARY OF SITE RISKS

This section of the Proposed Plan should summarize the extent of contamination at the site and the risks posed to human health and the environment using information developed during the RFI/RI. The summary of site risks should include key findings

made in the baseline risk assessment conducted as part of the RFI/RI. This section should clearly link the site risks to the basis for action for the unit or subunits as appropriate. This discussion should be broken down into the following two subsections: (1) human health risks and (2) ecological risks.

Generally, the risk summary in the Proposed Plan should be a narrative description rather than a tabular presentation. Risk tables are more appropriate for the level of detail needed in a ROD than for the Proposed Plan. The length of most risk descriptions in the Proposed Plan should be limited to no more than two or three paragraphs (for each subunit, if applicable). For sites that are complex or for sites where there is heightened public interest, more risk assessment information may be needed in the Proposed Plan. A risk assessor should be consulted if a streamlined risk summary table is presented in the Proposed Plan to ensure that it is consistent with the summary tables in the risk assessment.

Summary of Human Health Risk Assessment

- Major human health COCs in each medium
- Land and groundwater use assumptions
- Potentially exposed populations in current and future risk scenarios (e.g., worker currently on site, adult or children living on site in the future)
- Exposure pathways (routes of exposure) and how they relate to current or reasonably anticipated future land, groundwater, and surface water use
- Estimated cancer and non-cancer risks associated with exposure pathways for COCs that are driving the need to implement the preferred alternative

Summary of Ecological Risk Assessment

Summary of the ecological risk assessment (e.g., the basis of environmental risks associated with specific media, how these risks were determined, and the potential risks to endangered species).

- Major ecological COCs
- Potential ecological receptors, i.e., plant and animal populations, communities, habitats, and sensitive environments
- Potential exposure pathways, i.e., how ecosystems or other ecological receptors are likely to become exposed to COCs
- Describe potential ecological effects from exposure

Summary of Contaminant Fate and Transport Analysis

- Major contaminant migration constituents of concern (CMCOCs)
- Modeled concentration and time to exceed a groundwater protection standard [e.g., maximum contaminant level (MCL)] or a risk-based concentration (RBC)

Identify whether PTSM or low-level threat source material exists at the unit (waste cannot always be characterized as either one or the other; it is not a mandatory classification).

Conclusion

Conclude the risk section with a standard statement that supports the need for taking action, unless it is a "no action" situation.

Actual or threatened releases of hazardous substances from this waste unit, if not addressed by the Preferred Alternative or one of the other active measures considered, may present a current or potential threat to public health, welfare, or the environment.

VI. REMEDIAL ACTION OBJECTIVES

Briefly describe the proposed remediation objectives [i.e., remedial action objectives (RAOs)] for the OU and how they mitigate site risks (e.g., prevent contamination from reaching the groundwater by treating the contaminated soils)

Please note that interim actions should present interim RAOs as well as final RAOs (if known).

Remedial action objectives (RAOs) are media- or OU-specific objectives for protecting human health and the environment. RAOs usually specify potential receptors and exposure pathways, and are identified during project scoping once the CSM is understood. RAOs describe what the remediation must accomplish and are used as a framework for developing remedial alternatives. The RAOs are based on the nature and extent of contamination, threatened resources, and the potential for human and environmental exposure.

The future land use of the unit acronym is assumed to be industrial or unrestricted land use with DOE maintaining control of the land. The following RAOs have been identified for the unit acronym to support the future land use.

- [list RAOs in bullet format and by subunit if appropriate].

Remedial Goal Options

Present remediation goal options for refined COCs and their basis (e.g., preliminary remediation goal of 5 ppm for TCE is based on the Federal MCL for drinking water). Include a table summarizing the remedial goal options (Table 1).

Remedial goal options (RGOs) serve to provide a range of cleanup goals for each COC and are typically identified along with the RAOs. These cleanup goals are either concentration levels that correspond to a specific risk or hazard or are based on Applicable, or Relevant and Appropriate Requirements (ARARs). Following public comment and approval of the SB/PP, the RGOs for the selected remedy are documented as final cleanup goals or remedial goals (RGs) in the ROD.

The [identify document, e.g., CMS/FS] presents a range of human health RGOs (add reference) corresponding to target cancer risks of 1 x 10^{-6} and target HQs of 1. RGOs were calculated for the [identify receptor(s), i.e. future industrial worker, future resident] and are presented in Table 1.

[Add discussion of ecological receptors and RGOs, if appropriate].

Applicable or Relevant and Appropriate Requirements

ARARs are cleanup standards, standards of control and other substantive requirements, criteria or limitations promulgated under federal, state, or local environmental laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a

CERCLA site. Section 121(d) of CERCLA, as amended by the Superfund Amendments Reauthorization Act (SARA), requires that remedial actions comply with requirements and standards set forth under federal and state environmental laws.

Three categories of ARARs are identified 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 the characteristics of the unit:
- Chemical-specific ARARs are media-specific concentration limits promulgated under federal or state law.

A summary of the ARARs for the preferred alternative are presented in Table 2.

VII. SUMMARY OF REMEDIAL ALTERNATIVES

Provide a brief narrative description of the alternatives evaluated including remedy components and distinguishing features unique to each alternative. A minimum of 3 alternatives must be evaluated. For example, if a No Action Alternative and a Land Use Control Alternative are under consideration, a third alternative that reduces the toxicity, mobility, or volume of the hazardous substances, pollutants, or contaminants must also be included. (Reference 40 CFR 300.430(e)(3) for more information).

Examples of remedy components for the narrative discussion may include the following:

- Treatment technologies employed and how they will reduce the intrinsic threat posed by the contamination
- Engineered controls including temporary storage and permanent on-site containment
- Land use controls that will restrict future activities that might result in exposure to contamination. The land use controls should be descriptive and specific for the remedy.

Distinguishing features will vary based on remedy specifications. Examples of distinguishing features for the narrative discussion may include the following:

- RAOs to be achieved by the alternative (e.g., return surface water to recreational use)
- Estimated quantities of material to be addressed by major components
- Implementation requirements (e.g., the need for an off-site disposal facility)
- Reasonably anticipated future land use and whether or not it will be achieved by the alternative
- Provide a summary level narrative of ARARs evaluated for each alternative, with emphasis on key ARARs that differ from those that must be attained by other alternatives. **List the detailed ARARs for the preferred remedy only in**

Table 2 (i.e., do not include the ARARs for all alternatives in the table). **No ARARs are required for LUC only remedies.** Any proposed ARAR waivers and any RCRA treatability or no migration variances must be discussed. There are no ARARs for LUC only remedies.

- Use of presumptive remedies or innovative technologies
- Estimated time to construct and implement the remedy until RAOs are met. Identify time savings if schedule was accelerated (i.e., previous removal actions, etc.)
- Expected outcomes (e.g., RAOs that the alternative will attain)
- Estimated costs

Estimated costs include the capital cost, operations and maintenance cost, and present worth cost (Table 3). The summary of costs may also be provided in the text for each alternative in place of Table 3 as follows:

Capital	$XXX
O&M Cost	$XXX
Total Present-Worth Cost	$XXX

Detailed cost estimates should be included in the Appendix.

The discount rate (0.9% for 1 to 3 years, 1.5% for 4 to 5 years, 1.9% for 6 to 7 years, 2.2% for 8 to 10 years, 2.7% for 11 to 20 years, 2.8% for 21 to 29 years, and 2.7% for 30 years or longer) and the length of time used for O&M costs must be stated. (See Technical Memo ERTEC-2009-00004 for current discount rates). Use the actual expected length of time in the calculations. If the costs are expected to continue beyond 30 years, without a definite end point, use 200 years. Use the same time period for each alternative to discuss PW costs. For alternatives that are complete (no O&M required) earlier than others, show that there are no costs for the years after completion.

In instances where a CMS/FS report was not required: state that a CMS/FS was not needed (include reasons) and that the SB/PP must be modified to add some items that normally would have appeared in the CMS/FS. In general, the screening of alternatives, comparison of alternatives, and detailed present value cost estimates for the alternatives should be added to the Appendix. Do not put all of this information in the body of the SB/PP. The SB/PP is written primarily for the public. It should be easy to understand and concise, but thorough enough to describe the logic involved in selecting the preferred alternative. Detailed information, if needed, should be placed in the Appendix.

VIII. EVALUATION OF ALTERNATIVES

This section summarizes the results of the evaluation of the remedial alternatives in the unit acronym Corrective Measures Study/Feasibility Study [or reference relevant appendices if CMS/FS information is part of the SB/PP].

The NCP [40 CFR 300.430(e)(9)] requires that potential remedial alternatives undergo detailed analysis using relevant evaluation criteria that will be

used to select a final remedy. USEPA has established nine evaluation criteria to address the statutory requirements under CERCLA. The criteria fall into categories of threshold criteria, primary balancing criteria, and modifying criteria. The nine evaluation criteria are detailed in Table 4.

Comparative Analysis of Alternatives

The potential remedial alternatives have been evaluated against the threshold and primary balancing 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. Provided below is a summary of the comparison of the alternatives against the CERCLA evaluation criteria. Key advantages and disadvantages for each alternative relative to one another and in relation to the two threshold criteria and five primary balancing criteria are discussed below and summarized in Table 5.

Overall Protection of Human Health and the Environment

Evaluate each alternative on the basis of how the alternative eliminates, reduces, or controls the risk of exposure to contaminants through engineered or institutional controls or treatment. Each alternative is examined as to whether it creates any unacceptable short-term risks to human health.

Compliance with ARARs

Evaluate whether each alternative meets cleanup standards, or other substantive requirements, criteria, or limitations promulgated under federal, state, or local environmental law. Discuss with respect to chemical-, action-, and location-specific ARARs. Discuss any ARAR waivers and the justification for invoking the waiver.

Short-Term Effectiveness

Consider the length of time needed to implement each alternative the risks posed to workers, residents, and the environment during implementation whether each alternative meets cleanup standards

Add a statement of the potential for each remedial alternative to avoid, mitigate, compensate for, or cause or increase injury to a natural resource. For example, explain if LUCs or MNA would increase the risk, duration, or severity of injuries to natural resources.

Long-Term Effectiveness and Permanence

Evaluate each alternative's ability to maintain protection of human health and the environment over time. Evaluate magnitude of residual risk and reliability of controls.

Reduction of Toxicity, Mobility, or Volume through Treatment

Evaluate each alternative's use of treatment to reduce the harmful effects of principal contaminants, the amount of hazardous materials destroyed or treated, the degree of expected reductions in toxicity, mobility, or volume, the degree to which treatment is irreversible, and the type and quantity of residuals remaining after treatment.

Implementability

Evaluate the technical and administrative feasibility to implement each alternative, including factors such

as ease to construct and operate, ability to monitor effectiveness of the remedy, availability of equipment and technologies, and availability of off-site treatment, storage, and disposal services if appropriate.

Cost

Compare the cost of each alternative. Cost includes estimated capital cost, annual operations and maintenance costs, and present worth costs.

IX. PREFERRED ALTERNATIVE

Briefly, state the Preferred Alternative and provide the most compelling reason(s) for selecting this alternative.

- Use maps and figures, as necessary, to illustrate the preferred alternative
- If groundwater monitoring is required, describe monitoring and performance/ effectiveness requirements (use maps and figures, as appropriate)
- For remedies that include land use controls, use the following language.

Land use controls for the unit acronym or OU subunit name include the following:

- Insert OU Specific LUCs (i.e., maintenance of soil cover, plugging and grouting of manholes and pipelines, signage at the OU boundaries, etc).
- Institutional controls (i.e., administrative controls) and use restrictions for on-site workers via the Site Use/Site Clearance Program. Other administrative controls to ensure worker safety include work controls, worker training, and worker briefing of health and safety requirements.
- SRS access controls against trespassers as described in the 2000 RCRA Part B Permit Renewal Application, Volume I, Section F.1, which describes the security procedures and equipment, 24-hour surveillance system, artificial or natural barriers, control entry systems, and warning signs in place at the SRS boundary.

The preferred remedy for the unit acronym or OU subunit name leaves hazardous substances in place that pose a potential future risk and will require land use restrictions for an indefinite period of time. As negotiated with USEPA, and in accordance with USEPA - Region 4 Policy (*Assuring Land Use Controls at Federal Facilities*, April 21, 1998), SRS has developed a Land Use Control Assurance Plan (LUCAP) (WSRC 2011b) to ensure that land use restrictions are maintained and periodically verified. The unit-specific Land Use Control Implementation Plan (LUCIP) that will be referenced in the ROD for this unit acronym or OU subunit name will provide details and specific measures required for the Land Use Controls (LUCs) selected as part of this preferred remedy. The USDOE is responsible for implementing, maintaining, monitoring, reporting upon, and enforcing the LUCs described in this SB/PP. The LUCIP, developed as part of this action, will be submitted concurrently with the Corrective Measures Implementation/Remedial Action Implementation Plan (CMI/RAIP), as required in the FFA for review and approval by USEPA and

SCDHEC. [Delete reference to CMI/RAIP]. Upon final approval, the LUCIP will be appended to the LUCAP and is considered incorporated by reference into the unit acronym or OU subunit name ROD, establishing LUC implementation and maintenance requirements enforceable under CERCLA. The approved LUCIP will establish implementation, monitoring, maintenance, reporting, and enforcement requirements for the unit. The LUCIP will remain in effect until modified as needed to be protective of human health and the environment. LUCIP modification will only occur through another CERCLA document. Approval by USEPA and SCDHEC is required for any modification or termination of the LUCs.

State that the Preferred Alternative can change in response to public comment or new information.

Provide a descriptive paragraph that thoroughly details the logic behind selecting the preferred alternative. This should compare the preferred alternative to each of the other alternatives and point out the most decisive considerations for making the selection. The argument should be convincing and not leave questions as to why some other alternative was not preferred.

- Discuss how it meets key ARARs and the RAOs.
- Detail any uncertainties or contingency measures.
- Describe the expected outcomes of the Preferred Alternative, including risk reduction (how risk identified in the baseline risk assessment will be addressed).
- Summarize the support agency's concurrence or non-concurrence with the Preferred Alternative, if known.

Include a summary statement by the lead agency at the end of this section similar to:

Based on information currently available, the lead agency believes that [identify preferred alternative] provides the best balance of tradeoffs among the other alternatives with respect to the evaluation criteria. The USDOE expects the Preferred Alternative to satisfy the statutory requirements in CERCLA Section 121(b) to: (1) be protective of human health and the environment, (2) comply with ARARs (or justify a waiver), (3) be cost-effective, (4) utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable, and (5) satisfy the preference for treatment as a principal element (or justify not meeting the preference).

[This statement is not necessary for a No Action decision.]

X. POST-ROD SCHEDULE

For interim actions, include an implementation schedule (Figure 4) showing interim submittals and interim actions, additional documents leading to the final ROD, post-ROD documents, and the Final Remedial Action start.

For final actions, include an implementation schedule showing ROD date, post-ROD document submittals, and Remedial Action Start date

XI. REFERENCES

Provide a list of the references that are referred to in the SB/PP. (Those listed below are referenced in the generic SB/PP language and should be retained).

FFA, 1993. *Federal Facility Agreement for the Savannah River Site*, Administrative Docket No. 89-05-FF (Effective Date: August 16, 1993)

WSRC, 2011a. *Savannah River Site Federal Facility Agreement Community Involvement Plan (U)*, Revision 7, WSRC-RP-96-120, Savannah River Nuclear Solutions, LLC, Savannah River Site, Aiken, SC (February).

WSRC, 2011b. *Land Use Control Assurance Plan for the Savannah River Site*, WSRC-RP-98-4125, Revision 1.1, August 1999, updated October 2011, Savannah River Nuclear Solutions, LLC, Savannah River Site, Aiken, SC.

XII. GLOSSARY

Administrative Record File: A file that is maintained and contains all information used to make a decision on the selection of a response action under the Comprehensive Environmental Response, Compensation and Liability Act. This file is to be available for public review, and a copy is to be established at or near the Site, usually at one of the information repositories. Also a duplicate file is held in a central location, such as a regional or state office.

ARARs: Applicable, or Relevant and Appropriate Requirements. Refers to the federal and state requirements that a selected remedy will attain. These requirements may vary from site to site.

Baseline Risk Assessment: Analysis of the potential adverse health effects (current or future) caused by hazardous substance release from a site in the absence of any actions to control or mitigate these releases.

Characterization: The compilation of all available data about the waste units to determine the rate and extent of contaminant migration resulting form the waste site, and the concentration of any contaminants that may be present.

Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), 1980: A federal law passed in 1980 and modified in 1986 by the Superfund Amendments and Reauthorization Act.

Corrective Action: A USEPA requirement to conduct remedial procedures under RCRA 3998(h) at a facility when there has been a release of hazardous waste or constituents into the environment. Corrective action may be required beyond the facility boundary and can be required regardless of when the waste was placed at the facility.

Exposure: Contact of an organism with a chemical or physical agent. Exposure is quantified as the amount of the agent available at the exchange boundaries of the organism (e.g., skin, lungs, digestive tract, etc.) and available for absorption.

Federal Facility Agreement (FFA): The legally binding agreement between regulatory agencies (USEPA and SCDHEC) and regulated entities (USDOE) that sets the standards and schedules for the comprehensive remediation of the SRS.

Land Use Controls: Legal and/or administrative mechanisms as well as physical installations that modify or guide human behavior at operable units where residual contamination remains in place. Institutional controls and engineering controls are types of land use controls.

Media: Pathways through which contaminants are transferred. Five media to which a release of contaminants may occur are groundwater, soil, surface water, sediments, and air.

National Priorities List : USEPA's formal list of the nation's most serious uncontrolled or abandoned waste sites, identified for possible long-term remedial response, as established by CERCLA.

Operable Unit (OU): A discrete action taken as one part of an overall site cleanup. The term is also used

in USEPA guidance documents to refer to distinct geographic areas or media-specific units within a site. A number of operable units can be used in the course of a cleanup.

Operation and Maintenance (O&M): Activities conducted at a site after a response action occurs to ensure that the cleanup and/or systems are functioning properly.

Overall Protection of Human Health and the Environment: The assessment against this criterion describes how the alternative, as a whole, achieves and maintains protection of human health and the environment.

Proposed Plan: A legal document that provides a brief analysis of remedial alternatives under consideration for the site/operable unit and proposes the preferred alternative. It actively solicits public review and comment on all alternatives under consideration.

Reasonable Maximum Exposure (RME): This is the value that the average concentration will fall below 95 percent of the time.

Record of Decision (ROD): A legal document that explains to the public which alternative will be used at a site/operable unit. The record of decision is based on information and technical analysis generated during the remedial investigation/ feasibility study and consideration of public comments and community concerns.

Resource Conservation and Recovery Act (RCRA), 1976: A Federal law that established a regulatory system to track hazardous substances from their generation to disposal. The law requires safe and secure procedures to be used in treating, transporting, storing, and disposing of hazardous substances. RCRA is designed to prevent the creation of new, uncontrolled hazardous waste sites.

Responsiveness Summary: A summary of oral and/or written comments received during the proposed plan comment period and includes responses to those comments. The responsiveness summary is a key part of the ROD, highlighting community concerns.

Statement of Basis: A report describing the corrective measures/remedial actions being conducted pursuant to South Carolina Hazardous Waste Management Regulations, as amended.

Superfund: The common name used for CERCLA; also referred to as the Trust Fund. The Superfund program was established to help fund cleanup of hazardous waste sites. It also allows for legal action to force those responsible for the sites to clean them up.

Target Risk Range: USEPA guidance for carcinogenic risk due to exposure to a known or suspected carcinogen between one excess cancer in an exposed population of ten thousand (1.0×10^{-4}) and one excess cancer in an exposed population of one million (1.0×10^{-6}). Risks within this range require risk management evaluation of remedial action alternatives to determine if risks can be reduced below one excess cancer in one million (1.0×10^{-6}). Risks greater than 1.0×10^{-4} indicate that remedial action is generally warranted.

Figure 1. Location of the Unit Acronym within the Savannah River Site

Figure 2. Layout of the Unit Acronym

Figure 3. Schematic Cross Section of the Unit Acronym

Figure 4. Post-ROD Schedule

Table 1. Summary of the RGOs for the Unit Acronym

Table 2. Potential ARARs for the Preferred Remedial Alternative for Unit Acronym

Chemical –Specific ARARs			
Action	**Requirements**	**Prerequisites**	**Citation**
Screening Level for Lead	*Establishes a screening level for lead in soil at commercial/industrial (i.e., nonresidential) sites of 800 ppm as found in Frequent Questions From Risk Assessors on the Adult Lead Methodology (ALM) accessed at: http://www.epa.gov/superfund/health/contaminants/lead /almfaq.htm*	*Removal of lead-contaminated soils - **TBC***	*EPA-540-R-03-001* *National Health and Nutrition Examination Survey III*
Action-Specific ARARs			
Action	**Requirements**	**Prerequisites**	**Citation**
Activities causing fugitive dust emissions	*Non-attainment zones-all persons shall take necessary precautions to prevent particulate matter from becoming airborne including, but not limited to:* • *Use, where possible, of water or chemicals for control of dust in demolition or construction operations, the grading of roads, or the clearing of land;* • *Application of asphalt (cut back asphalt is prohibited), water, or suitable chemicals on dirt roads, material stockpiles, and other surfaces which can give rise to airborne dust;* • *Installation and use of hoods, scrubbers, fabric filters or other dust cleaning devices where feasible and effective to capture and contain fugitive particulate matter while handling dusty materials. Adequate containment methods shall be employed during sandblasting or other similar operations;* • *Paving of roadways and the prompt removal of earth or other materials from paved streets that have been deposited by vehicular traffic, earth moving equipment, water erosion or other means;* • *Stabilization of long term storage piles by vegetation or appropriate chemicals and reclamation of mined area;* • *Modifying the process or materials handling system*	*Fugitive emissions from land-disturbing activities (e.g., excavation, construction) – **relevant and appropriate***	*SC. R. 61-62.6(I)(a)(1-11)*

	• *Use of a slurry to move material if feasible* • *Use of traveling booms, telescopic chutes, rotary stackers, adequate shrouding of openings in containers to be filled* • *Avoid use of front end loader in handling dry dusty materials unless there is no other reasonable option;* • *Imposing slow speed limits for vehicular traffic on plant property or construction/destruction sites* • *Ensuring proper loading of equipment to prevent spillage on paved roadways*		
	No personnel shall allow fugitive particulate matter to escape into the ambient area in "problem areas".	*Fugitive emissions from land-disturbing activities (e.g., excavation, construction) –* ***relevant and appropriate***	*SC R. 61-62.6(II)(a)-(b)*
	Address the control of fugitive particulate matter as required in SC R. 61-62.6(III)	*Fugitive emissions from land-disturbing activities (e.g., excavation, construction) –* ***Applicable***	*SC R. 61-62.6(III)(a)-(d)*
	Shall not cause or allow fugitive dust to be emitted in such as manner to exceed 150 micrograms per cubic meter in a 24-hour average concentration.	*Fugitive emissions from land-disturbing activities (e.g., excavation, construction) –* ***Applicable***	*40 CFR 50.6*
Transportation of samples (i.e. contaminated soils and wastewaters)	*Are not subject to any requirements of 40 CFR Parts 261 through 268 or 270 when:* • *The sample is being transported to a laboratory for the purpose of testing; or* • *The sample is being transported back to the sample collector after testing.*	*Samples of solid waste or a sample of water, soil for purpose of conducting testing to determine its characteristics or composition –* ***Applicable***	*40 CFR 261.4(d)*
	In order to qualify for the exemption in paragraphs (d)(1)(i) and (ii), a sample collector shipping samples to a laboratory must: • *Comply with U.S. DOT, U.S. Postal Service, or any other applicable shipping requirements* • *Assure that the information provided in (1) thru (5) of this section accompanies the sample.* • *Package the sample so that it does not leak, spill, or vaporize from its packaging.*		

Location-Specific ARARs			
Action	**Requirements**	**Prerequisites**	**Citation**
Protection of Endangered Species	*Establishes protective regulations governing threatened and endangered species and plants.*	*Threatened or endangered species may be present in the vicinity. -* ***applicable***	*Endangered Species Act 50 CFR 17* *50 CFR 402 Interagency Cooperation- Endangered Species Act* *The Atomic Energy Act as amended*

Table 3. Summary of the Present Value Costs of the Alternatives

Table 4. Description of CERCLA Evaluation Criteria

Threshold Criteria:
• *Overall Protectiveness of Human Health and the Environment* determines whether an alternative eliminates, reduces, or controls threats to public health and the environment through institutional controls, engineering controls, or treatment. • *Compliance with ARARs* evaluates whether the alternative meets Federal and State environmental statutes, regulations, and other requirements that pertain to the site. ARARs may be waived under certain circumstances. ARARs are divided into chemical-specific, location-specific, and action-specific criteria.
Primary Balancing Criteria:
• *Long-Term Effectiveness and Permanence* considers the ability of an alternative to maintain protection of human health and the environment over time. It evaluates magnitude of residual risk and adequacy of reliability of controls. • *Reduction of Toxicity, Mobility, or Volume of Contaminants through Treatment* evaluates an alternative's use of treatment to reduce the harmful effects of principal contaminants, their ability to move in the environment, and the amount of contamination present. • *Short-Term Effectiveness* considers the length of time needed to implement an alternative and the risks the alternative poses to workers, residents, and the environment during implementation. • *Implementability* considers the technical and administrative feasibility of implementing the alternative, including factors such as the relative availability of goods and services. • *Cost* includes estimated capital and annual operations and maintenance costs, as well as present worth cost. Present worth cost is the total cost of an alternative over time in terms of today's dollar value. Cost estimates are expected to be accurate within a range of +50 to -30 percent.
Modifying Criteria:
• *State Support/Agency Acceptance* considers whether USEPA and SCDHEC agree with the analyses and recommendations by the USDOE. Approval of the Record of Decision constitutes approval of the selected alternative by the regulatory agencies. • *Community Acceptance* considers whether the local community agrees with the Preferred Alternative. Comments received on the Statement of Basis/Proposed Plan during the public comment period are an important indicator of community acceptance. Comments from the public are considered in the final remedy selection in the Record of Decision.

Table 5. Comparison of Alternatives against the CERCLA Evaluation Criteria

Criteria	Alternative A-1 No Action	Alternative A-2 (Alternative name)	Alternative A-3 (Alternative name)
Overall protection of human health and the environment			
Protection of Human Health	Not protective	Protective.	Protective.
Protection of the Environment	Not protective	Not Protective	Protective.
Compliance with ARARs			
Chemical-specific	Not applicable	Not applicable	Meets groundwater classification and groundwater protection standards.
Action-specific	Not applicable	Not applicable	Not applicable
Location-specific	Not applicable	Not applicable	Not applicable
Long-term effectiveness and permanence			
Magnitude of Residual Risks	Not applicable. Risk remains unchanged.	Risks are reduced to acceptable levels by controlling exposure.	Risks are reduced to acceptable levels by installation of cover system.
Adequacy of Controls	Not adequate	Adequate	Adequate
Permanence	Not permanent	Not permanent	Permanent
Reduction of toxicity, mobility, or volume through treatment			
Treatment Process	No treatment	No treatment	No treatment
Degree of Expected Reduction in Toxicity, Mobility, or Volume	None	None	None
Short-term effectiveness			
Risk to Remedial Workers	Not applicable; no remedial action involved.	None	None
Risk to Community	Not applicable; no remedial action involved.	None	None
Risk to Environment	Not applicable; no remedial action involved.	None	None
Estimated Time Frame to Achieve RAOs or RGs	Not applicable; no remedial action involved.	2 years	1 month
Implementability			
Availability of materials, equipment, and skilled labor	No implementation	Readily implemented	Readily implemented
Ability to construct and operate remedial technology	Not Applicable	Readily available. No specialized	Readily available. No specialized

Criteria	Alternative A-1 No Action	Alternative A-2 (Alternative name)	Alternative A-3 (Alternative name)
		materials, equipment or labor required.	materials, equipment or labor required.
Ability to obtain permits/approvals from Agencies	Not Applicable	Not Applicable	Not Applicable
Ease of undertaking additional actions	Compatible	Compatible	Compatible
Time to implement	Readily Implementable	6 months	1 month
Cost			
Total Present-Worth Costs	$0	$132,236	$1,197,272
State Support/Agency Acceptance	Not acceptable.	Not acceptable.	Both EPA and SCDHEC support the preferred remedy.
Community Acceptance	This criterion will be completed following public review.	This criterion will be completed following public review.	This criterion will be completed following public review.

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[This template was prepared for the development of a Statement of Basis/Proposed Plan fact sheet. Delete the "Statement of Basis" terminology in title, headers, and text for a CERCLA only operable unit. Use "Interim Action Proposed Plan (IAPP)" or "Early Action Proposed Plan (EAPP)" terminology in place of "Statement of Basis/Proposed Plan", if appropriate]

INTRODUCTION

This fact sheet summarizes the Statement of Basis/Proposed Plan for the [OU Name] located at the Savannah River Site (SRS). The United States Department of Energy (USDOE) owns and operates the SRS. Hazardous substances that are regulated under the federal law requirements of the Resource Conservation and Recovery Act (RCRA) and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) are managed at the SRS as part of a comprehensive cleanup program.

A remedial action is needed at the [OU Name] because [list contaminants] are present in [list media, i.e., soil, sediment, surface water, and/or groundwater] that may pose a threat to human health and the environment. The Statement of Basis/Proposed Plan for the [OU Name] outlines the range of remedial alternatives evaluated to clean up the contaminated [list media] and presents the proposed remedy. The document describes how the public can comment on the proposed action through written comments and by participating in public meetings.

[OU NAME] BACKGROUND

Briefly describe site history including:

- Site Description: location and size
- A current photograph of the operable unit if available or a figure that presents the layout of the OU
- History of waste generation or disposal that led to current problems
- Identification of contaminated media at the site (e.g., soil, air, groundwater, and surface water). If the OU consists of multiple subunits, present information on a subunit by subunit basis.

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– Description of removal or previous remedial actions conducted under CERCLA or other authorities

– Contaminants of concern, risk evaluation results, and land use. Public friendly definitions of risk, hazard, PTSM, etc., should be included in the summary such as the following:

- *A risk greater than or equal to 1E-06 indicates a probability of 1 chance in 1,000,000 of an individual developing cancer.*
- *A hazard quotient (HQ) greater than or equal to 1 indicates that an individual could experience adverse health effects from exposure to the contaminant.*
- *Principal threat source materials (PTSM) are described as highly toxic materials that would present a significant risk to human health or the environment should exposure occur.*

CLEANUP GOALS

- Summarize contaminants of concern (i.e., human health, ecological, principal threat source material [PTSM], and contaminant migration). Identify if there are no contaminant of concerns.

- Briefly describe the cleanup goals. Examples may include one or more of the following:
  - Prevent exposure of human receptors (i.e., industrial workers and/or residents) to [identify contaminants] in [identify media and depth if appropriate].
  - Prevent exposure of ecological receptors [identify receptors] to [identify contaminants] in [identify media and depth if appropriate].
  - Prevent migration of contaminants in soil [identify depth if appropriate] to groundwater at levels that could exceed a regulatory standard (e.g., MCLs)
  - Remove or treat Principal Threat Source Material located in [identify media and depth if appropriate] that exceeds a risk to the industrial worker greater than 1E-03.
  - Prevent exposure of industrial workers and potential residents to buried friable asbestos.
  - [Others as needed.]

PROPOSED REMEDY

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- Describe the proposed remedial action and explain how it meets the cleanup goals.
- If appropriate, include a statement that the USDOE will restrict land use through administrative measures and the placement and maintenance of signs at the waste unit.
- State that the United States Environmental Protection Agency (USEPA) and South Carolina Department of Health and Environmental Control (SCDHEC) concur with the proposed remedy.

FOR MORE INFORMATION

The Administrative Record File, which contains the information pertaining to the selection of the response action, is available at the following locations:

US Department of Energy
Public Reading Room
Gregg-Graniteville Library
University of South Carolina – Aiken
171 University Parkway
Aiken, South Carolina 29801
(803) 641-3465

Thomas Cooper Library
Government Documents Department
University of South Carolina
Columbia, South Carolina 29208
(803) 777-4866

Hard copies of the Statement of Basis/Proposed Plan for the [OU Name] are available at the following locations:

Reese Library
Government Information Section
Augusta State University
2500 Walton Way
Augusta, Georgia 30910
706-737-1744

Asa H. Gordon Library
Savannah State University
Tompkins Road
Savannah, Georgia 31404
912-356-2183

HOW TO SUBMIT COMMENTS

United States Department of Energy
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The public comment period for the Statement of Basis/Proposed Plan for [OU Name] begins [date] and ends [date]. To request a public meeting during the public comment period, to obtain more information concerning this document, or to submit written comments, contact one of the following: [delete SCDHEC contact information if CERCLA only unit]

Paul Sauerborn
Savannah River Nuclear Solutions, LLC
Public Involvement
Savannah River Site
Building 730-1B
Aiken, South Carolina 29808
803-952-6658
paul.sauerborn@srs.gov

The South Carolina Department of Health and Environmental Control
Attn: Richard Haynes, P.E., Director
Division of Waste Management
Bureau of Land and Waste Management
2600 Bull Street
Columbia, South Carolina 29201
803-896-4000

See Attachment A Example Fact Sheet

Attachment A – Example Fact Sheet

United States Department of Energy Statement of Basis/Proposed Plan Fact Sheet for the [OU NAME]

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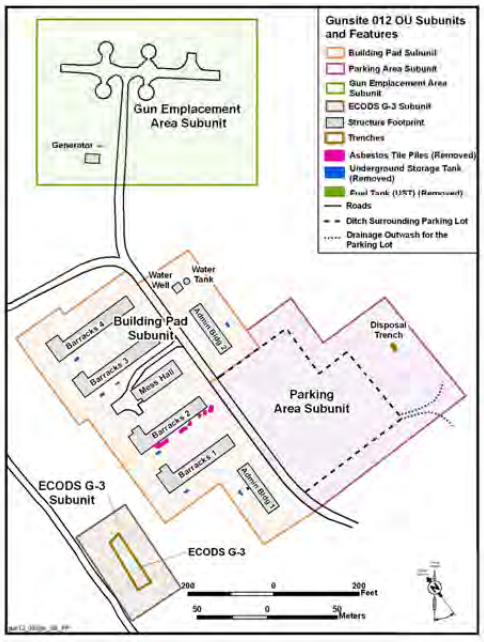
INTRODUCTION

This fact sheet summarizes the Statement of Basis/Proposed Plan for the Gunsite 012 Operable Unit (OU) located at the Savannah River Site (SRS). The United States Department of Energy (USDOE) owns and operates the SRS. Hazardous substances that are regulated under the federal law requirements of the Resource Conservation and Recovery Act (RCRA) and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) are managed at the SRS as part of a comprehensive cleanup program.

A remedial action is needed at the Gunsite 012 OU because polyaromatic hydrocarbons (PAHs), mainly benzo(a)pyrene, and antimony are present in soil at levels that may pose a threat to human health and the environment. The Statement of Basis/Proposed Plan for the Gunsite 012 OU outlines the range of remedial alternatives evaluated to clean up the contaminated soil and presents the proposed remedy. The document describes how the public can comment on the proposed action through written comments and by participating in public meetings.

GUNSITE 012 OU BACKGROUND



The Gunsite 012 OU is located northeast of the geographical center of the SRS and is approximately 3 miles form the nearest site boundary. Gunsite facilities at SRS were anti-aircraft gun emplacements that operated from 1955 to 1957 to provide physical protection for SRS against possible enemy air attack. Before being made obsolete by intercontinental missiles, military personnel manned 75-mm and 90-mm anti-aircraft gun emplacements. The Gunsite 012 OU was one of five central gunsites and included extensive administrative support facilities such as barracks, mess halls, office buildings and motor vehicle pools. The support facilities were dismantled to their concrete slab foundations in 1961.

Three RCRA/CERCLA units were located within the Gunsite 012 footprint and included the Gunsite 012

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Rubble Pile, the Rubble Pile Across from Gunsite 012, and the Early Construction and Operation Disposal Site (ECODS) G-3. In 1998, these three units were merged to form the Gunsite 012 OU. A risk evaluation for human and ecological receptors was conducted at each unit in addition to an evaluation for principal threat source material (PTSM), better described as highly toxic materials. The potential for surface contaminants to migrate to groundwater was also considered.

The current land use of the Gunsite 012 OU is industrial and future unrestricted land use is not anticipated.

Gunsite 012 Rubble Pile

The Gunsite 012 Rubble Pile contains the Building Pad Subunit and the Parking Area Subunit. The Building Pad Subunit is approximately 5 acres in size and consisted of four barracks, a mess hall, two administrative buildings, fuel storage tanks, an underground septic system, a drinking water well and a water storage tank. The facilities were dismantled in 1961 and the fuel oil tanks removed. The drinking water well was disconnected and capped after dismantlement of the buildings. The Building Pad Subunit now consists of the concrete slab foundations and the remaining sidewalks and driveways.

Characterization of the Building Pad Subunit in May 2007 showed that PAHs existed in the 0 to 1 foot soil interval and exceeded a risk level greater than 1E-06 for both an industrial and residential receptor. A risk greater than or equal to 1E-06 indicates a probability of 1 chance in 1,000,000 of an individual developing cancer. In addition, asbestos-containing floor tiles that were used in the barracks, administrative buildings, and mess hall were located in soil piles on the ground between the building pads. Prior to remediation of the PAH-contaminated soil, a non-time critical removal action will be used to remove the asbestos-containing floor tiles in addition to raking and scraping of adjoining soil as necessary. SRS will also perform a maintenance action to remove any remaining floor tiles that are adhered to the concrete building slabs including the associated adhesive and tar material located on the slabs and between the expansion joints.

The Parking Area Subunit is adjacent to the Building Pad Subunit and consists of the remaining gravel parking lot and a small disposal trench likely used for disposal of construction debris. The Parking Area Subunit is approximately 4 acres in size. Characterization activities in 2007 found

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PAHs in the gravel parking lot, but it was determined that the low levels were similar to PAH levels expected in any parking lot in the United States and no remedial response was needed. In the disposal trench, antimony was detected in soil at levels that would pose an unacceptable hazard to an unrestricted human receptor (i.e., future resident). A hazard quotient (HQ) greater than or equal to 1 indicates that an individual could experience adverse health effects from exposure to the contaminant. The source of antimony was likely from the previous disposal of metal scraps or cans and buckets in the trench.

Rubble Pile Across from Gunsite 012

The Rubble Pile Across from the Gunsite 012 contains the Gun Emplacement Subunit. This subunit consists of the concrete building slab of a former generator building and is located about halfway between the gun emplacements and the Gunsite 012 Rubble Pile. Characterization activities in May 2007 identified one PAH and trace amounts of petroleum analytes. All detections were below an action level for industrial or unrestricted use and no cleanup is necessary.

ECODS G-3 (Adjacent to Gunsite 012)

The ECODS G-3 Subunit is located in the southwest corner of the OU approximately 200 feet southwest of the Gunsite 012 Rubble Pile. Characterization of the ECODS G-3 subunit indicates that waste from construction of the facility was likely disposed of at this location. Sampling activities in May 2007 found trace amounts of PAHs, petroleum analytes, solvents, pesticides, polychlorinated biphenyls and metals in soil. All detections were below an action level for industrial or unrestricted use.

CLEANUP GOALS

There are no constituents present at the Gunsite 012 OU that have an adverse effect on ecological receptors. There is no PTSM present and no potential for migration of surface contaminants to groundwater. PAHs and antimony are present at the Building Pad Subunit and the Parking Area Subunit at levels that are not suitable for unrestricted use. Therefore, the cleanup goals (i.e., remedial goals) for these two subunits include the following:

- Prevent exposure of future residential receptors to PAHs in surface soil at concentrations exceeding 1E-06 risk at the Building Pad Subunit

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- Prevent future residential receptors from exposure to antimony in the disposal trench surface soil at concentrations that would pose an unacceptable hazard (i.e., HQ > 1) at the Parking Area Subunit

PROPOSED REMEDY

The preferred alternative is Land Use Controls (LUCs) to prevent unrestricted land use at the Gunsite 012 OU. The USDOE will restrict land use through administrative measures and the placement and maintenance of warning signs at the Gunsite 012 OU. The United States Environmental Protection Agency and the South Carolina Department of Health and Environmental Control concur with the proposed remedy.

FOR MORE INFORMATION

The Administrative Record File, which contains the information pertaining to the selection of the response action, is available at the following locations:

US Department of Energy
Public Reading Room
Gregg-Graniteville Library
University of South Carolina – Aiken
171 University Parkway
Aiken, South Carolina 29801
803-641-3465

Thomas Cooper Library
Government Documents Department
University of South Carolina
Columbia, South Carolina 29208
803-777-4866

Hard copies of the Statement of Basis/Proposed Plan for the Gunsite 012 OU are available at the following locations:

Reese Library
Augusta State University
2500 Walton Way
Augusta, Georgia 30910
706-737-1744

Asa H. Gordon Library
Savannah State University
Tompkins Road
Savannah, Georgia 31404
912-356-2183

Attachment A – Example Fact Sheet

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HOW TO SUBMIT COMMENTS

The public comment period for the Statement of Basis/Proposed Plan for Gunsite 012 OU begins [date] and ends [date]. To request a public meeting during the public comment period, to obtain more information concerning this document, or to submit written comments, contact one of the following:

Paul Sauerborn
Savannah River Nuclear Solutions, LLC
Public Involvement
Savannah River Site
Building 730-1B
Aiken, South Carolina 29808
803-952-6658
paul.sauerborn@srs.gov

The South Carolina Department of Health and Environmental Control
Attn: Richard Haynes, P.E., Director
Division of Waste Management
Bureau of Land and Waste Management
2600 Bull Street
Columbia, South Carolina 29201
803-896-4000

DECLARATION FOR THE (INTERIM) RECORD OF DECISION

Unit Name and Location

Operable Unit Name (Bldg. No.)
Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) Identification Number: OU- CERCLIS number
Savannah River Site
Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) Identification Number: SC1 890 008 989
Aiken, South Carolina
United States Department of Energy

The Operable Unit Name (Bldg. No.) Operable Unit (OU) (unit acronym) is listed as a Resource Conservation and Recovery Act (RCRA) 3004(u) Solid Waste Management Unit/CERCLA unit in Appendix C of the Federal Facility Agreement (FFA) for the Savannah River Site (SRS).

The FFA is a legally binding agreement between regulatory agencies [United States Environmental Protection Agency (USEPA) and South Carolina Department of Health and Environmental Control (SCDHEC)] and regulated entities [United States Department of Energy (USDOE)] that establishes the responsibilities and schedules for the comprehensive remediation of SRS. The media associated with this operable unit are (insert list of media associated with the unit [e.g., surface soil and groundwater]; also list site-specific factors that required consideration during remediation, if any.). (If the groundwater is being addressed in a separate OU, name that OU here.)

If an interim action, include a paragraph that discusses the SRS RCRA permit modification process applicability to the interim action. For example, the following paragraph may be used:

An SRS RCRA permit modification is not required at this time since this is an interim action. However the RCRA permit will be revised to reflect selection of the final remedy using the procedures under 40 Code of Federal Regulation (CFR) Part 270, and South Carolina Hazardous Waste Management Regulations (SCHWMR) R.61-79.264.101; 270.

Statement of Basis and Purpose

This section should contain the factual and legal basis for the selected remedy. Insert the following language:

This decision document presents the selected (insert interim if appropriate) remedial action for the unit acronym, in location, which was chosen in accordance with CERCLA, as amended by the Superfund Amendments Reauthorization Act (SARA), and, to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). This decision is based on the information contained in the Administrative Record File for this site.

The USEPA, SCDHEC and USDOE concur with the selected remedy.

Assessment of the Site

There has been a release of (insert contaminants) at the unit acronym into the environment. The response action selected in this ROD (or IROD) is necessary to protect the public health or welfare or the environment from actual or threatened releases of hazardous substances into the environment.

Description of the Selected Remedy

The selected remedy for the unit acronym is insert title of the selected remedy.

List the future land use assumed for the OU.

Describe the selected remedy and list the major components of the selected remedy in a bullet fashion, including land use controls and the time to complete construction.

Describe how this operable unit addresses principal and low-level threats at the site (i.e., what is being treated, what is being contained, and what is the rationale for each).

If land use controls are part of the remedy, specify those activities the LUC is designed to protect. Example: The LUC component of the remedy will protect against: 1) disturbance of the soil overlaying the cap, 2) changes in grade that would interfere with storm water runoff from cap, 3) the use of groundwater for any purpose.

Describe the scope and role of this operable unit within the overall site management strategy.

The RCRA permit will be revised to reflect selection of the final remedy using the procedures under 40 CFR Part 270, and SCHWMR R.61-79.264.101; 270.

[Note: Delete RCRA reference if this is a CERCLA only unit.]

Statutory Determinations

Based on the unit RCRA Facility Investigation/Remedial Investigation with Baseline Risk Assessment (RFI/RI/BRA) report the unit acronym poses a threat to human health and the environment. Therefore, alternative number, and title, has been selected as the remedy for the unit acronym. As part of the selected remedy, the future land use of the unit acronym will be industrial or unrestricted.

If the five-year remedy review is applicable, use the following language:

In accordance with Section 121(c) of CERCLA and NCP §300.430(f)(5)(iii)(c), a statutory review will be conducted within 5 years of initiation of the remedial action, and every 5 years thereafter, to ensure that the remedy continues to be protective of human health and the environment.

If the five-year review is not applicable, use the following language:

Because this remedy will not result in hazardous substances, pollutants, or contaminants remaining on-site above levels that allow for unlimited use and unrestricted exposure, a five-year review will not be required for this remedial action.

If the selected remedy satisfies the CERCLA 121 preference for treatment as a principal element, use the following language:

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

If the selected remedy does not satisfy the preference for treatment as a principal element, use the following language:

The selected remedy is protective of human health and the environment, complies with Federal and State requirements that are legally applicable or relevant and appropriate to the remedial action (unless justified by a waiver), and is cost-effective. The remedy in this OU does not satisfy the statutory preference for treatment as a principal element of the remedy for the following reasons (give reasons).

For an interim action, use the following language:

This interim action is protective of human health and the environment, complies with Federal and State requirements that are legally applicable or relevant and appropriate to the limited-scope remedial action (unless justified by a waiver), and is cost-effective. This action is interim and is not intended to utilize permanent solutions and alternative treatment (or resource recovery)

technologies to the maximum extent practicable for this OU. [Note: where treatment is utilized, replace the prior sentence with the following sentence: Although this interim action is not intended to fully address the statutory mandate for permanence and treatment to the maximum extent practicable, this interim action utilizes treatment and thus is in furtherance of that statutory mandate.] Because this action does not constitute the final remedy for the unit acronym, the statutory preference for remedies that employ treatment that reduces toxicity, mobility, or volume as a principal element [Note: Include if treatment is being used: *although partially addressed in this remedy*] will be addressed by the final response action. Subsequent actions are planned to fully address the threats posed by the conditions at this OU.

Because this remedy will result in hazardous substances, pollutants, or contaminants remaining on-site above levels that allow for unlimited use and unrestricted exposure, a statutory review will be conducted to ensure that the remedy continues to provide adequate protection of human health and the environment within five years after commencement of the remedial action. Because this is an IROD, review of this OU and of this remedy will be continuing as USDOE continues to develop remedial alternatives for the unit acronym.

For remedies that invoke an applicable or relevant and appropriate requirement (ARAR) waiver, please be sure to include a statement to that effect. For example, in the case of an action that invokes an MCL waiver, the following statement can be used:

An applicable or relevant and appropriate requirement (ARAR) waiver under §300.430(f)(1)(ii)(C) of the NCP for all groundwater constituents of concern (COCs) has been invoked because the selected remedy is an interim action measure that will become part of a total remedial action that will ultimately attain ARARs (MCLs).

For remedies that include land use controls, use the following language:

In the long term, if the property, or any portion thereof, is ever transferred from DOE, the U.S. Government and/or DOE will take those actions necessary pursuant to Section 120(h)(1) of CERCLA. Those actions will include in any contract, deed, or other transfer document, notice of

the type and quantity of any hazardous substances that were known to have been stored (for more than one year), released, or disposed of on the property. The notice will also include the time at which the storage, release, or disposal took place to the extent such information is available.

In addition, if the property, or any portion thereof, is ever transferred by deed, the U.S. Government will also satisfy the requirements of CERCLA 120(h)(3). The requirements include: a description of the remedial action taken, a covenant, and an access clause. These requirements are also consistent with the intent of the RCRA deed notification requirements at final closure of a RCRA facility if contamination will remain at the unit.

LUCs will be implemented through the following:

- The contract, deed, or other transfer document shall also include restrictions precluding residential use of the property. However, the need for these restrictions may be reevaluated at the time of transfer in the event that exposure assumptions differ and/or the residual contamination no longer poses an unacceptable risk under residential use. Any reevaluation of the LUCs will be done through an amended ROD with USEPA and SCDHEC review and approval.

- In addition, if the site is ever transferred to nonfederal ownership, a survey plat of the OU will be prepared, certified by a professional land surveyor, and recorded with the appropriate county recording agency.

In the event of a property lease or interagency agreement, the equivalent restrictions will be implemented as required by CERCLA Section 120(h).

The selected remedy for the unit acronym or OU subunit name leaves hazardous substances in place that pose a potential future risk and will require land use restrictions for as long as necessary to keep the selected remedy fully protective of human health and the environment. As agreed on March 30, 2000, among the USDOE, USEPA, and SCDHEC, SRS is implementing a Land Use Control Assurance Plan (LUCAP) to ensure that the Land Use Controls (LUCs)

required by numerous remedial decisions at SRS are properly maintained and periodically verified. The unit-specific Land Use Control Implementation Plan (LUCIP) incorporated by reference into this ROD will provide details and specific measures required to implement and maintain the LUCs selected as part of this remedy. The USDOE is responsible for implementing, maintaining, monitoring, reporting upon, and enforcing the LUCs selected under this ROD. The LUCIP, developed as part of this action, will be submitted concurrently with the Corrective Measures Implementation (CMI)/Remedial Action Implementation Plan (RAIP), as required in the FFA for review and approval by USEPA and SCDHEC. Upon final approval, the LUCIP will be appended to the LUCAP and is considered incorporated by reference into the ROD, establishing LUC implementation and maintenance requirements enforceable under CERCLA. The approved LUCIP will establish implementation, monitoring, maintenance, reporting, and enforcement requirements for the unit. The LUCIP will remain in effect unless and until modifications are approved by the USEPA and SCDHEC as needed to be protective of human health and the environment. LUCIP modification will only occur through another CERCLA document.

Data Certification Checklist

The Declaration should certify that the following information is included in the ROD (or provide a brief explanation for why this information is not included).

This ROD (or IROD) provides the following information: [include section numbers for each bullet item]

COCs and their respective concentrations

Baseline risk represented by the COCs

Cleanup levels established for the COCs and the basis for the levels

Current and reasonably anticipated future land and groundwater use assumptions used in the Baseline Risk Assessment (BRA) and ROD

Potential land and groundwater use that will be available at the site as a result of the selected remedy

Estimated capital, operation and maintenance, and total present worth cost; discount rate; and the number of years over which the remedy cost estimates are projected

Key decision factor(s) that led to selecting the remedy (i.e., describe how the selected remedy provides the best balance of tradeoffs with respect to the balancing and modifying criteria)

How source materials constituting principal threats are addressed

I. SAVANNAH RIVER SITE AND OPERABLE UNIT NAME, LOCATION, AND DESCRIPTION

Unit Name, Location, and Brief Description

Operable Unit Name (Bldg. No.)
Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) Identification Number: OU- CERCLIS number
Savannah River Site
Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) Identification Number: SC1 890 008 989
Aiken, South Carolina
United States Department of Energy (USDOE)

Savannah River Site (SRS) occupies approximately 802.9 km^2 (310 mi^2) of land adjacent to the Savannah River, principally in Aiken and Barnwell counties of South Carolina (Figure 1). SRS is located approximately 40.2 km (25 mi) southeast of Augusta, Georgia, and 32.1 km (20 mi) south of Aiken, South Carolina.

The USDOE owns SRS, which historically produced tritium, plutonium, and other special nuclear materials for national defense and the space program. Chemical and radioactive wastes are by-products of nuclear material production processes. Hazardous substances, as defined by the CERCLA, are currently present in the environment at SRS.

The Federal Facility Agreement (FFA) (FFA 1993) for SRS lists the Operable Unit Name (Bldg. No.) Operable Unit (OU) (unit acronym) as a Resource Conservation and Recovery Act Solid Waste Management Unit/Comprehensive Environmental Response, Compensation and Liability Act (RCRA/CERCLA) unit requiring further evaluation.

The unit acronym was evaluated through an investigation process that integrates and combines the RCRA corrective action process with the CERCLA remedial process to determine the actual or potential impact to human health and the environment of releases of hazardous substances to the environment.

II. SITE AND OPERABLE UNIT COMPLIANCE HISTORY

SRS Operational and Compliance History

The primary mission of SRS has been to produce tritium, plutonium, and other special nuclear materials for our nation's defense programs. Production of nuclear materials for the defense program was discontinued in 1988. SRS has provided nuclear materials for the space program, as well as for medical, industrial, and research efforts up to the present. Chemical and radioactive wastes are by-products of nuclear material production processes. These wastes have been treated, stored, and in some cases, disposed at SRS. Past disposal practices have resulted in soil and groundwater contamination.

Hazardous waste materials handled at SRS are managed under RCRA, a comprehensive law requiring responsible management of hazardous waste. Certain SRS activities require South Carolina Department of Health and Environmental Control (SCDHEC) operating or post-closure permits under RCRA. SRS received a RCRA hazardous waste permit from the SCDHEC, which was most recently renewed on September 30, 2003. Module VIII of the Hazardous and Solid Waste Amendments (HSWA) portion of the RCRA permit mandates corrective action requirements for non-regulated solid waste management units subject to RCRA 3004(u).

On December 21, 1989, SRS was included on the National Priorities List (NPL). The inclusion created a need to integrate the established RCRA facility investigation (RFI) program with CERCLA requirements to provide for a focused environmental program. In accordance with Section 120 of CERCLA 42 United States Code Section 9620, USDOE has negotiated a FFA (FFA 1993) with United States Environmental Protection Agency (USEPA) and SCDHEC to coordinate remedial activities at SRS into one comprehensive strategy which fulfills these dual regulatory requirements. USDOE functions as the lead agency for remedial activities at SRS, with concurrence by the USEPA - Region 4 and the SCDHEC.

Operable Unit Operational and Compliance History

Provide a brief description of operating history, how the unit received waste that led to the current problems.

Provide an overview of the OU, including the size of the site (e.g., acres).

Provide a description of surface and subsurface features (e.g., number and volume of tanks, lagoons, structures, and drums at the site).

Provide geographical and topographical information (e.g., surface waters, flood plains, wetlands). If groundwater is in the OU, state where drinking water source wells are located.

Include the document submittal and history information. Provide information on any removal and remedial actions conducted under CERCLA or other authorities.

Include maps, (Figure 2) a site plan, or other graphical presentations, as appropriate.

III. HIGHLIGHTS OF COMMUNITY PARTICIPATION

Both RCRA and CERCLA require the public to be given an opportunity to review and comment on the draft permit modification and proposed remedial alternative. Public participation requirements are listed in South Carolina Hazardous Waste Management Regulation (SCHWMR) R.61-79.124 and Sections 113 and 117 of CERCLA (42 United States Code Sections 9613 and 9617). These requirements include establishment of an Administrative Record File that documents the investigation and selection of the remedial alternative for addressing the unit acronym soils and groundwater. The Administrative Record File must be established at or near the facility at issue.

The SRS FFA Community Involvement Plan (WSRC 2011b) is designed to facilitate public involvement in the decision-making process for permitting, closure, and the selection of remedial alternatives. The plan addresses the requirements of RCRA, CERCLA, and the National Environmental Policy Act, 1969 (NEPA). SCHWMR R.61-

79.124 and Section 117(a) of CERCLA, as amended, require the advertisement of the draft permit modification and notice of any proposed remedial action and provide the public an opportunity to participate in the selection of the remedial action. The proposed plan document name, a part of the Administrative Record File, highlights key aspects of the investigation and identifies the preferred action for addressing the unit acronym.

The FFA Administrative Record File, which contains the information pertaining to the selection of the response action, is available at the following locations:

US Department of Energy
Public Reading Room
Gregg-Graniteville Library
University of South Carolina – Aiken
171 University Parkway
Aiken, South Carolina 29801
(803) 641-3465

Thomas Cooper Library
Government Documents Department
University of South Carolina
Columbia, South Carolina 29208
(803) 777-4866

The RCRA Administrative Record File for SCDHEC is available for review by the public at the following locations:

The South Carolina Department of Health and Environmental Control
Bureau of Land and Waste Management
8911 Farrow Road
Columbia, South Carolina 29203
(803) 896-4000

The South Carolina Department of Health and Environmental Control – Region 5
Aiken Environmental Quality Control Office
206 Beaufort Street, Northeast
Aiken, South Carolina 29801
(803) 641-7670

[Note: Insert this paragraph for interim actions: An SRS RCRA permit modification is not required at this time since this is an interim action. However, the RCRA permit will be revised to reflect selection of the final selected remedy using the procedures under 40 CFR Part 270, and SCHWMR R.61-79.264.101; 270.]

The public was notified of the public comment period through mailings of the *SRS Environmental Bulletin*, a newsletter sent to citizens in South Carolina and Georgia, and through notices in the *Aiken Standard*, the *Allendale Citizen Leader*, the *Augusta*

Chronicle, the *Barnwell People-Sentinel*, and *The State* newspaper. The public comment period was also announced on local radio stations.

The SB/PP 45-day (or IAPP 30-day) public comment period began on start date and ended on end date. A Responsiveness Summary, prepared to address any comments received during the public comment period, is provided in Appendix A of the ROD. A Responsiveness Summary will also be available in the final RCRA permit.

If there were any SRS CAB activities or recommendations regarding the operable unit, include a summary in this section.

[Note: Delete RCRA time period and references to RCRA if a CERCLA only unit.]

IV. SCOPE AND ROLE OF THE OPERABLE UNIT

Due to the complexity and size of multiple waste units in different areas, the SRS is divided into watersheds for the purpose of managing a comprehensive cleanup strategy. The SRS is segregated into six watersheds: Upper Three Runs, Lower Three Runs, Fourmile Branch, Steel Creek, Pen Branch, and the Savannah River. In addition, the SRS also identifies six Integrator Operable Units (IOUs) which are the surface water bodies and associated wetlands that correspond to the six respective watersheds. Waste units within a watershed may be evaluated and remediated individually or grouped with other waste units and evaluated as part of a larger Area OU. Upon disposition of all the waste units within a watershed, a final comprehensive ROD for the corresponding IOU (i.e., surface water and associated wetlands) will be pursued with additional public involvement. The [OU name] is located within the [name] watershed. [Include map (Figure 3)].

[In addition to the previous paragraph, insert the following text if this ROD also addresses an Area OU]. In 2003, a new completion strategy for environmental restoration at SRS was developed to accelerate cleanup completion. A key component of the plan is to implement an area-by-area remediation strategy. Through the sequencing of

environmental restoration and decommissioning activities, environmental cleanup can be completed for entire areas of the SRS. In [month year], the USDOE, USEPA, and SCDHEC convened and agreed that using the Area OU strategy to manage surface units at the unit acronym was appropriate and the waste units and facilities in the area were consolidated to form a single Area OU.

Describe the scope of the problem(s) that will be addressed by the remedial action(s) for this OU.

The following activities have been or will be performed to support the overall cleanup strategy for the [OU name].

For interim RODs, state that the OU response action will be consistent with the final action selected for the site.

V. OPERABLE UNIT CHARACTERISTICS

Provide operable unit characteristics including maps, figures, and photos as appropriate to depict the nature and extent of contamination. For an interim action, this section should focus on the description of those site or operable unit characteristics to be addressed by the interim remedy.

[Note: Describe by subunit, when appropriate.]

Conceptual Site Model (CSM) for the Unit Acronym

Identify primary and secondary sources of contamination and release mechanisms, contaminated media, migration pathways, exposure pathways, and potential receptors (insert the latest revision of the CSM, Figure 4).

Media Assessment

Briefly describe the media assessment.

[Note: The following subheadings (soil investigation and groundwater investigation) are included as typical media for the OU. Additional subheadings should be added for any affected media at the OU.]

Soil Investigation

Briefly describe the soil investigation.

Groundwater Investigation

Briefly describe the groundwater investigation.

Media Assessment Results

Summarize the results of the investigation.

Insert the Schematic Cross Section (Figure 5) of the unit acronym from the Scoping Summary.

Describe types of contamination by affected media (e.g., soils, vadose zone, and groundwater) and by discrete unit (if appropriate) [e.g., Pit Soils, Sewer Line Soils, Groundwater, etc.]

- Identify whether RCRA listed or characteristic hazardous wastes are at the unit
- Quantity/volume of waste that needs to be addressed
- Concentrations of contaminants of concern (COCs) in each medium
- Types and characteristics of COCs (e.g., toxic, mobile, carcinogenic, noncarcinogenic)

Identify principal and low-level threat wastes at the site (e.g., location of mobile/high toxicity source materials and non-mobile/low toxicity source material) [Note: Per USEPA guidance, some wastes can not be classified as either principal or low-level threats.]

[Note: The following subheadings (soil and groundwater) are included as typical media for the OU. Additional subheadings should be added for any affected media at the OU.]

Soil

Summarize the soil assessment results.

Groundwater

Summarize the groundwater assessment results.

Site Specific Factors

Identify any other site-specific factors that may affect response actions at the site. If there are none, use "No site-specific factors requiring special consideration that might affect the remedial action for the unit acronym are present at the site."

Contaminant Transport Analysis

Describe location of contamination and known or potential routes of off-site migration including:

- Likelihood for migration of COCs
- Population and environmental areas that could be affected, if exposed
- Lateral and vertical extent of contamination
- Current and potential surface and subsurface pathways of migration

For sites with groundwater contamination, describe the following, if appropriate

- Aquifer(s) affected or threatened by site contamination, types of geologic materials, approximate depths, whether aquifer is confined or unconfined
- Groundwater flow directions within each aquifer and between aquifers and groundwater discharge locations (e.g., surface waters, wetlands, other aquifers)
- Confirmed or suspected presence and locations of non-aqueous phase liquids (NAPLs)
- If groundwater transport models were used to define fate and transport of COCs, identify the model used and assumptions

- Surface and subsurface features (e.g., number and volume of tanks, lagoons, structures, drums at the site)
- Interconnection between surface contamination (e.g., soils, surface water/sediments) and groundwater contamination

VI. CURRENT AND POTENTIAL FUTURE SITE AND RESOURCE USES

Land Uses

Describe current on-site land uses.

Describe current adjacent/surrounding land uses.

Describe reasonably anticipated future land uses and bases for future use assumptions. This requires a specific statement describing the future land use assumed for the OU used to evaluate the remedial actions. Sample language, change use and reference numbers as appropriate: According to the Savannah River Site Future Use Project Report (USDOE 1996), residential uses of SRS land should be prohibited. The Land Use Control Assurance Plan for the Savannah River Site (WSRC 1999) designates the unit acronym OU as being within an [administrative, industrial] area. (Figure 6). The future land use is reasonably anticipated to remain [industrial] with DOE maintaining control of the land.

Groundwater Uses/Surface Water Uses

Describe current ground/surface water uses on the site and in its vicinity.

Describe potential beneficial ground/surface water uses (e.g., potential drinking water, irrigation, recreational) and bases for future use assumptions.

If beneficial use is potential drinking water source, identify the appropriate time frame of projected future drinking water uses (e.g., groundwater aquifer not currently used as a drinking water source, but expected to be utilized in 30-50 years).

Describe the location of the anticipated use in relation to location and anticipated migration of contamination.

VII. SUMMARY OF OPERABLE UNIT RISKS

Baseline Risk Assessment

Summarize briefly the baseline risk assessment process utilizing text and table formats (see example tables and sample language provided). Also, provide an illustration depicting the risk and final COCs for affected pathways. This section should focus on the information that is driving the need for the specific response action described in the ROD. It is not necessarily a summary of the entire baseline risk assessment.

As a component of the RFI/Remedial Investigation (RI) process, a baseline risk assessment (BRA) was performed to evaluate risks associated with the unit acronym. The BRA estimates what risks the site poses if no action were taken. It provides the bases for taking action and identifies the contaminants and exposure pathways that need to be addressed by the remedial action. The BRA includes human health and ecological risk assessments. This section of the ROD summarizes the results of the BRA for this OU.

[Note: Describe risks by subunit, when appropriate.]

Summary of Human Health Risk Assessment

Identification of COCs (Table 1) (from RAGS Part D Standard Table 3.1)

- COCs in each medium
- Minimum/maximum detects and frequency
- Data quality
- Exposure point concentration for each COC (95% UCL)

Exposure Assessment (from RAGS Part D Standard Table 1)

- Use CSM as a reference to determine exposure scenarios and pathways
- Potentially exposed populations in current/future scenarios
- Sensitive sub-populations
- Routes of exposure

Toxicity Assessment (from RAGS Part D Standard Tables 5 and 6)

- Carcinogenic/non-carcinogenic toxicity data used to calculate risk of each COC
- Source of toxicity information
- Primary target organs/health effects non-carcinogenic COCs (Tables 2 and 3)

Risk Characterization

Include the following for all current/future land use scenarios that present unacceptable risks:

- Carcinogenic risks for each COC by medium and pathway
- Combine carcinogenic risks for total exposure to COCs in medium and pathway
- HQ for each COC in each medium for each pathway
- HI for combined non-carcinogenic effects
- Combined carcinogenic and HIs for paths to which individuals could be exposed
- Qualitative descriptions of risks
- Explanation of quantitative risk versus qualitative
- Table summary (Tables 4 and 5) (RAGS Part D Table 10)

Include Significant Sources of Uncertainty:

- Uncertainty due to number of samples
- Uncertainty due to fate and transport models
- Uncertainty due to default exposure assumptions
- Uncertainty due to available toxicity data (Tables 4 and 5)

The following sample language may be included in this section.

For carcinogens, risks are generally expressed as the incremental probability of an individual developing cancer over a lifetime as a result of exposure to the carcinogen. Excess lifetime cancer risk is calculated from the following equation:

Risk = CDI x SF

where: risk = a unitless probability (e.g., 2×10^{-5}) of an individual developing cancer

CDI = chronic daily intake averaged over 70 years (mg/kg-day)

SF = slope factor, expressed as (mg/kg-day)-1.

These risks are probabilities that usually are expressed in scientific notation (e.g., 1×10^{-6}). An excess lifetime cancer risk of 1×10^{-6} indicates that an individual experiencing the reasonable maximum exposure estimate has a 1 in 1,000,000 chance of developing cancer as a result of site-related exposure. This is referred to as an "excess lifetime cancer risk" because it would be in addition to the risks of cancer individuals face from other causes such as smoking or exposure to too much sun. The chance of an individual developing cancer from all other causes has been estimated to be as high as one in three. USEPA's generally acceptable risk range for site-related exposures is 10^{-4} to 10^{-6}.

The potential for noncarcinogenic effects is evaluated by comparing an exposure level over a specified time period (e.g., lifetime) with a reference dose (RfD) derived for a similar exposure period. An RfD represents a level that an individual may be exposed to that is not expected to cause any deleterious effect. The ratio of exposure to toxicity is called a hazard quotient (HQ). An HQ<1 indicates that a receptor's dose of a single contaminant is less than the RfD, and that toxic noncarcinogenic effects from that chemical are unlikely. The Hazard Index (HI) is generated by adding the HQs for all constituent(s) of concern that affect the same target organ (e.g., liver) or that act through the same mechanism of action within a medium or across all media to which a given individual may reasonably be exposed. An HI<1 indicates that, based on the sum of all HQs from different contaminants and exposure routes, toxic noncarcinogenic effects from all contaminants are unlikely. An HI> 1 indicates that site-related exposures may present a risk to human health.

The HQ is calculated as follows:

Non-cancer HQ = CDI/RfD

where: CDI = Chronic daily intake

RfD = reference dose

CDI and RfD are expressed in the same units and represent the same exposure period (i.e., chronic, subchronic, or short-term).

Summary of Ecological Risk Assessment

Identification of COCs

- Summary of toxicity data used to evaluate constituents of potential concern (COPCs) plus background concentrations for each chemical
- COPCs in each medium
- Range of detected concentrations and frequency of detects for each COPC in each medium
- Mean and maximum concentrations of COPCs
- Ecological HQ and COC flag (yes or no) for each COPC
- Data quality (data usability section of ecological risk assessment)

Exposure Assessment

- Description of ecological setting (habitat maps, sensitive areas, etc.)
- Key species exposed; threatened, endangered species (Table 6)
- Exposure pathways for receptors plus exposure point concentrations
- Monitoring/modeling data and assumptions used for exposure point concentrations
- Summary of field studies conducted

Ecological Effects Assessment

- Summary of toxicity tests/field studies used to evaluate adverse ecological effects
- Description of the assessment and measurement endpoints

Ecological Risk Characterization

- Summary of environmental risks associated with a relevant media, the basis of these risks, how risks were determined, and COC concentrations expected to be protective of ecological receptors. (Table 7)

Summary of the Fate and Transport Analysis

Summarize the results of the fate and transport analysis with emphasis on where remedial action is required.

Discussion of Principal Threat Source Material (PTSM)

Discuss whether the OU does/does not contain PTSM and its location.

Risk Assessment Summary

This section may be organized by subunit, when applicable.

Conclusions

This section may be organized by subunit, when applicable. State basis for remedial action, which is generally warranted if one or more of the following conditions is met: (1) the cumulative excess carcinogenic risk to an individual exceeds the acceptable risk for the current or future land use; (2) the non-carcinogenic hazard index is greater than one for either current or future land use; (3) site-specific contaminants cause adverse environmental impacts; or (4) chemical-specific standards or other measures that define acceptable risk levels are exceeded.

VIII. REMEDIAL ACTION OBJECTIVES AND REMEDIAL GOALS

Present a clear statement of the specific remedial action objectives (RAOs) for the operable unit or site (e.g., treatment of contaminated soils above health-based action levels, restoration of groundwater plume to drinking water standards, and containment of dense non-aqueous phase liquid (DNAPL) source areas).

Discuss the basis and rationale for RAOs (e.g., current and reasonably anticipated future land use and potential beneficial groundwater use).

[Note: RAOs should be specific at this point and indicate the remedial levels to achieve (can refer to table). An example is: Protect future workers from contact with soil containing levels of B(a)P in excess of 200 µg/kg.]

Include an RAO to ensure that the future land use for which remedial goals are developed is maintained (e.g., "Prevent residential and/or agricultural land use").

Explain how the RAOs address risks identified in the risk assessment (e.g., how will the risks driving the need for action be addressed by the response action).

Based upon the appropriate human health and ecological COCs, provide the remedial goals (RGs) for the operable unit (use tables and illustrations as appropriate).

Remedial Action Objectives

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

- [list RAOs in bullet format and by subunit if appropriate]

Remedial Goals

Remedial goals can be qualitative statements or numerical values often expressed as concentrations in soil and groundwater, or actions (installation of engineered barriers, placement of caps and covers, etc.) that achieve the RAO. These cleanup goals are either concentration levels that correspond to a specific risk or hazard or are based on Applicable, or Relevant and Appropriate Requirements (ARARs). Final RGs will be monitored to determine when the remedial action is complete. options (RGOs) serve to provide a range of cleanup goals for each COC and are typically identified along with the RAOs.

RGs were calculated for the future industrial worker and future resident (unrestricted) receptor to correspond to a target cancer risk of 1 x 10^{-6} or target HQ of 1 and are presented in Table X.

Applicable or Relevant and Appropriate Requirements

Section 121(d) of CERCLA, as amended by the Superfund Amendments Reauthorization Act (SARA), requires that remedial actions for cleanup of hazardous substances must comply with requirements and standards set forth under federal and state environmental laws and regulations that are applicable or relevant and appropriate (i.e., ARARs). ARARs include only federal or state environmental or facility laws and regulations and do not include occupational safety or worker protection requirements. SARA requires that the remedial action for a site meet all ARARs unless a waiver is invoked.

ARARs consist of two sets of requirements: those that are applicable, and those that are relevant and appropriate. Applicable requirements are those substantive standards that specifically address the situation at a CERCLA site and are promulgated under federal or state environmental laws. If a requirement is not applicable, it may still be relevant and appropriate. "Applicability" is a legal and jurisdictional determination, while the determination of "relevant and appropriate" relies on professional judgment, considering environmental and technical factors at the site. A requirement may be "relevant", in that it covers situations similar to that at the site, but may not be "appropriate" to apply for various reasons and, therefore, not well suited to the site. In some situations, only portions of a requirement or regulation may be judged relevant and appropriate; if a requirement is applicable, however, all substantive parts must be followed. 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. Such information is required to-be-considered when RGs are developed.

Key ARARs associated with each alternative are discussed in more detail in the Description of Alternatives section. The complete list of ARARs for the selected remedy are presented in Table 8.

IX. DESCRIPTION OF ALTERNATIVES

The objective of this section is to provide a brief understanding of the remedial alternatives developed for the site. A minimum of 3 alternatives must be evaluated. For example, if a No Action Alternative and a Land Use Control Alternative are under consideration, a third alternative that reduces the toxicity, mobility, or volume of the hazardous substances, pollutants, or contaminants must also be included. (Reference 40 CFR 300.430(e)(3) for more information).

Remedy Components, Common Elements, and Distinguishing Features of Each Alternative

Up front, provide the following information for each alternative:

- Estimated Present Value Cost
- Construction Time to Complete

Present worth (PW) costs should include a statement listing the basis for those costs. The discount rate (0.9% for 1 to 3 years, 1.5% for 4 to 5 years, 1.9% for 6 to 7 years, 2.2% for 8 to 10 years, 2.7% for 11 to 20 years, 2.8% for 21 to 29 years, and 2.7% for 30 years or longer) and the length of time used for O&M costs must be stated. (See Technical Memo ERTEC-2009-00004 for current discount rates). Use the actual expected length of time in the calculations. If the costs are expected to continue beyond 30 years, without a definite end point, use 200 years. Use the same time period for each alternative to discuss PW costs. For alternatives that are complete (no O&M required) earlier than others, show that there are no costs for the years after completion.

Describe the remedy and provide a bulleted list of the major components of each alternative, as they logically occur in the remediation process. Describe common

elements and distinguishing features unique to each response action. Examples of these include:

- Treatment technologies and the materials they will address (e.g., principal threat). Note: Regulators do consider monitored natural attenuation as meeting the preference for treatment. Also, natural radioactive decay qualifies, but time must be short.
- Containment components of remedy (e.g., engineering controls, cap, hydraulic barriers) and the materials they will address (e.g., low-level threat source materials, treatment residuals)
- Land Use Controls (Institutional Controls and Engineering Controls) (Identify entity responsible for implementing, monitoring, reporting, and a reference to the LUCIP form implementation details, including monitoring frequency)
- Operations and Maintenance (O & M) activities required to maintain the integrity of the remedy (e.g., cap maintenance)
- Monitoring requirements
- Identify key ARARs associated with each alternative (i.e., those ARARs that would be different between alternatives and are the basis for developing the alternative). Identify all ARARs for the selected remedy only in table format. (DO NOT list the ARARs for all alternatives in the table). Reference Table 8 ARARs for the selected remedy.
- Long-term reliability of remedy (potential for remedy failure/replacement costs)
- Quantity of untreated waste and treatment residuals to be disposed off-site or managed on-site in a containment system and degree of hazard remaining in such waste
- Available land uses upon achieving remediation goals. Note: Timeframe to achieve goals (e.g., commercial or light industrial use available in 3 years when cleanup levels are achieved)
- Available groundwater uses upon achieving remediation goals. Note timeframe to achieve goals (e.g., restricted use for industrial purposes in Technical Impracticability (TI) waiver zone, drinking water use in non-TI zone achieving cleanup levels in 100 years). Also include a statement on current groundwater uses.
- Other impacts or benefits associated with each alternative

For an interim action, this section should describe the limited alternatives (including the No Action alternative) that were considered for the interim action (generally three or fewer). Only those requirements that are ARARs for the limited-scope interim action should be incorporated into the description of alternatives.

X. COMPARATIVE ANALYSIS OF ALTERNATIVES

Briefly compare the relative performance of each alternative against the others with respect to the nine evaluation criteria (summarize in a table if appropriate):

[Note: The discussion for each criterion should be in decreasing order of the alternative's ability to satisfy the respective criterion.]

Overall protection of human health and the environment (specify "industrial" or "residential" to qualify the protectiveness statements.)

Compliance with ARARs

Long-term effectiveness and permanence

Reduction of toxicity, mobility, or volume through treatment

Short-term effectiveness[1]

Implementability

Cost

State acceptance

Community acceptance

For an interim action, this section should be presented in light of the limited scope of the action. Evaluation criteria not relevant to evaluation of interim actions need not be addressed in detail. Rather, their irrelevance to the decision should be noted briefly.

[Note: A summary table may be added, in addition to the discussion in the text to clarify.]

[1] *Include discussion of the potential for each remedial alternative to avoid, mitigate, compensate for, cause or increase injury to a natural resource. For example, would LUCs or MNA increase the risk, duration, or severity of natural resource injuries?*

XI. THE SELECTED REMEDY

Detailed Description of the Selected Remedy

Expand on the description of the Selected Remedy from that which was provided in the Description of Alternatives section.

Include a clear, concise, thorough explanation of the logic behind selecting the alternative. This should discuss the major distinguishing features over each of the other alternatives.

Mention that the remedy may change as a result of the remedial design or construction processes. Changes to the remedy described in the ROD will be documented in the Administrative Record utilizing a memo, an Explanation of Significant Difference (ESD), or ROD Amendment.

If a selected alternative is and/or includes Land Use Controls, describe the LUC objectives: [include the following list and add OU specific objective as appropriate]

The following LUC objectives are necessary to ensure protectiveness of the selected remedy:

Prevent contact, removal, or excavation of [list media or components for specific waste unit, e.g. contaminated soil and pipelines, buried waste, etc.]

Prohibit the development and use of property for residential housing, elementary and secondary schools, child care facilities and playgrounds.

Maintain the integrity of any current or future remedial or monitoring system, such as SVE systems, soil covers, or groundwater monitoring wells

Prevent access or use of contaminated groundwater until cleanup levels are met; and

Prevent construction of inhabitable buildings without an evaluation of indoor air quality to address vapor intrusion.

If a selected alternative is and/or includes Land Use Controls, describe the LUCs for the OU (i.e., maintenance of a soil cover, plugging and grouting of manholes, pipelines, signage at the OU boundaries, etc.). Reference Table 9, which shows the Type of Control, Purposes of Control, Duration, Implementation (including when it will be implemented) and Affected Areas.

Land use controls (LUCs) for the unit acronym are presented in Table 9 and include the following:

- [Insert OU specific controls]
- Signage will be located at the unit acronym boundaries shown in Figure X to alert on-site workers to the presence of hazardous substances and to prevent unauthorized entry and unrestricted uses. The date for installation of the signs will be stated in the unit-specific LUCIP referenced in this ROD.
- Institutional controls (i.e., administrative measures) and use restrictions for on-site workers via the Site Use/Site Clearance Program. Other administrative controls to ensure worker safety include work controls, worker training, and worker briefings of health and safety requirements.
- SRS access controls to prevent exposure to trespassers, as described in the 2000 RCRA Part B Permit Renewal Application, Volume I, Section F.1, which describes the security procedures and equipment, 24-hour surveillance system, artificial or natural barriers, control entry systems, and warning signs in place at the SRS boundary.

For remedies that include institutional controls (i.e., a type of administrative land use control), include the following language:

In the long term, if the property, or any portion thereof, is ever transferred from DOE, the U.S. Government and/or DOE will take those actions necessary pursuant to Section 120(h)(1) of CERCLA. Those actions will include in any contract, deed, or other transfer document, notice of the type and quantity of any hazardous substances that were known to have been stored (for more than one year), released, or disposed of on the property. The notice will also include the time at which the storage, release, or disposal took place to the extent such information is available.

In addition, if the property, or any portion thereof, is ever transferred by deed, the U.S. Government will also satisfy the requirements of CERCLA 120(h)(3). The requirements include: a description of the remedial action taken, a covenant, and an access clause. These requirements are also consistent with the intent of the RCRA deed notification requirements at final closure of a RCRA facility if contamination will remain at the unit.

The LUCs will be implemented through the following:

- The contract, deed, or other transfer document shall also include restrictions precluding residential use of the property. However, the need for these restrictions may be reevaluated at the time of transfer in the event that exposure assumptions differ and/or the residual contamination no longer poses an unacceptable risk under residential use. Any reevaluation of the LUCs will be done through an amended ROD with USEPA and SCDHEC review and approval.

- In addition, if the site is ever transferred to nonfederal ownership, a survey plat of the OU will be prepared, certified by a professional land surveyor, and recorded with the appropriate county recording agency.

In the event of a property lease or interagency agreement, the equivalent restrictions will be implemented as required by CERCLA Section 120(h).

The selected remedy for the unit acronym or OU subunit name leaves hazardous substances in place that pose a potential future risk and will require land use restrictions for as long as necessary to keep the selected remedy fully protective of human health and the environment. As agreed on March 30, 2000, among the USDOE, USEPA, and SCDHEC, SRS is implementing a Land Use Control Assurance Plan (LUCAP) to ensure that the LUCs required by numerous remedial decisions at SRS are properly maintained and periodically verified. The unit-specific LUCIP referenced in this ROD will provide details and specific measures required to implement and maintain the LUCs selected as part of this remedy. The USDOE is responsible for implementing, maintaining, monitoring, reporting upon, and enforcing the LUCs selected under this ROD. The LUCIP, developed as part of this action, will be submitted concurrently with the CMI/RAIP, as required in the FFA for review and approval by USEPA and SCDHEC. Upon final approval, the LUCIP will be appended to the LUCAP and is considered incorporated by reference into the ROD, establishing LUC implementation and maintenance requirements enforceable under CERCLA and the *SRS Federal Facility Agreement*. The approved LUCIP will establish implementation, monitoring, maintenance, reporting, and enforcement requirements for the unit. The LUCIP will remain in effect unless and until modifications are approved as needed to be protective of human health and the environment. The LUCs shall be maintained until the concentration of hazardous substances associated with the unit have been reduced to levels that allow for unlimited exposure and unrestricted use. Approval by EPA and SCDHEC is required for any modification or termination of the OU specific LUCs.

USDOE has recommended that residential use of SRS land be controlled; therefore, future residential use and potential residential water usage will be restricted to ensure long-term protectiveness. LUCs will restrict the [operable unit name] to future industrial use and will prohibit residential use of the area. Unauthorized excavation will also be

prohibited and the waste unit will remain undisturbed. LUCs selected as part of this action will be maintained for as long as they are necessary and termination of any LUCs will be subject to CERCLA requirements for documenting changes in remedial actions.

Cost Estimate for the Selected Remedy

Present a detailed, activity-based breakdown of the estimated costs associated with implementing and maintaining the remedy (include estimated capital, O & M, and present worth costs, and the number of years to completion of the remedy. All alternatives will have the same time period for the purpose of calculating remedy cost estimates).

Standard language from guidance for Cost Estimate Disclaimer: The information in this cost estimate summary table is based on the best available information regarding the anticipated scope of the remedial alternative. Changes in the cost elements are likely to occur as a result of new information and data collected during the engineering design of the remedial alternative. Major changes may be documented in the form of a memorandum in the Administrative Record File, an ESD, or a ROD amendment. This is an order-of-magnitude engineering cost estimate that is expected to be within +50 to –30 percent of the actual project cost.

Estimated Outcomes of Selected Remedy

Brief description based on elements relevant to the unit.

Available land use(s) upon achieving remediation goals. Note timeframe to achieve goals (e.g., commercial or light industrial use available in 3 years when cleanup levels are achieved).

Available groundwater use(s) upon achieving remediation goals. Note timeframe to achieve goals (e.g., restricted use for industrial purposes in TI waiver zone, drinking water use in non-TI zone upon achieving cleanup levels in 100 years).

Final cleanup levels for each media (i.e., contaminant specific remediation goals), basis for cleanup levels, and risk at cleanup levels (if appropriate).

Anticipated environmental and ecological benefits (e.g., restoration of sensitive ecosystems, protection of endangered species, protection of wildlife populations, wetlands restoration).

Waste Disposal and Transport

Include the following language to discuss waste management procedures.

All unused environmental samples may be returned to the waste site, within the Area of Contamination. This only includes samples that have had no preservatives added.

Decontamination solutions and rinsates from cleaning items intended for reuse or recycle (e.g., field sampling tools, equipment, or personal protective equipment) may be discharged to the ground surface at an area which will not runoff or cause erosion. This method for handling decontamination solutions does not require an engineering evaluation to determine a waste disposal strategy. Decontamination wash and rinse solutions typically include laboratory grade soap and deionized water, and laboratory grade isopropyl alcohol for residual organic compound stripping and tool drying. Any residual isopropyl alcohol must be containerized and combined with the soapy wash water before the solution is discharged to the ground surface, to avoid discharging an ignitable hazardous solution.

Environmental sampling boreholes may be abandoned by backfilling with native soil. This is regardless of the level of contamination. The soil will be placed in the borehole in the reverse order as removed, to maintain the original stratigraphy.

If the OU has been identified in previous documents as being a RCRA listed waste site, include the following bullet also:

Environmental media that contains RCRA listed waste is subject to applicable RCRA requirements until determined to no longer contain hazardous waste. Environmental media and/or secondary waste will be determined to no longer contain listed hazardous waste by direct comparison to the Health Based Levels (HBLs) for soil and groundwater. The HBLs for soil are based on the lower of (1) the USEPA Region 9 Preliminary Remediation Goals (PRGs) for the residential exposure scenario or (2) the RCRA toxicity characteristic level (due to the 20-fold dilution factor inherent in the TCLP analysis of solids, the RCRA TCLP values are multiplied by 20). Due to the analytical method limitations, groundwater (as defined by South Carolina Regulation 61-68) HBLs are based on the higher of (1) MCLs, or (2) USEPA RCRA (SW-846) analytical minimum detection levels (MDLs).

XII. STATUTORY DETERMINATIONS

See the Statutory Determination section of the Declaration for text options; these sections should coincide.

Based on the unit RFI/RI/BRA report, the unit acronym poses a threat to human health and the environment. Therefore, Alternative selected alternative number and title has been selected as the remedy for the unit acronym.

Include a statement indicating whether the unit does/does not contain PTSM.

Explain how the remedy satisfies the requirements of Section 121 of CERCLA:

- Protection of human health and the environment
- Compliance with key ARARs or justify a waiver (summarize in a table if appropriate)
- Cost-effectiveness

- Utilization of permanent solutions and alternative treatment (resource recovery) technologies to the maximum extent practicable (i.e., explain why the Selected Remedy represents the best options).

- Preference for treatment as a principal element (or justify not meeting this preference). Excavation does not meet the standard for treatment.

- Explain five-year remedy review requirements for the Selected Remedy.

- Include the following language for remedial actions requiring a 5-year remedy review:

In accordance with Section 121(c) of CERCLA and NCP §300.430(f)(5)(iii)(c), a statutory review will be conducted within 5 years of initiation of the remedial action, and every 5 years thereafter, to ensure that the remedy continues to be protective of human health and the environment.

For an interim action, this section should address only those ARARs specific for this action (e.g., residual management during implementation). The discussion under "utilization of permanent solutions and treatment to the maximum extent practicable" should indicate that the interim action is not designed or expected to be final, but that the selected remedy represents the best balance of trade-offs among the alternatives with respect to pertinent criteria, given the limited scope of the action. The discussion under the "preference of treatment" section should note that the preference will be addressed in the final decision document for the site or final operable unit, although treatment components "that support the preference" should be noted.

XIII. EXPLANATION OF SIGNIFICANT CHANGES

If there are no significant changes in the selected remedy from the preferred alternative identified in the proposed plan, then insert the following text.

"The remedy/remedies selected in this ROD do no contain any significant changes from the preferred alternative(s) presented in the SB/PP (or PP or IAPP as applicable). No comments were received during the public comment period".

If there are significant changes in the selected remedy from the preferred alternative identified in the proposed plan, then:

- Discuss the preferred alternative originally presented in the proposed plan.
- Describe the significant changes in the selected remedy.
- Explain the rationale for the changes and how they could have been reasonably anticipated based on the information presented in the proposed plan.

XIV. RESPONSIVENESS SUMMARY

The Responsiveness Summary serves the dual purposes of (1) presenting stakeholder concerns about the site and preferences regarding the remedial alternatives, and (2) explaining how those concerns were addressed and how the preferences were factored into the remedy selection process. This discussion should cross-reference sections of the Decision Summary that demonstrate how issues raised by the community have been addressed. SRS CAB recommendations or comments made during the public comment period should be summarized and responded to in the Responsiveness Summary.

This section should include the following statement:

The Responsiveness Summary is included as Appendix A of this document.

XV. POST-ROD DOCUMENT SCHEDULE AND DESCRIPTION

Identify by bullets the major post-ROD submittals and attach a schedule.

For a final ROD, this section should include explicit statements telling the reader when cleanup will start in the field and when cleanup is scheduled for completion.

For an IROD, this section should include explicit statements telling the reader when cleanup will start in the field, when cleanup is scheduled for completion, any needed statements about a final Corrective Measures Study/Feasibility Study to arrive at a proposed final remedy for the site, a statement identifying the timing of the public comment period for the final Statement of Basis/Proposed Plan and when the final ROD is scheduled for approval.

XVI. REFERENCES

Provide additional references that are listed in the ROD (or IROD). (Those listed below are referenced in the generic ROD language and should be retained).

FFA, 1993. *Federal Facility Agreement for the Savannah River Site*, Administrative Docket No. 89-05-FF (Effective Date: August 16, 1993)

USDOE, 1996. *SRS Future Use Project Report, Stakeholder Preferred Recommendations for SRS Land Use Facilities*, United States Department of Energy, Savannah River Operations Office, Aiken, SC

WSRC, 2011a. *Land Use Control Assurance Plan for the Savannah River Site*, WSRC-RP-98-4125, Revision 1.1, August 1999, updated October 2011, Savannah River Nuclear Solutions, LLC, Savannah River Site, Aiken, SC.

WSRC, 2011b. *Savannah River Site Federal Facility Agreement Community Involvement Plan (U)*, Revision 7, WSRC-RP-96-120, Savannah River Nuclear Solutions, LLC, Savannah River Site, Aiken, SC (February).

Figure 1. Location of the Unit Acronym within the Savannah River Site

Figure 2. Layout of the Unit Acronym

Figure 3. Layout of the Unit Acronym within the IOU Acronym Watershed

Figure 4. Conceptual Site Model for the Unit Acronym

Figure 5. Schematic Cross Section of the Unit Acronym

Figure 6. Land Use Map for Unit Acronym

Table 1. Summary of Constituents of Concern and Medium-Specific Exposure Point Concentrations

Scenario Timeframe: Current
Medium: Soil
Exposure Medium: Soil

Exposure Route	Constituent of Concern	Concentration Detected		Units	Frequency of Detection	Exposure Point Concentration	Exposure Point Concentration Units	Statistical Measure
		Min	Max					
Soil Onsite – Direct Contact	Benzo(a) pyrene	100	430	ppm	20/24	300	ppm	95% UCL
	4,4'-DDT	20	350	ppm	8/24	350	ppm	MAX
	Dieldrin	15	60	ppm	15/24	40	ppm	95% UCL

Key

ppm: parts per million
95% UCL: 95% Upper Confidence Limit
MAX: maximum concentration

Sample Language Describing Summary of Constituents of Concern and Medium-Specific Exposure Point Concentrations

The table presents the constituents of concern (COCs) and exposure point concentration (EPC) for each of the COCs detected in soil (i.e., the concentration that will be used to estimate the exposure and risk from each COC in the soil). The table includes the range of concentrations detected for each COC, as well as the frequency of detection (i.e., the number of times the chemical was detected in the samples collected at the site), the EPC, and how the EPC was derived. The table indicates that benzo(a)pyrene is the most frequently detected COC in soil at the site. The 95% UCL on the arithmetic mean was used as the EPC for benzo(a)pyrene and dieldrin. However, due to the limited amount of sample data available for 4,4'-DDT, the maximum concentration was used as the default EPC.

NOTE: In a ROD, this table would be expanded to include all exposure points that have significant routes of exposure for the soil. Additional versions of this table format would be presented to include other media (e.g., groundwater) or other exposure media (e.g., dust) with significant routes of exposure.

Table 2. Cancer Toxicity Data Summary

Pathway: Ingestion, Dermal

Constituent of Concern	Oral Cancer Slope Factor	Dermal Cancer Slope Factor	Slope Factor Units	Weight of Evidence/ Cancer Guideline Description	Source	Date (Year)
Benzo(a)pyrene	7.3	7.3	(mg/kg)/day	B2	IRIS	1998
4,4'-DDT	0.34	0.34	(mg/kg)/day	B2	IRIS	1998
Dieldrin	16	16	(mg/kg)/day	B2	IRIS	1998
TCE	0.011	0.011	(mg/kg)/day	B2	IRIS	1998

Pathway: Inhalation

Constituent of Concern	Unit Risk	Units	Inhalation Cancer Slope Factor	Units	Weight of Evidence/ Cancer Guideline Description	Source	Date (Year)
Benzo(a)pyrene	---	NA	---		B2	IRIS	1998
4,4'-DDT	9.7×10^{-5}	NA	---		B2	IRIS	1998
Dieldrin	4.6×10^{-3}	NA	---		B2	IRIS	1998
TCE	---	NA	---		B2	IRIS	1998

Pathway: External (Radiation)[1]

Constituent of Concern	Cancer Slope or Conversion Factor	Exposure Route	Units	Weight of Evidence/ Cancer Guideline Description	Source	Date (Year)
---	---	---	---	---	---	---
---	---	---	---	---	---	---

Key
---: No information available
IRIS: Integrated Risk Information System, USEPA
NA: Not Applicable

1- This pathway would be used in the event that one of the contaminants of concern was a radionuclide. If there are no radionuclides associated with a particular site, then this column can be deleted.

EPA Group

A- Human carcinogen
B1- Probable human carcinogen – indicates that limited human data are available
B2- Probable human carcinogen – indicates sufficient evidence in animals and inadequate or no evidence in humans
C- Possible human carcinogen
D- Not classifiable as a human carcinogen
E- Evidence of noncarcinogenicity

Sample Language Describing Summary of Toxicity Assessment

This table provides carcinogenic risk information that is relevant to the COCs in both soil and groundwater. At this time, slope factors are not available for the dermal route of exposure. Thus, the dermal slope factors used in the assessment have been extrapolated from oral values. An adjustment factor is sometimes applied, and is dependent upon how well the chemical is absorbed via the oral route. Adjustments are particularly important for chemicals with less than 50% absorption via the ingestion route. However, adjustment is not necessary for the chemicals evaluated at this site. Therefore, the same values presented above were used as the dermal carcinogenic slope factors for these contaminants.

Two of the COCs are also considered carcinogenic via the inhalation route. Dieldrin and 4,4'-DDT have inhalation unit risk factors of 4.6×10^{-3} and 9.7×10^{-5}, respectively (Source: IRIS, USEPA 1998). TCE (found in the groundwater) and benzo(a)pyrene lack sufficient toxicity information via the inhalation route to support the development of specific inhalation carcinogenic toxicity criteria.

Table 3. Non-Cancer Toxicity Data Summary

Pathway: Ingestion, Dermal

Constituent of Concern	Chronic/ Subchronic	Oral RfD Value	Oral RfD Units	Dermal RfD	Dermal RfD Units	Primary Target Organ	Combined Uncertainty/ Modifying Factors	Sources of RfD: Target Organ	Dates of RfD: Target Organ (M/D/Y)
Benzo(a) pyrene	---	---	---	---	---	---	---	---	---
4,4'-DDT	Chronic	5.0×10^{4}	mg/kg day	5.0×10^{4}	mg/kg day	Liver	---	IRIS	1998
Dieldrin	Chronic	5.0×10^{4}	mg/kg day	5.0×10^{4}	mg/kg day	Liver	---	IRIS	1998
TCE	---	---	---	---	---	---	---	---	---

Pathway: Inhalation

Constituent of Concern	Chronic/ Subchronic	Inhalation RfC	Inhalation RfC Units	Inhalation RfD	Inhalation RfD Units	Primary Target Organ	Combined Uncertainty/ Modifying Factors	Sources of RfC:RfD : Target Organ	Dates (M/D/Y)
Benzo(a) pyrene	---	---	---	---	---	---	---	---	---
4,4'-DDT	---	---	---	---	---	---	---	---	---
Dieldrin	---	---	---	---	---	---	---	---	---
TCE	---	---	---	---	---	---	---	---	---

Key

---: **no information available**
IRIS: **Integrated Risk Information System, USEPA**
RfDs: **reference dose**
RfC: **reference concentration**

Sample Language Describing Summary of Toxicity Assessment

This table provides noncarcinogenic risk information that is relevant to the COCs in both soil and groundwater. Two of the COCs have toxicity data indicating their potential for adverse noncarcinogenic health effects in humans. The chronic toxicity data available for both 4,4'-DDT and dieldrin for oral exposures, have been used to develop oral reference doses (RfDs). The oral RfDs for 4,4'-DDT and dieldrin are 5.0×10^{-4} mg/kg/day, and 5.0×10^{-4} mg/kg/day, respectively (Source: IRIS, USEPA 1998). The available toxicity data, from both chronic and subchronic animal studies, indicate that both dieldrin and 4,4'-DDT primarily affect the liver. Reference doses are not available for benzo(a)pyrene or TCE, neither are dermal RfDs or inhalation RfCs for any of the contaminants. As was the case for the carcinogenic data, dermal RfDs can be extrapolated from the oral RfDs applying and adjustment factor as appropriate. However, for dieldrin and 4,4'-DDT no adjustment is necessary, and the oral RfDs discussed were used as the dermal RfDs for these contaminants. At this time, inhalation reference concentrations are not available for any of the COCs.

Table 4. Risk Characterization Summary - Carcinogens

Scenario Timeframe: Current
Receptor Population: Resident
Receptor Age: Child

Medium	Exposure Medium	Exposure Route	Constituent of Concern	Carcinogenic Risk				
				Ingestion	Inhalation	Dermal	External (Radiation)[1]	Exposure Routes Total
Soil	Soil	Soil Onsite-Direct Contact	Benzo(a) pyrene	1.2×10^{-2}	N/A	3.3×10^{-6}	---	1.2×10^{-2}
		Soil Onsite-Direct Contact	4,4'-DDT	6.5×10^{-4}	N/A	4.5×10^{-7}	---	6.5×10^{-4}
		Soil Onsite-Direct Contact	Dieldrin	3.5×10^{-3}	N/A	4.8×10^{-6}	---	3.5×10^{-3}
	Dust	Soil Onsite-Inhalation of Soil as Dust	Benzo(a) pyrene	N/A	---	N/A	---	
		Soil Onsite-Inhalation of Soil as Dust	4,4'-DDT	N/A	9.7×10^{-4}	N/A	---	9.7×10^{-4}
		Soil Onsite-Inhalation of Soil as Dust	Dieldrin	N/A	8.5×10^{-3}	N/A	---	8.5×10^{-3}
							Soil Risk Total =	2.6×10^{-2}
Ground-water	Ground-water	Aquifer X-Tap Water	TCE	2.5×10^{-3}	---	1.4×10^{-7}	---	2.5×10^{-3}
							Groundwater Risk Total =	2.5×10^{-3}
							Total Risk =	2.9×10^{-2}

Key
---: Toxicity criteria are not available to quantitatively address this route of exposure.
N/A: Route of exposure is not applicable to this medium.
1--- This column would be used in the event that one of the contaminants of concern was a radionuclide. If there are no radionuclides associated with a particular site, then this column can be deleted.

Sample Language Describing Risk Characterization

Table 4 provides risk estimates for the significant routes of exposure. These risk estimates are based on a reasonable maximum exposure and were developed by taking into account various conservative assumptions about the frequency and duration of a child's exposure to soil and groundwater, as well as the toxicity of the COCs (benzo(a)pyrene, 4,4'-DDT, dieldrin, and TCE). The total risk from direct exposure to contaminated soil and groundwater at this site to a current child resident is estimated to be 2.85×10^{-2}. The COCs contributing most to this risk level are benzo(a)pyrene and dieldrin in soil and TCE in groundwater. This risk level indicates that if no cleanup action is taken, an individual would have an increased probability of 3 in 100 of developing cancer as a result of site-related exposure to the COCs.

NOTE: Additional versions of this table format would be presented to include other receptors with significant exposure (scenario timeframe, receptor population, receptor age).

Table 5. Risk Characterization Summary – Non-Carcinogens

Scenario Timeframe: Current
Receptor Population: Resident
Receptor Age: Child

Medium	Exposure Medium	Exposure Route	Constituent of Concern	Primary Target Organ	Non-Carcinogenic Hazard Quotient			
					Ingestion	Inhalation	Dermal	Exposure Routes Total
Soil	Soil	Soil Onsite-Direct Contact	Benzo(a) pyrene	Liver	---	N/A	---	---
		Soil Onsite-Direct Contact	4,4'-DDT	Liver	3.8	N/A	$1.5x10^{-2}$	3.9
		Soil Onsite-Direct Contact	Dieldrin	Liver	4.4	N/A	$2.7x10^{-4}$	4.4
							Soil Hazard Index Total =	8.3
Ground-water	Ground-water	Aquifer X-Tap Water	TCE	---	---	---	---	---
							Groundwater Hazard Index Total =	---
							Receptor Hazard Index =	8.3
							Liver Hazard Index =	8.3

Key
---: Toxicity criteria are not available to quantitatively address this route of exposure.
N/A: Route of exposure is not applicable to this medium.

Sample Language Describing Risk Characterization

Table 5 provides hazard quotients (HQs) for each route of exposure and the hazard index (HI)(sum of hazard quotients) for all routes of exposure. The Risk Assessment Guidance (RAGS) for Superfund states that, generally, a HI greater than 1 indicates the potential for adverse noncancer effects. The estimated HI of 8.3 indicates that the potential for adverse noncancer effects could occur from exposure to contaminated soil containing 4,4'-DDT, dieldrin and benzo(a)pyrene. The noncancer risk from exposure to contaminated groundwater could not be evaluated due to the lack of noncarcinogenic toxicity criteria for TCE.

NOTE: Additional versions of this table format would be presented to include other receptors with significant exposure (scenario timeframe (e.g., chronic versus subchronic exposures), receptor population, receptor age)

Table 6. Ecological Exposure Pathways of Concern

Exposure Medium	Sensitive Environment Flag (Y or N)	Receptor	Endangered/ Threatened Species Flag (Y or N)	Exposure Routes	Assessment Endpoints	Measurement Endpoints
Sediment	N	Benthic organisms	N	Ingestion, respiration, and direct contact with chemicals in sediment	Benthic invertebrate community species diversity and abundance	• Toxicity of soil to *Hyallela* • Species diversity index
Surface Water	N	Fish	N	Ingestion, respiration, and direct contact with chemicals in surface water	Maintenance of an abundant and productive game fish population	• Toxicity of surface water to *Pimephales promelas* • Species diversity index
Soil	N	Terrestrial invertebrates	N	Ingestion and direct contact with chemicals in wetland soils	Survival of terrestrial invertebrate community	• Toxicity of sediments to *Lumbricus terrestris*
		Terrestrial plants	Y	Uptake of chemicals via root systems	Maintenance/ enhancement of native wetland vegetation	• Species diversity index • Survival of seedlings
Surface Water (Vernal pools)	Y	Aquatic invertebrates	N	Ingestion, respiration, and direct contact with chemicals in surface water	Maintenance of a balanced, indigenous aquatic invertebrate community	• Species diversity index

Table 7. COC Concentrations Expected to Provide Adequate Protection of Ecological Receptors

Habitat Type/ Name	Exposure Medium	COC	Protective Level[1.]	Units	Basies	Assessment/Measurement Endpoint (protocol)
Small Freshwater Stream/ West Branch Maple Creek	Sediment	Arsenic	6	mg/kg	Toxicity Reference Value (TRV) protocol	Benthic invertebrate community species diversity and abundance
		Lead	15	mg/kg	Significant difference in Benthic Diversity Index between the site and the reference site.	
		Total PCBs	0.03-0.05	mg/kg	TRV	
	Surface Water	Aluminum	123	ug/l	TRV	Maintenance of an abundant and productive game fish population
		Arsenic	208	ug/l	TRV	
		Total PCBs	0.1	ug/l	Bioaccumulation factor (BAF) protocol	

Notes

1. A range of levels may be provided.

Table 8. Potential ARARs for the Selected Remedial Alternative for the Unit Acronym

Chemical –Specific ARARs			
Action	**Requirements**	**Prerequisites**	**Citation**
Screening Level for Lead	*Establishes a screening level for lead in soil at commercial/industrial (i.e., nonresidential) sites of 800 ppm as found in Frequent Questions From Risk Assessors on the Adult Lead Methodology (ALM) accessed at: http://www.epa.gov/superfund/health/contaminants/lead /almfaq.htm*	*Removal of lead-contaminated soils - **TBC***	*EPA-540-R-03-001* *National Health and Nutrition Examination Survey III*
Action-Specific ARARs			
Action	**Requirements**	**Prerequisites**	**Citation**
Activities causing fugitive dust emissions	*Non-attainment zones-all persons shall take necessary precautions to prevent particulate matter from becoming airborne including, but not limited to:* • *Use, where possible, of water or chemicals for control of dust in demolition or construction operations, the grading of roads, or the clearing of land;* • *Application of asphalt (cut back asphalt is prohibited), water, or suitable chemicals on dirt roads, material stockpiles, and other surfaces which*	*Fugitive emissions from land-disturbing activities (e.g., excavation, construction) – **relevant and appropriate***	*SC. R. 61-62.6(I)(a)(1-11)*

	can give rise to airborne dust; • *Installation and use of hoods, scrubbers, fabric filters or other dust cleaning devices where feasible and effective to capture and contain fugitive particulate matter while handling dusty materials. Adequate containment methods shall be employed during sandblasting or other similar operations;* • *Paving of roadways and the prompt removal of earth or other materials from paved streets that have been deposited by vehicular traffic, earth moving equipment, water erosion or other means;* • *Stabilization of long term storage piles by vegetation or appropriate chemicals and reclamation of mined area;* • *Modifying the process or materials handling system* • *Use of a slurry to move material if feasible* • *Use of traveling booms, telescopic chutes, rotary stackers, adequate shrouding of openings in containers to be filled* • *Avoid use of front end loader in handling dry dusty materials unless there is no other reasonable option;* • *Imposing slow speed limits for vehicular traffic on plant property or construction/destruction sites* • *Ensuring proper loading of equipment to prevent spillage on paved roadways*		
	No personnel shall allow fugitive particulate matter	*Fugitive emissions from*	*SC R. 61-62.6(II)(a)-*

	to escape into the ambient area in "problem areas".	*land-disturbing activities (e.g., excavation, construction) –* ***relevant and appropriate***	*(b)*
	Address the control of fugitive particulate matter as required in SC R. 61-62.6(III)	*Fugitive emissions from land-disturbing activities (e.g., excavation, construction) –* ***Applicable***	*SC R. 61-62.6(III)(a)-(d)*
	Shall not cause or allow fugitive dust to be emitted in such as manner to exceed 150 micrograms per cubic meter in a 24-hour average concentration.	*Fugitive emissions from land-disturbing activities (e.g., excavation, construction) –* ***Applicable***	*40 CFR 50.6*
Transportation of samples (i.e. contaminated soils and wastewaters)	*Are not subject to any requirements of 40 CFR Parts 261 through 268 or 270 when:* • *The sample is being transported to a laboratory for the purpose of testing; or* • *The sample is being transported back to the sample collector after testing.*	*Samples of solid waste or a sample of water, soil for purpose of conducting testing to determine its characteristics or composition –* ***Applicable***	*40 CFR 261.4(d)*
	In order to qualify for the exemption in paragraphs (d)(1)(i) and (ii), a sample collector shipping samples to a laboratory must: • *Comply with U.S. DOT, U.S. Postal Service, or any other applicable shipping requirements* • *Assure that the information provided in (1) thru*		

	(5) of this section accompanies the sample. *• Package the sample so that it does not leak, spill, or vaporize from its packaging.*		
Location-Specific ARARs			
Action	**Requirements**	**Prerequisites**	**Citation**
Protection of Endangered Species	*Establishes protective regulations governing threatened and endangered species and plants.*	*Threatened or endangered species may be present in the vicinity.* ***- applicable***	*Endangered Species Act* *50 CFR 17* *50 CFR 402 Interagency Cooperation-Endangered Species Act* *The Atomic Energy Act as amended*

Table 9. Land Use Controls for the Unit Acronym (Example – modify specific for OU as necessary)

Type of Control	Purpose of Control	Duration	Implementation	Affected Areas[a]
1. Property Record Notices[b]	Provide notice to anyone searching records about the existence and location of contaminated areas.	Until the concentration of hazardous substances associated with the unit have been reduced to levels that allow for unlimited exposure and unrestricted use.	Notice recorded by USDOE in accordance with state laws at County Register of Deeds office if the property or any portion thereof is ever transferred to non-federal ownership.	Waste management areas identified in this ROD where hazardous substances are left in place at levels requiring land use and/or groundwater restrictions.
2. Property record restrictions[c]: A. Land Use B. Groundwater	Restrict use of property by imposing limitations. Prohibit the use of groundwater.	Until the concentration of hazardous substances associated with the unit have been reduced to levels that allow for unlimited exposure and unrestricted use.	Drafted and implemented by USDOE upon any transfer of affected areas. Recorded by USDOE in accordance with state law at County Register of Deeds office.	Waste management areas identified in this ROD where hazardous substances are left in place at levels requiring land use and/or groundwater restrictions.
3. Other Notices[d]	Provide notice to city &/or county about the existence and location of waste disposal and residual contamination areas for zoning/planning purposes.	Until the concentration of hazardous substances associated with the unit have been reduced to levels that allow for unlimited exposure and unrestricted use.	Notice recorded by USDOE in accordance with state laws at County Register of Deeds office if the property or any portion thereof is ever transferred to non-federal ownership.	Waste management areas identified in this ROD where hazardous substances are left in place at levels requiring land use and/or groundwater restrictions.
4. Site Use Program[e]	Provide notice to worker/developer (i.e., permit requestor) on extent of contamination and prohibit or limit excavation/penetration activity.	As long as property remains under USDOE control	Implemented by USDOE and site contractors Initiated by permit request	Waste management areas and remediation systems identified in this ROD where hazardous substances are left in place at levels requiring land use and / or groundwater restrictions.
5. Physical Access Controls[f] (e.g., fences, gates, portals)	Control and restrict access to workers and the public to prevent unauthorized access.	Until the concentration of hazardous substances associated with the unit have been reduced to levels that allow for unlimited exposure and unrestricted use.	Controls maintained by USDOE.	Security is provided at site boundaries in accordance with SRS procedures. *[Add OU specific access controls if needed].]*
6. Warning Signs[g]	Provide notice or warning to prevent unauthorized uses.	Until the concentration of hazardous substances associated with the unit have been reduced to levels that allow for unlimited exposure and unrestricted use.	Signage maintained by USDOE.	Warning signs will be posted in accordance with applicable site procedures and will be placed in appropriate areas at the XXOU.
7. Security Surveillance Measures	Control and monitor access by workers/public.	Until the concentration of hazardous substances associated with the unit have been reduced to levels that allow for unlimited exposure and unrestricted use.	Established and maintained by USDOE Necessity of patrols evaluated upon completion of remedial actions or property transfer.	Patrol of waste management areas identified in this ROD, as necessary.

[a]Affected areas – Specific locations identified in the OU-specific LUCIP or subsequent post-ROD documents.
[b]Property Record Notices – Refers to any non-enforceable, purely informational document recorded along with the original property acquisition records of USDOE and its predecessor agencies that alerts anyone searching property records to important information about residual contamination; waste disposal areas in the property.
[c]Property Record Restrictions – Includes conditions and/or covenants that restrict or prohibit certain uses of real property and are recorded along with original property acquisition records of USDOE and its predecessor agencies.
[d]Other Notices – Includes information on the location of waste disposal areas and residual contamination depicted on as survey plat, which is provided to a zoning authority (i.e., city planning commission) for consideration in appropriate zoning decisions for non-USDOE property.
[e]Site Use Program – Refers to the internal USDOE/USDOE contractor administrative program(s) that requires the permit requestor to obtain authorization, usually in the form of a permit, before beginning any excavation/penetration activity (e.g., well drilling) for the purpose of ensuring that the proposed activity will not affect underground utilities/structures, or in the case contaminated soil or groundwater, will not disturb the affected areas without the appropriate precautions and safeguards.
[f]Physical Access Controls – Physical barriers or restrictions to entry.
[g]Signs – Posted command, warning or direction.

APPENDIX A –
RESPONSIVENESS SUMMARY

Additional appendices can be added as needed.

APPENDIX A -

RESPONSIVENESS SUMMARY

Responsiveness Summary

The 45-day (or 30-day) public comment period for the Statement of Basis/Proposed Plan (or Proposed Plan) for the unit name (bldg. no) began on start date and ended on end date.

Public Comments

If no comments were received from the public, please state so.

POST-CONSTRUCTION REPORT/CORRECTIVE MEASURES IMPLEMENTATION REPORT/REMEDIAL ACTION COMPLETION REPORT FORMAT

1.0 GENERAL DESCRIPTION

1.1 Purpose and Scope

This Post-Construction Report/Corrective Measures Implementation Report/ Remedial Action Completion Report (PCR/CMIR/RACR) documents the completion of field implementation of the remedial action (RA) for the closure of the *Operable Unit Name* operable unit (OU). It summarizes construction activities performed to implement the RA requirements in the *Operable Unit Name (acronym)* Record of Decision (ROD) (SRNS XXXX) in accordance with the approved Corrective Measures Implementation /Remedial Action Implementation Report (CMI/RAIP) (SRNS XXXX). [Note: Delete CMIR from throughout this document if the OU is CERCLA only.]

This PCR/CMIR/RACR was completed after final inspection of construction and a determination that the RA is complete. The Savannah River Site (SRS) notified U.S. Environmental Protection Agency (USEPA) Region 4 and South Carolina Department of Health and Environmental Control (SCDHEC) regarding completion of the aforementioned final inspection and the operation and function determination on (date). This PCR/CMIR/RACR is submitted to USEPA and SCDHEC for approval in accordance with Federal Facility Agreement (FFA) (FFA 1993) requirements. The planned post-construction activities are reported in Section 7.0 in accordance with the FFA.

This report includes the following items:

- A brief description of the OU background, including a brief statement on RA requirements and objectives in the ROD
- A chronology of completed events related to remediation of the OU

- A summary of construction activities performed
- Deviations from the original design of the approved CMI/RAIP (SRNS XXXX)
- Performance standards and quality control inspections, including a summary of performance test results documenting verification of compliance with the acceptance criteria in the CMI/RAIP
- Final inspection and veification of OU closure
- As-built drawings
- Land use controls
- Project costs [including RA capital costs incurred to date, forecast RA operating costs, post-RA annual operations and maintenance (O&M) costs and total present worth (PW) costs.]

1.1.1 Document Format

[Typically addresses the document format used, including the basis for the format. This section should include specific details regarding any deviation from the generic description as well as the basis of the deviation.]

This report has been prepared in accordance with the requirements for submittal of regulatory documents as identified in the FFA (1993) and the latest format for the PCR/CMIR/RACR in the Regulatory Document Handbook (SRNS 2012). This format was developed in accordance with the resolution of regulatory comments on required contents for PCR/CMIR/RACRs and USEPA latest guidelines (USEPA 2011).

The Operable Unit name RA is complete and does not require long-term RAs, i.e., the final RA does not require long-term operation of constructed equipment or systems for treatment of contaminants in the source unit or in the groundwater. Therefore, the PCR and CMIR/RACR are herein combined.

1.2 Operable Unit Background

The *Operable Unit Name* source OU is listed as a RCRA 3004(u) Solid Waste Management Unit/CERCLA unit in Appendix C of the FFA for SRS.

[Copy an abbreviated description of the waste unit from the ROD. Include only the components addressed by the RA. Include all components with an RAO. The description should include location, size, and the background and operational history of the unit requirements, including whether the OU is a RCRA and/or CERCLA unit. The section may also include a short paragraph identifying the predecessor documents related to the selection of the RA. Provide figures showing RA location at SRS (Figure 1) and a pre-RA site layout (Figure 2). A very condensed presentation of information is appropriate for this section since the same information has been covered in greater detail in previous documents required by the FFA process.]

Figure 1. ***Operable Unit Name*** **Location on SRS Map**

Figure 2. ***Operable Unit Name*** **Pre-Remedial Action Site Plan**

1.2.1 General Description and Location of Operable Unit Name

The *Operable Unit Name* (Figure 1) is located within the SRS, approximately TBD feet south of the (e.g., C, K, L, P, or R-Area Reactor) perimeter fence and XXXX feet north of .....

1.2.2 Nature and Extent of Contamination in Operable Unit Name Soils (Source Unit)

[Briefly identifies the constituents of concern (COCs) and principal threat source material (PTSM) copied from the ROD (the table may be used) that are considered for the RA, and the associated risks, specific components of the unit requiring remediation and locations of COCs and PTSMs with respect to the zone of remediation (areas and depths). Because the information is covered in greater detail in previous FFA documents, a condensed presentation (synopsis or summary) is appropriate for this section. Provide or reference figures or maps for the design clarification of data already provided in the ROD to illustrate the nature and horizontal and vertical extent of COCs and PTSM (Figure 3).]

Figure 3. Nature and Horizontal and Vertical Extent of COCs

1.3 Remedial Action Requirements and Objectives

1.3.1 Remedial Action Objectives

As detailed in the ROD, the remedial action objectives (RAOs) for the *Operable Unit Name* are as follows:

[Copy RAO text from the ROD for OU.]

Per the ROD, RAOs for this RA would be achieved by implementing the RA described below.

achieved by implementing the below remedial action.

1.3.2 Selected Remedial Action

As stated in the ROD (SRNS XXXX), the selected RA for the *Operable Unit Name* soils included the following key elements:

[May include a schematic illustration of the selected remedy from the ROD.]

Figure 4. Post-Remediation Action Site Plan

Figure 5. Conceptual Site Model

1.4 Chronology of Events

[A tabular summary (reference Table 1) that lists major milestones and dates related to the RA for the OU, including the ROD signature, CMI/RAIP approval, major construction events (e.g., RA start, mobilization, pilot test, etc.), verification sampling and performance testing, inspections, identification and resolution of non-conformances (if any), demobilization and final inspection (regulatory walkdown) of completed construction.]

Table 1. Chronology of Events

Description of Activity	Start Date

2.0 CONSTRUCTION ACTIVITIES

[Provides a summary of construction activities performed during the construction phase in accordance with the approved CMI/RAIP. The first numbered section, which should be titled "OU Construction Team," briefly describes names and roles of prime subcontractors associated with the RA. The next numbered sections will provide a brief narrative following the sequence of activities listed in Section 1.4. The narrative will describe any treatment process required to implement the remedial design, materials and equipment used, successes and problems encountered during construction and resolution of problems (including innovative solutions, if any), and causes for delay. These sections also include brief discussions of unexpected conditions encountered in the field, particularly those that affected the scope or schedule of the construction work.

The last numbered section, which should be titled "Secondary Waste Disposal," provides the specific details of the unit's waste management plan and the CMI/RAIP waste section.

Describe the waste types, waste volumes, methods, consistent with SRS procedures, that were used for waste characterization (e.g., testing methods), disposal (include location such as onsite, offsite at SRS, off SRS at XYZ facility) and transportation (include contaminant limits) during construction, as applicable to the selected RA].

3.0 DEVIATIONS FROM ORIGINAL DESIGN

[Identifies design changes required during construction as well as the technical basis for those changes. The discussion includes all changes made during construction, regardless of whether those changes were previously communicated to South Carolina Department of Health and Environmental Control (SCDHEC) and United States Environmental Protection Agency (USEPA). The process and scope of design change notifications are discussed in the CMI/RAIP.]

Several design and construction changes were needed during construction to resolve construction problems. The project team reviewed all changes prior to implementation to ensure compliance with regulatory requirements in the ROD and the CMI/RAIP. Consistent with the CMI/RAIP, notifications were made to USEPA and SCDHEC prior to implementation, as appropriate. Table 2 provides a summary of all such changes.

The basis and resolution of deviations from the original design are detailed below. Where applicable, a statement is provided on whether the deviation still meets a performance criterion.

Table 2. Summary of Design Changes

Item	Change	Reason
1		
2		
3		

4.0 VERIFICATION SAMPLING, TESTING, ANALYSIS, PERFORMANCE STANDARDS, AND CONSTRUCTION QUALITY CONTROL

4.1 Performance Requirements/Standards

[For each RA component (e.g., cover, soil treatment, soil disposal, etc.), subsections of Section 4.0 will cite appropriate references to the performance requirements (acceptance criteria) as required per the CMI/RAIP for the RA and the construction quality control requirements in the specification. Provides a brief discussion and table of test samples, a comparison of test results with CMI/RAIP acceptance criteria, and a description of how those criteria were met but with allowances for deviations outlined in Section 3.0. It also provides discussion on other non-conforming conditions identified during the quality control inspection and how those non-conformances were resolved to meet the specified performance criteria.]

[Each subsequent section should provide a list or table of performance requirements, acceptance criteria and/or process control parameters copied from the approved CMI/RAIP. A summary table (Table 3) is suggested which lists the specific attributes required and the specific tests for each attribute. If numerous tests are conducted, a summary providing minimum, maximum, and average test results shall be provided with footnotes for failed entries where applicable.]

Table 3. ***Operable Unit Name*** **As-Built CMI/RAIP Characteristic Test Results**

4.2 Construction and Quality Control

[Provides a summary of quality assurance (QA) and quality control procedures that were implemented to ensure successful implementation of the RA. It also includes any special or unit-specific strategy applicable to the RA.]

5.0 VERIFICATION OF RA COMPLETION AND FINAL INSPECTION

[Note: If the waste unit is being released for unrestricted land use (e.g., no institutional controls) use the words "OU Closure" instead of "RA Completion" in the title. Provide text stating the following:

(1) As detailed in Section 4.0, the construction activities required for the RA have met the acceptance criteria established in the approved CMI/RAIP, but with allowances for deviations outlined in Section 3.0;

(2) As detailed in Section 5.1, the RA is verified as complete and construction and testing was in accordance with the ROD RAOs. Section 5.1's verification is typically based upon the result of performance tests and quality control inspections provided in the verification in Section 4.0.

(3) As outlined in Section 5.2, the final walkdown inspection with participation of USEPA and SCDHEC (as applicable) has been performed and issues have been closed out.]

5.1 Verification of RA Completion

[List the primary RA components (e.g., a cover, soil treatment, soil disposal, etc.) and include a certification statement on which and how each applicable RAO was met. Each RAO should be copied from the ROD.]

This section provides the verification that RAOs established in the ROD have been met through field implementation of the RA per the approved CMI/RAIP (SRNS XXXX). The verification is based on the Section 5.2 walkdown and successful achievement of the RAOs per discussion above. It is concluded that the *Operable Unit Name* closure has been completed satisfactorily in accordance with the requirements of the *Operable Unit Name* ROD. The results of any analytical sampling and testing have been documented and the records are on file at SRS ERD Document Control in the project file. In accordance with the ROD, applicable post-closure activities (e.g., land use control, 5-year remedy reviews, etc.) will be performed as described in Section 7.0 of this PCR/CMIR/RACR.

5.2 Final Inspection for Acceptance of *Operable Unit Name* Closure

A final joint walkdown was performed on month/day/year by the *Operable Unit Name* Project Team, SCDHEC and USEPA. No further outstanding issues resulted from the walkdown. A summary and participants of the USEPA/SCDHEC inspection are provided in Appendix X.

6.0 AS-BUILT DOCUMENTATION

6.1 As-Built Drawings

[This section provides the as-built drawings for the project, which are updated CMI/RAIP drawings and are included in Appendix X of this PCR/CMIR/RACR.]

6.2 Well Modifications

[This section provides a summary or attaches a report of any well modifications (e.g., well abandonment, well extension or protection).]

See Appendix X of this PCR/CMIR/RACR for attached reports.

7.0 POST-PCR/CMIR/RACR ACTIVITIES AND LAND USE CONTROL IMPLEMENTATION PLAN (LUCIP)

For Post-PCR/CMIR/RACR activities, see the OU specific LUCIP required for the RA. Maintenance and land use controls per the LUCIP (if applicable) will be reported during the five-year review of the remedy.

7.1 5-Year Remedy Review

Section 300.430(f)(ii) of the National Contingency Plan (NCP) requires that a five-year remedy review be performed if hazardous substances, pollutants, or contaminants above levels that allow for unlimited use and unrestricted exposure remain in the OU. The three parties, SCDHEC, USEPA, and USDOE have determined that a five-year review of the remedy for the *Operable Unit Name* will be performed to ensure that the remedy continues to provide adequate protection of human health and the environment.

8.0 PROJECT COSTS

[Provides (reference Table 4) a cost comparison of the final costs for the RA to the original ROD cost estimate. Cost deviations, beyond –30% and +50%, from the ROD cost estimate are discussed. The cost breakdown is limited to that which was presented in the ROD (e.g., limited to the soil cover total capital and total O&M costs and the air spurge/soil vapor extraction (AS/SVE) total capital and total five-year O&M costs). As an example, the combined RA comparative capital costs and O&M costs for a soil cover and an AS/SVE system are as follows:]

Table 4. Project Cost Comparison

Project Cost Comparison (Example)			
	ROD Cost ($K)	Incurred Cost ($K)	Delta Cost (%)
Soil Cover Capital	175	157	(10%)
AS/SVE Capital	800	690	(14%)
Soil Cover O&M	20	25	+25%
AS/SVE O&M	1200	2735*	+228%**

[If applicable, separate costs into equipment, non-equipment and O&M categories.]

9.0 REFERENCES

[Provides a list of documents referenced in the body of the PCR/CMIR/RACR document. Note: Regulators have asked that the Erosion Control Plan, HASP and well abandonment applications be included in the appendix rather than simply referenced.]

FFA, 1993. *Federal Facility Agreement for the Savannah River Site*, Administrative Docket No. 89-05-FF (Effective Date: August 16, 1993)

SRNS, XXXX. *Record of Decision, Remedial Alternative Selection for the Operable Unit Name*

SRNS, XXXX. *Corrective Measures Implementation Plan/Remedial Action Implementation Plan/Remedial Action Implementation Plan for the Operable Unit Name*

SRNS, XXXX. *Operable Unit Name Remediation System Startup Test Plan (U)*, Q-SUP-X-XXXX, Revision 2, Westinghouse Savannah River Company, Savannah River Site, Aiken, SC

SRNS, XXXX. "*Operable Unit Name Startup Test Procedure* (U)", ER-TP-XXX, Revision 0, Westinghouse Savannah River Company, Savannah River Site, Aiken, SC

SRNS, 2012. *Regulatory Document Handbook (U)*, Protocol F.21, "Post-Construction Report/Corrective Measures Implementation Report/ Remedial Action Completion Report Format", ERD-AG-003, Revision 17, Savannah River Nuclear Solutions, Aiken, SC (June).

SRS, 1994a. SRS E7 Manual, *Conduct of Engineering and Technical Support (U), Rev. 7*, Westinghouse Savannah River Company, Savannah River Site, Aiken, SC

SRS, 1994b. SRS Procedure Manual 1Q, *Quality Assurance (U), Rev. 0*, Westinghouse Savannah River Company, Savannah River Site, Aiken, SC

USEPA, 2011. *Close Out Procedures for National Priorities List Sites*, USEPA OSWER Directive 9320.2-22, Office of Superfund Remediation and Technology Innovation, Washington, D.C.

WSRC, 1994. *Investigation-Derived Waste Management Plan (U)*, WSRC-RP-94-1227, Rev. 9, Westinghouse Savannah River Company, Savannah River Site, Aiken, SC

Appendix X

[Examples: As-built drawings, RA Start Notification Letter, Fact Sheet, USEPA/SCDHEC Walkdown Memo, Erosion Control Plan, HASP, and Well Abandonment Reports.]

LAND USE CONTROL IMPLEMENTATION PLAN FORMAT

1.0 INTRODUCTION

This Land Use Control Implementation Plan (LUCIP) has been prepared for Operable Unit Name (OU) at the Savannah River Site (SRS). The Operable Unit Name comprises several subunits within X Area and covers approximately X ha (X ac). Groundwater is (or is not) considered part of the scope of the Operable Unit Name. The purpose of this LUCIP is to describe how the land use controls (LUCs) selected in the Operable Unit Name Record of Decision (ROD) will be implemented and maintained. The LUC objectives have been documented in the Operable Unit Name ROD and are listed in Section 3.0.

The selected remedy leaves hazardous substances in place that pose a potential future risk and will require land use restrictions until the concentrations of hazardous substances in the soil and groundwater are at levels that allow for unrestricted use. As agreed on March 30, 2000, among the United States Department of Energy (USDOE), the United States Environmental Protection Agency (USEPA), and the South Carolina Department of Health and Environmental Control (SCDHEC), SRS is implementing a Land Use Control Assurance Plan (LUCAP) (WSRC 2011) to ensure that the LUCs required by numerous remedial decisions at SRS are properly maintained and periodically verified. The requirements of that LUCAP also apply to the LUCs that were selected as part of the remedial action (RA) for Operable Unit Name. This additional document, the Operable Unit Name LUCIP, contains the detailed and specific measures required to implement and maintain the LUCs selected as part of this particular remedial decision. The LUCs shall be maintained until the OU is suitable for unlimited exposure and unrestricted use. Approval by USEPA and SCDHEC is required for any modification or termination of the LUCs.

USDOE is responsible for implementing, maintaining, monitoring, reporting, and enforcing the LUCs in accordance with the approved LUCIP. Upon final approval, the LUCIP will be appended to the LUCAP and should be considered incorporated by reference into the Operable Unit Name ROD, establishing implementation and maintenance requirements for the LUCs

under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the SRS Federal Facility Agreement (FFA) (FFA 1993). The LUCIP will remain in effect unless and until modifications are approved by USEPA and SCDHEC as necessary for protection of human health and the environment. In accordance with Section 121(c) of CERCLA and NCP §300.430(f)(5)(iii)(c), a statutory review will be conducted within 5 years of initiation of the remedial action, and every 5 years thereafter, to ensure that the remedy continues to be protective of human health and the environment. Any approved LUCIP modification will be appropriately documented for incorporation by reference into the Operable Unit Name ROD.

1.1 Format of LUCIP

[States the document format used, including the basis for the format. This section also lists any deviations from the format, including the basis for the deviation.]

The format of this LUCIP is consistent with the FFA protocol format approved by the USEPA and SCDHEC in March 2004.

2.0 OVERVIEW OF OPERABLE UNIT NAME REMEDIAL ACTION

2.1 General Description and History of the Operable Unit Name

[This section should briefly describe the waste unit. The description should include location, size (acreage), and background of operational history. A discussion of subunits within the OU should be included if appropriate. Text should reference Figure 1 (location map) and Figure 2 (OU subunit map.)]

2.2 Nature and Extent of Contamination in Operable Unit Name

[This section should identify the specific constituents of concern (COCs) and the associated residual risks. Relate the residual risk to the need for implementing and maintaining LUCs as "an integral part of the remedial action selected in the ROD."]

The selected remedy for the Operable Unit Name leaves hazardous substances in place that pose a potential future risk and will require land use restrictions until the concentrations of hazardous substances in the soil and groundwater are at levels that allow for unrestricted use and exposure.

2.3 Remedial Action Selected

[This section should briefly state the selected remedy. Identify the ROD selecting the remedial action and briefly summarize the remedial action and LUC elements of the action. The section should also discuss any early action or removal action decisions and how this impacts the land use controls, i.e., cap installed as an early action will require LUCs beyond the early action and long term maintenance.]

The post-RA conceptual site model (Figure 3) demonstrates that the exposure pathways to an industrial worker are incomplete following implementation of the RA. According to the *Savannah River Site Future Use Project Report* (USDOE 1996), residential use of SRS land is prohibited.

3.0 LAND USE CONTROL OBJECTIVES

[For the Operable Unit Name, list the LUC objectives necessary to ensure protectiveness of the selected remedy. Each LUC objective should be related to one or more of the remedial objectives that it is expected to help achieve. LUC objectives should not be confused with actual LUCs.]

[As a minimum, the following text should be included.]

The following Operable Unit Name LUC objectives have been developed to ensure the protectiveness of the remedy described above:

- Copy the list provided in the ROD. The list should be in bulleted form

Current access controls and land transfer requirements needed to maintain the future land use are described in the following sections of this LUCIP.

4.0 IMPLEMENTATION OF LAND USE CONTROLS

[This section provides specific details about how each of the LUCs will be implemented and maintained. Each subsection should specify details and address subjects relevant to implementing and maintaining of that type of LUC (e.g., when will it be first be implemented)? What steps will be taken to put the LUC in place? What organization will be responsible for each required activity? What portion(s) of the overall OU will be subject to that LUC? How will the effectiveness of the LUC be monitored and maintained? The information in Section 4 is summarized in Table 1.]

[As a minimum, the following text should be included in Section 4.0.]

This section describes the LUCs selected in the ROD to achieve the LUC objectives stated in Section 3.0. A summary of the types of LUCs controls is provided in Table 1. USDOE is responsible for implementing, maintaining, reporting on and enforcing the LUCs required for the Operable Unit Name. The LUCIP will become enforceable and will be implemented when approved by USEPA and SCDHEC following the completion of the RAs prescribed by the Operable Unit Name ROD. USDOE shall notify USEPA and SCDHEC 60 days in advance of any proposed land use changes that are inconsistent with LUC objectives or the selected remedy.

The Operable Unit Name will be maintained as an industrial use area by implementation of the property record notices and restrictions (Section 4.1) and the LUC boundary map (Section 4.2).

The Site Use Program (Section 4.3) will be implemented to prevent onsite worker exposure to contamination left in place at the Operable Unit Name. Other existing measures (i.e. Site Clearance Program, worker training, health and safety requirements, work controls) will also be used to ensure worker safety at the Operable Unit Name. Physical access controls (Section 4.4) are implemented at the SRS boundary to control and restrict public and trespasser access to the Operable Unit Name.

Signs at the Operable Unit Name will be maintained to alert onsite workers to the presence of hazardous substances. The signs will also convey the restrictions of unauthorized personnel.

Access control warning signs will be placed and maintained around the Operable Unit Name to prevent unknowing entry and unrestricted use.

4.1 Property Record Notices and Restrictions

In the long term, if the property, or any portion thereof, is ever transferred from DOE, the U.S. Government and/or DOE will take those actions necessary pursuant to Section 120(h)(1) of CERCLA. Those actions will include in any contract, deed, or other transfer document, notice of the type and quantity of any hazardous substances that were known to have been stored (for more than one year), released, or disposed of on the property. The notice will also include the time at which the storage, release, or disposal took place to the extent such information is available.

In addition, if the property, or any portion thereof, is ever transferred by deed, the U.S. Government will also satisfy the requirements of CERCLA 120(h)(3). The requirements include: a description of the remedial action taken, a covenant, and an access class. These requirements are also consistent with the intent of the RCRA deed notification requirements at final closure of a RCRA facility if contamination will remain at the unit.

LUCs will be implemented through the following:

- The contract, deed, or other transfer document shall also include restrictions precluding residential use of the property. However, the need for these restrictions may be reevaluated at the time of transfer in the event that exposure assumptions differ and/or the residual contamination no longer poses an unacceptable risk under residential use. Any reevaluation of the LUCs will be done through an amended ROD with USEPA and SCDHEC review and approval.

- In addition, if the site is ever transferred to nonfederal ownership, a survey plat of the OU will be prepared, certified by a professional land surveyor, and recorded with the appropriate county recording agency.

In the event of a property lease or interagency agreement, the equivalent restrictions will be implemented as required by CERCLA Section 120(h).

USDOE shall provide the USEPA and SCDHEC at least six months notice prior to transfer or sale of property subject to LUCs to ensure that USEPA and SCDHEC can be involved in discussions to ensure that appropriate provisions are included in the transfer documents to maintain effective LUCs. If it is not possible for the USDOE to notify the USEPA and SCDHEC at least six months prior to the transfer or sale, then the facility will notify the USEPA and SCDHEC as soon as possible but no later than 60 days prior to the transfer or sale of any property subject to LUCs. In addition to the land transfer notice and discussion provisions above, USDOE further agrees to provide the USEPA and SCDHEC with similar notice within the same time frames as to federal-to-federal transfer of property.

4.2 LUC Boundary Maps

This LUCIP identifies the proposed area under land use restrictions in Figure 4 for the Operable Unit Name. (Insert the most current LUC figure or design sketch with boundary coordinates, if available. Refer to Tech Memo ERTEC-2010-0004 for LUC map development). Following field implementation of the remedial action, a final (as-built) survey plat is developed and certified by a professional land surveyor registered in the State of SC. The final plat will include the boundary coordinates for the area subject to land use restrictions and general locations of access control warning signs. The final as-built survey plat will be submitted to USEPA and SCDHEC in the Post-Construction Report (PCR) or PCR/Remedial Action Completion Report (RACR) (choose the applicable title).

If there is a groundwater component in the OU, the LUC map (Figure X) in the LUCIP will identify the surface area subject to LUCs and depict the current estimated location of the groundwater plume subject to LUCs. The certified as-built survey plat presented in the PCR or PCR/RACR is only required for the surface area LUC boundary. Preparation of a certified

survey plat for the groundwater portion will be deferred until the site is transferred to non-federal ownership. However, a figure should be included in the PCR or PCR/RACR depicting the estimated groundwater plume location under LUCs.

In addition, if the site is ever transferred to non-federal ownership, a certified survey plat of the OU will be prepared at or near the time of conveyance to support the LUCIP required restrictive covenants on land use and will be recorded with the appropriate county recording agency.

4.3 Site Use Program

Under DOE Order 430.1A, *Life Cycle Management* (USDOE 1998), SRS is required to implement an asset management program for the use, maintenance, and disposal of physical assets, including real estate. SRS complies with this DOE Order through the Site Use Program which is administered by Site Development Control (SDC) in accordance with SRS Manual 1D, *Site Infrastructure and Services Manual*, Procedure 3.02, "Site Real Property Configuration Control" (SRS 2006). Use of all lands and waters on the SRS are coordinated via the Site Use Program. No use of land (i.e., excavation or any other land use) shall be undertaken without prior approval by the USDOE and documented by a Site Use Permit.

SRS identifies all buildings, facilities, and FFA waste units on SRS site development maps that are maintained by SDC in accordance with SRS Manual 1D. If LUCs are required for an FFA waste unit, the unit-specific LUC boundaries are identified on the SRS site development maps. SDC must verify that any proposed work to be performed on a site is sanctioned by a Site Use Permit and verify that the proposed activity does not conflict with any previously approved land use.

In addition to the management of the use of SRS lands and waters through the Site Use Program, the SDC also administers the Site Clearance Program to control the construction, alteration, or demolition activities at SRS. Before any work that adds or modifies features or facilities portrayed on the SRS site development maps is conducted, a Site Clearance Permit is required. USDOE approval of the intended land via a Site Use Permit must be verified before a Site

Clearance Permit is issued. If a Site Clearance request potentially impacts a FFA waste unit, the Site Clearance Request Form is sent to the appropriate FFA reviewer for approval. The FFA reviewer will evaluate the proposed activity to identify any conflicts with the waste unit and to verify that waste unit specific LUCs are not compromised. The roles and responsibilities of the individuals responsible for review and approval of Site Use and Site Clearance permits are detailed in SRS 1D, Procedure 3.02. All employees, contractors, and visitors at SRS are required to adhere to the Site Use Program and the Site Clearance Program.

The USDOE will notify USEPA and SCDHEC in advance of any change to any internal procedure, including the Site Use Program, which would affect implementing or maintaining the LUCs. Approval by USEPA and SCDHEC is required for any modification or termination of the LUCs and implementation actions, and the USDOE must obtain prior approval from USEPA and SCDHEC before taking any anticipated action that may disrupt the effectiveness of the LUCs or alter or negate the need for LUCs. The Site Use Permit and site development maps must be amended when the geographic configuration or buffer zone used to establish the permit boundary changes or there is a change to the land use. The processes are controlled within the SRS Quality Assurance (QA) Program in accordance with SRS 1Q Manual, *Quality Assurance* (SRS 2007). The SRS QA program governs all SRS activities.

4.4 Physical Access Controls

[Address subjects relevant to implementing and maintaining physical access controls (e.g., fences, gates, barriers). Specify the following, as applicable: (1) when it will be first implemented, (2) what steps will be taken to put the LUC in place, (3) what organization will be responsible for each required activity, (4) what portion(s) of the overall OU will be subject to that LUC, and (5) how effectiveness of the LUC will be monitored and maintained.]

[If physical access controls are not required, then insert the following paragraph.]

There are no physical access controls required at the Operable Unit Name; however, physical access controls are provided at the SRS boundary as mentioned in Table 1, item 5.

4.5 Warning Signs

To prevent unknowing entry and to ensure that unrestricted use of the waste unit does not occur while the unit is under ownership of the USDOE, access control warning signs as shown in Appendix A will be posted at the unit. Installation of the access control warning signs will follow the Operable Unit Name construction schedule as described in the Remedial Action Implementation Plan (RAIP) and will be completed by Month Yr (add date). In addition, the final placement of the signage will be document in the PCR or PCR/(RACR) (choose the applicable title). The signs will be legible for a distance of at least 25 feet.

Custodial responsibilities for maintenance and inspection of the Operable Unit Name will be maintained by the SRS Post-Closure Maintenance Group.

4.6 Other Access Controls and Security/Surveillance Measures

While under the ownership of USDOE, access control of the entire SRS will be maintained in accordance with the 2000 RCRA Part B Permit Renewal Application, Volume I, Section F.1. This section describes the 24-hour surveillance system (R.61-79.264.14(b)(1)), artificial or natural barriers (R.61-79.264.14(b)(2)(I)), control entry systems (R.61-79.264.14(b)(2)(ii)), and access control warning signs (R.61-79.264.14(c)) in place at the SRS boundary to comply with the security requirements for a RCRA-permitted facility.

4.7 Field Inspection and Maintenance for Land Use Controls

[Describe the maintenance and inspection used to enforce the land use controls at the OU. Include the frequency of inspection in the description.]

After remediation of the Operable Unit Name, only inspection and maintenance activities will be required by this RA. [If applicable add the following: No operations other than Groundwater Mixing Zone Application (GMZA) monitoring will be required.]

The Operable Unit Name will be inspected per the Field Inspection Checklist in Appendix B. Field inspections will be performed annually. Additional inspections may be necessary in the event of unusual weather or any other condition warranting inspection. [Add OU specific details as appropriate, i.e., For the Operable Unit Name, inspections will be performed to ensure that access control signs are in place. Necessary repairs will be performed for items in Appendix B that are found to be in unsatisfactory condition].

Any activity that is inconsistent with the LUC objectives or use restrictions, or any other action that may interfere with the effectiveness of the LUCs will be addressed by the USDOE as soon as practicable, but in no case will the process be initiated later than 10 days after the USDOE becomes aware of the breach. The USDOE will notify USEPA and SCDHEC as soon a practicable but no longer than 10 days after discovery of any activity that is inconsistent with the LUC objectives or use restrictions, or any other action that may interfere with the effectiveness of the LUCs. The USDOE will notify USEPA and SCDHEC regarding how the USDOE has addressed or will address the breach within 10 days of sending USEPA and SCDHEC notification of the breach.

The FFA Annual Progress Report, submitted to the regulatory agencies by USDOE, will provide the status of the LUCs and describe how any LUC deficiencies or inconsistent uses have been addressed. In the event of property transfer or lease, the Annual Report will cite findings on the following: whether the use restrictions and controls referenced above were communicated in the deed(s) or lease restrictions; whether property use conforms with the deed or lease restrictions and controls; and whether the owners and state/local agencies have been notified regarding the deed or lease restrictions and controls. The FFA Annual Progress Report(s) will be used in the preparation of the Five-Year Remedy Review Report.

All other routine maintenance activities will be documented and maintained in files subject to USEPA and SCDHEC review and audit. A copy of the completed inspection form is maintained in the ACP Document Control. The LUCs shall be maintained until the concentration of

hazardous substances associated with the unit have been reduced to levels that allow for unlimited exposure and unrestricted use.

The waste unit inspectors are to be trained in Hazardous Waste Operations and Emergency Response (HAZWOPER), RCRA Well Inspections (ACP-specific training), ACP RCRA Waste Unit Inspections, Radiological Worker Training, etc., as applicable for the specific inspection. They will also be trained based on the individual requirements of the regulatory approved closure documents for each waste unit. In addition, the inspectors are to attend yearly refresher courses. Over the years, different personnel may conduct the inspections and maintenance activities.

This unit-specific LUCIP, including the checklist (Appendix B), will be appended to the SRS LUCAP upon final regulatory approval. After completion of the PCR or PCR/RACR (choose the applicable title), the preliminary checklist in the LUCAP will be replaced with the final approved checklist.

5.0 REFERENCES

FFA, 1993. *Federal Facility Agreement for the Savannah River Site*, Administrative Docket No. 89-05-FF (Effective Date: August 16, 1993)

USDOE, 1996. *Savannah River Site Future Use Project Report*, Stakeholder-Preferred Recommendations for SRS Land and Facilities, USDOE Savannah River Operations Office, January

SRS, 2006. SRS Procedure Manual 1D, *Site Infrastructure and Services Manual (U)*, Procedure 3.02, “Site Real Property Configuration Control," Savannah River Site, Aiken, SC

SRS, 2007. SRS Procedure Manual 1Q, *Quality Assurance (U)*, Savannah River Site, Aiken, SC

USDOE, 1998. DOE Order 430.1A, *Life Cycle Management* (Approved October 14, 1998)

WSRC, 2011. *Land Use Control Assurance Plan for the Savannah River Site*, WSRC-RP-98-4125, Revision 1.1, August 1999, updated October 2011, Savannah River Nuclear Solutions, LLC, Savannah River Site, Aiken, SC.

Figure 1. Location of the Operable Unit Name within the Savannah River Site

Figure 2. Location of the Operable Unit Name Subunits

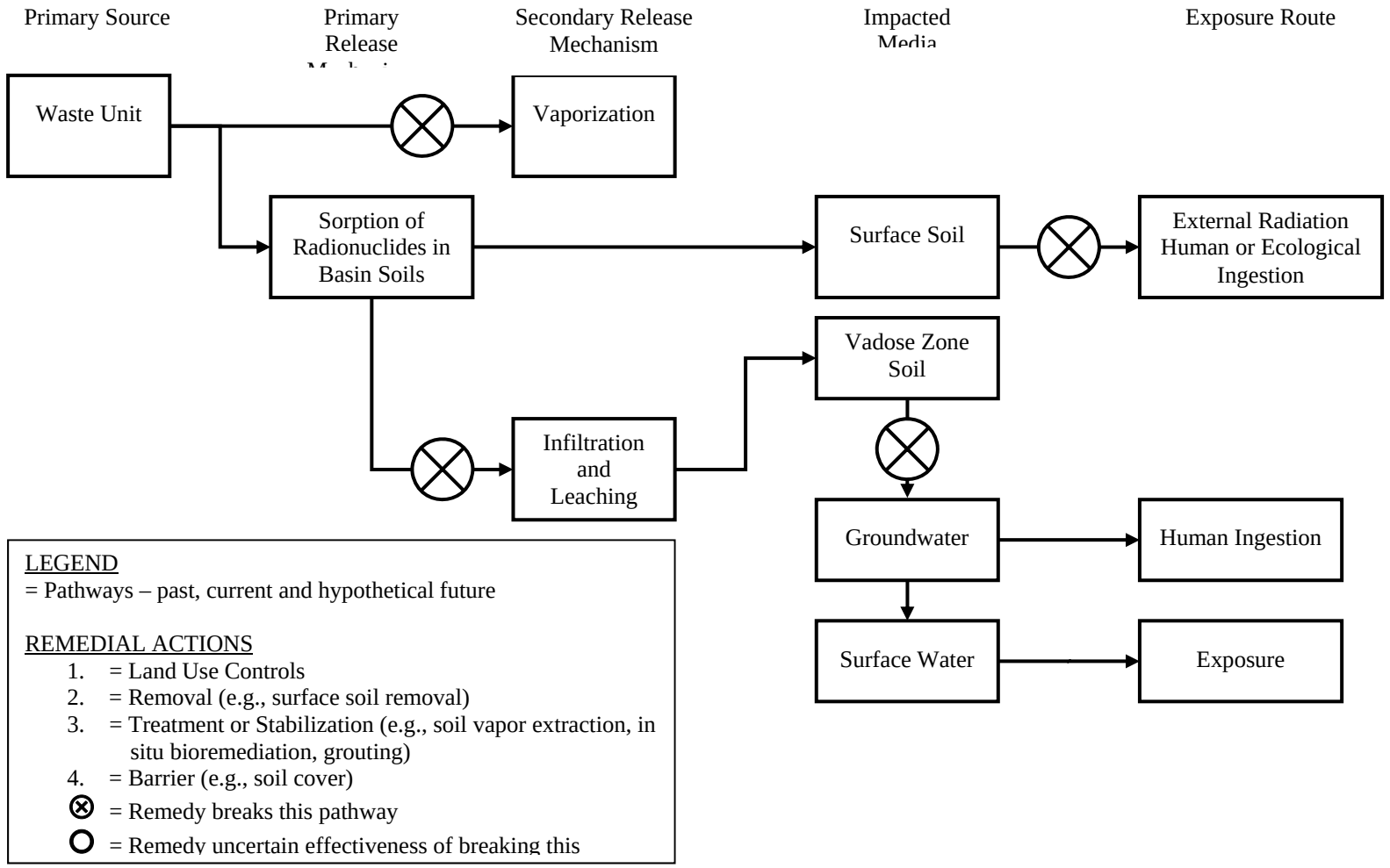

Figure 3. Post-Remedial Action Conceptual Site Model for the Operable Unit Name

Figure 4. Land Use Control Boundary for the Operable Unit Name

Table 1. Land Use Controls for the Operable Unit Name (Example – modify specific for OU as necessary)

Type of Control	Purpose of Control	Duration	Implementation	Affected Areas[a]
1. Property Record Notices[b]	Provide notice to anyone searching records about the existence and location of contaminated areas.	Until the concentration of hazardous substances associated with the unit have been reduced to levels that allow for unlimited exposure and unrestricted use.	Notice recorded by USDOE in accordance with state laws at County Register of Deeds office if the property or any portion thereof is ever transferred to non-federal ownership.	Waste management areas under this LUCIP where hazardous substances are left in place at levels requiring land use and/or groundwater restrictions.
2. Property record restrictions[c]: A. Land Use B. Groundwater	Restrict use of property by imposing limitations. Prohibit the use of groundwater.	Until the concentration of hazardous substances associated with the unit have been reduced to levels that allow for unlimited exposure and unrestricted use.	Drafted and implemented by USDOE upon any transfer of affected areas. Recorded by USDOE in accordance with state law at County Register of Deeds office.	Waste management areas under this LUCIP where hazardous substances are left in place at levels requiring land use and/or groundwater restrictions.
3. Other Notices[d]	Provide notice to county/city about the existence and location of waste disposal and residual contamination areas for zoning/planning purposes.	Until the concentration of hazardous substances associated with the unit have been reduced to levels that allow for unlimited exposure and unrestricted use.	Notice recorded by USDOE in accordance with state laws at County Register of Deeds office if the property or any portion thereof is ever transferred to non-federal ownership.	Waste management areas under this LUCIP where hazardous substances are left in place at levels requiring land use and/or groundwater restrictions.
4. Site Use Program[e]	Provide notice to worker/developer) i.e., permit requestor) on extent of contamination and prohibit or limit excavation/penetration activity.	As long as property remains under USDOE control.	Implemented by USDOE and site contractors. Initiated by permit request.	Waste management areas and remediation systems under this LUCIP where hazardous substances are left in place at levels requiring land use and/or groundwater restrictions.

Table 1. Land Use Controls for the Operable Unit Name (Continued) (Example – modify specific for OU as necessary)

Type of Control	Purpose of Control	Duration	Implementation	Affected Areas[a]
5. Physical Access Controls[f] (e.g., fences, gates, portals)	Control and restrict access to workers and the public to prevent unauthorized.	Until the concentration of hazardous substances associated with the unit have been reduced to levels that allow for unlimited exposure and unrestricted use.	Controls maintained by USDOE	Security is provided at site boundaries in accordance with SRS procedures. *[Add OU specific access controls if appropriate]*
6. Warning Signs[g]	Provide notice or warning to prevent unauthorized uses	Until the concentration of hazardous substances associated with the unit have been reduced to levels that allow for unlimited exposure and unrestricted use.	Signage maintained by USDOE	Warning signs will be posted in accordance with applicable site procedures and will be placed in appropriate areas at the XXOU.
7. Security Surveillance Measures	Control and monitor access by workers/public	Until the concentration of hazardous substances associated with the unit have been reduced to levels that allow for unlimited exposure and unrestricted use.	Established and maintained by USDOE. Necessity of patrols evaluated upon completion remedial actions or property transfer.	Patrol of waste management areas under this LUCIP, as necessary.

[a]Affected areas – Specific locations identified in the OU-specific LUCIP or subsequent post-ROD documents.

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

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

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

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

[f]Physical Access Controls – Physical barriers or restrictions to entry.

[g]Signs – Posted command, warning or direction.

APPENDIX A

ACCESS CONTROL WARNING SIGNS

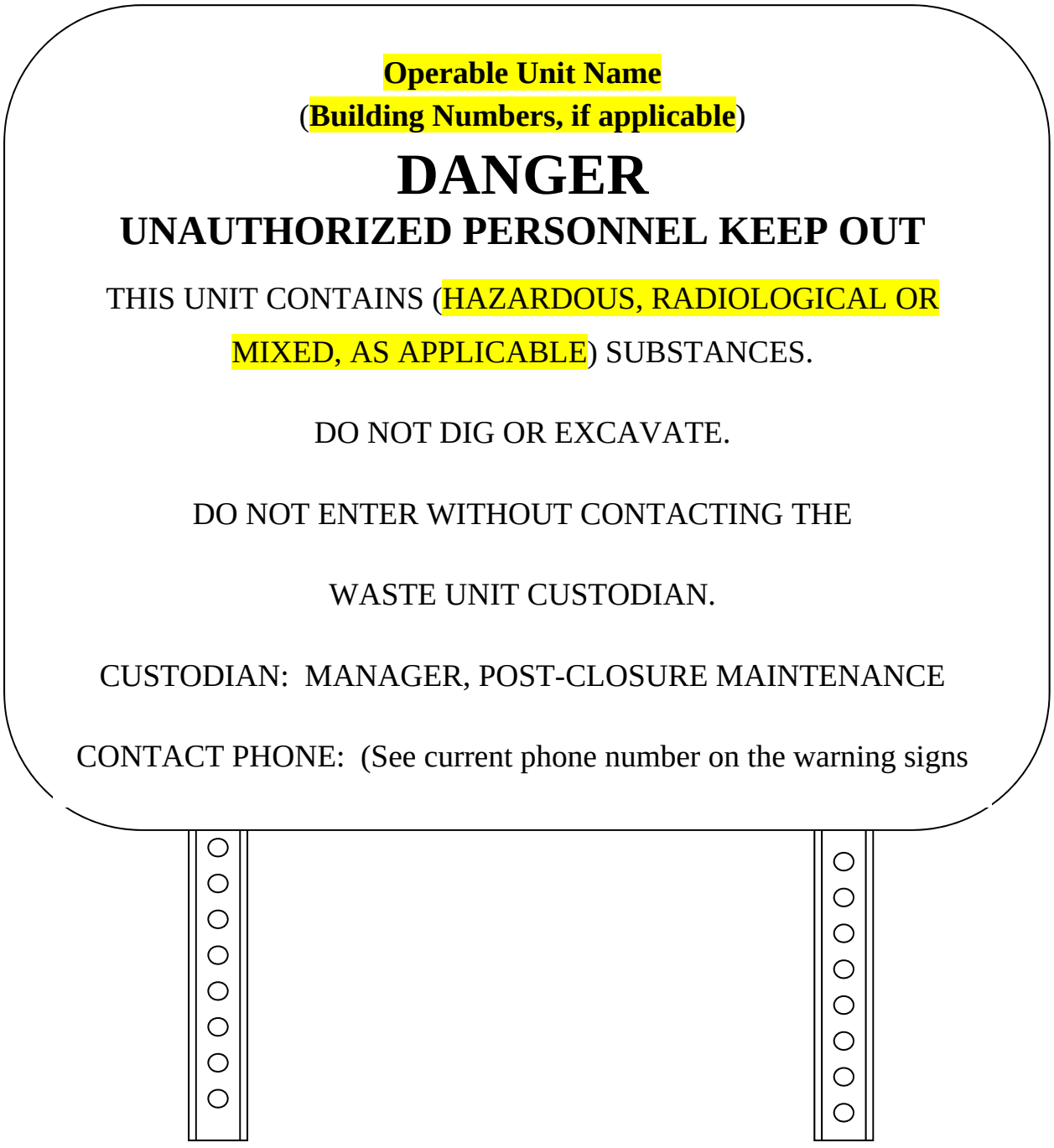

Figure A-1. Access Control Warning Sign

APPENDIX B

FIELD INSPECTION CHECKLIST

FOR OPERABLE UNIT NAME

FIELD INSPECTION CHECKLIST

FOR OPERABLE UNIT NAME

[Provide a site-specific inspection sheet with appropriate inspection items directly related to determining whether each specific LUC objective identified in the ROD and LUCIP are being achieved. If the waste unit does not contain the specific features listed below (e.g., such as drainage ditches, fences, etc.), exclude them from the checklist and list any additional specific features checklists items should sequentially follow the inspector's movements.]

❑ **SCHEDULED** ❑ **UNSCHEDULED**

A= Satisfactory X= Unsatisfactory (Explanation required)	A or X	Observation of Corrective Action Taken
1. Verify that the roads are accessible.		
2. Verify that the waste unit signs [specify the number] are in acceptable condition, have the correct information, and are legible from a distance of 25 feet.		
3. Verify that the fence is locked and in good condition [if applicable].		
4. Verify that there are no excavation, digging, or construction activities on the soil cover.		
5. Verify that the integrity of any drainage ditches, sediment basins and required land grading for proper drainage is maintained and they are free of excessive erosion, sediment buildup, and any debris restricting water flow.		
6. Verify that no woody vegetation is growing on the soil cover. Remove or identify as needed.		
7. Verify that the grass density has no bare spots more than 3 by 3 feet in area. The height of the vegetative cover should not impair the visual inspection of the soil cover.		

FIELD INSPECTION CHECKLIST
FOR OPERABLE UNIT NAME (Continued)

8. Verify that the soil cover has no signs of unacceptable erosion or depressions (subsidence).		
9. Verify that signs of burrowing or mounding animals are not present.		

Inspected by:

_____/_____ Date:_____
(Print Name) (Signature)

Post-Closure Manager:

_____/_____ Date:_____
(Print Name) (Signature)

CAUTION: The inspector shall notify the Post-Closure Manager (PCM) and Environmental Compliance Authority (ECA) **IMMEDIATELY** if there has been a breach or compromise of the land use controls of this waste unit. The notification shall be in accordance with SRS post-closure inspection procedures.

[If applicable]

NOTE: Monitoring wells associated with this waste unit are maintained in accordance with ACP Monitoring Well Procedures.

PROTOCOL

RFI/RI/BRA DOCUMENT GUIDE

The purpose of the RCRA Facility Investigation/ Remedial Investigation/ Baseline Risk Assessment (RFI/RI/BRA) document is to provide a description of the nature and extent of contamination at the unit, an evaluation of the fate and potential for transport of those contaminants, an assessment of baseline risks, a discussion of conceptual site model uncertainty, the development of remedial action objectives, and the development of remedial goal options. The location of these items in the report is shown in Table 1, below.

Table 1. Overview of the RFI/RI/BRA Document

CHAPTER	DESCRIPTION
1.	The purpose of the report and basic information about the unit under investigation is presented.
2.	The conceptual site model for the unit is discussed.
3.	Information on the broader region surrounding the unit is presented.
4.	The physical and analytical results of the investigation with a focus on the nature and extent of contamination is presented. A screening of the constituents against background concentrations is performed (USCs) and any constituents exceeding ARARs are identified (*preliminary* ARAR COCs). Based on professional judgment, prepare planar maps, cross-sectional plots, or other illustrations for each USC in each exposure group, which will be useful in illustrating the nature and extent of contamination at the unit. At a minimum, plots will be provided for each constituent identified as a *preliminary* COC (ARAR, HH, CM, ECO).
5.	The determination of exposure point concentrations is presented. This information will be used for fate and transport analysis and human health and ecological risk evaluations in the following chapters.
6.	A screening of the constituents against protective soil screening levels is performed (CM COPCs). The technical analysis of the likelihood of transport of the contamination is presented. Based on the technical analysis, *preliminary* CM COCs are identified.

CHAPTER	DESCRIPTION
7.	A screening of the constituents against protective human health concentrations is performed. The constituents, which exceed the screening criteria, are the basis for further human health risk evaluation. Technical analyses of baseline human health risks are presented. Based on the technical analysis, *preliminary* HH COCs are identified.
8.	A site-specific toxicological evaluation will be performed on those constituents which exceed the ecological risk evaluation conducted during the RFI/RI Work Plan. Unit-specific analyses of the toxicological experiments are presented. Based on these analyses, *final* ECO COCs are identified.
9.	Uncertainty associated with the conceptual site model is discussed and *refined COCs* (ARAR, HH, ECO, CM) are selected. The conceptual site model is revised based on the technical and uncertainty analysis.
10.	Remedial action objectives (RAOs) for the unit are identified. Remedial goal options to support the RAOs are presented.
11.	The findings of the primary and secondary source evaluation, natural resource injury evaluation, contaminant migration analysis, human health and ecological risk evaluation, and remedial goal options are summarized.
12.	Bibliography

An annotated outline has been provided as a separate document. It is referenced in the FIP. The contents of this outline have been agreed to by the EPA, SCDHEC and SRS. The latest version of the outline should be used for all RFI/RI/BRA documents.

PROTOCOL

Development of Exposure Groups

Introduction

This protocol has been developed in order to support the Savannah River Site environmental remediation program. Before characterizing a unit, a conceptual site model will be developed. In this model, a concept of the potential human and ecological receptors, the type of contaminated media at the unit, and transport routes will be identified. Each is described briefly below.

Receptors
Human health and ecological receptors are the known and hypothetical humans, animals, fish, etc., which may come into contact with contaminated media at the unit.

Media
Media of potential concern are defined as any medium through which human or ecological receptors may be exposed to constituents or through which constituents may be transported to potential receptors. Typical media include the following:

- Surface soil
- Subsurface soil
- Surface water
- Groundwater (by aquifer)
- Sediments
- Air
- Biota

Routes
Transport routes of constituents to receptors include the following:

- Ingestion (of soil, water, etc.)
- Inhalation (of dust particles, vapors)
- Dermal exposure

The purpose of the development of exposure groups is to provide an estimate of the concentration of contaminants in order to support an analysis of the extent of contamination at the unit and the risks associated with the presence of the contaminants.

The first step in the process is to determine the concentrations of contaminants in all of the media of potential concern. The data analysis process begins with two sets of samples, as follows:

- unit-background samples
- unit-source samples

Data from the investigation will be further grouped into sets and subsets for each medium. Exposure group, abbreviated as 'EG', is the term used to refer to the appropriate set of data that will be used to calculate the exposure point concentration for a given media of potential concern. Special EGs may be developed for hot spots, if needed.

The second step in the process is to determine if the contaminants have the potential to migrate from their present locations. Appropriate exposure groups are specified to support this analysis.

The third step in the process is to determine risks for each of these *receptor/media/route* combinations. These risks will be estimated in order to determine the total media risk as presented in the Human Health Constituents of Concern Protocol. Appropriate exposure groups are specified to support this analysis.

Details

Background Exposure Groups

There are three exposure groups for background soils.

Soil from 0 to 1 foot, background for the unit.
Soil from 0 to 4 feet, background for the unit.
Soil from 0 to WT (water table), background for the unit.

For groundwater, all of the background samples will be pooled, as appropriate.
For surface water, all of the background samples will be pooled, as appropriate.
For sediments, all of the background samples will be pooled, as appropriate.

Contaminant Migration Exposure Group

The exposure group for contaminant migration includes all of the unit-source soil analytical results for all of the samples taken anywhere between the surface of the unit soils and the uppermost aquifer. All of these data will be pooled into one exposure group. Other EGs may be developed, as needed, such as those, which represent hot spots.

Risk Assessment Exposure Groups

In the risk assessment, consideration will be given to a variety of *receptor/media/route* combinations. It is important to note that EGs are developed for each unit under investigation and are tailored to the needs of the risk assessment for that unit. Additional EGs may be developed, as needed.

Typical EGs are as follows:

Soil from 0 to 1 foot, over the area of the unit.
Soil from 0 to 4 feet, over the area of the unit.
Groundwater in a designated aquifer system (may be in the highly concentrated area of the plume, if appropriate).
Surface Water in a nearby water system.
Sediments in nearby drainage areas.

PROTOCOL

Exposure Pathways

Introduction

This protocol has been developed in order to support the Savannah River Site environmental remediation program. The purpose of this protocol is to provide clarification on the concept of exposure pathways.

Details

An exposure pathway describes the course a contaminant takes from source to the exposed individual. It consists of five elements, as follows:

source (landfill, spill, etc.);
exposure media (groundwater, air, etc.);
exposure point (drinking water well, shower, etc.);
exposure route (ingestion, inhalation, dermal absorption, etc.); and
receptor (resident, worker, etc.).

Information about exposure pathways is included in the discussions on risk characterization in order to describe the situation at the unit under investigation.

PROTOCOL

Addressing the Combined Surficial Risks from Adjacent Units

Introduction

This protocol has been developed in order to support the Savannah River Site environmental remediation program. It provides guidance on the establishment of Exposure Units and a methodology for addressing the combined surficial risks from Subunits within an Exposure Unit in support of an Area Completion strategy. A Subunit is an individual Federal Facility Agreement (FFA) waste unit or a facility (remnant) remaining after decommissioning. An Exposure Unit is a grouping of Subunits based on the areal extent of a receptor's movements during a defined time period. The protocol instructions are based on the latest available USEPA guidance and agreement from the staff of USEPA, SCDHEC, and USDOE as members of the Risk Assessment Design Team (RADT).

Exposure Unit Determination

Exposure Units should be determined by the Area Project Core Team (APCT) during project scoping following a review of existing data and site specific information. In the absence of an industry standard on the anticipated range for a future industrial worker, the Exposure Unit area designation is determined on a site-specific basis by the APCT.

Based on an assumed range for a future industrial worker in an Area Operable Unit (OU) setting, the typical size of an Exposure Unit is 1 to 5 acres. However, exceptions may include larger, homogeneous waste sites, or smaller, geographically isolated waste sites as determined by the APCT. When defining the Exposure Unit boundaries, the first exposure area designation should be based on a reasonable maximum exposure (RME) scenario (worst case) to minimize underestimating the risk over a larger area. Existing features such as roads, fences, or other natural breaks/features may also be considerations in defining the boundary. The Exposure Unit's unavailability to potential receptors needs to be taken into consideration when defining the physical dimensions of each Exposure Unit. If the pathways for exposure are incomplete due to greater restrictions (e.g., physical barriers and institutional controls), then that should be identified as such on the Conceptual Site Model and not be included in the Exposure Unit area designation. Ultimately, the Exposure Unit designation should be determined by the APCT based upon project specific considerations.

Each Subunit must be accounted for in an Exposure Unit. Subunits should not be divided between Exposure Units. A remedial decision will be made for each Exposure Unit and could address multiple Exposure Units in an Area OU setting.

Exposure Unit Risk Evaluation Methodology

Typically, human health risk in the Soil and Groundwater Closure Projects (SGCP) program is evaluated on a Subunit-by-Subunit basis; this approach may also be appropriate in some cases for an Area Operable Unit evaluation (e.g., a release site or waste unit that is geographically isolated from the rest of the area). Additionally, a receptor specific exposure area approach which combines the risk of individual Subunits within an Exposure Unit may be more efficient for data collection and remedial decisions.

In addition to the individual Subunit risk evaluation, the Exposure Unit risk is determined using an area-weighted approach. The area of each Subunit is weighted against the total Exposure Unit area to estimate the risk contribution of each subunit to the Exposure Unit. The Exposure Unit risk estimate is determined by considering the area-weighted Subunit risks. In this way, the total risk for a receptor (i.e., future industrial worker) would be "proportionalized" based on the area of each of the Subunits.

Details

1. A risk assessment should be performed for each Subunit (waste units/facilities) within an Area Operable Unit. Calculation of the risk estimate for each Subunit will be in accordance with SGCP protocols (Human Health Constituent of Concern Protocol). Refined COCs (RCOCs) should be identified in accordance with the Refinement of Constituents of Concern protocol.
2. For each Subunit, the risk will be considered in the Exposure Unit risk evaluation if there are RCOCs identified.
3. The Exposure Unit risk is calculated by using an area-weighted approach. This approach considers the range of the receptor (industrial worker) and the amount of time that he would theoretically spend at each of the Subunits. The formula for calculating the Exposure Unit risk estimate is provided below:

Exposure Unit risk estimate = Sum of [(risk for Subunit) x (area of Subunit / area of the Exposure Unit)]

Example Calculation for Exposure Unit

Summary of Risk Estimate and Area of Each Subunit in Exposure Unit

Subunit	Risk Estimate	Area
FFA Waste Unit A	2.0E-05	2.5 acre
FFA Waste Unit B	Site Evaluation NFA	0.3 acre
FFA Waste Unit C	No RCOCs (i.e., <1E-06)	0.2 acre
D&D Building Slab D	8.0E-06	1.0 acre
D&D Building Slab E	Simple Model[1]	0.1 acre
Space not occupied by subunits		0.9 acre
Total Area of Exposure Unit =		**5 acres**

1. The term "Simple Model" is part of the graded approach implemented by Site D&D that is based on the hazards commensurate with the unit's relative importance to safety and degree of complexity. Simple model facilities are assumed to have <1E-06 risk for a future industrial worker (i.e. negligible chemical or radiological risk) and will not be included in the Area Operable Unit or subsequent area evaluations (in accordance with FFA Section XL).

In this example, only 2 subunits area determined to contribute to the overall Exposure Unit risk.

Risk Estimate Using an Area-Weighted Approach

Subunit[1]	Risk Estimate[2]	Weighted Area[3]	Area-Weighted Risk Estimate[4]
Waste Unit A	2.0E-05	2.5 acre/ 5 acre = 0.5	1.0E-05
Building Slab D	8.0E-06	1 acre/ 5 acre = 0.2	1.6E-06
Exposure Unit Risk[5] =			**1.2E-05**

1. Only those subunits with RCOCs identified are considered in the Exposure Unit risk estimate.
2. Risk estimate = result of risk evaluation using SGCP protocols.
3. Weighted area = area of the Subunit/area of the Exposure Unit
4. Area-weighted risk estimate = risk estimate x weighted area
5. Exposure Unit risk = sum of the weighted area risks of each of the Subunits

ELECTRONIC DATA DELIVERABLE FORMAT REQUIREMENTS FOR RCRA/CERCLA DOCUMENTS (U)

I. Electronic Data Deliverable Format Requirements For Data Summary Reports (U)

The purpose of this document is to specify the version and format requirements for electronic data deliverables (EDD) to be used in the preparation of regulatory documents such as, but not limited to, the RCRA RFI/RI/Baseline Risk Assessment (BRA), Feasibility, and Treatability Study Reports.

Any revisions to this document must be coordinated with the Environmental Monitoring Section (EMS) of the Environmental Protection Department. EMS typically provides the services associated with data management, which is the subject of this document. Other SRS groups or subcontractors performing these activities for Environmental Restoration Division (ERD) would also be required to follow this document. This document does not instruct EMS, other SRS groups, or subcontractors as to how to perform their data management activities. This document specifies the EDD version and format requirements for analytical data, which are provided in support of the ERD program. Providing the files in multiple versions and formats removes the need for extensive data management on the part of SRS and subcontractor resources.

The required versions are as follows:

1. Version 1 - Full Data Set will be used by SRS and subcontractor resources who want to double check the screening process applied by EMS in order to produce the Production Data Set. This version will also be used by individuals who are trying to determine the cause of any anomalies in the data set. The EDD format for the Full Data Set is described in the Environmental Geochemistry Group Operating Handbook (EGG-OH) sections 2.410 and 3.320, with modifications discussed in the Data Request Process section of this document.

2. Version 2 - Production Data Set will be used by both SRS and subcontractor personnel in the processing of data in support of regulatory documents. The EDD format for the Production Data Set is described in EGG-OH section 2.530, with modifications discussed in the Data Request Process section of this document.

3. Version 3 - FFA Data Set will be used to provide data to the regulators in the EDD format described in Appendix J of the Federal Facility Agreement (FFA).

4. Version 4 - Statistical Summary Report will be used to facilitate the production of Baseline Risk Assessment (BRA) documents, and is a statistical summary of the data contained in the Full Data Set. The Statistical Summary Report (SSR) will be a subsection of the DSR and the associated EDD is defined in the Data Request Process section of this document.

Terms and Definitions

ASCII File - A file containing electronic data in the ASCII format.

BRA - Baseline Risk Assessments document the analysis of the potential for adverse effects associated with exposure to contaminants likely to be present at the unit. Baseline risks are those risks to human health and the environment that can be anticipated to be present in the absence of any remedial efforts or institutional controls for the unit.

CERCLA - Comprehensive Environmental Response Compensation and Liability Act of 1980 as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986.

COC - Constituent of concern.

ERD - Environmental Restoration Division.

EGG-OH - Environmental Geochemistry Group Operating Handbook.

EMS - Environmental Monitoring Section.

Excel Spreadsheet - A file containing data and other information that is compatible with the computer program know as “Excel”.

Feasibility Study - A report documenting the technical evaluation of various remediation options.

FFA - Federal Facility Agreement.

IFF - Interchange File Format. This is the EPA Region IV standardized electronic data deliverable format.

Rads - Radionuclide constituents.

RCRA - Resource Conservation and Recovery Act of 1976 as amended by the Hazardous and Solid Waste Amendments (HSWA) of 1984.

RFI/RI - RFI is the RCRA term standing for RCRA Facility Investigation program. RI is the CERCLA term standing for Remedial Investigation program. When the ERD program addresses both, the terms are combined.

SSR - Statistical Summary Report.

SVOCs - Semi-volatile organic compounds.

Treatability Study - A report documenting the technical evaluation of various options for the treatment of unit contaminants.

VOCs - Volatile organic compounds.

Data Request Process

A. Data to be used in the preparation of regulatory documents are to be requested from EMS, or the group responsible for analytical services supporting ERD RCRA/CERCLA programs. A written request should be sent to the responsible organization, either by letter or using an electronic mail system (e-mail), which specifies the EDD requirements. If the project is split into multiple phases, then the request should indicate if only combined document delivery is required or if multiple deliveries are required for the various phases.

B. Data files provided to ERD in support of RCRA/CERCLA projects shall be provided as described in following four different EDD versions:

(1) Version 1 - Full Dataset

This version will contain the all of the AN95 fields for the data set, and it will include all quality assurance/quality control results, including the laboratory duplicates, matrix spike duplicates, matrix spikes, field duplicates, and blanks. This data set will also include the station data files, so the coordinates for each sample location are readily available. The file will include the ERD sample location identifier and the full analyte name will replace the analyte code for each line of data. This information will be provided in two formats, the usual flat ASCII format and also in an Excel spreadsheet format.

(2) Version 2 - Production Dataset

This version of data will be a subset of the version 1 dataset. It will be used for the production of the exposure group concentrations for the RFI/RI, BRA and other regulatory documents. The specific fields, which shall be included by the responsible organization, include the following:

- ERD sample location identifier
- Station coordinates
- Depth interval for each sample
- Sample date
- Analytical suite (VOC, SVOC, metals, rads, if any)
- Full analyte name
- Method detection limit
- Practical quantitation limit
- Counting uncertainty for radionuclides
- Result qualifier
- Result
- Unit

The specific fields, which shall be excluded by the responsible organization, are listed below:

- The COC number
- The analyte code
- All records for rejected results ("R" result qualifiers)
- All Field and Lab QC results including the surrogate spikes, matrix spikes, matrix spike duplicates, blank spikes, blank spike duplicates, lab duplicates, lab replicates, field splits, field duplicates, field rinsate blanks, field blanks, and trip blanks
- In the event a sample is re-analyzed by the laboratory include the re-analyzed result only. (However, the data validator needs to evaluate the results for diluted and non-diluted samples to determine the best single analytical result.)
- All calibration data including standards, blanks, and all interference check samples
- All Tentatively identified compounds (TICs)
- The analysis qualifier column

The file will be provided both as an ASCII file and as an Excel spreadsheet.

(3) Version 3 - FFA Data Set

This version will be provided electronically in the EPA Region IV Interchange File Format (IFF) as described in Appendix J of the FFA. The EDD will be accompanied by a data dictionary and a report identifying what data set is being supplied, the media of delivery, and a description of what is contained in the data package. This data dictionary and report will be provided both on disk and in hard copy.

(4) Version 4 - Statistical Summary Report

This report will be a subsection of the DSR and the data will be provided electronically in an Excel spreadsheet as determined for each project by the project team. Attachment I is an example of the directions provided to generate the Statistical Summary Report. The following fields are to be generated for each subgroup determined by the project team:

- Analyte
- Units
- Soil Interval
- Frequency of Detection ("U" qualified)
- Frequency of Estimated Data ("J" qualified)
- Method Detection Limit
- Minimum Detection
- Maximum Detection
- Average Result
- Distribution

- 95% UCL
- Standard Deviation
- Log Transform
- Exposure Concentration
- Two Times Background Concentration

C. ERD Records Management will use the ERD Filing Facility as the central point for storage of the data disks. A copy of each of the versions is to be provided to the ERD records management center for filing. This provides centralized tracking and management of the files.

References

Corrective Action Report, "Improper Analysis of Data Qualifiers", 95-CAR-21-0001, 12/28/95

Corrective Action Report, "Environmental Data", 95-CAR-21-0001, Rev 1, 1/10/96

Root Cause Analysis Results for Corrective Action Report 95-CAR-21-001, 3/7/96

Quarterly Status for CAR: 95-CAR-21-001, Rev 1, dated 4/16/96 by John Hart

WSRC-05-94-42, FFA Appendix J, Data Management Plan

ATTACHMENTS

Attachment I: Example of Statistical Summary Report Request: Request for Analytical Data for the SRL Seepage Basins (U).

Attachment II: Example of Statistical Summary Report: DO-E97-12-03, TNX New Seepage Basin (TNXNSB) Statistical Summary Report and Excel Files.

March 20, 1998 **ESH-EMS-980067**
6316.980320.005

Mr. Robert Craig
Environmental Geochemistry Group
Environmental Protection Department
Westinghouse Savannah River Company
Aiken, South Carolina 29808-1001

REFERENCE: **Contract No. AB60294N, Subcontract No. SAIC 01027, Environmental Data Management and Project Reporting Services**

DO-E97-12-03, TNX New Seepage Basin (TNXNSB) Statistical Summary Report and Excel Files

Dear Mr. Craig,

Enclosed are three bound copies of the Statistical Summary Report for the TNX New Seepage Basin (TNXNSB) RFI/RI project. Also provided are three diskettes containing the summary statistics in Excel format. This letter and its enclosures were prepared by Science Applications International Corporation (SAIC). If you have any questions concerning this deliverable, please feel free to call me at (706) 724-5589.

Sincerely,

SCIENCE APPLICATIONS INTERNATIONAL CORPORATION

Allen F. Volesky

enclosures

cc: TNXNSB Project File (Kathie Spooner)
EGG Program File (Brenda Walker)
David Nix – WSRC
Dave Amick - SAIC, Augusta
Martha Turpin - SAIC, Oak Ridge
Horace Bledsoe - ExR, Augusta
Contract Files
Central Records Facility

Analysis	Result Units	Proportion Detected	Proportion "J" Qualified	Average MDL	Minimum Detect	Maximum Detect	Average Result	Std. Dev.	2 X Background
Pesticides/PCBs									
Aldrin	mg/kg	1/ 9	0/ 9	0.0010	0.0033	0.0033	0.0008	0.0009	0.00159
Dieldrin	mg/kg	2/ 9	1/ 9	0.0019	0.0013	0.0068	0.0017	0.0019	0.0033
Endosulfan I	mg/kg	1/ 9	0/ 9	0.0019	0.0040	0.0040	0.0013	0.0010	0.00262
Endosulfan II	mg/kg	1/ 9	1/ 9	0.0039	0.0037	0.0037	0.0021	0.0007	0.00424
Endosulfan sulfate	mg/kg	1/ 9	0/ 9	0.0039	0.0042	0.0042	0.0022	0.0008	0.0044
Endrin	mg/kg	1/ 9	1/ 9	0.0019	0.0018	0.0018	0.0011	0.0003	0.00212
gamma-Benzene hexachloride (Lindane)	mg/kg	1/ 9	1/ 9	0.0010	0.0009	0.0009	0.0005	0.0002	0.001064
p,p'-DDT	mg/kg	1/ 9	0/ 9	0.0039	0.0048	0.0048	0.0023	0.0010	0.0045
Physical Parameters									
Ammonia nitrogen	mg/kg	9/ 9	1/ 9	0.55	7.75	36.70	21.00	9.93	42
Total Phosphates (as P)	mg/kg	9/ 9	0/ 9	0.50	169.00	330.00	228.00	53.19	456
Radionuclides									
Actinium-228	pCi/g	9/ 9	0/ 9	0.0200	0.3420	0.9520	0.5500	0.2371	1.1000
Cesium-137	pCi/g	9/ 9	0/ 9	0.0068	0.0599	0.2800	0.1410	0.0665	0.2820
Curium-242	pCi/g	1/ 9	0/ 9	0.0570	0.1160	0.1160	0.0362	0.0316	0.0724
Curium-243/244	pCi/g	3/ 8	0/ 8	0.0781	0.3300	0.4040	0.1690	0.1746	0.3380
Gross Alpha	pCi/g	9/ 9	0/ 9	1.7278	4.8700	14.3000	8.9900	3.5771	17.9800
Lead-212	pCi/g	9/ 9	0/ 9	0.0106	0.3370	1.0300	0.5760	0.2740	1.1520
Non-volatile Beta	pCi/g	9/ 9	0/ 9	3.0322	6.5200	13.0000	9.3300	2.1905	18.6600
Plutonium-238	pCi/g	1/ 9	0/ 9	0.0439	1.5300	1.5300	0.1890	0.5028	0.3780
Plutonium-239/240	pCi/g	2/ 9	0/ 9	0.0194	0.0327	0.1170	0.0243	0.0356	0.0486
Potassium-40	pCi/g	9/ 9	0/ 9	0.0524	1.3700	3.0500	2.2500	0.5776	4.5000
Radium-226	pCi/g	9/ 9	0/ 9	0.0468	0.3510	0.9890	0.6680	0.1938	1.3360
Radium-228	pCi/g	9/ 9	0/ 9	0.0900	0.3340	1.0200	0.7340	0.2399	1.4680
Thorium-228	pCi/g	9/ 9	0/ 9	0.0399	0.4680	0.9810	0.6910	0.2036	1.3820
Thorium-230	pCi/g	9/ 9	0/ 9	0.0178	0.4030	0.8790	0.5910	0.1336	1.1820
Thorium-232	pCi/g	9/ 9	0/ 9	0.0161	0.4370	0.9450	0.6590	0.1920	1.3180
Thorium-234	pCi/g	9/ 9	0/ 9	0.2924	0.2780	1.0500	0.6090	0.2540	1.2180
Uranium-233/234	pCi/g	9/ 9	0/ 9	0.0222	0.3750	0.9080	0.5710	0.2126	1.1420
Uranium-235	pCi/g	9/ 9	0/ 9	0.0171	0.0165	0.1310	0.0490	0.0373	0.0980
Uranium-238	pCi/g	9/ 9	0/ 9	0.0187	0.3100	0.7360	0.4930	0.1863	0.9860
TAL Inorganics									
Aluminum	mg/kg	9/ 9	2/ 9	1.88	1990.00	7190.00	3360.00	1721.06	6720
Barium	mg/kg	9/ 9	0/ 9	0.02	19.30	62.10	38.50	15.82	77
Beryllium	mg/kg	9/ 9	9/ 9	0.01	0.13	0.41	0.23	0.10	0.468
Boron, total recoverable	mg/kg	5/ 9	5/ 9	0.96	0.62	1.30	0.66	0.26	1.316
Cadmium	mg/kg	1/ 9	0/ 9	0.01	0.39	0.39	0.05	0.13	0.0964
Calcium	mg/kg	9/ 9	0/ 9	0.77	37.60	249.00	113.00	66.58	226
Chromium	mg/kg	8/ 9	4/ 9	0.04	1.77	8.40	3.37	2.30	6.74
Cobalt	mg/kg	9/ 9	1/ 9	0.03	0.49	4.85	1.80	1.50	3.6

Analysis	Result Units	Proportion Detected	Proportion "J" Qualified	Average MDL	Minimum Detect	Maximum Detect	Average Result	Std. Dev.	2 X Background
TAL Inorganics (cont)									
Copper	mg/kg	8/ 9	1/ 9	0.07	1.14	5.98	2.63	1.81	5.26
Cyanide	mg/kg	1/ 9	1/ 9	0.17	0.09	0.09	0.08	0.00	0.1674
Iron	mg/kg	9/ 9	8/ 9	0.43	1480.00	12500.00	3710.00	3386.18	7420
Lead	mg/kg	9/ 9	8/ 9	0.03	2.24	7.79	4.22	1.69	8.44
Magnesium	mg/kg	9/ 9	0/ 9	0.17	50.40	146.00	108.00	31.67	216
Manganese	mg/kg	9/ 9	4/ 9	0.05	64.20	868.00	378.00	236.38	756
Mercury	mg/kg	9/ 9	4/ 9	0.02	0.01	1.02	0.15	0.33	0.308
Nickel	mg/kg	7/ 9	3/ 9	0.11	0.98	2.80	1.41	0.94	2.82
Potassium	mg/kg	9/ 9	7/ 9	0.29	48.10	168.00	92.10	35.83	184.2
Sodium	mg/kg	1/ 9	1/ 9	1.46	10.20	10.20	1.78	3.16	3.56
Vanadium	mg/kg	9/ 9	4/ 9	0.02	2.59	24.40	7.27	6.60	14.54
Zinc	mg/kg	9/ 9	4/ 9	0.05	3.49	8.08	5.48	1.69	10.96
TCL Semivolatiles									
Benzo(b)fluoranthene	mg/kg	1/ 9	0/ 9	0.0003	0.0076	0.0076	0.0010	0.0025	0.001978
Benzoic acid	mg/kg	7/ 9	0/ 9	0.0073	0.2640	1.3600	0.4290	0.4172	0.858
Di-n-butyl phthalate	mg/kg	1/ 9	1/ 9	0.0040	0.0234	0.0234	0.0044	0.0071	0.00876
TCL Volatiles									
1,1,1-Trichloroethane	mg/kg	5/ 9	0/ 9	0.00018	0.00009	0.00057	0.00019	0.00017	0.00038
2-Butanone (MEK)	mg/kg	2/ 9	1/ 9	0.00212	0.00034	0.00202	0.00109	0.00042	0.00218
Acetone	mg/kg	7/ 9	3/ 9	0.00224	0.00374	0.01750	0.00640	0.00503	0.0128
Carbon disulfide	mg/kg	2/ 9	2/ 9	0.00216	0.00022	0.00029	0.00090	0.00036	0.001792
Chloroform	mg/kg	5/ 9	2/ 9	0.00024	0.00005	0.00009	0.00009	0.00003	0.00018
Dichloromethane	mg/kg	3/ 9	0/ 9	0.00025	0.00161	0.00337	0.00088	0.00121	0.001754
(Methylene chloride)									
Ethylbenzene	mg/kg	3/ 9	0/ 9	0.00023	0.00008	0.00010	0.00011	0.00001	0.000212
Styrene	mg/kg	3/ 9	1/ 9	0.00022	0.00006	0.00050	0.00014	0.00013	0.000288
Tetrachloroethene	mg/kg	3/ 9	1/ 9	0.00023	0.00006	0.00010	0.00011	0.00002	0.00021
Toluene	mg/kg	6/ 9	6/ 9	0.00022	0.00015	0.00055	0.00027	0.00018	0.000546
Trichloroethene (TCE)	mg/kg	1/ 9	0/ 9	0.00027	0.00008	0.00008	0.00013	0.00002	0.000256
Xylenes (total)	mg/kg	6/ 9	3/ 9	0.00042	0.00009	0.00120	0.00031	0.00035	0.000628

Analysis	Result Units	Proportion Detected	Proportion "J" Detected	Average MDL	Minimum Detect	Maximum Detect	Average Result	Std. Dev.	Dist.	95% UCL of Mean	Exposure Concentration
Pesticides/PCBs											
Aroclor 1260	mg/kg	1/ 6	0/ 6	0.0009	0.0200	0.0200	0.0037	0.0080	D	0.0103	0.0103
Endrin	mg/kg	1/ 6	1/ 6	0.0003	0.0033	0.0033	0.0007	0.0013	D	0.0017	0.0017
p,p'-DDE	mg/kg	1/ 6	1/ 6	0.0001	0.0038	0.0038	0.0007	0.0015	D	0.0019	0.0019
Physical Parameters											
Nitrate-Nitrite as Nitrogen	mg/kg	6/ 6	1/ 6	0.0680	0.7340	6.3300	3.5600	2.1343	N	5.3100	5.3100
Radionuclides											
Actinium-228	pCi/g	6/ 6	0/ 6	0.1089	0.3860	1.8800	1.1800	0.4979	N	1.5900	1.5900
Cesium-137	pCi/g	6/ 6	0/ 6	0.0325	0.0364	0.1360	0.0824	0.0433	L	0.1970	0.1360
Gross Alpha	pCi/g	6/ 6	4/ 6	3.9600	8.2000	56.3000	26.7000	17.1519	L	83.1000	56.3000
Lead-212	pCi/g	6/ 6	0/ 6	0.0485	0.4690	2.0500	1.2300	0.5150	N	1.6600	1.6600
Non-volatile Beta	pCi/g	6/ 6	0/ 6	5.7567	6.0200	43.3000	19.7000	13.3190	L	74.4000	43.3000
Plutonium-239/240	pCi/g	1/ 6	0/ 6	0.1600	0.0468	0.0468	0.0853	0.1400	D	0.2010	0.0468
Potassium-40	pCi/g	6/ 6	0/ 6	0.3096	1.1300	4.1000	2.5800	1.1243	N	3.5000	3.5000
Radium-226	pCi/g	6/ 6	0/ 6	0.0831	0.6910	3.6300	1.6500	1.1495	L	5.0300	3.6300
Radium-228	pCi/g	5/ 5	0/ 5	0.1462	1.1600	2.0300	1.4300	0.3448	L	1.8600	1.8600
Thorium-228	pCi/g	5/ 6	0/ 6	0.4213	0.6020	1.9800	1.0400	0.6325	N	1.5600	1.5600
Thorium-230	pCi/g	6/ 6	0/ 6	0.2058	0.3340	1.4800	0.8970	0.4201	N	1.2400	1.2400
Thorium-232	pCi/g	5/ 6	0/ 6	0.2180	0.4870	1.4400	0.8140	0.5256	N	1.2500	1.2500
Thorium-234	pCi/g	6/ 6	0/ 6	1.2025	2.1100	8.4600	4.5200	2.6481	N	6.7000	6.7000
Uranium-233/234	pCi/g	6/ 6	0/ 6	0.0184	0.9890	3.6000	2.2600	1.1087	L	5.1500	3.6000
Uranium-235	pCi/g	6/ 6	0/ 6	0.0141	0.0705	0.2550	0.1640	0.0790	L	0.3710	0.2550
Uranium-238	pCi/g	6/ 6	0/ 6	0.0141	1.6800	6.6700	4.0500	2.0420	N	5.7300	5.7300
TAL Inorganics											
Aluminum	mg/kg	6/ 6	0/ 6	1.88	11200.00	38300.00	#######	10275.41	L	44600.00	38300.00
Arsenic	mg/kg	6/ 6	0/ 6	0.15	7.82	44.10	18.90	13.21	L	51.50	44.10
Barium	mg/kg	6/ 6	0/ 6	0.02	73.00	592.00	345.00	241.72	N	543.00	543.00
Beryllium	mg/kg	6/ 6	6/ 6	0.01	0.25	0.37	0.32	0.05	L	0.38	0.37

Analysis	Result Units	Proportion Detected	Proportion "J" Detected	Average MDL	Minimum Detect	Maximum Detect	Average Result	Std. Dev.	Dist.	95% UCL of Mean	Exposure Concentration
Cadmium	mg/kg	4/ 6	1/ 6	0.01	0.20	3.00	1.35	1.43	D	2.53	2.53
Calcium	mg/kg	6/ 6	0/ 6	0.77	2940.00	21500.00	#######	6920.92	L	42700.00	21500.00
Chromium	mg/kg	6/ 6	0/ 6	0.04	45.90	883.00	219.00	326.41	X	487.00	487.00
Cobalt	mg/kg	6/ 6	0/ 6	0.03	6.60	55.90	19.30	18.21	L	70.40	55.90
TAL Inorganics, continued											
Copper	mg/kg	6/ 6	0/ 6	0.07	160.00	1520.00	503.00	511.83	L	2150.00	1520.00
Cyanide	mg/kg	1/ 6	0/ 6	0.22	3.20	3.20	0.63	1.26	D	1.66	1.66
Iron	mg/kg	6/ 6	6/ 6	0.43	21800.00	203000.00	#######	63154.83	L	349000.00	203000.00
Lead	mg/kg	6/ 6	0/ 6	0.03	19.70	216.00	107.00	84.42	L	932.00	216.00
Magnesium	mg/kg	6/ 6	0/ 6	0.17	669.00	7210.00	4030.00	2626.14	N	6190.00	6190.00
Manganese	mg/kg	6/ 6	0/ 6	0.05	5580.00	46400.00	#######	15371.95	L	100000.00	46400.00
Mercury	mg/kg	6/ 6	0/ 6	0.02	0.92	4.00	2.17	1.38	N	3.30	3.30
Nickel	mg/kg	6/ 6	0/ 6	0.11	2100.00	17800.00	7430.00	5836.10	L	43300.00	17800.00
Potassium	mg/kg	6/ 6	0/ 6	0.29	380.00	1770.00	974.00	478.86	L	2180.00	1770.00
Selenium	mg/kg	5/ 6	0/ 6	0.07	2.28	8.63	3.61	2.91	N	6.00	6.00
Silver	mg/kg	6/ 6	0/ 6	0.03	1.02	19.80	8.98	7.02	N	14.80	14.80
Sodium	mg/kg	6/ 6	0/ 6	1.46	2270.00	19800.00	#######	6577.57	N	17400.00	17400.00
Thallium	mg/kg	6/ 6	0/ 6	0.13	7.25	55.00	25.50	17.50	L	104.00	55.00
Vanadium	mg/kg	6/ 6	0/ 6	0.02	3.72	49.50	13.00	17.98	X	27.70	27.70
Zinc	mg/kg	6/ 6	0/ 6	0.05	157.00	892.00	473.00	259.47	L	1330.00	892.00
TCL Semivolatiles											
Benzo(b)fluoranthene	mg/kg	1/ 6	0/ 6	0.00033	0.67000	0.67000	0.11200	0.27346	D	0.33700	0.33700
Bis(2-ethylhexyl) phthalate	mg/kg	6/ 6	0/ 6	0.00699	2.30000	18.10000	6.23000	5.94727	L	23.90000	18.10000
TCL Volatiles											
Acetone	mg/kg	2/ 6	0/ 6	0.00224	0.03860	0.06930	0.01870	0.02896	D	0.04260	0.04260
Benzene	mg/kg	4/ 6	1/ 6	0.00025	0.00254	0.10700	0.02590	0.04308	D	0.06130	0.06130
Dichloromethane (Methylene chloride)	mg/kg	1/ 6	0/ 6	0.00025	0.04730	0.04730	0.00799	0.01926	D	0.02380	0.02380
Ethylbenzene	mg/kg	1/ 6	1/ 6	0.00023	0.00079	0.00079	0.00023	0.00028	D	0.00046	0.00046

Analysis	Result Units	Proportion Detected	Proportion "J" Detected	Average MDL	Minimum Detect	Maximum Detect	Average Result	Std. Dev.	Dist.	95% UCL of Mean	Exposure Concentration
Xylenes (total)	mg/kg	1/ 6	0/ 6	0.00042	0.00307	0.00307	0.00069	0.00117	D	0.00165	0.00165

Distribution Codes: L-distribution most similar to lognormal.
N-distribution most similar to normal.
X-distribution significantly different from normal and lognormal.
D-distribution not determined because the number of detects was less than half the total number of samples.
Z-distribution with negative results and therefore treated as normal.

Analysis	Result Units	Proportion Detected	Proportion "J" Qualified	Average MDL	Minimum Detect	Maximum Detect	Average Result	Std. Dev.	Dist.	95% UCL of Mean	Exposure Concentration
Physical Parameters											
Nitrate-Nitrite as Nitrogen	mg/kg	3/ 3	0/ 3	0.0680	0.9230	1.4900	1.2800	0.3139	D	1.8100	1.4900
Radionuclides											
Actinium-228	pCi/g	3/ 3	0/ 3	0.0154	0.8360	1.0600	0.9480	0.1120	D	1.1400	1.0600
Cesium-137	pCi/g	3/ 3	0/ 3	0.0048	0.0154	0.0209	0.0178	0.0028	D	0.0225	0.0209
Gross Alpha	pCi/g	3/ 3	0/ 3	3.2000	3.5200	7.8800	6.3100	2.4225	D	10.4000	7.8800
Lead-212	pCi/g	3/ 3	0/ 3	0.0083	0.9010	1.0800	0.9790	0.0917	D	1.1300	1.0800
Non-volatile Beta	pCi/g	1/ 3	0/ 3	5.4000	6.3400	6.3400	4.0700	2.0305	D	7.4900	6.3400
Potassium-40	pCi/g	3/ 3	0/ 3	0.0424	2.1600	3.6300	3.0800	0.8018	D	4.4300	3.6300
Radium-226	pCi/g	1/ 1	0/ 1	0.0562	0.7680	0.7680	0.7680		D		0.7680
Radium-228	pCi/g	1/ 1	0/ 1	0.1010	1.0100	1.0100	1.0100		D		1.0100
Thorium-228	pCi/g	1/ 1	0/ 1	0.1720	1.2800	1.2800	1.2800		D		1.2800
Thorium-230	pCi/g	1/ 1	0/ 1	0.0846	0.7480	0.7480	0.7480		D		0.7480
Thorium-232	pCi/g	1/ 1	0/ 1	0.0768	0.8490	0.8490	0.8490		D		0.8490
Thorium-234	pCi/g	1/ 3	0/ 3	0.2503	0.9480	0.9480	0.4000	0.4743	D	1.2000	0.9480
Uranium-233/234	pCi/g	1/ 1	0/ 1	0.0164	0.9440	0.9440	0.9440		D		0.9440

Analysis	Result Units	Proportion Detected	Proportion "J" Qualified	Average MDL	Minimum Detect	Maximum Detect	Average Result	Std. Dev.	Dist.	95% UCL of Mean	Exposure Concentration
Uranium-235	pCi/g	1/ 1	0/ 1	0.0165	0.0668	0.0668	0.0668		D		0.0668
Uranium-238	pCi/g	1/ 1	1/ 1	0.0065	1.1700	1.1700	1.1700		D		1.1700
TAL Inorganics											
Aluminum	mg/kg	3/ 3	0/ 3	1.88	7610.00	13700.00	11200.00	3172.96	D	16500.00	13700.00
Arsenic	mg/kg	3/ 3	0/ 3	0.15	1.60	2.54	2.06	0.47	D	2.85	2.54
Barium	mg/kg	3/ 3	1/ 3	0.02	25.80	27.80	26.50	1.13	D	28.40	27.80
Beryllium	mg/kg	3/ 3	3/ 3	0.01	0.16	0.20	0.19	0.02	D	0.23	0.20
Calcium	mg/kg	3/ 3	1/ 3	0.77	481.00	663.00	590.00	96.01	D	752.00	663.00
Chromium	mg/kg	3/ 3	0/ 3	0.04	11.20	14.10	12.70	1.45	D	15.10	14.10
Cobalt	mg/kg	3/ 3	0/ 3	0.03	1.62	1.97	1.78	0.18	D	2.08	1.97
Copper	mg/kg	3/ 3	0/ 3	0.07	16.00	31.10	21.50	8.34	D	35.60	31.10
Cyanide	mg/kg	1/ 3	1/ 3	0.22	0.26	0.26	0.16	0.08	D	0.30	0.26
Iron	mg/kg	3/ 3	3/ 3	0.43	10800.00	11700.00	11100.00	493.29	D	12000.00	11700.00
Lead	mg/kg	3/ 3	0/ 3	0.03	4.78	7.65	6.34	1.45	D	8.79	7.65
Magnesium	mg/kg	3/ 3	0/ 3	0.17	190.00	221.00	203.00	16.26	D	230.00	221.00
TAL Inorganics, continued											
Manganese	mg/kg	3/ 3	0/ 3	0.05	605.00	979.00	754.00	198.24	D	1090.00	979.00
Mercury	mg/kg	3/ 3	0/ 3	0.02	0.19	0.37	0.26	0.09	D	0.42	0.37
Nickel	mg/kg	3/ 3	0/ 3	0.11	184.00	372.00	254.00	102.55	D	427.00	372.00
Potassium	mg/kg	3/ 3	1/ 3	0.29	196.00	243.00	223.00	24.27	D	264.00	243.00
Selenium	mg/kg	3/ 3	3/ 3	0.07	0.28	0.42	0.36	0.07	D	0.47	0.42
Silver	mg/kg	2/ 3	2/ 3	0.03	0.11	0.29	0.14	0.14	D	0.37	0.29
Sodium	mg/kg	3/ 3	0/ 3	1.46	174.00	669.00	404.00	249.28	D	825.00	669.00
Thallium	mg/kg	1/ 3	1/ 3	0.13	0.69	0.69	0.28	0.36	D	0.89	0.69
Vanadium	mg/kg	3/ 3	0/ 3	0.02	24.40	26.70	25.30	1.21	D	27.40	26.70
Zinc	mg/kg	3/ 3	0/ 3	0.05	19.80	28.60	22.90	4.92	D	31.20	28.60
TCL Volatiles											
1,1,1-Trichloroethane	mg/kg	1/ 3	1/ 3	0.0002	0.0006	0.0006	0.0002	0.0003	D	0.0007	0.0006
2-Butanone (MEK)	mg/kg	1/ 3	0/ 3	0.0021	0.0090	0.0090	0.0037	0.0046	D	0.0115	0.0090
Acetone	mg/kg	2/ 3	0/ 3	0.0022	0.0114	0.1370	0.0498	0.0757	D	0.1770	0.1370

Analysis	Result Units	Proportion Detected	Proportion "J" Qualified	Average MDL	Minimum Detect	Maximum Detect	Average Result	Std. Dev.	Dist.	95% UCL of Mean	Exposure Concentration
Benzene	mg/kg	3/ 3	2/ 3	0.0003	0.0023	0.0077	0.0041	0.0031	D	0.0093	0.0077
Chloroform	mg/kg	1/ 3	1/ 3	0.0002	0.0009	0.0009	0.0004	0.0005	D	0.0012	0.0009
Chloromethane (Methyl chloride)	mg/kg	1/ 3	1/ 3	0.0004	0.0016	0.0016	0.0007	0.0008	D	0.0020	0.0016
Dichloromethane (Methylene chloride)	mg/kg	2/ 3	2/ 3	0.0003	0.0078	0.0215	0.0098	0.0108	D	0.0281	0.0215
Toluene	mg/kg	2/ 3	2/ 3	0.0002	0.0004	0.0005	0.0003	0.0002	D	0.0007	0.0005

Distribution Codes: L–distribution most similar to lognormal.
N–distribution most similar to normal.
X–distribution significantly different from normal and lognormal.
D–distribution not determined because the number of detects was less than half the total number of samples.
Z–distribution with negative results and therefore treated as normal.

Analysis	Result Units	Proportion Detected	Proportion "J" Qualified	Average MDL	Minimum Detect	Maximum Detect	Average Result	Std. Dev.	Dist.	95% UCL of Mean	Exposure Concentration
Physical Parameters											
Ammonia nitrogen	ug/L	1/ 3	1/3	28.00	40.00	40.00	22.70	15.01	D	48.00	40.00
Total Phosphates (as P)	ug/L	3/ 3	1/3	25.00	120.00	1550.00	623.00	803.51	D	1980.00	1550.00
Radionuclides											
Gross Alpha	pCi/L	1/ 3	0/3	1.20	3.95	3.95	1.74	1.92	D	4.97	3.95
Non-volatile Beta	pCi/L	3/ 3	0/3	1.89	3.61	11.10	6.42	4.08	D	13.30	11.10
TAL Inorganics											
Aluminum	ug/L	2/ 3	0/3	37.60	196.00	4350.00	1520.00	2451.07	D	5650.00	4350.00
Antimony	ug/L	2/ 3	2/3	1.64	1.14	2.50	1.49	0.89	D	2.99	2.50
Barium	ug/L	3/ 3	0/3	0.33	16.50	20.60	18.30	2.11	D	21.80	20.60
Beryllium	ug/L	1/ 3	1/3	0.22	0.19	0.19	0.14	0.05	D	0.21	0.19
Boron, total recoverable	ug/L	3/ 3	0/3	19.10	9530.00	68800.00	29500.00	34027.79	D	86900.00	68800.00

Analysis	Result Units	Proportion Detected	Proportion "J" Qualified	Average MDL	Minimum Detect	Maximum Detect	Average Result	Std. Dev.	Dist.	95% UCL of Mean	Exposure Concentration
Calcium	ug/L	3/ 3	0/3	15.40	2890.00	5340.00	4480.00	1381.17	D	6810.00	5340.00
Chromium	ug/L	1/ 3	0/3	0.73	5.70	5.70	2.14	3.08	D	7.34	5.70
Cobalt	ug/L	1/ 3	1/3	0.67	2.25	2.25	0.97	1.11	D	2.84	2.25
Copper	ug/L	3/ 3	2/3	1.32	3.73	166.00	57.80	93.66	D	216.00	166.00
Iron	ug/L	3/ 3	0/3	8.63	941.00	6270.00	2760.00	3042.93	D	7890.00	6270.00
Lead	ug/L	1/ 3	0/3	0.68	8.24	8.24	2.97	4.56	D	10.70	8.24
Magnesium	ug/L	3/ 3	0/3	3.33	424.00	722.00	617.00	167.62	D	900.00	722.00
Manganese	ug/L	3/ 3	0/3	0.90	88.20	878.00	359.00	449.55	D	1120.00	878.00
Mercury	ug/L	1/ 3	0/3	0.10	3.47	3.47	1.19	1.97	D	4.52	3.47
Nickel	ug/L	3/ 3	0/3	2.27	54.70	267.00	126.00	121.83	D	332.00	267.00
Potassium	ug/L	3/ 3	0/3	5.87	3630.00	4730.00	4340.00	613.30	D	5370.00	4730.00
Silver	ug/L	1/ 3	0/3	0.62	4.69	4.69	1.77	2.53	D	6.03	4.69
Sodium	ug/L	3/ 3	0/3	29.10	55700.00	226000.00	113000.00	97949.63	D	278000.00	226000.00
Vanadium	ug/L	3/ 3	2/3	0.43	1.17	25.70	9.44	14.08	D	33.20	25.70
Zinc	ug/L	2/ 3	0/3	0.97	14.30	68.40	27.70	35.89	D	88.20	68.40
TCL Volatiles											
2-Butanone (MEK)	ug/L	1/ 3	1/3	2.12	0.74	0.74	0.95	0.18	D	1.26	0.74
Acetone	ug/L	3/ 3	1/3	2.24	4.00	6.84	5.42	1.42	D	7.81	6.84

Distribution Codes:

L–distribution most similar to lognormal.

N–distribution most similar to normal.

X–distribution significantly different from normal and lognormal.

D–distribution not determined because the number of detects was less than half the total number of samples.

Z–distribution with negative results and therefore treated as normal.

PROTOCOL

CONSTITUENTS OF CONCERN (COC) REFINEMENT PROCESS

Introduction

The contaminant migration technical analyses, human health assessment, the ecological assessment, the Applicable or Relevant and Appropriate Requirements (ARAR) screening, and the source material screening that are used in the remedial investigative reports are performed using a process agreed upon by the three parties to the Federal Facility Agreement (FFA). This process is performed in accordance with the agreed upon protocol and USEPA guidance and agreement from the staff of USEPA, SCDHEC, and USDOE as members of the Risk Assessment Design Team (RADT). These assessments and analyses are used to identify contaminants which may require remedial action due to risk, regulatory, or source control concerns. In some cases, however, remedial action may not be necessary or appropriate for these identified contaminants. Therefore, a secondary selection process would be beneficial to identify the constituents of concern (COCs) which should be carried forward for remedial alternative screening. This selection process should identify those COCs which have a reasonable likelihood of having been or might be released, are consistent with the conceptual site model, and pose an adverse hazard or risk to human health or the environment. COCs that are carried forward following the refinement process are designated as refined COCs (RCOCs). This protocol provides the description of the refinement process.

The recommendation of whether or not a COC should be carried forward for further remedial evaluations must be based on a thorough analysis of each COC. It is unlikely that any one COC will be eliminated based on a single uncertainty category. Instead, all of the applicable uncertainty factors are compared and the cumulative aspects of the factors are used to determine whether a COC should be eliminated from further consideration. It should be noted that the presence of high uncertainty in a category does not in itself lead to non-selection. In fact, the presence of a high degree of uncertainty regarding concentration or distribution could lead to inclusion as a RCOC. This protocol provides a listing and discussion of a number of uncertainty factors which may be important for determining whether a constituent should or should not be carried forward for further remedial considerations.

1.0 Refinement Process Criteria

A. The uncertainty analysis will be performed for the following types of COCs: ARAR COCs, Contaminant Migration COCs (CMCOCs), Human Health COCs (HHCOCs), Ecological COCs (ECO COCs), and Principle Threat Source Material (PTSM) COCs.

B. For each individual COC, prepare an interpretive discussion of the applicable uncertainty factors and provide a recommendation to indicate whether the constituent should or should not be carried forward for further remedial evaluation.

C. For the RCOCs recommended for further remedial evaluations, Remedial Alternative Objectives (RAOs) and Remedial Goal Options (RGOs) will be developed.

1.1 Major Categories of Uncertainty

The following uncertainty categories of information relating to the selection process have been developed for use at the SRS. For each COC, as applicable, individual uncertainty factors are grouped and discussed under four major uncertainty categories to include unit related, data quality, risk assessment, and contaminant migration uncertainties. These major uncertainty categories will be used to provide a complete summary discussion for each COC. Individual uncertainty factors are briefly discussed below:

Unit Related Uncertainty
Nature and Extent of Contamination
Consistency with History of Use
Presence in Background

Data Quality Uncertainty
Analytical Data Quality
Physical Characteristics

Risk Assessment Uncertainty
Toxicity Data
Radioactive Decay

Contaminant Migration Uncertainty
Presence in Groundwater

2.0 Description of Uncertainty Factors

2.1 Nature and Extent of Contamination

Unit-related contamination should be evaluated based on the nature and extent (distribution) of contamination. This analysis should be primarily based on the relative abundance of “detects” in the total number of samples and the presence or lack of discernible patterns of contamination in the impacted media and source. This evaluation should also consider the quantity of data points and the quality of the dataset in question, as appropriate. The evaluation should determine if the distribution of the data indicates the constituent is ubiquitous for the unit or from a discernible source. Planar maps and cross-sections of the distribution of analytes may be used to illustrate the results. Statistical analysis may also be used.

2.2 Consistency with History of Use

SRS has compiled a significant amount of historical information on the usage of the site, including past disposal inventory reports. Unit history is just one of several potential lines of evidence that are available in the COC refinement process. Although the amount of historical information will differ between waste units, historical consistency in the contaminant types and concentrations found at the unit may be important considerations in the overall uncertainty evaluation. Based on this information, a determination could be made as to whether the history of use is consistent with the concentration and type of contaminant found at the unit.

2.3 Presence in Background

SRS has extensive information based on USEPA and SRS published documents on the concentration of contaminants in the non-unit related media at the SRS and surrounding region. An evaluation should be made as to whether the contaminant is present at a concentration significantly different from unit background and/or SRS background. Alternate graphical and/or statistical methods of comparison may be used to support this evaluation. The USEPA and SCDHEC will be consulted with regard to the use of alternate methods for comparison of background data sets.

2.4 Analytical Data Quality

The Data Summary Report for the unit provides all of the analytical data and the associated analytical qualifiers. In some cases, constituents may have data quality flags (result and analytical qualifiers) indicating the concentration was estimated and providing the nature of the analytical problem. An evaluation must be made whether the data quality is sufficient to serve as the basis for remedial decisions. If there is uncertainty concerning the concentration of a COC, then additional samples should be collected to confirm the concentration. In addition, if the data set is not of sufficient quality to serve as a basis for a remedial decision, then no COCs should be removed and additional data should be collected. A COC may be removed from further remedial evaluation if the data is of excellent quality and there is supporting information that infrequent detections are not due to a source release. After examining the entire data set, a recommendation can be made as to whether the COC should or should not be considered for further remedial evaluation.

2.5 Physical Characteristics

If an analyte seems out of place within a given media, then evaluate the probability that it actually exists using its' physical characteristics. For example, if a radionuclide COC is naturally occurring in the environment and associated daughter products from the same decay series are detected at similar concentrations (secular equilibrium), then this would increase the uncertainty that the parent constituent is unit related. In addition, a short-lived radionuclide detected in soil long after it should have decayed away would also be viewed with uncertainty indicating that the constituent may be a "false positive" detection. Additional characterization may be needed to determine if the constituent is actually present in the environment. In the absence of unit related activities, the physical characteristics of a COC should be considered to determine if the constituent

should be considered for further remedial evaluations, or if additional characterization is needed to better manage the uncertainty.

2.6 Toxicity Data

COCs which were determined based on the use of surrogate or provisional toxicity, or where toxicity reference values for a given constituent are highly variable, should be closely examined. The specific details of the status of the provisional toxicity information and the chemical/physical relationships between the COC and the surrogate should be closely examined before considering the COC for further remedial evaluation.

2.7 Radioactive Decay

Many of the assessments performed in support of the RI/BRA assume that the present day concentration of contaminants will persist through out the period of interest. This is not an accurate assumption for many radionuclide constituents. As part of the uncertainty analysis, radiological analytes should be mathematically decayed over the time period of interest. For example, if 30 years is the period of interest, then the radionuclide should be decayed over that time and the final activity reported. For contaminant migration, the radionuclide should be decayed for the travel time to the aquifer. Radionuclide decay and the decayed activity for the period of interest should be evaluated and used in the determination of whether a COC should be carried forward for further remedial evaluation.

2.8 Presence in Groundwater (contaminant migration consideration only)

This category is used to evaluate whether groundwater sampling results corroborate the contaminant migration modeling predictions. For example, if the model predicts that a contaminant should be present in groundwater 10 years after it was disposed to the soils and the empirical groundwater data indicates it is not present although disposal took place 40 years ago, retaining the COC for further remedial evaluation is viewed with greater uncertainty. The presence or absence of the contaminant in actual groundwater sampling results should be evaluated and used in the determination of whether a COC should be carried forward for further remedial evaluation.

PROTOCOL

GROUNDWATER MONITORING REPORTS

Introduction

This protocol has been developed in order to support the Savannah River Site Environmental Restoration Division. This protocol applies to the preparation of quarterly, semi-annual and annual groundwater monitoring reports.

Details

Groundwater Monitoring Repots are reports that document groundwater-monitoring activities, summarize data results, and discuss interpretations of the data. Reports are issued for individual groundwater management units and the contents and schedules for each unit vary. The report for a particular unit will be prepared in accordance with the specific governing regulatory document (i.e., permit IIIB.H11.b or c, or other regulatory document) for a specific unit.

Requirements

The following basic requirements shall be defined within each unit report. (There may be additional/special requirements defined in each unit's permit or regulatory document).

1. Current and historical water elevation and water quality data in table form for all constituents detected (include data from at least the previous three (3) sampling events);

2. Hydrographs for all wells depicting groundwater elevations through time (clustered wells should be shown on a single graph);

3. Time versus concentration plots for each point of compliance and plume definition well identified per unit permit and depicting the unit constituents of concern (data from clustered wells should be shown on a single plot);

4. Isoconcentration maps depicting the constituents of the unit for each hydrologic unit, except for wells abandoned for greater than one (1) year. Maps for each hydrologic unit shall include the location of all Point-of-Compliance (POC), plume definition, and background wells identified by the unit permit which are screened within the hydrologic unit depicted. The locations of recovery wells in the vicinity are to be included on all isoconcentration maps;

5. Potentiometric maps depicting groundwater flow direction of the unit for each hydrologic unit. Maps for each hydrologic unit shall include the location of all POC, plume definition, and background wells identified by the unit permit and which are screened within the hydrologic unit depicted. The locations of recovery wells and production wells in the vicinity are to be included on all potentiometric maps;

6. Recharge data (inches of rainfall during the reporting period);

7. Discussion of proposed and/or implemented modification to the groundwater monitoring system.

Report Content

A. Introduction – As directed by the RCRA Permit/FFA (SCDHEC), the introduction shall provide a description of the facilities and shall include information on groundwater monitoring and corrective action for the facilities.

B. Executive Summary – This section depicts the sampling to determine groundwater constituents and pint-of-compliance (POC), background, and plume definition wells, as well as the time period (quarter) that sampling was performed. The constituents that exceeded the Groundwater Protection Standards (GWPS) or Monitoring Constituent Standard (MCS) are identified in the Executive Summary. In addition wells which contained elevated constituents and wells that were not sampled (and the reason) are identified.

C. Analytical Results- Analytical results are usually submitted in tabular form and include sample or batch specific quality assurance/quality control information defined by data modifiers (also to as qualifiers) which can be a key component assessing data usability. The lettered modifiers are bas3edibn EPA's Storet codes and are provided to the primary laboratories by EPD/EMS. The modifiers appear in the data tables under the column Mod.

D. Figures – Figures typically depict the location of the monitoring wells with their corresponding well number. Cross-sections, when require, provide geologic information relative to soil layers surrounding a particular well. Plume maps show the known area of extent of a contaminant.

E. Tables – Tables may be used to display analytical data as well as other types of data including average water elevation, flow rate, rainfall and recharge for a facility.

F. Appendixes – Supporting information is included in the appendixes and may include Groundwater Protection Standards, time series plots depicting concentrations over a period of time, and hydrographs depicting water elevations over a period of time.

INTERNAL SRS PROTOCOL

Development, Review and Approval of Pre-Work Plan Sampling and Analysis Plan

Introduction

The following protocol has been developed in order to support the Savannah River Site (SRS) Environmental Restoration program. This protocol provides instructions for the development, review and approval of sampling and analysis plans for the collection of pre-work plan characterization data. The protocol is intended to promote the optimization of data collection for use in the Resource Conservation and Recovery Act (RCRA) Facility Investigation/Remedial Investigation (RFI/RI) and Baseline Risk Assessment (BRA) process.

Pre-work plan characterization is the work performed to learn about a unit in order to prepare a formal RFI/RI work plan. The sampling and analysis plan for this phase of the work should be based on a well thought out concept of exposure pathways as documented in a preliminary conceptual site model (CSM).

Data from this sampling and analysis will be used to (1) determine the nature and extent of contamination at the unit, (2) perform an ecological risk assessment, and (3) begin the process of formulating a hydrogeologic conceptual model in support of groundwater modeling for the unit.

Details

A preliminary CSM must be developed as a part of each pre-work plan sampling and analysis plan. All sampling and analysis plans developed for the purpose of collecting pre-work plan characterization data shall be prepared, reviewed, and approved by personnel serving on the project team that are responsible for the following technical aspects of the project:

- Site Characterization
- Human Health Risk Assessment
- Ecological Risk Assessment
- Fate and Transport
- Feasibility Studies
- Remedial Design
- Technical Lead

The review shall be documented with a formal review/approval sign-off sheet attached to the sampling and analysis plan.

PROTOCOL

Groundwater Modeling in the RCRA/CERCLA Process

Introduction

The following protocol has been developed to provide guidance for groundwater modeling for the Savannah River Site Environmental Restoration Program. This protocol is intended to provide guidance that will promote consistency in the application of groundwater modeling in the Work Plan, RFI/RI/BRA, and CMS/FS stages of the RCRA/CERCLA process. The objective is to develop a technically defensible and accurate modeling tool during the RFI/RI/BRA stage for predicting contaminant plume configurations in the future (rather than a snap shot in time), use the model to assess the need for early action, and then evaluate the proposed remedial strategies during the CMS/FS stage.

Details

Work Plan Stage

The need for groundwater modeling should be evaluated early in the RCRA/CERCLA process beginning with the Work Plan stage. Input from the modeling lead should be solicited at this time. Evaluating potential modeling needs at the Work Plan stage will allow for the collection of the necessary data and will reduce the uncertainty in model predictions. Therefore, the quality and quantity of these data must be sufficient for construction of a model that responds in a manner that is consistent with the physical system.

RFI/RI/BRA Stage

Groundwater modeling is required as part of the RFI/RI/BRA if groundwater contamination in excess of MCLs has been identified or if future groundwater contamination is imminent, as determined by the core team. The purpose of performing modeling in the RFI/RI/BRA stage of an operable unit (OU) is to identify data gaps that may exist in the characterization, predict what the plume will look like in the future, and assess the need for early action. Groundwater modeling is required only for the refined groundwater Constituents of Concern (COCs); however, modeling of other constituents may be included on the basis of parent/daughter relationships with the refined COCs, potential future threat to groundwater, etc. The following steps describe the modeling approach and documentation of the modeling effort performed during this stage of the RCRA/CERCLA process.

Step 1. Develop a Hydrogeologic Conceptual Model

The hydrogeologic conceptual model (HCM) is a simplified representation of the groundwater flow system, frequently in pictorial form that defines the hydrostratigraphic units of interest and all system boundaries. The HCM involves delineation of groundwater sources and sinks, expected flow directions, model discretization (in terms of space and time), and selection of appropriate computer code(s). The HCM and modeling code will be discussed with technical team members from each agency at an HCM meeting. The results of the HCM meeting will be presented to the core team for approval at the Post Characterization Scoping Summary meeting.

To design the model, it is necessary to specify the model type (i.e., 1D, 2D, or 3D) that bests suits the objectives of modeling, the data set available, the model domain and the conditions encountered at the site. Once the model type has been specified, it is possible to discretize the model domain in time and space. One goal of model design is to simplify the system so it can be analyzed by reasonable means.

Normally, modeling performed as part of the RFI/RI/BRA shall use codes available in the Department of Defense Groundwater Modeling System (GMS). The US EPA and SCDHEC have accepted GMS for use at the SRS. When needed for special modeling tasks, SRS will obtain approval from US EPA and SCDHEC for use of other groundwater modeling codes that are not part of the GMS suite of codes. This is exclusive of parameter estimation codes used for model calibration (such as PEST or HydroFACT), or for quantifying the uncertainty in model predictions. The modeling codes to be used will be discussed at the HCM meeting and a technical recommendation will be presented to the core team for approval. The modeling lead for the respective teams have the responsibility for preparing and presenting the ER position to the core team.

Step 2. Calibrate the Model

The calibration of a groundwater flow model is the process of adjusting hydraulic parameters, boundary conditions and initial conditions within reasonable ranges to obtain a match between observed and simulated potentials, flow rates, and other calibration targets. The range over which model parameters and boundary conditions may be varied is determined by data presented in the conceptual model. In the case where parameters are well characterized by field measurements, the range over which that parameter is varied in the model should be consistent with the range observed in the field. The degree of fit between model simulations and field measurements can be quantified by statistical means. The following paragraphs describe the steps to be taken for calibration of the model.

Prior to calibration of the groundwater flow model appropriate calibration targets are selected from the available head data or other field data. The calibration criteria are then defined, providing the rationale for establishing when a model is calibrated and when calibration

efforts should be terminated. The appropriate rationale for establishing acceptable quantitative calibration target residuals and residual statistics for analyzing model error (how well the model simulates the physical system) depends on several factors: the degree of natural heterogeneity or complexity of boundary conditions; location, number and accuracy of water level measurements; and the model purpose. The acceptable residual should be a small fraction of the difference between the highest and lowest heads across the site and be based on:

- The magnitude of the change in heads over the problem domain in the specific area(s) of interest;
- The ratio of the Root Mean Squared (RMS) error to the total head loss should be small;
- Head differential of <5% for the residual mean and standard deviation, and <10% for the ratio of the standard deviation to total head change.
- Krig the measured hydraulic head distribution to produce unbiased estimates of variance (standard deviation) as a function of location in the model domain.

After calibration, the coefficients of variation as well as the differences between calibrated targets and simulated heads and fluxes shall be presented in the model documentation. A modeling report shall be prepared to provide a discussion of the calibration procedure, changes in initial parameter estimates, and the sensitivity of the model to these changes.

Step 3. Perform Calibration Sensitivity Analysis

The purpose of calibration sensitivity analysis is to quantify the sensitivity of the calibrated model to changes in the estimates of aquifer and confining unit parameters, stresses and boundary conditions (i.e. the goal is to identify model inputs that have the most influence on model calibration and predictions). The magnitude in the changes in parameters should be based on estimates of uncertainty in the parameter values. During the CMS/FS process (discussed below), uncertainty analysis is performed to assess the effect of uncertainty on model predictions using the calibrated model.

At a minimum, the following parameters will be considered in the calibration sensitivity analysis: hydraulic conductivity, recharge, K_d, dispersivity, and porosity. Other inputs (such as boundary conductance or heads) that are likely to effect the computed head, groundwater flow rates and mass flux of contaminants may be varied as appropriate. The primary parameters to use in the sensitivity analysis will be discussed and decided on by the core team at the Post Characterization Scoping Summary meeting. The sensitivity of each parameter to the model solution is evaluated by looking at residuals (observed value minus the predicted value) and calibration statistics in tabular and graphical forms (comparing objective functions and residuals vs. perturbation multipliers) and using maps with residual postings.

Step 4. Document the Modeling Effort

A stand-alone document will be prepared which documents the detailed assumptions, inputs, sensitivity analysis and evaluation of the model limitations. The Executive Summary of this document shall be written in sufficient detail, so that it can be incorporated in Chapter 6 of the RFI/RI/BRA Report.

CMS/FS Stage

In the CMS/FS stage, the groundwater model may be revised to include any new data that was collected that may aid in reducing the uncertainty in model predictions. Also, proposed remedial alternatives will be studied and compared based on the developed remedial alternatives conceptual model (RACM), as required. The RACM consists of a short summary and description of how each remedial alternative being considered in the CMS/FS will be modeled. THE RACM will also include justification for any groupings of alternatives in the modeling. The modeling of the proposed remedial alternatives will be performed in a manner similar to the steps defined above for the RFI/RI/BRA stage. Typical uses for modeling at the CMS/FS stage are to evaluate combinations of active and passive remedial alternatives, to analyze changes in plume dynamics (e.g., accelerating/retarding contaminant transport, contamination of other areas, etc.) and to predict aquifer restoration time. The remedial alternatives to be modeled will be discussed, and agreed to, by the technical team members from each agency. The results of the RACM meeting will be presented to the core team at the FS Scoping meeting.

Uncertainty associated with modeling predictions for remedial alternatives will be studied and presented in the CMS/FS. The uncertainty is a deviation between model predictions because of incomplete knowledge about head distribution, aquifer parameters and/or hydrologic stresses. Sources of uncertainty in model predictions are usually; 1) conceptual uncertainty – unsure of the physical processes occurring, 2) model derived uncertainty – the modeling approach is a simplified representation of reality, and 3) parameter uncertainty – unsure of the modeling parameter values used in the model.

The Monte Carlo Analysis approach will be used for assessing prediction sensitivity (uncertainty) analysis. Monte Carlo Analysis involves running many realizations or scenarios (random combinations of parameters) and comparing predictions or results for those realizations that are reasonable (within realistic ranges for the parameters) and remain in calibration. The parameter uncertainty, correlations (if any), expected Monte Carlo realizations, and predicted values for will be specified in the RACM for each remedial alternative.

The uncertainty will be studied for the “base case” (i.e., natural attenuation), and for each proposed remedial alternative. The results should be summarized and compared by studying calibration residuals and statistics in tabular and graphical forms. Also, the predicted values for each scenario will be summarized and compared for selected observation points within the model domain.

A stand-alone document that describes the modeling performed for the remedial alternatives will be prepared with the results being incorporated and evaluated in the CMS/FS.

PROTOCOL

Unit-Source Data Processing

Introduction

The following protocol has been developed in order to support the Savannah River Site environmental remediation program. The protocol applies to the processing of data for use in the RFI/RI/BRA report.

This data processing protocol will be applied to each unit-source exposure group as specified in the Development of Exposure Groups protocol. An exposure group, abbreviated as 'EG', is the term used to refer to the set of data that will be used to calculate the exposure point concentration for a given media of potential concern.

Details

A. Determine Unit-Source Maximum Values

For each constituent in each exposure group for the unit-source samples, determine the maximum value from the detected concentrations only. Designate the value as the unit-source maximum value for the exposure group.

B. Calculate Unit-Source Average Values

For each constituent in each exposure group of unit-source samples, determine the arithmetic average value of all samples using a surrogate value for the non-detects. The Surrogates for Non-Detects Protocol provides further information for the use of surrogate values for non-detects.

C. Reasonable Maximum Exposure (RME) Values

1. Determine the UCL 95 value[1].

2. For each constituent in each exposure group for the unit-source samples, compare the UCL 95 value and the maximum value. Designate the lower of these two as the unit-source RME concentration for that constituent in that exposure group.

[1] "Supplemental Guidance to RAGS: Calculating the Concentration Term.", EPA Publication 9285.7-081, May 1992. The UCL 95 value is at the 95'th percentile upper confidence level of the population mean.

PROTOCOL

Unit- Background Data Processing

Introduction

The following protocol has been developed in order to support the Savannah River Site environmental remediation program. This protocol applies to the processing of unit-background data for use in the RFI/RI/BRA report.

This data processing protocol will be applied to each background exposure group as specified in the Development of Exposure Groups protocol. An exposure group, abbreviated as 'EG', is the term used to refer to the set of data that will be used to calculate the exposure point concentration for a given media of potential concern.

Details

A. Determine Unit-Background Maximum Values

For each constituent from the unit-background samples, determine the maximum value from the detected concentrations only. Designate the value as the unit-background maximum value.

B. Calculate Unit-Background Average Values

For each constituent from the unit-background samples, determine the arithmetic average value of all samples using a surrogate value for the non-detects.

If there are no detects for the constituent, assign a value equal to zero.

C. Calculate Unit-Background Reasonable Maximum Exposure (RME) Values

1. Determine the UCL 95 value[1].

2. Compare the UCL 95 value and the maximum value. Designate the lower of these two as the unit-background RME concentration for the exposure group.

[1] "Supplemental Guidance to RAGS: Calculating the Concentration Term.", EPA Publication 9285.7-081, May 1992. The UCL 95 value is at the 95'th percentile upper confidence level of the population mean.

PROTOCOL

Surrogates for Non-Detects

Introduction

The following protocol has been developed in order to support the Savannah River Site environmental remediation program. The protocol applies to the processing of **non-radionuclide** data for use in the RFI/RI/BRA report. Method Detection Limits (MDLs) are commonly used as surrogates for nondetects of metals in water samples. However, for some analyses, a corrected MDL (cMDL) should be used. cMDLs should be used for soil metal determinations.[1]

Note that for background samples without any detects, the concentration value should be set equal to zero.

The cMDL takes into account sample preparation factors (SPF). The decision as to whether the MDL or cMDL should be used is made on a case-by-case basis.

Details

A. Surrogates for Samples Without SPFs

Use a surrogate value equal to one-half of the method detection limit (MDL).

B. Surrogates for Samples with SPFs

Use a surrogate value equal to one-half of the corrected method detection limit (cMDL).

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[1]EPA Guidance for Data Useability in Risk Assessment, Interim final (EPA/540/G-90/008, October 1990).

An example of the use of the SPF to determine a cMDL is shown below.

EXAMPLE

Consider the determination of arsenic using an Inductively Coupled Plasma (ICP) technique from one of the laboratories used to support the RFI/RI/BRA investigation. The MDL for arsenic for the instrument in this example is 0.04 mg/L.

When a sample of soil is sent to this laboratory, it is prepared for analysis by treating a measured quantity of soil (1 gram) in a 15 ml volume of acid at elevated temperature. This acid solution is then centrifuged to settle solids. The remaining solution is then diluted up to 50 ml with clean water. A small portion of this solution is injected into the analytical instrument for measurement of the analyte concentration.

The sample preparation factor (SPF) for this example would be 50 ml / 1.0 gram (which equals 50 L/kg). Therefore, if the reading from the instrument was 10 ppm, which equals 10 mg/L, then this concentration is multiplied by 50 L/kg and the concentration in the soil would be reported as 500 mg/kg.

In order to correct the MDL for the SPF, a similar mathematical correction must be performed. Since the MDL for this instrument was 0.04 ppm (which is 0.04 mg/L) then the cMDL would be 0.04 mg/L multiplied by 50 L/kg and the result would be 2 mg/kg as shown in Table 1 below:

Table 1. Detection Limits for Arsenic in Soils by ICP

MEANING	ACRONYM	VALUE	UNITS
MDL	MDL	0.04	mg/L
Corrected MDL	cMDL	2	mg/kg

PROTOCOL

Unit-Specific Constituents

Introduction

The following protocol has been developed in order to support the Savannah River Site environmental remediation program. This protocol addresses the identification of unit-specific constituents (USCs). The exposure groups to be used in this process have been described in the Exposure Group Protocol. This process is intended to be used after application of the Unit-Background Data Processing Protocol and the Unit-Source Data Processing Protocol.

Details[1]

1. For each constituent in each unit-source exposure group[2], compare the unit-source maximum concentration to twice the unit-background average concentrations. In a table, identify the unit-source maximum concentration as either greater than twice the unit-background concentration or less than the twice the unit-background concentration. Those constituents whose unit-source maximum concentrations are greater than twice the unit-background concentration are labeled as Unit Specific Constituents (USCs).

2. Based on professional judgment, prepare planar maps, cross-sectional plots, or other illustrations for each USC in each exposure group which will be useful in illustrating the nature and extent of contamination at the unit. At a minimum, plots will be provided for each constituent which is identified as a *preliminary* COC (ARAR, HH, CM, ECO)[3]. It is expected that data for all preliminary COCs will be interpreted. The nature and extent of contamination summary and conclusions will provide the method of managing uncertainty where interpretation is not possible based on inadequate data quality or quantity.

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[1] Note that the USC screening is used for nature and extent discussion and for contaminant migration analysis. It is not used as the basis for risk analysis.

[2] For the soils medium, use only the 0 to WT exposure groups for the unit-source and the unit-background.

[3] Preliminary COC – constituents found at the unit that have undergone detailed analysis and have been found to present a potential threat to human health and the environment.

PROTOCOL

ARAR Constituents of Concern

Introduction

The following protocol has been developed in order to support the Savannah River Site environmental remediation program. This protocol provides instructions for the analysis of unit-source data for contaminant concentrations, which exceed concentration-based *applicable or relevant and appropriate requirements* (ARARs). These constituents will be identified as ARAR *preliminary* constituents of concern (ARAR COCs).

Details

1. Identify all ARARs for the unit. At a minimum, this list will contain all of the MCLs[1] for groundwater, the AWQSs[2] for surface waters, and the soil limits for PCBs and lead.

2. For each exposure group, compare the unit-source maximum value to the ARAR value. If the unit-source maximum concentration is greater than the ARAR value, identify the constituent as a *preliminary* ARAR COC for that exposure group. Drop the constituent from further consideration if it is less than the screening value.

3. The constituents retained to this point in the process, identified as *preliminary* ARAR COCs, will be carried forward in the RFI/RI/BRA report for uncertainty analysis and the development of remedial goals, if appropriate.

[1] Maximum Contaminant Levels
[2] Ambient Water Quality Standards

PROTOCOL

ARAR Remedial Goal Options

Introduction

This protocol, developed in order to support the Savannah River Site environmental remediation program, provides instructions for the identification of ARAR remedial goal options (ARAR RGOs). The starting point for this protocol is the list of *preliminary* ARAR constituents of concern (ARAR COCs).

Details

First, perform an uncertainty analysis in order to evaluate such factors as the CSM, probable conditions, frequency of detection, site history, and data quality for each *preliminary* ARAR COC. Consider whether the amount of uncertainty in the analysis is too large to warrant retention of the COC. If the COC is not to be retained, provide a detailed discussion in the uncertainty section of the RFI/RI/BRA. Those COCs which are retained are placed on a *refinedl* list of ARAR COCs.

Next, remedial action objectives (RAOs) will be developed for the unit. The appropriate RGOs will be developed for ARAR COCs remaining after the uncertainty analysis.

PROTOCOL

Contaminant Migration Constituents of Potential Concern

Introduction

The following protocol has been developed in order to support the Savannah River Site environmental remediation program. This protocol provides instructions for the development of a list of contaminant migration constituents of potential concern (CM COPCs). It is used to identify constituents that have the potential to migrate from vadose zone soils and into groundwater. This protocol is intended to be used after application of the Unit-Specific Constituents screening. The list of USCs determined in Chapter 4 is the starting point for this analysis.

This protocol is to be applied to all constituents, including radionuclides, except for the following constituents (calcium, chloride, iodine, magnesium, phosphorous, potassium, sodium). These constituents are excluded because they are essential nutrients that are not considered to be toxic and do not have health based limits.

Considerations of contaminant migration are limited to a time frame of 1000 years because, as explained in NRC guidance documents and existing regulations, there is a very large uncertainty associated with predicting conditions beyond this time frame.[1,2,3,4] As needed, additional information from EPAs Soil Screening Guidance[5] is referred to in this protocol, however, it is not repeated in the protocol.

[1] NUREG 1500, Working Draft, "Regulatory Guide on Release Criteria for Decommissioning: NRC Staff's Draft for Comment, August 1994.

[2] DG-8017, "Radiological Criteria for Decommissioning: Dose Calculations and Surveys", Draft, September 21, 1995.

[3] 10 CFR 20. 1997. "Radiological Criteria for License Termination". Code of Federal Regulations.

[4] 40 CFR 192. 1983. "Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings". Code Of Federal Regulations.

[5] "EPA Soil Screening Guidance, Technical Background Document", EPA/540/R-95/128, May 1996.

Details

A. Determination of Unit-Specific Dilution Attenuation Factors (DAF)

Determine a unit-specific DAF using unit-specific input parameters as defined by EPAs Soil Screening Guidance.

B. Calculation and Selection of Unit-Specific Soil Screening Levels

Using the unit-specific DAF value, calculate both a standard SSL and a mass-limit SSL for each constituent. Refer to the EPA Soil Screening Guidance for instructions on how to perform the calculations.

Select the appropriate unit-specific SSL based on understanding of the CSM.

An appropriate surrogate constituent may be substituted if constituent specific information is not available.

C. Comparison of Maximum Value to Unit-Specific SSL Screening

Compare the unit-source maximum value to the unit-specific SSL. Identify the constituents as either passing through this screen or being retained by it.

D. RME Determination Based on CSM

Examine the conceptual site model and empirical data and determine the appropriate RME source term value. (e.g., should the RME be based on the entire soil column [0 to WT] or on a subset representing a hot spot.)

E. Comparison to Unit-Specific SSL Screening

Compare the unit-source RME value to the unit-specific SSL. Identify the constituents as either passing through this screen or being retained by it.

Examine the results of the screening for consistency with what is known about the site. In particular, determine if the contaminants which are predicted to be in the groundwater are present and if there are contaminants present in the groundwater which are not expected based on current soil concentrations.

F. CM COPC List

The constituents retained to this point in the process are identified as CM COPCs. They will be carried forward into a more detailed analysis of contaminant migration which will utilize an appropriate model to determine the expected groundwater concentrations over time. If no CM COPCs have been identified at this point, then the contaminant migration analysis is complete.

PROTOCOL

Contaminant Migration

Constituents of Concern

Introduction

The following protocol has been developed in order to support the Savannah River Site environmental remediation program. The starting point for this protocol is the contaminant migration technical analysis, which consists of using an appropriate fate and transport model to determine the expected groundwater concentration over time. The purpose of this protocol is to determine the constituents, which will be identified as *preliminary* contaminant migration constituents of concern (CM COCs).

Details

1. From the modeling performed for the technical analysis, develop a plot of groundwater concentration over time. Indicate on the plot the appropriate MCL and RBC values for the constituents under review.

2. Determine if the concentration over time exceeds an MCL. If so, then designate the constituent as a *preliminary* CM COC.

3. If there is not an MCL, go to the next step.

4. Determine if the concentration over time exceeds a RBC for tap water. If so, then designate the constituent as a *preliminary* CM COC.

PROTOCOL

Contaminant Migration Remedial Goal Options

Introduction

This protocol, developed in order to support the Savannah River Site environmental remediation program, provides instructions for the identification of contaminant migration remedial goal options (CM RGOs). The starting point for this protocol is with the list of *preliminary* contaminant migration constituents of concern (CM COCs) developed in the fate and transport analysis using an appropriate fate and transport model to determine the expected groundwater concentration over time.

Details

First, perform an uncertainty analysis in order to evaluate such factors as the CSM, probable conditions, frequency of detection, site history, and data quality for each *preliminary* CM COC. Consider whether the amount of uncertainty in the analysis is too large to warrant retention of the COC. If the COC is not to be retained, provide a detailed discussion in the uncertainty section of the RFI/RI/BRA. Those COCs, which are retained, are placed on a *refined* list of CM COCs.

Next, remedial action objectives (RAOs) will be developed for the unit. The appropriate RGOs will be developed for refined CM COCs remaining after the uncertainty analysis.

In order to back-calculate the RGOs, perform the next two steps, in order, as needed.

1. For constituents with MCLs, back calculate CM RGOs by determining the soil concentration, which would be, needed in order to prevent any exceedences of the water MCL. This concentration becomes the RGO. If there is not an MCL, go to the next step.

2. Back calculate the soil concentration which would be needed in order to provide protection of groundwater to the following cancer risk levels - 1E-4, 1E-5, and 1E-6 for carcinogens and hazard quotients of 0.1, 1, and 3 for non-carcinogens.

PROTOCOL

CUMULATIVE CONTAMINANT MIGRATION

The following describes SRS's approach to evaluate the impact of cumulative contaminant migration (CM) in groundwater from units in proximity to each other. The cumulative impact will be evaluated by preparing a list of preliminary CM constituents of concern (COCs) from each unit. The basic approach to be applied is as follows:

1) Concentration-Based Standards. For any constituent that has a concentration-based regulatory limit for groundwater, any preliminary CM COC from any of the individual basins will be listed as a preliminary CM COC for the basins as a group. The regulatory limits include maximum concentration limits (MCLs) and risk-based concentrations or activities. Concentration-based standards includes metals, organics, inorganics and alpha-emitting radionuclides. The MCL for gross alpha particle activity is 15 pCi/L, exclusive of radon and uranium. Additionally, if the gross alpha particle activity is greater than 5 pCi/L, the activity of radium-226 and radium-228 must be determined.

2) Dose-Based Standards. The principal exception from concentration-based standards beta-emitting radionuclides. Gross beta particle activity is a dose-based MCL to which a suite of radionuclides may contribute, Safe Drinking Water Act, (40 CFR 141.16). The average annual dose of beta particle and photon radioactivity from man-made radionuclides in drinking water shall not produce an annual dose equivalent to the total body or an internal organ greater than 4 mrem/year).

3) CONSTITUENTS WITH **CONCENTRATION-BASED STANDARDS**

For constituents with concentration-based regulatory limits, there is no additive increase to groundwater contamination from adjacent units since the maximum predicted groundwater concentration from any single basin would not be exceeded by the combined leachate from all the basins due to dilution. The combined outcome is controlled by the volume and concentration mixing ratios as presented in the equation:

$$C_1V_1 + C_2V_2 = C_3V_3$$

where:

C_1 = the predicted concentration below unit 1

V_1 = the volume of the leachate below unit 1

C_2 = the predicted concentration below unit 2

V_2 = the volume of the leachate below unit 2

C_3 = aggregated concentration at a well in close proximity to unit 1 and 2

V_3 = the total volume of leachate below the aggregated units

Solving for C_3 (the aggregated concentration):

$$C_3 = \frac{C_1V_1 + C_2V_2}{V_3}$$

The total leachate volume is equal to the sum of the two leachate volumes, so

$$V_3 = V_1 + V_2$$

Substituting,

$$C_3 = \frac{C_1V_1 + C_2V_2}{V_1 + V_2}$$

As indicated by this equation, the aggregated concentration (C_3) will not exceed the maximum concentration from the particular unit contributing the highest concentration (Cmax). Attachment A provides a visual representation of the above. Thus, constituents with concentration-based regulatory limits can be dropped from the cumulative analysis.

DOSE-BASED REGULATORY STANDARDS

For those constituents with a dose-based MCL, i.e, beta-emitters, separate radionuclides could contribute to a combined dose or radioactivity that exceeds the level of the individual radionuclides. Therefore, it is appropriate to sum the activities of beta-emitting radionuclides in the modeled release to determine if the total dose exceeds regulatory limits. The applicable MCL is the 4 mrem/year limit for beta-emitting radionuclides in groundwater. The process for evaluating the additive effect is described below.

The cumulative effect of the constituents with a dose-based limit is evaluated to determine if the combined release will result in an exceedance of the regulatory standard for groundwater.

Consideration is given to those constituents that were identified as CM-COPCs and are predicted to reach the water table within 1,000 years. To assess the effect from beta-emitting radionuclides that appear at more than one unit, only the maximum predicted groundwater activity for a given radionuclide from each waste unit in the group would is selected. Adding the dose, utilizing the maximum predicted activities for each radionuclide from all units, will provide the most conservative estimate of the total radioactivity that could be released in the groundwater. Beta-emitters present in the aquifer at the current time, also need to be factored into the summation as well as any modeled releases. This assumption is only valid if the waste units are oriented parallel to the groundwater flow direction and are adjacent to each other, and if leachate below all units would actually mix into a co-mingled plume.

If the additive groundwater activities exceed the regulatory standard, the data is re-evaluated to assess predicted travel times from the bottom of the waste unit through the vadose zone to the aquifer. The dose of each of the predicted radionuclides (if they are ever present in the groundwater simultaneously) are summed to determine their combined activities and then compared to the regulatory standard.

If consideration of the temporal effects on leachate activities still indicates a potential problem, the scenario is re-evaluated to determine which exposure units actually lie parallel to the groundwater flow path. The data would be re-sorted for only those units that have the potential to successively contribute leachate to a single volume of groundwater, i.e. a co-mingled plume. Attachment B is a flow chart depicting the process of addressing dose as a result of contaminant migration from units in proximity to one another.

The doses resulting from all the manmade beta-emitting radionuclides cannot exceed 4 mrem/yr. The concentrations of the more important manmade isotopes that result in a 4 mrem/yr dose have previously been calculated by USEPA (USEPA, Radioactivity in Drinking Water, EPA-570/9-76-003, Appendix III, January 1981).

Consider the following example. Two waste units are contiguous to one another. Both are oriented parallel to the groundwater flow direction. Modeling indicates that a hypothetical receptor well, in common and downgradient from both waste units, will yield the following results, as depicted in Tables 1 and 2.

Table 1. Example of Model Predictions for Concentrations and Travel Times

Beta-Emitting-CM-COPC	Predicted Maximum Concentration, pCi/L	Predicted Travel Time, years
Cesium-137	0	>1,000
Iodine-129	.2	4
Strontium-90	6	170
Technetium-99	180	5.5

Table 2. Example for Calculation of Additive Dose

Beta-Emitting-CM-COPC	Concentration, pCi/L	Concentration Yielding a Dose of 4 mrem/yr	Resulting Dose, mrem/yr
Cesium-137	0	200	0
Iodine-129	.2	1	.8
Strontium-90	6	8	3
Technetium-99	180	900	.8
Additive Dose			**4.6**

The equation used to calculate the dose for the individual radionuclide is:

$$C_w/E_q*4\text{mrem/yr} = \text{mrem/yr}$$

Where:

C_w = Radionuclide concentration in groundwater (pCi/L)

E_q = Radionuclide-specific 4 mrem/yr equivalent dose (pCi/L)

The additive dose is then calculated by summing the doses for each of the individual beta-emitting radionuclides.

Because the additive dose of beta-emitting radionuclides (4.6 mrem/yr) exceeds the regulatory standard (4 mrem/yr), a temporal analysis of the travel times must be performed to determine if any of the radionuclides will ever be present in the aquifer simultaneously. Please refer to the graph in Attachment C.

Temporal Analysis

Based upon the data in the graph (Attachment C) it will be noted that the Sr-90 dose is predicted to peak at 3 mrem/yr in approximately 180 years. Because no other beta-emitting radionuclides are present within the Sr-90 rise-fall time and the predicted peak does not exceed 4 mrem/yr, Sr-90 could not be considered a CM-COC. Similarly, no Cs-137 is predicted to leach to the aquifer, so it could not be considered as a CM-COC either.

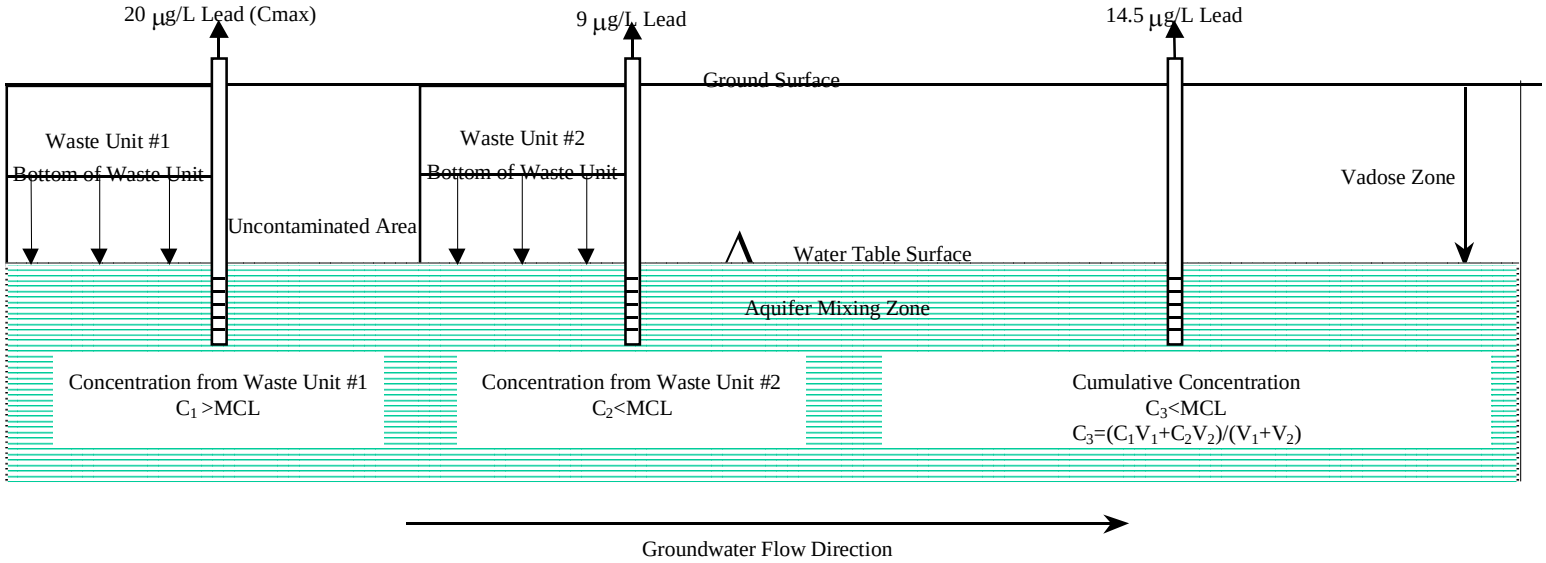
However, the temporal analysis of the rise-fall times for I-129 and Tc-99 indicate an overlapping of their respective curves. The midpoint of the overlap occurs at approximately 8 years when both I-129 and Tc-99 occur simultaneously within the aquifer. In this case, the temporal analysis requires that the two radionuclides be evaluated for additive dose to determine if the 4 mrem/yr regulatory standard is exceeded. Summing the maximum doses at the overlap will yield the maximum dose possible for contributions from both radionuclides. In this case, the additive dose is 1.2 mrem/yr, which still does not exceed the regulatory standard.

ATTACHMENT A: CUMULATIVE LEAD CONCENTRATIONS FROM ADJACENT WASTE

$$C_3 = \frac{C_1V_1 + C_2V_2}{V_1 + V_2}$$

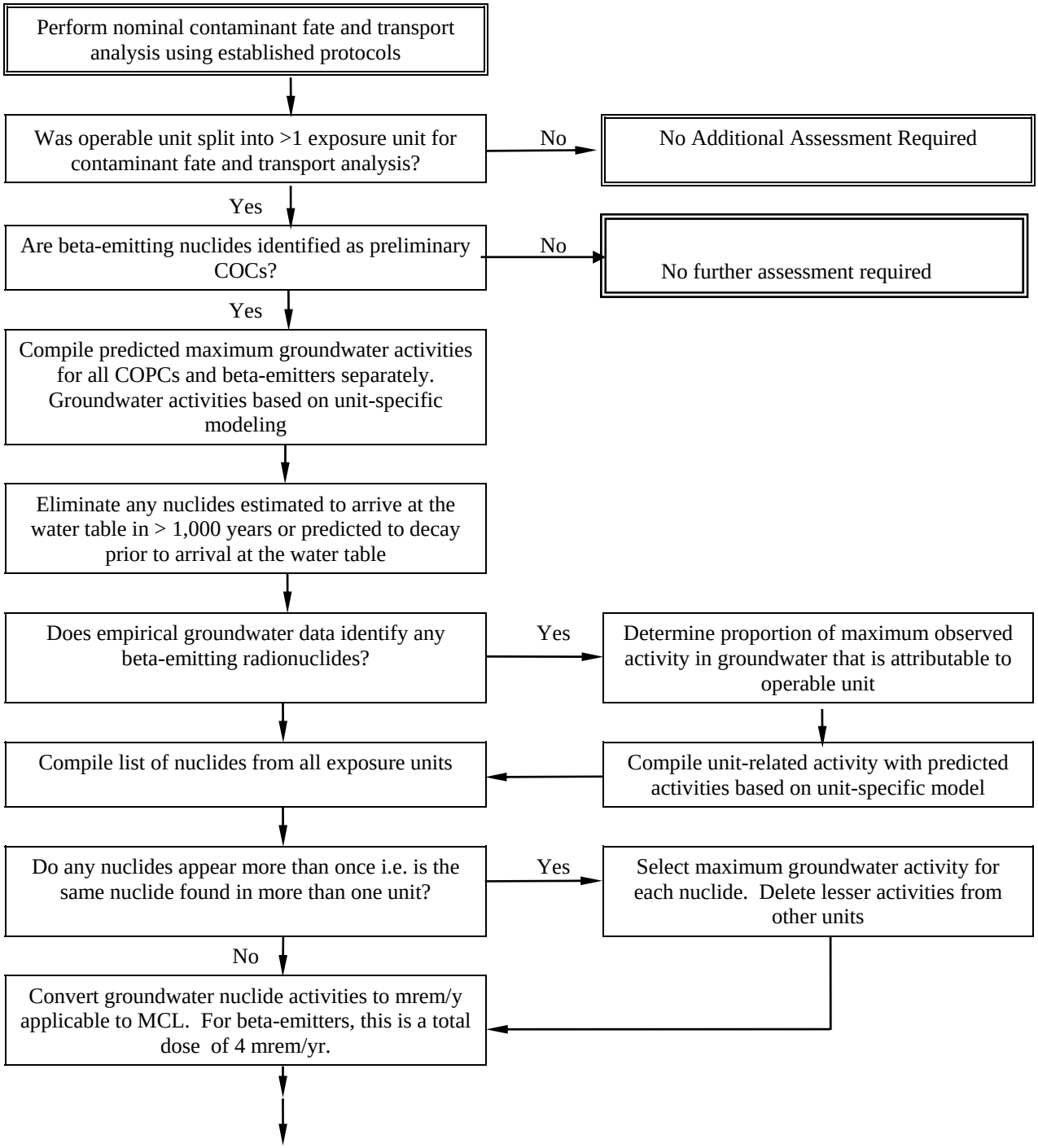
If:
C_1=20 μg/L
V_1=500,000 Liters
C_2=9 μg/L
V_2=500,000 Liters
C_3=14.5 μg/L

Background = 0.0 μg/L Lead
MCL = 15 μg/L Lead



CROSS SECTIONAL VIEW

ATTACHMENT B. DRAFT PROCEDURE FOR AGGREGATING CONTAMINANT FATE AND TRANSPORT ANALYSIS RESULTS FOR AN OPERABLE UNIT



Sum individual doses from beta-emitting nuclides or calculate total dose

Does total dose contributed by individual nuclides exceed MCL for beta-emitters?

No → Aggregated risk is below criteria. No additional preliminary COCs identified. No further assessment required.

Yes

Plot each nuclide as a function of time using predictions of unit-specific model, simplified model, or radioactive decay, as appropriate. Time period from 0 to 1,000 years

Produce cumulative curve based on summation of individual plots

Does predicted cumulative effect exceed MCL?

No → No Further Assessment Required.

Yes

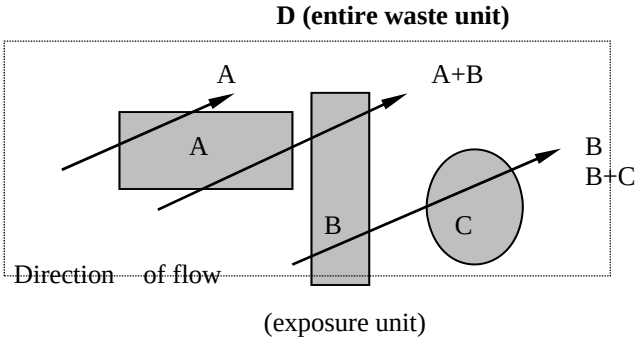
Based on direction of groundwater flow, determine which exposure units lie along a single groundwater flow path. These units have the potential to successively contribute leachate to a single volume of groundwater

Do all exposure units lie along a single groundwater flow path?

Yes → Aggregated predicted dose exceeds MCL. All contributing nuclides added to preliminary COC list.

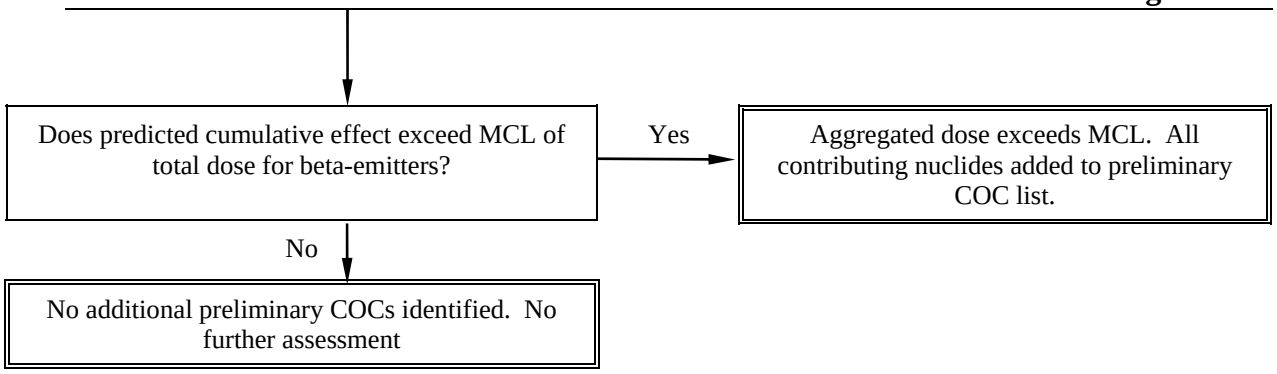
No

For distinct groundwater flow paths, determine exposure units that lie along flow path (see figure)

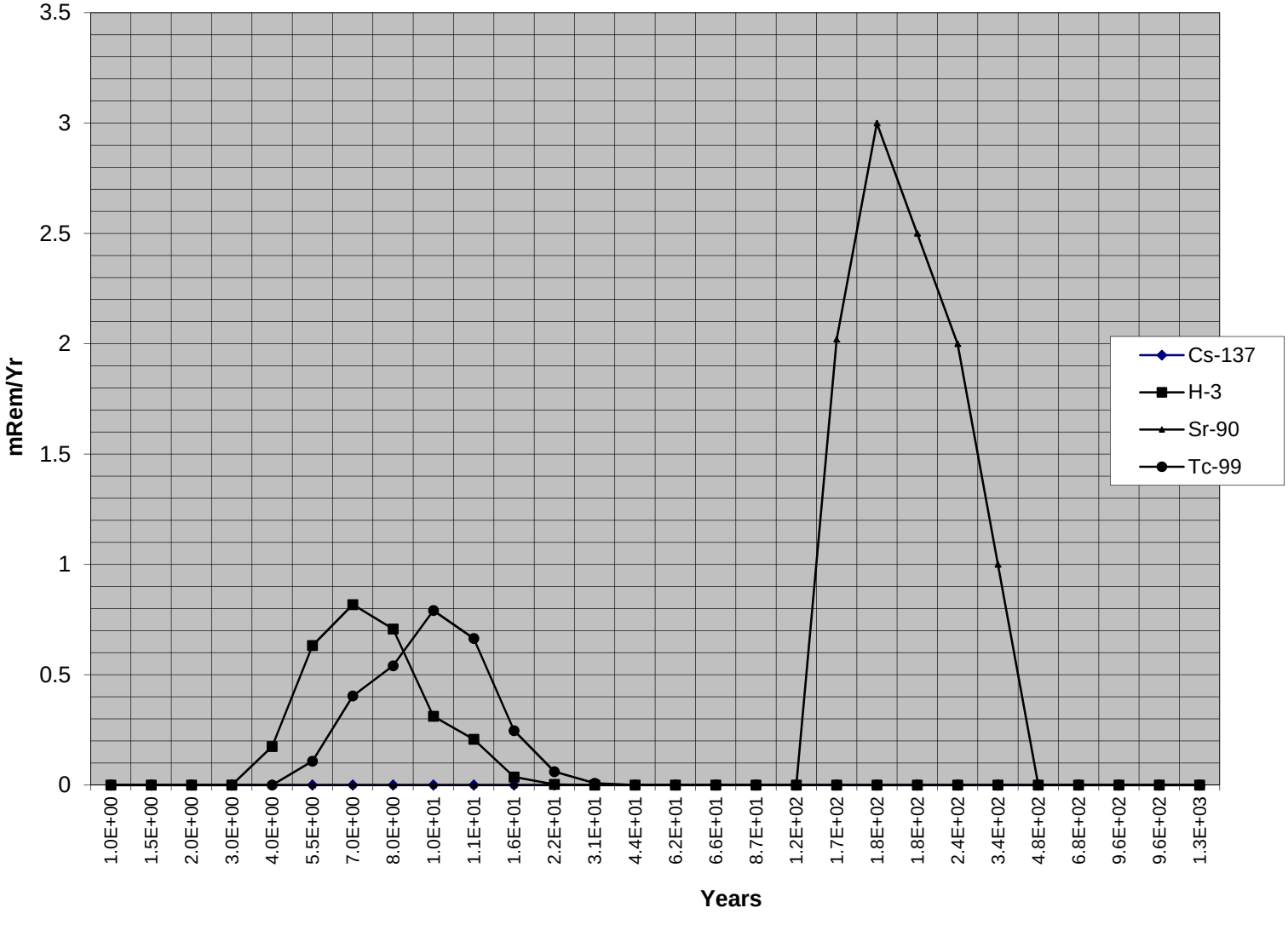


Segregate nuclides based on flow paths

Sum predicted nuclide doses for each flow path



Attachment C: Example of Additive Dose for Temporal Analysis



PROTOCOL

Human Health Constituents of Potential Concern

Introduction

This protocol has been developed in order to support the Savannah River Site environmental remediation program. It provides instructions for the identification of human health constituents of potential concern (HH COPCs). The protocol instructions are based on the latest available USEPA guidance and agreement from the staff of USEPA, SCDHEC, and USDOE as members of the Risk Assessment Design Team (RADT).

This protocol is considered the first step in the formal human health risk evaluation process. Ideally it is implemented after the exposure groups have been identified and the data appropriately processed in accordance with established protocols.

Preliminary remediation goals (PRGs) are risk-based tools used to evaluate potentially contaminated waste sites. PRGs are derived in accordance with the methodologies described in the Risk Assessment Guidance for Superfund (RAGS) documents published by USEPA. PRG concentrations (activities) are based on pathways for which generally accepted methods, models, and assumptions have been developed.

The most current USEPA Region 9 table is the source of the PRGs described in this protocol for nonradiological constituents; it combines current USEPA toxicity values with standard exposure factors to estimate contaminant concentrations in environmental media that the agency considers protective of humans. More detailed information can be found at the USEPA Region 9 website: www.epa.gov/region09/waste/sfund/prg/index.htm.

USEPA does not publish screening values for radiological constituents in a standardized table as they do for nonradiological PRGs. However, the Superfund radionuclide PRG website provides a database tool with which to derive risk-based PRGs using standard default parameters and the latest toxicity values; it also allows the user to modify input parameters to create site-specific PRGs. The PRGs for radiological constituents described in this protocol are developed using the USEPA Radionuclide PRGs for Superfund Electronic Calculator. The radionuclide PRGs will be revised whenever changes to the database tool significantly impact the PRG concentration. More detailed information can be found at the USEPA PRG Radcalculator website: http://epa-prgs.ornl.gov/radionuclides/.

Standardized reference tables that contain PRGs can be used in all stages of the risk-decision making process. The SRS risk assessment technical staff controls and maintains the PRG tables for use by Soil and Groundwater Closures Projects (SGCP).

Details

Figure 1 is a flowchart of the HH COPC selection process described below. Table 1 is a sample HH COPC screening table.

Step 1: DATA PREPARATION

Data for each constituent should be sorted by medium as described in the Development of Exposure Groups Protocol. Data should be processed in accordance with the Unit-Source Data Processing Protocol, Unit-Background Data Processing Protocol, and Surrogates for Non-Detects Protocol. For any data which have qualifiers, determine if the qualified data should be retained. Do not eliminate data based on "J" qualifiers.

Calcium, chloride, iodine, magnesium, phosphorous, potassium and sodium are excluded from further evaluation because they are essential nutrients that are not considered toxic and do not have health-based limits.

Step 2: PRG COMPARISON

Use the residential soil PRGs for the unit soil, sediment and concrete media, and the tap water values for groundwater and surface water. (Although it is recognized that exposure to concrete media should not be the same as soil media, the soil PRGs are used as a conservative screening step.)

For carcinogenic effects, compare the maximum concentration (activity) of each constituent in each exposure group to the $1x10^{-6}$ PRG concentration (activity).

For non-carcinogenic effects, compare the unit maximum concentration of each constituent in each exposure group to the hazard quotient (HQ) level of 0.1.

Retain the constituent for further analysis if its maximum value exceeds the appropriate PRG screening value The constituent is eliminated from further evaluation if its maximum value is less than the PRG screening value.

If PRG values are not available, then determine if a surrogate value can be used. If an appropriate surrogate value can be identified, then implement this step of the protocol. If no surrogate values can be determined, carry the constituent forward to the human health constituent of concern (HH COC) list.

Determine if the constituent is naturally occurring or anthropogenic. Anthropogenic constituents that exceed the PRG screen will be identified as HH COPCs (Step 5) and carried forward through a more detailed analysis of human health risk. Naturally occurring constituents that exceed the PRG screen shall proceed to Step 3.

Step 3: BACKGROUND COMPARISON

For naturally occurring inorganics and radionuclide constituents, compare the maximum concentration to two times the background average concentration (unit specific background or approved SRS background) for each exposure group.

For soils and sediments, the 0-1 foot (ft) unit maximum value is compared to two-times the background average value.

For concrete media, the surficial maximum value (typically 0-0.5 inch) may be compared to two-times the 0-1 ft background average value for soils.

For groundwater, compare the maximum concentration in each distinct aquifer to two times the unit-background average values for the same aquifer.

Retain the constituent for further analysis if its maximum value exceeds the unit-specific background screening value. The constituent is eliminated from further evaluation if its maximum value is less than the unit- specific background screening value.

Step 4: RE-INCLUSION STEP

Consider whether any previously eliminated constituent should be re-included due to historical information or other considerations including mobility, bioaccumulation, persistence, and toxicity. Also, any member of a chemical class that has other members selected as COPCs should be retained (e.g., carcinogenic PAHs, PCBs, dioxins and furans).

Step 5: FINAL HH COPC IDENTIFICATION

The constituents retained to this point in the process are identified as HH COPCs. They will be carried forward through a more detailed analysis of human health risk (i.e., Human Health Constituents of Concern Protocol). If no HH COPCs have been identified at this point, then this part of the analysis is complete.

Figure 1. Flowchart of Human Health COPC Selection Process

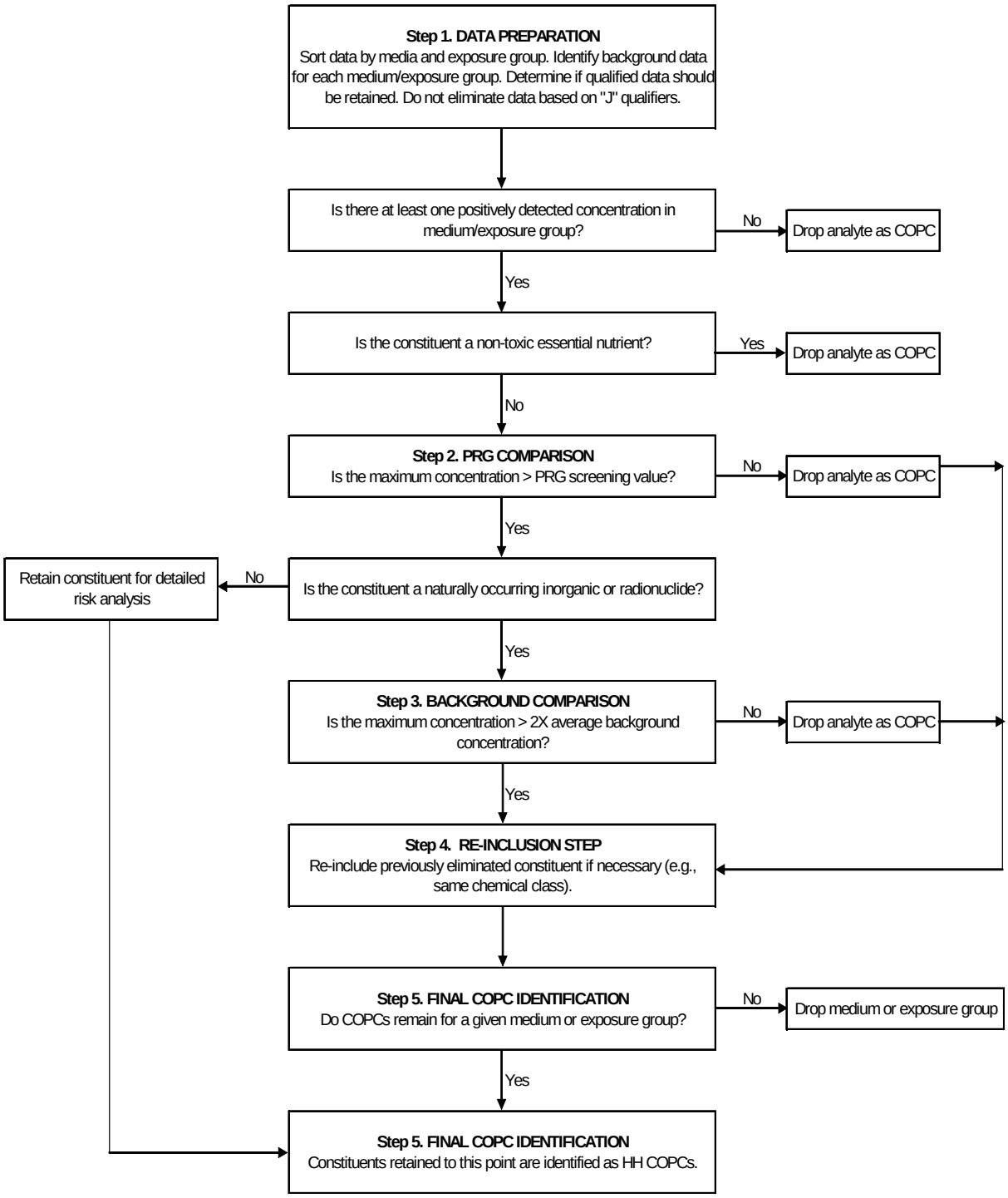


Table 1. (Sample) Human Health COPC Screening
Exposure Group Surface Soil, 0.0 to 0.3 m (0.0 to 1.0 ft)

Analyte	Detected Maximum Concentration	Human Health Screening Value	Human Health Screening Value Source[A]	Exceeds Human Health Screening Value?	2X Average Background Concentration	Exceeds 2X Average Background?[B]	COPC?
Inorganics *(mg/kg)*							
Constituent A	1.05E+04	7.61E+03	0.1xPRG	YES	1.30E+04	no	**COPC**
Constituent B	3.98E+00	3.90E-01	PRG	YES	2.60E+00	YES	**COPC**
Constituent C	3.82E+01	5.37E+02	0.1xPRG	no	4.58E+01	no	no
Constituent D	9.30E-01	1.54E+01	0.1xPRG	no	ND	YES	no
Constituent E	5.92E+02	NA	Nutrient	no[C]	4.88E+02	YES	no
Constituent F	4.32E+01	2.11E+02	PRG	no	2.96E+01	YES	no
Constituent G	4.30E+00	3.13E+02	0.1xPRG	no	6.16E+00	no	no
Organics *(mg/kg)*							
Constituent H	7.23E+02	1.24E+01	0,1xPRG	YES	7.25E+02	NA	**COPC**
Constituent I	1.35E-01	1.57E+02	0.1xPRG	no	ND	NA	no
Constituent J	6.54E+01	9.11E+00	PRG	YES	1.55E-02	NA	**COPC**
Constituent K	4.16E-02	7.33E+02	0.1xPRG	no	ND	NA	no
Constituent L	3.36E-03	1.51E+00	PRG	no	1.08E-03	NA	no
Pesticides/PCBs *(mg/kg)*							
Constituent M	4.89E+01	1.72E+00	PRG	YES	9.04E-04	NA	**COPC**
Constituent N	1.22E-03	1.83E+01	PRG	no	1.60E-03	NA	no
Radionuclides *(pCi/g)*							
Constituent O	1.35E+00	7.32E+02	PRG	no	2.14E+00	no	no
Constituent P	8.47E-01	8.19E+03	PRG	no	1.43E+00	no	no
Constituent Q	4.99E+02	2.79E+02	PRG	YES	1.06E+00	YES	**COPC**
Constituent R	1.94E+01	6.05E-02	PRG	YES	8.02E-01	YES	**COPC**
Constituent S	9.55E-01	4.63E+04	PRG	no	1.53E+00	no	no
Constituent T	1.38E+00	1.38E-01	PRG	YES	2.94E+00	no	no
Constituent U	8.47E-01	1.31E-02	PRG	YES	1.43E+00	no	no

A - Nonradiological PRGs are residential soil values from the EPA Region IX PRG table; radiological PRGs are residential soil values from the Engineering Calculation XXX.
B - For screening purposes, maximum concentration of only the naturally-occurring (nonanthropogenic) constituents are compared to 2X average background
Background concentration of anthropogenic constituents are presented for information purposes only.
C - Essential nutrients are not identified as COPCs.
NA - Not available
ND- Not detected

PROTOCOL

Human Health Receptors and Scenarios

Introduction

This protocol has been developed in order to support the Savannah River Site environmental remediation program. It provides details on the standard receptors and scenarios used for human health risk evaluation. The protocol instructions are based on the latest available USEPA guidance and agreement from the staff of USEPA, SCDHEC, and USDOE as members of the Risk Assessment Design Team (RADT).

The receptor scenarios defined in this protocol are consistent with the standard scenarios described by USEPA, with the exception of the exposure pathways for concrete as described below. More detailed information can be found at the USEPA Region 09 website: www.epa.gov/region09/waste/sfund/prg/index.htm or the USEPA PRG Radcalculator website: http//epa-prgs.ornl.gov/radionuclides/.

Pathways for receptor exposure to potentially contaminated concrete media are not described in USEPA guidance documents. Pathways identified for future industrial worker exposure to concrete is based on agreements from the Risk Assessment Design Team. Because exposure to concrete would likely occur in an industrial setting, the Risk Assessment Design Team agreed that an exposure pathway for a residential scenario did not need to be evaluated.

A quantitative evaluation will be performed for the following on-unit hypothetical exposure scenarios:

- Future Industrial Worker
- Future Resident

Evaluation of other human receptors such as trespassers, recreational users or site-specific workers, may be appropriate in addition to the standard receptors presented above. Evaluation of additional receptors will be assessed on a case-by-case basis and approved by the project core team. This protocol provides brief descriptions of the standard human health receptor scenarios. Specific values for exposure parameters can be found in the Human Health Exposure Parameter-RME Protocol.

Details

Future Industrial Worker Exposure Scenario

The future industrial worker exposure scenario is a standard USEPA scenario, which addresses long-term risks to workers who are exposed to unit contaminants while working within an industrial setting. The future industrial worker is an adult who hypothetically works on-unit in an outdoor industrial setting for the majority of his time. The primary exposure pathways for evaluation relative to the future industrial worker include:

- Exposure to contaminated soils (incidental ingestion, dermal contact, inhalation of windblown dust, inhalation of volatile constituents, and external exposure from radionuclides).
- Exposure to contaminated concrete via incidental ingestion, dermal contact, and external exposure from radionuclides.
- Exposure to groundwater through ingestion of drinking water from contaminated sources

Future Resident Exposure Scenario

The future resident exposure scenario evaluates long term risks to individuals expected to have unrestricted use of the unit. It assumes that residents hypothetically live on the unit and are exposed chronically, both indoors and outdoors, to unit contaminants. The future resident includes adults and children who will be exposed to all of the contaminated media.

The primary exposure routes utilized for evaluation relative to the hypothetical on-unit resident (adult and child) include:

- Exposure to contaminated soils (incidental ingestion, inhalation of windblown dust and possibly volatile constituents, dermal contact, and external exposure from radionuclides);
- Exposure to groundwater (ingestion, dermal contact, and possibly inhalation of volatile contaminants);
- Exposure to contaminated sediments and surface water, if present (recreational use scenario – ingestion, external exposure, and dermal contact).

The RADT has agreed that there is no need to calculate concrete PRGs for this scenario. It is acknowledged that the areas for Area Completion will maintain some level of Institutional Controls to restrict residential land use. However, if the Core Team determines that the residential scenario is warranted, this scenario can be added. In addition, waste units that may not be part of an Area Completion project typically require a residential evaluation if a No Action is warranted (i.e., no Institutional Controls).

PROTOCOL

Human Health Exposure Parameters - RME

Introduction

This protocol has been developed in order to support the Savannah River Site environmental remediation program. It describes the exposure assumptions and input parameters used to derive the PRGs for the reasonable maximum exposure (RME) scenario. The protocol instructions are based on the latest available USEPA guidance and agreement from the staff of USEPA, SCDHEC, and USDOE as members of the Risk Assessment Design Team (RADT).

The exposure parameters defined in this protocol are consistent with standard EPA values, when applicable. In most instances, these are default assumptions (with the exception noted below). More detailed information can be found at the USEPA Region 9 website: www.epa.gov/region09/waste/sfund/prg/index.htm or the USEPA Radionuclide PRGs for Superfund Electronic Calculator website: http//epa-prgs.ornl.gov/radionuclides/.

Exposure parameters for concrete media are not described USEPA guidance documents. Assumptions for future industrial worker exposure to concrete are based on agreements from the Risk Assessment Design Team.

Specific conditions at a given unit may justify the use of differing assumptions. These unit-specific assumptions must be justified and approved by the project core team on a case-by-case basis. This protocol only identifies the assumptions for the standard exposure scenarios that are described in the Human Health Receptors and Scenarios Protocol.

Details

1. Non-radiological Constituents

The standard default factors used in the derivation of PRGs by USEPA Region 9 are identified in Table 1:

- Future Industrial Worker
    - soil media
    - groundwater
    - concrete media *
- Future Resident
    - soil media
    - groundwater (tap water)
    - surface water **

- sediment **

2. Radiological Constituents

The inputs used in the derivation of SRS-specific PRGs are identified in Table 2. Default assumptions are applied if appropriate. Exposure assumptions for the derivation of PRGs for concrete media (industrial worker) are also provided in the table.

- Future Industrial Worker
  - soil media
  - groundwater
  - concrete media *
- Future Resident
  - soil media
  - groundwater (tap water)
  - surface water **
  - sediment **

* It is recognized that the exposure assumptions for concrete media should not be the same as the exposure assumptions for soil media; however, no exposure information for concrete is available in technical literature or guidance. Because of the physical nature of concrete, it is expected that the ingestion, inhalation and dermal contact pathways would be much less for concrete as compared to soil. The potential for exposure via these pathways for competent, hardened concrete is considered negligible. However, weathering of concrete could change the physical properties of the medium enough to allow some exposure through the ingestion pathway and potentially provide a media for which exposure could occur. For this reason, the Risk Assessment Design Team agreed that approximately 1/10th of the standard exposure of non-radiological constituents in soil would be a reasonable assumption for the available fraction of concrete due to weathering. This is considered a conservative approach since the ingestion, inhalation, and dermal contact pathways are all taken into consideration in the soil PRG calculation. A value of ten times (10x) the soil PRG shall be used in the risk estimate of non-radiological constituents for concrete media.

** There are no standard default factors for surface water or sediment media. The exposure assumptions are based on a recreational use scenario.

Table 1. Exposure Assumptions for Non-radiological Constituents

Symbol[a]	Definition (units)	Default	Reference
BWa	Body weight, adult (kg)	70	RAGS (Part A), USEPA 1989
BWc	Body weight, child (kg)	15	Exposure Factors, USEPA 1991b
ATc	Averaging time - carcinogens (days)	25550	RAGS (Part A), USEPA 1989
ATn	Averaging time - noncarcinogens (days)	EDc*365	RAGS (Part A), USEPA 1989
SAa	Exposed surface area (cm^2/day) – adult resident – adult worker	 5700 3300	Dermal Assessment, USEPA 2004
SAc	Exposed surface area, child (cm^2/day)	2800	Dermal Assessment, USEPA 2004
AFa	Adherence factor, soils/sediment (mg/cm^2) – adult resident – adult worker (soil only)	 0.07 0.2	Dermal Assessment, USEPA 2004
AFc	Adherence factor, child (mg/cm^2)	0.2	Dermal Assessment, USEPA 2004
ABS	Skin absorption defaults (unitless): – semi-volatile organics – volatile organics – inorganics	 0.1 -- --	Dermal Assessment, USEPA 2004
IRAa	Inhalation rate - adult (m^3/day)	20	Exposure Factors, USEPA 1991b
IRAc	Inhalation rate - child (m^3/day)	10	Exposure Factors, USEPA 1991b
IRA-conc	*Inhalation rate from concrete*	--	RADT Assumption
IRWa	*Drinking water ingestion - adult (L/day)*	*2*	RAGS(Part A), USEPA 1989
IRWc	*Drinking water ingestion - child (L/day)*	*1*	PEA, Cal-USEPA (DTSC, 1994)
IRWw	*Drinking water ingestion - worker (L/day)*	*1*	Exposure Factors, USEPA 1991b
IRWsw-a	*Incidental surface water ingestion – adult (L/day)*	*0.02*	USEPA 1995, Region IV Bulletin
IRWsw-c	*Incidental surface water ingestion – child (L/day)*	*0.1*	USEPA 1995, Region IV Bulletin
IRSa	Soil/sediment ingestion - adult (mg/day)	100	Exposure Factors, USEPA 1991b
IRSc	Soil/sediment ingestion - child (mg/day)	200	Exposure Factors, USEPA 1991b
IRSo	Soil ingestion - worker (mg/day)	100	Soil Screening Guidance (USEPA 2001)
IRS-conc	Concrete ingestion – worker (mg/day)	10	RADT Assumption
EFr	Exposure frequency - residential (d/y)	350	Exposure Factors, USEPA 1991b
EFo	Exposure frequency - worker (d/y)	250	Exposure Factors, USEPA 1991b
EFsed,sw	*Exposure frequency - residential sed/sw (d/yr)*	*50*	*USEPA 1995, Region IV Bulletin*
EDr	Exposure duration - residential (years)	30[b]	Exposure Factors, USEPA 1991b
EDc	Exposure duration - child (years)	6	Exposure Factors, USEPA 1991b
EDo	Exposure duration - worker (years)	25	Exposure Factors, USEPA 1991b
	Age-adjusted factors for carcinogens:		
IFSadj	Ingestion factor, soils/sediment ([mg-yr]/[kg-d])	114	RAGS(Part B), USEPA 1991a
SFSadj	Dermal factor, soils/sediment ([mg-yr]/[kg-d])	361	By analogy to RAGS (Part B)
SFWadj-sw	*Dermal factor, surface water ([L-yr]/[kg-d])*	*3074*	By analogy to RAGS (Part B)
InhFadj	Inhalation factor, air ([m^3-yr]/[kg-d])	11	By analogy to RAGS (Part B)
IFWadj	*Ingestion factor, drinking water ([L-yr]/[kg-d])*	*1.1*	By analogy to RAGS (Part B)
IFWadj-sw	*Ingestion factor, surface water ([L-yr]/[kg-d])*	*0.05*	By analogy to RAGS (Part B)
VFw	*Volatilization factor for water (L/m^3)*	*0.5*	RAGS(Part B), USEPA 1991a
PEF	Particulate emission factor (m^3/kg)	1.316×10^9	Soil Screening Guidance (USEPA 1996a,b)
PC	*Dermal Permeability Coefficient (cm/hr), surface water*	Chemical specific[c]	Dermal Assessment, USEPA 2004
VFs	Volatilization factor for soil (m^3/kg)	Chemical specific[c]	Soil Screening Guidance (USEPA 1996a,b)
sat	Soil saturation concentration (mg/kg)	Chemical specific[c]	Soil Screening Guidance (USEPA 1996a,b)

[a] Symbols are from equations used to derive PRGs; more information can be found at USEPA Region 9 website.
[b] Exposure duration for lifetime residents is assumed to be 30 years total. For carcinogens, exposures are combined for children (6 years) and adults (24 years).
[c] Equations used to derive chemical -specific volatilization factors and soil saturation limits are presented at the USEPA Region 9 website.
Parameters presented in *italics* apply to water media.

Table 2. Exposure Assumptions for Radiological Constituents[a]

Symbol[b]	Definition (units)	Default	Reference
ED	Exposure duration (years) -resident -outdoor worker	 30 25	USEPA Website standard default parameter
EF	Exposure frequency (days/year) - resident (soil, tapwater) *- resident (surface water, sediment)* - outdoor worker (soil, concrete, groundwater)	 350 *50* 225	 USEPA Website standard default parameter Exposure factors, USEPA 1991b USEPA Website standard default parameter
IRs	Ingestion rate (mg/day) -resident (soil, sediment) -outdoor worker (soil) -outdoor worker (concrete)	 120 100 10	 USEPA Website standard default parameter USEPA Website standard default parameter Concrete ingestion rate per Risk Assessment Design Team meeting, March 23, 2005
IRw	*Ingestion rate of water (liters/day)* *- resident (tapwater)* *- outdoor worker* *- resident (surface water)*	 *2* *1* *0.02*	 USEPA Website standard default parameter Exposure factors, USEPA 1991b USEPA 1995, Region IV Bulletin
IRi	Inhalation rate (meters^3/day) -resident (soil) *-resident (tap water)* -outdoor worker (soil) -outdoor worker (concrete)	 18 *20* 20 --	USEPA Website standard default parameter Concrete inhalation rate per Risk Assessment Design Team meeting, March 23, 2005
t	Time of exposure over which the radionuclide decays (yrs) -resident -outdoor worker	 30 25	USEPA Website standard default parameter
K	*Andelman volatilization factor (liters/cubic meter) (tap water only)* *-resident* *-outdoor worker*	 *0.5* --	USEPA Website standard default parameter (applies to tritium and C-14 only: zero for all other radionuclides)
ETo	Outdoor exposure time fraction (unitless) - resident (soil) - outdoor worker - resident (surface water, sediment)	 0.073 0.333 0.083	 USEPA Website standard default parameter USEPA Website standard default parameter 2 hr / 24 hr
ETi	Indoor exposure time fraction (unitless) - resident (soil) - outdoor worker - resident (surface water, sediment)	 0.683 -- 0	 USEPA Website standard default parameter 0 hr / 24 hr
DFi	Indoor dilution factor (unitless)	0.4	USEPA Website standard default parameter
ACF	Area correction factor (unitless) Shoreline reduction factor (sediment)	0.9 0.2	USEPA Website standard default parameter USEPA 1993
PEF	Particulate Emission Factor for southeast (meters^3 per kg)	9.44E+09	USEPA Website parameter for Charleston, SC
GSF	Gamma shielding factor (unitless) GSF for concrete media	0.4 1.0	USEPA Website standard default parameter GSF for concrete per Risk Assessment Design Team meeting, March 23, 2005
Lambda	Ln 2/ radionuclide half life	radionuclide specific	--

[a]Exposure assumptions for radiological constituents are described in the appropriate Engineering Calculation.
[b]Symbols are from appropriate Engineering Calculation to derive radiological PRGs.
Parameters presented in *italics* apply to water media.

Sources

EPA 1989. *"Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A),"* Interim Final, EPA/540/1-89/002, Office of Emergency and Remedial Response, USEPA, Washington, D.C., December 1989.

EPA 1991b. *"Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual, Supplemental Guidance, Standard Default Exposure Factors,"* Interim Final, OSWER Directive: 9285.6-03, Office of Emergency and Remedial Response Toxics Integration Branch, USEPA, Washington, D. C., March 25, 1991.

EPA 1991a. "*Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual (Part B, Development of Risk-based Preliminary Remediation Goals),"* Interim, PB92-963333, Office of Emergency and Remedial Response Toxics Integration Branch, USEPA, Washington, D. C., December 1991.

EPA 1996a, *Soil Screening Guidance: Technical Background Document.* EPA/540/R-95/128. Office of Emergency and Remedial Response, Washington, DC. PB96-963502.

EPA 1996b, *Soil Screening Guidance: User's Guide.* EPA/540/R-96/018. Office of Emergency and Remedial Response, Washington, DC. PB96-963502.

EPA 2001. *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites*, Interim Guidance. OSWER 9355.4-24.

EPA 2004. *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment),* Interim Guidance. EPA/540/R-99/005. Office of Solid Waste and Emergency Response, Washington, DC. PB99-963312.

PROTOCOL

Human Health Constituents of Concern

Introduction

This protocol has been developed in order to support the Savannah River Site environmental remediation program. It provides instructions for the identification of Human Health Constituents of Concern (HH COCs). The protocol instructions are based on the latest available USEPA guidance and agreement from the staff of USEPA, SCDHEC, and USDOE as members of the Risk Assessment Design Team (RADT).

This protocol is to be applied to constituents when a risk (hazard) estimate is needed. Ideally it is implemented after Human Health Constituents of Potential Concern (HH COPCs) have been identified; however it can be used on the entire list of detected analytes if the formal COPC screening has not been performed.

Preliminary remediation goals (PRGs) are risk-based tools used to evaluate potentially contaminated waste sites. They are derived in accordance with the methodologies described in the Risk Assessment Guidance documents published by USEPA. PRGs concentrations (activities) are based on pathways for which generally accepted methods, models, and assumptions have been developed. PRGs are concentrations (activities) that correspond to fixed levels of risk (i.e., either one-in-one million [1×10^{-6}] cancer risk or noncarcinogenic hazard quotient (HQ) of 1. If a substance causes both cancer and noncancer (systemic) effects, the most stringent criteria shall take precedence.

The most current USEPA Region 9 table is the source of the PRGs described in this protocol for nonradiological constituents; it combines current USEPA toxicity values with standard exposure factors to estimate contaminant concentrations in environmental media that the agency considers protective of humans. More detailed information on input parameters, exposure assumptions and calculation methods can be found at the USEPA Region 9 website: www.epa.gov/region09/waste/sfund/prg/index.htm.

USEPA does not publish values for radiological constituents in a standardized table as they do for nonradiological PRGs. However, the USEPA Radionuclide PRGs for Superfund Electronic Calculator website provides a database tool with which to derive risk-based PRGs using standard default parameters and the latest toxicity values; it also allows the user to modify input parameters to create site specific PRGs. More detailed information can also be found at the USEPA Radcalculator website: http://epa-prgs.ornl.gov/radionuclides/.

Standardized reference tables that contain PRGs can be used in all stages of the risk decision-making process. The SRS risk assessment technical staff maintains and controls the PRG tables for use by Soil and Groundwater Closure Projects (SGCP).

Details

1. Segregate carcinogenic (risk) and non-carcinogenic (hazard) constituents.

2. For carcinogens, calculate the risk based on the following equation:

$$\text{risk estimate} = ([\text{EPC}] / [\text{PRG}]) \times 1\text{E-}06$$

EPC = exposure point concentration

PRG = for radiological constituents: SRS-specific value for soil, concrete or groundwater (residential) media; or unit-specific value for sediment, surface water, or groundwater (industrial worker) media.

= for non-radiological constituents: USEPA Region 9 soil or tapwater value for soil or groundwater (residential); or 10X USEPA Region 9 soil value for concrete; or unit-specific values for sediment, surface water, and groundwater (industrial worker).

(Note that a risk estimate for volatile organic compounds (VOCs) in concrete media is not required since the pathways for exposure from concrete are not considered significant).

Sum the risk estimates of the chemical constituents to obtain a Total Chemical Risk estimate. Sum the risk estimates of the radiological constituents to obtain a Total Radiological Risk estimate. Sum the Total Chemical Risk estimate and the Total Radiological Risk estimate to obtain a Total Media Risk estimate. Constituents with an individual cancer risk greater than 1E-06 are identified as HH COCs.

Table 1 is a sample table for providing the human health carcinogenic risk estimate.

3. For noncarcinogens, calculate the hazard based on the following equation:

$$\text{HQ} = ([\text{EPC}] / [\text{PRG}])$$

HQ = hazard quotient

EPC = exposure point concentration

PRG = USEPA Region 9 soil or tapwater value (for soil or groundwater), or 10X EPA Region 9 soil value (for concrete)

(Note that a hazard estimate for volatile organic compounds (VOCs) in concrete media is not required since the pathways for exposure from concrete are not considered significant).

Sum the HQs to obtain a Total Media Hazard Index (HI). If the Total Media HI is less than one, then no COCs are identified. If the Total Media HI is greater than one, then the constituents are segregated based on relevant target organs. Sum the HQs according to target organs. Constituents are identified as COCs if the Total Organ HQ is greater than 0.1 and the Total Organ HI is greater than one. If the Total Organ HI is less than one, then the constituents are not identified as HH COCs.

Table 2 is a sample table for providing the human health noncarcinogenic risk estimate.

4. Constituents retained to this point in the process are identified as HH COCs. They will be carried forward to an uncertainty discussion (i.e., Constituents of Concern Refinement Process Protocol). If no HH COCs have been identified at this point, then this part of the analysis is considered complete.

Table 1. (Sample) Human Health Carcinogenic Risk Estimate
Exposure Group Surface Soil, 0.0 to 0.3 m (0.0 to 1.0 ft)

Analyte[1]	Exposure Point Concentration[2]	Residential PRG[3]	Residential Risk Estimate[4]	Industrial PRG[3]	Industrial Risk Estimate[4]	COC?[5]
Inorganics (mg/kg)						
Constituent A	2.01E+00	3.90E-01	**5.15E-06**	1.59E+00	**1.26E-06**	**COC**
Organics (mg/kg)						
Constituent B	7.85E-02	6.21E-01	1.26E-07	2.11E+00	3.72E-08	no
Constituent C	1.03E-01	6.21E-02	**1.66E-06**	2.11E-01	4.88E-07	**COC**
Constituent D	1.74E-01	6.21E-01	2.80E-07	2.11E+00	8.25E-08	no
Total Chemical Risk			**7.22E-06**		**1.87E-06**	
Radionuclides (pCi/g)						
Constituent E	2.57E-01	6.05E-02	**4.25E-06**	1.12E-01	**2.29E-06**	**COC**
Constituent F	3.48E-01	1.97E-01	**1.77E-06**	3.94E-01	8.83E-07	**COC**
Constituent G	2.31E+01	7.77E-01	**2.97E-05**	1.79E+00	**1.29E-05**	**COC**
Total Radionuclide Risk			**3.57E-05**		**1.61E-05**	
Total Media Risk			**4.30E-05**		**1.80E-05**	

[1]Analytes that are identified as COPCs.

[2]Exposure Point Concentration (EPC) = Lesser of 95th% UCL of the mean concentration and the maximum concentration

[3]Nonradiological PRGs from the EPA Region 9 PRG table: Radiological PRGs from Engineering Calculation K-CLC-XXX

[4]Risk estimate = ([EPC] / [PRG]) x 1E-06.

[5]Constituent is a COC if risk estimate > 1E-06.

Table 2. (Sample) Human Health Noncarcinogenic Hazard Estimate
Exposure Group Surface Soil, 0.0 to 0.3 m (0.0 to 1.0 ft)

Analyte[1]	Exposure Point Concentration[2]	Residential PRG[3]	Residential Hazard (HQ) Estimate[4]	Industrial PRG[3]	Industrial Hazard (HQ) Estimate[4]	COC?[5]
Inorganics (mg/kg)						
Constituent A	9.08E+03	7.61E+04	1.19E-01	1.00E+05	9.08E-02	no
Constituent B	2.01E+00	2.16E+01	9.31E-02	2.56E+02	7.85E-03	no
Constituent C	9.40E+03	2.35E+04	4.00E-01	1.00E+05	9.40E-02	no
Constituent D	1.93E+01	4.00E+02	4.83E-02	7.50E+02	2.57E-02	no
Constituent E	8.04E+02	1.76E+03	4.57E-01	1.95E+04	4.12E-02	no
Constituent F	9.51E-01	2.35E+01	4.05E-02	3.07E+02	3.10E-03	no
Constituent G	1.07E+00	5.16E+00	2.07E-01	6.75E+01	1.59E-02	no
Total Media Hazard Index			**1.37E+00**		2.79E-01	

[1]Analytes that are identified as COPCs.

[2]Exposure Point Concentration (EPC) = lesser of 95th% UCL of the mean concentration and the maximum concentration

[3]PRGs from the EPA Region 9 PRG table

[3]Hazard estimate = [EPC] / [PRG].

[4]If the total media hazard index is less than 1, then no COCs are identified. If the total media hazard index is greater than 1, then the constituents are segregated based on relevant target organs. HQs are summed according to target organs. Constituents are identified as COCs (based on land use) if the HQ is greater than 0.1 and the total organ hazard index is greater than 1.

Analyte	Target Organ	Source[1]	HQ (residential)	
Constituent A	CNS	NCEA	1.19E-01	
Constituent E	CNS	IRIS	4.57E-01	
Constituent F	CNS	IRIS	4.05E-02	
			6.17E-01	*Total CNS Target Organ Hazard Index*
Constituent B	Skin	IRIS	9.31E-02	
			9.31E-02	*Total Skin Target Organ Hazard Index*
Constituent C	Liver	NCEA / ATSDR	4.00E-01	
			4.00E-01	*Total Liver Target Organ Hazard index*
Constituent D	Blood	IRIS	4.83E-02	
Constituent G	Blood	IRIS	2.07E-01	
			2.55E-01	*Total Blood Target Organ Hazard Index*

[1]IRIS = Integrated Risk Management System
[1]NCEA = National Center for Environmental Assessment
[1]ATSDR = Agency for Toxic Substances and Disease Registry

PROTOCOL

Human Health Remedial Goal Options

Introduction

This protocol has been developed in order to support the Savannah River Site environmental remediation program. It provides instructions for the identification of human health remedial goal options (HH RGOs). The protocol instructions are based on the latest available USEPA guidance and agreement from the staff of USEPA, SCDHEC, and USDOE as members of the Risk Assessment Design Team (RADT).

This protocol is to be applied to the human health refined constituents of concern (HH RCOCs) that are available after performing an uncertainty analysis.

Details

1. Calculate RGOs at the 1 x 10^{-6}, 1 x 10^{-5}, and 1 x 10^{-4} risk level for carcinogenic constituents.

2. Calculate RGOs at the 0.1, 1, and 3 hazard quotient (HQ) levels for noncarcinogenic constituents.

Table 1 provides a sample table for the identification of RGOs.

Table 1. (Sample) Remedial Goal Options

RCOC	Units	Industrial Worker 1E-06	Industrial Worker 1E-05	Industrial Worker 1E-04	Industrial Worker HQ= 0.1	Industrial Worker HQ = 1	Industrial Worker HQ = 3
Constituent A	mg/kg	1.6	16	160	25.6	256	768
Constituent B	mg/kg	--	--	--	666	6660	19980
Constituent C	pCi/g	0.112	1.12	11.2	--	--	--

Note - Preliminary Remediation Goals (PRGs) are useful tools for identifying the initial cleanup goals at a site, and can be used as a basis to establish RGOs. The SRS risk assessment technical staff controls and maintains the PRG tables for use by Soil and Groundwater Closure Projects.

PROTOCOL

ECOLOGICAL SCREENING VALUES (ESVs)

Introduction

The following protocol has been developed to support the Savannah River Site (SRS) environmental remediation program. The ecological risk assessment (ERA), a component of the environmental remediation program, consists of identifying constituents that may adversely affect ecological receptors in the environment. Typically, this is accomplished by comparing abiotic concentrations at the site of interest with regulatory or technically defensible screening values. This protocol presents a comprehensive listing of non-radiological ecological screening values for surface water, sediment, and soil.

A listing of the ecological screening values that are proposed for the SRS remediation program are presented in Tables 1 – 3. These values are presented alphabetically for soil, sediment, and surface water.

Soil

Ecological screening values for soil are presented in Table 1. The EPA has not issued guidance values for soil. The available soil screening values are limited to those benchmarks issued by the Oak Ridge National Laboratory (ORNL) (Efroymson et al. 1997 a,b), and the Canadian (CCME 1998b) and Dutch (Crommentuijn 1997; MHSPE 1994) governments (WSRC 1998). The U.S. Fish and Wildlife Service (USFWS) (Beyer 1990) values are based on Dutch Ministry numbers issued in the 1980's (MHSPE 1994). The recommended soil screening values (Table 1) represent the lower or most conservative value with three exceptions: 1) when screening values from both USFWS (Beyer 1990) and Maximum Permissible Concentration (MPCs) (Crommentuijn 1997) are available, the latter is used; 2) when target values (MHSPE 1994) and MPCs (Crommentuijn 1997) are available, the latter is used; 3) if only an intervention value (MHSPE 1994) is available, it is divided by a factor of 10 to derive the recommended ESV (WSRC 1998).

Sediment

Ecological screening values for sediment are listed in Table 2. The preferred source used in this table is the most conservative EPA Region IV Screening Values (EPA 1995). If no EPA Region IV values were available, the most conservative value from EPA Ecotox Threshold screening values were used (EPA 1996). Other sources for values include benchmarks issued by the Canadian (CCME 1998a) and Dutch (MHSPE 1994) governments. For many constituents, multiple sources for sediment screening values are few or unavailable. In some cases, only a single screening value is available. If the Dutch Ministry intervention value (MHSPE 1994) is

the only available screening value, the value is divided by a factor of 10 to obtain the recommended value (WSRC 1998).

Surface water

Ecological screening values for surface water are presented in Table 3. The preferred ecological screening values for surface water are the chronic Region IV Ambient Water Quality (AWQ) values (EPA 1995). If AWQ values are not available, EPA Ecotox threshold (EPA 1996) values (i.e., final chronic values) are used. It should be noted that some Tier II values from Ecotox Thresholds (EPA 1996) are based on calculations by Suter and Mabrey (1994). When this occurs, the secondary chronic Tier II value (Suter and Tsao 1996) is used because it is more conservative and based on more recent data. If a screening value is not available from any of the three sources identified previously, the lowest chronic value or Canadian (CCME 1998c) benchmark is used.

Details

The approach described here is designed to support Step A of the ecological constituents of potential concern (COPC) selection process protocol. It should be noted that this protocol cannot be used until all data have been evaluated for compliance with data quality objectives (DQOs).

A. Partition the data into the following media: surface water, sediment, or soil. All units of measurement should be included (i.e., mg/L, mg/kg, etc.).

B. Determine the maximum concentration of each constituent.

C. Compare the maximum concentration of the constituent with the appropriate ESVs in Table 1 (soil), Table 2 (sediment), or Table 3 (surface water).

D. If the maximum value does not equal or exceed the ESV, the constituent is eliminated from further consideration in the ecological risk assessment. If the concentration of the constituent exceeds the ESV, the constituent is retained for further examination. If there is no ESV available for a constituent, it is also retained for further study in Step C of the ecological COPC selection process protocol.

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Table 1. Ecological Screening Values for Soil (mg/kg).

Constituent	TAL/ TCL[a]	U.S. Fish and Wildlife Service[b]			Oak Ridge National Laboratory			CCME[j]	Dutch Ministry Standards			ESV
		A[c]	B[d]	C[e]	Earthworms[f]	Micro-organisms[f]	Soil Phytoxicity[g]		Target Value[k]	Intervention Value[k]	MPC[l]	
Inorganics												
Aluminum	●					600	50					**50**
Antimony	●						5				3.5	**3.5**
Arsenic	●	20	30	50	60	100	10	12	29	55	34	**10**
Barium	●	200	400	2000		3000	500	500	200	625	165	**165**
Beryllium	●						10				1.1	**1.1**
Boron						20	0.5					**0.5**
Bromine		20	50	300			10					**10**
Cadmium	●	1	5	20	20	20	0.4	10	0.8	12	1.6	**1.6**
Calcium	●											
Chromium	●	100	250	8000	32 [h]	10	1	64	100	380	100	**32**
Cobalt	●	20	50	800		1000	20		20	240	33	**20**
Copper	●	50	100	500	50	100	100	63	36	190	40	**40**
Cyanide, free	●	1	10	100				0.9	1	2		**0.9**
Cyanide, complex	●	5	50	500								**5**
Cyanide complex (pH<5)	●								5	650		**5**
Cyanide complex (pH>5)	●								5	50		**5**
Fluorine					30	30	200					**30**
Iodine							4					**4**
Iron	●					200						**200**
Lanathum						50						**50**
Lead	●	50	150	600	500	900	50	140	85	530	140	**50**
Lithium						10	2					**2**
Magnesium	●											
Manganese	●					100	500					**100**
Mercury (inorganic)	●	0.5	2	10	5 [i]	30	0.3	6.6	0.3	10	2.2	**0.3**
Molybdenum		10	40	200		200	2		10	200	254	**2**

Table 1. Ecological Screening Values for Soil (mg/kg).

Constituent	TAL/ TCL[a]	U.S. Fish and Wildlife Service[b]			Oak Ridge National Laboratory			CCME[j]	Dutch Ministry Standards			ESV
		A[c]	B[d]	C[e]	Earthworms[f]	Micro-organisms[f]	Soil Phytoxicity[g]		Target Value[k]	Intervention Value[k]	MPC[l]	
Nickel	●	50	100	500	200	90	30	50	35	210	38	**30**
Potassium	●											
Selenium	●				70	100	1				0.81	**0.81**
Silver	●					50	2					**2**
Sodium	●											
Sulfur		2	20	200								**2**
Technetium							0.2					**0.2**
Thallium	●						1	1			1.3	**1**
Tin		20	50	300		2000	50				53	**50**
Thiocyanates										20		**2**
Titanium						1000						**1000**
Tungsten						400						**400**
Uranium							5					**5**
Vanadium	●					20	2	130			43	**2**
Zinc	●	200	500	3000	200	100	50	200	140	720	160	**50**
Organics												
1,1,1-Trichloroethane	✓											
1,1,2,2-Tetrachloroethane	✓											
1,1,2-Trichloroethane	✓											
1,1-Dichloroethane	✓											
1,1-Dichloroethylene	✓											
1,2,3,4-Tetrachlorobenzene					10							**10**
1,2,3-Trichlorobenzene					20							**20**
1,2,4-Trichlorobenzene	✓				20							**20**
1,2-Dichlorobenzene	✓											
1,2-Dichloroethane	✓											

Table 1. Ecological Screening Values for Soil (mg/kg).

Constituent	TAL/ TCL[a]	U.S. Fish and Wildlife Service[b]			Oak Ridge National Laboratory			CCME[j]	Dutch Ministry Standards			ESV
		A[c]	B[d]	C[e]	Earthworms[f]	Micro-organisms[f]	Soil Phytoxicity[g]		Target Value[k]	Intervention Value[k]	MPC[l]	
1,2-Dichloroethylene (trans)	✓											
1,2-Dichloropropane	✓				700							**700**
1,3-Dichlorobenzene	✓											
1,3-Dichloropropene	✓											
1,4-Dichlorobenzene	✓				20							**20**
2,3,4,5-Tetrachlorophenol					20							**20**
2,3,5,6-Tetrachloroaniline					20		20					**20**
2,4,5-Trichloroaniline					20		20					**20**
2,4,5-Trichlorophenol	✓				9		4					**4**
2,4,6-Trichlorophenol	✓				10							**10**
2,4-Dichloroaniline					100							**100**
2,4-Dichlorophenol	✓											
2,4-Dimethylphenol	✓											
2,4-Dinitrophenol	✓						20					**20**
2,4-Dinitrotoluene	✓											
2,6-Dinitrotoluene	✓											
2-Chloronaphthalene	✓											
2-Chlorophenol	✓											
2-Hexanone	✓											
2-Methyl-4,6-dinitrophenol	✓											
2-Methylnaphthalene	✓											
2-Nitrophenol	✓											
3,3'-Dichlorobenzidine	✓											
3,4-Dichloroaniline					20							**20**
3,4-Dichlorophenol	✓				20		20					**20**
3-Chloraniline					30		20					**20**
3-Chlorophenol	✓				10		7					**7**

Table 1. Ecological Screening Values for Soil (mg/kg).

Constituent	TAL/ TCL[a]	U.S. Fish and Wildlife Service[b]			Oak Ridge National Laboratory			CCME[j]	Dutch Ministry Standards			ESV
		A[c]	B[d]	C[e]	Earthworms[f]	Micro-organisms[f]	Soil Phytoxicity[g]		Target Value[k]	Intervention Value[k]	MPC[l]	
4-Bromophenyl phenyl ether	✓											
4-Chloroaniline	✓											
4-Chloro-m-cresol	✓											
4-Chlorophenyl phenyl ether	✓											
4-Nitrophenol	✓				7							**7**
-BHC	✓								0.0025			**0.0025**
Acenaphthene	✓						20					**20**
Acetone	✓											
-Chlordane	✓											
Acrylonitrile						1000						**1000**
Aldrin	✓								0.0025			**0.0025**
Aliphatic Chlorinated Hydrocarbons (each)		0.1	5	50								**0.1**
Aliphatic Chlorinated Hydrocarbons (total)		0.1	7	70								**0.1**
Anthracene	✓	0.1	10	100								**0.1**
Atrazine									0.00005	6		**0.00005**
-BHC	✓								0.001			**0.001**
Benzene	✓	0.1	0.5	5				0.5	0.05	1		**.05**
Benzidine	✓											
Benzo[a]anthracene	✓											
Benzo[a]pyrene	✓	0.1	1	10				0.7				**0.1**
Benzo[b]fluoranthene	✓											
Benzo[g,h,i]perylene	✓											
Benzo[k]fluoranthene	✓											
Benzoic acid	✓											
Benzyl alcohol	✓											
Biphenyl							60					**60**

Table 1. Ecological Screening Values for Soil (mg/kg).

Constituent	TAL/ TCL[a]	U.S. Fish and Wildlife Service[b]			Oak Ridge National Laboratory			CCME[j]	Dutch Ministry Standards			ESV
		A[c]	B[d]	C[e]	Earthworms[f]	Micro-organisms[f]	Soil Phytoxicity[g]		Target Value[k]	Intervention Value[k]	MPC[l]	
Bis(2-chloroethoxy) methane	✓											
Bis(2-chloroethyl) ether	✓											
Bis(2-chloroisopropyl) ether	✓											
Bis(2-ethylhexyl)phthalate	✓											
Bromodichloromethane	✓											
Bromoform	✓											
Bromomethane (Methyl bromide)	✓											
Butylbenzyl phthalate	✓											
Carbaryl										5		**0.5**
Carbofuran										2		**0.2**
Carbon disulfide	✓											
Carbon tetrachloride	✓					1000						**1000**
Catechol										20		**2**
Chlorinated hydrocarbons		1	8	80								**1**
Chloroacetamide					2							**2**
Chlorobenzene (each)	✓	0.05	1	10								**0.05**
Chlorobenzene (total)	✓	0.05	2	20	40					30		**0.05**
Chloroethane	✓											
Chloroethene (Vinyl chloride)	✓											
Chloroform	✓											
Chloromethane (Methyl chloride)	✓											
Chloronaphthalene										10		**1**
Chlorophenols (each)	✓	0.01	0.5	5								**0.01**
Chlorophenols (total)	✓	0.01	1	10						10		**0.01**
Chrysene	✓											
1,4-dichloro-2-butene (cis)						1000						**1000**
1,4-dichloro-2-butene (trans)						1000						

Table 1. Ecological Screening Values for Soil (mg/kg).

Constituent	TAL/ TCL[a]	U.S. Fish and Wildlife Service[b]			Oak Ridge National Laboratory			CCME[j]	Dutch Ministry Standards			ESV
		A[c]	B[d]	C[e]	Earthworms[f]	Micro-organisms[f]	Soil Phytoxicity[g]		Target Value[k]	Intervention Value[k]	MPC[l]	
Cresols (total)										5		**0.5**
Cyclohexane		0.1	6	60								**0.1**
Cyclohexanone									0.1	270		**0.1**
-BHC	✓											
DDT/DDE/DDD (total)	✓								0.0025	4		**0.0025**
Dibenz[a,h]anthracene	✓											
Dibenzofuran	✓											
Dibromochloromethane	✓											
Dichlorobenzene (total)	✓								0.01			**0.01**
Dichloromethane (Methylene chloride)	✓									20		**2**
Dichlorphenols (total)	✓								0.003			**0.003**
Dieldrin	✓								0.0005			**0.0005**
Diethyl phthalate	✓						100					**100**
Dimethyl phthalate	✓				200							**200**
Di-n-butyl phthalate	✓						200					**200**
Di-n-octyl phthalate	✓											
Endosulfan I	✓											
Endosulfan II	✓											
Endosulfan sulfate	✓											
Endosulfan, mixed isomers	✓											
Endrin	✓								0.001			**0.001**
Endrin ketone	✓											
Ethylbenzene	✓	0.05	5	50				0.7	0.05	50		**0.7**
Ethylene glycol								960				**960**
Fluoranthene	✓	0.1	10	100								**0.1**
Fluorene	✓											
Furan							600					**600**

Table 1. Ecological Screening Values for Soil (mg/kg).

Constituent	TAL/ TCL[a]	U.S. Fish and Wildlife Service[b]			Oak Ridge National Laboratory			CCME[j]	Dutch Ministry Standards			ESV
		A[c]	B[d]	C[e]	Earthworms[f]	Micro-organisms[f]	Soil Phytoxicity[g]		Target Value[k]	Intervention Value[k]	MPC[l]	
Gasoline		20	100	800								**20**
-BHC (Lindane)	✓								0.00005			**0.00005**
-Chlordane	✓											
Heptachlor	✓											
Heptachlor epoxide	✓											
Hexachlorobenzene	✓					1000			0.0025			**0.0025**
Hexachlorobutadiene	✓											
Hexachlorocyclopentadiene	✓						10					**10**
Hexachloroethane	✓											
Hydrochinon										10		**1**
Indeno(1,2,3-c,d)pyrene	✓											
Iodine							4					**4**
Isophorone	✓											
Maneb										35		**3.5**
Methoxychlor	✓											
Methyl ethyl ketone	✓											
Methyl isobutyl ketone	✓											
Mineral Oils		100	1000	5000					50	5000		**50**
m-Nitroaniline	✓											
Monocyclic Aromatic Hydrocarbons (total)		0.1	7	70								**0.1**
m-Xylene	✓											
Naphthalene	✓	0.1	5	50				0.6				**0.1**
Nitrobenzene	✓				40	1000						**40**
N-Nitrosodiphenylamine	✓				20							**20**
N-Nitrosodipropylamine	✓											
o-Cresol (2-Methylphenol)	✓											
o-Nitroaniline	✓											

Table 1. Ecological Screening Values for Soil (mg/kg).

Constituent	TAL/ TCL[a]	U.S. Fish and Wildlife Service[b]			Oak Ridge National Laboratory			CCME[j]	Dutch Ministry Standards			ESV
		A[c]	B[d]	C[e]	Earthworms[f]	Micro-organisms[f]	Soil Phytoxicity[g]		Target Value[k]	Intervention Value[k]	MPC[l]	
Organochlorinated Pesticides (each)		0.1	0.5	5								**0.1**
Organochlorinated Pesticides (total)		0.1	1	10								**0.1**
DDD	✓											
DDE	✓											
DDT	✓							0.7				**0.7**
PAHs (total)		1	20	200					1	40		**1**
PCB 1016	✓											
PCB 1221	✓											
PCB 1232	✓											
PCB 1242	✓											
PCB 1248	✓											
PCB 1254	✓											
PCB 1260	✓											
PCBs (total)	✓	0.05	1	10			40	0.3	0.02	1		**0.02**
p-Cresol (4-Methylphenol)	✓											
Pentachloroaniline					100							**100**
Pentachlorobenzene					20				0.0025			**0.0025**
Pentachlorophenol	✓				6	400	3	7.6	0.002			**0.002**
Pesticides (total)		0.1	2	20								**0.1**
Phenanthrene	✓	0.1	5	50								**0.1**
Phenol	✓	0.02	1	10	30	100	70	3.8	0.05	40		**0.02**
Phthalates (total)									0.1	60		**0.1**
p-Nitroaniline	✓											
Pyrene	✓	0.1	10	100								**0.1**
Pyridine		0.1	2	20					0.1	1		**0.1**
Resorcinol										10		**1**
Styrene	✓	0.1	5	50			300		0.1	100		**0.1**

Table 1. Ecological Screening Values for Soil (mg/kg).

Constituent	TAL/ TCL[a]	U.S. Fish and Wildlife Service[b]			Oak Ridge National Laboratory			CCME[j]	Dutch Ministry Standards			ESV
		A[c]	B[d]	C[e]	Earthworms[f]	Micro-organisms[f]	Soil Phytoxicity[g]		Target Value[k]	Intervention Value[k]	MPC[l]	
Tetrachlorobenzenes (total)									0.01			**0.01**
Tetrachloroethylene	✓							0.2	0.01	4		**0.01**
Tetrachloromethane									0.001	1		**0.001**
Tetrachlorophenols (total)									0.001			**0.001**
Tetrahydrofuran		0.1	4	40					0.1	0.4		**0.1**
Tetrahydrothiophene		0.1	5	50					0.1	90		**0.1**
Toluene	✓	0.05	3	30			200	0.8	0.05	130		**0.05**
Toxaphene	✓											
Trichlorobenzenes (total)	✓								0.01			**0.01**
Trichloroethylene	✓							3	0.001	60		**0.001**
Trichloromethane (Chloroform)									0.001	10		**0.001**
Trichlorophenols (total)										0.001		**0.0001**
Vinyl acetate	✓											
Vinyl chloride										0.1		**0.01**
Xylenes (total)	✓	0.05	5	50								**0.05**

a- TAL/TCL designation: ●=TAL; ✓=TCL.
b- Beyer (1990).
c- A-refers to background concentrations in soil or detection limits.
d- B-refers to moderate soil contamination that requires additional study.
e- C-refers to threshold values that require immediate cleanup.
f- Efroymson et al. (1997a).
g- Efroymson et al. (1997b).
h- Value is for Chromium III.
i- Mercury value taken from Eisler (1987).
j- CCME (1998b).
k- MHSPE (1994).
l- Crommentuijn et al. (1997).

Table 2. Ecological Screening Values for Sediment (mg/kg).

Constituent	TAL/ TCL[a]	EPA Region IV[b]			Ecotox Thresholds[c]			Environment Canada[f]		Dutch Ministry Standards[i]		ESV
		Effects Values	CLP Practical Quantitation Limit	Screening Value	EPA Sediment Quality[d]	EPA Sediment Quality Benchmark[e]	Effects Range-Low	TEL[g]	PEL[h]	Target Value	Intervention Value	
Inorganics												
Aluminum	●											
Antimony	●	2	12	12								**12**
Arsenic	●	7.24	2	7.24				5.9	17	29	55	**7.24**
Arsenic III	●						8.2					**8.2**
Arsenic V	●											
Barium	●									200	625	**200**
Beryllium	●											
Cadmium	●	0.676	1	1			1.2	0.596	3.53	0.8	12	**1**
Calcium	●											
Chromium	●	52.3	2	52.3			81	37.3	90	100	380	**52.3**
Cobalt	●									20	240	**20**
Copper	●	18.7	5	18.7			34	35.7	197	36	190	**18.7**
Cyanide (free)	●									1	20	**1**
Cyanide complex (pH<5)	●									5	650	**5**
Cyanide complex (pH>5)	●									5	50	**5**
Iron	●											
Lead	●	30.2	0.6	30.2			47	35	91.3	85	530	**30.2**
Magnesium	●											
Manganese	●											
Mercury (inorganic)	●	0.13	0.02	0.13			0.15	0.174	0.486	0.3	10	**0.13**
Molybdenum										10	200	**10**
Nickel	●	15.9	8	15.9			21			35	210	**15.9**
Potassium	●											
Selenium	●											
Silver	●	0.733	2	2								**2**

Table 2. Ecological Screening Values for Sediment (mg/kg).

Constituent	TAL/ TCL[a]	EPA Region IV[b]			Ecotox Thresholds[c]			Environment Canada[f]		Dutch Ministry Standards[i]		ESV
		Effects Values	CLP Practical Quantitation Limit	Screening Value	EPA Sediment Quality[d]	EPA Sediment Quality Benchmark[e]	Effects Range-Low	TEL[g]	PEL[h]	Target Value	Intervention Value	
Inorganics - continued												
Sodium	●											
Thallium	●											
Thiocyanates (total)											20	**2**
Vanadium	●											
Zinc	●	124	4	124			150	123	315	140	720	**124**
Organics												
1,1,1-Trichloroethane	✓					0.170						**0.170**
1,1,2,2-Tetrachloroethane	✓					0.940						**0.940**
1,1,2-Trichloroethane	✓											
1,1-Dichloroethane	✓											
1,1-Dichloroethylene	✓											
1,2,4-Trichlorobenzene	✓					9.2						**9.2**
1,2-Dichlorobenzene	✓					0.340						**0.340**
1,2-Dichloroethane	✓										4	**0.400**
1,2-Dichloroethylene (trans)	✓											
1,2-Dichloropropane	✓											
1,3-Dichlorobenzene	✓					1.7						**1.7**
1,3-Dichloropropene	✓											
1,4-Dichlorobenzene	✓					0.350						**0.350**
2,4,5-Trichlorophenol	✓											
2,4,6-Trichlorophenol	✓											
2,4-Dichlorophenol	✓											
2,4-Dimethylphenol	✓											

Table 2. Ecological Screening Values for Sediment (mg/kg).

Constituent	TAL/ TCL[a]	EPA Region IV[b]			Ecotox Thresholds[c]			Environment Canada[f]		Dutch Ministry Standards[i]		ESV
		Effects Values	CLP Practical Quantitation Limit	Screening Value	EPA Sediment Quality[d]	EPA Sediment Quality Benchmark[e]	Effects Range-Low	TEL[g]	PEL[h]	Target Value	Intervention Value	
2,4-Dinitrophenol	✓											
2,4-Dinitrotoluene	✓											
2,6-Dinitrotoluene	✓											
2-Chloronaphthalene	✓											
2-Chlorophenol	✓											
2-Hexanone	✓											
2-Methyl-4,6-dinitrophenol	✓											
2-Methylnaphthalene	✓	0.02	0.330	0.330				0.02	0.201			**0.33**
2-Nitrophenol	✓											
3,3'-Dichlorobenzidine	✓											
4-Bromophenyl phenyl ether	✓					1.3						**1.3**
4-Chloroaniline	✓											
4-Chloro-m-cresol	✓											
4-Chlorophenyl phenyl ether	✓											
4-Nitrophenol	✓											
Acenaphthene	✓	0.007	0.330	0.330	0.620		0.016	0.0067	0.089			**0.330**
Acenaphthylene	✓	0.0059	0.330	0.330				0.0059	0.128			**0.330**
Acetone	✓											
Aldrin	✓									0.0025		**0.0025**
Anthracene	✓	0.047	0.330	0.330				0.047	0.245			**0.330**
Atrazine										0.00005	6.0	**0.00005**
Benzene	✓					0.057				50	1000	**0.057**
Benzidine	✓											
Benzo[a]anthracene	✓	0.075	0.330	0.330				0.032	0.385			**0.330**

Table 2. Ecological Screening Values for Sediment (mg/kg).

Constituent	TAL/ TCL[a]	EPA Region IV[b]			Ecotox Thresholds[c]			Environment Canada[f]		Dutch Ministry Standards[i]		ESV
		Effects Values	CLP Practical Quantitation Limit	Screening Value	EPA Sediment Quality[d]	EPA Sediment Quality Benchmark[e]	Effects Range-Low	TEL[g]	PEL[h]	Target Value	Intervention Value	
Benzo[a]pyrene	✓	0.089	0.330	0.330			0.430	0.032	0.782			**0.330**
Benzo[b]fluoranthene	✓											
Benzo[g,h,i]perylene	✓											
Benzo[k]fluoranthene	✓											
Benzoic acid	✓											
Benzyl alcohol	✓											
-BHC	✓									0.0025		**0.0025**
-BHC	✓									0.001		**0.001**
-BHC	✓											
-BHC (Lindane)	✓	0.00032	0.0033	0.0033		0.0037		0.00094	0.0027	0.00005		**0.0033**
Biphenyl						1.1						**1.1**
Bis(2-chloroethoxy) methane	✓											
Bis(2-chloroethyl) ether	✓											
Bis(2-chloroisopropyl) ether	✓											
Bis(2-ethylhexyl)phthalate	✓	0.182	.0036	0.182								**0.182**
Bromodichloromethane	✓											
Bromoform	✓											
Bromomethane (Methyl bromide)	✓											
Butylbenzyl phthalate	✓					11.0						**11.0**
Carbaryl											5	**0.500**
Carbofuran											2	**0.200**
Carbon disulfide	✓											
Carbon tetrachloride	✓											
Catechol											20	**2**

Table 2. Ecological Screening Values for Sediment (mg/kg).

Constituent	TAL/ TCL[a]	EPA Region IV[b]			Ecotox Thresholds[c]			Environment Canada[f]		Dutch Ministry Standards[i]		ESV
		Effects Values	CLP Practical Quantitation Limit	Screening Value	EPA Sediment Quality[d]	EPA Sediment Quality Benchmark[e]	Effects Range-Low	TEL[g]	PEL[h]	Target Value	Intervention Value	
Chlordane	✓	0.0005	0.0017	0.0017				0.0045	0.0089			**0.0017**
Chlorobenzenes (total)	✓					0.820					30	**0.820**
Chloroethane	✓											
Chloroethene (Vinyl chloride)	✓											
Chloroform	✓											
Chloromethane (Methyl chloride)	✓											
Chloronaphthalene											10	**1**
Chlorophenols (total)	✓										10	**1**
Chrysene	✓	0.108	0.330	0.330				0.057	0.862			**0.330**
o-Cresol (2-Methylphenol)	✓											
p-Cresol (4-Methylphenol)	✓											
Cresols (total)											5	**0.500**
Cyclohexanone										0.100	270	**0.100**
DDD	✓	0.002	0.0033	0.0033				0.0035	0.0085			**0.0033**
p,p'-DDD	✓	0.00122	0.0033	0.0033								**0.0033**
DDE	✓	0.002	0.0033	0.0033				0.0014	0.0068			**0.0033**
p,p'-DDE	✓	0.0021	0.0033	0.0033								**0.0033**
DDT	✓	0.001	0.0033	0.0033			0.0016	0.0012	0.0048			**0.0033**
p,p'-DDT	✓	0.0012	0.0033	0.0033								**0.0033**
DDT (total)	✓	0.0016	0.0033	0.0033								**0.0033**
DDT/DDE/DDD (total)	✓									0.0025	4	**0.0025**
Diazinon						0.0019						**0.0019**
Dibenz[a,h] anthracene	✓	0.0062	0.330	0.330				0.0062	0.135			**330**
Dibenzofuran	✓					2						**2**

Table 2. Ecological Screening Values for Sediment (mg/kg).

Constituent	TAL/ TCL[a]	EPA Region IV[b]			Ecotox Thresholds[c]			Environment Canada[f]		Dutch Ministry Standards[i]		ESV
		Effects Values	CLP Practical Quantitation Limit	Screening Value	EPA Sediment Quality[d]	EPA Sediment Quality Benchmark[e]	Effects Range-Low	TEL[g]	PEL[h]	Target Value	Intervention Value	
Dibromo-chloromethane	✓											
Dichlorobenzene (total)	✓									0.010		**0.010**
Dichloromethane (Methylene chloride)	✓										20	**2**
Dichlorphenols (total)	✓									0.003		**0.003**
Dieldrin	✓	0.002	0.0033	0.0033	0.052			0.0029	0.0067	0.0005		**0.00002**
Diethyl phthalate	✓					0.360						**0.360**
Dimethyl phthalate	✓											
Di-n-butyl phthalate	✓					11						**11**
Di-n-octyl phthalate	✓											
Endosulfan I	✓					0.0029						**0.0029**
Endosulfan II	✓					0.014						**0.014**
Endosulfan sulfate	✓											
Endosulfan, mixed isomers	✓					0.0054						**0.0054**
Endrin	✓	0.00002	0.0033	0.0033	0.020			0.0027	0.062	0.001		**0.0033**
Endrin ketone	✓											
Ethylbenzene	✓					3.60				0.050	50	**3.60**
Fluoranthene	✓	0.113	0.330	0.330	2.90		0.600	0.111	2.355			**0.330**
Fluorene	✓	0.021	0.330	0.330		0.540		0.021	0.144			**0.330**
Heptachlor	✓											
Heptachlor epoxide	✓							0.0006	0.027			**0.0006**
Hexachlorobenzene	✓											
Hexachlorobutadiene	✓											
Hexachloro-cyclopentadiene	✓											
Hexachloroethane	✓											

Table 2. Ecological Screening Values for Sediment (mg/kg).

Constituent	TAL/ TCL[a]	EPA Region IV[b]			Ecotox Thresholds[c]			Environment Canada[f]		Dutch Ministry Standards[i]		ESV
		Effects Values	CLP Practical Quantitation Limit	Screening Value	EPA Sediment Quality[d]	EPA Sediment Quality Benchmark[e]	Effects Range-Low	TEL[g]	PEL[h]	Target Value	Intervention Value	
Hydrochinon											10	**1**
Indeno(1,2,3-c,d)pyrene	✓											
Isophorone	✓											
Malathion						0.00067						**0.00067**
Maneb											35	**3**
Methoxychlor	✓					0.019						**0.019**
Methyl ethyl ketone	✓											
Methyl isobutyl ketone	✓											
Mineral Oil										50	5000	**50**
Monochlorphenols (total)										0.0025		**0.0025**
Naphthalene	✓	0.035	0.330	0.330		0.480	0.160	0.035	0.391			**0.330**
Nitrobenzene	✓											
o-Nitroaniline	✓											
m-Nitroaniline	✓											
N-Nitroso-diphenylamine	✓											
N-Nitroso-dipropylamine	✓											
PAHs (high molecular weight)		0.655	0.330	0.655								**0.655**
PAHs (low molecular weight)		0.312	0.330	0.330								**0.330**
PAHs (total)		1.684	0.330	1..684			4			1	40	**1.684**
Parathion												
PCB 1016	✓											

Table 2. Ecological Screening Values for Sediment (mg/kg).

Constituent	TAL/ TCL[a]	EPA Region IV[b]			Ecotox Thresholds[c]			Environment Canada[f]		Dutch Ministry Standards[i]		ESV
		Effects Values	CLP Practical Quantitation Limit	Screening Value	EPA Sediment Quality[d]	EPA Sediment Quality Benchmark[e]	Effects Range-Low	TEL[g]	PEL[h]	Target Value	Intervention Value	
PCB 1221	✓		0.067	0.067								**0.067**
PCB 1232	✓											
PCB 1242	✓											
PCB 1248	✓											
PCB 1254	✓											
PCB 1260	✓											
PCBs (total)	✓	0.022	0.067	0.067			0.023	0.034	0.277	0.020	1	**0.067**
Pentachlorobenzene						0.690				0.0025		**0.690**
Pentachlorophenol	✓									0.002		**0.002**
Phenanthrene	✓	0.087	0.330	0.330	0.850		0.240	0.042	0.515			**0.330**
Phenol	✓									0.050	40	**0.050**
Phthalates (total)										0.100	60	**0.100**
p-Nitroaniline	✓											
Pyrene	✓	0.153	0.330	0.330			0.660	0.053	0.875			**0.330**
Pyridine										0.100	1	**0.100**
Resorcinol											10	**1**
Styrene	✓									0.100	1	**0.100**
Tetrachlorobenzenes (total)										0.010		**0.010**
Tetrachloroethene	✓					0.530				0.010	4	**0.530**
Tetrachloromethane						1.2				0.001	1	**1.2**
Tetrachlorophenols (total)										0.001		**0.001**
Tetrahydrofuran										0.100	0.400	**0.100**
Tetrahydrothiophene										0.100	90	**0.100**
Toluene	✓					0.670						**0.670**
Toxaphene	✓					0.028		0.0015		0.050	130	**0.028**

Table 2. Ecological Screening Values for Sediment (mg/kg).

Constituent	TAL/ TCL[a]	EPA Region IV[b]			Ecotox Thresholds[c]			Environment Canada[f]		Dutch Ministry Standards[i]		ESV
		Effects Values	CLP Practical Quantitation Limit	Screening Value	EPA Sediment Quality[d]	EPA Sediment Quality Benchmark[e]	Effects Range-Low	TEL[g]	PEL[h]	Target Value	Intervention Value	
Tribromomethane						0.650						**0.650**
Trichlorobenzenes (total)	✓									0.010		**0.010**
Trichloroethene	✓					1.6				0.001	60	**1.6**
Trichloromethane										0.001	10	**0.001**
Trichlorophenols (total)										0.001		**0.001**
Vinyl acetate	✓											
Vinyl chloride											0.100	**0.010**
m-Xylene	✓					0.025						**0.025**
Xylenes (total)	✓									0.050	25	**0.050**

a- TAL/TCL designation: ●=TAL; ✓=TCL.
b- EPA (1995).
c- EPA (1996).
d- Values assume 1% organic carbon and are the lower limit of the 95% confidence interval.
e- Sediment Quality Benchmarks by equilibrium partitioning (assumes 1% organic carbon).
f- CCME (1998a).
g- Threshold Effects Level.
h- Probable Effects Level.
i- MHSPE (1994).

Table 3. Ecological Screening Values for Surface Water (µg/L).

Constituent	TAL / TCL[a]	AWQ values[b] Acute	AWQ values[b] Chronic	Ecotox Thresholds[e] AWQC[f] or FCV[g]	Ecotox Thresholds[e] Tier II	ORNL Tier II[h] Secondary Acute	ORNL Tier II[h] Secondary Chronic	ORNL[h] Lowest Chronic Value for: Fish	Daphnids	Invertebrates	Aquatic Plants	All Organisms	CCME[i]	ESV
Inorganics														
Aluminum	●	750 [c]	87 [c]					3288	1900		460	460	5-100	**87**
Ammonia		8400 [d]	1270 [d]					1.7	630		2400	1.7	1370-2200	**1270**
Antimony	●	1300	160			180	30	1600	5400		610	610		**160**
Arsenic	●												2.2	**2.2**
Arsenic III	●	360	190	190				2962	914		2320	914		**190**
Arsenic V	●				8.1	66	3.1	892	450		48	48		**3.1**
Barium	●				3.9	110	4							**3.9**
Beryllium	●	16	0.53			35	0.66	57	5.3		100000	5.3		**0.53**
Boron			750		5.1	30	1.6		8830			8830		**750**
Cadmium	●	1.79 [j]	0.66 [j]	1				1.7	0.15		2	0.15	0.017	**0.66**
Calcium	●								116000			116000		**116000**
Chloride		860000	230000											**230000**
Chlorine (Total Residue)		19	11											**11**
Chromium III	●	984.32 [j]	117.32 [j]	180				69	<44		397	<44	8.9	**117.32**
Chromium VI	●	16	11	10				73.2	6.1		2	2	1.0	**11**
Cobalt	●				3	1500	23	290	5.1			5.1		**3**
Copper	●	9.22 [j]	6.54 [j]	11				3.8	0.23	6.07	1	0.23	2-4	**6.54**
Cyanide	●	22	5.2	5.2				7.8		18.3	30	7.8	5	**5.2**
Iron	●		1000	1000				1300	158			158	300	**1000**
Lead	●	33.78 [j]	1.32 [j]	2.5				18.9	12.3	25.5	500	12.3	1-7	**1.32**
Lithium						260	14							**14**
Magnesium	●								82000			82000		**82000**
Manganese	●				80	2300	120	1780	<1100			<1100		**80**
Mercury (inorganic)	●	2.4	0.012	1.3			1.36	<0.23	0.96		5	<0.23		**0.012**

Table 3. Ecological Screening Values for Surface Water (µg/L).

Constituent	TAL / TCL[a]	AWQ values[b] Acute	AWQ values[b] Chronic	Ecotox Thresholds[e] AWQC[f] or FCV[g]	Ecotox Thresholds[e] Tier II	ORNL Tier II[h] Secondary Acute	ORNL Tier II[h] Secondary Chronic	ORNL[h] Lowest Chronic Value for: Fish	Daphnids	Invertebrates	Aquatic Plants	All Organisms	CCME[i]	ESV
Mercury (methyl)					0.003	0.099	0.0028	0.52	<0.04		0.8-4.0	<0.04		**0.0028**
Molybdenum					240	16000	370		880			880	73	**240**
Nickel	●	789 [j]	87.71 [j]	160				<35	<5.0	128.4	5	<5.0	25-150	**87.71**
Nitrite													60	**60**
Potassium	●								53000			53000		**53000**
Selenium	●	20	5	5				88.3	91.7		100	88.3	1.0	**5**
Silver	●	1.23 [j]	0.012				0.36	0.12	2.6		30	0.12	0.1	**0.012**
Sodium	●								680000			680000		**680000**
Strontium						15000	1500		42000			42000		**1500**
Sulfide (S2-, HS)			2											**2**
Thallium	●	140	4			110	12	57	130		100	57	0.8	**4**
Tin						2700	73		350			350		**73**
Uranium						46	2.6	142				142		**2.6**
Vanadium	●				19	280	20	80	1900			80		**19**
Zinc	●	65.04 [j]	58.91 [j]	100				36.4	46.7	>5243	30	30	30	**58.91**
Zirconium						310	17	548				548		**17**
Organics														
1,1,1-Trichloroethane	✓	5280	44.9		62	200	11	3493			>669000	3493		**44.9**
1,1,2,2-Tetrachloroethane	✓	932	240		420	2100	610	2400	9900		136000	2400		**240**
1,1,2-Trichloroethane	✓	3600	940			5200	1200	94000	18400			9400		**940**
1,1-Dichloroethane	✓				47	830	47	14680				14680		**47**
1,1-Dichloroethene		3030	303			450	25	>2800	4720		>798000	>2800		**303**
1,1-Dichloroethylene	✓													

Table 3. Ecological Screening Values for Surface Water (µg/L).

Constituent	TAL / TCL[a]	AWQ values[b]		Ecotox Thresholds[e]		ORNL Tier II[h]		ORNL[h] Lowest Chronic Value for:					CCME[i]	ESV
		Acute	Chronic	AWQC[f] or FCV[g]	Tier II	Secondary Acute	Secondary Chronic	Fish	Daphnids	Invertebrates	Aquatic Plants	All Organisms		
1,2,3,4-Tetrachlorobenzene													1.8	**1.8**
1,2,3-Trichlorobenzene													8	**8**
1,2,4,5-Tetrachlorobenzene		250	50											**50**
1,2,4-Trichlorobenzene	✓	150	44.9		110	700	110						24	**44.9**
1,2-Dichlorobenzene	✓	158	15.8		14	260	14						0.7	**15.8**
1,2-Dichloroethane	✓	118000	2000			8800	910	41364	15200			15200	100	**2000**
1,2-Dichloroethene						1100	590	9538				9538		**590**
1,2-Dichloroethylene (trans)	✓	13500	1350											**1350**
1,2-Dichloropropane	✓	5250	525											**525**
1,2-Diphenylhydrazine		27	2.7											**2.7**
1,3-Dichlorobenzene	✓	502	50.2		71	630	71						150	**50.2**
1,3-Dichloropropene	✓					0.99	0.055	244	805		4950	244		**0.055**
1,3-Dichloropropylene		606	24.4											**24.4**
1,4-Dichloro-2-butene														
1,4-Dichlorobenzene	✓	112	11.2		15	180	15						26	**11.2**
1-Methylnaphthalene						37	2.1	526				526		**2.1**
1-Pentanol						2000	110	30493			30493			**110**
2,4,5-Trichlorophenol	✓													
2,4,6-Trichlorophenol	✓	32	3.2											**3.2**
2,4-Dichlorophenol	✓	202	36.5											**36.5**
2,4-Dimethylphenol	✓	212	21.2											**21.2**
2,4-Dinitrophenol	✓	62	6.2											**6.2**
2,4-Dinitrotoluene	✓	3100	310											**310**
2,6-Dinitrotoluene	✓													
2-Butanone						240000	14000	282170	1394927			282170		**14000**
2-Chloroethylvinyl ether		35400	3540											**3540**
2-Chloronaphthalene	✓													

Table 3. Ecological Screening Values for Surface Water (µg/L).

Constituent	TAL / TCL[a]	AWQ values[b]		Ecotox Thresholds[e]		ORNL Tier II[h]		ORNL[h] Lowest Chronic Value for:					CCME[i]	ESV
		Acute	Chronic	AWQC[f] or FCV[g]	Tier II	Secondary Acute	Secondary Chronic	Fish	Daphnids	Invertebrates	Aquatic Plants	All Organisms		
2-Chlorophenol	✓	438	43.8											**43.8**
2-Hexanone	✓					1800	99	32783				32783		**99**
2-Methyl-4,6-dinitrophenol	✓	23	2.3											**2.3**
2-Methylnaphthalene	✓													
2-Methylphenol						230	13	489	1316			489		**13**
2-Nitrophenol	✓		3500											**3500**
2-Octanone						150	8.3							**8.3**
2-Propanol						130	7.5	590				590		**7.5**
3,3'-Dichlorobenzidine	✓													
3-methyl-4-Chlorophenol		3	0.3											**0.3**
4-Bromophenyl phenyl ether	✓				1.5		1.5							**1.5**
4-Bromophenyl phenyl phthalate		36	12.2											**12.2**
4-Chloroaniline	✓													
4-Chloro-2-methyl phenoxy acetic acid													2.6	**2.6**
4-Chloro-m-cresol	✓													
4-Chlorophenyl phenyl ether	✓													
4-Methyl-2-pentanone						2200	170	77400				77400		**170**
4-Nitrophenol	✓	828	82.8			1200	300	481	7100		4190	481		**82.8**
Acenaphthene	✓	170	17	23				74	6646	227	520	74	5.8	**17**
Acetone	✓					28000	1500	507640	1560			507640		**1500**
Acridine													4.4	**4.4**
Acrolein		6.8	2.1											**2.1**
Acrylonitrile		755	75.5											**75.5**
Aldicarb													1.0	**1.0**
Aldrin	✓	3	0.3											**0.3**
Aniline													2.2	**2.2**

Table 3. Ecological Screening Values for Surface Water (µg/L).

Constituent	TAL / TCL[a]	AWQ values[b]		Ecotox Thresholds[e]		ORNL Tier II[h]		ORNL[h] Lowest Chronic Value for:					CCME[i]	ESV
		Acute	Chronic	AWQC[f] or FCV[g]	Tier II	Secondary Acute	Secondary Chronic	Fish	Daphnids	Invertebrates	Aquatic Plants	All Organisms		
Anthracene	✓					13	0.73	0.09	<2.1			0.09	0.012	**0.73**
Atrazine													1.8	**1.8**
Benzene	✓	530	53		46	2300	130		>98000		525000	525000	370	**53**
Benzidine	✓	250	25			70	3.9	134				134		**25**
Benzo[a]anthracene	✓					0.49	0.027		0.65			0.65	0.018	**0.027**
Benzo[a]pyrene	✓				0.014	0.24	0.014		0.3			0.3	0.015	**0.014**
Benzo[b]fluoranthene	✓													
Benzo[g,h,i]perylene	✓													
Benzo[k]fluoranthene	✓													
Benzoic acid	✓					740	42	12976				12976		**42**
Benzyl alcohol	✓					150	8.6	589				589		**8.6**
-BHC	✓		500											**500**
-BHC	✓		5000											**5000**
-BHC	✓													
-BHC (Lindane)	✓	0.95 c	0.08	0.08				14.6	14.5	3.3	500	3.3		**0.08**
BHC (Other)	✓					39	2.2		95			95		**2.2**
Biphenyl					14		14							**14**
Bis(2-chloroethoxy) methane	✓													
Bis(2-chloroethyl) ether	✓	23800	2380											**2380**
Bis(2-chloroisopropyl) ether	✓													
Bis(2-ethylhexyl)phthalate	✓	1110	<0.3		32	27	3		912			912		**<0.3**
Bromocil													5.0	**5.0**
Bromodichloromethane	✓													
Bromoform	✓	2930	293		320	2300	320							**293**
Bromomethane (Methyl bromide)	✓	1100	110											**110**
Bromoxynil													5.0	**5.0**
Butylbenzyl phthalate	✓	330	22		19		19							**22**

Table 3. Ecological Screening Values for Surface Water (µg/L).

Constituent	TAL / TCL[a]	AWQ values[b]		Ecotox Thresholds[e]		ORNL Tier II[h]		ORNL[h] Lowest Chronic Value for:					CCME[i]	ESV
		Acute	Chronic	AWQC[f] or FCV[g]	Tier II	Secondary Acute	Secondary Chronic	Fish	Daphnids	Invertebrates	Aquatic Plants	All Organisms		
Captan													1.3	**1.3**
Carbaryl													0.2	**0.2**
Carbofuran													1.8	**1.8**
Carbon disulfide	✓					17	0.92	9538	244			244		**0.92**
Carbon tetrachloride	✓	3520	352			180	9.8	1970	5580			1970		**352**
Chlordane	✓	2.4	0.0043					1.6	16	1.09		1.09	0.006	**0.0043**
Chloroacetamide														
Chlorobenzene	✓	1950	195		130	1100	64	1203	15042		224000	1203		**195**
Chloroethane	✓													
Chloroethene (Vinyl chloride)	✓													
Chloroform	✓	2890	289			490	28	1240	4483			1240	1.8	**289**
Chloromethane (Methyl chloride)	✓	55000	5500											**5500**
Chloronaphthalene														
Chlorophenols	✓													
Chlorothalonil													0.18	**0.18**
Chlorpyrifos		0.083	0.041										0.0035	**0.041**
Chrysene	✓													
o-Cresol (2-Methylphenol)	✓													
p-Cresol (4-Methylphenol)	✓													
Cyanizine													2	**2**
DDD	✓	0.064	0.0064			0.19	0.011	1.69				1.69		**0.0064**
DDE	✓	105	10.5											**10.5**
DDT	✓	1.1	0.001		0.013		0.013	0.73	0.016		0.3	0.3		**0.001**
Decane						880	49		7874			7874		**49**
Deltamethrin													.0004	**.0004**
Demeton			0.1											**0.1**
Diazinon				0.043		0.17	0.043							**0.043**

Table 3. Ecological Screening Values for Surface Water (µg/L).

Constituent	TAL / TCL[a]	AWQ values[b]		Ecotox Thresholds[e]		ORNL Tier II[h]		ORNL[h] Lowest Chronic Value for:					CCME[i]	ESV
		Acute	Chronic	AWQC[f] or FCV[g]	Tier II	Secondary Acute	Secondary Chronic	Fish	Daphnids	Invertebrates	Aquatic Plants	All Organisms		
Dibenz[a,h]anthracene	✓													
Dibenzofuran	✓				20	66	3.7		1003			1003		**3.7**
Dibromochloromethane	✓													
Dicamba													10	**10**
Dichlorobenzene (total)	✓													
Dichloromethane (Methylene chloride)	✓	193000	1930			26000	2200	108000	42667			42667	98.1	**1930**
Dichlorphenols (total)	✓												0.2	**0.2**
Diclofop-methyl													6.1	**6.1**
Dieldrin	✓	0.24	0.056	0.062										**0.056**
Diethyl phthalate	✓	5210	521		220	1800	210				85600	85600		**521**
Dimethoate													6.2	**6.2**
Dimethyl phthalate	✓	3300	330											**330**
Di(2-ethylhexyl) phthalate													16	**16**
Di-n-butyl phthalate	✓	94	9.4		33	190	35	717	697			697	19	**9.4**
Di-n-octyl phthalate	✓							3822	708			708		**708**
Dinoseb													0.05	**0.05**
Dioxin (2,3,7,8-TCDD)		0.1	1E-05											**0.00001**
Endosulfan I	✓	0.22	0.056		0.051		0.051						0.02	**0.056**
Endosulfan II	✓	0.22	0.056		0.051		0.051						0.02	**0.056**
Endosulfan sulfate	✓													
Endosulfan, mixed isomers	✓													
Endrin	✓	0.18	0.0023	0.061										**0.0023**
Endrin ketone	✓													
Ethylbenzene	✓	4530	453		290	130	7.3	>440	12922		>438000	>440	90	**453**
Ethylene glycol													192000	**192000**
Fluoranthene	✓	398	39.8	8.1				30	15		54400	15	0.04	**39.8**
Fluorene	✓				3.9	70	3.9						3	**3.9**

Table 3. Ecological Screening Values for Surface Water (μg/L).

Constituent	TAL / TCL[a]	AWQ values[b]		Ecotox Thresholds[e]		ORNL Tier II[h]		ORNL[h] Lowest Chronic Value for:					CCME[i]	ESV
		Acute	Chronic	AWQC[f] or FCV[g]	Tier II	Secondary Acute	Secondary Chronic	Fish	Daphnids	Invertebrates	Aquatic Plants	All Organisms		
Glyphosate													65	**65**
Guthion			0.01											**0.01**
Heptachlor	✓	0.52	0.0038		0.007	0.125	0.0069	1.26	3.18		26.7	1.26		**0.0038**
Heptachlor epoxide	✓	0.52	0.0038											**0.0038**
Hexachlorobenzene	✓													
Hexachlorobutadiene	✓	9	0.93										1.3	**0.93**
Hexachlorocyclopentadiene	✓	0.7	0.07											**0.07**
Hexachloroethane	✓	98	9.8		12	210	12							**9.8**
Hexane						10	0.58	65712				65712		**0.58**
Indeno(1,2,3-c,d)pyrene	✓													
Isophorone	✓	11700	1170											**1170**
Linuron													7	**7**
Malathion			0.1		0.097									**0.1**
Metalochlor													7.8	**7.8**
Methoxychlor	✓		0.03		0.019		0.019							**0.03**
Methyl ethyl ketone	✓													
Methyl isobutyl ketone	✓													
Metribuzin													1	**1**
Mirex			0.001											**0.001**
Monochlorobenzene													1.3	**1.3**
Monochlorophenol													7	**7**
Naphthalene	✓	230	62		24	190	12	620	1163		33000	620	1.1	**62**
Nitrobenzene	✓	2700	270											**270**
o-Nitroaniline	✓													
m-Nitroaniline	✓													
N-Nitrosodiphenylamine	✓	585	58.5			3800	210	332	1042			332		**58.5**
N-Nitrosodipropylamine	✓													

Table 3. Ecological Screening Values for Surface Water (µg/L).

Constituent	TAL / TCL[a]	AWQ values[b]		Ecotox Thresholds[e]		ORNL Tier II[h]		ORNL[h] Lowest Chronic Value for:					CCME[i]	ESV
		Acute	Chronic	AWQC[f] or FCV[g]	Tier II	Secondary Acute	Secondary Chronic	Fish	Daphnids	Invertebrates	Aquatic Plants	All Organisms		
Oil & Grease			0.01											**0.01**
Parathion		0.065	0.013											**0.013**
PCB 1016	✓	0.2	0.014											**0.014**
PCB 1221	✓	0.2	0.014			5	0.28	60				60		**0.014**
PCB 1232	✓	0.2	0.014			10	0.58	124				124		**0.014**
PCB 1242	✓	0.2	0.014			1.2	0.053	9		4.9	300	4.9		**0.014**
PCB 1248	✓	0.2	0.014			1.4	0.081							**0.014**
PCB 1254	✓	0.2	0.014			0.6	0.033		2.9		0.1	0.1		**0.014**
PCB 1260	✓	0.2	0.014			1700	94	<1.3				2.3		**0.014**
PCBs (total)	✓				0.19		0.14	0.2	2.1	0.8	0.144	0.1		**0.14**
Pentachlorobenzene		250	50		0.47	8.4	0.47						6	**50**
Pentachlorophenol	✓	19	15	13									0.5	**15**
Phenanthrene	✓			6.3					200			200	0.4	**6.3**
Phenol	✓	1020	256					<200	2005		20000	<200		**256**
Phenols (mono- & dihydric)													4	**4**
Phenoxy herbicides													4	**4**
Picloram													29	**29**
p-Nitroaniline	✓													
Propylene glycol													500000	**500000**
Pyrene	✓												0.025	**0.025**
Quinoline													3.4	**3.4**
Simazine													10	**10**
Styrene	✓												72	**72**
Tebuthiuron													1.6	**1.6**
Tetrachloroethene	✓	528	84		120	830	98	840	750		>816000	750	111	**84**
Tetrachloromethane					240	4400	240						13.3	**240**
Tetrachlorophenols													1	**1**

Table 3. Ecological Screening Values for Surface Water (µg/L).

Constituent	TAL / TCL[a]	AWQ values[b] Acute	AWQ values[b] Chronic	Ecotox Thresholds[e] AWQC[f] or FCV[g]	Ecotox Thresholds[e] Tier II	ORNL Tier II[h] Secondary Acute	ORNL Tier II[h] Secondary Chronic	ORNL[h] Lowest Chronic Value for: Fish	Daphnids	Invertebrates	Aquatic Plants	All Organisms	CCME[i]	ESV
Toluene	✓	1750	175		130	120	9.8	1263	25229		245000	1269	2	**175**
Toxaphene	✓	0.73	0.0002		0.011									**0.0002**
Triallate													0.24	
Tributyltin		0.46 c	0.063 c										0.008	**0.063**
Trichloroethylene	✓				350	440	47	11100	7257			7257	21	**47**
Trichlorophenols													18	**18**
Trifluralin													0.2	**0.2**
Triphenyltin													0.022	**0.022**
Vinyl acetate	✓					280	16	810				810		**16**
m-Xylene	✓				1.8	32	1.8							**1.8**
Xylene	✓					230	13	62308				62308		**13**

a- TAL/TCL designation: ●=TAL; ✓=TCL.
b- Region IV Ambient Water Quality Values (EPA 1995) unless otherwise noted.
c- pH 6.5-9.0.
d- Ammonia is pH dependent. The value if from the 4-day average chronic concentration in water having a pH of 8.0 when salmonids and other sensitive coldwater species are absent (EPA 1998).
e-EPA (1996)
f- Ambient Water Quality Criteria (EPA 1996).
g- Final Chronic Value (EPA 1996).
h- Suter and Tsao (1996).
i- CCME (1998c).
j- Hardness Dependent Based on the following equations:

Compound	Acute Screening Value	Chronic Screening Value
Cadmium	$e^{(1.128(\ln H)-3.828)}$	$e^{(0.7825(\ln H)-3.49)}$
Chromium III	$e^{(0.819(\ln H)+3.688)}$	$e^{(0.819(\ln H)+1.561)}$
Copper	$e^{(0.9422(\ln H)-1.464)}$	$e^{(0.8545(\ln H)-1.465)}$

Table 3. Ecological Screening Values for Surface Water (μg/L).

Lead	$e^{(1.273(\ln H)-1.46)}$	$e^{(1.273(\ln H)-4.705)}$
Nickel	$e^{(0.846(\ln H)+3.3612}$	$e^{(0.846(\ln H)+1.1645)}$
Silver	$e^{(1.72(\ln H)-6.52)}$	
Zinc	$e^{(0.8473(\ln H)+0.8604)}$	$e^{(0.8473(\ln H)+0.7614)}$

PROTOCOL

ECOLOGICAL CONSTITUENTS OF POTENTIAL CONCERN SELECTION PROCESS

Introduction

The following protocol has been developed in order to support the Savannah River Site (SRS) environmental remediation program. This protocol provides instructions for the development of a list of ecological constituents of potential concern (COPCs) in the ecological risk assessment (ERA) process. The protocol instructions are based on the latest available Environmental Protection Agency (EPA) guidance, as well as, on input from the staff of EPA Region IV and the South Carolina Department of Health and Environmental Control (SCDHEC). The COPC selection process is the SRS implementation of Steps 1 through 3 of the "Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments" (EPA 1997). When adequate abiotic data are available, the COPC selection process is conducted in the work plan. The COPC selection process is conducted in the baseline ecological risk assessment when adequate abiotic data were unavailable in the work plan or when new abiotic data have been collected since the initial selection process.

The process described below is intended to be applied after application of the "Unit-Source Data Process Protocol," "Unit-Background Data Process Protocol," and the "Surrogates for Non-Detects Protocol." Ecological screening values (ESVs) and toxicity reference values (TRVs) identified in the protocol will be addressed in the "Ecological Screening Values (ESVs)" and "Terrestrial Toxicity Reference Values (TRVs)" protocols, respectively. The appropriate assessment endpoints and their representative receptors to be used in the COPC selection process will be addressed in the "Assessment and Measurement Endpoint Selection Process Protocol." The exposure groups are described in the "Exposure Group Protocol." For the purposes of ecological risk assessment, only the following exposure groups may be evaluated:

- Soil from 0 to 0.3 m (0 to 1 ft)
- Soil from 0 to 1.2 m (0 to 4 ft)
- Surface Water
- Surface Sediments

Prior to implementing the steps presented below, the data for the detected constituents are sorted and grouped by medium and exposure group. The appropriate set of background data for each medium and exposure group is then identified. For example, for the 0 to 0.3

meter soil exposure group, background samples corresponding to the 0 to 0.3 meter soil interval will be used to calculate average background concentrations. For each constituent in each medium or exposure group, constituents are eliminated that have no detects. For each constituent in each medium and exposure group, the following parameters are determined: detection frequency, method detection limit (MDL), minimum detection, maximum detection, average detection, and two times (2x) average background concentration.

Details

The COPC selection process is divided into two components: screening (Steps A and B) and problem formulation (Steps C - G). These steps are described below and presented in Figure 1.

Screening Steps (A and B)

STEP A

The purpose of this step is to determine whether the constituent in each exposure group has an ecological screening value (ESV). [Note: the appropriate ESVs are identified in the protocol for “Ecological Screening Values (ESVs)."] If ESVs are unavailable for a given constituent, the constituent is carried forward to Step C.

STEP B

The purpose of this step is to identify constituents with screening-level hazard quotients (HQs) greater than one. If the maximum media concentration of the constituent divided by its associated ESV (obtained in Step A) is less than one, then it is not of concern for further evaluation in the ERA. These constituents will be identified and dropped from further consideration. If the HQ is greater than one, then the constituent is to be carried forward to Step C.

Problem Formulation Steps (C - G)

STEP C

The purpose of this step is to identify constituents for which background media concentrations can be used to eliminate them from further consideration. For each constituent in each exposure group, compare the maximum constituent concentration to two times the average unit background concentration. Identify the constituent as to whether it is above or below the background value. For surface soil (0 to 0.3 m), the interval is compared to the 2x average surface background concentration. For subsurface soil (0 to 1.2 m), the interval is compared to the 2x average composite (0 to depth) background concentration. For surface water or sediment, the media concentration is compared to the 2x average background concentration of the upgradient or reference background location(s) for surface water or sediment. Drop the constituent if it is less than its associated background value. Otherwise, the constituent is carried forward to Step D. Constituents retained upon completion of Step C are identified as COPCs.

STEP D

The purpose of this step is to identify constituents for which bioaccumulation or bioconcentration may be of concern and should be re-included. For each constituent, determine if the constituent should be retained per the protocol for "Bioaccumulation and Bioconcentration Screening." The constituent is to be carried forward to Step E if it is included in the protocol for "Bioaccumulation and Bioconcentration Screening" and its maximum concentration is greater than 2X average background.

STEP E

The purpose of this step is to identify whether the remaining constituents pose potential risk through direct contact and/or through exposure from ingestion of contaminated media (e.g., biota).

For constituents that pose a potential risk through direct contact, the maximum and average unit media concentrations are identified and carried into Step F.

For constituents that pose potential risk through exposure from ingestion of contaminated media, a daily intake of each constituent is calculated. Conversion of the environmental concentration of each constituent to an estimated daily intake for a receptor at the unit is necessary prior to evaluation of potentially toxic effects. A unit-specific exposure dose of each constituent is calculated using a food chain uptake model consistent with EPA Region IV guidance (EPA 1995) for receptors representing each media of potential concern. The exposure dose (ED) is generated using maximum and average unit media concentrations and takes into account the unit foraging factor (UFF) and other receptor-specific input parameters (e.g., ingestion rates and body weight). However, the UFF is assumed to be one to ensure conservativeness in this step of the process.

Whether the constituent poses potential risk through direct contact and/or through exposure from ingestion of contaminated media, the following steps are completed.

E.1 Based on the chemicals detected at the exposure unit and their mechanisms of toxicity to unit receptors,, select one or more appropriate assessment endpoints and their associated representative receptors based on the assessment endpoint and receptor selection criteria. [Note: these criteria will be identified in the protocol for "Assessment and Measurement Endpoint Selection Process."] Two types of exposures are distinquished in toxicological assessments: exposures through direct contact with contaminated media and exposure through ingestion of contaminated media (e.g., soil, surface water, sediment, or biota). TRVs for chemicals administered through direct contact are often expressed as concentrations in the abiotic exposure medium. TRVs for chemicals administered through the diet are often expressed as milligrams ingested per kilogram of body weight per day."

E.2 Based on the receptor and constituents identified, select the receptor- and constituent-specific input parameters.

Upon completion of Step E, proceed to Step F.

STEP F

The purpose of this step is to identify constituents with evaluation-level hazard quotients greater than one and to perform a weight-of-evidence evaluation on these constituents based on magnitude of exceedances. The generation of evaluation-level HQs for constituents posing potential risk through direct contact and constituents posing potential risk through exposure from ingestion of contaminated media are described below, respectively.

. For direct contact constituents, compare maximum and average unit concentrations to their associated no observed adverse effects level (NOAEL) and lowest observed adverse effects level (LOAEL)-based TRVs for each exposure group. The evaluation-level HQ is calculated by dividing the unit media concentration by its associated TRV. If all of the evaluation-level HQs are less than the one, then the constituent is dropped from further consideration based on direct contact. If any evaluation level HQ is greater than one for a given constituent, a weight-of-evidence evaluation based on magnitude of exceedances (e.g., NOAEL versus LOAEL, maximum versus average comparisons, and bioavailability considerations) is performed. An evaluation of the effects of using unit-specific UFFs may also be conducted in this step. Direct contact constituents may be eliminated based on these evaluations.

For constituents posing potential risk through ingestion of contaminated media, the evaluation-level HQ is calculated by dividing the ED by the TRV. If all of the evaluation-level HQs are less than the one, then the constituent is dropped from further consideration for ingestion constituents. If any evaluation level HQ is greater than one for a given constituent, a weight-of-evidence evaluation based on magnitude of exceedances (e.g., NOAEL versus LOAEL and maximum versus average comparisons) is performed. An

evaluation of the effects of using unit-specific UFFs may also be conducted in this step. Ingestion constituents may be eliminated based on these evaluations.

Constituents remaining upon completion of Step F are further evaluated in Step G.

STEP G

Constituents remaining following completion of Step F are further evaluated using a weight-of-evidence approach in the categories of frequency of detections (i.e., analytical qualifier evaluation) and patterns of detections (i.e., evaluation of background versus unit concentrations). This evaluation is based on an interpretation of the available data, interpretation of the available information, and professional judgement. Constituents remaining upon completion of this evaluation are identified as final COPCs.

Conclusions

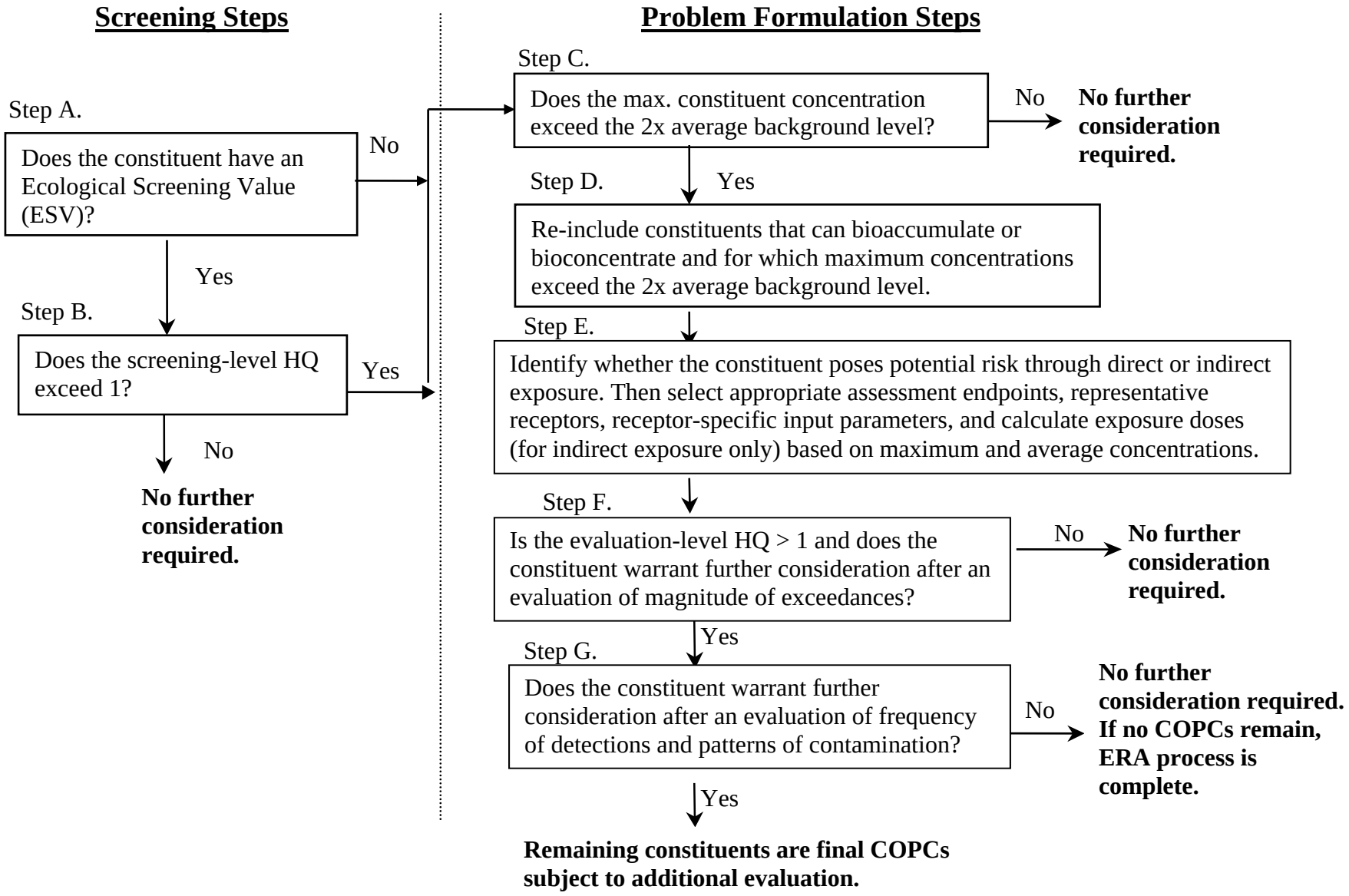
Constituents remaining upon completion of the COPC selection process are the final COPCs retained for further evaluation. If no COPCs remain, the ERA process is complete and no further documentation is required. If COPCs remain, the constituents are the starting point of the ecological risk assessment analysis.

References

EPA. 1995. *Supplemental Guidance to RAGS: Region 4 Bulletins, Ecological Risk Assessment.* Draft, Office of Health Assessment, EPA Region IV, Atlanta, GA.

EPA. 1997. *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments.* Interim Final, Environmental Response Team, Edison, NJ.

Figure 1. Ecological COPC Selection Process



PROTOCOL

TERRESTRIAL TOXICITY REFERENCE VALUES (TRVs) (INCLUDING EXPOSURE DOSE (ED) AND HAZARD QUOTIENT (HQ) CALCULATIONS)

Introduction

Toxicity reference values (TRVs) are used in the problem formulation stage of the ecological risk assessment (ERA) process per the Ecological Constituent of Potential Concern (COPC) Selection Process. The evaluation conducted using TRVs is performed in Step F of the Ecological COPC Selection Process. Step F, which includes the use of TRVs, involves the refinement of the COPCs identified in the screening step of the COPC Selection Process. Step E requires selection of appropriate assessment endpoint(s), and selection of representative receptors with which to perform TRV-based calculations for exposure dose estimates. The dose estimates, calculated based on the maximum and average concentrations, are then compared to the lowest observable adverse affect level (LOAEL) and the no observable adverse effects level (NOAEL) to calculate a hazard quotient (HQ) for each constituent.

This protocol uses soil invertebrates (earthworms), birds, and mammals as target receptors. Constituents are evaluated using exposure models (discussed in the TRV Based Estimates of Exposure section) that incorporate non-scaled TRVs. TRVs are based LOAELs and NOAELs. Where LOAELs are unavailable, the no observed adverse effects levels (NOAELs) can be estimated by multiplying the NOAEL by 10 (EPA 1995). The technical approach and supportive estimate calculations are presented in TRV Based Estimates of Exposure section. The lists of receptor- and constituent-specific TRVs are presented in the TRV Table section. The technical justification for deriving the TRVs is presented in the Terrestrial TRV Technical Justification Document that is a companion to this protocol. The TRVs used in this protocol and documented in the technical justification document have been primarily abstracted from two reports: (1) Toxicological Benchmarks for Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Processes: 1997 Revision (Efroymson et al. 1997) for earthworm receptors, and (2) Toxicological Benchmarks for Wildlife: 1996 Revision (Sample et al. 1996) for bird and mammal receptors. The authors of these two reports have compiled and interpreted toxicity information and data from a variety of sources to develop the TRVs, cited herein for use in Savannah River Site (SRS) ERA constituent evaluation. Where more appropriate TRVs are available from other sources or to supplement the sources above when TRVs are unavailable, these are so noted in the tables (such as the use of the latest version of the Integrated Risk Information System when TRVs are unavailable from other sources). In addition, where unit-specific body burden data are available for a given waste unit, other data sources, such as the Fish and Wildlife Service reports by Eisler may be used.

The lists of TRVs provided in TRV Table section are not comprehensive lists of TRVs that will be needed for constituent evaluation at the SRS. Additional TRVs will be compiled and incorporated into the lists presented below, on a periodic basis, as required based on project-

specific needs. The additional TRVs will be obtained for constituents that exceed the ecological screening value (ESV) comparisons conducted in Step B of the Ecological COPC Selection Process. Further revisions of this protocol will focus on TRVs specific to SRS biota, beginning with the vertebrate fauna. This is contingent upon the selection of receptor species indigenous to SRS based on the protocol for "Assessment and Measurement Endpoint Selection Process."

Details

TRV Based Estimates of Exposure

This protocol is used to estimate the exposure of soil invertebrates and/or wildlife species to soil using TRVs.

The resulting soil invertebrate threshold values are used to indicate whether soil concentrations pose potential risks to soil invertebrates. The contaminant exposure is generally expressed as the average and maximum concentrations of a constituent in soil compared to a risk-based dietary benchmark

The resulting wildlife threshold values are used to indicate if tissue residues pose potential unacceptable risks to ecological receptors. The contaminant exposure is generally expressed as a daily dietary exposure with the units of mg of contaminant per kg body weight of the receptor per day (mg/kg/day). The average and maximum concentrations of a constituent in soil is incorporated into a dietary intake equation and the resulting exposure dose is compared to a risk-based dietary benchmark, as detailed below.

To quantify exposures of terrestrial receptors to each constituent, a daily intake of each constituent is calculated. Conversion of the environmental concentration of each constituent to an estimated daily intake for receptors at the unit is necessary. Exposure rates for each receptor are based upon ingestion of constituents from soil and also from consumption of other organisms. Potential risk from dermal and/or inhalation exposure pathways are generally not quantified for receptors given the insignificance of these pathways relative to the major exposure pathways (e.g., ingestion) and due to the scarcity of data available for these pathways.

The first step in measuring exposure rates for terrestrial wildlife is the calculation of food ingestion rates for the receptors under evaluation. The EPA's Wildlife Exposure Factors Handbook (EPA 1993) includes a variety of exposure information for a number of avian, herptile, and mammalian species. For other species for which data are not provided, the document provides an allometric equation (Nagy 1987, cited by Sample et al. 1996) to estimate food intake based on body mass, as follows:

$$FI = 0.648 (BW^{0.651})$$

where:

FI	=	food intake rate (g/day)
BW	=	body weight (g)

A unit-specific exposure dose of each constituent is calculated using a food chain uptake model consistent with EPA Region IV guidance (EPA 1995). This algorithm accounts for exposure via incidental ingestion of contaminated soil, ingestion of plants grown in contaminated soil, and ingestion of lower trophic level animals associated with contamination. The soil exposure equation for lower trophic level receptors is as follows:

$$ED_{soil} = C_s \times [(SP \times CF \times I_p) + (BAF_{inv} \times I_a) + (ST \times I_s)] \times UFF / BW$$

where:

ED_{soil}	=	Soil exposure dose for terrestrial receptor (mg/kg/d)
C_s	=	Concentration in soil (mg/kg)
SP	=	Soil-to-plant uptake factor (kg soil/kg plant)
CF	=	Plant wet-weight-to-dry-weight conversion factor (unitless)
I_p	=	Receptor-specific ingestion rate of plant material (kg/d)
BAF_{inv}	=	Invertebrate bioaccumulation factor, constituent-specific bioaccumulation factor for transfer from soil to invertebrate tissue (kg soil/kg tissue)
I_a	=	Receptor-specific ingestion rate of animal material (kg/d)
I_s	=	Receptor-specific ingestion rate of soil (kg/d)
ST	=	Bioavailability factor for constituents ingested in soil
UFF	=	Unit foraging factor (smaller of 1 and exposure area/home-range)
BW	=	Body weight (kg)

Where it is assumed that the vegetation consumed by a given receptor is comprised largely leaves, stems, and roots of plants (EPA 1993), values of SP_v (soil-to-vegetative tissue uptake factor comprised mainly of leaves, stems, and roots) are used to calculate their exposure to constituents. Where it is assumed that the vegetation consumed by a receptor is predominately berries and fruits (EPA 1993), values of SP_r (soil-to-reproductive tissue uptake factor comprised mainly of berries and fruits) are used to calculate their exposure to constituents. BAF_{inv} is used to calculate the exposure of receptors to constituents by ingestion of soil invertebrates. If soil invertebrates are not consumed by the receptor under investigation, the appropriate BAF value would be used instead. BAF and SP values are obtained from the protocol for *Bioaccumulation and Bioconcentration Screening.* Equations used to derive these values are contained within the sources cited in the BAF/BCF protocol.

For the exposure of higher trophic level receptors to constituents from their diet, an algorithm similar to the exposure equation used for lower trophic level receptors is used:

$$ED_{soil} = [(C_s \times SP \times CF \times I_{p(predator)}) + (C_p \times I_{a(predator)}) + (C_s \times I_{s(predator)} \times ST)] \times UFF / BW$$

where:

ED_{soil}	=	Soil exposure dose for terrestrial receptor (mg/kg/day)
C_s	=	Concentration in soil (mg/kg)
SP	=	Soil-to-plant uptake factor (kg soil/kg plant);
CF	=	Plant wet-weight-to-dry-weight conversion factor (unitless)
$I_{p(predator)}$	=	Ingestion rate of plant material by the predator (kg/day)
C_p	=	Concentration in prey tissue (mg/kg)
$I_{a(predator)}$	=	Ingestion rate of animal material by the predator (kg/day)
$I_{s(predator)}$	=	Ingestion rate of soil by the predator (kg/day)
ST	=	Bioavailability factor for constituents ingested in soil
UFF	=	Unit foraging factor (unitless)
BW	=	Body weight (kg)

The constituent concentration in prey tissue (C_p) is calculated using a bioaccumulation factor for ingested constituents to tissue. This factor (BAF_{mamm}) relates constituent tissue concentration to daily constituent intake rather than to soil concentrations and has units of d/kg [concentration in tissue (mg/kg) divided by daily intake (mg/d)]. The equation for concentration in prey tissue is:

$$C_p = [(C_s \times SP \times CF \times I_{p(prey)}) + (BAF_{inv} \times I_{a(prey)}) + (I_{s(prey)} \times ST)] \times BAF_{mamm}$$

where:

$I_{p(prey)}$	=	Ingestion rate of plant material by the prey (kg/day)
BAF_{inv}	=	Invertebrate bioaccumulation factor, constituent-specific bioaccumulation factor for soil invertebrates (kg soil/kg tissue); if soil invertebrates are not consumed by the receptor under investigation, the appropriate BAF value would be used instead.$I_{s(prey)}$ = Ingestion rate of soil by the prey (kg/day)
$I_{a(prey)}$	=	Ingestion rate of animal material by the prey (kg/day)
ST	=	Bioavailability factor for constituents ingested in soil
BAF_{mamm}	=	Mammalian bioaccumulation factor, bioaccumulation factor of constituent ingested by the prey (d/kg)

The intake equations presented above utilize receptor-specific input parameters. The process for identifying appropriate, unit-specific receptors is being developed as part of the protocol for "Assessment and Measurement Endpoint Selection Process."

Once the exposure doses are calculated, maximum and average-based exposure doses are compared to their associated NOAEL- and LOAEL-based or dose-based TRV. The hazard quotient is calculated by dividing the ED by the TRV for indirect toxicity constituents or by dividing the unit media concentrations by the TRV for direct toxicity constituents. If all of the HQs are less than the one, then the constituent is dropped from further consideration.

TRV Tables

The list of terrestrial TRVs for soil invertebrates (earthworms) are presented in Table 1. The TRVs for wildlife are presented in Table 2 for mammals and Table 3 for birds. The technical justification supporting these TRVs is provided in the Terrestrial TRV Justification Document that is a companion to this TRV protocol.

Table 1. Toxicity Reference Values for Earthworms

Constituent	(mg/kg soil)	
Inorganics		
Arsenic	60	
Cadmium	20	
Chromium	32	
Copper	50	
Lead	500	
Mercury[a]	5	a
Nickel	200	
Selenium	70	
Zinc	200	
Organics		
Chloroacetamide	2	
3-chloroaniline	30	
2,4-dichloroaniline	100	
3,4-dichloroaniline	20	
2,4,5-trichloroaniline	20	
2,3,5,6-tetrachloroaniline	20	
Pentachloroaniline	100	
1,2-dichloropropane	700	
Dimethylphthalate	200	
Fluorene	30	
N-nitrosodiphenylamine	20	
Phenol	30	
4-nitrophenol	7	
3-chlorophenol	10	
3,4-dichlorophenol	20	
2,4,5-trichlorophenol	9	
2,4,6-trichlorophenol	10	
2,3,4,5-tetrachlorophenol	20	
Pentachlorophenol	6	
Chlorobenzene	40	
1,4-dichlorobenzene	20	
1,2,3-trichlorobenzene	20	
1,2,4-trichlorobenzene	20	
1,2,3,4-tetrachlorobenzene	10	
Pentachlorobenzene	20	
Nitrobenzene	40	

TRV = toxicity reference value
TRVs are from Efroymson et al. (1997) unless otherwise noted.
[a] Eisler (1987)

Table 2. Toxicity Reference Values for Mammals

Constituent	Test Species	Toxicity benchmark (NOAEL, mg/kg/d)	Toxicity benchmark (LOAEL, mg/kg/d)	Ref.
Inorganics				
Aluminum	Mouse	1.93E-00	1.93E+01	d
Antimony	Mouse	1.25E-01	1.25E-00	d
Arsenic	Mouse	1.26E-01	1.26E-00	d
Barium	Rat	5.10E-00	1.98E+01	b
Beryllium	Rat	6.60E-01	6.60E-00	c
Boron	Rat	2.80E+01	9.36E+01	a
Cadmium	Rat	1.00E-00	1.00E+01	a
Chromium	Rat	2.74E+03	2.74E+04	c
Copper	Mink	1.17E+01	1.54E+01	a
Cyanide	Rat	6.87E+01	6.87E+02	c
Fluoride	Mink	3.14E+01	5.28E+01	a
Lead	Rat	8.00E-00	8.00E+01	a
Lithium	Rat	9.40E-00	1.88E+01	a
Manganese	Rat	8.80E+01	2.84E+02	a
Mercury	Mink	1.00E-00	1.00E+01	c
Molybdenum	Mouse	2.60E-01	2.60E-00	d
Nickel	Rat	4.00E+01	8.00E+01	a
Niobium	Mouse	1.55E-01	1.55E-00	d
Nitrate	Guinea pig	5.07E+02	1.13E+03	a
Selenium	Rat	2.00E-01	3.30E-01	a
Strontium	Rat	2.63E+02	2.63E+03	c
Thallium	Rat	7.40E-03	7.40E-02	f
Tin	Mouse	2.34E+01	3.50E+01	a
Uranium	Mouse	3.07E-00	6.13E-00	a
Vanadium	Rat	2.10E-01	2.10E-00	d
Zinc	Rat	1.60E+02	3.20E+02	a
Organics				
Acenaphthene	Mouse	1.75E+02	3.50E+02	j
Acetone	Rat	1.00E+01	5.00E+01	g
Anthracene	Mouse	1.00E+02	1.00E+03	i
Benzene	Mouse	2.64E+01	2.64E+02	d
Benzidine	Mouse	2.70E-01	2.70E+00	k
Benzo(a)pyrene	Mouse	1.00E-00	1.00E+01	d
Bis(2-chloroisopropyl)ether	Mouse	3.58E+01	1.98E+02	j
Organics (cont.)				

Constituent	Test Species	Toxicity benchmark (NOAEL, mg/kg/d)	Toxicity benchmark (LOAEL, mg/kg/d)	Ref.
Bis(2-ethylhexyl) phthalate	Mouse	1.83E+01	1.83E+02	d
Bromodichloromethane	Mouse	1.79E+00	1.79E+01	k
Bromoform	Rat	2.50E+00	5.00E+01	l
Bromomethane	Rat	1.40E-01	7.10E-01	l
Butylbenzyl phthalate	Rat	1.59E+02	4.70E+02	j
Carbon tetrachloride	Rat	1.60E+01	1.60E+02	c
4-Chloroaniline	Rat	1.25E+00	1.25E+01	k
Chlorobenzene	Beagle dog	2.73E+01	5.45E+01	j
Chloroform	Rat	1.50E+01	4.10E+01	g
Dibromochloromethane	Rat	3.00E+00	6.00E+01	l
1,2-Dichlorobenzene	Rat	1.20E+02	1.20E+03	h
1,2-Dichloroethane	Mouse	5.00E+01	5.00E+02	c
1,2-Dichloroethene	Mouse	4.52E+01	4.52E+02	f
1,1-Dichloroethylene	Rat	3.00E+01	3.00E+02	c
1,2-Dichloroethylene	Rat	4.52E+01	4.52E+02	e
2,4-Dichlorophenol	Rat	3.00E-01	3.00E+00	k
1,3-Dichloropropene	Rat	3.00E+00	3.00E+01	k
Diethylphthalate	Mouse	4.58E+03	4.58E+04	d
2,4-Dimethylphenol	Mouse	5.00E+00	2.50E+01	l
Di-n-butylphthalate	Mouse	5.50E+02	1.83E+03	a
2,4-Dinitrotoluene	Beagle Dog	2.00E-01	1.50E+00	i
D-n-hexylphthalate	Mouse	5.50E+01	5.50E+02	d
Ethanol	Rat	3.19E+01	3.19E+02	d
Ethyl acetate	Rat	9.00E+01	3.60E+02	g
Fluoranthene	Mouse	1.32E+01	1.32E+02	h
Fluorene	Mouse	1.25E+01	2.50E+01	l
Formaldehyde	Beagle dog	9.40E-00	9.40E+01	c
Hexachlorocyclo-pentadiene	Rat	1.00E+00	1.9E+00	l
Hexachloroethane	Rat	1.00E-01	1.5E+00	l
Methanol	Rat	5.00E+01	2.50E+02	g
Methylene chloride	Rat	5.85E-00	5.00E+01	a
Methyl Ethyl Ketone	Rat	1.77E+03	4.57E+03	a
4-Methyl-2-pentanone	Rat	2.50E+01	2.50E+02	e
Naphthalene	Rat	1.00E+01	2.00E+01	l
Nitrobenzene	Mouse/Rat	4.60E-01	4.36E+00	m
Pentachlorophenol	Rat	2.40E-01	2.40E-00	a
Phenol	Rat	6.00E+01	1.20E+02	j
Pyrene	Mouse	7.50E+01	7.50E+02	h
Styrene	Beagle dog	2.00E+01	4.00E+01	l
Organics (cont.)				

Constituent	Test Species	Toxicity benchmark (NOAEL, mg/kg/d)	Toxicity benchmark (LOAEL, mg/kg/d)	Ref.
Tetrachloroethene	Mouse	1.40E-00	7.00E-00	a
Toluene	Mouse	2.60E+01	2.60E+02	d
1,2,4-Trichlorobenzene	Rat	1.48E+01	5.36E+01	j
1,1,1-Trichloroethane	Mouse	1.00E+03	1.00E+04	c
1,1,2-Trichloroethane	Mouse	3.90E+-01	3.90E+00	i
Trichloroethylene	Mouse	7.00E-01	7.00E+00	f
2,4,5-Trichlorophenol	Rat	1.00E+01	1.00E+02	i
Vinyl chloride	Rat	1.70E-01	1.70E-00	d
Xylenes (total)	Mouse	1.03+03	2.06E+03	a
Pesticides/PCBs				
Aldrin	Rat	2.00E-01	1.00E-00	a
Aroclor 1016	Mink	1.37E-00	3.43E-00	a
Aroclor 1242	Mink	6.90E-02	6.90E-01	d
Aroclor 1248	Rhesus monkey	1.00E-02	1.00E-01	d
Aroclor 1254	Oldfield mouse	6.80E-02	6.80E-01	d
Chlordane	Mouse	4.60E-00	9.20E-00	a
Chlordecone (kepone)	Rat	8.80E-02	4.00E-01	a
o-Cresol	Mink	2.19E+02	2.19E+03	c
DDT and metabolites	Rat	8.00E-01	4.00E-00	a
Dieldrin	Rat	2.00E-02	2.00E-01	d
1,4-Dioxane	Rat	5.00E-01	1.00E-00	a
Endosulfan	Rat	1.50E-01	1.50E-00	f
Endrin	Mouse	9.20E-02	9.20E-01	d
Heptachlor	Mink	1.00E-01	1.00E-00	a
Heptachlor epoxide	Beagle dog	1.25E-03	1.25E-02	k
Lindane	Rat	8.00E-00	8.00E+01	c
Methoxychlor	Rat	4.00E-00	8.00E-00	a
Toxaphene	Rat	8.00E-00	8.00E+01	c
Dioxins/Furans				
1,2,3,6,7,8-Hexachlorodibenzofuran	Rat	1.60E-04	1.60E-03	g
1,2,3,4,8-Pentachlorodibenzofuran	Rat	4.80E-02	4.80E-01	e
1,2,3,7,8-Pentachlorodibenzofuran	Rat	1.60E-04	1.60E-03	g
2,3,7,8-TCDD	Rat	1.00E-06	1.00E-05	a

TRV = toxicity reference value

a Sample et al. (1996)
b Sample et al. (1996); LOAEL derived from subchronic LOAEL
c Sample et al. (1996); LOAEL derived from NOAEL
d Sample et al. (1996) NOAEL derived from LOAEL
e Sample et al. (1996); LOAEL derived from subchronic NOAEL
f Sample et al. (1996); LOAEL derived from subchronic LOAEL
g Sample et al. (1996); NOAEL and LOAEL derived from subchronic NOAEL and LOAEL
h IRIS (EPA 1998); LOAEL derived from NOAEL
i IRIS (EPA 1998); NOAEL and LOAEL derived from subchronic NOAEL
j IRIS (EPA 1998);
k IRIS (EPA 1998); NOAEL derived from LOAEL
l IRIS (EPA 1998); NOAEL and LOAEL derived from subchronic NOAEL and LOAEL
m IRIS (EPA 1998); NOAEL and LOAEL derived from subchronic LOAEL

Table 3. Toxicity Reference Values for Birds

Constituent	Test Species	Toxicity benchmark (NOAEL, mg/kg/d)	Toxicity benchmark (LOAEL, mg/kg/d)	Ref.
Inorganics				
Aluminum	Ringed dove	1.10E+02	1.10E+03	b
Arsenic	Mallard duck	5.14E-00	1.28E+01	a
Barium	Chick (1-day old)	2.08E+01	4.17E+01	f
Boron	Mallard duck	2.88E+01	1.00E+02	a
Cadmium	Mallard duck	1.45E-00	2.00E+01	a
Chromium	Black duck	1.00E-00	5.00E-00	a
Copper	Chick (1-day old)	4.70E+01	6.17E+01	a
Fluoride	Screech owl	7.80E-00	3.20E+01	a
Lead	Japanese quail	1.13E-00	1.13E+01	a
Manganese	Japanese quail	9.97E+02	9.77E+03	b
Mercury	Japanese quail	4.50E-01	9.00E-01	a
Molybdenum	Chicken	3.50E-00	3.53E+01	c
Nickel	Mallard duckling	7.74E+01	1.07E+02	a
Selenium	Mallard duck	5.00E-01	1.00E-00	a
Tin	Japanese quail	6.80E+00	1.69E+01	a
Uranium	Black duck	1.60E+01	1.60E+02	d
Vanadium	Mallard duck	1.14E+01	1.14E+02	b
Zinc	White Leghorn chicken	1.45E+01	1.31E+02	a
Organics				
Bis(2-ethylhexyl)phthalate	Ringed dove	1.10E-00	1.10E+01	b
1,2-Dichloroethane	Chicken	1.72E+01	3.44E+01	a
Di-n-butyl phthalate	Ringed Dove	1.10E-01	1.10E-00	a
Pentachloronitrobenzene	Chicken	7.07E-00	7.07E+01	a
Toxaphene	Black Ducks	2.00E-00	1.00E+01	g
Pesticides/PCBs				
Aroclor 1242	Screech owl	4.10E-01	4.10E-00	b
Aroclor 1254	Ring-necked pheasant	1.80E-01	1.80E-00	c
Benzene Hexachloride (mixed isomers)	Japanese Quail	5.60E-01	2.25E+01	a
Chlordane	Red-winged blackbird	2.14E-00	1.07E+01	a
Pesticides/PCBs (cont.)				

Constituent	Test Species	Toxicity benchmark (NOAEL, mg/kg/d)	Toxicity benchmark (LOAEL, mg/kg/d)	Ref.
DDT and metabolites	Brown pelican	2.80E-03	2.80E-02	c
Dieldrin	Barn owl	7.70E-02	7.70E-01	b
Endosulfan	Gray partridge	1.00E+01	1.00E+02	b
Endrin	Screech owl	1.00E-02	1.00E-01	c
Lindane	Mallard duck	2.00E-00	2.00E+01	c
Dioxins/Furans				
2,3,7,8-TCDD	Ring-necked pheasant	1.40E-05	1.40E-04	a
2,3,7,8-Tetrachlorodibenzofuran	Chick	1.00E-06	1.00E-05	e

TRV = toxicity reference value

a Sample et al. (1996).
b Sample et al. (1996); LOAEL derived from NOAEL.
c Sample et al. (1996); NOAEL derived from LOAEL.
d Sample et al. (1996); LOAEL derived from subchronic NOAEL.
e Sample et al. (1996); LOAEL derived from subchronic LOAEL.
f Sample et al. (1996); NOAEL and LOAEL derived from subchronic NOAEL and LOAEL, respectively.
g Mehrle et al., 1979.

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PROTOCOL

BIOACCUMULATION AND BIOCONCENTRATION SCREENING

Introduction

This protocol has been developed to support the bioaccumulation and bioconcentration evaluation that is conducted as part of the Ecological Constituent of Potential Concern (COPC) Selection Process. This protocol specifically addresses the screening conducted in Step D of the Ecological COPC Selection Process. The purpose of Step D is to identify constituents for which bioaccumulation or bioconcentration may be of concern. This is accomplished using this protocol to determine: (1) if the constituent exceeds an octonal/water partition coefficient (K_{ow}) threshold for surface water, (2) if the constituent exceeds a bioaccumulation factor (BAF) threshold for soil or sediment, or (3) if the constituent exceeds a bioconcentration factor (BCF) for surface water. If the K_{ow}, BAF, or BCF exceeds the screening threshold and its maximum concentration exceeds its two times average background concentration, the constituent is carried forward to Step E of the Ecological COPC Selection Process for further processing. Step E is also where radionuclides are first evaluated (including their relevant BAFs and BCFs); therefore, radionuclides are not included in this protocol.

Details

Screening Steps

This protocol segregates the bioaccumulation and bioconcentration screening process into two steps. Each step is presented below and results in a list of constituents associated with each step for which bioaccumulation or bioconcentration is of concern. The lists will be used in Step D of the Ecological COPC Selection Process.

Step 1: Octanol-Water Partition Coefficient (K_{ow}) Threshold Screening

Step 1 is used for organic constituents in surface water and is based on K_{ow} screening. A BCF may be estimated from a K_{ow} based on a mathematical conversion. It has been shown that the K_{ow} and BCF have a functional relationship in that the higher the K_{ow}, the higher the BCF. However, this functional relationship exists only within a specific range of K_{ow} values. Therefore, the K_{ow} rather than the BCF is used in this screening step. This step is restricted to organic constituents in surface water since K_{ow} values, as an indicator of surface water bioconcentration potential, have proven to be reasonably accurate for this class of compounds. Generally, bioaccumulation is most likely to occur with persistent and very hydrophobic chemicals; that is, those with log K_{ow} values from 5 to 8 (Hoffman et al. 1995). Screening for this step identifies the constituents in Table 1 with a K_{ow} between 5 to 8 as constituents likely to bioaccumulate or bioconcentrate.

The Step 1 evaluation identifies the following constituents as likely to bioaccumulate or bioconcentrate:

- Benzo(a)anthracene
- Benzo(a)pyrene
- Benzo(b and k)fluoranthene
- Benzo(g,h,i)perylene
- Bis(2-ethylhexyl)phthalate
- Chrysene
- Dibenzo(a,h)anthracene
- Di-n-butylphthalate
- Di-n-octylphthalate
- Fluoranthene
- Indeno(1,2,3-c,d)pyrene
- Pyrene
- Aroclors
-
- alpha-Chlordane
- gamma-Chlordane
- 4,4'-DDD
- 4,4'-DDE
- 4,4'-DDT
- Dioxins
- Endrin
- Heptachlor epoxide

Step 2: BAF and BCF Threshold Screening

Step 2 is based on BAF and BCF threshold screening. Constituent-specific BCFs and BAFs are listed in Table 1 and were obtained from the literature where possible (HAZWRAP 1994). A default value of 1 was used for BCFs and BAFs when no published literature value was available. In general, literature references pertaining to BAF or BCF thresholds refer to high BAF and BCF values as those from 300 to 1000. Calabrese and Baldwin (1993) refer to the use of safety factors that may be applied to such thresholds. Safety factors may be used to add conservatism to thresholds which is an important consideration when dealing with early screening of constituents. Therefore, a two-fold safety factor is being applied to the 1000 upper threshold to produce a screening threshold of 10. The Step 2 screening, based on a threshold of 10, is applied to identify constituents with BAFs for soil or sediment or BCFs for inorganics in surface water greater than 10 as constituents for which bioaccumulation or bioconcentration is of concern. Table 1 includes BAFs and BCFs for groups of receptors that are likely to be evaluated during the risk assessment process including plants, invertebrates, mammals, and fish.

The Step 2 evaluation identifies the following constituents as likely to bioaccumulate or bioconcentrate for surface water:

- Aluminum
- Arsenic
- Cadmium
- Chromium
- Cobalt
- Copper
- Lead
- Manganese
- Mercury
- Nickel
- Zinc

The Step 2 evaluation identifies the following constituents as likely to bioaccumulate or bioconcentrate for soil or sediment:

- Cadmium
- Mercury
- Di-n-octylphthalate

References

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Table 1. Biouptake Factors

Constituent	Log K_{ow}	Soil-to-Plant		Soil-to-Animal*	Animal-to-Animal	Soil-to-Tissue	Water-to-Fish
		SP_v	SP_r	BAF_{inv}	BAF_{mamm}	ST	BCF
Inorganics							
Aluminum		8.00E-04 a	1.30E-04 a	7.50E-02 b	7.50E-02 b	1.00E+00 c	1.00E+01 b
Antimony		4.00E-02 a	6.00E-03 a	5.00E-02 b	5.00E-02 b	1.00E+00 c	1.00E+00 b
Arsenic		8.00E-03 a	1.20E-03 a	6.60E-03 b	1.00E-01 b	1.00E+00 c	2.80E+02 b
Barium		3.00E-02 b	3.00E-02 b	7.50E-03 b	7.50E-03 b	1.00E+00 c	4.00E+00 b
Beryllium		2.00E-03 b	2.00E-03 b	5.00E-02 b	5.00E-02 b	1.00E+00 c	2.00E+00 b
Boron		1.00E+00 c	1.00E+00 c	1.00E+00 c	1.00E+00 c	1.00E+00 c	1.00E+00 c
Cadmium		1.10E-01 a	3.00E-02 a	1.10E+01 b	2.80E-02 b	1.00E+00 c	5.00E+01 b
Calcium		7.00E-01 a	7.00E-02 a	1.00E+00 c	1.00E+00 c	1.00E+00 c	1.00E+00 c
Chromium		1.50E-03 a	9.00E-04 a	1.60E-01 b	2.80E-01 b	1.00E+00 c	2.00E+02 b
Cobalt		4.00E-03 b	4.00E-03 b	1.00E+00 b	1.00E+00 b	1.00E+00 c	3.00E+02 b
Copper		8.00E-02 a	5.00E-02 a	1.60E-01 b	5.00E-01 b	1.00E+00 c	2.10E+02 b
Cyanide		1.00E+00 b	1.00E+00 b	0.00E+00 b	0.00E+00 b	1.00E+00 c	0.00E+00 b
Iron		8.00E-04 a	2.00E-04 a	1.00E+00 c	1.00E+00 c	1.00E+00 c	1.00E+00 c
Lead		9.00E-03 a	1.80E-03 a	see note d	1.50E-02 b	1.00E+00 c	3.00E+02 b
Magnesium		2.00E-01 a	1.10E-01 a	1.00E+00 c	1.00E+00 c	1.00E+00 c	1.00E+00 c
Manganese		5.00E-02 a	1.00E-02 a	2.00E-02 b	2.00E-02 b	1.00E+00 c	4.00E+02 b
Mercury		1.80E-01 a	4.00E-02 a	3.40E-01 b	1.30E+01 b	1.00E+00 c	6.30E+04 b
Nickel		1.20E-02 b	1.20E-02 b	2.30E-01 b	3.00E-01 b	1.00E+00 c	1.00E+02 b
Potassium		2.00E-01 a	1.10E-01 a	1.00E+00 c	1.00E+00 c	1.00E+00 c	1.00E+00 c
Selenium		5.00E-03 b	5.00E-03 b	7.60E-01 b	7.50E-01 b	1.00E+00 c	8.00E+00 b
Silver		8.00E-02 a	2.00E-02 a	1.50E-01 b	1.50E-01 b	1.00E+00 c	2.00E+00 b
Sodium		1.50E-02 a	1.10E-02 a	1.00E+00 c	1.00E+00 c	1.00E+00 c	1.00E+00 c
Thallium		8.00E-04 a	8.00E-05 a	1.00E+00 c	1.00E+00 c	1.00E+00 c	1.00E+00 c
Vanadium		1.10E-03 a	6.00E-04 a	1.30E-01 b	1.30E-01 b	1.00E+00 c	1.00E-02 b
Zinc		3.00E-01 a	1.80E-01 a	1.80E+00 b	5.00E+00 b	1.00E+00 c	1.00E+03 b
Organics							
Acenaphthene	3.9	2.00E-02 b	2.00E-02 b	5.00E-02 b	1.20E-02 b	1.00E+00 c	3.90E+02 b
Acenaphthylene	4.1	2.00E-02 b	2.00E-02 b	5.00E-02 b	1.90E-02 b	1.00E+00 c	6.90E+02 b
Acetone	-.24	2.00E-02 b	2.00E-02 b	5.00E-02 b	8.70E-07 b	1.00E+00 c	2.00E-01 b
Anthracene	4.5	2.00E-02 b	2.00E-02 b	5.00E-02 b	4.80E-02 b	1.00E+00 c	1.40E+03 b
Benzene	2.1	2.00E-02 b	2.00E-02 b	5.00E-02 b	1.90E-04 b	1.00E+00 c	3.20E+01 b
Benzo(a)anthracene	5.7	3.90E-03 b	3.90E-03 b	5.00E-02 b	7.60E-01 b	1.00E+00 c	1.30E+04 b
Benzo(a)pyrene	6.0	2.60E-03 b	2.60E-03 b	5.00E-02 b	1.50E+00 b	1.00E+00 c	3.00E+01 b
Benzo(b and k)fluoranthene	6.1	2.30E-03 b	2.30E-03 b	5.00E-02 b	1.90E+00 b	1.00E+00 c	2.60E+04 b
Benzo(g,h,i)perylene	6.6	1.20E-03 b	1.20E-03 b	5.00E-02 b	6.00E+00 b	1.00E+00 c	6.50E+04 b
Benzo(a)pyrene	6	2.60E-03 b	2.60E-03 b	5.00E-02 b	1.50E+00 b	1.00E+00 c	3.00E+01 b
Bis(2-ethylhexyl)phthalate	5.1	8.70E-03 b	8.70E-03 b	5.00E-02 b	1.90E-01 b	1.00E+00 c	3.10E+02 b

Table 1. Biouptake Factors (continued)

Constituent	Log K_{ow}	Soil-to-Plant		Soil-to-Animal*	Animal-to-Animal	Soil-to-Tissue	Water-to-Fish
		SP_v	SP_r	BAF_{inv}	BAF_{mamm}	ST	BCF
Bromomethane		1.00E+00 c	1.00E+00 c	1.00E+00 c	1.00E+00 c	1.00E+00 c	1.00E+00 c
2-Butanone		2.00E-02 b	2.00E-02 b	5.00E-02 b	2.90E-06 b	1.00E+00 c	6.00E-01 b
Butylbenzylphthalate	4.9	2.00E-02 b	2.00E-02 b	5.00E-02 b	1.20E-01 b	1.00E+00 c	6.60E+02 b
Carbon disulfide		1.00E+00 c	1.00E+00 c	1.00E+00 c	1.00E+00 c	1.00E+00 c	1.00E+00 c
Carbon tetrachloride		1.00E+00 c	1.00E+00 c	1.00E+00 c	1.00E+00 c	1.00E+00 c	1.00E+00 c
Carbazole	3.8	2.00E-02 b	2.00E-02 b	5.00E-02 b	8.70E-03 b	1.00E+00 c	3.70E+02 b
4-Chloroaniline	1.8	2.00E-02 b	2.00E-02 b	5.00E-02 b	9.50E-05 b	1.00E+00 c	1.10E+01 b
Chlorobenzene	2.8	2.00E-02 b	2.00E-02 b	5.00E-02 b	9.50E-04 b	1.00E+00 c	4.50E+02 b
Chloroform	2	2.00E-02 b	2.00E-02 b	5.00E-02 b	1.50E-04 b	1.00E+00 c	6.00E+00 b
4-Chloro-3-methylphenol	3.1	2.00E-02 b	2.00E-02 b	5.00E-02 b	1.90E-03 b	1.00E+00 c	1.10E+02 b
Chrysene	5.7	3.90E-03 b	3.90E-03 b	5.00E-02 b	7.60E-01 b	1.00E+00 c	1.30E+04 b
Dibenzo(a,h) anthracene	6.5	1.40E-03 b	1.40E-03 b	5.00E-02 b	4.80E+00 b	1.00E+00 c	5.40E+04 b
Dibenzofuran	4.1	2.00E-02 b	2.00E-02 b	5.00E-02 b	1.90E-02 b	1.00E+00 c	6.90E+02 b
1,2-Dichloroethane	1.5	2.00E-02 b	2.00E-02 b	5.00E-02 b	6.00E-04 b	1.00E+00 c	8.00E+00 b
1,2-Dichloroethene	2	2.00E-02 b	2.00E-02 b	5.00E-02 b	1.50E-04 b	1.00E+00 c	8.60E-01 b
Diethylphthalate	3.2	2.00E-02 b	2.00E-02 b	5.00E-02 b	2.40E-03 b	1.00E+00 c	1.20E+02 b
Di-n-butylphthalate	5.2	7.60E-03 b	7.60E-03 b	5.00E-02 b	2.40E-01 b	1.00E+00 c	5.10E+03 b
Di-n-octylphthalate	9.2	3.70E-05 b	3.70E-05 b	5.00E-02 b	2.40E+03 b	1.00E+00 c	9.30E+03 b
2,6,-Dinitrotoluene	2.1	2.00E-02 b	2.00E-02 b	5.00E-02 b	1.90E-04 b	1.00E+00 c	2.60E+01 b
Ethylbenzene	3.2	2.00E-02 b	2.00E-02 b	5.00E-02 b	2.40E-03 b	1.00E+00 c	2.90E+02 b
Fluoranthene	5.0	2.00E-02 b	2.00E-02 b	5.00E-02 b	1.30E-01 b	1.00E+00 c	3.20E+03 b
Fluorene	4.2	2.00E-02 b	2.00E-02 b	5.00E-02 b	2.40E-02 b	1.00E+00 c	8.30E+02 b
2-Hexanone		1.00E+00 c	1.00E+00 c	1.00E+00 c	1.00E+00 c	1.00E+00 c	1.00E+00 c
Indeno(1,2,3-c,d) pyrene	6.6	1.20E-03 b	1.20E-03 b	5.00E-02 b	6.00E+00 b	1.00E+00 c	6.50E+04 b
Methylene chloride	1.3	2.00E-02 b	2.00E-02 b	5.00E-02 b	3.00E-05 b	1.00E+00 c	4.00E+00 b
Methyl Ethyl Ketone		2.00E-02 b	2.00E-02 b	5.00E-02 b	2.90E-06 b	1.00E+00 c	6.00E-01 b
4-Methyl-2-pentanone		2.00E-02 b	2.00E-02 b	5.00E-02 b	2.40E-05 b	1.00E+00 c	6.00E+00 b
2-Methylnaphthalene	1.9	2.00E-02 b	2.00E-02 b	5.00E-02 b	1.90E-08 b	1.00E+00 c	4.30E+02 b
2-Methylphenol	2.0	2.00E-02 b	2.00E-02 b	5.00E-02 b	1.50E-04 b	1.00E+00 c	1.50E+01 b
2-Methylphenol	2.0	2.00E-02 b	2.00E-02 b	5.00E-02 b	1.50E-04 b	1.00E+00 c	1.50E+01 b
4-Methylphenol	1.9	2.00E-02 b	2.00E-02 b	5.00E-02 b	1.20E-04 b	1.00E+00 c	1.30E+01 b
Naphthalene	3.6	2.00E-02 b	2.00E-02 b	5.00E-02 b	6.00E-03 b	1.00E+00 c	4.30E+02 b
3-Nitroaniline		2.00E-02 b	2.00E-02 b	5.00E-02 b	3.80E-05 b	1.00E+00 c	5.10E+00 b
4-Nitroaniline		2.00E-02 b	2.00E-02 b	5.00E-02 b	3.80E-05 b	1.00E+00 c	5.10E+00 b
Nitrobenzene	1.9	2.00E-02 b	2.00E-02 b	5.00E-02 b	1.20E-04 b	1.00E+00 c	1.30E+01 b
2-Nitrophenol	1.9	2.00E-02 b	2.00E-02 b	5.00E-02 b	1.20E-04 b	1.00E+00 c	1.30E+01 b
4-Nitrophenol	1.9	2.00E-02 b	2.00E-02 b	5.00E-02 b	1.20E-04 b	1.00E+00 c	1.30E+01 b
N-Nitrosodiphenylamine	3.1	2.00E-02 b	2.00E-02 b	5.00E-02 b	1.90E-03 b	1.00E+00 c	8.10E+01 b
Phenanthrene	4.5	2.00E-02 b	2.00E-02 b	5.00E-02 b	4.80E-02 b	1.00E+00 c	1.40E+03 b
Phenol	1.5	2.00E-02 b	2.00E-02 b	5.00E-02 b	4.80E-05 b	1.00E+00 c	7.80E+02 b

Table 1. Biouptake Factors (continued)

Constituent	Log K_{ow}	Soil-to-Plant		Soil-to-Animal*	Animal-to-Animal	Soil-to-Tissue	Water-to-Fish
		SP_v	SP_r	BAF_{inv}	BAF_{mamm}	ST	BCF
Pyrene	5.3	6.70E-03 b	6.70E-03 b	5.00E-02 b	3.00E-01 b	1.00E+00 c	6.10E+03 b
Styrene		1.00E+00 c	1.00E+00 c	1.00E+00 c	1.00E+00 c	1.00E+00 c	1.00E+00 c
1,1,2,2-Tetrachloroethane	2.6	2.00E-02 b	2.00E-02 b	5.00E-02 b	6.00E-04 b	1.00E+00 c	8.00E+00 b
Tetrachloroethene	3.4	2.00E-02 b	2.00E-02 b	5.00E-02 b	3.80E-03 b	1.00E+00 c	4.40E+01 b
Toluene	2.7	2.00E-02 b	2.00E-02 b	5.00E-02 b	7.60E-04 b	1.00E+00 c	8.30E+01 b
1,1,1-Trichloroethane		1.00E+00 c	1.00E+00 c	1.00E+00 c	1.00E+00 c	1.00E+00 c	1.00E+00 c
Trichloroethene	2.4	2.00E-02 b	2.00E-02 b	5.00E-02 b	3.80E-04 b	1.00E+00 c	1.70E+01 b
2,4,6-Trichlorophenol	3.7	2.00E-02 b	2.00E-02 b	5.00E-02 b	7.60E-03 b	1.00E+00 c	3.30E+02 b
Vinyl chloride		1.00E+00 c	1.00E+00 c	1.00E+00 c	1.00E+00 c	1.00E+00 c	1.00E+00 c
Xylenes, total	3.2	2.00E-02 b	2.00E-02 b	5.00E-02 b	2.40E-03 b	1.00E+00 c	1.70E+01 b
Pesticides/PCBs							
Aldrin	3.0	2.00E-02 b	2.00E-02 b	5.60E-01 b	2.90E+00 b	1.00E+00 c	1.10E+04 b
Aroclor-1254	6.0	3.80E-01 b	3.80E-01 b	5.80E+00 b	2.90E+00 b	1.00E+00 c	1.00E+07 b
Aroclor-1260	7.1	3.80E-01 b	3.80E-01 b	5.80E+00 b	2.90E+00 b	1.00E+00 c	1.00E+07 b
alpha-BHC	3.8	2.00E-02 b	2.00E-02 b	2.60E+00 b	2.90E+00 b	1.00E+00 c	7.10E+02 b
beta-BHC	3.8	2.00E-02 b	2.00E-02 b	2.60E+00 b	2.90E+00 b	1.00E+00 c	7.20E+02 b
delta-BHC	4.1	2.00E-02 b	2.00E-02 b	2.60E+00 b	2.90E+00 b	1.00E+00 c	6.90E+02 b
gamma-BHC (Lindane)	4.1	2.00E-02 b	2.00E-02 b	2.60E+00 b	2.90E+00 b	1.00E+00 c	1.00E+03 B
-Chlordane	5.5	5.10E-03 b	5.10E-03 b	1.60E+00 b	2.90E+00 b	1.00E+00 c	1.40E+06 b
gamma-Chlordane	5.5	5.10E-03 b	5.10E-03 b	1.60E+00 b	2.90E+00 b	1.00E+00 c	7.60E+04 b
4,4'-DDD	6.0	1.30E-03 b	1.30E-03 b	3.30E+00 b	2.95E+00 b	1.00E+00 c	1.75E+05 b
4,4'-DDE	5.7	2.00E-03 b	2.00E-03 b	1.70E+00 b	2.90E+00 b	1.00E+00 c	1.84E+07 b
4,4'-DDT	6.4	7.70E-04 b	7.70E-04 b	5.70E-01 b	2.90E+00 b	1.00E+00 c	3.40E+04 b
Dieldrin	4.6	2.00E-02 b	2.00E-02 b	5.50E+00 b	2.90E+00 b	1.00E+00 c	1.40E+04 b
Dioxins	-	3.80E-01 e	3.80E-01 e	5.80E+00 e	2.90E+00 e	1.00E+00 c	1.00E+07 e
Endosulfan I	3.6	2.00E-02 b	2.00E-02 b	5.50E+00 b	2.90E+00 b	1.00E+00 c	2.80E+02 b
Endosulfan II	3.6	2.00E-02 b	2.00E-02 b	5.50E+00 b	2.90E+00 b	1.00E+00 c	2.80E+02 b
Endosulfan sulfate	3.1	2.00E-02 b	2.00E-02 b	5.50E+00 b	2.90E+00 b	1.00E+00 c	1.10E+02 b
Endrin	5.6	4.50E-03 b	4.50E-03 b	1.90E+00 b	2.90E+00 b	1.00E+00 c	2.60E+03 b
Endrin aldehyde	3.1	2.00E-02 b	2.00E-02 b	1.90E+00 b	2.90E+00 b	1.00E+00 c	1.20E+02 b
Endrin ketone	3.1	2.00E-02 b	2.00E-02 b	1.90E+00 b	2.90E+00 b	1.00E+00 c	1.20E+02 b
Heptachlor	4.3	2.00E-02 b	2.00E-02 b	1.00E+00 b	2.90E+00 b	1.00E+00 c	1.40E+04 b
Heptachlor epoxide	5.4	5.90E-03 b	5.90E-03 b	1.00E+00 b	2.90E+00 b	1.00E+00 c	1.40E+04 B
Methoxychlor	4.8	2.00E-02 b	2.00E-02 b	5.70E-01 b	2.90E+00 b	1.00E+00 c	8.30E+03 b

Table 1. Biouptake Factors (continued)

SP = Soil-to-Plant Transfer; v = vegetative parts, r = reproductive parts
BAF = Bioaccumulation Factor; inv = invertebrate (unitless), mamm = mammal (d/kg)
* BAF_{inv} also used for sediment-to-invertebrate transfer
BCF = Bioconcentration factor for transfer from water to fish and other aquatic biota (L/kg)
a Baes et al. (1984), SP converted to wet weight assuming 80% water by weight
b HAZWRAP (1994)
c Default value
d Calcium-dependent: BAF-Pb = $C_{Worm\text{-}Pb}/C_{Soil\text{-}Pb}$, where $C_{Worm\text{-}Pb} = 14.45 \times 10^{0.916 \log(CSoil\text{-}Pb)}/10^{0.326\log(CSoil\text{-}Ca)}$ from HAZWRAP (1994)
e Aroclor-1254 used as a surrogate.

PROTOCOL

ECOLOGICAL RISK-BASED REMEDIAL GOAL OPTIONS

Introduction

The following protocol has been developed in order to support the Savannah River Site (SRS) environmental remediation program. This protocol provides instructions for identification of ecological remedial goal options (ECO RGOs). The protocol instructions are based on the latest available EPA guidance as well as input from the staffs of the Environmental Protection Agency (EPA) and the South Carolina Department of Health and Environmental Control (SCDHEC). The starting point for this protocol is with the list of preliminary ecological constituents of concern (ECO COCs) developed in the baseline risk assessment (BRA).

Development of ECO RGOs occurs early in the Remedial Investigation / Feasibility Study (RI/FS) and requires the following unit-specific data:

- Media of concern
- Constituents of concern for each assessment endpoint
- Probable future land use

In general, RGOs provide long-term targets to use during analysis and selection of remedial alternatives. RGOs will be determined for the final list of ECO COCs remaining after the uncertainty analysis.

RGOs are developed using literature-based toxicity values (Toxicity Reference Values [TRVs]) or estimated from unit-specific biological data, where applicable. RGO ranges will be calculated using both NOAELs and LOAELs.

Details

A. EXPOSURE MEDIA

RGOs are developed for soil, sediment, and surface water exposure media.

B. ASSESSMENT ENDPOINT

RGOs are developed for those assessment endpoints that have been determined to be appropriate endpoints for the particular waste-unit.

C. EXPOSURE FACTORS

Exposure factors used in the development of RGOs should include the following:

1. Dietary exposure parameters;

2. Bioaccumulation factors (BAFs) and bioconcentration factors (BCFs); and

3. Unit-foraging factors (UFFs).

D. EFFECTS EVALUTION

In order to remediate the environment, protection of the assessment endpoints is critical. As in the ERA, the TRVs obtained from the *Toxicity Reference Values (TRVs)* protocol or from field-derived biological characterization data are considered in evaluating constituent RGOs for the representative ecological receptors.

E. CALCULATIONS

The RGO is the environmental concentration of contaminant when the HQ is 1. Examples of the RGO equations for soil, sediment, and surface water are provided below.

1. Risk-based RGOs for soil

Risk-based RGOs for soil-dwelling receptors (e.g., earthworms) assumed to be exposed directly and continuously to contaminants in soil is derived by:

$$RGO = TRV$$

where:

RGO = remedial goal options (mg/kg soil),

TRV = receptor-specific toxicity reference value (mg/kg soil) or unit-specific toxicity data if available.

Risk-based RGOs for herbivores, omnivores, and carnivores are derived from modeled exposure and from receptor-specific toxicity threshold by a rearrangement of the equation for the HQ. The HQ equation is:

$$HQ = ED/\ TRV$$

where:

HQ = hazard quotient,

ED = exposure dose, receptor-specific exposureto contaminants from soil (mg/kg/d), and

TRV = receptor-specific toxicity reference values (mg/kg/d).

An example of the RGO equation for a higher, trophic level receptor is provided below.

$$RGO = \frac{TRV \times BW}{UFF\left[\left(SP \times I_p\right) + \left(BAF \times I_a\right) + I_s\right]}$$

where:

RGO = remedial goal option (mg/kg soil),

TRV = receptor-specific toxicity reference values (mg/kg/d),

BW = body weight of the receptor (kg),

UFF = Unit foraging factor,

SP = soil-to-plant bioaccumulation factor (kg soil/kg tissue),

I_p = daily ingestion of plant tissue (kg/d),

BAF = soil-to-plant bioaccumulation factor for prey (kg soil/kg tissue),

I_a = daily ingestion of animal tissue (kg/d), and

I_s = daily soil ingestion (kg/d).

2. Risk-based RGOs for sediment

RGOs for sediment are derived using risk-based values because there are no Federal or State applicable and appropriate requirements (ARARs) for sediment. These risk-based values are the TRVs to be identified in the "Aquatic Toxicity Reference Values (TRVs)" protocol. The example sediment RGO equation is provided below.

$$RGO = \frac{BW \times TRV}{UFF\left[\frac{I_w}{K_d} + I_t \times BAF\right]}$$

where:

RGO	=	remedial goal option (mg/kg soil),
BW	=	body weight of the receptor (kg),
TRV	=	receptor-specific toxicity reference values (mg/kg/d),
UFF	=	Unit foraging factor,
I_w	=	daily ingestion of water (L/d),
K_d	=	Distribution coefficient for chemical between concentration in water and concentration in sediment (L/kg),
I_t	=	total ingestion (animal, plant, sediment) (kg/d), and
BAF	=	bioaccumulation factor for food item (kg soil/kg tissue).

3. Risk-based RGOs for surface water

ARARs such as National Ambient Water Quality Criteria (NAWQC) and Tier II Secondary Chronic Values are available for some contaminants in surface water. These values represent the highest environmental concentration at which exposure to contaminants in surface water are not harmful to biological individuals, ecological populations, or communities. When chronic NAWQC and Tier II values are available, these values will be chosen as RGOs for protection of aquatic receptors.

In addition to aquatic receptors, some terrestrial receptors are exposed to contaminants in surface water by ingestion of aquatic receptors and surface water. Risk-based RGOs are developed for the representative receptors that are exposed through the food web to surface water contaminants as shown in the example provided below.

$$RGO = \frac{1000 \times TRV \times BW}{UFF\left[\left(BCF \times I_t\right) + \left(I_W\right)\right]}$$

where:

RGO = remedial goal option (ug/L),

1000 = conversion factor, ug/mg,

TRV = receptor-specific toxicity reference value (mg/kg/d),

BW = body weight of the receptor (kg),

UFF = Unit foraging factor,

BCF = water-to-fish prey bioconcentration factor (L/kg tissue),

I_t = daily ingestion of total food (animal and plant) (kg/d), and

I_w = daily drinking water ingestion (L/d).

The following example table should be included with the RGO chapter:

Media	Receptor	Constituent	RGO Range	MR RGO[1]	HQ Basis

1 MR RGO = Most restrictive RGO.

PROTOCOL

AQUATIC TOXICITY REFERENCE VALUES (TRVs)

Introduction

Toxicity reference values (TRVs) are used in the ecological risk assessment (ERA) process as part of the *Ecological Constituent of Potential Concern (COPC) Selection Process* (WSRC 1999b). The evaluation conducted using TRVs is performed in Step F of the Ecological COPC Selection Process. Step E of the Ecological COPC Selection Process requires selection of appropriate assessment endpoint(s), and selection of representative receptors with which to perform TRV-based calculations for exposure dose estimates. The dose estimates, which are based on maximum and average concentrations, are then compared to the lowest recorded median lethal concentration (LC_{50}, the concentration at which 50% of the test population dies) or median effects concentration (EC_{50}, the concentration at which 50% of the test population exhibits an effect) showing reproductive effects, in order to calculate a hazard quotient (HQ) for each constituent.

For aquatic receptors, the preferred source of aquatic surface water TRVs is *Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota: 1996 Revision* (Suter and Tsao 1996). This document provides a compilation of aquatic toxicity values, including Federal Ambient Water Quality Criteria (AWQC), derived Tier II values (secondary chronic and acute values), and chronic values from a variety of other governmental sources. Uncertainty factors (other than use for use of a surrogate chemical) are not applied to TRVs from the above sources because the methods of their derivation already account for uncertainties. AWQC values based on SCDHEC water quality criteria (EPA 1992) are applicable or relevant and appropriate requirements (ARARs) and are the preferred value for the surface water TRVs. If no AWQCs are available, the lowest (most conservative) value from the other sources is used as the surface water TRV. In the absence of TRVs for a constituent of potential concern (COPC) from the above sources, aquatic toxicity data from the Aquatic Information Retrieval System (AQUIRE) or Hazardous Substances Data Bank (HSBD) databases or other sources are used. The databases are searched for the lowest recorded LC_{50} or EC_{50} for reproductive effects. Taxonomic preference for the lowest value occurs in the following order: (1) native species potentially present at the unit; (2) proxy species commonly studied in the laboratory, such as fathead minnow (*Pimephales promelas);* or (3) other species most similar taxonomically and physiologically to native species. The lowest (most conservative) appropriate value from the preferred data is used as the TRV for each of the surface water COPCs.

Sediment is also evaluated for potential toxicity to aquatic receptors. The preferred source of sediment TRVs is *Toxicological Benchmarks for Screening Contaminants of Potential Concern*

for Effects on Sediment Associated Biota (Jones et al. 1997). This document compiles the following:

- Sediment toxicity values, including EPA Sediment Quality Criteria for Protection of Benthic Organisms
- Derived Sediment quality benchmarks for nonionic organic chemicals based on equilibrium partitioning
- Washington State sediment quality standards for some ionic organic compounds
- National Oceanic and Atmospheric Administration (NOAA) values from Long and Morgan (1991) and Long et al. (1995)
- Values from other governmental sources

The lists of TRVs (surface water TRVs for aquatic receptors are presented in Table 1; sediment TRVs for aquatic receptors are presented in Table 2) are not comprehensive lists of TRVs, but will be needed for constituent evaluation at the SRS. Additional TRVs will be compiled and incorporated into the lists presented below, on a periodic basis, as required based on project-specific needs. The additional TRVs will be obtained for constituents that exceed the ecological screening value (ESV) comparisons conducted in Step B of the Ecological COPC Selection Process. Further revisions of this protocol will focus on TRVs specific to SRS biota, beginning with the aquatic fauna. This is contingent upon the selection of receptor species indigenous to SRS based on the draft protocol for *Assessment and Measurement Endpoint Selection Process* WSRC 1999a).

Table 1. Surface Water Toxicity Reference Values

Constituent	TRV (ug/L)	Source
Inorganics		
Aluminum [a]	87	1
Antimony	160	2
Arsenic [b]	190	1
Barium	4.0	3
Beryllium	0.53	2
Boron	750	1
Cadmium [c]	0.66	1
Calcium	116000	4
Chloride	230000	1
Chlorine	11	1
Chromium [b]	117.32	1
Cobalt	23	3
Copper [c]	6.54	1
Cyanide	5.2	6
Iron	1000	1
Lead [c]	1.32	1
Lithium	14	3
Magnesium	82000	4
Manganese	120	3
Mercury	0.012	1
Molybdenum	370	4
Nickel [c]	87.71	1
Potassium	53000	4
Selenium	5	1
Silver	0.012	5
Sodium	680000	4
Strontium	1500	3
Thallium	12	3
Tin	73	3
Uranium	2.6	3
Vanadium	20	3
Zinc [c]	120	6
Zirconium	17	3
Organics		
Acenaphthene	17	5

Table 1. Surface Water Toxicity Reference Values

Constituent	TRV (ug/L)	Source
Acetone	1500	3
Organics (continued)		
Acrolein	2.1	5
Acrylonitrile	75.5	3
Anthracene	0.73	3
Aldrin	0.3	5
Benzene	0.73	3
Benzidine	3.9	3
Benzo(a)anthracene	0.027	3
Benzo(a)pyrene	0.014	3
Benzoic acid	42	3
Benzyl alcohol	8.6	3
α-BHC	500	5
β-BHC	5000	5
γ-BHC (Lindane)	0.08	1,5
Biphenyl	14	3
Bis(2-chloroethyl)ether	2380	5
Bis(2-ethylhexyl)phthalate	3.0	3
Bromoform	293	5
4-Bromophenyl phenyl ether	1.5	3
Butylbenzyl phthalate	19	3
2-Butanone	14000	3
Carbon disulfide	0.92	3
Carbon tetrachloride	9.8	3
Chlordane	0.0043	1
Chlorobenzene	64	3
2-Chloroethylvinyl ether	3540	5
Chloroform	28	3
2-Chlorophenol	43.8	5
Chlorpyrifos	0.041	1
DDD	0.001	6
DDE	10.5	5
DDT	0.001	1
Decane	49	3
Demeton	0.1	1
Di-n-butyl phthalate	35	3
Diazinon	0.043	3

Table 1. Surface Water Toxicity Reference Values

Constituent	TRV (ug/L)	Source
Dibenzofuran	3.7	3
1,2-Dichlorobenzene	14	3
1,3-Dichlorobenzene	50.2	5
Organics (continued)		
1,4-Dichlorobenzene	11.2	5
1,1-Dichloroethane	47	3
1,2-Dichloroethane	910	3
1,1-Dichloroethene	25	3
1,2-Dichloroethene	590	3
2,4-Dichlorophenol	36.5	5
1,2-Dichloropropane	525	5
Dichloropropylene	24.4	5
Dieldrin	0.0019	1
Diethyl phthalate	210	3
2,4-Dimethylphenol	21.2	5
2,4-Dinitrophenol	6.2	5
Di-n-octyl phthalate	708	4
2,4-Dinitrotoluene	310	5
Dioxin	0.00001	5
1,2-Diphenylhydrazine	2.7	5
Endosulfan I	0.056	1
Endosulfan II	0.056	1
Endrin	0.0023	1
Ethylbenzene	7.3	3
Fluoranthene	39.8	5
Fluorene	3.9	3
Guthion	0.01	1
Heptachlor	0.0036	1
Heptachlor epoxide	0.0036	1
Hexane	0.58	3
2-Hexanone	99	3
Hexachlorobutadiene	0.93	5
Hexachlorocyclopentadiene	0.07	5
Hexachloroethane	9.8	5
Isophorone	1170	5
Malathion	0.1	1
Methoxychlor	0.03	6

Table 1. Surface Water Toxicity Reference Values

Constituent	TRV (ug/L)	Source
Methyl bromide	110	5
Methyl chloride	5500	5
1-Methylnaphthalene	2.1	3
2-Methyl-4,6-dinitrophenol	2.3	5
3-Methyl-4-chlorophenol	0.3	5
Organics (continued)		
4-Methyl-2-pentanone	170	3
2-Methylphenol	13	3
Methylene chloride	1930	5
Methoxychlor	0.03	1
Mirex	0.001	1
Naphthalene	12	3
2-Nitrophenol	3500	5
4-Nitrophenol	82.8	5
N-Nitrosodiphenylamine	58.5	5
2-Octanone	8.3	3
Parathion	0.013	1
PCBs (total)	0.14	3
Aroclor 1016	0.014	1
Aroclor 1221	0.014	1
Aroclor 1232	0.014	1
Aroclor 1242	0.014	1
Aroclor 1248	0.014	1
Aroclor 1254	0.014	1
Aroclor 1260	0.014	1
Pentachlorobenzene	0.47	3
Pentachlorophenol [d]	13	1
1-Pentanol	110	3
2-Propanol	7.5	3
1,2,4,5-Tetrachlorobenzene	50	5
1,1,2,2-Tetrachloroethane	240	5
Tetrachloroethene	98	3
Tetrachloromethane	240	3
Toluene	9.8	3
Toxaphene	0.0002	1
Tribromomethane	320	3
Tributyltin	0.026	5

Table 1. Surface Water Toxicity Reference Values

Constituent	TRV (ug/L)	Source
1,2,4-Trichlorobenzene	44.9	5
1,1,1-Trichloroethane	11	3
1,1,2-Trichloroethane	1200	3
Trichloroethene	47	3
2,4,6-Trichlorophenol	3.2	5
Vinyl acetate	16	3
Xylene	13	3
Organics (continued)		
m-Xylene	1.8	3

TRV = toxicity reference value
1 – SCDHEC AWQC (EPA 1992)
2 – Ecotox Threshold (Tier II) Values (EPA 1996)
3 – Secondary Chronic Value (Suter and Tsao 1996)
4 – Lowest Chronic Value for Daphids (Suter and Tsao 1996)
5 - EPA Region IV Chronic Screening Values (EPA 1995)
6 – National AWQC (EPA 1998)
a- pH 6.5-9.0.
b- Values are for Arsenic III and Chromium III.
c- Hardness Dependent Based on the following equations:

Compound	Acute Screening Value	Chronic Screening Value
Cadmium	$e^{(1.128(\ln H)-3.828)}$	$e^{(0.7825(\ln H)-3.49)}$
Chromium III	$e^{(0.819(\ln H)+3.688)}$	$e^{(0.819(\ln H)+1.561)}$
Copper	$e^{(0.9422(\ln H)-1.464)}$	$e^{(0.8545(\ln H)-1.465)}$
Lead	$e^{(1.273(\ln H)-1.46)}$	$e^{(1.273(\ln H)-4.705)}$
Nickel	$e^{(0.846(\ln H)+3.3612}$	$e^{(0.846(\ln H)+1.1645)}$
Silver	$e^{(1.72(\ln H)-6.52)}$	
Zinc	$e^{(0.8473(\ln H)+0.8604)}$	$e^{(0.8473(\ln H)+0.7614)}$

d- pH dependent based on the following equation:

Compound	Acute Screening Value	Chronic Screening Value
Pentachlorophenol	$e^{(1.005pH-4.869)}$	$e^{(1.005pH-5.134)}$

Table 2. Sediment Toxicity Reference Values

Constituent	TRV (mg/kg)	Ref.
Inorganics		
Antimony	2	1
Arsenic	8.2	1
Cadmium	1.2	1
Chromium	81	1
Copper	34	1
Lead	46.7	1
Mercury	0.15	1
Nickel	20.9	1
Silver	1	1
Zinc	150	1
Organics		
Acenaphthene	0.016	1
Acenaphthylene	0.044	1
Anthracene	0.085	1
Benzo(a)anthracene	0.261	1
Benzo(a)pyrene	0.430	1
Benzoic acid	0.650	2
Benzyl alcohol	0.057	2
Chlordane	0.0005	1
Chrysene	0.384	1
DDD	0.002	1
DDE	0.0022	1
DDT	0.0016	1
Dibenzo(a,h)anthracene	0.063	1
Dieldrin	0.00002	1
2,4-Dimethyl phenol	0.029	2
Endrin	0.00002	1
Fluoranthene	0.600	1
Fluorene	0.019	1
2-Methylnaphthalene	0.070	1
2-Methyl phenol	0.063	2
4-Methyl phenol	0.670	2
PAHs (Total Low Molecular Weight)	0.552	1
PAHs (Total High Molecular Weight)	1.700	1
PAHs (Total)	4.022	1
PCBs (Total)	0.023	1
Pentachlorophenol	0.360	2
Phenanthrene	0.240	1

Table 2. Sediment Toxicity Reference Values

Constituent	TRV (mg/kg)	Ref.
Phenol	0.420	2
Organics (continued)		
Pyrene	0.665	1

TRV = toxicity reference value.
1 – Effects Range – Low (Jones et al. 1997).
2 – Washington state sediment quality standards for ionizable organic compounds (Jones et al. 1997).

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(7) WSRC. 1999a. *Assessment and Measurement Endpoint Selection Process*. April 1999, Westinghouse Savannah River Company, Savannah River Site, Aiken, SC.

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GROUNDWATER MODELING GUIDELINES

I. Evaluating Hydrogeological and Hydrochemical Data for Groundwater Modeling

This guideline describes the steps necessary for assuring that the data used for groundwater modeling are valid and representative of conditions over the model domain.

Details

The first step in the groundwater modeling process is formulation of a conceptual model based on existing data. A conceptual model is a qualitative representation used to provide a basis for the assessment of flow system behavior. This representation also involves a comprehensive evaluation of existing data to develop spatial distributions of material properties for model input. Given the imperfect knowledge of the flow system, refinement of the conceptual model should be expected during the modeling process.

Once a conceptual model is defined, it is refined through analytical/numerical model development. This is accomplished by adjusting model parameters (i.e., model calibration). The goal is to minimize the differences between simulated and observed values that serve as calibration targets. Hypotheses regarding flow system behavior are evaluated, resulting in an updated conceptual model and refinement of the conceptual understanding of the groundwater flow system within the model domain.

In order to construct a model that is representative of a physical system, it is essential to evaluate the data available. A groundwater flow model is the combination of field data, parameters and conditions within established boundaries to represent the groundwater flow system. The use of valid, representative data is paramount to creation of a site-specific model that is capable of producing meaningful results.

Typically, the data required for groundwater modeling include:
Hydrogeologic data – water level measurements from groundwater monitoring wells and piezometers, hydrographs for individual wells or piezometers, contour maps showing hydraulic head distribution, estimates of hydraulic parameters and groundwater recharge/discharge rates and areas. Examples of hydraulic parameters are horizontal and vertical hydraulic conductivity, transmissivity, storativity and coefficient of leakance. These parameters can be estimated by conducting aquifer injection/extraction (pumping) tests, slug tests or laboratory tests. Pumping test data are reflective of average conditions between injection/extraction wells and observation wells, and slug tests are useful for characterizing formation materials directly adjacent to the well tested. Laboratory analysis of disturbed samples includes falling head/constant head permeameter tests and sieve analysis. The data from these tests may not be directly comparable (scale-specific), and may provide a range of hydraulic conductivity values that differ by several orders of magnitude.

Hydrochemical data – analytical data from chemical analysis of soil or water samples, and plume maps created from the data. Only validated data may be used for modeling purposes. These data have been checked for laboratory errors, and are quantified down to sample-specific detection limits.

Surface hydrology data – surface water (stream) flow records and water quality parameters. These data are used to determine quantitative relationships between surface water and groundwater. Topographic data are used in conjunction with surface hydrology data.

Chemical-Specific Data – chemical-specific data include parameters for contaminants detected at site, including adsorption distribution coefficient (K_d), organic carbon partitioning coefficient (K_{oc}), retardation/degradation rates, half-life and decay chain (for radiological constituents) and half-life, degradation rate and degradation chain (for organic constituents). In reality, these parameters are dependent on conditions such as pH, redox potential, fraction organic carbon (f_{oc}), dispersivity, etc. If available, site-specific values are used. Otherwise, values are taken from literature.

Geological data – includes interpretation of geologic conditions from tests or observations such as borehole lithological and core descriptions, structural features and lithofacies maps, geophysical logs, stratigraphic cross sections and fence diagrams, and isopach maps. Geologic and topographic data are used to determine relationships between hydrostratigraphic units.

Climatological data – records of precipitation (amount and frequency), temperature, barometric pressure, solar radiation and results of evapotranspiration studies. In conjunction with geological data, these data are used for deriving infiltration and aquifer recharge rates.

Topographic data - stream/wetland elevations. Surface elevations are taken from 7.5 minute series U.S.G.S. quadrangle maps, or site series 3302 topographic maps.

Water-use data – well location and design information, and groundwater injection/extraction rates for wells effecting the area to be modeled.

While groundwater models are constructed using all of these types of data, hydrogeologic and hydrochemical data are the parameters used for establishing initial conditions in the model and are the basis for flow and solute transport modeling. Therefore, the quality and quantity of these data must be sufficient for construction of a model that responds in a manner that is consistent with the physical system.

Steps for gathering, reviewing and evaluating hydrogeologic and hydrochemical data are discussed below.

Step 1

Gather existing hydrogeological and hydrochemical data. Data sources for specific modeling parameters include:

Model Input Parameters	Source of Data
Hydraulic conductivity	Slug, pumping and packer tests and published reports
Distribution of hydrogeologic units	Boring logs, geophysical logs, etc.

Specific Storage	Slug and pumping tests
Specific Yield	Pumping tests and porosity data
Recharge/discharge areas	Precipitation data, soil properties, streamflow, elevation
Unsaturated soil properties	Permeameter tests
Initial water levels, gradients	Water level measurements
Molecular diffusion coefficient	Published data
Dispersivity	Published data, tracer tests
Adsorption distribution coefficient	Batch and column tests, published data, calculated
	(organics)
Soil bulk density	Soil analysis
Density/viscosity	Published data
Source term	Inventory, historical sources, leachate tests

Sources of site-specific hydrogeologic and hydrochemical data include:

- WSRC documents such as RFI/RI/BRA or CMS/FS reports, groundwater modeling reports, aquifer pumping test (injection/extraction) reports. These documents are available from individuals within the ERD, SGS or SRTC organizations, or through the ERD document control center. In addition, a groundwater modeling report database/repository and hydraulic parameter database has been established by SGS.
- The Geochemical Information Management System (GIMS) database managed by the Environmental Geochemistry Group of EPD. This is accessible through the SRS home page ShRINE at the URL address http://www.srs.gov/html/gims/index2.html. GIMS contains data for all wells that are sampled or monitored at the site. The data include water level measurements, water quality parameters and results of chemical analyses.

Step 2

Once data has been accumulated, it is necessary to perform a critical review and discard questionable or unrepresentative data. This is accomplished by examining well installation reports and core data or boring logs and create hydrostratigraphic cross sections to determine the relationship of screened intervals to the aquifers of interest. Examples of "bad" data include hydraulic conductivity values calculated from an observation well that is screened across a confining unit (or zone), from a slug test using an inappropriate analytical solution, or from a slug test in a well that was installed using mud-rotary techniques without proper removal of the mudcake in the borehole. Some degree of data variability is expected due to the heterogeneous geologic conditions at the site.

The use of valid data is necessary to produce meaningful results, but data of a lesser quality (or graded quality) may be used to fill data gaps. In some cases, the use of these data is better than the absence of data. These data may have been collected using obsolete or inferior methodologies (or without data validation), and may not have the same accuracy as more recent data. These data may have a role in the formulation of a conceptual model, but may not be honored as rigorously during the calibration process.

Once it has been determined that the data are representative of site conditions, the data set may be used for groundwater modeling tasks. The data coverage over the model domain is further evaluated during model calibration.

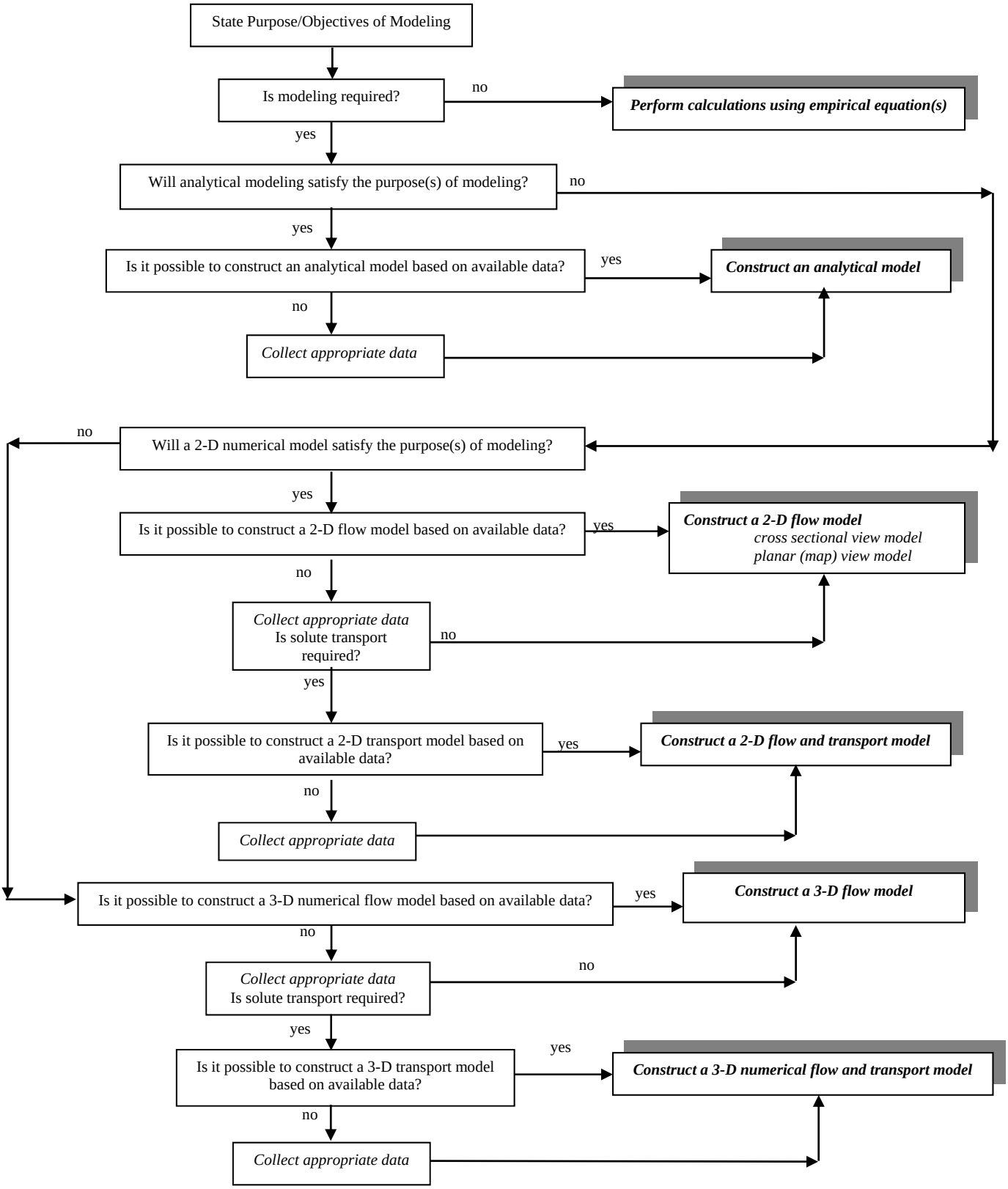
GROUNDWATER MODELING GUIDELINES

II. Determining the Level of Groundwater Modeling Required

This guideline describes the steps necessary to identify the appropriate level of groundwater modeling.

Details

Refinement and testing of conceptual models may be accomplished using mathematical models. A mathematical model is a device that represents an approximation of a field scenario. Different levels may be appropriate; ranging from solving highly simplified 1-D equations to analytical models and complex 2-D or 3-D numerical flow and transport simulations. The following simplified flowchart presents the steps to determine the appropriate level of mathematical modeling required based on project objectives:



Flow Chart Depicting the Steps for Determining the Appropriate Level of Modeling

Step 1

The first step in any modeling project is to state the purpose of the modeling study. The reason for modeling may encompass several objectives. Typical modeling objectives are:

- Enhancement of conceptual understanding of the flow system
- Identify data gaps and guide site characterization activities (including placement of monitoring wells)
- Simulate the present and predict the future concentrations of contaminant compounds in groundwater
- Compare the effectiveness of remedial alternatives
- Characterize source areas
- Estimate risk (human health or ecological) versus cost (regulatory requirement)
- Optimize remediation plans, engineering design or monitoring network
- Characterize uncertainty to support management decisions

Step 2

Once the purpose has been established, the actual characteristics of the model are considered. Examples are:

- Area(s) to be modeled
- Wells to be included in the study
- Aquifer(s) and zones of interest
- Transport concerns (particle tracking and/or concentrations, transport times)
- Steady-state or transient conditions
- Units and coordinate system to be used.

Step 3

The next step is to assemble and evaluate the data available for modeling. These data include hydraulic parameters derived from aquifer pumping tests and slug test data, water level measurements (head), chemical concentrations, etc. Evaluation of data is the subject of the previous guideline, “Evaluating Hydrogeological and Hydrochemical Data for Groundwater Modeling.”

Step 4

The final step is to determine the type of model required that satisfies the project objective(s). In some cases, an approach as simple as solving a mathematical equation may be suitable for satisfying the objectives. An example is the Ogata-Banks equation, a 1-D advection-dispersion equation. In other cases, analytical or numerical modeling may be required. If the existing data do not support the modeling efforts, collection of additional data is warranted.

GROUNDWATER MODELING GUIDELINES

III. Groundwater Model Design and Application

The purpose of this guideline is to provide direction for the design and application of groundwater models at SRS.

Details

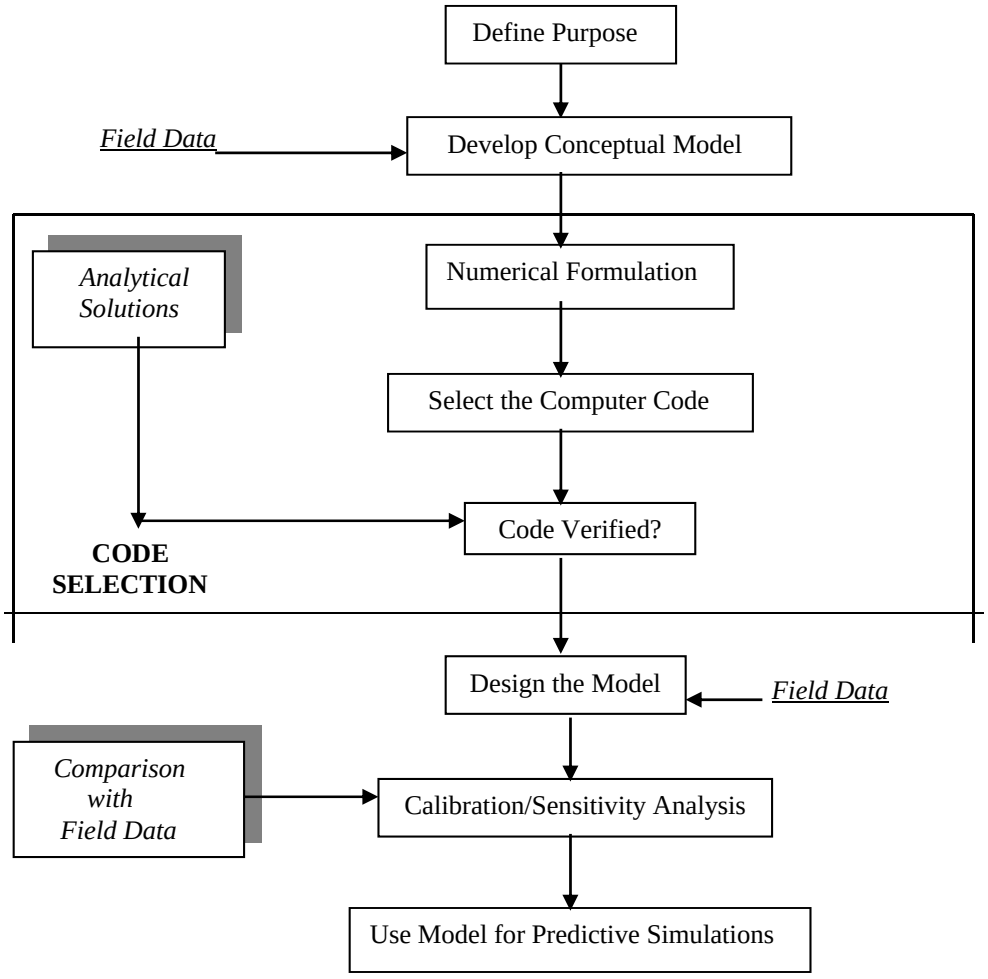
When it has been established that analytical or numerical modeling is necessary and the data are valid, the tasks of model design and application begin. This protocol describes the steps required for analytical and groundwater flow and transport model design and application.

Analytical Modeling

Analytical modeling uses the same general approach as numerical modeling, except for the solution process of the mathematical model. Analytical solutions are used for flow or transport problems as well as aquifer performance tests. In transport problems, analytical solutions may become complex, thus eliminating advantages over numerical methods.

Numerical Modeling

If the complexity of the mathematical model prevents an analytical analysis, numerical models allow for analysis of flow and contaminant transport. The steps required for numerical modeling are summarized in the following diagram. The summation of these steps is creation of a valid, site-specific model that is capable of producing meaningful results.



Steps for Groundwater Flow and Transport Model Design and Application

Step 1

Develop a conceptual model of the system. A conceptual model is a simplified representation of the groundwater flow system, frequently in pictorial form that defines the hydrostratigraphic units of interest and all system boundaries. During this step, field data are assembled including information on water balance and data needed to assign values to aquifer parameters and hydrologic stresses. This includes definition of hydrostratigraphic units and system boundaries.

Step 2

Select the computer code to be used. The code is the computer program that contains an algorithm to numerically solve the mathematical model. Both the governing equation and code should be verified to demonstrate; a) the governing equation accurately describes the physical processes occurring, and b) the computer program accurately solve the equations that make-up the mathematical model.

Step 3
Design the model. The conceptual model is put into a form suitable for modeling. This step includes grid design, selection of time steps, setting boundary and initial conditions, and preliminary selection of values for aquifer parameters and hydrologic stresses.

Step 4
Calibrate the model. The purpose of calibration is to establish that the model can reproduce field-measured heads and flows within a reasonable margin of error. Calibration is accomplished by trial-and-error adjustment of parameters or by using an automated parameter estimation code.

Step 5
Conduct sensitivity analysis. Sensitivity analysis is performed to ascertain the effects of uncertainty on the calibrated model. The model is influenced by uncertainty owing to the inability to define the exact spatial and temporal distribution of parameter values in the problem domain. There is also uncertainty over definition of boundary conditions and stresses.

Step 6
Use the model for predictive simulations. Prediction quantifies the response of the system to future events. The model is run with calibrated values for parameters and stresses, except for those stresses expected to change in the future. Uncertainty in a predictive simulation arises from uncertainty in the calibrated model and the inability to estimate accurate values for the magnitude and timing of future stresses. Predictive sensitivity analysis quantifies the uncertainty in parameter values on the prediction. Ranges in estimated future stresses are simulated to examine the impact on the model's prediction.

The specific requirements of the above modeling steps are discussed in the following sections.

Step 1 – Develop a Conceptual Model of the System

The reason for constructing a conceptual model is to simplify the field problem and organize the associated field data so that the system can be analyzed more readily. The conceptual model should be as simplified as possible, yet retain enough complexity to adequately reproduce system behavior.

Examples of data used to develop a conceptual model are:

Physical Framework
1. Geologic map and cross sections showing the horizontal and vertical extent and boundaries of the system.
2. Topographic map showing surface water bodies and divides.
3. Contour maps showing the elevation of the base of the aquifers and confining beds.
4. Isopach maps showing the thickness of the aquifers and confining beds.
5. Maps showing the extent and thickness of stream and lake sediments

Hydrogeologic Framework

1. Water table and potentiometric maps for all aquifers.
2. Hydrographs of groundwater head and surface water levels and discharge rates.
3. Maps and cross sections showing the hydraulic conductivity and/or transmissivity distribution.
4. Maps and cross sections showing the storage properties of the aquifers and confining beds.
5. Hydraulic conductivity values and their distribution for streams and lake sediments.
6. Spatial and temporal distributions of rates of evapotranspiration, groundwater recharge, surface water-groundwater interaction, pumping and natural groundwater discharge.

There are three steps in building a conceptual model; A) Define the hydrostratigraphic units and model boundaries, B) Prepare a water budget, and C) Define the flow system.

Substep A – Define the Hydrostratigraphic Units and Model Boundaries

Geologic information such as geologic maps and cross sections, well logs and core descriptions are combined with hydrogeologic data to define hydrostratigraphic units. Hydrostratigraphic units comprise geologic units of similar hydrogeologic properties. These properties may be defined through use of geophysical logs, hydraulic response test data (well injection/extraction tests or slug tests) or via geotechnical evaluations. In some cases, geologic facies can be used to define hydrostratigraphic units. In thick sequences of interbedded sand and clay, model layers may be defined using regional head data to identify units of similar hydrogeologic properties. Site-specific information on stratigraphy and hydraulic conductivity is required to define hydrostratigraphic units on a local scale.

Numerical models require boundary conditions, such that the head or flux must be specified at the borders of the model. Boundary conditions are mathematical statements specifying the dependent variable (flux) at the boundaries of the problem domain. Types of hydrogeologic boundaries are physical boundaries, hydraulic boundaries and hydrogeologic boundaries. Physical boundaries are formed by the presence of an impermeable body of rock or a large body of surface water. Hydraulic boundaries include groundwater divides and streamlines.

The following types of mathematical conditions represent hydrogeologic boundaries:

Type 1. Specified head boundaries (Dirichlet conditions) for which head is given. General Specified Head Boundaries occur wherever head can be specified as a function of position and time over part of the boundary surface of a groundwater system. When the boundary is a river, head along the boundary will vary spatially. For lakes, the boundary is described by constant head conditions.

Type 2. Specified flow boundaries (Neumman conditions) for which the derivative of head (flux) across the boundary is given. Specified flow boundaries describe fluxes to surface water bodies, springflow, underflow and seepage to or from bedrock underlying the modeled system. Specified flow boundaries can also be used to simulate hydraulic boundaries defined from information on the regional flow system.

Type 3. Specifying flux to zero sets no-flow boundary conditions.

Type 4. Head-dependent flow boundaries (mixed-boundary conditions) depend on the difference between the user-supplied specified head on one side of the boundary and the model-calculated head on the other. Examples are leakage to or from a river, lake or reservoir.

Descriptions and examples of the hydrogeologic boundaries are presented in the following table:

Type of Modeled Boundary	Sub-Type of Modeled Boundary	Description	Example
Specified Head, or Dirichlet Boundary Type	General Specified-Head Boundary	Head can be specified as a function of position and time.	Aquifer exposed along the bottom of a stream whose stage is independent of groundwater seepage. Heads along the stream bed are specified according to circumstances external to the groundwater flow system and maintain specified values throughout the problem solution.
Specified Head, or Dirichlet Boundary Type	Constant-Head Boundary	The aquifer system coincides with a surface of unchanging head through time.	Aquifer bordered by a lake where the surface water stage is constant over all points of the boundary in time or position.
Specified Flux, or Neumman Boundary Type	No Flow or Streamline Boundary	The flux across the boundary surface can be specified as a function of position and time (according to circumstances external to the groundwater flow system). The specified flux values are maintained throughout the problem solution.	Impermeable boundary - (if the hydraulic conductivity of adjacent materials differs by orders of magnitude). Groundwater divide – however, may be subject to change with changing conditions and may produce invalid results.
Head Dependent Flux, or Cauchy Type	None	Flux across a part of the boundary surface changes in response to changes in head within the aquifer adjacent to the boundary. A practical limit exists beyond which changes in head cease to cause a change in flux.	The upper surface of an aquifer overlain by a confining bed that is in turn overlain by a body of surface water.
Free-Surface Boundary Type	None	A moveable boundary where the head is equal to the elevation of the boundary (no pressure head).	Water table
Seepage-Face Boundary Type	None	A boundary between the saturated flow field and the atmosphere along which groundwater discharges, either by evaporation or movement “downhill” along the land surface in response to gravity.	Seep line

The steps in boundary definition include:

1. Identification of the physical boundaries of the flow system boundaries - Identify as closely as possible the physical boundaries of the flow system. The 3-D bounding surfaces must be defined (even for 2-D models). Even if the boundaries are far from the area of interest, it is important to understand the location and hydraulic conditions on the flow system boundaries.

2. Formulation of the mathematical representation of the boundaries – Determine the hydraulic condition on the boundaries: specified head, specified flux, head-dependent flux, free surface boundary or seepage face.

3. Examination and sensitivity testing of boundary conditions that change when the system is stressed (stress dependent boundaries) – Test the model to determine the stress dependency of boundaries (to see if natural boundaries are compatible with their representation in the model.) If boundaries are stress dependent, the model cannot be considered a tool for investigating any stress on the system as it will give valid results only when the stresses do not impact the boundary. If not represented correctly, change the boundary type.

4. Revision and final formulation of the initial model boundaries – Based on sensitivity testing (see Step 5 on page 24), revise boundaries and document the stresses for which the boundaries are designed.

Substep B – Prepare a Water Budget

The sources/sinks of the system (recharge/discharge areas) as well as expected flow directions should be included in the conceptual model. The inflows include groundwater recharge from precipitation, overland flow, or recharge from surface water bodies. Outflows may include springflow, baseflow to streams, evapotranspiration and groundwater pumping. The water budget summarizes the magnitudes of inflows and outflows, plus changes in storage. During calibration, this water budget will be used for comparison to the water budget computed by the groundwater model.

Substep C – Define the Flow System

Hydrologic data (precipitation, evaporation and surface water runoff), head data and hydrochemical data are used to conceptualize the movement of groundwater through the system. Water level measurements are used to define the general direction of groundwater flow, the locations of recharge/discharge areas, and the relationships between aquifers and surface water systems. Water chemistry data can be used to define local or regional flow systems, flow direction, sources and amounts of recharge and groundwater flow rates.

Step 2 - Select the Computer Code to be used

The set of commands used to solve a mathematical model forms a computer program, or code. The code solves a set of algebraic equations generated by approximating the partial differential equations (governing equation, boundary conditions and initial conditions) that form the mathematical model. Approximating techniques such as finite difference and finite element methods operate on the mathematical model and change it into a form that can be solved quickly by a computer.

Choosing Finite Difference or Finite Element

The choice between a finite difference and finite element model depends on the problem to be solved and preference of the user. Finite difference methods compute a value for the head at the node (which is also the average head for the cell that surrounds the node). No assumption is made about the form of the variation from one node to the next. Finite elements precisely define the variation in head within an element by means of interpolation (basis) functions. Heads are calculated at nodes for convenience, but head is defined everywhere by basis functions. In

general, fewer input data are needed to construct a finite difference grid, but finite element meshes are better able to approximate irregular boundaries, internal boundaries (such as faults), point sources, sinks, seepage faces and moving water tables.

Groundwater modeling involves simplifying assumptions concerning the parameters being simulated. These parameters will influence the type and complexity of the equations used to represent the model mathematically. Five major parameters of groundwater systems must be considered when selecting a computer code for simulating groundwater flow, and seven additional parameters for contaminant transport:

Groundwater Flow Parameters

1. Type of Aquifer/Flow Conditions (confined/unconfined, horizontal/vertical, saturated/unsaturated)
2. Matrix Characteristics
3. Homogeneity and Isotropy
4. Fluid Phases
5. Number of Aquifers

Contaminant Transport Parameters

1. Initial Concentration – specify starting concentrations without considering the type of source.
2. Type of Source – point, line, area or volume source.
3. Type of Source Release – release of an instantaneous pulse (or slug) or continuous release.
4. Dispersion – accurate modeling requires incorporation of transport via dispersion.
5. Adsorption – use of a K_d. Non-linear adsorption and temporal/spatial variation are difficult to model.
6. Degradation – easiest when simple first-order degradation coefficients are used. Second-order degradation coefficients (resulting from variations in parameters such as pH, substrate concentration and microbial population) are more difficult. Radioactive decay chains are well known.
7. Density/Viscosity Effects – If the temperature or salinity of the plume differs greatly from ambient conditions, simulations must include the effects of density/viscosity variations.

Typically, the following questions should be answered when selecting a computer code: 1) Has the accuracy of the code been checked (verified) against one or more analytical solutions? 2) Does the code contain a water balance calculation?

Code Verification

The purpose of code verification is to demonstrate that the numerical solution is relatively free of round-off and truncation errors, which can lead to an unstable solution. The comparison of numerical results with an analytical solution will also depend on the choice of error criterion, grid spacing and time step.

In general, the small round-off and truncation errors associated with numerically stable codes are not of concern in solving groundwater problems, except when focusing on the leading edge of contaminant fronts.

Water Balance Calculation

Water balance calculations involves computation of flows across boundaries, to and from sources and sinks and storage. The water balance gives information about discharge rates to surface water bodies, or recharge rates across the water table. Some models provide a node-by-node printout of boundary fluxes, and may compute fluxes between layers. A small error in the water balance is another assurance that the code correctly and accurately solves the mathematical model.

Step 3 - Design the Model

To design the model, it is necessary to specify the model type that bests suits the objectives of modeling, the data set available, the model domain and the conditions encountered at the site. Once the model type has been specified, it is possible to discretize the model domain in time and space. The goal of model design is to simplify the system so it can be analyzed by reasonable means.

The types of available models vary in simplicity, the amount of site-specific data required and the degree of representation of the natural system. Three-dimensional models closely approximate natural conditions, but require extensive site-specific data. Multi-layered models represent stratified aquifers as a combination of 2-D layers linked by leakage. Two-dimensional models neglect flow and transport in either the vertical or horizontal direction, producing predictions in two-dimensions and averaged in the third dimension. If $i^2 << 1.0$ (where i is the gradient), the error in making the two-dimensional assumption for flow is small. The vertical cross section is a 2-D model oriented vertically. Descriptions of models typically used in industry and the modeled processes are presented in the following table:

Name of Model	General Description	Modeled Processes
MODFLOW/ MODFLOWT	2-D or 3-D widely-used, modular, block centered, finite difference model. Additional simulation package handles contaminant transport.	Calculates head distributions, flow rates and water balances. Simulation of advective-dispersive transport with adsorption and first-order decay.
FTWORK	3-D, finite difference, groundwater flow and solute transport model	Advection, hydrodynamic dispersion, adsorption and radioactive decay
MT3D	3-D, finite difference, contaminant transport in groundwater	Advection, dispersion, non-linear sorption, first-order irreversible decay and biodegradation
FACT	3-D finite difference/finite element model used for simulating solute transport in variably and fully saturated media.	Advection, hydrodynamic dispersion, adsorption and first order degradation.

Three-Dimensional Models

Fully 3-D models incorporate all three spatial components of flow in all model cells. The main advantage of 3-D modeling is that simplifying spatial assumptions and heterogeneity are not necessary, and multiple layers, vertical variations and sources can be accommodated with less simplification. Multiple layers, vertical variations and point and area sources can be

accommodated. The disadvantages are the time, expense and data needs for defining and calibrating a 3-D model. Many model cells are used to represent each hydraulic unit, enabling simulation of stratification of flow or transport. Applications that necessitate three-dimensional modeling usually involve:

- Thick aquifers
- Multiple aquifers
- Steeply sloping aquifers
- Multiple or multi-level sinks or sources
- Significant anisotropy or fracturing

Multi-Layered Models

Ideal applications for multi-layered models include sites with many thin aquifers and aquitards that vary in thickness and are not horizontal. A multi-layer model consists of a vertically stacked sequence of 2-D, depth-averaged models that are linked together by sources and sinks. This type of model is quasi 3-D in that horizontal and vertical flow and transport components are simulated. In multi-layered flow models, flow in intervening aquitards is approximated by a leakage term. Flow in aquifer layers is assumed to be horizontal, and flow through aquitards is vertical.

The advantages of the multi-layered approach are that variations in transmissivity of layered aquifers may be simulated by varying thickness of model cells. A complex layered sequence of aquifers or units may be represented by a reasonably small number of model cells. Vertical stratification within aquifers can be simulated by multiple layers.

The disadvantages are:

- Aquifer pinch-outs may not be well simulated
- Steeply sloping aquifers (grade greater than 10%) may not be accurately simulated due to violation of the Dupuit assumption of horizontal flow.

Two-Dimensional Models

Two-dimensional models may be used for four types of aquifers; confined, leaky-confined, unconfined and mixed aquifers.

Discretization of the Model Domain

Selection of the optimum model domain involves balancing the following factors:

- The domain should cover the entire area of interest, including areas that may be effected by future chemical-species transport, and should encompass the effects of internal disturbances (aquifer injection/extraction, or seepage from impoundments). Future transport can be roughly estimated by calculating transport velocities and retardation factors or by analytical solution. The entire chemical-species plume must be included in the model domain, or overall mass balances will not be possible.
- The boundaries of the domain should take advantage of natural groundwater boundaries such as rivers, lakes, drains, groundwater divides, edge of aquifer, boundary between adjacent pumping centers, groundwater recharge/discharge areas, or boundary location distant from the area of interest.
- The model domain should be oriented parallel to the primary groundwater flow direction (in the primary area of interest) to reduce numerical dispersion.

- Available data should be able to adequately define conditions throughout the domain selected.
- Domain size should be minimized to reduce computational effort

Factors that commonly effect model discretization and selection of the model grid include:

Factor	Aspect of Model Discretization Effected
Modeling objectives	Domain size and areas of finer resolution
Area and duration of interest	Domain size
Location of Sources and Sinks	Finer discretization zone
Heterogeneity and anisotropy	Orientation and refinement of grid
Particle velocity and retardation	Cell size and domain size
Natural boundaries	Limit on cell size to simulate boundary
Numerical stability	Limit on ratio of cell sizes
Numerical accuracy	Limit on cell sizes
Computational effort	Limit on total number of cells
Resolution of flow field	Finer discretization where high flow gradient
Resolution of concentration distribution gradient	Finer discretization where high concentration

Selection of time and space dimensionality can be achieved by optimizing the following:
- Enhance model solution stability and convergence.
- Increase model resolution.
- Minimize numerical dispersion.
- Minimize computational requirements for memory, data storage and run time.

Model solution stability and convergence can be improved by the selection of time steps and calculation-mesh cell sizes that are consistent. For example, stability will be ensured by the following condition for a 2-D, transient flow problem (Spitz and Moreno, 1996):

$$0 < dt < \frac{S}{2T} \frac{\Delta x^2 \Delta y^2}{(\Delta x^2 + \Delta y^2)}$$

S = storativity (1/L)
T = transmissivity (L^2/T)
Δx = cell width in the x-dimension (L)
and, Δy = cell width in the y-direction (L)

Accurate predictions require selecting a cell size sufficiently fine to represent local variations in hydraulic head or concentrations, and defining time steps small enough to represent temporal variation of conditions. While variable cell size allows for greater flexibility, highly variable cell sizes can introduce loss in accuracy and stability. Numerical dispersion (or unnatural expansion of a chemical-species plume), occurs due to neglect of higher-order terms in the Taylor Series expansion of the finite difference or finite element formulation of the governing equations. It can

also occur due to inappropriate space or time discretization. Numerical dispersion can be minimized by selection of appropriate mesh cell size, mesh orientation and the size of time steps.

In discretizing a model, the following factors must be considered; 1) the orientation of the model, 2) space discretization, and 3) time discretization.

Orientation of the Model Grid

The following factors must be considered for grid orientation:

- Key hydrologic, hydrogeologic and geologic features of the site – Representation of natural boundaries such as rivers, streams, impoundments, and faults can be simplified by appropriate orientation of the mesh.
- Predominant groundwater flow direction – To minimize numerical dispersion (due to the groundwater velocity being split into components parallel to the calculation mesh axes), orient the mesh along the direction of predominant water flow. If flow direction varies within the model domain, align the mesh with the flow direction in the primary area of interest.
- Anisotropy of hydraulic properties – Since the hydraulic conductivity in the model is expressed as components aligned with the calculation mesh, choose a mesh oriented coincident with the conductivity tensor.

Space Discretization

The resolution of the results provided by the model relates directly to the degree of discretization of the groundwater system. The following factors must be considered in choosing a model grid:

- Degree of heterogeneity in hydraulic transport parameters and boundary conditions
- Model domain size
- The predicted resolution required to meet modeling objectives
- Restrictions imposed by computational resources

These factors also apply to vertical discretization, with the added considerations of stratification due to density effects, recharge, and shallow or deep sources or sinks of groundwater or contaminants. In general, the accuracy of the predicted results improves with finer mesh sizes, but computational time and data space requirements increase correspondingly.

For transport problems, the cell size that minimizes numerical dispersion can be calculated using the Peclet number (Pe), which is the ratio of the advective to diffusive terms in the transport equation. To ensure numerical stability and minimize numerical dispersion, the cell Peclet number should be no greater than 2. The cell Peclet is defined as the dimensionless ratio:

$$Pe = \frac{\Delta x}{\alpha_x} \leq 2$$

Where:

Δx = cell size in the x-direction (L)

and; α_x = longitudinal dispersion in the x-direction (L)

In practice, the Peclet number constraint is often relaxed outside of the area of interest where lower predictive accuracy is acceptable.

The appropriate ratio of the lengths of the cell sides (cell aspect ratio) is calculated by comparing the travel time across the cell in each direction. Ideally, the travel times should be unity, though ratios up to 10:1 may be used without introducing significant error. In general, the greater the variability in cell size, the greater the computational effort required for generating a convergent solution. Cell size increases between adjacent cells no greater than a factor of 1.5 will facilitate model convergence, increase stability and reduce error.

Selection of Time Step

The time step size (Δt) that reduces numerical dispersion can be calculated using the Courant number (Co), which is the ratio of the advective velocity to time-dependent terms in the transport equation:

$$Co = \left| v \frac{\Delta t}{\Delta x} \right| \leq 1$$

To minimize numerical dispersion and maximize stability, the cell Courant number should be no greater than unity for the smallest cell.

Preparing Model Input Data

Field data provide local estimates of conditions, whereas a model requires input of data distributed over the entire model domain. The distribution of data can be accomplished through establishing zones (with homogeneous values within each zone), or by interpolating between data points. For zones, the grid is divided so that sets of nodes have similar aquifer properties based on the extent of the hydrostratigraphic units. The thickness of each unit is assigned to each node.

The head calculation is conducted differently for finite difference and finite element models. A finite difference model calculates the head at the node. In a block-centered-grid, aquifer properties and hydraulic stresses are typically assigned to the block surrounding the node. In a mesh-centered-grid, properties are assigned to the area of influence surrounding the node. In finite element models, aquifer properties may be assigned to the node, element, or area of influence around the node.

Assigning parameter values to the grid requires values for each node, cell or element. Since field data are typically sparse, interpolation of measured data points is necessary for defining the spatial variability over the problem domain. One possible interpolation technique is Kriging, which is a statistical interpolation method that chooses the best linear unbiased estimate for the variable. Higher correlation between measurement points is expected for smaller separation distances. Kriging considers the spatial structure of the variable and provides an estimate of the interpolation error (the standard deviation of the kriged values), while preserving the parameter value at measurement points..

Step 4 - Calibrate the Model

The calibration of a groundwater flow model is the process of adjusting hydraulic parameters, boundary conditions and initial conditions within reasonable ranges to obtain a match between observed and simulated potentials, flow rates, or other calibration targets. The range over which model parameters and boundary conditions may be varied is determined by data presented in the conceptual model. In the case where parameters are well characterized by field measurements, the range over which that parameter is varied in the model should be consistent with the range observed in the field. The degree of fit between model simulations and field measurements can be quantified by statistical means.

Model calibration is frequently accomplished by making trial-and-error adjustments of the model's input data to match field observations. Automatic inverse techniques are another type of calibration procedure. In both trial-and-error and inverse techniques, sensitivity analysis plays a key role in the calibration process by identifying those parameters that are most important in model reliability. Sensitivity analysis is used extensively in inverse techniques to make adjustments to model parameters. The calibration process continues until the degree of correspondence between the simulation and the physical hydrogeological system is consistent with the objectives of the project.

Calibration is evaluated through analysis of residuals. Calibration may be viewed as a regression analysis designed to bring the mean of the residuals close to zero, and to minimize the standard deviation of the residuals. Calibration often necessitates reconstruction of portions of the model, resulting in changes or refinements in the conceptual model to achieve a better representation of the physical system. Calibration to a single set of field measurements does not guarantee a unique solution.

The model calculations may be compared to a second set of field observations that represent a different set of boundary conditions or stresses (a process called model verification). The results are compared to the field measurements to assess the degree of correspondence. If the comparison is not favorable, additional calibration or data collection is required. Successful verification results in a higher degree of confidence in model predictions. A calibrated but unverified model may be used for predictive simulations when coupled with a careful sensitivity analysis. The following steps should be taken for model calibration:

Step 1 - Determine the boundary conditions and model parameters to vary for calibration (ex. hydraulic conductivity, storativity, recharge rates, flow rates, etc.) Also, field measured fluxes such as baseflow, streamflow, infiltration from a losing stream, or evapotranspiration may be selected.

Step 2 - Determine the model calibration targets - measured, observed, calculated or estimated heads or flow rates that a model must reproduce to be considered calibrated (i.e. the calibrated value and its associated error). The error should be a small fraction of the difference between the highest and lowest heads across the site. Errors in the estimates of flow rates are greater than estimates of head.

Step 3 - Determine calibration range over which model parameters and boundary conditions may be varied by data presented in the conceptual model (consistent with the range observed in field measurements).

Step 4 - Decide calibration technique to use (trial-and-error or automatic calibration techniques). In trial and error calibration, after parameter values are initially assigned to each node or element in the grid, they are adjusted in sequential model runs to match simulated heads and flows to calibration targets. The amount of adjustment depends on the range of uncertainty for each parameter. Automatic calibration (such as automatic inverse modeling) is performed using codes that use either indirect or direct approaches. In a direct solution, the unknown parameters are treated as dependent variables in the governing equation, and heads are independent variables. The indirect approach is similar to trial-and-error in that the forward problem is solved repeatedly (in a systematic way that minimizes the difference between simulated and observed heads or residual statistics).

Step 5 - Perform the calibration When modeling transient conditions, begin with a steady-state scenario to calibrate hydraulic conductivity (or transmissivity). Then, use the transient scenario to calibrate the specific storage (or storativity). Perform the following to make adjustments in the model:

- To raise the hydraulic head at a point in the model, decrease the hydraulic conductivity upstream, increase recharge, decrease the conductance of the boundary nodes to which groundwater at that point discharges, and/or increase flow through the node.
- To speed up the response of water levels at a point to a change in boundary conditions, increase the hydraulic conductivity between that area and the changed boundary, or decrease the specific storage (or storativity) in that area.
- Near a surface water boundary, vary the hydraulic conductivity to raise or lower the slope of the water table (or piezometric surface) and vary the conductance (leakance term) for the boundary or the reference head to raise or lower all water levels nearby by the same amount. If the conductance term is too large, it will function as a constant head boundary.
- To equalize groundwater levels on opposite sides of a confining layer, increase the leakance of the confining layer.
- To remove spatial correlation among residuals, re-parameterize model inputs to define zones of equal parameter values, and smooth transition areas between zones.
- A model with too many constant head boundaries may prove difficult to calibrate. Re-evaluate the conceptual model to determine if boundary conditions are correct.

Step 6 - Analyze calibration qualitatively and quantitatively - Automatic techniques may perform analysis for the modeler. Trial-and-error requires the following analysis:
Qualitatively – assess the distribution of error by comparing contour maps of measured and simulated heads and residuals, and construct scatterplots of data for comparison.
Quantitatively – calculate the differences in measured and simulated head and quantify the average error in the calibration results by calculating the root mean square (RMS) error:

$$RMS = \left[\frac{1}{n} \sum_{i=1}^{n} (h_m - h_s)^2 \right]^{0.5}$$

Where:

h_m = measured heads
h_s = simulated heads
n = the number of observations

The RMS (or standard deviation) is the average of the squared differences in measured and simulated heads.

Step 7 - Repeat the above process until the degree of correspondence between the simulation and the physical hydrogeological system is consistent with the objectives of the project. If the comparison is not favorable, additional calibration or data collection is required.

In summary, the following procedures should be used before and after calibration:

Before Calibration

1. Select calibration values from heads, head gradients, flows or other field data.
2. Estimate the error in the calibration values including measurement error, interpolation error, and errors from scale effects and transient effects. Define calibration targets.
3. Compile the field data needed to set boundary conditions, parameter values, and hydrologic stresses, and estimate plausible ranges in boundary conditions, parameter values and hydrological stresses.
4. Assign parameter values to zones in the grid and calculate the coefficient of variation for each zone.
5. Prepare a map showing the location of calibration targets relative to nodes in the grid.
6. Prepare a table showing initial estimates of boundary conditions, parameters and hydrologic stresses and their coefficients of variation.

After Calibration

1. Calculate coefficients of variation (standard deviation divided by mean value) using calibrated estimates of parameter values. A small coefficient of variation indicates a relatively high degree of certainty. The range of accepted parameter values is determined during calibration and sensitivity analysis.
2. Prepare a table showing differences between calibrated targets and simulated heads and fluxes.

3. Calculate the mean error (ME), mean absolute error (MAE) and RMS error in the heads. The ME is the mean difference between measured heads (h_m) and simulated heads (h_s):

$$ME = \frac{1}{n} \sum_{i=1}^{n} (h_m - h_s)$$

The MAE is the mean of the absolute value of the differences in measured and simulated heads:

$$MAE = \frac{1}{n} \sum_{i=1}^{n} \left| (h_m - h_s) \right|$$

4. Present the spatial distribution of residual in several ways, selecting from the following types of presentation: (a) map of superimposed contours of head, (b) map showing contours of head residuals, (c) map showing the location and value of calibrated targets and simulated values, (d) plot of calibration values vs. simulated values showing deviation from a straight-line correspondence, (e) box plot of residual heads for each important calibration run, (f) plot of ME, MAE and RMS vs. the calibration run number to show the approach to calibration, (g) plot of ME, MAE, and RMS vs. parameter values to show the sensitivity of the calibration to changes in a parameter value.
5. Prepare a discussion of the calibration procedure and discuss changes in initial parameter estimates and the sensitivity of the model to these changes.

Step 5 - Conduct Sensitivity Analysis

After a groundwater model has been calibrated, sensitivity analysis should be performed. The purpose of sensitivity analysis is to quantify the uncertainty in the calibrated model caused by uncertainty in the estimates of aquifer parameters, stresses and boundary conditions (i.e. identify the model inputs that have the most influence on model calibration and predictions). Sensitivity analysis results in quantitative relationships between model results and the input hydraulic properties or boundary conditions of the aquifer(s). Examination of the sensitivity of calibration residuals and model conclusions to model inputs is a method for assessing the adequacy of the model with respect to its intended function.

Substep A - Identify which model inputs to vary

Identify model inputs that are likely to effect computed head and groundwater flow rates at the times and locations where similar measured quantities exist, and thereby affect calibration results. Calibrated values for hydraulic conductivity, storage parameters, recharge and boundary conditions are systematically changed within the previously established plausible range. Also, identify model inputs that are likely to affect the computed hydraulic heads upon which the models' conclusions are based in the predictive simulations. The magnitude of change in heads from the calibrated solution is a measure of sensitivity of the solution to that particular parameter.

Substep B - Execute calibration and prediction with the value of the input varied over a specific range

For each input: execute calibration and prediction with the value of the input varied over a specific range; graph calibration results and model predictions as functions of the value of input; and determine the type of sensitivity that the model has with respect to the input. Rather than display the effect of every residual, it is appropriate to display residual statistics. The graph should include the following parameters: maximum residual, minimum residual, residual mean, and standard deviation of the residual. In some cases, it may be more illustrative to present contours of head change as a result of variation of input values. In transient simulations, graphs of head change versus time may be presented.

Usually, changing the input value of a single node or element will not significantly affect results. It is important to assemble model inputs into meaningful groups for variation. If the model was not calibrated to multiple hydrologic conditions, variation of more than one type of input at a time can be used to identify potential non-uniqueness of the calibrated input data sets. For each input (or group of inputs) to be varied, the modeler must decide upon the range over which to vary the values. Some should be varied arithmetically, and others geometrically.

Step 6 – Use the Model for Predictive Simulations

In a predictive simulation, the parameters determined during calibration are used to predict the response of the system to future events. The confidence in model predictions is based upon the results of calibration and sensitivity analysis. The two major pitfalls in making predictions are the uncertainty in the calibrated model and uncertainty about future hydrological stresses. In many cases, errors in prediction can be attributed to errors in the conceptual model.

Prediction quantifies the response of the system to future events. The model is run with calibrated values for parameters and stresses, except for those stresses expected to change in the future. Uncertainty in a predictive simulation arises from uncertainty in the calibrated model and the inability to estimate accurate values for the magnitude and timing of future stresses. Predictive sensitivity analysis quantifies the uncertainty in parameter values on the prediction. Ranges in estimated future stresses are simulated to examine the impact on the model's prediction.

The interpretation of the model predictions should include an assessment of where the accuracy of the model is degraded, and the relative degree of uncertainty in the predictions. The uncertainty in the model should be addressed in qualitative and quantitative terms.

The following should be checked to ensure consistency and credibility in model predictions:

- Plot input data and check for accuracy and consistency.
- Check the Courant number for appropriate cell sizes.
- Check the model stability and convergence behavior. Corrections to previous solutions should monotonically decrease with time after each change in stress.
- Check the model flow and solute mass balances.

PROTOCOL

Sensitivity and Uncertainty Analyses for RCRA/CERCLA Groundwater Modeling

Introduction

The following protocol has been developed to support the Savannah River Site (SRS) Soil and Groundwater Closure Projects (SGCP) program. A detailed technical discussion on the actual background of this summary can be found in the ER Engineering Technical Memo entitled "Guidance: Sensitivity and Uncertainty Analyses for RCRA/CERCLA Groundwater Modeling"(ERTEC-2003-00006). This protocol has been reviewed by the Groundwater Modeling Design Team, made up of technical experts representing SCDHEC, USEPA, and WSRC and summarizes the basic steps for analyses.
A sensitivity analysis is performed on a calibrated model by varying one parameter at a time and evaluating model calibration and other pertinent model results. An uncertainty analysis is performed by simultaneously varying multiple uncertain parameters, and evaluating results within a certain calibration range.

Details

Sensitivity Analysis

The basic steps for a sensitivity analysis are:

Step 1. Identify the parameters

The parameters used in the sensitivity analysis should be recommended by the technical project staff, and agreed to by the core team. At a minimum, the following parameters should be considered in the sensitivity analysis: hydraulic conductivity (horizontal for aquifers, vertical for aquitards), recharge, sorption, dispersivity, and porosity.

Step 2. Identify the output results to observe

Model outputs as agreed by the technical staff and core team can include: water balance, calibration statistics, model fluxes, and transport predictions (transport times, concentrations, total plume masses/activities, mass/activity fluxes, etc.).

Step 3. Execute the simulations

Simulation runs of a single change from the calibrated value for a single parameter will be performed and the outputs identified in Step 2 are saved, as appropriate. Non-convergence cases may need additional runs with appropriate documentation.

Depending on specific project requirements, the impact of significant dependencies or correlations between model parameters may be investigated.

Step 4. Document the results

The documentation of a sensitivity analysis should include: discussion of the parameters and parameter ranges/values selected for evaluation, the methodology used, and the results of the analyses with appropriate Tables and Figures. Significant results should be presented in graphical forms.

Uncertainty Analysis

The basic steps for an uncertainty analysis are as follows:

Step 1. Identify the output results to study

Necessary outputs must be identified in consultation with the project and core teams prior to initiation of the analysis. These may include: contaminant flux to streams, location of maximum contaminant concentration discharge to streams, reduction in stream flux due to remedial alternative implementation, concentrations at designated locations, plume volume/mass/activity, and vertical extent of contamination, etc. Outputs should be recommended by the technical project staff, and agreed to by the core team.

Step 2. Identify and define the uncertain parameters to evaluate

Uncertain parameters for the analysis should be selected from the set of parameters that the model was most sensitive to, as identified in the sensitivity analysis. Appropriate individual parameter functions (PDFs – normal, lognormal, uniform, etc.) should be defined based on qualitative and quantitative information available for each parameter. Parameters and PDFs should be recommended by the technical project staff, and agreed to by the core team.

Step 3. Define the calibration criteria

The calibration criteria for the uncertainty analysis should be similar to the criteria used in the original model calibration and only realizations meeting calibration criteria should be included in the uncertainty analysis results.

Step 4. Execute the analysis

A Monte Carlo analysis, using custom or commercial software, will be implemented and consists of creating a combined set of results from different realizations. A plan for computation configuration (single computer, distributed processing, etc.) should be made to allow completion in a reasonable time frame.

Step 5. Evaluate adequacy of the results

In order to determine if there have been enough realizations to adequately represent the results, the result statistics (mean, variance) should be evaluated along with appropriate repeatability checks, as applicable, to the specific project.

Step 6. Calculate confidence intervals

Confidence intervals will be calculated by determining the confidence limits from the set of Monte Carlo realizations of output results. The values at the limits are determined by creating a cumulative distribution function and using the appropriate percentiles.

Step 7. Document the results

A thorough discussion of the methods, inputs, and results of the uncertainty analysis should be presented with detailed information on the input distributions, input parameter correlation's (dependencies), adequacy of the results (with plots of cumulative statistics -- mean and variance), along with confidence intervals for each output defined in Step 1.

GROUNDWATER MIXING ZONE GUIDELINE

I. Process for Use of the Natural Attenuation (Groundwater Mixing Zone) Alternative

This guideline describes the process required for establishing groundwater mixing zones, demonstration criteria required for pursuing the natural attenuation alternative and the use of groundwater models in groundwater mixing zone applications. The SCDHEC Guidance on Mixing Zone Applications (1995) was followed for preparation of this guideline.

Details

The State of South Carolina Water Classifications and Standards (R.61-68 and R.61-69) apply to all groundwater of the state. Active cleanup measures are required for contaminants at concentrations that exceed regulatory limits (State Primary Drinking Water Standards). R.61-68 allows for establishment of "groundwater mixing zones", where contaminants may exceed maximum contaminant levels (MCLs) if certain conditions are met. Groundwater mixing zones are areas downgradient from a source of contamination where concentrations are decreasing as a result of contaminant degradation, volatilization and/or mixing with the natural waters of the formation.

Each proposed mixing zone requires unique hydrogeologic information and assessment, depending on the contaminants present and conditions at the site. Natural attenuation as a remedial option may lend itself to the types of contaminants and conditions that exist at SRS.

Conditions for Establishing Groundwater Mixing Zones

The conditions for establishment of a groundwater mixing zone include:

Reasonable measures have been taken or binding commitments made to minimize the addition of contaminants to groundwater and/or control the migration of contaminants in groundwater.

The groundwater in question is confined to a shallow geologic unit that has little or no potential of being an underground source of drinking water, and discharges or will discharge to surface waters without contravening the surface water standards set forth in R.61-68.

The contaminant(s) in question occur on the property of the applicant, and there is minimum possibility for groundwater withdrawals (present or future) to create drawdown such that contaminants would flow off-site.

The contaminants are not dangerously toxic, mobile or persistent.

The steps required for reviewing the conditions with respect to a specific site under consideration for a mixing zone application are:

Step 1 – Determine the relative toxicity of the contaminants present in groundwater. If contaminants are especially toxic (e.g. dioxin), use of the natural attenuation alternative is not practical.

Step 2 – Determine the relative persistence and mobility of the contaminants in the aquifer(s). If the contaminants are long-lived (e.g. PCBs) or highly mobile in groundwater, use of the natural attenuation alternative is not practical.

Step 3 - Determine which aquifer(s) are effected by existing contamination.

Step 4 - Evaluate the source of the contamination and the likelihood for additional spreading of contaminant plume(s). Take into account source removal or mitigation (by capping, or through active or passive treatment, etc.), the type of contaminants (i.e., VOCs vs. metals or radioactive compounds), and the potential for additional contaminant transport.

Step 5 - Consider the likelihood of additional contamination of groundwater via transport of contaminant(s) through the soil column to groundwater. As part of this, consider vadose zone transport parameters; thickness of the vadose zone, vertical groundwater velocity, recharge rate, f_{oc}, cation exchange capacity, etc. Use of vadose zone transport models (e.g. MEPAS or SESOIL) or relevant equations may aid in this assessment.

Step 6 - Determine the potential for future use of shallow groundwater aquifers as a source of drinking water.

Step 7 – Review analytical data to ascertain that contamination is limited to shallow aquifers, and compare hydraulic head measurements in shallow and deep aquifers to assess vertical flow potential and possible flow across confining (or semi-confining units).

Step 8 – Consult hydrostratigraphic maps and potentiometric maps to establish the relationship between flow in effected aquifer units/zones and surface water features. If aquifer(s) are discharging to surface water, compare contaminant concentrations from the well or CPT location nearest the discharge point to surface water standards (set forth in R.61-68).

Step 9 – Check contaminant plume maps to ensure that contaminant plume(s) do not extend beyond SRS property boundaries or into adjacent operable unit(s). Assess the possibility of co-mingling contaminant plumes. If co-mingling plumes exist, the concentrations of contaminants entering the operable unit under study must be considered as part of the groundwater mixing zone application.

Step 10 – Check for nearby production wells, and determine the potential effects of pumping on contaminant plume geometry.

If the four conditions for establishing a groundwater mixing zone are met, a case may be made for use of the natural attenuation remediation alternative. In order to accomplish this, a groundwater mixing zone application must be approved by DHEC.

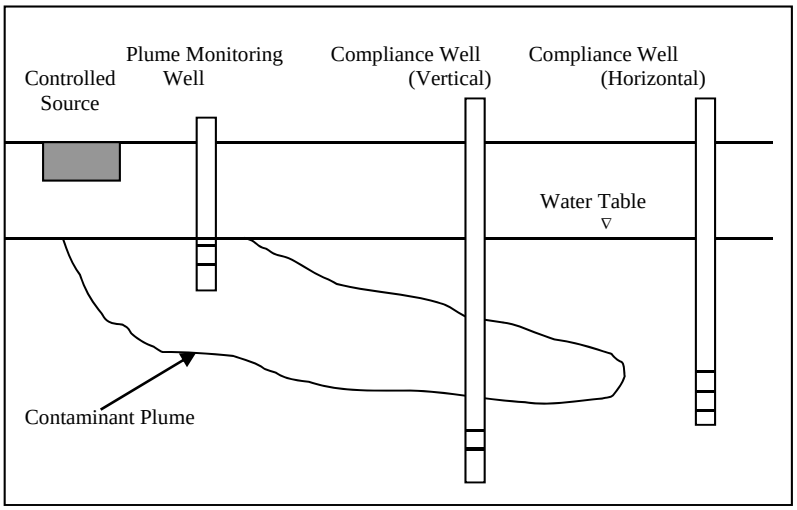
Demonstration Criteria for the Mixing Zone Application

Per DHEC guidance, the following must be specifically addressed in the mixing zone application. Typically, most of these criteria are part of the RI/RFI document.

Demonstration that the source has been removed, remediated, and/or contained to minimize additional contamination of the aquifer and/or prevent exposure to any receptor (also part of the first condition). Demonstration that contamination in groundwater has been completely characterized by establishing the types and concentrations of contaminants that exist at the site.

Definition of the horizontal/vertical extent of soil and/or groundwater contamination and plume movement.

Demonstration that contaminants will remain confined in a shallow geologic unit until discharge to surface water or attenuation to standards (MCLs) occurs. The contaminants must not migrate to a deeper aquifer. A cross sectional view of a compliance monitoring scenario to satisfy this is shown below:



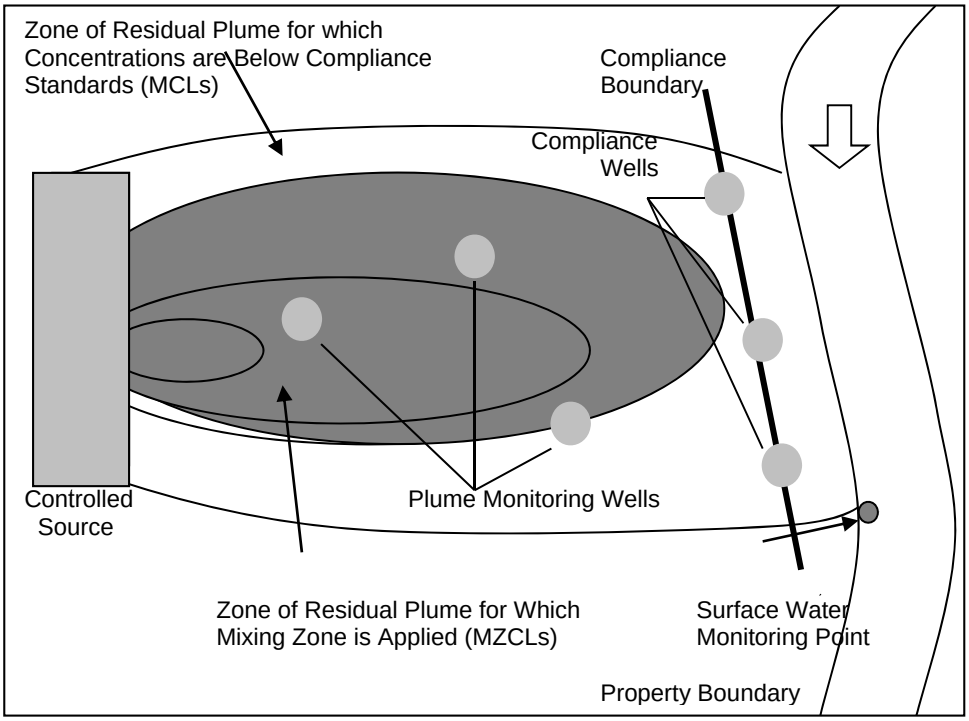
Compliance and Monitoring Well Scenario with Vertical (Depth), Horizontal (Downgradient) and Plume Monitoring

1. Demonstration that the area or volume of contamination that exceeds MCLs is not significantly increasing prior to discharge or attenuation.
2. Demonstration that contaminants (at concentrations above MCLs) will not extend beyond property boundaries or the established compliance boundary. This is accomplished by groundwater flow/fate and transport modeling or through other hydrogeologic evidence (including calculations).
3. Demonstration that potential receptors (e.g. through drinking water wells) have been identified.
4. Demonstration that there is no current use (and a minimum potential for future use) of effected groundwater as a source of drinking water for the anticipated duration of the mixing zone status period.
5. If groundwater discharges to surface water (on-site or at the property boundary), data must be obtained to identify the concentrations of contaminants and rate of discharge to the surface water body. Documentation of in-stream water quality standards (surface water monitoring) is required.

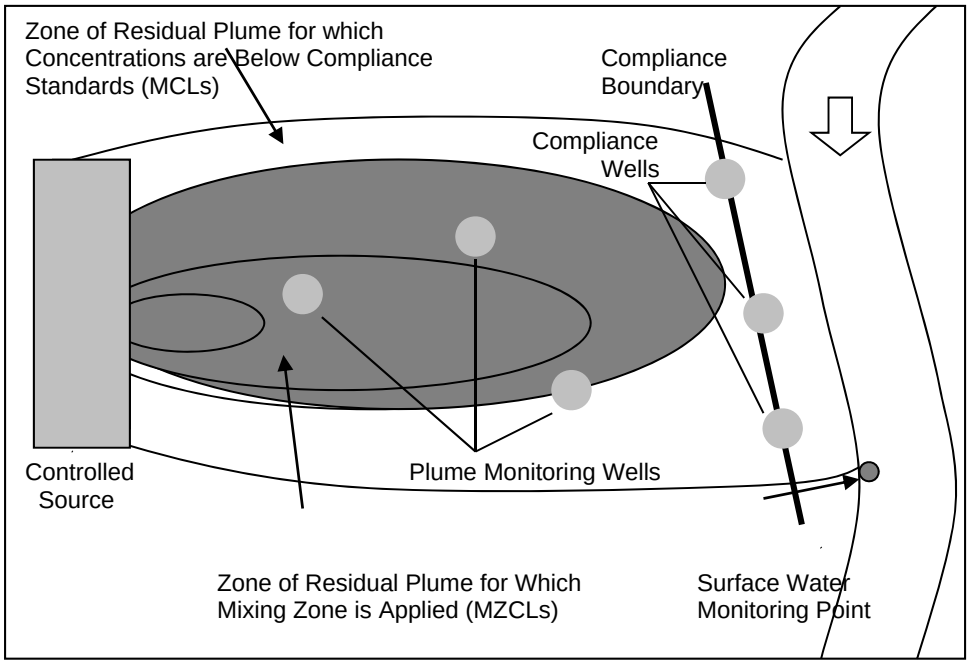
6. Site-specific mixing zone concentration limits (MZCLs) must be established for the site. MZCLs are the highest concentration for the specific contaminants identified at the site.

Compliance Monitoring

As part of the groundwater mixing zone application, a monitoring program must be proposed to show compliance with mixing zone requirements. The program must demonstrate compliance with; (1) MZCLs within the plume(s), and (2) MCLs at compliance boundaries. Compliance boundaries are required near the down-gradient plume boundary, at property boundaries, or surface discharge areas. The monitoring program will continue until MCLs within the plume are achieved. Mixing zone scenarios for compliance monitoring with and without surface water discharge are shown in the following diagrams:



Potential Mixing Zone Scenario with Plume Discharging to On-Site Stream



Potential Mixing Zone Scenario with Plume Confined to Property

Use of Groundwater Modeling in Support of the Mixing Zone Application

Groundwater flow/contaminant transport models are useful for satisfying the requirements of groundwater mixing zone applications. Models may be used for the following:

1. Demonstrate site flow conditions and contaminant transport over time (horizontal and vertical migration).
2. Verify the time required for mixing zone status (exceeding regulatory status) and the area/volume effected.
3. Demonstrate that contaminants are highly unlikely to contaminate deeper aquifer zones (at concentrations greater than standards). Vertical movement must be especially well defined in potential recharge areas.
4. Demonstrate that migration of contaminants at concentrations above MCLs will not likely extend offsite. The demonstration must include the potential for groundwater use in the surrounding area (if this applies) that may result in contaminant flow offsite (for the time period the mixing zone will be in effect).
5. Identify appropriate down-gradient locations for compliance boundary wells.

The type of model selected (groundwater flow/contaminant transport) depends on the conditions at a particular site and the goals of modeling. Refer to the Groundwater Modeling Protocols for guidance in model selection, data evaluation and model design/application.

Definitions

Analytical element method – a means of using the principle of superposition to combine the solutions to many analytical equations. Analytical functions representing stresses such as wells, line sinks and circular recharge areas and features, such as an impermeable barrier, are summed and expressed in terms of discharge potential.

Analytical model – a model that uses closed-form solutions to the governing equations applicable to groundwater flow and transport processes.

Application verification – using the set of parameter values and boundary conditions from a calibrated model to approximate acceptably a second set of field data measured under similar hydrologic conditions.

Boundary condition – a mathematical expression of a state of the physical system that constrains the equations of the mathematical model.

Calibrated model – a model for which all residuals between calibration targets and corresponding modeling outputs, or statistics computed from residuals, are less than pre-set acceptable values.

Calibration – the process of refining the model representation of the hydrogeologic framework, hydraulic properties and boundary conditions to achieve a desired degree or correspondence between the model simulations and observations of the groundwater flow system.

Calibration targets – measured, observed, calculated or estimated hydraulic heads or groundwater flow rates that a model must reproduce, at least approximately, to be considered calibrated. The calibration target includes the value of the head or flow rate and its associated error of measurement, so that undue effort is not expended attempting to get a model application to closely reproduce a value, which is known only to within an order of magnitude.

Code verification – software testing that includes comparison with analytical solutions and other similar codes to demonstrate that the code used represents its mathematical foundations.

Computer code – the assembly of numerical techniques, bookkeeping, and control language that represents the model from acceptance of input data and instructions to delivery of output.

Conceptual model – an interpretation or working description of the characteristics and dynamics of the physical system.

Converged Solution - the solution resulting from the iterative solution process.

Convergence Criterion - the amount of acceptable solved parameter differences between iteration solutions in the iterative solution process. This is typically a limiting parameter defined by the user in numeric groundwater models.

Darcy's Law - the basic equation of flow for groundwater systems. Flow velocity (rate) equals hydraulic conductivity times the gradient.

Deterministic process – a process in which there is an exact mathematical relationship between the independent and dependent variables in the system.
Dirichlet condition – specified head boundaries for which head is given.

Domain - the area of a groundwater system being modeled.

Dupuit assumptions – assumptions applied to an unconfined aquifer; 1) flow lines are horizontal and equipotential lines are vertical, and 2) the horizontal hydraulic gradient is equal to the slope of the free surface and is invariant with depth.

Fidelity – the degree to which a model application is designed to resemble the physical hydrogeologic system.

Finite-difference method – a numerical technique for solving a system of equations using a rectangular mesh representing the aquifer and solving for the dependent variable in a piece-wise manner.

Finite-element method – a numerical technique for solving a system of equations using an irregular triangular or quadrilateral mesh representing the aquifer and solving for the dependent variable in a continuous manner.

Flow model - a groundwater model that solves for heads (and resultant flow directions and magnitudes).

Gradient - the measure of the head changes in a groundwater system. For an unconfined aquifer, the slope of the water table surface is essentially equal to gradient.

Grid - the collection of nodes in a numeric groundwater model.

Groundwater flow model – an application of a mathematical model to represent a site-specific groundwater flow system.

Hydraulic Head - the term used to represent the energy of the groundwater system at any particular point. Head is essentially equivalent to the water table in unconfined aquifers. Head is measured in length (height) units like feet or meters from a datum elevation (such as mean seal level).

Heterogeneity - a term indicating that a parameter changes spatially.

Homogeneity - a term indicating that a parameter does not change spatially.

Hydraulic conductivity - the measure of a porous media’s ability to transmit water. Used in Darcy's Law as the proportionality constant between the gradient and flow velocity terms.

Hydrodynamic dispersion - the combined effects of molecular diffusion and mechanical dispersion. Also commonly just called dispersion.

Hydraulic properties – properties of soil and rock that govern the transmission (e.g., hydraulic conductivity, transmissivity, and leakance) and storage (e.g. specific storage, storativity and specific yield) of water.

Hydrostratigraphic units - units that are delineated based on hydrogeological as well as geological parameters.

Iterative solution - the process and result of finding an answer by using better and better approximate solutions. A technique commonly used in numeric groundwater models. Each cycle of the process is called an iteration.

Inverse method – a method of calibrating a groundwater flow model using a computer code to systematically vary inputs or input parameters to minimize residuals or residual statistics.

Mathematical model – mathematical equations expressing the physical system and including simplifying assumptions. The representation of a physical system by mathematical expressions from which the behavior of the system can be predicted.

Mechanical dispersion - a physical process that represents the mixing of solutes due to variations in flow velocities. These variations are due to three primary factors: (1) variations in pore sizes, (2) differences in path lengths, and (3) variations of velocities within each pore due to friction at the pore walls.

Method of characteristics (MOC) – a numerical method to solve solute transport equations by construction of an equivalent of ordinary differential equations using moving particles as reference points. Also known as the particle-in-cell method.

Model – an assembly of concepts in the form of mathematical equations that portray understanding of a natural phenomenon.

Molecular diffusion - a chemical process at the molecular level that causes areas of higher concentrations to want to equilibrate with areas of lower concentrations.

Nodes - the discrete points in numeric groundwater models where we solve for head.

Numerical methods – a set of procedures used to solve the equations of a mathematical model in which the applicable partial differential equations are replaced by a set of algebraic equations written in terms of discrete values of state variables at discrete points in space and time. Those in common use are the finite-difference method, finite-element method, boundary-element method and analytical element method.

Over-calibration – achieving artificially low residuals by inappropriately fine-tuning model parameters and not performing application verification.

Random walk – a method of tracking a large number of particles with the number of particles proportional to solute concentration, and each particle advected deterministically and dispersed probabilistically.

Residual – the difference between the computed and observed values of a variable at a specific time and location.

Sensitivity – the degree to which the model result is affected by changes in a selected model input representing hydrogeologic framework, hydraulic properties and boundary conditions.

Simulation – one complete execution of a groundwater modeling program, including input and output.

Sink – a process or a feature from which water is extracted from the groundwater flow system.

Steady-State - if a groundwater system does not change over time, then the system is in a steady-state condition. Also refers to the type of numeric modeling where results are not expected to change over time.

Stochastic – consideration of subsurface media and flow parameters as random variables.

Stochastic model – a model representing groundwater parameters as random variables.

Stochastic process – a process in which the dependent variable is random (so that prediction of its value depends on a set of underlying probabilities) and the outcome at any instant is not known with certainty.

Transient - if a groundwater system changes over time, then the system is in a transient condition. Also refers to the type of numeric modeling where the results reflect changes over time.

Transport model - a groundwater model that solves for concentrations of solutes.

Water balance - a process of equating the water inflows to a groundwater system with the water outflows, accounting for any changes in storage of water in the system.

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PROTOCOL

Evaluation of Source Materials at SRS Waste Units

Introduction

This protocol has been developed to provide guidance on the evaluation of source materials at SRS waste units, specifically presenting a methodology for determining whether principal threat source material (PTSM) is present.

The concept of principal threat waste and low level threat waste as developed by the U.S. Environmental Protection Agency (USEPA) in the National Contingency Plan (NCP) (40 CFR 300.430(a)(1)(iii)) is to be applied on a site-specific basis when characterizing source material. Source materials are those materials that include or contain hazardous substances, pollutants, or contaminants that act as a reservoir for migration of contamination to groundwater, surface water, or air, or that act as a source for direct exposure (USEPA, 1991). Source characterizations are necessary to determine whether the source(s) can be designated as PTSM, low-level threat source material (LLTSM), or non-hazardous materials. The NCP expectations for addressing PTSM and LLTSM are to:

- Use treatment to address the principal threats posed by a unit, wherever practicable
- Use engineering controls (i.e. containment) for wastes that pose a relatively low long-term threat or where treatment is impracticable
- Use a combination of methods where appropriate
- Use institutional controls as appropriate for short- and long-term management to prevent or limit exposure

This protocol reflects the U. S. Department of Energy (USDOE), USEPA, and South Carolina Department of Environmental Control (SCDHEC) expectations with respect to defining and managing PTSM at SRS (WSRC, 2005a). The following discussion is divided into three sections: 1) evaluation of source material at SRS, 2) determination of

PTSM, and 3) expectation for addressing PTSM in remedial alternative development and selection.

Evaluation of Source Material at SRS

The determination of whether the source materials present at a waste unit would be classified as PTSM is based principally on USEPA, 1991. In this guidance, the USEPA defines principal threat wastes as "those source materials considered to be highly toxic or mobile that generally cannot be reliably contained or would present a significant risk to human health or the environment should exposure occur". They include liquids and other highly mobile materials (e.g., materials that are released from surface soil due to volatilization, leaching, or surface runoff) or materials having high concentrations of toxic compounds. No "threshold level" of toxicity/risk has been established to equate to "principal threat". However, the guidance does state that treatment alternatives for source materials should generally be evaluated where the combined toxicity and mobility pose a potential risk of 10^{-3} or greater.

The USEPA, SCDHEC, and USDOE evaluated the USEPA guidance with respect to toxicity and contaminant migration analyses performed at SRS (WSRC, 2005a). In practice, the SRS risk assessment and contaminant migration evaluations identify COCs associated with source material or impacted media and determine the associated risk or potential impact to groundwater. If threshold risk levels are exceeded or groundwater protection standards are predicted to be contravened in less than 1000 years, these problems are identified and an evaluation of remedial alternatives is conducted in the Feasibility Study (FS). Since the risk assessment does not evaluate human receptor exposure to subsurface soils, further evaluation is needed to account for highly toxic source material or contaminated soils at depth that would result in unacceptable risk should exposure occur. However, since the existing program determines contaminant migration COCs for the entire soil column (vadose zone) in the remedial investigation, and addresses these COCs in the FS with evaluation of at least one treatment or removal

alternative, the mobility aspect of PTSM is already being addressed as part of the RI/FS process. Therefore, a separate quantitative determination of whether PTSM exists based on mobility as part of this protocol is not required.

Determination of PTSM

Initially, a qualitative assessment of the source material(s) can be used to determine if the source material should be considered PTSM. These source materials would include containerized liquid wastes (e.g. drums) or non-aqueous phase liquids (NAPL) (e.g. perched dense NAPLs in the vadose zone), and highly toxic solid wastes such as PCB transformers or lead batteries.

In order to determine whether contaminated source material/soils/sediment should be preliminarily considered PTSM, a simple quantitative assessment evaluating the toxicity of the source is used as described in the following paragraphs.

A source term concentration is established for all the unit-specific constituents (USC) identified. The samples collected from within the source material area or zone of highly contaminated soils/sediment are considered the source group samples. Sufficient process knowledge and characterization is required to adequately define the source term concentration for PTSM determination. The PTSM evaluation is applicable to the entire soil column. Examples include the first few feet of sediment in the bottom of a seepage or discharge basin, the burn/sludge zone at the base of a burning trench, contaminated concrete in a sump, or sludge/sediment in a pipe. Summary statistics (i.e., the mean value, the 95 percent upper confidence limit on the mean [95% UCL] value, and the maximum value) are compiled for each USC associated with each source group. The PTSM exposure point concentration (EPC) is determined by the lower of the 95% UCL or the maximum value and is used to represent the overall source.

In determining whether the source should be considered PTSM, the evaluation considers the cumulative effects of both the potential risk from carcinogenic constituents and the adverse health effects from noncarcinogens to human receptors. Because the most likely future land use scenario for most SRS operable units being evaluated is industrial, the toxicity assessment of the source material is based on the potential exposure of a future on-unit industrial worker. If appropriate, other exposure scenarios should be considered on a case-by-case basis, as agreed to by the project-specific core team. The most current USEPA Region 9 preliminary remedial goals (PRGs) (USEPA, 2004) for industrial scenario exposure to soil were used to develop the PTSM threshold criteria for chemical carcinogens and noncarcinogens. For radionuclides, SGCP radionuclide PRGs (based on the USEPA Radionuclide PRGs for Superfund Electronic Calculator) are used (WSRC, 2003). If a concrete slab or sump is the source material, the PRGs for concrete media (WSRC, 2005b) that were developed by SGCP will be used to identify PTSM.

The source material is preliminarily considered to be PTSM if the cumulative risk exceeds one of the following toxicity threshold criteria:

- Carcinogens - greater than 1×10^{-3} industrial worker risk
- Noncarcinogens – industrial worker hazard index (HI) greater than 10

For carcinogens, the individual risk is calculated by multiplying the ratio of the EPC over the PRG by 1×10^{-6} . Each of these risks is summed to calculate the cumulative carcinogenic risk of the source. For noncarcinogens, an individual hazard quotient (HQ) is equal to the ratio of the EPC over the PRG. These HQ's are summed to derive the cumulative HI.

An uncertainty analysis will be conducted in the RI to further evaluate the constituents and source(s) that exceed the PTSM toxicity criteria. This analysis is intended to help the project-specific core team make a final determination as to the presence of PTSM at the specific unit. Some examples where it may not be appropriate to identify the source as PTSM include: (1) if the source defined as PTSM is of very limited extent or volume, (2)

if the source term concentration appears skewed based on a single value, (3) if a published toxicity value is undergoing additional evaluation, or (4) if the HI exceeds 10 based on the cumulative effects of noncarcinogens that effect different target organs.

Remedial Alternative Expectations

For those source materials that are considered to be PTSM, the remedial action objectives (RAOs) addressing PTSM should be written in a manner consistent with USEPA Guidance (USEPA, 1988). For example, “prevent potential future exposure of an industrial worker to PTSM levels of uranium-238 in concrete at depth”, rather than “treat or remove PTSM levels of uranium-238 in concrete to the extent practicable”. This will allow a full range of alternatives to be considered by the core team in the remedy selection process. Treatment (such as soil vapor extraction, biodegradation, in-situ oxidation, stabilization, grouting, etc.) and off-site disposal alternatives are preferred in the NCP for addressing principal threats. In addition, containment and institutional controls can be evaluated as part of the nine criteria analysis conducted in the FS, considering the level of toxicity/risk, mobility, the volume of the PTSM, the depth below the surface (likelihood of exposure), the likely land-use scenario in the area, and any land use controls that will be required as part of the overall remedy.

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INTERNAL SRS PROTOCOL

DOCUMENT CONTROL

1. Numbering

Numbers for Environmental Compliance & Area Completion Projects (EC&ACP) documents are assigned through the Records Management Group Web Page. The numbering format is SRNS-RP-YEAR-Number. Contact the EC&ACP Document Control Center (DCC) for assistance.

2. Distribution

Distribution of documents to EPA and SCDHEC is completed by Environmental Compliance (EC) personnel. The document and associated paperwork will be gathered by the EC team member and delivered to EC&ACP DCC for distribution. All reference documents, if not previously submitted to EC&ACP DCC, should also be submitted for future records and reference. All on-site distribution is completed by EC&ACP DCC.

EC&ACP DCC will issue electronic copies of the information provided (e.g., submittal letters, comment responses, and documents). EC&ACP DCC will issue hard copies [controlled or uncontrolled (i.e., information only)] if requested and will ensure updates to the appropriate copyholders, as needed.

This process is repeated by the EC team member and EC&ACP DCC for all regulatory submittals (i.e., Revision 0, Revision 1, comment responses only, etc.)

3. Revisions/Changes

All changes to previously submitted documents require a change to the revision number. Changes may be made by a complete revision of the document or by page change(s) only. If page changes are used, each revised page in the document should contain the document number, new revision number, and date (i.e., month

and year). Even though the unrevised pages remain the same, the revision of the entire document has changed. The document title page should be changed to indicate the new revision. After submitting the revised document, any additional changes require a new revision number.

3.1 Addendum

If an addendum is submitted for a document, the addendum must carry a separate document number and be treated as a stand-alone document.

3.2 Documents within Documents

On occasion, an entire supporting document with a separate document number (e.g., Data Usability Report) is inserted within the main document as an attachment. When compiled this way, the attached document is not traceable. The preferred method is to reference the supporting document in the main report but not include it as an attachment. The supporting document is included with the regulatory submittal as a stand-alone document with its own document number.

4. Review for Off-Site Release

All EC&ACP documents are subject to review requirements prior to release to the public. In general, EC&ACP Documents that address approved operable units or areas can undergo an in-house Designated Unclassified Subject Areas (DUSA) review. The list of approved DUSAs is provided on the Area Completion Projects web page. These subject areas have been determined to have little or no potential for relational ties to classified or sensitive unclassified information. Documents that do not meet the requirements for DUSA approval must be submitted for a Request for Information Review and Release before off-site release. The administrative steps for off-site approval are provided below.

4.1 Review for Off-Site Release

Documents are submitted to the DUSA Reviewer for review for off-site release. The DUSA Reviewer will complete the appropriate form for off-site release. Documents can also be submitted electronically through Lotus Notes using the Request for Information Review and Release form. All documents, including any reference documents, must have approval for off-site release before they will be accepted for the Administrative Record File (ARF).

All revision/versions including drafts must be submitted and approved for release prior to being sent off-site.

4.2 Redline Documents

Redline documents are reviewed for off-site release at each revision. Once the document is accepted by the regulators, the clean copy will not need to be re-reviewed as long as no changes were made or if the changes were editorial only. If non-editorial changes are made, a new revision and off-site release review is required.