

PLUG-IN RECORD OF DECISION: IN-SITU STABILIZATION AND LOW-PERMEABILITY SOIL COVER

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ABSTRACT

The **Plug-in Record of Decision** (ROD) is a unique administrative and technical approach that allows waste sites that have common characteristics to use or “plug into” a single ROD. This approach, developed by the U.S. Environmental Protection Agency (US EPA) and used previously by the U.S. Department of Energy (US DOE) at Hanford, will be implemented at eight high-risk radioactively contaminated seepage basins at Savannah River Site (SRS).

The plug-in approach specifies criteria that a waste unit must meet to use the common remedy specified in the plug-in ROD. The plug-in criteria developed for radioactively contaminated seepage basins at SRS include (1) radionuclides as primary soil contaminants, (2) location in a current nuclear use area, (3) principal threat source materials that pose risks exceeding 1×10^{-3} to future workers, and (4) no adjacent surface water or groundwater.

The plug-in remedy for radioactively contaminated seepage basins meets US EPA's bias for treatment and provides for better long-term protection of groundwater. The features of this action include

- institutional controls,
- in-situ stabilization of principal threat source materials soil within the basins,
- a low-permeability cover system placed over the stabilized soil to reduce water infiltration and provide shielding,
- pipelines grouted in place or excavated, and
- excavation and consolidation of any contaminated soil surrounding the pipelines.

INTRODUCTION

Many federal facility waste sites (e.g., liquid waste disposal trenches and solid waste burial grounds) have similar characteristics due to common waste management practices and, thus, offer potential opportunities to cut costs and schedules by utilizing these similarities to focus the remedy selection process. This concept of utilizing similarities between sites to streamline remedial planning and implementation is embodied in US EPA's presumptive remedy policy [1] and serves as the basis for implementing plug-in approaches to site remediation.

Plug-in approaches are remedial strategies that use the knowledge gained from previous experience at a waste site(s) to serve as the basis and justification for subsequent responses at

similar sites. The plug-in approach identifies a preferred remedial action and then defines a process that shall be used to determine when that remedial action can be applied.

Plug-in approaches have been used by the US EPA, US DOE, and the US Air Force to accelerate remedial actions at other sites [2, 3, 4]. The plug-in concept and beneficial features are highlighted below.

The plug-in approach varies from the standard Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) process due primarily to the fact that the remedial decision making is initiated by defining the conditions for which a proven response is applicable and then identifying units that meet those conditions. Conversely, the standard CERCLA process would start with defining characteristics for a waste unit in a remedial investigation and then determining an appropriate response for those characteristics through a feasibility study.

The plug-in ROD does not select a remedial action for a specific operable unit (OU), but selects a remedial action to apply to any OU exhibiting characteristics that meet the plug-in criteria. Individual remedial decisions for these units will be documented through a unit-specific decision document, which is developed consistent with the process defined in the plug-in ROD.

This plug-in approach is consistent with the DOE plan “Accelerating Cleanup: Focus On 2006.” It will permit SRS to take early remedial actions that have final remedial action objectives (RAOs) on the contaminated source units. As a program management tool, this approach will allow defensible decisions to be reached more efficiently and effectively.

DOE-Savannah River has adopted the use of plug-in approaches to OU remediation due to the presence of recurrent problems (waste units) warranting similar responses.

Plug-In Concept
● Developed by EPA Region IX at the Indian Bend Wash Site in Tempe, AZ ● Plug-In ROD defines conditions (e.g., existence of principal threat source material in a discreet subgrade layer) for which a proven response is applicable ● The remedy is applied to any operable units that meet those conditions
Key Features
● Joint venture between US DOE, US EPA Region IV, South Carolina Department of Health and Environmental Control (SCDHEC) ● Implements Superfund Reform: Data collection and risk evaluation focused on plug-in criteria and satisfying remedy design needs ● Provides for early interim action at high risk sites ● Comes to early consensus on remedial goals ● Reaches consistent defensible remedial decisions with stakeholder input ● Streamlines documentation and shortens the time from characterization to remedial decisions

CANDIDATE UNITS

OUs at SRS consist of both source term (contaminated soils and/or pipelines) and potentially impacted media such as surface water, sediment, and groundwater [5]. The source term at these waste units accounts for a significant portion of the current risk to human health and the environment and is a potential long-term threat to groundwater. Therefore, expedient and effective source term control is key to the overall site strategy. Based on similar process histories and the available data, the following CERCLA OUs are the initial candidates for the plug-in ROD: C-Area Reactor Seepage Basins (CSB), K-Area Reactor Seepage Basin (KSB), L-Area Reactor Seepage Basin (LSB), and P-Area Reactor Seepage Basins (PSB). The locations of these units are shown in Figure 1.

These open reactor seepage basins all received discharge water from the reactor disassembly basins. The water from the disassembly basins generally contained tritium and other radionuclides. The key contaminants of concern (COCs) include cesium-137, cobalt-60 (direct exposure risks), strontium-90 and carbon-14 (migration to groundwater risks). Long-lived transuranics, such as plutonium, may be present but at low levels.

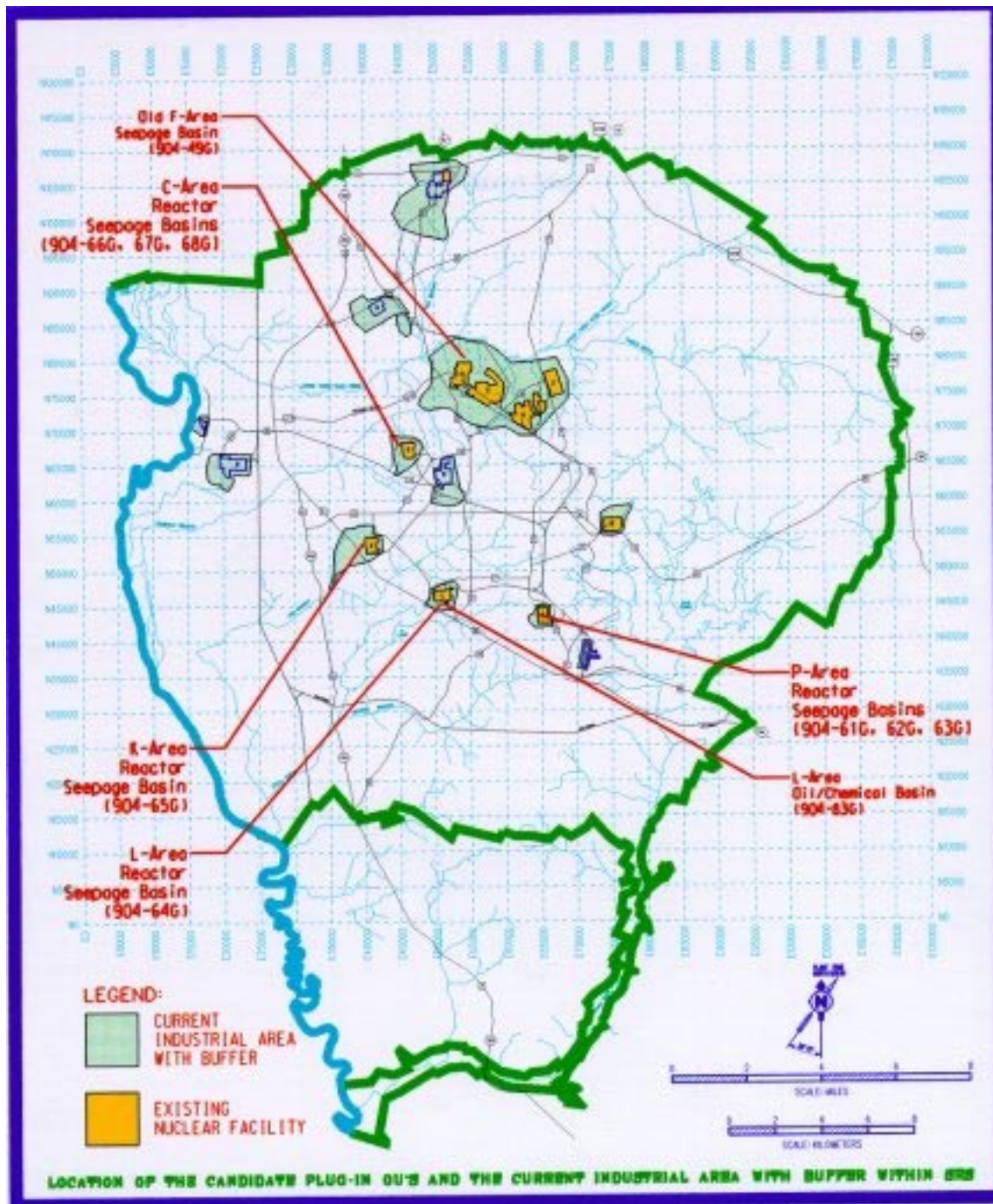


Figure 1. Map of SRS Showing the Location of the Candidate Plug-In Operable Units and the Current Industrial Use Area (with Buffer) Adjacent to an SRS Nuclear Facility

At CSB and PSB, the basins were connected in series so that the first basin would fill and any overflow would go to the next until that basin was full. The second basin would then overflow into the third. This type of operation allowed the first few feet of soil in the first basin to become more highly contaminated while the soil in subsequent basins remained less contaminated because they received less of the discharge. Table 1 shows a distribution of COCs for basins with available data.

After review of the candidate units, the following common RAOs were developed:

- 1) Prevent the exposure of future workers and trespassers to principal threat source material (PTSM).
- 2) Reduce risks to human health (i.e., current workers, future workers, and trespassers) associated with external exposure or direct contact to soil/pipelines and ingestion of soil. Remedial goals (RGs) for COCs are established at 1×10^{-6} for carcinogens at the surface (0 to 1 foot) or background (where background levels of COCs exceed 1×10^{-6}), as required by SCDHEC.
- 3) Prevent the release of COCs to groundwater beneath the unit above maximum contaminant levels (MCLs) or risk-based concentrations (RBCs) if there are no MCLs. The soil remedial goals (RGs) are back calculated based on these values.
- 4) Protect the ecological receptors indigenous to the area by preventing or limiting contact with contaminated soil/pipelines and preventing the plant and animals from bringing contaminants up toward the surface.

DEVELOPMENT OF THE PLUG-IN APPROACH

Development of the plug-in approach at SRS was initiated with three specific goals in mind.

- 1) develop the approach with a unified team of decision makers;
- 2) use existing site precedents to the extent practicable to identify the appropriate plug-in remedy; and
- 3) communicate early and often with stakeholders.

The effort associated with achieving each of these goals is discussed in more detail below.

Decision-maker Interaction

The plug-in approach, while not unique to the industry, is still considered relatively innovative. Additionally, any attempt to modify typical remedial decision making must take caution not to circumvent sound and defensible decision making. In order to ensure that the plug-in approach was developed in a manner that everyone would be comfortable with, all parties were included in the process.

A number of working (brainstorming) meetings including US EPA Region 4, the SCDHEC, US DOE, and technical experts from the site contractor were held. The team invested significant time and energy in understanding the plug-in process in concept and then evaluated opportunities to apply it at SRS. Reviewing and revising the documentation of the approach was much more focused and resulted in “fine-tuning” as opposed to significant modifications.

The plug-in approach is also endorsed by the US EPA National Remedy Review Board, who provided specific recommendations for its implementation at SRS.

Table I. Radionuclide Distribution for Candidate Units

Operable Unit	Basin	Sample Depth (ft bbb)	Cs-137 (pCi/g)	Cs-137 (risk)	Sr-90 (pCi/g)	Sr-90 (risk)	Pu (pCi/g)	Pu (risk)	Co-60 (pCi/g)	Co-60 (risk)	Cumulative risk
C SB	904-066G	0-1'	157.00	1.5E-03	5.60	9.8E-08	4.60	4.6E-07	9.90	4.4E-04	1.9E-03
		1-4'	145.00	1.4E-03	34.50	6.0E-07	10.60	1.0E-06	10.70	4.7E-04	1.8E-03
		4-6'	210.00	2.0E-03	136.10	2.4E-06	1.83	1.8E-07	6.72	3.0E-04	2.3E-03
		7-10'	1.60	1.5E-05	39.40	6.9E-07	0.04	4.0E-09	0.08	3.5E-06	1.9E-05
		10-13'	1.60	1.5E-05	18.40	3.2E-07	0.08	7.9E-09	0.16	7.0E-06	2.2E-05
		13-16'	1.90	1.8E-05	42	7.3E-07	u	0.0E+00	0.14	6.2E-06	2.5E-05
	904-067G	0-1'	52.50	5.0E-04	2.40	4.2E-08	1.13	1.1E-07	0.22	9.7E-06	5.1E-04
		1-4'	113.90	1.1E-03	18.50	3.2E-07	0.95	9.4E-08	0.37	1.6E-05	1.1E-03
		4-7'	0.38	3.6E-06	24.70	4.3E-07	u	0.0E+00	0.06	2.6E-06	6.7E-06
		7-10'	0.82	7.7E-06	7.20	1.3E-07	0.03	3.0E-09	0.01	4.4E-07	8.3E-06
		10-13'	0.05	4.7E-07	5.10	8.9E-08	u	0.0E+00	u	0.0E+00	5.6E-07
	904-068G	0-1'	9.00	8.5E-05	u	0.0E+00	0.21	2.1E-08	0.01	4.4E-07	8.5E-05
		1-4'	0.20	1.9E-06	u	0.0E+00	u	0.0E+00	0.01	4.4E-07	2.3E-06
		4-5.5'	0.17	1.6E-06	u	0.0E+00	u	0.0E+00	0.01	4.4E-07	2.0E-06
		7-10'	0.01	9.4E-08	0.2	3.5E-09	u	0.0E+00	0.01	4.4E-07	5.4E-07
K SB	904-65G	0-1'	1328	1.3E-02	111.4	1.9E-06	12.1	1.2E-06	1.73	7.6E-05	1.3E-02
		1-3'	210	2.0E-03	36.2	6.3E-07	1.07	1.1E-07	0.25	1.1E-05	2.0E-03
		3-5'	24.2	2.3E-04	12.2	2.1E-07	0.48	4.8E-08	0.04	1.8E-06	2.3E-04
		5-7'	23.1	2.2E-04	3.3	5.8E-08	0.18	1.8E-08	0.02	8.8E-07	2.2E-04
		7-9'	46.8	4.4E-04	2.6	4.5E-08	0.65	6.4E-08	0.08	3.5E-06	4.5E-04
		9-11'	97.3	9.2E-04	0.14	2.4E-09	0.18	1.8E-08	0.03	1.3E-06	9.2E-04
		11-13'	15.5	1.5E-04	0.78	1.4E-08	0.41	4.1E-08	u	0.0E+00	1.5E-04
P SB	904-61G	0-1'	115	1.1E-03	44	7.7E-07	na		u	0.0E+00	1.1E-03
		1-2'	49.8	4.7E-04	108	1.9E-06	na		u	0.0E+00	4.7E-04
		2-4'	33.4	3.2E-04	na		na		28.5	1.3E-03	1.6E-03
		4-6'	7.4	7.0E-05	na		na		2.4	1.1E-04	1.8E-04
		6-8'	4	3.8E-05	na		na		0.7	3.1E-05	6.9E-05
		8-10'	1.6	1.5E-05	106	1.9E-06	na		u	0.0E+00	1.7E-05
	904-62G	0-1'	238	2.2E-03	73	1.3E-06	na		50	2.2E-03	4.4E-03
		1-2'	76	7.2E-04	0.8	1.4E-08	na		u	0.0E+00	7.2E-04
		2-4'	85	8.0E-04	na		na		u	0.0E+00	8.0E-04
		4-6'	10.5	9.9E-05	na		na		u	0.0E+00	9.9E-05
		6-8'	34	3.2E-04	na		na		u	0.0E+00	3.2E-04
		8-10'	51	4.8E-04	3	5.2E-08	na		u	0.0E+00	4.8E-04
	904-63G	0-1'	0.34	3.2E-06	0.9	1.6E-08	na		u	0.0E+00	3.2E-06
		1-2'	0.48	4.5E-06	1.1	1.9E-08	na		u	0.0E+00	4.5E-06
		2-4'	0.1	9.4E-07	na		na		u	0.0E+00	9.4E-07
		4-6'	u	0.0E+00	na		na		u	0.0E+00	0.0E+00
		6-8'	0.3	2.8E-06	na		na		u	0.0E+00	2.8E-06
		8-10'	u	0.0E+00	0.7	1.2E-08	na		u	0.0E+00	1.2E-08

Notes:

- 1) Concentrations shown are averages
- 2) u = not detected
- 3) na = not analyzed
- 4) Pu = Pu-238 and Pu-239/240
- 5) bbb = below basin bottom
- 6) risk >1.0E-03 is Principal Threat Source Material (PTSM)
- 7) **PTSM is Bolded**
- 8) Shading is the best estimate for grout depth
- 9) PSB data is from 1976, no data available for LSB

SRS Precedents

Two radioactive disposal basins at SRS, the L-Area Oil and Chemical Basin (LAOCB) and Old F-Area Seepage Basin (OFASB), have undergone complete evaluations under the SRS Federal Facility Agreement (SRS FFA) environmental restoration program [6,7].

Review of these two precedent units showed that the contamination history was similar to that of the plug-in candidate units. The two precedent sites had the following features:

- receipt of radioactively contaminated waste water;
- presence of elevated levels of radionuclides as primary soil contaminants;
- location in a current industrial use area (with buffer) adjacent to a nuclear facility;
- unacceptable risks to future workers in their current state;
- contaminated soils not in direct contact with surface water or groundwater; and
- associated pipelines potentially contaminated.

Further, the RAOs were similar to the objectives for the candidate units, and the same remedial action decision (in situ stabilization with a low-permeability soil cover system) was reached at both units. Based on all of these similarities, it was determined that the selected remedy for the precedent units should be applicable to the plug-in candidates.

Additional SRS precedent was the *Alternative Screening Report for the Radioactive Soils/Debris Consolidation Facility/Off Unit Disposal*, which evaluated whether the construction of a soil consolidation facility was warranted for the numerous radiological contaminated units at SRS [8]. The report concluded that, except for those waste units located outside of current nuclear industrial use zones, construction of a soils consolidation facility was not appropriate, considering factors of risk, cost, and future land use. The report recommends those waste units located within the current nuclear industrial use zones consider capping or an in situ stabilization/capping response action.

Stakeholder Involvement

The public had previously participated in two remedial decisions that selected the use of in situ stabilization with a low-permeability cover system at radioactive basins; therefore, they were familiar and comfortable with applying the technologies at SRS. Through presentations of the plug-in concept and site specific applications, the SRS Citizens Advisory Board was able to provide input on the plug-in approach during its development. The Board accepted the approach and has subsequently passed a motion to implement the plug-in approach at radiological contaminated waste units.

The general public will also be provided the opportunity to comment on the approach through the typical review cycles associated with proposed plans and RODs.

PLUG-IN REMEDY DESCRIPTION

The common remedy, in situ stabilization with a low-permeability soil cover system, contains the following five key aspects: institutional controls, in situ stabilization, a low-permeability soil cover system, consolidation of contaminated soil around the pipelines, and the grouting of pipelines. This remedy meets all the RAOs described above for protecting human health and the environment. The details of the remedy components are discussed below.

Institutional Controls

Institutional controls will be applied to all OUs that plug-in to the ROD. Institutional controls are needed to ensure that land use remains consistent with the RAOs established above. Existing site controls are assumed to remain in place for 100 years to limit activities at the units to monitoring and maintenance by workers. Should the property ever be transferred to a nonfederal owner, the U.S. Government will take those actions necessary pursuant to Section 120(h) of CERCLA.

These actions will likely include deed restrictions to limit use to nonresidential activities and prohibit excavation in areas where stabilized wastes are present, which support the first and second RAOs.

However, the need for deed restrictions may be reevaluated at the time of transfer in the event that exposure assumptions differ and/or contamination no longer poses an unacceptable risk under residential use.

In Situ Stabilization

In situ soil stabilization is a treatment technology application that reduces the accessibility and mobility of contaminants. It will be applied to soils that are considered PTSM to the extent practicable, meeting the first RAO.

PTSM is defined by the US EPA as follows [9]:

“Principal threat wastes are 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., solvents) or materials having high concentrations of toxic compounds. No “threshold level” of toxicity/risk has been established to equate to “principal threat.” However, where toxicity and mobility of source material combine to pose a potential risk of 10^{-3} or greater, generally treatment alternatives should be evaluated.”

In order to streamline the plug-in remedy criteria, PTSM is defined as soil which poses a radiological risk (using baseline risk assessment exposure assumptions) to a future industrial worker equal to or greater than 1×10^{-3} . Based on the presumptive approach used in this plug-in ROD (PP) and the previous decisions, a bias for treatment of PTSM will be used. This decision is also consistent with the National Contingency Plan's preference for treatment [10]. Stabilization treatment will provide for greater long-term effectiveness in protecting groundwater and will also serve to augment prevention of potential direct exposure to the principal threat

source material by converting the waste into a form less susceptible to uptake by human intruders.

In situ soil stabilization is performed by injecting or mixing the solidification agents directly into or with the contaminated soil. The specific chemical formulation of the stabilization agents will be matched to the contaminants present to maximize the effectiveness of the stabilization agents in reducing mobility.

Low-permeability Soil Cover System

A low-permeability soil cover system will be placed over all the open basins. The soil cover system will be designed with a low enough permeability to prevent leaching of COCs to groundwater at concentrations that will exceed MCLs for 1,000 years. The soil cover system will consist of compacted layers of local clay-rich soil placed over the contaminated area. The primary purpose of the cover is to reduce the infiltration rate through the contaminated zone and thus reduce contaminant migration and/or the impact of infiltrating water on the stabilized soils. This action will meet the third RAO. The cover provides a barrier between potential receptors at the surface and the contaminants.

Based on the use of natural materials and its simple structure, the soil cover system can be maintained to provide long-term protection. Typically the soil cover is mounded, feathered into the surrounding area, and vegetated to minimize the impact of erosion. Based on the burrowing depth of animals and depth of root penetration [11], the depth to the waste must be at least 6 feet to prevent inadvertent plant or animal intrusion into the waste through the soil cover system. Six feet is conservative based on a review of animal burrowing depths for SRS species. If the depth to the contaminated soils is less than 6 feet, a bio-barrier will be included as part of the cover system, so plants and animals will not contact the waste. This action will meet the fourth RAO.

Consolidation

Consolidation within the area of contamination (AOC) of a given unit will be used to ensure that the footprints of the OUs are reduced to the extent practical. This will reduce both the footprint of the contaminated area and the maintenance costs associated with the implementation of the containment remedy. This could include contaminated soils associated with pipelines and incidentally impacted surface soils around the basins.

For subsurface soils (deeper than 1 foot), the need for consolidation will be based on leachability RGs, supporting the third RAO. Based on modeling results, groundwater will be protected such that residual soil concentrations will not result in groundwater contamination above MCLs in the next 1,000 years. Should the back-calculated soil concentrations protective to these levels be below background concentrations, background concentrations will be used as the remedial goal.

For surficial soils, the amount of contaminated soils being consolidated would be driven by exposure at the surface, which supports the second RAO. RGs for COCs are established at 1×10^{-6} for carcinogens at the surface (0 to 1 foot) or background (where background levels of COCs exceed 1×10^{-6}), as required by SCDHEC. Contaminant concentrations of nonradionuclides (if present) would also be reduced to acceptable risk levels.

Any soil to be consolidated that meets the definition of PTSM will be excavated and consolidated into the primary discharge basin before any in situ stabilization is started. Soils exceeding RGs that are not PTSM will be placed in the basin before filling to grade but may not be stabilized.

Pipelines

The remedy for pipelines is in situ grouting of the interior space of the pipeline, which will meet the fourth RAO by preventing access by small animals. This will also stabilize any potential contamination left inside the pipeline.

Cost

The estimated costs for this remedy for the candidate units range from about 2.5 million dollars to 6.5 million dollars. The costs depend on the number and size of the basins present at each operable unit and the estimated depth of soils requiring in situ stabilization. Although the ROD will provide a cumulative cost for all the candidate units identified, the remedial action will be staggered and costs tracked by each candidate unit.

PLUG-IN DECISION PROCESS AND DOCUMENTATION

The basic process for the Plug-In ROD is shown in Figure 2. As can be seen from this figure, two basic steps are taken. First, an analysis is conducted to determine if the candidate OU meets the plug-in criteria that demonstrate that the common remedy is appropriate. Then the decision to plug the unit into the plug-in ROD is documented in a decision document and the unit-specific application of the remedy is described.

Plug-In Criteria

The specific criteria have been formulated as key questions that the decision makers (US DOE, US EPA and SCDHEC) must consider when evaluating a unit for applicability for the plug-in ROD. If the answer to any of the indicated four questions is “No”, then this Plug-In ROD is not appropriate and an alternate pathway will be used. The plug-in criteria are as follows:

Question 1 - Does the unit contain radionuclides as primary soil contaminants?

Should a unit be free of radionuclides, then it would not plug-in because the plug-in remedy has not been evaluated at nonradioactively contaminated units.

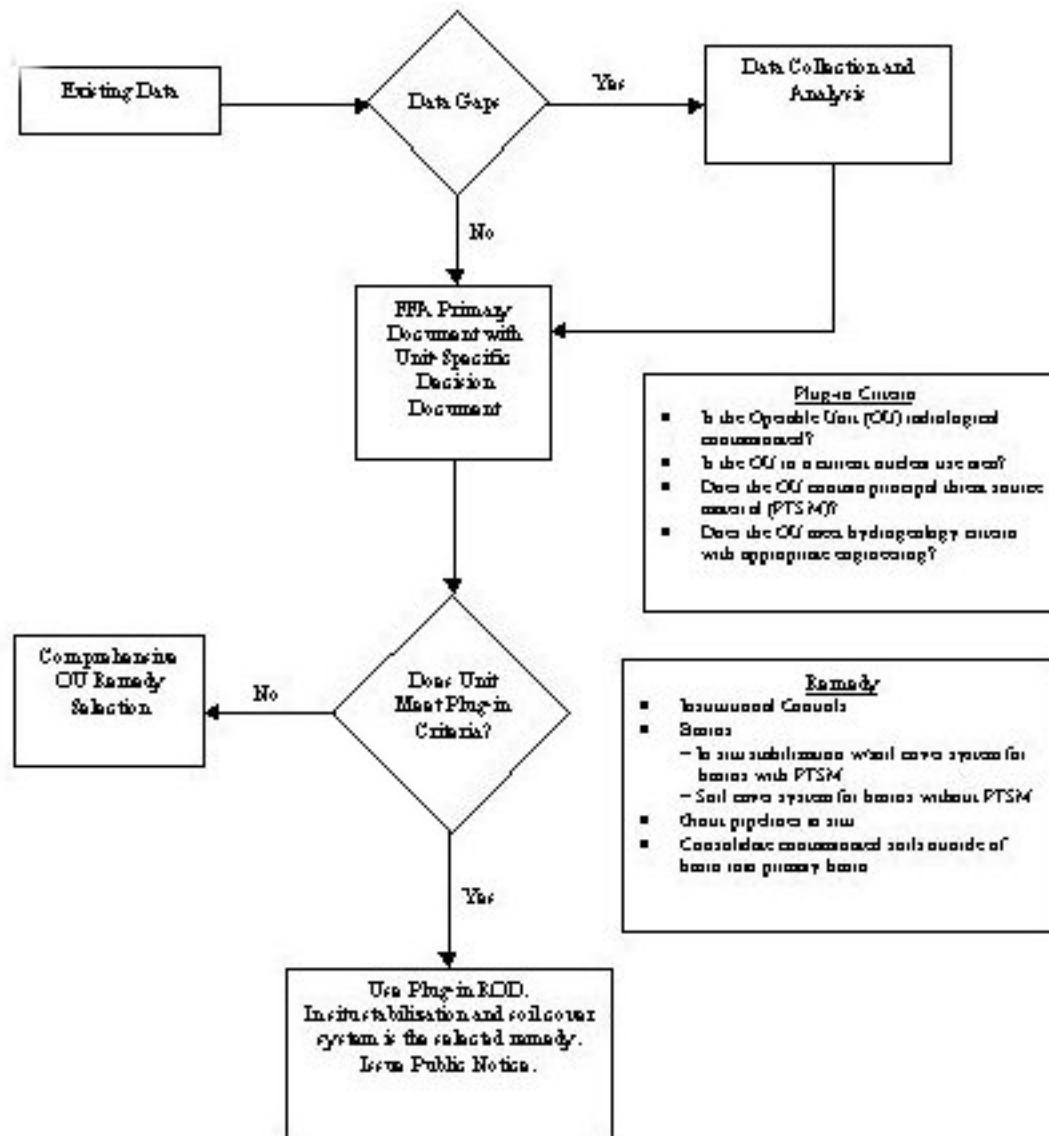


Figure 2. Plug-in Logic and Mechanics

Question 2 - Is the unit located in a current industrial use area (with buffer) adjacent to a nuclear facility?

During the development of the RAOs, one of the key assumptions was that controls would be placed on the OUs that would restrict the future land use around that unit to nonresidential. At the present time, agreement has been reached that the areas around the current industrial use area (with buffer) adjacent to a nuclear facility (e.g., the reactor facilities, see Figure 1) will be used in the future only for nonresidential uses [12, 13]. Therefore, if the unit is in a current industrial use area (with buffer) adjacent to a nuclear facility, it will satisfy the assumptions of the RAOs.

Question 3 - Does the unit contain PTSM?

This plug-in ROD is biased toward active remediation and treatment of units known, or expected, to present a significant threat to human health and the environment. If the unit does not contain PTSM (basin soils posing a risk to a future industrial worker equal to or greater than 1×10^{-3}), then a remedy considering use of engineering controls without treatment may be appropriate.

Question 4 - Are the contaminated soils not in direct contact with surface water or groundwater?

The two cases to be considered are groundwater intrusion into the PTSM and surface water proximity to the waste such that the PTSM or the soil cover system could be eroded over time. This situation would preclude the use of this remedy unless engineering controls were first implemented to mitigate the problem.

Decision Document

In order to determine if an OU meets the criteria of the plug-in ROD, the existing historical and characterization data will be evaluated to determine if the data is sufficient to show that the OU meets the criteria. If the historical data are not sufficient, then focussed characterization data will be collected to fill any data gaps.

The evaluation of a candidate OU to determine if it meets the criteria of the plug-in ROD will be documented in the Unit Specific Plug-In Decision Document. Once the three parties agree that the unit meets the criteria contained in the plug-in ROD, a public notice will be issued with the decision (see Figure 2).

Mechanics of Plugging-in New OUs

The method for plugging in a new OU, not initially identified as a candidate, will require an update of the plug-in ROD through the use of an Explanation of Significant Difference (ESD). The ESD will present a preliminary description of the OU, indicate it meets the plug-in criteria, and include it as an additional candidate unit.

CONCLUSION

The plug-in ROD identifies in situ stabilization with a low-permeability soil cover system (including institutional control and management of pipeline and associated soils) as the preferred

response action for radioactively contaminated source units in a current industrial use area (with buffer) adjacent to a nuclear facility. This conclusion was reached based on review of SRS decision precedents (e.g., previous RODs) in support of development of this common remedy that will be implemented by the plug-in approach. This response action will address the source unit portion of the OU as an interim action. The plug-in remedy may be applicable to any unit at SRS that exhibits the specific unit characteristics that meet the requirements defined in the plug-in ROD.

A preliminary evaluation of the candidate open reactor seepage basins against the plug-in criteria was made indicating that KSB, CSB, and PSB would meet the plug-in criteria. LSB will require additional data before a determination can be made. Based on the distribution of radionuclides shown in Table 1, the estimated depth of soil to be in situ stabilized in each basin is shaded.

Employing the plug-in ROD at the currently identified candidate units, should save approximately \$1 million dollars total and one year for each unit from documentation efficiencies alone. Additional savings related to improved relationships with regulatory agencies by taking a team approach are also considered significant.

The plug-in approach is ideally suited for use at a facility such as SRS where there are multiple waste units sharing the same conceptual site model.

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