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**ENVIRONMENTAL
RESTORATION
PROGRAM**

**Methodology for Generating Waste
Volume Estimates**

**J. Q. Miller
T. Hale
D. Miller**

**MANAGED BY
MARTIN MARIETTA ENERGY SYSTEMS, INC.
FOR THE UNITED STATES
DEPARTMENT OF ENERGY**

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Methodology for Generating Waste Volume Estimates

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managing the

Oak Ridge National Laboratory

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Oak Ridge Y-12 Plant

Paducah Gaseous Diffusion Plant

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for the

U.S. DEPARTMENT OF ENERGY

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FOREWARD

This methodology is prepared for use by Environmental Restoration Waste Management Program participants. Any and all changes, updates, or reconfigurations to this methodology must be authorized by Jerome Q. Miller, Environmental Restoration Waste Management Program Systems and Planning Manager.

EXECUTIVE SUMMARY

This document describes the methodology that will be used to calculate waste volume estimates for site characterization and remedial design/remedial action activities at each of the DOE Field Office, Oak Ridge (DOE-OR) facilities. This standardized methodology is designed to ensure consistency in waste estimating across the various sites and organizations that are involved in environmental restoration activities. The criteria and assumptions that are provided for generating these waste estimates will be implemented across all DOE-OR facilities and are subject to change based on comments received and actual waste volumes measured during future sampling and remediation activities.

1. INTRODUCTION

This document describes the methodology used to calculate waste volume estimates for site characterization and remedial design/remedial action (RD/RA) activities at each DOE Field Office, Oak Ridge (DOE-OR) facility. It was necessary to establish a standard methodology so that consistency in generating waste estimates at the various sites and organizations that are involved in ER activities is ensured. Criteria and assumptions for making estimates are provided, especially for sites where little is known about the sampling approaches, extent of contamination, hydrogeology, and types of remediation to be proposed. Deviation from the criteria and assumptions outlined in this document is acceptable only if site-specific information is provided to justify the use of different criteria.

Waste volumes are estimated for three phases of remedial action: the preliminary assessment/site investigation (PA/SI), the remedial investigation/feasibility study (RI/FS), and RD/RA. Volume estimates for the PA/SI stage include wastes from limited sampling and activities that are necessary to identify the presence of contamination. The RI/FS stage involves a more comprehensive or expanded sampling program focused on determining the extent of contamination. The volume estimates for the RI/FS will, therefore, be similar in composition to those for the PA/SI but will be of a larger quantity. The volume of solid waste for the design/remediation phase is estimated three different ways: clean closure, dirty closure, and most probable scenario. Clean closure would involve excavation and removal of contaminated material (source and limited surrounding contaminated soil) from the site. Dirty closure would involve containment of contamination at the site (i.e., capping and vertical barriers). A most probable scenario is defined as the scenario most likely to occur based on current information; it could be any of several remediation technologies or combinations thereof. In addition to the estimates required for the three remediation scenarios described above, the quantity of groundwater requiring treatment is also estimated.

For each site and each phase, waste estimates are categorized as solid or liquid and are differentiated as to the type of waste. The possible types include low-level waste, transuranic waste, Toxic Substances Control Act waste, Resource Conservation and Recovery Act (RCRA) hazardous waste, sanitary waste, and any combination of these types (except for sanitary). Criteria for establishing these categories of waste will be integrated into the methodology by the end of FY 1991 [as suggested during the Environmental Restoration (ER)-Waste Management Plan Team Meeting, April 16, 1991]. Container volumes assume the use of drums (55 gal or 7.35 ft³) and metal boxes (96 ft³ B-25 boxes), each filled to 95% capacity.

Standard forms are used for preparation and documentation of the estimates. These are included in Appendix A. The forms for the PA/SI and the RI/FS phases contain information such as the DOE number (site identification number), the plant/site designation, a list of reference documents, site description, sampling strategy, detail for the soil sampling and well installation activities (such as the number, diameter, and depth of holes and the type, volume, and category of waste generated), a summary of the wastes (including equivalent volumes of drums for liquids and equivalent volumes of drums and boxes for solids), and the year the waste is scheduled to be generated. The form for the design/remediation estimates includes

the DOE number; plant/site designation; site description; description of each closure alternative; the type, volume, and category of the wastes (including equivalent container volumes); and the year(s) the waste is scheduled to be generated. Site descriptions for each form should be explicit and should include physical descriptions, site dimensions, waste descriptions, Environmental Protection Agency hazard codes (if known), and contaminants (reference contaminant concentrations if available).

2. SITE CHARACTERIZATION WASTE TYPES AND QUANTITIES

The types of waste generated during the PA/SI and RI/FS phases include soil cuttings, decontamination solutions, well development and purge water, and miscellaneous trash. The following sections describe the methodology used to estimate volumes of these wastes.

Soil sampling and groundwater well installation can be accomplished by methods described in the Martin Marietta Energy Systems, Inc., *Environmental Surveillance Procedures Quality Control Program Manual*, ESH/Sub/87/21706/1/R1 (hereafter called the QC Manual). Groundwater wells can be drilled using several methods, including use of augers, air rotary equipment, air hammer, and water/mud rotary equipment. Methods of soil sampling described in the QC Manual include sampling with a split-barrel (split spoon), shelby tube, hand auger, scoop, and others. Soil sampling requires augering to depths specified in the sampling plan or depths indicated by field conditions. Therefore, soil sampling results in waste soil cuttings and associated decontamination solutions.*

2.1 SOIL CUTTINGS

The volume of a soil cutting can be estimated by calculating the circular area of the borehole, based on the diameter of the auger or bit, and multiplying by the depth of the borehole or well. Soil-sampling augers have a diameter ranging from 7 to 12 in., and boreholes drilled for groundwater wells range from 9 to 13.5 in. in diameter. Table 1 provides guidance on which auger diameter to use in the estimates when sampling plans do not specify otherwise. The estimated depth of soil borings and wells will be site specific and will be based on the contaminant source, hydrogeological conditions, etc., as specified in sampling plans or preliminary assessments. A swell factor of 40% will be applied to all estimates (multiply volume by 1.4) to account for the soil being less compact after being augered and placed in drums/boxes.

Table 1. Auger diameter criteria for waste estimates

Installation	Soil boring auger diameter (in.)	Well drilling auger diameter (in.)
Oak Ridge Reservation and Off-Site locations	8	10
Portsmouth Gaseous Diffusion Plant	6	8
Paducah Gaseous Diffusion Plant	12	13.4

*Surface-soil sampling (sampling up to 2 ft) by scoop or hand auger does not generate a substantial quantity of soil waste; thus, no waste estimates are required for surface-soil sampling.

Field screening of soil cuttings for contamination is regularly practiced at ER sites. Soil cuttings are screened for pH, organic vapors, and radioactivity as a basis for health and safety protection of workers and segregation of waste cuttings. All soil cuttings are collected in containers for disposal; the final disposition of waste will be based on laboratory analysis performed on representative samples. For the purposes of these estimates, it is assumed that the soil cuttings are contaminated and must be containerized and disposed of accordingly. The waste category should be based on contaminants suspected to be present at the site per the "site description" section of the estimate.

2.2 WELL INSTALLATION AND SAMPLING

Well installation basically involves installation of well casing, screens, etc., following the drilling activities described in Sect. 2.1. During the well installation process, the well must be developed (i.e., water is pumped out to prepare the well). Also, prior to each sampling event, the water from the well must be pumped out (purged). Both well-development water and purge water must be placed in drums, sampled, and treated/disposed of accordingly. The waste category should be based on contaminants suspected to be present at the site per the "Site Description" section of the estimating form. Criteria for estimating volumes of well-development and purge water are included in Table 2.

Table 2. Well wastewater—criteria for waste estimates

Installation	Development water (gal/well)	Purge water (gal/sampling event)
Oak Ridge Reservation and Off-Site locations	150	50
Portsmouth Gaseous Diffusion Plant	150	50
Paducah Gaseous Diffusion Plant	750	150

Note: Estimates should address only wells installed and/or sampled for ER and should not include wells installed and/or sampled for monitoring required by Environmental Management organizations.

2.3 DECONTAMINATION SOLUTIONS

All sampling and excavation equipment such as hollow-stem auger flights, split-barrel samplers, sample-mixing trays, trowels, backhoes, and bulldozers must be decontaminated after each use according to the specifications (ESP-900) detailed in the QC Manual. Decontamination is accomplished with a water solution that is collected following decontamination and is then considered to be waste. The waste volumes resulting from this procedure can be estimated using the procedures outlined in Table 3.

Table 3. Estimated volumes for specified activities

Activity	Estimated volume
Split spoon sampling	5 gal/lin ft of hole
Well installation	5 gal/lin ft of well
Hand augering	2 gal/lin ft of hole
Well sampling decontamination	2 gal/well
Surface water sampling decontamination	2 gal/sample

2.4 MISCELLANEOUS TRASH

Miscellaneous trash associated with drilling operations or decontamination must be containerized. Plastic, wipes, tape, Tyvek clothing, or other materials that might contact site contaminants are assumed to be contaminated until testing characterizes the contents. Miscellaneous trash from the support zone (clean zone) such as paper and cardboard, aluminum, plastic and foam packing, rubber, sweepings, and food wastes, will be considered sanitary waste. Based on previous drilling operations performed at the Oak Ridge Y-12 Plant and the Oak Ridge K-25 Site, about 3–5 ft³ of trash is generated per borehole. An average volume used for estimating purposes is 3 ft³ of contaminated trash and 1 ft³ of sanitary trash per borehole.

2.5 OTHER

Biota sampling, primarily associated with the Off-Site ER Program, generates fish carcasses during processing. These are placed in plastic bags and frozen until results are received regarding contaminant concentrations in the tissue. If there is no contamination, the carcass is disposed of as a sanitary waste. If the carcass is contaminated it is disposed of following Energy Systems disposal procedures. Estimates will be generated on a site-specific basis; however, if no other information is available it will be assumed that all sampled fish carcasses are contaminated and require disposal.

Other characterization activities will be accomplished for which little or no waste is produced. Waste estimates will not be generated for activities such as site preparation (clearing brush and trees—unless contamination is known), civil surveys, geophysical surveys, health and safety monitoring, air monitoring, and radiation surveys. Water and sediment sampling generally collect no more than the quantity of material sufficient for analysis and archiving. Because samples submitted to the laboratory are often archived, waste estimates should only be prepared if sample residue (sample remaining after analysis) is returned to ER for disposal. Wastes produced from laboratory analysis will not be estimated. Any treatability studies that are required to support selection and design of remediation technologies will not be included in RI/FS estimates but will be estimated as part of the design/remediation phase, as required.

3. PA/SI AND RI SITE CHARACTERIZATION WASTE ESTIMATES

In the past, various types of documentation have been prepared for the ER sites at the five DOE-OR facilities. This documentation ranges from PA/SI work plans to RI/FS reports and most recently to draft records of decision. Because the ER activities at each of the DOE-OR facilities are in various stages of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) process, the prepared documentation is not necessarily being used for its intended purpose. For instance, because of regulatory demands and the necessity of utilizing a more encompassing CERCLA approach, K-25 and Y-12 will be implementing some site-specific RCRA Facility Investigation (RFI) plans as "expanded" PA/SI plans. Confusion over how to address this issue has caused inconsistency in the waste estimates across the sites. In addition, many of the sites for which waste estimates are required currently have no prepared documentation or sampling plans. Therefore, to ensure that waste estimates are generated consistently, the following methodology has been derived. The derivation of this methodology is based on past experience and best professional judgment. Upon issuance, this methodology will be implemented across all facilities and will be subject to change based on comments received and actual waste volumes measured during future activities.

3.1 GENERATION OF SITE CHARACTERIZATION WASTE ESTIMATES

The waste estimating methodology has been outlined in several logic diagrams that are described in detail in the following sections. Each of the following sections begins with a discussion of the appropriate logic diagram, the assumptions to be used, and examples of waste estimates. Estimates for soil and groundwater follow separate logic diagrams and will, therefore, be discussed in separate sections. It should be noted that the criteria in the tables do not take into account the materials (waste piles, drum contents, etc.) that are located at the site.

3.1.1 Soil Characterization Estimates

To estimate the number and depth of soil samples to be taken, calculate the *area to be sampled*. When estimating the *area to be sampled*, use the criteria outlined in Table 4, along with the known dimensions of the site. Use of the area criteria set forth in Table 4 will ensure consistency between the characterization estimates and the "clean closure" estimates outlined in Sect. 4 of this report.

To estimate the *area to be sampled*, draw a rectangle around the area and use the map scale to determine the length and width of the rectangle. Area measurements, with the exception of pipelines, should be calculated in square feet. Once the *area to be sampled* has been determined, the waste estimation process can begin. Figure 1 is an illustration of the calculation of the *area to be sampled*. For all sites, the originally calculated *area to be sampled* will be used for the first phase of investigation (PA/SI or RI Phase I). For all subsequent phases, the area (or length of the pipeline) used in the previous phase (PA/SI or RI Phase I) will be doubled. Thus, if the *area to be sampled* in the PA/SI was 500 ft², the *area to be sampled* in RI Phases I and II would be 1000 ft² and 2000 ft², respectively.

Fig. 1. Illustration for determining the size of the *area to be sampled*.

As outlined in Fig. 2, there are several questions the estimator should answer prior to determining the number of soil samples to be taken. First, the estimator should determine if existing PA/SI or RI/FS plans are available. Then, depending on the type of available plan and its intended use, the estimator should determine the appropriate pathway on the logic diagram. Waste estimates should then be generated using the instructions in the logic diagram and the criteria outlined in Tables 5 and 6.

The maximum study area listed on both Tables 5 and 6 is 43,500 ft², or one acre. If the site is greater than an acre, simply multiply the total acreage by the number of samples required per acre (i.e., 15 acres by 12 samples/acre = 180 samples). If this results in a fractional number, round the number of samples to the next whole number. Also, as discussed in Sect. 2.1, surface-soil sampling using a scoop or a hand auger (<2 ft deep) generally does not generate waste soil cuttings; most of the soil removed is used for sample analysis. Therefore, when calculating estimates for the PA/SI phase at such sites (streams, storage yards, landfarms, etc.), do not estimate for waste soil cuttings.

Table 4. Area criteria for various site types

Site type	Area criteria
Burial grounds	5 ft beyond the boundary
Pipelines—above and below ground	Estimates will be in linear feet. To estimate the <i>area to be sampled</i> , calculate the number of linear feet of pipeline to be investigated
Tanks—above and below ground	5 ft beyond the outer wall/diked area
Pits—lined and unlined	5 ft beyond the outer pit wall
Man-made ponds/impoundments	Estimate area using the area of the pond or impoundment bottom plus area of the banks
Streams	Estimate area using the area of the stream plus the area of the banks
Natural rivers/lakes	Estimate area using the area of the river/lake bottom
Storage areas/yards/drums/waste piles/scrap piles	5 ft beyond the boundary of the disposal area
Landfarms	5 ft beyond the boundary of the disposal area
Floodplains/wetlands	Estimate using the area of the 20-year floodplain

Fig. 2. Soil sampling logic diagram.

Table 5. PA/SI phase soil-sampling criteria

Site type	Sample depth ^a	Samples per area
Burial grounds	Refusal	<i>b</i>
Pipelines—aboveground		
0–25 lin ft	5 ft	3
25–50 lin ft		4
50–100 lin ft		5
Pipelines—underground		
0–25 lin ft	5 ft below bottom	3
25–50 lin ft	of pipe	4
50–100 lin ft		5
Tanks—aboveground	5 ft below surface or bottom of diked area	4 per tank
Tanks—underground	5 ft below bottom of tank	4 per tank
Pits—lined (e.g., concrete)	5 ft below bottom of pit	4 per pit
Pits—unlined	5 ft below bottom of pit	6 per pit
Ponds/impoundments (man-made)	Sludge (if any) plus 6 in.	<i>b</i>
Streams	1 ft	<i>b</i>
Rivers/lakes (naturally occurring)	3 ft or refusal, whichever is less	<i>b</i>
Storage areas/yards/drums/ waste piles/scrap	Pad per waste (if any) plus 6 in.	<i>b</i>
Landfarms	1 ft	<i>b</i>
Floodplains/wetlands	2 ft	<i>b</i>

^aDue to the significant depth to bedrock/refusal at Paducah, 30 ft will be considered the maximum soil depth to be sampled (groundwater wells will be sampled to 65 ft).

^bIf study area to be sampled is

- > 0 but ≤ 2725 ft², then take 4 samples
- > 2725 but ≤ 5450 ft², then take 6 samples
- > 5450 but $\leq 10,900$ ft², then take 8 samples
- > 10,900 but $\leq 21,800$ ft², then take 10 samples
- > 21,800 but $\leq 43,560$ ft², then take 12 samples

Table 6. RI/FS Phase I and Phase II soil-sampling criteria

Site type	Sample depth ^a	Samples per area
Burial grounds	Refusal	<i>b</i>
Pipelines—above ground		
0–25 lin ft	Refusal	3
25–50 lin ft		4
50–100 lin ft		5
Pipelines—underground		
0–25 lin ft	Refusal	3
25–50 lin ft		4
50–100 lin ft		5
Tanks—aboveground	Refusal	4 per tank
Tanks—underground	Refusal	4 per tank
Pits—lined (e.g., concrete)	Refusal	4 per pit
Pits—unlined	Refusal	6 per pit
Ponds/impoundments (man-made)	Refusal	<i>b</i>
Streams	Refusal ^c	<i>b</i>
Rivers/lakes (naturally occurring)	3 ft or refusal, whichever is less	<i>b</i>
Storage areas/yards/drums/ waste piles/scrap	Refusal	<i>b</i>
Landfarms	Refusal	<i>b</i>
Floodplains/wetlands	Refusal	<i>b</i>

^aDue to the significant depth to bedrock/refusal at Paducah, 30 ft will be considered the maximum soil depth to be sampled (groundwater wells will be sampled to 65 ft).

^bIf study area to be sampled is

- > 0 but ≤ 2725 ft², then take 4 samples
- > 2725 but ≤ 5450 ft², then take 6 samples
- > 5450 but $\leq 10,900$ ft², then take 8 samples
- > 10,900 but $\leq 21,800$ ft², then take 10 samples
- > 21,800 but $\leq 43,560$ ft², then take 12 samples

^cSite-specific conditions may not allow sampling to refusal. In such cases, the estimated depth is 3 ft.

3.1.2 Soil Characterization Scenario

As an example of the implementation of the methodology, the following scenario will be used to illustrate the steps involved in estimating soil wastes generated during site characterization.

The site to be characterized in this exercise is a drum storage pad upon which are three drums containing waste soil cuttings from another Oak Ridge Reservation site. Soil sampling will be conducted in the area surrounding the storage pad. The dimensions of the pad are 40 ft × 140 ft × 6 in. No existing plans are available for this site. However, it is known that a PA/SI followed by a two-phased RI will occur at the site sometime in the next two years. It is also known that refusal (bedrock) in the area is 20 ft. A diagram representing the site has been provided in Fig. 1.

3.1.2.1 Step 1—Determine the *area to be sampled*

Based on the schematic of the site in Fig. 1, the estimator must calculate the *area to be sampled*. Using the area criteria from Table 4, estimates of the *area to be sampled* should include dimensions of the pad plus 5 ft beyond the boundary. Using the following formula, the estimator can calculate the *area to be sampled* during the PA/SI.

$$A = [\text{length (ft)} + 2 (ac)] \times [\text{width (ft)} + 2 (ac)] ,$$

where A is the *area to be sampled* and ac is the area criteria from Table 4.

Note: This formula can be used to estimate for burial grounds, pits, tanks, storage areas, and landfarms only. Refer to Table 4 for instructions on calculating the area for other types of sites.

Using the known dimensions of the site and the area criteria from Table 4, the *area to be sampled* is calculated as

$$A = [140 \text{ ft} + 2 (5 \text{ ft})] \times [40 \text{ ft} + 2 (5 \text{ ft})] = 7500 \text{ ft}^2 .$$

Using this area measurement, the estimator can now calculate the *area to be sampled* for RI Phases I and II (see Sect. 3.1.1).

$$A \text{ for RI Phase I} = 7500 \text{ ft}^2 \times 2 = 15,000 \text{ ft}^2 .$$

$$A \text{ for RI Phase II} = 15,000 \text{ ft}^2 \times 2 = 30,000 \text{ ft}^2 .$$

3.1.2.2 Step 2—Follow the soil logic diagram

The information available about the site indicated that no documents were currently available, but that a PA/SI and two phases of RI work were to be conducted for the site. Based on this information, the estimator can use the soil logic diagram (Fig. 2) to determine how the waste estimates should be calculated. The shaded path on the logic diagram presented in Fig. 3 depicts the appropriate path for this scenario.

3.1.2.3 Step 3—Determine the number and depth of samples

Using the *area to be sampled* (as calculated in Step 1) the estimator can now determine the number and depth of samples for each phase of investigation using Tables 5 and 6. The estimator should locate the appropriate site type (i.e., storage pad) on the tables and should then record the number of samples and their depth for use in Step 5. Thus, for the current scenario, 8 PA/SI samples would be required for this area of 7500 ft², the RI Phase I area of 15,000 ft² would require 10 samples, and the RI Phase II area of 30,000 ft² would require 12 samples. The depth of the PA/SI samples would be the thickness of the pad (6 in.) plus 6 in. of soil for a total of 1 ft. The depth of the RI Phase I and Phase II samples would be refusal or, in this case, 20 ft (see Sect. 3.1.2).

3.1.2.4 Step 4—Follow the methodology outlined in the logic diagram

Waste estimates can now be generated using the following:

- The *area to be sampled* as calculated in Step 1.

PA/SI = 7500 ft²,
 RI Phase I = 15,000 ft², and
 RI Phase II = 30,000 ft².

- The methodology outlined in the logic diagram (Fig. 3).
- The criteria contained in Tables 5 and 6 for determining the number and depth of samples.

PA/SI—8 samples to a depth of 1 ft,
 RI Phase I—10 samples to refusal (20 ft), and
 RI Phase II—12 samples to refusal (20 ft).

- The criteria for estimating wastes in Tables 1 and 3 (remember the swell factor of 1.4!).

The waste estimates for this site will then be calculated as outlined below.

Estimate waste soil cuttings

- PA/SI—Not applicable for the PA/SI phase because the pad plus 6 in. is less than the 2-ft cutoff for surface-soil sampling (see Sect. 2.1).
- RI Phases I and II—Estimate volume based on the diameter and depth of the boreholes, using the following equation:

Fig. 3. Soil sampling logic diagram (example).

$$\text{Volume per borehole} = \pi \left(\frac{D}{2} \right)^2 h .$$

where D is the diameter of the borehole and h is the depth of the borehole.
Thus, the volume per borehole is calculated as

$$\text{Volume per borehole} = 3.14 \times \left(\frac{0.667 \text{ ft}}{2} \right)^2 \times 20 \text{ ft} = 6.98 \text{ ft}^3 .$$

For RI Phases I and II, simply multiply the volume per borehole by the number of boreholes to be sampled.

$$\text{RI Phase I} = (10 \text{ boreholes})(6.98 \text{ ft}^3) = 69.80 \text{ ft}^3 .$$

$$\text{RI Phase II} = (12 \text{ boreholes})(6.98 \text{ ft}^3) = 83.76 \text{ ft}^3 .$$

Lastly, the swell factor must be incorporated into the waste estimates.

$$\text{RI Phase I soil volume} = (69.80 \text{ ft}^3)(1.4) = 97.72 \text{ ft}^3 .$$

$$\text{RI Phase II soil volume} = (83.76 \text{ ft}^3)(1.4) = 117.26 \text{ ft}^3 .$$

Estimate decontamination solutions

Estimates for decontamination solutions are calculated using the criteria outlined in Sect. 2. The following equation can be used to calculate all decontamination solutions DS resulting from soil sampling.

$$DS = (\text{No. of samples})(\text{No. of feet per sample})(\text{volume per feet of hole})$$

Thus, the estimated volume of decontamination solutions for each phase is

$$\text{PA/SI } DS = (8 \text{ samples})(2 \text{ ft/sample})(2 \text{ gal/ft}) = 32 \text{ gal} ,$$

$$\text{RI Phase I } DS = (10 \text{ samples})(20 \text{ ft/sample})(5 \text{ gal/ft}) = 1000 \text{ gal} ,$$

and

$$\text{RI Phase II } DS = (12 \text{ samples})(20 \text{ ft/sample})(5 \text{ gal/ft}) = 1200 \text{ gal} .$$

Estimate miscellaneous trash

Estimates for trash must be separated into estimates for contaminated trash and estimates for sanitary trash. The criteria used for determining the volume of trash are listed in Sect. 2.4 of this report.

The equation for calculating the amount of contaminated trash CT is as follows:

$$CT = (3 \text{ ft}^3/\text{borehole})(\text{No. of boreholes}) .$$

Thus, the volume of contaminated trash for each phase is calculated as

$$\text{PA/SI } CT = (3 \text{ ft}^3/\text{borehole})(8 \text{ boreholes}) = 24 \text{ ft}^3 ,$$

$$\text{RI Phase I } CT = (3 \text{ ft}^3/\text{borehole})(10 \text{ boreholes}) = 30 \text{ ft}^3 ,$$

and

$$\text{RI Phase II } CT = (3 \text{ ft}^3/\text{borehole})(12 \text{ boreholes}) = 36 \text{ ft}^3 .$$

Similarly, the equation for calculating the amount of sanitary trash ST is

$$ST = (1 \text{ ft}^3/\text{borehole})(\text{No. of boreholes}) .$$

Thus, the volume of sanitary trash for each phase is calculated as

$$\text{PA/SI } ST = (1 \text{ ft}^3/\text{borehole})(8 \text{ boreholes}) = 8 \text{ ft}^3 ,$$

$$\text{RI Phase I } ST = (1 \text{ ft}^3/\text{borehole})(10 \text{ boreholes}) = 10 \text{ ft}^3 ,$$

and

$$\text{RI Phase II } ST = (1 \text{ ft}^3/\text{borehole})(12 \text{ boreholes}) = 12 \text{ ft}^3 .$$

3.1.3 Groundwater Characterization Estimates

In estimating the amount of waste generated by the installation and sampling of groundwater wells, one must first determine the *area of the site* under investigation. Once this is accomplished, the estimator should then proceed to the PA/SI groundwater logic diagram (Fig. 4). The logic diagram leads the estimator through a series of questions beginning with whether or not a PA/SI will be performed. Depending on the availability and intended use of the existing PA/SI plans, the number of wells for which one should estimate can easily be determined using Fig. 4. Subsequent to the generation of estimates for the PA/SI, the RI groundwater logic diagram (Fig. 5) should be used to estimate waste for RI Phases I and II. If the *area of the site* is less than or equal to one-half acre (i.e., *area of the site* ≥ 0.5 acre) and no existing plans are available, estimation of the amount of waste generated by installing and sampling efforts should be based on a maximum of four wells throughout all phases (i.e., PA/SI wells + RI Phase I wells + RI Phase II wells ≤ 4 wells).

Estimates of the amount of waste (soil cuttings, purge water, development water, etc.) generated during the installation and sampling of both existing wells and new wells should be based on the criteria in Tables 2 and 3. All groundwater wells will be sampled quarterly for a period of one year.

3.1.4 Groundwater Characterization Scenario

As an example of the implementation of the methodology, the following scenario will be used to illustrate the steps involved in estimating wastes generated during groundwater site characterization. The example has been broken down into the PA/SI phase and the RI/FS Phase to facilitate use of both the PA/SI and RI groundwater logic diagrams. The *area of the site* under investigation is ~2 acres. There are currently three groundwater monitoring wells at the site which were installed as compliance monitoring wells. A site-specific RFI plan was prepared for this site which proposed the installation and sampling of four groundwater monitoring wells and the sampling of existing monitoring wells during the RFI investigation. The monitoring wells will be installed to a depth of 20 ft. Because of regulatory constraints, this RFI plan will be used as an expanded PA/SI plan.

3.1.4.1 PA/SI Step 1—Follow the PA/SI logic diagram

Using the PA/SI logic diagram (Fig. 4), the estimator should first determine if a PA/SI will be conducted at this site. For the scenario that is currently under evaluation, a PA/SI will be performed. Therefore, the next question the estimator must address is whether or not some type of plan is available for the PA/SI phase. For this site, no PA/SI plan is available; however, an RFI plan is available and will be used as an expanded PA/SI. Next, determine if groundwater wells are proposed in the plan (yes) and if so, how many (four). Finally, the estimator must address the presence of existing groundwater wells. For this site, three wells are currently available. The pathway followed on the PA/SI groundwater logic diagram has been highlighted in Fig. 6.

3.1.4.2 PA/SI Step 2—Estimate wastes for installation and sampling of new wells

The existing RFI plan for this site called for the installation of four groundwater monitoring wells during the PA/SI investigation. Waste estimates can now be generated using

**Note: If area of site is less than or equal to 1/2 acre, never install more than 4 wells throughout all phases (See text).

Fig. 4. PA/SI groundwater logic diagram.

Fig. 5. RI Phase I and II groundwater logic diagram.

Fig. 6. PA/SI groundwater logic diagram (example).

the number of wells to be installed (four), the number of times the wells are to be sampled after installation (quarterly for one year or four times), and the appropriate criteria outlined in Tables 2 and 3 and Sect. 2.4.

Installation of new groundwater monitoring wells results in the generation of soil cuttings, development water, purge water, decontamination solutions, and miscellaneous trash. Estimates will be generated using the following equations.

Estimate soil cuttings

During well installation, soil cuttings are generated as a result of the advancement of the auger. These cuttings must be collected and disposed of properly. The following equations are based on the criteria in Table 1 and a well depth of 20 ft.

$$\text{Volume per well} = \pi \left(\frac{D}{2} \right)^2 h .$$

where D is the diameter of the borehole and h is the depth of the borehole.

Using this equation, the volume per well is calculated as

$$\text{Volume per well} = 3.14 \times \left(\frac{0.833 \text{ ft}}{2} \right)^2 \times 20 \text{ ft} = 10.91 \text{ ft}^3 .$$

Thus, for the PA/SI, simply multiply the volume per well by the number of wells to be installed for each phase.

$$\text{PA/SI} = (4 \text{ wells})(10.91 \text{ ft}^3/\text{well}) = 43.63 \text{ ft}^3 .$$

Lastly, the 40% swell factor must be incorporated into the waste estimates.

$$\text{PA/SI soil volume} = (43.63 \text{ ft}^3)(1.4) = 61.08 \text{ ft}^3 .$$

Estimate development water

The installation of a new well includes pumping a certain volume of water (development water) from the well and then allowing the well to recover prior to the initial sampling activities. Estimates of the volume of development water must be generated for all new wells. The following equation can be used to calculate the volume of development water DW .

$$DW = (\text{No. of new wells})(150 \text{ gal/well}) .$$

Therefore, the volume estimate for development water in the PA/SI phase is calculated as

$$\text{PA/SI DW} = (4 \text{ wells})(150 \text{ gal/well}) = 600 \text{ gal} .$$

Estimate purge water

Prior to sampling of monitoring wells, all water is pumped (purged) from the well and collected for future disposal. The volume of this purge water *PW* can be calculated using the following equation.

$$PW = (\text{No. of sampling events})(\text{volume per sampling event}) .$$

Therefore, the volume of purge water for the PA/SI phase is calculated as

$$\text{PA/SI PW} = (4 \text{ sampling events})(50 \text{ gal/sampling event}) = 200 \text{ gal} .$$

Estimate decontamination solutions

Estimates of the decontamination waste volumes generated during installation and sampling of wells must be separated into two categories. First, one must estimate for the decontamination solutions generated during well installation. Second, one must estimate for the decontamination solutions generated during sampling. These estimates differ because a greater volume of water is necessary to decontaminate drilling equipment.

Estimates for decontamination solutions are calculated using the criteria outlined in Sect. 2. The equation for estimating decontamination solutions generated during installation is as follows:

$$\text{Installation DS} = (\text{No. of wells})(\text{No. of feet per well})(\text{volume per feet of well}) .$$

Thus, for the PA/SI phase, the volume of decontamination solutions generated by installation is calculated as

$$\text{PA/SI installation DS} = (4 \text{ wells})(20 \text{ ft/well})(5 \text{ gal/ft}) = 400 \text{ gal} .$$

The following equation can be used to calculate all decontamination solutions resulting from soil sampling.

$$\text{Sampling DS} = (\text{No. of sampling events})(\text{volume per sampling event})(\text{No. of wells}) .$$

Therefore, the volume of decontamination solution generated by sampling during the PA/SI phase is

$$\text{PA/SI sampling } DS = (1 \text{ sampling events})(2 \text{ gal/sampling event})(4 \text{ wells}) = 32 \text{ gal} .$$

Estimate miscellaneous trash

Estimates for trash must be categorized into estimates for contaminated trash and estimates for sanitary trash. The criteria used for determining the volume of trash are listed in Sect. 2.4 of this report. Estimates for miscellaneous trash were calculated only for well installation. The volume of trash generated during sampling is not considered to be significant.

The equation for estimating the amount of contaminated trash *CT* is as follows:

$$CT = (3 \text{ ft}^3/\text{well})(\text{No. of wells}) .$$

Therefore, the estimate for contaminated trash generated during the PA/SI phase is

$$\text{PA/SI } CT = (3 \text{ ft}^3/\text{well})(4 \text{ wells}) = 12 \text{ ft}^3 .$$

Similarly, the equation for estimating the amount of sanitary trash *ST* is

$$ST = (1 \text{ ft}^3/\text{well})(\text{No. of wells}) .$$

Thus, the estimate for sanitary trash generated during the PA/SI phase is calculated as

$$\text{PA/SI } ST = (1 \text{ ft}^3/\text{well})(4 \text{ wells}) = 4 \text{ ft}^3 .$$

3.1.4.3 PA/SI Step 3—Estimate wastes generated during sampling of existing wells

As previously discussed, wastes generated during sampling of existing wells include purge water and decontamination solutions. Estimates for the sampling of the 3 existing wells can be made using the criteria outlined in Tables 2 and 3 and Sect. 2.4 of this report.

Estimate purge water

Prior to sampling of monitoring wells, all water is pumped (purged) from the well and collected for future disposal. The volume of this purge water *PW* can be calculated using the following equation.

$$PW = (\text{No. of sampling events})(\text{volume per sampling event})(\text{No. of wells}) .$$

Thus, the purge water generated during the PA/SI phase is calculated as

$$PA/SI PW = (4 \text{ sampling events})(50 \text{ gal/sampling event})(3 \text{ wells}) = 600 \text{ gal} .$$

Estimate decontamination solutions

Estimates for decontamination solutions are calculated using the criteria outlined in Sect. 2, information from the scenario description, and the methodology outlined in the logic diagram (Fig. 4). The following equation can be used to calculate all decontamination solutions *DS* resulting from groundwater sampling.

$$\text{Sampling } DS = (\text{No. of sampling events})(\text{volume per sampling event})(\text{No. of wells}) .$$

Using this equation, the estimated volume of decontamination solutions in the PA/SI phase is calculated as

$$PA/SI DS = (4 \text{ sampling events})(2 \text{ gal/sampling event})(3 \text{ wells}) = 24 \text{ gal} .$$

Thus, the estimates for the PA/SI phase are complete. Using the same scenario as outlined above, the estimator should now proceed with the estimates for RI Phases I and II.

3.1.4.4 RI Step 1—Follow the RI Phase I and II groundwater logic diagram

Using the information provided in the scenario, the existing RFI plan was used for the expanded PA/SI and, therefore, is no longer available for use in estimating waste for the RI phases. Thus, when the estimator follows the RI groundwater logic diagram (Fig. 5), the answer to, “RI/RFI plans available?” would be “No.” According to the logic diagram, the next determination to be made is whether existing wells are present at the site. The information provided in the scenario description indicated that three existing monitoring wells were at the site prior to the PA/SI. However, because four wells were installed during the PA/SI, there are now seven wells at the site. The estimator must now follow the methodology outlined in the logic diagram. The pathway followed for the RI phase of investigation has been highlighted on Fig. 7.

3.1.4.5 RI Step 2—Estimate waste generated during installation and sampling of new wells

Waste estimates can now be generated using the number of wells to be installed, the number of times the wells are to be sampled after installation (Sect. 3.1.3), and the appropriate criteria outlined in Tables 2 and 3 and Sect. 2.4.

Fig. 7. RI Phase I and II groundwater logic diagram (example).

Estimate RI Phase I and II soil cuttings

During well installation, soil cuttings are generated as a result of the advancement of the auger. These cuttings must be collected and disposed of properly. The following equation is based on the criteria in Table 1 and a well depth of 20 ft.

$$\text{Volume per well} = \pi \left(\frac{D}{2} \right)^2 h .$$

where D is the diameter of the borehole and h is the depth of the borehole. Using this equation, estimates for soil cuttings for RI Phases I and II can be calculated.

$$\text{Volume per well} = 3.14 \times \left(\frac{0.833 \text{ ft}}{2} \right)^2 \times 20 \text{ ft} = 10.91 \text{ ft}^3 .$$

Thus, for the PA/SI and RI Phases I and II, simply multiply the volume per well by the number of wells to be installed for each phase.

$$\text{RI Phase I soil cuttings} = (4 \text{ wells})(10.91 \text{ ft}^3/\text{well}) = 43.63 \text{ ft}^3 .$$

$$\text{RI Phase II soil cuttings} = (4 \text{ wells})(10.91 \text{ ft}^3/\text{well}) = 43.63 \text{ ft}^3 .$$

Lastly, the 40% swell factor must be incorporated into the waste estimates.

$$\text{RI Phase I soil volume} = (43.63 \text{ ft}^3)(1.4) = 61.08 \text{ ft}^3 .$$

$$\text{RI Phase II soil volume} = (43.63 \text{ ft}^3)(1.4) = 61.08 \text{ ft}^3 .$$

Estimate RI Phase I and II development water

The installation of a new well includes pumping a certain volume of water (development water) from the well and then allowing the well to recover prior to the initial sampling activities. Estimates of the volume of development water must be generated for all new wells. The following equation can be used to calculate the volume of development water DW .

$$DW = (\text{No. of new wells})(150 \text{ gal/well}) .$$

Therefore, the volume of development water for RI Phases I and II is calculated as

$$\text{RI Phase I } DW = (4 \text{ wells})(150 \text{ gal/well}) = 600 \text{ gal}$$

and

$$\text{RI Phase II } DW = (4 \text{ wells})(150 \text{ gal/well}) = 600 \text{ gal} .$$

Estimate RI Phase I and II purge water

Prior to sampling of monitoring wells, all water is pumped (purged) from the well and is collected for future disposal. The volume of this purge water *PW* can be calculated using the following equation.

$$PW = (\text{No. of sampling events})(\text{volume per sampling event})(\text{No. of wells})$$

Thus, the volume of purge water for RI Phases I and II is calculated as

$$\text{RI Phase I } PW = (4 \text{ sampling events})(50 \text{ gal/sampling event})(4 \text{ wells}) = 800 \text{ gal}$$

and

$$\text{RI Phase II } PW = (4 \text{ sampling events})(50 \text{ gal/sampling event})(4 \text{ wells}) = 800 \text{ gal} .$$

Estimate RI Phase I and II decontamination solutions

Estimates of the decontamination waste volumes generated during installation and sampling of wells must be separated into two categories. First, one must estimate for the decontamination solutions generated during well installation. Second, one must estimate for the decontamination solutions generated during sampling. These estimates differ because a greater volume of water is necessary to decontaminate drilling equipment. Estimates for decontamination solutions are calculated using the criteria outlined in Sect. 2.

For decontamination solutions *DS* generated during installation, the following equation is used.

$$\text{Installation } DS = (\text{No. of wells})(\text{No. of feet per well})(\text{volume per feet of well}) .$$

Thus, for RI Phases I and II, *DS* is calculated as

$$\text{RI Phase I } DS = (4 \text{ wells})(20 \text{ ft/well})(5 \text{ gal/ft}) = 400 \text{ gal}$$

and

$$\text{RI Phase II } DS = (4 \text{ wells})(20 \text{ ft/well})(5 \text{ gal/ft}) = 400 \text{ gal} .$$

The following equation can be used to calculate all decontamination solutions resulting from soil sampling.

$$\text{Sampling } DS = (\text{No. of sampling events})(\text{volume per sampling event})(\text{No. of wells}) .$$

Thus, decontamination solutions generated during sampling for RI Phases I and II are calculated as

$$\text{RI Phase I } DS = (4 \text{ sampling events})(2 \text{ gal/sampling event})(4 \text{ wells}) = 32 \text{ gal}$$

and

$$\text{RI Phase II } DS = (4 \text{ sampling events})(2 \text{ gal/sampling event})(4 \text{ wells}) = 32 \text{ gal} .$$

Estimate miscellaneous trash

Estimates for trash must be separated into estimates for contaminated trash and estimates for sanitary trash. The criteria used for determining the volume of trash are listed in Sect. 2.4 of this report. Estimates for miscellaneous trash were calculated only for well installation. The volume of trash generated during sampling is not considered to be significant.

To estimate the volume of contaminated trash CT , the following equation is used.

$$CT = (3 \text{ ft}^3/\text{well})(\text{No. of wells}) .$$

Thus, the estimates for contaminated trash generated during RI Phases I and II are

$$\text{RI Phase I } CT = (3 \text{ ft}^3/\text{well})(4 \text{ wells}) = 12 \text{ ft}^3$$

and

$$\text{RI Phase II } CT = (3 \text{ ft}^3/\text{well})(4 \text{ wells}) = 12 \text{ ft}^3 .$$

Similarly, the equation for estimating the volume of sanitary trash ST is as follows:

$$ST = (1 \text{ ft}^3/\text{well})(\text{No. of wells}) .$$

Thus, the estimates for sanitary trash generated during RI Phases I and II are

$$\text{RI Phase I } ST = (1 \text{ ft}^3/\text{well})(4 \text{ wells}) = 4 \text{ ft}^3$$

and

$$\text{RI Phase II } ST = (1 \text{ ft}^3/\text{well})(4 \text{ wells}) = 4 \text{ ft}^3 .$$

3.1.4.6 RI Step 3—Estimate wastes generated during sampling of existing wells

As previously discussed, wastes generated during sampling of existing wells include purge water and decontamination solutions. Estimates for the sampling of the existing wells can be made using the criteria outlined in Tables 2 and 3 and Sect. 2.4 of this report.

Estimate purge water

Prior to sampling of monitoring wells, all water is pumped (purged) from the well and is collected for future disposal. The volume of this purge water PW can be calculated using the following equation.

$$PW = (\text{No. of sampling events})(\text{volume per sampling event})(\text{No. of wells}) .$$

Using this equation, the volume of purge water for RI Phases I and II can be calculated.

$$\text{RI Phase I } PW = (4 \text{ sampling events})(50 \text{ gal/event})(7 \text{ wells}) = 1400 \text{ gal} .$$

$$\text{RI Phase II } PW = (4 \text{ sampling events})(50 \text{ gal/event})(11 \text{ wells}) = 2200 \text{ gal} .$$

Estimate decontamination solutions

Estimates for decontamination solutions are calculated using the criteria outlined in Sect. 2, information from the scenario description, and the methodology outlined in the logic diagram (Fig. 4). The following equation can be used to calculate all decontamination solutions DS resulting from groundwater sampling.

$$\text{Sampling } DS = (\text{No. of sampling events})(\text{volume per sampling event})(\text{No. of wells}) .$$

Using this equation, estimates of decontamination solutions generated from groundwater sampling during RI Phases I and II can be calculated.

$$\text{RI Phase I sampling } DS = (4 \text{ sampling events})(2 \text{ gal/sampling event})(7 \text{ wells}) = 56 \text{ gal} .$$

$$\text{RI Phase II sampling } DS = (4 \text{ sampling events})(2 \text{ gal/sampling event})(11 \text{ wells}) = 88 \text{ gal} .$$

4. RD/RA PHASE WASTES

The types of waste generated during the RD/RA Phase will typically include excavated soil/sludge, pretreatment residues, and groundwater. The following sections describe the methodology used to estimate volumes of these wastes.

4.1 SOLID WASTE/SOIL REMEDIATION

Estimates will be generated based on three scenarios: clean closure, dirty closure, and most probable scenario. A swell factor of 40% will be applied to all estimates (multiply volume by 1.4) to account for the soil being less compact after being augered and placed in drums.

4.1.1 Clean closure

For the purposes of this estimate, clean closure will be defined as the removal of the source of contamination. Unless definitive site-characterization data and cleanup criteria are available, it will be assumed that contamination has not migrated extensively beyond the boundaries of the source or contamination that has migrated extensively beyond the contaminant source can be remediated by a technology that produces minimal waste. Table 7 provides guidance for defining the area and depth of various hazardous sites if limited (or no) characterization data are available.

All excavation equipment such as backhoes and bulldozers must be decontaminated after each use. This is accomplished with a water solution that is collected (and considered to be waste) following decontamination.*

Miscellaneous trash associated with remediation operations must be containerized and can be disposed of as a sanitary waste if used only in the support zone or if sampling results indicate that it is clean. Plastic, wipes, tape, Tyvek clothing, and paper are examples of miscellaneous trash.†

4.1.2 Dirty closure

For the purposes of this estimate, dirty closure will be defined as containment of all waste and soil contamination at the site. Contamination at the site would be contained by layer(s) of capping material (synthetic membrane, clay, crushed rock, sand, topsoil, etc.), surface water diversion, and possibly grout walls or French drains. Construction of grout walls or French drains will require excavation of soil; it will be assumed that the excavated soil is "clean" and can be used at the site as fill.

*The waste volumes from this procedure are estimated using a ratio of 1 gal/250 ft³ of soil removed, with a minimum of 250 gal.

†The volume of these wastes are estimated based on a ratio of 1 ft³ of trash per 1000 ft³ of soil removed, with a minimum of 150 ft³. Assume only one-fourth (25%) of the trash is a sanitary waste and the remaining is contaminated with the same contaminants present at the site.

Table 7. Clean closure boundaries for various hazardous sites

Site types	Area	Depth
Burial ground/landfill	5 ft beyond trench boundary	Surface to bottom of the trench + 6 in. of soil
Pipelines	2 ft beyond pipeline on each side	Top of pipe down to 5 ft below pipe invert
Tanks/pits	5 ft beyond outer wall	Top of tank down to 5 ft below tank bottom
Ponds/impoundments	Area of pond bottom and banks	Sludge (if any) + 6 inches in depth
Streams	Area of stream bottom and banks	1 ft of sediment
Wetland/floodplain	20 year flood plain	1 ft of sediment
River/lake	Area of lake bottom	3 ft of sediment
Storage area/yards	5 ft beyond boundary	Pad (if any) + 6 in. of soil
Waste piles	5 ft beyond boundary	Waste + 6 in. of soil
Landfarm	5 ft beyond boundary	1 ft of soil

Note: Schematics to aid in the determination of the area to be circumscribed by the clean-closure boundaries are given in Appendix B.

Decontamination of earthmoving equipment will still be required under a dirty closure scenario. A minimum of 250 gal (based on wastewater generated by the decontamination of one piece of earthmoving equipment) is assumed for dirty closures that do not involve excavation but may involve earthmoving equipment.

Miscellaneous trash (as described in Sect. 4.1.1) will also be generated under a dirty-closure scenario and must be containerized. The volume of these wastes is estimated based on a ratio of 100 ft³ of trash per acre of site. Assume that only one-fourth (25%) of the trash is a sanitary waste and that the remaining is contaminated with the same contaminants present at the site.

4.1.3 Most Probable Scenario

The most probable scenario is defined as the scenario most likely to occur based on current information. Any of several remediation technologies (including the dirty and clean closure scenarios described above) or combinations thereof can be employed at the site. Table 8 is a partial list of some on-site remediation technologies that may be considered.

Table 8. On-site remediation technologies

General response	Specific technologies
Removal	Total excavation (clean closure) Limited (hot spot) excavation
Containment (dirty closure)	Single-layer or multilayer caps Surface-water diversion Grout curtain/slurry wall French drain
In situ treatment	Fixation/encapsulation Biological treatment Vitrification Soil venting
Pretreatment	Thermal treatment Compaction Soil washing/extraction

All remediation technologies have unique capabilities for producing waste which should be estimated on a site-specific basis. For example, when using a thermal treatment technology, the category of the waste being treated may change if volatile organic compounds are removed or destroyed; the volume of waste being treated may decrease if high-temperature treatments such as incineration are used; and secondary wastes such as scrubber contaminants from off-gas may be produced. Soil washing can also change the waste category of the "washed soil" and produce secondary wastes such as contaminated extraction fluid. Soil venting and biological treatment may produce excess soil cuttings from installing vent and groundwater wells. Treatment and pretreatment technologies may require treatability studies and pilot-scale studies to support design activities and will result in waste. Estimates prepared for removal or containment should use the criteria included under dirty and clean closure scenario sections. Decontamination and miscellaneous trash estimates should be included as applicable.

4.2 GROUNDWATER REMEDIATION

In most cases, groundwater treatment will be performed on an areawide/regional basis instead of a site-specific basis. Therefore, most of the estimates for groundwater will be completed on separate design/remediation forms. Assumptions should be documented for each individual site which include the disposition of the effluent (discharge to surface waters or to the aquifer via recharge).

Groundwater treatment usually results in the production of solids requiring disposal. Solid wastes may include neutralized solids, biological sludge, filtered solids (including filtering materials), carbon waste, and other miscellaneous materials. If the groundwater treatment technology is unknown, assume 0.1% of the volume of groundwater requiring treatment will be solid residue.

Appendix A

STANDARD FORMS FOR PREPARATION AND DOCUMENTATION OF ESTIMATES

PA/SI WASTE VOLUME ESTIMATE

DOE NUMBER: PLANT/SITE:

REFERENCE DOCUMENTS:

SITE DESCRIPTION:

SAMPLING STRATEGY:

SOLIDS SAMPLING

<u>No. of holes</u>	<u>Dia.</u>	<u>Depth</u>	<u>Type</u>	<u>Waste Volume/Category</u>	
				<u>Solid</u>	<u>Liquid</u>

WELL INSTALLATION

<u>No. of wells</u>	<u>Dia.</u>	<u>Depth</u>	<u>Type</u>	<u>Waste Volume/Category</u>	
				<u>Solid</u>	<u>Liquid</u>

SUMMARY:

<u>Category</u>	<u>Liquid</u>		<u>Solid</u>		
	<u>Gallons</u>	<u>Drum Eq.</u>	<u>Ft³</u>	<u>Drum Eq.</u>	<u>Box eq.</u>

GENERATION DATE (FISCAL YEAR):

RI/FS, PHASE I, WASTE VOLUME ESTIMATE

DOE NUMBER: PLANT/SITE:

REFERENCE DOCUMENTS:

SITE DESCRIPTION:

SAMPLING STRATEGY:

SOLIDS SAMPLING

<u>No. of holes</u>	<u>Dia.</u>	<u>Depth</u>	<u>Type</u>	<u>Waste Volume/Category</u>	
				<u>Solid</u>	<u>Liquid</u>

WELL INSTALLATION

<u>No. of wells</u>	<u>Dia.</u>	<u>Depth</u>	<u>Type</u>	<u>Waste Volume/Category</u>	
				<u>Solid</u>	<u>Liquid</u>

SUMMARY:

<u>Category</u>	<u>Liquid</u>		<u>Solid</u>		
	<u>Gallons</u>	<u>Drum Eq.</u>	<u>Ft³</u>	<u>Drum Eq.</u>	<u>Box eq.</u>

GENERATION DATE (FISCAL YEAR):

RI/FS, PHASE II, WASTE VOLUME ESTIMATE

DOE NUMBER: PLANT/SITE:

REFERENCE DOCUMENTS:

SITE DESCRIPTION:

SAMPLING STRATEGY:

SOLIDS SAMPLING

<u>No. of holes</u>	<u>Dia.</u>	<u>Depth</u>	<u>Type</u>	<u>Waste Volume/Category</u>	
				<u>Solid</u>	<u>Liquid</u>

WELL INSTALLATION

<u>No. of wells</u>	<u>Dia.</u>	<u>Depth</u>	<u>Type</u>	<u>Waste Volume/Category</u>	
				<u>Solid</u>	<u>Liquid</u>

SUMMARY:

<u>Category</u>	<u>Liquid</u>		<u>Solid</u>		
	<u>Gallons</u>	<u>Drum Eq.</u>	<u>Ft³</u>	<u>Drum Eq.</u>	<u>Box eq.</u>

GENERATION DATE (FISCAL YEAR):

Appendix B

SCHEMATICS FOR DETERMINING *AREA TO BE SAMPLED*

RD/RA WASTE VOLUME ESTIMATE

DOE NUMBER:

PLANT/SITE:

SITE DESCRIPTION:

REMEDIALATION ALTERNATIVES

	<u>Type</u>	<u>Waste Volume/Category</u>	
		<u>Solid</u>	<u>Liquid</u>
CLEAN CLOSURE:			

DIRTY CLOSURE:

MOST PROBABLE:

SUMMARY: VOLUME EQUIVALENTS (BOXES/DRUMS)

CategorySolidLiquid

Clean Closure

Dirty Closure

Most Probable

GENERATION DATE (FISCAL YEAR):

SITE TYPE: BURIAL GROUND/LANDFILL

PLAN

SECTION

SCHEMATIC OF CLEAN CLOSURE BOUNDARY FOR BURIAL GROUND/LANDFILL

SITE TYPE:PIPELINES

SCHEMATIC OF
CLEAN CLOSURE BOUNDARY
FOR PIPELINES

REFERENCE: TABLE 7
METHODOLOGY FOR GENERATING
WASTE VOLUME ESTIMATES

SITE TYPE: TANKS/PITS

SCHEMATIC OF CLEAN CLOSURE BOUNDARY FOR TANKS/PITS

REFERENCE: TABLE 7
METHODOLOGY FOR GENERATING
WASTE VOLUME ESTIMATES

SITE TYPE: PONDS/IMPOUNDMENTS

SCHEMATIC OF CLEAN CLOSURE BOUNDARY FOR PONDS/IMPOUNDMENTS

REFERENCE: TABLE 7
METHODOLOGY FOR
GENERATING
WASTE VOLUME ESTIMATES

SITE TYPE: STREAM

SCHEMATIC OF CLEAN CLOSURE BOUNDARY FOR STREAMS

REFERENCE: TABLE 7
METHODOLOGY FOR GENERATING
WASTE VOLUME ESTIMATES

SITE TYPE: RIVER/LAKE

SCHEMATIC OF
CLEAN CLOSURE BOUNDARY
FOR RIVER/LAKE

REFERENCE: TABLE 7
METHODOLOGY FOR GENERATING
WASTE VOLUME ESTIMATES

SITE TYPE: WETLAND/FLOODPLAIN

SCHEMATIC OF
CLEAN CLOSURE BOUNDARY
FOR WETLAND/FLOODPLAIN

REFERENCE: TABLE 7
METHODOLOGY FOR GENERATING
WASTE VOLUME ESTIMATES

SITE TYPE: STORAGE AREA/YARDS

PLAN

SECTION

SCHEMATIC OF CLEAN CLOSURE BOUNDARY FOR STORAGE AREA/YARDS

REFERENCE: TABLE 7
METHODOLOGY FOR
GENERATING
WASTE VOLUME ESTIMATES

SITE TYPE: WASTE PILES

SCHEMATIC OF CLEAN CLOSURE BOUNDARY FOR WASTE PILES

REFERENCE: TABLE 7
METHODOLOGY FOR GENERATING
WASTE VOLUME ESTIMATES

SITE TYPE: LANDFARM

SCHEMATIC OF CLEAN CLOSURE BOUNDARY FOR LANDFARM

REFERENCE: TABLE 7
METHODOLOGY FOR GENERATING
WASTE VOLUME ESTIMATES

DISTRIBUTION

1. J. K. Bailey
2. L. D. Bates
3. S. C. Bieniak
4. V. Brumback
5. C. Clark
6. K. W. Cook
7. D. G. Cope
8. T. K. Cothron
9. M. P. DeLozier
10. N. W. Durfee/L. V. Asplund
11. C. J. Ford
12. C. E. Frye
13. C. D. Goins
14. J. T. Grumski
15. D. B. Gunter
16. J. L. Haymore
17. K. G. Kahl
18. B. L. Kimmel
19. T. J. Newsom
20. D. R. Nutile
- 21-22. P. T. Owen
23. T. P. A. Perry
24. B. E. Phifer
25. G. E. Rymer
26. L. D. Schooler
27. R. H. Snyder
28. L. H. Stinton
29. D. W. Swindle
30. B. D. Walker
31. S. H. Welch
32. D. C. White
33. M. L. Whitehead
34. Central Research Library
- 35-39. ER Document Management Center
40. ORNL Laboratory Records
41. P. H. Edmonds, Radian Corporation, 120 South Jefferson Circle, Oak Ridge, TN 37830
- 42-45. W. E. Murphie, Department of Energy, Office of Environmental Restoration, Eastern Area D&D Branch, EM-423 (GTN), Washington, DC 20545
- 46-48. R. C. Sleeman, Department of Energy Field Office, Oak Ridge, P.O. Box 2001, Oak Ridge, TN 37831-8541
49. Science Applications International Corporation, 301 Laboratory Road, Oak Ridge, Tennessee 37831
- 50-51. Office of Scientific and Technical Information, P.O. Box 62, Oak Ridge, TN 37831

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