

ENVIRONMENTAL CALCULATION COVER PAGE

Section 1: Completed by the Responsible Manager

Project: 200-EA-1

Date: 09/13/2017

Calculation Title & Description: Pore Volume Calculation - 200-EA-1 OV Liquid Waste Disposal Sites

RELEASE / ISSUE

DATE:
Sep 20, 2017



Section 2: Completed by Preparer

Calculation No.: ECF-200EA1-17-0066

Revision No.: Rev 0

Revision History

Revision No.	Description	Date	Affected Pages	ADD ROW
				X

Section 3: Completed by the Responsible Manager

Document Control:

- Is the document intended to be controlled within the Document Management Control System (DMCS)? Yes No
- Does document contain scientific and technical information intended for public use? Yes No
- Does document contain controlled-use information Yes No

Section 4: Document Review & Approval

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APPLICABLE IF CALCULATION IS A RISK ASSESSMENT OR USES AN ENVIRONMENTAL MODEL		
n/a		
Risk/Modeling Integration Manager: (Name /Position)	Signature	Date
n/a		
Responsible Manager: (Name /Position)	Signature	Date

APPROVED
By Julia Raymer at 2:26 pm, Sep 20, 2017

Approved for Public Release;
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1 Purpose

The calculation purpose is to determine the pore volumes disposed to the 200-EA-1 Operable Unit (OU) liquid disposal waste sites identified in Table 2-2 of DOE/RL-2016-58, *200-EA-1 Operable Unit RCRA Facility Investigation/Corrective Measures Study/Remedial Investigation/Feasibility Study Work Plan (200-EA-1 OU RFI/CMS/RS/FS Work Plan)*. The pore volume calculation is one of several lines of evidence used to support the waste site initial evaluations. This calculation is a simplified, one-dimensional model that neglects lateral spreading and assumes that discharged liquid is distributed evenly across the waste site. The calculation is used to normalize the volume of liquid disposed and the surficial area over which liquids were disposed to provide a consistent basis to evaluate the relative depth of vadose zone contamination and the potential for groundwater impacts.

2 Background

The 200-EA-1 OU includes 68 liquid transfer, waste holding, and disposal sites (e.g., cribs, ditches, trenches, retention basins, French drains, reverse wells, septic systems, pipelines, valve pits, and depressions/pits). A total of 44 sites are associated with liquid waste disposal, including cribs, ditches, trenches, French drains, reverse wells, and septic systems. Insufficient site information was available for the calculations for 27 sites, specifically the minimum inputs required to calculate pore volumes, which includes the volume that is disposed and the geometry of the waste site bottom. Sufficient information was available to calculate pore volumes disposed at 41 of the 200-EA-1 OU liquid disposal waste sites.

3 Methodology

The following steps were used to determine the correlation between waste volume disposed and the depth of contaminated media at the waste site. Available characterization data were reviewed for each waste site using the individual scoping summaries in SGW-60540, *200-EA-1 Operable Unit Scoping*, and underlying reference documents. Computations were performed using Microsoft® Excel® spreadsheets.

1. Volume discharged: Identify volume of liquid waste disposed in each 200-EA-1 OU waste site and cite the source scoping summary or underlying reference documents. Convert all volumes to cubic feet for consistency.
2. Waste site bottom footprint: Identify waste site bottom footprint from individual scoping summaries and underlying reference documents.
3. Waste site adjusted footprint: Certain liquid disposal facilities are small diameter engineered features (e.g., reverse wells, French drains) with a small footprint at the base for discharge of liquids (less than 0.09 m² [1 ft²] to 1.77 m² [19 ft²]). These sites were assigned an adjusted footprint of 2.32 m² (25 ft²) to compensate for the improbably narrow soil column.
4. Waste site bottom depth: Identify bottom depth of each waste site from individual scoping summaries and underlying reference documents.
5. Depth to groundwater: Identify depth to groundwater from each waste site bottom, convert to feet, and subtract the depth to the bottom of the waste site (step 3) from the depth to water.
6. Calculate the soil column pore volume (ft³) = Waste site bottom footprint (or adjusted footprint; ft²) × Distance from bottom of waste unit to groundwater (ft) × 0.3.

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7. Calculate the pore volume(s) disposed to the each waste site rounded to the nearest 1/10th pore volume using the equation below.

$$\text{Calculated pore volume(s) disposed to waste site} = \frac{\text{Volume discharged (ft}^3\text{)}}{\text{Calculated soil column pore volume (ft}^3\text{)}}$$

4 Assumptions and Inputs

Assumptions:

1. Volume discharged: none
2. Waste site bottom footprint: For small footprint waste sites (e.g., French drains and reverse wells), a minimum footprint of 2.3 m² (25 ft²) was used to correct for the improbably narrow soil column
3. Waste site bottom depth: none
4. Depth to groundwater: none
5. Calculated soil column pore volume

Effective soil porosity: 30%, approximate, depth integrated effective porosity for 200-EA-1 OU sites based on DOE/RL-2011-50, *Regulatory Basis and Implementation of a Graded Approach to Evaluation of Groundwater Protection - Hydrostatigraphic Profile 216-A-x for Shallow Disposal Sites*. This equation does not account for potential lateral spreading and is therefore conservative with respect to vertical depth.

6. Calculated pore volume disposed to waste site: none

Inputs:

1. Volume discharged: Waste site liquid waste volume data are from Table 4-3 of DOE/RL-2009-127, *Remedial Investigation Report for the 200-BP-5 Groundwater Operable Unit*, and Table 4-3a of DOE/RL-2009-85, *Remedial Investigation Report for the 200-PO-1 Groundwater Operable Unit*, except where noted.

For volumes reported as gallons, multiply by 0.1337 gal/ft³. For volumes reported as liters, multiply by 0.03531 L/ft³.

2. Waste site bottom foot print: The larger of area data from SGW-60540 or adjusted footprint of 2.3 m² (25 ft²).
3. Waste site bottom depth: Depth data from SGW-60540

Depth to groundwater: Water level data from SGW-58828, *Water Table Maps for the Hanford Site 200 East Area, 2013 and 2014*, was selected to reduce the temporal variability in depth to water and to reduce the influence of pressure head on water level measurements from monitoring wells with variable perforated intervals. The depth to groundwater data is from SGW-58828 (Figure 3-1 and Table A-1) from the monitoring well nearest to the 200-EA-2 OU waste site. Convert the depth to water from meters to feet, multiplying by 3.281 ft/m.

4. Calculate the soil column pore volume: none.
5. Calculate the pore volume(s) Disposed to the each waste site: none.

5 Software Applications

Excel was used to document information and perform the calculations (Hanford Information System Inventory ID 1915). This software is an appropriate and applicable tool for these uses.

An Excel workbook was compiled using the methodology, assumptions, and inputs identified in Chapters 3 and 4 of this calculation. The workbook is presented in Appendix A.

6 Calculation

Below is a general description of the columns contained in the Excel workbook noted above. Each column records information gathered or executes a step of the methodology.

1. Volume discharged
 - a. Column A: Waste site identification (ID) – Identifies the individual waste site in the 200 EA-1 OU.
 - b. Column B: Site type – Identifies the waste site type.
 - c. Column C: Volume (L) – Contains the volume of waste discharged in liters to the waste site over the operating life of the waste site.
 - d. Column D: Volume (gal) – Contains the volume of waste discharge in gallons to the waste site over the operating life of the waste site.
 - e. Column E: Volume (ft³) – Contains the volume of liquid waste discharged in cubic feet to the waste site over the operating life of the waste site.
 - f. Column F: Volume source document – Identifies the source document for liquid waste volumes recorded in columns C or D.
2. Waste site bottom footprint
 - a. Column G: Waste site bottom footprint: (ft²) – Contains the available dimensions and area of the bottom of the waste site.
 - b. Column H: Adjusted footprint (ft²) – Contains the greater of the minimum footprint area of 25 ft² or the footprint area identified in column G.
 - c. Column I: Footprint source document – Identifies the source of footprint dimensions and area identified in column G.
3. Waste site bottom depth (Column J in ft below ground surface [bgs]) – Contains the bottom depth of the waste site below ground surface.
4. Distance from bottom of waste site to groundwater
 - a. Column K: Distance from bottom of waste site to groundwater (ft) – Contains the distance from the bottom of the waste unit identified in column J, subtracted from the depth to the groundwater table near the waste site identified in column L.
 - b. Column L: Depth to groundwater (ft, bgs) – Contains the depth in feet below ground surface to the groundwater table near the waste site.

- c. Column M: Groundwater monitoring well – Identifies the monitoring well used to measure the depth to groundwater in column L.
- 5. Calculated soil column pore volume (column N; in ft³) – Contains the pore volume within the column of soil beneath the waste site calculated by multiplying the greater of the waste site foot print bottom or the minimum adjusted footprint area of 25 ft² in column H times the distance from the bottom of the waste site to groundwater in column K times the assumed effective porosity of 30%.
- 6. Calculated pore volume(s) disposed to waste site (column O) – Contains the number of pore volumes discharged to the soil column beneath the waste site calculated by dividing the volume of liquid discharged in column E by the calculated soil column pore volume in column N.

7 Results/Conclusions

The following section contains the results of the calculation performed for each of the waste sites.

The liquid waste disposal sites at the 200-EA-1 OU were sorted into three categories of pore volumes disposed:

1. No Pore Volumes Disposed
2. Greater Than Zero to Less Than One-Half Pore Volumes Disposed
3. Greater Than One-Half Pore Volumes Disposed.

Evaluation of the nature and extent of contamination at 200-EA-1 OU waste sites uses several lines of evidence, including this calculation of pore volumes disposed to waste sites. The potential depth of vadose zone contamination for each 200-EA-1 OU waste site relative to pore volumes disposed are defined as follows:

- *Shallow Vadose Zone Contamination:* Sites that received little or no liquid disposed, where potential site contamination is only expected to reside above 4.6 m (15 ft) bgs (Table 1).
- *Partial-thickness Vadose Zone Contamination:* Sites that received greater than zero to less than one-half pore volumes of liquid disposed, where potential site contamination is expected to be present deeper than 4.6 m (15 ft) bgs but does not likely extend to the water table (Table 2).
- *Full-thickness Vadose Zone Contamination:* Sites that received greater than one-half pore volumes of liquid disposed, where potential site contamination is expected to be present deeper than 4.6 m (15 ft) bgs with possible groundwater impacts (Table 3).

The tables list the calculation results for 200-EA-1 waste sites and the potential relative depth of vadose zone contamination. All results and conclusions are intended for use in the context of additional remedial investigation/feasibility study/*Resource Conservation and Recovery Act of 1976* facility investigation/corrective measures study work planning for the 200-EA-1 OU.

Table 1. Waste Sites with No Pore Volumes Disposed – Shallow Vadose Zone Contamination

Waste Site ID	Calculated Pore Volumes Disposed
216-A-18	0.0
216-A-38-1	0.0
216-A-41	0.0

Table 1. Waste Sites with No Pore Volumes Disposed – Shallow Vadose Zone Contamination

Waste Site ID	Calculated Pore Volumes Disposed
216-B-51	0.0
216-B-59	0.0

Table 2. Waste Sites with Greater than Zero to Less than One-Half Pore Volumes Disposed – Partial-Thickness Vadose Zone Contamination

Waste Site ID	Calculated Pore Volumes Disposed
200-E-4	0.3
216-A-1	0.1
216-A-36A	0.4
216-B-10B	0.1
216-C-4	0.4
216-C-5	0.1
216-C-7	0.1

Table 3. Waste Sites with Greater than One-Half Calculated Pore Volumes Disposed – Full-Thickness Vadose Zone Contamination

Waste Site ID	Calculated Pore Volumes Disposed
200-E PD	143.2
200-E-100	3.6
200-E-25	1.2
200-E-99	2.9
216-A-10	109.5
216-A-19	0.9
216-A-20	0.8
216-A-27	4.5
216-A-29	5,819.4
216-A-3	3.0
216-A-30	240.1
216-A-36B	22.6
216-A-37-1	23.0
216-A-37-2	34.9
216-A-45	2.3

Table 3. Waste Sites with Greater than One-Half Calculated Pore Volumes Disposed – Full-Thickness Vadose Zone Contamination

Waste Site ID	Calculated Pore Volumes Disposed
216-A-6	137.4
216-A-9	49.9
216-B-10A	26.7
216-B-12	77.7
216-B-2-1	1,361.6
216-B-2-2	2.3
216-B-55	68.8
216-B-62	23.7
216-B-63	317.9
216-C-1	53.7
216-C-10	2.3
216-C-2	58.9
216-C-3	4.2
216-C-6	1.1

8 References

- DOE/RL-2009-85, 2012, *Remedial Investigation Report for the 200-PO-1 Groundwater Operable Unit*, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: <http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0091415>.
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- SGW-58828, 2015, *Water Table Maps for the Hanford Site 200 East Area, 2013 and 2014*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: <http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0079727H>.
- SGW-60540, pending, *200-EA-1 Operable Unit Scoping*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington.

Appendix A

200-EA-1 Waste Site Pore Volume Calculation

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A1 Introduction

A Microsoft® Excel® workbook (Table A-1) was compiled using the methodology, assumptions, and inputs identified in Chapters 3 and 4 of the main text.

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Table A-1. 200-EA-1 OU Waste Site Pore Volume Calculation

Waste Site ID	Site Type	Volume Discharged			Volume Source Document	Waste Site Bottom Footprint (ft ²)	Adjusted Footprint (ft ²) ^a	Footprint Source Document	Waste Site Bottom Depth (ft, bgs)	Distance from Bottom of Waste Site to Groundwater (ft) ^b	Depth to Groundwater ^c (ft, bgs)	Groundwater Monitoring Well	Calculated Soil Column Pore Volume (ft ³)	Calculated Pore Volume(s) Disposed to Waste Site
		Volume (L)	Volume (gal)	Volume (ft ³)										
200-E PD	Ditch	--	3.48E+09	4.65E+08	97-EAP-683	38420	38,420	Scoping summary	9.8	282	292	299-E24-25	3,249,536	143.2
200-E-100	French drain	2.37E+05	--	8.37E+03	DOE/RL-2009-127, Draft A	2	25	Scoping summary	1.0	309	310	299-E28-17	2,315	3.6
200-E-25	French drain	7.39E+04	--	2.61E+03	DOE/RL-2009-127, Draft A	2 × 2 ft (6.3 ft ²)	25	Scoping summary	20.0	290	310	299-E28-17	2,173	1.2
200-E-99	French drain	1.92E+05	--	6.78E+03	DOE/RL-2009-127, Draft A	2 ft dia (3.1 ft ²)	25	Scoping summary	1.0	309	310	299-E28-17	2,315	2.9
216-A-10	Crib	3.16E+09	--	1.12E+08	DOE/RL-2009-85, Rev. 1	275 × 45 ft (12,375 ft ²)	12,375	Scoping summary	45.0	275	320	299-E24-16	1,019,339	109.5
216-A-19	Trench	1.10E+06	2.91E+05	3.88E+04	Scoping summary	25 × 25 ft (625 ft ²)	625	Scoping summary	15.0	235	250	299-E26-4	44,065	0.9
216-A-20	Trench	9.61E+05	2.54E+05	3.39E+04	Scoping summary	25 × 25 ft (625 ft ²)	625	Scoping summary	15.0	235	250	299-E26-4	44,065	0.8
216-A-27	Crib	2.32E+07	--	8.19E+05	DOE/RL-2009-85, Rev. 1	200 × 10 ft (2,000 ft ²)	2,000	Scoping summary	14.0	306	320	299-E24-16	183,342	4.5
216-A-29	Ditch	2.96E+11	--	1.05E+10	DOE/RL-2008-53, Rev. 0	4,000 × 6 ft (24,000 ft ²)	24,000	Scoping summary	15.0	249	264	299-E25-34	1,796,030	5,819.4
216-A-3	Crib	3.05E+06	--	1.08E+05	DOE/RL-2009-85, Rev. 1	20 × 20 ft (400 ft ²)	400	Scoping summary	15.0	300	315	299-E24-21	36,036	3.0
216-A-30	Crib	7.64E+09	--	2.70E+08	DOE/RL-2009-85, Rev. 1	1,400 × 10 ft (14,000 ft ²)	14,000	Scoping summary	12.0	268	280	299-E25-19	1,123,673	240.1
216-A-36B	Crib	3.15E+08	--	1.11E+07	DOE/RL-2009-85, Rev. 1	500 × 11 ft (5,500 ft ²)	5,500	Scoping summary	24.0	298	322	299-E17-18	491,479	22.6
216-A-37-1	Crib	3.68E+08	--	1.30E+07	DOE/RL-2009-85, Rev. 1	700 × 10 ft (7,000 ft ²)	7,000	Scoping summary	11.0	269	280	299-E25-19	563,937	23.0
216-A-37-2	Crib	1.10E+09	--	3.88E+07	DOE/RL-2009-85, Rev. 1	1,400 × 10 ft (14,000 ft ²)	14,000	Scoping summary	16.0	265	281	299-E25-24	1,113,763	34.9
216-A-45	Crib	1.03E+08	--	3.64E+06	DOE/RL-2009-85, Rev. 1	310 × 60 ft (18,600 ft ²)	18,600	Scoping summary	44.5	280	324	299-E17-22	1,562,349	2.3
216-A-6	Crib	3.36E+09	--	1.19E+08	DOE/RL-2009-85, Rev. 1	100 × 100 ft (10,000 ft ²)	10,000	Scoping summary	21.0	288	309	299-E25-36	863,226	137.4
216-A-9	Crib	9.81E+08	--	3.46E+07	DOE/RL-2009-85, Rev. 1	420 × 20 ft (8,400 ft ²)	8,400	Scoping summary	13.0	275	288	299-E24-22	694,008	49.9
216-B-10A	Crib	9.98E+06	--	3.52E+05	DOE/RL-2009-127, Draft A	12 × 12 ft (144 ft ²)	144	Scoping summary	4.0	306	310	299-E28-17	13,207	26.7
216-B-12	Crib	1.43E+09	--	5.05E+07	DOE/RL-2009-127, Draft A	161 × 51 ft (8,211 ft ²)	8,211	Scoping summary	30.0	264	294	299-E28-18	649,448	77.7

Table A-1. 200-EA-1 OU Waste Site Pore Volume Calculation

Waste Site ID	Site Type	Volume Discharged			Volume Source Document	Waste Site Bottom Footprint (ft ²)	Adjusted Footprint (ft ²) ^a	Footprint Source Document	Waste Site Bottom Depth (ft, bgs)	Distance from Bottom of Waste Site to Groundwater (ft) ^b	Depth to Groundwater ^c (ft, bgs)	Groundwater Monitoring Well	Calculated Soil Column Pore Volume (ft ³)	Calculated Pore Volume(s) Disposed to Waste Site
		Volume (L)	Volume (gal)	Volume (ft ³)										
216-B-2-1	Ditch	1.49E+11	--	5.26E+09	Scoping summary	3,500 × 15 ft (52,500 ft ²)	52,500	Scoping summary	6.0	245	251	299-E27-18	3,863,862	1,361.6
216-B-2-2	Ditch	4.97E+07	--	1.75E+06	DOE/RL-92-19, Rev. 0	3,500 × 3 ft (10,500 ft ²)	10,500	Scoping summary	8.0	243	251	299-E27-18	766,472	2.3
216-B-55	Crib	1.23E+09	--	4.34E+07	DOE/RL-2009-127, Draft A	750 × 10 ft (7,500 ft ²)	7,500	Scoping summary	13.0	281	294	299-E28-18	631,461	68.8
216-B-62	Crib	2.80E+08	--	9.89E+06	DOE/RL-2009-127, Draft A	500 × 10 ft (5,000 ft ²)	5,000	Scoping summary	15.0	279	294	299-E28-18	417,974	23.7
216-B-63	Ditch	7.98E+09	--	2.82E+08	DOE/RL-2009-127, Draft A	1,600 × 8 ft (12,800 ft ²)	12,800	Scoping summary	10.0	231	241	299-E34-10	886,370	317.9
216-C-1	Crib	2.34E+07	--	8.26E+05	DOE/RL-2009-127, Draft A	23 × 8 ft (184 ft ²)	184	Scoping summary	13.0	279	292	299-E24-25	15,383	53.7
216-C-10	Crib	8.97E+05	--	3.17E+04	DOE/RL-2009-127, Draft A	32.5 × 5 ft (162.5 ft ²)	162.5	Scoping summary	7.0	285	292	299-E24-25	13,878	2.3
216-C-2	Injection/Reverse well	3.15E+06	--	1.11E+05	DOE/RL-2009-127, Draft A	12 in. dia (0.79 ft ²)	25	Scoping summary	40.0	252	292	299-E24-25	1,888	58.9
216-C-3	Crib	5.00E+06	--	1.77E+05	DOE/RL-2009-127, Draft A	50 × 10 ft (500 ft ²)	500	Scoping summary	10.0	282	292	299-E24-25	42,252	4.2
216-C-6	Crib	5.31E+05	--	1.87E+04	DOE/RL-2009-127, Draft A	10 × 20 ft (200 ft ²)	200	Scoping summary	16.0	276	292	299-E24-25	16,541	1.1

Note: Complete reference citations are provided in Chapter A2.

a. Adjusted footprint value of 25 ft² used for reverse well and French drains to compensate for narrow soil column.

b. Depth to water selected from well-located nearest to waste site based on SGW-58828, *Water Table Maps for the Hanford Site 200 East Area, 2013 and 2014*, Figure 3-1 and Table A-1.

c. Depth to water in feet = M × 3.281

A2 References

- 97-EAP-683, 1997, "Proposed Reduction/Elimination of Effluent to the 284 East Trench" (letter to D.S. Dougherty, Washington State Department of Ecology, from J.E. Rasmussen), U.S. Department of Energy, Richland Operations Office, Richland, Washington, September 25.
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