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WHC-EP-0367

Liquid Effluent Study Final Project Report

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Prepared for the U.S. Department of Energy
Office of Environmental Restoration and
Waste Management

Westinghouse
Hanford Company Richland, Washington

Hanford Operations and Engineering Contractor for the
U.S. Department of Energy under Contract DE-AC06-87RL10930

Approved for Public Release

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Environmental Division

Date Published
August 1990

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Office of Environmental Restoration and
Waste Management

Westinghouse Hanford Company
P.O. Box 1970
Richland, Washington 99352

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1.0 INTRODUCTION

1.1 PROJECT SCOPE

In response to public comments received on the Hanford Federal Facility Agreement and Consent Order (Agreement) (Ecology et al. 1989), and at the request of the Washington Department of Ecology (Ecology) and the U.S. Environmental Protection Agency (EPA), the U.S. Department of Energy (DOE) conducted a study to document the discharge history and characteristics of liquid discharges at the Hanford Site. The original commitment to undertake the study was documented in a letter from DOE, Richland Operations Office (DOE-RL), dated May 13, 1989, to EPA and Ecology (Exhibit 1, Appendix A). The study was scheduled to be completed in a 14-month time period.

The study addressed the 33 liquid effluent streams identified in the Annual Status Report of the Plan and Schedule to Discontinue Disposal of Contaminated Liquid into the Soil Column at the Hanford Site (Stordeur 1988) and the 27 receiving sites associated with the 33 effluent streams. A listing of the 33 effluent streams and associated 27 receiving sites is provided in Table 1-1. Locations of the 27 receiving sites are shown in the site map given in Figure 1-1.

The purpose of the study was to: (1) provide a detailed characterization of each of the Hanford Site's 33 liquid effluents, (2) sample and analyze the effluents and propose wastestream designations for each pursuant to WAC 173-303, (3) sample and analyze the vicinity groundwater and assess groundwater contamination in area wells, and (4) evaluate the potential for contaminant migration within receiving site soils (flow and transport analyses). The study thus provides a means to assess the incremental impacts on the environment of continued liquid effluent discharges at each of the receiving sites. The results of this project will be used to determine the need for additional waste stream analysis and/or to negotiate additional Agreement milestones pertaining to the effluent discharges.

1.2 PROJECT BACKGROUND

As a result of the DOE-RL letter issued in May 1989 (Exhibit 1, Appendix A), DOE-RL, through its operating contractor Westinghouse Hanford Company (Westinghouse Hanford), provided in June 1989 a study implementation plan, the Liquid Effluent Study Project Plan (WHC 1990c). The project plan described all activities to be accomplished during the characterization and assessment effort, outlined the plan for execution of the study activities, and identified interim schedule milestones. The study consisted of four major activities: compilation of existing data on the 33 liquid effluents and the associated receiving sites and groundwater; collection of additional, detailed effluent sampling data and submittal of proposed wastestream designations; additional, site-specific analyses of groundwater in the vicinity of the receiving sites; and flow and transport analyses of the soil column at receiving sites. The results of these efforts are reported in various documents; a pictorial description of the project document and information hierarchy is given in Figure 1-2.

Table 1-1. Listing of Liquid Waste Receiving Sites and Associated Effluent Streams (page 1 of 2)

Receiving Site	Associated Stream(s)
1. 100-D Ponds	183-D Filter Backwash Wastewater
2. 1324N/NA Pond	163N Demineralization Plant Wastewater
3. 1325N Crib	N Reactor Effluent
4. 216-A-8 Crib	241-AY/AZ Tank Farm Steam Condensate
5. 216-A-29 Ditch	PUREX Plant Chemical Sewer
6. 216-A-30 Crib	PUREX Plant Steam Condensate
7. 216-A-36B Crib	PUREX Plant Ammonia Scrubber Condensate
8. 216-A-37-1 Crib	242-A Evaporator Process Condensate
9. 216-A-37-2 Crib	PUREX Plant Steam Condensate
10. 216-A-45 Crib	PUREX Plant Process Condensate
11. 216-B-3 Pond System	PUREX Plant Chemical Sewer PUREX Plant Cooling Water 242-A Evaporator Cooling Water B Plant Cooling Water 241-A Tank Farm Cooling Water 284-E Powerplant Wastewater 244-AR Vault Cooling Water 242-A Evaporator Steam Condensate
12. 216-B-55 Crib	B Plant Steam Condensate
13. 216-B-62 Crib	B Plant Process Condensate
14. 216-B-63 Ditch	B Plant Chemical Sewer
15. 216-C-7 Crib	209-E Laboratory Reflector Water
16. 216-S-10 Ditch	S Plant Wastewater
17. 216-S-26 Crib	222-S Laboratory Wastewater
18. 216-T-1 Ditch	T Plant Laboratory Wastewater
19. 216-T-4-2 Ditch	T Plant Wastewater

Table 1-1. Listing of Liquid Waste Receiving Sites and Associated Effluent Streams (page 2 of 2)

Receiving Site	Associated Stream(s)
20. 216-U-14 Ditch	UO_3/U Plant Wastewater 242-S Evaporator Steam Condensate
21. 216-U-17 Crib	UO_3 Plant Process Condensate
22. 216-W-LC Crib	2724-W Laundry Wastewater
23. 216-Z-20 Crib	Plutonium Finishing Plant Wastewater
24. 200-W Powerhouse Pond	284-W Powerplant Wastewater
25. 2101-M Pond	2101-M Laboratory Wastewater
26. 300 Area Process Trenches	300 Area Process Wastewater
27. 400 Area Ponds	400 Area Secondary Cooling Water

The project plan was submitted to EPA and Ecology for review and, as a result of their comments, underwent two revisions; the final revision (Revision 2) was provided in March 1990. On April 9, 1990, the project plan was approved by EPA and Ecology, but that approval was made conditional upon satisfying six specific concerns (Exhibit 2, Appendix A). The six concerns focused on the level-of-detail and submittal schedule for the bimonthly study progress reports, the progress and reporting of the effluent sampling effort for active streams, requirements concerning future sampling and analysis of all streams which did not discharge to the soil column during the study period, and presentation of the flow and transport conceptual model to Ecology and EPA. These six concerns were satisfactorily addressed by DOE-RL in transmittals to Ecology and EPA on May 4 (Exhibit 3, Appendix A) and May 10 (Exhibit 4, Appendix A) 1990. The project plan (WHC 1990c) was issued in August 1990.

The first major submittal specified in the project plan was the Waste Stream Characterization Report (WHC 1989a), issued as four volumes in August 1989. The report compiled existing data and provided:

- o a description of each of the 33 waste streams
  - discharge history, including incidents and routine discharges
  - physical, chemical, and radiological nature of discharges
  - evaluation of effluent characterization data available at that time
  - list of potential contaminants based on process knowledge of effluents
  - effluent sample locations
  - proposed sampling schedules
  - listing of proposed analytical parameters and procedures.

- o a description of each of the 27 receiving sites
  - evaluation of available vadose zone soil column data
  - evaluation of relevant groundwater monitoring well data
  - groundwater well sample locations
  - proposed sampling schedules
  - listing of proposed analytical parameters and procedures.

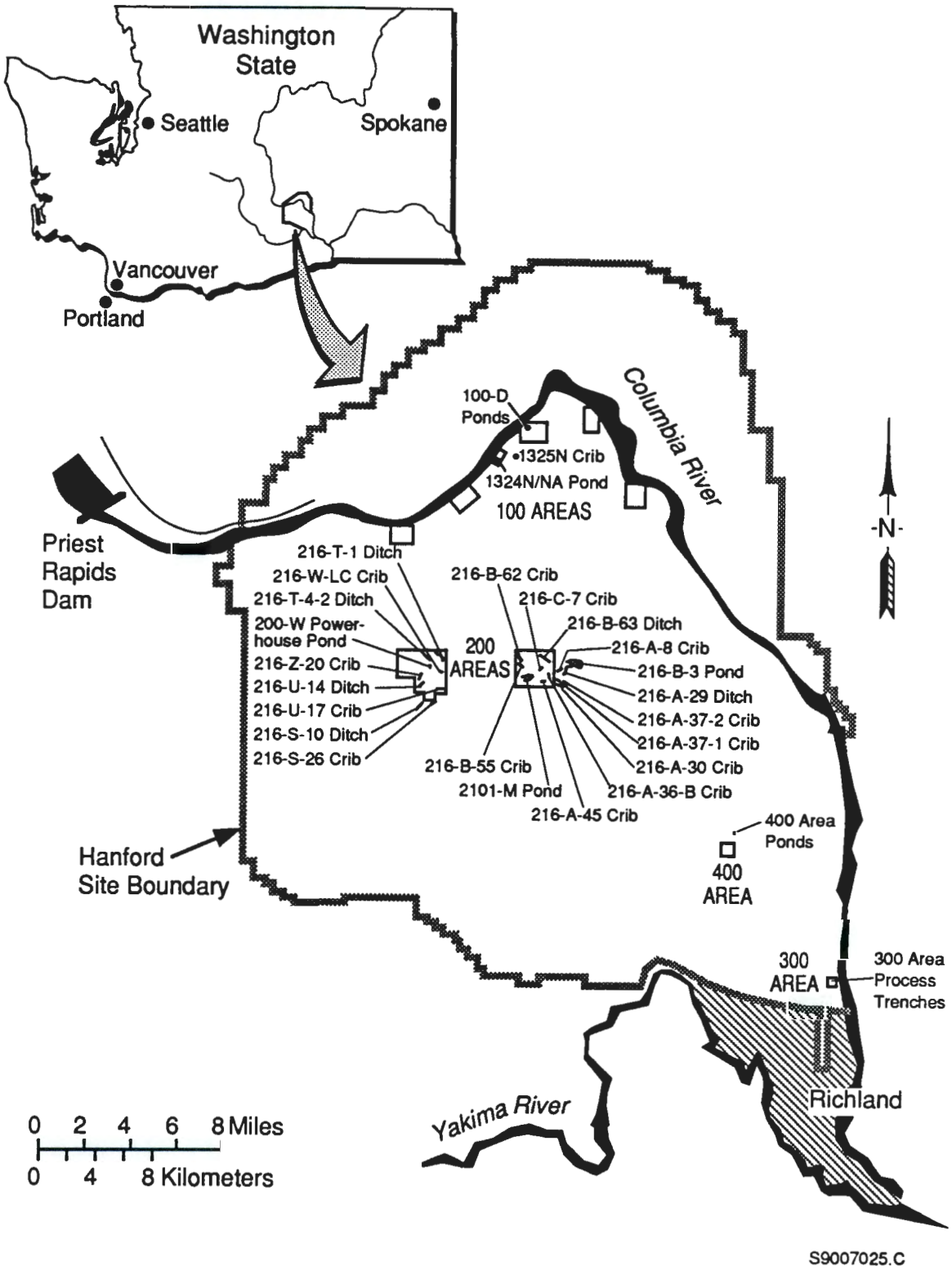
On May 22, 1990, DOE transmitted, in draft form for regulatory review, the Hanford Site Preliminary Stream-Specific Reports (WHC 1990a). This set of reports consisted of an overview document and 33 addenda, each addendum corresponding to one of the 33 effluent streams. The overview document explained the general approach used in the characterization and designation of the waste streams. Each stream-specific report addendum was written as a stand-alone document for the specific effluent stream. The addenda provided detailed descriptions and evaluations of process knowledge and sample analytical data collected prior to October 1989 for development and justification of a waste stream designation, in accordance with the Washington Administrative Code (WAC) 173-303, Dangerous Waste Regulations (Ecology 1989). A companion document, Wastestream Designation of Liquid Effluent Analytical Data (Jungfleisch 1990), was issued with the stream-specific reports. Jungfleisch (1990) described methods for analytical data evaluation to support the wastestream characterization and designation.

Additional liquid effluent sampling data were collected specifically for the study during the period from October 1989 through March 1990. These "new" data were submitted in a separate document, entitled Liquid Effluent Study Characterization Data (WHC 1990b), on May 23, 1990. New data are available for 24 of the 33 effluents. The following nine wastestreams were not sampled during the time period of this study:

- o PUREX Ammonia Scrubber Condensate
- o B Plant Process Condensate
- o B Plant Steam Condensate
- o UO_3 Plant Process Condensate
- o 241-AY/AZ Tank Farm Steam Condensate
- o 242-A Evaporator Process Condensate
- o 242-A Evaporator Cooling Water
- o 209-E Laboratory Reflector Water
- o 2101-M Laboratory Wastewater.

For these effluents, only "old" data (data collected before October 1989) is available. Revision and finalization of the preliminary stream-specific reports entailed incorporating the additional effluent sampling data into the respective addenda and addressing review comments received from EPA and Ecology. While each stream-specific report includes both old and new data, only new data are used in the 24 applicable reports for designation purposes and other evaluations. Old data are used for the latter applications in the nine cases for which new data are not available.

Figure 1-1. Receiving Sites Location Map.



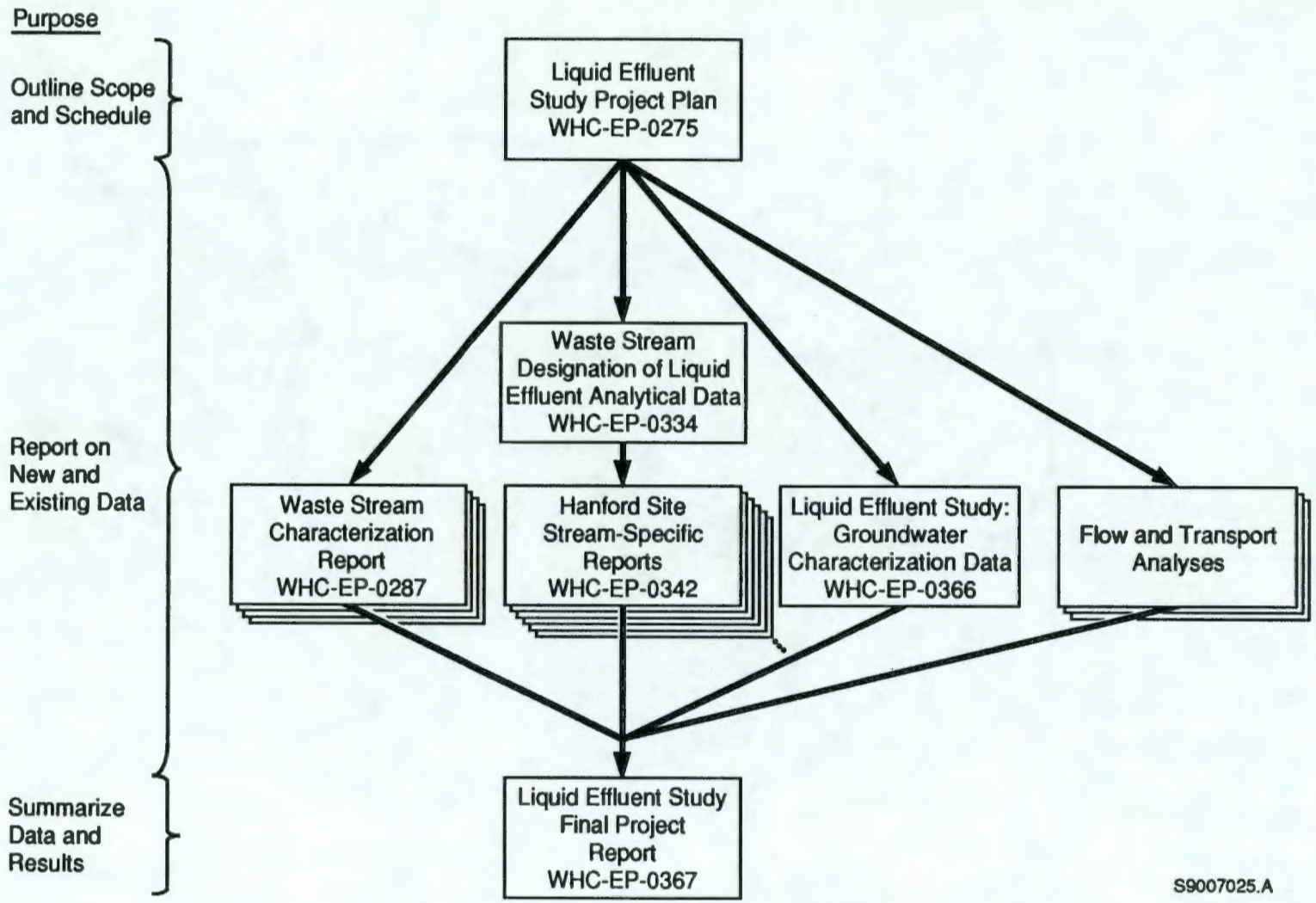


Figure 1-2. Liquid Effluent Study Information Hierarchy.

In addition to the information documented in the Waste Stream Characterization Report (WHC 1989a), DOE, through Westinghouse Hanford, has been collecting and evaluating data to assess the 27 receiving sites. Efforts included obtaining additional groundwater characterization data and performing vadose zone flow and transport analyses of the receiving sites. A summary of this newly generated information has been combined with information extracted from the previously issued reports to produce this final report.

Groundwater data collected and/or evaluated for this study are summarized on a site-by-site basis in a supporting document entitled Liquid Effluent Study: Groundwater Characterization Data (WHC 1990d). Detailed well-by-well analytical sampling results are available through access to the Hanford Groundwater Database. A hard copy output of the database is accessible through the Hanford Site Administrative Record system.

Analyses of vadose zone flow and transport characteristics for the 27 receiving sites were performed to assess the impact, with regard to contaminant migration, of past and continued effluent discharges on the vadose zone and groundwater systems underlying the receiving sites. These preliminary assessments consider a one-dimensional flow and transport analysis of vertical travel time from the receiving site to the groundwater.

In conjunction with the one-dimensional analyses, more detailed, two- and three-dimensional flow and transport analyses were also performed at three locations to more rigorously assess and quantify the potential for migration of contaminants through the vadose zone soil column and into the groundwater system. The three locations are: (1) 1325N Crib, (2) 216-U-17 Crib, and (3) 216-A-30/A-37-1/A-37-2 Cribs. Ecology and EPA were apprised of the selection of these three sites in a letter dated May 11, 1990 from DOE-RL (Exhibit 5, Appendix A).

1.3 DECISION TREE ANALYSIS

A decision tree to be used in evaluating each of the receiving sites and its corresponding effluent stream(s) is discussed in the Liquid Effluent Study Project Plan (WHC 1990c). The decision tree diagram, taken from the project plan, is repeated in Figure 1-3. The data and results presented in this final report are organized around the elements of the decision tree. Conclusions on the impacts identified in the decision tree elements are discussed in Chapter 2 for each receiving site and are summarized in Chapter 3. The logic of the decision tree is summarized as follows.

Information obtained through waste stream characterization and the proposed wastestream designations (pursuant to WAC 173-303 [Ecology 1989]) (elements 2 and 3 of Figure 1-3) is used to categorize the effluent as either <u>dangerous</u> (element 4), <u>nondangerous/radioactive</u> (element 5), or <u>nondangerous/ nonradioactive</u> (element 6). For the purposes of decision tree analysis, radioactive is defined as exceeding the concentration standards for radionuclides in the Westinghouse Hanford Company Environmental Compliance Manual, Part N, "Groundwater Protection" (WHC 1989b). An effluent is radioactive if concentrations of radionuclides exceed maximum contaminant levels for drinking water.

If the present stream is categorized as dangerous per WAC 173-303 (Ecology 1989), no further evaluation is required as part of the liquid effluent study.

If the effluent stream is categorized as nondangerous/radioactive, the scheduled date for termination of discharge is considered. If termination of the waste stream discharge (element 7) is expected by January 1992, the project plan (WHC 1990c) does not require further evaluation. However, if the scheduled termination date is postponed beyond January 1992, the project plan indicates that further evaluation of the stream may be warranted at a later date.

If the effluent stream is not scheduled for termination, a series of questions needs to be answered using additional information from receiving site characterization (element 1) to assess the impact of the effluent on groundwater quality and flow patterns (element 8).

Even if the effluent does not directly contribute contaminants to the groundwater, the impact of its volume on the receiving site needs to be assessed (element 12). For example, movement of fluids through the vadose zone may mobilize contaminants, potentially impacting groundwater quality. Discharges of liquid effluent may influence the local hydraulic gradient, affecting movement of existing groundwater plumes. For this study, an effluent discharge rate greater than the estimated natural recharge rate (approximately 1 ft^3/sec; Graham 1981) to the unconfined aquifer beneath the 200 Areas plateau from Cold Creek is considered significant (WHC 1990c).

If the effluent directly contributes contaminants to the groundwater, additional questions need to be addressed regarding the concentration levels, sources of the contaminants, and impacts of the contaminants. The concentration of a chemical contaminant is compared to the applicable drinking water standard (maximum contaminant level [MCL]) and to the respective detection limit (element 9). The concentration of a radioactive contaminant is compared to the applicable derived concentration guide (DCG) as outlined in the Westinghouse Hanford Company Environmental Compliance Manual, Part N, "Groundwater Protection" (WHC 1989b).

Identifying the source of the contamination detected in the groundwater is needed to determine whether the contaminants resulted from discharge of the waste stream to the receiving site in question or, for example, from an upgradient groundwater plume intersecting the site (element 10). A wastestream contaminant will be judged as having a significant impact if it is present in the groundwater at a concentration above the drinking water standard (element 11).

Although wastestreams which are designated as dangerous wastes or are scheduled to terminate by January 1992 do not require further evaluation as part of the liquid effluent study, such streams are assessed in Chapter 2 for completeness and for use as a reference point.

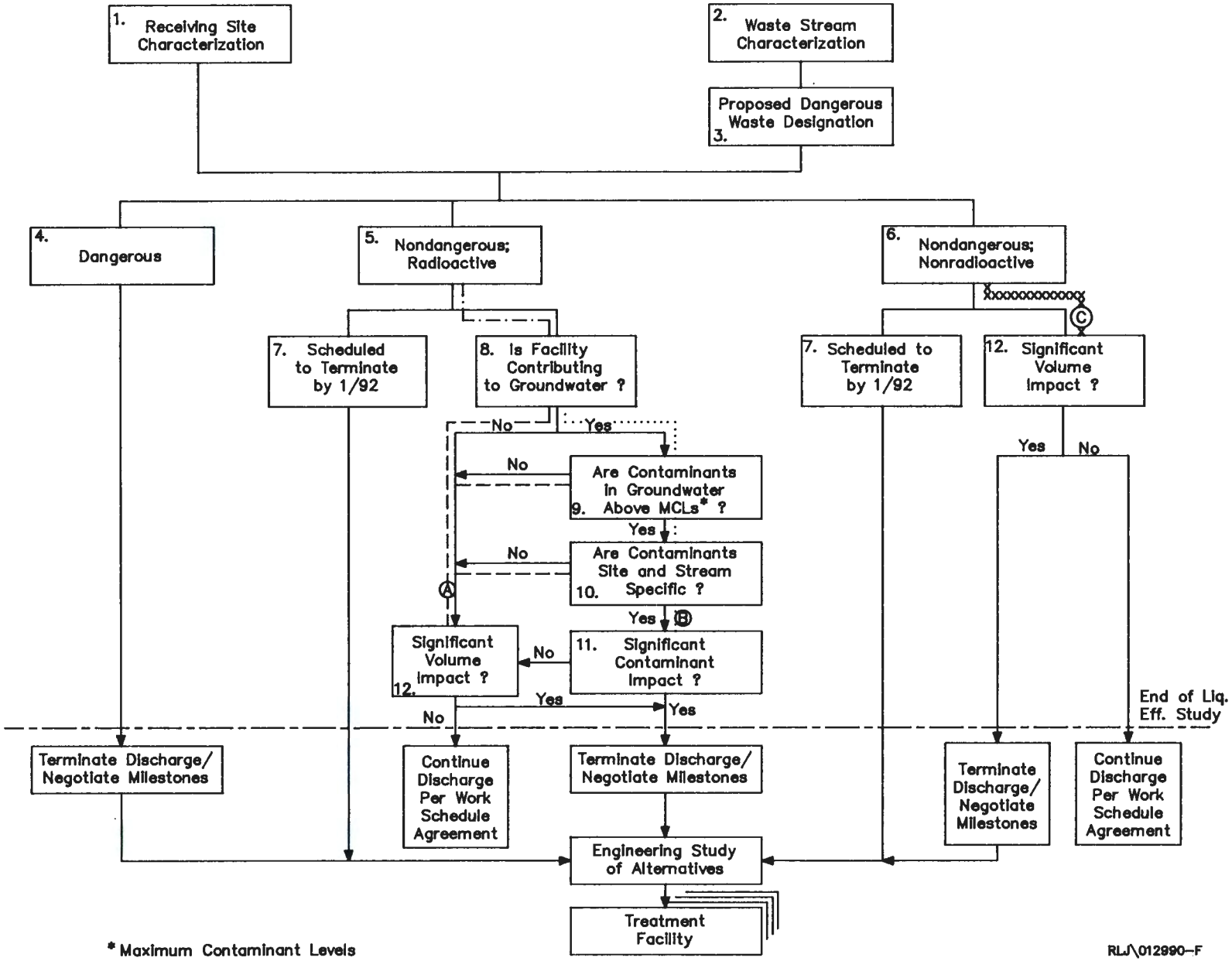


Figure 1-3. Decision Tree.

If the effluent stream is categorized as nondangerous/nonradioactive, considerations only need to be given to whether the stream is scheduled for termination (by January 1992) or whether the effluent would pose a significant volume impact on the receiving site (element 12).

Note that in the decision tree diagram, the liquid effluent study only carries through the information and evaluations described by elements 1 through 12. Further recommendations and decisions beyond the liquid effluent study (shown below the dotted line on Figure 1-3) are outside the scope of this report and will be the subject of additional assessments and regulatory agency negotiations.

1.4 SCOPE AND PURPOSE OF FINAL PROJECT REPORT

In keeping with the project plan for the study (WHC 1990c), the purpose of this final report is to contain and discuss data and results acquired during the study, as supplemented by supporting data extracted from existing databases. The report focuses on individual receiving site characteristics and effluent-specific flow and transport analyses to assess known and potential contaminant migration through the vadose zone soil columns into area groundwater.

This final report integrates data from the various sources into a single document to facilitate future assessments and decision-making regarding changes to operations and regarding specific requirements for site remediation. This report focuses on the liquid effluents that are discharged, the receiving sites to which the effluents are discharged, and the effects of the discharges on the vadose zone and groundwater systems.

The sources of information used to generate this final report represent a very large body of data. Both existing data and data acquired during this study were reported in other Liquid Effluent Study documents (Figure 1-2). This final report includes only those key pieces which are critical to assessing each site according to the decision tree. For brevity, the details of information presented in the supporting documents are not repeated in this final report, but instead references to the location of specific details are provided in the text as appropriate. The locations within each supporting document of details about each wastestream and receiving site are indicated in the cross-reference table (Table 1-2).

1.5 ORGANIZATION OF FINAL PROJECT REPORT

Chapter 2 of this report includes the data and results needed to assess the 27 effluent receiving sites and their associated effluent streams. Each site is discussed in the same order as shown on Table 1-1. The information is organized around the elements of the decision tree analysis. Each of the 27 sections, numbered 2.1 through 2.27, provides a brief description of the receiving (disposal) site (Section 2.xx.1), a summary of the associated effluent stream(s) characterization (Section 2.xx.2), an analysis of flow and transport within the soil column underneath the site (Section 2.xx.3), an assessment of the impact of the discharge on the groundwater quality underneath the site (Section 2.xx.4), and an assessment of the impact of continued operation of the site (Section 2.xx.5).

Chapter 3 provides a summary based on the decision tree evaluation for each of the receiving sites. Chapter 4 provides a list of references used. Following the report are appendices containing the referenced project correspondence and additional detail on the flow and transport analyses.

Table 1-2. Listing of Reference Documents for Liquid Effluent Study.

Receiving Site	Associated Effluent Stream(s)	Waste Stream Characterization Report WHC-EP-0287 Vol. 2, Appendix No._	Waste Stream Characterization Report WHC-EP-0287 Vol. 3, Appendix No._	Hanford Site Stream-Specific Reports WHC-EP-0342 Addendum No._	Groundwater Characterization Data Report WHC-EP-0366 Appendix A, Subappendix No._	Liquid Effluent Study Final Project Report WHC-EP-0367 Chapter 2, Section No._
100-D Ponds	183-D Filter Backwash Wastewater	3	1	33	1	1
1324N/NA Pond	163-N Demineralization Plant Wastewater	2	2	4	2	2
1325N Crib	N Reactor Effluent	1	3	3	3	3
216-A-8 Crib	241-AY/AZ Tank Farm Steam Condensate	20	4	30	4	4
216-A-29 Ditch	PUREX Plant Chemical Sewer	4	5	2	5	5
216-A-30 Crib	PUREX Plant Steam Condensate	7	6	5	6	6
216-A-36B Crib	PUREX Plant Ammonia Scrubber Condensate	6	7	14	7	7
216-A-37-1 Crib	242-A Evaporator Process Condensate	21	8	15	8	8
216-A-37-2 Crib	PUREX Plant Steam Condensate	7	9	5	9	9
216-A-45 Crib	PUREX Plant Process Condensate	5	10	12	10	10
216-B-3 Pond System	PUREX Plant Chemical Sewer	4	11	2	11	11
	PUREX Plant Cooling Water	8		20		
	242-A Evaporator Cooling Water	23		21		
	B Plant Cooling Water	12		22		
	241-A Tank Farm Cooling Water	19		23		
	284-E Powerplant Wastewater	30		24		
	244-AR Vault Cooling Water	25		25		
	242-A Evaporator Steam Condensate	22		26		
216-B-55 Crib	B Plant Steam Condensate	11	12	16	12	12
216-B-62 Crib	B Plant Process Condensate	10	13	17	13	13
216-B-63 Ditch	B Plant Chemical Sewer	9	14	6	14	14
216-C-7 Crib	209-E Laboratory Reflector Water	26	15	31	15	15
216-S-10 Ditch	S Plant Wastewater	14	16	9	16	16
216-S-26 Crib	222-S Laboratory Wastewater	27	17	13	17	17
216-T-1 Ditch	T Plant Laboratory Wastewater	15	18	32	18	18
216-T-4-2 Ditch	T Plant Wastewater	16	19	10	19	19
216-U-14 Ditch	UO_3/U Plant Wastewater	18	20	7	20	20
	242-S Evaporator Steam Condensate	24		29		
216-U-17 Crib	UO_3 Plant Process Condensate	17	21	19	21	21
216-W-LC Crib	2724-W Laundry Wastewater	29	22	11	22	22
216-Z-20 Crib	Plutonium Finishing Plant Wastewater	13	23	8	23	23
200-W Powerhouse Pond	284-W Powerplant Wastewater	31	24	27	24	24
2101-M Pond	2101-M Laboratory Wastewater	28	25	18	25	25
300 Area Process Trenches	300 Area Process Wastewater	32	26	1	26	26
400 Area Ponds	400 Area Secondary Cooling Water	33	27	28	27	27

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2.0 RECEIVING SITE ASSESSMENTS

Each of the 27 receiving site assessments which follow this section evaluates data reported for the associated effluent stream(s), the soil column underlying the receiving site, and the groundwater underlying the receiving site. Study guidelines were established to select key constituents for each wastestream. The key constituents were then analyzed in terms of their migration rates through the soil column and their concentrations in the underlying groundwater. This section explains the study guidelines and provides descriptions of the data and assumptions used in the receiving site and effluent stream descriptions, the flow and transport analyses, and the groundwater quality assessments.

STUDY GUIDELINES

Study guidelines, which are based on current and proposed regulatory limits, are used to select key effluent constituents and to evaluate groundwater quality. It is important to note that these guidelines are used in this study only for evaluating the relative significance of the magnitude and occurrence of detected constituents. No regulatory requirement or policy is intended or implied by the use of these guidelines. The study guidelines, as shown in Table 2-1, are divided into three categories:

Group A: Current and proposed primary and secondary drinking water standards, also known as maximum contaminant levels (MCL) and derived concentration guides (DCG)

Group B: Estimated background levels for constituents in Hanford groundwater

Group C: Constituent-specific land disposal restriction (LDR) limits, extraction procedure (EP) toxicity limits, and toxic characteristic leaching procedure (TCLP) limits.

The LDR and the TCLP/EP toxicity standards are only applicable to the effluent discharges. The other standards, while not directly applicable to the effluent discharges, are considered relevant for purposes of evaluation of potential impacts on groundwater quality. Drinking water standards are generally used as applicable or relevant and appropriate requirements (ARAR) for Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) actions at contaminated disposal sites.

Table 2-1. Effluent Study Guidelines. (Page 1 of 6)

Group A: MCL, proposed MCL, and DCG

Reference	Constituent	Guideline Limit	Units	Source of Guideline
40 CFR 141 Primary Drinking Water Standards	1,1,1-trichloroethane	200	ppb	MCLG
	1,1-dichloroethylene	7	ppb	MCLG
	1,2-dichloroethane	5	ppb	MCL
	2,4-D	100	ppb	MCL
	2,4,5 Silvex	10	ppb	MCL
	Alpha, high detec. level	15	pCi/L	MCL
	Arsenic	50	ppb	MCL
	Arsenic, filtered	50	ppb	MCL
	Barium	1,000	ppb	MCL
	Barium, filtered	1,000	ppb	MCL
	Benzene	5	ppb	MCL
	Bromodichloromethane	100	ppb	MCL
	Bromoform	100	ppb	MCL
	Cadmium	10	ppb	MCL
	Cadmium, filtered	10	ppb	MCL
	Carbon tetrachloride	5	ppb	MCL
	Chloroform	100	ppb	MCL
	Chromium	50	ppb	MCL
	Chromium, filtered	50	ppb	MCL
	Chromium-6	.05	ppb	MCL
	Coliform (membrane filter)	1	ppb	MCL
	Coliform bacteria	1	MPN	MCL
	Dibromochloromethane	100	ppb	MCL
	Endrin	.2	ppb	MCL
	Fluoride	4,000	ppb	MCL
	Fluoride, low detec. level	4,000	ppb	MCL
	Gross alpha[b]	15	pCi/L	MCL
	Gross beta[b]	50	pCi/L	MCL[a]
	Lead (graphite furnace)	50	ppb	MCL
	Lead, filtered	50	ppb	MCL
	Lindane, alpha-BHC	4	ppb	MCL
	Lindane, beta-BHC	4	ppb	MCL
	Lindane, delta-BHC	4	ppb	MCL
	Lindane, gamma-BHC	4	ppb	MCL
	Mercury	2	ppb	MCL
	Mercury, filtered	2	ppb	MCL
	Methoxychlor	100	ppb	MCL
	Nitrate	45,000	ppb	MCL
	Nitrate, high detec. level	45,000	ppb	MCL
	Nitrate, phenodisulfonic acid	45	mg/L	MCL
	Nitrate-ion	45	mg/L	MCL
	Selenium	10	ppb	MCL
	Selenium, filtered	10	ppb	MCL
	Silver	50	ppb	MCL
	Silver, filtered	50	ppb	MCL
	Toxaphene	5	ppb	MCL
	Trichloroethylene	5	ppb	MCL

Table 2-1. Effluent Study Guidelines. (Page 2 of 6)

Group A: MCL, proposed MCL, and DCG

Reference	Constituent	Guideline Limit	Units	Source of Guideline
40 CFR 141 (Contd)	Turbidity[b]	5	NTU	MCL
	p-Dichlorobenzene	750	ppb	MCL
	Vinyl chloride	2	ppb	MCL
40 CFR 143 Secondary Drinking Water Standards	Chloride	250,000	ppb	SMCL
	Copper	1,000	ppb	SMCL
	Copper, filtered	1,000	ppb	SMCL
	Iron	300	ppb	SMCL
	Iron, filtered	300	ppb	SMCL
	Manganese	50	ppb	SMCL
	Manganese, filtered	50	ppb	SMCL
	Sulfate	250,000	ppb	SMCL
	Total dissolved solids[b]	500,000	ppb	SMCL
	Zinc	5,000	ppb	SMCL
	Zinc, filtered	5,000	ppb	SMCL
	pH, field measurement, max.[b]	8.5		SMCL
	pH, lab. measurement, max.[b]	8.5		SMCL
54 FR 22062 Proposed Primary and Secondary Drinking Water Standards	1,2-dibromo-3-chloropropane	.2	ppb	MCL prop
	1,2-dichloropropane	5	ppb	MCL prop
	Alachlor	2	ppb	MCL prop
	Aluminum	50	ppb	SMCL prop
	Aluminum, filtered	50	ppb	MCL prop
	Arochlor 1016	.5	ppb	MCL prop
	Arochlor 1221	.5	ppb	MCL prop
	Arochlor 1232	.5	ppb	MCL prop
	Arochlor 1242	.5	ppb	MCL prop
	Arochlor 1248	.5	ppb	MCL prop
	Arochlor 1254	.5	ppb	MCL prop
	Arochlor 1260	.5	ppb	MCL prop
	Chlordane	2	ppb	MCL prop
	Chlorobenzene	100	ppb	MCL prop
	Chlorobenzene (by ABN)	60	ppb	MCL prop
	Ethyl benzene	700	ppb	MCL prop
	Heptachlor	.4	ppb	MCL prop
	Nitrite	3,300	ppb	MCL prop
	Pentachlorophenol	200	ppb	MCL prop
	Styrene	5	ppb	MCL prop
	Tetrachloroethylene	5	ppb	MCL prop
	Toluene	2,000	ppb	MCL prop
	Xylene-m	10,000	ppb	MCL prop
	Xylene-o,p	10,000	ppb	MCL prop
	trans-1,2 Dichloroethylene	100	ppb	MCL prop

Table 2-1. Effluent Study Guidelines. (Page 3 of 6)

Group A: MCL, proposed MCL, and DCG

Reference	Constituent	Guideline Limit	Units	Source of Guideline
DOE 5400.5 DCG, Adjusted to 4 mrem/yr allowable dose per primary drinking water water standards primary	Americium-241	1.2	pCi/L	1/25 DCG
	Antimony-124	400	pCi/L	1/25 DCG
	Antimony-125	2,000	pCi/L	1/25 DCG
	Barium-140	800	pCi/L	1/25 DCG
	Carbon-14	2,800	pCi/L	1/25 DCG
	Cerium-141	2,000	pCi/L	1/25 DCG
	Cerium-144	280	pCi/L	1/25 DCG
	Cesium-134	80	pCi/L	1/25 DCG
	Cesium-137	120	pCi/L	1/25 DCG
	Cobalt-58	1,600	pCi/L	1/25 DCG
	Cobalt-60	200	pCi/L	1/25 DCG
	Curium-242	40	pCi/L	1/25 DCG
	Curium-244	2.4	pCi/L	1/25 DCG
	Europium-154	800	pCi/L	1/25 DCG
	Europium-155	4,000	pCi/L	1/25 DCG
	Iodine-129, low detec. level	20	pCi/L	1/25 DCG
	Iodine-131	120	pCi/L	1/25 DCG
	Iron-59	800	pCi/L	1/25 DCG
	Lanthanum-140	800	pCi/L	1/25 DCG
	Lead-210	1.2	pCi/L	1/25 DCG
	Manganese-54	2,000	pCi/L	1/25 DCG
	Molybdenum-99	1,200	pCi/L	1/25 DCG
	Nickel-63	12,000	pCi/L	1/25 DCG
	Niobium-95	2,400	pCi/L	1/25 DCG
	Phosphorus-32	800	pCi/L	1/25 DCG
	Plutonium-238	1.6	pCi/L	1/25 DCG
	Plutonium-239/40	1.2	pCi/L	1/25 DCG
	Plutonium-241	80	pCi/L	1/25 DCG
	Praseodymium-144	280	pCi/L	1/25 DCG
	Promethium-147	4,000	pCi/L	1/25 DCG
	Radium-228	4	pCi/L	1/25 DCG
	Ruthenium-103	2,000	pCi/L	1/25 DCG
	Ruthenium-106	240	pCi/L	1/25 DCG
	Silver-110 mestable	400	pCi/L	1/25 DCG
	Sodium-22	400	pCi/L	1/25 DCG
	Strontium-89	800	pCi/L	1/25 DCG
	Strontium-90	40	pCi/L	1/25 DCG
	Strontium-90, low detec. level	40	pCi/L	1/25 DCG
	Technetium-99	4,000	pCi/L	1/25 DCG
	Tin-113 daughter	2,000	pCi/L	1/25 DCG
	Tritium (Hydrogen-3)	80,000	pCi/L	1/25 DCG
	Uranium-234	20	pCi/L	1/25 DCG

Table 2-1. Effluent Study Guidelines. (Page 4 of 6)

Group A: MCL, proposed MCL, and DCG

Reference	Constituent	Guideline Limit	Units	Source of Guideline
DOE 5400.5 (Contd)	Uranium-235	24	pCi/L	1/25 DCG
	Uranium-236	20	pCi/L	1/25 DCG
	Uranium-238	24	pCi/L	1/25 DCG
	Zinc-65	360	pCi/L	1/25 DCG
	Zirconium-95	1,600	pCi/L	1/25 DCG

[a]This value represents a screening value for assumed compliance with the 4 mrem/yr MCL (WAC 248-54-185).

[b]These parameters not used to select key constituents since they are indicator parameters and not actual discrete chemical or radiological constituents.

ABN = acid-based neutrals
BHC = benezine hexachloride
MCLG = maximum contamination level goal
MPN = most probable number
NTU = nephelometric turbidity unit
SMCL = secondary maximum contamination level.

Table 2-1. Effluent Study Guidelines. (Page 5 of 6)

Group B: Estimated Background Levels for Selected Constituents in Hanford Groundwater

Constituent	Detection Limit[a]	Background Concentration[a]
Aluminum	2[b]	<2[b]
Ammonia	50	<50
Arsenic	0.2[b]	3.9 ± 2.4[b]
Barium	6	42 ± 20
Beryllium	0.3[b]	<0.3[b]
Bismuth	0.02[b]	<0.02[b]
Boron	50[b]	<50[b]
Cadmium	0.2[b]	<0.2[b]
Calcium	50	40,400 ± 10,300
Chloride	500	10,300 ± 6,500
Chromium	2[b]	4.0 ± 2.0[b]
Copper	1[b]	<1[b]
Cyanide	10	<10
Fluoride	500	370 ± 100
Lead	0.5[b]	<0.5[b]
Magnesium	10	11,800 ± 3,400
Manganese	5	7 ± 5
Mercury	0.1	<0.1
Nickel	4[b]	<4[b]
Phosphate	1,000	<1,000
Potassium	100	4,950 ± 1,240
Selenium	2[b]	<2[b]
Silver	10	<10
Sodium	10	18,260 ± 10,150
Strontium	20	236 ± 102
Sulfate	500	34,300 ± 16,900
Uranium	0.5[c]	1.7 ± 0.8[c]
Vanadium	5	17 ± 9
Zinc	5	6 ± 2
Alkalinity	--	123,000 ± 21,000
pH	--	7.64 ± 0.16
Total Organic Carbon	200	586 ± 347
Conductivity	1[d]	380 ± 82[d]
Gross Alpha	0.5[c]	2.5 ± 1.4[c]
Gross Beta	4[c]	19 ± 12[c]
Radium	0.2[c]	<0.2[c]

[a]Units in parts per billion unless otherwise noted.
[b]Based on inductively coupled plasma/mass spectroscopy data.
[c]Units in picocuries per liter.
[d]Units in mho per centimeters.

Table 2-1. Effluent Study Guidelines. (Page 6 of 6)

Group C: EP Toxicity, LDR, TCLP

Constituent[a,b]	(RCRA waste code)	40 CFR 268 LDR[a]	40 CFR 261 TCLP[a]	WAC 173-303 EP Toxicity
Arsenic	(D004)	5,000	5,000	5,000
Barium	(D005)	100,000	100,000	100,000
Cadmium	(D006)	1,000	1,000	1,000
Chromium	(D007)	5,000	5,000	5,000
Lead	(D008)	5,000	5,000	5,000
Mercury	(D009)	200	200	200
Nickel	c	134,000	none	none
Selenium	(D010)	1,000	1,000	1,000
Silver	(D011)	5,000	5,000	5,000
Thallium	c	130,000	none	none
Acetone	(F003)	50	none	none
1-Butanol	(F003)	5,000	none	none
Carbon tetrachloride	(F001)(D019)	50	500	none
Chloroform	(D022)	none	6,000	none
Methylene chloride	(F001)	200	none	none
Methyl ethyl ketone[d]	(F005)(D035)	50	200,000	none
Methyl isobutyl ketone[e]	(F003)	50	none	none
Pyridine	(F005)(D038)	1,120	5,000	none
Tetrachloroethylene	(F001)(D039)	79	700	none
Trichloroethylene	(F001)(D040)	62	500	none
Trichlorofluoromethane	(F002)	50	none	none
Toluene	(F005)	1,120	none	none
Xylene(s)	(F003)	50	none	none

[a]Units are parts per billion.
[b]Comparisons with these guidelines are made only to identify constituents of interest and do not imply designation, which is presented in the Hanford Site Stream-Specific Reports (WHC 1990a).
[c]Guideline for characteristic wastes containing indicated constituent.
[d]Also referred to as 2-butanone.
[e]Also referred to as hexone.

The scope and application of each of these guideline groups are provided below:

- Group A Study Guidelines --

  40 CFR 141 and 143 - Primary and Secondary Drinking Water Regulations

  Primary drinking water standards are applicable to water which is delivered to the free-flowing outlet of the ultimate user of a public water system, where a public water system is defined as one which serves, at a minimum, 25 users or 15 service connections at least 60 days out of a year. Since there is no intent that the Hanford waste stream discharges be considered drinking water sources, this is a very conservative comparison for the purpose of determining potential environmental and health impacts.

  Secondary drinking water standards (SMCL) are established for contaminants in water used in a public water system, as defined above, which primarily affect aesthetic qualities related to public acceptance of drinking water. The standards do not have associated health implications at the levels established. Comparisons of effluent analytical data to these standards is made merely to provide some perspective regarding the significance of the constituent concentration in the effluent.

  FR 54 22062 - Proposed Drinking Water MCL

  These are standards for primary and secondary drinking water quality (MCLG and SMCLG) which were proposed in 1989. There is no indication that these standards will be promulgated soon. However, these standards greatly expand the list of constituents for which some health based numerical limit is indicated, and thus these have been used for comparison purposes in essentially the same manner as the fully promulgated drinking water MCL.

  Standards for Radionuclides:

  DOE Order 5400.5 - Derived Concentration Guides (DCG) for Radionuclides

  The DOE promulgated DCG are applicable to water at an offsite location which may be ingested or used for agricultural purposes. The DCG specify the concentration of an individual radionuclide which would result in a dose of 100 mrem/yr to a hypothetical recipient who used this water exclusively. While not directly applicable to the wastewater discharge, use of these standards provides a conservative indication of potential environmental impacts, since the concentrations in wastewater are being compared to a standard for offsite use.

Safe Drinking Water Act MCL

These limits for radionuclides establish a concentration in public drinking water supplies which will limit an individual radiation dose to 4 mrem/yr. The MCL for radionuclides are based on an outdated International Council of Radiation Protection (ICRP) 2 model. The DCG are based on the more recent ICRP 30 model. Common practice is to attempt to show equivalency of the DCG and MCL by dividing the DCG by 25, i.e., based on dose equivalency, DCG dose basis (100 mrem/yr)/ 25 = MCL dose basis (4 mrem/yr). However, because two sets of standards were developed with different dose models, dividing DCG by 25 does not necessarily yield MCL.

- Group B Study Guidelines --

Background groundwater concentrations are based on a previous study which evaluated groundwater monitoring data from selected wells in the Hanford 600 Area during the period from January to June, 1988 (Evans et al. 1989).

- Group C Study Guidelines --

40 CFR 268 - Land Disposal Restrictions

The numerical standards used are the treatment performance standards for residuals from waste treatment (constituent concentrations in waste extracts).

WAC 173-303-90 - Extraction Procedure (EP) Toxicity

These regulations provide numerical limits for determination of dangerous waste designation by virtue of a waste's toxicity. The numerical limits are provided for selected toxic metals and pesticides.

40 CFR 261 - Toxicity Characteristic Leaching Procedure

These recently promulgated numerical limits are similar in applicability to the EP toxicity limits. These new regulations add additional organic compounds to the list of substances regulated.

The Group A and B study guidelines are also used as a basis for evaluation of the groundwater data.

Key constituents of the effluent streams have been identified as those whose concentrations exceed either the Group A or Group C study guidelines.

RECEIVING SITE AND EFFLUENT STREAM DESCRIPTIONS

The purpose of the receiving site and effluent stream descriptions is to summarize the information necessary to provide a framework for the discussions on contaminant flow and transport, the assessments of

groundwater impact, and the decision tree analysis. The primary emphasis of the descriptions, therefore, is on the types and amounts of effluents that have been discharged. The sources of this information were the supporting study documents (Figure 1-1) and existing databases.

Types of Effluents Discharged

The effluent sampling data, which are discussed in Section 2.xx.2 for each site, consist of two data sets as follows:

- Old Data - A data set which represents effluent sampling and analysis through September 1989. This data set includes routine radionuclide monitoring of facility effluents over a period which began as far back as 1976. In some cases, the range of dates may be shorter than 1976-1989, depending on the operating mode(s) of the plant. The radionuclide analyses contained in this data set were performed at three laboratories: the 105-N and 222-S laboratories operated by Westinghouse Hanford and the independent contract laboratory (U.S. Testing). The chemical data in this data set represents sampling starting as far back as 1985. All chemical analyses were performed by the contract laboratory (U.S. Testing). All data in the old data set through 1988 were previously reported in the Waste Stream Characterization Report (WHC 1989a, Vol. 2). A more detailed description of this data source is given in Volume 1 of that report.

- New Data - A data set which represents effluent samples specifically acquired for this study during the period from October 1989 through March 1990. This data set includes a broad range of both chemical and radiologic species analyzed by the contract laboratory (U.S. Testing). These data were previously documented by WHC (1990b). This data set, for streams where such data were available, also forms the basis for the stream-specific characterization and designation effort which was documented in the stream-specific report addenda (WHC 1990a). For streams where new data were not available, e.g., the facility was not operating during the operating period, the old data set was used.

For purposes of evaluation and discussion in this report, each of the data sets was compared against study guidelines to identify key constituents. Key constituents, thus identified, are listed on Table 2.xx-2 for each effluent and for each operating mode (if applicable).

Amounts of Effluents Discharged

The total volume of effluent discharged and the average rate of discharge are fundamental input data for estimating the migration rates for contaminants through the vadose zone. Assessment of the volume impact is also based on these data.

Part of the discussions on amounts of effluents that have been discharged includes estimates of the loading of chemical and radionuclide constituents at the receiving sites from the effluent streams. Loading,

defined as the rate of deposition for a given constituent at the receiving site, is expressed as kilograms per month or picocuries per month, and is calculated by multiplying the concentration of the constituent (e.g., kilograms per liter) times the effluent flow rate (e.g., liters per month). If the effluent concentrations and flow rates have not changed over time, loading can be used to estimate an upper bound of the chemical and radionuclide inventory (i.e., the accumulated constituent load), not taking into account decay or transport out of the disposal structure and into the soil column/groundwater. The chemical and radionuclide loading data presented for each receiving site is based only on effluent constituent concentrations measured over the period specified in the individual table footnotes (October 1989 to March 1990 for those wastestreams sampled during this study). As such, the data may not be representative for other plant operating modes or for other time periods of discharge. Actual inventory calculations would require extensive sampling of the disposal structure and receiving site soil.

FLOW AND TRANSPORT ANALYSES

A preliminary assessment was made of the theoretical potential for vertical contaminant migration at each of the liquid waste receiving sites. This theoretical potential is discussed in terms of travel time for water to flow vertically from the receiving site through the soil column to groundwater and in terms of relative mobility of the key constituents.

A one-dimensional flow and transport analysis of the vadose zone beneath each receiving site provided the primary basis for the preliminary assessments. The one-dimensional model that was used was defined in Appendices O and Q of the final environmental impact statement for Hanford defense wastes (DOE 1987). Appendix B provides a brief summary of the assumptions and the key equations of the model.

In support of the one-dimensional analyses, a literature review was completed to determine the transport characteristics (relative mobility and persistence) for each of the key constituents. Mobility was assessed in terms of solubility and adsorption whereas persistence was assessed in terms of either radiogenic or biological half-life. Summarized results from the literature review on transport characteristics is provided in Appendix C.

To support the one-dimensional flow and transport analyses, a model of the soil column at each of the receiving sites was conceptualized. The formulation of this conceptual model used information on the hydraulic behavior of Hanford soil samples collected and analyzed previously. Moisture retention curves were measured in the laboratory and based on these data, unsaturated hydraulic conductivities versus moisture content were estimated using the van Genuchten-Mualem formulation discussed by Smoot (1989). Basically, the results from 24 moisture-retention curves were applied as follows:

- Using the results from the 24 moisture-retention curves, a hypothetical moisture-retention curve for each of five soil types common to Hanford (sand and gravel, coarse gravel, fine sand, sand and silt, and moderately calcinated sand and silt, or caliche) was constructed. The resulting curves are shown in Figure B-1 (Appendix B).

- A representative geologic log at each receiving site was selected. Each representative geologic log is included in the corresponding receiving site assessment.

- Using lithologic descriptions and information on grain size distribution as a guide, the geologic log at each site was divided into layers that match the five generic soil types.

- Each layer was then assigned the corresponding characteristic moisture-retention curve (Figure B-1).

The preliminary assessments were based on an assumption of unit gradient steady-state flow in a layered system. The travel time for water was calculated for the vadose zone soil column and is assumed to be very conservative. This nominal travel time for water was then adjusted to account for the transport characteristics of some of the effluent key constituents. The transport characteristics for each contaminant were also defined in terms of pH, overall organic content, and overall inorganic content.

Detailed vadose zone flow and transport analyses were performed using numerical simulation models at three receiving site locations. These detailed analyses provided additional information to determine the effect that soil layering has on the:

- rate of soil wetting (i.e., rate of increase of moisture content)

- rate of contaminant migration through the partially saturated flow regimes

- tendency for contaminants to spread laterally under layered conditions.

The three locations selected for detailed analyses were: the 1325N Crib, the 216-U-17 Crib, and the 216-A-30, 216-A-37-1, and 216-A-37-2 cribs. Selection of these three locations provided information on the characteristics of soil wetting and lateral spreading in three different hydrologic settings on the Hanford Site. The settings are summarized as follows:

- The 1325N Crib is located in the vicinity of the N Reactor adjacent to the Columbia River. The crib is located in the vadose zone approximately 50 ft above the unconfined aquifer. The soil in the vadose zone tends to be rather homogeneous sand and gravel.

- The 216-U-17 Crib receives process condensate from the operation of the UO_3 Plant located in the 200 West Area. The partially saturated soil column above the unconfined aquifer is several hundred feet thick consisting of many layers, which tend to significantly lengthen the travel time through the vadose zone.

- The 216-A-30/216-A-37-1/216-A-37-2 cribs are located in 200 East Area and support the operation of the PUREX facility. Although the partially saturated soil column in this location is also several hundred feet thick, the soil layering in the 200 East Area is not as stratified as the soil layering in 200 West Area.

In addition to covering a range of hydrogeologic regimes on the Hanford Site, the assessments were intended to address (WHC 1990c):

- The impact of continued discharge of liquid effluent into a soil column that may contain existing levels of soil and groundwater contamination.
- The impact associated with continued operation of the receiving site.
- The impact of continued operation of a liquid effluent stream containing low levels of radioactive contaminants.

The selection of the three site locations was intended to address the three conditions from the project plan listed above and the three conditions discussed in the decision tree (labeled "A", "B", and "C", Figure 1-3). The selection of the three locations and identification of the three decision tree conditions was explained in a letter to Ecology and EPA, dated May 11, 1990 (Exhibit 5, Appendix A).

As stated in the project plan (WHC 1990c) and the letter to Ecology and EPA (Exhibit 5, Appendix A), the emphasis of the detailed flow and transport analyses is to evaluate: (1) the risk to human health or the environment, and (2) the impact on future cleanup activities of continued discharge of liquid effluents into the soil column. The detailed flow and transport analyses are used to assess the impact of continued liquid discharges on future cleanup activities at all three selected locations. Assessment of the potential impact of continuing liquid discharges on human health or the environment is briefly discussed only for the 1325N Crib site as associated with the springs along the Columbia River (N-Springs).

The results from these numerical simulations of the three selected locations are summarized in Appendix D.

GROUNDWATER QUALITY ASSESSMENT

Groundwater quality data for this study were obtained from ongoing programs as well as from additional sampling of existing wells as required by the project plan (WHC 1990c). The data were summarized, in support of the decision tree analysis (element 8, Figure 1-3), over the time period of January 1, 1989 to April 20, 1990. Most of the sampling conducted specifically for this study occurred between October 1989 and February 1990 with additional followup sampling between February and April 20, 1990. A summary of groundwater sampling events is depicted in Figure 2-1.

The groundwater sampling period was chosen to maximize the probability of including data indicative of operating modes of the facilities, as opposed to standby modes, taking into consideration the predicted travel times of water through the vadose zone. The predicted travel times beneath receiving sites in the 200 Areas are on the order of months (Appendix B). Therefore, the groundwater sampling data set is believed to be inclusive.

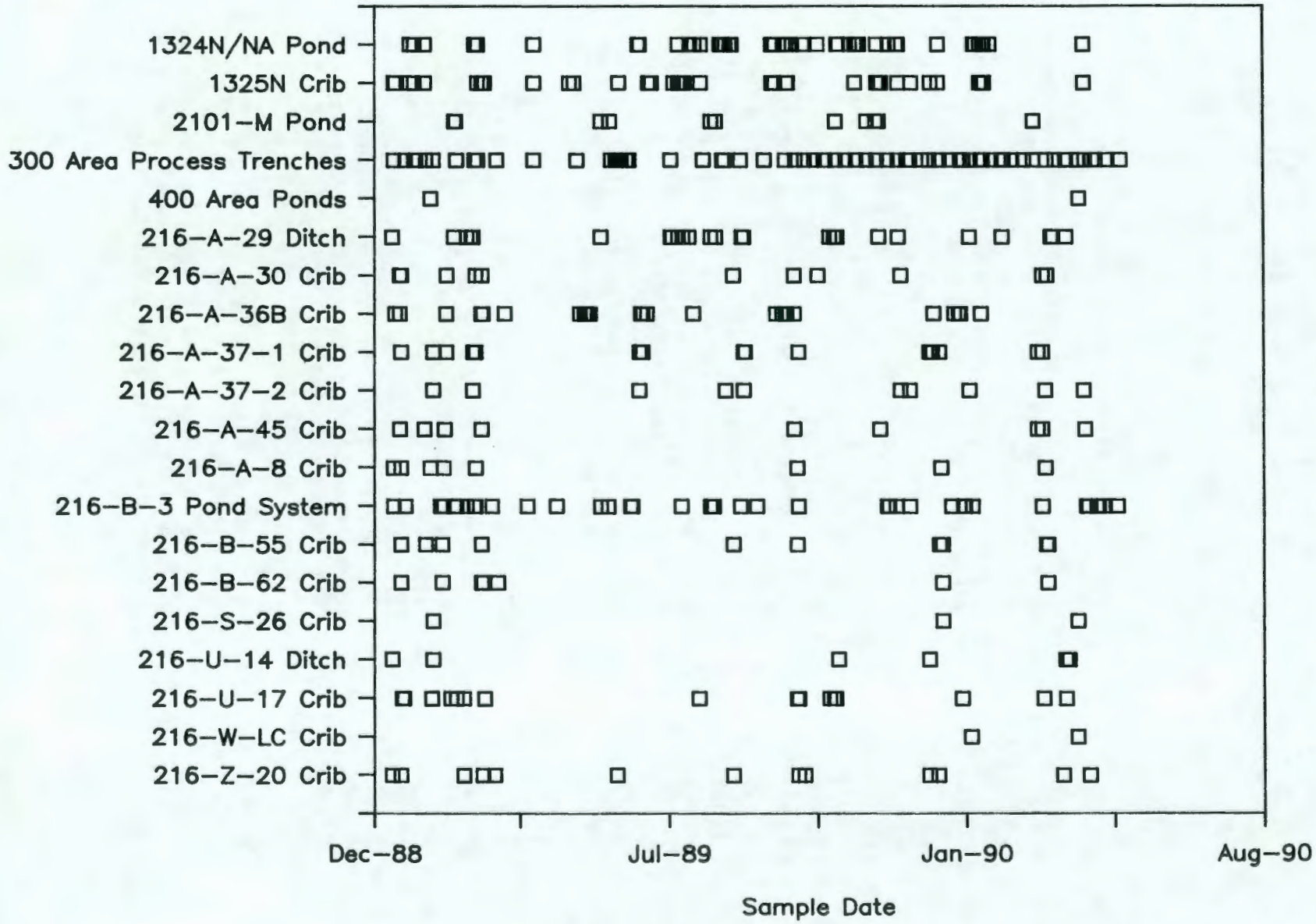

Figure 2-1. Groundwater Sampling Events at Liquid Effluent Disposal Facilities.

Because no new groundwater monitoring wells were constructed for this study, groundwater data could only be collected at the 20 receiving sites which had existing groundwater monitoring wells. Modeling predictions must be relied on to assess impact on groundwater quality at the remaining seven sites:

- o 100-D Ponds
- o 216-B-63 Ditch
- o 216-C-7 Crib
- o 216-S-10 Ditch
- o 216-T-1-Ditch
- o 216-T-4-2 Ditch
- o 200-W Powerhouse Pond

Groundwater monitoring wells have recently been completed at the 216-B-63 Ditch and the 216-S-10 Ditch.

As previously stated, groundwater quality data were obtained from ongoing sampling programs as well as from sampling events specifically for this study. The groundwater samples collected specifically for this study were analyzed for 40 CFR 264, Appendix IX constituents and for site-specific radionuclides as identified in the Waste Stream Characterization Report (WHC 1989a). Sampling for many of the ongoing programs included analyses for 40 CFR 264, Appendix IX constituents while some of the ongoing programs only required analyses for indicator-type parameters (i.e., total organic carbon [TOC], total organic halogens [TOX], conductivity, pH, drinking water and water quality indicators, gross alpha, and gross beta). All results for a given constituent were evaluated in the groundwater quality data set.

In this final report, groundwater data are presented for all constituents that were above the analytical detection limit. A key constituent is considered to be "significant" if the analytical result is greater than Group A study guidelines. The groundwater data are compared to natural background concentrations for the Hanford Site as reported by Evans et al. (1989) (Group B study guidelines). Where necessary, data on upgradient sources of groundwater contamination are also used for comparison (Evans et al. 1990). The data are also discussed with respect to such factors as well integrity and sampling reliability, trends in time series indicators (where available), and frequency of occurrence. A single recorded result exceeding a guideline is reported but is considered inconclusive.

The above information is presented for each receiving site in two tables: a computer-generated analytical summary table derived from the information stored in the Hanford Ground Water Data Base, and a ratio table relating the average and maximum value reported in the analytical summary table to the corresponding Hanford Site background value.

Groundwater Data Tables

The analytical summary tables only include analytes which were above detection limits. The analytes are arranged alphabetically under the four major groups: "Contamination Indicator Parameters", "Drinking Water Parameters", "Groundwater Quality Parameters", and "Site-Specific and Other Parameters". Additional descriptive information is added as appropriate, following a comma. "Filtered" indicates result is for a filtered sample; an analyte listing without this designation is for an unfiltered sample.

A description of the individual column headings is as follows:

- Units -- Units are in parts per billion or micrograms per liter unless indicated otherwise. Radionuclide results are expressed as picocuries per liter.

- Detection Limits -- The detection limits that were established for the U.S. Testing contract for the Resource Conservation and Recovery Act of 1976 (RCRA) groundwater monitoring program (roughly equivalent to the practical quantitation limit [PQL]).

- Number of Analyses -- Total number of analyses for an analyte used in the analysis summary columns. For some analytes, numerous results were available from other programs during the time period of interest for this study. This accounts for the large number of results for certain sites and wells.

- Number Detected -- This column indicates the number of results for an analyte that were above the detection limit.

- Average Result -- Arithmetic mean of all positive results. Significant figures are limited to three; additional places indicated are computer generated.

- Maximum Result -- Maximum value in the set. The first three digits from the left of each entry indicate the actual significant figures for the method/result.

- Minimum Result -- Minimum value; in some cases, listed as detection limit.

- Maximum Limit -- The standards used for this study; see Table 2-1 for source and status (same units notes as in item 2 above).

- Number > Limit -- Number of results exceeding the indicated standard (Maximum Limit column). Note: a zero entry is only significant if there is a corresponding standard for the analyte in the preceding column.

The complete list of wells sampled, analytes, and a description of quality control and other sampling and analysis details are included in a supporting document entitled Liquid Effluent Study: Groundwater Characterization Data (WHC 1990d). Well-by-well results are available from the Hanford Ground Water Data Base, an electronic data base. In addition, a printout of the well-by-well results are available for public access through the Administrative Record system.

It should also be noted that analytical methods with lower detection limits than available for this study were used for determination of many of the background concentrations. When a background concentration is listed as less than the detection limit, observed concentrations for this study that are at or near their detection limit may yield artifically large ratios when divided by background.

QUALITY ASSURANCE/QUALITY CONTROL

Discussion of the plans for quality assurance (QA) and procedures for the quality control (QC) of field and laboratory activities for the waste-stream characterization portion of the Liquid Effluent Study are contained in Appendix A of volume I of the Waste Stream Characterization Report (WHC 1989a). QC and data validation results are summarized in Section 3.2 of the Hanford Site Stream-Specific Reports (WHC 1990a).

A separate discussion of QA plans and QC procedures for the groundwater characterization portion of the study is contained in Section 2.2.11 of Volume IV of the Waste Stream Characterization Report (WHC 1989a). A more detailed summary has also been included in Section 3.0 of the Liquid Effluent Study: Ground Water Characterization Data report (WHC 1990d). This section of the data report also presents summary information on QC results and data validation activities associated with the analytical results.

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2.1 100-D PONDS

Certain metals and sulfate in the effluent discharged to this disposal facility exceeded study guidelines. However, short-term continued operation is judged to have minimal additional impact on soil column contamination and groundwater quality.

2.1.1 Receiving Site Description

The 100-D Ponds were constructed in 1977 to dispose of liquid effluents from the 183-D Water Treatment Facility located in the 100-D Area. This facility received sand filter backwash effluents and small quantities of filtered, chlorinated water from hydraulic test loops and fuel discharge trampoline tests. The disposal facility is being closed as a former RCRA treatment, storage, and/or disposal facility.

The locations of the ponds and their spatial relationship to other facilities are shown in Figure 2.1-1.

2.1.2 Effluent Stream Description

The 183-D Water Treatment Facility treats Columbia River water by sedimentation, filtration, and chlorination. Alum is added to the raw water as a flocculating agent. The filtration units consist of conventional sand filters which are periodically backwashed to remove filtered sediments.

Table 2.1-1 summarizes information pertaining to the effluent stream. Key effluent constituents are listed in Table 2.1-2. Table 2.1-3 provides data on receiving site loadings.

Sampling data indicate concentrations of metals and sulfate which exceed Group A study guidelines. The elevated concentrations of metals and sulfate are attributed to normal operation of the water treatment system which concentrates such raw water constituents and alum residues in the sand filters. There are no radioactive constituents in this stream which exceed study guidelines.

2.1.3 Flow and Transport Analysis

For transport calculations, the soil column beneath the pond is treated as a single layer of coarse sand and gravel with a depth to water of approximately 20 m (Figure 2.1-2). The calculated travel time for wastewater to reach groundwater under average discharge conditions (Table 2.1-1) is 589 days (see Appendix B for computational details).

Based on general effluent characteristics and corresponding sorption parameters (Appendix C) for the key constituents identified in Table 2.1-2, the calculated migration rates (Appendix B, Table B-1) are 3.4 cm/day for mobile constituents (sulfate and chromium), and 0.01 to 0.03 cm/day for the less mobile constituents (manganese, mercury, lead, aluminum, and iron). These migration rates suggest that after a 13-yr discharge period (1977 to present), and assuming a continuous average discharge rate of 1.9E+05 L/mo

(Appendix B, Table B-1), the maximum depth of penetration of the less mobile constituents is approximately 1.5 m. Breakthrough of the mobile constituents occurs after less than 2 yr (Appendix B, Table B-1).

2.1.4 Groundwater Quality Assessment

Because there are no groundwater monitoring wells in close proximity to the 100-D Ponds, groundwater quality cannot be evaluated directly. However, groundwater monitoring wells are proposed for this facility (Tri-Party Agreement milestone M24-16, change number M24-89-1, due December 1991).

2.1.5 Impact of Continued Operation

Perturbation of the local groundwater flow regime is an unlikely consequence of the average discharge rate to this site. For example, the discharge rate to the ponds is small in relation to the natural recharge to the unconfined aquifer (i.e., less than upper Cold Creek flow rate). Additionally, natural fluctuations in water table elevation due to river stage changes will mask any small flow perturbations due to waste discharge.

Migration rate estimates for most of the key constituents in the effluent stream (Section 2.1.3) suggest that they are retained on the soil column. Sulfate and chromium, on the other hand, would be expected to occur in vicinity groundwater; for example, based on average effluent conditions indicated in Table 2.1-1, maximum groundwater concentrations about five times the Group A study guidelines may occur. Mitigating factors include dispersion and dilution by mixing with groundwater and eventually, additional dilution by mixing with the nearby river water (700 to 800 ft to the shoreline).

Because of the low infiltration rate (Appendix B, Table B-1), remobilization of contaminants previously retained on the soil should not be a significant impact at this site (Section 2.1.3).

Figure 2.1-1. Well Location and Site Map for 100-D Ponds.

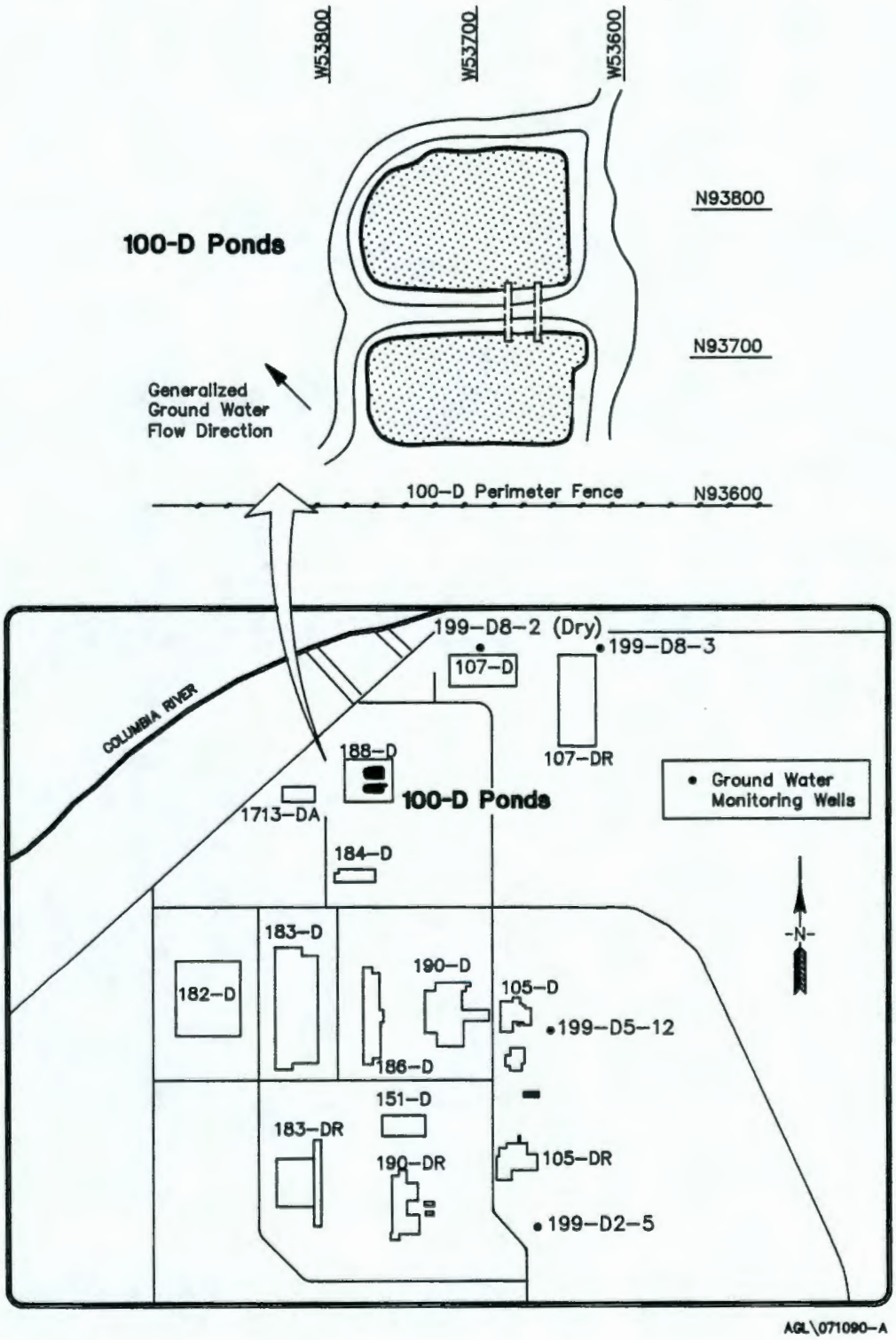

Figure 2.1-2. Lithology of Well 199-D8-3 Near 100-D Ponds.

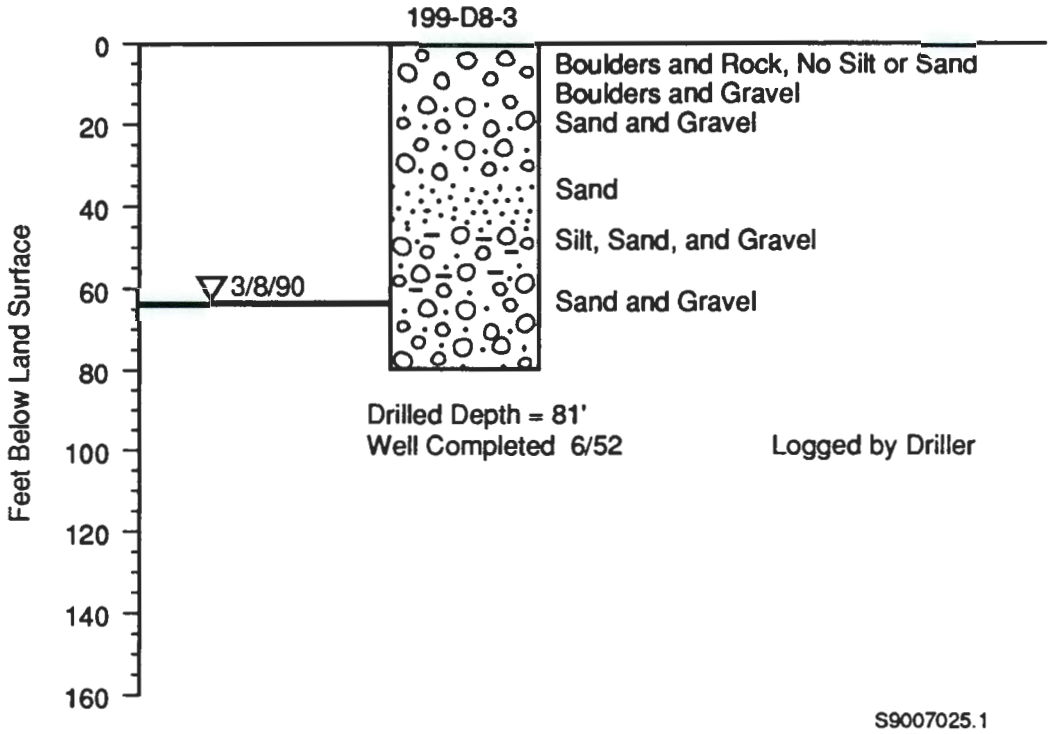

Table 2.1-1. Effluent Stream Description, 183-D Filter Backwash.

Total volume of effluent discharged to subject receiving site: (assuming constant average discharge rate since 1977)	3.1E+07 L from 1/77 to 7/90
Average effluent discharge rate, by operating mode: (WHC 1990a, WHC-EP-0342, Addendum 33)	1.89E+05 L/mo
Current average effluent discharge rate: (WHC 1990a, WHC-EP-0342, Addendum 33)	1.89E+05 L/mo
Effluent designation: (WHC 1990a, WHC-EP-0342, Addendum 33)	Nondangerous, nonradioactive
Effluent status:	Active discharge to 100-D Ponds

Table 2.1-2. Effluent Stream Sampling Data, 183-D Filter Backflush.

Key Constituents	Detection Limit[a]	Detection/ Analyses	Sample Concentration 90% CI[a]	Detection Limit[a]	Detection/ Analyses	Sample Concentration 90% CI[a]
	04/87 to 01/88, During Routine Operation			10/89 to 3/90, During Routine Operation		
aluminum		4/4	290,000		4/4	34,800
chromium	10	4/4	220	10	3/4	17[b]
iron	30	4/4	32,000	30	4/4	3,930
lead	5	4/4	120	5	3/4	13[b]
manganese	5	4/4	910	5	4/4	120
mercury	0.1	4/4	10	0.1	4/4	1[b]
sulfate	500	4/4	1,500,000	500	4/4	19,000[b]

[a]Units: chemical--parts per billion
radionuclides--picocurie per liter.

CI: confidence interval.

[b]Concentration below Group A and C study guidelines; value given for comparison purposes only.

Table 2.2-3. Radionuclide and Chemical Loading, 183-D-Filter Backflush Wastewater.

Flow Rate: 1.89E+05 L/mo

Constituent	Kg/L*	Kg/mo*
aluminum	2.25E-05	4.26E+00
arsenic	8.75E-09	1.66E-03
barium	4.45E-08	8.42E-03
boron	2.50E-08	4.73E-03
calcium	2.05E-05	3.88E+00
chloride	2.85E-06	5.39E-01
chromium	1.37E-08	2.59E-03
copper	4.25E-08	8.04E-03
fluoride	1.59E-07	3.01E-02
iron	2.61E-06	4.94E-01
lead	1.00E-08	1.89E-03
magnesium	4.57E-06	8.65E-01
manganese	8.15E-08	1.54E-02
mercury	7.37E-10	1.39E-04
potassium	8.63E-07	1.63E-01
silicon	5.17E-06	9.78E-01
sodium	2.34E-06	4.43E-01
strontium	1.13E-07	2.14E-02
sulfate	1.72E-05	3.26E+00
uranium	3.53E-09	6.68E-04
vanadium	7.25E-09	1.37E-03
zinc	6.02E-08	1.14E-02
ammonia	6.45E-08	1.22E-02
2-butanone	1.07E-08	2.02E-03
trichloromethane	2.05E-08	3.88E-03
unknown aliphatic HC	4.00E-07	7.57E-02
unknown compound	1.60E-06	3.03E-01
unknown fatty acid	1.45E-08	2.74E-03
alpha activity *	3.90E-12	7.38E-07
beta activity *	3.53E-12	6.68E-07
suspended solids	6.37E-05	1.21E+01
TDS	7.65E-05	1.45E+01
TOC	7.05E-06	1.33E+00
total carbon	1.49E-05	2.82E+00
TOX (as Cl)	2.00E-07	3.79E-02
ruthenium-106 *	1.29E-11	2.44E-06

Footnotes:

Data collected from October 1989 through March 1990.

Flow rate is the average of rates from the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 33).

Constituent concentrations are average values from the statistics in the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 33).

Concentration units of flagged (*) constituents are reported as curies per liter.

Loading units of flagged (*) constituents are reported as curies per month.

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2.2 1324N/NA POND

Demineralizer-related constituents in vicinity groundwater at this site exceed Group A study guidelines. However, additional or future impacts on soil and groundwater quality due to continued, intermittent use of this facility are judged to be minimal for purposes of this report.

2.2.1 Receiving Site Description

The 1324N/NA Pond, located in the 100-N Area, consists of two facilities: the lined 1324N Surface Impoundment and the unlined 1324NA Percolation Pond. The 1324N Facility was designed to receive corrosive (i.e., untreated) wastewater from the 163N Demineralization Plant and to contain it while it was mixed with acid or caustic until neutralized and then discharged to the 1324NA Percolation Pond. Built in 1977, the 1324NA Percolation Pond receives pH-neutralized wastewater. Since 1983, it has received pH-neutralized wastewater from the 1324N Facility or the Elementary Neutralization Unit which replaced the 1324N Facility in 1988.

In November 1988, use of the 1324N Surface Impoundment was discontinued. This impoundment is undergoing RCRA closure. The 1324NA Percolation Pond continues to receive neutralized wastewater from the Elementary Neutralization Unit or the 163N Demineralization Plant.

Figure 2.2-1 shows the location of the groundwater monitoring wells and the 1324N/NA Pond relative to other facilities in the vicinity.

2.2.2 Effluent Stream Description

The 163N Demineralization Plant uses conventional cation and anion exchangers to produce high quality, demineralized water from filtered Columbia River water. Sulfuric acid and caustic are used to regenerate the ion exchange resins. The regenerating reagents are neutralized in the elementary neutralization unit prior to wastewater discharge. The facility operates in two modes: one associated with ion exchanger regeneration and the other with bypass of the demineralizer system. At present, the 1324NA facility is not receiving any effluent. After the final resin backwash and removal, the 163N Demineralization Plant will not be operated.

Table 2.2-1 summarizes information pertaining to the effluent stream. Table 2.2-2 provides effluent stream sampling data for key constituents. An estimate of constituent loading at 1324NA is included in Table 2.2-3.

Sampling data for the 163N Demineralization Plant showed no constituents that exceeded study guidelines. Effluent constituent concentrations are not expected to change as the demineralizer has been reduced to only intermittent use since April 1990 and at present, except for resin removal, there is no discharge to the 1324NA Percolation Pond.

2.2.3 Flow and Transport Analysis

For transport calculations, the soil column above the water table in the vicinity of the pond is treated as a single layer of coarse sand and gravel (Figure 2.2-2). The calculated travel time to reach groundwater is about 3 days under average previous discharge conditions, extending to several months under recent low discharge rate conditions (Appendix B).

2.2.4 Groundwater Quality Assessment

Eighteen wells (the RCRA interim-status assessment monitoring network for 1301N and 1324NA) were sampled during the period of interest for the effluent for 40 CFR 264 Appendix IX (or equivalent) constituents as well as additional indicator parameters. For the purposes of this evaluation, only the data from the four wells (all RCRA-compliant) immediately adjacent to 1324N/NA have been assessed. The data from these four wells reflect the impacts of the most recent facility operations. Summary data for these four wells are included in Table 2.2-4 of this report. Data summaries for all wells sampled are in Appendix A2 of the Groundwater Characterization Data document (WHC 1990d).

Several constituents from wells immediately adjacent to the pond (Figure 2.2-1) exceed Group A study guidelines (Table 2.2-4). The most significant of these are the demineralization-related constituents (sodium and sulfate). The widespread occurrence of these major constituents at this site is attributed primarily to past operational discharges. With the greatly reduced discharge volumes to this facility, concentrations will decline as the previous contaminant plume moves toward the river in response to the natural groundwater flow regime.

Other constituents exceeding Group A study guidelines include metals that are commonly associated with unfiltered samples from wells with high turbidity and carbon steel casing (WHC 1990d). However, as shown in Table 2.2-4, there are also above-guideline occurrences of certain metals (manganese and aluminum) in the filtered samples. Thus, some of the above-guideline metal occurrences at this site may be related to past disposal activities.

Background comparisons for selected constituents are shown in Table 2.2-5.

2.2.5 Impact of Continued Operation

Current discharge to this disposal facility is only a fraction of previous discharges. The termination of discharge of the 163N Demineralizer wastewater, and the reduced volume input to the pond suggests little if any future impact from this facility.

Figure 2.2-1. Well Location and Site Map for 1324N/NA Pond.

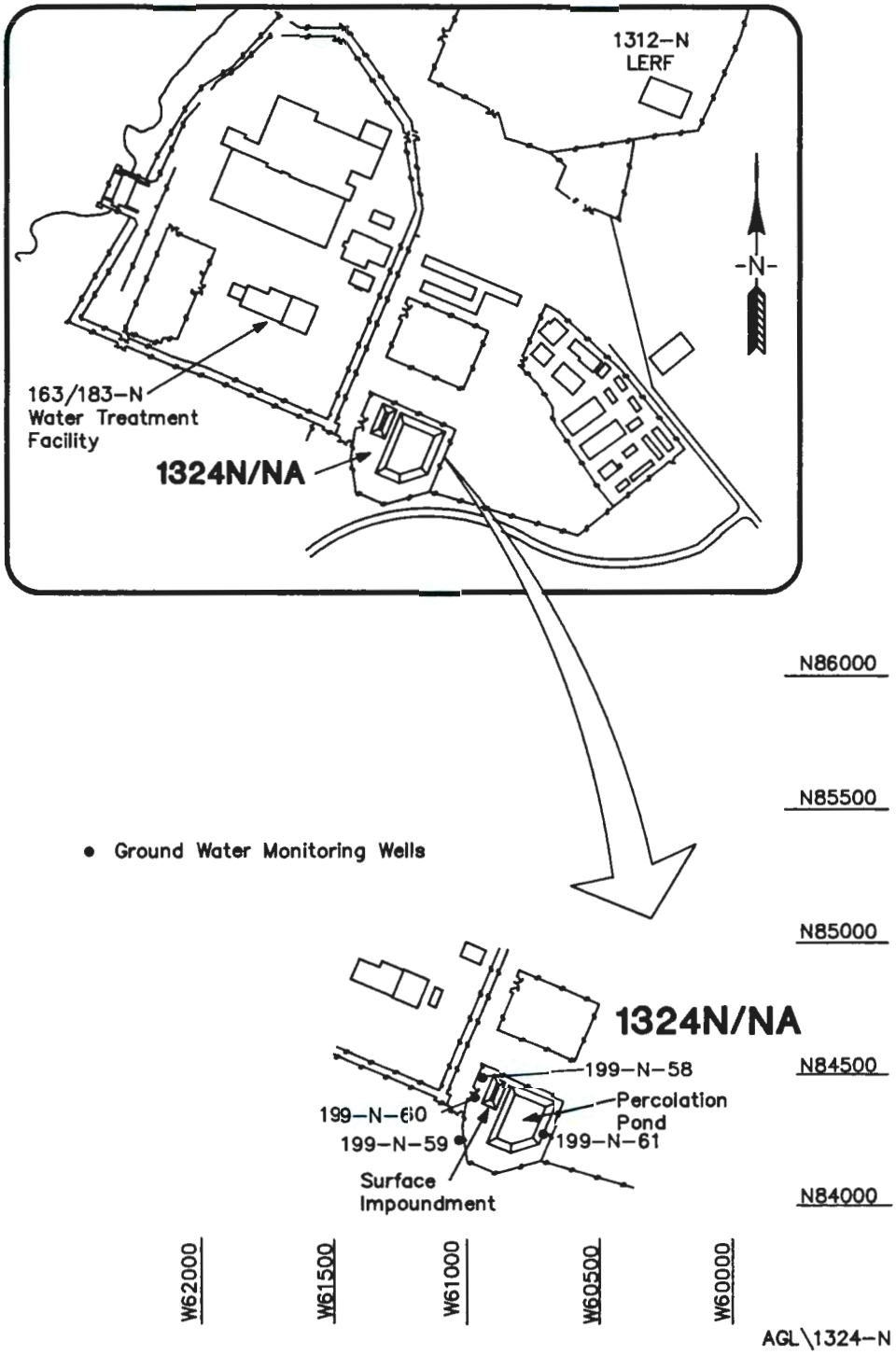

Figure 2.2-2. Lithology of Well 199-N-60 Near the 1324N/NA Pond.

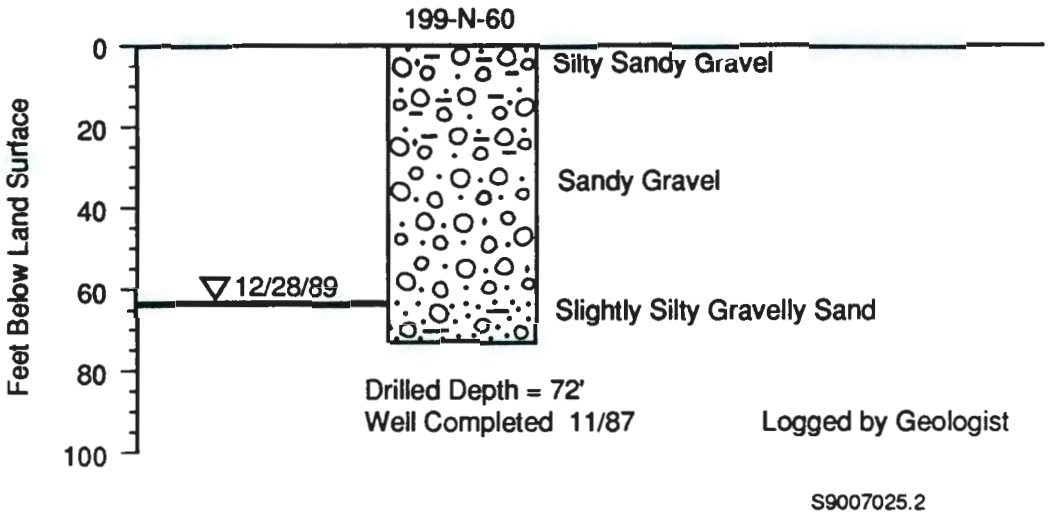

Table 2.2-1. Effluent Stream Description: 163N Demineralizer Wastewater.

Total volume of effluent discharged to subject receiving site:	3.92E+08 gal from 1977 to 3/90[b]
Average effluent discharge rate, by operating mode: (WHC 1990a, WHC-EP-0342, Addendum 4)	Bypass configuration: 1.32E+06 L/mo[a]
Current average effluent discharge rate: (WHC 1990a, WHC-EP-0342, Addendum 4)	Bypass configuration: 1.32E+06 L/mo[a]
Effluent designation: (WHC 1990a, WHC-EP-0342, Addendum 4)	Nondangerous, nonradioactive
Effluent status: (WHC 1990a, WHC-EP-0342, Addendum 4)	Intermittent discharge from 3/90 to 8/90[c] to 1324N/NA Pond

[a]Average flow rate estimated during sampling time period, 10/89 to 3/90. Demineralizer in both regeneration and bypass configurations during sampling time period, however, only sampled during bypass configuration.

[b]Unpublished data, source is plant operating personnel

[c]After the final resin backwash and removal, the 163N Demineralization Plant is not currently planned to be operated (unpublished information, source is plant operating personnel).

Table 2.2-2. Effluent Sampling Data, 163N Demineralizer Wastewater.

Key Constituents	Detection Limit[a]	Detection/ Analyses	Sample Concentration 90% CI[a]	Detection Limit[a]	Detection/ Analyses	Sample Concentration 90% CI[a]
	01/88 to 09/88, During Routine Operation			10/89 to 03/90, During Routine Operation		
None	None			None		

[a]Units: chemical--parts per billion
radionuclides--picocurie per liter.

CI: confidence interval.

Table 2.2-3. Radionuclide and Chemical Loading, 163N Demineralizer Plant Wastewater.

Flow Rate: 1.32E+06 L/mo[a]

Constituent	Kg/L*	Kg/mo*
barium	2.25E-08	2.98E-02
boron	2.85E-08	3.77E-02
calcium	1.42E-05	1.88E+01
chloride	1.25E-06	1.65E+00
fluoride	1.70E-07	2.25E-01
magnesium	3.44E-06	4.55E+00
nitrate	5.00E-07	6.61E-01
potassium	5.11E-07	6.76E-01
silicon	1.86E-06	2.46E+00
sodium	1.69E-06	2.24E+00
strontium	6.60E-08	8.73E-02
sulfate	1.58E-05	2.09E+01
zinc	1.20E-08	1.59E-02
ammonia	2.36E-07	3.12E-01
hydrazine	5.90E-08	7.80E-02
trichloromethane	1.10E-08	1.45E-02
beta activity *	2.85E-11	3.77E-05
TDS	4.70E-05	6.22E+01
total carbon	1.54E-05	2.04E+01
TOX (as Cl)	4.30E-08	5.69E-02
cesium-137 *	1.29E-11	1.71E-05

Footnotes:

[a]Loading calculated only for bypass mode using an approximate flow rate of 8 gal/min during October 1989 through March 1990 sampling period.

Data collected from October 1989 through March 1990.

Flow rate is the average of rates from the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 4).

Constituent concentrations are average values from the statistics in the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 4).

Concentration units of flagged (*) constituents are reported as curies per liter.

Loading units of flagged (*) constituents are reported as curies per month.

Table 2.2-4. Groundwater Analysis Results for 1324N/NA Pond. (Page 1 of 2)

CONSTITUENT			ANALYSIS SUMMARY					GROUP A STUDY GUIDELINES	
Group Name	Units	Detection Limit	Number of Analyses	Number > Det.	Average Result	Maximum Result	Minimum Result	Max Limit	Number > Limit
CONTAMINATION INDICATOR PARAMETERS									
Conductivity, Laboratory	UMHO	1.00	58	58	2318.10	3890.00	1120.00	700.0	58
Specific conductance	UMHO	1.00	77	77	2127.69	3910.00	1037.00	700.0	77
Total Organic Halogen, Low Det. Level	PPB	10.00	64	62	23.08	137.00	9.00		0
Total organic carbon	PPB	2000.00	43	5	1300.00	2300.00	700.00		0
pH, Field Measurement		.10	68	68	7.25	7.82	6.46	8.5	0
pH, Laboratory Measurement		.01	47	47	7.15	8.00	5.86	8.5	0
DRINKING WATER PARAMETERS									
Alpha, High Detection Level	PCI/L	4.00	24	1	1.14	5.53	-1.83	15.0	0
Barium	PPB	6.00	29	29	32.21	53.00	11.00	1000.0	0
Barium, filtered	PPB	6.00	28	28	31.21	52.00	13.00	1000.0	0
Cadmium, filtered	PPB	2.00	24	1	2.04	3.00	2.00	10.0	0
Chromium	PPB	10.00	28	16	12.57	26.00	10.00	50.0	0
Coliform (Membrane Filter)	PPB	1.00	15	1	1.07	2.00	1.00	1.0	1
Fluoride	PPB	500.00	26	23	2157.69	3900.00	500.00	4000.0	0
Gross beta	PCI/L	8.00	24	2	4.36	11.70	.59	50.0	0
Nitrate	PPB	500.00	28	28	2896.79	5200.00	1600.00	45000.0	0
GROUNDWATER QUALITY PARAMETERS									
Chloride	PPB	500.00	26	26	6676.92	14000.00	2500.00	250000.0	0
Iron	PPB	30.00	28	24	100.57	356.00	30.00	300.0	2
Iron, filtered	PPB	30.00	25	3	31.48	50.00	30.00	300.0	0
Manganese	PPB	5.00	27	17	38.52	212.00	5.00	50.0	5
Manganese, filtered	PPB	5.00	24	6	32.00	208.00	5.00	50.0	4
Sodium	PPB	200.00	29	29	450793.10	1010000.00	218000.00		0
Sodium, filtered	PPB	200.00	29	29	445034.48	972000.00	236000.00		0
Sulfate	PPB	500.00	29	29	1173758.62	2180000.00	495000.00	250000.0	29
SITE SPECIFIC AND OTHER PARAMETERS									
Alkalinity		20000.00	4	4	69000.00	94000.00	46000.00		0
Aluminum	PPB	150.00	25	4	168.16	379.00	150.00	50.0	4
Aluminum, filtered	PPB	150.00	25	2	161.92	302.00	150.00	50.0	2

Table 2.2-4. Groundwater Analysis Results for 1324N/NA Pond. (Page 2 of 3)

CONSTITUENT			ANALYSIS SUMMARY					GROUP A STUDY GUIDELINES	
Group Name	Units	Detection Limit	Number of Analyses	Number > Det.	Average Result	Maximum Result	Minimum Result	Max Limit	Number > Limit
SITE SPECIFIC AND OTHER PARAMETERS									
Beryllium	PPB	5.00	25	3	5.24	8.00	5.00		0
Beryllium, filtered	PPB	5.00	24	1	5.04	6.00	5.00		0
Bis(2-ethylhexyl) phthalate	PPB	10.00	8	2	10.75	15.00	10.00		0
Boron	PPB	10.00	28	28	20.75	39.00	11.00		0
Boron, filtered	PPB	10.00	29	28	20.38	35.00	10.00		0
Calcium	PPB	50.00	28	28	120089.29	302000.00	24000.00		0
Calcium, filtered	PPB	50.00	29	29	116486.21	292000.00	25600.00		0
Chloroform	PPB	5.00	18	15	7.78	15.00	3.00	100.0	0
Copper	PPB	10.00	24	2	10.17	12.00	10.00	1000.0	0
Lithium	PPB	10.00	25	3	10.20	14.00	10.00		0
Lithium, filtered	PPB	10.00	25	3	10.16	12.00	10.00		0
Magnesium	PPB	50.00	29	29	24032.07	55000.00	6060.00		0
Magnesium, filtered	PPB	50.00	29	29	23511.72	53200.00	6260.00		0
Nickel	PPB	10.00	25	3	10.20	13.00	10.00		0
Potassium	PPB	100.00	29	29	5026.55	10100.00	1540.00		0
Potassium, filtered	PPB	100.00	29	29	5011.38	9510.00	1650.00		0
Silicon	PPB	50.00	29	29	12988.28	18200.00	5570.00		0
Silicon, filtered	PPB	50.00	29	29	12997.59	18700.00	5950.00		0
Strontium	PPB	10.00	29	29	459.03	1050.00	127.00		0
Strontium, filtered	PPB	10.00	29	29	457.69	995.00	135.00		0
Turbidity	NTU	.10	16	16	1.34	4.50	.20	5.0	0
Uranium	PCI/L	.50	24	23	1.61	5.88	.45	40.0	0
Vanadium	PPB	5.00	24	3	5.04	6.00	5.00		0
Vanadium, filtered	PPB	5.00	25	4	5.20	8.00	5.00		0
Zinc	PPB	5.00	28	17	9.39	27.00	5.00	5000.0	0
Zinc, filtered	PPB	5.00	26	12	8.65	25.00	5.00	5000.0	0

Table 2.2-5. Background Comparison, 1324N/NA Ponds.

Constituent	Background[a]	Average/ Background[b]	Maximum/ Background[b]
aluminum	2.0	84.08 (80.96)	189.50 (151.00)
ammonia	50.0		
arsenic	6.3		
barium	62.0	0.52 (0.50)	0.85 (0.84)
beryllium	0.3	17.47 (16.80)	26.67 (20.00)
bismuth	0.02		
boron	50.0	0.41 (0.41)	0.78 (0.70)
cadmium	0.2	(10.20)	(15.00)
calcium	50,700	2.37 (2.30)	5.96 (5.76)
chloride	16,800	0.40	0.83
chromium	6.0	2.10	4.33
copper	1.0	10.17	12.00
cyanide	10		
fluoride	470	4.59	8.30
lead	0.5		
magnesium	15,200	1.58 (1.55)	3.62 (3.50)
manganese	12.0	3.21 (2.67)	17.67 (17.33)
mercury	0.1		
nickel	4.0	2.55	3.25
phosphate	1,000		
potassium	6,190	0.81	1.63
selenium	2.0		
silver	10		
sodium	28,410	15.87 (15.66)	35.55 (34.21)
strontium	338	1.36 (1.35)	3.11 (2.94)
sulfate	51,200	22.92	42.58
uranium	2.5	0.64	2.35
vanadium	26	0.19 (0.20)	0.23 (0.31)
zinc	8.0	1.17 (1.08)	3.38 (3.13)
alkalinity	144,000	0.48	0.65
pH	7.8	0.93	1.00
TOC	933	1.39	2.47
conductivity	462	4.61	8.46
gross alpha	3.9	0.29	1.42
gross beta	31	0.14	0.38
radium	0.2		

TOC: total organic carbon. ( ): filtered samples.

[a]Background is the mean plus one standard deviation for the values listed in Table 2-1. Amounts of uranium, gross alpha, gross beta, and radium given in picocuries per liter. All others are in parts per billion.

[b]Average and maximum values from Table 2.2-4.

2.3 1325N CRIB

Discharge of N Reactor effluent to the 1325N Crib has contributed contaminants in excess of Group A study guidelines to the groundwater underlying the site. However, no significant additional impact on soil and groundwater quality is likely under the current (dry layup) operating mode due to the greatly reduced discharge to the crib.

2.3.1 Receiving Site Description

The 1325N Crib and Trench, located in the 100-N Area, has been the primary liquid effluent receiving site for N Reactor effluent since 1985. At that time, it replaced the 1301N Crib and trench. The 1325N Crib first received effluent in 1983; the 1325N Trench, which is divided into four sections, was added in 1986. Only the first of the four sections of the trench has received effluent flow, and then only on two occasions. Figure 2.3-1 depicts the location of the crib, trench, and monitoring wells relative to other facilities in the vicinity.

2.3.2 Effluent Stream Description

The N Reactor effluent consists primarily of cooling water and decontamination flush water used at various points within the system. Radioactive contamination of the wastewater contributors occurs during reactor operations. Sources of these radioactive constituents include activation products produced in the primary coolant system and fission products that result from occasional fuel cladding failures. Chemical contamination can occur as a result of corrosion products and residuals remaining following reactor decontamination activities.

The N Reactor was operated from December 1963 until January 1987, when it was placed in "cold standby" status. In early 1990, the N Reactor was placed in "dry layup" status. Wastewater flow rates and concentrations of contaminants have decreased as a result of each change in status.

Information on the effluent stream is given in Table 2.3-1. Table 2.3-2 provides effluent sampling data for key constituents. Crib loading information is provided in Table 2.3-3.

The sample analytical data indicate that effluent discharges contain numerous radionuclides in concentrations which, in most cases, greatly exceed Group A study guideline concentrations. Note that disposal to the crib began in 1983 but the old radiological data set included some samples taken prior to 1983. While concentrations of these constituents have decreased since the N Reactor was placed in dry layup, concentrations of some radioactive constituents remain high as a result of residual contamination remaining in the system. The loading data indicate that tritium, strontium-90, and cesium-137 are the principal radionuclides being discharged which each exceed 1 Ci/mo.

Chemical sampling data indicate that only iron exceeds Group A study guidelines in the old data set.

2.3.3 Flow and Transport Analysis

For transport calculations, the soil column or vadose zone beneath the 1325N Crib is assumed to be a single layer of sand and gravel (Figure 2.3-2). Depth to the water table beneath the crib is estimated to be 15 m. The calculated wastewater travel time through the vadose zone with a simple analytical model is 4 days, based on the average (past) discharge rate to the crib (Appendix B). Analysis of vadose zone travel time using a more sophisticated numerical model, VAM2DH, indicates a travel time of 4 days (see Appendix D).

To estimate contaminant migration rates, the wastewater discharged to the crib is characterized as neutral to basic (pH = 7.8) and is low in both organic and inorganic constituents. Under these conditions (Appendix C), most of the cationic constituents tend to be immobile (e.g., calculated migration rates on the order of 1 to 3 cm/day; see Appendix B). Tritium and the anionic constituents (iodine-131 and ruthenium-106) are treated as nonsorbing, for which a migration rate equivalent to water is assumed (approximately 360 cm/day; Appendix B).

These migration rate estimates correspond to travel times through the vadose zone of 500 to 4,200 days for the "immobile" contaminants and 4 days for the mobile contaminants. At the current discharge rate (Table 2.3-1), estimated contaminant travel times are proportionately longer (Appendix B).

A more detailed numerical unsaturated/saturated flow and solute transport model was also used to estimate contaminant transport at this site. A discussion of these results is provided in Appendix D.

2.3.4 Groundwater Quality Assessment

Several constituents in monitoring well samples exceeded Group A study guidelines (Table 2.3-4). However, of these, only strontium-90 and tritium are major key constituents in recent N Reactor effluent (Table 2.3-2, cold standby period). The above-guideline occurrences of metals and PCB indicated in Table 2.3-4 are attributed to artifacts of well construction and/or sampling equipment (Smith and Gorst 1990). For example, 12 out of 13 wells sampled were older wells constructed with carbon steel casing, which is subject to corrosion. The source of PCB was traced to the submersible pump(s) in use in the monitoring wells (i.e., after an old pump was replaced, the PCB concentration in water samples from the well were below the detection limit (Smith et al. 1990). Additional sampling and analysis details are contained in Liquid Effluent Study: Ground Water Characterization Data (WHC 1990d).

Acetone, a key effluent constituent (Table 2.3-2), was detected in only one of 53 groundwater sample analyses; thus, the presence of this constituent in vicinity groundwater at the 1325N Crib is questionable.

Zinc is judged to be the only potentially significant occurrence among those constituents exceeding the Group B guidelines (see Table 2.3-5). The other constituents exceeding Group B (ratios >1) are attributed to well casing and/or sampling artifacts (WHC 1990d). It should also be noted that a number of constituents are below the guidelines (ratios <1), indicating

either dilution of groundwater by the effluent and or mixing with river water from past high river stages.

The zinc anomaly noted does not appear to be related to the current effluent composition (e.g., an average effluent concentration of only 11 ppb). Since 14 of 54 filtered samples yielded positive results (up to a maximum of 91 ppb), these occurrences appear to be real. An additional check for possible sources (e.g., galvanized pump tubing, etc.) may be needed.

The origin and distribution of strontium-90 noted previously has been extensively evaluated for operational, RCRA and site-wide surveillance programs (e.g., see Perkins 1988, Serkowski and Jordan 1989, Smith and Gorst 1990). The contaminant plume from the 1325N Crib travels about 2,000 ft to the Columbia River where it emerges in the N-Springs. The strontium-90 concentration in N-Springs water has progressively increased since 1980 to a maximum of approximately 8,000 pCi/L in 1988-89 (see Appendix D for solute transport analysis at this site). Although the estimated groundwater travel time from the cribs to the stream bank is approximately 30 days (Appendix D), strontium-90 migrates at a much slower rate due to interaction with aquifer solids. The increasingly higher concentrations observed at the N-Springs over the last few years represents the arrival or "front" of the contaminant plume that originated at the 1301N Crib in 1963 when the crib was placed into service. (The 1301N Crib was phased out in September 1985 after which all N Reactor effluent went to the 1325N Crib.) The observations and modeling results presented in Appendix D suggest that strontium-90 has spread throughout the aquifer between the cribs and shoreline and will attenuate in N-Springs water at a very slow rate; approximately 20 yr to decline to one-half the maximum value observed today, based on steady-state predictions (Appendix D).

2.3.5 Impact of Continued Operation

2.3.5.1 Volume Impact. Although N Reactor is in dry layup, wastewater has and may still be discharged to the 1325N Crib from those few systems still in service for fire protection and radiation protection. Future discharge volumes, however, will be significantly lower than during the operational mode and should have little impact on the local groundwater flow regime. For example, the groundwater mound in the vicinity of this crib nearly disappeared during 1989 (Hartman 1990), reflecting the lower effluent discharge rates. This should slow the rate of contaminant migration through the aquifer to N-Springs and decrease the amount of strontium-90 added to the Columbia River. However, even with complete termination of effluent discharge to this crib, strontium-90 and other contaminants stored in the aquifer will still move toward and be released from the N-Springs area. This would be caused by the natural groundwater movement toward the river and the influence that the rise and fall of the river levels have on the local hydrology.

A more rigorous modeling and analysis of various discharge scenarios at this site is being conducted in support of the N-Springs Stabilization and Treatment Study which will be completed in FY 91.

2.3.5.2 Groundwater Quality. Future groundwater quality in the immediate vicinity of the crib should improve as the strontium-90 concentrations slowly decline and tritium flushes from the system. However, since strontium-90 has already appeared in the aquifer, slow migration toward the N-Springs will result in the long-term presence of this contaminant between the crib and N-Springs. As noted above, the strontium-90 contribution from 1325N Crib will merge with the past input from 1301N Crib. It should also be noted that the N-Springs area is treated as a direct discharge to the river and is regulated under a National Pollutant Discharge Elimination System permit (Rokkan 1988). The offsite radiation dose from this source is estimated to be less than 1 mrem/yr (Jacquish and Bryce 1989). The annual dose from the strontium-90 release at N-Springs will be calculated as part of the N-Springs Stabilization and Treatment Study and compared to previously derived doses.

2.3.5.3 Remobilization. While it is evident (Section 2.3.3) that many key constituents (cationic radionuclides) are retained on the soil column, it is unlikely that continued discharge to the crib at the current reduced rate (Table 2.3-1) will cause remobilization of these constituents. The high cesium-137 concentration in past effluent, for example, and its conspicuous absence in groundwater samples support this conclusion. Strontium-90 on the other hand, as noted, has already broken through the soil column. This contaminant would continue to be leached from the soil column to groundwater with and without continued use of the crib. The much lower expected (future) discharge to the crib than during the operating mode would reduce this effect.

Figure 2.3-1. 1325N Liquid Waste Disposal Facility.

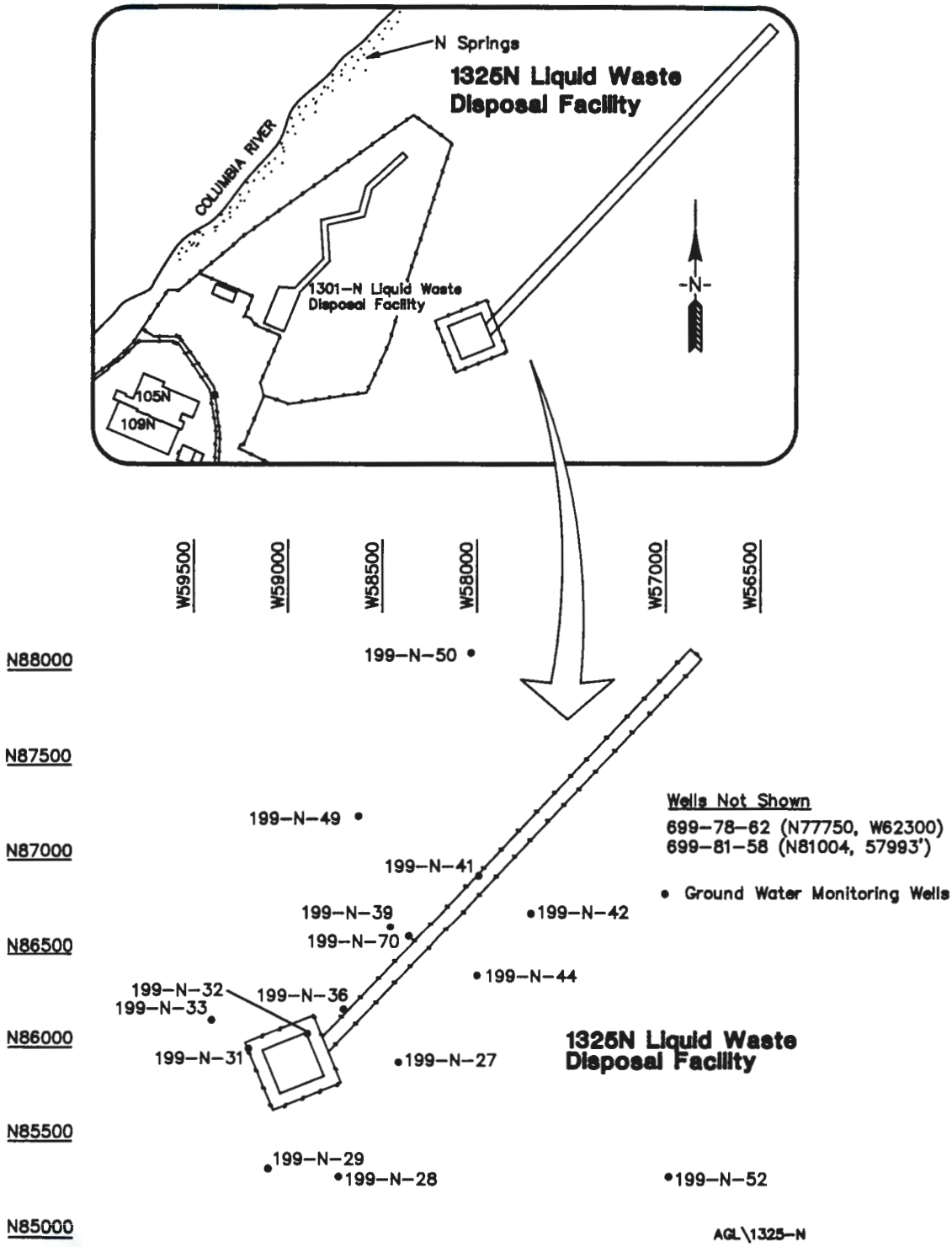

Figure 2.3-2. Lithology of Well 199-N-70 Near the 1325N Crib.

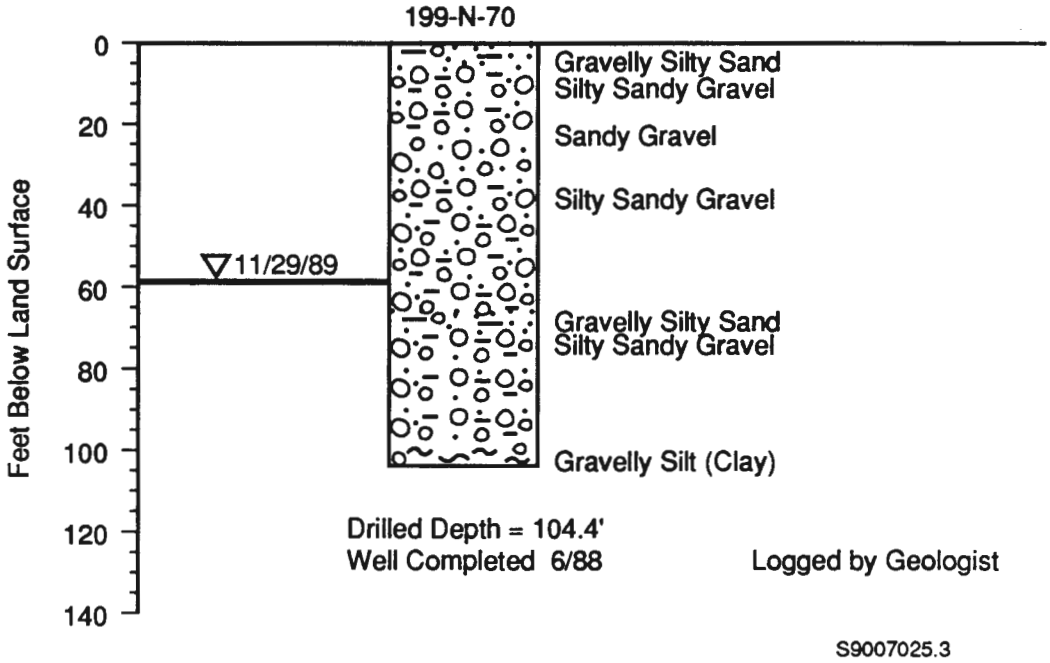

Table 2.3-1. Effluent Stream Description, N Reactor Effluent.

Total volume of effluent discharged to subject receiving site:	7.15E+09 L from 1/83 to 4/90[c]
Average effluent discharge rate, by operating mode: (WHC 1990a, WHC-EP-0342, Addendum 3)	Operating: approximately 1,300 gal/min from 1985 to 07/87[a] Cold standby: approximately 300 to 1,600 gal/min from 7/87 to 3/90 Dry layup: less than 100 gal/min since 3/90
Current average effluent discharge rate: (WHC 1990a, WHC-EP-0342, Addendum 3)	Approximately 300 gal/min[b] Dry layup: less than 100 gal/min since 3/90
Effluent designation: (WHC 1990a, WHC-EP-0342, Addendum 3)	Nondangerous, radioactive
Effluent status: (WHC 1990a, WHC-EP-0342, Addendum 3)	Effluent currently active; N Reactor in dry layup status. Discharge to 1325N Crib

[a]Based on average flow rate during last full year of N Reactor operation. Pre-1987 flow rate averaged 1,000 to 1,600 gal/min during normal operations.

[b]Average flow rate in cold standby mode during sampling period 10/89 to 3/90.

[c]Unpublished data, source is plant operating personnel.

Table 2.3-2. Effluent Stream Sampling Data, N Reactor Effluent.

Key Constituents	Detection Limit[a]	Detection/ Analyses	Sample Concentration 90% CI[a]	Detection Limit[a]	Detection/ Analyses	Sample Concentration 90% CI[a]
	03/88 to 08/88, During Cold Standby			10/89 to 03/90, During Cold Standby		
iron	30	4/4	420	30	4/4	296[b]
	1976 to 1988, During Routine Operation[c]			10/89 to 03/90, During Cold Standby		
hydrogen-3	1,000	206/NA	110,000	100	3/3	198,000
manganese-54	10	231/NA	64,000	NA	3/3	604[b]
iron-59	10	86/NA	22,000	NA	ND	ND
cobalt-60	10	236/NA	41,000	1	3/3	700
zinc-65	100	12/NA	2,500	NA	ND	ND
strontium-89	100	121/NA	74,000	NA	ND	ND
strontium-90	200	205/NA	33,000	0.1	2/4	176,000
ruthenium-106	100	9/NA	31,000	50	1/4	1,720
iodine-131	100	91/NA	160,000	NA	ND	ND
cesium-134	10	96/NA	1,500	NA	2/2	167
cesium-137	10	236/NA	42,000	1	3/3	47,000
lanthanum-140	10	102/NA	910,000	NA	ND	ND
plutonium-239	0.1	206/NA	420	0.001	3/3	66
americium-241	20	ND	ND	NA	3/4	70
phosphorus-32	NA	136/NA	4,500	NA	ND	ND
cobalt-58	NA	16/NA	3,300	NA	ND	ND
zirconium-95	NA	79/NA	11,000	NA	ND	ND
niobium-95	NA	118/NA	23,000	NA	ND	ND
molybdenum-99	NA	73/NA	400,000	NA	ND	ND
ruthenium-103	NA	100/NA	7,600	NA	ND	ND
antimony-124	NA	4/NA	1,600	NA	ND	ND
antimony-125	NA	8/NA	5,000	NA	ND	ND
barium-140	NA	99/NA	48,000	NA	ND	ND
cerium-141	NA	72/NA	15,000	NA	ND	ND
plutonium-238	NA	201/NA	64	NA	3/3	11
lead-210	NA	ND	ND	NA	1/3	3

[a]Units: chemical--parts per billion
radionuclides--picocurie per liter.
[b]Concentrations below Group A study guidelines; values given for purposes of comparison.
[c]Disposal of effluent to the 1325N Crib began in 1983; thus, this data set includes some samples taken prior to 1983.

CI: confidence interval.
NA: not available.
ND: not detected.

Table 2.3-3. Effluent Stream Sampling Data, N Reactor Effluent.

Flow Rate: 4.95E+07 L/mo

Constituent	Kg/L*	Kg/mo*
barium	3.67E-08	1.82E+00
boron	6.12E-08	3.03E+00
cadmium	2.00E-09	9.90E-02
calcium	1.16E-05	5.74E+02
chloride	1.13E-06	5.59E+01
fluoride	1.48E-07	7.33E+00
iron	2.53E-07	1.25E+01
magnesium	2.90E-06	1.44E+02
manganese	6.75E-09	3.34E-01
nitrate	4.02E-07	1.99E+01
potassium	4.75E-07	2.35E+01
silicon	1.48E-06	7.33E+01
sodium	1.53E-06	7.57E+01
strontium	5.95E-08	2.95E+00
sulfate	1.06E-05	5.25E+02
uranium	1.96E-09	9.70E-02
zinc	1.07E-08	5.30E-01
acetone	9.78E-09	4.84E-01
ammonia	1.82E-07	9.01E+00
benzoic acid	1.10E-07	5.45E+00
1-butanol	2.70E-08	1.34E+00
2-butanone	1.72E-08	8.51E-01
butylated hydroxy toluene	1.07E-08	5.30E-01
hydrazine	3.05E-08	1.51E+00
MIBK (hexone)	1.01E-08	5.00E-01
toluene	5.08E-09	2.51E-01
trichloromethane	4.85E-09	2.40E-01
unknown	4.70E-08	2.33E+00
unknown glycol	2.80E-08	1.39E+00
unknown hydrocarbon	1.90E-07	9.41E+00
unknown oxygenated PAH	9.00E-09	4.45E-01
unknown phthalate	9.00E-09	4.45E-01
alpha activity *	2.94E-11	1.46E-03
beta activity *	7.03E-08	3.48E+00
TDS	3.97E-05	1.97E+03
TOC	7.25E-07	3.59E+01
total carbon	8.53E-06	4.22E+02
TOX (as Cl)	1.80E-08	8.91E-01
americium-241 *	3.48E-11	1.72E-03
curium-242 *	1.67E-13	8.27E-06
curium-244 *	3.68E-13	1.82E-05
cobalt-60 *	4.36E-10	2.16E-02
cesium-134 *	9.43E-11	4.67E-03
cesium-137 *	2.29E-08	1.13E+00
carbon-14 *	2.22E-12	1.10E-04
hydrogen-3 *	1.02E-07	5.05E+00
manganese-54 *	3.19E-10	1.58E-02
lead-210 *	1.22E-12	6.04E-05
plutonium-238 *	4.82E-12	2.39E-04
plutonium-239/240 *	3.62E-11	1.79E-03
Radium Total *	1.78E-13	8.81E-06
ruthenium-106 *	4.63E-10	2.29E-02
strontium-90 *	8.40E-08	4.16E+00
uranium-234 *	1.34E-12	6.63E-05
uranium-235 *	1.51E-13	7.47E-06
uranium-238 *	9.12E-13	4.51E-05

Footnotes:

Data collected from October 1989 through March 1990.

Flow rate is the average of rates from the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 3).

Constituent concentrations are average values from the statistics in the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 3).

Concentration units of flagged (*) constituents are reported as curies per liter.

Loading units of flagged (*) constituents are reported as curies per month.

Table 2.3-4. Groundwater Analysis Results for 1325N Crib (1989-1990). (Page 1 of 3).

CONSTITUENT			ANALYSIS SUMMARY					GROUP A STUDY GUIDELINES	
Group Name	Units	Detection Limit	Number of Analyses	Number > Det.	Average Result	Maximum Result	Minimum Result	Max Limit	Number > Limit
CONTAMINATION INDICATOR PARAMETERS									
Conductivity, Laboratory	UMHO	1.00	150	150	164.73	390.00	106.00	700.0	0
Specific conductance	UMHO	1.00	144	144	167.71	343.00	98.00	700.0	0
Total Organic Halogen, Low Det. Level	PPB	10.00	181	89	33.38	498.00	-1.00		0
Total organic carbon	PPB	2000.00	117	1	717.09	2300.00	100.00		0
pH, Field Measurement		.10	152	152	8.08	9.00	7.20	8.5	7
pH, Laboratory Measurement		.01	91	91	8.15	8.53	7.70	8.5	2
DRINKING WATER PARAMETERS									
Arsenic	PPB	5.00	53	23	5.87	14.00	5.00	50.0	0
Arsenic, filtered	PPB	5.00	53	17	5.42	7.00	5.00	50.0	0
Barium	PPB	6.00	56	56	15.79	71.00	7.00	1000.0	0
Barium, filtered	PPB	6.00	57	57	14.47	31.00	7.00	1000.0	0
Cadmium	PPB	2.00	53	1	2.02	3.00	2.00	10.0	0
Cadmium, filtered	PPB	2.00	55	1	2.02	3.00	2.00	10.0	0
Chromium	PPB	10.00	54	9	11.83	66.00	10.00	50.0	1
Chromium, filtered	PPB	10.00	56	7	13.27	81.00	10.00	50.0	2
Gross beta	PCI/L	8.00	59	53	337.38	2970.00	.87	50.0	33
Lead (graphite furnace)	PPB	5.00	53	1	5.08	9.00	5.00	50.0	0
Nitrate	PPB	500.00	58	58	6256.84	28800.00	500.00	45000.0	0
Nitrate, High Detection Level	PPB	2500.00	9	7	5144.44	12100.00	2500.00	45000.0	0
GROUNDWATER QUALITY PARAMETERS									
Chloride	PPB	500.00	56	56	1806.61	10300.00	600.00	250000.0	0
Iron	PPB	30.00	58	51	603.43	13500.00	30.00	300.0	14
Iron, filtered	PPB	30.00	56	7	40.79	439.00	30.00	300.0	1
Manganese	PPB	5.00	56	17	12.80	240.00	5.00	50.0	2
Manganese, filtered	PPB	5.00	56	2	5.21	14.00	5.00	50.0	0
Sodium	PPB	200.00	58	58	4015.86	16300.00	1140.00		0
Sodium, filtered	PPB	200.00	61	61	4222.30	17900.00	1230.00		0
Sulfate	PPB	500.00	56	56	14798.21	55700.00	7300.00	250000.0	0

Table 2.3-4. Groundwater Analysis Results for 1325N Crib (1989-1990). (Page 2 of 3).

CONSTITUENT			ANALYSIS SUMMARY					GROUP A STUDY GUIDELINES	
Group Name	Units	Detection Limit	Number of Analyses	Number > Det.	Average Result	Maximum Result	Minimum Result	Max Limit	Number > Limit
SITE SPECIFIC AND OTHER PARAMETERS									
Acetone by VOA	PPB	10.00	54	1	10.52	45.00	5.00		0
Alkalinity		20000.00	4	4	95250.00	116000.00	64000.00		0
Aluminum	PPB	150.00	53	5	282.06	5550.00	150.00	50.0	5
Ammonium ion	PPB	50.00	59	2	50.93	90.00	50.00		0
Antimony-125	PCI/L	48.00	2	2	90.10	93.60	86.60	2000.0	0
Arochlor 1016	PPB	1.00	29	6	10.23	148.00	1.00	.5	6
Arochlor 1221	PPB	1.00	27	1	1.08	3.21	1.00	.5	1
Beryllium	PPB	5.00	54	2	5.06	7.00	5.00		0
Beryllium, filtered	PPB	5.00	56	1	5.05	8.00	5.00		0
Bis(2-ethylhexyl) phthalate	PPB	10.00	22	1	10.62	19.60	10.00		0
Boron	PPB	10.00	59	58	24.95	54.00	10.00		0
Boron, filtered	PPB	10.00	60	57	24.05	50.00	10.00		0
Calcium	PPB	50.00	58	58	21525.86	39400.00	17100.00		0
Calcium, filtered	PPB	50.00	61	61	21875.41	40200.00	16600.00		0
Chloroform	PPB	5.00	56	18	6.14	21.00	3.00	100.0	0
Cobalt-60	PCI/L	22.50	56	15	18.12	51.50	-3.84	200.0	0
Copper	PPB	10.00	53	1	10.13	17.00	10.00	1000.0	0
Fluoride, Low Detection Level	PPB	20.00	11	11	198.00	280.00	155.00	4000.0	0
Magnesium	PPB	50.00	58	58	4618.28	10600.00	2790.00		0
Magnesium, filtered	PPB	50.00	61	61	4716.07	11400.00	2660.00		0
Methyl ethyl ketone	PPB	10.00	53	3	9.64	18.00	3.00		0
Nickel	PPB	10.00	54	5	18.81	479.00	10.00		0
Nickel, filtered	PPB	10.00	56	2	10.29	19.00	10.00		0
Potassium	PPB	100.00	58	58	2525.34	4690.00	1330.00		0
Potassium, filtered	PPB	100.00	61	61	2531.97	5000.00	1230.00		0
Silicon	PPB	50.00	59	59	9728.31	27300.00	4800.00		0
Silicon, filtered	PPB	50.00	61	61	9542.95	15800.00	4540.00		0
Strontium	PPB	10.00	59	59	117.24	235.00	72.00		0
Strontium, filtered	PPB	10.00	59	59	121.51	271.00	70.00		0
Strontium-90	PCI/L	5.00	56	32	195.37	1750.00	-.48	40.0	26
Titanium	PPB	60.00	53	2	66.92	420.00	60.00		0
Total carbon	PPB	1000.00	23	23	15417.39	23900.00	11400.00		0

Table 2.3-4. Groundwater Analysis Results for 1325N Crib (1989-1990). (Page 3 of 3).

CONSTITUENT			ANALYSIS SUMMARY					GROUP A STUDY GUIDELINES	
Group Name	Units	Detection Limit	Number of Analyses	Number > Det.	Average Result	Maximum Result	Minimum Result	Max Limit	Number > Limit
SITE SPECIFIC AND OTHER PARAMETERS									
Total dissolved solids		5000.00	12	12	105041.67	227000.00	70000.00	500000.0	0
Tritium	PCI/L	500.00	57	52	63742.89	260000.00	-44.20	80000.0	16
Turbidity	NTU	.10	43	40	7.81	200.00	.10	5.0	4
Unknown	PPB	0.00	3	3	25.67	33.00	20.00		0
Unknown Aliphatic Hydrocarbon	PPB		10	10	32.60	58.00	21.00		0
Uranium	PCI/L	.50	59	33	.71	6.46	.29	40.0	0
Vanadium	PPB	5.00	57	48	15.42	58.00	5.00		0
Vanadium, filtered	PPB	5.00	60	52	13.68	33.00	5.00		0
Zinc	PPB	5.00	58	30	167.09	8800.00	5.00	5000.0	1
Zinc, filtered	PPB	5.00	57	14	9.54	91.00	5.00	5000.0	0

Table 2.3-5. Background Comparisons, 1325N Crib.

Constituent	Background[a]	Average/ Background[b]	Maximum/ Background[b]
aluminum	2.0	141.03	2,775.00
ammonia	50.0	1.02	1.80
arsenic	6.3	0.93 (0.86)	2.22 (1.11)
barium	62.0	0.25 (0.23)	1.15 (0.5)
beryllium	0.3	16.87 (16.87)	23.33 (26.67)
bismuth	0.02		
boron	50.0	0.50 (0.48)	1.08 (1.00)
cadmium	0.2	1.01 (1.01)	15.00 (15.00)
calcium	50,700	0.42 (0.43)	0.78 (0.79)
chloride	16,800	0.11	0.61
chromium	6.0	1.97 (2.21)	11.00 (13.50)
copper	1.0	10.13	17.00
cyanide	10.0		
fluoride	470.0	0.42	0.60
lead	0.5	10.16	18.00
magnesium	15,200	0.30 (0.31)	0.70 (0.75)
manganese	12.0	1.07 (0.43)	20.00 (1.17)
mercury	0.1		
nickel	4.0	4.70 (2.57)	119.75 (4.75)
phosphate	1,000		
potassium	6,190	0.41 (0.41)	0.76 (0.81)
selenium	2.0		
silver	10		
sodium	28,410	0.14 (0.15)	0.57 (0.63)
strontium	338	0.35 (0.36)	0.70 (0.80)
sulfate	51,200	0.29	1.09
uranium	2.5		
vanadium	26	0.59 (0.53)	2.23 (1.27)
zinc	8.0	20.89 (1.19)	1,100.00 (11.38)
alkalinity	144,000	0.66	0.81
pH	7.8	1.04	1.15
TOC	933	0.77	2.47
conductivity	462	0.36	0.74
gross alpha	3.9		95.81
gross beta	31	10.88	
radium	0.2		

TOC: total organic carbon. ( ): filtered samples.

[a]Background is the mean plus one standard deviation for the values listed in Table 2-1. Amounts of uranium, gross alpha, gross beta, and radium given in picocuries per liter. All others are in parts per billion.

[b]Average and maximum values from Table 2.3-4.

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2.4 216-A-8 CRIB

No adverse impact on groundwater quality is expected from the projected wastestream contaminant loadings predicted for this crib. However, there is uncertainty concerning the status of a potentially large residual organic load and radionuclide inventory from past disposal operations. A volume restriction may be needed to avoid potential breakthrough.

2.4.1 Receiving Site Description

The 216-A-8 Crib, located in the 200 East Area (Figure 2.4-1), has been in operation since 1955. Prior to 1976, the site received wastewater consisting primarily of steam condensate from waste storage tanks in the 241-A and 241-AX Tank Farms. From January through April 1978, the site received 241-A, 241-AX, and 241-AY Tank Farm steam condensate. In October 1983, the site was reactivated to receive the 241-AY and 241-AZ Tank Farm steam condensate. From October 1983 to March 1984, the crib was inactive; flow was diverted to tanks due to high radiation alarms. In March 1984, the site was again reactivated to receive the 241-AY/AZ steam condensate. In early 1985, flow was again diverted from the crib to double-shell tanks. Condensate has not been discharged to the crib since early 1985. Current efforts are being made toward resuming crib discharge in the future pending upgrades to the discharge configuration. The locations of monitoring wells and spatial relationship to other facilities are shown in Figure 2.4-1.

2.4.2 Effluent Stream Description

The 241-AY and 241-AZ Tank Farm steam condensates are generated when steam is condensed in coils that are used to periodically heat wastes in the tanks of the 241-AY and 241-AZ Tank Farms. The steam condensate flow rate is variable, depending on the amount of steam used and the number of tanks being heated. Table 2.4-1 summarizes the effluent stream characteristics. Table 2.4-2 provides effluent stream sampling data for key constituents. Radionuclide and chemical loading information is provided in Table 2.4-3.

Analyses of the 241-AY/AZ Tank Farm condensate are available from only one sample in the old data set. The data show that the acetone concentration exceeded the Group C guidelines.

Radionuclide constituents strontium-90, cesium-137, and uranium isotopes exceeded Group A study guidelines by significant margins (1983 to 1989 period in Table 2.4-2).

2.4.3 Flow and Transport Analysis

A simplified soil column consisting of three layers or soil types is used to simulate the stratigraphic information depicted in Figure 2.4-2. These layers are: (1) coarse sand extending for 7 m beneath the bottom of the crib, (2) a 3-m-thick layer of sand and silt below the coarse sand, and (3) a 62-m thickness of coarse sand and gravel beneath the sand and silt layer. Based on an average discharge rate of 1.2 L/sec distributed over the areal dimensions of the crib, travel time is calculated to be 242 days (see

Appendix B for computational details). Contaminant mobility is estimated using this travel time and the retardation factors summarized in Appendix C.

The estimated migration rate for the mobile key constituent (acetone) is 30 cm/day and 0.2, 0.3, and 1.2 cm/day for cesium-137, uranium, and strontium-90, respectively (Appendix B).

It should be noted that the above estimates are based on many conservative assumptions regarding liquid movement in the soil column that could lead to overestimates of the actual migration rates (see Appendix B). It should also be recognized that any unexpected changes in chemical conditions in the waste-stream (e.g., acid spill, complexants, etc.) could increase the migration rates for strontium and cesium significantly.

2.4.4 Groundwater Quality Assessment

Several analytes in samples from the two monitoring wells at this facility exceeded Group A study guidelines; only one of which (uranium) was a key effluent constituent (Table 2.4-2). The above-guideline occurrences are attributed to either artifacts of well construction and/or sampling (i.e., unfiltered, bailed samples from carbon steel wells; see WHC 1990d), or past-practice upgradient operations (i.e., uranium, as discussed below).

Since no liquid has been discharged to this crib since 1985, current groundwater contamination should be due primarily to adjacent facilities and/or upgradient disposal activities. For example, positive occurrences (Table 2.4-4) of tritium, uranium, iodine-129, and nitrate are widespread as these are commonly occurring contaminants related to past operations.

Several constituents exceed background or Group B guidelines (Table 2.4-5). Some of the metals in this group are attributed to well construction materials and/or because the bailed samples were unfiltered and acidified. However, no explanation is readily apparent for other above-background occurrences (e.g., vanadium, arsenic, and barium).

2.4.5 Impact of Continued Operation

The average flow rate of 1.2 L/sec compared to the natural Cold Creek recharge rate of 28 L/sec suggests operation of this crib would have an insignificant impact on the local groundwater flow regime.

Based on current or recent effluent characteristics (volume, chemistry, and contaminant load) and the migration rate estimates presented in Section 2.4.3, it is highly unlikely that groundwater quality would be adversely impacted by discharge of tank farm steam condensate to this crib. However, this crib has previously received several hundred curies of cesium-137, strontium-90, cobalt-60, and other short-lived radionuclides for which remobilization needs to be considered (WHC 1989a). For example, gross gamma logs (WHC 1989a) suggest a maximum depth of penetration of cesium-137 of approximately 30 m beneath the bottom of the crib after over 20 yr of active use and addition of over a billion liters of wastewater. (Recent spectral gamma logs at this site confirm the assumption the gross gamma results are due to cesium-137.) The maximum input rate (continuous operation) of

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1.2 L/sec over 4 yr of proposed use would result in: 1.2 L/sec*3.15E+07 sec/yr*4 yr = 1.5E+08 L or about 10% of the total previous discharge to this crib. The incremental effect of discharge volumes of this magnitude on movement of previous contaminant loads on the soil column can be estimated using the flow and transport information in Section 2.4.3. This approach is illustrated for selected constituents in Figure 2.4-3. Except for strontium-90, discharge volumes in this range would result in only a few meters of additional movement of previous loads. However, to avoid potential breakthrough of the existing strontium-90 load, Figure 2.4-3 suggests the total additional volume of wastewater to the crib not exceed about 10,000,000 L.

It should be noted that Figure 2.4-3 is based on many simplifying assumptions and that it is also assumed that no perturbations in wastestream chemical composition or loss of well integrity occur during the proposed operating period. Nevertheless, it is noteworthy that the predicted depth of penetration (approximately 20 m) for cesium-137 at the total discharge volume previously added to the crib (i.e., 1.15E+09 L; see illustration in Figure 2.4-3) is in fair agreement with the results indicated by gamma log data from wells at the 216-A-8 Crib (i.e., maximum observed penetration depth of approximately 30 m). More rigorous modeling and additional (spectral) gamma logs are needed to confirm the latter preliminary observation. However, the apparent concurrence between observed and predicted cesium movement lends support to the approach used to estimate migration rates. These estimates provide reasonable assurance that continued operations, under conditions described above, should have minimal impact on additional radioactive waste movement in the soil column, or should at least be controllable to an acceptable degree (i.e., optimize pH and restrict discharge rate to achieve only a few meters or less of additional movement).

Less certain, however, is the status of the large quantities of hexone and dibutyl phosphate (DBP) added during an earlier or past-practice period. For example, the Hanford Site Waste Information Data System hazardous chemical inventory sheet indicates 130,000 kg of DBP and 50,000 kg of hexone were added to this crib (WHC 1989, p. A.4-21). The environmental behavior data for these chemicals (Appendix C) suggest DBP would be moderately sorbed whereas hexone apparently exhibits little affinity for sediments. It is highly likely that this input occurred several years ago. Considering the moderately rapid migration rate of mobile contaminants (Section 2.4.3), this large organic load may have already been flushed from the soil column. Additionally, biodegradation may in part help to mitigate the impact of these waste constituents (Appendix C).

Figure 2.4-1. Well Location and Site Map for 218-A-8 Crib.

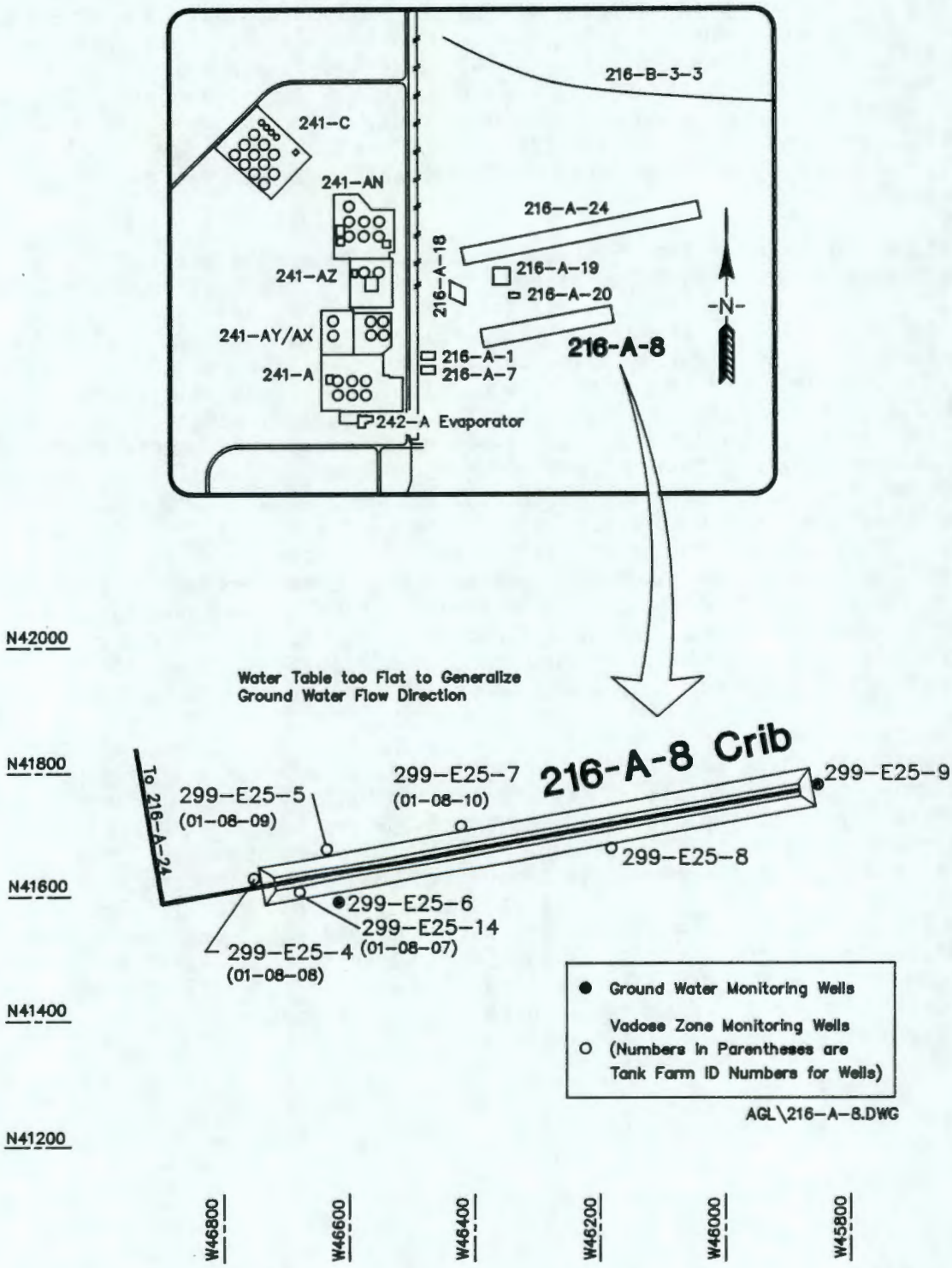

Figure 2.4-2. Lithology of Well 299-E25-9 Near the 216-A-8 Crib.

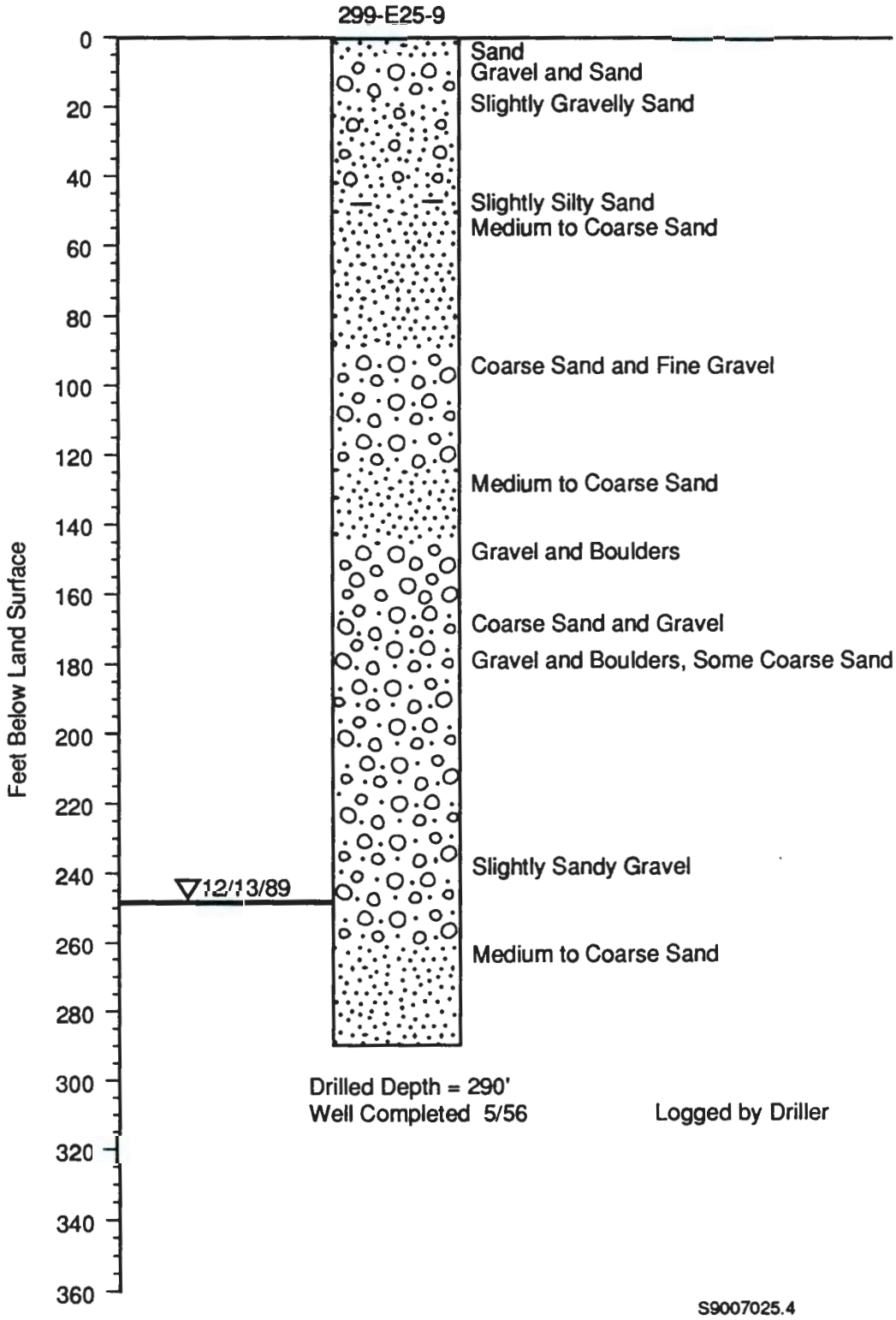

Figure 2.4-3. Theoretical Penetration Depth Versus Wastewater Discharge to 216-A-8 Crib (assumes discharge rate of 1.2 L/sec; retardation factor [R_f] derived from data in Appendix C).

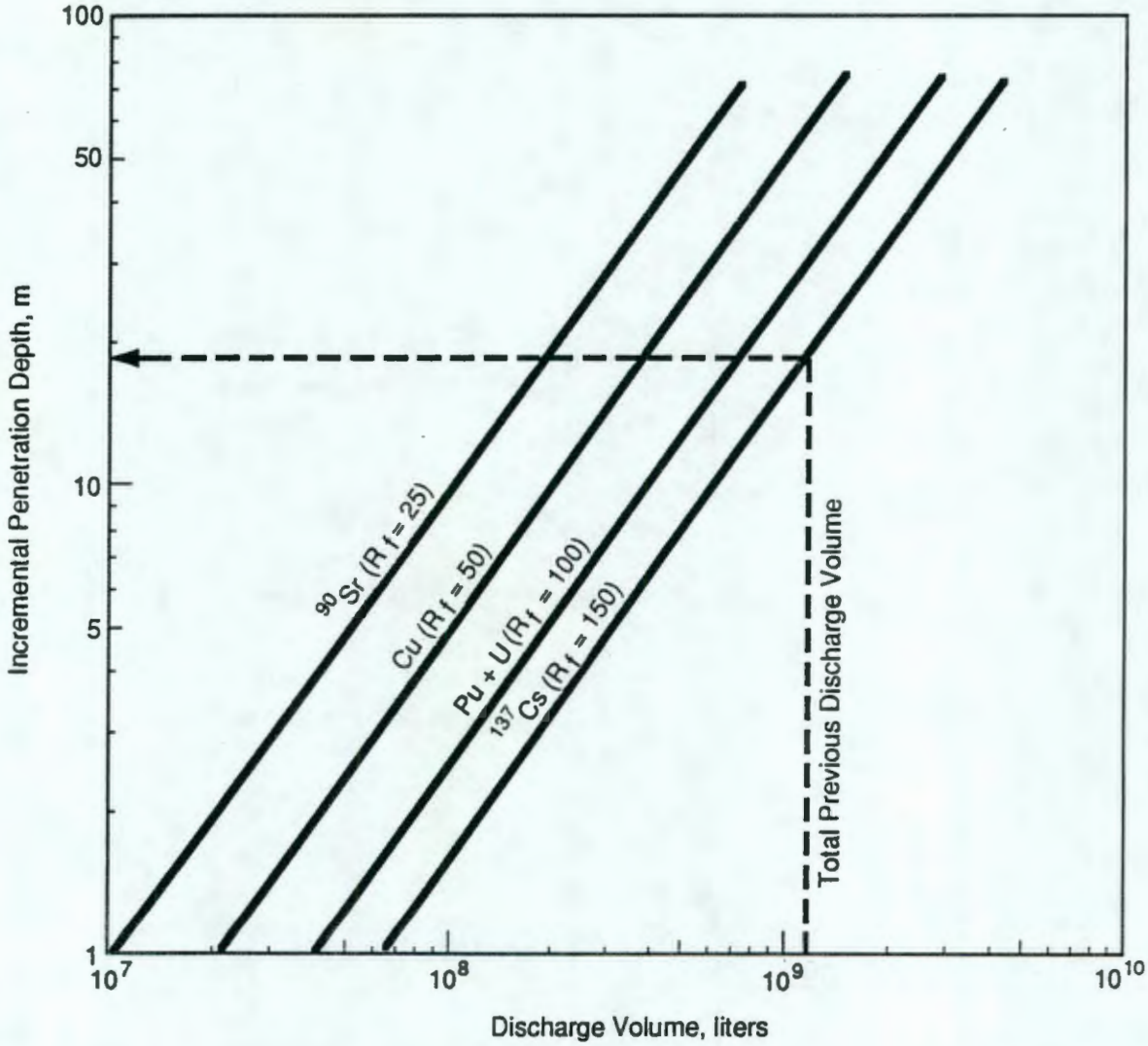

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Table 2.4-1. Effluent Stream Description, 241-AY/AZ Tank Farm Condensate.

Total volume of effluent discharged to subject receiving site: (WHC 1989a, WHC-EP-0287, Volume 2)	1.15E+09 L from 12/55 to 2/85
Average effluent discharge rate, by operating mode: (WHC 1990a, WHC-EP-0342, Addendum 30)	1.14E+05 L/mo
Current average effluent discharge rate: (WHC 1990a, WHC-EP-0342, Addendum 30)	None to site
Effluent designation: (WHC 1990a, WHC-EP-0342, Addendum 30)	Nondangerous, radioactive
Effluent status: (WHC 1990a, WHC-EP-0342, Addendum 30)	Routed to double-shell tanks; no discharge to site

Table 2.4-2. Effluent Stream Sampling Data, 241-AY/AZ Tank Farm Condensate.

Key Constituents	Detection Limit[a]	Detection/ Analyses	Sample Concentration 90% CI[a]	Detection Limit[a]	Detection/ Analyses	Sample Concentration 90% CI[a]
	10/11/88 One Sample, During Routine Operation			10/89 to 03/90, During Routine Operation		
acetone	10	1/1	86	No Data		
	1983 to 1989, During Routine Operation			10/89 to 03/90, During Routine Operation		
strontium-90	30	7/NA	12,000	No Data		
cesium-137	80	7/NA	42,000			
uranium (isotopes)[b]	20	2/NA	220			

[a]Units: chemical--parts per billion
radionuclides--picocurie per liter.

[b]Uranium-234 Group A study guideline used as the most restrictive for determination of key constituents.

CI: confidence interval.
NA: not available.

Table 2.4-3. Radionuclide and Chemical Loading, 241-AY/AZ Tank Farm Steam Condensate.

Flow Rate: 1.14E+05 L/mo

Constituent	Kg/L*	Kg/mo*
calcium	1.42E-07	1.61E-02
copper	3.70E-08	4.20E-03
iron	8.90E-08	1.01E-02
manganese	2.30E-08	2.61E-03
nitrate	1.70E-06	1.93E-01
uranium	3.93E-10	4.46E-05
zinc	8.00E-09	9.08E-04
acetone	8.60E-08	9.77E-03
ammonia	5.00E-07	5.68E-02
2-butanone	1.30E-08	1.48E-03
beta activity *	1.75E-10	1.99E-05
TOC	1.10E-06	1.25E-01

Footnotes:

Data collected during October 1988.

Condensate routed to double-shell tanks since 1985.

Flow rate is the average of rates from the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 30).

Constituent concentrations are average values from the statistics in the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 30).

Concentration units of flagged (*) constituents are reported as curies per liter.

Loading units of flagged (*) constituents are reported as curies per month.

Table 2.4-4. Groundwater Analysis Results, 216-A-8 Crib, 1989 to 1990 (page 1 of 2).

CONSTITUENT			ANALYSIS SUMMARY					GROUP A STUDY GUIDELINES	
Group Name	Units	Detection Limit	Number of Analyses	Number > Det.	Average Result	Maximum Result	Minimum Result	Max Limit	Number > Limit
CONTAMINATION INDICATOR PARAMETERS									
Conductivity, Laboratory	UMHO	1.00	4	4	234.00	242.00	220.00	700.0	0
Specific conductance	UMHO	1.00	4	4	222.75	256.00	203.00	700.0	0
pH, Field Measurement		.10	4	4	8.27	8.64	7.80	8.5	1
pH, Laboratory Measurement		.01	4	4	7.75	7.80	7.60	8.5	0
DRINKING WATER PARAMETERS									
Arsenic	PPB	5.00	2	2	18.00	21.00	15.00	50.0	0
Barium	PPB	6.00	2	2	265.50	289.00	242.00	1000.0	0
Cadmium	PPB	2.00	2	2	68.00	81.00	55.00	10.0	2
Chromium	PPB	10.00	2	2	141.50	153.00	130.00	50.0	2
Gross beta	PCI/L	8.00	13	2	5.58	8.18	3.05	50.0	0
Lead (graphite furnace)	PPB	5.00	2	2	14.00	19.00	9.00	50.0	0
Nitrate	PPB	500.00	4	4	1525.00	1700.00	1400.00	45000.0	0
Nitrate, High Detection Level	PPB	2500.00	4	1	2750.00	3500.00	2500.00	45000.0	0
Radium	PCI/L	1.00	2	1	1.01	1.52	.49	100.0	0
GROUNDWATER QUALITY PARAMETERS									
Chloride	PPB	500.00	4	4	3475.00	4000.00	3000.00	250000.0	0
Iron	PPB	30.00	2	2	259500.00	312000.00	207000.00	300.0	2
Manganese	PPB	5.00	2	2	2010.00	2090.00	1930.00	50.0	2
Sodium	PPB	200.00	2	2	14500.00	14600.00	14400.00		0
Sulfate	PPB	500.00	4	4	17775.00	23400.00	14100.00	250000.0	0
SITE SPECIFIC AND OTHER PARAMETERS									
Aluminum	PPB	150.00	2	2	4630.00	4730.00	4530.00	50.0	2
Ammonium ion	PPB	50.00	2	1	73.50	97.00	50.00		0
Boron	PPB	10.00	2	2	35.00	46.00	24.00		0
Calcium	PPB	50.00	2	2	35450.00	35900.00	35000.00		0
Cobalt	PPB	20.00	2	2	22.00	24.00	20.00		0
Copper	PPB	10.00	2	2	70.00	75.00	65.00	1000.0	0
Iodine-129 (Drinking Water Standard)	PCI/L	1.00	2	2	4.42	4.53	4.31	20.0	0
Magnesium	PPB	50.00	2	2	8315.00	8590.00	8040.00		0

Table 2.4-4. Groundwater Analysis Results, 216-A-8 Crib, 1989 to 1990 (page 2 of 2).

CONSTITUENT			ANALYSIS SUMMARY					REGULATORY STANDARDS	
Group Name	Units	Detection Limit	Number of Analyses	Number > Det.	Average Result	Maximum Result	Minimum Result	Max Limit	Number > Limit
SITE SPECIFIC AND OTHER PARAMETERS									
Natural uranium	UG/L	.73	2	2	3.02	3.76	2.27	59.0	0
Nickel	PPB	10.00	2	2	84.00	89.00	79.00		0
Potassium	PPB	100.00	2	2	5185.00	5190.00	5180.00		0
Silicon	PPB	50.00	2	2	39950.00	44800.00	35100.00		0
Strontium	PPB	10.00	2	2	167.00	173.00	161.00		0
Titanium	PPB	60.00	2	2	442.00	461.00	423.00		0
Total carbon	PPB	1000.00	2	2	20800.00	21300.00	20300.00		0
Tritium	PCI/L	500.00	10	10	4517.00	8620.00	2600.00	80000.0	0
Turbidity	NTU	.10	2	2	155.50	200.00	111.00	5.0	2
Uranium	PCI/L	.50	2	2	1.73	1.94	1.52	40.0	0
Vanadium	PPB	5.00	2	2	335.50	336.00	335.00		0
Zinc	PPB	5.00	2	2	30.00	36.00	24.00	5000.0	0

Table 2.4-5. Background Comparison, 216-A-8 Crib.

Constituent	Background[a]	Average/ Background[b]	Maximum/ Background[b]
aluminum	2.0	2,315.00	2,365.00
ammonia	50.0	1.47	1.94
arsenic	6.3	2.86	3.33
barium	62.0	4.28	4.66
beryllium	0.3		
bismuth	0.02		
boron	50.0	0.70	0.92
cadmium	0.2	340.00	405.00
calcium	50,700	0.70	0.71
chloride	16,800	0.21	0.24
chromium	6.0	23.58	25.50
copper	1.0	70.00	75.00
cyanide	10.0		
fluoride	470		
lead	0.5	28.00	38.00
magnesium	15,200	0.55	0.57
manganese	12.0	167.50	174.17
mercury	0.1		
nickel	4.0	21.00	22.25
phosphate	1,000		
potassium	6,190	0.84	0.84
selenium	2.0		
silver	10		
sodium	28,410	0.51	0.51
strontium	338	0.49	0.51
sulfate	51,200	0.35	0.46
uranium	2.5	0.69	0.78
vanadium	26	12.90	12.92
zinc	8.0	3.75	4.50
alkalinity	144,000		
pH	7.8	1.06	1.11
TOC	933		
conductivity	462	0.48	0.55
gross alpha	3.9		
gross beta	31	0.18	0.26
radium	0.2	5.05	7.60

TOC: total organic carbon.

[a]Background is the mean plus one standard deviation for the values listed in Table 2-1. Amounts of uranium, gross alpha, gross beta, and radium given in picocuries per liter. All others are in parts per billion.

[b]Average and maximum values from Table 2.4-4.

2.5 216-A-29 DITCH

Replacement of this open wastewater conveyance system with a pipeline is planned for the near future. No significant additional impacts on soil and groundwater quality in the vicinity of the 216-A-29 Ditch are expected from its continued use during the interim period.

2.5.1 Receiving Site Description

The 216-A-29 Ditch was constructed in 1955 to convey the PUREX chemical sewer line (CSL) wastestream (liquid wastes from the 202-A [PUREX] chemical sewer and acid fractionator) to the 216-B-3 Pond System. Figure 2.5-1 shows the location of the ditch relative to nearby facilities and the location of groundwater monitoring wells.

2.5.2 Effluent Stream Description

The PUREX CSL, which flows into the 216-A-29 Ditch, consists of cooling water and heating steam condensate from the vacuum fractionator, and a mixture of wastewaters which originate in nonradiologically controlled source areas. The nonradiologically controlled sources include ventilation system effluents, other steam condensates, cooling water from air compressors, overflow from the sanitary water high tank, and a raw water addition. The CSL sometimes contains regenerate from the ion exchange beds, and can contain room drainage and overflow from the chemical sewer system. At one time, the vacuum fractionator, which processes radionuclide-containing liquids, used an atmospheric condenser whose overheads flowed into the CSL. This configuration was later changed when shell and tube condensers were added, resulting in fewer contaminants being discharged to the CSL. There are two operating modes for the CSL: ion exchanger regeneration and routine operation. Table 2.5-1 summarizes effluent stream information. Table 2.5-2 shows key constituents from sampling data, and Table 2.5-3 provides data on loadings.

Sampling data during PUREX operations showed several chemical constituents which were above Group A or C study guidelines, with the greater number of constituents resulting from the ion exchanger regeneration mode. As explained in the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 2), acetone is thought to originate from the degradation of organic deionizer resins.

Several radionuclides were found from the old data set in concentrations slightly above Group A study guidelines. While the concentrations do not greatly exceed the guidelines, they do indicate that radioactive materials have entered this wastestream. The new data, which represent PUREX operations during stabilization, show no radionuclides above study guidelines, and only two chemical constituents resulting from operations during stabilization.

2.5.3 Flow and Transport Analysis

The soil column beneath the 216-A-29 Ditch is modeled as a two-layer system consisting of 2 m of sand and silt underlain by a 76-m layer of coarse sand (Figure 2.5-2). The calculated wastewater travel time under average discharge conditions is 417 days (see Appendix B for computational details). Corresponding travel times for the key constituents are several years for the radionuclides and 417 days for the mobile constituents (acetone and sulfate). With the exception of the mobile constituents, the migration rate or travel time estimates (Appendix B) suggest most of the chemical/radionuclide load from past input is very likely high in the soil column. The more mobile (nondegradable) key constituents should be observable in vicinity groundwater. For example, sulfate should be detectable while acetone is subject to biodegradation (10-day degradation half-time [Appendix C] in relation to a 417-day estimated travel time).

2.5.4 Groundwater Quality Assessment

Of the key constituents, only iron and aluminum exceeded Group A study guidelines in vicinity monitoring wells (Table 2.5-4), both of which are attributed to casing corrosion and/or related factors (WHC 1990d). Excluding the metals-related anomaly noted above, sulfate is the only important occurrence above Group B guidelines (background) related to waste disposal operations. Larger departures from background also occur for beryllium and copper for which no explanation is apparent (Table 2.5-5).

The maximum sulfate of about four times the background threshold (Group B guidelines) may be related to the expected breakthrough of sulfate indicated in Section 2.5.3.

Iodine-129 and tritium were also detected. However, these occurrences are a result of past disposal activities from adjacent facilities. In any event, it would not be possible to distinguish a 216-A-29 source from ambient sources.

2.5.5 Impact of Continued Operation

The average effluent flow rate (Table 2.5-1) indicated for this conveyance system is about double the natural recharge rate of Cold Creek. However, perturbation of the groundwater flow regime due to the 216-B-3 Pond System masks any contribution from the 216-A-29 Ditch.

Based on existing groundwater quality data, and assuming no major change in wastestream composition in the future, only marginally significant impact on groundwater quality is expected (sulfate/demineralizer waste constituents).

Planned rerouting of this stream directly to the 216-B-3 Pond System through a pipeline will eliminate the 216-A-29 Ditch as a potential contaminant source in the near future (summer 1991).

Figure 2.5-1. Well Location and Site Map, 216-A-29 Ditch.

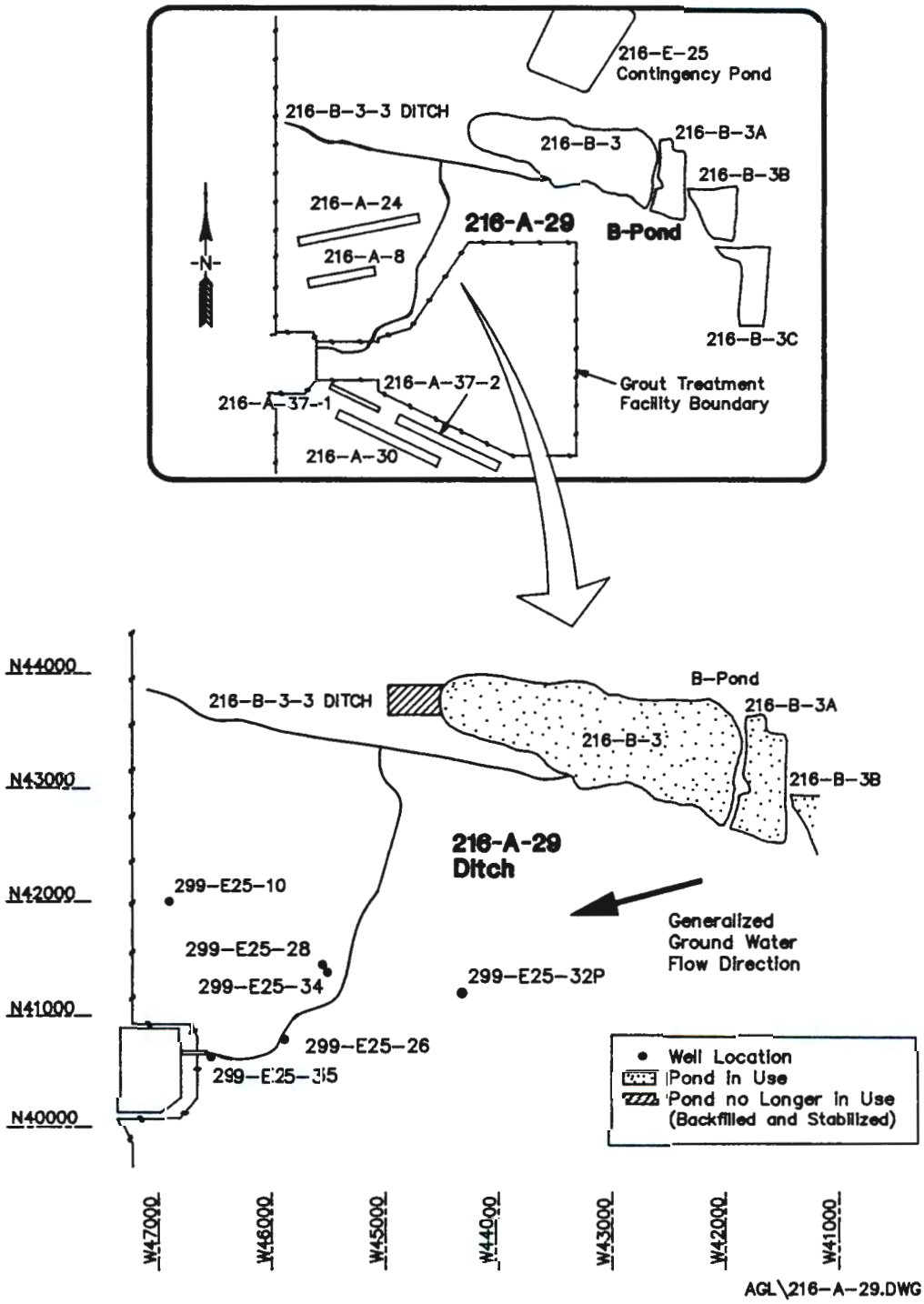


Figure 2.5-2. Lithology of Well 299-E25-28 Near the 216-A-29 Ditch.

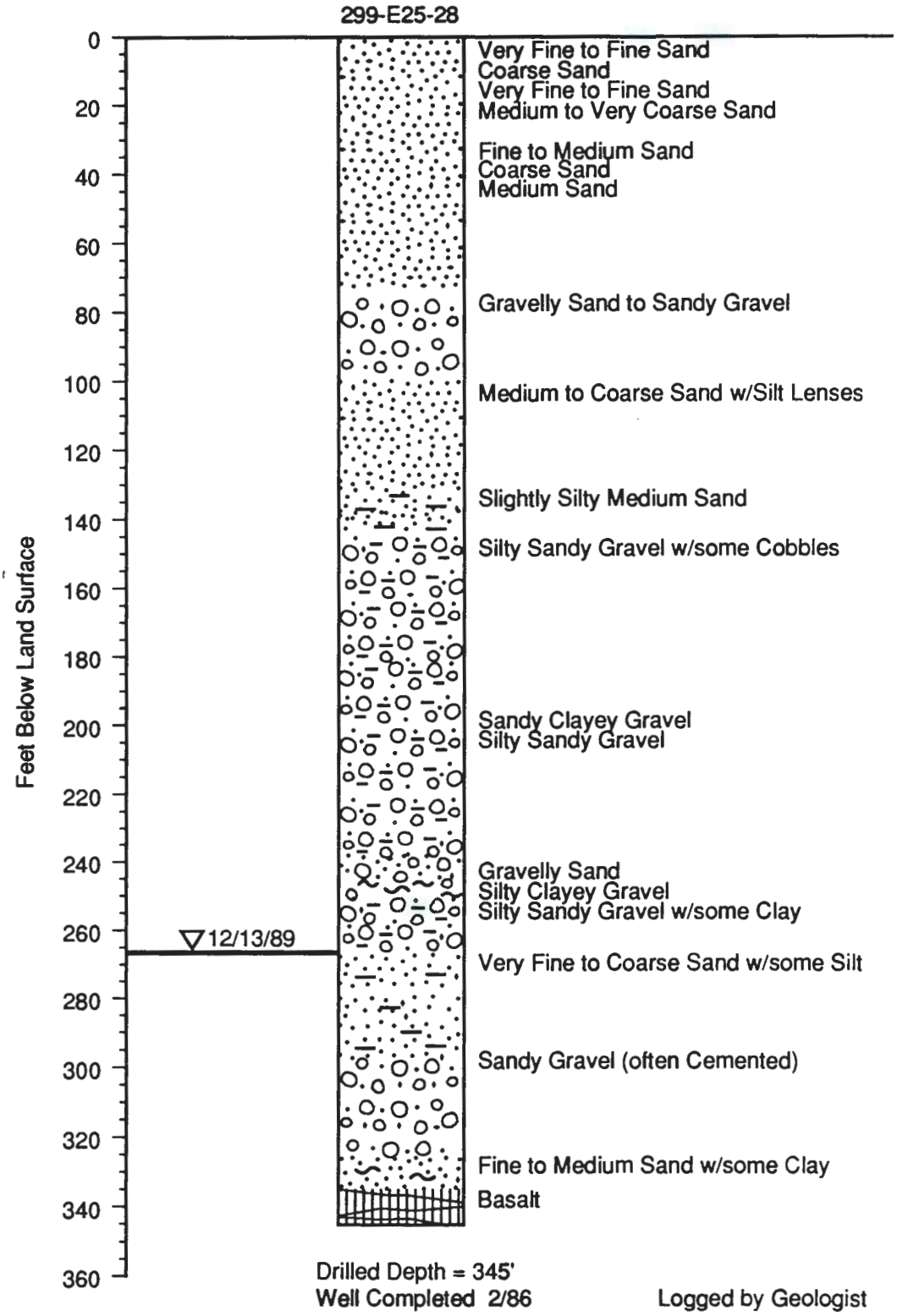


Table 2.5-1. Effluent Stream Description, PUREX Chemical Sewer.

Total volume of effluent discharged to subject receiving site: (WHC 1989, WHC-EP-0287, Volume 2)	1.04E+10 L from 1/76 to 12/88
Average effluent discharge rate, by operating mode: (WHC 1990a, WHC-EP-0342, Addendum 2)	Routine: 1.65E+08 L/mo Ion exchanger regeneration: 1.8E+08 L/mo
Current average effluent discharge rate: (WHC 1990a, WHC-EP-0342, Addendum 2)	7.67E+07 L/mo[a]
Effluent designation: (WHC 1990a, WHC-EP-0342, Addendum 2)	Nondangerous, nonradioactive
Effluent status:	Plant in shutdown mode: currently discharging to 216-A-29 Ditch

[a]Average flow rate during sampling 10/89 to 3/90.

Table 2.5-2. Effluent Stream Sampling Data, PUREX Chemical Sewer.

Key Constituents	Detection Limit[a]	Detection/ Analyses	Sample Concentration 90% CI[a]	Detection Limit[a]	Detection/ Analyses	Sample Concentration 90% CI[a]
	08/86 to 03/88, During IX Regenerate			10/89 to 03/90, During IX Regenerate		
acetone	10	3/3	150	No Data		
nitrate	500	2/5	70,300			
chloroform	5	2/5	240			
aluminum	NA	3/5	500			
cadmium	2	3/5	11			
copper	NA	3/5	1,310			
iron	30	5/5	675			
manganese	5	5/5	58			
sulfate	500	5/5	1,470,000			
	08/85 to 04/87, During Routine Operation			10/89 to 03/90, During Stabilization		
aluminum	NA	1/5	200	NA	1/6	341
iron	30	5/5	140[b]	30	6/6	443
acetone	10	2/5	340	10	ND	ND
	1976 to 1988, During All Modes			10/89 to 03/90, During Stabilization		
strontium-90	30	25/NA	150	0.1	ND	ND
cesium-137	80	12/NA	330	NA	1/6	0.5[b]
americium-241	40	1/NA	48	0.001	4/6	0.2[b]
promethium-147	NA	8/NA	4,300	NA	ND	ND
uranium (isotopes)[c]	20	4/NA	150	NA	4/4	0.4[b,d]
plutonium-239	50	35/NA	6	0.001	4/4	0.5[b]

[a]Units: chemical--parts per billion
radionuclides--picocurie per liter.

[b]Concentration below Group A and C study guidelines; value given for comparison purposes only.
[c]Uranium-234 Group A study guideline used as the most restrictive for determining key constituents.
[d]Consists of 0.2 pCi/L uranium-234 and 0.2 pCi/L uranium-235.

CI: confidence interval.
ND: not detected.
NA: not available.

Table 2.5-3. Radionuclide and Chemical Loading, PUREX Chemical Sewer.

Flow Rate: 7.67E+07 L/mo

Constituent	Kg/L*	Kg/mo*
aluminum	2.27E-07	1.74E+01
barium	3.13E-08	2.40E+00
boron	1.60E-08	1.23E+00
calcium	1.84E-05	1.41E+03
chloride	1.55E-06	1.19E+02
copper	2.93E-08	2.25E+00
fluoride	1.40E-07	1.07E+01
iron	2.16E-07	1.66E+01
lead	5.50E-09	4.22E-01
magnesium	4.21E-06	3.23E+02
manganese	1.57E-08	1.20E+00
mercury	1.10E-10	8.43E-03
nitrate	5.16E-07	3.96E+01
potassium	7.19E-07	5.51E+01
silicon	2.57E-06	1.97E+02
sodium	2.07E-06	1.59E+02
strontium	9.08E-08	6.96E+00
sulfate	1.12E-05	8.59E+02
uranium	4.65E-10	3.57E-02
zinc	1.47E-08	1.13E+00
ammonia	5.77E-08	4.42E+00
butylated hydroxy toluene	1.00E-08	7.67E-01
trichloromethane	8.83E-09	6.77E-01
alpha activity *	9.84E-13	7.54E-05
beta activity *	2.22E-12	1.70E-04
TDS	5.63E-05	4.32E+03
total carbon	1.44E-05	1.10E+03
TOX (as Cl)	7.05E-08	5.41E+00
americium-241 *	1.03E-13	7.90E-06
cesium-137 *	2.85E-13	2.19E-05
carbon-14 *	3.33E-12	2.55E-04
hydrogen-3 *	2.29E-10	1.76E-02
plutonium-238 *	7.62E-15	5.84E-07
plutonium-239/240 *	3.09E-13	2.37E-05
radium total *	9.74E-14	7.47E-06
uranium-234 *	1.71E-13	1.31E-05
uranium-238 *	1.50E-13	1.15E-05

Footnotes:

Data collected from October 1989 through March 1990.

Flow rate is the average of rates from the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 2).

Constituent concentrations are average values from the statistics in the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 2).

Concentration units of flagged (*) constituents are reported as curies per liter.

Loading units of flagged (*) constituents are reported as curies per month.

Table 2.5-4. Groundwater Analysis Results for 216-A-29 Ditch, 1989 to 1990 (page 1 of 2).

CONSTITUENT			ANALYSIS SUMMARY					GROUP A STUDY GUIDELINES	
Group Name	Units	Detection Limit	Number of Analyses	Number > Det.	Average Result	Maximum Result	Minimum Result	Max Limit	Number > Limit
CONTAMINATION INDICATOR PARAMETERS									
Conductivity, Laboratory	UMHO	1.00	47	47	387.85	794.00	160.00	700.0	4
Specific conductance	UMHO	1.00	90	90	316.59	785.00	100.00	700.0	8
Total Organic Halogen, Low Det. Level	PPB	10.00	108	19	21.58	329.00	.01		0
pH, Field Measurement		.10	78	78	7.98	8.80	6.90	8.5	3
pH, Laboratory Measurement		.01	30	30	7.98	8.23	7.30	8.5	0
DRINKING WATER PARAMETERS									
Alpha, High Detection Level	PCI/L	4.00	30	4	1.81	5.53	-.10	15.0	0
Arsenic	PPB	5.00	32	19	6.88	11.00	5.00	50.0	0
Arsenic, filtered	PPB	5.00	30	17	6.87	11.00	5.00	50.0	0
Barium	PPB	6.00	33	33	17.70	36.00	9.00	1000.0	0
Barium, filtered	PPB	6.00	38	38	17.50	34.00	11.00	1000.0	0
Chromium	PPB	10.00	42	33	44.48	140.00	10.00	50.0	13
Chromium, filtered	PPB	10.00	30	1	10.00	10.00	10.00	50.0	0
Fluoride	PPB	500.00	29	8	538.07	1000.00	500.00	4000.0	0
Gross beta	PCI/L	8.00	31	7	6.19	23.00	.63	50.0	0
Lead (graphite furnace)	PPB	5.00	28	1	5.04	6.00	5.00	50.0	0
Nitrate	PPB	500.00	31	31	3424.71	12500.00	700.00	45000.0	0
Selenium	PPB	5.00	29	4	5.21	7.00	5.00	10.0	0
Selenium, filtered	PPB	5.00	29	4	5.24	7.00	5.00	10.0	0
GROUNDWATER QUALITY PARAMETERS									
Chloride	PPB	500.00	30	30	4262.67	8000.00	2800.00	250000.0	0
Iron	PPB	30.00	42	39	284.31	804.00	30.00	300.0	17
Iron, filtered	PPB	30.00	35	11	32.74	61.00	30.00	300.0	0
Manganese	PPB	5.00	37	19	8.59	27.00	5.00	50.0	0
Manganese, filtered	PPB	5.00	31	3	5.06	6.00	5.00	50.0	0
Sodium	PPB	200.00	42	42	13547.62	45000.00	5260.00		0
Sodium, filtered	PPB	200.00	43	43	13598.37	45900.00	5400.00		0
Sulfate	PPB	500.00	30	30	54506.67	221000.00	11700.00	250000.0	0

Table 2.5-4. Groundwater Analysis Results for 216-A-29 Ditch, 1989 to 1990 (page 1 of 2).

CONSTITUENT			ANALYSIS SUMMARY					GROUP A STUDY GUIDELINES	
Group Name	Units	Detection Limit	Number of Analyses	Number > Det.	Average Result	Maximum Result	Minimum Result	Max Limit	Number > Limit
SITE SPECIFIC AND OTHER PARAMETERS									
Alkalinity		20000.00	3	3	104000.00	108000.00	102000.00		0
Aluminum	PPB	150.00	29	1	153.24	244.00	150.00	50.0	1
Beryllium	PPB	5.00	29	2	5.03	6.00	5.00		0
Beryllium, filtered	PPB	5.00	29	1	5.03	6.00	5.00		0
Bis(2-ethylhexyl) phthalate	PPB	10.00	8	1	10.50	14.00	10.00		0
Boron	PPB	10.00	37	30	17.05	38.00	10.00		0
Boron, filtered	PPB	10.00	35	24	18.91	54.00	10.00		0
Calcium	PPB	50.00	41	41	28002.44	75100.00	16800.00		0
Calcium, filtered	PPB	50.00	41	41	28414.63	72800.00	17600.00		0
Copper	PPB	10.00	29	2	11.79	52.00	10.00	1000.0	0
Copper, filtered	PPB	10.00	29	2	10.17	13.00	10.00	1000.0	0
Iodine-129 (Drinking Water Standard)	PCI/L	1.00	3	2	1.68	2.79	.68	20.0	0
Magnesium	PPB	50.00	42	42	8313.33	27300.00	4850.00		0
Magnesium, filtered	PPB	50.00	43	43	8235.35	25100.00	4890.00		0
Nickel	PPB	10.00	42	31	24.33	72.00	10.00		0
Potassium	PPB	100.00	42	42	4375.48	6040.00	3530.00		0
Potassium, filtered	PPB	100.00	43	43	4456.05	6460.00	3610.00		0
Silicon	PPB	50.00	43	43	13138.14	19300.00	8140.00		0
Silicon, filtered	PPB	50.00	43	43	13323.49	18900.00	9290.00		0
Strontium	PPB	10.00	40	40	150.18	382.00	95.00		0
Strontium, filtered	PPB	10.00	42	42	147.81	359.00	92.00		0
Total carbon	PPB	1000.00	29	29	20717.24	33700.00	16300.00		0
Total dissolved solids		5000.00	6	6	192833.33	444000.00	25000.00	500000.0	0
Tritium	PCI/L	500.00	18	15	17817.81	69900.00	-55.70	80000.0	0
Turbidity	NTU	.10	31	30	2.57	19.50	.10	5.0	4
Unknown Halogenated Hydrocarbon	PPB		1	1	14.00	14.00	14.00		0
Uranium	PCI/L	.50	10	10	1.54	4.56	.68	40.0	0
Vanadium	PPB	5.00	38	36	21.13	41.00	5.00		0
Vanadium, filtered	PPB	5.00	38	38	20.61	42.00	6.00		0
Zinc	PPB	5.00	40	32	11.50	30.00	5.00	5000.0	0
Zinc, filtered	PPB	5.00	32	17	7.97	30.00	5.00	5000.0	0

Table 2.5-5. Background Comparisons, 216-A-29 Ditch.

Constituent	Background[a]	Average/ Background[b]	Maximum/ Background[b]
aluminum	2.0	76.62	122.00
ammonia	50.0		
arsenic	6.3	1.09 (1.09)	1.75 (1.75)
barium	62.0	0.29 (0.28)	0.58 (0.55)
beryllium	0.3	16.77 (16.77)	20.00 (20.00)
bismuth	0.02		
boron	50.0	0.34 (0.38)	0.76 (1.08)
cadmium	0.2		
calcium	50,700	0.55 (0.56)	1.48 (1.44)
chloride	16,800	0.25	0.48
chromium	6.0	7.41 (1.67)	23.33 (1.67)
copper	1.0	11.79 (10.17)	52.00 (13.00)
cyanide	10.0		
fluoride	470	1.14	2.13
lead	0.5	10.08	12.00
magnesium	15,200	0.55 (0.54)	1.80 (1.65)
manganese	12.0	0.72 (0.42)	2.25 (0.50)
mercury	0.1		
nickel	4.0	6.08	18.00
phosphate	1,000		
potassium	6,190	0.71 (0.72)	0.98 (1.04)
selenium	2.0	2.61 (2.62)	3.50 (3.50)
silver	10		
sodium	28,410	0.48 (0.48)	1.58 (1.62)
strontium	338	0.44 (0.44)	1.13 (1.06)
sulfate	51,200	1.06	4.32
uranium	2.5	0.62	1.82
vanadium	26	0.81 (0.79)	1.58 (1.62)
zinc	8.0	1.44 (1.00)	3.75 (3.75)
alkalinity	144,000	0.72	0.75
pH	7.8	1.02	1.13
TOC	933		
conductivity	462	0.69	1.70
gross alpha	3.9		
gross beta	31	0.20	0.74
radium	0.2		

TOC: total organic carbon. ( ): filtered samples.

[a]Background is the mean plus one standard deviation for the values listed in Table 2-1. Amounts of uranium, gross alpha, gross beta, and radium given in picocuries per liter. All others are in parts per billion.

[b]Average and maximum values from Table 2.5-4.

2.6 216-A-30 CRIB

No significant additional impacts on soil and groundwater quality from routine use of this crib until 1995 were identified.

2.6.1 Receiving Site Description

The 216-A-30 Crib, located just east of the 200 East Area, became operational in 1961 to receive the steam condensate from the PUREX Plant. Since 1983, about two-thirds of the steam condensate has gone to the 216-A-30 Crib and the other third has been disposed to the 216-A-37-2 Crib. Figure 2.6-1 shows the location of the 216-A-30 Crib relative to other disposal facilities and shows the placement of associated groundwater and vadose zone monitoring wells.

2.6.2 Effluent Stream Description

The PUREX Plant steam condensate consists almost entirely of condensed steam and warm, "raw" water that have been used to control the temperature (via heating and cooling coils) of certain process vessels in the PUREX Plant. Table 2.6-1 summarizes information pertaining to the effluent stream. Key constituents and loading estimates are given in Tables 2.6-2 and 2.6-3, respectively.

The old sampling data show that during routine operations, four radionuclides exceeded the Group A study guideline concentrations, although by relatively small margins. The new data set showed plutonium-239, cerium/praseodymium-144, and radium to be above Group A study guidelines.

2.6.3 Flow and Transport Analysis

Appendix D summarizes the results of an analysis using numerical models to simulate the wetting of the soil column that resulted during the operation of the 216-A-30 Crib. Based on these analyses, the time required for the wetted front to reach the water table is estimated to be 1-3/4 yr. Once the soil column has been wetted, the unit gradient model can be used to provide a reasonable estimate of time of travel. For the latter purpose, a seven-layer model consisting of four soil types was used to simulate the soil column which was based on the stratigraphic information collected at well 299-E16-2 (Figure 2.6-2). The calculated travel time for movement of wastewater through the soil column under average discharge conditions is 177 days or a migration rate of 45 cm/day. The corresponding migration rates for the key constituents range from 0.05 to 4.5 cm/day (Appendix B). Migration rates for strontium-90 and cesium-137, the constituents of most concern at this site, are 0.4 and 0.2 cm/day, respectively. These migration rates indicate that breakthrough of key constituents should not occur; e.g., the shortest corresponding travel time is 4.8 yr (Appendix B).

2.6.4 Groundwater Quality Assessment

None of the key constituents exceeded Group A study guidelines. Nitrate and tritium are not key effluent constituents but were, however, above-guideline occurrences (Table 2.6-4). Above-guideline concentrations of metals are attributed to well casing and sampling artifacts (WHC 1990d). The metals exceeding Group B study guidelines (or background) are also attributed to well casing and sampling problems (i.e., only unfiltered, bailed samples could be collected). Additionally, concentrations of major chemical constituents (chloride, sodium, calcium, etc.) fell well below the Group B guidelines (Table 2.6-5). This is a consequence of dilution of local groundwater by the wastestream.

Concentrations of tritium in the groundwater versus time are shown in Figure 2.6-3(A). The figure illustrates the time course of tritium concentrations (far above Group A study guidelines) in Well 2-E25-11 from 1986 through 1988, with a decline in 1989 and 1990. Nitrate concentrations in groundwater show a similar pattern. The low concentrations of these constituents in PUREX Plant steam condensate and the location of this crib near the 216-A-37-1 Crib, a known source of elevated tritium and nitrate, are good indications that the 216-A-30 Crib is not the source, as further illustrated in Figure 2.6-3(B).

2.6.5 Impact of Continued Operation

The relatively low volume of effluent discharged to this crib is deemed to have only minor and very localized impact on the groundwater flow regime.

Current monitoring data suggest this site has a minor impact on groundwater quality. However, better monitoring wells are needed to eliminate the suspected false positive results for various metals. In addition, masking from adjacent facilities may continue to complicate interpretation of monitoring results. Based on wastestream analyses and the estimated migration rate of key constituents in the soil column, continued operation (4 more yr) should not have an adverse impact on groundwater quality.

Waste records indicate previous radionuclide loads of approximately 120 Ci of cesium-137 and 95 Ci of strontium-90 (WHC 1989, p. A.6 to 28). It is assumed this loading occurred early in the operating history of the crib (i.e., recent effluent concentrations and volumes would not result in this quantity). Using the migration rates indicated in Section 2.6.3, and assuming an average discharge rate of 7 L/sec as used for the wastewater transport estimate, plots of contaminant migration rate versus time can be constructed as illustrated in Figure 2.6-4.

Based on the assumptions noted previously, the predicted depths of migration for strontium-90 and cesium-137 during the 28-yr (or 10,700-day) period of use are 44 and 22 m, respectively. The observed maximum depth of penetration of cesium-137 (as indicated by gross gamma logs; WHC 1989, p. A.6-10) is approximately 15 m. Using the same assumption of average discharge rate (7 L/sec) and the same wastestream conditions that prevailed during the past 28 yr, the estimated incremental or additional movement of the contaminant load on the soil column during 4 more yr of operation would be 6 and 3 m, respectively, for strontium-90 and cesium-137. Assuming the overestimate of migration rate indicated by the gamma log profile data at this crib applies equally to cesium as well as to strontium, the incremental movement may be reduced by (15 m/22 m = 0.68). This correction suggests approximately 4 m of additional movement for strontium-90 and 2 m for cesium-137.

Higher discharge rates, of course, would result in reaching these depth increments sooner. However, if the former or average conditions prevail, the incremental increase in downward contaminant movement is approximately 14% of the existing maximum (observed) depth of penetration. For strontium-90, this would be the difference between an estimated existing depth of penetration of 44 x 0.68 = 30 m versus an additional increment of 4 m, or a total of 34 m. From a remediation standpoint, there is very little difference between these two cases. Thus, operation of the crib under the conditions specified above should not exacerbate future cleanup activities due to the additional movement of these key contaminants at this site.

It should also be noted that a minor uranium release to this crib occurred in May 1989. A prediction of the effect of this spill is provided in Appendix D. These results suggest the maximum uranium concentration in groundwater will be at or below the Group A study guideline.

Figure 2.6-1. Well Location and Site Map, 216-A-30 Crib.

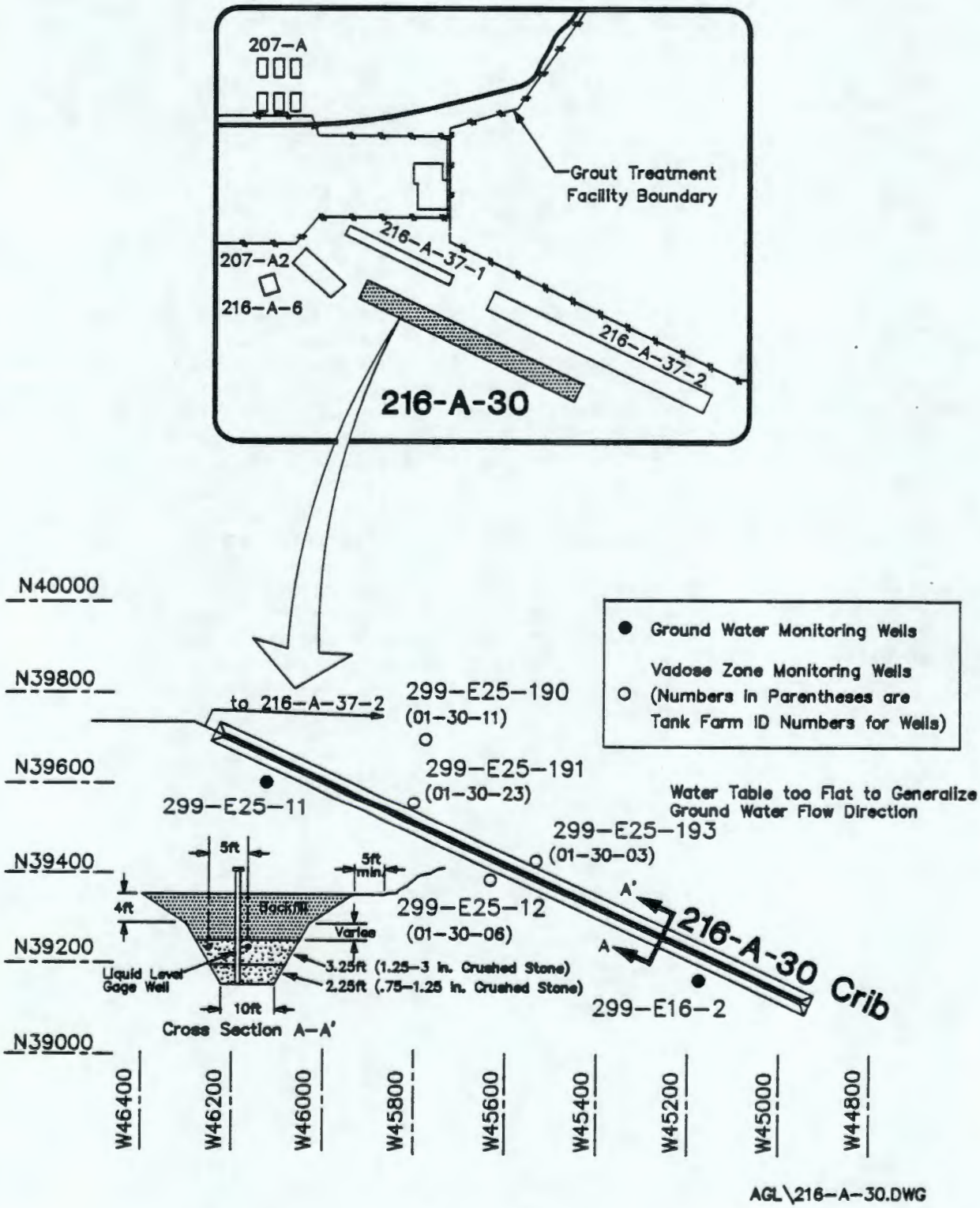
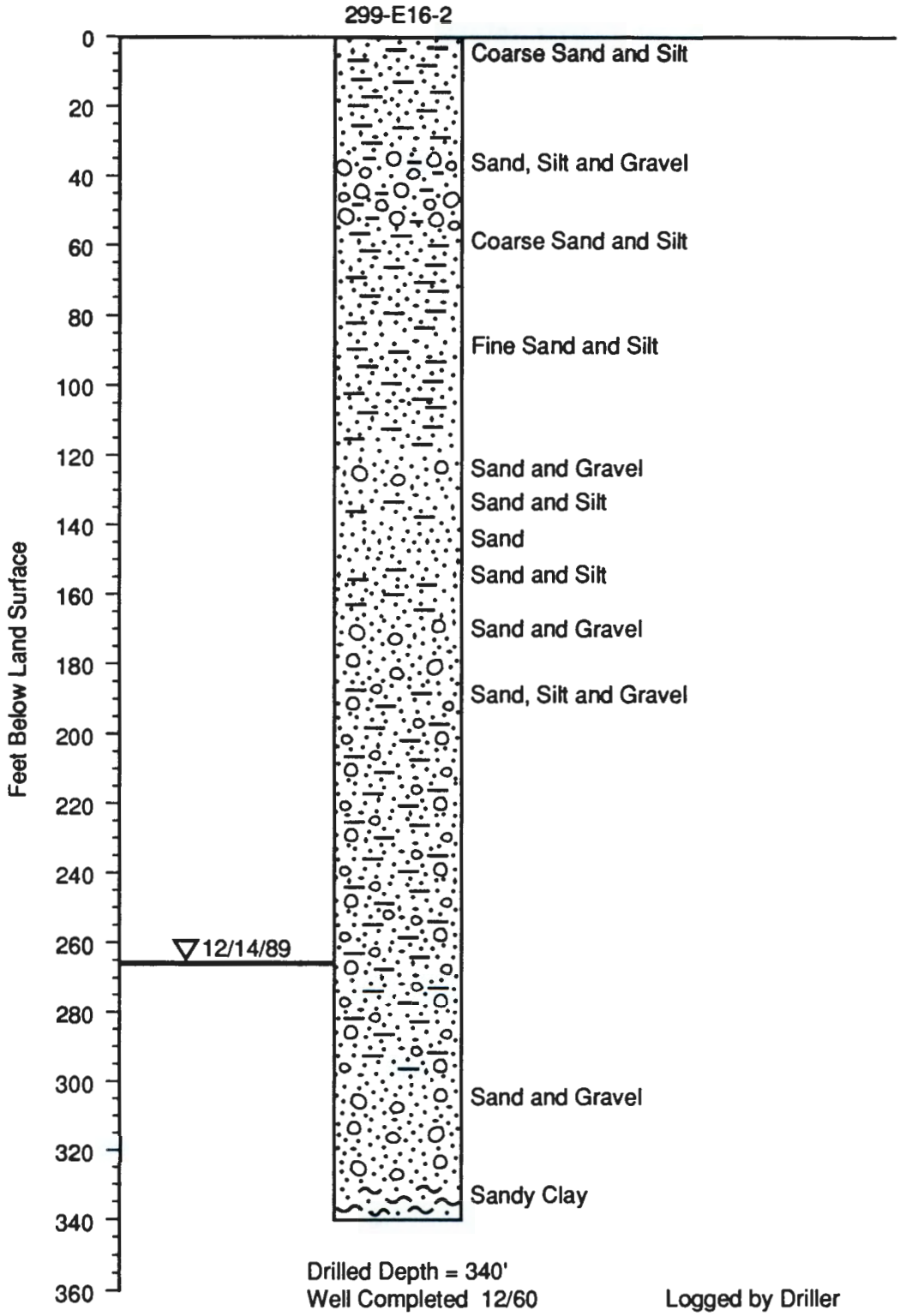


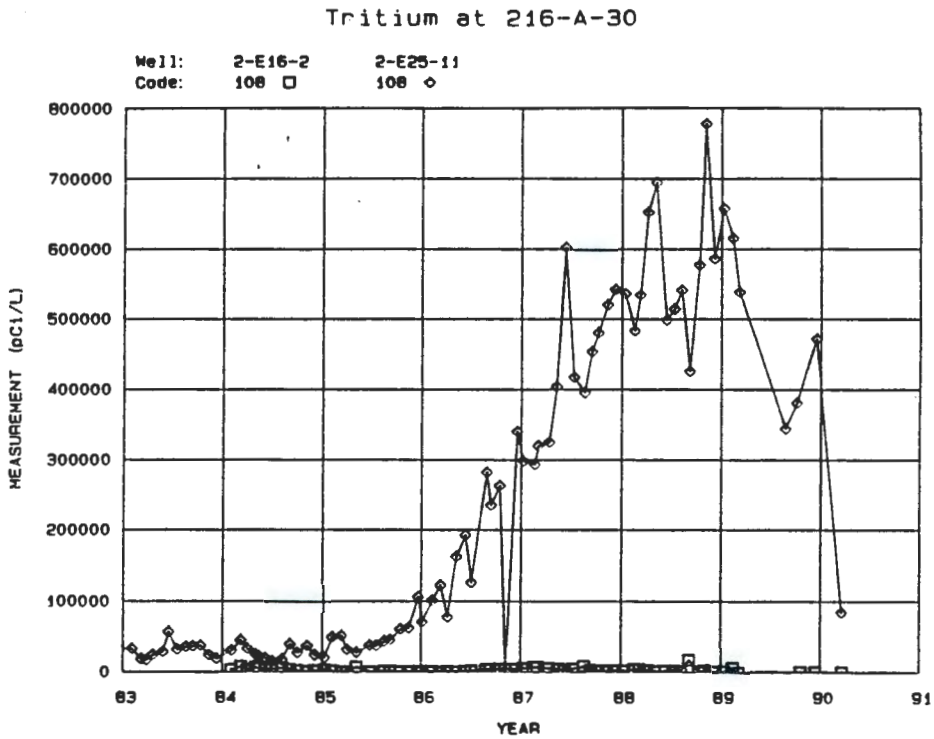
Figure 2.6-2. Lithology of Well 299-E16-2 Near the 216-A-30 Crib.



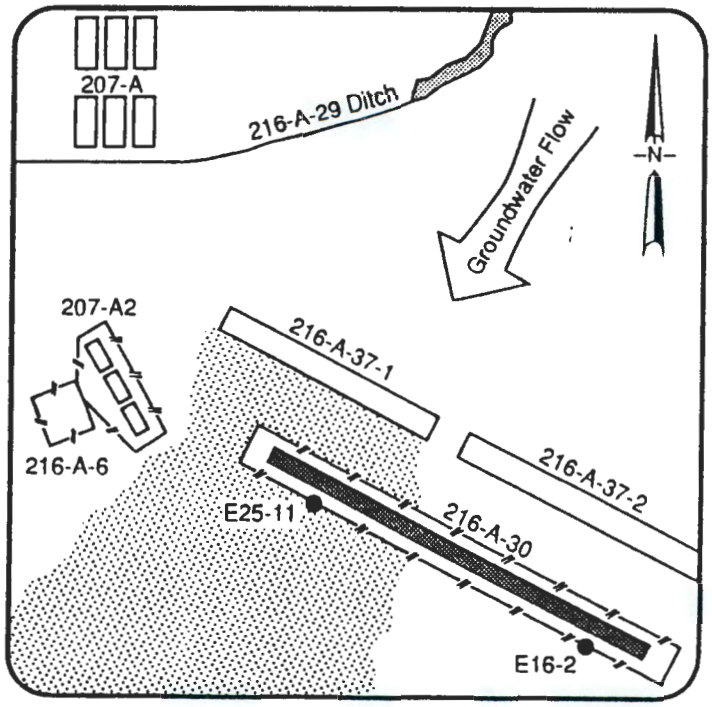
S9007025.6

Figure 2.6-3. Hydrogen-3 Concentrations in Groundwater Versus Time at the 216-A-30 Crib (A).

Inset (B) illustrates hypothesized intersection of contaminant plume from 216-A-37-1 Crib with one of the two monitoring wells at the subject crib.



(B)



S9007025.28

Figure 2.6-4. Predicted Contaminant Migration Depths Versus Time, 216-A-30 Crib.

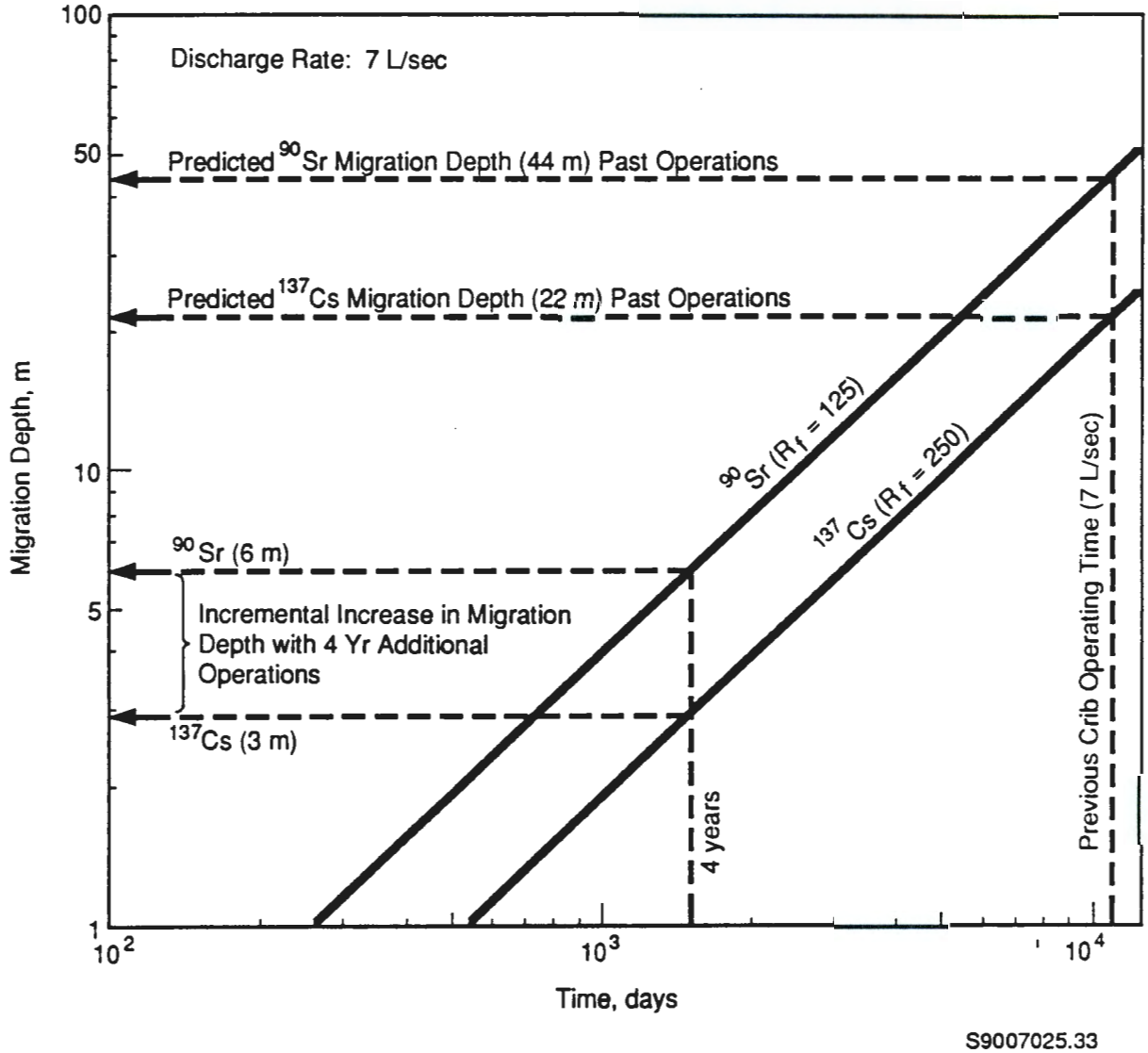


Table 2-6-1. Effluent Stream Description, PUREX Steam Condensate to 216-A-30 Crib.

Total volume of effluent discharged to subject receiving site: (WHC 1989a, WHC-EP-0287, Volume 3)	7.97E+08 L from 03/83 to 12/88
Average effluent discharge rate, by operating mode: (WHC 1990a, WHC-EP-0342, Addendum 5)	4.29E+07 L/mo[a]
Current average effluent discharge rate: (WHC 1990a, WHC-EP-0342, Addendum 5)	4.29E+07 L/mo[a]
Effluent designation: (WHC 1990a, WHC-EP-0342, Addendum 5)	Nondangerous, radioactive
Effluent status:	Currently active discharge to 216-A-30 and 216-A-37-2 cribs.

[a]Based on average flow rate during sampling period 10/89 to 03/90. This flow rate does not take into account the parallel discharge to the 216-A-30 and 216-A-37-2 cribs.

Table 2.6-2. Effluent Stream Sampling Data, PUREX Steam Condensate.

Key Constituents	Detection Limit[a]	Detection/ Analyses	Sample Concentration 90% CI[a]	Detection Limit[a]	Detection/ Analyses	Sample Concentration 90% CI[a]
	1976 to 1988, During Routine Operation			10/89 to 03/90, During Stabilization		
strontium-90	30	53/NA	960	0.1	5/6	3[c]
cesium-137	80	59/NA	290	1	5/6	16[b]
uranium (isotopes)[d]	20	7/NA	47	NA	6/6	0.4[c,e]
plutonium-239	50	64/NA	45	0.001	6/6	7.2
cerium/praseo-dymium-144	NA	ND	ND	NA	5/5	337
radium (total)	NA	ND	ND	NA	6/6	4.4

[a]Units: chemical--parts per billion
radionuclides--picocurie per liter.
[b]Ill-conditioned data set.
[c]Concentrations below Group A study guidelines; values given for purposes of comparison.
[d]Uranium-234 used as the most restrictive Group A study guideline for determining key constituents.
[e]Consists of 0.26 pCi/L uranium-234 and 0.18 pCi/L uranium-238.

CI: confidence interval.
NA: not available.

Table 2.6-3. Radionuclide and Chemical Loading, PUREX Steam Condensate.

Flow Rate: 4.29E+07 L/mo

Constituent	Kg/L*	Kg/mo*
barium	2.82E-08	1.21E+00
boron	1.75E-08	7.50E-01
calcium	1.72E-05	7.37E+02
chloride	9.50E-07	4.07E+01
fluoride	1.18E-07	5.06E+00
iron	3.13E-08	1.34E+00
magnesium	4.07E-06	1.74E+02
nitrate	5.46E-07	2.34E+01
potassium	6.82E-07	2.92E+01
silicon	2.21E-06	9.47E+01
sodium	1.98E-06	8.49E+01
strontium	8.33E-08	3.57E+00
sulfate	9.47E-06	4.06E+02
uranium	5.25E-10	2.25E-02
zinc	5.33E-09	2.28E-01
acetone	1.00E-08	4.29E-01
1-butanol	2.40E-08	1.03E+00
tributylphosphate	1.08E-08	4.63E-01
alpha activity *	5.38E-12	2.31E-04
beta activity *	1.59E-10	6.82E-03
TDS	6.25E-05	2.68E+03
TOC	1.02E-06	4.37E+01
total carbon	1.36E-05	5.83E+02
TOX (as Cl)	6.17E-09	2.64E-01
americium-241 *	5.39E-13	2.31E-05
cerium/praseodymium-144 *	2.22E-10	9.52E-03
cesium-137 #,*	1.02E-11	4.37E-04
plutonium-238 *	4.26E-13	1.83E-05
plutonium-239/240 *	5.49E-12	2.35E-04
radium total *	2.01E-12	8.62E-05
strontium-90 #,*	1.76E-12	7.54E-05
uranium-234 *	2.34E-13	1.00E-05
uranium-238 *	1.57E-13	6.73E-06

Footnotes:

Data collected from October 1989 through March 1990.

Flow rate is the average of rates from the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 5).

Constituent concentrations are average values from the statistics in the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 5).

Concentration units of flagged (*) constituents are reported as curies per liter.

Loading units of flagged (*) constituents are reported as curies per month.

Constituents are flagged (#) if any detected result is less than any detection limit.

Table 2.6-4. Groundwater Analysis Results, 216-A-30 Crib, 1989 to 1990 (page 1 of 2).

CONSTITUENT			ANALYSIS SUMMARY					GROUP A STUDY GUIDELINES	
Group Name	Units	Detection Limit	Number of Analyses	Number > Det.	Average Result	Maximum Result	Minimum Result	Max Limit	Number > Limit
CONTAMINATION INDICATOR PARAMETERS									
Conductivity, Laboratory	UMHO	1.00	4	4	274.00	308.00	238.00	700.0	0
Specific conductance	UMHO	1.00	4	4	276.75	309.00	244.00	700.0	0
Total Organic Halogen, Low Det. Level	PPB	10.00	4	1	5.75	12.00	2.00		0
pH, Field Measurement		.10	4	4	8.05	8.63	7.09	8.5	1
pH, Laboratory Measurement		.01	4	4	7.78	7.90	7.50	8.5	0
DRINKING WATER PARAMETERS									
Alpha, High Detection Level	PCI/L	4.00	11	3	2.57	7.28	.02	15.0	0
Arsenic	PPB	5.00	2	2	26.00	38.00	14.00	50.0	0
Barium	PPB	6.00	2	2	184.50	269.00	100.00	1000.0	0
Cadmium	PPB	2.00	2	2	31.50	42.00	21.00	10.0	2
Chromium	PPB	10.00	2	2	52.00	55.00	49.00	50.0	1
Fluoride	PPB	500.00	4	3	550.00	600.00	500.00	4000.0	0
Gross alpha	PCI/L	4.00	2	1	4.80	6.41	3.19	15.0	0
Gross beta	PCI/L	8.00	13	12	12.79	20.80	7.54	50.0	0
Lead (graphite furnace)	PPB	5.00	2	2	32.50	50.00	15.00	50.0	1
Nitrate	PPB	500.00	4	4	13900.00	43300.00	1100.00	45000.0	0
Nitrate, High Detection Level	PPB	2500.00	8	5	26037.50	47300.00	2500.00	45000.0	2
Radium	PCI/L	1.00	2	1	.74	1.19	.29	100.0	0
GROUNDWATER QUALITY PARAMETERS									
Chloride	PPB	500.00	4	4	1650.00	2700.00	1200.00	250000.0	0
Iron	PPB	30.00	2	2	80100.00	116000.00	44200.00	300.0	2
Manganese	PPB	5.00	2	2	2605.00	3330.00	1880.00	50.0	2
Sodium	PPB	200.00	2	2	19200.00	21000.00	17400.00		0
Sulfate	PPB	500.00	4	4	19350.00	24300.00	15800.00	250000.0	0
SITE SPECIFIC AND OTHER PARAMETERS									
Aluminum	PPB	150.00	2	2	8015.00	14000.00	2030.00	50.0	2
Ammonium ion	PPB	50.00	2	1	71.50	93.00	50.00		0
Bis(2-ethylhexyl) phthalate	PPB	10.00	2	1	13.00	16.00	10.00		0
Boron	PPB	10.00	2	2	18.00	24.00	12.00		0

Table 2.6-4. Groundwater Analysis Results, 216-A-30 Crib, 1989 to 1990 (page 2 of 2).

CONSTITUENT			ANALYSIS SUMMARY					GROUP A STUDY GUIDELINES	
Group Name	Units	Detection Limit	Number of Analyses	Number > Det.	Average Result	Maximum Result	Minimum Result	Max Limit	Number > Limit
SITE SPECIFIC AND OTHER PARAMETERS									
Calcium	PPB	50.00	2	2	29600.00	30000.00	29200.00		0
Cobalt	PPB	20.00	2	1	20.50	21.00	20.00		0
Copper	PPB	10.00	2	2	62.50	78.00	47.00	1000.0	0
Lithium	PPB	10.00	2	1	14.50	19.00	10.00		0
Magnesium	PPB	50.00	2	2	9955.00	12400.00	7510.00		0
Nickel	PPB	10.00	2	2	38.00	44.00	32.00		0
Potassium	PPB	100.00	2	2	8780.00	9850.00	7710.00		0
Silicon	PPB	50.00	2	2	41500.00	54300.00	28700.00		0
Strontium	PPB	10.00	2	2	176.50	189.00	164.00		0
Titanium	PPB	60.00	2	2	674.00	1120.00	228.00		0
Toluene	PPB	5.00	4	1	13.00	37.00	5.00	2000.0	0
Total carbon	PPB	1000.00	2	2	23750.00	24500.00	23000.00		0
Tritium	PCI/L	500.00	13	10	238449.62	657000.00	155.00	80000.0	7
Turbidity	NTU	.10	2	2	122.00	200.00	44.00	5.0	2
Uranium	PCI/L	.50	2	2	1.00	1.05	.95	40.0	0
Vanadium	PPB	5.00	2	2	166.50	249.00	84.00		0
Zinc	PPB	5.00	2	2	74.50	79.00	70.00	5000.0	0

Table 2.6-5. Background Comparisons, 216-A-30 Crib.

Constituent	Background[a]	Average/ Background[b]	Maximum/ Background[b]
aluminum	2.0	4,007	7,000
ammonia	50.0	1.43	1.86
arsenic	6.3	4.13	6.03
barium	62.0	2.98	4.34
beryllium	0.3		
bismuth	0.02		
boron	50.0	0.36	0.48
cadmium	0.2	157.50	210.00
calcium	50,700	0.58	0.59
chloride	16,800	0.10	0.16
chromium	6.0	8.67	9.17
copper	1.0	62.50	78.00
cyanide	10.0		
fluoride	470	1.17	1.28
lead	0.5	65.0	100.00
magnesium	15,200	0.65	0.82
manganese	12.0	217.08	277.50
mercury	0.1		
nickel	4.0	9.50	11.00
phosphate	1,000		
potassium	6,190	1.42	1.59
selenium	2.0		
silver	10		
sodium	28,410	0.68	0.74
strontium	338	0.52	0.56
sulfate	51,200	0.38	0.47
uranium	2.5	0.40	0.42
vanadium	26	6.40	9.58
zinc	8.0	9.31	9.88
alkalinity	144,000		
pH	7.8	1.03	1.11
TOC	933		
conductivity	462	0.59	0.67
gross alpha	3.9	1.23	1.64
gross beta	31	0.41	0.67
radium	0.2	3.70	5.95

TOC: total organic carbon.

[a]Background is the mean plus one standard deviation for the values listed in Table 2-1. Amounts of uranium, gross alpha, gross beta, and radium given in picocuries per liter. All others are in parts per billion.

[b]Average and maximum values from Table 2.6-4.

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2.7 216-A-36B CRIB

The PUREX ammonia scrubber condensate, formerly discharged to the subject crib, has been designated as a radioactive, dangerous waste. Accordingly, use of the crib was discontinued in September 1987 and the wastestream routed to temporary underground tank storage.

Significant levels of tritium and nitrate were detected in groundwater near the crib and are attributed to past disposal activities. Favorable agreement between predicted and observed radionuclide migration depths for this site lend support to the flow and transport calculations.

2.7.1 Receiving Site Description

The 216-A-36B Crib is located in the 200 East Area approximately south of the PUREX Plant. The crib was constructed in 1966 to dispose of PUREX ammonia scrubber condensate wastestream. The wastestream was disposed to the crib from March 1966 to October 1972, and again from November 1982 to September 1987. Use of the crib has been discontinued. Monitoring well locations and spatial relationship to other facilities are shown in Figure 2.7-1.

2.7.2 Effluent Stream Description

Gaseous ammonia produced in the fuel cladding dissolution process is scrubbed from the offgas in the ammonia scrubber. In the past, the resulting ammonia solution, contaminated with radionuclides from the fuel, was boiled to separate the ammonia and water from the radionuclides. The resulting ammonia/water stream was discharged as the ammonia scrubber condensate. The ammonia scrubber condensate discharge from PUREX to the 216-A-36B Crib was discontinued in September 1987, and the wastestream routed to a temporary storage facility for eventual treatment and disposal. Future plans include implementation of an ammonia destruction process to mitigate ammonia discharges.

Table 2.7-1 summarizes information pertaining to the wastestream. Key constituents and loadings are included in Tables 2.7-2 and 2.7-3, respectively.

The occasional discharge of ammonia from this plant in high concentrations in past operations has resulted in this stream being classified as a dangerous waste by virtue of toxicity.

The sampling data showed several radionuclides to be above Group A study guidelines by substantial margins.

2.7.3 Groundwater Quality Assessment

Enhanced groundwater sampling was conducted at this facility to provide additional post-shutdown characterization data for the crib and to support similar activities for other nearby waste disposal facilities (Table 2.7-4). Current groundwater contamination is due partly to this and adjacent facili-

indicator parameter investigation (Smith and Gorst 1990) has been under way at this site since 1988. Recent results of this investigation are included in the data set used for the following evaluation.

Constituents that were significantly above Group A study guidelines include tritium, ruthenium-106, and nitrate. Other constituents exceeding these study guidelines may be due to well casing and related sampling artifacts (WHC 1990d).

A comparison of positive results with available background values (Group B guidelines) is shown in Table 2.7-5. Several constituents appear outside the background range. Some of the above-background metal occurrences may be attributed to well casing related corrosion products (WHC 1990d). Some of the constituents in this category were identified in the effluent stream previously discharged to this crib but at levels below maximum contaminant levels.

2.7.4 Flow and Transport Analysis

Using information from the stratigraphic log collected at well 299-E17-14 (Figure 2.7-2), the soil column beneath the crib was modeled as a single layer of coarse sand. Depth to groundwater from the bottom of the crib is estimated to be 93 m. Based on the average discharge rate to the crib, the calculated travel time for wastewater to reach groundwater is 310 days (see Appendix B for computational details). The corresponding key constituent migration rates are 27.7 cm/day for tritium, 0.79 cm/day for strontium-90, and 0.55 cm/day for cesium-137 and plutonium-239. Uranium is intermediate with a migration rate of 6 cm/day.

2.7.5 Impact of Continued Operation

There are no current plans for continued use of this crib. Thus, consideration of future impact on groundwater quality and remobilization of existing contaminant loading on the soil column beneath the 216-B-36B Crib is inappropriate for decision tree purposes. However, additional characterization data (soil core samples beneath the crib) are available (Smith and Kasper 1983) with which to compare predicted versus observed contaminant migration depths.

The subject crib received several hundred curies of strontium-90 and cesium-137 during 1966 through 1972 (WHC 1989a, Volume 3). The depth distribution of these radioactive contaminants was evaluated by coring and sampling prior to restart of PUREX in 1983 (Smith and Kasper 1983). The high pH and presence of ammonium ion modified the retention characteristics of the soil column (Smith and Kasper 1983). These effects are in general accounted for with the retardation coefficients (Appendix B) which are based on Appendix C wastestream characteristics/properties groupings. Using the migration rate of water based on the single-layer model of stratigraphic properties (coarse sand), and retardation factors of 35 and 50 for strontium and cesium, respectively, a comparison can be made between the model predictions and the observed migration depth from core data (see Appendix B for the 1966 to 1972 case listed in the computational table). This comparison is illustrated graphically in Figure 2.7-3. The predicted values

shown are for the total volume added to the crib prior to collection of the core data (i.e., additions between 1966 and 1972). The observed migration depths beneath the crib are from interpretation of the core data reported by Smith and Kasper (1983). The favorable agreement between predicted and observed migration depths supports the approach used in this study. The figure also illustrates the predicted effect that various waste water volumes would have on additional movement of previous soil column loads of strontium and cesium. For example, since 1972, an estimated additional volume of 2.8E+08 L has been discharged to the crib. The predicted migration depths read from Figure 2.7-3 for the total volume added to the crib (3.8E+08 L) is approximately 50 and 70 m for cesium-137 and strontium-90, respectively. Although variable, the greatest depth of penetration indicated by recent gross gamma logs at this crib (WHC 1989a, Vol. 3) suggests a maximum depth of penetration for cesium-137 of over 43 m, as compared to the 50-m maximum predicted above.

Figure 2.7-1. Well Location and Site Map for 216-A-36B Crib.

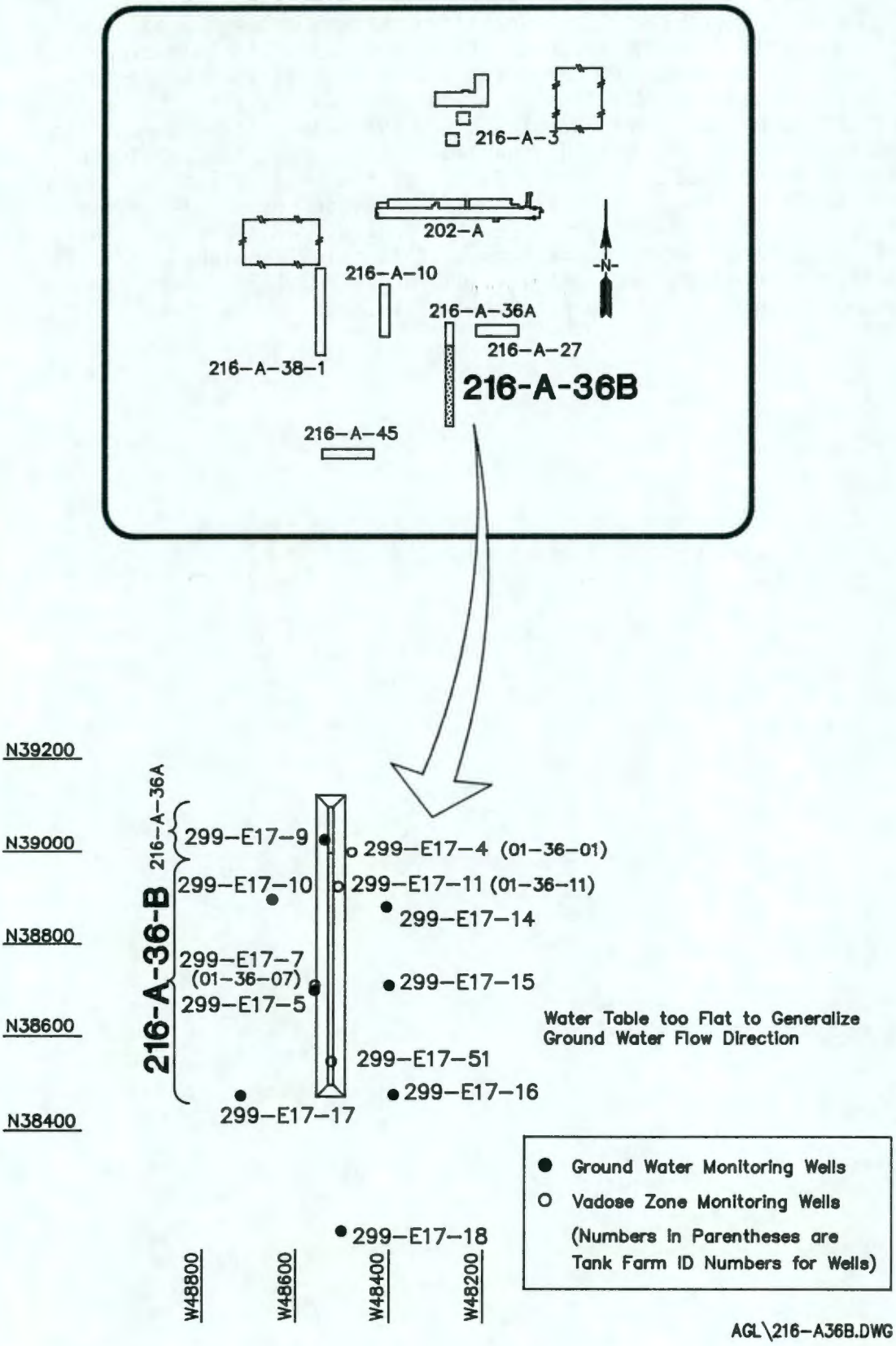

Figure 2.7-2. Lithology of Well 299-E17-14 Near 216-A-36B Crib.

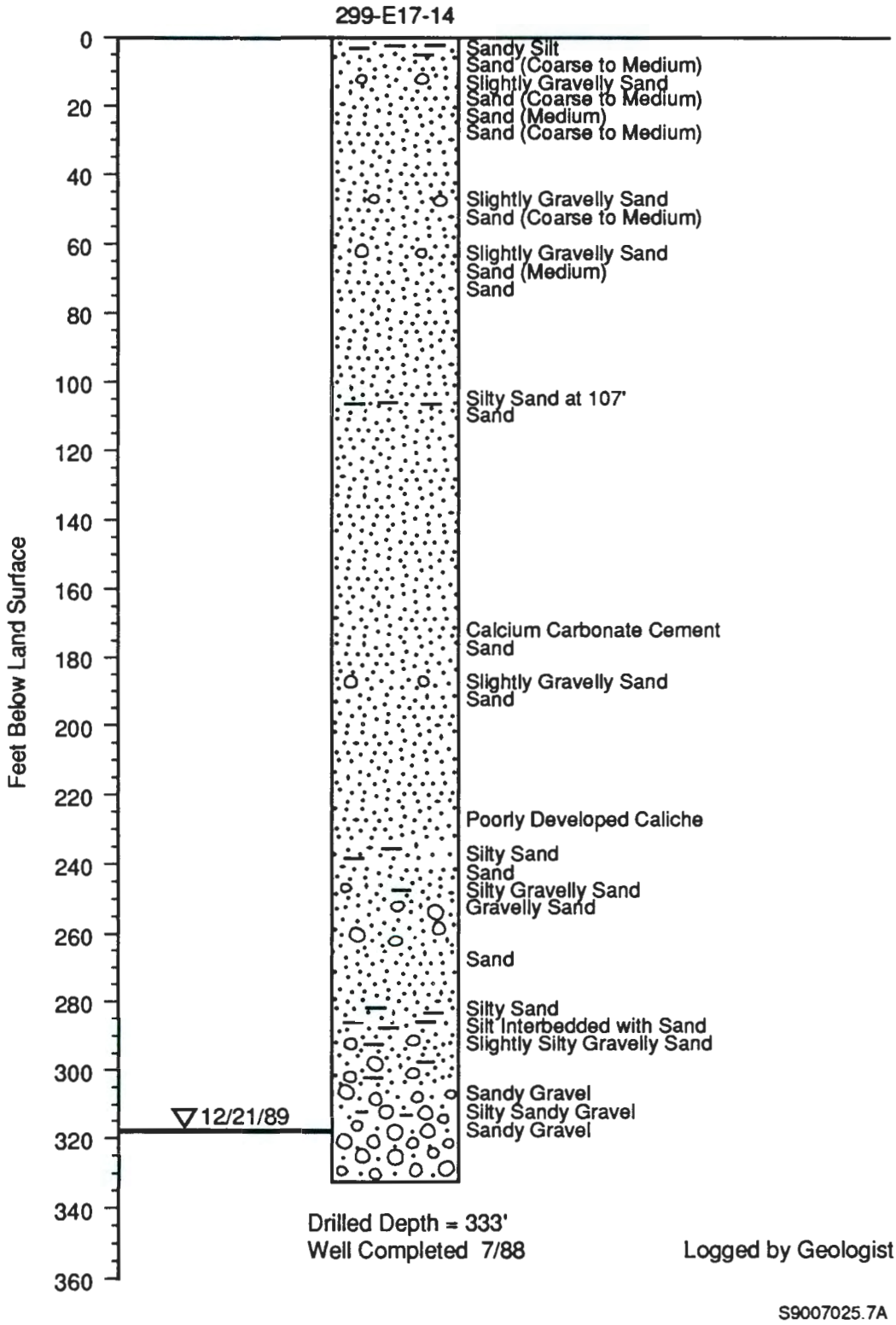

Figure 2.7-3. Penetration Depth Beneath 216-A-36B Crib Versus Cumulation Volume Added.

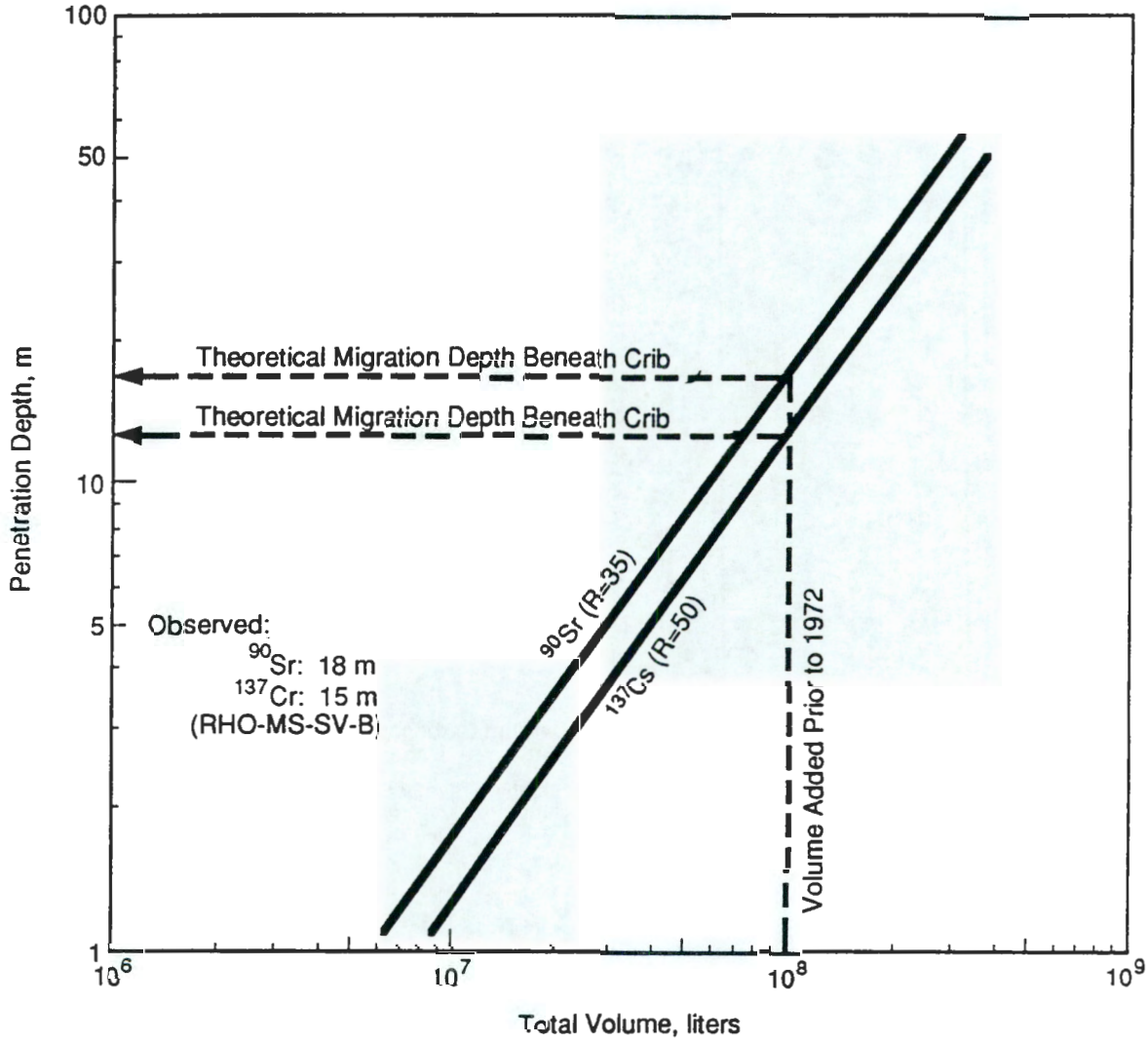

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Table 2.7-1. Effluent Stream Description, PUREX Ammonia Scrubber Condensate.

Total volume of effluent discharged to subject receiving site: (WHC 1989a, WHC-EP-0287, Volume 2)	3.15E+08 L from 12/66 to 09/87
Average effluent discharge rate, by operating mode: (WHC 1990a, WHC-EP-0342, Addendum 14)	1.26E+06 L/mo
Current average effluent discharge rate:	None
Effluent designation: (WHC 1990a, WHC-EP-0342, Addendum 14)	Dangerous[a], radioactive
Effluent status:	Presently inactive; to be discharged to LERF when operations resume

[a]Dangerous designation due to high ammonia concentrations. When operations resume, an ammonia destruction process will be in place and a new designation of the stream will be proposed.

Table 2.7-2. Effluent Stream Sampling Data, PUREX Ammonia Scrubber Condensate.

Key Constituents	Detection Limit[a]	Detection/ Analyses	Sample Concentration 90% CI[a]	Detection Limit[a]	Detection/ Analyses	Sample Concentration 90% CI[a]
	08/85 to 07/87, During Routine Operation			10/89 to 03/90, During Stabilization		
	None			No Data		
	1982 to 1987, During Routine Operation			10/89 to 03/90, During Stabilization		
hydrogen-3	5,000	41/NA	4,300,000	No Data		
strontium-90	30	45/NA	19,000			
cesium-137	80	46/NA	11,000			
plutonium-239	50	37/NA	160			
ruthenium-106	600	38/NA	280,000			
ruthenium-103	NA	20/NA	63,000			
promethium-147	NA	32/NA	37,000			
uranium (isotope)[b]	20	2/NA	160			
americium-241	40	3/NA	2,100			
iodine-129	20	2/NA	140			
plutonium-241	NA	36/NA	5,600			
tin-113	NA	17/NA	34,000			

[a]Units: chemical--parts per billion
radionuclides--picocurie per liter.

[b]Uranium-234 used as the most restrictive Group A study guideline for purposes of detemrining key constituents.

CI: confidence interval.
NA: not available.

Table 2.7-3. Radionuclide and Chemical Loading, PUREX Ammonia Scrubber Condensate.

Flow Rate: 1.26E+06 L/mo

Constituent	Kg/L*	Kg/mo*
calcium	6.80E-08	8.57E-02
chloride	1.17E-06	1.47E+00
chromium	1.06E-08	1.34E-02
magnesium	2.10E-08	2.65E-02
nickel	1.02E-08	1.29E-02
nitrate	5.50E-07	6.93E-01
sodium	2.79E-07	3.52E-01
uranium	3.91E-10	4.93E-04
zinc	3.50E-08	4.41E-02
ammonia	3.66E-04	4.61E+02
1-butanol	1.20E-08	1.51E-02
alpha activity *	3.01E-11	3.79E-05
beta activity *	3.99E-08	5.03E-02
TOC	2.16E-06	2.72E+00

Footnotes:

Data collected during August 1985, May 1987, June 1987 and July 1987.

Flow rate is the average of rates from the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 14).

Nonsteady-state, batch process sampled at less than maximal constituent concentrations.

Constituent concentrations are average values from the statistics in the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 14).

Concentration units of flagged (*) constituents are reported as curies per liter.

Loading units of flagged (*) constituents are reported as curies per month.

Table 2.7-4. Effluent Study Groundwater Summary Report. (Page 1 of 3).

CONSTITUENT			ANALYSIS SUMMARY					GROUP A STUDY GUIDELINES	
Group Name	Units	Detection Limit	Number of Analyses	Number > Det.	Average Result	Maximum Result	Minimum Result	Max Limit	Number > Limit
CONTAMINATION INDICATOR PARAMETERS									
Conductivity, Laboratory	UMHO	1.00	32	32	482.19	834.00	240.00	700.0	6
Specific conductance	UMHO	1.00	71	71	437.41	675.00	224.00	700.0	0
Total Organic Halogen, Low Det. Level	PPB	10.00	91	14	4.77	15.00	-2.00		0
pH, Field Measurement		.10	77	77	7.77	8.30	7.08	8.5	0
pH, Laboratory Measurement		.01	30	30	7.89	8.10	7.70	8.5	0
DRINKING WATER PARAMETERS									
Alpha, High Detection Level	PCI/L	4.00	40	12	3.86	16.50	1.17	15.0	1
Arsenic	PPB	5.00	31	31	9.32	15.00	6.00	50.0	0
Arsenic, filtered	PPB	5.00	31	31	8.48	14.00	5.00	50.0	0
Barium	PPB	6.00	33	33	46.91	73.00	29.00	1000.0	0
Barium, filtered	PPB	6.00	34	34	47.74	74.00	29.00	1000.0	0
Cadmium, filtered	PPB	2.00	31	3	2.35	7.00	2.00	10.0	0
Chromium	PPB	10.00	32	22	26.88	96.00	10.00	50.0	6
Fluoride	PPB	500.00	30	23	576.67	1000.00	500.00	4000.0	0
Gross beta	PCI/L	8.00	43	41	149.77	845.00	4.95	50.0	20
Lead (graphite furnace)	PPB	5.00	30	1	5.03	6.00	5.00	50.0	0
Nitrate	PPB	500.00	34	34	120420.59	354000.00	4900.00	45000.0	26
Nitrate, High Detection Level	PPB	2500.00	9	9	114066.67	137000.00	74000.00	45000.0	9
Radium	PCI/L	1.00	33	2	.24	1.08	-.04	100.0	0
Selenium	PPB	5.00	30	1	5.03	6.00	5.00	10.0	0
Selenium, filtered	PPB	5.00	30	1	5.13	9.00	5.00	10.0	0
GROUNDWATER QUALITY PARAMETERS									
Chloride	PPB	500.00	32	32	5146.88	24000.00	2900.00	250000.0	0
Iron	PPB	30.00	34	29	132.65	492.00	30.00	300.0	3
Iron, filtered	PPB	30.00	32	10	32.53	53.00	30.00	300.0	0
Manganese	PPB	5.00	31	16	6.29	11.00	5.00	50.0	0
Manganese, filtered	PPB	5.00	30	6	5.17	6.00	5.00	50.0	0
Sodium	PPB	200.00	33	33	24230.30	39100.00	16600.00		0
Sodium, filtered	PPB	200.00	34	34	24397.06	36200.00	16300.00		0
Sulfate	PPB	500.00	32	32	37234.38	102000.00	23200.00	250000.0	0

Table 2.7-4. Effluent Study Groundwater Summary Report. (Page 2 of 3).

CONSTITUENT			ANALYSIS SUMMARY					GROUP A STUDY GUIDELINES	
Group Name	Units	Detection Limit	Number of Analyses	Number > Det.	Average Result	Maximum Result	Minimum Result	Max Limit	Number > Limit
GROUNDWATER QUALITY PARAMETERS									
SITE SPECIFIC AND OTHER PARAMETERS									
Beryllium, filtered	PPB	5.00	31	1	5.03	6.00	5.00		0
Bis(2-ethylhexyl) phthalate	PPB	10.00	10	1	10.20	12.00	10.00		0
Boron	PPB	10.00	34	34	19.94	32.00	14.00		0
Boron, filtered	PPB	10.00	33	33	20.24	28.00	11.00		0
Calcium	PPB	50.00	34	34	47067.65	97000.00	21900.00		0
Calcium, filtered	PPB	50.00	34	34	47297.06	90400.00	21200.00		0
Carbon-14	PCI/L	20.00	2	1	17.30	28.20	6.40	2800.0	0
Cobalt-60	PCI/L	22.50	40	9	13.78	54.40	-2.27	200.0	0
Copper	PPB	10.00	33	12	35.61	798.00	10.00	1000.0	0
Copper, filtered	PPB	10.00	31	9	10.81	16.00	10.00	1000.0	0
Iodine-129	PCI/L	15.00	6	1	9.51	16.00	2.03		0
Iodine-129 (Drinking Water Standard)	PCI/L	1.00	2	2	2.12	2.24	1.99	20.0	0
Magnesium	PPB	50.00	34	34	13386.76	25900.00	6400.00		0
Magnesium, filtered	PPB	50.00	33	33	13292.42	24300.00	6350.00		0
Natural uranium	UG/L	.73	9	8	-29.63	8.47	-313.00	59.0	0
Nickel	PPB	10.00	34	22	17.74	52.00	10.00		0
Nickel, filtered	PPB	10.00	32	6	10.50	14.00	10.00		0
Potassium	PPB	100.00	34	34	6084.71	7430.00	4500.00		0
Potassium, filtered	PPB	100.00	34	34	6139.12	8030.00	4500.00		0
Ruthenium-106	PCI/L	172.50	40	4	56.02	547.00	-66.00	240.0	3
Silicon	PPB	50.00	34	34	18644.12	20700.00	17300.00		0
Silicon, filtered	PPB	50.00	34	34	18914.71	21600.00	17300.00		0
Strontium	PPB	10.00	34	34	254.21	488.00	117.00		0
Strontium, filtered	PPB	10.00	34	34	257.12	505.00	114.00		0
Strontium-90	PCI/L	5.00	12	1	4.82	28.10	-.16	40.0	0
Technetium-99	PCI/L	15.00	8	6	157.24	599.00	2.25	4000.0	0
Total carbon	PPB	1000.00	32	32	21809.38	24500.00	17900.00		0
Trichloromonofluoromethane	PPB	10.00	9	1	10.33	13.00	10.00		0
Tritium	PCI/L	500.00	40	40	1527095.00	5200000.00	27400.00	80000.0	31
Turbidity	NTU	.10	30	29	.70	1.40	.10	5.0	0

Table 2.7-4. Effluent Study Groundwater Summary Report. (Page 3 of 3).

CONSTITUENT			ANALYSIS SUMMARY					GROUP A STUDY GUIDELINES	
Group Name	Units	Detection Limit	Number of Analyses	Number > Det.	Average Result	Maximum Result	Minimum Result	Max Limit	Number > Limit
SITE SPECIFIC AND OTHER PARAMETERS									
Uranium	PCI/L	.50	2	2	3.32	4.52	2.11	40.0	0
Vanadium	PPB	5.00	34	34	24.74	36.00	16.00		0
Vanadium, filtered	PPB	5.00	33	33	24.94	37.00	20.00		0
Zinc	PPB	5.00	33	24	21.52	177.00	5.00	5000.0	0
Zinc, filtered	PPB	5.00	32	15	6.19	14.00	5.00	5000.0	0

Table 2.7-5. Background Comparison, 216-A-36B Crib.

Constituent	Background[a]	Average/ Background[b]	Maximum/ Background[b]
aluminum	2.0		
ammonia	50.0		
arsenic	6.3	1.48 (1.35)	2.38 (2.22)
barium	62.0	0.76 (0.77)	1.18 (1.19)
beryllium	0.3	(16.77)	(20.00)
bismuth	0.02		
boron	50.0	0.40 (0.40)	0.64 (0.56)
cadmium	0.2	(11.75)	(35.00)
calcium	50,700	0.93 (0.93)	1.91 (1.78)
chloride	16,800	0.31	1.43
chromium	6.0	4.48	16.00
copper	1.0	35.61 (10.81)	798.00 (16.00)
cyanide	10.0		
fluoride	470	1.23	2.13
lead	0.5	10.06	12.00
magnesium	15,200	0.88 (0.87)	1.70 (1.60)
manganese	12.0	0.52 (0.43)	0.92 (0.50)
mercury	0.1		
nickel	4.0	4.44 (2.63)	13.00 (3.50)
phosphate	1,000		
potassium	6,190	0.98 (0.99)	1.20 (1.30)
selenium	2.0	2.52 (2.57)	3.00 (4.50)
silver	10		
sodium	28,410	0.85 (0.86)	1.38 (1.27)
strontium	338	0.75 (0.76)	1.44 (1.49)
sulfate	51,200	0.73	1.99
uranium	2.5	1.33	1.81
vanadium	26	0.95 (0.96)	1.38 (1.42)
zinc	8.0	2.69 (0.77)	22.13 (1.75)
alkalinity	144,000		
pH	7.8	1.00	1.06
TOC	933		
conductivity	462	0.95	1.46
gross alpha	3.9		
gross beta	31	4.83	27.26
radium	0.2	1.20	5.40

TOC: total organic carbon. ( ): filtered samples.

[a]Background is the mean plus one standard deviation for the values listed in Table 2-1. Amounts of uranium, gross alpha, gross beta, and radium given in picocuries per liter. All others are in parts per billion.

[b]Average and maximum values from Table 2.7-4.

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2.8 216-A-37-1 CRIB

Process-related contaminants occur at concentrations above study guidelines in both effluent and groundwater at this site. The wastestream is designated as dangerous and radioactive. Accordingly, the evaporator process condensate, formerly discharged to the subject crib, has been discontinued with a shut down of the 242-A Evaporator facility.

2.8.1 Receiving Site Description

The 216-A-37-1 Crib was constructed in 1977 to dispose of low-level radioactive liquid effluents from the 242-A Evaporator. Figure 2.8-1 shows the locations of groundwater monitoring wells and the crib relative to other facilities in the vicinity.

2.8.2 Effluent Stream Description

The 242-A Evaporator is the primary waste concentrator for Hanford Site wastes that are stored and treated in underground, double-shell tanks. The wastes are processed in different batches according to their classification by total organic content, transuranic content, and effects on the evaporation process. The process condensate consists primarily of condensed water from boiloff in the evaporator. Contaminants consist chiefly of volatile organics which boiloff with the water and radionuclides which are entrained in the vapors.

Table 2.8-1 summarizes information pertaining to the effluent stream. Sampling data were obtained during operations with four separate evaporator feeds. Key constituents from each feed mode are shown in Table 2.8-2. Loading data are given in Table 2.8-3.

The old chemical data set showed acetone, 2-butanone, aluminum, and 1-butanol to exceed Group A and C study guidelines in some feed modes. The evaporator was not operating during the new data sampling period.

The old data set for radionuclides showed four elements in excess of Group A study guidelines, with tritium being the predominant species in the effluent. Note, however, that the crib was put in use in 1983 but some of the samples in this data set were taken prior to 1983.

2.8.3 Flow and Transport Analyses

Appendix D summarizes the results of an analysis using numerical models to simulate the wetting of the soil column that resulted during the operation of the 216-A-37-1 Crib. Based on these analyses, the time required for breakthrough of the wetted front is estimated to be 3 yr. Once the soil column has been wetted, the unit gradient model (Appendix B) can be used to provide a reasonable estimate of time of travel. For example, based on the average effluent discharge rate and a seven-layer stratigraphic model consisting of six combinations of sand and gravel with a bottom layer of silt (derived from Figure 2.8-2), the estimated travel time is 243 days. Appendix B contains the input parameters and computational details.

Based on the estimated travel time and appropriate retardation coefficients for the key constitents from Appendix C, the average rate of migration of wastewater and mobile constituents (R_f = 1) is estimated to be 33 cm/day. The more reactive constituents with R_f of 35 to 50, have calculated migration rates on the order of 0.7 to 0.9 cm/day (Appendix B). The total depth of penetration resulting from past operation is estimated to be 24 m for aluminum and cesium-137, and 36 m for strontium-90. Although mobile, acetone and 2-butanone are expected to degrade in the soil before reaching groundwater (Appendix C, Table C-27). Tritium, 1-butanol, and ruthenium-106 should be detectable in groundwater within approximately 8 mo of entering the crib, however, appreciable degradation of the 1-butanol will have occurred ($t_{1/2}$ ~ 10 to 100 days).

2.8.4 Groundwater Quality Assessment

Elevated concentrations of a number of constituents occurred in the groundwater at this site. For example, tritium and nitrate concentrations are far above Group A study guidelines (Table 2.8-4). Other constituents exceeding Group A study guidelines include metals (unfiltered aluminum, iron, manganese, etc.) for which the elevated concentrations are attributed to artifacts of sampling (carbon steel casing, sampled by bailer [WHC 1990d]). Tritium was a dominant constituent in effluent discharged to this crib. Nitrate, although present in effluent, is much higher in groundwater. For example, the maximum wastestream nitrate concentration was 5,000 ppb (WHC 1990a, Addendum 15, p. 3-4) as compared to a maximum groundwater value of 235,000 ppb. The only other major nitrogen-containing chemical species is ammonium for which a maximum wastestream value of 2,200,000 ppb was reported (WHC 1990a, Addendum 15, p. 3-4.), while this constituent was virtually undetected in the groundwater at this site.

Excluding the anomalously high metals due to sampling artifacts (discussed above), the following constituents appear to be moderately above the background range (Group B study guidelines): barium, uranium, vanadium, cyanide, and zinc (Table 2.8-5). Although these constituents have been identified in evaporator process condensate, the concentrations are very low, suggesting the wastestream is not the source.

Other positive occurrences of potential interest include: hydrazine (one positive result out of four was close to the detection limit), iodine-129, toluene (one occurrence out of eight measurements), and uranium (maximum of 8.7 pCi/L). Of these, only iodine-129 and uranium are judged to be "real" occurrences.

Excluding aluminum (discussed above), tritium was the only key wastestream constituent detected in groundwater; this is consistent with the predicted behavior of the key constituents (Section 2.8.3).

2.8.5 Impact of Continued Operation

Effluent formerly discharged to this crib will be stored at the Liquid Effluent Retention Facility pending construction of a treatment facility. The following is included for reference or comparison purposes only.

9 1 1 2 1 8 7 0 1 1 8

Groundwater and effluent characterization results suggest groundwater was significantly impacted by this disposal facility. Assuming a similar wastestream composition would have been discharged in the future, this crib would have a significant impact for decision tree evaluation purposes.

Based on discharge records and gamma logs (WHC 1989, Vol. 3), radionuclide and chemical loads retained on the soil column are considered to be minor.

Figure 2.8-1. Well Location and Site Map for 216-A-37-1 Crib.

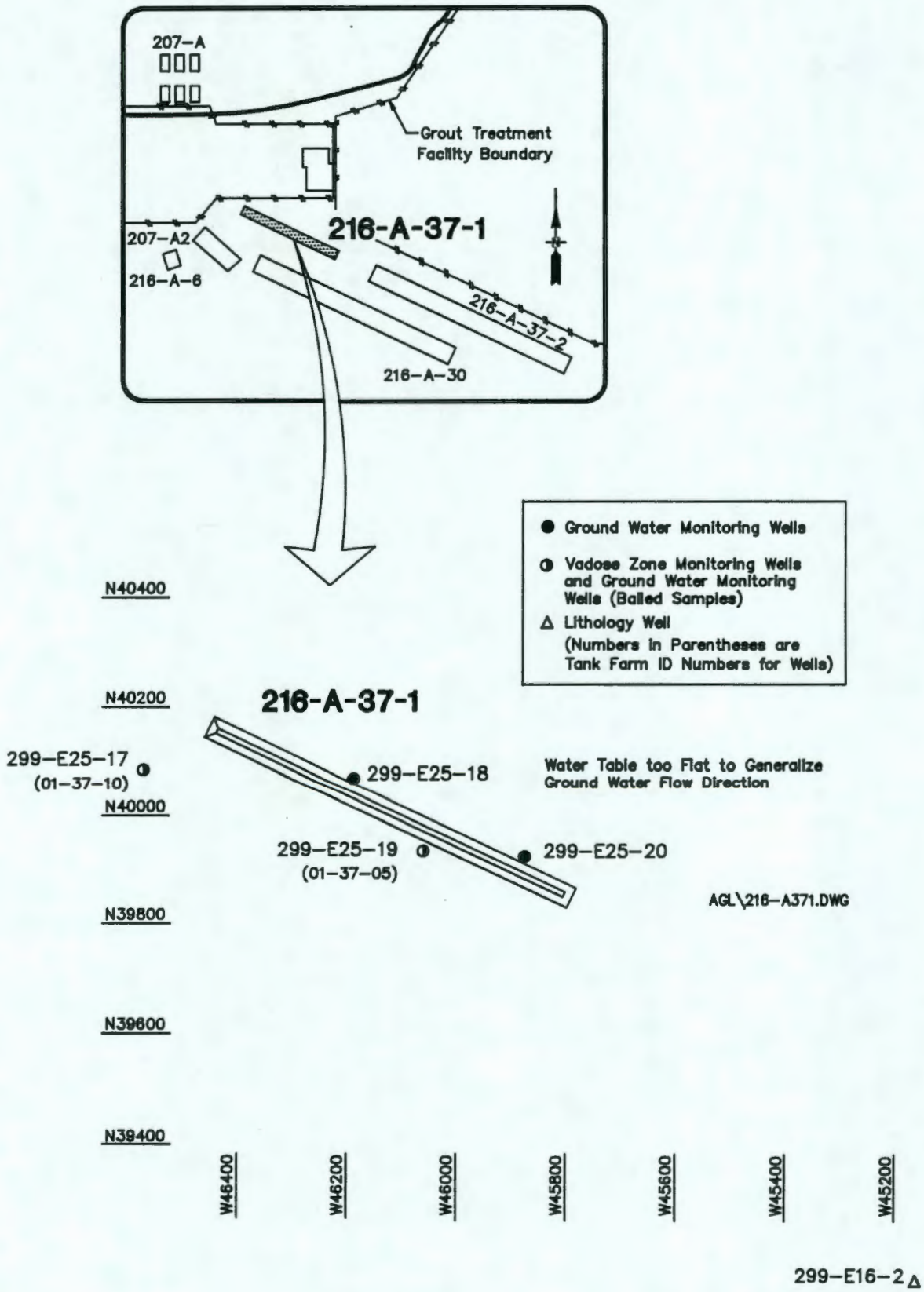

Figure 2.8-2. Lithology of Well 299-E16-2 Near 216-A-37-1 Crib.

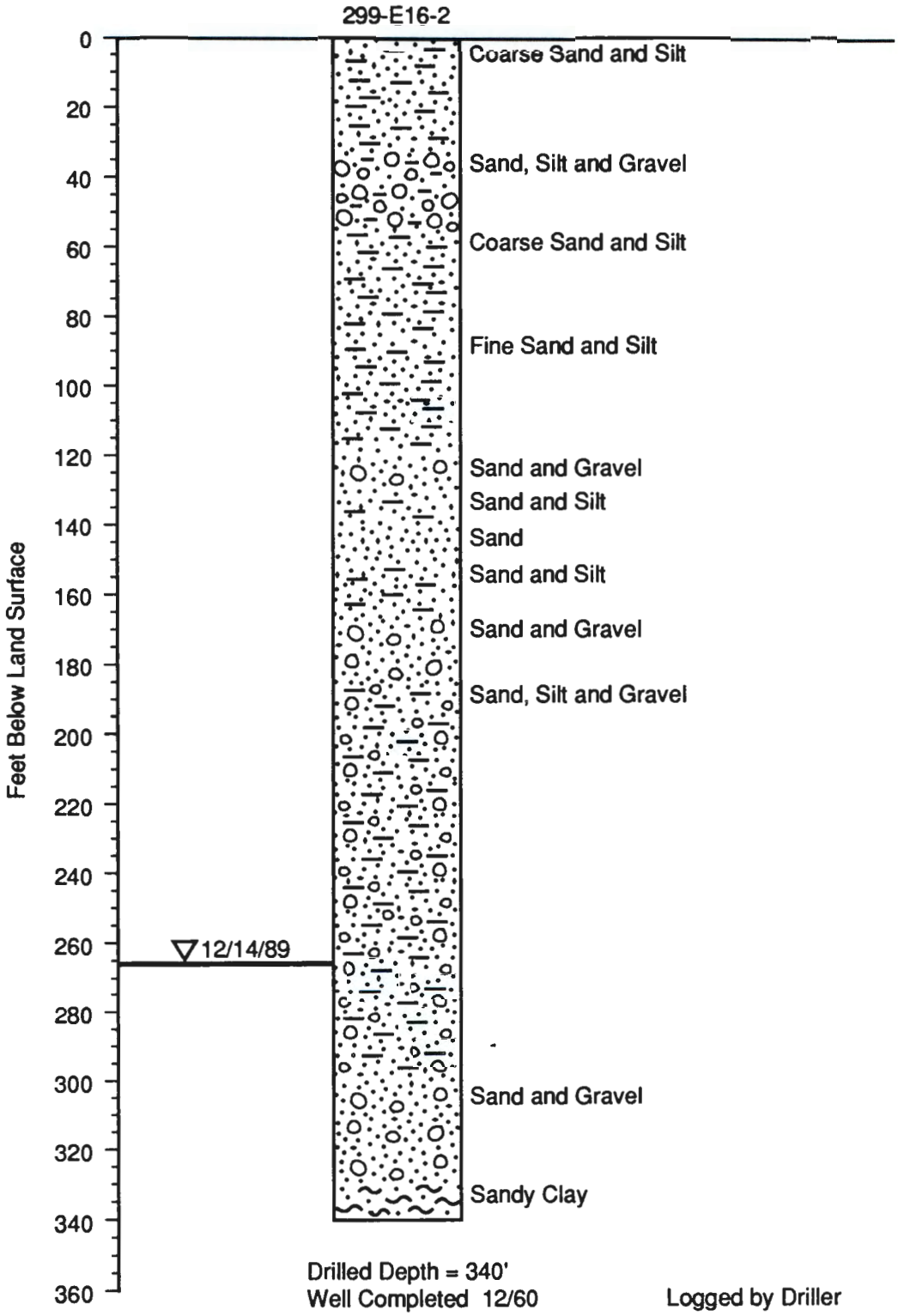

Table 2.8-1. Effluent Stream Description, 242-A Evaporator Process Condensate.

Total volume of effluent discharged: (WHC 1989a, WHC-EP-0287, Volume 2)	3.27E+08 from 3/77 to 12/88
Average effluent discharge rate, by operating mode: (WHC 1990a, WHC-EP-0342, Addendum 15)	Operating: 4.10E+06 L/min[a] Standby: no flow
Current average effluent discharge rate: (WHC 1990a, WHC-EP-0342, Addendum 15)	None
Effluent designation (WHC 1990a, WHC-EP-0342, Addendum 15)	Dangerous, radioactive
Effluent status: (WHC 1990a, WHC-EP-0342, Addendum 15)	Standby mode, no discharge

[a]Based on ASF feed.

Table 2.8-2. Effluent Stream Sampling Data, 242-A Evaporator Process Condensate.

Key Constituents	Detection Limit[a]	Detection/ Analyses	Sample Concentration 90% CI[a]	Detection Limit[a]	Detection/ Analyses	Sample Concentration 90% CI[a]
	03/88 to 05/88, During CRW Feed			10/89 to 03/90, During Inactive Mode		
acetone	10	5/5	2,540	No Data		
aluminum	NA	5/5	1,290			
1-butanol	NA	5/5	75,100			
	08/85 to 12/88, During Linked Feed			01/88 to 03/89, During ASF Feed		
acetone	10	11/11	1,690	10	9/9	1,270
aluminum	NA	11/12	765	NA	9/10	1,150
2-butanone	10	2/7	58	10	9/10	44[c]
1-butanol	NA	10/10	589[c]	NA	9/9	46,400
	07/88, During Saltwell Feed					
acetone	10	4/4	1,040			
aluminum	NA	4/4	633			
	1977 to 1988, During Routine Operation[b]					
hydrogen-3	5,000	83/NA	6,300,000			
strontium-90	30	46/NA	760			
ruthenium-106	600	5/NA	3,500			
cesium-137	80	47/NA	540			

[a]Units: chemical--parts per billion
radionuclides--picocurie per liter.

CI: confidence interval.
NA: not available.

[b]Disposal of effluent to the 216-A-37-1 Crib began in 1983; thus, this data set includes some samples taken prior to 1983.

[c]Concentrations below Group A or Group C study guideline; values given for purposes of comparison.

Table 2.8-3a. Radionuclide and Chemical Loading, 242-A Evaporator Process Condensate - CRW Feed.

Flow Rate: 4.67E+06 L/mo

Constituent	Kg/L*	Kg/mo*
aluminum	1.14E-06	5.32E+00
barium	6.00E-09	2.80E-02
calcium	4.97E-06	2.32E+01
chloride	6.23E-07	2.91E+00
magnesium	5.42E-08	2.53E-01
mercury	5.26E-10	2.45E-03
potassium	6.03E-07	2.81E+00
uranium	3.88E-10	1.81E-03
zinc	5.00E-09	2.33E-02
acetone	2.10E-06	9.80E+00
ammonia	6.41E-04	2.99E+03
benzyl alcohol	1.47E-08	6.86E-02
butanal	4.42E-08	2.06E-01
1-butanol	4.60E-05	2.15E+02
2-butanone	7.16E-08	3.34E-01
2-butoxyethanol	5.52E-07	2.58E+00
butoxyglycol	2.77E-07	1.29E+00
3,5-dimethylpyridine	2.07E-08	9.66E-02
2-hexanone	9.25E-09	4.32E-02
MIBK (Hexone)	4.33E-09	2.02E-02
2-pentanone	8.75E-09	4.08E-02
2-propanol	3.90E-08	1.82E-01
tetradecane	1.92E-08	8.96E-02
tetrahydrofuran	1.50E-08	7.00E-02
tributylphosphate	3.59E-06	1.67E+01
tridecane	1.27E-08	5.92E-02
unknown	4.40E-08	2.05E-01
alpha activity *	2.15E-13	1.00E-06
beta activity *	3.86E-10	1.80E-03
TOC	4.38E-05	2.04E+02

Loading Rate for 242-A Evaporator Process Condensate-CRW Feed Continued

Footnotes:

Data collected during March 1988 and May 1988.

Flow rate is the average of rates from the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 15).

Constituent concentrations are average values from the statistics in the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 15).

Concentration units of flagged (*) constituents are reported as curies per liter.

Loading units of flagged (*) constituents are reported as curies per month.

Table 2.8-3b. Radionuclide and Chemical Loading, 242-A Evaporator Process Condensate - Linked Feed.

Flow Rate: 2.70E+06 L/mo

Constituent	Kg/L*	Kg/mo*
aluminum	5.99E-07	1.62E+00
barium	6.00E-09	1.62E-02
cadmium	2.25E-09	6.07E-03
calcium	2.04E-06	5.51E+00
chloride	5.94E-07	1.60E+00
copper	1.11E-08	3.00E-02
fluoride	2.21E-08	5.96E-02
iron #	5.46E-08	1.47E-01
magnesium	5.17E-07	1.40E+00
mercury	2.22E-10	5.99E-04
nickel	1.12E-08	3.02E-02
nitrate	9.83E-07	2.65E+00
potassium	4.07E-07	1.10E+00
sodium	2.87E-06	7.74E+00
sulfate	2.04E-06	5.51E+00
sulfide	6.73E-06	1.82E+01
uranium	1.54E-10	4.16E-04
vanadium	5.00E-09	1.35E-02
zinc	7.33E-09	1.98E-02
acetone	1.10E-06	2.97E+00
ammonia	7.55E-05	2.04E+02
benzaldehyde	2.30E-08	6.21E-02
benzyl alcohol	1.00E-08	2.70E-02
butanal	1.20E-07	3.24E-01
1-butanol	3.99E-07	1.08E+00
2-butanone	4.17E-08	1.13E-01
butoxydiglycol	1.10E-08	2.97E-02
2-butoxyethanol	4.82E-07	1.30E+00
butoxyglycol	8.48E-08	2.29E-01
dodecane	4.30E-08	1.16E-01
ethoxytriethylene glycol	1.50E-07	4.05E-01
heptadecane	1.80E-08	4.86E-02
hexadecane	1.70E-08	4.59E-02
hexanoic acid	7.00E-08	1.89E-01
2-hexanone	1.12E-08	3.02E-02
methoxydiglycol	2.80E-08	7.56E-02
methoxytriglycol	3.70E-07	9.98E-01
MIBK (Hexone) #	1.46E-08	3.94E-02
n-nitrosodimethylamine	1.39E-08	3.75E-02
pentadecane	2.00E-08	5.40E-02
2-pentanone	9.75E-09	2.63E-02
phenol	1.19E-08	3.21E-02
2-propanol	1.60E-08	4.32E-02
pyridine	5.04E-07	1.36E+00
tetradecane	1.16E-07	3.13E-01
tetrahydrofuran	1.98E-08	5.34E-02
tributylphosphate	3.30E-06	8.91E+00
tridecane	1.01E-07	2.73E-01
triglyme	9.00E-08	2.43E-01
alpha activity *	7.52E-13	2.03E-06
beta activity #,*	1.29E-09	3.48E-03
TOC	1.76E-05	4.75E+01

Footnotes:

Data collected during August 1985, June 1986, July 1986, October 1986, March 1987, September 1987 and February 1988.

Flow rate is the average of rates from the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 15).

Constituent concentrations are average values from the statistics in the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 15).

Concentration units of flagged (*) constituents are reported as curies per liter.

Loading units of flagged (*) constituents are reported as curies per month.

Constituents are flagged (#) if any detected result is less than any detection limit.

Table 2.8-3c. Radionuclide and Chemical Loading, 242-A Evaporator Process Condensate - ASF Feed.

Flow Rate: 4.10E+06 L/mo

Constituent	Kg/L*	Kg/mo*
aluminum	9.44E-07	3.87E+00
barium	6.30E-09	2.58E-02
boron	1.07E-08	4.39E-02
calcium	3.46E-06	1.42E+01
chloride	7.00E-07	2.87E+00
copper	1.02E-08	4.18E-02
fluoride #	1.47E-07	6.03E-01
iron	2.77E-08	1.14E-01
magnesium	1.20E-07	4.92E-01
manganese	5.00E-09	2.05E-02
mercury	1.79E-10	7.34E-04
nickel	1.04E-08	4.26E-02
potassium	5.11E-06	2.09E+01
silicon	6.72E-06	2.75E+01
sodium	4.02E-06	1.65E+01
strontium #	1.85E-08	7.58E-02
sulfate	2.01E-06	8.24E+00
uranium	5.43E-10	2.23E-03
vanadium	5.50E-09	2.25E-02
zinc	6.33E-09	2.59E-02
acetone	1.03E-06	4.22E+00
ammonia	8.20E-04	3.36E+03
benzyl alcohol #	1.19E-08	4.88E-02
butanal	8.67E-09	3.55E-02
1-butanol	2.84E-05	1.16E+02
2-butanone	3.38E-08	1.39E-01
butoxydiglycol	2.70E-08	1.11E-01
2-butoxyethanol	2.89E-07	1.18E+00
butoxyglycol	1.88E-07	7.71E-01
butoxytriethyleneglycol	3.50E-08	1.43E-01
ethanol	2.00E-09	8.20E-03
2-hexanone	3.20E-08	1.31E-01
2-methylnonane	1.55E-08	6.35E-02
2-propanol	1.90E-08	7.79E-02
tetradecane	1.40E-08	5.74E-02
tetrahydrofuran	2.92E-08	1.20E-01
tributylphosphate	3.95E-06	1.62E+01
tridecane	1.27E-08	5.21E-02
unknown	2.88E-07	1.18E+00
unknown aliphatic HC	1.20E-08	4.92E-02
alpha activity *	3.72E-13	1.52E-06
beta activity *	4.11E-09	1.68E-02
TDS	2.25E-05	9.22E+01
TOC	2.70E-05	1.11E+02

Footnotes:

Data collected during January 1988, August 1988, October 1988, February 1989 and March 1989.

Flow rate is the average of rates from the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 15).

Constituent concentrations are average values from the statistics in the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 15).

Concentration units of flagged (*) constituents are reported as curies per liter.

Loading units of flagged (*) constituents are reported as curies per month.

Constituents are flagged (#) if any detected result is less than any detection limit.

Table 2.8-3d. Radionuclide and Chemical Loading, 242-A Evaporator Process Condensate - Saltwell Feed.

Flow Rate: 4.21E+06 L/mo

Constituent	Kg/L*	Kg/mo*
aluminum	5.93E-07	2.50E+00
calcium	3.65E-07	1.54E+00
mercury	1.83E-10	7.70E-04
nickel	1.07E-08	4.50E-02
potassium	4.81E-06	2.03E+01
sodium	1.74E-06	7.33E+00
zinc	1.55E-08	6.53E-02
acetone	8.00E-07	3.37E+00
ammonia	7.97E-05	3.36E+02
benzyl alcohol	1.10E-08	4.63E-02
butanal	3.10E-08	1.31E-01
1-butanol	3.90E-07	1.64E+00
2-butanone	3.25E-08	1.37E-01
2-butoxyethanol	7.17E-08	3.02E-01
butoxyglycol	7.02E-07	2.96E+00
ethoxytriethylene glycol	8.20E-08	3.45E-01
2-hexanone	6.25E-09	2.63E-02
methoxydiglycol	5.20E-08	2.19E-01
methoxytriglycol	6.50E-08	2.74E-01
MIBK (Hexone)	8.00E-09	3.37E-02
2-propanol	2.35E-08	9.89E-02
tetradecane	1.38E-07	5.81E-01
tetrahydrofuran	1.07E-07	4.50E-01
tributylphosphate	3.64E-06	1.53E+01
tridecane	1.45E-07	6.10E-01
unknown	4.47E-08	1.88E-01
beta activity *	1.27E-09	5.35E-03
TOC	2.36E-05	9.94E+01
TOX (as Cl)	1.15E-08	4.84E-02

Footnotes:

Data collected during July 1988.

Flow rate is the average of rates from the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 15).

Constituent concentrations are average values from the statistics in the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 15).

Concentration units of flagged (*) constituents are reported as curies per liter.

Loading units of flagged (*) constituents are reported as curies per month.

Table 2.8-4. Effluent Study Groundwater Summary Report. (Page 1 of 2)

CONSTITUENT			ANALYSIS SUMMARY					GROUP A STUDY GUIDELINES	
Group Name	Units	Detection Limit	Number of Analyses	Number > Det.	Average Result	Maximum Result	Minimum Result	Max Limit	Number > Limit
CONTAMINATION INDICATOR PARAMETERS									
Conductivity, Laboratory	UMHO	1.00	8	8	484.50	721.00	272.00	700.0	1
Specific conductance	UMHO	1.00	22	22	489.18	741.00	257.00	700.0	5
pH, Field Measurement		.10	21	21	7.89	8.25	7.48	8.5	0
pH, Laboratory Measurement		.01	8	8	7.88	8.40	7.70	8.5	0
DRINKING WATER PARAMETERS									
Alpha, High Detection Level	PCI/L	4.00	18	5	2.43	9.00	.15	15.0	0
Arsenic	PPB	5.00	10	9	12.40	56.00	5.00	50.0	1
Arsenic, filtered	PPB	5.00	10	9	7.50	11.00	5.00	50.0	0
Barium	PPB	6.00	10	10	72.20	343.00	13.00	1000.0	0
Barium, filtered	PPB	6.00	13	13	45.85	85.00	13.00	1000.0	0
Cadmium	PPB	2.00	10	1	22.90	211.00	2.00	10.0	1
Chromium	PPB	10.00	10	1	41.10	321.00	10.00	50.0	1
Fluoride	PPB	500.00	14	8	600.00	1000.00	500.00	4000.0	0
Gross beta	PCI/L	8.00	22	19	13.23	32.30	6.11	50.0	0
Lead (graphite furnace)	PPB	5.00	10	1	9.70	52.00	5.00	50.0	1
Nitrate	PPB	500.00	15	15	132546.67	235000.00	16200.00	45000.0	12
Nitrate, High Detection Level	PPB	2500.00	7	7	60314.29	186000.00	24300.00	45000.0	2
Radium	PCI/L	1.00	11	1	.21	1.65	-.05	100.0	0
GROUNDWATER QUALITY PARAMETERS									
Chloride	PPB	500.00	15	15	3753.33	5100.00	2600.00	250000.0	0
Iron	PPB	30.00	11	11	54022.64	592000.00	36.00	300.0	2
Iron, filtered	PPB	30.00	12	2	30.17	32.00	30.00	300.0	0
Manganese	PPB	5.00	10	5	630.90	6240.00	5.00	50.0	1
Manganese, filtered	PPB	5.00	12	1	5.08	6.00	5.00	50.0	0
Sodium	PPB	200.00	11	11	34100.00	53500.00	17400.00		0
Sodium, filtered	PPB	200.00	13	13	36100.00	56700.00	18000.00		0
Sulfate	PPB	500.00	15	15	42573.33	78400.00	23300.00	250000.0	0

Table 2.8-4. Effluent Study Groundwater Summary Report. (Page 2 of 2)

CONSTITUENT			ANALYSIS SUMMARY					GROUP A STUDY GUIDELINES	
Group Name	Units	Detection Limit	Number of Analyses	Number > Det.	Average Result	Maximum Result	Minimum Result	Max Limit	Number > Limit
SITE SPECIFIC AND OTHER PARAMETERS									
Aluminum	PPB	150.00	10	1	253.00	1180.00	150.00	50.0	1
Ammonium ion	PPB	50.00	4	2	112.00	257.00	50.00		0
Boron	PPB	10.00	11	11	41.27	115.00	13.00		0
Boron, filtered	PPB	10.00	13	13	30.31	47.00	13.00		0
Calcium	PPB	50.00	11	11	46881.82	68500.00	25200.00		0
Calcium, filtered	PPB	50.00	13	13	48238.46	66800.00	24800.00		0
Cobalt	PPB	20.00	10	1	21.00	30.00	20.00		0
Copper	PPB	10.00	10	1	16.30	73.00	10.00	1000.0	0
Hydrazine, Low Detection Level	PPB	30.00	4	1	32.00	38.00	30.00		0
Iodine-129 (Drinking Water Standard)	PCI/L	1.00	4	4	2.08	2.52	1.08	20.0	0
Lithium	PPB	10.00	10	2	10.30	12.00	10.00		0
Lithium, filtered	PPB	10.00	12	3	10.17	11.00	10.00		0
Magnesium	PPB	50.00	11	11	12385.45	17600.00	7280.00		0
Magnesium, filtered	PPB	50.00	12	12	12500.83	17900.00	7320.00		0
Nickel	PPB	10.00	10	1	27.30	183.00	10.00		0
Plutonium-239/40	PCI/L	.10	4	1	.11	.44	-.00	1.2	0
Potassium	PPB	100.00	11	11	8668.18	13100.00	5190.00		0
Potassium, filtered	PPB	100.00	12	12	8882.50	12600.00	5340.00		0
Silicon	PPB	50.00	11	11	26290.91	73600.00	17100.00		0
Silicon, filtered	PPB	50.00	13	13	22315.38	28300.00	17700.00		0
Strontium	PPB	10.00	11	11	252.45	352.00	131.00		0
Strontium, filtered	PPB	10.00	13	13	252.15	336.00	132.00		0
Titanium	PPB	60.00	10	1	66.80	128.00	60.00		0
Toluene	PPB	5.00	8	1	6.75	19.00	5.00	2000.0	0
Total carbon	PPB	1000.00	4	4	20300.00	23900.00	18500.00		0
Tritium	PCI/L	500.00	16	16	1197187.50	4170000.00	254000.00	80000.0	16
Turbidity	NTU	.10	4	4	51.60	200.00	.50	5.0	1
Uranium	PCI/L	.50	5	5	2.87	8.73	1.03	40.0	0
Vanadium	PPB	5.00	11	11	91.36	656.00	32.00		0
Vanadium, filtered	PPB	5.00	13	13	34.23	41.00	30.00		0
Zinc	PPB	5.00	10	10	24.70	68.00	9.00	5000.0	0
Zinc, filtered	PPB	5.00	13	11	9.85	20.00	5.00	5000.0	0

Table 2.8-5. Background Comparison, 216-A-37-1 Crib.

Constituent	Background[a]	Average/ Background[b]	Maximum/ Background[b]
aluminum	2.0	126.50	590.00
ammonia	50.0	2.24	5.14
arsenic	6.3	1.97 (1.19)	8.89 (1.75)
barium	62.0	1.16 (0.74)	5.53 (1.37)
beryllium	0.3		
bismuth	0.02		
boron	50.0	0.83 (0.61)	2.30 (0.94)
cadmium	0.2	114.50	1,055.00
calcium	50,700	0.92 (0.95)	1.35 (1.32)
chloride	16,800	0.22	0.30
chromium	6.0	6.85	53.50
copper	1.0	16.30	73.00
cyanide			
fluoride	470		
lead	0.5	19.40	104.00
magnesium	15,200	0.81 (0.82)	1.16 (1.18)
manganese	12.0	52.58 (0.42)	520.00 (0.50)
mercury	0.1		
nickel	4.0	6.83	45.75
phosphate	1,000		
potassium	6,190	1.40 (1.43)	2.12 (2.04)
selenium	2.0		
silver	10		
sodium	28,410	1.20 (1.27)	1.88 (2.00)
strontium	338	0.75 (0.75)	1.04 (0.99)
sulfate	51,200	0.83	1.53
uranium	2.5	1.15	3.49
vanadium	26	3.51 (1.32)	25.23 (1.58)
zinc	8.0	3.09 (1.23)	8.50 (2.50)
alkalinity	144,000		
pH	7.8	1.01	1.06
TOC	933		
conductivity	462	1.06	1.60
gross alpha	3.9		
gross beta	31	0.43	1.04
radium	0.2	1.05	8.25

TOC: total organic carbon. ( ): filtered samples.

[a]Background is the mean plus one standard deviation for the values listed in Table 2-1. Amounts of uranium, gross alpha, gross beta, and radium given in picocuries per liter. All others are in parts per billion.

[b]Average and maximum values from Table 2.8-4.

2.9 216-A-37-2 CRIB

No significant additional impacts on soil and groundwater quality from continued use of this crib were identified.

2.9.1 Receiving Site Description

The 216-A-37-2 Crib, located just east of the 200 East Area, began operation in 1983 to receive the steam condensate waste from the PUREX Plant. One-third of the effluent stream is discharged to this crib and the other two-thirds goes to the 216-A-30 Crib. Figure 2.9-1 shows the location of the 216-A-37-2 Crib relative to other disposal facilities and shows the placement of associated groundwater monitoring wells.

2.9.2 Effluent Stream Description

The PUREX Plant steam condensate consists almost entirely of condensed steam and warm, "raw" water that have been used to control the temperature (via heating and cooling coils) of certain process vessels in the PUREX Plant. Table 2.9-1 summarizes information pertaining to the effluent stream. Key constituents and loading estimates are given in Tables 2.9-2 and 2.9-3, respectively.

The old sampling data show that during routine operations, four radionuclides exceeded the Group A study guideline concentrations, although by relatively small margins. Note that the crib was placed in service in 1983. However, the old data set include samples taken prior to 1983. The new data set showed plutonium-239, cerium/praseodymium-144, and radium to be above Group A study guidelines.

2.9.3 Flow and Transport Analysis

Appendix D summarizes the results of an analysis using numerical models to simulate initial wetting of the soil column during operation of the 216-A-37-2 Crib. Results of this analysis suggest a breakthough time for the wetted front of 1-1/2 yr. Once the soil column has been wetted, the unit gradient model (described in Appendix B) can be used to calculate the wastewater travel time under steady-state conditions. Assuming the average discharge rate (Table 2.9-1) to the crib and a seven-layer soil column consisting of sand and gravel with a bottom layer of sand and silt (based on Figure 2.9-2), a calculated travel time of 156 days is obtained (see Appendix B for computational details).

The corresponding key constituent migration rates are on the order of 0.05 to 5 cm/day as compared to a wastewater migration rate of 51 cm/day (Appendix B, sorption data from Appendix C). Uranium, a potential contaminant of interest at this site due to a reportable quantity release in May 1989, has an estimated steady-state migration rate of approximately 5 cm/day or a total travel time of 4.3 yr (Appendix B).

Based on the above migration rates, and assuming similar conditions in the future, operation for an additional 4 yr would result in approximately 3 to 6 m of additional downward movement of cesium-137 and strontium-90.

2.9.4 Groundwater Quality Assessment

Styrene was the only constituent found in groundwater that was above Group A study guidelines (Table 2.9-4). However, a single occurrence (one out of four) near the detection limit of 5 ppb is judged to be insignificant for purposes of this study.

Comparison with Group B guidelines indicate that many constituents are lower than background (Table 2.9-5). This is due to the dilution effect of the wastestream on groundwater. A few constituents that are slightly above background are also identified in PUREX steam condensate (WHC 1990a, Addendum 5, Table 3-1). However, their concentrations in the wastestream do not exceed maximum contaminant levels.

Uranium, although detected, is at or below natural background.

2.9.5 Impact of Continued Operation

Based on soil column loading, effluent characteristics, average chemical composition (WHC 1989, Vol. 3), recent groundwater data, and assuming similar effluent composition in the future, no significant impact on groundwater quality due to continued operation is evident. The possible appearance of elevated uranium concentrations, however, could result as the small release of uranium that occurred May 1989 works through the soil column. (Maximum groundwater concentrations are expected to be less than the Group A study guideline, Appendix D.)

The short operating history and minimal soil column loading to this crib, coupled with the slow contaminant migration rate estimates for key consituents (Section 2.9.3), suggest continued operation would not have an adverse impact on future remediation efforts.

Figure 2.9-1. Well Location and Site Map for 216-A-37-2 Crib.

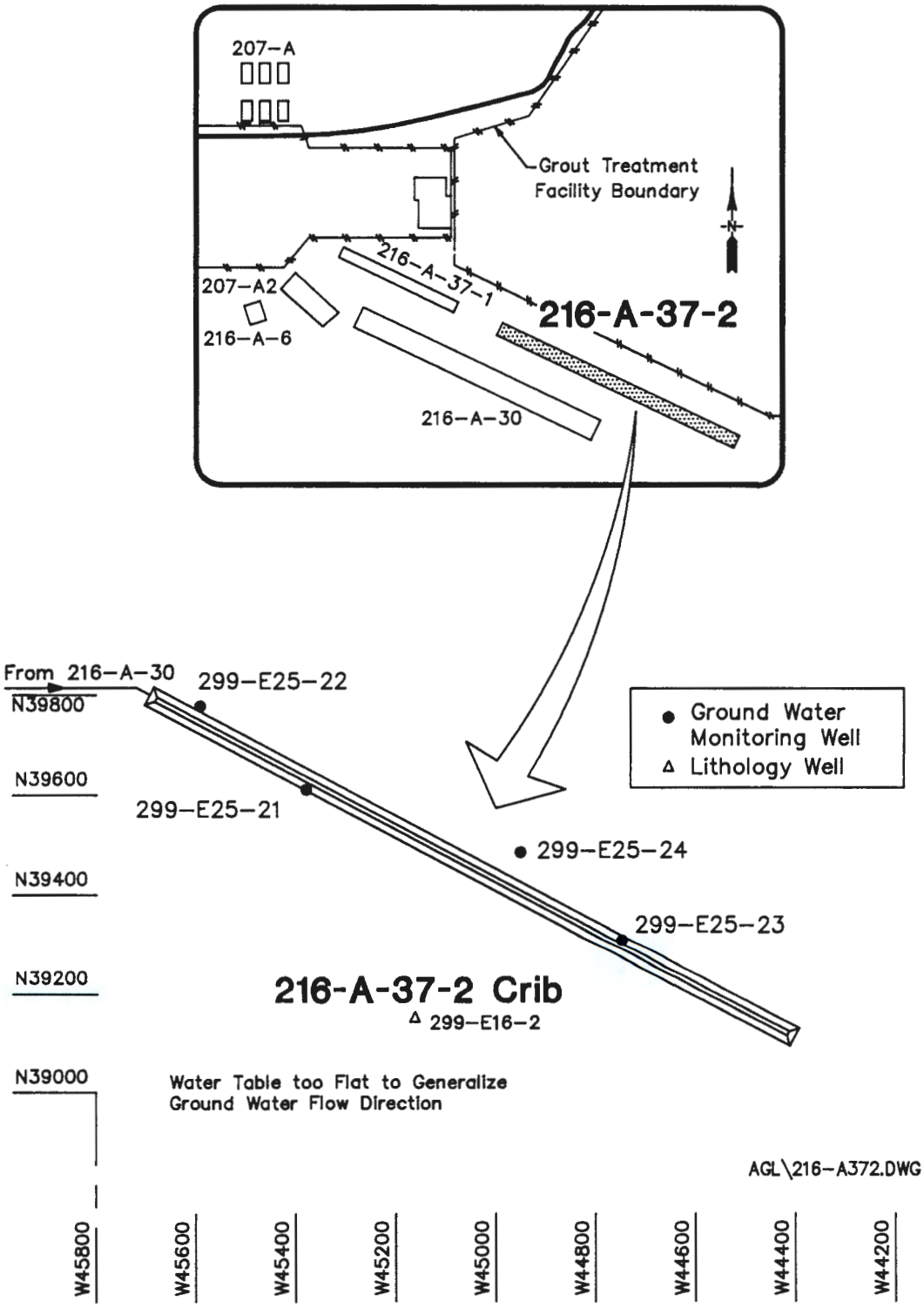

Figure 2.9-2. Lithology of Well 299-E16-2 Near 216-A-37-2 Crib.

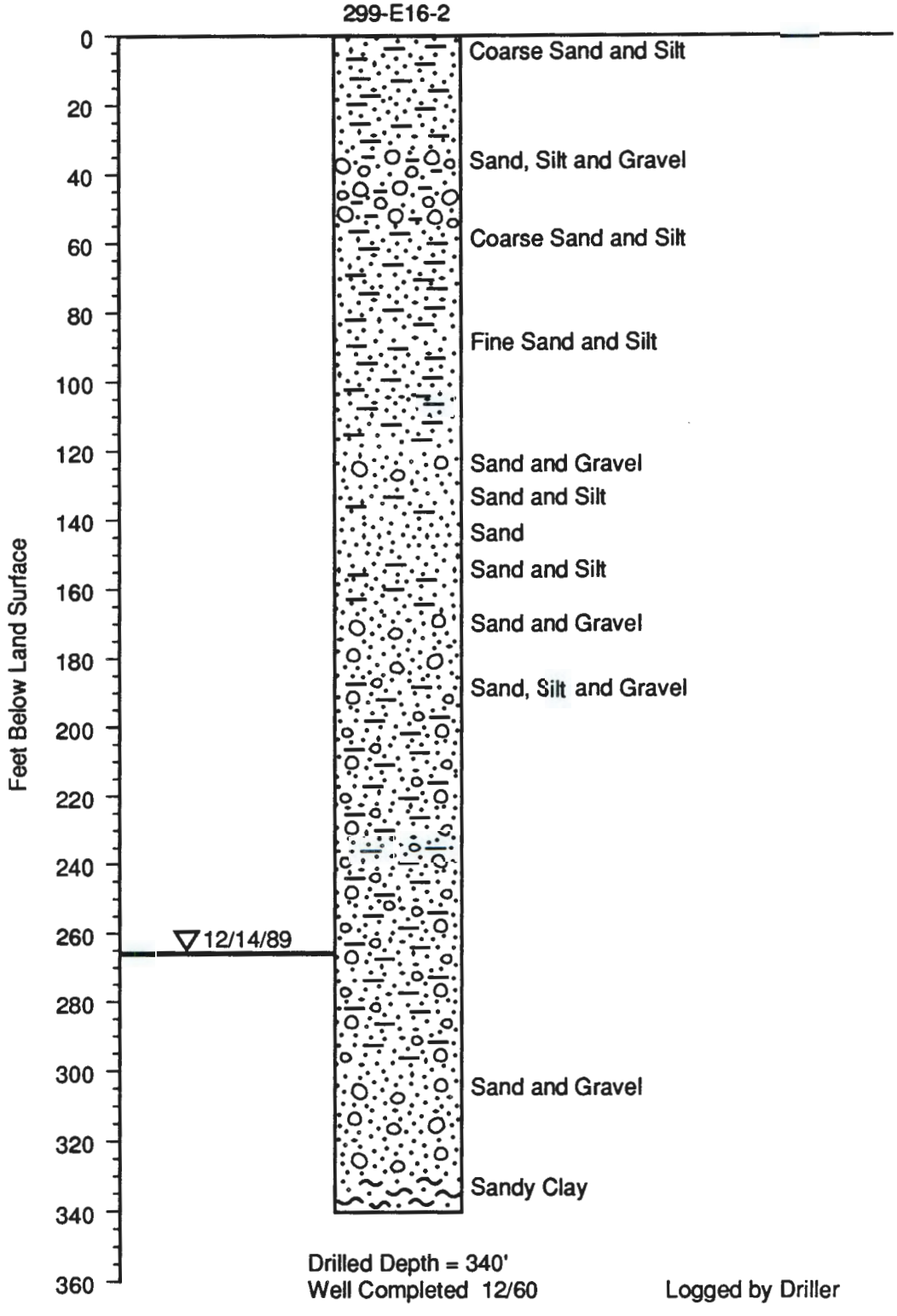

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Table 2.9-1. Effluent Stream Description, PUREX Steam Condensate to 216-A-37-2 Crib.

Total volume of effluent discharged to subject receiving site: (WHC 1989a, WHC-EP-0287, Volume 3)	1.09E+09 L from 3/83 to 12/89
Average effluent discharge rate, by operating mode: (WHC 1990a, WHC-EP-0342, Addendum 5)	4.29E+07 L/mo[a]
Current average effluent discharge rate: (WHC 1990a, WHC-EP-0342, Addendum 5)	4.29E+07 L/mo[a]
Effluent designation: (WHC 1990a, WHC-EP-0342, Addendum 5)	Nondangerous, radioactive
Effluent status:	Currently active discharge to 216-A-37-2 Crib and 216-A-30 Crib

[a]Based on average flow rate during the sampling period 10/89 to 3/90. This flow rate does not take into account the parallel discharge to the 216-A-30 and 316-A-37-2 cribs.

Table 2.9-2. Effluent Stream Sampling Data, PUREX Steam Condensate.

Key Constituents	Detection Limit[a]	Detection/ Analyses	Sample Concentration 90% CI[a]	Detection Limit[a]	Detection/ Analyses	Sample Concentration 90% CI[a]
	1976 to 1988, During Routine Operation[e]			10/89 to 03/90, During Routine Operation		
strontium-90	30	53/NA	960	0.1	5/6	3[c]
cesium-137	80	59/NA	290	1	5/6	16[b]
uranium (isotopes)[d]	20	7NA	47	NA	6/6	0.4[c,f]
plutonium-239	50	64/NA	45	0.001	6/6	7.2
cerium/praseodymium-144	N/A	ND	ND	NA	5/5	337
radium (total)	NA	ND	ND	NA	6/6	4.4

[a]Units: chemical--parts per billion
radionuclides--picocurie per liter.
[b]Ill-conditioned data set.
[c]Concentratins below Group A study guideline; values given for purposes of comparison.
[d]Uranium-234 used as the most restrictive Group A study guideline for determining key constituents.
[e]Disposal of effluent to the 216-A-37-2 Crib began in 1983; thus, this data set includes some samples taken prior to 1983.
[f]Consists of 0.26 pCi/L uranium-234 and 0.18 pCi/L uranium-238.

CI: confidence interval.
NA: not available.

Table 2.9-3. Radionuclide and Chemical Loading, PUREX Steam Condensate.

Flow Rate: 4.29E+07 L/mo

Constituent	Kg/L*	Kg/mo*
barium	2.82E-08	1.21E+00
boron	1.75E-08	7.50E-01
calcium	1.72E-05	7.37E+02
chloride	9.50E-07	4.07E+01
fluoride	1.18E-07	5.06E+00
iron	3.13E-08	1.34E+00
magnesium	4.07E-06	1.74E+02
nitrate	5.46E-07	2.34E+01
potassium	6.82E-07	2.92E+01
silicon	2.21E-06	9.47E+01
sodium	1.98E-06	8.49E+01
strontium	8.33E-08	3.57E+00
sulfate	9.47E-06	4.06E+02
uranium	5.25E-10	2.25E-02
zinc	5.33E-09	2.28E-01
acetone	1.00E-08	4.29E-01
1-butanol	2.40E-08	1.03E+00
tributylphosphate	1.08E-08	4.63E-01
alpha activity *	5.38E-12	2.31E-04
beta activity *	1.59E-10	6.82E-03
TDS	6.25E-05	2.68E+03
TOC	1.02E-06	4.37E+01
total carbon	1.36E-05	5.83E+02
TOX (as Cl)	6.17E-09	2.64E-01
americium-241 *	5.39E-13	2.31E-05
cerium/praseodymium-144 *	2.22E-10	9.52E-03
cesium-137 #,*	1.02E-11	4.37E-04
plutonium-238 *	4.26E-13	1.83E-05
plutonium-239/240 *	5.49E-12	2.35E-04
radium total *	2.01E-12	8.62E-05
strontium-90 #,*	1.76E-12	7.54E-05
uranium-234 *	2.34E-13	1.00E-05
uranium-238 *	1.57E-13	6.73E-06

Footnotes:

Data collected from October 1989 through March 1990.

Flow rate is the average of rates from the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 5).

Constituent concentrations are average values from the statistics in the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 5).

Concentration units of flagged (*) constituents are reported as curies per liter.

Loading units of flagged (*) constituents are reported as curies per month.

Constituents are flagged (#) if any detected result is less than any detection limit.

Table 2.9-4. Effluent Study Groundwater Summary Report. (Page 1 of 2)

CONSTITUENT			ANALYSIS SUMMARY					GROUP A STUDY GUIDELINES	
Group Name	Units	Detection Limit	Number of Analyses	Number > Det.	Average Result	Maximum Result	Minimum Result	Max Limit	Number > Limit
CONTAMINATION INDICATOR PARAMETERS									
Conductivity, Laboratory	UMHO	1.00	8	8	278.63	350.00	225.00	700.0	0
Specific conductance	UMHO	1.00	22	22	258.00	338.00	180.00	700.0	0
Total Organic Halogen, Low Det. Level	PPB	10.00	24	1	3.50	15.00	-1.00		0
pH, Field Measurement		.10	24	24	7.97	8.75	7.29	8.5	1
pH, Laboratory Measurement		.01	8	8	7.91	8.10	7.60	8.5	0
DRINKING WATER PARAMETERS									
Arsenic	PPB	5.00	10	10	13.80	24.00	8.00	50.0	0
Arsenic, filtered	PPB	5.00	10	10	13.60	20.00	8.00	50.0	0
Barium	PPB	6.00	10	10	21.10	33.00	12.00	1000.0	0
Barium, filtered	PPB	6.00	14	14	21.50	32.00	13.00	1000.0	0
Fluoride	PPB	500.00	14	6	579.79	800.00	500.00	4000.0	0
Gross beta	PCI/L	8.00	18	6	7.40	10.00	4.22	50.0	0
Nitrate	PPB	500.00	14	14	2464.29	4000.00	1100.00	45000.0	0
Nitrate, High Detection Level	PPB	2500.00	4	2	4017.50	6270.00	2500.00	45000.0	0
GROUNDWATER QUALITY PARAMETERS									
Chloride	PPB	500.00	14	14	2192.86	3500.00	1000.00	250000.0	0
Iron	PPB	30.00	10	8	122.10	296.00	30.00	300.0	0
Iron, filtered	PPB	30.00	14	2	31.00	41.00	30.00	300.0	0
Manganese	PPB	5.00	10	5	8.80	20.00	5.00	50.0	0
Manganese, filtered	PPB	5.00	14	4	5.50	10.00	5.00	50.0	0
Sodium	PPB	200.00	10	10	18570.00	31600.00	14900.00		0
Sodium, filtered	PPB	200.00	14	14	19864.29	36900.00	13900.00		0
Sulfate	PPB	500.00	14	14	23892.86	34400.00	15400.00	250000.0	0
SITE SPECIFIC AND OTHER PARAMETERS									
Alkalinity		20000.00	1	1	124000.00	124000.00	124000.00		0
Bis(2-ethylhexyl) phthalate	PPB	10.00	4	1	10.75	13.00	10.00		0
Boron	PPB	10.00	10	10	19.90	33.00	12.00		0
Boron, filtered	PPB	10.00	14	13	23.79	51.00	10.00		0
Calcium	PPB	50.00	10	10	22270.00	28500.00	18700.00		0

Table 2.9-4. Effluent Study Groundwater Summary Report. (Page 2 of 2)

CONSTITUENT			ANALYSIS SUMMARY					GROUP A STUDY GUIDELINES	
Group Name	Units	Detection Limit	Number of Analyses	Number > Det.	Average Result	Maximum Result	Minimum Result	Max Limit	Number > Limit
SITE SPECIFIC AND OTHER PARAMETERS									
Calcium, filtered	PPB	50.00	14	14	22114.29	27900.00	17900.00		0
Iodine-129 (Drinking Water Standard)	PCI/L	1.00	5	1	.59	1.41	-.09	20.0	0
Magnesium	PPB	50.00	10	10	5422.00	6460.00	3880.00		0
Magnesium, filtered	PPB	50.00	14	14	5410.00	6690.00	3800.00		0
Potassium	PPB	100.00	10	10	6714.00	8540.00	4920.00		0
Potassium, filtered	PPB	100.00	14	14	6739.29	8630.00	4780.00		0
Silicon	PPB	50.00	10	10	26150.00	32600.00	18300.00		0
Silicon, filtered	PPB	50.00	14	14	26107.14	32400.00	17800.00		0
Strontium	PPB	10.00	10	10	121.30	163.00	103.00		0
Strontium, filtered	PPB	10.00	14	14	123.36	161.00	96.00		0
Styrene	PPB	5.00	4	1	5.00	5.00	5.00	5.0	1
Total carbon	PPB	1000.00	3	3	23166.67	28000.00	19800.00		0
Total dissolved solids		5000.00	1	1	208000.00	208000.00	208000.00	500000.0	0
Tritium	PCI/L	500.00	11	5	2918.50	10100.00	11.50	80000.0	0
Turbidity	NTU	.10	4	4	.65	1.20	.40	5.0	0
Uranium	PCI/L	.50	4	4	.75	.95	.50	40.0	0
Vanadium	PPB	5.00	10	10	90.50	139.00	42.00		0
Vanadium, filtered	PPB	5.00	14	14	90.43	140.00	39.00		0
Zinc	PPB	5.00	10	8	8.20	15.00	5.00	5000.0	0
Zinc, filtered	PPB	5.00	14	5	6.00	10.00	5.00	5000.0	0

Table 2.9-5. Background Comparison, 216-A-37-2 Crib.

Constituent	Background[a]	Average/ Background[b]	Maximum/ Background[b]
aluminum	2.0		
ammonia	50.0		
arsenic	6.3	2.19 (2.16)	3.81 (3.17)
barium	62.0	0.34 (0.35)	0.53 (0.52)
beryllium	0.3		
bismuth	0.02		
boron	50.0	0.40 (0.48)	0.66 (1.02)
cadmium	0.2		
calcium	50,700	0.44 (0.44)	0.56 (0.55)
chloride	16,800	0.13	0.21
chromium	6.0		
copper	1.0		
cyanide	10.0		
fluoride	470	1.23	1.70
lead	0.5		
magnesium	15,200	0.36 (0.36)	0.43 (0.44)
manganese	12.0	0.73 (0.46)	1.67 (0.83)
mercury	0.1		
nickel	4.0		
phosphate	1,000		
potassium	6,190	1.08 (1.09)	1.38 (1.39)
selenium	2.0		
silver	10		
sodium	28,410	0.65 (0.70)	1.11 (1.30)
strontium	338	0.36 (0.36)	0.48 (0.48)
sulfate	51,200	0.47	0.67
uranium	2.5	0.30	0.38
vanadium	26	3.48 (3.48)	5.35 (5.38)
zinc	8.0	1.03 (0.75)	1.88 (1.25)
alkalinity	144,000	0.86	0.86
pH	7.8	1.02	1.12
TOC	933		
conductivity	462	0.56	0.73
gross alpha	3.9		
gross beta	31	0.24	0.32
radium	0.2		

TOC: total organic carbon. ( ): filtered samples.

[a]Background is the mean plus one standard deviation for the values listed in Table 2-1. Amounts of uranium, gross alpha, gross beta, and radium given in picocuries per liter. All others are in parts per billion.

[b]Average and maximum values from Table 2.9-4.

2.10 216-A-45 CRIB

Discharge to this crib was discontinued in mid-1989 and the wastestream routed to storage tanks. At present, there are no plans for future or continued use of the crib. Vicinity groundwater contamination is due to crib drainage and the residual from past and/or adjacent operations.

2.10.1 Receiving Site Description

The 216-A-45 Crib, located in the 200 East Area, was put into service in 1987 to dispose of the PUREX Plant process condensate. Monitoring well locations and spatial relationship to other facilities are shown in Figure 2.10-1.

2.10.2 Effluent Stream Description

The PUREX process condensate consists of condensed vapors from concentrators which process aqueous solutions in the PUREX Plant. The condensate stream is distilled water containing primarily neutralized nitric acid and radionuclides, mostly uranium. The Table 2.10-1 summarizes information pertaining to the effluent stream. Key constituent sampling data are given in Table 2.10-2. Loading estimates, based on new data taken during the stabilization campaign, are given in Table 2.10-3.

The old and new chemical sampling data showed that the condensate stream exceeded study guidelines for several constituents. Note that the old sampling data represent a period of operation prior to use of the 216-A-45 crib for condensate disposal.

Several radiological constituents exceeded Group A study guidelines from the old data set, although the new data set showed only one detectable radiological constituent. Samples from the new data set were taken during the PUREX stabilization campaign.

2.10.3 Flow and Transport Analysis

For the purpose of performing transport calculations, the sediment column beneath the crib is considered to be a two-layer system, 84 m in depth (Figure 2.10-2 and Appendix B. The estimated travel time for water to reach the water table under average discharge conditions is 444 days (see Appendix B for data and computations).

Based on general effluent characteristics and corresponding sorption parameters (Appendix C) for the key constituents identified in Table 2.10-2, the calculated migration rates (Appendix B) range from about 19 cm/day for the mobile constituents (acetone, 2-butanone, nitrate, nitrite, fluoride, tritium, and iodine-129) to <1 cm/day for the relatively immobile constituents.

2.10.4 Groundwater Quality Assessment

The only key constituent occurrence in vicinity groundwater at concentrations significantly above Group A guidelines (Table 2.10-4) is tritium. While this radioactive contaminant previously occurred in the wastestream at levels several hundred times higher than Group A guidlines, it was also present in groundwater prior to use of this crib for disposal of PUREX process condensate beginning in March 1987 (Figure 2.10-3). The pre-existing tritium shown in this figure is attributed to 216-A-10 and the 216-A-36B Cribs. In addition, there are no significant occurrences above Group B guidelines (Table 2.10-5), and in fact, several major groundwater constituents are below the background guideline, due to dilution of vicinity groundwater by the wastestream (i.e., due to mixing of essentially distilled water with groundwater).

The only other key constituents detected were nitrate and iodine-129. A plot of iodine-129 over time is shown in Figure 2.10-4). The abrupt increase that occurred during the 1990 sampling event may be related to elevated concentrations that occurred in the wastestream in September 1987, June 1988, and July 1988. The time difference is approximately the same as the calculated travel time indicated in Section 2.10.3.

2.10.5 Impact From Continued Operation

Since there are no current plans for continued use of this crib, impacts of continued operation were not considered.

Figure 2.10-1. Well Location and Site Map for 216-A-45 Crib.

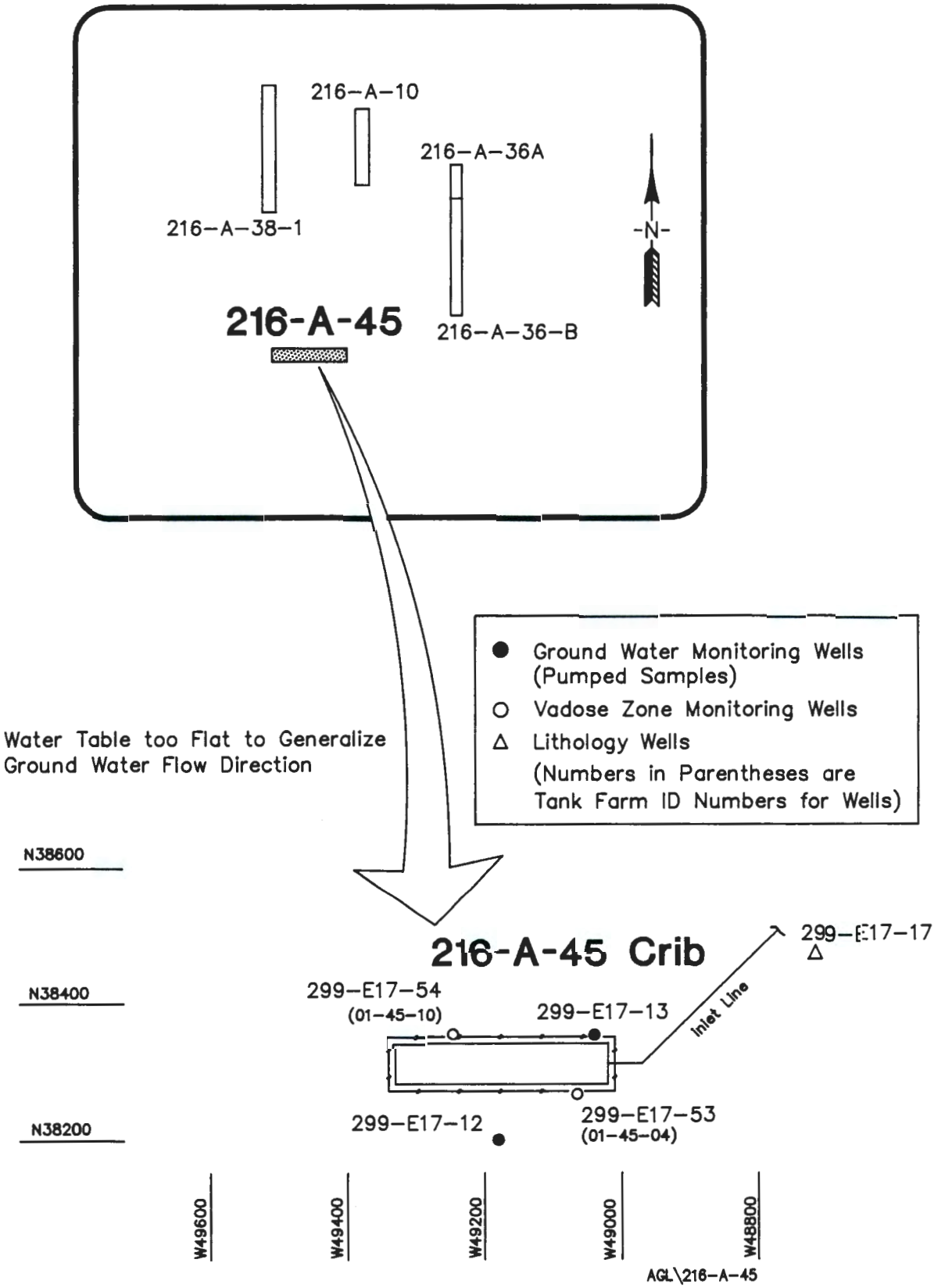
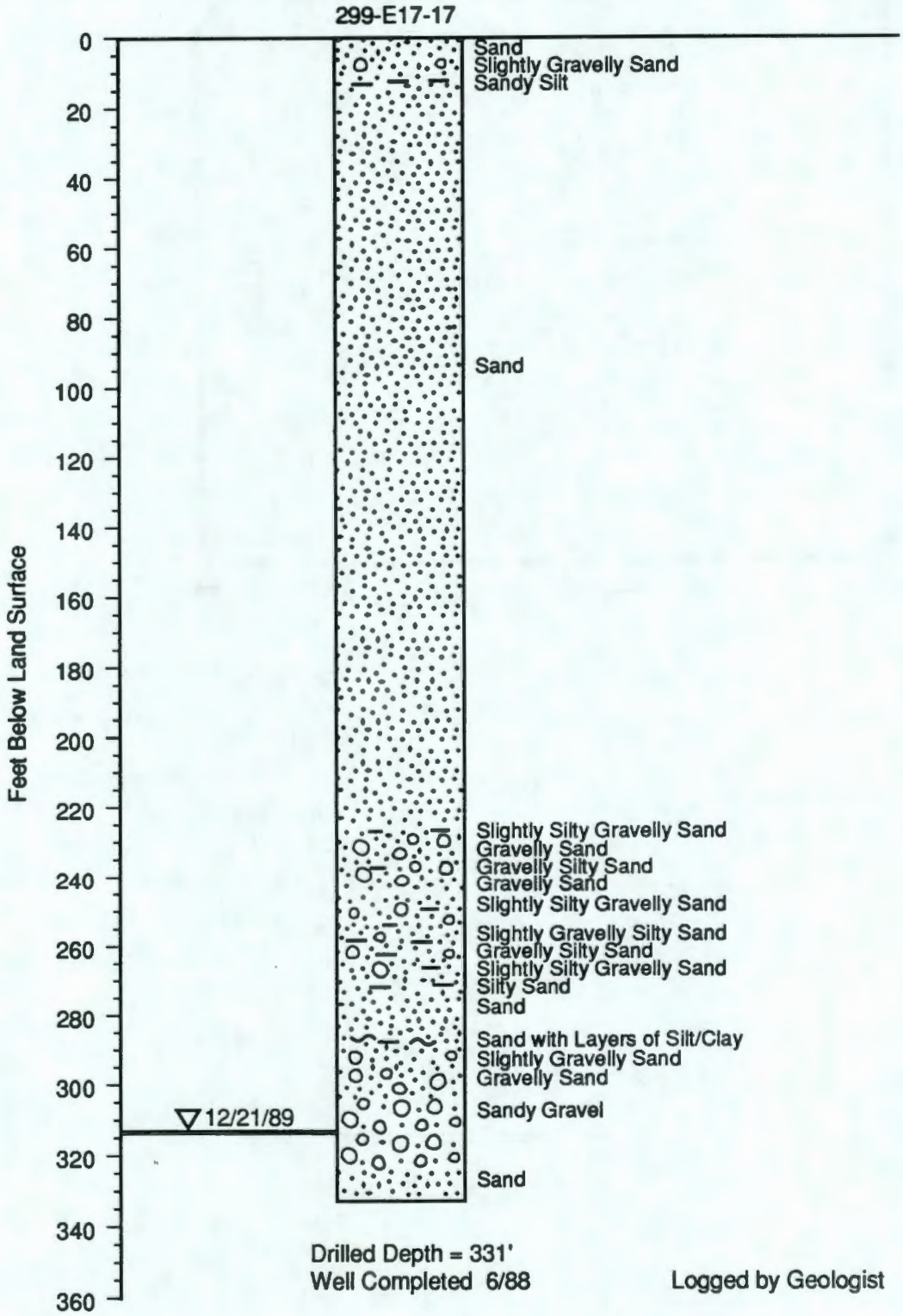


Figure 2.10-2. Lithology of Well 299-E17-17 Near 216-A-45 Crib.



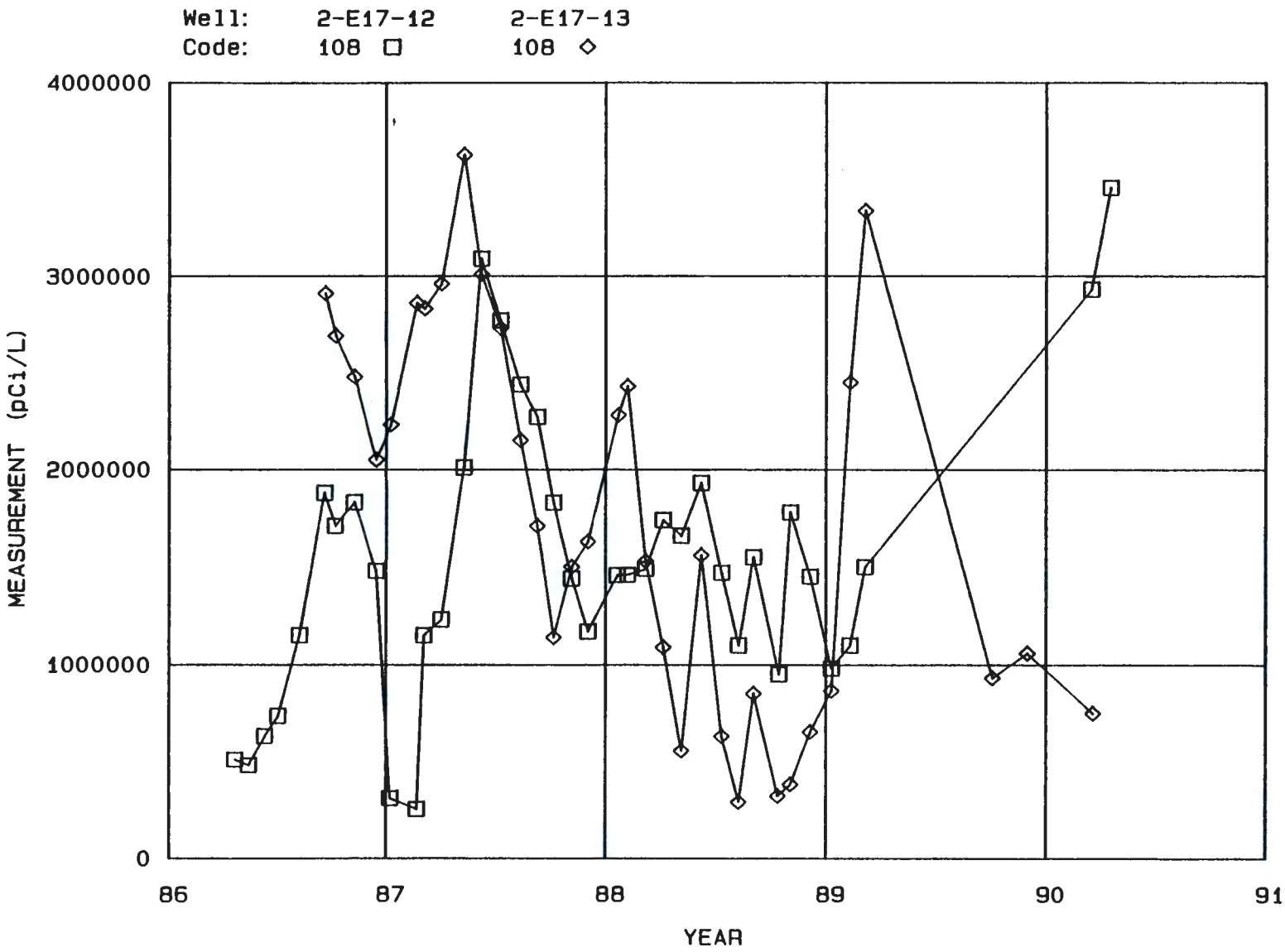


Figure 2.10-3. Concentration of Tritium Versus Time in Groundwater at the 216-A-45 Crib.

Figure 2.10-4. Iodine-129 in Groundwater Versus Time at the 216-A-45 Crib.

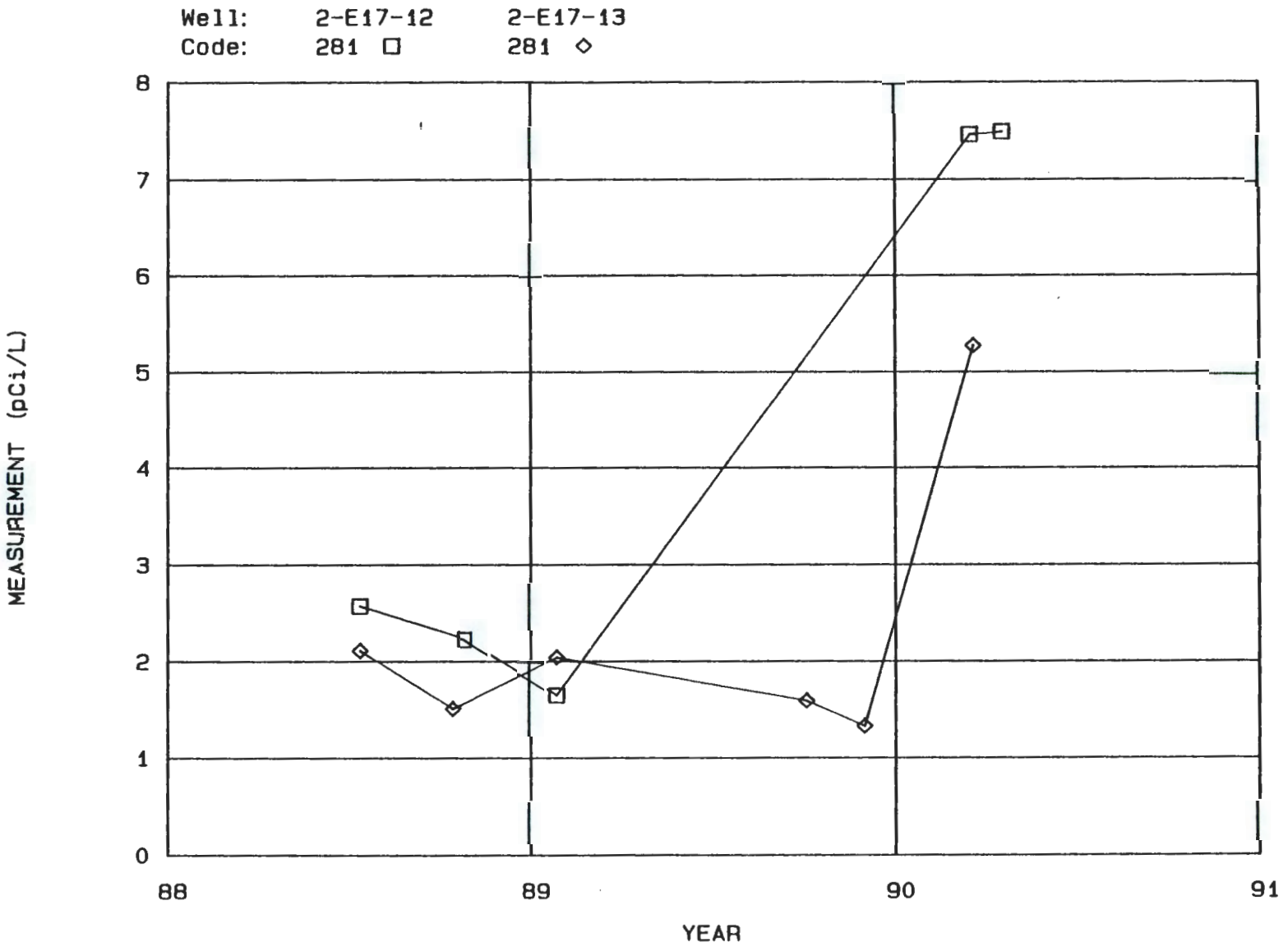


Table 2-10-1. Effluent Stream Description, PUREX Process Condensate

Total volume effluent discharged to subject receiving site: (WHC 1989a, WHC-EP-0287, Volume 2)	4.23E+08 L from 10/81 to 12/88
Average effluent discharge rate, by operating mode: (WHC 1990a, WHC-EP-0342, Addendum 12)	1.56E+06 L/mo[a]
Current average effluent discharge rate: (WHC 1990a, WHC-EP-0342, Addendum 12)	1.56E+06 L/mo[a]
Effluent designation: (WHC 1990a, WHC-EP-0342, Addendum 12)	Nondangerous/nonradioactive
Effluent status: (WHC 1990a, WHC-EP-0342, Addendum 12)	Intermittent discharge. During months when solvent extraction operating, stream is discharged to underground storage tanks.

[a]Average flow rate for sampling period 1/90 through 3/90. Discharge was intermittent during sampling period. Flow rate calculated by measurement of total volume of effluent discharged per month. Effluent was not discharged to soil column.

Table 2.10-2. Effluent Stream Sampling Data, PUREX Process Condensate.

Key Constituents	Detection Limit[a]	Detection/ Analyses	Sample Concentration 90% CI[a]	Detection Limit[a]	Detection/ Analyses	Sample Concentration 90% CI[a]
	08/85 to 08/87, During Routine Operation			10/89 to 03/90, During Stabilization		
acetone	10	6/8	680	10	3/4	84
2-butanone	10	4/8	72	10	4/4	52
nitrate	500	8/8	600,000	500	5/5	119,000
nitrite	NA	ND	ND	NA	4/5	96,100
fluoride	50	2/8	7,300	50	2/5	1,210
mercury	0.1	8/8	3.9	0.1	4/5	1.4
	1981 to 1988, During Routine Operation			10/89 to 03/90, During Stabilization		
hydrogen-3	5,000	59/NA	68,000,000	100	ND	ND
ruthenium-106	600	30/NA	55,000	50	ND	ND
iodine-129	20	22/NA	780	NA	ND	ND
cesium-137	80	30/NA	88,000	1	1/2	4[b]
plutonium-238	NA	33/NA	2,200	0.001	ND	ND
plutonium-239	50	59/NA	7,300	0.001	ND	ND
plutonium-240	50	ND	ND	0.001	ND	ND
americium-241	40	8/NA	12,000	0.001	ND	ND
strontium-90	30	27/NA	850	NA	ND	ND
ruthenium-103	NA	19/NA	2,700	NA	ND	ND
promethium-147	NA	44/NA	4,200	NA	ND	ND
uranium (isotopes)	20	51/NA	64	NA	ND	ND
plutonium-241	NA	54/NA	190,000	NA	ND	ND

[a]Units: chemical--parts per billion
radionuclides--picocurie per liter.

CI: confidence interval.
NA: not available.
ND: not detected.

[b]Concentration below Group A and C study guidelines; value given for purposes of comparison.
[c]Disposal of effluent to the 1325N Crib began in 1983; thus, this data set includes some samples taken prior to 1983.
[d]Uranium-234 Group A study guideline used as the most restrictive for determining key constituents.
[e]Consists of 0.2 pCi/L uranium-234 and 0.2 pCi/L uranium-235.

Table 2.10-3. Radionuclide and Chemical Loading, PUREX Process Condensate.

Flow Rate: 1.56E+06 L/mo

Constituent	Kg/L*	Kg/mo*
boron	1.64E-08	2.55E-02
calcium	5.02E-08	7.81E-02
cyanide	3.57E-08	5.55E-02
fluoride	8.60E-07	1.34E+00
mercury	9.66E-10	1.50E-03
nitrate	5.56E-05	8.65E+01
nitrite #	4.93E-05	7.67E+01
potassium	5.08E-07	7.90E-01
silicon	2.19E-07	3.41E-01
sodium	1.29E-05	2.01E+01
acetone	5.75E-08	8.95E-02
ammonia	5.32E-08	8.28E-02
1-butanol	1.90E-08	2.96E-02
2-butanone	2.85E-08	4.43E-02
butylated hydroxy toluene	1.00E-07	1.56E-01
dibutylphosphate	1.74E-05	2.71E+01
dodecane	9.14E-06	1.42E+01
tetradecane	2.10E-05	3.27E+01
tetrahydrofuran	7.45E-08	1.16E-01
tributylphosphate	7.78E-05	1.21E+02
tridecane	3.28E-05	5.10E+01
undecane	1.20E-07	1.87E-01
unknown	3.78E-06	5.88E+00
unknown aliphatic HC	1.19E-06	1.85E+00
unknown ester	5.24E-07	8.15E-01
unknown ester	3.07E-08	4.78E-02
unknown hydrocarbon	1.55E-05	2.41E+01
alpha activity *	2.25E-11	3.51E-05
beta activity *	7.89E-12	1.23E-05
TOC	1.06E-04	1.65E+02
TOX (as Cl)	4.80E-08	7.47E-02
cesium-137 *	1.41E-12	2.20E-06

Footnotes:

Data collected from October 1989 through March 1990.

Flow rate is the average of rates from the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 12).

Constituent concentrations are average values from the statistics in the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 12).

Concentration units of flagged (*) constituents are reported as curies per liter.

Loading units of flagged (*) constituents are reported as curies per month.

Constituents are flagged (#) if any detected result is less than any detection limit.

Table 2.10-4. Effluent Study Groundwater Summary Report. (Page 1 of 2)

CONSTITUENT			ANALYSIS SUMMARY					GROUP A STUDY GUIDELINES	
Group Name	Units	Detection Limit	Number of Analyses	Number > Det.	Average Result	Maximum Result	Minimum Result	Max Limit	Number > Limit
CONTAMINATION INDICATOR PARAMETERS									
Conductivity, Laboratory	UMHO	1.00	3	3	326.33	363.00	282.00	700.0	0
Specific conductance	UMHO	1.00	7	7	357.57	388.00	291.00	700.0	0
Total Organic Halogen, Low Det. Level	PPB	10.00	4	1	7.00	15.00	1.00		0
pH, Field Measurement		.10	7	7	8.10	8.42	7.52	8.5	0
pH, Laboratory Measurement		.01	3	3	7.87	7.90	7.80	8.5	0
DRINKING WATER PARAMETERS									
Alpha, High Detection Level	PCI/L	4.00	9	1	3.33	6.42	1.07	15.0	0
Arsenic	PPB	5.00	2	2	9.50	10.00	9.00	50.0	0
Arsenic, filtered	PPB	5.00	2	2	9.00	9.00	9.00	50.0	0
Barium	PPB	6.00	2	2	34.50	35.00	34.00	1000.0	0
Barium, filtered	PPB	6.00	5	5	35.80	38.00	34.00	1000.0	0
Fluoride	PPB	500.00	4	2	500.00	500.00	500.00	4000.0	0
Gross beta	PCI/L	8.00	11	11	39.96	71.70	12.80	50.0	4
Nitrate	PPB	500.00	4	4	27800.00	29300.00	24000.00	45000.0	0
Nitrate, High Detection Level	PPB	2500.00	7	7	34714.29	42800.00	28000.00	45000.0	0
GROUNDWATER QUALITY PARAMETERS									
Chloride	PPB	500.00	4	4	3950.00	4300.00	3700.00	250000.0	0
Iron	PPB	30.00	2	2	207.50	373.00	42.00	300.0	1
Manganese	PPB	5.00	2	1	5.50	6.00	5.00	50.0	0
Sodium	PPB	200.00	2	2	19750.00	20900.00	18600.00		0
Sodium, filtered	PPB	200.00	5	5	19860.00	22900.00	18100.00		0
Sulfate	PPB	500.00	4	4	38025.00	46100.00	30000.00	250000.0	0
SITE SPECIFIC AND OTHER PARAMETERS									
Alkalinity		20000.00	1	1	88000.00	88000.00	88000.00		0
Boron	PPB	10.00	2	2	15.50	18.00	13.00		0
Boron, filtered	PPB	10.00	5	5	20.20	27.00	15.00		0
Calcium	PPB	50.00	2	2	27800.00	29100.00	26500.00		0
Calcium, filtered	PPB	50.00	5	5	28000.00	29600.00	24800.00		0
Fluoride, Low Detection Level	PPB	20.00	1	1	531.00	531.00	531.00	4000.0	0

Table 2.10-4. Effluent Study Groundwater Summary Report. (Page 2 of 2)

CONSTITUENT			ANALYSIS SUMMARY					GROUP A STUDY GUIDELINES	
Group Name	Units	Detection Limit	Number of Analyses	Number > Det.	Average Result	Maximum Result	Minimum Result	Max Limit	Number > Limit
SITE SPECIFIC AND OTHER PARAMETERS									
Iodine-129 (Drinking Water Standard)	PCI/L	1.00	7	7	3.83	7.49	1.33	20.0	0
Magnesium	PPB	50.00	2	2	8390.00	8650.00	8130.00		0
Magnesium, filtered	PPB	50.00	5	5	8494.00	9350.00	7870.00		0
Natural uranium	UG/L	.73	7	7	5.05	6.22	4.49	59.0	0
Potassium	PPB	100.00	2	2	4985.00	4990.00	4980.00		0
Potassium, filtered	PPB	100.00	5	5	5076.00	5570.00	4830.00		0
Silicon	PPB	50.00	2	2	17200.00	17300.00	17100.00		0
Silicon, filtered	PPB	50.00	5	5	18360.00	18800.00	18000.00		0
Strontium	PPB	10.00	2	2	139.00	141.00	137.00		0
Strontium, filtered	PPB	10.00	5	5	142.80	149.00	132.00		0
Total carbon	PPB	1000.00	1	1	22000.00	22000.00	22000.00		0
Total dissolved solids		5000.00	2	2	214500.00	228000.00	201000.00	500000.0	0
Tritium	PCI/L	500.00	11	11	1761000.00	3460000.00	751000.00	80000.0	11
Turbidity	NTU	.10	2	1	.40	.70	.10	5.0	0
Uranium	PCI/L	.50	2	2	2.80	2.90	2.70	40.0	0
Uranium-234	PCI/L	.10	7	7	1.64	1.79	1.44	20.0	0
Uranium-235	PCI/L	.10	7	1	.13	.58	.04	24.0	0
Uranium-238	PCI/L	.10	7	7	1.58	2.08	1.21	24.0	0
Vanadium	PPB	5.00	2	2	26.00	28.00	24.00		0
Vanadium, filtered	PPB	5.00	4	4	26.75	30.00	25.00		0
Zinc	PPB	5.00	2	2	17.00	21.00	13.00	5000.0	0
Zinc, filtered	PPB	5.00	5	3	7.20	11.00	5.00	5000.0	0

Table 2.10-5. Background Comparison, 216-A-45 Crib.

Constituent	Background[a]	Average/ Background[b]	Maximum/ Background[b]
aluminum	2.0		
ammonia	50.0		
arsenic	6.3	1.51 (1.43)	1.59 (1.43)
barium	62.0	0.56 (0.58)	0.56 (0.61)
beryllium	0.3		
bismuth	0.02		
boron	50.0	0.3 (0.40)	0.36 (0.54)
cadmium	0.2		
calcium	50,700	0.55 (0.55)	0.57 (0.58)
chloride	16,800	0.23	0.26
chromium	6.0		
copper	1.0		
cyanide	10.0		
fluoride	470	1.13	1.13
lead	0.5		
magnesium	15,200	0.55 (0.56)	0.57 (0.61)
manganese	12.0	0.46	0.50
mercury	0.1		
nickel	4.0		
phosphate	1,000		
potassium	6,190	0.81 (0.82)	0.81 (0.90)
selenium	2.0		
silver	10		
sodium	28,410	0.70 (0.70)	0.74 (0.81)
strontium	338	0.41 (0.42)	0.42 (0.44)
sulfate	51,200	0.74	0.90
uranium	2.5	1.12	1.16
vanadium	26	1.00 (1.03)	1.08 (1.15)
zinc	8.0	2.13 (0.90)	2.63 (1.38)
alkalinity	144,000	0.61	0.61
pH	7.8	1.04	1.08
TOC	933		
conductivity	462	0.71	0.79
gross alpha	3.9		
gross beta	31	1.29	2.31
radium	0.2		

TOC: total organic carbon. ( ): filtered samples.

[a]Background is the mean plus one standard deviation for the values listed in Table 2-1. Amounts of uranium, gross alpha, gross beta, and radium given in picocuries per liter. All others are in parts per billion.

[b]Average and maximum values from Table 2.10-4.

2.11 216-B-3 POND SYSTEM

No adverse impact on groundwater quality is evident due to operation of this disposal facility. However, the volume of water discharged has a major influence on groundwater flow patterns and an unknown but potential impact on the deep aquifer system. Closure of the 216-B-3 portion of the pond system is indicated because of contaminated sediments from past spills.

2.11.1 Receiving Site Description

The subject disposal system consists of a series of four earthen, unlined, interconnected ponds and the 216-B-3-3 Ditch that receive wastewater from various 200 East Area operating facilities. The four ponds, collectively referred to as "B Pond System", are designated the 216-B-3, 216-B-3A, 216-B-3B and 216-B-3C ponds. These ponds were placed into service in 1945, 1983, 1984, and 1985, respectively. The location of the B Pond System in relation to adjacent facilities and groundwater monitoring wells is shown in Figure 2.11-1.

Currently 216-B-3 Pond covers a surface area of approximately 39 acres. Historical records indicate the surface area has varied from 19 to 46 acres (DOE 1990). The maximum depth of the pond is about 18 ft. The 216-B-3A, 216-B-3B, and 216-B-3C expansion lobes are 10, 10, and 41 acres, respectively. These expansion lobes have a maximum capacity depth of about 4 ft. The -3A and -3B lobes have a single trench in the bottom, while the -3C lobe has a series of nine trenches. These trenches are on the order of 4 ft in depth and provide additional infiltration capacity.

2.11.2 Effluent Stream Description

The pond system receives radioactive and nonradioactive process and cooling water from the PUREX Plant, B-Plant, and other 200 Area facilities. Effluent is also received from the PUREX Plant chemical sewer via the 216-A-29 Ditch. Historically, the pond system routinely received corrosive waste from PUREX demineralizer regeneration. Treatment of this waste occurred by successive discharge of acidic and caustic waste, which is assumed to have neutralized the corrosivity of the waste prior to and upon reaching the pond. Reaction with the calcareous soil beneath the pond is assumed to have neutralized any residual acidity (DOE 1990). During peak facility operations, approximately 22,000,000 gal/day were discharged to the pond system which has a maximum design capacity of approximately 28,000,000 gal/day (DOE 1990).

Based on past records, the cumulative volume discharged to the pond system is 2.3E+11 L. The only significant radionuclide inventory in the pond system should be strontium-90 and cesium-137, estimated to be less than 103 and 95 Ci, respectively (DOE 1990, p. 4-2), apparently due to spills that occurred in 1970. Other waste inventories or loadings of significant magnitude include cadmium (380,000 lb from cadmium nitrate spills), hydrazine (a listed waste), and ammonium fluoride/ammonium nitrate discharges (185,000 lb).

The eight individual effluent streams which discharge to the 216-B-3 Pond System are produced by the following processes at the following facilities:

- 242-A Evaporator Steam Condensate - Reboiler steam condensate, air sampler pump seal, steam condensate and raw water from heating and cooling jackets, and purge system steam trap condensate.
- 244-AR Vault Cooling Water - HVAC steam condensate and compressor cooling water.
- 284-E Powerplant Wastewater - Component cooling water, water softener regenerate water, and blowdown water.
- 241-A Tank Farm Cooling Water - Contaminated water vapor condenser cooling water, floor drains, and compressor cooling water.
- B-Plant Cooling Water - Raw water passed through cooling coils and condensers.
- 242-A Evaporator Cooling Water - Evaporator and other system cooling water and steam condensate.
- PUREX Plant Cooling Water - Cooling water and steam condensate.
- PUREX Plant Chemical Sewer - By way of the 216-A-29 Ditch, condenser cooling water, HVAC cooling water, facility floor and sink drains (see Section 2.5).

Table 2.11-1 summarizes information pertaining to each of the effluent streams. Selected wastestream sampling data and chemical and radionuclide loading data are included in Tables 2.11-2 and 2.11-3, respectively. More detailed chemical discharge information is also contained in the draft closure/postclosure plan for the B Pond System (DOE-RL 1990).

2.11.2.1 242-A Evaporator Steam Condensate. Sampling data show that aluminum and iron were the only chemical constituents to exceed Group A study guidelines. Routine radiological sampling data from the old data set indicate that several radionuclides exceeded Group A study guidelines. Contract laboratory data from the October 1989 to March 1990 sampling period indicated all radionuclides except strontium-90 to be below detection.

2.11.2.2 244-AR Vault Cooling Water. Sampling data showed two metals to exceed Group A study guidelines. Radiological sampling data from 1976 through 1988 indicate concentrations of several radionuclides exceeding Group A study guidelines. Further examination of the data, however, showed that sample results for strontium-90 above 100 pCi/L occurred twice in 1977 and 1978. Installation of upgrades to the facility since that time has resulted in the reduction of the discharge of radionuclides. The average result for strontium-90 since 1985 is 22.3 pCi/L, which is below the Group A study guidelines. The more recent data, October 1989 through March 1990, show very small concentrations of the radionuclides.

2.11.2.3 284-E Powerplant Wastewater. Of the three operating modes, the analytical data prior to October 1989 indicate that the water softener

regeneration mode produces an effluent with the most chemical constituents exceeding Group A study guidelines. Barium, aluminum, zinc, manganese, chloride, fluoride, and sulfate exceed drinking water maximum contaminant levels (MCL) by large margins. However, such results are typical for water softener operation.

2.11.2.4 241-A Tank Farm Cooling Water. The May 1986 through February 1987 sampling data set showed several chemical constituent exceeding Group A study guidelines. The new data set showed only one detection for manganese at a low level (6 ppb) which is below Group A study guidelines.

The routine radiological sampling from the period 1976 to 1988 shows that cesium-137, uranium, and plutonium-239 exceed the Group A study guideline concentrations. New data from the October 1989 through March 1990 period show all three elements to be below Group A study guideline concentrations.

2.11.2.5 B-Plant Cooling Water. No chemical constituents were found to exceed Group A study guideline concentrations in any of the sampling data sets. The old data set showed several radionuclides which exceeded Group A study guidelines concentrations.

2.11.2.6 242-A Evaporator Cooling Water. Radiological data from routine plant monitoring during the 12-yr period from 1976 to 1988 indicate concentrations of strontium-90, cesium-137, and uranium above Group A study guidelines. Samples for alpha/beta analysis (contract laboratory) during the August 1989 through May 1987 period indicate much lower levels of radioactivity in this stream. Upgrades to the facility have included installation of a spare condenser. No data were available during the October 1989 through March 1990 operating period since the evaporator was shut down.

2.11.2.7 PUREX Cooling Water. Iron and aluminum were found to exceed study guideline concentrations in the old data set. Routine radiological sampling during 1976 to 1988 showed cesium-137, uranium, and plutonium-239 concentrations exceeding Group A study guidelines. Sampling during the October 1989 through March 1990 period, representing the PUREX stabilization run, indicated only small concentrations of uranium and plutonium isotopes.

2.11.3 Flow and Transport Analysis

The main pond, 216-B-3, of the B Pond System is an older pond with a low rate of infiltration. The other three lobes of the system, 216-B-3A, -3B, and -3C, were constructed more recently and have higher rates of infiltration. The measured infiltration rate of the main pond is about 1 gal/day/ft^2). This value has been applied in the following analysis.

The three expansion ponds are assumed to have the same infiltration rate, calculated by subtracting the estimated flow lost by infiltration in the main pond from the main flow and dividing by the area of the three ponds. However the third lobe, 216-B-3C, is only partially wetted, so only one-fourth of its area was used in the calculation.

Based on Figure 2.11-2, the sediment column beneath the main pond and the -3A lobe was considered to be a three-layer system, while the sediment column beneath the -3B and -3C lobes was treated as a one-layer system of sand and gravel. The travel times for wastewater to migrate to the water table under average discharge conditions are calculated to be 214, 105, 86, and 86 days for 216-B-3, -3A, -3B, and -3C, respectively (data and computational details are in Appendix B).

Based on general effluent characteristics and corresponding sorption parameters (Appendix C), estimated contaminant migration rates of the key constituents (Table 2.11-2) range from about 49 cm/day for mobile constituents in the -3B and -3C lobes to as low as 0.02 cm/day for immobile constituents in all four ponds (see Appendix B for complete listing). (Note sorption parameters used from Appendix C were for pond water chemical conditions, i.e., low salt, low organic content, and a pH of neutral to slightly basic.)

2.11.4 Groundwater Quality Assessment

Several metals in the key constituent group exceeded Group A study guidelines. Tritium is the only other constituent exceeding Group A study guidelines (Table 2.11-4). Except for manganese, the elevated metals can be attributed to artifacts of well construction, development and/or sampling (WHC 1990d). This is indicated by the particulate nature of most of the elevated metal results (i.e., the unfiltered sample results). The relatively high (filtered) manganese in both a RCRA-compliant well and an older type well may be related to reducing conditions; unfortunately, dissolved oxygen is not measured for any of the RCRA wells, so it is not possible to test this hypothesis. Additional sampling, including dissolved oxygen measurements, would be needed to resolve the manganese anomaly. The elevated tritium is most likely due to mixing of low tritium water of (recent) B Pond origin with high tritium content, vicinity groundwater from past disposal activities. This explanation is further supported by the very minor occurrence of tritium in recent effluent discharged to B Pond (i.e., at much lower concentrations in effluent than in vicinity groundwater [Table 2.11-4]).

Most constituents exceeding Group B guidelines (background) consist of the metals noted above (Table 2.11-5). The elevated aluminum and beryllium are for unfiltered samples, i.e., filtered samples do not show this anomaly. This may simply be a result of acid dissolution of aluminosilicate mineral phases present from wells with elevated turbidity. These above-background occurrences are not considered important for purposes of this study.

Table 2.11-5 also illustrates the effect of dilution of vicinity groundwater by water from the B Pond System. For example, the major groundwater chemical constituents are significantly lower than background. This is because concentrations of these constituents are much lower in pond water (derived from Columbia River water) than in groundwater.

It should also be noted that the 216-B-3 Pond System RCRA groundwater monitoring program is assessing the possibility of contamination reflected in slightly elevated concentrations of TOC and TOX in groundwawter samples collected at two of the 13 wells used in this study.

2.11.5 Impact of Continued Operation

2.11.5.1 Volume Impact. More than 90% of the water disposed to ground in the 200 Areas is discharged to the B Pond System, and has a volume approximately 30 times greater than the natural recharge to the 200 Areas plateau from Cold Creek. The groundwater mound formed beneath the pond system has a major perturbation on the easterly flow of groundwater from the recharge area west of the Hanford Site to the Columbia River on the east. This perturbation provides a localized radial groundwater flow outward from the mound, resulting in additional groundwater flow northward through Gable Gap (the area between Gable Mountain and Gable Butte). It also serves as a hydraulic barrier to the easterly flow of groundwater toward the Columbia River. This hydraulic barrier also causes a longer flow path for groundwater as it flows from the 200 Areas toward the Columbia River in a southeasterly direction. The barrier may provide some benefit to migration of contaminants from 200 East Area by controlling the horizontal gradient.

Variations in the volume disposed to the pond over time could result in reversal of the direction of flow in the vicinity of the pond. The area east of the 200 East Area could be impacted in this event, complicating interpretation of groundwater monitoring data at regulated facilities.

In addition to influences on horizontal flow, the mound caused by B Pond provides potential for downward movement of contaminants into the upper confined aquifers. Tritium, although currently at low levels, has been detected in the upper confined aquifer near B Pond. The larger the mound, the greater the driving force for transporting contaminants into deeper aquifers. Unfortunately, only meager data are available for evaluating the likelihood and extent of this possible effect.

2.11.5.2 Groundwater Quality. For this study, the B Pond System is judged to have no adverse impact on vicinity groundwater quality. Assuming future chemical loading is similar to existing discharges to the pond system and assuming no major unplanned releases occur, continued operation should not result in degradation of groundwater quality.

2.11.5.3 Contaminant Mobilization. Previous spills or unplanned releases resulted in loading of primarily the original pond (216-B-3). The cadmium, strontium-90, cesium-137, etc., should be primarily associated with the pond sediment and underlying strata in the 216-B-3 segment (Figure 2.11-1). Using the contaminant transport and behavior estimates from Section 2.11.3 and Appendix C, the effect of continued operation on downward contaminant movement beneath the 216-B-3 segment can be estimated as illustrated in Figure 2.11-3.

For this estimate, only the stratigraphic and related hydraulic parameters pertaining to the 216-B-3 portion of the pond system are used (see Appendix B for migration rates and computational details). The migration depth-time plots suggest continued operation for a few more years would result in very little additional downward movement of the larger contaminant loads (strontium-90 and cesium-137). The curves also suggest that since the time of the earliest (recorded) spills (circa 1970 to present, 20 yr or about 7,300 days), penetration depths of 6 to 14 m may have occurred for strontium, cesium, and other metals. Although the more mobile organic constituents such as acetone may have been present in B Pond

wastestreams in trace amounts, they are expected to undergo degradation (half-times of 10 to 100 days, Appendix C; Table A-27).

The above analysis supports or is consistent with one of the proposed courses of action identified in the closure plan (DOE 1990); i.e., near-term decommissioning of the 216-B-3 segment of the B Pond System, with continued use of the newer expansion lobes.

Figure 2.11-1. Well Location and Site Map for 216-B-3 Pond System.

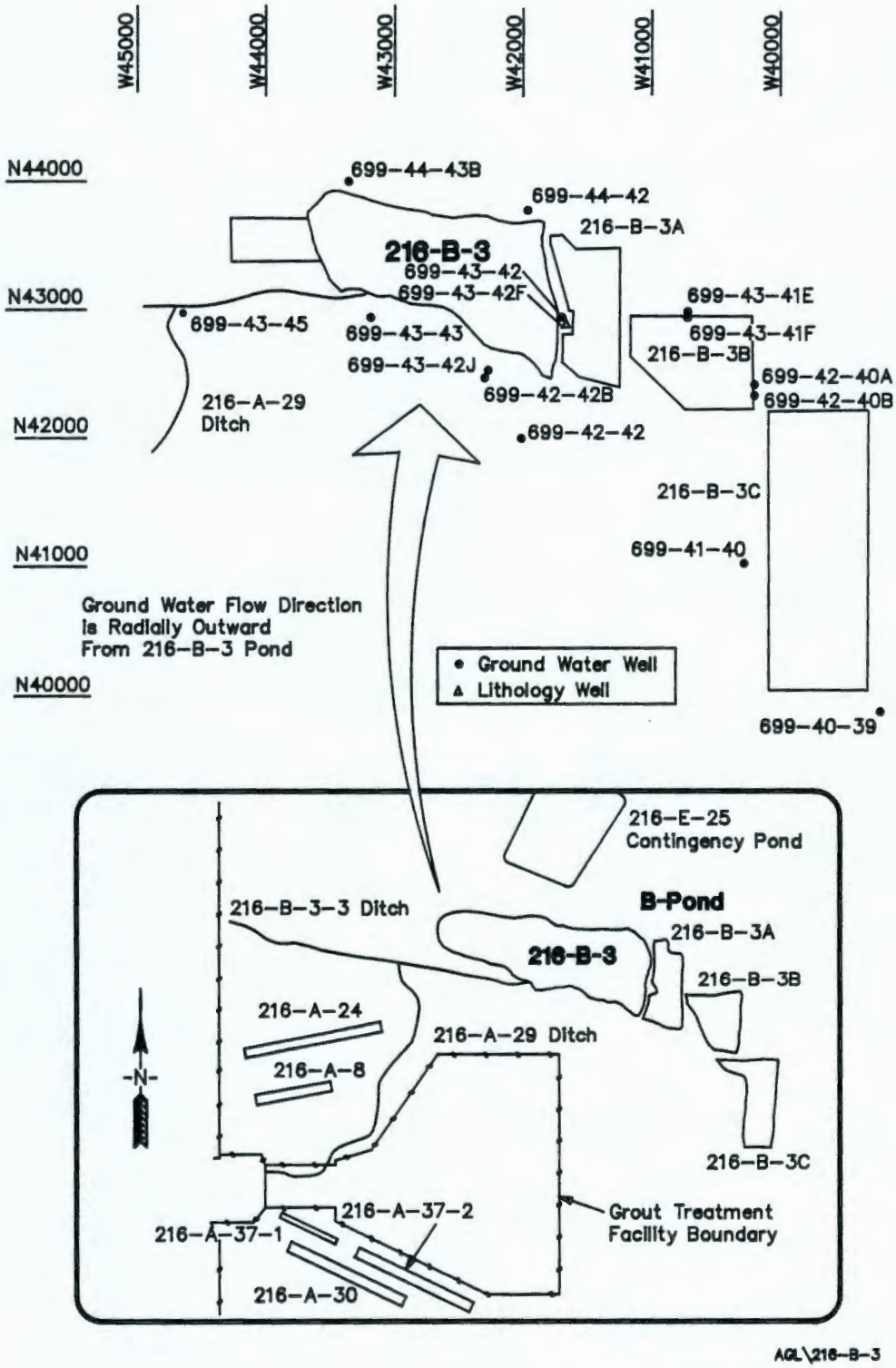


Figure 2.11-2. Lithology of Well 699-43-42F at 216-B-3 Pond System.

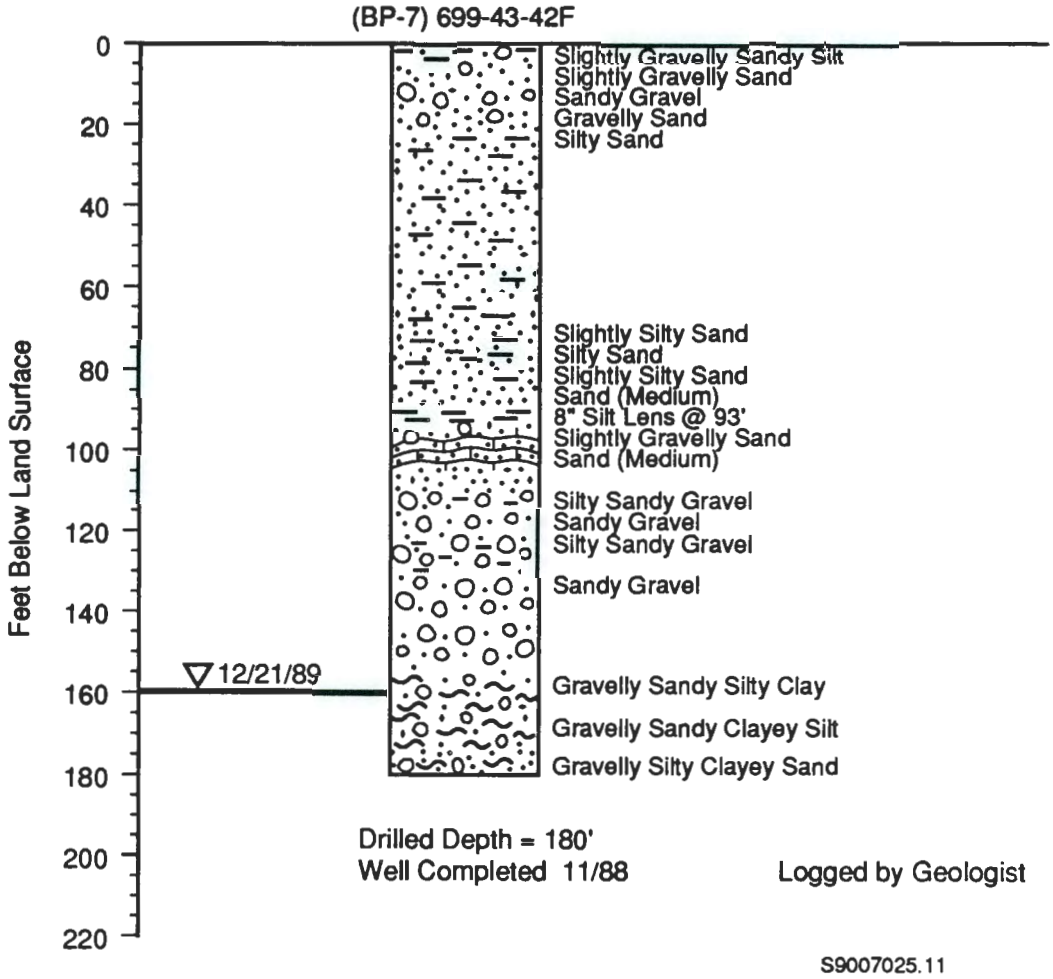


Figure 2.11-3. Migration Depth Beneath 216-B-3 Pond Versus Time.

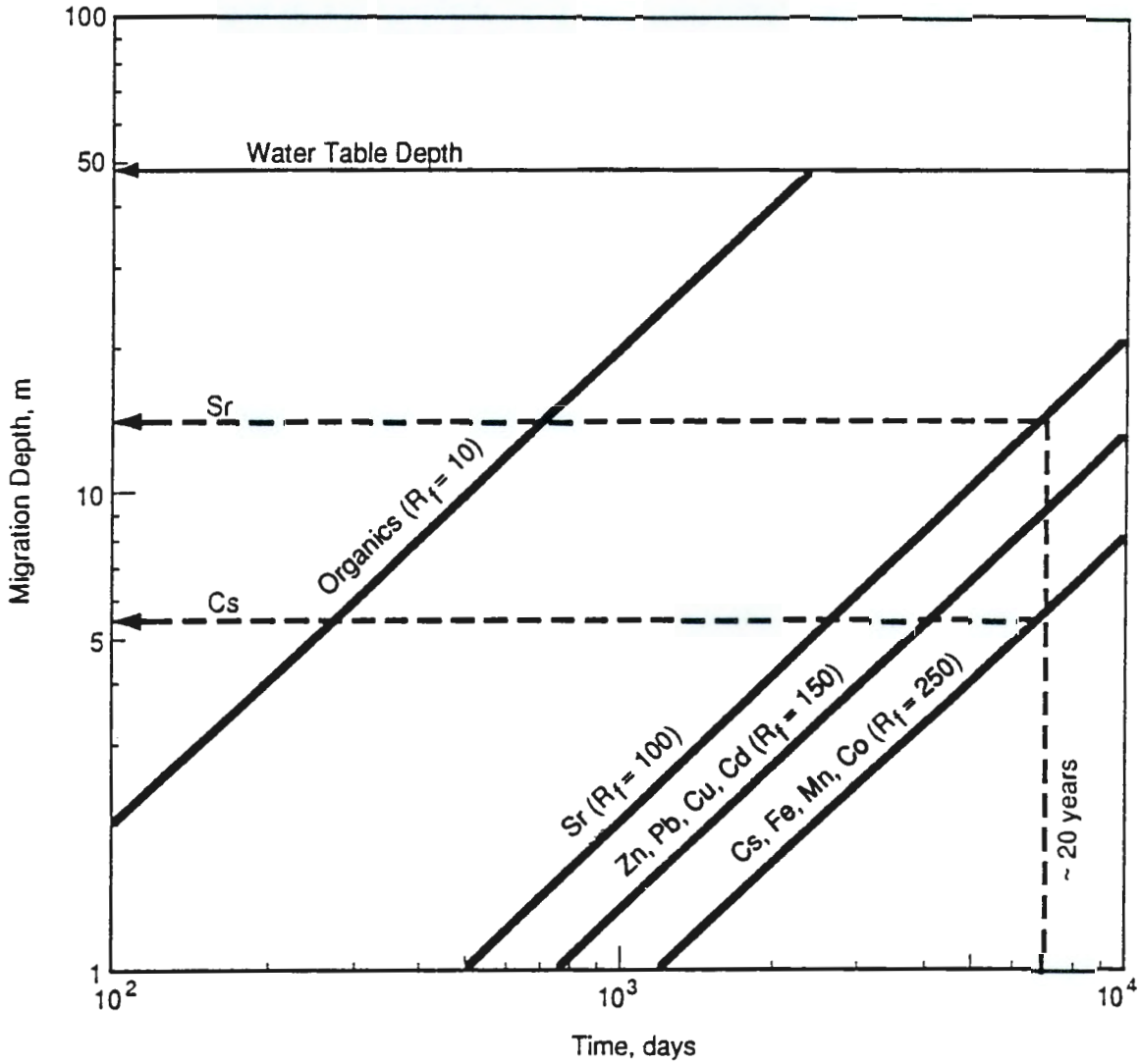


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Table 2.11-1a. Effluent Stream Description, PUREX Plant Chemical Sewer.

Total volume of effluent discharged to subject receiving site: (WHC 1989a, WHC-EP-0287, Volume 2)	1.04E+10 L from 1/76 to 12/88
Average effluent discharge rate, by operating mode:	Routine: 1.65E+08 L/mo Ion exchanger regeneration: 2.0E+08 L/mo
Current average effluent discharge rate:	Shutdown: 7.67E+07 L/mo[a]
Effluent designation: (WHC 1990a, WHC-EP-0342, Addendum 2)	Nondangerous, nonradioactive
Effluent status:	Shutdown mode: currently discharging to 216-B-3 Pond

[a]Average flow rate during sampling period 10/89 to 3/90, shutdown.

Table 2.11-1b. Effluent Stream Description, PUREX Plant Cooling Water.

Total volume of effluent discharged to subject receiving site: (WHC 1989a, WHC-EP-0287, Volume 2)	8.07E+10 L from 1/76 to 12/88
Average effluent discharge rate, by operating mode:	Operating: 1/14E+09 L/mo[a] Shutdown: 5.23E+08 L/mo[b]
Current average effluent discharge rate: (WHC 1990a, WHC-EP-0342, Addendum 20)	5.23E+08 L/mo[b]
Effluent designation: (WHC 1990a, WHC-EP-0342, Addendum 20)	Nondangerous, nonradioactive
Effluent status:	Shutdown mode: active discharge to 216-B-3 Pond

[a]Unpublished data; source is plant operating personnel.
[b]Average flow rate during sampling 10/89 to 3/90.

Table 2.11-1c. Effluent Stream Description, 242-A Evaporator Cooling Water.

Total volume of effluent discharged to subject receiving site: (WHC 1989a, WHC-EP-0287, Volulme 2)	3.61E+10 L from 3/77 to 12/88
Average effluent discharge rate, by operating mode: (WHC 1990a, WHC-EP-0342, Addendum 21)	Operating: 3,650 gal/min Standby: approximately 10 gal/min[a]
Current average effluent discharge rate:	Approximately 10 gal/min[a]
Effluent designation: (WHC 1990a, WHC-EP-0342, Addendum 21)	Nondangerous, radioactive
Effluent status: (WHC 1990a, WHC-EP-0342, Addendum 21)	Standby: currently active discharge to 216-B-3 Pond

[a]Unpublished data; source is plant operating personnel.

Table 2.11-1d. Effluent Stream Description, B Plant Cooling Water.

Total volume of effluent discharged to subject receiving site: (WHC 1989a, WHC-EP-0287, Volume 2)	6.3E+10 L from 1/68 to 12/87[a]
Average effluent discharge rate, by operating mode: (WHC 1990a, WHC-EP-0342, Addendum 22)	2.77E+08 L/mo
Current average effluent discharge rate: (WHC 1990a, WHC-EP-0342, Addendum 22)	2.77E+08 L/mo
Effluent designation: (WHC 1990a, WHC-EP-0342, Addendum 22)	Nondangerous, nonradioactive
Effluent status: (WHC 1990a, WHC-EP-0342, Addendum 22)	Currently active discharge to 216-B-3 Pond

[a]Flow data prior to 1/68 not available.

Table 2.11-1e. Effluent Stream Description, 241-A Tank Farm Cooling Water.

Total volume of effluent discharged to subject receiving site: (WHC 1989a, WHC-EP-0287, Volume 2)	1.75E+10 L from 1/76 to 12/88
Average effluent discharge rate, by operating mode: (WHC 1990a, WHC-EP-0342, Addendum 23)	7.29E+07 L/mo
Current average effluent discharge rate: (WHC 1990a, WHC-EP-0342, Addendum 23)	7.29E+07 L/mo
Effluent designation: (WHC 1990a, WHC-EP-0342, Addendum 23)	Nondangerous, radioactive
Effluent status:	Currently active discharge to 216-B-3 Pond

Table 2.11-1f. Effluent Stream Description, 284-E Powerplant Wastewater.

Total volume of effluent discharged to subject receiving site:	Data not available
Average effluent discharge rate, by operating mode: (WHC 1990a, WHC-EP-0342, Addendum 24)	Routine: 3.25E+06 gal/mo Ion exchanger regeneration: additional 300,000 gal/mo Blowdown: additional 100,000 gal/mo
Current average effluent discharge rate: (WHC 1990a, WHC-EP-0342, Addendum 24)	Routine: 3.25E+06 gal/mo
Effluent designation: (WHC 1990a, WHC-EP-0342, Addendum 24)	Nondangerous, nonradioactive
Effluent status:	Routine mode[a]: currently active discharge to 216-B-3 Pond

[a]Routine mode during sampling 10/89 to 3/90.

Table 2.11-1g. Effluent Stream Description, 244-AR Vault Cooling Water.

Total volume of effluent discharged to subject receiving site: (WHC 1989a, WHC-EP-0287, Volume 2)	1.26E+09 L from 1/76 to 12/88
Average effluent discharge rate, by operating mode: (WHC 1990a, WHC-EP-0342, Addendum 25)	42 gal/min
Current average effluent discharge rate: (WHC 1990a, WHC-EP-0342, Addendum 25)	42 gal/min
Effluent designation: (WHC 1990a, WHC-EP-0342, Addendum 25)	Nondangerous, nonradioactive
Effluent status:	Currently active discharge to 216-B-3 Pond

Table 2.11-1h. Effluent Stream Description, 242-A Evaporator Steam Condensate.

Total volume of effluent discharged to subject receiving site: (WHC 1989a, WHC-EP-0287, Volume 2)	5.18E+08 L from 3/77 to 12/88
Average effluent discharge rate, by operating mode: (WHC 1990a, WHC-EP-0342, Addendum 26)	Operating: 1.7E+06 gal/yr Standby: 90 gal/hr
Current average effluent discharge rate: (WHC 1990a, WHC-EP-0342, Addendum 26)	90 gal/hr[a]
Effluent designation: (WHC 1990a, WHC-EP-0342, Addendum 26)	Nondangerous, nonradioactive
Effluent status: (WHC 1990a, WHC-EP-0342, Addendum 26)	Standby: currently discharging to 216-B-3 Pond

[a]Average flow during sampling period 10/89 to 3/90 was 22 gal/hr.

Table 2.11-2a. Effluent Stream Sampling Data, PUREX Chemical Sewer.

Key Constituents	Detection Limit[a]	Detection/ Analyses	Sample Concentration 90% CI[a]	Detection Limit[a]	Detection/ Analyses	Sample Concentration 90% CI[a]
	08/86 to 03/88, During IX Regenerate			10/89 to 03/90, During IX Regenerate		
acetone	10	3/3	150	No Data		
nitrate	500	2/5	70,300			
chloroform	5	2/5	240			
aluminum	NA	3/5	500			
cadmium	2	3/5	11			
copper	NA	3/5	1,310			
iron	30	5/5	675			
manganese	5	5/5	58			
sulfate	500	5/5	1,470,000			
	08/85 to 04/87, During Routine Operation			10/89 to 03/90, During Clean Out		
aluminum	NA	1/5	200	NA	1/6	341
iron	30	5/5	140[b]	30	6/6	443
acetone	10	2/5	340	10	ND	ND
	1976 to 1988, During All Modes[c]			10/89 to 03/90, During Clean Out		
strontium-90	30	25/NA	150	0.1	ND	ND
cesium-137	80	12/NA	330	1	1/4	0.5[b]
americium-241	40	1/NA	48	0.001	4/4	0.2[b]
promethium-147	NA	8/NA	4,300	NA	ND	ND
uranium (isotopes)[b]	20	4/NA	150	NA	4/4	0.4[b,e]
plutonium-239	50	35/NA	6	0.001	4/4	0.5[b]

[a]Units: chemical--parts per billion

CI: confidence interval.

ND: not detected.

[b]Concentrations below Group A study guidelines; values given for purposes of comparison.

[c]Uranium-234 Group A study guideline used as the most restrictive for determining key constituents.

Table 2.11-2b. Effluent Stream Sampling Data, PUREX Cooling Water.

Key Constituents	Detection Limit[a]	Detection/ Analyses	Sample Concentration 90% CI[a]	Detection Limit[a]	Detection/ Analyses	Sample Concentration 90% CI[a]
	08/85 to 03/87, During Routine Operation					
aluminum	NA	1/5	220	NA	ND	ND
iron	30	4/5	330	30	6/6	53[b]
	1976 to 1988, During Routine Operation			10/89 to 03/90, During Stabilization		
cesium-137	80	9/NA	260	1	ND	ND
uranium (isotopes)[d]	20	2/NA	62	NA	3/3	0.4[b,c]
plutonium-239	50	25/NA	10	0.001	2/3	ND

[a]Units: chemical--parts per billion
radionuclides--picocurie per liter.

[b]Concentrations below Group A and C study guidelines; value given for comparison purposes only.
[c]Consists of 0.003 pCi/L uranium-239/240, 0.026 pCi/L uranium-234, and 0.188 pCi/L uranium-238.
[d]Uranium-234 Group A study guideline used as the most restrictive for determination of key constituents.

CI: confidence interval.
ND: not detected.
NA: not available.

Table 2.11-2c. Effluent Stream Sampling Data, 242-A Evaporator Cooling Water.

Key Constituents	Detection Limit[a]	Detection/ Analyses	Sample Concentration 90% CI[a]	Detection Limit[a]	Detection/ Analyses	Sample Concentration 90% CI[a]
	1976 to 1988, During Routine Operation			10/89 to 03/90, During Inactive Mode		
strontium-90	30	8/NA	190	No Data		
cesium-137	80	9/NA	160			
uranium (isotopes)[b]	20	2/NA	140			

[a]Units: chemical--parts per billion
radionuclides--picocurie per liter.

[b]Uranium-234 Group A guideline used as the most restrictive for determination of key constituents.

CI: confidence interval.
ND: not detected.
NA: not available.

Table 2.11-2d. Effluent Stream Sampling Data, B Plant Cooling Water.

Key Constituents	Detection Limit[a]	Detection/ Analyses	Sample Concentration 90% CI[a]	Detection Limit[a]	Detection/ Analyses	Sample Concentration 90% CI[a]
	09/85 to 01/87, During Routine Operation			10/89 to 03/90, During Routine Operation		
None	None			None		
	1976 to 1988, During Routine Opertion			10/89 to 03/90, During Routing Operation		
americium-241	20	1/NA	540	NA	ND	ND
cobalt-60	NA	2/NA	700	0.1	1/3	0.6[b]
cesium-137	80	36/NA	960	1	ND	ND
strontium-90	30	30/NA	97	0.1	2/3	0.2[b]
uranium (isotopes)[c]	NA	10/NA	380	NA	3/3	0.5[b,d]

[a]Units: chemical--parts per billion
radionuclides--picocurie per liter.
[b]Concentrations below Group A guidelines; values given for comparison purposes.
[c]Uranium-234 Group A guideline used as the most restrictive for determination of key constituents.
[d]Consists of 0.3 pCi/L uranium-234 and 0.2 pCi/L uranium-238.

CI: confidence interval.
ND: not detected.

Table 2.11-2e. Effluent Stream Sampling Data, 241-A Tank Farm Cooling Water.

Key Constituents	Detection Limit[a]	Detection/ Analyses	Sample Concentration 90% CI[a]	Detection Limit[a]	Detection/ Analyses	Sample Concentration 90% CI[a]
	05/86 to 02/87, During Routine Operation			10/89 to 03/90, During Routine Operation		
manganese	5	4/4	230	5	1/4	6
aluminum	NA	2/5	4,800			
iron	30	3/5	4,700			
lead	5	3/5	110	5	1/4	5
	1976 to 1988, During Routine Operation			10/89 to 03/90, During Routine Operation		
cesium-137	80	4/NA	1,100	1	ND	ND
uranium (isotopes)[c]	20	4/NA	340	NA	3/3	0.5[b,d]
plutonium-239	50	20/NA	3.5	0.001	ND	ND

[a]Units: chemical--parts per billion
radionuclides--picocurie per liter.
[b]Concentration below Group A and C guidelines; value given for comparison purposes only.
[c]Uranium-234 Group A guideline used as the most restrictive for determination of key constituents.
[d]Consists of 0.3 pCi/L uranium-234 and 0.2 pCi/L uranium-235.

CI: confidence interval.
ND: not detected.

Table 2.11-2f. Effluent Stream Sampling Data, 284-E Powerplant Wastewater.

Key Constituents	09/85 to 01/87, During Blowdown			10/89 to 03/90, During Blowdown		
	Detection Limit[a]	Detection/ Analyses	Sample Concentration 90% CI[a]	Detection Limit[a]	Detection/ Analyses	Sample Concentration 90% CI[a]
None	None					No Data
	11/87 to 04/88, During Water Softener Regeneration			10/89 to 03/90, During Water Softener Regeneration		
barium	6	4/4	14,000			
chloride	500	4/4	71,000,000			
fluoride	50	2/4	160,000			No Data
manganese	5	3/4	240			
sulfate	500	2/4	1,200,000			
zinc	5	4/4	13,000			
	07/88 to 03/89, During Routine Operation			10/89 to 03/90, During Routine Operation		
None	None			None		

[a]Units: chemical--parts per billion
radionuclides--picocurie per liter.

CI: confidence interval.

Table 2.11-2g. Effluent Stream Sampling Data, 244-AR Vault Cooling Water.

Key Constituents	Detection Limit[a]	Detection/ Analyses	Sample Concentration 90% CI[a]	Detection Limit[a]	Detection/ Analyses	Sample Concentration 90% CI[a]
	06/86 to 03/87, During Routine Operation			10/89 to 03/90, During Routine Operation		
manganese	5	2/4	57	5	1/4	17[b]
iron	30	3/4	340	30	4/4	459
	1976 to 1988, During Routine Operation			10/89 to 03/90, During Routine Operation		
strontium-90	30	11/NA	16,000	0.1	2/3	0.29[b]
cesium-137	80	6/NA	200	1	ND	ND
uranium (isotopes)[c]	20	6/NA	54	NA	3/3	0.4[b,d]
plutonium-239	50	14/NA	8.7	0.001	2/2	0.009[b]

[a]Units: chemical--parts per billion
radionuclides--picocurie per liter.

CI: confidence interval.
ND: not detected.

[b]Concentrations below Group A guidelines; values given for comparison purposes.

[c]Uranium-234 Group A guideline used as the most restrictive for determination of key constituents.

[d]Consists of 0.26 pCi/L uranium-234 and 0.18 pCi/L uranium-238.

Table 2.11-2h. Effluent Stream Sampling Data, 242-A Evaporator Steam Condensate.

Key Constituents	Detection Limit[a]	Detection/ Analyses	Sample Concentration 90% CI[a]	Detection Limit[a]	Detection/ Analyses	Sample Concentration 90% CI[a]
	08/85 to 02/87 During Routine Operation			10/89 to 03/90, During Shutdown Mode		
aluminum	NA	1/5	180	NA	ND	ND
iron	30	5/5	21,000	30	4/4	153[b]
	1977 to 1988, During Routine Operation			10/89 to 03/90, During Shutdown Mode		
strontium-90	30	5/NA	48	0.1	2/2	1[b]
cesium-137	80	9/NA	200	1	ND	ND
hydrogen-3	5,000	63/NA	95,000	100	ND	ND
americium-241	40	1/NA	100	0.001	ND	ND
plutonium-239	50	9/NA	4.5	0.001	ND	ND

[a]Units: chemical--parts per billion
radionuclides--picocurie per liter.

[b]Concentrations below Group A study guidelines; values given for purposes of comparison.

CI: confidence interval.
ND: not detected.
NA: not available.

Table 2.11-3a. Radionuclide and Chemical Loading, PUREX Chemical Sewer.

Flow Rate: 7.67E+07 L/mo

Constituent	Kg/L*	Kg/mo*
aluminum	2.27E-07	1.74E+01
barium	3.13E-08	2.40E+00
boron	1.60E-08	1.23E+00
calcium	1.84E-05	1.41E+03
chloride	1.55E-06	1.19E+02
copper	2.93E-08	2.25E+00
fluoride	1.40E-07	1.07E+01
iron	2.16E-07	1.66E+01
lead	5.50E-09	4.22E-01
magnesium	4.21E-06	3.23E+02
manganese	1.57E-08	1.20E+00
mercury	1.10E-10	8.43E-03
nitrate	5.16E-07	3.96E+01
potassium	7.19E-07	5.51E+01
silicon	2.57E-06	1.97E+02
sodium	2.07E-06	1.59E+02
strontium	9.08E-08	6.96E+00
sulfate	1.12E-05	8.59E+02
uranium	4.65E-10	3.57E-02
zinc	1.47E-08	1.13E+00
ammonia	5.77E-08	4.42E+00
butylated hydroxy toluene	1.00E-08	7.67E-01
trichloromethane	8.83E-09	6.77E-01
alpha activity *	9.84E-13	7.54E-05
beta activity *	2.22E-12	1.70E-04
TDS	5.63E-05	4.32E+03
total carbon	1.44E-05	1.10E+03
TOX (as Cl)	7.05E-08	5.41E+00
americium-241 *	1.03E-13	7.90E-06
cesium-137 *	2.85E-13	2.19E-05
carbon-14 *	3.33E-12	2.55E-04
hydrogen-3 *	2.29E-10	1.76E-02
plutonium-238 *	7.62E-15	5.84E-07
plutonium-239/240 *	3.09E-13	2.37E-05
radium total *	9.74E-14	7.47E-06
uranium-234 *	1.71E-13	1.31E-05
uranium-238 *	1.50E-13	1.15E-05

Footnotes:

Data collected from October 1989 through March 1990.

Flow rate is the average of rates from the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 2).

Constituent concentrations are average values from the statistics in the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 2).

Concentration units of flagged (*) constituents are reported as curies per liter.

Loading units of flagged (*) constituents are reported as curies per month.

9 1 1 2 1 1 7 0 1 7 4

Table 2.11-3b. Radionuclide and Chemical Loading, PUREX Cooling Water.

Flow Rate: 5.23E+08 L/mo

Constituent	Kg/L*	Kg/mo*
barium	3.05E-08	1.60E+01
boron	1.81E-08	9.47E+00
calcium	1.91E-05	9.99E+03
chloride	1.05E-06	5.49E+02
copper	1.05E-08	5.49E+00
fluoride	1.35E-07	7.06E+01
iron	4.75E-08	2.48E+01
magnesium	4.39E-06	2.30E+03
manganese	6.17E-09	3.23E+00
nitrate	5.81E-07	3.04E+02
potassium	7.48E-07	3.91E+02
silicon	2.49E-06	1.30E+03
sodium	2.13E-06	1.11E+03
strontium	9.68E-08	5.06E+01
sulfate	1.05E-05	5.49E+03
uranium	5.12E-10	2.68E-01
zinc	7.05E-09	3.69E+00
acetone	1.05E-08	5.49E+00
ammonia	5.07E-08	2.65E+01
2-butanone	1.00E-08	5.23E+00
butylated hydroxy toluene	1.00E-08	5.23E+00
dichloromethane	5.33E-09	2.79E+00
TDS	6.62E-05	3.46E+04
TOC	1.10E-06	5.75E+02
total carbon	1.50E-05	7.85E+03
TOX (as Cl)	1.00E-08	5.23E+00
americium-241 *	2.79E-15	1.46E-06
carbon-14 *	3.86E-12	2.02E-03
iodine-129 *	5.46E-14	2.86E-05
plutonium-239/240 *	2.13E-15	1.11E-06
strontium-90 *	2.38E-13	1.24E-04
uranium-234 *	2.15E-13	1.12E-04
uranium-238 *	1.65E-13	8.63E-05

Footnotes:

Data collected from October 1989 through March 1990.

Flow rate is the average of rates from the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 20).

Constituent concentrations are average values from the statistics in the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 20).

Concentration units of flagged (*) constituents are reported as curies per liter.

Loading units of flagged (*) constituents are reported as curies per month.

Table 2.11-3c. Radionuclide and Chemical Loading, 242-A Evaporator Cooling Water.

Flow Rate: 6.89E+07 L/mo

Constituent	Kg/L*	Kg/mo*
barium	3.04E-08	2.10E+00
cadmium	2.00E-09	1.38E-01
calcium	1.93E-05	1.33E+03
chloride	7.84E-07	5.40E+01
chromium	1.04E-08	7.17E-01
copper	7.36E-08	5.07E+00
iron	1.04E-07	7.17E+00
lead	1.26E-08	8.69E-01
magnesium	4.35E-06	3.00E+02
manganese	1.07E-08	7.38E-01
nickel	1.12E-08	7.72E-01
nitrate	1.19E-06	8.20E+01
potassium	8.01E-07	5.52E+01
sodium	2.35E-06	1.62E+02
sulfate	1.03E-05	7.10E+02
uranium	6.43E-10	4.43E-02
zinc	4.78E-08	3.30E+00
1-butanol	1.10E-08	7.58E-01
alpha activity *	8.12E-13	5.60E-05
beta activity *	1.01E-11	6.96E-04
TOC	1.70E-06	1.17E+02
TOX (as Cl)	1.44E-08	9.93E-01

Footnotes:

Data collected during August 1985, June 1986, August 1986, November 1986 and January 1987.

Flow rate is the average of rates from the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 21).

Constituent concentrations are average values from the statistics in the Hanford Site Stream-Specific Reports (WHC 1990a Addendum 21).

Concentration units of flagged (*) constituents are reported as curies per liter.

Loading units of flagged (*) constituents are reported as curies per month.

Table 2.11-3d. Radionuclide and Chemical Loading, B-Plant Cooling Water.

Flow Rate: 2.77E+08 L/mo

Constituent	Kg/L*	Kg/mo*
barium	3.15E-08	8.74E+00
boron	1.57E-08	4.35E+00
calcium	1.88E-05	5.21E+03
chloride	8.75E-07	2.43E+02
fluoride	1.32E-07	3.66E+01
iron	3.50E-08	9.71E+00
lead	5.50E-09	1.53E+00
magnesium	4.36E-06	1.21E+03
manganese	5.00E-09	1.39E+00
nitrate	5.00E-07	1.39E+02
potassium	7.41E-07	2.05E+02
silicon	2.46E-06	6.82E+02
sodium	2.06E-06	5.71E+02
strontium	9.40E-08	2.61E+01
sulfate	1.03E-05	2.86E+03
uranium	7.91E-10	2.19E-01
zinc	6.00E-09	1.66E+00
acetone	1.15E-08	3.19E+00
1-butanol	1.20E-08	3.33E+00
2-butanone	1.00E-08	2.77E+00
trichloromethane	5.75E-09	1.59E+00
beta activity *	2.49E-12	6.91E-04
TDS	6.05E-05	1.68E+04
TOC	1.07E-06	2.97E+02
total carbon	1.50E-05	4.16E+03
TOX (as Cl)	8.25E-09	2.29E+00
cobalt-60 *	2.85E-13	7.90E-05
plutonium-239/240 *	2.37E-15	6.57E-07
radium total *	1.14E-13	3.16E-05
strontium-90 *	1.82E-13	5.05E-05
uranium-234 *	2.51E-13	6.96E-05
uranium-238 *	1.92E-13	5.32E-05

Footnotes:

Data collected from October 1989 through March 1990.

Flow rate is the average of rates from the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 22).

Constituent concentrations are average values from the statistics in the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 22).

Concentration units of flagged (*) constituents are reported as curies per liter.

Loading units of flagged (*) constituents are reported as curies per month.

Table 2.11-3e. Radionuclide and Chemical Loading, 241-A Tank Farm Cooling Water.

Flow Rate: 7.29E+07 L/mo

Constituent	Kg/L*	Kg/mo*
barium	3.00E-08	2.19E+00
boron	2.10E-08	1.53E+00
calcium	1.86E-05	1.36E+03
chloride	1.00E-06	7.29E+01
copper	1.77E-08	1.29E+00
fluoride	1.39E-07	1.01E+01
iron	5.07E-08	3.70E+00
lead	5.00E-09	3.64E-01
magnesium	4.33E-06	3.16E+02
manganese	5.25E-09	3.83E-01
nitrate	5.25E-07	3.83E+01
potassium	7.29E-07	5.31E+01
silicon	2.47E-06	1.80E+02
sodium	2.04E-06	1.49E+02
strontium	9.50E-08	6.93E+00
sulfate	1.03E-05	7.51E+02
uranium	5.80E-10	4.23E-02
zinc	1.62E-08	1.18E+00
ammonia	5.50E-08	4.01E+00
1-butanol	1.10E-08	8.02E-01
butylated hydroxy toluene	9.00E-09	6.56E-01
alpha activity *	6.61E-13	4.82E-05
TDS	5.10E-05	3.72E+03
TOC	1.17E-06	8.53E+01
total carbon	1.58E-05	1.15E+03
uranium-234 *	2.25E-13	1.64E-05
uranium-238 *	1.70E-13	1.24E-05

Footnotes:

Data collected from October 1989 through March 1990.

Flow rate is the average of rates from the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 23).

Constituent concentrations are average values from the statistics in the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 23).

Concentration units of flagged (*) constituents are reported as curies per liter.

Loading units of flagged (*) constituents are reported as curies per month.

Table 2.11-3f. Radionuclide and Chemical Loading, 284-E Powerplant Wastewater.

Flow Rate: 1.38E+07 L/mo

Constituent	Kg/L*	Kg/mo*
aluminum	3.64E-07	5.03E+00
barium	6.02E-08	8.32E-01
boron	5.25E-08	7.26E-01
calcium	1.96E-05	2.71E+02
chloride	3.70E-06	5.11E+01
fluoride	1.57E-07	2.17E+00
iron	1.54E-07	2.13E+00
magnesium	4.34E-06	6.00E+01
manganese	5.50E-09	7.60E-02
nitrate	5.25E-07	7.26E+00
potassium	8.56E-07	1.18E+01
silicon	3.10E-06	4.29E+01
sodium	9.04E-06	1.25E+02
strontium	2.40E-07	3.32E+00
sulfate	1.71E-05	2.36E+02
uranium	4.72E-10	6.52E-03
zinc	7.25E-09	1.00E-01
ammonia	5.35E-08	7.40E-01
1-butanol	1.80E-08	2.49E-01
trichloromethane	1.55E-08	2.14E-01
alpha activity *	8.98E-13	1.24E-05
beta activity *	1.80E-12	2.49E-05
suspended solids	1.50E-05	2.07E+02
TDS	8.70E-05	1.20E+03
TOC	1.70E-06	2.35E+01
total carbon	1.52E-05	2.10E+02
TOX (as Cl)	9.32E-08	1.29E+00

Footnotes:

Data collected from October 1989 through March 1990.

Flow rate is the average of rates from the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 24).

Constituent concentrations are average values from the statistics in the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 24).

Concentration units of flagged (*) constituents are reported as curies per liter.

Loading units of flagged (*) constituents are reported as curies per month.

Table 2.11-3g. Radionuclide and Chemical Loading, 244-AR Vault Cooling Water.

Flow Rate: 7.34E+06 L/mo

Constituent	Kg/L*	Kg/mo*
barium	3.17E-08	2.33E-01
boron	1.30E-08	9.54E-02
calcium	1.86E-05	1.36E+02
chloride	1.02E-06	7.48E+00
copper	8.28E-08	6.08E-01
fluoride	1.54E-07	1.13E+00
iron	2.15E-07	1.58E+00
magnesium	4.15E-06	3.04E+01
manganese	9.50E-09	6.97E-02
nitrate	5.50E-07	4.04E+00
potassium	7.58E-07	5.56E+00
silicon	2.41E-06	1.77E+01
sodium	2.18E-06	1.60E+01
strontium	9.72E-08	7.13E-01
sulfate	1.04E-05	7.63E+01
uranium	5.54E-10	4.06E-03
zinc	1.65E-08	1.21E-01
ammonia	5.67E-08	4.16E-01
1-butanol	5.00E-09	3.67E-02
alpha activity *	6.75E-13	4.95E-06
TDS	6.57E-05	4.82E+02
total carbon	1.58E-05	1.16E+02
TOX (as Cl)	7.75E-09	5.69E-02
cobalt-60 *	6.60E-13	4.84E-06
iodine-129 *	9.08E-14	6.66E-07
plutonium-239/240 *	7.57E-15	5.55E-08
radium total *	1.67E-13	1.23E-06
ruthenium-106 *	3.06E-12	2.25E-05
strontium-90 *	1.75E-13	1.28E-06
uranium-234 *	2.21E-13	1.62E-06
uranium-238 *	1.66E-13	1.22E-06

Footnotes:

Data collected from October 1989 through March 1990.

Flow rate is the average of rates from the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 25).

Constituent concentrations are average values from the statistics in the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 25).

Concentration units of flagged (*) constituents are reported as curies per liter.

Loading units of flagged (*) constituents are reported as curies per month.

Table 2.11-3h. Radionuclide and Chemical Loading, 242-A Evaporator Steam Condensate.

Flow Rate: 6.31E+04 L/mo

Constituent	Kg/L*	Kg/mo*
barium	3.12E-08	1.97E-03
boron	1.85E-08	1.17E-03
calcium	1.93E-05	1.22E+00
chloride	1.10E-06	6.94E-02
copper	1.10E-08	6.94E-04
fluoride	1.29E-07	8.14E-03
iron	8.40E-08	5.30E-03
lead	5.50E-09	3.47E-04
magnesium	4.54E-06	2.87E-01
manganese	1.42E-08	8.96E-04
mercury	1.05E-10	6.63E-06
nitrate	5.50E-07	3.47E-02
potassium	7.50E-07	4.73E-02
silicon	2.50E-06	1.58E-01
sodium	2.20E-06	1.39E-01
strontium	9.62E-08	6.07E-03
sulfate	1.05E-05	6.63E-01
uranium	5.20E-10	3.28E-05
zinc	1.87E-08	1.18E-03
ammonia	6.30E-08	3.98E-03
alpha activity *	6.46E-13	4.08E-08
TDS	7.60E-05	4.80E+00
TOC	1.10E-06	6.94E-02
total carbon	1.43E-05	9.02E-01
carbon-14 *	4.04E-12	2.55E-07
strontium-90 *	4.98E-13	3.14E-08
uranium-234 *	1.92E-13	1.21E-08
uranium-238 *	1.69E-13	1.07E-08

Footnotes:

Data collected from October 1989 through March 1990.

Flow rate is the average of rates from the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 26).

Constituent concentrations are average values from the statistics in the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 26).

Concentration units of flagged (*) constituents are reported as curies per liter.

Loading units of flagged (*) constituents are reported as curies per month.

Table 2.11-4. Effluent Study Groundwater Summary Report. (Page 1 of 3)

CONSTITUENT			ANALYSIS SUMMARY					GROUP A STUDY GUIDELINES	
Group Name	Units	Detection Limit	Number of Analyses	Number > Det.	Average Result	Maximum Result	Minimum Result	Max Limit	Number > Limit
CONTAMINATION INDICATOR PARAMETERS									
Conductivity, Laboratory	UMHO	1.00	51	51	322.39	489.00	142.00	700.0	0
Specific conductance	UMHO	1.00	121	121	284.36	447.00	137.00	700.0	0
Total Organic Halogen, Low Det. Level	PPB	10.00	136	30	47.60	1310.00	.01		0
pH, Field Measurement		.10	121	121	8.03	8.53	6.95	8.5	1
pH, Laboratory Measurement		.01	40	40	7.96	8.40	7.40	8.5	0
DRINKING WATER PARAMETERS									
Alpha, High Detection Level	PCI/L	4.00	50	8	2.37	7.93	-.38	15.0	0
Arsenic	PPB	5.00	46	25	7.17	16.00	5.00	50.0	0
Arsenic, filtered	PPB	5.00	45	24	7.07	15.00	5.00	50.0	0
Barium	PPB	6.00	39	36	41.62	117.00	6.00	1000.0	0
Barium, filtered	PPB	6.00	39	36	39.69	110.00	6.00	1000.0	0
Cadmium	PPB	2.00	37	5	3.08	41.00	2.00	10.0	1
Cadmium, filtered	PPB	2.00	36	1	2.03	3.00	2.00	10.0	0
Chromium	PPB	10.00	42	34	44.93	206.00	10.00	50.0	13
Chromium, filtered	PPB	10.00	38	2	10.13	15.00	10.00	50.0	0
Fluoride	PPB	500.00	44	16	531.36	700.00	500.00	4000.0	0
Gross beta	PCI/L	8.00	57	7	5.83	12.70	1.32	50.0	0
Lead (graphite furnace)	PPB	5.00	42	5	5.69	25.00	5.00	50.0	0
Nitrate	PPB	500.00	47	43	8463.83	29600.00	500.00	45000.0	0
GROUNDWATER QUALITY PARAMETERS									
Chloride	PPB	500.00	44	44	4920.91	9800.00	2500.00	250000.0	0
Iron	PPB	30.00	42	42	3143.40	116000.00	44.00	300.0	20
Iron, filtered	PPB	30.00	39	18	49.26	318.00	30.00	300.0	1
Manganese	PPB	5.00	41	34	74.44	1790.00	5.00	50.0	7
Manganese, filtered	PPB	5.00	38	17	29.16	231.00	5.00	50.0	6
Sodium	PPB	200.00	42	42	17831.19	34100.00	3540.00		0
Sodium, filtered	PPB	200.00	41	41	18281.95	34500.00	4040.00		0
Sulfate	PPB	500.00	47	47	25961.70	70300.00	3700.00	250000.0	0

Table 2.11-4. Effluent Study Groundwater Summary Report. (Page 2 of 3)

CONSTITUENT			ANALYSIS SUMMARY					GROUP A STUDY GUIDELINES	
Group Name	Units	Detection Limit	Number of Analyses	Number > Det.	Average Result	Maximum Result	Minimum Result	Max Limit	Number > Limit
SITE SPECIFIC AND OTHER PARAMETERS									
Acetone by VOA	PPB	10.00	45	2	9.87	13.30	6.00		0
Alkalinity		20000.00	1	1	53000.00	53000.00	53000.00		0
Aluminum	PPB	150.00	38	9	361.08	7110.00	150.00	50.0	9
Ammonium ion	PPB	50.00	44	3	55.16	149.00	50.00		0
Beryllium	PPB	5.00	37	1	5.14	10.00	5.00		0
Boron	PPB	10.00	42	38	21.36	61.00	10.00		0
Boron, filtered	PPB	10.00	40	38	21.38	62.00	10.00		0
Calcium	PPB	50.00	42	42	26104.76	44200.00	16900.00		0
Calcium, filtered	PPB	50.00	40	40	26237.50	44000.00	19100.00		0
Copper	PPB	10.00	37	3	11.00	39.00	10.00	1000.0	0
Copper, filtered	PPB	10.00	36	1	10.17	16.00	10.00	1000.0	0
Hydrazine, Low Detection Level	PPB	30.00	42	1	30.14	36.00	30.00		0
Lithium	PPB	10.00	37	5	10.32	15.00	10.00		0
Lithium, filtered	PPB	10.00	36	4	10.25	15.00	10.00		0
Magnesium	PPB	50.00	42	42	8022.14	13600.00	4010.00		0
Magnesium, filtered	PPB	50.00	41	41	8017.07	13500.00	4950.00		0
Methylene Chloride	PPB	5.00	44	1	5.02	6.00	5.00		0
Natural uranium	UG/L	.73	2	2	1.00	1.02	.97	59.0	0
Nickel	PPB	10.00	42	30	24.88	100.00	10.00		0
Nickel, filtered	PPB	10.00	36	3	10.50	24.00	10.00		0
Phosphate	PPB	1000.00	44	2	1063.64	3200.00	1000.00		0
Potassium	PPB	100.00	42	42	4802.62	6950.00	2190.00		0
Potassium, filtered	PPB	100.00	41	41	4873.17	6250.00	2380.00		0
Silicon	PPB	50.00	41	41	15281.71	21700.00	3830.00		0
Silicon, filtered	PPB	50.00	39	39	15250.77	20000.00	3950.00		0
Strontium	PPB	10.00	41	41	156.32	238.00	78.00		0
Strontium, filtered	PPB	10.00	39	39	158.00	231.00	96.00		0
Titanium	PPB	60.00	37	1	71.57	488.00	60.00		0
Total carbon	PPB	1000.00	41	41	25151.22	36500.00	15300.00		0
Total dissolved solids		5000.00	7	7	167714.29	216000.00	68000.00	500000.0	0
Tritium	PCI/L	500.00	55	29	22746.33	232000.00	-93.90	80000.0	3
Turbidity	NTU	.10	43	43	5.22	82.00	.25	5.0	10

Table 2.11-4. Effluent Study Groundwater Summary Report. (Page 3 of 3)

CONSTITUENT			ANALYSIS SUMMARY					GROUP A STUDY GUIDELINES	
Group Name	Units	Detection Limit	Number of Analyses	Number > Det.	Average Result	Maximum Result	Minimum Result	Max Limit	Number > Limit
SITE SPECIFIC AND OTHER PARAMETERS									
Unknown	PPB	0.00	1	1	32.00	32.00	32.00		0
Uranium	PCI/L	.50	16	16	2.70	9.32	.70	40.0	0
Uranium-234	PCI/L	.10	2	2	.39	.41	.38	20.0	0
Uranium-238	PCI/L	.10	2	2	.30	.31	.29	24.0	0
Vanadium	PPB	5.00	39	33	27.23	60.00	5.00		0
Vanadium, filtered	PPB	5.00	38	33	27.29	64.00	5.00		0
Zinc	PPB	5.00	40	27	28.03	448.00	5.00	5000.0	0
Zinc, filtered	PPB	5.00	39	20	12.87	89.00	5.00	5000.0	0

Table 2.11-5. Background Comparison, 216-B-3 Pond.

Constituent	Background[a]	Average/ Background[b]	Maximum/ Background[b]
aluminum	2.0	180.54	3,555.00
ammonia	50.0	1.10	2.98
arsenic	6.3	1.14 (1.12)	2.54 (2.38)
barium	62.0	0.67 (0.64)	1.89 (1.77)
beryllium	0.3	17.13	33.33
bismuth	0.02		
boron	50.0	0.43 (0.43)	1.22 (1.24)
cadmium	0.2	15.4 (10.15)	205.00 (15.00)
calcium	50,700	0.51 (0.52)	0.87 (0.87)
chloride	16,800	0.29	0.58
chromium	6.0	7.49 (1.69)	34.33 (2.50)
copper	1.0	11.00 (10.17)	39.00 (16.00)
cyanide	10.0		
fluoride	470	1.13	1.49
lead	0.5	11.38	50.00
magnesium	15,200	0.53 (0.53)	0.89 (0.89)
manganese	12.0	6.20 (2.43)	149.17 (19.25)
mercury	0.1		
nickel	4.0	6.22 (2.63)	25.00 (6.00)
phosphate	1,000	1.06	3.20
potassium	6,190	0.78 (0.79)	1.12 (1.01)
selenium	2.0		
silver	10		
sodium	28,410	0.63 (0.64)	1.20 (1.21)
strontium	338	0.46 (0.47)	0.70 (0.68)
sulfate	51,200	0.51	1.37
uranium	2.5	1.08	3.73
vanadium	26	1.05 (1.05)	2.31 (2.46)
zinc	8.0	3.50 (1.61)	56.00 (11.13)
alkalinity	144,000	0.37	0.37
pH	7.8	1.03	1.09
TOC	933		
conductivity	462	0.70	0.97
gross alpha	3.9		
gross beta	31	0.19	0.41
radium	0.2		

TOC: total organic carbon. ( ): filtered samples.

[a]Background is the mean plus one standard deviation for the values listed in Table 2-1. Amounts of uranium, gross alpha, gross beta, and radium given in picocuries per liter. All others are in parts per billion.

[b]Average and maximum values from Table 2.11-4.

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2.12 216-B-55 CRIB

There were no significant additional impacts to soil or groundwater quality identified that would result from continued interim use of this crib.

2.12.1 Receiving Site Description

The 216-B-55 Crib has been in operation since 1967. Figure 2.12-1 depicts the location of the crib with respect to groundwater monitoring wells, B-Plant, and other facilities in the vicinity.

2.12.2 Effluent Stream Description

The 216-B-55 Crib receives wastewater from the B-Plant steam condensate, which is associated with the E-23-3 waste concentrator in the 221-B Building. Previous flow originated from the vessel ventilation system, however, ventilation solutions are currently being routed to double-shell tanks. During operation of the concentrator, the average condensate flow rate ranges from 30 to 40 gal/min. Tube bundles within the E-23-3 concentrator are contributors to this waste stream. At this time (July 1990), the concentrator is used for limited testing of a recently installed deentrainer and for training of operations personnel. Table 2.12-1 summarizes information pertaining to the steam condensate stream. Selected wastestream sampling and chemical and radionuclide loading data are included in Tables 2.12-2 and 2.12-3, respectively.

Chemical sampling conducted from December 1985 to December 1988 did not indicate any chemical constituents above Group A study guidelines. Sampling was not performed during the October 1989 to March 1990 period because the plant is in a maintenance outage.

Routine radiological sampling during the 1976 to 1988 period indicates concentrations of several radionuclides above Group A study guidelines.

2.12.3 Flow and Transport Analysis

For transport calculations, the sediment column beneath the crib is treated as a three-layer system 87 m in depth (Figure 2.12-2 and Appendix B). The calculated travel time for wastewater to reach the water table is 270 days (see Appendix B for data and computations).

Based on general effluent characteristics and corresponding sorption parameters (Appendix C) for the key constituents identified in Table 2.12-2, the calculated migration rates (Appendix B) are 0.03 to 0.26 cm/day for the relatively immobile constituents and 3.2 cm/day for the more mobile uranium. Assuming a 20-yr period of continuous past use, steady-state conditions, and average wastestream flow rates, the maximum migration depth for the immobile constituents is calculated to be approximately 23 m. The indicated travel time for uranium is about 7 yr (Appendix B). Thus, uranium would be expected to occur in groundwater beneath this crib (Appendix B).

2.12.4 Groundwater Quality Assessment

Nitrate and tritium were the only significant occurrences in the groundwater above Group A study guidelines (Table 2.12-4). Metals reported as above the these guidelines are attributed to well and sampling artifacts (well casing corrosion products, see WHC 1990d). The tritium and nitrate are attributed to upgradient sources (Serkowski and Jordan 1989, Figures 16 and 17; Evans etal. 1990, Figures 2-12, 2-14, and 2-15).

Except for the metals noted above, the Group B study guidelines or background comparison (Table 2.12-5) does not indicate any major anomalies.

There were no occurrences of key constituents in vicinity groundwater above Group A study guidelines. Uranium, however, was detected at two to three times the Group B (background) guideline (Table 2.12-5). This observation is consistent with the migration rate estimates noted in Section 2.12.3.

2.12.5 Impact of Continued Operation

The discharge rate to this crib is less than the Cold Creek recharge; thus, there should be no impact on the groundwater flow regime beyond the immediate vicinity of the crib.

Based on recently reported effluent composition and minor soil column loading (WHC 1989, Vol. 3), key constituent waste migration rate estimates (Section 2.12.3) and recent groundwater characterization results (Section 2.12.3), no adverse impact on groundwater quality is expected from continued operation.

Previous records (WHC 1989a, Vol. 3) suggest minor radioactive or chemical waste loading due to the B-Plant steam condensate. Assuming these records are reliable, and assuming similar operating conditions in the future, remobilization of previous contaminant loads due to continued use of this disposal site should not complicate future cleanup efforts.

Figure 2.12-1. Well Location and Site Map for 216-B-55 Crib.

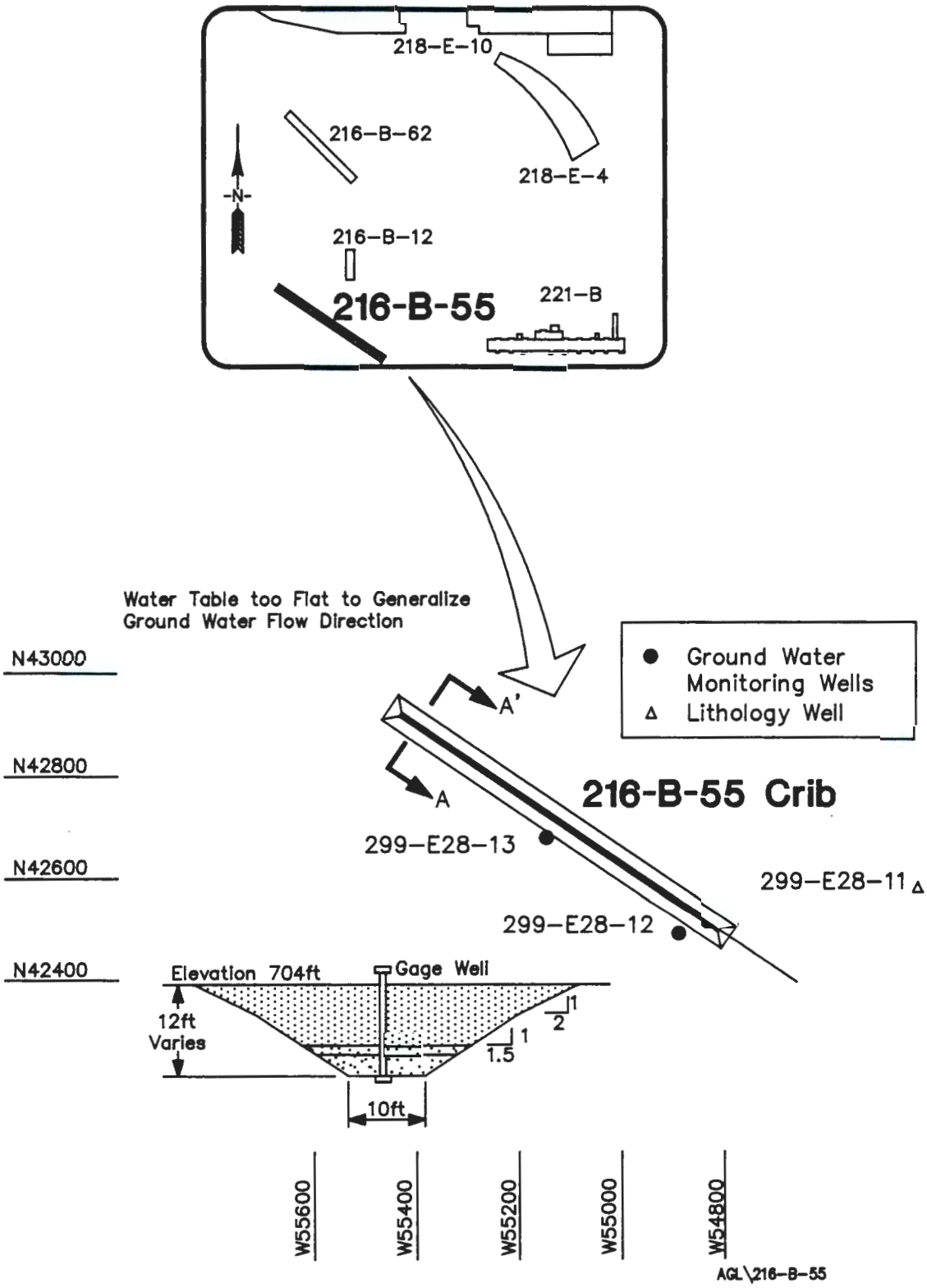


Figure 2.12-2. Lithology of Well 299-E28-11 Near the 216-B-55 Crib.

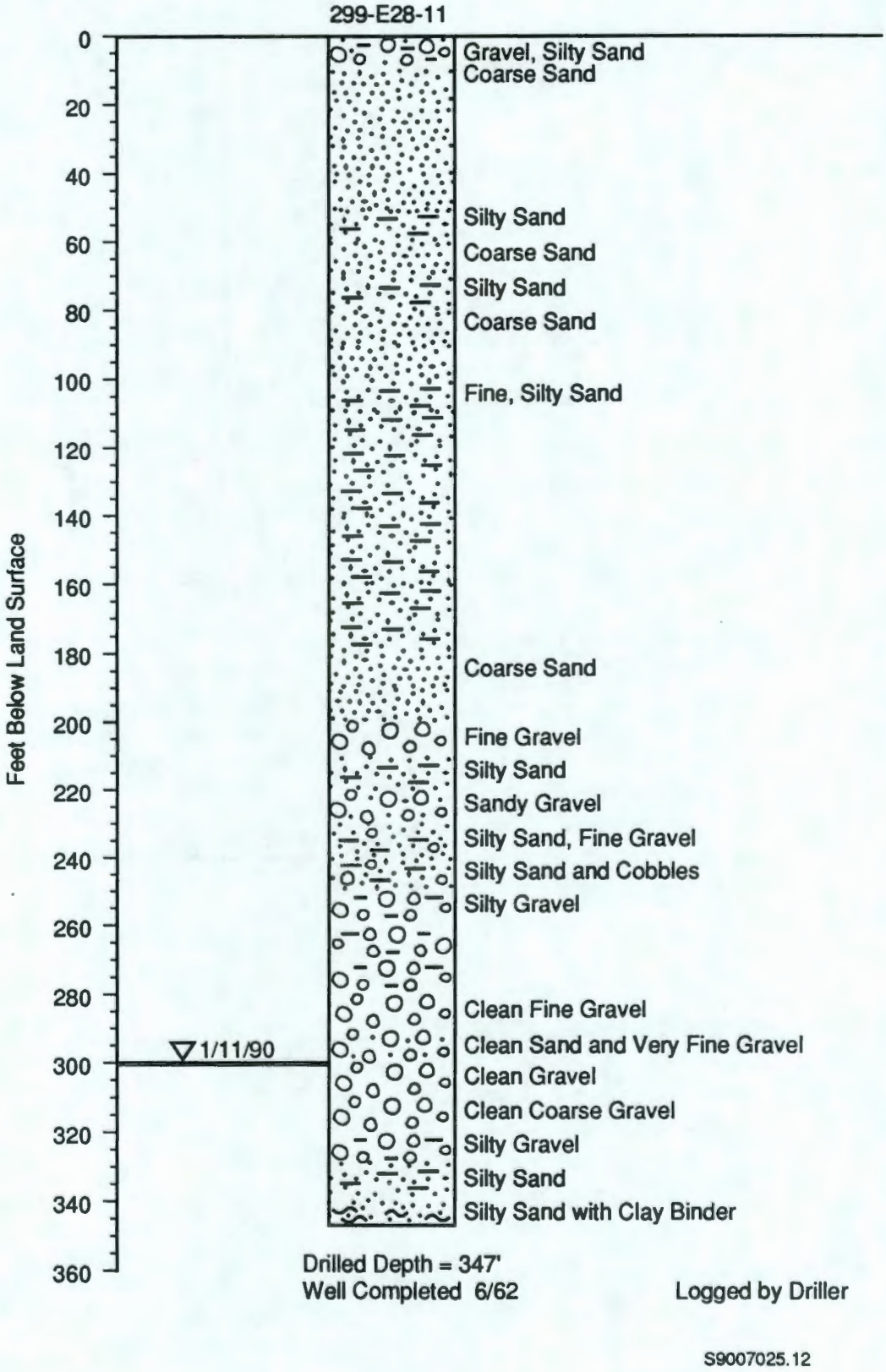


Table 2.12-1. Effluent Stream Description, B Plant Steam Condensate.

Total volume of effluent discharged to subject receiving site: (WHC 1989a, WHC-EP-0287, Volume 3)	1.06E+09 L from 12/67 to 12/88
Average effluent discharge rate, by operating mode: (WHC 1990a, WHC-EP-0342, Addendum 16)	5.18E+05 L/mo
Current average effluent discharge rate: (WHC 1990a, WHC-EP-0342, Addendum 16)	None
Effluent designation: (WHC 1990a, WHC-EP-0342, Addendum 16)	Nondangerous, radioactive
Effluent status: (WHC 1990a, WHC-EP-0342, Addendum 16)	Maintenance outage; no discharge[a]

[a]During the sampling period 10/89 to 3/90, 12,600 gal of steam condensate was discharged to the 216-B-55 Crib in January 1990 during training activities at a rate of 30 to 40 gal/min.

Table 2.12-2. Effluent Stream Sampling Data, B-Plant Steam Condensate.

Key Constituents	Detection Limit[a]	Detection/ Analyses	Sample Concentration 90% CI[a]	Detection Limit[a]	Detection/ Analyses	Sample Concentration 90% CI[a]
	1976 to 1988, During Routine Operation			10/89 to 03/90, During Inactive Mode		
strontium-90	30	81/NA	3,600	No Data		
cesium-137	80	81/NA	6,300			
ruthenium-106	600	3/NA	11,000			
cerium-144	NA	8/NA	30,000			
cobalt-60	NA	3/NA	5,200			
uranium (isotopes)[b]	20	1/NA	38			

[a]Units: chemical--parts per billion
radionuclides--picocurie per liter.

[b]Uranium-234 Group A study guideline used as the most restrictive for determining key constituents.

CI: confidence interval.
NA: not available.

Table 2.12-3. Radionuclide and Chemical Loading, B Plant Steam Condensate.

Flow Rate: 5.18E+05 L/mo

Constituent	Kg/L*	Kg/mo*
calcium	1.78E-07	9.23E-02
copper	1.07E-08	5.55E-03
iron	9.41E-08	4.88E-02
lead	5.00E-09	2.59E-03
magnesium	5.07E-08	2.63E-02
mercury	1.14E-10	5.91E-05
nickel	1.01E-08	5.23E-03
nitrate	9.17E-07	4.75E-01
potassium	1.00E-07	5.18E-02
sodium	1.87E-07	9.69E-02
uranium #	2.67E-10	1.38E-04
zinc	1.27E-08	6.58E-03
acetone	3.14E-08	1.63E-02
ammonia	1.15E-07	5.96E-02
phenol	1.01E-08	5.23E-03
unknown	3.30E-08	1.71E-02
alpha activity #,*	3.02E-12	1.57E-06
beta activity *	6.97E-11	3.61E-05

Footnotes:

Data collected during December 1985, May 1986, September 1986, November 1986, August 1988, November 1988 and December 1988.

Flow rate is the average of rates from the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 16).

Constituent concentrations are average values from the statistics in the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 16).

Concentration units of flagged (*) constituents are reported as curies per liter.

Loading units of flagged (*) constituents are reported as curies per month.

Constituents are flagged (#) if any detected result is less than any detection limit.

Table 2.12-4. Effluent Study Groundwater Summary Report. (Page 1 of 2)

CONSTITUENT			ANALYSIS SUMMARY					GROUP A STUDY GUIDELINES	
Group Name	Units	Detection Limit	Number of Analyses	Number > Det.	Average Result	Maximum Result	Minimum Result	Max Limit	Number > Limit
CONTAMINATION INDICATOR PARAMETERS									
Conductivity, Laboratory	UMHO	1.00	4	4	648.00	829.00	486.00	700.0	2
Specific conductance	UMHO	1.00	4	4	621.25	767.00	480.00	700.0	2
pH, Field Measurement		.10	4	4	7.80	7.85	7.76	8.5	0
pH, Laboratory Measurement		.01	4	4	7.55	7.60	7.50	8.5	0
DRINKING WATER PARAMETERS									
Alpha, High Detection Level	PCI/L	4.00	4	2	4.58	6.63	2.17	15.0	0
Barium	PPB	6.00	2	2	96.00	110.00	82.00	1000.0	0
Barium, filtered	PPB	6.00	2	2	82.00	88.00	76.00	1000.0	0
Cadmium	PPB	2.00	2	1	5.00	8.00	2.00	10.0	0
Chromium	PPB	10.00	2	1	13.50	17.00	10.00	50.0	0
Fluoride	PPB	500.00	4	3	500.00	500.00	500.00	4000.0	0
Gross beta	PCI/L	8.00	10	7	16.73	45.40	6.22	50.0	0
Lead (graphite furnace)	PPB	5.00	2	1	7.00	9.00	5.00	50.0	0
Nitrate	PPB	500.00	4	4	112500.00	241000.00	35400.00	45000.0	2
GROUNDWATER QUALITY PARAMETERS									
Chloride	PPB	500.00	4	4	8825.00	9600.00	8300.00	250000.0	0
Iron	PPB	30.00	2	2	11644.00	23200.00	88.00	300.0	1
Manganese	PPB	5.00	2	1	717.50	1430.00	5.00	50.0	1
Sodium	PPB	200.00	2	2	29600.00	32700.00	26500.00		0
Sodium, filtered	PPB	200.00	2	2	27250.00	28800.00	25700.00		0
Sulfate	PPB	500.00	4	4	60400.00	62700.00	57900.00	250000.0	0
SITE SPECIFIC AND OTHER PARAMETERS									
Aluminum	PPB	150.00	2	1	225.50	301.00	150.00	50.0	1
Boron	PPB	10.00	2	2	26.00	27.00	25.00		0
Boron, filtered	PPB	10.00	2	2	25.50	28.00	23.00		0
Calcium	PPB	50.00	2	2	63000.00	80700.00	45300.00		0
Calcium, filtered	PPB	50.00	2	2	46950.00	49100.00	44800.00		0
Copper	PPB	10.00	2	1	12.00	14.00	10.00	1000.0	0
Magnesium	PPB	50.00	2	2	18300.00	22500.00	14100.00		0

Table 2.12-4. Effluent Study Groundwater Summary Report. (Page 2 of 2)

CONSTITUENT			ANALYSIS SUMMARY					GROUP A STUDY GUIDELINES	
Group Name	Units	Detection Limit	Number of Analyses	Number > Det.	Average Result	Maximum Result	Minimum Result	Max Limit	Number > Limit
SITE SPECIFIC AND OTHER PARAMETERS									
Magnesium, filtered	PPB	50.00	2	2	14550.00	15500.00	13600.00		0
Nickel	PPB	10.00	2	1	11.00	12.00	10.00		0
Potassium	PPB	100.00	2	2	6765.00	7280.00	6250.00		0
Potassium, filtered	PPB	100.00	2	2	6355.00	6570.00	6140.00		0
Silicon	PPB	50.00	2	2	17400.00	17900.00	16900.00		0
Silicon, filtered	PPB	50.00	2	2	17600.00	18500.00	16700.00		0
Strontium	PPB	10.00	2	2	277.50	321.00	234.00		0
Strontium, filtered	PPB	10.00	2	2	248.00	268.00	228.00		0
Technetium-99	PCI/L	15.00	2	1	29.36	54.80	3.91	4000.0	0
Total carbon	PPB	1000.00	2	2	30350.00	32700.00	28000.00		0
Tritium	PCI/L	500.00	10	10	75038.00	134000.00	5880.00	80000.0	6
Turbidity	NTU	.10	2	2	23.15	46.00	.30	5.0	1
Uranium	PCI/L	.50	2	2	4.82	7.54	2.10	40.0	0
Vanadium	PPB	5.00	2	2	18.00	19.00	17.00		0
Vanadium, filtered	PPB	5.00	2	2	17.50	19.00	16.00		0
Zinc	PPB	5.00	2	2	13.00	15.00	11.00	5000.0	0
Zinc, filtered	PPB	5.00	2	1	7.50	10.00	5.00	5000.0	0

Table 2.12-5. Background Comparison, 216-B-55 Crib.

Constituent	Background[a]	Average/ Background[b]	Maximum/ Background[b]
aluminum	2.0	112.75	150.5
ammonia	50.0		
arsenic	6.3		
barium	62.0	1.55 (1.32)	0.77 (1.42)
beryllium	0.3		
bismuth	0.02		
boron	50.0	0.52 (0.51)	0.54 (0.56)
cadmium	0.2	25.0	40.0
calcium	50,700	1.24 (0.93)	1.59 (0.97)
chloride	16,800	0.53	0.57
chromium	6.0	2.25	2.83
copper	1.0	12.0	14.0
cyanide	10.0		
fluoride	470	1.06	1.06
lead	0.5	14.0	18.0
magnesium	15,200	1.20 (0.96)	1.48 (1.02)
manganese	12.0	59.8	119
mercury	0.1		
nickel	4.0	2.75	3.0
phosphate	1,000		
potassium	6,190	1.09 (1.03)	1.18 (1.06)
selenium	2.0		
silver	10.0		
sodium	28,410	1.04 (0.96)	1.15 (1.01)
strontium	338	0.82 (0.73)	0.95 (0.79)
sulfate	51,200	1.18	1.22
uranium	2.5	1.93	3.02
vanadium	26	0.96 (0.67)	0.73 (0.73)
zinc	8.0	1.63 (0.94)	1.88 (1.25)
alkalinity	144,000		
pH	7.8	1.00	1.01
TOC	933		
conductivity	462	1.34	1.66
gross alpha	3.9		
gross beta	31	0.54	1.46
radium	0.2		

TOC: total organic carbon. ( ): filtered samples.

[a]Background is the mean plus one standard deviation for the values listed in Table 2-1. Amounts of uranium, gross alpha, gross beta, and radium given in picocuries per liter. All others are in parts per billion.

[b]Average and maximum values from Table 2.12-4.

9 1 1 2 1 3 7 0 1 2 6

2.13 216-B-62 CRIB

No significant additional impact on groundwater quality due to continued use of this crib was identified. Input volume restrictions are being considered to minimize potential remobilization of previous contaminant loads.

2.13.1 Receiving Site Description

The 216-B-62 Crib, located in the 200 East Area, was constructed in 1973 to dispose of process condensate effluent from B Plant. Figure 2.13-1 depicts the locations of groundwater monitoring wells and the crib relative to other nearby facilities.

2.13.2 Effluent Stream Description

B-Plant, constructed in 1943, was used until 1952 for recovery of plutonium using the bismuth phosphate chemical separation process. In 1968, B-Plant began operations in recovery, purification, and encapsulation of cesium and strontium removed from tank wastes. A waste concentrator is used for concentration and volume reduction of low-level radioactive wastes. The process condensate is produced by the condensation of vapors boiled off in the concentrator. The condensate is discharged to the crib in batches via holding tanks after sampling. Table 2.13-1 summarizes information pertaining to the process condensate stream. Key constituents from sampling data are indicated in Table 2.13-2. Loading estimates are provided in Table 2.13-3.

Old sampling data indicate acetone, 2-butanone, mercury, and several radionuclides in concentrations above Group A or Group C study guidelines. The radiological constituents exceed guideline concentrations by significant margins. Equipment upgrades were installed in the concentrator in 1988 to improve the radiological decontamination of the process condensate stream. A project is under design to provide treatment of the process condensate stream for removal of radioactive and hazardous constituents.

2.13.3 Flow and Transport Analysis

For transport calculation purposes, the sediment column beneath the crib is treated as a four-layer system with a depth of 83 m (Figure 2.13-2 and Appendix B). The calculated travel time for waste water to reach the water table under average discharge conditions is 238 days (see Appendix B for data and computations).

Based on general effluent characteristics and corresponding sorption parameters (Appendix C) for the key constituents identified in Table 2.13-2, the calculated migration rates (Appendix B) range from about 35 cm/day for mobile constituents (acetone and 2-butanone) to 0.03 to 3.5 cm/day for the relatively immobile constituents. Only uranium should have reached groundwater during the operational period of the crib (i.e., a uranium travel time of 6.5 yr [Appendix B] as compared to an approximately 20-yr period of active use).

It should also be noted that a study of radionuclide mobility at this crib was conducted in 1982 (Smith 1983), suggesting cesium-137 and strontium-90 should exhibit similar migration rates (effective retardation coefficients of approximately 40 for both radionuclides). This is contrary to most Hanford soils for which strontium is generally more mobile than cesium. However, the presence of high concentrations of the ammonium ion (NH_4^+) in past waste effluent discharged to this crib may have modified the retention properties of the soil column. For example, Jacobs (1960) showed that ammonium causes a large decrease in cesium sorption and retention by layer silicate minerals. This additional wastewater chemical factor needs to be considered in estimating past and/or potential future contaminant mobilization beneath this crib.

2.13.4 Groundwater Quality Assessment

Of the key constituents (Table 2.13-2), tritium is the only significant occurrence in vicinity groundwater above Group A study guidelines (Table 2.13-4). Since this crib has not been used since 1986, current groundwater contamination should be due primarily to upgradient disposal activities, as suggested by the time series plot shown in Figure 2.13-3 and by the upgradient areal distribution pattern of tritium (Evans et al. 1990, Figures 2-14 and 2-15).

Uranium is the only significant anomaly indicated in the Group B or background comparison (Table 2.13-5). Uranium concentrations in groundwater beneath the 216-B-62 Crib have shown a steady decline since 1985 as indicated by the time series plot of gross alpha (Figure 2.13-4). However, based on the "old" effluent composition (Table 2.13-2) and travel time estimates for uranium (Section 2.13.3), some of the uranium in groundwater beneath the 216-B-62 Crib may have been due to past discharges to this crib. The elevated iron (unfiltered) is attributed to an artifact of sampling from wells with carbon steel casings (WHC 1990d).

2.13.5 Impact of Continued Operation

Based on the average discharge rate indicated in Table 2.13-2, there would be an insignificant impact on the local groundwater flow regime.

Considering the projected or future chemical composition of B-Plant process condensate (i.e., post-upgrade and/or best available technology [BAT] treated; WHC 1990a, Addendum 17), there should not be an adverse impact on groundwater quality beneath this crib. The presence of residual contaminants from nearby past-practice disposal units (e.g., 216-B-12 Crib), however, may impact the ability of the groundwater monitoring network to detect potential stream-specific contaminants.

The potential movement of previous contaminant loads, however, needs to be considered. For example, this crib has an estimated 140 Ci of cesium-137 and 75 Ci of strontium-90 on the soil column from past operations, with lesser amounts of shorter-lived neutron activation products and small amounts of transuranics (WHC 1989a, Vol. 3). The actual depth distribution of strontium-90 and cesium-137 was measured by collection of core samples in 1982 (Smith 1983). These data show an observed maximum depth of penetration

of approximately 55 ft (16.8 m) beneath the bottom of the crib for cesium and strontium. More recent (March 1989) gross gamma logs from a vadose zone monitoring well at the head end of the crib indicate a depth of penetration of approximately 70 ft (21 m) from the bottom of the crib.

The theoretical depth of penetration based on the wastewater migration rate in Section 2.13.4 and the site-specific retardation coefficients from Smith (1983), is shown graphically in Figure 2.13-5. Only the top 40 m layer of soil and associated hydraulic properties are used for this calculation (Appendix B). This plot suggests that an incremental depth of penetration beneath the crib of about 45 m should have occurred for the total discharge volume added through 1986 (i.e., 2.8E+08 L). The observed maximum depth of cesium-137 beneath the crib is 21 m (WHC 1989, Vol. 1-3, p. A-13.14). Thus, the simplified model overpredicts migration depth in this case by about twofold.

Assuming the same average discharge rate as used for Figure 2-13-5, the total volume discharged in 4 yr of proposed or continued operation would result in 14 m of additional movement of the cesium and strontium load on the soil column. Applying the overestimate noted above, the actual additional penetration would be about 7 m ([observed/predicted] x predicted) = 21/45 x 14 = 6.53).

Based on the above estimates and uncertainty concerning modification of soil sorptive properties at this site, a total volume and discharge rate restriction may be appropriate. More rigorous modeling would be needed to estimate an acceptable discharge volume.

Figure 2.13-1. Well Location and Site Map for 216-B-62 Crib.

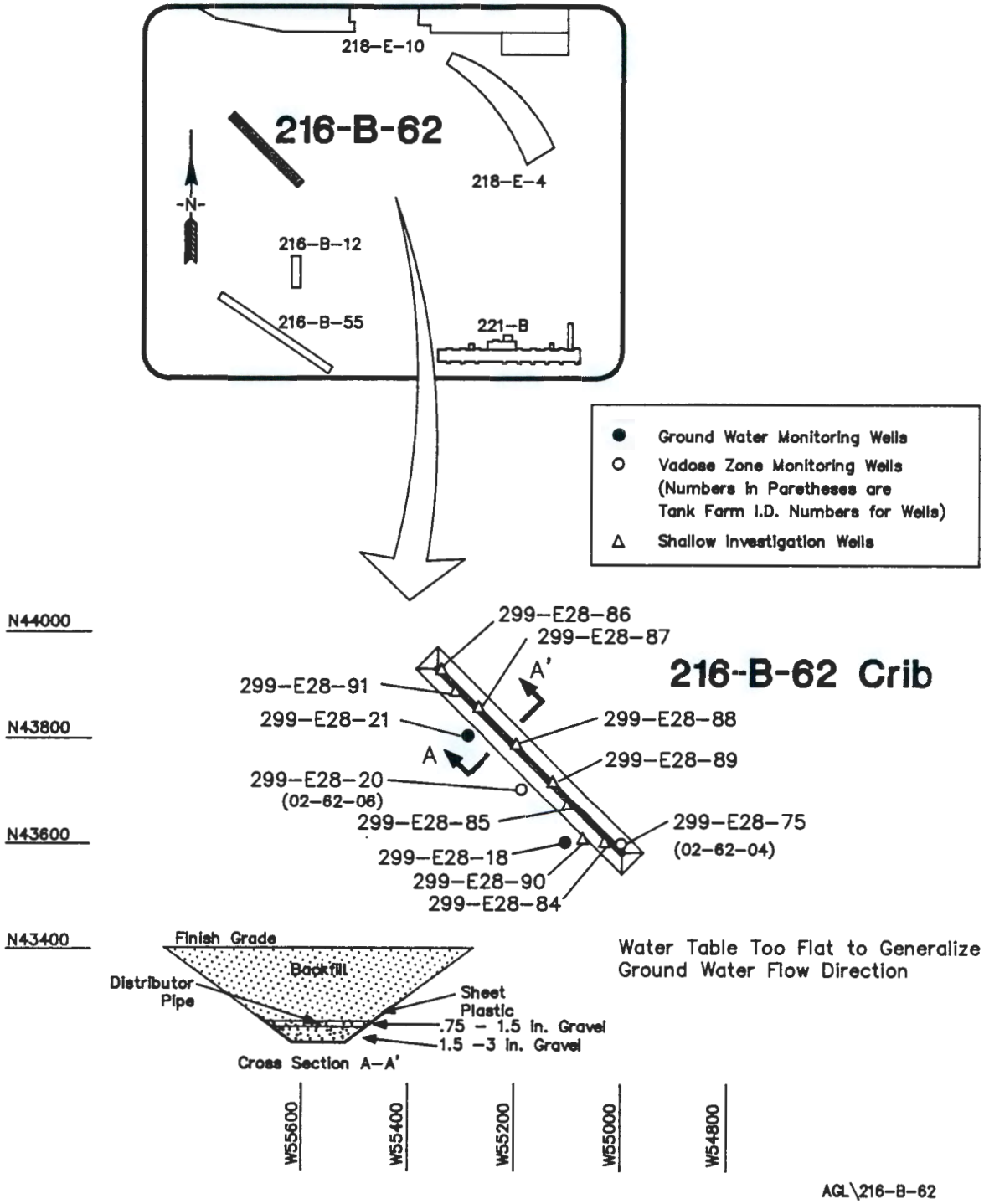
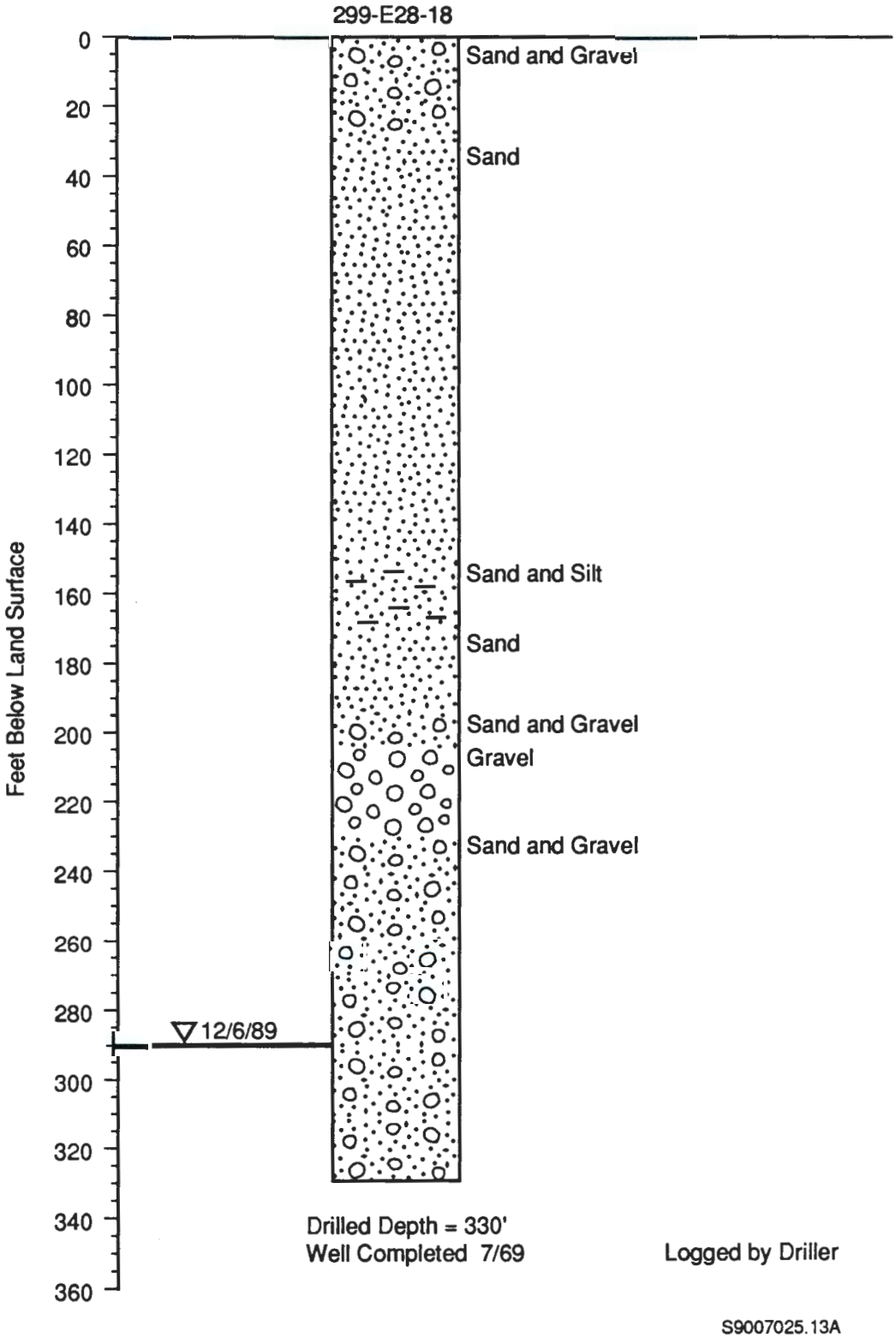


Figure 2.13-2. Lithology of Well 299-E28-18 at the 216-B-62 Crib.



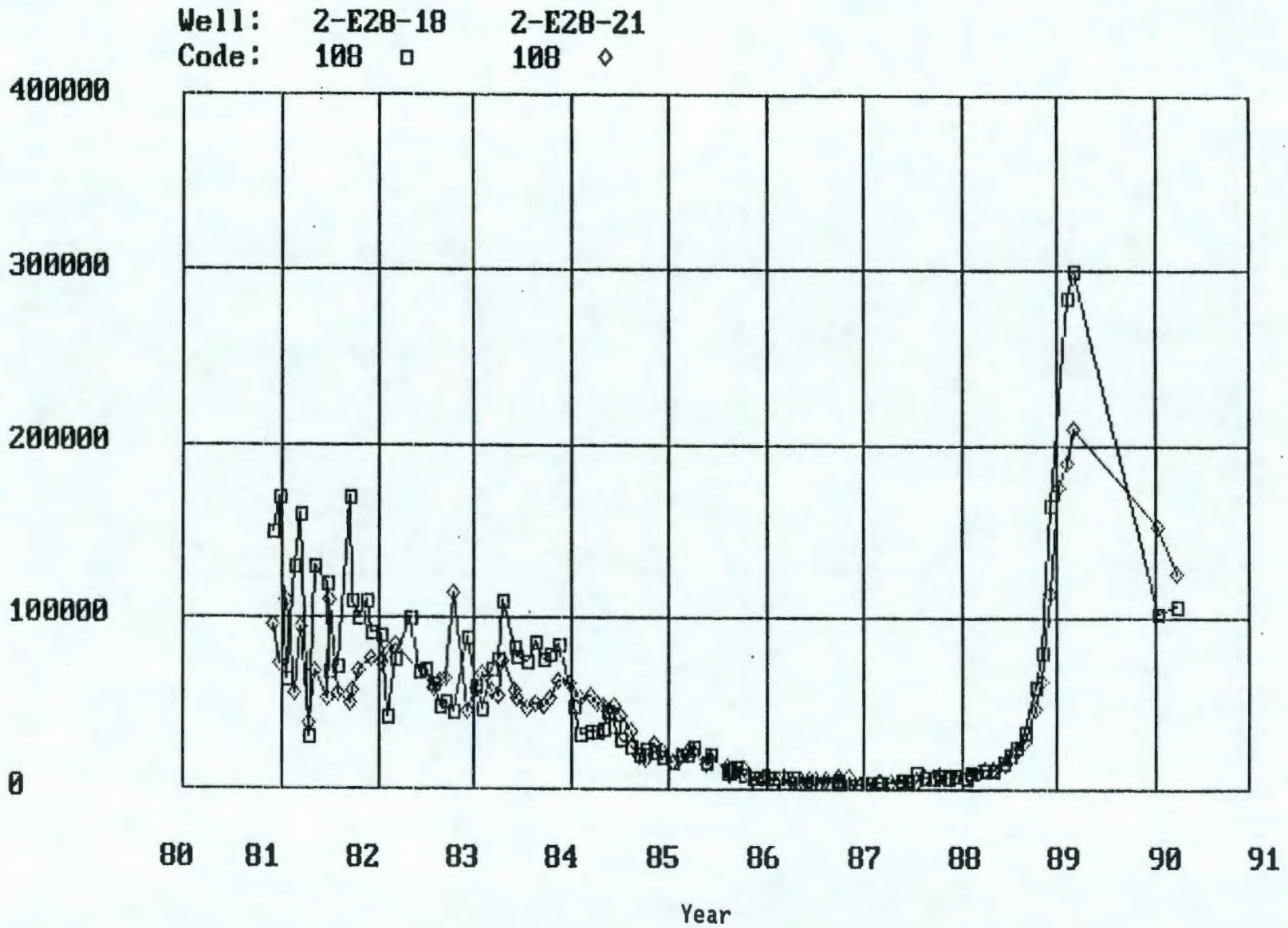


Figure 2.13-3. Tritium Versus Time at the 216-B-62 Crib.

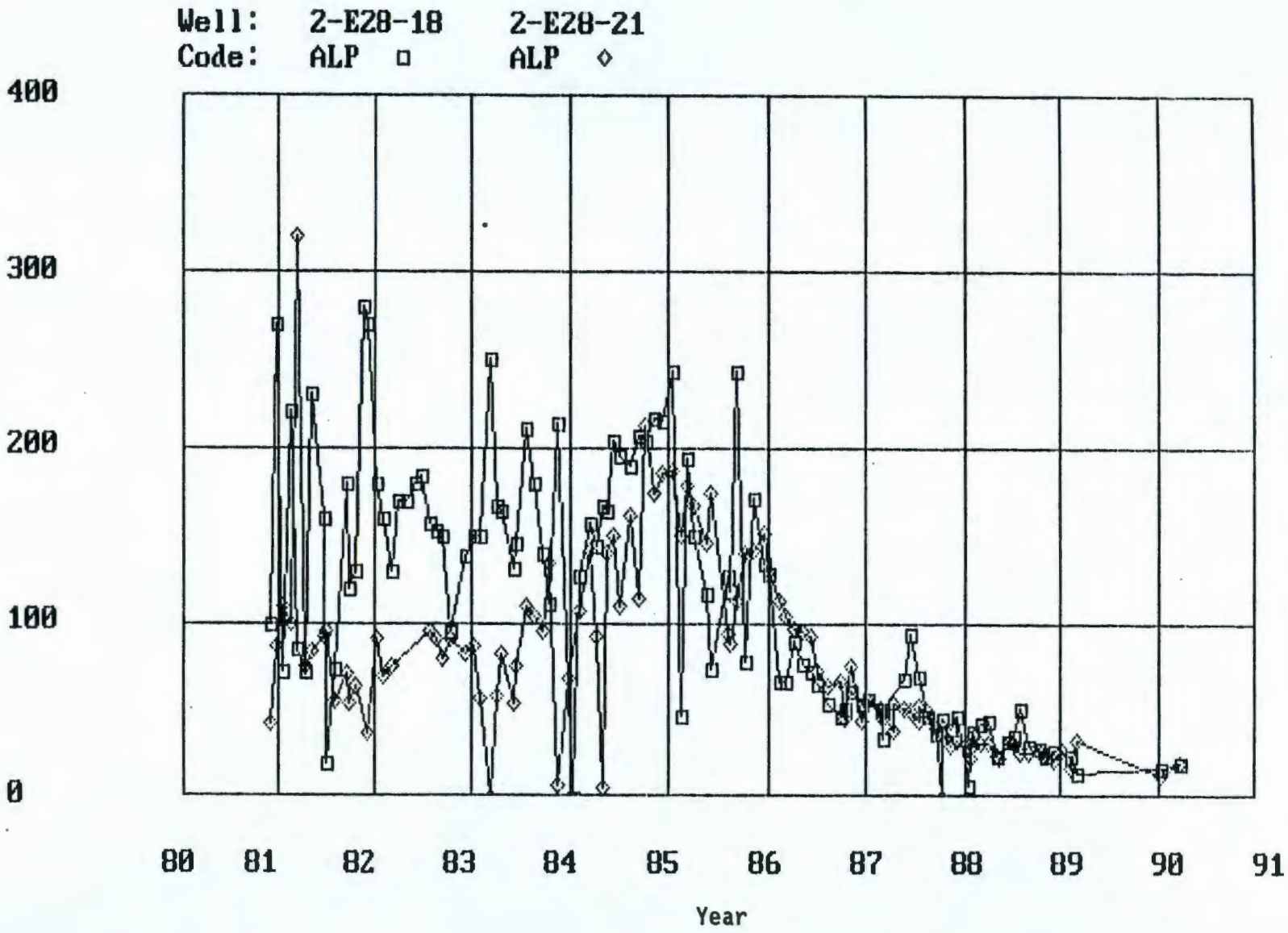


Figure 2.13-4. Gross Alpha Versus Time at the 216-B-62 Crib.

Figure 2.13-5. Penetration Depth Versus Wastewater Discharge Volume Added to 216-B-62 Crib.

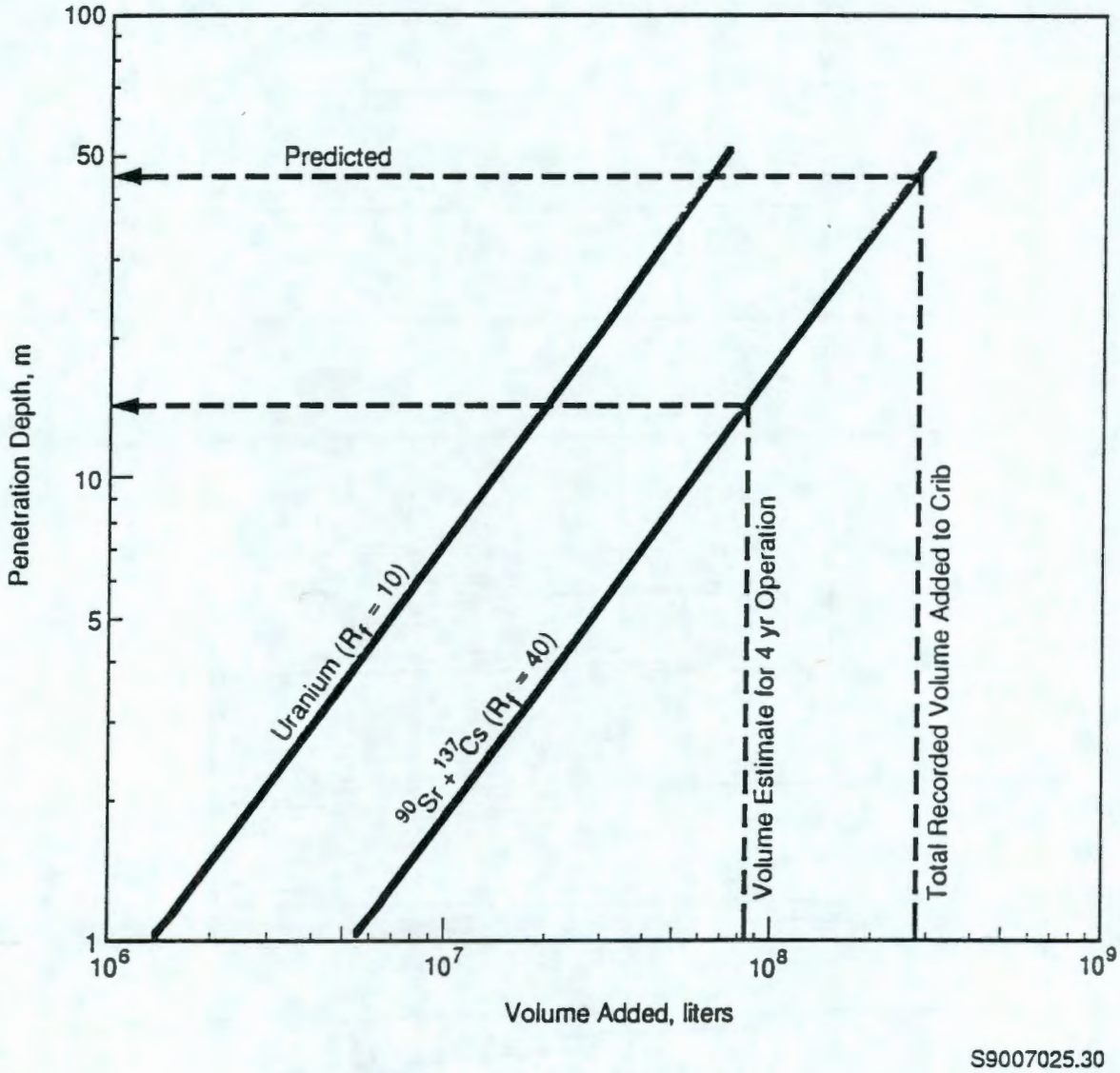


Table 2.13-1. Effluent Stream Description, B-Plant Process Condensate.

Total volume of effluent discharged to subject receiving site: (WHC 1989a, WHC-EP-0287, Volume 3)	2.00E+08 L from 12/73 to 12/86
Average effluent discharge rate, by operating mode: (WHC 1990a, WHC-EP-0342, Addendum 17	25 to 30 gal/min
Current average effluent discharge rate:	None
Effluent designation: (WHC 1990a, WHC-EP-0342, Addendum 17)	Not determined[a], radioactive
Effluent status: (WHC 1990a, WHC-EP-0342, Addendum 17)	Maintenance outage; no discharge

[a]The B Plant Process Condensate (BCP) wastestream cannot be designated at this time, pursuant to Washington Administrative Code (WAC) 173-303, Dangerous Waste Regulations. Sample data (January 1987 to October 1989) of the BCP wastestream, was not sufficient to determine if the effluent contains a dangerous listed waste (WAC 173-303-080).

Table 2.13-2. Effluent Stream Sampling Data, B Plant Process Condensate.

Key Constituents	Detection Limit[a]	Detection/ Analyses	Sample Concentration 90% CI[a]	Detection Limit[a]	Detection/ Analyses	Sample Concentration 90% CI[a]
	01/87 to 10/89, During Routine Operation			10/89 to 03/90, During Inactive Mode		
acetone	10	2/2	362	No Data		
2-butanone	10	1/2	79			
mercury	0.1	2/2	12			
	1976 to 1988, During Routine Operation			10/89 to 03/90, During Inactive Mode		
strontium-90	30	126/NA	670,000	No Data		
cesium-137	80	120/NA	1,200,000			
ruthenium-106	600	11/NA	390,000			
cesium-134	NA	46/NA	16,000			
cerium-144	NA	38/NA	96,000			
cobalt-58	NA	1/NA	69,000			
cobalt-60	NA	10/NA	160,000			
antimony-125	NA	20/NA	150,000			
uranium (isotopes)[b]	20	4/NA	1,300			
hydrogen-3	5,000	67/NA	720,000			
americium-241	40	40/NA	1,200			
europium-155	NA	36/NA	120,000			
europium-154	NA	29/NA	260,000			

[a]Units: chemical--parts per billion
radionuclides--picocurie per liter.

[b]Uranium-234 Group A study guideline used as the most restrictive for determining key constituents.

CI: confidence interval.
NA: not available.

Table 2.13-3. Radionuclide and Chemical Loading, B Plant Process Condensate.

Flow Rate: 3.58E+04 L/mo

Constituent	Kg/L*	Kg/mo*
calcium	6.92E-06	2.48E-01
iron	4.75E-08	1.70E-03
lead	1.45E-08	5.19E-04
magnesium	2.43E-07	8.69E-03
manganese	7.00E-09	2.50E-04
mercury	8.40E-09	3.00E-04
nitrate	9.00E-07	3.22E-02
zinc	8.20E-08	2.93E-03
acetone	2.92E-07	1.04E-02
ammonia	1.25E-06	4.47E-02
2-butanone	2.70E-08	9.66E-04
decane	2.00E-08	7.15E-04
heneicosane	3.20E-08	1.14E-03
2-hexanone	9.00E-09	3.22E-04
unknown	2.80E-08	1.00E-03
unknown aliphatic HC	9.10E-08	3.25E-03
alpha activity *	3.27E-12	1.17E-07
beta activity *	2.43E-08	8.69E-04
TOC	1.00E-06	3.58E-02

Footnotes:

Data collected from October 1989 through March 1990.

Flow rate is the average of rates from the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 17).

Constituent concentrations are average values from the statistics in the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 17).

Concentration units of flagged (*) constituents are reported as curies per liter.

Loading units of flagged (*) constituents are reported as curies per month.

Table 2.13-4. Effluent Study Groundwater Summary Report. (Page 1 of 2)

CONSTITUENT			ANALYSIS SUMMARY					GROUP A STUDY GUIDELINES	
Group Name	Units	Detection Limit	Number of Analyses	Number > Det.	Average Result	Maximum Result	Minimum Result	Max Limit	Number > Limit
CONTAMINATION INDICATOR PARAMETERS									
Conductivity, Laboratory	UMHO	1.00	4	4	514.75	521.00	510.00	700.0	0
Specific conductance	UMHO	1.00	4	4	495.25	505.00	475.00	700.0	0
pH, Field Measurement		.10	4	4	7.79	7.84	7.74	8.5	0
pH, Laboratory Measurement		.01	4	4	7.63	7.70	7.50	8.5	0
DRINKING WATER PARAMETERS									
Alpha, High Detection Level	PCI/L	4.00	8	8	19.64	32.30	12.20	15.0	6
Barium	PPB	6.00	2	2	34.00	40.00	28.00	1000.0	0
Barium, filtered	PPB	6.00	4	4	33.00	41.00	24.00	1000.0	0
Gross alpha	PCI/L	4.00	1	1	26.50	26.50	26.50	15.0	1
Gross beta	PCI/L	8.00	9	8	11.36	18.10	7.34	50.0	0
Nitrate	PPB	500.00	4	4	38050.00	40000.00	36100.00	45000.0	0
Nitrate, High Detection Level	PPB	2500.00	5	5	42320.00	43600.00	41000.00	45000.0	0
Selenium	PPB	5.00	2	2	5.00	5.00	5.00	10.0	0
Selenium, filtered	PPB	5.00	2	1	5.00	5.00	5.00	10.0	0
GROUNDWATER QUALITY PARAMETERS									
Chloride	PPB	500.00	4	4	9875.00	10300.00	9300.00	250000.0	0
Iron	PPB	30.00	2	2	265.50	308.00	223.00	300.0	1
Manganese	PPB	5.00	2	1	5.50	6.00	5.00	50.0	0
Sodium	PPB	200.00	2	2	23800.00	24000.00	23600.00		0
Sodium, filtered	PPB	200.00	4	4	24250.00	25300.00	22300.00		0
Sulfate	PPB	500.00	4	4	89650.00	93500.00	86800.00	250000.0	0
SITE SPECIFIC AND OTHER PARAMETERS									
Boron	PPB	10.00	2	2	118.50	136.00	101.00		0
Boron, filtered	PPB	10.00	4	4	122.50	137.00	101.00		0
Calcium	PPB	50.00	2	2	53800.00	54500.00	53100.00		0
Calcium, filtered	PPB	50.00	4	4	52850.00	53200.00	52200.00		0
Magnesium	PPB	50.00	2	2	14000.00	14400.00	13600.00		0
Magnesium, filtered	PPB	50.00	4	4	13950.00	14100.00	13500.00		0
Natural uranium	UG/L	.73	5	5	35.18	46.40	22.10	59.0	0

Table 2.13-4. Effluent Study Groundwater Summary Report. (Page 2 of 2)

CONSTITUENT			ANALYSIS SUMMARY					GROUP A STUDY GUIDELINES	
Group Name	Units	Detection Limit	Number of Analyses	Number > Det.	Average Result	Maximum Result	Minimum Result	Max Limit	Number > Limit
SITE SPECIFIC AND OTHER PARAMETERS									
Potassium	PPB	100.00	2	2	5620.00	5870.00	5370.00		0
Potassium, filtered	PPB	100.00	4	4	5575.00	5630.00	5460.00		0
Silicon	PPB	50.00	2	2	16250.00	16600.00	15900.00		0
Silicon, filtered	PPB	50.00	4	4	16350.00	17000.00	15800.00		0
Strontium	PPB	10.00	2	2	231.00	236.00	226.00		0
Strontium, filtered	PPB	10.00	4	4	232.25	239.00	222.00		0
Total carbon	PPB	1000.00	2	2	27450.00	27700.00	27200.00		0
Tritium	PCI/L	500.00	9	9	182888.89	300000.00	103000.00	80000.0	9
Turbidity	NTU	.10	2	2	.65	1.00	.30	5.0	0
Uranium	PCI/L	.50	2	2	18.10	19.10	17.10	40.0	0
Uranium-234	PCI/L	.10	2	2	12.05	12.10	12.00	20.0	0
Uranium-235	PCI/L	.10	2	2	.58	.61	.55	24.0	0
Uranium-238	PCI/L	.10	2	2	11.70	11.70	11.70	24.0	0
Vanadium	PPB	5.00	2	2	17.00	18.00	16.00		0
Vanadium, filtered	PPB	5.00	4	4	14.25	18.00	11.00		0
Zinc	PPB	5.00	2	2	19.50	33.00	6.00	5000.0	0
Zinc, filtered	PPB	5.00	4	3	17.25	30.00	5.00	5000.0	0

Table 2.13-5. Background Comparison, 216-B-62 Crib.

Constituent	Background[a]	Average/ Background[b]	Maximum/ Background[b]
aluminum	2.0		
ammonia	50.0		
arsenic	6.3		
barium	62.0	0.55 (0.53)	0.65 (0.66)
beryllium	0.3		
bismuth	0.02		
boron	50.0	2.37 (2.45)	2.72 (2.74)
cadmium	0.2		
calcium	50,700	1.06 (1.04)	1.07 (1.05)
chloride	16,800	0.59	0.61
chromium	6.0		
copper	1.0		
cyanide	10.0		
fluoride	470		
lead	0.5		
magnesium	15,200	0.92 (0.92)	0.95 (0.93)
manganese	12.0	0.46	0.50
mercury	0.1		
nickel	4.0		
phosphate	1,000		
potassium	6,190	0.91 (0.90)	0.95 (0.91)
selenium	2.0	2.50 (2.50)	2.50 (2.50)
silver	10		
sodium	28,410	0.84 (0.85)	0.84 (0.89)
strontium	338	0.68 (0.69)	0.70 (0.71)
sulfate	51,200	1.75	1.83
uranium	2.5	7.24	7.64
vanadium	26	0.65 (0.55)	0.69 (0.69)
zinc	8.0	2.44 (2.16)	4.13 (3.75)
alkalinity	144,000		
pH	7.8	1.00	1.01
TOC	933		
conductivity	462	1.07	1.09
gross alpha	3.9	6.79	6.79
gross beta	31	0.37	0.58
radium	0.2		

TOC: total organic carbon. ( ): filtered samples.

[a]Background is the mean plus one standard deviation for the values listed in Table 2-1. Amounts of uranium, gross alpha, gross beta, and radium given in picocuries per liter. All others are in parts per billion.

[b]Average and maximum values from Table 2.13-4.

2.14 216-B-63 DITCH

Continued use of this ditch during the interim period (1990 through 1995) is expected to have only minimal additional impact on soil and groundwater quality. This is based on modeling and stream designations.

2.14.1 Receiving Site Description

The 216-B-63 Ditch, located in 200 East Area, was constructed in 1970 as a percolation trench to dispose of the B-Plant chemical sewer wastewater. Plant upgrades are planned which will eliminate the use of this disposal ditch. The location of the ditch and spatial relationship to other facilities are shown in Figure 2.14-1.

2.14.2 Effluent Stream Description

B-Plant, constructed in 1943, was used until 1952 for recovery of plutonium using the bismuth phosphate chemical separation process. In 1968, B-Plant began operations in recovery, purification, and encapsulation of cesium and strontium removed from tank wastes. The chemical sewer can receive spills, chemical drains, water flushes, and other effluents from drains in buildings where chemicals are stored and used. It can also receive steam condensate, cooling water, demineralizer regenerate wastes, HVAC unit water, sanitary water, and other effluents from the encapsulation facility and other buildings associated with the operation of B-Plant. Physical barriers and administrative controls have been instituted to mitigate contaminant discharges. Table 2.14-1 summarizes information pertinent to the effluent stream. Table 2.14-2 indicates key constituents from sampling data. Table 2.14-3 provides loading estimates.

The B-Plant chemical sewer effluent operates under three operational modes: the anion exchanger regenerate, the cation exchanger regenerate, and routine operation. The sampling data indicated that the anion exchanger regenerate mode could have acetone and several inorganics exceeding Group A or Group C study guidelines. The metals are likely the normal concentration of ions on the resin which are then released during regeneration. The cation exchanger regeneration mode shows inorganic constituents which exceed Group A study guidelines.

Several radionuclide constituents exceeded Group A study guidelines in the old data set. The new data set showed negligible levels of these constituents.

2.14.3 Flow and Transport Analysis

For the purpose of estimating transport times, the sediment column beneath the ditch is treated as a single layer of sand and gravel with a depth of 64 m (Figure 2.14-2 and Appendix B). The calculated travel time for wastewater to reach the water table under average discharge conditions is 25 days (see Appendix B for data and computations).

Based on general effluent characteristics and corresponding sorption parameters (Appendix C) for the key constituents identified in Table 2.14-1, the calculated migration rates are about 257 cm/day for mobile constituents (acetone, chromium, tritium, fluoride, and sulfate) and from <1 to about 5 cm/day for the more immobile contaminants (Appendix B). Acetone is expected to degrade before reaching groundwater (i.e., a degradation half-time of 10 days as compared to an estimated travel time of 257 days, Appendix B and C).

2.14.4 Groundwater Quality Assessment

Because there were no groundwater monitoring wells in close proximity to the 216-B-63 Ditch (at the time of the study), groundwater quality cannot be evaluated.

2.14.5 Impact of Continued Operation

The average discharge rate to this ditch is less than the recharge from Cold Creek and, therefore, no significant impact beyond the immediate vicinity of the ditch is expected.

Since effluent composition during recent operations (Table 2.14-2) indicates relatively minor quantities of contaminants, environmental degradation due to continued operation is expected to be minimal over the interim period (1990 to 1995). Confirmation would require collection of subsurface sediment samples and groundwater monitoring data. (Four new wells have been installed in compliance with Tri-Party Agreement milestone M-24-08, but were not available for use during the present study.)

Based on the migration rate estimates for the more immobile key constituents, additional soil column movement or previous contaminant loads is expected to be minor.

Figure 2.14-1. Well Location and Site Map for 216-B-63 Ditch.

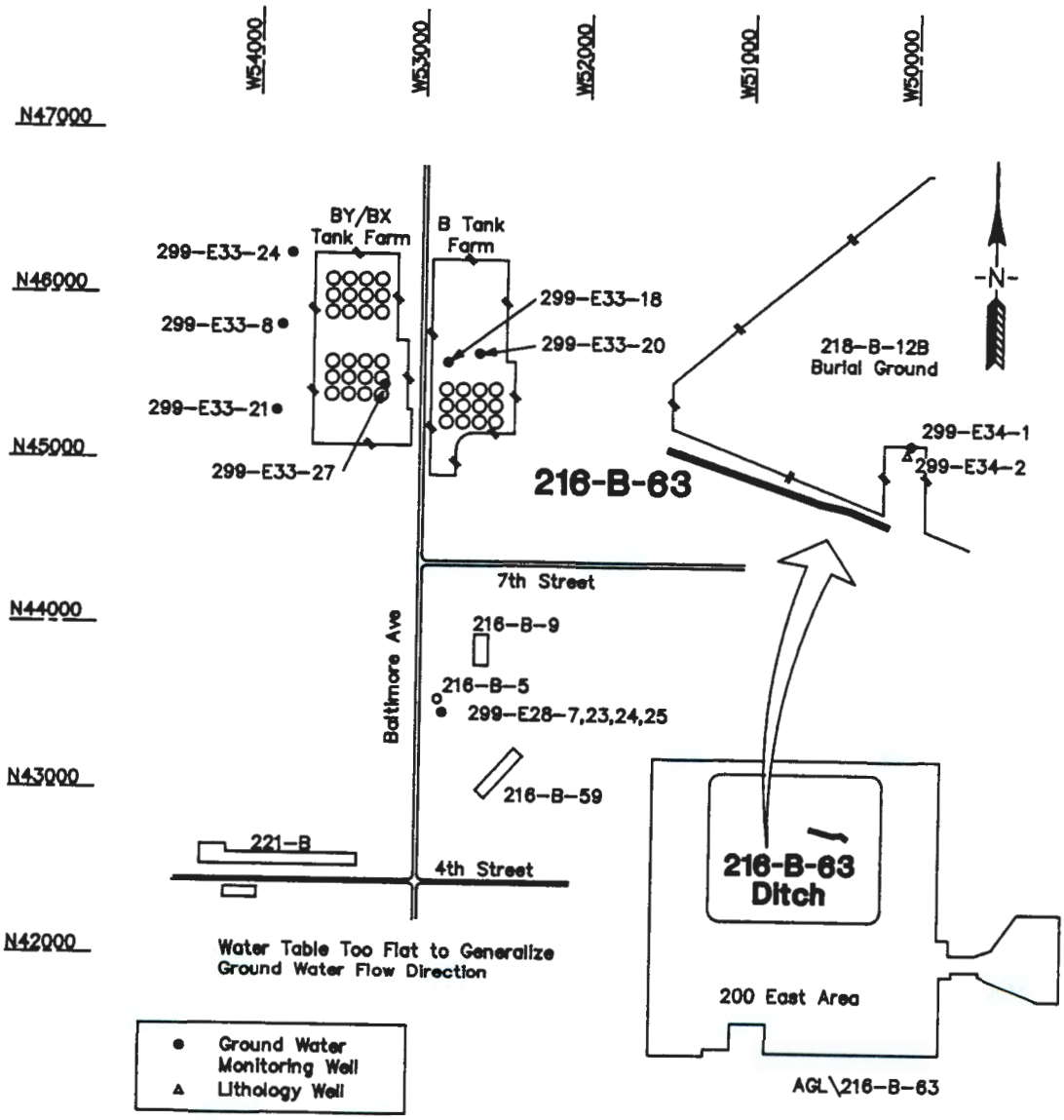


Figure 2.14-2. Lithology of Well 299-E34-2 Near 216-B-63 Ditch.

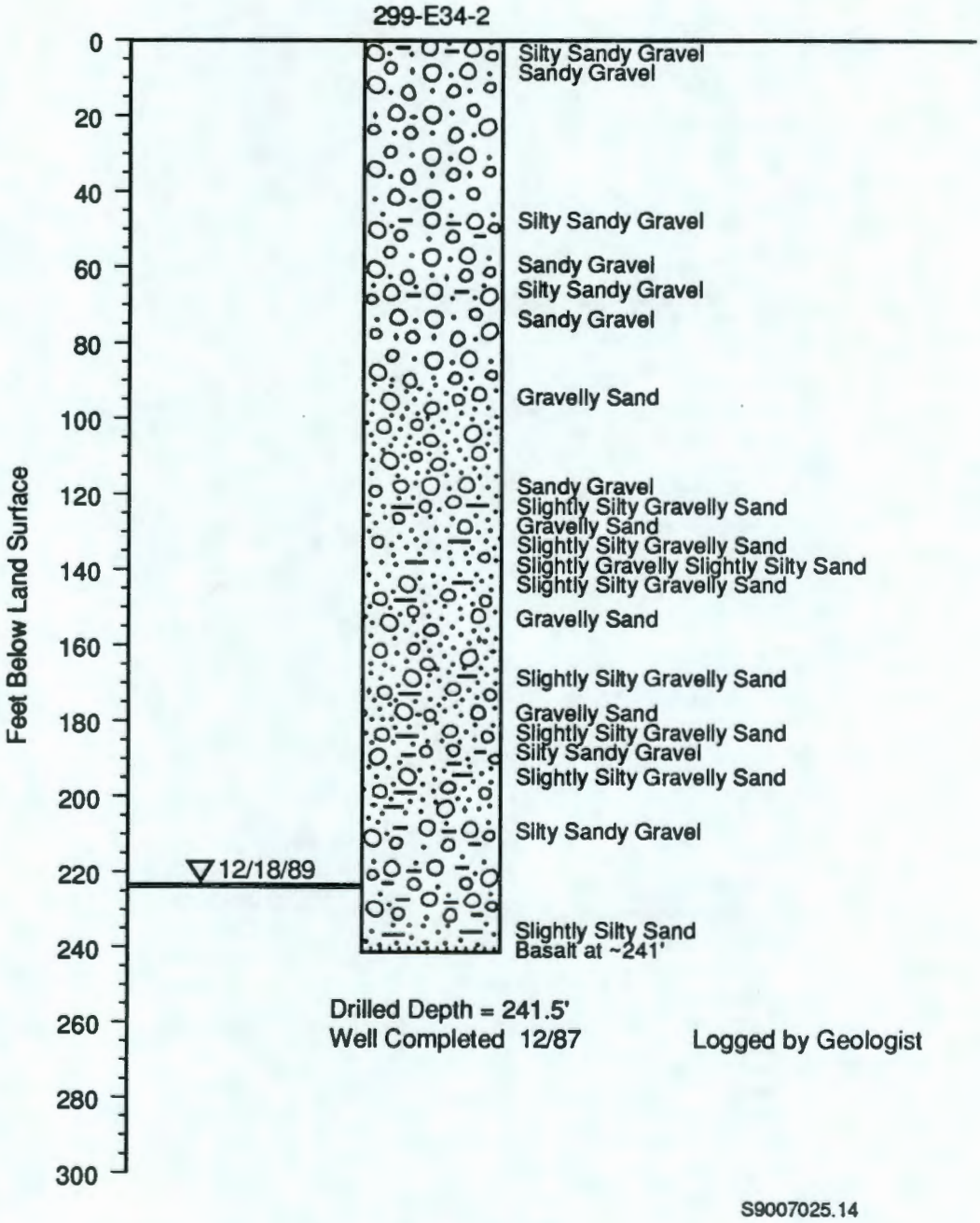


Table 2.14-1. Effluent Stream Description, B-Plant Chemical Sewer.

Total volume of effluent discharged to subject receiving site: (WHC 1989a, WHC-EP-0287, Volume 3)	6.54E+09 L from 3/70 to 12/88
Average effluent discharge rate, by operating mode:	Routine: 2.18E+07 L/mo Ion exchanger regeneration: [a]
Current average effluent discharge rate: (WHC 1990a, WHC-EP-0342, Addendum 6)	Approximately 130 gal/min[b]
Effluent designation (WHC 1990a, WHC-EP-0342, Addendum 6)	Nondangerous, nonradioactive
Effluent status: (WHC 1990a, WHC-EP-0342, Addendum 6)	Active discharge to 216-B-63 Ditch

[a]Ion exchangers are normally regenerated semiannually; regeneration effluent volume is 11,000 gal.

[b]Estimated flow rate during sampling period 10/89 to 3/90.

Table 2.14-2. Effluent Stream Sampling Data, B Plant Chemical Sewer.

Key Constituents	Detection Limit[a]	Detection/ Analyses	Sample Concentration 90% CI[a]	Detection Limit[a]	Detection/ Analyses	Sample Concentration 90% CI[a]
	04/86 to 12/87, During AER			10/89 to 03/90, During AER		
aluminum	NA	4/5	1,600	No Data		
fluoride	50	3/5	28,000			
sulfate	500	4/5	2,100,000			
acetone	10	2/5	84			
chromium	10	4/5	320			
lead	5	3/5	79			
manganese	5	5/5	190			
	09/85 to 10/87, During CER			10/89 to 03/90, During CER		
manganese	5	7/7	77	No Data		
aluminum	NA	6/7	680			
iron	30	7/7	1,500			
mercury	0.1	5/7	4.6			
sulfate	500	6/7	4,000,000			
	06/86 to 04/87, During Routine Operation			10/89 to 03/90, During Routine Operation		
None	None			None		
	1976 to 1988, During All Modes			10/89 to 03/90, During Routine Operation		
strontium-90	30	29/NA	95	0.1	2/3	0.20[b]
americium-241	40	1/NA	70	0.001	ND	ND
cesium-134	NA	1/NA	15,000	NA	ND	ND
cesium-137	80	16/NA	160	1	2/2	3[b]
cobalt-60	NA	1/NA	2,100	NA	ND	ND
uranium (isotopes)[c]	20	3/NA	42	NA	3/3	0.4[b,d]
hydrogen-3	5,000	5/NA	96,000	100	1/3	285[b]
europium-155	NA	1/NA	69,000	NA	ND	ND

[a]Units: chemical--parts per billion
radionuclides--picocurie per liter.

CI: confidence interval.
ND: not detected.
NA: not available.

[b]Concentrations below Group A guidelines; values given for comparison purposes.
[c]Uranium-234 Group A guideline used as the most restrictive for determination of key constituents.
[d]Consists of 0.20 pCi/L uranium-234 and 0.14 pCi/L uranium-238.

Table 2.14-3. Radionuclide and Chemical Loading, B Plant Chemical Sewer.

Flow Rate: 2.18E+07 L/mo

Constituent	Kg/L*	Kg/mo*
barium	2.92E-08	6.36E-01
boron	1.85E-08	4.03E-01
calcium	1.84E-05	4.01E+02
chloride	1.50E-06	3.27E+01
copper	2.12E-08	4.62E-01
fluoride	1.39E-07	3.03E+00
iron	5.32E-08	1.16E+00
magnesium	4.15E-06	9.04E+01
manganese	5.75E-09	1.25E-01
potassium	8.01E-07	1.75E+01
silicon	2.32E-06	5.06E+01
sodium	2.12E-06	4.62E+01
strontium	9.62E-08	2.10E+00
sulfate	1.11E-05	2.42E+02
uranium	4.71E-10	1.03E-02
zinc	1.27E-08	2.77E-01
acetone	1.12E-08	2.44E-01
ammonia	5.52E-08	1.20E+00
unknown amide	2.30E-08	5.01E-01
alpha activity *	5.55E-13	1.21E-05
beta activity *	2.18E-12	4.75E-05
TDS	5.07E-05	1.11E+03
TOC	1.10E-06	2.40E+01
total carbon	1.43E-05	3.12E+02
TOX (as Cl)	4.32E-08	9.42E-01
curium-242 *	4.56E-15	9.94E-08
cesium-137 *	1.11E-12	2.42E-05
carbon-14 *	4.24E-12	9.24E-05
hydrogen-3 *	1.59E-10	3.47E-03
strontium-90 *	1.44E-13	3.14E-06
uranium-234 *	1.60E-13	3.49E-06
uranium-238 *	1.37E-13	2.99E-06

Footnotes:

Data collected from October 1989 through March 1990.

Flow rate is the average of rates from the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 6).

Constituent concentrations are average values from the statistics in the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 6).

Concentration units of flagged (*) constituents are reported as curies per liter.

Loading units of flagged (*) constituents are reported as curies per month.

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2.15 216-C-7 CRIB

Operation of this site has been discontinued. Results of effluent sampling during the last period of operation (1987) indicated no contaminants exceeded study guidelines. There are no monitoring wells at this crib. Transport calculations suggest the time for moisture to travel to the water table is on the order of 140 yr.

2.15.1 Receiving Site Description

The 216-C-7 Crib, located in the 200 East Area, was constructed in 1961 to dispose of low-level radioactive liquid effluents from the 209-E Building Critical Mass Laboratory. Discharge to the crib was discontinued in December 1987. The location of the crib and spatial relationship to other facilities are shown in Figure 2.15-1.

2.15.2 Effluent Stream Description

Water was used as a neutron shield, or reflector, during critical mass laboratory projects. Prior to 1984, operations were conducted in a batch mode, i.e., after each experiment or series of experiments, this water was sampled, analyzed, and then discharged into a holding tank and periodically discharged to the crib. Between 1984 and 1987, the holding tank was no longer used and following sampling and analyses, the reflector tank water was released directly to the 216-C-7 Crib. Table 2.15-1 summarizes information pertaining to the effluent stream. Table 2.15-2 indicates key constituents from sampling data. Table 2.15-3 provides loading estimates. Sampling data for the last period of operation did not indicate any constituents which exceeded study guidelines.

2.15.3 Flow and Transport Analysis

For performing transport computations, the sediment column beneath the crib was treated as a five-layer system totalling 83 m in depth (Figure 2.15-2 and Appendix B). With the low volume of effluent disposed to the crib (1.85E+02 L/mo averaged over the 27 yr of operation for the crib), the estimated time for moisture to travel to the water table is 51,462 days (on the order of 140 yr). Appendix B provides basic data and computational details. Since there were no constituents identified as exceeding study guidelines, no computations were performed in Appendix B for rates of contaminant migration.

2.15.4 Groundwater Quality Assessment

Because there are no groundwater monitoring wells in close proximity to the 216-C-7 Crib, groundwater quality cannot be evaluated with respect to effluent stream constituents at this time.

2.15.5 Impact of Continued Operation

Since operation of the crib has been discontinued, there is no impact of continuing operation.

Figure 2.15-1. Well Location and Site Map for 216-C-7 Crib.

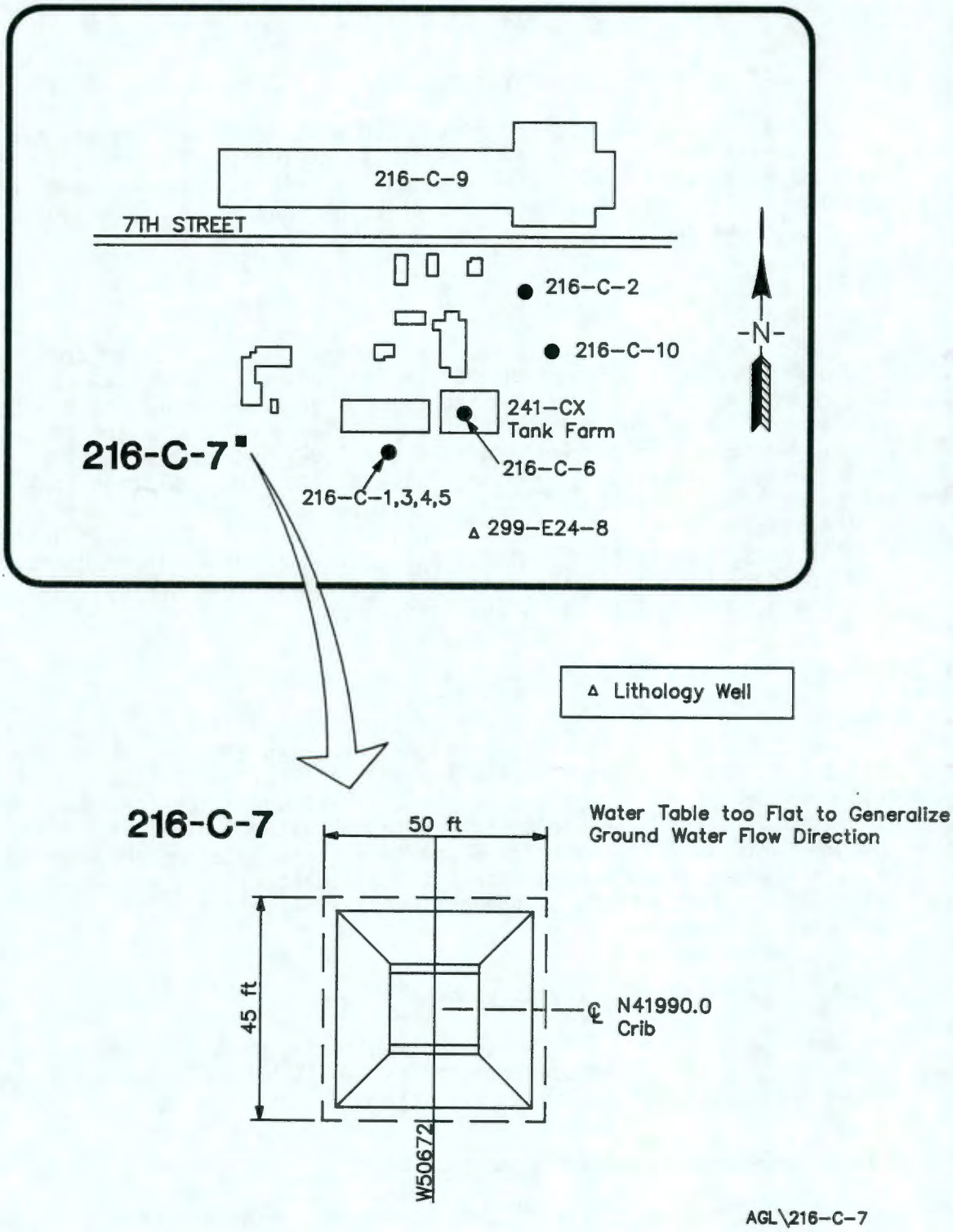

Figure 2.15-2. Lithology of Well 299-E24-8 Near 216-C-7 Crib.

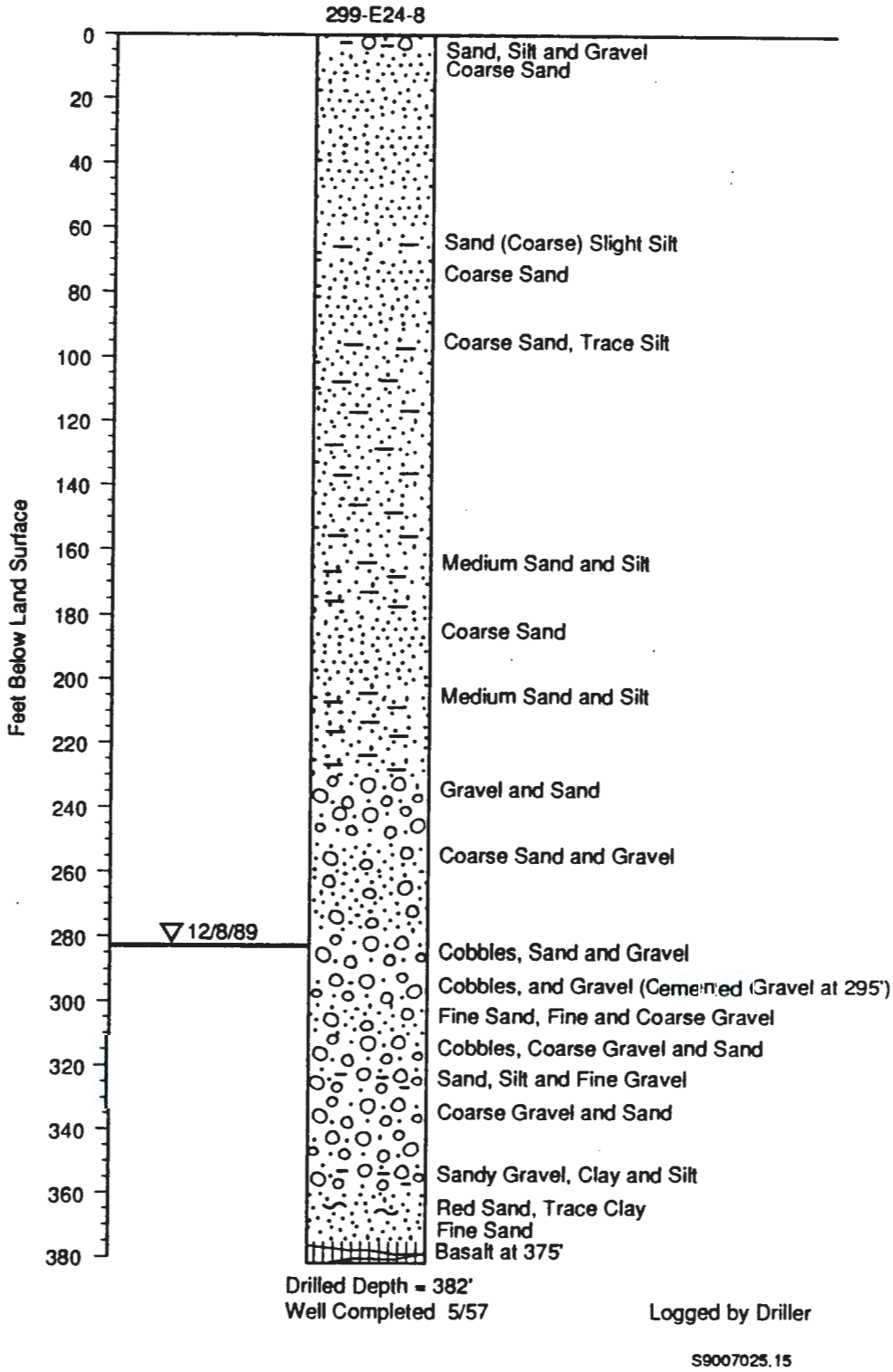

Table 2.15-1. Effluent Stream Description, 209-E Laboratory Reflector Water.

Total volume of effluent discharged to subject receiving site: (WHC 1989a, WHC-EP-0287, Volume 3)	60,100 L from 1961 to 12/83
Maximum effluent discharge rate, by operating mode:	1,210 L/test; maximum 7 discharges/yr[a]
Current average effluent discharge rate: (WHC 1990a, WHC-EP-0342, Addendum 31)	None
Effluent designation: (WHC 1990a, WHC-EP-0342, Addendum 31)	Nondangerous, nonradioactive
Effluent status:	Inactive discharge; operations have been discontinued

[a]Information from plant personnel.

Table 2.15-2. Effluent Stream Sampling Data, 209-E Laboratory Reflector Water.

Key Constituents	Detection Limit[a]	Detection/ Analyses	Sample Concentration 90% CI[a]	Detection Limit[a]	Detection/ Analyses	Sample Concentration 90% CI[a]
	12/87 to 12/87, During Three Routine Samples			10/89 to 03/90, During Inactive Mode		
None	None			No Data		

[a]Units: chemical--parts per billion
radionuclides--picocurie per liter.

CI: confidence interval.

Table 2.15-3. Radionuclide and Chemical Loading, 209-E Laboratory Reflector Water.

Flow Rate: 1.21E+03 L/test

Constituent	Kg/L*	Kg/Test*
barium	3.80E-08	4.60E-05
calcium	1.97E-05	2.39E-02
chloride	1.06E-06	1.28E-03
copper	2.90E-08	3.51E-05
fluoride	1.28E-07	1.55E-04
iron	1.11E-07	1.34E-04
lead	9.00E-09	1.09E-05
magnesium	4.48E-06	5.43E-03
manganese	3.07E-08	3.72E-05
potassium	7.16E-07	8.67E-04
sodium	2.13E-06	2.58E-03
strontium	9.63E-08	1.17E-04
sulfate	1.04E-05	1.26E-02
uranium	6.03E-10	7.30E-07
zinc	1.76E-07	2.13E-04
alpha activity *	7.88E-13	9.54E-10
beta activity *	1.81E-12	2.19E-09
TOC	1.30E-06	1.57E-03

Footnotes:

Data collected during three tests in December 1987.

Flow rate is the average of rates from the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 31).

Constituent concentrations are average values from the statistics in the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 31).

Concentration units of flagged (*) constituents are reported as curies per liter.

Loading units of flagged (*) constituents are reported as curies per test.

2.16 216-S-10 DITCH

Based on effluent composition and flow and transport calculations, continued use of this ditch is judged to have only minimal additional impact on soil and groundwater quality.

2.16.1 Receiving Site Description

The 216-S-10 Ditch, located in 200 West Area, was constructed in 1952 to dispose of liquid effluents from the 202-S Building. The ditch currently receives wastewater from 202-S Buildings and the 2901-S-901 Water Tower. Future plans call for eliminating the 202-S air compressor cooling water discharge to the ditch by 1994 and the overflow from the water tower by 2017. Until that time, discharge rates are not expected to change dramatically. The location of the ditch and spatial relationship to other facilities are shown in Figure 2.16-1.

2.16.2 Effluent Stream Description

The S Plant wastewater consists principally of air compressor cooling water and sanitary water overflow from the water tower. When 202-S was an active Hanford facility, the ditch received discharges from 202-S floor drains, funnels, process vessel cooling water, and chemical sewer lines, drains from the 241-S Tank Farm, station drains in 211-S, and floor drains from the 276-S Building. Table 2.16-1 summarizes information pertaining to the effluent stream. Key constituents from sampling data are indicated in Table 2.16-2. Loading estimates are provided in Table 2.16-3.

The S Plant wastewater exceeded the Group A study guidelines for four radionuclides by small margins. The new data set showed negligible levels of these constituents.

2.16.3 Flow and Transport Analysis

For estimating travel time, the sediment column beneath the ditch was treated as a two-layer system 59 m in depth (Figure 2.16-2 and Appendix B). The computed travel time for wastewater to reach the water table under average conditions is 99 days (see Appendix B for data and computations).

Based on general effluent characteristics and corresponding sorption parameters (Appendix C) for the key constituents identified in Table 2.16-1, the computed migration rates range from 0.2 to 6 cm/day (Appendix B).

2.16.4 Groundwater Quality Assessment

Because there are no groundwater monitoring wells in close proximity to the 216-S-10 Ditch, groundwater quality cannot be evaluated with respect to effluent stream constituents at this time. Six RCRA-compliant monitoring wells were proposed for the facility and three of these have been completed, but not in time to be incorporated in this assessment. During drilling, a perched water zone was encountered in one of the wells at a depth of approximately 38 m below surface grade.

2.16.5 Impact of Continued Operation

The long-term average discharge rate to this trench (2.59E+07 L/mo; Appendix B) is about one-third the natural recharge rate from the Cold Creek/Dry Creek area. The average for the last 5 yr is slightly lower, 1.17E+07 L/mo. While a major impact on the groundwater flow regime is not discernible beyond the immediate vicinity of the discharge site, the volume disposed to the ditch is larger in comparison to most of the other liquid discharge sites. Because of the relatively large volume of wastewater and the presence of a well-defined caliche and/or fine sedimentary layer located approximately 38 m beneath this site, the potential exists for a perched water zone, as found in one of the recent monitoring wells constructed.

Based on wastestream characteristics discussed previously, it is not likely that groundwater quality has been adversely impacted at this site. Sampling and analysis of monitoring wells recently completed will provide confirmation.

Based on the modest radioactive and chemical loading at this site and retention characteristics of key constituents, remobilization of soil column contaminants is judged not to be a significant issue at this site.

Figure 2.16-1. Well Location and Site Map for 216-S-10 Ditch.

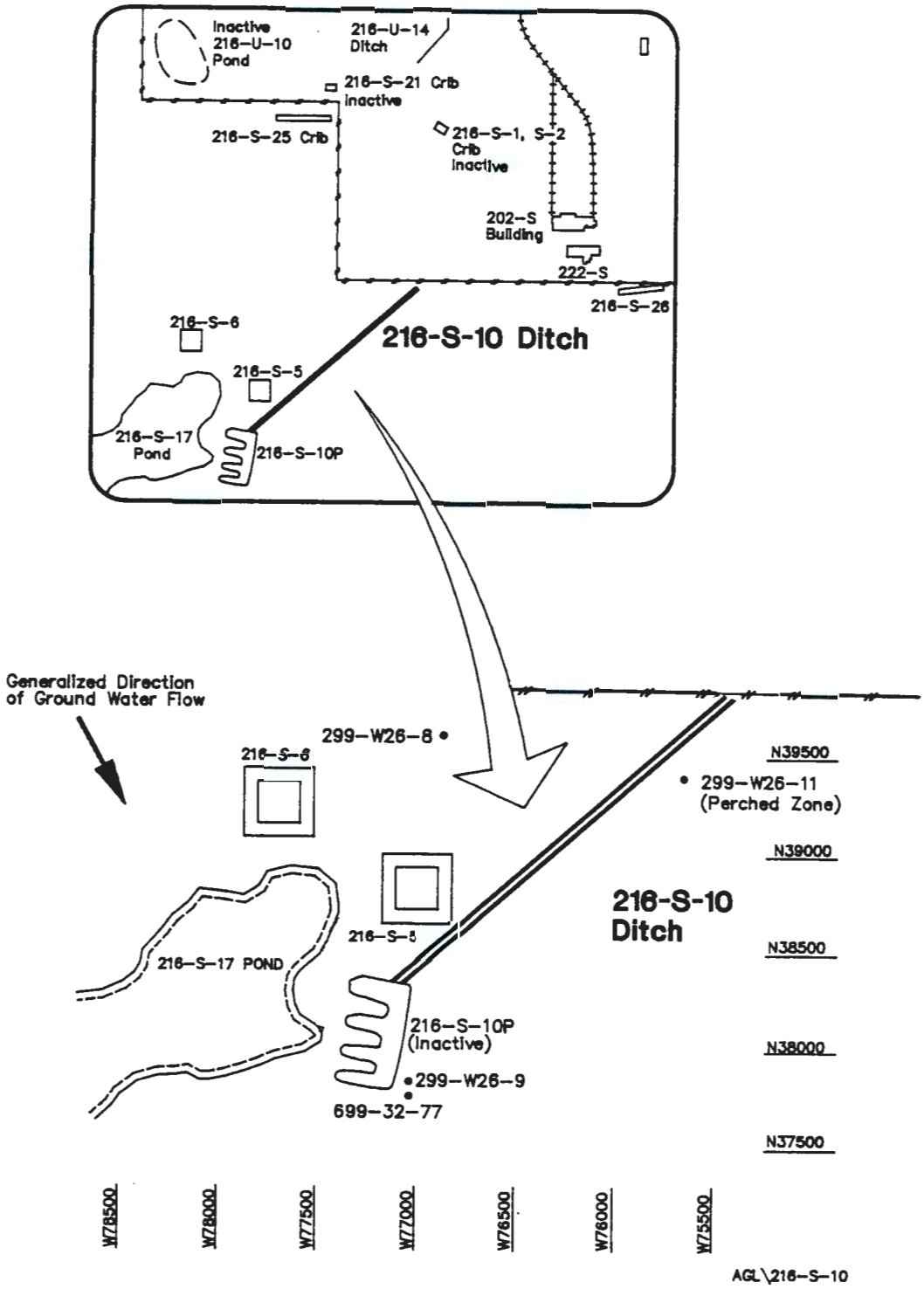

Figure 2.16-2. Lithology of Well 299-W26-8 Near 216-S-10 Ditch.

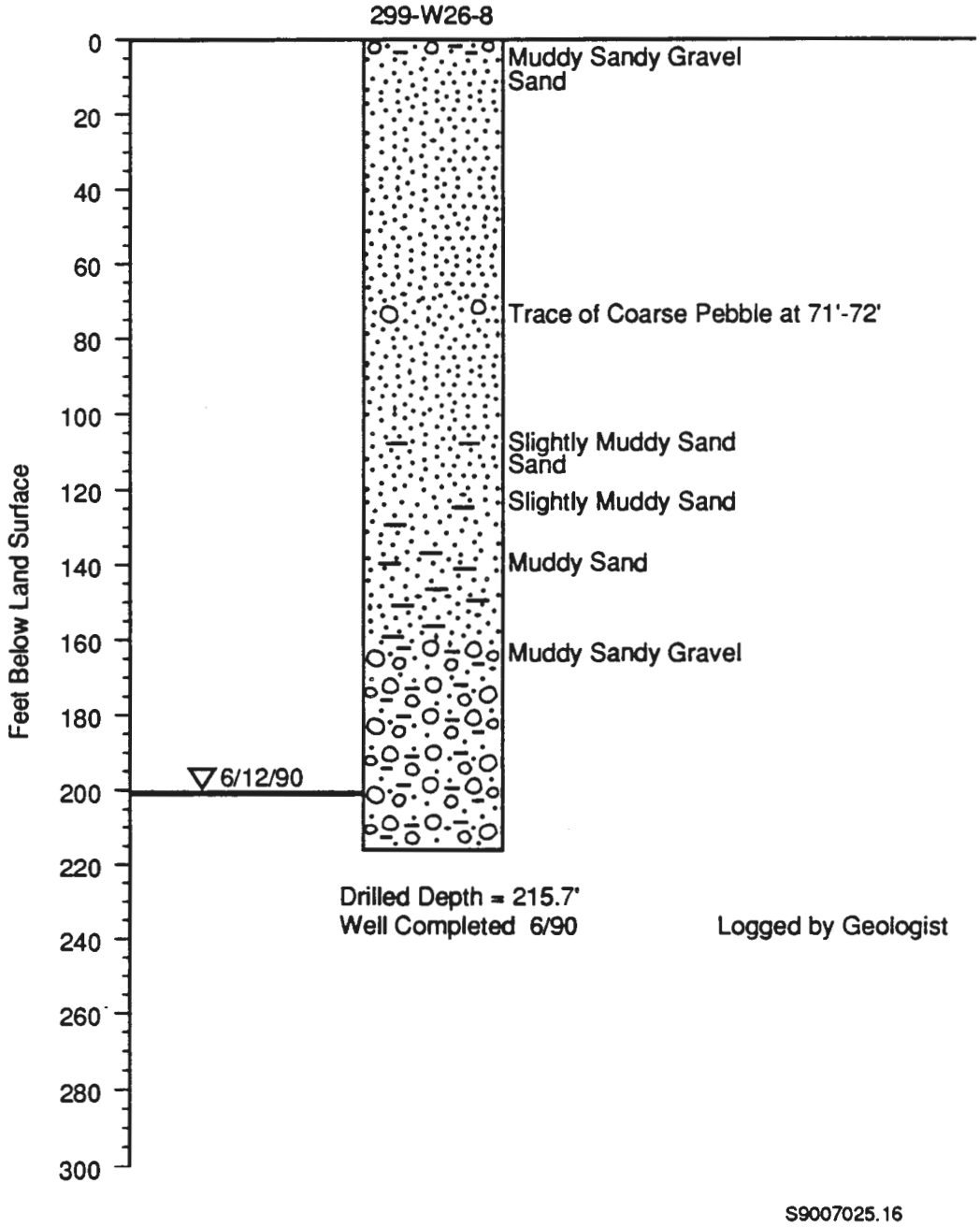

Table 2.16-1. Effluent Stream Description, S Plant Wastewater.

Total volume of effluent discharged to subject receiving site: (RHO 1979, RHO-CD-798; WHC 1990a, WHC-EP-0342, Addendum 9)	8.58E+09 L from 2/54 to 12/88
Average effluent discharge rate, by operating mode: (WHC 1990a, WHC-EP-0342, Addendum 9)	4.03E+07 L/mo[a]
Current average effluent discharge rate: (WHC 1990a, WHC-EP-0342, Addendum 9)	4.03E+07 L/mo[a]
Effluent designation (WHC 1990a, WHC-EP-0342, Addendum 9)	Nondangerous, nonradioactive
Effluent status:	Active discharge to 216-S-10 Ditch

[a]Average during sampling period 10/89 to 3/90.

Table 2.16-2. Effluent Stream Sampling Data, S-Plant Wastewater.

Key Constituents	Detection Limit[a]	Detection/ Analyses	Sample Concentration 90% CI[a]	Detection Limit[a]	Detection/ Analyses	Sample Concentration 90% CI[a]
	1976 to 1988, During Routine Operation			10/89 to 03/90, During Routine Operation		
cesium-137	80	11/NA	340	1	ND	ND
strontium-90	30	7/NA	53	0.1	1/3	0.3[b]
uranium (isotopes)[c]	20	4/NA	38	NA	3/3	0.4[b,d]
plutonium-239	50	20/NA	2.2	0.001	1/2	0.008[b]

[a]Units: chemical--parts per billion
radionuclides--picocurie per liter.

[b]Concentrations below Group A guidelines; values given for comparison purposes.
[c]Uranium-234 Group A guideline used as the most restrictive for determination of key constituents.
[d]Consists of 0.22 pCi/L uranium-234 and 0.03 pCi/L uranium-235 and 0.17 pCi/L uranium-238.

CI: confidence interval.
ND: not detected.
NA: not available.

Table 2.16-3. Radionuclide and Chemical Loading, S Plant Wastewater.

Flow Rate: 4.03E+07 L/mo

Constituent	Kg/L*	Kg/mo*
barium	2.92E-08	1.18E+00
boron	1.25E-08	5.04E-01
calcium	1.84E-05	7.42E+02
chloride	1.37E-06	5.52E+01
fluoride	1.26E-07	5.08E+00
iron	3.30E-08	1.33E+00
magnesium	4.30E-06	1.73E+02
manganese	5.25E-09	2.12E-01
nitrate	5.00E-07	2.02E+01
potassium	7.32E-07	2.95E+01
silicon	2.22E-06	8.95E+01
sodium	2.05E-06	8.26E+01
strontium	9.15E-08	3.69E+00
sulfate	1.08E-05	4.35E+02
uranium	5.23E-10	2.11E-02
zinc	6.00E-09	2.42E-01
butylated hydroxy tolue	8.00E-09	3.22E-01
trichloromethane	6.25E-09	2.52E-01
TDS	7.57E-05	3.05E+03
TOC	1.00E-06	4.03E+01
total carbon	1.44E-05	5.80E+02
TOX (as Cl)	5.25E-08	2.12E+00
americium-241 *	1.16E-14	4.68E-07
cobalt-60 *	9.37E-13	3.78E-05
plutonium-239/240 *	2.92E-15	1.18E-07
strontium-90 *	2.26E-13	9.11E-06
uranium-234 *	1.88E-13	7.58E-06
uranium-235 *	7.99E-15	3.22E-07
uranium-238 *	1.43E-13	5.76E-06

Footnotes:

Data collected from October 1989 through March 1990.

Flow rate is the average of rates from the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 9).

Constituent concentrations are average values from the statistics in the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 9).

Concentration units of flagged (*) constituents are reported as curies per liter.

Loading units of flagged (*) constituents are reported as curies per month.

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2.17 216-S-26 CRIB

No adverse impacts on soil and groundwater quality were identified at this site and no significant additional impact to the subsurface environment is expected from continued operation during the interim (1990 through 1995).

2.17.1 Disposal Site Description

The 216-S-26 Crib, located outside the 200 West Area, was constructed in 1984 to receive wastewater from the 222-S Laboratory facilities. Monitoring well location and spatial relationship to other facilities are shown in Figure 2.17-1.

2.17.2 Effluent Stream Description

The 222-S Laboratory provides analytical services to the 200 Area operations. Radioactive samples are handled in the laboratory. Wastewater sources include drains from laboratory sinks, hood drains, drinking water fountains, service sinks, bathroom sinks, distilled water supplies, equipment cooling water, and steam condensate. Table 2.17-1 summarizes information pertaining to 222-S Laboratory effluent stream. Table 2.17-2 provides effluent stream sampling data for key constituents. Radionuclide and chemical loading information is provided in Table 2.17-3.

The 222-S Laboratory wastewater contained aluminum which was above the Group A study guideline. The old data showed several radionuclides which exceeded Group A study guidelines. The new data set showed only americium-241 to be above Group A study guidelines. Note that the crib was placed in service in 1984, but the old data set includes samples taken prior to 1984.

2.17.3 Flow and Transport Analysis

For transport calculation purposes, the sediment column beneath the crib (Figure 2.17-2) is treated as a two-layer system of 60 m depth. The calculated travel time for wastewater to reach the water table under average discharge conditions is 168 days.

Based on general effluent characteristics and corresponding sorption parameters (Appendix C), the calculated migration rates are about 0.04 to 3.6 cm/day for the key constituents. Long travel times for the key constituents (Appendix B) indicate only minor additional movement should occur with continued interim use of the ditch.

2.17.4 Groundwater Quality Assessment

Nitrate and selenium are the only constituents exceeding Group A study guidelines (Table 2.17-4), neither of which were ever identified as wastestream related contaminants. The elevated levels of nitrate (and perhaps selenium) are attributed to previous disposal activities in the 200 West Area. For example, Figures 2.17-3 and 2.17-4 illustrate a general

decline in levels of tritium and nitrate believed to be due to movement of upgradient sources of residual contaminants from past disposal activities in the 200 West Area (Serkowski and Jordan 1989 and Evans et al. 1990, Figures 2-14, 2-17, and 2-32).

Selenium is the only signficant above-background (Group B guidelines) occurrence in Table 2.17-5. Since there are two positive results (35 and 33 ppb, respectively) which are five times higher than the detection limit, this result is judged to be real. No explanation is readily apparent.

There were no significant occurrences of key constituents in groundwater at this site. However, uranium was detected at a concentration slightly above natural background (Group B guidelines) which may indicate soil column breakthrough from past disposal activities.

2.17.5 Impact of Continued Operation

Based on current (and historical) discharge rates to this crib, impact on the local groundwater flow regime should be negligible.

No signficant impact on groundwater quality from this facility is indicated by the groundwater characterization data (Table 2.17-4). Assuming similar wastewater composition in the future, no adverse impact on groundwater quality due to continued interim use of this crib is expected.

Based on the minor chemical and radiological loading to the soil column beneath the 216-S-26 Crib, and contaminant retention and transport characteristics (Section 2.17.3), remobilization is a minor consideration for disposal site.

Figure 2.17-1. Well Location and Site Map for 216-S-26 Crib.

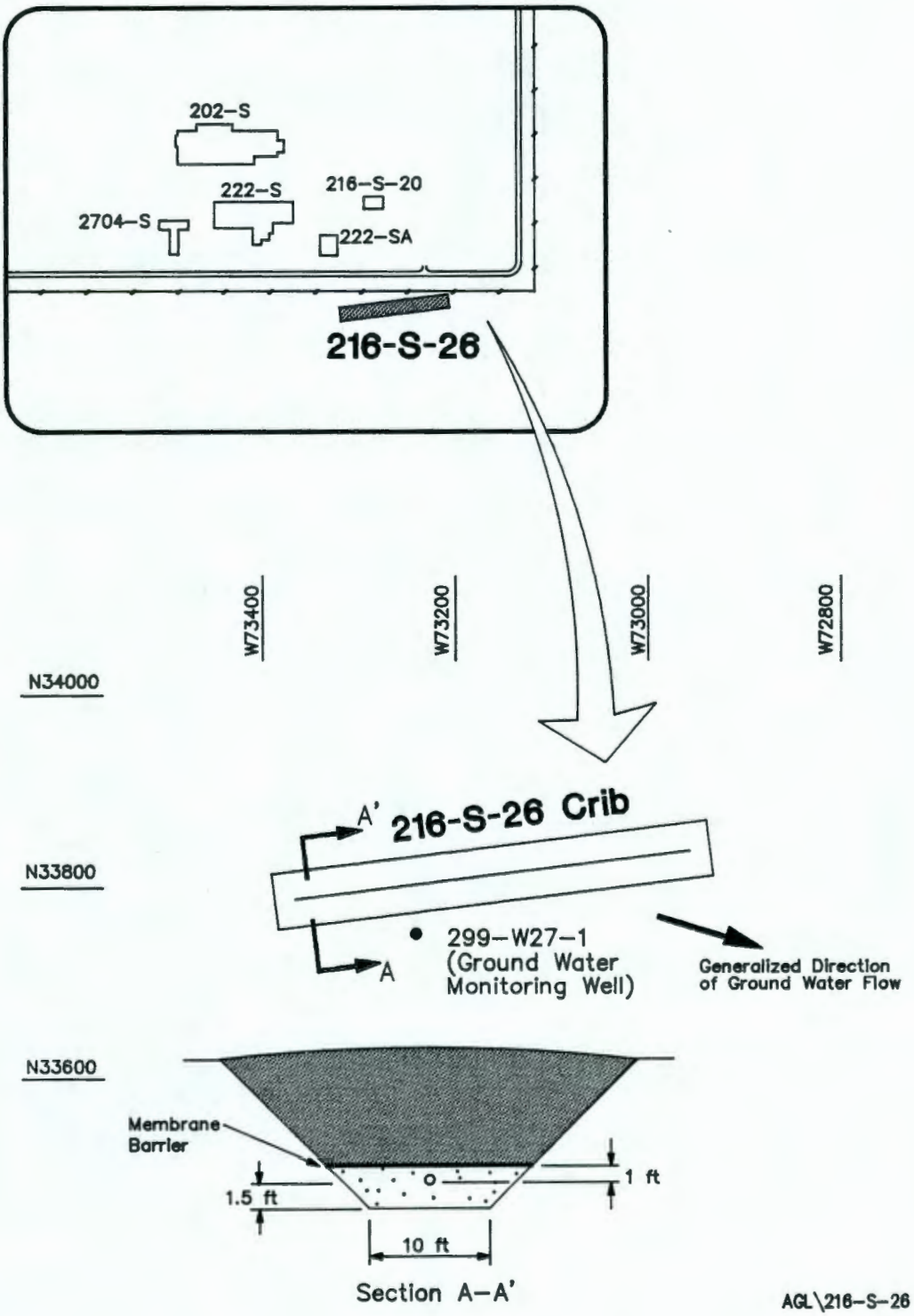

Figure 2.17-2. Lithology of Well 299-W27-1 at 216-S-26 Crib.

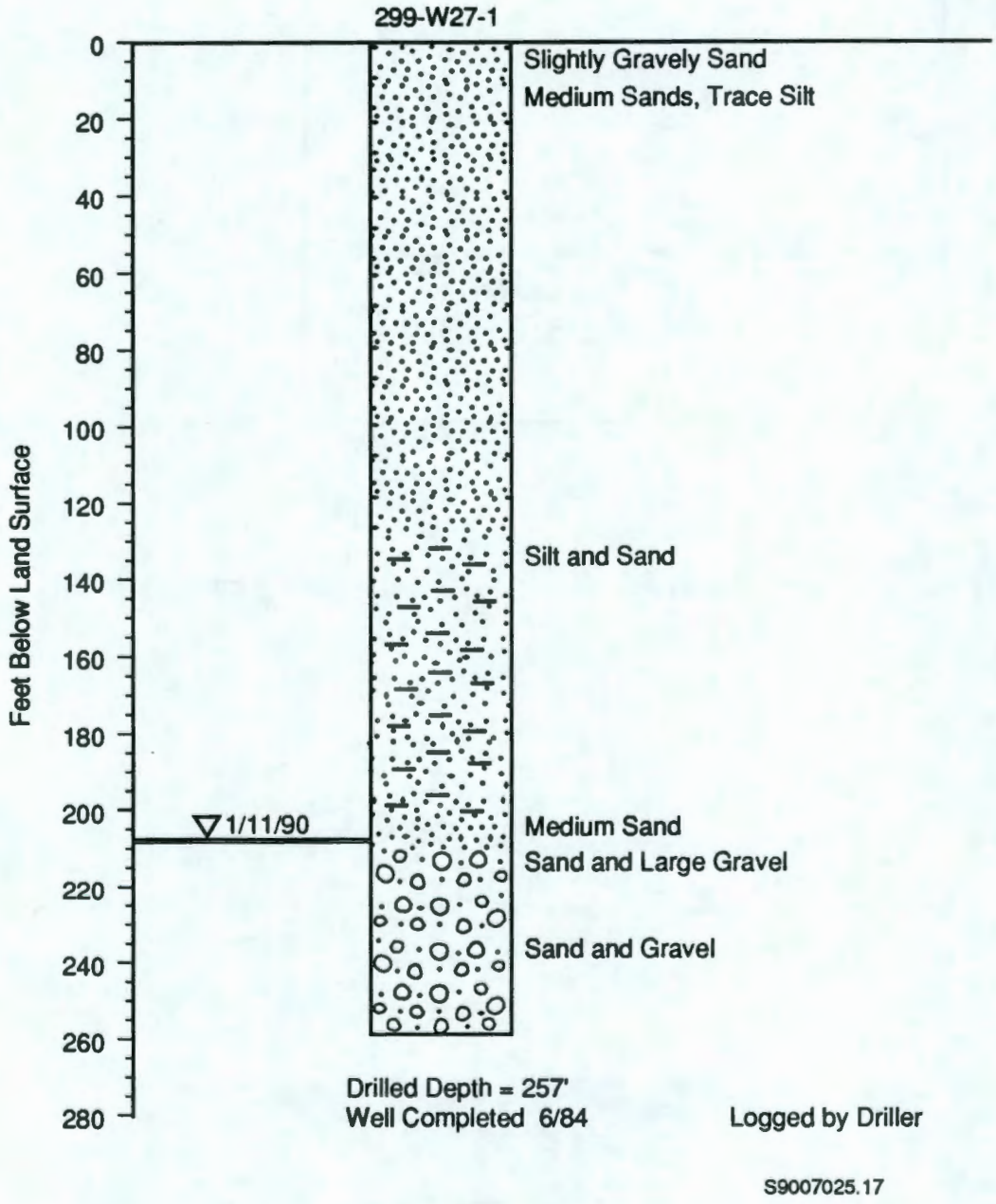

Figure 2.17-3. Time Response Plot of Nitrate at the 216-S-26 Crib.

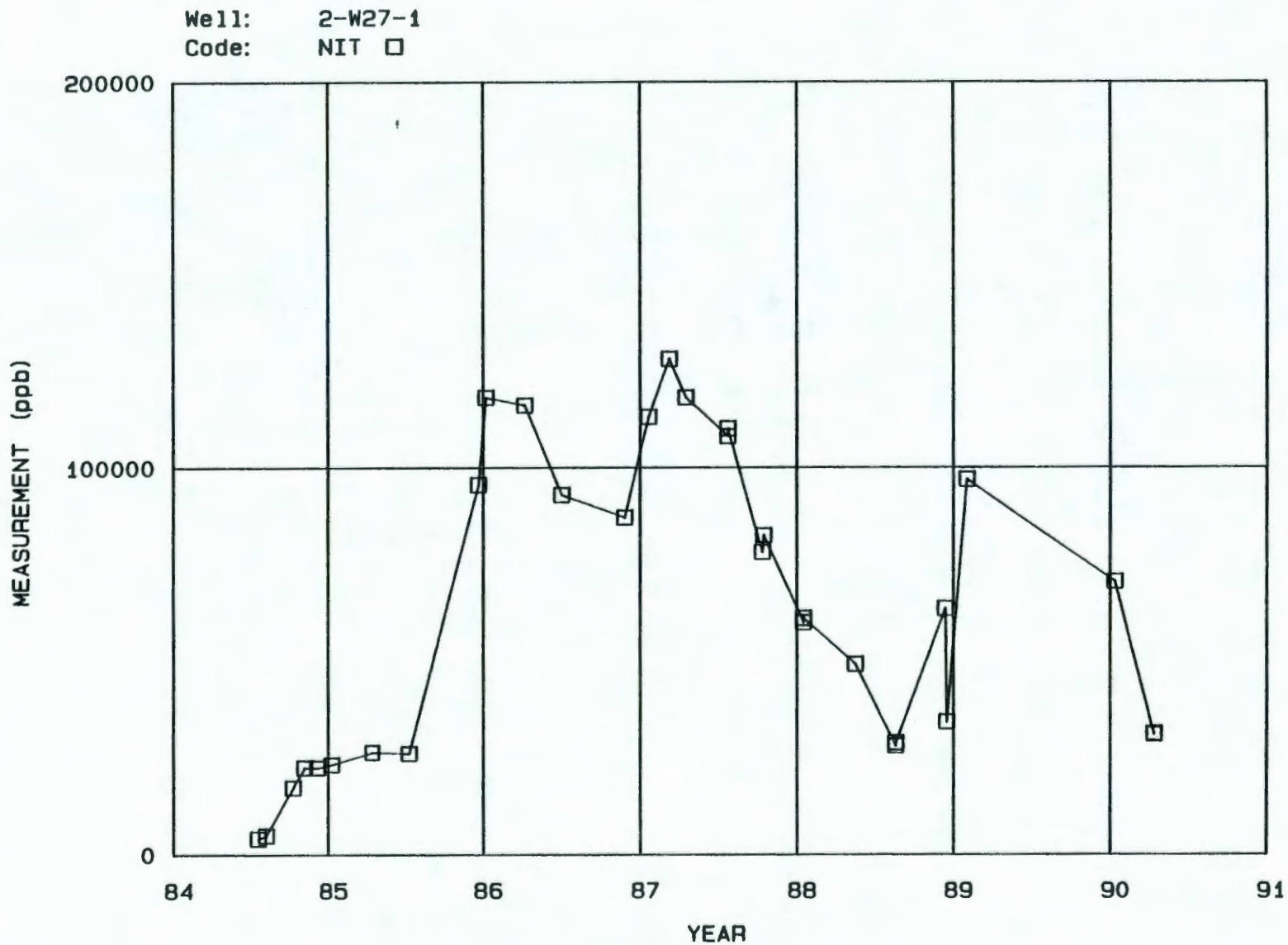

Figure 2.17-4. Time Response Plot of Tritium at the 216-S-26 Crib.

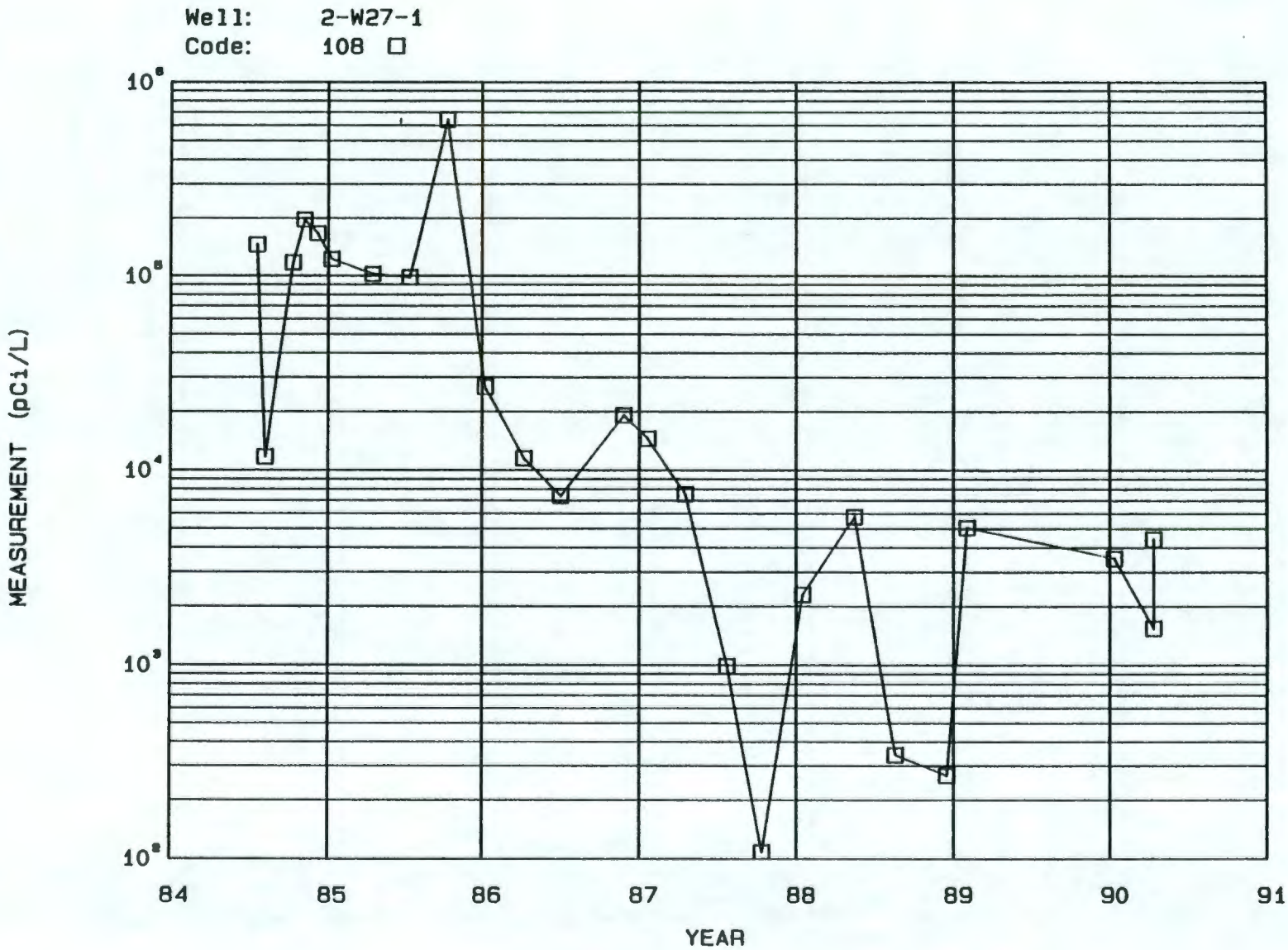

Table 2.17-1. Effluent Stream Description, 222-S Laboratory Wastewater.

Total volume of effluent discharged to subject receiving site: (Coony and Thomas 1989, WHC-EP-0141-1)	1.51E+08 L from 10/84 to 12/88
Average effluent discharge rate, by operating mode: (WHC 1990a, WHC-EP-0342, Addendum 13)	2.34E+06 L/mo
Current average effluent discharge rate: (WHC 1990a, WHC-EP-0342, Addendum 13)	2.34E+06 L/mo
Effluent designation: (WHC 1990a, WHC-EP-0342, Addendum 13)	Nondangerous, radioactive
Effluent status:	Active discharge to 216-S-26 Crib

Table 2-17-2. Effluent Stream Sampling Data, 222-S Laboratory Wastewater.

Key Constituents	Detection Limit[a]	Detection/ Analyses	Sample Concentration 90% CI[a]	Detection Limit[a]	Detection/ Analyses	Sample Concentration 90% CI[a]
	09/85 to 04/89, During Routine Operation			10/89 to 03/90, During Routine Operation		
aluminum	NA	2/17	330	NA	ND	ND
	1976 to 1988, During Routine Operation[e]			10/89 to 03/90, During Routine Operation		
americium-241	40	1/NA	63	NA	4/4	2
cobalt-60	NA	1/NA	280	1	ND	ND
cesium-137	80	18/NA	360	1	ND	ND
manganese-54	NA	1/NA	1,900	NA	ND	ND
strontium-90	30	17/NA	82	0.1	1/4	0.2[b]
uranium (isotopes)[c]	NA	4/NA	670	NA	4/4	0.267[b,d]

[a]Units: chemical--parts per billion
radionuclides--picocurie per liter.
[b]Concentrations below Group A guidelines; values given for comparison purposes.
[c]Uranium-234 Group A guideline used as the most restrictive for determination of key constituents.
[d]Consists of 0.14 pCi/L uranium-234 and 0.13 pCi/L uranium-238.
[e]Disposal of effluent to the 216-S-26 Crib began in 1984; thus, this data set includes some samples taken prior to 1984.

CI: confidence interval.

Table 2.17-3. Radionuclide and Chemical Loading, 222-S Laboratory Wastewater.

Flow Rate: 2.34E+06 L/mo

Constituent	Kg/L*	Kg/mo*
barium	2.82E-08	6.60E-02
boron	1.65E-08	3.86E-02
calcium	1.69E-05	3.95E+01
chloride	3.70E-06	8.66E+00
copper	1.52E-07	3.56E-01
fluoride	1.25E-07	2.92E-01
iron	1.26E-07	2.95E-01
magnesium	3.94E-06	9.22E+00
manganese	7.25E-09	1.70E-02
nitrate	5.75E-07	1.35E+00
potassium	7.64E-07	1.79E+00
silicon	1.95E-06	4.56E+00
sodium	2.13E-06	4.98E+00
strontium	9.15E-08	2.14E-01
sulfate	1.31E-05	3.07E+01
uranium	5.24E-10	1.23E-03
vanadium	5.50E-09	1.29E-02
zinc	1.52E-08	3.56E-02
acetone	1.02E-08	2.39E-02
ammonia	6.72E-08	1.57E-01
trichloromethane	1.97E-08	4.61E-02
unknown amide	2.60E-08	6.08E-02
alpha activity *	2.00E-12	4.68E-06
beta activity *	2.60E-12	6.08E-06
suspended solids	9.25E-06	2.16E+01
TDS	5.82E-05	1.36E+02
TOC	1.05E-06	2.46E+00
total carbon	1.25E-05	2.92E+01
TOX (as Cl)	1.14E-07	2.67E-01
americium-241 *	7.86E-13	1.84E-06
carbon-14 *	2.61E-12	6.11E-06
hydrogen-3 *	1.75E-10	4.09E-04
plutonium-238 *	1.61E-14	3.77E-08
plutonium-239/240 *	2.21E-13	5.17E-07
radium total *	9.45E-14	2.21E-07
strontium-90 *	1.24E-13	2.90E-07
uranium-234 *	1.05E-13	2.46E-07
uranium-238 *	1.02E-13	2.39E-07

Footnotes:

Data collected from October 1989 through March 1990.

Flow rate is the average of rates from the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 13).

Constituent concentrations are average values from the statistics in the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 13).

Concentration units of flagged (*) constituents are reported as curies per liter.

Table 2.17-4. Effluent Study Groundwater Summary Report. (Page 1 of 2)

CONSTITUENT			ANALYSIS SUMMARY					GROUP A STUDY GUIDELINES	
Group Name	Units	Detection Limit	Number of Analyses	Number > Det.	Average Result	Maximum Result	Minimum Result	Max Limit	Number > Limit
CONTAMINATION INDICATOR PARAMETERS									
Conductivity, Laboratory	UMHO	1.00	2	2	493.00	544.00	442.00	700.0	0
Specific conductance	UMHO	1.00	1	1	501.00	501.00	501.00	700.0	0
Total Organic Halogen, Low Det. Level	PPB	10.00	2	2	11.00	12.00	10.00		0
pH, Field Measurement		.10	1	1	7.90	7.90	7.90	8.5	0
pH, Laboratory Measurement		.01	2	2	7.85	7.90	7.80	8.5	0
DRINKING WATER PARAMETERS									
Alpha, High Detection Level	PCI/L	4.00	3	3	5.97	7.21	4.40	15.0	0
Barium	PPB	6.00	1	1	40.00	40.00	40.00	1000.0	0
Barium, filtered	PPB	6.00	3	3	32.00	40.00	27.00	1000.0	0
Chromium	PPB	10.00	1	1	13.00	13.00	13.00	50.0	0
Chromium, filtered	PPB	10.00	3	2	11.00	12.00	10.00	50.0	0
Gross alpha	PCI/L	4.00	1	1	5.90	5.90	5.90	15.0	0
Nitrate	PPB	500.00	3	3	44333.33	70500.00	31100.00	45000.0	1
Nitrate, High Detection Level	PPB	2500.00	1	1	96900.00	96900.00	96900.00	45000.0	1
Selenium	PPB	5.00	1	1	35.00	35.00	35.00	10.0	1
Selenium, filtered	PPB	5.00	1	1	33.00	33.00	33.00	10.0	1
GROUNDWATER QUALITY PARAMETERS									
Chloride	PPB	500.00	2	2	7800.00	9700.00	5900.00	250000.0	0
Iron	PPB	30.00	1	1	177.00	177.00	177.00	300.0	0
Iron, filtered	PPB	30.00	3	1	102.67	248.00	30.00	300.0	0
Manganese, filtered	PPB	5.00	3	1	5.33	6.00	5.00	50.0	0
Sodium	PPB	200.00	1	1	34800.00	34800.00	34800.00		0
Sodium, filtered	PPB	200.00	3	3	32433.33	35100.00	30500.00		0
Sulfate	PPB	500.00	3	3	43800.00	58700.00	36100.00	250000.0	0
SITE SPECIFIC AND OTHER PARAMETERS									
Boron	PPB	10.00	1	1	30.00	30.00	30.00		0
Boron, filtered	PPB	10.00	3	3	34.33	37.00	32.00		0
Calcium	PPB	50.00	1	1	49800.00	49800.00	49800.00		0
Calcium, filtered	PPB	50.00	3	3	42300.00	50600.00	37100.00		0

Table 2.17-4. Effluent Study Groundwater Summary Report. (Page 2 of 2)

CONSTITUENT			ANALYSIS SUMMARY					GROUP A STUDY GUIDELINES	
Group Name	Units	Detection Limit	Number of Analyses	Number > Det.	Average Result	Maximum Result	Minimum Result	Max Limit	Number > Limit
SITE SPECIFIC AND OTHER PARAMETERS									
Chloroform	PPB	5.00	2	2	10.00	14.00	6.00	100.0	0
Magnesium	PPB	50.00	1	1	13100.00	13100.00	13100.00		0
Magnesium, filtered	PPB	50.00	3	3	10963.33	13400.00	9390.00		0
Natural uranium	UG/L	.73	1	1	11.40	11.40	11.40	59.0	0
Potassium	PPB	100.00	1	1	6010.00	6010.00	6010.00		0
Potassium, filtered	PPB	100.00	3	3	5556.67	6140.00	5170.00		0
Silicon	PPB	50.00	1	1	14300.00	14300.00	14300.00		0
Silicon, filtered	PPB	50.00	3	3	14066.67	14400.00	13800.00		0
Strontium	PPB	10.00	1	1	264.00	264.00	264.00		0
Strontium, filtered	PPB	10.00	3	3	217.67	263.00	188.00		0
Total carbon	PPB	1000.00	1	1	32200.00	32200.00	32200.00		0
Tritium	PCI/L	500.00	2	2	4280.00	5050.00	3510.00	80000.0	0
Turbidity	NTU	.10	1	1	.80	.80	.80	5.0	0
Uranium	PCI/L	.50	1	1	5.55	5.55	5.55	40.0	0
Uranium-234	PCI/L	.10	1	1	3.75	3.75	3.75	20.0	0
Uranium-235	PCI/L	.10	1	1	.13	.13	.13	24.0	0
Uranium-238	PCI/L	.10	1	1	3.13	3.13	3.13	24.0	0
Vanadium	PPB	5.00	1	1	19.00	19.00	19.00		0
Vanadium, filtered	PPB	5.00	3	3	18.00	20.00	16.00		0
Zinc	PPB	5.00	1	1	31.00	31.00	31.00	5000.0	0
Zinc, filtered	PPB	5.00	2	2	28.50	30.00	27.00	5000.0	0

Table 2.17-5. Background Comparison, 216-S-26 Crib.

Constituent	Background[a]	Average/ Background[b]	Maximum/ Background[b]
aluminum	2.0		
ammonia	50.0		
arsenic	6.3		
barium	62.0		
beryllium	0.3		
bismuth	0.02		
boron	50.0	0.60 (0.69)	0.60 (0.74)
cadmium	0.2		
calcium	50,700	0.98 (0.83)	0.98 (1.00)
chloride	16,800	0.43	0.58
chromium	6.0	2.17 (1.83)	2.17 (2.00)
copper	1.0		
cyanide	10.0		
fluoride	470		
lead	0.5		
magnesium	15,200	0.86 (0.72)	0.86 (0.88)
manganese	12.0		
mercury	0.1		
nickel	4.0		
phosphate	1,000		
potassium	6,190	0.97 (0.90)	0.97 (0.99)
selenium	2.0	17.50 (16.50)	17.50 (16.50)
silver	10		
sodium	28,410	1.22 (1.14)	1.22 (1.24)
strontium	338	0.78 (0.64)	0.78 (0.78)
sulfate	51,200	0.86	1.15
uranium	2.5		
vanadium	26		
zinc	8.0		
alkalinity	144,000		
pH	7.8	1.01	1.01
TOC	933		
conductivity	462	1.08	1.08
gross alpha	3.9	1.51	1.51
gross beta	31		
radium	0.2		

TOC: total organic carbon. ( ): filtered samples.

[a]Background is the mean plus one standard deviation for the values listed in Table 2-1. Amounts of uranium, gross alpha, gross beta, and radium given in picocuries per liter. All others are in parts per billion.

[b]Average and maximum values from Table 2.17-4.

2.18 216-T-1 DITCH

Three metals in the effluent disposed to this facility exceeded the Group A study guidelines. There are no monitoring wells at this ditch. However, on the basis of transport modeling, continued operation is judged to have only minimal impact on soil and groundwater quality.

2.18.1 Receiving Site Description

The 216-T-1 Ditch, located in 200 West Area, was constructed in 1944 to dispose of low-level radioactive liquid effluents from the head end of T Plant. Figure 2.18-1 shows the location of the ditch relative to other facilities in the vicinity.

2.18.2 Effluent Stream Description

The T Plant headend was used from 1945 to 1956 for fuel dissolution as part of spent fuel reprocessing. Discharges included steam condensate and cooling water. After fuel reprocessing operations were terminated, the T Plant headend was converted to a containment systems test facility. This test facility, which is referred to as the T Plant Laboratory, was operated from 1964 to 1990. No operations are scheduled after FY 1990, although some wastewater from the ventilation system and floor washdown may continue to be discharged to the 216-T-1 Ditch.

The liquid effluent stream disposed to the 216-T-1 Ditch is produced by facility drains, cooling systems, and steam condensate associated with laboratory activities and routine plant HVAC condensate. There are two operating modes associated with sampling: T Plant Laboratory routine (plasma torch operations) and standby (plasma torch standby). Table 2.18-2 summarizes information pertaining to the effluent stream. Key constituents from sampling data are indicated in Table 2.18-2. Loading estimates are provided in Table 2.18-3.

The sampling data indicate several metals as constituents exceeding Group A study guidelines.

2.18.3 Flow and Transport Analysis

For performing transport calculations, the sediment column beneath the ditch is treated as a four-layer system of 73 m depth (Figure 2.18-2 and Appendix B). The travel time for the wastewater to reach the water table under average conditions is estimated to be 607 days (see Appendix B for data and computations).

Based on general effluent characteristics and corresponding sorption parameters (Appendix C) for the key constituents identified in Table 2.18-2, the computed rates of contaminant migration range from 0.05 to 0.12 cm/day for relatively immobile constituents manganese, lead, iron, and aluminum. Very little downward migration is expected for these constituents (Appendix B).

2.18.4 Groundwater Quality Assessment

Because there are no groundwater monitoring wells in close proximity to the 216-T-1 Ditch, groundwater quality cannot be evaluated with respect to effluent stream constituents at this time.

2.18.5 Impact from Continued Operation

Transport calculations indicate that the key constituents have not migrated significantly and that interim operation of this facility will not significantly impact the subsurface environment.

Figure 2.18-1. Well Location and Site Map for 216-T-1 Ditch.

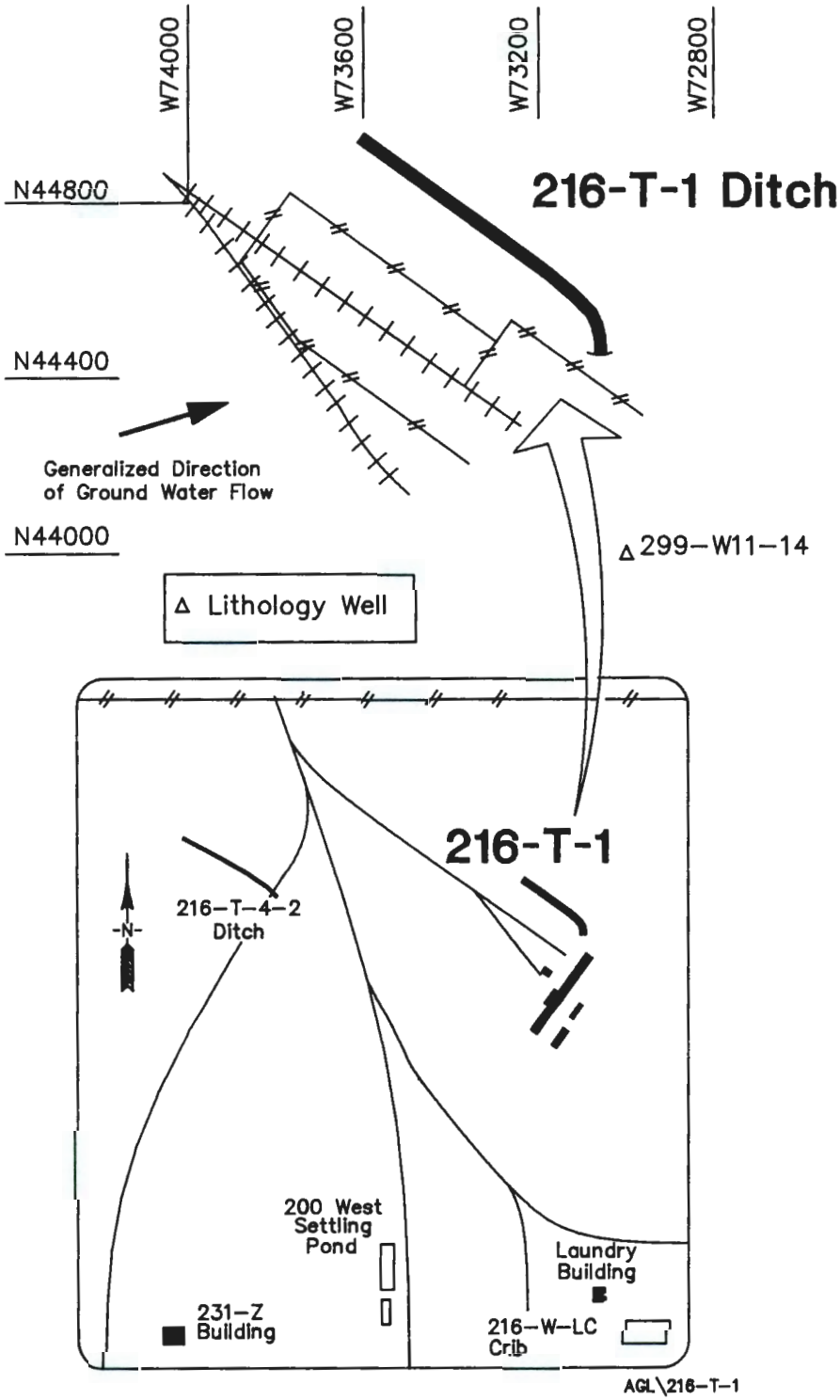

Figure 2.18-2. Lithology of Well 299-W11-14 Near 216-T-1 Ditch.

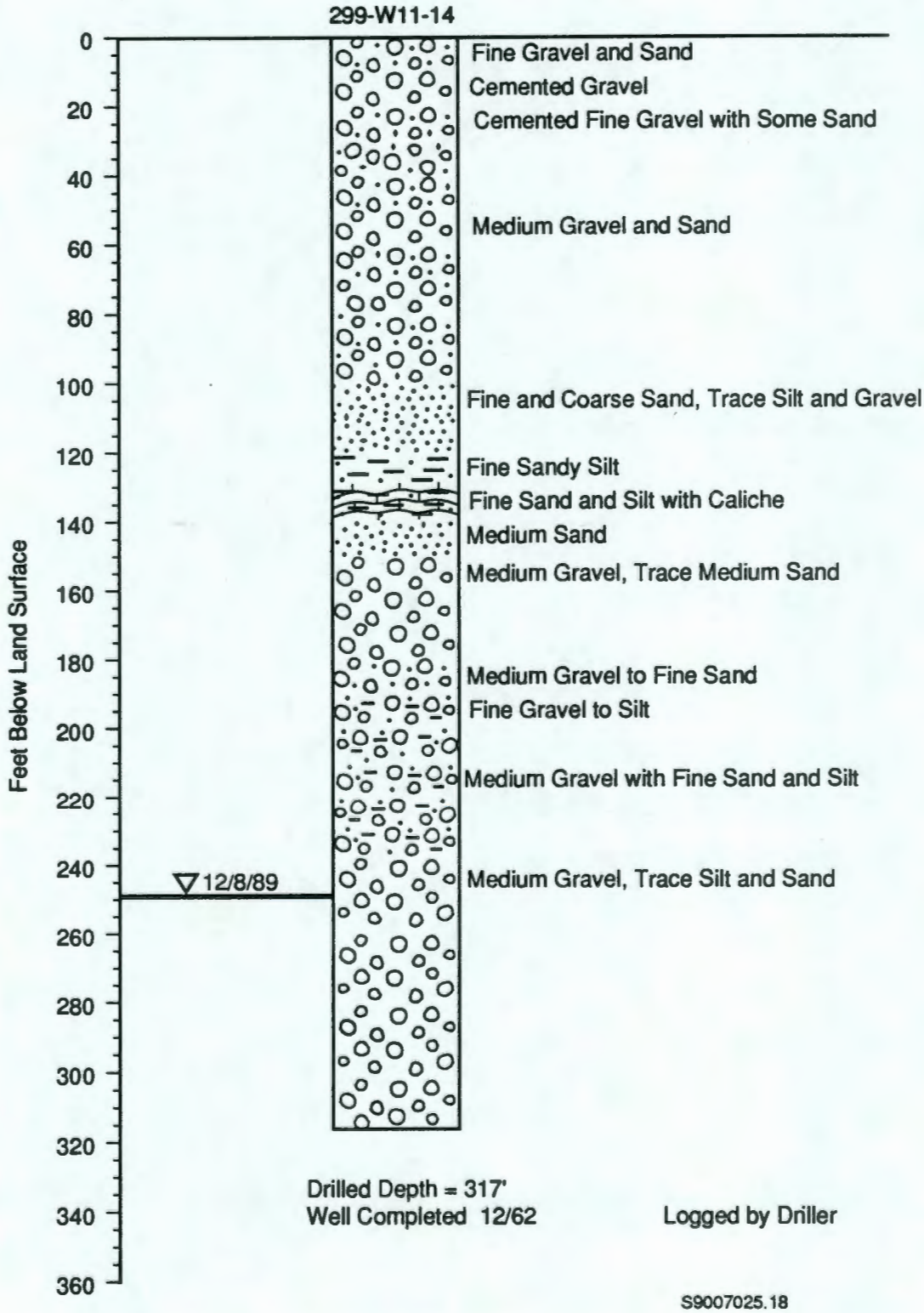

Table 2.18-1. Effluent Stream Description, T-Plant Laboratory Wastewater.

Total volume of effluent discharged to subject receiving site: (WHC 1989a, WHC-EP-0287, (Volume 3)	1.77E+08 L from 1944 to 1975
Average effluent discharge rate, by operating mode: (WHC 1990a, WHC-EP-0342, (Addendum 32)	Plasma torch operation: 250 L/min Standby: 20 L/min
Current average effluent discharge rate: (WHC 1990a, WHC-EP-0342, Addendum 32)	1.2E+05 L/mo[a]; 8.74E+05 L/mo[b]
Effluent designation (WHC 1990a, WHC-EP-0342, Addendum 32)	Nondangerous, nonradioactive
Effluent status:	Standby: currently discharging to 216-T-1 Ditch

[a]Plasma torch operated 2 days during 6-mo sampling period.

[b]In standby mode for 6 mo less 2 days during 6-mo sampling period. No testing currently scheduled (WHC 1990a, Addendum 32).

Table 2.18-2. Effluent Stream Sampling Data, T Plant Laboratory Wastewater.

Key Constituents	Detection Limit[a]	Detection/ Analyses	Sample Concentration 90% CI[a]	Detection Limit[a]	Detection/ Analyses	Sample Concentration 90% CI[a]
	12/85 to 08/86, During Wastewater 1--Plasma Torch Operation			10/89 to 03/90, During Wastewater 1		
aluminum	NA	3/3	270	NA	ND	ND
iron	30	3/3	1,100	30	1/1	125[b]
lead	5	1/3	160	5	ND	ND
manganese	5	3/3	620	5	1/1	45[b]
	12/86 to 03/88, During Wastewater 2--Plasma Torch Standby			10/89 to 03/90, During Wastewater 2		
aluminum	NA	1/3	200	NA	1/4	180
manganese	5	4/4	180	5	4/4	180
lead	5	4/4	56	5	1/4	10[b]
iron	30	4/4	2,800	30	4/4	397

[a]Units: chemical--parts per billion
radionuclides--picocurie per liter.

[b]Concentrations below Group A study guidelines; values given for purposes of comparison.

CI: confidence interval.
NA: not available.
ND: not detected.

Table 2.18-3a. Radionuclide and Chemical Loading, T Plant Laboratory Wastewater Plasma Torch Operation.

Flow Rate: 1.20E+05 L/month

Constituent	Kg/L*	Kg/mo*
barium	2.50E-08	3.00E-03
boron	2.40E-08	2.88E-03
calcium	1.78E-05	2.14E+00
chloride	2.70E-06	3.24E-01
fluoride	1.13E-07	1.36E-02
iron	1.25E-07	1.50E-02
magnesium	4.10E-06	4.92E-01
manganese	4.50E-08	5.40E-03
potassium	7.01E-07	8.41E-02
silicon	2.11E-06	2.53E-01
sodium	1.93E-06	2.32E-01
strontium	8.70E-08	1.04E-02
sulfate	1.36E-05	1.63E+00
zinc	2.90E-08	3.48E-03
ammonia	6.90E-08	8.28E-03
trichloromethane	1.50E-08	1.80E-03
unknown	2.20E-08	2.64E-03
TDS	7.80E-05	9.36E+00
total carbon	1.39E-05	1.67E+00
TOX (as Cl)	8.00E-08	9.60E-03

Footnotes:

Data collected from October 1989 through March 1990.

Flow rate is the average of rates from the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 32).

Constituent concentrations are average values from the statistics in the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 32).

Concentration units of flagged (*) constituents are reported as curies per liter.

Loading units of flagged (*) constituents are reported as curies per test.

Table 2.18-3b. Radionuclide and Chemical Loading, T Plant Laboratory Wastewater Standby Plasma Torch.

Flow Rate: 8.74E+05 L/mo

Constituent	Kg/L*	Kg/mo*
aluminum	1.62E-07	1.42E-01
barium	2.70E-08	2.36E-02
boron	1.32E-08	1.15E-02
calcium	1.74E-05	1.52E+01
chloride	3.25E-06	2.84E+00
copper	1.45E-08	1.27E-02
fluoride	1.30E-07	1.14E-01
iron	2.63E-07	2.30E-01
lead	7.00E-09	6.12E-03
magnesium	3.82E-06	3.34E+00
manganese	1.23E-07	1.07E-01
nitrate	5.25E-07	4.59E-01
potassium	6.85E-07	5.98E-01
silicon	2.00E-06	1.75E+00
sodium	1.95E-06	1.70E+00
strontium	8.60E-08	7.51E-02
sulfate	1.22E-05	1.07E+01
uranium	3.86E-10	3.37E-04
zinc	6.02E-08	5.26E-02
acetone	1.17E-08	1.02E-02
ammonia	5.15E-08	4.50E-02
trichloromethane	2.65E-08	2.32E-02
unknown	4.50E-08	3.93E-02
alpha activity *	7.62E-13	6.66E-07
beta activity *	3.78E-12	3.30E-06
TDS	5.71E-05	4.99E+01
total carbon	1.29E-05	1.13E+01
TOX (as Cl)	1.99E-07	1.74E-01
cobalt-60 *	1.14E-12	9.96E-07
cesium-137 *	1.34E-12	1.17E-06
radium total *	1.34E-13	1.17E-07

Footnotes:

Data collected from October 1989 through March 1990.

Flow rate is the average of rates from the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 32).

Constituent concentrations are average values from the statistics in the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 32).

Concentration units of flagged (*) constituents are reported as curies per liter.

Loading units of flagged (*) constituents are reported as curies per month.

2.19 216-T-4-2 DITCH (216-T-4 DITCH)

No significant additional impacts on soil and groundwater quality from interim use of this ditch are expected due to the minimal contaminant loadings and relatively low average discharge rate of T Plant wastewater.

2.19.1 Receiving Site Description

The 216-T-4-2 Ditch, located in the 200 West Area, has disposed of wastewater from the T Plant complex since 1972. The location of the ditch and spatial relationship to other facilities are shown in Figure 2.19-1.

2.19.2 Effluent Stream Description

T Plant, built in 1944, was used to process spent reactor fuel, using the bismuth phosphate process, until it was shut down in 1956. In 1957, T Plant was converted to a decontamination and equipment refurbishment facility. These operations are currently ongoing. The wastewater stream consists of steam condensate, cooling water, and heating coil water from several buildings in the T Plant complex. Table 2.19-1 summarizes additional waste stream information. Two metals were found in the old data set which exceeded Group A study guidelines, as indicated in Table 2.19-2. Loading estimates are provided in Table 2.19-3.

2.19.3 Flow and Transport Analysis

For calculating transport times, the sediment column beneath the ditch is taken as a four-layer system of 61-m depth (Figure 2.19-2 and Appendix B). The travel time for wastewater to reach the water table under average conditions was calculated to be 279 days (see Appendix B for data and computational details). On the basis of general effluent characteristics and corresponding sorption parameters (Appendix C) for the key constituents identified in Table 2.19-2, the calculated rates of migration (Appendix B) are 0.09 cm/day for iron and 0.22 cm/day for aluminum.

2.19.4 Groundwater Quality Assessment

Because there are no groundwater monitoring wells in close proximity to the 216-T-4-2 Ditch, groundwater quality cannot be evaluated with respect to effluent stream constituents at this time. Previously drilled borings and wells have encountered a caliche zone beneath much of the 200 West Area. While lateral extent is not well defined, a potential exists for creating a perched zone beneath the ditch.

2.19.5 Impact of Continued Operation

Only two constituents (both highly immobile) in the effluent stream exceeded Group A study guidelines. There are no monitoring wells at this ditch. Continued use of this ditch is deemed to have no significant impact on the environment.

Figure 2.19-1. Well Location and Site Map for 216-T-4-2 Ditch.

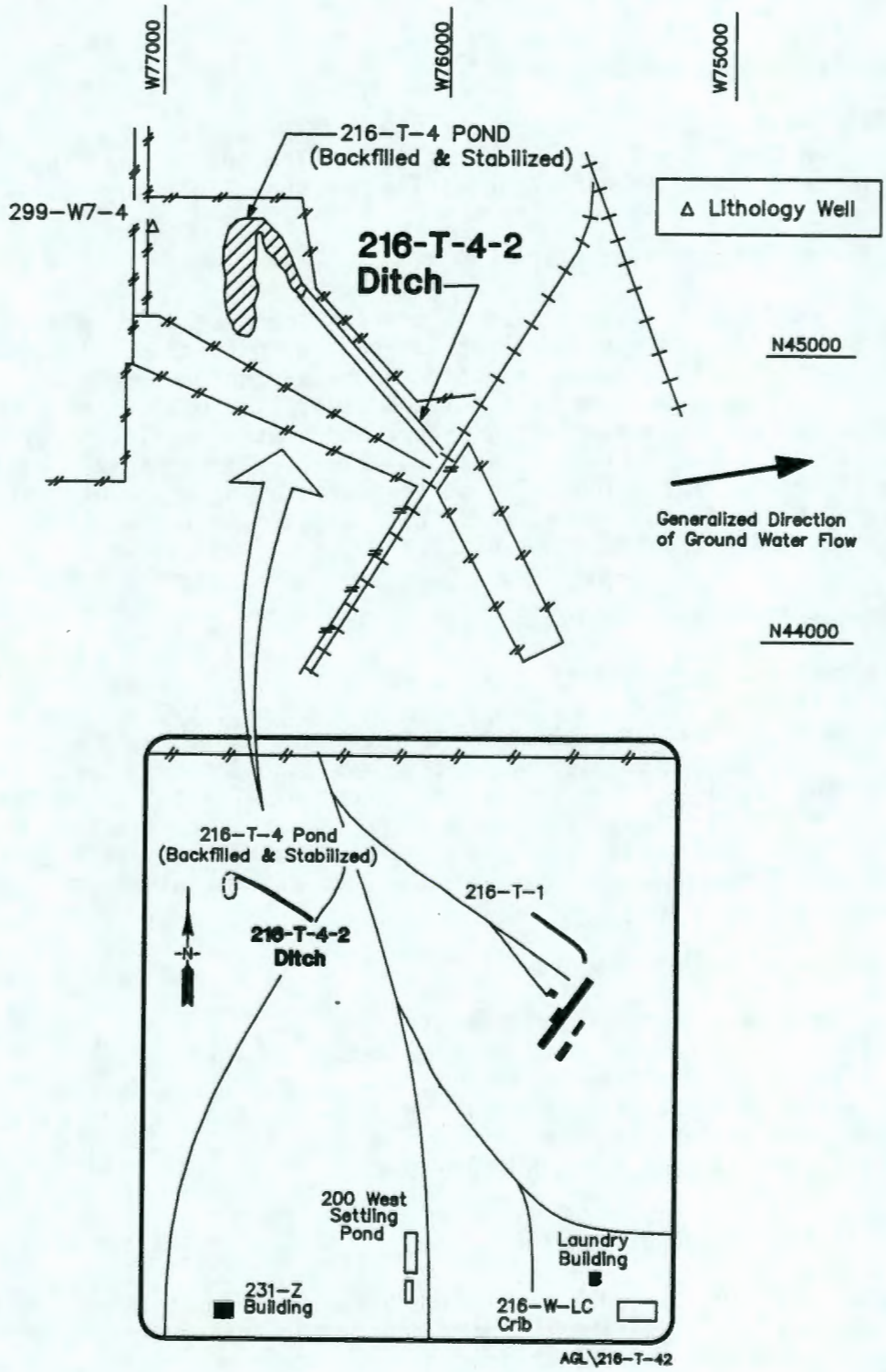

Figure 2-19-2. Lithology of Well 299-W7-4 at 216-T-4-2 Ditch.

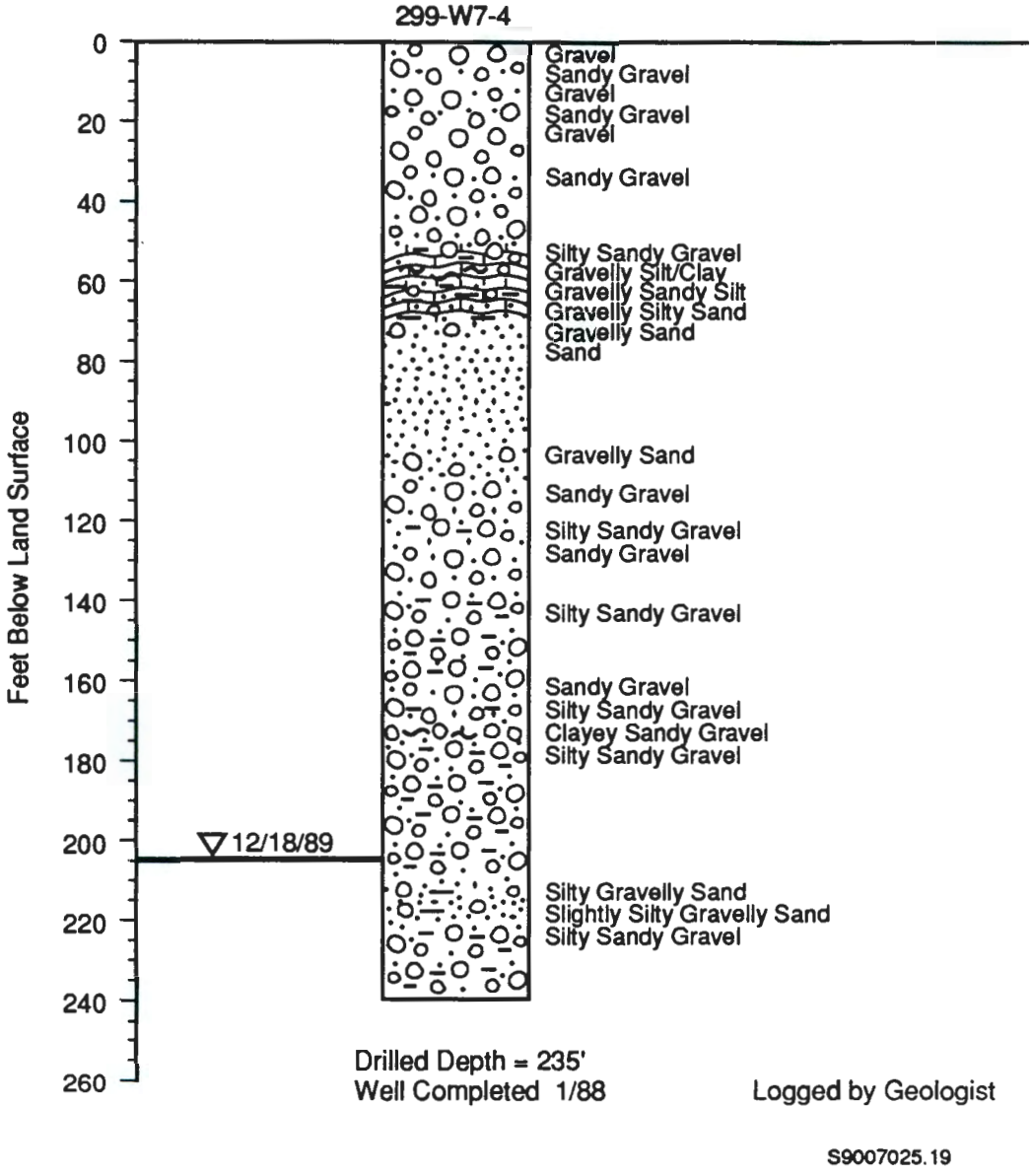

Table 2.19-1. Effluent Stream Description, T Plant Wastewater.

Total volume of effluent discharged to subject receiving site: (Willett 1987, PFD-D-020-00001)	2.98E+08 L from 1972 to 1987
Average maximum effluent discharge rate, by operating mode: (WHC 1990a, WHC-EP-0342, Addendum 10)	1.60E+06 L/mo
Current average maximum effluent discharge rate: (WHC 1990a, WHC-EP-0342, Addendum 10)	1.60E+06 L/mo
Effluent designation: (WHC 1990a, WHC-EP-0342, Addendum 10)	Nondangerous, nonradioactive
Effluent status:	Active discharge to 216-T-4-2 Ditch

Table 2.19-2. Effluent Stream Sampling Data, T Plant Wastewater.

Key Constituents	Detection Limit[a]	Detection/ Analyses	Sample Concentration 90% CI[a]	Detection Limit[a]	Detection/ Analyses	Sample Concentration 90% CI[a]
	12/85 to 01/87, During Routine Operation			10/89 to 03/90, During Routine Operation		
aluminum	NA	1/5	360	NA	ND	ND
iron	30	4/5	400	30	4/4	77[b]

[a]Units: chemical--parts per billion
radionuclides--picocurie per liter.
[b]Concentrations below Group A study guidelines; values given for purposes of comparison.

CI: confidence interval.

Table 2.19-3. Radionuclide and Chemical Loading, T Plant Wastewater.

Flow Rate: 1.60E+06 L/mo

Constituent	Kg/L*	Kg/mo*
barium	3.00E-08	4.80E-02
boron	2.00E-08	3.20E-02
cadmium	2.00E-09	3.20E-03
calcium	1.90E-05	3.04E+01
chloride	1.17E-06	1.87E+00
copper	1.75E-08	2.80E-02
fluoride	1.45E-07	2.32E-01
iron	5.40E-08	8.64E-02
magnesium	3.97E-06	6.35E+00
manganese	9.00E-09	1.44E-02
nitrate	5.00E-07	8.00E-01
potassium	7.57E-07	1.21E+00
silicon	2.05E-06	3.28E+00
sodium	2.03E-06	3.25E+00
strontium	9.55E-08	1.53E-01
sulfate	1.01E-05	1.62E+01
uranium	4.70E-10	7.52E-04
zinc	5.42E-08	8.67E-02
ammonia	5.40E-08	8.64E-02
1-butanol	1.20E-08	1.92E-02
unknown amide	2.60E-08	4.16E-02
beta activity *	2.59E-12	4.14E-06
TDS	6.05E-05	9.68E+01
TOC	1.00E-06	1.60E+00
total carbon	1.54E-05	2.46E+01
TOX (as Cl)	1.27E-08	2.03E-02
cesium-137 *	7.67E-13	1.23E-06
radium total *	1.08E-13	1.73E-07

Footnotes:

Data collected from October 1989 through March 1990.

Flow rate is the average of rates from the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 10).

Constituent concentrations are average values from the statistics in the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 10).

Concentration units of flagged (*) constituents are reported as curies per liter.

Loading units of flagged (*) constituents are reported as curies per month.

2.20 216-U-14 DITCH

No significant additional impact on soil and groundwater quality should occur due to routine, interim operation of this disposal facility. However, the fate of uranium from an unplanned release remains uncertain.

2.20.1 Receiving Site Description

The 216-U-14 Ditch, located in the 200 West Area, was constructed in 1944 to dispose of low-level radioactive liquid effluents consisting of UO_3/U Plant wastewater and 242-S Evaporator steam condensate. Figure 2.20-1 depicts the location of the ditch relative to other facilities in the vicinity.

2.20.2 Effluent Stream Description

2.20.2.1 UO_3/U Plant Wastewater. The UO_3 Plant and U Plant are a complex of buildings which have been used to convert uranyl nitrate hexahydrate into uranium trioxide (UO_3). The UO_3/U Plant wastewater stream consists of steam condensates from concentrators, heating coils, and steam jackets; cooling water from coolers, condensers, and heat exchangers; rain and flush water; and nonradioactive floor drains from three buildings. Unplanned releases have occurred in the past, releasing quantities of uranium in a nitric acid solution. The UO_3/U Plant complex is currently in a standby mode. Table 2.20-1a summarizes information pertaining to the effluent stream. Key constituents from sampling data are indicated in Table 2.20-2a. Loading estimates are provided in Table 2.20-3a.

Four radioactive constituents exceeded the Group A study guidelines for the old data. The new data show negligible levels of radioactive constituents.

2.20.2.2 242-S Steam Condensate. The 242-S Evaporator operated from 1973 until 1980. Its purpose was to concentrate low-level radioactive waste in the double-shell tanks. The steam condensate stream included condensate from the evaporator reboiler, steam heating coils, purging system steam traps, and seal water from an air sampling pump. The seal water is the only currently active wastestream (since 1980). Table 2.20-1b summarizes information pertaining to the effluent stream. Key constituents from sampling data are indicated in Table 2.20-2b. Loading estimates are provided in Table 2.20-3b.

Old radiological sampling data indicate several radionuclides which exceeded Group A study guidelines by small margins. The sampling period represents 4 yr of evaporator operation and 8 yr of the shutdown mode. New data show negligible levels of these constituents. There are no plans to operate this evaporator in the future.

2.20.3 Flow and Transport Analysis

For transport calculation purposes, the sediment column beneath the ditch is treated as a three-layer system 61 m in depth (Figure 2.20-2 and Appendix B). The calculated travel time for wastewater to reach the water table under average discharge conditions is 79 days.

On the basis of general effluent characteristics and corresponding sorption parameters (Appendix C) for the key constituents identified in Table 2.20-2, the calculated rates of migration (Appendix B) range from 0.08 to 7.7 cm/day. Based on the estimated travel times (Appendix B), only breakthrough of uranium is expected.

2.20.4 Groundwater Quality Assessment

Carbon tetrachloride and unfiltered metals are the only constituents exceeding Group A guidelines (Table 2.20-4). Carbon tetrachloride is attributed to upgradient disposal activities in the 200 West Area (Serkowski and Jordan 1989 and Evans et al. 1990, Figure 2-8) and the metals are considered to be sampling artifacts (see WHC 1990b).

Several constituents, primarily the metals for unfiltered samples, exceeded Group B guidelines (Table 2.20-5). As indicated above, these are most likely sampling artifacts.

The slightly elevated uranium, however, may be indicative of breakthrough related to an unplanned release.

Of the key effluent constituents, only uranium was detected in groundwater. This is consistent with the migration rates indicated in Section 2.20.3. However, the uranium occurrence in groundwater beneath this crib may be more related to the unplanned release mentioned previously than to routine operations. Alternatively, this occurrence may be due to the widespread uranium contamination from nearby cribs (Evans et al. 1990, Figure 2-26).

2.20.5 Impact From Continued Operation

The discharge rate to this site is insignificant in relation to Cold Creek recharge. Thus, the groundwater flow regime beyond the immediate vicinity of the ditch should be unaffected. However, a perched water zone may exist due to a caliche or fine sediment layer approximately 40 m below the bottom of the ditch.

For purposes of this study, impact of past operations on groundwater quality, as indicated by recent sampling results, is judged to be minimal (i.e., not significant for decision tree analysis).

Based on the small loading of key constituents from routine operations and their retention characteristics (Section 2.20.4) at this site, remobilization of contaminants retained on the soil column from past operations is judged to be minimal. However, additional core sampling beneath the site may be needed for confirmation.

Assuming the characterization data and conclusions concerning the uranium spill of 1986 are representative, groundwater quality should not be adversely impacted due to continued use of this ditch.

Figure 2.20-1. Well Location and Site Map for 216-U-14 Ditch.

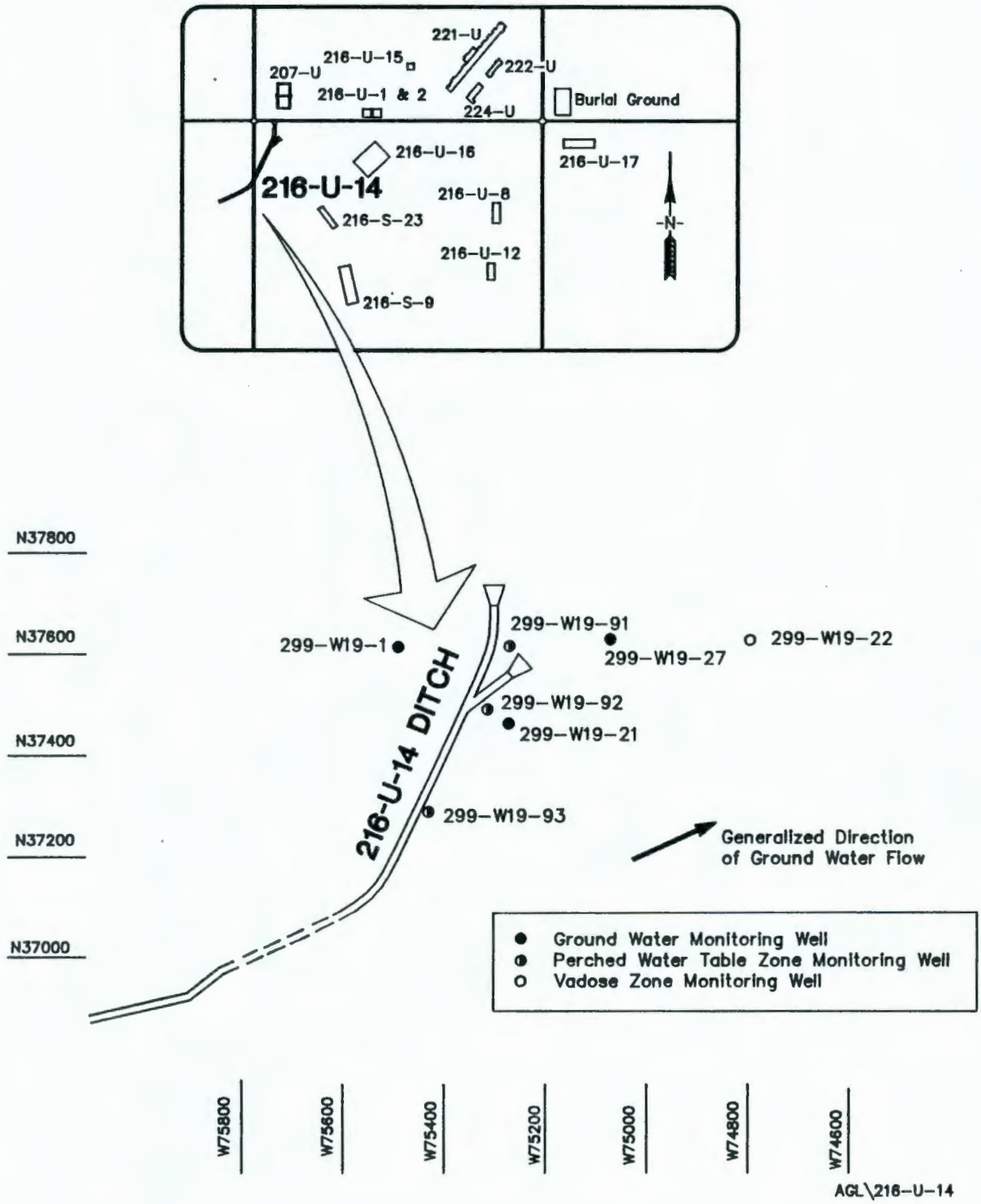

Figure 2.20-2. Lithology of Well 299-W19-27 at 216-U-14 Ditch.

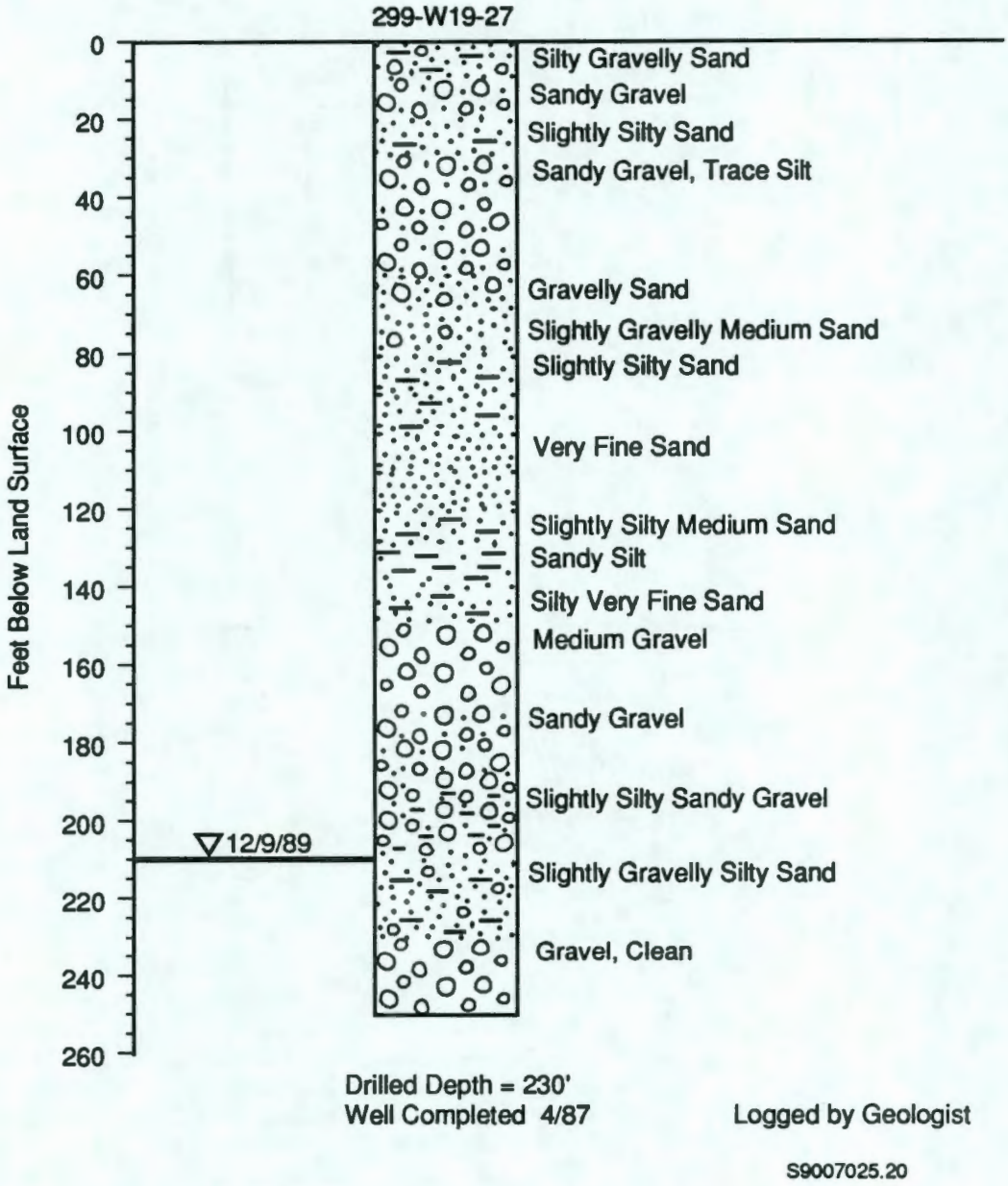

Table 2.20-1a. Effluent Stream Description, UO_3/U Plant Wastewater.

Total volume of effluent discharged to subject receiving site: (WHC 1989a, WHC-EP-0287, Volume 2)	2.30E+09 L from 1/84 to 12/88
Average effluent discharge rate, by operating mode: (WHC 1990a, WHC-EP-0342, Addendum 7)	Standby: 380 to 760 L/min Operating: 3,000 to 3,800 L/min
Current average effluent discharge rate: (WHC 1990a, WHC-EP-0342, Addendum 7)	2.24E+07 L/mo
Effluent designation: (WHC 1990a, WHC-EP-0342, Addendum 7)	Nondangerous, nonradioactive
Effluent status: (WHC 1990a, WHC-EP-0342, Addendum 7)	Standby: active discharge to 216-U-14 Ditch

Table 2.20-1b. Effluent Stream Description, 242-S Evaporator Steam Condensate.

Total volume of effluent discharged to subject receiving site: (WHC 1989a, WHC-EP-0287, Volume 2)	4.39E+08 L from 1/76 to 12/81; 2.0E+07 gal from 10/84 to 9/89
Average effluent discharge rate, by operating mode: (WHC 1990a, WHC-EP-0342, Addendum 29)	Operating: 1.7E+07 gal/yr Shutdown: approximately 450 gal/hr
Current average effluent discharge rate: (WHC 1990a, WHC-EP-0342, Addendum 29)	Approximately 600 gal/hr
Effluent designation: (WHC 1990a, WHC-EP-0342, Addendum 29)	Nondangerous, nonradioactive
Effluent status:	Shutdown: effluent discharging to 216-U-14 Ditch

Table 2.20-2a. Effluent Stream Sampling Data, UO_3/U Plant Wastewater.

Key Constituents	Detection Limit[a]	Detection/ Analyses	Sample Concentration 90% CI[a]	Detection Limit[a]	Detection/ Analyses	Sample Concentration 90% CI[a]
	09/85 to 01/87, During Routine Operation			10/89 to 03/90, During Routine Operation		
strontium-90	30	2/NA	1,800	0.1	ND	ND
plutonium-239	50	19/NA	17	0.001	1/4	0.006[b]
uranium (isotopes)[c]	20	46/NA	41	NA		2.2
americium-241	40	1/NA	260	0.001		ND

[a]Units: chemical--parts per billion
radionuclides--picocurie per liter.

CI: confidence interval.
NA: not available.
ND: not detected.

[b]Concentrations below Group A guidelines; values given for comparison purposes.
[c]Uranium-234 Group A guideline used as the most restrictive for determination of key constituents.
[d]Consists of 1.16 pCi/L uranium-234 and 0.13 pCi/L uranium-235 and 0.87 pCi/L uranium-238.

Table 2.20-2b. Effluent Stream Sampling Data, 242-S Evaporator Steam Condensate.

Key Constituents	Detection Limit[a]	Detection/ Analyses	Sample Concentration 90% CI[a]	Detection Limit[a]	Detection/ Analyses	Sample Concentration 90% CI[a]
	10/86 to 05/87, During Air Sampling Pump Shutdown Mode			10/89 to 03/90, During Air Sampling Pump Shutdown Mode		
	No Chemicals			No Chemicals		
	1976 to 1987, During Evaporator (1976 to 1980) and Shutdown Modes (1980 to 1987)			10/89 to 03/90, During Air Sampling Pump Shutdown Mode		
cesium-137	80	6/NA	150	1	ND	ND
strontium-90	30	9/NA	72	0.1	1/2	0.24[b]
ruthenium-106	600	1/NA	820	.50	ND	ND
cerium-144	NA	1/NA	920	NA	ND	ND
uranium (isotopes)[c]	20	3/NA	110	NA	3/3	0.32[b,d]

[a]Units: chemical--parts per billion
radionuclides--picocurie per liter.

[b]Concentrations below Group A guidelines; values given for comparison purposes.
[c]Uranium-234 Group A guideline used as the most restrictive for determination of key constituents.
[d]Consists of 0.20 pCi/L uranium-234 and 0.12 pCi/L uranium-238.

CI: confidence interval.
ND: not detected.
NA: not available.

Table 2.20-3a. Radionuclide and Chemical Loading, UO_3/U Plant Wastewater.

Flow Rate: 2.24E+07 L/mo

Constituent	Kg/L*	Kg/mo*
barium	2.92E-08	6.54E-01
boron	1.95E-08	4.37E-01
calcium	1.79E-05	4.01E+02
chloride	9.30E-07	2.08E+01
copper	1.87E-08	4.19E-01
fluoride	1.29E-07	2.89E+00
iron	3.12E-08	6.99E-01
magnesium	4.31E-06	9.65E+01
nitrate	5.24E-07	1.17E+01
potassium	7.16E-07	1.60E+01
silicon	2.15E-06	4.81E+01
sodium	1.98E-06	4.43E+01
strontium	9.42E-08	2.11E+00
sulfate	1.00E-05	2.24E+02
thallium	5.50E-09	1.23E-01
uranium	1.32E-09	2.96E-02
zinc	5.25E-09	1.18E-01
ammonia	5.32E-08	1.19E+00
alpha activity *	1.82E-12	4.08E-05
beta activity *	2.20E-12	4.93E-05
TDS	6.95E-05	1.56E+03
TOC	1.00E-06	2.24E+01
total carbon	1.51E-05	3.38E+02
TOX (as Cl)	1.22E-08	2.73E-01
cobalt-60 *	6.25E-13	1.40E-05
plutonium-239/240 *	3.55E-15	7.95E-08
uranium-234 *	6.52E-13	1.46E-05
uranium-235 *	5.64E-14	1.26E-06
uranium-238 *	5.08E-13	1.14E-05

Footnotes:

Data collected from October 1989 through March 1990.

Flow rate is the average of rates from the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 7).

Constituent concentrations are average values from the statistics in the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 7).

Concentration units of flagged (*) constituents are reported as curies per liter.

Loading units of flagged (*) constituents are reported as curies per month.

Table 2.20-3b. Radionuclide and Chemical Loading, 242-S Evaporator Steam Condensate.

Flow Rate: 1.62E+06 L/mo

Constituent	Kg/L*	Kg/mo*
barium	3.00E-08	4.85E-02
boron	1.60E-08	2.59E-02
calcium	1.92E-05	3.10E+01
chloride	3.75E-06	6.06E+00
copper	1.07E-08	1.73E-02
fluoride	2.50E-07	4.04E-01
magnesium	4.32E-06	6.98E+00
nitrate	5.00E-07	8.08E-01
potassium	7.38E-07	1.19E+00
silicon	2.16E-06	3.49E+00
sodium	2.16E-06	3.49E+00
strontium	9.60E-08	1.55E-01
sulfate	1.41E-05	2.28E+01
uranium	2.99E-10	4.83E-04
zinc	3.10E-08	5.01E-02
ammonia	5.00E-08	8.08E-02
halogenated hydrocarbons	3.40E-08	5.50E-02
trichloromethane	1.75E-08	2.83E-02
unknown	5.20E-08	8.41E-02
alpha activity *	5.33E-13	8.62E-07
beta activity *	1.06E-12	1.71E-06
TDS	7.60E-05	1.23E+02
total carbon	1.40E-05	2.26E+01
TOX (as Cl)	1.56E-07	2.52E-01
cobalt-60 *	8.22E-13	1.33E-06
strontium-90 *	1.79E-13	2.89E-07
uranium-234 *	1.37E-13	2.21E-07
uranium-238 *	1.08E-13	1.75E-07

Footnotes:

Data collected from October 1989 through March 1990.

Flow rate is the average of rates from the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 29).

Constituent concentrations are average values from the statistics in the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 29).

Concentration units of flagged (*) constituents are reported as curies per liter.

Loading units of flagged (*) constituents are reported as curies per month.

Table 2.20-4. Effluent Study Groundwater Summary Report. (Page 1 of 3)

Groundwater Analysis Results for 216-U-14 Ditch (1989-1990)

CONSTITUENT			ANALYSIS SUMMARY					GROUP A STUDY GUIDELINES	
Group Name	Units	Detection Limit	Number of Analyses	Number > Det.	Average Result	Maximum Result	Minimum Result	Max Limit	Number > Limit
CONTAMINATION INDICATOR PARAMETERS									
Conductivity, Laboratory	UMHO	1.00	3	3	226.33	251.00	197.00	700.0	0
Specific conductance	UMHO	1.00	5	5	223.40	270.00	189.00	700.0	0
Total Organic Halogen, Low Det. Level	PPB	10.00	5	3	9.60	13.00	6.00		0
pH, Field Measurement		.10	5	5	8.27	9.14	7.42	8.5	1
pH, Laboratory Measurement		.01	3	3	8.33	8.60	8.00	8.5	1
DRINKING WATER PARAMETERS									
Alpha, High Detection Level	PCI/L	4.00	5	5	9.27	14.40	4.25	15.0	0
Arsenic	PPB	5.00	3	2	10.33	14.00	5.00	50.0	0
Arsenic, filtered	PPB	5.00	2	2	12.50	13.00	12.00	50.0	0
Barium	PPB	6.00	3	3	88.67	222.00	21.00	1000.0	0
Barium, filtered	PPB	6.00	4	4	18.25	20.00	16.00	1000.0	0
Cadmium	PPB	2.00	3	1	32.67	94.00	2.00	10.0	1
Chromium	PPB	10.00	3	1	56.33	149.00	10.00	50.0	1
Fluoride	PPB	500.00	5	1	500.00	500.00	500.00	4000.0	0
Gross alpha	PCI/L	4.00	2	2	10.49	11.80	9.18	15.0	0
Gross beta	PCI/L	8.00	7	3	6.72	11.60	3.32	50.0	0
Lead (graphite furnace)	PPB	5.00	3	1	11.67	25.00	5.00	50.0	0
Nitrate	PPB	500.00	5	4	860.00	1300.00	500.00	45000.0	0
Radium	PCI/L	1.00	3	1	.32	1.01	-.03	100.0	0
GROUNDWATER QUALITY PARAMETERS									
Chloride	PPB	500.00	5	5	1980.00	4800.00	1200.00	250000.0	0
Iron	PPB	30.00	3	3	92042.33	276000.00	36.00	300.0	1
Manganese	PPB	5.00	3	1	1006.67	3010.00	5.00	50.0	1
Sodium	PPB	200.00	3	3	24933.33	39900.00	12600.00		0
Sodium, filtered	PPB	200.00	4	4	16825.00	21700.00	12100.00		0
Sulfate	PPB	500.00	5	5	16980.00	39200.00	9600.00	250000.0	0
SITE SPECIFIC AND OTHER PARAMETERS									
2,6-Bis(1,1-Dimethylethyl)-4-Methyl Phen	PPB		1	1	20.00	20.00	20.00		0
Aluminum	PPB	150.00	3	1	5000.00	14700.00	150.00	50.0	1

Table 2.20-4. Effluent Study Groundwater Summary Report. (Page 2 of 3)

Groundwater Analysis Results for 216-U-14 Ditch (1989-1990)

CONSTITUENT			ANALYSIS SUMMARY					GROUP A STUDY GUIDELINES	
Group Name	Units	Detection Limit	Number of Analyses	Number > Det.	Average Result	Maximum Result	Minimum Result	Max Limit	Number > Limit
SITE SPECIFIC AND OTHER PARAMETERS									
Ammonium ion	PPB	50.00	3	1	59.67	79.00	50.00		0
Boron	PPB	10.00	3	3	32.00	40.00	20.00		0
Boron, filtered	PPB	10.00	4	4	29.75	43.00	20.00		0
Calcium	PPB	50.00	3	3	19066.67	22600.00	16700.00		0
Calcium, filtered	PPB	50.00	4	4	16875.00	18100.00	15600.00		0
Carbon Tetrachloride by GC/MS	PPB	5.00	5	3	7.20	13.00	4.00	5.0	3
Copper	PPB	10.00	3	1	19.33	38.00	10.00	1000.0	0
Fluoride, Low Detection Level	PPB	20.00	1	1	205.00	205.00	205.00	4000.0	0
Lithium	PPB	10.00	3	1	12.33	17.00	10.00		0
Magnesium	PPB	50.00	3	3	7300.00	10200.00	5440.00		0
Magnesium, filtered	PPB	50.00	4	4	5632.50	6250.00	4950.00		0
Natural uranium	UG/L	.73	2	2	17.50	21.90	13.10	59.0	0
Nickel	PPB	10.00	3	1	32.67	78.00	10.00		0
Potassium	PPB	100.00	3	3	4266.67	6670.00	2870.00		0
Potassium, filtered	PPB	100.00	4	4	2882.50	3150.00	2620.00		0
Silicon	PPB	50.00	3	3	23233.33	35900.00	14700.00		0
Silicon, filtered	PPB	50.00	4	4	16525.00	18700.00	14600.00		0
Strontium	PPB	10.00	3	3	86.67	101.00	73.00		0
Strontium, filtered	PPB	10.00	4	4	76.25	84.00	68.00		0
Technetium-99	PCI/L	15.00	1	1	29.90	29.90	29.90	4000.0	0
Titanium	PPB	60.00	3	1	496.67	1370.00	60.00		0
Toluene	PPB	5.00	5	1	6.60	13.00	5.00	2000.0	0
Total carbon	PPB	1000.00	3	3	19933.33	23900.00	15800.00		0
Total dissolved solids		5000.00	2	2	116500.00	123000.00	110000.00	500000.0	0
Turbidity	NTU	.10	3	3	66.93	200.00	.20	5.0	1
Uranium	PCI/L	.50	5	5	11.46	20.90	4.39	40.0	0
Uranium-234	PCI/L	.10	2	2	6.02	7.85	4.18	20.0	0
Uranium-235	PCI/L	.10	2	2	.29	.31	.27	24.0	0
Uranium-238	PCI/L	.10	2	2	5.81	7.82	3.79	24.0	0
Vanadium	PPB	5.00	3	3	68.00	145.00	20.00		0
Vanadium, filtered	PPB	5.00	4	4	28.00	36.00	20.00		0
Zinc	PPB	5.00	3	3	50.67	127.00	11.00	5000.0	0

Table 2.20-4. Effluent Study Groundwater Summary Report. (Page 3 of 3)

Groundwater Analysis Results for 216-U-14 Ditch (1989-1990)

CONSTITUENT			ANALYSIS SUMMARY					GROUP A STUDY GUIDELINES	
Group Name	Units	Detection Limit	Number of Analyses	Number > Det.	Average Result	Maximum Result	Minimum Result	Max Limit	Number > Limit
SITE SPECIFIC AND OTHER PARAMETERS									
Zinc, filtered	PPB	5.00	4	3	7.25	9.00	5.00	5000.0	0

Table 2.20-5. Background Comparison, 216-U-14 Ditch.

Constituent	Background[a]	Average/ Background[b]	Maximum/ Background[b]
aluminum	2.0	2,500.00	7,350.00
ammonia	50.0	1.19	1.58
arsenic	6.3	1.64 (1.98)	2.22 (2.06)
barium	62.0	1.43 (0.29)	3.58 (0.32)
beryllium	0.3		
bismuth	0.02		
boron	50.0	0.64 (0.60)	0.80 (0.86)
cadmium	0.2	163.35	470.00
calcium	50,700	0.38 (0.33)	0.45 (0.36)
chloride	16,800	0.12	0.29
chromium	6.0	9.39	24.83
copper	1.0	19.33	38.00
cyanide	10.0		
fluoride	470	1.06	1.06
lead	0.5	23.34	50.00
magnesium	15,200	0.48 (0.37)	0.67 (0.41)
manganese	12.0	83.89	250.83
mercury	0.1		
nickel	4.0	8.17	19.5
phosphate	1,000		
potassium	6,190	0.69 (0.47)	1.08 (0.51)
selenium	2.0		
silver	10		
sodium	28,410	0.88 (0.59)	1.40 (0.76)
strontium	338	0.26 (0.23)	0.30 (0.25)
sulfate	51,200	0.33	0.77
uranium	2.5	4.58	8.36
vanadium	26	2.62 (1.08)	5.58 (1.38)
zinc	8.0	6.33 (0.91)	15.88 (1.13)
alkalinity	144,000		
pH	7.8	1.06	1.17
TOC	933		
conductivity	462	0.48	0.58
gross alpha	3.9	2.69	3.03
gross beta	31	0.22	0.37
radium	0.2	1.60	5.05

TOC: total organic carbon. ( ): filtered samples.

[a]Background is the mean plus one standard deviation for the values listed in Table 2-1. Amounts of uranium, gross alpha, gross beta, and radium given in picocuries per liter. All others are in parts per billion.

[b]Average and maximum values from Table 2.20-4.

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2.21 216-U-17 CRIB

Key effluent constituents are not expected to reach groundwater during interim use of this crib due to low infiltration rates and natural barriers to downward flow. Preexisting, above-guideline concentrations of key constituents from past-practice sources, however, may complicate interpretation of future groundwater monitoring results.

2.21.1 Receiving Site Description

The 216-U-17 Crib, located in the 200 West Area, was placed in service in 1988 to dispose of process condensate from the UO_3 Plant. Figure 2.21-1 shows location of the crib relative to other facilities in the vicinity.

2.21.2 Effluent Stream Description

The UO_3 Plant is a complex of buildings used to convert uranyl nitrate hexahydrate (UNH) into uranium trioxide (UO_3). The UO_3 Plant process condensate is a condensate waste from the concentration and calcination of UNH. The condensate consists primarily of condensed water and nitric acid vapor which is neutralized prior to crib discharge. Phosphoric acid and potassium hydroxide are used as buffering and neutralizing agents. There are two operating modes, calcination and calciner standby. Table 2.21-1 summarizes information pertaining to the effluent stream. Key constituents for each operating mode are indicated in Table 2.21-2. Loading estimates are provided in Table 2.21-3.

Sampling data show several constituents which exceed Group A or C study guidelines with the predominant species being tritium, nitrate, and uranium. Note, however, that the crib was placed in service in 1988 but the data set for radionuclides includes samples from 1981 to 1988. Elevated levels of radionuclides were attributed to the crib discharge of C-Cell sump collection tank prior to 1984. This sump was rerouted to the Uranium Recycle Concentrator in 1984. Radionuclide discharges are to be further mitigated by installing a mist eliminator downstream of the UNH concentrators.

2.21.3 Flow and Transport Analysis

For the unit gradient transport calculation, the sediment column beneath the crib (Figure 2.21-2) is treated as an eight-layer system with a depth of 71 m (i.e., similar to that used for the numerical modeling in Appendix D). The calculated travel time for wastewater to reach the water table under average discharge conditions is 794 days (see Appendix B for data and computations).

Transport analysis using PORFLO-3 model (Appendix D) yields a longer travel time than obtained with the unit gradient model above. Due to barriers to downward flow, primarily the caliche zone prevalent in the 200 West Area, the wastewater spreads horizontally, increasing the average time to reach groundwater. When these effects are accounted for as in the PORFLO-3 model, approximately 20 yr are required for the wastewater to first reach groundwater (after the initial wetting period, the travel time would decrease).

Based on general effluent characteristics, the unit gradient travel time result and corresponding sorption parameters (Appendix C) for the key constituents (Table 2.21-2), the calculated rates of migration (Appendix B) are about 9 cm/day for mobile constituents (acetone, chromium, fluoride, nitrate, tritium, americium-241, and cobalt-60); 2.5 cm/day for uranium isotopes; and 0.1 to 0.9 cm/day for slightly mobile constituents (mercury, and strontium-90). The corresponding travel times for the key constituents range from 794 to nearly 20,000 days (Appendix B). The calculated contaminant migration rates would be even longer using the PORFLO-3 model.

The above estimates indicate that under the conditions used for the above analysis, contaminants may never reach groundwater beneath this disposal facility. However, based on the above migration rate estimates, the mobile key constituents should all reach the caliche layer (Figure 2.21-2) within a few years. Acetone is expected to degrade within this time (Appendix C).

2.21.4 Groundwater Quality Assessment

Several constituents exceed Group A guidelines (Table 2-21-4). Of these, uranium, nitrate, and iron are identified as key constituents in Table 2.21-2 (old data). However, groundwater beneath the 216-U-17 Crib was already contaminated from upgradient sources before the crib was placed into operation in February 1988. For example, Figures 2.21-3 and 2.21-4 illustrate the concentrations of uranium and gross beta (attributed predominantly to technetium-99) in the groundwater in wells upgradient and downgradient from the crib, respectively, showing contamination before the crib went into operation. The primary source(s) of the preexisting technetium-99 and uranium are either the inactive 216-U-1/2 Cribs or a leaking effluent line from UO_3 Plant to the 216-U-12 Crib (this line was taken out of service when the 216-U-17 Crib went into operation to replace the 216-U-12 Crib). Preliminary sampling of two new wells completed in 1989, one upgradient of the effluent line and another downgradient from the line, suggests this is the source of the uranium and technetium in the groundwater at the 216-U-17 Crib. This preliminary conclusion requires additional sampling under the routine operational monitoring program for confirmation. The carbon tetrachloride and nitrate (Table 2.21-4) are also attributed to upgradient or nearby sources (Evans et al. 1990, Figure 2-8 and 2-13).

In addition to the above, several metals appear to exceed Group B guidelines (Table 2.21-5). No explanation is apparent for these above-background occurrences. For example, all of the monitoring wells included in the network for this site were constructed of stainless steel from which corrosion products are not expected.

2.21.5 Impact of Continued Operation

As stated above, the volume of effluent disposed to this crib is quite small, with a relatively long travel time to reach the water table. Therefore, no significant impact on groundwater flow direction or movement of existing contaminant plumes is expected.

For the reasons discussed previously (Section 2.21.3), operation of this crib should not have a direct impact on groundwater quality, and contaminant loads for the less mobile constituents should remain high in the soil column over the next few years. Nitrate, tritium, fluoride, chromium, americium-241, and cobalt-60, however, would eventually reach groundwater.

Figure 2.21-1. Well Location and Site Map for 216-U-17 Crib.

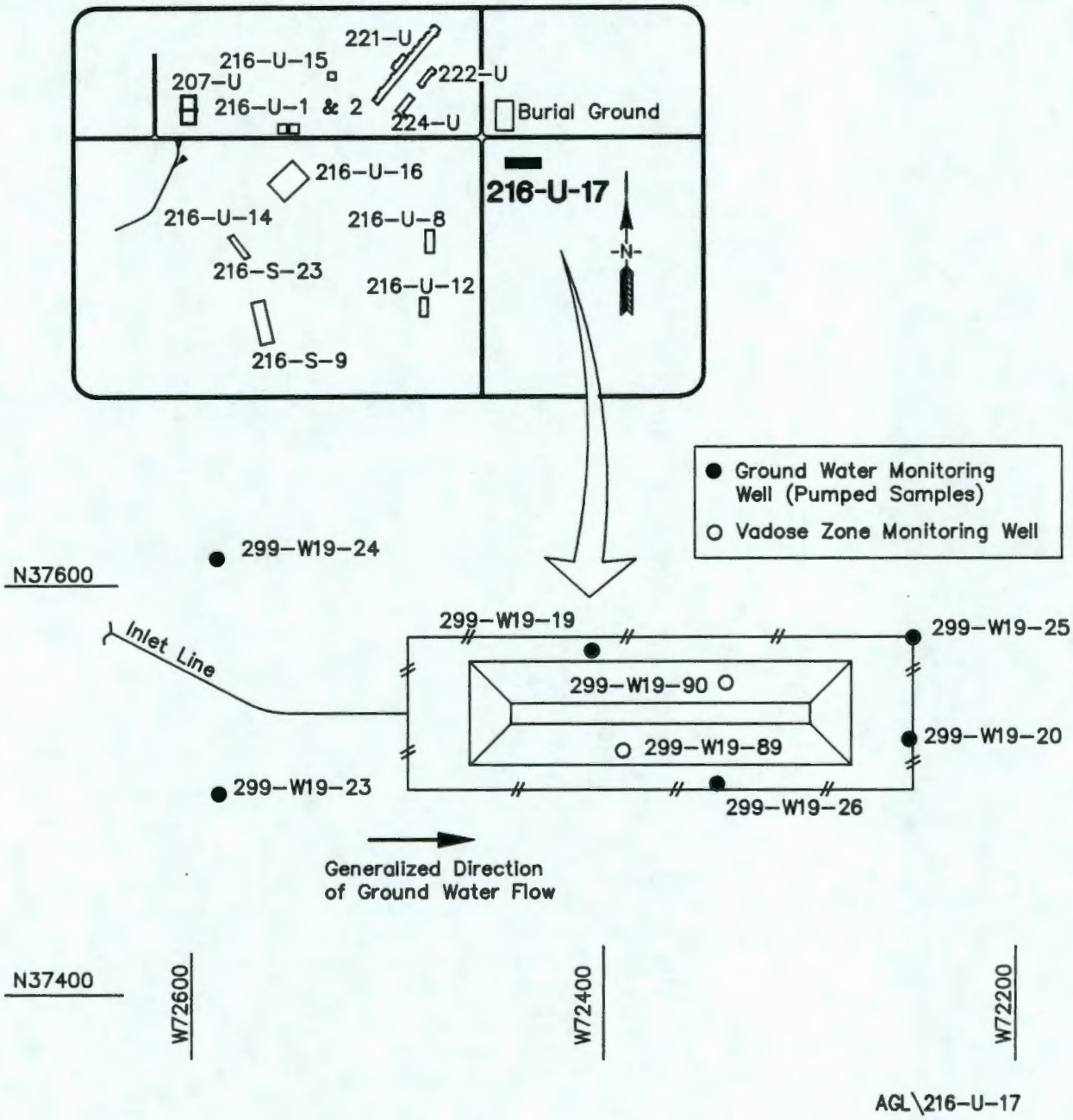
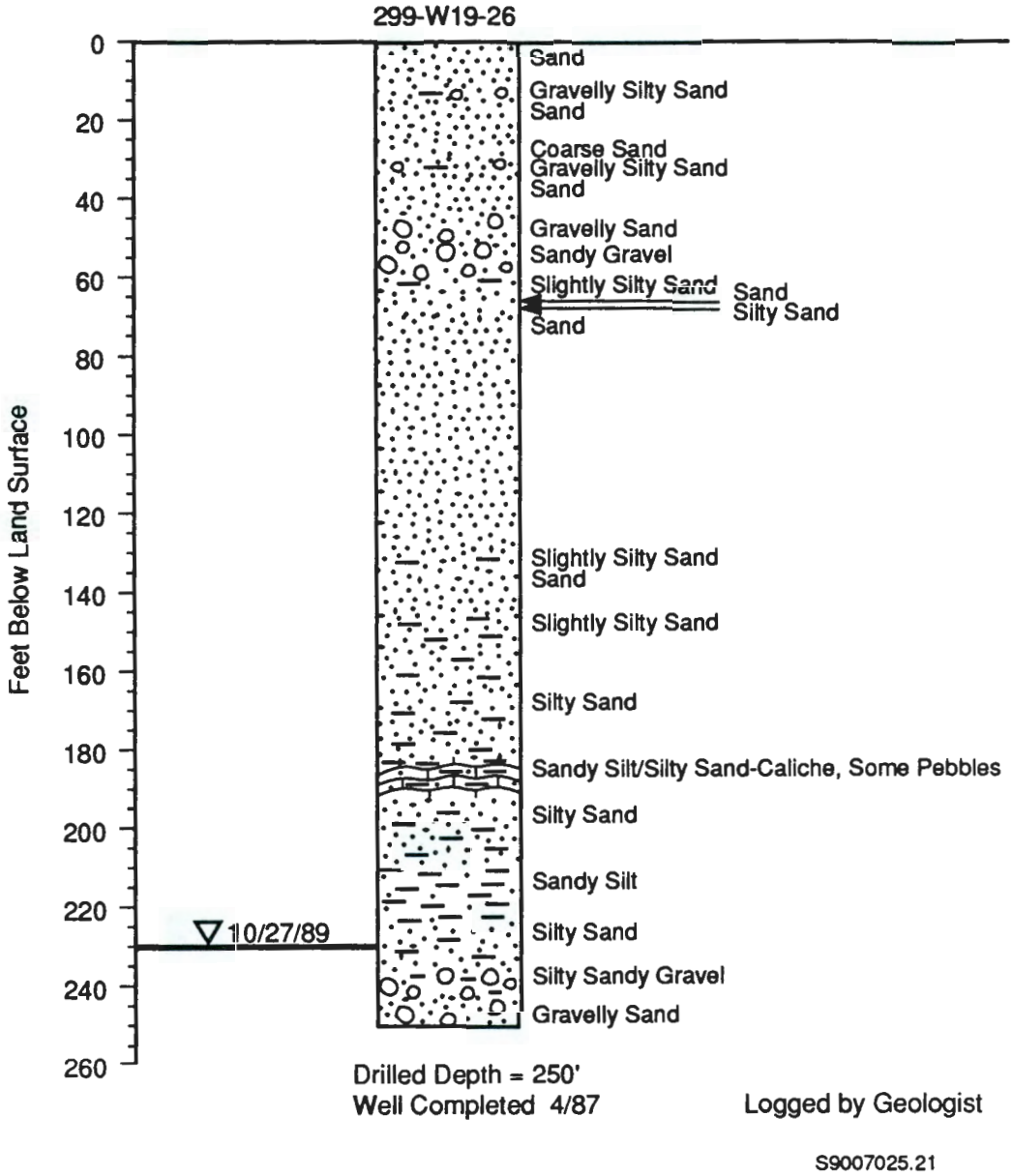


Figure 2.21-2. Lithology of Well 299-W19-26 at 216-U-17 Crib.



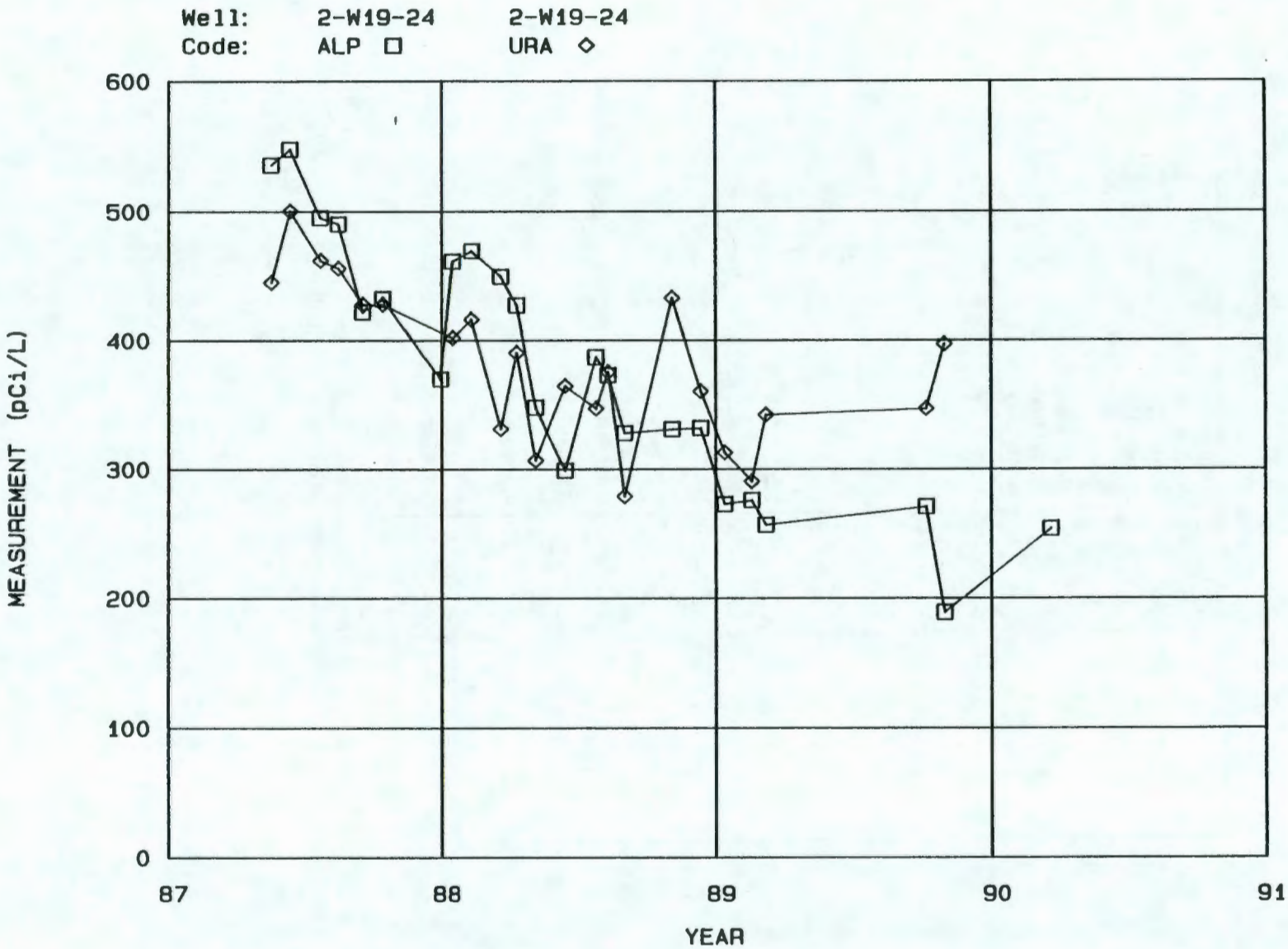


Figure 2.21-3. Time Series Plot of Uranium and Gross Alpha in Groundwater at the 216-U-17 Crib.

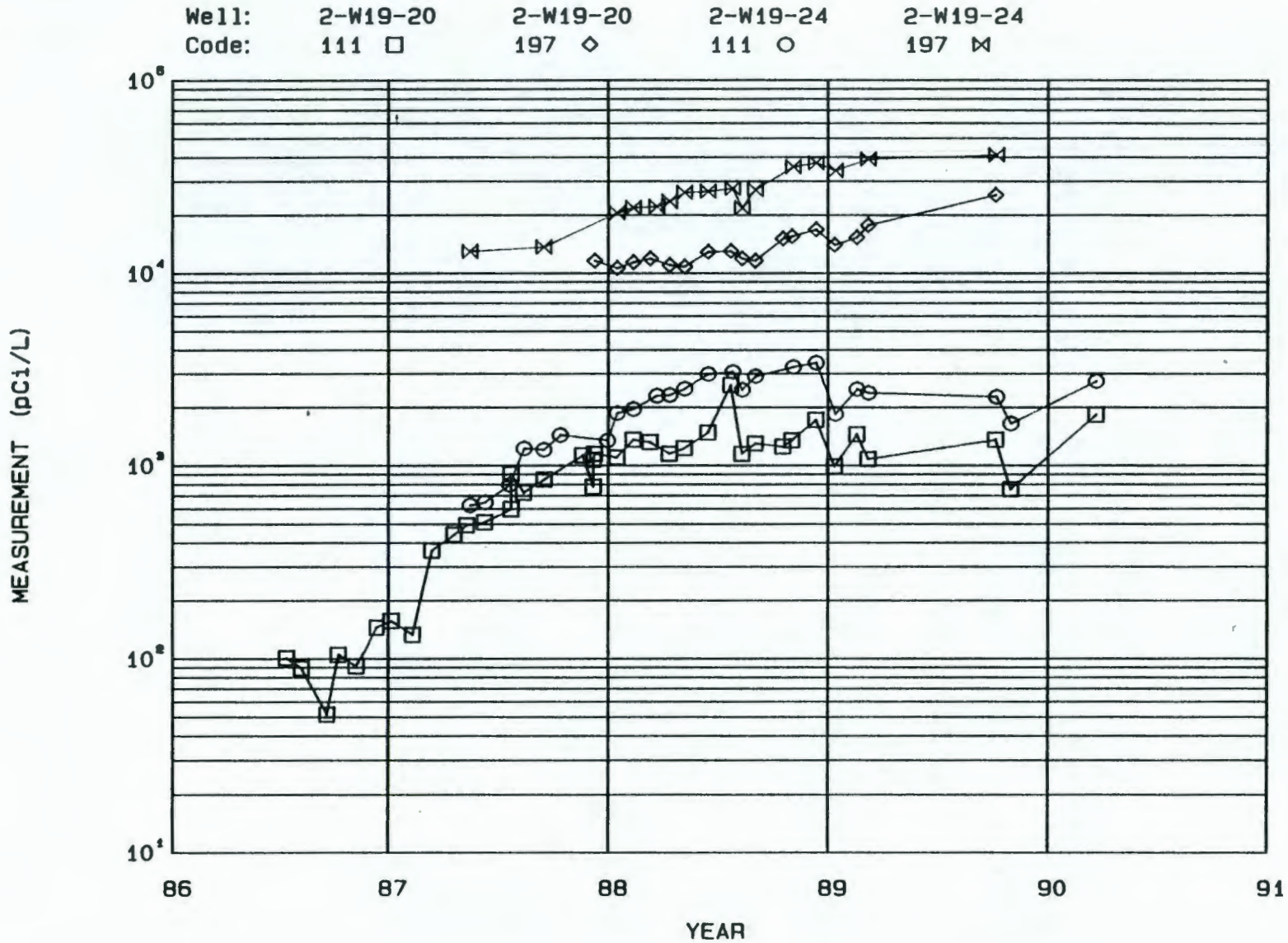


Figure 2.21-4. Time Series Plot of Technetium-99 and Gross Beta in Groundwater at the 216-U-17 Crib.

Table 2.21-1. Effluent Stream Description, UO_3 Plant Process Condensate.

Total volume of effluent discharged to subject receiving site: (WHC 1989a, WHC-EP-0287, Volume 3)	7.2E+05 L from 1/88 to 12/88 to 216-U-17 Crib
Average effluent discharge rate, by operating mode: (WHC 1990a, WHC-EP-0342, Addendum 19)	Calcination: approximately 9.18E+05 L/mo Standby: approximately 5.03E+04 L/mo
Current average effluent discharge rate: (WHC 1990a, WHC-EP-0342, Addendum 19)	None during repairs
Effluent designation: (WHC 1990a, WHC-EP-0342, Addendum 19)	Nondangerous, radioactive
Effluent status: (WHC 1990a, WHC-EP-0342, Addendum 19)	Currently inactive effluent during repairs. In standby mode.

Table 2.21-2. Effluent Stream Sampling Data, UO_3 Plant Process Condensate.

Key Constituents	Detection Limit[a]	Detection/ Analyses	Sample Concentration 90% CI[a]	Detection Limit[a]	Detection/ Analyses	Sample Concentration 90% CI[a]
	02/88, During Uranium Calcination			10/89 to 03/90, During Inactive Mode		
chromium	10	1/1	108	No Data		
mercury	0.1	1/1	8			
fluoride	50	1/1	24,700			
nitrate	500	1/1	15,200,000			
	08/86 to 08/88, During Standby			10/89 to 03/90, During Inactive Mode		
acetone	10	2/2	273	No Data		
nitrate	500	4/4	537,000			
	1981 to 1988, During All Modes[c]			10/89 to 03/90, During Inactive Mode		
hydrogen-3	5,000	14/NA	7,500,000	No Data		
strontium-90	30	11/NA	210			
uranium-isotopes[b]	20	78/NA	280,000			
americium-241	40	6/NA	280			
cesium-137	80	16/NA	330			
cobalt-60	NA	1/NA	420			
plutonium-239	NA	37/NA	13			

[a]Units: chemical--parts per billion
radionuclides--picocurie per liter.

[b]Uranium-234 Group A guideline used as the most restrictive for determination of key constituents.

[c]Disposal of effluent to the 216-U-17 Crib began in 1988; thus, data set includes some samples taken prior to 1988.

CI: confidence interval.
NA: not available.

Table 2-21-3a. Radionuclide and Chemical Loading, UO_3 Plant Process Condensate - Uranium Calcination.

Flow Rate: 9.18E+05 L/mo

Constituent	Kg/L*	Kg/mo*
barium	8.00E-09	7.34E-03
cadmium	2.00E-09	1.84E-03
chromium	1.08E-07	9.91E-02
fluoride	2.47E-05	2.27E+01
manganese	9.00E-09	8.26E-03
mercury	3.68E-09	3.38E-03
nickel	5.50E-08	5.05E-02
nitrate	1.52E-02	1.40E+04
phosphate	2.66E-04	2.44E+02
potassium	1.22E-02	1.12E+04
sodium	2.24E-05	2.06E+01
uranium	4.19E-07	3.85E-01
zinc	1.10E-08	1.01E-02
acetone	2.30E-08	2.11E-02
benzoic acid	1.40E-08	1.29E-02
1-butanol	5.00E-09	4.59E-03
2-butanone	1.20E-08	1.10E-02
2-butoxyethanol	5.80E-08	5.32E-02
butyl nitrate	4.40E-08	4.04E-02
trans-4-chlorocyclohexanol	7.80E-08	7.16E-02
methyl nitrate	6.60E-08	6.06E-02
2-methyl-5-propylnonane	5.00E-08	4.59E-02
nitroethane	4.30E-08	3.95E-02
n-nitrosodimethylamine	4.00E-08	3.67E-02
unknown	7.00E-09	6.43E-03
unknown aliphatic HC	9.80E-08	9.00E-02
alpha activity *	4.47E-10	4.10E-04
beta activity *	7.07E-09	6.49E-03
TOC	6.39E-06	5.87E+00
TOX (as Cl)	2.18E-08	2.00E-02

Footnotes:

Data collected during February 1988.

Flow rate is the average of rates from the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 19).

Constituent concentrations are average values from the statistics in the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 19).

Concentration units of flagged (*) constituents are reported as curies per liter.

Loading units of flagged (*) constituents are reported as curies per month.

Table 2-21-3b. Radionuclide and Chemical Loading, U03 Plant Process Condensate - Standby.

Flow Rate: 5.03E+04 L/mo

Constituent	Kg/L*	Kg/mo*
chloride	7.31E-07	3.68E-02
chromium	2.57E-08	1.29E-03
cyanide	1.67E-07	8.40E-03
fluoride	5.53E-07	2.78E-02
iron	4.50E-08	2.26E-03
mercury	1.25E-10	6.29E-06
nickel	2.15E-08	1.08E-03
nitrate	2.98E-04	1.50E+01
phosphate	1.41E-04	7.09E+00
potassium	3.64E-04	1.83E+01
sodium	7.10E-07	3.57E-02
sulfate	6.83E-05	3.44E+00
uranium	4.10E-08	2.06E-03
zinc	5.25E-09	2.64E-04
acetone	1.50E-07	7.54E-03
ammonia	7.37E-08	3.71E-03
9,10-anthracenedione	1.80E-08	9.05E-04
2-butanone	1.67E-08	8.40E-04
phenanthrene	2.15E-08	1.08E-03
unknown aliphatic HC	1.10E-08	5.53E-04
alpha activity *	2.62E-11	1.32E-06
beta activity *	5.40E-10	2.72E-05
TOC	8.94E-07	4.50E-02
TOX (as Cl)	6.98E-08	3.51E-03

Footnotes:

Data collected during March 1988, May 1988, June 1988 and August 1988.

Flow rate is the average of rates from the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 19).

Constituent concentrations are average values from the statistics in the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 19).

Concentration units of flagged (*) constituents are reported as curies per liter.

Loading units of flagged (*) constituents are reported as curies per month.

Constituents are flagged (#) if any detected result is less than any detection limit.

Table 2.21-4. Effluent Study Groundwater Summary Report. (Page 1 of 3)

CONSTITUENT			ANALYSIS SUMMARY					GROUP A STUDY GUIDELINES	
Group Name	Units	Detection Limit	Number of Analyses	Number > Det.	Average Result	Maximum Result	Minimum Result	Max Limit	Number > Limit
CONTAMINATION INDICATOR PARAMETERS									
Conductivity, Laboratory	UMHO	1.00	7	7	1721.29	2310.00	955.00	700.0	7
Specific conductance	UMHO	1.00	12	12	1802.83	2640.00	283.00	700.0	11
Total Organic Halogen, Low Det. Level	PPB	10.00	13	13	27.69	52.00	20.00		0
pH, Field Measurement		.10	12	12	7.47	7.69	7.18	8.5	0
pH, Laboratory Measurement		.01	7	7	7.44	7.60	7.30	8.5	0
DRINKING WATER PARAMETERS									
Alpha, High Detection Level	PCI/L	4.00	28	28	209.85	363.00	35.80	15.0	28
Barium	PPB	6.00	7	7	196.57	290.00	84.00	1000.0	0
Barium, filtered	PPB	6.00	12	12	198.92	279.00	66.00	1000.0	0
Cadmium	PPB	2.00	7	1	2.00	2.00	2.00	10.0	0
Chromium	PPB	10.00	7	3	15.43	47.00	10.00	50.0	0
Coliform bacteria	MPN	2.20	7	1	2.46	4.00	2.20	1.0	1
Fluoride	PPB	500.00	12	3	950.00	1700.00	500.00	4000.0	0
Gross alpha	PCI/L	4.00	5	5	209.72	285.00	94.60	15.0	5
Gross beta	PCI/L	8.00	33	33	1317.61	2770.00	134.00	50.0	33
Lead (graphite furnace)	PPB	5.00	7	1	6.57	16.00	5.00	50.0	0
Nitrate	PPB	500.00	13	13	834846.15	1300000.00	266000.00	45000.0	13
Nitrate, High Detection Level	PPB	2500.00	21	21	946190.48	1360000.00	330000.00	45000.0	21
Selenium	PPB	5.00	7	4	6.29	10.00	5.00	10.0	1
Selenium, filtered	PPB	5.00	7	3	6.00	9.00	5.00	10.0	0
GROUNDWATER QUALITY PARAMETERS									
Chloride	PPB	500.00	13	13	23907.69	36500.00	19000.00	250000.0	0
Iron	PPB	30.00	7	7	2225.14	7770.00	362.00	300.0	7
Iron, filtered	PPB	30.00	12	6	84.58	256.00	30.00	300.0	0
Manganese	PPB	5.00	7	3	7.29	13.00	5.00	50.0	0
Manganese, filtered	PPB	5.00	12	2	5.33	7.00	5.00	50.0	0
Sodium	PPB	200.00	7	7	40171.43	52100.00	28000.00		0
Sodium, filtered	PPB	200.00	12	12	41658.33	55100.00	26700.00		0
Sulfate	PPB	500.00	13	13	72715.38	121000.00	62000.00	250000.0	0

Table 2.21-4. Effluent Study Groundwater Summary Report. (Page 2 of 3)

CONSTITUENT			ANALYSIS SUMMARY					GROUP A STUDY GUIDELINES	
Group Name	Units	Detection Limit	Number of Analyses	Number > Det.	Average Result	Maximum Result	Minimum Result	Max Limit	Number > Limit
SITE SPECIFIC AND OTHER PARAMETERS									
Alkalinity		20000.00	1	1	121000.00	121000.00	121000.00		0
Boron	PPB	10.00	7	7	34.57	43.00	29.00		0
Boron, filtered	PPB	10.00	12	12	37.83	58.00	32.00		0
Calcium	PPB	50.00	7	7	226714.29	308000.00	108000.00		0
Calcium, filtered	PPB	50.00	12	12	234491.67	325000.00	90900.00		0
Carbon Tetrachloride by GC/MS	PPB	5.00	12	12	26.92	51.00	10.00	5.0	12
Chloroform	PPB	5.00	12	5	4.83	9.00	3.00	100.0	0
Copper	PPB	10.00	7	2	41.71	232.00	10.00	1000.0	0
Copper, filtered	PPB	10.00	12	2	10.33	14.00	10.00	1000.0	0
Cyanide	PPB	10.00	8	3	10.53	12.40	10.00		0
Fluoride, Low Detection Level	PPB	20.00	6	6	368.50	418.00	339.00	4000.0	0
Iodine-129 (Drinking Water Standard)	PCI/L	1.00	5	4	1.74	2.33	.89	20.0	0
Lithium	PPB	10.00	7	2	10.14	11.00	10.00		0
Lithium, filtered	PPB	10.00	12	7	10.42	12.00	10.00		0
Magnesium	PPB	50.00	7	7	77657.14	108000.00	32100.00		0
Magnesium, filtered	PPB	50.00	12	12	80141.67	114000.00	26700.00		0
Natural uranium	UG/L	.73	21	21	530.95	2900.00	165.00	59.0	21
Nickel	PPB	10.00	7	1	12.43	27.00	10.00		0
Nickel, filtered	PPB	10.00	12	1	10.17	12.00	10.00		0
Plutonium-238	PCI/L	.10	14	1	.02	.17	-.00	1.6	0
Plutonium-239/40	PCI/L	.10	14	1	.02	.12	-.00	1.2	0
Potassium	PPB	100.00	7	7	9437.14	11100.00	6470.00		0
Potassium, filtered	PPB	100.00	12	12	9518.33	11500.00	5680.00		0
Silicon	PPB	50.00	7	7	23785.71	25400.00	21500.00		0
Silicon, filtered	PPB	50.00	12	12	23058.33	28500.00	20000.00		0
Strontium	PPB	10.00	7	7	1158.29	1630.00	483.00		0
Strontium, filtered	PPB	10.00	12	12	1206.83	1690.00	391.00		0
Technetium-99	PCI/L	15.00	21	21	17363.06	41000.00	27.20	4000.0	16
Total carbon	PPB	1000.00	6	6	32400.00	34600.00	29800.00		0
Total dissolved solids		5000.00	7	7	1376142.86	1880000.00	609000.00	500000.0	7
Tritium	PCI/L	500.00	29	28	1906.72	3760.00	411.00	80000.0	0
Turbidity	NTU	.10	7	7	36.21	185.00	2.30	5.0	4

Table 2.21-4. Effluent Study Groundwater Summary Report. (Page 3 of 3)

CONSTITUENT			ANALYSIS SUMMARY					REGULATORY STANDARDS	
Group Name	Units	Detection Limit	Number of Analyses	Number > Det.	Average Result	Maximum Result	Minimum Result	Max Limit	Number > Limit
SITE SPECIFIC AND OTHER PARAMETERS									
Uranium	PCI/L	.50	7	7	250.21	547.00	2.04	40.0	5
Uranium-234	PCI/L	.10	17	17	161.84	465.00	67.90	20.0	17
Uranium-235	PCI/L	.10	17	17	8.92	29.30	3.10	24.0	1
Uranium-238	PCI/L	.10	17	17	165.64	484.00	70.50	24.0	17
Vanadium	PPB	5.00	7	7	16.86	30.00	10.00		0
Vanadium, filtered	PPB	5.00	12	12	11.58	16.00	9.00		0
Zinc	PPB	5.00	7	7	139.14	542.00	8.00	5000.0	0
Zinc, filtered	PPB	5.00	12	12	77.92	429.00	6.00	5000.0	0

Table 2.21-5. Background Comparison, 216-U-17 Crib.

Constituent	Background[a]	Average/ Background[b]	Maximum/ Background[b]
aluminum	2.0		
ammonia	50.0		
arsenic	6.3		
barium	62.0	3.17 (3.21)	4.68 (4.50)
beryllium	0.3		
bismuth	0.02		
boron	50.0	0.69 (0.76)	0.86 (1.16)
cadmium	0.2	10.0	10.0
calcium	50,700	4.47 (4.63)	6.07 (6.41)
chloride	16,800	1.42	2.17
chromium	6.0	2.57	7.83
copper	1.0	41.71 (10.33)	232.00 (14.00)
cyanide	10.0	1.05	1.24
fluoride	470	2.02	3.62
lead	0.5	13.14	32.00
magnesium	15,200	5.11 (5.27)	7.11 (7.50)
manganese	12.0	0.61 (0.44)	1.08 (0.58)
mercury	0.1		
nickel	4.0	3.11 (2.54)	6.75 (3.00)
phosphate	1,000		
potassium	6,190	1.52 (1.54)	1.79 (1.86)
selenium	2.0	3.15 (3.00)	5.00 (4.50)
silver	10		
sodium	28,410	1.41 (1.47)	1.83 (1.94)
strontium	338	3.43 (3.57)	4.82 (5.00)
sulfate	51,200	1.42	2.36
uranium	2.5	100.08	218.80
vanadium	26	0.65 (0.45)	1.15 (0.62)
zinc	8.0	17.39 (9.74)	67.75 (53.63)
alkalinity	144,000	0.84	0.84
pH	7.8	0.95	0.99
TOC	933		
conductivity	462	3.90	5.00
gross alpha	3.9	53.77	73.08
gross beta	31	42.50	89.35
radium	0.2		

TOC: total organic carbon. ( ): filtered samples.

[a]Background is the mean plus one standard deviation for the values listed in Table 2-1. Amounts of uranium, gross alpha, gross beta, and radium given in picocuries per liter. All others are in parts per billion.

[b]Average and maximum values from Table 2.21-4.

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2.22 216-W-LC CRIB (Laundry Crib)

No adverse impact of continued, near-term use of this crib is evident on the basis of the flow and transport analysis. The groundwater quality assessment for this site is incomplete.

2.22.1 Receiving Site Description

The 216-W-LC Crib, located in the 200 West Area, was constructed in 1981 to dispose of wastewater from the laundry complex (2724-W). The monitoring well location and spatial relationship to other facilities are shown in Figure 2.22-1.

2.22.2 Effluent Stream Description

The 2724-W laundry complex consists of a series of buildings where soiled protective work clothing used on the Hanford Site is cleaned. Two-thirds of the clothing handled is radioactively contaminated. The decontamination station in the Mask Cleaning and Maintenance Facility is also connected to the crib, but operations there were only conducted during a 6-wk demonstration project in October 1986. Table 2.22-1 summarizes information pertaining to the effluent stream. Key constituent sampling data are given in Table 2.22-2. Loading estimates are provided in Table 2.22-3.

The sampling data show that Group A or C study guidelines were exceeded for chloroform, fluoride, several metals, and several radionuclides. Both old and new data sets show elevated concentrations of about the same order of magnitude for most of the constituents. A new laundry facility is planned for operation after 1995, at which time the effluent will no longer be disposed to this crib.

2.22.3 Flow and Transport Analysis

For transport calculation purposes, the sediment column beneath the crib is treated as a four-layer system of 72 m depth (Figure 2.22-2 and Appendix B). The calculated travel time for wastewater to reach the water table under average discharge conditions is 211 days.

Based on general effluent characteristics and corresponding sorption parameters (Appendix C) for the key constituents identified in Table 2.22-2, the calculated rates of migration (Appendix B) range from about 34 cm/day for mobile constituents (chloroform, chromium, and fluoride) to several centimeters per day (manganese, cobalt-60, and iron) to fractions of 1 cm/day for relatively immobile constituents (cadmium, lead, cesium-137, aluminum, isotopic plutonium, radium-228, barium, and strontium-90).

The above migration rate estimates indicate very long travel times for most of the key constituents (several years to tens of years, Appendix B). Thus, except for mobile constituents (chloroform, chromium, and fluoride), the depth of additional migration would be very minor over the next few years.

2.22.4 Groundwater Quality Assessment

Table 2.22-4 summarizes effluent study groundwater analysis results. Well casing corrosion products and related metals were the only constituents exceeding Group A study guidelines. These occurrences are thought to be sampling artifacts associated with unfiltered, bailed samples from carbon steel wells (WHC 1990d). Other metals are also above Group B guidelines or background (Table 2.22-5). Not all of these, however, appear to be due to simple corrosion of carbon steel (see WHC 1990d). In any event, additional sampling and/or well remediation or replacement is needed before reliable samples for metal analyses can be obtained at this site.

Of the key constituents that were detected in groundwater, all were metals which appear to be well casing-related or sampling artifacts. As noted above, followup sampling after well remediation or replacment will be needed to confirm this explanation.

In addition to the above considerations, it is noteworthy that chloroform was not detected in groundwater even though its estimated travel time is less than 1 yr (Appendix B). This constituent (unlike chromium) should not be affected by the sampling and well construction problems noted above for the metal results.

2.22.5 Impact of Continued Operation

The discharge rate to this crib is insignificant in relation to the natural recharge from Cold Creek. Thus, no major impact on the groundwater flow regime is expected.

Because of the extremely limited sampling results obtained for this study, the impact on groundwater quality from past crib operations cannot be adequately assessed. However, assuming the explanations provided above are valid, and that no major changes in wastewater composition occur in the future, no adverse impact is expected from continued operation. Improved groundwater monitoring facilities at this site would be needed to confirm this preliminary conclusion.

Remobilization of previous loading retained on the soil column is not expected to be significant (Section 2.22-3).

Figure 2.22-1. Well Location and Site Map for 216-W-LC Crib.

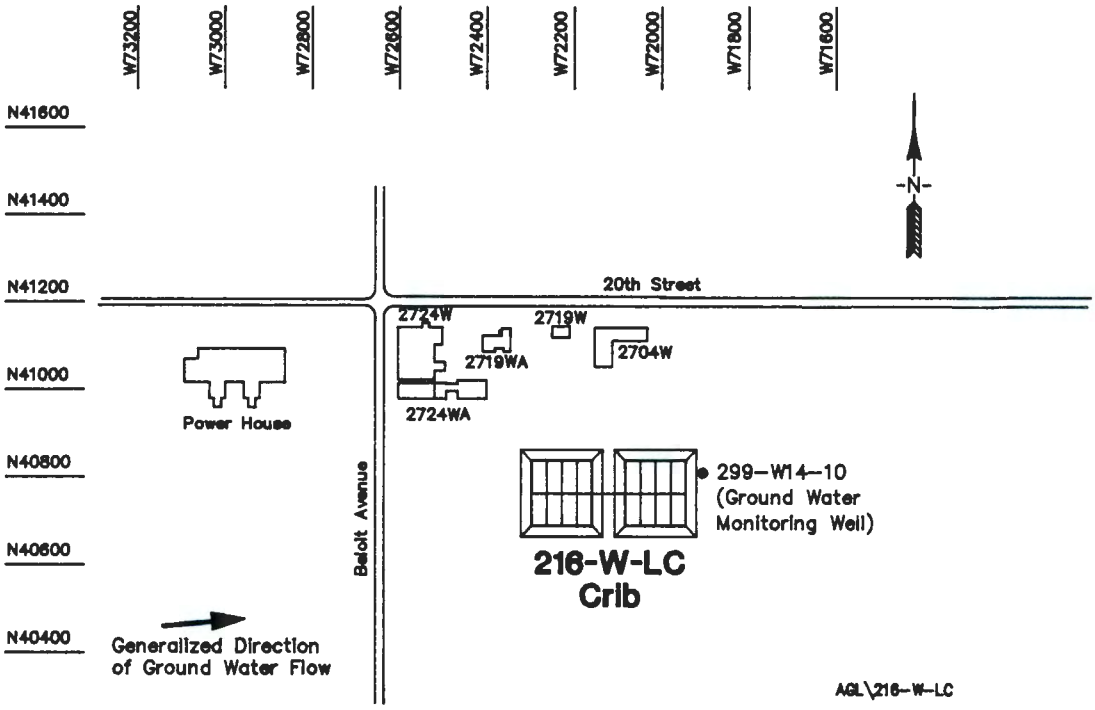

Figure 2.22-2. Lithology of Well 299-W14-10 at 216-W-LC Crib.

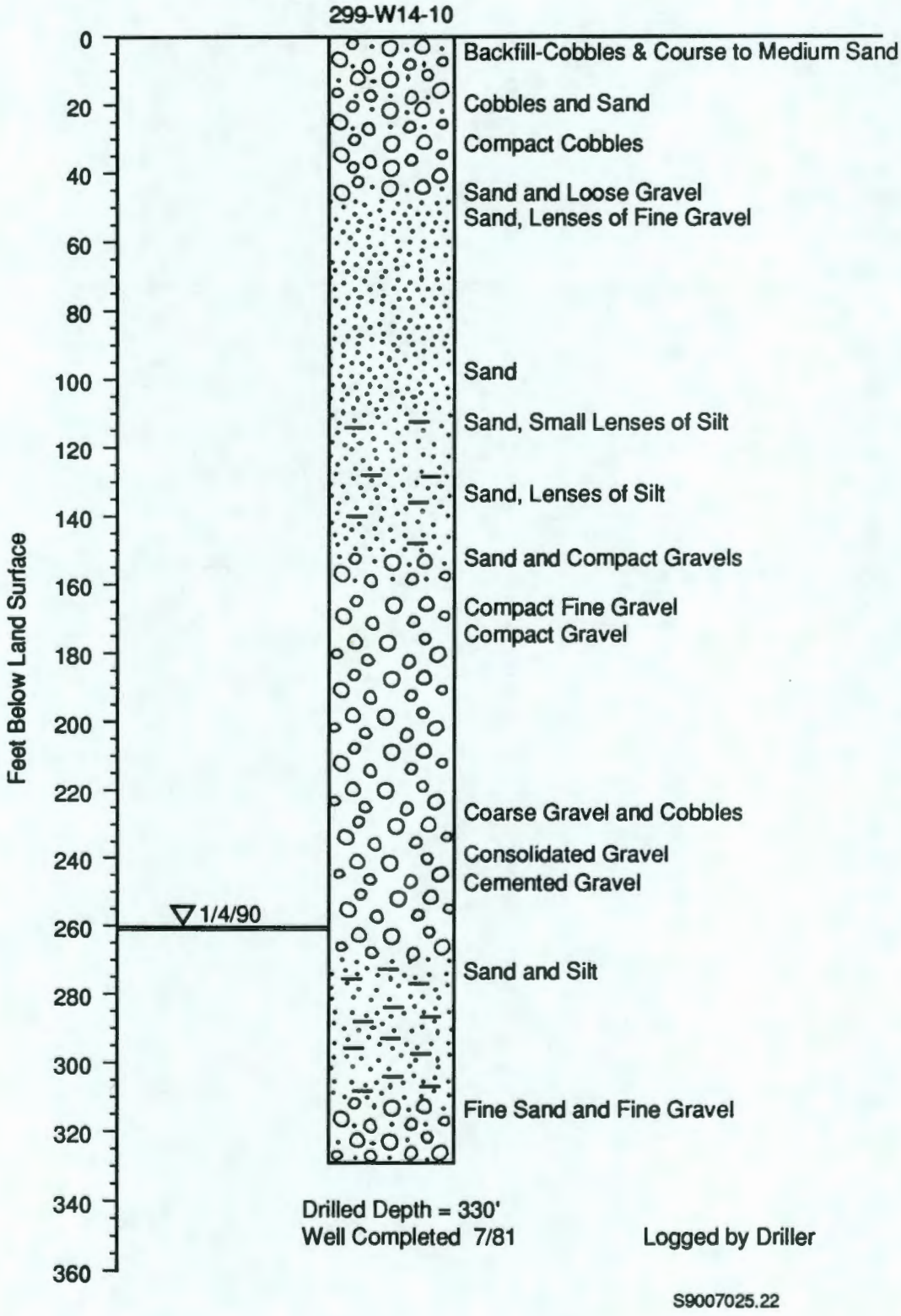

Table 2.22-1. Effluent Stream Description, 2724-W Laundry Wastewater.

Total volume of effluent discharged to subject receiving site: (WHC 1989a, WHC-EP-0287, Volume 2)	1.58E+09 L from 1/76 to 12/88
Average effluent discharge rate, by operating mode: (WHC 1990a, WHC-EP-0342, Addendum 11)	Approximately 5.2E+05 to 9.5E+05 gal/mo from 1981 to 1989
Current average effluent discharge rate: (WHC 1990a, WHC-EP-0342, Addendum 11)	2.61E+06 L/mo
Effluent designation: (WHC 1990a, WHC-EP-0342, Addendum 11)	Nondangerous, radioactive
Effluent status: (WHC 1990a, WHC-EP-0342, Addendum 11)	Active discharge to 216-W-LC Crib

Table 2.22-2. Effluent Stream Sampling Data, 2724-W Laundry Wastewater.

Key Constituents	Detection Limit[a]	Detection/ Analyses	Sample Concentration 90% CI[a]	Detection Limit[a]	Detection/ Analyses	Sample Concentration 90% CI[a]
	06/86 to 01/87, During Routine Operation			10/89 to 03/90, During Routine Operation		
barium	6	4/4	230	6	4/4	1,260
chromium	10	4/4	47	10	2/4	64
fluoride	50	3/4	45,000	50	4/4	1,070[b]
aluminum	NA	4/4	1,400	NA	4/4	3,810
cadmium	2	3/4	12	2	2/4	22
chloroform	5	3/4	140	5	4/4	67[b]
iron	NA	4/4	6,900	NA	4/4	11,700
lead	5	3/4	130	5	4/4	226
manganese	5	4/4	76	5	4/4	134
	1976 to 1988, During Routine Operation			10/89 to 03/90, During Routine Operation		
cobalt-60	60	17/NA	1,200	1	3/4	545
cesium-137	80	94/NA	590	1	3/4	357
plutonium-239/240	50	66/NA	4	0.001	4/4	395
radium-228	NA	ND	ND	NA	1/4	250
strontium-90	30	113/NA	330	0.1	4/4	3,220
uranium (isotopes)[c]	20	10/NA	170	NA	4/4	320[d]
americium-241	40	14/NA	49	0.001	2/3	116
plutonium-238	NA	ND	ND	0.001	4/4	34
lead-210	NA	ND	ND	NA	2/4	2

[a]Units: chemical--parts per billion
radionuclides--picocurie per liter.

CI: confidence interval.
NA: not available.
ND: not detected.

[b]Concentrations below Group A and C guidelines; values given for comparison purposes.

[c]Uranium-234 Group A guideline used as the most restrictive for determination of key constituents.

[d]Consists of 142 pCi/L uranium-234 and 15 pCi/L uranium-235 and 163 pCi/L uranium-238.

Table 2.22-3. Radionuclide and Chemical Loading, 2724-W Laundry Wastewater.

Flow Rate: 2.61E+06 L/mo

Constituent	Kg/L*	Kg/mo*
aluminum	1.76E-06	4.60E+00
arsenic	6.25E-09	1.63E-02
barium	5.44E-07	1.42E+00
boron	1.26E-07	3.29E-01
cadmium	1.05E-08	2.75E-02
calcium	2.13E-05	5.57E+01
chloride	1.51E-05	3.95E+01
chromium	3.20E-08	8.37E-02
copper	2.23E-07	5.83E-01
cyanide	2.65E-08	6.93E-02
fluoride	7.15E-07	1.87E+00
iron	5.06E-06	1.32E+01
lead	1.08E-07	2.82E-01
lithium	4.45E-07	1.16E+00
magnesium	5.98E-06	1.56E+01
manganese	6.65E-08	1.74E-01
mercury	3.10E-10	8.10E-04
nickel	4.85E-08	1.27E-01
nitrate	1.37E-06	3.58E+00
phosphate	9.31E-05	2.43E+02
potassium	9.34E-06	2.44E+01
silicon	2.72E-05	7.11E+01
sodium	1.09E-04	2.85E+02
strontium	1.11E-07	2.90E-01
sulfate	1.77E-05	4.63E+01
sulfide	1.40E-06	3.66E+00
titanium	1.80E-07	4.71E-01
uranium	1.13E-07	2.95E-01
vanadium	8.00E-09	2.09E-02
zinc	6.08E-07	1.59E+00
acetone	1.40E-08	3.66E-02
ammonia	1.82E-05	4.76E+01
benzoic acid	1.54E-07	4.03E-01
benzyl alcohol	1.43E-07	3.74E-01
bis(2-ethylhexyl) phthalate	7.15E-08	1.87E-01
1-butoxy-2-propanol	1.20E-07	3.14E-01
butylbenzyl phthalate	3.95E-08	1.03E-01
di-n-octyl phthalate	1.11E-07	2.90E-01
hydrazine	5.32E-08	1.39E-01
phthalic anhydride	1.20E-08	3.14E-02
trichloromethane	3.32E-08	8.68E-02
unknown	5.52E-08	1.44E-01
unknown acid	2.20E-08	5.75E-02
unknown aliphatic alcohol	1.60E-08	4.18E-02
unknown aliphatic HC	2.42E-08	6.33E-02
unknown amine	2.10E-08	5.49E-02
unknown fatty acid	1.59E-07	4.16E-01
unknown glycol	9.20E-08	2.41E-01
unknown hydrocarbon	9.00E-08	2.35E-01
unknown phthalate	4.70E-08	1.23E-01
unknown polycyclic HC	5.40E-08	1.41E-01
unknown sulfur compound	1.30E-08	3.40E-02
alpha activity *	2.09E-10	5.46E-04
beta activity *	1.66E-09	4.34E-03
suspended solids	1.53E-04	4.00E+02
TDS	4.95E-04	1.29E+03
TOC	4.86E-05	1.27E+02
TOX (as Cl)	1.10E-04	2.88E+02
Total Carbon	4.21E-07	1.10E+00
americium-241 *	4.41E-11	1.15E-04
curium-244 *	6.05E-13	1.58E-06
cobalt-60 *	2.93E-10	7.66E-04
cesium-137 *	1.70E-10	4.44E-04
hydrogen-3 *	1.27E-09	3.32E-03
manganese-54 *	4.04E-11	1.06E-04
sodium-22 *	8.88E-11	2.32E-04
lead-210 *	1.22E-12	3.19E-06
plutonium-238 *	1.76E-11	4.60E-05
plutonium-239/240 *	2.04E-10	5.33E-04
radium total *	7.51E-13	1.96E-06
radium-228 *	2.50E-10	6.54E-04
ruthenium-106 *	3.27E-11	8.55E-05
strontium-90 *	1.46E-09	3.82E-03
uranium-234 *	5.84E-11	1.53E-04
uranium-235 *	5.96E-12	1.56E-05
uranium-238 *	6.60E-11	1.73E-04

Footnotes:

Data collected from October 1989 through March 1990.

Flow rate is the average of rates from the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 11).

Constituent concentrations are average values from the statistics in the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 11).

Concentration units of flagged (*) constituents are reported as curies per liter.

Loading rate units of flagged (*) constituents are reported as curies per month.

Table 2.22-4. Effluent Study Groundwater Summary Report. (Page 1 of 2)

Groundwater Analysis Results for 216-W-LWC Crib (1989-1990)

CONSTITUENT			ANALYSIS SUMMARY					GROUP A STUDY GUIDELINES	
Group Name	Units	Detection Limit	Number of Analyses	Number > Det.	Average Result	Maximum Result	Minimum Result	Max Limit	Number > Limit
CONTAMINATION INDICATOR PARAMETERS									
Conductivity, Laboratory	UMHO	1.00	2	2	384.50	409.00	360.00	700.0	0
Specific conductance	UMHO	1.00	2	2	411.00	471.00	351.00	700.0	0
Total Organic Halogen, Low Det. Level	PPB	10.00	2	2	23.00	26.00	20.00		0
Total organic carbon	PPB	2000.00	1	1	2800.00	2800.00	2800.00		0
pH, Field Measurement		.10	2	2	8.64	9.00	8.28	8.5	1
pH, Laboratory Measurement		.01	2	2	8.60	8.70	8.50	8.5	2
DRINKING WATER PARAMETERS									
Barium	PPB	6.00	1	1	49.00	49.00	49.00	1000.0	0
Cadmium	PPB	2.00	1	1	13.00	13.00	13.00	10.0	1
Chromium	PPB	10.00	1	1	16.00	16.00	16.00	50.0	0
Gross beta	PCI/L	8.00	2	2	16.85	20.30	13.40	50.0	0
Lead (graphite furnace)	PPB	5.00	1	1	33.00	33.00	33.00	50.0	0
Nitrate	PPB	500.00	2	1	7400.00	14300.00	500.00	45000.0	0
GROUNDWATER QUALITY PARAMETERS									
Chloride	PPB	500.00	2	2	22450.00	22500.00	22400.00	250000.0	0
Iron	PPB	30.00	1	1	37700.00	37700.00	37700.00	300.0	1
Manganese	PPB	5.00	1	1	432.00	432.00	432.00	50.0	1
Sodium	PPB	200.00	1	1	32500.00	32500.00	32500.00		0
Sulfate	PPB	500.00	2	2	62400.00	63900.00	60900.00	250000.0	0
SITE SPECIFIC AND OTHER PARAMETERS									
Aluminum	PPB	150.00	1	1	2030.00	2030.00	2030.00	50.0	1
Ammonium ion	PPB	50.00	1	1	94.00	94.00	94.00		0
Bis(2-ethylhexyl) phthalate	PPB	10.00	1	1	15.00	15.00	15.00		0
Bisphenol A	PPB		1	1	42.00	42.00	42.00		0
Boron	PPB	10.00	1	1	587.00	587.00	587.00		0
Calcium	PPB	50.00	1	1	21500.00	21500.00	21500.00		0
Copper	PPB	10.00	1	1	78.00	78.00	78.00	1000.0	0
DDT	PPB	.10	1	1	.10	.10	.10		0
Magnesium	PPB	50.00	1	1	17300.00	17300.00	17300.00		0

Table 2.22-4. Effluent Study Groundwater Summary Report. (Page 2 of 2)

Groundwater Analysis Results for 216-W-LWC Crib (1989-1990)

CONSTITUENT			ANALYSIS SUMMARY					GROUP A STUDY GUIDELINES	
Group Name	Units	Detection Limit	Number of Analyses	Number > Det.	Average Result	Maximum Result	Minimum Result	Max Limit	Number > Limit
SITE SPECIFIC AND OTHER PARAMETERS									
Nickel	PPB	10.00	1	1	19.00	19.00	19.00		0
Nitrite	PPB	1000.00	2	1	1100.00	1200.00	1000.00	3300.0	0
Potassium	PPB	100.00	1	1	9290.00	9290.00	9290.00		0
Silicon	PPB	50.00	1	1	11300.00	11300.00	11300.00		0
Silver-110 Metastable	PCI/L		1	1	5.38	5.38	5.38	400.0	0
Strontium	PPB	10.00	1	1	93.00	93.00	93.00		0
Titanium	PPB	60.00	1	1	193.00	193.00	193.00		0
Total carbon	PPB	1000.00	1	1	20400.00	20400.00	20400.00		0
Tritium	PCI/L	500.00	2	2	1310.00	1400.00	1220.00	80000.0	0
Turbidity	NTU	.10	1	1	33.00	33.00	33.00	5.0	1
Uranium	PCI/L	.50	1	1	1.10	1.10	1.10	40.0	0
Vanadium	PPB	5.00	1	1	9.00	9.00	9.00		0
Zinc	PPB	5.00	1	1	404.00	404.00	404.00	5000.0	0

Table 2.22-5. Background Comparison, 216-W-LC Crib.

Constituent	Background[a]	Average/ Background[b]	Maximum/ Background[b]
aluminum	2.0	1,015.00	1,015.00
ammonia	50.0	1.88	1.88
arsenic	6.3		
barium	62.0	0.79	0.79
beryllium	0.3		
bismuth	0.02		
boron	50.0	11.74	11.74
cadmium	0.2	65.0	65.0
calcium	50,700	0.42	0.42
chloride	16,800	1.34	1.34
chromium	6.0	2.67	2.67
copper	1.0	78.00	78.00
cyanide	10.0		
fluoride	470		
lead	0.5	66.00	66.00
magnesium	15,200	1.14	1.14
manganese	12.0	36.00	36.00
mercury	0.1		
nickel	4.0	4.75	4.75
phosphate	1,000		
potassium	6,190	1.50	1.50
selenium	2.0		
silver	10		
sodium	28,410	1.14	1.14
strontium	338	0.28	0.28
sulfate	51,200	1.22	1.25
uranium	2.5	0.44	0.44
vanadium	26	0.35	0.35
zinc	8.0	50.50	50.50
alkalinity	144,000		
pH	7.8	1.11	1.15
TOC	933	3.00	3.00
conductivity	462	0.89	1.02
gross alpha	3.9		
gross beta	31	0.54	0.65
radium	0.2		

TOC: total organic carbon. ( ): filtered samples.

[a]Background is the mean plus one standard deviation for the values listed in Table 2-1. Amounts of uranium, gross alpha, gross beta, and radium given in picocuries per liter. All others are in parts per billion.

[b]Average and maximum values from Table 2.22-4.

2.23 216-Z-20 CRIB

Based primarily on flow and transport calculations, no significant additional impacts to soil and groundwater quality are likely due to interim use of this crib.

2.23.1 Receiving Site Description

The 216-Z-20 Crib, located in the 200 West Area, was constructed in 1981 to dispose of liquid effluents from the PFP. Figure 2.23-1 depicts the location of groundwater monitoring wells and the crib relative to other facilities in the vicinity.

2.23.2 Effluent Stream Description

Production operations at the Plutonium Finishing Plant (PFP) Complex consist of plutonium reclamation and plutonium conversion. The Plutonium Reclamation Facility (PRF) reclaims plutonium for recovery as plutonium nitrate. Plutonium nitrate is converted to metallic plutonium in the Remote Mechanical C (RMC) line. The wastewater stream disposed to 216-Z-20 Crib is contributed by drinking fountains, cooling water, steam condensate, air conditioning condensate, chemical laboratory sinks, nonradiological laboratory sinks in radiation zones, wound flushing stations, eyewash stations, safety showers, floor drains, roof drains, and storm sewers. The bulk of the wastewater is equipment cooling water and HVAC steam condensate. Table 2.23-1 summarizes information pertaining to the effluent stream.

Sampling data represent three modes of operation: (1) operation of the PRF, (2) operation of the RMC line, and (3) operations of both PRF and RMC and operations where neither the PRF or RMC lines are active (referred to as "other"). All modes were functioning during the collection of old sampling data. During the new data sampling period, the "other" mode was the only process configuration functioning.

Old sampling data show that Group A or C study guidelines have been exceeded for acetone, aluminum, and several radionuclides for all modes of operation (Table 2.23-2). Note that the crib was placed in service in 1981 but the old data set includes samples taken prior to 1981. New sampling data for the "other" mode shows only traces of acetone and radionuclides (below study guidelines), although the new data set shows plutonium-239 in a concentration above Group A study guidelines.

2.23.3 Flow and Transport Analysis

For transport calculation purposes, the sediment column beneath the crib is treated as a three-layer system of 60 m depth (Figure 2.23-2 and Appendix B). The calculated travel time for wastewater to reach the water table under average discharge conditions is 121 days (see Appendix B for data and computations).

Based on general effluent characteristics and corresponding sorption parameters (Appendix C) for key constituents identified in Tables 2.23-2 and 2.23-3, calculated rates of migration range from about 50 cm/day for mobile constituents (acetone) to fractions of 1 cm/day for the relatively immobile

radionuclides (Appendix B). These calculations indicate that breakthrough is not likely for immobile constituents. Acetone, a mobile constitutent, is expected to largely be degraded before reaching groundwater (Appendix C).

2.23.4 Groundwater Quality Assessment

A summary of all positive results obtained for analyses of groundwater samples taken from two monitoring wells at the 216-Z-20 Crib are shown in Table 2.23-4. Of those constituents that exceed Group A study guidelines, none were key effluent constituents. The cadmium, chromium, iron, manganese, and aluminum are judged to be an artifact of sampling and not related to operation of the discharge facility (WHC 1990d). For example, wells at this facility have carbon steel casings and were not equipped with dedicated submersible sample pumps (i.e., only unfiltered samples were initially obtained with a bailer). A followup resampling effort for this study conducted on April 20, 1990, at one of the two wells (2-W18-17), involved installation of a temporary submersible pump and time series sampling for selected constituents (trace metals and plutonium) during purgewater removal. This study showed that the indicated metals and turbidity declined significantly during removal of purgewater. Filtered samples at the end of the purgewater removal did not exceed the guidelines for these metals although the unfiltered results for at least iron were still above guidelines. Additionally, all plutonium results were below the detection limit of 0.1 pCi/L.

Chlorinated hydrocarbons, on the other hand, increased significantly after sampling with the temporary submersible pump. This is probably because the bailer collects only the upper, more stagnant portion of the water column in the well. Thus, the higher values obtained and reported in Table 2.23-4 are probably more representative of formation water conditions at this site.

The other positive results indicated in Table 2.23-4 are within expected ranges of background for the Hanford Site with the possible exceptions of nitrate (maximum of 24 ppm), lead, and chromium. The nitrate is a ubiquitous contaminant in the 200 Areas from past operations and the lead and chromium are judged to be an artifact of sampling, i.e., unfiltered samples with high turbidity (WHC 1990d).

The only significant contaminant occurrences in groundwater beneath the subject crib are the chlorinated hydrocarbons (carbon tetrachloride, chloroform, and trichloroethylene). While these constituents have been detected in PFP wastewater (WHC 1989 and WHC 1990a), only chloroform, an expected constituent in this wastestream, has been reported as consistently present (up to 33 ppb). The relatively high concentration of carbon tetrachloride shown in Table 2.23-4 (maximum of 2,000 ppb) is most likely a result of past operations (Serkowski et al. 1989, Jacquish and Bryce 1989 and Evans et al. 1990) at disposal facilities upgradient from the 216-Z-20 Crib (e.g., from the now inactive 216-Z-18 and Z-1A cribs, and possibly others). All that can be concluded is that the observed maximum value of 204 ppb of chloroform in groundwater beneath the 216-Z-20 Crib is a result of both past operations (chloroform is generally found with carbon tetrachloride occurrences) and current trace inputs from treated surface water supplies from PFP operations. Since the maximum concentration of chloroform is only about two times higher than study guidelines and because there are multiple sources

of this constituent (i.e., both past practice and current operations), this occurrence is judged not to be significant for decision tree evaluation purposes.

Analyses of the groundwater collected from wells in the vicinity of PFP and the 216-Z-20 Crib do not show an adverse impact on the groundwater from chemicals and radionuclides associated with the operation of the liquid waste disposal facility. The addition of radiological and chemical constituents from the waste stream may result in, on a per kilogram basis, constituents being added to the groundwater system beneath the 200 West Area. However, the net impact, on a concentration basis, may actually result in a dilution when comparing effluent water quality to upgradient groundwater quality.

2.23.5 Impact of Continued Operation

Both current and past discharge rates to this crib are less than the Cold Creek recharge rate; thus, no impact on the groundwater flow regime beyond the immediate vicinity of the crib is expected.

There may, however, be some potential for a development of a perched water zone due to the fine sediment/caliche layer(s) commonly encountered in the 200 West Area.

Based on the current assessment of groundwater characterization results for this study (Section 2.23.4) and assuming no major change in waste stream composition in the future, there is no compelling evidence suggesting that continued operation of this crib would have an adverse impact on groundwater quality. Improved monitoring wells, however, are needed to eliminate false positive results for various metals.

Available chemical and radiological loading information, and soil gamma logs (WHC 1989, Vol. 3), suggest only minor possible contaminant loads on the soil column beneath this crib. Additionally, most of the key constituents identified for this site migrate very slowly through the soil column (a few centimeters per day based on the very conservative wastewater travel time at the 10 L/sec discharge rate). A possible exception is acetone; however, the environmental degradation rate (10-day half-time) indicated for this constituent (Appendix C) suggests it would decompose before reaching groundwater.

Assuming unfavorable conditions that could modify the soil retention properties do not occur in the future, remobilization is judged to be a minor possible impact at this site.

It is noted that a nitric acid spill of approximately 7,600 lb occurred at this site in 1984 (WHC 1989a, Vol. 3). However, it is highly likely that the acid reacted with the carbonate in the soil. For example, assuming an average soil/sediment carbonate content of 1% (a typical value for Hanford sediments), a 1-m depth increment beneath the crib area of 1,380 m^2 would contain approximately 270 kmol of $CaCO_3$. The 7,600 lb of HNO_3 represents approximately 54 kmol. Stoichiometrically, it would require only 27 kmol of $CaCO_3$ to react with 54 kmol of nitric acid. Thus, the depth increment potentially influenced by this spill should be very minor.

Figure 2.23-1. Well Location and Site Map for 216-Z-20 Crib.

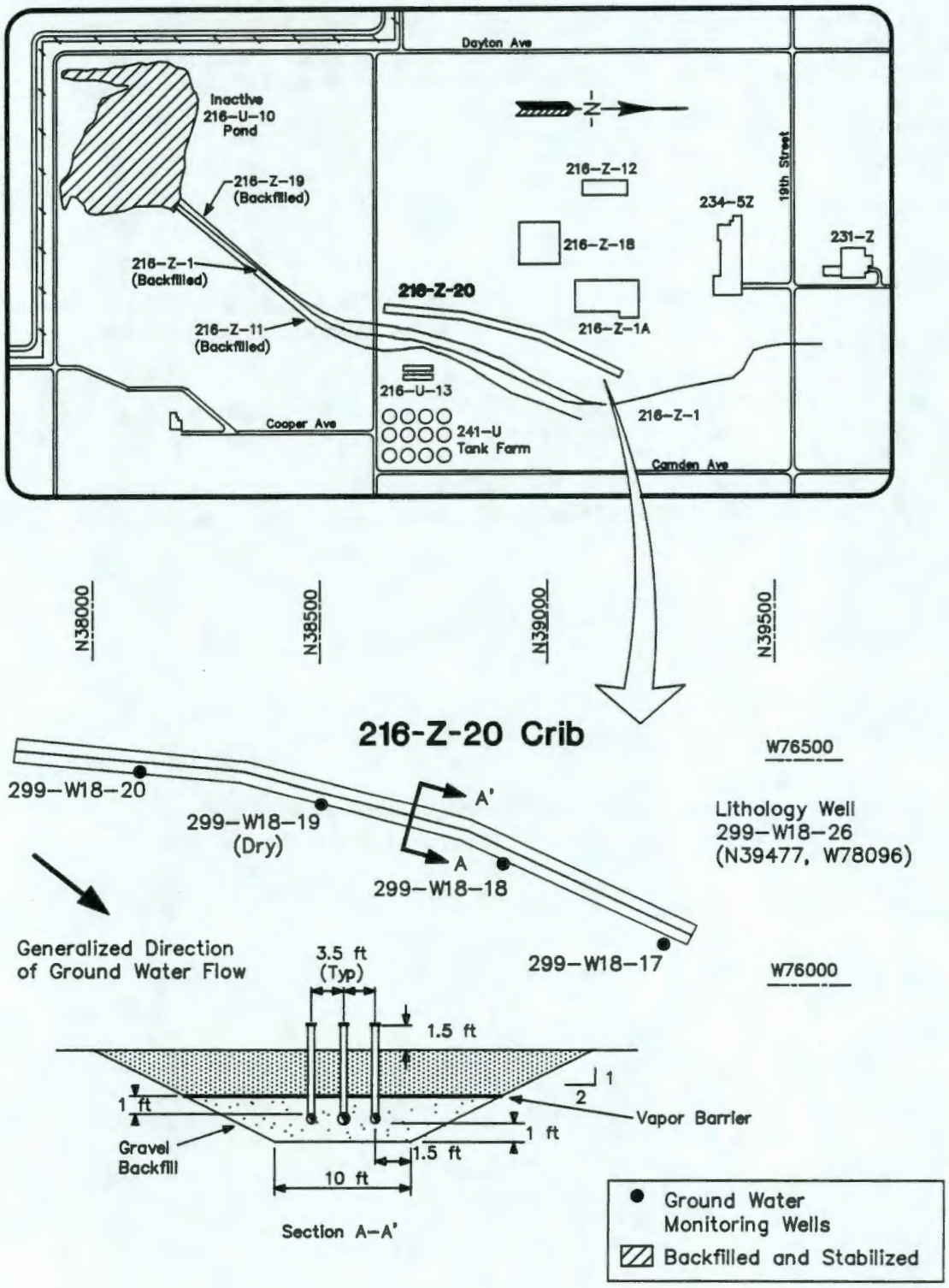

Figure 2.23-2. Lithology of Well 299-W18-26 at 216-Z-20 Crib.

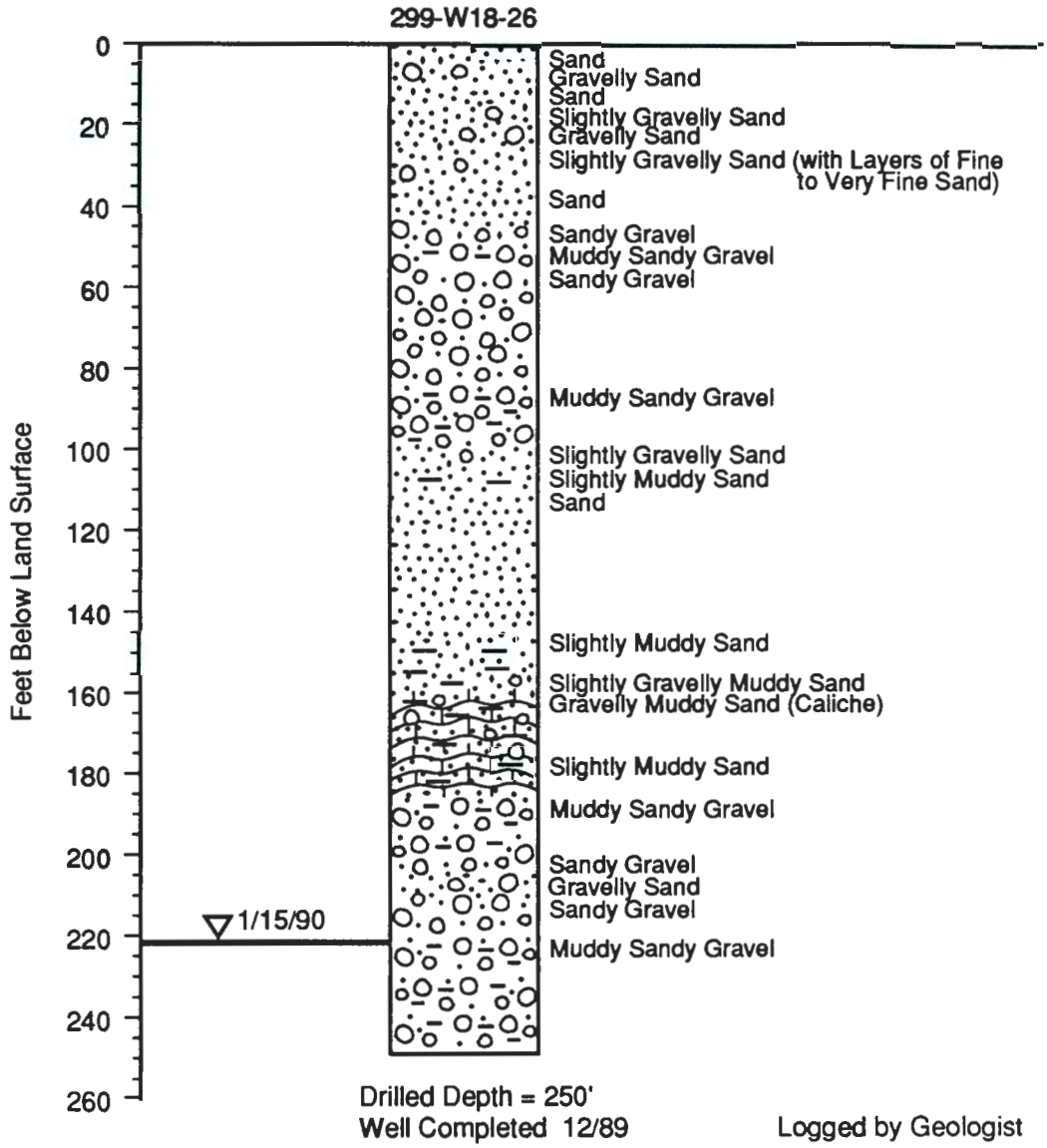

Table 2.23-1. Effluent Stream Description, Plutonium Finishing Plant Wastewater.

Total volume of effluent discharged to subject receiving site: (WHC 1989a, WHC-EP-0287, Volume 3)	2.81E+09 from 9/81 to 12/88
Average effluent discharge rate, by operating mode: (WHC 1990a, WHC-EP-0342, Addendum 8)	PRF: 15.9 L/sec[a] RMC: 10.2 L/sec[a] Other: 9 L/sec
Current average effluent discharge rate: (WHC 1990a, WHC-EP-0342, Addendum 8)	9 L/sec
Effluent designation (WHC 1990a, WHC-EP-0342, Addendum 8)	Nondangerous, radioactive
Effluent status:	Active effluent; mode is not PRF or RMC, i.e., "other" discharging to 216-Z-20 Crib

[a]Unpublished data, source is plant operating personnel.

Table 2.23-2. Effluent Stream Sampling Data, Plutonium Finishing Plant Wastewater.

Key Constituents	Detection Limit[a]	Detection/ Analyses	Sample Concentration 90% CI[a]	Detection Limit[a]	Detection/ Analyses	Sample Concentration 90% CI[a]
	08/87 to 9/87, During PRF			10/89 to 03/90, During PRF		
acetone	10	1/4	420	No Data		
aluminum	NA	2/4	320			
	09/85 to 08/88, During RMC			10/89 to 03/90, During RMC		
acetone	10	2/9	470	No Data		
aluminum	NA	4/9	320			
	04/86 to 06/87, During Other Modes			10/89 to 03/90, During Other Modes		
acetone	10	2/4	1,100	10	1/4	13[b]
aluminum	NA	4/4	230	NA	ND	ND
	1976 to 1988, During All Modes[e]			10/89 to 03/90, During All Modes		
cobalt-60	60	2/NA	4,300	1	ND	ND
strontium-90	30	27/NA	2,600	0.1	2/2	0.7[b]
cesium-134	80	2/NA	16,000	NA	ND	ND
cesium-137	80	27/NA	4,100	1	1/2	2[b]
americium-241	40	7/NA	2,000	0.001	3/3	2[b]
plutonium-241	NA	47/NA	3,200	0.001	ND	ND
plutonium-238	NA	9/NA	37	0.001	3/3	0.4[b]
uranium (isotopes)[c]	20	1/NA	110	NA	3/3	0.4[b,d]
plutonium-239	50	97/NA	340	0.001	3/3	15

[a]Units: chemical--parts per billion
radionuclides--picocurie per liter.

CI: confidence interval.
NA: not available.
ND: not detected.

[b]Concentrations below Group A and C guidelines; values given for comparison purposes.
[c]Uranium-234 Group A guideline used as the most restrictive for determination of key constituents.
[d]Consists of 0.22 pCi/L uranium-234 and 0.18 pCi/L uranium-238.
[e]Disposal of effluent to the 216-Z-20 Crib began in 1981; thus, this data set includes some samples taken prior to 1981.

Table 2.23-3. Radionuclide and Chemical Loading, Plutonium Finishing Plant Wastewater.

Flow Rate: 2.33E+07 L/mo

Constituent	Kg/L*	Kg/mo*
barium	2.82E-08	6.57E-01
boron	1.50E-08	3.49E-01
calcium	1.80E-05	4.19E+02
chloride	2.53E-06	5.89E+01
copper	1.30E-08	3.03E-01
fluoride	1.35E-07	3.14E+00
iron	7.27E-08	1.69E+00
magnesium	4.28E-06	9.97E+01
mercury	2.75E-10	6.40E-03
potassium	7.16E-07	1.67E+01
silicon	2.00E-06	4.66E+01
sodium	2.00E-06	4.66E+01
strontium	9.07E-08	2.11E+00
sulfate	1.31E-05	3.05E+02
uranium	3.84E-10	8.94E-03
zinc	1.45E-08	3.38E-01
acetone	1.12E-08	2.61E-01
caffeine	9.00E-09	2.10E-01
decane	8.00E-09	1.86E-01
tetrachloromethane	5.00E-09	1.16E-01
trichloromethane	2.05E-08	4.77E-01
unknown	6.50E-08	1.51E+00
unknown aliphatic HC	1.00E-08	2.33E-01
unknown hydrocarbon	5.00E-09	1.16E-01
alpha activity *	8.35E-12	1.94E-04
TDS	6.85E-05	1.59E+03
TOC	1.00E-06	2.33E+01
total carbon	1.36E-05	3.17E+02
TOX (as Cl)	1.49E-07	3.47E+00
americium-241 *	1.29E-12	3.00E-05
cesium-137 *	7.73E-13	1.80E-05
plutonium-238 *	3.22E-13	7.50E-06
plutonium-239/240 *	8.66E-12	2.02E-04
radium total *	2.15E-13	5.01E-06
strontium-90 *	3.35E-13	7.80E-06
uranium-234 *	1.57E-13	3.66E-06
uranium-238 *	1.48E-13	3.45E-06

Footnotes:

Data collected from October 1989 through March 1990.

Flow rate is the average of rates from the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 8).

Constituent concentrations are average values from the statistics in the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 8).

Concentration units of flagged (*) constituents are reported as curies per liter.

Table 2.23-4. Effluent Study Groundwater Summary Report. (Page 1 of 2)

CONSTITUENT			ANALYSIS SUMMARY					GROUP A STUDY GUIDELINES	
Group Name	Units	Detection Limit	Number of Analyses	Number > Det.	Average Result	Maximum Result	Minimum Result	Max Limit	Number > Limit
CONTAMINATION INDICATOR PARAMETERS									
Conductivity, Laboratory	UMHO	1.00	4	4	177.00	241.00	138.00	700.0	0
Specific conductance	UMHO	1.00	5	5	182.40	222.00	115.00	700.0	0
Total Organic Halogen, Low Det. Level	PPB	10.00	4	4	361.50	1170.00	38.00		0
pH, Field Measurement		.10	5	5	8.00	8.57	7.48	8.5	1
pH, Laboratory Measurement		.01	5	5	7.76	8.30	7.00	8.5	0
DRINKING WATER PARAMETERS									
Alpha, High Detection Level	PCI/L	4.00	12	2	2.58	12.40	-.07	15.0	0
Barium	PPB	6.00	7	7	30.57	36.00	25.00	1000.0	0
Barium, filtered	PPB	6.00	1	1	22.00	22.00	22.00	1000.0	0
Cadmium	PPB	2.00	4	3	10.75	22.00	2.00	10.0	2
Chromium	PPB	10.00	5	4	36.80	85.00	10.00	50.0	2
Gross beta	PCI/L	8.00	16	3	5.12	24.60	-1.28	50.0	0
Lead (graphite furnace)	PPB	5.00	2	2	9.50	12.00	7.00	50.0	0
Nitrate	PPB	500.00	5	3	1020.00	2400.00	500.00	45000.0	0
Nitrate, High Detection Level	PPB	2500.00	5	1	2600.00	3000.00	2500.00	45000.0	0
GROUNDWATER QUALITY PARAMETERS									
Chloride	PPB	500.00	6	6	3833.33	4200.00	3500.00	250000.0	0
Iron	PPB	30.00	7	7	15998.57	49900.00	810.00	300.0	7
Manganese	PPB	5.00	7	7	283.43	604.00	29.00	50.0	5
Sodium	PPB	200.00	6	6	6845.00	8490.00	5890.00		0
Sodium, filtered	PPB	200.00	1	1	5970.00	5970.00	5970.00		0
Sulfate	PPB	500.00	5	5	7280.00	16300.00	2200.00	250000.0	0
SITE SPECIFIC AND OTHER PARAMETERS									
Alkalinity		20000.00	1	1	72400.00	72400.00	72400.00		0
Aluminum	PPB	150.00	6	5	390.33	676.00	150.00	50.0	5
Americium-241	PCI/L	.10	2	1	.07	.12	.01		0
Ammonium ion	PPB	50.00	3	2	145.67	194.00	50.00		0
Boron	PPB	10.00	7	7	21.86	28.00	17.00		0
Boron, filtered	PPB	10.00	1	1	18.00	18.00	18.00		0

Table 2.23-4. Effluent Study Groundwater Summary Report. (Page 2 of 2)

CONSTITUENT			ANALYSIS SUMMARY					GROUP A STUDY GUIDELINES	
Group Name	Units	Detection Limit	Number of Analyses	Number > Det.	Average Result	Maximum Result	Minimum Result	Max Limit	Number > Limit
SITE SPECIFIC AND OTHER PARAMETERS									
Calcium	PPB	50.00	7	7	22500.00	25000.00	16000.00		0
Calcium, filtered	PPB	50.00	1	1	24200.00	24200.00	24200.00		0
Carbon Tetrachloride by GC/MS	PPB	5.00	4	3	507.75	2000.00	5.00	5.0	3
Chloroform	PPB	5.00	4	4	72.25	204.00	25.00	100.0	1
Copper	PPB	10.00	2	2	16.00	21.00	11.00	1000.0	0
Magnesium	PPB	50.00	7	7	7525.71	8420.00	5730.00		0
Magnesium, filtered	PPB	50.00	1	1	7560.00	7560.00	7560.00		0
Methylene Chloride	PPB	5.00	4	1	5.50	7.00	5.00		0
Nickel	PPB	10.00	5	4	28.80	47.00	10.00		0
Plutonium-239/40	PCI/L	.10	7	1	.07	.43	-.00	1.2	0
Potassium	PPB	100.00	7	7	3008.57	3330.00	2830.00		0
Potassium, filtered	PPB	100.00	1	1	2770.00	2770.00	2770.00		0
Silicon	PPB	50.00	7	7	21271.43	24800.00	12900.00		0
Silicon, filtered	PPB	50.00	1	1	22600.00	22600.00	22600.00		0
Strontium	PPB	10.00	7	7	97.86	114.00	59.00		0
Strontium, filtered	PPB	10.00	1	1	104.00	104.00	104.00		0
Titanium	PPB	60.00	2	1	65.00	70.00	60.00		0
Total carbon	PPB	1000.00	3	3	15233.33	15600.00	14500.00		0
Trichloroethylene	PPB	5.00	4	1	7.50	15.00	5.00	5.0	1
Tritium	PCI/L	500.00	10	2	588.30	3300.00	102.00	80000.0	0
Turbidity	NTU	.10	2	2	101.00	108.00	94.00	5.0	2
Uranium	PCI/L	.50	2	1	.77	1.11	.43	40.0	0
Vanadium	PPB	5.00	7	7	42.86	48.00	39.00		0
Vanadium, filtered	PPB	5.00	1	1	38.00	38.00	38.00		0
Zinc	PPB	5.00	7	7	16.86	42.00	6.00	5000.0	0

Table 2.23-5. Background Comparison, 216-Z-20 Crib.

Constituent	Background[a]	Average/ Background[b]	Maximum/ Background[b]
aluminum	2.0	195.17	338.00
ammonia	50.0	2.51	3.88
arsenic	6.3		
barium	62.0	0.49 (0.35)	0.58 (0.35)
beryllium	0.3		
bismuth	0.02		
boron	50.0	0.44 (0.36)	0.56 (0.36)
cadmium	0.2	53.75	110.00
calcium	50,700	0.44 (0.48)	0.49 (0.48)
chloride	16,800	0.23	0.25
chromium	6.0	6.13	14.17
copper	1.0	16.00	21.00
cyanide	10.0		
fluoride	470		
lead	0.5	19.00	24.00
magnesium	15,200	0.50 (0.50)	0.55 (0.50)
manganese	12.0	23.62	50.33
mercury	0.1		
nickel	4.0	7.20	11.75
phosphate	1,000		
potassium	6,190	0.49 (0.45)	0.54 (0.45)
selenium	2.0		
silver	10		
sodium	28,410	0.24 (0.21)	0.30 (0.21)
strontium	338	0.29 (0.31)	0.34 (0.31)
sulfate	51,200	0.14	0.32
uranium	2.5	0.31	0.44
vanadium	26	1.65 (1.46)	1.85 (1.46)
zinc	8.0	2.11	5.25
alkalinity	144,000	0.50	0.50
pH	7.8	1.03	1.10
TOC	933		
conductivity	462	0.39	0.48
gross alpha	3.9		
gross beta	31	0.17	0.79
radium	0.2		

TOC: total organic carbon. ( ): filtered samples.

[a]Background is the mean plus one standard deviation for the values listed in Table 2-1. Amounts of uranium, gross alpha, gross beta, and radium given in picocuries per liter. All others are in parts per billion.

[b]Average and maximum values from Table 2.23-4.

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2.24 200-W POWERHOUSE POND

Several metals in addition to chloride and fluoride in the effluent stream discharged to this pond exceed Group A study guidelines. An analysis of the key constituents indicates that the weighted-average concentrations of chloride and aluminum in pond water could exceed study guidelines and, therefore, have the potential to impact groundwater quality. However, there are no monitoring wells in the vicinity of the pond with which to evaluate this possibility.

2.24.1 Receiving Site Description

The 200-W Powerhouse Pond, located in the 200 West Area, has been in use since 1984 to dispose of liquid effluents from the 284-W Powerplant. The location of the pond and spatial relationship to other facilities are shown in Figure 2.24-1.

2.24.2 Effluent Stream Description

The 284-W Powerplant produces steam for plant operations in conventional coal-fired boilers. Wastewater consists chiefly of once-through cooling water used in the powerplant. Other wastewater sources include boiler blowdowns and regenerate solutions from zeolite water softeners (approximately 9% sodium chloride). Powerplant operations include three operating modes: routine operations, water softener regeneration and boiler blowdown. Effluent stream information is summarized in Table 2.24-1. Key constituents are given in Table 2.24-2 and loading estimates are provided in Table 2.24-3.

The analytical data indicate that all modes produce metallic ions and anions exceeding Group A study guidelines, some by large margins, the predominant species being chloride. The sampling results for water softener operation are typical for such systems.

2.24.3 Flow and Transport Analysis

For determining travel times through the vadose zone, the sediment column beneath the pond is treated as a five-layer system with a depth of 62 m (Figure 2.24-2 and Appendix B). The estimated travel time for wastewater to reach the water table under average flow discharge conditions is 200 days (see Appendix B for data and computations).

Based on general effluent characteristics and corresponding sorption parameters (Appendix C) for the key constituents identified in Table 2.24-2, the calculated migration rates are about 31 cm/day for mobile constituents (chloride and fluoride) and less than 1 cm/day for the more immobile constituents (lead, aluminum, iron, barium, and manganese).

2.24.4 Groundwater Quality Assessment

Because there are no groundwater monitoring wells in close proximity to the 200-W Powerhouse Pond, groundwater quality cannot be directly evaluated.

2.24.5 Impact of Continued Operation

The discharge rate to the pond is significantly less than natural recharge from Cold Creek. Thus, no significant impact on the groundwater flow regime is expected. However, the discharge rate is sufficient for potential development of a perched water zone above the caliche layer.

To address the possible impact of this disposal system on local groundwater, an estimate of the average chemical composition of the pond water itself is needed. This can be accomplished by calculating a weighted average chemical composition for the combined wastestreams from the reported results for the three modes listed in Table 2.24-1 (i.e., routine operations, water softener regenerate, and blowdown). The concentrations and flowrates with which to calculate the weighted average values (Table 2.24-4) were obtained from the stream-specific report for the 248-W Powerplant (WHC 1990a, Addendum 27). The weighted average concentrations in Table 2.24-4 are assumed to be representative of water entering the soil column beneath the pond. Aluminum and chloride are significantly above the reference groundwater standards used for this study (i.e., approximately three and six times higher than reference standards, respectively).

Based on the above considerations, the estimated travel time and the volume of water discharged to this site, chloride in groundwater within the vicinity of this disposal site may have exceeded its secondary water quality standard. Mitigating conditions include dilution and dispersion.

Figure 2.24-1. Well Location and Site Map for 200-W Powerhouse Pond.

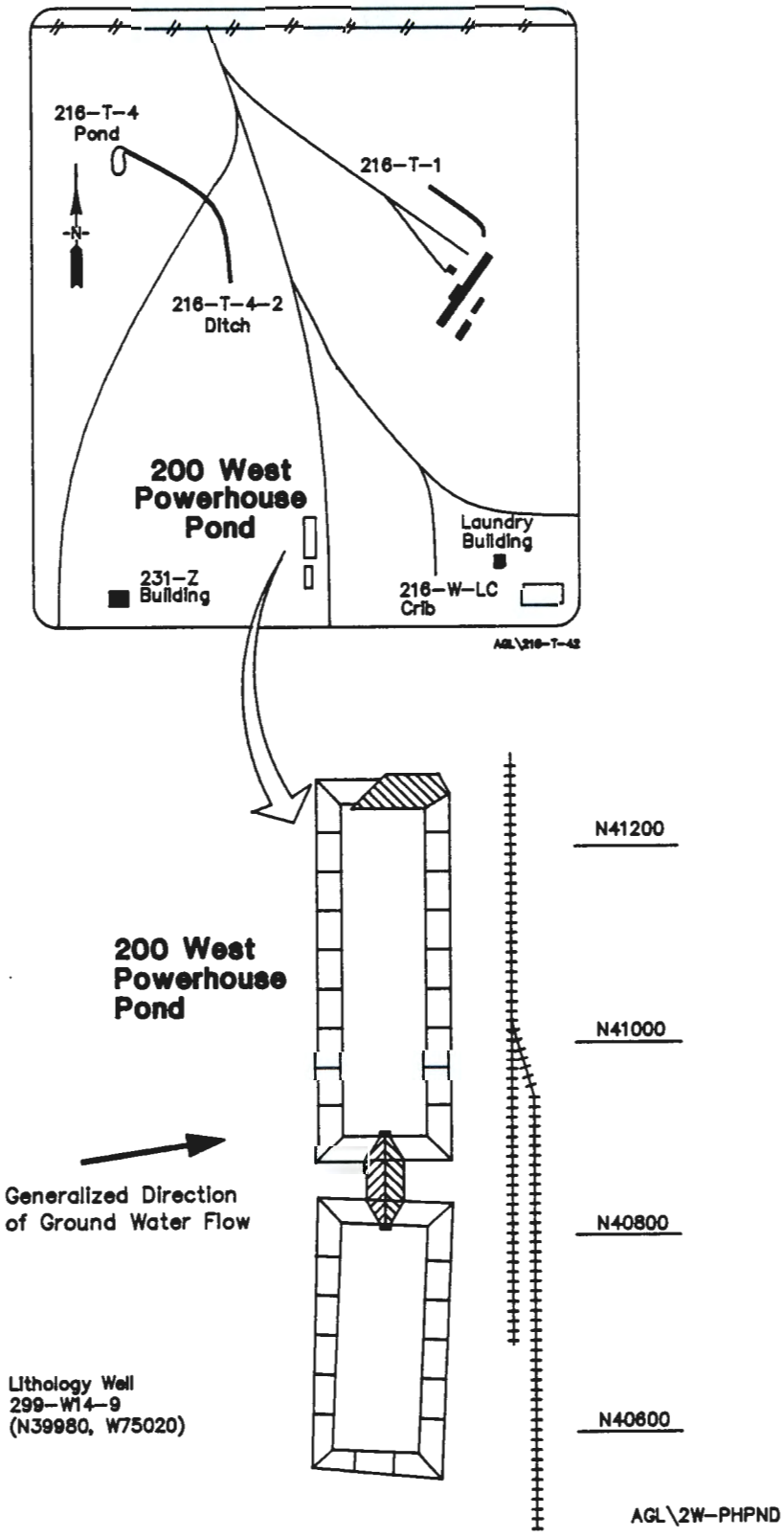


Figure 2.24-2. Lithology of Well 299-W14-9 at 200-W Powerhouse Pond.

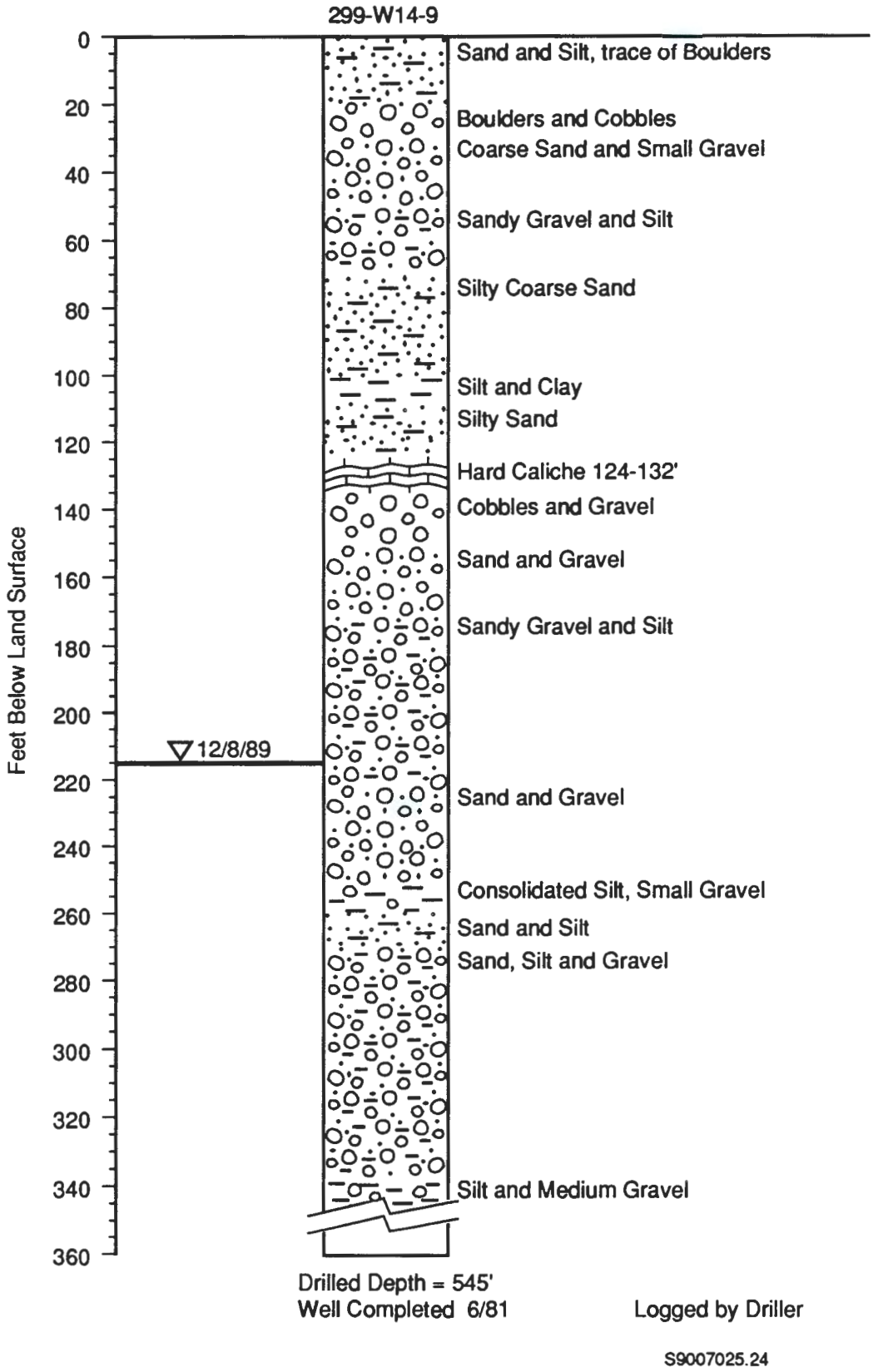


Table 2.24-1. Effluent Stream Description, 284-W Powerplant Wastewater.

Total volume of effluent discharged to subject receiving site:	No data available
Average effluent discharge rate, by operating mode: (WHC 1990a, WHC-EP-0342, Addendum 27)	Routine: 1.23E+07 L/mo Softener regenerate: additional 5.68E+05 L/mo Blowdown: additional 1.89E+05 L/mo
Current average effluent discharge rate: (WHC 1990a, WHC-EP-0342, Addendum 27)	1.31E+07 L/mo total average monthly flow rate
Effluent designation: (WHC 1990a, WHC-EP-0342, Addendum 27)	Nondangerous, nonradioactive
Effluent status:	Active discharge to 400 Area Ponds

Table 2.24-2. Effluent Stream Sampling Data, 284-W Powerplant Wastewater.

Key Constituents	Detection Limit[a]	Detection/ Analyses	Sample Concentration 90% CI[a]	Detection Limit[a]	Detection/ Analyses	Sample Concentration 90% CI[a]
	09/85 to 01/87, During Blowdown			10/89 to 03/90, During Blowdown		
aluminum	NA	4/5	550	No Data		
iron	30	5/5	980			
	11/87 to 04/88, During Water Softener Regeneration			10/89 to 03/90, During Water Softener Regeneration		
aluminum	NA	1/4	830	No Data		
barium	6	4/4	75,000			
chloride	500	4/4	61,000,000			
fluoride	50	3/4	120,000			
lead	5	2/4	61			
manganese	5	3/3	380			
	07/87 to 03/89, During Routine Operation			10/89 to 03/90, During Routine Operation		
aluminum	NA	1/5	160	NA	3/4	292
chloride	500	5/5	3,600	500	4/4	1,920,000

[a]Units: chemical--parts per billion
radionuclides--picocurie per liter.

CI: confidence interval.
NA: not available.

Table 2.24-3. Radionuclide and Chemical Loading, 284-W Powerplant Wastewater.

Flow Rate: 1.31E+07 L/mo

Constituent	Kg/L*	Kg/mo*
aluminum	2.08E-07	2.72E+00
barium	2.43E-07	3.17E+00
boron	6.02E-08	7.86E-01
cadmium	4.25E-09	5.55E-02
calcium	1.98E-04	2.59E+03
chloride	7.31E-04	9.55E+03
cobalt	2.65E-08	3.46E-01
copper	1.12E-08	1.46E-01
fluoride	1.64E-07	2.14E+00
iron	1.04E-07	1.36E+00
lithium	1.72E-08	2.25E-01
magnesium	7.23E-05	9.44E+02
manganese	9.50E-09	1.24E-01
mercury	4.10E-10	5.35E-03
nitrate	5.75E-07	7.51E+00
potassium	8.74E-06	1.14E+02
silicon	2.87E-06	3.75E+01
sodium	2.92E-04	3.81E+03
strontium	1.01E-06	1.32E+01
sulfate	2.68E-05	3.50E+02
uranium	5.18E-10	6.76E-03
vanadium	5.00E-09	6.53E-02
zinc	2.20E-08	2.87E-01
trichloromethane	6.25E-09	8.16E-02
beta activity *	3.15E-12	4.11E-05
suspended solids	7.25E-06	9.47E+01
TDS	9.69E-04	1.27E+04
TOC	1.30E-06	1.70E+01
total carbon	1.55E-05	2.02E+02
TOX (as Cl)	5.15E-08	6.72E-01

Footnotes:

Data collected from October 1989 through March 1990.

Flow rate is the average of rates from the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 27).

Constituent concentrations are average values from the statistics in the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 27).

Concentration units of flagged (*) constituents are reported as curies per liter.

Loading units of flagged (*) constituents are reported as curies per month.

Table 2.24-4. Major Chemical Constituents in Contributor Streams and Weighted Average Concentrations for the Combined Stream.

284-W Powerplant Wastewater

Constituent	Blowdown (1.5%)[a]	Softener (4.5%)[a]	Normal (94%)[a]	Weighted Average (ppb)
aluminum	340	830	160	193
calcium	18,000	23,000,000	17,000	1,100,000
chlorine	3,800	33,000,000	3,100	1,500,000
fluorine	100[b]	85,000	130	4,000
iron	630	210	120	132
magnesium	4,200	1,000,000	3,800	49,000
NO_3	900	100[b]	900	860
sodium	38,000	90,000,000	20,000	4,100,000
strontium	100[b]	29,000	89	1,400
SO_4	30,000	65,000	24,000	26,010
potassium	1,600	170,000	1,000	8,600
barium	34	32,000	25	1,500
curium	240	270	15	30

[a] based on percent of total effluent discharge rate contributed by each mode (Table 2.24-1).

[b] Assigned value for purpose of calculating the weighted average.

2.25 2101-M POND

2.25.1 Disposal Site Description

The 2101-M Pond, located in the 200 East Area, was constructed in 1953 to dispose of wastewater from the 2101-M Building. Figure 2.25-1 depicts the location of the pond and monitoring wells relative to other facilities in the vicinity.

2.25.2 Effluent Stream Description

Several types of activities are conducted in the 2101-M laboratory. These include soils testing laboratories, a spare parts warehouse, craft shops, and offices. The laboratories conduct physical testing of soils which do not require the use of chemicals. During the period from 1983 to 1986, laboratory activities were conducted in support of the Basalt Waste Isolation Project (BWIP) which resulted in small amounts of chemicals being released to the 2101-M Pond. The major contributors to the wastewater stream include HVAC steam condensates and the reservoir overflow from the air conditioning system. Small contributors include the laboratory and janitorial sinks and drains and a small flow from the compressed air dryer system. Chemical constituents consist chiefly of commercial cleaning solutions. Waste stream flow information and related data are summarized in Table 2.25-1. Key constituents from sampling data are indicated in Table 2.25-2. Loading estimates are provided in Table 2.25-3.

Old effluent sampling data for the 2101-M laboratory wastestream indicated that aluminum and iron were above Group A study guideline concentrations.

2.25.3 Flow and Transport Analysis

For transport calculation purposes, the sediment column beneath the pond is treated as a two-layer system of depth 94 m (Figure 2.25-2 and Appendix B). The calculated travel time for wastewater to reach the water table under average discharge conditions is 69 days (see Appendix B for data and computations).

Based on general effluent characteristics and corresponding sorption parameters (Appendix C) for the key constituents identified in Table 2.25-1, the calculated migration rates (Appendix B) range from 0.55 to 1.37 cm/day (iron and aluminum).

2.25.4 Groundwater Quality Assessment

Quarterly groundwater sampling is presently conducted to support the RCRA closure process. The analysis for the effluent study is based entirely on the existing RCRA groundwater data.

Four RCRA-compliant wells (2-E18-1 through 2-E18-4) equipped with Hydrostar positive displacement pumps have been sampled on a quarterly basis from July 1988 to present. The upgradient well (2-E18-1) and one downgradient well (2-E18-3) were sampled for Appendix IX and site-specific radioactive constituents on 10-31-89 and 11-27-89, respectively. Other indicator constituents are available for the other two wells from the RCRA monitoring program.

A summary of positive results is shown in Table 2.25-4. Constituents exceeding Group A guidelines are unfiltered aluminum, chromium, iron, and turbidity. Aluminum and iron are identified as key constituents in Table 2.25-2. The elevated iron (unfiltered) is attributed to an artifact of sampling (WHC 1990d). The elevated aluminum and turbidity suggest that the aluminum may be from suspended sediment in the sample as a result of insufficient well purging. The chromium (unfiltered) is present in both the upgradient and down gradient wells. Analysis of filtered samples for chromium show levels near the detection limit.

A comparison of positive results with available background values is shown in Table 2.25-5. Constituents that exceed Group B guidelines include aluminum, arsenic, barium, beryllium, cadmium, calcium, chromium, copper, fluoride, magnesium, manganese, nickel, potassium, selenium, sodium, sulfate, uranium, vanadium, zinc, pH, and conductivity.

Of the constituents exceeding background values for groundwater, aluminum, barium, calcium, chromium, copper, magnesium, manganese, potassium, sodium, sulfate, uranium, and zinc have been identified in the wastewater stream for the 2101-M Building (WHC 1990, Addendum 18, Table 3-1). No measurable levels of arsenic, copper, or beryllium were observed in the upgradient well, but were detected in wells down gradient of the 2101-M Pond. Compounds containing these three constituents have been identified in the BWIP chemical inventory. Aluminum and selenium were observed in the upgradient well, but were below detection levels in the downgradient wells. While many constituents have been identified as exceeding background values, only results for unfiltered aluminum, chromium, and iron exceed Group A guidelines.

Chemical constituents detected in soil sediments beneath the pond included acetone, methylene chloride, toluene, butanoic acid, ethanol, propanol, ammonium, copper, silver, and sulfate (DOE 1989). While these constituents were detectable, they are present at concentrations that should not preclude clean closure (DOE 1989).

2.25.5 Impact of Continued Operation

This disposal facility is scheduled (proposed) for clean closure. Thus, no further analysis for purposes of this study is needed.

Figure 2.25-1. Well Location and Site Map for 2101-M Pond.

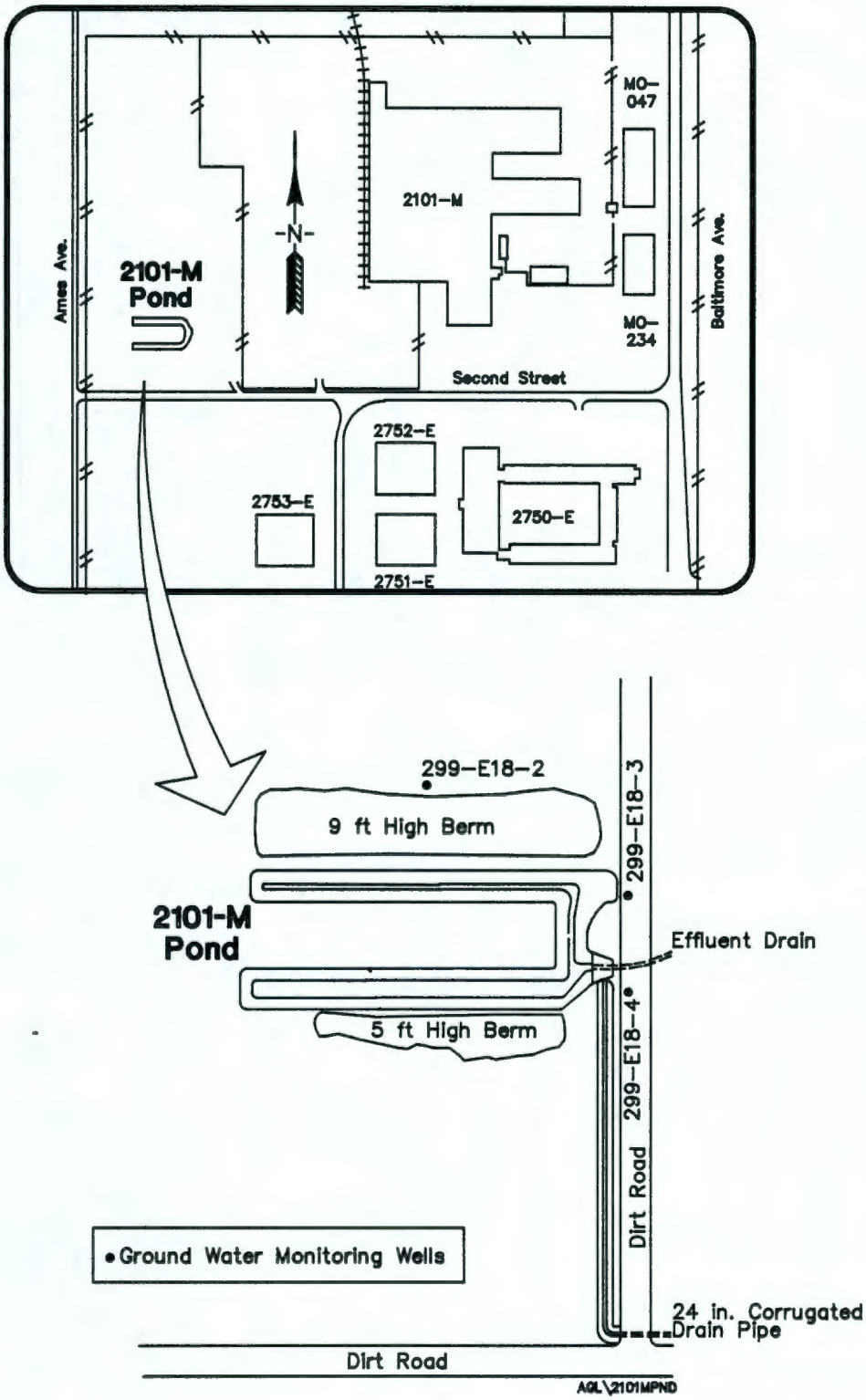


Figure 2.25-2. Lithology of Well 299-E18-3 at 2101-M Pond.

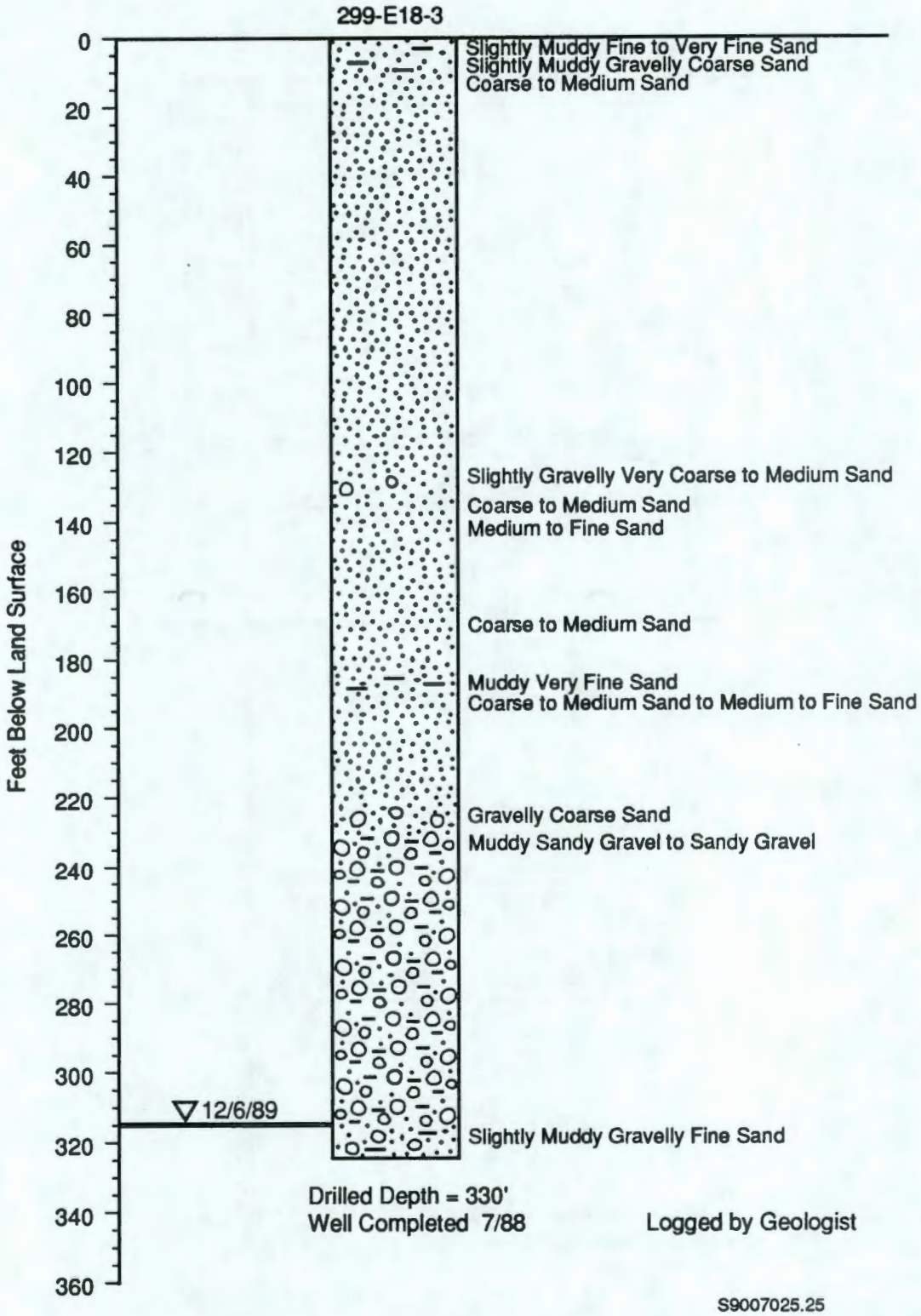


Table 2.25-1. Effluent Stream Description, 2101-M Laboratory Wastewater.

Total volume of effluent discharged to subject receiving site: (WHC 1989a, WHC-EP-0287, Volume 2)	5.5E+08 L as of 12/88
Average effluent discharge rate, by operating mode: (WHC 1990a, WHC-EP-0342, Addendum 18)	1.75E+06 gal/yr Approximately 1E+04 to 6E+05 gal/mo[a]
Current average effluent discharge rate: (WHC 1990a, WHC-EP-0342, Addendum 18)	5.68E+05 L/mo
Effluent designation: (WHC 1990a, WHC-EP-0342, Addendum 18)	Nondangerous, nonradioactive
Effluent status: (WHC 1990a, WHC-EP-0342, Addendum 18)	Active discharge to 2101-M Pond

[a]Flow rate varies by seasonal temperatures.

Table 2.25-2. Effluent Stream Sampling Data, 2101-M Laboratory Wastewater.

Key Constituents	Detection Limit[a]	Detection/ Analyses	Sample Concentration 90% CI[a]	Detection Limit[a]	Detection/ Analyses	Sample Concentration 90% CI[a]
	09/85 to 01/87, During Routine Operation			10/89 to 03/90, During Routine Operation		
aluminum	NA	3/5	330	NA	3/5	264
iron	30	5/5	800	NA	5/5	792

[a]Units: chemical--parts per billion
radionuclides--picocurie per liter.

CI: confidence interval.
NA: not available.

Table 2.25-3. Radionuclide and Chemical Loading, 2101-M Laboratory Wastewater.

Flow Rate: 5.68E+05 L/mo

Constituent	Kg/L*	Kg/mo*
aluminum	2.12E-07	1.20E-01
barium	2.16E-08	1.23E-02
calcium	1.31E-05	7.44E+00
chloride	2.43E-06	1.38E+00
chromium	1.00E-08	5.68E-03
copper	2.59E-07	1.47E-01
iron	4.75E-07	2.70E-01
lead	2.37E-08	1.35E-02
magnesium	2.98E-06	1.69E+00
manganese	9.20E-09	5.22E-03
mercury	4.20E-10	2.38E-04
nitrate	5.00E-07	2.84E-01
phosphate	1.09E-06	6.19E-01
potassium	6.85E-07	3.89E-01
sodium	1.70E-06	9.65E-01
sulfate	1.08E-05	6.13E+00
uranium	4.59E-10	2.61E-04
zinc	8.14E-08	4.62E-02
acetone	4.00E-08	2.27E-02
ammonia	8.96E-08	5.09E-02
bis(2-ethylhexyl) phthalate	1.50E-07	8.52E-02
trichloromethane	1.76E-08	9.99E-03
alpha activity *	6.49E-13	3.68E-07
beta Activity *	5.07E-12	2.88E-06
TOC	4.17E-06	2.37E+00
TOX (as Cl)	1.13E-07	6.42E-02

Footnotes:

Data collected during September 1985, May 1986, July 1986, October 1986 and January 1987.

Flow rate is the average of rates from the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 18).

Constituent concentrations are average values from the statistics in the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 18).

Concentration units of flagged (*) constituents are reported as curies per liter.

Loading units of flagged (*) constituents are reported as curies per month.

Table 2.25-4. Effluent Study Groundwater Summary Report. (Page 1 of 2)

CONSTITUENT			ANALYSIS SUMMARY					GROUP A STUDY GUIDELINES	
Group Name	Units	Detection Limit	Number of Analyses	Number > Det.	Average Result	Maximum Result	Minimum Result	Max Limit	Number > Limit
CONTAMINATION INDICATOR PARAMETERS									
Conductivity, Laboratory	UMHO	1.00	55	55	329.91	552.00	178.00	700.0	0
Specific conductance	UMHO	1.00	47	47	331.11	568.00	156.00	700.0	0
Total Organic Halogen, Low Det. Level	PPB	10.00	53	16	7.72	21.00	.01		0
pH, Field Measurement		.10	38	38	7.90	8.26	6.90	8.5	0
pH, Laboratory Measurement		.01	27	27	8.00	8.20	7.30	8.5	0
DRINKING WATER PARAMETERS									
Alpha, High Detection Level	PCI/L	4.00	20	4	2.63	5.53	.85	15.0	0
Arsenic	PPB	5.00	18	14	9.22	14.00	5.00	50.0	0
Arsenic, filtered	PPB	5.00	19	14	8.68	14.00	5.00	50.0	0
Barium	PPB	6.00	19	19	51.00	62.00	25.00	1000.0	0
Barium, filtered	PPB	6.00	20	20	53.50	73.00	25.00	1000.0	0
Cadmium, filtered	PPB	2.00	16	1	2.00	2.00	2.00	10.0	0
Chromium	PPB	10.00	20	20	50.15	104.00	16.00	50.0	9
Chromium, filtered	PPB	10.00	17	1	10.12	12.00	10.00	50.0	0
Coliform (Membrane Filter)	PPB	1.00	3	1	1.00	1.00	1.00	1.0	1
Fluoride	PPB	500.00	16	7	550.00	700.00	500.00	4000.0	0
Gross beta	PCI/L	8.00	20	3	6.04	10.60	1.78	50.0	0
Nitrate	PPB	500.00	19	13	2987.89	12500.00	500.00	45000.0	0
Selenium	PPB	5.00	16	4	5.38	7.00	5.00	10.0	0
Selenium, filtered	PPB	5.00	16	4	5.44	7.00	5.00	10.0	0
GROUNDWATER QUALITY PARAMETERS									
Chloride	PPB	500.00	17	17	7417.65	14600.00	4900.00	250000.0	0
Iron	PPB	30.00	20	20	368.60	858.00	77.00	300.0	12
Iron, filtered	PPB	30.00	19	9	32.63	41.00	30.00	300.0	0
Manganese	PPB	5.00	19	14	9.58	18.00	5.00	50.0	0
Manganese, filtered	PPB	5.00	17	2	5.06	6.00	5.00	50.0	0
Sodium	PPB	200.00	20	20	13636.00	27800.00	5410.00		0
Sodium, filtered	PPB	200.00	20	20	14408.50	30500.00	5700.00		0
Sulfate	PPB	500.00	18	18	52450.00	153000.00	12500.00	250000.0	0

Table 2.25-4. Effluent Study Groundwater Summary Report. (Page 2 of 2)

CONSTITUENT			ANALYSIS SUMMARY					GROUP A STUDY GUIDELINES	
Group Name	Units	Detection Limit	Number of Analyses	Number > Det.	Average Result	Maximum Result	Minimum Result	Max Limit	Number > Limit
SITE SPECIFIC AND OTHER PARAMETERS									
Alkalinity		20000.00	13	13	99623.08	108000.00	90000.00		0
Aluminum	PPB	150.00	16	1	155.88	244.00	150.00	50.0	1
Beryllium, filtered	PPB	5.00	17	1	5.00	5.00	5.00		0
Boron	PPB	10.00	19	18	19.53	38.00	10.00		0
Boron, filtered	PPB	10.00	20	18	20.95	42.00	10.00		0
Calcium	PPB	50.00	20	20	34215.00	58000.00	25400.00		0
Calcium, filtered	PPB	50.00	20	20	36100.00	69500.00	25300.00		0
Chloroform	PPB	5.00	10	1	7.00	25.00	5.00	100.0	0
Copper	PPB	10.00	17	4	11.06	18.00	10.00	1000.0	0
Copper, filtered	PPB	10.00	17	3	10.18	11.00	10.00	1000.0	0
Magnesium	PPB	50.00	20	20	9127.00	14700.00	7190.00		0
Magnesium, filtered	PPB	50.00	20	20	9473.50	16200.00	7140.00		0
Methylene Chloride	PPB	5.00	10	2	11.80	75.00	3.00		0
Nickel	PPB	10.00	20	18	26.65	54.00	10.00		0
Nickel, filtered	PPB	10.00	18	4	10.72	17.00	10.00		0
Potassium	PPB	100.00	20	20	5265.00	5780.00	4660.00		0
Potassium, filtered	PPB	100.00	20	20	5381.00	6210.00	4780.00		0
Silicon	PPB	50.00	20	20	17690.00	19800.00	13600.00		0
Silicon, filtered	PPB	50.00	20	20	18230.00	22600.00	14000.00		0
Strontium	PPB	10.00	20	20	172.10	257.00	141.00		0
Strontium, filtered	PPB	10.00	19	19	179.53	283.00	143.00		0
Total carbon	PPB	1000.00	7	7	23957.14	25000.00	21500.00		0
Total dissolved solids		5000.00	1	1	347000.00	347000.00	347000.00	500000.0	0
Turbidity	NTU	.10	14	14	5.02	19.50	.70	5.0	3
Uranium	PCI/L	.50	1	1	4.56	4.56	4.56	40.0	0
Vanadium	PPB	5.00	19	18	22.84	32.00	5.00		0
Vanadium, filtered	PPB	5.00	19	19	24.32	35.00	6.00		0
Zinc	PPB	5.00	19	19	16.47	30.00	5.00	5000.0	0
Zinc, filtered	PPB	5.00	18	12	10.39	30.00	5.00	5000.0	0

Table 2.25-5. Background Comparison, 2101-M Pond.

Constituent	Background[a]	Average/ Background[b]	Maximum/ Background[b]
aluminum	2.0	77.94	122.00
ammonia	50.0		
arsenic	6.3	1.46 (1.38)	2.22 (2.22)
barium	62.0	0.82 (0.86)	1.00 (1.18)
beryllium	0.3	(16.67)	(16.67)
bismuth	0.02		
boron	50.0	0.39 (0.42)	0.76 (0.84)
cadmium	0.2	10.0	10.0
calcium	50,700	0.67 (0.71)	1.14 (1.37)
chloride	16,800	0.44	0.87
chromium	6.0	8.36 (1.69)	17.33 (2.00)
copper	1.0	11.06 (10.18)	18.00 (11.00)
cyanide	10.0		
fluoride	470	1.17	1.49
lead	0.5		
magnesium	15,200	0.60 (0.62)	0.97 (1.07)
manganese	12.0	0.80 (0.42)	1.50 (0.50)
mercury	0.1		
nickel	4.0	6.66 (2.68)	13.50 (4.25)
phosphate	1,000		
potassium	6,190	0.85 (0.87)	0.93 (1.00)
selenium	2.0	2.69 (2.72)	3.50 (3.50)
silver	10		
sodium	28,410	0.48 (0.51)	0.98 (1.07)
strontium	338	0.51 (0.53)	0.76 (0.84)
sulfate	51,200	1.02	2.99
uranium	2.5	1.82	1.82
vanadium	26	0.88 (0.94)	1.23 (1.35)
zinc	8.0	2.06 (1.30)	3.75 (3.75)
alkalinity	144,000	0.69	0.75
pH	7.8	1.01	1.06
TOC	933		
conductivity	462	0.72	1.23
gross alpha	3.9		
gross beta	31	0.19	0.34
radium	0.2		

TOC: total organic carbon. ( ): filtered samples.

[a]Background is the mean plus one standard deviation for the values listed in Table 2-1. Amounts of uranium, gross alpha, gross beta, and radium given in picocuries per liter. All others are in parts per billion.

[b]Average and maximum values from Table 2.25-4.

2.26 300 AREA PROCESS TRENCHES

The 300 Area Process Trenches have received effluents from 300 Area facilities since 1975. Recent sampling of effluent streams indicates that several constituents exceed guidelines by small margins. The key contaminant found in the groundwater is uranium, which is from past processing operations. The occurrence of uranium is presently under RCRA assessment. Contaminant transport calculations and current wastestream composition indicate that interim (until 1995) use of these trenches should have minimal additional impact on the subsurface environment.

2.26.1 Receiving Site Description

The 300 Area Process Trenches have been in use since 1975 to dispose of wastewater effluents from 300 Area facilities. The process trenches have been designated as a RCRA TSD facility and will be closed. Figure 2.26-1 depicts the location of the trenches and monitoring wells relative to other facilities in the vicinity.

2.26.2 Effluent Stream Description

The 300 Area contains a large complex of buildings and other facilities which historically have been dedicated chiefly to nuclear fuel fabrication and a wide range of testing and reseach and development activities. Over 50 buildings are connected to the process sewer system which leads to the process disposal trenches. Fuel fabrication activities were the most significant sources for chromium, copper, uranium, nitrate, sulphate, beryllium, and fluoride ions as well as caustics and perchloroethylene. Since the fuel fabrication complex has been deactivated, there have been significant reductions in contaminants from these facilities. Current contributors to the wastewater consist primarily of potable water overflow, equipment cooling water, steam condensates, and testing/research laboratory sinks and drains. Table 2.26-1 summarizes information pertaining to the effluent stream. Key constituents in the effluent are indicated in Table 2.26-2. Loading estimates are provided in Table 2.26-3.

Sample data from Sample Point #1 (the combined effluents, see WHC 1990a, Addendum 1) indicate the presence of aluminum and silver as exceeding Group A study guidelines.

Radioactive constituents which exceed Group A study guidelines are uranium-234 and uranium-238.

2.26.3 Flow and Transport Analysis

For the purpose of performing transport calculations, the sediment column beneath the trenches is considered to be a single layer of sand and gravel of 7 m in depth (Figure 2.26-2 and Appendix B). The calculated travel time for wastewater to reach this shallow water table under average discharge conditions is 1 day (see Appendix B for data and computations).

Based on general effluent characteristics and corresponding sorption parameters (Appendix C) for the key constituents identified in Table 2.26-2, the calculated migration rates (see Appendix B for computations) range from 81.2 cm/day for mobile constituents (uranium-234 and -238) to 5.41 cm/day for silver.

2.26.4 Groundwater Quality Assessment

Groundwater in the vicinity of the 300 Area Process Trenches has been monitored extensively since 1985 in connection with a RCRA interim status groundwater quality assessment for this facility (Smith and Gorst 1990). Thirty-five wells were sampled during the time period of interest for the liquid effluent study, over half of which were RCRA-compliant wells. Analyses were performed for Appendix IX (or equivalent) constituents and site-specific radionuclide and chemical constituents. A large number of analyses for indicator/site-specific parameters were also performed. The summary presented in this section is based entirely on existing data.

A summary of positive results obtained from the above sampling effort is shown in Table 2.26-4. Constituents exceeding Group A guidelines include gross alpha, coliform, iron, manganese, trans-1,2-dichlorethene, tetrachloroethylene, trichloroethylene, fluoride, and uranium.

The gross alpha is related to the uranium which is due to past disposal practices. This constituent has been identified in effluent above guidelines, although apparently not during the most recent sampling conducted for this study (WHC 1990b). Thus, the elevated uranium concentrations in groundwater are attributed to past operations and disposal activities. For example, fuel fabrication, a source of uranium and technetium-99, was terminated in February 1987. Residual contamination in the disposal system and aquifer will now attenuate. However, because this facility is in the assessment mode, this occurrence is under evaluation for the RCRA program as noted above. The chlorinated hydrocarbons do not appear to be present at a level (a few occurrences not greatly above the guidelines). Thus, chlorinated hydrocarbons are judged not to be significant occurrences for the purpose of this investigation. The average fluoride concentration of 753 ppb is well below the guideline value of 4,000 ppb, with a maximum occurrence of approximately six times guideline. The elevated coliform is apparently due to sanitary sewage discharges (see Figure 2.26-1). The slightly elevated metals (chromium, iron, and manganese) are attributed to artifacts of sampling (i.e., carbon steel casing, etc.).

Average values for naturally occurring major and trace constituents are generally within the range of background values for Hanford groundwater (Table 2.26-5). Exceptions are aluminum, beryllium, cadmium, copper, fluoride, nickel, and uranium. Maximum values in some cases exceed the Group B guidelines. However, with the exception of fluoride, these are modest deviations from natural levels and are judged not to be significant for purposes of this study. The average gross beta is within the natural background range with a maximum occurrence of just slightly above the Group B guideline.

Of the key wastestream constituents noted in Table 2.26-2, only uranium and aluminum occur in vicinity groundwater in significant concentrations (i.e., above Group A guidelines). As noted above, the source of uranium has been eliminated due to termination of fuel fabrication activities in 1987. Organic constituents detected in groundwater, that were also reported in effluents, include chloroform and hydrocarbons. Other trace contaminants detected in 300 Process Trench wastestreams include aromatic hydrocarbons, but these constituents were not detected in vicinity groundwater.

2.26.5 Impact of Continued Operation

The average discharge rate to the 300 Process Trenches exceeds the Cold Creek recharge by approximately fourfold; however, the groundwater flow regime at this location is controlled by the seasonal changes in river water levels (Smith and Gorst 1990). Thus, the volume impact on contaminant plume movement is minimal compared to the natural perturbations caused by the Columbia River.

Because of the short travel times noted in Section 2.26.3, a significant load of retained contaminants on the soil column is unlikely. Thus, continued use of the crib should not adversely impact groundwater quality due to elution or migration of contaminants from the soil column, or exacerbate any future remediation that might be required of contaminated sediments.

Figure 2.26-1. Well Location and Site Map for 300 Area Process Trenches.

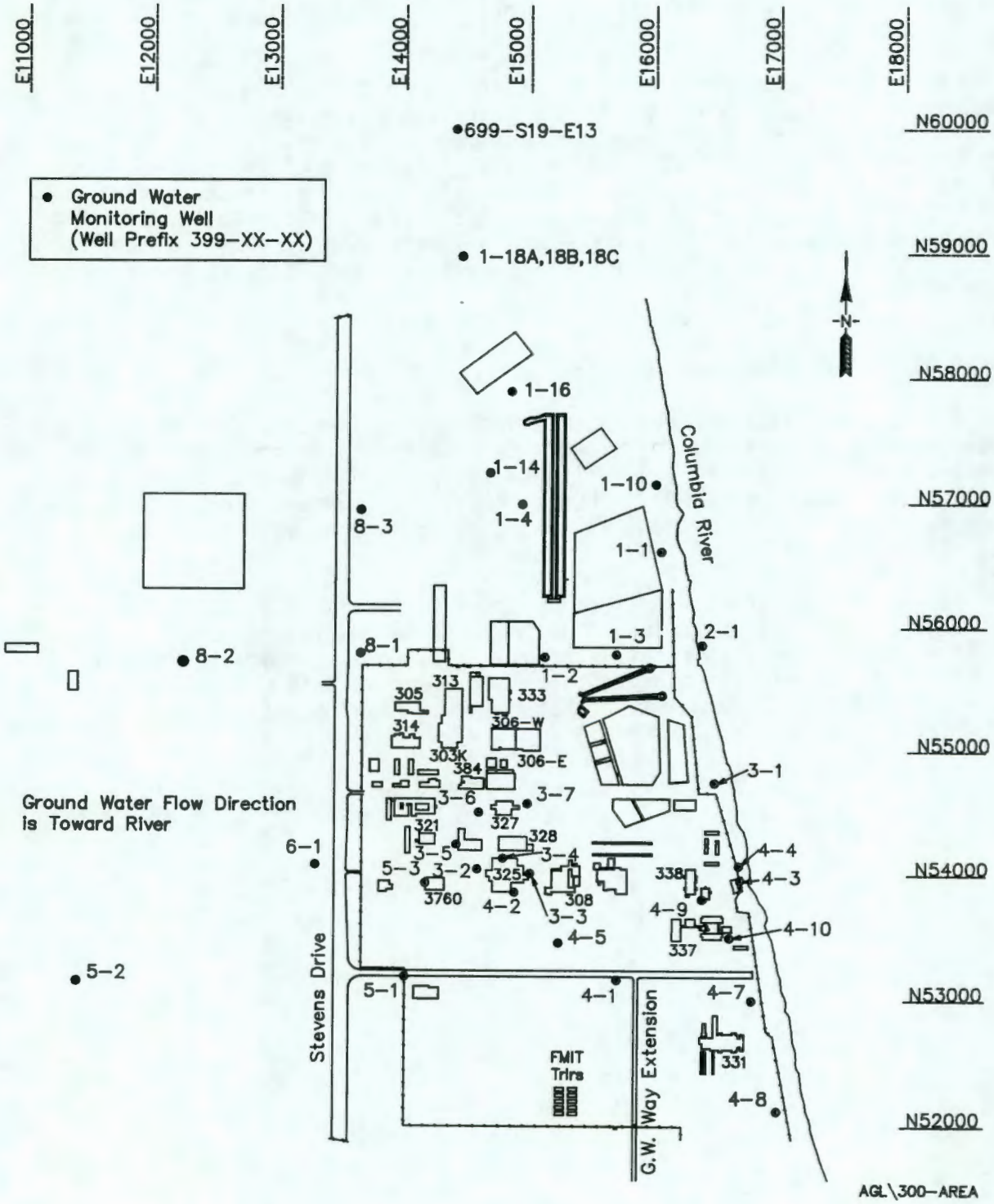


Figure 2.26-2. Lithology of Well 399-1-4 at 300 Area Process Trenches.

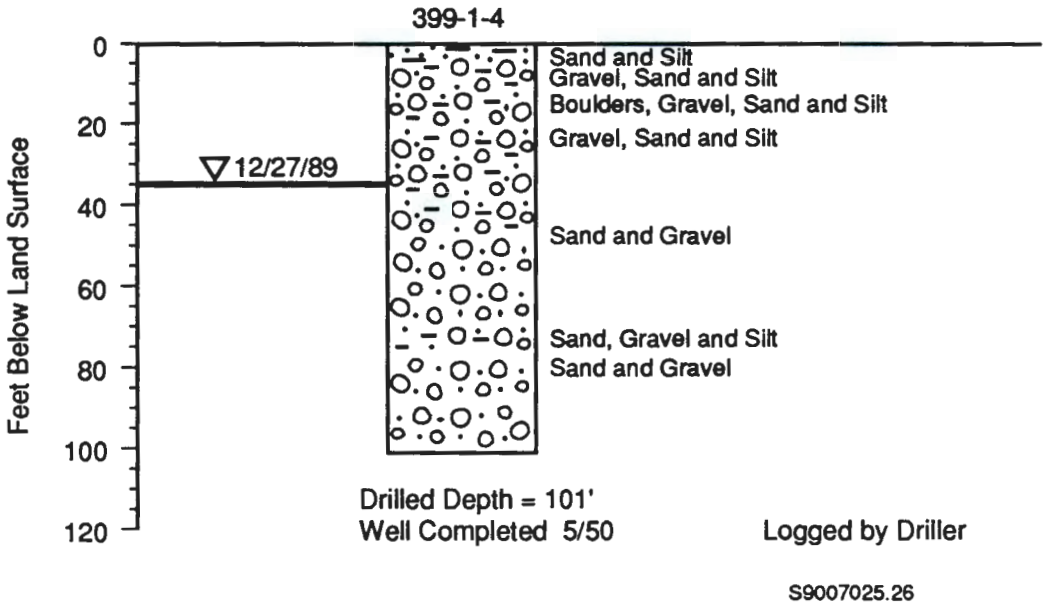


Table 2.26-1. Effluent Stream Description, 300 Area Process Wastewater.

Total volume of effluent discharged to subject receiving site:	Data not available
Average effluent discharge rate, by operating mode: (WHC 1990a, WHC-EP-0342, Addendum 1)	Approximately 1.52E+08 L/mo
Current average effluent discharge rate: (WHC 1990a, WHC-EP-0342, Addendum 1)	Approximately 1.52E+08 L/mo
Effluent designation: (WHC 1990a, WHC-EP-0342, Addendum 1)	Nondangerous, nonradioactive
Effluent status: (WHC 1990a, WHC-EP-0342, Addendum 1)	Active discharge to 300 Area Process Trenches

Table 2.26-2. Effluent Stream Sampling Data, 300 Area Process Wastewater.

Key Constituents	Detection Limit[a]	Detection/ Analyses	Sample Concentration 90% CI[a]	Detection Limit[a]	Detection/ Analyses	Sample Concentration 90% CI[a]
	02/87 to 06/89, During Routine Operation			10/89 to 03/90, During Routine Operation		
aluminum	NA	5/7	290	NA	2/4	351
silver	NA	2/7	56	NA	ND	ND
	1976 to 1988, During Routine Operation			10/89 to 03/90, During Routine Operation		
uranium-234	NA	13/NA	36	0.1	3/3	1[b]
uranium-238	NA	13/NA	30	NA	2/2	1[b]

[a]Units: chemical--parts per billion
radionuclides--picocurie per liter.
[b]Concentrations below Group A study guidelines; values given for purposes of comparison.

CI: confidence interval.
NA: not available.
ND: not detected.

NOTE: Only samples taken at the 300 Area process trench weir are considered in this table.

Table 2.26-3. Radionuclide and Chemical Loading, 300 Area Process Wastewater.

Flow Rate: 1.52E+08 L/mo

Constituent	Kg/L*	Kg/mo*
aluminum	2.33E-07	3.53E+01
barium	3.20E-08	4.85E+00
beryllium	5.75E-09	8.71E-01
boron	1.95E-08	2.95E+00
calcium	1.95E-05	2.95E+03
chloride	4.07E-06	6.17E+02
copper	1.60E-08	2.42E+00
fluoride	1.99E-07	3.01E+01
iron	7.22E-08	1.09E+01
magnesium	4.57E-06	6.92E+02
manganese	5.50E-09	8.33E-01
nitrate	1.32E-06	2.00E+02
phosphate	1.10E-06	1.67E+02
potassium	9.35E-07	1.42E+02
silicon	2.56E-06	3.88E+02
sodium	4.60E-06	6.97E+02
strontium	1.04E-07	1.58E+01
sulfate	1.71E-05	2.59E+03
uranium	1.44E-09	2.18E-01
zinc	1.87E-08	2.83E+00
acetone	1.25E-08	1.89E+00
ammonia	1.13E-07	1.71E+01
bis(2-ethylhexyl) phthalate	1.10E-08	1.67E+00
1-butanol	3.10E-08	4.70E+00
trichloromethane	1.82E-08	2.76E+00
unknown	8.00E-09	1.21E+00
alpha activity *	1.42E-12	2.15E-04
TDS	6.20E-05	9.39E+03
TOC	1.62E-06	2.45E+02
total carbon	1.47E-05	2.23E+03
TOX (as Cl)	1.54E-07	2.33E+01
americium-241 *	3.10E-14	4.70E-06
cobalt-60 *	6.11E-13	9.26E-05
hydrogen-3 *	2.31E-10	3.50E-02
plutonium-238 *	2.41E-14	3.65E-06
plutonium-239/240 *	1.78E-14	2.70E-06
strontium-90 *	2.45E-13	3.71E-05
uranium-234 *	7.41E-13	1.12E-04
uranium-235 *	2.26E-14	3.42E-06
uranium-238 *	6.52E-13	9.88E-05

Footnotes:

Data collected from October 1989 through March 1990.

Flow rate is the average of rates from the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 1).

Constituent concentrations are average values from the statistics in the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 1).

Concentration units of flagged (*) constituents are reported as curies per liter.

Loading units of flagged (*) constituents are reported as curies per month.

Table 2.26-4. Effluent Study Groundwater Summary Report. (Page 1 of 3)

CONSTITUENT			ANALYSIS SUMMARY					GROUP A STUDY GUIDELINES	
Group Name	Units	Detection Limit	Number of Analyses	Number > Det.	Average Result	Maximum Result	Minimum Result	Max Limit	Number > Limit
CONTAMINATION INDICATOR PARAMETERS									
Conductivity, Laboratory	UMHO	1.00	3	3	353.00	469.00	230.00	700.0	0
Specific conductance	UMHO	1.00	124	124	266.15	523.00	139.00	700.0	0
Total Organic Halogen, Low Det. Level	PPB	10.00	118	99	32.12	82.00	-1.00		0
pH, Field Measurement		.10	123	123	7.45	8.97	5.83	8.5	3
pH, Laboratory Measurement		.01	10	10	7.69	8.10	7.20	8.5	0
DRINKING WATER PARAMETERS									
Alpha, High Detection Level	PCI/L	4.00	57	40	23.82	162.00	-.80	15.0	18
Arsenic	PPB	5.00	49	7	5.06	6.00	5.00	50.0	0
Arsenic, filtered	PPB	5.00	49	5	5.04	6.00	5.00	50.0	0
Barium	PPB	6.00	56	56	34.54	77.00	11.00	1000.0	0
Barium, filtered	PPB	6.00	58	58	34.97	79.00	12.00	1000.0	0
Cadmium	PPB	2.00	55	2	2.04	3.00	2.00	10.0	0
Cadmium, filtered	PPB	2.00	57	3	2.04	3.00	2.00	10.0	0
Chromium	PPB	10.00	55	4	10.40	30.00	10.00	50.0	0
Coliform (Membrane Filter)	PPB	1.00	23	2	113.96	2400.00	1.00	1.0	2
Coliform bacteria	MPN	2.20	26	2	7.49	79.00	2.20	1.0	2
Fluoride	PPB	500.00	127	13	752.76	25000.00	500.00	4000.0	1
Gross beta	PCI/L	8.00	59	23	10.80	46.70	1.20	50.0	0
Nitrate	PPB	500.00	129	120	5921.71	23700.00	500.00	45000.0	0
Nitrate, High Detection Level	PPB	2500.00	9	6	10533.33	20300.00	2500.00	45000.0	0
Groundwater Quality Parameters									
Chloride	PPB	500.00	127	126	17816.54	75100.00	500.00	250000.0	0
Iron	PPB	30.00	56	43	197.52	2230.00	30.00	300.0	8
Iron, filtered	PPB	30.00	56	13	51.73	327.00	30.00	300.0	1
Manganese	PPB	5.00	55	16	18.22	106.00	5.00	50.0	8
Manganese, filtered	PPB	5.00	57	12	15.32	85.00	5.00	50.0	6
Sodium	PPB	200.00	58	58	20505.69	68500.00	5400.00		0
Sodium, filtered	PPB	200.00	59	59	20022.71	68900.00	5130.00		0
Sulfate	PPB	500.00	129	126	22555.81	52100.00	500.00	250000.0	0

Table 2.26-4. Effluent Study Groundwater Summary Report. (Page 2 of 3)

CONSTITUENT			ANALYSIS SUMMARY					GROUP A STUDY GUIDELINES	
Group Name	Units	Detection Limit	Number of Analyses	Number > Det.	Average Result	Maximum Result	Minimum Result	Max Limit	Number > Limit
SITE SPECIFIC AND OTHER PARAMETERS									
1,1,1-trichloroethane	PPB	5.00	115	1	5.00	9.00	3.00	200.0	0
1,2-dichloroethane	PPB	5.00	115	1	5.03	8.00	5.00	5.0	1
Acetone by VOA	PPB	10.00	115	1	9.71	13.00	3.00		0
Alkalinity		20000.00	49	48	93946.94	185000.00	5400.00		0
Aluminum, filtered	PPB	150.00	56	1	153.13	325.00	150.00	50.0	1
Ammonium ion	PPB	50.00	29	6	60.90	129.00	50.00		0
Beryllium	PPB	5.00	56	1	5.07	9.00	5.00		0
Beryllium, filtered	PPB	5.00	56	2	5.05	8.00	5.00		0
Boron	PPB	10.00	58	54	35.33	273.00	10.00		0
Boron, filtered	PPB	10.00	59	56	37.71	265.00	10.00		0
Calcium	PPB	50.00	58	58	27012.07	50200.00	10300.00		0
Calcium, filtered	PPB	50.00	59	59	27420.34	63200.00	10200.00		0
Chloroform	PPB	5.00	115	88	14.74	36.00	5.00	100.0	0
Copper	PPB	10.00	56	10	11.77	50.00	10.00	1000.0	0
Copper, filtered	PPB	10.00	57	11	11.26	26.00	10.00	1000.0	0
Lithium	PPB	10.00	55	13	11.07	19.00	10.00		0
Lithium, filtered	PPB	10.00	57	16	11.00	20.00	10.00		0
Magnesium	PPB	50.00	58	58	6080.86	12200.00	3430.00		0
Magnesium, filtered	PPB	50.00	59	59	6159.83	12900.00	3310.00		0
Methyl ethyl ketone	PPB	10.00	115	1	9.99	11.00	9.00		0
Methylene Chloride	PPB	5.00	115	3	4.97	15.00	2.00		0
Nickel	PPB	10.00	55	6	12.64	80.00	10.00		0
Nickel, filtered	PPB	10.00	56	6	12.34	75.00	10.00		0
Potassium	PPB	100.00	58	58	3949.62	9930.00	978.00		0
Potassium, filtered	PPB	100.00	59	59	3928.27	10100.00	908.00		0
Silicon	PPB	50.00	57	57	11807.72	28100.00	2600.00		0
Silicon, filtered	PPB	50.00	59	59	11751.69	27700.00	2580.00		0
Strontium	PPB	10.00	56	56	125.88	232.00	76.00		0
Strontium, filtered	PPB	10.00	59	59	127.22	287.00	74.00		0
Technetium-99	PCI/L	15.00	12	4	14.19	71.80	-2.21	4000.0	0
Tetrachloroethylene	PPB	5.00	115	1	4.92	5.00	1.00	5.0	1
Total carbon	PPB	1000.00	33	33	24581.82	43500.00	12600.00		0

Table 2.26-4. Effluent Study Groundwater Summary Report. (Page 3 of 3)

CONSTITUENT			ANALYSIS SUMMARY					GROUP A STUDY GUIDELINES	
Group Name	Units	Detection Limit	Number of Analyses	Number > Det.	Average Result	Maximum Result	Minimum Result	Max Limit	Number > Limit
SITE SPECIFIC AND OTHER PARAMETERS									
Total dissolved solids		5000.00	29	29	172948.28	278000.00	82500.00	500000.0	0
Trans-1,2-dichloroethene	PPB	5.00	115	4	6.83	135.00	5.00	70.0	2
Trichloroethylene	PPB	5.00	115	8	5.15	23.00	1.00	5.0	8
Tritium	PCI/L	500.00	33	7	1206.04	8480.00	-93.30	80000.0	0
Turbidity	NTU	.10	29	23	.53	9.00	.10	5.0	1
Unknown	PPB	0.00	2	2	45.00	61.00	29.00		0
Unknown Aliphatic Hydrocarbon	PPB		1	1	90.00	90.00	90.00		0
Uranium	PCI/L	.50	128	124	70.36	370.00	-.03	40.0	57
Vanadium	PPB	5.00	56	14	6.18	14.00	5.00		0
Vanadium, filtered	PPB	5.00	58	26	6.76	15.00	5.00		0
Zinc	PPB	5.00	56	24	7.91	35.00	5.00	5000.0	0
Zinc, filtered	PPB	5.00	56	19	8.29	80.00	5.00	5000.0	0

Table 2.26-5. Background Comparison, 300 Area Process Trenches.

Constituent	Background[a]	Average/ Background[b]	Maximum/ Background[b]
aluminum	2.0	76.57	162.50
ammonia	50.0	1.22	2.58
arsenic	6.3	0.80 (0.80)	0.95 (0.95)
barium	62.0	0.56 (0.56)	1.24 (1.27)
beryllium	0.3	16.90 (16.83)	30.00 (26.67)
bismuth	0.02		
boron	50.0	0.71 (0.75)	5.46 (5.30)
cadmium	0.2	10.2 (10.2)	15.00 (15.00)
calcium	50,700	0.53 (0.54)	0.99 (1.25)
chloride	16,800	1.06	4.47
chromium	6.0	1.73	5.00
copper	1.0	11.77 (11.26)	50.00 (26.00)
cyanide	10.0		
fluoride	470	1.60	53.19
lead	0.5		
magnesium	15,200	0.40 (0.41)	0.80 (0.85)
manganese	12.0	1.52 (1.28)	8.83 (7.08)
mercury	0.1		
nickel	4.0	3.16 (3.09)	20.00 (18.75)
phosphate	1,000		
potassium	6,190	0.62 (0.63)	1.60 (1.63)
selenium	2.0		
silver	10		
sodium	28,410	0.72 (0.70)	2.41 (2.43)
strontium	338	0.37 (0.38)	0.69 (0.85)
sulfate	51,200	0.44	1.02
uranium	2.5	28.14	148.00
vanadium	26	0.24 (0.26)	0.54 (0.58)
zinc	8.0	0.99 (1.04)	4.38 (10.00)
alkalinity	144,000	0.65	1.28
pH	7.8	0.96	1.15
TOC	933		
conductivity	462	0.58	1.13
gross alpha	3.9		
gross beta	31	0.35	1.51
radium	0.2		

TOC: total organic carbon. ( ): filtered samples.

[a]Background is the mean plus one standard deviation for the values listed in Table 2-1. Amounts of uranium, gross alpha, gross beta, and radium given in picocuries per liter. All others are in parts per billion.

[b]Average and maximum values from Table 2.26-4.

2.27 400 AREA PROCESS PONDS

No significant impacts were identified that would result from continued operation of the 400 Area Process Ponds. However, nitrate in groundwater beneath the ponds has shown a steady increase over the last 3 yr. This occurrence is attributed to a nearby source of sanitary wastewater.

2.27.1 Disposal Site Description

The 400 Area Process Ponds are located in the 600 Area, north of the 400 Area fence. The unlined ponds have been in operation since 1979 and receive liquid effluents from the 400 Area Process Sewer. Figure 2.27-1 depicts the locations of the percolation ponds and monitoring well relative to other facilities in the vicinity.

2.27.2 Effluent Stream Description

The 400 Area contains a complex of buildings and facilities dedicated to operations of a research reactor and a fuel material test facility. The two principal facilities are the Fast Flux Test Facility (FFTF), an experimental reactor, and the Fuel Materials and Examination Facility (FMEF), a fuel assembly and testing facility. Wastewater discharges from the 400 Area facilities are collected in the 400 Area Process Sewer. Routine waste stream contributors consist primarily of cooling waters from the FFTF and FMEF facilities. There are also numerous drains, sinks, sumps, and other effluent sources which are intermittent or infrequent contributors. Effluent stream information is summarized in Table 2.27-1. Key constituents are given in Table 2.27-2 and loading estimates are provided in Table 2.27-3.

No constituents which exceed study guidelines were indicated in any of the sampling data.

2.27.3 Flow and Transport Analysis

For the purpose of computing transport times, the sediment column beneath the ponds was treated as a single layer of fine sand with a depth to water of 32 m (Figure 2.27-2 and Appendix B). The calculated travel time for wastewater to reach the water table under average discharge conditions is 139 days (see Appendix B for data and computations).

There were no key constituents identified in Table 2.27-2, and therefore estimates of contaminant migration rates are not appropriate.

2.27.4 Groundwater Quality Assessment

Enhanced groundwater sampling was conducted at this facility to provide baseline information for future use of the ponds. One non-RCRA compliant well (699-2-7) with a submersible pump was sampled on 4/13/90 for 40 CFR 264, Appendix IX and site-specific radioactive constituents. Other indicator constituents were available from the operational monitoring program.

A summary of positive results is shown in Table 2.27-4. The constituents exceeding Group A guidelines are specific conductance, total dissolved solids (TDS), nitrate, and iron. The elevated iron (unfiltered) is attributed to an artifact of sampling from wells with carbon steel casings. The elevated conductivity and TDS are attributed to the discharge of concentrated, naturally occurring salts that result from the evaporation of the cooling tower water (WHC 1990, Addendum 28). The water supply for the 400 Area is provided primarily (about 93%) by well 499-S1-8J, which is screened from approximately 360 to 390 ft below grade; well 499-S0-7, screened from 221 to 396 ft below grade, is the secondary source.

The elevated nitrate is substantially higher than indicated in the 400 Area wastestream. A nitrate plume from upgradient sources (200 East Area) exists beneath the site in the vicinity of the 400 Area, but levels in the well are higher than those for the plume in that area (Evans et al. 1990). Figure 2.27-3 is a time series plot of nitrate data from the monitoring well and nearby wells. The figure shows a significant variation in nitrate levels for the monitoring well in comparison to other wells in the area. A possible explanation for the elevated nitrate is discharge of sanitary sewage from a nearby disposal site.

A comparison of positive results with available background values is shown in Table 2.27-5. No major deviations from background values are evident.

No key constituents were identified for this study. Other above-background or positive occurrences in groundwater, however, were also reported in the wastestream (WHC 1990a, Addendum 28, Table 3.2). These constituents include calcium, chloride, nitrate, magnesium, potassium, sodium, strontium, sulfate, uranium, and zinc. With the exception of nitrate, the remaining constituents are found in the groundwater at levels similar to or slightly less than in the wastestream. Nitrate, as discussed previously, is substantially higher than levels reported in the waste-stream.

2.27.5 Impact of Continued Operation

The average discharge rate to this crib is insignificant in comparison to Cold Creek natural recharge rate; thus, no impact on the groundwater flow regime (beyond the immediate vicinity of the ponds) is expected.

Assuming the increasing nitrate observed the past 3 yr (Figure 2.27-2) is due to a nearby sanitary disposal facility and assuming no major changes in wastewater composition in the future, operation of these ponds should have only minimal impact on vicinity groundwater quality.

The low chemical loading (as indicated by secondary cooling water composition) suggests that remobilization should not be a significant issue at this disposal site.

Figure 2.27-1. Well Location and Site Map for 400 Area Ponds.

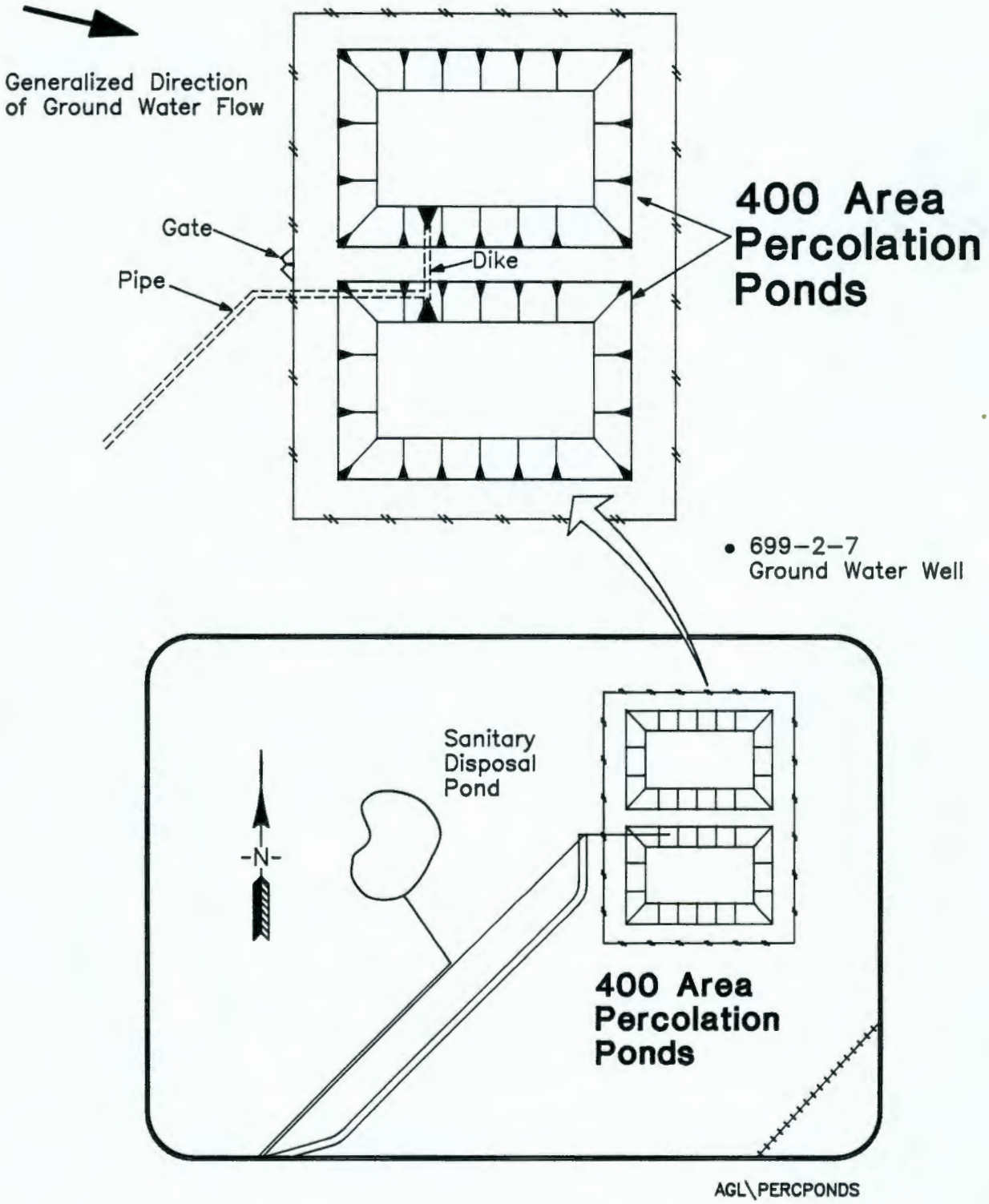
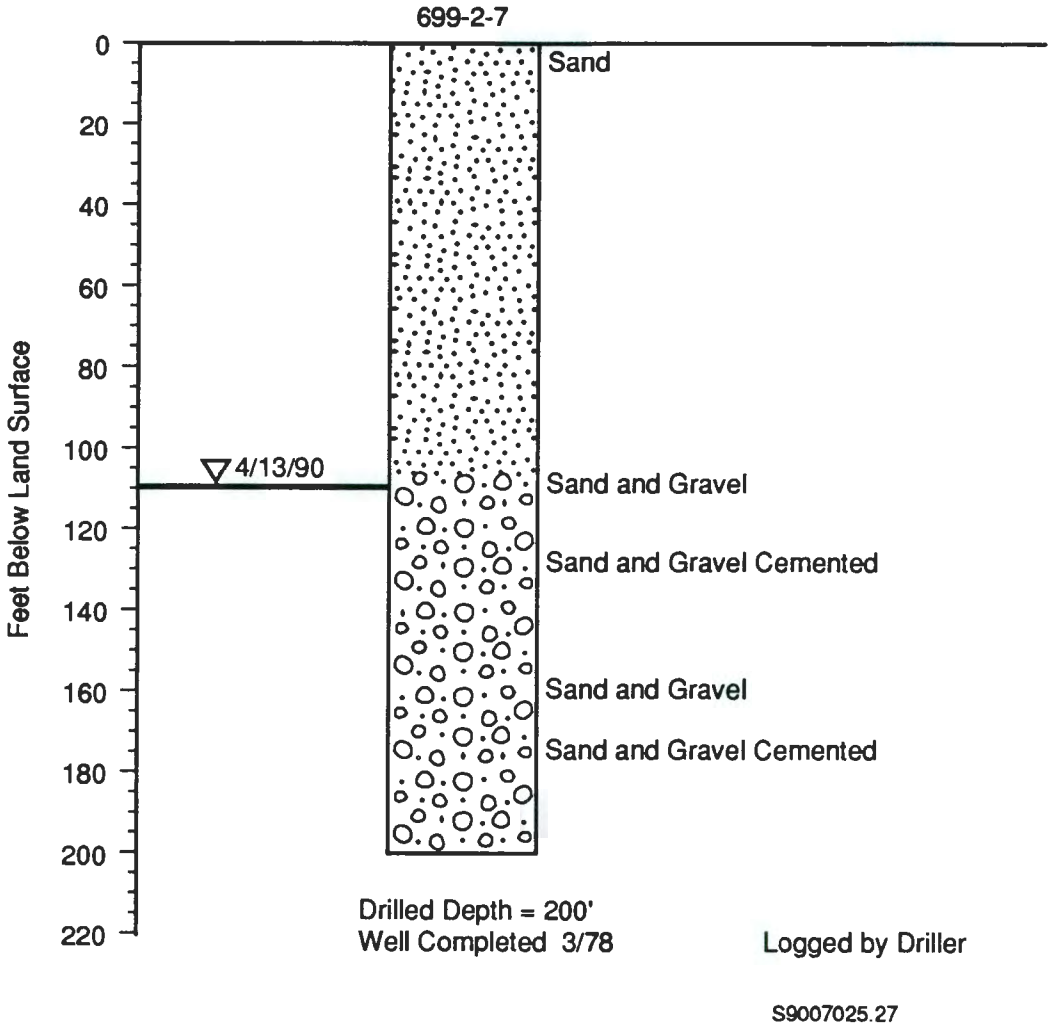


Figure 2.27-2. Lithology of Well 699-2-7 at 400 Area Ponds.



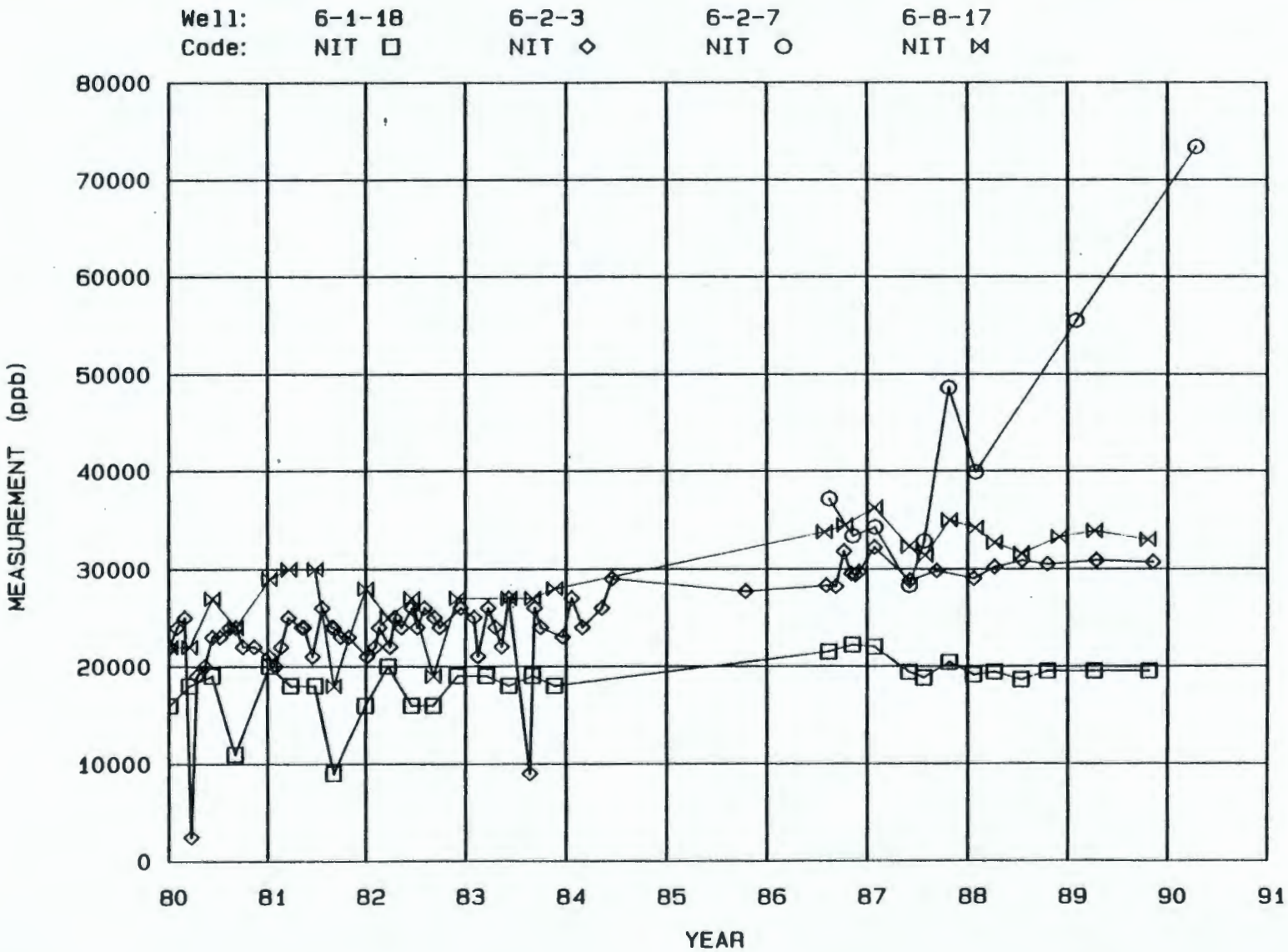


Figure 2.27-3. Time Series Plot of Nitrate Data from Monitoring Well 699-2-7 and Adjacent Wells Near the 400 Area Ponds.

Table 2.27-1. Effluent Stream Description, 400 Area Secondary Cooling Water.

Total volume of effluent discharged to subject receiving site: (WHC 1990a, WHC-EP-0342, Addendum 28)	4E+08 L from 1979 to 1990
Average effluent discharge rate, by operating mode: (WHC 1990a, WHC-EP-0342, Addendum 28)	2.98E+06 L/mo
Current average effluent discharge rate: (WHC 1990a, WHC-EP-0342, Addendum 28)	2.98E+06 L/mo
Effluent designation (WHC 1990a, WHC-EP-0342, Addendum 28)	Nondangerous, nonradioactive
Effluent status:	Active discharge to 400 Area Ponds

Table 2.27-2. Effluent Stream Sampling Data, 400 Area Secondary Cooling Water.

Key Constituents	Detection Limit[a]	Detection/ Analyses	Sample Concentration 90% CI[a]	Detection Limit[a]	Detection/ Analyses	Sample Concentration 90% CI[a]
	02/87 to 08/87, During Routine Operation			10/89 to 03/90, During Routine Operation		
None	None			None		

[a]Units: chemical--parts per billion
radionuclides--picocurie per liter.

CI: confidence interval.

Table 2.27-3. Radionuclide and Chemical Loading, 400 Area Secondary Cooling Water.

Flow Rate: 2.98E+06 L/mo

Constituent	Kg/L*	Kg/mo*
barium	3.45E-08	1.03E-01
boron	4.85E-08	1.44E-01
calcium	5.51E-05	1.64E+02
chloride	2.06E-05	6.13E+01
copper	1.02E-08	3.04E-02
fluoride	6.69E-07	1.99E+00
iron	5.37E-08	1.60E-01
lithium	2.87E-08	8.54E-02
magnesium	1.57E-05	4.67E+01
manganese	1.32E-08	3.93E-02
nitrate	1.11E-06	3.30E+00
potassium	1.62E-05	4.82E+01
silicon	3.74E-05	1.11E+02
sodium	6.46E-05	1.92E+02
strontium	2.85E-07	8.48E-01
sulfate	6.40E-05	1.90E+02
uranium	3.19E-10	9.49E-04
zinc	3.40E-08	1.01E-01
acetone	1.42E-08	4.23E-02
ammonia	8.00E-08	2.38E-01
bromodichloromethane	5.00E-09	1.49E-02
2-butanone	9.50E-09	2.83E-02
trichloromethane	5.75E-09	1.71E-02
beta activity *	1.90E-11	5.65E-05
TDS	4.57E-04	1.36E+03
TOC	2.17E-06	6.46E+00
total carbon	6.09E-05	1.81E+02
TOX (as Cl)	1.42E-07	4.23E-01
cobalt-60 *	2.32E-11	6.90E-05
cesium-137 *	3.19E-11	9.49E-05
hydrogen-3 *	6.54E-09	1.95E-02
radium total *	1.39E-13	4.14E-07

Footnotes:

Data collected from October 1989 through March 1990.

Flow rate is the average of rates from the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 28).

Constituent concentrations are average values from the statistics in the Hanford Site Stream-Specific Reports (WHC 1990a, Addendum 28).

Concentration units of flagged (*) constituents are reported as curies per liter.

Loading units of flagged (*) constituents are reported as curies per month.

Table 2.27-4. Effluent Study Groundwater Summary Report. (Page 1 of 2)

CONSTITUENT			ANALYSIS SUMMARY					GROUP A STUDY GUIDELINES	
Group Name	Units	Detection Limit	Number of Analyses	Number > Det.	Average Result	Maximum Result	Minimum Result	Max Limit	Number > Limit
CONTAMINATION INDICATOR PARAMETERS									
Conductivity, Laboratory	UMHO	1.00	1	1	845.00	845.00	845.00	700.0	1
Specific conductance	UMHO	1.00	1	1	760.00	760.00	760.00	700.0	1
pH, Field Measurement		.10	1	1	8.05	8.05	8.05	8.5	0
pH, Laboratory Measurement		.01	1	1	7.60	7.60	7.60	8.5	0
DRINKING WATER PARAMETERS									
Alpha, High Detection Level	PCI/L	4.00	1	1	9.11	9.11	9.11	15.0	0
Barium	PPB	6.00	1	1	45.00	45.00	45.00	1000.0	0
Barium, filtered	PPB	6.00	1	1	51.00	51.00	51.00	1000.0	0
Gross beta	PCI/L	8.00	1	1	12.10	12.10	12.10	50.0	0
Nitrate	PPB	500.00	1	1	73400.00	73400.00	73400.00	45000.0	1
Nitrate, High Detection Level	PPB	2500.00	1	1	55500.00	55500.00	55500.00	45000.0	1
GROUNDWATER QUALITY PARAMETERS									
Chloride	PPB	500.00	1	1	30000.00	30000.00	30000.00	250000.0	0
Iron	PPB	30.00	1	1	461.00	461.00	461.00	300.0	1
Manganese	PPB	5.00	1	1	10.00	10.00	10.00	50.0	0
Manganese, filtered	PPB	5.00	1	1	8.00	8.00	8.00	50.0	0
Sodium	PPB	200.00	1	1	36200.00	36200.00	36200.00		0
Sodium, filtered	PPB	200.00	1	1	43000.00	43000.00	43000.00		0
Sulfate	PPB	500.00	1	1	121000.00	121000.00	121000.00	250000.0	0
SITE SPECIFIC AND OTHER PARAMETERS									
Alkalinity		20000.00	1	1	189000.00	189000.00	189000.00		0
Boron	PPB	10.00	1	1	41.00	41.00	41.00		0
Boron, filtered	PPB	10.00	1	1	47.00	47.00	47.00		0
Calcium	PPB	50.00	1	1	89700.00	89700.00	89700.00		0
Calcium, filtered	PPB	50.00	1	1	87700.00	87700.00	87700.00		0
Magnesium	PPB	50.00	1	1	23400.00	23400.00	23400.00		0
Magnesium, filtered	PPB	50.00	1	1	24800.00	24800.00	24800.00		0
Potassium	PPB	100.00	1	1	7630.00	7630.00	7630.00		0
Potassium, filtered	PPB	100.00	1	1	8620.00	8620.00	8620.00		0

Table 2.27-4. Effluent Study Groundwater Summary Report. (Page 2 of 2)

CONSTITUENT			ANALYSIS SUMMARY					REGULATORY STANDARDS	
Group Name	Units	Detection Limit	Number of Analyses	Number > Det.	Average Result	Maximum Result	Minimum Result	Max Limit	Number > Limit
SITE SPECIFIC AND OTHER PARAMETERS									
Silicon	PPB	50.00	1	1	15200.00	15200.00	15200.00		0
Silicon, filtered	PPB	50.00	1	1	16000.00	16000.00	16000.00		0
Strontium	PPB	10.00	1	1	374.00	374.00	374.00		0
Strontium, filtered	PPB	10.00	1	1	423.00	423.00	423.00		0
Total dissolved solids		5000.00	1	1	502000.00	502000.00	502000.00	500000.0	1
Tritium	PCI/L	500.00	2	2	13300.00	14300.00	12300.00	80000.0	0
Turbidity	NTU	.10	1	1	1.10	1.10	1.10	5.0	0
Uranium	PCI/L	.50	1	1	5.40	5.40	5.40	40.0	0
Zinc	PPB	5.00	1	1	8.00	8.00	8.00	5000.0	0
Zinc, filtered	PPB	5.00	1	1	9.00	9.00	9.00	5000.0	0

Table 2.27-5. Background Comparison, 400 Area Ponds.

Constituent	Background[a]	Average/ Background[b]	Maximum/ Background[b]
aluminum	2.0		
ammonia	50.0		
arsenic	6.3		
barium	62.0	0.73 (0.82)	0.73 (0.82)
beryllium	0.3		
bismuth	0.02		
boron	50.0	0.82 (0.94)	0.82 (0.94)
cadmium	0.2		
calcium	50,700	1.77 (1.73)	1.77 (1.73)
chloride	16,800	1.79	1.79
chromium	6.0		
copper	1.0		
cyanide	10.0		
fluoride	470		
lead	0.5		
magnesium	15,200	1.54 (1.63)	1.54 (1.63)
manganese	12.0	0.83 (0.67)	0.83 (0.67)
mercury	0.1		
nickel	4.0		
phosphate	1,000		
potassium	6,190	1.23 (1.39)	1.23 (1.39)
selenium	2.0		
silver	10		
sodium	28,410	1.27 (1.51)	1.27 (1.51)
strontium	338	1.03 (1.25)	1.03 (1.25)
sulfate	51,200	2.36	2.36
uranium	2.5	2.16	2.16
vanadium	26		
zinc	8.0	1.00 (1.13)	1.00 (1.13)
alkalinity	144,000	1.31	1.31
pH	7.8	1.11	1.11
TOC	933		
conductivity	462	1.65	1.65
gross alpha	3.9		
gross beta	31	0.39	0.39
radium	0.2		

TOC: total organic carbon. ( ): filtered samples.

[a]Background is the mean plus one standard deviation for the values listed in Table 2-1. Amounts of uranium, gross alpha, gross beta, and radium given in picocuries per liter. All others are in parts per billion.

[b]Average and maximum values from Table 2.27-4.

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3.0 SUMMARY

Major results of the Liquid Effluent Study and a discussion of associated limitations are presented in this section. The decision tree assessments discussed individually for each receiving site in Chapter 2 are summarized in Section 3.1. The uncertainties concerning the assessments and recommendations to address those uncertainties are discussed in Section 3.2.

3.1 MAJOR RESULTS

The decision tree (Figure 1-3) was designed as a logic process for assessing the impact of discharging liquid effluents to the soil column. The key elements of the decision tree require:

- A proposed dangerous waste designation, pursuant to WAC 173-303, for each effluent stream.
- An impact assessment of wastestream discharges on each receiving site.

Detailed discussion of the decision tree and identification of the criteria by which impacts are considered to be significant for the purposes of this study are provided in Section 1.3. Table 3-1 summarizes the key decision tree elements for each receiving site and associated stream(s). According to the decision tree, wastestreams which are designated as dangerous wastes or are scheduled to terminate by January 1992 do not require further evaluation as part of the Liquid Effluent Study. However, for completeness and for use as a reference point, such streams are assessed in Chapter 2 and have been included in the decision tree summary.

3.1.1 Stream Designation

Two streams were proposed for designation as dangerous wastes pursuant to WAC 173-303 in the Hanford Site Stream-Specific Reports (WHC 1990a):

- PUREX Plant Ammonia Scrubber Condensate
- 242-A Evaporator Process Condensate.

A designation was not proposed for the B Plant Process Condensate because the available effluent data were insufficient in the current plant configuration. Feed for this stream is routed to double-shell tanks. The stream will be resampled upon startup of plant operations.
The remaining 30 streams were designated as nondangerous (Table 3-1, Column 1).

Twelve streams were classified as radioactive, according to concentration standards for radionuclides in the Westinghouse Hanford Company Environmental Compliance Manual, Part N, "Groundwater Protection" (WHC 1989b) (Table 3-1, Column 2):

- N Reactor Effluent
- 241-AY/AZ Tank Farm Steam Condensate
- PUREX Plant Steam Condensate
- PUREX Plant Ammonia Scrubber Condensate
- 242-A Evaporator Process Condensate
- 242-A Evaporator Cooling Water
- B Plant Steam Condensate
- B Plant Process Condensate
- 222-S Laboratory Wastewater
- UO_3 Plant Process Condensate
- 2724-W Laundry Wastewater
- Plutonium Finishing Plant Wastewater

The remaining 21 streams were determined to be both nondangerous and nonradioactive.

3.1.2 Impact on Groundwater Quality

Columns 3 and 4 on Table 3-1 summarize information used to assess the likelihood that each receiving site has impacted local groundwater quality. Key constituents exceeding study guidelines (Table 2-1) were detected in all but the following three wastestreams (Table 3-1, Column 3):

- 163N Demineralization Plant Wastewater
- 209-E Laboratory Reflector Water
- 400 Area Secondary Cooling Water.

The key constituents are listed for the other 30 wastestreams in the corresponding site assessments in Chapter 2.

For the purposes of this study, a key effluent constituent may have a significant impact on groundwater quality if it is present in the groundwater at a concentration exceeding Group A study guidelines (primarily the drinking water standard or equivalent, Table 2-1). Column 4 considers only those key constituents determined to be present in the groundwater as a result of discharge operations at the specific site; contaminants from other sources, such as upgradient sources or well corrosion products, have been excluded based on the site assessments in Chapter 2. The specific groundwater constituents which exceed study guidelines at each receiving site are listed in the corresponding site assessments in Chapter 2.

Key effluent constituents exceeding Group A study guidelines were detected in the groundwater at five receiving sites (Table 3-1, Column 4):

- 1325N Crib
- 216-A-36B Crib
- 216-A-37-1 Crib
- 216-A-45 Crib
- 300 Area Process Trenches.

Effluent discharges to the 216-A-36B, 216-A-37-1, and 216-A-45 cribs have been permanently terminated from their associated effluent streams; these cribs will no longer be used as receiving sites. The 1325N Crib is currently receiving significantly reduced discharge volumes and concentrations of key constituents. The primary key constituent (uranium) in the 300 Area process wastewater has been significantly reduced by closing down the fuel fabrication facilities. These facilities were the main source of uranium in the effluent stream.

The following seven receiving sites did not have groundwater monitoring wells at the time groundwater samples were collected for this study:

- 100-D Ponds
- 216-B-63 Ditch
- 216-C-7 Crib
- 216-S-10 Ditch
- 216-T-1 Ditch
- 216-T-4-2 Ditch
- 200-W Powerhouse Pond.

Because contaminant concentrations in groundwater are not available for these sites, any evaluation or preliminary conclusion regarding groundwater quality is based on effluent composition and model predictions. One groundwater well was sampled at the 216-L-WC Crib; however, well rehabilitation or replacement is required to obtain representative samples at this site.

3.1.3 Impact on Receiving Site Cleanup

Exacerbation of future cleanup activities is assessed by predicting the additional downward migration of existing soil column contamination as a result of continued discharge to the receiving site until 1995. As a result of downward migration through the soil column, additional key constituents might break through from the vadose zone to the groundwater (Table 3-1, Column 5), impacting groundwater quality, or an additional portion of the soil column could become contaminated (Table 3-1, Column 6), increasing the volume of contaminated soil.

Estimations of the additional downward movement of contaminants during continued operation of the receiving site is based on average discharge rates and one-dimensional flow and transport analyses (Appendix B). However, relatively little information is available on the inventory and distribution of contaminants currently within the soil column. In addition, chemical and physical properties of the vadose zone sediments at each receiving site are required to accurately determine migration rates of contaminants and to predict downward migration rates with confidence. In

the absence of this site-specific data, technical judgment was applied to assess the significance of continued operation of the receiving site.

Breakthrough to the groundwater of additional key constituents currently in the soil column is likely by 1995 for four sites (Table 3-1, Column 5):

- 100-D Ponds - The migration rate through the vadose zone to the groundwater table for sulfate and chromium at this site is estimated to be less than 2 yr. Based on the 13-yr discharge history to 100-D Ponds, these key constituents are expected to have already broken through to the groundwater. However, groundwater monitoring wells are needed for confirmation.

- 1325N Crib - Although present in the N Reactor effluent in relatively high concentrations, cesium has not been detected in the groundwater samples. If discharge to the 1325N Crib continues at its past average rate, cesium is expected to breakthrough to the groundwater table before 1995. However, at the reduced, current discharge rate, breakthrough of cesium is unlikely.

- 216-U-14 Ditch - In 1986, a uranium spill occurred at the 216-U-14 Ditch. The migration rate estimate for this constituent suggests that breakthrough is likely within the next 5 yr at current discharge rates. The expected concentration of uranium in the groundwater from breakthrough of uranium is not known.

- 200-W Powerhouse Pond - The migration rate through the vadose zone for chloride, which is present in the effluent in high concentrations, is about 6 mo. Based on the 6-yr discharge history to the 200-W Powerhouse Pond, chloride is expected to have already broken through to the groundwater. However, groundwater monitoring wells are needed to confirm this.

The anticipated impact on groundwater quality at all four of these receiving sites is judged to be only minimal.

Breakthrough of key effluent constituents to the groundwater is anticipated at two additional receiving sites, based on average discharge rates:

- 216-A-8 Crib
- 216-B-62 Crib.

However, at the current reduced discharge rates to these receiving sites, breakthrough of additional key constituents is not expected within the next 5 yr.

For purposes of this study, contamination of an additional portion of the soil column was judged to be significant if the contaminants moved through at least 10% of the currently available, unused portion of the soil column. No receiving sites met this criterion at their current discharge rates.

Significant additional contamination of the soil column is anticipated at three receiving sites, based on average discharge rates:

- 1325N Crib
- 216-A-8 Crib
- 216-B-62 Crib.

However, at the current, reduced discharge rates to these receiving sites, significant additional contamination is not expected within the next 5 yr.

3.1.4 Impact on Groundwater Flow Patterns

For the purposes of this study, a wastestream is considered to have a significant volume impact if its discharge rate is greater than the natural recharge rate from the Cold Creek/Dry Creek recharge area. Effluent discharge has a significant impact on groundwater flow patterns at only two receiving sites (Table 3-1, Column 7):

- 216-B-3 Pond System - The groundwater mound formed beneath the 216-B-3 Pond System has a major perturbation on the easterly flow of groundwater from the recharge area west of the Hanford Site to the Columbia River on the east. Radial flow outward from the mound also moves groundwater and contaminants northward toward Gable Gap. However, the mound may serve as a hydraulic barrier which lengthens the flow path and increases the travel time for groundwater and contaminants underneath the 200 Areas to reach the Columbia River. Changes in the size of the groundwater mound will have significant consequences on local groundwater flow directions and contaminant migration within the unconfined aquifer.

- 300 Area Process Trenches - Discharge volumes from the 300 Area Process wastewater exceed the criterion for impact on groundwater flow patterns. However, groundwater flow direction in this area is more a function of seasonal changes in river flow than crib discharge volumes (see Smith and Gorst 1990).

3.1.5 Impact of Continued Use of Receiving Sites

Four receiving sites will not be used again to receive liquid discharges (Table 3-1, column 8):

- 216-A-36B Crib
- 216-A-37-1 Crib
- 216-A-45 Crib
- 216-C-7 Crib.

For these four sites, the discussion of the impact of continued use is not applicable.

For the other 23 receiving sites, impacts are assessed based on whether continued use is expected to exacerbate cleanup activities. The impacts are considered for two conditions (Table 3-1, Columns 9 and 10): discharge of the stream(s) in an operational mode for the generating facility, and discharge of the associated liquid effluent stream(s) in a reduced discharge mode (e.g., shutdown mode for the generating facility). Based on their current operating modes (indicated in Column 9 or 10 by the shaded pattern), continued use of one receiving site is judged to have an impact on future cleanup activities:

- 216-B-3 Pond System - Use of the 216-B-3 Pond System in the current operational mode will continue to have a volume impact on the groundwater flow patterns.

Continued use of the following three sites currently receiving effluents at a reduced discharge mode is judged not to have a significant impact on cleanup activities:

- 1325N Crib
- 216-A-8 Crib
- 216-B-62 Crib.

However, if these cribs were to begin receiving discharges from facilities in an operational mode, a detailed assessment of the cribs would be required prior to the start of operations.

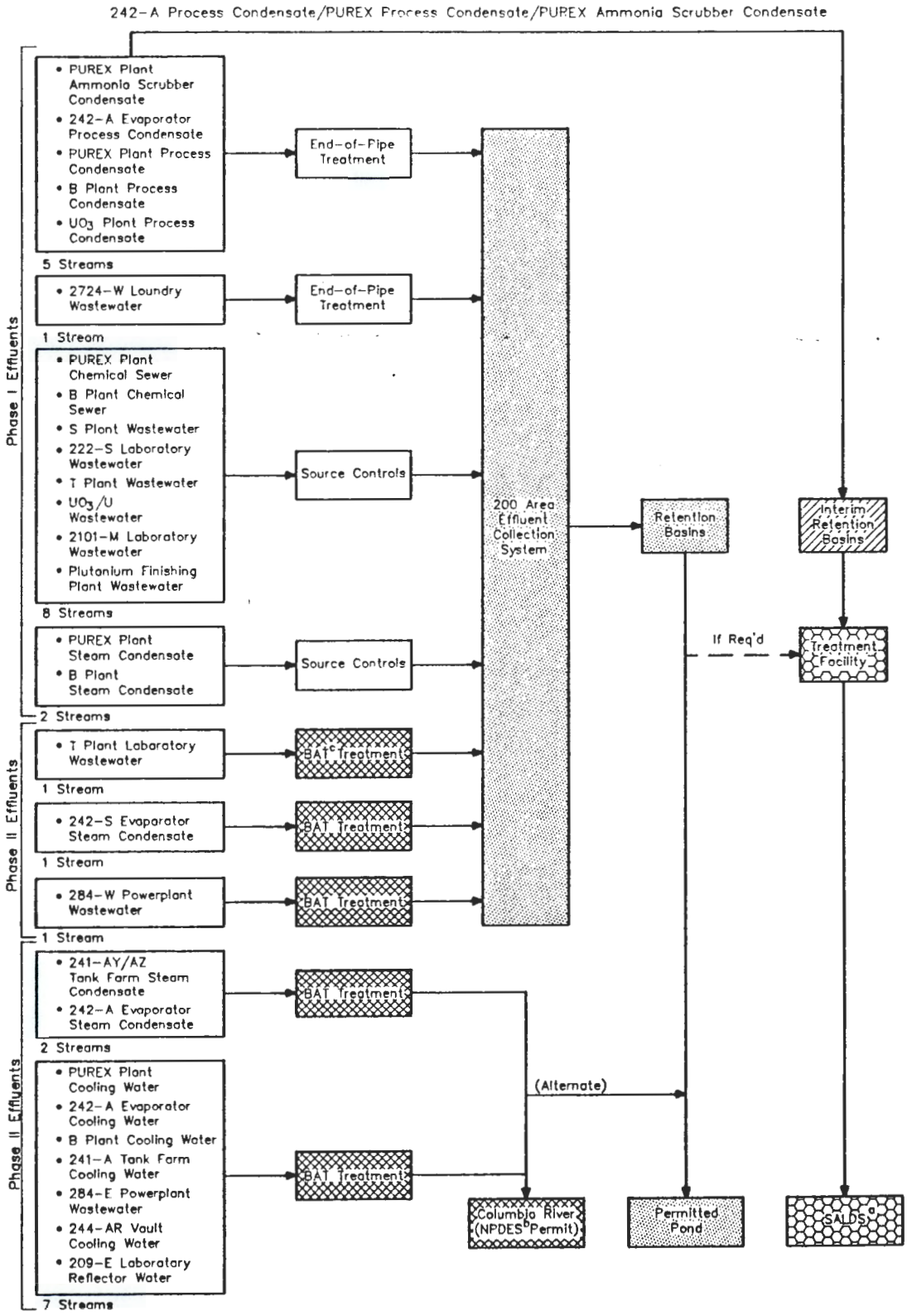
3.1.6 Treatment and Disposal Projects

Columns 11 and 12 of Table 3-1, summarize which effluent streams currently have alternative disposal methods scheduled and the respective current estimated year of completion. An explanation of this summary is presented below.

A plan and schedule has been developed to provide alternative treatment and disposal methods for the 33 major wastestreams on the Hanford Site (DOE-RL 1987). In this plan, the wastestreams were prioritized into two phases. The Phase I streams were the higher priority and will have alternative treatment and disposal systems implemented by June 1995 (Milestone M-17-00 of the Agreement). The Phase II streams are to be addressed after the completion of the Phase I projects.

An illustration of the alternative treatment and disposal methods to be used in the 200 Area of the Hanford Site is presented in Figure 3-1. As the figure illustrates, alternative treatment and disposal systems will be provided by three validated projects. The Liquid Effluent Retention Facility (Project W-105) will provide interim storage for the following three Phase I effluents: 242-A Evaporator process condensate, the PUREX Plant process condensate, and the PUREX Plant ammonia scrubber distillate. The evaporator and PUREX condensate treatment facility (Project C-018H) will provide a treatment system and a disposal site for these three effluents.

Figure 3-1. 200 Area Liquid Effluent Treatment Projects.



As shown in Figure 3-1, Project W-049H will provide an alternative disposal system for the 13 remaining Phase I effluents and three Phase II effluents in the 200 Areas. In accordance with DOE Order 5400.5, a Best Available Technology (BAT) evaluation will be performed during FY 1991 on the remaining nine Phase II streams. These studies will form the basis for any additional projects which may be needed to provide alternative disposal systems.

The 13 Phase I effluents within the scope of the Project W-049H include: PUREX chemical sewer, PUREX steam condensate, B Plant chemical sewer, UO_3/U Plant wastewater, Plutoniuim Finishing Plant wastewater, S Plant wastewater, T Plant wastewater, 222-S Laboratory wastewater, B Plant steam condensate, B Plant process condensate, 2101-M Laboratory wastewater, and UO_3 Plant process condensate. The 2724-W Laundry will be replaced by a new laundry. The effluent from this new laundry is within the scope of Project W-049H.

The three Phase II streams within the scope of Project W-049H include: 284-W powerhouse cooling water, 242-S steam condensate, and the T Plant laboratory wastewater.

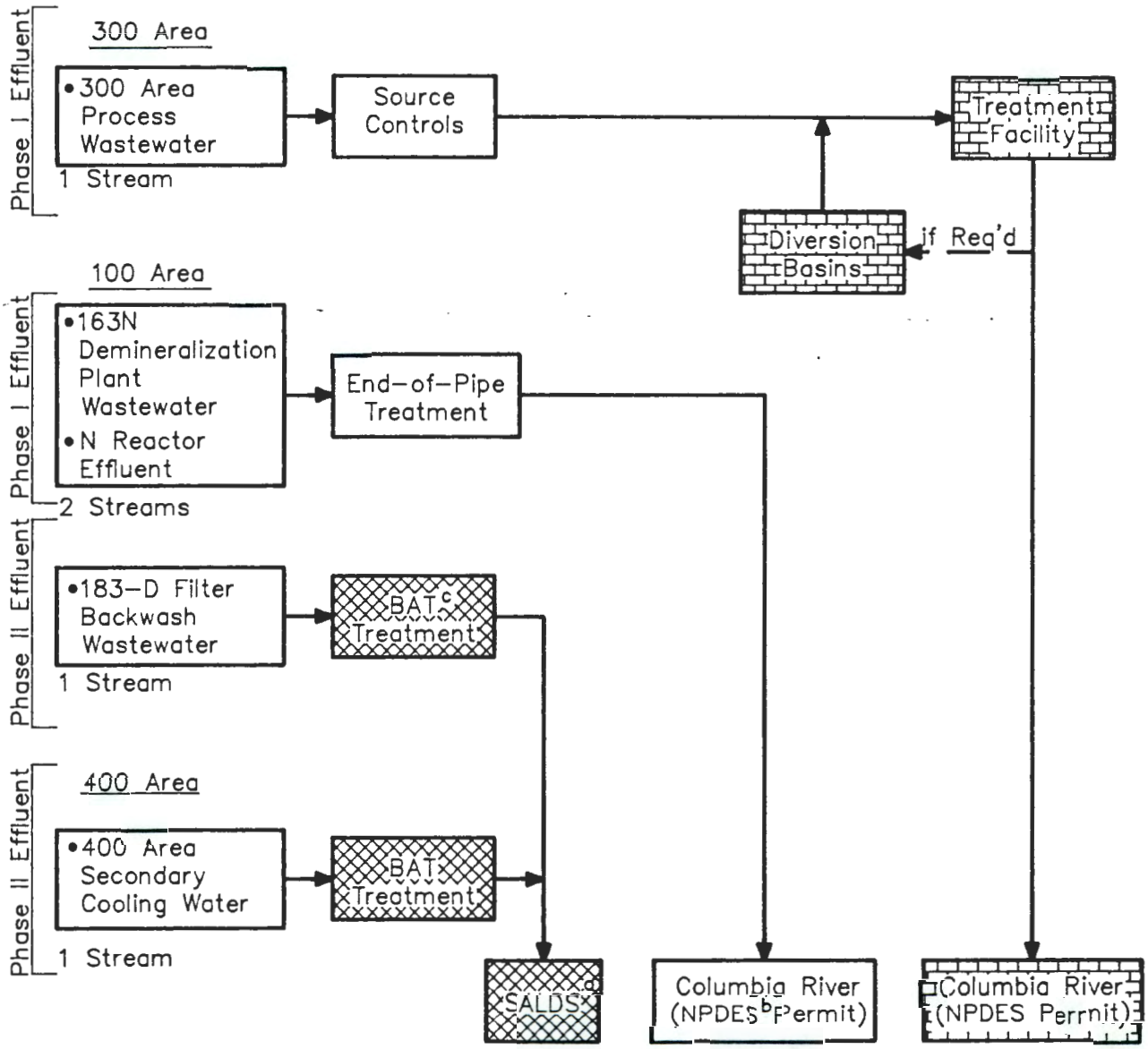
An illustration of the alternative treatment and disposal method to be used in the 300, 100, and 400 areas of the Hanford Site is presented in Figure 3-2. As the figure illustrates, a single validated project will provide an alternative disposal system in the 300 Area. In the 100 Area, a treatment system is currently online for the 163-N Demineralization Plant wastewater and a BAT evaluation is scheduled to be completed on the 183-D filter backwash wastewater in FY 1991. The one remaining effluent in the 100 Area will be eliminated by the recent decision to place the N Reactor in dry layup. The 400 Area effluent will be the subject of an engineering evaluation in FY 1991.

3.2 LIMITATIONS/RECOMMENDATIONS

A considerable quantity of data was compiled, collected, and analyzed during the Liquid Effluent Study. The study tasks focused on the 33 liquid effluent wastestreams, the 27 associated receiving sites, and the vicinity groundwater. Based on these results, assessments were made of the impacts of continuing liquid discharges to the receiving sites. However, uncertainties are associated with each set of data which must be considered when decisions are made regarding continued operations. This section discusses those limitations of the available data and makes recommendations for possible future work that would address those uncertainties.

A general note regarding the quality of the analytical data used in this report is necessary. Westinghouse Hanford has taken some steps towards validating the results reported in this study (e.g., procedural validation of results, interlaboratory comparisons), and more validation investigations of the entire data base are planned by both Westinghouse Hanford and PNL. A few minor problems with the Liquid Effluent Study data (wastestream and groundwater) have been noted. No major problems with the data have been discovered in either the wastestream or the groundwater characterization analytical results. Based on the results of validation activities, the data used in this report appear to meet the requirements established in the project plan (WHC 1990c).

Figure 3-2. 100, 300, and 400 Areas Liquid Effluent Treatment Projects.



Project	Start Operation
HEC[d] Subproject L-045H	Dec 1994
Future Projects	TBD

[a] SALDS = State Approved Land Disposal Structure
[b] NPDES = National Pollution Discharge Elimination System
[c] BAT = Best Available Technology
[d] HEC = Hanford Environmental Compliance

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3.2.1 Effluent Streams

The 33 addenda to the Hanford Site Stream-Specific Reports (WHC 1990a) address recommendations for future waste characterization tasks for the liquid effluents that are within the scope of the Liquid Effluent Study. These characterization tasks address whether the characterization data presented in the reports are representative of the wastestream and whether additional information is recommended to confirm the proposed designation. For example, future sampling is discussed for wastestreams that did not discharge to the soil column, and for process configurations that were not active, during the time period of this study. In some cases, recommendations are made for wastestream sampling at alternative sampling points or for improved flow monitoring instrumentation. Recommendations specific to each waste stream are provided in the corresponding stream-specific report addendum.

3.2.2 Receiving Sites

Relatively little information is available about the chemical and physical properties of the vadose zone sediments or about the distribution and identity of contaminants within the vadose zone under the individual receiving sites. Such site-specific data would remove uncertainties concerning soil column loading and would improve "calibration" of contaminant migration models. For example, results of the numerical flow and transport analyses conducted at three locations (Appendix D) indicate that subtle changes in the properties of the soil produce significant differences in moisture and contaminant migration rates. Collection and analysis of data on the distribution and inventory of contaminants within the soil column at each site would provide a means to confirm predictions about remobilization of existing contaminants and additional contaminant migration resulting from continued operation of receiving sites.

Characterization of the vadose zone could be incorporated into one of two ongoing Hanford Site programs. Regulated disposal units (Table 3-1) could be characterized as part of the Resource Conservation and Recovery Act (RCRA) program. Nonregulated units could be investigated as part of the operational groundwater monitoring program.

3.2.3 Groundwater

Limitations concerning the groundwater characterization data arise primarily from the lack of adequate monitoring wells at receiving sites. For example, during the time period of this study, seven of the receiving sites had no groundwater monitoring wells. Monitoring networks at the other 20 sites include older wells which were not constructed to current RCRA standards and/or do not contain adequate sampling pumps; sampling data from these wells are qualified by discussion of the well construction methods or sampling methods. Specific discussion of the groundwater data are provided in the receiving site assessments in Chapter 2 and in the Liquid Effluent Study: Ground Water Characterization Data report (WHC 1990d). Specific data needs to remove uncertainties at individual sites are discussed in the site assessments in Chapter 2.

Continued sampling and analysis of groundwater at receiving sites will provide a means to validate predictions about continued use of the sites and to monitor the concentrations and movement of contaminants in the unconfined aquifer. Regulated disposal units with in-place, RCRA-compliant monitoring programs are monitored on a routine basis. Any additional groundwater monitoring wells could be installed at regulated disposal units through the RCRA program. Nonregulated receiving sites with inadequate monitoring networks could be upgraded to meet minimum standards as part of the operational groundwater monitoring program.

It is recommended that the overall effect of the 216-B-3 Pond System groundwater mound be assessed to determine its influence on groundwater flow and contaminant migration from past practices. The extent of the groundwater mound at this site, its location between the Columbia River and the 200 Separations Areas, and the possibility that future discharge rates to the Pond System will change, all suggest that enhanced understanding of this particular site would provide fundamental information for decisions involving operations and environmental restoration activities (Section 3.1.4).

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Table 3-1. Summary of Receiving Site Assessments

		Liquid Effluent Study												Treatment & Disposal Projects & Engineering Evaluations
		Waste Stream			Receiving Site									
Receiving Site	Associated Effluent Stream	1 Effluent Designated Dangerous Waste [c,d]	2 Effluent Determined Radioactive [c,e]	3 Presence of Key Chem./Rad. Constituents [f,g]	4 Presence of Key Chem./Rad. Constituents in Groundwater [g,h]	5 Breakthrough of Other Key Chem./Rad. Constituents [f,g,i]	6 Use of at Least an Additional 10% of Remaining Soil Column [j]	7 Volume Impact on Groundwater Flow Regime [k]	8 Planned Continued Operations Until Treatment	9 Operational Mode	10 Reduced Discharge Mode	11 Impact of Continued Use [m,r] Project # or Engineering Evaluation	12 Current Estimated Year to be Completed
1 100-D Ponds [a]	183-D Filter Backwash Wastewater	No	No	Yes	N/D[v]	Yes	No	No	Yes	No	N/A	BAT	1991
2 1324N/NA Pond [a]	163N Demineralization Plant Wastewater	No	No	No	No	No	No	No	Yes	No	No	Z	TBD
3 1325N Crib [a]	N Reactor Effluent	No	Yes	Yes	Yes	Yes	No [n]	No	Yes	Yes[w]	No	H-682[y]	1995
4 216-A-8 Crib	241-AY/AZ Tank Farm Steam Condensate [b]	No	Yes	Yes	No	No[n]	No [n]	No	Yes	Yes[w]	No[aa]	BAT	1991
5 216-A-29 Ditch [a]	PUREX Plant Chemical Sewer [u]	No	No	Yes	No	No	No	No	Yes	No	N/A	W-049H W-019	1995 1991
6 216-A-30 Crib	PUREX Plant Steam Condensate [t]	No	Yes	Yes	No	No	No	No	Yes	No	No	W-049H	1995
7 216-A-36B Crib [a]	PUREX Plant Ammonia Scrubber Condensate [b]	Yes	Yes	Yes	Yes	N/A	N/A	N/A	No	N/A	N/A	C-018H	1993
8 216-A-37-1 Crib [a]	242-A Evaporator Process Condensate [b]	Yes	Yes	Yes	Yes	N/A	N/A	N/A	No	N/A	N/A	C-018H	1993
9 216-A-37-2 Crib	PUREX Plant Steam Condensate [t]	No	Yes	Yes	No	No	No	No	Yes	No	No	W-049H	1995
10 216-A-45 Crib	PUREX Plant Process Condensate	No	No	Yes	Yes	N/A	N/A	N/A	No	N/A	N/A	C-018H	1993
11 216-B-3 Pond System [a]	PUREX Plant Chemical Sewer [u]	No	No	Yes	No	No	No	Yes	Yes	Yes[s]	N/A	W-049H	1995
	PUREX Plant Cooling Water	No	No	Yes								BAT	1991
	242-A Evaporator Cooling Water [b]	No	Yes	Yes								BAT	1991
	B Plant Cooling Water	No	No	Yes								BAT	1991
	241-A Tank Farm Cooling Water	No	No	Yes								BAT	1991
	284-E Powerplant Wastewater	No	No	Yes								BAT	1991
	244-AR Vault Cooling Water	No	No	Yes								BAT	1991
	242-A Evaporator Steam Condensate	No	No	Yes								BAT	1991
12 216-B-55 Crib	B Plant Steam Condensate [b]	No	Yes	Yes	No	No	No	No	Yes	No	No	W-049H	1995
13 216-B-62 Crib.	B Plant Process Condensate [b]	TBD[cc]	Yes	Yes	No	No [n]	No [n]	No	Yes	Yes[w]	No[dd]	W-049H	1995
14 216-B-63 Ditch [a]	B Plant Chemical Sewer	No	No	Yes	N/D[q]	No	No	No	Yes	No	N/A	W-049H	1995
15 216-C-7-Crib	209-E Laboratory Reflector Water [b]	No	No	No	N/D[v]	N/A	N/A	N/A	No	N/A	N/A	N/A	–
16 216-S-10 Ditch [a]	S Plant Wastewater	No	No	Yes	N/D[q]	No	No	No	Yes	No	N/A	W-049H	1995
17 216-S-26 Crib	222-S Laboratory Wastewater	No	Yes	Yes	No	No	No	No	Yes	No	N/A	W-049H	1995
18 216-T-1 Ditch	T Plant Laboratory Wastewater	No	No	Yes	N/D[v]	No	No	No	Yes	No	N/A	W-049H	1995
19 216-T-4-2 Ditch	T Plant Wastewater	No	No	Yes	N/D[v]	No	No	No	Yes	No	N/A	W-049H	1995
20 216-U-14 Ditch	UO_3/U Plant Wastewater	No	No	Yes	No	Yes	No	No	Yes	No[s]	No[s]	W-049H	1995
	242-S Evaporator Steam Condensate	No	No	Yes									
21 216-U-17 Crib	UO_3 Plant Process Condensate [b]	No	Yes	Yes	No	No	No	No	Yes	No	No	W-049H	1995
22 216-W-LC Crib	2724-W Laundry Wastewater	No	Yes	Yes	N/D[v]	No	No	No	Yes	No	N/A	W-049H	1995
23 216-Z-20 Crib	Plutonium Finishing Plant Wastewater	No	Yes	Yes	No	No	No	No	Yes	No	N/A	W-049H	1995
24 200-W Powerhouse Pond	284-W Powerplant Wastewater	No	No	Yes	N/D[v]	Yes	No	No	Yes	No	N/A	BAT	1991
25 2101-M Pond [a]	2101-M Laboratory Wastewater [b]	No	No	Yes	No	No	No	No	Yes	No	N/A	W-049H	1995
26 300 Area Process Trenches [a]	300 Area Process Wastewater	No	No	Yes	Yes	No	No	No	Yes	No	N/A	L-045H	1994[bb]
27 400 Area Ponds	400 Area Secondary Cooling Water	No	No	No	No	No	No	No	Yes	No	N/A	BAT	1991

JJA\083090-D

FOOTNOTES:

a) Regulated units based on previous identification as RCRA disposal TSD facility.
b) Wastestream not sampled as part of Liquid Effluent Study.
c) Based on effluent sampling data collected from October 1989 to March 1990 as part of Liquid Effluent Study or on sampling data collected from 1985 to October 1989 for wastestreams identified in footnote b.
d) Designation based on determinations proposed in Hanford Site Stream-Specific Reports (WHC 1990c, WHC-EP-0342).
e) For this study, wastestreams are radioactive if any constituent exceeds concentration standards in Westinghouse Environmental Compliance Manual (1989b), Part N, Groundwater Protection.
f) Based on effluent sampling data collected from 1985 to March 1990.
g) Key constituents are effluent constituents that exceed study guidelines in Table 2-1. (No regulatory requirement or policy is intended or implied by these guidelines.)
h) Key effluent constituents present in the groundwater that exceed Group A study guidelines in Table 2-1 and have resulted from discharges to the receiving site. (No regulatory requirement or policy is intended or implied by these guidelines.) Based on groundwater sampling data collected from January 1989 to May 1990.
i) Movement of other key effluent constituents from the vadose zone into the groundwater based on average discharge rates and one-dimensional flow and transport analyses (Appendix B).
j) Based on average discharge rates and one-dimensional flow and transport analyses (Appendix B).
k) Based on an effluent discharge rate greater than the natural recharge rate from Cold Creek/Dry Creek recharge area for 200 Area sites. Groundwater patterns at sites along the Columbia River are important only when associated with groundwater mounds due to artificial recharge and mounds not masked by fluctuations of river.
m) Impacts are based on continued use exacerbating cleanup activities at the site and/or adjacent areas/sites.
n) Based on current discharge rates to the soil column and/or water quality.
p) Assumes ketones are degraded before reaching the groundwater.
q) No groundwater data as of August 1990; monitoring wells recently completed.
r) Shaded pattern in Operational or Reduced Discharge mode signifies current mode of receiving site. No pattern in both columns signifies the receiving site will no longer receive effluent.
s) A groundwater evaluation to be initiated to more accurately assess impacts of continued use of receiving site.
t) PUREX Steam Condensate stream discharges to 216-A-30 and 216-A-37-2 cribs.
u) PUREX Chemical Sewer discharges to 216-A-29 Ditch which flows into the 216-B-3 Pond System.
v) No wells at receiving site to sample groundwater; well 216-W-LC Crib requires rehabilitation to collect representative groundwater sample.
w) If receiving sites are to be used in the future, a site-specific evaluation will be required before operation.
y) Project H-682 will be completed only if the N Reactor effluent stream continues to discharge to 1325N Crib.
z) Discharges to receiving site may be terminated and diverted to the river. This will require modification to existing NPDES permit.
aa) Feed stream currently discharged to double-shell tanks; receiving site can handle reduced volume discharges.
bb) Change request to move date of ceasing discharges to the trenches from December 1991 to 1994 submitted for regulatory approval.
cc) Will be designated upon startup of B Plant.

BAT = Best available technology engineering evaluation
N/A = Not applicable N/D = Not determined TBD = To be determined

Table B-1. Estimated Contaminant Migration for the 27 Sites. (Page 1 of 13).

Rpt Sec No	Disposal Facility	Time Frame	Rate (L/mo)	Area (sq m)	f Infil Rate (cm/sec)	Layer No.	Thick. (m)	Soil Type	ThetaS	Ks (cm/sec)	Theta	Moist. State	q (cm/sec)	t (sec)	T (days)	Estimated Moisture Migration (cm/day)	Constituent	Rf	Estimated Contaminant Migration (cm/day)	Contaminant Transport to WT (days)	Contaminant Transport to WT (years)
1	100-D Ponds		1.90E+05	1839	3.93E-06	1	20	A	0.5	5.0E-03	0.1	U	3.93E-06	5.09E+07	589	3.4	chromium	1	3.40	589	1.61
																	iron	250	0.01	147158	402.90
																	lead	150	0.02	88295	241.74
																	manganese	250	0.01	147158	402.90
																	mercury	150	0.02	88295	241.74
																	sulfate	1	3.40	589	1.61
																	aluminum	100	0.03	58863	161.16
2	1324-N/NA Pond		9.37E+06	2700	1.32E-04	1	15	A	0.5	5.0E-03	0.22	U	1.32E-04	2.50E+06	29	51.9	none				
3	1325-N Crib	past	8.01E+07	5574	5.47E-04	1	15	A	0.5	5.0E-03	0.31	U	5.47E-04	8.50E+05	10	152.5	iron	250	0.61	2459	6.73
																	Pu-238	125	1.22	1230	3.37
																	Pu-239	125	1.22	1230	3.37
																	Am-241	1000	0.15	9837	26.93
																	tritium	1	152.48	10	0.027
																	P-32	250	0.61	2459	6.733
																	Mn-54	250	0.61	2459	6.73
																	Co-58	250	0.61	2459	6.73
																	Fe-59	250	0.61	2459	6.73
																	Co-60	250	0.61	2459	6.73
																	Zn-65	150	1.02	1476	4.04
																	Sr-89	125	1.22	1230	3.37
																	Sr-90	125	1.22	1230	3.37
																	Zr-95	200	0.76	1967	5.39
																	Nb-95	200	0.76	1967	5.39
																	Mo-99	200	0.76	1967	5.39
																	Ru-103	100	1.52	984	2.69
																	Ru-106	100	1.52	984	2.69
																	Sb-124	1	152.48	10	0.03

Table B-1. Estimated Contaminant Migration for the 27 Sites. (Page 2 of 13).

Rpt Sec No	Disposal Facility	Time Frame	Rate (L/mo)	Area (sq m)	f Infil Rate (cm/sec)	Layer No.	Thick. (m)	Soil Type	ThetaS	Ks (cm/sec)	Theta	Moist. State	q (cm/sec)	t (sec)	T (days)	Estimated Moisture Migration (cm/day)	Constituent	Rf	Estimated Contaminant Migration (cm/day)	Contaminant Transport to WT (days)	Contaminant Transport to WT (years)
																	Sb-125	1	152.48	10	0.03
																	I-131	1	152.48	10	0.03
																	Cs-134	250	0.61	2459	6.73
																	Cs-137	250	0.61	2459	6.73
																	La-140	1000	0.15	9837	26.93
																	Ba-140	125	1.22	1230	3.37
																	Ce-141	1000	0.15	9837	26.93
																	Ce-144	1000	0.15	9837	26.93
																	Pb-210	150	1.02	1476	4.04
		fut.	4.97E+07	5574	3.39E-04	1	15	A	0.5	5.0E-03	0.28	U	3.39E-04	1.24E+06	14	104.7	iron	250	0.42	3580	9.80
																	Ru-106	100	1.05	1432	3.92
																	Pu-239	125	0.84	1790	4.90
																	Am-241	1000	0.10	14320	39.21
																	tritium	1	104.75	14	0.04
																	Sr-90	125	0.84	1790	4.90
																	Mn-54	250	0.42	3580	9.80
																	Cs-134	250	0.42	3580	9.80
																	Cs-137	250	0.42	3580	9.80
																	Co-60	250	0.42	3580	9.80
4	216-A-8 Crib		2.90E+06	1579	7.00E-05	1	7	B	0.5	1.0E-03	0.26	U	7.00E-05	2.60E+06			Sr-90	25	1.19	6055	16.58
						2	3	D	0.4	1.0E-04	0.35	U	7.00E-05	1.50E+06			Cs-137	150	0.20	36331	99.47
						3	62	A	0.5	5.0E-03	0.19	U	7.00E-05	1.68E+07			acetone	1	29.73	242	0.66
							72							2.09E+07	242	29.7	uranium	100	0.30	24221	66.31
5	216-A-29 Ditch				5.00E-05	1	2	C	0.4	5.0E-04	0.26	U	5.00E-05	1.04E+06			acetone	1	18.72	417	1.14
						2	76	B	0.5	1.0E-03	0.23	U	5.00E-05	3.50E+07			nitrate	1	18.72	417	1.14
							78							3.60E+07	417	18.7	Sr-90	125	0.15	52083	142.60
																	Cs-137	250	0.07	104167	285.19

Table B-1. Estimated Contaminant Migration for the 27 Sites. (Page 3 of 13).

Rpt Sec No	Disposal Facility	Time Frame	Rate (L/mo)	Area (sq m)	f Infil Rate (cm/sec)	Layer No.	Thick. (m)	Soil Type	ThetaS	Ks (cm/sec)	Theta	Moist. State	q (cm/sec)	t (sec)	T (days)	Estimated Moisture Migration (cm/day)	Constituent	Rf	Estimated Contaminant Migration (cm/day)	Contaminant Transport to WT (days)	Contaminant Transport to WT (years)
																	Am-241	1000	0.02	416667	1140.77
																	Pm-147	1000	0.02	416667	1140.77
																	Pu-239	125	0.15	52083	142.60
																	uranium	10	1.87	4167	11.41
																	chloroform	1	18.72	417	1.14
																	aluminum	100	0.19	41667	114.08
																	cadmium	150	0.12	62500	171.12
																	copper	150	0.12	62500	171.12
																	iron	250	0.07	104167	285.19
																	manganese	250	0.07	104167	285.19
																	sulfate	1	18.72	417	1.14
6	216-A-30 Crib		2.04E+07	1301	5.97E-04	1	6	A	0.5	5.0E-03	0.32	U	5.97E-04	3.21E+05			Sr-90	125	0.36	22095	60.49
						2	12	B	0.5	1.0E-03	0.38	U	5.97E-04	7.63E+05			Cs-137	250	0.18	44190	120.99
						3	10	A	0.32	5.0E-03	0.32	U	5.97E-04	5.36E+05			radium	125	0.36	22095	60.49
						4	10	C	0.4	5.0E-04	0.4	S	5.00E-04	8.00E+05			uranium	10	4.53	1768	4.84
						5	3	A	0.5	5.0E-03	0.31	U	5.00E-04	1.86E+05			cerium/Pr-144	1000	0.05	176761	483.95
						6	9	B	0.5	1.0E-03	0.37	U	5.00E-04	6.66E+05			Pu-239	125	0.36	22095	60.49
						7	30	D	0.4	1.0E-04	0.4	S	1.00E-04	1.20E+07							
							80							1.53E+07	177	45.3					
7	216-A-36B Crib	T	1.26E+06	511	9.37E-05	1	93	B	0.5	1.0E-03	0.27	U	9.37E-05	2.68E+07	310	30.0	tritium	1	29.99	310	0.85
																	Sr-90	35	0.86	10852	29.71
																	Cs-137	50	0.60	15503	42.45
																	Pu-239	50	0.60	15503	42.45
																	Pu-241	50	0.60	15503	42.45
																	uranium	5	6.00	1550	4.24
																	Ru-103	1	29.99	310	0.85
																	Ru-106	1	29.99	310	0.85
																	Sn-113	50	0.60	15503	42.45

Table B-1. Estimated Contaminant Migration for the 27 Sites. (Page 4 of 13).

Rpt Sec No	Disposal Facility	Time Frame	Rate (L/mo)	Area (sq m)	f Infil Rate (cm/sec)	Layer No.	Thick. (m)	Soil Type	ThetaS	Ks (cm/sec)	Theta	Moist. State	q (cm/sec)	t (sec)	T (days)	Estimated Moisture Migration (cm/day)	Constituent	Rf	Estimated Contaminant Migration (cm/day)	Contaminant Transport to WT (days)	Contaminant Transport to WT (years)
																	I-129	1	29.99	310	0.85
																	Pm-147	10	3.00	3101	8.49
																	Am-241	10	3.00	3101	8.49
		P	1.12E+06	511	8.34E-05	1	93	B	0.5	1.0E-03	0.26	U	8.34E-05	2.90E+07	336	27.7	tritium	1	27.71	336	0.92
																	Sr-90	35	0.79	11747	32.16
																	Cs-137	50	0.55	16782	45.95
																	Pu-239	50	0.55	16782	45.95
																	Pu-241	50	0.55	16782	45.95
																	uranium	5	5.54	1678	4.59
																	Ru-103	1	27.71	336	0.92
																	Ru-106	1	27.71	336	0.92
																	Sn-113	50	0.55	16782	45.95
																	I-129	1	27.71	336	0.92
																	Pm-147	10	2.77	3356	9.19
																	Am-241	10	2.77	3356	9.19
8	216-A-37-1 Crib		2.64E+06	650	1.55E-04	1	6	A	0.5	5.0E-03	0.24	U	1.55E-04	9.31E+05			acetone	1	32.88	243	0.67
						2	12	8	0.5	1.0E-03	0.29	U	1.55E-04	2.25E+06			2-butanone	1	32.88	243	0.67
						3	10	A	0.5	5.0E-03	0.24	U	1.55E-04	1.55E+06			tritium	1	32.88	243	0.67
						4	10	C	0.4	5.0E-04	0.33	U	1.55E-04	2.13E+06			Sr-90	35	0.94	8517	23.32
						5	3	A	0.5	5.0E-03	0.24	U	1.55E-04	4.66E+05			Ru-106	1	32.88	243	0.67
						6	9	B	0.5	1.0E-03	0.29	U	1.55E-04	1.69E+06			Cs-137	50	0.66	12167	33.31
						7	30	D	0.4	1.0E-04	0.4	S	1.00E-04	1.20E+07			aluminum	50	0.66	12167	33.31
							80							2.10E+07	243	32.9	1-butanol	1	32.88	243	0.67
9	216-A-37-2 Crib		1.33E+07	650	7.80E-04	1	6	A	0.5	5.0E-03	0.34	U	7.80E-04	2.62E+05			Sr-90	125	0.41	19545	53.51
						2	12	B	0.5	1.0E-03	0.42	U	7.80E-04	6.46E+05			Cs-137	250	0.20	39090	107.02
						3	10	A	0.5	5.0E-03	0.34	U	7.80E-04	4.36E+05			uranium	10	5.12	1564	4.28
						4	10	C	0.4	5.0E-04	0.4	S	0.005	8.00E+04			cerium/Pr-144	1000	0.05	156359	428.09

Table B-1. Estimated Contaminant Migration for the 27 Sites. (Page 5 of 13).

Rpt Sec No	Disposal Facility	Time Frame	Rate (L/mo)	Area (sq m)	f Infil Rate (cm/sec)	Layer No.	Thick. (m)	Soil Type	ThetaS	Ks (cm/sec)	Theta	Moist. State	q (cm/sec)	t (sec)	T (days)	Estimated Moisture Migration (cm/day)	Constituent	Rf	Estimated Contaminant Migration (cm/day)	Contaminant Transport to WT (days)	Contaminant Transport to WT (years)
						5	3	A	0.5	5.0E-03	0.31	U	0.005	1.86E+04			radium	125	0.41	19545	53.51
						6	9	B	0.5	1.0E-03	0.37	U	0.005	6.66E+04			Pu-239	125	0.41	19545	53.51
						7	30	D	0.4	1.0E-04	0.4	S	0.0001	1.20E+07							–
							80							1.35E+07	156	51.2					
10	216-A-45 Crib		3.04E+06	1728	6.69E-05	1	58	C	0.4	5.0E-04	0.29	U	6.69E-05	2.51E+07			acetone	1	18.94	444	1.21
						2	26	D	0.4	1.0E-04	0.34	U	6.69E-05	1.32E+07			2-butanone	1	18.94	444	1.21
							84							3.83E+07	444	18.9	methylene chloride	1	18.94	444	1.21
																	nitrate	1	18.94	444	1.21
																	tritium	1	18.94	444	1.21
																	Ru-106	25	0.76	11090	30.36
																	I-129	1	18.94	444	1.21
																	Cs-137	250	0.08	110905	303.64
																	Pu-238	50	0.38	22181	60.73
																	Pu-239	50	0.38	22181	60.73
																	Pu-240	50	0.38	22181	60.73
																	Am-241	25	0.76	11090	30.36
																	uranium	5	3.79	2218	6.07
																	Sr-90	100	0.19	44362	121.46
																	Ru-103	25	0.76	11090	30.36
																	Pm-147	25	0.76	11090	30.36
																	Pu-241	50	0.38	22181	60.73
																	nitrite	1	18.94	444	1.21
																	fluoride	1	18.94	444	1.21
																	mercury	50	0.38	22181	60.73
11	216-B-3 Pond System		4.45E+08																		
	216-B-3		5.01E+06	142000	5.00E-05	1	12	A	0.5	5.0E-03	0.18	U	5.00E-05	4.32E+06			Sr-90	125	0.18	26736	73.20
						2	12	B	0.5	1.0E-03	0.23	U	5.00E-05	5.52E+06			Cs-137	250	0.09	53472	146.40

Table B-1. Estimated Contaminant Migration for the 27 Sites. (Page 6 of 13).

Rpt Sec No	Disposal Facility	Time Frame	Rate (L/mo)	Area (sq m)	f Infil Rate (cm/sec)	Layer No.	Thick. (m)	Soil Type	ThetaS	Ks (cm/sec)	Theta	Moist. State	q (cm/sec)	t (sec)	T (days)	Estimated Moisture Migration (cm/day)	Constituent	Rf	Estimated Contaminant Migration (cm/day)	Contaminant Transport to WT (days)	Contaminant Transport to WT (years)
						3	24	A	0.5	5.0E-03	0.18	U	5.00E-05	8.64E+06			barium	125	0.18	26736	73.20
							48							1.85E+07	214	22.4	chloride	1	22.44	214	0.59
																	fluoride	1	22.44	214	0.59
																	manganese	250	0.09	53472	146.40
																	sulfate	1	22.44	214	0.59
																	zinc	150	0.15	32083	87.84
																	acetone	1	22.44	214	0.59
																	aluminum	100	0.22	21389	58.56
																	chromium	1	22.44	214	0.59
																	iron	250	0.09	53472	146.40
																	lead	150	0.15	32083	87.84
																	Am-241	1000	0.02	213889	585.60
																	tritium	1	22.44	214	0.59
																	uranium	10	2.24	2139	5.86
																	Co-60	250	0.09	53472	146.40
																	Pm-147	1000	0.02	213889	585.60
																	Pu-239	125	0.18	26736	73.20
																	nitrate	1	22.44	214	0.59
																	chloroform	1	22.44	214	0.59
																	cadmium	150	0.15	32083	87.84
																	copper	150	0.15	32083	87.84
	216-B-3A		1.51E+08	44500	1.29E-04	1	12	A	0.5	5.0E-03	0.23	U	1.29E-04	2.13E+06			Sr-90	125	0.37	13143	35.98
						2	12	B	0.5	1.0E-03	0.29	U	1.29E-04	2.69E+06			Cs-137	250	0.18	26285	71.97
						3	24	A	0.5	5.0E-03	0.23	U	1.29E-04	4.26E+06			barium	125	0.37	13143	35.98
							48							9.08E+06	105	45.7	chloride	1	45.65	105	0.29
																	fluoride	1	45.65	105	0.29
																	manganese	250	0.18	26285	71.97
																	sulfate	1	45.65	105	0.29
																	zinc	150	0.30	15771	43.18

Table B-1. Estimated Contaminant Migration for the 27 Sites. (Page 7 of 13).

Rpt Sec No	Disposal Facility	Time Frame	Rate (L/mo)	Area (sq m)	f Infil Rate (cm/sec)	Layer No.	Thick. (m)	Soil Type	ThetaS	Ks (cm/sec)	Theta	Moist. State	q (cm/sec)	t (sec)	T (days)	Estimated Moisture Migration (cm/day)	Constituent	Rf	Estimated Contaminant Migration (cm/day)	Contaminant Transport to WT (days)	Contaminant Transport to WT (years)
																	acetone	1	45.65	105	0.29
																	aluminum	100	0.46	10514	28.79
																	chromium	1	45.65	105	0.29
																	iron	250	0.18	26285	71.97
																	lead	150	0.30	15771	43.18
																	Am-241	1000	0.05	105142	287.86
																	tritium	1	45.65	105	0.29
																	uranium	10	4.57	1051	2.88
																	Co-60	250	0.18	26285	71.97
																	Pm-147	1000	0.05	105142	287.86
																	Pu-239	125	0.37	13143	35.98
																	nitrate	1	45.65	105	0.29
																	chloroform	1	45.65	105	0.29
																	cadmium	150	0.30	15771	43.18
																	copper	150	0.30	15771	43.18
	216-B-38		1.51E+08	44500	1.29E-04	1	42	A	0.5	5.0E-03	0.23	U	1.29E-04	7.46E+06	86	48.6	Sr-90	125	0.39	10796	29.56
																	Cs-137	250	0.19	21592	59.11
																	barium	125	0.39	10796	29.56
																	chloride	1	48.63	86	0.24
																	fluoride	1	48.63	86	0.24
																	manganese	250	0.19	21592	59.11
																	sulfate	1	48.63	86	0.24
																	zinc	150	0.32	12955	35.47
																	acetone	1	48.63	86	0.24
																	aluminum	100	0.49	8637	23.65
																	chromium	1	48.63	86	0.24
																	iron	250	0.19	21592	59.11
																	lead	150	0.32	12955	35.47
																	Am-241	1000	0.05	86366	236.46

Table B-1. Estimated Contaminant Migration for the 27 Sites. (Page 8 of 13).

Rpt Sec No	Disposal Facility	Time Frame	Rate (L/mo)	Area (sq m)	f Infil Rate (cm/sec)	Layer No.	Thick. (m)	Soil Type	ThetaS	Ks (cm/sec)	Theta	Moist. State	q (cm/sec)	t (sec)	T (days)	Estimated Moisture Migration (cm/day)	Constituent	Rf	Estimated Contaminant Migration (cm/day)	Contaminant Transport to WT (days)	Contaminant Transport to WT (years)
																	tritium	1	48.63	86	0.24
																	uranium	10	4.86	864	2.36
																	Co-60	250	0.19	21592	59.11
																	Pm-147	1000	0.05	86366	236.46
																	Pu-239	125	0.39	10796	29.56
																	nitrate	1	48.63	86	0.24
																	chloroform	1	48.63	86	0.24
																	cadmium	150	0.32	12955	35.47
																	copper	150	0.32	12955	35.47
	216-B-3C		1.38E+08	40500	1.29E-04	1	42	A	0.5	5.0E-03	0.23	U	1.29E-04	7.47E+06	86	48.6	Sr-90	125	0.39	10808	29.59
																	Cs-137	250	0.19	21616	59.18
																	barium	125	0.39	10808	29.59
																	chloride	1	48.58	86	0.24
																	fluoride	1	48.58	86	0.24
																	manganese	250	0.19	21616	59.18
																	sulfate	1	48.58	86	0.24
																	zinc	150	0.32	12970	35.51
																	acetone	1	48.58	86	0.24
																	aluminum	100	0.49	8646	23.67
																	chromium	1	48.58	86	0.24
																	iron	250	0.19	21616	59.18
																	lead	150	0.32	12970	35.51
																	Am-241	1000	0.05	86463	236.72
																	tritium	1	48.58	86	0.24
																	uranium	10	4.86	865	2.37
																	Co-60	250	0.19	21616	59.18
																	Pm-147	1000	0.05	86463	236.72
																	Pu-239	125	0.39	10808	29.59
																	nitrate	1	48.58	86	0.24

Table B-1. Estimated Contaminant Migration for the 27 Sites. (Page 9 of 13).

Rpt Sec No	Disposal Facility	Time Frame	Rate (L/mo)	Area (sq m)	f Infil Rate (cm/sec)	Layer No.	Thick. (m)	Soil Type	ThetaS	Ks (cm/sec)	Theta	Moist. State	q (cm/sec)	t (sec)	T (days)	Estimated Moisture Migration (cm/day)	Constituent	Rf	Estimated Contaminant Migration (cm/day)	Contaminant Transport to WT (days)	Contaminant Transport to WT (years)
																	chloroform	1	48.58	86	0.24
																	cadmium	150	0.32	12970	35.51
																	copper	150	0.32	12970	35.51
12	216-B-55 Crib		4.43E+06	697	2.42E-04	1	27	C	0.4	5.0E-04	0.36	U	2.42E-04	4.01E+06			Sr-90	125	0.26	33758	92.42
						2	24	D	0.4	1.0E-04	0.4	S	1.00E-04	9.60E+06			Cs-137	250	0.13	67516	184.85
						3	36	B	0.5	1.0E-03	0.27	U	1.00E-04	9.72E+06			Co-60	250	0.13	67516	184.85
							87							2.33E+07	270	32.2	Ru-106	100	0.32	27006	73.94
																	Ce-144	1000	0.03	270063	739.39
																	uranium	10	3.22	2701	7.39
13	216-B-62 Crib		1.57E+06	465	1.28E-04	1	40	C	0.4	5.0E-04	0.31	U	1.28E-04	9.66E+06			Sr-90	125	0.28	29726	81.39
						2	6	D	0.4	1.0E-04	0.4	S	1.00E-04	2.40E+06			Cs-137	250	0.14	59452	162.77
						3	8	C	0.4	5.0E-04	0.3	U	1.00E-04	2.40E+06			mercury	150	0.23	35671	97.66
						4	29	A	0.5	5.0E-03	0.21	U	1.00E-04	6.09E+06			acetone	1	34.90	238	0.65
							83							2.05E+07	238	34.9	2-butanone	1	34.90	238	0.65
																	tritium	1	34.90	238	0.65
																	uranium	10	3.49	2378	6.51
																	Co-58	250	0.14	59452	162.77
																	Co-60	250	0.14	59452	162.77
																	Ru-106	100	0.35	23781	65.11
																	Sb-125	1	34.90	238	0.65
																	Cs-134	250	0.14	59452	162.77
																	Ce-144	1000	0.03	237810	651.09
																	Eu-154	1000	0.03	237810	651.09
																	Eu-155	1000	0.03	237810	651.09
																	Am-241	1000	0.03	237810	651.09
14	216-B-63 Trench		3.01E+07	1041	1.10E-03	1	64	A	0.5	5.0E-03	0.37	U	1.10E-03	2.15E+06	25	256.8	acetone	1	256.83	25	0.07
																	chromium	1	256.83	25	0.07

Table B-1. Estimated Contaminant Migration for the 27 Sites. (Page 10 of 13).

Rpt Sec No	Disposal Facility	Time Frame	Rate (L/mo)	Area (sq m)	f Infil Rate (cm/sec)	Layer No.	Thick. (m)	Soil Type	ThetaS	Ks (cm/sec)	Theta	Moist. State	q (cm/sec)	t (sec)	T (days)	Estimated Moisture Migration (cm/day)	Constituent	Rf	Estimated Contaminant Migration (cm/day)	Contaminant Transport to WT (days)	Contaminant Transport to WT (years)
																	lead	150	1.71	3738	10.23
																	manganese	50	5.14	1246	3.41
																	Sr-90	50	5.14	1246	3.41
																	Am-241	500	0.51	12460	34.11
																	tritium	1	256.83	25	0.07
																	uranium	3.5	73.38	87	0.24
																	Co-60	50	5.14	1246	3.41
																	Cs-134	50	5.14	1246	3.41
																	Cs-137	50	5.14	1246	3.41
																	Eu-155	500	0.51	12460	34.11
																	aluminum	100	2.57	2492	6.82
																	fluoride	1	256.83	25	0.07
																	sulfate	1	256.83	25	0.07
																	iron	50	5.14	1246	3.41
																	mercury	150	1.71	3738	10.23
15	216-C-7 Crib	1.85E+02	37	1.90E-07	1	26	B	0.5	1.0E-03	0.07	U	1.90E-07	9.58E+08				none				
					2	26	D	0.4	1.0E-04	0.15	U	1.90E-07	2.05E+09								
					3	8	B	0.5	1.0E-03	0.07	U	1.90E-07	2.95E+08								
					4	7	D	0.4	1.0E-04	0.15	U	1.90E-07	5.53E+08								
					5	16	B	0.5	1.0E-03	0.07	U	1.90E-07	5.89E+08								
						83							4.4E+09	51462	0.2						
16	216-S-10 Ditch	2.59E+07	1254	7.86E-04	1	47	C	0.4	5.0E-04	0.4	S	5.00E-04	3.76E+06				Cs-137	250	0.24	24769	67.81
					2	12	D	0.4	1.0E-04	0.4	S	1.00E-04	4.80E+06				Sr-90	125	0.48	12384	33.91
						59							8.56E+06	99	59.6		Pu-239	125	0.48	12384	33.91
																	uranium	10	5.96	991	2.71
17	216-S-26 Crib	2.69E+06	390	2.63E-04	1	36	C	0.4	5.0E-04	0.36	U	2.63E-04	4.93E+06				aluminum	100	0.36	16822	46.06
					2	24	D	0.4	1.0E-04	0.4	S	1.00E-04	9.60E+06				manganese	250	0.14	42055	115.14

Table B-1. Estimated Contaminant Migration for the 27 Sites. (Page 11 of 13).

Rpt Sec No	Disposal Facility	Time Frame	Rate (L/mo)	Area (sq m)	f Infil Rate (cm/sec)	Layer No.	Thick. (m)	Soil Type	ThetaS	Ks (cm/sec)	Theta	Moist. State	q (cm/sec)	t (sec)	T (days)	Estimated Moisture Migration (cm/day)	Constituent	Rf	Estimated Contaminant Migration (cm/day)	Contaminant Transport to WT (days)	Contaminant Transport to WT (years)
							60							1.45E+07	168	35.7	uranium	10	3.57	1682	4.61
																	Co-60	250	0.14	42055	115.14
																	Sr-90	125	0.29	21028	57.57
																	Cs-137	250	0.14	42055	115.14
																	Am-241	1000	0.04	168221	460.57
18	216-T-1 Ditch		3.35E+05	502	2.54E-05	1	27	A	0.5	5.0E-03	0.16	U	2.54E-05	1.70E+07			lead	150	0.08	91103	249.43
						2	6	B	0.5	1.0E-03	0.2	U	2.54E-05	4.72E+06			manganese	250	0.05	151838	415.71
						3	11	D	0.4	1.0E-04	0.29	U	2.54E-05	1.25E+07			aluminum	100	0.12	60735	166.28
						4	29	A	0.5	5.0E-03	0.16	U	2.54E-05	1.82E+07			iron	250	0.05	151838	415.71
							73							5.25E+07	607	12.0					
19	216-T-4-2 Ditch		1.37E+06	975	5.35E-05	1	14	A	0.5	5.0E-03	0.18	U	5.35E-05	4.71E+06			aluminum	100	0.22	27923	76.45
						2	8	D	0.4	1.0E-04	0.33	U	5.35E-05	4.94E+06			iron	250	0.09	69807	191.12
						3	9	C	0.4	5.0E-04	0.26	U	5.35E-05	4.38E+06							
						4	30	A	0.5	5.0E-03	0.18	U	5.35E-05	1.01E+07							
							61							2.41E+07	279	21.8					
20	216-U-14 Ditch		3.30E+07	520	2.42E-03	1	37	A	0.5	5.0E-03	0.44	U	2.42E-03	6.74E+05			Sr-90	25	3.08	1983	5.43
						2	6	D	0.4	1.0E-04	0.4	S	1.00E-04	2.40E+06			Pu-239	100	0.77	7933	21.72
						3	18	A	0.5	5.0E-03	0.21	U	1.00E-04	3.78E+06			Cs-137	150	0.51	11899	32.58
							61							6.85E+06	79	76.9	Ce-144	500	0.15	39663	108.59
																	uranium	10	7.69	793	2.17
																	Am-241	1000	0.08	79326	217.18
																	Ru-106	200	0.38	15865	43.44
21	216-U-17 Crib		9.17E+04	139	2.51E-05	1	4	A	0.5	5.0E-03	0.15	U	2.51E-05	2.39E+06			acetone	1	8.94	794	2.17
						2	15	B	0.5	1.0E-03	0.2	U	2.51E-05	1.20E+07			mercury	10	0.89	7943	21.75
						3	10	C	0.4	5.0E-04	0.23	U	2.51E-05	9.18E+06			Co-60	1	8.94	794	2.17
						4	2	A	0.5	5.0E-03	0.15	U	2.51E-05	1.20E+06			fluoride	1	8.94	794	2.17

Table B-1. Estimated Contaminant Migration for the 27 Sites. (Page 12 of 13).

Rpt Sec No	Disposal Facility	Time Frame	Rate (L/mo)	Area (sq m)	f Infil Rate (cm/sec)	Layer No.	Thick. (m)	Soil Type	ThetaS	Ks (cm/sec)	Theta	Moist. State	q (cm/sec)	t (sec)	T (days)	Estimated Moisture Migration (cm/day)	Constituent	Rf	Estimated Contaminant Migration (cm/day)	Contaminant Transport to WT (days)	Contaminant Transport to WT (years)
						5	20	C	0.4	5.0E-04	0.23	U	2.51E-05	1.84E+07			nitrate	1	8.94	794	2.17
						6	2	D	0.4	1.0E-04	0.29	U	2.51E-05	-2.31E+06			tritium	1	8.94	794	2.17
						7	10	E	0.4	5.0E-05	0.35	U	2.51E-05	1.40E+07			Sr-90	10	0.89	7943	21.75
						8	8	D	0.4	1.0E-04	0.29	U	2.51E-05	9.26E+06			U-isotopes	3.5	2.55	2780	7.61
							71							6.86E+07	794	8.9	Am-241	1	8.94	794	2.17
																	Pu-239	3.5	2.55	2780	7.61
																	Cs-137	25	0.36	19857	54.36
																	chromium	1	8.94	794	2.17
22	216-W-LWC Crib		1.20E+07	3707	1.23E-04	1	9	A	0.5	5.0E-03	0.22	U	1.23E-04	1.61E+06			cadmium	50	0.68	10565	28.93
						2	18	C	0.4	5.0E-04	0.31	U	1.23E-04	4.54E+06			chloroform	1	34.08	211	0.58
						3	14	D	0.4	1.0E-04	0.4	S	1.00E-04	5.60E+06			lead	50	0.68	10565	28.93
						4	31	A	0.5	5.0E-03	0.21	U	1.00E-04	6.51E+06			manganese	15	2.27	3169	8.68
							72							1.83E+07	211	34.1	Co-60	15	2.27	3169	8.68
																	Cs-137	250	0.14	52824	144.63
																	aluminum	100	0.34	21130	57.85
																	iron	15	2.27	3169	8.68
																	Pu-239/240	50	0.68	10565	28.93
																	Ra-228	100	0.34	21130	57.85
																	Sr-90	100	0.34	21130	57.85
																	uranium	5	6.82	1056	2.89
																	Pu-238	50	0.68	10565	28.93
																	Am-241	25	1.36	5282	14.46
																	barium	100	0.34	21130	57.85
																	chromium	1	34.08	211	0.58
																	fluoride	1	34.08	211	0.58
																	Pb-210	50	0.68	10565	28.93
23	216-Z-20 Crib		3.47E+07	1412	9.36E-04	1	43	A	0.5	5.0E-03	0.36	U	9.36E-04	1.65E+06			acetone	1	49.78	121	0.33
						2	6	E	0.4	5.0E-05	0.4	S	5.00E-05	4.80E+06			Co-60	250	0.20	30131	82.49

Table B-1. Estimated Contaminant Migration for the 27 Sites. (Page 13 of 13).

Rpt Sec No	Disposal Facility	Time Frame	Rate (L/mo)	Area (sq m)	f Infil Rate (cm/sec)	Layer No.	Thick. (m)	Soil Type	ThetaS	Ks (cm/sec)	Theta	Moist. State	q (cm/sec)	t (sec)	T (days)	Estimated Moisture Migration (cm/day)	Constituent	Rf	Estimated Contaminant Migration (cm/day)	Contaminant Transport to WT (days)	Contaminant Transport to WT (years)
24	200W Powerhouse Pond		2.38E+07	3642	2.49E-04	1	18	A	0.5	5.0E-03	0.26	U	2.49E-04	1.88E+06			barium	50	0.62	10020	27.43
						2	9	B	0.5	1.0E-03	0.33	U	2.49E-04	1.19E+06			chloride	1	30.94	200	0.55
						3	8	D	0.4	1.0E-04	0.4	S	1.00E-04	3.20E+06			fluoride	1	30.94	200	0.55
						4	3	E	0.4	5.0E-05	0.4	S	5.00E-05	2.40E+06			lead	150	0.21	30060	82.30
						5	24	A	0.5	5.0E-03	0.18	U	5.00E-05	8.64E+06			manganese	50	0.62	10020	27.43
							62							1.73E+07	200	30.9	aluminum	100	0.31	20040	54.87
																	iron	50	0.62	10020	27.43
25	2101-M Pond		1.27E+06	93	5.22E-04	1	67	B	0.5	1.0E-03	0.31	U	5.22E-04	3.98E+06			aluminum	100	1.37	6883	18.85
						2	27	A	0.5	5.0E-03	0.38	U	5.22E-04	1.97E+06			iron	250	0.55	17209	47.11
							94							5.95E+06	69	136.6					
26	300 Process Trenches		3.45E+08	2852	4.61E-03	1	7	A	0.5	5.0E-03	0.49	U	4.61E-03	7.45E+04	1	812.0	aluminum	100	8.12	86	0.236
																	silver	150	5.41	129	0.354
																	uranium-234	10	81.20	9	0.024
																	uranium-238	10	81.20	9	0.024
27	400 Area Pond		1.89E+06	929	7.75E-05	1	32	C	0.4	5.0E-04	0.29	U	7.75E-05	1.20E+07	139	23.1	none				

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Table 3-1. Summary of Receiving Site Assessments

		Liquid Effluent Study										Treatment & Disposal Projects & Engineering Evaluations	
		Waste Stream					Receiving Site						
Receiving Site	Associated Effluent Stream	1 Effluent Designated Dangerous Waste c,d	2 Effluent Determined Radioactive c,e	3 Presence of Key Chem./Rad. Constituents f,g	4 Presence of Key Chem./Rad. Constituents in Groundwater g,h	5 Breakthrough of Other Key Chem./Rad. Constituents f,g,i	6 Use of at Least an Additional 10% of Remaining Soil Column j	7 Volume Impact on Groundwater Flow Regime k	8 Planned Continued Operations Until Treatment	9 Operational Mode	10 Reduced Discharge Mode	11 Impact of Continued Use m,r Project # or Engineering Evaluation	12 Current Estimated Year to be Completed
1 100-D Ponds a	183-D Filter Backwash Wastewater	No	No	Yes	N/D v	Yes	No	No	Yes	No	N/A	BAT	1991
2 1324N/NA Pond a	163N Demineralization Plant Wastewater	No	No	No	No	No	No	No	Yes	No	No	Z	TBD
3 1325N Crib a	N Reactor Effluent	No	Yes	Yes	Yes	Yes	No n	No	Yes	Yes w	No	H-682 y	1995
4 216-A-8 Crib	241-AY/AZ Tank Farm Steam Condensate b	No	Yes	Yes	No	No n	No n	No	Yes	Yes w	No cc	BAT	1991
5 216-A-29 Ditch a	PUREX Plant Chemical Sewer u	No	No	Yes	No	No	No	No	Yes	No	N/A	W-049H W-019	1995 1991
6 216-A-30 Crib	PUREX Plant Steam Condensate t	No	Yes	Yes	No	No	No	No	Yes	No	No	W-049H	1995
7 216-A-36B Crib a	PUREX Plant Ammonia Scrubber Condensate b	Yes	Yes	Yes	Yes	N/A	N/A	N/A	No	N/A	N/A	C-018H	1993
8 216-A-37-1 Crib a	242-A Evaporator Process Condensate b	Yes	Yes	Yes	Yes	N/A	N/A	N/A	No	N/A	N/A	C-018H	1993
9 216-A-37-2 Crib	PUREX Plant Steam Condensate t	No	Yes	Yes	No	No	No	No	Yes	No	No	W-049H	1995
10 216-A-45 Crib	PUREX Plant Process Condensate	No	No	Yes	Yes	N/A	N/A	N/A	No	N/A	N/A	C-018H	1993
11 216-B-3 Pond System a	PUREX Plant Chemical Sewer u	No	No	Yes	No	No	No	Yes	Yes	Yes s	N/A	W-049H	1995
	PUREX Plant Cooling Water	No	No	Yes								BAT	1991
	242-A Evaporator Cooling Water b	No	Yes	Yes								BAT	1991
	B Plant Cooling Water	No	No	Yes								BAT	1991
	241-A Tank Farm Cooling Water	No	No	Yes								BAT	1991
	284-E Powerplant Wastewater	No	No	Yes								BAT	1991
	244-AR Vault Cooling Water	No	No	Yes								BAT	1991
	242-A Evaporator Steam Condensate	No	No	Yes								BAT	1991
12 216-B-55 Crib	B Plant Steam Condensate b	No	Yes	Yes	No	No	No	No	Yes	No	No	W-049H	1995
13 216-B-62 Crib	B Plant Process Condensate b	TBD cc	Yes	Yes	No	No n	No n	No	Yes	Yes w	No cc	W-049H	1995
14 216-B-63 Ditch a	B Plant Chemical Sewer	No	No	Yes	N/D q	No	No	No	Yes	No	N/A	W-049H	1995
15 216-C-7-Crib	209-E Laboratory Reflector Water b	No	No	No	N/D v	N/A	N/A	N/A	No	N/A	N/A	N/A	–
16 216-S-10 Ditch a	S Plant Wastewater	No	No	Yes	N/D q	No	No	No	Yes	No	N/A	W-049H	1995
17 216-S-26 Crib	222-S Laboratory Wastewater	No	Yes	Yes	No	No	No	No	Yes	No	N/A	W-049H	1995
18 216-T-1 Ditch	T Plant Laboratory Wastewater	No	No	Yes	N/D v	No	No	No	Yes	No	N/A	W-049H	1995
19 216-T-4-2 Ditch	T Plant Wastewater	No	No	Yes	N/D v	No	No	No	Yes	No	N/A	W-049H	1995
20 216-U-14 Ditch	UO_3/U Plant Wastewater	No	No	Yes	No	Yes	No	No	Yes	No s	No s	W-049H	1995
	242-S Evaporator Steam Condensate	No	No	Yes									
21 216-U-17 Crib	UO_3 Plant Process Condensate b	No	Yes	Yes	No	No	No	No	Yes	No	No	W-049H	1995
22 216-W-LC Crib	2724-W Laundry Wastewater	No	Yes	Yes	N/D v	No	No	No	Yes	No	N/A	W-049H	1995
23 216-Z-20 Crib	Plutonium Finishing Plant Wastewater	No	Yes	Yes	No	No	No	No	Yes	No	N/A	W-049H	1995
24 200-W Powerhouse Pond	284-W Powerplant Wastewater	No	No	Yes	N/D v	Yes	No	No	Yes	No	N/A	BAT	1991
25 2101-M Pond a	2101-M Laboratory Wastewater b	No	No	Yes	No	No	No	No	Yes	No	N/A	W-049H	1995
26 300 Area Process Trenches a	300 Area Process Wastewater	No	No	Yes	Yes	No	No	No	Yes	No	N/A	L-045H	1994 bb
27 400 Area Ponds	400 Area Secondary Cooling Water	No	No	No	No	No	No	No	Yes	No	N/A	BAT	1991

JJA\083090-D

FOOTNOTES:

a) Regulated units based on previous identification as RCRA disposal TSD facility.
b) Wastestream not sampled as part of Liquid Effluent Study.
c) Based on effluent sampling data collected from October 1989 to March 1990 as part of Liquid Effluent Study or on sampling data collected from 1985 to October 1989 for wastestreams identified in footnote b.
d) Designation based on determinations proposed in Hanford Site Stream-Specific Reports (WHC 1990c, WHC-EP-0342).
e) For this study, wastestreams are radioactive if any constituent exceeds concentration standards in Westinghouse Environmental Compliance Manual (1989b), Part N, Groundwater Protection.
f) Based on effluent sampling data collected from 1985 to March 1990.
g) Key constituents are effluent constituents that exceed study guidelines in Table 2-1. (No regulatory requirement or policy is intended or implied by these guidelines.)
h) Key effluent constituents present in the groundwater that exceed Group A study guidelines in Table 2-1 and have resulted from discharges to the receiving site. (No regulatory requirement or policy is intended or implied by these guidelines.) Based on groundwater sampling data collected from January 1989 to May 1990.
i) Movement of other key effluent constituents from the vadose zone into the groundwater based on average discharge rates and one-dimensional flow and transport analyses (Appendix B).
j) Based on average discharge rates and one-dimensional flow and transport analyses (Appendix B).
k) Based on an effluent discharge rate greater than the natural recharge rate from Cold Creek/Dry Creek recharge area for 200 Area sites. Groundwater patterns at sites along the Columbia River are important only when associated with groundwater mounds due to artificial recharge and mounds not masked by fluctuations of river.
m) Impacts are based on continued use exacerbating cleanup activities at the site and/or adjacent areas/sites.
n) Based on current discharge rates to the soil column and/or water quality.
p) Assumes ketones are degraded before reaching the groundwater.
q) No groundwater data as of August 1990; monitoring wells recently completed.
r) Shaded pattern in Operational or Reduced Discharge mode signifies current mode of receiving site. No pattern in both columns signifies the receiving site will no longer receive effluent.
s) A groundwater evaluation to be initiated to more accurately assess impacts of continued use of receiving site.
t) PUREX Steam Condensate stream discharges to 216-A-30 and 216-A-37-2 cribs.
u) PUREX Chemical Sewer discharges to 216-A-29 Ditch which flows into the 216-B-3 Pond System.
v) No wells at receiving site to sample groundwater; well 216-W-LC Crib requires rehabilitation to collect representative groundwater sample.
w) If receiving sites are to be used in the future, a site-specific evaluation will be required before operation.
y) Project H-682 will be completed only if the N Reactor effluent stream continues to discharge to 1325N Crib.
z) Discharges to receiving site may be terminated and diverted to the river. This will require modification to existing NPDES permit.
aa) Feed stream currently discharged to double-shell tanks; receiving site can handle reduced volume discharges.
bb) Change request to move date of ceasing discharges to the trenches from December 1991 to 1994 submitted for regulatory approval.
cc) Will be designated upon startup of B Plant.

BAT = Best available technology engineering evaluation
N/A = Not applicable N/D = Not determined TBD = To be determined

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APPENDIX A

REFERENCED PROJECT CORRESPONDENCE

Appendix A contains the following correspondence related to the Liquid Effluent Study:

- Exhibit 1 -- Letter from J. J. Lawrence, DOE-RL, to C. Gregoire, Ecology, and R. Russell, EPA, May 13, 1989.
- Exhibit 2 -- Letterfrom T. L. Nord, Ecology, and P. T. Day, EPA, to S. H. Wisness, DOE-RL, April 9, 1990.
- Exhibit 3 -- Letter from S. H. Wisness, DOE-RL, to P. T. Day, EPA, and T. L. Nord, Ecology, May 4, 1990.
- Exhibit 4 -- Letter from S. H. Wisness, DOE-RL, to P. T. Day, EPA, and T. L. Nord, Ecology, May 10, 1990.
- Exhibit 5 -- Letter from R. E. Lerch, WHC, and R. D Izatt, DOE-RL, to P. T. Day, EPA, and T. L. Nord, Ecology, May 11, 1990.

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WHC-EP-0367

Department of Energy
Richland Operations Office
P.O. Box 550
Richland, Washington 99352

MAY 1 3 1989

Ms. Christine Gregoire, Director
State of Washington
Department of Ecology
Mailstop PV-11
Olympia, Washington 98504

Mr. Robie Russell, Administrator
U.S. Environmental Protection Agency
Region X
1200 Sixth Avenue, SO 121
Seattle, Washington 98101

Dear Ms. Gregoire and Mr. Russell:

Several comments were received during the public comment period of the Hanford Federal Facility Agreement and Consent Order (Agreement) regarding continued liquid discharges to the soil. In response to these comments, and at the request of the Department of Ecology and U.S. Environmental Protection Agency, the U.S. Department of Energy (DOE) will undertake and fund a separate study as described in the attachment to this letter. This study may result in a reevaluation of the Agreement liquid discharge milestones. It will include a detailed characterization of each of Hanford's 33 liquid effluents and substantially increased analyses of these effluents and vicinity groundwaters. This study will be conducted in part to provide verifiable data and information that will confirm that all continuing liquid discharges do not contain hazardous waste.

In the event that EPA or Ecology determine at any time, as a result of new information from the study, that such discharges contained or now contain hazardous waste, DOE agrees that such a determination, and the information it is based on, shall be regarded as new information for purposes of Paragraph 126 of the Agreement. The study will be completed and a final report submitted to EPA and Ecology by August 31, 1990.

I am committing to you that any and all information on liquid effluents requested or received by Ecology or EPA subsequent to our February 27, 1989, Notice of Intent to Execute Hanford Agreement, including but not limited to public comment, will be considered new information under the Agreement's Article XLVI, paragraph 126.

Ecology and EPA are consequently free to utilize such information and to exercise those administrative and judicial remedies which are available to you consistent with the Agreement.

Sincerely,

Michael J. Lawrence

Michael J. Lawrence
Manager

Attachment

LIQUID EFFLUENT STUDY

The Department of Energy (DOE) will complete a special project designed to document the discharge history and the character of Hanford liquid discharges. This project will also assess the potential for contaminant migration within receiving site soils, and the extent of groundwater contamination within area wells. The results of this project will be utilized in determining the need for additional waste stream analysis, and/or to negotiate additional milestones pertaining to such discharges in the Hanford Federal Facility Agreement and Consent Order (Agreement).

BACKGROUND

The Department of Energy's present RCRA effluent characterization program has been scheduled to end in FY 1989. This effort involved the collection of four random (one per quarter) samples per waste stream or sub-partition thereof. This program will now be extended under the project described below.

PROJECT SCOPE

The study will address all 19 Phase I and 14 Phase II streams and associated receiving sites as identified within the "Annual Status Report of the Plan and Schedule to Discontinue Disposal of Contaminated Liquids into the Soil Column at the Hanford Site" (September 1988).

APPROACH

The study will be based on the development of (1) an initial project plan, (2) a characterization report covering Hanford's 33 liquid effluent streams, and (3) a final project report. These plans and reports will be designed as follows:

Project Plan: This plan will describe all activities to be accomplished during the characterization and assessment effort. This initial plan will be submitted for Ecology and EPA approval on or about June 30, 1989. Ecology and EPA will review and comment within two weeks.

Waste Stream Characterization Report: This report will incorporate the following elements:

(a) waste stream description;
(b) discharge history including incidents and routine discharges, including their physical, chemical, and radiological nature;
(c) evaluation of existing characterization data;
(d) description of the receiving site, including an evaluation of available soil column and relevant groundwater monitoring well data;
(e) list of potential contaminants derived from process knowledge;
(f) description of effluent and groundwater well sample locations;

(g) proposed sampling schedule;
(h) proposed listing of analytical project parameters and procedures.

These characterization reports will delineate the number of samples to be taken from each waste stream and vicinity groundwater monitoring wells. Sufficient samples will be obtained to ensure representative data. These data will include representative analyses for radiological and 40 CFR 264 Appendix IX constituents.

Effluent data will be collected and streams fully designated under the state's dangerous waste management program, including criteria testing under WAC 173-303-070(4) if required by the state, and limited to state regulatory authority over dangerous waste.

Final Project Report: This report will contain and discuss data and results acquired during the study. The report will also focus on individual receiving site characteristics and known and potential contaminant migration into soil columns and area groundwater. The final report will incorporate effluent specific performance assessments, and appropriate fate and transport flow modeling results.

Work performed by the DOE and its contractors under this study will not be performed to the detriment of schedules or activities under the Agreement. All additional sampling and analysis conducted will be conducted in accordance with the requirements of Article XXX of the Hanford Federal Facility Agreement and Consent Order.

SCHEDULES

Submittals to Ecology and EPA under this project will be as follows:

(a) Initial Project Plan: June 30, 1989;
(b) Waste Stream Characterization Report: August 31, 1989;
(c) Waste Stream and Monitoring Data: bi-monthly throughout the study;
(d) Final Project Report: August 31, 1990.

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APR 1990
Received

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
Mail Stop PV-11 • Olympia, Washington 98504-8711 • (206) 459-6000

RECEIVED
APR 11 1990
CORRESPONDENCE CONTROL

April 9, 1990

Mr. Steven H. Wisness
Hanford Project Manager
Department of Energy
Richland, Washington

Dear Mr. Wisness:

Re: Liquid Effluent Study Project Plan

The Department of Ecology (Ecology) and the Environmental Protection Agency (EPA) have completed a review of the Liquid Effluent Study Project Plan (March 1990). Several issues have been raised recently which must be addressed as part of this study:

1) The bi-monthly reports submitted to date lack sufficient detail to evaluate the performance during the report period. Specific areas of concern are lack of detail on why projects are behind schedule and methods which are necessary to bring the project back on schedule.

2) The plan must reduce the submittal of the bi-monthly report from one month after the report period to two (2) weeks.

3) Ecology and EPA are concerned with the progress of the stream sampling effort. Therefore, in the bi-monthly report for February and March, identify the waste streams that have been sampled, the parameters analyzed in these streams (hazardous and radiological), and the dates and times at which samples were taken. As described in Appendix A of the Project Plan, new information gathered during the study will be used to determine if such discharges now contain hazardous wastes. This effort represents a key component of the study project. Stream specific reports will not be considered complete until new data is presented for all waste streams.

4) Stream specific reports must contain sampling and analytical results for all waste streams that were active during the study period. All liquid effluent streams not active during the study period which are intended for soil column discharge must be sampled at the time of restart.

Mr. Steven H. Wisness
April 9, 1990
Page 2

5) It is our understanding that certain waste streams were not sampled because they were being routed to the tanks rather than to the soil column. Any waste stream sent to the double shell tank system must be characterized according to the Waste Analysis Plan currently under development for these tanks. Should DOE wish to return any of these streams to the soil column, all phases of the Liquid Effluent Study Project Plan (to include full characterization, flow and transport modelling for the new discharge site, etc.) would be required prior to soil discharge.

6) The flow and transport characteristic activities should be completed through the first two tasks (see section 5.2). Once these two tasks are complete, a conceptual model of how the flow and transport analysis will be performed should be presented to the Ecology and EPA. Ecology and EPA recommend that a meeting be set up during the first week in May to discuss radionuclide and hazardous substance transport properties, soil characteristics, and release and discharge model input for the flow and transport analysis.

Ecology and EPA approve the Liquid Effluent Study Project Plan subject to the provisions explained above. Satisfactory completion of the study must include stream sampling for all liquid effluents and credible flow and transport analyses for the three receiving sites selected. This project is an important effort which requires the cooperation of all parties for its successful completion.

Any questions regarding this issue may be directed to either Mr. Toby M. Michelena of Ecology or Mr. Doug Sherwood of EPA at (206) 438-7016 or (509) 376-9529 respectively.

Sincerely,

Timothy L. Nord
Hanford Project Manager
Department of Ecology

Paul T. Day
Hanford Project Manager
Environmental Protection Agency
Region 10

cc: Doug Sherwood
Toby M. Michelena
George Hofer
Roger Stanley

WHC-EP-0367

9002001

Department of Energy

Richland Operations Office
P.O. Box 550
Richland, Washington 99352

MAY 0 4 1990

MAY 1990
Received
Disposition

Mr. Paul T. Day
Hanford Project Manager
U. S. Environmental Protection Agency
Region 10
P. O. Box 550, A7-70
Richland, Washington 99352

Mr. Timothy L. Nord
Hanford Project Manager
State of Washington
Department of Ecology
Mail Stop PV-11
Olympia, Washington 98504-8711

MAY 0 9 1990

Dear Messrs. Day and Nord:

LIQUID EFFLUENT STUDY

References: (1) Ecology letter to S. H. Wisness from T. L. Nord and P. T. Day, subject "Liquid Effluent Study Project Plan," dated April 9, 1990.

(2) EPA letter to S. H. Wisness from P. T. Day, subject "Liquid Effluent Study," dated May 2, 1990.

In response to Mr. Paul T. Day's letter dated May 2, 1990, concerning the Liquid Effluent Study, the Department of Energy (DOE) is providing the requested information answering Items 1 and 3 found in your letter dated April 9, 1990.

Item 1 of Reference 1 expresses a concern about the insufficient amount of detail provided to evaluate status in the bimonthly reports. This issue has also been a matter of concern to DOE and we are moving to remedy the problem in future reports. The February-March bimonthly report has been forwarded to you under separate correspondence.

One area of delay is the completion of the Preliminary Stream Specific Reports. During review of drafts of these reports by DOE, it became clear that additional work was necessary to ensure appropriate treatment of the issues and consistency of quality for all 33 reports. A recovery schedule is in place and we anticipate that all the reports will be delivered by May 21, 1990. Currently no other issues place the August 31, 1990, deadline in jeopardy.

Messrs. Day and Nord

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Attached are tabulations of the sample data and the analytical parameters in response to Item 3 of your April 9 letter. The sample data show dates and times samples were taken and corresponding sample numbers. The analytical parameters indicate analytes detected at least once since August 1985. Analytical results will be provided in a separate report to be issued in mid-May. As you have been previously advised, these new data will be included in the final Stream Specific Reports but not in the Preliminary Stream Specific Reports.

If you have any questions, please contact Mr. Madan Dev of the Waste Management Division on 376-3412.

Sincerely,

for
Steven H. Wisness
Hanford Project Manager

WMD:MD

Attachment
1. Sample Data Tabulations
2. Liquid Effluent Study Analytes

cc w/att:
D. A. Turner, WHC
J. L. Waite, WHC
R. R. Thompson, WHC

WHC-EP-0367

Department of Energy
Richland Operations Office
P.O. Box 550
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MAY 10 1990

Mr. Paul T. Day
Hanford Project Manager
U. S. Environmental Protection Agency
Region 10
Post Office Box 550, A7-70
Richland, Washington 99352

Mr. Timothy L. Nord
Hanford Project Manager
State of Washington
Department of Ecology
Mail Stop PV-II
Olympia, Washington 98504-8711

Dear Messrs. Day and Nord:

LIQUID EFFLUENT STUDY

References:
(1) Ecology letter to S. H. Wisness from T. L. Nord and P. T. Day, subject "Liquid Effluent Study Project Plan," dated April 9, 1990.

(2) EPA letter to S. H. Wisness from P. T. Day, subject "Liquid Effluent Study," dated May 2, 1990.

(3) DOE-RL letter to P. T. Day and T. L. Nord, subject "Liquid Effluent Study," dated May 4, 1990

In response to Mr. Paul T. Day's letter dated May 2, 1990, Reference 2, concerning the Liquid Effluent Study, the Department of Energy, Richland Operations Office (DOE-RL) is providing the requested information answering Items 2, 4, 5 and 6 found in your letter dated April 9, 1990, Reference 1. Reference 3 provided information in response to items 1 and 3 of the same letter.

Item 2 of Reference 1 requests submittal of the bimonthly reports two weeks after the end of the report period. A schedule has been prepared whereby DOE-RL will transmit the April-May bimonthly report by close of business on June 15, 1990.

Item 4 of Reference 1 requests that all liquid effluent streams not active during the study period intended for soil column discharge be sampled at the time of restart. DOE-RL will sample all streams which were inactive during the study intended for discharge to the soil column at the time of restart. Sampling and analytical results for streams sampled during the study

Messrs. Day and Nord

MAY - 0 1990

period will be included in the final Stream Specific Reports. The preliminary reports will not include this data; however, there is a plan in place to provide the analytical results separately within the next two weeks.

Item 5 of Reference 1 requests special study of waste streams not sampled during the study and routed to double-shell tanks rather than the soil column. DOE-RL will designate these streams as specified in WAC-173-303-070 prior to any proposed discharge.

Item 6 of Reference 1 requests participation in the flow and transport analysis. DOE-RL will arrange a briefing on progress in this portion of the study for Ecology and the EPA at Richland before the end of May.

If you have any questions on this letter, please contact Mr. Madan Dev of the Waste Management Division on 376-3412.

Sincerely,

Steven H. Wisness
Hanford Project Manager

WMD:MD

WHC-EP-0367 9002761

Department of Energy

Richland Operations Office
P.O. Box 550
Richland, Washington 99352

MAY 11 1990

JUN 29 1990
CORRESPONDENCE CONTROL

Mr. Paul T. Day
Hanford Project Manager
U. S. Environmental Protection Agency
Region 10
Post Office Box 550
Richland, Washington 99352

Mr. Timothy L. Nord
Hanford Project Manager
State of Washington
Department of Ecology
Mail Stop PV-11
Olympia, Washington 98504-8711

Dear Messrs. Day and Nord:

SELECTION OF SITES FOR FLOW AND TRANSPORT ANALYSIS WITHIN THE LIQUID EFFLUENT STUDY

One aspect of the Liquid Effluent Study is an assessment of the potential for contaminant migration. This assessment is being performed as part of the Flow and Transport Characteristics task identified in the Liquid Effluent Study Project Plan. The emphasis of this task is to evaluate: (1) the risk to human health or to the environment, and (2) the impact on future clean-up activities of continued discharge of liquid effluents into the soil column. This letter is to apprise you of the receiving sites which have been selected for study and to explain the rationale for their selection.

To date, two sites have been selected for flow and transport analysis:

1. The 216-U-17 Crib, which receives the UO_3 Plant Process Condensate effluent, is located in the 200 West Area. The proposed designation is that the waste stream is nondangerous; however, the waste stream contains radiological contamination. Although the effluent has not contributed to groundwater, groundwater data collected from wells around 216-U-17 indicate elevated radiological contamination from previous discharges in other locations. Thus groundwater data cannot be easily used to assess the environmental impacts associated with discharges to the 216-U-17 crib. Instead, flow and transport analysis will be used to evaluate the impact of continued discharge at this site. The conditions associated with the operation of this liquid waste site generally satisfy the conditions as outlined in path "A" on Figure 2 of the Liquid Effluent Study Project Plan (see Enclosure).

Messrs. Day and Nord MAY 11 1990

2. The N-Springs, which discharge groundwater contaminated by N Reactor operations, are located along the banks of the Columbia River in the vicinity of the 100-N Area. The proposed designation for the N Reactor effluent is that the waste stream is nondangerous and in the future nonradioactive; however, the soils do contain radiological contamination as a result of previous operations. Although the reactor has been placed in cold standby, operation of the 1325-N Crib is scheduled to continue, and the impact of this operation on the potential for exacerbating future clean-up operations will be studied. This site was selected because of its direct communication with the Columbia River and consequent potentially immediate impact on human health and the environment. The conditions associated with continued planned usage of this liquid waste site satisfy the conditions as outlined in path "C" on Figure 2.

As per the guidance in the Liquid Effluent Study Project Plan, a third site will be selected for purposes of evaluation. Consistent with this guidance, it is proposed that the 216-A-30/216-A-37-2 liquid waste site be evaluated.

3. The 216-A-30/216-A-37-2 Cribs, which receive the PUREX Steam Condensate effluent, are located in the 200 East Area. This site will be studied as a companion to the 216-U-17 site. The proposed designation is that the waste stream is nondangerous; however, it contains radiological contamination. The high profile of this site and its history of uranium releases make it an appropriate candidate for evaluation. The conditions associated with continued operation of this waste site generally satisfy the conditions as identified in path "B" on Figure 2.

As discussed in the Liquid Effluent Study Project Plan, these three sites have been selected to evaluate:

- The risk that results from the continued discharge of liquid effluent into a soil column that contains low levels of radiation as represented through the continued operation of the 216-A-30/216-A-37-2 Cribs

- The risk that results from the continued discharge of a liquid effluent stream that contains low levels of radiation as represented through continued operation of the 216-U-17 Crib

- An evaluation of the impact (exacerbation) associated with continued operation of a disposal unit as represented through continued operation of the 1325-N Crib.

Messrs. Day and Nord

MAY 11 1990

If you have any questions or need additional information regarding the selection of the three liquid effluent waste sites, please contact Mr. M. Dev, DOE-RL, on 376-3412, or Mr. K. R. Fecht, Westinghouse Hanford Company, on 376-0940.

Sincerely,

R. D. Izatt, Director
Environmental Restoration Division
Richland Operations Office

R. E. Lerch, Manager
Environmental Division
Westinghouse Hanford Company

Enclosure:
Decision Tree
(WHC-EP-0275, Rev. 2, Fig. 2)

cc: R. E. Lerch, WHC (w/o encl.)
[redacted] (w/o encl.)

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APPENDIX B

ONE-DIMENSIONAL FLOW AND TRANSPORT ANALYSIS

A preliminary assessment was made of the movement of moisture and contaminants from liquid waste disposal facilities through the vadose zone to the water table. For this assessment, a simple analytical model was employed to provide an initial indication of travel times that would suggest the relative importance of the 27 disposal sites associated with this study.

The model selected is a one-dimensional analytical model that was applied in the final environmental impact statement for Hanford Site defense wastes and described fully in Appendices O and Q of that document (DOE 1987). The model only considers flow in the vertical direction and does not allow for lateral spreading, and thus is expected to provide an estimated travel time that is faster than would occur in the subsurface environment.

The model addresses steady-state flow in the unsaturated zone and assumes a unit hydraulic gradient. The basic equation for any layer of sediments is

$$t = L \times \theta/q \qquad (1)$$

where:

t = time of travel through layer, sec
L = thickness of layer, cm
θ = moisture content of sediment, related to hydraulic conductivity
q = Darcy velocity or moisture flux in layer, cm/sec.

The total travel time, T, is determined as the summation of the travel times for each of the "i" layers:

$$T = \sum_{i=1}^{n} L_i \times \theta_i/q_i \qquad (2)$$

where n is the number of sediment layers selected to model a particular disposal site.

The relationship between hydraulic conductivity, K, and moisture content, θ, is described graphically in Figure B-1. These curves were derived empirically from laboratory tests on over 20 different Hanford Site sediment types and were used to establish five major sediment types, as noted in the figure.

Some of the sediment layers beneath the liquid waste disposal facilities may be saturated. In these cases, the steady-state Darcy velocity or water flux is described by the Green-Ampt equation (Bouwer 1978, p. 253), which results in the flux, q, being equal to the saturated hydraulic conductivity, K_S.

The one-dimensional flow analysis embodied in Eq. 2 was carried out for each of the 27 liquid disposal facilities on a Symphony spreadsheet, the major parts of which are contained in Table B-1. The total travel time, T, obtained with Eq. 2 is divided into the vadose zone thickness to provide an estimate of the rate of moisture migration from the disposal facility to the groundwater.

To obtain contaminant migration rate estimates, the moisture migration rate was divided by the appropriate retardation factor (R_f) for a contaminant/waste stream combination. A brief discussion of the application and limitations in the use of retardation factors for this study is provided in Appendix C.

Some general comments are appropriate before discussing the details. Some facilities have changed size over the years; for others, the average volume of effluent has changed over time. The attempt herein has been to average the total volume disposed over the life of a facility as a measure of the driving force to provide an indication of contaminant movement.

The effluent records for each of the facilities were reviewed to establish the rate of inflow, listed as liters per month on the spreadsheet. Effluent volumes through 1987 listed in WHC-EP-0287, Vol. 3, were updated to include 1988 and 1989 (WHC 1989). The total volume (liters) was divided by the corresponding time of operation (month) of the disposal facility to establish a rate of inflow averaged over the life of the facility. This effluent rate was divided by the area of the facility to obtain an estimate of the average infiltration rate at that facility. Receiving site dimensions used for calculations are provided in Waste Stream Characterization Report (WHC 1989). For some ponds, only part of the area is wetted, and an estimate of this area was used in the infiltration computation. For the 1325N Crib, two flow conditions were evaluated: past operating conditions and future conditions to account for smaller flows during deactivation.

An exception to the discussion of the previous paragraph is the 216-A-29 Ditch. This ditch conveys effluent from PUREX to the 216-B-3-3 Ditch, and there is no estimate of the flow from the one ditch into the other. Therefore, the infiltration rate of the 216-A-29 Ditch was chosen as 1 gal/day/ft^2, corresponding to the measured rate of infiltration at 216-B-3 Pond, which is of similar age. The estimated total infiltration into 216-A-29 Ditch was then subtracted from the total flow in the 216-B-3 Pond system when estimating the rate of infiltration in the three expansion ponds, 216-B-3A, -3B, and -3C. The 1 gal/day/ft^2 rate of infiltration was also applied to the main pond, 216-B-3.

The following is a step-by-step discussion to explain the method of applying this preliminary assessment of flow and transport in the vadose zone. As an aid to understanding, reference is made to the computations for the 216-B-55 Crib. This crib is section number 12 in this report, which is also noted in column 1 of the spreadsheet, Table B-1.

- The infiltration rate, f, for each disposal facility is estimated on the basis of the rate of effluent disposal and the area of the disposal facility.

- Each of the paragraphs with a dash applies to the 216-B-55 Crib. The infiltration rate, f, is 2.42E-04 cm/sec, obtained from the effluent rate of 4.43E+06 L/mo and the area of the bottom of the crib, 697 m^2.

- A stratigraphic column obtained from a geologists or drillers log from a well near the disposal site is used to select the n layers of the model, and one of the five sediment types of Figure B-1 is assigned to each layer. Thus the saturated moisture content, θ_s, and the saturated hydraulic conductivity, K_s, for each layer are specified.

  - From Figure B-2, the sediment profile is estimated to consist of (in descending order) 27 m (2,700 cm) of fine sand (denoted by C in Figure B-1), 24 m (2,400 cm) of sand, silt (D in Figure B-1), and 36 m (3,600 cm) of coarse sand (B in Figure B-1). From the legend in Figure B-1, the saturated hydraulic properties of these sediments are as follows:

Layer	Soil Type	θ_s	K_s (cm/sec)
1	C	0.4	5E-04
2	D	0.4	1E-04
3	B	0.5	1E-03

- For layer i immediately beneath the disposal facility, if f exceeds K_s, the layer is saturated; otherwise it is unsaturated. For saturated conditions $q = K_s$ and $\theta = \theta_s$, while for unsaturated conditions q = f and θ is read from Figure B-1 using a value of K = f. The appropriate values are substituted into Eq. 1 to estimate t for that layer.

  - For the fine sand, denoted as C, of the uppermost layer, the sediment is unsaturated since f = 2.42E-04 cm/sec is less than K_s = 5E-04 cm/sec. Therefore, q = f = 2.42E-04 cm/sec, and θ is read from the Figure B-1 as 0.36 (entering the ordinate with K = 2.42E-04, moving horizontally to curve C, and moving vertically to read 0.36 on the abscissa).

- Each of the layers beneath the uppermost layer are treated similarly to that layer. When moving down from an unsaturated layer to a saturated layer with a resulting greater q, an implicit assumption is that the area of the moisture plume expands to preserve continuity. Another important point is that when moving down from a saturated layer to an unsaturated layer beneath it, q_i is taken to be equal to q_{i-1}.

  - For the second layer of sediment D, f = 2.42E-04 cm/sec is greater than K_s = 1E-04 cm/sec, and therefore is saturated. In this case $q = K_s$ = 1E-04 cm/sec and $\theta = \theta_s = 0.4$.

- In the third layer of sediment B, the flux, q, is taken to be the same as in layer 2 (i.e., q = 1E-04 cm/sec). When this q is compared with the K_s = 1E-03 cm/sec for sediment B, the flow is deemed to be unsaturated.

o The travel times, t, for the individual i layers are summed over the n layers to obtain the total travel time, T, in seconds which is converted to days.

- The travel time, t, for each of the layers is computed as follows and summed to obtained the total travel time, T:

1 t_1 = 2,700*0.36/2.42E-04 = 4.01E+06 sec

2 t_2 = 2,400*0.4/1E-04 = 9.60E+06 sec

3 t_3 = 3,600*0.27/1E-04 = 9.72E+06 sec

T = 2.33E+07 sec

= 270 days.

o An estimation of the rate of moisture migration in

centimeters is obtained from the depth of the vadose zone $(\sum_{i=1}^{n} L_i)$ and the total travel time, T.

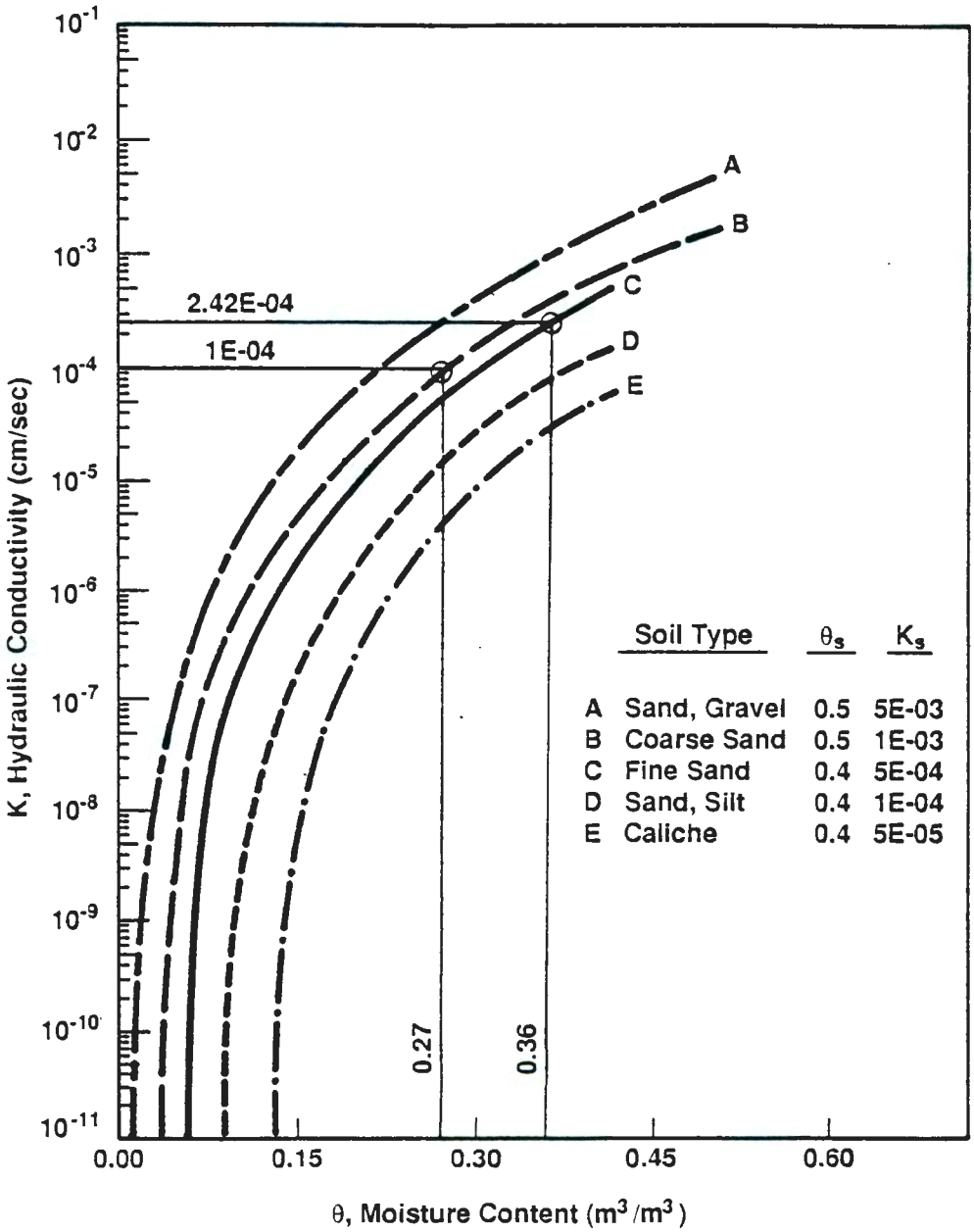
- Dividing the sediment depth of 87 m (8,700 cm) by the travel time of 270 days yields an estimated moisture migration of 32.2 cm/day.

o The R_f for each key constituent is estimated from: $R_f = (1 + 5R_d)$, an approximation for Hanford Site soils using R_d values summarized in Appendix C. When the estimated rate of moisture migration is divided by the R_f, an estimate is obtained for the rate of migration for that constituent.

- Estimated R_f for strontium-90 and cesium-137 are 125 and 250, respectively. The predicted rates of movement of these radionuclides are 0.26 cm/day and 0.13 cm/day, respectively.

In the interpretation of the results from the above analyses, it should be remembered that this is a simplified, one-dimensional model that negelects lateral spreading and makes use of generalized moisture curves from the Hanford Site that are not specific to any individual site. Therefore, the rates of moisture and contaminant migration are to be viewed as approximations that are expected to be conservative (i.e., faster than would be observed). However, they should be useful to obtain an estimate for the relative importance of the 27 disposal sites.

Figure B-1. Hydraulic Conductivity Versus Moisture Content for 216-B-55 Crib.



PS-90-144

Figure B-2. Stratigraphic Column at 216-B-55.

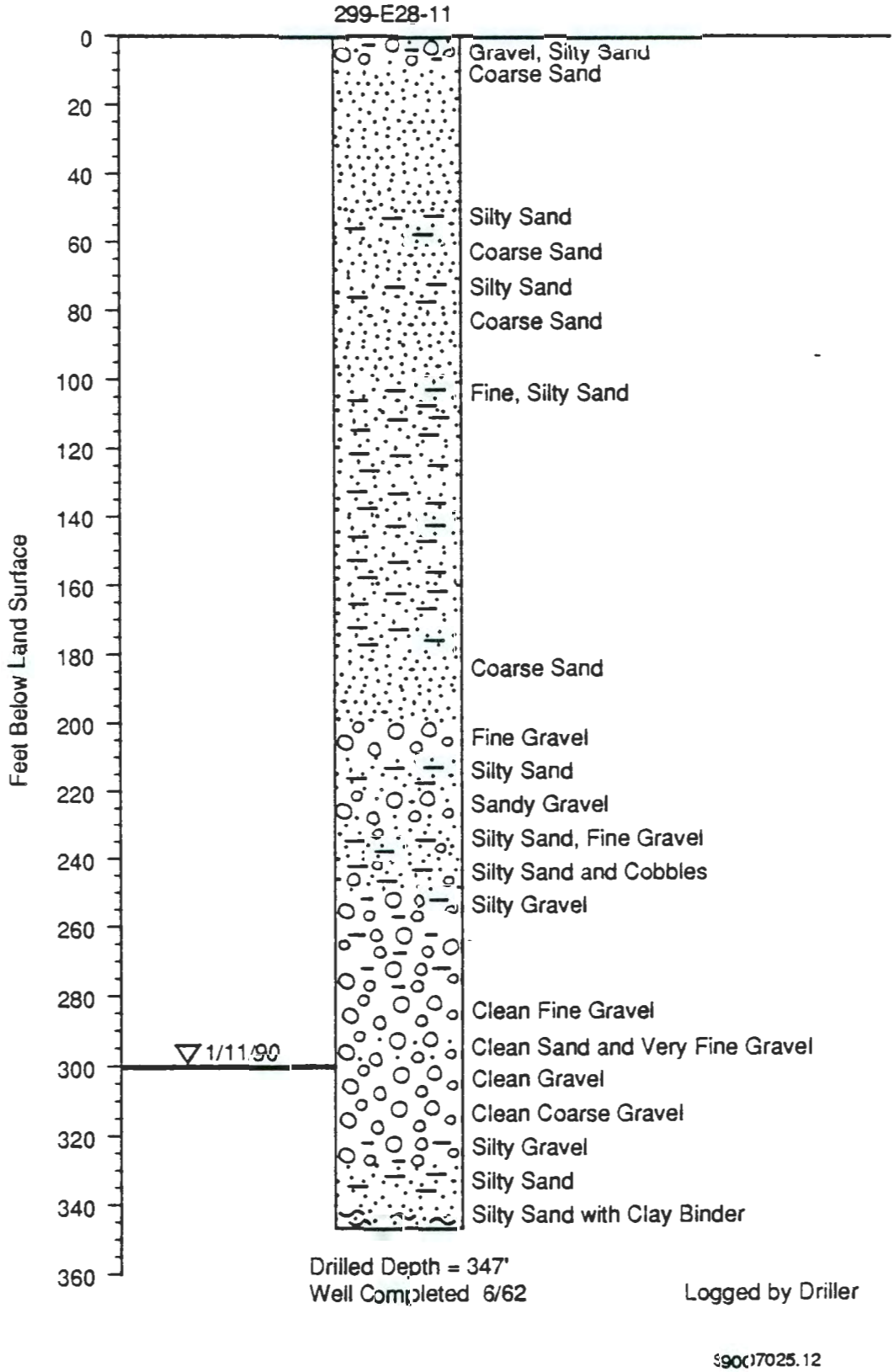


Table B-1. Estimated Contaminant Migration for the 27 Sites. (Page 1 of 13).

Rpt Sec No	Disposal Facility	Time Frame	Rate (L/mo)	Area (sq m)	f Infil Rate (cm/sec)	Layer No.	Thick. (m)	Soil Type	ThetaS	Ks (cm/sec)	Theta	Moist. State	q (cm/sec)	t (sec)	T (days)	Estimated Moisture Migration (cm/day)	Constituent	Rf	Estimated Contaminant Migration (cm/day)	Contaminant Transport to WT (days)	Contaminant Transport to WT (years)
1	100-D Ponds		1.90E+05	1839	3.93E-06	1	20	A	0.5	5.0E-03	0.1	U	3.93E-06	5.09E+07	589	3.4	chromium	1	3.40	589	1.61
																	iron	250	0.01	147158	402.90
																	lead	150	0.02	88295	241.74
																	manganese	250	0.01	147158	402.90
																	mercury	150	0.02	88295	241.74
																	sulfate	1	3.40	589	1.61
																	aluminum	100	0.03	58863	161.16
2	1324-N/NA Pond		9.37E+06	2700	1.32E-04	1	15	A	0.5	5.0E-03	0.22	U	1.32E-04	2.50E+06	29	51.9	none				
3	1325-N Crib	past	8.01E+07	5574	5.47E-04	1	15	A	0.5	5.0E-03	0.31	U	5.47E-04	8.50E+05	10	152.5	iron	250	0.61	2459	6.73
																	Pu-238	125	1.22	1230	3.37
																	Pu-239	125	1.22	1230	3.37
																	Am-241	1000	0.15	9837	26.93
																	tritium	1	152.48	10	0.027
																	P-32	250	0.61	2459	6.733
																	Mn-54	250	0.61	2459	6.73
																	Co-58	250	0.61	2459	6.73
																	Fe-59	250	0.61	2459	6.73
																	Co-60	250	0.61	2459	6.73
																	Zn-65	150	1.02	1476	4.04
																	Sr-89	125	1.22	1230	3.37
																	Sr-90	125	1.22	1230	3.37
																	Zr-95	200	0.76	1967	5.39
																	Nb-95	200	0.76	1967	5.39
																	Mo-99	200	0.76	1967	5.39
																	Ru-103	100	1.52	984	2.69
																	Ru-106	100	1.52	984	2.69
																	Sb-124	1	152.48	10	0.03

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Table B-1. Estimated Contaminant Migration for the 27 Sites. (Page 2 of 13).

Rpt Sec No	Disposal Facility	Time Frame	Rate (L/mo)	Area (sq m)	f Infil Rate (cm/sec)	Layer No.	Thick. (m)	Soil Type	ThetaS	Ks (cm/sec)	Theta	Moist. State	q (cm/sec)	t (sec)	T (days)	Estimated Moisture Migration (cm/day)	Constituent	Rf	Estimated Contaminant Migration (cm/day)	Contaminant Transport to WT (days)	Contaminant Transport to WT (years)
																	Sb-125	1	152.48	10	0.03
																	I-131	1	152.48	10	0.03
																	Cs-134	250	0.61	2459	6.73
																	Cs-137	250	0.61	2459	6.73
																	La-140	1000	0.15	9837	26.93
																	Ba-140	125	1.22	1230	3.37
																	Ce-141	1000	0.15	9837	26.93
																	Ce-144	1000	0.15	9837	26.93
																	Pb-210	150	1.02	1476	4.04
		fut.	4.97E+07	5574	3.39E-04	1	15	A	0.5	5.0E-03	0.28	U	3.39E-04	1.24E+06	14	104.7	iron	250	0.42	3580	9.80
																	Ru-106	100	1.05	1432	3.92
																	Pu-239	125	0.84	1790	4.90
																	Am-241	1000	0.10	14320	39.21
																	tritium	1	104.75	14	0.04
																	Sr-90	125	0.84	1790	4.90
																	Mn-54	250	0.42	3580	9.80
																	Cs-134	250	0.42	3580	9.80
																	Cs-137	250	0.42	3580	9.80
																	Co-60	250	0.42	3580	9.80
4	216-A-8 Crib		2.90E+06	1579	7.00E-05	1	7	B	0.5	1.0E-03	0.26	U	7.00E-05	2.60E+06			Sr-90	25	1.19	6055	16.58
						2	3	D	0.4	1.0E-04	0.35	U	7.00E-05	1.50E+06			Cs-137	150	0.20	36331	99.47
						3	62	A	0.5	5.0E-03	0.19	U	7.00E-05	1.68E+07			acetone	1	29.73	242	0.66
							72							2.09E+07	242	29.7	uranium	100	0.30	24221	66.31
5	216-A-29 Ditch				5.00E-05	1	2	C	0.4	5.0E-04	0.26	U	5.00E-05	1.04E+06			acetone	1	18.72	417	1.14
						2	76	B	0.5	1.0E-03	0.23	U	5.00E-05	3.50E+07			nitrate	1	18.72	417	1.14
							78							3.60E+07	417	18.7	Sr-90	125	0.15	52083	142.60
																	Cs-137	250	0.07	104167	285.19

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Table B-1. Estimated Contaminant Migration for the 27 Sites. (Page 3 of 13).

Rpt Sec No	Disposal Facility	Time Frame	Rate (L/mo)	Area (sq m)	f Infil Rate (cm/sec)	Layer No.	Thick. (m)	Soil Type	ThetaS	Ks (cm/sec)	Theta	Moist. State	q (cm/sec)	t (sec)	T (days)	Estimated Moisture Migration (cm/day)	Constituent	Rf	Estimated Contaminant Migration (cm/day)	Contaminant Transport to WT (days)	Contaminant Transport to WT (years)
																	Am-241	1000	0.02	416667	1140.77
																	Pm-147	1000	0.02	416667	1140.77
																	Pu-239	125	0.15	52083	142.60
																	uranium	10	1.87	4167	11.41
																	chloroform	1	18.72	417	1.14
																	aluminum	100	0.19	41667	114.08
																	cadmium	150	0.12	62500	171.12
																	copper	150	0.12	62500	171.12
																	iron	250	0.07	104167	285.19
																	manganese	250	0.07	104167	285.19
																	sulfate	1	18.72	417	1.14
6	216-A-30 Crib		2.04E+07	1301	5.97E-04	1	6	A	0.5	5.0E-03	0.32	U	5.97E-04	3.21E+05			Sr-90	125	0.36	22095	60.49
						2	12	B	0.5	1.0E-03	0.38	U	5.97E-04	7.63E+05			Cs-137	250	0.18	44190	120.99
						3	10	A	0.32	5.0E-03	0.32	U	5.97E-04	5.36E+05			radium	125	0.36	22095	60.49
						4	10	C	0.4	5.0E-04	0.4	S	5.00E-04	8.00E+05			uranium	10	4.53	1768	4.84
						5	3	A	0.5	5.0E-03	0.31	U	5.00E-04	1.86E+05			cerium/Pr-144	1000	0.05	176761	483.95
						6	9	B	0.5	1.0E-03	0.37	U	5.00E-04	6.66E+05			Pu-239	125	0.36	22095	60.49
						7	30	D	0.4	1.0E-04	0.4	S	1.00E-04	1.20E+07							
							80							1.53E+07	177	45.3					
7	216-A-36B Crib	T	1.26E+06	511	9.37E-05	1	93	B	0.5	1.0E-03	0.27	U	9.37E-05	2.68E+07	310	30.0	tritium	1	29.99	310	0.85
																	Sr-90	35	0.86	10852	29.71
																	Cs-137	50	0.60	15503	42.45
																	Pu-239	50	0.60	15503	42.45
																	Pu-241	50	0.60	15503	42.45
																	uranium	5	6.00	1550	4.24
																	Ru-103	1	29.99	310	0.85
																	Ru-106	1	29.99	310	0.85
																	Sn-113	50	0.60	15503	42.45

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Table B-1. Estimated Contaminant Migration for the 27 Sites. (Page 4 of 13).

Rpt Sec No	Disposal Facility	Time Frame	Rate (L/mo)	Area (sq m)	f Infil Rate (cm/sec)	Layer No.	Thick. (m)	Soil Type	ThetaS	Ks (cm/sec)	Theta	Moist. State	q (cm/sec)	t (sec)	T (days)	Estimated Moisture Migration (cm/day)	Constituent	Rf	Estimated Contaminant Migration (cm/day)	Contaminant Transport to WT (days)	Contaminant Transport to WT (years)
																	I-129	1	29.99	310	0.85
																	Pm-147	10	3.00	3101	8.49
																	Am-241	10	3.00	3101	8.49
		P	1.12E+06	511	8.34E-05	1	93	B	0.5	1.0E-03	0.26	U	8.34E-05	2.90E+07	336	27.7	tritium	1	27.71	336	0.92
																	Sr-90	35	0.79	11747	32.16
																	Cs-137	50	0.55	16782	45.95
																	Pu-239	50	0.55	16782	45.95
																	Pu-241	50	0.55	16782	45.95
																	uranium	5	5.54	1678	4.59
																	Ru-103	1	27.71	336	0.92
																	Ru-106	1	27.71	336	0.92
																	Sn-113	50	0.55	16782	45.95
																	I-129	1	27.71	336	0.92
																	Pm-147	10	2.77	3356	9.19
																	Am-241	10	2.77	3356	9.19
8	216-A-37-1 Crib		2.64E+06	650	1.55E-04	1	6	A	0.5	5.0E-03	0.24	U	1.55E-04	9.31E+05			acetone	1	32.88	243	0.67
						2	12	B	0.5	1.0E-03	0.29	U	1.55E-04	2.25E+06			2-butanone	1	32.88	243	0.67
						3	10	A	0.5	5.0E-03	0.24	U	1.55E-04	1.55E+06			tritium	1	32.88	243	0.67
						4	10	C	0.4	5.0E-04	0.33	U	1.55E-04	2.13E+06			Sr-90	35	0.94	8517	23.32
						5	3	A	0.5	5.0E-03	0.24	U	1.55E-04	4.66E+05			Ru-106	1	32.88	243	0.67
						6	9	B	0.5	1.0E-03	0.29	U	1.55E-04	1.69E+06			Cs-137	50	0.66	12167	33.31
						7	30	D	0.4	1.0E-04	0.4	S	1.00E-04	1.20E+07			aluminum	50	0.66	12167	33.31
							80							2.10E+07	243	32.9	1-butanol	1	32.88	243	0.67
9	216-A-37-2 Crib		1.33E+07	650	7.80E-04	1	6	A	0.5	5.0E-03	0.34	U	7.80E-04	2.62E+05			Sr-90	125	0.41	19545	53.51
						2	12	B	0.5	1.0E-03	0.42	U	7.80E-04	6.46E+05			Cs-137	250	0.20	39090	107.02
						3	10	A	0.5	5.0E-03	0.34	U	7.80E-04	4.36E+05			uranium	10	5.12	1564	4.28
						4	10	C	0.4	5.0E-04	0.4	S	0.005	8.00E+04			cerium/Pr-144	1000	0.05	156359	428.09

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Table B-1. Estimated Contaminant Migration for the 27 Sites. (Page 5 of 13).

Rpt Sec No	Disposal Facility	Time Frame	Rate (L/mo)	Area (sq m)	f Infil Rate (cm/sec)	Layer No.	Thick. (m)	Soil Type	ThetaS	Ks (cm/sec)	Theta	Moist. State	q (cm/sec)	t (sec)	T (days)	Estimated Moisture Migration (cm/day)	Constituent	Rf	Estimated Contaminant Migration (cm/day)	Contaminant Transport to WT (days)	Contaminant Transport to WT (years)
						5	3	A	0.5	5.0E-03	0.31	U	0.005	1.86E+04			radium	125	0.41	19545	53.51
						6	9	B	0.5	1.0E-03	0.37	U	0.005	6.66E+04			Pu-239	125	0.41	19545	53.51
						7	30	D	0.4	1.0E-04	0.4	S	0.0001	1.20E+07							–
							80							1.35E+07	156	51.2					
10	216-A-45 Crib		3.04E+06	1728	6.69E-05	1	58	C	0.4	5.0E-04	0.29	U	6.69E-05	2.51E+07			acetone	1	18.94	444	1.21
						2	26	D	0.4	1.0E-04	0.34	U	6.69E-05	1.32E+07			2-butanone	1	18.94	444	1.21
							84							3.83E+07	444	18.9	methylene chloride	1	18.94	444	1.21
																	nitrate	1	18.94	444	1.21
																	tritium	1	18.94	444	1.21
																	Ru-106	25	0.76	11090	30.36
																	I-129	1	18.94	444	1.21
																	Cs-137	250	0.08	110905	303.64
																	Pu-238	50	0.38	22181	60.73
																	Pu-239	50	0.38	22181	60.73
																	Pu-240	50	0.38	22181	60.73
																	Am-241	25	0.76	11090	30.36
																	uranium	5	3.79	2218	6.07
																	Sr-90	100	0.19	44362	121.46
																	Ru-103	25	0.76	11090	30.36
																	Pm-147	25	0.76	11090	30.36
																	Pu-241	50	0.38	22181	60.73
																	nitrite	1	18.94	444	1.21
																	fluoride	1	18.94	444	1.21
																	mercury	50	0.38	22181	60.73
11	216-B-3 Pond System		4.45E+08																		
	216-B-3		5.01E+06	142000	5.00E-05	1	12	A	0.5	5.0E-03	0.18	U	5.00E-05	4.32E+06			Sr-90	125	0.18	26736	73.20
						2	12	B	0.5	1.0E-03	0.23	U	5.00E-05	5.52E+06			Cs-137	250	0.09	53472	146.40

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Table B-1. Estimated Contaminant Migration for the 27 Sites. (Page 6 of 13).

Rpt Sec No	Disposal Facility	Time Frame	Rate (L/mo)	Area (sq m)	f Infil Rate (cm/sec)	Layer No.	Thick. (m)	Soil Type	ThetaS	Ks (cm/sec)	Theta	Moist. State	q (cm/sec)	t (sec)	T (days)	Estimated Moisture Migration (cm/day)	Constituent	Rf	Estimated Contaminant Migration (cm/day)	Contaminant Transport to WT (days)	Contaminant Transport to WT (years)
						3	24	A	0.5	5.0E-03	0.18	U	5.00E-05	8.64E+06			barium	125	0.18	26736	73.20
							48							1.85E+07	214	22.4	chloride	1	22.44	214	0.59
																	fluoride	1	22.44	214	0.59
																	manganese	250	0.09	53472	146.40
																	sulfate	1	22.44	214	0.59
																	zinc	150	0.15	32083	87.84
																	acetone	1	22.44	214	0.59
																	aluminum	100	0.22	21389	58.56
																	chromium	1	22.44	214	0.59
																	iron	250	0.09	53472	146.40
																	lead	150	0.15	32083	87.84
																	Am-241	1000	0.02	213889	585.60
																	tritium	1	22.44	214	0.59
																	uranium	10	2.24	2139	5.86
																	Co-60	250	0.09	53472	146.40
																	Pm-147	1000	0.02	213889	585.60
																	Pu-239	125	0.18	26736	73.20
																	nitrate	1	22.44	214	0.59
																	chloroform	1	22.44	214	0.59
																	cadmium	150	0.15	32083	87.84
																	copper	150	0.15	32083	87.84
	216-B-3A		1.51E+08	44500	1.29E-04	1	12	A	0.5	5.0E-03	0.23	U	1.29E-04	2.13E+06			Sr-90	125	0.37	13143	35.98
						2	12	B	0.5	1.0E-03	0.29	U	1.29E-04	2.69E+06			Cs-137	250	0.18	26285	71.97
						3	24	A	0.5	5.0E-03	0.23	U	1.29E-04	4.26E+06			barium	125	0.37	13143	35.98
							48							9.08E+06	105	45.7	chloride	1	45.65	105	0.29
																	fluoride	1	45.65	105	0.29
																	manganese	250	0.18	26285	71.97
																	sulfate	1	45.65	105	0.29
																	zinc	150	0.30	15771	43.18

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Table B-1. Estimated Contaminant Migration for the 27 Sites. (Page 7 of 13).

Rpt Sec No	Disposal Facility	Time Frame	Rate (L/mo)	Area (sq m)	f Infil Rate (cm/sec)	Layer No.	Thick. (m)	Soil Type	ThetaS	Ks (cm/sec)	Theta	Moist. State	q (cm/sec)	t (sec)	T (days)	Estimated Moisture Migration (cm/day)	Constituent	Rf	Estimated Contaminant Migration (cm/day)	Contaminant Transport to WT (days)	Contaminant Transport to WT (years)
																	acetone	1	45.65	105	0.29
																	aluminum	100	0.46	10514	28.79
																	chromium	1	45.65	105	0.29
																	iron	250	0.18	26285	71.97
																	lead	150	0.30	15771	43.18
																	Am-241	1000	0.05	105142	287.86
																	tritium	1	45.65	105	0.29
																	uranium	10	4.57	1051	2.88
																	Co-60	250	0.18	26285	71.97
																	Pm-147	1000	0.05	105142	287.86
																	Pu-239	125	0.37	13143	35.98
																	nitrate	1	45.65	105	0.29
																	chloroform	1	45.65	105	0.29
																	cadmium	150	0.30	15771	43.18
																	copper	150	0.30	15771	43.18
	216-B-3B		1.51E+08	44500	1.29E-04	1	42	A	0.5	5.0E-03	0.23	U	1.29E-04	7.46E+06	86	48.6	Sr-90	125	0.39	10796	29.56
																	Cs-137	250	0.19	21592	59.11
																	barium	125	0.39	10796	29.56
																	chloride	1	48.63	86	0.24
																	fluoride	1	48.63	86	0.24
																	manganese	250	0.19	21592	59.11
																	sulfate	1	48.63	86	0.24
																	zinc	150	0.32	12955	35.47
																	acetone	1	48.63	86	0.24
																	aluminum	100	0.49	8637	23.65
																	chromium	1	48.63	86	0.24
																	iron	250	0.19	21592	59.11
																	lead	150	0.32	12955	35.47
																	Am-241	1000	0.05	86366	236.46

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Table B-1. Estimated Contaminant Migration for the 27 Sites. (Page 8 of 13).

Rpt Sec No	Disposal Facility	Time Frame	Rate (L/mo)	Area (sq m)	f Infil Rate (cm/sec)	Layer No.	Thick. (m)	Soil Type	ThetaS	Ks (cm/sec)	Theta	Moist. State	q (cm/sec)	t (sec)	T (days)	Estimated Moisture Migration (cm/day)	Constituent	Rf	Estimated Contaminant Migration (cm/day)	Contaminant Transport to WT (days)	Contaminant Transport to WT (years)
																	tritium	1	48.63	86	0.24
																	uranium	10	4.86	864	2.36
																	Co-60	250	0.19	21592	59.11
																	Pm-147	1000	0.05	86366	236.46
																	Pu-239	125	0.39	10796	29.56
																	nitrate	1	48.63	86*	0.24
																	chloroform	1	48.63	86	0.24
																	cadmium	150	0.32	12955	35.47
																	copper	150	0.32	12955	35.47
	216-B-3C		1.38E+08	40500	1.29E-04	1	42	A	0.5	5.0E-03	0.23	U	1.29E-04	7.47E+06	86	48.6	Sr-90	125	0.39	10808	29.59
																	Cs-137	250	0.19	21616	59.18
																	barium	125	0.39	10808	29.59
																	chloride	1	48.58	86	0.24
																	fluoride	1	48.58	86	0.24
																	manganese	250	0.19	21616	59.18
																	sulfate	1	48.58	86	0.24
																	zinc	150	0.32	12970	35.51
																	acetone	1	48.58	86	0.24
																	aluminum	100	0.49	8646	23.67
																	chromium	1	48.58	86	0.24
																	iron	250	0.19	21616	59.18
																	lead	150	0.32	12970	35.51
																	Am-241	1000	0.05	86463	236.72
																	tritium	1	48.58	86	0.24
																	uranium	10	4.86	865	2.37
																	Co-60	250	0.19	21616	59.18
																	Pm-147	1000	0.05	86463	236.72
																	Pu-239	125	0.39	10808	29.59
																	nitrate	1	48.58	86	0.24

Table B-1. Estimated Contaminant Migration for the 27 Sites. (Page 9 of 13).

Rpt Sec No	Disposal Facility	Time Frame	Rate (L/mo)	Area (sq m)	f Infil Rate (cm/sec)	Layer No.	Thick. (m)	Soil Type	ThetaS	Ks (cm/sec)	Theta	Moist. State	q (cm/sec)	t (sec)	T (days)	Estimated Moisture Migration (cm/day)	Constituent	Rf	Estimated Contaminant Migration (cm/day)	Contaminant Transport to WT (days)	Contaminant Transport to WT (years)
																	chloroform	1	48.58	86	0.24
																	cadmium	150	0.32	12970	35.51
																	copper	150	0.32	12970	35.51
12	216-B-55 Crib		4.43E+06	697	2.42E-04	1	27	C	0.4	5.0E-04	0.36	U	2.42E-04	4.01E+06			Sr-90	125	0.26	33758	92.42
						2	24	D	0.4	1.0E-04	0.4	S	1.00E-04	9.60E+06			Cs-137	250	0.13	67516	184.85
						3	36	B	0.5	1.0E-03	0.27	U	1.00E-04	9.72E+06			Co-60	250	0.13	67516	184.85
							87							2.33E+07	270	32.2	Ru-106	100	0.32	27006	73.94
																	Ce-144	1000	0.03	270063	739.39
																	uranium	10	3.22	2701	7.39
13	216-B-62 Crib		1.57E+06	465	1.28E-04	1	40	C	0.4	5.0E-04	0.31	U	1.28E-04	9.66E+06			Sr-90	125	0.28	29726	81.39
						2	6	D	0.4	1.0E-04	0.4	S	1.00E-04	2.40E+06			Cs-137	250	0.14	59452	162.77
						3	8	C	0.4	5.0E-04	0.3	U	1.00E-04	2.40E+06			mercury	150	0.23	35671	97.66
						4	29	A	0.5	5.0E-03	0.21	U	1.00E-04	6.09E+06			acetone	1	34.90	238	0.65
							83							2.05E+07	238	34.9	2-butanone	1	34.90	238	0.65
																	tritium	1	34.90	238	0.65
																	uranium	10	3.49	2378	6.51
																	Co-58	250	0.14	59452	162.77
																	Co-60	250	0.14	59452	162.77
																	Ru-106	100	0.35	23781	65.11
																	Sb-125	1	34.90	238	0.65
																	Cs-134	250	0.14	59452	162.77
																	Ce-144	1000	0.03	237810	651.09
																	Eu-154	1000	0.03	237810	651.09
																	Eu-155	1000	0.03	237810	651.09
																	Am-241	1000	0.03	237810	651.09
14	216-B-63 Trench		3.01E+07	1041	1.10E-03	1	64	A	0.5	5.0E-03	0.37	U	1.10E-03	2.15E+06	25	256.8	acetone	1	256.83	25	0.07
																	chromium	1	256.83	25	0.07

Table B-1. Estimated Contaminant Migration for the 27 Sites. (Page 10 of 13).

Rpt Sec No	Disposal Facility	Time Frame	Rate (L/mo)	Area (sq m)	f Infil Rate (cm/sec)	Layer No.	Thick. (m)	Soil Type	ThetaS	Ks (cm/sec)	Theta	Moist. State	q (cm/sec)	t (sec)	T (days)	Estimated Moisture Migration (cm/day)	Constituent	Rf	Estimated Contaminant Migration (cm/day)	Contaminant Transport to WT (days)	Contaminant Transport to WT (years)
																	lead	150	1.71	3738	10.23
																	manganese	50	5.14	1246	3.41
																	Sr-90	50	5.14	1246	3.41
																	Am-241	500	0.51	12460	34.11
																	tritium	1	256.83	25	0.07
																	uranium	3.5	73.38	87	0.24
																	Co-60	50	5.14	1246	3.41
																	Cs-134	50	5.14	1246	3.41
																	Cs-137	50	5.14	1246	3.41
																	Eu-155	500	0.51	12460	34.11
																	aluminum	100	2.57	2492	6.82
																	fluoride	1	256.83	25	0.07
																	sulfate	1	256.83	25	0.07
																	iron	50	5.14	1246	3.41
																	mercury	150	1.71	3738	10.23
15	216-C-7 Crib		1.85E+02	37	1.90E-07	1	26	8	0.5	1.0E-03	0.07	U	1.90E-07	9.58E+08			none				
						2	26	D	0.4	1.0E-04	0.15	U	1.90E-07	2.05E+09							
						3	8	8	0.5	1.0E-03	0.07	U	1.90E-07	2.95E+08							
						4	7	D	0.4	1.0E-04	0.15	U	1.90E-07	5.53E+08							
						5	16	8	0.5	1.0E-03	0.07	U	1.90E-07	5.89E+08							
							83							4.4E+09	51462	0.2					
16	216-S-10 Ditch		2.59E+07	1254	7.86E-04	1	47	C	0.4	5.0E-04	0.4	S	5.00E-04	3.76E+06			Cs-137	250	0.24	24769	67.81
						2	12	D	0.4	1.0E-04	0.4	S	1.00E-04	4.80E+06			Sr-90	125	0.48	12384	33.91
							59							8.56E+06	99	59.6	Pu-239	125	0.48	12384	33.91
																	uranium	10	5.96	991	2.71
17	216-S-26 Crib		2.69E+06	390	2.63E-04	1	36	C	0.4	5.0E-04	0.36	U	2.63E-04	4.93E+06			aluminum	100	0.36	16822	46.06
						2	24	D	0.4	1.0E-04	0.4	S	1.00E-04	9.60E+06			manganese	250	0.14	42055	115.14

Table B-1. Estimated Contaminant Migration for the 27 Sites. (Page 11 of 13).

Rpt Sec No	Disposal Facility	Time Frame	Rate (L/mo)	Area (sq m)	f Infil Rate (cm/sec)	Layer No.	Thick. (m)	Soil Type	ThetaS	Ks (cm/sec)	Theta	Moist. State	q (cm/sec)	t (sec)	T (days)	Estimated Moisture Migration (cm/day)	Constituent	Rf	Estimated Contaminant Migration (cm/day)	Contaminant Transport to WT (days)	Contaminant Transport to WT (years)
							60							1.45E+07	168	35.7	uranium	10	3.57	1682	4.61
																	Co-60	250	0.14	42055	115.14
																	Sr-90	125	0.29	21028	57.57
																	Cs-137	250	0.14	42055	115.14
																	Am-241	1000	0.04	168221	460.57
18	216-T-1 Ditch		3.35E+05	502	2.54E-05	1	27	A	0.5	5.0E-03	0.16	U	2.54E-05	1.70E+07			lead	150	0.08	91103	249.43
						2	6	B	0.5	1.0E-03	0.2	U	2.54E-05	4.72E+06			manganese	250	0.05	151838	415.71
						3	11	D	0.4	1.0E-04	0.29	U	2.54E-05	1.25E+07			aluminum	100	0.12	60735	166.28
						4	29	A	0.5	5.0E-03	0.16	U	2.54E-05	1.82E+07			iron	250	0.05	151838	415.71
							73							5.25E+07	607	12.0					
19	216-T-4-2 Ditch		1.37E+06	975	5.35E-05	1	14	A	0.5	5.0E-03	0.18	U	5.35E-05	4.71E+06			aluminum	100	0.22	27923	76.45
						2	8	D	0.4	1.0E-04	0.33	U	5.35E-05	4.94E+06			iron	250	0.09	69807	191.12
						3	9	C	0.4	5.0E-04	0.26	U	5.35E-05	4.38E+06							
						4	30	A	0.5	5.0E-03	0.18	U	5.35E-05	1.01E+07							
							61							2.41E+07	279	21.8					
20	216-U-14 Ditch		3.30E+07	520	2.42E-03	1	37	A	0.5	5.0E-03	0.44	U	2.42E-03	6.74E+05			Sr-90	25	3.08	1983	5.43
						2	6	D	0.4	1.0E-04	0.4	S	1.00E-04	2.40E+06			Pu-239	100	0.77	7933	21.72
						3	18	A	0.5	5.0E-03	0.21	U	1.00E-04	3.78E+06			Cs-137	150	0.51	11899	32.58
							61							6.85E+06	79	76.9	Ce-144	500	0.15	39663	108.59
																	uranium	10	7.69	793	2.17
																	Am-241	1000	0.08	79326	217.18
																	Ru-106	200	0.38	15865	43.44
21	216-U-17 Crib		9.17E+04	139	2.51E-05	1	4	A	0.5	5.0E-03	0.15	U	2.51E-05	2.39E+06			acetone	1	8.94	794	2.17
						2	15	B	0.5	1.0E-03	0.2	U	2.51E-05	1.20E+07			mercury	10	0.89	7943	21.75
						3	10	C	0.4	5.0E-04	0.23	U	2.51E-05	9.18E+06			Co-60	1	8.94	794	2.17
						4	2	A	0.5	5.0E-03	0.15	U	2.51E-05	1.20E+06			fluoride	1	8.94	794	2.17

Table B-1. Estimated Contaminant Migration for the 27 Sites. (Page 12 of 13).

Rpt Sec No	Disposal Facility	Time Frame	Rate (L/mo)	Area (sq m)	f Infil Rate (cm/sec)	Layer No.	Thick. (m)	Soil Type	ThetaS	Ks (cm/sec)	Theta	Moist. State	q (cm/sec)	t (sec)	T (days)	Estimated Moisture Migration (cm/day)	Constituent	Rf	Estimated Contaminant Migration (cm/day)	Contaminant Transport to WT (days)	Contaminant Transport to WT (years)
						5	20	C	0.4	5.0E-04	0.23	U	2.51E-05	1.84E+07			nitrate	1	8.94	794	2.17
						6	2	D	0.4	1.0E-04	0.29	U	2.51E-05	2.31E+06			tritium	1	8.94	794	2.17
						7	10	E	0.4	5.0E-05	0.35	U	2.51E-05	1.40E+07			Sr-90	10	0.89	7943	21.75
						8	8	D	0.4	1.0E-04	0.29	U	2.51E-05	9.26E+06			U-isotopes	3.5	2.55	2780	7.61
							71							6.86E+07	794	8.9	Am-241	1	8.94	794	2.17
																	Pu-239	3.5	2.55	2780	7.61
																	Cs-137	25	0.36	19857	54.36
																	chromium	1	8.94	794	2.17
22	216-W-LWC Crib		1.20E+07	3707	1.23E-04	1	9	A	0.5	5.0E-03	0.22	U	1.23E-04	1.61E+06			cadmium	50	0.68	10565	28.93
						2	18	C	0.4	5.0E-04	0.31	U	1.23E-04	4.54E+06			chloroform	1	34.08	211	0.58
						3	14	D	0.4	1.0E-04	0.4	S	1.00E-04	5.60E+06			lead	50	0.68	10565	28.93
						4	31	A	0.5	5.0E-03	0.21	U	1.00E-04	6.51E+06			manganese	15	2.27	3169	8.68
							72							1.83E+07	211	34.1	Co-60	15	2.27	3169	8.68
																	Cs-137	250	0.14	52824	144.63
																	aluminum	100	0.34	21130	57.85
																	iron	15	2.27	3169	8.68
																	Pu-239/240	50	0.68	10565	28.93
																	Ra-228	100	0.34	21130	57.85
																	Sr-90	100	0.34	21130	57.85
																	uranium	5	6.82	1056	2.89
																	Pu-238	50	0.68	10565	28.93
																	Am-241	25	1.36	5282	14.46
																	barium	100	0.34	21130	57.85
																	chromium	1	34.08	211	0.58
																	fluoride	1	34.08	211	0.58
																	Pb-210	50	0.68	10565	28.93
23	216-Z-20 Crib		3.47E+07	1412	9.36E-04	1	43	A	0.5	5.0E-03	0.36	U	9.36E-04	1.65E+06			acetone	1	49.78	121	0.33
						2	6	E	0.4	5.0E-05	0.4	S	5.00E-05	4.80E+06			Co-60	250	0.20	30131	82.49

Table B-1. Estimated Contaminant Migration for the 27 Sites. (Page 13 of 13).

Rpt Sec No	Disposal Facility	Time Frame	Rate (L/mo)	Area (sq m)	f Infil Rate (cm/sec)	Layer No.	Thick. (m)	Soil Type	ThetaS	Ks (cm/sec)	Theta	Moist. State	q (cm/sec)	t (sec)	T (days)	Estimated Moisture Migration (cm/day)	Constituent	Rf	Estimated Contaminant Migration (cm/day)	Contaminant Transport to WT (days)	Contaminant Transport to WT (years)
						3	11	A	0.5	5.0E-03	0.18	U	5.00E-05	3.96E+06			Sr-90	125	0.40	15065	41.25
							60							1.04E+07	121	49.8	Cs-134	250	0.20	30131	82.49
																	Cs-137	250	0.20	30131	82.49
																	Am-241	1000	0.05	120523	329.97
																	Pu-238	125	0.40	15065	41.25
																	Pu-239	125	0.40	15065	41.25
																	Pu-241	125	0.40	15065	41.25
																	uranium	10	4.98	1205	3.30
																	aluminum	100	0.50	12052	33.00
24	200W Powerhouse Pond		2.38E+07	3642	2.49E-04	1	18	A	0.5	5.0E-03	0.26	U	2.49E-04	1.88E+06			barium	50	0.62	10020	27.43
						2	9	B	0.5	1.0E-03	0.33	U	2.49E-04	1.19E+06			chloride	1	30.94	200	0.55
						3	8	D	0.4	1.0E-04	0.4	S	1.00E-04	3.20E+06			fluoride	1	30.94	200	0.55
						4	3	E	0.4	5.0E-05	0.4	S	5.00E-05	2.40E+06			lead	150	0.21	30060	82.30
						5	24	A	0.5	5.0E-03	0.18	U	5.00E-05	8.64E+06			manganese	50	0.62	10020	27.43
							62							1.73E+07	200	30.9	aluminum	100	0.31	20040	54.87
																	iron	50	0.62	10020	27.43
25	2101-M Pond		1.27E+06	93	5.22E-04	1	67	B	0.5	1.0E-03	0.31	U	5.22E-04	3.98E+06			aluminum	100	1.37	6883	18.85
						2	27	A	0.5	5.0E-03	0.38	U	5.22E-04	1.97E+06			iron	250	0.55	17209	47.11
							94							5.95E+06	69	136.6					
26	300 Process Trenches		3.45E+08	2852	4.61E-03	1	7	A	0.5	5.0E-03	0.49	U	4.61E-03	7.45E+04	1	812.0	aluminum	100	8.12	86	0.236
																	silver	150	5.41	129	0.354
																	uranium-234	10	81.20	9	0.024
																	uranium-238	10	81.20	9	0.024
27	400 Area Pond		1.89E+06	929	7.75E-05	1	32	C	0.4	5.0E-04	0.29	U	7.75E-05	1.20E+07	139	23.1	none				

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APPENDIX C

TRANSPORT CHARACTERISTICS

A literature review was performed to assess the transport characteristics of the radionuclides and chemical constituents identified in the Waste Stream Characterization Report (WHC 1989). The study was performed by L. L. Ames and R. J. Serne of the Pacific Northwest Laboratory. Contained in this appendix is a summary of their findings. A topical report that details this work is scheduled to be prepared in the future.

Contained herein is a best estimate on the transport potential for constituents identified in the 33 wastestreams. Specifically, the potential for migration is quantified through the use of three geochemical parameters: water solubility, an adsorption distribution coefficient, and a persistence factor (radiogenic or biological half-life). The wastestream constituents include radionuclides and both inorganic and organic chemicals.

C.1 CONSTITUENTS

C.1.1 Radionuclides

The distribution of radionuclides found in the 33 wastestreams is provided in Table C-1. The radionuclide occurrence frequency is shown for the samples collected. The fission and activation products ^{137}Cs, ^{239}Pu, and ^{90}Sr are the most prevalent. As presented in Table C-2, most of the radioactivity is concentrated in four wastestreams. Although the N Reactor effluent stream (105N cooling water and fuel basin water) contained more than half of the total radioactivity in the 33 wastestreams, this wastestream is operating at a reduced volume, and the quantity of radionuclides discharged has dropped significantly since reactor operation ceased in January 1987.

C.1.2 Inorganic Chemicals

A total of 33 inorganic constituents constitute the bulk of the inorganic materials (irrespective of radionuclides) reported as occurring in the 33 wastestreams. These are given in Table C-3 in terms of analytical reporting frequency. Uranium, classifiable as a radionuclide or a heavy metal, was the most frequently reported analyte, with sodium, calcium, and potassium nearly as frequent. Magnesium and zinc, a common rust-inhibiting coating applied to nuts, bolts, pipes, and other steel hardware exposed to moisture, are also commonly found. Of more interest to determining environmental fate is the total wastestream content of inorganics as shown in Table C-4. For comparison, Hanford groundwater and Columbia River water range from 7E-03 to 1E-03 M. Most of the wastestreams are more dilute than these natural waters. Note that the powerplant wastewaters were among the highest in total dissolved inorganics. Only three of the wastestreams show average field pH values less than 6.0, and all wastestreams have a pH greater than 5.2.

C.1.3 Organic Chemicals

There are 51 organic constituents identified at least twice in analyses of the 33 wastestreams. These constituents and their frequency are listed in Table C-5. Note that chloroform was the most prevalent organic analyte even though it is not used in any of the chemical processes at Hanford (Jungfleisch 1988). The chlorination of natural waters has been shown to commonly produce chloroform as well as other halogenated hydrocarbons (Dowty et al. 1975, Rook 1977, Larson and Rockwell 1979, Norwood et al. 1980). Of these constituents, chloroform and the phthalates are considered carcinogens (Ecology 1987).

The wastestreams containing the highest concentrations of organic analytes are shown in Table C-6. The PUREX process condensate stream contains the highest concentration of organics.

In addition to the organic analyte content of the 33 wastestream listed in Table C-5, there is a considerable volume of data on organic compounds found in groundwaters from wells associated with the wastestream disposal sites. For example, Table C-7 gives the analytical data on three 200 West Area wellwater samples. There is also a large amount of wellwater sample analytical data reported (WHC 1989) associated with the ground disposal of the 33 wastestreams. The origins, uses, and degradation sequences of organic extractants and solvents used to purify uranium and plutonium and their degradation products are found in Lane (1960), Blake et al. (1963), Huggard and Warner (1963), Gaumann et al. (1972), Nowak (1971), Lane (1963), Burr (1958), and the PUREX Operations Manual (GE 1955).

C.2 SEDIMENT INTERACTIONS

Cation exchange capacity (CEC) is one of the more important soil characteristics associated with determining the fate of constituents for liquid wastes disposed into sediments. The typical Hanford sediments are high in sand content with an average CEC of 4.3 meq/100 g and an average organic carbon content (OC) of slightly less than 0.10 wt%. The organic carbon content of the soil/sediment is important because neutral hydrophobic organic compounds have been shown to adsorb preferentially onto the organic carbon content of the soil (Lambert et al. 1965, Briggs 1973).

Once the liquid wastes contact the vadose zone sediments, they may chemically interact with the soils and sediments. The major geochemical processes affecting transport include: dissolution/precipitation, adsorption/desorption, filtration of colloids and small suspended particles, diffusion into micropores within mineral grains, and volatilization and eventual escape to the atmosphere. The former two processes are considered more important for the inorganic wastes present in the 33 wastestreams. Volatilization should also be considered when assessing the organics in the wastestreams. Further, for the Hanford Site low-level waste disposal application, precipitation is likely significant only for cases where pH and/or reduction-oxidation changes occur when wastestream contact the sediments. In most active Hanford Site liquid discharge situations, it is speculated that adsorption processes are the key to

inorganic contaminant migration. The knowledge base for the environmental fate of organics identified in the wastes is meager and therefore, an opinion on what specific process likely dominates their fate cannot be specified with any certainty.

Adsorption reactions have been acknowledged as the most important contaminant retardation process in far-field transport analyses for hazardous waste disposal options. Adsorption processes are known to retard the migration of some constituents, thereby increasing the travel times for these constituents by 1E+03 to 1E+06 times relative to the groundwater movement. Such long travel times allow nuclides to decay to lower concentrations and less hazardous nuclides before reaching the accessible environment (i.e., the biosphere). Furthermore, some adsorption processes are effectively irreversible and permanently prevent contaminants from reaching the groundwater, thus preventing their release to the biosphere.

In the constant distribution coefficient (R_d) model, the distribution of the contaminant of interest between the solid adsorbent and solution is assumed to be a constant value. There is no explicit accommodation of dependence on characteristics of the sediments, groundwater, or contaminant concentration. Typically, an R_d value for a given contaminant is determined in the laboratory using sediment from the study area and actual or simulated groundwater to which a radionuclide tracer is added at some trace concentration. Then,

$$R_d = \frac{\text{amount of radionuclide adsorbed on solid per gram}}{\text{amount of radionuclide in solution per milliliter}} \quad (1)$$

The term "trace" typically denotes that a low mass is added, but the tracer mass or activity must be sufficient to facilitate good counting statistics. The experiments are often equilibrated by contacting the solid with several aliquots of the water before adding the radiotracer, to attempt to approach the condition expected in the field. Several standardized laboratory techniques (ASTM 1984, Serne and Relyea 1983) are commonly used to determine this ratio.

Most of the laboratory experiments performed to measure distribution coefficients (K_d) do not systematically investigate the effect of important parameters and do not attempt to identify the processes causing the observed adsorption. Because it is an empirical measurement, the constant distribution coefficient, R_d, value does not necessarily denote an equilibrium value or require some of the other assumptions inherent in the more rigorous use of the term distribution coefficient K_d. The term "R_d" is used as simply the observed distribution ratio of nuclide between the solid and solution. The term "K_d" is reserved for true equilibrium reactions that show reversibility and further do not yield a distribution ratio that is dependent on the tracer concentration in solution.

Furthermore, it is customary with the R_d model to measure the total concentration or radioactivity of the tracer and thus to treat the tracer as being one species. This assumption is not an inherent requirement, but it is generally applied for convenience. If it is known that the tracer distributes among several species and the distribution can be measured or

predicted, separate R_d values can be and should be calculated for each species.

This conceptual model, which depends on experimental determination of R_d, is quite simple, but it is also limited in that it does not address sensitivity to changing conditions. If the groundwater properties (e.g., pH, dissolved solids content) change, a new experiment must be performed.

The R_d model is mathematically very simple and readily incorporated into transport models and codes via the retardation factor term. That is, for porous flow

$$R_f = 1 + \frac{\rho_b}{n_e} R_d \qquad (2)$$

where:

R_f = retardation factor

ρ_b = porous media bulk density (mass/length)

n_e = effective porosity at saturation of media

R_d = constant distribution coefficient.

For the R_d model, the R_f is a constant for each layer of geologic media (each layer is assumed to have a constant bulk density and saturated effective porosity). Thus, this transport equation does not require knowledge of any other parameters such as pH or surface area, and it is easily solved to determine the solution concentration as a function of time at any given point. It is the use of the R_d conceptualization in the R_f that has caused most of the criticism. Few natural groundwater pathways are spatially or geochemically homogeneous to the extent that the R_f for a species remains constant.

C.3 DATA SUMMARY

The liquid effluent wastestream types are categorized using five parameters: (1) volume (whether the wastestream represents a large or small discharge); (2) dissolved solids content (whether the wastestream has greater than or less than 10^{-2}M dissolved salts); (3) pH (whether the wastestream is acidic or basic); (4) radionuclide content (whether the wastestream contains greater than or less than 1% of the total quantity of radionuclides discharged); and (5) organic content (whether the wastestream contains greater than or less than 2 mg/L organics).

Table C-8 lists the 33 wastestreams and their shorthand designation (A.1 to A.33). Table C-9 places each wastestream in one of the 32 categories based on the five parameters chosen to describe the wastestream. In general, migration potential and resultant hazard increases for wastestream categorized as high volume, high dissolved solids, high organics, high radionuclide activity, and acidic pH. Conversely, wastestream with low values for volume, dissolved solids, radioactivity, organics, and a basic pH are not likely to promote migration of contaminants.

Most of the wastestreams are found in the categories that do not promote migration. Wastestreams A.3, A.4, A.7, A.8, A.10 to A.13, A.15, A.18, A.26 to A.28, and A.33 have low values for all of the designated parameters. Wastestreams A.14, A.16, A.19, A.22, A.25, and A.32 are low in all parameters but discharge volume. The designated "low value" wastestreams represent chemical sewerage, steam and process condensates, cooling waters, and miscellaneous laboratory wastewaters.

Three wastestreams have three high values and two low values for the five designated parameters. Generally, these three streams may warrant closer scrutiny than all of the others. The three wastestreams are (1) the PUREX ammonia scrubber condensate with high volume, high dissolved solids and high organic content; (2) UO_3 Plant process condensate with high dissolved solids, high organics, and acid pH; and (3) 242-A evaporator process condensate with high dissolved solids, high organics, and high radionuclide content.

C.3.1 Distribution Coefficients for Inorganics and Radionuclides

Tables C-10 through C-24 provide "expert-opinion" estimates for R_d values for selected inorganic and radionuclide constituents found in the 33 wastestreams. R_d values are presented for each of eight waste categories based on the nature of the wastestream's pH, total dissolved solids content, and organic content.

The R_d tables provide estimates for each wastestream category for a typical Hanford sediment. Accurate R_d values require actual testing on site-specific sediments and the specific wastestream of interest. The R_d values in the tables represent a conservative estimate to use for scoping performance assessment calculations (enclosed by parentheses) and an estimate of the range in values. When a specific reference that provides data on a Hanford sediment and liquid waste similar to one of the 33 discharges is available, it is cited. Where no citations are given, on experience and general knowledge of contaminant-sediment interactions were used (e.g., Serne and Wood 1990, Ames and Rai 1978, Coughtrey et al. 1983-1986).

C.3.2 Distribution Coefficients for Organics

The process affecting migration rates of both organic and inorganic compounds are given in Table C-25. Volatilization can be an important exchange process between a compound dissolved in solution and vaporized in the atmosphere. Organic compounds with high vapor pressures and low water solubilities are most susceptible to volatilization (for example, aliphatic hydrocarbons, monocyclic aromatics, and some nitrogen-substituted compounds). The magnitude of Henry's Law constant is used as an indicator of compound volatility because it accounts for compound water solubility and vapor pressure. However, quantitative measurement of compound volatility also must take into account wind velocity, water turbulence, and temperature. Photolysis is another example of a transformation process that depends on compound properties and environmental conditions. The degree of photolysis is dependent on the amount of light a chemical can absorb and the efficiency with which it uses that energy as well as sunlight intensity,

cloud cover, time of day, season, latitude, ozone layer thickness, and water turbidity. The transformation processes shown in Table C-25 are quantified using parameters shown in Table C-26.

The migration behavior of organic compounds in the environment is primarily a result of the interaction between the physical and chemical properties of the compound and sorbent. The effect of these properties in the water and sediment column may be subject to changes as variables such as pH, Eh, other dissolved organics and inorganics, temperature, and water hydrodynamics vary. Table C-27 lists some important reaction mechanisms controlling the transformations and removal processes for the different organic compound groups. For some groups such as halogenated aliphatic hydrocarbons, a single property dominates the transformation mechanism. The fate of many organic compounds is more complex and depends on competing processes which vary in importance depending on compound properties and prevailing environmental conditions. For example, monocyclic aromatics are susceptible to either volatilization followed by atmospheric photolysis or sorption followed by bioaccumulation. The pair of transformation processes that control compound persistence may vary with environmental factors such as wind speed, temperature, and availability of particulates in the water column for sorption.

The presence of solvents other than water can alter an organic compound's water solubility. Hence, the presence of cosolutes must be considered when attempting to predict the transport of organic contaminants through the hydrogeology. In general, sediment contaminated with low water-solubility organics tends to bind other soluble organics to the organic carbon fraction of the sediment. However, if existing sorbed organics are contacted by other low water-solubility (hydrophobic) organics (cosolvents), the existing organics may be mobilized in the cosolvents.

Data on transformation (e.g., biological degradation) of organic compounds in water and sediments are available in many cases, but are not very useful for predicting fate at Hanford because of the numerous uncertainties involved, deriving from the influences of many environmental factors on transformation or degradation rates. The environmental factors include the presence, number, and species of organisms in the sediments, sediment pH, sediment type, moisture content, and temperature of the environment.

Degradation rates or organic compounds' half-lives tend to be specific for a given environment and often cover a wide range of values for the same organic. Because the bulk of the half-lives given in the literature lack Hanford Site applicability, the values listed in Appendix C should not be given much credence because none were obtained in environments germane to Hanford. Rather, the biological half-life information should be considered as qualitative guidance.

The soil/sediment partition coefficient, K_{oc}, is defined as the ratio of adsorbed organic chemical per unit weight of organic carbon content of the sediment to the aqueous solute concentration. K_{oc} has units of volume/weight just like R_d. In fact, R_d values are the product of K_{oc} * f_{oc}, where f_{oc} is the fractional weight of organic carbon in the sediment. For typical Hanford sediments, f_{oc} = 0.001. Organic compounds that bind strongly to organic carbon have characteristically low water solubilities. Likewise organic compounds with low tendency to sorb onto organic carbon

have high water solubilities. Organics that sorb onto organic materials, if present in an aquifer, are retarded in their movement in respect to the groundwater.

The $K_{o/w}$ of an organic solute is the n-octanol/water partition coefficient and is defined as the equilibrium ratio of the solute concentration in the water-saturated n-octanol phase to the solute concentration in the n-octanol-saturated water phase. $K_{o/w}$ values are unitless. For ionizable organic compounds (acids, amines and phenols), $K_{o/w}$ values are a function of pH. If a $K_{o/w}$ value is reported for an ionizable compound, the pH also should be reported for the $K_{o/w}$ to be useful (see Means et al. 1982). Karickhoff et al. (1979) reported, for sorption based on an organic carbon basis (K_{oc}), a significant correlation between the adsorption of several aromatic hydrocarbons and the partitioning of the aromatic hydrocarbons between octanol and water ($K_{o/w}$),

$$\log K_{oc} = 1.00 \log K_{o/w} - 0.21 \quad (R_f^2 = 1.00) \tag{3}$$

where R_f^2 was the least-squares linear regression coefficient of determination. Linear least-squares fitting of the $K_{o/w}$ and K_{oc} data from a series of polycyclic aromatics and chlorinated hydrocarbons ranging in water solubility from 1 ppb to 1,000 ppm gave the equation $K_{oc} = 0.63\ K_{o/w}$ ($R_f^2 = 0.96$). Unfortunately, as Means et al. (1982) point out, the above relationship is applicable only to hydrophobic, nonionizable organic compounds, and sediments containing more than 1 wt% organic carbon content. As discussed previously, Hanford sediments are very low in organic carbon, generally containing less than 0.10 wt%. Hence, the above $K_{o/w}$ and K_{oc} relationships are not applicable to Hanford conditions.

The Henry's Law constant, sometimes referred to as the air-water partition coefficient, is defined as the ratio of the partial pressure of a compound in air to the concentration of the compound in water under equilibrium conditions. If the vapor pressure and water solubility of a compound are known, Henry's Law constant can be calculated at one atmosphere (760 mm mercury) as:

$$H = \frac{(P)\ (S)}{(760)\ (FW)} \tag{4}$$

where:

H = Henry's Law constant ($atm*m^3/mol$)
P = compound's vapor pressure (mm mercury at 25°C)
S = water solubility (g/L)
FW = compound's formula weight (g/mol).

According to Lyman et al. (1982), if H is less than 1E-07 $atm*m^3/mol$, the substance has low volatility. If H is greater than 1E0-7 but less than 1E-05 $atm*m^3/mol$, the substance will volatilize slowly. Volatilization becomes an important transfer mechanism when H is between 1E-05 and 1E-03 $atm*m^3/mol$. When H is larger than 10^{-3} $atm*m^3/mol$, volatilization becomes a principal transfer mechanism. Estimating the Henry's Law constant for many compounds assumes that the gas phase obeys the ideal gas law and that the

aqueous solution acts as an ideal dilute solution. Neither of these assumptions always hold. Also, the solubility and vapor pressure data used in equation (4) are generally obtained from the pure substance. Many contaminants are not derived from pure substances and often vapor pressure and solubility data are obtained without regard to standard states and temperatures.

The data presented herein, Henry's Law constants, water solubilities and degradation rates for the organic chemicals were mainly obtained from two computer data banks. The two data bases are the Soil Transport and Fate Data Base available from Utah State University, Department of Civil and Environmental Engineering (Sims et al. 1988) and Syracuse Research Corporation's Environmental Fate Data Base as described in Howard (1986).

The adsorption, water solubility, volatilization (Henry's Law constants), and degradation tendencies for those organic compounds identified in Table C-5 are presented in Table C-28. When no data were found in the literature, estimates were made qualitatively whether the compound would exhibit high, medium, or low adsorption, water solubility, volatility or degradation rates in Hanford Site sediments containing solution representative of the 33 wastestreams.

Based on the organic carbon content in the sediments (0.1 wt%) and K_{oc} values in the literature, Hanford-specific R_d values were estimated for the most prevalent organic analytes. The results are shown in Table C-28. The R_d data are given to show trends only. As mentioned previously, R_d values computed from K_{oc} values for soils containing less than 1.0 wt% organic carbon are speculative.

Table C-1. Radionuclide Reporting Frequency (N) in the 33 Wastestreams by WHC (1989).

Measurement	N	Measurement	N
Gross β	1,745	I-133	61
Cs-137	1,006	Xe-135	60
Pu-239	941	I-135	59
Sr-90	900	Na-24	53
H-3	803	Eu-155	51
Gross α	717	Kr-85	46
Co-60	509	KrRb-88	41
Mn-54	464	Mn-56	40
Ce-144	321	Cs-138	40
Total U	279	Np-239	40
Nb-95	254	Sr-91	34
Ru-103	254	Eu-154	31
Pu-238	243	Sn-113	30
Fe-59	214	Sb-125	28
Zr-95	200	Sm-153	27
La-140	190	I-129	24
Ce-141	175	Zn-65	24
I-131	155	Kr-87	24
Cs-134	146	Sb-125	22
Pu-241	137	ZrNb-97	16
P-32	136	U-234	13
Co-58	130	U-235	13
Mo-99	130	U-238	13
Sr-89	121	Ag-110m	10
Ba-140	118	Tc-99	5
Ru-106	117	Sb-122	3
Pm-147	114	U-236	2
Cr-51	87	Ar-41	1
Am-241	84	Mixed Fission Products	1
I-132	80		
Xe-134	64		

Table C-2. Wastestreams with the Bulk of the Total Radioactivity in the 33 Wastestreams.

Wastestream	Total activity, Ci/yr	Percent of total activity
N Reactor effluent (1976-1988)	2,400	54.00
PUREX process condensate	1,500	35.00
242-A evaporator cooling water	280	6.30
242-A evaporator process condensate	150	3.50
Total	4,330	98.80

Table C-3. Inorganic Analyte Reporting Frequency (N) for the 33 Wastestream Analyses Reported by WHC (1989).

Analyte	N	Analyte	N
Uranium	314	Mercury	97
Sodium	310	Silicon	74
Calcium	307	Lead	61
Potassium	300	Nickel	43
Zinc	285	Cadmium	39
Magnesium	281	Chromium	38
Sulfate	277	Vanadium	33
Barium	265	Phosphate	24
Chloride	250	Sulfide	16
Iron	227	Beryllium	5
Fluoride	178	Silver	4
Manganese	171	Lithium	2
Copper	155	Arsenic	1
Nitrate	146	Antimony	1
Strontium	136	Tin	1
Aluminum	128	Titanium	1
Ammonium	124		

Table C-4. Wastestream Inorganic Analyte Content and Mean Field pH on WHC (1989a) Reported Data.

Waste Stream	Total Inorganics, M	Field Mean pH
N Reactor effluent	2.98E-04	7.8
163N Demineralization Plant wastewater	1.27E-02	6.1
183-D Filter backwash wastewater	6.09E-03	6.3
PUREX Plant chemical sewer	5.74E-03	6.2
PUREX Plant process condensate	2.39E-03	6.6
PUREX Plant ammonia scrubber condensate	2.05E-02	9.3
PUREX Plant steam condensate	6.20E-04	6.1
PUREX Plant cooling water	8.29E-04	6.7
B Plant chemical sewer	1.07E-01	7.4
B Plant process condensate	1.57E-04	8.2
B Plant steam condensate	2.70E-05	6.3
B Plant cooling water	7.71E-04	6.8
Plutonium Finishing Plant wastewater	1.05E-03	6.4
S Plant wastewater	7.40E-04	6.6
T Plant laboratory wastewater	3.68E-04	6.8
T Plant wastewater	7.11E-04	6.3
UO_3 Plant process condensate	1.58E-01	5.8
UO_3/U Plant wastewater	7.39E-04	6.6
241-A Tank Farm cooling water	8.65E-04	6.4
241-AY/AZ Tank Farms steam condensate	3.99E-05	5.2
242-A Evaporator process condensate	2.09E-02	10.4
242-A Evaporator steam condensate	4.15E-04	6.1
242-A Evaporator cooling water	7.76E-04	6.2
242-S Evaporator steam condensate	7.71E-04	5.7
244-AR Vault cooling water	7.80E-04	6.8
209-E Laboratory reflector water	8.01E-04	7.3
222-S Laboratory wastewater	7.27E-04	6.3
2101-M Laboratory wastewater	5.71E-04	6.2
2724-W Laundry wastewater	6.55E-03	9.1
284-E Powerplant wastewater	5.43E-01	8.3
284-W Powerplant wastewater	1.52E0	8.2
300 Area process wastewater	8.93E-04	6.0
400 Area secondary cooling water	6.74E-03	8.0

Table C-5. Analytical Frequency (N) for the Organic Analytes Reported by WHC (1989).

Organic Analyte	N	Organic Analyte	N
Chloroform	153	3,5-dimethylpyridine	3
Acetone	97	Ethyl alcohol	3
Butyl alcohol	44	Heptadecane	3
Tributylphosphate	39	Hexadecane	3
Methylethylketone	35	Hexadecanoic acid	3
Tridecane	31	Methyl formate	3
2-butoxyethanol	30	Acetophenone	2
Tetradecane	30	Benzaldehyde	2
Tetrahydrofuran	26	Butoxydiglycol	2
Butoxyglycol	21	Butylbenzl phthalate	2
Methyl-n-butyl ketone	19	Decane	2
Butyraldehyde	17	Di-n-butyl phthalate	2
Bis (ethylhexyl) phthalate	16	Dichlorofluoromethane	2
Benzl alcohol	13	Dimethoxymethane	2
2-propanol	12	Dimethylnitrosoamine	2
MIBK (hexone)	11	Di-n-octyl phthalate	2
Dodecane	9	Methoxydiglycol	2
Methylene chloride	9	Methoxytriglycol	2
Methyl n-propyl ketone	8	2-methylnonane	2
Butrylnitrate	7	2-methl-5-propylnonane	2
Methyl nitrate	6	Morpholine	2
Pentadecane	6	Pelargic acid	2
Phenol	6	Phenanthrene	2
N-methoxymethanamine	5	Tetrachloroethylene	2
Ethoxytriethylene glycol	4	Undecane	2
Benzoic acid	3		

Table C-6. Wastestreams Containing the Largest Contents of Organic Analytes Reported by WHC (1989).

Waste Stream	Total Organic Contents, ppb
Purex Process Condensate	240,945
242-A Evaporator Process Condensate	24
2724-W Laundry Wastewater	8,962
UO_3 Plant Process Condensate	2,465
2101-M Laboratory Wastewater	737
UO_3/U Plants Wastewater	510
B Plant Process Condensate	485
Plutonium Finishing Plant Wastewater	421
B Plant Chemical Sewer	195
241-AY, 241-AZ Tank Farms Steam Condensate	99

Table C-7. Organic Analytes Reported in Three 200 West Area Wellwater Samples.

Organic Analyte	Concentration, ppb		
	Well 699-38-70	Well R699-35-78	Well 699-49-79
	Volatile Compounds		
Carbon Tetrachloride	5.95	---	---
Chloroform	13.56	0.33	81.90
Dichloromethane	2.94	1.15	0.29
Trichloroethylene	0.90	---	---
Cyclohexane	0.71	---	---
Methylcyclohexane	12.91	---	20.48
Toluene	9.51	---	---
2-Butoxyethanol	11.33	---	---
2-Ethyl-1-Hexanol	2.56	---	---
	Solvent Extractable Compounds		
Tri-N-Butylphosphate (TBP)	3	---	---
Di-n-octyladipate	---	590	---
Bis(2-ethylhexyl)phthalate	2	---	2
Di-n-octylphthalate	---	8	---
Phthalates, mixed	---	140	10
	Chelating Agents		
Ethylenediaminetetraacetic acid (EDTA)	≤0.1	---	≤0.1

Table C-8. Wastestream Identification.

Designation	Wastestream
A.1	N Reactor effluent
A.2	163N Demineralization Plant wastewater
A.3	183-D Filter backwash wastewater
A.4	PUREX Plant chemical sewer
A.5	PUREX Plant process condensate
A.6	PUREX Plant ammonia scrubber condensate
A.7	PUREX Plant steam condensate
A.8	PUREX Plant cooling water
A.9	B Plant chemical sewer
A.10	B Plant process condensate
A.11	B Plant condensate
A.12	B Plant cooling water
A.13	Plutonium Finishing Plant wastewater
A.14	S Plant wastewater
A.15	T Plant Laboratory wastewater
A.16	T Plant wastewater
A.17	UO_3 Plant process condensate
A.18	UO_3/U Plant wastewater
A.19	241-A Tank Farm cooling water
A.20	241-AY/AZ Tank Farms steam condensate
A.21	242-A Evaporator process condensate
A.22	242-A Evaporator steam condensate
A.23	242-A Evaporator cooling water
A.24	242-A Evaporator steam condensate
A.25	244-AR Vault cooling water
A.26	209-E Laboratory reflector water
A.27	222-S Laboratory wastewater
A.28	2101-M Laboratory wastewater
A.29	2724-W Laundry wastewater
A.30	284-E Powerplant wastewater
A.31	284-W Powerplant wastewater
A.32	300 Area process wastewater
A.33	400 Area secondary cooling water

Table C-9. Classification of Wastestreams Based on Five Key Parameters.

		HIGH VOLUME (>2.0% of total)				LOW VOLUME			
		HIGH DISSOLVED SOLIDS (>10^{-2}M)		LOW DISSOLVED SOLIDS		HIGH DISSOLVED SOLIDS		LOW DISSOLVED SOLIDS	
		HIGH ORGANICS (>2000PPB)	LOW ORGANICS	HIGH ORGANICS	LOW ORGANICS	HIGH ORGANICS	LOW ORGANICS	HIGH ORGANICS	LOW ORGANICS
NEUTRAL TO BASIC pH	LOW ACTIVITY	A.6	A.9, A.30, A.31		A.14, A.16, A.19, A.22, A.25, A.32		A.2	A.29	A.3, A.4, A.7 A.8, A.10, A.11 A.12, A.13, A.15, A.18, A.26, A.27, A.28, A.33
NEUTRAL TO BASIC pH	HIGH ACTIVITY				A.23	A.21		A.5	A.1
ACIDIC pH (<6.0)	LOW ACTIVITY				A.24	A.17			A.20
ACIDIC pH (<6.0)	HIGH ACTIVITY (>1% of total)								

Table C-10. R_d Estimates (mL/g) for Beryllium, Calcium, and Magnesium.

	HIGH SALT (>1X10^{-2}M)		LOW SALT	
	High Organic (>2000ppb)	Low Organic	High Organic	Low Organic
NEUTRAL TO BASIC pH	3-15 (5)	7-70 (7.5)	15-70 (15)	15-200 (20)
ACID pH (<6.0)	0.1-5 (1.5)	0.5-15 (3.5)	3-15 (7.5)	7-15 (10)

Table C-11. R_d Estimates (mL/g) for Strontium and Barium.

	HIGH SALT (>1X10^{-2}M)		LOW SALT	
	High Organic (>2000ppb)	Low Organic	High Organic	Low Organic
NEUTRAL TO BASIC pH	5-20 (7) Rhodes (1956); Routson et. al (1981)	10-100 (10) Routson et. al (1981)	20-100 (20)	20-200 (25) McHenry (1958) Rhodes (1956); Routson et. al (1981)
ACID pH (<6.0)	0.1-5 (2) Knoll (1969)	0.5-20 (5) Hawkins and Short (1985)	5-15 (10)	50-20 (5) Rhodes (1957a)

Table C-12. R_d Estimates (mL/g) for Lithium, Potassium, Sodium, and Ammonium.

	HIGH SALT (>1X10^{-2}M)		LOW SALT	
	High Organic (>2000ppb)	Low Organic	High Organic	Low Organic
NEUTRAL TO BASIC pH	0-30 (1)	0-30 (2)	1-30 (2)	1-30 (4) Buelt et al. (1988)
ACID PH (<6.0)	0-10 (0)	0-10 (0)	0-10 (0)	0-10 (1)

Table C-13. R_d Estimates (mL/g) for Cobalt, Iron, and Manganese.

	HIGH SALT (>1X10^{-2}M)		LOW SALT	
	High Organic (>2000ppb)	Low Organic	High Organic	Low Organic
NEUTRAL TO BASIC pH	0.1-10 (3) Haney (1967) Barney (1978)	5-20 (10) Routson et al. (1981)	0.1-10 (3) Wilding and Rhodes (1963)	10-3000 (50) Routson et al. (1981)
ACID pH (≤6.0)	0 Rhodes and Nelson (1957) Haney (1957)	0.2-20 (5)	0	0.2-20 (5)

Table C-14. R_d Estimates (mL/g) for Lead, Zinc, Cadmium, Copper, Nickel, Silver, and Mercury.

	HIGH SALT (>1X10^{-2}M)		LOW SALT	
	High Organic (>2000ppb)	Low Organic	High Organic	Low Organic
NEUTRAL TO BASIC pH	0-100 (10)	0-200 (30)	0-200 (10)	100-200 (30)
ACID PH (<6.0)	0-10 (2)	(5-50) (6)	0-40 (2)	10-100 (10)

Table C-15. R_d Estimates (mL/g) for Antimony, Molybdenum, and Sulfide.

	HIGH SALT (>1X10^{-2}M)		LOW SALT	
	High Organic (>2000ppb)	Low Organic	High Organic	Low Organic
NEUTRAL TO BASIC pH	0-2 (0)	0-5 (0) Ames and Rai (1978) Haney (1967)	0-2 (0)	0-40 (0)
ACID pH (<6.0)	0-5 (0)	(2-20) (2)	0-5 (0)	2-40 (2)

Table C-16. R_d Estimates (mL/g) for Zirconium, Niobium, and Tin.

	HIGH SALT (>1X10^{-2}M)		LOW SALT	
	High Organic (>2000ppb)	Low Organic	High Organic	Low Organic
NEUTRAL TO BASIC pH	0-30 (10) Prout (1959)	20-500 (20)	2-20 (10)	10-1000 (40) Rhodes (1957a)
ACID pH (<6.0)	0-10 (5) Prout (1959)	10-500 (10)	2-20 (5)	10-1000 (20) Rhodes (1957a)

Table C-17. R_d Estimates (mL/g) for Chromium(VI), Tritium, Technetium, Chloride, Fluoride, Iodine, Sulfate, Nitrate, Xenon, Krypton, and Argon.

	HIGH SALT (>1X10^{-2}M)		LOW SALT	
	High Organic (>2000ppb)	Low Organic	High Organic	Low Organic
NEUTRAL TO BASIC pH	0	0 Brown and Haney (1964) Brown (1967)	0	0 Rouston et al. (1976) Wildung et al (1975) Haney (1963, 1964)
ACID pH (<6.0)	0	0	0	0

Table C-18. R_d Estimates (mL/g) for Cesium.

	HIGH SALT (>1X10^{-2}M)		LOW SALT	
	High Organic (>2000ppb)	Low Organic	High Organic	Low Organic
NEUTRAL TO BASIC pH	3-300 (10) Barney (1978)	3-300 (10) Rhodes and Nelson (1957) Routson et al. (1981) Hajek and Ames (1968)	50-3000 (50) Barney (1978)	50-3000 (50) Rhodes and Nelson(1957) Routson et al. (1981) Hajek and Ames (1968)
ACID PH (<6.0)	5-50 (5) Knoll (1969)	5-50 (5) McHenry (1 54) Rhodes and Nelson (1957)	10-100 (30)	10-100 (30) McHenry (1954) Rhodes and Nelson(1957)

Table C-19. R_d Estimates (mL/g) for Chromium(III), Rare Earths (Cerium, Lanthanum, Europium, and Promethium), Americium, and Curium.

	HIGH SALT (>1X10^{-2}M)		LOW SALT	
	High Organic (>2000ppb)	Low Organic	High Organic	Low Organic
NEUTRAL TO BASIC pH	0-10 (2)	10-200 (100) Hajek (1966) Benson (1960)	0-20 (5)	100-500 (200) Sheppard et al. (1976) Routson et al. (1976) Benson (1960)
ACID pH (<6.0)	0-2 (0) Knoll (1969)	(10-40) (20) Hajek and Knoll (1966) Rhodes (1957a)	0-10 (2)	50-200 (100) Routson et al. (1976) Rhodes (1957a)

Table C-20. R_d Estimates (mL/g) for Plutonium.

	HIGH SALT (>1X10^{-2}M)		LOW SALT	
	High Organic (>2000ppb)	Low Organic	High Organic	Low Organic
NEUTRAL TO BASIC pH	0.2-20 (10)	20-200 (50) Rhodes (19 7c)	0.2-20 (10)	100-2000 (25) Rhodes (1957) Emery et al. (1974) Emery and Garland (1974)
ACID pH (<6.0)	0.1-1.0 (0.5) Benson (1960) Knoll (1969)	1-20 (5) Hajek and Knoll (1966)	0.1-10 (2)	20-200 (20) Rhodes (1957c)

Table C-21. R_d Estimates (mL/g) for Neptunium and Uranium.

	HIGH SALT (>1X10^{-2}M)		LOW SALT	
	High Organic (>2000ppb)	Low Organic	High Organic	Low Organic
NEUTRAL TO BASIC pH	0.2-20 (1)	0.2-200 (0.5) Routson et al. (1976)	0.2-20 (1)	2-2000 (2) Benson (1961) Routson et al. (1976) Sheppard et al. (1976)
ACID pH (<6.0)	0.1-1.0 (0.5)	2-20 (10)	0.1-10 (0.5)	20-200 (20)

Table C-22. R_d Estimates (mL/g) for Aluminum, Silicon, and Titanium.

	HIGH SALT (>1X10^{-2}M)		LOW SALT	
	High Organic (>2000ppb)	Low Organic	High Organic	Low Organic
NEUTRAL TO BASIC pH	1-1000 (10)	5-2000 (20)	10-1000 (20)	10-2000 (20)
ACID pH (<6.0)	3-1000 (3)	5-2000 (5)	10-1000 (20)	10-2000 (20)

Table C-23. R_d Estimates (mL/g) Phosphate and Vanadium.

	HIGH SALT (>1X10^{-2}M)		LOW SALT	
	High Organic (>2000ppb)	Low Organic	High Organic	Low Organic
NEUTRAL TO BASIC pH	10-300 (20)	30-300 (50)	50-3000 (50)	50-3000 (50)
ACID pH (<5.0)	5-500 (15)	5-500 (20)	10-500 (20)	10-1000 (30)

Table C-24. R_d Estimates (mL/g) for Ruthenium.

	HIGH SALT (>1X10^{-2}M)[a]		LOW SALT	
	High Organic (>2000ppb)	Low Organic	High Organic	Low Organic
NEUTRAL TO BASIC pH	0-30 (0) Raymond (1964, 1965)	0-500 (2) Barney (1978) Ames and Rai (1978)	2-20 (5) Wilding and Rhodes (1963)	10-1000 (20) Rhodes (1957a)
ACID pH (<6.0)	0-10 (2)	1-500 (50)	2-1000 (20)	10-1000 (40) Rhodes (1957a)

(a) Presence of high nitrates and/or nitrites lowers adsorption tendencies, other salts not important

Table C-25. Physical and Chemical Processes Used to Assess Distribution and Fate of Organic Compounds (Witkowski et al. 1987).

Process	Definition and Controlling Variables
Volatilization	1. Evaporative loss of a chemical. 2. Depends on vapor pressure and water solubility of the chemical and environmental variables like wind, water turbulence, and temperature. 3. Potentially important for compounds with high vapor pressures, low solubilities, and high activity coefficients.
Sorption	1. General term encompassing surface attraction (adsorption) and partition (solubilization). 2. Depends on the hydrophilic and lipophilic properties of the chemical and the composition of the sorbent. 3. Indicative parameters are solubility, octanol-water partition coefficient, and sorbent organic carbon content.
Photolysis	1. Nonmetabolic degradation requiring light energy: chemical undergoes either a direct transformation reaction from the absorbed energy or an indirect change from a reaction-- for example, oxidation, with an excited chemical species or free radical. 2. Depends on the chemical's absorption spectrum coefficient in the ultraviolet to visible range as well as the sunlight intensity distribution for a given time of day, season, latitude, depth in water, and ozone thickness. Also depends on the chemical's reaction quantum yield.
Chemical oxidation	1. Breaking down of the chemical bonds in organic compounds through a chemical reaction with photochemically derived oxidants (single oxygen or free radicals). 2. Depends on the number and types of possible reactive sites and on the presence of oxidants. 3. Rate constants either measured directly or estimated from structure-activity relations.
Hydrolysis	1. Reaction of a chemical with water, hydrogen, or hydroxide ion, commonly resulting in the introduction of a hydroxyl group in exchange for the removal of another functional group. 2. Depends on the presence and number of hydrolyzable functional groups at neutral pH plus the catalytic effect of the addition of acids and bases at other pHs.
Bioaccumulation	1. Uptake and retention of chemicals in the water column by aquatic organisms through intake from water or diet. 2. Depends on the nature of the chemical (lipophilic) and the organism's fat content, metabolic, and depuration rates.
Biotransformation and biodegradation	1. Enzyme catalyzed transormation of chemicals as a source of energy, carbon, and nutrients. 2. Depends on the refractory and toxic nature of the chemical, and the presence of an acclimated microbial population, and a host of environmental factors including pH, temperature, dissolved oxygen, available nutrients, and cometabolites.

Table C-26. Physiochemical Properties Used in Evaluation of Transport Properties of Organic Compounds (Witkowski et al. 1987).

Characteristics	Definitions
Water solubility	Indicative of chemical's hydrophobic/hydrophilic nature, the limiting load in water, and its potential behavior in solution. Units: mass per volume.
Vapor pressure	The partial pressure of vapor that is in equilibrium with a substance impure state at a specified temperature. Relative or qualitative measure of the volatility of the chemical in its pure state. Units: mass/length*time^2 (e.g., Pascal).
Henry's law constant	Relative equilibrium concentration of a compound in air and water at standard temperature and pressure. Ratio of the vapor pressure divided by the chemical's water solubility; indicative of the compound's volatility. Units: mass*length^2/t^2*mole (e.g., atm*m^3/mole).
Reaeration rate ratio	Ratio of the first-order rate constant for loss of a chemical from aqueous solution divided by the rate constant for oxygen uptake by the same solution. Unitless. Estimate of the volatility of compounds with Henry's constants >3,500 torr/molar for which the volatilization rate constant is limited by diffusion through the liquid-phase boundary layer.
Partition coefficient	Equilibrium distribution of a compound solubilized between two immiscible solvents. Unitless.
Octanol-water partition coefficient	Equilibrium distribution of a compound between water and n-octanol. Indicative characteristic of the bioconcentration potential of compounds. Unitless.
Soil/sediment partition coefficient	Equilibrium distribution of a compound between water and a sediment/soil substrate. Mass of chemical per mass of sediment divided by the dissolved mass of chemical in solution per mass of solution volume. Units: mL/g.
Soil/sediment organic carbon partition constant	Soil/sediment partition coefficient divided by the sediment/soil percent organic carbon content. This normalizes the partition coefficient to a sediment/soil substrate that is 100% organic carbon, permitting comparison of partition coefficients between substrates of differing carbon content. Units: mL/g.
Absorption spectrum coefficient	Quantity of light absorbed by the chemical at a particular wavelength in the ultraviolet-visible range of the electromagnetic spectrum.
Reaction quantum yield	Efficiency of light utilization by a chemical. Ratio of the number of moles of the chemical transformed to the quantity (flux) of light adsorbed. Unitless.
Photolysis rate constant	First-order rate constant for direct photolysis. Units: reciprocal time.
Oxidation rate constant	Sum of the rate constants for each individual type of reactive site in the compound. Units: reciprocal time.
Hydrolosis rate constant	First-order rate constant at pH of 7 and the second-order rate constants for acid- and base-promoted hydrolosis. Units: reciprocal time.
Bioconcentration factor	Concentration of a chemical in tissue on a dry-weight basis divided by the concentration in water. Also the ratio of the uptake to depuration rates for a compound in a given organism. Unitless.
Biotransformation rate	Second-order rate constant dependent on the chemical concentration and the microbial biomass. Units: reciprocal time.

Table C-27. Environmental Processes Affecting the Organic Compounds Identified in the 33 Wastestreams (Witkowski et al. 1987).

Chemical group	Primary mechanism	Secondary mechanism	Comments
1. Halogenated aliphatic hydrocarbons	Volatilization		Compounds with more than five chlorine atoms are sorptive have a potential for bioaccumulation.
2. Halogenated ethers			
aliphatic-------→	Hydrolysis----→	Volatilization and photo-oxidation in atmosphere	Some persistence due to high solubility. Also persistence potential due to lipophilicity.
aromatic-------→	Sorption------→	Bioaccumulation and biodergradation	
3. Monocyclic aromatics	Volatilization---→	Atmospheric oxidation/photolysis	Volatilization/sorption are competing reactions with environmental conditions determining dominance of one reaction. Some persistence from high solubility.
	Sorption and-----→ bioaccumulation	Slow biodegradation (especially nitrogen compounds)	
4. Phenols	Photolysis-------→	(near air-water surface)	No accumulation/persistence except for nitrophenols which sorb readily to clays.
	Biodegradation---→	(near water sediment if sufficient microbes)	
5. Monocyclic aromatics and phenols with 5 or more chlorines	Sorption Bioaccumulation		Chlorine content dominates compound behavior.
6. Phthalate esters	Sorption	Bioaccumulation Biotransformation Biodegradation	Biologically reactive in metabolic processes. Because of sorption, transport depends on hydrogeoligic conditions.
7. Polynuclear aromatic hydrocarbons	Sorption Bioaccumulation Biodegradation	Photolysis (for compounds with low ring numbers)	Bioaccumulation short-term because readily metabolized. Sorption increases and biodegradation decreases with with increasing number of benzene rings.
8. Nitrogen compounds			
aliphatic-------→	Photolysis		Mainly hydrospheric photolysis due to high solubility but also atmospheric.
aromatic--------→	Sorption-------→	Biodegradation	

Table C-28. Available Physiochemical Data for Organic Compounds Listed in Table C-5. (Page 1 of 3)

R_d was determined assuming f_{oc} of 0.1 wt% or, as a fraction, 0.001 carbon. The relationship used for determination of an R_d value was $(K_{oc})(f_{oc}) = R_d$.

Organic Compound	Water Solubility, 25°C	Henry's Law Constant Atm. m^3/mol at 25°C	$K_{o/w}$	K_{oc}	R_d, mL/g	Dissociation Constants Acids and Bases
tributyl phosphate	280 mg/L	1.9E-02	1E+03	6E+03	6	
tridecane	1E-03 mg/L	NA	4.5E+06	2.8E+06	3.0E+03	
tetradecane	0.3E-03 to 7E-03 mg/L	0.3 to 1.2	1.6E+07	1.01E+07	1.0E+04	
dodecane	3E-03 to 8E-03 mg/L	7.5 ± 2.5	1.0E+06	6.3E+05	6.0E+02	
pentadecane	7E-05 mg/L	NA	5.2E+07	3.28E+07	3.0E+04	
tetrachloroethylene	200 mg/L	1.84E+02	400 to 2,500	238 to 1,600	0.2 to 1.6	
chloroform	7.95 g/L	3.67E-03	93	45	0.05	
bis(2-ethylhexyl)-phthalate	0.40 mg/L	1.47E-05	4,170 to 12,800	87,000	87	
undecane	1E-02 to 4E-02 mg/L	1.8 ± 0.8	0.4E+06 to 5.5E+06	2.5E+05 to 3.5E+06	300 to 3,000	
2-butoxyethanol	45 g/L	2.8E-07	6.76	67	0.07	
butyl alcohol	74 g/L	8.81E-06	NA	72	0.07	
acetone	Miscible	3.88E-05	0.575	18	0.02	
hexadecane	0.02E-03 to 6.3E-03 mg/L	0.3E-01 to 2.3E-01	1.8E+08	1.13E+08	1E+05	
methyl nitrate	Slightly water soluble, explosive vapor at room temperature, density = 1.2075 (air = 1), melting point = 82.3°C, boiling point (explosive) = 64.6°C.					
dimethoxymethane	Moderately water soluble, colorless gas, flammable, density = 1.617 (air = 1), one volume of water dissolves 37 volumes of the gas, flash point -41°C.					
heptadecane	6E-06 mg/L	NA	0.6E+09 to 2.1E-09	3.8E+08 to 1.3E+09	4E+05 to 1E+06	
octadecane	2E-03 to 6E-03 mg/L	NA	6.17E+08	3.9E+08	4E+05	
decane	2E-02 to 5E-02 mg/L	7 ± 3	1.0E+05	6.3E+04	60	
methyl formate	170 g/L	9.12E-03	Colorless, flammable liquid; flashpoint, closed cup = -19°C, density at 15°C = 0.987			
phenol	82.8 g/L	3.33E-07	28.84	38.8	0.04	10
N-methoxymethanamine	CNF					
di-n-butylphthalate	11.2 mg/L	2.8E-07	758 to 52,490	170,000	170	
benzyl alcohol	40 g/L	NA	12.30	95.5	0.09	
methylene chloride	13.7 g/L	2.19E-03	17.38	28	0.03	
di-n-octylphthalate	3.0 mg/L	4.45E-07	7.4E+09	3.6E+09	4E+06	
benzioc acid	3.4 g/L	0.287E-05	74.13	182	.02	4.205
methylethyl ketone	223 g/L	5.59E-05	1.07	5.2	0.005	
butyl benzyl phthalate	2.69 mg/L	1.26E-06	81,280	17,000	17	
2-methyl-5-propyl nonane	CNF					
pelargonic acid	CNF					

CNF: compound not found in literature.
NA: not available.

Table C-28. Available Physiochemical Data for Organic Compounds Listed in Table C-5. (Page 2 of 3)

R_d was determined assuming f_{oc} of 0.1 wt% or, as a fraction, 0.001 carbon. The relationship used for determination of an R_d value was $(K_{oc})(f_{oc}) = R_d$.

Organic Compound	Comment	Qualitative Estimate			
		Solubility	Volatility	Sorption	Degradation
tributylphosphate	Readily degrades, $t^{1/2}$ = 6 days in river water	medium	high	medium	medium
tridecane	Sorbed on sediment clays and organic carbon	low	high	high	medium
tetradecane	Sorbed on sediment clays and organic carbon	low	high	high	medium
dodecane	Sorbed on sediment clays and organic carbon	low	high	high	high
pentadecane	Sorbed on sediment clays and organic carbon	low	high	high	medium
tetrachloroethylene	Little sorption	medium	high	low	low
chloroform	Little sorption	high	medium	low	low
bis-(2-ethylhexyl) phthalate	Sorbed on sediment clays and organic carbon	medium	low	high	medium
undecane	Sorbed on sediment clays and organic carbon	low	high	high	medium
2-butoxyethanol	Little sorption	high	low	low	medium
butyl alcohol	Little sorption	high	low	low	medium
acetone	Little sorption	high	low	low	high
hexadecane	Sorbed on sediment clays and organic carbon	low	high	high	medium
methyl nitrate		medium	high	low	low
dimethoxymethane		medium	high	low	low
heptadecane	Sorbed on sediment clays and organic carbon	low	high	high	medium
octadecane	Sorbed on sediment clays and organic carbon	low	high	high	medium
decane	Sorbed on sediment clays and organic carbon	low	high	medium	medium
methyl formate		high	high	low	low
phenol	Sorption a function of pH	high	low	low	medium
N-methoxymethanamine					
di-n-butylphthalate	Sorbed on sediment clays and organic carbon	medium	low	high	medium
benzyl alcohol	Little sorption	high	low	low	medium
methylene chloride	Little sorption	high	medium	low	medium
di-n-octylphthalate	Sorbed on sediment organic carbon	medium	low	high	medium
benzioc acid	Sorption function of pH	high	low	low	low
methylethyl ketone	Little sorption	high	low	low	high
butyl benzyl phthalate	Sorbed on sediment organic carbon	medium	low	medium	high
2-methyl-5-propyl nonane					
pelargonic acid					

Table C-28. Available Physiochemical Data for Organic Compounds Listed in Table C-5. (Page 3 of 3)

R_d was determined assuming f_{oc} of 0.1 wt% or, as a fraction, 0.001 carbon. The relationship used for determination of an R_d value was $(K_{oc})(f_{oc}) = R_d$.

Organic Compound	Comment	Qualitative Estimate			
		Solubility[a]	Volatility[b]	Sorption[c]	Degradation[d]
ethyl alcohol	little sorption	high	medium	low	high
2-propanol	little sorption	high	medium	low	low
tetrahydrofuran	little sorption	high	high	low	low
benzaldehyde	little sorption	high	medium	low	medium
butyraldehyde	little sorption	high	medium	low	medium
methyl n-butyl ketone	little sorption	high	medium	low	low
methyl isobutyl ketone	little sorption	high	medium	low	medium
methyl n-propyl ketone	little sorption	high	medium	low	medium
acetophenone	little sorption	high	medium	low	high
hexadecanoic acid	sorption a function of pH; ordinarily a solid	low	low	high	low
dimethyl nitrosamine	little sorption	high	low	low	medium
3,5-dimethylpyridine	little sorption; odor of pyoidine and peppermint	high	medium	low	low
morpholine	little sorption	high	low	low	medium
dichlorofluoromethane	little sorption	high	medium	low	medium
butyl nitrate	little sorption	high	medium	low	low
methoxydiglycol	little sorption on organic carbon; some clay sorption	high	low	low	medium
methoxytriglycol	little sorption on organic carbon; some clay sorption	high	low	low	medium
ethoxytriethylene-glycol	little sorption on organic carbon; some clay sorption	high	low	low	medium
phenanthrene	good sorption	medium	low	high	medium
butoxydiglycol	little sorption on organic carbon; some clay sorption	high	low	low	medium
2-methylnonane	good sorption	low	high	high	medium

[a]Solubility:

High, g/L

Medium, mg/L

Low, <mg/L.

[b]Volatility:

High, >5E-02, atm*m^3/mol

Medium, 5E-02 to 1E-04, atm*m^3/mol

Low, <1E-04, atm*m^3/mol.

NA: not available.

[c]Sorption:

High, $R_d \geq 50$ mL/g

Medium, $2 < R_d < 50$ mL/g

Low, $R_d < 2$ mL/g.

[d]Degradation:

High, $t^{1/2} < 10$ days

Medium, $t^{1/2} \sim 10$ to 100 days

Low, $t^{1/2} > 100$ days.

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APPENDIX D

FLOW AND TRANSPORT ANALYSIS

A groundwater flow and solute transport analysis was performed at three sites. These analyses were performed using existing numerical models and available data. The purpose for performing these analyses was to simulate the migration of contaminants in three different hydrologic regimes on the Hanford Site. The results from these analyses combined with the results from simplified one-dimensional flow and transport analyses performed at each liquid waste disposal site provided a basis for estimating the effect that the operation of these facilities has on the environment.

The three sites selected for analyses included: (1) a liquid waste disposal site in the 100 Area, (2) a site in the 200 West Area, and (3) a liquid waste disposal site in the 200 East Area. In the 100 Area, the 1301N and subsequent 1325N Cribs that supported the operation of the N Reactor over the years were selected. In the 200 West Area, the 216-U-17 Crib was selected. This crib supported the continued operation of the UO_3 Plant. In the 200 East Area, the 216-A-30 Crib was selected. Using the conceptual and numerical model developed for the 216-A-30 Crib, a cursory analysis of the 216-A-37-1 Crib and the 216-A-37-2 Crib was also included. The only adjustment was to modify the source term.

In the sections that follow, a description of the conceptual model, numerical model, and a discussion of the results for each of these sites is provided.

D.1 1301N AND 1325N FLOW AND TRANSPORT ANALYSES

D.1.1 Introduction

Over the years, the groundwater flow pattern beneath the 100-N Area has been influenced through the operations of several liquid waste disposal facilities. The disposal facilities of primary interest include the 1301N Crib, 1325N Crib, and the 1324N/NA percolation pond. With the discontinuance of operating N Reactor, discharges of effluent to these facilities will decrease and this decrease will affect the groundwater flow pattern. A study has been initiated to assess in detail the effect of this change in operation on the migration of existing contamination contained in the soil and groundwater. Both two- and three-dimensional analyses have been performed in support of this evaluation. These analyses were performed in support of the N-Springs Stabilization and Treatment Study, which will be completed in FY 91.

A two-dimensional analysis was performed as a precursor to the three-dimensional analysis. The purpose of performing the two-dimensional analysis was to provide a basis for scoping the three-dimensional analysis, in particular, to quantify those factors that affect travel times, and to identify data needs. It was recognized that the effects associated with variations in groundwater mounding could only be addressed through the use of a three-dimensional model. Contained herein is a summary discussion of the results from the two-dimensional analysis using the VAM2DH groundwater flow and solute transport model (Huyakorn et al. 1989). Documentation of the results from the three-dimensional analysis using PORFLO-3 (WHC 1990) are in progress and will be issued under separate cover.

D.1.2 Conceptual Model

The 1301N and 1325N liquid waste disposal facilities are structures that permit infiltration to take place below grade. These facilities tend to be rectangular in shape, covered, and are commonly called cribs on the Hanford Site. The 1301N Crib is an unlined rectangular basin that measures 38 by 76 m. A thick layer (approximately 1 m) of stones has been placed along the bottom of the crib. Attached to the crib is a zigzag trench approximately 488 m in length. The entire structure is oriented parallel to and approximately 244 m from the Columbia River. The facility was operated from 1963 to 1985.

The 1325N Crib was built to replace the 1301N Crib and became operational in 1983. This crib consists of a rectangular infiltration basin with concrete walls. The crib is 73 m wide and 76 m long. Shortly after startup in 1983, it became apparent that the facility would not accommodate the volume of effluent discharge to the crib. An extension trench 914 m long, divided into four sections, was added to the facility and became operational in 1985. Only the first of the four sections has received N Reactor effluent. Similar to the 1301N Crib, the 1325N Crib parallels the Columbia River but is located approximately 760 m from the river.

Both facilities are located in the vadose zone. Depth from the bottom of the crib to the unconfined aquifer is estimated to be 15 to 17 m. During operation of these cribs, a water mound formed beneath the facilities. The stratigraphic units that encompass the unconfined aquifer and the overlying unsaturated (or vadose) zone are the Ringold and Hanford formations. The deeper Ringold sediments consist of fluvial and lacustrine deposits of sand, silt, minor amounts of clay, and gravel. The Ringold Formation commonly displays graded bedding that locally contain caliche. The Hanford formation consists of glaciofluvial deposits of unconsolidated sand, boulders, gravel, and silt. The elevation of the contact between the two formations is the approximate location of the water table in the 100-N Area.

The 1301N Crib was the only facility that was used for disposal of radionuclides in the 100-N Area from 1963 until 1983. In 1965, when the wastewater volume exceeded the capacity of the facility, the extension trench was added. The 1325N Crib became operational in 1983. However, shortly after the start of operation, it was discoverd that a trench was needed to support operation of this facility. During a short period of time, 1983-1985, approximately 80% of the liquid effluent was discharged to the 1301N Crib. Beginning in September 1985, except for brief intermittent discharges to the 1301N Crib, all of the liquid effluent has been discharged to the 1325N Crib. Prior to 1973, the volumetric discharge to the 1301N Crib was not recorded.

As discussed in Section 2.3, a contaminant of interest in the 100-N Area is strontium-90. The amount of strontium-90 that has been released to the cribs has been measured since 1973 and is listed in Table D.1-1. Also listed in Table D.1-1 is the concentration of strontium-90 measured at N-Springs. These springs are located along the bank of the Columbia River and the concentration of strontium-90 in these waters has been measured over the years. These measured concentrations were used for purposes of calibrating the numerical groundwater flow and transport model.

D.1.3 Numerical Model

As mentioned previously, the VAM2DH two-dimensional, finite-element model was used to simulate the water flow and solute transport under variably saturated conditions. The governing flow equations are solved numerically using the Galerkin finite-element method. The relationships between hydraulic conductivity versus moisture content and pressure head versus moisture content were developed based on use of the van Genuchten - Mualem formulation (van Genuchten, 1978; Mualem, 1976).

A vertical cross-section that passes through both the 1325N Crib and the 1301N Crib and intersects the Columbia River was modeled. The model domain encompasses a cross-sectional area of approximately 31,250 m^2. The dimensions of the model are approximately 1,250 m horizontal and 25 m vertical. The computer geometry used for analysis is shown in Figure D.1-1. As shown in Figure D.1-1, approximately 1,000 elements were used for the simulation. The location of the two cribs coincides with the high density of finite elements centered at approximately 500 and 975 m. The nominal thickness of the unsaturated zone is 17.4 m and the saturated zone is defined to be 7.6 m. In Figure D.1-1, flow in the saturated zone is from

left to right. Each stratigraphic unit (finite element) is assumed to be of constant thickness.

Since volumetric discharge data were not available before 1973, information on infiltration capacity was used as a basis for estimating volumetric inflow. Using this approach, the average inflow to the crib was calculated to be 2.68E+06 L/day from 1963 to 1965, and 8.64E+06 L/day from 1965 to 1973. As indicated, discharge data became available after 1973. As discussed previously, from late 1963 to October 1983, all of the volumetric discharge was assumed to flow into the 1301N Crib. Between 1983 and September 1985, 20% of the flow was directed to the 1325N Crib and the balance of the flow was discharged into the 1301N Crib. Since September 1985, all of the flow has been discharged into the 1325N Crib.

Table D.1-1 lists the annual loadings in curies of strontium-90 that have been discharged to the cribs since 1973. Prior to 1973, a constant concentration of 20 nCi/L was assumed.

A summary of the hydrogeologic parameters used in the 1301N/1325N Crib analyses is provided in Table D.1-2. Information on the hydrologic characteristics, permeability versus moisture content, and matric potential versus moisture content was derived from laboratory measurements performed on Hanford formation soils collected elsewhere on the Hanford Site. These measurements were performed in support of the grout performance assessment and are summarized by the Pacific Northwest Laboratory (1990, Table 2-9).

The initial and boundary conditions are summarized as follows:

- A constant infiltration rate of 5 cm/yr was assumed along the top boundary. Assuming a unit gradient model (see Appendix B), this rate of infiltration was used to initialize volumetric moisture content in the unsaturated zone. Using this approach, a volumetric moisture content of 0.11 m^3/m^3 or 31% of the effective porosity was assigned.

- The elevation of the river stage was assumed constant. Fluctuations in river elevation were not taken into consideration in these analyses.

- A small finite gradient from left to right was assigned to the unconfined aquifer but the effect of this gradient was damped out (inundated) as the mound beneath each crib began to form.

- In the unsaturated zone, a zero flux boundary condition was assumed along each vertical boundary.

D.1.4 Results

Selected results from the flow model simulation are shown in Figures D.1-2 through D.1-8. Figures D.1-2 and D.1-3 show the pressure head and moisture saturation contours, respectively, a short period after the wetting front reaches the water table. Figure D.1-4 shows the pressure head contours, indicating the rising phreatic surface and building of the

groundwater mound beneath the crib. Figure D.1-5 shows that the groundwater mound had reached the bottom of the crib, and a conduit is well established for wastewater to flow from the crib to the unconfined aquifer. Figure D.1-6 shows the pressure head contours in an approximate steady-state situation after the volumetric discharge of wastewater reached a maximum of 8.6E+06 L/day. Figure D.1-7 shows the pressure head contours during 1983 when the wastewater was being disposed in both cribs. Figure D.1-8 shows the pressure head contours when the 1325N Crib became fully operational and the disposal of wastewater in the 1301N Crib had been discontinued.

A breakthrough curve for a conservative nonretarded solute is shown in Figure D.1-9. The travel time for wastewater to travel from the 1301N Crib to N-Springs is estimated to be 29 days (breakthrough of 10% concentration). Similarly, vertical travel time to the water table is estimated to be approximately 4 days.

The transport model was calibrated by adjusting the constant distribution coefficients (R_d). During this process, it was discovered that to match the concentration measurements collected in the field, an additional delay factor was needed. It was assumed that a filter phenomenon occurred at the bottom of the crib. Assuming this mechanism to occur, an effective R_d was adjusted until a fit was obtained. A seemingly unrealistically high constant distribution coefficient (R_d) of 1,628 mL/g was required to fit the field measurements. However, using this information, a good comparison of calculated strontium-90 with measured strontium-90 concentration data was obtained and is shown in Figure D.1-10. Figure D.1-11 shows the predicted concentration of strontium-90 at N-Springs during 1990 through 2010. The R_d assigned to the Hanford and Ringold formations soils was 10 mL/g. The volumetric flow rate during the period 1990 through 2010 was assumed to be 1.9E+06 L/yr and the concentration of strontium-90 was assumed to be 25.0E-09 Ci/L. These values were derived based on the last 3 yr of operation.

For purposes of comparison, a parametric analysis was performed to evaluate the effect associated with changing the governing transport parameters (decay and sorption). The characteristics of decay and sorption were adjusted to evaluate the effect on time of arrival and concentration attenuation. The aspect of decay was evaluated by arbitrarily adjusting the effective half-life. Three values (1 yr, 29 yr, and infinity) were assumed. Two values of R_d were assumed: 0 and 20. The results from these analyses are shown in Figures D.1-12 and D.1-13.

The results from these analyses can be used to draw some conclusions on the behavior of two other radionuclides (tritium and cesium-137) discussed in Section 2.3. The radiogenic half-life of tritium and cesium-137 are 12 and 30 yr, respectively. The nominal R_d assigned to tritium is zero, and for cesium-137, the nominal R_d ranges from 5 to 50 (see Appendix C). For N Reactor wastewater characteristics, the cesium-137 is assumed to be highly sorbed in the sediments. Based on results shown in Figure D.1-12, it can be assumed that the maximum concentrations in the tritium plume that resulted from the operation of the 1301N and 1325N cribs have been observed and that these concentrations are receding. Similarly, based on information shown in Figure D.1-13, it can be assumed that the maximum concentrations resulting from the cesium-137 plume have not been observed. These results do not include the filter phenomenon discussed previously. Including this

phenomenon, it is estimated that these maximum concentrations will not occur for several tens of years. It is recognized that future operation of the 1325N Crib will influence the rate at which this contaminant migrates through the soil column; however, an analysis of this variation was not evaluated in this study.

D.1.5 Conclusions

Using a two-dimensional model, the travel time for water to flow from the crib to N-Springs is estimated to be approximately 1 mo. Travel time for wastewater to flow through the vadose zone to the groundwater is estimated to take 4 days. The soil column beneath the crib was calculated to become saturated forming a groundwater mound. This mound has been observed in the field.

The attenuation of strontium-90 and cesium-137 has been measured in the field and was simulated. The model was calibrated using measured data at N-Springs. Based on the simulations that have been performed, it is estimated that the maximum concentrations of tritium and strontium-90 measured at N-Springs have been observed. Based on the results of the parametric analysis reported herein, it is concluded that the maximum concentration of cesium-137 has not been measured. Additional field work is required to support this conclusion.

Table D.1-1. Information on Disposal of Strontium-90, 1301N and 1325N Cribs.

A	B	C	D	E	F	G	H
YEAR	INFLUX l/day	OUTFLUX l/day	RATIO W	CURIES CRIB	CURIES N-SPRINGS	CONC. (M) CRIB NANOCURIES	CONC. (M) NSPRING NANOCURIES
1973	8.70E+06	4.35E+06	0.500	1.60E+01	3.10E-01	1.50E+01	1.70E-01
1974	9.50E+06	4.84E+06	0.509	6.30E+01	3.00E-01	1.90E+01	1.70E-01
1975	9.50E+06	4.80E+06	0.505	9.30E+01	4.00E-01	2.60E+01	2.10E-01
1976	9.90E+06	5.00E+06	0.505	1.10E+02	3.50E-01	3.10E+01	1.90E-01
1977	1.45E+07	7.30E+06	0.503	1.20E+02	1.00E+00	2.30E+01	3.70E-01
1978	1.25E+07	6.10E+06	0.488	1.20E+02	1.30E+00	2.50E+01	5.90E-01
1979	1.35E+07	6.50E+06	0.481	1.30E+02	1.60E+00	2.70E+01	6.50E-01
1980	1.25E+07	6.30E+06	0.504	1.60E+02	1.80E+00	3.50E+01	7.80E-01
1981	1.05E+07	5.00E+06	0.476	8.40E+01	1.80E+00	2.30E+01	9.40E-01
1982	1.05E+07	5.00E+06	0.476	1.40E+02	2.70E+00	3.60E+01	1.50E+00
1983	8.90E+06	4.70E+06	0.528	1.10E+02	4.00E+00	3.40E+01	2.30E+00
1984	1.00E+07	5.00E+06	0.500	3.10E+02	7.00E+00	8.20E+01	3.50E+00
1985	1.00E+07	5.00E+06	0.500	2.40E+02	8.40E+00	6.50E+01	4.50E+00
1986	7.25E+06	3.62E+06	0.499	3.60E+01	7.90E+00	1.40E+01	5.90E+00
1987	2.10E+06	1.14E+06	0.543	1.50E+01	2.40E+00	1.90E+01	6.00E+00
1988	1.66E+06	8.50E+05	0.512	1.50E+01	2.00E+00	2.50E+01	8.00E+00
1989	1.66E+06	8.70E+05	0.524	3.90E+01	2.00E+00	6.20E+01	6.20E+00

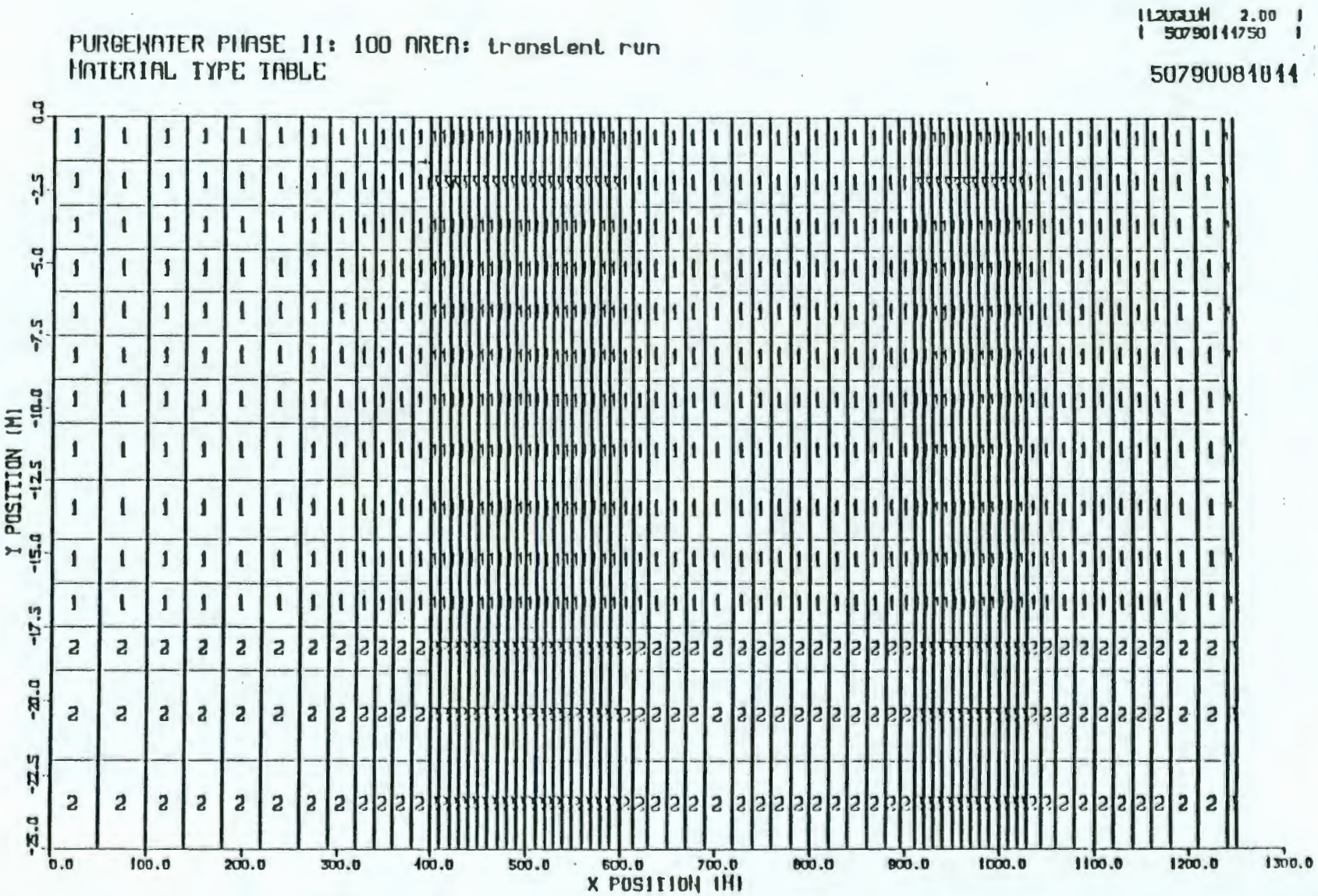


Figure D.1-1. Two-Dimensional Cross-Section Model Setup. (Numbers show material types.)

Table D.1-2. Parameters Used in the 100-N Area Liquid Effluent Study.

Model Flow Equation	Hanford Formation	Ringold Formation	Crib Floors
Hydraulic Conductivity	560 m/yr (H) 560 m/yr (V)	10,000 m/yr (H) 5,000 m/yr (V)	560 m/yr (H) 560 m/yr (V)
Effective Porosity	0.35	0.26	0.35
Volumetric Moisture Content	0.11	0.26	0.35
Van Genuchten Moisture Characteristic Parameters Alpha N	 5.266/cm 1.4419	 N/A N/A	 5.266/cm 1.4419
Model Transport Equation	**Hanford Formation**	**Ringold Formation**	**Crib Floors**
Bulk Density	1.72gm/cc	1.60gm/cc	1.72gm/cc
Molecular Diffusivity	0.000442 sq m/yr	0.000442 sq m/yr	0.000442 sq m/yr
Longitudinal Dispersivity Alpha-L	1.0	1.0	1.0
Transverse Dispersivity Alpha-T	0.1	0.1	0.1
Sorption Coefficient Sr-90	10 ml/g	10 ml/g	1628 ml/g
Half-life Sr-90	29 years	29 years	29 years

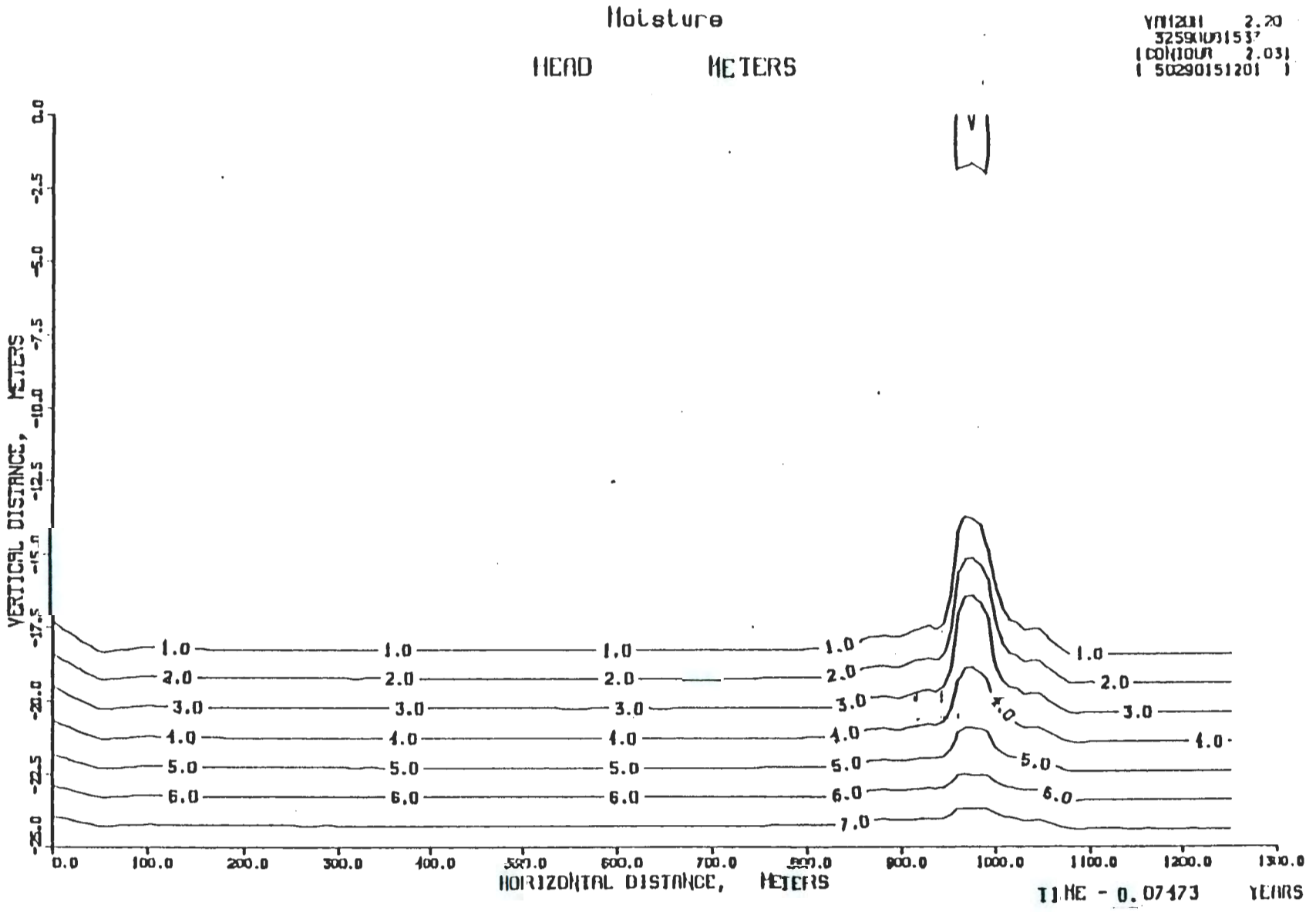


Figure D.1-2. Pressure Head Contours a Short Period After the Wetting Front Reaches the Water Table.

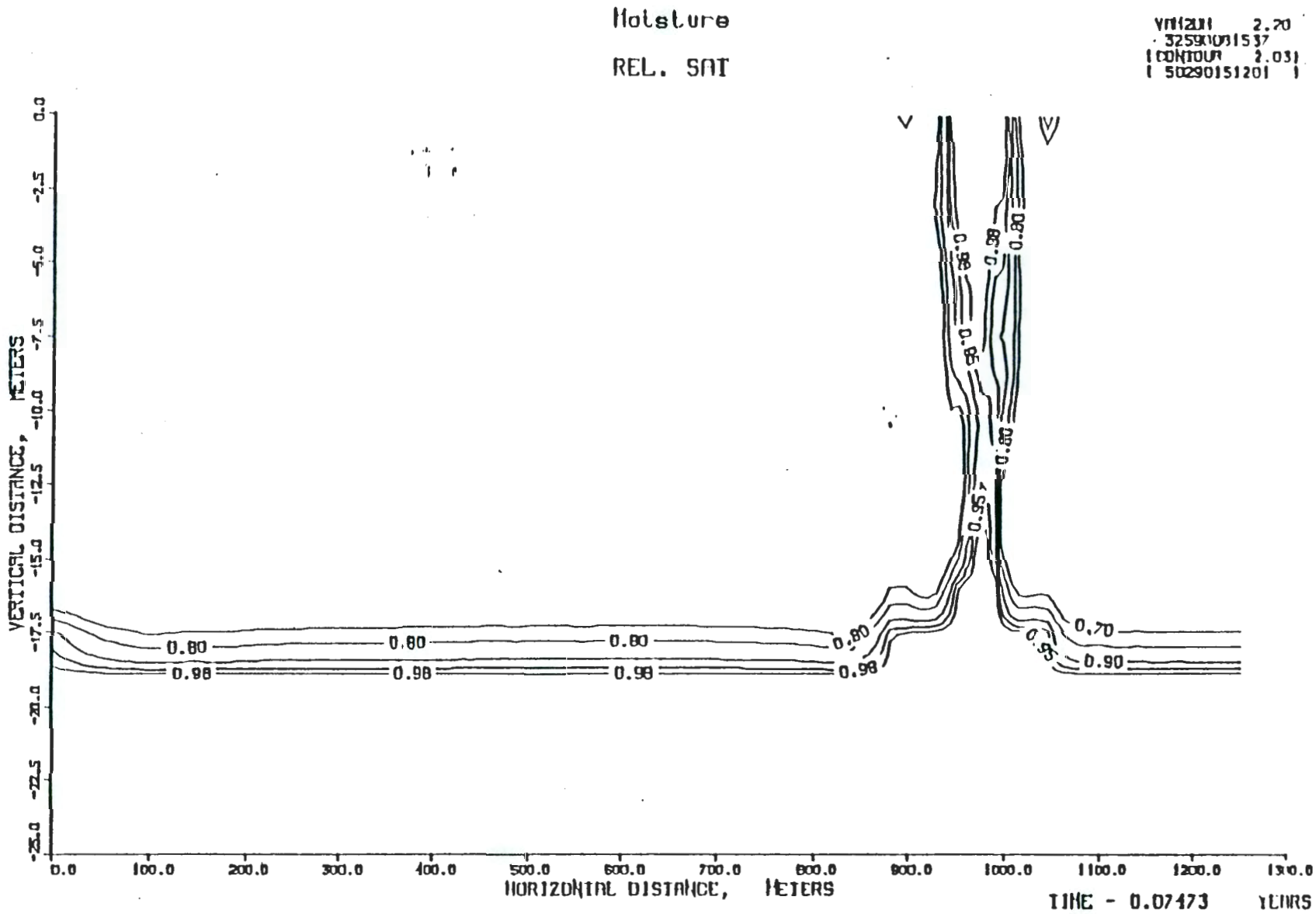


Figure D.1-3. Moisture Saturations Contours a Short Period After the Wetting Front Reaches the Water Table.

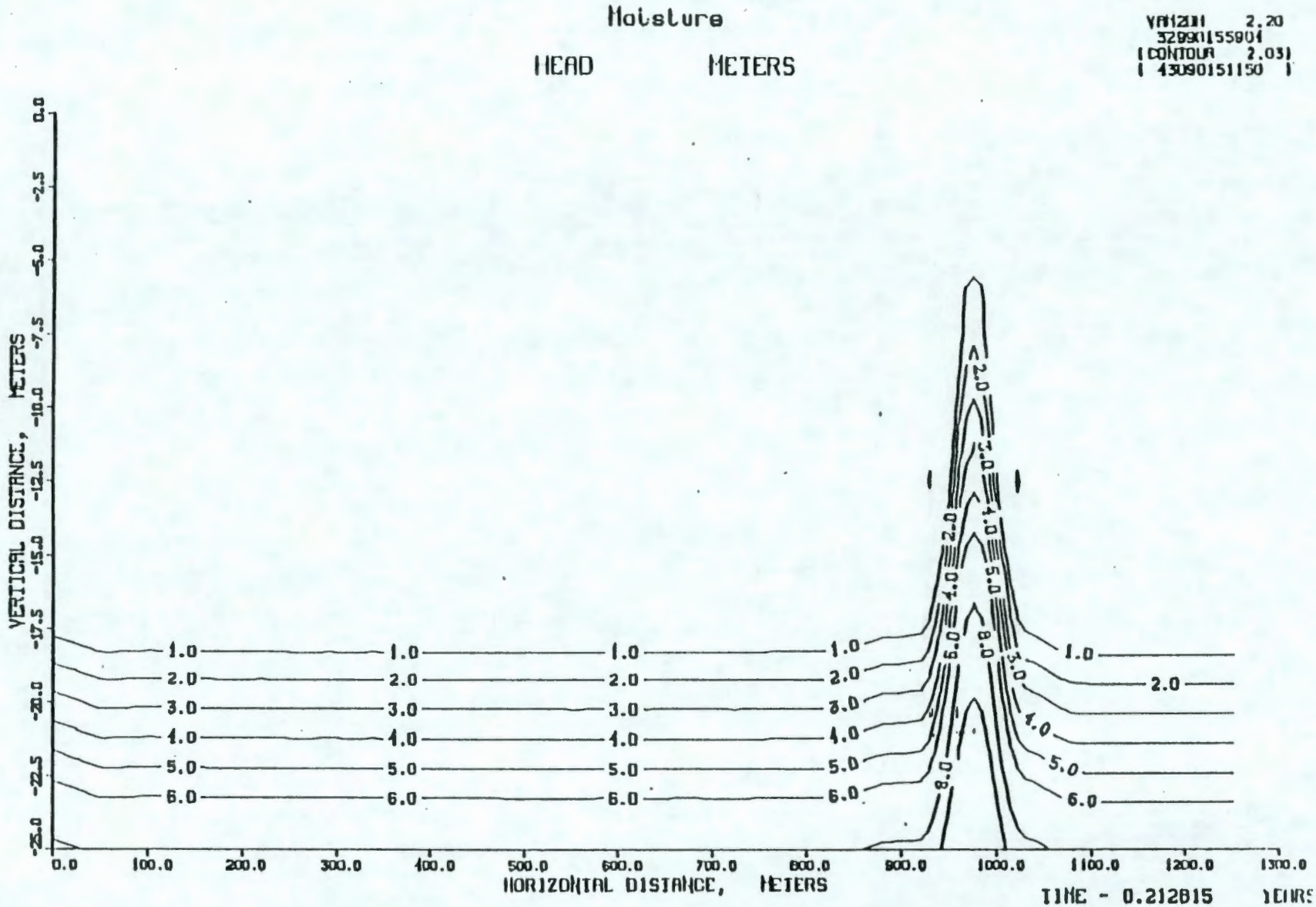


Figure D.1-4. Pressure Head Contours Indicating the Rising Phreatic Surface.

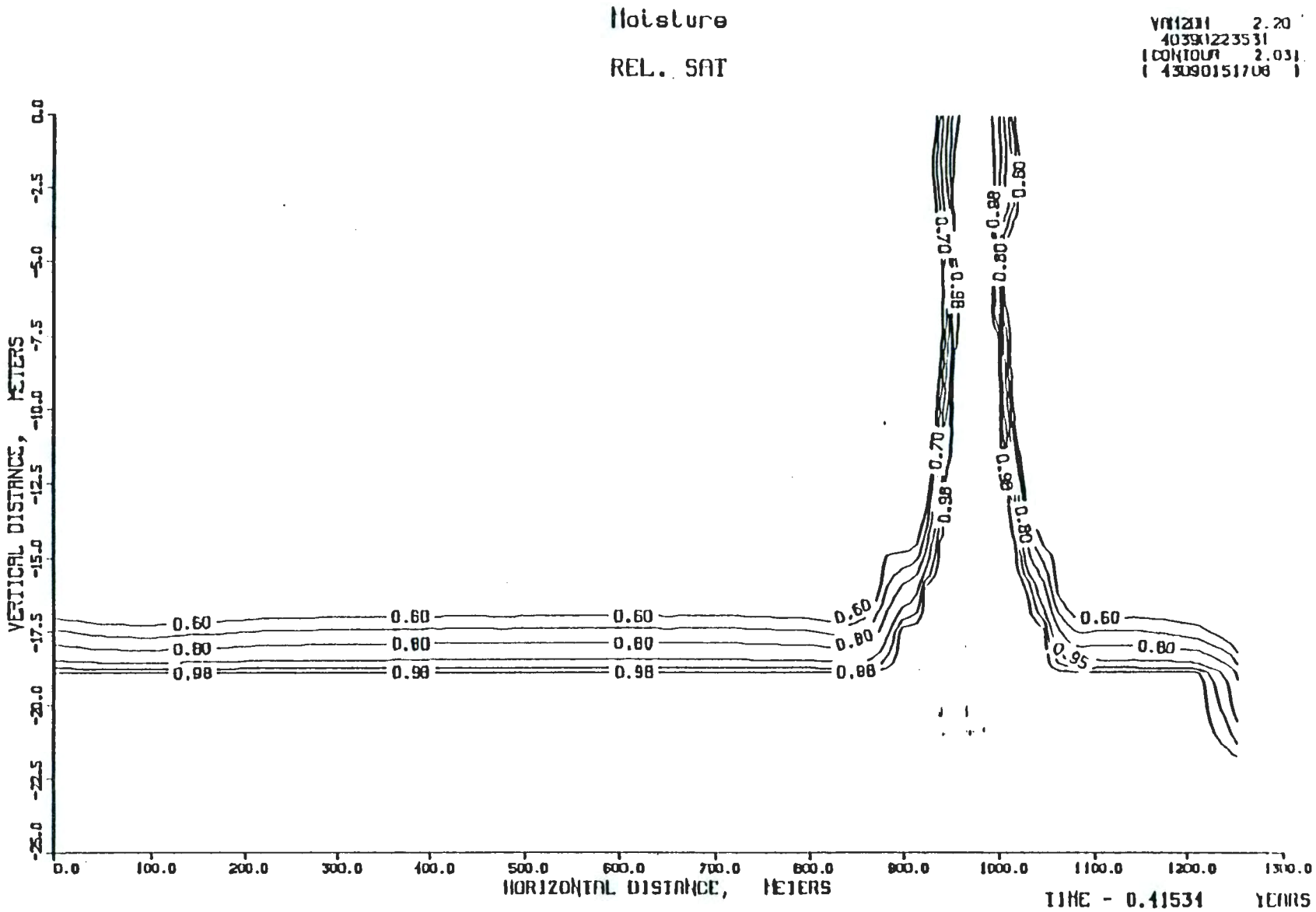
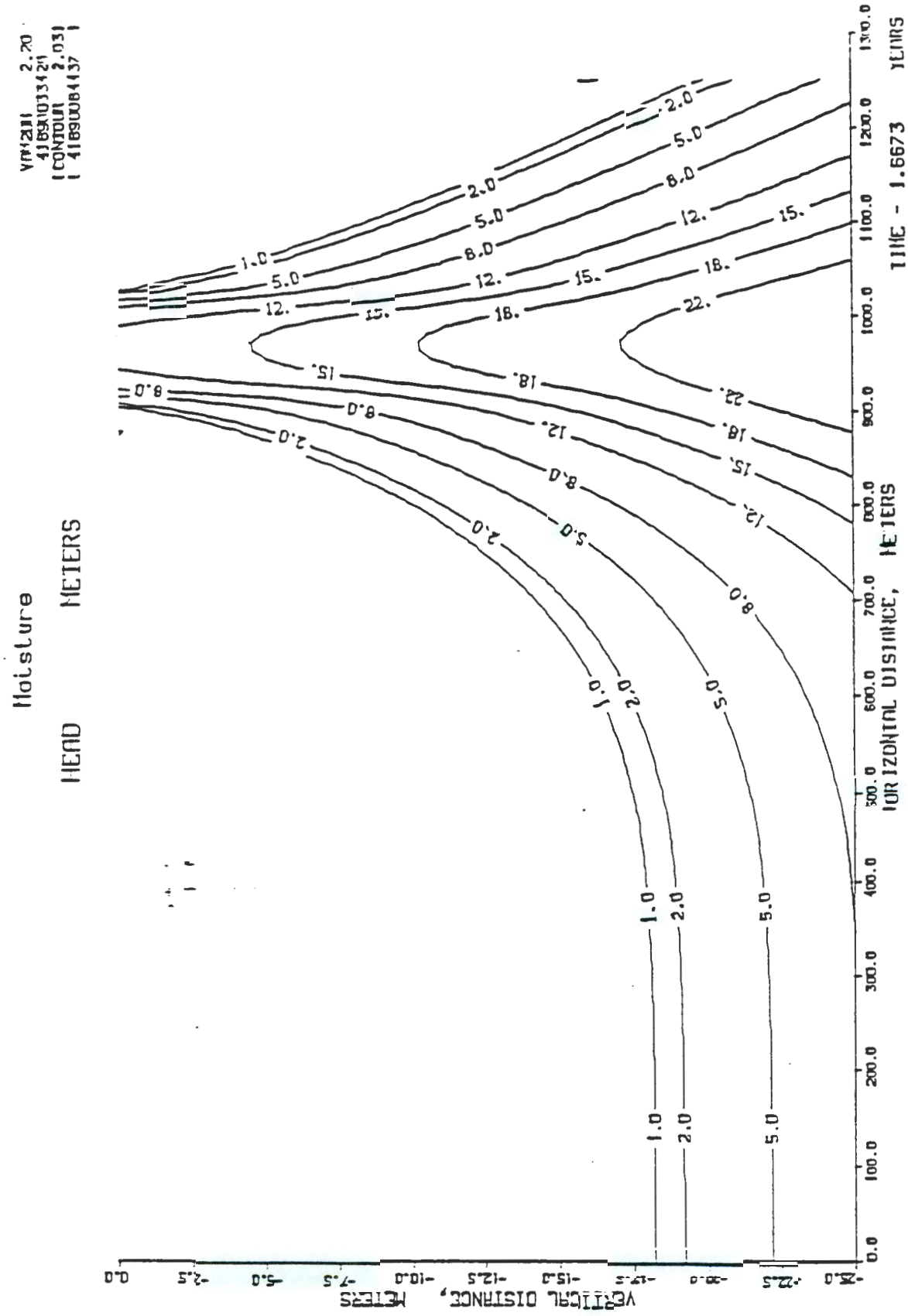


Figure D.1-5. Moisture Saturation Contours Indicating a Conduit Well Established from Crib to River.

Figure D.1-6. Pressure Head Contours After the Discharge Wastewater Reaches its Maximum Average of 2.25 Million Gal/Day.



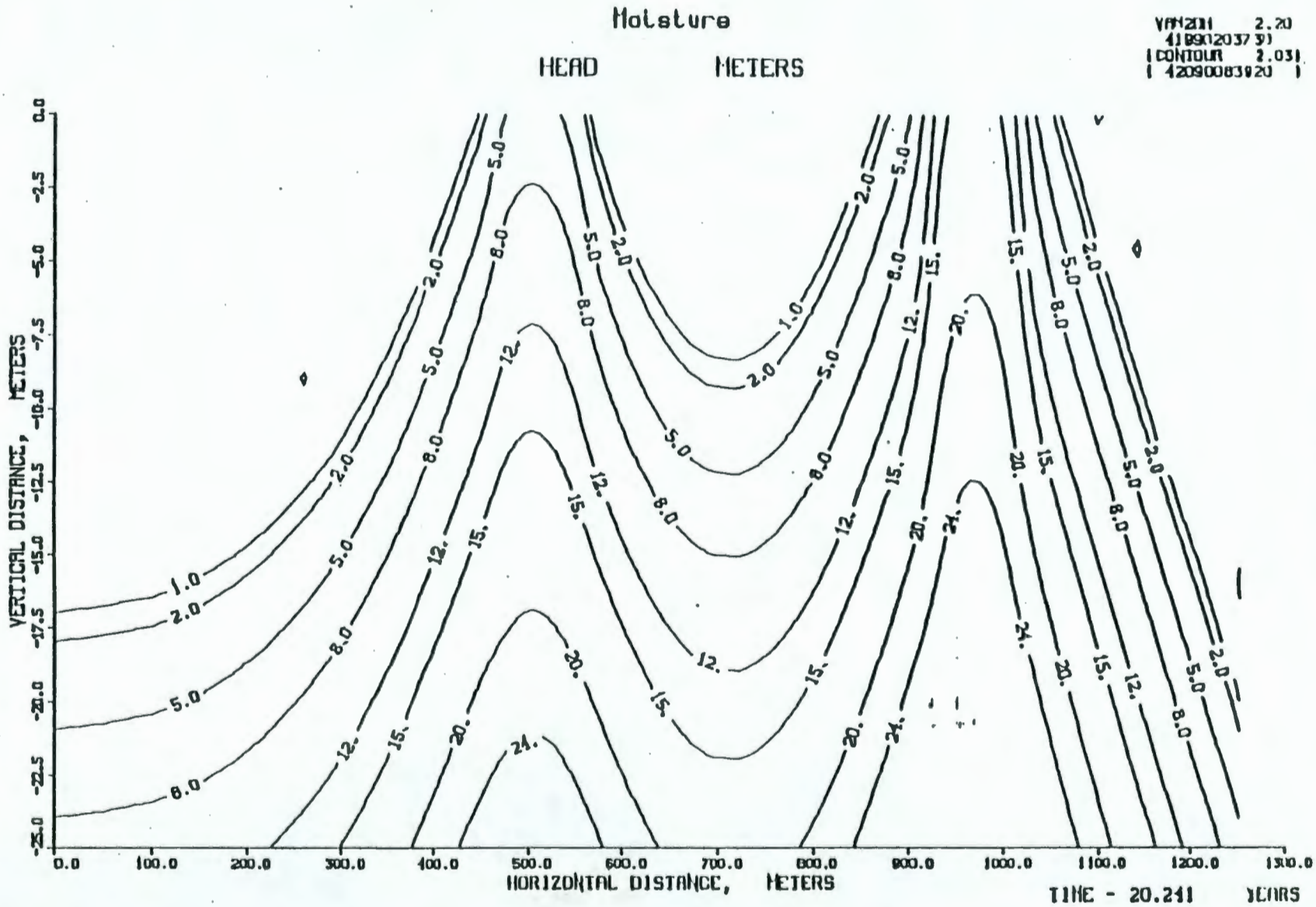


Figure D.1-7. Pressure Head Contours During 1983 When the Waste was Disposed by Both Cribs.

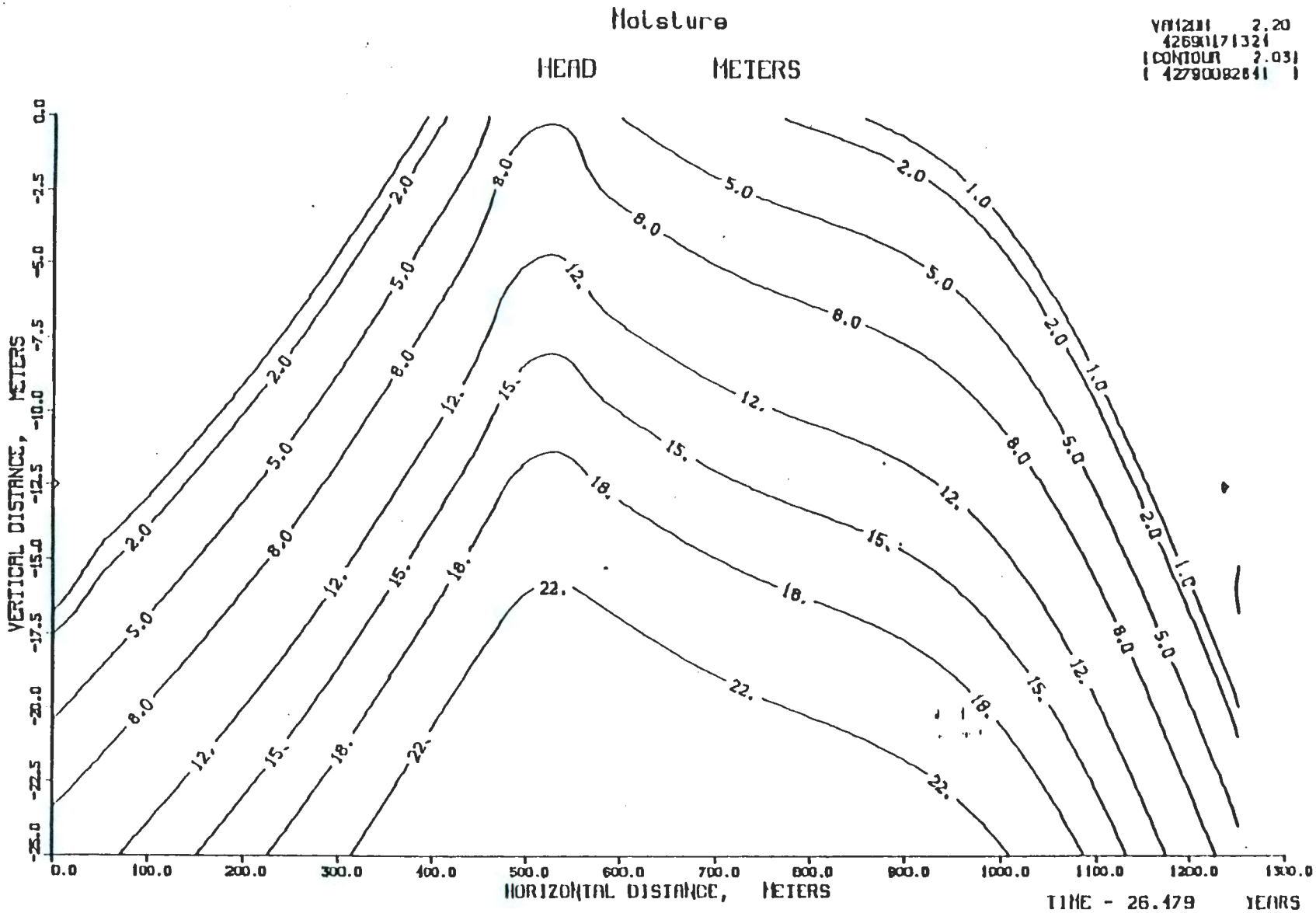


Figure D.1-8. Pressure Head Contours When 1325N Crib Became Fully Operational.

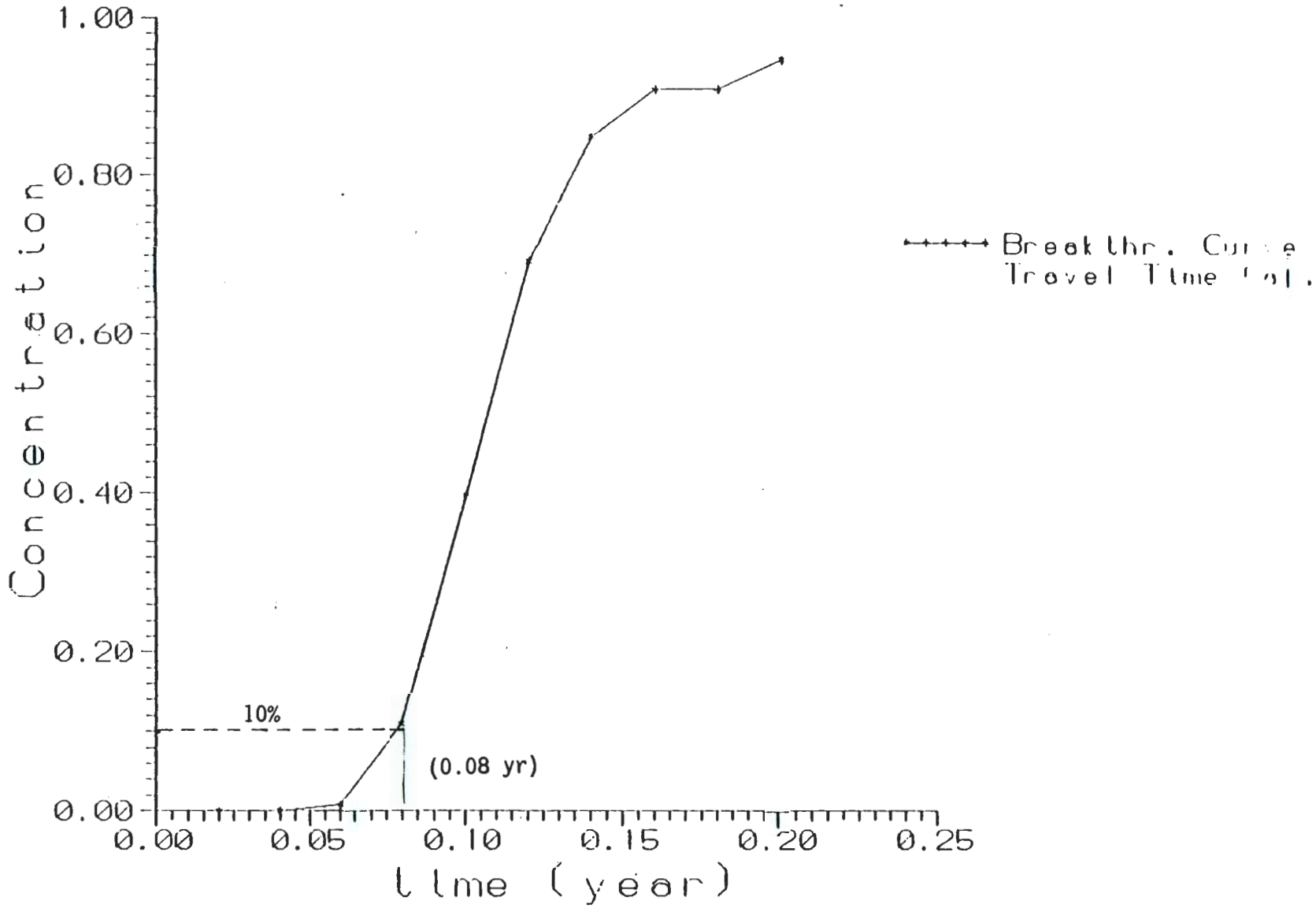


Figure D.1-9. Arrival Time at River for a Conservative Solute.

Figure D.1-10. Comparison of Strontium-90 Concentration in Nanocuries at N-Springs.

o = Measured; * = Calculated

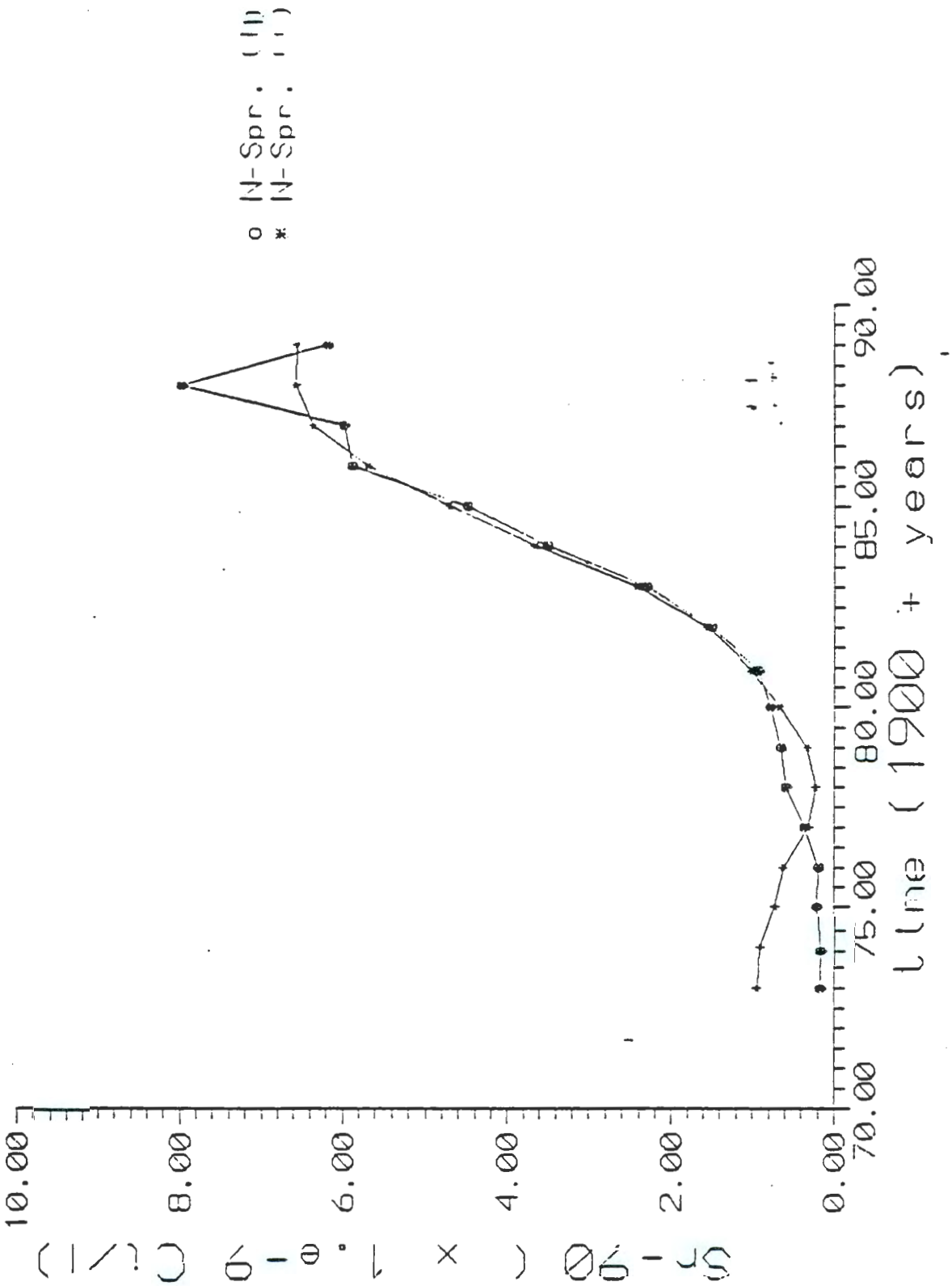
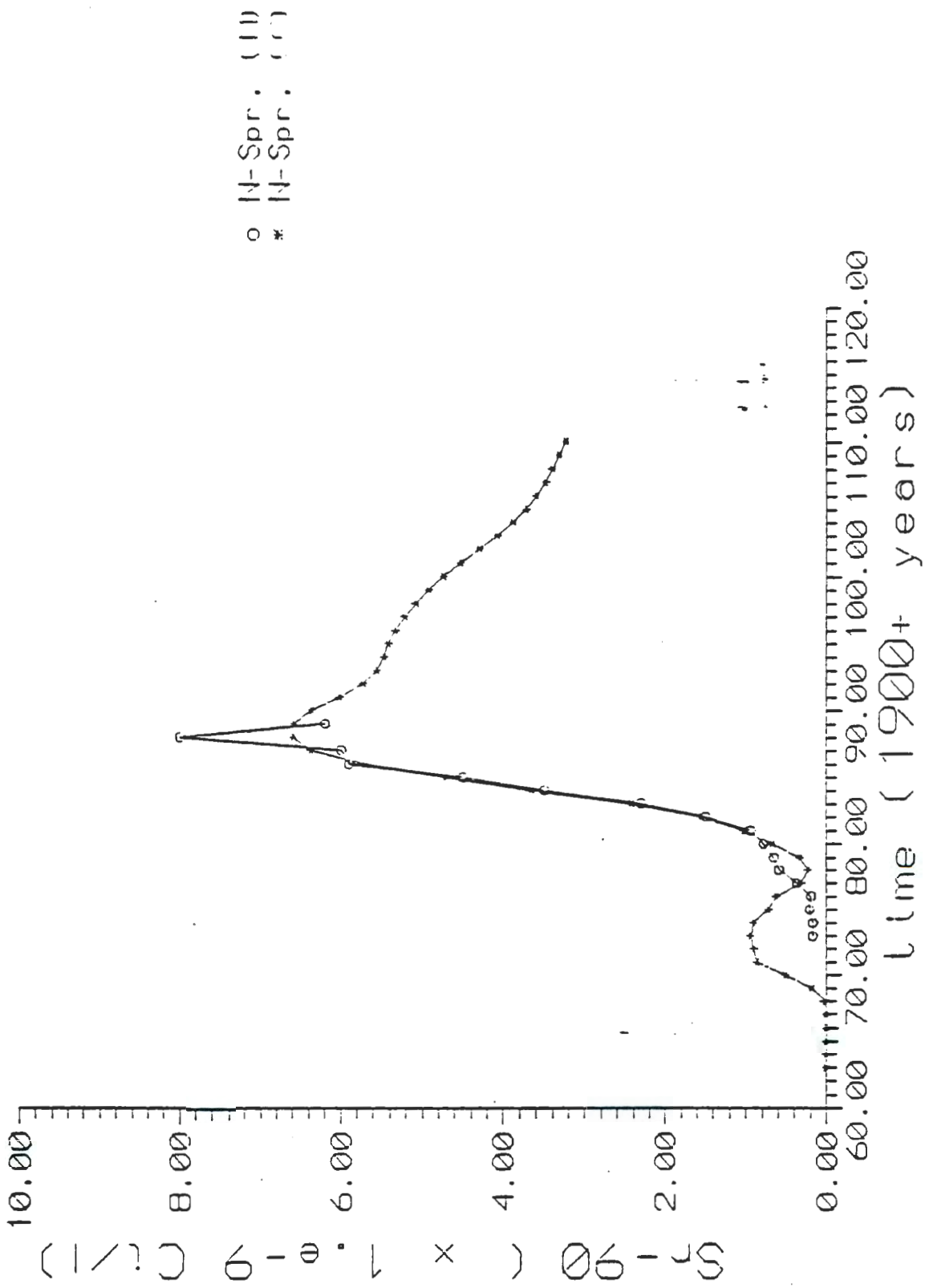


Figure D.1-11. Predicted Strontium-90 Concentration in Nanocuries at N-Springs During 1990 to 2010 Using Calibrated Model (1973-1989).



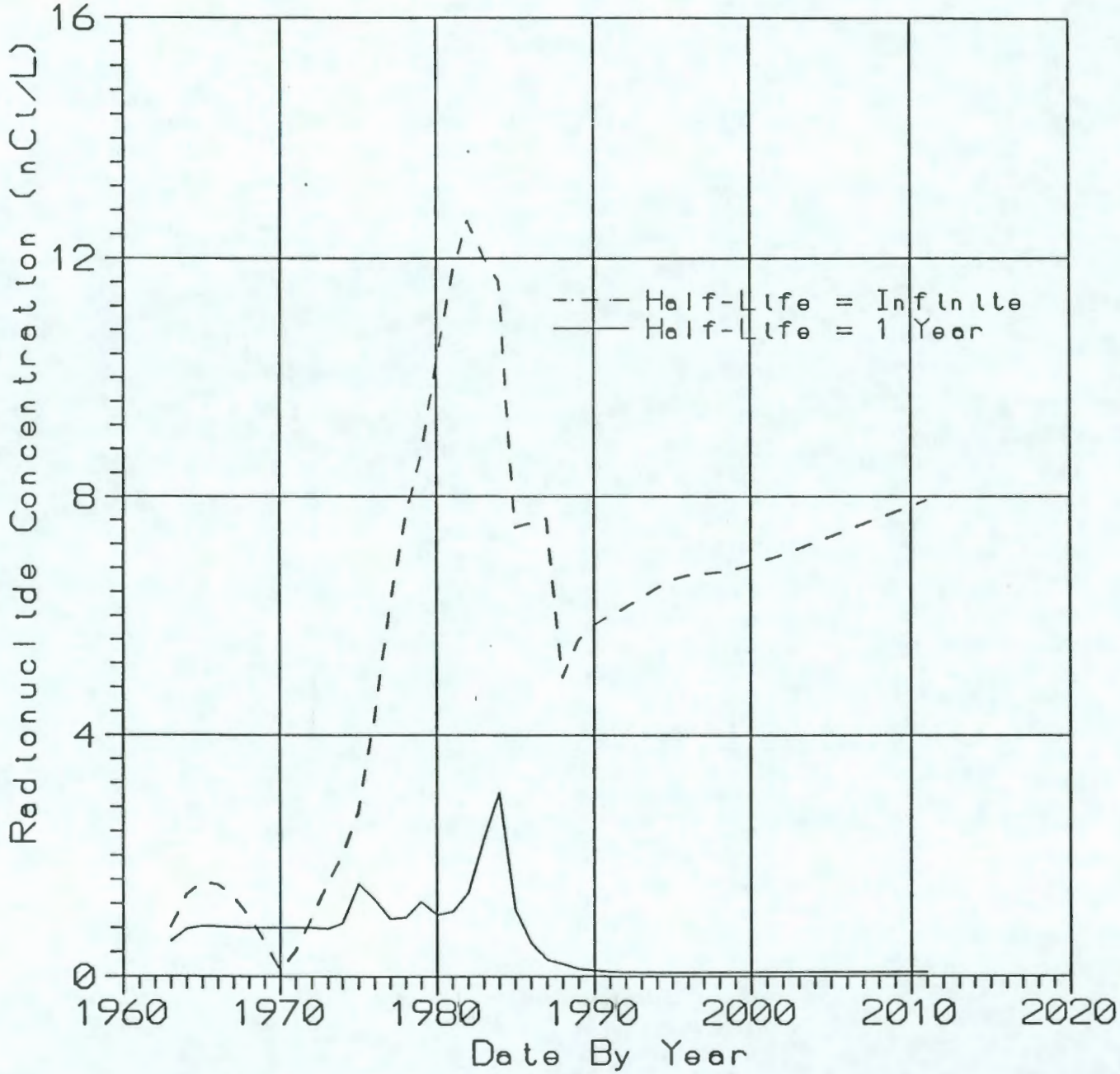


Figure D.1-12. Effect of Half-Life on Radionuclide Constant Distribution Coefficient (R_d) = 0.

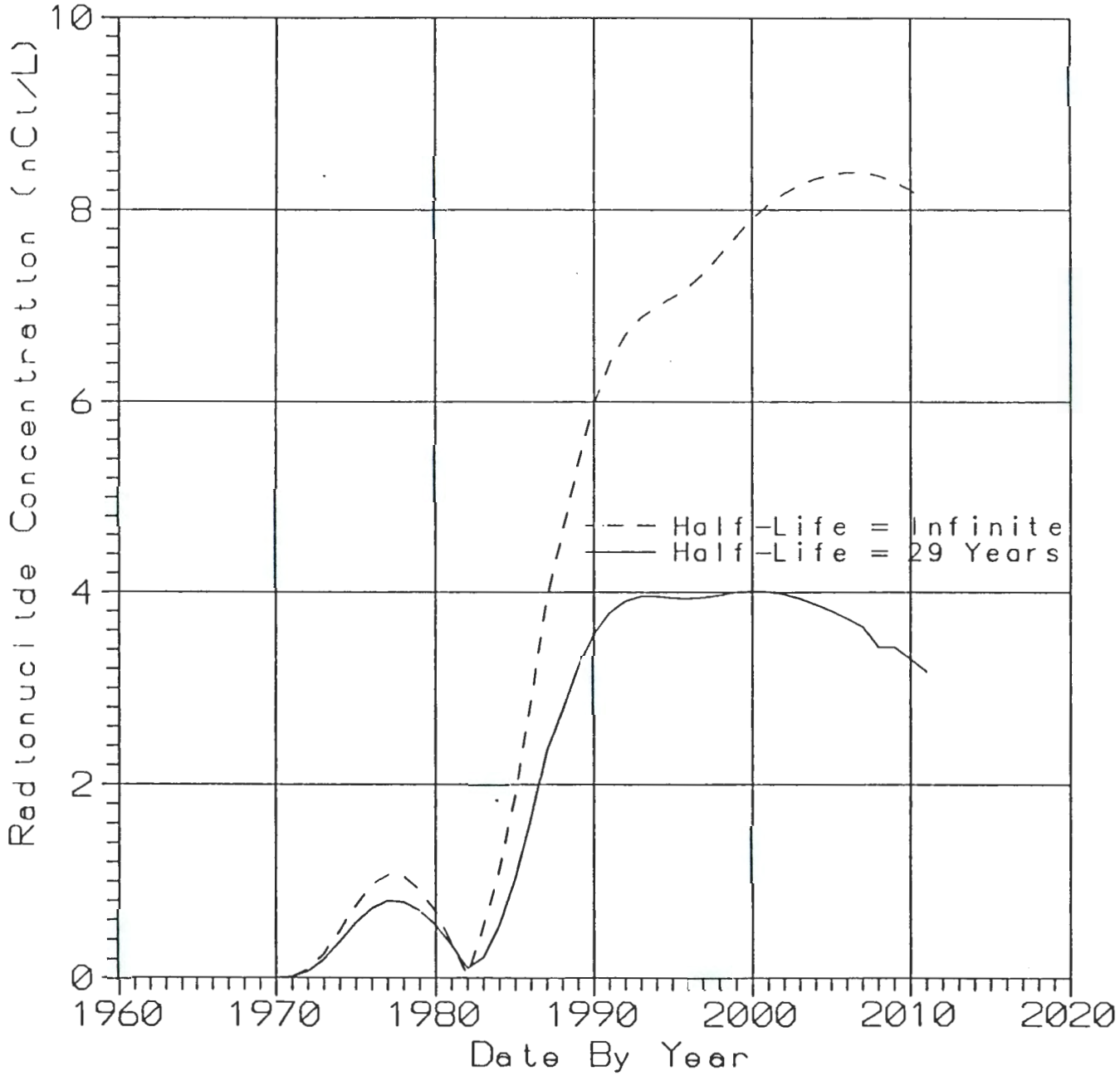


Figure D.1-13. Effect of Half-Life on Radionuclide Constant Distribution Coefficient (R_d) = 20.

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D.2 216-U-17 CRIB FLOW AND TRANSPORT ANALYSES

D.2.1 Introduction

The 216-U-17 Crib has been in operation since February 1988. This facility receives liquid waste in the form of process condensates from operations within the UO_3 Plant. A summary of the characteristics of this waste stream and disposal facility is provided in Section 2.21. A summary of the simulation on operation of the 216-U-17 Crib follows. The PORFLO-3 model (WHC 1990) was used to perform these analyses.

D.2.2 Conceptual Model

A plan view of the 216-U-17 Crib site is shown in Figure D.2-1. The crib is an excavated trench with sloped walls. The crib is approximately 46 m long and 3 m wide. Along the length of the crib, approximately 1 m above the bottom, a perforated pipe has been installed that allows for distribution of the wastewater within the crib. A 2-m layer of gravel has been placed along the bottom of the crib to augment drainage. A polyvinyl chloride (PVC) membrane has been placed on top of the gravel and the trench backfilled with excavated soil. The dimensions of the crib and the orientation of the natural gradient are such that a two-dimensional analyses is appropriate for the simulation. The PORFLO-3 model was applied in a two-dimensional mode by assuming a unit thickness.

Operations records show that the average discharge to the crib is approximately 3,000 L/day. Assuming full use of the crib, this results in an average loading of approximately 14 L/m^2-day. This loading is far less than the typical design capacity of cribs suggesting that not all of the crib is being utilized. Facility design drawings indicate that the perforated pipe slopes downward from west to east. Therefore, the assumption was made that the wastewater would concentrate at the east end of the crib.

As discussed in Section 2.21.2, constituents of interest include: acetone, chromium, nitrate, tritium, strontium-90, uranium isotopes, and americium-241. Characteristics of the wastestream are summarized in Appendix C.

The 216-U-17 Crib is located in the 200 West Area. Depth to the water table is approximately 70 m. The soil column consists of both Hanford and Ringold formations sediments. A conceptual model of the soil column was prepared using the soil log from well 299-W19-26 (see Section 2.21). The soil column was divided into nine textural or hydrostratigraphic units. Eight units were located above the water table. Each unit is modeled as a horizontal homogeneous layer.

Figure D.2-2 depicts the thickness of each unit and general makeup of the soil contained in each unit. These descriptions and information on the textural composition for each unit were used as a basis to define the hydraulic characteristics used in the analysis. The approach consisted of selecting an appropriate moisture retention curve for each unit from a set of existing moisture retention curves. The existing moisture retention curves had been derived from laboratory analysis of soil samples collected at other locations on the Hanford Site.

The net rate of infiltration at the 216-U-17 Crib site was assumed to be 5 cm/yr. The initial soil moisture content in each of the layers was determined by applying the unit gradient model discussed in Section 2.3.

D.2.3 Numerical Model

As discussed previously, the soil column was modeled as nine layers. Eight of these layers were located above the water table. An estimate of the unsaturated hydraulic behavior (moisture retention characteristics) was made using an existing data base that consists of moisture retention curves compiled from analysis of various Hanford soils. These moisture curves were reviewed with respect to lithologic and textural considerations and a moisture retention curve was selected for each layer. The van Genuchten fitting parameters and saturated hydraulic conductivities were then assigned. Table D.2-1 is a summary of the van Genuchten parameters (a, n), saturated hydraulic conductivity (Ksat), specific storage (Ss), and initial pressure head or suction head assigned to each layer.

The general flow direction of the groundwater is from west to east as shown in Figure D.2-1. The hydraulic gradient of the saturated zone is about 5 ft/mi (0.001). The pressure head boundary condition for the saturated zone was set equal to zero. Zero flux was assigned for the vertical boundaries within the unsaturated zone. The upper boundary of the simulation domain is defined as a recharge boundary and set equal to the natural rate of infiltration. Nodes simulating the source (crib) are set as recharge nodes with appropriate values. Along the bottom is a zero no flux boundary. These conditions result in the lateral outflow of groundwater from the simulation domain.

The transport of contaminants is dominated by advection. The coefficient of diffusion for all species was assigned a value of 0.03 m^2/yr. The longitudinal and transverse dispersivities of the host medium were set at 1.0 m and 0.1 m, respectively. The assignment of these parameters is not considered critical to the current exercise. In general, the contaminant plume for a nonretarded (Kd = 0.0), conservative constituent was assumed and observed to track along the wetted front. It was also observed that lateral spreading of the plume was more a function of contrasting hydraulic conductivity and relative wetting than diffusion and/or dispersivity.

A conservative source term was defined that took into consideration the finite difference grid spacing used in the numerical model, and the design rate of infiltration, assuming that infiltration takes place over only a portion of the crib. The design rate of infiltration for liquid waste disposal facilities in the 200 West Area ranges from 40 to 200 L/m^2-day). A crib loading of 3,000 L/day requires a surface area ranging from approximately 15 m^2 to 75 m^2. The horizontal surface area associated with each node in the computational grid space is approximately 30 m^2. Therefore, it was assumed for this analysis, that the entire discharge (3,000 L/day) was distributed over one cell or grid space. This assumption resulted in assigning a rate of infiltration equal to 36.5 m/yr, rounded to 40 m/yr. As will be discussed, the results of the analysis show that the time required for wastewater to flow from the crib to the unconfined aquifer is relatively insensitive to this boundary condition.

The UO_3 process condensate is neutral to basic, high in dissolved solids, and high in organics. Under these conditions, the contaminants of interest tend to be mobile. An effective retardation coefficient of unity was assumed for all contaminants except strontium-90. Strontium-90 was assigned an R_f of 10.

Two cross-sections were considered for modeling. One cross-section was along the center line of the crib, and the other was perpendicular to the centerline. However, because the entire source was assigned to a single cell, only one discretization of the spacial domain was prepared.

Discrete nodes are defined by the intersection of horizontal and vertical grid lines. Parameters (pressure, hydraulic conductivity, etc.) are defined at each node. A variable grid spacing was used where steep gradients were anticipated to help alleviate computational difficulties. For example, variable spacing was used to transition between the various hydrostratigraphic units or soil layers. Figure D.2-3 shows the grid spacing used in the analysis. The grid consists of 40 columns and 50 rows. The minimum horizontal surface area associated with each vertical cell is approximately 30 m^2.

D.2.4 Results

The net natural recharge or rate of infiltration is 5 cm/yr. This rate of infiltration is low compared to the recharge due to disposal of liquid effluent to the crib. Therefore, once the crib begins operation, the soil column beneath the crib begins to wet.

Prior to crib startup, the moisture content in all layers is less than saturation. Figure D.2-4 shows the variation in moisture content as a function of relative saturation. The initial conditions represented by this figure were calculated using the unit gradient model (Appendix B). As shown in Figure D.2-4, a true steady-state solution had not been established. This is evidenced by the high moisture contents that exist immediately above the gravel layer (elevation 178 m) and the layer of caliche at elevation 155 m. It was determined that this approximation was adequate to initiate the simulated operation of the crib.

Operation of the crib was simulated as increasing from zero inflow to the average volumetric inflow over a 1-mo period. Following the start of crib operation, moisture content in the soil beneath the crib was observed to increase. The wetting front moved downward under the influence of gravity. At the end of 1 yr, the plume had migrated a depth of approximately 20 m as shown in Figure D.2-5. Some horizontal spreading of the plume is shown.

Figure D.2-6 shows the moisture content relative to saturation of the various hydrostratigraphic units at the end of 2 yr. At this time, the wetted front has reached the gravel layer (elevation 178 m). This gravel layer acts as a hydraulic barrier to flow, forcing the water to mound above it as shown in Figure D.2-7. This mounding continues until the pressure head becomes sufficient to overcome the resistance to flow; wetting of the gravel layer follows. Figure D.2-7 shows the relative saturation of the layers at the end of 3 yr.

Another hydraulic barrier to flow exists at elevation 155 m, where a caliche layer is encountered. Similar to the layer of gravel, as wetting of this layer occurs, a groundwater mound is formed. Figure D.2-8 shows the moisture content at the end of 5 yr. Figures D.2-9 and D.2-10 show the moisture content at the end of 10 and 15 yr, respectively. At the end of 15 yr, the wastewater has penetrated the layer of caliche. The wastewater reaches the water table a short time later (16.6 yr).

As shown in Figure D.2-11, at 20 yr, the wastewater has reached the water table. The response of the wastewater plume to the establishment of saturated flow conditions is shown in Figures D.2-12, D.2-13, and D.2-14. These figures show the simulated moisture content in the soil column beneath the crib at 25, 30, and 35 yr, respectively.

A parametric analysis was performed to evaluate the effect on the time required to wet the soil column of different unit loadings (length/time) to the crib. This analysis restrained infiltration to a single cell. The unit loading was arbitrarily increased to twice (2X) and five (5X) the average or nominal unit loading (infiltration rate) of approximately 40 m/yr. The results from these analyses expressed in terms of arrival time of the wetting front are summarized as follows:

Flow rate	40 m/yr	80m/yr	200 m/yr
First Arrival - increase in moisture content above the water table (yr)	16.4	14.9	13.6
Saturation of soil above the water table (yr)	16.6	15.1	13.8

These results show surprisingly little difference in the time required for the wastewater to break through to the unconfined aquifer. This suggests that the hydrologic structure and, in particular, the layer of caliche controls the flow.

As discussed previously, it is assumed that most of the constituents with the exception of strontium-90 will migrate at the same rate as the wetted front. Strontium-90 is assumed to move at a rate one-tenth that of the other constituents.

D.2.5 Conclusions

The effect of soil layering on the development of a plume beneath an operating crib is emphasized in the preceding analyses. It is estimated that the two hydraulic barriers account for more than half the time (10 yr) required for the wetting front to reach the water table. In addition, as the discharge to the crib increases, the ponding of water and lateral spreading above the layer of caliche is extensive. Under these conditions, it is possible that the wastewater could migrate a considerable distance laterally before breakthrough to the groundwater occurs. If a path of less

resistance is encountered, the wastewater will follow this path. Such a situation is discussed by Baker et al. (WHC 1988) on the mobilization of uranium beneath the 216-U-1/2 cribs resulting from the operation of the 216-U-16 Crib.

For all loadings, the wetted front migrates relatively slowly. Under these conditions, most organics and short half-life radionuclides will be attenuated or decayed away. Furthermore, it is suggested that future operation of the crib could be improved through cation exchange if the wastewater were neutralized and the organic and inorganic loading reduced.

Figure D.2-1. Site Map of Active 216-U-17 Crib Showing Well Locations.

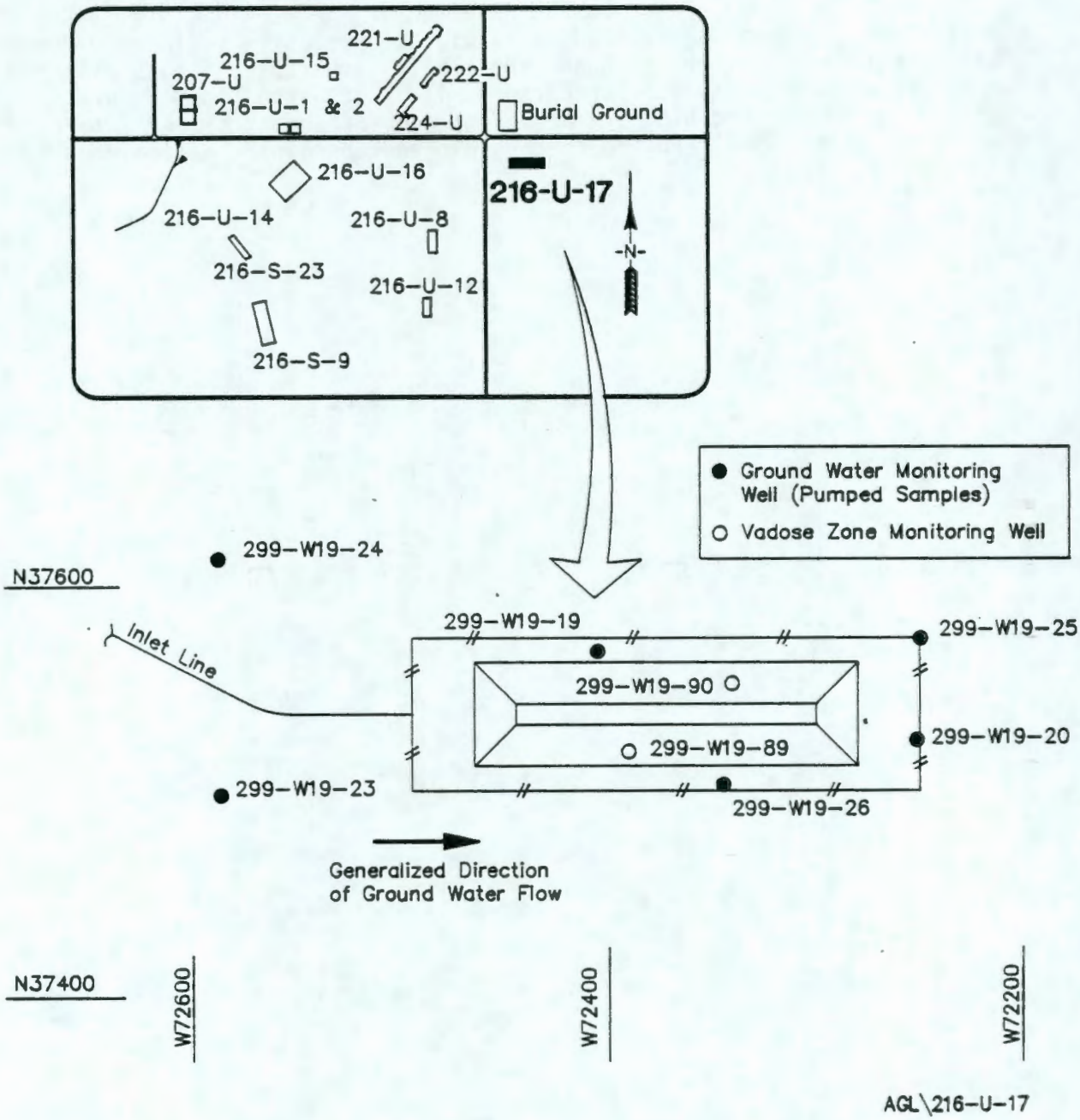


Figure D.2-2. Longitudinal Cross-Section of Stratigraphy Under the 216-U-17 Crib.

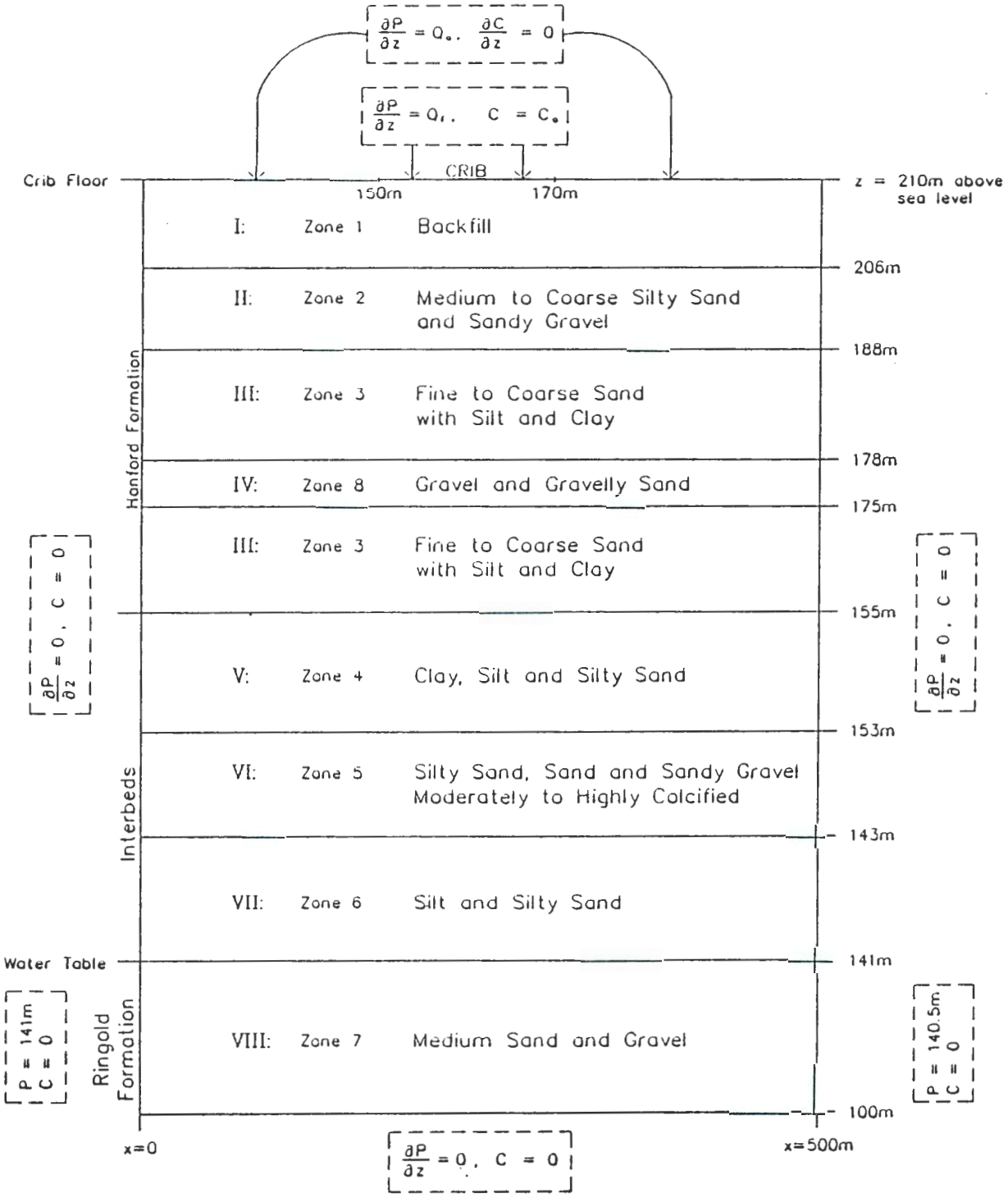


Table D.2-1. Summary of Hydraulic Properties and Initial Soil Matric Potential for 216-U-17 Crib Model

Layer	Thickness (m)	Ksat (m/hr)	a (m)	n (unitless)	Ss (1/m)	Initial (m)
1	4	0.071	0.0117	1.343	0.4	-0.1
2	18	0.044	0.0253	1.346	0.4	-0.2
3	10	0.001	0.5118	1.318	0.3	-0.5
4	3	0.010	0.0477	1.341	0.4	-0.35
5	20	0.001	0.5118	1.318	0.3	-0.5
6	2	0.008	0.0205	1.300	0.4	-0.9
7	10	0.002	0.8475	1.395	0.5	-0.5
8	2	0.292	0.2024	3.286	0.4	-0.1
9	41	0.065	-	-	0.6	0

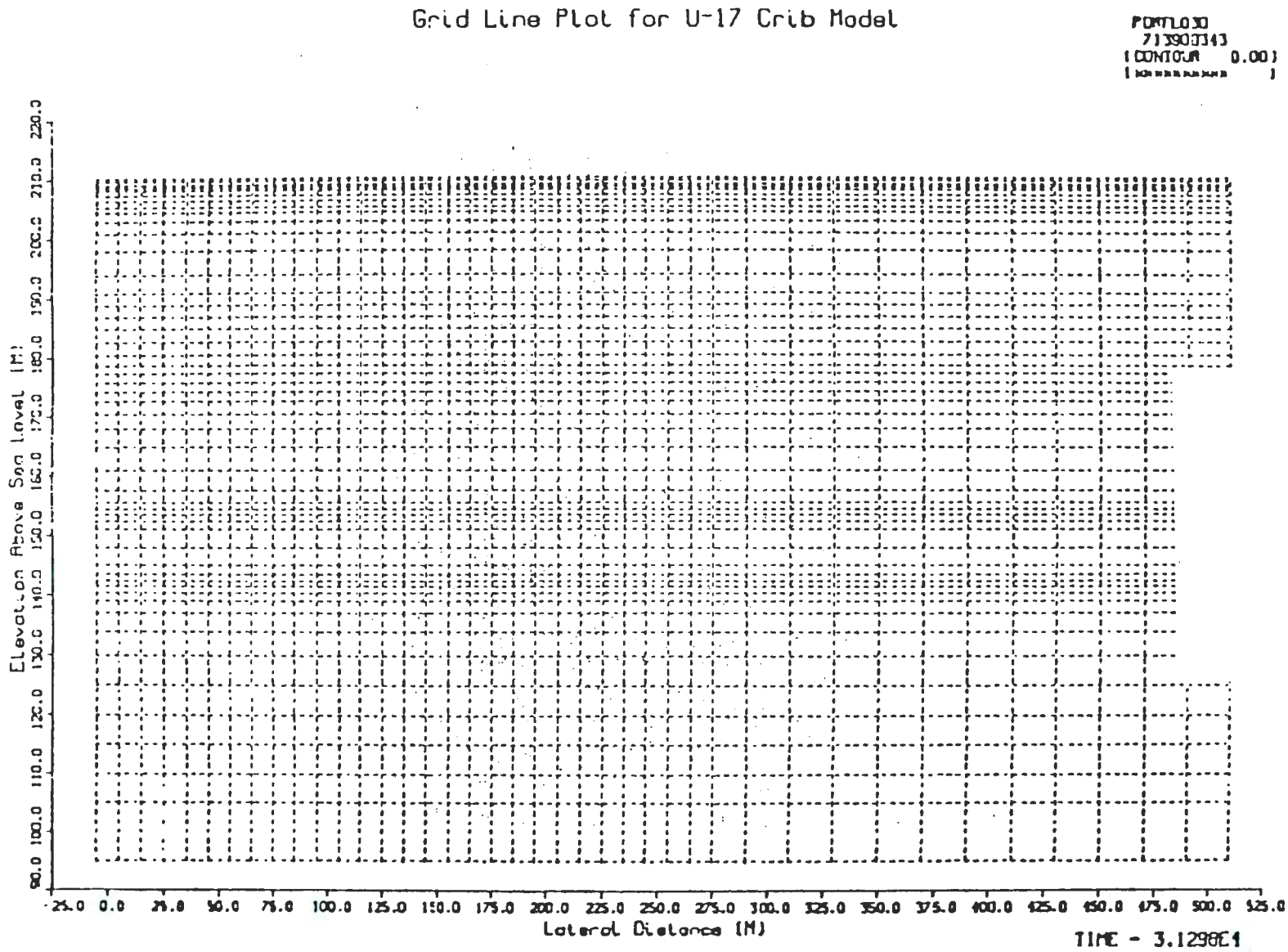


Figure D.2-3. Finite Difference Grid for the 216-U-17 Crib.

Figure D.2-4. 216-U-17 Crib: Steady-State Relative Saturation.

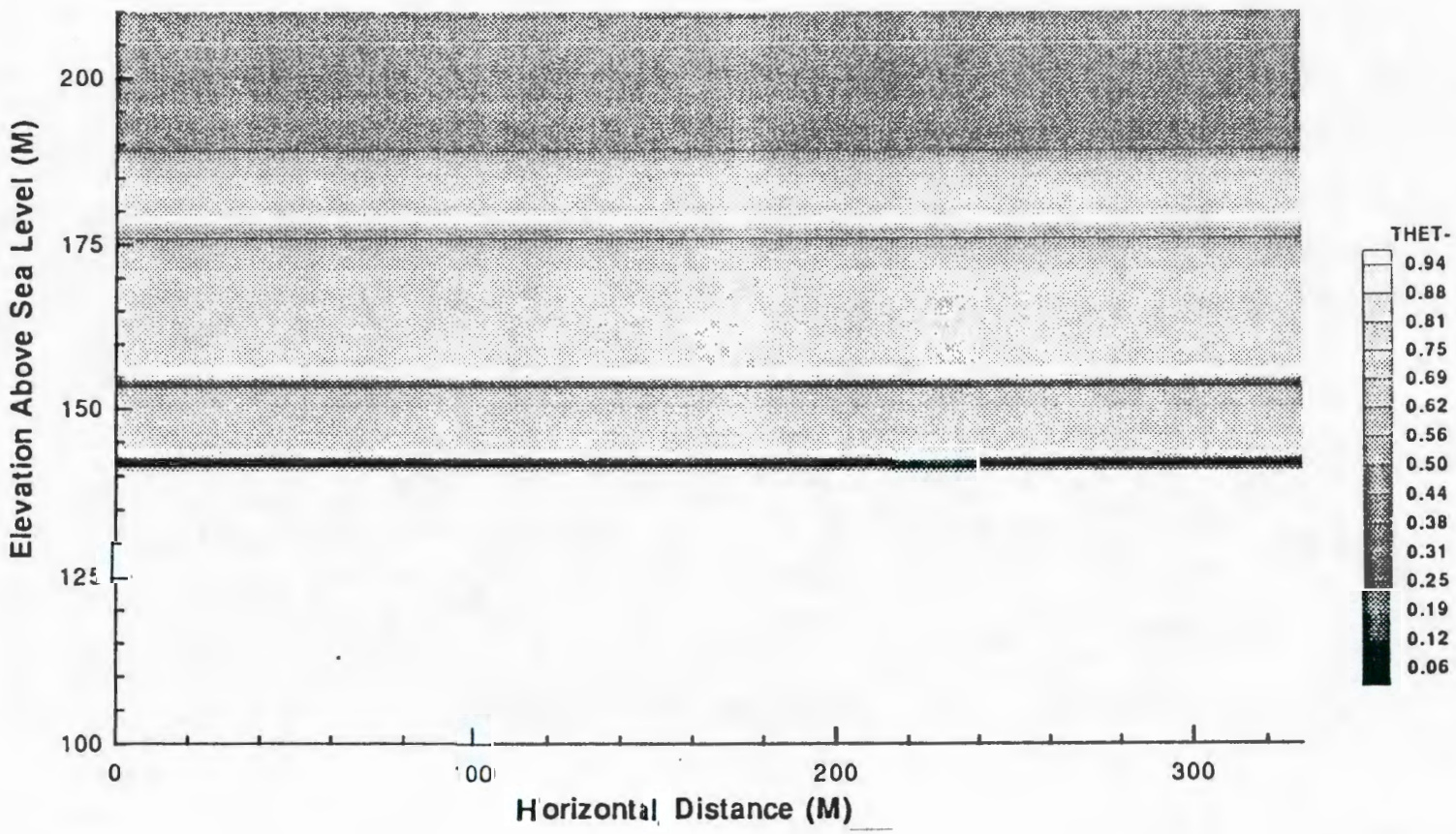


Figure D.2-5. 216-U-17 Crib: Relative Saturation Content at 1 Yr.

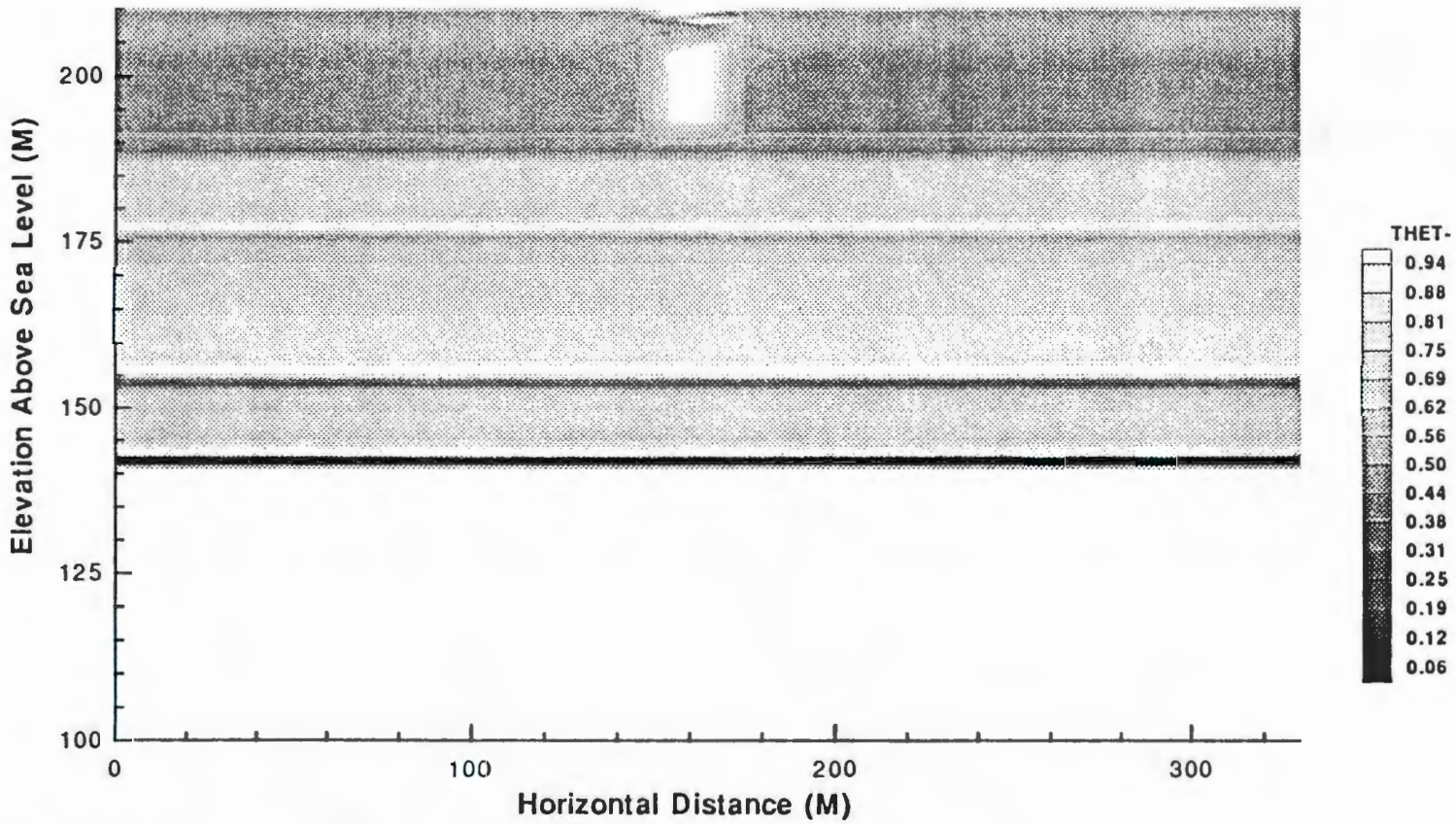


Figure D.2-6. 216-U-17 Crib: Relative Saturation Content at 2 Yr.

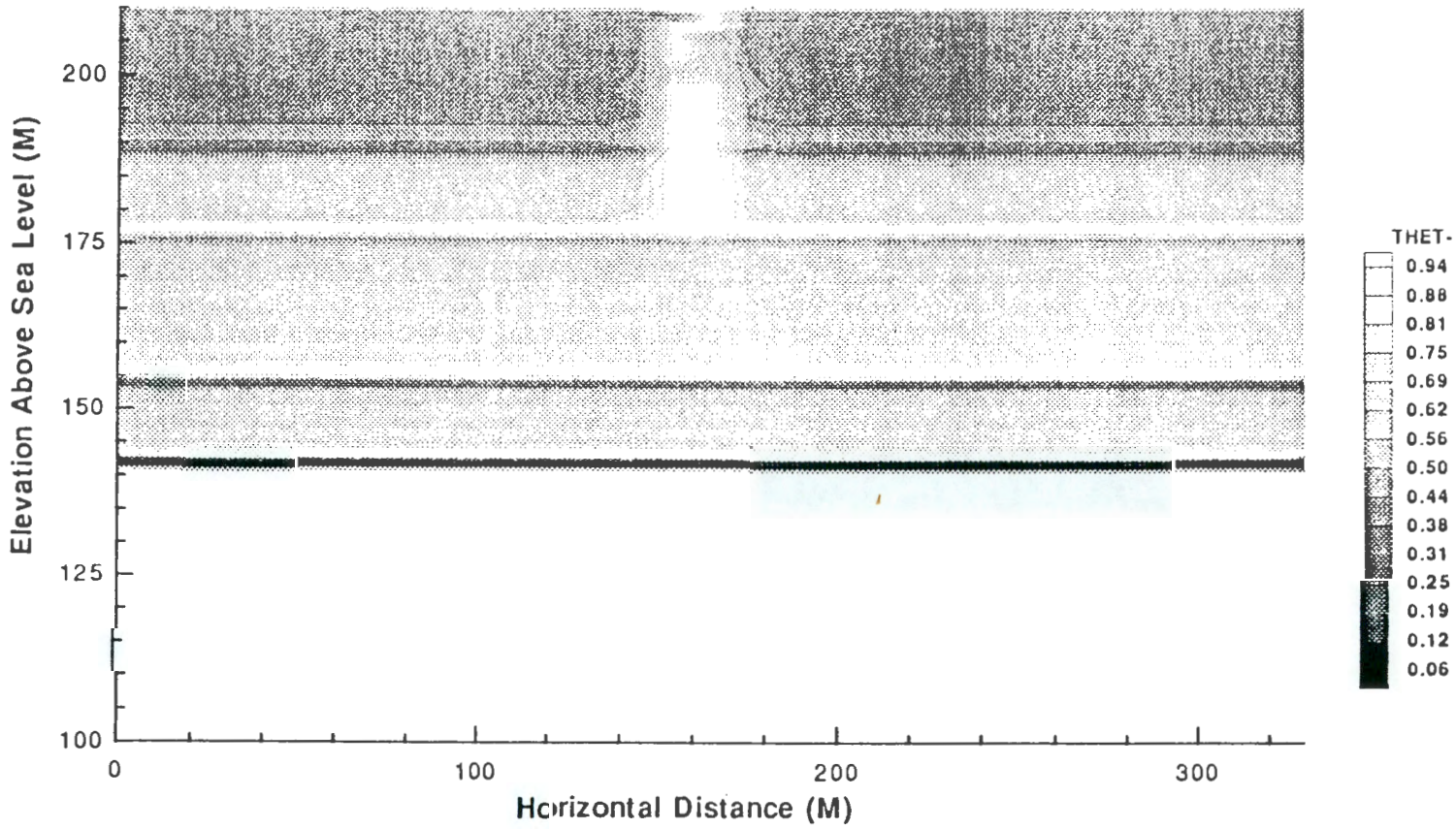


Figure D.2-7. 216-U-17 Crib: Relative Saturation Content at 3 Yr.

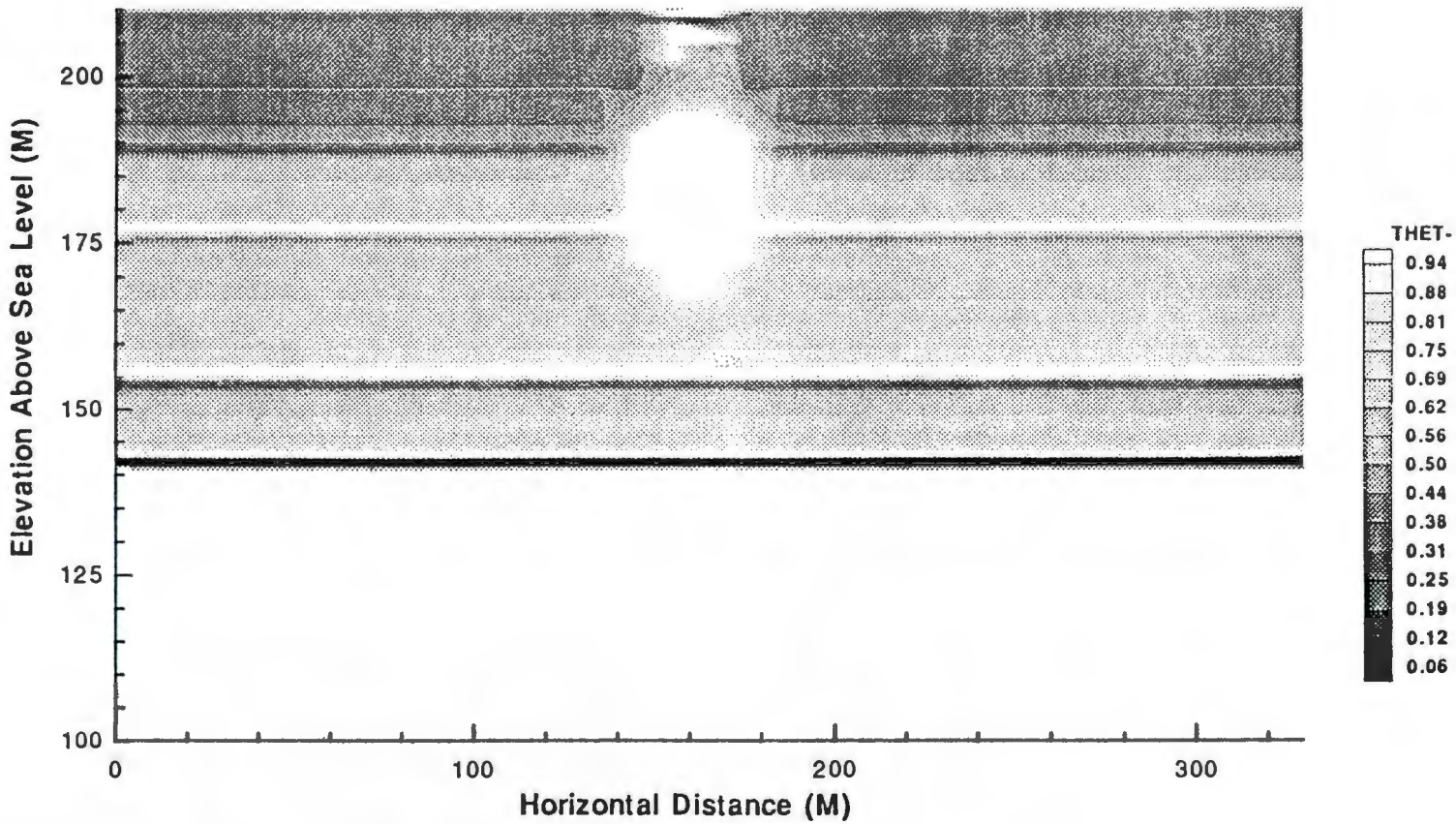


Figure D.2-8. 216-U-17 Crib: Relative Saturation Content at 5 Yr.

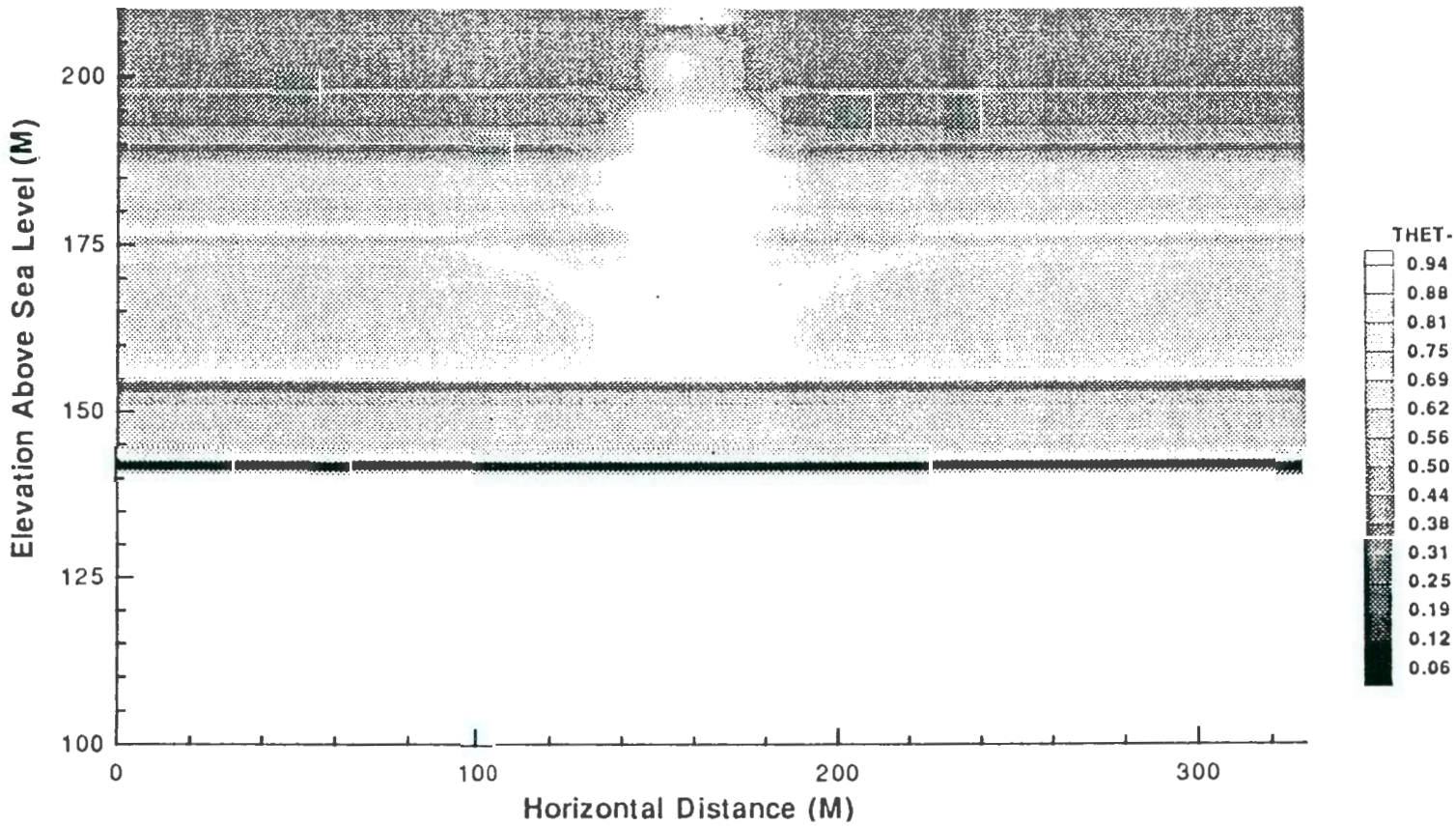


Figure D.2-9. 216-U-17 Crib: Relative Saturation Content at 10 Yr.

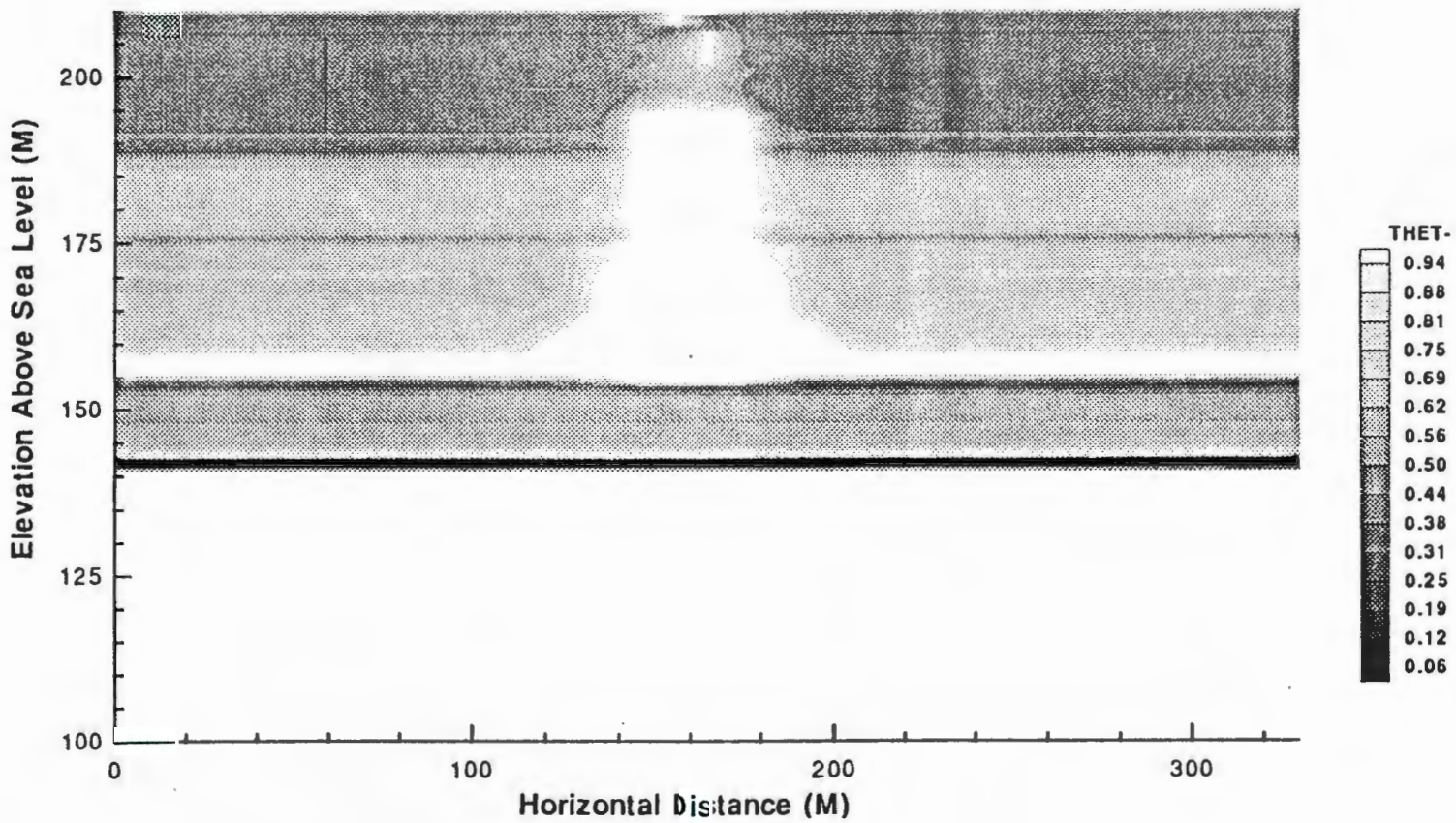


Figure D.2-10. 216-U-17 Crib: Relative Saturation Content at 15 Yr.

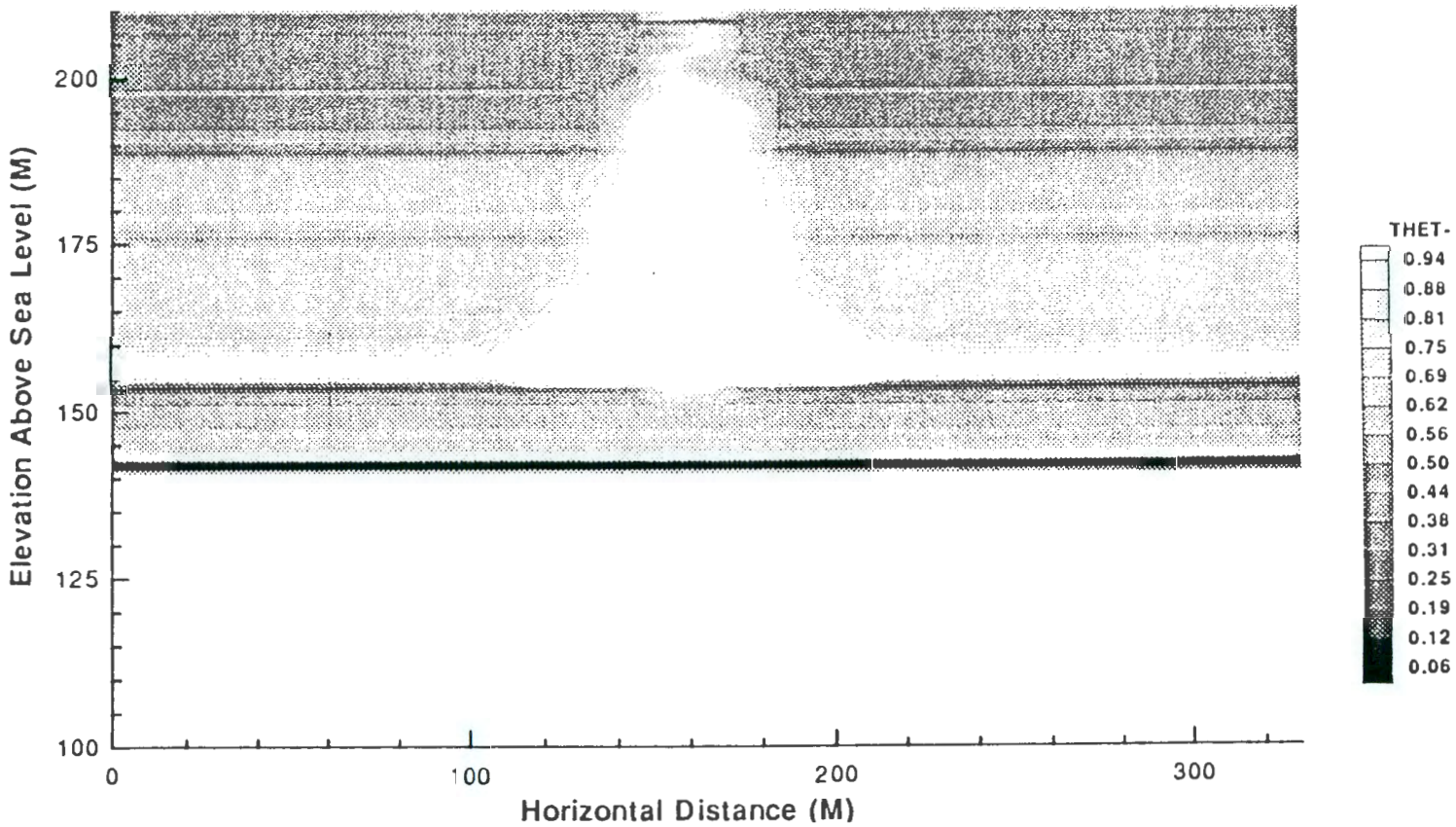


Figure D.2-11. 216-U-17 Crib: Relative Saturation Content at 20 Yr.

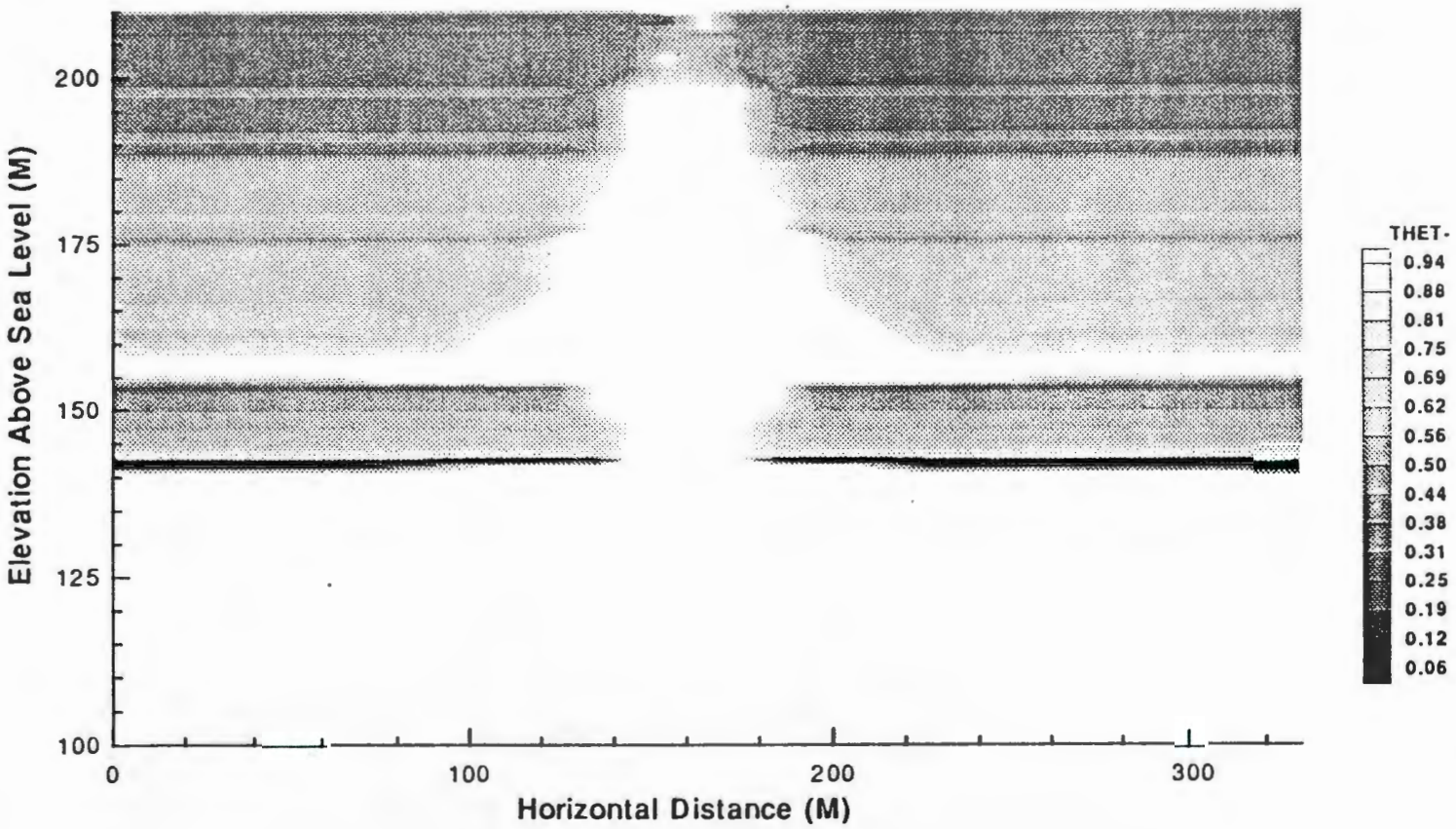


Figure D.2-12. 216-U-17 Crib: Relative Saturation Content at 25 Yr.

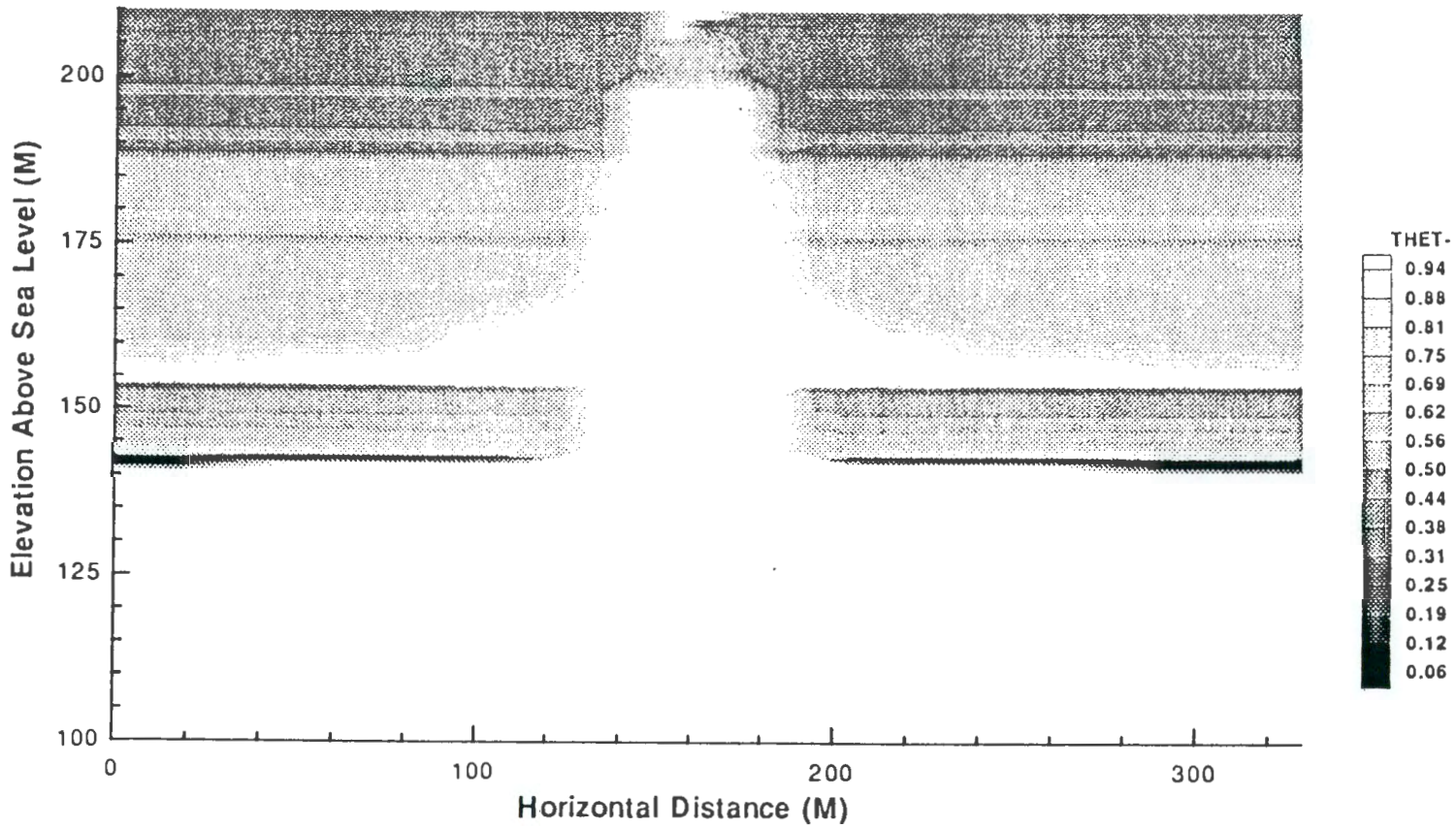


Figure D.2-13. 216-U-17 Crib: Relative Saturation Content at 30 Yr.

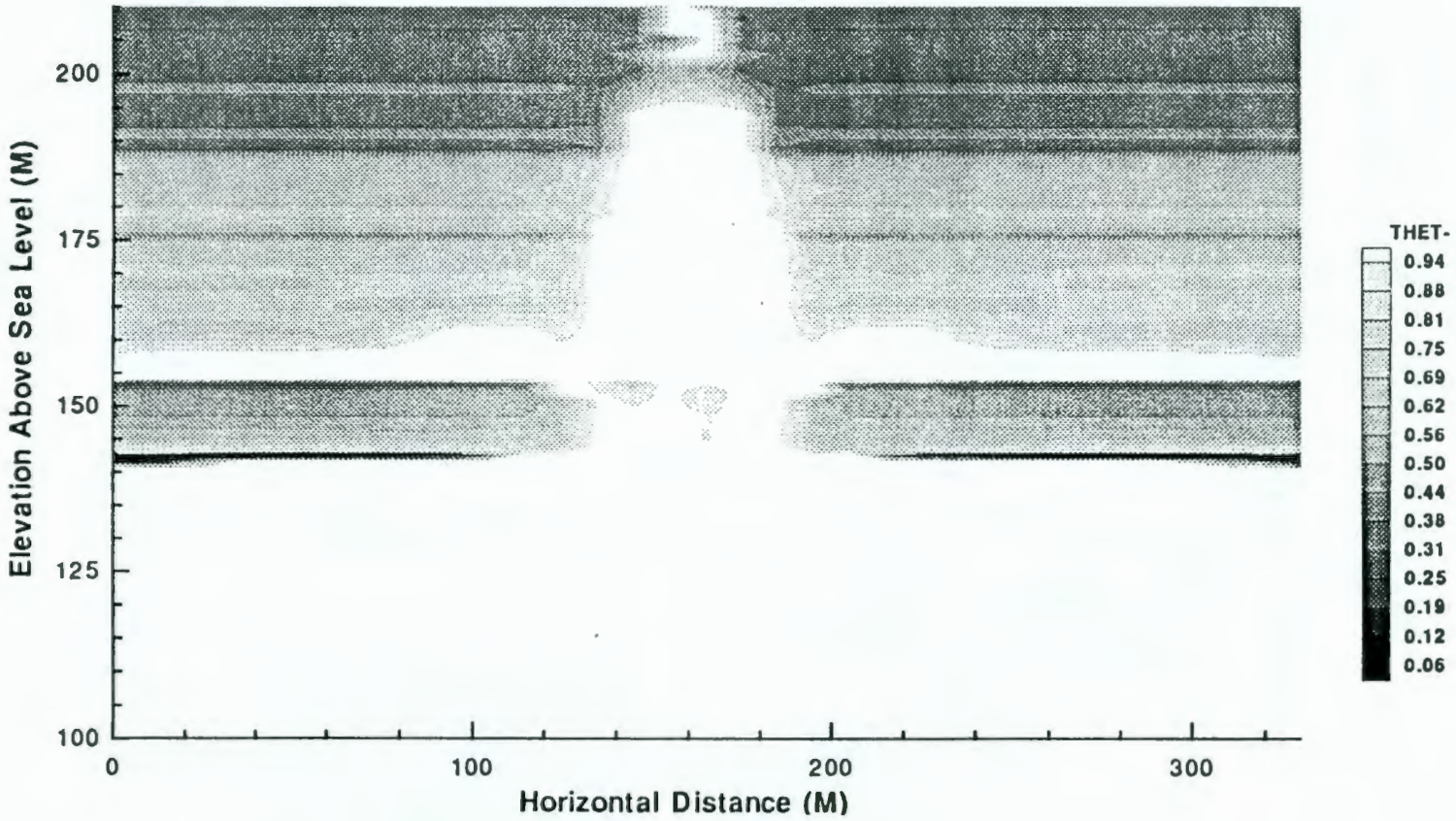
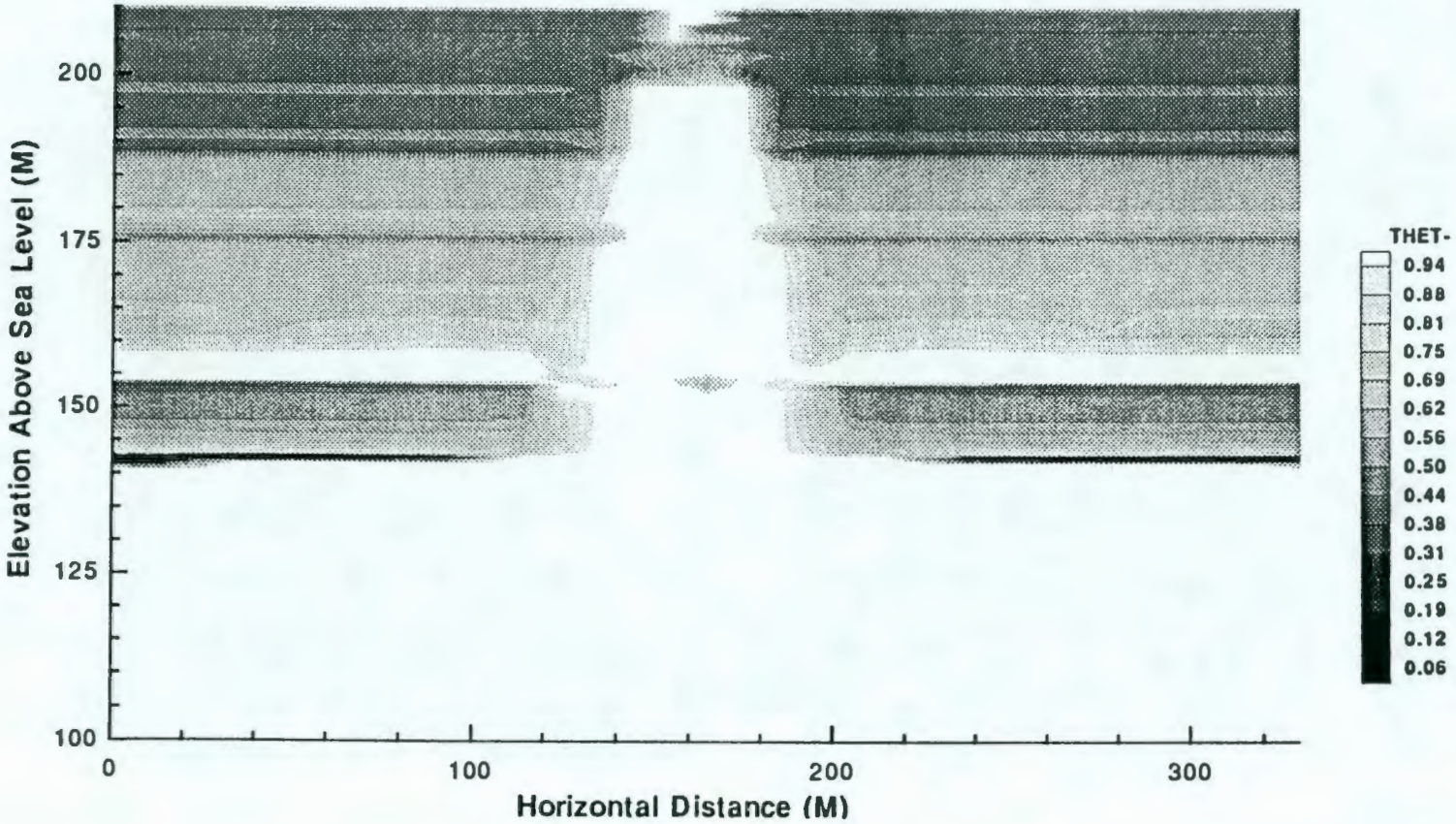


Figure D.2-14. 216-U-17 Crib: Relative Saturation Content at 35 Yr.



D.3 216-A-30 CRIB FLOW AND TRANSPORT ANALYSES

D.3.1 Introduction

The 216-A-30 Crib is located outside of the main 200 East Area, a few hundred feet east of the main perimeter fence. The 216-A-37-1 and 216-A-37-2 cribs are located to the northeast and are within 100 ft of the 216-A-30 Crib. Depth to the water table is approximately 76 m below land surface. The Hanford formation extends to the water table and consists of glacio-fluvial deposits of silt, sand, and gravel. The geology in this part of the Hanford Site is relatively uniform and consistent. Therefore, the geo-hydrologic conceptual and numerical models defined for the 216-A-30 Crib site can be applied to evaluate the flow and transport characteristics beneath the 216-A-37-1 and 216-A-37-2 cribs.

D.3.2 Conceptual Model

A plan view showing the spatial relationship and orientation of the three cribs is provided in Figure D.3-1. Each of these cribs is a trapezoidal trench excavated to a depth of 10 to 15 ft. A layer of gravel has been placed along the bottom of each crib. Soil is used as backfill to bring the elevation of the finished facility up to grade. The bottom of each trench is about 10 ft wide. Both the 216-A-37-1 and 216-A-37-2 cribs are 700 ft long, whereas the 216-A-30 Crib is 1,400 ft long.

The 216-A-30 Crib has been in operation since 1961 and receives steam condensate wastewater from the PUREX Plant. Over the years, the volumetric flow rate to the facility has averaged approximately 7 L/sec. As discussed in Section 2.6.3, the key constituents of primary interest are strontium-90 and cesium-137. In addition, the potential migration of uranium that was accidentally released to the facility is examined.

The 216-A-37-1 Crib has been in operation since 1977. This disposal facility receives wastewater in the form of process condensate from the 242-A Evaporator. As discussed in Section 2.8.3, over the years, the average volumetric discharge to the crib has averaged about 1 L/sec. The key constituents include: strontium-90, cesium-137, tritium, ruthenium-106, acetone, and MEK. Of these constituents, only tritium has been measured in the groundwater.

The 216-A-37-2 Crib has been in operation since 1983. The facility receives steam condensate from the PUREX Plant. The volumetric discharge to the facility has averaged 5.1 L/sec. Of the three adjacent cribs, unit loading (volumetric flow rate/unit surface area) is the highest to the 216-A-37-2 Crib. As discussed in Section 2.9, the PUREX Plant steam condensate consists primarily of condensed steam and warm untreated Columbia River water. Strontium-90, cesium-137, and uranium have been identified as constituents of interest (Section 2.9.3), although the concentration for these constituents is within regulatory limits.

Although these three cribs are relatively close to one another and have been operated concurrently, no interaction between the resulting wastewater plumes was hypothesized prior to performing the analysis.

A conceptual model of the soil column was prepared using the soil log collected during the drilling of the 299-E16-2 Well (see Section 2.6). An eight-layer model that consists of various gradations of sand, silt, and gravel was used for purposes of analysis. This conceptual model is depicted in Figure D.3-2. The vadose zone was modeled as eight layers with the unconfined aquifer simulated by one of the layers. The initial moisture content in each of the layers was defined using the unit gradient model. The steady-state natural recharge rate was assumed to be 5 cm/yr. The artificial recharge (crib loading) distributed uniformly over the crib.

D.3.3 Numerical Model

The PORFLO-3 finite difference nodal point integration groundwater flow and transport model (WHC 1990) was used for purposes of numerical simulation. Model setup (gridding, zoning, material specification, and assignment of initial and boundary conditions) was similar to the approach discussed in Section D.2.3. A two-dimensional cross section perpendicular to the crib centerline was assumed for purposes of analysis. The computational grid that was used is shown in Figure D.3-3. This grid consists of 18 columns and 46 rows. The density of the rows (number of rows per stratigraphic unit) is less than the computational grid used for numerical analysis of the 216-U-17 Crib since the geology appeared to be more uniform.

The soil column was modeled as eight hydrostratigraphic units. The approach described in the 216-U-17 Crib discussion was used to assign the hydraulic properties to each of these units. The van Genuchten fitting parameters (a, n) and Ksat were assigned to each of the layers. A summary of the hydraulic information used during the 216-A-30/A-37-1/A-37-2 crib analysis is provided in Table D.3-1. In addition to these conductivities, a longitudinal and transverse dispersivity of 1.0 m and 0.1 m, respectively, were assigned to each of the stratigraphic units. The assignment of these dispersivities is not critical to the analysis.

Individual source terms were assigned to the operation of each crib. A summary of loading (m/yr) and list of potential contaminants for each disposal facility is provided in Table D.3-2. Because the minimum loading was calculated to be over 40 m/yr, it was assumed that infiltration occurred over the entire bottom area of the crib. As discussed in Appendix C, the wastestream characteristics for the two streams of interest, PUREX steam condensate and 242-A Evaporator process condensate are different. The steam condensate is low in dissolved solids, low in organic content, and neutral to basic; whereas, the process condensate from the evaporator is high in both dissolved solids and organics and neutral to basic. This difference affects the sorptive nature of strontium-90, uranium, and cesium-137. The R_f assigned to each contaminant of interest is included in Table D.3-2.

Although the transport of contaminants is dominated by the convective or advective processes, an effective liquid diffusion coefficient of 0.03 m^2/yr is assigned to each of the soluble contaminants.

D.3.4 Results

In this study, primary emphasis was placed upon modeling flow and simulating the development of the wastewater plume that forms beneath each of the three cribs. The following discussion covers the simulated development of the wastewater plume beneath each of the cribs. These modeling results have not been confirmed through field measurement. A cursory check on time of travel estimates is included using data on the migration of tritium away from the 216-A-37-1 Crib. The discussion is organized into two sections (flow and transport) to highlight the findings.

D.3.4.1 Flow. Using a rate of 5 cm/yr natural infiltration, the unit gradient flow model (Appendix B) estimated the initial moisture content in each of the hydrostratigraphic units. The numerical simulation model was then balanced to adjust these estimates over a 1-yr simulation period to smooth the transitions between soil layers. The distribution of the steady-state moisture content (initial condition) is the same for all three cases and is shown in Figure D.3-4. After steady-state moisture content was attained, the flow from the cribs was initiated. Flow rate to each of the cribs was increased from zero to the average flow rates (hydraulic loading) tabulated in Table D.3-2 over a simulated 1-mo period.

The development of the wastewater plume beneath the 216-A-37-1 Crib is shown in Figures D.3-5 through D.3-9. Although the loading to 216-A-37-1 Crib is approximately the same as the loading applied to the 216-U-17 Crib, 49 m/yr versus 40 m/yr, the time required for wastewater to flow from the crib to the water table is much less than calculated in Section D.2. As shown in Figure D.3-5, a minor hydraulic barrier is encountered approximately 20 m below the surface. This barrier reflects the transition from sand to sand and gravel as shown in Figure D.3-2. However, as shown in Figure D.3-6, after less than 1 yr, the wetting front has moved past this barrier and encountered another minor barrier at a depth of approximately 50 m below the surface. Once again, this barrier reflects a transition from a sand into a sand and gravel. Breakthrough occurs before the end of the third year as shown in Figure D.3-7. A more detailed examination of the time required for the wastewater to breakthrough to the groundwater is provided through examination of the moisture content in a computational cell located directly above the water table and beneath the crib. Figure D.3-10 shows the increase in relative saturation as the wetting front approaches the water table. Figures D.3-8 and D.3-9 present the moisture distribution at 4 and 7 yr, respectively, after initiation of crib operation.

The development of the wastewater plume beneath the 216-A-30 Crib is provided in Figures D.3-11 through D.3-14. Figure D.3-11 is identical to Figure D.3-5 and reflects the steady-state moisture distribution prior to crib startup. Figures D.3-12, D.3-13, and D.3-14 depict the simulated moisture distributions at the end of 1 yr, 2 yr, and 3 yr, respectively. As summarized in Table D.3-2, the hydraulic loading to the 216-A-30 Crib is approximately four times greater than the loading to the 216-A-37-1 Crib, and this difference is reflected in the rate at which the wastewater wets

the soils beneath the crib. The amount of ponding that occurs above the two hydraulic barriers discussed in the previous paragraph is also greater. Breakthrough to the water table is calculated to occur 2 yr after operation of the crib is initiated.

Figures D.3-15 through D.3-17 depict the development of the wastewater plume beneath the 216-A-37-2 Crib. The volumetric flow rate to this crib is approximately six times greater than the volumetric flow rate assigned to the operation of the 216-A-37-1 Crib. As expected, breakthrough to the water table is calculated to take place shortly before the end of year two (1.8 yr), and the extent of ponding is greater than for the two previous cases.

As shown in Figures D.3-13 and D.3-16, as the wastewater plume develops beneath each of the cribs, the lateral spreading of the wastewater is extensive. This lateral spreading is calculated to extend 30 to 35 m beyond the edge of the crib. It is concluded that the clustering and concurrent operation of the three cribs could result in overlapping of plumes in the vadose zone during the plume's development. This potential for coalescing was not taken into consideration when modeling each of the plumes. The effect of this changing boundary condition on these results (Figures D.3-5 through D.3-17) is unknown. It is probable that the joining of plumes would reduce the time required to saturate the soil column. As indicated in Figures D.3-9, D.3-14, and D.3-17, once the soil column has been wetted and breakthrough has occurred, the plumes from each the cribs are much more confined and no interaction or overlap is anticipated.

D.3.4.2 Transport. As summarized in Table D.3-2, the potential contaminants of concern include: strontium-90, cesium-137, tritium, ruthenium-106, uranium, acetone, and MEK. Tritium, ruthenium, acetone, and MEK will essentially move with the wastewater and not be sorbed or interact with the surrounding sediments. As discussed in Appendix C, acetone is expected to degrade, whereas MEK is more stable. The radiogenic half-life for tritium is 12 yr, whereas the radiogenic half-life for ruthenium-106 is approximately 1 yr. The R_d for strontium-90 is estimated to range from 35 to 125, from 1 to 10 for uranium, and from 50 to 250 for cesium-137. The half-life for uranium, strontium, and cesium are 23 million years, 29 yr and 30 yr, respectively.

A preliminary evaluation on the transport behavior of tritium and cesium released to the 216-A-37-1 Crib was performed. The calculated time required for tritium to migrate through the soil column to the unconfined aquifer was compared to in situ measurements. The transport of cesium was selected on the basis that this radionuclide is the least mobile of the six identified contaminants and therefore reflects a lower bound on the extent of migration.

Figures D.3-18 and D.3-19 provide information of the concentration of tritium measured in the wastewater discharged to the 216-A-37-1 Crib and the groundwater near the crib between July 1983 and April 1988. Of interest is the time delay between the peak of disposal and the peak of arrival for this situation. Based upon the information provided in these two figures, the time of travel for wastewater to flow from the crib into the groundwater is less than 16 mo.

An analysis was performed that assumed tritium was introduced at a constant rate and uniform concentration (unity) a short time after breakthrough had occurred. The results from this analysis are presented in Figures D.3-20 through D.3-23. These figures show the calculated normalized concentration of tritium at 3 mo, 6 mo, 1 yr, and 2 yr after the release was initiated. As shown in Figure D.3-23, tritium is calculated to arrive at the water table approximately 1 yr after the release was initiated. Figure D.3-24 shows in more detail the arrival of tritium at the water table. This figure plots the relative concentration that results from a pulse release (unit release for 7 days) as a function of time. No attempt was made to simulate the transport of tritium in the groundwater. The direction of flow and existing hydraulic gradient were not explicitly factored into the analysis.

Figure D.3-25 shows the migration of the cesium plume 3 yr after cesium is introduced to the crib. As expected, little migration is observed.

A parametric analysis was performed to evaluate the transport of uranium accidentally released into the 216-A-37-2 Crib. Two values for the R_f were assigned, 1 and 10. The release of uranium was assumed to occur subsequent to breakthrough. The travel time for uranium to migrate through the soil column is estimated to range from a few months to approximately 3 yr. These results are summarized in Figure D.3-26.

D.3.5 Conclusions

Based upon the flow and transport analyses presented in Section D.3, the following conclusions are drawn:

- The time of travel for wastewater to migrate from the 216-A-30/A-37-1/A-37-2 cribs to the groundwater is substantially less than the time (months to years versus tens of years) required for similar migration beneath the 216-U-17 Crib.

- The time required to establish the moisture plume beneath the 216-A-30/A-37-1/A-37-2 cribs ranges between less than 2 to less than 3 yr. Once the moisture plume has been established, the time of travel is reduced. In the case of the 216-A-37-1 Crib, this reduction is from less than 3 yr total travel time for the wastewater to less than 1 yr for the travel time of water.

- The simulated time of travel once the plume has been established, agrees with tritium concentration data collected in the field.

- The steady-state time of travel for the 216-A-37-1 Crib was estimated to be 250 days or approximately 8 mo using the unit gradient model. For this application, results from application of the unit gradient model compare reasonably well with the results from the numerical simulation.

- Little migration of strontium-90 and cesium-137 is anticipated.

Figure D.3-1. Site Map of Active 216-A-30 Crib Showing Well Locations.

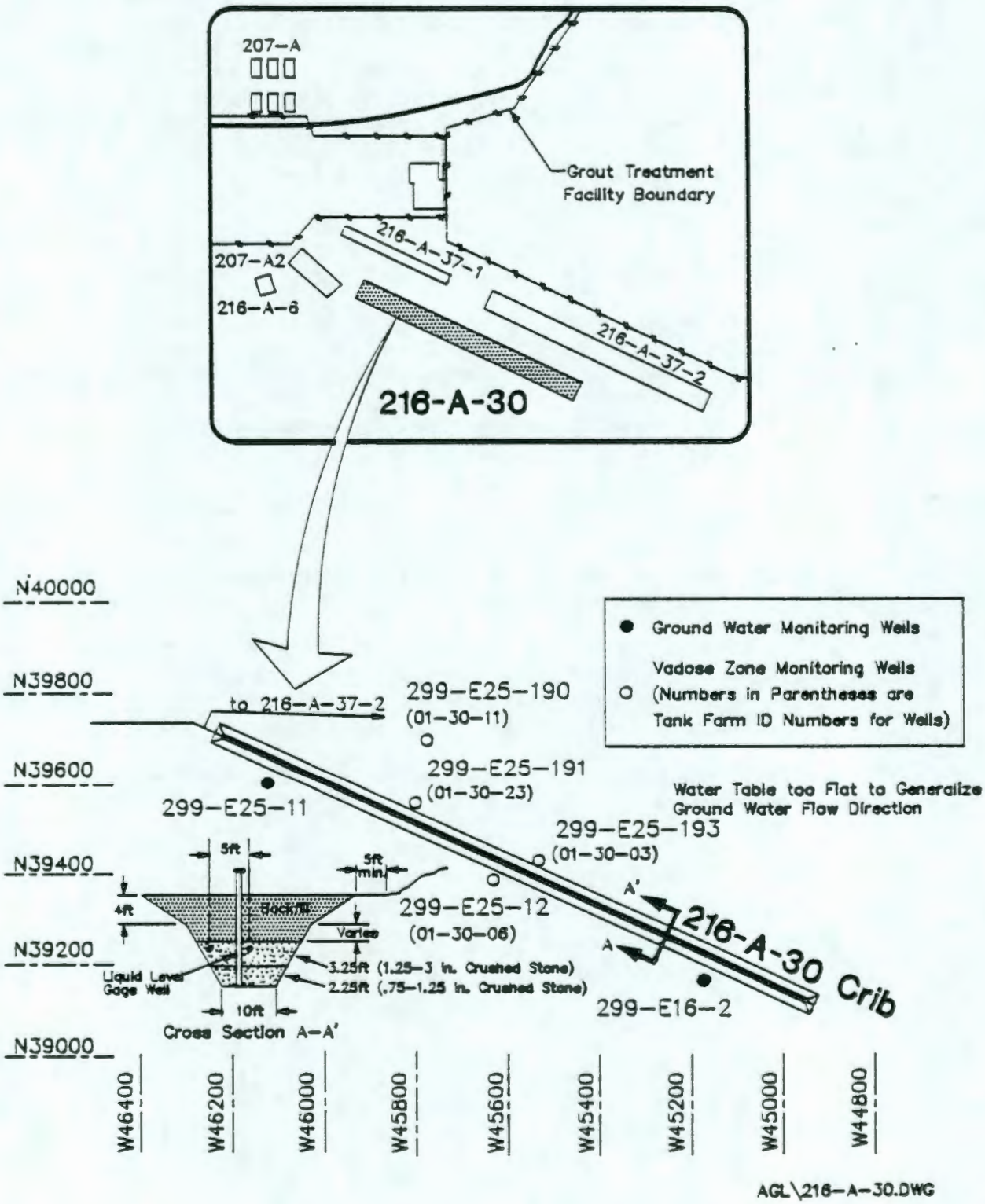
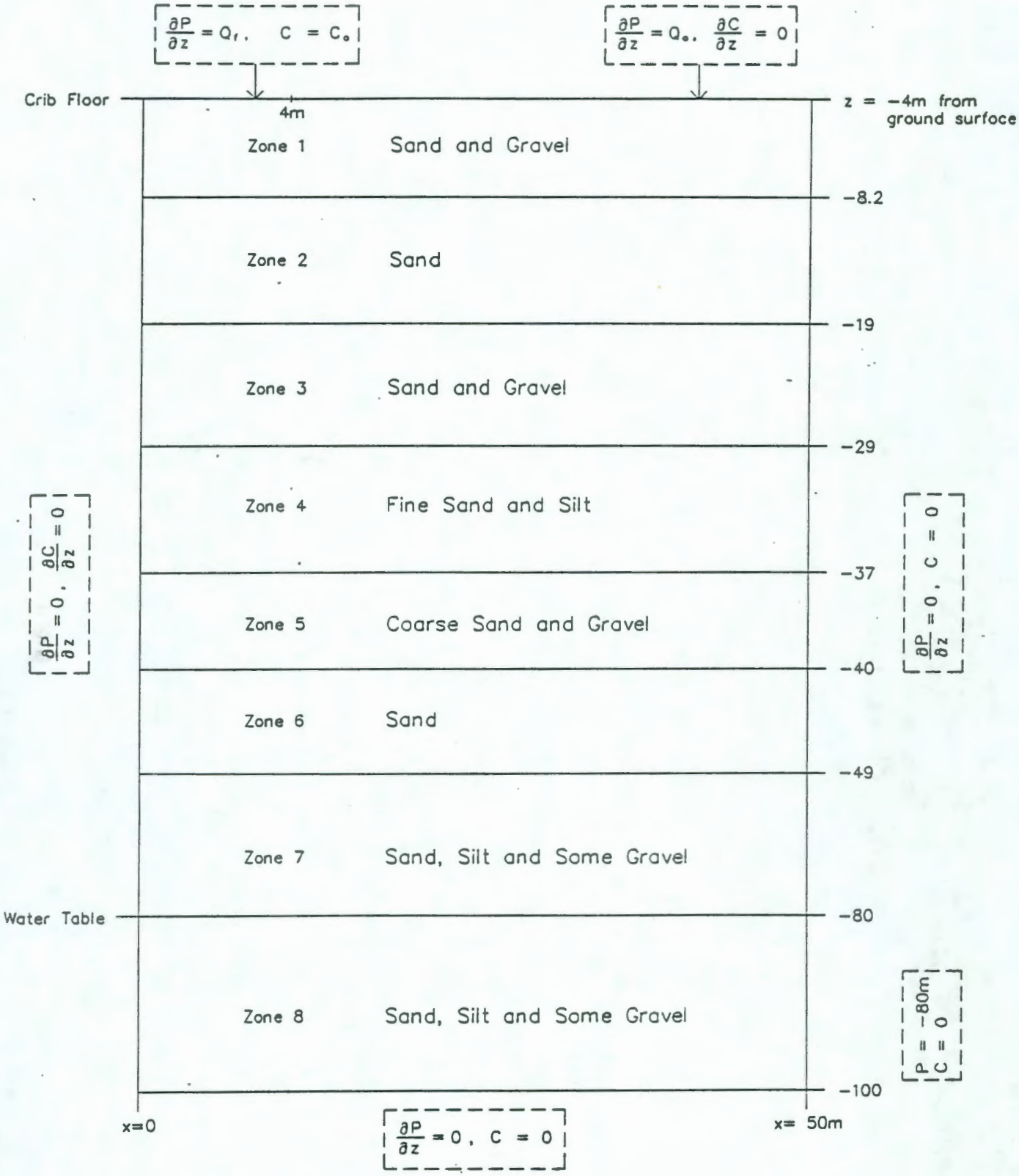


Figure D.3-2. Transverse Cross Section of Stratigraphy Under the 216-A-30 Crib.



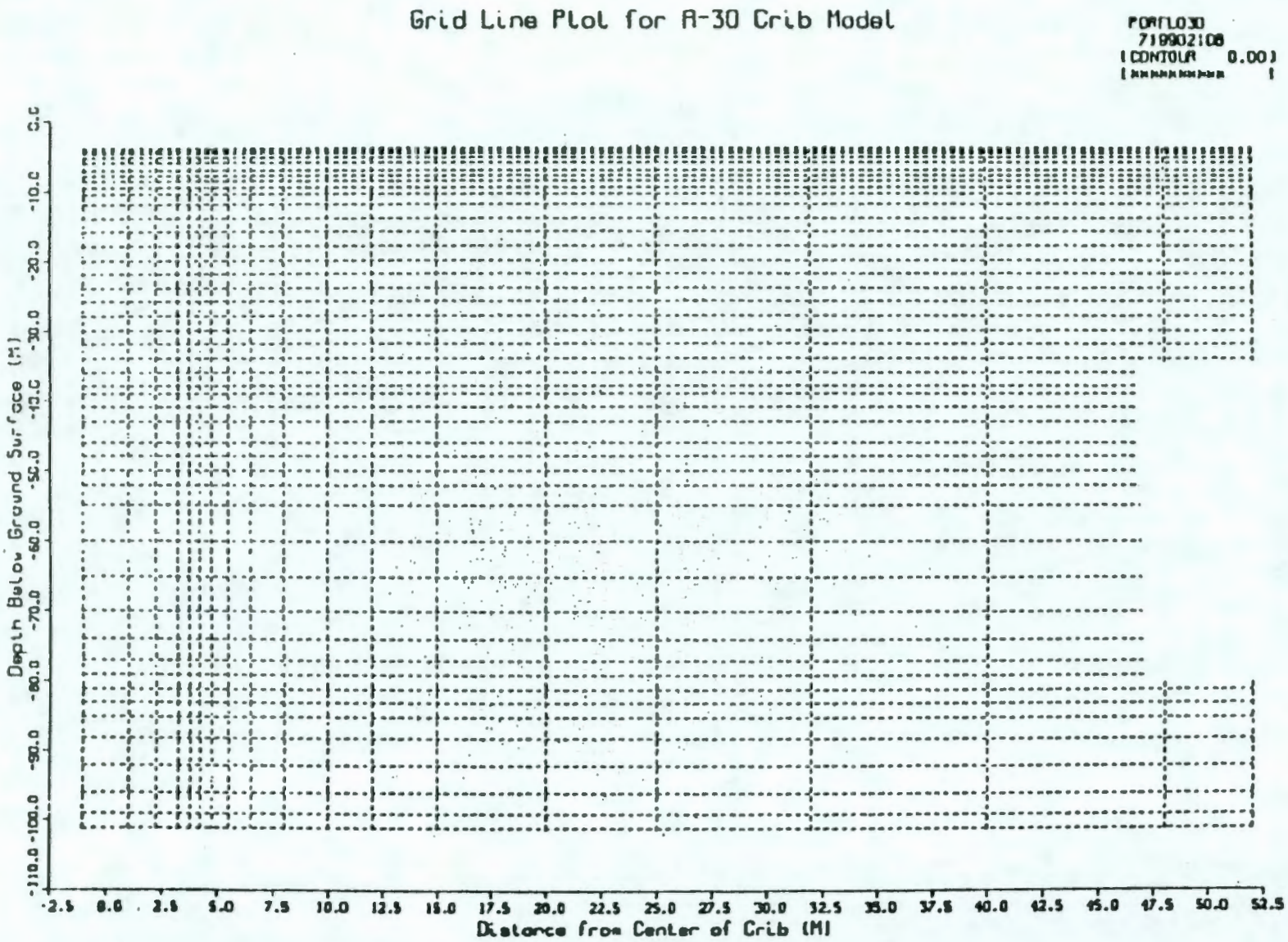


Figure D.3-3. Finite Difference Grid for the 216-A-30 Model.

Table D.3-1. Summary of Hydraulic Properties and Initial Soil Matrix Potential for 216-A-30 Crib Model.

Layer	Thickness (m)	Ksat (m/yr)	a (m)	n (unitless)	Ss (1/m)	Initial (m)
1	4	568	0.130	1.389	0.5	-0.3
2	11	382	0.025	1.346	0.4	-0.2
3	10	568	0.130	1.389	0.5	-0.3
4	8	182	0.110	1.283	0.6	-0.1
5	3	710	0.150	2.675	0.5	-0.5
6	9	382	0.025	1.346	0.4	-0.2
7	31	182	0.110	1.283	0.6	-0.1
8	20	182	-	-	0.6	0

Table D.3-2 Summary of Source Term Information for 216-A-30/A-37-1/A-37-2 Cribs.

Crib	Year Startup	Hydraulic Loading (m/yr)	Potential Contaminant Loading
216-A-37-1	1977	49	strontium-90 (R_f = 35) cesium-137 (R_f = 50) hydrogen-3 (R_f = 1) ruthenium-106 (R_f = 1) acetone (R_f = 1) MEK (R_f = 1)
216-A-30	1961	188	strontium-90 (R_f = 125) cesium-137 (R_f = 250) uranium-235 (R_f = 1, 10)
216-A-37-2	1983	246	strontium-90 (R_f = 125) cesium-137 (R_f = 250) uranium-235 (R_f = 1, 10)

Figure D.3-4. A-37-1 Crib: Steady State Relative Saturation Content.

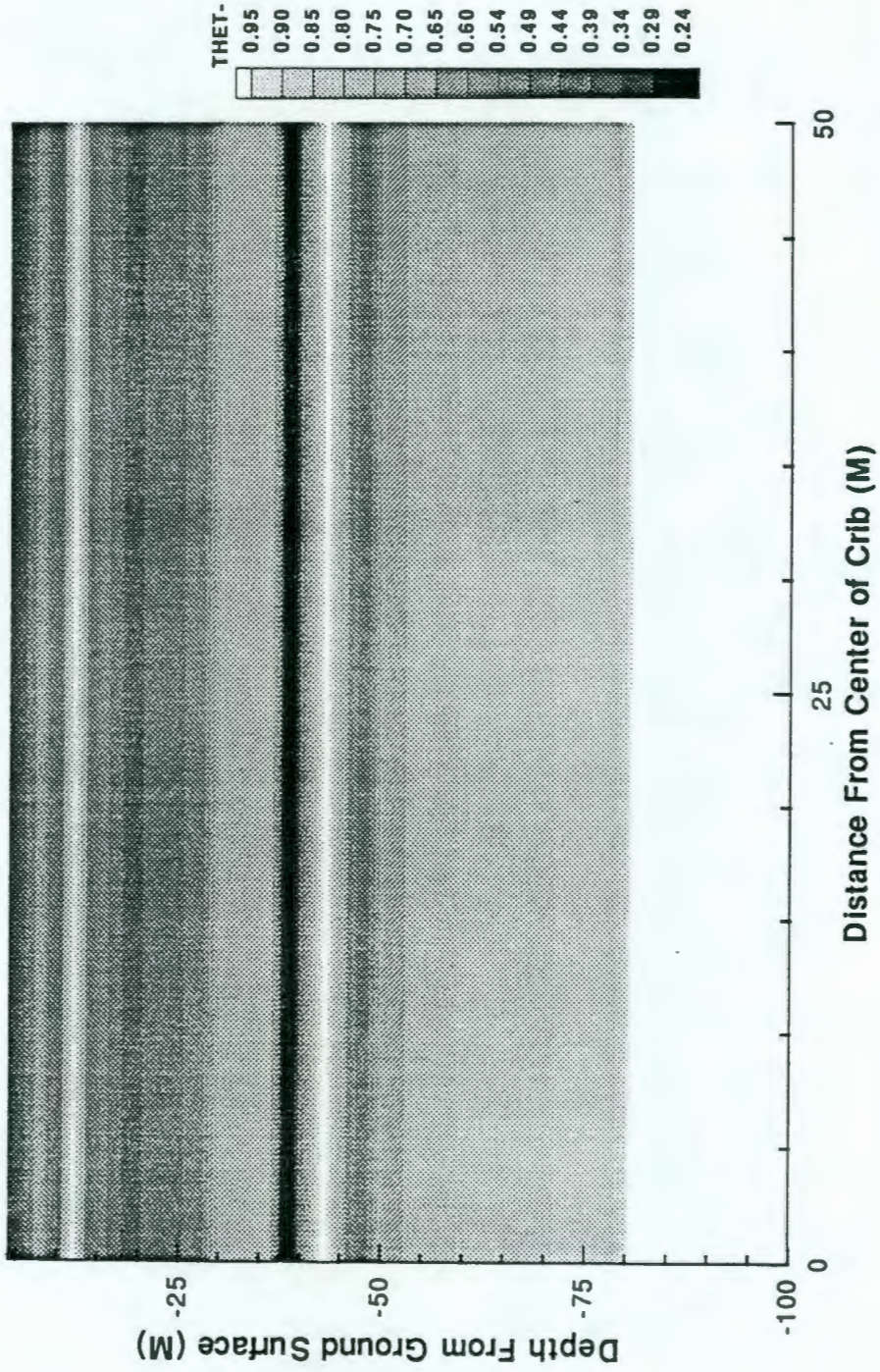
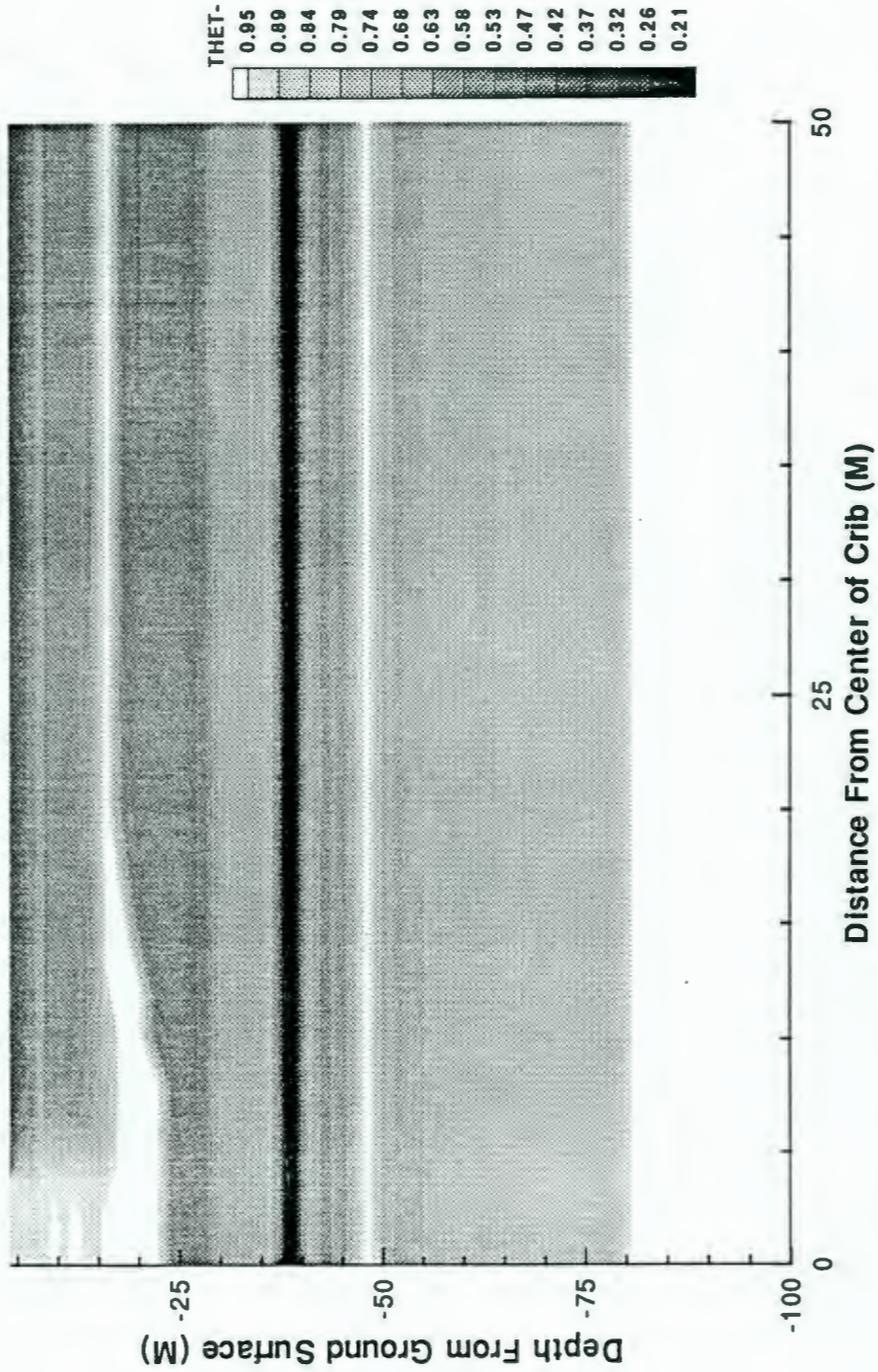


Figure D.3-5. A-37-1 Crib: Relative Saturation Content at 1 Year.



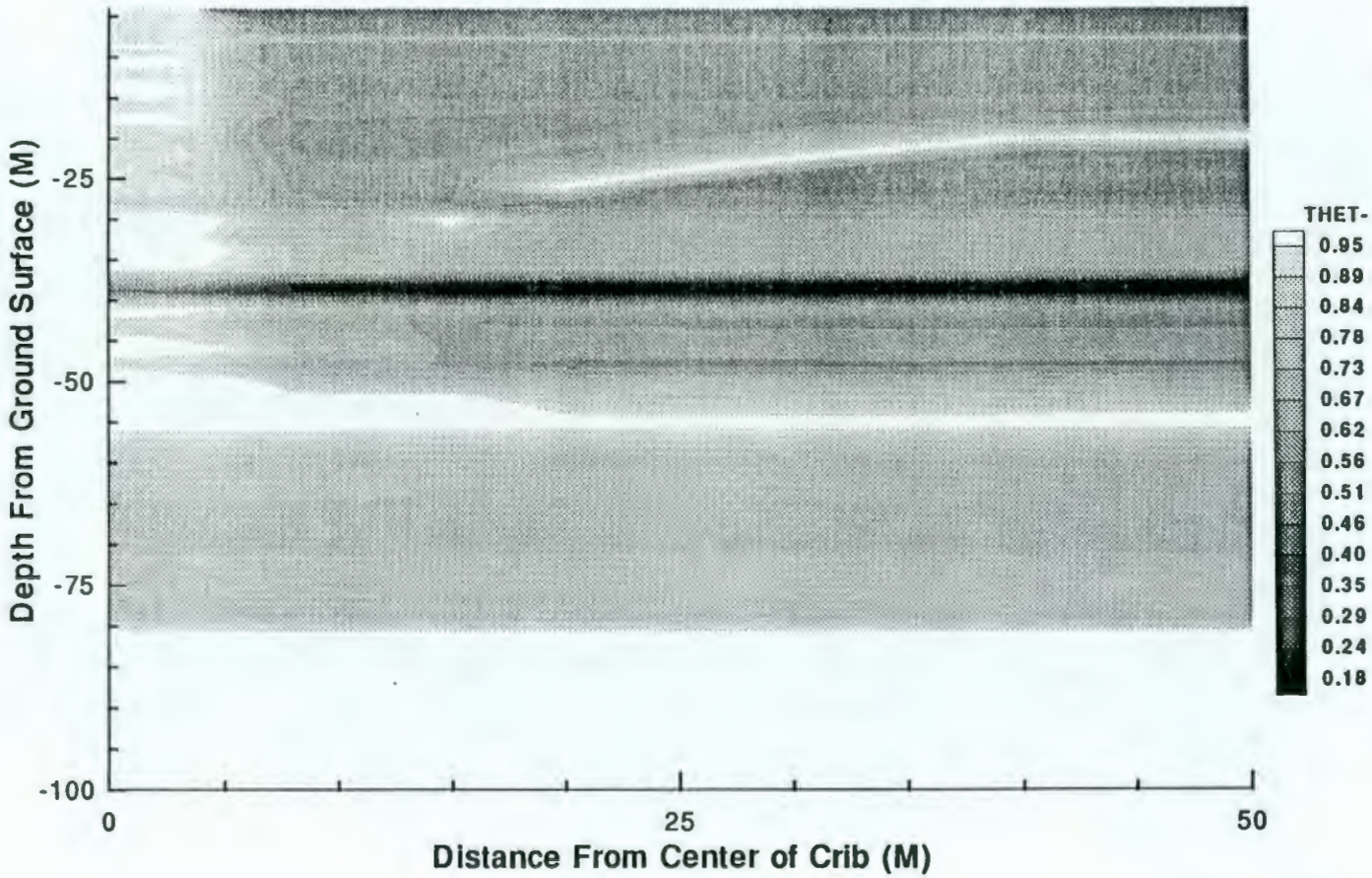


Figure D.3-6. A-37-1 Crib: Relative Saturation Content at 2 Years.

Figure D.3-7. A-37-1 Crib: Relative Saturation Content at 3 Years.

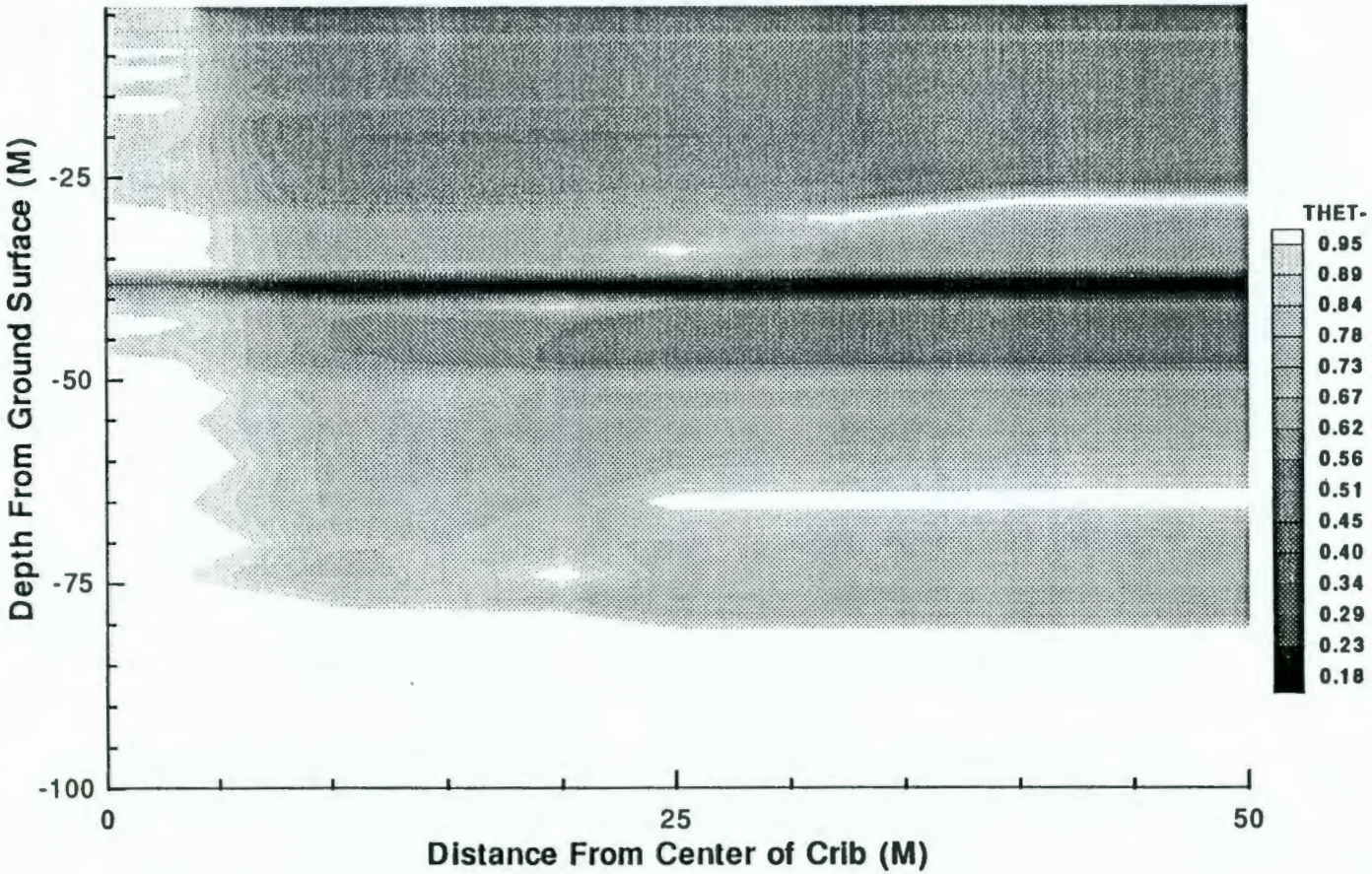


Figure D.3-8. A-37-1 Crib: Relative Saturation Content at 4 Years.

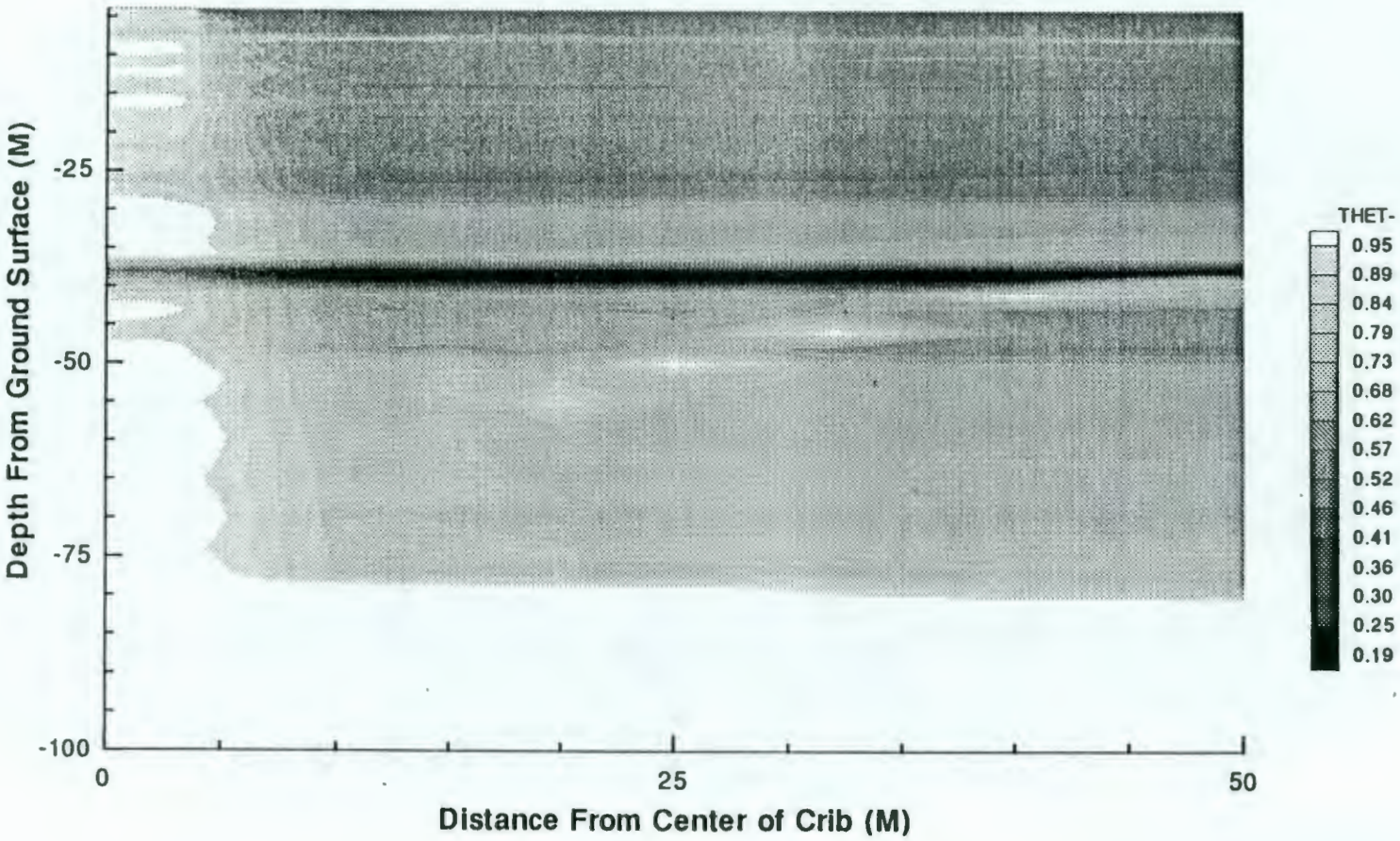
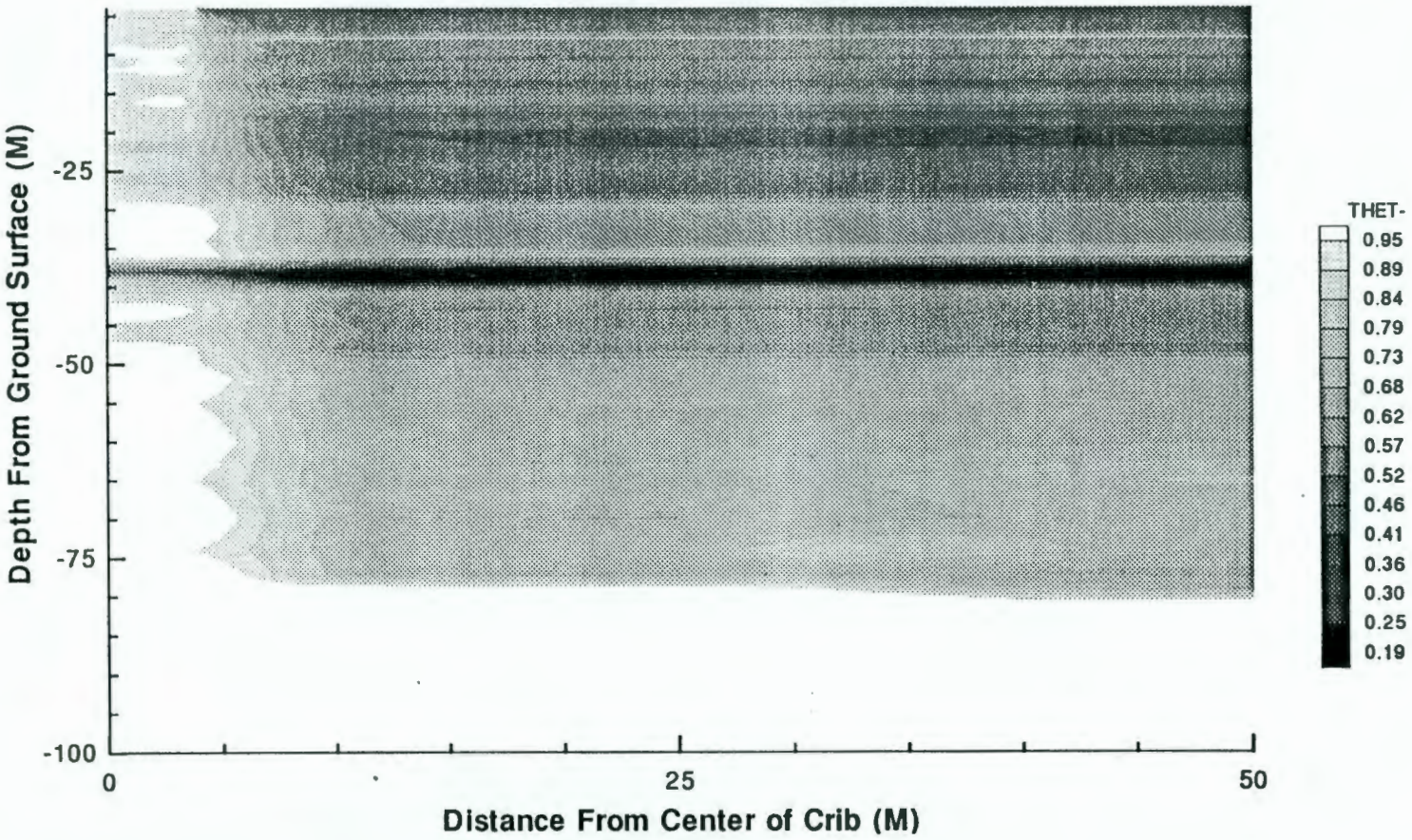


Figure D.3-9. A-37-1 Crib: Relative Saturation Content at 7 Years.



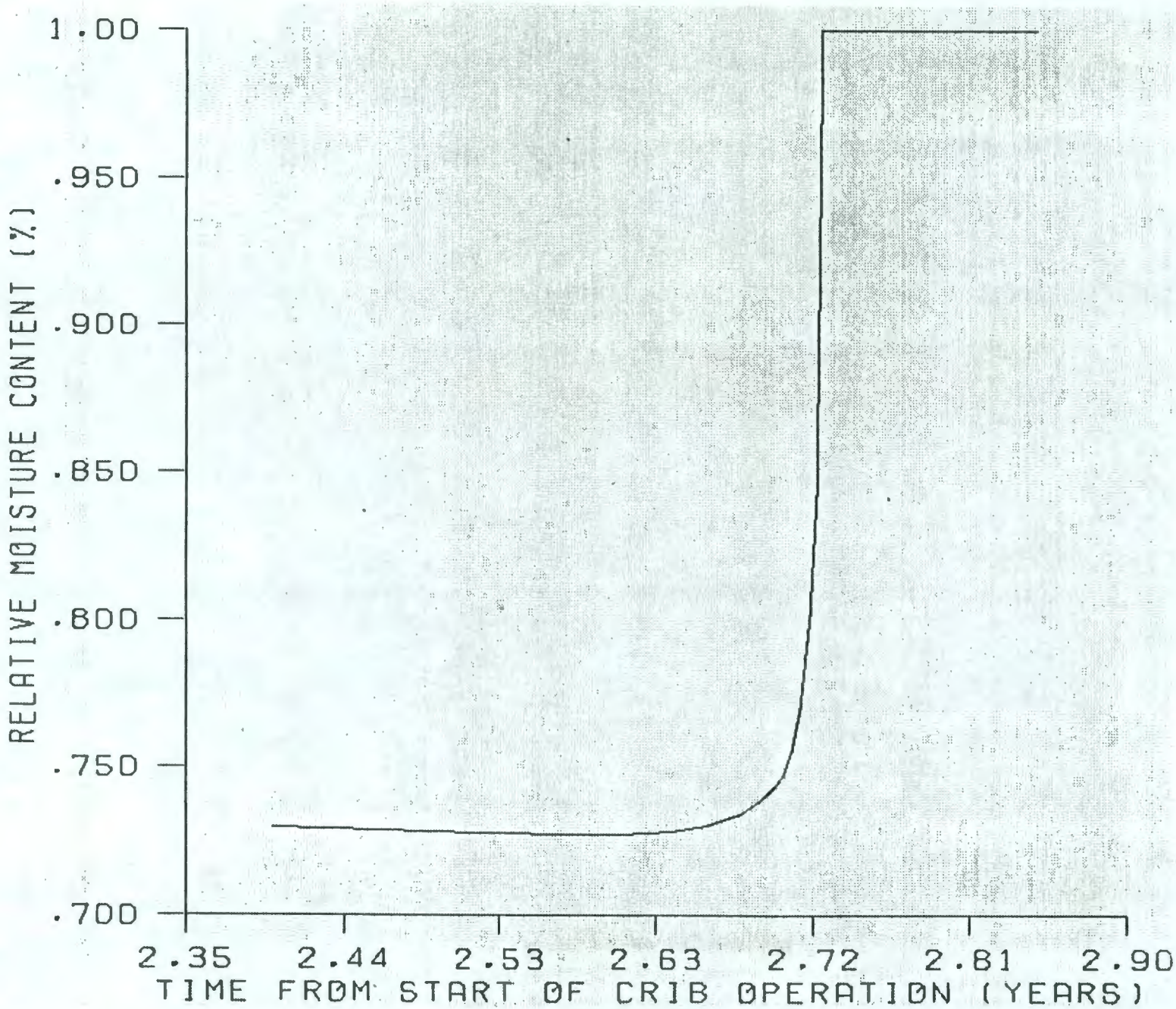


Figure D.3-10. A-37-1 Crib: Arrival of Wetting Front at Water Table.

Figure D.3-11. 216-A-30 Crib: Steady State Relative Saturation Content.

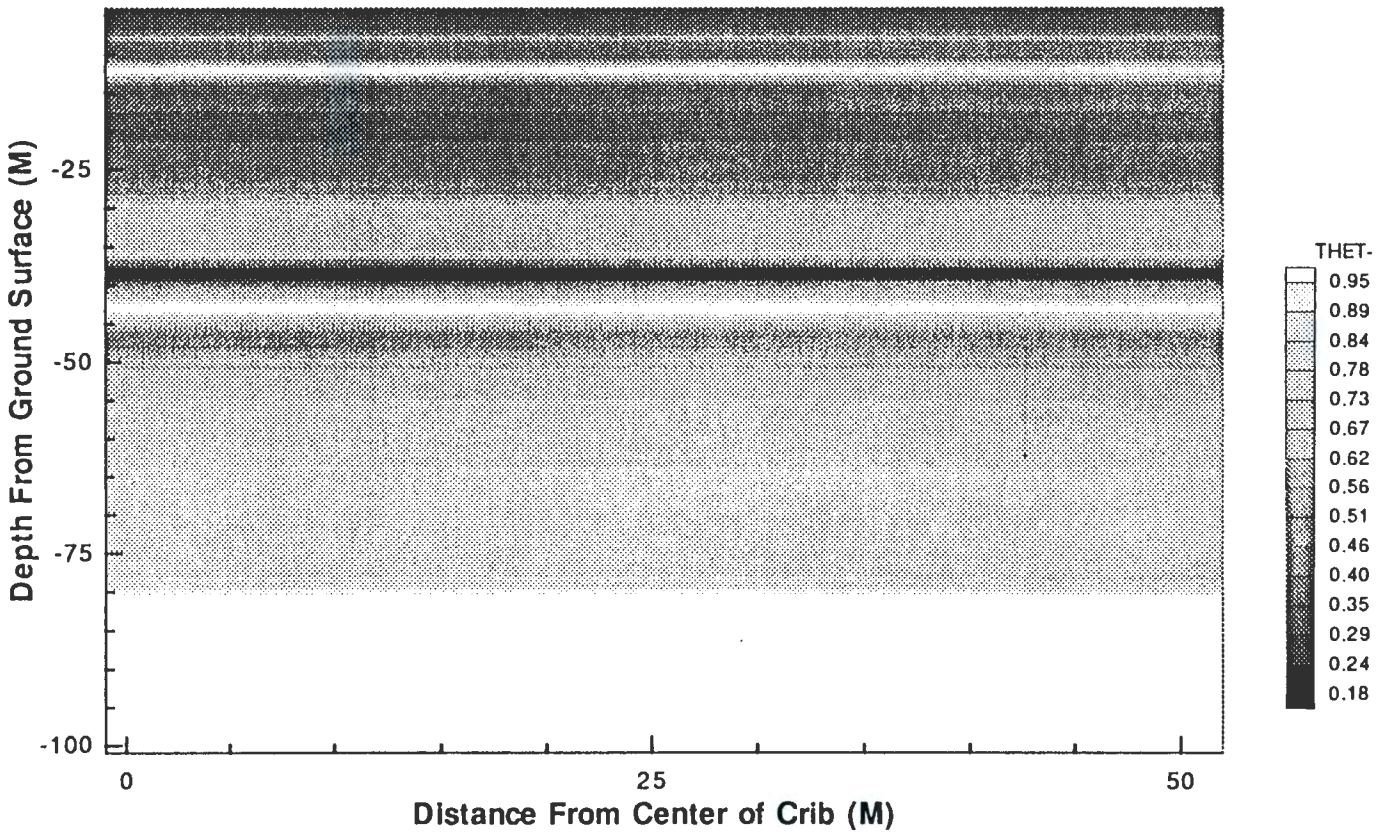


Figure D.3-12. 216-A-30 Crib: Relative Saturation Content at 1 Year.

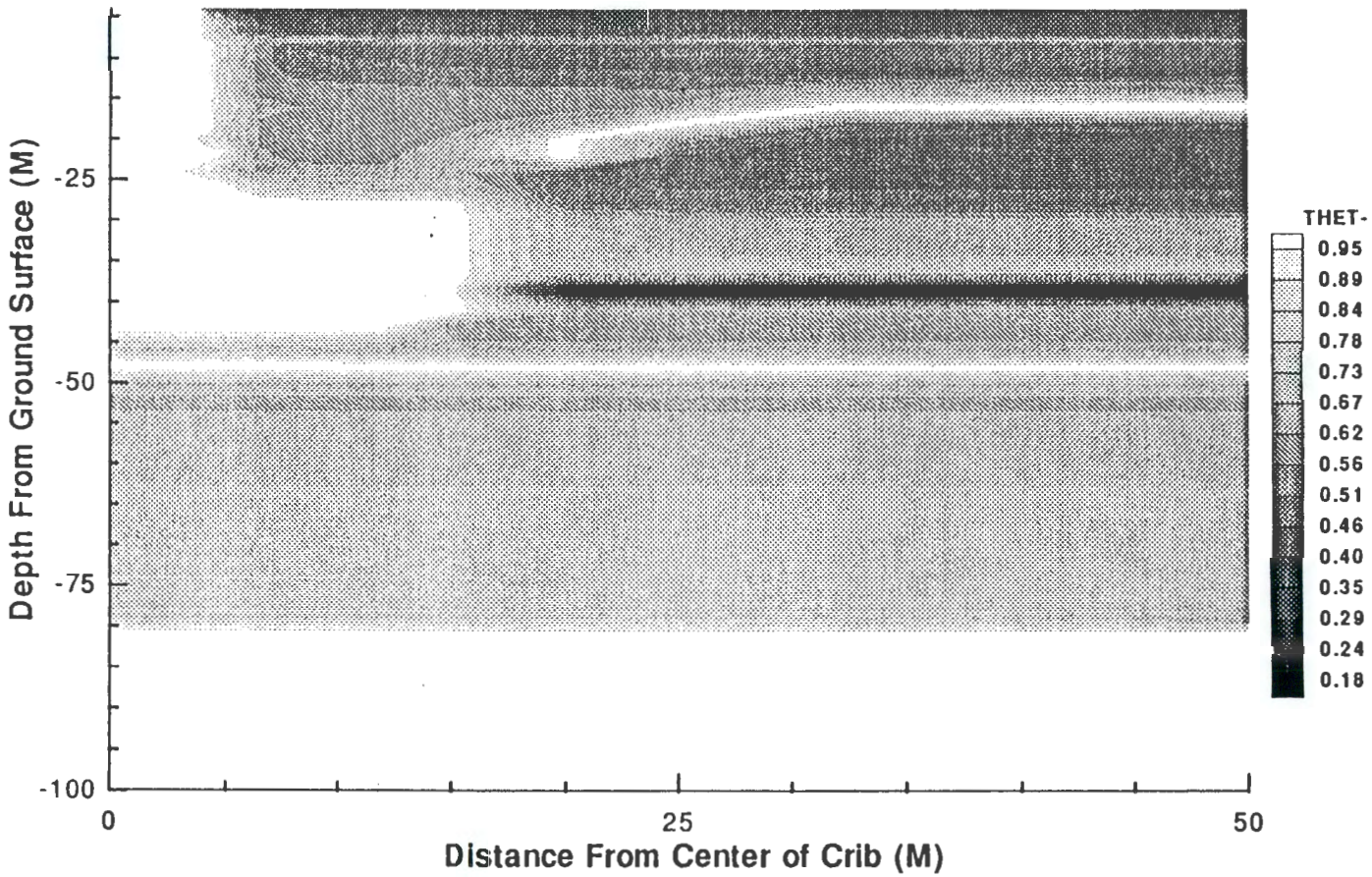


Figure D.3-13. 216-A-30 Crib: Relative Saturation Content at 2 Years.

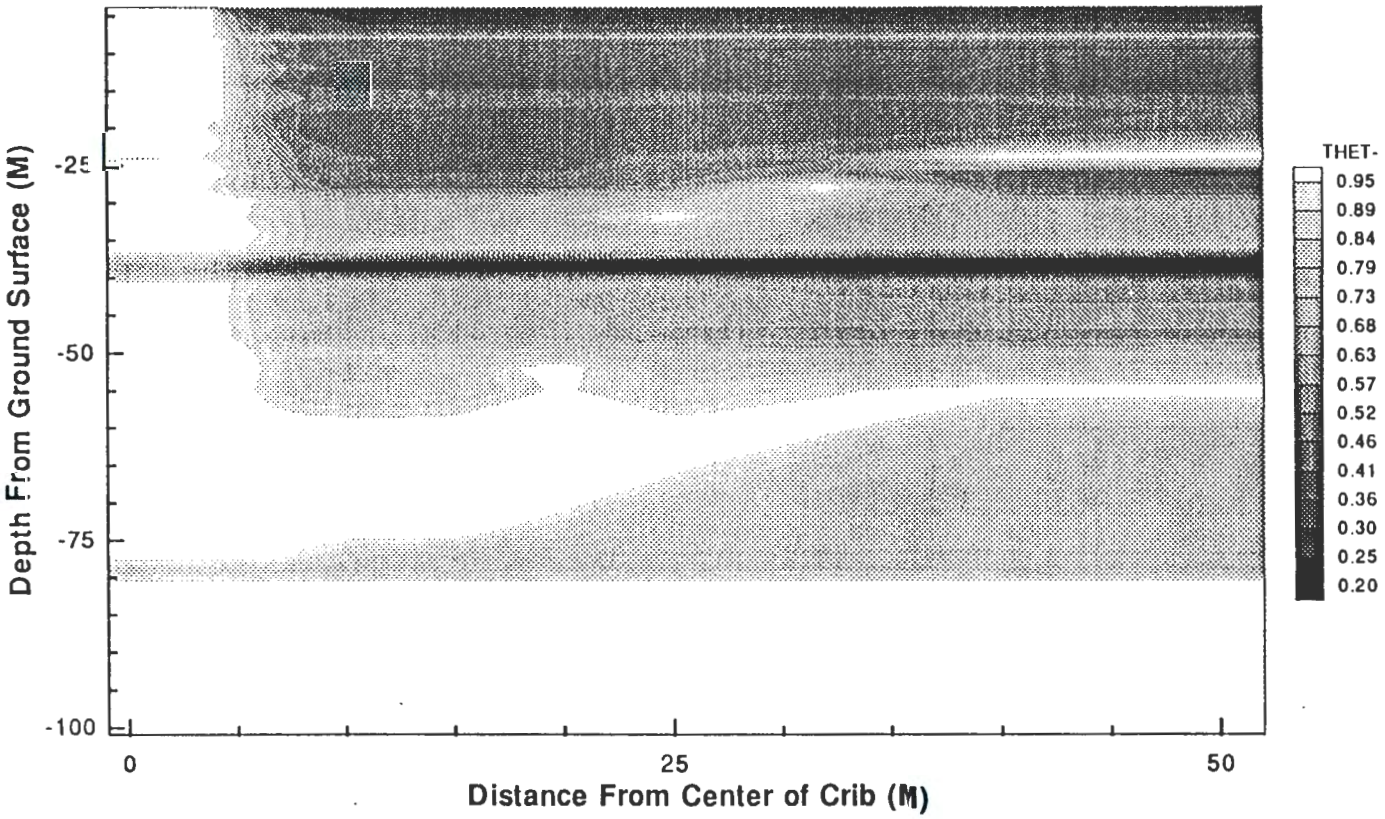


Figure D.3-14. 216-A-30 Crib: Relative Saturation Content at 3 Years.

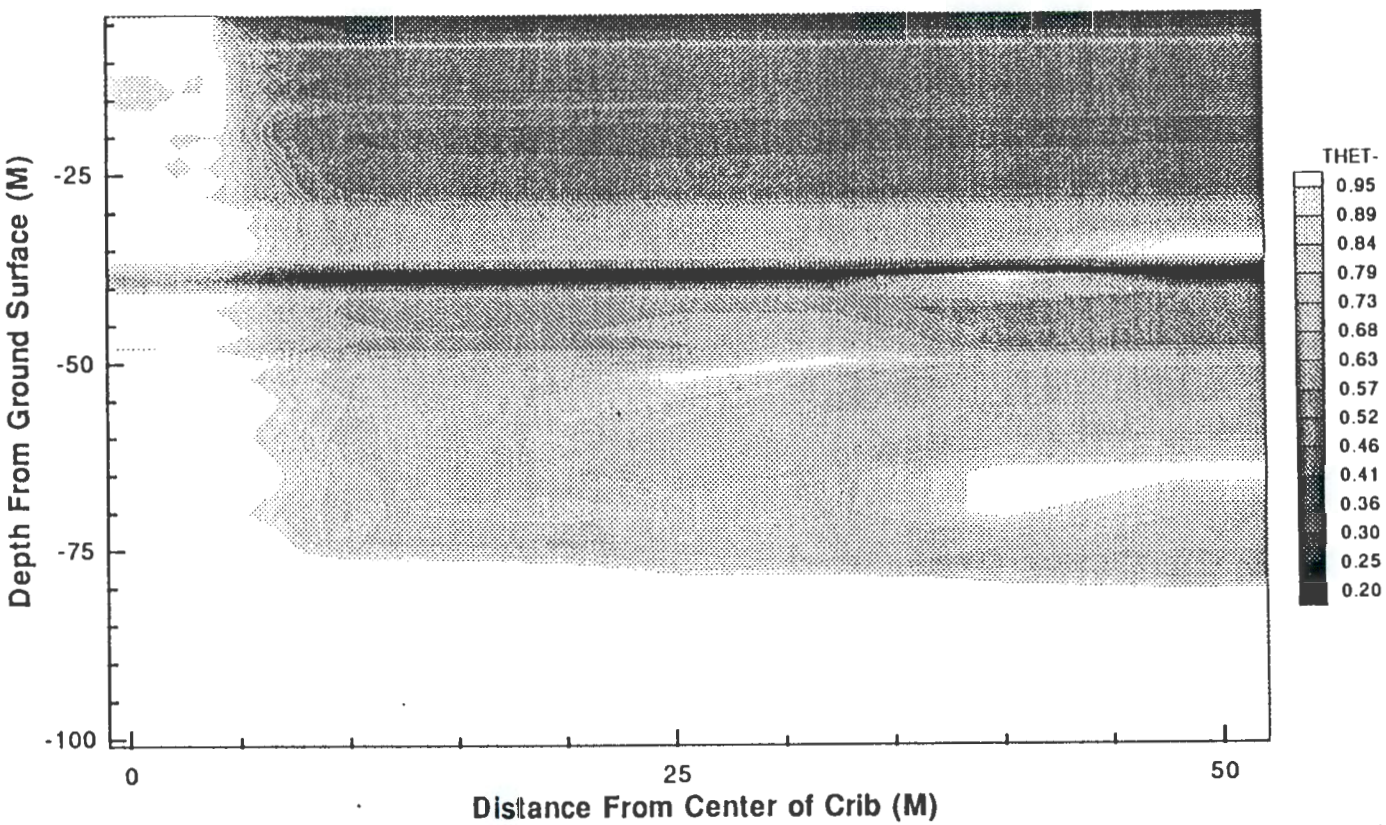


Figure D.3-15. A-37-2 Crib: Relative Saturation Content at 1 Year.

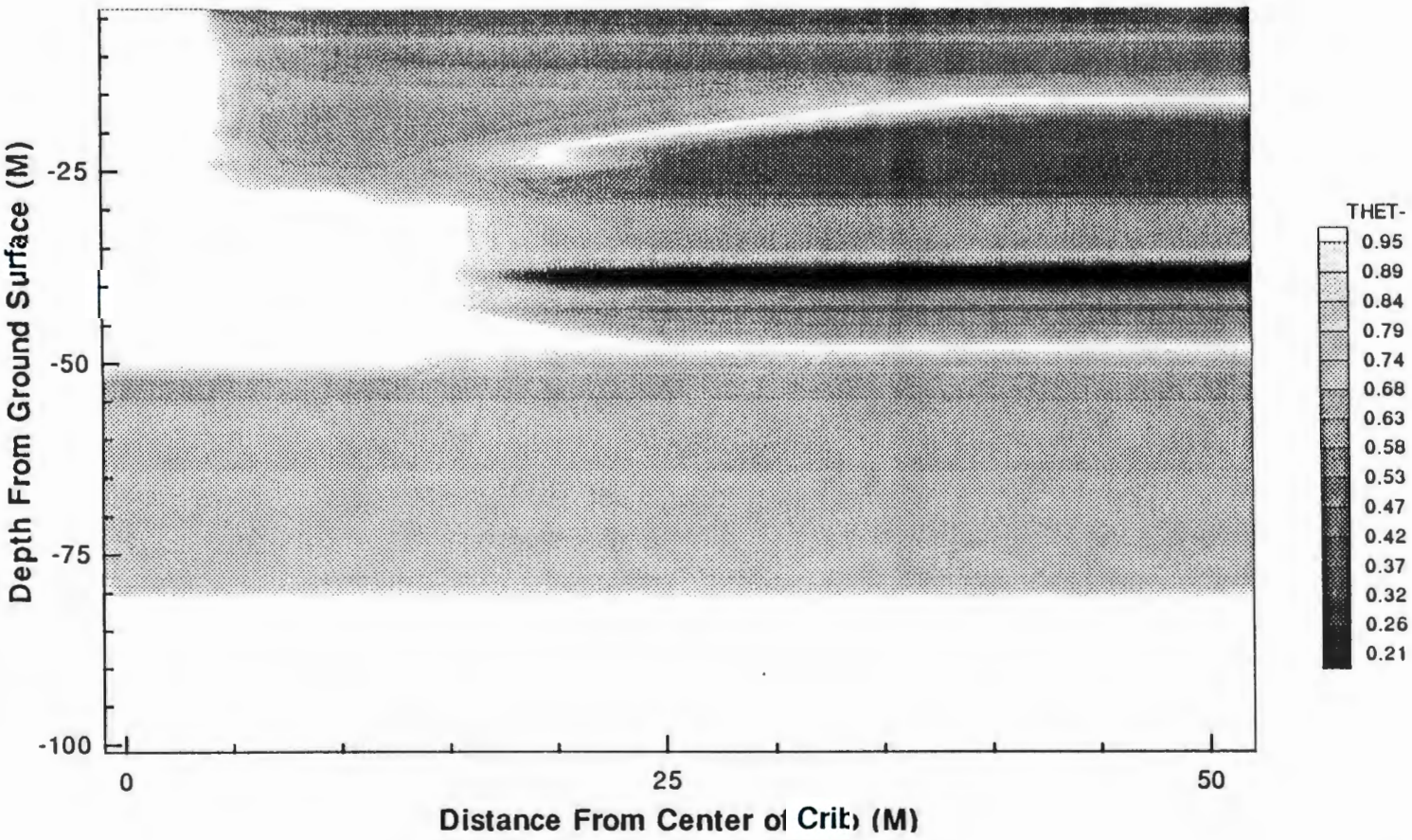


Figure D.3-16. A-37-2 Crib: Relative Saturation Content at 2 Years.

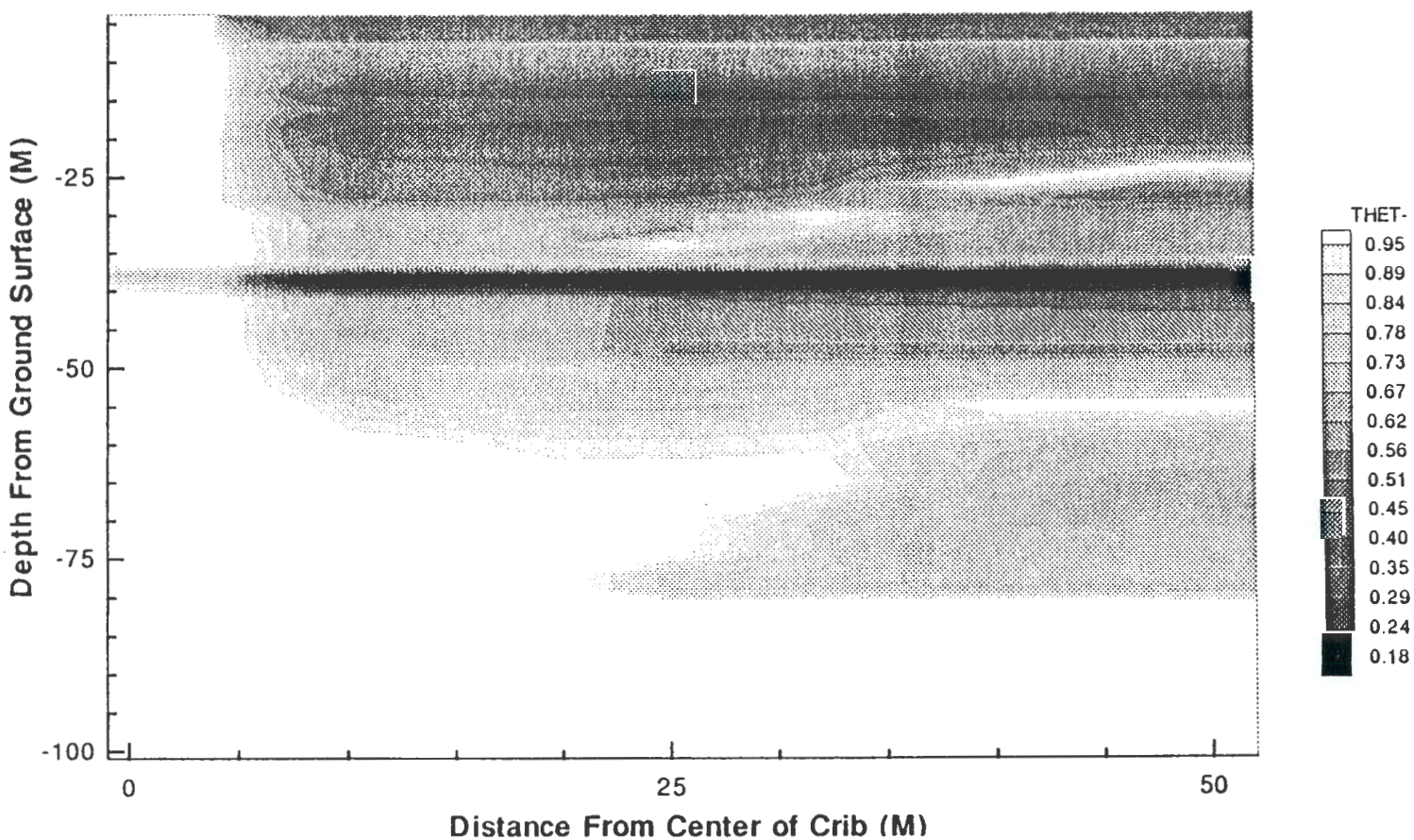
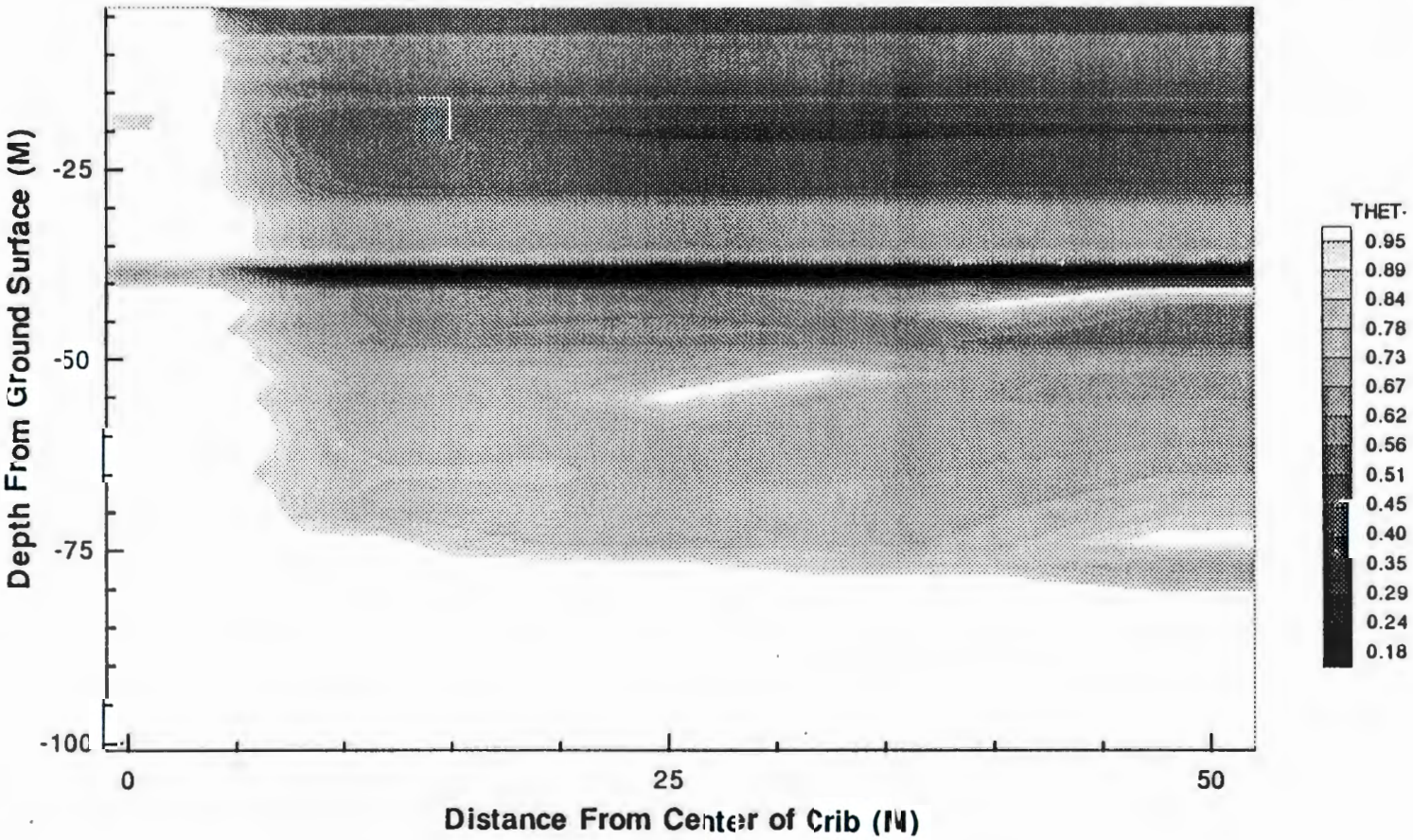


Figure D.3-17. A-37-2 Crib: Relative Saturation Content at 3 Years.



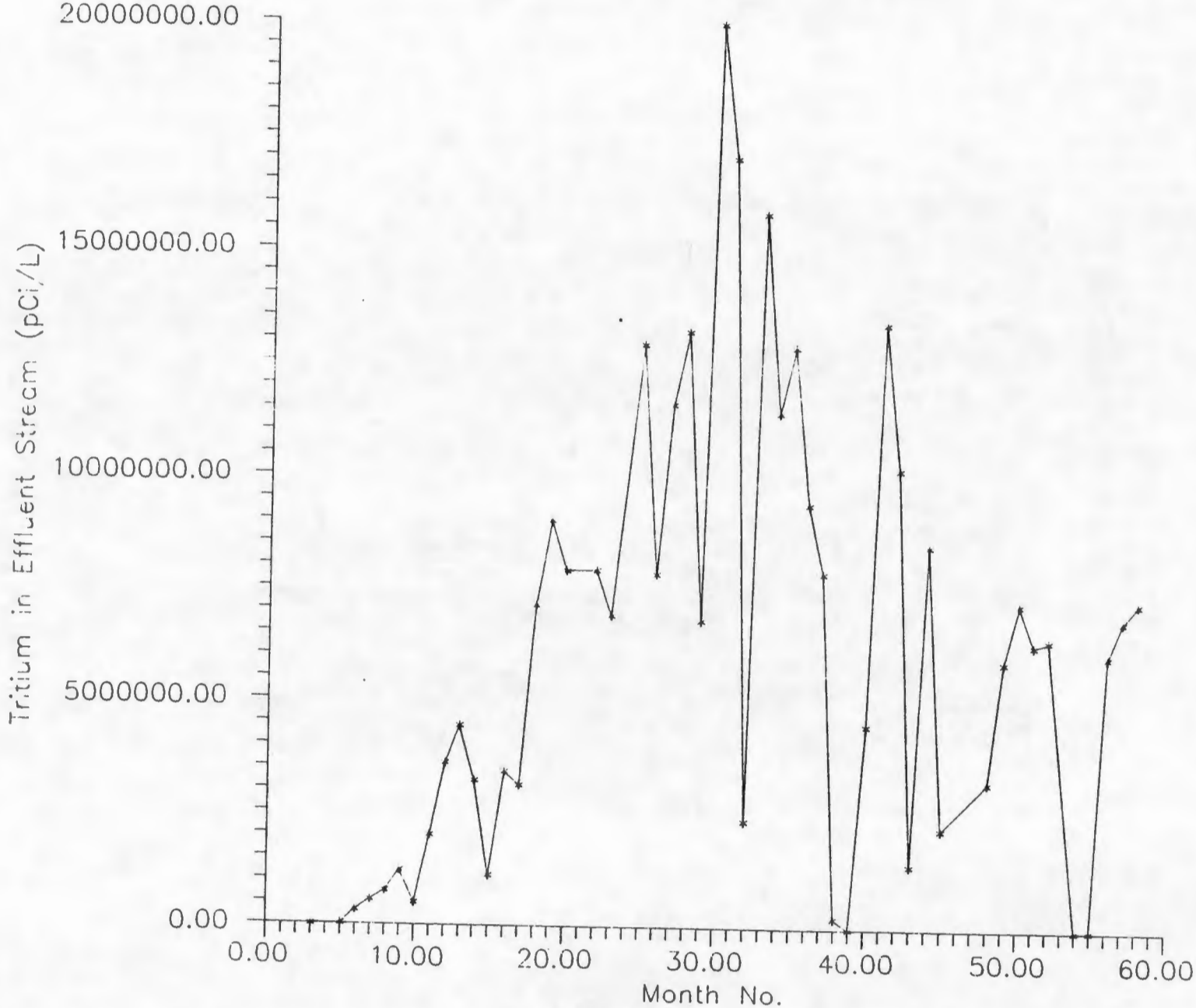


Figure D.3-18. Concentration of Tritium Released to the 216-U-37-1 Crib.

9 1 1 2 1 8 7 0 5 1 5

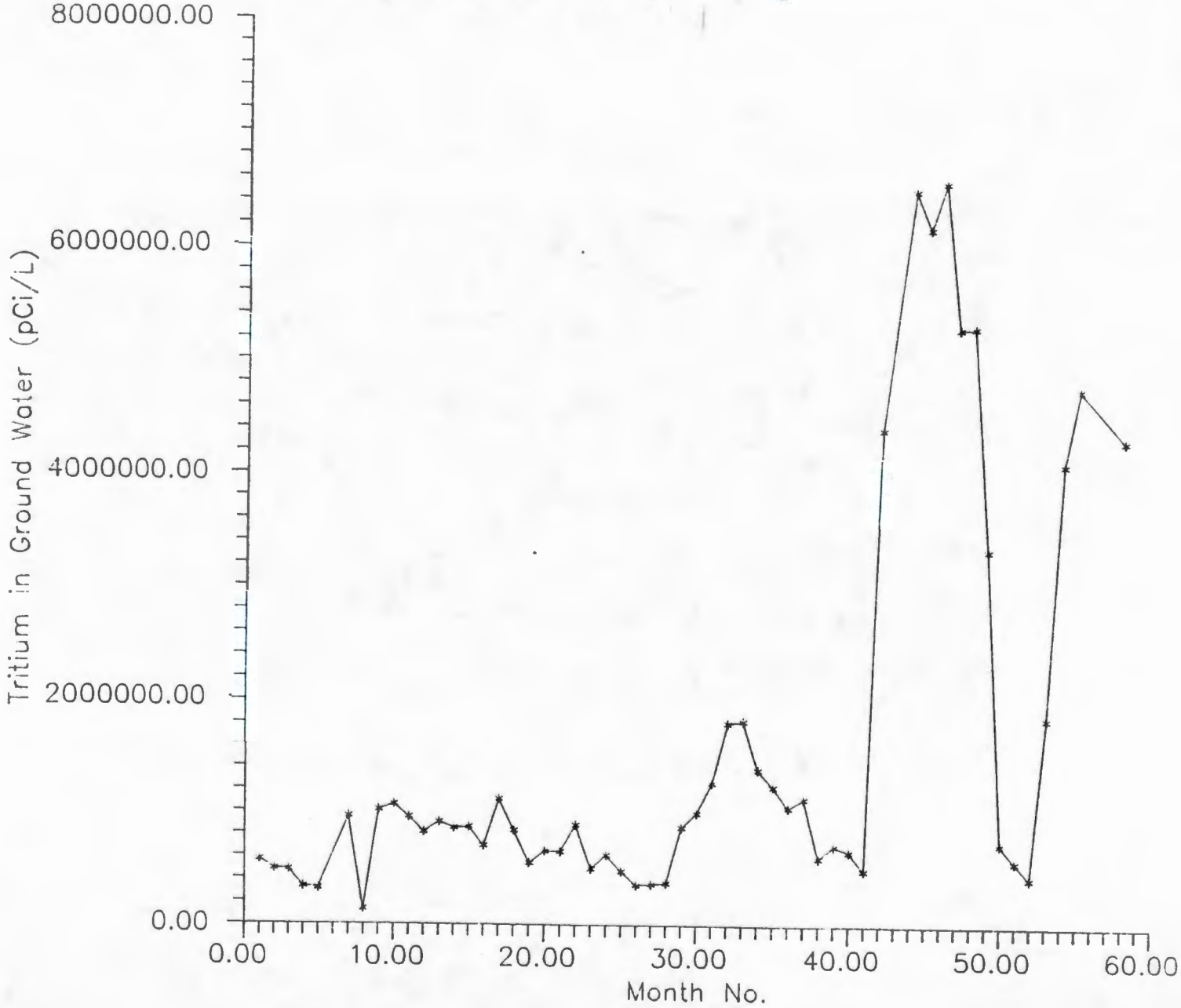


Figure D.3-19. Concentration of Tritium Measured in the Groundwater.

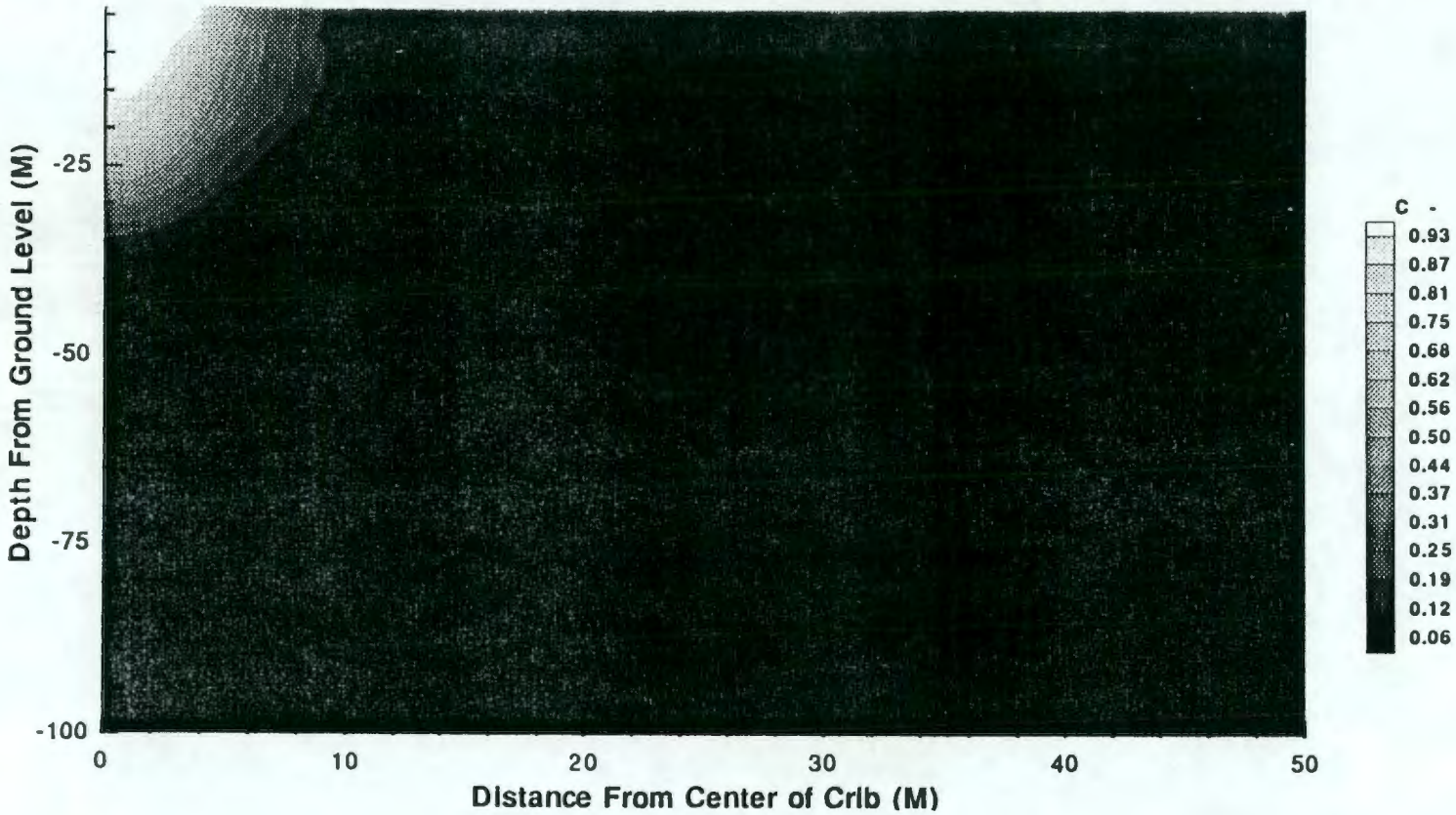


Figure D.3-20. A-37-1 Crib: Normalized Tritium Concentration 3 Months After Release.

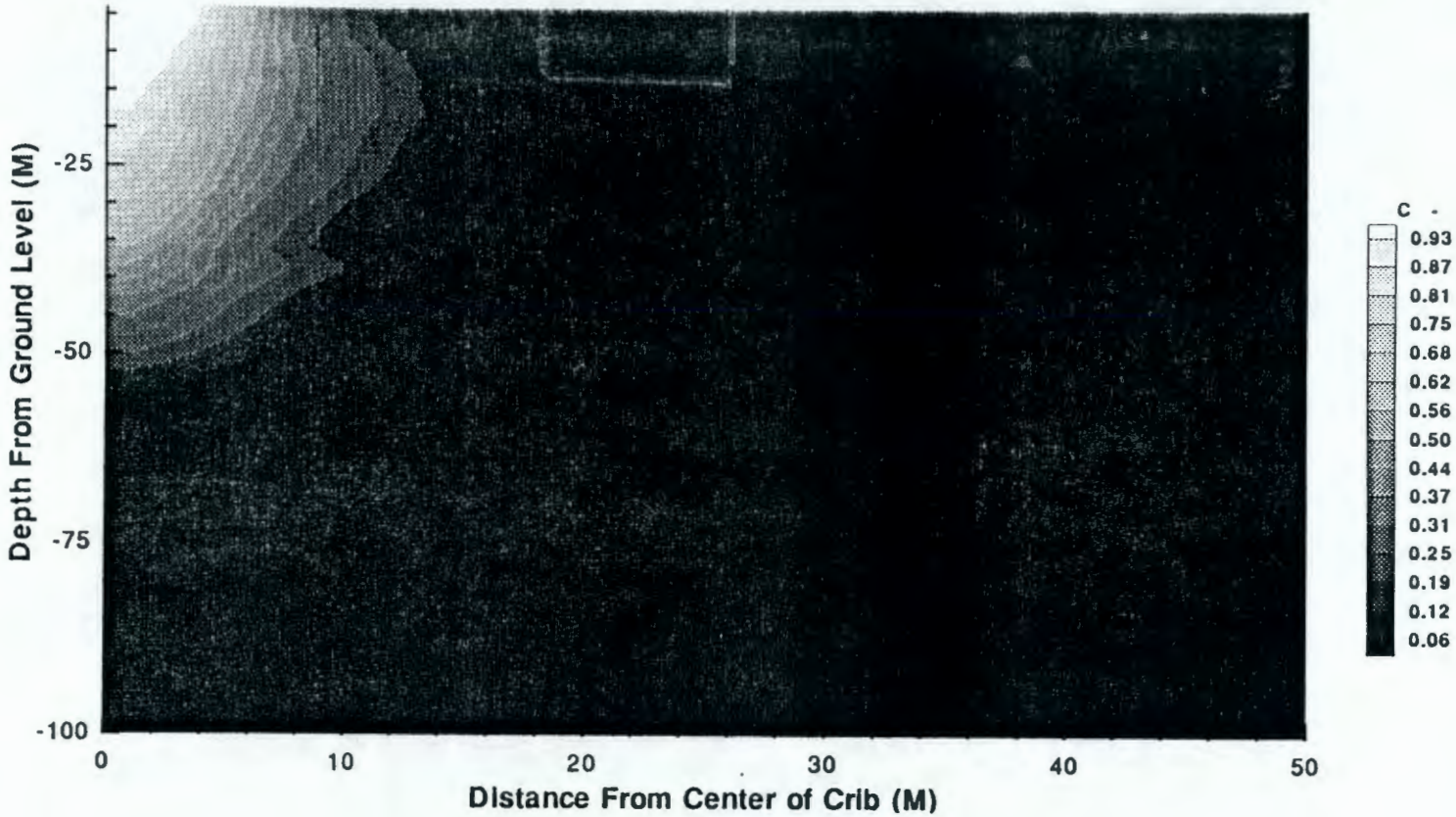


Figure D.3-21. A-37-1 Crib: Normalized Tritium Concentration 6 Months After Release.

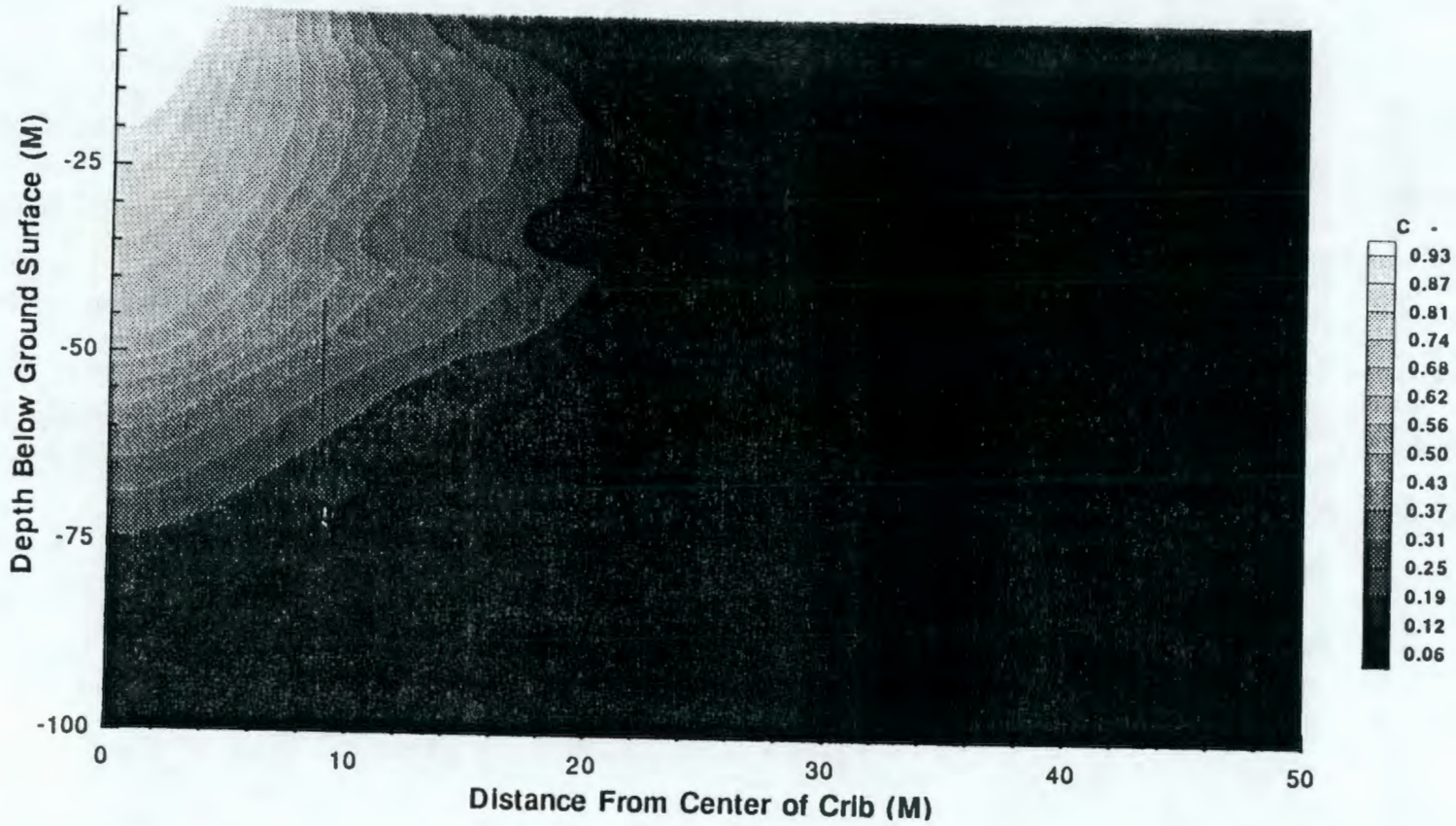


Figure D.3-22. A-37-1 Crib: Normalized Tritium Concentration 1 Year After Release.

Figure D.3-23. A-37-1 Crib: Normalized Tritium Concentration 2 Years After Release.

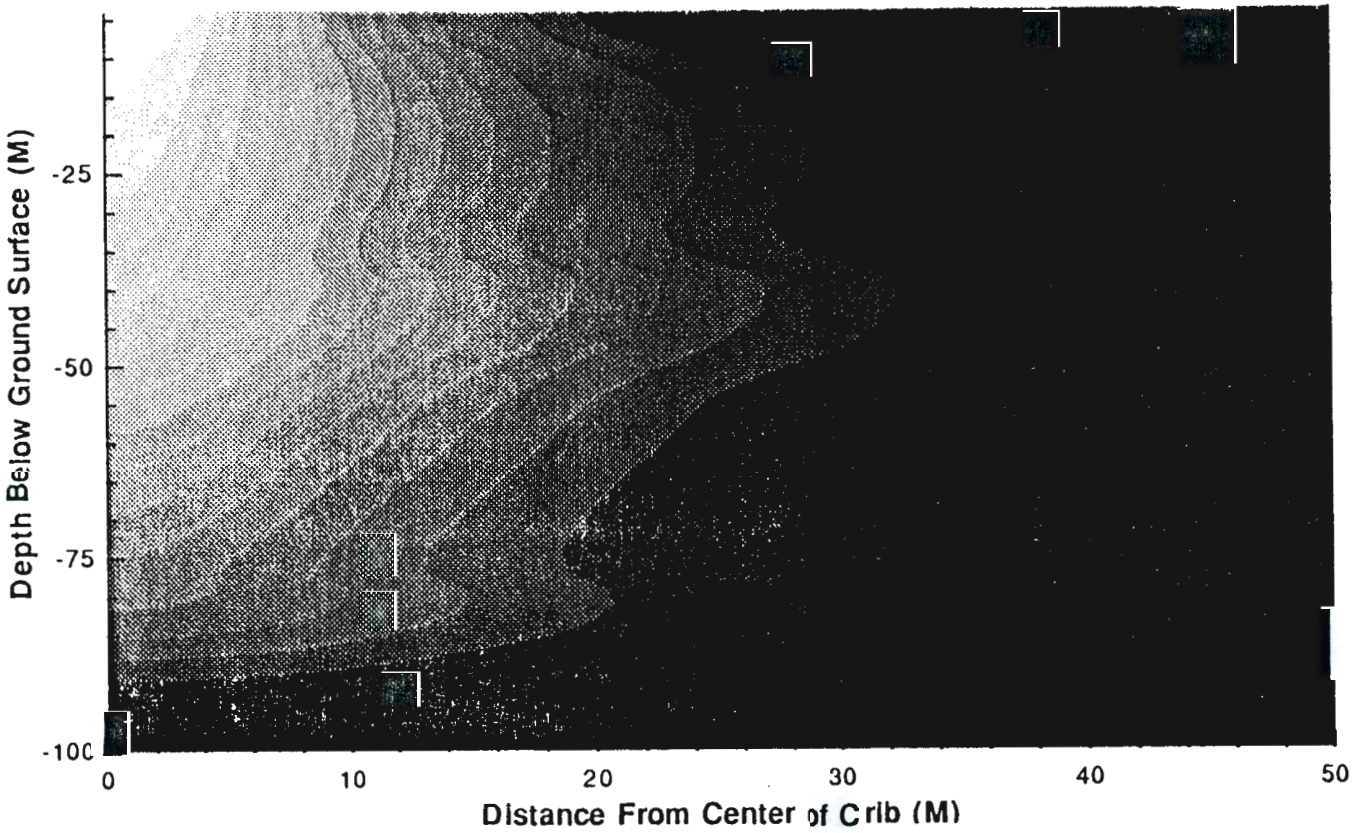


Figure D.3-24. A-37-1 Crib: Arrival of Tritium at Water Table.

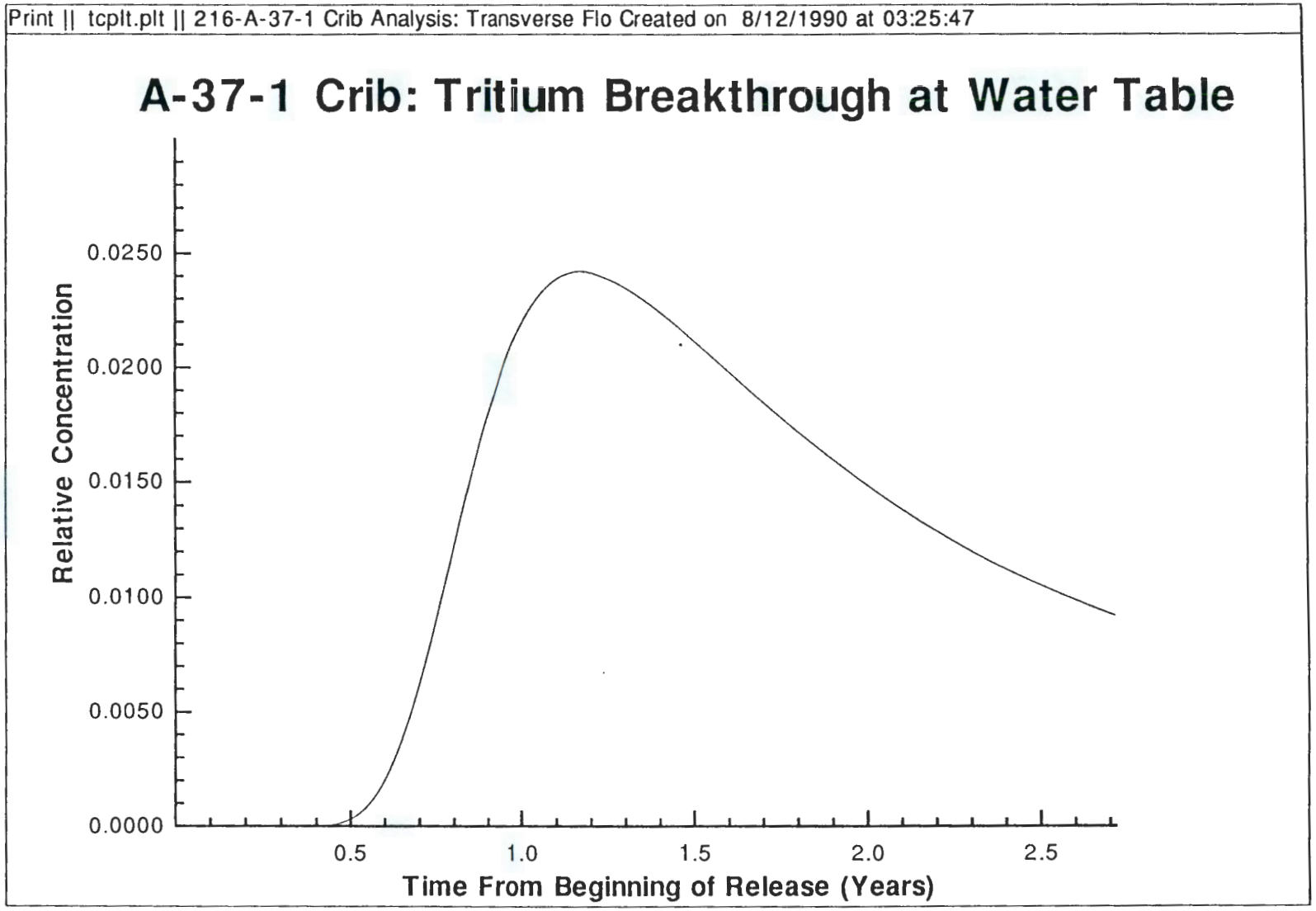


Figure D.3-25. A-37-1 Crib: Cesium Concentration at 3 Years.

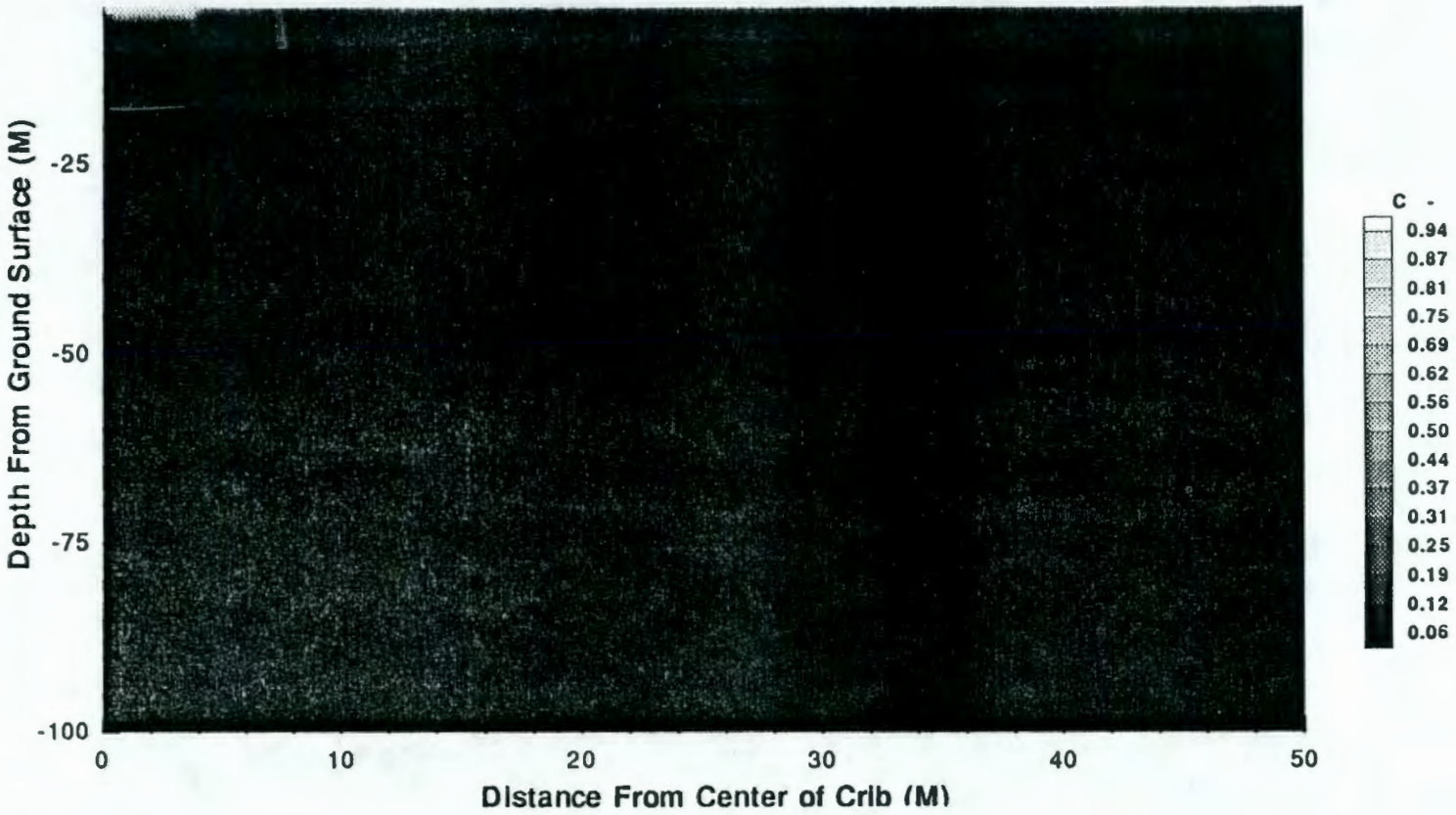
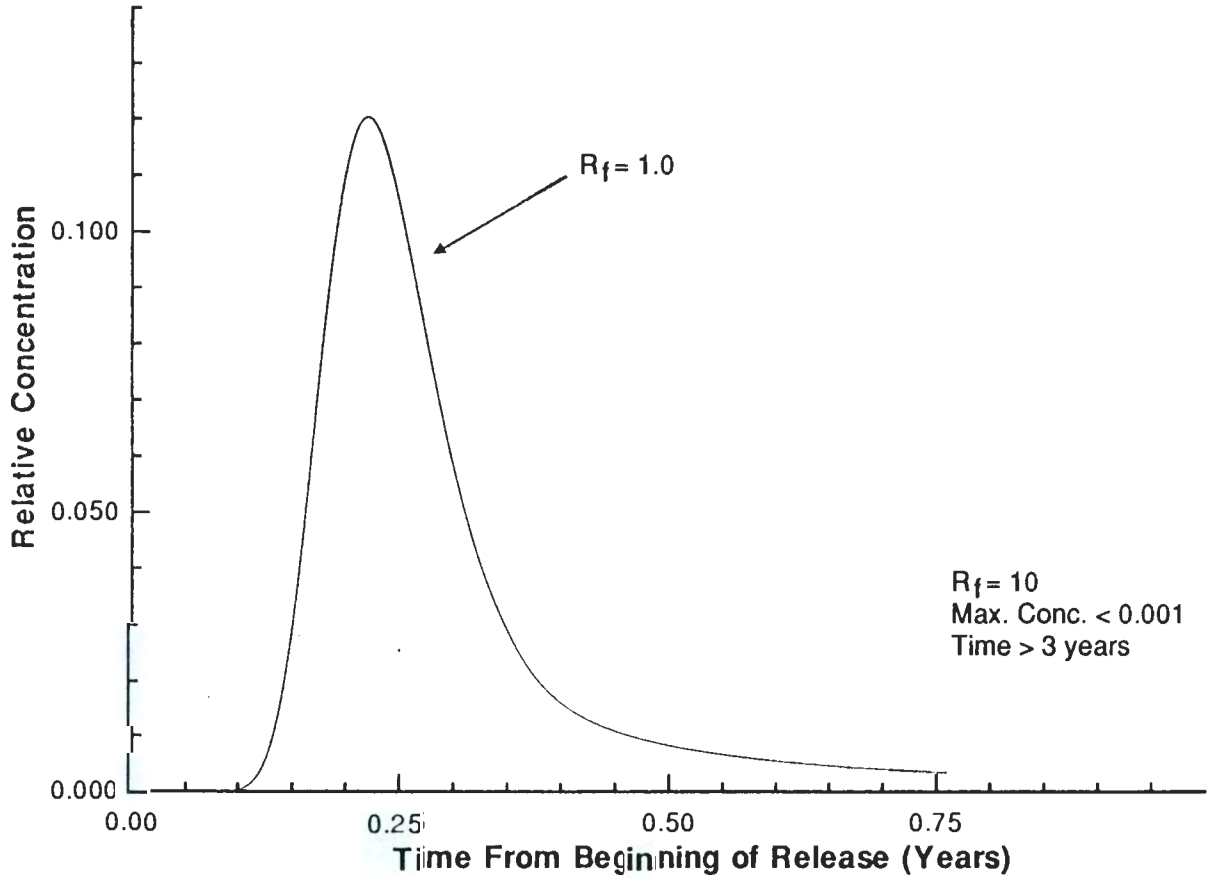


Figure D.3-26. Arrival of Uranium-235 at Water Table (R_f = 1, R_f = 10).



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